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Review of Salmon Escapement Goals in Upper Cook Inlet, Alaska, 2011

by

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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	$\geq$
harvest per unit effort	HPUE
less than	$<$
less than or equal to	$\leq$
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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The Fishery Manuscript series was established in 1987 by the Division of Sport Fish for the publication of technically-oriented results of several years' work undertaken on a project to address common objectives, provide an overview of work undertaken through multiple projects to address specific research or management goal(s), or new and/or highly technical methods, and became a joint divisional series in 2004 with the Division of Commercial Fisheries. Fishery Manuscripts are intended for fishery and other technical professionals. Fishery Manuscripts are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm This publication has undergone editorial and peer review.

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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 most escapement goals remain status quo. However, the committee recommended reinstating the previous Fish Creek coho salmon sustainable escapement goal (SEG) of 1,200–4,400 dropped during the 2004–2005 review. A risk-based lower bound SEG of 380 is proposed to replace the existing SEG range of 50–700 for the Campbell Creek Chinook salmon stock. The Kenai River sockeye salmon SEG range of 500,000–800,000 based on Bendix sonar should change to an SEG range of 700,000–1,200,000 based on DIDSON sonar, and the Kasilof sockeye salmon biological escapement goal (BEG) of 150,000–250,000 based on Bendix sonar should change to a BEG range of 160,000–340,000 based on DIDSON sonar. Due to the amount of uncertainty associated with escapement estimates, the committee recommended changing early- and late-run Kenai River Chinook salmon goal type from BEGs to SEGs. Similarly, uncertainty in Deshka River Chinook salmon commercial harvests prompted a change from a BEG to SEG-type goal. Lastly, returns from 2001 to 2003 brood years provided sufficient information to develop a BEG of 22,000–42,000 (previously an SEG of 14,000–37,000) for early-run Russian River sockeye salmon.

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 subdivided 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 2010 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. 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), this review reanalyzed only those goals with recent (2007–2009) 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 2010 review process, the committee evaluated escapement goals for various 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

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[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*).

In February 2010, 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 data through 2009. For Kenai and Kasilof river sockeye salmon, however, we used data through 2010 because part of their runs originated from very large, and potentially influential escapements in the mid-2000s. 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. Data available for escapement goal analysis for all UCI stocks are found in this report (Appendices A–D).

Chinook Salmon

Escapements for most Chinook salmon stocks 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. These measurements provide a ranking of escapement magnitude across years, but alone these measurements provide little information on the total number of fish in the escapement. Hydroacoustics (sonar) were used to assess early- and late-run Chinook salmon inriver runs to the Kenai River (Miller et al. 2010). 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 2007).

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 monitored by ADF&G (Tobias and Willette 2010). For coho salmon stocks, escapements are monitored with single foot surveys on Jim Creek and weirs on Fish Creek and Little Susitna River (Bue and Hasbrouck *Unpublished*).

Sockeye Salmon

Sonar is used to estimate sockeye salmon abundance passing specific locations in the Crescent, Kasilof, Kenai, and Yentna rivers where high glacial turbidity precludes visual enumeration (Westerman and Willette 2010). 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 from 2004 to 2007, and on the Kasilof River from 2007 to 2009. For this review, to revise Kenai and Kasilof abundance estimates from Bendix sonar to DIDSON, regression equations relating the daily estimates (Maxwell et al. *In prep*) developed from comparison studies adjusted historical daily Bendix sonar abundance to DIDSON units. Next, we estimated daily sockeye salmon abundance from sonar and fish wheel catches. We used mean annual ratios between the 2 sonar estimates (Kasilof=1.022, Kenai=1.406) to adjust annual sockeye salmon abundance prior to 1979 on the Kenai and prior to 1983 on the Kasilof because daily sonar estimates were unavailable by bank and sonar configurations were different. Sonar counts are apportioned to species using fish wheel catches, which also supply information about age, sex, and size (Westerman and Willette 2010). Beginning in 2010, the Yentna River sonar project ceased producing salmon estimates for inseason management, although the project continues operating to determine if it is feasible to reconstruct the historical record of escapements measured with a Bendix sonar (Maxwell et al. *In prep*) while adjusting for species selectivity.

In clear-water systems of UCI, 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 2007), and Fish Creek (Oslund and Ivey 2010). Historically at Packers Creek, escapement has been counted with both video cameras and weirs. In 2009 and 2010, we operated a video camera to estimate escapement (Shields 2010).

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 has operated near the Tustumena Lake outlet from 1968 to 1982 and at rkm 12.1 immediately upstream of the Sterling Highway bridge since 1983 (Figure 1). Although sockeye salmon hatchery stocking has occurred in the Kasilof system, hatchery fish were not removed from the total return estimate. The hatchery run to the Kasilof River averaged about 32,000 fish, or 3–6% of the total return. However, the last adults returned from the 2004 Tustumena Lake fry release (Shields 2007) in 2010.

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 and Willette 2010). 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. 2010) and creel surveys (1994, 1995) conducted during the fishery (King 1995, 1997). Prior to 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 2010); after 1999, it was determined from the recovery of otolith thermal-marked salmon.

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 2010). Prior to 2005, a weighted age composition apportionment model estimated stock-specific harvests of sockeye salmon in commercial gillnet fisheries (Tobias and Willette 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. Harvest allocation for each stock was estimated by harvest location and age composition. The age composition catch apportionment method utilizes 4 data types: (1) commercial harvests, (2) escapements into major UCI drainages, (3) age composition of harvests, and (4) age composition of escapements. 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). Sockeye salmon harvest age composition is estimated annually using a stratified systematic sampling design (Tobias and Willette 2010). 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 postal SWHS conducted annually by the Division of Sport Fish (Jennings et al. 2010).

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 (2006–2009) 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. *In prep* 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 2010 sockeye salmon run estimates, the catch allocation model used DIDSON estimates for Kenai and Kasilof, and a 4-year average (2006–2009) mark–recapture estimate for Susitna River sockeye salmon escapement.

ESCAPEMENT GOAL DETERMINATION

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 maximum sustainable yield (MSY) 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 CTC (1999) 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 logarithm 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 escapement goals for Kenai and Kasilof river sockeye salmon, similar to Clark et al. (2007).

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 conducted 2 different analyses to examine the fit of 2 stock-recruitment models. In the first analysis, we fit the 2 models to data from brood years 1969–2005 (i.e., all available spawner-return data). In the second analysis, we fit the 2 models to data from brood years 1979–2005 because more consistent methods were used to estimate sockeye salmon escapements, age compositions, and total returns during this period.

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 hierarchal 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 conducted 2 different analyses to examine the fit of 7 stock-recruitment models to the DIDSON-adjusted spawner-return data (Appendix C6). In the first set, we fit the 7 models to data from brood years 1969–2005 because these data were used in earlier stock-recruitment analyses for this system (Carlson et al. 1999; Clark et al. 2007). In the second set, we fit the 7 models to data from brood years 1979–2005 because more consistent methods were used to estimate sockeye salmon escapements, age compositions, and total returns for all major UCI river systems during this period. In both sets of analyses, 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 γ<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 β<0 and γ=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 β=0 and γ >0:

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

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 1–3 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 one 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 was based on a brood-interaction simulation model (Carlson et al. 1999) and Markov yield analysis (Fried 1999). We ran 2 sets of simulations using brood-interaction model parameters obtained from 2 different regression analyses applied to the full and reduced data sets as previously described. Each set 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 500,000–800,000 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 million. Escapement goal ranges corresponding to a <6% risk (about once every 20 years) of a yield <1 million 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). For this review, Campbell Creek Chinook salmon was the only applicable stock. Although the risk analysis approach to setting escapement goals has not previously been applied to UCI stocks, it is common practice for other areas of Alaska (Munro and Volk 2010). In essence, recommended lower bound SEGs are chosen based on minimizing risk for triggering an unwarranted management concern and an approximately equal risk of failing to detect the maximum allowed percentage drop in mean escapement.

The escapement time series was first log-transformed and tested for deviations from normality using a one-sample Kolmogorov-Smirov test. The log-transformed escapement time series did not contain serial correlation, so further modeling was unnecessary. Because the BOF meets on a 3-year cycle for each regulatory area, the number of consecutive years to warrant a management action (k) was set at 3. For consistency with other risk-based goals in Central Region (Bristol Bay, Cook Inlet, and Prince William Sound), recommended escapement thresholds were chosen based on an estimated risk of 15% or less for triggering an unwarranted management action and an approximately equal risk of failing to detect the maximum percentage drop in mean escapement.

RESULTS AND DISCUSSION

From this review, the majority of salmon escapement goals in UCI remain unchanged (Table 2). The committee recommended changes to 3 BEGs and one SEG of the total 21 goals for Chinook salmon, one of the 3 SEGs for coho salmon, and one BEG and 2 SEGs of the 10 sockeye salmon goals. 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 (2010) provide a comprehensive review of goal performance from 2001 to 2009 (for 2007–2009, see Table 3).

CHINOOK SALMON

Campbell Creek

In 1993 ADF&G established an escapement threshold of 250 Chinook salmon for Campbell Creek, prior to any legal harvests. In 2002 the threshold became an SEG of 50–700 Chinook salmon. During the 2004/2005 review, the goal was eliminated because no fishery existed. In January of 2005 however, the BOF created a small youth-only fishery, warranting an escapement goal. Therefore, ADF&G re-instated the SEG of 50–700 during the 2007/2008 review. In this review, we developed a lower bound SEG of 380 using risk analysis because Campbell Creek Chinook salmon are passively managed (i.e., postseason assessment of escapement coupled with low harvest rate).

Foot survey escapement data for Campbell Creek Chinook salmon have been collected sporadically since 1958. The risk analysis only used data since 1982 (Appendix A2) because prior to this, survey methodology was inconsistent (Appendix A2). The 1982–2009 (n=25) average escapement is 701 (SD=283). A lower bound SEG of 380 (autocorrelation not detected) results in a 1% estimated risk of an unwarranted management action, with a 1% estimated risk that a drop in mean escapement of 90% (Figure 2) will not be detected in 3 years. Similar to other risk-based goals, the desire is to maintain the median escapement at 730.

Deshka River

ADF&G has indexed Deshka River Chinook salmon escapements with single aerial surveys in most years since 1974 (Appendix A8). However, a weir project started in 1995 has been the cornerstone for inseason management of this fishery. The relationship between weir and aerial counts from 1995 to 2009 was used to estimate the escapements from 1974 to 1994, when only aerial surveys were done. In 2002 an updated stock-recruitment model using expanded aerial surveys prompted a change from a point goal of 17,500, established in 1999, to a BEG of 13,000–28,000 (Bue and Hasbrouck *Unpublished*).

For this review, uncertainty in Deshka River Chinook salmon marine harvests has prompted a recommended change from a BEG to SEG-type goal, although the range of 13,000–28,000 remains the same. When calculating total return for brood tables, Deshka River Chinook salmon average harvest from the Statewide Harvest Survey (Jennings et al. 2010) is typically used as an estimate of sport harvest, while marine harvest is estimated by taking a proportion of the combined catches in the Northern District directed commercial setnet, Tyonek subsistence, and Kustatan Subdistrict commercial setnet fisheries. That proportion is the aerial survey of the Deshka Chinook salmon escapement divided by the sum of all aerial Chinook salmon in the Northern Cook Inlet area (Oslund and Ivey 2010). This approach assumes that Northern Cook Inlet area stocks are equally vulnerable to these fisheries. The sources of uncertainty in this procedure probably centers on the estimation of the proportion, calculated using single aerial surveys, which tend to be biased and highly variable from the true abundance (Jones et. al 1998; Holt and Cox 2008), and the assumption of equal exploitation. Other factors that affect aerial survey abundance estimates, and hence the estimated proportion of Deshka River Chinook salmon, are differences in stream morphology and the lack of assessment for all Chinook salmon systems. The sport harvest may also be biased, as a substantial portion of the sport fishing effort appears to be located at the confluence of the Deshka and Susitna rivers, possibly causing some of the Deshka River reported harvest to contain migrating Chinook salmon from stocks bound farther up the Susitna River.

Kenai River

Two stocks of Chinook salmon return to the Kenai River to spawn, classified as early (Appendix A10) and late (Appendix A11) runs. In 2005 the early-run BEG of 7,200–14,400 changed to 4,000–9,000 (McKinley and Fleischman 2010). The late-run BEG of 17,800–35,700 has not changed since 1999.

Since 1988, sonar (dual- and split-beam) has been the primary means of estimating inriver run. Results of a comprehensive research program initiated in the mid-1990s indicate that the current estimates based on split-beam sonar are subject to substantial measurement error and bias. In addition, mixed-stock harvest estimates for the late run in the commercial eastside setnet fishery and Deep Creek marine recreational fishery introduce additional uncertainty into estimates of total run.

Studies have concluded that DIDSON sonar and genetic stock identification (GSI) techniques have much promise for improved estimates of abundance and harvest composition. Plans are currently being developed for a transition to, and developing escapement goals for management based on, DIDSON-based estimates of abundance. In the interim, based on the amount of uncertainty associated with current abundance estimates, the committee recommended changing early- and late-run Kenai River Chinook salmon BEGs to SEGs.

