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Review of Salmon Escapement Goals in Upper Cook Inlet, Alaska, 2016

by

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February 2017

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

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ABSTRACT

The Alaska Department of Fish and Game interdivisional escapement goal review committee reviewed Pacific salmon *Oncorhynchus* spp. escapement goals for the major river systems in Upper Cook Inlet. Escapement goals were reviewed for 21 Chinook salmon *O. tshawytscha*, 1 chum salmon *O. keta*, 4 coho salmon *O. kisutch*, and 9 sockeye *O. nerka* salmon stocks. The committee recommended to the Divisions of Commercial Fisheries and Sport Fish directors changes to 2 Chinook salmon goals (early- and late- run Kenai River), 1 chum salmon goal (Clearwater Creek), and 4 sockeye salmon goals (Chelatna, Judd, and Larson lakes and Fish Creek). The committee also recommended creating 1 Chinook salmon (Little Susitna River; weir-based goal) and 1 coho salmon (Deshka River) escapement goal.

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

INTRODUCTION

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

The Alaska Department of Fish and Game (ADF&G) reviews escapement goals for UCI salmon stocks on a schedule corresponding to the Alaska Board of Fisheries (BOF) 3-year cycle for considering area regulatory proposals. Management of these stocks is based on achieving escapements for each system within a specific escapement goal range or above a lower bound. Escapement refers to the annual estimated number of fish in 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 2016 and presents information from the previous 3 years in the context of these goals. The purpose of this report is to document the review of UCI salmon escapement goals and the review committee's recommendations to the Division of Commercial Fisheries and Sport Fish directors. Many salmon escapement goals in UCI have been set and evaluated at regular intervals since statehood (Fried 1994). Due to the thoroughness of previous analyses by Bue and Hasbrouck[1], Clark et al. (2007), Hasbrouck and Edmundson (2007), and Fair et al. (2007, 2010, 2013), this review reanalyzed only those goals with recent (2013–2015) data that could potentially result in a substantially different escapement goal from the last review, or those that should be eliminated or established.

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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*).

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 2016 review, the committee evaluated escapement goals for Chinook, chum, coho, and sockeye salmon stocks:

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

There are no pink salmon stocks in UCI that have escapement goals.

In November 2015, ADF&G established an escapement goal review committee (hereafter referred to as the committee), consisting of Division of Commercial Fisheries and Division of Sport Fish personnel (Table 1). The committee formally met via teleconference in November and December of 2015, and February, 2016 to review escapement goals and develop recommendations. The committee also met several times during the summer and fall of 2016 to discuss the development of escapement goals specific to Kenai River Chinook salmon. 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.

OBJECTIVES

Objectives of the 2016 review were to:

1) Review existing goals to determine whether they were still appropriate given (a) new data collected since the last review, (b) current assessment techniques, and (c) current management practices;

2) Review the methods used to establish the existing goals to determine whether alternative methods should be investigated;

3) Consider any new stocks for which there may be sufficient data to develop a goal; and

4) Recommend new goals if appropriate and eliminate existing goals that are no longer appropriate.

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 about the stock become available.

DATA AVAILABLE TO DEFINE ESCAPEMENT GOALS

Return data through 2015 were used for all stocks in this review. The previous review used return data through 2012 except for Kenai and Kasilof River sockeye salmon, which used return data through 2013. 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). Weirs tend to be the most reliable assessment tool, providing a count of the total number of fish in the escapement. Depending on location, mark–recapture and sonar projects typically provide the next most reliable abundance estimates. Differences in methods among years can affect the comparability and reliability of data. In some systems, harvests occur upstream of the counting location; in these systems, estimates of harvest and sometimes catch-and-release mortality are subtracted to estimate escapement. Data available for escapement goal analyses for all UCI stocks are found in this report (Appendices A–D).

Chinook Salmon

Escapements for most Chinook salmon stocks assessed in UCI have been monitored by single helicopter or foot surveys. Such surveys provide an index of escapement. The indices are a measurement that provides information about the relative level of escapement.

Since 1995, Deshka River Chinook salmon escapement has been assessed with a weir project, although previously (1974–1994) it was indexed annually by single aerial surveys. To estimate total escapement for those early years, aerial surveys were expanded using their relationship to weir counts.[2]

Aerial surveys via helicopter have been conducted for Chinook salmon on the Little Susitna River in most years since 1983. Additionally, a weir for counting Chinook salmon was operated concurrently in years that aerial surveys occurred in 1988, 1994, 1995, 2014, and 2015.

A separate report was written detailing the escapement goal analysis for Kenai River Chinook salmon 75 cm METF and longer (Fleischman and Reimer 2017); however some information is provided within this report. Two stocks of Chinook salmon return to the Kenai River to spawn, classified as early- and late-runs; hydroacoustics have been used to assess both runs (Miller et al. 2016). An associated gillnetting program has been used to sample Chinook salmon to estimate age, sex, and size composition (Perschbacher 2015). A sampling program of the catch in the adjacent commercial east side setnet fishery was modified beginning in 2012 by the Division of Sport Fish to generate stock specific estimates of harvest (Eskelin and Barclay 2016). ADF&G reviewed and implemented the current SEGs for Kenai River early- and late-run Chinook salmon in 2013. In those reviews the early-run SEG of 4,000–9,000 changed to a SEG of 3,800–8,500 (McKinley and Fleischman 2013) and for the late run changed from a SEG of 17,800–35,700 to an SEG of 15,000–30,000 (Fleischman and McKinley 2013). The 2013 goals were assessed using abundance estimates derived by fitting a mixture model to midriver Dual-frequency identification sonar (DIDSON)[3] and netting data collected at river mile 8.6. These data were spatially expanded to account for incomplete sonar coverage of the river. A complete listing of annual abundance, harvest, and age data available for Kenai River Chinook salmon 75 cm METF and longer can be found in Fleischman and Reimer 2017.

A weir project also operates on Crooked Creek to count and sample Chinook salmon (Begich and Pawluk 2010).

Chum Salmon

Peak aerial fixed-wing surveys are used to index escapement of chum salmon in Clearwater Creek, the only chum salmon stock in UCI that has an escapement goal monitored by ADF&G (Tobias et al. 2013). Stock specific harvest rates for Clearwater Creek chum salmon are not available; however, the estimated mean harvest rate (1972–2015) for Chinitna Bay chum salmon is 26% and has declined dramatically since the 1970s. Annual harvest rates for Chinitna Bay chum salmon, which includes the Clearwater Creek chum salmon stock were estimated by expanding peak aerial survey indices by 2.55 (Fair et al. 2009). The contrast in the Clearwater Creek chum salmon escapements for this same time period is 28.

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[2] Rich Yanusz, retired Sport Fish Research Biologist, ADF&G, Palmer; personal communication.

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

Coho Salmon

Coho salmon escapements are monitored with a single foot survey on McRoberts Creek (a tributary of Jim Creek), and weirs on Jim and Fish creeks, as well as, Little Susitna and Deshka rivers (Oslund and Ivey 2017).

Sockeye Salmon

Sonar is used to estimate sockeye salmon abundance passing specific locations in the Kasilof and Kenai rivers, where high glacial turbidity precludes visual enumeration (Westerman and Willette 2013). Studies compared sockeye salmon abundance estimated using the historical Bendix sonar and the more modern DIDSON on the Kenai River during part of the season from 2004 to 2007, and on the Kasilof River during part of the season from 2007 to 2009. In the 2010/2011 escapement goal review, ADF&G used those comparisons to convert historical daily Bendix sonar abundance estimates to DIDSON units (Maxwell et al. 2011). In clearwater systems of UCI that are assessed, fish are counted with weirs or video cameras. Weirs are used to count and sample adult sockeye salmon escapements in the Susitna River drainage (Chelatna, Judd, and Larson lakes; Fair et al. 2009), Russian River (Begich and Pawluk 2010), and Fish Creek (Oslund and Ivey 2010). Historically at Packers Creek, escapement has been counted with both video cameras and weirs. From 2009 to 2012, a video camera was operated at Packers Creek to estimate sockeye salmon escapement (Shields and Dupuis 2013), although equipment complications prevented complete counts in 2010, 2011, and 2012.

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

The Kenai River late-run sockeye salmon escapement goal is based on reconstructions of the total return by brood year, and the number of sockeye salmon spawning within the watershed. Prior to this review (Fair et al. 2013) the escapement was estimated by subtracting the number of sockeye salmon harvested in recreational fisheries upstream of the sonar site and the number of hatchery-produced sockeye salmon passing the Hidden Lake weir from the sockeye salmon sonar count (rkm 30.9; Tobias et al. 2013). For this review the number of hatchery-produced sockeye salmon passing the Hidden Lake weir was not subtracted from the sockeye salmon sonar count, because hatchery-produced Hidden Lake fish were not enumerated in the commercial, sport or personal use harvests, and their contribution to Kenai River sockeye salmon sonar estimates were very small (1981–2014 average 1.5%). 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. 2015) and creel surveys (1994, 1995) conducted during the fishery (King 1995, 1997).

Commercial catch statistics are compiled from ADF&G fish ticket information. The majority of sockeye salmon returning to UCI are caught in mixed stock fisheries (Shields and Dupuis 2013). Prior to 2005, a weighted age composition apportionment model estimated stock-specific harvests of sockeye salmon in commercial gillnet fisheries (Tobias and Tarbox 1999). 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 estimates for all contributing stocks. Since 2006, the primary means for estimating stock-specific sockeye salmon harvests has been the use of genetic markers (Habicht et al. 2007; Barclay et al. 2010). Age composition of the sockeye salmon harvest is estimated annually using a stratified systematic sampling design (Tobias et al. 2013). Estimates of sport harvest originate from the SWHS conducted annually by the Division of Sport Fish (Jennings et al. 2015).

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 (2006–2014) 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 weighted age composition apportionment model uses escapements for all major UCI sockeye salmon stocks (Kenai, Kasilof, Susitna, Crescent rivers, Fish Creek, and unmonitored stocks) and because historical Bendix sonar estimates may not reliably index Susitna River sockeye salmon abundances (Fair et al. 2009), we used mark–recapture estimates of Susitna River sockeye salmon escapement (Yanusz et al. 2007; Yanusz et al. 2011 a, b) for 2006–2009, and an average of these escapement estimates for the years prior to 2006 in the weighted age composition apportionment model. For the 2015 sockeye salmon run estimates, the catch allocation model used DIDSON estimates for Kenai and Kasilof River escapements, and expanded (based on mark–recapture) weir counts (Judd, Chelatna, and Larson lakes) for Susitna River sockeye salmon escapement. The catch allocation model rather than a mixed stock analysis based on genetic stock identification was used to estimate sockeye salmon runs in 2015 because the estimates based on genetics were unavailable.

ESCAPEMENT GOAL DEVELOPMENT

For the purposes of this review, all references to "significance" indicate results of a statistical test using an alpha level of 0.05 (i.e. 5% probability that the result is by chance alone).

Stock-Recruitment Analyses

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

Evaluation of Kasilof River Sockeye Salmon Escapement Goal

We applied the same methods used in a previous escapement goal review Kasilof River sockeye salmon (Hasbrouck and Edmundson 2007) to the updated brood table (Appendix D4) described above. We examined the fit of 2 stock-recruitment models to data from brood years 1969 to 2009 (i.e., all available spawner-return data).

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

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

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, ε indicates process error and t indicates the brood year. Next, we examined serial correlation in process error with a lag of 1 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 $\hat{S}_{MSY}$ (the estimate of escapement that provides the largest surplus production) calculated as described by Clark et al. (2007). We evaluated model fits using likelihood ratio tests for hierarchical models (Hilborn and Mangel 1997). Escapement goal ranges were derived that provided for 90–100% of maximum sustained yield (MSY). This range meets the common standard of Optimum Yield (≥90% of MSY) used by the Alaska Department of Fish and Game (Bernard and Jones 2010)

Evaluation of Kenai River Sockeye Salmon Escapement Goal

Following methods from a previous Kenai River sockeye salmon escapement goal review (Clark et al. 2007) we fit 9 different stock-recruitment models to the DIDSON-adjusted spawner-return data. We fit the models to data from all available brood years, 1969 to 2009. 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):

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

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

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

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

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).

For this escapement goal review we also fit a Beverton-Holt model to the data set using the methods of Quinn and Deriso (1999):

$$R_t = \frac{\alpha S_t}{1 + \beta S_t} \varepsilon_t ,$$

where α is the number of recruits per spawner at low numbers of spawners and all other terms are defined above.

A Hockey Stick model was also fit to the data set using methods of Johnston et al. (2002) and Schwarz (2015):

$$R_t = \alpha S_t + \beta (S_t - C) + \varepsilon_t$$

where β is the number of recruits per spawner at high spawner abundance, C is the cutpoint where the slope of the regression changes, and (S_t - C) is a derived variable that takes the value of 0 for values of S_t less than C and the values S_t - C for values of S_t greater than C. The model was fit to the data using a non-linear regression method that solved for the value of C.

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

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

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}):

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

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

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

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

Evaluation of Kenai River Early- and Late-run Chinook Salmon Escapement Goals

Beginning in 2013 Adaptive Resolution Imaging Sonar (ARIS) was deployed upstream from RM 8.6 to RM 13.7, where it is possible to monitor nearly the entire cross section of the river and produce direct counts of Chinook salmon 75 cm METF and longer. For this review, age-structured spawner-recruit models were fitted to 1986–2015 abundance, harvest, and age data for Chinook salmon 75 cm METF and longer. These analyses are detailed in a separate report (Fleischman and Reimer 2017).

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 number 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 currently have SEGs that were developed in 2001 with the 4-tier Percentile Approach (Bue and Hasbrouck) For this approach Bue and Hasbrouck developed an algorithm using percentiles of observed escapements, whether estimates or indices, that considered contrast in the escapement data and exploitation of the stock to choose escapement goal ranges. 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 0^{th} 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 are the maximum observed escapement divided by the minimum observed escapement. As contrast increases 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 25^{th} percentile as a precautionary measure for stock protection:

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

Clark et al. (2014) provided a comprehensive evaluation of the Percentile Approach used to establish sustainable escapement goals for stocks that lack sufficient stock productivity information. Since it came into use in 2001, the Percentile Approach has been the principal method used to develop nearly half of the escapement goals currently in use throughout Alaska (Munro and Volk 2016). Although the concept and basis for the Percentile Approach as a proxy for S_{MSY} was considered robust, Clark et al. (2014) offered the following summation of their review:

> *"All of [our] analyses indicate that the four tiers of the Percentile Approach are likely sub-optimal as proxies for determining a range of escapements around S_{MSY}. The upper bounds of SEGs developed with this approach may actually be unsustainable in that they may specify spawning escapement that is close to or exceeds the carrying capacity of the stock. The lower bound percentile of SEG Tier 1 (25%) also appears somewhat higher than necessary. Escapements in the lower 60 to 65 percentiles are optimal across a wide range of productivities, serial correlation in escapements, and measurement error in escapements."*

Clark et al. (2014) recommended that the 4 tiers of the Percentile Approach be replaced with the following 3 tiers for stocks with low to moderate (<0.40) average harvest rates:

- Tier 1 – high contrast (>8) and high measurement error (aerial and foot surveys) with low to moderate average harvest rates (<0.40), the 20^{th} to 60^{th} percentiles;
- Tier 2 – high contrast (>8) and low measurement error (weirs, towers) with low to moderate average harvest rates (<0.40), the 15^{th} to 65^{th} percentiles;
- Tier 3 – low contrast ($\leq$8) with low to moderate average harvest rates (<0.40), the 5^{th} to 65^{th} percentiles

Both percentile approaches have been used to develop SEGs in UCI, so to avoid confusion, hereafter we will refer to the Bue and Hasbrouck method as the 4-tier Percentile Approach and the Clark et al. (2014) method as the 3-tier Percentile Approach. Clark et al. (2014) recommended not using the 3-tier Percentile Approach for stocks with average harvest rates $\geq$ 0.40, or those that have both very low contrast ($\leq$4) and high measurement error. For a more comprehensive review and analysis of the 3-tier Percentile Approach, see Clark et al. (2014).

For this review, the SEG ranges of all stocks with existing percentile-based goals were re-evaluated using the 3-tier and 4-tier Percentile Approaches 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. For Chinook salmon stocks, especially those designated as stocks of concern, there was concern with lowering goals by using the 3-tier Percentile Approach. The committee decided it was not prudent to use the lower percentiles recommend by Clark et al. for the lower bounds of the escapement goals until the impact of recent low runs on future runs can be assessed.

Risk Analysis

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

RESULTS AND DISCUSSION

From this review, the majority of salmon escapement goals in UCI remain unchanged (Table 2). The committee recommended to the Commercial Fisheries and Sport Fish division directors changes to 2 Chinook salmon goals, 4 sockeye salmon goals, and 1 chum salmon goal. The committee also recommended creating 1 Chinook salmon and 1 coho salmon escapement goal. Details on the recommendations are provided below. Generally 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 (2016) provide a comprehensive review of goal performance from 2007 to 2015 escapements (for 2013–2015, see Table 3).

