Fishery Manuscript No. 05-05

Review of Salmon Escapement Goals in the Kodiak Management Area

by

Patricia A. Nelson,

Mark J. Witteveen,

Steve G. Honnold,

Ivan Vining,

and

James J. Hasbrouck

September 2005

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

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

FISHERY MANUSCRIPT NO. 05-05

REVIEW OF SALMON ESCAPEMENT GOALS IN THE KODIAK MANAGEMENT AREA

by

Patricia A. Nelson,
Mark J. Witteveen,
Steve G. Honnold,
Ivan Vining
Division of Commercial Fisheries, Kodiak
and
James J. Hasbrouck,
Division of Sport Fish, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1599

September 2005

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

Patricia A. Nelson,
Mark J. Witteveen,
Steve G. Honnold,
Ivan Vining,
Alaska Department of Fish and Game, Division of Commercial Fisheries,
211 Mission Road, Kodiak, AK 99615, USA
and
James J. Hasbrouck,
Alaska Department of Fish and Game, Division of Sport Fish
333 Raspberry Road, Anchorage, AK 99518, USA

This document should be cited as:
Nelson P. A., M. J. Witteveen, S. G. Honnold, I. Vining, and J. J. Hasbrouck. 2005. Review of salmon escapement goals in the Kodiak Management Area. Alaska Department of Fish and Game, Fishery Manuscript No. 05-05, Anchorage.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (CONTINUED)

Page

TABLE OF CONTENTS (CONTINUED)

Page

TABLE OF CONTENTS (CONTINUED)

Page

TABLE OF CONTENTS (CONTINUED)

Page

TABLE OF CONTENTS (CONTINUED)

Page

TABLE OF CONTENTS (CONTINUED)

Page

TABLE OF CONTENTS (CONTINUED)

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF APPENDICES (CONTINUED)

Appendix **Page**

LIST OF APPENDICES (CONTINUED)

Appendix **Page**

LIST OF APPENDICES (CONTINUED)

Appendix **Page**

LIST OF APPENDICES (CONTINUED)

Appendix **Page**

LIST OF APPENDICES (CONTINUED)

Appendix **Page**

LIST OF APPENDICES (CONTINUED)

Appendix **Page**

ABSTRACT

In June 2004, a salmon escapement goal interdivisional team, including staff from the Divisions of Commercial Fisheries and Sport Fish, was formed to review Pacific salmon *Oncorhynchus* spp. escapement goals in the Kodiak Management Area (KMA; Area K). This report is the result of the review, 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). This comprehensive review of the 46 existing salmon escapement goals in the KMA resulted in recommendations to leave 4 goals unchanged, change 21 goals, create 1 goal that would replace 6 goals, and eliminate 21 goals.

The team recommended that no changes in the current biological escapement goals (BEGs) were warranted for the 2 Chinook salmon *O. tshawytscha* systems in the KMA. Both the Karluk and Ayakulik Chinook BEGs were reevaluated in 2001 and additional data available for this review did not change the results significantly.

Following the evaluation of escapement goals for 15 sockeye salmon *O. nerka* stocks, the team recommended that 2 of these goals should remain unchanged. While there was not enough compelling evidence to change the current Buskin sockeye salmon sustainable escapement goal (SEG) at this time, the team recommended that assessment of this stock should continue, so that a BEG could potentially be developed in 3 years. The current Saltery Lake sockeye salmon BEG was established in 2001 and additional data available for this review did not change the results significantly.

The team recommended changing 10 sockeye salmon escapement goals. These changes included reducing the SEGs for Malina Lakes and Pauls Bay drainage sockeye salmon based on limnological models that indicated that the lake rearing capacity for both systems is less than the current escapement goals suggest. Based on a Ricker spawner-recruit analysis and the results of the zooplankton biomass assessment, the team also recommended reducing the current Afognak Lake SEG to a BEG of 20,000 to 50,000 fish. The team recommended reducing the current Karluk early- and late-run BEGs based on significant spawner-recruit relationships that indicated that the level of spawning escapement that will produce maximum sustained yield or S_{msy} can be achieved at escapements lower than the current goal ranges. The recommended change to the early-run goal was relatively minor (100,000 to 210,000 vs. 150,000 to 250,000); however, the team recommended a substantial decrease in the late-run goal (170,000 to 380,000 vs. 400,000 to 550,000). After considering all analyses, the team also recommended changing the current Ayakulik River escapement goal range to 200,000 - 500,000, which would increase the current upper goal but leave the lower goal unchanged. The spawner-recruit, yield analysis and zooplankton biomass analyses all suggested that an increase in the current Ayakulik SEG would increase the likelihood of maximizing yield.

The team recommended reducing the current Upper Station early-run sockeye SEG to 30,000 - 65,000 fish based on the escapement percentile approach. It should be noted that the Alaska Board of Fisheries (BOF) adopted an optimal escapement goal (OEG) of 25,000 for Upper Station early-run sockeye in 1999, which is still lower than the recommended SEG. The team also recommended changing the current Upper Station late-run sockeye SEG to a BEG of 120,000 to 265,000 fish based on a significant Ricker spawner-recruit relationship. Combining the recommended early- and late-run goals resulted in an overall goal of 150,000 - 330,000, which falls within the range of lake rearing capacity based on zooplankton biomass, corroborating the recommendation. The team recommended changing the current Frazer Lake BEG (140,000 to 200,000) to 70,000 - 150,000 fish based on a Ricker spawner-recruit relationship. This recommendation was corroborated by the estimates that were calculated from smolt biomass as a function of zooplankton biomass. The team recommended increasing the current sockeye SEG for Pasagshak (1,000 to 5,000) to 3,000 - 12,000. This recommendation was based on the percentile approach, which was corroborated by risk analysis.

The team recommended eliminating sockeye salmon escapement goals for 3 systems including Little River and Uganik and Akalura Lakes. This recommendation was based on the fact that reliable escapement estimates have not been consistently collected for these stocks and due to budget constraints, are not expected to be collected in the future. In addition, it is not possible to actively manage escapements specific to these systems.

A total of 16 coho salmon *O. kisutch* escapement goals (6 road systems and 10 remote systems) were evaluated during this review. The team made a recommendation to change the current Buskin River coho SEG to a BEG of 3,200 to 7,200 spawning fish. The number of spawning fish must take into account 20% of the sport harvest that occurs upstream of the weir. This recommendation was based primarily on the updated brood table and a Ricker spawner-recruit analysis, but was corroborated by a theoretical spawner-recruit relationship. The team recommended changing 3 road system coho escapement goals based on theoretical spawner-recruit analyses. The recommended coho salmon SEG for the American River was 400 to 900, for the Olds River 1,000 to 2,200, and for Pasagshak River 1,200 to 3,300. The team recommended that the coho SEGs for Roslyn and Saltery Creeks be eliminated because of a lack of consistent and/or validated escapement assessment. The team recommended eliminating all 10 remote system coho SEGs because reliable escapement estimates have not been consistently collected for these stocks and, due to budget constraints, are not expected in the future.

The team recommended replacing the current Afognak, Northwest Kodiak, Southwest Kodiak, Alitak Bay, Eastside Kodiak and Northeast Kodiak district-wide pink salmon SEGs (6 even- and odd-year SEGs) with 1 Kodiak Archipelago aggregate SEG of 2 million to 5 million pink salmon *O. gorbuscha* for both even- and odd-years. This recommendation was based on the projected yield for both even- and odd-year pink salmon using the conditional sustained yield analysis. Management objectives by district will be determined based on the relationship of escapement indices averaged across years. The team recommended changing the Mainland District pink salmon SEG to 250,000 - 750,000 for both even- and odd-years (changing 2 SEGs). This recommendation was based on the projected yield for both even- and odd-year pink salmon using the conditional sustained yield analysis and is similar to the current Mainland District even-year pink salmon SEG.

It was the recommendation of the team to change all 6 district-wide chum salmon *O. keta* SEGs based on the percentile approach and risk analyses. In each case the recommended goal is a single number representing the lower end of the SEG. In the case of chum salmon the team did not feel that they could develop a defensible upper end goal and did not feel that one was biologically necessary. The recommended chum salmon SEG for the Northwest Kodiak District was 53,000, for the Southwest Kodiak District 7,300, for the Alitak Bay District 28,000, for the Eastside Kodiak District 50,000, for the Northeast Kodiak District 9,000, and for the Mainland District 153,000.

Key words: Pacific salmon, *Oncorhynchus,* escapement goal, Kodiak, Area K, stock status.

INTRODUCTION

This report documents a review of the existing escapement goals for Kodiak Management Area (KMA) salmon stocks based on the Policy for the Management of Sustainable Salmon Fisheries (SSFP; 5 AAC 39.222) and the Policy for Statewide Salmon Escapement Goals (EGP; 5 AAC 39.223). The Alaska Board of Fisheries (BOF) adopted these policies into regulation in 2000 and 2001, respectively, to ensure that the state's salmon stocks would be conserved, managed and developed using the sustained yield principle.

Two important terms defined in the SSFP are:

> "*Biological escapement goal* (BEG): the escapement that provides the greatest potential for maximum sustained yield (MSY)" and,
>
> "S*ustainable 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 due to the absence of a stock-specific catch estimate."

A report documenting the established escapement goals for stocks of 5 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 were based on average escapement estimates and spawning habitat availability.

In June 2004, a salmon escapement goal interdivisional review team was formed to evaluate the existing KMA salmon escapement goals. The team included staff from the Division of Commercial Fisheries (CF) and Sport Fish Division (SF): Patricia Nelson (CF), Jim McCullough

(CF), Mark Witteveen (CF), Steve Honnold (CF), Steve Schrof (CF), Rob Baer (CF), Kevin Brennan (CF), Ivan Vining (CF), John H. Clark (CF), Doug Eggers (CF), Dave Bernard (SF), Jim Hasbrouck (SF), Bob Clark (SF), Dan Sharp (SF), Len Schwarz (SF), and Donn Tracy (SF).

The purpose of the team was to:

1. Determine the appropriate goal type (BEG or SEG) for each KMA salmon stock with an existing goal, based on the quality and quantity of available data.
2. Determine the most appropriate methods to evaluate the escapement goal ranges.
3. Estimate the escapement goal for each stock and compare these estimates with the current goal.
4. Determine if a goal could be developed for any stocks or stock-aggregates that currently have no goal.

   and,

5. Develop recommendations for each goal evaluated and present these recommendations to the Directors of Commercial Fisheries and Sport Fish Divisions for approval.

During the review process, escapement goals were evaluated for 2 Chinook, 15 sockeye, and 16 coho salmon stocks (Tables 1 and 2). In addition, 7 pink (even- and odd-year; Table 3) and 6 chum salmon stock-aggregate goal ranges (Table 2) were reviewed. Formal meetings via teleconference, to discuss and develop recommendations, were held on June 10, June 16, August 2, September 2, November 8, December 3 and December 6, 2004. The team also communicated on a regular basis by telephone and email.

STUDY AREA

The KMA comprises the waters of the western Gulf of Alaska surrounding the Kodiak Archipelago, and along that portion of the Alaska Peninsula that drains into Shelikof Strait between Cape Douglas and Kilokak Rocks (Figure 1).

The archipelago is approximately 150 miles long extending from Shuyak Island south to Tugidak Island. The Alaska Peninsula portion is about 160 miles long and is separated from the archipelago by Shelikof Strait, which averages 30 miles in width. Chirikof Island, located approximately 40 miles south southwest of Tugidak Island, is also included in the KMA.

Regulations define the KMA as:

> "All waters of Alaska south of a line extending from Cape Douglas (58° 51.10' N. lat.), west of 150° W. long., north of 55° 30.00' N. lat., and north and east of a line extending 135° southeast for 3 miles from a point near Kilokak Rocks at 57° 10.34' N. lat., 156° 20.22' W. long. (the longitude of the southern entrance of Imuya Bay), then due south" (5 AAC 18,100).

