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Review of Salmon Escapement Goals in Upper Cook Inlet, Alaska, 2019

by

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

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, 1 chum salmon, 4 coho salmon, and 9 sockeye salmon stocks. The committee recommended to the Commercial Fisheries and Sport Fish division directors updates to 7 Chinook salmon goals (Deshka River, Alexander Creek, Chulitna River, Chuitna River, Theodore River, Little Susitna River, and Crooked Creek), consolidation of 10 Chinook salmon goals into 3 goals (Eastside Susitna, Talkeetna River, and Yentna River), a discontinuation of 11 Chinook salmon goals (Goose Creek, Little Willow Creek, Montana Creek, Sheep Creek, Willow Creek, Clear [Chunilna] Creek, Prairie Creek, Talachulitna River, Lake Creek, Peters Creek, and Lewis River), updates to 3 coho salmon goals (Fish Creek, Jim Creek, and Little Susitna River), and updates to 3 sockeye salmon goals (Kasilof River, Kenai River, and late-run Russian River).

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

INTRODUCTION

Upper Cook Inlet (UCI), Alaska, supports 5 species of Pacific salmon (*Oncorhynchus* spp.) The UCI commercial fisheries management unit consists of that portion of Cook Inlet north of Anchor Point and is divided into Central and Northern districts (Figure 1). The Central District is approximately 120 km (75 miles) long, averages 50 km (32 miles) in width, and is further divided into 6 subdistricts. The Northern District is 80 km (50 miles) long, averages 32 km (20 miles) in width, and is divided into 2 subdistricts. Commercial salmon fisheries primarily target sockeye salmon (*O. nerka*) with secondary catches of Chinook (*O. tshawytscha*), coho (*O. kisutch*), chum (*O. keta*), and pink (*O. gorbuscha*) salmon. Sport fishery management is divided into Northern Kenai Peninsula, Northern Cook Inlet, and Anchorage management areas. Upper Cook Inlet provides subsistence, commercial, personal use, and sport 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 2018–2019 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 Commercial Fisheries and Sport Fish division directors. Many salmon escapement goals in UCI have been set and evaluated at regular intervals since statehood (Fried 1994). Due to the thoroughness of previous analyses by Bue and Hasbrouck[1], Clark et al. (2007), Hasbrouck and Edmundson (2007), Fair et al. (2007, 2010, 2013), and Erickson et al. (2017), this review reanalyzed only those goals with recent (2016–2018) data that could potentially result in a

[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*).

substantially different escapement goal from the last review, or goals that should be eliminated or established.

ADF&G reviews escapement goals based on the *Policy for the Management of Sustainable Salmon Fisheries* (SSFP; 5 AAC 39.222) and the *Policy for Statewide Salmon Escapement Goals* (EGP; 5 AAC 39.223). The BOF adopted these policies into regulation during the 2000/2001 Upper Cook Inlet BOF cycle meeting 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; the BEG will be the primary management objective for the escapement unless an optimal escapement or inriver run goal has been adopted; the BEG will be developed from the best available biological information, and should be scientifically defensible on the basis of available biological information; the BEG will be determined by ADF&G and will be expressed as a range based on factors such as salmon stock productivity and data uncertainty; ADF&G will seek to maintain evenly distributed salmon escapements within the bounds of a BEG.
>
> 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 BOF; 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 ADF&G and will take into account data uncertainty and will be stated as either an "SEG range" or "lower bound SEG"; ADF&G will seek to maintain escapements within the bounds of the SEG range or above the level of a lower bound SEG.

During the 2018–2019 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 2018, ADF&G established an escapement goal review 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 2018, and January and February 2019 to review escapement goals and develop recommendations. 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 2018–2019 review were as follows:

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.
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 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. Escapement goals for salmon are often based on stock-recruitment relationships (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 information about the stock becomes available.

DATA AVAILABLE TO DEFINE ESCAPEMENT GOALS

Recent return data were used for all stocks in this review. 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 that passed some point in a river or stream. Depending on site-characteristics, 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

Susitna River

There are 25 tributaries in the Susitna River drainage in which adult Chinook salmon have been monitored annually with single aerial surveys, multiple aerial surveys, or weirs, and 13 of these have escapement goals. In this review, Alexander Creek and Chulitna River Chinook salmon each have SEGs that are reviewed; the 11 other systems are being aggregated into 4 stocks. The 4 stocks were defined by dividing the Susitna River drainage into geographical units similar to existing management units used in ADF&G sport fishing regulations: 1) the Deshka River, 2) the Talkeetna River, 3) Eastside Susitna streams, and 4) the Yentna River. A complete listing of total run, inriver run, and escapement for Susitna River Chinook salmon can be found in Reimer and DeCovich (2020: Appendix C).

Comprehensive analyses of all relevant stock assessment data were conducted in the context of an integrated state-space model of historical run abundance and stock dynamics. A separate report (Reimer and DeCovich 2020) details the escapement goal analysis for 4 Susitna River Chinook salmon stocks; however, some information from that analysis is also provided within this report. Data for that analysis was primarily based on aerial surveys and the Deshka River weir. Other fishery data, such as inriver and marine harvest estimates, age estimates, recent mark–recapture abundance estimates, and spawner distribution data were also included. The state-space model, patterned closely after those of Fleischman and McKinley (2013), assumed a Ricker stock-recruit relationship and time-varying productivity. This model was age-structured, which enabled a realistic depiction of observation error in abundance, age composition, and harvest. The model was fit to multiple sources of information of historical abundance as well as data on age composition and harvest, permitting simultaneous reconstruction of historical abundance and estimation of stock productivity and yield.

Deshka River Stock

Prior to 1995, the Deshka River Chinook salmon escapement was monitored using a single aerial survey conducted yearly after the sport fishery had taken place. Due to the popularity of the fishery and declining escapement indices in the early and mid-1990s, a weir was installed in 1995. The weir provided accurate inseason data about escapement as well as the biological composition of the escapement (Lescanec 2017). Aerial surveys were continued in some years.

Eastside Susitna Stock

Aerial survey data are available for 6 spawning aggregations within the Eastside Susitna stock. Surveyed areas cover the known major spawning areas for this stock.

For this analysis, Willow Creek survey counts were combined with Deception Creek (a tributary of Willow Creek) counts. Chinook salmon that spawn in the mainstem of Willow Creek are predominantly wild fish, whereas runs to Deception Creek include hatchery-reared fish. Deception Creek represents the only hatchery component to the Susitna River drainage Chinook salmon runs. Our run reconstruction requires pairing mark–recapture derived abundance estimates with aerial survey counts from the same stock. Mark–recapture estimates were germane to both hatchery and wild Chinook salmon, and radiotelemetry data used to estimate stock composition did not distinguish between Willow and Deception creeks, so aerial survey counts from both streams must be pooled in this analysis. Hatchery fish are allowed to spawn and contribute to returns in each brood year.

Additionally, actual counts were provided by a weir located between the Parks Highway and the Willow Creek–Deception Creek confluence was operated on Willow Creek as part of a coded wire tag study from 2000 through 2002, and escapement counts of Chinook salmon were recorded (Suzanne Hayes, ADF&G Fishery Biologist, unpublished data). A weir was also operated on Montana Creek in 2013 and 2014 as part of Susitna River mark–recapture studies, and Chinook salmon escapement was counted in both years (unpublished data from Cleary et al. 2014a; Cleary et al. 2014b).

Talkeetna River Stock

Aerial survey data are available for 2 spawning aggregations (Clear [Chunilna] and Prairie creeks) in the Talkeetna River stock. Survey conditions are often favorable for these 2 creeks and they represent the major spawning areas for Chinook salmon in the Talkeetna River drainage. One other tributary (Iron Creek) has been shown to support some spawning habitat (DeCovich et al. *In prep)*, but this is glacial and therefore not flown during annual survey flights.

Yentna River Stock

Aerial survey data are available for 4 spawning aggregations within the Yentna River stock: Lake, Cache, Peters creeks and Talachilitna River. Two other spawning aggregations, Cache and Peters creeks, are also surveyed. Numerous small spawning populations, which together are a significant portion of the total, are too diffuse to be enumerated by aerial survey. Survey conditions are often favorable in the tributaries flown, with no counts being missed in the last 28 years (1990–2017) for Lake Creek and the Talachulitna River. Cache Creek has substantial mining activity and complete counts are sometimes not available because of cloudy water from holding ponds draining into the main channel.

Other Northern District Stocks

Escapements for most Chinook salmon stocks assessed in West Cook Inlet, Knik Arm, and Anchorage have been monitored annually since the late 1970s by single aerial or foot surveys. Such surveys provide an index of escapement. The indices provide information about the relative levels of escapement for the Lewis, Chuitna, Theodore rivers and Campbell Creek Chinook salmon stocks.

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, and 2014–2018.

Northern Kenai Peninsula Stocks

The Kenai River has 2 Chinook salmon stocks, classified as early- and late-runs, that are assessed using hydroacoustics (Miller et al. 2016). An associated gillnetting program is used to sample Chinook salmon to estimate age, sex, and size composition (Perschbacher and Eskelin 2016). A sampling program of the catch in the adjacent commercial Eastside set gillnet fishery was modified beginning in 2012 by the Division of Sport Fish to generate stock-specific estimates of harvest (Eskelin and Barclay 2019). The current large fish SEGs for Kenai River early- and late-run Chinook salmon (2,800–5,600 and 13,500–27,000, respectively) were adopted in 2017. The 2017 goals were assessed using 1986–2015 abundance, harvest, and age data for Chinook salmon 75 cm mid eye to tail fork length (METF) and longer (Fleischman and Reimer 2017). Only 3 years of additional data have been collected since then, and the committee recommended no changes to the goal at this time.

A weir project was operated on Crooked Creek to count and sample Chinook salmon (Begich et al. 2017). Returning adults were examined for a missing adipose fin, indicating hatchery origin, as well as sampled for age, length, and sex. Only naturally produced fish (fish with an adipose fin) ocean age 2 or older are used in the escapement goal analysis and in assessing the SEG.

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 (SEG) monitored by ADF&G (Tobias et al. 2013). Aerial survey data are available from 1971 to 2018 with the exception of 1972 and 1988, when escapement was not monitored.

Coho Salmon

Coho salmon escapements have been monitored with a single foot survey on McRoberts Creek (a tributary of Jim Creek) from 1985 to present. A weir has also been operated on Jim Creek to enumerate coho salmon (data not provided), but a goal has not yet been developed.

Weirs are also operated on Fish Creek, and the Little Susitna and Deshka rivers to assess escapement for each stock (Oslund et al. 2017). On the Little Susitna River, estimates of harvest from the ADF&G statewide harvest survey (SWHS[2]) have been used in conjunction with weir counts to estimate escapement.

Sockeye Salmon

Kasilof and Kenai rivers sockeye salmon escapement goals are primarily based on escapement data from sonar projects, harvest estimates, and age data. Sonar was used to estimate sockeye salmon abundance passing specific locations in these rivers because the size of the channels and high glacial turbidity precludes visual enumeration (Glick and Willette 2018). 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. 2013), Russian River (Begich et al. 2017), and Fish Creek (Oslund et al. 2017). Packers Creek escapement has been counted with both video cameras and weirs. From 2009 to 2018, a video camera was operated at Packers Creek to estimate sockeye salmon escapement (Shields and Frothingham 2018), although equipment complications prevented complete counts in 2010–2013 and 2016–2017.

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. Hatchery-reared sockeye salmon juveniles were stocked annually in the Kasilof River drainage from 1976 to 2004; returning hatchery adults were not removed from Kasilof River sockeye salmon total return estimates. The last adults returned in 2010 from the last Tustumena Lake fry release (Shields and Dupuis 2013). Escapement is estimated by subtracting the number of sockeye salmon harvested in sport fisheries upstream of the sonar site and, when applicable, the number of sockeye salmon removed for hatchery broodstock 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.

The current 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. A separate report was written detailing the escapement goal analysis for Kenai River sockeye salmon (Hasbrouck et al. *In prep*); however, some information is provided within this report. Prior to the 2016 review (Erickson et al. 2017), the escapement was estimated by subtracting the number

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[2] Alaska Sport Fishing Survey database [Internet]. 1996–present. Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/.

of sockeye salmon harvested in sport 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 and the prior 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 was very small (1981–2014 average 1.5%). The number of sockeye salmon harvested in sport fisheries upstream of the sonar site is estimated annually using the SWHS and creel surveys (1994, 1995) conducted during the fishery (Schwager-King 1995; King 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 2017). 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.

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 1968. Genetic stock-specific harvest estimates (2006–2017) 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, and Crescent rivers, and Fish Creek; as well as 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. 2011a; Yanusz et al. 2011b) 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 2018 sockeye salmon run estimates, the catch allocation model used DIDSON estimates for Kenai River and Kasilof River escapements and expanded (based on mark–recapture) weir counts (Judd, Chelatna, and Larson lakes) for the 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 2018 because the estimates based on genetics were unavailable.

ESCAPEMENT GOAL DEVELOPMENT

Stock-Recruitment Analyses

When possible we used a Ricker (1954) stock-recruitment model to estimate escapement that maximizes sustainable yields to develop spawning escapement goals. Hilborn and Walters (1992), Quinn and Deriso (1999), and the Chinook Technical Committee of the Pacific Salmon

Commission (CTC 1999) provide clear descriptions of the Ricker model and diagnostics to assess model fit.

Evaluation of Susitna River Chinook Salmon Escapement Goals

Reference Points and Optimal Yield Profiles

A state-space model was developed to generate annual abundance estimates for 4 Susitna River Chinook salmon stocks and fit stock-recruitment (S-R) relationships for use in developing escapement goal recommendations based on estimates of MSY (Reimer and Decovich 2020). Model fitting involved finding parameter values that could have plausibly resulted in the observed data. Optimum yield profiles were used to quantify the yield (of prospective escapement goals), taking into consideration the uncertainty about the true abundance and productivity of the stock.

Escapement Goals Standardized to S_{MSY}

To compare escapement goals from this study to goals for other Alaska stocks, we divided the lower and upper bounds of 21 published goals for Alaska Chinook salmon (Munro and Volk 2016) by point estimates of S_{MSY} associated with each goal range, thereby expressing all goal ranges in terms of multiples of S_{MSY}. These values were used to provide a graphical comparison of the recommended goals for each of the 4 Susitna River Chinook salmon stock goals with the existing goals for 21 other Alaskan Chinook salmon stocks (e.g., see tick marks on Figure 2).

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

Beginning in 2013, adaptive resolution imaging sonar (ARIS) was deployed at RM 13.7, making it possible to monitor nearly the entire cross section of the river to produce direct counts of Chinook salmon 75 cm METF and longer. For the escapement goal review in 2016, age-structured stock-recruit models were fitted to 1986–2015 abundance, harvest, and age data for Chinook salmon 75 cm METF and longer (Fleischman and Reimer 2017). It was decided from the recent 3 years of data (2016–2018), that these escapement goals did not need reanalysis or updating.

Evaluation of Kenai and Kasilof Rivers Sockeye Salmon Escapement Goals

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. We applied additional stock-recruitment models (Hasbrouck et al. *In prep*; described below) to examine stock productivity and evaluate the existing escapement goal for Kenai River sockeye salmon.

We compared the fit of 5 candidate stock-recruitment models to data from brood years 1968 to 2012 (i.e., all available spawner-return data): classical Ricker, autoregressive Ricker, brood year interaction Ricker, Beverton-Holt, and Deriso-Schnute.

<u>Classic Ricker model</u>

$$R_t = S_t \ exp\left[\alpha - \beta S_t\right] + \varepsilon_t \qquad (1)$$

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. The Ricker model assumes over-compensative density-dependent effects that produce lower recruits after a certain number of spawners has been exceeded.

Autoregressive Ricker model

$$R_t = S_t \ exp\left[\alpha - \beta S_t\right] + \varphi \varepsilon_{t-1} \tag{2}$$

where φ is a lag-1 autoregressive parameter. In this autoregressive Ricker model, process errors are not independent, but serially dependent on process error from the previous brood year. This model was selected to develop the current escapement goal for Kasilof River sockeye salmon.

Beverton-Holt model

$$R_t = \frac{\alpha S_t}{1 + \beta S_t} + \varepsilon_t \tag{3}$$

The Beverton-Holt model (Beverton and Holt 1957) assumes compensative density-dependence that would produce constant recruits after a certain number of spawners has been exceeded.

Deriso-Schnute model

$$R_t = \alpha S_t \left(1 - \beta \gamma S_t\right)^{1/\gamma} + \varepsilon_t \tag{4}$$

where γ is a parameter. The Deriso-Schnute model (Deriso 1980; Schnute 1985) is an intermediate between the Ricker and Beverton-Holt models. When $\gamma = 0$, this model is equivalent to the Ricker model, and when $\gamma = -1$, the Deriso-Schnute model is equivalent to the to Beverton-Holt model.

Additive brood interaction Ricker model

$$R_t = S_t \ exp\left[\alpha - \beta_1 S_t - \beta_2 S_{t-1}\right] + \varepsilon_t \tag{5}$$

where S_{t-1} is spawners from the previous year. The additive brood interaction Ricker model assumes that density dependent effects are additive between brood year spawners (S_t) and spawners from the previous brood year (S_{t-1}). This is based on an observation that sockeye salmon juveniles entering nursery lakes must compete with those of previous year.

Multiplicative brood interaction Ricker model

$$R_t = S_t \ exp\left[\alpha - \beta S_t S_{t-1}\right] + \varepsilon_t \tag{6}$$

The multiplicative brood interaction Ricker model (Carlson et al. 1999) assumes that density dependent effects are multiplicative between brood years. This model was run for Kenai River populations selected for consideration in the previous Kenai River escapement goal review (Erickson et al. 2017). The multiplicative brood interaction Ricker model was used only for the Kenai River stock, which was also analyzed using the 5 models listed above.

In all 6 models above, log-normal error structure was assumed. All models were fitted using Bayesian modeling software (JAGS; Appendix F1). In this, the following model transformations were implemented: 1) all models were converted into log-linear form, 2) spawner abundance (S) was divided by 10,000, and 3) γ parameter of Deriso-Schnute model was multiplied by −1. These transformations were made so that all the estimated model parameters would fall into a similar range between 0 and 10. Model parameter priors were set to a uniform distribution of range between 0 and 10. The starting value of the model was randomly selected by the model default. The model was run for 100,000 iterations, of which the first 20,000 were thrown away (i.e., burned in), and samples were taken every 10th iteration (i.e., thinning by 10). For selection of the best model, Deviance Information Criterion (DIC) was calculated. DIC is a Bayesian equivalent of Akaike's Information Criterion (AIC; Akaike 1973). As a rule of thumb, a difference of DIC less than 5 is not considered definitive (Carlin and Louis 2009).

For Kasilof River sockeye salmon, the recommend escapement goal range was derived from model estimates of escapement that provide for 90–100% of maximum sustained yield (MSY). This range meets a common standard of Optimum Yield (≥90% of MSY) used by the Alaska Department of Fish and Game (Bernard and Jones III 2010).

Yield Analysis

In this review, we developed a Markov yield table for the Kasilof River sockeye salmon data set (Hilborn and Walters 1992). We constructed the yield table by partitioning the data into overlapping intervals of 100,000 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 with the Percentile Approach (Clark et al. 2014). This approach is used to establish sustainable escapement goals for stocks that lack sufficient stock productivity information. For the Percentile Approach, the percentiles of observed escapements (whether estimates or indices) and consideration for contrast in the escapement data, exploitation of the stock, as well as measurement error in the assessment, are used to choose escapement goal ranges. Percentile ranking is the percent of all observed 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 set as the 0th percentile (i.e., none of the escapement values are less than the smallest). The percentiles of all remaining escapement values are cumulative, or a summation of $1/(n-1)$, where n is the number of escapement values. Contrast in the escapement data is the maximum observed escapement divided by the minimum observed escapement. Clark et al. (2014) provided a comprehensive evaluation of the Percential Approach and recommended 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 20th to 60th percentiles;
- Tier 2 – high contrast (>8) and low measurement error (weirs, towers) with low to moderate average harvest rates (<0.40), the 15th to 65th percentiles;
- Tier 3 – low contrast (≤8) with low to moderate average harvest rates (<0.40), the 5th to 65th percentiles

They also recommended not using the 3-tier Percentile Approach for stocks with average harvest rates ≥0.40, or those that have both very low contrast (≤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 Percentile Approach with updated or revised escapement data. If the estimated SEG range was consistent with the current goal (i.e., a high degree of overlap), the committee recommended no change to the goal.

Risk Analysis

In UCI, Campbell Creek Chinook salmon is the only goal based on the risk analysis method (Bernard et al. 2009). The risk analysis method is used to develop lower bound SEGs for stocks that are passively managed and have coincidental (nondirected) harvests. 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 committee recommended to the Commercial Fisheries and Sport Fisheries division directors that for Susitna River drainage Chinook salmon, 10 of the 13 goals be discontinued, and those goals be revised into 3 aggregated stock goals (Eastside Susitna, Talkeetna River, and Yentna River; Table 2). The 3 remaining escapement goals for Susitna River Chinook salmon (Deshka River, Alexander Creek, and Chulitna River), all have recommended updates in ranges, as well as changing the Deshka River SEG to a BEG. Of the 23 other salmon escapement goals in UCI, the committee recommended the following: discontinuing 1 Chinook salmon goal (Lewis River) and making changes to 4 Chinook salmon SEGs (Chuitna River, Theodore River, Little Susitna River aerial, and Crooked Creek); updating ranges for 3 coho salmon SEGs (Fish Creek, Jim Creek, and Little Susitna River); and updating ranges for 3 sockeye salmon goals (BEG for Kasilof River, SEGs for Kenai River and late-run Russian River). 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 discussed here remained *status quo*. Munro (2019) provides a comprehensive review of goal performance from the 2010 to 2018 escapements (see Table 3 for summary of current escapement goals and escapements from 2016 through 2018).

