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Review of Salmon Escapement Goals in Upper Cook Inlet, Alaska, 2014

by

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and

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December 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

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

The Alaska Department of Fish and Game interdivisional escapement goal review committee for the Southcentral Region reviewed Pacific salmon *Oncorhynchus* spp. escapement goals for the major river systems in Upper Cook Inlet. Escapement goals were evaluated for 21 Chinook salmon, 1 chum salmon, 3 coho salmon, and 10 sockeye salmon stocks. The committee recommended to the Commercial Fisheries and Sport Fish division directors that all but 2 escapement goals remain status quo. The committee recommended changing the Jim Creek coho salmon sustainable escapement goal (SEG) range of 450–700 to an SEG of 450–1,400. This change is the result of incorporating escapement information acquired after the original goal was established in 2001. From 2001 to 2009, the stock experienced large returns from large parent escapements, which provided additional sustained yield information. The committee also recommended eliminating the Crescent River sockeye salmon biological escapement goal (BEG) range of 30,000–70,000 because the stock's assessment project is no longer funded.

Key words: Upper Cook Inlet, escapement goal, biological escapement goal, BEG, sustainable escapement goal, SEG, sockeye salmon, *Oncorhynchus nerka,* Chinook salmon, *O. tshawytscha*, coho salmon, *O. kisutch*, chum salmon, *O. keta*, Alaska Board of Fisheries.

INTRODUCTION

Upper Cook Inlet (UCI), Alaska, supports 5 species of Pacific salmon *Oncorhynchus* spp. The UCI commercial fisheries management unit consists of that portion of Cook Inlet north of Anchor Point and is divided into Central and Northern districts (Figure 1). The Central District is approximately 120 km (75 miles) long, averages 50 km (32 miles) in width, and is further divided into 6 subdistricts. The Northern District is 80 km (50 miles) long, averages 32 km (20 miles) in width, and is divided into 2 subdistricts. Commercial salmon fisheries primarily target sockeye salmon (*O. nerka*) with secondary catches of Chinook (*O. tshawytscha*), coho (*O. kisutch*), chum (*O. keta*), and pink (*O. gorbuscha*) salmon. Sport fishery management is divided into Northern Kenai Peninsula, Northern Cook Inlet, and Anchorage management areas. These areas offer diverse subsistence, commercial, personal use, and recreational fishing opportunities for all 5 species of Pacific salmon.

The Alaska Department of Fish and Game (ADF&G) reviews escapement goals for UCI salmon stocks on a schedule corresponding to the Alaska Board of Fisheries (BOF) 3-year cycle for considering area regulatory proposals. Management of these stocks is based on achieving escapements for each system within a specific escapement goal range or above a lower bound. Escapement refers to the annual estimated size of the spawning salmon stock, and is affected by a variety of factors including exploitation, predation, disease, and physical and biological changes in the environment.

This report describes UCI salmon escapement goals reviewed in 2013 and presents information from the previous 3 years in the context of these goals. The purpose of this report is to inform the BOF about the review of UCI salmon escapement goals and the review committee's recommendations to the Commercial Fisheries and Sport Fish division directors. Many salmon escapement goals in UCI have been set and evaluated at regular intervals since statehood (Fried 1994). Due to the thoroughness of previous analyses by Bue and Hasbrouck[1], Clark et al. (2007), Hasbrouck and Edmundson (2007), and Fair et al. (2007, 2010), this review reanalyzed

[1] Bue, B. G. and J. J. Hasbrouck. *Unpublished*. Escapement goal review of salmon stocks of Upper Cook Inlet. Alaska Department of Fish and Game, Report to the Alaska Board of Fisheries, November 2001 (and February 2002), Anchorage. Subsequently referred to as Bue and Hasbrouck (*Unpublished*).

only those goals with recent (2010–2012) data that could potentially result in a substantially different escapement goal from the last review, or those that should be eliminated or established.

ADF&G reviews escapement goals based on the *Policy for the Management of Sustainable Salmon Fisheries* (SSFP; 5 AAC 39.222) and the *Policy for Statewide Salmon Escapement Goals* (EGP; 5 AAC 39.223). The Alaska Board of Fisheries adopted these policies into regulation during the 2000/2001 cycle to ensure that the state's salmon stocks are conserved, managed, and developed using the sustained yield principle. For this review, there are 2 important terms defined in the SSFP:

> 5 AAC 39.222 (f)(3) "*biological escapement goal*" or "(BEG)" means the escapement that provides the greatest potential for maximum sustained yield; BEG will be the primary management objective for the escapement unless an optimal escapement or inriver run goal has been adopted; BEG will be developed from the best available biological information, and should be scientifically defensible on the basis of available biological information; BEG will be determined by the department and will be expressed as a range based on factors such as salmon stock productivity and data uncertainty; the department will seek to maintain evenly distributed salmon escapements within the bounds of a BEG; and

> 5 AAC 39.222 (f)(36) "*sustainable escapement goal*" or "(SEG)" means a level of escapement, indicated by an index or an escapement estimate, that is known to provide for sustained yield over a 5 to 10 year period, used in situations where a BEG cannot be estimated or managed for; the SEG is the primary management objective for the escapement, unless an optimal escapement or inriver run goal has been adopted by the board; the SEG will be developed from the best available biological information; and should be scientifically defensible on the basis of that information; the SEG will be determined by the department and will take into account data uncertainty and be stated as either an "SEG range" or "lower bound SEG"; the department will seek to maintain escapements within the bounds of the SEG range or above the level of a lower bound SEG.

During the 2013 review process, the committee evaluated escapement goals for Chinook, chum, coho, and sockeye salmon stocks:

- Chinook salmon: Alexander, Campbell, Clear, Crooked, Goose, Lake, Little Willow, Montana, Peters, Prairie, Sheep, and Willow creeks; and Chuitna, Chulitna, Deshka, Kenai (early and late run), Lewis, Little Susitna, Talachulitna, and Theodore rivers
- Chum salmon: Clearwater Creek
- Coho salmon: Fish and Jim creeks; and Little Susitna River
- Sockeye salmon: Fish and Packers creeks; Chelatna, Judd, and Larson lakes; and Crescent, Kasilof, Kenai, and Russian (early and late run) rivers

In March 2013, ADF&G established an escapement goal review committee (hereafter referred to as the committee). The committee consisted of 9 Division of Commercial Fisheries and 11 Division of Sport Fish personnel (Table 1). The committee recommended the appropriate type of escapement goal (BEG or SEG) and provided an analysis for recommending escapement goals. All committee recommendations are reviewed by ADF&G regional and headquarters staff prior to adoption as escapement goals per the SSFP and EGP.

METHODS

Available escapement, harvest, and age data for each stock were compiled from research reports, management reports, and unpublished historical databases. The committee determined the appropriate goal type (BEG or SEG) for each salmon stock with an existing goal and considered other monitored, exploited stocks without an existing goal. The committee evaluated the type, quality, and quantity of data for each stock to determine the appropriate type of escapement goal as defined in regulation. Generally speaking, an escapement goal for a stock should provide escapement that produces sustainable yields. Escapement goals for salmon are typically based on stock-recruitment relations (e.g., Beverton and Holt 1957; Ricker 1954), representing the productivity of the stock and estimated carrying capacity. In this review, the information sources for stock-recruitment models are spawner-return data. However, specific methods to determine escapement goals vary in their technical complexity, and are largely determined by the quality and quantity of the available data. Thus, escapement goals are evaluated and revised over time as improved methods of assessment and goal setting are developed, and when new and better information become available.

DATA AVAILABLE TO DEFINE ESCAPEMENT GOALS

For most stocks in this review we used return data through 2012. The previous review used return data through 2009, except for Kenai and Kasilof River sockeye salmon, which used return data through 2010. In this review, for Kenai and Kasilof River sockeye salmon, we used data through 2013 because some of the age classes of the runs originated from very large and potentially influential escapements that occurred in the mid-2000s. Although this review uses 3 additional years of return data (2011, 2012, and 2013) for the Kasilof and Kenai River sockeye salmon data sets, the increase in brood years is only 2. During the last review (Fair et al. 2010) we projected the age-2.3 return for year 2011, giving us completed (using the 4 major age classes: 1.2, 1.3, 2.2, and 2.3) brood years through 2005. Unfortunately, the projected estimate of age-2.3 returns for 2011 was highly inaccurate so we used actual completed brood years for this review. The age-2.3 returns that occurred in 2013 completed the 2007 brood year.

Estimates or indices of salmon escapement were obtained with a variety of methods such as foot and aerial surveys, mark–recapture experiments, weir counts, and hydroacoustics (sonar). Weir data tends to be the most reliable assessment tool, providing a count of the total number of fish in the escapement. Depending on its location, mark–recapture and sonar projects typically provide the next most reliable abundance estimates. Differences in methods among years can affect the comparability and reliability of data. In some systems, harvests occur upstream of the counting location; in these systems, estimates of harvest and sometimes catch-and-release mortality is subtracted for estimates of escapement. Data available for escapement goal analyses for all UCI stocks are found in this report (Appendices A–D).

Chinook Salmon

Escapements for most Chinook salmon stocks assessed in UCI have been monitored by single aerial (rotary wing or helicopter) or foot surveys. Such surveys provide an index of escapement. The indices are a measurement that provides information only about the relative level of escapement. Hydroacoustics (sonar) were used to assess early- and late-run Chinook salmon inriver runs to the Kenai River (Miller et al. 2012). An associated gillnetting program samples Chinook salmon to estimate age, sex, and size composition (Eskelin 2010). Since 1995, a weir project counts and samples the Deshka River Chinook salmon escapement, although previously (1974–1994) it was indexed annually by single aerial surveys. To estimate total escapement for those early years, we expanded aerial surveys using their relationship to weir counts (Yanusz *In prep*). A weir project also operates on Crooked Creek to count and sample Chinook salmon (Begich and Pawluk 2010).

Chum and Coho Salmon

Peak aerial fixed-wing surveys are used to index escapement of chum salmon in Clearwater Creek, the only chum salmon stock in UCI that has an escapement goal monitored by ADF&G (Tobias et al. 2013). For coho salmon stocks, escapements are monitored with single foot surveys on Jim Creek and weirs on Fish Creek and Little Susitna River (Oslund and Ivey 2010).

Sockeye Salmon

Sonar is used to estimate sockeye salmon abundance passing specific locations in the Kasilof, Kenai, and Yentna rivers, where high glacial turbidity precludes visual enumeration (Westerman and Willette 2013). In 2002, studies compared salmon abundance estimated using the historical Bendix sonar and the more modern Dual-frequency Identification Sonar (DIDSON; Maxwell and Gove 2007). Similar comparison studies occurred on the Kenai River during part of the season in 2004–2007, and on the Kasilof River during part of the season in 2007–2009. Prior to the review in 2010/2011, the ADF&G used those comparisons to convert historical daily Bendix sonar abundance estimates to DIDSON units (Maxwell et al. 2011). Beginning in 2010, the Yentna River sonar project ceased producing salmon estimates for inseason management. The Yentna project continues operating to determine if it is feasible to reconstruct the historical record of escapements (measured with a Bendix sonar) while adjusting for species selectivity of fish wheels that were used to apportion the historical sonar counts.

In clearwater systems of UCI that are assessed, fish are counted with weirs or video cameras. Weirs are used to count and sample adult sockeye salmon escapements in the Susitna River drainage (Chelatna, Judd, and Larson lakes; Fair et al. 2009), Russian River (Begich and Pawluk 2010), and Fish Creek (Oslund and Ivey 2010). Historically at Packers Creek, escapement has been counted with both video cameras and weirs. From 2009 to 2012, we operated a video camera at Packers Creek to estimate sockeye salmon escapement (Shields and Dupuis 2013), although equipment complications prevented complete counts in 2010, 2011, and 2012.

The Kasilof River sockeye salmon escapement goal is based on reconstructions of the total return by brood year, and the total number of sockeye salmon spawning (wild and hatchery) within the watershed. Escapement is estimated by subtracting (a) the number of sockeye salmon harvested in recreational fisheries upstream of the sonar site, and (b) when applicable, the number of sockeye salmon removed for hatchery brood stock, from the sockeye salmon sonar count. The sonar was operated near the Tustumena Lake outlet from 1968 to 1982, and immediately upstream of the Sterling Highway bridge (rkm 12.1) since 1983 (Figure 1). Although hatchery-reared sockeye salmon juveniles were stocked annually in the Kasilof drainage from 1976 to 2004, returning hatchery adults were not removed from Kasilof River sockeye salmon total return estimates. The hatchery run to the Kasilof River averaged about 32,000 fish, or 3–6% of the total return. The last adults returned from the last (year 2004) Tustumena Lake fry release in 2010 (Shields and Dupuis 2013).

The Kenai River late-run sockeye salmon escapement goal is based on reconstructions of the total return by brood year, and the number of wild sockeye salmon spawning within the watershed. Escapement is estimated by subtracting (a) the number of sockeye salmon harvested in recreational fisheries upstream of the sonar site, and (b) the number of hatchery-produced sockeye salmon passing the Hidden Creek weir from the sockeye salmon sonar (measured at rkm 30.9) count (Tobias et al. 2013). The number of sockeye salmon harvested in recreational fisheries upstream of the sonar site is estimated annually using the Statewide Harvest Survey (SWHS; Jennings et al. 2011) and creel surveys (1994, 1995) conducted during the fishery (King 1995, 1997). Through 1999, we estimated the number of hatchery-produced sockeye salmon passing the Hidden Creek weir from the ratio of hatchery-to-wild smolt by brood year (Tobias and Willette 2004). Beginning in 1999, it was estimated from the recovery of otolith thermal-marked salmon marked as juveniles and recovered via a sample of adults at the Hidden Creek weir.

Commercial catch statistics are compiled from ADF&G fish ticket information. The majority of sockeye salmon returning to UCI are caught in mixed stock fisheries (Shields and Dupuis 2013). Prior to 2005, a weighted age composition apportionment model estimated stock-specific harvests of sockeye salmon in commercial gillnet fisheries (Barclay et al. 2010). This method assumes age-specific exploitation rates are equal among stocks in the gillnet fishery (Bernard 1983) and is dependent upon accurate and precise escapement measures for all contributing stocks. Since 2006, the primary means for estimating stock-specific sockeye salmon harvests has been the use of genetic markers (Habicht et al. 2007; Barclay et al. 2010). Age composition of the sockeye salmon harvest is estimated annually using a stratified systematic sampling design (Tobias et al. 2013). A minimum sample (n=403) of readable scales is sufficient to estimate sockeye salmon age composition in each stratum within 5% of the true proportion 90% of the time (Thompson 1987). Estimates of sport harvest originate from the SWHS conducted annually by the Division of Sport Fish (Jennings et al. 2011).

DIDSON-adjusted historical escapement estimates for Kasilof and Kenai River sockeye salmon were used to construct brood tables for these 2 stocks using the weighted age composition apportionment model (Tobias and Tarbox 1999) beginning with brood year 1969. Genetic stock-specific harvest estimates (2006–2012) were incorporated into the brood tables (Barclay et al. 2010) by assuming that the age composition of stock-specific harvests was the same as stock-specific escapements (i.e., no age-dependent gear selectivity). Because the catch allocation model uses escapements for all major UCI sockeye salmon stocks (Kenai, Kasilof, Susitna, Crescent, Fish Creek, and unmonitored stocks) and because historical Bendix sonar estimates may not reliably index Susitna sockeye salmon abundances (Fair et al. 2009), we used mark–recapture estimates of Susitna sockeye salmon escapement (Yanusz et al. 2007; Yanusz et al. 2011 a, b) for 2006–2009, and an average of these escapement estimates for the years prior to 2006 in the weighted age composition apportionment model. For the 2013 sockeye salmon run estimates, the catch allocation model used DIDSON estimates for Kenai and Kasilof, and expanded (based on mark–recapture) weir counts (Judd, Chelatna, and Larson lakes) for Susitna River sockeye salmon escapement.

ESCAPEMENT GOAL

For the purposes of this review, all references to “significance” use an alpha-level of 0.05.

Stock-Recruitment Analysis

We used a Ricker (1954) stock-recruitment model to estimate escapement that maximizes sustainable yields and develop escapement goal ranges. Results were not used if the model fit the data poorly ($p \geq 0.20$) or model assumptions were violated. Hilborn and Walters (1992), Quinn and Deriso (1999), and the Chinook Technical Committee (CTC; 1999) of the Pacific Salmon Commission provide clear descriptions of the Ricker model and diagnostics to assess model fit. We tested all stock-recruitment models for serial correlation of residuals, and corrected them when necessary. Additionally, the Ricker α parameter was corrected for the logarithmic transformation bias induced into the model as described in Hilborn and Walters (1992), from fitting a linear regression line to ln(recruits/spawners) versus spawners. We fit additional stock-recruitment models (described below) to examine stock productivity and evaluate the existing escapement goal for Kenai River sockeye salmon.

Evaluation of Kasilof River Sockeye Salmon Escapement Goal

We applied the same methods used in a previous Kasilof River sockeye salmon escapement goal review (Hasbrouck and Edmundson 2007) to the updated brood table (Appendix C5) described above. We examined the fit of 2 stock-recruitment models to data from brood years 1969 to 2007 (i.e., all available spawner-return data). In the last review (Fair et al. 2010) we analyzed these 2 models using the full data set and a partial data set. In that review we concluded that the full data set was preferable because it includes the smaller escapements (<100,000), giving it greater contrast and more information for model development.