The KMA is divided into 7 commercial fishing districts: the Afognak, Northwest Kodiak, Southwest Kodiak, Alitak Bay, Eastside Kodiak, Northeast Kodiak, and Mainland Districts (Figure 1). These are further subdivided into a number of sections, each of which is composed of a number of smaller statistical areas, including terminal or special harvest areas for enhanced or rehabilitated salmon stocks. For commercial salmon fisheries, legal gear in various districts or sections can consist of purse seines, hand purse seines, beach seines, or set gillnets.

BACKGROUND

The majority of sockeye salmon and all Chinook salmon escapement counts are obtained through the use of fish weirs (Kuriscak and Bond *In prep*). Weirs are used on up to 15 different spawning systems. In the KMA, salmon escapement passing through fish weirs is hand tallied by species. Escapement gates within the weir are closed when Alaska Department of Fish and Game (ADF&G) personnel are not present to count. Escapement counts are transmitted daily from fish counting camps to the Kodiak ADF&G office. These data allow for precise stock-specific management. The remainder of the KMA sockeye salmon systems are monitored by aerial observation using small fixed-wing aircraft. Most pink and chum salmon estimates of escapement are collected from fixed-wing aircraft surveys of bays and streams. Aerial and foot survey counts are considered an index of the actual escapement, for use inseason to aid fishery management. A "peak indexed escapement" estimate is calculated postseason for all systems surveyed. A combination of weirs, aerial surveys and foot surveys are used to monitor coho salmon systems.

Escapement goals are currently established for 2 Chinook salmon systems in the KMA (Table 1; Nelson and Lloyd 2001). Chinook salmon escapement to both of these systems (Karluk and Ayakulik Rivers; Figure 2) is monitored by weirs established mainly to account for sockeye salmon escapement.

A total of 15 sockeye salmon stocks (13 systems) in the KMA have established escapement goals (Table 1; Nelson and Lloyd 2001). There are 3 of these systems located in the Afognak District, on Afognak Island (Figure 2). The remaining systems are located on Kodiak Island. There are 2 sockeye systems located in the Northwest Kodiak District, 2 are in the Southwest Kodiak District, 3 are found in the Alitak Bay District, 2 are located in the Eastside Kodiak District and 1 is in the Northeast Kodiak District (Table 1; Figure 3). The strength of 6 of these stocks, from 5 systems, affect daily management of associated fisheries and all currently have weirs for direct enumeration of escapement. There are 4 additional stocks, from 3 additional systems that also have weirs and are subject to less intensive management (direct management for shorter time or only in small areas adjacent to these systems).

There are established escapement goals for 16 coho salmon stocks (Table 2; Nelson and Lloyd 2001). There are 6 of these systems located along the Kodiak road system. Of these systems, 2 are located on Shuyak Island and 3 are on Afognak Island. The remaining systems are located on Kodiak Island, with 2 in the Southwest Kodiak District and 3 in the Alitak Bay District (Figure 2). Most systems' coho escapements are monitored by aerial and foot surveys. While 6 of these systems currently have weirs, coho salmon escapements continue until late in the year (often into November) after weirs have been removed and late season escapement surveys are limited by budget constraints.

Pink salmon in the KMA are managed as aggregates of streams by district. A total of 7 district-wide even- and odd-year pink salmon escapement goals have been established in the KMA (Table 3; Figure 2). The 7 district-wide goals comprise the respective sums of aerial survey escapement management objectives (MOs) for 47 individual index streams (Nelson and Lloyd 2001).

Similar to pink salmon in the KMA, chum salmon are managed as aggregates of streams by district. There are 6 district-wide (aggregate) escapement goals for chum salmon in the KMA

(Table 2; Figure 2). The Afognak District does not have a chum salmon escapement goal due to the low numbers of chum salmon in this district. The 6 district-wide goals comprise the respective sums of aerial survey escapement MOs for 52 individual index streams (Nelson and Lloyd 2001). Aerial survey counts of chum salmon for the KMA are considered minimum estimates of actual escapement.

METHODS

Available escapement, harvest, and age data associated with each stock or combination of stocks to be examined 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 according to criteria described in Bue and Hasbrouck (2001). This evaluation was used to initially determine the appropriate type of escapement goal to apply to each stock, as defined in the SSFP and EGP.

BIOLOGICAL ESCAPEMENT GOAL DETERMINATION

If sufficient time series of escapement and total return estimates were available, contrast in the escapement data (the ratio of the largest escapement to the smallest escapement) was sufficiently large (>4.0; CTC 1999), and estimates were sufficiently accurate and precise, then the data were considered sufficient to attempt to estimate the escapement level with the greatest potential to provide maximum sustained yeild (MSY). This level of spawning escapement is identified as S_{msy} (Hilborn and Walters 1992; CTC 1999; Quinn and Deriso 1999). Spawner-return data were analyzed using a mathematical stock recruitment model to estimate MSY, and the BEG range surrounding S_{msy}.

Spawner-return data were analyzed using a Ricker (1954) stock-recruitment model to estimate S_{msy} and the BEG range surrounding S_{msy}. Results were not used if the model fit the data poorly or if model assumptions were violated. Hilborn and Walters (1992), Quinn and Deriso (1999), and the Chinook Technical Committee (CTC 1999) provide good descriptions of the Ricker model and diagnostics to assess model fit. All Ricker models were tested and corrected for residual autocorrelation when necessary. In a few instances, a gamma spawner-recruit model (Reish et al. 1985) was fitted to available spawner-return data and similar model diagnostics were performed.

Additional methods used to evaluate BEGs included conditional sustained yield analysis, a tabular yield per recruit approach (Hilborn and Walters 1992), and a habitat based model. When auxiliary data were available (e.g., light penetration, zooplankton, smolt abundance) additional limnological analyses were performed and compared to estimates of smolt and adult production. In cases where sufficient data existed but determining a scientifically defensible BEG was still not possible, other methods were used to establish an SEG.

SUSTAINABLE ESCAPEMENT GOAL DETERMINATION

If total return estimates were not available because harvest and/or age were not consistently measured, then the data were considered of fair to poor quality. These data would not provide an accurate estimate of S_{msy} and subsequent BEG. As a result, these data were evaluated using other methods to establish an SEG. Methods used to develop SEGs included the percentile approach, risk analysis, limnological models, a spawning habitat model, evaluation of smolt produced per adult spawner, and theoretical spawner-recruit analysis.

The percentile approach followed the methods of Bue and Hasbrouck (2001) whereby the contrast of the escapement data and the exploitation rate of the stock were used to select the percentiles of observed annual escapements to be used for estimating the SEG. Low contrast (<4) implies that stock productivity is known for only a limited range of escapements. According to this approach, percentiles of the total range of observed annual escapements that are used to estimate an SEG for a stock with low contrast should be relatively wide, in an attempt to improve future knowledge of stock productivity. In cases where data contrast was less than 4 and the exploitation rate was low, the lower end of the SEG range was the 15th percentile of the escapement data and the upper end of the range was the maximum escapement estimate. Alternately, in cases where contrast was larger, the percentiles of observed annual escapements used to estimate an SEG were narrowed. For stocks with high contrast and at least moderate exploitation, the lower end of the SEG range was increased from the 15th to the 25th percentile as a precautionary measure for stock protection.

The risk analysis method (Bernard et al. *In prep*) was used to establish an SEG, in the form of a precautionary reference point (PRP), from a time series of observed escapement estimates using probability distributions. This method is based on estimating the risk of management error and is particularly appropriate in situations where a particular stock (or stock aggregate) is not "targeted" and observed escapement estimates are the only reliable data available. In essence, this analysis begins with estimating the probability of detecting escapement falling below the SEG in a predetermined number of consecutive years (k). For example, if we believe there is cause for concern when escapement falls below the SEG for 3 consecutive years, k would be equal to 3. Simultaneously, a second probability is estimated, that is the probability of taking action (e.g., closing a fishery to protect the stock) for 3 consecutive years when no action was needed. This analysis assumes that escapement observations follow a lognormal distribution and have a stationary mean (no temporal trend).

There were 2 limnological models used in this escapement goal review to corroborate spawner-recruit and stock-recruitment yield analyses, and to estimate SEGs. The euphotic volume (EV) model estimated adult escapement in part by determining the volume of lake water capable of primary production, which could sustain a rearing juvenile fish population (Koenings and Burkett 1987). The EV indicated a level of phytoplankton forage (primary production) available to zooplankton, and thus a level of zooplankton forage available for rearing juvenile fish. It was inferred from the model that shallower light penetration would also result in lower adult production compared to lakes with deeper light penetration because the shallower lakes would not have the primary production necessary to sustain a larger rearing population. The EV model assumed that the lake was deep enough to achieve 1% light penetration in the water column. Rearing capacity is reached when nursery lakes produce threshold-sized smolt (about 60 mm or 2-g). Sockeye salmon life-stage survivals at a lake's rearing limitation based on euphotic volume (per EV unit) include 800-900 adult escapement, 110,000 spring fry, 33,000 fall fry, 23,000 threshold-sized smolt, and 2,500 total adults produced (35% escapement and 65% harvested). Survival rates and densities were determined from multiyear measurements at over a dozen nursery lakes; spring fry-to-smolt survival averaged 21%, mean smolt-to-adult survival was 12%, and harvest rates were about 65% for escapement of about 900 adults per EV unit.

The second limnological model (i.e., zooplankton model), estimated smolt production based on the amount of available zooplankton biomass fed upon by smolt of a targeted threshold-size, in a lake of known area (Koenings and Kyle 1997). The zooplankton model, like the EV model, relied upon the premise that the availability of forage to juvenile fish could impact their survival and subsequently, adult production. The zooplankton model further assumed that zooplankton were the only available forage. Adult production was calculated using marine survival rates applied to a range of smolt sizes. A marine survival rate of 12% was used for threshold-sized (2.0-g) smolt and a marine survival rate of 21% was used for optimum-sized (5.0 g) smolt. For systems where smolt size and abundance data were available, average smolt sizes and known marine survivals were used. Depending on the average size of smolt, marine survival rates within the range of 12% or 21% were used for systems without known marine survival rates.

Additional models used to estimate SEGs included a spawning habitat model, which considered the amount of available salmon spawning habitat to estimate the spawning capacity of the drainage (Burgner et al. 1969). When smolt outmigration estimates were available, the numbers of smolt produced per spawner were evaluated to determine average escapement levels that would likely result in the largest level of smolt production.

CHINOOK SALMON

Annual Chinook salmon escapements for both Karluk and Ayakulik Rivers were estimated by subtracting the estimates of recreational and subsistence harvest from the inriver run. The inriver run was counted at a weir on both systems (Schwarz et al. 2002, Tracy et al. *In prep*). At the Karluk River, weir counts were available from 1976 to 2003. Although weir counts at the Ayakulik River were available for the period from 1972 to 2003, data from 1972 to 1976 were excluded because these counts likely did not represent the entire run of Chinook salmon in those years. Counts for 1980 and 1982 were expanded based on average run timing to the weir to account for days the weir was not operational.

Inriver recreational harvest was estimated beginning in 1982 for Karluk River and 1983 for Ayakulik River, through 2003 (Mills 1983-1994; Howe et al. 1995 and 1996; Howe et al. 2001a-d; Walker et al. 2003; Jennings et al. 2004, *In prep*a, b). Subsistence harvest was estimated from permit returns. Because most of the recreational and subsistence harvest occurs upstream of each weir (Schwarz 1996, Motis 1997, Clapsadl 2002, Tracy et al. *In prep*), these harvests were subtracted from the inriver run to estimate escapement of each system for each year. No estimates of recreational harvest were available for earlier years. There were no responses to the Statewide Harvest Survey of anglers who fished either system during these years, so the recreational harvest was assumed to be zero during these years (i.e., 1976 to 1981 for the Karluk River and 1977 to 1982 for the Ayakulik River).