COHO SALMON

Fish Creek

In most years since 1969, ADF&G counted Fish Creek coho salmon with a weir (Appendix B1). In 1994 ADF&G established a point goal of 2,700. The goal was changed to an SEG of 1,200–4,400 in 2002 (Bue and Hasbrouck *Unpublished*) and dropped in 2005 (Hasbrouck and Edmundson 2007) because the weir was no longer operated during the coho salmon migration. In 2009 and 2010, funding obtained by a grant from the U.S. Fish and Wildlife Service allowed weir operations to continue through the coho salmon migration. Because future funding opportunities may allow weir operations through the entire coho salmon run, we recommended that the previous SEG of 1,200–4,400 be reinstated.

SOCKEYE SALMON

Kasilof River

The current BEG of 150,000–250,000 was implemented in 1986. Results from this review use DIDSON as the estimate of inriver abundance. Over the past 42 years, Kasilof River sockeye salmon escapement ranged from approximately 39,000 to 522,000 (Figure 3, Appendix C5). During this same time span, recruit/spawner values ranged from approximately 0.7 to 8.4 (Figure 3). The classic Ricker model had significant fits to the DIDSON-adjusted Kasilof spawner-return data with both the full (1969–2005: R^2=0.243, P=0.002) and reduced (1979–2005: R^2=0.295, P=0.003) datasets. However, analysis of model residuals showed significant lag-1 autocorrelation. Likelihood ratio tests demonstrated that an autoregressive Ricker model provided the best fit, and escapements that provided for 90–100% of MSY were 160,000–340,000 based on the full dataset and 160,000–350,000 based on the reduced dataset (Table 4, Figure 4). 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 5). A Markov yield table (Table 5, Figure 6) predicts escapements ranging from 160,000–340,000 will produce yields averaging approximately 760,600 (range 340,100–1,598,500), whereas escapements below this range will produce yields averaging approximately 344,000 (range: 64,000–629,900), and escapements above this range will produce yields averaging 649,100 (range: -138,200–1,257,300).

The committee recommended that the Kasilof River sockeye salmon BEG be set at 160,000–340,000 spawners as modeled using the full data set. This goal range is also supported by higher producing yields from the raw data (Figure 6). The primary advantage of using the full data set is that it includes small escapements (<100,000), giving it greater contrast and more information for model development. This escapement goal will be assessed with DIDSON.

Kenai River

ADF&G adopted the current escapement goal range of 500,000–800,000 in 1999. In 2005 the goal changed from a BEG to an SEG (Clark et al. 2007). The goal does not include hatchery-produced sockeye salmon passing through the Hidden Creek weir. Results from this review use DIDSON as the estimate of inriver abundance.

Over the past 43 years, Kenai River sockeye salmon escapements ranged from about 73,000 to about 2.0 million (Figure 7, Appendix C6). During this same time span, recruit/spawner estimates ranged from approximately 1.4 to 12.7 (Figure 7). The second highest estimated escapement level occurred in 1987 and produced recruits at the rate of about 5 to 1, while a similar escapement in 1989 produced recruits at a rate of about 2 to 1. The highest estimate of recruits/spawner (12.7) came from the 1982 escapement (755,413).

Using the full data set, 1969–2005, 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=0.157), and γ was not different from one (P=0.897; Table 6). For the classic Ricker model (Figure 8), β was significantly different from zero (P=0.004), but a lag-1 autoregressive (φ) parameter was not significant (P=0.079; Table 6). The density-dependent parameter (γ) in the Cushing model significantly differed from one (P=0.014). 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≥0.100). A stepwise regression procedure revealed a brood-interaction model describing the stock-recruitment relationship. The β parameter was significantly different from zero (P=0.006) in a 3-parameter model, but γ was not significantly different from one (P=0.824). A simplified 2-parameter brood-interaction model best described (P<0.001) the stock-recruitment relationship for this stock (Table 6, Figure 9). 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 in 1987 and 1989 (Figure 10). The improved fit of the simple brood-interaction model was also due to brood years 2004 and 2005, produced by the 3rd and 5th largest escapements.

Using the 1979–2005 data, the Ricker and Cushing models did not fit the spawner-return data for Kenai River sockeye salmon (Table 7). For the classic Ricker model, β was significantly different from zero (P=0.016), but the R^2 for a regression of observed versus predicted adult returns was only 0.06. For the autoregressive Ricker model, β did not significantly differ from zero (P=0.839), but the lag-1 autoregressive parameter was significantly different from zero (P=0.003). For the autoregressive Ricker model, the R^2 for a regression of observed versus predicted adult returns increased to 0.23, and the likelihood ratio test demonstrated a significant (P<0.05) improvement in model fit over the classic Ricker model. For the classic Ricker model with a single brood-interaction term, the first density-dependent parameter (β_1) did not significantly differ from zero (P=0.088), but β_2 was different from zero (P=0.021). As before, a stepwise regression procedure revealed a simplified 2-parameter brood-interaction model that best fit the spawner-return data (Table 7). Likelihood profiles of escapements that produced high sustained yields further showed the simple brood interaction model as the best described stock-recruitment relationship for this stock (Figure 11).

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 using parameters from analysis of the 1969–2005 data suggest a goal range of 650,000–950,000 (Table 8). Simulations using parameters from analysis of the 1979–2005 data suggest a goal range of 500,000–1,000,000. Using escapements that represent 90–100% MSY (1969–2005: MSY = 3,103,000; 1979–2005: MSY = 3,378,000), the ranges were 700,000–1,200,000 and 650,000–1,100,000 spawners for the full and reduced data sets (Table 8).

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 (Tables 6 and 7). 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.

Using the full data set (1969–2005), a Markov yield analysis indicated highest (>3.9 million) mean yields occur within a range of 600,000–900,000 spawners (Table 9), and that escapements from 500,000–1,200,000 also produce high (>2.3 million) yields. Escapements below 400,000 salmon never produced yields exceeding 948,000. The highest yields (Figure 12) 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 513,000–8,396,000. In this updated data set, 4 year classes (2002–2005) were added to the upper escapement interval (Appendix C6). Yield from the 2002 year class (2,543,500) was above average (2,459,400), whereas yields from 2003 to 2005 year classes (513,500, 1,551,300, and 1,003,300) were below average. This pattern of reduced yield from consecutive large escapements is consistent with the brood interaction observed in brood years 1987–1990.

We recommend that the Kenai River late-run sockeye salmon SEG be set at 700,000–1,200,000 spawners as estimated using the brood-interaction model fit to the full data set. The related inriver goal will be assessed with DIDSON. The range approximately represents the escapement that on average will produce 90–100% of MSY. We also recommend using the 90–100% range to set the SEG because it results in a broader interval with the highest predicted yield near its center. Basing a goal range from a model's prediction of escapements that produce 90–100% MSY is common practice throughout Alaska. Finally, this goal is supported by a plot of yield versus escapement, showing that escapements in this range generally produce the highest yields (Figure 12).

Russian River Early Run

The Russian River sockeye salmon early run has an SEG of 14,000–37,000, developed in the 2001/2002 review using the 25^{th} and 75^{th} percentile of the 1965–2000 weir escapement data. We currently have escapement, total return, and exploitation data for 40 years (1970–2009; Appendix C9).

During the 2007 escapement goal review, inclusion of escapement data for the past 6 years into the original SEG percentile analysis resulted in a slight increase in both the lower and upper values of the SEG range due to large escapements between 2001–2006 that were in excess of the upper goal range. During this same review, a Ricker model was fit to the brood year data (1970–1999); however, the β parameter was not significant, probably because the large escapements from 2001 to 2006 were not included since their brood years were still incomplete. Therefore, the goal remained status quo because the committee believed that returns from these larger escapements may provide better information to estimate S_{MSY} in the near future as more data are added.

During this review, the committee's recommendation was to revise the Russian River early-run sockeye salmon escapement goal based on a stock-recruitment analysis. Returns from large escapements from 2001 to2003 provided a fit to estimate the Ricker β parameter, and hence, S_{MSY} (Table 10). To develop a revised escapement goal range we bootstrapped (1,000 replications) the residuals of the Ricker model (1970–2003 brood years) to estimate the uncertainty of all parameters and calculations, including the range that produced 90% or more of MSY; the model estimated S_{MSY} at 36,255 (Figure 13). The outcome of the simulation was the probability of achieving 90% or more of MSY for a range of escapements (Figure 14). Given the strong defining shape of the 90% probability curve and the desire to include S_{MSY} within the goal range, an appropriate escapement goal is 22,000–42,000. Escapements within this range have a probability greater than 40% of producing sustained yields at least 90% of MSY. Lastly, the committee recommended changing the goal from an SEG to a BEG because the new range of escapements includes S_{MSY} and has the greatest probability of producing the highest and most consistent expected sustained yields.

Yentna River

Prior to 2009, Yentna River sockeye salmon had a sonar-based SEG of 90,000–160,000, adopted in 2001. Considerable uncertainty was associated with the sonar escapement assessment and productivity of the stock (Fair et al. 2009), which was designated as a stock of yield concern by the BOF in 2008. A thorough review of the goal determined it to be inappropriate given the escapement uncertainties associated with the Bendix sonar program. In particular, based on mark-recapture studies since 2006, comparisons between Bendix sonar and DIDSON, weir counts from various lakes in the Yentna River drainage, and previous studies suggesting pink salmon are more vulnerable to fish wheels than other salmon, we believe that the most likely cause of historically inaccurate Bendix-based sockeye salmon abundance estimates is the fish wheel species apportionment program. Hence, we applied the percentile approach to escapement information for Chelatna, Judd, and Larson lakes within the Susitna River drainage to establish 3 new SEGs (Fair et al. 2009). We eliminated the Yentna River sockeye salmon SEG and replaced it with 2 SEGs represented by Chelatna (20,000–65,000) and Judd (25,000–55,000) lakes. Additionally, for the Susitna River mainstem, we developed a Larson Lake SEG of 15,000–50,000 spawners.

SUMMARY

The committee recommended that most 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), and in this review.

In summary, the escapement goal committee reviewed 34 UCI salmon escapement goals with recommendations to reinstate one previous goal, change one goal from an SEG range to a lower bound SEG, change the ranges of 2 goals, change 3 goals from BEGs to SEGs, and, change one goal from an SEG to a BEG and its range.

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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 2010/2011 escapement goal review.

Name	Position	Affiliation
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
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
Jeff Fox	Area Management Biologist	ADF&G, Div. of Commercial Fisheries
Jim Hasbrouck	Regional Supervisor	ADF&G, Div. of Sport Fish
Tracy Lingnau	Regional Management Biologist	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
Jeff Regnart	Regional Supervisor	ADF&G, Div. of Commercial Fisheries
Dave Rutz	Area Management Biologist	ADF&G, Div. of Sport Fish
Pat Shields	Asst. 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, 2010.

	Current Escapement Goal			Recommended Escapement Goal			
					Escapement		
System	Goal	Type	Year Adopted	Range/Lower Bound	Type	Data[a]	Action
Chinook Salmon							
Alexander Creek	2,100–6,000	SEG	2002			SAS	No Change
Campbell Creek	50–700	SEG	2008	380	SEG	SFS	Change to lower bound SEG
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	BEG	2002	13,000–28,000	SEG	Weir	Change to SEG
Goose Creek	250–650	SEG	2002			SAS	No Change
Kenai River - Early Run	4,000–9,000	BEG	2005	4,000–9,000	SEG	Sonar	Change to SEG
Kenai River - Late Run	17,800–35,700	BEG	1999	17,800–35,700	SEG	Sonar	Change to SEG
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

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	Current Escapement Goal			Recommended Escapement Goal			
					Escapement		
System	Goal	Type	Year Adopted	Range/Lower Bound	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	Weir	Reinstate previous SEG
Jim Creek	450–700	SEG	2002			SFS	No Change
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	No Change
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	150,000–250,000	BEG	1986	160,000–340,000	BEG	Sonar	Change in Range
Kenai River	500,000–800,000	SEG	2005	700,000–1,200,000	SEG	Sonar	Change in Range
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	14,000–37,000	SEG	2002	22,000–42,000	BEG	Weir	Change in Range and to BEG
Russian River - Late Run	30,000–110,000	SEG	2005			Weir	No Change
Yentna River	90,000–160,000	SEG	2002	Eliminated in 2009	Eliminated in 2009		Eliminated in 2009

[a] PAS = Peak Aerial Survey, SAS = Single Aerial Survey, and SFS = Single Foot Survey.

Table 3.–Current escapement goals, escapements observed from 2007 through 2009 for Chinook, chum, coho, and sockeye salmon stocks of Upper Cook Inlet.