We first fit a classic Ricker model to the Kasilof stock-recruitment data:

$$R_t = S_t \exp(\alpha - \beta S_t + \varepsilon)$$

where R_t is number of recruits, S_t is number of spawners, α is a density-independent parameter, β is a density-dependent parameter, and t indicates the brood year. Next, we examined serial correlation in process error with a lag of one year using a time series regression of the simple model. In this autoregressive Ricker model, process errors are not independent, but serially dependent on process error from the previous brood year:

$$R_t = S_t \exp(\alpha - \beta S_t + \varphi \varepsilon_{t-1})$$

where φ is a lag-1 autoregressive parameter. Adjustments to $\ln \hat{\alpha}$ for asymmetric log-normal process error were applied and $\hat{S}_{MSY}$ calculated as described by Clark et al. (2007). We evaluated model fits using likelihood ratio tests for hierarchical models (Hilborn and Mangel 1997). Escapement goal ranges were derived that provided for 90–100% of MSY.

Evaluation of Kenai River Sockeye Salmon Escapement Goal

Following methods from a previous Kenai River sockeye salmon escapement goal review (Clark et al. 2007) we fit 7 different stock-recruitment models to the DIDSON-adjusted spawner-return data (Appendix C6). We fit the models to data from all available brood years, 1969 to 2007, because these data were used in earlier stock-recruitment analyses for this system (Carlson et al. 1999; Clark et al. 2007) and because in the last review (Fair et al. 2010) the full data set was chosen to be more desirable than the partial data set using brood years 1979 to 2005.

We first fit a general Ricker model that provides for depensation at low stock size and compensation at high stock size (Reisch et al. 1985; Hilborn and Walters 1992; Quinn and Deriso 1999):

$$R_t = S_t^{\gamma} \exp(\alpha - \beta S_t + \varepsilon_t),$$

where R_t is number of recruits, S_t is number of wild spawners, α is a density-independent parameter, γ and β are density-dependent parameters, and t indicates the brood year. In all models, density-independent survival is given by ε_t, which is assumed to be a random variable with a mean of zero and a constant variance, σ^2. When $\gamma<1$, the stock-recruitment curve is dome shaped like the Ricker model (Quinn and Deriso 1999). Depensation is indicated if γ is significantly greater than 1.0. Hilborn and Walters (1992) suggest that γ should be 2.0 or larger for strong depensatory effects. The classic Ricker model (Ricker 1954, 1975) is a special case when $\beta<0$ and $\gamma=1$, and the autoregressive Ricker model includes serial dependence of process error from the previous brood year as previously described.

The Cushing model (Cushing 1971, 1973) is a special case when $\beta=0$ and $\gamma>0$:

$$R_t = \alpha S_t^{\gamma} + \varepsilon_t \,.\, R_t = \alpha S_t^{\gamma} + \varepsilon_t$$

However, the Cushing model is not used much in practice because it predicts infinite recruitment for infinite spawning stock (Quinn and Deriso 1999). The case when $\gamma \leq 0$ does not correspond to a valid stock-recruitment model because it does not go through the origin (Quinn and Deriso 1999).

Several authors have examined density-dependent models that include interaction terms between brood-year spawners and prior year spawners with lags from 1 to 3 years (Ward and Larkin 1964; Larkin 1971; Collie and Walters 1987; and Welch and Noakes 1990). However, Myers et al. (1997) examined data from 34 sockeye salmon stocks and found no evidence for brood interactions at lags exceeding 1 year. We fit the Kenai River sockeye salmon data to a modified Ricker model (Clark et al. 2007) used by many of these investigators with only a 1-year lag:

$$R_t = S_t \exp(\alpha - \beta_1 S_t - \beta_2 S_{t-1} + \varepsilon_t)$$

where S_{t-1} is spawners from the previous year. We then used a general Ricker model (Clark et al. 2007) with brood-interaction that also included a statistical interaction (multiplicative) term between brood year spawners (S_t) and spawners from the previous brood year (S_{t-1}):

$$R_t = S_t^{\gamma} \exp[\alpha - \beta_1 S_t - \beta_2 S_{t-1} - \beta_3 S_t S_{t-1} + \varepsilon_t].$$

To develop the most parsimonious brood-interaction model, we utilized a stepwise multiple regression procedure. The F and t statistics aided the selection of variables for inclusion in the model. To provide a comparison of fit among models, we calculated the coefficient of determination and model P-values by regressing observed on predicted recruits (natural logarithm transformed). Akaike's Information Criteria (AIC; Akaike 1973) compared goodness of fit among models.

The current SEG is based on a brood-interaction simulation model (Carlson et al. 1999) that consisted of 29 simulations of the population dynamics of the stock over 1,000 generations. In each simulation, the number of spawners remained constant, i.e., a constant escapement goal policy. Escapement was incremented by 50,000 spawners from a range of 100,000 to 1,500,000 (n=29 simulations).

The current SEG of 700,000–1,200,000 based on simulation results indicates that escapements maintained within this range sustain high yields and have a low probability (about once every 20 years) of producing poor yields less than 1,000,000 sockeye salmon (Fried 1999). This corresponded to a <6% risk level in the simulation. As in the original analysis, we estimated mean yield, the coefficient of variation of yields, and the probabilities of yields <1,000,000. Escapement goal ranges corresponding to a <6% risk (about once every 20 years) of a yield <1,000,000 sockeye salmon and 90–100% of MSY (assuming a constant escapement goal policy) are compared.

Yield Analysis

For the Kenai River sockeye salmon stock, Clark et al. (2007) conducted a Markov yield analysis (Hilborn and Walters 1992) to further evaluate the escapement goal range. In this review, we developed a Markov yield table for Kenai and Kasilof River sockeye salmon data sets. We constructed the yield table by partitioning the data into overlapping intervals of 100,000 (Kasilof) or 200,000 (Kenai) spawners. The mean numbers of spawners, mean returns, mean return per spawner, mean yield, and the range of yields were calculated for each interval of spawner abundance. A more simplistic approach that was also employed examined a plot of the relationship between yield and spawners, looking for escapements that on average produce the highest yields.

Percentile Approach

Many salmon stocks in UCI have an SEG developed using the percentile approach. In 2001, Bue and Hasbrouck (*Unpublished*) developed an algorithm using percentiles of observed escapements, whether estimates or indices, that incorporated contrast in the escapement data and exploitation of the stock. Percentile ranking is the percent of all escapement values that fall below a particular value. To calculate percentiles, escapement data are ranked from the smallest to the largest value, with the smallest value the 0th percentile (i.e., none of the escapement values are less than the smallest). The percentile of all remaining escapement values is cumulative, or a summation, of 1/(n-1), where n is the number of escapement values. Contrast in the escapement data is the maximum observed escapement divided by the minimum observed escapement. As contrast increases, meaning more information about the run size are known, the percentiles used to estimate the SEG are narrowed, primarily from the upper end, to better utilize the yields from the larger runs. For exploited stocks with high contrast, the lower end of the SEG range is increased to the 25th percentile as a precautionary measure for stock protection:

Escapement Contrast and Exploitation	SEG Range
Low Contrast (<4)	15th Percentile to maximum observation
Medium Contrast (4 to 8)	15th to 85th Percentile
High Contrast (>8); Low Exploitation	15th to 75th Percentile
High Contrast (>8); Exploited Population	25th to 75th Percentile

For this review, the SEG ranges of all stocks with existing percentile-based goals were re-evaluated using the percentile approach with updated or revised escapement data. If the estimated SEG range was consistent with the current goal (i.e., a high degree of overlap), the committee recommended no change to the goal.

Risk Analysis

For stocks that are passively managed and coincidentally harvested, we calculated lower bound SEGs following methods outlined in Bernard et al. (2009). In UCI, Campbell Creek Chinook salmon is the only goal based on the risk analysis method. Following standard practice for this type of precautionary goal, we did not re-evaluate the Campbell Creek Chinook salmon escapement data during this review period.

RESULTS AND DISCUSSION

From this review, the majority of salmon escapement goals in UCI remain unchanged (Table 2). The committee recommended a range change to 1 coho salmon SEG and to eliminate 1 sockeye salmon goal. Details on the recommendations are provided below. Only stocks having goals that were modified, added, or deleted since the previous review are discussed in this section. Any goals not listed here remained status quo. Munro and Volk (2013) provide a comprehensive review of goal performance from 2004 to 2012 (for 2010–2012, see Table 3).

CHINOOK SALMON

Kenai River

Two stocks of Chinook salmon return to the Kenai River to spawn, classified as early (Appendix A10) and late (Appendix A11) runs. Kenai River early- and late-run Chinook salmon goals were revised out-of-cycle in the spring of 2013 due to a change in assessment methodology. In those reviews the early-run SEG of 4,000–9,000 changed to a SEG of 3,800–8,500 (McKinley and Fleischman 2013) and for the late run it changed from a SEG of 17,800–35,700 to an SEG of 15,000–30,000 (Fleischman and McKinley 2013). ***Due to a lack of new information, these 2 goals did not merit additional analysis during this review period.***

COHO SALMON

Deshka River

The committee considered the development of an escapement goal for Deshka River coho salmon. The committee reviewed available escapement data from the Deshka River weir and drainagewide abundance data from recent mark–recapture studies, and concluded that optimally, a Susitna drainage-wide goal would best suit management needs. ***The committee recommended that an escapement goal not be developed for Deshka River coho salmon*** because coho salmon run timing and abundance is difficult to assess accurately during periods of high stream flow and because highly variable inter-annual run timing based largely on stream flow limits the ability of the weir to provide reliable inseason information to manage the sport fishery. Currently, 16 years of annual weir counts are available; however, high water events compromised the weir for 5 of those years.

Ongoing coho salmon studies in the Susitna drainage will allow us to better evaluate whether Deshka River coho run strength is representative of run strength in the entire Susitna drainage and whether a drainagewide escapement goal can be developed. Currently, there are 3 years (2010–2012) of drainagewide estimates for Susitna River coho salmon.

Jim Creek

The committee recommends changing the Jim Creek coho salmon SEG of 450–700. This change is the result of incorporating escapement information acquired after the original goal was established in 2001. A single annual foot survey on McRobert's Creek is used to assess this stock. From 2001 to 2009, coho salmon counts exceeded the upper bound of the SEG in 8 of 9 years. Concurrently, sport fish harvests were higher than average, resulting in large returns from large parent escapements, and providing us with additional sustained yield information from which to better evaluate the current goal. ***Using the percentile approach (25th to 75th percentiles) with data since 1985, we recommend a revised SEG of 450–1,400.***

SOCKEYE SALMON

Given that management of UCI commercial fisheries is driven primarily towards achieving the Kasilof and Kenai River sockeye salmon escapement goals, we reanalyzed their updated stock-recruitment data using similar methods as in the previous review.

Kasilof River

ADF&G implemented the current BEG of 160,000–340,000 in 2011. Assessment of the stock and the goal are expressed in DIDSON units of fish. Over the past 45 years, Kasilof River sockeye salmon escapement has ranged from approximately 39,000 to 522,000 (Figure 2; Appendix C5). During this same time span, recruit/spawner values, which are a function of spawning stock size and productivity, ranged from approximately 0.7 to 8.4 (Figure 2).

Incorporating recent production data (2011–2013) had little impact on estimates of escapement that produce maximum yields of Kasilof River sockeye salmon, so ***the committee recommended no change to the current BEG of 160,000–340,000***. The classic Ricker model had significant fits to the spawner-return data (1969–2007: R^2=0.317, P<0.01). However, analysis of model residuals showed significant lag-1 autocorrelation (P<0.01). Likelihood ratio tests demonstrated that an autoregressive Ricker model provided the best fit, and escapements that provided for 90–100% of MSY were 150,000–320,000 (Table 4; Figure 3). The narrower likelihood profiles of escapements that produced MSY also indicated the autoregressive Ricker model best described the stock-recruitment relationship for this stock (Figure 4). A Markov yield table (Table 5; Figure 5) predicts escapements ranging from 160,000 to 340,000 will produce yields averaging approximately 765,000 (range 340,000–1,598,000), whereas escapements below this range will produce yields averaging approximately 344,000 (range: 64,000–630,000), and escapements above this range will produce yields averaging 515,000 (range: 138,000–1,257,000).

Kenai River

ADF&G implemented the current SEG range of 700,000–1,200,000 in 2011. The goal is based on DIDSON estimates of inriver abundance and does not include hatchery-produced sockeye salmon passing through the Hidden Creek weir. Over the past 46 years, Kenai River sockeye salmon escapements ranged from approximately 73,000 to 2,027,000 (Figure 6; Appendix C6). During this same time span, recruit/spawner estimates ranged from approximately 1.4 to 12.7 (Figure 7).

The general Ricker model was significant (P<0.001) for the Kenai sockeye salmon spawner-return data. However, the density-dependent parameter (β) did not significantly differ from zero (P=0.196), and γ was not different from one (P=0.974; Table 6). For the classic Ricker model

(Figure 7), β was significantly different from zero (P=0.005), and a lag-1 autoregressive (φ) parameter was not significant (P=0.109; Table 6). The density-dependent parameter (γ) in the Cushing model significantly differed from one (P<0.001). Finally, the density-dependent parameters in the classic Ricker model with a single brood-interaction term (Carlson et al. 1999) did not significantly differ from zero (P≥0.08). A stepwise regression procedure revealed a brood-interaction model describing the stock-recruitment relationship. The β parameter was significantly different from zero (P=0.043) in a 3-parameter model, but γ was not significantly different from one (P=0.789). A simplified 2-parameter brood-interaction model best described (P<0.001) the stock-recruitment relationship for this stock (Table 6; Figure 8). The improved fit of the simple brood-interaction model over the classic Ricker was primarily due to brood years 1988–1990, which followed the largest escapements ever observed (1987 and 1989; Figure 9). Likelihood profiles of escapements that produced high sustained yields further showed the simple brood interaction model as the best described stock-recruitment relationship (Figure 10). However, inclusion of brood years 2006 and 2007 in this review reduced this model's fit based on lower R^2 and higher AIC values compared to the previous review (Fair et al. 2010).

Applying the same criteria (<6% risk of a yield <1 million sockeye salmon) used to establish the current SEG (Carlson et al. 1999), simulations of the brood-interaction model suggest a goal range of 700,000–1,150,000 (Table 7). Using escapements that represent 90–100% MSY the range was 750,000–1,400,000 spawners (Table 7).

A simple 2-parameter brood-interaction model (Carlson et al. 1999) best fit the Kenai River sockeye salmon spawner-return data based on R^2 and AIC values (Table 6). Edmundson et al. (2003) hypothesized that brood interactions likely result from food limitation and subsequent mortality of fry immediately following emergence and during the first winter. Large fry populations from the previous brood year cause reduced copepod (zooplankton) density the following spring, limiting food resources for subsequent fry. The effect that fry grazing on copepod biomass has the following spring is caused by the 2-year lifecycle of the dominant copepod species in this system.

A Markov yield analysis indicated highest (>3.9 million) mean yields occur within a range of 600,000–900,000 spawners (Table 8), and that escapements from 500,000 to 1,200,000 also produce high (>2,300,000) mean yields. Escapements below 400,000 salmon never produced yields exceeding 948,000. The highest yields (Figure 11) originated from escapements of 755,000, 792,000, and 1,983,000 sockeye salmon (brood years 1982, 1983, and 1987). When escapements exceeded 900,000, yields were highly variable, ranging from 513,000 to 8,396,000. In this updated data set, the 2006 year class was added to the upper escapement interval (Appendix C6). Yields from the 2005 and 2006 year classes, both having large escapements, were above average. This pattern of greater than average yield from consecutive large escapements is inconsistent with the brood interaction observed in brood years 1987–1990, and hence, accounts for the reduced fit in this review.

The committee recommended that the Kenai River late-run sockeye salmon SEG be kept at 700,000–1,200,000 spawners. This range approximately represents the escapement that, on average, will produce 90–100% of MSY. We prefer using the 90–100% range for an SEG because it results in a broader interval with the highest predicted yield near its center. Maintaining this goal is supported by a plot of yield versus escapement, showing that escapements in this range generally produce the highest yields, and that escapements above this range can produce highly variable yields (Figure 11).

Crescent River

The committee recommended eliminating the Crescent River sockeye salmon BEG of 30,000–70,000. ADF&G has estimated sockeye salmon abundance for this stock using sonar since 1975. Since 1999, escapements in 12 of 14 years exceeded the upper bound of the escapement goal range. The final year of assessment was 2012 and for this reason, the goal should be eliminated.

OTHER STOCKS CONSIDERED

Six other salmon stocks in NCI were considered by the committee to address 2014 UCI BOF proposals. The public requested the BOF consider adopting escapement goals for the following stocks during the January 2014 UCI BOF meeting.

Kashwitna River Chinook salmon

The Kashwitna River Chinook salmon escapement has been assessed annually by a single fixed-wing survey since 1979. The Kashwitna River is a semi-glacial river. The system is difficult to assess due to turbid water conditions and only the north fork of the Kashwitna River is surveyed. The number of fish counted in the survey may not reflect the true spawning escapement. Ongoing Susitna-wide Chinook salmon abundance and distribution studies that started in 2012 may help determine if the north fork Kashwitna River is a reliable index stream. The committee recommends no goal be developed for Kashwitna River Chinook salmon.