Commercial harvests were obtained from the Division of Commercial Fisheries Westward Region Fish Ticket database (Schwarz 1996, Motis 1997, Clapsadl 2002, Tracy et al. *In prep*). Because stock-specific harvests by the commercial fishery were not estimated, the total commercial harvests of Chinook salmon harvested in the Inner (255-10) and Outer (255-20) Karluk statistical areas from June 1 through July 15 were assumed to be Karluk River fish. Similarly, all Chinook salmon in the Inner (256-15) and Outer (256-20) Ayakulik statistical areas from June 1 through July 15 were assumed to be Ayakulik River fish. Harvests from these statistical areas were used because they are closest to the respective river mouth, and from June 1 through July 15 because this time period is similar to the run timing of these Chinook salmon stocks to the weir.

Scales were collected from fish sampled at each respective weir to estimate age composition of the run (Schwarz 1996, Motis 1997, Clapsadl 2002, Tracy et al. *In prep*). Age composition of the commercial harvest was assumed the same as that observed at the weir. This assumption is probably valid given that the commercial fishery is restricted to seine gear and likely not selective relative to the size and age of Chinook salmon. Age composition data were only available from 1993 to 2003. Age composition of run years prior to 1993 were estimated using the average age composition of the runs from 1993 to 2003.

A brood table was constructed from the runs by year and the age composition of these runs. Total run by age was estimated by multiplying total run and the age composition of Chinook salmon sampled at the weir. Age-specific returns were summed for each brood year to estimate total return by brood year. Return-per-spawner was then estimated as the total return of each brood year divided by the escapement for that brood year.

Spawner-Recruit Analysis

These data were considered sufficient to estimate MSY (Hilborn and Walters 1992; CTC 1999; Quinn and Deriso 1999) and to develop a BEG. Spawner-return data were analyzed using a mathematical stock recruitment model (Ricker 1954) to estimate MSY and the BEG range. If the analyses indicated there was significant autocorrelation ($\alpha = 0.05$) among the residuals of the model, the methods of Noakes et al. (1987) and Pankratz (1991) were used to alleviate bias in the parameter estimates. The BEG range was estimated using 2 approaches. The first approach was to multiply S_{msy} by 0.8 and 1.6 as suggested by Eggers (1993) who showed that in general this range of escapements produces average yields that are 90%-100% of MSY. The second approach used parameter estimates from the Ricker model directly to estimate the 2 spawning escapements that would produce 90% of MSY.

Habitat-Based Model

Productivity of these 2 Chinook salmon stocks was estimated from a meta-analysis developed by Parken (*unpublished*). Parken compared and related estimates of carrying capacity (S_{eq}) and S_{msy} for 13 stream-type (age 1. and older smolt) and 12 ocean-type (age 0. smolt) Chinook salmon stocks along the North Pacific coast, including stocks from interior and southeast Alaska. The premise behind the meta-analysis is that physically larger drainages that contain Chinook salmon also tend to have proportionally larger populations than smaller drainages that contain Chinook salmon. The relationship between S_{eq} and watershed area was found to fit an allometric power (log-log) model very well, with R^2 values of 0.83 for ocean-type and 0.87 for stream-type Chinook with watersheds ranging from approximately 90 km^2 (King Salmon River in southeast Alaska) to over 130,000 km^2 (a portion of the Columbia River drainage). Similarly, the relationship between S_{msy} and watershed area fit an allometric power model equally well (R^2 = 0.82 for ocean-type and 0.88 for stream-type stocks). Both Chinook salmon stocks likely have a stream-type life history so the relation developed for stream-type stocks was utilized in the analysis. From Parken (*unpublished*), the relationship between watershed area and S_{eq} for the 13 stream-type stocks of Chinook salmon is:

$$\ln\left(S_{eq}\right) = 0.684 \cdot \ln\left(watershed\ area\right) + 3.90 \qquad (1)$$

The relationship for S_{msy} is:

$$\ln\left(S_{msy}\right) = 0.698 \cdot \ln(watershed\ area) + 2.81 \qquad (2)$$

Estimates of S_{eq} and S_{msy} were calculated from equations 1 and 2 using the watershed area of each respective system in square km.

SOCKEYE SALMON

Malina Lakes

Malina Lakes are located on the southwest end of Afognak Island and support a small sockeye salmon run (Kyle and Honnold 1991; Schrof and Honnold 2003). A rehabilitation project began in 1991 at Malina Lakes to increase the natural production of sockeye salmon into the system. The lakes were fertilized from 1991 to 2001 (lower lake from 1996-2001) and were stocked with indigenous juvenile sockeye fry from 1992 to 1999 (Schrof and Honnold 2003).

The first published escapement goal for Malina Lakes was developed in 1988 and was set at 5,000 to 10,000 sockeye salmon based upon historical aerial survey indexed escapements and to a lesser extent cursory spawning habitat evaluations (Nelson and Lloyd 2001). The current Malina Lakes SEG of 10,000 to 20,000 was established in 1992 and was based upon further limnological studies and rehabilitation investigations (Kyle and Honnold 1991). Sockeye salmon escapements to Malina Lakes were enumerated by aerial and weir counts. Aerial counts were available from 1968 though 1991 and in 2003. Weir data were obtained from 1992 to 2002.

Stock-specific harvest estimates were not available for the Malina Lakes sockeye salmon fisheries.

Percentile Approach

The percentile approach (Bue and Hasbrouck 2001) was used as one alternative to evaluate the Malina Lakes sockeye salmon SEG. Selection of the percentiles used in the calculation were based on escapement contrast and fishery exploitation of the stock (Bue and Hasbrouck 2001). There were 3 different sets of escapement data analyzed: 1) weir and aerial survey data from 1968 to 2003, 2) weir data from 1992 to 2002, and 3) aerial data from 1968 to 2003. These alternatives were selected due the assumption that weir counts were more accurate than aerial survey estimates.

Euphotic Volume Model

Light penetration data were collected from Malina Lakes monthly from May through September from 1989 to 2003. These data were used to calculate the Euphotic Zone Depth (EZD) of the lake (Kirk 1994). The EV of Malina Lakes was calculated using the EZD of 11.3 m and the surface area of 1.2 km^2 for the upper lake (Koenings and Kyle 1997). For the lower lake, the surface area of 0.7 km^2 was used along with the mean depth of 6.9 m. The mean depth was used in this case because the EZD exceeded the maximum depth on most occasions. The number of adult sockeye salmon that the lakes can support was generated from the EV model (EV units multiplied by 800-900 escapement per EV unit).

Zooplankton Based Model

The mean zooplankton biomass in Malina Lakes was estimated from samples collected from the lakes seasonally (May through September). Samples were collected at Upper Malina Lake from 1989 to 2004 and at Lower Malina Lake from 1989 to 2003. Samples collected when the lakes were not fertilized in 1989, 1990, and 2002 to 2004 for Upper Malina Lake and from Lower Malina Lake from 1989 to 1995, 2002, and 2003 were used for the analysis. The lakes are not expected to be fertilized in the future, so these samples are more representative of the zooplankton biomass trends expected in upcoming years. The mean zooplankton biomass of the upper (66.5 mg m^2) and lower (17.9 mg m^2) lakes was applied to the zooplankton biomass model independently to predict the number of smolt each lake can support (Koenings and Kyle 1997).

The model predicts the number of 5.0-g optimum sized smolt and the number of 2.0-g threshold-sized smolt that the zooplankton biomass can sustain. The average size (2.9-g) of smolt that emigrated from Malina Lake from 1991 though 1995 and 2001 and 2002 was also applied to the model to predict a third level of smolt production. Smolt emigrating from 1996 to 2000 were larger than average as a result of previous year releases of presmolt (>5.0-g) and were not included in the calculation of average size. Adult production was predicted from these smolt production estimates using smolt-to-adult survivals of 12% for threshold and 21% for optimum and 12% for average size smolt (Koenings and Edmundson 1991; Koenings and Kyle 1997). Escapement was assumed to be 35% of adult production (Koenings and Kyle 1997). Production calculations from each lake were summed to provide an overall estimate of escapement for the Malina Lakes.

Spawning Habitat Model

Kyle and Honnold (1991) reported that the Malina Lake drainage had 20,876 m^2 of available salmon spawning habitat. An optimal sockeye salmon spawning density of one female per 2.0 m^2 (Burgner et al. 1969) was used to estimate the spawning capacity of the drainage. The ratio of females to males was assumed to be 1:1.

Pauls Bay Drainage

The Pauls Bay drainage (includes Pauls, Laura and Gretchen Lakes) is located on the north end of Afognak Island and supports a small sockeye salmon run (Honnold and Edmundson 1993; Schrof and Honnold 2003; Wadle 2004). Prior to the early-1950s, sockeye salmon escapement was limited to a few hundred fish due to natural waterfall barriers (Honnold and Edmundson 1993). Fishways were installed and sockeye salmon eggs were planted in an upstream tributary (Gretchen Creek) in the early-1950s to create a self-sustaining sockeye salmon run, which was established throughout the Pauls Bay drainage by the late-1950s. Concerns over declining sockeye production in the 1980s prompted a rehabilitation effort in the Pauls Bay drainage, which included fertilizing Laura Lake from 1993 to 2001 and stocking indigenous juvenile sockeye in the lake from 1994 to 1996 and 1999 (Schrof and Honnold 2003). The run returns from late-May until mid-to-late July.

The current SEG of 20,000 to 40,000 for the Pauls Bay drainage was established in 1988 and was founded upon historical escapements, which produced larger than average runs, and to a lesser extent on cursory spawning habitat evaluations (Nelson and Lloyd 2001). Sockeye salmon escapements to the Pauls Bay drainage were enumerated by tributary surveys from 1969 to 1977 and weir counts from 1978 to 2004.

Stock-specific harvest estimates were not available for the Pauls Bay drainage sockeye salmon run.

Percentile Approach

The percentile approach (Bue and Hasbrouck 2001) was used as one alternative to evaluate the Pauls Bay drainage sockeye salmon SEG. Selection of the percentiles used in the calculation were based on escapement contrast and fishery exploitation of the stock (Bue and Hasbrouck 2001). There were 4 different sets of escapement data analyzed: 1) weir and tributary survey data from 1969 to 2003, 2) weir data from 1978 to 2003, 3) tributary data from 1969 to 1977, and 4) weir data from 1978 to 1995, which excluded years of fertilization and stocking effects. These alternatives were selected due to the assumption that weir counts were more accurate than tributary survey estimates and that fertilization and stocking effects would influence escapements.

Euphotic Volume Model

Light penetration data were collected from Laura Lake monthly (from May through September) from 1990 to 2003 and from Pauls Lake in 1994. These data were used to calculate the EZD of the lakes (Kirk 1994). The EV of Laura Lake was calculated using the EZD of 7.8 m and the surface area of 4.2 km^2 while the EV of Pauls Lake was calculated using EZD of 9.8 m and the surface area of 0.6 km^2 (Koenings and Kyle 1997). The number of adult sockeye salmon that the lakes can support was generated from the EV model (EV units multiplied by 800-900 escapement per EV unit).

Zooplankton Based Model

The mean zooplankton biomass in Laura Lake was estimated from samples collected from the lake seasonally (May through September) from 1990 to 1992, 2002 and 2003 (years when the lake was not fertilized). Non-fertilized years were selected for the analysis to better represent future productivity, as there are no plans to resume lake enrichment. The mean zooplankton biomass of the lake (138 mg m^2) was applied to the zooplankton biomass model to predict the number of smolt the lake can support (Koenings and Kyle 1997). The model predicts the number of 5.0-g optimum sized smolt and the number of 2.0-g threshold-sized smolt that the zooplankton biomass can sustain. The average size (4.3-g) of smolt that emigrated from Pauls Bay drainage from 1994 to 2003 (excluding 1997 and 2000 when large sized stocked smolt would have emigrated) was also applied to the model to predict a third level of smolt production. Adult production was predicted from these smolt production estimates using smolt-to-adult survivals of 12% for threshold and 21% for optimum and average size smolt (Koenings and Edmundson 1991; Koenings and Kyle 1997). Escapement was assumed to be 35% of adult production (Koenings and Kyle 1997).