System	Escapement Data [a]	Current Escapement Goal Type (BEG, SEG)	Range	Escapements [b] 2007	2008	2009
Chinook Salmon						
Alexander Creek	SAS	SEG	2,100–6,000	480	150	275
Campbell Creek	SFS	SEG	50–700	588	439	554
Chuitna River	SAS	SEG	1,200–2,900	1,180	586	1,040
Chulitna River	SAS	SEG	1,800–5,100	5,166	2,514	2,093
Clear (Chunilna) Creek	SAS	SEG	950–3,400	3,310	1,795	1,205
Crooked Creek [c]	Weir	SEG	650–1,700	965	879	617
Deshka River	Weir	BEG	13,000–28,000	18,714	7,533	11,960
Goose Creek	SAS	SEG	250–650	105	117	65
Kenai River - Early Run	Sonar	BEG	4,000–9,000	12,504	11,732	9,771
Kenai River - Late Run	Sonar	BEG	17,800–35,700	32,618	24,144	17,158
Lake Creek	SAS	SEG	2,500–7,100	4,081	2,004	1,394
Lewis River	SAS	SEG	250–800	0	120	111
Little Susitna River	SAS	SEG	900–1,800	1,731	1,297	1,028
Little Willow Creek	SAS	SEG	450–1,800	1,103	NS	776
Montana Creek	SAS	SEG	1,100–3,100	1,936	1,357	1,460
Peters Creek	SAS	SEG	1,000–2,600	1,225	NS	1,283
Prairie Creek	SAS	SEG	3,100–9,200	5,036	3,039	3,500
Sheep Creek	SAS	SEG	600–1,200	400	NS	500
Talachulitna River	SAS	SEG	2,200–5,000	3,871	2,964	2,608
Theodore River	SAS	SEG	500–1,700	486	345	352
Willow Creek	SAS	SEG	1,600–2,800	1,373	1,255	1,133
Chum Salmon						
Clearwater Creek	PAS	SEG	3,800–8,400	NS	4,530	8,300
Coho Salmon						
Jim Creek [c]	SFS	SEG	450–700	725	1,890	1,331
Little Susitna River	Weir	SEG	10,100–17,700	17,573	18,485 [d]	9,523
Pink Salmon						
No stocks with an escapement goal						

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System	Escapement Data [a]	Current Escapement Goal: Type (BEG, SEG)	Current Escapement Goal: Range	Escapements [b]: 2007	2008	2009
Sockeye Salmon						
Chelatna Lake [e]	Weir	SEG	20,000–65,000	41,290	73,469	17,721
Crescent River [f]	Sonar	BEG	30,000–70,000	79,406	62,030	125,114
Fish Creek (Knik) [g]	Weir	SEG	20,000–70,000	27,948	19,339	83,480
Judd Lake	Weir	SEG	25,000–55,000	58,134	54,304	44,616
Kasilof River [h]	Sonar	BEG	150,000–250,000	336,886	301,469	297,125
Kenai River [h]	Sonar	SEG	500,000–800,000	602,186	407,118	537,070 [i]
Larson Lake	Weir	SEG	15,000–50,000	47,736	35,040	40,933
Packers Creek	Weir	SEG	15,000–30,000	46,637	25,247	16,473
Russian River - Early Run	Weir	SEG	14,000–37,000	27,298	30,989	52,178
Russian River - Late Run	Weir	SEG	30,000–110,000	53,068	46,638	80,088

[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; 10,000 sockeye salmon at the Kasilof River; and 5,000 sockeye salmon at Fish Creek.

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

[d] Incomplete weir count due to flooding.

[e] Weir inoperable during high water events in 2007; missing counts filled in using proportion of radio tagged fish passing during high water (Fair et al. 2009).

[f] The Crescent River sonar project did not operate in 2009; escapement was estimated using commercial catch and the mean (20012008) harvest rate.

[g] The goal represents total spawner abundance minus sockeye salmon taken for broodstock.

[h] Escapements for these systems use Bendix sonar abundance estimates.

[i] Used preliminary estimate of sport harvest upstream of sonar.

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 1969–2005 and 1979–2005.

				Parameters				Negative	Likelihood		MSY Escapement		
Dataset	Model	Structure	n	σ	lnα'	β	φ	log-likelihood	Ratio	P-value	Estimate	Lower	Upper
1969-2005	Classic Ricker	$\ln R_t/S_t = \alpha - \beta S_t$	37	0.388	1.842	-0.00195	NA	16.430			350,000	230,000	500,000
	Autoregressive Ricker	$\ln R_t/S_t = \alpha - \beta S_t + \phi e_{t-1}$	37	0.323	1.981	-0.00298	0.656	10.953	10.955	<0.001	240,000	160,000	340,000
1979-2005	Classic Ricker	$\ln R_t/S_t = \alpha - \beta S_t$	27	0.387	2.031	-0.00258	NA	11.646			281,000	180,000	400,000
	Autoregressive Ricker	$\ln R_t/S_t = \alpha - \beta S_t + \phi e_{t-1}$	27	0.304	2.099	-0.00299	0.623	5.234	12.842	<0.001	248,000	160,000	350,000

NA = not applicable.

Table 5.–Markov yield table for Kasilof River sockeye salmon, brood years 1969–2005 (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	257–1109
150-250	15	197	845	4.3	648	340–1109
200-300	13	235	955	4.1	741	398–1598
250-350	8	279	1,217	4.3	938	398–1598
300-400	4	327	1,311	4.1	984	487–1336
>350	3	460	907	2.0	446	-138 – +991

Table 6.–Summary of adult stock-recruitment models evaluated for Kenai River late-run sockeye salmon (brood years 1969–2005).

Model	Parameter	Estimate	*P*-value	R^2	AIC	Residual White noise test
General Ricker model			<0.001	0.528	59.68	0.549
	σ	0.52				
	lna	1.60	0.266			
	b	5.75E-04	0.157			
	g	1.03	0.897			
Classic Ricker model			<0.001	0.528	57.32	0.523
	σ	0.51				
	lna	1.78	<0.001			
	b	5.29E-04	0.004			
Autoregressive Ricker model			<0.001	0.556	57.59	0.642
	σ	0.50				
	lna	1.64	<0.001			
	b	3.60E-04	0.112			
	φ	0.28	0.079			
Cushing model			<0.001	0.499	59.52	0.182
	σ	0.52				
	lna	3.33	<0.001			
	g	0.69	0.014			
Classic Ricker model with brood interaction			<0.001	0.561	57.17	0.499
	σ	0.50				
	lna	1.89	<0.001			
	b_1	3.49E-04	0.100			
	b_2	3.24E-04	0.130			
General Ricker model with brood interaction			<0.001	0.600	53.55	0.667
	σ	0.48				
	lna	1.48	0.125			
	b_3	4.69E-07	0.006			
	g	1.04	0.824			
Simple brood interaction model			<0.001	0.600	51.23	0.652
	σ	0.47				
	lna	1.69	<0.001			
	b_3	4.43E-07	<0.001			

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

Table 7.–Summary of stock-recruitment models evaluated for Kenai River late-run sockeye salmon (brood years 1979–2005).

Model	Parameter	Estimate	*P*-value	R^2	AIC	Residual White noise test
General Ricker model			0.173	0.073	50.08	0.456
	σ	0.57				
	lna	5.82	0.367			
	b	1.20E-05	0.991			
	g	0.33	0.543			
Classic Ricker model			0.207	0.063	47.96	0.541
	σ	0.56				
	lna	1.92	<0.001			
	b	6.29E-04	0.016			
Autoregressive Ricker model			0.011	0.230	46.48	0.313
	σ	0.53				
	lna	1.31	<0.001			
	b	5.02E-05	0.839			
	φ	0.54	0.003			
Cushing model			0.173	0.073	47.54	0.458
	σ	0.56				
	lna	5.75	0.002			
	g	0.34	0.013			
Classic Ricker model			0.008	0.249	44.39	0.115
with brood interaction	σ	0.51				
	lna	2.28	<0.001			
	b_1	4.23E-04	0.088			
	b_2	6.01E-04	0.021			
General Ricker model			0.004	0.282	43.16	0.139
with brood interaction	σ	0.50				
	lna	1.18	0.610			
	b_3	5.86E-07	0.014			
	g	1.10	0.778			
Simple brood			0.004	0.282	40.71	0.165
interaction model	σ	0.49				
	lna	1.83	<0.001			
	b_3	5.36E-07	<0.001			

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

Table 8.–Simulation results from a brood-interaction model for Kenai River late-run sockeye salmon (numbers of fish in thousands).

	1969–2005				1979–2005			
Escapement	Mean Run	Mean Yield	Yield CV (%)	P<1000	Mean Run	Mean Yield	Yield CV (%)	P<1000
100	641	541	0.64	0.934	746	646	0.63	0.886
150	947	797	0.56	0.768	1,101	951	0.56	0.632
200	1,247	1,047	0.53	0.544	1,448	1,248	0.53	0.416
250	1,539	1,289	0.52	0.380	1,783	1,533	0.53	0.265
300	1,822	1,522	0.51	0.265	2,105	1,805	0.52	0.174
350	2,094	1,744	0.51	0.189	2,410	2,060	0.52	0.122
400	2,352	1,952	0.51	0.140	2,697	2,297	0.52	0.086
450	2,597	2,147	0.51	0.105	2,964	2,514	0.52	0.068
500	2,826	2,326	0.52	0.083	**3,209**	**2,709**	**0.53**	**0.056**
550	3,038	2,488	0.52	0.071	**3,431**	**2,881**	**0.53**	**0.050**
600	3,232	2,632	0.52	0.064	**3,628**	**3,028**	**0.53**	**0.043**
650	**3,408**	**2,758**	**0.53**	**0.059**	**3,800**	**3,150**	**0.54**	**0.040**
700	**3,565**	**2,865**	**0.53**	**0.053**	**3,946**	**3,246**	**0.54**	**0.039**
750	**3,702**	**2,952**	**0.53**	**0.050**	**4,066**	**3,316**	**0.54**	**0.039**
800	**3,820**	**3,020**	**0.54**	**0.050**	**4,160**	**3,360**	**0.55**	**0.039**
850	**3,917**	**3,067**	**0.54**	**0.050**	**4,228**	**3,378**	**0.56**	**0.041**
900	**3,995**	**3,095**	**0.55**	**0.053**	**4,272**	**3,372**	**0.56**	**0.044**
950	**4,053**	**3,103**	**0.56**	**0.058**	**4,291**	**3,341**	**0.57**	**0.050**
1,000	4,092	3,092	0.56	0.062	**4,287**	**3,287**	**0.58**	**0.056**
1,050	4,112	3,062	0.57	0.066	4,261	3,211	0.59	0.064
1,100	4,114	3,014	0.58	0.071	4,214	3,115	0.60	0.071
1,150	4,100	2,950	0.59	0.080	4,149	2,999	0.61	0.083
1,200	4,069	2,869	0.60	0.089	4,067	2,868	0.63	0.100
1,250	4,023	2,774	0.62	0.104	3,969	2,721	0.65	0.124
1,300	3,963	2,665	0.63	0.123	3,858	2,560	0.67	0.150
1,350	3,891	2,543	0.65	0.143	3,736	2,389	0.69	0.180
1,400	3,807	2,410	0.67	0.172	3,606	2,210	0.72	0.225
1,450	3,713	2,267	0.69	0.203	3,470	2,027	0.75	0.261
1,500	3,612	2,117	0.72	0.238	3,334	1,845	0.80	0.318

Note: Model parameters were obtained from regression analyses conducted using brood year 1969–2005, and 1979–2005 data. Ranges corresponding to the original criteria (<6% risk of a yield <1 million salmon; Carlson et al. 1999) used to establish the SEG range are indicated in bold. Ranges corresponding to escapement needed to produce 90100% of maximum yield (assuming a constant escapement goal policy) are shaded.

Table 9.–Markov yield table for Kenai River late-run sockeye salmon constructed using data from brood years 1969–2005 (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	8	555	3,048	5.3	2,493	999–6,393
600–800	8	724	4,798	6.6	4,075	788–8,697
700–900	7	771	4,731	6.1	3,960	788–8,697
800–1,000	5	931	3,458	3.8	2,527	698–4,840
900–1,100	5	971	3,289	3.4	2,318	698–4,840
1,000–1,200	3	1,148	3,483	3.0	2,335	1,377–3,084
1,200–1,400	3	1,343	2,863	2.1	1,520	513–2,301
>1,300	7	1,623	4,190	2.5	2,566	513–8,396

Table 10.–Summary of stock-recruitment model for Russian River early-run sockeye salmon, brood years 1970–2003.

