Review of Salmon Escapement Goals in the Alaska Peninsula and Aleutian Islands Management Areas, 2018

by

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Symbols and Abbreviations

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Weights and measures (metric)		General		Mathematics, statistics	
centimeter	cm	Alaska Administrative		*all standard mathematical*	
deciliter	dL	Code	AAC	*signs, symbols and*	
gram	g	all commonly accepted		*abbreviations*	
hectare	ha	abbreviations	e.g., Mr., Mrs.,	alternate hypothesis	H_A
kilogram	kg		AM, PM, etc.	base of natural logarithm	*e*
kilometer	km	all commonly accepted		catch per unit effort	CPUE
liter	L	professional titles	e.g., Dr., Ph.D.,	coefficient of variation	CV
meter	m		R.N., etc.	common test statistics	$(F, t, \chi^2, \text{etc.})$
milliliter	mL	at	@	confidence interval	CI
millimeter	mm	compass directions:		correlation coefficient	
		east	E	(multiple)	R
Weights and measures (English)		north	N	correlation coefficient	
cubic feet per second	ft^3/s	south	S	(simple)	r
foot	ft	west	W	covariance	cov
gallon	gal	copyright	©	degree (angular)	°
inch	in	corporate suffixes:		degrees of freedom	df
mile	mi	Company	Co.	expected value	*E*
nautical mile	nmi	Corporation	Corp.	greater than	>
ounce	oz	Incorporated	Inc.	greater than or equal to	≥
pound	lb	Limited	Ltd.	harvest per unit effort	HPUE
quart	qt	District of Columbia	D.C.	less than	<
yard	yd	et alii (and others)	et al.	less than or equal to	≤
		et cetera (and so forth)	etc.	logarithm (natural)	ln
Time and temperature		exempli gratia		logarithm (base 10)	log
day	d	(for example)	e.g.	logarithm (specify base)	$\log_2$, etc.
degrees Celsius	°C	Federal Information		minute (angular)	'
degrees Fahrenheit	°F	Code	FIC	not significant	NS
degrees kelvin	K	id est (that is)	i.e.	null hypothesis	H_O
hour	h	latitude or longitude	lat or long	percent	%
minute	min	monetary symbols		probability	P
second	s	(U.S.)	$, ¢	probability of a type I error	
		months (tables and		(rejection of the null	
Physics and chemistry		figures): first three		hypothesis when true)	α
all atomic symbols		letters	Jan,...,Dec	probability of a type II error	
alternating current	AC	registered trademark	®	(acceptance of the null	
ampere	A	trademark	™	hypothesis when false)	β
calorie	cal	United States		second (angular)	"
direct current	DC	(adjective)	U.S.	standard deviation	SD
hertz	Hz	United States of		standard error	SE
horsepower	hp	America (noun)	USA	variance	
hydrogen ion activity	pH	U.S.C.	United States	population	Var
(negative log of)			Code	sample	var
parts per million	ppm	U.S. state	use two-letter		
parts per thousand	ppt, ‰		abbreviations		
volts	V		(e.g., AK, WA)		
watts	W				

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF APPENDICES (Continued)

ABSTRACT

In January 2018, an interdivisional team, including staff from the Division of Commercial Fisheries and the Division of Sport Fish, was formed to review Pacific salmon *Oncorhynchus* sp. escapement goals in the Alaska Peninsula and Aleutian Islands Management areas (Area M). This 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). Of the 23 existing Area M salmon escapement goals evaluated, the team recommended revising 6 goals, discontinuing 1 goal, and leaving the remaining 16 goals unchanged.

After a comprehensive review of the available data, the team recommended that no changes in the current sustainable escapement goals (SEGs) were warranted for 10 sockeye salmon *O. nerka* systems that include runs to Orzinski, Bear (early and late run), and Thin Point lakes; Mortensens, and Christianson lagoons; and the Cinder, Meshik, Sandy, and Ilnik rivers. No change was recommended for the sockeye salmon biological escapement goal (BEG) at Nelson River. In addition, the team recommended no changes to two of the current aggregate district SEGs for chum salmon *O. keta* in the North Peninsula, and two coho salmon *O. kisutch* goals at Nelson and Ilnik rivers. The team did recommend revision of six goals (Nelson River Chinook salmon *O. tshawytscha* BEG 2,400 to 5,000; McLees Lake sockeye salmon Lower Bound-SEG >10,000; North Creek sockeye salmon SEG 7,500 to 10,000; Southeastern District aggregate chum salmon SEG 62,500 to 151,800; South Central District aggregate chum salmon SEG 68,900 to 99,200; Southwestern District aggregate chum salmon SEG 86,900 to 159,900). The chum salmon aggregate goal reviews incorporated a reduction to the number of index streams, which accounts for the apparent large changes in these goals. The Swanson Lagoon sockeye salmon escapement goal is recommended to be discontinued.

Key words: Pacific salmon, *Oncorhynchus*, escapement goal, Area M, Alaska Peninsula, stock status

INTRODUCTION

This report documents the 2018 review of salmon escapement goals in the Alaska Peninsula and Aleutian Islands Management areas (Area M) based on the Alaska Board of Fisheries (the Board) *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). Recommendations from this review are made to the directors of the divisions of Commercial Fisheries and Sport Fish of the Alaska Department of Fish and Game (ADF&G) and are intended to take effect for salmon stocks returning in 2019. Salmon escapement goals in Area M were last reviewed in 2015 (Schaberg et al. 2015).

Two important terms defined in the SSFP are as follows:

1. "*biological escapement goal* (BEG): the escapement that provides the greatest potential for maximum sustained yield (MSY);" and
2. "*sustainable escapement goal* (SEG): 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".

A report documenting the established escapement goals for stocks of five Pacific salmon species (Chinook *Oncorhynchus tshawytscha*, sockeye *O. nerka*, coho *O. kisutch*, pink *O. gorbuscha*, and chum *O. keta* salmon) spawning in the Kodiak, Chignik, Alaska Peninsula, and Aleutian Islands Management areas of Alaska was prepared in 2001 (Nelson and Lloyd 2001). Most of the escapement goals documented in the 2001 report were based on average escapement estimates and spawning habitat availability and had been implemented in the early 1970s and 1980s.

Since 2001, escapement goals for Area M have gone through review five times (Nelson et al. 2006, Honnold et al. 2007, Witteveen et al. 2009, Sagalkin and Erickson 2013, Schaberg et al. 2015).

In January 2018, the Salmon Escapement Goal Interdivisional Review Team (hereafter referred to as the team) was formed to review the existing Area M salmon escapement goals and recent escapements for stocks with escapement goals. The team included staff from the Division of Commercial Fisheries (CF) and the Division of Sport Fish (SF): Kevin Schaberg (CF), Tim McKinley (SF), Nicholas Sagalkin (CF), Heather Finkle (CF), Birch Foster (CF), Michelle Wattum (CF), Jeff Wadle (CF), Dawn Wilburn (CF), Bob Murphy (CF), Lukas Stumpf (CF), Lisa Fox (CF), Andrew Munro (CF), Jim Hasbrouck (SF), Tom Vania (SF), Adam St. Saviour (SF), David Evans (SF), Tyler Polum (SF), and Mark Witteveen (SF).

For this review the team 1) reviewed recent escapements to all stocks with escapement goals; 2) determined the appropriate goal type (BEG or SEG) for each Area M salmon stock with an existing goal, based on the quality and quantity of available data; 3) determined the most appropriate methods to evaluate the escapement goal ranges; 4) estimated the escapement goal for each stock and compared these estimates with the current goal; 5) determined if a goal could be developed for any stocks or stock-aggregates that currently have no goal; and 6) developed recommendations for each goal evaluated to present to the directors of the divisions of Commercial Fisheries and Sport Fish for approval.

STUDY AREA

Area M comprises 2 separate management areas: 1) the Alaska Peninsula Management Area and 2) the Aleutian Islands Management Area (Figure 1).

Alaska Peninsula Management Area includes all waters of Alaska from Cape Menshikof to Cape Sarichef and from a line extending from Scotch Cap through the easternmost tip of Ugamak Island to a line extending 135° southeast from Kupreanof Point (55°33.98′ N lat, 159°35.88′ W long; 5 AAC 09.100). The area is divided into 6 commercial fishing districts: the Southeastern (comprising the Southeastern District Mainland and the Shumagin Islands), South Central, Southwestern, Unimak, Northwestern, and Northern districts (5 AAC 09.200). Commonly, aggregates of these districts are referred to as the South Peninsula and North Peninsula (Figure 2). These districts are further subdivided into sections and smaller statistical areas.

The Aleutian Islands Management Area includes the waters of Alaska surrounding the Aleutian Islands west of Cape Sarichef and west of a line extending from Scotch Cap through the easternmost tip of Ugamak Island, including waters surrounding the Pribilof Islands (5 AAC 12.100), except the Atka-Amlia Islands Area described in 5 AAC 11.101 (Figure 1). The Aleutian Islands area is separated into 4 commercial fishing districts: the Akutan, Unalaska, Umnak, and Adak districts. There is little commercial salmon fishing in the area and very few of the 458 known salmon streams are consistently monitored for escapement (Holmes 1997).

BACKGROUND

Nelson River on the North Peninsula is the only Chinook salmon system in Area M with an escapement goal (Table 1; Figure 3). Chinook salmon escapement at this system is primarily monitored by weir counts. There are no spawning stocks of Chinook salmon documented along the South Peninsula or Aleutian Islands.

A total of 14 sockeye salmon stocks (13 systems) in Area M have escapement goals in place. Three of these stocks are located along the South Peninsula, 10 are located along the North Peninsula, and one is located on Unalaska Island (Table 1; Figures 3 and 4). All of these stocks

directly affect the daily management of associated fisheries and six of these systems currently have weirs for direct enumeration of escapement. Escapements of the remaining stocks are monitored via aerial surveys.

Coho salmon are not monitored in some Area M streams due to the difficulty and expense of conducting surveys during late fall. However, there are escapement goals in place for two coho stocks on the North Peninsula (Table 1; Figure 3). There are no coho salmon escapement goals for the Aleutian Islands where conducting aerial surveys has proven to be difficult and expensive.

Pink salmon are generally a high-volume commercial species in Area M and are managed as aggregates of streams. The stock-aggregate pink salmon escapement goal for the South Peninsula was converted to an annual goal implemented in 2016 due to reduced variability in even- and odd- year run sizes, as well as redefining the harvest as being that from July 15 on, to not include non-local pink salmon in the run reconstruction (Table 1; Figure 3). The stock-aggregate goal comprises the respective sums of aerial survey escapement objectives for 165 individual index streams (Honnold et al. 2007; Nelson and Lloyd 2001).

A total of five stock-aggregate escapement goals are currently established for chum salmon in Area M (Table 1; Figures 2 and 3). These stock-aggregate goals comprise the respective sums of aerial survey escapement objectives for 136 individual index streams (Honnold et al. 2007; Nelson and Lloyd 2001). Sixty-seven of these index streams are located along the South Peninsula and 69 are along the North Peninsula. There are no chum salmon escapement goals for the Aleutian Islands, where conducting aerial surveys to monitor escapement are problematic and costly.

METHODS

During the review process all escapement goals were reviewed and three sockeye salmon stocks, one Chinook salmon stock, and three chum salmon aggregates were reevaluated (Table 1). Our review examined recent (2015 to 2017) data and updated previous analyses. We did not review or analyze data for most stocks for which goals were recently analyzed (2012 and 2015). A formal meeting, via teleconference, to discuss and develop recommendations was held in January 2018. The team also communicated on a regular basis by telephone and email.

Available escapement, harvest, and age data associated with each stock or combination of stocks were compiled from research reports, management reports, and unpublished historical databases. Limnological and spawning habitat data were compiled for each system when available. The team evaluated the type, quality, and amount of data for each stock (Table 2). This evaluation was used to assist in determining the appropriate type of escapement goal to apply to each stock, as defined in the SSFP and EGP.

BIOLOGICAL ESCAPEMENT GOAL DETERMINATION

In Alaska, most salmon BEGs are developed using Ricker (1954) spawner-recruit models (Munro 2018). BEG ranges, as defined in the SSFP (5AAC 39.222), are estimates of the number of spawners that provide the greatest potential for maximum sustained yield, abbreviated as S_{MSY}. Only the Nelson River Chinook salmon BEG was reevaluated during this review.

SUSTAINABLE ESCAPEMENT GOAL DETERMINATION

Sustainable escapement goals (SEGs) for Area M salmon stocks were determined using the "4-tier Percentile Approach" of Bue and Hasbrouck (Unpublished) for goals implemented prior to 2014 and the Clark et al. (2014) "3-tier Percentile Approach" for goals reevaluated and implemented after 2014. The Percentile Approach is based on the principle that escapements of a stock within some range of percentiles observed over the time series of escapements and associated harvest from fishing represents a proxy for maintaining escapements within a range that encompasses S_{MSY} (Clark et al. 2014).

The 3-tier Percentile Approach considers the measurement error of the data collection method (e.g., weirs and towers have lower measurement error than aerial or foot surveys), contrast of the escapement data (i.e., the ratio of highest observed escapement to the lowest observed escapement), and the average harvest rate of the stock. Based on these criteria, Clark et al. (2014) recommended the following tiers to set the SEG range.

Tier	Escapement contrast	Measurement error	Harvest rate	SEG range
1	>8	High (aerial and foot surveys)	Low to moderate (<.40)	20th–60th percentile
2	>8	Low (weirs and towers)	Low to moderate (<.40)	15th–65th percentile
3	4-8	-	Low to moderate (<.40)	5th–65th percentile

CHINOOK SALMON

Nelson River

Escapement Goal Background and Previous Reviews

Nelson River is in the Nelson Lagoon Section of the Northern District of the Alaska Peninsula Management Area (Figures 2 and 3). Nelson River has the only Chinook salmon escapement goal currently established in Area M. Escapement has been counted almost every year since 1974 from either a tower (1974 to 1988) or a weir (1989 to present). Since 1985, salmon escapement was only assessed through the end of the sockeye salmon run. In nearly all years, an aerial survey was conducted to count Chinook salmon downstream of the tower or weir on the day that, or a few days after, the weir or tower was removed. Stock-specific catch data are available from the Nelson Lagoon Section gillnet fishery due to the terminal nature of that fishery. The first published escapement goal for Nelson River was developed in 1985, and a range was set at 4,500 to 9,000 Chinook salmon based on weir and counting tower data collected from 1978 to 1984 (Nelson and Lloyd 2001; Appendix A). The goal was changed in 1993 to a range of 3,200 to 6,400 Chinook salmon based on aerial survey data collected from 1985 to 1992 (Nelson and Lloyd 2001). The SEG was modified in 2003 (Nelson et al. 2006) to a BEG of 2,400 to 4,400 fish using a habitat model and corroborated with a Ricker spawner-recruit curve (Ricker 1954). The BEG was corroborated in 2006 using a Ricker spawner-recruit curve, and there was consensus to not reevaluate the goal in 2009, 2012, and 2015 resulting in no change to the Nelson River Chinook salmon BEG (Witteveen et al. 2009; Sagalkin and Erickson 2013; Schaberg et al. 2015).

Nelson River Chinook salmon escapements since the last review were within or above the current BEG 6 out of 11 years (Appendix A2). The team determined that since the last formal review was done in 2006, it would be beneficial to review this goal in 2018.

SOCKEYE SALMON

Orzinski Lake

Escapement Goal Background and Previous Reviews

Orzinski Lake is located in the Northwest Stepovak Section of the Southeastern District (Figures 2 and 3). The first published escapement goal for Orzinski Lake was developed in 1980, and a range was set at 15,000 to 20,000 sockeye salmon (Nelson and Lloyd 2001; Appendix B). Aerial surveys were used to estimate escapement into Orzinski Lake from 1968 through 1989, and a weir was used from 1990 through the present. An escapement goal review of this system was conducted in 2003. All available stock assessment data were analyzed using the percentile, euphotic volume, smolt biomass as a function of zooplankton biomass, and lake surface area methods, and these analyses reasonably corroborated the existing SEG and no change was warranted (Nelson et al. 2006). During the 2006 escapement goal review (Honnold et al. 2007), staff examined escapement data using the 4-tier Percentile Approach and determined there was no significant change in the estimate and that the goal would remain the same. With additional years of data, the 2009, 2012, and 2015 escapement goal review teams determined that the additional stock assessment data would not substantially affect the results of previous escapement goal analyses (Witteveen et al. 2009; Sagalkin and Erickson 2013; Schaberg et al. 2015).

2018 Review

Stock-specific harvest estimates for Orzinski Lake sockeye salmon were not available. Recent escapement estimates and age compositions were examined to determine if a change in the escapement goal was justified. Escapements since the last review were similar to those in the recent past (Appendix B2), and the team agreed that no further analysis was necessary in 2018.

Thin Point Lake

Escapement Goal Background and Previous Reviews

Thin Point Lake is in the Thin Point Section of the Southwestern District (Figures 2 and 3). The first published escapement goal for Thin Point Lake was developed in the late 1980s and a range was set at 14,000 to 28,000 sockeye salmon (Nelson and Lloyd 2001; Appendix C). Aerial surveys have been used to estimate escapement into Thin Point Lake from 1968 to the present and a weir was used from 1994 to 1998.

An escapement goal review of this system was conducted during 2003. All available stock assessment data were analyzed using the 4-tier Percentile Approach, euphotic volume analysis, smolt biomass as a function of zooplankton biomass, and lake surface area methods (Nelson et al. 2006). The authors concluded that these analyses reasonably corroborated the existing SEG and no change warranted (Table 1). With additional years of data, the 2009, 2012, and 2015 escapement goal review teams determined that the additional stock assessment data would not

substantially affect the results of previous escapement goal analyses. (Witteveen et al. 2009; Sagalkin and Erickson 2013; Schaberg et al. 2015).

2018 Review

Stock-specific harvest estimates for Thin Point Lake sockeye salmon were not available. Recent escapement data (Appendix C2) were examined to determine if a change in the escapement goal was justified. The escapement has met or exceeded the current escapement goal in seven of the past ten years, and the team agreed that no further analysis was necessary in 2018.

Mortensens Lagoon

Escapement Goal Background and Previous Reviews

Mortensens Lagoon is in the Cold Bay Section of the Southwestern District (Figures 2 and 3). The first published escapement goal range for Mortensens Lagoon was developed in the late 1980s and set at 3,200 to 6,400 sockeye salmon (Nelson and Lloyd 2001; Appendix D). Aerial surveys have been used to estimate escapement into Mortensens Lagoon from 1968 to the present and a weir was operated from 2001 to 2006.

An escapement goal review conducted during 2003 using the 4-tier Percentile Approach, euphotic volume analysis, smolt biomass as a function of zooplankton biomass, and lake surface area methods concluded that these analyses reasonably corroborated the existing SEG and no change was warranted (Nelson et al. 2006). During the subsequent 2006 escapement goal review, the team utilized the 4-tier Percentile Approach, which corroborated the 3,200 to 6,400 sockeye salmon SEG (Honnold et al. 2007). With additional years of data, the 2009, 2012, and 2015 escapement goal review teams determined that the additional stock assessment data would not substantially affect the results of previous escapement goal analyses (Witteveen et al. 2009; Sagalkin and Erickson 2013; Schaberg et al. 2015).

2018 Review

Stock-specific harvest estimates for Mortensens Lagoon sockeye salmon were not available. Recent escapement data (Appendix D2) were examined to determine if a change in the escapement goal was justified. The current escapement goal has been met or exceeded in seven of the last ten years, and the team agreed that no further analysis was necessary in 2018.

Christianson Lagoon

Escapement Goal Background and Previous Reviews

Christianson Lagoon is in the Urilia Bay Section of the Northwestern District (Figures 2 and 3). The first published escapement goal range for Christianson Lagoon was developed in the 1980s and set at 25,000 to 50,000 sockeye salmon (Nelson and Lloyd 2001; Appendix E). Aerial surveys have been used to estimate escapement into Christianson Lagoon from 1960 to the present.

An escapement goal review of this system conducted during 2003 using the 4-tier Percentile Approach concluded that the analysis reasonably corroborated the existing SEG and no change was warranted (Nelson et al. 2006). The 2006 escapement goal review, also using the 4-tier Percentile Approach, corroborated the 25,000 to 50,000 sockeye salmon SEG (Honnold et al. 2007). With additional years of data, the 2009, 2012, and 2015 escapement goal review teams determined that the additional stock assessment data would not substantially affect the results of

previous escapement goal analyses (Witteveen et al. 2009; Sagalkin and Erickson 2013; Schaberg et al. 2015).

Stock-specific harvest estimates for Christianson Lagoon sockeye salmon were not available. Recent escapement data (Appendix E2) were examined to determine if a change in the escapement goal was justified. The current escapement goal has been met or exceeded in eight of the past ten years, and the team agreed that no further analysis was necessary in 2018.

Swanson Lagoon

Escapement Goal Background and Previous Reviews

Swanson Lagoon is in the Swanson Lagoon Section of the Northwestern District (Figures 2 and 3). The first published escapement goal range for Swanson Lagoon was developed in 1990 and set at 8,000 to 16,000 sockeye salmon (Nelson and Lloyd 2001; Appendix F). Aerial surveys have been used to estimate escapement into Swanson Lagoon from 1960 to the present. The escapement goal review of this system in 2003 using the 4-tier Percentile Approach concluded that no change in the SEG was warranted at that time (Nelson et al. 2006). The subsequent 2006 escapement goal review also utilized the 4-tier Percentile Approach and changed the goal to 6,000 to 16,000 sockeye salmon SEG (Honnold et al. 2007). In 2009, the escapement goal was reviewed using updated escapement estimates from 1990 to 2008 and the 4-tier Percentile Approach. Based on the results of this analysis, the team recommended maintaining the existing 6,000 to 16,000 sockeye salmon SEG (Witteveen et al. 2009). The 2012 escapement goal review team determined that the additional stock assessment data would not substantially affect the results of previous escapement goal analyses, and no review was conducted (Sagalkin and Erickson 2013). The stock was, however, recommended for a stock of management concern designation due to repeated escapements below the escapement goal. In 2015 the goal was assessed using the new 3-tier Percentile Approach and determined that it would not significantly change the current goal. Swanson Lagoon sockeye salmon were recommended for continuation of the stock of concern designation again in 2015 (Schaberg et al. 2015).

2018 Review

Stock-specific harvest estimates for Swanson Lagoon sockeye salmon were not available. Analysis of recent escapement data (Appendix F2) revealed escapements continued to be low, and the stock has been a stock of management concern since 2012. The team determined this stock required further review and evaluated if the recent low escapements and environmental conditions would significantly impact and warrant changing or removing the escapement goal.

North Creek

Escapement Goal Background and Previous Reviews

North Creek is in the Black Hills Section of the Northern District (Figures 2 and 3). The first published escapement goal for North Creek was developed in the late 1980s, and a range was set at 4,400 to 8,800 sockeye salmon (Nelson and Lloyd 2001; Appendix G). Aerial surveys have been used to estimate escapement into North Creek from 1960 to the present. An escapement goal review of this system conducted during 2003 using the 4-tier Percentile Approach concluded that the analysis reasonably corroborated the existing SEG, and no change was warranted (Nelson et al. 2006). During the 2006 escapement goal review, the team used the 4-tier

Percentile Approach and corroborated the 4,400 to 8,800 sockeye salmon SEG (Honnold et al. 2007). During the 2009 escapement goal review, the percentile ranges were recalculated using the 4-tier Percentile Approach and updated escapement estimates from 1990 to 2008. Based on the results of this analysis the team recommended maintaining the existing 4,400 to 8,800 sockeye salmon SEG (Witteveen et al. 2009). The 2012 and 2015 escapement goal review teams determined that the additional stock assessment data would not substantially affect the results of previous escapement goal analyses, and no review was conducted (Sagalkin and Erickson 2013; Schaberg et al. 2015).

2018 Review

Stock-specific harvest estimates for North Creek sockeye salmon were not available. Recent escapement data (Appendix G2) were examined to determine if a change in the escapement goal was justified when analyzed with the updated 3-tier Percentile Approach (Clark et al. 2014).

