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Abundance of Late-run Kasilof River Chinook Salmon, 2005–2008

by

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and

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October 2012

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

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
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 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
mid eye to fork	MEF
mid eye 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

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ABSTRACT

The abundance of wild Chinook salmon, ocean-age-.2 or greater, migrating into the Kasilof River was estimated using modified 2-event mark–recapture experiments from 2005 to 2008. Radiotelemetry was used to investigate and correct for the effects of handling and marking on fish behavior. In 2005, a pilot study yielded only limited information about abundance. With 90% probability, the 2005 abundance was between 5,837 and 25,637 fish. Improvements in study design and sample size yielded better precision in succeeding years. With 90% probability, the 2006 abundance was between 6,517 and 11,514 fish, the 2007 abundance was between 6,433 and 11,002 fish, and the 2008 abundance was between 5,563 and 13,613 fish. The most likely values (modes of Bayesian posterior probability distributions) of abundance were 8,611 in 2006, 8,522 in 2007, and 8,276 in 2008. A point estimate for 2005 is meaningless due to the imprecision of the estimate although there is 87%, 89%, and 83% probability that the 2005 abundance exceeded 2006–2008 abundances, respectively. The inriver run was predominantly age 1.4 for the years 2005–2007 but predominantly age 1.3 in 2008.

Key words: Kasilof River, Chinook salmon, *Oncorhynchus tsawytscha*, mark–recapture, radiotelemetry, gillnetting, Bayesian statistics

INTRODUCTION

The Kasilof River watershed encompasses 860 square miles of the western Kenai Peninsula. The headwaters include Tustumena Glacier, which affects the water level and turbidity in Kasilof River. Mean daily discharges peak at over 6,500 ft^3/s in August and September but are less than 1,500 ft^3/s from December to June[1]. The Kasilof River drains Tustumena Lake into Cook Inlet (Figure 1), flowing 19 miles through low-lying terrain, with an average width of 225 feet (J. Frost, Bureau of Land Management, 7 April 2005, personal communication[2]). The lower 5.5 miles of the river are tidally influenced. There are only 2 tributaries to the Kasilof River mainstem: Coal Creek (river mile [RM] 4.1) and Crooked Creek (RM 6.9). There are 12 tributaries to Tustumena Lake.

The Kasilof River supports populations of Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), pink salmon (*O. gorbuscha*), Dolly Varden (*Salvelinus malma*), and anadromous rainbow trout (*O. mykiss*). Chinook salmon run timing in the Kasilof River is bimodal; an early run enters in May–June and a late run enters in July–August. Early-run Chinook salmon are a combination of hatchery-reared and "naturally-produced" Chinook salmon that spawn in Crooked Creek. Naturally-produced fish rear in Crooked Creek and are the progeny of both hatchery-reared fish that have been allowed to spawn freely and wild fish. Hatchery-reared fish are produced by artificially spawning naturally-produced fish returning to Crooked Creek, rearing the eggs in a hatchery for 1 or 2 years, and releasing the progeny back into Crooked Creek as smolt. Prior to release, all hatchery-reared smolt are marked with an adipose fin clip (AFC) and injected with a coded wire tag.

Late-run Kasilof River Chinook salmon compose a wild stock. Abundance of the population is unknown and little is known about age, sex, and length (ASL) composition or run timing. The sport harvest is small (Table 1), although additional harvests of unknown magnitude likely occur in the Upper Cook Inlet commercial fisheries and the Central Cook Inlet marine recreational fishery. Late-run Kasilof River Chinook salmon spawn in the mainstem of the Kasilof River. This is similar to the nearby Kenai River, where tributary-spawning fish arrive earlier than

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1 Viewed online 2/5/06 from a U.S. Geological Survey website, http://waterdata.usgs.gov/ak/nwis/monthly?referred_module=sw&site_no=15242000&por_15242000_1=623469,00060,1,1949-07,1970-09&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file &submitted_form=parameter_selection_list.

2 Draft memorandum entitled "Navigability of the Kasilof River in the Cook Inlet Region" contained within case file AA-085446 (1864).

mainstem-spawning fish (Bendock and Alexandersdottir 1992; Burger et al. 1983; Hammarstrom et al. 1985).

There is no management plan for late-run Kasilof River Chinook salmon. Sport harvest was not allowed until 1985, when regulations allowing Chinook salmon harvest were extended through July downstream of the Sterling Highway Bridge. Regulatory changes since 1985 have largely been directed at the early-run Kasilof River Chinook salmon fishery.

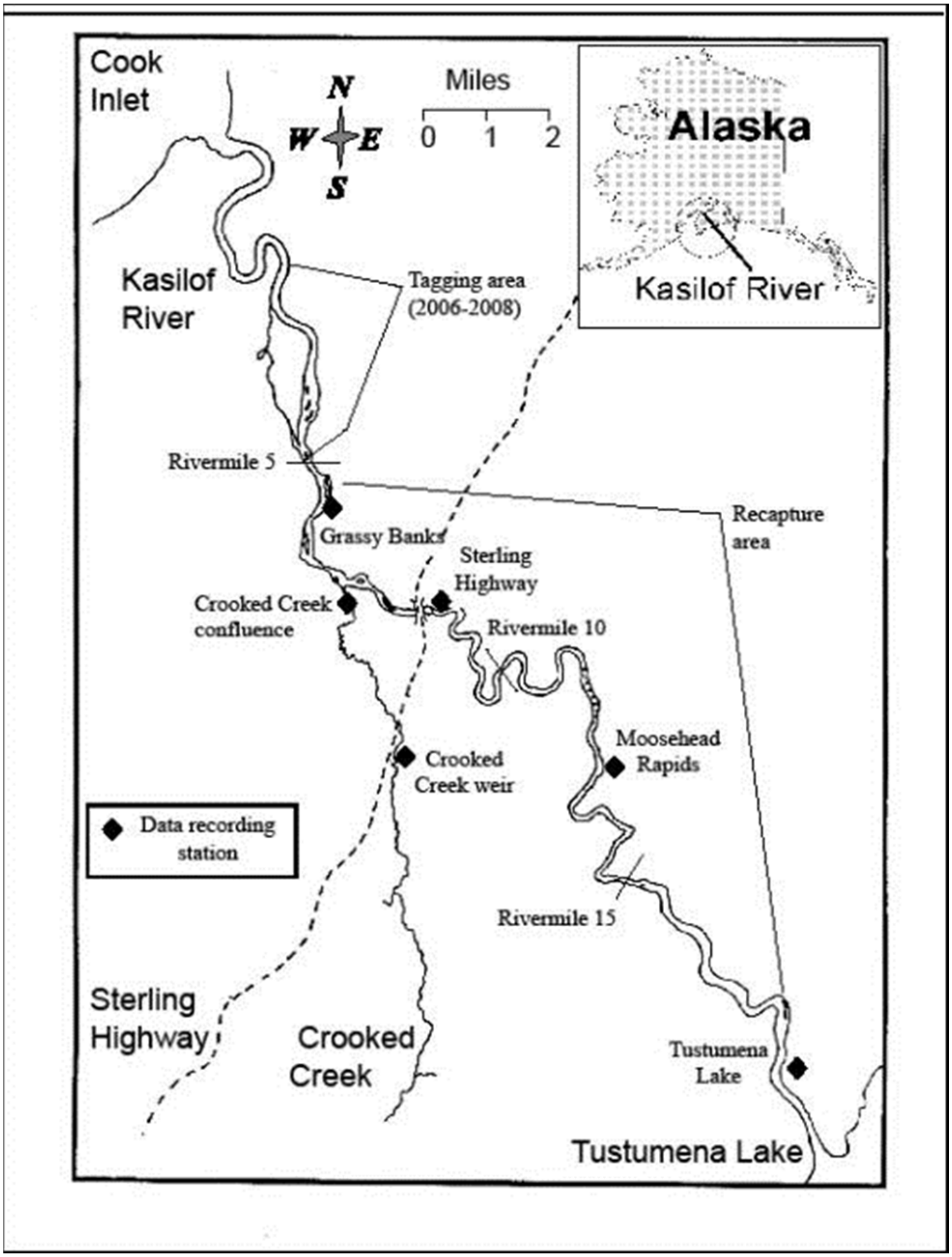

Figure 1.–Map of Kasilof River on Kenai Peninsula in Southcentral Alaska.

Table 1.–Historical estimates of late-run Kasilof River Chinook salmon catch and harvest, 1996–2008.

	Late-run Chinook salmon	
Year	Catch [a]	Harvest [b]
1996	2,344	833
1997	3,183	1,101
1998	1,050	638
1999	1,559	658
2000	2,511	1,086
2001	2,872	1,378
2002	2,398	445
2003	3,019	1,144
2004	2,997	1,038
2005	2,459	1,052
2006	1,441	883
2007	2,603	1,062
2008	1,399	806
Median	2,459	1,038
Mean	2,295	933
Minimum	1,050	445
Maximum	3,183	1,378

Source: Catch and harvest estimates from Alaska Statewide Harvest Survey reports (Howe et al. 2001a-d; Walker et al. 2003; Jennings et al. 2004, 2006a-b, 2007, 2009a-b, 2010a-b).

[a] "Catch" = fish harvested plus fish released.

[b] "Harvest" = fish kept.

RESEARCH HISTORY

Harvest

The Alaska Department of Fish and Game (ADF&G) fielded a late-run Kasilof River Chinook salmon creel survey during 1985, the first season the fishery was open in July, but creel sampling was discontinued on 10 July due to a lack of angler effort (Hammarstrom and Larson 1986). A late-run creel was conducted in 1986 and estimated that 314 (SE 48) Chinook salmon were harvested during 11,024 (SE 2,056) angler-hours of effort (Hammarstrom et al. 1987). The authors believed that the 186 Chinook salmon harvested by boat anglers were likely mainstem "spawners" (heading to the mainstem to spawn) whereas shore-based anglers were probably harvesting Crooked Creek-bound fish staging in the mainstem Kasilof River during July.

The ADF&G Statewide Harvest Survey has differentiated early-run from late-run Kasilof River Chinook salmon harvests since 1996 (Howe et al. 2001a). Estimates of late-run Chinook salmon sport harvests have ranged from 445 to 1,378 fish and averaged 933 fish (Table 1). Additional harvest information was obtained from catch-sampling programs for late-run Kasilof River Chinook salmon during the 2002 and 2003 seasons. Those studies found that hatchery-reared Chinook salmon did not contribute significantly to the late-run harvest, and that ocean-age-3 Chinook salmon were the predominant age class within the harvest (Breakfield and King 2007).

Run Timing

Prior to this study, run-timing information for late-run Kasilof River Chinook salmon was limited to a feasibility study conducted in 2002. Drift gillnets were fished in the lower Kasilof River 1 day per week from 3 July through 31 July 2002. A total of 49 Chinook salmon were caught in drift gillnets, spaghetti tagged, and released. The peak catch rate occurred on 17 July and declined rapidly toward the end of July. This information conflicted with local knowledge that asserted that the entry of late-run Kasilof River Chinook salmon peaked sometime in August.

Four tags were recovered from the 2002 feasibility study. Only 1 of the 4 Chinook salmon, which was tagged on 17 July and captured by a sport angler on 19 July, could have been a mainstem Kasilof River spawner. Of the remaining 3 tagged Chinook salmon, 2 entered Crooked Creek to spawn, and 1 was captured by a sport angler on the Kenai River. The Crooked Creek fish were tagged on 3 July and 10 July; both passed the weir on 25 July. The Kenai River sport harvested fish was tagged 24 July and harvested 29 July.

Spawning Distribution

The spawning distribution of late-run Kasilof River Chinook salmon was studied in 1987 using radiotelemetry (Faurot and Jones 1990). Significant spawning areas included Crooked Creek and 3 mainstem areas of the Kasilof River: near the mouth of Crooked Creek (RM 6.9), RM 9–10, and the slack water area (RM 15–18). Faurot and Jones (1990) concluded that the Crooked Creek spawners were from the early run because they were tagged in early July and had dark coloration. The authors verified that the mainstem was an important late-run spawning area by noting spent Chinook salmon carcasses along the banks of the mainstem as well as successful hatchery egg takes in the slack water area in mid-September. However, the marking area for this study (RM 7.9) may have been too far upstream because additional mainstem spawning areas may exist downstream. For example, late-run Kenai River Chinook salmon spawn within the tidally influenced area (Burger et al. 1983; Hammarstrom et al. 1985).

OBJECTIVE

This report details investigations of the abundance of late-run Kasilof River Chinook salmon.[3]

During 2005, the objective was to assess the feasibility of abundance estimation with a pilot study.

The specific objective for 2006–2008 was to estimate the inriver abundance of wild Chinook salmon, ocean-age-.2 or greater, spawning in the Kasilof River from 20 June through 31 August, excluding those bound for Crooked Creek, such that both ends of the 90% Bayesian credibility interval[4] were within 35% of the posterior mode.

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[3] Spawning distribution was also investigated as a part of this study, but those results will be reported separately.

[4] In order to assess the uncertainty associated with abundance estimates as completely and accurately as possible, we employed Bayesian statistical methods. The output of our Bayesian analysis is the posterior probability distribution for abundance. The 90% Bayesian credibility interval, roughly analogous to a standard confidence interval, is the narrowest interval from the posterior distribution which includes 90% probability density. We chose the mode of the posterior distribution as the measure of central tendency because it is the most likely value for the true abundance.

METHODS

STUDY DESIGN

The inriver abundance of wild Chinook salmon, ocean-age-2 or greater (age-.2+), was estimated using a modified 2-event mark–recapture experiment. The marking events consisted of gillnetting programs conducted within the intertidal area of the Kasilof River. Spaghetti tags were used as the primary mark, tag scars and dorsal fin hole punches were the secondary mark. The recapture events consisted of gillnetting programs conducted within known late-run Kasilof River Chinook salmon spawning and holding areas.

Two modifications to the classic 2-event mark–recapture experiment were necessary. The first modification was required because Pacific salmon captured in estuaries may exhibit delayed or failed migration due to handling (Bernard et al. 1999). Including these fish in the marked sample would result in overestimating abundance. To correct for this, a subset of marked fish received a radio tag. By monitoring radiotagged fish and the spawning condition of Chinook salmon captured in the recapture event, we estimated the spawning success of radiotagged Chinook salmon. The abundance estimate was reduced by the proportion of radiotagged Chinook salmon that failed to spawn.

The second design modification was necessary because of the presence of Chinook salmon bound for Crooked Creek. Hatchery-reared Chinook salmon were culled from the experiment based on presence of an AFC. Naturally-produced Chinook salmon bound for Crooked Creek could not be visually identified; including these fish in the marked sample would result in overestimating abundance. Therefore, the abundance estimate was further reduced by the proportion of naturally-produced Chinook salmon bound for Crooked Creek captured in the marking event. Two independent sources of information were used to estimate this proportion: 1) the proportion of radiotagged fish that migrated into Crooked Creek after handling, and 2) information derived from the number of hatchery-reared Chinook salmon encountered during the marking event.

The study design differed between years because latter experiments benefited from knowledge obtained during the 2005 pilot study.

Marking Events

From 20 June through late August each year, Kasilof River Chinook salmon were captured daily using drift gillnets. Capture events were terminated annually when the daily drift gillnet catches declined to less than 1% of the cumulative catch for 3 consecutive days. Sampling dates were initially based on anecdotal information but were refined as the project progressed in order to be inclusive of the late-run Chinook salmon run. The downstream sampling boundary was at the most upstream commercial mooring buoys (RM 2.5) in all years. The upstream boundary, established downstream of known Chinook salmon spawning habitat, was located at RM 5.7 in 2005 and relocated to RM 5.0 in 2006–2008 (Figure 1). The change was based on observation of ripe Chinook salmon holding near RM 5.6 in 2005.

In 2005, sampling occurred from 1230 hours to 1930 hours and the fishing location was moved up- and downriver to avoid fishing during high slack tide. Analysis of 2005 data showed that the percentage of radiotagged fish that migrated into the recapture reach was unrelated to tide stage during capture (χ^2 = 1.99, df = 6, P = 0.921). In 2006 and 2007, sampling occurred from approximately 3 h before to 3 h after 1 daylight low tide daily (6.5 h per day). During all years, sampling effort was distributed as equally as possible up- and downriver and between banks, striking a subjective balance between targeting productive locations and prospecting at others.

Gillnet specifications were as follows:

1) 5.0-inch multi-fiber, 45 meshes deep, 5 fathoms long, smoky blue, MS73 twine

2) 7.5-inch multi-fiber, 30 meshes deep, 5 fathoms long, smoky blue, MS93 twine

Each mesh size was fished alternately for 1-hour periods with the starting mesh size alternated daily. These two mesh sizes have been used on the Kenai River since 2002, where they were chosen to minimize overall size selectivity for Chinook salmon (Reimer 2004a-b). Because late-run Kasilof River Chinook salmon and Kenai River Chinook salmon are similar in size, selectivity should also be minimized for late-run Kasilof Chinook salmon.

The net was retrieved immediately after a Chinook salmon was captured. Age-.1 (less than 20 inch total length [TL]) Chinook salmon and all other species were recorded and immediately released. Hatchery-reared Chinook salmon (AFC present) were recorded, given a dorsal fin punch for identification in the event of recapture, and released. Wild age-.2+ Chinook salmon were restrained using a padded aluminum cradle, sampled for ASL information and marked. Mid eye to tail fork (METF) length was measured to the nearest 5 mm and sex was determined from visual characteristics (e.g., head shape and presence of ovipositor, eggs, or milt). Three scales were collected from the right side of the fish approximately 2 rows above the lateral line along a diagonal line from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin and placed on gum cards. Finally, skin color (chrome, pink, red) and injury status (OK, bleeding gills, lesions, lethargy, other) were recorded for each sampled Chinook salmon. Presence of a radio tag, spaghetti tag, tag scar, or secondary mark identified recaptured fish. The cradle and sampling and marking equipment were positioned so that the gills remained continuously underwater throughout handling.

Wild age-.2+ Chinook salmon were marked with spaghetti tags fabricated by Floy Tag Manufacturing, Inc.[5] (model FT-4). Each tag was uniquely numbered, 15 inches long, and grey in color. Tags were secured by using a hollow applicator needle to penetrate the skin and muscle tissue, while carrying the tag, about 2.5 cm below and 2.5 cm anterior of the posterior insertion of the dorsal fin. The needle was removed from the far side of the fish and the tag was secured in place with an overhand knot.

A subset of wild age-.2+ Chinook salmon received a pulse-coded radio transmitter. Transmitters were deployed by pulse code to minimize the likelihood of encountering co-located transmitters on the same frequency. In 2005, 2 transmitters were deployed daily. From 2006 to 2008, 1 to 3 transmitters were deployed daily in a pattern approximating prior years' run timing. Immediately prior to marking, the radio tag was tested to ensure it was transmitting. Radio tags were deployed on the first fish captured during each 1/*i* of the shift where *i* represents the number of radio tags scheduled to be deployed that day. Variability in capture rate caused occasional deviations from this schedule.

In 2005, external-mount radio transmitters manufactured by Advanced Telemetry Systems (ATS, model F2120) were used in lieu of a spaghetti tag. Transmitters measured 19 mm by 50 mm by

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[5] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

9 mm, weighed 16 g, and had 2 Teflon®-coated, 18-8 braided stainless steel wires protruding out one side. Transmitters were secured by using 16-gauge, hollow medical needles to penetrate the skin and muscle tissue, while carrying the wires, such that the radio tag was positioned parallel to the insertion of the dorsal fin and about 2.5 cm below it. The needles were removed from the far side of the fish and a 25-mm diameter numbered Petersen disk was slipped over each wire. Each disk was held snugly using #3 single-barrel, anodized steel sleeve crimped onto the wire. Given that tag weight should not exceed 2% of the fish weight (Winter 1983), fish as small as 0.80 kg could be marked, which is smaller than an age-.2 Chinook salmon.

In the years 2006–2008, esophageal implant radio transmitters manufactured by ATS (model F1845B) were used in conjunction with spaghetti tags. The bottle-shaped transmitters were 19 mm in diameter, 56 mm long and weighed 24 g. Transmitters were inserted with an applicator made from 2 concentric pipes of polyvinyl chloride. The outer pipe was three-quarters of an inch outside diameter with rounded edges and one end split into quarters. The inner pipe fit snugly inside the outer pipe but would slide with minimal effort. Likewise, the narrow end of the radio tag fit snugly within the split end of the outer pipe. Transmitters were inserted by gently pressing the tag against the esophageal sphincter until the sphincter relaxed and allowed the tag to pass into the stomach. The transmitter was then dislodged from the applicator using the inner pipe as a plunger. Given that tag weight should not exceed 2% of the fish weight (Winter 1983), fish as small as 1.20 kg could be marked.

Data were recorded using Juniper Systems Inc. Allegro CE field computers. Information recorded for each set included date, mesh size, net set time, net pull time, river mile at pull location, river bank at pull location, and the number captured by species. For each wild age-.2+ Chinook salmon captured, additional information was recorded including sex, METF length, skin color (chrome, pink, red), injury status (OK, bleeding gills, lesions, lethargy, other), scale card number, fish number, spaghetti tag number, radiotag frequency (if applicable), and radiotag pulse code (if applicable). Data exported from field computers were converted from a proprietary format into comma-separated ASCII files that conformed to ADF&G's mark-sense revised tagging file format.

Recapture Events

While the primary objective in 2005 was to assess the feasibility of abundance estimation, 2 putative recapture events provided data that could be used to develop an estimate of abundance. Neither event was specifically designed as a recapture event. From 20 June to 31 July sport-harvested fish were sampled 5 days per week at Trujillo's Landing, and from 24 August to 16 September mainstem spawning areas were sampled 2 to 4 days per week with drift gillnets. The harvest-monitoring program was a continuation of a creel survey ADF&G conducted during the early-run Kasilof River Chinook salmon fishery, while the spawning area sampling was designed to supplement a Chinook salmon genetic database for the ADF&G Gene Conservation Laboratory.

During the 2005 harvest-sampling event, anglers were queried as they exited the fishery about the number of hours they fished and the number of fish caught or harvested by species. Each wild age-.2+ Chinook salmon harvested was inspected for the presence of a radio tag, spaghetti tag, or a tag scar. In addition, ASL data were collected as described for the marking event. Unfortunately, the harvest-monitoring program was a poor recapture event due to significant overlap between the marking event sampling area and the geographic footprint of the sport fishery. Therefore, sport harvest data were used to test assumptions of the mark–recapture experiment, but were not used to generate abundance estimates.

In 2005, gillnets were drifted near important mainstem spawning areas, as identified by radiotelemetry, with a goal of obtaining genetic samples from a minimum of 200 wild age-.2+ Chinook salmon. Most of the sampling occurred near Crooked Creek (RM 6.9), RM 9.5–10.0, and the slack water area between RM 15.0 and RM 18.0. Gillnet specifications and fishing procedures were similar to the marking event. Fish were handled and sampled as described for the marking event except that inspection for a radio tag, spaghetti tag, or a tag scar was emphasized and maturity (firm, ripe, spent) and genetic vial number were recorded for each fish sampled. Additionally, sampled Chinook salmon were given an upper caudal fin hole punch to prevent resampling.

From 2006 through 2008, dedicated recapture events were conducted 3 days per week between RM 5.7 and RM 18. Recapture events were conducted from 4 July to 19 September in 2006; 3 July to 28 September in 2007; and 8 July to 22 September in 2008. Sampling occurred for 6.5 hours per day. Sampling effort was distributed among 3 reaches; from RM 5.7 up to RM 8.9, from RM 8.9 up to RM 14.0, and from RM 14.0 up to RM 18.0; in approximate proportion to prior years' radiotagged fish locations. Within each reach, samplers tried to distribute drift gillnetting effort as equally as possible up- and downriver and between banks, striking a subjective balance between targeting productive locations and prospecting at others. Some river sections were too hazardous to fish with gillnets due to currents, obstructions, or sport fishing boats. Gillnets with the specifications described above were fished alternately as described for the marking event. Fish were handled and sampled as described for the marking event except that inspection for a radio tag, spaghetti tag, or a tag scar was emphasized, and maturity (firm, ripe, spent) was recorded for each fish. Captured fish were marked with an upper caudal fin hole punch to identify previously sampled fish.