Spawning Habitat Model

Honnold and Edmundson (1993) reported that the Pauls Bay drainage had 26,452 m^2 of available salmon spawning habitat. An optimal sockeye salmon spawning density of one female per 2.0 m^2 (Burgner et al. 1969) was used to estimate the spawning capacity of the drainage. The ratio of females to males was assumed to be 1:1.

Afognak Lake

Afognak Lake is located on the southeast side of Afognak Island and has supported one of the largest sockeye salmon runs on the island (Schrof and Honnold 2003; Figure 2). The run returns from late-May until mid-to-late July.

The current SEG for Afognak Lake, 40,000 to 60,000, was established in 1988 based on review of escapements and subsequent returns (Nelson and Lloyd 2001). The goal was designed to manage escapement through the Afognak River weir, which is located 27 m upstream of the Afognak River and Afognak Bay confluence. Sockeye salmon escapements to Afognak Lake were enumerated by weir counts and aerial surveys. These data were available from 1921 to 1933 and 1966 to 2004.

Stock-specific harvest estimates for the Afognak Lake sockeye salmon fisheries from 1978 to 2004 were obtained by statistical area from the ADF&G's Division of Commercial Fisheries fish ticket database. It was assumed that the majority of Afognak Lake sockeye salmon were harvested in Afognak Bay (statistical area 252-34).

Due to poor escapements and smolt production in the 1980s, Afognak Lake was fertilized from 1990 to 2000 (Schrof and Honnold 2003). The lake was also stocked with indigenous juvenile sockeye salmon in 1992, 1994, and from 1996 to 1998.

Spawner-Recruit Analysis

Spawner-return data were analyzed using Ricker (Ricker 1954) and gamma (Reish et al. 1985) spawner-recruit models to estimate the escapement level with the greatest potential to provide MSY. This level of spawning escapement is identified as S_{msy} (Hilborn and Walters 1992; CTC 1999; Quinn and Deriso 1999). S_{msy} and the BEG range surrounding S_{msy} were estimated by fitting the models to the available time series of escapement and total return data if contrast in the escapement data (the ratio of the largest escapement to the smallest escapement) was large enough (>4.0; CTC 1999) and if estimates were considered accurate and precise. Hilborn and Walters (1992), Quinn and Deriso (1999), and the Chinook Technical Committee (1999) describe in detail the Ricker model and diagnostics to assess model fit. Quinn and Deriso (1999) describe the gamma model and diagnostics to assess model fit. Akaike Information Criteria (AIC, Burnham and Anderson 1985) was also used to assess the best model when both a Ricker and gamma model were significant. All models were tested and corrected for residual autocorrelation, when necessary.

Percentile Approach

The percentile approach (Bue and Hasbrouck 2001) was also used to evaluate the Afognak Lake sockeye salmon SEG. Selection of the percentiles used in the calculation were based on escapement contrast and fishery exploitation of the stock (Bue and Hasbrouck 2001). Four different sets of escapement data were analyzed: 1) all available data from 1921 to 1933, 1966 to 2004, 2) all weir data from 1921 to 1933, 1978 to 2004, 3) recent weir data from 1978 to 2004, and 4) recent weir data from non-fertilized years, 1978 to 1993. The second alternative was selected due to the perceived bias of non-weir data. The third and fourth alternatives were selected because the recent weir data were more reliable and to differentiate the affects of lake fertilization (fourth alternative).

Euphotic Volume Model

Light penetration data were collected from Afognak Lake monthly from May through September from 1987 to 2003 (Schrof et al. 2000; Schrof and Honnold 2003). These data were used to calculate the EZD of the lake (Kirk 1994). The EV of Afognak Lake was calculated using the EZD (9.3 m) and the surface area (5.3 km^2) of the lake (Koenings and Kyle 1997). The number of adult sockeye salmon the lake can support was generated from the EV model (EV units multiplied by 800-900 escapement per EV unit).

Zooplankton Based Model

The mean zooplankton biomass in Afognak Lake was estimated from samples collected from the lake seasonally (May through September) from 1987 to 2004 (Schrof et al. 2000; Schrof and Honnold 2003). The mean zooplankton biomass (264 mg m^2) was applied to the zooplankton biomass model to predict the number of smolt the lake can support (Koenings and Kyle 1997). The model predicts the number of 5.0-g optimum sized smolt and the number of 2.0-g threshold-sized smolt that the zooplankton biomass can sustain. The average size (3.5-g) of smolt that emigrated from Afognak Lake from 1987 to 2003 (excluding 2001 and 2002 when few smolt were sampled for size) was also applied to the model to predict a third level of smolt production. Adult production was predicted from these smolt production estimates using smolt-to-adult survivals of 12% for threshold, 21% for optimum, and 16.5% for average size smolt (Koenings and Edmundson 1991; Koenings and Kyle 1997). Escapement was assumed to be 35% of adult production (Koenings and Kyle 1997). In addition, the mean zooplankton biomass (153 mg m^2) during the same period excluding years of fertilization (1990 to 2000) was applied to the zooplankton biomass model as described above to estimate adult production and escapement.

Little River

Little River sockeye salmon escapements were enumerated through the use of a weir from 2001 to 2003 and aerial surveys from 1975 to 2000, and 2004. Analyses were done using all data (weir counts and aerial surveys) and on just aerial surveys.

Risk Analysis

Each set of data were first log-transformed and tested for normality using a one-sample Kolmogorov-Smirnov test (Conover 1980) to determine whether escapement estimates followed a lognormal distribution (P>0.15). The log-transformed escapement time series were then tested for serial correlation using diagnostics in Chatfield (1984).

Based on the results, escapements were modeled as lognormally distributed variables. The number of consecutive years where escapement levels below the SEG would cause a concern (PRP) was set at 3, the number of years between each regularly scheduled BOF meeting. Risk of an unwarranted restriction due to a management concern (π_k) was estimated directly from the log-transformed mean (μ), standard deviation (σ), and number of consecutive years to warrant a concern (k = 3) for various values of an SEG (X) as per Bernard et al. (*In prep*):

$$\hat{\pi}_k = \left\{pr\left[(N : \hat{\mu}, \hat{\sigma}^2) \leq \ln X\right]\right\}^k \tag{3}$$

The risk of detecting a drop in mean escapement was estimated in the same way as risk of an unwarranted restriction, except that the risk of not detecting ($1-\hat{\pi}_k$) was estimated and the mean escapement ($\hat{\mu}$) was changed by the desired percentage drop (Δ) in the mean to be detected with the SEG:

$$1-\hat{\pi}_k = \left\{pr\left[(N : \hat{\mu}+\Delta, \hat{\sigma}^2) \leq \ln X\right]\right\}^k \tag{4}$$

The desired percentage drop in the mean to be detected was estimated as the observed percent difference between the mean escapement and the minimum escapement greater than zero.

Percentile Approach

For purposes of comparison, the percentile approach (Bue and Hasbrouck 2001) was used. Selection of the percentiles used in the calculation were based on escapement contrast and fishery exploitation of the stock (Bue and Hasbrouck 2001).

Uganik Lake

Uganik Lake is a deep, glacially fed system on the west side of Kodiak Island and is a moderate producer of sockeye salmon (Booth 1993). Uganik River flows from the lake approximately

6.5 km into the East Arm of Uganik Bay. The majority of the sockeye salmon run enters Uganik Lake between June and July (Barrett and Nelson 1994).

The current Uganik Lake sockeye salmon SEG of 40,000 to 60,000 fish was implemented in the late-1980s and based mainly upon historical aerial survey indexed total escapement that produced larger than average runs (Nelson and Lloyd 2001). Sockeye salmon escapements from Uganik Lake were estimated via fixed-wing aerial surveys. These data were available from 1974 to 2003 (excluding 1975 and 1978). Escapement was enumerated with a weir operating from 1928 to 1932 and 1990 to 1992, although with variable seasonal timeframes.

Percentile Approach

The percentile approach (Bue and Hasbrouck 2001) was used as one alternative to evaluate the Uganik Lake sockeye salmon SEG. Selection of the percentiles used in the calculation were based on escapement contrast and fishery exploitation of the stock (Bue and Hasbrouck 2001). There were 4 different sets of escapement data analyzed: 1) weir and aerial survey data from 1974 to 2003, 2) aerial survey data from 1974 to 1988, 3) weir and aerial survey data from 1989 to 2003, and 4) all weir data. These alternatives were selected due to a perceived difference in productivity prior to 1988.

Risk Analysis

There were 2 sets of data from Uganik Lake analyzed using risk analysis following equations (3) and (4): 1 with all data (peak aerial survey and weir counts), and 1 omitting years when a weir was in operation.

Euphotic Volume Model

Light penetration data were collected from Uganik Lake 4 times annually from May through October during 1990, 1991, and 1996 (Schrof et al. 2000). These data were used to calculate the EZD of the lake (Kirk 1994). The EV of Uganik Lake was calculated using the EZD (14.9 m) and the surface area (3.93 km^2) of the lake (Koenings and Kyle 1997). The number of adult sockeye salmon the lake can support was generated from the EV model (EV units multiplied by 800-900 escapement per EV unit).

Zooplankton Based Model

The mean zooplankton biomass in Uganik Lake was estimated from samples collected from the lake seasonally (May through September) during 1990, 1991, and 1996 (Schrof et al. 2000). The mean zooplankton biomass (138 mg m^2) was applied to the zooplankton biomass model to predict the number of smolt the lake can support (Koenings and Kyle 1997). The model predicts the number of 5.0-g optimum sized smolt and the number of 2.0-g threshold-sized smolt that the zooplankton biomass can sustain. Adult production was predicted from these smolt production estimates using smolt-to-adult survivals of 12% for threshold and 21% for optimum size smolt (Koenings and Edmundson 1991; Koenings and Kyle 1997). Escapement was assumed to be 35% of adult production (Koenings and Kyle 1997).

Karluk Lake

Karluk Lake is located on the west side of Kodiak Island and supports the largest sockeye salmon run in the KMA (Wadle 2004). There are 2 temporally distinct sockeye salmon runs that utilize Karluk Lake (Barrett and Nelson 1994). The early run returns from late-May until mid-July while the late run returns from mid-July through September.

The current sockeye salmon BEG for the Karluk early run is 150,000 to 200,000 while the BEG for the late run is 400,000 to 550,000. These BEGs were established in 1992 based on spawner-recruit curves (Nelson and Lloyd 2001).

Sockeye salmon escapements from Karluk Lake were enumerated by weir counts. These data were available from 1922 to 2004. Escapement assigned to the early run was estimated by including all counts prior to July 22 while escapement assigned to the late run was estimated by including all counts after July 21.

Stock-specific harvest estimates were available for the Karluk Lake sockeye salmon fisheries from 1985 to 2004. An age marker analysis was used to estimate harvest attributable to Karluk Lake (Barrett and Nelson 1994) from the Uyak Bay (254-10, 20, 30, 40), Uganik Bay (253-11, 12, 13, 14), Viekoda Bay (253-31, 32, 33, 35), and Inner (255-10) and Outer (255-20) Karluk and Sturgeon (256-40) Sections. Harvest attributable to the early run was estimated by including harvests prior to July 16 while harvest attributable to the late run was estimated by including harvests after July 15.

Rehabilitation efforts have occurred in recent years on Karluk Lake sockeye salmon. Karluk Lake was fertilized from 1986 to 1990 and sockeye salmon fry from Upper Thumb River, a Karluk Lake tributary, were backstocked into the Upper Thumb River from 1979 to 1987.

Spawner-Recruit Analysis

Spawner-recruit relationships were estimated for the early run, late run, and early and late runs combined. Spawning stock and recruitment data were analyzed using a Ricker spawner-recruit model (Ricker 1954) with a multiplicative error structure (Quinn and Deriso 1999). If a Ricker spawner-recruit model was significant, then S_{msy} was estimated along with the range of escapements that would produce 90% to 100% of MSY. Residuals were examined for autocorrelation, temporal trends, potential bias due to lake fertilization and stocking, and early versus late-run interactions.