Nelson River

Escapement Goal Background and Previous Reviews

Nelson River is in the Nelson Lagoon Section of the Northern District (Figures 2 and 3). The first published escapement goal for Nelson River was developed in 1979, with a range of 100,000 to 150,000 sockeye salmon (Nelson and Lloyd 2001; Appendix H). Tower counts were used to estimate escapement into Nelson River from 1962 to 1988, and a weir has been used from 1989 to the present. An escapement goal review of this system conducted during 2003 using the Ricker spawner-recruit model, 4-tier Percentile Approach, euphotic volume analysis, smolt biomass as a function of zooplankton biomass, and lake surface area method recommended that the escapement goal should be reclassified as a BEG, with a range from 97,000 to 219,000 sockeye salmon (Nelson et al. 2006). The 2006 escapement goal review analysis using the Ricker spawner-recruit model corroborated the 97,000 to 219,000 sockeye salmon BEG (Honnold et al. 2007). With additional years of data, the 2009, 2012, and 2015 escapement goal review teams determined that the additional stock assessment data would not substantially affect the results of previous escapement goal analyses (Witteveen et al. 2009; Sagalkin and Erickson 2013; Schaberg et al. 2015).

2018 Review

Stock-specific harvest estimates for Nelson River sockeye salmon were available from 1970 to the present. Recent run data (Appendix H2) were examined to determine if a change in the escapement goal was justified. The run data from 2015 to 2017 were similar to the recent past, so the team agreed that no further analysis was necessary in 2018.

Bear Lake

Escapement Goal Background and Previous Reviews

Bear Lake is in the Bear River Section of the Northern District (Figures 2 and 3). The first published escapement goals for Bear Lake were developed in late 1960s, with ranges of 150,000 to 175,000 sockeye salmon for the early run; 50,000 to 75,000 sockeye salmon for the late run; and a total range of 200,000 to 250,000 sockeye salmon (Nelson and Lloyd 2001; Appendix I). Tower counts were used to estimate escapement into Bear River from 1964 to 1985, and a weir has been used from 1986 to the present.

An escapement goal review of this system conducted during 2003 using the Ricker spawner-recruit model, 4-tier Percentile Approach, euphotic volume analysis, smolt biomass as a function of zooplankton biomass, and lake surface area method indicated that the escapement goal range should be increased to 293,000 to 488,000 sockeye salmon for the total Bear Lake run (176,000 to 293,000 for the early run; 117,000 to 195,000 for the late run; Nelson et al. 2006). The 2006 escapement goal review analysis also utilized the Ricker spawner-recruit model, 4-tier Percentile Approach, euphotic volume analysis, smolt biomass as a function of zooplankton biomass, and lake surface area methods to analyze data; these methods corroborated the SEGs established in 2003, and no changes were made to the Bear Lake escapement goals (Honnold et al. 2007). With additional years of data, the 2009, 2012, and 2015 escapement goal review teams determined that the additional stock assessment data would not substantially affect the results of previous escapement goal analyses (Witteveen et al. 2009; Sagalkin and Erickson 2013; Schaberg et al. 2015).

2018 Review

Stock-specific harvest estimates were not available for early-run Bear Lake sockeye salmon, but available for the late run. Recent escapement data (Appendix I2) were examined to determine if a change in the escapement goal was justified. Escapements for both runs have been within or above the current goals in eight of the last ten years, and the team agreed that no further analysis was necessary for the Bear Lake runs in 2018.

Sandy River

Escapement Goal Background and Previous Reviews

Sandy River is in the Bear River Section of the Northern District (Figures 2 and 3). Escapement has been monitored with aerial surveys since 1960, and a tower was used from 1962 to 1964. An aerial indexed total escapement goal range of 20,000 to 30,000 sockeye salmon was developed in the 1970s (Nelson and Lloyd 2001; Appendix J). In 1994, a weir was established for Sandy River and the goal range was doubled (40,000 to 60,000 fish) to account for more complete counts made at the weir (Nelson and Lloyd 2001). An escapement goal review of this system conducted during 2003 using the 4-tier Percentile Approach, euphotic volume analysis, smolt biomass as a function of zooplankton biomass, and lake surface area method concluded that because of data uncertainty and that the established SEG produced sufficient returns of escapement and harvest, no change in the SEG was warranted (Nelson et al. 2006). The 2006 escapement goal review using the 4-tier Percentile Approach with weir and aerial survey count data recommended changing the SEG range to 34,000 to 74,000 fish (Honnold et al. 2007). With additional years of data, the 2009, 2012, and 2015 escapement goal review teams determined that the additional stock assessment data would not substantially affect the results of previous escapement goal analyses (Witteveen et al. 2009; Sagalkin and Erickson 2013; Schaberg et al. 2015).

2018 Review

Stock-specific harvest estimates for Sandy River sockeye salmon were not available. Recent escapement data (Appendix J2) were examined to determine if a change in the escapement goal was justified. Escapements have been within or above the current goal in eight of the last ten years, and the team agreed that no further analysis was necessary in 2018.

Ilnik River

Escapement Goal Background and Previous Reviews

The Ilnik River is in the Ilnik Section of the Northern District and includes 4 distinct spawning populations: Ilnik River, Willie Creek, Ocean River, and Wildman Lake (Figures 2 and 3). The current SEG for the Ilnik River system was developed in 1991 and set at 40,000 to 60,000 sockeye salmon (Nelson and Lloyd 2001; Appendix K). Aerial surveys were used to estimate escapement into the Ilnik River system from 1960 through 1990, and a weir was used from 1991 through the present. An escapement goal review of this system conducted during 2003 using the 4-tier Percentile Approach, euphotic volume analysis, smolt biomass as a function of zooplankton biomass, and lake surface area method concluded that the existing escapement goal had produced sufficient returns and found that no change was warranted (Nelson et al. 2006). The 2006 escapement goal review using the 4-tier Percentile Approach with weir count data corroborated the existing SEG (Honnold et al. 2007). With additional years of data, the 2009, 2012, and 2015 escapement goal review teams determined that the additional stock assessment data would not substantially affect the results of previous escapement goal analyses (Witteveen et al. 2009; Sagalkin and Erickson 2013; Schaberg et al. 2015).

2018 Review

Stock-specific harvest estimates for Ilnik River sockeye salmon were not available. Recent escapement estimates (Appendix K2) and age compositions were examined to determine if a change in the escapement goal was justified. The run and age data from 2015 to 2017 were similar to the recent past, so the team agreed that no further analysis was necessary in 2018.

Meshik River

Escapement Goal Background and Previous Reviews

Meshik River is in the Inner Port Heiden Section of the Northern District (Figures 2 and 3). The SEG range of 10,000 to 20,000 was initially established in the late 1980s and was based on average peak aerial survey escapements (Nelson and Lloyd 2001; Appendix L). Aerial surveys have been used to estimate escapement into Meshik River from 1960 through the present. An escapement goal review of this system conducted during 2003 using the 4-tier Percentile Approach concluded that the analysis reasonably corroborated the existing SEG and no change was warranted (Nelson et al. 2006). Following the 2006 escapement goal review using the 4-tier Percentile Approach, it was recommended to increase the Meshik River SEG to 20,000 to 60,000 fish; this change was implemented to reflect increased aerial survey effort and the subsequent increased sockeye salmon escapement estimates (Honnold et al. 2007).

In 2007, the Board allowed fishing time in the Outer Port Heiden Section, which would affect escapement to the Meshik River. The Meshik River sockeye salmon escapement goal did not consider escapement to Red Bluff and Yellow Bluff creeks, which contribute a substantial number of fish to the total escapement transiting the Port Heiden area (generally on the order of 25%) and cannot be managed separately from Meshik River sockeye salmon escapement. With inclusion of the Red Bluff and Yellow Bluff creeks' escapements, the upper range of the 75th percentile of escapement increased substantially, suggesting the need for increasing the upper and lower bounds of the escapement goal. Because of increased aerial surveying effort and the need to account for the contribution of Red Bluff Creek and Yellow Bluff Creek sockeye salmon escapements, the team recommended changing the Meshik River escapement goals from an SEG

of 20,000 to 60,000 fish to an SEG of 25,000 to 100,000 fish (Witteveen et al. 2009). With three years of additional data, the 2012 escapement goal review team determined that the additional stock assessment would not substantially affect the results of previous escapement goal analyses. Thus, there was a consensus to not reevaluate the goal in 2012, and there was no change to the Meshik River sockeye salmon SEG (Sagalkin and Erickson 2013). In 2015 the SEG range was revised to 48,000 to 86,000 fish, using the 3-tier Percentile Approach (Schaberg et al. 2015; Clark et al. 2014)

2018 Review

Stock-specific harvest estimates for Meshik River sockeye salmon were not available. Recent escapement estimates (Appendix L2) were examined to determine if a change in the escapement goal was justified. The team determined that this stock did not warrant further review as it was updated in 2015, and there would only be 3 years of additional escapement information.

Cinder River

Escapement Goal Background and Previous Reviews

Cinder River is in the Cinder River Section of the Northern District (Figures 2 and 3). An escapement goal range of 6,000 to 12,000 sockeye salmon was initially established in the late 1980s and was based on average peak escapements (Nelson and Lloyd 2001; Appendix M). Aerial surveys have been used to estimate escapement into Cinder River from 1960 through the present. An escapement goal review of this system conducted during 2003 using the 4-tier Percentile Approach concluded that the analysis reasonably corroborated the existing SEG and no change was warranted (Nelson et al. 2006). The 2006 escapement goal review, also using the 4-tier Percentile Approach, recommended an increase to the Cinder River SEG to 12,000 to 48,000 fish; this change was implemented to reflect increased aerial survey effort and the subsequent increased sockeye salmon escapement estimates (Honnold et al. 2007). In 2009, the team reviewed escapement data from Mud Creek and Cinder River. Mud Creek and Cinder River share the same outlet; therefore, Mud Creek cannot be managed independently of the Cinder River if a fishery were opened in the Cinder River Section. However, the team found that escapement between the 2 streams was not correlated and surveys of Mud Creek are incomplete. Based on these results, the team recommended keeping the SEG the same (Witteveen et al. 2009). In 2012, escapement data were examined to determine if a change in the escapement goal was justified, and the team agreed that no further analysis was necessary in 2012 (Sagalkin and Erickson 2013). In 2015 the escapement from Cinder River and Mud Creek were combined and evaluated with the 3-tier Percentile Approach (Clark et al. 2014), resulting in revising the SEG to 36,000 to 94,000 fish (Schaberg et al. 2015).

2018 Review

Stock-specific harvest estimates for Cinder River sockeye salmon were not available. Recent escapement estimates (Appendix M2) were examined to determine if a change in the escapement goal was justified. The team determined that this stock did not warrant further review as it was updated in 2015, and the high values added to the escapement data set in 2016 and 2017 have not produced returns.

McLees Lake

Escapement Goal Background and Previous Reviews

McLees Lake is in the Unalaska District within the Aleutian Islands Management Area (Figure 4). The first published escapement goal for McLees Lake was developed in 1993 and a range was set at 4,000 to 6,000 sockeye salmon based on spawning capacity (Nelson and Lloyd 2001; Appendix N). Aerial surveys have been used to estimate escapement into McLees on a limited basis from 1967 to 2003, and a weir has been operated by the U.S. Fish and Wildlife Service (USFWS) since 2001. No sockeye salmon were observed during aerial surveys of McLees Lake until 1974. An escapement goal review of this system in 2003, using the 4-tier Percentile Approach from aerial survey numbers, concluded that with limited aerial survey estimates, few years of weir counts, and no history of management action ever exercised, the goal would be eliminated, but reevaluated in 3 years (Nelson et al. 2006). In 2006, the McLees Lake system was reevaluated with the 4-tier Percentile Approach, and it was determined that no goal was justified; however, the McLees Lake sockeye salmon system would be reassessed pending collection of additional stock assessment data (Honnold et al. 2007). In 2009, an SEG for McLees Lake sockeye salmon was estimated according to the 4-tier Percentile Approach resulting in an SEG of 12,000 to 59,000 fish. From the time the weir was first installed at McLees Lake in 2001 until 2004, the average sockeye salmon annual escapement was 71,000 fish. The magnitude of production from a lake the size of McLees was unexpected. The average annual escapement from 2005 to 2008 was 14,000 fish. Based on limited knowledge of McLees Lake sockeye salmon, a wide escapement goal range (10,000 to 60,000 fish) was recommended during years when a weir is operated, and no SEG in the absence of a weir (Witteveen et al. 2009). In 2012 and 2015, escapement data were examined to determine if a change in the escapement goal was justified, and the teams agreed that no further analysis was necessary (Sagalkin and Erickson 2013; Schaberg et al. 2015).

2018 Review

Stock-specific subsistence harvest estimates for McLees Lake sockeye salmon are available and commercial salmon harvest in the Aleutian Islands is infrequent. Recent escapement data (Appendix N2) were examined and the team determined that with 9 more years of weir counts since the current SEG was instituted, this stock required further review.

COHO SALMON

Nelson River

Escapement Goal Background and Previous Reviews

Nelson River is in the Nelson Lagoon Section of the Northern District (Figures 2 and 3). The first published escapement goal for Nelson River coho salmon was developed in the early 1980s, and a range was set at 18,000 to 25,000 fish (Nelson and Lloyd 2001; Appendix O). Aerial surveys were used to estimate coho salmon escapement into Nelson River from 1968 through 2014. An escapement goal review of this system conducted during 2003, using a risk analysis, concluded that the lower end (18,000) of the existing goal was appropriate as a Lower-Bound (LB; Nelson et al. 2006). The 2006 review of the Nelson River coho salmon escapement goal was limited by insufficient data that was too poor to estimate an SEG; therefore, no change was warranted for the LB SEG (Honnold et al. 2007). With additional years of data, the 2009, 2012, and 2015 escapement goal review teams determined that the additional stock assessment data

would not substantially affect the results of previous escapement goal analyses (Witteveen et al. 2009; Sagalkin and Erickson 2013; Schaberg et al. 2015).

<div align="center">***2018 Review***</div>

Stock-specific harvest estimates were not available for the Nelson River coho salmon fisheries. Recent escapement estimates (Appendix O2) were examined to determine if a change in the escapement goal was justified. The LB SEG has been met in nine of the last ten years, and the team agreed that no further analysis was necessary in 2018.

Ilnik River

<div align="center">***Escapement Goal Background and Previous Reviews***</div>

An Ilnik River coho salmon escapement goal of 10,000 to 19,000 was adopted in 1993 (Table 1; Appendix P). This goal was eliminated following the 2004 escapement goal review. Historical aerial survey escapement estimates were often sporadic, due to airplane availability, poor weather, or the frequent turbid conditions in the Ilnik River. Escapement estimates during that time were generally below the SEG, likely due to the poor aerial survey coverage. During the 2009 review, it was noted that sport fishing effort increased and there was some directed commercial fishing effort. In response to the increased effort, aerial survey effort also increased. Ilnik River coho salmon escapement data from 1985 to 2008 were assessed with the 4-tier Percentile Approach and risk analysis methods. With the increase of sport fishery harvest and the use of coho salmon catch-per-unit-effort (CPUE) data to make management decisions, the team recommended a LB SEG of 9,000 fish based on the risk analysis method for Ilnik River (Witteveen et al. 2009). With additional years of data, the 2012 and 2015 escapement goal review team determined that the additional stock assessment data would not substantially affect the results of previous escapement goal analyses (Sagalkin and Erickson 2013; Schaberg et al. 2015).

<div align="center">***2018 Review***</div>

Stock-specific harvest estimates were not available for the Ilnik River coho salmon fisheries. Recent escapement estimates (Appendix P2) were examined to determine if a change in the escapement goal was justified. The LB SEG has been met in nine of the last ten years, and the team agreed that no further analysis was necessary in 2018.

PINK SALMON

Pink salmon escapement estimates in Area M are based on aerial surveys of fish returning to spawn. Each year since 1968, pink salmon have been counted during one or more flights along the Alaska Peninsula area (Figure 1). Total indexed escapement estimates were calculated by Area M management biologists, with estimation techniques outlined in Poetter and Nichols (2014).

South Peninsula

<div align="center">***Escapement Goal Background and Previous Reviews***</div>

Even- and odd-year pink salmon escapement goals, by district, were first established in 1992 (Nelson and Lloyd 2001; Appendix Q). The sum of the district escapement goal ranges for the South Alaska Peninsula was 1,864,600 to 3,729,300 fish in even years and 1,637,800 to 3,275,700 fish in odd years. The difference between even- and odd-year escapement goals was

due to higher even-year escapement goals in the Southwestern and Unimak districts.

Stock specific catch data are not available in this area, however; during a 2003 review of escapement goals (Nelson et al. 2006), the district escapement estimates were aggregated into a single South Peninsula area wide escapement that was used, and the total pink salmon catch of the South Peninsula, to develop a single Ricker spawner-recruit model (Ricker 1954). Spawner-recruit models were developed from even-year, odd-year, and combined even- and odd-year escapement and catch data from 1975 to 2001. The contrast (3.2) in the even-year model was below the recommended minimum contrast of 4. The odd-year model was had appropriate contrast and resulted in an S_{MSY} estimate of 2.77 (90% S_{MSY} range of 1.75 to 4.0) million fish. The model developed using the combined even- and odd-year escapement and catch data was considered the best model (Nelson et al. 2006) and resulted in an S_{MSY} estimate of 2.33 (90% S_{MSY} range of 1.52 to 3.29) million fish. The results from this model corroborated the aggregate even-and odd-year goals (sum of the district escapement goal ranges), which were then designated BEGs (Nelson et al. 2006).

The 2006 escapement goal review of South Peninsula pink salmon followed the same methods as the 2003 review with the addition of 2004 and 2005 data. No change was recommended to the escapement goal range; however, the goal was reclassified as an SEG because it was based on aerial survey data (Honnold et al. 2007). In both 2009 and 2012 reviews, the team determined that the additional stock assessment data would not substantially affect the results of the previous escapement goal analyses. Thus, there was consensus to not reevaluate the goals in 2009 and 2012, and there was no change to the even- and odd-year South Peninsula pink salmon SEGs (Witteveen et al. 2009; Sagalkin and Erickson 2013).

With low pink salmon escapement in the South Peninsula for even years since 2010, the team decided it prudent to reassess the current goal with the new information available in 2015. However, the inherent relationship between the even- and odd-year goals justified a reevaluation of both goals. Both even-, odd-, and combined-year datasets were analyzed with the Ricker spawner-recruit framework. However, one important adaptation was employed to more accurately model the population. This was to define the total harvest estimate for South Peninsula pink salmon as that occurring from July 15 to the end of the season for more precise accounting for local stocks (Matt Keyse, ADF&G Area Management Biologist-Area M, Sand Point Alaska, personal communication). Given the similarity in the estimates of S_{MSY} from even- and odd-year models, and the uncertainty associated with the models, the SEG was updated in 2015 into an annual SEG of 1,750,000 to 4,000,000 fish based on the examination of the combined-year spawner-recruit models and the existing goals (Schaberg et al. 2015).

2018 Review

Aggregate stock harvest estimates for South Alaska Peninsula pink salmon were available. Recent run data (Appendix Q2) were examined to determine if a change in the escapement goal was justified. The run data from 2015 to 2017 indicate the cycling among even- and odd- year runs may be more prevalent again. However, with only one even year being included since the latest revision to this goal, the review team agreed that no further analysis was necessary in 2018.

CHUM SALMON

Chum salmon escapement estimates in Area M are based on aerial surveys of fish returning to spawn. Total indexed escapement estimates were calculated by Area M management biologists, with estimation techniques outlined in Poetter and Nichols (2014).

South Peninsula

Escapement Goal Background and Previous Reviews

Chum salmon escapement goals, aggregated by district, were established in 1992 (Nelson and Lloyd 2001; Appendices R through T) and remained unchanged after the escapement goal review in 2003 (Nelson et al. 2006). The 2006 escapement goal review of South Peninsula chum salmon corroborated the original goals, with the exception of Unimak District, which was changed from an SEG to LB SEG after review of risk analysis results (Honnold et al. 2007). With 3 years of additional data, the 2009 escapement goal review team determined that the additional stock assessment data would not substantially affect the results of previous escapement goal analyses. Thus, there was consensus to not reevaluate the goal in 2009, and there was no change to the chum salmon aggregate SEGs (Witteveen et al. 2009). In 2012 the team reviewed the escapement information from the Unimak District and recommended removing the LB SEG for this district due to poor quality data. All other district goals were not reviewed, as escapement was adequate and did not indicate review was necessary (Sagalkin and Erickson 2013). The escapement goal review team in 2015 determined it was unnecessary to review the district aggregate goals (Schaberg et al. 2015).

2018 Review

Stock-specific harvest estimates for South Peninsula chum salmon were not available. Recent escapement estimates (Appendices R2, S2, T2) were examined to determine if a change in the escapement goal was justified. The team agreed further review of the chum salmon aggregate escapement goals was warranted using new escapement information and the updated 3-tier Percentile Approach (Clark et al. 2014).

North Alaska Peninsula

Escapement Goal Background and Previous Reviews

Chum salmon escapement goals, aggregated by district, were set in 1992 at ranges of 223,600 to 447,200 for the Northwestern District and 119,600 to 239,200 for the Northern District (Nelson and Lloyd 2001; Appendices U and V). Based on separate Ricker spawner-recruit analyses during the 2003 escapement goal review, the Northwestern District escapement goal was changed to a BEG of 100,000 to 215,000 fish and no change was recommended for the Northern District BEG (Nelson et al. 2006). The 2006 escapement goal review of North Alaska Peninsula chum salmon also used Ricker spawner-recruit models to analyze the available data. No changes were made to the goal ranges; however, the escapement goals were reclassified from BEGs to SEGs as aerial survey data were used to provide indices of escapement rather than total escapement estimates. With additional years of data, the 2009, 2012, and 2015 escapement goal review teams determined that the additional stock assessment data would not substantially affect the results of previous escapement goal analyses (Witteveen et al. 2009; Sagalkin and Erickson 2013; Schaberg et al. 2015).

Stock-specific harvest estimates for North Alaska Peninsula chum salmon were not available. Recent escapement estimates (Appendices U2 and V2) were examined to determine if a change in the escapement goal was justified, but the team agreed that no further analysis was necessary in 2018.

RESULTS

BIOLOGICAL ESCAPEMENT GOAL ESTIMATES

Chinook Salmon

Nelson River

Stock Status

Chinook salmon escapement into Nelson River has ranged from 1,092 to 12,561 fish since 1974 (Appendix A2). Harvest during the same timeframe has ranged from 254 to 12,042 fish, with harvest rates being moderate to high historically (mean 0.39, maximum 0.74 1974–2017) and lower recently (mean 0.25 2003–2017; Appendix A2).

Evaluation of Recent Data

Inriver run (1974–2017) was estimated from a combination of tower/weir counts and aerial survey counts made below the counting site after cessation of tower or weir operations. Commercial harvests from Nelson Lagoon (1974–2017; statistical area 313-30) were obtained from fish tickets, and sport harvest above and below the weir (2007-2017; Appendix A2) were obtained from guide log books. Sport harvests prior to 2007 were modelled as a function of average harvest rate during 2007-2017 and inriver run size. Age composition data (1985–2003 and 2014; Appendix A3) were obtained by sampling the commercial fishery; these data were assumed to represent the run in each calendar year.

A Bayesian age-structured state-space model was fitted to Nelson River Chinook salmon inriver run, harvest, and age composition data. The model used methods described in Fleischman et al. (2013) and is set up with a Ricker spawner-recruit relationship, autoregressive lag-1 productivity and a Dirichlet age-at-maturity schedule; a trending age-at-maturity schedule component (A. Reimer, Sport Fish Biometrician ADF&G, personal communication) was also examined but had little influence on results and so was not considered further.

The model was fitted in R (R Core Team 2017) using multi-chain Monte Carlo (MCMC) techniques in the package rjags (Plummer 2016). MCMC samples were drawn from the joint posterior probability distribution of all unknowns in the model. For each of two Markov chains initialized, a 300,000-sample burn-in was discarded, after which each chain ran for an additional 100,000 iterations. After thinning by a factor of 10, a total of 20,000 samples were used to estimate the marginal posterior statistics. Gelman-Rubin convergence diagnostics (Brooks and Gelman 1998), along with visual inspections of trace plots of nodes were used to assess convergence of the chains.

Medians of important spawner-recruit statistics (e.g., S_{msy}, S_{max}, S_{eq}, Ricker alpha and beta parameters) were calculated. Credibility interval estimates were obtained for each reported statistic from the percentiles of the posterior distribution. Sustainable yield curves (Fleischman et al. 2013) and the fitted Ricker model were also plotted.

Escapement Goal Recommendation

The median of the posterior distribution of S_{MSY} for Nelson River Chinook salmon is 3,944 (95% credibility interval of 1,058 to 7,798; Appendix A5). A return vs. spawner plot, along with the fitted model and credibility errors, is presented in Appendix A6. The probability that sustainable yield is within 90% of MSY is given Appendix A7. The analysis suggests there is substantial positive autocorrelation at lag-1 ($\phi = 0.83$; Appendix A5). In a previous analysis, autocorrelation at lag-2 was detected (Nelson et.al 2006); none was found in this analysis, however. No major problems were encountered in assessment of convergence of the MCMC chains.