Big River Lake and Kustatan River coho salmon

No stock assessment is currently conducted on either stock. ADF&G was unsuccessful in its attempt to place a video weir in Wolverine Creek (which drains into Big River Lake) in the early 2000s to assess sockeye salmon. ADF&G is aware of the increase in sport fishing effort on this stock. The committee recommended no goal be developed for either stock since ADF&G does not have an escapement monitoring program for coho salmon on these systems or any escapement data for coho salmon from which to establish an escapement goal.

Little Susitna River sockeye salmon

ADF&G has operated a weir on the Little Susitna River since 1986 to monitor coho salmon escapements and for Chinook salmon on some years. Other fish species are counted, but many years these counts are incomplete due to the location of the weir or timing of installation. From 1996 to 2011, the weir was located well upstream of Nancy Lake Creek, a tributary of the Little Susitna that the majority of sockeye salmon migrate up to spawn. ADF&G has 5 years of complete sockeye salmon counts on the Little Susitna (1988–1989, 1994–1995, and 2013) from years in which the weir was operated in the lower river and downstream of sockeye spawning destinations. The data set is insufficient to develop an escapement goal for Little Susitna River sockeye salmon.

Little Susitna River chum salmon

Chum salmon runs have been counted in the past 26 years, of which 5 years are at the current lower site (rivermile 32.5) and 3 are at the upper site (rivermile 71). Annual sport harvest is believed to be 2–3% of the inriver run. The committee recommends no goal be developed for Little Susitna River chum salmon.

Moose Creek Chinook salmon

ADF&G conducts an aerial index survey of spawning Chinook salmon in Moose Creek on an annual basis. Moose Creek is characterized as a narrow corridor creek with large cottonwoods that forces surveys to be flown at higher elevations than other index streams in northern Cook Inlet and has overhanging alder, and a preponderance of log jams, making sighting and counting fish difficult. Moose Creek has been closed to sport fishing for Chinook salmon since 1964. The committee recommends no goal be created for Moose Creek since the assessment may not reliably index escapement and there is no sport fishery.

SUMMARY

The escapement goal committee reviewed 35 UCI salmon escapement goals with recommendations to change the range of 1 goal and eliminate 1 other. The committee recommended that all but 2 escapement goals for UCI salmon stocks remain status quo (Table 2). Through their respective time frames, data in the appendices were used in the review of escapement goals and development of SEGs of UCI salmon stocks in 2001 (Bue and Hasbrouck *Unpublished*), 2004 (Clark et al. 2007; Hasbrouck and Edmundson 2007), 2007 (Fair et al. 2007), 2010 (Fair et al. 2010), and in this review.

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TABLES AND FIGURES

Table 1.–List of members on the Alaska Department of Fish and Game Upper Cook Inlet salmon escapement goal committee who assisted with the 2013/2014 escapement goal review.

Name	Position	Affiliation
Tim Baker	Regional Management Biologist	ADF&G, Div. of Commercial Fisheries
Robert Begich	Area Management Biologist	ADF&G, Div. of Sport Fish
Dan Bosch	Area Management Biologist	ADF&G, Div. of Sport Fish
Bob Clark	Chief Fisheries Scientist	ADF&G, Div. of Sport Fish
Aaron Dupuis	Asst. Area Management Biologist	ADF&G, Div. of Commercial Fisheries
Jack Erickson	Regional Research Biologist	ADF&G, Div. of Sport Fish
Lowell Fair	Regional Research Biologist	ADF&G, Div. of Commercial Fisheries
Steve Fleischman	Fisheries Scientist	ADF&G, Div. of Sport Fish
Jim Hasbrouck	Regional Supervisor	ADF&G, Div. of Sport Fish
Sam Ivey	Area Management Biologist	ADF&G, Div. of Sport Fish
Tracy Lingnau	Regional Supervisor	ADF&G, Div. of Commercial Fisheries
Tim McKinley	Area Research Biologist	ADF&G, Div. of Sport Fish
Matt Miller	Regional Management Biologist	ADF&G, Div. of Sport Fish
Andrew Munro	Fisheries Scientist	ADF&G, Div. of Commercial Fisheries
Pat Shields	Area Management Biologist	ADF&G, Div. of Commercial Fisheries
Tom Vania	Regional Management Biologist	ADF&G, Div. of Sport Fish
Eric Volk	Chief Fisheries Scientist	ADF&G, Div. of Commercial Fisheries
Mark Willette	Area Research Biologist	ADF&G, Div. of Commercial Fisheries
Rich Yanusz	Area Research Biologist	ADF&G, Div. of Sport Fish
Xinxian Zhang	Regional Biometrician	ADF&G, Div. of Commercial Fisheries

Table 2.–Summary of current escapement goals and recommended escapement goals for salmon stocks in Upper Cook Inlet, 2013.

	Current Escapement Goal			Recommended Escapement Goal			
					Escapement		
System	Goal	Type	Year Adopted	Range	Type	Data[a]	Action
Chinook Salmon							
Alexander Creek	2,100–6,000	SEG	2002			SAS	No Change
Campbell Creek	380	SEG	2011			SFS	No Change
Chuitna River	1,200–2,900	SEG	2002			SAS	No Change
Chulitna River	1,800–5,100	SEG	2002			SAS	No Change
Clear (Chunilna) Creek	950–3,400	SEG	2002			SAS	No Change
Crooked Creek	650–1,700	SEG	2002			Weir	No Change
Deshka River	13,000–28,000	SEG	2011			Weir	No Change
Goose Creek	250–650	SEG	2002			SAS	No Change
Kenai River - Early Run	3,800–8,500	SEG	2013			Sonar	No Change
Kenai River - Late Run	15,000–30,000	SEG	2013			Sonar	No Change
Lake Creek	2,500–7,100	SEG	2002			SAS	No Change
Lewis River	250–800	SEG	2002			SAS	No Change
Little Susitna River	900–1,800	SEG	2002			SAS	No Change
Little Willow Creek	450–1,800	SEG	2002			SAS	No Change
Montana Creek	1,100–3,100	SEG	2002			SAS	No Change
Peters Creek	1,000–2,600	SEG	2002			SAS	No Change
Prairie Creek	3,100–9,200	SEG	2002			SAS	No Change
Sheep Creek	600–1,200	SEG	2002			SAS	No Change
Talachulitna River	2,200–5,000	SEG	2002			SAS	No Change
Theodore River	500–1,700	SEG	2002			SAS	No Change
Willow Creek	1,600–2,800	SEG	2002			SAS	No Change

-continued-

Table 2.–Page 2 of 2.

	Current Escapement Goal			Recommended Escapement Goal			
					Escapement		
System	Goal	Type	Year Adopted	Range	Type	Data[a]	Action
Chum Salmon							
Clearwater Creek	3,800–8,400	SEG	2002			PAS	No Change
Coho Salmon							
Fish Creek (Knik)	1,200–4,400	SEG	2011			Weir	No Change
Jim Creek	450–700	SEG	2002	450–1,400	SEG	SFS	Change in Range
Little Susitna River	10,100–17,700	SEG	2002			Weir	No Change
Sockeye Salmon							
Chelatna Lake	20,000–65,000	SEG	2009			Weir	No Change
Crescent River	30,000–70,000	BEG	2005			Sonar	Eliminated
Fish Creek (Knik)	20,000–70,000	SEG	2002			Weir	No Change
Judd Lake	25,000–55,000	SEG	2009			Weir	No Change
Kasilof River	160,000–340,000	BEG	2011			Sonar	No Change
Kenai River	700,000–1,200,000	SEG	2011			Sonar	No Change
Larson Lake	15,000–50,000	SEG	2009			Weir	No Change
Packers Creek	15,000–30,000	SEG	2008			Weir	No Change
Russian River - Early Run	22,000–42,000	BEG	2011			Weir	No Change
Russian River - Late Run	30,000–110,000	SEG	2005			Weir	No Change

[a] PAS = peak aerial survey, SAS = single aerial survey, and SFS = single foot survey, BEG = biological escapement goal, SEG = sustainable escapement goal.

Table 3.–Current escapement goals, escapements observed from 2010 through 2012 for Chinook, chum, coho, and sockeye salmon stocks of Upper Cook Inlet.

		Current Escapement Goal				
	Escapement	Type		Escapements [b]		
System	Data [a]	(BEG, SEG)	Range	2010	2011	2012
Chinook Salmon						
Alexander Creek	SAS	SEG	2,100–6,000	177	343	181
Campbell Creek	SFS	SEG	380	290	260	NS
Chuitna River	SAS	SEG	1,200–2,900	735	719	502
Chulitna River	SAS	SEG	1,800–5,100	1,052	1,875	667
Clear (Chunilna) Creek	SAS	SEG	950–3,400	903	512	1,177
Crooked Creek	Weir	SEG	650–1,700	1,088	654	631
Deshka River	Weir	SEG	13,000–28,000	18,594	19,026	14,096
Goose Creek	SAS	SEG	250–650	76	80	57
Kenai River - Early Run	Sonar	SEG	3,800–8,500	6,393	8,448	5,044
Kenai River - Late Run	Sonar	SEG	15,000–30,000	16,210	19,680	27,710
Lake Creek	SAS	SEG	2,500–7,100	1,617	2,563	2,366
Lewis River	SAS	SEG	250–800	56	92	107
Little Susitna River	SAS	SEG	900–1,800	589	887	1,154
Little Willow Creek	SAS	SEG	450–1,800	468	713	494
Montana Creek	SAS	SEG	1,100–3,100	755	494	416
Peters Creek	SAS	SEG	1,000–2,600	NC	1,103	459
Prairie Creek	SAS	SEG	3,100–9,200	3,022	2,038	1,185
Sheep Creek	SAS	SEG	600–1,200	NC	350	363
Talachulitna River	SAS	SEG	2,200–5,000	1,499	1,368	847
Theodore River	SAS	SEG	500–1,700	202	327	179
Willow Creek	SAS	SEG	1,600–2,800	1,173	1,061	756
Chum Salmon						
Clearwater Creek	PAS	SEG	3,800–8,400	13,700	11,630	5,300
Coho Salmon						
Fish Creek	Weir	SEG	1,200–4,400	6,977	1,428 [c]	1,237
Jim Creek [d]	SFS	SEG	450–700	242	229	213
Little Susitna River	Weir	SEG	10,100–17,700	9,214	4,826	6,779 [e]
Pink Salmon						
No stocks with an escapement goal						

-continued-

Table 3.–Page 2 of 2.

System	Escapement Data [a]	Current Escapement Goal Type (BEG, SEG)	Current Escapement Goal Range	Escapements [b] 2010	2011	2012
Sockeye Salmon						
Chelatna Lake	Weir	SEG	20,000–65,000	37,784	70,353	36,577
Crescent River	Sonar	BEG	30,000–70,000	86,333	81,952	58,838
Fish Creek (Knik)	Weir	SEG	20,000–70,000	126,836	66,678	18,813
Judd Lake	Weir	SEG	25,000–55,000	18,361	39,997	18,303
Kasilof River	Sonar	BEG	160,000–340,000	293,765	243,767	372,523
Kenai River	Sonar	SEG	700,000–1,200,000	1,015,106	1,275,369	1,197,518
Larson Lake	Weir	SEG	15,000–50,000	20,324	12,413	16,708
Packers Creek	Weir	SEG	15,000–30,000	NS		
Russian River - Early Run	Weir	BEG	22,000–42,000	27,074	29,129	24,115
Russian River - Late Run	Weir	SEG	30,000–110,000	38,848	41,529	54,911

Note: Blank cells in the table represent incomplete assessments. BEG = biological escapement goal, SEG = sustainable escapement goal.

[a] SAS = single aerial survey, PAS = peak aerial survey, SFS = single foot survey.

[b] NS = No Survey. Fish required to meet broodstock needs, in addition to meeting escapement goal, include 250 Chinook salmon at Crooked Creek and 10,000 sockeye salmon at the Kasilof River.

[c] Incomplete count because the weir was removed on August 15 prior to the end of the coho salmon run.

[d] Foot survey of McRoberts Creek only, upon which the SEG is based.

[e] Incomplete count because of flooding.

Table 4.–Model parameters, negative log-likelihoods, escapements producing MSY, and 90% MSY escapement ranges for 2 stock-recruitment models fit to the Kasilof River sockeye salmon data, brood years 1969–2007.

			Parameters				Negative	Likelihood		MSY Escapement		
Model	Structure	n	σ	$\ln\alpha'$	B	φ	log-likelihood	Ratio	P-value	Estimate	Lower	Upper
Classic Ricker	$\ln\frac{R_t}{S_t} = \alpha - \beta S_t$	39	0.397	1.892	-0.00230	NA	18.328		<0.001	300,000	190,000	430,000
Autoregressive Ricker	$\ln\frac{R_t}{S_t} = \alpha - \beta S_t + \varphi e_{t-1}$	39	0.321	1.967	-0.00314	0.686	11.417	13.820	<0.001	230,000	150,000	320,000

Note: NA = not applicable.

Table 5.–Markov yield table for Kasilof River sockeye salmon, brood years 1969–2007 (numbers in thousands of fish).

Escapement		Mean	Mean	Return per	Yield	
Interval	n	Spawners	Returns	Spawner	Mean	Range
0–50	4	43	236	5.5	193	64–301
50–150	7	115	488	4.3	373	203–582
100–200	13	156	696	4.5	540	257–1,109
150–250	15	197	845	4.3	648	340–1,109
200–300	13	235	955	4.1	741	398–1,598
250–350	8	279	1,217	4.3	938	398–1,598
300–400	6	344	1,082	3.3	738	140–1,336
>350	5	427	793	1.9	366	-138–991

Table 6.–Summary of adult stock-recruitment models evaluated for Kenai River late-run sockeye salmon from brood years 1969–2007.

Model	Parameter	Estimate	*P*-value	R^2	AIC	Residual White noise test
General Ricker model			<0.001	0.554	60.04	0.543
	σ	0.50				
	lnα	1.70	0.211			
	β	4.84E-04	0.191			
	g	1.01	0.966			
Classic Ricker model			<0.001	0.554	57.69	0.535
	σ	0.49				
	lnα	1.76	<0.001			
	β	4.71E-04	0.005			
Autoregressive Ricker model			<0.001	0.580	57.84	0.641
	σ	0.49				
	lnα	1.66	<0.001			
	β	3.46E-04	0.062			
	φ	0.26	0.126			
Cushing model			<0.001	0.532	59.57	0.215
	σ	0.50				
	lnα	3.22	<0.001			
	g	0.71	0.014			
Classic Ricker model			0.012	0.568	58.82	0.443
with brood interaction	σ	0.49				
	lnα	1.83	<0.001			
	β_1	3.46E-04	0.082			
	β_2	2.04E-04	0.287			
General Ricker model			<0.001	0.583	57.40	0.377
with brood interaction	σ	0.48				
	lnα	1.90	0.050			
	β_3	2.98E-07	0.043			
	g	0.96	0.782			
Simple brood			0.001	0.583	55.13	0.371
interaction model	σ	0.48				
	lnα	1.64	<0.001			
	β_3	3.27E-07	0.001			

Note: Significance levels for γ test whether the parameter was different from 1.0.

Table 7.–Simulation results from a brood-interaction model for Kenai River late-run sockeye salmon (numbers of fish in thousands).

	1969–2007			
Escapement	Mean Run	Mean Yield	Yield CV (%)	P<1000
100	611	511	0.65	0.947
150	904	754	0.57	0.812
200	1,192	992	0.54	0.587
250	1,475	1,225	0.53	0.428
300	1,750	1,450	0.52	0.302
350	2,018	1,668	0.52	0.220
400	2,276	1,876	0.52	0.158
450	2,523	2,073	0.52	0.124
500	2,758	2,258	0.52	0.089
550	2,981	2,431	0.52	0.072
600	3,190	2,590	0.53	0.066
650	3,385	2,735	0.53	0.060
700	**3,565**	**2,865**	**0.53**	**0.053**
750	**3,729**	**2,979**	**0.53**	**0.052**
800	**3,877**	**3,077**	**0.54**	**0.051**
850	**4,009**	**3,159**	**0.54**	**0.049**
900	**4,125**	**3,225**	**0.55**	**0.049**
950	**4,224**	**3,274**	**0.55**	**0.049**
1,000	**4,307**	**3,307**	**0.56**	**0.051**
1,050	**4,373**	**3,323**	**0.56**	**0.052**
1,100	**4,422**	**3,322**	**0.57**	**0.053**
1,150	**4,456**	**3,307**	**0.58**	**0.057**
1,200	4,475	3,275	0.58	0.062
1,250	4,479	3,229	0.59	0.066
1,300	4,468	3,169	0.60	0.070
1,350	4,444	3,095	0.61	0.079
1,400	4,407	3,008	0.63	0.087
1,450	4,358	2,910	0.64	0.108
1,500	4,298	2,800	0.65	0.127

Note: Model parameters were obtained from regression analyses conducted using brood year 1969–2007. Ranges corresponding to the original criteria (<6% risk of a yield <1 million salmon; Carlson et al. 1999) used to establish the sustainable escapement goal range are indicated in bold. Ranges corresponding to escapement needed to produce 90–100% of maximum yield (assuming a constant escapement goal policy) are shaded.

Table 8.–Markov yield table for Kenai River late-run sockeye salmon constructed using data from brood years 1969–2007 (numbers in thousands of fish).