CHINOOK SALMON

Kenai River

Following methods detailed in Fleischman and Reimer (2017), S_{MSY} was estimated to be 3,283 fish for the early run and 18,477 fish for the late run , for Chinook salmon 75 cm METF and longer. Based on these analyses and consideration of the optimum yield profiles for each stock, the committee ***recommended SEGs of 2,800–5,600 for the Kenai River early run and 13,500–27,000 for the Kenai River late run***, for Chinook salmon 75 cm METF and longer. These analyses are detailed in a separate report (Fleischman and Reimer 2017).

Little Susitna River

A relationship between paired weir counts and aerial index counts (2.3:1) collected during 5 years, was used to expand aerial survey counts to estimate equivalent weir counts in 23 additional years (Appendix A13). As the characteristics of this stock do not fit any of the tiers in the 3-Tier Percentile Approach (harvest rate >40%, contrast = 6), a goal range was produced using the same method that was used to produce the aerial SEG range for the same stock (4-tier Percentile Approach 15^{th}–85^{th} percentiles; Bue and Hasbrouck). Weir-based Chinook salmon counts allow for a more accurate assessment of run strength compared to aerial counts. The escapement goal committee ***recommended a weir-based SEG of 2,100–4,300 be established for Little Susitna River Chinook salmon***. The new weir-based escapement goal is considered the primary goal for escapement performance and management purposes, and the existing aerial-based SEG (900–1,800) will only be used to assess escapement performance if the weir becomes inoperable inseason for a significant period.

Other Northern District Chinook Salmon Stocks with SEGs

The committee was hesitant to recommend updating the goals for these stocks during a period of low productivity; specifically, there was concern that goals would lower partly due to recent low runs, when the production from these low runs hasn’t been seen yet. Chinook salmon stocks in general statewide, including those in the Northern District of Cook Inlet, have been in a period of decline. Additionally, 7 of the Chinook stocks in the Northern District are *Stocks of Concern* (Alexander, Goose, Sheep, and Willow creeks, as well as the Chuitna, Lewis, and Theodore rivers). In the Susitna River drainage, ADF&G plans to reconstruct drainagewide runs to comprehensively assess current aerial surveys and escapement goals.

CHUM SALMON

Clearwater Creek

The current SEG (3,800–8,400) for Clearwater Creek was established in 2002. For this review, the committee updated the escapement time series through 2015 and applied the 3-tier Percentile Approach to the data set. Average annual harvest rate for Chinitna Bay chum salmon from 1972 to 2015 is 26% and the contrast in escapements for Clearwater Creek chum salmon during this same time period is 28. The escapement goal recommendation was developed from the 20^{th} and 60^{th} percentiles (Tier 1 of the 3-tier Percentile Approach). The committee ***recommended the SEG for Clearwater Creek chum salmon be updated to 3,500–8,000***.

COHO SALMON

Deshka River

Currently there is no escapement goal for Deshka River coho salmon. ADF&G has been hesitant to set an escapement goal for Deshka River coho salmon, largely due to occasional flooding that has resulted in incomplete weir counts in some years, but also the potential difficulty of inseason run calls due to the characteristically sporadic passage of coho salmon. However, a weir has been operated during the coho salmon run on the Deshka River successfully for 14 of 21 years, since 1995. For escapement goal development, the 14 years of weir counts used were recent and complete (1997, 2000–2001, 2003–2005, 2007–2010, and 2012–2015); the tier 2 percentiles (15^{th} to 65^{th}) were then used to set the SEG. The committee ***recommended an SEG of 10,200–24,100***, be adopted for Deshka River coho salmon.

SOCKEYE SALMON

Chelatna, Judd and Larson lakes

The SEGs for these 3 stocks were established in 2008 from limited times series (Appendices D1, D3, and D6). The current SEGs are Chelatna Lake 20,000–65,000; Judd Lake 25,000–55,000; and Larson Lake 15,000–50,000. For this review, aggregate total run for Chelatna, Judd, and Larson lake sockeye salmon was estimated from the weir counts and the aggregate commercial catch from 2006 to 2015. The estimated average annual commercial harvest rate (40.7%) from 2006–2015 is slightly greater than the 40% harvest rate recommended by Clark et al. (2014) for the 3-Percentile Approach. Contrast in escapement for Chelatna, Judd, and Larson lake sockeye salmon stocks were 4.8, 4.5, and 6.4 respectively. Considering 7 additional years of escapement data since the goals were developed, coupled with the 3-tier Percentile Approach, the committee ***recommended updating the SEG as follows: Chelatna Lake 20,000–45,000; Judd Lake 15,000–40,000; and Larson Lake 15,000–35,000.***

The only lower bound recommended for change is Judd Lake from 25,000 to 15,000. Four of the 7 recent escapements added to the time series since the goal was established in 2009 were below the current SEG and 3 were within the SEG. The drop in the lower bound is a result of these additional years of reduced escapement, coupled with use of the 3-tier Percentile Approach.

Clark et al. 2014 recommend using the 5th percentile for establishing the lower bound for these stocks whereas the 4-tier Percentile Approach recommended the 15th percentile. Likewise, the drop in the upper bounds for each of the 3 goals is a result of using the 65th percentile recommended by the 3-tier Percentile Approach rather than the 85th percentile recommended by the 4-tier Percentile Approach.

Fish Creek

The current SEG (20,000–70,000) for Fish Creek was established in 2002. For this review, the committee updated the escapement time series through 2015 (Appendix D2) and applied the 3-tier Percentile Approach. The estimated average annual harvest rate for Fish Creek sockeye salmon from 2006 to 2014 is 37%, which includes commercial, sport and personal use fisheries. Contrast in escapements from 1946 to 2015, excluding years with hatchery production (1977–2011) was 55.5. The committee ***recommended the SEG range for Fish Creek sockeye salmon be updated to 15,000–45,000***. The escapement goal recommendation was developed from the 15th and 65th percentiles (Tier 2 of the 3-tier Percentile Approach).

Kasilof River

ADF&G implemented the current BEG of 160,000–340,000 in 2011. Assessments of the escapement goal are expressed in DIDSON units of fish. Over the past 48 years, Kasilof River sockeye salmon escapement has ranged from approximately 39,000 to 524,000 and returns/spawner values ranged from approximately 0.7 to 8.4 (Figure 2; Appendix D4). Incorporating recent production data (brood years 2008–2009) had little impact on estimates of escapement that produce maximum yields of Kasilof River sockeye salmon, so the committee ***recommended no change to the current BEG of 160,000–340,000***. The classic Ricker model fit the spawner-return data (1969–2009: $R^2 = 0.324$, $P < 0.001$). However, analysis of model residuals showed significant lag-1 autocorrelation ($\varphi = 0.629$; $P < 0.001$). Likelihood ratio tests demonstrated that an autoregressive Ricker model provided the best fit, and escapements that provided for 90–100% of MSY were 150,000–340,000 (Table 4; Figure 3). The narrower likelihood profiles of escapements that produced MSY also indicated the autoregressive Ricker model best described the stock-recruitment relationship for this stock (Figure 4). A Markov yield table (Table 5; Figure 5) predicts escapements ranging from 160,000 to 340,000 will produce yields averaging approximately 753,000 (range: 342,000–1,601,000), whereas escapements below this range will produce yields averaging approximately 344,000 (range: 64,000–631,000), and escapements above this range will produce yields averaging 508,000 (range: 131,000–1,219,000).

Kenai River

ADF&G implemented the current SEG range of 700,000–1,200,000 in 2011. The goal is based on DIDSON estimates of inriver abundance subtracting inriver harvests above the sonar site. Over the past 46 years, Kenai River late run sockeye salmon escapements ranged from approximately 73,000 to 2,027,000 and recruits/spawner estimates ranged from approximately 1.4 to 12.7 (Figure 6; Appendix D5).

The general Ricker model was significant ($P < 0.001$; Table 6) for the Kenai River late run sockeye salmon spawner-return data. However, the density-dependent parameter (β) did not significantly differ from 0 ($P = 0.184$), and γ was not different from 1 ($P = 0.980$; Table 6). For the classic Ricker model (Figure 7), β was significantly different from 0 ($P = 0.004$; Table 6), and a lag-1 autoregressive (φ) parameter was not significant (P = 0.114; Table 6). The density-dependent parameter (γ) in the Cushing model significantly differed from 1 (P < 0.001; Table 6). For the Beverton-Holt model (Figure 8), α was significantly different from 0 (P < 0.001; Table 6), and β was significantly different from 0 (P = 0.002; Table 6). For the Hockey Stick model (Figure 8), α was significantly different from 0 (P = 0.001; Table 6) and β was not significantly different from 0 (P = 0.510; Table 6).

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 0 (P = 0.08; Table 6). A stepwise regression procedure revealed a brood-interaction model describing the stock-recruitment relationship. The β parameter was significantly different from 0 (P = 0.037; Table 6) in a 3-parameter model, but γ was not significantly different from 1 (P = 0.777; Table 6). A simplified 2-parameter brood-interaction model best described (P = 0.001; Table 6) the stock-recruitment relationship for this stock (Table 6). The improved fit of the simple brood-interaction model over the classic Ricker was primarily due to brood years 1988–1990, which followed the largest escapements ever observed (1987 and 1989; Figure 9; Appendix D5). Likelihood profiles of escapements that produced high sustained yields further showed the simple brood interaction model as the best stock-recruitment model (Figure 10).

Applying the same criteria (<6% risk of a yield <1 million sockeye salmon) used to establish the current SEG (Carlson et al. 1999), simulations of the brood-interaction model suggest a goal range of 650,000–1,200,000 (Table 7). Using escapements that represent 90–100% MSY the range was 750,000–1,400,000 spawners (Table 7). The range of 750,000–1,400,000 meets the requirements for a SEG under the SSFP (5 AAC 39.222). This range also meets the common standard of Optimum Yield (≥90% of MSY) used by ADF&G (Bernard and Jones 2010) A simple 2-parameter brood-interaction model (Carlson et al. 1999) best fit the Kenai River sockeye salmon spawner-return data based on R^2 and AIC values (Table 6). Edmundson et al. (2003) hypothesized that brood interactions probably result from food limitation and subsequent mortality of fry immediately following emergence and during the first winter. Large fry populations from the previous brood year cause reduced copepod (zooplankton) density the following spring, limiting food resources for subsequent fry. The effect that fry grazing on copepod biomass has the following spring is caused by the 2-year lifecycle of the dominant copepod species in this system.

A Markov yield analysis indicated highest (>3.7 million) mean yields occur within a range of 600,000–900,000 spawners (Table 8), and that escapements from 500,000 to 1,200,000 also produce high (>2,400,000) mean yields. Escapements below 400,000 salmon never produced yields exceeding 947,000. The highest yields (Figure 11) originated from escapements of 756,000, 793,000, and 2,012,000 sockeye salmon (brood years 1982, 1983, and 1987). When escapements exceeded 1,200,000, yields were highly variable, ranging from 520,000 to 8,345,000.

Incorporating recent production data (brood years 2008–2009) had little impact on estimates of escapements that produce maximum yields of Kenai River late-run sockeye salmon, so the committee recommended ***no change to the Kenai River late-run sockeye salmon SEG of 700,000–1,200,000 spawners.*** Maintaining this goal is supported by a plot of yield versus escapement, showing that escapements in this range generally produce the highest yields, and that escapements above this range can produce highly variable yields (Figure 11).

SUMMARY

The escapement goal committee reviewed the current UCI salmon escapement goals with recommendations to change the range of 7 goals and establish 2 new goals. The committee recommended that all other 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 escapement goals of UCI salmon stocks in 2001 (Bue and Hasbrouck), 2004 (Clark et al. 2007; Hasbrouck and Edmundson 2007), 2007 (Fair et al. 2007), 2010 (Fair et al. 2010), 2013 (Fair et al. 2013) and in this review.

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TABLES AND FIGURES

Table 1.–List of members on the Alaska Department of Fish and Game Upper Cook Inlet salmon escapement goal committee who assisted with the 2015/2016 escapement goal review.

Name	Position	Affiliation
Escapement Goal Committee		
Robert Begich	Area Management Biologist/Area Research Biologist	Div. of Sport Fish
Bob Clark	Chinook Salmon Advisor	Div. of Sport Fish
Nick Decovich	Area Research Biologist	Div. of Sport Fish
Jack Erickson	Regional Research Biologist	Div. of Commercial Fisheries
Steve Fleischman	Fisheries Scientist	Div. of Sport Fish
Jim Hasbrouck	Chief Fisheries Scientist	Div. of Sport Fish
Tim McKinley	Regional Research Biologist	Div. of Sport Fish
Andrew Munro	Fisheries Scientist	Div. of Commercial Fisheries
Adam Reimer	Biometrician/Area Research Biologist	Div. of Sport Fish
Bill Templin	Chief Fisheries Scientist	Div. of Commercial Fisheries
Eric Volk	Chief Fisheries Scientist	Div. of Commercial Fisheries
Mark Willette	Area Research Biologist	Div. of Commercial Fisheries
Rich Yanusz	Area Research Biologist	Div. of Sport Fish, now retired
Other Participants		
Tim Baker	Regional Management Biologist	Div. of Commercial Fisheries
Jay Baumer	Area Management Biologist	Div. of Sport Fish
Dan Bosch	Area Management Biologist/Regional Management Biologist	Div. of Sport Fish
Aaron Dupuis	Asst. Area Management Biologist	Div. of Commercial Fisheries
Sam Ivey	Area Management Biologist	Div. of Sport Fish
Tracy Lingnau	Regional Supervisor	Div. of Commercial Fisheries
Matt Miller	Regional Management Biologist	Div. of Sport Fish
Adam St. Saviour	Area Research Biologist	Div. of Sport Fish
Pat Shields	Area Management Biologist	Div. of Commercial Fisheries
Tom Vania	Regional Supervisor	Div. of Sport Fish
Xinxian Zhang	Regional Biometrician	Div. of Commercial Fisheries

Table 2.–Summary of current escapement goals and recommended escapement goals for salmon stocks in Upper Cook Inlet, 2016.

	Current Escapement Goal			Recommended Escapement Goal			
System	Goal	Type	Year Adopted	Range	Type	Data[a]	Action
Chinook Salmon							
Alexander Creek	2,100–6,000	SEG	2002			SAS	No Change
Campbell Creek	380	SEG	2011			SFS	No Change
Chuitna River	1,200–2,900	SEG	2002			SAS	No Change
Chulitna River	1,800–5,100	SEG	2002			SAS	No Change
Clear (Chunilna) Creek	950–3,400	SEG	2002			SAS	No Change
Crooked Creek	650–1,700	SEG	2002			Weir	No Change
Deshka River	13,000–28,000	SEG	2011			Weir	No Change
Goose Creek	250–650	SEG	2002			SAS	No Change
Kenai River - Early Run	3,800–8,500 (all sizes)	SEG	2013	2,800–5,600 (fish 75 cm METF or longer)	SEG	Sonar	Change in Range
Kenai River - Late Run	15,000–30,000(all sizes)	SEG	2013	13,500–27,000 (fish 75 cm METF or longer)	SEG	Sonar	Change in Range
Lake Creek	2,500–7,100	SEG	2002			SAS	No Change
Lewis River	250–800	SEG	2002			SAS	No Change
Little Susitna River [b]	900–1,800	SEG	2002			SAS	No Change
Little Susitna River [b]				2,100–4,300	SEG	Weir	New Goal
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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Table 2.–Page 2 of 2.

System	Current Escapement Goal: Goal	Type	Year Adopted	Recommended Escapement Goal: Range	Type	Data[a]	Action
Chum Salmon							
Clearwater Creek	3,800–8,400	SEG	2002	3,500–8,000	SEG	PAS	Change in Range
Coho Salmon							
Deshka River				10,200–24,100	SEG	Weir	New Goal
Fish Creek (Knik)	1,200–4,400	SEG	2011			Weir	No Change
Jim Creek	450–1,400	SEG	2014			SFS	No Change
Little Susitna River	10,100–17,700	SEG	2002			Weir	No Change
Pink Salmon							
No stocks with an escapement goal							
Sockeye Salmon							
Chelatna Lake	20,000–65,000	SEG	2009	20,000–45,000	SEG	Weir	Change in Range
Fish Creek (Knik)	20,000–70,000	SEG	2002	15,000–45,000	SEG	Weir	Change in Range
Judd Lake	25,000–55,000	SEG	2009	15,000–40,000	SEG	Weir	Change in Range
Kasilof River	160,000–340,000	BEG	2011			Sonar	No Change
Kenai River	700,000–1,200,000	SEG	2011			Sonar	No Change
Larson Lake	15,000–50,000	SEG	2009	15,000–35,000	SEG	Weir	Change in Range
Packers Creek	15,000–30,000	SEG	2008			Weir	No Change
Russian River - Early Run	22,000–42,000	BEG	2011			Weir	No Change
Russian River - Late Run	30,000–110,000	SEG	2005			Weir	No Change

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

[b] The Little Susitna Chinook stock has 2 escapement goals; the current aerial survey goal, and a recommended weir-based goal. The weir-based goal takes precedent unless water levels preclude a complete weir count, in which case the aerial survey goal would be used to assess whether escapements were sufficient.