The yield curves (Appendix A7) suggest the current lower bound of the escapement goal range is reasonable, while the upper bound should be raised, such that there is an 80% probability of sustainable yield reaching 80% of MSY over the long term. The resulting Nelson River Chinook salmon BEG range is 2,400 to 5,000.

SUSTAINABLE ESCAPEMENT GOAL ESTIMATES

Sockeye Salmon

Swanson Lagoon

Stock Status

ADF&G has conducted aerial surveys of Swanson Lagoon to estimate escapement since 1970. Successful Swanson Lagoon aerial surveys at peak run time is sometimes precluded by survey efforts at Christianson Lagoon, or by algal blooms impeding survey conditions (Schaberg et al. 2015). Peak aerial survey (PAS) counts of Swanson Lagoon sockeye salmon since 1970 ranged from 50 to 32,900 fish. The average PAS from 2005–2017 was 2,895 fish. With the exception of 2007, escapements have failed to meet the current SEG since it was adopted in 2006 (Appendix F3).

Evaluation of Recent Data

Current regulations aimed at conserving Swanson Lagoon sockeye salmon are ineffective due to environmental conditions that annually impede salmon migration. The Swanson Lagoon drainage is annually impaired by a sand berm that builds up at the mouth of the lagoon by local wind and wave action. The berm opens occasionally and allows fish passage, however, timing of the creation of a channel does not always coincide with timing of sockeye salmon migration. This occurs frequently enough to render management actions ineffective in achieving escapement goals. In addition, current regulations only allow commercial salmon fishing by emergency order which has been in effect since 2013 when the weekly fishing periods were rescinded by the BOF. This emergency order authority has not been exercised since its inception due to poor escapement into the system, which is heavily tied to the geomorphological conditions at the mouth.

Escapement Goal Recommendation

ADF&G recommends the SEG be removed as poor escapement into Swanson Lagoon is attributable to a naturally occurring sand berm rather than fishery processes. It is also uncertain if aerial survey data for Swanson Lagoon sockeye salmon adequately index trends in spawning escapement because of problems with survey timing and conditions, and more recently the sand

berm. Additionally, the department recommends the board *discontinue Swanson Lagoon sockeye salmon as a stock of management concern.*

North Creek

Stock Status

Since 1990, escapement estimates have exceeded the upper range of the goal 13 times, with the largest estimated escapements occurring in 2005, 2008, and 2016 (Appendices G2 and G3).

Evaluation of Recent Data

An SEG for North Creek sockeye salmon was estimated according to the updated 3-tier Percentile Approach of Clark et al. (2014) using aerial survey escapement estimates from 1970 to 2017. Harvest of this stock is moderate, however, it only started increasing since 1995. The escapement estimates showed high contrast (90) when using the full data set, as well as data from 1995 to 2017 (contrast = 13).

Escapement Goal Recommendation

The team recommended applying the 3-tierPercentile Approach (Clark et al. 2014) to the last 22 years (1995–2017) of aerial survey escapement data, using the 20th to 60th percentiles, and establishing an SEG range of 7,500 to 10,000 sockeye salmon.

McLees Lake

Stock Status

The most recent 5-year average of McLees Lake sockeye salmon escapement is approximately 20,000 fish. Escapement has been above the lower bound of the escapement goal since original adoption in 2009, however, escapement has generally been in the lower half of the range. (Appendix N4).

Evaluation of Recent Data

An SEG for McLees Lake sockeye salmon was determined according to the 3-tier Percentile Approach using weir data from 2001 to present, with the exclusion of 2012 due to incomplete monitoring. High contrast in the escapement estimates (11.8) and low harvest of this stock resulted in a SEG range of 12,179 to 35,662 (15th to 65th percentiles).

Dependent upon smolt size and the associated marine survival, the zooplankton model (Koenings and Kyle 1997) yielded escapement estimates of 21,800 (5.0 g smolt), and 31,100 (2.0 g smolt) sockeye salmon (Appendix N5). No average smolt size data have ever been collected at McLees Lake. Recent measurements of light penetration have frequently shown the entire volume of McLees Lake to be photosynthetically active. Based on an average euphotic volume of $23.0 \times 10^6 m^3$ the escapement capacity for McLees Lake was estimated to be between 18,400 and 20,700 sockeye salmon (Koenings and Burkett 1987; Appendix N5).

Escapement Goal Recommendation

The team recommended revising the current McLees Lake SEG range to a lower bound SEG of 10,000 fish based on the 3-tier Percentile Approach and results of the zooplankton biomass and EV assessment. While McLees Lake supports a subsistence fishery, commercial sockeye salmon harvest has not occurred in the statistical area adjacent to McLees Lake and it is unlikely current

fishing power would be capable of constraining escapements to an upper end of an escapement goal.

Chum Salmon

South Peninsula

Stock Status

The current South Peninsula chum salmon SEG ranges were established in 1992 and have remained unchanged through several escapement goal review cycles with the exception of the Unimak District goal (which was changed to an SEG threshold and ultimately removed). The current Southeastern District chum salmon SEG is 106,400–212,800 (Table 1). Since the implementation of the goal (26 years ago), escapement has been within the goal 9 years, above the goal 10 years, and below the goal 7 years (Appendices R2 and R3). The current South Central District chum salmon SEG is 89,800–179,600 (Table 1). In the last 26 years, escapement has been within the goal 13 years, above the goal 8 years, and below the goal 5 years (Appendices S2 and S3). The current Southwestern District chum salmon SEG is 133,400–266,800 (Table 1). In the last 26 years, escapement has been within the goal 12 years, above the goal 12 years, and below the goal 2 years (Appendices T2 and T3).

Evaluation of Recent Data

Current South Alaska Peninsula chum salmon goals were calculated using an indexed total escapement method (incorporates 21-day stream life, carcasses, mouth counts) that is described in detail in annual management report appendices (e.g., Fox et al. 2018). The goals were based on a select number of individual streams (index streams) that were combined to form the district goals. A lack of consistency in the number and scope of individual aerial survey estimates annually decreased the ability to assess these escapement goals.

It was determined that peak aerial survey (PAS) counts of chum salmon would be a better metric for escapement goal evaluation. Peak aerial surveys were compiled from a database maintained by the Kodiak ADF&G office for the review process. To standardize past and future evaluation, and reduce any inconsistencies in the data points, the escapement number used to develop the goal were PAS that adhere to these criteria:

- Include a single flight
    - with the highest count for the year (PAS)
- Include counts from within the stream itself (no bays, mouths, or other areas)
- Include only live fish (no carcasses)

The team ensured that the number of systems included in the evaluation of escapement goals was consistent. To warrant inclusion, a system must first have met the above criteria in at least 29 of the last 31 years. Systems that represented the majority of the escapement in these areas met this initial validation, as they were known chum systems, and surveyed annually. This resulted in 26 index streams in the Southeastern District, 10 index streams in the South Central District, and 19 streams in the Southwestern District. Appendices R1, S1, and T1 have the list of individual streams.

Escapement Goal Recommendation

Peak counts of fish observed in each index system were aggregated to create a PAS index for each district. Contrast, measurement error, and harvest rates were examined to determine the

proper percentile ranges that should be used to establish SEGs with the 3-tier Percentile Approach (Clark et. al 2014). This resulted in the selection of the 20th–60th percentile range for the Southeastern and South Central districts, and the selection of the 5th–65th percentile range for the Southwestern District. The team recommends changing the chum salmon escapement goals to an SEG of 62,500–151,900 fish for the Southeastern District (Appendix R1), an SEG of 68,900–99,200 fish for the South Central District (Appendix S1), and an SEG of 86,900–159,500 fish for the Southwestern District (Appendix T1).

These escapement goal revisions appear to be significantly lower than the current goals, however, this is because of the switch to Peak Aerial Surveys in place of the previous escapement indices, more stringent criteria for inclusion of surveys, and a reduced number of index streams in some districts.

DISCUSSION

Establishing prudent escapement goals is an evolving process, not only because each year provides more data, but also because methods to determine such goals are becoming more standardized and well documented. The SSFP and EGP are important steps in this evolution. Ideally, escapement goals should be based, in part, on ecological theory, principles of sustained yield, and empirical observations (Ricker 1954).

The methodologies used in this escapement goal evaluation were limited by the available data. Stock-specific catch data were not available for any stocks in Area M, with the exception of Nelson River Chinook and sockeye salmon and Bear Lake late-run sockeye salmon. While five systems in Area M (plus one additional system in the Aleutian Islands Management Area) currently have weirs for direct enumeration of escapement and are easily accessible for collection of representative age data, escapement estimates for the remaining systems are determined via aerial survey observations. Aerial survey escapement estimates can be inaccurate and imprecise due to weather conditions, differences between observers, and logistical limitations.

The comprehensive review of the 23 existing Area M salmon escapement goals resulted in recommendations to leave 16 goals unchanged, revise six goals, and discontinue one goal. Systems that did not warrant a change to their goals because either their escapement levels have consistently met their goals or have been comparable over the last 3 years include 11 sockeye salmon systems (Orzinski and Thin Point lakes, Mortensens and Christianson lagoons, North Creek, Nelson, Bear [2 goals; early and late], Sandy, and Ilnik rivers, and McLees Lake); 2 coho salmon systems (Nelson and Ilnik rivers); and 2 chum salmon aggregates.

After a review of the available data, the team recommended that changes to the current escapement goals were warranted for Nelson River Chinook salmon (BEG 2,400–5,000); North Creek sockeye salmon (SEG 7,500–10,000); McLees Lake sockeye salmon (LB SEG >10,000); Southeastern District chum salmon (SEG 62,500–151,900); South Central District chum salmon (SEG 68,900–99,200); Southwestern District chum salmon (SEG 86,900–159,500); and discontinuation of one goal (Swanson Lagoon; Table 1). While these changes represent more biologically sound and streamlined escapement goals, they should have a limited effect on the traditional management under the auspices of current management plans.

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TABLES AND FIGURES

Table 1.–Current escapement goals, escapements observed from 2015 through 2017, and escapement goal recommendations in 2018 for Chinook, sockeye, coho, pink, and chum salmon stocks of the Alaska Peninsula and Aleutian Islands Management areas.

Species	System	Data Type [a]	Current escapement goal		Escapement			Escapement goal recommendation for 2018
			Type	Range	2015	2016	2017	
Chinook Salmon	Nelson River	WC	BEG	2,400–4,400	2,890	4,618	1,852	BEG: 2,400–5,000
Sockeye Salmon	Orzinski Lake	WC	SEG	15,000–20,000	26,534	21,019	20,989	No Change
	Thin Point Lake	PAS	SEG	14,000–28,000	19,900	36,400	44,300	No Change
	Mortensens Lagoon	PAS	SEG	3,200–6,400	NA	13,000	15,500	No Change
	Christianson Lagoon	PAS	SEG	25,000–50,000	6,700	111,700	290,600	No Change
	Swanson Lagoon	PAS	SEG	6,000–16,000	3,500	3,000	860	Discontinue
	North Creek	PAS	SEG	4,400–8,800	18,000	21,000	5,800	SEG: 7,500–10,000
	Nelson River	WC	BEG	97,000–219,000	257,000	300,000	381,000	No Change
	Bear Lake							
	Early	WC	SEG	176,000–293,000	304,356	293,280	570,840	No Change
	Late	WC	SEG	117,000–195,000	210,644	139,720	229,160	No Change
	Sandy River	WC	SEG	34,000–74,000	116,000	170,000	145,000	No Change
	Ilnik River	WC	SEG	40,000–60,000	26,000	124,000	238,000	No Change
	Meshik River	PAS	SEG	48,000–86,000	171,700	131,800	191,525	No Change
	Cinder River	PAS	SEG	36,000–94,000	118,000	200,500	222,600	No Change
	McLees Lake	WC	SEG	10,000–60,000	20,284	39,892	13,195	LB SEG: >10,000
Coho Salmon	Nelson River	PAS	Lower-bound SEG	>18,000	45,000	45,000	19,000	No Change
	Ilnik River	PAS	Lower-bound SEG	>9,000	14,000	28,000	6,000	No Change
Pink Salmon	South Peninsula all-years	PAS	SEG	1,750,000–4,000,000	7,820,800	1,038,160	5,663,637	No Change
Chum Salmon	Southeastern District	PAS	SEG	106,400–212,800	250,370	150,456	592,460	[b] SEG: 62,500–151,900
	South Central District	PAS	SEG	89,800–179,600	298,800	248,360	810,053	[b] SEG: 68,900–99,200
	Southwestern District	PAS	SEG	133,400–266,800	351,150	220,060	363,000	[b] SEG: 86,900–159,500
	Northwestern District	PAS	SEG	100,000–215,000	89,800	113,250	195,700	No Change
	Northern District	PAS	SEG	119,600–239,200	189,194	277,674	234,440	No Change

[a] PAS = Peak Aerial Survey, WC = Weir Count.

[b] The recommended goals were calculated with a reduced number of index streams. Escapement values in this table are from the prior escapement enumeration method for comparison with the current escapement goals, not the 2018 recommendations with a reduced number of index streams.

24

Table 2.–General criteria used to assess quality of data in estimating Area M salmon escapement goals.

Data quality	Criteria
Excellent	Escapement, harvest, and age all estimated with relatively good accuracy and precision (i.e., escapement estimated by a weir or hydroacoustics; harvest estimated by Statewide Harvest Survey or fish tickets); escapement and return estimates can be derived for a sufficient time series to construct a brood table and estimate S_{msy}.
Good	Escapement, harvest, and age estimated with reasonably good accuracy and/or precision (i.e., escapement estimated by capture-recapture experiment or multiple foot/aerial surveys); no age data or data of questionable accuracy and/or precision; data may allow construction of brood table; data time series relatively short to accurately estimate S_{msy}.
Fair	Escapement estimated or indexed and harvest estimated with reasonably good accuracy, but precision lacking for one, if not both; no age data; data insufficient to estimate total return and construct brood table.
Poor	Escapement indexed (i.e., single foot/aerial survey) such that the index provides a fairly reliable measure of escapement; no harvest and age data.
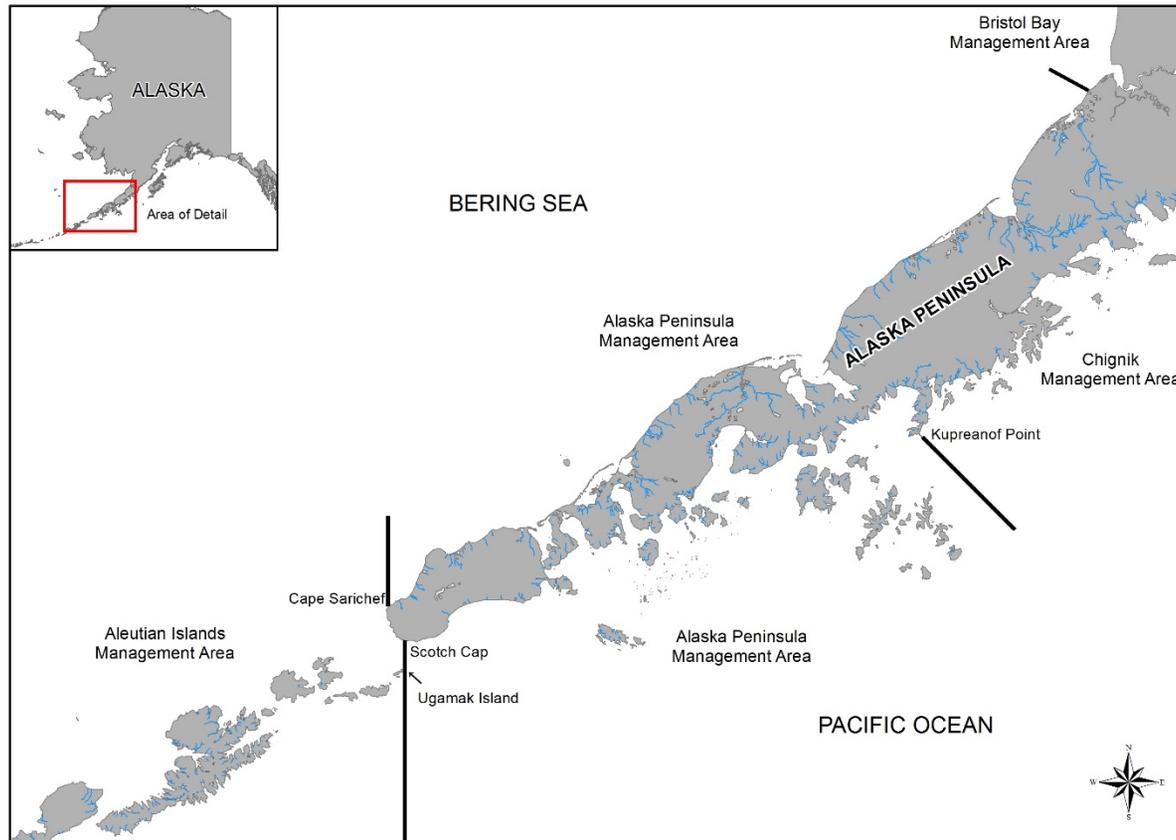
Figure 1.–Map of the Alaska Peninsula and Aleutian Islands Management areas.
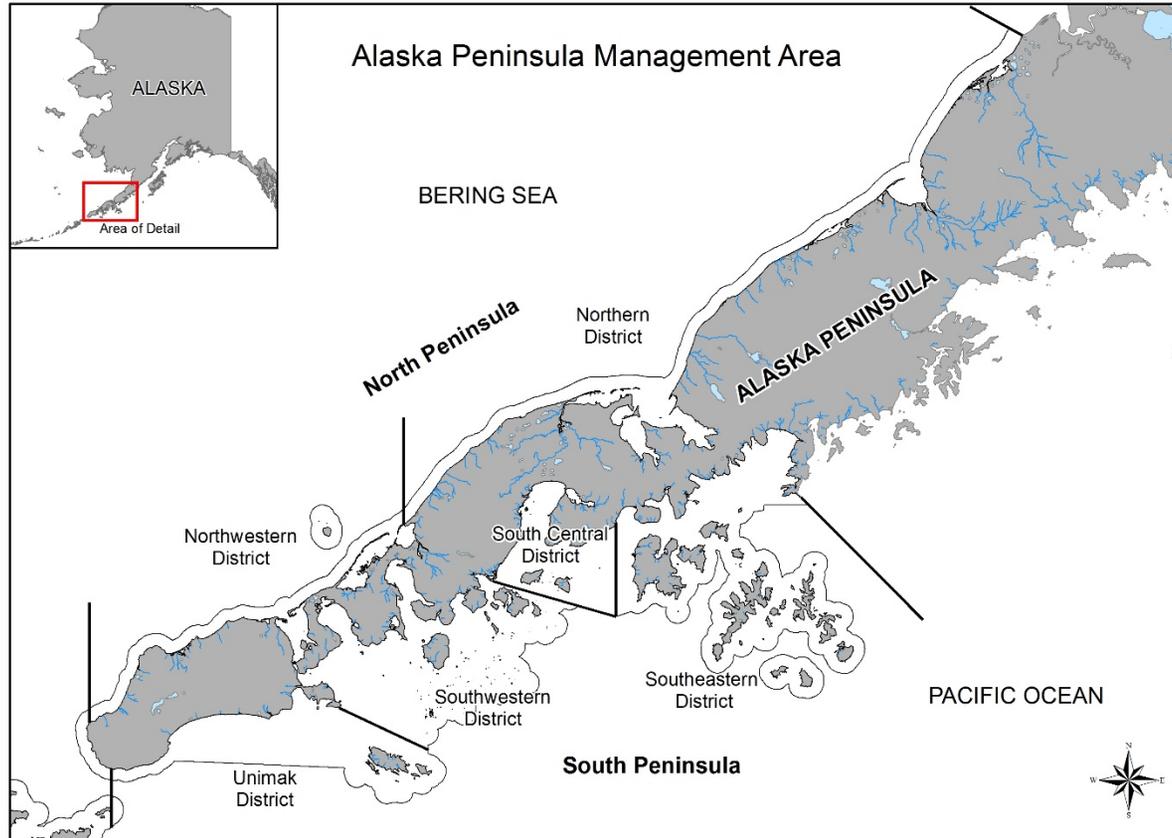
Figure 2.–Map of the Alaska Peninsula Management Area with commercial salmon fishing districts depicted.
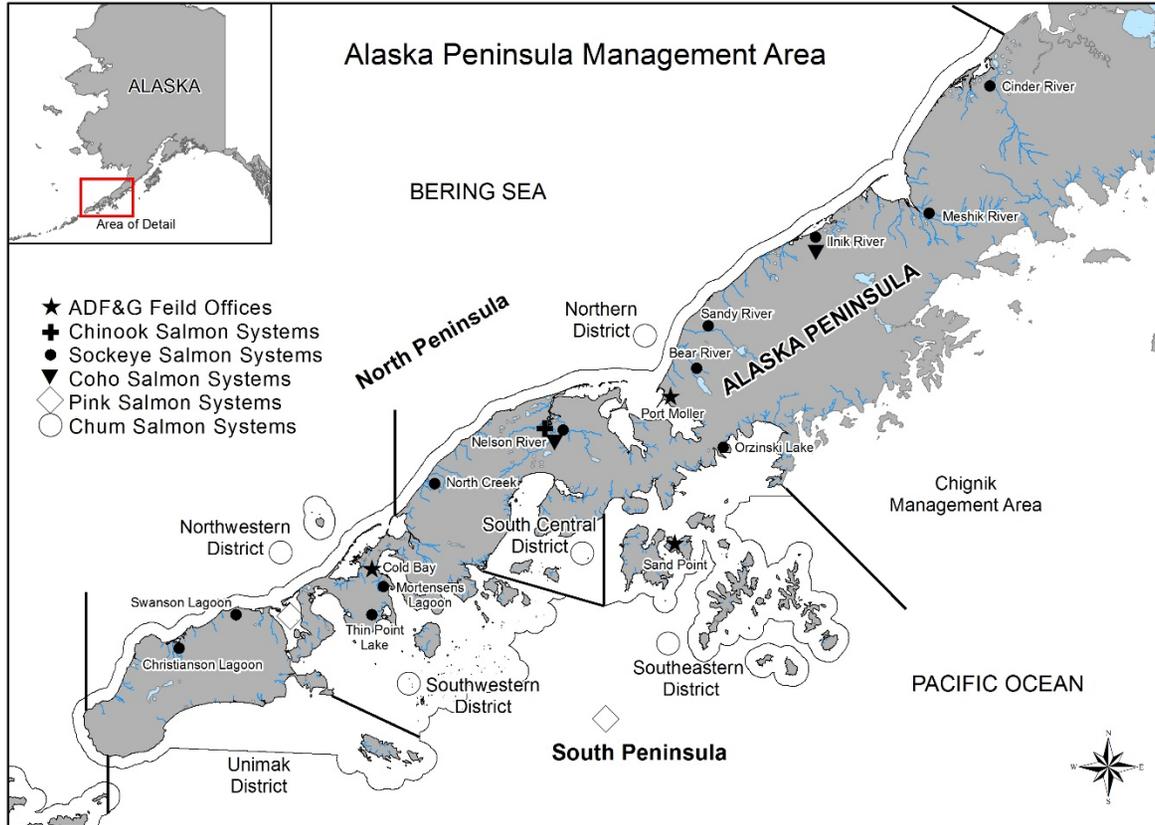
Figure 3.–Map of the Alaska Peninsula Management Area with salmon systems that currently have escapement goals depicted.
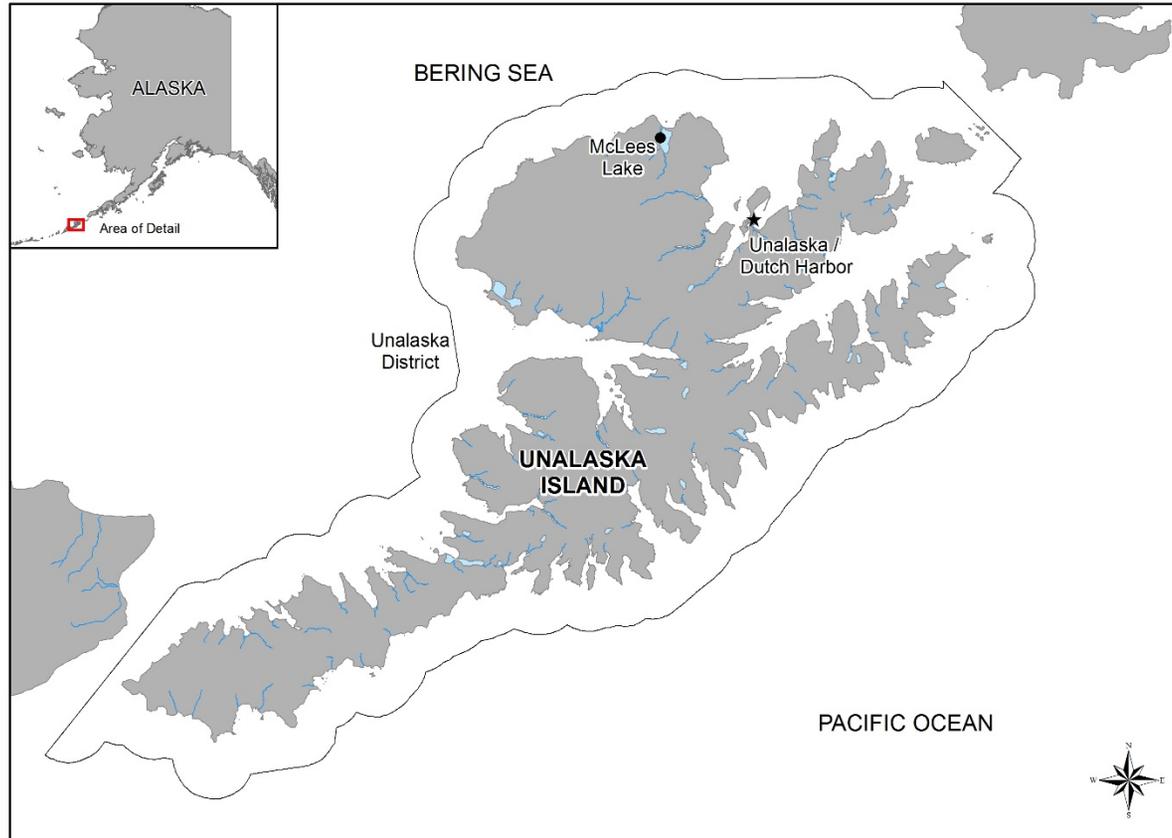
Figure 4.–Map of Unalaska Island within the Aleutian Islands Management Area with McLees Lake depicted.