Euphotic Volume Model

Light penetration data were collected from Karluk Lake 4 to 10 times annually from May through October during 1990 to 1996 (Schrof et al. 2000). These data were used to calculate the EZD of the lake (Kirk 1994). The EV of Karluk Lake was calculated using the EZD (21.3 m) and the surface area (39.4 km^2) of the lake (Koenings and Kyle 1997). The number of adult sockeye salmon the lake can support was generated from the EV model (EV units multiplied by 800-900 escapement per EV unit).

Zooplankton Based Model

The mean zooplankton biomass in Karluk Lake was estimated from samples collected from the lake seasonally (May through September) from 1981 to 2004 (Schrof et al. 2000). The mean zooplankton biomass (1,214 mg m^2) was applied to the zooplankton biomass model to predict the number of smolt the lake can support (Koenings and Kyle 1997). The model predicts the number of 5.0-g optimum sized smolt and the number of 2.0-g threshold-sized smolt that the zooplankton biomass can sustain. Adult production was predicted from these smolt production estimates using smolt-to-adult survivals of 12% for threshold and 21% for optimum size smolt (Koenings and Edmundson 1991; Koenings and Kyle 1997). Escapement was assumed to be 35% of adult production (Koenings and Kyle 1997).

An alternate escapement estimate was calculated using the predicted number of smolt and back calculating to the number of spawning adults necessary to produce the smolt (Honnold and Sagalkin 2001).

Ayakulik River

The Ayakulik River drainage is the second largest river system on Kodiak Island and drains approximately 500 km^2 of land on southwest Kodiak Island, including Red Lake. (Hander 1997). The Ayakulik River sockeye salmon run extends from late-May until mid-August. Escapement timing extends over a longer period than most single-run systems (Barrett and Nelson 1994).

The current sockeye salmon SEG for the Ayakulik River is 200,000 to 300,000 fish. This SEG was established in 1983 based on spawning habitat observations of different run segments, historical escapement numbers, and recommendation from previous fishery managers (Nelson and Lloyd 2001). Sockeye salmon escapements from Ayakulik River were enumerated by weir counts. These data were available intermittently from 1929 to 1961 and annually from 1962 to 2004.

Stock-specific harvest estimates were available for the Ayakulik sockeye salmon fisheries from 1970 to 2004. Portions of the Inner and Outer Ayakulik Sections (256-10 to 256-20) and the Halibut Bay Section (256-25 to 256-30) commercial sockeye salmon harvest are attributed to the Ayakulik River. In the absence of unique age markers in the escapement, allocation was done assuming historical proportions based on tagging and migration studies subject to run timing (Tyler et al. 1981).

Spawner-Recruit Analysis

Ricker and gamma spawner-recruit relationships were evaluated for Ayakulik River sockeye salmon (Ricker 1954; Quinn and Deriso 1999). If a spawner-recruit model was significant, then S_{msy} was estimated along with the range of escapements that would produce 90% to 100% of MSY. Residuals were examined for autocorrelation and temporal trends.

Stock-Recruitment Yield Analysis

A tabular approach was used to examine stock-recruitment yield relationships for the Ayakulik sockeye salmon run from 1966 to 1998. The analysis followed the Hilborn and Walters (1992) Markov model. Escapements and returns were arranged into intervals. The frequency that an escapement range produced a recruitment range, within given escapement and recruitment intervals, was calculated. The relative proportion of recruitment in each escapement interval was also calculated. Average surplus yield (estimated as the recruitment minus parental spawning escapement) within each escapement interval was also calculated. Different intervals were specified and compared, due to changes in categorical yield that corresponded with changes in interval specification.

Euphotic Volume Model

Light penetration data were collected from Red Lake from May through October from 1990 to 1996 (Schrof et al. 2000). These data were used to calculate the EZD of the lake (Kirk 1994). The EV of Red Lake was calculated using the EZD (17.8 m) and the surface area (8.4 km^2) of the lake (Koenings and Kyle 1997). The number of adult sockeye salmon the lake can support was generated from the EV model (EV units multiplied by 800-900 escapement per EV unit).

Zooplankton Based Model

The mean zooplankton biomass in Red Lake was estimated from samples collected from the lake seasonally (May through September) from 1990 to 1996 (Schrof et al. 2000). The mean zooplankton biomass (1,464 mg m^2) was applied to the zooplankton biomass model to predict the number of smolt the lake can support (Koenings and Kyle 1997). The model predicts the number of 5.0-g optimum sized smolt and the number of 2.0-g threshold-sized smolt that the zooplankton biomass can sustain. Adult production was predicted from these smolt production estimates using smolt-to-adult survivals of 12% for threshold and 21% for optimum and average size smolt (Koenings and Edmundson 1991; Koenings and Kyle 1997). In addition, the model was used to predict the number of smolt that the zooplankton biomass can sustain based on the average sized smolt sampled during a smolt project at Red Lake between 1990 and 1996 (8.7-g and 104 mm). Adult production was predicted from these smolt production estimates using smolt-to-adult survivals of 25-35%; smolt-to-adult survival was estimated from Koenings et al. (1993). Escapement was assumed to be 35% of adult production (Koenings and Kyle 1997).

Akalura Lake

Akalura Lake is located on the southwest side of Kodiak Island and supports a small sockeye salmon run (Wadle 2004). Although it has been reported that the lake supports 2 temporally distinct sockeye salmon runs, review of escapement timing curves from 1975 to 2001 indicated no substantial escapement before mid-July (Nelson and Lloyd 2001). While a few thousand fish may enter the system early in the season, the run typically returns from mid-July through September.

The current sockeye salmon SEG for Akalura Lake of 40,000 to 60,000 was established in 1988 based on historical escapements that produced larger than average runs and, to a lesser extent, spawning habitat evaluations (Nelson and Lloyd 2001). Sockeye salmon escapements to Akalura Lake were enumerated by weir counts for most years from 1923 to 1958 (data were not collected in 1943 and 1951). Escapement data were not collected from 1959 to 1966. Escapements were enumerated by weir counts from 1968 to 1972, 1974 to 1977, 1986 to 1997, and from 2000 to 2003. Peak aerial survey data were used to estimate escapements in 1967, 1978 to 1985, 1998 and 1999. Stock-specific harvest estimates were not available for the Akalura Lake sockeye salmon run.

Percentile Approach

The percentile approach (Bue and Hasbrouck 2001) was used as one alternative to evaluate the Akalura Lake sockeye salmon SEG. Selection of the percentiles used in the calculation were based on escapement contrast and fishery exploitation of the stock (Bue and Hasbrouck 2001). There were 4 different sets of escapement data analyzed: 1) weir and aerial survey data from 1923 to 2003, 2) weir and aerial survey data from 1970 to 2003, 3) weir data from 1923 to 2003, and 4) weir data from 1970 to 2003. These alternatives were selected due to a perceived difference in productivity prior to 1970 (higher) compared to post 1970 (lower) and also the assumption that weir counts were more accurate than aerial survey estimates.

Euphotic Volume Model

Light penetration data were collected from Akalura Lake monthly from May through September from 1990 to 1996 (Schrof et al. 2000). These data were used to calculate the EZD of the lake (Kirk 1994). The EV of Akalura Lake was calculated using the EZD (10.3 m) and the surface area (4.9 km^2) of the lake (Koenings and Kyle 1997). The number of adult sockeye salmon the lake can support was generated from the EV model (EV units multiplied by 800-900 escapement per EV unit).

Zooplankton Based Model

The mean zooplankton biomass in Akalura Lake was estimated from samples collected from the lake seasonally (May through September) from 1987 to 1996 (Schrof et al. 2000). The mean zooplankton biomass (330 mg m^2) was applied to the zooplankton biomass model to predict the number of smolt the lake can support (Koenings and Kyle 1997). The model predicts the number of 5.0-g optimum sized smolt and the number of 2.0-g threshold-sized smolt that the zooplankton biomass can sustain. The average size (4.7-g) of smolt that emigrated from Akalura Lake from 1990 to 1997 was also applied to the model to predict a third level of smolt production. Adult production was predicted from these smolt production estimates using smolt-to-adult survivals of 12% for threshold, and 21% for optimum and average size smolt (Koenings and Edmundson 1991; Koenings and Kyle 1997). Escapement was assumed to be 35% of adult production (Koenings and Kyle 1997).

Spawning Habitat Model

Edmundson et al. (1994) reported that the Akalura Lake system had 87,015 m^2 of available salmon spawning habitat. An optimal sockeye salmon spawning density of one female per 2.0 m^2 (Burgner et al. 1969) was used to estimate the spawning capacity of the lake. The ratio of females to males was assumed to be 1:1.

Smolt-per-Spawner

The numbers of sockeye salmon smolt by age emigrating from Akalura Lake were estimated each year from 1990 to 1997 (Coggins and Sagalkin 1999). These estimates were apportioned by brood year escapement to estimate the number of smolt produced per spawner. The brood years with complete emigration data (1988 to 1993) were used for this analysis. The number of smolt produced per spawner was calculated for the different escapement ranges.

Upper Station (South Olga Lakes)

The Upper Station system, also referred to as South Olga Lakes system, is composed of 2 major lakes located on the southern end of Kodiak Island and supports 1 of the largest sockeye salmon runs in the Kodiak Archipelago (Wadle 2004). There are 2 temporally distinct sockeye salmon runs that return to Upper Station (Barrett and Nelson 1994). The early run returns from late-May through mid-July while the late run returns from mid-July through September.

The current Upper Station early-run sockeye salmon SEG is 50,000 to 75,000 and the late-run goal is 150,000 to 200,000 (Nelson and Lloyd 2001). The goals were established in 1988 based on review of escapements and subsequent returns. An Optimal Escapement Goal (OEG) was established for the early Upper Station run by the BOF in 1999. Escapement goals prior to 1978 were not published. From 1978 to 1982 the escapement goal range was 100,000 to 180,000 and was stratified by month, rather than separated into early- and late-run goals. In 1983, the department increased the escapement goal (through 1987) to 250,000; a minimum goal of 150,000 for both runs combined was also established (Nelson and Lloyd 2001). Sockeye salmon escapements to Upper Station were enumerated by weir counts. Escapement assigned to the early run was estimated by including all counts prior to July 16 while escapement assigned to the late run was estimated by including all counts after July 15. These data were available from 1969 to 2003 for the early run and 1966 to 2003 for the late run.

Stock-specific harvest estimates were available for the Upper Station sockeye salmon fisheries from 1971 to 2003. Both scale pattern analysis (Swanton 1992; Sagalkin 1999) and age marker analysis were used to estimate harvest attributable to Upper Station from the Cape Alitak Section (statistical areas 257-10, -20, -60, and -70), the Moser-Olga Bay Section (prior to 2000; statistical areas 257-40 and 257-41), the Moser Bay Section (after 2000; 257-43) and the Olga Bay Section (after 2000; 257-40), subject to run timing considerations. Harvest attributable to the early run was estimated by including harvests prior to July 16 while harvest attributable to the late run was estimated by including harvests after July 15. Sockeye salmon originating from the South Olga Lakes are primarily harvested in the Cape Alitak and Moser-Olga Bay Sections of the Alitak Bay District (Tyler et al. 1981).

Spawner-Recruit Analysis

Spawner-recruit relationships were estimated for the early run, late run, and early and late runs combined. There were 2 spawner-recruit relationships estimated for each run by analyzing spawning stock and recruitment data from brood years 1969 to 1997 and brood years 1975 to 1997 using a Ricker spawner-recruit model (Ricker 1954; Hilborn and Walters 1992) with a multiplicative error structure (Quinn and Deriso 1999). If a Ricker spawner-recruit model was significant, then S_{msy} was estimated along with the range of escapements that would produce 90% to 100% of MSY. Residuals were examined for autocorrelation and temporal trends.

Percentile Approach

The percentile approach (Bue and Hasbrouck 2001) was used as an alternative to evaluate the Upper Station sockeye salmon SEGs. Selection of the percentiles used in the calculation were based on escapement contrast and fishery exploitation of the stock (Bue and Hasbrouck 2001). Escapement data from 1969 to 2003 were analyzed for both the early and late runs and both runs combined.