Escapement		Mean	Mean	Return per	Yield	
Interval	n	Spawners	Returns	Spawner	Mean	Range
0–200	3	120	679	5.7	559	358–871
100–300	3	165	798	5.0	633	449–871
200–400	2	292	1,055	3.6	763	578–948
300–500	4	414	2,180	5.1	1,766	580–3,419
400–600	9	495	2,450	5.0	1,955	580–3,419
500–700	9	571	3,204	5.5	2,633	999–6,399
600–800	8	717	4,799	6.6	4,083	786–8,836
700–900	6	774	4,779	6.1	4,005	786–8,836
800–1,000	6	935	3,612	3.9	2,677	698–4,839
900–1,100	6	969	3,472	3.6	2,503	698–4,839
1,000–1,200	3	1,149	3,483	3.0	2,334	1,376–3,084
1,100–1,400	5	1,279	3,083	2.4	1,804	513–3,084
1,300–1,500	3	1,343	2,863	2.1	1,520	513–2,301
> 1,400	5	1,842	5,483	2.9	3,641	1,474–8,396

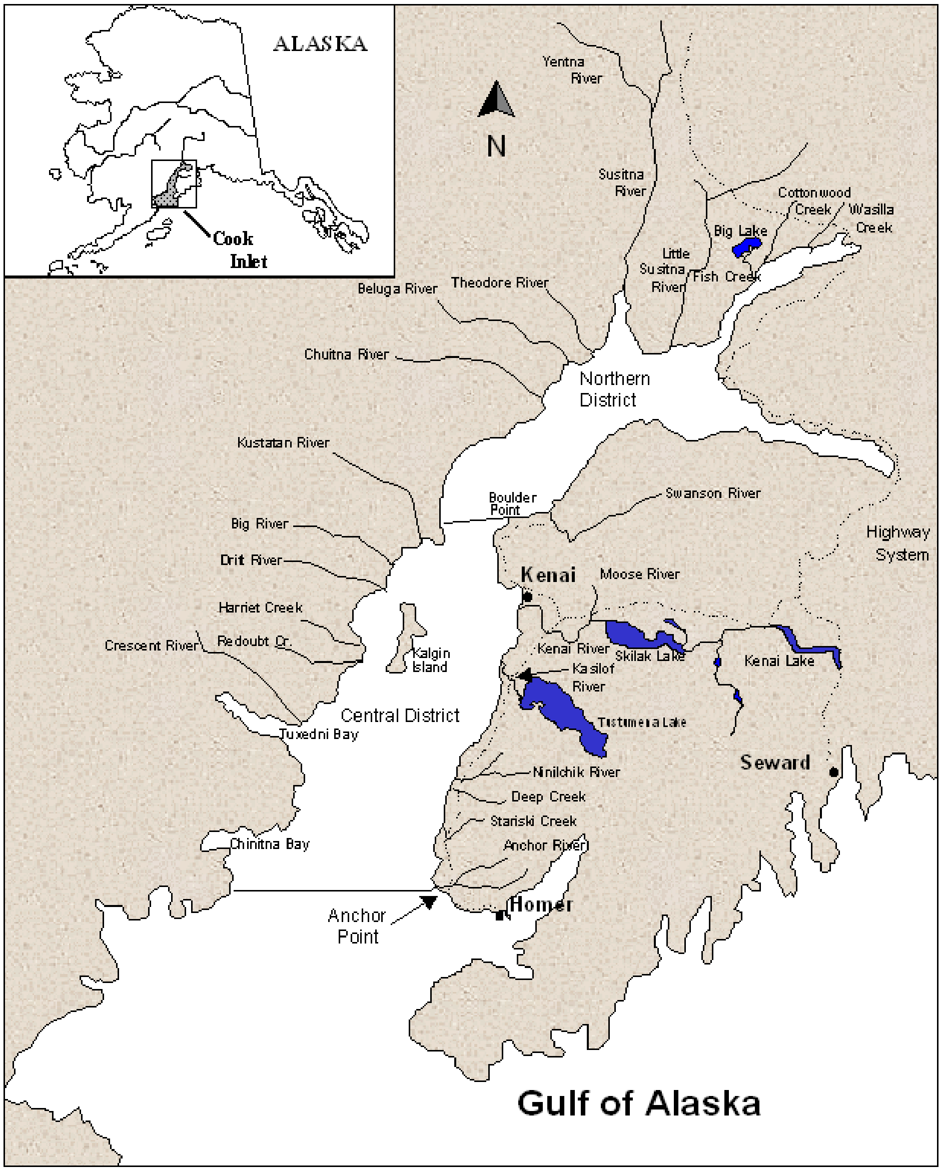


Figure 1.–Map of Upper Cook Inlet showing locations of the Northern and Central districts and the primary salmon spawning drainages.

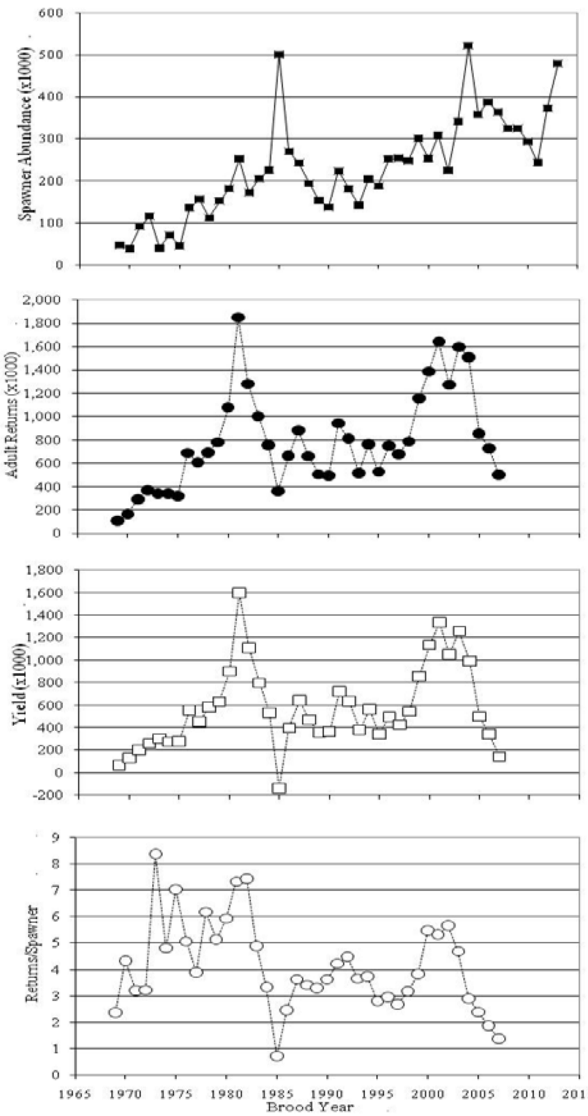
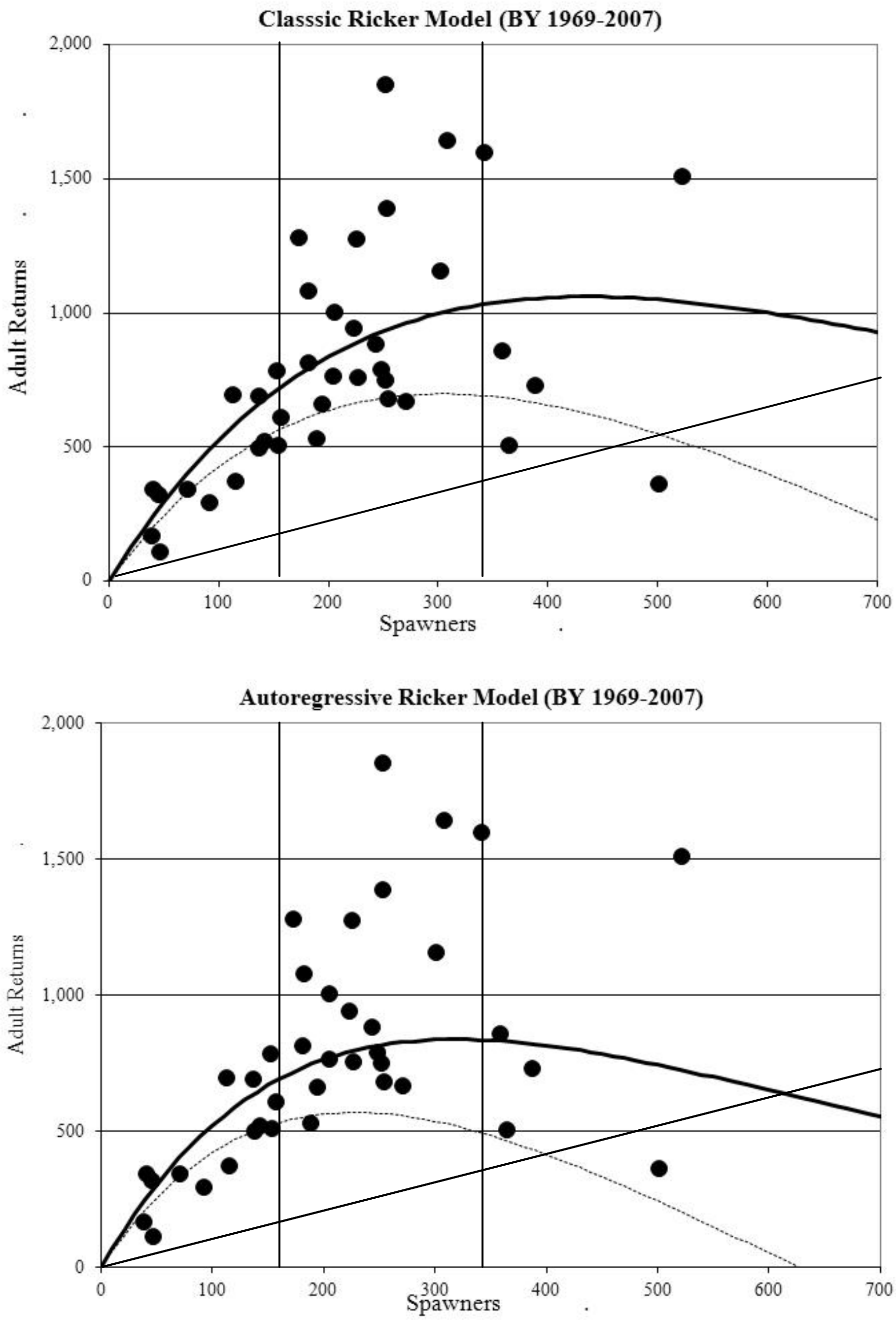
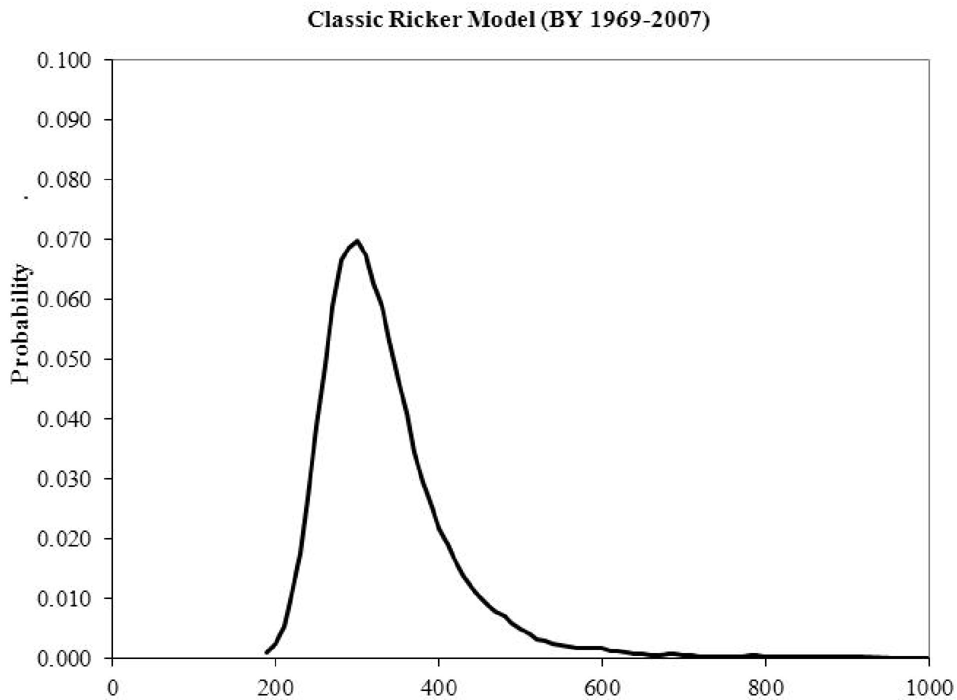


Figure 2.–Time series of spawner abundance (escapement), adult returns, yields, and returns-per-spawner for Kasilof River sockeye salmon, 1969–2013.



Note: Solid vertical lines are the existing sustainable escapement goal range and the straight line connected to the origin is the replacement line.

Figure 3.–Scatter plots of Kasilof River sockeye salmon spawner-return data (in thousands of fish), including adult returns (solid line) and yields (dashed line) predicted by the classic Ricker and autoregressive Ricker models fit to data from brood years 1969–2007.



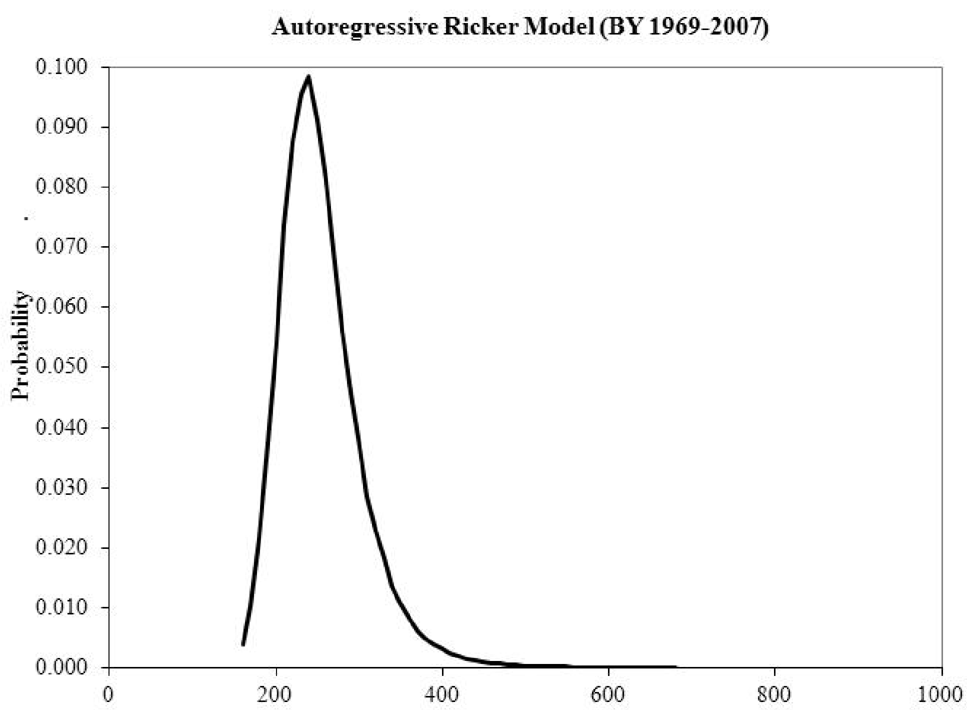
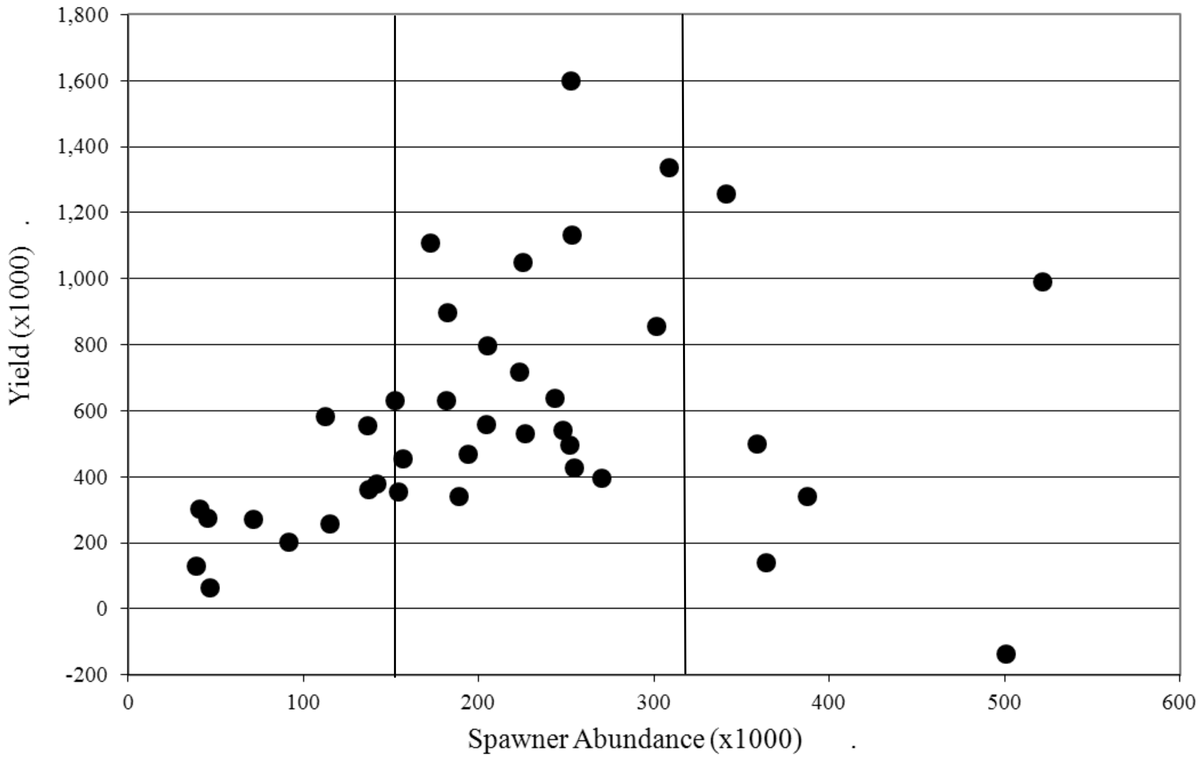


Figure 4.–Likelihood profiles for Kasilof River sockeye salmon spawner abundances (escapements) that produced MSY estimated by the classic Ricker and autoregressive Ricker models fit to data from brood years 1969–2007.