APPENDIX A. SUPPORTING INFORMATION FOR THE NELSON RIVER CHINOOK SALMON ESCAPEMENT GOAL

Appendix A1.–Description of stock and escapement goal for Nelson River Chinook salmon.

System: **Nelson River.**

Species: **Chinook salmon.**

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial set and drift gillnet.
Current escapement goal:	BEG: 2,400 to 4,400 (2004).
Recommended escapement goal:	BEG: 2,400 to 5,000.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Tower 1974–1988;
	Weir 1989–present.
Data summary:	
Data quality	Good.
Data type	Tower or weir and aerial counts, commercial harvest from fish tickets, age from commercial harvest (1985–2003 and 2014).
Comments	Current BEG was based on a Ricker analysis and corroborated with a habitat model. New analysis is a Bayesian age-structured state space model to estimate spawner-recruit parameters.

Appendix A2.–Nelson River Chinook salmon escapement, harvest, and total run estimates, 1974–2017.

System: **Nelson River.**

Species: **Chinook salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]	Commercial Harvest [b]	Inriver Sport Harvest	Total Run	Harvest Rate
1974	1,092	1,987		3,079	0.65
1975	1,917	1,074		2,991	0.36
1976	3,232	1,982		5,214	0.38
1977	4,844	1,548		6,392	0.24
1978	3,901	2,991		6,892	0.43
1979	10,463	4,820		15,283	0.32
1980	4,506	7,996		12,502	0.64
1981	5,046	9,804		14,850	0.66
1982	6,503	12,042		18,545	0.65
1983	12,561	11,594		24,155	0.48
1984	5,412	6,965		12,377	0.56
1985	4,500	10,388		14,888	0.70
1986	4,757	4,329		9,086	0.48
1987	3,854	5,536		9,390	0.59
1988	1,873	5,335		7,208	0.74
1989	2,500	3,413		5,913	0.58
1990	1,800	2,923		4,723	0.62
1991	4,981	2,738		7,719	0.35
1992	2,320	2,141		4,461	0.48
1993	5,160	4,256		9,416	0.45
1994	4,552	3,193		7,745	0.41
1995	2,127	3,377		5,504	0.61
1996	3,967	2,224		6,191	0.36
1997	6,902	3,075		9,977	0.31
1998	4,809	2,349		7,158	0.33
1999	3,907	1,746		5,653	0.31
2000	3,891	1,229		5,120	0.24
2001	7,088	1,908		8,996	0.21
2002	6,750	1,181		7,931	0.15
2003	5,154	906		6,060	0.15
2004	7,664	2,710		10,374	0.26
2005	4,993	2,887		7,880	0.37
2006	2,516	3,020		5,536	0.55
2007	2,492	1,372	175	4,039	0.38
2008	5,012	881	153	6,046	0.17
2009	2,048	575	41	2,664	0.23
2010	2,769	360	14	3,143	0.12
2011	1,704	499	19	2,222	0.23
2012	1,092	254	0	1,346	0.19
2013	1,221	346	0	1,567	0.22
2014	3,801	415	0	4,216	0.10
2015	2,890	1,035	0	3,925	0.26
2016	4,618	1,188	0	5,806	0.20
2017	1,852	652	0	2,504	0.26

[a] The cumulative tower or weir count and aerial survey count downstream of the tower/ weir site; includes enumeration of carcasses, as well as ancillary and qualitative data.

[b] Commercial harvest in the Nelson Lagoon (313-30) statistical area with an estimated proportion of the David's River Stock removed annually.

Appendix A3.–Age composition proportions of Chinook salmon from Nelson Lagoon commercial harvest.

System: **Nelson River.**

Species: **Chinook salmon.**

Data available for analysis of escapement goal.

Year	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8
1991	0.01	0.21	0.30	0.33	0.15	0.00
1992	0.00	0.23	0.36	0.36	0.06	0.00
1993	0.00	0.05	0.17	0.76	0.03	0.00
1994	0.01	0.15	0.14	0.59	0.11	0.00
1995	0.00	0.26	0.07	0.60	0.07	0.00
1996	0.01	0.14	0.27	0.39	0.19	0.00
1997	0.01	0.19	0.15	0.60	0.05	0.00
1998	0.03	0.46	0.17	0.30	0.04	0.00
1999	0.03	0.39	0.19	0.34	0.06	0.00
2000	0.00	0.30	0.18	0.41	0.10	0.00
2001	0.02	0.23	0.23	0.38	0.13	0.02
2002	0.03	0.27	0.17	0.43	0.09	0.00
2003	0.14	0.33	0.17	0.29	0.08	0.00
2004						
2005						
2006						
2007						
2008						
2009						
2010						
2011						
2012						
2013						
2014	0.07	0.28	0.37	0.26	0.02	0.00
2015						
2016						
2017						

System: **Nelson River.**

Species: **Chinook salmon.**

Solid circles represent tower counts, X-symbols represent weir counts, and dashed lines are the historic SEGs and current BEG.
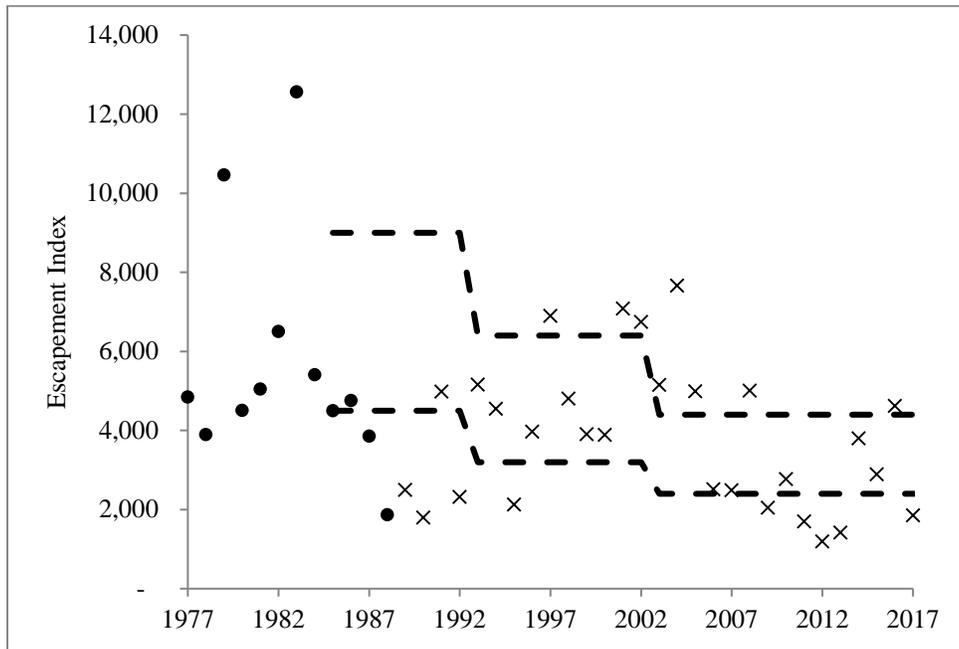
Appendix A5.–Nelson River Chinook salmon, posterior percentiles for important statistics of the Bayesian spawner-recruit analysis. [a]

System: **Nelson River.**

Species: **Chinook salmon.**

Statistic	2.50%	50%	97.50%
S.eq	5,120	10,420	41,409
S.max	4,495	6,582	12,234
S.msy	1,058	3,944	7,798
U.msy	0.15	0.61	0.89
alpha	0.75	3.37	17.19
beta	0.00008	0.00015	0.00022
lnalpha	-0.29	1.21	2.84
lnalpha.c	0.74	1.58	5.84
phi	0.57	0.83	0.99
pi[1]	0.18	0.22	0.27
pi[2]	0.15	0.19	0.23
pi[3]	0.42	0.47	0.52
pi[4]	0.09	0.12	0.15
sigma.red	0.54	0.82	2.81
sigma.white	0.33	0.45	0.63

[a] Node definitions are as defined in Fleischman et al (2013).

Appendix A6.–Nelson River Chinook salmon fitted Ricker relationship, R-S pairs and R = S; error bars are 90% credibility intervals.

System: **Nelson River.**

Species: **Chinook salmon.**
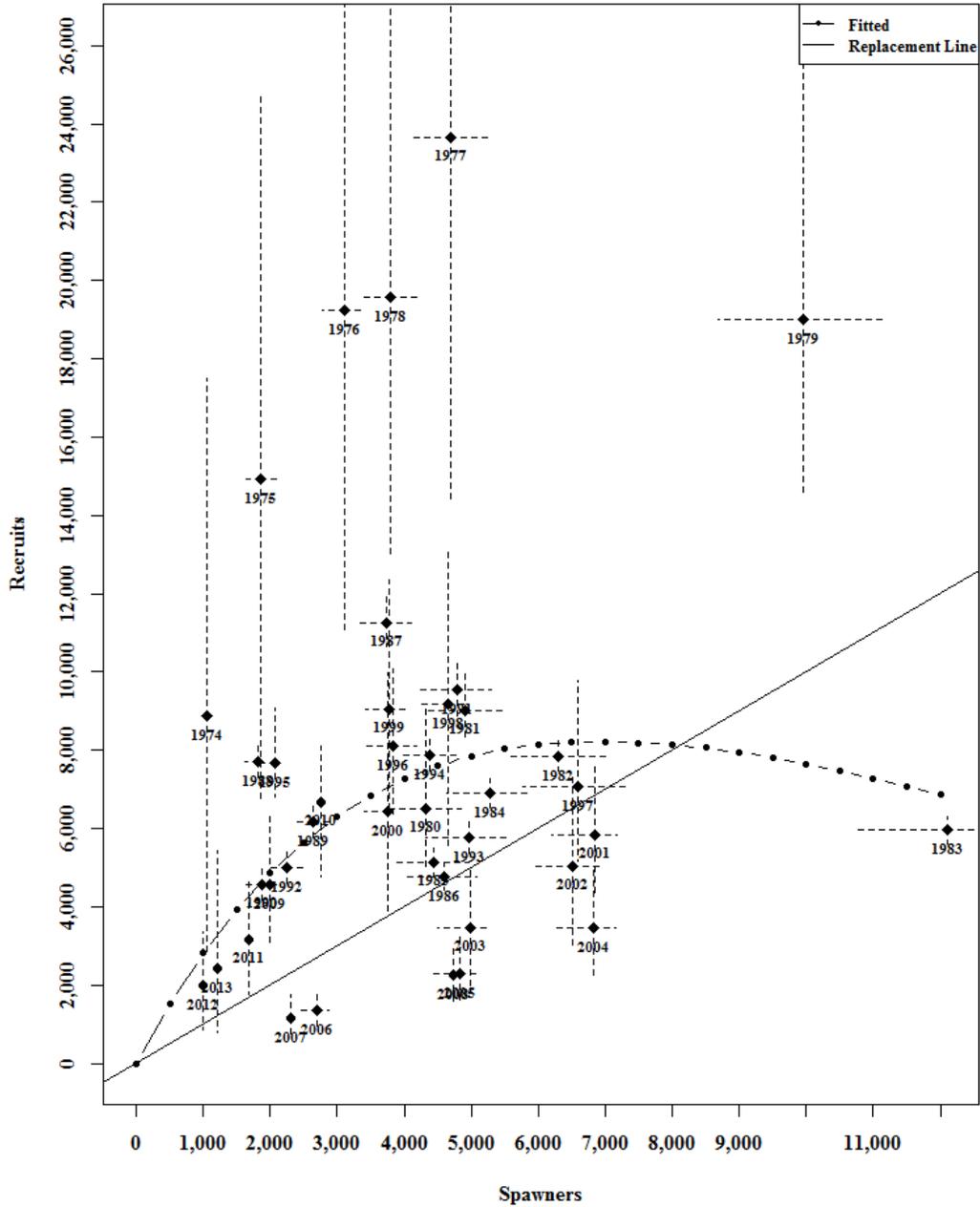
Appendix A7.–Nelson River Chinook, probability that sustained yield (SY) is greater than X% of maximum sustained yield (MSY).

System: **Nelson River.**

Species: **Chinook salmon.**
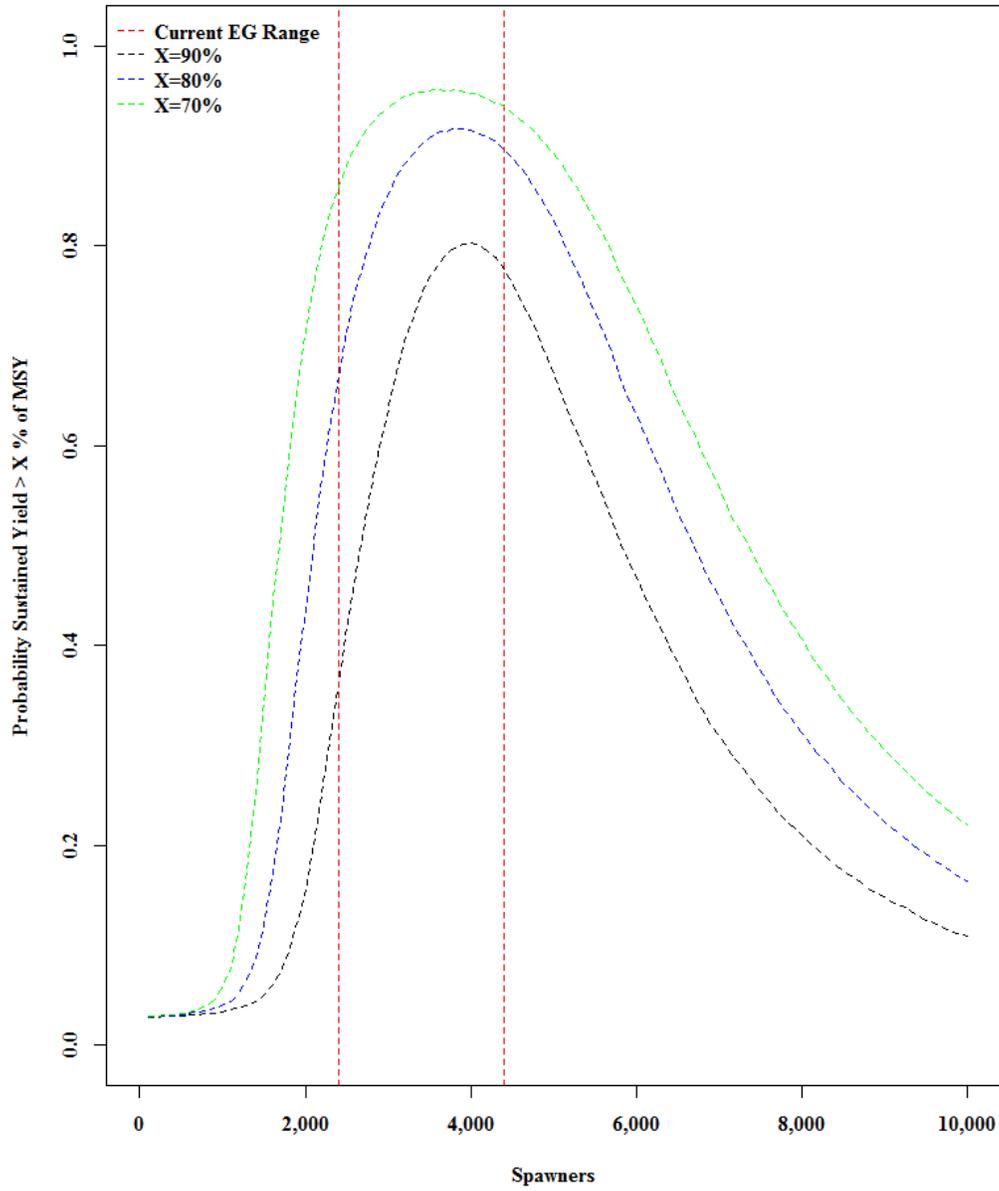
APPENDIX B. SUPPORTING INFORMATION FOR THE ORZINSKI LAKE SOCKEYE SALMON ESCAPEMENT GOAL

Appendix B1.–Description of stock and escapement goal for Orzinski Lake sockeye salmon.

System: Orzinski Lake.

Species: Sockeye salmon.

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial set gillnet and purse seine.
Current escapement goal:	SEG: 15,000–20,000 (1992).
Recommended escapement goal:	No change.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1970–1989; weir 1990 to present.
Data summary:	
Data quality	Fair for aerial surveys; good for weir enumeration.
Data type	Escapement age date 1990 to present. No stock-specific harvest information is available.
Comments	SEG estimate based on 3-tier Percentile Approach reasonably supports current goal.

Appendix B2.–Orzinski sockeye salmon escapements.

System: **Orzinski Lake.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]	Weir Counts
1970	4,450	
1971	11,100	
1972	6,500	
1973	1,200	
1974	61,500	
1975	22,500	
1976	24,600	
1977	17,000	
1978	22,000	
1979	20,000	
1980	12,100	
1981	14,000	
1982	9,000	
1983	21,300	
1984	19,300	
1985	14,000	
1986	10,300	
1987	11,400	
1988	19,500	
1989	16,700	
1990		15,000
1991		40,000
1992		25,000
1993		24,700
1994		38,000
1995		30,000
1996		30,000
1997		35,000
1998		25,000
1999		15,000
2000		21,500
2001		31,200
2002		42,849
2003		70,690
2004		75,450
2005		44,797
2006		18,000
2007		10,643
2008		36,839
2009		21,457
2010		18,039
2011		16,764
2012		17,243
2013		17,386
2014		13,600
2015		26,534
2016		21,019
2017		20,989

[a] The estimated total escapement represents the peak aerial survey, enumeration of carcasses, as well as ancillary and qualitative data.

System: **Orzinski Lake.**

Species: **Sockeye salmon.**

Solid circles represent aerial survey data, X-symbols represent weir counts, and dashed lines are the current SEG.
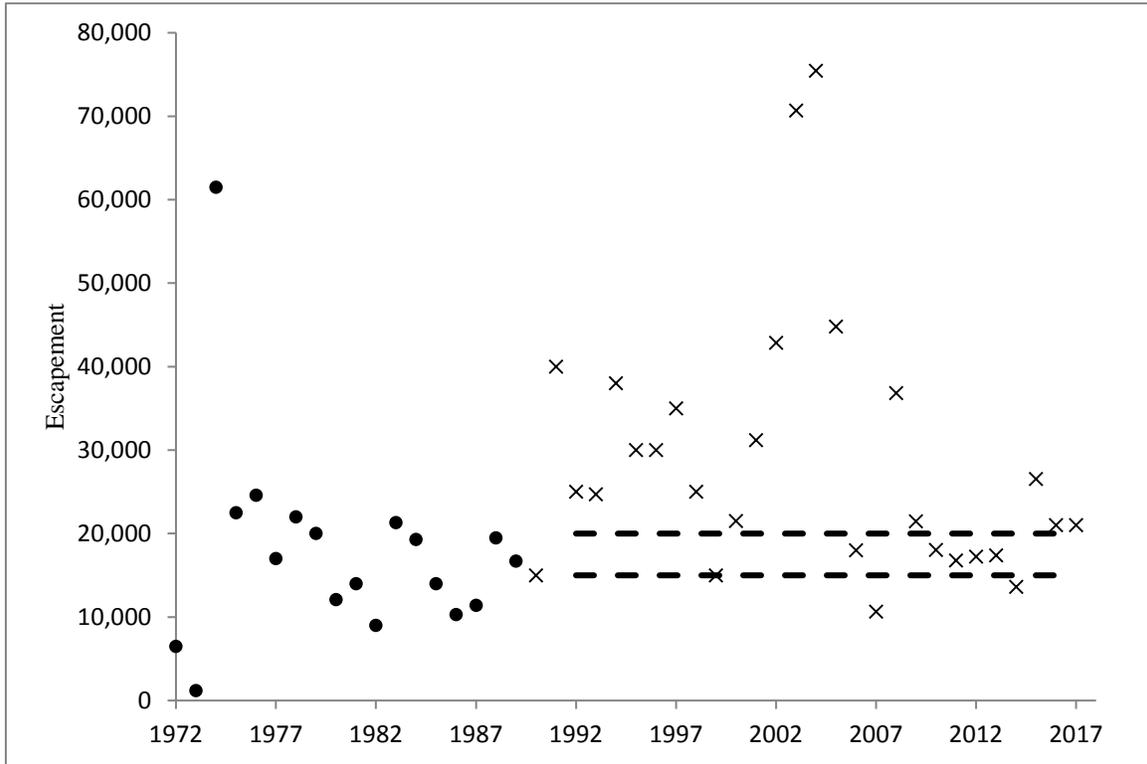
APPENDIX C. SUPPORTING INFORMATION FOR THE THIN POINT LAKE SOCKEYE SALMON ESCAPEMENT GOAL

Appendix C1.–Description of stock and escapement goal for Thin Point Lake sockeye salmon.

System: Thin Point Lake.

Species: Sockeye salmon.

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine and set and drift gillnet.
Current escapement goal:	SEG: 14,000–28,000 (late 1980s).
Recommended escapement goal:	No change.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1968 to present;
	Weir counts, 1994–1998.
Data summary:	
Data quality	Fair for aerial surveys; poor for weir counts.
Data type	Due to prolonged milling behavior in Thin Point Lagoon below the weir site, most of the yearly escapement was not counted past the weir; therefore, aerial survey counts are considered more accurate. No stock-specific harvest information is available.
Comments	3-tier Percentile Approach supports current SEG.

Appendix C2.–Thin Point Lake sockeye salmon escapements.

System: **Thin Point Lake.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]
1970	1,100
1971	1,300
1972	1,300
1973	700
1974	16,000
1975	6,100
1976	20,500
1977	17,700
1978	7,400
1979	6,900
1980	12,000
1981	7,500
1982	8,800
1983	6,500
1984	5,000
1985	7,500
1986	12,400
1987	8,700
1988	23,500
1989	21,500
1990	15,000
1991	35,800
1992	32,600
1993	22,600
1994	25,000
1995	31,700
1996	9,000
1997	10,000
1998	21,000
1999	20,500
2000	12,000
2001	47,900
2002	51,000
2003	40,000
2004	34,500
2005	21,000
2006	11,510
2007	21,550
2008	18,900
2009	33,500
2010	12,400
2011	14,500
2012	19,000
2013	5,700
2014	8,600
2015	19,900
2016	36,400
2017	44,300

[a] The estimated total escapement represents the peak aerial survey, enumeration of carcasses, and ancillary and qualitative data.