Radiotelemetry

Radiotelemetry was used to assess survival and behavior of the marked population. Three questions were addressed: 1) what fraction of the marked population continued upstream migration into the recapture area, 2) what fraction of the marked population migrated into Crooked Creek, and 3) how did capture and marking affect the behavior and migratory patterns of Kasilof River Chinook salmon. Radiotagged Chinook salmon were monitored passively, using a network of stationary radio receiving stations, and actively, by foot, boat, or plane surveys. Stationary receiving stations allowed 24-hour monitoring of radiotagged Chinook salmon at key points along their migration routes while manual tracking was used to determine specific locations. This system provided multiple, redundant locations for each animal with resolution sufficient to detect noteworthy behavior patterns.

Radio transmitters for this project were pulse-coded, broadcasting between 151.004 MHz and 151.534 MHz. The tags were tuned preseason by acoustically determining the "best" frequency for each transmitter while it was underwater in the Kasilof River. If the average "best" frequency, for all pulse codes on a printed frequency, differed from the printed frequency, the "best" frequency was used during tracking. The "best" frequency was generally within 1 KHz of the printed frequency. Warranty battery life was 90 days for the 2005 transmitters and 126 days for the 2006–2008 transmitters, which is 2–3 times the estimated stream life for Chinook salmon (Bendock and Alexandersdottir 1992).

Pulse-coded transmitters allow the use of fewer frequencies, and thus reduced total scan time. During stationary radio tracking, the scan time for each frequency was 7 seconds (s) with a 2 s timeout. Thus, each frequency was monitored for 2 s; if a transmission was noted then the frequency was monitored for an additional 7 s on each antenna while the equipment determined and electronically recorded the pulse code and the signal strength. Total scan time for all frequencies ranged from approximately 30 s, when no signals were detected, to 2–3 min when several signals were detected. During manual radio tracking, the timeout for each frequency was 2 seconds. If a signal was detected, the scan was paused manually until the location could be determined by triangulation and electronically recorded. Total scan time was approximately 30 s. Given an average pulse rate of 45.8 pulses per minute, a 2 s timeout provides sufficient time for each tag to send 2–3 transmissions during each timeout.

Most telemetry data were collected at automated, fixed, data-recording stations. Sites consisted of a 10–15 ft pole supporting 2–3 Yagi directional antennas (Cuschcraft Inc. model P154-4) connected via coaxial and communication cable to a 3 dB attenuator (Mini-Circuits, model CAT-3), amplifying antenna switch (ATS, model 100), radio receiver (ATS, model 4000 or 4100), and data collection computer (ATS, model 5041). The receiver and computer were stored in a weather-resistant box with a 12-volt marine battery. The system continuously scanned the transmitter frequencies and electronically recorded the frequency, pulse code, mortality code, date, time, antenna, and a measure of signal strength whenever a decodable transmission was detected. Sites were visited weekly to download stored data and change the battery.

Fixed radio receiving stations were placed at key sites along Kasilof River Chinook salmon migration routes (Table 2). Sites were chosen to maximize antenna height above the river surface using adjacent cut banks or bluffs whenever possible. The Trujillo's pullout and Grassy banks sites recorded fish migrating in or out of the recapture area. The Crooked Creek and Crooked Creek weir sites recorded the fraction of radiotagged Chinook salmon that migrated into Crooked Creek. The Sterling Highway bridge site recorded when fish migrated out of the sport fishery. The Moosehead Rapids and Tustumena Lake outlet sites recorded fish movements relative to the primary spawning area. Finally, the Kenai River site recorded the fraction of Chinook salmon that exited the Kasilof River and went up the Kenai River. Each fixed station was equipped with 2 or 3 directional antennas. By orienting the antennas parallel to the river channel, direction of travel could be discerned by comparing antenna signal strength within the chronological data.

To complement fixed-station data, radio tags were tracked by boat 3 to 4 times per week using an ATS 4500 receiver and single Yagi-style antenna (Cuschcraft Inc. model P154-4). The boat was driven at a moderate speed while scanning active frequencies. If a signal was detected, the scan was paused until the tag location could be determined by triangulation. For each radiotagged fish located, the date, time, frequency and pulse code, mortality code, river mile, river bank, GPS coordinates, and a general description of the location were recorded on paper data forms.

Table 2.–Locations of automated, fixed, data-recording stations used for Kasilof River Chinook salmon radiotelemetry studies, 2005–2008.

			Year [a]			
Drainage	River mile	Description [b]	2005	2006	2007	2008
Kasilof River	3.7	Trujillo's pullout	X			
	5.7	Grass banks		X	X	X
	6.9	Crooked Creek confluence	X	X	X	X
		Crooked Creek weir (TRM 3.4)[b]	X	X	X	X
	7.9	Sterling Highway bridge	X	X	X	X
	12.6	Moosehead Rapids		X	X	X
	18.4	Tustumena Lake outlet	X	X	X	X
Kenai River	8.5	Chinook Salmon Sonar Site	X			

[a] "X" = locations was used that year; blank space = location not used that year.
[b] "TRM" = tributary river mile.

DATA ANALYSIS

To estimate the abundance of mainstem-spawning, wild age-.2+ Kasilof River Chinook salmon, data were analyzed in the context of a modified 2-event mark–recapture model. In the standard Petersen model for a population of N fish, M fish are marked in the marking event. A recapture event is conducted in which C fish are inspected, and observation of the relative number of marked fish (R) and unmarked fish (C-R) are used to make inference about the abundance N.[6]

Conditions for a Consistent Petersen Estimator

For the estimate of abundance from a classical Petersen 2-event mark–recapture experiment to be unbiased, certain assumptions needed to be fulfilled (Seber 1982). The standard assumptions, expressed in terms of the conditions of this study, respective design considerations, and test procedures are listed below. Where the standard assumptions do not hold, the ramifications and adjustments to the study design are discussed.

(1) The population must be closed to births, deaths, immigration, and emigration.

This assumption was violated on 2 fronts. Harvest occurred between events in the form of an inriver sport fishery. However, assuming that marked and unmarked fish were harvested at the same rate and that there was no immigration of fish "between" events, the Peterson estimator is an unbiased estimate of the abundance at the marking event (RM 5.0).

Unfortunately, there may have been immigration of fish prior to both events in 2006–2008. Early-run Chinook salmon that entered the Kasilof River before the marking event began and remained until after the recapture event began would violate the assumption that no fish were added to the population "between" events, and would cause a positive bias. We used the catch rates of hatchery-reared Chinook salmon in the recapture event to evaluate the magnitude of this bias[7]. In 2006 and 2007 hatchery-reared fish comprised 1.2% and 3.3% of the fish captured in

---

6 If the marks are unique, sampling in the second event is without replacement and R has a hypergeometric distribution. If the marks are not unique, sampling is with replacement and R is a binomial count with proportion M/N and order C (Seber 1982).

7 In 2006 and 2007, hatchery-reared and naturally-produced fish returned to Crooked Creek in approximately equal proportions; therefore, the catch of hatchery-reared fish, which we can detect by observing adipose fin clips, approximated the catch of naturally-produced Crooked Creek bound fish, which we cannot detect. In 2008, naturally-produced fish outnumbered hatchery-reared fish in Crooked Creek, so the catch of hatchery-reared Crooked Creek-bound fish underestimated the catch of naturally-produced Crooked Creek-bound fish.

the second event, respectively. Bias associated with immigration of fish prior to both events should be minimal because early-run fish were only marginally represented in the recapture sample regardless of whether they entered the Kasilof River before or after the recapture event began.

During 2008, bias associated with immigration of fish prior to both events was more severe because hatchery-reared Chinook salmon comprised 5.7% of the fish captured in the recapture event, and the hatchery-reared catch should have been significantly smaller than the wild Chinook salmon catch. To minimize this bias, the first 3 days (8 July, 10 July, and 12 July) of the 2008 recapture event were removed from the analysis. After this truncation of the data set, hatchery-reared fish (including those that migrated after 20 June) comprised 0.3% of the fish captured in the second event in 2008.

(2) Handling and marking must not affect the catchability of Chinook salmon in the second event.

This assumption was also violated. There is no explicit test for this assumption because the behavior of unmarked fish could not be observed. However, Kenai River Chinook salmon captured in the estuary exhibited delayed migration (Bernard et al. 1999), and we anticipated that Kasilof River Chinook salmon would behave similarly. Ignoring this violation would overestimate the number of marks M available for recapture in the second event, thereby introducing a positive bias into the abundance estimates.

To minimize handling effect in this study, the drift gillnet was pulled immediately after Chinook salmon were captured and sampling was conducted quickly while the fish remained underwater. Obviously stressed or injured fish were not marked. Nevertheless, some effect of handling or marking remained, and it differed among fish. Furthermore, it was not possible to measure handling effect directly, because one cannot obtain behavior information from an individual fish without somehow handling and marking it. Instead, we derived a measure of spawning success for individual radiotagged fish, which served as surrogate for the proportion of marked fish available for capture in the recapture event. This information was used to correct the estimate of abundance for bias due to handling effect. See “Quantify the Proportion of Marked Fish Available for Recapture” below for details.

Cause of the handling effect was investigated by testing for an association between injury status and fate of radiotagged fish. Size-selective handling effect was investigated by testing for an association between fate and size or age.

(3) Marked fish must not lose their tags between events.

Spaghetti tags were very securely attached to the fish. During a 6-year study using spaghetti tags with coho salmon on the Kenai River, tag loss was negligible (Rob Massengill, ADF&G Soldotna, personal communication). Tag loss was monitored by examining sampled fish for marking scars and secondary marks during both events. During our study, every spaghetti tag loss was documented, and it occurred only rarely (unknown recaptures, Table 3).

Table 3.–Accounting of wild Chinook salmon (age .2 or greater) captured during Kasilof River mark–recapture studies, 2005–2008.

	Wild Chinook salmon age-.2 or greater (no. of fish)					
				2008 [a]		
				METF length		
	2005	2006	2007	<930 mm	≥930 mm	All combined
Tagging events						
Radio tags deployed	143	129	134	50	62	112
Spaghetti tags deployed	734	514	612	223	168	391
Total marked-M	877	643	746	273	230	503
Not suitable for marking		24	12	5	0	5
Total captured	877	667	758	278	230	508
Recapture events						
No tags or scars	266	872	1,026	355	390	745
Radio tag recapture	2	12	10	0	9	9
Spaghetti tag recapture	6	25	36	9	13	22
Unknown recapture		1	4	1		1
Total recaptured-R	8	38	50	10	22	32
Total examined-C	274	910	1,076	365	412	777

[a] Post-season analysis showed evidence of size or age selectivity in 2008 (Appendices A1 and A5) requiring stratification of this data by size. Two groups of fish (<930 mm METF and ≥930 mm METF) provided test results which were consistent with equal probability of capture during the recapture event for all factors.

(4) All Chinook salmon must have equal probabilities of capture in either the marking event or the recapture event; or, marked fish must mix completely with unmarked fish between samples.

Complete mixing between events was not possible because run duration (~70 days) exceeded estimated stream life (30–60 days) for Chinook salmon (Bendock and Alexandersdottir 1992). Likewise, equal probability of capture during the 2005 recapture event was not possible because of the short sampling time frame. Thus, equal probability of capture was only possible for the marking event of the 2005 experiment and for either event of the 2006–2008 experiments.

The marking events were designed to yield approximately equal probability of capture by sampling the entire duration of the late run and distributing sampling effort over the length of the marking reach, on both banks, and in mid-channel. Daily crew shift length was held constant.[8] Equal probability of capture during the marking event was tested by comparing marked-to-unmarked ratios among temporal and geographic subsets of the recapture event. Temporal strata were 1–15 July, 16–31 July, 24 August–4 September, and 4–16 September in 2005; 4–16 July, 17 July–1 August, 2–25 August, and 26 August–19 September in 2006; 3–9 July, 9–31 July, 1–22 August, and 23 August–28 September in 2007; and 24 July–3 August, 4–28 August, and 29 August–22 September in 2008. Boundaries between geographic strata were river mile 8.0 in 2005 and river miles 11.0 and 15.0 in the years 2006–2008. Stratum breaks were chosen to

[8] However, constant daily shift length during the marking events did not equate to constant effort, measured by daily number of drifts or total net soak time. We investigated possible relationships between effort and abundance that could result in unequal probabilities of capture during the marking event.

provide equal time or area per stratum in 2005, and to approximate migratory patterns in the years 2006–2008.

Both sport-harvest sampling and spawning-ground gillnetting were used to test for equal probability of capture by time and area during the 2005 marking event. This approach was more powerful because it maximized sample size and distribution[9]. However, to maintain relevance of the results, only the spawning-ground gillnetting samples were used to test for equal probability of capture by sex, age, and length.

In 2005, we neither attempted nor expected equal probability of capture during the recapture events and conducted no time or area tests. In 2006–2008, the recapture event was redesigned to distribute effort proportional to abundance over time and area based on 2005 radiotagged Chinook salmon locations. Likewise, set location was varied to distribute tags representatively over the length of the marking reach and on fish from both banks and mid-channel. Equal probability of capture during the recapture event was tested by contingency-table analysis of recapture rates for temporal (20–28 June, 29 June–27 July, and 28 July–29 August in 2006; 20–28 June, 29 June–14 July, 15 July–3 August, and 4–29 August in 2007; and 20 June–2 July, 3–31 July, and 1–25 August in 2008) and geographic (RM 2.6–4.4 and RM 4.5–5.3 in all years) subsets of the marking event. Temporal stratum breaks were chosen to isolate periods of differing CPUE during the marking event. The geographic stratum break identifies a change in hydrological conditions within the marking area.

During the 2008 recapture event, a gross violation of our equal probability of capture assumption occurred when increased sport fishing effort below the Sterling Highway Bridge made the area too congested to fish safely and effectively. Thus, we were unable to stage the recapture event below the Sterling Highway Bridge on 4 days (15, 17, 19, and 22 July) when all of the radiotagged Chinook salmon were still in this area. All 4 days were removed from the analysis.

Equal probability of capture was also tested by size and sex. These tests are described in Appendix A1.

Quantifying the Proportion of Marked Fish Available for Recapture

The Petersen abundance estimator hinges on knowledge of the number of marked fish available for recapture during the second event. All healthy, wild, age-.2+ Chinook salmon without an AFC captured during the marking event were marked; however, not all were available for recapture. As mentioned above, handling and marking can profoundly affect fish behavior and spawning success. If marked fish are less likely to successfully ascend the river and spawn than unmarked fish, ignoring this effect would cause a positive bias in the abundance estimate because the number of marked fish in the recapture reach (and thus the number of recaptures) is artificially reduced. As mentioned previously, it is not possible to directly measure the effect of handling on availability for recapture for all radiotagged fish. Instead, we obtained a measure of relative spawning success, which is inclusive of availability for recapture, as an approximate correction for the handling-induced bias. Because spawning success is a more rigorous requirement than availability for recapture, our estimate is more conservative. However, we are able to estimate spawning success for all radiotagged Chinook salmon in an objective and repeatable manner. Specifically, we assessed the relative spawning success θ for each individual

[9] We also conducted the tests using just the spawning ground gillnetting samples and achieved similar, although less powerful results.

radiotagged fish, and use the mean, weighted by weekly catch per unit effort (CPUE), of those probabilities to estimate the proportion q of tagged fish that successfully spawned:

$$\hat{q} = \frac{\sum_i \hat{q}_i CPUE_i}{\sum_i CPUE_i}, \tag{1}$$

where

$$\hat{q}_i = \frac{\sum_j^{n_i} \hat{\theta}_{ij}}{n_i}, \tag{2}$$

and j indexes radiotagged fish, and i indexes week (week of initial capture in the case of θ_{ij}).

Radiotagged fish that failed to migrate into the recapture reach (upstream of RM 5.0) were assigned a value of $\theta = 0$ because our telemetry suggests that the recapture reach includes all spawning areas. Fish that ultimately migrated into Crooked Creek were assigned a value of $\theta = 1$ because they successfully migrated into their spawning destination. Fish that were harvested by sport anglers were removed from the analysis because the record of their upstream migration was truncated.

For each remaining radiotagged fish, we assessed its probability of spawning success by comparing the record of its upstream progress (from the radiolocation data) with the relative frequency of successful spawners over time and space as estimated from recapture event data. For fish encountered during the recapture event, maturity states of "ripe" or "spent" were taken as evidence of spawning (success = 1), whereas any other state indicated a fish that had not yet spawned (success = 0). A logistic regression model was fit to the binary success data as follows:

$$\text{logit(success)} = \alpha_0 + \alpha_1 y + \alpha_2 t + \alpha_3 d \tag{3}$$

where y is year (classification variable), t is Julian date (1 to 365, within a year), d is distance upriver (miles from river mouth), and the coefficients (α) are parameters. The logit function and its inverse areas are as follows:

$$\text{logit}(x) = \log_e\left(\frac{x}{1-x}\right) \tag{4}$$

$$\text{logistic}(x) = \frac{e^x}{1\text{-}e^x}. \tag{5}$$

The resulting model (Figure 2) provided estimates of the proportion of fish spawning as a function of time (date) and space (river mile), where the intercept could change from one year to the next. The logistic regression function was evaluated for each radiolocation of each radiotagged fish, yielding an estimated proportion of spawning fish for that time and place (Figure 3). For each radiotagged fish that was not sport-harvested and which did not eventually migrate to Crooked Creek, the maximum of these evaluated proportions was used as an estimate of its relative spawning success, θ.

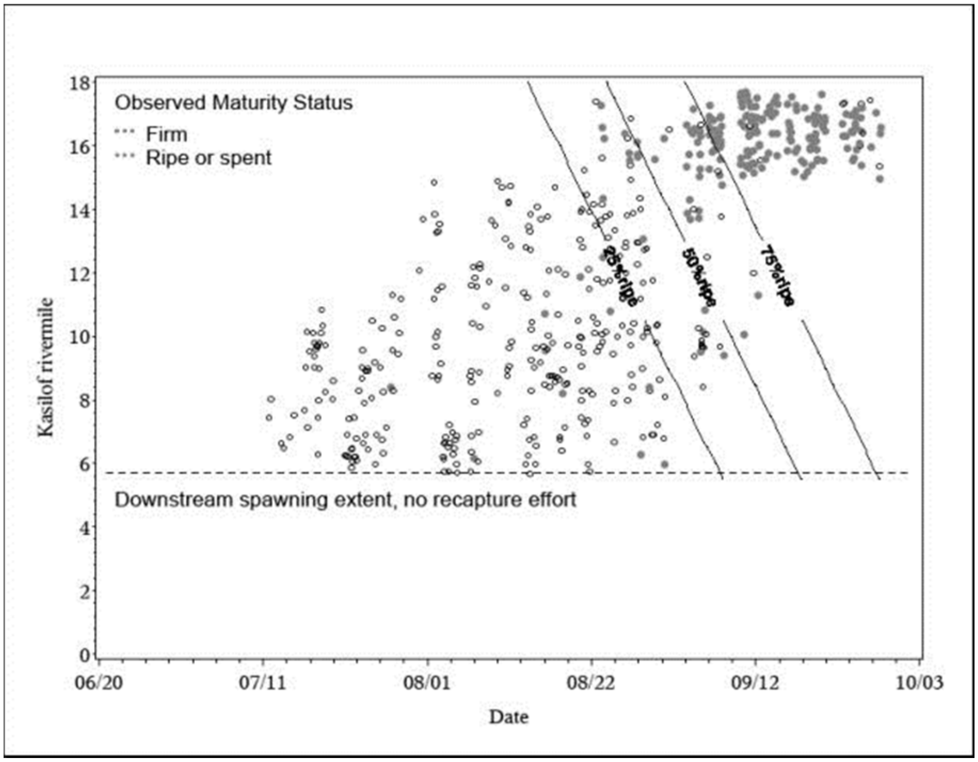

Figure 2.–Maturity status of Kasilof River Chinook salmon by river mile and date, 20 June–3 October 2007.

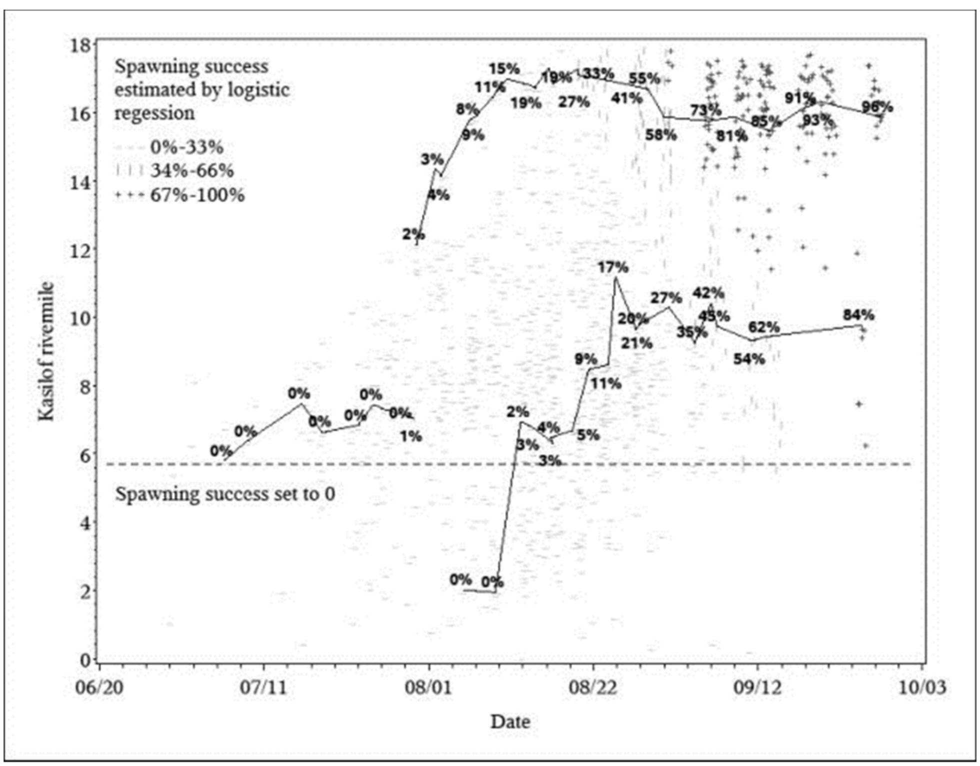

Figure 3.–Estimated spawning success of radiotagged Kasilof River Chinook salmon by river mile and date, 20 June–3 October 2007.

The examples illustrated in Figures 2–3 show the range of migratory patterns found within the data set. For example, the fish whose migratory trajectory began on 6 July was never surrounded by more than 1% spawning or spent fish. Clearly, the probability that this fish engaged in a normal migration and successfully spawned was very low. Conversely, the fish whose migratory trajectory began on 7 August was ultimately surrounded by fish that were estimated to be 84% spawning or spent. This fish probably spawned successfully, and there is little direct evidence that its behavior was adversely affected by being handled and tagged. We contend that the maximum spawning success associated with each trajectory is a meaningful index of the spawning success of that fish, as well has its availability for recapture. In general, the greater the duration in the spawning reach, and the farther upriver the fish ascends, the greater the probability of successful spawning and availability for recapture.

Estimating the Proportion of Marked Fish Not Originating from Crooked Creek

During the first few weeks of each season, some unclipped naturally-produced early-run Chinook salmon ultimately bound for Crooked Creek were unavoidably marked. Including these fish, which are not the target of this study, would have artificially inflated the number of marks M and caused the abundance estimate to be positively biased. To correct for this bias, the fraction of marked fish not ultimately bound for Crooked Creek, r, was estimated. Two independent sources of information were used to estimate r. The first estimator, based solely on radiotelemetry data, was

$$\hat{r}_{1i} = 1 - \frac{x_{CCi}}{\sum_{j}^{n_i} \hat{\theta}_{ij}}, \tag{6}$$

where x_{CCi} is the number of radiotagged fish arriving at Crooked Creek in week i and the denominator is the sum of relative spawning success values for fish radiotagged in week i.

The second estimator, based on data from the marking event and the Crooked Creek weir, was

$$\hat{r}_{2i} = 1 - \frac{M_{AFCi}/\pi_{AFC} - M_{AFCi}}{M_i}, \tag{7}$$

where M_{AFCi} is the number of AFC Chinook salmon captured during the marking event in week i and π_{AFC} is the mean weekly proportion of AFC Chinook salmon at the Crooked Creek weir during the 4 weeks following passage of the first tagged fish through the weir.