	Lower 80%	Point Estimate	Upper 80%
ln α	1.073	1.325	1.585
β	9.4E-06	1.7E-05	2.4E-05
σ	0.512	0.630	0.692
S_{MAX}	42,549	60,514	104,023
S_{EQ}	71,942	92,159	135,844
S_{MSY}	27,704	36,255	55,117
U_{MSY}	0.518	0.599	0.668
MSY	42,565	55,066	73,360

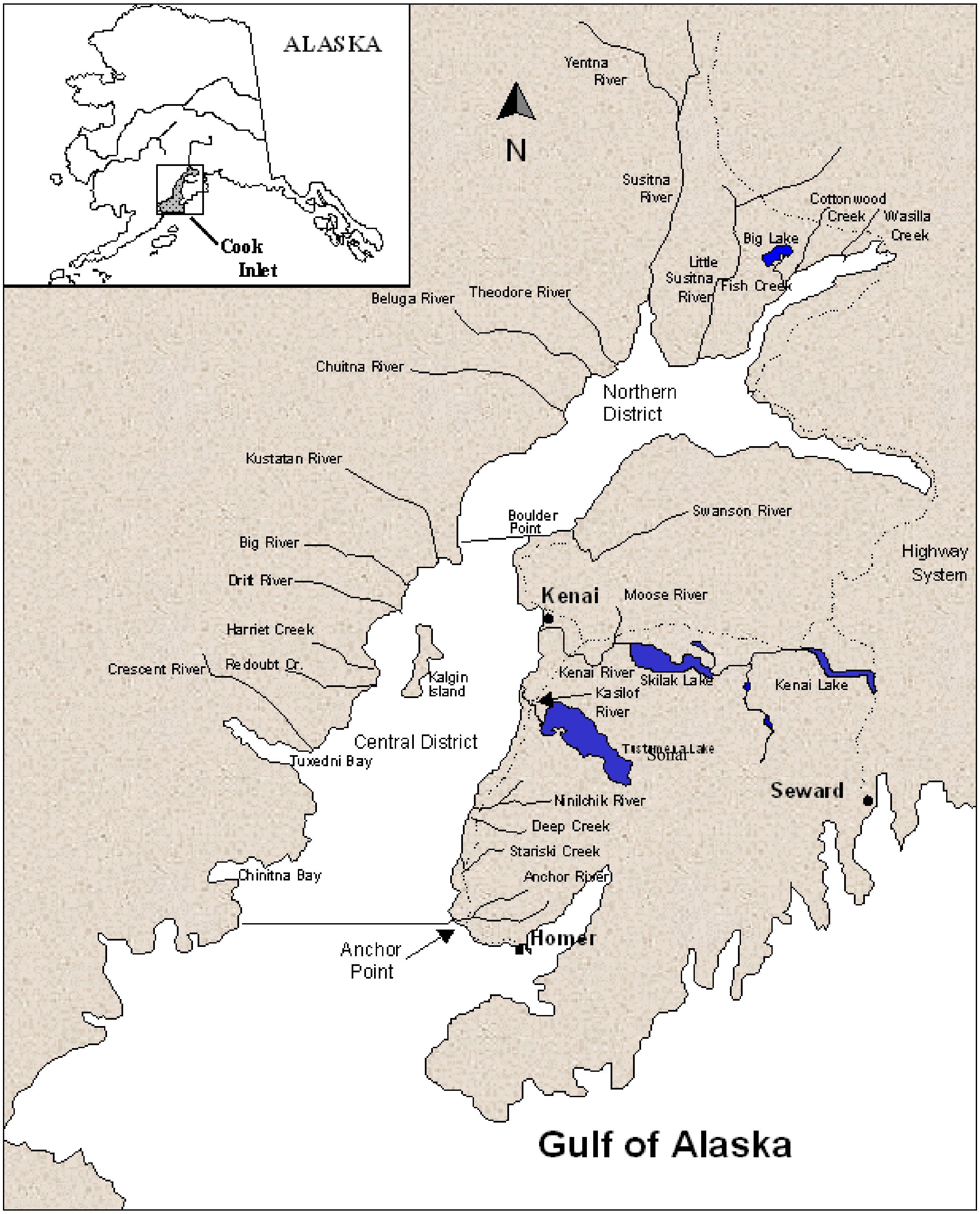


Figure 1.–Map of Upper Cook Inlet showing locations of the Northern and Central districts and the primary salmon spawning drainages.

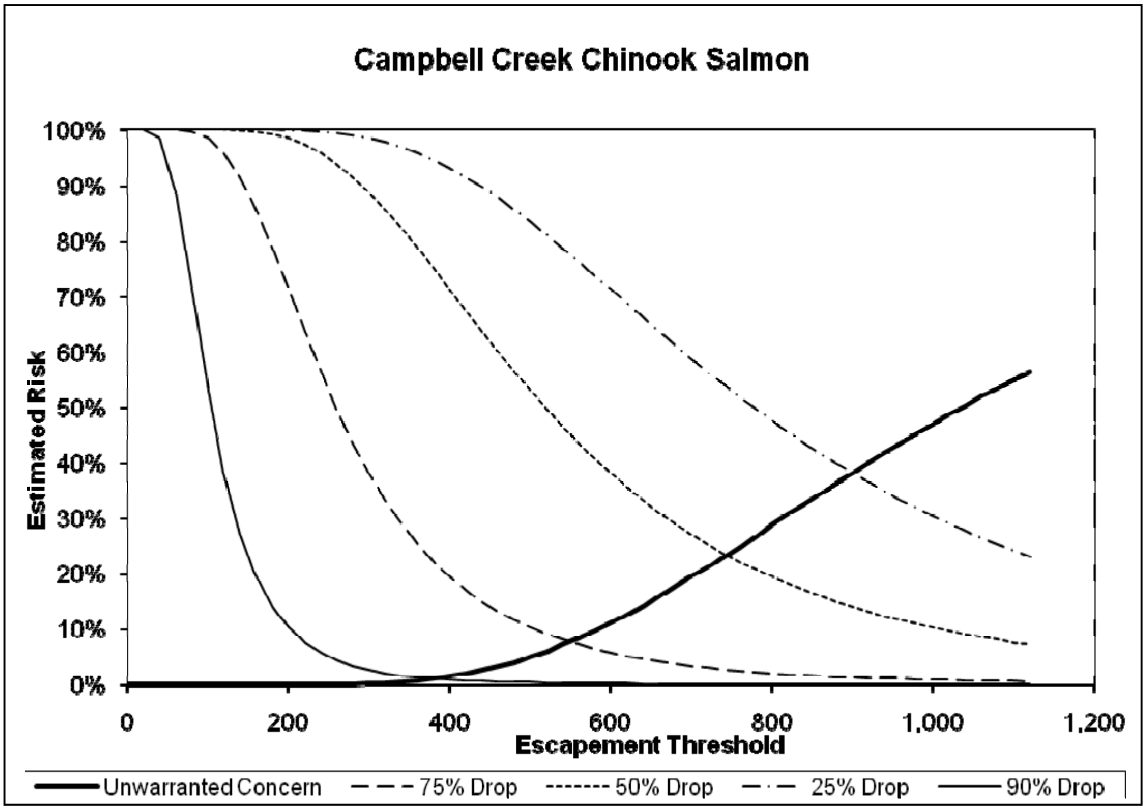


Figure 2.–Campbell Creek Chinook salmon risk analysis summary showing the risk of an unwarranted management action and the estimated risk that a drop in various levels of mean escapement would not be detected.

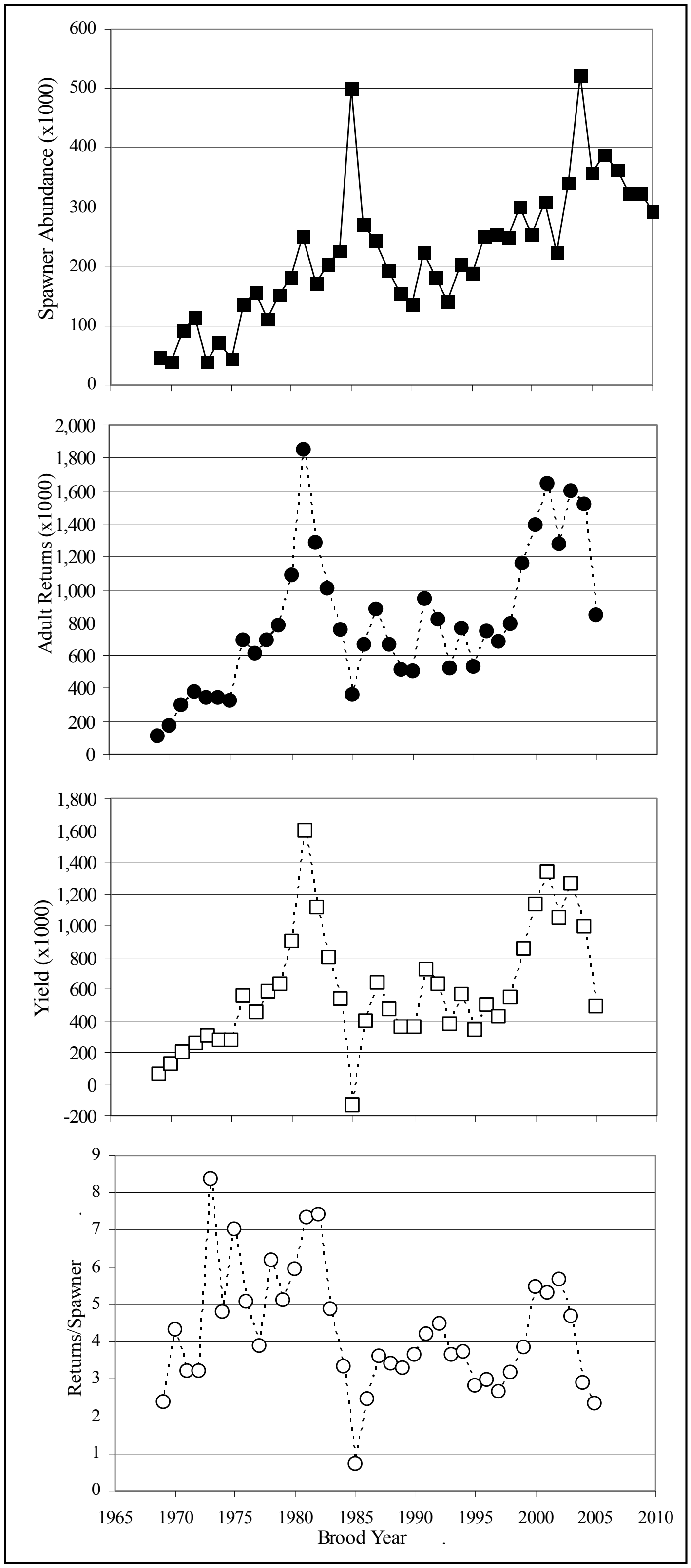
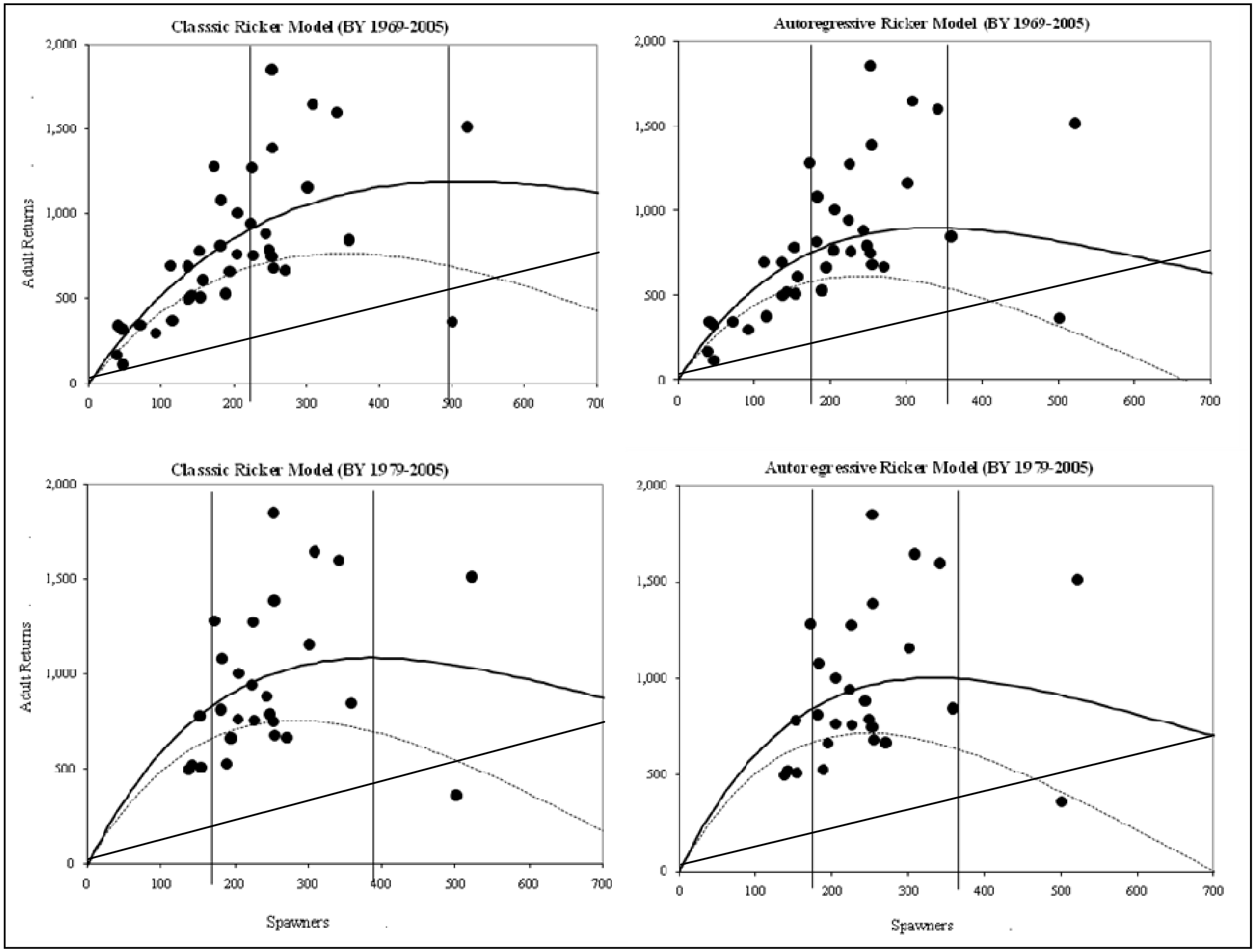


Figure 3.–Time series of spawner abundance (escapement), adult returns, yields, and returns-per-spawner for Kasilof River sockeye salmon, 1969–2010.