CHINOOK SALMON

Susitna River drainage

Deshka River

Deshka River Chinook salmon have an existing SEG of 13,000–28,000 fish. Escapements at the lower bound of the range have 97% probability of producing a yield greater than 80% of MSY, whereas escapements at the upper bound of the range have 11% probability of producing yields greater than 80% of MSY, based on the analysis in Reimer and DeCovich (2020) (Figure 2). The recommended BEG of 9,000–18,000 fish has 90% probability of achieving 80% of MSY at the lower bound and 76% probability of achieving 80% MSY at the upper bound.

Eastside Susitna River

Goose, Little Willow, Montana, Sheep, and Willow creek stocks have existing SEGs based on single aerial surveys. For management purposes, ADF&G has used these 5 annual single aerial surveys to make 5 run size determinations without considering the variability associated among aerial counts. This analysis leveraged the six[3] pieces of information to make 1 run-size estimate (for the stock aggregate) while accounting for correlation in run sizes among the spawning populations and variability in survey observability.

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[3] Kashwitna River is surveyed but does not have an existing goal range.

The proposed SEG of 13,000–25,000 fish has 96% probability of achieving greater than 80% of MSY at the lower bound and 20% probability of achieving greater than 80% of MSY at the upper bound (Figure 3). Modeled escapements were lower than 13,000 in 1980–1982 and 2010–2012 (6 of 39 modeled years). Modeled escapements above the upper bound of 25,000 occurred in 18 of 39 modeled years.

Talkeetna River

Clear Creek and Prairie Creek spawning aggregates have SEGs that are based on single annual aerial surveys. ADF&G has used these surveys to make 2 run size determinations without considering the variability associated between the aerial counts. The state-space analysis leveraged the 2 pieces of information to make 1 run size estimate (for the stock) and accounted for correlation in run sizes between spawning populations and variability in survey observability.

The proposed SEG of 9,000–17,500 fish has 94% probability of achieving greater than 80% of MSY at the lower bound and 41% probability of achieving greater than 80% of MSY at the upper bound (Figure 4). Modeled escapements were lower than 9,000 in 2011 and 2017, and 19 of 39 modeled years were above the upper bound of 17,500.

Yentna River

Lake Creek, Peters Creek, and Talachulitna River stocks have existing SEGs that are based on single annual aerial surveys. ADF&G has used the counts from the aerial survey to make 3 run size determinations without considering the variability associated among the aerial counts. This analysis leveraged four[4] pieces of information to estimate run size for the entire stock while accounting for correlation in run sizes among the spawning populations and variability in survey observability.

The proposed SEG of 13,000–22,000 fish has a 98% probability of achieving greater than 80% of MSY at the lower bound and 47% probability of achieving greater than 80% of MSY at the upper bound (Figure 5).

Alexander Creek

Alexander Creek was not included in the Susitna River drainage run reconstruction and escapement goal analysis because it is physically outside the scope of the mark–recapture abundance projects conducted in the Susitna River drainage in recent years. The current single aerial survey SEG (2,100–6,000) for Alexander Creek was established in 2002. For this review, the committee updated the escapement time series through 2005 (prior to apparently large impacts from invasive northern pike predation; Appendix A1) and applied the 3-tier percentile approach (Clark et al. 2014) to the data set. The committee recommends the Alexander Creek Chinook salmon SEG be updated to 1,900–3,700 (Table 2).

Chulitna River

Chulitna River was originally included in the run reconstruction work for Chinook salmon stocks in the Susitna River drainage. However, model output for this stock was not considered an improvement for escapement goal setting over a single aerial survey because model outputs in the run reconstruction did not give realistic results (Reimer and DeCovich 2020). For example, for some years when abundance apportioned by radiotelemetry data and aerial survey counts were

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[4] Cache Creek is surveyed but does not have an existing goal range.

both available, the telemetry data suggested relatively high abundance and the aerial survey data suggested relatively low abundance. Efforts are currently underway to collect more data that could potentially help diagnose this issue. Until then, the current run assessment strategy is viewed as acceptable. The current single aerial survey SEG (1,800–5,100) for Chulitna River Chinook salmon was established in 2002. For this review, the committee updated the escapement time series through 2018 (Appendix A4) and applied the percentile approach (Clark et al. 2014) to the data set. The committee recommends the SEG for Chulitna River Chinook salmon be updated to 1,200–2,900 fish (Table 2).

Other Northern District Chinook Salmon Stocks with SEGs

Chuitna River

The current single aerial survey SEG (1,200–2,900) for Chuitna River Chinook salmon was established in 2002. For this review, the committee updated the escapement time series only through 2015 (Appendix A3) because aerial counts in the last 3 years are very low relative to other years in the dataset, and we have not seen returns from them yet; therefore, we do not have information on whether they produce sustained yields. The 3-tier Percentile Approach (Clark et al. 2014) was applied to the data set, and the committee recommends the SEG for Chuitna River Chinook salmon be updated to 1,000–1,500 (Table 2).

Theodore River

The current single aerial survey SEG (500–1,700) for Theodore River Chinook salmon was established in 2002. For this review, the committee updated the escapement time series only through 2015 (Appendix A21) because aerial counts in the last 3 years are very low relative to other years in the dataset, and we have not seen returns from them yet; therefore, we do not have information on whether they produce sustained yields. The 3-tier Percentile Approach (Clark et al. 2014) was applied to the data set, and the committee recommends the SEG for Theodore River Chinook salmon be updated to 500–1,000 (Table 2).

Lewis River

The Chinook salmon escapement goal for the Lewis River (SEG; 250–800; Table 2) was last met in 2006. The Lewis River overflowed its bank approximately 1 mile downstream of Beluga Road during a large flood event in in 2006. During an annual Chinook salmon aerial survey conducted the following year (late July 2007), ADF&G staff observed that the channel had diverged into adjacent wetlands cutting off connection with Cook Inlet; this was the first time that ADF&G had knowledge of such an event occurring. No Chinook salmon were observed during this survey (Appendix A12). Action was taken by ADF&G to plug the breach in late July, restoring the original channel; however, it is possible that no Chinook salmon spawned in the Lewis River in 2007.

The river overflowed at the same site during another large flood event in 2012, resulting in the same actions being taken by staff to restore the channel in 2013. The small numbers of Chinook salmon counted in 2012 and 2013 are believed to have ascended the river during flows large enough to allow passage up the old channel (spring thaw and fall rains typically produce the highest annual flows). Sometime prior to the 2015 season, the river overflowed its bank again at the same site, but no action was taken by ADF&G to restore the river. Only 5 Chinook salmon were counted in the 2015 survey, and none were observed in the 2016, 2017, 2018, or 2019 surveys.

The present situation on the Lewis River is that it is forked, flowing east into wetlands by way of an undefined channel and south into Cook Inlet by way of the original channel. The connection with Cook Inlet is thought to be intermittent and dependent on flow volume. The eastern flow may connect with the Ivan River, during higher flows; this was observed in a survey conducted on September 8, 2017. ADF&G considers the present situation of intermittent connection to Cook Inlet to be long-term. Because this greatly affects the ability of Chinook salmon to enter Lewis River, the committee recommends discontinuing the escapement goal.

Little Susitna River

There are 2 Chinook salmon SEGs for this stock: one assessed via a floating weir and the other assessed via single aerial survey (Table 2). The current weir goal was established in 2017 and was not updated during this review. The single aerial survey goal is used only to assess the escapement goal if the Little Susitna River weir is inoperable for a sustained period and complete fish passage can't be assessed. The current single aerial survey SEG (900–1,800) for Little Susitna River Chinook salmon was established in 2002. For this review, the committee updated the escapement time series only through 2017 (Appendices A13 and A14); the aerial count in 2018 was not included because it was very low (530) and we have not seen returns from this escapement yet; therefore, we do not have information on whether it will produce sustained yield. The 3-tier Percentile Approach (Clark et al. 2014) was applied to the data set, and the committee recommends the Little Susitna River single aerial survey Chinook salmon SEG be updated to 700–1,500 (Table 2).

Northern Kenai Peninsula

Kenai River

Large fish (fish ≥75 cm mid eye to tail fork) early-run (2,800-5,600) and late-run (13,500-27,000) Chinook salmon SEGs (assessed via sonar) were adopted for the first time for both of these stocks in 2017 (Fleischman et al 2017). With only 3 new years of return data for both stocks (Appendices A9 and A10), it was concluded that updating the analyses for these stocks would not likely result in substantially different escapement goals; therefore, the committee recommends no changes at this time.

Crooked Creek

The Crooked Creek Chinook salmon SEG of 650–1,700 ocean-age-2 or older fish was last modified in 2002. The SEG only includes naturally produced fish, although hatchery-produced fish pass through the weir and spawn in Crooked Creek. The escapements of naturally produced fish since 2004 are direct counts.

The 3-tier Percentile Approach (Clark et al. 2014) was applied to the data set for 2004–2018. Data prior to 2004 were excluded from this analysis because 100% of the hatchery-produced smolt were not marked with an adipose finclip until smolt year 2000; therefore, the number of naturally produced adults could not be counted accurately. Based on the 3-tier Percentile Approach, the committee recommends the Crooked Creek weir SEG be updated to 700–1,400 fish.

Chum Salmon

Clearwater Creek

The current SEG (3,500–8,000) for Clearwater Creek was established in 2017. For this review, the committee updated the escapement time series through 2018 (Appendix B1). The committee reviewed the updated escapement time series and concluded that updating the analysis for this stock would not likely result in a substantially different escapement goal; therefore, the committee recommends no change to the SEG of 3,500–8,000.

Coho Salmon

Deshka River

A weir-based coho salmon escapement goal (SEG; 10,200–24,100) was adopted for the first time for this stock 2 years ago in 2017. With only 3 new years of return data (Appendix C1), it was concluded that updating the analyses for this stock would not likely result in a substantially different escapement goal; therefore, the committee recommends no changes at this time.

Fish Creek

The current weir-based coho salmon SEG of 1,200–4,400 was established in 2011. The committee updated the escapement time series using weir data through 2018 (Appendix C2). The 3-tier Percentile Approach (Clark et al. 2014) was applied to the data set, and the committee recommends the Fish Creek coho salmon SEG be updated to 1,200–6,000 (Table 2).

Jim Creek

The current SEG of 450–1,400 was established in 2014. Although a weir has been operated on Jim Creek for a few years (1993–1994 and 2015–2018), the current goal and goal assessment is based on a single foot survey of the McRoberts Creek tributary. A weir-based escapement goal is considered preferable because it represents escapements to the entire Jim Creek drainage, not just the easily surveyed McRoberts Creek. The committee will explore a weir-based goal when more years of counts are available, providing additional information about what returns might be expected at a given escapement level. For this report, the committee updated the escapement time series using foot survey data through 2018 (Appendix C3). The 3-tier Percentile Approach (Clark et al. 2014) was applied to the data set, and the committee recommends the Jim Creek coho salmon single foot survey SEG be updated to 250–700 fish.

Little Susitna River

The current SEG of 10,100–17,700 for Little Susitna River coho salmon was established in 2002. The committee updated the escapement time series using weir data (subtracting harvest above the weir) through 2018 (Appendix C4). The 3-tier Percentile Approach (Clark et al. 2014) was applied to the data set, and the committee recommends the Little Susitna River coho salmon SEG be updated to 9,200–17,700 fish.

Sockeye Salmon

Chelatna, Judd, and Larson lakes

The SEGs for the Chelatna, Judd, and Larson lakes sockeye salmon stocks were first established in 2008 from limited times series (Appendices D1, D3, and D6) and were updated in 2017 (Erickson et al. 2017). The current SEGs are Chelatna Lake 20,000–45,000, Judd Lake 15,000–

40,000, and Larson Lake 15,000–35,000. For this review, the committee reviewed the updated times series and concluded that updating the analyses for these stocks would not likely result in substantially different escapement goals. The committee recommends no changes to the SEGs for Chelatna Lake (20,000–45,000), Judd Lake (15,000–40,000), and Larson Lake (15,000–35,000).

Fish Creek

The current SEG (15,000–45,000) for Fish Creek sockeye salmon was established in 2017. For this review, the committee updated and reviewed the escapement time series through 2018 (Appendix D2) and concluded that updating the analyses for this stock would not likely result in a substantially different escapement goal. The committee recommends no change to the SEG range of 15,000–45,000 fish.

Russian River

The current weir-based early-run sockeye salmon SEG (22,000–42,000) was adopted in 2011 using 34 years of data. Updating the stock-recruit analysis with the 7 recent brood returns (Appendix D8) changed estimates of S_{MSY} very little, and the committee recommended no change to the current goal.

The late-run sockeye salmon stock is currently managed to achieve an SEG of 30,000–110,000 established in 2005. Escapement data beginning with 1979 was used, as a fish pass around Russian River falls became operational in that year. Based on the analysis of the 1979–2018 escapements (Appendix D9), the committee recommends a change to the SEG range for late-run Russian River sockeye salmon to 44,000–85,000. The 25th and 75th percentiles were selected due to the annual harvest rate (>60%) of this stock (Clark et al. 2014).

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. Since 1968, Kasilof River sockeye salmon escapement has ranged from approximately 39,000 to 524,000 and returns per spawner values ranged from approximately 0.74 to 8.36 (Figure 6; Appendix D4).

For this review, the committee updated the escapement time series and incorporated production data through 2018. The committee then examined the fit of 5 stock-recruit models to data from brood years 1968–2012 (i.e., all available spawner-return data). Point estimates of S_{MSY} from the 5 models ranged from a low of 222,000 for the Ricker auto regressive model with a 1-yar lag (AR1) to a high of 415,000 for the Beverton-Holt model (Figure 7). The best fitting model based on smallest deviation information criteria (DIC) was the AR1 model (Table 4) that estimates 90% of maximum sustained yield (MSY) at escapements between 140,000 and 320,000 fish (Figure 8). A Markov yield table (Table 5) predicts escapements ranging from 150,000–350,000 will produce yields averaging approximately 700,000 (range 328,000–1,591,000), whereas escapements below this range will produce yields averaging approximately 275,000 (range 64,000–577,00) and escapements above this range will produce yields averaging approximately 450,000 (range −143,000 to +1,207,000). Similarly, the Ricker AR1 yield profile predicts escapements within the proposed BEG (140,000–320,000) will produced yields of approximately 690,000 (range 328,000–1,591,000) (Figure 9). The committee recommends the BEG range of Kasilof River sockeye salmon be updated to 140,000–320,000.

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 51 years (1968–2018), Kenai River late-run sockeye salmon escapements ranged from approximately 73,000 to 2,027,000 and recruits per spawner estimates ranged from approximately 1.22 to 12.69.

Following methods discussed above, the classic Ricker model with data from brood years 1968 through 2012 resulted in an estimate of the spawning escapement that produces maximum sustained yield (S_{MSY}) of 1,290,000 sockeye salmon and escapement bounds that produce 90% of maximum sustained yield (MSY) of 830,000 to 1,822,000 fish. However, as noted in Clark et al. (2007), assessment methodology used for spawner abundance and run size estimates are most consistent starting in 1979, and so 1968–1978 estimates may be inaccurate. Using data from brood years 1979–2012 resulted in an estimated S_{MSY} of 1,206,000 fish and escapement bounds that produce 90% MSY were 774,000 and 1,716,000 fish. These results are consistent with those reported previously (Clark et al. 2007; Erickson et al. 2017; Cunningham 2018). Based on these analyses and consideration of the optimum yield profiles of this stock from multiple stock-recruit models, the committee recommends an SEG of 750,000–1,300,000 for late-run Kenai River sockeye salmon. The analyses are detailed in a separate report (Hasbrouck et al. *In prep*).

Packers Creek

The current SEG (15,000–30,000) for Packers Creek sockeye salmon was established in 2008. For this review, the committee updated the escapement time series through 2018. Since the current SEG was implemented, this stock has achieved the SEG each of the 6 years it was assessed (Appendix D7). The committee reviewed the escapement time series and concluded that updating the analysis for this stock would not likely result in a substantially different escapement goal; therefore, the committee recommended no change.

SUMMARY

The escapement goal committee reviewed the current UCI salmon escapement goals with recommendations to discontinue 10 Chinook salmon goals in the Susitna River drainage and revise those into goals for 3 stocks (Eastside Susitna, Talkeetna River, and Yentna River), discontinue 1 Chinook salmon goal (Lewis River), and change the range of 13 other salmon 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 *Unpublished*), 2004 (Clark et al. 2007; Hasbrouck and Edmundson 2007), 2007 (Fair et al. 2007), 2010 (Fair et al. 2010), 2013 (Fair et al. 2013), 2016 (Erickson et al. 2017) and in this review.

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REFERENCES CITED

Akaike, H. 1973. Information theory and an extension of the maximum likelihood principle. Pages 267-281 [*In*]: Petranand, B. N., and F. Csaki, editors. International Symposium on Information theory. 2nd edition. Akademiai Kiadi, Budapest, Hungary.

Barclay, A. W., C. Habicht, T. Tobias, and T. M. Willette. 2010. Genetic stock identification of Upper Cook Inlet sockeye salmon harvest, 2009. Alaska Department of Fish and Game, Fishery Data Series No. 10–93, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FDS10-93.pdf

Begich, R. N., J. A. Pawluk, J. L. Cope, and S. K. Simons. 2017. 2014–2015 Annual Management Report and 2016 sport fisheries overview for Northern Kenai Peninsula: fisheries under consideration by the Alaska Board of Fisheries, 2017. Alaska Department of Fish and Game, Fishery Management Report No. 17-06, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMR17-06.pdf

Bernard, D. R. 1983. Variance and bias of catch allocations that use the age composition of escapements. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet No. 227, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/afrbil.227.pdf

Bernard, D. R., J. J. Hasbrouck, B. G. Bue, and R. A. Clark. 2009. Estimating risk of management error from precautionary reference points (PRPs) for non-targeted salmon stocks. Alaska Department of Fish and Game, Special Publication No. 09-09, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/SP09-09.pdf

Bernard, D. R., and E. L. Jones III. 2010. Optimum escapement goals for Chinook salmon in the transboundary Alsek River. Alaska Department of Fish and Game, Fishery Manuscript Series No. 10-02, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FMS10-02.pdf

Beverton, R. J. H., and S. J. Holt. 1957. On the dynamics of exploited fish populations. Fisheries Investment Series 2, Vol. 19 U.K. Ministry of Agriculture and Fisheries, London.

Carlin, B. P., and T. A. Louis. 2009. Bayesian methods for data analysis, 3rd edition. CRC Press.

Carlson, S. R., K. E. Tarbox, and B. G. Bue. 1999. The Kenai Sockeye Salmon Simulation Model: A Tool for Evaluating Escapement and Harvest Levels. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A99-08, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/RIR.2A.1999.08.pdf

Clark, J. H., D. M. Eggers, and J. A. Edmundson. 2007. Escapement goal review for Kenai River late-run sockeye salmon: Report to the Alaska Board of Fisheries, January 2005. Alaska Department of Fish and Game, Special Publication No. 07-12, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/sp07-12.pdf

Clark, R. A., D. M. Eggers, A. R. Munro, S. J. Fleischman, B. G. Bue, and J. J. Hasbrouck. 2014. An evaluation of the percentile approach for establishing Sustainable Escapement Goals in lieu of stock productivity information. Alaska Department of Fish and Game, Fishery Manuscript No. 14-06, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMS14-06.pdf

Cleary, P., J. Campbell, and R. Yanusz. 2014a. Susitna River Chinook and coho salmon inriver abundance and distribution and pink salmon spawning distribution. Alaska Department of Fish and Game, Regional Operational Plan ROP.SF.2A.2014.15, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/ROP.SF.2A.2014.15.pdf

Cleary, P., R. Yanusz, and J. Campbell. 2014b. Susitna River Chinook and coho salmon inriver abundance and distribution and pink salmon spawning distribution. Alaska Department of Fish and Game, Division of Sport Fish, Regional Operational Plan ROP.SF.2A.2013.24, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/ROP.SF.2A.2013.24.pdf

Cope, J. 2011. Early-run Chinook salmon creel survey, Kasilof River, Alaska, 2002–2008. Alaska Department of Fish and Game, Fishery Data Series No. 11-18, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FDS11-18.pdf

REFERENCES CITED (Continued)

Cope J. 2012. Early-run Chinook salmon creel survey, Kasilof River, Alaska, 2009–2010. Alaska Department of Fish and Game, Fishery Data Series No. 12-80, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FDS12-80

CTC (Chinook Technical Committee). 1999. Maximum sustained yield of biologically sustained escapement goals for selected Chinook stocks used by the Pacific Salmon Commission's Joint Technical Committee for escapement assessment, Volume 1. Pacific Salmon Commission Joint Technical Committee Report No. TCCHINOOK (99)-3, Vancouver, British Columbia, Canada.