Annual estimates $\hat{r}_1$ and $\hat{r}_2$ were obtained as a weighted mean of the weekly estimates, with CPUE values as weights (Equation 1 with appropriate substitutions).

Standard errors of $\hat{q}$, $\hat{r}_1$, and $\hat{r}_2$ were estimated by generating 500 bootstrap values of each. Gillnetting data from the marking and recapture events were resampled using 2-stage procedures with date as the first stage and set (or fish) within date as the second stage. Weir data were resampled (for estimates of $\hat{r}_2$) by choosing 1 week of weir data at random from the first 4 weeks following passage of the first tagged fish through the weir. [10]

For the Bayesian statistical model of abundance (see Estimating Abundance) we needed to summarize knowledge of q and r in the form of probability distributions for each. Therefore we fit beta distributions (using SAS/STAT, proc UNIVARIATE, SAS Institute Inc. 2004) to the bootstrap values of q, r_1, and r_2; and then summed the fitted beta distribution parameters for r_1 and r_2.[11]

Differential effect of marking was assessed using ANOVA to identify significant differences in q associated with geographic strata, sex, and age. The geographic strata were the same as were used to test for unequal probability of capture in the recapture event (see Conditions for a Consistent Petersen Estimator).

Estimating Abundance

In order to assess the uncertainty associated with abundance estimates as completely and accurately as possible, we employed Bayesian statistical methods. Bayesian methods use probability distributions to quantify uncertainty about model parameters. The "prior" probability distribution expresses knowledge about the parameters before the experiment is conducted. Herein, we specified a non-informative prior distribution for Chinook abundance; i.e., we claimed no knowledge about abundance before the experiments.

The output of a Bayesian analysis is the "posterior" distribution, which describes the new, updated knowledge about the parameters after consideration of the data. Percentiles of the posterior distribution can be used to construct 1-sided probability statements or 2-sided intervals about the parameters. Point estimates are de-emphasized in Bayesian statistics, however the mean, median, or mode of the posterior can be used to describe the central tendency of knowledge about a parameter. The standard deviation of the posterior distribution is roughly analogous to the standard error of a point estimate in classical statistics.

The Bayesian analysis considers all the data simultaneously in the context of the following 2-event mark–recapture statistical model, modified and extended from the simple Petersen model discussed earlier:

> The total number of age-.2+ Chinook salmon to migrate upstream of RM 5.0 is N_{all}, the proportion r of which is late-run Kasilof River Chinook salmon mainstem spawners, and the proportion $1 - r$ is early-run Crooked Creek spawners. The product of N_{all} and r (= N) is the quantity we are most interested in: abundance of wild, mainstem-spawning, age-.2+ Kasilof Chinook salmon spawning upstream of RM 5.0.
>
> During the marking event, M fish without AFCs are captured and receive a mark. A subset of n marked fish also receive a radio tag. Due to handling or marking effects, only a fraction q of marked fish (total m successful migrants) migrate to the spawning ground and spawn successfully. Additional mortality, from natural causes and due to the sport

[10] The proportion of AFC fish at the weir varied over time, and run timing through the marking reach was poorly correlated with run timing through the weir. Therefore, there was much uncertainty about the relative abundance of AFC versus non-AFC fish during any specific period of the marking event. The bootstrap procedure was designed to capture that uncertainty.

[11] The latter procedure is equivalent to using the beta distribution associated with r_1 as the prior distribution for Bayesian analysis of r_2 data, or vice versa. Either way, the end result combines the information from both data sources in a way that takes the relative precision of the two estimates into consideration.

fishery, takes place between the marking and recapture events, and is the same for marked and unmarked fish.

During the recapture event C_{all} fish are captured, some of which have AFCs. Of the remaining C fish that do not, R fish possess marks. Because marked fish are uniquely identifiable and all fish are upper caudal fin hole-punched in event 2, sampling is without replacement, and R has a hypergeometric (N,m,C) distribution.[12]

Bayesian analyses require that prior probability distributions be specified for all unknowns in the model. Abundance parameter N_{all} was given a non-informative prior designed to have minimal effect on the posterior. Proportions r and q were given the beta distributions described previously, derived from radiotelemetry, gillnetting, and weir data.

Markov-Chain Monte Carlo (MCMC) samples were drawn from the joint posterior probability distribution of all unknowns in the model. Three Markov chains were initiated, a 2,000-sample burn-in period was discarded, and 8,000 updates were generated to estimate the marginal posterior means, standard deviations, and percentiles. The diagnostic tools of WinBUGS (Gilks et al. 1994) were used to assess mixing and convergence. Interval estimates were obtained from percentiles of the posterior distribution. WinBUGS code is listed in Appendices B1 and B2. Probability that 2005 abundance exceeded 2006–2008 abundance was assessed by comparing abundance estimates for each MCMC sample and tallying which year had the greater abundance.

RESULTS

MARKING EVENTS

In 2005, we drifted gillnets daily from 20 June to 31 August for a mean of 183 minutes (min) per day (Appendix C1). Minimum daily effort was 72 min and maximum daily effort was 300 min. A total of 1,974 salmonids were captured: 877 wild age-.2+ Chinook salmon, 5 wild age-.1 Chinook salmon, 26 hatchery-reared Chinook salmon, 924 sockeye salmon, 127 coho salmon, 5 pink salmon, 9 Dolly Varden, and 1 steelhead. All 877 wild, age-.2+ Chinook salmon that were captured were marked, 143 with radio transmitters and Peterson disks and 734 with spaghetti tags (Table 3).

In 2006, we drifted gillnets daily between 20 June and 29 August for an average of 187 min per day (Appendix C2). Minimum daily effort was 77 min and maximum daily effort was 266 min. A total of 3,077 salmonids were captured: 667 wild age-.2+ Chinook salmon, 23 wild age-.1 Chinook salmon, 30 hatchery-reared Chinook salmon, 1,420 sockeye salmon, 128 coho salmon, 802 pink salmon, 5 Dolly Varden, and 2 steelhead. A total of 643 wild age-.2+ Chinook salmon were marked, 129 with radio transmitters and spaghetti tags and 514 with spaghetti tags alone (Table 3). The remaining 24 wild age-.2+ Chinook salmon were in poor condition and unsuitable for marking.

In 2007, we drifted gillnets daily between 20 June and 29 August for an average of 159 min per day (Appendix C3). Minimum daily effort was 56 min and maximum daily effort was 248 min. A total of 2,620 salmonids were captured: 758 wild age-.2+ Chinook salmon, 17 wild age-.1 Chinook salmon, 78 hatchery-reared Chinook salmon, 1,700 sockeye salmon, 56 coho salmon, 6 pink salmon, and 5 Dolly Varden. All 746 wild age-.2+ Chinook salmon were marked, 134

[12] Probability of R recaptures given abundance N, successful migrants m, and event-2 captures C = m choose R * (N-m) choose (C-R) / N choose C; where "X choose Y" = $X!/Y!/(X-Y)!$ = number of ways to choose X items, Y at a time if the order of selection does not matter.

with radio transmitters and spaghetti tags and 612 with spaghetti tags alone (Table 3). The remaining 12 wild age-.2+ Chinook salmon were in poor condition and unsuitable for marking.

In 2008, we drifted gillnets daily between 20 June and 25 August for an average of 175 min per day (Appendix C4). Minimum daily effort was 52 min and maximum daily effort was 275 min. A total of 3,991 salmonids were captured: 508 wild age-.2+ Chinook salmon, 22 wild age-.1 Chinook salmon, 35 hatchery-reared Chinook salmon, 1,912 sockeye salmon, 101 coho salmon, 1,405 pink salmon, 5 Dolly Varden, and 3 steelhead. A total of 503 wild age-.2+ Chinook salmon were marked: 112 with radio transmitters and spaghetti tags and 391 with spaghetti tags alone (Table 3). The remaining 5 wild age-.2+ Chinook salmon were in poor condition and unsuitable for marking.

Injuries were recorded on 17.1%, 8.2%, 7.0% and 10.5% of the wild age-.2+ Chinook salmon marked in 2005–2008, respectively. Bleeding gills were the most prevalent injury noted. Injuries were more common in the 7.5-inch mesh than in the 5.0-inch mesh during all years. Injury rates were not significantly different ($P > 0.05$) by sex or age, except for 2007 ($\chi^2 = 6.14$, df = 2, $P = 0.046$) and 2008 ($\chi^2 = 19.54$, df = 2, $P = 0.000$), when significantly more age-1.2 fish were injured. Injury rates were not significantly different ($P > 0.05$) for spaghetti-tagged or radiotagged fish in 2005 or 2008 although they were in 2006 ($\chi^2 = 7.26$, df = 1, $P = 0.007$) and 2007 ($\chi^2 = 7.58$, df = 1, $P = 0.006$). In both years, injured fish were more often marked with only a spaghetti tag.

RECAPTURE EVENTS

From 24 August to 16 September 2005 we drifted gillnets for an average of 88 min per day (Appendix D1). Minimum daily effort was 43 min and maximum daily effort was 121 min. A total of 404 salmonids were captured: 274 wild age-.2+ Chinook salmon, 94 sockeye salmon, 31 coho salmon, 3 Dolly Varden, and 2 steelhead. All 274 wild age-.2+ Chinook salmon were examined for tags resulting in 8 recaptures, 2 with radio transmitters and Peterson disks and 6 with spaghetti tags (Table 3).

From 5 July to19 September 2006 we drifted gillnets 3 days per week for an average of 111 min per day (Appendix D2). Minimum daily effort was 45 min and maximum daily effort was 207 min. A total of 1,594 salmonids were captured: 910 wild age-.2+ Chinook salmon, 9 wild age-.1 Chinook salmon, 11 hatchery-reared Chinook salmon, 284 sockeye salmon, 44 coho salmon, 326 pink salmon, 7 Dolly Varden, and 3 steelhead. All 910 wild age-.2+ Chinook salmon were examined for tags resulting in 38 recaptures, 12 with radio transmitters, 25 with spaghetti tags and 1 where tag number was not recorded (Table 3).

From 3 July to 28 September 2007, we drifted gillnets 3 days per week for an average of 107 min per day (Appendix D3). Minimum daily effort was 54 min and maximum daily effort was 168 min. A total of 1,685 salmonids were captured: 1,076 wild age-.2+ Chinook salmon, 11 wild age-.1 Chinook salmon, 36 hatchery-reared Chinook salmon, 445 sockeye salmon, 77 coho salmon, 16 Dolly Varden, and 24 steelhead. All 1,076 wild age-.2+ Chinook salmon were examined for tags resulting in 50 recaptures, 10 with radio transmitters, 36 with spaghetti tags and 4 where tag number was not recorded (Table 3).

From 8 July to 22 September 2008 we drifted gillnets 3 days per week for an average of 109 min per day (Appendix D4). Minimum daily effort was 68 min and maximum daily effort was 192 min. A total of 1,787 salmonids were captured: 915 wild age-.2+ Chinook salmon, 12 wild

Chinook salmon, 52 hatchery-reared Chinook salmon, 322 sockeye salmon, 61 coho salmon, 402 pink salmon, 17 Dolly Varden, and 6 steelhead. After truncating the recapture event to 24 July to 22 September 2008, there were 777 wild age-.2+ Chinook salmon examined for tags resulting 32 recaptures, 9 with radio transmitters, 22 with spaghetti tags, and 1 where tag number was not recorded (Table 3).

Chinook salmon were present within the recapture reach all years through mid- to late September. The amount of time between marking and recapture was approximately 2 weeks over a range of several hours to 1.5 months. The time interval between marking and recapture was similar each year for radiotagged and spaghetti-tagged fish.

TESTS OF ASSUMPTIONS

Equivalence of Tag Types

Statistical tests indicated that mark–recapture data could be pooled by tag type. Contingency tables of tag type (radio tag or spaghetti tag) by fate (not recovered, ADF&G recapture, sport harvest, and commercial harvest) found no significant difference (Fisher's exact test, $P < 0.05$) in the years 2006–2008. In 2005, commercial fishermen recovered a larger percentage of radio tags (Fisher's exact test, $P = 0.002$), probably due to increased visibility of yellow Peterson disks compared to grey spaghetti tags. Recapture rates were 1.4%, 9.3%, 7.5%, and 8.0% for radio tags and 0.8%, 4.9%, 5.9%, and 5.6% for spaghetti tags in the years 2005 through 2008, respectively (**Error! Reference source not found.**). The mean lengths of radio- and spaghetti-tagged fish were similar (Kuiper 2-sample test, $P < 0.05$) each year; the mean length differed by 8 mm, 29 mm, 25 mm, and 32 mm in the years 2005 through 2008, respectively. Finally, the time between release and recapture did not differ by tag type (See Recapture Events section). These results indicate equal probability of capture by tag type and justify treatment as a single mark during mark–recapture calculations.

Equal Probability of Capture

Because complete mixing was not possible, it was necessary to achieve equal probability of capture in at least 1 event each year. Equal probability of capture over time and space during the marking event was tested by comparing marked-to-unmarked ratios among temporal and spatial subsets of the recapture event. Equal probability of capture over time and space during the recapture event was tested by comparing recapture rates of fish marked during subsets of the marking event. Differences in probability of capture by age and size were tested following the procedures in Appendix A1.

2005

The marked-to-unmarked ratio did not differ statistically over time or area in the 2005 recapture event (Appendix A2), which is consistent with equal probability of capture over time and area during the marking event. It is important to note, however, that the tests had low power because of the small number of recaptures. The recapture event was not designed to have equal probability of capture.

Comparisons of marked and captured fish indicated that probability of capture by size and age differed between events in 2005 (Appendices A1 and A2). Normally, this would indicate that the abundance estimate should be stratified by size. The small number of recaptures precluded this option.

In summary, the 2005 data set suffers from 2 shortcomings (inability to rigorously test time or area differences in capture probability, and evidence of size or age selectivity), that may result in biased estimates of abundance. There are no remedies available because of the small number of recaptures.

2006

The marked-to-unmarked ratio differed over time and area in the 2006 recapture event (Appendix A3), indicating unequal probability of capture with respect to time or area during the marking event. Unequal capture probability may have resulted from unequal sampling effort on days with dissimilar Chinook salmon abundance, as indicated by the inverse relationship between Chinook CPUE and gillnet soak time (Figure 4). We attempted to correct for this relationship using 2 methods: 1) by weighting tags relative to several measures of sampling effort and 2) by sub-sampling drift net sets such that the resampled data set had equal daily soak time. Neither method altered the marked-to-unmarked ratio enough to indicate equal capture probability during the marking event. Recapture rates did not differ statistically among temporal or spatial subsets of the 2006 marking event (Appendix A3), which is consistent with equal probability of capture over time and space during the recapture event.[13]

There was no evidence of selectivity for size, age, or sex in 2006 (Appendices A1 and A3).

In summary, the equal probability of capture assumption was satisfied for the 2006 recapture event. This justifies use of the modified Petersen estimator, without the need for stratification by time, location, or size.

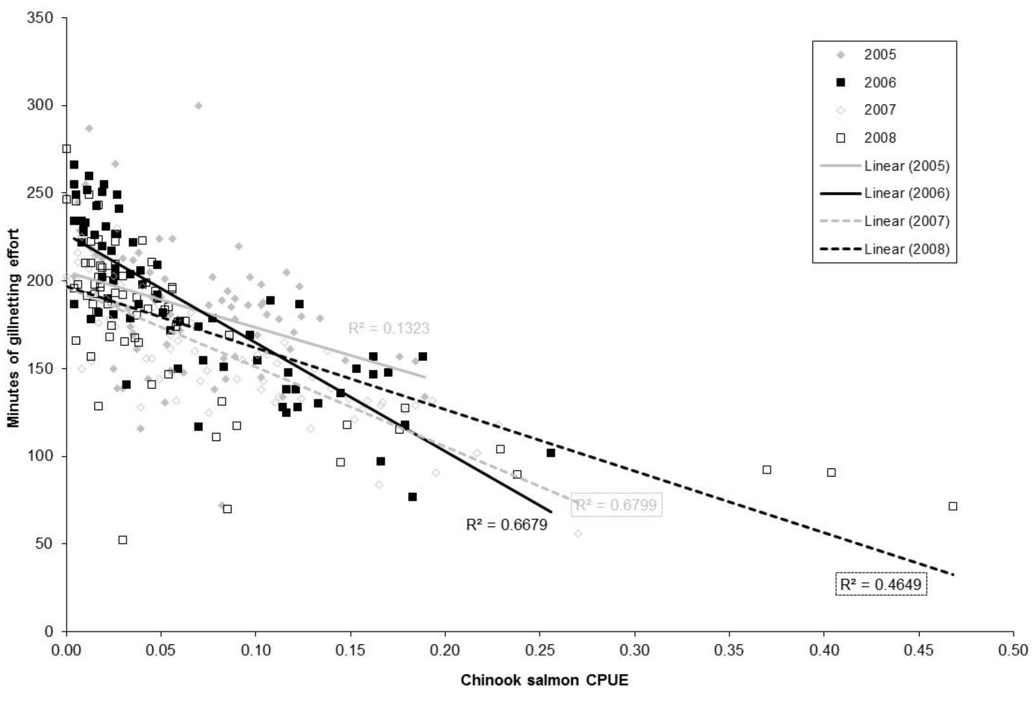

Figure 4.–Relationship between effort and catch per unit effort during marking events on the Kasilof River, 2005–2008.

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[13] This was in spite of evidence that the 2006 recapture event was inadvertently terminated before capture success fell to zero.

2007

The marked-to-unmarked ratio differed by area in the 2007 recapture event (Appendix A4), indicating unequal capture probabilities during the marking event. Recapture rates did not differ statistically among temporal or spatial subsets of the 2007 marking event (Appendix A4), which is consistent with equal probability of capture over time and space during the recapture event.

There was no evidence of selectivity for size, age, or sex in 2007 (Appendices A1 and A4).

In summary, the equal probability of capture assumption was satisfied for the 2007 recapture event. This justifies use of the modified Petersen estimator, without the need for stratification by time, location, or size.

2008

The marked-to-unmarked ratio differed by time and area in the 2008 recapture event (Appendix A5), indicating unequal capture probabilities during the marking event. Recapture rates did not differ statistically among temporal or spatial subsets of the 2008 marking event (Appendix A5), which is consistent with equal probability of capture over time and space during the recapture event.

There was evidence of size or age selectivity in 2008 (Appendices A1 and A5), requiring stratification by size. Groups of less than 930 mm METF and at least 930 mm METF provided test results that were consistent with equal probability of capture during the recapture event for all factors.

In summary, the equal probability of capture assumption was satisfied for the 2008 recapture event after stratifying by size. This required the use of the modified Petersen estimator for each stratum. Overall abundance was estimated by summing the abundance estimates for each stratum. Composition parameters were estimated for each size stratum using data from the recapture event only because stratification failed to eliminate variability in capture probabilities for the marking event. Overall composition parameters were estimated by combining stratum composition estimates weighted by estimated stratum abundance.

ESTIMATES OF SPAWNING SUCCESS AND THE CONTRIBUTION OF MAINSTEM SPAWNERS

In 2005, 143 backpack-style radio tags were released during the marking event (Table 3). Weekly estimates of spawning success, q_i, ranged from 0.08 (SE 0.07) to 0.62 (SE 0.11) (Table 4). Weekly estimates of the mainstem spawning component $\hat{r}$, began at 0.00 (SE 0.05) and 0.04 (SE 0.23) for r_1 (radiotelemetry estimate) and r_2 (marking–Crooked Creek weir estimate), respectively, and climbed to 1.00 (SE 0.00) for both variables by early July. Estimates of r indicate the majority of Crooked Creek fish had left the marking area by early July. After weighting by average weekly CPUE (equation 1), the annual estimate of spawning success, q, was 0.37 (SE 0.06) and the annual estimate of the mainstem spawning component, r, was 0.95 (SE 0.01) (Table 5).

In 2006, 129 esophageal radio tags were released during the marking event (Table 3). Weekly estimates of spawning success, q_i, ranged from 0.13 (SE 0.10) to 0.78 (SE 0.07) (Table 4). Weekly estimates of the mainstem spawning component, $\hat{r}$, began at 0.11 (SE 0.10) and 0.57 (SE 0.22) for r_1 and r_2, respectively, and climbed to 1.00 (SE 0.00) for both variables by early July. Estimates of r indicate the majority of Crooked Creek fish had left the marking area by early July. After weighting by CPUE (equation 1), the annual estimate of spawning success, q, was 0.52 (SE 0.04) and the annual estimate of the mainstem spawning component, r, was 0.92 (SE 0.02) (Table 5).

In 2007, 134 esophageal radio tags were released during the marking event (Table 3). Weekly estimates of spawning success, q_i , ranged from 0.00 (SE 0.00) to 0.74 (SE 0.16) (Table 4). Weekly estimates of the mainstem spawning component, $\hat{r}$, began at 0.03 (SE 0.05) and 0.00 (SE 0.20) for r_1 and r_2, respectively, and climbed to 1.00 (SE 0.00) for both variables by mid-July. Estimates of r indicate Crooked Creek fish were present within the marking area through early July. After weighting by CPUE (equation 1), the annual estimate of spawning success, q, was 0.47 (SE 0.05) and the annual estimate of the mainstem spawning component, r, was 0.86 (SE 0.03) (Table 5).

In 2008, 112 esophageal radio tags were released during the marking event, 50 on Chinook salmon less than 930 mm METF and 62 on Chinook salmon at least 930 mm METF (Table 3). Weekly estimates of spawning success, q_i , ranged from 0.03 (SE 0.03) to 0.82 (SE 0.09) for Chinook salmon less than 930 mm METF and from 0.01 (SE 0.01) to 0.84 (SE 0.11) for Chinook salmon at least 930 mm METF (Table 4). Weekly estimates of the mainstem spawning component, $\hat{r}$, began at 0.00 (SE 0.00) and 0.00 (SE 0.30) for r_1 and r_2, respectively, and climbed to 1.00 (SE 0.00) for both variables by mid-July for Chinook salmon less than 930 mm METF. For Chinook salmon at least 930 mm METF, weekly estimates of the mainstem spawning component, $\hat{r}$, were 1.00 (SE 0.00) for all but 1 weekly stratum. After weighting by CPUE (equation 1), the annual estimate of spawning success, q, was 0.56 (SE 0.07) for Chinook salmon less than 930 mm METF and 0.48 (SE 0.07) for Chinook salmon at least 930 mm METF (Table 5). After weighting by CPUE (equation 1), the annual estimate of the mainstem spawning component, r, was 0.84 (SE 0.04) for Chinook salmon less than 930 mm METF and 0.99 (SE 0.01) for Chinook salmon at least 930 mm METF (Table 5).

Table 4.–Weekly estimates of spawning success, q, and contribution of mainstem spawners, r, for radiotagged Kasilof River Chinook salmon, 2005–2008.

			Proportion of successful spawners		Proportion of fish spawning in the mainstem			
Time period [a]	Weighted CPUE[b]	SE	q_i	SE	r_1[c]	SE	r_2[d]	SE
Chinook salmon (all lengths)								
20–26 June 2005	0.04	0.01	0.36	0.15	0.00	0.05	0.04	0.23
27 June–3 July 2005	0.04	0.01	0.10	0.08	0.27	0.41	0.92	0.08
4–10 July 2005	0.04	0.01	0.08	0.07	1.00	0.00	1.00	0.00
11–17 July 2005	0.09	0.02	0.11	0.07	1.00	0.00	0.96	0.04
18–24 July 2005	0.08	0.02	0.35	0.12	1.00	0.00	1.00	0.00
25–31 July 2005	0.15	0.02	0.30	0.12	1.00	0.00	1.00	0.00
1–7 August 2005	0.14	0.02	0.47	0.13	1.00	0.00	1.00	0.00
8–14 August 2005	0.16	0.02	0.27	0.11	1.00	0.00	1.00	0.00
15–21 August 2005	0.13	0.02	0.61	0.13	1.00	0.00	1.00	0.00
22–31 August 2005	0.11	0.03	0.62	0.11	1.00	0.00	1.00	0.00

-continued-

Table 4.–Part 2 of 2.