Euphotic Volume Model

Light penetration data were collected from the larger, upper Olga Lake monthly from May to September from 1990 to 1993 and in 1995, 1999, and 2000 (Schrof and Honnold 2003). These data were used to calculate the EZD of the lake (Kirk 1994). The EV of the larger lake was calculated using the EZD (19.0 m) and the surface area (7.9 km^2) of the lake (Koenings and Kyle 1997). The smaller (lower) lake is extremely shallow (maximum depth 2.0 m; Schrof et al. 2000), so the total lake volume ($5.9 \times 10^6 m^3$) was used to approximate EV. The number of adult sockeye salmon the system can support was generated from the EV model (EV units multiplied by 800-900 escapement per EV unit).

Zooplankton Based Model

The mean zooplankton biomass in both lakes was estimated from samples collected from the lakes seasonally (May through September 1990 to 1993, 1995, 1999, and 2000 (Schrof and Honnold 2003). The mean zooplankton biomass of the upper (1,184 mg m^2) and lower (7.6 mg m^2) lakes were applied to the zooplankton biomass model to predict the number of smolt the system can support (Koenings and Kyle 1997). The model predicts the number of 5.0-g optimum sized smolt and the number of 2.0-g threshold-sized smolt that the zooplankton biomass can sustain. The average size of smolt that emigrated from the upper (6.6-g) and lower (1.9-g) lakes from 1990 to 1993 (Schrof et al. 2000) was also applied to the model to predict a third level of smolt production for each lake. Adult production was predicted from these smolt production estimates using smolt-to-adult survivals of 12% for threshold and average size smolt from the lower lake smolt and 21% for optimum and average size smolt from the upper lake (Koenings and Edmundson 1991; Koenings and Kyle 1997). Escapement was assumed to be 35% of adult production (Koenings and Kyle 1997).

Spawning Habitat Model

Surveys of the Upper Station Lake system in 1999 resulted in estimates of about 20,000 m^2 of available tributary (early-run spawning location) habitat and 630,000 m^2 of available shoal and outlet stream (late-run spawning location) habitat (N. Sagalkin, Alaska Department of Fish and Game, Kodiak, personal communication). An optimal sockeye salmon spawning density of one female per 2.0 m^2 (Burgner et al. 1969) was used to estimate the spawning capacity of the lake. The ratio of females to males was assumed to be 1:1.

Frazer Lake

Frazer Lake is located on the southwest side of Kodiak Island. Sockeye salmon were introduced into the previously barren lake from 1951 through 1971. A fish pass was constructed in 1962 to allow sockeye salmon to migrate around the barrier falls and into the lake. Frazer Lake now supports one of the largest sockeye salmon runs in the Kodiak Archipelago (Wadle 2004). The run returns from late-May until late-July through early-August.

The current sockeye salmon BEG for Frazer Lake, 140,000 to 200,000, was established in 1988 based on review of escapements and subsequent returns (Nelson and Lloyd 2001). The goal was designed to manage escapement through the Dog Salmon weir, which is located further downstream of the Frazer Lake fish pass, while the actual goal for Frazer Lake was set at 124,000 to 181,600 (Malloy and Prokopowich 1992). Prior to this review, the Frazer Lake escapement goal had been 200,000 to 275,000 from 1986 to 1988, 350,000 to 400,000 from 1981 to 1985, and 175,000 sockeye salmon during the 1950s through the 1970s when the run was in the development phase (Brennan 1998). Sockeye salmon escapements to Frazer Lake were enumerated by weir (fish pass) counts. These data were available from 1956 to 2004.

Stock-specific harvest estimates were available for the Frazer Lake sockeye salmon fisheries from 1966 to 2002. Both scale pattern analysis (Swanton 1992; Sagalkin 1999) and age marker analysis were used to estimate harvest attributable to Frazer Lake from the Cape Alitak Section (statistical areas 257-10, -20, -60, and -70), the Moser-Olga Bay Section (prior to 2000; statistical areas 257-40 and -41), the Moser Bay Section (after 2000; 257-43) and the Olga Bay Section (after 2000; 257-40), subject to run timing considerations.

Due to poor escapements and smolt production in the mid-1980s, Frazer Lake was fertilized from 1988 to 1992.

Spawner-Recruit Analysis

Spawner-recruit relationships were estimated for the run by analyzing spawning stock and recruitment data from brood years 1966 to 1995 using a Ricker spawner-recruit model (Ricker 1954; Hilborn and Walters 1992; Eggers 2001) with a multiplicative error structure (Quinn and Deriso 1999). A separate analysis was conducted excluding brood years 1985 to 1991 in order to assess spawner-recruit relationships not affected by fertilization. If a Ricker spawner-recruit model was significant, then S_{msy} was estimated along with the range of escapements that would produce 90% to 100% of MSY. Residuals were examined for autocorrelation, temporal trends, and potential bias due to lake fertilization.

Percentile Approach

The percentile approach (Bue and Hasbrouck 2001) was used as an alternative to evaluate the Frazer Lake sockeye salmon escapement goal. Selection of the percentiles used in the calculation were based on escapement contrast and fishery exploitation of the stock (Bue and Hasbrouck 2001). There were 3 different sets of escapement data analyzed: 1) weir data from 1956 to 2003, 2) weir data from 1978 to 2003, and 3) weir data from 1978 to 2003, excluding 1985 to 1991. The first 2 alternatives were selected due to a perceived difference in productivity prior to 1978 (lower) compared to post 1978 (higher). The third alternative was selected to differentiate the affects of lake fertilization.

Euphotic Volume Model

Light penetration data were collected from Frazer Lake monthly from May through September from 1987 to 1997 and 2001 to 2002 (Schrof et al. 2000; Schrof and Honnold 2003; Sagalkin *In prep*). These data were used to calculate the EZD of the lake (Kirk 1994). The EV of Frazer Lake was calculated using the EZD (16.1 m) and the surface area (16.6 km^2) of the lake (Koenings and Kyle 1997). The number of adult sockeye salmon the lake can support was generated from the EV model (EV units multiplied by 800-900 escapement per EV unit).

Zooplankton Based Model

The mean zooplankton biomass in Frazer Lake was estimated from samples collected from the lake seasonally (May through September) from 1985 to 2003 (Schrof et al. 2000; Schrof and Honnold 2003; Sagalkin *In prep*). The mean zooplankton biomass (236 mg m^2) was applied to the zooplankton biomass model to predict the number of smolt the lake can support (Koenings and Kyle 1997). The model predicts the number of 5.0-g optimum sized smolt and the number of 2.0-g threshold-sized smolt that the zooplankton biomass can sustain. The average size (5.1-g) of smolt that emigrated from Frazer Lake from 1994 to 2003 was also applied to the model to predict a third level of smolt production. Adult production was predicted from these smolt production estimates using smolt-to-adult survivals of 12% for threshold and 21% for optimum and average size smolt (Koenings and Edmundson 1991; Koenings and Kyle 1997). Escapement was assumed to be 35% of adult production (Koenings and Kyle 1997). In addition, the mean zooplankton biomass (267 mg m^2) during the same period excluding years of fertilization (1988-1992) was applied to the zooplankton biomass model as described above to estimate adult production and escapement.

Spawning Habitat Model

Blackett (1979) and Kyle et al. (1988) reported that the Frazer Lake system had 365,000 m^2 of available salmon spawning habitat. An optimal sockeye salmon spawning density of 1 female per 2.0 m^2 (Burgner et al. 1969) was used to estimate the spawning capacity of the lake. The ratio of females to males was assumed to be 1:1.

Smolt-per-Spawner

The numbers of sockeye salmon smolt by age emigrating from Frazer Lake were estimated each year from 1991 to 2004 (Sagalkin *In prep*). These estimates were apportioned by brood year escapement to estimate the number of smolt produced per spawner. The brood years not directly affected by fertilization with complete emigration data (1992 to 1998) were used for this analysis. The number of smolt produced per spawner was calculated for the different escapement ranges.

Buskin

Annual escapement of sockeye salmon to the Buskin watershed was counted at a weir since 1985 (Schmidt et al. *In prep*). In early years the weir was located in the Buskin River about 1.5 miles upstream of the river mouth, but many years the weir washed out during high water. Beginning in 1990, the weir has been located at the outlet of Buskin Lake. In general the weir was operational from late-May through late-July or early-August each year. In some years since 1990, a portion of the total escapement was estimated when high water precluded the controlled passage of fish. These estimates were calculated using the corresponding average daily escapements from the most recent 10-year period.

Annual subsistence harvests of Buskin drainage sockeye salmon were estimated from returns of completed permits received by the Division of Commercial Fisheries. Annual return rates of completed permits have been relatively high, 95% or higher since 2000 (J. Shaker, Alaska Department of Fish and Game, Kodiak, personal communication). It is not possible to determine the harvest of households that do not return permits, but it is believed to be low.

The sport fishery harvests of sockeye salmon were estimated by the Statewide Harvest Survey (Mills 1991-1994; Howe et al. 1995, 1996, and 2001a-d; Walker et al. 2003; Jennings et al. 2004, *In prep* a-b). Commercial harvests were tallied from the Division of Commercial Fisheries Statewide Harvest Receipt (fish ticket) database. Because stock-specific harvests by the commercial fishery were not estimated, the total commercial harvests of sockeye salmon in Woman's Bay (259-22) were assumed to be Buskin River fish.

Scales were collected from fish sampled at the weir to estimate age composition of the escapement (Schmidt et al. *In prep.*). Scales were also collected from fish harvested in the subsistence fishery to estimate age composition of this harvest. Age composition of the commercial and sport harvests were assumed the same as that observed at the weir. Age composition data were available for all years except 1999. Age composition of the 1999 run was estimated using the average age composition observed during 1996-1998.

A brood table was developed beginning with the 1990 run when the weir was first moved to the outlet of Buskin Lake. The brood table was constructed from the runs by year and the age composition of these runs. Total run was estimated by summing escapement with sport, subsistence, and commercial harvests of each year. Total run by age was estimated by summing estimates of number by age from the escapement and both sport and commercial harvests, all based on age data collected at the weir, with number by age in the subsistence harvest. Age-specific returns were summed for each brood year to estimate total return by brood year. Return-per-spawner was then estimated as the total return of each brood year divided by the escapement for that brood year.

Spawner-Recruit Analysis

These data were considered sufficient to estimate MSY (Hilborn and Walters 1992; CTC 1999; Quinn and Deriso 1999) and to develop a BEG. Spawner-return data were analyzed using a mathematical stock recruitment model (Ricker 1954) to estimate MSY and the BEG range. There were 2 methods used to model the spawner-recruit data. The first method was a traditional least squares regression to fit the linearized Ricker spawner-recruit function. The second method estimated spawner-recruit parameters of the Ricker model using Bayesian methods (Steve Fleischman, Alaska Department Fish and Game, Anchorage; personal communication). If the analyses indicated there was significant autocorrelation (α = 0.05) among the residuals of the model, the methods of Noakes et al. (1987) and Pankratz (1991) were used to alleviate bias in the parameter estimates. The BEG range was estimated using parameter estimates from the Ricker model to estimate the 2 spawning escapements that would produce 90% of MSY.

Pasagshak River

Pasagshak River sockeye salmon escapements were indexed by peak aerial surveys since 1968. All analyses for this review were performed using peak aerial indices. Subsequent fisheries management will rely on peak escapement indices to measure achievement of the escapement goal. No stock-specific harvest information is available for commercial fisheries, but annual catch data are available from Commercial Fisheries databases for nearby statistical areas (unpublished data). Since 1993 annual subsistence harvests of Pasagshak River sockeye salmon were estimated from returns of completed permits received by the Division of Commercial Fisheries. The sport fishery harvests of sockeye salmon were estimated by the Statewide Harvest Survey since 1977 (Mills 1979-1994; Howe et al. 1995, 1996, and 2001 a-d; Walker et al. 2003; Jennings et al. 2004, *In prep* a, b). No age data were collected from harvests or escapements.

