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Upper Russian River Late-Run Sockeye Salmon Run Reconstructions, 2006–2008

by

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May 2013

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

Alaska 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)

Mathematics, statistics

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

FISHERY DATA SERIES NO. 13-22

UPPER RUSSIAN RIVER LATE-RUN SOCKEYE SALMON RUN RECONSTRUCTIONS, 2006–2008

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TABLE OF CONTENTS

LIST OF TABLES iii
LIST OF FIGURES iii
LIST OF APPENDICES iii
ABSTRACT 1
INTRODUCTION 1
Background 1
Genetic Stock Identification 2
Run Reconstruction 2
METHODS 4
Study Design 4
Harvest Downstream of RKM 31.1 4
UCI Commercial Fishery 4
Kenai River Personal Use Fishery 5
Kenai River Sport Fishery Downstream of RKM 31.1 5
Abundance at RKM 31.1 5
Sport Fishery Harvest Upstream of RKM 31.1 6
Tissue Sampling for GSI 6
Baseline 6
Mixture samples 6
Tissue Handling 7
Laboratory Analysis 7
Assaying Genotypes 7
Laboratory Failure Rates and Quality Control 8
Data Analysis 8
Data Retrieval, Quality Control, and Baseline Development 8
Baseline Evaluation for Genetic Stock Identification 8
Baseline Differences between Mixtures 8
Reporting Groups and Reporting Group Nomenclature 8
GSI Statistical Methods 8
Proof Tests 9
Genetic Stock Identification 9
Run Reconstruction of URRLR Sockeye Salmon 10
URRLR harvest downstream of RKM 31.1: $\hat{H}_R$ and $\hat{V}(\hat{H}_R)$ 10
UCI Commercial Fishery Harvest 11
Kenai River Personal Use Harvest 12
Sport Fishery Harvest Downstream of RKM 31.1 12
URRLR Passage at RKM 31.1: $\hat{F}_R$ and $\hat{V}(\hat{F}_R)$ 13
URRLR Sport Fishery Harvest Upstream of RKM 31.1 15
Run Timing 15
RESULTS 16
Tissue Sampling 16
Baseline 16
Mixtures 16
Laboratory Analysis 18
Laboratory Failure Rates and Quality Control 18
Data Analysis 18

TABLE OF CONTENTS (Continued)

Data Retrieval and Quality Control and Baseline Development 18
Baseline Evaluation for GSI 18
Proof Tests 18
Mixed Stock Analysis 19
UCI Commercial Fishery 19
Personal Use Fishery 25
Sport Fishery Downstream of RKM 31.1 25
RKM 31.1 27
RKM 31.1 Mark–Recapture Assumptions 29
2006 Run Reconstruction 30
UCI Commercial Fishery Harvest 30
Kenai River PU Fishery Harvest 31
Sport Fishery Harvest Downstream of RKM 31.1 31
Passage at RKM 31.1 31
Total Run–2006 32
2007 Run Reconstruction 32
UCI Commercial Fishery Harvest 32
Kenai River PU Fishery Harvest 32
Sport Fishery Harvest Downstream of RKM 31.1 34
Passage at RKM 31.1 34
Total Run–2007 34
2008 Run Reconstruction 34
UCI Commercial Fishery Harvest 34
Kenai River PU Fishery Harvest 35
Sport Fishery Harvest Downstream of RKM 31.1 35
Passage at RKM 31.1 35
Total Run–2008 36
Harvest of URRLR Sockeye Salmon by Year and Fishery 36
Run Timing 36
2006 36
2007 36
2008 37
DISCUSSION 37
Genetics 37
Run Reconstruction 38
URRLR Harvest Sources 38
Passage at RKM 31.1 38
2006 Run Reconstruction 38
2007 Run Reconstruction 39
2008 Run Reconstruction 39
2006–2008 Run Comparison 40
Run Timing 42
Recommendations and Summary 43
ACKNOWLEDGEMENTS 44
REFERENCES CITED 45
APPENDIX A: UPPER RUSSIAN RIVER LATE-RUN SOCKEYE SALMON PROPORTION ESTIMATES AND CREDIBILITY INTERVALS 47

LIST OF TABLES

Table **Page**

1. Dirichlet priors based on the best available information for the first stratum within the personal use fishery, sport fishery, and RKM 31.1 fish wheel samples for 2006. 10
2. Collection dates, number of samples collected, number of samples analyzed, and number of samples suitable for GSI analysis for the 2006, 2007, and 2008 personal use fishery collections. 16
3. Collection dates, number of samples collected, number of samples analyzed, and number of samples suitable for GSI analysis for the 2006, 2007, and 2008 sport fishery downstream of RKM 31.1 collections. 17
4. Collection dates, number of samples collected, number of samples analyzed, and number of samples suitable for GSI analysis for the 2006, 2007, and 2008 RKM 31.1 collections. 17
5. Allocation proportions and BAYES 90% credibility interval for mixtures of known fish removed from the baseline populations that contribute to each reporting group. 19
6. Estimated proportion and number of Upper Russian River late-run sockeye salmon harvested in Upper Cook Inlet commercial fisheries, Kenai River personal use dip net fishery, and Kenai River sport fishery in 2006. 20
7. Estimated proportion and number of Upper Russian River late-run sockeye salmon harvested in Upper Cook Inlet commercial fisheries, Kenai River dip net personal use fishery, and Kenai River sport fishery in 2007. 22
8. Estimated proportion and number of Upper Russian River late-run sockeye salmon harvested in Upper Cook Inlet commercial fisheries, Kenai River personal use dip net fishery, and Kenai River sport fishery in 2008. 24
9. Number of sockeye salmon captured and PIT-tagged at the RKM 31.1 fish wheels and the estimated proportion of Upper Russian River late-run sockeye salmon with 90% credibility intervals by temporal strata for each year, 2006–2008. 29
10. Number of Upper Russian River late-run sockeye salmon harvested and 90% credibility intervals from all sockeye salmon captured in the Upper Cook Inlet commercial set and drift gillnet fisheries in 2006, 2007, and 2008. 30
11. Run reconstruction summaries by year for Upper Russian River late-run sockeye salmon entering Upper Cook Inlet, Alaska, 2006–2008. 33

LIST OF FIGURES

Figure **Page**

1. Map of Upper Cook Inlet and the western Kenai Peninsula showing commercial, personal use, and sport harvest sampling sources for Upper Russian River late-run sockeye salmon. 3
2. Proportion and harvest of Upper Russian River late-run sockeye salmon in the Kenai River personal use fishery with 90% credibility intervals, 2006–2008. 26
3. Proportion and 90% credibility intervals of Upper Russian River late-run sockeye salmon in the Kenai River sport fishery downstream of RKM 31.1, 2006–2008. 27
4. Proportion and 90% credibility intervals of Upper Russian River late-run sockeye salmon in fish wheel samples collected for PIT tagging at RKM 31.1 on the Kenai River, 2006–2008. 28
5. Estimated harvest, escapement, and total run for Upper Russian River late-run sockeye salmon, 2006–2008. 41
6. Proportion estimates of commercial, personal use, and sport fishery harvests of Upper Russian River late-run sockeye salmon, 2006–2008. 41

LIST OF APPENDICES

Appendix **Page**

A1. Upper Russian River late-run sockeye salmon proportion estimates and credibility intervals from mixtures of sockeye salmon captured in the Central District drift gillnet fishery, personal use fishery, sport fishery downstream of RKM 31.1, and at the RKM 31.1 fish wheels in 2006, 2007, and 2008. 48

ABSTRACT

A 3-year study (2006–2008) was conducted using mark–recapture and genetic stock identification (GSI) methods to reconstruct the annual runs of Upper Russian River late-run (URRLR) sockeye salmon (*Oncorhynchus nerka*). Prior to this study, total run size, exploitation rates, and timing of URRLR sockeye salmon migrations were unknown. Run reconstructions contained 4 estimated components: harvest in the Upper Cook Inlet commercial fishery, the Kenai River personal use fishery, and the Kenai River sport fishery downstream of river kilometer (RKM) 31.1, and the abundance of URRLR sockeye salmon at RKM 31.1 of the Kenai River. Harvest of URRLR sockeye salmon in the mixed stock fisheries was estimated using GSI methods. Abundance at RKM 31.1 was estimated using passive integrated transponder tags and both mark–recapture and GSI methods. The total run estimate was simply the estimate of total harvest below RKM 31.1 plus abundance at RKM 31.1. The number of URRLR sockeye salmon harvested in the sport fishery upstream of RKM 31.1 was estimated indirectly as the difference between the abundance estimate at RKM 31.1 and the escapement of late-run sockeye salmon counted at the Russian River weir. Estimated total run size of URRLR sockeye salmon that entered Upper Cook Inlet was 157,164 (SE 22,107) in 2006, 204,387 (SE 14,555) in 2007, and 174,680 (SE 10,231) in 2008. The harvest rate of Upper Russian River late-run sockeye salmon was 43% in 2006, 74% in 2007, and 73% in 2008. On average, the sport fishery accounted for 48% of the harvest of URRLR sockeye salmon, the Upper Cook Inlet commercial fishery accounted for 41% of the harvest, and the Kenai River personal use fishery accounted for the remaining 11% of the harvest.

Key words: sockeye salmon, Russian River, late run, mark–recapture, genetic stock identification, GSI, run reconstruction, Kenai River

INTRODUCTION

BACKGROUND

The Russian River is a clearwater tributary of the Kenai River on the Kenai Peninsula approximately 100 miles south of Anchorage (Figure 1). The drainage supports one of the largest freshwater sport fisheries for sockeye salmon (*Oncorhynchus nerka*) in Alaska and has 2 distinct runs. Early-run sockeye salmon enter the Kenai River in May and June, migrate 120 river kilometers (RKM) upstream to the Russian River, and spawn in the upper reaches of the drainage. Most of the early-run sockeye salmon in the Kenai River are of Russian River origin. Harvest of this stock occurs primarily in the Russian River area sport fishery. Late-run sockeye salmon bound for the Russian River drainage enter the Kenai River in July and August along with other spawning aggregates returning to numerous locations throughout the Kenai River drainage. These fish are harvested by a combination of commercial, sport, personal use, and subsistence user groups. The Russian River late run has 2 discrete components: one that spawns in the Russian River downstream of the falls at RKM 4.8, and another that spawns upstream of the falls. The downstream component is closely related to Kenai River sockeye salmon, whereas the upstream component is genetically distinct from Kenai River sockeye salmon and fish that spawn in the Russian River downstream of the falls (Seeb et al. 2000). The upstream component is referred to as the Upper Russian River late run (URRLR) and is the subject of this report.

The Alaska Department of Fish and Game (ADF&G) began studying Russian River sockeye salmon in the 1960s. Early studies included a counting tower, creel censuses, spawning surveys, tagging, fecundity estimates, egg deposition rates, predation rates, and age analysis through scale patterns. A weir, installed in early June each year at the outlet of Lower Russian Lake, has been used to enumerate early- and late-run sockeye salmon escapement (Engel 1970). Sockeye salmon passing the weir prior to 15 July are classified as early run and those passing the weir on or after 15 July are classified as late run. Although Russian River sockeye salmon have been studied for several decades, their population dynamics are not well understood. More is known about the early run because the total number that return each year has been estimated by adding estimated sport fishery harvest (the only known source of significant early-run harvest) to enumerated escapement past the Russian River weir. A brood table has been developed for the early run, and stock–recruit analyses have been conducted periodically (Hasbrouck and Edmundson 2007). A sustainable escapement goal (SEG) of 22,000–42,000 sockeye salmon past the weir is in place for the early run. Unfortunately, estimating total run size of URRLR sockeye salmon that return to Upper Cook Inlet (UCI) is more complicated because URRLR sockeye salmon are harvested in several mixed stock fisheries and until this study, their contribution to those fisheries was not known. Consequently, total run size (harvest plus escapement) has not been accurately estimated for any year prior to this report. With a lack of total return estimates, Russian River escapements have been used to assess the status of URRLR sockeye salmon. Escapement goal analyses are periodically conducted with available information. The current SEG of 30,000–110,000 URRLR sockeye salmon was derived using the 25th and 75th percentiles of the historic escapements and has been in place since 2005. Generally, escapements within the SEG are attained; however, future returns and yields from given escapements are unknown.

GENETIC STOCK IDENTIFICATION

A suite of genetic markers has been used for genetic stock identification (GSI) applications in Pacific salmon (reviewed in Habicht et al. 2007). Single nucleotide polymorphism (SNP) marker applications in GSI studies of Pacific salmon have become increasingly common (Smith et al. 2005a, 2007; Habicht et al. 2007, 2010; Narum et al. 2008; Dann et al. 2009). ADF&G developed assays for SNP markers for sockeye salmon (Smith et al. 2005b; Elfstrom et al. 2006), that are now used by laboratories in the United States for sockeye salmon projects by the Pacific Salmon Commission in the Alaska–British Columbia Northern Boundary region. This same method has been used by ADF&G in Bristol Bay with sockeye salmon, both inseason, to estimate relative stock contributions passing through the Port Moller test fishing area, and postseason to estimate the commercial-catch stock contributions in fisheries (Dann et al. 2009). This same set of SNP assays was also used to determine the contribution of all UCI sockeye salmon stocks to the UCI commercial fisheries (Barclay et al. 2010).

A recent study of coastwide sockeye salmon populations demonstrated that URRLR sockeye salmon are genetically distinct (Habicht et al. 2010). Consequently, URRLR sockeye salmon are easily differentiated in a mixed stock sample. This report describes how URRLR sockeye salmon can be identified in mixed stock fisheries and the use of GSI techniques to reconstruct runs of URRLR sockeye salmon returning to UCI (2006–2008).

RUN RECONSTRUCTION

URRLR sockeye salmon are harvested primarily in 3 fisheries: 1) a commercial fishery occurring throughout UCI that includes both drift and set gillnets (Shields 2007a), 2) a personal use (PU) dip net fishery from the mouth of the Kenai River upstream to Warren Ames Bridge at RKM 8.2 (Dunker 2010; Dunker and Lafferty 2007), and 3) a sport fishery, which occurs throughout the Kenai River (King 1997) and in the Russian River downstream of the falls (Marsh 1998; Figure 1).

Estimates of these 3 harvest components and the number past RKM 31.1 of the Kenai River provided the necessary data to reconstruct the URRLR sockeye salmon runs for the years 2006–2008. Total run size estimates obtained from these reconstructions will be used for brood table development and escapement goal analyses. Run timing information will be used to support inseason management of the fishery.

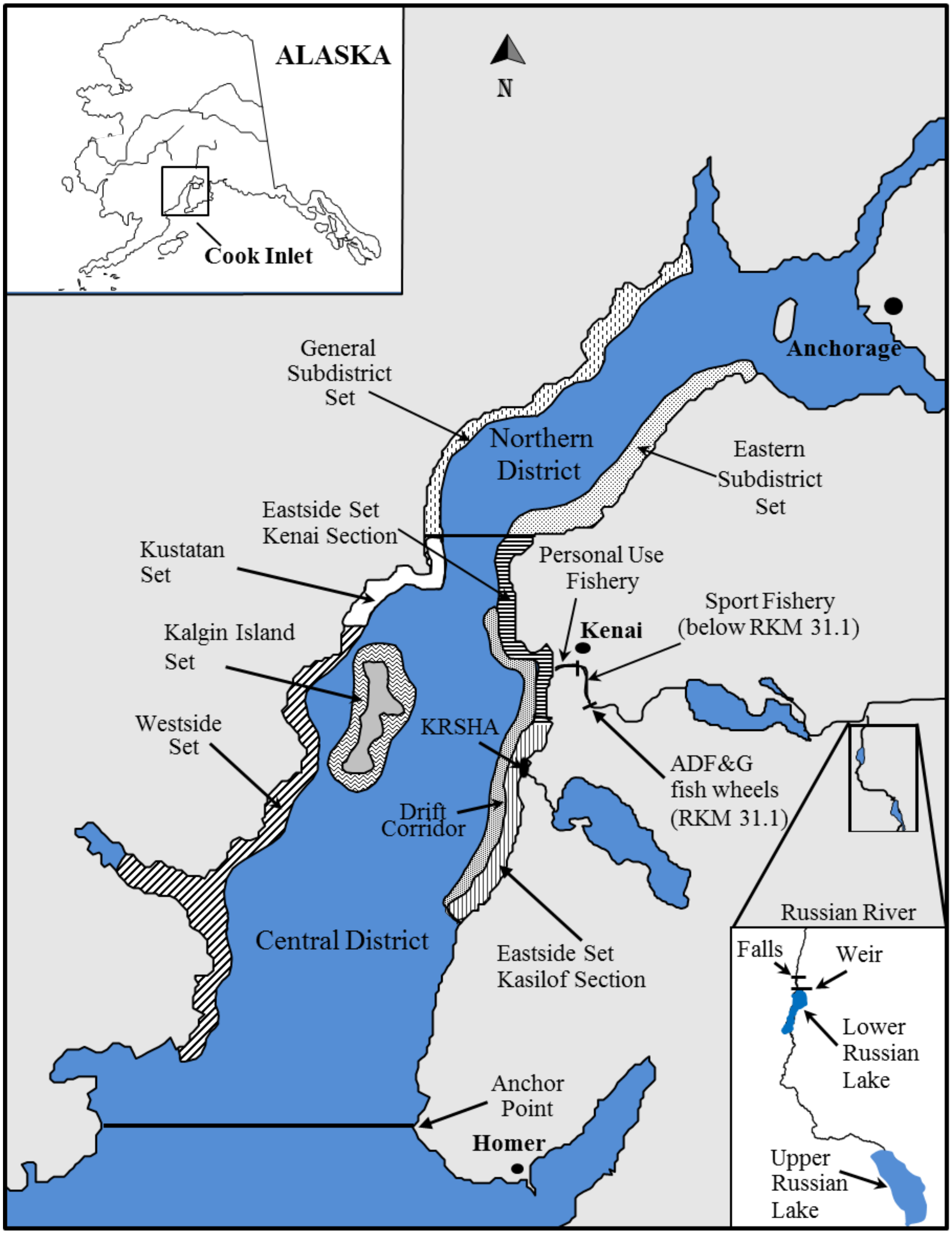

Figure 1.–Map of Upper Cook Inlet and the western Kenai Peninsula showing commercial, personal use, and sport harvest sampling sources for Upper Russian River late-run sockeye salmon.

Note: "ADF&G" = Alaska Department of Fish and Game; "KRSHA" = Kasilof River Special Harvest Area; "Set" = commercial set gillnet fishery; "Drift" = commercial drift gillnet fishery.