Cunningham, C. J. 2018. Exploration of overcompensation and spawning abundance producing maximum sustainable yield for Upper Cook Inlet sockeye salmon stocks. In NPFMC. 2018. Discussion Paper: Revisions to the Fishery Management Plan for the salmon fisheries in the EEZ off Alaska. November 6, 2018. Anchorage, AK 99501.

DeCovich, N., J. Campbell, and D. Evans. *In prep*. Susitna River Chinook salmon abundance and distribution, 2017. Alaska Department of Fish and Game, Fishery Data Series No. 20-04, Anchorage.

Deriso, R. B. 1980. Harvesting strategies and parameter estimation for an age-structured model. Canadian Journal of Fisheries and Aquatic Sciences 37(2):268-282. https://doi.org/10.1139/f80-034

Erickson, J. W., T. M. Willette, and T. McKinley. 2017. Review of salmon escapement goals in Upper Cook Inlet, Alaska, 2016. Alaska Department of Fish and Game, Fishery Manuscript No. 17-03, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMS17-03.pdf

Eskelin, A., and A. W. Barclay. 2019. Eastside set gillnet Chinook salmon harvest composition in Upper Cook Inlet, Alaska, 2018, with large fish composition estimates for 2010–2014. Alaska Department of Fish and Game, Fishery Data Series No. 19-26, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FDS19-26.pdf

Fair, L. F., R. A. Clark, and J. J. Hasbrouck. 2007. Review of salmon escapement goals in Upper Cook Inlet, Alaska, 2007. Alaska Department of Fish and Game, Fishery Manuscript No. 07-06, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fms07-06.pdf

Fair, L. F., T. M. Willette, and J. Erickson. 2009. Escapement goal review for Susitna River sockeye salmon, 2009. Alaska Department of Fish and Game, Fishery Manuscript Series No. 09-01, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fms09-01.pdf

Fair, L. F., T. M. Willette, and J. W. Erickson. 2013. Review of salmon escapement goals in Upper Cook Inlet, Alaska, 2013. Alaska Department of Fish and Game, Fishery Manuscript Series No. 13-13, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FMS13-13

Fair, L. F., T. M. Willette, J. W. Erickson, R. J. Yanusz, and T. R. McKinley. 2010. Review of salmon escapement goals in Upper Cook Inlet, Alaska, 2011. Alaska Department of Fish and Game, Fishery Manuscript Series No. 10-06, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FMS10-06.pdf

Fleischman, S. J., and T. R. McKinley. 2013. Run reconstruction, spawner–recruit analysis, and escapement goal recommendation for late-run Chinook salmon in the Kenai River. Alaska Department of Fish and Game, Fishery Manuscript Series No. 13-02, Anchorage. http://www/adfg/alaska.gov/FedAidpdfs/FMS13-02

Fleischman, S. J., and A. M. Reimer. 2017. Spawner-recruit analyses and escapement goal recommendations for Kenai River Chinook salmon. Alaska Department of Fish and Game, Fishery Manuscript Series No. 17-02, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMS17-02.pdf

Fried, S. M. 1994. Pacific salmon spawning escapement goals for the Prince William Sound, Cook Inlet, and Bristol Bay areas of Alaska. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Special Publication No. 8, Juneau. http://www.adfg.alaska.gov/FedAidPDFs/cfsp.08.pdf

Glick, W. J., and T. M. Willette. 2018. Upper Cook Inlet sockeye salmon escapement studies, 2015. Alaska Department of Fish and Game, Fishery Data Series No. 18-22, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FDS18-22.pdf

REFERENCES CITED (Continued)

Habicht, C., W. D. Templin, T. M. Willette, L. F. Fair, S. W. Raborn, and L. W. Seeb. 2007. Post-season stock composition analysis of Upper Cook Inlet sockeye salmon harvest, 2005-2007. Alaska Department of Fish and Game, Fishery Manuscript No. 07-07, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fms07-07.pdf

Hasbrouck, J. J., and J. A. Edmundson. 2007. Escapement goals for salmon stocks in Upper Cook Inlet, Alaska: report to the Alaska Board of Fisheries, January 2005. Alaska Department of Fish and Game, Special Publication No. 07-10, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/sp07-10.pdf

Hasbrouck, J. J., W. D. Templin, A. R. Munro, K. G. Howard, and T. Hamazaki. *In prep*. Spawner–recruit analyses and escapement goal recommendation for Kenai River late-run sockeye salmon. Alaska Department of Fish and Game, Fishery Manuscript Series, Anchorage.

Hilborn, R., and C. J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics and uncertainty. Chapman and Hall, New York. King, M. A. 1997. Fishery surveys during the recreational and personal use dip net fisheries for late-run sockeye salmon to the Kenai River, 1995. Alaska Department of Fish and Game, Fishery Data Series No. 97-4, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds97-04.pdf

Lescanec, D. 2017. Deshka River Chinook and coho salmon escapement studies, 2005–2014. Alaska Department of Fish and Game, Fishery Data Series No. 17-10, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FDS17-10.pdf

Miller, J. D., D. L. Burwen, B. H. Key, and S. J. Fleischman. 2016. Chinook salmon passage in the Kenai River at River Mile 13.7 using adaptive resolution imaging sonar, 2014. Alaska Department of Fish and Game, Fishery Data Series No. 16-44, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FDS16-44.pdf

Munro, A. R. 2019. Summary of Pacific salmon escapement goals in Alaska with a review of escapements from 2010 to 2018. Alaska Department of Fish and Game, Fishery Manuscript Series No. 19-05, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMS19-05.pdf

Munro, A. R., and E. C. Volk. 2016. Summary of Pacific salmon escapement goals in Alaska with a review of escapements from 2007 to 2015. Alaska Department of Fish and Game, Fishery Manuscript Series No. 16-04, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMS16-04.pdf

Oslund, S., S. Ivey, and D. Lescanec. 2017. Area management report for the recreational fisheries of northern Cook Inlet, 2014–2015. Alaska Department of Fish and Game, Fishery Management Report No. 17-07, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMR17-07.pdf

Perschbacher, J., and T. Eskelin. 2016. Chinook salmon creel survey and inriver gillnetting study, Lower Kenai River, Alaska, 2014. Alaska Department of Fish and Game, Fishery Data Series No. 16-54, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FDS16-54.pdf

Quinn, T. J., II, and R. Deriso. 1999. Quantitative fish dynamics. Oxford University Press, New York.

Ricker, W. E. 1954. Stock and recruitment. Journal of Fisheries and Research Board of Canada 11:559-623.

Reimer, A. M. and N. A. DeCovich. 2020. Susitna River Chinook salmon run reconstruction and escapement goal analysis. Alaska Department of Fish and Game, Fishery Manuscript No. 20-01, Anchorage.

Schnute, J. 1985. A general theory for analysis of catch and effort data. Canadian Journal of Fisheries and Aquatic Sciences 42(3):414-429.

Schwager-King, M. A. 1995. Fishery surveys during the recreational fishery for late-run sockeye salmon in the Kenai River, 1994. Alaska Department of Fish and Game, Fishery Data Series No. 95-28, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds95-28.pdf

Shields, P., and A. Dupuis. 2013. Upper Cook Inlet commercial fisheries annual management report, 2012. Alaska Department of Fish and Game, Fishery Management Report No. 13-21, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMR13-21.pdf

REFERENCES CITED (Continued)

Shields, P., and A. Dupuis. 2017. Upper Cook Inlet commercial fisheries annual management report, 2016. Alaska Department of Fish and Game, Fishery Management Report No. 17-05, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMR17-05.pdf

Shields, P., and A. Frothingham. 2018. Upper Cook Inlet commercial fisheries annual management report, 2017. Alaska Department of Fish and Game, Fishery Management Report No. 18-10, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMR18-10.pdf

Tobias, T., and K. E. Tarbox. 1999. An estimate of total return of sockeye salmon to Upper Cook Inlet, Alaska, 1976-1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A99-11, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/RIR.2A.1999.11.pdf

Tobias, T. M., W. M. Gist, and T. M. Willette. 2013. Abundance, age, sex, and size of Chinook, sockeye, coho, and chum salmon returning to Upper Cook Inlet, Alaska, 2011. Alaska Department of Fish and Game, Fishery Data Series No. 13-49, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FDS13-49.pdf

Yanusz, R., R. Merizon, D. Evans, M. Willette, T. Spencer, and S. Raborn. 2007. Inriver abundance and distribution of spawning Susitna River sockeye salmon Oncorhynchus nerka, 2006. Alaska Department of Fish and Game, Fishery Data Series No. 07-83, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds07-83.pdf

Yanusz, R. J., R. A. Merizon, T. M. Willette, D. G. Evans, and T. R. Spencer. 2011a. Inriver abundance and distribution of spawning Susitna River sockeye salmon *Oncorhynchus nerka,* 2008. Alaska Department of Fish and Game, Fishery Data Series No. 11-12, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FDS11-12.pdf

Yanusz, R. J., R. A. Merizon, T. M. Willette, D. G. Evans, and T. R. Spencer. 2011b. Inriver abundance and distribution of spawning Susitna River sockeye salmon *Oncorhynchus nerka*, 2007. Alaska Department of Fish and Game, Fishery Data Series No. 11-19, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FDS11-19.pdf

TABLES

Table 1.–List of members on the Alaska Department of Fish and Game Upper Cook Inlet salmon escapement goal committee who assisted with the 2018/2019 escapement goal review.

Name	Position	Division affiliation
Escapement Goal Committee		
Robert Begich	Area Research Biologist	Sport Fish
Robert DeCino	Area Research Biologist	Commercial Fisheries
Nick DeCovich	Area Research Biologist	Sport Fish
Jack Erickson	Regional Research Biologist	Commercial Fisheries
Jim Hasbrouck	Chief Fisheries Scientist	Sport Fish
Katherine Howard	Fisheries Scientist	Sport Fish
Tim McKinley	Regional Research Biologist	Sport Fish
Andrew Munro	Fisheries Scientist	Commercial Fisheries
Adam Reimer	Biometrician/Area Research Biologist	Sport Fish
Bill Templin	Chief Fisheries Scientist	Commercial Fisheries
Other Participants		
Jay Baumer	Area Management Biologist/Regional Management Biologist	Sport Fish
Brittany Blain	Area Management Biologist	Sport Fish
Rich Brenner	Headquarters Research Biologist	Commercial Fisheries
Tony Eskelin	Area Research Biologist	Sport Fish
Alyssa Frothingham	Asst. Area Management Biologist	Commercial Fisheries
Bill Glick	Area Research Biologist	Commercial Fisheries
Rick Green	Special Assistant to the Commissioner	Commissioners Office
Hamachan Hamazaki	Regional Biometrician	Commercial Fisheries
Sam Ivey	Area Management Biologist	Sport Fish
Bert Lewis	Regional Supervisor	Commercial Fisheries
Colton Lipka	Area Management Biologist	Sport Fish
Brian Marston	Area Management Biologist	Commercial Fisheries
Matt Miller	Regional Management Biologist	Sport Fish
Aaron Poetter	Regional Management Biologist	Commercial Fisheries
Adam St. Saviour	Area Research Biologist	Sport Fish
Pat Shields	Regional Management Biologist	Commercial Fisheries
Tom Vania	Regional Supervisor	Sport Fish
Tania Vincent	Regional Research Biologist	Sport Fish
Xinxian Zhang	Regional Biometrician	Commercial Fisheries

Table 2.–Summary of current escapement goals and recommended escapement goals for salmon stocks in Upper Cook Inlet, 2019.

	Current escapement goal			Recommended escapement goal							
System	Goal	Type	Year adopted	Range or lower bound	Type	Data	Action	Contrast	Harvest rate	Measurement error	Tier
Chinook Salmon											
Susitna River Drainage (Included in run reconstruction. New group goals replace individual tributary goals.)											
Yentna River				13,000–22,000	SEG	SR model	New				
Talachulitna R.	2,200–5,000	SEG	2002	discontinue	SEG	SAS	discontinue				
Lake Creek	2,500–7,100	SEG	2002	discontinue	SEG	SAS	discontinue				
Peters Creek	1,000–2,600	SEG	2002	discontinue	SEG	SAS	discontinue				
Deshka River				9,000–18,000	BEG	SR model	New				
Deshka River	13,000–28,000	SEG	2011	discontinue	SEG	Weir	discontinue				
Talkeetna R.				9,000–17,500	SEG	SR model	New				
Clear (Chunilna) Cr.	950–3,400	SEG	2002	discontinue	SEG	SAS	discontinue				
Prairie Creek	3,100–9,200	SEG	2002	discontinue	SEG	SAS	discontinue				
Eastside Susitna River				13,000–25,000	SEG	SR model	New				
Goose Creek	250–650	SEG	2002	discontinue	SEG	SAS	discontinue				
Little Willow Cr.	450–1,800	SEG	2002	discontinue	SEG	SAS	discontinue				
Montana Cr.	1,100–3,100	SEG	2002	discontinue	SEG	SAS	discontinue				
Sheep Creek	600–1,200	SEG	2002	discontinue	SEG	SAS	discontinue				
Willow Creek	1,600–2,800	SEG	2002	discontinue	SEG	SAS	discontinue				
Chulitna River	1,800–5,100	SEG	2002	1,200–2,900	SEG	SAS	Update [a]	13.5	<0.40	High	T1
Alexander Creek	2,100–6,000	SEG	2002	1,900–3,700	SEG	SAS	Update [a]	6.1	<0.40	High	T3

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	Current escapement goal			Recommended escapement goal							
System	Goal	Type	Year adopted	Range or lower bound	Type	Data	Action	Contrast	Harvest rate	Measurement error	Tier
Chinook Salmon											
West Cook Inlet and Knik Arm											
Lewis River	250–800	SEG	2002	discontinue	SEG	SAS	Discontinue. Stream cut off from sea.	200	<0.40	High	T1
Chuitna River	1,200–2,900	SEG	2002	1,000–1,500	SEG	SAS	Update [a]	17.2	<0.40	High	T1
Theodore River	500–1,700	SEG	2002	500–1,000	SEG	SAS	Update [a]	123.3	<0.40	High	T1
Little Susitna R. weir [b]	2,300–3,900	SEG	2017	2,100–4,300	SEG	Weir	No change	3	<0.40	Low	T3
Little Susitna R. aerial [b]	900–1,800	SEG	2002	700–1,500	SEG	SAS	Update [a]	6	<0.40	High	T3
Anchorage											
Campbell	380	LB SEG	2011	380	LB SEG	SFS	No change				
Northern Kenai Peninsula											
Crooked Creek	650–1,700	SEG	2002	700–1,400	SEG	Weir	Update	3.6	<0.40	Low	T3
Kenai R. early run large fish	2,800–5,600 [c]	SEG	2017	2,800–5,600 [c]	SEG	Sonar	No change				
	3,900–6,600	OEG	2017	3,900–6,600	OEG						
Kenai R. late run large fish	13,500–27,000 [c]	SEG	2017	13,500–27,000 [c]	SEG	Sonar	No change				
Chum Salmon											
Clearwater Creek	3,500–8,000	SEG	2017	3,500–8,000	SEG	PAS	No change				
Coho Salmon											
Susitna River Drainage											
Deshka River	10,200–24,100	SEG	2017	10,200–24,100	SEG	Weir	No change				
Knik Arm											
Fish Creek (Knik)	1,200–4,400	SEG	2011	1,200–6,000	SEG	Weir	Update [a]	52.3	<0.40	Low	T2
Jim Creek	450–1,400	SEG	2014	250–700	SEG	SFS	Update [a]	422.9	<0.40	High	T1
Little Susitna River [d]	10,100–17,700	SEG	2002	9,200–17,700	SEG	Weir	Update [a]	15.9	<0.40	Low	T2

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Table 2.–Page 3 of 3.

	Current escapement goal			Recommended escapement goal							
System	Goal	Type	Year adopted	Range or lower bound	Type	Data	Action	Contrast	Harvest rate	Measurement error	Tier
Sockeye salmon											
Susitna River											
Chelatna Lake	20,000–45,000	SEG	2017	20,000–45,000	SEG	Weir	No change				
Judd Lake	15,000–40,000	SEG	2017	15,000–40,000	SEG	Weir	No change				
Larson Lake	15,000–35,000	SEG	2017	15,000–35,000	SEG	Weir	No change				
Cook Inlet and Knik Arm											
Fish Creek	15,000–45,000	SEG	2017	15,000–45,000	SEG	Weir	No change				
Packers Creek	15,000–30,000	SEG	2008	15,000–30,000	SEG	Weir	No change				
Northern Kenai Peninsula											
Kasilof River	160,000–340,000 160,000–390,000	BEG OEG	2011 2011	140,000–320,000	BEG	Sonar	Update				
Kenai River	700,000–1,200,000	BEG	2011	750,000–1,300,000	SEG	Sonar	Update				
Russian River early run	22,000–42,000	BEG	2011	22,000–42,000	BEG		No change				
Russian River late run	30,000–110,000	SEG	2005	44,000–85,000	SEG	Weir	Update	5.1	0.40>	Low	-

Note: SEG means sustainable escapement goal and BEG means biological escapement goal. PAS means peak aerial survey, SAS means single aerial survey, and SFS means single foot survey. SR model means stock-recruit model. Shaded cells indicate new recommendations.

[a] 3-tier Percentile Approach.

[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.

[c] Fish 75 cm mid eye to tail fork (METF) or longer.

[d] Based on escapement (weir count minus harvest above weir).

Table 3.–Current escapement goals and escapements observed from 2016 through 2018 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] 2016	2017	2018
Chinook Salmon						
Alexander Creek	SAS	SEG	2,100–6,000	754	170	296
Campbell Creek	SFS	LB SEG	380	544	475	287
Chuitna River	SAS	SEG	1,200–2,900	1,372	235	939
Chulitna River	SAS	SEG	1,800–5,100	1,151	NS	1,125
Clear (Chunilna) Creek	SAS	SEG	950–3,400	NS	780	940
Crooked Creek	Weir	SEG	650–1,700	1,747	911	714
Deshka River	Weir	SEG	13,000–28,000	22,774	11,383	8,549
Goose Creek	SAS	SEG	250–650	NS	148	90
Kenai River early-run	Sonar	SEG	2,800-5,600			
Kenai River early-run	Sonar	OEG	3,900–6,600	6,478	6,725	2,909
Kenai River late -un	Sonar	OEG	13,500–27,000	14,676	20,634	17,285
Lake Creek	SAS	SEG	2,500–7,100	3,588	1,601	1,767
Lewis River	SAS	SEG	250–800	0	0	0
Little Susitna River (aerial)	SAS	SEG	900–1,800	1,622	1,192	530[a]
Little Susitna River (weir)	Weir	SEG	2,100-4,300	4,969	2,531	936[C]
Little Willow Creek	SAS	SEG	450–1,800	675	840	280
Montana Creek	SAS	SEG	1,100–3,100	692	603	473
Peters Creek	SAS	SEG	1,000–2,600	1,122	307	1,674
Prairie Creek	SAS	SEG	3,100–9,200	1,853	1,930	1,194
Sheep Creek	SAS	SEG	600–1,200	NS	NS	334
Talachulitna River	SAS	SEG	2,200–5,000	4,295	1,087	1,483
Theodore River	SAS	SEG	500–1,700	68[c]	21[c]	18[c]
Willow Creek	SAS	SEG	1,600–2,800	1,814	1,329	411
Chum Salmon						
Clearwater Creek	PAS	SEG	3,500–8,000	5,056	7,040	1,800
Coho Salmon						
Fish Creek	Weir	SEG	1,200–4,400	2,484	8,966	5,022
Jim Creek [d]	SFS	SEG	450–1,400	106	607	758
Little Susitna River [e]	Weir	SEG	10,100–17,700	9,096	17,600	NS
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] 2016	2017	2018
Sockeye Salmon						
Chelatna Lake	Weir	SEG	20,000–45,000	60,792	26,986	20,434
Fish Creek (Knik)	Weir	SEG	15,000–45,000	46,202	63,882	72,157
Judd Lake	Weir	SEG	15,000–40,000	NS	35,731	30,844
Kasilof River	Sonar	BEG	160,000–340,000	239,981	358,724	388,009
Kenai River [f]	Sonar	SEG	700,000–1,200,000	1,118,155	1,056,773	831,096
Larson Lake	Weir	SEG	15,000–35,000	14,333	31,866	23,632
Packers Creek	Weir	SEG	15,000–30,000	NS	17,164	16,247
Russian River - Early Run	Weir	BEG	22,000–42,000	38,739	37,123	44,110
Russian River - Late Run	Weir	SEG	30,000–110,000	37,837	45,012	71,052

Note: BEG = biological escapement goal, SEG = sustainable escapement goal, LB SEG = lower bound SEG. NS means no survey.

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

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

[e] Little Susitna River escapement is the weir count minus sport harvest above the weir.

[f] Hidden Lake enhancement passing the weir were not subtracted from the escapement.

Table 4.–Summary of stock-recruit models evaluated for Kasilof River sockeye salmon, brood years 1968–2012.