Percentile Approach

The percentile approach (Bue and Hasbrouck 2001) was used as an alternative to evaluate the Pasagshak River sockeye salmon SEG. Aerial and foot survey escapement data from 1968 to 2003 were analyzed, while selection of the percentiles used in the calculation were based on escapement contrast and fishery exploitation of the stock (Bue and Hasbrouck 2001).

Risk Analysis

The peak survey escapement index time series was first log-transformed and tested for normality using a one-sample Kolmogorov-Smirnov test (α = 0.05) to determine whether escapement estimates followed a lognormal distribution. The log-transformed escapement time series was then tested for serial correlation using diagnostics in Abraham and Ledolter (1983). Based on the results, escapements were modeled as lognormally distributed variables and analyzed using risk analysis following equations (3) and (4).

Saltery Lake

Saltery Lake is located southwest of the city of Kodiak and is one of the most productive sockeye salmon systems on the east side of Kodiak Island (Honnold and Sagalkin 2001; Wadle 2004). The run returns from late-June to mid-August, peaking in mid-July.

Prior to 2001 the Saltery Lake escapement goal was 20,000 to 40,000 sockeye salmon (Nelson and Lloyd 2001). This escapement goal was considered an SEG and was based upon historical escapements and limited spawning habitat surveys. The current BEG for Saltery Lake of 15,000 to 30,000 was established in 2001 based on analyses of spawner-recruit, euphotic zone depth and volume, smolt biomass as a function of zooplankton biomass, smolt biomass as a function of lake rearing availability and spawning habitat availability (Honnold and Sagalkin 2001).

Stock-specific harvest estimates for the Saltery Lake sockeye salmon fisheries from 1976 to 2003 were obtained by statistical area from the ADF&G's Division of Commercial Fisheries fish ticket database. It was assumed that the majority of Saltery Lake sockeye salmon were harvested in the Inner Ugak Bay Section (statistical areas 259-41, and 259-42).

Spawner-Recruit Analysis

Spawner-recruit relationships were estimated for the run by analyzing spawning stock and recruitment data from brood years 1976 to 1996 using a Ricker spawner-recruit model (Ricker 1954; Hilborn and Walters 1992) with a multiplicative error structure (Quinn and Deriso 1999). If a Ricker spawner-recruit model was significant, then S_{msy} was estimated along with the range of escapements that would produce 90% to 100% of MSY. Residuals were examined for autocorrelation and temporal trends.

Percentile Approach

The percentile approach (Bue and Hasbrouck 2001) was used as an alternative to evaluate the Saltery Lake sockeye salmon escapement goal. Selection of the percentiles used in the calculation were based on escapement contrast and fishery exploitation of the stock (Bue and Hasbrouck 2001). There were 2 different sets of escapement data analyzed: 1) all data from 1976-2003 and 2) available weir data from 1976 to 2003. The latter data set was assumed to more accurately represent escapements, as aerial survey estimates are likely biased to some degree.

Euphotic Volume Model

Light penetration data were collected from Saltery Lake monthly from May through September from 1994 to 1999 (Schrof et al. 2000; Honnold and Sagalkin 2001; Schrof and Honnold 2003). These data were used to calculate the EZD of the lake (Kirk 1994). The EV of Saltery Lake was calculated using the EZD (8.3 m) and the surface area (1.1 km^2) of the lake (Koenings and Kyle 1997). The number of adult sockeye salmon the lake can support was generated from the EV model (EV units multiplied by 800-900 escapement per EV unit).

Zooplankton Based Model

The mean zooplankton biomass in Saltery Lake was estimated from samples collected from the lake seasonally (May through September) from 1994 to 2004 (Schrof et al. 2000; Honnold and Sagalkin 2001; Schrof and Honnold 2003). The mean zooplankton biomass (439 mg m^2) was applied to the zooplankton biomass model to predict the number of smolt the lake can support (Koenings and Kyle 1997). The model predicts the number of 5.0-g optimum sized smolt and the number of 2.0-g threshold-sized smolt that the zooplankton biomass can sustain. The average size (5.1-g) of smolt that emigrated from Saltery Lake from samples collected in 2002 was also applied to the model to predict a third level of smolt production. Adult production was predicted from these smolt production estimates using smolt-to-adult survivals of 12% for threshold and 21% for optimum and average size smolt (Koenings and Edmundson 1991; Koenings and Kyle 1997). Escapement was assumed to be 35% of adult production (Koenings and Kyle 1997).

Spawning Habitat Model

Honnold and Sagalkin (2001) reported that the Saltery Lake system had an estimated 39,000 m^2 of available salmon spawning habitat. An optimal sockeye salmon spawning density of one female per 2.0 m^2 (Burgner et al. 1969) was used to estimate the spawning capacity of the lake. The ratio of females to males was assumed to be 1:1.

Coho Salmon

Stocks Along the Kodiak Road System

Coho salmon escapements in the KMA along the Kodiak road system were enumerated by foot survey (American, Olds, Pasagshak Rivers and Roslyn Creek), aerial survey (Saltery Creek), and weir (Buskin River and Saltery Creek). These data were available from 1980 to 2003. Accuracy of foot surveys in the American and Olds rivers were investigated during 1997 and 1998 via mark-recapture estimation and found to be adequate for indexing escapement of coho salmon in these systems (Begich et al. 2000). Stock-specific harvests were estimated from recreational harvest in freshwater (see Jennings et al. 2004). Although there are no stock-specific harvest information available for subsistence and commercial fisheries, annual catch data are available from Commercial Fisheries databases for nearby statistical areas (unpublished data). After preliminary review of the data available, it was decided to review and attempt to revise escapement goals for coho salmon in the American, Olds, Pasagshak, and Buskin rivers, and Saltery and Roslyn creeks.

Theoretical Spawner-Recruit Analysis

Theoretical spawner-recruitment (spawner-recruit) relationships were investigated for the major yield producing systems along the Kodiak Road System that have ongoing coho salmon assessment programs (American, Olds, Pasagshak, Buskin). Given that the long-term yields and escapements in these systems have stable trends and have occurred with little or no change in the regulations, it seems reasonable to assume that they are in equilibrium. Moreover, annual escapement and run (escapement plus harvest) averaged over a long time period likely represent x-y coordinates on the true spawner-recruit relationship. Assuming that the spawner-recruit relationship follows the form of Ricker (Ricker 1975), several spawner-recruit relationships can be realized that encompass a range of productivity commonly seen for coho salmon. Defensible escapement goal ranges that incorporate known yields, stock productivity, data uncertainty, and maximization of yields can be developed from this analysis.

Average harvests and average escapement survey counts were estimated from available data for each river (generally 1980 to 2003 with some missing years):

$$\bar{h} = \frac{1}{n}\sum_{i}^{n} h_i \text{ and } \bar{s} = \frac{1}{n}\sum_{i}^{n} s_i \tag{5}$$

Foot surveys do not count all salmon that are in the escapement to these streams so that exploitation rate calculated from these data were assumed to be the maximum exploitation rate. From mark-recapture experiments (Begich et al. 2000) and managers opinion, it is thought that 80 to 100% of the escapement is counted via foot surveys each year.

Assuming that harvest and escapements are in equilibrium, average maximum exploitation rate was estimated as:

$$\bar{u} = \frac{\bar{h}}{\left(\bar{s} + \bar{h}\right)} \tag{6}$$

Exploitation rate at MSY depends solely on the Ricker productivity parameter α (Ricker 1975). However, the productivity of coho salmon stocks in Kodiak is unknown so a range of productivity parameter was chosen (4 to 8) that represents the likely range of productivity commonly observed in coho salmon. Assuming α is known and the observed average exploitation rate and the average foot survey count over a number of years are in equilibrium, an estimate of escapement (in terms of survey units) that will produce MSY (from Hilborn and Walters (1992) and Ricker (1975)) can be calculated:

$$s_{MSY} = \bar{s}\,\frac{0.5\ln(\alpha) - 0.07\ln(\alpha)^2}{\ln\left(\alpha\left(1-\bar{u}\right)\right)} \tag{7}$$

To compare estimates of S_{msy} and spawner-recruit relationships derived from different assumed αs, the β parameter was estimated for each spawner-recruit relationship by first estimating the exploitation rate at MSY by solving:

$$\ln(\alpha) = u_{MSY} - \ln(1-u_{MSY}) \tag{8}$$

for u_{MSY} (from Ricker 1975). The β parameter was then calculated from (Ricker 1975):

$$\beta = \frac{u_{MSY}}{s_{MSY}} \tag{9}$$

From these spawner-recruit relationships the range around S_{msy} that produces 90% or more of MSY was also calculated. Since the resulting ranges were based on foot surveys (an index of escapement) rather than the actual escapement they were considered SEG ranges.

Spawner-Recruit Analysis

Spawning stock and recruitment data from the Buskin River were analyzed using a Ricker spawner-recruit model (Ricker 1975) with a multiplicative error structure (Quinn and Deriso 1999). If a Ricker spawner-recruit model was significant, then S_{msy} was estimated along with the range of escapements that would produce 90% to 100% of MSY.

Remote Stocks

Remote coho salmon escapements in the KMA were enumerated by weir counts, foot surveys and aerial surveys, depending on the river system. Weir count data were available for Portage Creek (1987, 1988 and 1990), Afognak River (1984 to 2003), Pauls Bay drainage (1984 to 1990 and 1993 to 2001), Karluk River (1974 to 2004), Ayakulik River (1978 to 2004), Akalura Creek (1974 to 2003 except 1979 to 1985), Upper Station (1974 to 2004), and Dog Salmon Creek (1983 to 2004). Most of the weirs for these systems were dedicated to sockeye salmon counts and, though coho salmon were counted, the weir was usually removed at the end of the sockeye salmon run. Since the weirs on these systems are rarely kept in for the entire time of the coho salmon run, for each system a cut-off day was chosen that provided escapement estimates for most (80%) of the years weir counts were available.

Aerial survey data were available for Big Bay (1984 to 1985, 1989 to 1998, 2000 to 2002, and 2004), Bear Creek (1985, 1989 to 1990, 1992 to 2000, and 2002), Portage Creek (1968 to 1970, 1972 and 1973, 1975, 1978 to 1986, 1989, 1993 to 1994, 1997 to 2001 and 2003) and Pauls Bay drainage 1991 to 1992 and 2002 to 2003. The aerial survey data were expanded by local management biologists for some years, however due to inconsistencies in how this expansion was done, the peak aerial survey escapement estimates for each year were used in the analyses.

Risk Analysis

Individual river systems with weir counts or peak escapement time series were first log-transformed and tested for normality using a one-sample Kolmogorov-Smirnov test (Conover 1980) to determine whether escapement estimates followed a lognormal distribution (P>0.15). The log-transformed escapement time series were then tested for serial correlation using diagnostics in Chatfield (1984). Based on the results, escapements were modeled as lognormally distributed variables and analyzed using risk analysis following equations (3) and (4).

Percentile Approach

For purposes of comparison and where escapement estimates were not lognormally distributed (risk analysis would be inappropriate), the percentile approach (Bue and Hasbrouck 2001) was used. Selection of the percentiles used in the calculation were based on escapement contrast and fishery exploitation of the stock (Bue and Hasbrouck 2001). All coho systems not on the road system have low exploitation.

PINK SALMON

Escapement Indices

Current SEGs for pink salmon in the KMA are based on aerial surveys of spawning fish from fixed-wing aircraft (Wadle 2004). Each year since 1964 pink salmon have been counted during one or more flights over a standardized subset of streams in the Kodiak Archipelago and across Shelikof Strait on the mainland (Figure 1). The highest number (peak count) of pink salmon observed during a single flight has been used as an annual index of abundance for that stream. These peak counts were summed over streams within several districts: Eastside, Northeast Kodiak, Afognak, Northwest Kodiak, Southwest Kodiak, Alitak Bay, and Mainland. These annual sums were in turn averaged to produce SEGs for each district and for the Kodiak Archipelago as a whole (Table 3). Because all pink salmon in a brood year mature in the same calendar year, 2 years after birth (Heard 1991), goals have been calculated separately for odd- and even-year subpopulations.