Note: Solid vertical lines are 90% MSY escapement goal range estimates using each model and the straight line connected to the origin is the replacement line.

Figure 4.–Scatter plots of Kasilof River sockeye 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 1969–2005 and 1979–2005.

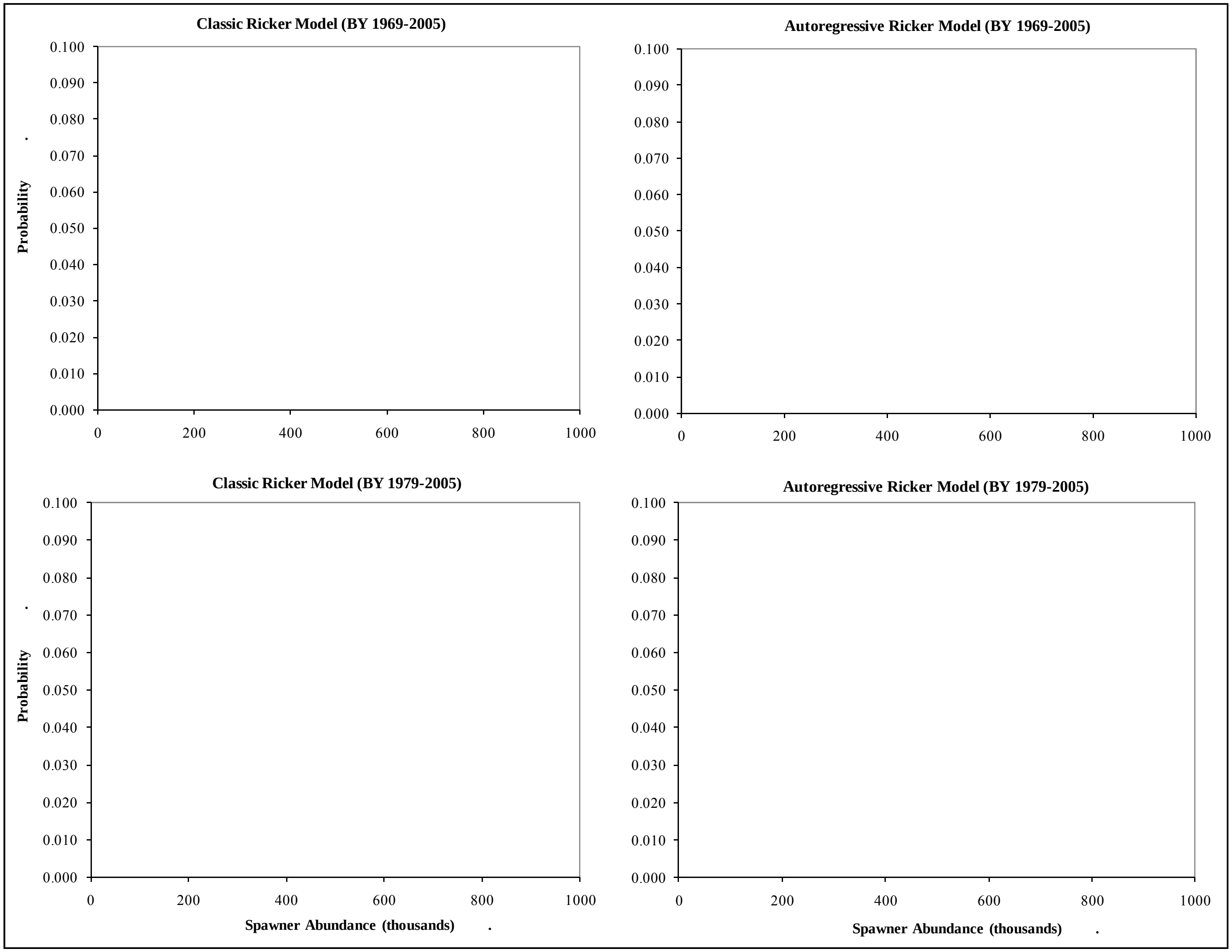
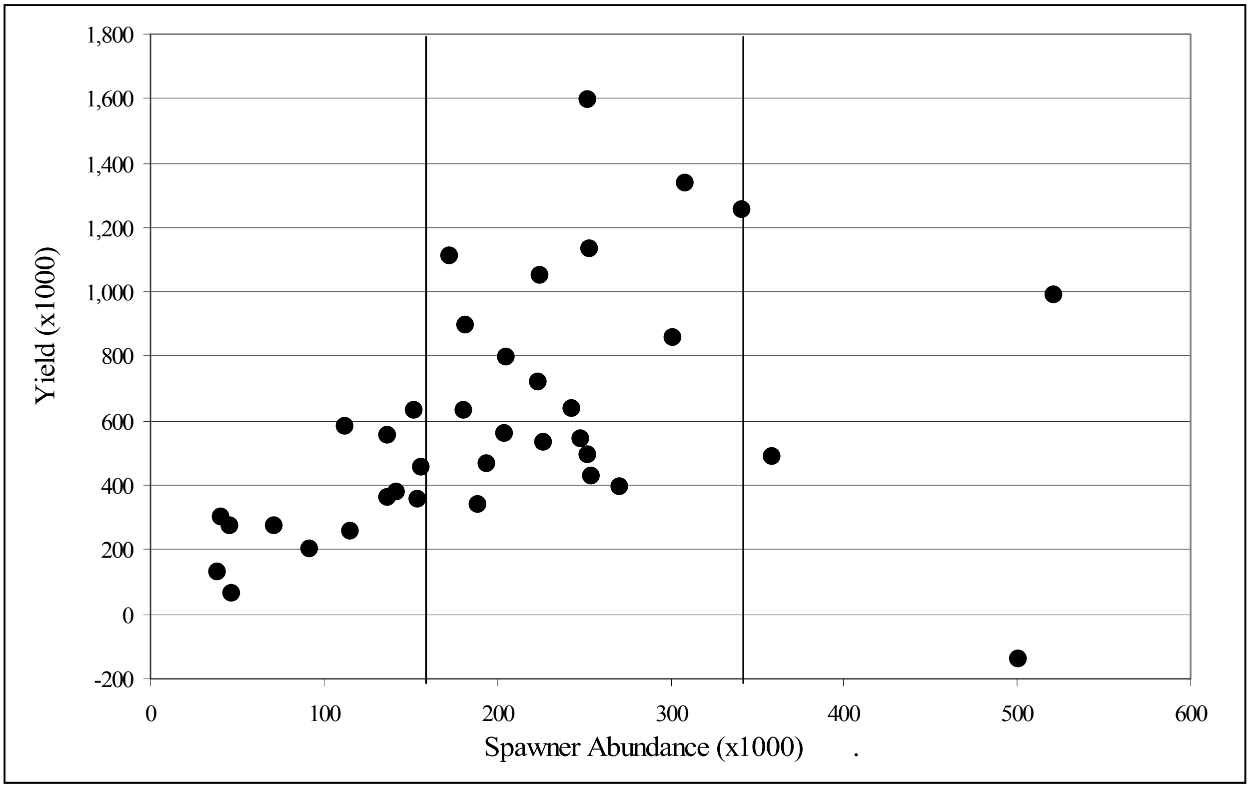


Figure 5.–Likelihood profiles for Kasilof River sockeye salmon spawner abundances (escapements) that produced MSY estimated by the classic Ricker and autoregressive Ricker models fit to data from brood years 1969–2005 and 1979–2005.



Note: Solid vertical lines are the recommended SEG range.

Figure 6.–Kasilof River sockeye salmon yields related to spawner abundances (escapements) in brood years 1969–2005.

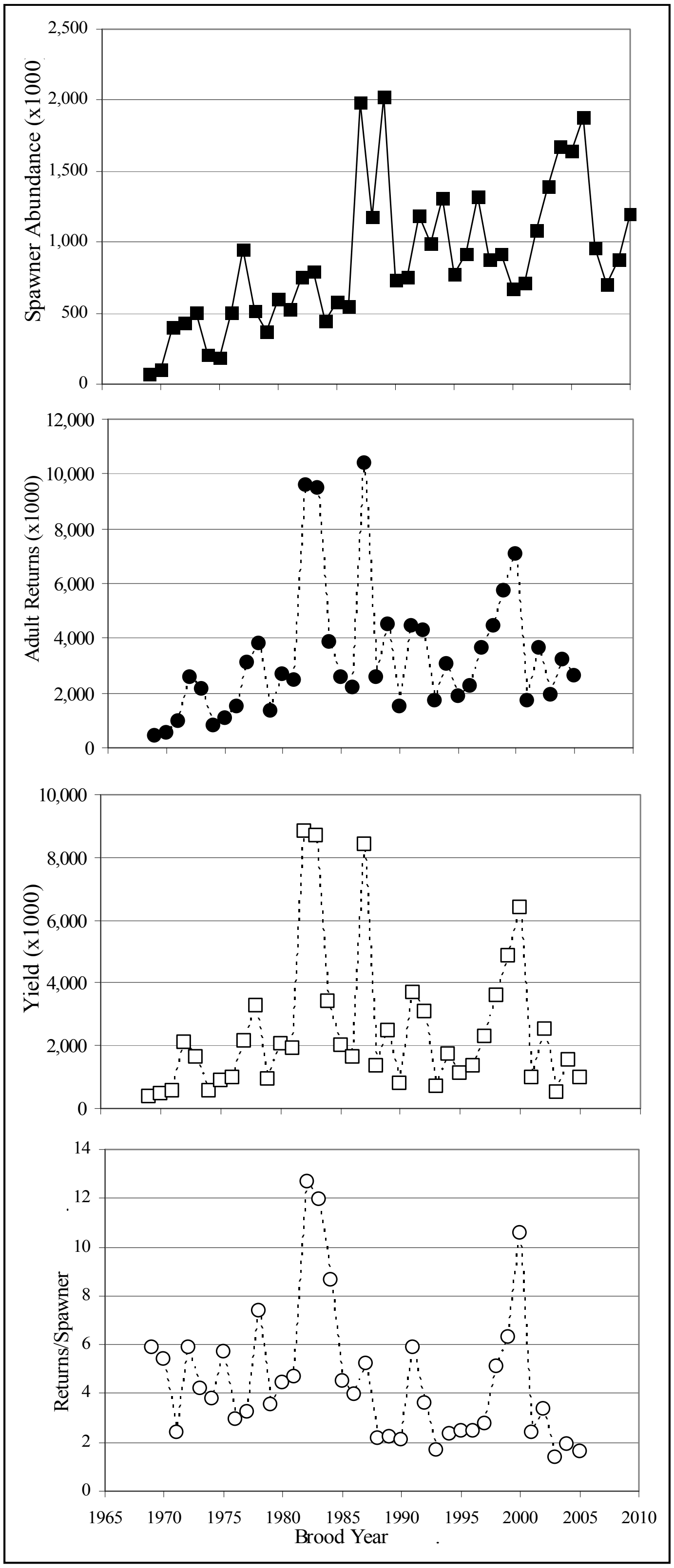
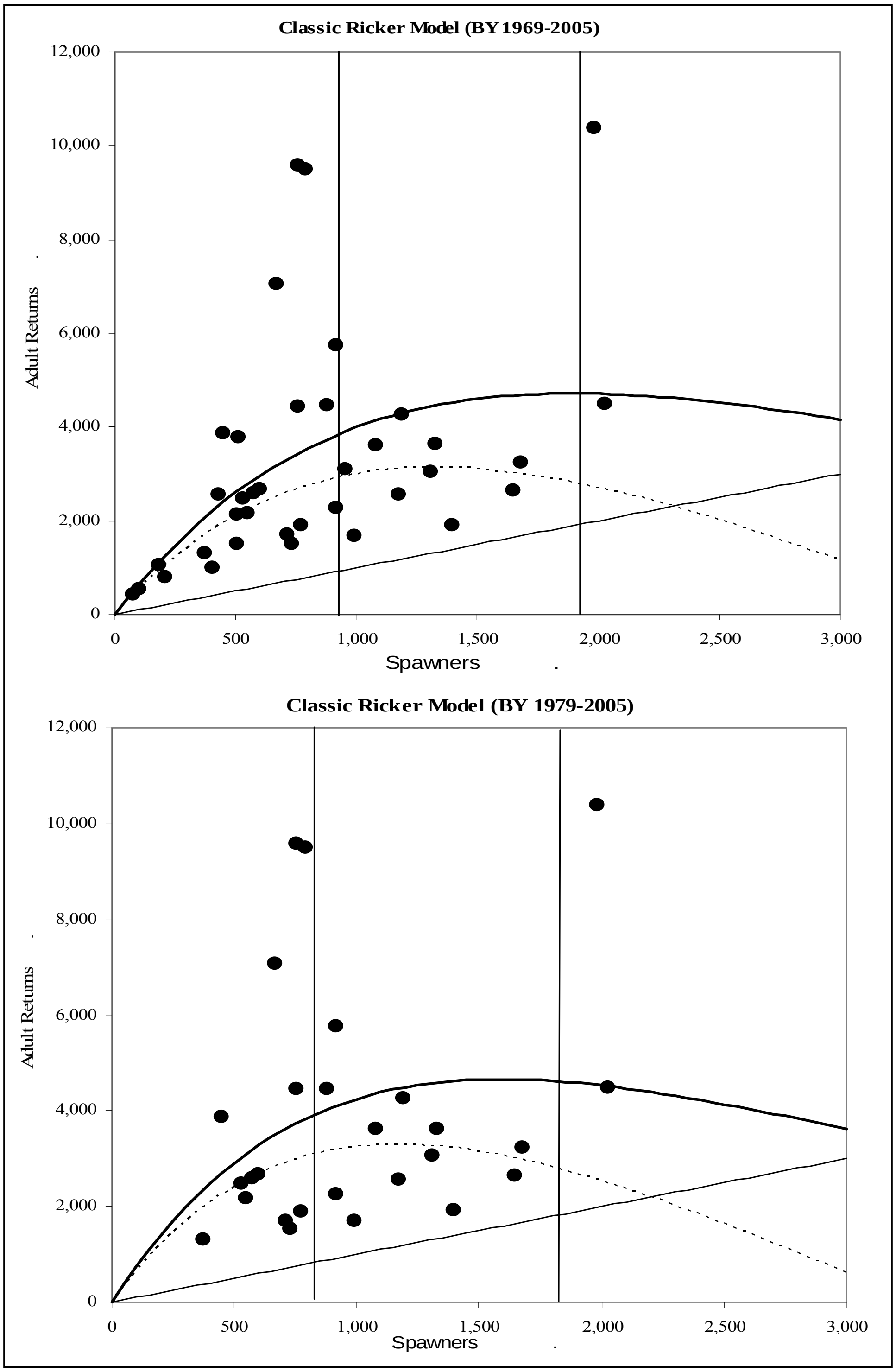
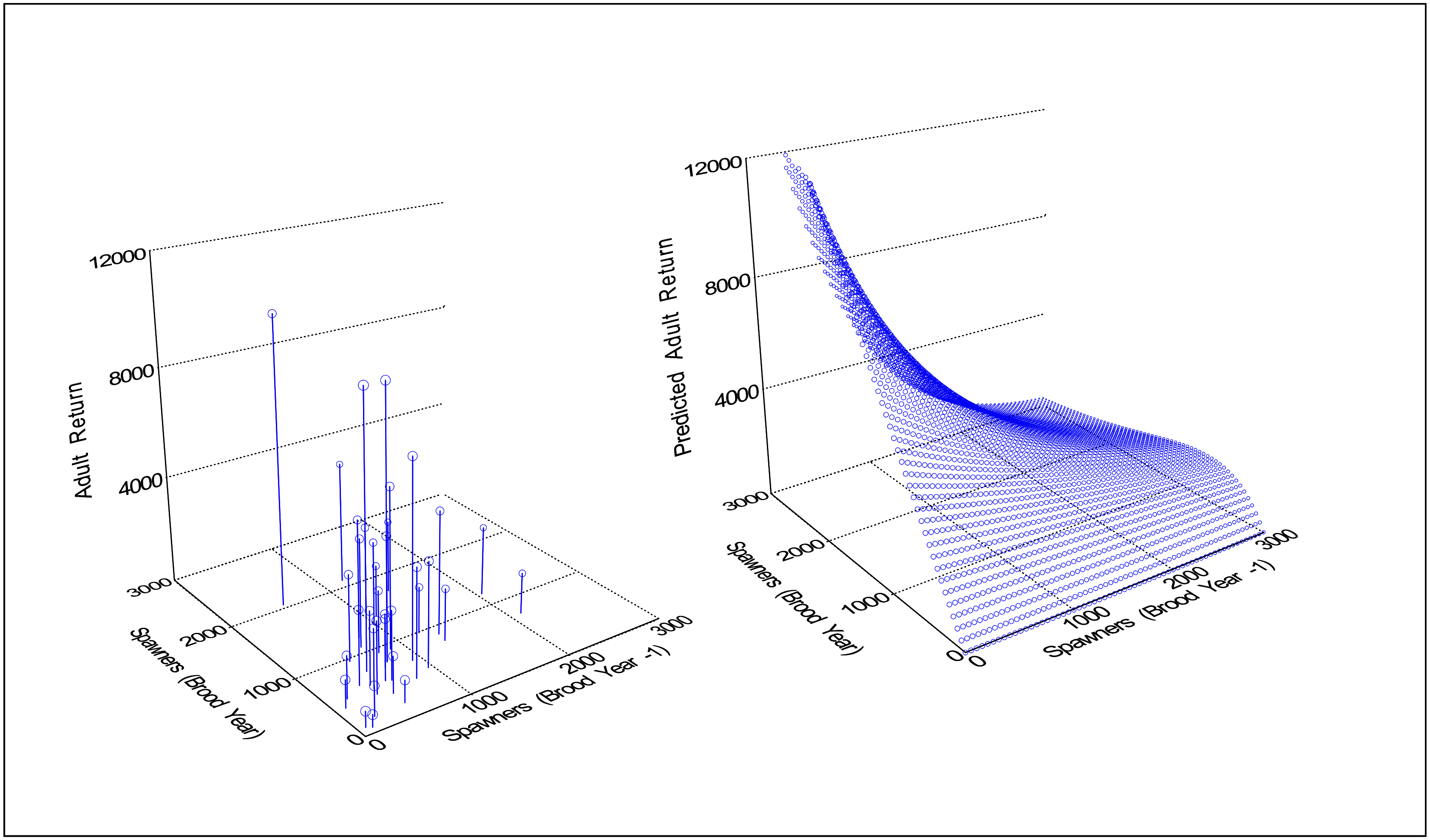