METHODS

STUDY DESIGN

Four main components of the URRLR sockeye salmon run were estimated: 1) harvest in Cook Inlet and in the Kenai River downstream of RKM 31.1 (together, these are referred to hereafter as harvest downstream of RKM 31.1), 2) estimated abundance at RKM 31.1, 3) harvest upstream of RKM 31.1, and 4) spawning escapement. The run reconstruction was partitioned at RKM 31.1 because RKM 31.1 was the location of the marking event in this project as well as the marking event of a concurrent 2-event mark–recapture experiment to estimate the drainagewide abundance and spawning distribution of Kenai River sockeye salmon (Willette et al. 2012).

Harvest of URRLR sockeye salmon downstream of RKM 31.1 was estimated for the UCI commercial fishery, Kenai River PU fishery, and the sport fishery using GSI techniques. Abundance of URRLR sockeye salmon at RKM 31.1 was estimated using both GSI and mark–recapture techniques. The total run was estimated using the estimated total harvest downstream of RKM 31.1 plus the estimated abundance at RKM 31.1. Escapement was monitored at the Russian River weir. Sport fishery harvest upstream of RKM 31.1 was estimated indirectly as the difference between the abundance estimate at RKM 31.1 and the escapement.

Harvest Downstream of RKM 31.1

UCI Commercial Fishery

The UCI commercial set and drift gillnet fisheries are divided into 2 districts (Central and Northern) with subdistricts within each district. In total there were 11 district–subdistrict groupings within the UCI commercial fishery for estimating commercial harvest of URRLR sockeye salmon. The following is a list of the 11 groups and their acronyms used hereafter:

District–Subdistrict group	Acronym
Central District Drift Gillnet	CDD
Central District Drift Gillnet Corridor	CDD corridor-only
Central District Upper Subdistrict Eastside Set Gillnet Kenai Section	ESSN Kenai section
Central District Upper Subdistrict Eastside Set Gillnet Kasilof Section	ESSN Kasilof section
Central District Upper Subdistrict Kasilof River Special Harvest Area Drift Gillnet	KRSHA drift
Central District Upper Subdistrict Kasilof River Special Harvest Area Set Gillnet	KRSHA set
Central District Upper Subdistrict Kasilof River Special Harvest Area Drift–Set Gillnet	KRSHA drift–set
Central District Kalgin Island Subdistrict Set Gillnet	Kalgin Island set
Central District Westside Subdistrict Set Gillnet	Westside set
Northern District Eastern Subdistrict Set Gillnet	ND Eastern set
Northern District General Subdistrict Set Gillnet	ND General set

A project to estimate stock composition of the major systems that compose the UCI commercial sockeye salmon fishery was conducted by ADF&G Division of Commercial Fisheries (CF) (Barclay et al. 2010); the proportion and harvest of URRLR sockeye salmon in the UCI commercial fishery from 2006 to 2008 was estimated using GSI. Over 15,000 tissue samples were collected by CF annually throughout the fishery and a subset of those samples was analyzed postseason using SNP markers to estimate stock-specific harvest through time for 8 reporting groups.

Kenai River Personal Use Fishery

The Kenai River PU fishery occurs downstream of Warren Ames Bridge (RKM 8.0) from 10 to 31 July, and is open daily from 6:00 AM to 11:00 PM. Nearly all shorebased dipnetting occurs at or near the river mouth. By regulation dipnetting from boats occurs between RKM 2.6 and the Warren Ames Bridge (RKM 8.2). The fishery was sampled for GSI 3 days per week at the 3 most common access points: the north and south beaches at the Kenai River mouth, and the City of Kenai boat launch (RKM 2.6). Time spent sampling alternated equally between access points.

Kenai River Sport Fishery Downstream of RKM 31.1

The Kenai River sockeye salmon fishery downstream from RKM 31.1 is shorebased and anglers are dispersed throughout the area. Very little sockeye salmon fishing occurs downstream of Beaver Creek (RKM 16.2). Sampling was conducted 4 days per week from RKM 31.1 downstream to its confluence with Beaver Creek. In addition to tissue sampling, counts of anglers fishing from the shoreline (shore anglers) were conducted each sampling day to provide 1) the weight needed to convert the Alaska Statewide Harvest Survey (SWHS; e.g., Jennings et al. 2011) estimate of sockeye salmon harvest from the Kenai River mouth to Soldotna Bridge into an estimate representing sport fishery harvest from the Kenai River mouth to RKM 31.1, and 2) the weight needed to partition the sport fishery harvest estimate downstream of RKM 31.1 into 2 temporal strata. Angler counts were stratified geographically by the number counted between the Soldotna Bridge (RKM 33.9) and RKM 31.1 and the number counted between RKM 31.1 and the Beaver Creek confluence. GSI sampling and angler counts commenced 1 July each year and concluded when anglers were essentially done harvesting sockeye salmon (usually mid to late August).

Abundance at RKM 31.1

The total number of URRLR sockeye salmon that migrated past RKM 31.1 of the Kenai River was estimated using GSI techniques in conjunction with a 2-event mark–recapture experiment to estimate Kenai River sockeye salmon abundance (Willette et al. 2012). During the marking (first) event, passive integrated transponder (PIT) tags were implanted into the cheeks of sockeye salmon in approximate proportion to their abundance as they were captured in fish wheels at RKM 31.1. One fish wheel was operated on each bank near the sockeye salmon sonar. The PIT-tagging rate was set at 1% of the adjacent sockeye salmon sonar count during 2006 and 2007, and 0.5% of the sonar count in 2008. Tissue samples were collected for GSI from a systematic sample (based on a predetermined rate per PIT-tagged fish per year) to provide an estimate of the number of marked URRLR sockeye salmon. Tagging-induced mortality was assessed by inserting esophageal radio transmitters into sockeye salmon deployed concurrently with the PIT-tagging effort at RKM 31.1. Radiotagged sockeye salmon that made it to RKM 45.1 (the nearest upstream fixed receiver location) were assumed to have survived the tagging event successfully and the mortality rate from handling and PIT-tagging fish was assumed equal to that of radiotagged fish. See Willette et al. (2012) for a more detailed description of methods for the RKM 31.1 marking event.

The recapture (second) event in the mark–recapture experiment took place at the Russian River weir, where late-run sockeye salmon passing through the weir were scanned for PIT tags using an automated electronic PIT-tag detection system with 2 antennas. The number of URRLR sockeye salmon that passed RKM 31.1 was estimated by utilizing the number of PIT-tagged sockeye salmon that passed the Russian River weir, the number of sockeye salmon PIT-tagged at RKM 31.1, the proportion of PIT-tagged fish that were of URRLR origin, and the escapement at the Russian River weir (see Equations 11–21 below).

The assumptions underlying this 2-event mark–recapture study were as follows (Seber 1982):

1) The population was closed.
2) There was either equal probability of capture for all sockeye salmon in the first or second event or there was complete mixing between events.
3) No marks were lost.
4) Marked fish did not behave differently from unmarked fish.
5) Marked fish were identified in the second event.

Sport Fishery Harvest Upstream of RKM 31.1

URRLR sockeye salmon harvest upstream of RKM 31.1 was estimated indirectly by subtracting the number of URRLR sockeye salmon past the Russian River weir from the estimated number of sockeye salmon that migrated upstream of RKM 31.1.

Tissue Sampling for GSI

To estimate the contribution of URRLR sockeye salmon to the mixed stock commercial, PU, and sport fisheries, a baseline of UCI sockeye salmon stocks was established (Seeb et al. 2000; Habicht et al. 2007; Barclay et al. 2010). Once the baseline was established, a number of tissue samples (mixtures) from the mixed stock fisheries were taken to estimate the contribution of the URRLR sockeye salmon stock to the harvests.

Baseline

Tissue samples were collected and analyzed using SNP markers to establish baseline allele frequencies for use in subsequent mixed stock analyses. These baseline samples were collected by ADF&G from spawning populations of sockeye salmon using gillnets and beach seines (Barclay et al. 2010). Most collections were made in the 1990s (Seeb et al. 2000; Habicht et al. 2007) and were augmented by collections reported in Barclay et al. (2010). These populations represent the known genetic diversity, both geographical (location) and temporal (early and late spawning), in sockeye salmon returning to Cook Inlet. The target sample size for baseline population estimates was 95 individuals across all sampled years to achieve acceptable precision for the allele frequency estimates (Allendorf and Phelps 1981; Waples 1990). Tissue samples were collected and subsequently frozen (heart, muscle, liver, and eye) or preserved in ethanol (axillary process). Tissue samples that were to be frozen were placed into individual vials, and ethanol-preserved samples were placed collectively into 125 ml to 500 ml containers containing ethanol, 1 container for each collection site for each year.

Mixture samples

Tissue samples of sockeye salmon were collected for genetic analysis without regard to size, sex, condition, or stock. These are called “mixture samples.”

Commercial fishery harvests were sampled using a stratified, systematic sampling design (Barclay et al. 2010). Area strata were predetermined using established fishery districts and subdistricts. Temporal stratification was determined post season, based on catch patterns in each fishery and the number of samples collected. Final target sample size within strata was set at

400 fish to provide point estimates within 0.05 of the true stock composition 90% of the time (Thompson 1987).

In the PU fishery, tissue samples were collected each sampling day by alternating sampling effort equally between the three most commonly used locations. Sampling locations were the City of Kenai boat launch (Kenai River RKM 2.6) and the two beaches (north and south) at the Kenai River mouth. Sampling times were dependent on tide stage to maximize sampling efficiency. Collections were stratified by week and were subsampled systematically postseason. Final target sample size within strata was set at 200 fish to provide point estimates within 0.07 of the true stock composition 95% of the time.

In the sport fishery downstream of RKM 31.1, a fishery technician traveled by boat to areas where anglers were fishing and collected tissue samples from harvested sockeye salmon. The collection effort was dispersed proportionally to observed fishing effort. Collections were divided into 2 temporal strata. The composite mixture was used for run reconstruction, whereas temporal stratification was examined to investigate run timing. Temporal strata were defined such that harvest was approximately equal in each stratum. Collections were subsampled postseason to provide a sample proportional to estimated angler effort by temporal stratum. Final target sample size within strata was set at 200 fish to provide point estimates within 0.07 of the true stock composition 95% of the time.

At RKM 31.1, tissue samples were collected from every sixth PIT-tagged fish in 2006, from every fifth PIT-tagged fish in 2007, and from every second PIT-tagged fish in 2008. Samples were stratified temporally based on PIT tag deployment such that 7 strata of approximately equal weight were defined each year.

Tissue Handling

An axillary process was excised from individual fish and placed in ethanol in either individually labeled 2-ml plastic vials or 48 deep-well plates. Deep-well plates were used in the commercial fishery only. Commercial fishery and RKM 31.1 fish wheel collections and associated data were collated and archived by CF staff in Soldotna. Collections and data from the Kenai River PU dip net fishery and the Kenai River sport fishery downstream of RKM 31.1 were collated and archived by ADF&G Division of Sport Fish (SF) staff in Soldotna.

LABORATORY ANALYSIS

Assaying Genotypes

Genomic DNA was extracted following the methods of Barclay et al. (2010). All baseline and mixture samples except for the 2006 commercial fishery samples were screened for 45 sockeye salmon SNP markers: 3 mitochondrial, and 42 nuclear DNA. The 2006 commercial fishery samples were screened for fewer SNP markers because baseline data was only available for 42 of the 45 SNPs at the time that they were screened (prior to 2007; Habicht et al. 2007). Baseline performance tests (proof tests) for the 42-SNP baseline demonstrated greater than 99% correct allocation of test mixture individuals to each of the 7 Upper Cook Inlet reporting groups reported in Habicht et al. (2007).

Laboratory Failure Rates and Quality Control

Genotyping failure rate calculations and quality control measures for the PU fishery, sport fishery, and RKM 31.1 fish wheel samples reported herein follow those reported for the commercial fishery in Barclay et al. (2010).

DATA ANALYSIS

Data Retrieval, Quality Control, and Baseline Development

Methods for data retrieval and quality control were reported in Barclay et al. (2010). In that report, a threshold of 80% of markers able to be scored per individual was established and all individuals that did not meet this threshold were excluded from GSI. This rule (referred to as the "80% rule") was used to filter samples from mixtures to decrease errors and to estimate variances caused by poor quality DNA and missing data. The same rule was applied to the individuals from the mixture samples in this report. Baseline development methods were also reported in Barclay et al. (2010) and include tests for Hardy–Weinberg equilibrium and linkage disequilibrium, methods for pooling collections into populations, testing for temporal stability, and visualizing population structure.

Baseline Evaluation for Genetic Stock Identification

Baseline Differences between Mixtures

Mixture samples collected in the commercial and personal use fisheries were analyzed using the same 59-population baseline as reported in Table 2 of Barclay et al. (2010). Sport fishery and RKM 31.1 fish wheel samples were analyzed using a subset of the baseline, which consisted of only the 13 Kenai River populations (Barclay et al. 2010).

Reporting Groups and Reporting Group Nomenclature

Reporting groups for mixture samples collected in the commercial and personal use fisheries differed from the reporting groups for mixture samples collected within the sport fishery and at RKM 31.1. For GSI of fish caught in the commercial and personal use fisheries, populations were assigned to 2 reporting groups: 1) URRLR populations ("URRLR") and 2) all other Cook Inlet sockeye salmon populations including other non-URRLR Kenai River populations ("Cook Inlet Other"). For GSI of fish caught in the sport fishery and samples obtained at the RKM 31.1 fish wheel, the baseline was reduced to only Kenai River populations and these populations were assigned to 2 reporting groups: 1) URRLR, as described above, and 2) all other Kenai River populations ("Kenai Other").

GSI Statistical Methods

All baseline evaluation tests were conducted using the program BAYES (Pella and Masuda 2001). Methods for analyzing mixtures using BAYES are the same as those reported in Barclay et al. (2010).

Proof Tests

Proof tests were used to examine baseline performance for GSI following the methods of Barclay et al. (2010). In these tests, a test mixture was created by sampling, from the baseline, approximately 200 fish from a single reporting group. The baseline was rebuilt excluding the sampled fish, then the stock composition of the test mixture was estimated using the rebuilt baseline and the program BAYES with a flat prior. All reporting groups were tested. These tests provided an indication of the power of the baseline for GSI assuming that all the populations were represented in the baseline.

Genetic Stock Identification

The stock composition of all mixtures was estimated using the same BAYES protocol as described in Barclay et al. (2010) except for differences in reporting groups as outlined above. Because the commercial fishery mixtures were originally analyzed for 8 reporting groups, the contribution of URRLR in the commercial fishery mixtures was estimated by resummarizing the BAYES output with respect to this particular group.

Following the methods of Barclay et al. (2010), an informative Dirichlet prior distribution based upon the best available information was used for each mixture analysis. For all Dirichlet priors, the sum of prior parameters was set to 1. The best available information for the prior was believed to be the results from GSI of similar mixtures. This information was not always available so a "step-wise" prior protocol was developed to standardize the methodology. For UCI commercial fishery mixtures, the same prior parameters were used, based on 8 reporting groups, as outlined in Barclay et al. (2010). For the Kenai River PU dip net and sport fishery mixtures, the protocol was as follows: for the first time stratum and the composite mixtures of all time strata within each fishery in 2006, the prior was based upon an approximation of the number of URRLR sockeye salmon caught in the 2006 Kenai River sport fishery upstream of RKM 31.1 plus the escapement of URRLR sockeye salmon at the Russian River weir divided by the total Kenai River sockeye salmon sonar passage at RKM 31.1. For the first RKM 31.1 fish wheel sample time stratum, priors were the posterior means (i.e., the stock composition estimates) of the first 2006 Kenai River PU dip net fishery time stratum (Table 1). For the composite mixture of all 2006 RKM 31.1 fish wheel samples, the priors were based on the composite mixture for the 2006 Kenai River sport fishery. For subsequent time strata within the PU fishery, sport fishery, and RKM 31.1 fish wheel samples in the same year, the priors were the posterior means of the previous time strata. For first time strata in subsequent years, the prior parameters were the posterior means from the first period of the same fishery from the previous year. For each composite mixture after 2006, the prior parameters were the posterior means of the previous year's composite mixture. For all priors, a minimum value of 0.01 was defined for each reporting group. Reporting groups with estimates below this value were set to 0.01 by normalizing the sum of prior parameters for all reporting groups to 1 after adjusting the value of the small proportion stocks. For all mixtures, the prior for a reporting group was divided equally among populations within that reporting group.

Table 1.–Dirichlet priors based on the best available information for the first stratum within the personal use fishery, sport fishery, and RKM 31.1 fish wheel samples for 2006.

		Sockeye salmon reporting groups[a] (proportions)	
Data source	Dates	URRLR	Kenai Other
Personal use fishery			
	10 Jul–16 Jul	0.06	0.94
	10 Jul–10 Aug	0.06	0.94
Sport fishery			
	1 Jul–2 Aug	0.06	0.94
	1 Jul–26 Aug	0.06	0.94
RKM 31.1 fish wheels			
	3 Jul–19 Jul	0.04	0.96
	3 Jul–22 Aug	0.04	0.96

[a] "URRLR" = Upper Russian River late run; "Kenai other" = all other Kenai River sockeye salmon.

Run Reconstruction of URRLR Sockeye Salmon

For each year, the total run of URRLR sockeye salmon was estimated by summing the estimates of harvest of the run below RKM 31.1 and the number of URRLR sockeye salmon estimated to have passed RKM 31.1:

$$\hat{T}_R = \hat{H}_R + \hat{F}_R, \tag{1}$$

where

$\hat{T}_R$ = estimated total URRLR sockeye salmon abundance,

$\hat{H}_R$ = estimated harvest of URRLR sockeye salmon downstream of RKM 31.1, and

$\hat{F}_R$ = estimated number of URRLR sockeye salmon that migrated past RKM 31.1.