Model	Parameter	Estimate	95% credible interval	DIC	S_{MSY}
Classic Ricker model				1,260.5	315,631
	$\ln\alpha$	1.713	1.433–1.996		
	β	0.208	0.096–0.317		
Autoregressive Ricker model				1,236.5	222,445
	$\ln\alpha$	2.050	1.639–2.250		
	β	0.330	0.206–0.460		
	φ	0.620	0.373–0.874		
Beverton-Holt model				1,263.5	414,830
	$\ln\alpha$	1.827	1.446–2.304		
	β	0.356	0.114–0.890		
Classic Ricker model with brood interaction				1,263.4	294,589
	$\ln\alpha$	1.731	1.417–2.047		
	β_1	0.231	0.080–0.411		
	β_2	0.007	-0.134–0.216		
Deriso-Schnute model				1,262.1	357,715
	$\ln\alpha$	1.750	1.431–2.134		
	β	0.257	0.105–0.601		
	γ	0.502	0.027–0.976		

Table 5.–Markov yield table for Kasilof River sockeye salmon, brood years 1968–2012 (numbers in thousands of fish).

Escapement interval	Number of years	Mean number of spawners	Mean return	Return per spawner	Yield	
					Mean	Range
0–50	4	44	236	5.4	192	64–301
50–150	7	111	435	3.9	324	549–577
100–200	11	156	716	4.6	560	257–1,103
150–250	15	199	815	4.1	616	328–1,103
200–300	16	246	939	3.8	693	328–1,591
250–350	12	286	1,092	3.8	805	391–1,591
300–400	9	347	986	2.9	638	119–1,309
>350	7	411	863	2.1	451	(-)143– (+)1,207

FIGURES

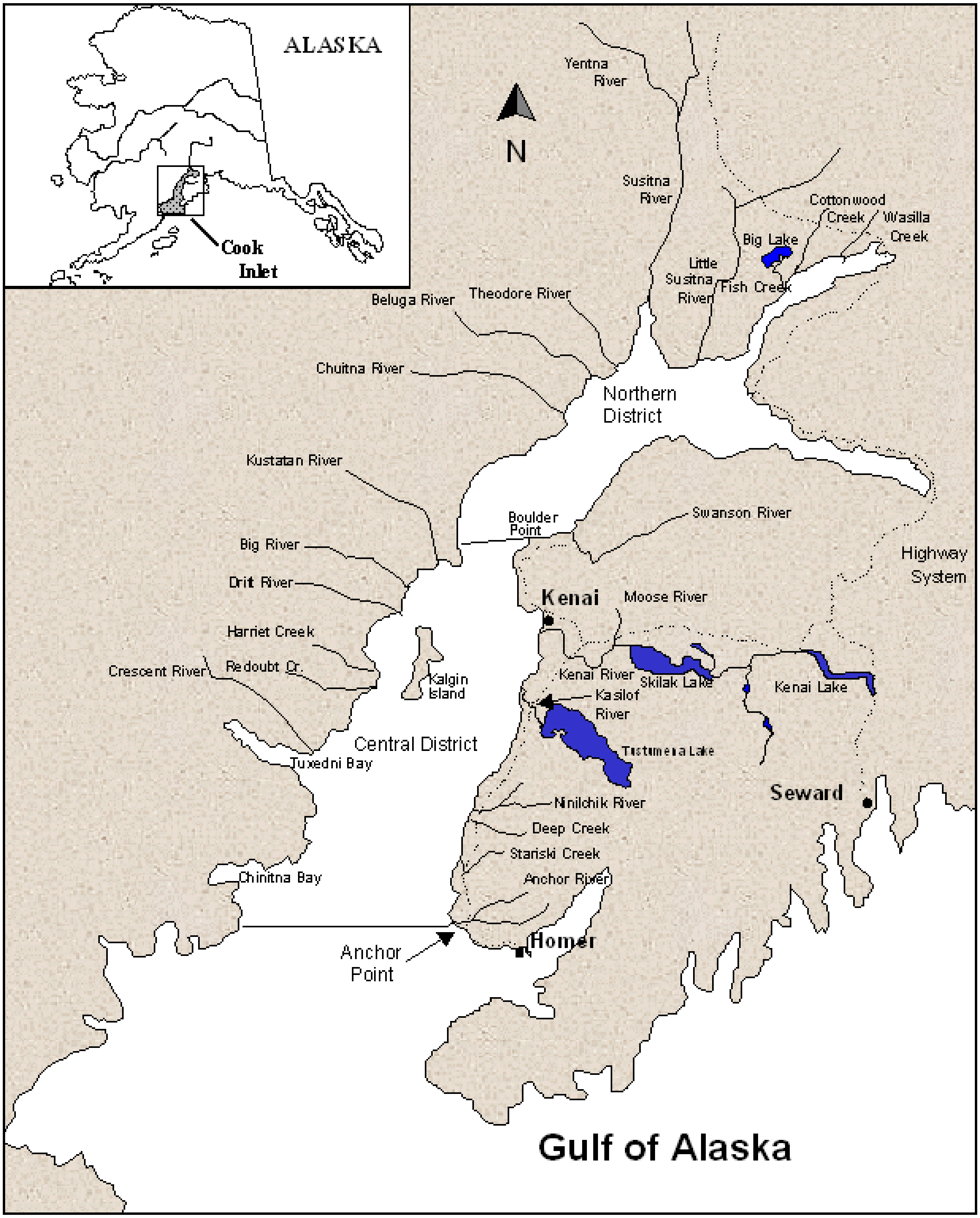

Figure 1.–Map of Upper Cook Inlet showing locations of the Northern and Central districts and the primary salmon spawning drainages.

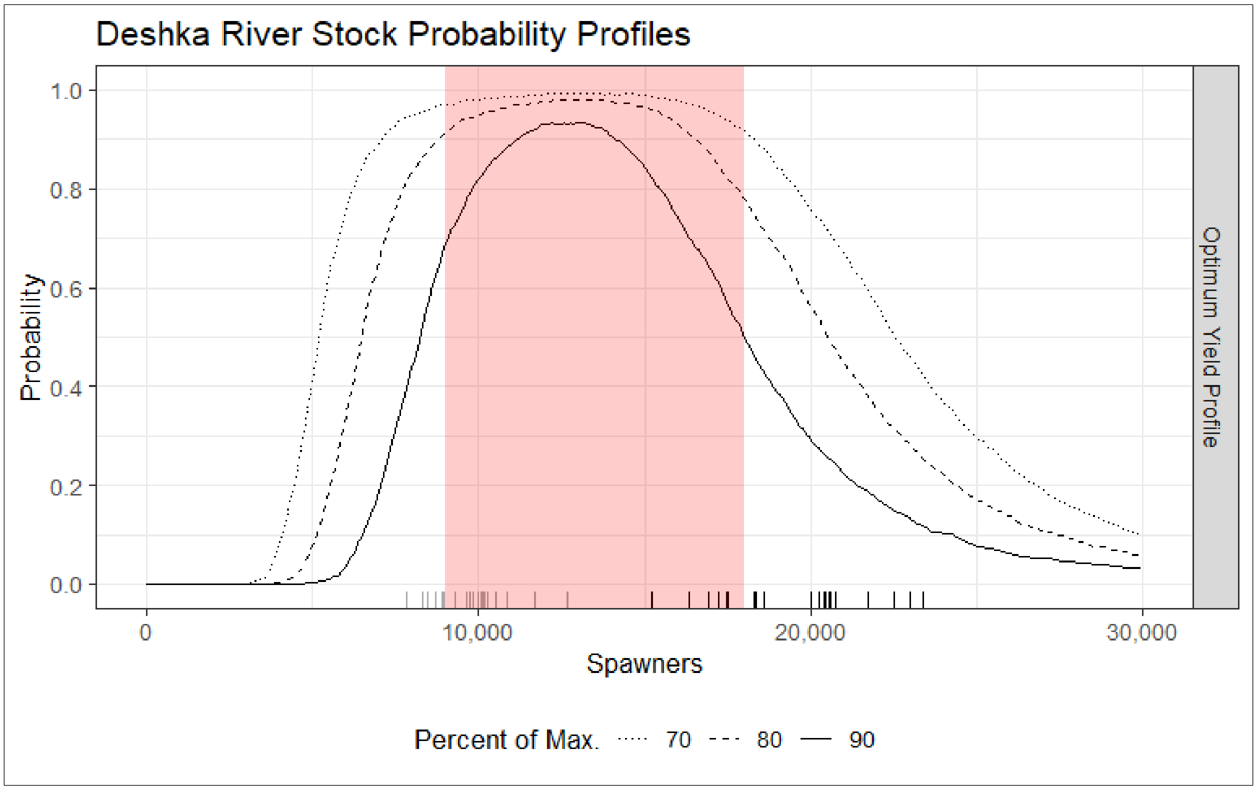

Figure 2.–Optimal yield (OYP) profile for the Deshka River Chinook salmon stock. Profiles show the probability that a specified spawning abundance will result in specified fractions (70%, 80%, and 90% line) of maximum sustained yield.

Note: Pink shaded areas bracket the proposed goal range; grey and black marks along the *x*-axis show comparable lower and upper bounds, respectively, scaled by S_{MSY} ratios for other Alaskan Chinook salmon stocks.

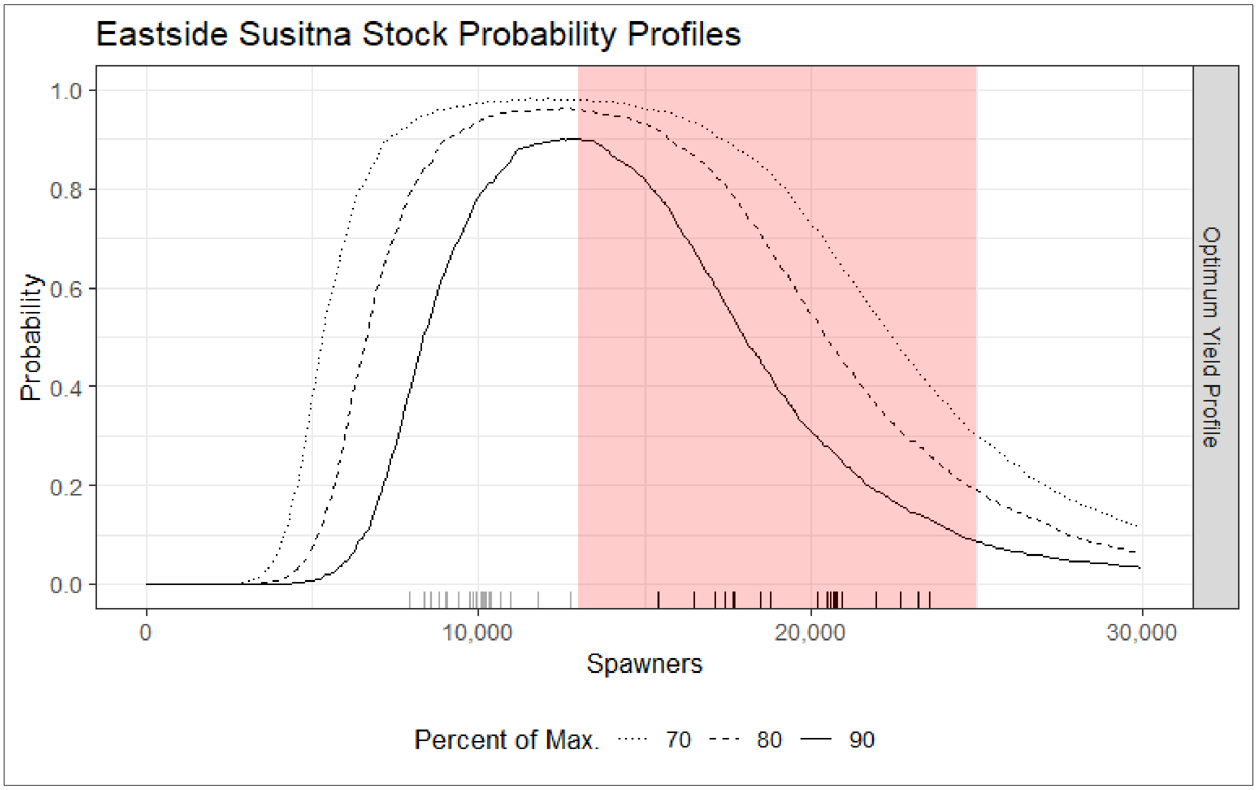

Figure 3.–Optimal yield (OYP) profile for the Eastside Susitna Chinook salmon stock. Profiles show the probability that a specified spawning abundance will result in specified fractions (70%, 80%, and 90% line) of maximum sustained yield.

Note: Pink shaded areas bracket the proposed goal range; grey and black marks along the *x*-axis show comparable lower and upper bounds, respectively, scaled by S_{MSY} ratios for other Alaskan Chinook salmon stocks.

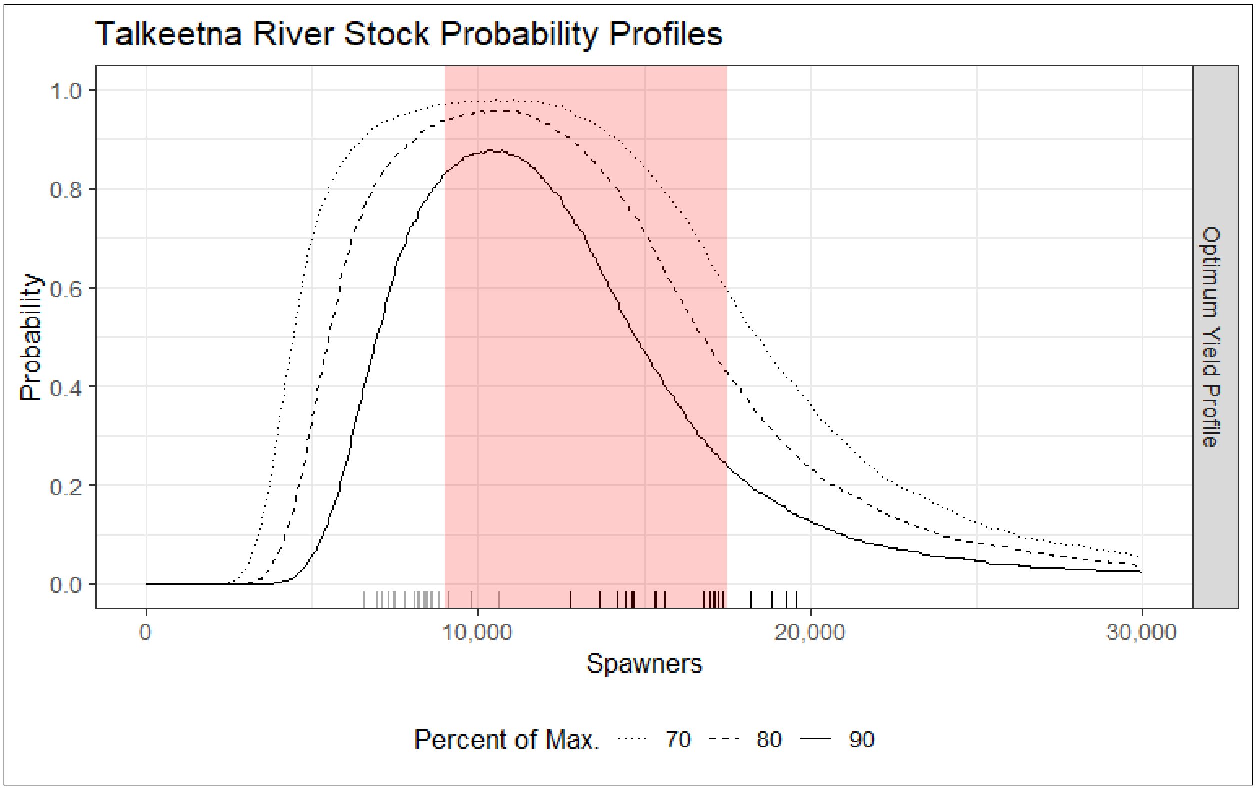

Figure 4.– Optimal yield (OYP) profile for the Talkeetna River Chinook salmon stock. Profiles show the probability that a specified spawning abundance will result in specified fractions (70%, 80%, and 90% line) of maximum sustained yield.

Note: Pink shaded areas bracket the proposed goal range; grey and black marks along the *x*-axis show comparable lower and upper bounds, respectively, scaled by S_{MSY} ratios for other Alaskan Chinook salmon stocks.

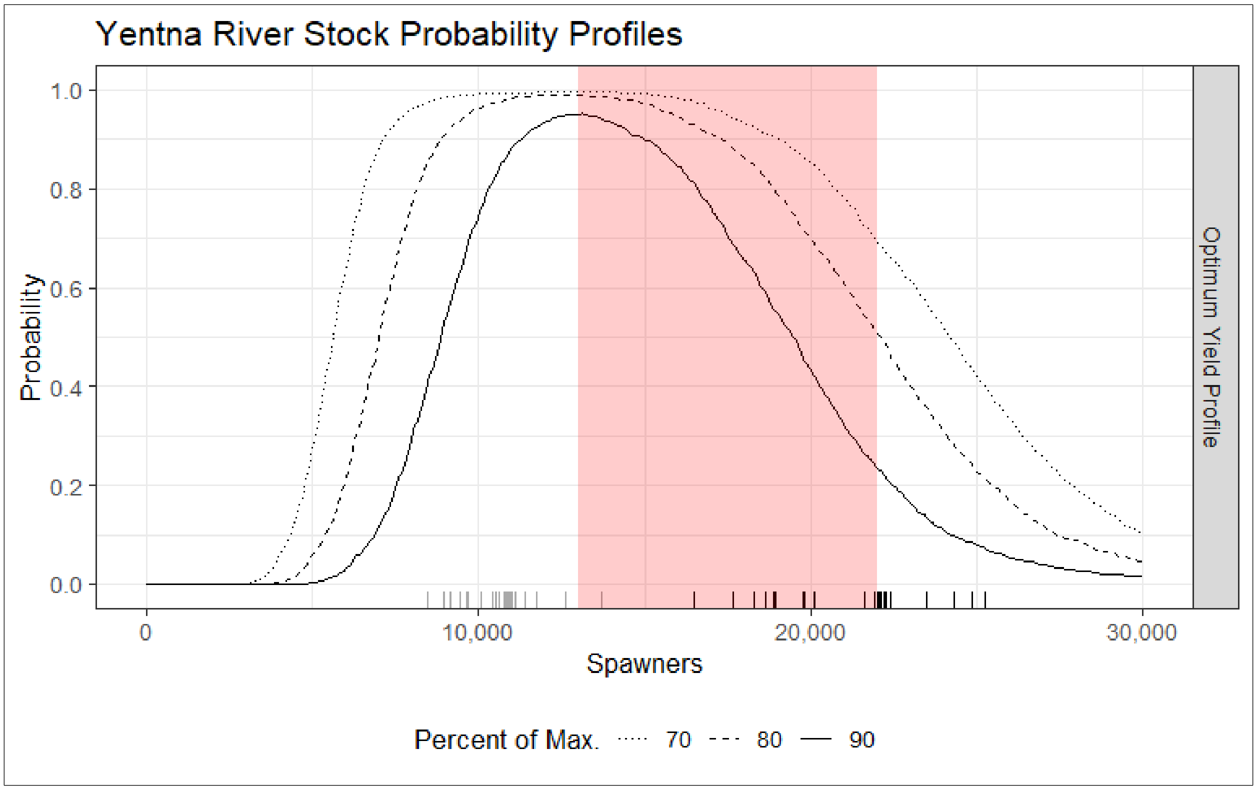

Figure 5.– Optimal yield (OYP) profile for the Yentna River Chinook salmon stock. Profiles show the probability that a specified spawning abundance will result in specified fractions (70%, 80%, and 90% line) of maximum sustained yield.

Note: Pink shaded areas bracket the proposed goal range; grey and black marks along the *x*-axis show comparable lower and upper bounds, respectively, scaled by S_{MSY} ratios for other Alaskan Chinook salmon stocks.