Time period [a]	Weighted CPUE[b]	SE	Proportion of successful q_i	SE	Proportion of fish spawning in the mainstem r_1[c]	SE	r_2[d]	SE
Chinook salmon (all lengths)								
20–26 June 2006	0.09	0.02	0.64	0.16	0.11	0.10	0.57	0.22
27 June–3 July 2006	0.03	0.01	0.22	0.14	0.36	0.38	0.75	0.26
4–10 July 2006	0.04	0.01	0.13	0.10	1.00	0.00	0.89	0.09
11–17 July 2006	0.05	0.01	0.20	0.09	1.00	0.00	1.00	0.00
18–24 July 2006	0.03	0.01	0.20	0.09	1.00	0.00	1.00	0.00
25–31 July 2006	0.16	0.05	0.39	0.07	1.00	0.00	1.00	0.00
1–7 August 2006	0.24	0.03	0.56	0.09	1.00	0.00	1.00	0.00
8–14 August 2006	0.17	0.02	0.48	0.10	1.00	0.00	1.00	0.00
15–21 August 2006	0.17	0.03	0.78	0.07	1.00	0.00	1.00	0.00
22–29 August 2006	0.03	0.01	0.70	0.11	1.00	0.00	1.00	0.00
Chinook salmon (all lengths)								
20–26 June 2007	0.14	0.04	0.74	0.16	0.03	0.05	0.00	0.20
27 June–3 July 2007	0.04	0.02	0.00	0.00	1.00	0.00	0.32	0.30
4–10 July 2007	0.03	0.01	0.36	0.16	0.53	0.34	0.63	0.27
11–17 July 2007	0.04	0.01	0.27	0.13	1.00	0.00	1.00	0.00
18–24 July 2007	0.08	0.01	0.36	0.11	1.00	0.00	1.00	0.00
25–31 July 2007	0.13	0.02	0.26	0.08	1.00	0.00	1.00	0.00
1–7 August 2007	0.15	0.02	0.33	0.09	1.00	0.00	1.00	0.00
8–14 August 2007	0.20	0.03	0.47	0.09	1.00	0.00	1.00	0.00
15–21 August 2007	0.18	0.02	0.73	0.08	1.00	0.00	1.00	0.00
22–29 August 2007	0.02	0.01	0.68	0.11	1.00	0.00	1.00	0.00
Chinook salmon (< 930 mm)								
20–26 June 2008	0.14	0.04	0.67	0.16	0.00	0.00	0.00	0.30
27 June–3 July 2008	0.05	0.02	0.25	0.21	0.00	0.47	0.00	0.35
4–10 July 2008	0.04	0.01	0.05	0.04	1.00	0.00	0.86	0.28
11–17 July 2008	0.04	0.01	0.43	0.20	1.00	0.00	1.00	0.00
18–24 July 2008	0.06	0.02	0.17	0.15	1.00	0.00	1.00	0.00
25–31 July 2008	0.06	0.02	0.03	0.03	1.00	0.00	1.00	0.00
1–7 August 2008	0.11	0.05	0.43	0.16	1.00	0.00	1.00	0.00
8–14 August 2008	0.41	0.07	0.82	0.09	1.00	0.00	1.00	0.00
15–21 August 2008	0.09	0.05	0.47	0.19	1.00	0.00	1.00	0.00
22–29 August 2008	0.01	0.01	0.45	0.16	1.00	0.00	1.00	0.00
Chinook salmon (≥ 930 mm)								
20–26 June 2008	0.00	0.00	ND	ND	ND	ND	ND	ND
27 June–3 July 2008	0.01	0.00	0.01	0.01	1.00	0.00	1.00	0.00
4–10 July 2008	0.02	0.01	0.08	0.03	1.00	0.00	1.00	0.00
11–17 July 2008	0.03	0.01	0.58	0.24	0.43	0.37	1.00	0.00
18–24 July 2008	0.07	0.02	0.42	0.16	1.00	0.00	1.00	0.00
25–31 July 2008	0.10	0.03	0.65	0.13	1.00	0.00	1.00	0.00
1–7 August 2008	0.09	0.02	0.33	0.11	1.00	0.00	1.00	0.00
8–14 August 2008	0.55	0.06	0.46	0.11	1.00	0.00	1.00	0.00
15–21 August 2008	0.14	0.04	0.60	0.14	1.00	0.00	1.00	0.00
22–29 August 2008	0.01	0.01	0.84	0.11	1.00	0.00	1.00	0.00

[a] Post-season analysis showed evidence of size or age selectivity in 2008 (Appendices A1 and A5) requiring stratification of these data by size. Two groups of fish (<930 mm METF and ≥930 mm METF) provided test results which were consistent with equal probability of capture during the recapture event for all factors.

[b] The CPUE estimate for each time period is weighted by the number of days in each time period. In most cases a time period is synonymous with a week, although the last time period of each year is a few days longer.

[c] r_1 = estimate from radiotelemetry data.

[d] r_2 = estimate from marking event and Crooked creek weir recaptures.

Table 5.–Beta distribution parameters for seasonal estimates of spawning success *q* and contribution of mainstem spawners *r* for radiotagged Kasilof River Chinook salmon, 2005–2008.

				2008 [a]	
Parameters	2005[b]	2006[b]	2007[b]	Length < 930 mm	Length ≥ 930 mm
Q					
Alpha	21.4	77.8	49.6	31.3	22.6
Beta	36.7	72.9	55.5	24.9	24.8
Mean	0.37	0.52	0.47	0.56	0.48
Std dev	0.06	0.04	0.05	0.07	0.07
r_1					
Alpha	86.0	101.7	79.7	53.0	28.6
Beta	6.0	10.3	13.1	10.6	0.5
Mean	0.94	0.91	0.86	0.83	0.98
Std dev	0.02	0.02	0.04	0.05	0.01
r_2					
Alpha	157.8	72.8	45.8	22.5	25.0
Beta	6.7	3.8	7.9	3.3	0.0
Mean	0.96	0.95	0.85	0.87	1.00
Std dev	0.02	0.03	0.05	0.07	0.00
R					
Alpha	243.8	174.5	125.5	75.5	53.6
Beta	12.7	14.0	21.0	13.9	0.5
Mean	0.95	0.92	0.86	0.84	0.99
Std dev	0.01	0.02	0.03	0.04	0.01

[a] Post-season analysis showed evidence of size or age selectivity in 2008 (Appendices A1 and A5) requiring stratification of this data by size. Two groups of fish (<930 mm METF and ≥930 mm METF) provided test results which were consistent with equal probability of capture during the recapture event for all factors.

[b] All METF lengths combined.

ESTIMATES OF ABUNDANCE

2005

The primary project objective in 2005 was to assess the feasibility of abundance estimation. Due to inadequate sample size, the abundance estimate for 2005 suffers from several important shortcomings. First, we were forced to ignore evidence of unequal probability of capture by size or age. If size or age selectivity was in the same direction for both events (probably true because the same sampling gear was used for both events), the effect of ignoring such selectivity would be to negatively bias the abundance estimate. Second, the small number of recaptures does not allow for meaningful tests of time or area differences in capture probability. Bias due to time or area differences could be in either direction. Third, even if one is willing to overlook these issues, the estimates are very imprecise, as described below.

The posterior distribution for the 2005 abundance of mainstem-spawning age-.2+ Kasilof River Chinook salmon is shown in Figure 5. The height of the curve at a given abundance is the relative probability that it represents the true abundance. The area under the curve bracketed by 2 abundance values is the probability that the true abundance is within the bracketed values. Descriptive statistics for the posterior probability distribution are given in Table 6. For instance, there is an 80% probability that the 2005 abundance was between 7,002 and 21,924 Chinook salmon.

Given the low (high uncertainty), wide (highly imprecise) 2005 posterior distribution of abundance, point estimates for 2005 abundance are not meaningful. Probability statements incorporate the uncertainty and imprecision of the 2005 abundance estimates but must be evaluated in context with the potential bias detailed above. For instance, there is a 90% probability that the abundance of mainstem-spawning age-.2+ Chinook salmon in 2005 was greater than 8,856 fish. Alternatively, the probability that there were more late-run Kasilof River Chinook salmon in 2005 than in 2006, 2007, and 2008 was 87%, 89%, and 83%, respectively. These statements would be robust against possible negative bias associated with size or age selectivity but could be compromised by high bias due to time or area differences in capture probability.

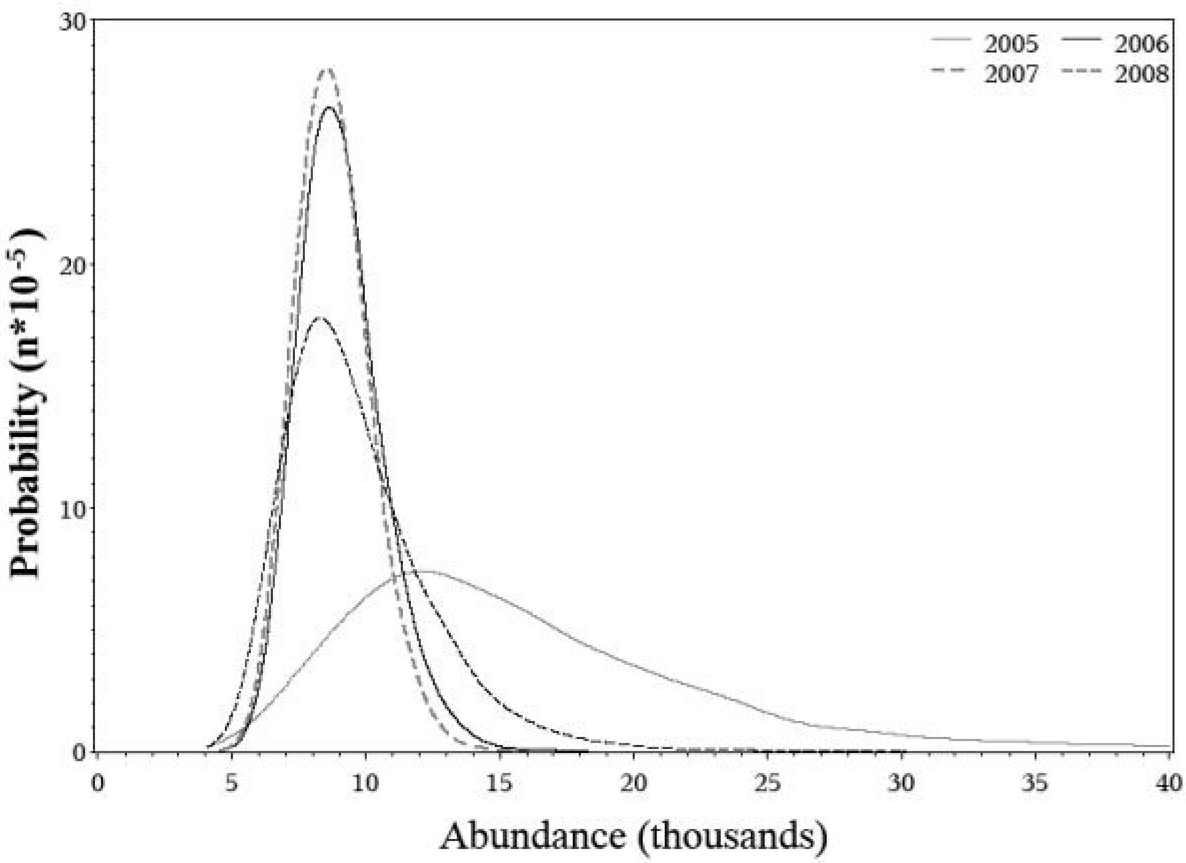

Figure 5.–Posterior distributions of estimated abundance of wild Kasilof River Chinook salmon (age .2 or greater), 2005–2008.

Table 6.–Descriptive statistics for posterior distributions of wild Chinook salmon (age .2 or greater) returning to the Kasilof River after 20 June 2005–2008.

	Estimated number of wild Chinook salmon (≥age-.2)			
Parameters	2005	2006	2007	2008
Centeral tendancy				
Mean	16,251	9,076	8,780	9,689
Median	14,580	8,917	8,676	9,136
Mode	12,097	8,611	8,522	8,276
Variability				
Standard deviation	7,510	1,575	1,406	2,815
Interquartile range	8,255	1,993	1,850	3,301
Range	72,793	13,254	11,482	29,165
Highest posterior density				
95%	4,891–30,878	6,159–12,216	6,111–11,565	5,097–15,129
90%	5,837–25,637	6,517–11,514	6,433–11,002	5,563–13,613
80%	7,002–21,924	6,941–10,771	6,869–10,371	6,059–12,125
70%	7,802–19,522	7,233–10,294	7,167–9,992	6,409–11,221
60%	8,457–17,848	7,498–9,950	7,408–9,705	6,701–10,550
50%	9,113–16,465	7,723–9,671	7,615–9,452	7,021–10,055
Percentiles				
5%	7,717	6,808	6,662	6,242
10%	8,856	7,228	7,072	6,746
15%	9,734	7,520	7,352	7,136
20%	10,440	7,763	7,585	7,463
25%	11,180	7,976	7,791	7,750
30%	11,780	8,174	7,975	8,021
35%	12,470	8,348	8,154	8,286
40%	13,110	8,532	8,332	8,559
45%	13,800	8,722	8,506	8,842
50%	14,580	8,917	8,676	9,136
55%	15,360	9,095	8,855	9,444
60%	16,190	9,289	9,029	9,784
65%	17,110	9,505	9,216	10,140
70%	18,285	9,714	9,415	10,570
75%	19,435	9,968	9,641	11,050
80%	20,920	10,280	9,898	11,610
85%	22,715	10,660	10,200	12,350
90%	25,190	11,140	10,620	13,240
95%	30,665	11,920	11,280	14,895

2006

The posterior probability distribution for the 2006 abundance of mainstem-spawning age-.2+ Kasilof River Chinook salmon is shown in Figure 5. Descriptive statistics for the posterior distribution are given in Table 6. There is 90% probability that the 2006 abundance was between 6,517 and 11,514 Chinook salmon. The mode of the posterior distribution (the most likely value for the true abundance) for 2006 is 8,611 fish. The objective criterion for precision of the abundance estimate was met in 2006.

2007

The posterior distributions for the 2007 abundance of mainstem-spawning age-.2+ Kasilof River Chinook salmon is shown in Figure 5. Descriptive statistics for the posterior probability distribution are given in Table 6. There is 90% probability that the 2007 abundance was between 6,433 and 11,002 Chinook salmon. The mode of the posterior distribution (the most likely value for the true abundance) for 2007 is 8,522 fish. The objective criterion for precision of the abundance estimate was met in 2007.

2008

The posterior distributions for the 2008 abundance of mainstem-spawning age-.2+ Kasilof River Chinook salmon is shown in Figure 5. Descriptive statistics for the posterior probability distribution are given in Table 6. There is 90% probability that the 2008 abundance was between 5,563 and 13,613 Chinook salmon. The mode of the posterior distribution (the most likely value for the true abundance) for 2008 is 8,276 fish. The objective criterion for precision was not met in 2008, although precision was compromised by required size stratification.

The relative precision and uncertainty for each year's posterior probability distribution of abundance displayed in Figure 5 illustrates project shortcomings from each season. In 2005, when the project was run as a feasibility assessment, the distribution is the widest (most imprecise) and lowest (most uncertain) of any year. The 2006 and 2007 posterior probability distributions of abundance represent the best precision and certainty we were able to achieve. In 2008, both precision and certainty were reduced due to the need for size stratification.

AGE, SEX, AND LENGTH COMPOSITION

2005

In 2005, age composition data from each sampling event were not combined after contingency table analysis revealed significant differences (Appendix A2) between events. Chinook salmon captured in the marking event were 7.8% (SE 1.0%) age 1.2, 24.6% (SE 1.6%) age 1.3, 66.6% (SE 1.8%) age 1.4, and 1.0% (SE 0.4%) age 1.5 (Appendix E1). Chinook salmon captured in the recapture event were 4.1% (SE 1.3%) age 1.2, 20.6% (SE 2.6%) age 1.3, 74.1% (SE 2.8%) age 1.4, and 1.2% (SE 0.7%) age 1.5 (Appendix E1). Run estimates by age or sex were not produced due to the poor precision of the 2005 abundance estimate.

In contrast to the predominantly age-1.4 fish sampled using drift gillnets, the 2005 harvest samples were considerably younger: 22.9% (SE 1.9%) age 1.2, 43.0% (SE 2.3%) age 1.3, and 34.1% (SE 2.2%) age 1.4 (Appendix E1). Anglers harvested a larger percentage of age-1.2 and age-1.3 fish and a smaller percentage of age-1.4 and age-1.5 fish than were captured by the gillnetting projects.

2006

In 2006, ASL data from both events were combined because significant size selectivity was not detected in either event (Appendices A1 and A3). Of the estimated 8,611 wild age-.2+ Chinook salmon that returned in 2006; 1,195 (SE 218) were age 1.2; 2,548 (SE 466) were age 1.3; 4,621 (SE 845) were age 1.4; and 247 (SE 45) were age 1.5 (Table 7). Age composition data for each sampling event are shown separately in Appendix E2.

Table 7.–Estimated inriver run by age and length-at-age for wild Kasilof River Chinook salmon (age .2 or greater), 2006.

	Age				
	1.2	1.3	1.4	1.5	Total
Female					
Sample size[a]	26	140	395	23	584
% total (SE)	2.1% (0.4%)	11.2% (0.9%)	31.5% (1.3%)	1.8% (0.4%)	46.6% (1.4%)
Inriver return estimate[a] (SE)	179 (32)	961 (175)	2,712 (496)	158 (28)	4,010 (733)
Mean METF (SE)	667 (9)	853 (4)	952 (3)	1,027 (9)	918 (4)
METF range	560-750	700-970	780-1,115	970-1,110	560-1,115
Male					
Sample size[a]	148	231	278	13	670
% total (SE)	11.8% (0.9%)	18.4% (1.1%)	22.2% (1.2%)	1.0% (0.3%)	53.4% (1.4%)
Inriver return estimate[a] (SE)	1,016 (185)	1,586 (290)	1,909 (349)	089 (16)	4,601 (841)
Mean METF (SE)	676 (4)	817 (4)	1,011 (5)	1,122 (19)	872 (6)
METF range	530-785	650-975	770-1,205	1,005-1,230	530-1,230
Male & Female					
Sample size[a]	174	371	673	36	1,254
% total (SE)	13.9% (1.0%)	29.6% (1.3%)	53.7% (1.4%)	2.9% (0.5%)	100.0% (0.0%)
Inriver return estimate[a] (SE)	1,195 (218)	2,548 (466)	4,621 (845)	247 (45)	8,611 (1,575)
Mean METF (SE)	675 (4)	831 (3)	976 (3)	1,062 (12)	894 (4)
METF range	530-785	650-975	770-1,205	970-1,230	530-1,230

[a] Units = number of fish.

2007

In 2007, ASL data from both events were combined because significant size selectivity was not detected in either event (Appendices A1 and A4). Of the estimated 8,522 wild age-.2+ Chinook salmon that returned in 2007, 1,451 (SE 239) were age 1.2; 2,236 (SE 369) were age 1.3; 4,725 (SE 779) were age 1.4; and 110 (SE 18) were age 1.5 (Table 8). Age composition data for each sampling event are shown separately in Appendix E3.

2008

In 2008, ASL data from only the recapture event was used to estimate age composition of the abundance (Appendices A1 and A5) because stratification failed to eliminate variability in capture probabilities for the marking event. Of the estimated 8,276 wild age-.2+ Chinook salmon that returned in 2008, 925 (SE 385) were age 1.2; 4,530 (SE 1,436) were age 1.3; 2,747 (SE 496) were age 1.4; and 73 (SE 25) were age 1.5 (Table 9). Age composition data for each size strata are shown in Appendix E4. Age composition data for each sampling event are shown in Appendix E5.

2005 Sport Harvest Monitoring

From 1 to 31 July 2005, interviews were conducted with 1,364 sport anglers as they exited the Kasilof River fishery at Trujillo’s pullout (Appendix F1). Total interviewed angler effort was 9,082 h, ranging from 36 h/day to 923 h/day. A total of 557 age-.2+ Chinook salmon were examined in the harvest; 551 wild, age-.2+ Chinook salmon, and 6 hatchery, age-.2+ Chinook salmon. The Alaska Statewide Harvest Survey estimate for 2005 was 1,052 (Jennings et al. 2009a) indicating approximately 53% of the harvest was examined by our field crew.

Table 8.–Estimated inriver run by age and length-at-age for wild Kasilof River Chinook salmon (age .2 or greater), 2007.

	Age				
	1.2	1.3	1.4	1.5	Total
Female					
Sample size[a]	27	181	538	10	756
% total (SE)	1.7% (0.3%)	11.7% (0.8%)	34.7% (1.2%)	0.6% (0.2%)	48.7% (1.3%)
Inriver return estimate[a] (SE)	148 (24)	995 (164)	2,956 (487)	055 (9)	4,154 (685)
Mean METF (SE)	689 (9)	876 (3)	967 (2)	1,024 (7)	936 (3)
METF[b] range	600–770	710–975	790–1,090	985–1,055	600–1,090
Male					
Sample size[a]	237	226	322	10	795
% total (SE)	15.3% (0.9%)	14.6% (0.9%)	20.8% (1.0%)	0.6% (0.2%)	51.3% (1.3%)
Inriver return estimate[a] (SE)	1,302 (214)	1,242 (204)	1,769 (292)	055 (9)	4,368 (720)
Mean METF (SE)	697 (3)	838 (4)	1,010 (4)	1,070 (17)	868 (5)
METF range	545–790	690–975	770–1,180	1,005–1,190	545–1,190
Male & Female					
Sample size[a]	264	407	860	20	1,551
% total (SE)	17.0% (1.0%)	26.2% (1.1%)	55.4% (1.3%)	1.3% (0.3%)	100.0% (0.0%)
Inriver return estimate[a] (SE)	1,451 (239)	2,236 (369)	4,725 (779)	110 (18)	8,522 (1,406)
Mean METF (SE)	696 (3)	855 (3)	983 (2)	1,047 (10)	901 (3)
METF range	545–790	690–975	770–1,180	985–1,190	545–1,190

[a] Units = number of fish.

Table 9.–Estimated inriver run by age and length-at-age for wild Kasilof River Chinook salmon (age .2 or greater), 2008.

	Age				
Parameter	1.2	1.3	1.4	1.5	Total
Female					
Sample size[a]	7	121	224	5	357
Inriver return estimate[a] (SE)	130 (73)	1,953 (843)	1,784 (435)	30 (15)	3,897 (1,240)
% total (SE)	1.6% (0.1%)	23.6% (0.5%)	21.6% (0.5%)	0.4% (0.1%)	47.1% (0.5%)
Mean METF (SE)	691 (25)	891 (3)	966 (3)	1,027 (11)	943 (3)
METF range	590–780	740–985	790–1,135	920–1,090	590–1,135
Male					
Sample size[a]	43	146	140	7	336
Inriver return estimate[a] (SE)	796 (378)	2,577 (1,162)	963 (237)	43 (19)	4,379 (1,619)
% total (SE)	9.6% (0.3%)	31.1% (0.5%)	11.6% (0.4%)	0.5% (0.1%)	52.9% (0.5%)
Mean METF (SE)	685 (5)	848 (4)	1,012 (5)	1,075 (22)	893 (6)
METF range	550–820	695–980	790–1,175	1,000–1,140	550–1,175
Male & Female					
Sample size[a]	50	267	364	12	693
Inriver return estimate[a] (SE)	925 (385)	4,530 (1,436)	2,747 (496)	73 (25)	8,276 (2,040)
% total (SE)	11.2% (0.3%)	54.7% (0.5%)	33.2% (0.5%)	0.9% (0.1%)	100.0% (0.0%)
Mean METF (SE)	686 (5)	866 (3)	983 (3)	1,043 (11)	919 (3)
METF range	550–820	695–985	790–1,175	920–1,140	550–1,175

[a] Units = number of fish.

DISCUSSION

ESTIMATED SPAWNING SUCCESS

During project planning, previous experience (Bendock and Alexandersdottir 1992; Carlon and Evans 2007) led us to expect that any detrimental effects of handling would be apparent immediately after marking because affected individuals would fail to migrate upstream from the marking location. Our inseason experiences revealed a more complicated situation. Some radiotagged Chinook salmon migrated upstream into the recapture reach only to proceed downstream shortly thereafter (e.g., tag no. 102960, Figure 6). Others remained alive for a week or more but never migrated into the recapture reach, which we believe to be synonymous with the spawning area (e.g., tag no. 102950, Figure 6).