Table 3.–Current escapement goals, and escapements observed from 2013 through 2015 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] 2013	2014	2015
Chinook Salmon						
Alexander Creek	SAS	SEG	2,100–6,000	588	911	1,117
Campbell Creek	SFS	SEG	380	NS	274	654
Chuitna River	SAS	SEG	1,200–2,900	1,690	1,398	1,965
Chulitna River	SAS	SEG	1,800–5,100	1,262	1,011	3,137
Clear (Chunilna) Creek	SAS	SEG	950–3,400	1,471	1,390	1,205
Crooked Creek	Weir	SEG	650–1,700	1,102	1,411	1,456
Deshka River	Weir	SEG	13,000–28,000	18,378	16,099	24,627
Goose Creek	SAS	SEG	250–650	62	232	NS
Kenai River - Early Run (fish of all sizes)	Sonar	SEG	3,800–8,500	4,525	5,776	6,190
Kenai River - Late Run (fish of all sizes)	Sonar	SEG	15,000–30,000	19,342	17,451	22,6420
Lake Creek	SAS	SEG	2,500–7,100	3,655	3,506	4,686
Lewis River	SAS	SEG	250–800	61	61	5
Little Susitna River	SAS	SEG	900–1,800	1,651	1,759	1,507
Little Willow Creek	SAS	SEG	450–1,800	858	684	788
Montana Creek	SAS	SEG	1,100–3,100	1,304	953	1,416
Peters Creek	SAS	SEG	1,000–2,600	1,643	1,443	1,514
Prairie Creek	SAS	SEG	3,100–9,200	3,304	2,812	3,290
Sheep Creek	SAS	SEG	600–1,200	NS	262	NS
Talachulitna River	SAS	SEG	2,200–5,000	2,285	2,256	2,582
Theodore River	SAS	SEG	500–1,700	476	312	426
Willow Creek	SAS	SEG	1,600–2,800	1,752	1,335	2,046
Chum Salmon						
Clearwater Creek	PAS	SEG	3,800–8,400	9,010	3,500	10,790
Coho Salmon						
Fish Creek	Weir	SEG	1,200–4,400	7,593 [c]	10,283	7,912
Jim Creek [d]	SFS	SEG	450–1,400	631	122	571
Little Susitna River	Weir	SEG	10,100–17,700	13,583 [e]	24,211	12,756 [e]
Pink Salmon						
No stocks with an escapement goal						

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Table 3.–Page 2 of 2.

System	Escapement Data [a]	Current Escapement Goal Type (BEG, SEG)	Range	Escapements [b] 2013	2014	2015
Sockeye Salmon						
Chelatna Lake	Weir	SEG	20,000–65,000	70,555	26,374	69,897
Fish Creek (Knik)	Weir	SEG	20,000–70,000	18,912	43,915	102,309
Judd Lake	Weir	SEG	25,000–55,000	14,088	22,229	47,934
Kasilof River	Sonar	BEG	160,000–340,000	489,654	440,192	470,677
Kenai River[f]	Sonar	SEG	700,000–1,200,000	980,208	1,218,342	1,325,673
Larson Lake	Weir	SEG	15,000–50,000	21,821	12,430	23,185
Packers Creek	Weir	SEG	15,000–30,000	NS	19,242	28,072
Russian River - Early Run	Weir	BEG	22,000–42,000	35,776	44,920	50,226
Russian River - Late Run	Weir	SEG	30,000–110,000	31,573	52,777	46,233

Note: BEG = biological escapement goal, SEG = sustainable escapement goal. NS = No Survey.

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

[b] Fish required to meet broodstock needs, in addition to meeting escapement goal, include 250 Chinook salmon at Crooked Creek and 10,000 sockeye salmon at the Kasilof River.

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

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

[e] Incomplete count because of flooding.

[f] Hidden Lake enhancement passing the weir were subtracted from the escapement.

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 1969–2009.

			Parameters				Negative	Likelihood		MSY Escapement		
Model	Structure	n	σ	lnα'	β	φ	log-likelihood	Ratio	P-value	Estimate	Lower	Upper
Classic Ricker	$\ln R_t/S_t = \alpha - \beta S_t$	41	0.386	1.888	-0.00230	NA	18.104			300,000	190,000	430,000
Autoregressive Ricker	$\ln R_t/S_t = \alpha - \beta S_t + \varphi \varepsilon_{t-1}$	41	0.321	1.987	-0.00299	0.629	11.791	12.627	<0.005	240,000	150,000	340,000

Note: NA = not applicable.

Table 5.–Markov yield table for Kasilof River sockeye salmon, brood years 1969–2009.

Escapement Interval	Number of years	Mean Spawners	Mean Returns	Return per Spawner	Yield Mean	Yield Range
0-50	4	43	236	5.5	193	64–301
50-150	7	116	489	4.2	373	203–583
100-200	13	156	698	4.5	542	257–1,115
150-250	15	197	847	4.3	650	342–1,115
200-300	12	238	981	4.1	742	404–1,601
250-350	10	289	1,161	4.1	873	404–1,601
300-400	8	340	1,046	3.2	707	119–1,319
>350	5	428	794	1.9	366	(-)131– (+)967

Note: Numbers in thousands of fish.

Table 6.–Summary of adult stock-recruitment models evaluated for Kenai River late-run sockeye salmon from brood years 1969–2009.

Model	Parameter	Estimate	*P*-value	R^2	AICc	Residual White noise test
General Ricker model			<0.001	0.556	61.08	0.510
	σ	0.49				
	$\ln\alpha$	1.73	0.194			
	β	4.74E-04	0.184			
	γ	1.01	0.980			
Classic Ricker model			0.004	0.556	58.75	0.505
	σ	0.48				
	$\ln\alpha$	1.75	<0.001			
	β	4.66E-04	0.004			
Autoregressive Ricker model			<0.001	0.556	58.77	0.622
	σ	0.48				
	$\ln\alpha$	1.65	<0.001			
	β	3.38E-04	0.062			
	φ	0.26	0.114			
Cushing model			<0.001	0.535	60.67	0.173
	σ	0.49				
	$\ln\alpha$	3.21	<0.001			
	γ	0.72	<0.001			
Beverton-Holt model			0.002	0.557	60.65	0.578
	σ	0.48				
	α	5.76	<0.001			
	β	7.98E-04	0.002			
Hockey Stick model			0.005	0.574	65.90	0.241
	σ	0.48				
	α	5.45	0.001			
	β	0.91	0.510			

Table 6.–Page 2 of 2.

Model	Parameter	Estimate	*P*-value	R^2	AICc	White noise test
Classic Ricker model			0.009	0.571	59.76	0.389
with brood interaction	σ	0.48				
	$\ln\alpha$	1.82	<0.001			
	β_1	3.41E-04	0.080			
	β_2	2.06E-04	0.271			
General Ricker model			<0.001	0.586	58.25	0.338
with brood interaction	σ	0.47				
	$\ln\alpha$	1.89	0.044			
	β_3	2.91E-07	0.037			
	γ	0.96	0.777			
Simple brood			0.001	0.586	56.00	0.335
interaction model	σ	0.47				
	$\ln\alpha$	1.63	<0.001			
	β_3	3.19E-07	0.001			

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

Table 7.–Simulation results from a brood-interaction model for Kenai River late-run sockeye salmon.

	Brood Years 1969–2009			
Number Spawners	Mean Run	Mean Yield	Yield CV	*P* < 1000
100	606	506	0.65	0.953
150	896	746	0.56	0.820
200	1,182	982	0.53	0.596
250	1,463	1,213	0.52	0.431
300	1,736	1,436	0.51	0.304
350	2,002	1,652	0.51	0.219
400	2,258	1,858	0.51	0.157
450	2,504	2,054	0.51	0.121
500	2,739	2,239	0.51	0.086
550	2,961	2,411	0.51	0.070
600	3,171	2,571	0.52	0.065
650	**3,366**	**2,716**	**0.52**	**0.057**
700	**3,547**	**2,847**	**0.52**	**0.052**
750	**3,712**	**2,962**	**0.52**	**0.051**
800	**3,862**	**3,062**	**0.53**	**0.048**
850	**3,996**	**3,146**	**0.53**	**0.046**
900	**4,114**	**3,214**	**0.54**	**0.043**
950	**4,216**	**3,266**	**0.54**	**0.044**
1,000	**4,302**	**3,302**	**0.55**	**0.047**
1,050	**4,371**	**3,321**	**0.55**	**0.050**
1,100	**4,425**	**3,325**	**0.56**	**0.052**
1,150	**4,463**	**3,313**	**0.56**	**0.052**
1,200	**4,485**	**3,285**	**0.57**	**0.057**
1,250	4,493	3,243	0.58	0.062
1,300	4,487	3,187	0.59	0.067
1,350	4,467	3,118	0.60	0.071
1,400	4,434	3,035	0.61	0.081
1,450	4,390	2,941	0.62	0.099
1,500	4,334	2,836	0.64	0.118

Note: Numbers are in thousands of fish. Model parameters were obtained from regression analyses conducted using brood year 1969–2009. Ranges corresponding to the original criteria (<6% risk of a yield <1 million salmon; Carlson et al. 1999) used to establish the sustainable escapement goal range are indicated in bold. Ranges corresponding to escapement needed to produce 90–100% of maximum yield (assuming a constant escapement goal policy) are shaded.

Table 8.–Markov yield table for Kenai River late-run sockeye salmon constructed using data from brood years 1969–2009.

Escapement Interval	Number of Years	Mean Spawners	Mean Returns	Return per Spawner	Yield Mean	Yield Range
0–200	4	119	749	6.3	631	358–871
100–300	4	153	839	5.8	686	449–871
200–400	2	292	1,055	4.4	763	578–947
300–500	4	414	2,179	5.1	1,764	580–3,413
400–600	9	497	2,448	4.9	1,950	580–3,413
500–700	8	563	3,046	5.3	2,483	999–6,361
600–800	9	734	4,636	6.3	3,902	713–8,694
700–900	8	768	4,497	5.9	3,729	713–8,694
800–1000	7	943	3,664	3.9	2,720	692–4,806
900–1,100	6	959	3,610	3.8	2,651	692–4,806
1,000–1,200	1	1,127	3,631	3.2	2,504	2,504–2,504
1,100–1,300	3	1,182	3,483	3.0	2,301	1,334–3,064
1,200–1,400	4	1,274	3,374	2.7	2,100	1,334–3,064
>1,300	8	1,669	4,558	2.6	2,889	520–8,345

Note: Numbers in thousands of fish.

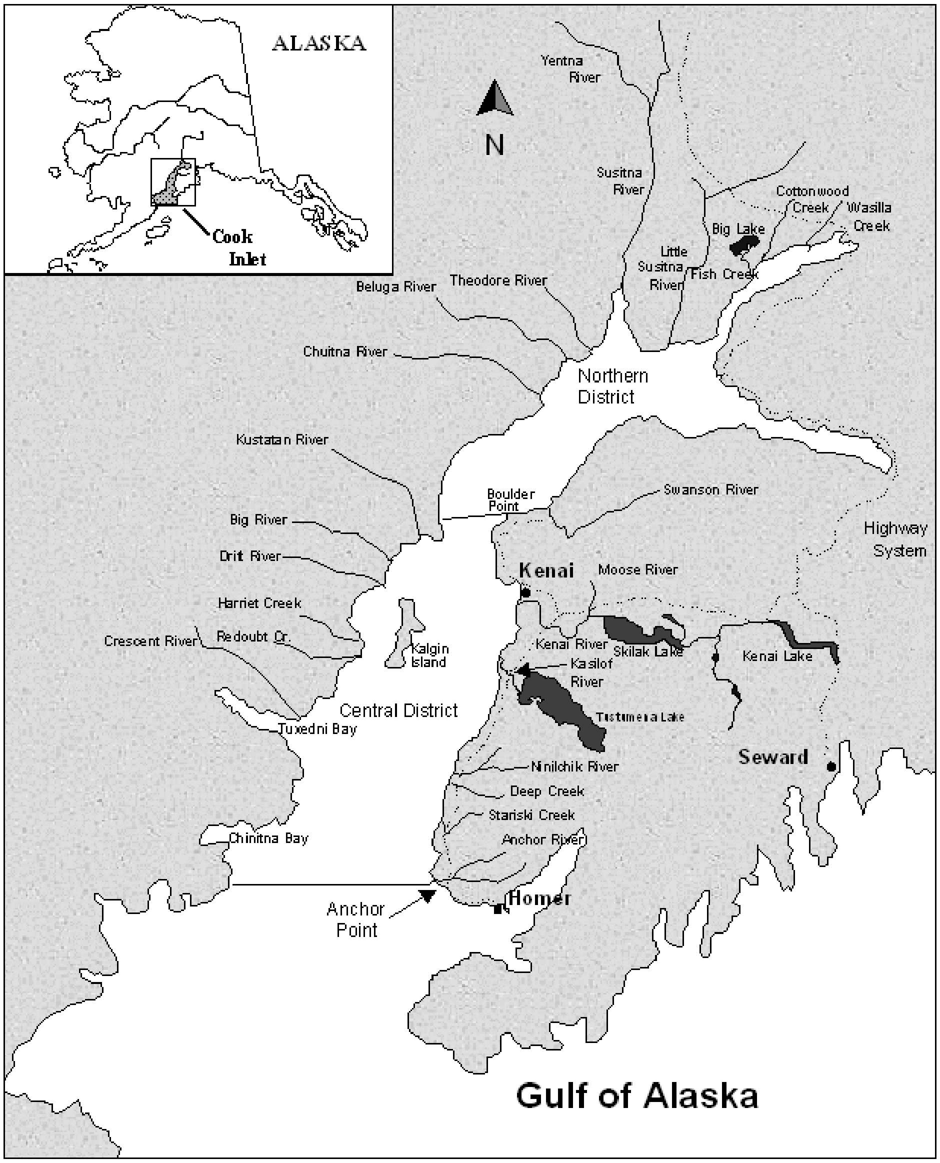


Figure 1.–Map of Upper Cook Inlet showing locations of the Northern and Central districts and the primary salmon spawning drainages.

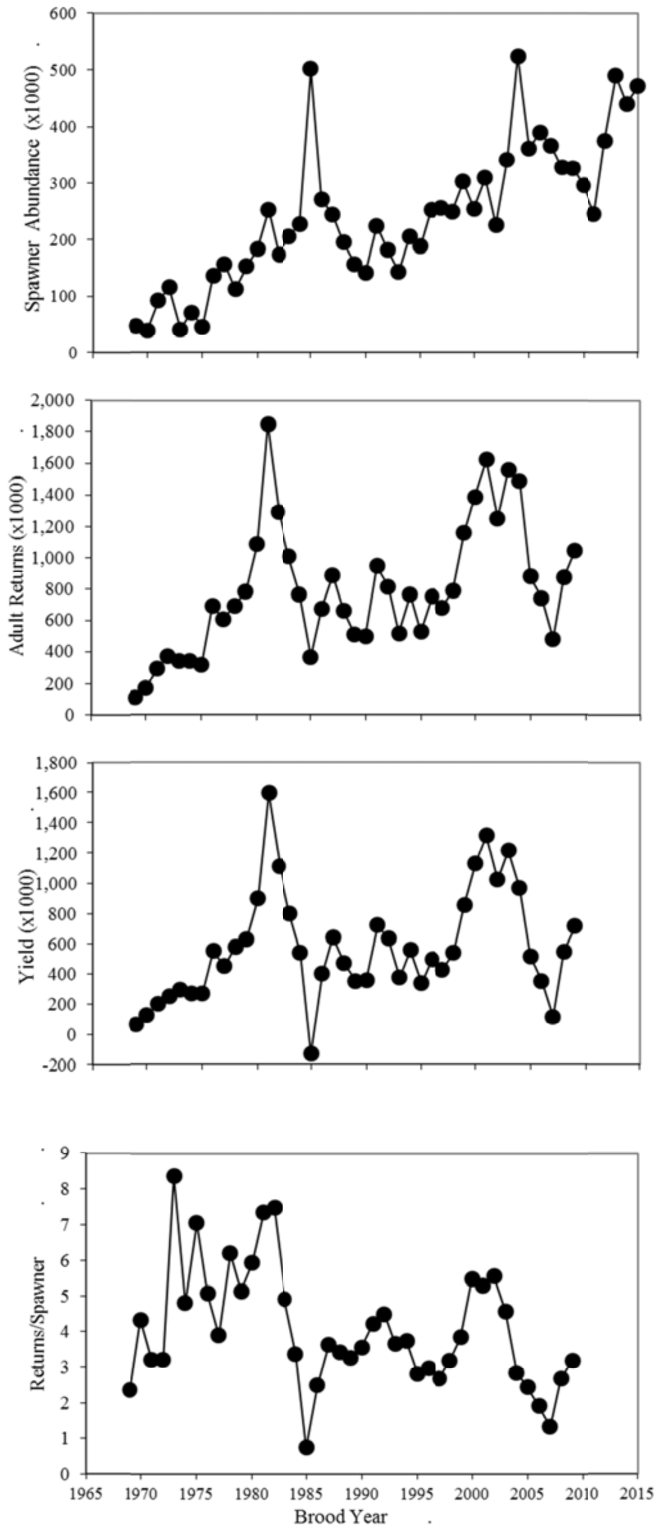


Figure 2.–Time series of spawner abundance (escapement), adult returns, yields, and returns-per-spawner for Kasilof River sockeye salmon, 1969–2009.