Note: Solid vertical lines are the existing sustainable escapement goal range.

Figure 5.–Kasilof River sockeye salmon yields related to spawner abundances (escapements) in brood years 1969–2007.

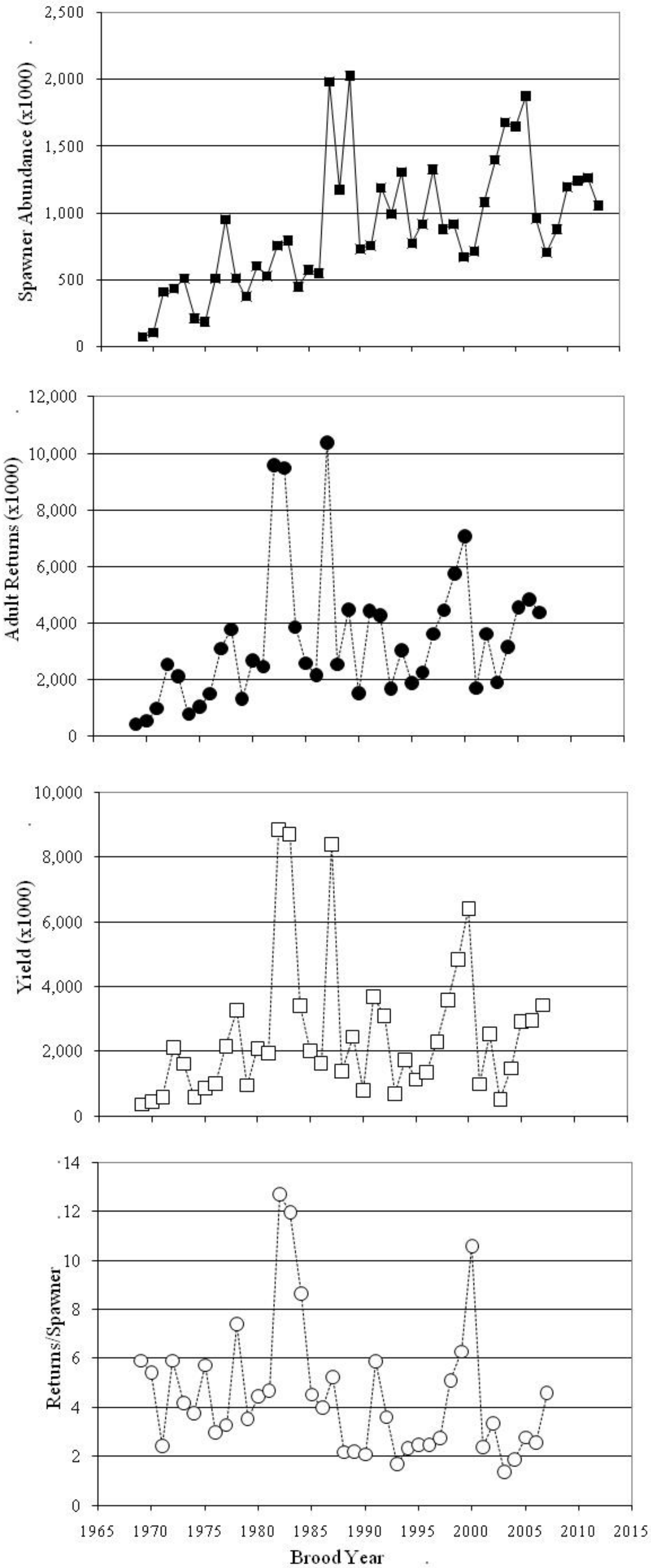
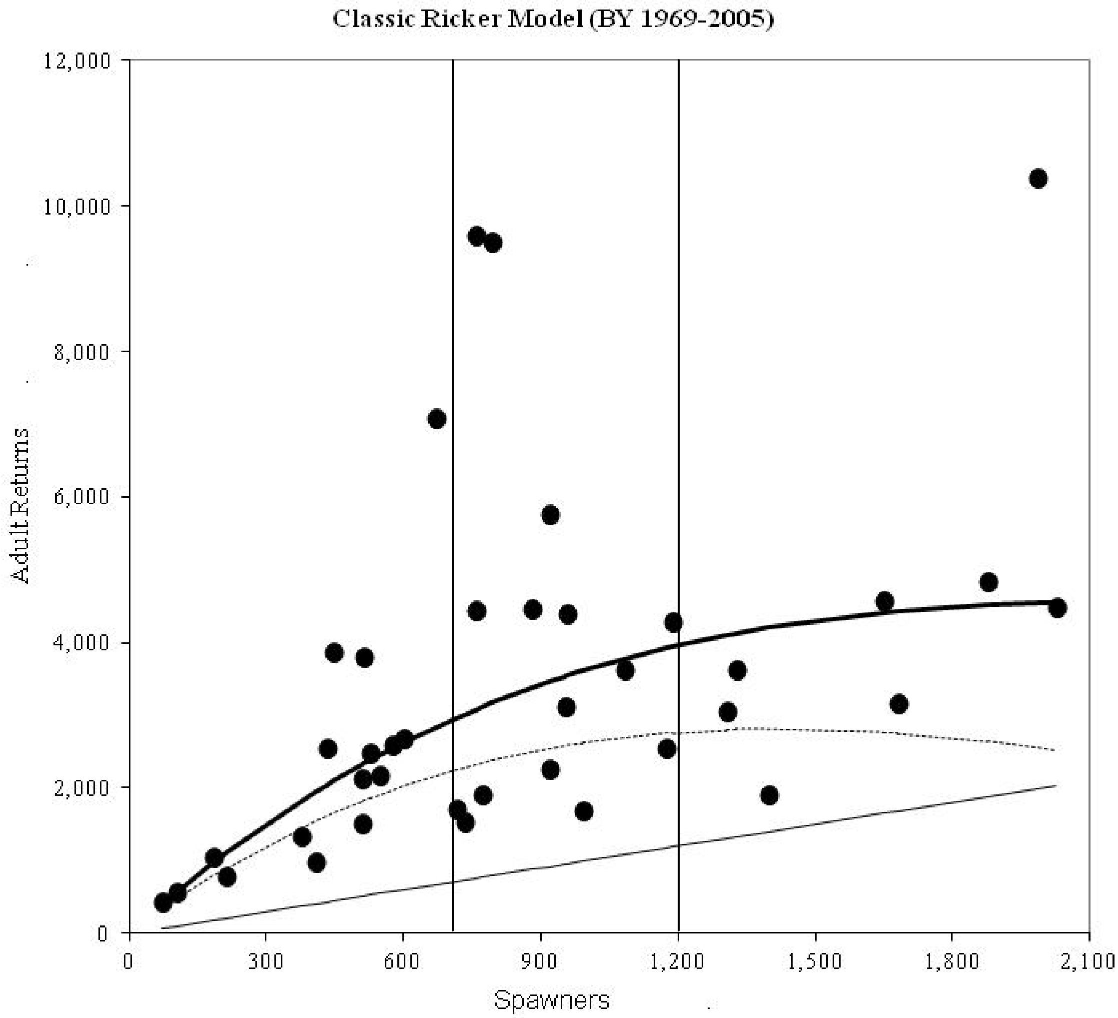
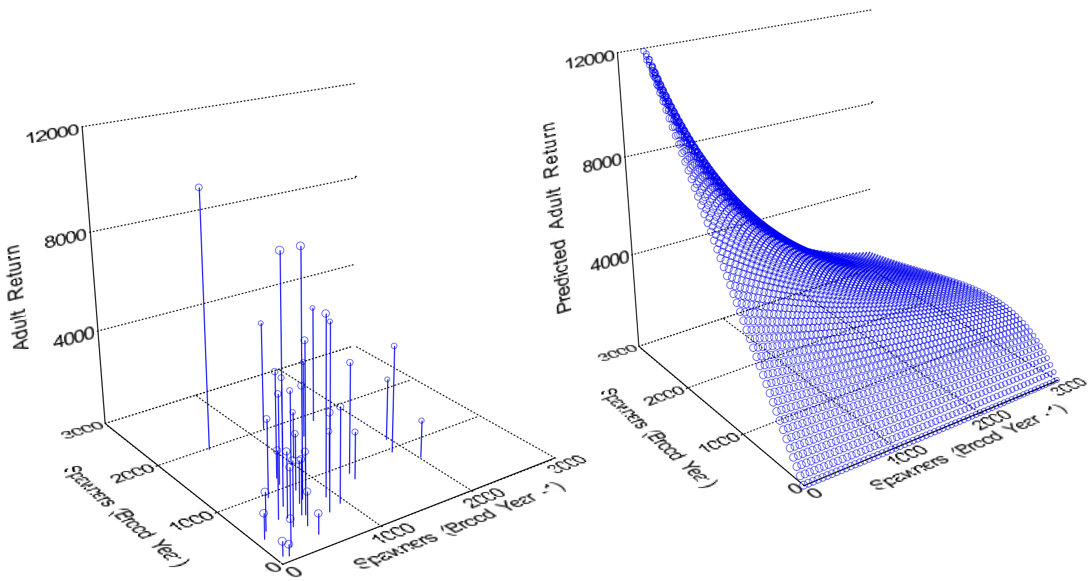


Figure 6.–Time series of spawner abundance (escapement), adult returns, yields, and returns-per-spawner for Kenai River late-run sockeye salmon, 1969–2013.



Note: Solid vertical lines are the existing sustainable escapement goal range and the straight line connected to the origin is the replacement line.

Figure 7.–Scatter plots of Kenai River late-run sockeye spawner-return data (in thousands of fish), including adult returns (solid line) and yields (dashed line) predicted by the classic Ricker model fit to data from brood years 1969–2007.



Note: Numbers are in thousands of fish.

Figure 8.–Kenai late-run sockeye salmon (a) spawner-return data (brood years 1969–2007) plotted with spawner abundance (escapement) in brood year-1, and (b) simple brood-interaction model predicted adult returns.

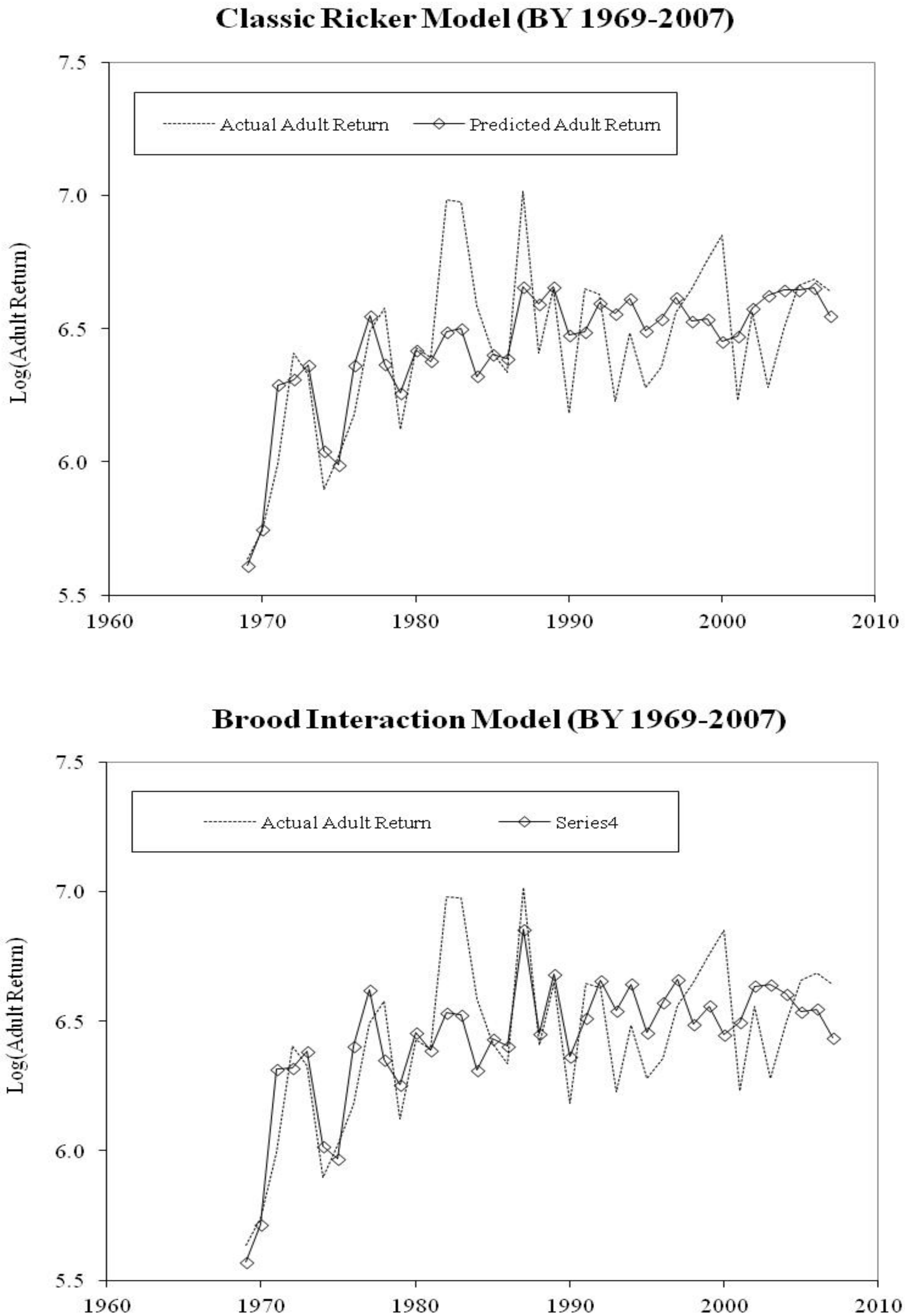


Figure 9.–Time series of actual Kenai River late-run sockeye salmon returns and returns predicted by the classic Ricker and brood-interaction models, brood years 1969–2007.