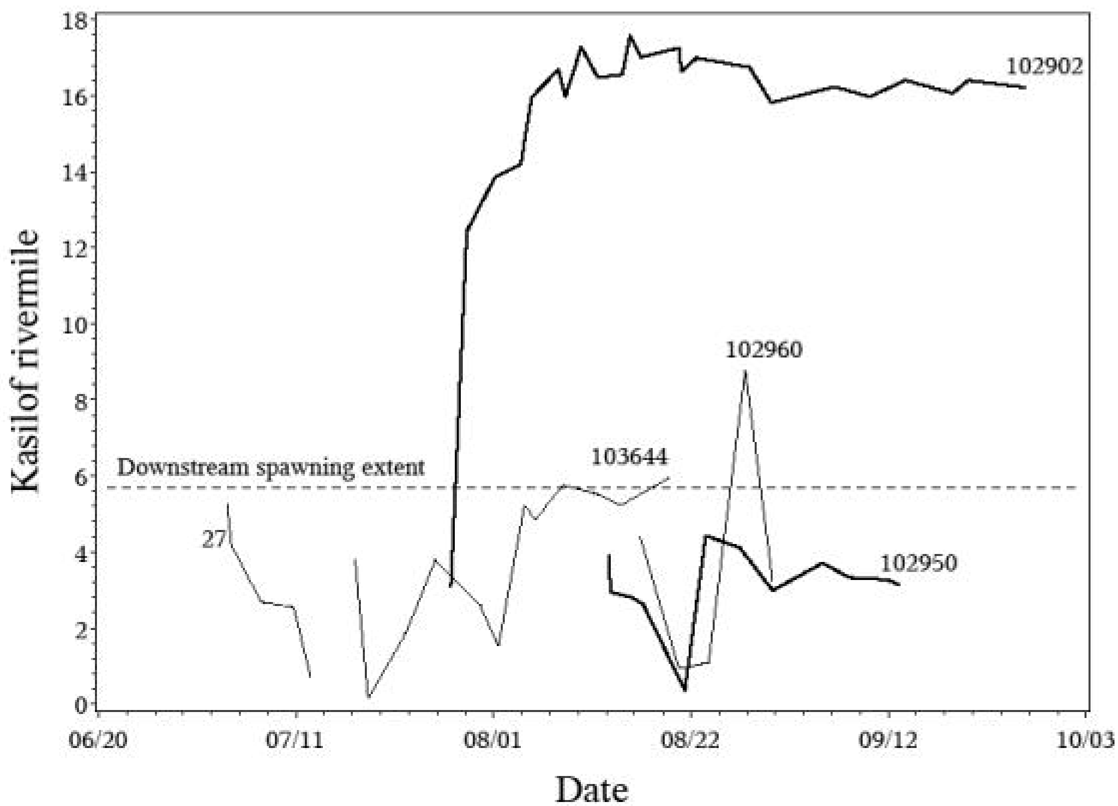

Figure 6.–Plotted inriver movements of 5 radiotagged Chinook salmon over time with respect to known Chinook salmon spawning areas in Kasilof River.

Note: the unique 2 to 6-digit numbers correspond to Kasilof River Chinook salmon that were radiotagged and tracked.

This behavior was troubling because, at its extreme, it would preclude successful spawning. While unmarked Chinook salmon could behave similarly, it would be counterproductive from a life-history or fitness standpoint. For this reason, we based our statistical models and inferences about abundance on the assumption that any behavior detrimental to successful spawning is a latent effect from the combined burden of being handled and marked, and of carrying the tag.

Handling effects on behavior have very important implications for our ability to assess abundance because it artificially reduces the availability of marked fish to subsequently recapture in the second event. Furthermore, because there is a continuum of such effects, as illustrated in Figure 6 by the wide variety of migration behavior, in many cases it is not possible to satisfactorily classify radiotagged fish as "successes" or "failures" relative to availability for recapture. Given the impossibility of directly measuring handling effect,[14] we elected to measure relative spawning success instead, which should be related to, although more conservative than, availability for recapture. This allowed us to produce an approximate correction for the handling-induced bias that is based on objective, meaningful measures of fish behavior.

This method applies more stringent criteria than previous methods of censoring radiotelemetric data because it requires that in addition to surviving until they reach the spawning grounds, fish must also spawn (reproduce), and because it employs a continuous scale rather than a binary scale. Had we used more conventional criteria, based on a binary categorization of entering the recapture reach, our dropout rates would be similar to what other authors have found working with Chinook salmon in tidally influenced areas (Bendock and Alexandersdottir 1992; Burger et al. 1983; Hammarstrom and Hasbrouck 1998, 1999; Craig Schwanke, ADF&G Dillingham, personal communication). We rejected these methods because it would have required including many tagged fish in the experiment that could not have reasonably spawned, and had only a marginal probability of recapture (Table 10). The resulting estimates of abundance would have been positively biased.

The statistical models and methods employed herein do not remove all possible sources of bias in the abundance estimates. For instance, the existence of a latent marking effect could affect the longevity of marks in the recapture event. During 2006–2008 recapture events, the marked-to-unmarked ratio decreased more dramatically in September than did daily CPUE. For example, on 19 September 2006, when the recapture event was terminated, 97% of the radiotagged fish had died while the daily CPUE was in the 30th percentile of all days in the recapture event. We were unable to attribute this pattern to deficiencies in the marking event. The pattern could be explained by a latent marking effect causing marked Chinook salmon to die earlier than unmarked Chinook salmon. If real, this effect would exert a negative bias to marked-to-unmarked ratios and a positive bias to estimates of abundance. Hypothetically, this would affect abundance estimates in all years.

[14] Unhandled fish could not be monitored.

Table 10.–Alternative criteria for assessing Chinook salmon handling survival for the migratory histories shown in Figure 6.

	Tag number				
Chinook salmon handling survival criteria:	27	102950	102960	103644	102902
Live 5 days past capture and tagging [a]	1	1	1	1	1
Enter recapture reach [b]	0	0	1	1	1
Live 14 days past capture & tagging [c]	0	1	0	1	1
Spend 14 days within recapture reach [d]	0	0	0	0	1
Logistic regression estimate [e]	0	0	0.18	0.05	0.96

[a] Bendock and Alexandersdottir (1992) considered Chinook salmon that lived for 5 days after being caught and released by sport anglers as survivors with respect to handling.

[b] Carlon and Evans (2007) considered coho salmon that migrated upstream to a certain cutoff to have survived the handling event.

[c] Literature reviews from several species suggest that salmon typically spend 10–16 days in close proximity to their spawning area with the time divided between redd selection, egg deposition, and redd defense (van den Berghe and Gross 1986; Fleming and Gross 1992, 1993; Lady and Skalski 1998). This criterion is liberal with respect to these estimates in that only a portion of time was not spent in areas suitable for spawning.

[d] Adds a geographic requirement to the "Live 14 days …" criterion in that fish are required to spend their 14 days within the known spawning reach.

[e] The method derived for this report.

The models also do not account for "immigration" between sampling events in the form of Crooked Creek-bound Chinook salmon that entered the Kasilof River before the marking event began but failed to enter Crooked Creek before the recapture event began. The effect of this omission would be to cause a slight negative bias in the marked-to-unmarked ratio and a small positive bias in abundance in 2006 and 2007.[15] The 2005 and 2008 estimates are immune from this potential bias because the recapture events started after most Crooked Creek-bound fish had left the recapture area.

Large effects of handling and marking may be an unavoidable consequence of marking within tidal influence. Conventional wisdom is that Chinook salmon ebb and flow with the tide in the estuary for days to weeks before committing to upstream migration. Because we captured most fish in the estuary, many may not have committed to freshwater at the time of marking. In the Kasilof River, this behavior would lead to a reduction in recapture availability, even in the absence of handling effect, due to exposure to commercial fishing activity near the river mouth. Additionally, fish that are not fully acclimated may be more susceptible to handling induced stress, leading to a continuum of responses including mortality, downstream migration, and postponed upstream migration. While we found no significant ($P > 0.05$) correlation between sulking time (time between marking and migration above tidal influence) and spawning success, estimates for q were always lower in July when sulking fish would be vulnerable to commercial harvest (Table 4).

It is noteworthy that there was a marked increase in our estimate of spawning success in 2006–2008, which corresponds to the change from external mount radio tags in 2005 to esophageal implant radio tags in 2006. Other authors have found esophageal implant radio tags reduced survival, migration distance, and stream life to a lesser extent than external mount radio tags (J. H. Eiler, National Marine Fisheries Service, Auke Bay, personal communication; Brown and Eiler 2000).

[15] The effect is less than 1.5% in 2006 and less than 3% in 2007.

MANAGEMENT IMPLICATIONS

Management concern for late-run Kasilof River Chinook salmon resulted from repeated harvests exceeding 1,000 fish that occurred after the year 2000. At that time, there was uncertainty over the stock composition of the harvests and whether harvests of that level were sustainable. Earlier studies indicated that hatchery-reared Chinook salmon did not contribute significantly to the late-run harvest (Breakfield and King 2007). During this study, we determined that hatchery-reared Chinook salmon did not contribute significantly to the inriver run in July and that few fish ultimately bound for the Kenai River occur in the Kasilof River.

The length-at-age and age-at-maturity of late-run Kasilof River Chinook salmon captured during this study was noteworthy. We combined ASL data from the marking and recapture events for all years for comparison to length-at-age and age-at-maturity data for 108 Chinook salmon populations sampled between 1987 and 1991 (Roni and Quinn 1995). The average ocean ages from sampled Chinook during our study (3.2 yrs for males and 3.7 yrs for females) indicate that late-run Kasilof River Chinook salmon mature later than many Chinook salmon stocks in the Pacific Northwest. Likewise, the overall length and length-at-age of age-.4 and age-.5 late-run Kasilof River Chinook salmon are comparable to the largest stocks included in the study by Roni and Quinn (1995).

Our estimates of inriver abundance suggest inriver sport harvest rates of 8–12%. The composition of the sport harvest reported herein and elsewhere (Breakfield and King 2007) indicate that the current management regime and sport fishing practices on the Kasilof River do not overexploit the uniquely large and old fish that make up the run.

Run timing for wild, age-.2+ Chinook salmon was considerably later than generally accepted late-run Chinook salmon timing for Upper Cook Inlet (Figure 7). Excluding the high daily CPUEs observed in late June (caused by naturally-produced, Crooked Creek-bound Chinook salmon) significant Chinook salmon catch rates did not occur until the last half of July and continued throughout most of August. The rarity of this pattern suggests that the temperature regime in the Kasilof River may be slightly warmer than typical for Upper Cook Inlet rivers, allowing Chinook salmon to develop rapidly. Unfortunately, we did not find appropriate temperature data to confirm this hypothesis.

The current study cannot estimate exploitation rate or total run because significant harvests may exist for this stock in marine waters. For example, the Upper Cook Inlet Upper Subdistrict set gillnet commercial fishery annual Chinook salmon harvest ranged from 7,442 to 22,101 fish during 2005–2008 (Shields 2009). An unknown fraction of these Chinook salmon originate from the Kasilof River late run, versus the larger Kenai River late-run stock. Late-run timing of the Kasilof stock may reduce its exposure to this fishing pressure. Conversely, the inriver run timing pattern may reflect significant marine harvest. Unfortunately, the stock compositions of these harvests are unknown.

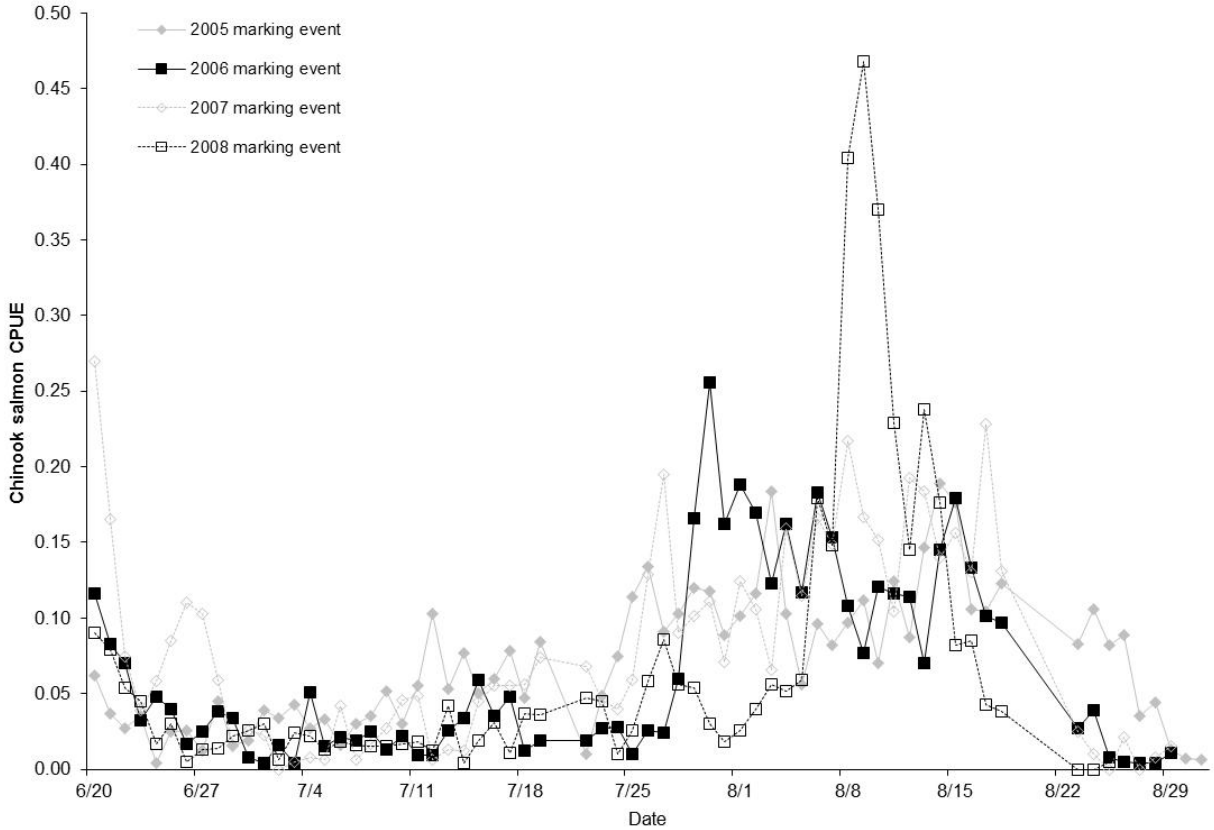

Figure 7.–Daily CPUE for wild Kasilof River Chinook salmon (age .2 or greater) during the marking event, 2005–2008.

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APPENDIX A: EQUAL PROBABILITY OF CAPTURE GUIDELINES AND TEST RESULTS

Appendix A1.–Detection of size or sex selective sampling during a 2-sample mark–recapture experiment and its effects on estimation of population size and population composition.

Size selective sampling: The Kolmogorov-Smirnov 2-sample test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (*M*) with that of marked fish recaptured during the second event (*R*), using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (*C*) with that of *R*. A third test, comparing *M* and *C*, is conducted and used to evaluate the results of the first 2 tests when sample sizes are small. Guidelines for small sample sizes are less than 30 for *R* and less than 100 for *M* or *C*.

Sex selective sampling: Contingency table analysis (χ^2-test) is generally used to detect significant evidence that sex selective sampling occurred during the first or second sampling events. The counts of observed males to females are compared between *M* and *R*, *C* and *R*, and *M* and *C* as described above, using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. When the proportions by gender are estimated for a sample (usually *C*), rather than observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are compared between samples using a 2-sample test (e.g., Student's t-test).

	M versus R	**C versus R**	**M versus C**
Case I:	Fail to reject H_o	Fail to reject H_o	Fail to reject H_o
There is no size/sex selectivity detected during either sampling event.			
Case II:	Reject H_o	Fail to reject H_o	Reject H_o
There is no size/sex selectivity detected during the first event but there is during the second event sampling.			
Case III:	Fail to reject H_o	Reject H_o	Reject H_o
There is no size/sex selectivity detected during the second event but there is during the first event sampling.			
Case IV:	Reject H_o	Reject H_o	Reject H_o
There is size/sex selectivity detected during both the first and second sampling events.			
Evaluation Required:	Fail to reject H_o	Fail to reject H_o	Reject H_o

Sample sizes and powers of tests must be considered as follows:

A. If sample sizes for *M* versus *R* and *C* versus *R* tests are not small and sample sizes for *M* versus *C* test are very large, the *M* versus *C* test is likely detecting small differences which have little potential to result in bias during estimation. *Case I* is appropriate.

B. If a) sample sizes for *M* versus *R* are small, b) the *M* versus *R* *P*-value is not large (~0.20 or less), and c) the *C* versus *R* sample sizes are not small and/or the *C* versus *R* *P*-value is fairly large (~0.30 or more), the rejection of the null in the *M* versus *C* test was likely the result of size/sex selectivity during the second event which the *M* versus *R* test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

C. If a) sample sizes for *C* versus *R* are small, b) the *C* versus *R* *P*-value is not large (~0.20 or less), and c) the *M* versus *R* sample sizes are not small and/or the *M* versus *R* *P*-value is fairly large (~0.30 or more), the rejection of the null in the *M* versus *C* test was likely the result of size/sex selectivity during the first event which the *C* versus *R* test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for *C* versus *R* and *M* versus *R* are both small, and b) both the *C* versus *R* and *M* versus *R* *P*-values are not large (~0.20 or less), the rejection of the null in the *M* versus *C* test may be the result of size/sex selectivity during both events which the *C* versus *R* and *M* versus *R* tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation.

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Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the *M* versus *R* test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the *C* versus *R* test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

If stratification by sex or length is necessary prior to estimating composition parameters, an overall composition parameter (p_k) is estimated by combining within stratum composition estimates using:

$$\hat{p}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik}, \text{ and} \tag{1}$$

$$\hat{V}[\hat{p}_k] \approx \frac{1}{\hat{N}_\Sigma^2} \left(\sum_{i=1}^{j} \hat{N}_i^2 \hat{V}[\hat{p}_{ik}] + \left(\hat{p}_{ik} - \hat{p}_k \right)^2 \hat{V}[\hat{N}_i] \right) \tag{2}$$

where:

j = the number of sex/size strata;

$\hat{p}_{ik}$ = the estimated proportion of fish that were age or size *k* among fish in stratum *i*;

$\hat{N}_i$ = the estimated abundance in stratum *i*;

$\hat{N}_\Sigma$ = sum of the $\hat{N}_i$ across strata.

Appendix A2.–Test results for equal probability of capture assumptions, Kasilof River, 2005.

Year	Event	Effect	Comparison [a]	Strata	Test	Value	df	*P*
2005	Marking	Time	C & R	1–15 Jul 16–31 Jul 24 Aug–4 Sep 5–16 Sep	Fisher's exact test			0.655
		Area	C & R	RM 3.7-8.0 RM 8.1-17.5	Chi-Square	$\chi^2 = 0.04$	1	0.840
		Sex	C & R	male female	Fisher's exact test			0.725
			M & C	male female	Chi-Square	$\chi^2 = 1.45$	1	0.229
		Size	C & R	METF length (mm)	Kolmogorov-Smirnov	D = 0.166		0.983
			M & C	METF length (mm)	Kolmogorov-Smirnov	D = 0.165		0.000
		Age	C & R	age 1.2 age 1.3 age 1.4 age 1.5	Fisher's exact test			1.000
			M & C	age 1.2 age 1.3 age 1.4 age 1.5	Chi-Square	$\chi^2 = 8.20$	3	0.042

[a] Comparison codes: C = all fish inspected for marks during the second event, R = all marked fish captured during the second event, and M = all fish marked during the first event.

Appendix A3.–Test results for equal probability of capture assumptions, Kasilof River, 2006.

Year	Event	Effect	Comparison [a]	Strata	Test	Value	df	*P*
2006	Marking	Time	C & R	4–16 Jul 17 Jul–1 Aug 2–25 Aug 26 Aug–19 Sep	Chi-Square	$\chi^2 = 9.31$	3	0.025
		Area	C & R	RM 5.7-11.0 RM 11.1-15.0 RM 15.1-17.4	Chi-Square	$\chi^2 = 12.7$	2	0.002
		Sex	C & R	male female	Chi-Square	$\chi^2 = 1.20$	1	0.274
			M & C	male female	Chi-Square	$\chi^2 = 1.82$	1	0.177
		Size	C & R	METF length (mm)	Kolmogorov-Smirnov	D = 0.162		0.293
			M & C	METF length (mm)	Kolmogorov-Smirnov	D = 0.055		0.192
		Age	C & R	age 1.2 age 1.3 age 1.4 age 1.5	Fisher's exact test			0.174
			M & C	age 1.2 age 1.3 age 1.4 age 1.5	Chi-Square	$\chi^2 = 5.36$	3	0.148
2006	Recapture	Time	M & R	20–28 Jun 29 Jun–27 Jul 28 Jul–29 Aug	Chi-Square	$\chi^2 = 1.61$	2	0.447
		Area	M & R	RM 2.6-4.4 RM 4.5-5.3	Chi-Square	$\chi^2 = 0.79$	1	0.375
		Sex	M & R	male female	Chi-Square	$\chi^2 = 2.23$	1	0.135
			M & C	male female	Chi-Square	$\chi^2 = 1.82$	1	0.177
		Size	M & R	METF length (mm)	Kolmogorov-Smirnov	D = 0.185		0.163
			M & C	METF length (mm)	Kolmogorov-Smirnov	D = 0.055		0.192
		Age	M & R	age 1.2 age 1.3 age 1.4 age 1.5	Fisher's exact test			0.410
			M & C	age 1.2 age 1.3 age 1.4 age 1.5	Chi-Square	$\chi^2 = 5.36$	3	0.148

[a] Comparison codes: C = all fish inspected for marks during the second event, R = all marked fish captured during the second event, and M = all fish marked during the first event.

Appendix A4.–Test results for equal probability of capture assumptions, Kasilof River, 2007.

Year	Event	Effect	Comparison [a]	Strata	Test	Value	df	*P*
2007	Marking	Time	C & R	3–9 Jul 9–31 Jul 1–22 Aug 23 Aug–28 Sep	Chi-Square	$\chi^2 = 2.60$	3	0.457
		Area	C & R	RM 5.7–11.0 RM 11.1–15.0 RM 15.1–18.0	Chi-Square	$\chi^2 = 7.38$	2	0.025
		Sex	C & R	male female	Chi-Square	$\chi^2 = 0.00$	1	0.932
			M & C	male female	Chi-Square	$\chi^2 = 3.11$	1	0.078
		Size	C & R	METF length (mm)	Kolmogorov-Smirnov	D = 0.150		0.256
			M & C	METF length (mm)	Kolmogorov-Smirnov	D = 0.154		0.000
		Age	C & R	age 1.2 age 1.3 age 1.4 age 1.5	Chi-Square	$\chi^2 = 1.89$	3	0.596
			M & C	age 1.2 age 1.3 age 1.4 age 1.5	Chi-Square	$\chi^2 = 11.7$	3	0.009
2007	Recapture	Time	M & R	20–30 Jun 1 Jul–3 Aug 4–29 Aug	Chi-Square	$\chi^2 = 3.02$	2	0.220
		Area	M & R	RM 2.6–4.4 RM 4.5–5.3	Chi-Square	$\chi^2 = 0.28$	1	0.596
		Sex	M & R	male female	Chi-Square	$\chi^2 = 0.41$	1	0.520
			M & C	male female	Chi-Square	$\chi^2 = 3.11$	1	0.078
		Size	M & R	METF length (mm)	Kolmogorov-Smirnov	D = 0.131		0.412
			M & C	METF length (mm)	Kolmogorov-Smirnov	D = 0.154		0.000
		Age	M & R	age 1.2 age 1.3 age 1.4 age 1.5	Chi-Square	$\chi^2 = 0.16$	3	0.984
			M & C	age 1.2 age 1.3 age 1.4 age 1.5	Chi-Square	$\chi^2 = 11.7$	3	0.009

[a] Comparison codes: C = all fish inspected for marks during the second event, R = all marked fish captured during the second event, and M = all fish marked during the first event.

Appendix A5.–Test results for equal probability of capture assumptions, Kasilof River, 2008.