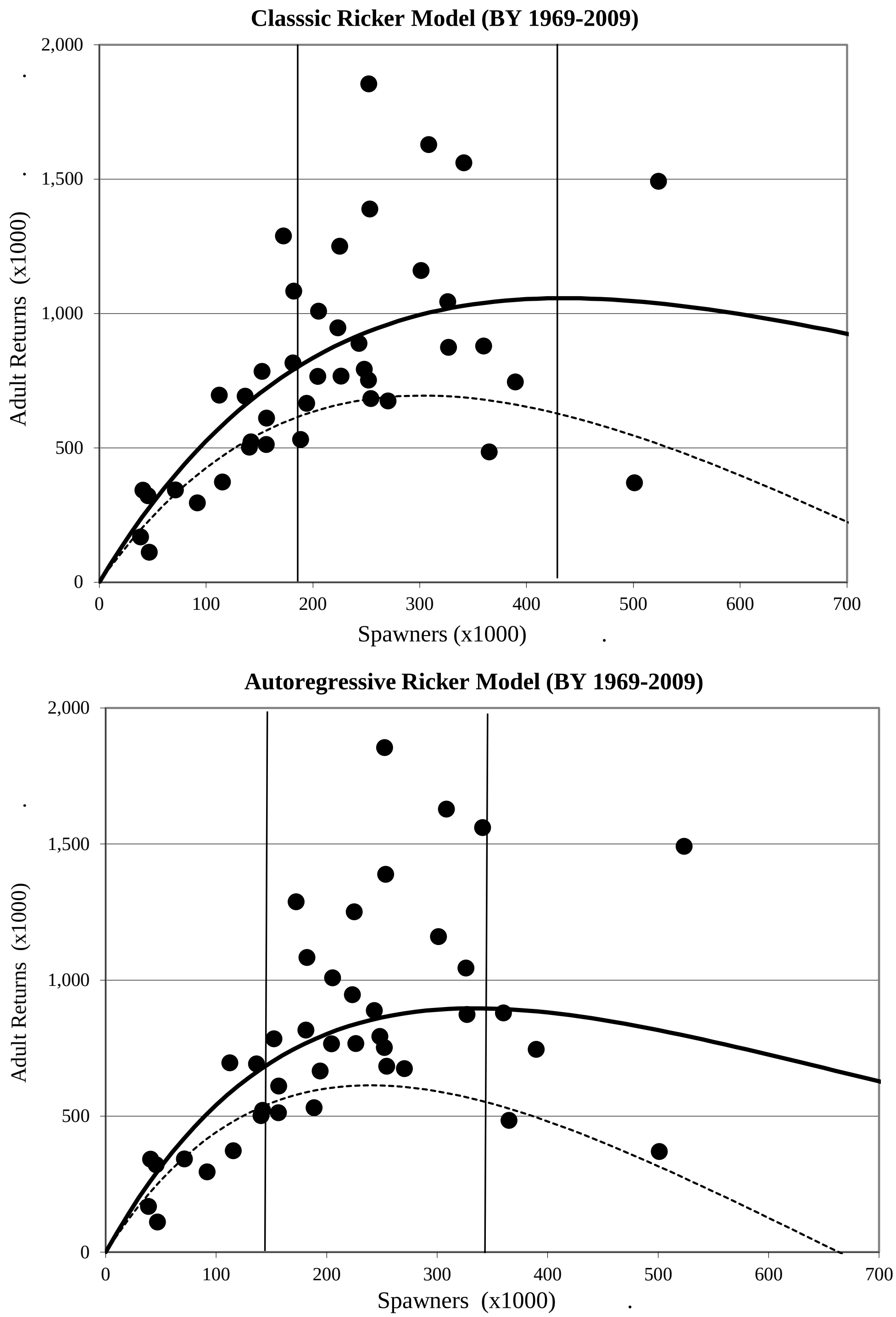


Figure 3.–Classic Ricker model and autoregressive Ricker model fits to Kasilof River sockeye salmon return per spawner data, brood years 1969–2009.

Note: The solid line indicates model predicted adult returns and the dashed line indicates predicted yields. Vertical line lines indicate the BEG range predicted by each model using a 90–100% MSY criterion.

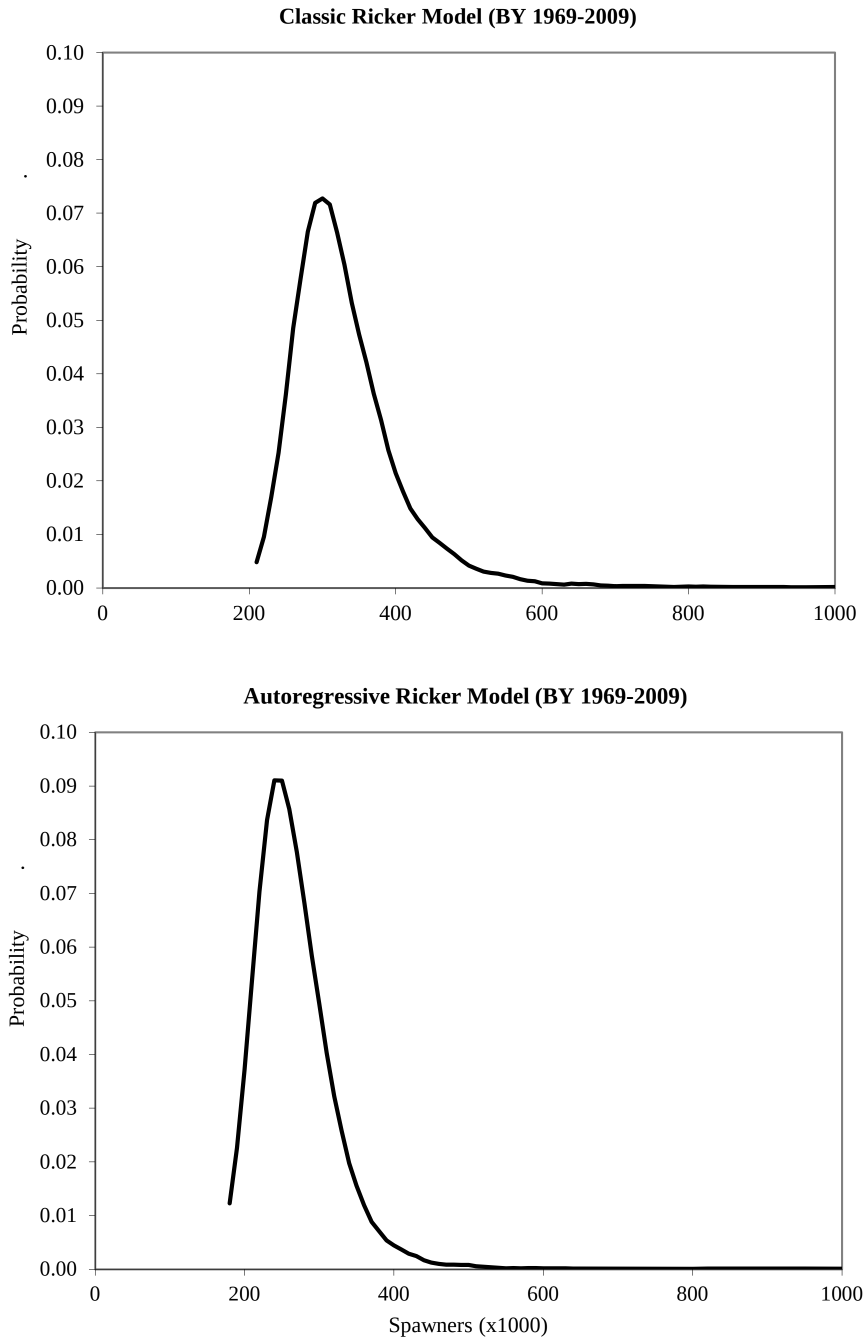


Figure 4.–Likelihood profiles for Kasilof River sockeye salmon spawner abundances that produced MSY estimated by the classic Ricker and autoregressive Ricker models fit to data from brood years 1969-2009.

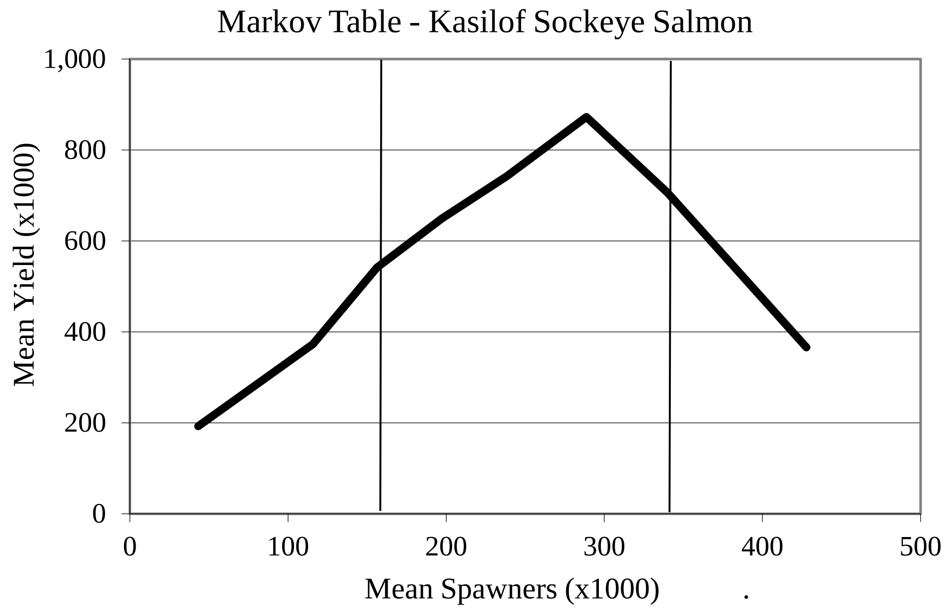


Figure 5.–Plot of Markov yield results for Kasilof River sockeye salmon, brood years 1969–2009.

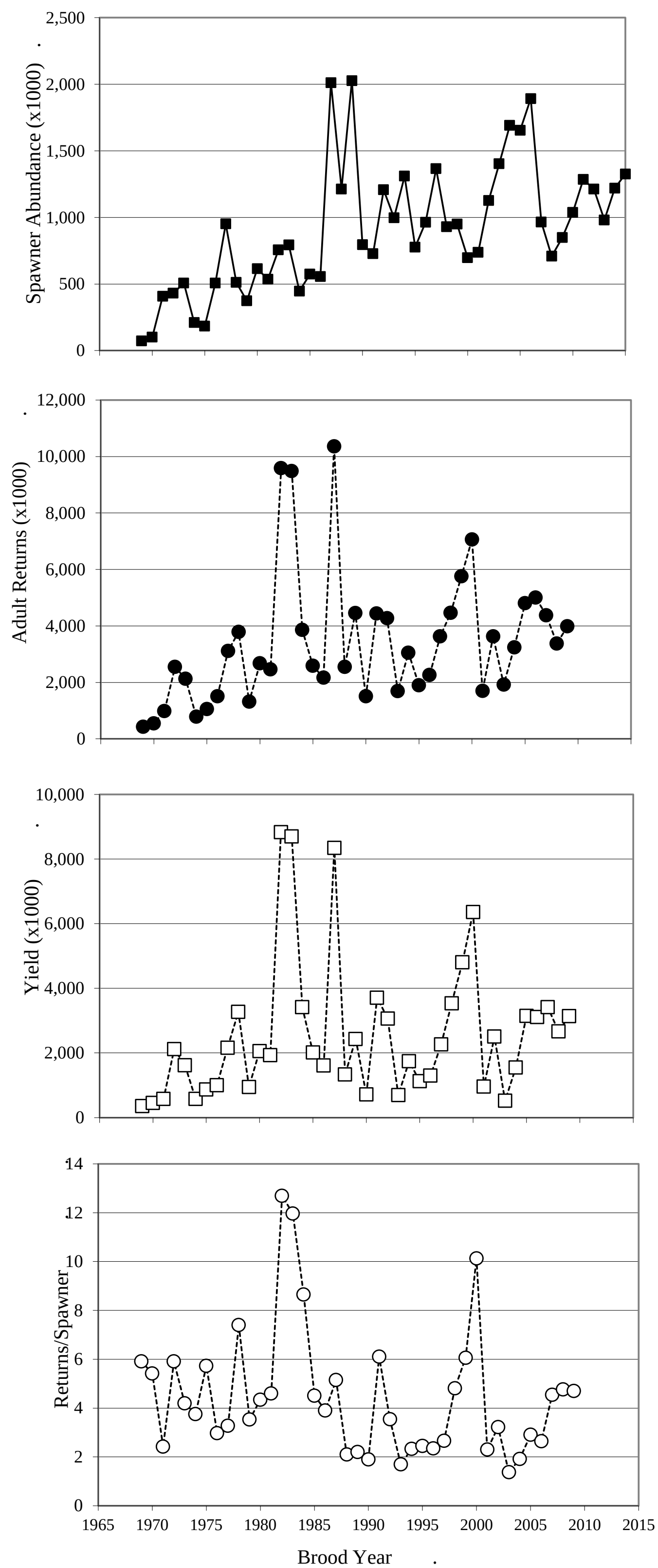


Figure 6.–Time series of spawner abundance (escapement), adult returns, yields, and returns-per-spawner for Kenai River late-run sockeye salmon, 1969–2009.

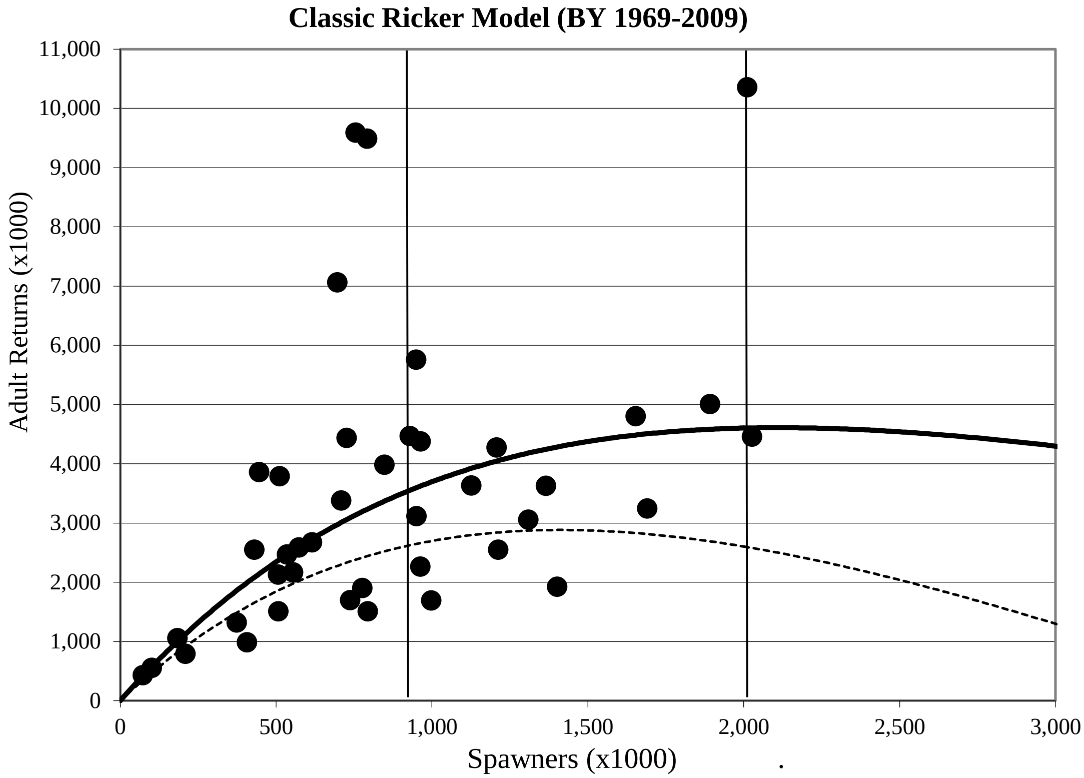


Figure 7.–Scatter plot of Kenai River late-run sockeye spawner-return data (in thousands of fish), including adult returns (solid line) and yields (dashed line) predicted by the classic Ricker model fit to data from brood years 1969–2009.

Note: Vertical lines indicate the SEG range predicted by the model using a 90–100% MSY criterion.