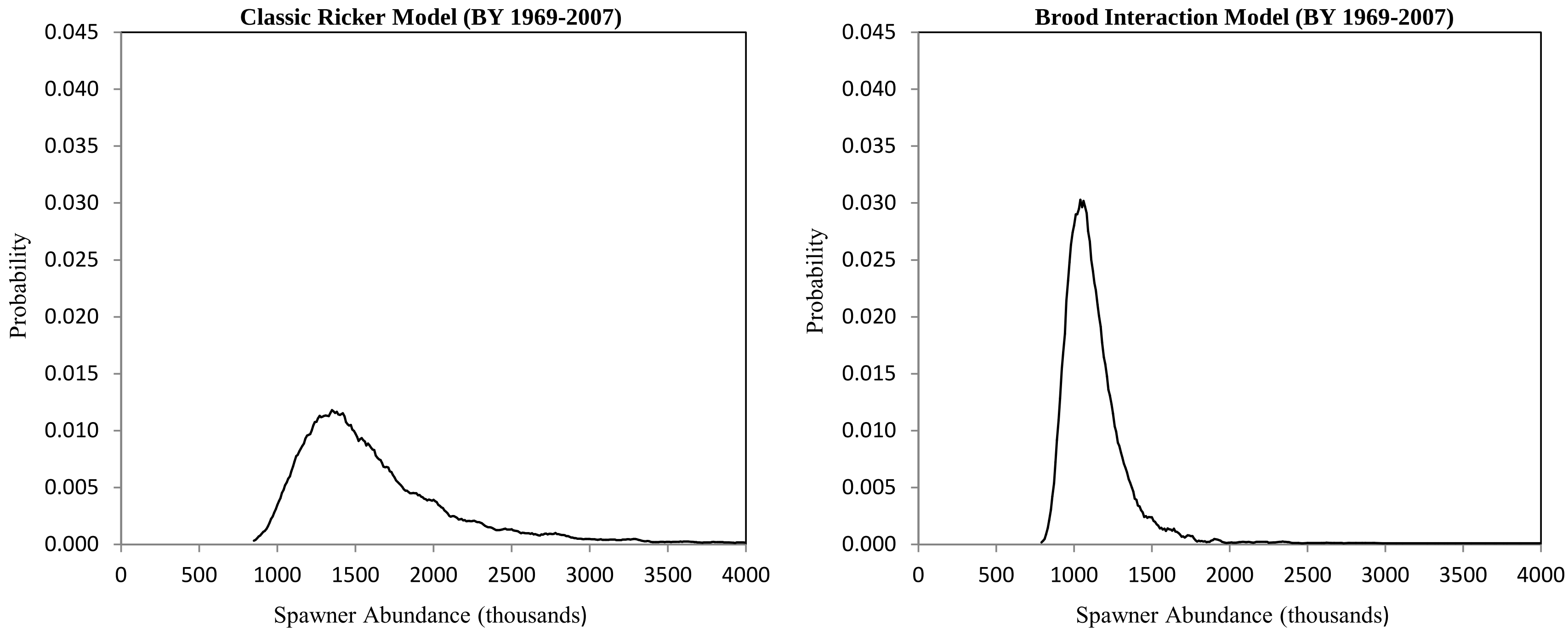
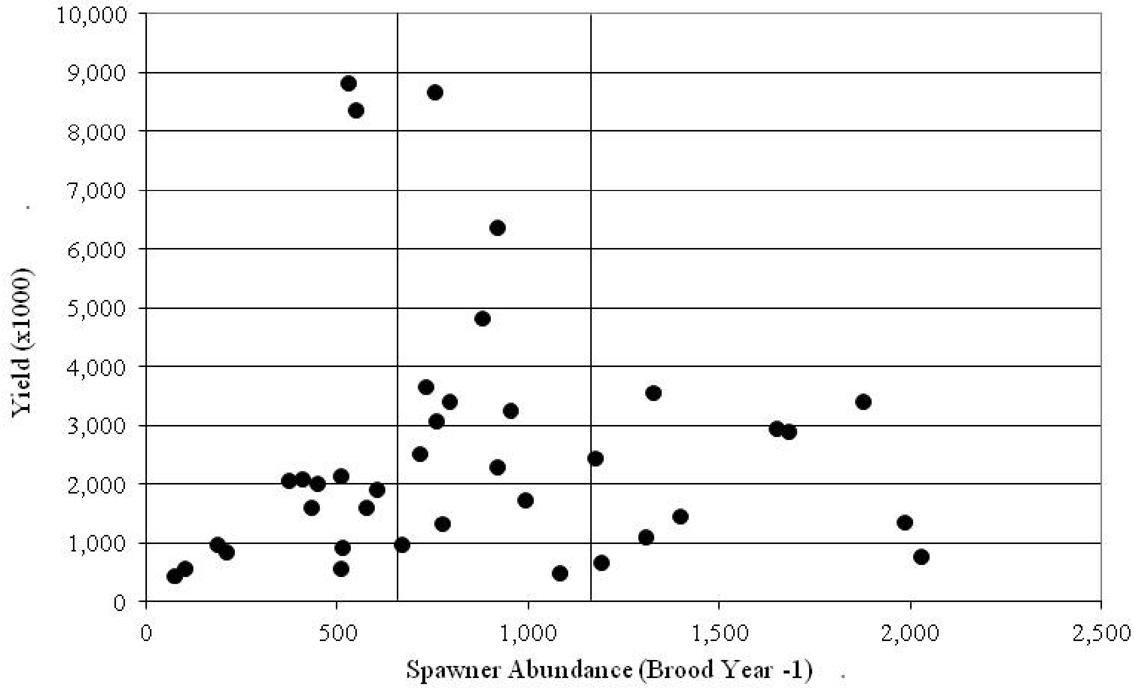
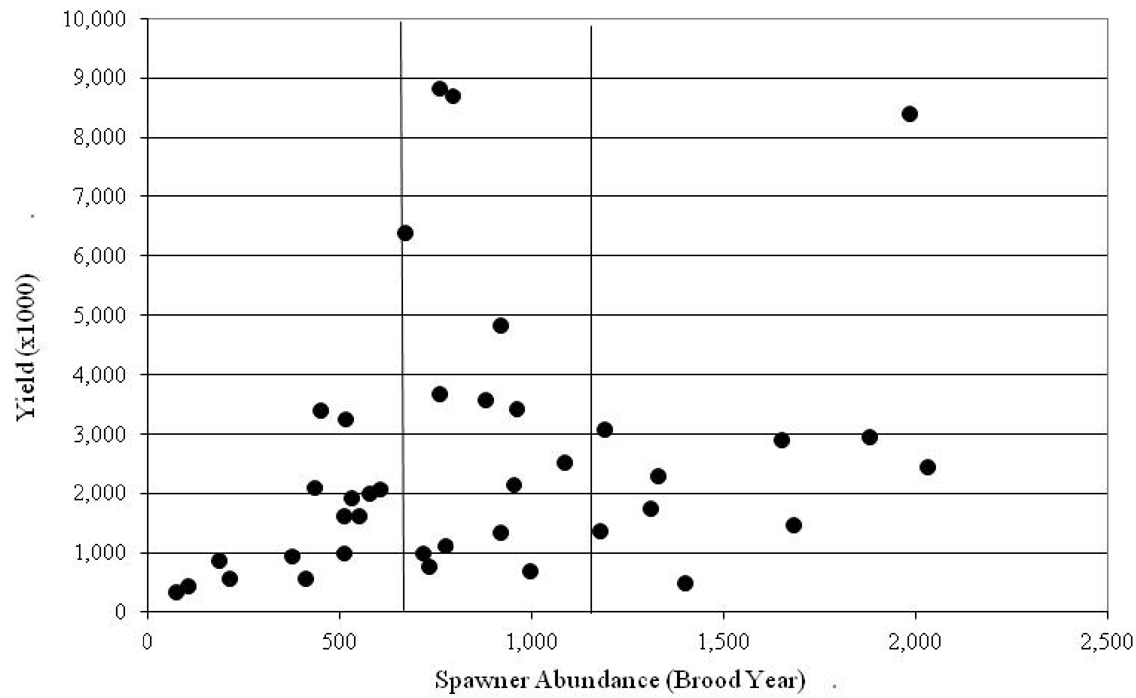


Figure 10.–Likelihood profiles for Kenai River late-run sockeye salmon spawner abundances (escapements) that produced high sustained yields estimated by the classic Ricker and simple brood interaction models (assuming a constant escapement goal policy) fit to data from brood years 1969–2007.





Note: Solid vertical lines are the sustainable escapement goal range.

Figure 11.–Kenai River late-run sockeye salmon yields related to spawner abundances (escapement, in thousands of fish) in brood years 1969–2007 and the previous year (brood year -1).

APPENDIX A.
SUPPORTING INFORMATION FOR UPPER COOK INLET CHINOOK SALMON ESCAPEMENT GOALS

Appendix A1.–Data available for analysis of Alexander Creek Chinook salmon escapement goal.

Year	Escapement [a]
1974	2,193
1975	1,878
1976	5,412
1977	9,246
1978	5,854
1979	6,215
1980	
1981	
1982	2,546
1983	3,755
1984	4,620
1985	6,241
1986	5,225
1987	2,152
1988	6,273
1989	3,497
1990	2,596
1991	2,727
1992	3,710
1993	2,763
1994	1,514
1995	2,090
1996	2,319
1997	5,598
1998	2,807
1999	3,974
2000	2,331
2001	2,282
2002	1,936
2003	2,012
2004	2,215
2005	2,140
2006	885
2007	480
2008	150
2009	275
2010	177
2011	343
2012	181

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix A2.–Data available for analysis of Campbell Creek Chinook salmon escapement goal.

Year	Escapement [a]
1982	68
1983	
1984	423
1985	
1986	733
1987	571
1988	
1989	218
1990	458
1991	590
1992	931
1993	937
1994	1,076
1995	734
1996	369
1997	1,119
1998	761
1999	1,035
2000	591
2001	717
2002	744
2003	745
2004	964
2005	1,097
2006	1,052
2007	588
2008	439
2009	554
2010	290
2011	260
2012	

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix A3.–Data available for analysis of Chuitna River Chinook salmon escapement goal.

Year	Escapement[a]
1977	
1978	
1979	1,246
1980	
1981	1,362
1982	3,438
1983	4,043
1984	2,845
1985	1,600
1986	3,946
1987	
1988	3,024
1989	990
1990	480
1991	537
1992	1,337
1993	2,085
1994	1,012
1995	1,162
1996	1,343
1997	2,232
1998	1,869
1999	3,721
2000	1,456
2001	1,501
2002	1,394
2003	2,339
2004	2,938
2005	1,307
2006	1,911
2007	1,180
2008	586
2009	1,040
2010	735
2011	719
2012	502

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix A4.–Data available for analysis of Chulitna River Chinook salmon escapement goal.

Year	Escapement [a]
1982	863
1983	4,058
1984	4,191
1985	783
1986	
1987	5,252
1988	
1989	
1990	2,681
1991	4,410
1992	2,527
1993	2,070
1994	1,806
1995	3,460
1996	4,172
1997	5,618
1998	2,586
1999	5,455
2000	4,218
2001	2,353
2002	9,002
2003	
2004	2,162
2005	2,838
2006	2,862
2007	5,166
2008	2,514
2009	2,093
2010	1,052
2011	1,875
2012	667

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix A5.–Data available for analysis of Clear Creek Chinook salmon escapement goal.

Year	Escapement [a]
1979	864
1980	
1981	
1982	982
1983	938
1984	1,520
1985	2,430
1986	
1987	
1988	4,850
1989	
1990	2,380
1991	1,974
1992	1,530
1993	886
1994	1,204
1995	1,928
1996	2,091
1997	5,100
1998	3,894
1999	2,216
2000	2,142
2001	2,096
2002	3,496
2003	
2004	3,417
2005	1,924
2006	1,520
2007	3,310
2008	1,795
2009	1,205
2010	903
2011	512
2012	1,177

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix A6.–Data (by return year) available for analysis of Crooked Creek Chinook salmon escapement goal.

Return	Count at the Weir [a]			Actual Escapement [b]		Return	Sport Harvest		
							Early Run[c]	Creel Survey[d]	
Year	Non-AFC	AFC	Total	Total	Wild	Year	(thru 6/30)	(thru 6/30)	Total
1976	1,682 [e]		1,682	1,537	1,537				
1977	3,069 [e]		3,069	2,390	2,390				
1978	4,535	180	4,715	4,388	4,220	1978			251
1979	2,774	770	3,544	3,177	2,487	1979			283
1980	1,764	518	2,282	2,115	1,635	1980			310
1981	1,871	1,033	2,904	2,919	1,881	1981			1,242
1982	1,449	2,054	3,503	4,107	1,699	1982			2,316
1983	1,543	2,762	4,305	3,842	1,377	1983			2,853
1984	1,372	2,278	3,650	3,409	1,281	1984			3,964
1985	1,175	1,637	2,812	2,491	1,041	1985			2,986
1986	1,539	2,335	3,874	4,055	1,611	1986			7,071
1987	1,444	2,280	3,724	3,344	1,297	1987			4,461
1988	1,174	2,622	3,796	700	216	1988			4,953
1989	1,081	1,930	3,011	750	269	1989			3,767
1990	1,066	1,581	2,647	1,663	670	1990			2,852
1991			2,281	893		1991			5,055
1992			3,533	843		1992			6,049
1993			2,291	657		1993			8,695
1994			1,790	640		1994			7,217
1995			2,206	750		1995			6,681
1996			2,224	764		1996	5,295		6,128
1997						1997	5,627		6,728
1998						1998	4,202		4,839
1999	1,559	232	1,791	1,397	1,206	1999	7,597		8,255
2000	1,224	192	1,416	1,077	940	2000	8,815		9,901
2001	2,122	464	2,586	2,315	1,897	2001	7,488		8,866
2002	2,526	800	3,326	2,708	1,933	2002	4,791		5,242
2003	2,923	1,204	4,127	3,597	2,500	2003	3,090		4,234
2004	2,641	2,232	4,873	4,356	2,196	2004	3,295	2,407	4,333
2005	2,018	1,060	3,168	2,936	1,909	2005	3,468	2,665	4,520
2006	1,589	1,057	2,646	2,569	1,516	2006	2,421	2,489	3,304
2007	1,038	489	1,527	1,452	965	2007	2,601	2,654	3,663
2008	1,018	396	1,414	1,181	879	2008	2,996	1,984	3,789
2009	674	255	929	734	617	2009	1,637	1,532	3,801
2010	1,090	262	1,352	1,348	1,088	2010	2,239	1,333	3,907
2011	677	256	933	782	654	2011	2,054		3,680
2012	633	163	796	731	631	2012	872		927

Note: AFC means adipose fin clip. Blank cells indicate no available data.

[a] Excludes age 0.1 fish. No weir count in 1997 and 1998.

[b] Number of fish estimated to have actually spawned. During all years fish were removed at the weir for brood stock and from 1988–1996 fish were also sacrificed for disease concerns.

[c] From Statewide Harvest Survey (Jennings et al. 2011) for the Kasilof River sport fishery (large fish >20” only). Includes both wild and hatchery fish and an unknown number of late-run fish prior to 1996.

[d] Harvest estimates from early-run Chinook salmon creel survey, Kasilof River (Cope 2011 and Cope 2012). Total harvest is naturally- and hatchery-produced combined.

[e] Assumed wild.

Appendix A7.–Data (by brood year) available for analysis of Crooked Creek Chinook salmon escapement goal.

Brood Year		Escapement [a] Naturally-produced	Hatchery-produced	Total	Total Return[a]	Yield [a,b] Naturally-produced	Hatchery-produced	Total
1999		469	928	1,397	1,791	2,201	1,742	1,273
2000		426	651	1,077	1,416	2,847	2,623	2,196
2001		554	1,761	2,315	2,586	2,549	1,341	787
2002		808	1,900	2,708	3,326	1,605	514	-295
2003		2,396	1,201	3,597	4,127	-561	633	-1,762
2004		2,196	2,160	4,356	4,873	-1,026	-990	-3,186
2005	c	1,909	1,027	2,936	3,168			
2006	c	1,516	1,053	2,569	2,646			
2007	c	965	487	1,452	1,527			
2008	c	879	302	1,181	1,414			
2009	c	617	117	734	929			
2010	c	1,088	260	1,348	1,352			
2011		654	128	782	933			
2012		631	100	731	796			

Note: Blank cells indicate no available data.

[a] Excludes 1-ocean Chinook salmon.

[b] Yield is total return minus escapement (includes broodstock collection and facility mortalities, brood stock include mortalities and not fish released upstream).

[c] Complete return data not yet available.

Appendix A8.–Data available for analysis of Deshka River Chinook salmon escapement goal.

Brood Year	Aerial Survey[a]	Escapement [b]	Weir Escapement[c]	Total Return [a]	Yield	Return per Spawner	Year	Sport Harvest[d]
1,974	5,279	15,201		61,394	46,194	4.04	1974	
1,975	4,737	14,088		33,533	19,446	2.38	1975	
1,976	21,693	48,916		37,763	-11,153	0.77	1976	
1,977	39,642	85,784		38,535	-47,249	0.45	1977	
1,978	24,639	54,967		44,888	-10,079	0.82	1978	
1,979	27,385	60,607		52,489	-8,119	0.87	1979	2,811
1,980		35,096 [e]		45,021	9,924	1.28	1980	3,685
1,981		23,162 [e]		44,951	21,789	1.94	1981	2,769
1,982	16,000	37,222		75,430	38,208	2.03	1982	4,307
1,983	19,237	43,871		36,337	-7,534	0.83	1983	4,889
1,984	16,892	39,054		35,464	-3,590	0.91	1984	5,699
1,985	18,151	41,640		47,082	5,441	1.13	1985	6,407
1,986	21,080	47,657		30,712	-16,945	0.64	1986	6,490
1,987	15,028	35,226		21,774	-13,451	0.62	1987	5,632
1,988	19,200	43,795		20,691	-23,104	0.47	1988	5,474
1,989		23,246 [e]		15,623	-7,624	0.67	1989	8,062
1,990	18,166	41,671		6,846	-34,825	0.16	1990	6,464
1,991	8,112	21,020		15,918	-5,102	0.76	1991	9,306
1,992	7,736	20,248		43,080	22,832	2.13	1992	7,256
1,993	5,769	16,207		31,748	15,541	1.96	1993	5,682
1,994	2,665	9,832		30,307	20,475	3.08	1994	624
1,995	5,150		10,048	52,976	42,928	5.27	1995	0
1,996	6,343		14,349	25,498	11,149	1.78	1996	11
1,997	19,047		35,587	33,619	-1,968	0.94	1997	42
1,998	15,556	36,310		42,143	5,832	1.16	1998	3,384
1,999	12,904		29,088	66,911	37,823	2.30	1999	3,496
2,000			33,965	46,864	12,899	1.38	2000	7,076
2,001			27,966	39,668	11,702	1.42	2001	5,007
2,002	8,749		28,535	30,860	2,325	1.08	2002	4,508
2,003			39,257	6,995	-32,262	0.18	2003	6,605
2,004	28,778		56,659	6,511	-50,148	0.11	2004	9,050
2,005	11,495		36,433	25,664	-10,769	0.70	2005	7,332
2,006	6,499		29,922	21,583	-8,339	0.72	2006	7,753
2,007 [f]	6,712		17,594				2007	5,696
2,008 [f]			7,284				2008	2,036
2,009 [f]	3,954		11,641				2009	723
2,010 [f]			18,223				2010	3,381
2,011 [f]	7,522		18,553				2011	3,139
2,012 [f]			13,952				2012	1,650

[a] Escapement not surveyed or monitored during years with no escapement value.

[b] Data used for spawner-recruit analysis. Aerial surveys were expanded, based on the relationship of aerial surveys to weir counts observed for 1995–2009, to obtain estimates of escapement (Yanusz *In prep*).

[c] Sport fish about the weir was subtracted from weir count.

[d] From Statewide Harvest Survey (Jennings et al. 2011). Years with no harvest estimate occur because the escapement time series precedes the survey (begun in 1977) or harvest could not be estimated from survey data.