The 2 estimates $\hat{H}_R$ and $\hat{F}_R$ were independent and the variance of $\hat{T}_R$ was estimated as follows:

$$\hat{V}(\hat{T}_R) = \hat{V}(\hat{H}_R) + \hat{V}(\hat{F}_R). \tag{2}$$

URRLR harvest downstream of RKM 31.1: $\hat{H}_R$ *and* $\hat{V}(\hat{H}_R)$

$\hat{H}_R$ was calculated as a sum of several independent components:

$$\hat{H}_R = \sum_i \hat{p}_{Ri} \hat{N}_i\ , \tag{3}$$

where

$\hat{p}_{Ri}$ = estimated proportion of harvest in fishery stratum *i* downstream of RKM 31.1 comprised of URRLR sockeye salmon (proportion of URRLR fish was obtained based on the Bayesian mixed stock analysis described above), and

$\hat{N}_i$ = the estimate of sockeye salmon harvest in fishery stratum *i* downstream of RKM 31.1 (known for commercial fishery strata and estimated for personal use and sport fishery strata),

and the variance $\hat{V}(\hat{H}_R)$ was calculated as

$$\hat{V}(\hat{H}_R) = \sum_i \hat{N}_i^2 \hat{V}(\hat{p}_{Ri}) + \hat{p}_{Ri}^2 \hat{V}(\hat{N}_i) - \hat{V}(\hat{p}_{Ri})\hat{V}(\hat{N}_i), \quad (4)$$

where $\hat{V}(\hat{p}_{Ri})$ was provided by software package BAYES (Pella and Masuda 2001).

The different fishery strata *i* were as follows:

1) UCI commercial fishery (N_{CF}): 11 substrata included CDD, CDD corridor-only, ESSN Kenai section, ESSN Kasilof section, KRSHA drift, KRSHA set, KRSHA drift–set, Kalgin set, Westside set, ND Eastern set, and ND General set

2) Kenai River PU fishery (N_{PU}): PU fishery was sampled in 3 temporal strata (weekly) and subsampled postseason within each week to provide the desired sample size of 200 fish per week.

3) Kenai River sport fishery downstream of RKM 31.1 ($N_{SF\text{-RKM } 31.1}$): Sport fishery samples were subsampled postseason in proportion to angler counts and to provide the desired sample size of 400 fish.

UCI Commercial Fishery Harvest

Estimating stock proportion of URRLR sockeye salmon and 90% credibility intervals (CI) in the UCI commercial fishery followed methods in Barclay et al. (2010) for each temporal and geographic stratum within each year. For each temporal stratum, the URRLR sockeye salmon harvest estimate and CI were calculated by multiplying the harvest from that stratum by the unrounded URRLR stock proportion estimate and the upper and lower bounds of the 90% CI. Estimates of the proportion of URRLR sockeye salmon for non-GSI represented strata were based on estimates from similar spatial and temporal strata from other years and in some cases, no harvest of URRLR sockeye salmon was assumed due to timing and location of the fishery.

URRLR stock proportion estimates from temporal strata were combined within statistical areas into yearly estimates by weighting them by their respective harvests according to the following equation:

$$\hat{p}_R = \frac{\sum_{i=1}^{S} N_{CF,i}\,\hat{p}_{R,i}}{\sum_{i=1}^{S} N_{CF,i}}, \quad (5)$$

where $N_{CF,i}$ is harvest in stratum i, $\hat{p}_{R,i}$ is the estimated proportion of URRLR sockeye salmon (R) in stratum i, and $\hat{p}_R$ is the estimated overall proportion of URRLR sockeye salmon in a given year with S strata. To calculate credibility intervals for N_{CF}, its distribution was estimated via Monte Carlo simulation by resampling 100,000 draws of the posterior output of $\hat{p}_{R,i}$ from each of the constituent temporal strata and multiplying them by the corresponding harvests according to the following equation:

$$\hat{N}_{CF} = \sum_{i=1}^{S} N_{CF,i}\,\hat{p}_{R,i}. \qquad (6)$$

This method yielded the same point estimate for number of harvested fish within a fishery and year as would be obtained by simply summing the point estimates from each constituent temporal strata, but produced more appropriate credibility intervals (Dann et al. 2009). This method also accommodated non-symmetric credibility intervals.

Reported URRLR stock proportion estimates were rounded to the nearest one-tenth of a percent. URRLR sockeye salmon harvest estimates were rounded to the nearest fish after all calculations were performed, recognizing that this level of precision was optimistic. Any discrepancies between the sum of within-strata harvest estimates and total harvest for each stratum were due to unavoidable rounding errors.

Kenai River Personal Use Harvest

PU harvest, N_{PU}, was estimated from an expansion of permit returns (Dunker 2010; Dunker and Lafferty 2007). Systematic samples from the PU fishery were constructed postseason within each temporal stratum, with the stratified estimator used to estimate total harvest of URRLR sockeye salmon in the PU fishery. The variance $\hat{V}(\hat{N}_{PU})$ was provided by Dunker and Lafferty (2007) and Dunker (2010).

Sport Fishery Harvest Downstream of RKM 31.1

Sport fishery harvest downstream of RKM 31.1, $N_{SF-RKM\,31.1}$, was estimated as follows:

$$\hat{N}_{SF-RKM\,31.1} = \hat{N}_{SF}\,\hat{\phi}, \qquad (7)$$

where $\hat{N}_{SF}$ is the estimated sport harvest from Cook Inlet to Soldotna Bridge (provided by SWHS) and $\hat{\phi}$ is the estimated proportion of that harvest occurring downstream of RKM 31.1, estimated as follows:

$$\hat{\phi} = \frac{\sum_{i=1}^{L} \bar{b}_{SF-RKM\,31.1,\,i}}{\sum_{i=1}^{L} \bar{b}_{SF,\,i}}, \qquad (8)$$

where

$\bar{b}_{SF-RKM\,31.1,i}$ = the average number of anglers counted between Cook Inlet and RKM 31.1 on day i of L angler survey days, and

$\bar{b}_{SF,i}$ = the average number of anglers counted between Cook Inlet and Soldotna Bridge on day i of L angler survey days.

The proportional sample from the sport fishery was constructed postseason, with contributions from stratum samples being proportional to $\hat{N}_{SF-RKM\,31.1}\hat{v}_j$, where $\hat{v}_j$ is the proportion of anglers counted between Cook Inlet and RKM 31.1 in the angler survey in temporal stratum j.

The variance $\hat{V}(\hat{N}_{SF-RKM\,31.1})$ was estimated using the formula of Goodman (1960) as follows:

$$\hat{V}(\hat{N}_{SF-RKM\,31.1}) = \hat{N}_{SF}^2\hat{V}(\hat{\phi}) + \hat{\phi}^2\hat{V}(\hat{N}_{SF}) - \hat{V}(\hat{\phi})\hat{V}(\hat{N}_{SF}), \tag{9}$$

with $\hat{V}(\hat{\phi})$ estimated as variance of a ratio estimator (Cochran 1977),

$$\hat{V}(\hat{\phi}) = \frac{1}{L \times \bar{b}_{SF}^{\,2}} \frac{\sum_{i=1}^{L}(\bar{b}_{SF-RKM\,31.1,i} - \hat{\phi} \times \bar{b}_{SF,i})^2}{L-1}, \tag{10}$$

and $\hat{V}(\hat{N}_{SF})$ provided by the SWHS.

URRLR Passage at RKM 31.1: $\hat{F}_R$ and $\hat{V}(\hat{F}_R)$

The abundance of URRLR sockeye salmon that migrated past RKM 31.1 was estimated using Bailey's estimator (Seber 1982):

$$\hat{F}_R = \frac{\hat{M}_R(E+1)}{(T+1)}, \tag{11}$$

where

$\hat{M}_R$ = estimated number of PIT tags applied to URRLR sockeye salmon at RKM 31.1 that resumed upstream migration after tagging,

E = URRLR sockeye salmon escapement at the Russian River weir, and

T = number of PIT tags detected at the Russian River weir.

The number of URRLR sockeye salmon PIT-tagged at RKM 31.1 was estimated as follows:

$$\hat{M}_R = \hat{p}_U\hat{p}_{RF}M, \tag{12}$$

where

M = number of PIT tags applied to sockeye salmon at RKM 31.1,

$\hat{p}_{RF}$ = estimated proportion of PIT tags applied to URRLR sockeye salmon at RKM 31.1 based on GSI, and

$\hat{p}_U$ = estimated proportion of PIT-tagged sockeye salmon that resumed upstream migration after tagging,

where

$$\hat{p}_U = \sum_{k=1}^{K} w_k \hat{p}_{Uk} , \tag{13}$$

where

K = number of weeks radio tags were applied to migrating sockeye salmon at RKM 31.1, and

w_k = proportion of total sockeye salmon sonar count in week k,

and where

$$\hat{p}_{Uk} = \frac{x_{Uk}}{n_{Sk}}, \tag{14}$$

with

n_{Sk} = number of sockeye salmon tagged with radio transmitters in week k, and

x_{Uk} = number of sockeye salmon tagged with radio transmitters out of n_{Sk} that resumed upstream migration after tagging.

The variance of $\hat{F}_R$ was estimated using Goodman's formula (Goodman 1960) for the product of 2 independent variables as follows:

$$\hat{V}(\hat{F}_R) = (E+1)^2 \left[\hat{M}_R^2 \hat{V}\left(\frac{1}{T+1}\right) + \left(\frac{1}{T+1}\right)^2 \hat{V}\left(\hat{M}_R\right) - \hat{V}\left(\frac{1}{T+1}\right)\hat{V}\left(\hat{M}_R\right) \right]. \tag{15}$$

The delta method was used to estimate $V\left(\frac{1}{T+1}\right)$ as follows:

$$\hat{V}\left(\frac{1}{T+1}\right) = \left(\frac{1}{T+1}\right)^4 \hat{V}(T+1) , \tag{16}$$

with $\hat{V}(T+1)$ estimated as the variance of a binomial random variable: *Binomial*(E, p_T), with p_T the proportion of the URRLR sockeye salmon migration past RKM 31.1 that received PIT tags and estimated as

$$\hat{p}_T = \frac{\hat{M}_R}{\hat{F}_R}, \quad (17)$$

such that

$$\hat{V}\left(\frac{1}{T+1}\right) = \left(\frac{1}{T+1}\right)^4 E\hat{p}_T(1-\hat{p}_T). \quad (18)$$

Goodman (1960) was also used to estimate $V(\hat{M}_R)$:

$$\hat{V}(\hat{M}_R) = M^2\left[\hat{p}_U^2\hat{V}(\hat{p}_{RF}) + \hat{p}_{RF}^2\hat{V}(\hat{p}_U) - \hat{V}(\hat{p}_{RF})\hat{V}(\hat{p}_U)\right], \quad (19)$$

where

$$\hat{V}(\hat{p}_{RF}) = (1 - \frac{n_{gsi}}{M}) \times \hat{V}(\hat{p}_{RF,gsi}), \quad (20)$$

and where the first term in Equation 20 is the finite population correction factor with n_{gsi} as the number of genetic samples taken at RKM 31.1 and $\hat{V}(\hat{p}_{RF,gsi})$ as the variance of the proportion of URRLR sockeye salmon provided by GSI.

Finally, $\hat{V}(\hat{p}_U)$ was estimated as follows:

$$\hat{V}(\hat{p}_U) = \sum_{k=1}^{K} w_k^2 \frac{\hat{p}_{Uk}(1-\hat{p}_{Uk})}{n_{Sk}-1}. \quad (21)$$

URRLR Sport Fishery Harvest Upstream of RKM 31.1

The sport fishery harvest upstream of RKM 31.1 was estimated indirectly by subtracting the total number of URRLR sockeye salmon past the Russian River weir from the estimated number of URRLR sockeye salmon past RKM 31.1 of the Kenai River.

Run Timing

Determining run timing of URRLR sockeye salmon was not an objective of this project. However, with temporally stratified harvest estimates and proportions of URRLR sockeye salmon in each fishery, we were able to investigate timing patterns of URRLR sockeye salmon in each fishery and passage at RKM 31.1.

RESULTS

TISSUE SAMPLING

Baseline

Baseline sampling results are reported in Barclay et al. (2010).

Mixtures

A total of 50,363 sockeye salmon were sampled for tissue suitable for genetic analysis from the UCI commercial fishery harvest in the years 2006–2008 and 23,336 samples were analyzed. These fish represented 283 individual collections representing 61 strata (Table 3 in Barclay et al. 2010). In the PU fishery, tissue samples from 4,847 sockeye salmon were suitable for genetic analysis and 1,803 samples were analyzed from 9 strata (Table 2). In the Kenai River sport fishery downstream of RKM 31.1, tissue samples from 3,886 sockeye salmon were suitable for genetic analysis and 1,199 samples were analyzed representing 6 strata (Table 3). At RKM 31.1, tissue samples from 5,122 sockeye salmon were suitable for genetic analysis and 5,108 samples were analyzed representing 21 strata (Table 4). Samples were temporally distributed within and among years for each fishery and at RKM 31.1.

Table 2.–Collection dates, number of samples collected, number of samples analyzed, and number of samples suitable for GSI analysis (N_{eff}) for the 2006, 2007, and 2008 personal use fishery collections.

		Personal use fishery samples[a]		
Year	Dates	Collected	Analyzed	N_{eff}
2006	10 Jul–16 Jul	679	242	224
	17 Jul–31 Jul	819	202	190
	3 Aug–10 Aug	435	194	145
	2006 Total	1,933	638	559
2007	10 Jul–16 Jul	169	168	151
	17 Jul–23 Jul	531	199	190
	24 Jul–31 Jul	860	199	198
	2007 Total	1,560	566	539
2008	10 Jul–16 Jul	181	181	177
	17 Jul–23 Jul	529	203	196
	24 Jul–31 Jul	644	215	190
	2008 Total	1,354	599	563
	Grand Total	4,847	1,803	1,661

[a] Units = number of sockeye salmon tissue samples (tips of axillary fins).

Table 3.–Collection dates, number of samples collected, number of samples analyzed, and number of samples suitable for GSI analysis (N_{eff}) for the 2006, 2007, and 2008 sport fishery downstream of RKM 31.1 collections.

		Sport fishery samples[a]		
Year	Dates	Collected[b]	Analyzed	N_{eff}
2006	1 Jul–2 Aug	451	189	181
	3 Aug–26 Aug	583	209	202
	2006 Total	1,034	398	383
2007	1 Jul–23 Jul	600	189	184
	24 Jul–22 Aug	1,265	212	206
	2007 Total	1,865	401	390
2008	2 Jul–22 Jul	591	212	209
	23 Jul–31 Jul	396	188	184
	2008 Total	987	400	393
	Grand Total	3,886	1,199	1,166

[a] Units = number of sockeye salmon tissue samples (tips of axillary fins).

[b] Collected downstream of RKM 31.1 fish wheels.

Table 4.–Collection dates, number of samples collected, number of samples analyzed, and number of samples suitable for GSI analysis (N_{eff}) for the 2006, 2007, and 2008 RKM 31.1 collections.

		RKM 31.1 samples[a]		
Year	Dates	Collected	Analyzed	N_{eff}
2006	3 Jul–19 Jul	153	152	152
	20 Jul–24 Jul	156	155	155
	25 Jul–29 Jul	143	142	141
	30 Jul–4 Aug	170	163	163
	5 Aug–10 Aug	149	149	149
	11 Aug–15 Aug	156	154	154
	16 Aug–22 Aug	202	201	201
	2006 Total	1,129	1,116	1,115
2007	3 Jul–22 Jul	226	226	221
	23 Jul–26 Jul	242	242	238
	27 Jul–1 Aug	208	208	208
	2 Aug–7 Aug	214	214	213
	08 Aug–10 Aug	172	172	167
	11 Aug–13 Aug	203	202	201
	14 Aug–23 Aug	267	267	260
	2007 Total	1,532	1,531	1,508
2008	8 Jul–17 Jul	399	399	380
	18 Jul–19 Jul	328	328	322
	20 Jul–22 Jul	338	338	334
	23 Jul–29 Jul	325	325	323
	30 Jul–1 Aug	400	400	382
	2 Aug–4 Aug	337	337	327
	5 Aug–17 Aug	334	334	318
	2008 Total	2,461	2,461	2,386
	Grand Total	5,122	5,108	5,009

[a] Units = number of sockeye salmon tissue samples (tips of axillary fins).

LABORATORY ANALYSIS

Laboratory Failure Rates and Quality Control

Failure and discrepancy rates for representative baseline and commercial fishery genotypes are reported in Barclay et al. (2010).

For the personal use fishery, genotypic failure rates among years ranged from 3.2% to 6.2% and discrepancy rates ranged from 0.09% to 0.36%. This discrepancy rate translated to a 0.05–0.18% estimated error rate in genotyping, assuming that half the errors occurred in the initial run and half in the quality-control process.

For the sport fishery, genotypic failure rates among years ranged from 2.6% to 3.4% and discrepancy rates ranged from 0.00% to 0.07%. This discrepancy rate translated to a 0.00–0.04% estimated error rate in genotyping, assuming that half the errors occurred in the initial run and half in the quality-control process.

For RKM 31.1, genotypic failure rates among years ranged from 0.5% to 3.3% and discrepancy rates ranged from 0.00% to 0.29%. This discrepancy rate translated to a 0.00–0.15% estimated error rate in genotyping, assuming that half the errors occurred in the initial run and half in the quality-control process.

DATA ANALYSIS

Data Retrieval and Quality Control and Baseline Development

Data retrieval and quality control results for the baseline and commercial fishery collections are reported in Barclay et al. (2010).

Based upon the criterion defined in Barclay et al. (2010), 15 duplicate individuals were removed from the PU fishery collections and 2 duplicate individuals were removed from the sport fishery collections. Of these duplicate individuals, 10 were removed from the 2006 PU fishery collection. Based upon the 80% marker able to be scored rule, 7.2%, 2.3%, and 1.8% of individuals were removed from the PU fishery, sport fishery, and RKM 31.1 collections, respectively.

Baseline development results, including test results for Hardy–Weinberg equilibrium and linkage disequilibrium, pooling of collections into populations, test results for temporal stability, and relationships among populations (populations structure) are reported in Barclay et al. (2010).

Baseline Evaluation for GSI

Proof Tests

In the proof test analyses using the 59-population Cook Inlet baseline, mixtures demonstrated high correct allocations for each reporting group (Table 5). In these tests, mixtures created from 200 genotypes from the “URRLR” and “Cook Inlet Other” reporting groups showed correct allocations greater than 99%. In tests using the reduced 13-population Kenai River baseline, mixtures created from 200 genotypes from the “URRLR” and “Kenai Other” reporting groups showed correct allocations greater than 99%.

Table 5.–Allocation proportions (P) and BAYES 90% credibility interval for mixtures of known fish removed from the baseline populations that contribute to each reporting group (proof tests).

		Sockeye salmon reporting groups								
		URRLR			Cook Inlet Other			Kenai Other		
			90% Credibility intervals			90% Credibility intervals			90% Credibility intervals	
Baseline	Mixture	P	5%	95%	P	5%	95%	P	5%	95%
Cook Inlet	URRLR	1.00	0.98	1.00	0.00	0.00	0.02			
	Cook Inlet Other	0.01	0.00	0.02	0.99	0.98	1.00			
Kenai River	URRLR	0.99	0.97	1.00				0.01	0.00	0.03
	Kenai Other	0.01	0.00	0.03				0.99	0.97	1.00

Note: "URRLR" = Upper Russian River late run; "Cook Inlet Other" = all other Cook Inlet including other non-URRLR Kenai River populations; "Kenai Other" = all other Kenai River populations.