									Length strata					
									< 930 mm			≥ 930 mm		
Year	Event	Effect	Comparison [a]	Strata	Test	Value	df	*P*	Value	df	*P*	Value	df	*P*
2008	Marking	Time	C & R	24 Jul–3 Aug 4–28 Aug 29 Aug–22 Sep	Chi-Square/Fisher	$\chi^2 = 9.78$	2	0.008			0.055	$\chi^2 = 5.05$	2	0.080
		Area	C & R	RM 5.7–11.0 RM 11.1–15.0 RM 15.1–18.0	Chi-Square/Fisher	$\chi^2 = 10.17$	2	0.006			0.100	$\chi^2 = 6.83$	2	0.033
		Sex	C & R	male female	Chi-Square/Fisher	$\chi^2 = 0.069$	1	0.793			0.505	$\chi^2 = 1.38$	1	0.240
			M & C	male female	Chi-Square	$\chi^2 = 0.01$	1	0.920	$\chi^2 = 0.41$	1	0.522	$\chi^2 = 1.451$	1	0.228
		Size	C & R	METF length (mm)	Kolmogorov-Smirnov	D = 0.220		0.101	D = 0.296		0.416	D = 0.289		0.052
			M & C	METF length (mm)	Kolmogorov-Smirnov	D = 0.103		0.003	D = 0.152		0.001	D = 0.090		0.166
		Age	C & R	age 1.2 age 1.3 age 1.4 age 1.5	Fisher's exact test			0.023			0.007			1.000
			M & C	age 1.2 age 1.3 age 1.4 age 1.5	Chi-Square	$\chi^2 = 19.51$	3	0.000	$\chi^2 = 40.65$	3	0.000	$\chi^2 = 1.22$	2	0.542

-continued-

Appendix A5.–Part 2 of 2.

									Length strata					
									< 930 mm			≥ 930 mm		
Year	Event	Effect	Comparison [a]	Strata	Test	Value	df	*P*	Value	df	*P*	Value	df	*P*
2008	Recapture	Time	M & R	20 Jun–2 Jul 3–31 Jul 1–25 Aug	Chi-Square/Fisher	$\chi^2 = 4.01$	2	0.135			0.399			0.700
		Area	M & R	RM 2.6–4.4 RM 4.5–5.3	Chi-Square/Fisher	$\chi^2 = 0.00$	1	0.938			1.000	$\chi^2 = 0.12$	1	0.726
		Sex	M & R	male female	Chi-Square/Fisher	$\chi^2 = 0.05$	1	0.820			0.492	$\chi^2 = 2.62$	1	0.105
			M & C	male female	Chi-Square	$\chi^2 = 0.01$	1	0.920	$\chi^2 = 0.41$	1	0.522	$\chi^2 = 1.451$	1	0.228
		Size	M & R	METF length (mm)	Kolmogorov-Smirnov	D = 0.296		0.009	D = 0.339		0.257	D = 0.230		0.203
			M & C	METF length (mm)	Kolmogorov-Smirnov	D = 0.103		0.003	D = 0.152		0.001	D = 0.090		0.166
		Age	M & R	age 1.2 age 1.3 age 1.4 age 1.5	Fisher's exact test			0.114			0.394			0.644
			M & C	age 1.2 age 1.3 age 1.4 age 1.5	Chi-Square	$\chi^2 = 19.51$	3	0.000	$\chi^2 = 40.65$	3	0.000	$\chi^2 = 1.22$	2	0.542

[a] Comparison codes: C = all fish inspected for marks during the second event, R = all marked fish captured during the second event, and M = all fish marked during the first event.

APPENDIX B: WINBUGS CODES FOR ESTIMATING ABUNDANCE OF WILD, AGE 2.+, KASILOF RIVER CHINOOK SALMON

Appendix B1.–WinBUGS code used to generate abundance estimates for Kasilof River wild, age-.2+ Chinook salmon 2005–2007.

```
N.all : number of fish passing during event 1
N : number of late-run Kasilof River Chinook salmon mainstem spawners passing during event 1
M : number marked during event 1, some of which succumb to handling effects
q : proportion of fish in event 1 that successfully migrate and reach maturity
r :  proportion of unclipped fish in event 1 that are not CC fish
m : number of marked fish successfully migrating and maturing
C : number inspected during event 2
R : the number of marks in C
   (result of the hypergeometrical draw)
   Pr(R|N,m,C) = mchooseR * (N-m)choose(C-R) / NchooseC

model {

  N.all ~ dflat()
  q ~ dbeta(qb1,qb2)         # from Kasilof QR strat point boot.sas
  r ~ dbeta(rb1,rb2)         # from Kasilof QR strat point boot.sas

  m <- round(q * M)
  N <- N.all * r

 # discrete likelihood function not computed when undefined
  for (R in 0:C){
      choice[R+1] <-step(C-R)*step(N-m)*step(m-R)*step(N-m-C+R)*step(N-C) + 1 ;
      Lkm[R+1,1] <- 0 ;
      log(Lkm[R+1,2]) <- term1[R+1] + term2[R+1] - term3[R+1];
      term1[R+1]  <- logfact(m) - logfact(R) - logfact( (m-R)*step(m-R) ) ;
           term2[R+1] <- logfact((N-m)*step(N-m)) - logfact((C-R)*step(C-R))
                                                        - logfact((N-m-C+R)*step(N-m-C+R)) ;
           term3[R+1] <- logfact(N) - logfact(C) - logfact((N-C)*step(N-C)) ;

      Lk[R+1] <- Lkm[R+1,choice[R+1]]
      }
  Rplus1_data ~ dcat(Lk[]) ;
  }

DATA

list(Rplus1_data= 9, C= 274,  M= 877, qb1=28.2, qb2=42.3, rb1=260.7, rb2=12.1)      # 2005
list(Rplus1_data= 39, C= 910,  M= 643, qb1=87.6, qb2=69.9, rb1=177.3, rb2=10.8)    # 2006
list(Rplus1_data= 51, C= 1076,  M= 746, qb1=62.2, qb2=56.8, rb1=129.8, rb2=20.1)    # 2007

INITS

list(N.all = 21500, q=0.8, r=0.95)
list(N.all =2000, q=0.3, r=0.7)
list(N.all                    =10000,                    q=0.55,                    r=0.9)
```

Appendix B2.–WinBUGS code used to generate abundance estimates for Kasilof River wild, age-.2+ Chinook salmon, 2008.

```
N.all : number of fish passing during event 1
N : number of late-run Kasilof River Chinook salmon mainstem spawners passing during event 1
M : number marked during event 1, some of which succumb to handling effects
q : proportion of fish in event 1 that successfully migrate and reach maturity
r :  proportion of unclipped fish in event 1 that are not CC fish
m : number of marked fish successfully migrating and maturing
C : number inspected during event 2
R : the number of marks in C
    (result of the hypergeometrical draw)
    Pr(R|N,m,C) = mchooseR * (N-m)choose(C-R) / NchooseC

model {
 for (size in 1:2) {
  N.all[size] ~ dflat()
  q[size] ~ dbeta(qb1[size],qb2[size])         # from Kasilof QR strat point boot.sas
  r[size] ~ dbeta(rb1[size],rb2[size])          # from Kasilof QR strat point boot.sas
  }
  m.1 <- round(q[1] * M.1)
  N.1 <- N.all[1] * r[1]
  m.2 <- round(q[2] * M.2)
  N.2 <- N.all[2] * r[2]
  N <- N.1 + N.2
 # discrete likelihood function not computed when undefined
  for (R in 0:C.1){
      choice.1[R+1] <-step(C.1-R)*step(N.1-m.1)*step(m.1-R)*step(N.1-m.1-
                    C.1+R)*step(N.1-C.1) + 1 ;
      Lkm.1[R+1,1] <- 0 ;
      log(Lkm.1[R+1,2]) <- term1.1[R+1] + term2.1[R+1] - term3.1[R+1];
      term1.1[R+1]  <- logfact(m.1) - logfact(R) - logfact( (m.1-R)*step(m.1-R) ) ;
          term2.1[R+1] <- logfact((N.1-m.1)*step(N.1-m.1)) - logfact((C.1-R)*step(C.1-R))
                                                - logfact((N.1-m.1-C.1+R)*step(N.1-m.1-C.1+R)) ;
          term3.1[R+1] <- logfact(N.1) - logfact(C.1) - logfact((N.1-C.1)*step(N.1-C.1)) ;
      Lk.1[R+1] <- Lkm.1[R+1,choice.1[R+1]]
      }
  Rplus1_data.1 ~ dcat(Lk.1[]) ;
  for (R in 0:C.2){
      choice.2[R+1] <-step(C.2-R)*step(N.2-m.2)*step(m.2-R)*step(N.2-m.2-
                    C.2+R)*step(N.2-C.2) + 1 ;
      Lkm.2[R+1,1] <- 0 ;
      log(Lkm.2[R+1,2]) <- term1.2[R+1] + term2.2[R+1] - term3.2[R+1];
      term1.2[R+1]  <- logfact(m.2) - logfact(R) - logfact( (m.2-R)*step(m.2-R) ) ;
          term2.2[R+1] <- logfact((N.2-m.2)*step(N.2-m.2)) - logfact((C.2-R)*step(C.2-R))
                                                - logfact((N.2-m.2-C.2+R)*step(N.2-m.2-C.2+R)) ;
          term3.2[R+1] <- logfact(N.2) - logfact(C.2) - logfact((N.2-C.2)*step(N.2-C.2)) ;
      Lk.2[R+1] <- Lkm.2[R+1,choice.2[R+1]]
      }
  Rplus1_data.2 ~ dcat(Lk.2[]) ;
 }

DATA
list(Rplus1_data.1=11,   Rplus1_data.2=23,   C.1=365,   C.2=412,      M.1=278,   M.2=230,   qb1=c(41.3,26.8),
qb2=c(31.2,25.7), rb1=c(74.5,63.2), rb2=c(12.4,0.4))

INITS
list(N.all =c(10000,10000) q=c(0.6,0.6), r=c(0.9,0.9))
list(N.all =c(5000,5000) q=c(0.5,0.5), r=c(0.7,0.7))
list(N.all =c(15000,15000) q=c(0.7,0.7), r=c(0.99,0.99))
```

APPENDIX C: DRIFT GILLNETTING EFFORT AND CATCH AT KASILOF RIVER CHINOOK SALMON MARKING EVENTS, 2005–2008

Appendix C1.-Drift gillnetting effort and catch at Kasilof River Chinook salmon marking events, 20 June–31 August 2005.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
		Drift time		Wild age .2+			Age .1	Hatchery					
Date	No. drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	Sockeye salmon	Coho salmon	Pink salmon	Dolly Varden	Steelhead
20 Jun	30	148	5.0	8	0.06	0.05	0	3	34	0	0	0	0
21 Jun	36	161	4.6	5	0.04	0.04	3	4	74	0	0	0	0
22 Jun	25	186	7.6	5	0.03	0.00	0	6	11	0	0	0	0
23 Jun	15	170	11.3	6	0.04	0.01	0	5	6	0	1	0	0
24 Jun	18	203	10.9	1	0.00	0.00	0	1	38	0	0	0	0
25 Jun	25	150	6.6	3	0.03	0.02	0	2	42	0	0	0	0
26 Jun	24	267	11.1	5	0.03	0.02	0	1	64	0	0	0	0
27 Jun	32	287	9.7	3	0.01	0.00	0	1	33	0	0	0	0
28 Jun	35	191	5.8	8	0.05	0.03	0	1	74	0	1	2	0
29 Jun	31	215	6.9	3	0.02	0.01	2	0	37	0	0	0	0
30 Jun	27	213	7.9	4	0.02	0.00	0	0	7	0	0	3	0
01 Jul	26	116	4.6	5	0.04	0.02	0	0	38	0	0	1	0
02 Jul	36	174	5.0	6	0.03	0.00	0	0	32	0	0	0	0
03 Jul	27	144	5.4	6	0.04	0.02	0	0	29	0	0	0	0
04 Jul	29	139	4.7	4	0.03	0.01	0	0	35	0	0	0	0
05 Jul	31	184	5.9	6	0.03	0.00	0	0	28	0	0	0	0
06 Jul	33	195	5.9	3	0.02	0.02	0	0	17	0	0	0	0
07 Jul	24	139	5.8	4	0.03	0.01	0	0	14	0	0	1	0
08 Jul	30	169	5.8	6	0.04	0.01	0	0	10	0	1	0	0
09 Jul	20	131	6.7	7	0.05	0.02	0	0	11	0	0	0	0
10 Jul	23	213	10.0	6	0.03	0.01	0	0	10	0	0	0	0
11 Jul	36	149	4.1	8	0.06	0.00	0	1	29	0	0	0	0
12 Jul	32	145	4.7	15	0.10	0.00	0	0	18	0	0	0	0
13 Jul	28	164	6.0	9	0.05	0.01	0	0	5	0	0	0	0
14 Jul	28	202	6.9	12	0.08	0.04	0	0	5	0	0	0	0
15 Jul	27	191	7.0	10	0.05	0.01	0	0	7	0	0	0	0
16 Jul	34	172	5.9	9	0.06	0.04	0	1	46	0	0	0	0
17 Jul	24	138	5.7	11	0.08	0.03	0	0	6	0	0	0	0
18 Jul	26	189	7.9	9	0.05	0.02	0	0	10	0	0	0	0
19 Jul	33	144	4.6	12	0.08	0.01	0	0	2	0	0	0	0

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Appendix C1.–Part 2 of 3.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
	No.	Drift time (min)		Wild age .2+			Age .1	Hatchery	Sockeye	Coho	Pink	Dolly	
Date	drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	salmon	salmon	salmon	Varden	Steelhead
20 Jul	39	190	4.9	17	0.09	0.00	0	0	12	0	0	0	0
21 Jul	36	181	5.0	10	0.06	0.01	0	0	4	0	0	0	0
22 Jul	20	255	12.6	2	0.01	0.01	0	0	4	0	0	0	0
23 Jul	34	224	6.7	11	0.05	0.01	0	0	14	0	0	0	0
24 Jul	35	186	5.3	14	0.08	0.00	0	0	4	0	0	0	0
25 Jul	32	134	4.5	16	0.11	0.07	0	0	4	0	0	0	0
26 Jul	44	179	4.3	24	0.13	0.01	0	0	3	0	0	0	0
27 Jul	42	220	5.2	20	0.09	0.00	0	0	2	0	0	0	0
28 Jul	41	198	4.8	20	0.10	0.01	0	0	3	0	0	0	0
29 Jul	38	171	4.5	20	0.12	0.01	0	0	4	0	0	0	0
30 Jul	37	161	4.7	18	0.12	0.03	0	0	27	1	0	0	0
31 Jul	36	178	5.1	18	0.09	0.04	0	0	8	1	0	0	0
01 Aug	33	169	5.4	18	0.10	0.02	0	0	0	0	0	0	0
02 Aug	31	205	6.6	22	0.12	0.04	0	0	3	0	0	0	0
03 Aug	38	154	4.1	29	0.18	0.03	0	0	3	0	0	0	0
04 Aug	37	186	5.0	20	0.10	0.02	0	0	1	1	0	0	0
05 Aug	38	224	5.9	13	0.06	0.01	0	0	6	1	0	0	0
06 Aug	34	186	5.4	19	0.10	0.02	0	0	5	1	0	0	0
07 Aug	15	72	4.8	6	0.08	0.00	0	0	0	0	0	0	0
08 Aug	34	202	5.8	21	0.10	0.02	0	0	0	0	0	0	0
09 Aug	29	178	6.1	19	0.11	0.03	0	0	0	0	0	0	0
10 Aug	30	300	10.0	17	0.07	0.03	0	0	1	0	0	0	0
11 Aug	36	180	4.9	20	0.12	0.05	0	0	9	2	0	0	0
12 Aug	34	185	5.7	20	0.09	0.05	0	0	3	2	0	0	0
13 Aug	38	155	4.2	22	0.15	0.05	0	0	6	4	1	0	0
14 Aug	42	134	3.2	26	0.19	0.04	0	0	3	2	0	0	0
15 Aug	33	157	4.9	28	0.18	0.02	0	0	0	2	0	0	0
16 Aug	35	181	5.3	20	0.11	0.03	0	0	1	1	0	1	0
17 Aug	35	188	5.5	21	0.10	0.03	0	0	0	3	0	0	0
18 Aug	36	197	5.3	18	0.12	0.08	0	0	2	3	0	0	0

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Appendix C1.–Part 3 of 3.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
		Drift time (min)		Wild age .2+			Age .1	Hatchery					
Date	No. drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	Sockeye salmon	Coho salmon	Pink salmon	Dolly Varden	Steelhead
19 Aug	34	194	6.5	18	0.09	0.03	0	0	1	4	0	1	0
20 Aug	30	216	7.2	8	0.04	0.01	0	0	2	1	0	0	0
21 Aug	33	201	6.2	11	0.05	0.01	0	0	0	3	0	0	0
22 Aug	29	155	5.4	16	0.10	0.05	0	0	0	4	0	0	0
23 Aug	34	156	4.7	13	0.08	0.00	0	0	2	5	0	0	0
24 Aug	32	160	5.0	17	0.11	0.00	0	0	2	9	0	0	0
25 Aug	34	189	5.5	12	0.08	0.07	0	0	1	11	0	0	0
26 Aug	22	157	7.8	10	0.09	0.09	0	0	0	4	0	0	0
27 Aug	20	212	11.2	8	0.04	0.01	0	0	3	24	0	0	0
28 Aug	22	205	9.4	9	0.04	0.00	0	0	4	8	0	0	0
29 Aug	28	219	7.9	3	0.01	0.00	0	0	0	10	0	0	1
30 Aug	11	229	23.3	2	0.01	0.01	0	0	2	16	1	0	0
31 Aug	8	245	35.2	2	0.01	0.01	0	0	3	4	0	0	0
Sum	2,224	13,357		877	5.11		5	26	924	127	5	9	1
Mean	30	183	6.9	12	0.07		0	0	13	2	0	0	0
Median	32	184	5.7	11	0.06		0	0	5	0	0	0	0
Min	8	72	3.2	1	0.00		0	0	0	0	0	0	0
Max	44	300	35.2	29	0.19		3	6	74	24	1	3	1

[a] Units = number of fish.

Appendix C2.-Drift gillnetting effort and catch at Kasilof River Chinook salmon marking events, 20 June–29 August 2006.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
	No. of	Drift time (min)		Wild age .2+			Age .1	Hatchery	Sockeye	Coho	Pink	Dolly	
Date	drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	salmon	salmon	salmon	Varden	Steelhead
20 Jun	29	125	4.3	14	0.12	0.04	5	3	70	0	0	0	0
21 Jun	32	151	4.6	12	0.08	0.01	0	5	49	0	0	0	0
22 Jun	22	117	5.5	8	0.07	0.01	2	4	31	0	0	0	0
23 Jun	31	141	4.5	4	0.03	0.02	1	1	52	0	0	0	0
24 Jun	31	192	6.9	9	0.05	0.02	0	1	74	0	0	0	0
25 Jun	30	198	6.6	8	0.04	0.00	0	4	73	0	0	0	0
26 Jun	29	182	6.3	3	0.02	0.01	2	2	140	0	0	0	0
27 Jun	30	181	5.7	5	0.03	0.00	2	6	97	0	0	0	0
28 Jun	22	187	8.6	7	0.04	0.02	0	0	11	1	0	0	0
29 Jun	28	179	6.2	6	0.03	0.00	0	0	94	0	0	0	0
30 Jun	22	234	10.6	2	0.01	0.01	0	0	18	0	0	0	0
01 Jul	14	187	13.9	1	0.00	0.00	0	0	6	0	0	1	0
02 Jul	25	243	9.9	4	0.02	0.01	1	0	93	0	0	0	0
03 Jul	22	266	12.3	1	0.00	0.00	0	0	13	0	0	1	0
04 Jul	28	182	7.0	9	0.05	0.01	1	2	95	0	0	0	0
05 Jul	18	226	12.4	3	0.02	0.01	2	0	20	0	0	1	0
06 Jul	19	231	12.4	5	0.02	0.00	2	2	30	0	0	0	0
07 Jul	26	202	7.8	5	0.02	0.02	0	0	56	0	0	2	0
08 Jul	15	200	13.3	5	0.03	0.01	0	0	12	0	0	0	0
09 Jul	19	178	9.0	2	0.01	0.01	0	0	24	0	0	0	0
10 Jul	23	190	8.2	4	0.02	0.01	0	0	80	0	0	0	0
11 Jul	19	228	11.9	2	0.01	0.00	0	0	9	0	0	0	0
12 Jul	15	231	15.6	2	0.01	0.00	0	0	9	0	0	0	0
13 Jul	16	203	12.6	5	0.03	0.01	0	0	3	0	0	0	0
14 Jul	21	204	10.0	7	0.03	0.00	1	0	21	0	0	0	0
15 Jul	22	150	6.8	9	0.06	0.00	0	0	24	0	0	0	0
16 Jul	27	222	8.2	8	0.04	0.02	0	0	8	0	0	0	0
17 Jul	25	209	8.5	10	0.05	0.01	0	0	11	0	0	0	0
18 Jul	16	260	15.7	2	0.01	0.01	2	0	5	0	0	0	0
19 Jul	20	251	12.6	5	0.02	0.01	0	0	1	0	0	0	0

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Appendix C2.–Part 2 of 3.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
	No. of	Drift time (min)		Wild age .2+			Age .1	Hatchery	Sockeye	Coho	Pink	Dolly	
Date	drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	salmon	salmon	salmon	Varden	Steelhead
20 Jul	22	255	11.6	5	0.02	0.01	0	0	7	0	0	0	0
21 Jul	19	207	10.7	6	0.03	0.01	1	0	17	0	0	0	0
22 Jul	21	220	10.3	4	0.02	0.00	0	0	4	0	0	0	0
23 Jul	21	249	11.7	7	0.03	0.01	1	0	10	0	0	0	0
24 Jul	20	241	12.0	7	0.03	0.01	0	0	7	0	0	0	0
25 Jul	20	233	11.9	2	0.01	0.01	0	0	6	0	0	0	0
26 Jul	26	227	8.7	6	0.03	0.01	0	0	4	0	0	0	0
27 Jul	16	217	13.3	6	0.02	0.01	0	0	2	0	0	0	0
28 Jul	23	177	7.7	10	0.06	0.03	0	0	48	1	0	0	0
29 Jul	22	97	4.4	16	0.17	0.01	0	0	0	0	0	0	0
30 Jul	35	102	2.9	24	0.26	0.09	0	0	15	0	1	0	0
31 Jul	33	147	4.5	24	0.16	0.02	0	0	4	1	0	0	0
01 Aug	35	157	4.2	21	0.19	0.11	0	0	7	3	2	0	0
02 Aug	28	148	5.2	25	0.17	0.01	0	0	2	0	1	0	0
03 Aug	34	187	5.4	20	0.12	0.04	0	0	5	0	2	0	0
04 Aug	32	157	4.9	25	0.16	0.02	0	0	1	1	3	0	0
05 Aug	32	148	4.7	17	0.12	0.03	0	0	2	0	0	0	0
06 Aug	21	77	3.6	15	0.18	0.04	0	0	0	0	2	0	0
07 Aug	38	150	4.0	23	0.15	0.02	0	0	0	0	6	0	0
08 Aug	33	189	5.8	21	0.11	0.01	0	0	0	1	2	0	0
09 Aug	35	179	5.0	13	0.08	0.02	0	0	3	1	1	0	0
10 Aug	32	138	4.3	15	0.12	0.05	0	0	2	3	1	0	0
11 Aug	29	138	4.6	15	0.12	0.02	0	0	5	2	0	0	0
12 Aug	24	128	5.4	14	0.11	0.01	0	0	1	2	1	0	0
13 Aug	30	174	5.8	12	0.07	0.01	0	0	6	6	15	0	0
14 Aug	30	136	4.4	15	0.15	0.07	0	0	4	9	45	0	0
15 Aug	33	118	3.6	21	0.18	0.02	0	0	8	9	54	0	0
16 Aug	26	130	5.1	18	0.13	0.02	0	0	3	4	42	0	0
17 Aug	30	155	5.3	16	0.10	0.03	0	0	7	8	59	0	0
18 Aug	17	169	9.2	9	0.10	0.07	0	0	1	4	35	0	0

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Appendix C2.–Part 3 of 3.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
	No. of	Drift time (min)		Wild age .2+			Age .1	Hatchery	Sockeye	Coho	Pink	Dolly	
Date	drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	salmon	salmon	salmon	Varden	Steelhead
19 Aug	29	155	5.4	11	0.07	0.01	0	0	2	2	21	0	0
20 Aug	33	128	4.0	16	0.12	0.04	0	0	2	11	58	0	0
21 Aug	28	190	7.0	9	0.05	0.01	0	0	1	8	40	0	0
22 Aug	29	172	6.0	10	0.06	0.03	0	0	0	2	79	0	0
23 Aug	25	227	9.0	6	0.03	0.01	0	0	2	10	40	0	0
24 Aug	33	206	6.2	8	0.04	0.00	0	0	1	8	103	0	0
25 Aug	22	222	10.1	2	0.01	0.01	0	0	0	5	55	0	0
26 Aug	22	249	11.2	1	0.01	0.01	0	0	2	11	42	0	1
27 Aug	19	255	13.5	1	0.00	0.00	0	0	0	4	31	0	0
28 Aug	23	234	10.3	1	0.00	0.00	0	0	0	6	51	0	1
29 Aug	15	252	17.1	3	0.01	0.01	0	0	0	5	10	0	0
Sum	1,791	13,290		667	4.53		23	30	1,420	128	802	5	2
Mean	25	187	8.1	9	0.06		0	0	20	2	11	0	0
Median	25	187	7.0	8	0.04		0	0	6	0	0	0	0
Min	14	77	2.9	1	0.00		0	0	0	0	0	0	0
Max	38	266	17.1	25	0.26		5	6	140	11	103	2	1

[a] Units = number of fish.