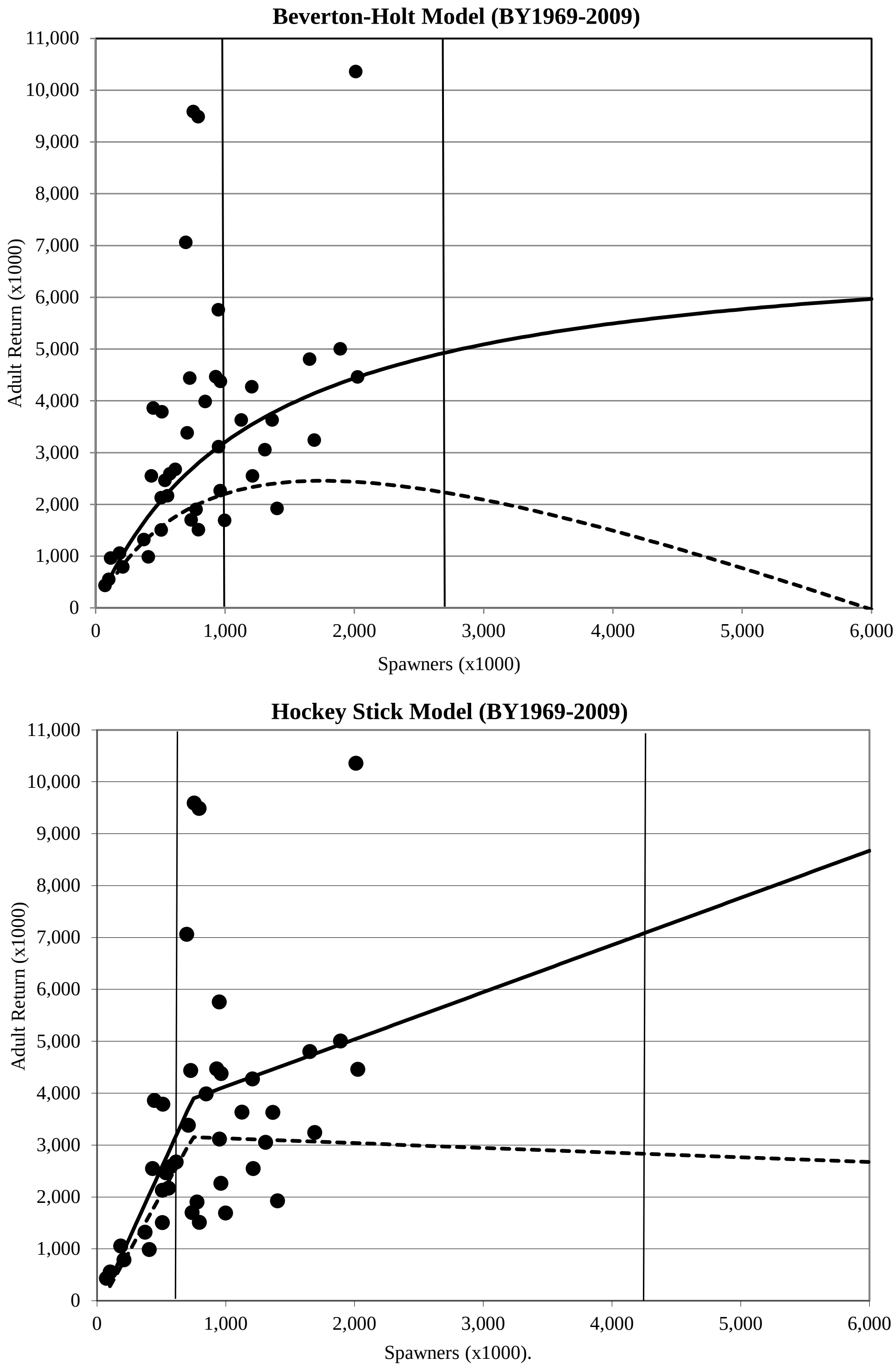


Figure 8.–Scatter plot of Kenai River late-run sockeye spawner-return data (in thousands of fish), including adult returns (solid line) and yields (dashed line) predicted by the Beverton-Holt and Hockey Stick models fit to data from brood years 1969–2009.

Note: Vertical lines indicate the SEG range predicted by the models using a 90–100% MSY criterion.

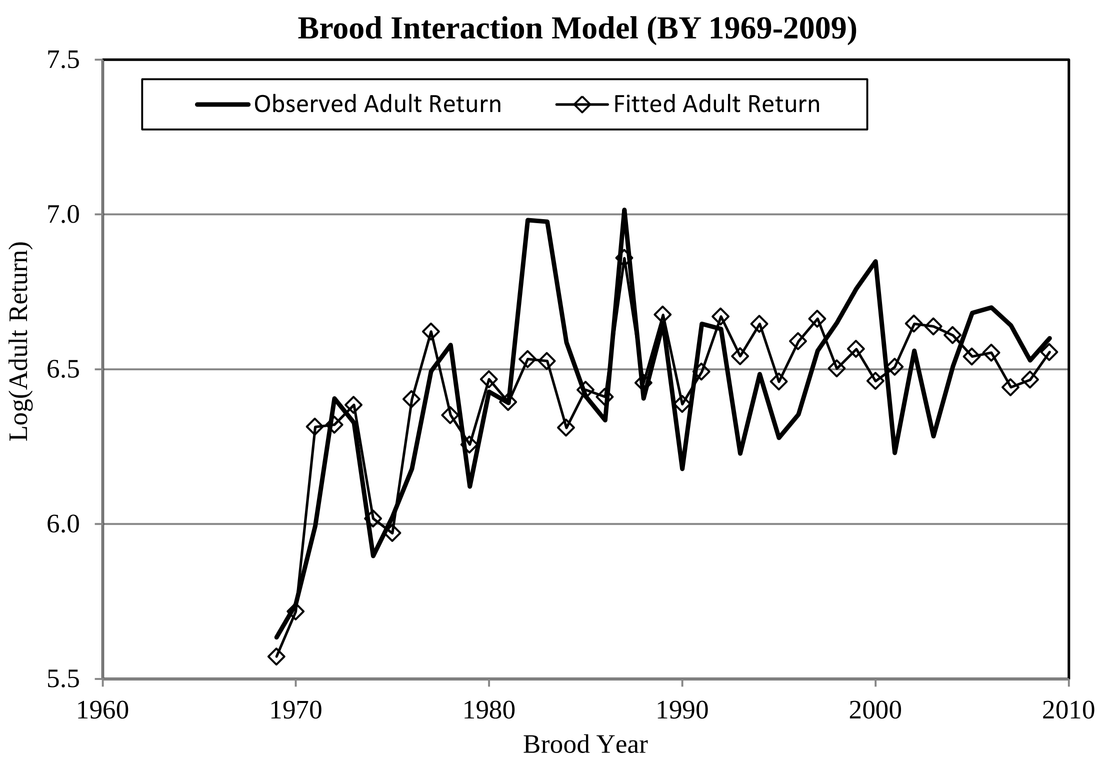


Figure 9.–Time series of actual Kenai River late-run sockeye salmon returns and returns predicted by the classic Ricker and brood-interaction models, brood years 1969–2009.

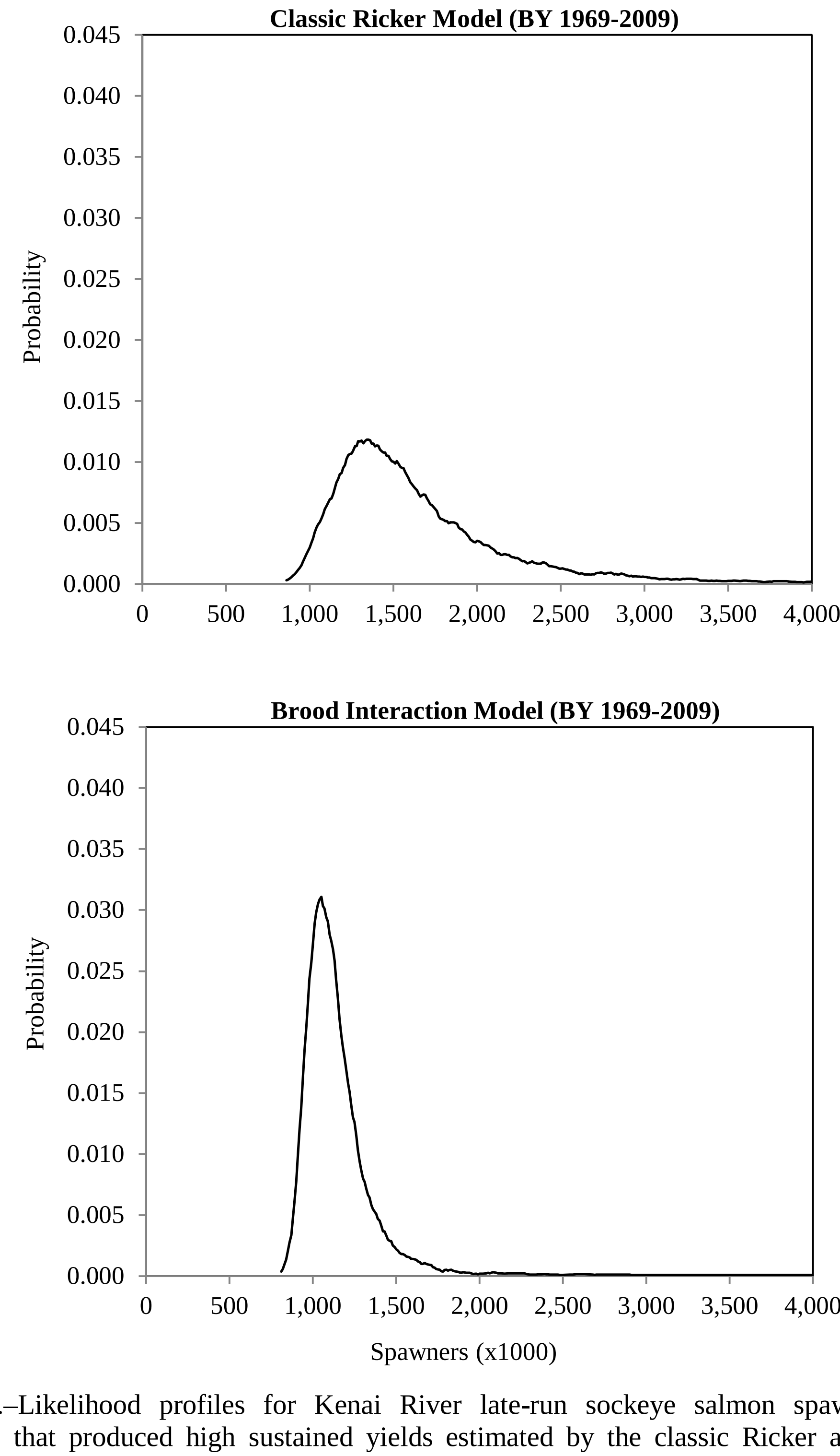
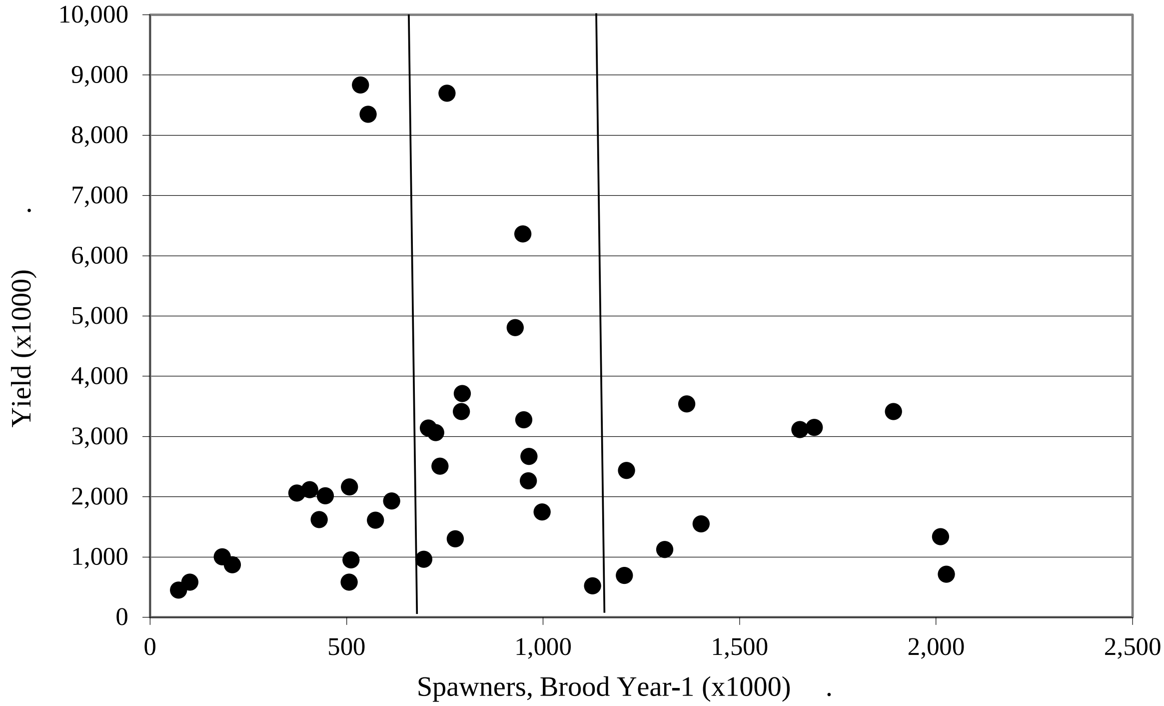


Figure 10.–Likelihood profiles for Kenai River late-run sockeye salmon spawner abundances (escapements) that produced high sustained yields estimated by the classic Ricker and simple brood interaction models (assuming a constant escapement goal policy) fit to data from brood years 1969–2009.



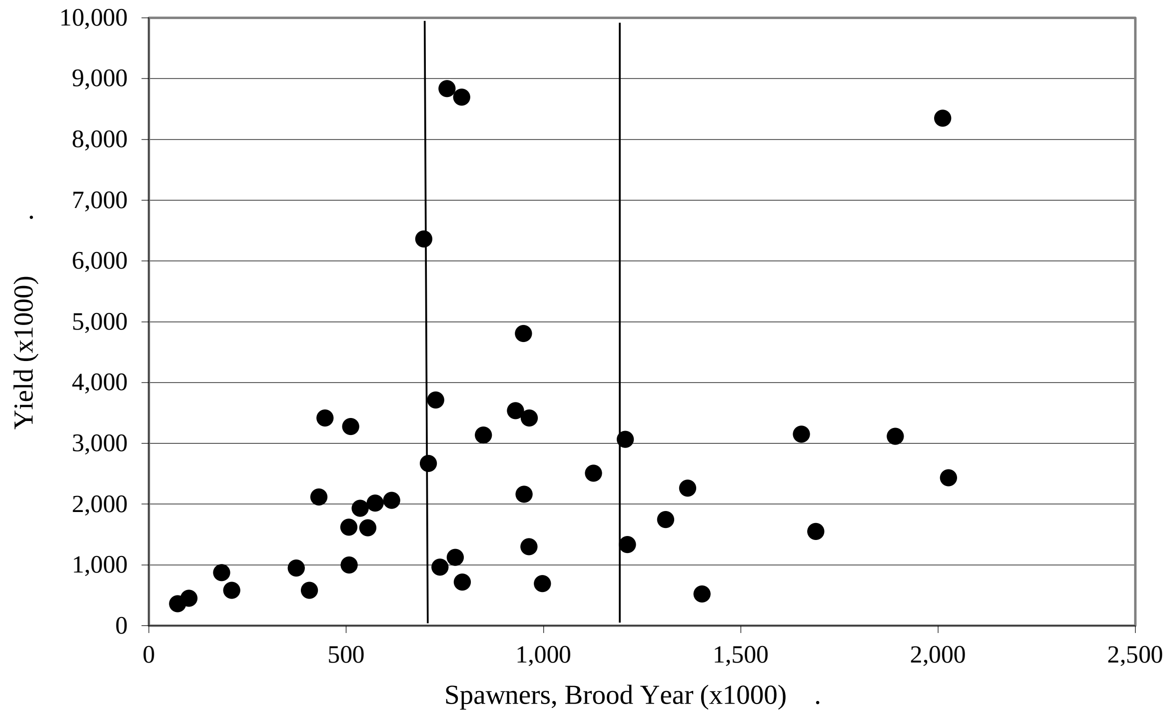


Figure 11.–Kenai River late-run sockeye salmon yields related to spawner abundances in brood years 1969–2009 and the previous year (Brood Year -1).

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

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
1974	2,193
1975	1,878
1976	5,412
1977	9,246
1978	5,854
1979	6,215
1980	NS
1981	NS
1982	2,546
1983	3,755
1984	4,620
1985	6,241
1986	5,225
1987	2,152
1988	6,273
1989	3,497
1990	2,596
1991	2,727
1992	3,710
1993	2,763
1994	1,514
1995	2,090
1996	2,319
1997	5,598
1998	2,807
1999	3,974
2000	2,331
2001	2,282
2002	1,936
2003	2,012
2004	2,215
2005	2,140
2006	885
2007	480
2008	150
2009	275
2010	177
2011	343
2012	181
2013	588
2014	911
2015	1,117

Note: NS = No survey.

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

Year	Escapement
1982	68
1983	NS
1984	423
1985	NS
1986	733
1987	571
1988	NS
1989	218
1990	458
1991	590
1992	931
1993	937
1994	1,076
1995	734
1996	369
1997	1,119
1998	761
1999	1,035
2000	591
2001	717
2002	744
2003	745
2004	964
2005	1,097
2006	1,052
2007	588
2008	439
2009	554
2010	290
2011	260
2012	NS
2013	NS
2014	274
2015	654

Note: NS = No survey.

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

Year	Escapement
1979	1,246
1980	NS
1981	1,362
1982	3,438
1983	4,043
1984	2,845
1985	1,600
1986	3,946
1987	NS
1988	3,024
1989	990
1990	480
1991	537
1992	1,337
1993	2,085
1994	1,012
1995	1,162
1996	1,343
1997	2,232
1998	1,869
1999	3,721
2000	1,456
2001	1,501
2002	1,394
2003	2,339
2004	2,938
2005	1,307
2006	1,911
2007	1,180
2008	586
2009	1,040
2010	735
2011	719
2012	502
2013	1,690
2014	1,398
2015	1,965

Note: NS = No survey.