Figure 7.–Time series of spawner abundance (escapement), adult returns, yields, and returns-per-spawner for Kenai River late-run sockeye salmon, 1969–2010.



Note: Solid vertical lines are 90% MSY escapement goal ranges estimated using each model. The straight line connected to the origin is the replacement line.

Figure 8.–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 1969–2005 and 1979–2005.



Note: Numbers are in thousands of fish.

Figure 9.–Kenai late-run sockeye salmon (a) spawner-return data (brood years 1969–2005) plotted with spawner abundance (escapement) in brood year-1, and (b) simple brood-interaction model predicted adult returns.

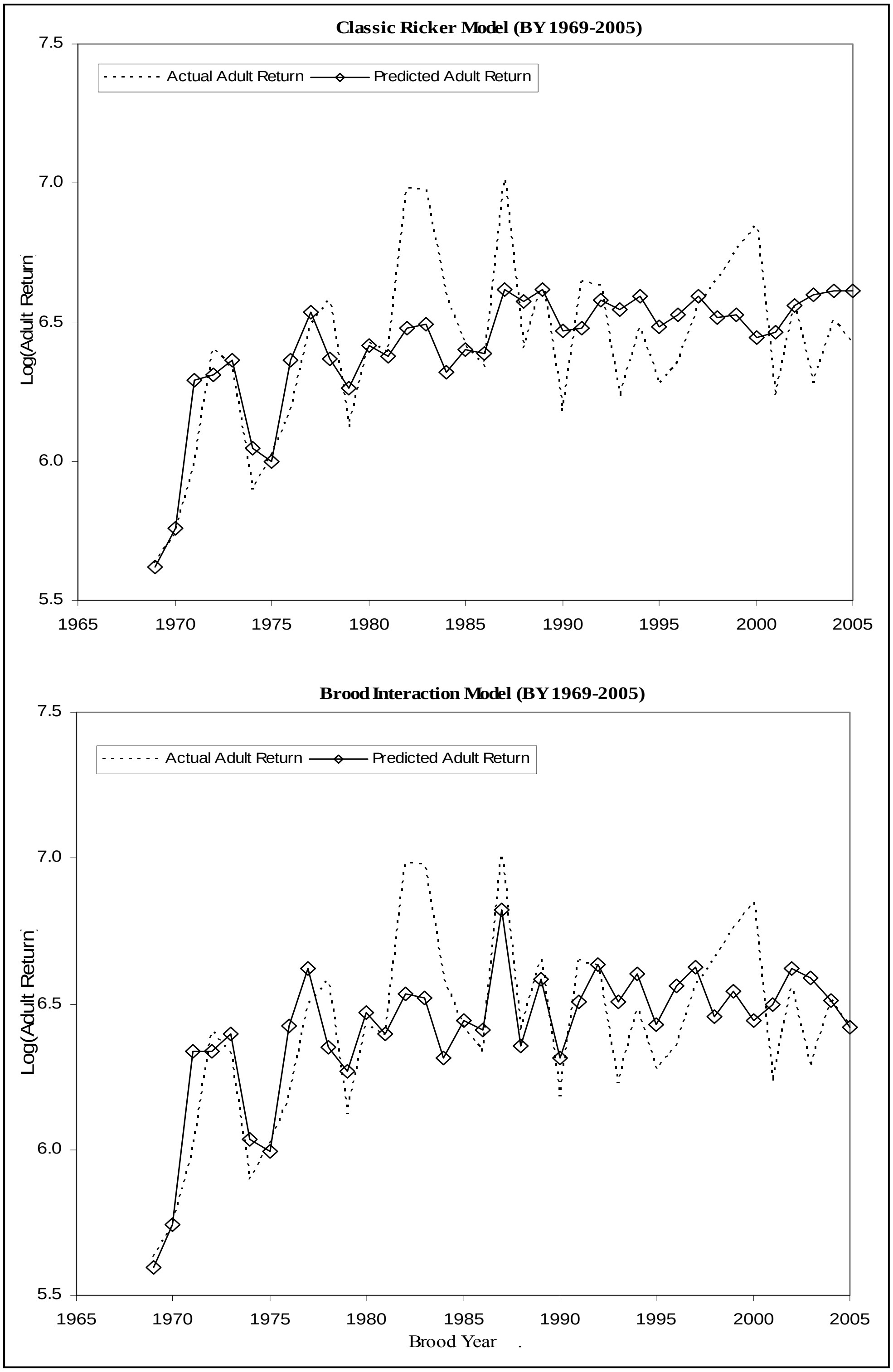


Figure 10.–Time series of actual Kenai River late-run sockeye salmon returns and returns predicted by the classic Ricker and brood-interaction models, brood years 1969–2005.