Appendix C3.-Drift gillnetting effort and catch at Kasilof River Chinook salmon marking events, 20 June–29 August 2007.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
		Drift time (min)		Wild age .2+			Age .1	Hatchery					
Date	No. of drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	Sockeye salmon	Coho salmon	Pink salmon	Dolly Varden	Steelhead
20 Jun	26	56	2.1	15	0.27	0.03	1	14	20	0	0	0	0
21 Jun	21	84	3.8	12	0.17	0.05	1	6	16	0	0	0	0
22 Jun	23	125	5.2	9	0.08	0.01	3	6	5	0	0	0	0
23 Jun	35	128	3.7	5	0.04	0.00	2	9	44	0	0	0	0
24 Jun	32	132	4.1	7	0.06	0.03	1	12	24	0	0	0	0
25 Jun	27	169	6.3	13	0.09	0.06	0	4	8	0	0	0	0
26 Jun	33	131	3.8	13	0.11	0.03	1	7	10	0	0	0	0
27 Jun	26	138	5.3	14	0.10	0.01	0	4	17	0	0	0	0
28 Jun	27	166	6.1	8	0.06	0.03	0	2	35	0	0	0	0
29 Jun	27	191	7.3	3	0.02	0.00	2	3	2	0	0	0	0
30 Jun	28	174	6.2	4	0.03	0.03	0	5	5	0	0	0	0
01 Jul	28	178	6.5	4	0.02	0.01	1	0	47	0	0	0	0
02 Jul	22	200	8.9	0	0.00	0.00	0	0	58	0	0	0	0
03 Jul	32	201	6.3	1	0.01	0.01	0	0	28	0	0	0	0
04 Jul	23	150	6.6	1	0.01	0.01	0	0	37	0	0	0	0
05 Jul	30	211	7.1	1	0.01	0.01	0	0	5	0	0	0	0
06 Jul	24	156	6.5	6	0.04	0.03	0	1	39	0	1	0	0
07 Jul	30	166	5.5	1	0.01	0.01	0	1	79	0	0	0	0
08 Jul	35	176	5.0	3	0.02	0.00	0	0	135	0	0	0	0
09 Jul	27	230	8.6	6	0.03	0.01	0	2	15	0	0	0	0
10 Jul	27	185	6.8	9	0.05	0.02	0	2	80	0	0	0	0
11 Jul	23	144	6.4	7	0.05	0.01	0	0	18	0	0	0	0
12 Jul	37	216	5.9	1	0.01	0.01	1	0	17	0	0	0	0
13 Jul	14	154	11.4	2	0.01	0.00	1	0	6	0	0	0	0
14 Jul	29	207	7.1	3	0.01	0.01	0	0	38	0	0	0	0
15 Jul	29	156	5.3	6	0.05	0.03	1	0	28	0	0	0	0
16 Jul	30	161	5.3	9	0.06	0.00	0	0	48	0	1	1	0
17 Jul	28	169	6.2	9	0.06	0.01	0	0	13	0	0	1	0
18 Jul	29	148	5.0	8	0.06	0.01	0	0	133	0	1	0	0
19 Jul	24	149	6.3	11	0.07	0.00	1	0	46	0	0	0	0

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Appendix C3.–Part 2 of 3.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
		Drift time (min)		Wild age .2+			Age .1	Hatchery					
Date	No. of drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	Sockeye salmon	Coho salmon	Pink salmon	Dolly Varden	Steelhead
20 Jul	32	176	5.2	12	0.07	0.01	0	0	45	0	0	0	0
21 Jul	28	134	4.8	14	0.11	0.03	0	0	147	0	0	0	0
22 Jul	32	160	4.9	11	0.07	0.01	0	0	48	0	0	0	0
23 Jul	32	190	5.8	8	0.05	0.01	0	0	15	0	0	1	0
24 Jul	26	197	7.5	7	0.04	0.02	0	0	83	1	1	0	0
25 Jul	38	178	4.7	10	0.06	0.01	0	0	51	0	0	0	0
26 Jul	27	116	4.3	15	0.13	0.00	0	0	48	0	0	0	0
27 Jul	25	91	3.7	18	0.20	0.02	0	0	29	0	0	0	0
28 Jul	30	144	4.8	13	0.09	0.03	0	0	9	0	0	0	0
29 Jul	34	158	4.7	16	0.10	0.00	0	0	10	0	0	0	0
30 Jul	36	153	4.3	17	0.11	0.02	0	0	27	0	0	0	0
31 Jul	29	143	5.0	10	0.07	0.02	0	0	16	1	0	0	0
01 Aug	34	133	3.9	15	0.12	0.05	0	0	3	1	0	0	0
02 Aug	35	158	4.6	17	0.11	0.03	0	0	4	0	1	0	0
03 Aug	30	182	6.4	12	0.07	0.01	0	0	2	0	0	0	0
04 Aug	30	132	4.3	20	0.16	0.03	0	0	12	0	0	0	0
05 Aug	28	165	6.2	19	0.12	0.05	0	0	5	0	0	0	0
06 Aug	36	129	3.6	21	0.17	0.05	0	0	14	0	0	0	0
07 Aug	30	133	4.5	20	0.15	0.01	0	0	1	2	0	0	0
08 Aug	32	102	3.1	20	0.22	0.05	0	0	15	0	0	1	0
09 Aug	26	131	5.1	22	0.17	0.01	0	0	0	0	0	0	0
10 Aug	26	121	4.6	17	0.15	0.05	0	0	5	1	0	0	0
11 Aug	33	143	4.4	16	0.10	0.06	0	0	24	1	0	0	0
12 Aug	37	132	3.5	22	0.19	0.10	0	0	5	3	0	0	0
13 Aug	37	129	3.6	23	0.18	0.08	0	0	2	5	1	0	0
14 Aug	28	139	4.8	14	0.14	0.09	0	0	1	1	0	1	0
15 Aug	38	127	3.4	18	0.16	0.05	0	0	4	6	0	0	0
16 Aug	32	145	4.5	18	0.13	0.03	0	0	6	4	0	0	0
17 Aug	38	118	3.1	26	0.23	0.04	0	0	1	1	0	0	0
18 Aug	39	150	3.8	19	0.13	0.04	0	0	4	2	0	0	0

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Appendix C3.–Part 3 of 3.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
	No. of	Drift time (min)		Wild age .2+			Age .1	Hatchery	Sockeye	Coho	Pink	Dolly	
Date	drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	salmon	salmon	salmon	Varden	Steelhead
19 Aug	42	126	3.0	23	0.18	0.04	0	0	2	4	0	0	0
20 Aug	45	160	3.5	19	0.14	0.08	0	0	1	2	0	0	0
21 Aug	40	155	3.8	14	0.09	0.01	0	0	1	3	0	0	0
22 Aug	22	198	8.8	4	0.03	0.03	0	0	1	4	0	0	0
23 Aug	20	203	10.2	5	0.03	0.02	1	0	1	1	0	0	0
24 Aug	20	211	13.4	2	0.01	0.00	0	0	1	5	0	0	0
25 Aug	16	248	15.5	0	0.00	0.00	0	0	1	3	0	0	0
26 Aug	18	190	10.5	4	0.02	0.00	0	0	0	0	0	0	0
27 Aug	16	203	12.7	0	0.00	0.00	0	0	0	2	0	0	0
28 Aug	18	225	13.4	3	0.01	0.01	0	0	0	1	0	0	0
29 Aug	20	215	10.7	3	0.02	0.01	0	0	0	2	0	0	0
Sum	2,061	11,294		758	5.84		17	78	1,700	56	6	5	0
Mean	29	159	6.0	11	0.08		0	1	24	1	0	0	0
Median	29	156	5.2	10	0.07		0	0	13	0	0	0	0
Min	14	56	2.1	0	0.00		0	0	0	0	0	0	0
Max	45	248	15.5	26	0.27		3	14	147	6	1	1	0

[a] Units = number of fish.

Appendix C4.-Drift gillnetting effort and catch at Kasilof River Chinook salmon marking events, June 20 to August 25, 2008.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
	No. of	Drift time (min)		Wild age .2+			Age .1	Hatchery	Sockeye	Coho	Pink	Dolly	
Date	drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	salmon	salmon	salmon	Varden	Steelhead
20 Jun	24	118	5.3	10	0.09	0.06	1	5	45	0	0	0	0
21 Jun	21	111	5.3	9	0.08	0.01	0	3	64	0	0	0	0
22 Jun	26	147	5.6	8	0.05	0.00	0	2	64	0	0	0	1
23 Jun	31	141	4.6	6	0.05	0.02	0	7	77	0	0	0	0
24 Jun	20	129	6.4	2	0.02	0.02	1	5	59	0	0	0	0
25 Jun	9	52	5.6	1	0.03	0.03	0	3	19	0	0	0	0
26 Jun	22	166	7.5	1	0.01	0.01	0	1	88	0	0	0	0
27 Jun	21	157	7.6	2	0.01	0.01	0	2	39	0	0	0	0
28 Jun	30	187	6.2	3	0.01	0.01	1	3	51	0	0	0	0
29 Jun	35	187	5.3	4	0.02	0.01	1	2	35	0	0	1	0
30 Jun	30	193	6.3	5	0.03	0.00	0	1	68	0	0	0	0
01 Jul	30	192	6.4	6	0.03	0.01	1	0	32	0	0	0	0
02 Jul	26	198	7.6	1	0.01	0.01	1	0	26	0	0	0	0
03 Jul	32	174	5.5	4	0.02	0.00	0	0	7	0	0	0	0
04 Jul	27	204	8.2	5	0.02	0.02	0	0	3	0	0	0	0
05 Jul	25	210	8.4	2	0.01	0.01	0	1	11	0	0	0	0
06 Jul	36	209	5.9	4	0.02	0.01	0	0	20	0	0	1	0
07 Jul	30	183	6.1	3	0.02	0.01	0	0	132	0	0	0	0
08 Jul	22	193	8.7	3	0.02	0.00	0	0	50	0	0	0	0
09 Jul	31	198	6.2	2	0.02	0.02	0	0	18	0	0	0	0
10 Jul	27	224	8.2	4	0.02	0.01	0	0	18	0	0	0	0
11 Jul	28	196	6.9	3	0.02	0.01	1	0	60	0	0	0	0
12 Jul	15	249	16.8	3	0.01	0.00	0	0	10	0	0	2	0
13 Jul	34	199	5.9	8	0.04	0.01	0	0	9	0	0	0	0
14 Jul	34	196	5.5	1	0.00	0.00	2	0	78	0	0	1	0
15 Jul	19	207	12.0	4	0.02	0.00	2	0	76	0	0	0	0
16 Jul	25	165	6.7	6	0.03	0.03	1	0	106	0	0	0	0
17 Jul	25	191	7.6	2	0.01	0.00	1	0	63	0	0	0	0
18 Jul	21	180	10.0	7	0.04	0.01	2	0	50	0	0	0	0
19 Jul	30	168	5.6	6	0.04	0.01	1	0	164	0	0	0	0

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Appendix C4.–Part 2 of 3.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
		Drift time (min)		Wild age .2+			Age .1	Hatchery					
Date	No. of drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	Sockeye salmon	Coho salmon	Pink salmon	Dolly Varden	Steelhead
20 Jul	25	177	7.8	11	0.06	0.02	0	0	18	0	0	0	0
21 Jul	21	190	9.1	7	0.04	0.00	0	0	39	0	0	0	0
22 Jul	24	194	8.2	9	0.05	0.02	0	0	13	0	0	0	0
23 Jul	25	211	8.4	8	0.05	0.03	0	0	18	0	0	0	0
24 Jul	17	210	12.4	2	0.01	0.00	1	0	7	0	0	0	0
25 Jul	22	223	10.1	6	0.03	0.01	0	0	52	0	0	0	0
26 Jul	26	174	6.6	10	0.06	0.00	0	0	56	1	0	0	0
27 Jul	36	169	4.7	14	0.09	0.03	1	0	89	0	0	0	0
28 Jul	28	195	7.0	11	0.06	0.00	4	0	7	0	1	0	0
29 Jul	20	185	9.6	10	0.05	0.00	0	0	6	0	2	0	0
30 Jul	25	203	8.2	6	0.03	0.01	0	0	2	0	1	0	0
31 Jul	24	198	8.2	3	0.02	0.01	0	0	2	0	0	0	0
01 Aug	23	210	9.0	6	0.03	0.01	0	0	2	0	4	0	0
02 Aug	29	223	7.8	9	0.04	0.00	0	0	4	1	2	0	0
03 Aug	30	196	6.5	11	0.06	0.00	0	0	3	1	8	0	0
04 Aug	29	184	6.3	9	0.05	0.02	0	0	6	0	14	0	0
05 Aug	21	177	8.6	10	0.06	0.02	0	0	3	1	17	0	0
06 Aug	26	128	4.5	14	0.18	0.13	0	0	3	1	57	0	0
07 Aug	34	118	3.4	18	0.15	0.02	0	0	0	1	69	0	0
08 Aug	30	91	2.9	28	0.40	0.22	0	0	15	4	34	0	0
09 Aug	33	71	2.1	30	0.47	0.10	0	0	3	10	77	0	0
10 Aug	32	92	2.9	34	0.37	0.00	0	0	9	8	79	0	0
11 Aug	31	104	3.3	24	0.23	0.00	0	0	4	9	80	0	0
12 Aug	22	96	4.3	13	0.15	0.05	0	0	1	2	172	0	0
13 Aug	29	90	3.2	21	0.24	0.11	0	0	0	2	122	0	0
14 Aug	28	116	4.0	14	0.18	0.13	0	0	2	6	136	0	0
15 Aug	29	132	4.9	11	0.08	0.02	0	0	2	3	110	0	0
16 Aug	18	70	3.8	6	0.09	0.00	0	0	0	2	44	0	0
17 Aug	24	184	7.6	8	0.04	0.00	0	0	1	4	58	0	0
18 Aug	25	165	6.5	6	0.04	0.01	0	0	1	4	112	0	0

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Appendix C4.–Part 3 of 3.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
	No. of	Drift time (min)		Wild age .2+			Age .1	Hatchery	Sockeye	Coho	Pink	Dolly	
Date	drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	salmon	salmon	salmon	Varden	Steelhead
19 Aug	26	168	6.5	4	0.02	0.01	0	0	0	3	99	0	1
20 Aug	21	202	9.3	2	0.02	0.02	0	0	0	6	54	0	1
21 Aug	16	243	15.2	4	0.02	0.00	0	0	0	5	1	0	0
22 Aug	18	222	12.4	3	0.01	0.00	0	0	1	8	18	0	0
23 Aug	20	247	12.3	0	0.00	0.00	0	0	0	8	23	0	0
24 Aug	12	275	22.9	0	0.00	0.00	0	0	1	6	8	0	0
25 Aug	10	245	24.8	1	0.01	0.01	0	0	0	5	3	0	0
Sum	1,695	11,702		508	4.22		22	35	1,912	101	1,405	5	3
Mean	25	175	7.6	8	0.06		0	1	29	2	21	0	0
Median	25	187	6.6	6	0.03		0	0	11	0	0	0	0
Min	9	52	2.1	0	0.00		0	0	0	0	0	0	0
Max	36	275	24.8	34	0.47		4	7	164	10	172	2	1

[a] Units = number of fish.

APPENDIX D: DRIFT GILLNETTING EFFORT AND CATCH AT KASILOF RIVER CHINOOK SALMON RECAPTURE EVENTS, 2005–2008

Appendix D1.–Drift gillnetting effort and catch at Kasilof River Chinook salmon recapture events, August and September 2005.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
	No. of	Drift time (min)		Wild age .2+			Age .1	Hatchery	Sockeye	Coho	Pink	Dolly	
Date	drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	salmon	salmon	salmon	Varden	Steelhead
24 Aug	23	104	4.5	22	0.21	0.11	0	0	5	0	0	0	0
25 Aug	28	97	2.9	25	0.45	0.28	0	0	29	1	0	1	0
01 Sep	17	43	2.6	21	0.48	0.18	0	0	0	0	0	0	1
02 Sep	26	110	4.6	35	0.27	0.08	0	0	13	1	0	0	0
06 Sep	14	60	3.9	25	0.49	0.13	0	0	3	0	0	0	0
07 Sep	25	66	3.1	40	0.61	0.06	0	0	11	1	0	0	0
08 Sep	20	58	2.9	30	0.66	0.42	0	0	8	0	0	1	0
09 Sep	28	96	3.4	15	0.15	0.01	0	0	0	13	0	0	1
13 Sep	33	118	3.5	14	0.14	0.12	0	0	13	3	0	0	0
14 Sep	32	121	8.0	15	0.07	0.07	0	0	0	5	0	0	0
15 Sep	17	94	5.5	18	0.19	0.01	0	0	1	1	0	0	0
16 Sep	17	93	5.5	14	0.15	0.05	0	0	11	6	0	1	0
Sum	280	1,060		274	3.88		0	0	94	31	0	3	2
Mean	23	88	4.2	23	0.32		0	0	8	3	0	0	0
Min	14	43	2.6	14	0.07		0	0	0	0	0	0	0
Max	33	121	8.0	40	0.66		0	0	29	13	0	1	1

[a] Units = number of fish.

Appendix D2.–Drift gillnetting effort and catch at Kasilof River Chinook salmon recapture events, July, August, and September 2006.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
		Drift time (min)		Wild age .2+			Age .1	Hatchery					
Date	No. of drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	Sockeye salmon	Coho salmon	Pink salmon	Dolly Varden	Steelhead
05 Jul	40	99	2.5	16	0.16	0.03	0	6	24	0	0	0	0
06 Jul	20	140	6.8	7	0.04	0.02	0	0	28	0	0	0	0
08 Jul	50	134	2.7	13	0.10	0.01	1	4	17	0	0	0	0
11 Jul	27	176	6.5	11	0.07	0.02	2	0	14	0	0	0	0
13 Jul	29	207	7.2	9	0.05	0.01	1	0	7	0	2	0	0
15 Jul	46	126	2.8	14	0.12	0.05	0	1	7	0	0	0	0
18 Jul	31	181	6.0	25	0.14	0.07	0	0	3	0	0	0	0
20 Jul	37	164	4.4	15	0.09	0.01	0	0	0	0	2	0	0
22 Jul	45	129	2.8	16	0.15	0.08	0	0	2	0	0	0	0
25 Jul	36	134	3.7	21	0.16	0.00	0	0	12	1	0	0	0
27 Jul	20	188	9.4	14	0.09	0.05	1	0	5	0	0	0	0
29 Jul	39	85	2.5	19	0.21	0.13	0	0	23	2	0	0	0
01 Aug	37	72	1.9	29	0.41	0.18	2	0	4	1	0	0	0
03 Aug	32	129	4.5	23	0.22	0.11	2	0	1	1	0	0	0
05 Aug	36	66	1.8	33	0.51	0.05	0	0	0	0	10	0	0
09 Aug	28	60	2.1	36	0.63	0.09	0	0	5	0	1	0	0
10 Aug	36	112	3.0	33	0.32	0.08	0	0	1	1	3	0	0
12 Aug	23	45	2.1	27	0.59	0.08	0	0	0	1	7	0	0
16 Aug	38	100	2.8	37	0.38	0.11	0	0	0	3	17	0	0
17 Aug	40	76	1.9	37	0.51	0.11	0	0	0	6	13	0	0
19 Aug	34	123	3.6	19	0.17	0.03	0	0	3	4	7	0	0
22 Aug	29	69	2.3	22	0.32	0.00	0	0	1	5	38	0	0
24 Aug	47	88	1.9	32	0.37	0.06	0	0	0	1	27	0	0
27 Aug	39	90	2.3	37	0.41	0.04	0	0	17	1	0	0	0
30 Aug	28	147	5.2	14	0.10	0.01	0	0	0	0	108	0	1
31 Aug	43	95	2.2	34	0.36	0.07	0	0	19	1	42	1	0
02 Sep	37	93	2.5	37	0.40	0.03	0	0	26	3	3	0	0
05 Sep	30	53	1.7	42	0.89	0.33	0	0	8	0	11	0	1
06 Sep	29	53	1.8	57	1.02	0.15	0	0	0	0	12	2	0
08 Sep	31	71	2.3	51	0.72	0.03	0	0	11	0	7	0	1

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Appendix D2.–Part 2 of 2.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
	No. of	Drift time (min)		Wild age .2+			Age .1	Hatchery	Sockeye	Coho	Pink	Dolly	
Date	drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	salmon	salmon	salmon	Varden	Steelhead
11 Sep	38	104	2.7	42	0.52	0.36	0	0	38	2	5	0	0
13 Sep	32	105	3.5	39	0.36	0.05	0	0	1	3	11	1	0
15 Sep	32	131	4.1	31	0.24	0.06	0	0	6	4	0	1	0
19 Sep	29	135	4.7	18	0.13	0.03	0	0	1	4	0	2	0
Sum	1,168	3,780		910	10.93		9	11	284	44	326	7	3
Mean	34	111	3.5	27	0.32		0	0	8	1	10	0	0
Min	20	45	1.7	7	0.04		0	0	0	0	0	0	0
Max	50	207	9.4	57	1.02		2	6	38	6	108	2	1

[a] Units = number of fish.