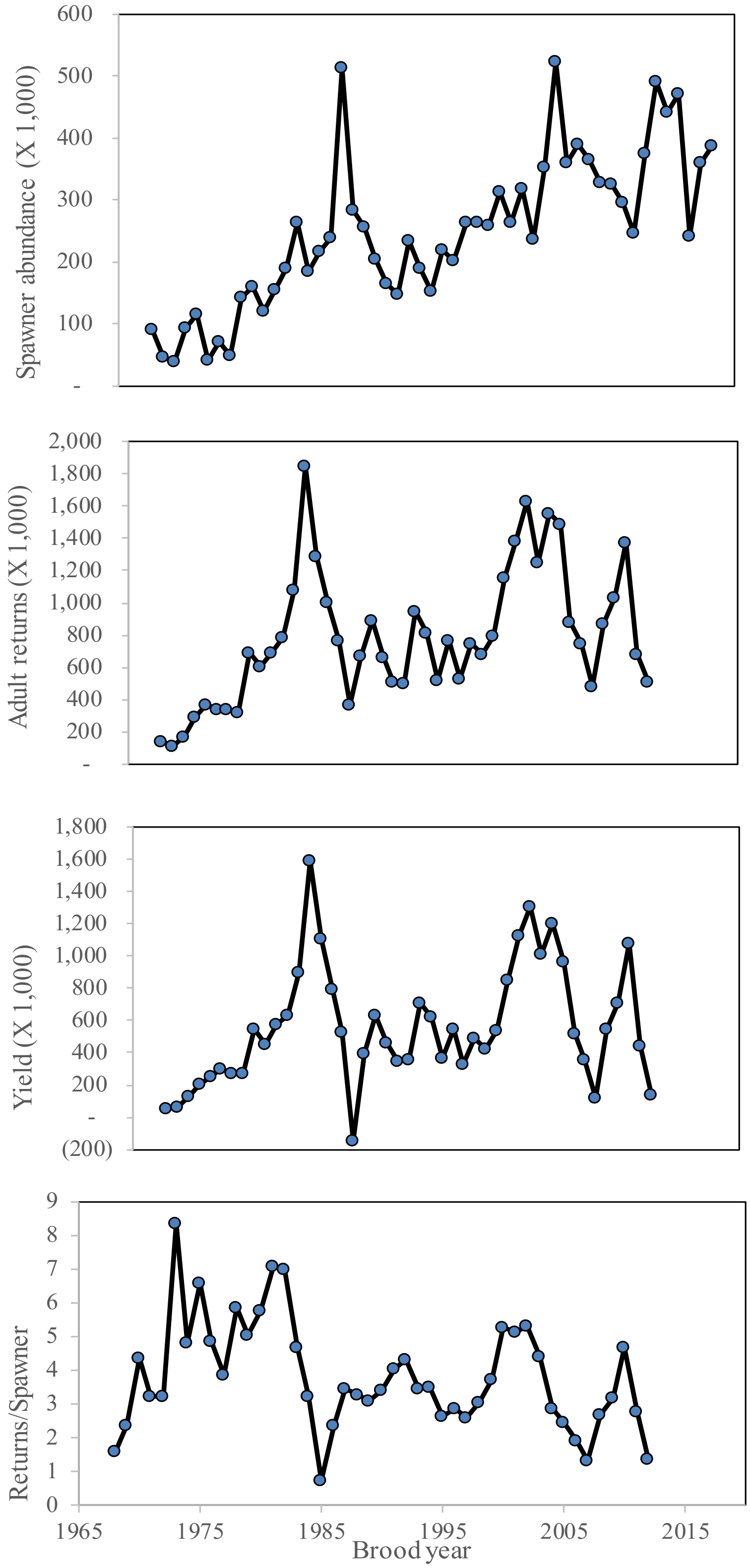

Figure 6.–Time series of spawner abundance (escapement), adult returns, yields, and returns-per-spawner for Kasilof River sockeye salmon, 1968–2012 brood years.

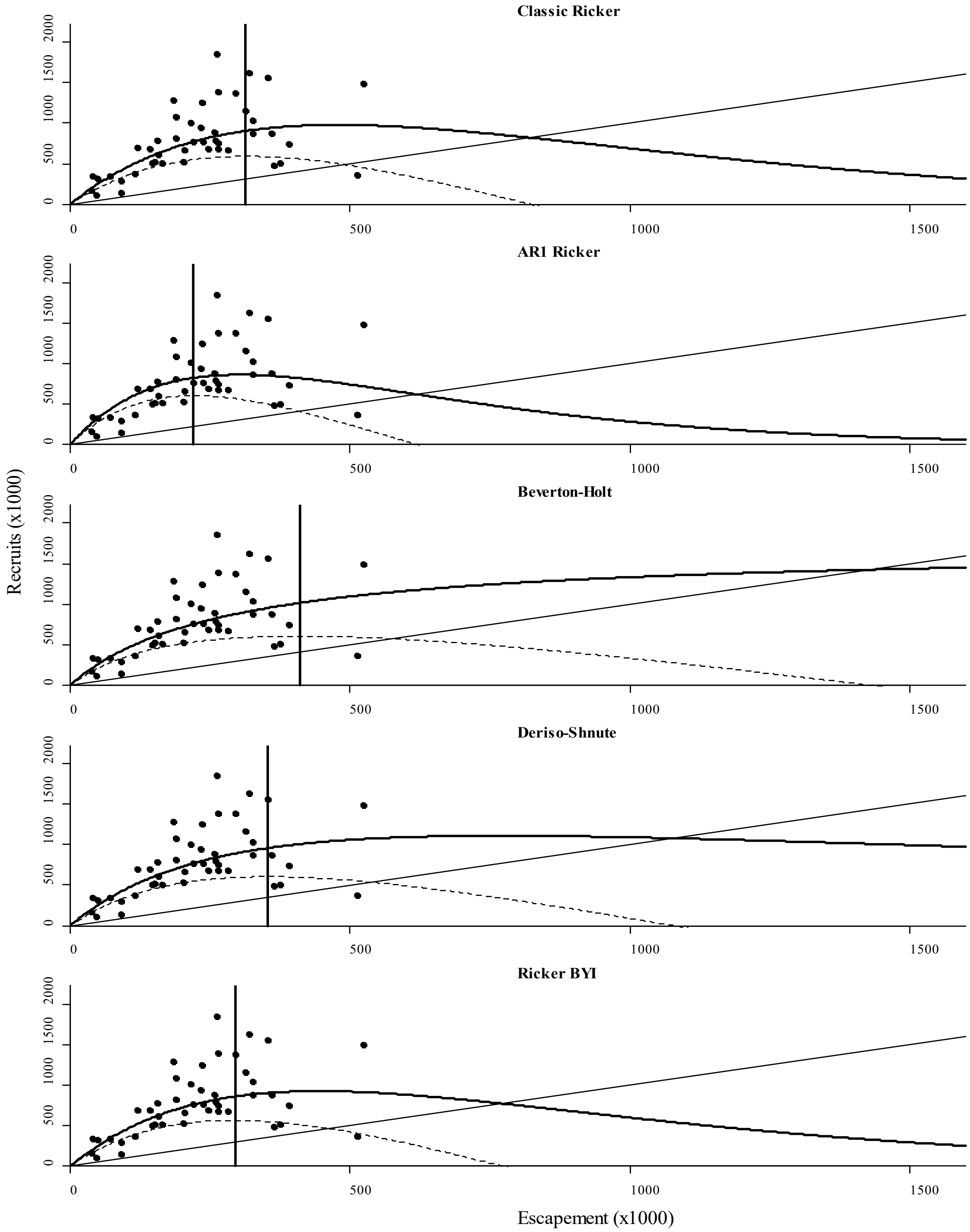

Figure 7.–Spawner-recruit models fit to Kasilof River sockeye salmon return per spawner data, brood years 1968–2012.

Note: The solid lines indicate model-predicted adult returns and the dashed lines indicate predicted yields. Vertical lines identify S_{MSY} for each model.

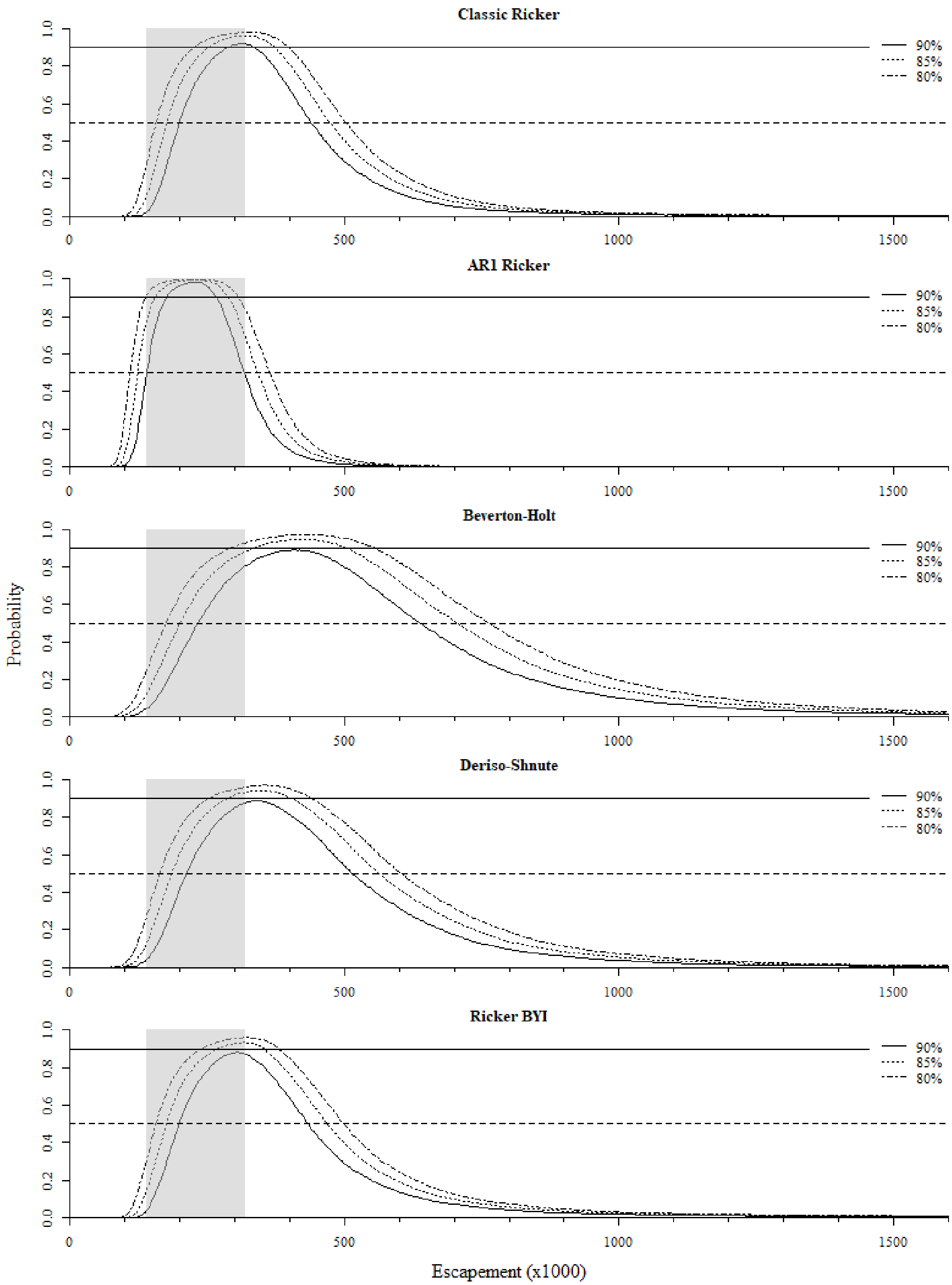

Figure 8.–Optimum yield profiles for Kasilof River sockeye salmon.

Note: Profiles show the probability that a specified spawning abundance will result specified fractions (80%, 85%, and 90% lines) of maximum sustained yield for 5 spawner-recruit models fit to data from brood years 1968–2012. Shaded ranges represent the recommended escapement goal (140,000–320,000).

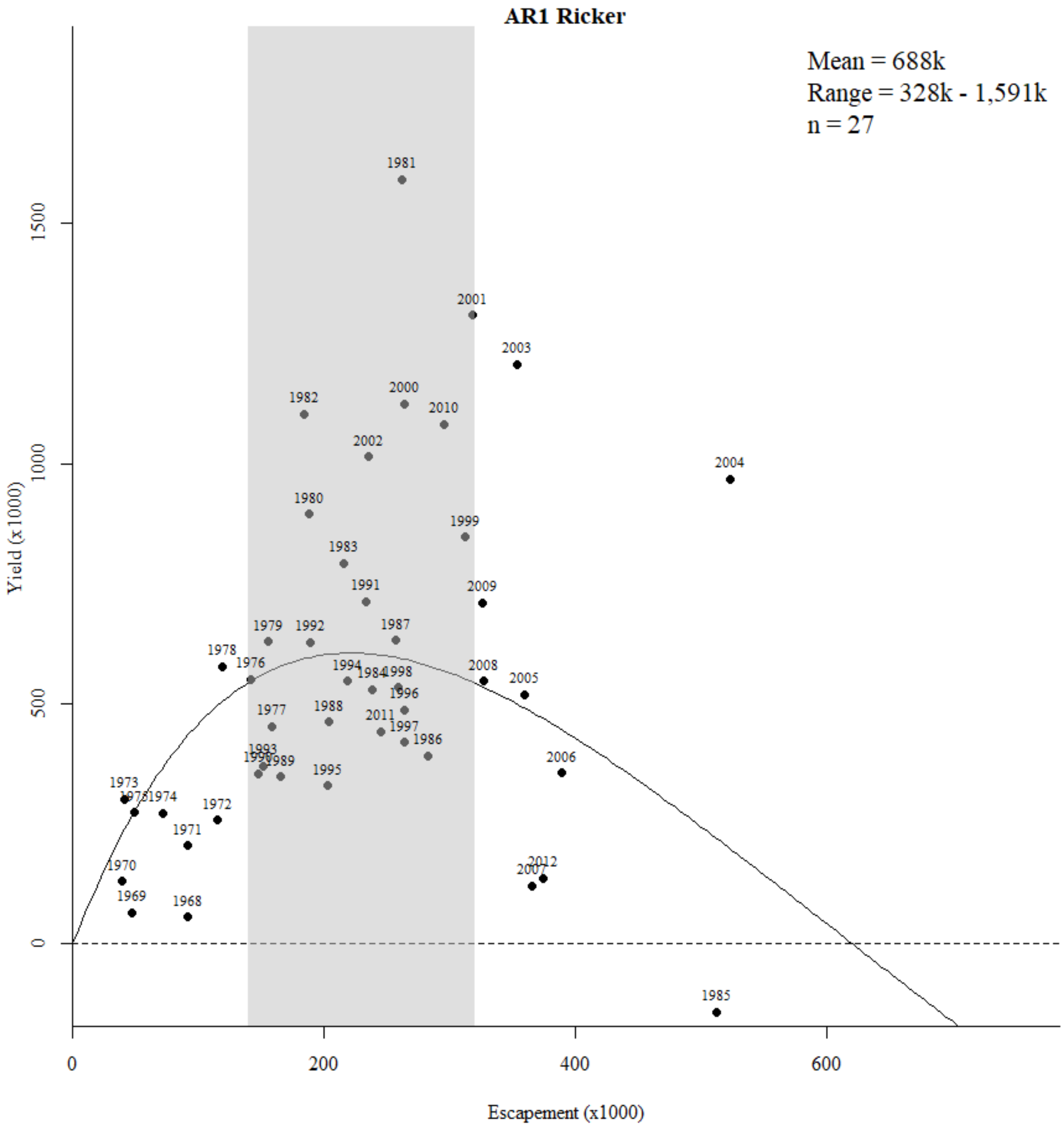

Figure 9.–Modeled and realized yield for Kasilof River sockeye salmon for brood years 1968–2012.

Note: Solid line represents AR1 yield curve. Shaded area represents recommend BEG range (140,000–320,00).

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

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

Year	Escapement [a]	Year	Escapement [a]
1974	2,193	1997	5,598
1975	1,878	1998	2,807
1976	5,412	1999	3,974
1977	9,246	2000	2,331
1978	5,854	2001	2,282
1979	6,215	2002	1,936
1980	NS	2003	2,012
1981	NS	2004	2,215
1982	2,546	2005	2,140
1983	3,755	2006	885
1984	4,620	2007	480
1985	6,241	2008	150
1986	5,225	2009	275
1987	2,152	2010	177
1988	6,273	2011	343
1989	3,497	2012	181
1990	2,596	2013	588
1991	2,727	2014	911
1992	3,710	2015	1,117
1993	2,763	2016	754
1994	1,514	2017	170
1995	2,090	2018	296
1996	2,319		

Note: Escapement goal recommended excludes years 2006–2018 because the population was depressed.

[a] Escapement not surveyed or monitored during years with NS.

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

Year	Escapement [a]	Year	Escapement [a]
1982	68	2001	717
1983	NS	2002	744
1984	423	2003	745
1985	NS	2004	964
1986	733	2005	1,097
1987	571	2006	1,052
1988	NS	2007	588
1989	218	2008	439
1990	458	2009	554
1991	590	2010	290
1992	931	2011	260
1993	937	2012	NS
1994	1,076	2013	NS
1995	734	2014	274
1996	369	2015	654
1997	1,119	2016	544
1998	761	2017	475
1999	1,035	2018	287
2000	591		

[a] Escapement not surveyed or monitored during years with NS.

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

Year	Escapement [a]	Year	Escapement [a]
1977	NS	1998	1,869
1978	NS	1999	3,721
1979	1,246	2000	1,456
1980	NS	2001	1,501
1981	1,362	2002	1,394
1982	3,438	2003	2,339
1983	4,043	2004	2,938
1984	2,845	2005	1,307
1985	1,600	2006	1,911
1986	3,946	2007	1,180
1987	NS	2008	586
1988	3,024	2009	1,040
1989	990	2010	735
1990	480	2011	719
1991	537	2012	502
1992	1,337	2013	1,690
1993	2,085	2014	1,398
1994	1,012	2015	1,965
1995	1,162	2016	1,372
1996	1,343	2017	235
1997	2,232	2018	939

[a] Escapement not surveyed or monitored during years with NS.

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

Year	Escapement [a]	Year	Escapement [a]
1982	863	2001	2,353
1983	4,058	2002	9,002
1984	4,191	2003	NS
1985	783	2004	2,162
1986	NS	2005	2,838
1987	5,252	2006	2,862
1988	NS	2007	5,166
1989	NS	2008	2,514
1990	2,681	2009	2,093
1991	4,410	2010	1,052
1992	2,527	2011	1,875
1993	2,070	2012	667
1994	1,806	2013	1,262
1995	3,460	2014	1,011
1996	4,172	2015	3,137
1997	5,618	2016	1,151
1998	2,586	2017	NS
1999	5,455	2018	1,125
2000	4,218		

[a] Escapement not surveyed or monitored during years with NS.

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

Year	Escapement [a]	Year	Escapement [a]
1979	864	1999	2,216
1980	NS	2000	2,142
1981	NS	2001	2,096
1982	982	2002	3,496
1983	938	2003	NS
1984	1,520	2004	3,417
1985	2,430	2005	1,924
1986	NS	2006	1,520
1987	NS	2007	3,310
1988	4,850	2008	1,795
1989	NS	2009	1,205
1990	2,380	2010	903
1991	1,974	2011	512
1992	1,530	2012	1,177
1993	886	2013	1,471
1994	1,204	2014	1,390
1995	1,928	2015	1,205
1996	2,091	2016	NS
1997	5,100	2017	780
1998	3,894	2018	940

[a] Escapement not surveyed or monitored during years with NS.

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

Return year	Count at the weir [a]			Actual escapement [b]		Sport harvest		
	Non-AFC	AFC	Total	Total	Wild	Early run [c] (through 6/30)	Creel survey [d] (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			251
1979	2,774	770	3,544	3,177	2,487			283
1980	1,764	518	2,282	2,115	1,635			310
1981	1,871	1,033	2,904	2,919	1,881			1,242
1982	1,449	2,054	3,503	4,107	1,699			2,316
1983	1,543	2,762	4,305	3,842	1,377			2,853
1984	1,372	2,278	3,650	3,409	1,281			3,964
1985	1,175	1,637	2,812	2,491	1,041			2,986
1986	1,539	2,335	3,874	4,055	1,611			7,071
1987	1,444	2,280	3,724	3,344	1,297			4,461
1988	1,174	2,622	3,796	700	216			4,953
1989	1,081	1,930	3,011	750	269			3,767
1990	1,066	1,581	2,647	1,663	670			2,852
1991			2,281	893				5,055
1992			3,533	843				6,049
1993			2,291	657				8,695
1994			1,790	640				7,217
1995			2,206	750				6,681
1996			2,224	764		5,295		6,128
1997						5,627		6,728
1998						4,202		4,839
1999	1,559	232	1,791	1,397	1,206	7,597		8,255
2000	1,224	192	1,416	1,077	940	8,815		9,901
2001	2,122	464	2,586	2,315	1,897	7,488		8,866
2002	2,526	800	3,326	2,708	1,933	4,791		5,242
2003	2,923	1,204	4,127	3,597	2,500	3,090		4,234
2004	2,641	2,232	4,873	4,356	2,196	3,295	2,407	4,333
2005	2,018	1,060	3,168	2,936	1,909	3,468	2,665	4,520
2006	1,589	1,057	2,646	2,569	1,516	2,421	2,489	3,304
2007	1,038	489	1,527	1,452	965	2,601	2,654	3,663
2008	1,018	396	1,414	1,181	879	2,996	1,984	3,789
2009	674	255	929	734	617	1,637	1,532	3,801
2010	1,090	262	1,352	1,348	1,088	2,239	1,333	3,907
2011	677	256	933	782	654	2,054		3,680
2012	633	163	796	731	631	872		927
2013	1,211	198	1,409	1,213	1,102	1,073		1,073
2014	1,522	911	2,433	2,148	1,411	323		323
2015	1,639	601	2,240	1,903	1,456	589		589
2016	1,833	2,184	4,017	3,847	1,747	683		683
2017	994	682	1,676	1,135	911	27		27
2018	777	964	1,741	1,022	714	30		30

-continued-

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 broodstock and from 1988–1996 fish were also sacrificed for disease concerns.