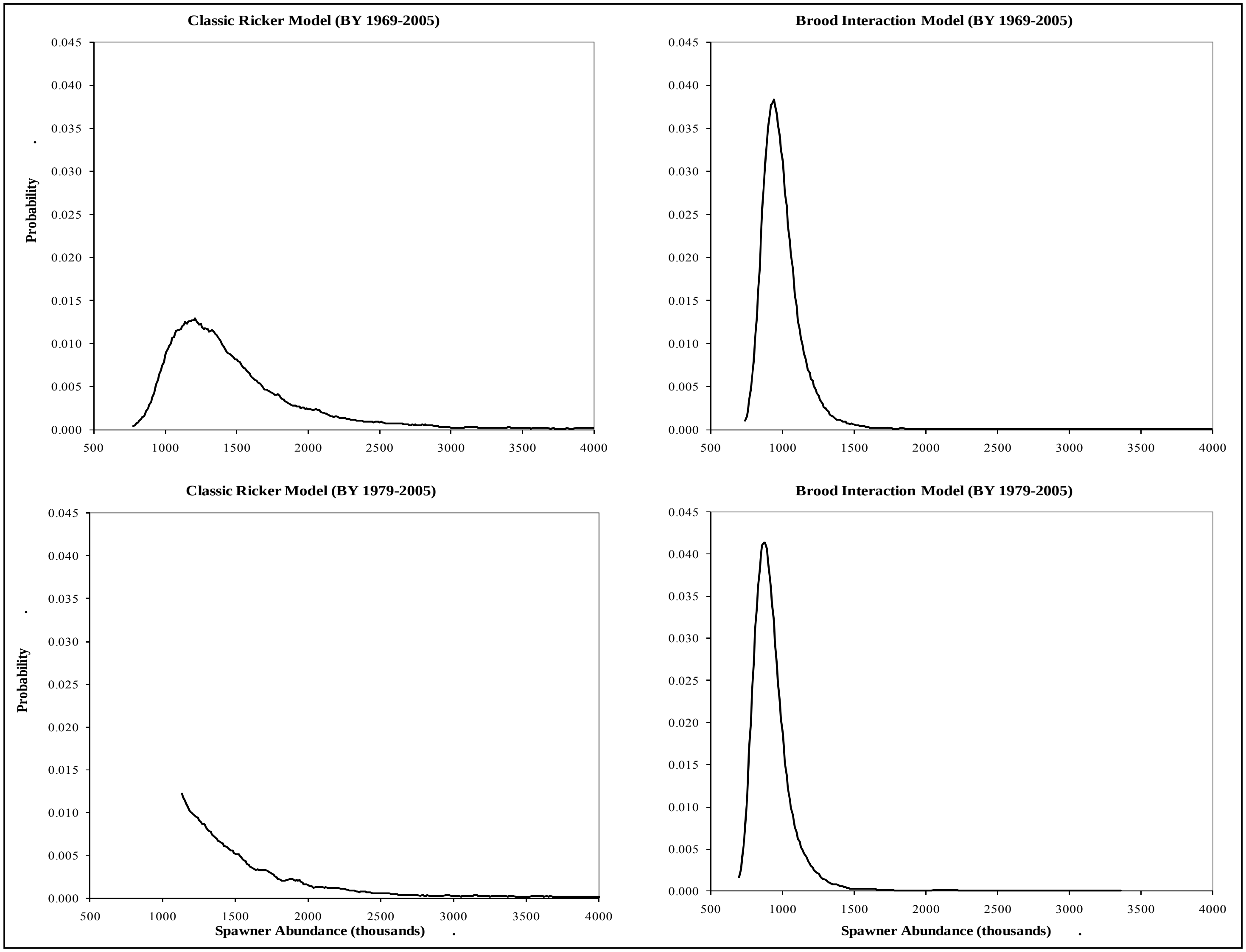
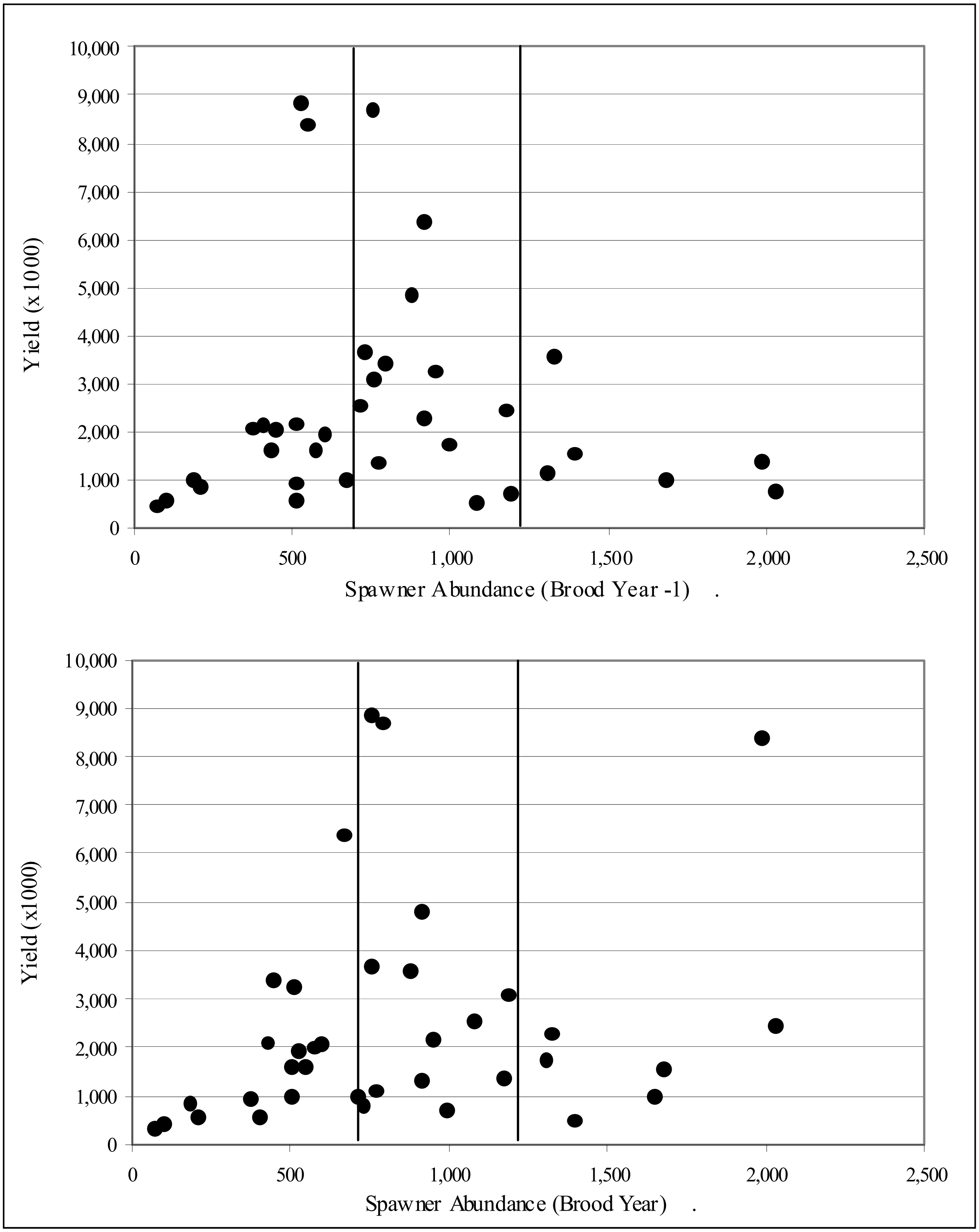


Figure 11.–Likelihood profiles for Kenai River late-run sockeye salmon spawner abundances (escapements) that produced high sustained yields estimated by the classic Ricker and simple brood interaction models (assuming a constant escapement goal policy) fit to data from brood years 1969–2005 and 1979–2005.



Note: Solid vertical lines are the recommended SEG range.

Figure 12.–Kenai River late-run sockeye salmon yields related to spawner abundances (escapement; in thousands of fish) in brood years 1969–2005 and the previous year (brood year -1).

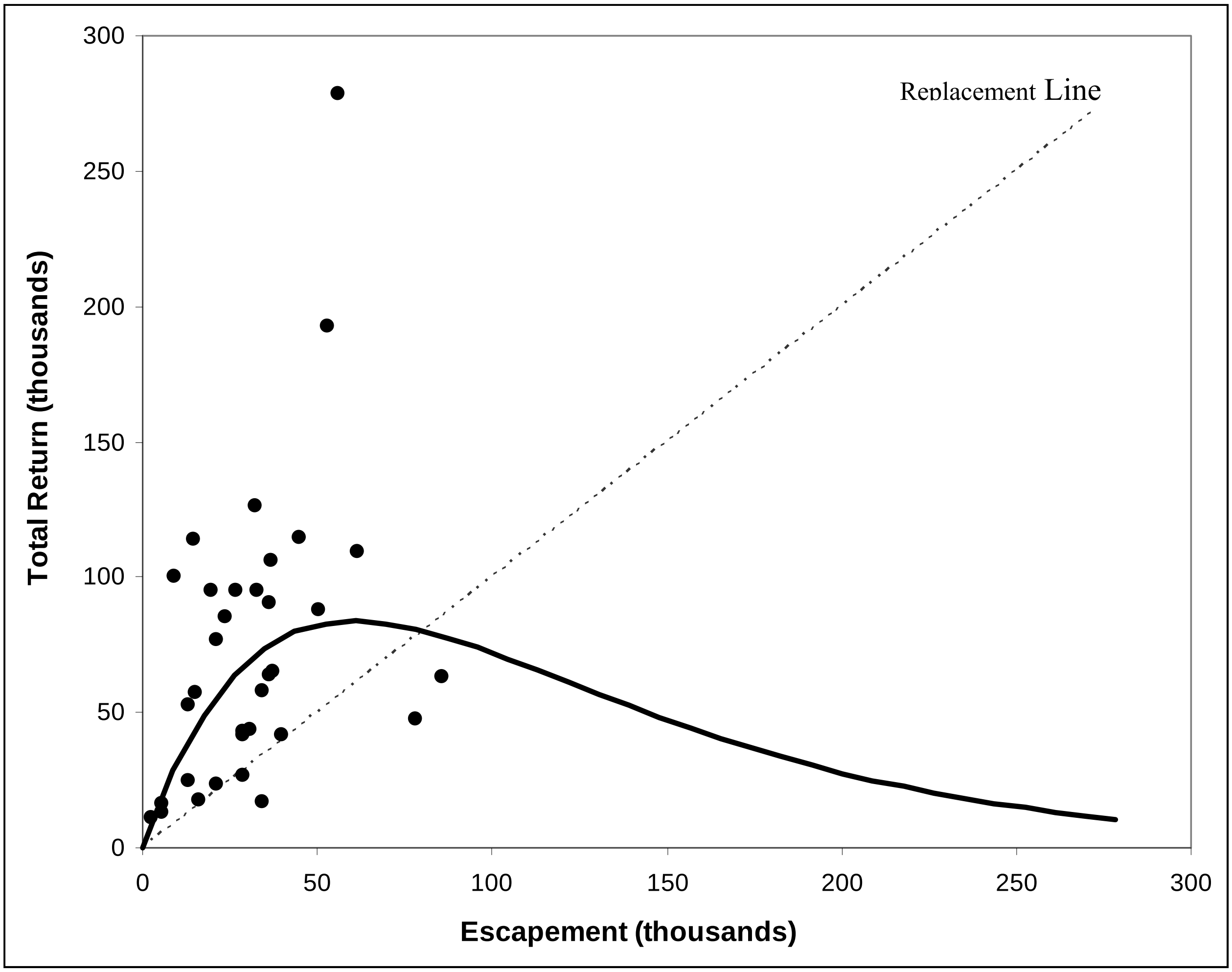


Figure 13.–Observed number of recruits with a line of replacement plotted against escapement and fitted Ricker curve for early-run Russian River sockeye salmon, brood years 1970–2003.

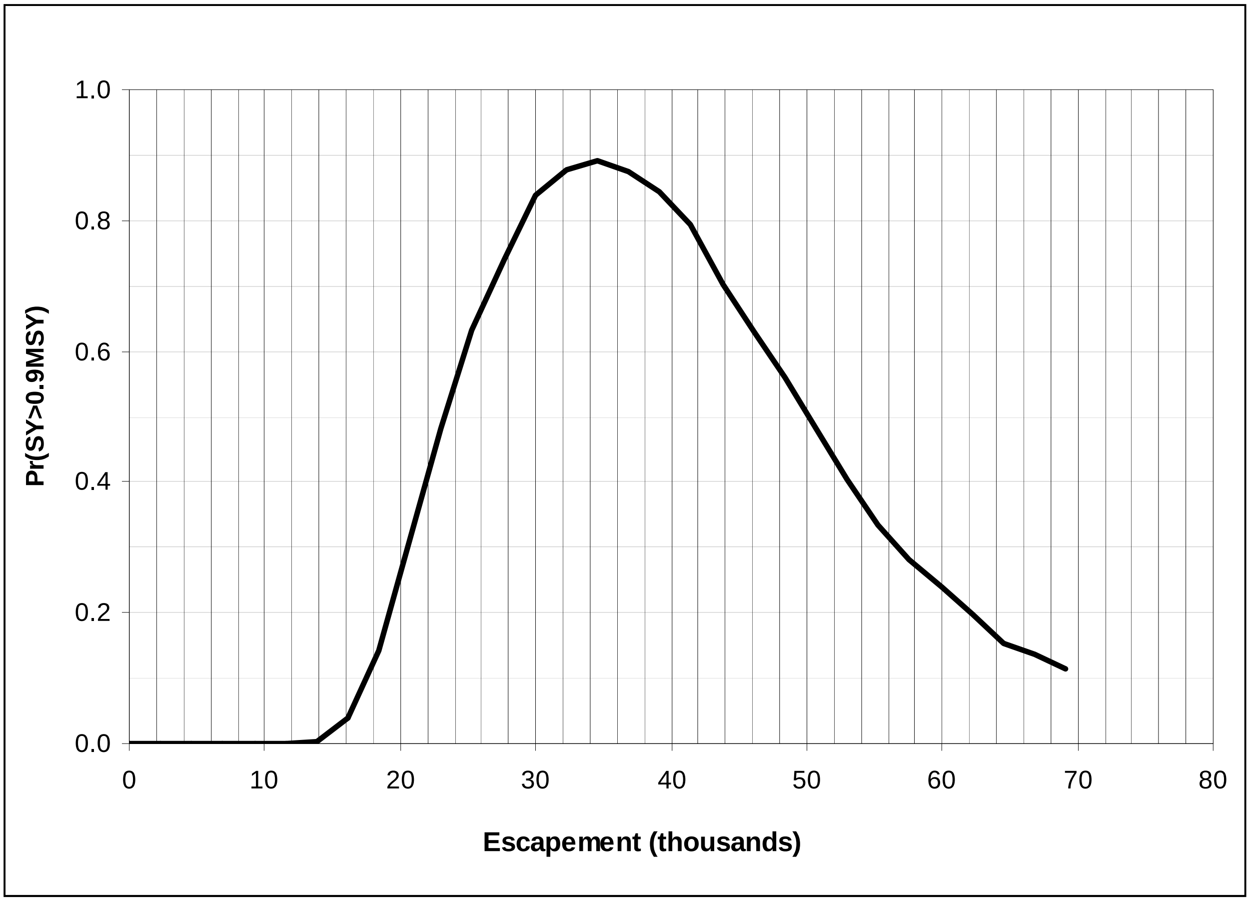


Figure 14.–Probability that sustained yields are greater than 90% MSY at various levels of escapement using a Ricker stock-recruitment model, Russian River early run sockeye salmon.

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

[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

[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

[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

[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

[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 Year	Count at the Weir [a] Wild	Hatchery	Total	Actual Escapement [b] Total	Wild	Return Year	Sport Harvest [c] Early Run (thru 6/30)	Total
1976	1,682 [d]		1,682	1,537	1,537			
1977	3,069 [d]		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	4,201	4,839
1999	602	1,189	1,791	1,503	505	1999	7,597	8,255
2000	662	752	1,414	1,100	515	2000	8,815	9,901
2001	2,122	462	2,584	3,023	1,381	2001	7,488	8,866
2002	2,506	797	3,303	3,254	958	2002	4,791	5,242
2003	2,923	1,204	4,127	4,780	2,554	2003	3,078	4,222
2004	2,641	2,232	4,873	4,674	2,196	2004	3,295	4,333
2005	2,107	1,055	3,162	2,923	1,903	2005	3,468	4,520
2006	1,589	1,056	2,645	2,568	1,516	2006	2,421	3,304
2007	1,038	489	1,527	1,452	965	2007	2,601	
2008	1,018	396	1,414	1,181	879	2008	2,996	
2009	674	255	929	734	617	2009	1,637	

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

[b] Number of fish estimated to have actually spawned. Includes fish counted during foot surveys below the weir. 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. 2010) 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] Assumed wild.