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

Year	Escapement
1982	863
1983	4,058
1984	4,191
1985	783
1986	NS
1987	5,252
1988	NS
1989	NS
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	NS
2004	2,162
2005	2,838
2006	2,862
2007	5,166
2008	2,514
2009	2,093
2010	1,052
2011	1,875
2012	667
2013	1,262
2014	1,011
2015	3,137

Note: NS = No survey.

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

Year	Escapement
1979	864
1980	NS
1981	NS
1982	982
1983	938
1984	1,520
1985	2,430
1986	NS
1987	NS
1988	4,850
1989	NS
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	NS
2004	3,417
2005	1,924
2006	1,520
2007	3,310
2008	1,795
2009	1,205
2010	903
2011	512
2012	1,177
2013	1,471
2014	1,390
2015	1,205

Note: NS = No survey.

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

Return	Count at the Weir [a]			Actual Escapement [b]		Return	Sport Harvest		
							Early Run[c]	Creel Survey[d]	
Year	Non-AFC	AFC	Total	Total	Wild	Year	(through 6/30)	(through 6/30)	Total
1976	1,682 [e]		1,682	1,537	1,537				
1977	3,069 [e]		3,069	2,390	2,390				
1978	4,535	180	4,715	4,388	4,220	1978			251
1979	2,774	770	3,544	3,177	2,487	1979			283
1980	1,764	518	2,282	2,115	1,635	1980			310
1981	1,871	1,033	2,904	2,919	1,881	1981			1,242
1982	1,449	2,054	3,503	4,107	1,699	1982			2,316
1983	1,543	2,762	4,305	3,842	1,377	1983			2,853
1984	1,372	2,278	3,650	3,409	1,281	1984			3,964
1985	1,175	1,637	2,812	2,491	1,041	1985			2,986
1986	1,539	2,335	3,874	4,055	1,611	1986			7,071
1987	1,444	2,280	3,724	3,344	1,297	1987			4,461
1988	1,174	2,622	3,796	700	216	1988			4,953
1989	1,081	1,930	3,011	750	269	1989			3,767
1990	1,066	1,581	2,647	1,663	670	1990			2,852
1991			2,281	893		1991			5,055
1992			3,533	843		1992			6,049
1993			2,291	657		1993			8,695
1994			1,790	640		1994			7,217
1995			2,206	750		1995			6,681
1996			2,224	764		1996	5,295		6,128
1997						1997	5,627		6,728
1998						1998	4,202		4,839
1999	1,559	232	1,791	1,397	1,206	1999	7,597		8,255
2000	1,224	192	1,416	1,077	940	2000	8,815		9,901
2001	2,122	464	2,586	2,315	1,897	2001	7,488		8,866
2002	2,526	800	3,326	2,708	1,933	2002	4,791		5,242
2003	2,923	1,204	4,127	3,597	2,500	2003	3,090		4,234
2004	2,641	2,232	4,873	4,356	2,196	2004	3,295	2,407	4,333
2005	2,018	1,060	3,168	2,936	1,909	2005	3,468	2,665	4,520
2006	1,589	1,057	2,646	2,569	1,516	2006	2,421	2,489	3,304
2007	1,038	489	1,527	1,452	965	2007	2,601	2,654	3,663
2008	1,018	396	1,414	1,181	879	2008	2,996	1,984	3,789
2009	674	255	929	734	617	2009	1,637	1,532	3,801
2010	1,090	262	1,352	1,348	1,088	2010	2,239	1,333	3,907
2011	677	256	933	782	654	2011	2,054		3,680
2012	633	163	796	731	631	2012	872		927
2013	1,211	198	1,409	1,213	1,102	2013	1,073		1,073
2014	1,522	911	2,433	2,148	1,411	2014	323		323
2015	1,639	601	2,240	1,903	1,456	2015	589		589

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

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

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

[c] From Statewide Harvest Survey (Jennings et al. 2015) for the Kasilof River sport fishery (large fish >20″ only). Includes both wild and hatchery fish and an unknown number of late-run fish prior to 1996.

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

[e] Assumed wild.

Appendix A7.–Data available for analysis of Deshka River Chinook salmon escapement goal.

Brood Year	Aerial Survey[a]	Escapement[b]	Weir Escapement[c]	Total Return[a]	Yield	Return per Spawner	Year	Sport Harvest[d]
1974	5,279	15,201		61,394	46,194	4.04	1974	
1975	4,737	14,088		33,533	19,446	2.38	1975	
1976	21,693	48,916		37,763	-11,153	0.77	1976	
1977	39,642	85,784		38,535	-47,249	0.45	1977	
1978	24,639	54,967		44,888	-10,079	0.82	1978	
1979	27,385	60,607		52,489	-8,119	0.87	1979	2,811
1980		35,096 [e]		45,021	9,924	1.28	1980	3,685
1981		23,162 [e]		44,951	21,789	1.94	1981	2,769
1982	16,000	37,222		75,430	38,208	2.03	1982	4,307
1983	19,237	43,871		36,337	-7,534	0.83	1983	4,889
1984	16,892	39,054		35,464	-3,590	0.91	1984	5,699
1985	18,151	41,640		47,082	5,441	1.13	1985	6,407
1986	21,080	47,657		30,712	-16,945	0.64	1986	6,490
1987	15,028	35,226		21,774	-13,451	0.62	1987	5,632
1988	19,200	43,795		20,691	-23,104	0.47	1988	5,474
1989		23,246 [e]		15,623	-7,624	0.67	1989	8,062
1990	18,166	41,671		6,846	-34,825	0.16	1990	6,464
1991	8,112	21,020		15,918	-5,102	0.76	1991	9,306
1992	7,736	20,248		43,080	22,832	2.13	1992	7,256
1993	5,769	16,207		31,748	15,541	1.96	1993	5,682
1994	2,665	9,832		30,307	20,475	3.08	1994	624
1995	5,150		10,048	52,976	42,928	5.27	1995	0
1996	6,343		14,349	25,498	11,149	1.78	1996	11
1997	19,047		35,587	33,619	-1,968	0.94	1997	42
1998	15,556	36,310		42,143	5,832	1.16	1998	3,384
1999	12,904		29,088	66,911	37,823	2.30	1999	3,496
2000			33,965	46,864	12,899	1.38	2000	7,076
2001			27,966	39,668	11,702	1.42	2001	5,007
2002	8,749		28,535	30,860	2,325	1.08	2002	4,508
2003			39,257	6,995	-32,262	0.18	2003	6,605
2004	28,778		56,659	6,511	-50,148	0.11	2004	9,050
2005	11,495		36,433	25,664	-10,769	0.70	2005	7,332
2006	6,499		29,922	21,583	-8,339	0.72	2006	7,753
2007	6,712		17,594	13,694	-3,900	0.78	2007	5,696
2008			7,284	23,155	15,871	3.18	2008	2,036
2009	3,954		11,641	15,382	3,741	1.32	2009	723
2010 [f]			18,223				2010	3,381
2011 [f]	7,522		18,553				2011	3,139
2012 [f]			13,952				2012	1,650
2013 [f]			18,378				2013	1,087
2014 [f]			16,099				2014	1,329
2015 [f]			23,627				2015	1,835

Note: Blank cells indicate no available data.

[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 (Rich Yanusz, Sport Fish Research Biologist, ADF&G, Palmer; personal communication).

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

[d] From Statewide Harvest Survey (Jennings et al. 2015). Years with no harvest estimate occur because the escapement time series precedes the survey (begun in 1977) or harvest could not be estimated from survey data.

[e] Based on average survey indices from nearby years for 1980 and an expectation-maximization (E-M) algorithm for 1981 and 1989 (Rich Yanusz, Sport Fish Research Biologist, ADF&G, Palmer; personal communication), and regression expansion.

[f] Complete return data not yet available.

Appendix A8.–Data available for analysis of Goose Creek Chinook salmon escapement goal.

Year	Escapement
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	NS
2002	565
2003	175
2004	417
2005	468
2006	306
2007	105
2008	117
2009	65
2010	76
2011	80
2012	57
2013	62
2014	232
2015	NS

Note: NS = No survey.

Appendix A9.–Estimates of escapement and total return of Kenai River early-run Chinook salmon 75 cm METF and longer.

Brood Year	Escapement	Total Return
1986	6,562	9,853
1987	4,660	12,076
1988	2,668	13,297
1989	2,663	11,700
1990	5,523	8,607
1991	6,830	8,933
1992	7,902	7,439
1993	3,108	7,889
1994	3,448	11,105
1995	1,962	10,206
1996	1,940	7,933
1997	2,898	15,639
1998	5,918	15,516
1999	2,808	17,518
2000	6,580	11,673
2001	6,455	7,286
2002	8,489	8,103
2003	11,735	7,390
2004	15,319	3,262
2005	11,529	6,444
2006	6,072	4,875
2007	5,151	2,279
2008	4,138	1,406
2009	4,034	3,955
2010	3,012	6,100
2011	5,196	
2012	2,977	
2013	1,601	
2014	2,621	
2015	4,198	

Source: Fleischman and Reimer 2017.

Note: Blank cells indicate no available data.

Appendix A10.–Estimates of escapement and total return of Kenai River late-run Chinook salmon 75 cm METF and longer.

Brood Year	Escapement	Total Return
1986	40,972	52,117
1987	47,070	59,676
1988	41,572	55,907
1989	25,336	38,640
1990	24,478	40,111
1991	26,303	50,992
1992	36,583	45,463
1993	32,448	43,137
1994	25,033	40,287
1995	24,016	48,753
1996	28,806	52,404
1997	24,822	65,395
1998	32,560	85,907
1999	28,520	97,451
2000	24,923	60,123
2001	28,442	41,366
2002	40,381	45,349
2003	48,278	32,442
2004	65,084	17,445
2005	54,669	28,511
2006	38,619	21,369
2007	29,461	18,982
2008	27,545	13,110
2009	17,992	21,093
2010	13,035	23,513
2011	15,742	
2012	22,455	
2013	12,308	
2014	11,972	
2015	16,830	

Source: Fleischman and Reimer 2017.

Note: Blank cells indicate no available data.

Appendix A11.–Data available for analysis of Lake Creek Chinook salmon escapement goal.

Year	Escapement
1979	4,196
1980	NS
1981	NS
1982	3,577
1983	7,075
1984	NS
1985	5,803
1986	NS
1987	4,898
1988	6,633
1989	NS
1990	2,075
1991	3,011
1992	2,322
1993	2,869
1994	1,898
1995	3,017
1996	3,514
1997	3,841
1998	5,056
1999	2,877
2000	4,035
2001	4,661
2002	4,852
2003	8,153
2004	7,598
2005	6,345
2006	5,300
2007	4,081
2008	2,004
2009	1,394
2010	1,617
2011	2,563
2012	2,366
2013	3,655
2014	3,506
2015	4,686

Note: NS = No survey.

Appendix A12.–Data available for analysis of Lewis River Chinook salmon escapement goal.

Year	Escapement
1979	546
1980	NS
1981	560
1982	606
1983	NS
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[a]
2008	120
2009	111
2010	56
2011	92
2012	107
2013	61
2014	61
2015	5

Note: NS = No survey.

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

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

Year	Aerial Escapement	Weir Escapement	Expanded Weir Escapement [a]
1983	929		2,138
1984	558		1,275
1985	1,005		2,315
1986	NS	NS	
1987	1,386		3,201
1988	3,197	7,712	
1989	NS	4,367	
1990	922		2,122
1991	892		2,052
1992	1,441		3,329
1993	NS	NS	
1994	1,221	2,981	
1995	1,714	2,893	
1996	1,079		2,487
1997	NS	NS	
1998	1,091		2,515
1999	NS	NS	
2000	1,094		2,522
2001	1,238		2,857
2002	1,660		3,839
2003	1,114		2,569
2004	1,694		3,918
2005	2,095		4,850
2006	1,855		4,292
2007	1,731		4,004
2008	1,297		2,994
2009	1,028		2,368
2010	589		1,347
2011	887		2,040
2012	1,154		2,662
2013	1,651		3,818
2014	1,759	3,135	
2015	1,507	5,026	

Note: NS = Escapement not surveyed. Blank cells indicate no available data.

[a] Weir escapement estimated from ratio of paired aerial survey and weir data (2.3) in years 1988, 1994, 1995, 2014, and 2015

Appendix A14.–Data available for analysis of Little Willow Creek Chinook salmon escapement goal.

Year	Escapement
1979	327
1980	NS
1981	459
1982	316
1983	1,042
1984	NS
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	NS
2009	776
2010	468
2011	713
2012	494
2013	858
2014	684
2015	788

Note: NS = No survey.

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

Year	Escapement
1981	814
1982	NS
1983	NS
1984	NS
1985	NS
1986	NS
1987	1,320
1988	2,016
1989	NS
1990	1,269
1991	1,215
1992	1,560
1993	1,281
1994	1,143
1995	2,110
1996	1,841
1997	3,073
1998	2,936
1999	2,088
2000	1,271
2001	1,930
2002	2,357
2003	2,576
2004	2,117
2005	2,600
2006	1,850
2007	1,936
2008	1,357
2009	1,460
2010	755
2011	494
2012	416
2013	1,304
2014	953
2015	1,416

Note: NS = No survey.

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

Year	Escapement
1983	2,272[a]
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	NS
2009	1,283
2010	NS
2011	1,103
2012	459
2013	1,643
2014	1,443
2015	1,514

Note: NS = No survey.

[a] In 1983, only a tributary was surveyed and not Peters Creek mainstem.

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

Year	Escapement
1981	1,875
1982	3,844
1983	3,200
1984	9,000
1985	6,500
1986	8,500
1987	9,138
1988	9,280
1989	9,463
1990	9,113
1991	6,770
1992	4,453
1993	3,023
1994	2,254
1995	3,884
1996	5,037
1997	7,710
1998	4,465
1999	5,871
2000	3,790
2001	5,191
2002	7,914
2003	4,095
2004	5,570
2005	3,862
2006	3,570
2007	5,036
2008	3,039
2009	3,500
2010	3,022
2011	2,038
2012	1,185
2013	3,304
2014	2,812
2015	3,290

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

Year	Escapement
1979	778
1980	NS
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	NS
1993	NS
1994	542
1995	1,049
1996	1,028
1997	NS
1998	1,160
1999	NS
2000	1,162
2001	NS
2002	854
2003	NS
2004	285
2005	760
2006	580
2007	400
2008	NS
2009	500
2010	NS
2011	350
2012	363
2013	NS
2014	262
2015	NS

Note: NS = No survey.

Appendix A19.–Data available for analysis of Talachulitna River Chinook salmon escapement goal.

Year	Escapement
1979	1,648
1980	NS
1981	2,025
1982	3,101
1983	10,014
1984	6,138
1985	5,145
1986	3,686
1987	NS
1988	4,112
1989	NS
1990	2,694
1991	2,457
1992	3,648
1993	3,269
1994	1,575
1995	2,521
1996	2,748
1997	4,494
1998	2,759
1999	4,890
2000	2,414
2001	3,309
2002	7,824
2003	9,573
2004	8,352
2005	4,406
2006	6,152
2007	3,871
2008	2,964
2009	2,608
2010	1,499
2011	1,368
2012	847
2013	2,285
2014	2,256
2015	2,582

Note: NS = No survey.

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

Year	Escapement
1979	512
1980	NS
1981	535
1982	1,368
1983	1,519
1984	1,251
1985	1,458
1986	1,281
1987	1,548
1988	1,906
1989	1,026
1990	642
1991	508
1992	1,053
1993	1,110
1994	577
1995	694
1996	368
1997	1,607
1998	1,807
1999	2,221
2000	1,271
2001	1,237
2002	934
2003	1,059
2004	491
2005	478
2006	958
2007	486
2008	345
2009	352
2010	202
2011	327
2012	179
2013	476
2014	312
2015	426

Note: NS = No survey.

Appendix A21.–Data available for analysis of Willow Creek Chinook salmon escapement goal.

Year	Escapement
1981	991
1982	592
1983	NS
1984	2,789
1985	1,856
1986	2,059
1987	2,768
1988	2,496
1989	5,060
1990	2,365
1991	2,006
1992	1,660
1993	2,227
1994	1,479
1995	3,792
1996	1,776
1997	4,841
1998	3,500
1999	2,081
2000	2,601
2001	3,188
2002	2,758
2003	3,964
2004	2,985
2005	2,463
2006	2,217
2007	1,373
2008	1,255
2009	1,133
2010	1,173
2011	1,061
2012	756
2013	1,752
2014	1,335
2015	2,046

Note: NS = No survey.

APPENDIX B
SUPPORTING INFORMATION FOR UPPER COOK INLET CHUM SALMON ESCAPEMENT GOALS

Appendix B1.–Data available for analysis of Clearwater Creek chum salmon escapement goal.

Year	Escapement [a]	Year	Escapement
1971	5,000	2000	31,800
1972	NS	2001	14,570
1973	8,450	2002	8,864
1974	1,800	2003	800
1975	4,400	2004	3,900
1976	12,700	2005	530
1977	12,700	2006	500
1978	6,500	2007	5,590
1979	1,350	2008	12,960
1980	5,000	2009	8,300
1981	6,150	2010	13,700
1982	15,400	2011	11,630
1983	10,900	2012	5,270
1984	8,350	2013	9.010
1985	3,500	2014	3,500
1986	9,100	2015	10,790
1987	6,350		
1988	NS		
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		

Note: NS = No survey.