[e] Based on average survey indices from nearby years for 1980 and an expectation-maximization (E-M) algorithm for 1981 and 1989 (Yanusz *In prep*), and regression expansion noted in footnote b.

[f] Complete return data not yet available.

Appendix A9.–Data available for analysis of Goose Creek Chinook salmon escapement goal.

Year	Escapement [a]
1981	262
1982	140
1983	477
1984	258
1985	401
1986	630
1987	416
1988	1,076
1989	835
1990	552
1991	968
1992	369
1993	347
1994	375
1995	374
1996	305
1997	308
1998	415
1999	268
2000	348
2001	
2002	565
2003	175
2004	417
2005	468
2006	306
2007	105
2008	117
2009	65
2010	76
2011	80
2012	57

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix A10.–Data available for analysis of Kenai River early-run Chinook salmon escapement goal.

Brood Year	Escapement	Total Return	Yield [a]	Return/ Spawner
1986	11,670	10,490	-1,180	0.90
1987	7,774	13,430	5,656	1.73
1988	4,295	15,350	11,055	3.57
1989	3,734	12,910	9,176	3.46
1990	7,637	10,460	2,823	1.37
1991	8,500	11,300	2,800	1.33
1992	9,444	10,220	776	1.08
1993	2,766	9,925	7,159	3.59
1994	4,691	16,000	11,309	3.41
1995	2,359	12,330	9,971	5.23
1996	2,687	11,290	8,603	4.20
1997	4,371	19,960	15,589	4.57
1998	10,480	18,670	8,190	1.78
1999	5,103	26620	21,517	5.22
2000	8,764	19,730	10,966	2.25
2001	11,400	13,180	1,780	1.16
2002	9,866	14,520	4,654	1.47
2003	16,960	11,770	-5,190	0.69
2004	19,850	5,419	-14,431	0.27
2005	16,650	9,047	-7,603	0.54
2006	13,270	8,318	-4,952	0.63
2007	9,856	8,949	-907	0.91
2008	6,570	7,282	712	1.11
2009	6,163	9,238	3,075	1.50
2010	6,393			
2011	8,448			
2012	5,044			

Note: Blank cells indicate no available data.

[a] Yield is total return minus escapement.

Appendix A11.–Data available for analysis of Kenai River late-run Chinook salmon escapement goal.

Brood Year	Escapement	Total Return	Yield [a]	Return/ Spawner
1986	52,550	51,810	-740	0.99
1987	50,280	59,950	9,670	1.19
1988	41,810	62,480	20,670	1.49
1989	26,550	43,520	16,970	1.64
1990	27,220	48,600	21,380	1.79
1991	31,000	64,470	33,470	2.08
1992	34,470	53,700	19,230	1.56
1993	31,930	44,930	13,000	1.41
1994	28,970	53,360	24,390	1.84
1995	31,660	63,300	31,640	2.00
1996	34,340	52,500	18,160	1.53
1997	27,760	71,250	43,490	2.57
1998	38,980	92,650	53,670	2.38
1999	30,520	130,000	99,480	4.26
2000	32,520	75,330	42,810	2.32
2001	37,580	53,570	15,990	1.43
2002	45,390	68,180	22,790	1.50
2003	66,900	44,870	-22,030	0.67
2004	63,770	21,280	-42,490	0.33
2005	60,060	38,680	-21,380	0.64
2006	48,970	28,330	-20,640	0.58
2007	36,950	51,660	14,710	1.40
2008	32,290	36,140	3,850	1.12
2009	21,390	40,490	19,100	1.89
2010	16,210			
2011	19,680			
2012	27,710			

Note: Blank cells indicate no available data.

[a] Yield is total return minus escapement.

Appendix A12.–Data available for analysis of Lake Creek Chinook salmon escapement goal.

Year	Escapement [a]
1979	4,196
1980	
1981	
1982	3,577
1983	7,075
1984	
1985	5,803
1986	
1987	4,898
1988	6,633
1989	
1990	2,075
1991	3,011
1992	2,322
1993	2,869
1994	1,898
1995	3,017
1996	3,514
1997	3,841
1998	5,056
1999	2,877
2000	4,035
2001	4,661
2002	4,852
2003	8,153
2004	7,598
2005	6,345
2006	5,300
2007	4,081
2008	2,004
2009	1,394
2010	1,617
2011	2,563
2012	2,366

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix A13.–Data available for analysis of Lewis River Chinook salmon escapement goal.

Year	Escapement [a]
1977	
1978	
1979	546
1980	
1981	560
1982	606
1983	
1984	947
1985	861
1986	722
1987	875
1988	616
1989	452
1990	207
1991	303
1992	445
1993	531
1994	164
1995	146
1996	257
1997	777
1998	626
1999	675
2000	480
2001	502
2002	439
2003	878
2004	1,000
2005	441
2006	341
2007	0[b]
2008	120
2009	111
2010	56
2011	92
2012	107

[a] Escapement not surveyed or monitored during years with no escapement value.

[b] Lack of a river channel following a flood event prevented upstream fish passage.

Appendix A14.–Data available for analysis of Little Susitna River Chinook salmon escapement goal.

Year	Escapement [a]
1977	
1978	
1979	
1980	
1981	
1982	
1983	929
1984	558
1985	1,005
1986	
1987	1,386
1988	3,197
1989	2,184
1990	922
1991	892
1992	1,441
1993	
1994	1,221
1995	1,714
1996	1,079
1997	
1998	1,091
1999	
2000	1,094
2001	1,238
2002	1,660
2003	1,114
2004	1,694
2005	2,095
2006	1,855
2007	1,731
2008	1,297
2009	1,028
2010	589
2011	887
2012	1,154

[a] Escapement not surveyed or monitored during years with no escapement value. No aerial survey conducted in 1989; however, in 1988, 1989, 1994, and 1995 a weir was operated on the Little Susitna River. Based on the relationship of weir counts to aerial surveys in 1988, 1994, and 1995, 50% of the 1989 weir count of 4,367 Chinook salmon was used for an index of escapement.

Appendix A15.–Data available for analysis of Little Willow Creek Chinook salmon escapement goal.

Year	Escapement [a]
1979	327
1980	
1981	459
1982	316
1983	1,042
1984	
1985	1,305
1986	2,133
1987	1,320
1988	1,515
1989	1,325
1990	1,115
1991	498
1992	673
1993	705
1994	712
1995	1,210
1996	1,077
1997	2,390
1998	1,782
1999	1,837
2000	1,121
2001	2,084
2002	1,680
2003	879
2004	2,227
2005	1,784
2006	816
2007	1,103
2008	
2009	776
2010	468
2011	713
2012	494

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix A16.–Data available for analysis of Montana Creek Chinook salmon escapement goal.

Year	Escapement [a]
1981	814
1982	
1983	
1984	
1985	
1986	
1987	1,320
1988	2,016
1989	
1990	1,269
1991	1,215
1992	1,560
1993	1,281
1994	1,143
1995	2,110
1996	1,841
1997	3,073
1998	2,936
1999	2,088
2000	1,271
2001	1,930
2002	2,357
2003	2,576
2004	2,117
2005	2,600
2006	1,850
2007	1,936
2008	1,357
2009	1,460
2010	755
2011	494
2012	416

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix A17.–Data available for analysis of Peters Creek Chinook salmon escapement goal.

Year	Escapement [a]
1983	2,272
1984	324
1985	2,901
1986	1,915
1987	1,302
1988	3,927
1989	959
1990	2,027
1991	2,458
1992	996
1993	1,668
1994	573
1995	1,041
1996	749
1997	2,637
1998	4,367
1999	3,298
2000	1,648
2001	4,226
2002	2,959
2003	3,998
2004	3,757
2005	1,508
2006	1,114
2007	1,225
2008	
2009	1,283
2010	NC
2011	1,103
2012	459

[a] In 1983, only a tributary was surveyed and not Peters Creek mainstem. Escapement not surveyed or monitored during years with no escapement value.

Appendix A18.–Data available for analysis of Prairie Creek Chinook salmon escapement goal.

Year	Escapement
1981	1,875
1982	3,844
1983	3,200
1984	9,000
1985	6,500
1986	8,500
1987	9,138
1988	9,280
1989	9,463
1990	9,113
1991	6,770
1992	4,453
1993	3,023
1994	2,254
1995	3,884
1996	5,037
1997	7,710
1998	4,465
1999	5,871
2000	3,790
2001	5,191
2002	7,914
2003	4,095
2004	5,570
2005	3,862
2006	3,570
2007	5,036
2008	3,039
2009	3,500
2010	3,022
2011	2,038
2012	1,185

Appendix A19.–Data available for analysis of Sheep Creek Chinook salmon escapement goal.

Year	Escapement [a]
1979	778
1980	
1981	1,013
1982	527
1983	975
1984	1,028
1985	1,634
1986	1,285
1987	895
1988	1,215
1989	610
1990	634
1991	154
1992	
1993	
1994	542
1995	1,049
1996	1,028
1997	
1998	1,160
1999	
2000	1,162
2001	
2002	854
2003	
2004	285
2005	760
2006	580
2007	400
2008	
2009	500
2010	NC
2011	350
2012	363

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix A20.–Data available for analysis of Talachulitna River Chinook salmon escapement goal.

Year	Escapement [a]
1979	1,648
1980	
1981	2,025
1982	3,101
1983	10,014
1984	6,138
1985	5,145
1986	3,686
1987	
1988	4,112
1989	
1990	2,694
1991	2,457
1992	3,648
1993	3,269
1994	1,575
1995	2,521
1996	2,748
1997	4,494
1998	2,759
1999	4,890
2000	2,414
2001	3,309
2002	7,824
2003	9,573
2004	8,352
2005	4,406
2006	6,152
2007	3,871
2008	2,964
2009	2,608
2010	1,499
2011	1,368
2012	847

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix A21.–Data available for analysis of Theodore River Chinook salmon escapement goal.

Year	Escapement [a]
1977	
1978	
1979	512
1980	
1981	535
1982	1,368
1983	1,519
1984	1,251
1985	1,458
1986	1,281
1987	1,548
1988	1,906
1989	1,026
1990	642
1991	508
1992	1,053
1993	1,110
1994	577
1995	694
1996	368
1997	1,607
1998	1,807
1999	2,221
2000	1,271
2001	1,237
2002	934
2003	1,059
2004	491
2005	478
2006	958
2007	486
2008	345
2009	352
2010	202
2011	327
2012	179

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix A22.–Data available for analysis of Willow Creek Chinook salmon escapement goal.

Year	Escapement [a]
1981	991
1982	592
1983	
1984	2,789
1985	1,856
1986	2,059
1987	2,768
1988	2,496
1989	5,060
1990	2,365
1991	2,006
1992	1,660
1993	2,227
1994	1,479
1995	3,792
1996	1,776
1997	4,841
1998	3,500
1999	2,081
2000	2,601
2001	3,188
2002	2,758
2003	3,964
2004	2,985
2005	2,463
2006	2,217
2007	1,373
2008	1,255
2009	1,133
2010	1,173
2011	1,061
2012	756

[a] Escapement not surveyed or monitored during years with no escapement value.

APPENDIX B.
SUPPORTING INFORMATION FOR UPPER COOK INLET COHO SALMON ESCAPEMENT GOALS

Appendix B1.–Data available for analysis of Fish Creek coho salmon escapement goal.

Year	Escapement [a]
1969	5,671[b]
1970	
1971	
1972	955[b]
1973	280[b]
1974	1,539[b]
1975	2,135[b]
1976	1,020[b]
1977	970
1978	3,184
1979	2,511
1980	8,924
1981	2,330
1982	5,201
1983	2,342
1984	4,510
1985	5,089
1986	2,166
1987	3,871
1988	2,162
1989	3,479
1990	2,673
1991	1,297
1992	1,705
1993	2,078
1994	350
1995	390
1996	682
1997	3,437[b]
1998	5,463
1999	1,766
2000	5,218
2001	9,247
2002	14,651
2003	1,231
2004	1,415
2005	3,011
2006	4,967
2007	6,868
2008	4,868
2009	8,214
2010	6,977
2011	1,428
2012	1,237

[a] Escapement not surveyed or monitored during years with no escapement value.

[b] Calculation of percentiles based on escapements in 1969, 1972–1976, 1978, 1997–2000, years with no stocking and for which weir was operated past September 1. Escapements for 1969, 1972–1976 and 1997, were expanded by 25% to account for removal of weir from September 1 to 17. In 1977 the weir was removed in August, and 1979–1996 were excluded because stocked fish returned.

Appendix B2.–Data available for analysis of Jim Creek coho salmon escapement goal.

Year	Escapement [a]
1981	
1982	
1983	
1984	
1985	662
1986	439
1987	667
1988	1,911
1989	597
1990	599
1991	484
1992	11
1993	503
1994	506
1995	702
1996	72
1997	701
1998	922
1999	12
2000	657
2001	1,019
2002	2,473
2003	1,421
2004	4,652
2005	1,464
2006	2,389
2007	725
2008	1,890
2009	1,331
2010	242
2011	229
2012	213

[a] Escapement for McRoberts Creek only, a tributary to Jim Creek. Escapement not surveyed or monitored during years with no escapement value.

Appendix B3.–Data available for analysis of Little Susitna River coho salmon escapement goal.

Year	Total Escapement [a]	% Hatchery Contribution to Escapement [b]	Escapement Hatchery	Escapement Wild	Sport Harvest [c]
1977					3,415
1978					4,865
1979					3,382
1980					6,302
1981					5,940
1982					7,116
1983					2,835
1984					14,253
1985					7,764
1986	6,999			6,999	6,039
1987					13,003
1988	20,491	22	4,428	16,063	19,009
1989	15,232	45	6,862	8,370	14,129
1990	14,310	24	3,370	10,940	7,497
1991	37,601	22	8,322	29,279	16,450
1992	20,393	11	2,324	18,069	20,033
1993	33,378	29	9,615	23,763	27,610
1994	27,820	18	5,124	22,696	17,665
1995	11,817	9	1,069	10,748	14,451
1996	16,699	3	444	16,255	16,753
1997	9,894			9,894	7,756
1998	15,159			15,159	14,469
1999	3,017			3,017	8,864
2000	15,436			15,436	20,357
2001	30,587			30,587	17,071
2002	47,938			47,938	19,278
2003	10,877			10,877	13,672
2004	40,199			40,199	15,307
2005	16,839			16,839	10,203
2006	8,786			8,786	12,399
2007	17,573			17,573	11,089
2008	18,485			18,485	13,498
2009	9,523			9,523	8,346
2010	9,214			9,214	10,622
2011	4,826			4,826	2,452
2012	6,779[d]			6,779	1,681

[a] Escapement not surveyed or monitored during years with no escapement value.

[b] Based on sampling and coded wire tag data collected at the weir in 1988–1996. Hatchery stocking program ended in 1995; thus, no hatchery-produced fish in the coho salmon run since 1997.

[c] From Statewide Harvest Survey (Jennings et al. 2011).

[d] Incomplete or partial count due to weir submersion.

APPENDIX C.
SUPPORTING INFORMATION FOR UPPER COOK INLET SOCKEYE SALMON ESCAPEMENT GOALS

Appendix C1.–Data available for analysis of Chelatna Lake sockeye salmon escapement goal.

Year	Escapement [a]
1992	35,300 [b]
1993	20,235
1994	28,303
1995	20,124
1996	35,747 [c]
1997	84,899
1998	51,798 [c]
1999	
2000	
2001	
2002	
2003	
2004	
2005	
2006	18,433 [d]
2007	41,290 [d]
2008	73,469
2009	17,721
2010	37,784
2011	70,353
2012	36,577

[a] Escapement not surveyed or monitored during years with no escapement value. Escapement estimated with weirs unless specified otherwise.

[b] Mark–recapture estimate.

[c] Weir inoperable during high water events; missing counts filled in using linear expansion between counts before and after high water (Fair et al. 2009).

[d] Weir inoperable during high water events; missing counts filled in using proportion of radio–tagged fish passing during high water (Fair et al. 2009).

Appendix C2.–Data available for analysis of Crescent River sockeye salmon escapement goal.

Year	Escapement [a]	Total Return	Yield [a]	Return/ Spawner
1975	41,000	216,167	99,684	5.27
1976	51,000	52,045	93,852	1.02
1977	87,000	99,418	86,317	1.14
1978	74,000	244,620	175,167	3.31
1979	86,654	245,231	1,045	2.83
1980	90,863	275,217	12,418	3.03
1981	41,213	163,083	170,620	3.96
1982	58,957	168,456	158,577	2.86
1983	92,122	181,744	184,354	1.97
1984	118,345	114,033	121,870	0.96
1985	128,628	53,617	109,499	0.42
1986 [b]	95,631	89,566	89,622	0.94
1987	120,219	64,167	-4,312	0.53
1988	57,716	50,636	-75,011	0.88
1989	71,064	80,264	-6,065	1.13
1990	52,238	41,689	-56,052	0.80
1991	44,578	54,931	-7,080	1.23
1992	58,229	85,015	9,200	1.46
1993	37,556	91,483	-10,549	2.44
1994	30,127	87,578	10,353	2.91
1995	52,311	137,517	26,786	2.63
1996	28,729	75,639	53,927	2.63
1997	70,768	99,721	57,451	1.41
1998	62,257	180,355	85,206	2.90
1999	66,519	159,026	46,910	2.39
2000	56,564	178,353	28,953	3.15
2001	78,081	111,675	118,098	1.43
2002	62,833	133,985	92,507	2.13
2003	122,159	104,219	121,789	0.85
2004	103,201	179,279	33,594	1.74
2005	125,623	140,365	14,742	1.12
2006	92,533	111,702	19,169	1.21
2007 [c]	79,406			
2008 [c]	62,030			
2009 [d]	125,114			
2010	86,333			
2011	81,952			
2012	58,838			

Note: Blank cells indicate no available data.