Appendix D3.–Drift gillnetting effort and catch at Kasilof River Chinook salmon recapture events, July, August, and September 2007.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
		Drift time (min)		Wild age .2+			Age .1	Hatchery					
Date	No. of drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	Sockeye salmon	Coho salmon	Pink salmon	Dolly Varden	Steelhead
03 Jul	29	64	2.1	19	0.37	0.17	1	7	6	0	0	0	0
05 Jul	33	137	4.3	15	0.11	0.01	1	8	5	0	0	0	0
07 Jul	35	112	3.2	25	0.23	0.10	0	10	22	0	0	0	0
10 Jul	31	151	4.9	8	0.05	0.01	0	2	14	0	0	0	0
12 Jul	44	111	2.7	17	0.15	0.01	1	4	4	0	0	0	0
14 Jul	37	104	2.8	16	0.16	0.12	1	5	26	0	0	2	0
17 Jul	34	122	3.6	19	0.16	0.01	1	0	0	0	0	0	0
19 Jul	38	95	2.6	22	0.23	0.02	0	0	7	0	0	0	0
22 Jul	32	92	2.9	30	0.33	0.05	0	0	14	0	0	2	0
24 Jul	30	108	3.6	26	0.26	0.09	1	0	8	0	0	0	0
26 Jul	32	123	3.8	24	0.20	0.01	0	0	13	0	0	0	0
28 Jul	41	104	2.5	30	0.29	0.13	1	0	0	0	0	0	0
01 Aug	18	54	2.8	16	0.50	0.30	1	0	3	1	0	0	0
02 Aug	35	98	2.8	38	0.39	0.02	0	0	1	0	0	2	0
04 Aug	34	100	2.9	35	0.35	0.00	1	0	0	0	0	0	0
07 Aug	32	63	2.0	41	0.67	0.13	1	0	0	0	0	0	0
09 Aug	40	145	3.7	26	0.18	0.01	0	0	5	0	0	0	0
11 Aug	36	100	2.8	31	0.31	0.01	0	0	6	2	0	0	0
14 Aug	43	93	2.1	39	0.45	0.14	0	0	5	2	0	0	0
16 Aug	36	90	2.4	36	0.46	0.21	0	0	0	0	0	0	0
18 Aug	35	70	2.0	43	0.62	0.06	0	0	2	5	0	0	0
21 Aug	44	92	2.1	40	0.44	0.02	0	0	0	6	0	0	0
23 Aug	42	90	2.2	42	0.47	0.04	0	0	9	1	0	0	0
25 Aug	42	94	2.3	24	0.26	0.05	0	0	0	5	0	0	0
27 Aug	40	90	2.2	40	0.50	0.19	0	0	7	1	0	0	0
29 Aug	46	102	2.2	30	0.30	0.09	0	0	0	14	0	0	0
31 Aug	31	63	1.9	23	0.46	0.19	0	0	4	16	0	1	2
04 Sep	35	83	2.3	38	0.52	0.24	0	0	12	0	0	0	1
05 Sep	33	121	3.9	23	0.22	0.14	0	0	1	9	0	0	4
07 Sep	42	100	2.4	40	0.38	0.05	0	0	30	0	0	0	5

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Appendix D3.–Part 2 of 2.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
	No. of	Drift time (min)		Wild age .2+			Age .1	Hatchery	Sockeye	Coho	Pink	Dolly	
Date	drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	salmon	salmon	salmon	Varden	Steelhead
11 Sep	34	87	2.6	43	0.50	0.15	1	0	58	0	0	2	0
12 Sep	38	102	2.7	27	0.27	0.05	0	0	26	1	0	0	1
14 Sep	38	116	3.1	33	0.30	0.11	0	0	42	5	0	0	0
17 Sep	37	136	3.7	25	0.19	0.04	0	0	16	3	0	2	2
19 Sep	35	152	4.4	29	0.19	0.02	0	0	35	0	0	2	0
20 Sep	25	136	5.3	24	0.18	0.00	0	0	14	0	0	2	1
24 Sep	30	142	4.9	20	0.19	0.12	0	0	20	3	0	0	4
26 Sep	24	159	6.8	12	0.08	0.04	0	0	19	2	0	0	2
28 Sep	22	168	8.6	7	0.05	0.04	0	0	11	1	0	1	2
Sum	1,363	4,169		1,076	11.94		11	36	445	77	0	16	24
Mean	35	107	3.2	28	0.31		0	1	11	2	0	0	1
Min	18	54	1.9	7	0.05		0	0	0	0	0	0	0
Max	46	168	8.6	43	0.67		1	10	58	16	0	2	5

[a] Units = number of fish.

Appendix D4.–Drift gillnetting effort and catch at Kasilof River Chinook salmon recapture events, July, August, and September, 2008.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
	No. of	Drift time (min)		Wild age .2+			Age .1	Hatchery	Sockeye	Coho	Pink	Dolly	
Date	drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	salmon	salmon	salmon	Varden	Steelhead
08 Jul	36	104	2.9	20	0.21	0.08	2	23	15	0	0	1	0
10 Jul	31	94	3.0	38	0.45	0.17	1	5	21	0	0	0	0
12 Jul	44	133	3.0	17	0.13	0.02	2	15	35	0	0	1	0
15 Jul	22	99	4.6	9	0.08	0.02	0	1	13	0	0	0	0
17 Jul	33	115	3.5	18	0.16	0.00	0	5	11	0	0	0	0
19 Jul	34	115	3.4	14	0.13	0.03	0	0	11	0	0	1	0
22 Jul	30	115	3.9	22	0.19	0.02	0	0	1	0	0	0	0
24 Jul	41	105	2.5	26	0.29	0.12	1	1	1	0	0	1	0
26 Jul	36	103	2.9	22	0.22	0.01	2	1	2	0	0	0	0
29 Jul	38	98	2.5	35	0.42	0.20	0	1	8	1	2	0	0
31 Jul	40	88	2.2	28	0.33	0.04	0	0	1	0	2	0	0
02 Aug	26	115	4.4	21	0.18	0.01	0	0	2	0	15	1	0
05 Aug	41	82	2.0	36	0.45	0.06	0	0	1	0	3	0	0
07 Aug	34	142	4.1	26	0.23	0.14	0	0	4	0	3	0	0
09 Aug	35	83	2.5	43	0.55	0.14	0	0	7	0	22	0	0
12 Aug	36	68	1.9	39	0.58	0.06	0	0	1	7	24	0	0
14 Aug	41	107	2.6	36	0.34	0.05	0	0	4	3	3	0	1
16 Aug	33	74	2.3	34	0.47	0.06	0	0	1	6	8	0	0
19 Aug	39	115	3.0	31	0.27	0.01	0	0	7	8	6	0	0
21 Aug	43	86	2.0	39	0.46	0.19	0	0	0	8	47	0	0
23 Aug	35	73	2.1	33	0.48	0.09	0	0	5	3	10	0	0
25 Aug	39	90	2.3	37	0.42	0.09	2	0	14	0	5	0	0
27 Aug	42	95	2.4	33	0.33	0.15	0	0	0	3	110	0	0
29 Aug	35	105	3.1	43	0.42	0.10	0	0	39	3	0	1	0
02 Sep	30	93	3.1	32	0.35	0.03	1	0	6	1	3	1	0
03 Sep	35	115	3.3	11	0.09	0.05	0	0	0	5	90	0	1
05 Sep	32	121	3.8	35	0.29	0.02	1	0	14	0	2	2	1
08 Sep	32	123	3.8	30	0.28	0.10	0	0	31	2	7	2	1
10 Sep	36	119	3.3	25	0.20	0.04	0	0	8	1	40	0	0
12 Sep	29	132	4.8	27	0.21	0.02	0	0	30	0	0	2	0

-continued-

Appendix D4.–Part 2 of 2.

	Drift gillnet			Chinook salmon					Catch (no. of fish)				
		Drift time (min)		Wild age .2+			Age .1	Hatchery					
Date	No. of drifts	Sum	Mean	Catch[a]	CPUE	SE	Catch[a]	Catch[a]	Sockeye salmon	Coho salmon	Pink salmon	Dolly Varden	Steelhead
15 Sep	28	158	6.0	26	0.17	0.05	0	0	7	0	0	2	0
17 Sep	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
19 Sep	26	156	6.2	21	0.13	0.01	0	0	20	4	0	1	0
22 Sep	23	192	8.5	8	0.04	0.01	0	0	2	6	0	1	2
08 Jul–22 Sep (full recapture event)													
Sum	1,135	3,613		915	9.52		12	52	322	61	402	17	6
Mean	34	109	3.4	28	0.29		0	2	10	2	12	1	0
Min	22	68	1.9	8	0.04		0	0	0	0	0	0	0
Max	44	192	8.5	43	0.58		2	23	39	8	110	2	2
24 Jul–22 Sep (truncated recapture event)													
Sum	905	2,838		777	8.18		7	3	215	61	402	14	6
Mean	36	101	2.9	31	0.34		0	0	8	2	17	0	0
Min	26	68	1.9	11	0.09		0	0	0	0	0	0	0
Max	43	142	4.8	43	0.58		2	1	39	8	110	2	1

[a] Units = number of fish.

APPENDIX E: AGE, SEX, AND LENGTH COMPOSITION OF LATE-RUN KASILOF RIVER CHINOOK SALMON, 2005–2008

Appendix E1.-Age, sex, and length composition for late-run Kasilof River Chinook salmon by sampling event, 2005.

	Age				
	1.2	1.3	1.4	1.5	Total
Marking event, 1 Jul–31 Aug					
Female					
Sample size[a]	12	85	303	3	403
% (SE)	1.7% (0.5%)	11.9% (1.2%)	42.3% (1.8%)	0.4% (0.2%)	56.3% (1.9%)
Mean METF (SE)	685 (19)	870 (5)	974 (3)	1,025 (16)	944 (4)
METF range	625–840	710–950	710–1,120	1,000–1,055	625–1,120
Male					
Sample size[a]	44	91	174	4	313
% (SE)	6.1% (0.9%)	12.7% (1.2%)	24.3% (1.6%)	0.6% (0.3%)	43.7% (1.9%)
Mean METF (SE)	657 (7)	832 (6)	1,024 (6)	106,808 (28)	917 (9)
METF range	535–755	725–985	800–1,195	1,000–1,135	535–1,195
Male & Female					
Sample size[a]	56	176	477	7	716
% (SE)	7.8% (1.0%)	24.6% (1.6%)	66.6% (1.8%)	1.0% (0.4%)	100.0% (0.0%)
Mean METF (SE)	663 (7)	850 (4)	992 (3)	1,050 (18)	932 (4)
METF range	535–840	710–985	710–1,195	1,000–1,135	535–1,195
Sport harvest, 1–31 Jul					
Female					
Sample size[a]	14	124	103		241
% (SE)	2.9% (0.8%)	25.6% (2.0%)	21.3% (1.9%)		49.8% (2.3%)
Harvest estimate[a] (SE)	30 (9)	270 (42)	224 (36)		524 (76)
Mean METF (SE)	695 (13)	868 (6)	962 (6)		898 (6)
METF range	621–789	689–1,004	610–1,112		610–1,112
Male					
Sample size[a]	97	84	62		243
% (SE)	20.0% (1.8%)	17.4% (1.7%)	12.8% (1.5%)		50.2% (2.3%)
Harvest estimate[a] (SE)	211 (35)	183 (31)	135 (24)		528 (76)
Mean METF (SE)	651 (6)	851 (8)	1,011 (8)		812 (10)
METF range	510–800	670–1,018	831–1,175		510–1,175
Male & Female					
Sample size[a]	111	208	165		484
% (SE)	22.9% (1.9%)	43.0% (2.3%)	34.1% (2.2%)		100.0% (0.0%)
Harvest estimate[a] (SE)	241 (39)	452 (66)	359 (54)		1,052 (144)
Mean METF (SE)	657 (6)	861 (5)	980 (5)		855 (6)
METF range	510–800	670–1,018	610–1,175		510–1,175

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Appendix E1.–Part 2 of 2.

	Age				Total
	1.2	1.3	1.4	1.5	
Recapture event, 24 Aug–16 Sep					
Female					
Sample size[a]		13	109	2	124
% (SE)		5.3% (1.4%)	44.9% (3.2%)	0.8% (0.6%)	51.0% (3.2%)
Mean METF (SE)		892 (12)	992 (5)	1,023 (23)	982 (6)
METF range		820–945	880–1,110	1,000–1,045	820–1,110
Male					
Sample size[a]	10	37	71	1	119
% (SE)	4.1% (1.3%)	15.2% (2.3%)	29.2% (2.9%)	0.4% (0.4%)	49.0% (3.2%)
Mean METF (SE)	620 (17)	858 (10)	1,045 (8)	1,115 (0)	951 (14)
METF range	530–685	720–960	865–1,230	1,115–1,115	530–1,230
Male & Female					
Sample size[a]	10	50	180	3	243
% (SE)	4.1% (1.3%)	20.6% (2.6%)	74.1% (2.8%)	1.2% (0.7%)	100.0% (0.0%)
Mean METF (SE)	620 (17)	867 (8)	1,013 (5)	1,053 (34)	967 (7)
METF range	530–685	720–960	865–1,230	1,000–1,115	530–1,230

[a] Units = number of fish.

Appendix E2.-Age, sex, and length composition for late-run Kasilof River Chinook salmon by sampling event, 2006.

	Age				
	1.2	1.3	1.4	1.5	Total
Marking event, 1 Jul–29 Aug [a]					
Female					
Marked (no. of fish)	14	38	190	9	251
% marked fish (SE)	2.7% (0.7%)	7.4% (1.2%)	36.8% (2.1%)	1.7% (0.6%)	48.6% (2.2%)
Mean METF (SE)	672 (12)	846 (10)	948 (4)	1,036 (14)	920 (6)
METF range	560–740	700–945	820–1,115	970–1,110	560–1,115
Male					
Marked (no. of fish)	54	90	117	4	265
% marked fish (SE)	10.5% (1.3%)	17.4% (1.7%)	22.7% (1.8%)	0.8% (0.4%)	51.4% (2.2%)
Mean METF (SE)	670 (8)	814 (6)	1,003 (7)	1,125 (48)	873 (9)
METF range	530–785	685–975	785–1,170	1,005–1,205	530–1,205
Male & Female					
Marked (no. of fish)	68	128	307	13	516
% marked fish (SE)	13.2% (1.5%)	24.8% (1.9%)	59.5% (2.2%)	2.5% (0.7%)	100.0% (0.0%)
Mean METF (SE)	670 (7)	823 (6)	969 (4)	1,064 (20)	896 (6)
METL range	530–785	685–975	785–1,170	970–1,205	530–1,205
Recapture event, 5 Jul–19 Sep					
Female					
Captured (no. of fish)	12	102	205	14	333
% captured fish (SE)	1.6% (0.5%)	13.8% (1.3%)	27.8% (1.6%)	1.9% (0.5%)	45.1% (1.8%)
Mean METF (SE)	660 (15)	856 (5)	955 (4)	1,022 (11)	917 (5)
METF range	580–750	750–970	780–1,090	970–1,110	580–1,110
Male					
Captured (no. of fish)	94	141	161	9	405
% captured fish (SE)	12.7% (1.2%)	19.1% (1.4%)	21.8% (1.5%)	1.2% (0.4%)	54.9% (1.8%)
Mean METF (SE)	679 (5)	819 (5)	1,016 (7)	1,121 (20)	872 (8)
METF range	555–785	650–930	770–1,205	1,030–1,230	555–1,230
Male & Female					
Captured (no. of fish)	106	243	366	23	738
% captured fish (SE)	14.4% (1.3%)	32.9% (1.7%)	49.6% (1.8%)	3.1% (0.6%)	100.0% (0.0%)
Mean METF (SE)	677 (5)	834 (4)	982 (4)	1,061 (14)	892 (5)
METF range	555–785	650–970	770–1,205	970–1,230	555–1,230

[a] Marking event data prior to July 1 were not used in order to remove Crooked Creek-bound Chinook salmon from analyses.

Appendix E3.-Age, sex, and length composition for late-run Kasilof River Chinook salmon by sampling event, 2007.

	Age				
	1.2	1.3	1.4	1.5	Total
Marking event, 1 Jul–29 Aug [a]					
Female					
Marked (no. of fish)	16	77	210	4	307
% marked fish (SE)	2.7% (0.7%)	12.8% (1.4%)	34.8% (1.9%)	0.7% (0.3%)	50.9% (2.0%)
Mean METF (SE)	693 (10)	870 (5)	950 (3)	1,019 (10)	918 (5)
METF range	635–770	710–970	795–1,085	995–1,040	635–1,085
Male					
Marked (no. of fish)	83	93	113	7	296
% marked fish (SE)	13.8% (1.4%)	15.4% (1.5%)	18.7% (1.6%)	1.2% (0.4%)	49.1% (2.0%)
Mean METF (SE)	689 (5)	831 (7)	1,003 (7)	1,054 (14)	862 (8)
METF range	545–790	690–975	800–1,155	1,005–1,110	545–1,155
Male & Female					
Marked (no. of fish)	99	170	323	11	603
% marked fish (SE)	16.4% (1.5%)	28.2% (1.8%)	53.6% (2.0%)	1.8% (0.5%)	100.0% (0.0%)
Mean METF (SE)	690 (5)	849 (5)	969 (4)	1,041 (11)	890 (5)
METF range	545–790	690–975	795–1,155	995–1,110	545–1,155
Recapture event, 3 Jul–28 Sep					
Female					
Captured (no. of fish)	11	104	328	6	449
% captured fish (SE)	1.2% (0.3%)	11.0% (1.0%)	34.6% (1.5%)	0.6% (0.3%)	47.4% (1.6%)
Mean METF (SE)	683 (16)	879 (4)	977 (3)	1,027 (10)	948 (4)
METF range	600–770	740–975	790–1,090	985–1,055	600–1,090
Male					
Captured (no. of fish)	154	133	209	3	499
% captured fish (SE)	16.2% (1.2%)	14.0% (1.1%)	22.0% (1.3%)	0.3% (0.2%)	52.6% (1.6%)
Mean METF (SE)	701 (4)	843 (5)	1,014 (5)	1,107 (43)	872 (7)
METF range	570–790	705–965	770–1,180	1,045–1,190	570–1,190
Male & Female					
Captured (no. of fish)	165	237	537	9	948
% captured fish (SE)	17.4% (1.2%)	25.0% (1.4%)	56.6% (1.6%)	0.9% (0.3%)	100.0% (0.0%)
Mean METF (SE)	699 (4)	859 (4)	991 (3)	1,053 (19)	908 (4)
METF range	570–790	705–975	770–1,180	985–1,190	570–1,190

[a] Marking event data prior to July 1 were not used in order to remove Crooked Creek-bound Chinook salmon from analyses.

Appendix E4.-Age, sex, and length composition for late-run Kasilof River Chinook salmon by length strata, 2008.

	Age				
	1.2	1.3	1.4	1.5	Total
<u>METF length <930 mm</u>					
Female					
Marked (no. of fish)	7	98	34		139
% marked fish (SE)	2.1% (0.8%)	30.0% (2.5%)	10.4% (1.7%)		42.5% (2.7%)
Inriver return estimate[a] (SE)	130 (73)	1,813 (842)	629 (302)		2,572 (1,187)
Male					
Marked (no. of fish)	43	136	9		188
% marked fish (SE)	13.1% (1.9%)	41.6% (2.7%)	2.8% (0.9%)		57.5% (2.7%)
Inriver return estimate[a] (SE)	796 (378)	2,516 (1,162)	167 (91)		3,479 (1,600)
Male & Female					
Marked (no. of fish)	50	234	43		327
% marked fish (SE)	15.3% (2.0%)	71.6% (2.5%)	13.1% (1.9%)		100.0% (0.0%)
Inriver return estimate[a] (SE)	925 (437)	4,330 (1,988)	796 (378)		6,051 (2,772)
<u>METF length ≥930 mm</u>					
Female					
Marked (no. of fish)		23	190	5	218
% marked fish (SE)		6.3% (1.3%)	51.9% (2.6%)	1.4% (0.6%)	59.6% (2.6%)
Inriver return estimate[a] (SE)		140 (46)	1,155 (313)	30 (15)	1,326 (358)
Male					
Marked (no. of fish)		10	131	7	148
% marked fish (SE)		2.7% (0.9%)	35.8% (2.5%)	1.9% (0.7%)	40.4% (2.6%)
Inriver return estimate[a] (SE)		61 (24)	797 (219)	43 (19)	900 (246)
Male & Female					
Marked (no. of fish)		33	321	12	366
% marked fish (SE)		9.0% (1.5%)	87.7% (1.7%)	3.3% (0.9%)	100.0% (0.0%)
Inriver return estimate[a] (SE)		201 (62)	1,952 (522)	73 (28)	2,225 (594)

[a] Units = number of fish.

Appendix E5.-Age, sex, and length composition for late-run Kasilof River Chinook salmon by sampling event, 2008.

	Age				
	1.2	1.3	1.4	1.5	Total
Marking event, 1 Jul–25 Aug [a]					
Female					
Marked (no. of fish)	1	41	174	11	227
% marked fish (SE)	0.2% (0.2%)	9.6% (1.4%)	40.7% (2.4%)	2.6% (0.8%)	53.2% (2.4%)
Mean METF (SE)	750 (0)	879 (7)	957 (4)	1,020 (13)	945 (4)
METF range	750–750	740–940	790–1,135	920–1,070	740–1,135
Male					
Marked (no. of fish)	47	67	85	1	200
% marked fish (SE)	11.0% (1.5%)	15.7% (1.8%)	19.9% (1.9%)	0.2% (0.2%)	46.8% (2.4%)
Mean METF (SE)	681 (8)	851 (7)	986 (7)	1,090 (0)	870 (10)
METF range	550–790	695–980	790–1,120	1,090–1,090	550–1,120
Male & Female					
Marked (no. of fish)	48	108	259	12	427
% marked fish (SE)	11.2% (1.5%)	25.3% (2.1%)	60.7% (2.4%)	2.8% (0.8%)	100.0% (0.0%)
Mean METF (SE)	682 (8)	861 (5)	966 (4)	1,025 (13)	910 (5)
METF range	550–790	695–980	790–1,135	920–1,090	550–1,135
Recapture event, 8 Jul–22 Sep					
Female					
Captured (no. of fish)	7	121	224	5	357
% captured fish (SE)	1.0% (0.4%)	17.5% (1.4%)	32.3% (1.8%)	0.7% (0.3%)	51.5% (1.9%)
Mean METF (SE)	683 (27)	895 (4)	973 (3)	1,042 (20)	942 (4)
METF range	590–780	750–985	810–1,080	970–1,090	590–1,090
Male					
Captured (no. of fish)	43	146	140	7	336
% captured fish (SE)	6.2% (0.9%)	21.1% (1.6%)	20.2% (1.5%)	1.0% (0.4%)	48.5% (1.9%)
Mean METF (SE)	690 (7)	847 (4)	1,028 (6)	1,073 (25)	907 (7)
METF range	610–820	720–980	850–1,175	1,000–1,140	610–1,175
Male & Female					
Captured (no. of fish)	50	267	364	12	693
% captured fish (SE)	7.2% (1.0%)	38.5% (1.9%)	52.5% (1.9%)	1.7% (0.5%)	100.0% (0.0%)
Mean METF (SE)	689 (7)	868 (3)	994 (3)	1,060 (17)	925 (4)
METFrange	590–820	720–985	810–1,175	970–1,140	590–1,175

[a] Marking event data prior to July 1 were not used in order to remove Crooked Creek-bound Chinook salmon from analyses.

APPENDIX F: SPORT FISHING EFFORT, HARVEST, AND CATCH FOR LATE-RUN KASILOF RIVER CHINOOK SALMON, 2005

Appendix F1.-Sport fishing effort, harvest, and catch for late-run Kasilof River Chinook salmon, 1–31 July 2005.

		Anglers		Chinook salmon			
				Wild		Hatchery-reared	
Date	No. of boats	Number	Effort (hrs fished)	Harvest	Catch	Harvest	Catch
01 Jul	2	6	44	1	1	0	0
02 Jul	9	27	156	5	6	1	1
03 Jul	4	12	61	0	0	0	0
04 Jul	30	103	642	27	39	1	1
05 Jul	9	26	182	2	4	1	2
06 Jul	3	7	50	0	0	0	0
07 Jul	4	11	69	2	3	0	0
08 Jul	5	17	124	3	3	0	0
09 Jul	10	32	185	9	11	0	0
10 Jul	3	8	36	2	2	0	0
11 Jul	37	129	852	25	28	1	1
12 Jul	8	29	234	12	15	0	0
13 Jul	7	24	192	7	7	0	0
14 Jul	7	24	174	10	12	0	0
15 Jul	14	49	358	18	26	0	0
16 Jul	17	62	481	28	33	0	0
17 Jul	7	24	114	11	12	0	0
18 Jul	35	129	923	38	49	0	0
19 Jul	9	32	223	20	24	0	0
20 Jul	15	52	396	23	23	0	0
21 Jul	6	21	144	11	11	0	0
22 Jul	14	51	298	16	20	0	0
23 Jul	19	62	407	19	19	0	0
24 Jul	7	18	77	8	11	0	0
25 Jul	37	119	750	59	71	2	2
26 Jul	6	20	151	12	12	0	0
27 Jul	13	51	340	27	37	0	0
28 Jul	12	43	305	23	27	0	0
29 Jul	13	46	306	37	47	0	0
30 Jul	25	89	624	70	79	0	0
31 Jul	13	41	188	26	41	0	0
Sum	400	1,364	9,082	551	673	6	7
Mean	13	44	293	18	22	0	0
Min	2	6	36	0	0	0	0
Max	37	129	923	70	79	2	2

Source: results of ADF&G interviews of 1,364 sport anglers at Trujillo's pullout as they exited the Kasilof River fishery, 1–31 July 2005.

Note: “harvest” = fish kept; “catch” = fish harvested plus fish released.