System: **Thin Point Lake.**

Species: **Sockeye salmon.**

Observed escapement by year (solid circles) and current SEG (dashed line).
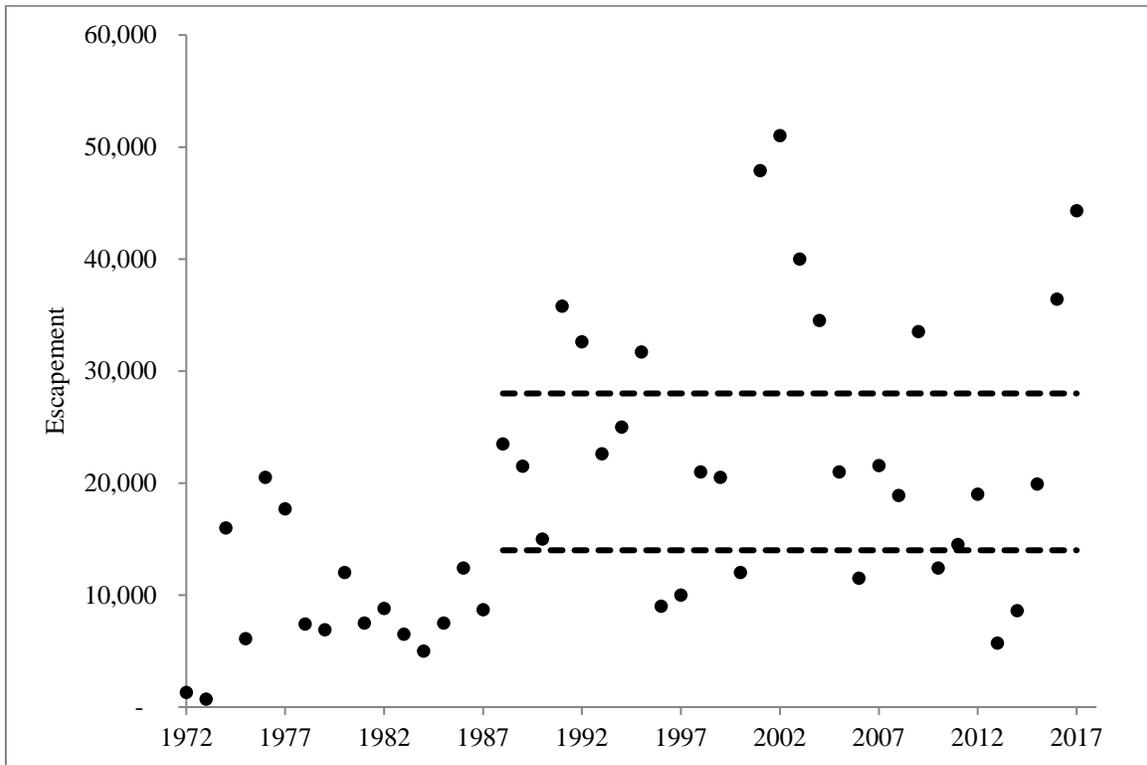
APPENDIX D. SUPPORTING INFORMATION FOR THE MORTENSENS LAGOON SOCKEYE SALMON ESCAPEMENT GOAL

Appendix D1.–Description of stock and escapement goal for Mortensens Lagoon sockeye salmon.

System: **Mortensens Lagoon.**

Species: **Sockeye salmon.**

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine and set gillnet.
Current escapement goal:	SEG: 3,200–6,400 (late 1980s).
Recommended escapement goal:	No change.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1970 to present;
	Weir counts, 2001–2006.
Data summary:	
Data quality	Poor for aerial surveys; good for weir counts.
Data type	Fixed aerial surveys from 1970 to present, and weir counts from 2001 to 2006, with escapement age data during weir counts. No stock-specific harvest information is available.
Comments	3-tier Percentile Approach supports current SEG.

Appendix D2.–Mortensens Lagoon sockeye salmon escapements.

System: **Mortensens Lagoon.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]	Weir Count
1970	800	
1971	800	
1972	1,000	
1973	1,250	
1974	3,070	
1975	4,000	
1976	3,400	
1977	5,700	
1978	13,000	
1979	5,900	
1980	2,600	
1981	3,800	
1982	1,800	
1983	5,750	
1984	4,700	
1985	4,400	
1986	1,620	
1987	4,000	
1988	6,000	
1989	4,300	
1990	6,200	
1991	7,100	
1992	9,100	
1993	6,400	
1994	4,300	
1995	8,300	
1996	2,200	
1997	5,200	
1998	5,300	
1999	3,600	
2000	3,800	
2001	9,100	
2002		5,200
2003		16,804
2004		7,215
2005		21,703
2006		14,688
2007	6,200	
2008	5,600	
2009	25,000	
2010	6,600	
2011	500	
2012	5,000	
2013	4,000	
2014	500	
2015		
2016	13,000	
2017	15,500	

[a] The estimated total escapement represents the peak aerial survey and enumeration of carcasses, as well as ancillary and qualitative data.

System: **Mortensens Lagoon.**

Species: **Sockeye salmon.**

Solid circles represent aerial survey data, X-symbols represent weir counts, and lines are the current SEG.
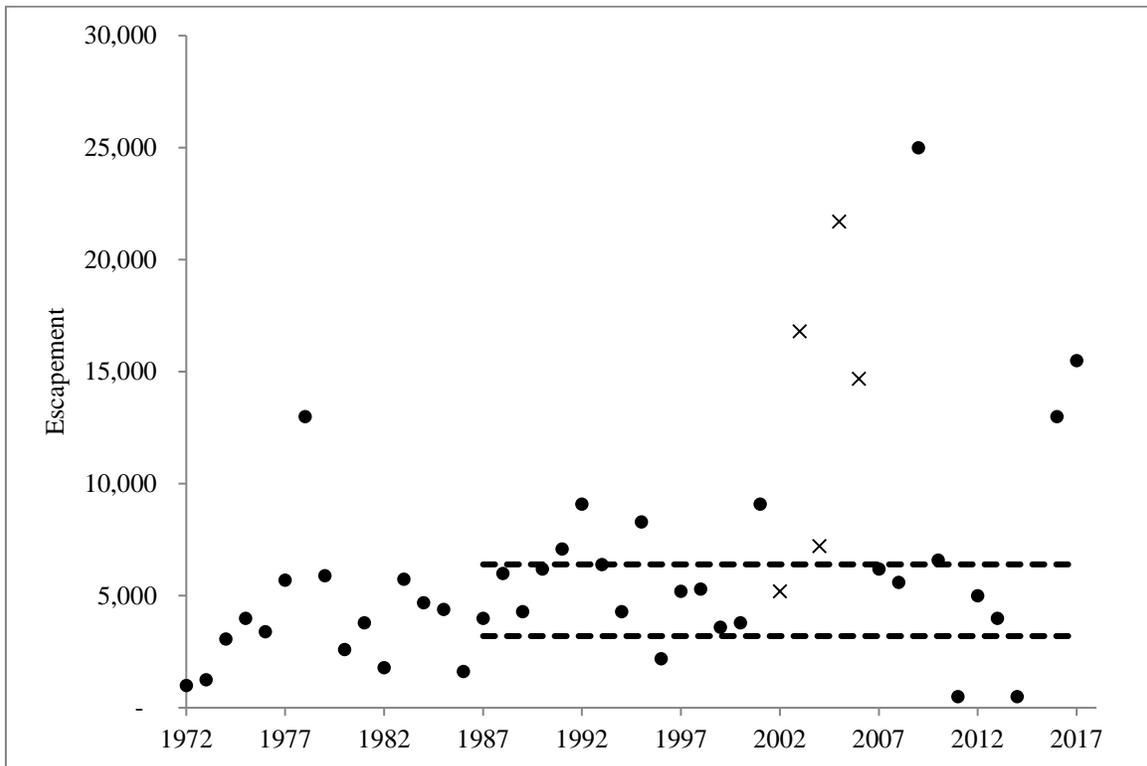
APPENDIX E. SUPPORTING INFORMATION FOR THE CHRISTIANSON LAGOON SOCKEYE SALMON ESCAPEMENT GOAL

Appendix E1.–Description of stock and escapement goal for Christianson Lagoon sockeye salmon.

System: Christianson Lagoon.

Species: Sockeye salmon.

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine and set gillnet.
Current escapement goal:	SEG: 25,000–50,000 (late 1980s).
Recommended escapement goal:	No change.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1971 to present.
Data summary:	
Data quality	Poor.
Data type	Fixed aerial surveys from 1971 to present; intermittent in 1960s. No stock-specific harvest information is available.
Comments	3-tier Percentile Approach supports current SEG.

Appendix E2.–Christianson Lagoon sockeye salmon escapements.

System: **Christianson Lagoon.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]
1971	29,500
1972	3,900
1973	4,100
1974	3,100
1975	10,400
1976	19,400
1977	13,700
1978	10,200
1979	25,600
1980	75,300
1981	59,100
1982	25,500
1983	13,500
1984	63,000
1985	25,800
1986	36,800
1987	24,200
1988	29,700
1989	46,700
1990	45,600
1991	64,900
1992	28,000
1993	30,600
1994	37,800
1995	41,800
1996	25,600
1997	33,200
1998	38,600
1999	48,000
2000	49,400
2001	36,400
2002	42,700
2003	52,200
2004	75,400
2005	54,500
2006	41,505
2007	48,075
2008	114,000
2009	48,100
2010	27,900
2011	35,200
2012	40,000
2013	16,500
2014	32,600
2015	6,700
2016	111,700
2017	290,600

[a] The estimated total escapement represents the peak aerial survey and enumeration of carcasses, as well as ancillary and qualitative data.

System: **Christianson Lagoon.**

Species: **Sockeye salmon.**

Solid circles represent aerial survey data and dashed lines are the historical SEGs.
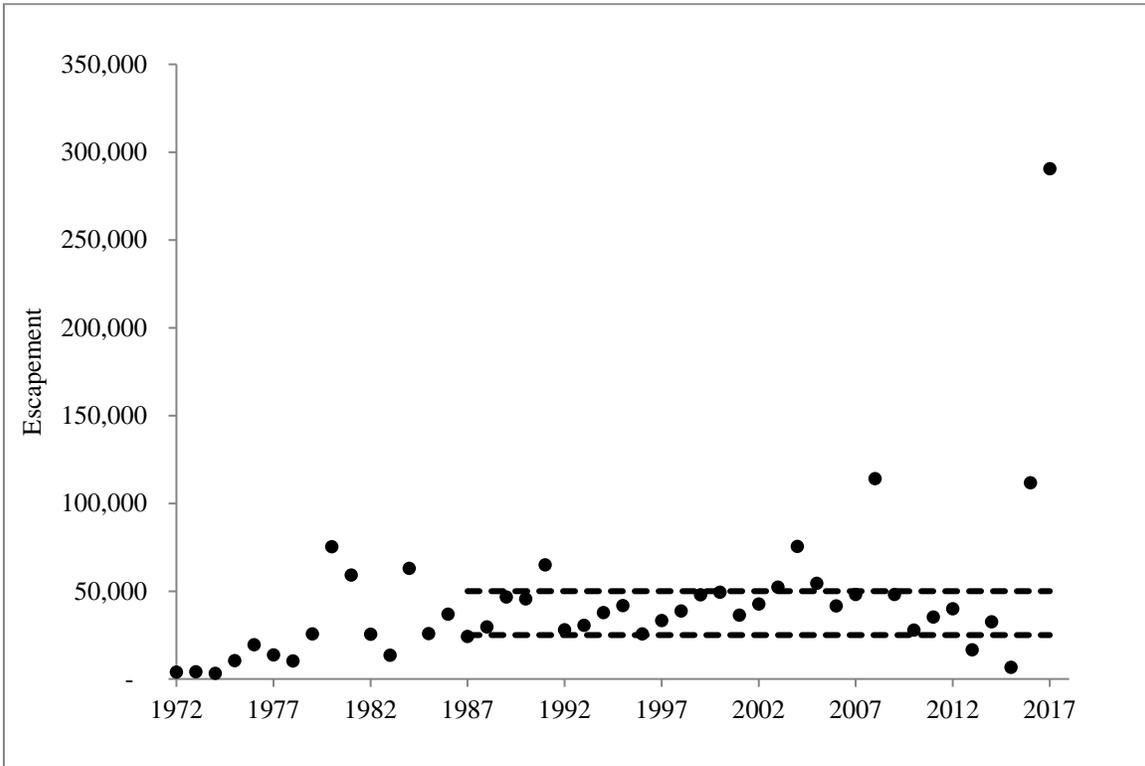
APPENDIX F. SUPPORTING INFORMATION FOR THE SWANSON LAGOON SOCKEYE SALMON ESCAPEMENT GOAL

Appendix F1.–Description of stock and escapement goal for Swanson Lagoon sockeye salmon.

System: **Swanson Lagoon.**

Species: **Sockeye salmon.**

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine and set and drift gillnet.
Current escapement goal:	SEG: 6,000–16,000 (2007).
Recommended escapement goal:	Remove
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1960 to present.
Data summary:	
Data quality	Poor.
Data type	Fixed aerial surveys from 1960 to present. No stock-specific harvest information is available.
Methodology	3-tier Percentile Approach.
Criteria for SEG	High contrast, low harvest.
Percentiles	20th–60th.
Comments	The Swanson Lagoon drainage is annually impaired by a berm that builds up at the mouth of the lagoon by local wind and wave action. The berm opens occasionally and allows fish passage, however, timing of the creation of a channel does not always coincide with timing of sockeye salmon migration. This occurs frequently enough to render management actions ineffective in achieving escapement goals when compared with this naturally occurring phenomenon. As such, an escapement goal is not feasible for management to achieve with fisheries action.

Appendix F2.–Swanson Lagoon sockeye salmon escapements.

System: **Swanson Lagoon.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]
1970	700
1971	300
1972	200
1973	100
1974	50
1975	1,400
1976	2,600
1977	12,000
1978	8,100
1979	8,400
1980	9,700
1981	600
1982	1,800
1983	300
1984	5,500
1985	3,400
1986	7,400
1987	9,600
1988	5,700
1989	5,500
1990	32,900
1991	11,200
1992	15,400
1993	7,600
1994	9,700
1995	10,300
1996	9,300
1997	7,800
1998	5,000
1999	7,900
2000	5,700
2001	10,600
2002	10,000
2003	16,100
2004	24,300
2005	3,500
2006	376
2007	9,200
2008	5,500
2009	1,000
2010	1,700
2011	1,000
2012	3,500
2013	3,000
2014	1,500
2015	3,500
2016	3,000
2017	860

[a] The estimated escapement representing the peak aerial survey and enumeration of carcasses, as well as ancillary and qualitative data, was used between 1970 and 2009. Peak aerial surveys were used from 2010 to the present.

System: **Swanson Lagoon.**

Species: **Sockeye salmon.**

Solid circles represent aerial survey data and dashed lines are the historical SEGs.
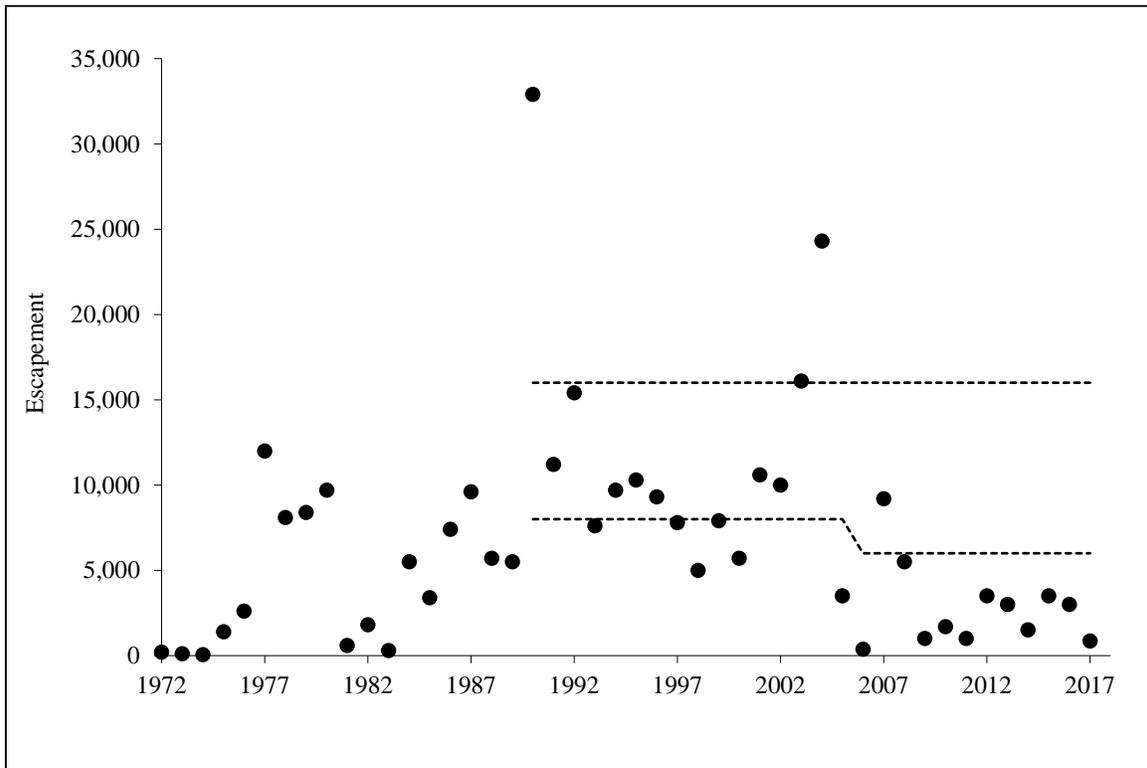
APPENDIX G. SUPPORTING INFORMATION FOR THE NORTH CREEK SOCKEYE SALMON ESCAPEMENT GOAL

Appendix G1.–Description of stock and escapement goal for North Creek sockeye salmon.

System: North Creek.

Species: Sockeye salmon.

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial set and drift gillnet.
Current escapement goal:	SEG: 4,400 to 8,800 (late 1980s).
Recommended escapement goal:	7,500 to 10,000
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1960–present.
Data summary:	
Data quality	Poor.
Data type	Fixed aerial surveys from 1960 to present. No stock-specific harvest information is available.
Data contrast	13 (1995 to 2017)
Methodology	3-tier Percentile Approach
Criteria for SEG	High contrast, Moderate Harvest
Percentiles	20th to 60th (high contrast)
Comments	SEG estimates based on the 3-tier Percentile Approach supported changing the goal. Data used was from 1995–2017

Appendix G2.–North Creek sockeye salmon escapements.

System: **North Creek.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]
1970	600
1971	
1972	
1973	
1974	1,800
1975	1,700
1976	7,100
1977	3,300
1978	500
1979	2,100
1980	3,400
1981	
1982	5,800
1983	2,000
1984	500
1985	3,600
1986	2,100
1987	8,300
1988	6,300
1989	7,000
1990	4,300
1991	9,000
1992	15,700
1993	9,700
1994	4,600
1995	3,400
1996	8,000
1997	5,700
1998	6,700
1999	10,900
2000	8,100
2001	8,000
2002	10,100
2003	10,200
2004	15,000
2005	45,000
2006	7,530
2007	16,800
2008	38,000
2009	8,000
2010	18,500
2011	10,200
2012	18,000
2013	8,500
2014	7,500
2015	18,000
2016	21,000
2017	5,800

[a] The estimated total escapement represents the peak aerial survey and enumeration of carcasses, as well as ancillary and qualitative data.

Appendix G3.–North Creek sockeye salmon escapement and escapement goals.

System: **North Creek.**

Species: **Sockeye salmon.**

Solid circles represent aerial survey data and dashed lines are the historical and recommended SEGs.
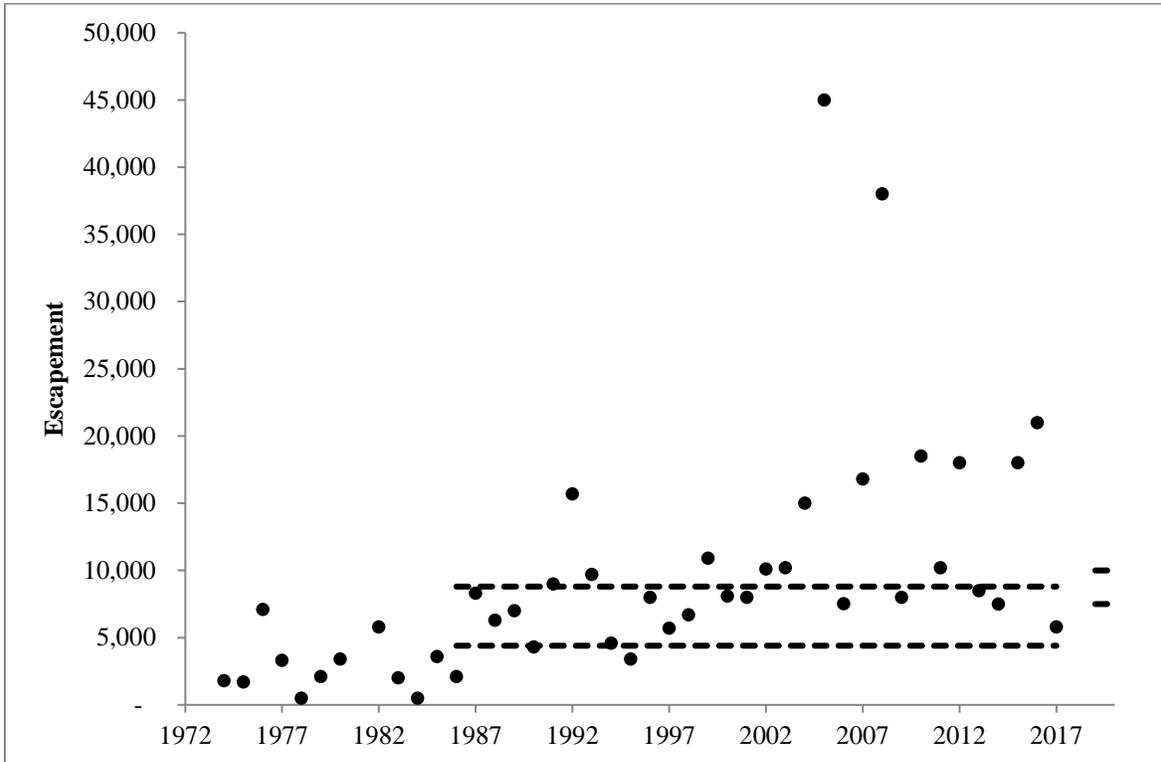
APPENDIX H. SUPPORTING INFORMATION FOR THE NELSON RIVER SOCKEYE SALMON ESCAPEMENT GOAL

Appendix H1.–Description of stock and escapement goal for Nelson River sockeye salmon.

System: Nelson River.

Species: Sockeye salmon.

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial set and drift gillnet.
Current escapement goal:	BEG: 97,000–219,000 (2004).
Recommended escapement goal:	No change.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Tower counts, 1962–1988;
	Weir counts, 1989 to present.
Data summary:	
Data quality	Good for tower counts; excellent for weir counts.
Data type	Tower counts from 1962–1988 and weir counts from 1989 to present. Escapement age data are available from 1985 to present. Stock-specific harvest information is available from 1970 to present.
Comments	Current BEG was based on Ricker spawner-recruit model.