Mixed Stock Analysis

UCI Commercial Fishery

Analyzed strata in the UCI commercial fishery harvest had sample sizes ranging between 100 and 400 fish with an average sample size of 383. Three collections were not subsampled due to a lack of adequate sample sizes to represent strata. No samples were collected from 21 strata; proportions of URRLR sockeye salmon from these strata were extrapolated from proximate sampled strata (Tables 6–8).

In the UCI commercial fishery, the contribution of URRLR sockeye salmon to the harvest was highest within the ESSN Kenai section and ranged from 2% to 7% (Tables 6, 7, and 8; Appendix A1). Within the ESSN Kasilof section, contribution of URRLR sockeye salmon to the harvest generally did not exceed 2%; however, in the late periods in 2007 (30 July–9 August) and 2008 (20–26 July) URRLR sockeye salmon contributed 5% and 3%, respectively. Within the CDD (openings not restricted to the corridor only), contribution of URRLR sockeye salmon ranged from 0% to 4% with only small differences between years. CDD corridor-only periods were only sampled during 2 time strata in 2006 and URRLR sockeye salmon contributed 0% and 3% in the early and late strata, respectively. For KRSHA drift and KRSHA set, the contribution of URRLR sockeye salmon to the harvest was less than 1% in 2006 and ranged from 0% to 2% in 2008 with later strata having higher contributions. KRSHA drift–set was not sampled in 2007. Within Kalgin set, URRLR sockeye salmon contributed 2% and 3% in both 2007 fishing periods (22 June–12 July and 16 July–18 August), respectively but did not exceed 1% in the 3 strata sampled in 2006 and 2008. Within Westside set, URRLR sockeye salmon contributed to only 1% of the set in the second period (12–31 July) in 2006. Within Eastside set, the contribution of URRLR sockeye salmon was 2% in 2006, 6% in 2007, and 4% in 2008. Within General set, less than 1% URRLR contribution was detected during sampled periods in 2008.

Table 6.–Estimated proportion and number of Upper Russian River late-run (URRLR) sockeye salmon harvested in Upper Cook Inlet commercial fisheries, Kenai River personal use dip net fishery, and Kenai River sport fishery downstream of RKM 31.1; proportion and number of URRLR sockeye salmon passing the fish wheels at Kenai River RKM 31.1; and total harvest and total run size estimates of URRLR sockeye salmon in 2006.

			Upper Russian River late-run estimates			
Data source and date(s) sampled	Mixed stock harvest (no. of fish)	N_{eff} [a]	Proportion	SE proportion	No. of fish	SE no. of fish
Upper Cook Inlet (UCI) commercial fishery						
Central District - drift gillnet (excluding corridor-only periods) (CDD)						
19 Jun–29 Jun	44,857	399	0.005	0.005	241	202
3 Jul–6 Jul	67,498	399	0.000	0.001	24	96
31 Jul	89,680	398	0.005	0.004	412	336
2 Aug	56,418	397	0.006	0.004	349	240
5 Aug–11 Aug	105,613	399	0.018	0.007	1,912	756
14 Aug–11 Sep[b]	6,320	NS	0.000	0.000	0	0
Subtotal	370,386	1,992			2,938	890
Central District - drift gillnet (corridor-only periods) (CDD corridor-only)						
30 Jun–1 Jul[c]	2,102	NS	0.000	0.000	0	0
7 Jul–8 Jul[c]	1,656	NS	0.000	0.000	0	0
10 Jul–13 Jul	3,313	199	0.000	0.002	1	6
17 Jul	15,370	300	0.029	0.010	448	153
1 Aug[d]	8,949	NS	0.029	0.010	261	89
3 Aug–8 Aug[d]	33,521	NS	0.029	0.010	977	334
Subtotal	64,911	499			1,688	378
Central District, Eastside Subdistrict, Kasilof section - set gillnet (ESSN Kasilof section)						
26 Jun–1 Jul	114,767	397	0.002	0.004	210	439
2 Jul–8 Jul	102,511	399	0.000	0.001	19	93
10 Jul–13 Jul	36,093	396	0.024	0.008	870	292
15 Jul–16 Jul	189,407	400	0.002	0.004	360	718
17 Jul–22 Jul	135,192	400	0.010	0.006	1,392	752
30 Jul–9 Aug	77,320	397	0.004	0.004	327	289
Subtotal	655,290	2,389			3,178	1,204
Central District, Eastside Subdistrict, Kenai section - set gillnet (ESSN Kenai section)						
10 Jul–13 Jul	16,826	398	0.040	0.011	672	187
17 Jul	29,728	397	0.066	0.013	1,955	387
31 Jul–9 Aug	261,276	397	0.024	0.008	6,192	2,167
Subtotal	307,830	1,192			8,818	2,209
Central District, Eastside Subdistrict, Kasilof River Special Harvest Area - drift, set gillnet (KRSHA drift–set)						
27 Jun–10 Jul[e]	60,131	NS	0.000	0.000	0	0
11 Jul–23 Jul	234,916	377	0.000	0.000	14	110
Subtotal	295,047	377			14	110
Central District, Eastside Subdistrict, Kasilof River Special Harvest Area - set gillnet (KRSHA set)						
24 Jul–29 Jul	182,426	398	0.005	0.004	829	696
Central District, Eastside Subdistrict, Kasilof River Special Harvest Area - drift gillnet (KRSHA drift)						
24 Jul–29 Jul	210,099	300	0.003	0.003	701	712

-continued-

Table 6.–Part 2 of 2.

Data source and date(s) sampled	Mixed stock harvest (no. of fish)	N_{eff} [a]	Upper Russian River late-run estimates: Proportion	SE proportion	No. fish	SE no. of fish
Upper Cook Inlet (UCI) commercial fishery (continued)						
Central District, Kalgin Island Subdistrict - set gillnet (Kalgin Island set)						
2 Jun–21 Jun[f]	14,644	NS	0.000	0.000	0	0
23 Jun–17 Aug	34,946	391	0.003	0.004	94	142
21 Aug–11 Sep[f]	501	NS	0.000	0.000	0	0
Subtotal	50,091	391			94	142
Central District, Westside Subdistrict - set gillnet (West Side set)						
19 Jun–10 Jul	11,353	396	0.000	0.000	0	1
12 Jul–31 Jul	19,815	395	0.007	0.005	142	91
2 Aug–28 Aug[f]	8,502	NS	0.000	0.000	0	0
Subtotal	39,670	791			142	91
Northern District, Eastern Subdistrict - set gillnet (ND Eastern set)						
27 May–6 Jul[f]	3,890	NS	0.000	0.000	0	0
7 Aug–14 Sep	5,527	388	0.021	0.008	117	44
Subtotal	9,417	388			117	
Northern District, General Subdistrict - set gillnet (ND General set)						
29 May–28 Aug[f]	3,036	NS	0.000	0.000	0	0
UCI Total	2,188,203	8,340			18,520	2,881
Kenai River personal use dip net fishery						
10 Jul–16 Jul	30,935	224	0.041	0.014	1,254	442
17 Jul–31 Jul	80,234	190	0.056	0.017	4,507	1,344
3 Aug–10 Aug	16,461	145	0.021	0.012	347	196
Total	127,630	559	0.048	0.011	6,107	1,432
Fish wheels - Kenai River (RKM 31.1)						
3 Jul–24 Aug		1,115	0.036	0.006	131,406	21,870
Kenai River sport fishery - downstream of RKM 31.1						
1 Jul–26 Aug	25,740	383	0.044	0.011	1,130	290
Total URRLR sockeye salmon harvest					68,004	22,107
Total URRLR sockeye salmon entering UCI					157,164	22,107

Note: "URRLR" = Upper Russian River late run; "NS" = not sampled; numbers may not sum to total due to rounding.

[a] Number of successfully screened fish from each stratum (N_{eff}) used for GSI analysis.

[b] Drift Areas 3 & 4, Chinitna Bay, pink salmon drift areas, and western half of Cook Inlet were the only areas fished during 14 Aug–11 Sep (Shields 2007a). Proportion URRLR (and SD) were assumed to be zero.

[c] Proportion URRLR (and SD) for periods 30 June–1 July and 7–8 July assumed to be zero based on 10–13 July period.

[d] Proportion URRLR (and SD) for periods 1 August and 3–8 August were assumed to be the same as 17 July period.

[e] Proportion URRLR (and SD) assumed to be zero based on 11–23 July period.

[f] Proportion URRLR (and SD) assumed to be zero based on timing and location of harvest.

Table 7.–Estimated proportion and number of Upper Russian River late-run (URRLR) sockeye salmon harvested in Upper Cook Inlet commercial fisheries, Kenai River dip net personal use fishery, and Kenai River sport fishery downstream of RKM 31.1; proportion and number of URRLR sockeye salmon passing the fish wheels at Kenai River RKM 31.1; and total harvest and total run size estimates of URRLR sockeye salmon in 2007.

Data source and date(s) sampled	Mixed stock harvest (no. of fish)	N_{eff} [a]	Upper Russian River late-run estimates: Proportion	SE proportion	No. of fish	SE no. of fish
Upper Cook Inlet commercial fishery						
Central District - drift gillnet (excluding corridor-only periods) (CDD)						
21 Jun–28 Jun	26,005	398	0.020	0.008	513	205
2 Jul–5 Jul	85,295	396	0.009	0.006	771	474
9 Jul–12 Jul	295,214	394	0.032	0.009	9,463	2,701
16 Jul	481,204	382	0.023	0.008	11,077	3,912
19 Jul	451,216	391	0.016	0.007	7,386	3,120
23 Jul–26 Jul	189,009	395	0.031	0.009	5,809	1,645
30 Jul–9 Aug	156,803	343	0.025	0.009	3,852	1,386
13 Aug–10 Sep[b]	2,184	NS	0.000	0.000	0	0
Subtotal	1,686,930	2,699			38,871	6,101
Central District - drift gillnet (corridor-only periods) (CDD corridor-only)						
29 Jun–14 Jul[c]	12,748	NS	0.000	0.002	6	22
21 Jul–10 Aug[c]	119,140	NS	0.029	0.010	3,473	1,186
Subtotal	131,888	0			3,479	1,187
Central District, Eastside Subdistrict, Kasilof section - set gillnet (ESSN Kasilof section)						
25 Jun–5 Jul	115,315	374	0.006	0.005	738	560
9 Jul–14 Jul	137,641	297	0.017	0.009	2,312	1,205
16 Jul–21 Jul	245,816	361	0.012	0.006	2,954	1,546
22 Jul–28 Jul	122,454	388	0.018	0.007	2,215	870
30 Jul–9 Aug	97,646	395	0.051	0.012	4,987	1,167
Subtotal	718,872	1,815			13,207	2,505
Central District, Eastside Subdistrict, Kenai section - set gillnet (ESSN Kenai section)						
9 Jul–12 Jul	10,625	389	0.033	0.010	350	103
16 Jul–19 Jul	51,623	387	0.044	0.012	2,273	634
21 Jul–28 Jul	338,985	394	0.019	0.007	6,534	2,530
30 Jul–9 Aug	217,671	371	0.051	0.012	11,199	2,596
Subtotal	618,904	1,541			20,355	3,681
Central District, Eastside Subdistrict, Kasilof River Special Harvest Area - set gillnet (KRSHA set)						
27 Jul–10 Aug[d]	15,631	NS	0.005	0.004	71	60
Central District, Eastside Subdistrict, Kasilof River Special Harvest Area - drift gillnet (KRSHA drift)						
27 Jul–10 Aug[d]	4,659	NS	0.003	0.003	16	16
Central District, Kalgin Island Subdistrict - set gillnet (Kalgin Island set)						
1 Jun–20 Jun[e]	12,799	NS	0.000	0.000	0	0
22 Jun–12 Jul	14,960	397	0.020	0.008	298	122
16 Jul–18 Aug	35,358	398	0.032	0.009	1,145	325
Subtotal	50,318	795			1,443	347

-continued-

Table 7.–Part 2 of 2.

Data source and date(s) sampled	Mixed stock harvest (no. of fish)	N_{eff} [a]	Upper Russian River late-run estimates: Proportion	SE proportion	No. of fish	SE no. of fish
Upper Cook Inlet commercial fishery (continued)						
Central District, Westside Subdistrict - set gillnet (West Side set)						
18 Jun–27 Aug	56,854	397	0.000	0.000	1	15
Northern District, Eastern Subdistrict - set gillnet (ND Eastern set)						
28 May–28 Jun[e]	1,253	NS	0.000	0.000	0	0
2 Jul–20 Aug	6,966	198	0.060	0.017	418	121
23 Aug–10 Sep[e]	1,003	NS	0.000	0.000	0	0
Subtotal	9,222	198			418	121
Northern District, General Subdistrict - set gillnet (ND General set)						
28 May–13 Sep[e]	8,245	NS	0.000	0.000	0	0
UCI Total	3,314,322	7,445			77,860	7,655
Kenai River personal use dip net fishery						
10 Jul–16 Jul	16,621	151	0.015	0.013	243	223
17 Jul–23 Jul	150,720	190	0.004	0.007	631	1,009
24 Jul–31 Jul	123,929	198	0.079	0.020	9,767	2,436
Total	291,270	539	0.037	0.009	10,642	2,644
Kenai River sport fishery - downstream of RKM 31.1						
1 Jul–22 Aug	62,225	390	0.052	0.012	3,237	735
Fish wheels - Kenai River (RKM 31.1)						
3 Jul–22 Aug		1,508	0.070	0.007	112,647	12,072
Total URRLR sockeye salmon harvest					151,319	14,555
Total URRLR sockeye salmon entering Upper Cook Inlet					204,387	14,555

Note: "URRLR" = Upper Russian River late run; "NS" = not sampled; numbers may not sum to total due to rounding.

[a] Number of successfully screened fish from each stratum (N_{eff}) used for GSI analysis.

[b] Drift Areas 3 & 4, Chinitna Bay, pink salmon drift areas, and western half of Cook Inlet were the only areas fished during 13 August–10 September (Shields 2007b). Proportion URRLR (and SD) were assumed to be zero.

[c] 2006 CDD corridor-only proportion URRLR (and SD) used to estimate proportion URRLR (and SD).

[d] 2006 Kasilof River special harvest area proportions (and SD) used to estimate 2007 estimates.

[e] Proportion URRLR (and SD) assumed to be zero based on timing and location of harvest.

Table 8.–Estimated proportion and number of Upper Russian River late-run (URRLR) sockeye salmon harvested in Upper Cook Inlet commercial fisheries, Kenai River personal use dip net fishery, and Kenai River sport fishery downstream of RKM 31.1; proportion and number of URRLR sockeye salmon passing the fish wheels at Kenai River RKM 31.1; and total harvest and total run size estimates of URRLR sockeye salmon in 2008.

			Upper Russian River late-run estimates			
Data source and date(s) sampled	Mixed stock harvest (no. of fish)	N_{eff} [a]	Proportion	SE proportion	No. of fish	SE no. of fish
Upper Cook Inlet commercial fishery						
Central District - drift gillnet (excluding corridor-only periods) (CDD)						
19 Jun–3 Jul	165,719	393	0.008	0.005	1,294	750
7 Jul–10 Jul	140,487	390	0.011	0.005	1,544	765
14 Jul–17 Jul	348,709	392	0.029	0.009	10,217	3,083
21 Jul–24 Jul	173,778	388	0.041	0.010	7,133	1,793
4 Aug–11 Sep[b]	1,802	NS	0.000	0.000	0	0
Subtotal	830,495	1,563			20,188	3,724
Central District - drift gillnet (corridor-only periods) (CDD corridor-only)						
28 Jun–12 Jul[c]	135,434	NS	0.00	0.00	0	0
Central District, Eastside Subdistrict, Kasilof section - set gillnet (ESSN Kasilof section)						
26 Jun–5 Jul	286,708	394	0.013	0.006	3,747	1,672
7 Jul–12 Jul	114,052	397	0.020	0.007	2,246	846
13 Jul–19 Jul	331,947	384	0.019	0.007	6,238	2,379
20 Jul–26 Jul	149,072	390	0.027	0.008	4,076	1,252
Subtotal	881,779	1,565			16,307	3,277
Central District, Eastside Subdistrict, Kenai section - set gillnet (ESSN Kenai section)						
10 Jul–17 Jul	252,012	379	0.048	0.011	12,092	2,882
21 Jul–24 Jul	108,946	392	0.066	0.013	7,189	1,402
Subtotal	360,958	771			19,281	3,205
Central District, Eastside Subdistrict, Kasilof River Special Harvest Area - drift, set gillnet (KRSHA drift–set)						
27 Jul–29 Jul	22,081	395	0.002	0.003	48	56
30 Jul–1 Aug	29,394	397	0.014	0.006	400	180
2 Aug–7 Aug	25,349	386	0.020	0.007	511	186
Subtotal	76,824	1,178			959	265
Central District, Kalgin Island Subdistrict - set gillnet (Kalgin Island set)						
2 Jun–26 Jun	16,385	397	0.001	0.005	25	80
30 Jun–16 Aug	25,988	398	0.006	0.004	145	104
Subtotal	42,373	795			169	131
Central District, Westside Subdistrict - set gillnet (Westside set)						
16 Jun–11 Aug	23,553	397	0.003	0.003	60	62
Northern District, Eastern Subdistrict - set gillnet (ND Eastern set)						
26 May–30 Jun [d]	4,275	NS	0.000	0.000	0	0
7 Jul–18 Aug	12,221	393	0.042	0.010	507	127
21 Aug–4 Sep[e]	156	NS	0.021	0.008	3	1
Subtotal	16,652	393			510	127

-continued-

Table 8.–Part 2 of 2.