[a] Escapements are peak aerial survey counts.

APPENDIX C
SUPPORTING INFORMATION FOR UPPER COOK INLET COHO SALMON ESCAPEMENT GOALS

Appendix C1.–Data available for analysis of Deshka River coho salmon escapement goal.

Year	Escapement
1995	12,824[a]
1996	1,394[a]
1997	8,063
1998	6,773[a]
1999	4,566[a]
2000	26,387
2001	29,927
2002	24,612[a]
2003	17,305
2004	62,940
2005	47,887
2006	59,419[a]
2007	10,575
2008	12,724
2009	27,348
2010	10,393
2011	7,326[a]
2012	6,825
2013	22,141
2014	11,578
2015	10,775

[a] Incomplete or partial count. Also, in 1995 and 1996, the weir was operated at RM 17, considerably upstream of the site for other years (RM 7), probably with some spawning occurring downstream. These years were not included in escapement goal development.

Appendix C2.–Data available for analysis of Fish Creek coho salmon escapement goal.

Year	Escapement	Year	Escapement
1969	5,671[a]	2012	1,237
1970	NS	2013	7,593[b]
1971	NS	2014	10,283
1972	955[a]	2015	7,912
1973	280[a]		
1974	1,539[a]		
1975	2,135[a]		
1976	1,020[a]		
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[a]		
1998	5,463		
1999	1,766		
2000	5,218		
2001	9,247		
2002	14,651		
2003	1,231		
2004	1,415		
2005	3,011		
2006	4,967		
2007	6,868		
2008	4,868		
2009	8,214		
2010	6,977		
2011	1,428		

Note: NS = No survey.

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

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

Appendix C3.–Data available for analysis of Jim Creek coho salmon escapement goal.

Year	Escapement [a]
1985	662
1986	439
1987	667
1988	1,911
1989	597
1990	599
1991	484
1992	11
1993	503
1994	506
1995	702
1996	72
1997	701
1998	922
1999	12
2000	657
2001	1,019
2002	2,473
2003	1,421
2004	4,652
2005	1,464
2006	2,389
2007	725
2008	1,890
2009	1,331
2010	242
2011	229
2012	213
2013	631
2014	122
2015	571

Note: NS = No survey.

[a] Escapement for McRoberts Creek only, (a tributary to Jim Creek).

Appendix C4.–Data available for analysis of Little Susitna River coho salmon escapement goal.

Year	Total Escapement	% Hatchery Contribution to Escapement [a]	Escapement Hatchery	Escapement Wild	Sport Harvest [b]
1977	NS				3,415
1978	NS				4,865
1979	NS				3,382
1980	NS				6,302
1981	NS				5,940
1982	NS				7,116
1983	NS				2,835
1984	NS				14,253
1985	NS				7,764
1986	6,999			6,999	6,039
1987	NS				13,003
1988	20,491	22	4,428	16,063	19,009
1989	15,232	45	6,862	8,370	14,129
1990	14,310	24	3,370	10,940	7,497
1991	37,601	22	8,322	29,279	16,450
1992	20,393	11	2,324	18,069	20,033
1993	33,378	29	9,615	23,763	27,610
1994	27,820	18	5,124	22,696	17,665
1995	11,817	9	1,069	10,748	14,451
1996	16,699	3	444	16,255	16,753
1997	9,894			9,894	7,756
1998	15,159			15,159	14,469
1999	3,017			3,017	8,864
2000	15,436			15,436	20,357
2001	30,587			30,587	17,071
2002	47,938			47,938	19,278
2003	10,877			10,877	13,672
2004	40,199			40,199	15,307
2005	16,839			16,839	10,203
2006	8,786			8,786	12,399
2007	17,573			17,573	11,089
2008	18,485			18,485	13,498
2009	9,523			9,523	8,346
2010	9,214			9,214	10,622
2011	4,826			4,826	2,452
2012	6,779 [c]			6,779	1,681
2013	13,583 [c]			13,583	5,229
2014	24,211			24,211	6,922
2015	12,756 [c]			12,756	8,880

Note: NS = No survey. Blank cells indicate no available data.

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

[b] From Statewide Harvest Survey (Jennings et al. 2015).

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

APPENDIX D
SUPPORTING INFORMATION FOR UPPER COOK INLET SOCKEYE SALMON ESCAPEMENT GOALS

Appendix D1.–Data available for analysis of Chelatna Lake sockeye salmon escapement goal.

Year	Escapement
1992	35,300 [a]
1993	20,235
1994	28,303
1995	20,124
1996	35,747 [b]
1997	84,899
1998	51,798 [b]
1999	NS
2000	NS
2001	NS
2002	NS
2003	NS
2004	NS
2005	NS
2006	18,433 [c]
2007	41,290 [c]
2008	74,469
2009	17,721
2010	37,784
2011	70,353
2012	36,736
2013	70,555
2014	26,374
2015	69,897

Note: NS = No Survey.

[a] Mark–recapture estimate.

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

[c] Weir inoperable during high water events; missing counts estimated using proportion of radiotagged fish passing during high water (Fair et al. 2009).

Appendix D2.–Data available for analysis of Fish Creek sockeye salmon escapement goal. Shaded values indicate years of hatchery production and were not used to evaluate the SEG recommendation.

Year	Escapement [a,b]	Year	Escapement [a,b]	Year	Escapement [a,b]
1946	57,000 [c]	1979	68,739	2012	18,813
1947	150,000 [c]	1980	62,828	2013	18,912
1948	150,000 [c]	1981	50,479	2014	43,915
1949	68,240	1982	28,164	2015	102,309
1950	29,659	1983	118,797		
1951	34,704	1984	192,352		
1952	92,724	1985	68,577		
1953	54,343	1986	29,800		
1954	20,904	1987	91,215		
1955	32,724	1988	71,603		
1956	32,663 [b]	1989	67,224		
1957	15,630	1990	50,000		
1958	17,573	1991	50,500		
1959	77,416 [d, e]	1992	71,385		
1960	80,000 [d, e]	1993	117,619		
1961	40,000 [d, e]	1994	95,107		
1962	60,000 [d, e]	1995	115,000		
1963	119,024 [d, e]	1996	63,160		
1964	65,000 [d, e]	1997	54,656		
1965	16,544 [d, e]	1998	22,853		
1966	41,312 [d, e]	1999	26,746		
1967	22,624 [d, e]	2000	19,533		
1968	19,616 [d, e]	2001	43,469		
1969	12,456	2002	90,483		
1970	25,000 [f]	2003	92,298		
1971	31,900 [g]	2004	22,157		
1972	6,981	2005	14,215		
1973	2,705	2006	32,562		
1974	16,225	2007	27,948		
1975	29,882	2008	19,339		
1976	14,032	2009	83,480		
1977	5,183	2010	126,836		
1978	3,555	2011	66,678		

Note: NS = No Survey

[a] 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.

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

[c] Escapement enumerated by ground surveys.

[d] Escapement enumerated using a counting screen.

[e] Minimum counts due to termination of counting before the end of the run.

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

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

Appendix D3.–Data available for analysis of Judd Lake sockeye salmon escapement goal.

Year	Escapement	Year	Escapement
1973	26,428 [a]	2013	14,088
1974	NS	2014	22,229
1975	NS	2015	47,934
1976	NS		
1977	NS		
1978	NS		
1979	NS		
1980	43,350 [a]		
1981	NS		
1982	NS		
1983	NS		
1984	NS		
1985	NS		
1986	NS		
1987	NS		
1988	NS		
1989	12,792		
1990	NS		
1991	NS		
1992	NS		
1993	NS		
1994	NS		
1995	NS		
1996	NS		
1997	NS		
1998	34,416		
1999	NS		
2000	NS		
2001	NS		
2002	NS		
2003	NS		
2004	NS		
2005	NS		
2006	40,633		
2007	57,392		
2008	53,681		
2009	44,616		
2010	18,446		
2011	39,984		
2012	18,715		

Note: NS = No Survey

[a] Aerial survey.

Appendix D4.–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	321,500	275,813	7.04
1976	136,595	691,693	555,098	5.06
1977	156,616	610,171	453,555	3.90
1978	112,484	695,679	583,195	6.18
1979	152,503	783,821	631,318	5.14
1980	182,284	1,082,721	900,437	5.94
1981	252,460	1,853,442	1,600,982	7.34
1982	172,470	1,287,592	1,115,122	7.47
1983	205,361	1,008,308	802,947	4.91
1984	226,469	766,694	540,225	3.39
1985	501,071	369,740	(131,331)	0.74
1986	270,559	674,252	403,693	2.49
1987	243,244	887,782	644,538	3.65
1988	194,322	665,176	470,854	3.42
1989	156,427	512,385	355,958	3.28
1990	140,589	501,812	361,223	3.57
1991	223,492	946,237	722,745	4.23
1992	181,394	815,919	634,525	4.50
1993	142,111	521,361	379,250	3.67
1994	204,604	765,529	560,925	3.74
1995	188,698	530,599	341,901	2.81
1996	252,213	751,566	499,353	2.98
1997	254,459	682,580	428,121	2.68
1998	248,220	792,308	544,088	3.19
1999	301,403	1,158,888	857,485	3.84
2000	253,514	1,388,432	1,134,918	5.48
2001	308,510	1,627,669	1,319,159	5.28
2002	225,184	1,250,022	1,024,838	5.55
2003	341,327	1,560,304	1,218,977	4.57
2004	523,653	1,491,097	967,444	2.85
2005	360,065	878,678	518,613	2.44
2006	389,645	744,647	355,002	1.91
2007	365,184	484,387	119,203	1.33
2008	327,018	873,422	546,404	2.67
2009	326,283	1,043,701	717,418	3.20
2010	295,265			
2011	245,721			
2012	374,523			
2013	489,654			
2014	440,192			
2015	470,677			

Note: Blank cells indicate no available data.

Appendix D5.–Data available for analysis of Kenai River sockeye salmon escapement goal.

Brood Year	Escapement	Returns	Yield	Return per Spawner	Exploitation Rate
1968	115,545	960,169			
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	1,055,373	871,111	5.73	0.83
1976	507,440	1,506,012	998,572	2.97	0.66
1977	951,038	3,112,620	2,161,582	3.27	0.69
1978	511,781	3,785,040	3,273,259	7.40	0.86
1979	373,810	1,321,039	947,229	3.53	0.72
1980	615,382	2,673,295	2,057,913	4.34	0.77
1981	535,524	2,464,323	1,928,799	4.60	0.78
1982	755,672	9,587,700	8,832,028	12.69	0.92
1983	792,765	9,486,794	8,694,029	11.97	0.92
1984	446,397	3,859,109	3,412,712	8.65	0.88
1985	573,836	2,587,921	2,014,085	4.51	0.78
1986	555,207	2,165,138	1,609,931	3.90	0.74
1987	2,011,772	10,356,627	8,344,855	5.15	0.81
1988	1,213,047	2,546,639	1,333,592	2.10	0.52
1989	2,026,638	4,458,679	2,432,041	2.20	0.55
1990	794,753	1,507,693	712,940	1.90	0.47
1991	727,159	4,436,074	3,708,915	6.10	0.84
1992	1,207,382	4,271,576	3,064,194	3.54	0.72
1993	997,730	1,689,779	692,049	1.69	0.41
1994	1,309,695	3,052,634	1,742,939	2.33	0.57
1995	776,881	1,899,870	1,122,989	2.45	0.59
1996	963,125	2,261,757	1,298,632	2.35	0.57
1997	1,365,746	3,626,402	2,260,656	2.66	0.62
1998	929,090	4,465,328	3,536,238	4.81	0.79
1999	949,276	5,755,063	4,805,787	6.06	0.84
2000	696,899	7,058,348	6,361,449	10.13	0.90
2001	738,229	1,698,142	959,913	2.30	0.57
2002	1,126,642	3,630,740	2,504,098	3.22	0.69
2003	1,402,340	1,922,165	519,825	1.37	0.27
2004	1,690,547	3,240,428	1,549,881	1.92	0.48
2005	1,654,003	4,802,362	3,148,359	2.90	0.66
2006	1,892,090	5,003,585	3,111,495	2.64	0.62
2007	964,261	4,376,406	3,412,145	4.54	0.78
2008	708,833	3,377,884	2,669,051	4.77	0.79
2009	848,117	3,983,872	3,135,755	4.70	0.79
2010	1,038,323				
2011	1,280,733				
2012	1,212,923				
2013	980,208				
2014	1,218,342				
2015	1,325,673[a]				

Note: Blank cells indicate no available data.

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

Appendix D6.–Data available for analysis of Larson Lake sockeye salmon escapement goal.

Year	Escapement
1984	35,252
1985	37,874
1986	32,322
1987	16,748
1988	NS
1989	NS
1990	NS
1991	NS
1992	NS
1993	NS
1994	NS
1995	NS
1996	NS
1997	40,163
1998	63,514
1999	18,943
2000	11,987
2001	NS
2002	NS
2003	NS
2004	NS
2005	9,955
2006	57,411
2007	47,924
2008	34,595
2009	40,929
2010	20,324
2011	12,190
2012	16,566
2013	21,821
2014	12,430
2015	23,185

Note: NS = No Survey.

Appendix D7.–Data available for analysis of Packers Creek sockeye salmon escapement goal.

Year	Escapement
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	NS
2002	NS
2003	NS
2004	NS
2005	22,000
2006	NS
2007	46,637
2008	25,247
2009	16,473
2010	NS
2011	NS
2012	NS
2013	NS
2014	19,242
2015	28,072

Note: NS = No Survey

Appendix D8.–Table of data available for analysis of early-run Russian River sockeye salmon escapement goal.

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

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Brood Year	Escapement [a]	Total Return	Yield	Return/ Spawner	Harvest [b]
2007	27,298	36,587	9,289	1.34	37,185
2008	30,989	72,061	41,072	2.33	43,420
2009	52,178	109,924	57,746	2.11	59,640
2010 [c]	27,074	32,707			24,047
2011 [c]	29,129	2,187			23,339
2012 [c]	24,115				16,098
2013 [c]	35,776				27,930
2014 [c]	44,920				37,146
2015 [c]	50,226				30,986

Note: Blank cells indicate no available data.

[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 1997–2015 from Statewide Harvest Survey (Jennings et al. 2015). Estimates are only of fish harvested near the Russian River itself.

[c] Complete return data not yet available.

Appendix D9.–Data available for analysis of late-run Russian River sockeye salmon escapement goal.

Year	Harvest [a]	Escapement Above weir[b]	Escapement Below weir[b]	Local run
1963	1,390	51,120	NS	52,510
1964	2,450	46,930	NS	49,380
1965	2,160	21,820	NS	23,980
1966	7,290	34,430	NS	41,720
1967	5,720	49,480	NS	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

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Year	Harvest [a]	Escapement Above weir[b]	Escapement Below weir[b]	Local run
2006	29,694	84,432	18,452	132,578
2007	17,161	53,068	4,504	74,733
2008	24,158	46,638	9,750	80,546
2009	34,366	80,088	10,740	125,194
2010	9,579	38,848	16,656	65,081
2011	14,723	41,529	35,415	91,628
2012	15,535	54,911	25,471	95,917
2013	20,713	31,573	18,972	71,258
2014	18,360	52,277	10,659	81,296
2015	14,448	46,223	11,172	71,843

Note: NS = no survey

[a] Harvest during 1963–1996 from an onsite creel survey and during 1997–2000 from Statewide Harvest Survey (Jennings et al. 2015). 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 E
ESCAPEMENT MEMOS AND RECORD COPIES PRESENTED TO THE ALASKA BOARD OF FISHERIES

Appendix E1.–Upper Cook Inlet escapement goal memo.

THE STATE of ALASKA
GOVERNOR BILL WALKER

Department of Fish and Game

DIVISIONS OF SPORT FISH and COMMERCIAL FISHERIES
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MEMORANDUM

TO:	Scott Kelley, Director Division of Commercial Fisheries Thomas Brookover, Director Division of Sport Fish	DATE:	October 3, 2016
THRU:	Tracy Lingnau, Regional Supervisor TL Division of Commercial Fisheries, Region II Thomas D. Vania, Regional Supervisor TV Division of Sport Fish, Region II	SUBJECT:	Upper Cook Inlet Escapement Goal Memo
FROM:	Jack W. Erickson, Regional Research Coordinator JWE Division of Commercial Fisheries, Region II Tim McKinley, Regional Research Coordinator TKM Division of Sport Fish, Region II		

The purpose of this memo is to report our progress reviewing and recommending escapement goals for Upper Cook Inlet (UCI). Escapement goals in this management area have been set and evaluated at regular intervals since statehood. This effort has resulted in many of the stocks having long-term historical databases. All UCI escapement goals were last reviewed by the Alaska Department of Fish and Game (department) (Fair et al. 2013) during the 2013–2014 Alaska Board of Fisheries (board) cycle.