System: **Nelson River.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Tower Escapement	Weir Escapement
1970	81,900	
1971	58,900	
1972	27,600	
1973	18,200	
1974	37,400	
1975	133,100	
1976	101,000	
1977	146,000	
1978	280,000	
1979	352,100	
1980	335,400	
1981	244,200	
1982	171,600	
1983	124,000	
1984	244,100	
1985	314,300	
1986	117,000	
1987	144,000	
1988	128,300	
1989		193,300
1990		240,700
1991		268,400
1992		162,300
1993		207,200
1994		325,300
1995		329,400
1996		250,500
1997		183,100
1998		159,800
1999		202,067
2000		182,700
2001		201,962
2002		315,693
2003		343,511
2004		480,097
2005		303,000
2006		215,000
2007		180,000
2008		141,600
2009		157,000
2010		108,000
2011		89,000
2012		103,300
2013		248,000
2014		250,000
2015		257,000
2016		300,000
2017		381,000

System: **Nelson River.**

Species: **Sockeye salmon.**

Solid circles represent tower count data, X-symbols represent weir counts, and dashed lines are the historical escapement goals.
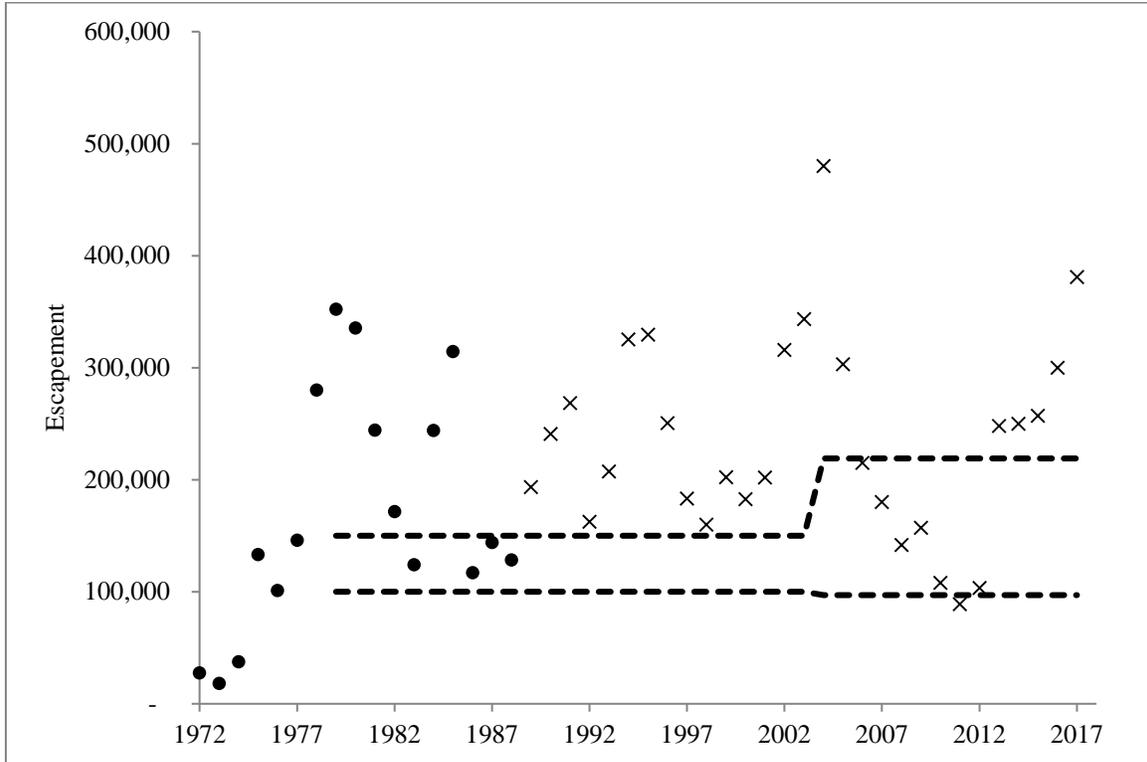
APPENDIX I. SUPPORTING INFORMATION FOR THE BEAR LAKE SOCKEYE SALMON ESCAPEMENT GOALS

Appendix I1.–Description of stock and escapement goals for Bear Lake sockeye salmon.

System: Bear Lake.

Species: Sockeye salmon.

Description of stock and escapement goals.

Regulatory area	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine and drift gillnet.
Previous escapement goal:	SEG: Early Run: 176,000–293,000 (2004).
	SEG: Late Run: 117,000–195,000 (2004).
Recommended escapement goal:	No change.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Tower counts, 1964–1985;
	Weir counts, 1986 to present.
Data summary:	
Data quality:	Good for tower counts; excellent for weir counts.
Data type:	Tower counts from 1964–1985; weir counts from 1986 to present. Escapement age data are available from 1985 to present and harvest age data are available from 1985 to present for the late run (after July 31). Stock-specific harvest information is available for the late run from 1970 to present. No-stock specific harvest information is available for the early run (prior to August 1).
Comments:	The Bear Lake system is considered spawner-limited and therefore, the spawning habitat model was used to estimate the SEG.

Appendix I2.–Bear Lake early-run sockeye salmon escapements.

System: **Bear Lake early run.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Tower Counts	Weir Counts
1970	147,367	
1971	65,950	
1972	106,571	
1973	90,998	
1974	143,505	
1975	138,793	
1976	163,135	
1977	153,383	
1978	311,528	
1979	384,613	
1980	436,962	
1981	475,272	
1982	195,497	
1983	157,857	
1984	286,849	
1985	269,261	
1986		174,453
1987		168,683
1988		172,363
1989		246,196
1990		283,854
1991		432,087
1992		254,170
1993		254,012
1994		260,559
1995		197,039
1996		247,371
1997		214,689
1998		221,580
1999		222,110
2000		184,053
2001		177,495
2002		179,480
2003		226,201
2004		354,565
2005		332,248
2006		262,995
2007		206,233
2008		125,526
2009		216,237
2010		226,534
2011		207,451
2012		173,158
2013		219,074
2014		259,046
2015		304,356
2016		293,280
2017		570,840

Appendix I3.–Bear Lake early-run sockeye salmon escapement and escapement goals.

System: **Bear Lake early run.**

Species: **Sockeye salmon.**

Solid circles represent tower count data, X-symbols represent weir counts, and dashed lines are the historical and current SEG.
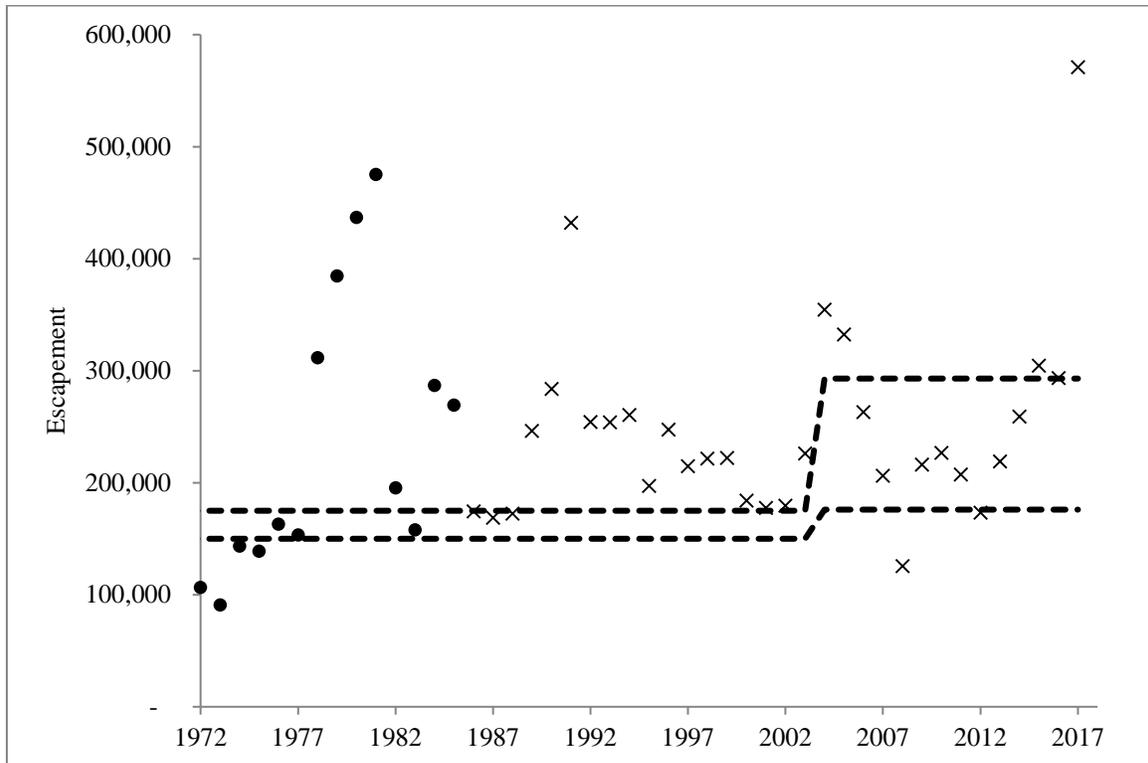
Appendix I4.–Bear Lake late-run sockeye salmon table.

System: **Bear Lake late run.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Tower Counts	Weir Counts
1970	121,633	
1971	185,050	
1972	20,429	
1973	34,002	
1974	106,495	
1975	131,207	
1976	121,865	
1977	61,617	
1978	418,472	
1979	567,387	
1980	238,038	
1981	214,728	
1982	104,503	
1983	172,143	
1984	108,151	
1985	170,739	
1986		98,047
1987		89,317
1988		140,637
1989		204,804
1990		262,946
1991		173,913
1992		195,830
1993		197,988
1994		204,441
1995		107,961
1996		119,629
1997		145,311
1998		193,420
1999		127,890
2000		90,947
2001		122,505
2002		95,520
2003		139,799
2004		80,435
2005		221,752
2006		182,005
2007		224,767
2008		195,474
2009		133,263
2010		142,966
2011		132,549
2012		116,442
2013		196,926
2014		206,954
2015		210,644
2016		139,720
2017		229,160

Appendix I5.–Bear Lake late-run sockeye salmon escapement and escapement goals.

System: **Bear Lake late run.**

Species: **Sockeye salmon.**

Solid circles represent tower count data, X-symbols represent weir counts, and dashed lines are the historical and current SEG.
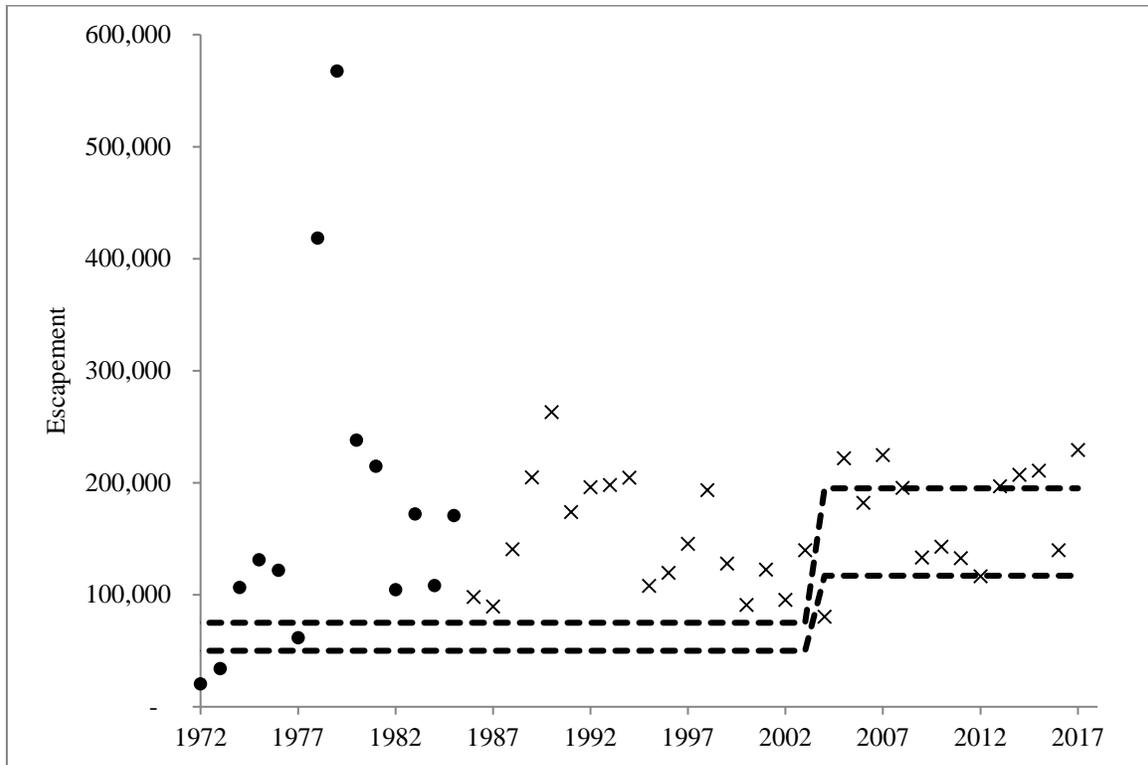
APPENDIX J. SUPPORTING INFORMATION FOR THE SANDY RIVER SOCKEYE SALMON ESCAPEMENT GOAL

System: **Sandy River.**

Species: **Sockeye salmon.**

Description of stock and escapement goals.

Regulatory area	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine and drift gillnet.
Previous escapement goal:	SEG: 34,000–74,000 (2007).
Recommended escapement goal:	No change.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1960–1993;
	Tower counts, 1962–1964;
	Weir counts, 1994 to present.
Data summary:	
Data quality:	Fair for aerial survey/tower count; good for weir counts.
Data type:	Weir counts from 1994 to 2017 are available and escapement age information is available during weir counts. No stock-specific harvest information is available.
Comments:	SEG based on the 4-tier Percentile Approach.

Appendix J2.–Sandy River sockeye salmon escapements.

System: **Sandy River.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]	Weir Counts
1970	25,000	
1971	30,000	
1972	8,400	
1973	5,100	
1974	16,500	
1975	40,000	
1976	43,000	
1977	50,200	
1978	64,000	
1979	61,000	
1980	76,000	
1981	51,500	
1982	61,300	
1983	28,000	
1984	19,000	
1985	11,500	
1986	6,900	
1987	8,700	
1988	34,500	
1989	36,000	
1990	17,500	
1991	75,200	
1992	21,200	
1993	49,300	
1994		115,000
1995		125,000
1996		64,000
1997		38,000
1998		52,000
1999		58,000
2000		40,000
2001		51,000
2002		49,000
2003		66,000
2004		32,000
2005		101,000
2006		48,000
2007		44,700
2008		32,200
2009		36,000
2010		37,000
2011		37,500
2012		27,100
2013		42,000
2014		59,000
2015		116,000
2016		170,000
2017		145,000

[a] The estimated total escapement represents the peak aerial survey and enumeration of carcasses, as well as ancillary and qualitative data.

System: **Sandy River.**

Species: **Sockeye salmon.**

Solid circles represent aerial survey data, X-symbols represent weir counts, and dashed lines are the historical SEGs.
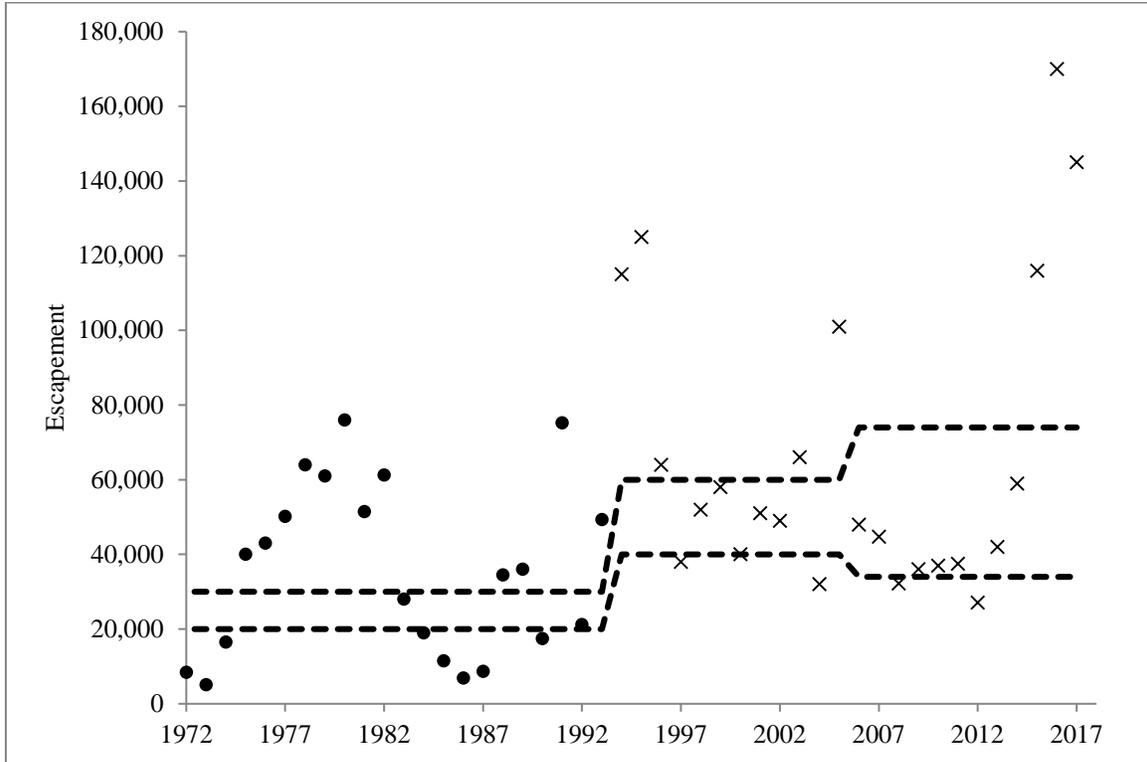
APPENDIX K. SUPPORTING INFORMATION FOR THE ILNIK RIVER SOCKEYE SALMON ESCAPEMENT GOAL

Appendix K1.–Description of stock and escapement goal for Ilnik River sockeye salmon.

System: Ilnik River.

Species: Sockeye salmon.

Description of stock and escapement goals.

Regulatory area	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial drift and set gillnet.
Previous escapement goal:	SEG: 40,000–60,000 (1991).
Recommended escapement goal:	No change.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1960–1990;
	Weir count, 1991 to present.
Data summary:	
Data quality	Fair for aerial surveys; good for weir counts.
Data type	Fixed-wing aerial surveys from 1970–1990; intermittent during 1960s. Weir counts from 1991 to present, with escapement age data available during weir counts. No stock-specific harvest information is available.
Comments	Current escapement based on percentile, euphotic volume analysis, smolt biomass as a function of zooplankton biomass, and lake surface area methods.

Appendix K2.–Ilnik River sockeye salmon escapements.

System: **Ilnik River.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]	Weir Counts
1970	15,300	
1971	26,100	
1972	13,100	
1973	16,000	
1974	14,500	
1975	40,500	
1976	37,500	
1977	30,000	
1978	23,100	
1979	97,200	
1980	97,600	
1981	97,500	
1982	42,500	
1983	28,600	
1984	29,500	
1985	27,000	
1986	66,800	
1987	30,700	
1988	26,900	
1989	16,500	
1990	35,700	
1991		135,000
1992		45,000
1993		70,000
1994		75,000
1995		39,000
1996		62,000
1997		82,000
1998		50,000
1999		75,000
2000		95,000
2001		58,000
2002		43,000
2003		69,000
2004		82,000
2005		154,000
2006		88,000
2007		93,000
2008		44,300
2009		66,000
2010		59,000
2011		43,000
2012		61,000
2013		51,000
2014		59,000
2015		26,000
2016		124,000
2017		238,000

[a] The estimated total escapement represents the peak aerial survey, enumeration of carcasses, and ancillary and qualitative data.

Appendix K3.–Ilnik River sockeye salmon escapement and escapement goal.

System: **Ilnik River.**

Species: **Sockeye salmon.**

Solid circles represent aerial survey data, X-symbols represent weir counts, and dashed lines are the current SEG.
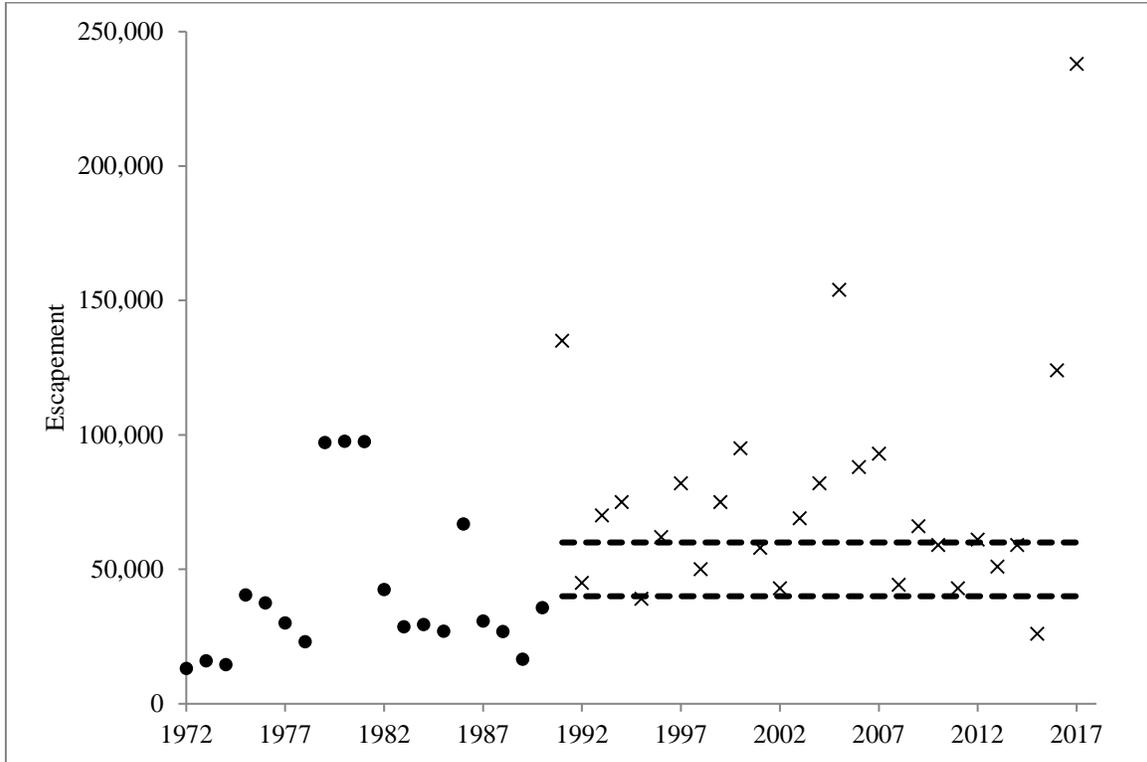
APPENDIX L. SUPPORTING INFORMATION FOR THE MESHIK RIVER SOCKEYE SALMON ESCAPEMENT GOAL

Appendix L1.–Description of stock and escapement goal for Meshik River sockeye salmon.

System: **Meshik River.**

Species: **Sockeye salmon.**

Description of stock and escapement goals.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial drift and set gillnet.
Current escapement goal:	SEG: 48,000 to 86,000 (2016)
Recommended escapement goal:	No change
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1970–present.
Data summary:	
Data quality	Poor.
Data type	Fixed-wing aerial surveys from 1960 to present; missing data points throughout period. 1990 to present includes increased aerial survey effort. No stock-specific harvest information is available.
Data contrast	1990–2017 = 12.2.
Methodology	3-tier Percentile Approach.
Criteria for SEG	High contrast, low to moderate harvest.
Percentiles	20th to 60th.
Comments:	This index includes Red Bluff (317-204A) and Yellow Bluff (317-204B) creeks in addition to Meshik River (317-207)). It *does not include* Unnamed (317-201), Charles (317-202), Birthday (307-208), and Barbara (317-209) creeks.

Appendix L2.–Meshik River sockeye salmon escapements.

System: **Meshik River.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Meshik System Index Escapement [a]
1990	26,200
1991	24,780
1992	32,400
1993	
1994	45,700
1995	85,600
1996	59,950
1997	15,100
1998	57,700
1999	74,700
2000	183,700
2001	112,000
2002	
2003	114,000
2004	102,200
2005	111,100
2006	138,010
2007	57,400
2008	83,250
2009	88,000
2010	63,700
2011	93,900
2012	50,900
2013	85,400
2014	114,700
2015	171,000
2016	131,800
2017	191,525

[a] The estimated total escapement represents the peak aerial survey and enumeration of carcasses, as well as ancillary and qualitative data. This index includes Red Bluff (317-204A) and Yellow Bluff (317-204B) creeks in addition to Meshik River (317-207).