Data source and date(s) sampled	Mixed stock harvest (no. of fish)	N_{eff} [a]	Upper Russian River late-run estimates: Proportion	SE proportion	No. of fish	SE no. of fish
Upper Cook Inlet commercial fishery (continued)						
Northern District, General Subdistrict - set gillnet (ND General set)						
26 May–30 Jun[d]	711	NS	0.000	0.000	0	0
3 Jul–25 Aug	8,867	396	0.000	0.000	0	1
Subtotal	9,578	396			0	1
UCI Total	2,377,646	7,058			57,475	5,914
Kenai River personal use dip net fishery						
10 Jul–16 Jul	40,580	177	0.059	0.018	2,410	738
17 Jul–23 Jul	122,742	196	0.075	0.019	9,213	2,340
24 Jul–31 Jul	70,787	190	0.120	0.024	8,528	1,676
Total	234,109	563	0.086	0.013	20,151	2,969
Kenai River sport fishery - downstream of RKM 31.1						
2 Jul–31 Jul	48,203	393	0.100	0.015	4,828	742
Fish wheels - Kenai River (RKM 31.1)						
8 Jul–17 Aug		2,386	0.098	0.006	92,226	7,767
Total URRLR sockeye salmon harvest					128,042	10,231
Total URRLR sockeye salmon entering Upper Cook Inlet					174,680	10,231

Note: "URRLR" = Upper Russian River late run; "NS" = not sampled; numbers may not sum to total due to rounding.

[a] Number of successfully screened fish from each stratum (N_{eff}) used for GSI analysis.

[b] Drift Areas 3 & 4, Chinitna Bay, pink salmon drift areas, and western half of Cook Inlet were only areas fished during 14 August–11 September (Shields 2009). Proportion URRLR (and SD) were assumed to be zero.

[c] Proportion URRLR (and SD) assumed to be zero based on 10–13 July period in 2006.

[d] Proportion URRLR (and SD) assumed zero to be based on timing and location of harvest.

[e] Proportion URRLR (and SD) assumed same as Northern district, eastern subdistrict 7 August–14 September period in 2006

Personal Use Fishery

From 9 fishery strata sampled over 3 years (2006–2008), 1,803 fish were subsampled to create 9 temporal mixtures for which the stock composition was estimated (Table 2). For these strata, sample sizes ranged from 168 to 242 fish. The contribution of URRLR sockeye salmon to the harvest ranged from 2% to 6% in 2006, 0% to 8% in 2007, and 6% to 12% in 2008 (Figure 2; Tables 6, 7, and 8).

Sport Fishery Downstream of RKM 31.1

From 6 fishery strata sampled over 3 years (2006–2008), 1,199 fish were subsampled to create 6 temporal and 3 composite mixtures from which the stock composition was estimated (Table 3). Sample sizes ranged from 188 to 212 fish for temporal strata and 398 to 401 fish for the composite strata. The contribution of URRLR sockeye salmon to the harvest ranged from 4% to 5% between strata in 2006, 2% to 8% in 2007, and 6% to 14% in 2008 (Figure 3). The contribution of URRLR sockeye salmon among the yearly composite mixtures was 4% in 2006, 5% in 2007, and 10% in 2008 (Figure 3; Tables 6, 7, and 8).

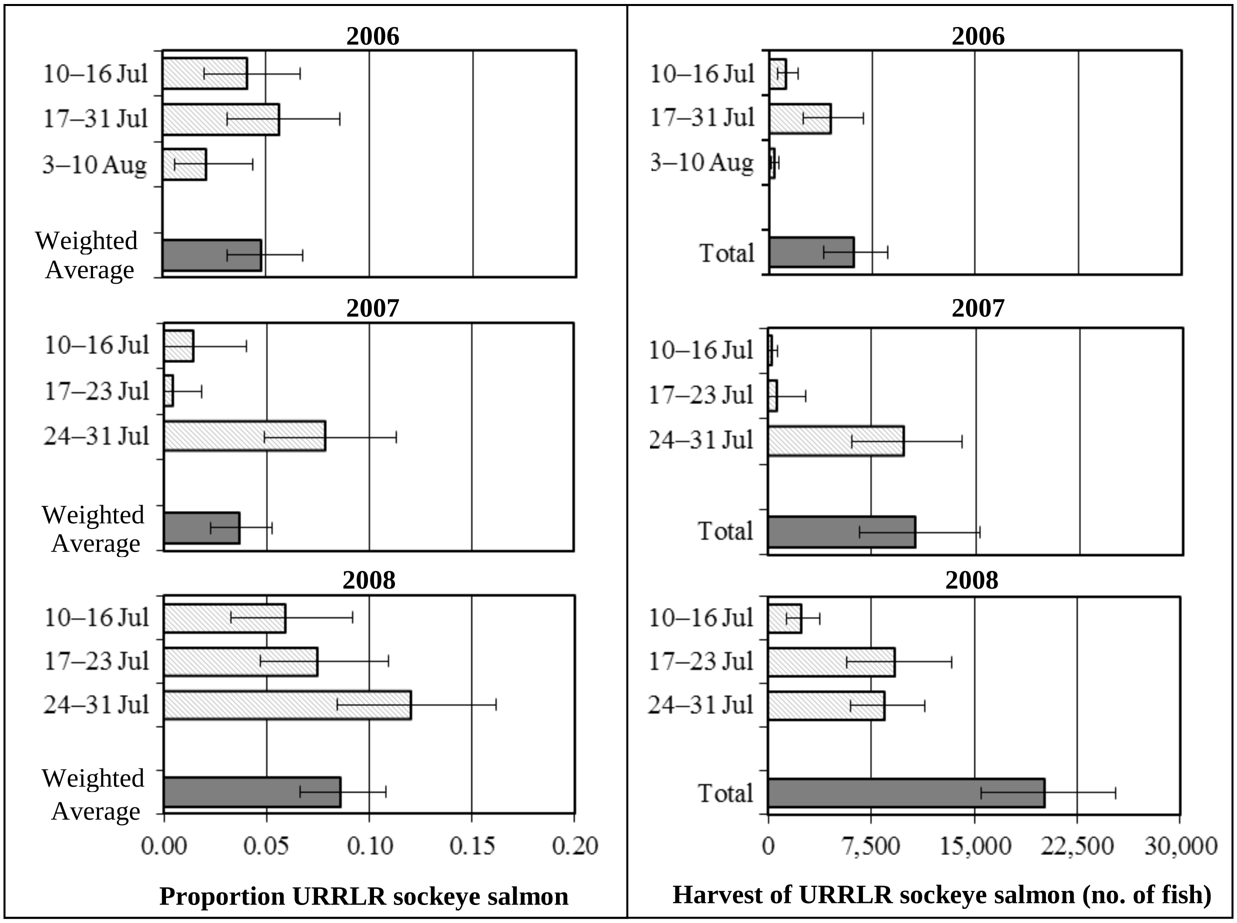

Figure 2.–Proportion (left) and harvest (right) of Upper Russian River late-run sockeye salmon in the Kenai River personal use fishery with 90% credibility intervals, 2006–2008.

Note: "URRLR" = Upper Russian River late run.

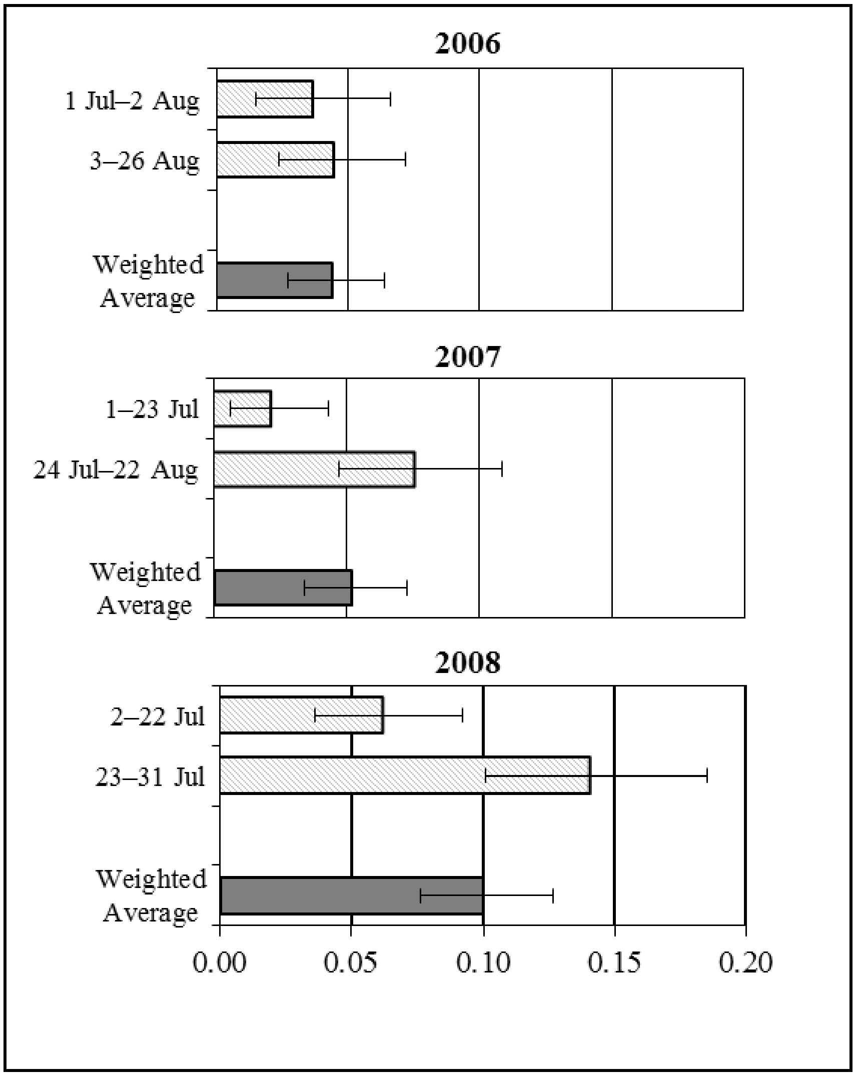

Figure 3.–Proportion and 90% credibility intervals of Upper Russian River late-run sockeye salmon in the Kenai River sport fishery downstream of RKM 31.1, 2006–2008.

Note: "URRLR" = Upper Russian River late run.

RKM 31.1

From 21 fishery strata sampled over 3 years (2006–2008), 5,108 fish were subsampled to create 21 temporal and 3 composite mixtures for which the stock composition was estimated (Table 4). These mixtures had sample sizes ranging from 142 to 400 fish for the temporal strata and 1,116 to 2,461 fish for the composite strata. In the 7 temporal mixtures from RKM 31.1 for each year, contribution of URRLR sockeye salmon ranged from 1% to 6% in 2006, 2% to 13% in 2007, 5% to 17% in 2008 (Figure 4; Table 9). The weighted average proportion of the contribution of URRLR sockeye salmon was 4% in 2006, 7% in 2007, and 10% in 2008.

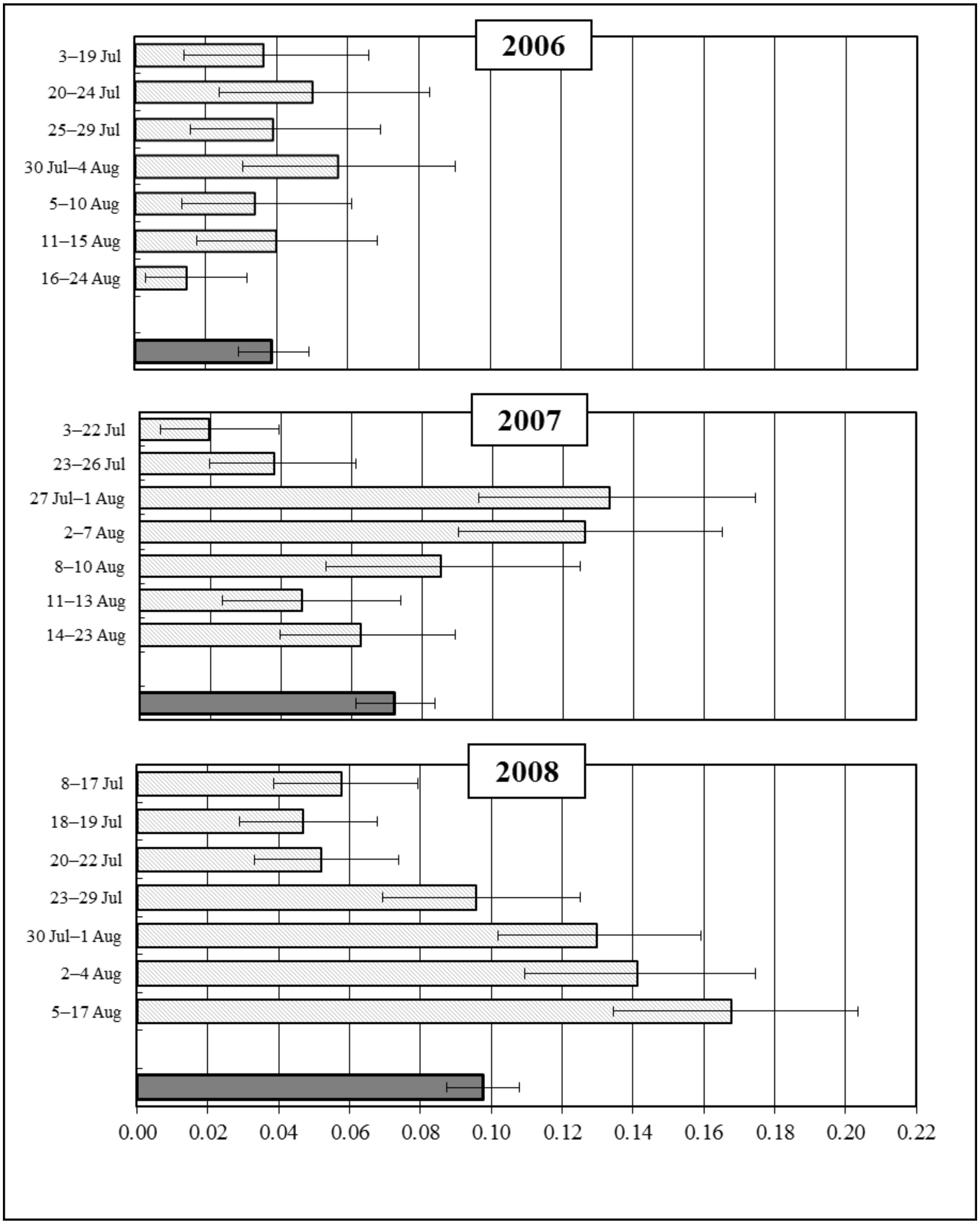

Figure 4.–Proportion and 90% credibility intervals of Upper Russian River late-run sockeye salmon in fish wheel samples collected for PIT tagging at RKM 31.1 on the Kenai River, 2006–2008.

Note: “URRLR” = Upper Russian River late run.

Table 9.–Number of sockeye salmon captured and PIT-tagged at the RKM 31.1 fish wheels and the estimated proportion of Upper Russian River late-run sockeye salmon with 90% credibility intervals by temporal strata for each year, 2006–2008.

				Upper Russian River late-run estimates			
		PIT-tagged				90% credibility intervals	
Year	Dates	(no. of fish)	N_{eff} [a]	Proportion	SE proportion	5%	95%
2006	3–19 Jul	420	152	0.04	0.02	0.01	0.07
	20–24 Jul	904	155	0.05	0.02	0.02	0.08
	25–29 Jul	867	141	0.04	0.02	0.02	0.07
	30 Jul–4 Aug	1,043	163	0.06	0.02	0.03	0.09
	5–10 Aug	974	149	0.03	0.01	0.01	0.06
	11–15 Aug	1,013	154	0.04	0.02	0.02	0.07
	16–24 Aug	1,643	201	0.01	0.01	0.00	0.03
	Total	6,864	1,115	0.04	0.01	0.03	0.05
2007	3–22 Jul	1,351	221	0.02	0.01	0.01	0.04
	23–26 Jul	1,271	238	0.04	0.01	0.02	0.06
	27 Jul–1 Aug	877	208	0.13	0.02	0.10	0.17
	2–7 Aug	1,276	213	0.13	0.02	0.09	0.17
	8–10 Aug	1,100	167	0.09	0.02	0.05	0.12
	11–13 Aug	978	201	0.05	0.02	0.02	0.07
	14–23 Aug	1,176	260	0.06	0.02	0.04	0.09
	Total	8,029	1,508	0.07	0.01	0.06	0.08
2008	8–17 Jul	838	380	0.06	0.01	0.04	0.08
	18–19 Jul	649	322	0.05	0.01	0.03	0.07
	20–22 Jul	689	334	0.05	0.01	0.03	0.07
	23–29 Jul	653	323	0.10	0.02	0.07	0.13
	30 Jul–1 Aug	791	382	0.13	0.02	0.10	0.16
	2–4 Aug	631	327	0.14	0.02	0.11	0.17
	5–17 Aug	666	318	0.17	0.02	0.13	0.20
	Total	4,917	2,386	0.10	0.01	0.09	0.11

[a] Number of successfully screened fish from each stratum (N_{eff}) used for GSI analysis.

RKM 31.1 Mark–Recapture Assumptions

The 5 assumptions (underlined below) principal to the 2-event mark–recapture experiment to estimate passage of URRLR sockeye salmon at RKM 31.1 were assumed to have been met for the following reasons:

1) Closed population: there was no recruitment but there was fishing mortality, making the abundance estimate germane only to RKM 31.1, where the tagging took place.
2) Equal probability of capture for all sockeye salmon in the first or second event or complete mixing between events: there was an equal probability of capture in the second event where all fish passing through the Russian River weir were scanned for marks.
3) No loss of mark: essentially no PIT-tag loss was detected in the Kenai River sockeye salmon mark–recapture study (Willette et al. 2012).
4) Tagged fish do not behave differently from untagged fish: most PIT-tagged and radiotagged sockeye salmon migrated upstream beyond RKM 31.1.

5) Marked fish are identified in the second event: daily tag detection studies and multiple tag readers at the Russian River weir ensured marks were identified in the second event (Willette et al. 2012).

2006 Run Reconstruction

UCI Commercial Fishery Harvest

A total of 16,914 tissue samples were collected in the commercial fishery (Barclay et al. 2010) of which 8,340 samples were used in mixtures to estimate stock-specific harvest (Table 6). The ESSN Kenai section harvested the most URRLR sockeye salmon (8,818; SE 2,209), followed by ESSN Kasilof section (3,178; SE 1,204), CDD (2,938; SE 890), CDD corridor-only (1,688; SE 378), and KRSHA drift–set (1,545; SE 1,002) (Table 6). The remaining URRLR sockeye salmon commercial harvest totaled 354 fish (SE 175). The total commercial harvest of URRLR sockeye salmon in 2006 was 18,520 fish (SE 2,881; Table 6).

The UCI sockeye salmon harvest was 2.188 million fish in 2006 (Shields 2007a) of which 2.044 million sockeye salmon (~93%) were represented through GSI sampling and 0.143 million (~7%) were not (i.e., no tissue samples were collected or analyzed for GSI; Table 10).