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

		Escapement [a]				Yield [a,b]		
Brood Year		Naturally-produced	Hatchery-produced	Total	Total Return [a]	Naturally-produced	Hatchery-produced	Total
1999		469	928	1,397	2,670	2,201	1,742	1,273
2000		426	651	1,077	3,273	2,847	2,623	2,196
2001		554	1,761	2,315	3,102	2,549	1,341	787
2002		808	1,900	2,708	2,413	1,605	514	-295
2003		2,396	1,201	3,597	1,835	-561	633	-1,762
2004		2,196	2,160	4,356	1,170	-1,026	-990	-3,186
2005	c	1,909	1,027	2,936				
2006	c	1,516	1,053	2,569				
2007	c	965	487	1,452				
2008	c	879	302	1,181				
2009	c	617	117	734				
2010	c	1,088	260	1,348				

[a] Excludes 1-ocean Chinook salmon.

[b] Yield is total return minus escapement.

[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	Total Return [a]	Yield	Return/ Spawner	Year	Sport Harvest [c]
1974	5,279	15,915		61,364	45,738	3.93	1974	
1975	4,737	14,840		33,661	19,131	2.32	1975	
1976	21,693	48,481		37,976	-10,831	0.78	1976	
1977	39,642	84,091		38,590	-46,502	0.45	1977	
1978	24,639	54,325		44,902	-9,861	0.82	1978	
1979	27,385	59,773		52,508	-7,806	0.87	1979	2,811
1980		35,132 [d]		45,008	9,802	1.28	1980	3,685
1981		23,605 [d]		44,948	21,487	1.92	1981	2,769
1982	16,000	37,186		75,448	38,150	2.02	1982	4,307
1983	19,237	43,608		36,488	-7,355	0.83	1983	4,889
1984	16,892	38,955		35,541	-3,561	0.91	1984	5,699
1985	18,151	41,453		47,329	5,682	1.14	1985	6,407
1986	21,080	47,264		30,960	-16,608	0.65	1986	6,490
1987	15,028	35,257		22,065	-13,268	0.62	1987	5,632
1988	19,200	43,534		21,150	-22,617	0.48	1988	5,474
1989		23,686 [d]		15,962	-7,582	0.68	1989	8,062
1990	18,166	41,483		6,925	-34,752	0.17	1990	6,161
1991	8,112	21,536		15,918	-5,435	0.75	1991	9,306
1992	7,736	20,790		43,103	22,510	2.09	1992	7,256
1993	5,769	16,887		31,782	15,166	1.91	1993	5,682
1994	2,665	10,729		30,327	19,986	2.93	1994	624
1995	5,150		10,048	52,973	42,925	5.27	1995	0
1996	6,343		14,349	25,490	11,141	1.78	1996	11
1997	19,047		35,587	33,599	-1,988	0.94	1997	42
1998	15,556	36,305		42,097	5,696	1.16	1998	3,384
1999	12,904		29,088	66,825	37,737	2.30	1999	3,496
2000			33,965	46,815	12,850	1.38	2000	7,075
2001			27,966	39,649	11,683	1.42	2001	5,007
2002	8,749		28,535	30,833	2,298	1.08	2002	4,508
2003			39,257				2003	6,605
2004 [e]	28,778		56,659				2004	9,050
2005 [e]	11,495		36,433				2005	7,332
2006 [e]	6,499		29,922				2006	7,753
2007 [e]	6,712		18,714				2007	5,696
2008 [e]			7,533				2008	2,036
2009 [e]	3,954		11,960				2009	723

[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] From Statewide Harvest Survey (Jennings et al. 2010). 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.

[d] 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.

[e] 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

[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		18,682	9,863	-8,819	0.53
1987		11,780	17,438	5,659	1.48
1988		5,331	20,736	15,404	3.89
1989		9,449	20,326	10,876	2.15
1990		8,494	19,716	11,222	2.32
1991		8,834	17,162	8,328	1.94
1992		7,610	11,008	3,398	1.45
1993		10,293	13,926	3,633	1.35
1994		9,947	21,814	11,867	2.19
1995		11,310	16,782	5,472	1.48
1996		16,595	8,857	-7,738	0.53
1997		8,185	12,516	4,331	1.53
1998		11,679	11,783	104	1.01
1999		17,276	21,101	3,825	1.22
2000		10,476	19,612	9,136	1.87
2001		14,073	14,377	304	1.02
2002		6,185	18,334	12,150	2.96
2003		10,097	17,216	7,118	1.70
2004	b	12,504			
2005	b	16,387			
2006	b	18,428			
2007	b	12,504			
2008	b	11,732			
2009	b	9,771			

[a] Yield is total return minus escapement.

[b] Complete return data not yet available.

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		47,375	47,475	99	1.00
1987		34,900	65,177	30,278	1.87
1988		32,137	71,743	39,605	2.23
1989		19,256	44,111	24,855	2.29
1990		26,508	49,078	22,570	1.85
1991		26,695	69,694	42,998	2.61
1992		22,524	48,786	26,262	2.17
1993		33,738	47,169	13,431	1.40
1994		35,065	52,719	17,654	1.50
1995		31,255	53,783	22,528	1.72
1996		30,907	39,288	8,381	1.27
1997		26,297	44,999	18,702	1.71
1998		26,768	68,448	41,680	2.56
1999		34,962	97,397	62,435	2.79
2000		29,627	56,921	27,294	1.92
2001		17,947	46,503	28,557	2.59
2002		30,464	59,557	29,093	1.95
2003		23,736	47,450	23,714	2.00
2004	[b]	40,198			
2005	[b]	26,046			
2006	[b]	24,423			
2007	[b]	32,619			
2008	[b]	24,144			
2009	[b]	17,158			

[a] Yield is total return minus escapement.

[b] Complete return data not yet available.

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

[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
2008	120
2009	111

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

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

[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

[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

[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

[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

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

[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

[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

[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

[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

[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 9/1. Escapements for 1969, 1972–1976 and 1997, were expanded by 25% to account for removal of weir from 9/1–9/17. 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

[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

[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. 2010).

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

[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	131,325	71,152	1.05
2006 [c]	92,533			
2007 [c]	79,406			
2008 [c]	62,030			
2009 [c]	125,114			

[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 yet available.

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

Year	Escapement [a, b,c]		Year	Escapement [a, b,c]
1938	182,463		1974	16,225
1939	116,588		1975	29,882
1940	306,982		1976	14,032
1941	55,077		1977	5,183
1942			1978	3,555
1943			1979	68,739
1944			1980	62,828
1945			1981	50,479
1946	57,000	d	1982	28,164
1947	150,000	d	1983	118,797
1948	150,000	d	1984	192,352
1949	68,240		1985	68,577
1950	29,659		1986	29,800
1951	34,704		1987	91,215
1952	92,724		1988	71,603
1953	54,343		1989	67,224
1954	20,904		1990	50,000
1955	32,724		1991	50,500
1956	32,663	c	1992	71,385
1957	15,630		1993	117,619
1958	17,573		1994	95,107
1959	77,416	e,f	1995	115,000
1960	80,000	e, f	1996	63,160
1961	40,000	e, f	1997	54,656
1962	60,000	e, f	1998	22,853
1963	119,024	e, f	1999	26,746
1964	65,000	e, f	2000	19,533
1965	16,544	e, f	2001	43,469
1966	41,312	e, f	2002	90,483
1967	22,624	e, f	2003	92,298
1968	19,616	e, f	2004	22,157
1969	12,456		2005	14,215
1970	25,000	g	2006	32,562
1971	31,900	h	2007	27,948
1972	6,981		2008	19,339
1973	2,705		2009	83,480

[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 8/8/70.
[h] Includes 500 sockeye salmon behind weir when it was removed on 8/7/71..

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

[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	1,512,460	990,667	2.90
2005	358,569	845,221	486,652	2.36
2006	387,769			
2007	364,261			
2008	324,880			
2009	324,783			
2010	293,765			

Appendix C6.–Data available for analysis of Kenai River sockeye salmon escapement goal (excludes late-run Russian River escapement through the weir and Hidden Lake enhanced).

Brood Year	Escapement	Returns	Yield	Return per Spawner	Harvest 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	527,553	2,465,818	1,938,265	4.67	0.79
1982	755,413	9,591,200	8,835,787	12.70	0.92
1983	792,368	9,489,648	8,697,280	11.98	0.92
1984	446,397	3,865,134	3,418,737	8.66	0.88
1985	573,611	2,592,968	2,019,357	4.52	0.78
1986	546,614	2,174,842	1,628,228	3.98	0.75
1987	1,982,501	10,378,573	8,396,072	5.24	0.81
1988	1,173,656	2,550,942	1,377,286	2.17	0.54
1989	2,027,299	4,480,888	2,453,589	2.21	0.55
1990	730,471	1,518,983	788,512	2.08	0.52
1991	756,348	4,444,531	3,688,183	5.88	0.83
1992	1,188,434	4,272,741	3,084,307	3.60	0.72
1993	992,096	1,690,264	698,168	1.70	0.41
1994	1,307,269	3,053,461	1,746,192	2.34	0.57
1995	771,935	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	877,434	4,466,351	3,588,917	5.09	0.80
1999	916,047	5,755,767	4,839,720	6.28	0.84
2000	668,510	7,061,112	6,392,602	10.56	0.91
2001	713,484	1,705,699	992,215	2.39	0.58
2002	1,081,577	3,625,113	2,543,536	3.35	0.70
2003	1,395,432	1,908,893	513,461	1.37	0.27
2004	1,678,521	3,229,841	1,551,320	1.92	0.48
2005	1,646,987	2,650,255	1,003,268	1.61	0.38
2006	1,876,088				
2007	957,584				
2008	704,154				
2009	876,593				
2010	1,194,883				

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

[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

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

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	Year	Harvest [b]
1965	21,510	5,970	-15,540	0.28	1965	10,030
1966	16,660	7,822	-8,838	0.47	1966	14,950
1967	13,710	18,662	4,952	1.36	1967	7,240
1968	9,120	19,800	10,680	2.17	1968	6,920
1969	5,000	13,169	8,169	2.63	1969	5,870
1970	5,450	12,642	7,192	2.32	1970	5,750
1971	2,650	8,728	6,078	3.29	1971	2,810
1972	9,270	98,980	89,710	10.68	1972	5,040
1973	13,120	26,788	13,668	2.04	1973	6,740
1974	13,160	52,849	39,689	4.02	1974	6,440
1975	5,650	14,130	8,480	2.50	1975	1,400
1976	14,735	115,408	100,673	7.83	1976	3,380
1977	16,060	17,515	1,455	1.09	1977	20,400
1978	34,240	17,001	-17,239	0.50	1978	37,720
1979	19,750	94,836	75,086	4.80	1979	8,400
1980	28,620	42,401	13,781	1.48	1980	27,220
1981	21,140	76,040	54,900	3.60	1981	10,720
1982	56,110	278,179	222,069	4.96	1982	34,500
1983	21,270	23,549	2,279	1.11	1983	8,360
1984	28,900	42,857	13,957	1.48	1984	35,880
1985	30,610	43,776	13,166	1.43	1985	12,300
1986	36,340	90,637	54,297	2.49	1986	35,100
1987	61,510	109,215	47,705	1.78	1987	154,200
1988	50,410	87,848	37,438	1.74	1988	54,780
1989	15,340	57,055	41,715	3.72	1989	11,290
1990	26,720	94,893	68,173	3.55	1990	30,215
1991	32,389	126,044	93,655	3.89	1991	65,390
1992	37,117	64,978	27,861	1.75	1992	30,512
1993	39,857	41,584	1,727	1.04	1993	37,261
1994	44,872	114,649	69,777	2.56	1994	48,923
1995	28,603	26,462	-2,141	0.93	1995	23,572
1996	52,905	192,657	139,752	3.64	1996	39,075
1997	36,280	63,876	27,596	1.76	1997	36,788
1998	34,143	57,692	23,549	1.69	1998	42,711
1999	36,607	106,219	69,612	2.90	1999	34,283
2000	32,736	94,932	62,196	2.90	2000	40,732
2001	78,255	47,731	-30,524	0.61	2001	35,400
2002	85,943	63,226	-22,717	0.74	2002	52,139
2003	23,650	85,053	61,403	3.59	2003	22,986
2004 [c]	56,582				2004	32,727
2005 [c]	52,903				2005	37,139
2006 [c]	80,524				2006	51,161
2007 [c]	27,298				2007	37,185
2008 [c]	30,989				2008	43,420
2009 [c]	52,178				2009	60,381

[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 1997–2000 from Statewide Harvest Survey (Jennings et al. 2007). 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	Escapement [b] 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	16,863	53,068	4,504	74,435
2008	23,680	46,638	9,750	80,068
2009	33,935	80,088	10,740	124,763

[a] Harvest during 1963–1996 from an onsite creel survey and during 1997–2000 from Statewide Harvest Survey (Jennings et al. 2007). 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

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