System: **Meshik River.**

Species: **Sockeye salmon.**

Observed Meshik River sockeye salmon escapement by year, and current SEG range (dotted lines).
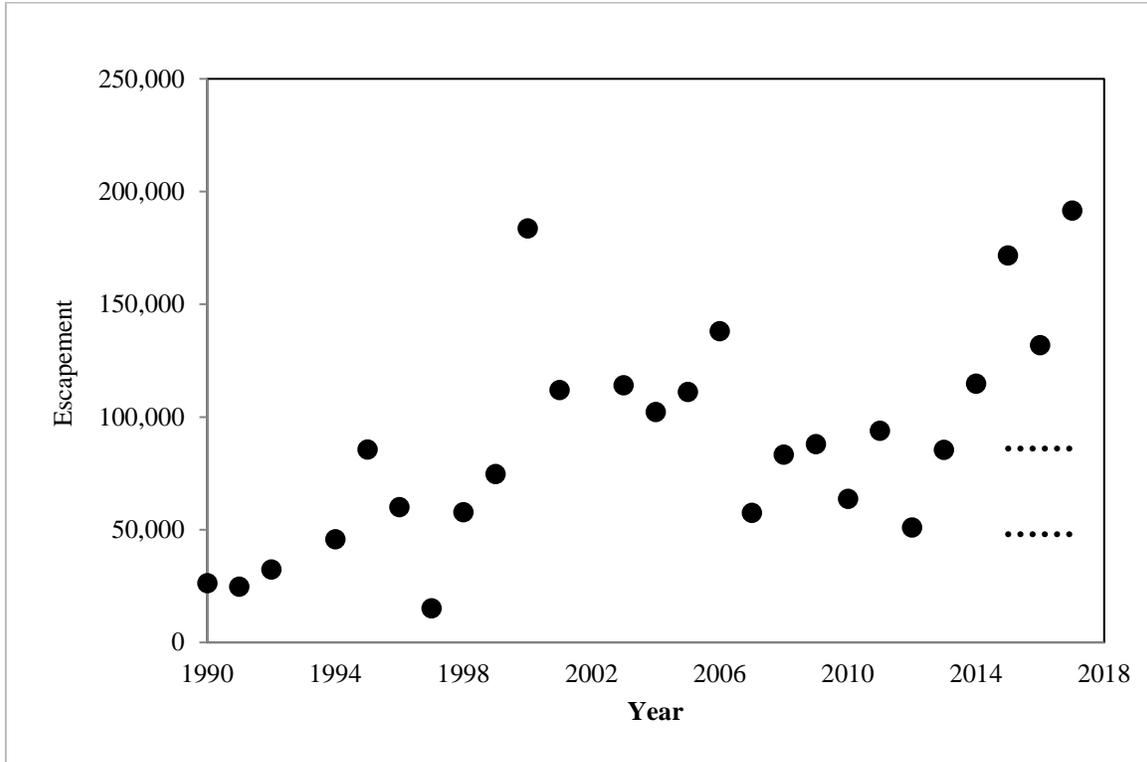
APPENDIX M. SUPPORTING INFORMATION FOR THE CINDER RIVER SOCKEYE SALMON ESCAPEMENT GOAL

Appendix M1.–Description of stock and escapement goal for Cinder River sockeye salmon.

System: **Cinder River.**

Species: **Sockeye salmon.**

Description of stock and escapement goals.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial drift and set gillnet.
Current escapement goal:	SEG: 36,000 to 94,000 (2016).
Recommended escapement goal:	No Change
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1970–present.
Data summary:	
Data quality	Poor.
Data type	Fixed-wing aerial surveys from 1960 to present; missing data points throughout time period. 1990 to present includes increased aerial survey effort. No stock-specific harvest information is available.
Data contrast	1990–2017= 10.9 (Cinder only), 12.4 (Cinder River and Mud Creek combined). 2003–2017= 2.4 (Cinder only), 2.5 (Cinder River and Mud Creek combined).
Methodology	3-tier Percentile Approach.
Criteria for SEG	High contrast, low harvest.
Percentiles	20th to 60th.
Comments	The 3-tier Percentile Approach used data from 1991 to the present as those data represent better quality aerial surveys. This index includes Mud Creek (318-2004) in addition to Cinder River (318-206).

Appendix M2.–Cinder River sockeye salmon escapements.

System: **Cinder River.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Cinder System Escapement Index [a]
1991	45,500
1992	11,100
1993	
1994	77,400
1995	36,000
1996	
1997	
1998	22,703
1999	18,000
2000	82,500
2001	51,000
2002	10,200
2003	111,000
2004	65,000
2005	120,000
2006	106,000
2007	130,000
2008	121,800
2009	131,000
2010	106,000
2011	105,500
2012	73,000
2013	90,000
2014	96,000
2015	118,000
2016	200,500
2017	222,600

[a]   The estimated total escapement represents the peak aerial survey and enumeration of carcasses, as well as ancillary and qualitative data. This index includes Mud Creek (318-2004) in addition to Cinder River (318-206).

System: **Cinder River.**

Species: **Sockeye salmon.**

Observed escapement by year and current SEG range (dotted lines).
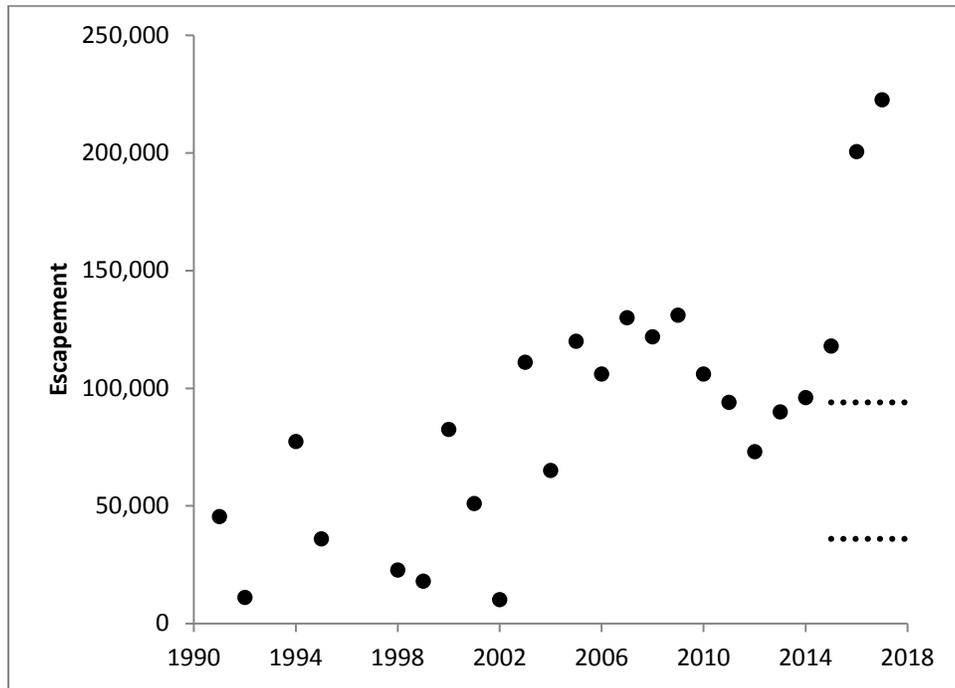
APPENDIX N. SUPPORTING INFORMATION FOR THE MCLEES LAKE SOCKEYE SALMON ESCAPEMENT GOAL

Appendix N1.–Description of stock and escapement goal for McLees Lake sockeye salmon.

System: **McLees Lake.**

Species: **Sockeye salmon.**

Description of stock and escapement goal.

Regulatory area	Aleutian Islands – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine.
Current escapement goal:	SEG: 10,000 to 60,000 (2010).
Recommended escapement goal:	Lower bound SEG: >10,000
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1974–2003;
	Weir counts, 2001–present.
Data summary:	
Data quality	Fair for aerial survey counts; good for weir counts.
Data type	No stock-specific harvest information is available.
Comments	Only weir escapement was included in the goal development.

Appendix N2.–McLees Lake sockeye salmon escapements.

System: **McLees Lake.**

Species: **Sockeye salmon.**

Data available for analysis of escapement goal.

Year	Weir Counts
2001	45,866
2002	97,780
2003	101,793
2004	40,328
2005	12,097
2006	12,936
2007	21,428
2008	8,661
2009	10,120
2010	32,842
2011	36,602
2012	15,111
2013	15,687
2014	12,424
2015	20,284
2016	39,892
2017	13,195

System: **McLees Lake.**

Species: **Sockeye salmon.**

Solid circles represent weir counts; the dashed lines represent the historical SEGs and the 2018 recommended escapement goal.
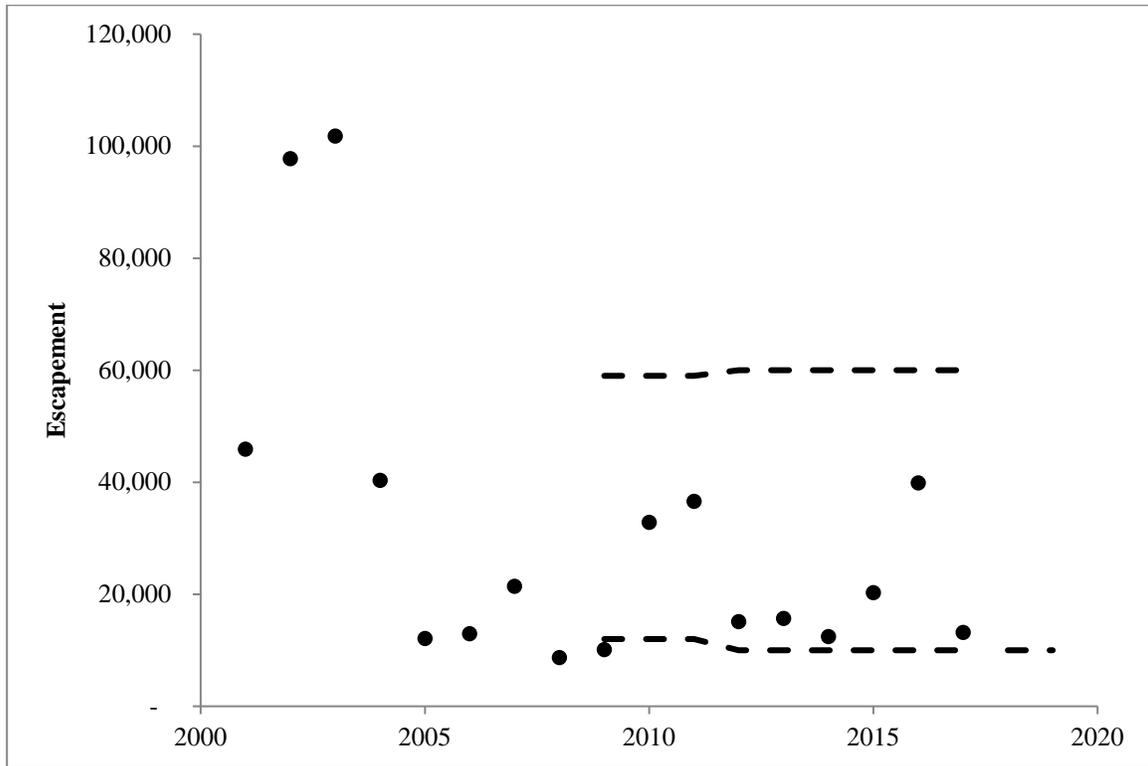
APPENDIX O. SUPPORTING INFORMATION FOR THE NELSON RIVER COHO SALMON ESCAPEMENT GOAL

Appendix O1.–Description of stock and escapement goal for Nelson River coho salmon.

System: Nelson River.

Species: Coho salmon.

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial set and drift gillnet.
Current escapement goal:	Lower Bound SEG: >18,000 (2004).
Recommended escapement goal:	No change.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1968 to present.
Data summary:	
Data quality	Fair for aerial survey counts.
Data type	Fixed-wing aerial surveys from 1968 to present. No stock-specific harvest information is available.
Comments	Current SEG was based on risk analysis.

System: **Nelson River.**

Species: **Coho salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]
1970	3,900
1971	3,400
1972	1,210
1973	1,500
1974	1,200
1975	1,200
1976	5,700
1977	13,000
1978	1,425
1979	17,000
1980	26,700
1981	30,000
1982	
1983	13,000
1984	28,630
1985	17,500
1986	23,000
1987	27,500
1988	17,000
1989	32,000
1990	30,000
1991	33,000
1992	20,000
1993	14,600
1994	18,000
1995	22,500
1996	20,500
1997	18,000
1998	20,000
1999	16,000
2000	18,000
2001	36,000
2002	35,500
2003	26,700
2004	52,500
2005	24,000
2006	19,000
2007	19,000
2008	24,000
2009	22,000
2010	15,000
2011	21,000
2012	19,160
2013	22,000
2014	25,000
2015	45,000
2016	45,000
2017	19,000

[a] The estimated total escapement represents the peak aerial survey, enumeration of carcasses, and ancillary and qualitative data.

System: **Nelson River.**

Species: **Coho salmon.**

Observed escapement by year (solid circles) with historical SEG range and current Lower Bound SEG (dashed lines).
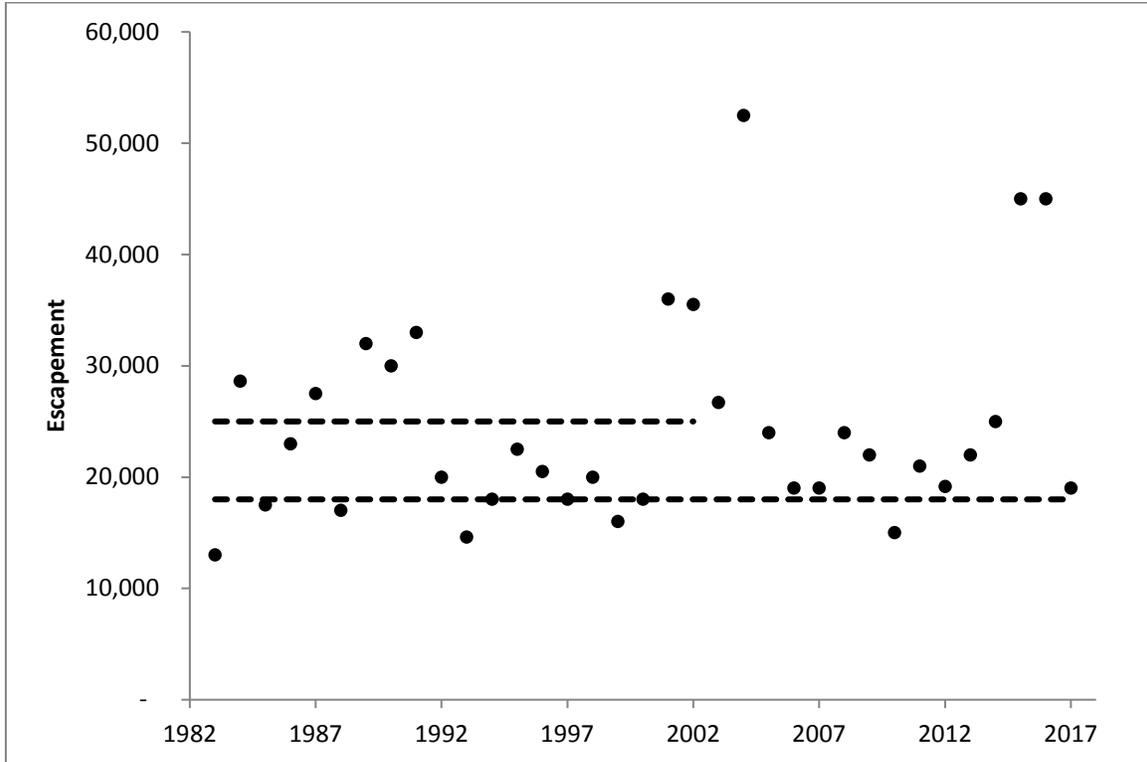
APPENDIX P. SUPPORTING INFORMATION FOR THE ILNIK RIVER COHO SALMON ESCAPEMENT GOAL

Appendix P1.–Description of stock and escapement goals for Ilnik River coho salmon.

System: Ilnik River.

Species: Coho salmon.

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial set and drift gillnet.
Current escapement goal:	Lower Bound SEG: >9,000 (2010).
Recommended escapement goal:	No change.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1968 to present.
Data summary:	
Data quality	Poor.
Data type	Fixed-wing aerial surveys sporadically 1968 to 1985; consistently surveyed 1985 to present. No stock-specific harvest information is available.
Comments	Current SEG was based on risk analysis.

Appendix P2.–Ilnik River coho salmon escapements.

System: **Ilnik River.**

Species: **Coho salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]
1985	35,000
1986	25,000
1987	8,000
1988	8,500
1989	25,300
1990	24,000
1991	27,000
1992	20,900
1993	28,000
1994	6,000
1995	12,000
1996	2,100
1997	19,000
1998	9,000
1999	1,000
2000	3,000
2001	37,000
2002	45,000
2003	37,000
2004	40,000
2005	
2006	27,000
2007	19,000
2008	27,000
2009	24,000
2010	19,600
2011	18,000
2012	11,800
2013	17,000
2014	33,000
2015	14,000
2016	28,000
2017	6,000

[a] The estimated total escapement represents the peak aerial survey, enumeration of carcasses, and ancillary and qualitative data. Missing values are years when surveys were not completed.

System: **Ilnik River.**

Species: **Coho salmon.**

Observed escapement by year (solid circles), and historical and current SEGs (dashed line).
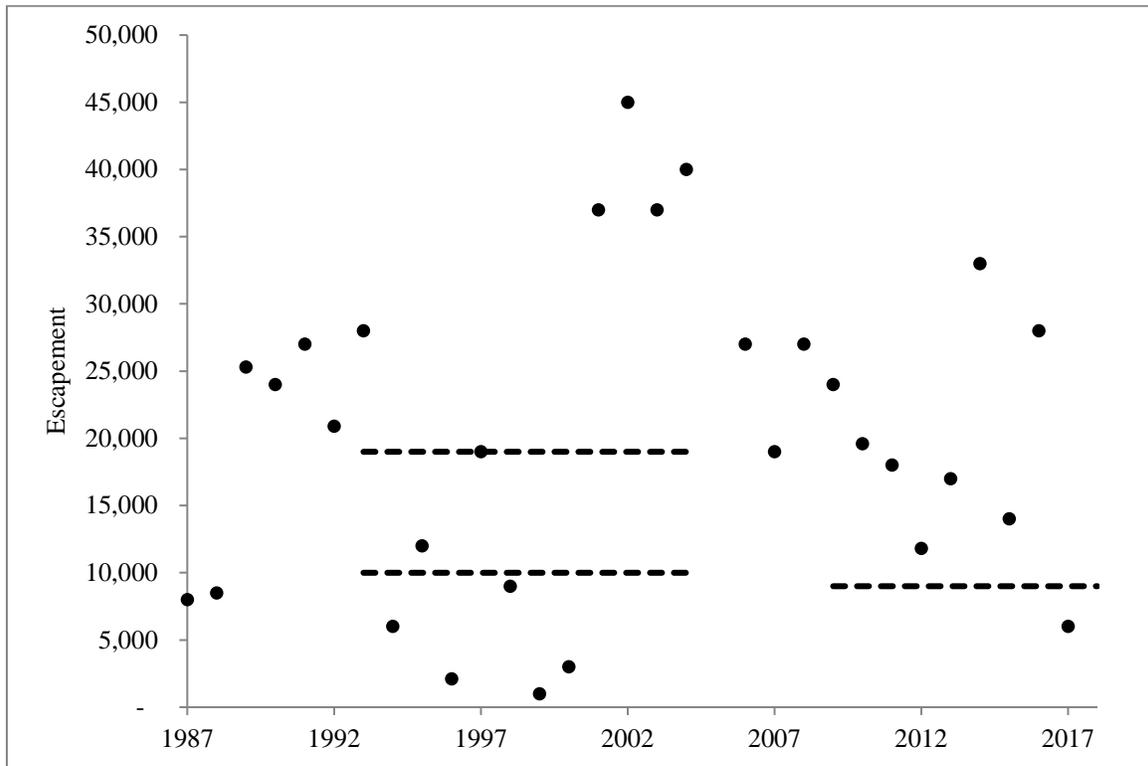
APPENDIX Q. SUPPORTING INFORMATION FOR THE SOUTH PENINSULA PINK SALMON ESCAPEMENT GOALS

Appendix Q1.–Description of stock and escapement goals for South Peninsula pink salmon.

System: South Peninsula.

Species: Pink salmon.

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine, and set and drift gillnet.
Current escapement goal:	SEG: Even/Odd year. 1,750,000 to 4,000,000 (2016)
Recommended escapement goal:	No change
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1968–present.
Data summary:	
Data quality	Fair.
Data type	Fixed-wing aerial surveys for most years 1960 to present. No stock-specific harvest information is available.
Comments	Escapement goal based on a Ricker stock recruitment analysis.

Appendix Q2.–South Peninsula aggregate pink salmon escapement, total harvest, and brood year recruitment, 1975 to 2017.

System: **South Peninsula.**

Species: **Pink salmon.**

Data available for analysis of escapement goal.

Year	Escapement	Total Harvest [a]	Recruitment	R/S
1975	552,100	55,395	4,113,817	7.5
1976	1,456,400	2,300,748	8,284,540	5.7
1977	2,677,800	1,436,017	8,980,149	3.4
1978	2,858,700	5,425,840	8,801,269	3.1
1979	2,629,500	6,350,649	6,829,503	2.6
1980	2,641,600	6,159,669	6,993,466	2.6
1981	2,306,800	4,522,703	3,576,093	1.6
1982	2,293,000	4,700,466	14,713,689	6.4
1983	851,200	2,724,893	5,913,566	6.9
1984	4,351,600	10,362,089	5,378,871	1.2
1985	1,613,800	4,299,766	2,698,805	1.7
1986	1,716,700	3,662,171	9,667,154	5.6
1987	1,540,500	1,158,305	8,783,157	5.7
1988	2,839,600	6,827,554	3,884,568	1.4
1989	1,870,900	6,912,257	12,903,424	6.9
1990	1,598,400	2,286,168	11,908,705	7.5
1991	2,946,800	9,956,624	12,820,896	4.4
1992	2,834,400	9,074,305	9,722,866	3.4
1993	2,990,100	9,830,796	22,523,513	7.5
1994	3,071,725	6,651,141	5,444,530	1.8
1995	6,406,300	16,117,213	6,948,735	1.1
1996	3,647,550	1,796,980	12,128,294	3.3
1997	5,243,275	1,705,460	13,201,054	2.5
1998	4,668,065	7,460,229	5,883,882	1.3
1999	5,015,310	8,185,744	6,887,202	1.4
2000	2,792,985	3,090,897	5,787,715	2.1
2001	2,965,136	3,922,066	9,483,367	3.2
2002	3,762,800	2,024,915	14,481,357	3.8
2003	5,511,220	3,972,147	13,600,587	2.5
2004	8,311,410	6,169,947	5,707,867	0.7
2005	6,165,634	7,434,953	9,522,831	1.5
2006	2,862,250	2,845,617	13,938,442	4.9
2007	2,680,213	6,842,618	8,175,290	3.1
2008	3,338,370	10,600,072	1,185,176	0.4
2009	3,067,000	5,108,290	6,616,906	2.2
2010	742,912	442,264	664,044	0.9
2011	2,494,950	4,121,956	9,623,217	3.9
2012	478,910	185,134	1,844,492	3.9
2013	2,320,790	7,302,427	23,065,223	9.9
2014	1,340,380	504,112	1,325,809	1.0
2015	7,820,800	15,244,423	25,543,714	3.3
2016	1,038,160	287,649		
2017	5,663,637	19,880,077		

[a] Total harvest was estimated using reported harvest from July 15 through the end of the season to more accurately estimate harvest of local stocks and exclude fish bound for other areas.

System: **South Peninsula (all years).**

Species: **Pink salmon.**

Observed escapement by year (solid circles), and current SEG (dotted line).
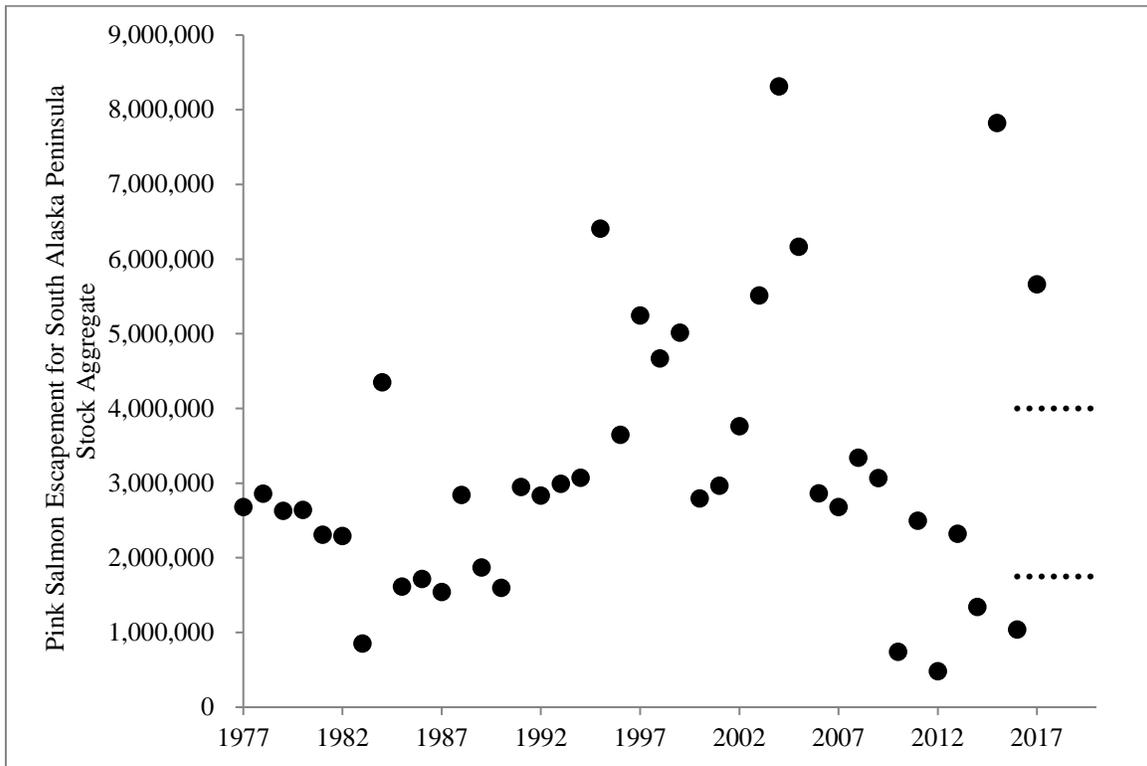
APPENDIX R. SUPPORTING INFORMATION FOR THE SOUTHEASTERN DISTRICT CHUM SALMON ESCAPEMENT GOAL

Appendix R1.–Description of stock and escapement goal for Southeastern District chum salmon.