The majority of non-GSI represented harvest (74%) occurred in the KRSHA drift–set (60,131 fish) and CDD corridor-only (46,228 fish). The rest of the non-GSI represented harvest was from Westside set (2–28 August; 8,502 fish), Kalgin Island set (15,145 fish), CDD (14 August–11 September; 6,320 fish), ND Eastern set (27 May–6 July; 3,890 fish), and ND General set (3,036 fish; Table 6).

The return of sockeye salmon to UCI in 2006 represented the latest run timing ever observed (Shields and Willette 2008). The late run timing was not immediately realized, which resulted in emergency orders to close commercial fishing and limit sockeye salmon harvest. Once the late run timing was realized, a large portion of sockeye salmon had already returned to the Kenai River.

Table 10.–Number of Upper Russian River late-run sockeye salmon harvested and 90% credibility intervals from all sockeye salmon captured in the Upper Cook Inlet commercial set and drift gillnet fisheries in 2006, 2007, and 2008.

	Sockeye salmon (no. of fish)						
	Upper Russian River late-run				All Upper Cook Inlet [a]		
			90% credibility intervals		GSI represented	Total	Non GSI represented
Year	Harvest [b]	SD	5%	95%	harvest	harvest	harvest [c]
2006	17,282	2,856	12,947	22,270	2,044,951	2,188,203	143,252
2007	74,295	7,546	62,454	87,225	3,136,660	3,314,322	177,662
2008	57,472	5,908	48,158	67,528	2,235,268	2,377,646	142,378

Note: BAYES with a sequential prior (see detailed methods in text) was used to estimate the proportions.

[a] "GSI" = genetic stock identification.

[b] Equals the number of sockeye salmon harvested for all strata for each year; derived from the harvest numbers and proportions in Tables 6, 7, and 8.

[c] Excludes unrepresented sockeye salmon harvest from Kustatan (e.g., 3,896 fish [2006], 2,453 fish [2007], and 1,852 fish [2008]) and Chinitna (108 fish [2006], 4 fish [2007], and 4 fish [2008]) subdistricts.

Kenai River PU Fishery Harvest

A total of 1,933 tissue samples were collected from the PU fishery in 2006 (Table 2). Of those, 559 samples suitable for genetic analysis were used in mixtures to estimate proportions and total harvest of URRLR sockeye salmon in the PU fishery: 224 in week 1 (10–16 July), 190 in week 2 (17–31 July), and 145 in week 3 (3–10 August) (Tables 2 and 6). Harvest during week 1 was 30,935 sockeye salmon of which 1,254 (SE 442) were URRLR fish (4%, SE 1%). During week 2, harvest was 80,234 sockeye salmon of which 4,507 (SE 1,344) were URRLR fish (6%, SE 2%). During week 3, harvest was 16,461 sockeye salmon of which 347 (SE 196) were URRLR fish (2%, SE 1%). The total Kenai River sockeye salmon PU harvest in 2006 was 127,630 fish (SE 183; Dunker and Lafferty 2007), whereas total harvest of URRLR sockeye salmon was 6,107 fish (SE 1,432; Table 6; Figure 2).

Several emergency closures and openers occurred during 2006. The fishery was closed by emergency order on 22 July, reopened by emergency order during 31 July, closed by regulation on 1 August, and then reopened again by emergency order during 3–10 August. The Kenai River sockeye salmon run was so late that many sockeye salmon entered the river after the fishery closed despite the 3–10 August emergency opening. Consequently, despite a large return of sockeye salmon to the Kenai River, the PU harvest was approximately half the recent 5-year average (Dunker and Lafferty 2007; Dunker 2010). The total harvest of URRLR sockeye salmon in the PU fishery was approximately 4% of the total PU sockeye salmon harvest.

Sport Fishery Harvest Downstream of RKM 31.1

Tissue samples were collected from 1,034 harvested sockeye salmon downstream of RKM 31.1 from 1 July to 26 August (Table 3). A total of 383 tissue samples suitable for genetic analysis were used in mixtures to estimate proportions and total harvest of URRLR sockeye salmon: 181 in stratum 1 (1 July–2 August) and 202 in stratum 2 (3–26 August). The estimated proportion of URRLR sockeye salmon in the sport fishery harvest was 0.04 (SE 0.01) overall (composite mixture): 0.037 in stratum 1 and 0.044 in stratum 2 (Figure 3). Using these proportions, SWHS harvest estimates, and angler counts upstream and downstream of the RKM 31.1 sockeye sonar, the estimated total sport fishery harvest of URRLR sockeye salmon downstream of RKM 31.1 was 1,130 fish (SE 290; Table 6).

Passage at RKM 31.1

In 2006, 6,864 sockeye salmon captured in fish wheels at RKM 31.1 were marked with PIT tags from 3 July to 24 August (Table 9). A total of 1,129 tissue samples from PIT-tagged sockeye salmon were collected; 1,115 samples were suitable for genetic analysis and used in mixtures to estimate passage of URRLR sockeye salmon at RKM 31.1 (Tables 4 and 6). Samples were divided into 7 strata with approximately 150 fish per stratum (Table 9). The highest proportion of URRLR sockeye salmon (0.06, SE 0.02) was observed during the 30 July–4 August stratum (Table 9; Figure 4). The lowest proportion of URRLR sockeye salmon (0.01, SE 0.01) was observed during the 16–24 August stratum. The weighted average proportion of URRLR sockeye salmon in RKM 31.1 fish wheel samples was 0.04 (SE < 0.01), which suggests that 250 (SE 36) URRLR sockeye salmon were marked with PIT tags at RKM 31.1.

Based on the estimated survival rate of PIT-tagged sockeye salmon (93%, SE 2%; Willette et al. 2012), an estimated 231 (SE 34) PIT-tagged URRLR sockeye salmon survived tagging to migrate upstream.

During the recapture event at the Russian River weir, 89,160 sockeye salmon passed through the weir from 15 July to 5 September. The PIT-tag detection system was not operational until 21 July and 3,235 sockeye salmon passed the weir from 15 to 20 July. The first PIT-tagged fish was detected on 24 July. A total of 156 PIT-tagged sockeye salmon were detected at the Russian River weir. Using Bailey's binomial model, an estimated 131,406 (SE 21,870) URRLR sockeye salmon passed the RKM 31.1 fish wheels (Table 6).

Total Run–2006

Estimated total run size of URRLR sockeye salmon was 157,164 fish (SE 22,107), which yielded a 95% relative precision (RP) of 28% (Table 6). Total harvest of URRLR sockeye salmon was 68,004 fish (SE 22,107), corresponding to an exploitation rate of 43%. Commercial, PU, and SF harvests comprised 27%, 9%, and 64% of the total URRLR sockeye salmon harvest, respectively (Table 11). The sport fishery downstream of RKM 31.1 accounted for 2% of harvest. The sport fishery upstream of RKM 31.1 (42,246 fish; SE 21,870) accounted for 62% of harvest.

2007 Run Reconstruction

UCI Commercial Fishery Harvest

A total of 17,972 tissue samples were collected in the UCI commercial fishery (Barclay et al. 2010) of which 7,445 samples were used in mixtures to estimate stock-specific harvest (Table 7). CDD (including CDD corridor-only) harvested the most URRLR sockeye salmon (42,350; SE 6,215), followed by the ESSN Kenai section (20,355; SE 3,681) and the ESSN Kasilof section (13,207; SE 2,505). The remaining URRLR sockeye salmon commercial harvest totaled 1,948 (SE 373). The total commercial harvest of URRLR sockeye salmon in 2007 was 77,860 fish (SE 7,655).

The UCI commercial fishery sockeye salmon harvest was approximately 3.314 million fish in 2007 (Shields 2007b) of which 3.137 million sockeye salmon (~95%) were represented through GSI sampling and 0.178 million sockeye salmon (~5%) were not (Table 10). The majority of non-GSI represented harvest (74%) occurred in the CDD corridor-only periods (131,888 fish). The remainder of the non-GSI represented harvest occurred in KRSHA drift and KRSHA set (20,290 fish), Kalgin Island set (1–20 June; 12,799 fish), ND General set (8,245 fish), and ND Eastern set (28 May–28 June, 23 Aug–10 September; 2,256 fish), as well as in the late period (13 August–10 September) in CDD (2,184 fish) (Table 7).

Kenai River PU Fishery Harvest

A total of 1,560 tissue samples were collected from the PU fishery in 2007 (Table 2). Of those, 539 samples suitable for genetic analysis were used in mixtures to estimate proportions and total harvest of URRLR sockeye salmon in the PU fishery: 151 in week 1 (10–16 July), 190 in week 2 (17–23 July), and 198 in week 3 (24–31 July; Tables 2 and 7). Harvest during week 1 was 16,621 sockeye salmon of which 243 (SE 223) were URRLR fish (1%, SE 1%). During week 2, harvest was 150,720 sockeye salmon of which 631 (SE 1,009) were URRLR fish (0.4%, SE 1.0%). During week 3, harvest was 123,929 sockeye salmon of which 9,767 (SE 2,436) were URRLR fish (8%, SE 2%). The total Kenai River sockeye salmon PU harvest in 2007 was 291,270 (SE 335 fish [Dunker 2010]) of which 10,642 (SE 2,644) were URRLR sockeye salmon (Table 7; Figure 2).

Table 11.–Run reconstruction summaries by year for Upper Russian River late-run sockeye salmon entering Upper Cook Inlet (UCI), Alaska, 2006–2008.

	Upper Russian River late-run sockeye salmon estimates											
	2006		2007		2008		Proportion of total run			Proportion of total harvest		
Data sources	No. fish	SE	No. fish	SE	No. fish	SE	2006	2007	2008	2006	2007	2008
UCI commercial harvest												
Eastside set gillnet - Kasilof section	3,178	1,204	13,207	2,505	16,307	3,277	0.02	0.06	0.09	0.05	0.09	0.13
Eastside set gillnet - Kenai section	8,818	2,209	20,355	3,681	19,281	3,205	0.06	0.10	0.11	0.13	0.13	0.15
Subtotal[a]	11,996	2,516	33,562	4,453	35,589	4,583	0.08	0.16	0.20	0.18	0.22	0.28
Central District drift gillnet[a]	4,625	967	42,350	6,215	20,188	3,724	0.03	0.21	0.12	0.07	0.28	0.16
Kasilof River Special Harvest Area[b]	1,545	1,002	87	62	959	265	0.01	0.00	0.01	0.02	0.00	0.01
All other UCI	354	175	1,861	368	740	193	0.00	0.01	0.00	0.01	0.01	0.01
Total UCI commercial harvest	18,520	2,881	77,860	7,655	57,475	5,914	0.12	0.38	0.33	0.27	0.51	0.45
Kenai River PU dip net harvest	6,107	1,432	10,642	2,644	20,151	2,969	0.04	0.05	0.12	0.09	0.07	0.16
Kenai River sport harvest												
Below RKM 31.1	1,130	290	3,237	735	4,828	742	0.01	0.02	0.03	0.02	0.02	0.04
Above RKM 31.1[c]	42,246	21,870	59,579	12,072	45,588	7,767	0.27	0.29	0.26	0.62	0.39	0.36
Total Kenai River sport harvest	43,376	21,872	62,816	12,094	50,416	7,802	0.28	0.31	0.29	0.64	0.42	0.39
Total harvest (all fisheries combined)	68,004	22,107	151,319	14,555	128,042	10,231						
Estimated URRLR passage at RKM 31.1[d]	131,406	21,870	112,647	12,072	92,226	7,767	0.84	0.55	0.53	NA	NA	NA
Russian River weir passage (Escapement)	89,160		53,068		46,638		0.57	0.26	0.27	NA	NA	NA
Total run	157,164	22,107	204,387	14,555	174,680	10,231						

Note: "NA" = not applicable. Numbers may not sum to totals due to rounding.

[a] Does not include harvest of URRLR sockeye salmon in Kasilof River Special Harvest Area.

[b] Includes all set and drift gillnet harvests of sockeye salmon in Kasilof River Special Harvest Area.

[c] Sport fishery above RKM 31.1 includes all URRLR sockeye salmon removals from RKM 31.1 to Russian River weir.

[d] Estimated using genetics and mark–recapture data.

Sport Fishery Harvest Downstream of RKM 31.1

Tissue samples were collected from 1,865 sockeye salmon downstream of RKM 31.1 from 1 July to 22 August (Table 3). A total of 390 tissue samples suitable for genetic analysis were used in mixtures to estimate proportions and total harvest of URRLR sockeye salmon: 184 in stratum 1 (1–23 July) and 206 in stratum 2 (24 July–22 August). The estimated proportion of URRLR sockeye salmon was 0.05 (SE 0.01) overall: 0.02 in stratum 1 and 0.08 in stratum 2 (Figure 3). The total sport fishery harvest of URRLR sockeye salmon downstream of RKM 31.1 was 3,237 fish (SE 735; Table 7).

Passage at RKM 31.1

In 2007, 8,029 sockeye salmon captured in fish wheels at RKM 31.1 were marked with PIT tags (Table 9). A total of 1,532 tissue samples were collected from PIT-tagged sockeye salmon of which 1,508 tissue samples suitable for genetic analysis were used in mixtures to estimate proportions and passage of URRLR sockeye salmon at RKM 31.1 (Tables 4 and 9). Samples were divided into 7 strata with approximately 215 fish per stratum. Proportion of URRLR sockeye salmon peaked at 0.13 during the 27 July–1 August and 2–7 August strata (Table 9; Figure 4). The weighted average proportion of URRLR fish in fish wheel samples was 0.07 (SE < 0.01) suggesting that 573 (SE 49) URRLR sockeye salmon were marked with PIT tags at RKM 31.1.

Based on the estimated survival rate of PIT-tagged sockeye salmon (93%, SE 2%; Willette et al. 2012), an estimated 533 (SE 46) PIT-tagged URRLR sockeye salmon survived the tagging event to migrate upstream.

During the recapture event at the Russian River weir, 53,068 sockeye salmon were examined for PIT tags from 15 July to 12 September and 250 fish with PIT tags were detected. It was estimated that 112,647 (SE 12,072) URRLR sockeye salmon passed RKM 31.1 (Table 7).

Total Run–2007

Total run size of URRLR sockeye salmon that entered UCI in 2007 was 204,387 fish (SE 14,555; RP 14%) (Table 7). Total harvest of URRLR sockeye salmon was 151,319 fish (SE 14,555), corresponding to a harvest rate of 74%. Commercial, PU, and SF harvests comprised 51%, 7%, and 42%, of the total URRLR sockeye salmon harvest, respectively (Table 11). The sport fishery downstream of RKM 31.1 accounted for 2% of the harvest. The sport fishery upstream of RKM 31.1 (59,579 fish; SE 12,072) accounted for 39% of harvest.

2008 RUN RECONSTRUCTION

UCI Commercial Fishery Harvest

A total of 15,477 tissue samples were collected (Barclay et al. 2010) in the commercial fishery of which 7,058 samples were used in mixtures to estimate stock-specific harvest (Table 8). The CDD harvested the most URRLR sockeye salmon (20,188; SE 3,724), followed by the ESSN Kenai section (19,281; SE 3,205) and the ESSN Kasilof section (16,307; SE 3,277). The remaining URRLR sockeye salmon commercial harvest totaled 1,698 fish (SE 327). The total commercial harvest of URRLR sockeye salmon in 2008 was 57,475 fish (SE 5,914).

The UCI commercial fishery harvest of sockeye salmon was approximately 2.378 million fish in 2008 (Shields 2009) of which 2.235 million sockeye salmon (~94%) were represented through

GSI sampling and 0.142 million (~6%) sockeye salmon were not (Table 10). Over 95% (135,434) of non-GSI represented harvest occurred in the CDD corridor-only periods. The remainder occurred in the ND Eastern set 26 May–30 June stratum (4,431 fish), the ND General set 26 May–30 June stratum (711 fish), and CDD 4 August–11 September stratum (1,802 fish; Table 8).

Kenai River PU Fishery Harvest

A total of 1,354 tissue samples were collected from the PU fishery in 2008 (Table 2). Of those, 563 samples suitable for genetic analysis were used in mixtures to estimate proportions and total harvest of URRLR sockeye salmon in the PU fishery: 177 in week 1 (10–16 July), 196 in week 2 (17–23 July), and 190 in week 3 (24–31 July) (Table 2 and Table 8). Harvest during week 1 was 40,580 sockeye salmon of which 2,410 (SE 738) were URRLR fish (6%, SE 2%). During week 2, harvest was 122,742 sockeye salmon of which 9,213 (SE 2,340) were URRLR fish (8%, SE 2%). During week 3, harvest was 70,787 sockeye salmon of which 8,528 (SE 1,676) were URRLR fish (12%, SE 2%). The total Kenai River sockeye salmon PU harvest in 2008 was 234,109 (SE 338; Dunker 2010) of which 20,151 (SE 2,969) were URRLR sockeye salmon (Table 8; Figure 2).

Sport Fishery Harvest Downstream of RKM 31.1

To meet escapement goals, an emergency order in the sport fishery closed the Kenai River downstream of RKM 31.1 to fishing for sockeye salmon, effective 1 August. Consequently, no sampling was conducted after the emergency order took effect. Due to the shortened season, sport fishery collections were stratified with shorter time periods than in 2006 and 2007, from 2 to 22 July (stratum 1) and from 23 to 31 July (stratum 2).

Tissue samples were collected from 987 sockeye salmon downstream of RKM 31.1 from 2 to 31 July (Table 3). A total of 393 tissue samples suitable for genetic analysis were used in mixtures to estimate proportions and total harvest of URRLR sockeye salmon: 209 in stratum 1 (2–22 July) and 184 in stratum 2 (23–31 July). The estimated proportion of URRLR sockeye salmon in the sport fishery harvest was 0.10 (SE 0.02) overall: 0.06 in stratum 1 and 0.14 in stratum 2 (Figure 3). The total sport fishery harvest of URRLR sockeye salmon downstream of RKM 31.1 was 4,828 fish (SE 742; Table 8).

Passage at RKM 31.1

In 2008, 4,917 sockeye salmon captured in fish wheels from 8 July to 17 August at RKM 31.1 were marked with PIT tags (Table 9). A total of 2,461 tissue samples were collected from PIT-tagged sockeye salmon of which 2,386 tissue samples suitable for genetic analysis were used in mixtures to estimate passage of URRLR sockeye salmon at RKM 31.1. Samples were divided into 7 strata with approximately 340 fish per stratum. The proportion of URRLR sockeye salmon in the fish wheel samples decreased slightly from 0.06 during 8–17 July to 0.05 during 18–19 July then increased thereafter (Table 9; Figure 4). The weighted average proportion of URRLR sockeye salmon in fish wheel samples was 0.10 (SE < 0.01), suggesting that an estimated 480 (SE 22) URRLR sockeye salmon were marked with PIT tags at RKM 31.1.