[c] From Statewide Harvest Survey (Alaska Sport Fishing Survey database [Internet]. 1996–present. Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish [cited December 2019]. Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/) for the Kasilof River sport fishery (large fish >20 inches 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, 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.

Year	Aerial survey [a]	Weir escapement[b]	Year	Aerial survey [a]	Weir escapement [b]
1974	5,279		1995	5,150	10,048
1975	4,737		1996	6,343	14,349
1976	21,693		1997	19,047	35,587
1977	39,642		1998	15,556	
1978	24,639		1999	12,904	29,088
1979	27,385		2000		33,965
1980			2001		27,966
1981			2002	8,749	28,535
1982	16,000		2003		39,257
1983	19,237		2004	28,778	56,659
1984	16,892		2005	11,495	36,433
1985	18,151		2006	6,499	29,922
1986	21,080		2007	6,712	17,594
1987	15,028		2008		7,284
1988	19,200		2009	3,954	11,641
1989			2010		18,223
1990	18,166		2011	7,522	18,553
1991	8,112		2012		13,952
1992	7,736		2013	8,686	18,378
1993	5,769		2014		16,099
1994	2,665		2015		23,627
			2016		22,099
			2017		11,034
			2018	2,977	8,549

[a] Escapement not surveyed or monitored during years with no escapement value.
[b] Sport fish above the weir was subtracted from weir count. Weir operations began in 1995.

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

Year	Escapement [a]
1981	262
1982	140
1983	477
1984	258
1985	401
1986	630
1987	416
1988	1,076
1989	835
1990	552
1991	968
1992	369
1993	347
1994	375
1995	374
1996	305
1997	308
1998	415
1999	268
2000	348
2001	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
2016	NS
2017	148
2018	90

[a] Escapement not surveyed or monitored during years with NS.

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	6,625
2012	2,977	6,354
2013	1,601	
2014	2,621	
2015	4,198	
2016	6,478	
2017	6,725	
2018	2,909	

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
2004	65,084	17,445
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	24,962
2012	22,455	27,125
2013	12,308	
2014	11,972	
2015	16,830	
2016	14,676	
2017	20,634	
2018	17,285	

Note: Blank cells indicate no available data.

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

Year	Escapement [a]
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
2016	3,588
2017	1,601
2018	1,767

[a] Escapement not surveyed or monitored during years with NS.

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

Year	Escapement [a]	Year	Escapement [a]
1977	NS	1998	626
1978	NS	1999	675
1979	546	2000	480
1980	NS	2001	502
1981	560	2002	439
1982	606	2003	878
1983	NS	2004	1,000
1984	947	2005	441
1985	861	2006	341
1986	722	2007	0[b]
1987	875	2008	120
1988	616	2009	111
1989	452	2010	56
1990	207	2011	92
1991	303	2012	107
1992	445	2013	61
1993	531	2014	61
1994	164	2015	5
1995	146	2016	0
1996	257	2017	0
1997	777	2018	0

[a] Escapement not surveyed or monitored during years with NS.

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

Year	Escapement [a]	Year	Escapement [a]
1977	NS	1998	1,091
1978	NS	1999	NS
1979	NS	2000	1,094
1980	NS	2001	1,238
1981	NS	2002	1,660
1982	NS	2003	1,114
1983	929	2004	1,694
1984	558	2005	2,095
1985	1,005	2006	1,855
1986	NS	2007	1,731
1987	1,386	2008	1,297
1988	3,197	2009	1,028
1989	2,184	2010	589
1990	922	2011	887
1991	892	2012	1,154
1992	1,441	2013	1,651
1993	NS	2014	1,759
1994	1,221	2015	1,507
1995	1,714	2016	1,622
1996	1,079	2017	1,192
1997	NS	2018	530 [b]

[a] Escapement not surveyed or monitored during years with NS.

[b] Not used in escapement goal calculation.

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

Year	Escapement [a]
1988	7,712
1989	4,367
1994	2,981
1995	2,893
–	–
2013	2,383 [a]
2014	3,135
2015	5,026
2016	4,969
2017	2,531
2018	549 [a]

[a] Incomplete count due to flooding of weir.

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

Year	Escapement [a]	Year	Escapement [a]
1979	327	1999	1,837
1980	NS	2000	1,121
1981	459	2001	2,084
1982	316	2002	1,680
1983	1,042	2003	879
1984	NS	2004	2,227
1985	1,305	2005	1,784
1986	2,133	2006	816
1987	1,320	2007	1,103
1988	1,515	2008	NS
1989	1,325	2009	776
1990	1,115	2010	468
1991	498	2011	713
1992	673	2012	494
1993	705	2013	858
1994	712	2014	684
1995	1,210	2015	788
1996	1,077	2016	675
1997	2,390	2017	840
1998	1,782	2018	280

[a] Escapement not surveyed or monitored during years with NS.

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

Year	Escapement [a]	Year	Escapement [a]
1981	814	2000	1,271
1982	NS	2001	1,930
1983	NS	2002	2,357
1984	NS	2003	2,576
1985	NS	2004	2,117
1986	NS	2005	2,600
1987	1,320	2006	1,850
1988	2,016	2007	1,936
1989	NS	2008	1,357
1990	1,269	2009	1,460
1991	1,215	2010	755
1992	1,560	2011	494
1993	1,281	2012	416
1994	1,143	2013	1,304
1995	2,110	2014	953
1996	1,841	2015	1,416
1997	3,073	2016	692
1998	2,936	2017	603
1999	2,088	2018	473

[a] Escapement not surveyed or monitored during years with NS.

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

Year	Escapement [a]	Year	Escapement [a]
1983	2,272	2001	4,226
1984	324	2002	2,959
1985	2,901	2003	3,998
1986	1,915	2004	3,757
1987	1,302	2005	1,508
1988	3,927	2006	1,114
1989	959	2007	1,225
1990	2,027	2008	NS
1991	2,458	2009	1,283
1992	996	2010	NC
1993	1,668	2011	1,103
1994	573	2012	459
1995	1,041	2013	1,643
1996	749	2014	1,443
1997	2,637	2015	1,514
1998	4,367	2016	1,122
1999	3,298	2017	307
2000	1,648	2018	1,674

[a] Escapement not surveyed or monitored during years with NS.

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

Year	Escapement	Year	Escapement
1981	1,875	2000	3,790
1982	3,844	2001	5,191
1983	3,200	2002	7,914
1984	9,000	2003	4,095
1985	6,500	2004	5,570
1986	8,500	2005	3,862
1987	9,138	2006	3,570
1988	9,280	2007	5,036
1989	9,463	2008	3,039
1990	9,113	2009	3,500
1991	6,770	2010	3,022
1992	4,453	2011	2,038
1993	3,023	2012	1,185
1994	2,254	2013	3,304
1995	3,884	2014	2,812
1996	5,037	2015	3,290
1997	7,710	2016	1,853
1998	4,465	2017	1,930
1999	5,871	2018	1,194

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

Year	Escapement [a]	Year	Escapement [a]
1979	778	1999	NS
1980	NS	2000	1,162
1981	1,013	2001	NS
1982	527	2002	854
1983	975	2003	NS
1984	1,028	2004	285
1985	1,634	2005	760
1986	1,285	2006	580
1987	895	2007	400
1988	1,215	2008	NS
1989	610	2009	500
1990	634	2010	NS
1991	154	2011	350
1992	NS	2012	363
1993	NS	2013	NC
1994	542	2014	262
1995	1,049	2015	NS
1996	1,028	2016	NS
1997	NS	2017	NS
1998	1,160	2018	334

[a] Escapement not surveyed or monitored during years with NS.

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

Year	Escapement [a]	Year	Escapement [a]
1979	1,648	1999	4,890
1980	NS	2000	2,414
1981	2,025	2001	3,309
1982	3,101	2002	7,824
1983	10,014	2003	9,573
1984	6,138	2004	8,352
1985	5,145	2005	4,406
1986	3,686	2006	6,152
1987	NS	2007	3,871
1988	4,112	2008	2,964
1989	NS	2009	2,608
1990	2,694	2010	1,499
1991	2,457	2011	1,368
1992	3,648	2012	847
1993	3,269	2013	2,285
1994	1,575	2014	2,256
1995	2,521	2015	2,582
1996	2,748	2016	4,295
1997	4,494	2017	1,087
1998	2,759	2018	1,483

[a] Escapement not surveyed or monitored during years with NS.

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

Year	Escapement [a]	Year	Escapement [a]
1977		1998	1,807
1978		1999	2,221
1979	512	2000	1,271
1980		2001	1,237
1981	535	2002	934
1982	1,368	2003	1,059
1983	1,519	2004	491
1984	1,251	2005	478
1985	1,458	2006	958
1986	1,281	2007	486
1987	1,548	2008	345
1988	1,906	2009	352
1989	1,026	2010	202
1990	642	2011	327
1991	508	2012	179
1992	1,053	2013	476
1993	1,110	2014	312
1994	577	2015	426
1995	694	2016	68[b]
1996	368	2017	21[b]
1997	1,607	2018	18[b]

[a] Escapement not surveyed or monitored during years with NS.

[b] Not used in escapement goal calculation.

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

Year	Escapement	Year	Escapement
1981	991	2000	2,601
1982	592	2001	3,188
1983	NS	2002	2,758
1984	2,789	2003	3,964
1985	1,856	2004	2,985
1986	2,059	2005	2,463
1987	2,768	2006	2,217
1988	2,496	2007	1,373
1989	5,060	2008	1,255
1990	2,365	2009	1,133
1991	2,006	2010	1,173
1992	1,660	2011	1,061
1993	2,227	2012	756
1994	1,479	2013	1,752
1995	3,792	2014	1,335
1996	1,776	2015	2,046
1997	4,841	2016	1,814
1998	3,500	2017	840
1999	2,081	2018	411

[a] Escapement not surveyed or monitored during years with NS.

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 [a]
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	2016	5,060
1988	NS	2017	7,040
1989	2,000	2018	1,800
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: Escapements are peak aerial survey counts.

[a] Escapement not surveyed or monitored during years with NS.

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	Year	Escapement
1995	12,824	2007	10,575
1996	1,394	2008	12,724
1997	8,063	2009	27,348
1998[a]	6,773	2010	10,393
1999[a]	4,566	2011[a]	7,326
2000	26,387	2012	6,825
2001	29,927	2013	22,141
2002[a]	24,612	2014	11,578
2003	17,305	2015	10,775
2004	62,940	2016[a]	6,820
2005	47,887	2017	36,869
2006	59,419	2018	13,072

[a] Weir inoperable for 6 or more days.

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

Year	Escapement [a]	Year	Escapement [a]
1969	5,671[b]	1994	350
1970	NS	1995	390
1971	NS	1996	682
1972	955[b]	1997	3,437[b]
1973	280[b]	1998	5,463[b]
1974	1,539[b]	1999	1,766[b]
1975	2,135[b]	2000	5,218[b]
1976	1,020[b]	2001	9,247[b]
1977	970	2002	14,651[b]
1978	3,184	2003	1,231[b]
1979	2,511	2004	1,415
1980	8,924	2005	3,011
1981	2,330	2006	4,967
1982	5,201	2007	6,868
1983	2,342	2008	4,868
1984	4,510	2009	8,214[b]
1985	5,089	2010	6,977[b]
1986	2,166	2011	1,428
1987	3,871	2012	1,237[b]
1988	2,162	2013	7,593[b]
1989	3,479	2014	10,283[b]
1990	2,673	2015	7,912[b]
1991	1,297	2016	2,484
1992	1,705	2017	8,966[b]
1993	2,078	2018	5,022[b]

[a] Escapement not surveyed or monitored during years with NS.

[b] Calculation of percentiles based on escapements in 1969, 1972–1976, 1978, 1997–2003, 2009–2010, 2012–2015, 2017–2018; these were 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 17. In 1977, the weir was removed in August, and 1979–1996 were excluded because stocked fish returned.

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

Year	Escapement [a]	Year	Escapement [a]
1981	NS	2000	657
1982	NS	2001	1,019
1983	NS	2002	2,473
1984	NS	2003	1,421
1985	662	2004	4,652
1986	439	2005	1,464
1987	667	2006	2,389
1988	1,911	2007	725
1989	597	2008	1,890
1990	599	2009	1,331
1991	484	2010	242
1992	11	2011	261
1993	503	2012	213
1994	506	2013	663
1995	702	2014	122
1996	72	2015	571
1997	701	2016	106
1998	922	2017	607
1999	12	2018	758

[a] Escapement for McRoberts Creek only; this is a tributary to Jim Creek. Escapement is not surveyed or monitored during years with NS.

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

Year	Sport harvest [a]	Total escapement [b]	Percent hatchery contribution to escapement [c]	Escapement Hatchery	Escapement Wild	Harvest above weir (lower weir site)	Used to calculate EG [d]
1977	3,415						
1978	4,865						
1979	3,382						
1980	6,302						
1981	5,940						
1982	7,116						
1983	2,835						
1984	14,253						
1985	7,764						
1986	6,039	6,999[e]			6,999		
1987	13,003						
1988	19,009	20,491	22	4,428	16,063		
1989	14,129	15,232[e]	45	6,862	8,370	400	
1990	7,497	14,310	24	3,370	10,940	683	10,257
1991	16,450	37,601	22	8,322	29,279	427	28,852
1992	20,033	20,393	11	2,324	18,069		
1993	27,610	33,378	29	9,615	23,763		
1994	17,665	27,820	18	5,124	22,696		
1995	14,451	11,817	9	1,069	10,748		
1996	16,753	16,699	3	444	16,255		16,255
1997	7,756	9,894[e]			9,894		
1998	14,469	15,159			15,159		15,159
1999	8,864	3,017			3,017		3,017
2000	20,357	15,436			15,436		15,436
2001	17,071	30,587			30,587		30,587
2002	19,278	47,938			47,938		47,938
2003	13,672	10,877			10,877		10,877
2004	15,307	40,199			40,199		40,199
2005	10,203	16,839[e]			16,839		
2006	12,399	8,786[e]			8,786		
2007	11,089	17,573			17,573		17,573
2008	13,498	18,485			18,485		18,485
2009	8,346	9,523			9,523		9,523
2010	10,622	9,214			9,214		9,214
2011	2,452	4,826			4,826		4,826
2012	1,681	6,779			6,779		
2013	5,229	13,583[e]			13,583	1,559	
2014	6,922	24,211			24,211	1,454	22,757
2015	8,880	12,756[e]			12,756	1,202	
2016	4,361	10,049			10,049	953	9,096
2017	3,068	17,781			17,781	181	17,600
2018		7,583[e]			7,583		

-continued-

[a] Source: Statewide Harvest Survey (Alaska Sport Fishing Survey database [Internet]. 1996–present. Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish [cited November 2019]. Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/).

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

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

[d] For the years 1996–2011, the weir was above the Parks Highway where fishing is prohibited, so the weir count is the escapement.

[e] 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	37,734
2011	70,353[d]
2012	37,736
2013	70,555
2014	26,374
2015	69,897
2016	60,792
2017	26,986
2018	20,434

Note: NS means 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 radio–tagged fish passing during high water (Fair et al. 2009).

[d] Includes 5,238 estimated passage over the weir during a highwater event.

Appendix D2.–Data available for analysis of Fish Creek sockeye salmon escapement goal.

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	2016	46,202
1951	34,704	1984	192,352	2017	63,882
1952	92,724	1985	68,577	2018	72,157
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: Shaded values indicate years of hatchery production and were not used to evaluate the SEG recommendation. NS means 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]	1996	NS
1974	NS	1997	NS
1975	NS	1998	34,416
1976	NS	1999	NS
1977	NS	2000	NS
1978	NS	2001	NS
1979	NS	2002	NS
1980	43,350 [a]	2003	NS
1981	NS	2004	NS
1982	NS	2005	NS
1983	NS	2006	40,633
1984	NS	2007	57,392
1985	NS	2008	53,681
1986	NS	2009	44,616
1987	NS	2010	18,466
1988	NS	2011	39,909
1989	12,792	2012	18,715
1990	NS	2013	14,088
1991	NS	2014	22,229
1992	NS	2015	47,934
1993	NS	2016	NS
1994	NS	2017	35,731
1995	NS	2018	30,844

Note: NS means 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
1968	90,958	145,853	54,895	1.60
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	71,540	342,896	271,356	4.79
1975	48,884	321,500	272,616	6.58
1976	142,058	691,693	549,635	4.87
1977	158,410	610,171	451,761	3.85
1978	119,165	695,679	576,514	5.84
1979	155,527	783,821	628,294	5.04
1980	188,314	1,082,721	894,407	5.75
1981	262,271	1,853,442	1,591,171	7.07
1982	184,204	1,287,592	1,103,388	6.99
1983	215,730	1,008,308	792,578	4.67
1984	238,413	766,694	528,281	3.22
1985	512,827	369,740	(143,087)	0.72
1986	283,054	674,252	391,198	2.38
1987	256,707	887,782	631,075	3.46
1988	204,336	665,176	460,840	3.26
1989	164,952	512,385	347,433	3.11
1990	147,663	501,812	354,149	3.40
1991	233,646	946,237	712,591	4.05
1992	188,819	815,919	627,100	4.32
1993	151,801	521,361	369,560	3.43
1994	218,826	765,529	546,703	3.50
1995	202,428	530,599	328,171	2.62
1996	264,511	751,566	487,055	2.84
1997	263,780	682,580	418,800	2.59
1998	259,045	792,308	533,263	3.06
1999	312,481	1,158,888	846,407	3.71
2000	263,631	1,388,432	1,124,801	5.27
2001	318,735	1,627,669	1,308,934	5.11
2002	235,732	1,250,022	1,014,290	5.30
2003	353,526	1,560,304	1,206,778	4.41
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	873,640	546,622	2.67
2009	326,283	1,035,630	709,347	3.17
2010	295,265	1,377,594	1,082,329	4.67
2011	245,721	686,373	440,652	2.79
2012	374,523	509,565	135,042	1.36

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Appendix D4.–Page 2 of 2.

Brood year	Escapement	Returns	Yield	Return per spawner
2013	489,654			
2014	440,192			
2015	470,677			
2016	239,981			
2017	358,724			
2018	388,009			

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
1968	115,545	960,169	844,624	8.31
1969	72,901	430,947	358,046	5.91
1970	101,794	550,923	449,129	5.41
1971	406,714	986,397	579,683	2.43
1972	431,058	2,547,851	2,116,793	5.91
1973	507,072	2,125,986	1,618,914	4.19
1974	209,836	788,067	578,231	3.76
1975	184,262	1,055,373	871,111	5.73
1976	507,440	1,506,012	998,572	2.97
1977	951,038	3,112,620	2,161,582	3.27
1978	511,781	3,785,040	3,273,259	7.40
1979	373,810	1,321,039	947,229	3.53
1980	615,382	2,673,295	2,057,913	4.34
1981	535,524	2,464,323	1,928,799	4.60
1982	755,672	9,587,700	8,832,028	12.69
1983	792,765	9,486,794	8,694,029	11.97
1984	446,297	3,859,109	3,412,812	8.65
1985	573,761	2,587,921	2,014,160	4.51
1986	555,207	2,165,138	1,609,931	3.90
1987	2,011,657	10,356,627	8,344,970	5.15
1988	1,212,865	2,546,639	1,333,774	2.10
1989	2,026,619	4,458,679	2,432,060	2.20
1990	794,616	1,507,693	713,077	1.90
1991	727,146	4,436,074	3,708,928	6.10
1992	1,207,382	4,271,576	3,064,194	3.54
1993	997,693	1,689,779	692,086	1.69
1994	1,309,669	3,052,634	1,742,965	2.33
1995	776,847	1,899,870	1,123,023	2.45
1996	963,108	2,261,757	1,298,649	2.35
1997	1,365,676	3,626,402	2,260,726	2.66
1998	929,090	4,465,328	3,536,238	4.81
1999	949,276	5,755,063	4,805,786	6.06
2000	696,899	7,058,333	6,361,435	10.13
2001	738,229	1,697,957	959,728	2.30
2002	1,126,616	3,628,712	2,502,096	3.22
2003	1,402,292	1,919,813	517,521	1.37
2004	1,690,547	3,236,600	1,546,053	1.91
2005	1,654,003	4,804,018	3,150,015	2.90
2006	1,892,090	5,006,280	3,114,190	2.65
2007	964,243	4,378,678	3,414,435	4.54
2008	708,805	3,380,397	2,671,592	4.77

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Appendix D5.–Page 2 of 2.

Brood year	Escapement	Returns	Yield	Return per spawner
2009	848,117	3,809,455	2,961,339	4.49
2010	1,038,302	3,625,388	2,587,086	3.49
2011	1,280,733	4,513,815	3,233,082	3.52
2012	1,212,921	1,484,043	271,122	1.22
2013	980,208			
2014	1,218,342			
2015	1,400,047			
2016	1,118,155			
2017	1,056,773			
2018	831,096			

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	Year	Escapement
1984	35,252	2002	NS
1985	37,874	2003	NS
1986	32,322	2004	NS
1987	16,748	2005	9,955
1988	NS	2006	57,411
1989	NS	2007	47,924
1990	NS	2008	34,595
1991	NS	2009	40,930
1992	NS	2010	20,324
1993	NS	2011	12,225
1994	NS	2012	16,557
1995	NS	2013	21,821
1996	NS	2014	12,430
1997	40,163	2015	23,185
1998	63,514	2016	14,333
1999	18,943	2017	31,866
2000	11,987	2018	23,632
2001	NS		

Note: NS means no survey.