System: Southeastern District.

Species: Chum salmon.

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine and set gillnet.
Current escapement goal:	SEG: 106,400 to 212,800 (1992).
Recommended escapement goal:	SEG: 62,500 to 151,900.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1960–present.
Data summary:	
Data quality	Fair.
Data Type	Fixed-wing aerial surveys available from 1960 to 2017. Data used in analysis represents indicator streams and years with a complete survey dataset from 1987 to present. No stock-specific harvest information is available.
Data contrast:	Aerial surveys, 1987–2017: 19
Methodology:	3-tier Percentile Approach
Criteria for SEG:	High contrast, moderate harvest (20th to 60th percentiles)
Comments	26 areawide systems were chosen to represent an indexed escapement goal:

281-1001 Dorenoi Bay, Major (SW)	281-7005 Beaver River
281-1002 Dorenoi Bay, Minor (NE River)	281-8008 Lefthand Bay Kagayan (Lefthand River)
281-2002 Chichagof Lagoon	281-8009 Foster Creek
281-3204 Little Norway	281-8014 Johnson Creek
281-3205 Clark Bay (SW)	281-8015 Coleman Creek
281-3207 Grub Gulch	281-9003 San Diego (West Side)
281-3301 Ramsey Bay (1st N Rock Wall)	281-9004 San Diego (Lagoon and Stream)
281-3302 Ramsey Bay (2nd N Rock Wall)	282-1011 Apollo Gold Mine Creek (Delarof Harbor)
281-3303 Louie's Corner	282-1203 Zachary Bay 1203
281-3304 Big River	282-1204 Zachary Bay 1204
281-3305 Stepovak River	282-1205 Zachary Bay 1205
281-3401 Granville Bay	282-1302 Dry Lagoon
281-3506 Boulder Bay	282-1303 Bay Point

Appendix R2.–Southeastern District chum salmon escapements.

System: **Southeastern District.**

Species: **Chum salmon.**

Data available for analysis of escapement goal.

Year	All System PAS Index	District Index
1987	167,300	118,375
1988	85,700	76,775
1989	99,650	59,575
1990	114,595	64,470
1991	181,365	150,650
1992	83,450	
1993	45,550	22,905
1994	59,800	27,130
1995	137,650	75,750
1996	133,600	102,600
1997	267,650	169,700
1998	246,025	168,700
1999	82,550	58,200
2000	179,950	134,150
2001	318,300	217,800
2002	204,150	152,150
2003	218,810	201,000
2004	367,200	251,100
2005	412,500	
2006	405,300	169,100
2007	201,451	165,301
2008	277,450	
2009	106,500	
2010	62,612	
2011	145,300	137,500
2012	31,072	30,152
2013	184,350	
2014	82,300	74,300
2015	250,370	
2016	150,456	
2017	592,460	416,845

Appendix R3.–Southeastern District chum salmon escapement and escapement goals.

System: **Southeastern District.**

Species: **Chum salmon.**

Observed escapement by year using the All PAS Index (solid circles) and revised District Index (open circles), and historical (dashed line) and recommended SEG (dotted line).
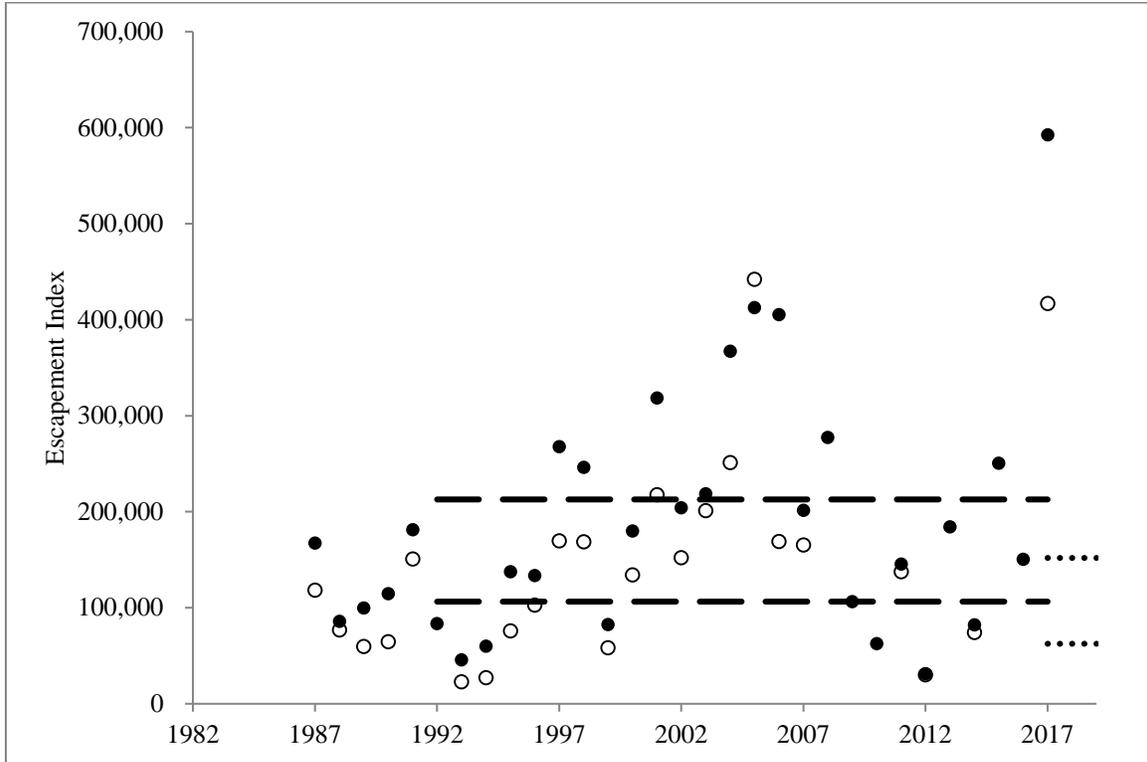
APPENDIX S. SUPPORTING INFORMATION FOR THE SOUTH CENTRAL DISTRICT CHUM SALMON ESCAPEMENT GOAL

Appendix S1.–Description of stock and escapement goal for South Central District chum salmon.

System: South Central District.

Species: Chum salmon.

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine and set gillnet.
Current escapement goal:	SEG: 89,800 to 179,600 (1992).
Recommended escapement goal:	SEG: 68,900 to 99,200.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1960–present.
Data summary:	
Data quality	Fair.
Data type	Fixed-wing aerial surveys available from 1960 to 2017. Data used in analysis represents indicator streams and years with a complete survey dataset from 1987 to present. No stock-specific harvest information is available.
Data contrast:	Aerial surveys, 1987–2017: 13
Methodology:	3-tier Percentile Approach
Criteria for SEG:	High contrast, moderate harvest (20th to 60th percentile)
Comments	10 areawide systems were chosen to represent an indexed escapement goal:
	283-6102 SW. Stream, Long John Lagoon
	283-6104 Long John Lagoon Springs
	283-6304 Stream S of Chinaman Lagoon
	283-6310 Chinaman Lagoon Main
	283-6313 Ruby's (Jackson's) Lagoon
	283-6316 Settlement Point (Creek)
	283-6405 Bluff Point
	283-6406 Canoe Bay River
	283-6408 Entrance (Arnies) Creek
	283-7001 Mino's Creek

Appendix S2.–South Central District chum salmon escapements.

System: **South Central District.**

Species: **Chum salmon.**

Data available for analysis of escapement goal.

Year	All System PAS Index	District Index
1987	161,900	80,300
1988	183,400	118,300
1989	89,530	47,500
1990	96,280	63,680
1991	163,990	96,700
1992	110,640	77,700
1993	126,800	69,540
1994	151,900	76,900
1995	187,100	104,150
1996	173,800	104,290
1997	274,400	221,000
1998	144,300	100,900
1999	253,500	89,200
2000	84,100	53,300
2001	155,500	81,900
2002	129,400	83,100
2003	79,000	42,900
2004	184,800	85,300
2005	235,700	198,900
2006	119,600	
2007	126,000	
2008	140,450	106,000
2009	18,600	
2010	85,600	63,600
2011	169,000	68,800
2012	86,190	
2013	155,050	101,400
2014	95,000	91,600
2015	298,800	182,000
2016	248,360	166,000
2017	810,053	566,213

System: **South Central District.**

Species: **Chum salmon.**

Observed escapement by year using the All PAS Index (solid circles) and revised District Index (open circles), and historical (dashed line) and recommended SEG (dotted line).
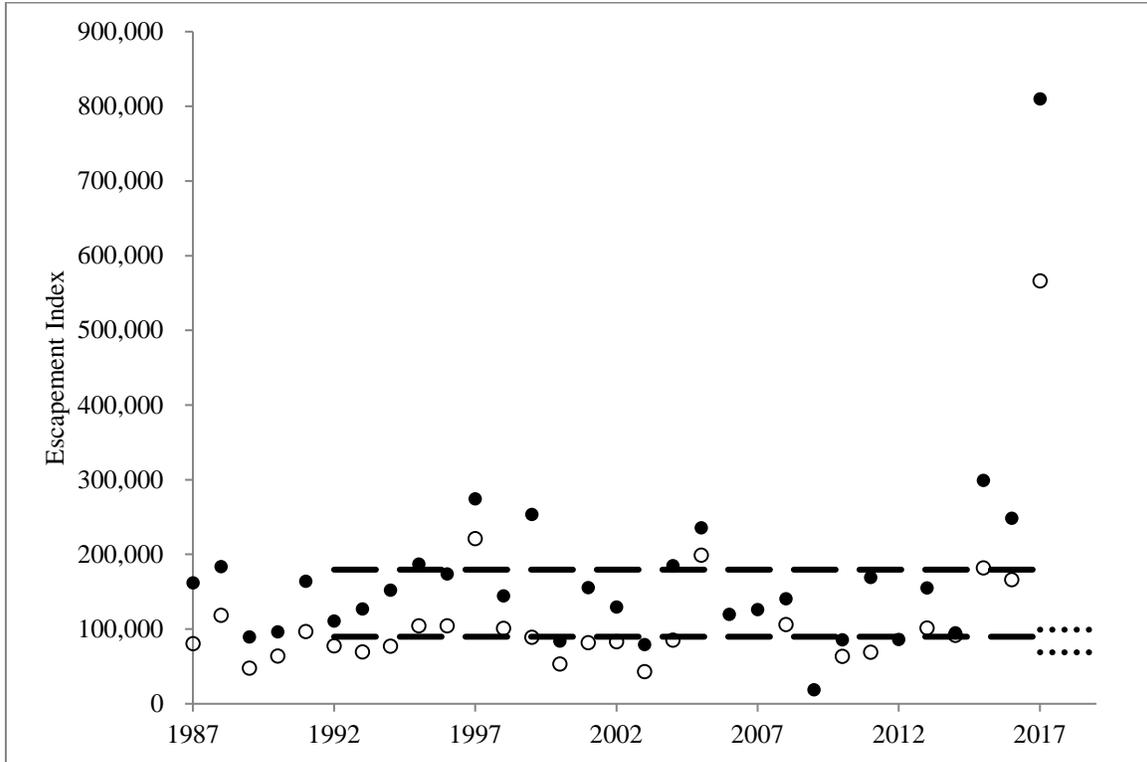
APPENDIX T. SUPPORTING INFORMATION FOR THE SOUTHWESTERN DISTRICT CHUM SALMON ESCAPEMENT GOAL

Appendix T1.–Description of stock and escapement goal for Southwestern District chum salmon.

System: Southwestern District.

Species: Chum salmon.

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine, and set and drift gillnet.
Current escapement goal:	SEG: 133,400 to 266,800 (1992).
Recommended escapement goal:	SEG: 86,900 to 159,500.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1960–present.
Data summary:	
Data quality	Fair.
Data type	Fixed-wing aerial surveys available from 1960 to 2017. Data used in analysis represents indicator streams and years with a complete survey dataset from 1987 to present. No stock-specific harvest information is available.
Data contrast:	Aerial surveys, 1987–2017: 7
Methodology:	3-tier Percentile Approach
Criteria for SEG:	Low contrast, moderate harvest (5th to 65th percentiles)
Comments	19 areawide systems were chosen to represent an indexed escapement goal:
	284-1211 Cannery Creek
	284-1212 Little John Lagoon S Spit
	284-1213 Little John Lagoon Stream
	284-2001 Sandy Cove Stream
	284-3201 Old Man's Lagoon Stream
	284-3305 Ram's Creek
	284-3402 Russel Creek
	284-3409 Barney's Creek
	284-3410 Delta Creek, Lenard Harbor
	284-4101 Belkofski Village Creek
	284-4207 Belkofski Bay River
	284-4209 Captain's Harbor
	284-5203 Little Bear Bay
	284-5205 Stream Guard Creek
	284-5206 West Spring Holes
	284-5207 Volcano Sloughs-Center
	284-5208 Volcano River
	284-6004 Ikatan River
	284-6006 Sankin Bay Creek

System: **Southwestern District.**

Species: **Chum salmon.**

Data available for analysis of escapement goal.

Year	All System PAS Index	District Index
1987	291,100	
1988	226,200	152,250
1989	120,830	47,380
1990	142,770	89,320
1991	241,600	
1992	141,000	86,900
1993	224,080	146,070
1994	365,900	212,700
1995	401,150	221,900
1996	302,100	210,500
1997	263,700	126,300
1998	351,410	169,710
1999	388,130	233,800
2000	257,225	144,525
2001	277,021	153,600
2002	268,000	137,000
2003	193,030	143,650
2004	180,000	118,100
2005	317,910	239,500
2006	231,935	
2007	398,010	314,210
2008	171,250	
2009	385,730	159,500
2010	142,650	
2011	176,425	
2012	87,230	
2013	163,200	
2014	130,745	
2015	351,150	
2016	220,060	146,200
2017	363,000	

System: **Southwestern District.**

Species: **Chum salmon.**

Observed escapement by year using the All PAS Index (solid circles) and revised District Index (open circles), and historical (dashed line) and recommended SEG (dotted line).
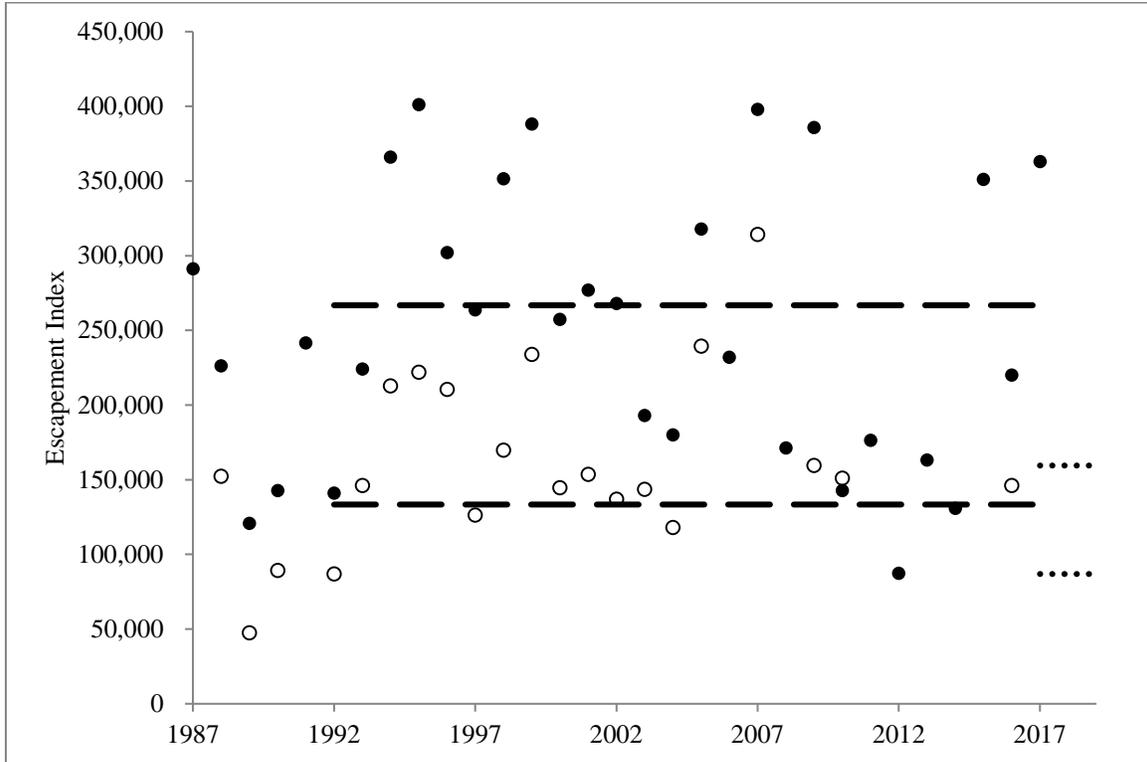
APPENDIX U. SUPPORTING INFORMATION FOR THE NORTHWESTERN DISTRICT CHUM SALMON ESCAPEMENT GOAL

Appendix U1.–Description of stock and escapement goal for Northwestern District chum salmon.

System: **Northwestern District.**

Species: **Chum salmon.**

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine, and set and drift gillnet.
Current escapement goal:	SEG: 100,000–215,000 (2007).
Recommended escapement goal:	No change.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1980 to present.
Data summary:	
Data quality	Fair.
Data type	Fixed-wing aerial surveys from 1980 to present. Indexed total escapement 1987 to present. No stock-specific harvest information is available.
Comments	Current SEG was based on spawner-recuit analysis.

Appendix U2.–Northwestern District chum salmon escapements.

System: **Northwestern District.**

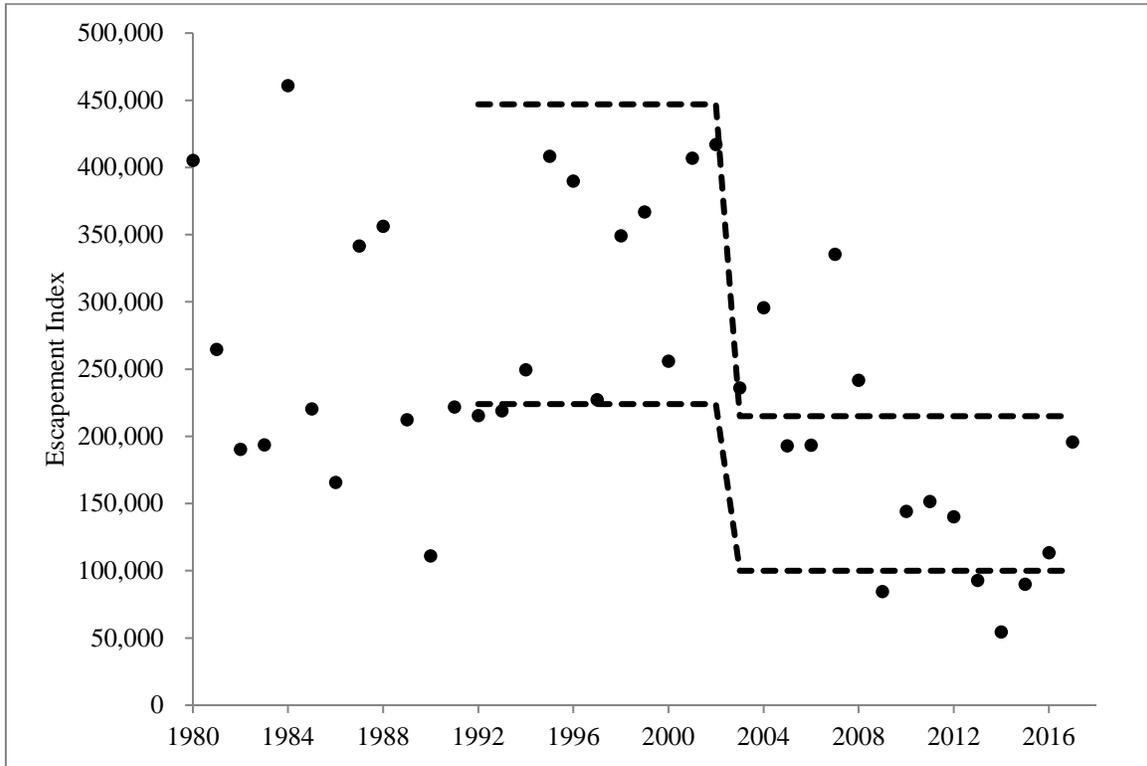**Species:** **Chum salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]
1980	405,300
1981	264,600
1982	190,200
1983	193,500
1984	460,900
1985	220,400
1986	165,700
1987	341,500
1988	356,200
1989	212,300
1990	110,905
1991	221,800
1992	215,300
1993	219,030
1994	249,420
1995	408,300
1996	389,730
1997	227,200
1998	349,000
1999	366,800
2000	255,800
2001	406,812
2002	417,100
2003	236,000
2004	295,600
2005	192,965
2006	193,460
2007	335,450
2008	241,750
2009	84,460
2010	144,100
2011	151,400
2012	140,000
2013	92,800
2014	54,525
2015	89,800
2016	113,250
2017	195,700

[a] The estimated total escapement represents the peak aerial survey, enumeration of carcasses, and ancillary and qualitative data.

System: **Northwestern District.**

Species: **Chum salmon.**

Observed escapement by year (solid circles) and historical SEGs (dashed line).

APPENDIX V. SUPPORTING INFORMATION FOR THE NORTHERN DISTRICT CHUM SALMON ESCAPEMENT GOAL

Appendix V1.–Description of stock and escapement goal for Northern District chum salmon.

System: Northern District.

Species: Chum salmon.

Description of stock and escapement goal.

Regulatory area:	Alaska Peninsula Management Area – Westward Region.
Management division:	Commercial Fisheries.
Primary fishery:	Commercial purse seine and set and drift gillnet.
Current escapement goal:	SEG: 119,600–239,200 (2007).
Recommended escapement goal:	No change.
Optimal escapement goal:	None.
Inriver goal:	None.
Action points:	None.
Escapement enumeration:	Aerial survey, 1982 to present.
Data summary:	
Data quality	Fair.
Data type	Fixed-wing aerial surveys from 1982 to present. Indexed total escapement 1987 to present. No stock-specific harvest information is available.
Comments	Current SEG was based on spawner-recuit analysis.

Appendix V2.–Northern District chum salmon escapements.

System: **Northern District.**

Species: **Chum salmon.**

Data available for analysis of escapement goal.

Year	Escapement Index [a]
1982	267,500
1983	199,100
1984	409,300
1985	123,900
1986	77,900
1987	161,400
1988	144,100
1989	102,300
1990	115,530
1991	81,450
1992	136,400
1993	183,350
1994	230,800
1995	347,700
1996	436,400
1997	160,985
1998	380,350
1999	299,475
2000	338,900
2001	285,900
2002	262,710
2003	214,660
2004	139,350
2005	103,675
2006	382,583
2007	243,334
2008	228,537
2009	154,131
2010	145,310
2011	96,952
2012	140,418
2013	137,251
2014	191,586
2015	189,194
2016	277,674
2017	234,440

[a] The estimated total escapement represents the peak aerial survey, enumeration of carcasses, and ancillary and qualitative data.

System: **Northern District.**

Species: **Chum salmon.**

Observed escapement by year (solid circles) and current SEG (dashed line).