Between December 2015 and September 2016, an interdivisional salmon escapement goal review committee, including staff from the divisions of Commercial Fisheries and Sport Fish, reviewed the 35 existing salmon escapement goals in the UCI management area. The review was based on the *Policy for the management of sustainable salmon fisheries* (5 AAC 39.222) and the *Policy for statewide salmon escapement goals* (5 AAC 39.223). Two important terms are:

> 5 AAC 39.222(f)(3) "biological escapement goal" or "(BEG)" means the escapement that provides the greatest potential for maximum sustained yield . . .;" and

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2016 UCI Escapement Goal Memo

> 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 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. Based on the quality and quantity of available data, the committee determined the most appropriate methods to evaluate the escapement goals. Due to the thoroughness of previous analyses by Bue and Hasbrouck (*Unpublished*), Clark et al. (2007), Hasbrouck and Edmundson (2007), and Fair et al. (2007, 2010, 2013), this review re-analyzed only those goals with recent (2010–2015) data that could potentially result in a substantially different escapement goal from the last review, or those that should be eliminated or established.

Escapement goals were evaluated for UCI stocks using a variety of methods: (1) spawner-recruit analyses; (2) yield analyses; (3) smolt/fry information; and/or (4) the recently updated percentile approach (Clark et al. 2014). The committee developed escapement goals for each stock, compared them with the current goal, and agreed on a recommendation to keep the current goal, change the goal, or eliminate the goal. The methods used to evaluate the escapement goals and the rationale for making subsequent recommendations will be described in a published report (Erickson et al. *In prep*) available prior to the February/March 2017 UCI board meeting.

Kenai River king salmon

The department is currently finalizing run reconstructions and stock-recruit analyses for fish approximately 34 inches in length or greater for both Kenai River king salmon runs. Based on these analyses, recommendations for new SEGs for fish 34 inches in length or greater for the early run and late run will be selected. In the Kenai River, fish of this size can be assessed more simply, accurately, and timely. The recommendations for these two goals will be presented in an updated Upper Cook Inlet Escapement Goal Memo, at or prior to the Lower Cook Inlet board meeting in late November 2016. A written report describing the analyses and results will be presented at the UCI board meeting.

Little Susitna River king salmon

The committee recommends a weir-based SEG of 2,300–3,900 king salmon be established for Little Susitna River. The proposed weir-based goal was developed using the percentile approach (Clark et al. 2014). A relationship developed between a long-term time series of aerial index counts and weir counts was used to leverage historical aerial survey data. The proposed weir-based escapement goal is considered the primary goal for escapement performance and management purposes, and the existing aerial-based SEG (900–1,800) will only be used to assess escapement performance if the weir becomes inoperable for a significant period of time.

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2016 UCI Escapement Goal Memo

Clearwater Creek chum salmon

The current SEG (3,800–8,400) for Clearwater Creek was established in 2002. For this review, the committee updated the escapement time series through 2015 and applied the Clark et al. (2014) percentile approach to the data set. The committee recommends the SEG for Clearwater Creek chum salmon be updated to 3,500–8,000.

Deshka River coho salmon

Currently there is no escapement goal for Deshka River coho salmon. A weir has been operated during the coho salmon run on the Deshka River since 1995. Although managing fisheries that harvest this stock is challenging due to the often pulse-like behavior of coho salmon passage (which is difficult to predict), and high water can render the weir inoperable during key passage times, the committee recommends an SEG of 10,200–24,100, derived using the Clark et al. (2014) percentile approach, be adopted for Deshka River coho salmon.

Kasilof and Kenai River sockeye salmon

During this review the committee updated the escapement time series and stock-recruit analyses for Kasilof and Kenai river sockeye salmon. Incorporating recent production data (2011–2013) had little effect on estimates of escapements that produce maximum yields of the Kasilof River sockeye salmon, so the committee recommended no change to the current goal of 160,000–340,000. Similarly for Kenai River sockeye salmon, recent production data indicates that escapements that produce maximum yields continue to support the current goal of 700,000–1,200,000.

Fish Creek sockeye salmon

The current SEG (20,000–70,000) for Fish Creek was established in 2002. For this review, the committee updated the escapement time series through 2015 and applied the percentile approach (Clark et al. 2014). The committee recommends the SEG range for Fish Creek sockeye salmon be updated to 15,000–45,000.

Chelatna, Judd, and Larson lakes sockeye salmon

The SEGs for these three stocks were established in 2009 from limited times series of data. The current SEGs are Chelatna Lake 20,000–65,000; Judd Lake 25,000–55,000; and Larson Lake 15,000–50,000. With 7 additional years of escapement data since these goals were developed, coupled with an updated methodology (Clark et al. 2014), the committee recommends updating the SEGs as follows: Chelatna Lake 20,000–45,000; Judd Lake 15,000–40,000; and Larson Lake 15,000–35,000.

In summary, the escapement goal committee reviewed 35 salmon escapement goals for the UCI management area with recommendations to establish a weir-based SEG for Little Susitna king salmon, update the range of the SEG for Clearwater Creek chum salmon, establish a new SEG

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for Deshka River coho salmon, and update SEG ranges for four sockeye salmon stocks (Chelatna, Judd, and Larson Lakes, as well as Fish Creek).

An oral and written report concerning escapement goals with specific recommendations will be presented to the board in February/March 2017. These reports will list all current and recommended escapement goals for UCI, as well as a detailed description of the methods used to reach recommendations.

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2016 UCI Escapement Goal Memo

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2016 UCI Escapement Goal Memo

Table 1.–Summary of current escapement goals and recommended escapement goals for salmon stocks in Upper Cook Inlet, 2016.

	Current Escapement Goal			Recommended Escapement Goal			
			Year	Escapement			
System	Goal	Type	Adopted	Range/Lower Bound	Type	Data[a]	Action
King Salmon							
Alexander Creek	2,100–6,000	SEG	2002	2,100–6,000	SEG	SAS	No Change
Campbell Creek	380	SEG	2011	380	SEG	SFS	No Change
Chuitna River	1,200–2,900	SEG	2002	1,200–2,900	SEG	SAS	No Change
Chulitna River	1,800–5,100	SEG	2002	1,800–5,100	SEG	SAS	No Change
Clear (Chunilna) Creek	950–3,400	SEG	2002	950–3,400	SEG	SAS	No Change
Crooked Creek	650–1,700	SEG	2002	650–1,700	SEG	Weir	No Change
Deshka River	13,000–28,000	SEG	2011	13,000–28,000	SEG	Weir	No Change
Goose Creek	250–650	SEG	2002	250–650	SEG	SAS	No Change
Kenai River - Early Run	3,800–8,500	SEG	2013	NA	SEG	Sonar	Change
Kenai River - Late Run	15,000–30,000	SEG	2013	NA	SEG	Sonar	Change
Lake Creek	2,500–7,100	SEG	2002	2,500–7,100	SEG	SAS	No Change
Lewis River	250–800	SEG	2002	250–800	SEG	SAS	No Change
Little Susitna River[b]				2,300–3,900	SEG	Weir	New Goal
Little Susitna River	900–1,800	SEG	2002	900–1,800	SEG	SAS	No Change
Little Willow Creek	450–1,800	SEG	2002	450–1,800	SEG	SAS	No Change

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2016 UCI Escapement Goal Memo

System	Current Escapement Goal			Recommended Escapement Goal			
	Goal	Type	Year Adopted	Escapement Range/Lower Bound	Type	Data[a]	Action
Montana Creek	1,100–3,100	SEG	2002	1,100–3,100	SEG	SAS	No Change
Peters Creek	1,000–2,600	SEG	2002	1,000–2,600	SEG	SAS	No Change
Prairie Creek	3,100–9,200	SEG	2002	3,100–9,200	SEG	SAS	No Change
Sheep Creek	600–1,200	SEG	2002	600–1,200	SEG	SAS	No Change
Talachulitna River	2,200–5,000	SEG	2002	2,200–5,000	SEG	SAS	No Change
Theodore River	500–1,700	SEG	2002	500–1,700	SEG	SAS	No Change
Willow Creek	1,600–2,800	SEG	2002	1,600–2,800	SEG	SAS	No Change
Chum Salmon							
Clearwater Creek	3,800–8,400	SEG	2002	3,500–8,000	SEG	PAS	Change in Range
Coho Salmon							
Deshka River				10,200–24,100	SEG	Weir	New Goal
Fish Creek (Knik)	1,200–4,400	SEG	2011	1,200–4,400	SEG	Weir	No Change
Jim Creek	450–1,400	SEG	2014	450–1,400	SEG	SFS	No Change
Little Susitna River	10,100–17,700	SEG	2002	10,100–17,700	SEG	Weir	No Change
Sockeye Salmon							
Chelatna Lake	20,000–65,000	SEG	2009	20,000–45,000	SEG	Weir	Change in Range
Fish Creek (Knik)	20,000–70,000	SEG	2002	15,000–45,000	SEG	Weir	Change in Range
Judd Lake	25,000–55,000	SEG	2009	15,000–40,000	SEG	Weir	Change in Range

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2016 UCI Escapement Goal Memo

	Current Escapement Goal			Recommended Escapement Goal			
			Year	Escapement			
System	Goal	Type	Adopted	Range/Lower Bound	Type	Data[a]	Action
Kasilof River	160,000–340,000	BEG	2011	160,000–340,000	BEG	Sonar	No Change
Kenai River	700,000–1,200,000	SEG	2011	700,000–1,200,000	SEG	Sonar	No Change
Larson Lake	15,000–50,000	SEG	2009	15,000–35,000	SEG	Weir	Change in Range
Packers Creek	15,000–30,000	SEG	2008	15,000–30,000	SEG	Weir	No Change
Russian River - Early Run	22,000–42,000	BEG	2011	22,000–42,000	BEG	Weir	No Change
Russian River - Late Run	30,000–110,000	SEG	2002	30,000–110,000	SEG	Weir	No Change

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

[b] Little Susitna River has two goals. The Primary goal is the weir goal. The goal based on aerial surveys will only be used if the weir is not operated or is not operational for a significant portion of the season.

NA: Range not available at this time. The recommendations for these two goals will be presented in an updated Upper Cook Inlet Escapement Goal Memo, at or prior to the Lower Cook Inlet board meeting in late November 2016.

Appendix E2.–Addendum to Upper Cook Inlet escapement goal memo dated October 3, 2016.

THE STATE of ALASKA
GOVERNOR BILL WALKER

Department of Fish and Game
DIVISIONS OF SPORT FISH and COMMERCIAL FISHERIES
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MEMORANDUM

TO: Scott Kelley, Director
Division of Commercial Fisheries

Thomas Brookover, Director
Division of Sport Fish

DATE: November 14, 2016

THRU: Tracy Lingnau, Regional Supervisor
Division of Commercial Fisheries, Region II

Thomas D. Vania, Regional Supervisor
Division of Sport Fish, Region II

SUBJECT: Addendum to Upper Cook Inlet Escapement Goal Memo dated October 3, 2016

FROM: Jack W. Erickson, Regional Research Coordinator
Division of Commercial Fisheries, Region II

Tim McKinley, Regional Research Coordinator
Division of Sport Fish, Region II

The purpose of this memo is to update the Upper Cook Inlet Escapement Goal Memo dated October 3, 2016 and presented at the Alaska Board of Fisheries Work Session as RC 7. An update is necessary because the department has since finalized run reconstructions and stock-recruit analyses for fish 75 cm or greater from mid-eye to fork (MEF), (which is approximately 33.3 inches in total length) for both Kenai River king salmon runs. Based on these analyses, the escapement goal committee recommends new SEGs for fish 75 cm MEF or greater in length for the early run and late run. For Kenai River early-run king salmon, the committee recommends a sonar-based goal of 2,800–5,600 king salmon 75 cm MEF or greater in length. For Kenai River late-run king salmon, the committee recommends a sonar-based goal of 13,500–27,000 king salmon 75 cm MEF or greater in length.

An oral and written report concerning escapement goals with specific recommendations will be presented to the board in February/March 2017. These reports will list all current and

-continued-

recommended escapement goals for UCI, as well as a detailed description of the methods used to reach recommendations.

Table 1.–Summary of current Kenai River king salmon escapement goals and recommended escapement goals, 2016.

	Current Escapement Goal			Recommended Escapement Goal			
System	Goal	Type	Year Adopted	Range	Type	Data	Action
King Salmon							
Kenai River - Early Run	3,800–8,500 (all sizes)	SEG	2013	2,800–5,600 (≥ 75 cm MEF[a])	SEG	Sonar	Change
Kenai River - Late Run	15,000–30,000 (all sizes)	SEG	2013	13,500–27,000 (≥ 75 cm MEF[a])	SEG	Sonar	Change

[a] MEF is mid-eye fork length

Appendix E3.–Upper Cook Inlet stock of concern recommendations.

THE STATE of ALASKA

GOVERNOR BILL WALKER

Department of Fish and Game

DIVISIONS OF SPORT FISH and COMMERCIAL FISHERIES

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fax: 907.465.2604

MEMORANDUM

TO: Members
Alaska Board of Fisheries

DATE: October 3, 2016

FROM:

Scott Kelley, Director
Division of Commercial Fisheries

Thomas Brookover, Director
Division of Sport Fish

SUBJECT: Upper Cook Inlet Stock of Concern Recommendations

The *Policy for the management of sustainable salmon fisheries* (SSFP; 5 AAC 39.222) directs the department to report to the Alaska Board of Fisheries (board) on the status of salmon stocks and identify any stocks that present a concern related to yield, management, or conservation during regular board meetings. This memorandum summarizes the results of the stock of concern evaluation for Upper Cook Inlet (UCI) salmon stocks for the 2016–2017 board regulatory cycle. The evaluation includes input from regional and area management staff from both fishery divisions.

During the 2016 escapement goal review process all king, sockeye, pink, coho, and chum salmon stocks in the UCI were examined for potential stock of concern status (Munro and Volk 2016). Currently, there are 8 stocks of concern in UCI (Table 1).

King salmon

The board has designated seven king salmon stocks as stocks of yield or management concern since the 2011 UCI board meeting (Table 1). Since 2009, the escapement goals were met in some years for only two of these stocks. With management actions being taken to limit fishing mortality on all seven stocks, the Willow Creek goal was achieved in three of the last four years, and the Chuitna River goal was achieved in each of the last four years (Table 1). The department recommends no change to the status of the seven king salmon stocks of concern.

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Upper Cook Inlet Stock of Concern Memo

Sockeye salmon

Since establishment of Susitna River sockeye salmon as a stock of yield concern in 2008, the sonar-based Yentna River sustainable escapement goal (SEG) was eliminated and replaced with three Susitna drainage weir-based SEGs (Fair et al. 2009): Chelatna Lake (Yentna River), Judd Lake (Yentna River), and Larson Lake (Susitna River mainstem). The current escapement goals (Table 1) were first in effect for the 2009 season. The Chelatna Lake escapement goal has been met in seven of the past eight years, Larson Lake in five of the past eight years, and Judd Lake in three of the past seven years counted. Note that the Judd Lake weir was not operated in 2016 due to lack of funding.

The department recommends no change to the status of Susitna River sockeye salmon stock of yield concern.

As part of the UCI escapement goal presentation to the board in February, staff will include an update on stocks of concern and review the department's recommendations for stocks of concern.

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Upper Cook Inlet Stock of Concern Memo

Table 1. Upper Cook Inlet stocks of concern, escapement goals, and escapements, 2009-2016 .

Stock	SOC Established	Survey Survey	Type	Goal Range	SOC	Escapement 2009	2010	2011	2012	2013	2014	2015	2016
King salmon													
Alexander Creek	2011	SAS	SEG	2,100–6,000	mngt.	275	177	343	181	588	911	1,117	754
Chuitna River	2011	SAS	SEG	1,200–2,900	mngt.	1,040	735	719	502	1,690	1,398	1,965	1,372
Goose Creek[a]	2014	SAS	SEG	250–650	mngt.	65	76	80	57	62	232	NS	NS
Lewis River	2011	SAS	SEG	250–800	mngt.	111	56	92	107	61	61	5	0
Sheep Creek	2014	SAS	SEG	600–1,200	mngt.	500	NS	350	363	NS	262	NS	NS
Theodore River	2011	SAS	SEG	500–1,700	mngt.	352	202	327	179	476	312	426	68
Willow Creek	2011	SAS	SEG	1,600–2,800	yield	1,113	1,173	1,061	756	1,752	1,335	2,046	1,814
Sockeye salmon													
Yentna River[b]	2008				yield	NA	NA	NA	NA	NA	NA	NA	NA
Chelatna Lake		weir	SEG	20,000–65,000	none	17,721	37,784	70,353	36,736	70,555	26,212	69,750	60,785[c]
Judd Lake[d]		weir	SEG	25,000–55,000	none	44,616	18,446	39,984	18,715	14,080	22,416	47,684	NS
Larson Lake		weir	SEG	15,000–50,000	none	40,929	20,324	12,413	16,566	21,821	12,040	23,214	14,313

[a]Goose Creek king salmon stock was originally designated a stock of yield concern in 2011.

[b]Yentna River sockeye salmon escapement goal was replaced by SEGs on Chelatna, Judd, and Larson lakes in 2009.

[c]Weir was pulled early (8/6/2016) due to flooding.

[d]Judd Lake weir was not operated in 2016.

notes: SAS is a single aerial survey; shaded cells identify years that stocks did not meet the lowerbound of the SEG.