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

Year	Escapement	Year	Escapement
1974	2,123	1997	31,439
1975	4,522	1998	17,728
1976	13,292	1999	25,648
1977	16,934	2000	20,151
1978	23,651	2001	NS
1979	37,755	2002	NS
1980	28,520	2003	NS
1981	12,934	2004	NS
1982	15,687	2005	22,000
1983	18,403	2006	NS
1984	30,403	2007	46,637
1985	36,864	2008	25,247
1986	29,604	2009	16,473
1987	35,401	2010	NS
1988	18,607	2011	NS
1989	22,304	2012	NS
1990	31,868	2013	NS
1991	41,275	2014	19,242
1992	30,143	2015	28,072
1993	40,869	2016	NS
1994	30,776	2017	17,164
1995	29,473	2018	16,247
1996	16,971		

Note: NS means no survey.

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

Brood year	Escapement [a]	Total return	Yield	Return/spawner	Harvest [b]
1965	21,510	5,970	(15,540)	0.28	10,030
1966	16,660	7,822	(8,838)	0.47	14,950
1967	13,710	18,662	4,952	1.36	7,240
1968	9,120	19,800	10,680	2.17	6,920
1969	5,000	13,169	8,169	2.63	5,870
1970	5,450	12,642	7,192	2.32	5,750
1971	2,650	8,728	6,078	3.29	2,810
1972	9,270	98,980	89,710	10.68	5,040
1973	13,120	26,788	13,668	2.04	6,740
1974	13,160	52,849	39,689	4.02	6,440
1975	5,650	14,130	8,480	2.50	1,400
1976	14,735	115,408	100,673	7.83	3,380
1977	16,060	17,515	1,455	1.09	20,400
1978	34,240	17,001	(17,239)	0.50	37,720
1979	19,750	94,836	75,086	4.80	8,400
1980	28,620	42,401	13,781	1.48	27,220
1981	21,140	76,040	54,900	3.60	10,720
1982	56,110	278,179	222,069	4.96	34,500
1983	21,270	23,549	2,279	1.11	8,360
1984	28,900	42,857	13,957	1.48	35,880
1985	30,610	43,776	13,166	1.43	12,300
1986	36,340	90,637	54,297	2.49	35,100
1987	61,510	109,215	47,705	1.78	154,200
1988	50,410	87,848	37,438	1.74	54,780
1989	15,340	57,055	41,715	3.72	11,290
1990	26,720	94,893	68,173	3.55	30,215
1991	32,389	126,044	93,655	3.89	65,390
1992	37,117	64,978	27,861	1.75	30,512
1993	39,857	41,584	1,727	1.04	37,261
1994	44,872	114,649	69,777	2.56	48,923
1995	28,603	26,462	(2,141)	0.93	23,572
1996	52,905	192,657	139,752	3.64	39,075
1997	36,280	63,876	27,596	1.76	36,788
1998	34,143	57,692	23,549	1.69	42,711
1999	36,607	106,219	69,612	2.90	34,283
2000	32,736	94,932	62,196	2.90	40,732
2001	78,255	77,071	(1,184)	0.98	35,400
2002	85,943	74,180	(11,763)	0.86	52,139
2003	23,650	68,346	44,696	2.89	22,986
2004	56,582	105,293	48,711	1.86	32,727
2005	52,903	31,718	(21,185)	0.60	37,139
2006	80,524	59,545	(20,979)	0.74	51,167
2007	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	48,772	1.93	59,702

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Appendix D8.–Page 2 of 2.

Brood year	Escapement [a]	Total return	Yield	Return/spawner	Harvest [b]
2010	27,074	63,213	36,139	2.34	24,027
2011 [c]	29,129				23381
2012 [c]	24,115				16,098
2013 [c]	35,776				27,930
2014 [c]	44,920				37146
2015 [c]	50,226				30,986
2016[c]	38,793				14,176
2017[c]	37,123				28,706
2018[c]	44,110				28,690

[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. 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 [b] above weir	Year	Harvest [a]	Escapement [b] above weir
1963	1,390	51,120	1991	31,450	78,180
1964	2,450	46,930	1992	26,101	63,478
1965	2,160	21,820	1993	26,772	99,259
1966	7,290	34,430	1994	26,375	122,277
1967	5,720	49,480	1995	11,805	61,982
1968	5,820	48,880	1996	19,136	34,691
1969	1,150	28,870	1997	12,910	65,905
1970	600	26,200	1998	25,110	113,477
1971	10,730	54,420	1999	32,335	139,863
1972	16,050	79,115	2000	30,229	56,580
1973	8,930	25,070	2001	18,550	74,964
1974	8,500	24,900	2002	31,999	62,115
1975	8,390	31,960	2003	28,085	157,469
1976	13,700	31,940	2004	22,417	110,244
1977	27,440	21,360	2005	18,503	54,808
1978	24,530	34,340	2006	29,694	84,432
1979	26,840	87,850	2007	17,161	53,068
1980	33,500	83,980	2008	24,158	46,638
1981	23,720	44,520	2009	34,366	80,088
1982	10,320	30,800	2010	9,579	38,848
1983	16,000	33,730	2011	14,723	41,529
1984	21,970	92,660	2012	15,535	54,911
1985	58,410	136,970	2013	20,713	31,573
1986	30,810	40,280	2014	18,360	52,277
1987	40,580	53,930	2015	14,448	46,223
1988	19,540	42,480	2016	12,129	37,837
1989	55,210	138,380	2017	10,828	45,012
1990	56,180	83,430	2018	15,707	71,052

Note: NS means no survey

[a] Harvest during 1963–1996 from an onsite creel survey and during 1997–2000 from Statewide Harvest Survey (Alaska Sport Fishing Survey database [Internet]. 1996–present. Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish [cited November 2019]. Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/). 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.–2019 Upper Cook Inlet escapement goal memo.

THE STATE of ALASKA

GOVERNOR MICHAEL J. DUNLEAVY

Department of Fish and Game

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MEMORANDUM

TO: Dave Rutz, Director, Division of Sport Fish

Sam Rabung, Director, Division of Commercial Fisheries

DATE: March 26, 2019

SUBJECT: Upper Cook Inlet Escapement Goal Memorandum

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

Bert Lewis, Regional Supervisor, Division of Commercial Fisheries, Region II

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

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

This memorandum summarizes the Alaska Department of Fish and Game (department) review of Upper Cook Inlet (UCI) escapement goals and associated recommendations for escapement goals. Escapement goals in this management area have been set and evaluated at regular intervals since statehood. All UCI escapement goals were last reviewed by the department (Erickson et al. 2017) during the 2016–2017 Alaska Board of Fisheries (board) cycle.

Between November 2018 and February 2019, an interdivisional salmon escapement goal review committee, including staff from the divisions of Commercial Fisheries and Sport Fish, met five times and reviewed existing salmon escapement goals in the UCI management area.

The department recognizes the importance of releasing escapement goal recommendations earlier in the year so the public may submit proposals relative to goal recommendations before the deadline of Wednesday April 10, 2019. Thus, department staff completed their review on an accelerated timeline, and developed recommendations for UCI salmon escapement goals (Table 1). It is important to note that any recommended changes will not take effect until the 2020 fishing season, as they are not officially

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adopted until approved by the department after the 2019–2020 board regulatory cycle.

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 used:

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

Accordingly, the committee also determined the appropriate goal type (BEG or SEG) for each salmon stock with an existing goal. Based on the quality and quantity of available data, the committee determined the most appropriate methods to evaluate the escapement goals.

Escapement goals were evaluated (or created in the case of new goals) for UCI stocks using a variety of methods: 1) spawner-recruit analyses, 2) yield analyses, 3) available smolt and fry information, and (or) 4) the percentile approach (Clark et al. 2014). The committee developed escapement goals for each stock, compared them with the current goal if one exists, and agreed on a recommendation to keep the current goal, change the goal, eliminate the goal, or adopt a new goal if no prior goal existed. The methods used to evaluate the escapement goals and the rationale for making subsequent recommendations will be described in a published report (McKinley et al. *In prep*) available prior to the February 2020 Upper Cook Inlet Regulatory Meeting.

Susitna River king salmon
The review team recommends consolidating the majority of the current Susitna River king salmon escapement goals into four escapement goals representing sub-basins within the Susitna River drainage. The Susitna River drainage has historically been split into sub-basins, or units, for king salmon management. The Deshka River, assessed via weir, and the remaining three sub-basins and their included streams with current Single Aerial Survey (SAS) goals are as follows (Figure 1):

1) The Deshka River.
2) The Eastside Susitna River, which includes Willow, Little Willow, Sheep, Goose, and Montana creeks.
3) The Talkeetna River, which includes Clear and Prairie creeks.
4) The Yentna River, which includes the Talachulitna River, and Lake and Peters creeks.

Each sub-basin is unique in terms of geography, harvest, and accessibility, and therefore the regulatory structure varies between areas; streams within each sub-basin tend to share the same set of regulations. These sub-basin goals have an advantage over SAS goals in that they are based on modeled estimates of total escapement (vs. an index of escapement), derived using stock-recruit analyses (vs. the percentile approach, which is a proxy for stock-recruit analysis), and can account for years in which some surveys were not conducted. To develop these goals, historical (1979–2017) run size for each of the four sub-basins was estimated using a model that incorporated data from aerial surveys, weirs, abundance estimates from mark-recapture projects, radio telemetry, and harvest. From these historical estimates of total annual run size and associated age composition, spawner-recruit relationships were modeled, and yield and recruitment profiles constructed to aid in selecting escapement goal ranges. Based on these analyses, the review committee recommends a BEG for Deshka River king salmon of 9,000–18,000; an SEG of 13,000–25,000 for Eastside Susitna River sub-basin king salmon; an SEG of 9,000–17,500 for Talkeetna River sub-basin king salmon; and an SEG of 13,000–22,000 for Yentna River sub-basin king salmon. Annual assessment of the Deshka River goal will be via weir counts; assessment of all other sub-basin goals will be from model output of escapement based on SAS of streams within each sub-basin. These goal changes have allocative implications in the Tyonek subsistence, Northern District setnet (NDSN), Upper Yentna River Subsistence salmon, and the inriver sport fisheries.

In consolidating the Susitna River drainage king salmon goals into four sub-basins, 10 of the tributary goals are recommended to be discontinued: Goose Creek, Little Willow Creek, Montana Creek, Sheep Creek, Willow Creek, Clear (Chunilna) Creek, Prairie Creek, Talachulitna River, Lake Creek, and Peters Creek. Some of these streams have had poor returns for multiple years and are in Stock-of-Concern status. These tributaries will continue to be monitored with a SAS as in the past as part of the assessment of the four sub-basin goals.

Alexander Creek king salmon
This stock was not included in the Susitna River drainage run reconstruction and escapement goal analysis because it is physically outside of the scope of the mark-recapture abundance project conducted in the Susitna River drainage in recent years. The current SAS SEG (2,100–6,000) for Alexander Creek was established in 2002. For this review, the committee updated the escapement time series through 2005 (prior to apparently large impacts from invasive northern pike predation) and applied the percentile approach (Clark et al. 2014) to the data set. The committee recommends the Alexander Creek king salmon SEG be updated to 1,900–3,700. The change in this goal has allocative implications in the Tyonek subsistence, NDSN, and the inriver sport fisheries.

Chulitna River king salmon
This stock was originally included in the run reconstruction/sub-basin goal work for king salmon stocks in the Susitna drainage. However, model output for the sub-basin inclusive of this stock, was not considered an improvement for escapement goal setting over a SAS. The current SAS SEG (1,800–5,100) for Chulitna River king salmon was established in 2002. For this review, the committee updated the escapement time series through 2018 and applied the percentile approach (Clark et al. 2014) to the data set. The committee recommends the SEG for Chulitna River king salmon be updated to 1,200–2,900. The change in this goal has allocative implications in the Tyonek subsistence, NDSN, and inriver sport fisheries.

Chuitna River king salmon
The current SAS SEG (1,200–2,900) for Chuitna River king salmon was established in 2002. For this review, the committee updated the escapement time series only through 2015; aerial counts in the last three years are very low and we have not seen returns from them yet; therefore, we do not have information on whether they produce sustained yields. The percentile approach (Clark et al. 2014) was applied to the data set, and the committee recommends the SEG for Chuitna River king salmon be

updated to 1,000–1,500. The change in this goal has allocative implications in the Tyonek subsistence, NDSN, and inriver sport fisheries.

Theodore River king salmon
The current SAS SEG (500–1,700) for Theodore River king salmon was established in 2002. For this review, the committee updated the escapement time series only through 2015; aerial counts in the last three years are very low and we have not seen returns from them yet; therefore, we do not have information on whether they produce sustained yields. The percentile approach (Clark et al. 2014) was applied to the data set, and the committee recommends the SEG for Theodore River king salmon be updated to 500–1,000. The change in this goal has allocative implications in the Tyonek subsistence, NDSN, and inriver sport fisheries.

Lewis River king salmon
The current SAS SEG (250–800) was established in 2002; in 2011, this stock was designated a Stock of Concern. At present, the Lewis River is forked and flowing east into wetlands by an undefined channel and south into Cook Inlet by way of the original channel. The connection with Cook Inlet is intermittent at best, and the river did not have a channel that flowed into Cook Inlet during aerial surveys conducted in the last four years (2015–2018). The eastern flow may be connecting with the Ivan River, at least during higher flows. The committee is considering discontinuing the escapement goal on the Lewis River, but will not make a final recommendation until after the 2019 season.

Little Susitna River king salmon aerial goal
There are two king salmon goals for this stock; one assessed via a floating weir and the other assessed via SAS. The current weir goal was established in 2017 and not updated during this board cycle. The SAS goal is used only if the Little Susitna River weir is inoperable for a sustained period and complete fish passage not assessed. The current SAS SEG (900–1,800) for Little Susitna River king salmon was established in 2002. For this review, the committee updated the escapement time series only through 2017; the aerial count in 2018 was not included because it was very low (530) and we have not seen returns from this escapement yet; therefore, we do not have information on whether it produces sustained yield. The percentile approach (Clark et al. 2014) was applied to the data set, and the committee recommends the Little Susitna River single aerial survey king salmon SEG be updated to 700–1,500. The change in this goal has allocative implications in the Tyonek subsistence, NDSN, and inriver sport fisheries.

Crooked Creek king salmon
Hatchery smolt produced from gametes taken from naturally-produced adults in Crooked Creek are stocked into Crooked Creek annually. The current weir SEG of 650–1,700 naturally-produced king salmon ocean age 2 and older was established in 2002. For this review, the committee updated the escapement time series using 2004–2018 weir data. Data prior to 2004 were excluded from this analysis because 100% of the hatchery-produced smolt were not marked by removing the adipose fin until smolt year 2000, hence the number of naturally-produced adults could not be counted with accuracy. The Clark et al. (2014) percentile approach was applied to the data set, and the committee recommends the Crooked Creek king salmon SEG be updated to 700–1,400 naturally-produced king salmon ocean age 2 and older. The change in this goal has allocative implications in the Kasilof River Personal Use setnet and the inriver sport fisheries.

Kenai River early- and late-run king salmon
Large fish (fish ≥75 cm mid-eye-to-fork of tail length) escapement goals (assessed via sonar) were adopted for the first time for both of these stocks two years ago (2017). With only 3 new years of return data for both stocks, it was concluded that updating the analyses for these stocks would not likely result in substantially different escapement goals; therefore, the committee recommends no changes at this time.

Deshka River coho salmon
A weir-based escapement goal (SEG; 10,200–24,100) was adopted for the first time for this stock two years ago, in 2017. With only 3 new years of return data, it was concluded that updating the analyses for this stock would not likely result in a substantially different escapement goal; therefore, the committee recommends no changes at this time.

Fish Creek coho salmon
The current weir-based SEG of 1,200–4,400 was established in 2011. The committee updated the escapement time series using weir data through 2018. The percentile approach (Clark et al. 2014) was applied to the data set, and the committee recommends the Fish Creek coho salmon SEG be updated to 1,200–6,000. The change in this goal has allocative implications in the Upper Cook Inlet driftnet (UCD), the Eastside setnet (ESSN), NDSN, and inriver sport fisheries.

Jim Creek coho salmon
The current SEG of 450–1,400 was established in 2014. Although a weir has been operated on Jim Creek for a few years, the current goal and goal assessment is based on a single foot survey of the McRoberts Creek tributary. The committee updated the escapement time series using foot survey data through 2018. The Clark et al. (2014) percentile approach was applied to the data set, and the committee recommends the Jim Creek coho salmon single foot survey SEG be updated to 250–700. The change in this goal has allocative implications in the UCD, ESSN, NDSN, and inriver sport fisheries.

Little Susitna River coho salmon
The current SEG of 10,100–17,700 was established in 2002. The committee updated the escapement time series using weir data (subtracting harvest above the weir) through 2018. The Clark et al. (2014) percentile approach was applied to the data set, and the committee recommends the Little Susitna River coho salmon SEG be updated to 9,200–17,700. The change in this goal has allocative implications in the UCD, ESSN, NDSN, and inriver sport fisheries.

Kasilof River sockeye salmon
The current sonar-based BEG (160,000–340,000) for Kasilof River sockeye salmon was established in 2011. For this review, the committee updated the escapement time series and incorporated production data through 2018. The committee then examined the fit of five stock-recruit models to data from brood years 1968 to 2012 (i.e., all available spawner-return data). The best fitting model was a Ricker Autoregressive with 1-year lag that estimates 90% of maximum sustained yield (MSY) at escapements between 140,000 and 320,000 fish. The committee recommends the BEG range for Kasilof River sockeye salmon be updated to 140,000–320,000. The change in this goal has allocative implications in the UCD, ESSN, Kasilof River Personal Use setnet and dip net, and inriver sport fisheries.

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Kenai River sockeye salmon

The current sonar-based SEG (700,000–1,200,000) for Kenai River sockeye salmon was established in 2011 based on the Ricker Brood Year Interaction No Main Effects model combined with a yield risk analysis. This review updated the escapement time series and incorporated production data through 2018. The committee then examined the fit of 6 stock-recruit models to the data from brood years 1968 to 2012: traditional Ricker, Ricker Autoregressive, Ricker Brood Year Interaction Main Effects, Beverton-Holt, Deriso-Schnute, and Ricker Brood Year Interaction No Main Effects. Results from these models indicated revision of the current escapement goal may improve chances of maximizing yield.

Based on statistical model selection criteria, none of these models clearly fit the stock-recruit data better than any of the other models considered. As suggested in Clark et al. (2007), the Ricker Brood Year Interaction No Main Effects model is inappropriate for revising the escapement goal; this is because both the model structure and taking the square root of the product of two successive escapements are flawed and because this model predicts maximum yield would occur only when very high escapements in one year (little fishing opportunity) are followed by very low escapements in the following year in an alternating pattern, a poor management strategy not in the best interests to the economy of Alaska. Beverton-Holt and Deriso-Schnute models are not generally used in Alaska to analyze salmon stock production, and parameter estimates of Ricker Autoregressive and Ricker Brood Year Interaction Main Effects models included zero, indicating those models would likely not be appropriate to provide an accurate estimate of maximum sustained yield. The remaining model was the traditional Ricker model, which is generally used in salmon escapement goal analysis.

The traditional Ricker model with data from brood years 1968 through 2012 resulted in an estimate of the spawning escapement that produces maximum sustained yield (S_{MSY}) of 1,290,000 sockeye salmon and escapement bounds that produce 90% of maximum sustained yield (MSY) of 830,000 and 1,822,000 fish. However, as noted in Clark et al. (2007), assessment methodology used for spawner abundance and run size estimates are most consistent starting in 1979, and so 1968–1978 estimates may be inaccurate. Using data from brood years 1979–2012 resulted in an estimated S_{MSY} of 1,206,000 fish and escapement bounds that produce 90% MSY were 774,000 and 1,716,000 fish. These results are consistent with those reported previously (Clark et al. 2007, Erickson et al. 2017, Cunningham 2018).

Because the time series of data does not contain large escapements where stocks failed to replace themselves, there is insufficient information in the data to understand the potential for overcompensation. Without this information, the traditional Ricker model provides the best estimates of MSY and S_{MSY} but the estimates remain potentially sensitive to additional (large escapement) data. However, these new results indicate the current Kenai River sockeye salmon SEG is probably too low to maximize yields. Results from the Ricker model and Markov yield table indicate escapements of 750,000 to 1,300,000 sockeye salmon produce sustained yields similar to those of the current goal and are more likely to include spawner abundances that contain S_{MSY}. Therefore, the committee recommends the Kenai River sockeye salmon SEG be updated to 750,000–1,300,000. This escapement goal range is precautionary regarding recognized limitations in available stock productivity information and avoids potential risks of adversely impacting available yield. The change in this goal has allocative implications in the UCD, ESSN, Kenai River Personal Use dip net, and inriver sport fisheries.

Fish Creek sockeye salmon
The current weir-based SEG (15,000–45,000) for Fish Creek was established in 2017. For this review, the committee updated the escapement time series through 2018 and concluded that updating the analysis for this stock would not likely result in a substantially different escapement goal; therefore, the committee recommends no change at this time.