Based on the estimated survival rate of PIT-tagged sockeye salmon (90%, SE 2%; Willette et al. 2012), an estimated 433 (SE 22) PIT-tagged URRLR sockeye salmon survived the tagging event to migrate upstream.

During the recapture event at the Russian River weir, 46,638 sockeye salmon were examined for PIT tags from 15 July to 11 September and 218 fish with PIT tags were detected, suggesting that an estimated 92,226 (SE 7,767) URRLR sockeye salmon passed RKM 31.1 (Table 8).

Total Run–2008

The total run size of URRLR sockeye salmon that entered UCI in 2008 was estimated to be 174,680 fish (SE 10,231; RP 11%; Table 8). Total harvest of URRLR sockeye salmon was 128,042 fish (SE 10,231), corresponding to a harvest rate of 73%. Commercial, PU, and SF harvests comprised 45%, 16%, and 39% of the total URRLR sockeye salmon harvest, respectively (Table 11). The sport fishery downstream of RKM 31.1 accounted for 4% of the total harvest. The sport fishery upstream of RKM 31.1 (45,588 fish, SE 7,767) accounted for 36% of the harvest.

HARVEST OF URRLR SOCKEYE SALMON BY YEAR AND FISHERY

The UCI commercial fishery harvested 12%, 38%, and 33% of the URRLR sockeye salmon runs in 2006–2008 (Table 11). Within the commercial fishery, the CDD (CDD corridor-only included) harvested 3% of the run in 2006, 21% in 2007, and 12% in 2008, whereas the ESSN fishery (Kenai and Kasilof sections included) harvested 8% of the run in 2006, 16% in 2007, and 20% in 2008. The ESSN Kenai section harvested more URRLR sockeye salmon than the ESSN Kasilof section. The combined total for Kalgin Island set, Westside set, ND Eastern, and ND General set accounted for only about 1% of the run each year. The PU fishery harvested 4% of the run in 2006, 5% in 2007, and 12% in 2008. The sport fishery harvested 28% of the run in 2006, 31% in 2007, and 29% in 2008.

For 2006–2008, the commercial fishery harvested on average 28% of the run, with the ESSN fishery harvesting 14%, the CDD fishery harvesting 12%, the KRSHA fishery harvesting 1%, and all other areas combined harvesting 1%. For the PU fishery, the average harvest was 7% of the run and for the sport fishery average harvest was 29% of the run.

RUN TIMING

2006

Peak harvest and proportions of URRLR sockeye salmon in the ESSN Kasilof section occurred during 17–22 July, whereas in the ESSN Kenai section, a peak occurred during 31 July–9 August (Table 6). In the CDD, a peak occurred during 5–11 August. Similarly, for CDD corridor-only periods, the peak occurred during 3–8 August. In the PU fishery, a peak occurred during week 2 (17–31 July; Figure 2). During the sport fishery downstream of RKM 31.1, the later time stratum (3–26 August) had a slightly higher proportion of URRLR sockeye salmon than the earlier time stratum (1 July–2 August; Figure 3). For RKM 31.1 fish wheel samples, the proportion of URRLR sockeye salmon was highest during 30 July–4 August, although the peak was not prominent (Table 9; Figure 4).

2007

Peak harvest of URRLR sockeye salmon in the ESSN Kasilof section occurred in the last stratum (30 July–9 August), although harvest was relatively high in each of 3 previous strata (7–14 July, 16–21 July, and 22–28 July; Table 7). For the ESSN Kenai section, a peak occurred during the last stratum (30 July–9 August). For the CDD, highest catches and proportions occurred during

9–12 July, 16 July, and 19 July strata. However, in the CDD, the proportion of URRLR sockeye salmon did not vary greatly between any strata for the entire year. In the PU fishery, harvest of URRLR sockeye salmon was very low during the first 2 weeks (10–16 July, 17–23 July), then a prominent peak occurred during week 3 (24–31 July) when over 90% of the harvest of URRLR sockeye salmon occurred (Figure 2). During the sport fishery downstream of RKM 31.1, the later time stratum (24 July–22 August) had a higher proportion of URRLR sockeye salmon than the earlier time stratum (1–23 July; Figure 3). For RKM 31.1 fish wheel samples, proportion URRLR was highest during 27 July–7 August (Table 9; Figure 4).

2008

The ESSN Kasilof section did not have a pronounced peak in 2008 (Table 8). The most URRLR sockeye salmon were harvested during the 13–19 July stratum, whereas the highest proportion of URRLR sockeye salmon in that section's harvest occurred during the 20–26 July stratum. Of the 2 strata for the ESSN Kenai section, the proportion of URRLR sockeye salmon was highest during the second stratum (21–24 July). Of the 3 strata for the KRSHA, the last stratum (2–7 August) had the highest proportion of URRLR sockeye salmon. Peaks occurred in the CDD during 14–17 July and 21–24 July. CDD corridor-only periods were not sampled. In the PU fishery, the proportion of URRLR sockeye salmon increased consistently through time from 6% during week 1 (10–16 July), to 8% during week 2 (17–23 July), to 12% in week 3 (24–31 July) (Figure 2). Harvest of URRLR sockeye salmon was highest during week 2. During the sport fishery downstream of RKM 31.1, the later time stratum (23–31 July) had a much higher proportion (0.14) of URRLR sockeye salmon than the earlier time stratum (0.06, 2–22 July) (Figure 3). For RKM 31.1 fish wheel samples, the proportion of URRLR sockeye salmon consistently increased through time with the peak occurring during the last stratum (5–17 August; Table 9; Figure 4).

DISCUSSION

GENETICS

In earlier genetic studies, Russian River sockeye salmon were identified as a highly distinct group (Allendorf and Seeb 2000; Seeb et al. 2000). Using the same data set, Reynolds and Templin (2004) separated Kenai River sockeye salmon populations into 5 groups. However, the study presented in this report is the first to apply multiple reporting groups to GSI of Kenai River sockeye salmon harvests. Because there was a high degree of genetic differentiation between populations spawning in the upper Russian River and other Kenai River populations, proof tests resulted in highly correct allocations (Habicht et al. 2010; Barclay et al. 2010; Table 5). This differentiation between upper Russian River and other Kenai River populations provides the basis for the run reconstruction presented here as well as for ongoing and future ADF&G genetic mark–recapture analyses to estimate the number of outmigrating sockeye salmon smolt.

Genetic variation within the Kenai River could lead to additional reporting groups within the Kenai River. Genetic segregation among populations from Hidden Lake, from mainstem spawners, and from tributary spawners was observed in Barclay et al. (2010). A new 96-locus baseline currently under development by the Gene Conservation Laboratory is expected to provide the ability to distinguish among all of these reporting groups. These additional reporting groups could lead to more applications, including multiple independent mark–recapture estimates for both smolt and adult enumeration.

RUN RECONSTRUCTION

URRLR Harvest Sources

In addition to the major harvest sources mentioned herein, there are other potential sources of URRLR sockeye salmon harvest in UCI, including non-GSI represented harvests in the UCI commercial fishery, educational fisheries near the mouth of the Kenai and Kasilof rivers, the Kasilof River PU fishery, and a subsistence fishery adjacent to federal lands in the Kenai River and Russian River downstream of the falls. Harvests of URRLR sockeye salmon in these fisheries were likely very small and represented a negligible portion of the run. However, at least a portion of the aforementioned harvests are not accounted for. Therefore, the estimated seasonal totals are biased and represent an underestimate, however only by a minimal degree.

The URRLR sockeye salmon harvest referred to as "URRLR sport fishery harvest upstream of RKM 31.1" was actually the number of URRLR sockeye salmon that passed RKM 31.1 but did not migrate past the Russian River weir. This included catch-and-release mortality, predation, natural mortality, and a small subsistence harvest. Consequently, the estimate of URRLR sockeye salmon harvest in the sport fishery upstream of RKM 31.1 is biased and overestimates harvest to an unknown but likely small degree. This bias did not affect total run size estimates because the total run estimate was produced independently of the sport fishery harvest estimate upstream of RKM 31.1.

Passage at RKM 31.1

To estimate the number of PIT-tagged fish that survived the tagging event, PIT-tagged fish were assumed to have the same survival rate from handling and tagging as radiotagged fish. This assumption could not be verified. Due to the less invasive nature of the tagging procedure, PIT-tagged fish likely survived at a greater rate than radiotagged fish. Other studies have shown that PIT-tagged fish do not behave markedly different than unmarked fish (Prentice et al. 1990). If the survival rate was greater for PIT-tagged fish than radiotagged fish, the estimate of URRLR sockeye salmon past RKM 31.1 would be biased and underestimate passage. Additionally, if the estimate of URRLR sockeye salmon past RKM 31.1 was biased and underestimated passage, then the estimate of sport fishery harvest upstream of RKM 31.1 was also biased and underestimated harvest. The estimated PIT-tagging survival rate based on radiotagged fish survival was approximately 93% in the first 2 years and 90% in the last year. Even if the actual survival rate was 100% for PIT-tagged fish, estimates of URRLR sockeye salmon passage at RKM 31.1 would be biased and underestimate passage by only 7.3% (10,300 fish) in 2006, 7.0% (8,500 fish) in 2007, and 10.0% (10,000 fish) in 2008.

Sockeye salmon that passed the Russian River weir prior to 15 July were counted as early-run fish. Sockeye salmon that passed the weir on 15 July or later were counted as late-run fish. Due to overlapping run timing, there were likely early-run fish counted as late-run fish and vice versa. The degree of overlap between the 2 runs is unknown and therefore the magnitude and direction of this potential bias is unknown.

2006 Run Reconstruction

The harvest of URRLR sockeye salmon in each fishery and the overall URRLR sockeye salmon harvest rate in 2006 was lower than 2007 and 2008 partly due to the latest run timing ever observed (Shields and Willette 2008). This resulted in inseason fishery management actions to close commercial fishing and limit sockeye salmon harvest. Once the late run timing was realized, a large portion of sockeye salmon had already returned to the Kenai River.

For estimation of URRLR sockeye salmon passage at RKM 31.1, there was an unintentional 6-day delay between the official start of late-run counts (15 July) at the Russian River weir and when the PIT-tag detection system at the weir was fully operational (21 July). Despite the delay, it is unlikely that any PIT-tagged fish were missed at the Russian River weir. No PIT-tagged fish were detected in the first 3 days of operation and only 2 PIT tags were detected in the first 9 days the scanners were operational. Consequently, even though a portion of the run was not scanned for PIT tags, it was assumed that all sockeye salmon that passed through the weir during the late run were scanned for tags. Furthermore, because nearly all URRLR sockeye salmon (96%) were scanned for tags as they passed through the weir, the assumption of equal probability of capture in the second event was likely met.

2007 Run Reconstruction

Run timing of sockeye salmon was more typical in 2007 than 2006 when compared to recent runs of sockeye salmon to UCI. The harvest of sockeye salmon in UCI commercial fisheries was 3.3 million fish, close to the average annual harvest of 2.9 million fish (Shields and Willette 2009). The midpoint of the run of all sockeye salmon to UCI in 2007 occurred on 19 July, which was 4 days late relative to the historical mean date of 15 July (Shields and Willette 2009). Several commercial periods were not sampled for genetic analysis in 2007. For non-sampled fishing periods in 2007, assumptions regarding the proportion of URRLR sockeye salmon were similar to those made in 2006. In some cases, 2006 proportions of URRLR sockeye salmon in the harvest were used to estimate 2007 URRLR harvests.

In the Kenai River PU fishery, one emergency order was issued that increased legal hours for dipnetting to 24 hours per day effective 11:00 PM, 25 July. The fishery closed on 31 July as scheduled. The sockeye salmon harvest in the PU fishery (291,270 fish) was the largest since inception of the current fishery (Dunker 2010). The harvest of URRLR sockeye salmon in the PU fishery was approximately 4% of the total Kenai River PU sockeye salmon harvest.

In the sport fishery, 1 emergency order was issued increasing the daily possession limit to 6 sockeye salmon beginning 26 July and was extended throughout the remainder of the season. Anglers were harvesting a sufficient number of sockeye salmon to warrant tissue sampling through 22 August.

PIT-tag readers at the Russian River weir were operational on 15 July. All fish passing the Russian River weir in the late run were scanned for PIT tags. The assumption of equal probability of capture in the second event of the mark–recapture experiment to estimate passage of URRLR sockeye salmon at RKM 31.1 was met.

2008 Run Reconstruction

The timing of the 2008 run of all sockeye salmon returning to UCI was estimated to be 4 days early relative to the 15 July midpoint measured at the test fishery at the Anchor Point transect line, representing the fourth earliest run timing since the test fishery began in 1979 (Shields 2009). The UCI commercial sockeye salmon harvest was 2.4 million fish, 19% below the average annual harvest of 2.9 million fish (Shields 2009). Management actions were taken to significantly reduce commercial harvest of Kenai River sockeye salmon stocks and concentrate harvest of Kasilof River sockeye salmon stocks after 24 July (Shields 2009). The CDD and the

ESSN Kenai section were not fished after 24 July. The ESSN Kasilof section did not open after 26 July. Instead, the KRSHA was fished exclusively during 27 July–7 August. CDD corridor-only periods were not sampled for GSI. It was assumed that no URRLR sockeye salmon harvest occurred during CDD corridor-only periods in 2008 (Table 8). The proportion of URRLR sockeye salmon during CDD corridor-only periods in 2008 was likely very low. During similar dates in CDD corridor-only periods in 2006, the proportion of URRLR sockeye salmon was less than 0.1%.

No management actions were taken in the Kenai River PU fishery. The total Kenai River sockeye salmon PU harvest (234,109 fish) in 2008 was near the 5-year average (~240,000 fish). URRLR sockeye salmon harvest in the PU fishery was approximately 9% of the total Kenai River sockeye salmon PU fishery harvest, the proportion being more than double what was observed in 2006 and 2007.

At RKM 31.1, tissue samples were collected from every second PIT-tagged sockeye salmon, resulting in the collection of 2,461 samples suitable for genetic analysis. Although the goal of 2,500 samples was not met, the number of samples collected in 2008 was considerably more than other years. The increase in number of collected samples was mostly responsible for the increase in precision of both the estimated number of sockeye salmon past RKM 31.1 and the total run size estimate.

2006–2008 Run Comparison

The total number of URRLR sockeye salmon returning to UCI varied approximately 25% during the 3 years of this project from a high of 204,387 fish (SE 14,555) in 2007 to a low of 157,164 fish (SE 22,107) in 2006 (Table 11). Harvest rates were similar in 2007 (74%) and 2008 (73%) whereas in 2006, the harvest rate was considerably lower (43%; Figure 5). The lower harvest rate could be attributed to the late run-timing and how fisheries were prosecuted.

Not surprisingly, fisheries closer to the Russian River harvested a higher percentage of URRLR sockeye salmon. The ESSN Kasilof section was opened more often than the ESSN Kenai section, yet the ESSN Kenai section harvest of URRLR sockeye salmon was greater and had a higher contribution of URRLR sockeye salmon in the harvest. In 2006, sport fisheries accounted for a larger part of the URRLR sockeye salmon harvest than the commercial fishery, whereas the opposite occurred in 2007 and 2008 (Figure 6). URRLR sockeye salmon harvest in the CDD fishery was more variable than in the ESSN fishery. In 2007, the CDD fishery accounted for 28% of the URRLR sockeye salmon harvest whereas in 2006 and 2008, the rates were 7% and 16%, respectively. The ESSN Kenai section accounted for a similar proportion (13–15%) of URRLR sockeye salmon harvest each year. When comparing the total URRLR sockeye salmon commercial fishery harvest to all other harvest sources, the proportion of the harvest was approximately equal in 2007 and 2008 (i.e., 50% commercial, 50% non-commercial) whereas in 2006, commercial fisheries accounted for only 27% of URRLR sockeye salmon harvest and all other harvest sources accounted for the remaining 73% of harvest. The large difference in proportions in 2006 was likely due to late run timing and resultant management actions.

The proportion of URRLR sockeye salmon in the PU fishery, sport fishery, and at RKM 31.1 was consistently greater in 2008 than in 2006 or 2007. The average proportion of URRLR sockeye salmon for all 3 inriver sampling locations was 0.04 in 2006, 0.05 in 2007, and 0.09 in 2008.

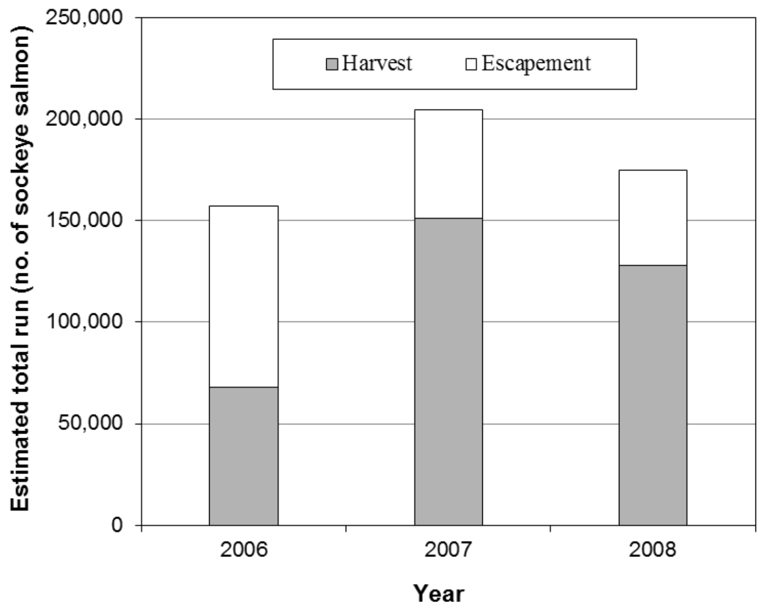

Figure 5.–Estimated harvest, escapement, and total run for Upper Russian River late-run sockeye salmon, 2006–2008.

Russian River late-run sockeye salmon escapement was below average in 2007 and 2008 and above average in 2006. In the past 20 years, 2007 (53,065 fish) and 2008 (46,638 fish) ranked as the second and third lowest seasonal counts, whereas 2006 (89,160 fish) ranked as the eighth highest seasonal count. The low harvest rate observed in 2006 was at least partly responsible for the large escapement when compared to 2007 and 2008. The escapement goal was met in each year.