[a] Escapement was estimated by sonar beginning in 1975.

[b] In 1986 the sonar operation was terminated earlier than usual on July 16. A total of 20,385 sockeye salmon had been counted through that date. To account for the missing period, total sockeye salmon escapement in 1986 was estimated using the exploitation rate through July 13 and total Western Subdistrict catch.

[c] Complete return data not available.

[d] Sonar project did not operate in 2009 (Redoubt volcano eruption). For this year, escapement was estimated using an average harvest rate model.

Appendix C3.–Data available for analysis of Fish Creek sockeye salmon escapement goal.

Year	Escapement [a,b,c]		Year	Escapement [a,b,c]
1946	57,000	[d]	1979	68,739
1947	150,000	[d]	1980	62,828
1948	150,000	[d]	1981	50,479
1949	68,240		1982	28,164
1950	29,659		1983	118,797
1951	34,704		1984	192,352
1952	92,724		1985	68,577
1953	54,343		1986	29,800
1954	20,904		1987	91,215
1955	32,724		1988	71,603
1956	32,663	[c]	1989	67,224
1957	15,630		1990	50,000
1958	17,573		1991	50,500
1959	77,416	[e,f]	1992	71,385
1960	80,000	[e, f]	1993	117,619
1961	40,000	[e, f]	1994	95,107
1962	60,000	[e, f]	1995	115,000
1963	119,024	[e, f]	1996	63,160
1964	65,000	[e, f]	1997	54,656
1965	16,544	[e, f]	1998	22,853
1966	41,312	[e, f]	1999	26,746
1967	22,624	[e, f]	2000	19,533
1968	19,616	[e, f]	2001	43,469
1969	12,456		2002	90,483
1970	25,000	[g]	2003	92,298
1971	31,900	[h]	2004	22,157
1972	6,981		2005	14,215
1973	2,705		2006	32,562
1974	16,225		2007	27,948
1975	29,882		2008	19,339
1974			2009	83,480
1975			2010	126,836
1976	14,032		2011	66,678
1977	5,183		2012	18,813
1978	3,555			

[a] Escapement not surveyed or monitored during years with no escapement value.

[b] Counting occurred downstream of Knik Road prior to 1983, at South Big Lake Road from 1983 to 1991, and at Lewis Road from 1992 to present.

[c] Data for 1979–2000 were excluded from analyses because hatchery stocks were present.

[d] Escapement enumerated by ground surveys.

[e] Escapement enumerated using a counting screen.

[f] Partial counts due to termination of counting before the end of the run.

[g] Includes 3,500 sockeye salmon behind weir when it washed out on August 8, 1970.

[h] Includes 500 sockeye salmon behind weir when it was removed on August 7, 1971.

Appendix C4.–Data available for analysis of Judd Lake sockeye salmon escapement goal.

Year	Escapement [a]
1973	26,428 [b]
1974	
1975	
1976	
1977	
1978	
1979	
1980	43,350 [b]
1981	
1982	
1983	
1984	
1985	
1986	
1987	
1988	
1989	12,792
1990	
1991	
1992	
1993	
1994	
1995	
1996	
1997	
1998	34,416
1999	
2000	
2001	
2002	
2003	
2004	
2005	
2006	40,633
2007	58,134
2008	54,304
2009	44,616
2010	18,361
2011	39,997
2012	18,303

[a] Escapement not surveyed or monitored during years with no escapement value. Escapement estimated with weirs unless specified otherwise.

[b] Aerial survey.

Appendix C5.–Data available for analysis of Kasilof River sockeye salmon escapement goal.

Brood Year	Escapement	Returns	Yield	Return per Spawner
1969	46,964	110,919	63,955	2.36
1970	38,797	168,239	129,442	4.34
1971	91,887	295,083	203,196	3.21
1972	115,486	372,639	257,153	3.23
1973	40,880	341,734	300,854	8.36
1974	71,335	342,896	271,561	4.81
1975	45,687	321,496	275,809	7.04
1976	136,595	691,521	554,926	5.06
1977	156,616	609,725	453,109	3.89
1978	112,484	694,637	582,153	6.18
1979	152,503	782,400	629,897	5.13
1980	182,284	1,081,103	898,819	5.93
1981	252,460	1,850,929	1,598,469	7.33
1982	172,470	1,281,861	1,109,391	7.43
1983	205,361	1,003,028	797,667	4.88
1984	226,469	757,118	530,649	3.34
1985	501,071	362,906	-138,165	0.72
1986	270,559	668,119	397,560	2.47
1987	243,244	882,204	638,960	3.63
1988	194,322	662,506	468,184	3.41
1989	154,070	508,618	354,548	3.30
1990	137,317	498,496	361,179	3.63
1991	223,492	942,751	719,259	4.22
1992	181,394	813,667	632,273	4.49
1993	142,111	519,995	377,884	3.66
1994	204,604	763,335	558,731	3.73
1995	188,698	528,759	340,061	2.80
1996	252,213	748,858	496,645	2.97
1997	254,459	680,347	425,888	2.67
1998	248,220	789,866	541,646	3.18
1999	301,403	1,156,874	855,471	3.84
2000	253,514	1,387,340	1,133,826	5.47
2001	308,510	1,644,503	1,335,993	5.33
2002	225,184	1,273,593	1,048,409	5.66
2003	341,327	1,598,617	1,257,290	4.68
2004	521,793	1,511,138	989,345	2.90
2005	358,569	857,699	499,130	2.39
2006	387,769	729,084	344,315	1.88
2007	364,261	504,211	139,950	1.38
2008	324,880			
2009	324,783			
2010	293,765			
2011	243,767			
2012	372,523			
2013	479,262			

Note: Blank cells indicate no available data.

Appendix C6.–Data available for analysis of Kenai River sockeye salmon escapement goal (excludes Hidden Lake enhanced).

Brood Year	Escapement	Returns	Yield	Return per Spawner	Exploitation Rate
1968	115,545				
1969	72,901	430,947	358,046	5.91	0.83
1970	101,794	550,923	449,129	5.41	0.82
1971	406,714	986,397	579,683	2.43	0.59
1972	431,058	2,547,851	2,116,793	5.91	0.83
1973	507,072	2,125,986	1,618,914	4.19	0.76
1974	209,836	788,067	578,231	3.76	0.73
1975	184,262	1,055,374	871,112	5.73	0.83
1976	507,440	1,506,075	998,635	2.97	0.66
1977	951,038	3,112,852	2,161,814	3.27	0.69
1978	511,781	3,785,623	3,273,842	7.40	0.86
1979	373,810	1,321,707	947,897	3.54	0.72
1980	600,813	2,675,007	2,074,194	4.45	0.78
1981	527,554	2,465,818	1,938,265	4.67	0.79
1982	755,413	9,591,200	8,835,787	12.70	0.92
1983	792,765	9,489,648	8,697,280	11.97	0.92
1984	446,397	3,865,134	3,418,737	8.66	0.88
1985	573,836	2,592,968	2,019,357	4.52	0.78
1986	546,872	2,174,842	1,628,228	3.98	0.75
1987	1,982,808	10,378,573	8,396,072	5.23	0.81
1988	1,174,729	2,550,942	1,377,286	2.17	0.54
1989	2,026,638	4,480,888	2,453,589	2.21	0.55
1990	733,155	1,518,983	788,512	2.07	0.52
1991	696,345	4,444,531	3,688,183	6.38	0.84
1992	1,188,534	4,272,741	3,084,307	3.59	0.72
1993	992,096	1,690,264	698,168	1.70	0.41
1994	1,307,440	3,053,461	1,746,192	2.34	0.57
1995	771,936	1,900,509	1,128,574	2.46	0.59
1996	916,244	2,262,667	1,346,423	2.47	0.60
1997	1,326,202	3,627,321	2,301,119	2.74	0.63
1998	877,707	4,466,351	3,588,917	5.09	0.80
1999	916,632	5,755,767	4,839,720	6.28	0.84
2000	669,406	7,068,840	6,400,330	10.56	0.91
2001	714,201	1,706,352	992,868	2.39	0.58
2002	1,082,561	3,625,363	2,543,786	3.35	0.70
2003	1,395,976	1,908,893	513,461	1.37	0.27
2004	1,679,806	3,154,177	1,475,656	1.88	0.47
2005	1,647,023	4,569,593	2,922,606	2.77	0.64
2006	1,876,180	4,833,454	2,957,366	2.58	0.61
2007	957,430	4,384,477	3,426,893	4.58	0.78
2008	703,979				
2009	843,255				
2010	1,015,106				
2011	1,275,369				
2012	1,197,518				
2013	1,055,000 [a]				

Note: Blank cells indicate no available data.

[a] Escapement is preliminary because sport harvest estimate is not final.

Appendix C7.–Data available for analysis of Larson Lake sockeye salmon escapement goal.

Year	Escapement [a]
1984	35,254
1985	37,874
1986	32,322
1987	16,753
1988	
1989	
1990	
1991	
1992	
1993	
1994	
1995	
1996	
1997	40,282
1998	63,514
1999	18,943
2000	11,987
2001	
2002	
2003	
2004	
2005	9,751
2006	57,411
2007	47,736
2008	35,040
2009	40,933
2010	20,324
2011	12,413
2012	16,708

[a] Escapement not surveyed or monitored during years with no escapement value.

Appendix C8.–Data available for analysis of Packers Creek sockeye salmon escapement goal.

Year	Escapement [a]
1974	2,123
1975	4,522
1976	13,292
1977	16,934
1978	23,651
1979	37,755
1980	28,520
1981	12,934
1982	15,687
1983	18,403
1984	30,403
1985	36,864
1986	29,604
1987	35,401
1988	18,607
1989	22,304
1990	31,868
1991	41,275
1992	30,143
1993	40,869
1994	30,776
1995	29,473
1996	16,971
1997	31,439
1998	17,728
1999	25,648
2000	20,151
2001	
2002	
2003	
2004	
2005	22,000
2006	
2007	46,637
2008	25,247
2009	16,473
2010	NA
2011	NA
2012	NA

[a] Escapement not surveyed or monitored during years with no escapement value. Years with NA were incomplete in their assessment.

Appendix C9.–Table of data available for analysis of early-run Russian River sockeye salmon escapement goal.

Brood Year	Escapement [a]	Total Return	Yield	Return/ Spawner	Harvest [b]
1965	21,510	5,970	-15,540	0.28	10,030
1966	16,660	7,822	-8,838	0.47	14,950
1967	13,710	18,662	4,952	1.36	7,240
1968	9,120	19,800	10,680	2.17	6,920
1969	5,000	13,169	8,169	2.63	5,870
1970	5,450	12,642	7,192	2.32	5,750
1971	2,650	8,728	6,078	3.29	2,810
1972	9,270	98,980	89,710	10.68	5,040
1973	13,120	26,788	13,668	2.04	6,740
1974	13,160	52,849	39,689	4.02	6,440
1975	5,650	14,130	8,480	2.50	1,400
1976	14,735	115,408	100,673	7.83	3,380
1977	16,060	17,515	1,455	1.09	20,400
1978	34,240	17,001	-17,239	0.50	37,720
1979	19,750	94,836	75,086	4.80	8,400
1980	28,620	42,401	13,781	1.48	27,220
1981	21,140	76,040	54,900	3.60	10,720
1982	56,110	278,179	222,069	4.96	34,500
1983	21,270	23,549	2,279	1.11	8,360
1984	28,900	42,857	13,957	1.48	35,880
1985	30,610	43,776	13,166	1.43	12,300
1986	36,340	90,637	54,297	2.49	35,100
1987	61,510	109,215	47,705	1.78	154,200
1988	50,410	87,848	37,438	1.74	54,780
1989	15,340	57,055	41,715	3.72	11,290
1990	26,720	94,893	68,173	3.55	30,215
1991	32,389	126,044	93,655	3.89	65,390
1992	37,117	64,978	27,861	1.75	30,512
1993	39,857	41,584	1,727	1.04	37,261
1994	44,872	114,649	69,777	2.56	48,923
1995	28,603	26,462	-2,141	0.93	23,572
1996	52,905	192,657	139,752	3.64	39,075
1997	36,280	63,876	27,596	1.76	36,788
1998	34,143	57,692	23,549	1.69	42,711
1999	36,607	106,219	69,612	2.90	34,283
2000	32,736	94,932	62,196	2.90	40,732
2001	78,255	77,071	-1,184	0.98	35,400
2002	85,943	74,180	-11,763	0.86	52,139
2003	23,650	68,346	44,696	2.89	22,986
2004	56,582	105,293	48,711	1.86	32,727
2005	52,903	31,718	-21,185	0.60	37,139
2006	80,524	59,545	-20,979	0.74	51,167
2007 [c]	27,298	12,506	ND	0.46	37,185
2008 [c]	30,989	0	ND	0.00	43,420
2009 [c]	52,178	0	ND	0.00	59,640
2010 [c]	27,074	ND	ND	ND	24,047
2011 [c]	29,129	ND	ND	ND	23,339
2012 [c]	24,115	ND	ND	ND	16,098

[a] Escapements of brood years 1965–1968 from tower counts and of 1969–2000 from weir counts.

[b] Harvest during 1965–1996 from an onsite creel survey and during 1997–2012 from Statewide Harvest Survey (Jennings et al. 2011). Estimates are only of fish harvested near the Russian River itself.

[c] Complete return data not yet available.

Appendix C10.–Data available for analysis of late-run Russian River sockeye salmon escapement goal.

Year	Harvest [a]	Escapement[b] Above weir	Below weir	Local return
1963	1,390	51,120	Unknown	52,510
1964	2,450	46,930	Unknown	49,380
1965	2,160	21,820	Unknown	23,980
1966	7,290	34,430	Unknown	41,720
1967	5,720	49,480	Unknown	55,200
1968	5,820	48,880	4,200	58,900
1969	1,150	28,870	1,100	31,120
1970	600	26,200	220	27,020
1971	10,730	54,420	10,000	75,150
1972	16,050	79,115	6,000	101,165
1973	8,930	25,070	6,680	40,680
1974	8,500	24,900	2,210	35,610
1975	8,390	31,960	690	41,040
1976	13,700	31,940	3,470	49,110
1977	27,440	21,360	17,090	65,890
1978	24,530	34,340	18,330	77,200
1979	26,840	87,850	3,920	118,610
1980	33,500	83,980	3,220	120,700
1981	23,720	44,520	4,160	72,400
1982	10,320	30,800	45,000	86,120
1983	16,000	33,730	44,000	93,730
1984	21,970	92,660	3,000	117,630
1985	58,410	136,970	8,650	204,030
1986	30,810	40,280	15,230	86,320
1987	40,580	53,930	76,530	171,040
1988	19,540	42,480	30,360	92,380
1989	55,210	138,380	28,480	222,070
1990	56,180	83,430	11,760	151,370
1991	31,450	78,180	22,270	131,900
1992	26,101	63,478	4,980	94,559
1993	26,772	99,259	12,258	138,289
1994	26,375	122,277	15,211	163,863
1995	11,805	61,982	12,479	86,266
1996	19,136	34,691	31,601	85,428
1997	12,910	65,905	11,337	90,152
1998	25,110	113,477	19,593	158,180
1999	32,335	139,863	19,514	191,712
2000	30,229	56,580	13,930	100,739
2001	18,550	74,964	17,044	110,558
2002	31,999	62,115	6,858	100,972
2003	28,085	157,469	27,474	213,028
2004	22,417	110,244	30,458	163,119
2005	18,503	54,808	29,048	102,359
2006	29,694	84,432	18,452	132,578
2007	17,161	53,068	4,504	74,733
2008	24,158	46,638	9,750	80,546
2009	34,366	80,088	10,740	125,194
2010	9,579	38,848	16,656	65,081
2011	14,723	41,529	35,415	91,628
2012	15,535	54,911	25,471	95,917

[a] Harvest during 1963–1996 from an onsite creel survey and during 1997–2000 from Statewide Harvest Survey (Jennings et al. 2011). Estimates are only of fish harvested near the Russian River itself.

[b] Escapements of brood years 1963–1968 from tower counts and 1969–2000 from weir counts.

APPENDIX D.
SUPPORTING INFORMATION FOR UPPER COOK INLET CHUM SALMON ESCAPEMENT GOALS

Appendix D1.–Data available for analysis of Clearwater Creek chum salmon escapement goal.

Year	Escapement [a]
1971	5,000
1972	
1973	8,450
1974	1,800
1975	4,400
1976	12,500
1977	12,700
1978	6,500
1979	1,350
1980	5,000
1981	6,150
1982	15,400
1983	10,900
1984	8,350
1985	3,500
1986	9,100
1987	6,350
1988	
1989	2,000
1990	5,500
1991	7,430
1992	8,000
1993	1,130
1994	3,500
1995	3,950
1996	5,665
1997	8,230
1998	2,710
1999	6,400
2000	31,800
2001	14,570
2002	8,864
2003	7,200
2004	3,900
2005	4,920
2006	8,300
2007	
2008	4,530
2009	8,300
2010	13,700
2011	11,630
2012	5,300

[a] Escapement not surveyed or monitored during years with no escapement value.