Chelatna, Judd, and Larson lakes sockeye salmon
The current weir-based SEGs for these three stocks were established in 2017. The current SEGs are Chelatna Lake 20,000–45,000; Judd Lake 15,000–40,000; and Larson Lake 15,000–35,000. The committee reviewed the updated escapement time series for each stock and concluded that updating the analyses for these stocks would not likely result in substantially different escapement goals; therefore, the committee recommends no changes at this time.

Early-run Russian River sockeye salmon
The current weir-based SEG (22,000–42,000) was adopted in 2011 using 34 years of data. Updating the stock-recruit analysis with the 7 recent brood returns changed parameter estimates very little, and the committee recommended no change to the current goal.

Late-run Russian River sockeye salmon
The current weir-based SEG (30,000–110,000) for late-run Russian River sockeye salmon was established in 2005. The committee updated the escapement time series using weir data through 2018. From run reconstruction work in 2006–2008 on this stock, it is known that the harvest rate averages greater than 0.60, so the 25th–75th percentile was applied to the data set (Clark et al. 2014), and the committee recommends the Russian River sockeye salmon SEG be updated to 44,000–85,000. The change in this goal has no allocative implications in UCI fisheries.

In summary, the escapement goal committee reviewed 36 salmon escapement goals for the UCI management area. Recommendations are as follows: update the Deshka River king salmon BEG goal; establish aerial survey-based, model output-assessed goals (all SEGs) for three additional sub-basins of the Susitna River drainage for king salmon; update the SEG range for six king salmon stocks (Alexander Creek, Chulitna River, Chuitna River, Theodore River, Little Susitna River aerial, and Crooked Creek); update the SEG range for three coho salmon stocks (Fish Creek, Jim Creek, and Little Susitna River); and update the range for three sockeye salmon stocks (BEG for Kasilof River, SEGs for Kenai River and late-run Russian River). In addition, the discontinuation of 10 king salmon goals are recommended (Goose Creek, Little Willow Creek, Montana Creek, Sheep Creek, Willow Creek, Clear [Chunilna] Creek, Prairie Creek, Talachulitna River, Lake Creek, and Peters Creek). The escapement goal for Lewis River king salmon may be discontinued when stock-of-concern recommendations are finalized after the 2019 field season.

Separate peer-reviewed reports detailing the analyses for the Susitna River king salmon sub-basin and the Kenai River sockeye salmon escapement goals are expected to be published prior to the February 2020 Upper Cook Inlet Regulatory Meeting. A report containing details of the other escapement goal analyses will undergo external peer-review also and is expected to be published prior to the February 2020 Upper Cook Inlet Regulatory meeting. A brief oral report will be given to the board at the October

2019 Work Session. A more detailed oral report concerning escapement goals will be presented to the board in February 2020. 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.

Salmon stock of concern recommendations will be finalized after the 2019 salmon season to include the most recent year's escapements. These recommendations will be formalized in a memo and presented at the board Work Session in October 2019.

References Cited

Clark, J. H., D. M. Eggers, and J. A. Edmundson. 2007. Escapement goal review for Kenai River late-run sockeye salmon: Report to the Alaska Board of Fisheries, January 2005. Alaska Department of Fish and Game, Special Publication No. 07-12, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/sp07-12.pdf

Clark, R. A., D. M. Eggers, A. R. Munro, S. J. Fleischman, B. G. Bue, and J. J. Hasbrouck. 2014. An evaluation of the percentile approach for establishing Sustainable Escapement Goals in lieu of stock productivity information. Alaska Department of Fish and Game, Fishery Manuscript No. 14-06, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMS14-06.pdf

Cunningham, C. J. 2018. Exploration of overcompensation and spawning abundance producing maximum sustainable yield for Upper Cook Inlet sockeye salmon stocks. In NPFMC. 2018. Discussion Paper: Revisions to the Fishery Management Plan for the salmon fisheries in the EEZ off Alaska. November 6, 2018. Anchorage, AK 99501.

Erickson, J. W., T. M. Willette, and T. McKinley. 2017. Review of salmon escapement goals in Upper Cook Inlet, Alaska, 2016. Alaska Department of Fish and Game, Fishery Manuscript No. 17-03, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMS17-03.pdf

McKinley, T. R., J. W. Erickson, N. Decovich, and R. Begich. *In prep*. Review of salmon escapement goals in Upper Cook Inlet, Alaska, 2019. Alaska Department of Fish and Game, Fishery Manuscript Series, Anchorage.

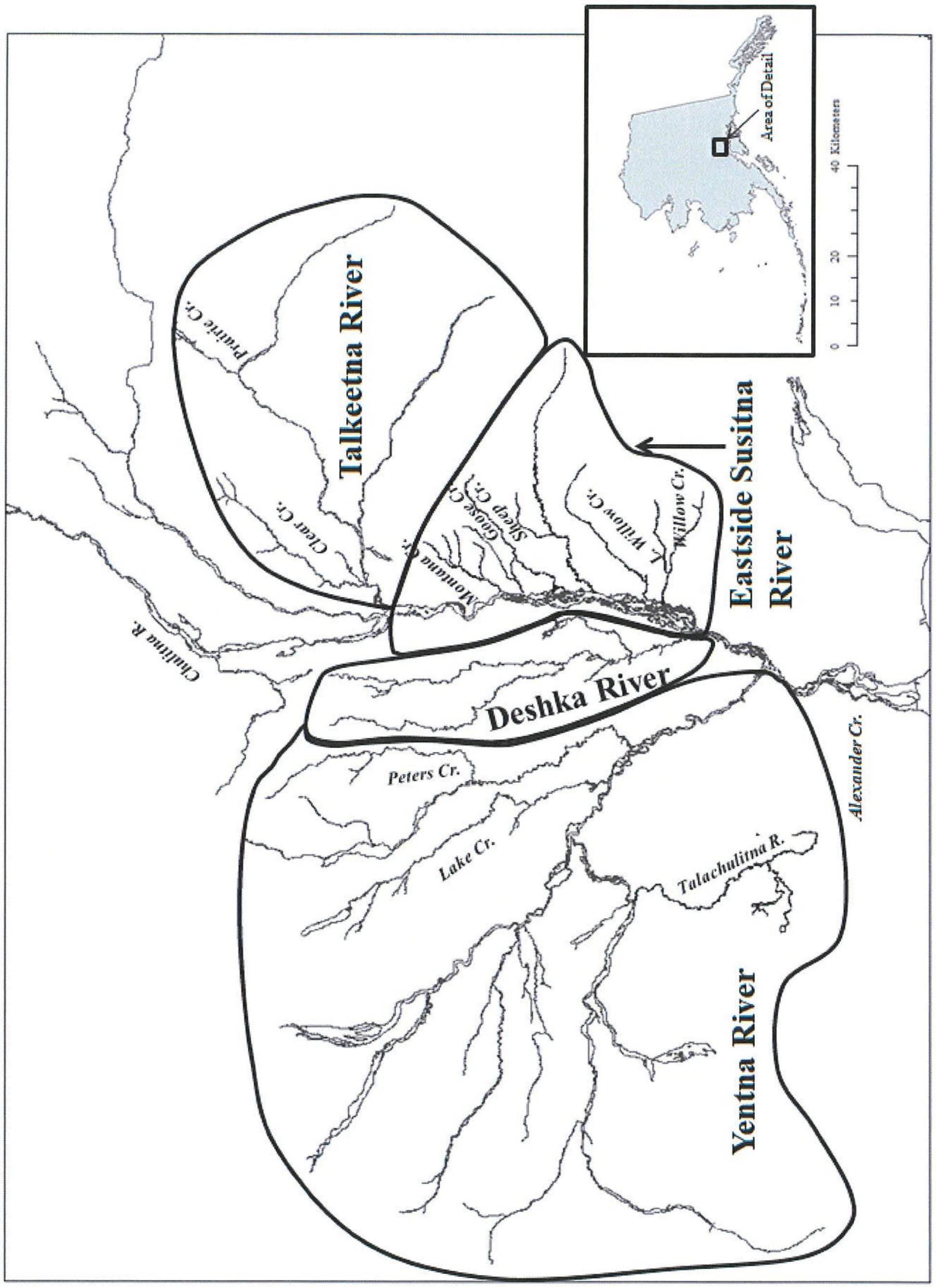

Figure 1.–Map of Susitna River king salmon escapement goal sub-basins. Streams that currently have single aerial survey goals are labeled.

9

Table 1.–Summary of current and recommended escapement goals for salmon stocks in Upper Cook Inlet, 2020.

	Current Escapement Goal			Recommended Escapement Goal changes beginning with 2020 season			
System	Goal	Type	Year adopted	Range or lower bound	Type	Data	Action
King Salmon							
Susitna River							
Deshka River	13,000–28,000	SEG	2011	**9,000–18,000**	BEG	weir	Update
Eastside Susitna River sub-basin				**13,000–25,000**	SEG	multiple aerial surveys[a]	New
Goose Creek	250–650	SEG	2002				discontinue[b]
Little Willow Creek	450–1,800	SEG	2002				discontinue[b]
Montana Creek	1,100–3,100	SEG	2002				discontinue[b]
Sheep Creek	600–1,200	SEG	2002				discontinue[b]
Willow Creek	1,600–2,800	SEG	2002				discontinue[b]
Talkeetna River sub-basin				**9,000–17,500**	SEG	multiple aerial surveys[a]	New
Clear (Chunilna) Creek	950–3,400	SEG	2002				discontinue[b]
Prairie Creek	3,100–9,200	SEG	2002				discontinue[b]
Yentna River sub-basin				**13,000–22,000**	SEG	multiple aerial surveys[a]	New
Talachulitna River	2,200–5,000	SEG	2002				discontinue[b]
Lake Creek	2,500–7,100	SEG	2002				discontinue[b]
Peters Creek	1,000–2,600	SEG	2002				discontinue[b]
Alexander Creek	2,100–6,000	SEG	2002	**1,900–3,700**	SEG	single aerial survey	Update
Chulitna River	1,800–5,100	SEG	2002	**1,200–2,900**	SEG	single aerial survey	Update
West Cook Inlet and Knik Arm							
Lewis River	250–800	SEG	2002			single aerial survey	may discontinue[c]
Chuitna River	1,200–2,900	SEG	2002	**1,000–1,500**	SEG	single aerial survey	Update
Theodore River	500–1,700	SEG	2002	**500–1,000**	SEG	single aerial survey	Update
Little Susitna River	2,300–3,900	SEG	2017			weir	No Change

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Table 1.–Page 2 of 3.

System	Current Escapement Goal			Recommended Escapement Goal changes beginning with 2020 season			
	Goal	Type	Year adopted	Range or lower bound	Type	Data	Action
West Cook Inlet and Knik Arm							
Little Susitna River aerial	900–1,800	SEG	2002	**700–1,500**	SEG	single aerial survey	Update
Anchorage							
Campbell	380	LB SEG	2011			single foot survey	No Change
Northern Kenai Peninsula							
Crooked Creek	650–1,700	SEG	2002	**700–1,400**	SEG	weir	Update
Kenai River - Early Run (large fish)	2,800–5,600[d]	SEG	2017			sonar	No Change
	3,900–6,600	OEG	2017				
Kenai River - Late Run (large fish)	13,500–27,000[d]	SEG	2017			sonar	No Change
Chum Salmon							
Clearwater Creek	3,500–8,000	SEG	2017			peak aerial survey	No Change
Coho Salmon							
Susitna River							
Deshka River	10,200–24,100	SEG	2017			weir	No Change
Knik Arm							
Fish Creek (Knik)	1,200–4,400	SEG	2011	**1,200–6,000**	SEG	weir	Update
Jim Creek	450–1,400	SEG	2014	**250–700**	SEG	single foot survey	Update
Little Susitna River	10,100–17,700	SEG	2002	**9,200–17,700[e]**	SEG	weir	Update

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Table 1.–Page 3 of 3.

System	Current Escapement Goal: Goal	Type	Year adopted	Recommended Escapement Goal beginning with 2020 season: Range or lower bound	Type	Data	Action
Sockeye Salmon							
Susitna River							
Chelatna Lake	20,000–45,000	SEG	2017			weir	No Change
Judd Lake	15,000–40,000	SEG	2017			weir	No Change
Larson Lake	15,000–35,000	SEG	2017			weir	No Change
Cook Inlet and Knik Arm							
Fish Creek	15,000–45,000	SEG	2017			weir	No Change
Packers Creek	15,000–30,000	SEG	2008			weir	No Change
Northern Kenai Peninsula							
Kasilof River	160,000–340,000	BEG	2011	**140,000–320,000**		sonar	Update
	160,000–390,000	OEG	2011				
Kenai River	700,000–1,200,000	SEG	2011	**750,000–1,300,000**		sonar	Update
Russian River-Early Run	22,000–42,000	BEG	2011				No Change
Russian River-Late Run	30,000–110,000	SEG	2005	**44,000–85,000**		weir	Update

[a] Single aerial surveys of individual tributaries are combined with other historical data to estimate annual run size for three sub-basins of the Susitna River drainage.
[b] Although the tributary goal is discontinued, the tributary will still be flown and counted.
[c] To be decided in the fall of 2019
[d] Fish 75 cm mid-eye-to-fork of tail length or longer
[e] Based on escapement (weir count - harvest above weir).

Appendix E2.–2019 Upper Cook Inlet escapement goal memo addendum.

THE STATE of ALASKA
GOVERNOR MICHAEL J. DUNLEAVY

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MEMORANDUM

TO:	Dave Rutz, Director, Division of Sport Fish Sam Rabung, Director, Division of Commercial Fisheries	DATE:	October 4, 2019
THRU:	Thomas D. Vania, Regional Supervisor, Division of Sport Fish, Region II Bert Lewis, Regional Supervisor, Division of Commercial Fisheries	SUBJECT:	Addendum to Upper Cook Inlet Escapement Goal Memorandum dated March 26, 2019
FROM:	Tim McKinley, Regional Research Coordinator, Division of Sport Fish, Region II Jack Erickson, Regional Research Coordinator, Division of Commercial Fisheries		

This memorandum finalizes the recommendation to discontinue the escapement goal for Lewis River king salmon.

The current Lewis River king salmon sustainable escapement goal of 250–800 fish was established in 2002. In 2011, this stock was designated a stock of management concern. At that time salmon migration was effectively eliminated by natural changes to the channel such that it no longer flows into Cook Inlet. Attempts to restore the channel and fish passage proved unsuccessful. Few if any adult king salmon have been documented in this river system since these natural channel changes cut off access to saltwater. It is unlikely these channel changes and associated blockage of fish passage will allow for a viable population of king salmon in the Lewis River.

In the March 20, 2019 Upper Cook Inlet escapement goal review memorandum, the department delayed a final recommendation on Lewis River king salmon sustainable escapement goal until after the 2019 season. This delay was to allow for final evaluation of the channel and population. The 2019 season did not change the department assessment of the unviable nature of this king salmon population. In a separate document, the Upper Cook Inlet 2019 Stock of Concern memo, the Upper Cook Inlet escapement goal committee is recommending that the stock of management concern designation be discontinued for Lewis River king salmon, since its connection with Cook Inlet is intermittent at best. For the same reasons, the department is recommending that the escapement goal for Lewis River king salmon be discontinued.

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An oral update on Upper Cook Inlet escapement goals will be given at the October 2019 Work Session. A more detailed oral report concerning escapement goals and stocks of concern will be presented to the Alaska Board of Fisheries in February 2020. This report will list all current and recommended Upper Cook Inlet escapement goals, as well as a detailed description of the methods used to reach recommendations.

APPENDIX F: JAGS MODEL CODES

Classic Ricker

```
parameters.CR <- c('lnalpha','beta','sigma')
jag.model.CR <- function(){
  for(y in 1:nyrs){
   s[y] <- S[y]/(10^d)
   lnRm[y] = log(S[y]) + lnalpha - beta * s[y]
      }
#    Define Priors
   lnalpha ~ dunif(0,10)
   beta ~ dunif(0,10)
   sigma ~ dunif(0,10)
   phi ~ dunif(-1,1)
   Tau <- 1/(sigma*sigma)
# Likelihood
   for(y in 1:nyrs){
     R[y] ~ dlnorm(lnRm[y],Tau)
           }
}
```

AR1 Ricker

```
parameters.AR1 <- c('lnalpha','beta','phi','lnresid0','sigma')
jag.model.AR1 <- function(){
  for(y in 1:nyrs){
   s[y] <- S[y]/(10^d)
   lnRm1[y] = log(S[y]) + lnalpha - beta * s[y]
   lnResid[y] = log(R[y]) - lnRm1[y]
      }
   lnRm[1] = lnRm1[1] + phi * lnresid0;
  for(y in 2:nyrs){
   lnRm[y] = lnRm1[y] + phi * lnResid[y-1]
   }
#    Define Priors
   lnalpha ~ dunif(0,10)
   beta ~ dunif(0,10)
   sigma ~ dunif(0,10)
   phi ~ dunif(-1,1)
   lnresid0 ~ dnorm(0,0.001)
   Tau <- 1/(sigma*sigma)
# Likelihood
   for(y in 1:nyrs){
     R[y] ~ dlnorm(lnRm[y],Tau)
           }
}
```

-continued-

Beverton-Holt

```
parameters.BH <- c('lnalpha','beta','sigma')
jag.model.BH <- function(){
  for(y in 1:nyrs){
   s[y] <- S[y]/(10^d)
   lnRm[y] <- lnalpha + log(S[y]) -log(1+beta*s[y])
       }
#     Define Priors
   lnalpha ~ dunif(0,10)
   beta ~ dunif(0,10)
   sigma ~ dunif(0,10)
   Tau <- 1/(sigma*sigma)
# Likelihood
   for(y in 1:nyrs){
     R[y] ~ dlnorm(lnRm[y],Tau)
            }
}
```

Deriso-Shunute

```
parameters.DS <- c('lnalpha','beta','c','sigma')
jag.model.DS <- function(){
  for(y in 1:nyrs){
     s[y] <- S[y]/(10^d)
   lnS[y] <- log(S[y])
   lnR[y] <- log(R[y])
   lnRm[y] = lnS[y] + lnalpha - log(1 + beta*c*s[y])/c
       }
#     Define Priors
   lnalpha ~ dunif(0,10)
   beta ~ dunif(0,10)
   sigma ~ dunif(0,10)
   c ~ dunif(0,1)
   Tau <- 1/(sigma*sigma)
# Likelihood
   for(y in 1:nyrs){
     R[y] ~ dlnorm(lnRm[y],Tau)
            }
}
```

Additive Brood Interaction

```
parameters.BI <- c('lnalpha','beta1','beta2','lnS0','sigma')
jag.model.BI<- function(){
```

```
  for(y in 1:nyrs){
    s[y] <- S[y]/(10^d)
   lnRm1[y] <- log(S[y]) + lnalpha - beta1*s[y]
     }
   lnRm[1] <- lnRm1[1] + beta2*exp(lnS0)/(10^d)
  for(y in 2:nyrs){
   lnRm[y] <- lnRm1[y] + beta2*s[y-1]
   }

#   Define Priors
   lnalpha ~ dunif(0,10)
   beta1 ~ dunif(0,10)
   sigma ~ dunif(0,10)
   beta2 ~ dunif(-10,10)
   lnS0 ~ dunif(0,16)
   Tau <- 1/(sigma*sigma)
# Likelihood
   for(y in 1:nyrs){
    R[y] ~ dlnorm(lnRm[y],Tau)
         }
}
Multiplicative Brood Interaction
parameters.BI2 <- c('lnalpha','beta3','lnS0','sigma')
jag.model.BI2<- function(){
  for(y in 1:nyrs){
    s[y] <- S[y]/(10^d)
     }
   lnRm[1] <- log(S[1]) + lnalpha - beta3*(s[1])*exp(lnS0)/(10^d)
  for(y in 2:nyrs){
   lnRm[y] <- log(S[y]) + lnalpha - beta3*s[y]*s[y-1]
   }
# Define Priors
   lnalpha ~ dunif(0,10)
   sigma ~ dunif(0,100)
   beta3 ~ dunif(-10,10)
   lnS0 ~ dunif(0,16)
   Tau <- 1/(sigma*sigma)
# Likelihood
   for(y in 1:nyrs){
    R[y] ~ dlnorm(lnRm[y],Tau)
         }
}
```

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JAGS model running code

```
nmodels <- 6
models <- list()
models$model1 = jag.model.CR
models$model2 = jag.model.AR1
models$model3 = jag.model.BH
models$model4 = jag.model.DS
models$model5 = jag.model.BI
models$model6 = jag.model.BI2

# Store Model Parameters
parlist <- list()
parlist$par1 = parameters.CR
parlist$par2 = parameters.AR1
parlist$par3 = parameters.BH
parlist$par4 = parameters.DS
parlist$par = parameters.BI
parlist$par6 = parameters.BI2

# Run JAGS Model
simlist <- list()
  for (i in 1:nmodels){
  sim <- jags(data=datnew, parameters.to.save=parlist[[i]],      model.file= models[[i]],n.chains=1,
          n.iter=100000,n.burnin=20000,n.thin=10,DIC=TRUE, working.directory=data_dir)
simlist[[i]] <- sim
 }
```