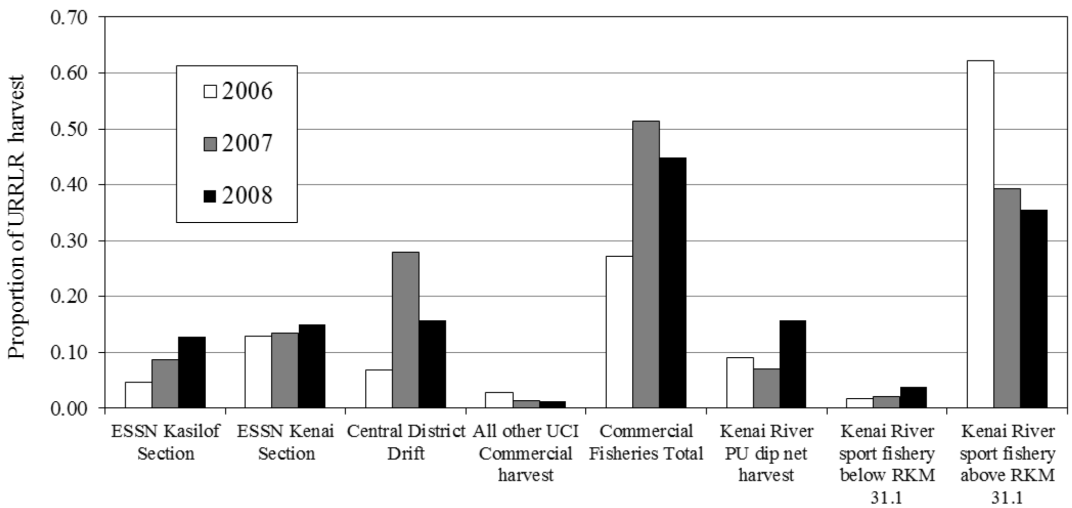

Figure 6.–Proportion estimates of commercial, personal use, and sport fishery harvests of Upper Russian River late-run sockeye salmon, 2006–2008.

Note: "URRLR" = Upper Russian River late run; "ESSN" = Eastside set gillnet commercial fishery; "Drift" = drift gillnet commercial fishery; "UCI" = Upper Cook Inlet, “PU” = personal use.

RUN TIMING

Major sources of harvest and timing information in the commercial fishery were from the ESSN Kenai and Kasilof sections and the CDD fishery. During the commercial fishery, dates of peak URRLR sockeye salmon harvest varied each year; however, harvest of URRLR sockeye salmon in the commercial fishery generally increased through time, peaking in late July and early August.

Because the PU fishery closed by regulation at the end of July, it was not possible to determine timing of URRLR sockeye salmon at the Kenai River mouth into August except during 2006, when the fishery was open by emergency order during 3–10 August. Only 6% of the total URRLR sockeye salmon PU harvest occurred during that time and the proportion of URRLR sockeye salmon in the harvest was lower than during previous strata. In 2007 and 2008, the last week of the PU fishery (24–31 July) had the highest proportion of URRLR sockeye salmon (Figure 2). For 2006, the highest proportion of URRLR sockeye salmon in the PU harvest was observed in stratum 2 (17–31 July); however, the fishery was only open 4 days during that time period. Harvest of URRLR sockeye salmon was highest from 17 to 31 July in 2006 and from 17 to 23 July in 2008. In 2007, the proportion and harvest of URRLR sockeye salmon was substantially higher during the last week (24–31 July) of the PU fishery. Approximately 92% of the harvest of URRLR sockeye salmon in 2007 occurred in week 3 even though the overall sockeye salmon harvest was greater in week 2.

The sport fishery downstream of RKM 31.1 was divided into 2 time strata. The later stratum had the highest proportion of URRLR sockeye salmon in each of the 3 years (Figure 3). This pattern was more evident in 2007 and 2008. In 2006, the proportion of URRLR sockeye salmon was comparable for both early and late strata.

The pattern of increasing URRLR proportions through time was less obvious at RKM 31.1. In 2008, proportions of URRLR fish past RKM 31.1 generally increased as the season progressed but not in 2006 and 2007 (Figure 4). Because it was not known whether fish wheel samples were representative of migration strength, it is possible that the use of sonar passage information coupled with fish wheel catches to estimate passage by stock could have considerable bias. Determining run timing within years and variation in run timing between years proved to be difficult; however, some insight was gained. By examining harvest of URRLR sockeye salmon for each year in the UCI commercial fishery, it appears that URRLR sockeye salmon entered UCI in appreciable numbers from mid to late July with runs continuing to build until near the end of July. As the migrations continued to the Kenai River, a peak was observed in the harvest of URRLR sockeye salmon in the PU fishery and sport fishery downstream of RKM 31.1 towards the end of July. As the run passed RKM 31.1, peaks at the end of July and into early August were also observed.

While results were not conclusive, a general pattern of later run timing for URRLR sockeye salmon than Kenai River late-run sockeye salmon was observed. This information could aid management of this run. Although anecdotal, previous observations suggested that URRLR sockeye salmon have later run timing than most sockeye salmon stocks within the Kenai River drainage; this is the first empirical data set describing migration timing of URRLR sockeye salmon upon entering UCI.

RECOMMENDATIONS AND SUMMARY

After reconstructing the 2006 run and conducting a precision vs. cost analysis, it was evident that the most cost effective way to increase precision of the total run size estimate would be to increase the number of tissue samples collected and analyzed at RKM 31.1. In 2007, the goal for the RKM 31.1 sampling was increased to 1,500 samples and after analysis of the 2007 run, the goal was further increased to 2,500 samples in 2008. In 2007, the sample goal was met, while in 2008 it was missed only by a small margin. By collecting more samples at RKM 31.1, the 95% relative precision of the total run-size estimate improved over the 3 years from 28% in 2006 to 11% in 2008. URRLR sockeye salmon harvest estimates in the PU fishery and sport fishery below RKM 31.1 had the lowest relative precision, but they contributed little to the estimated total run. If run reconstruction of this stock is planned in the future and the same study design is employed, a cost-effective way to increase precision of the total run size estimate would be to concentrate on collecting more tissue samples at RKM 31.1, given that the sampling effort of other fisheries remains the same.

Advances in GSI enabled this project, which was a collaboration of 3 separate projects. The Division of Commercial Fisheries (CF) sampled the UCI commercial harvest for post-season stock composition estimation and we were able to use those tissue samples to estimate harvest of URRLR sockeye salmon in the UCI commercial fishery. In addition, tagging of sockeye salmon at RKM 31.1 was conducted as part of a CF project to estimate the total number of sockeye salmon migrating upstream of RKM 31.1 (Willette et al. 2012). We were able to use the collected tagging information and supplement tissue sampling of tagged fish to estimate passage of URRLR sockeye salmon at RKM 31.1. Sampling of the PU fishery and sport fishery downstream of RKM 31.1 was conducted by SF to estimate the harvest of URRLR sockeye salmon occurring in those fisheries. SF also operated the Russian River weir to estimate sockeye salmon passage and collected PIT-tag passage information. Without the collaboration and concurrent timing of these projects, either this project would have not been possible due to funding constraints or the project would have been a much larger undertaking. This project represents the first study to accurately reconstruct runs and estimate total abundance, harvest, and timing of URRLR sockeye salmon to UCI. Results will be used to assess production, begin the development of a brood table, and will allow for a more informative escapement goal analysis for URRLR sockeye salmon. Although there are currently no plans to continue this run reconstruction project due to funding constraints, this project was successful and will provide previously unknown information that will benefit management of this stock.

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APPENDIX A: UPPER RUSSIAN RIVER LATE-RUN SOCKEYE SALMON PROPORTION ESTIMATES AND CREDIBILITY INTERVALS

Appendix A1.–Upper Russian River late-run sockeye salmon proportion estimates (P_{URRLR}) and credibility intervals (90%) from mixtures of sockeye salmon captured in the Central District drift gillnet fishery, personal use fishery, sport fishery downstream of RKM 31.1, and at the RKM 31.1 fish wheels in 2006, 2007, and 2008.

Data source	Year	Dates	Harvest (no. of fish)	N_{eff}	P_{URRLR}	90% credibility intervals 5%	95%
Central District drift gillnet (excluding corridor-only periods) (CDD)							
	2006	19–29 Jun	44,857	399	0.01	0.00	0.01
		3–6 Jul	67,498	399	0.00	0.00	0.00
		31 Jul	89,680	398	0.00	0.00	0.01
		2 Aug	56,418	397	0.01	0.00	0.01
		5–11 Aug	105,613	399	0.02	0.01	0.03
		14 Aug–11 Sep	6,320	–	–	–	–
	2007	21–28 Jun	26,005	398	0.02	0.01	0.03
		2–5 Jul	85,295	396	0.01	0.00	0.02
		9–12 Jul	295,214	394	0.03	0.02	0.05
		16 Jul	481,204	382	0.02	0.01	0.04
		19 Jul	451,216	391	0.02	0.01	0.03
		23–26 Jul	189,009	395	0.03	0.02	0.05
		30 Jul–9 Aug	156,803	343	0.02	0.01	0.04
		13 Aug–10 Sep	2,184	–	–	–	–
	2008	19 Jun–3 Jul	165,719	393	0.01	0.00	0.02
		7–10 Jul	140,487	390	0.01	0.00	0.02
		14–17 Jul	348,709	392	0.03	0.02	0.05
		21–24 Jul	173,778	388	0.04	0.03	0.06
		4 Aug–11 Sep	1,802	–	–	–	–
Central District drift gillnet (corridor-only periods) (CDD corridor-only)							
	2006	30 Jun–8 Jul	3,758	–	–	–	–
		10–13 Jul	3,313	199	0.00	0.00	0.00
		17 Jul	15,370	300	0.03	0.01	0.05
		1–8 Aug	42,470	–	–	–	–
	2007	29 Jun–10 Aug	131,888	–	–	–	–
	2008	28 Jun–12 Jul	135,434	–	–	–	–
Kasilof River Special Harvest Area drift gillnet (Central District, Eastside Subdistrict) (KRSHA drift)							
	2006	24–29 Jul	210,099	300	0.00	0.00	0.01

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Appendix A1.–Part 2 of 5.

Data source	Year	Dates	Harvest (no. of fish)	N_{eff}	P_{URRLR}	90% credibility intervals 5%	95%
Kasilof River Special Harvest Area drift, set gillnet (Central District, Eastside Subdistrict) (KRSHA drift–set)							
	2006	27 Jun–10 Jul	60,131	–	–	–	–
		11–23 Jul	234,916	377	0.00	0.00	0.00
	2007	27 Jul–10 Aug	20,290	–	–	–	–
	2008	27–29 Jul	22,081	395	0.00	0.00	0.01
		30 Jul–1 Aug	29,394	397	0.01	0.01	0.02
		2–7 Aug	25,349	386	0.02	0.01	0.03
Kasilof River Special Harvest Area set gillnet (Central District, Eastside Subdistrict) (KRSHA set)							
	2006	24–29 Jul	182,426	398	0.00	0.00	0.01
Kasilof Section set gillnet (Central District, Eastside Subdistrict) (ESSN Kasilof)							
	2006	26 Jun–1 Jul	114,767	397	0.00	0.00	0.01
		2–8 Jul	102,511	399	0.00	0.00	0.00
		10–13 Jul	36,093	396	0.02	0.01	0.04
		15–16 Jul	189,407	400	0.00	0.00	0.01
		17–22 Jul	135,192	400	0.01	0.00	0.02
		30 Jul–9 Aug	77,320	397	0.00	0.00	0.01
	2007	25 Jun–5 Jul	115,315	374	0.01	0.00	0.02
		9–14 Jul	137,641	297	0.02	0.00	0.03
		16–21 Jul	245,816	361	0.01	0.00	0.02
		22–28 Jul	122,454	388	0.02	0.01	0.03
		30 Jul–9 Aug	97,646	395	0.05	0.03	0.07
	2008	26 Jun–5 Jul	286,708	394	0.01	0.01	0.02
		7–12 Jul	114,052	397	0.02	0.01	0.03
		13–19 Jul	331,947	384	0.02	0.01	0.03
		20–26 Jul	149,072	390	0.03	0.01	0.04
Kenai Section set gillnet (Central District, Eastside Subdistrict) (ESSN Kenai)							
	2006	10–13 Jul	16,826	398	0.04	0.02	0.06
		17 Jul	29,728	397	0.07	0.05	0.09
		31 Jul–9 Aug	261,276	397	0.02	0.01	0.04
	2007	9–12 Jul	10,625	389	0.03	0.02	0.05
		16–19 Jul	51,623	387	0.04	0.03	0.07
		21–28 Jul	338,985	394	0.02	0.01	0.03
		30 Jul–9 Aug	217,671	371	0.05	0.03	0.07

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Appendix A1.–Part 3 of 5.

Data source	Year	Dates	Harvest (no. of fish)	N_{eff}	P_{URRLR}	90% credibility intervals 5%	95%
Central District, Eastside Subdistrict, Kenai section—set gillnet (ESSN Kenai section)							
	2008	10–17 Jul	252,012	379	0.05	0.03	0.07
		21–24 Jul	108,946	392	0.07	0.05	0.09
Central District, Kalgin Island Subdistrict—set gillnet (Kalgin Island set)							
	2006	2–21 Jun	14,644	–	–	–	–
		23 Jun–17 Aug	34,946	391	0.00	0.00	0.01
		21 Aug–11 Sep	501	–	–	–	–
	2007	1–20 Jun	12,799	–	–	–	–
		22 Jun–12 Jul	14,960	397	0.02	0.01	0.03
		16 Jul–18 Aug	35,358	398	0.03	0.02	0.05
	2008	2–26 Jun	16,385	99	0.00	0.00	0.01
		30 Jun–16 Aug	25,988	399	0.01	0.00	0.01
Central District, Westside Subdistrict—set gillnet (Westside set)							
	2006	19 Jun–10 Jul	11,353	396	0.00	0.00	0.00
		12–31 Jul	19,815	395	0.01	0.00	0.02
		2–28 Aug	8,502	–	–	–	–
	2007	18 Jun–27 Aug	56,854	397	0.00	0.00	0.00
	2008	16 Jun–11 Aug	23,553	396	0.00	0.00	0.01
Northern District, Eastern Subdistrict—set gillnet (ND Eastern set)							
	2006	27 May–6 Jul	3,890	–	–	–	–
		7 Aug–14 Sep	5,527	388	0.02	0.01	0.04
	2007	28 May–28 Jun	1,253	–	–	–	–
		2 Jul–20 Aug	6,966	198	0.06	0.03	0.09
		23 Aug–10 Sep	1,003	–	–	–	–
	2008	26 May–30 Jun	4,275	–	–	–	–
		7 Jul–18 Aug	12,221	393	0.04	0.03	0.06
		21 Aug–4 Sep	156	–	–	–	–
Northern District, General Subdistrict—set gillnet (ND General set)							
	2006	29 May–28 Aug	3,036	–	–	–	–
	2007	28 May–13 Sep	8,245	–	–	–	–

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Appendix A1.–Part 4 of 5.

Data source	Year	Dates	Harvest (no. of fish)	N_{eff}	P_{URRLR}	90% credibility intervals 5%	95%
Northern District, General Subdistrict—set gillnet (ND General set)							
	2008	26 May–30 Jun	711	–	–	–	–
		3 Jul–25 Aug	8,867	396	0.00	0.00	0.00
Kenai River Personal Use Fishery							
	2006	10–16 Jul	30,935	224	0.04	0.02	0.07
		20–31 Jul	80,234	190	0.06	0.03	0.09
		5–10 Aug	16,461	145	0.02	0.01	0.04
		All days	127,630				
	2007	10–16 Jul	16,621	151	0.01	0.00	0.04
		17–23 Jul	150,720	190	0.00	0.00	0.02
		24–31 Jul	123,929	198	0.08	0.05	0.11
		All days	291,270				
	2008	10–16 Jul	40,580	177	0.06	0.03	0.09
		17–23 Jul	122,742	196	0.08	0.05	0.11
		24–31 Jul	70,787	190	0.12	0.08	0.16
		All days	234,109				
Kenai River Sport Fishery (downstream of RKM 31.1)							
	2006	1 Jul–2 Aug	–	181	0.04	0.01	0.07
		3–26 Aug	–	202	0.04	0.02	0.07
		All days	25,740	383	0.04	0.03	0.06
	2007	1–22 Jul	–	184	0.02	0.01	0.04
		25 Jul–22 Aug	–	206	0.08	0.05	0.11
		All days	62,225	390	0.05	0.03	0.07
	2008	2–20 Jul	–	209	0.06	0.04	0.09
		24–31 Jul	–	184	0.14	0.10	0.19
		All days	48,203	393	0.10	0.08	0.13
ADF&G fish wheels (RKM 31.1)							
	2006	3–19 Jul	–	152	0.04	0.01	0.07
		20–24 Jul	–	155	0.05	0.02	0.08
		25–29 Jul	–	141	0.04	0.02	0.07
		30 Jul–4 Aug	–	163	0.06	0.03	0.09
		5–10 Aug	–	149	0.03	0.01	0.06
		11–15 Aug	–	154	0.04	0.02	0.07
		16–22 Aug	–	201	0.01	0.00	0.03
		All days	–	1,115	0.04	0.03	0.05

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Appendix A1.–Page 5 of 5.

Data source	Year	Dates	Harvest (no. of fish)	N_{eff}	P_{URRLR}	90% credibility intervals 5%	95%
ADF&G fish wheels (RKM 31.1)							
	2007	3–22 Jul	–	221	0.02	0.01	0.04
		23–26 Jul	–	238	0.04	0.02	0.06
		27 Jul–1 Aug	–	208	0.13	0.10	0.17
		2–7 Aug	–	213	0.13	0.09	0.17
		8–10 Aug	–	167	0.09	0.05	0.12
		11–13 Aug	–	201	0.05	0.02	0.07
		14–23 Aug	–	260	0.06	0.04	0.09
		All days	–	1,508	0.07	0.06	0.08
	2008	8–17 Jul	–	380	0.06	0.04	0.08
		18–19 Jul	–	322	0.05	0.03	0.07
		20–22 Jul	–	334	0.05	0.03	0.07
		23–29 Jul	–	323	0.10	0.07	0.13
		30 Jul–1 Aug	–	382	0.13	0.10	0.16
		2–4 Aug	–	327	0.14	0.11	0.17
		5–17 Aug	–	318	0.17	0.13	0.20
		All days	–	2,386	0.10	0.09	0.11

Note: The number of fish analyzed for each stratum (N) and the number of successfully screened fish from each stratum (N_{eff}) is indicated. Harvest numbers are given for each represented stratum and for unrepresented strata.