Analysis was restricted to providing evidence that current goals represent an SEG for 2 stocks, the mainland stock and the aggregated stock for the districts of the Kodiak Archipelago. Measurement error in indices precludes a straightforward estimation of a BEG for either of these stocks. However, arguably reasonable assumptions into the nature of this measurement error can be used in conjunction with statistics on harvest to show that current goals are SEGs and that 1 set of goals should be changed to improve expected yields.

Index – Abundance Relationship

A depensatory power function (Jones et al.1998) was used to model the relationship between the index of spawning salmon $\hat{S}_{cy}$ and actual abundance N_{cy} such that

$$\hat{S}_{cy} = pN_{cy}^{q} \exp(\gamma_{cy}) \tag{10}$$

where $0 < q \leq 1$, and $\gamma \sim Norm(0, \sigma_{\gamma}^{2})$, and cy is calendar year. Parameters p and q represent systematic measurement error that arises because not all salmon spawning in a year can be counted during a single day and because there is a tendency to undercount when large numbers of salmon are present. Often numbers of spawning pink salmon counted from the air have been a fraction of actual numbers with that fraction marginally less as spawning abundance increases (Eicher 1953; Shardlow et al. 1987; Jones et al. 1998; and others). The stochastic element γ represents random measurement error and is the reason for using $\hat{S}_{cy}$ instead of S_{cy} in (10). Random measurement error arises because of annual variation in flying and/or water conditions, staff availability and migratory timing of salmon. Actual spawning abundance can also be expressed as a function of harvest rates U_{cy} and harvest H_{cy} such that

$$N_{cy} = H_{cy}\frac{1-U_{cy}}{U_{cy}} \tag{11}$$

Plugging (10) into (11), applying some algebra, and taking the logarithms of both sides produces

$$\ln\hat{S}_{cy} = \ln p + q\ln\left[\frac{1-U_{cy}}{U_{cy}}\right] + q\ln H_{cy} + \gamma_{cy} \tag{12}$$

Note that $\ln[(1-U_{cy})/U_{cy}]$ is a logit, and as such should follow a normal distribution (Agresti 1990, p. 421-2) which implies that

$$\ln[(1-U_{cy})/U_{cy}] = \mu_\delta + \delta_{cy} \tag{13}$$

where μ_δ is the mean of logits across years and $\delta_{cy} \sim Norm(0,\sigma_\delta^2)$. Inserting (13) into (12) and collecting terms produces

$$\ln\hat{S}_{cy} = \{\ln p + q\mu_\delta\} + \{q\}\ln H_{cy} + \{\gamma_{cy} + q\delta_{cy}\} \tag{14}$$

The equation above is the stochastic form $y = \{a\} + \{b\}x + \{e\}$ where $e \sim Norm(0, q^2\sigma_\delta^2 + \sigma_\gamma^2)$ with $a \equiv \ln p + q\mu_\delta$, $b \equiv q$, and $\sigma_e^2 \equiv q^2\sigma_\delta^2 + \sigma_\gamma^2$. Parameters *a*, *q*, and σ_e^2 were estimated directly by fitting the equation to data collected from 1968 to 2003 (data from 1989 excepted due to closure of the fishery that year). A unique estimate of σ_γ^2 (random measurement error) could not be obtained from $\hat{\sigma}_e^2$, however, the value of σ_γ^2 was restricted to a range of possible values. If there is no variation in harvest rates ($\sigma_\delta^2 = 0$), then by $\sigma_e^2 \equiv q^2\sigma_\delta^2 + \sigma_\gamma^2$, $\hat{\sigma}_e^2$ represents a maximum value for σ_γ^2, that is $\sigma_\gamma^2 \leq \hat{\sigma}_e^2$

A minimum value for σ_γ^2 was obtained from variation in logits for "maximum" harvest rates for each calendar year:

$$U'_{cy} = \frac{H_{cy}}{H_{cy} + \hat{S}_{cy}} \tag{15}$$

where U'_{cy} is the "maximum" rate for the year. Variation in the logits $\ln[(1-U'_{cy})/U'_{cy}]$ across calendar years overstates σ_δ^2 because random measurement error from surveys is also included. Given that s_δ^2 is the sample variance for logits of "maximum" rates since 1968, $\sigma_\gamma^2 \geq \hat{\sigma}_e^2 - \hat{q}^2 s_\delta^2$. Calculating a unique estimate for *p* from $\hat{a}$ is also impossible without independent information from a weir, a tower, or capture-recapture program, but again, restricted ranges for *p* can be and were estimated using logits for "maximum" harvest rates. Remembering that $a \equiv \ln p + q\mu_\delta$, $p < \exp(\hat{a} - \hat{q}\mu'_\delta - \hat{\sigma}_e^2/2)$ because when $U_{cy} < U'_{cy}$, $\mu'_\delta < \mu_\delta$ (μ'_δ is the average of the logits of "maximum" rates and $\hat{\sigma}_e^2/2$ is the adjustment so that p represents the mean index given escapement instead of the median).

Evidence for Sustainable Yields

In general, harvests of pink salmon in the KMA have obviously been sustainable because both stocks and fishery have persisted. However, many escapements have been outside the current goal ranges. The question in an escapement goal analysis is: does surplus production on average result from a particular goal? Measurement error in escapement indices complicates the answer to this question, but enough evidence is available to show that surplus production (yields) can be expected if future indices are kept within the current goals.

The evidence comes from a transformation of (10) designed to estimate average escapement in actual numbers of pink salmon. Taking the root of (10) produces

$$\hat{S}_{cy}^{1/q} = p^{1/q} N_{cy} \exp(\gamma_{cy}/q) \tag{16}$$

Taking the expectation of both sides of (16), that is averaging over a range of values, gives

$$E[\hat{S}_{range}^{1/q}] = p^{1/q} E[N_{range}] \exp\left[\sigma_\gamma^2 / 2q^2\right] \tag{17}$$

Equation (17) was rearranged to provide a formulation to estimate actual escapement as a function of indices and parameter estimates for *p*, *q*, and random measurement error σ_γ^2:

$$\overline{N}_{range} = p^{-1/q} \left[\frac{\sum_{i=1}^{range} \hat{S}_i^{1/q}}{n}\right] \exp\left[-\sigma_\gamma^2 / 2q^2\right] \tag{18}$$

Conditional estimates of average escapement across a range of indices were calculated from (18) using extremes for σ_γ^2 and *p*. When this range corresponded to the current escapement goal, $\overline{N}_{range}$ became an estimate of average escapement in those years in which indices met the goal. When the range corresponded to subsequent progeny, $\overline{N}_{range}$ became an average estimate of the production that escaped harvest. Sustainable yields are indicated whenever average production of progeny (the sum of average escapement and average harvest in the same year) is greater than the estimated average escapement of parents. Unbiased estimates for *q* were used in all calculations.

CHUM SALMON

Chum salmon escapements in the KMA were enumerated by weir counts and aerial surveys, depending on the river system. The aerial survey peak escapement estimates and weir counts were combined as an aggregate for each of the 6 chum salmon districts of the KMA. The 6 chum salmon districts in the KMA are the Northwest Kodiak District, Southwest Kodiak District, Alitak Bay District, Eastside Kodiak District, Northeast Kodiak District, and Mainland District.

Risk Analysis

District-wide escapement estimate time series were first log-transformed and tested for normality using a one-sample Kolmogorov-Smirnov test (Conover 1980) to determine whether escapement estimates followed a lognormal distribution (P>0.15). The log-transformed escapement time series were then tested for serial correlation using diagnostics in Chatfield (1984). Based on the results, aggregate escapements were modeled as lognormally distributed variables and were analyzed using risk analysis following equations (3) and (4).

Percentile Approach

For purposes of comparison and in cases where aggregate escapement estimates were not lognormally distributed (risk analysis would be inappropriate), the percentile approach (Bue and Hasbrouck 2001) was used. Selection of the percentiles used in the calculation were based on aggregate escapement contrast and fishery exploitation of the stock (Bue and Hasbrouck 2001).

RESULTS

CHINOOK SALMON

Karluk River

The data available for the Karluk River Chinook salmon escapement goal analysis and the associated results of those analyses are located in Appendices A1-A5.

Stock Status

During the 2001-2002 Board of Fish meeting cycle, the BEG range of 4,500 to 8,000 spawners was changed to 3,600 – 7,300 spawners based on a Ricker analysis of spawner-recruit data (Table 1; Appendix A1; Hasbrouck and Clark *In prep*.). This recommendation was based on multiplying the escapement that produced MSY by 0.8 and 1.6 as suggested in Eggers (1993). 10 of the 28 years of escapements were within the current BEG range, 16 years of escapements were above the BEG range, and 2 years of escapements were below the BEG range (Appendix A2).

Spawner-Recruit Analysis

Chinook salmon escapements averaged about 9,000 (approximate range: 4,300 to 13,700) fish for complete brood years from 1976 to 1996 (Appendix A3). Total brood year returns averaged about 11,100 Chinook salmon during this period. The contrast in escapement data was 3.2 for this time period, below the recommended minimum contrast level of 4.0 (CTC 1999).

The Karluk River Chinook salmon spawner-recruit data were reanalyzed with the addition of the 1995 and 1996 brood years (Appendix A1-A5). There was a significant (P = 0.002) autocorrelation among residuals at lag-1 (Appendix A5) so a time series (autoregressive) term was incorporated into the Ricker model. The point estimate of escapement that produces MSY was 4,492 fish (Appendices A1 and A4). A BEG range based on (0.8, 1.6) was 3,594 – 7,187 and that based on 90% of MSY was 2,926 to 6,227. The fitted Ricker curve crossed the replacement line (S_{eq}) at an escapement of 10,901 fish (Appendix A4).

Habitat-Based Model

Watershed area of the Karluk River is 929 km^2. From watershed area, the estimate of S_{eq} was 5,295, about half (50%) that of the Ricker model. The estimate of S_{msy} was 1,959, also about half (50%) that of the Ricker model.

Escapement Goal Recommendation

The team recommended no change in the current BEG (3,600 to 7,300). A Ricker model with additional brood years of data provided very similar escapement goal ranges as those adopted in 2001-2002. The team believed the spawner-recruit data provided a more accurate estimate of stock productivity than the habitat-based model.

Ayakulik River

The data available for the Ayakulik River Chinook salmon escapement goal analysis and the associated results of those analyses are located in Appendices B1-B5.

Stock Status

During the 2001-2002 Board of Fish meeting cycle, the BEG range of 6,500 to 10,000 spawners was changed to 4,800 – 9,600 spawners based on a Ricker analysis of spawner-recruit data (Table 1; Appendix B1; Hasbrouck and Clark *In prep*). This recommendation was based on multiplying the escapement that produced MSY by 0.8 and 1.6 as suggested in Eggers (1993). Nine of the 27 years of escapements were within the current BEG range, with most recent escapements above the range (Appendix B2).

Spawner-Recruit Analysis

Chinook salmon escapements averaged about 10,000 (approximate range: 2,200 to 20,800) fish for complete brood years from 1977 to 1996 (Appendix B3). Total brood year returns averaged about 15,200 Chinook salmon during this period. The contrast in escapement data was 9.6 for this time period, above the recommended minimum contrast level of 4.0 (CTC 1999).

The Ayakulik River Chinook salmon spawner-recruit data were reanalyzed with the addition of the 1995 and 1996 brood years (Appendix B1-B5). There was no significant autocorrelation among residuals at lag-1 (Appendix B5) so no time series (autoregressive) term was incorporated into the Ricker model (i.e., P = 0.08 for autoregressive lag-1 parameter estimate). The point estimate of escapement that produces MSY was 6,638 fish (Appendices B1 and B4). A BEG range based on (0.8, 1.6) was 5,311 to 10,621 and that based on 90% of MSY was 4,297 to 9,279. The fitted Ricker curve crossed the replacement line at an escapement of 16,702 fish (Appendix B4).

Habitat-Based Model

Watershed area of the Karluk River is 389 km^2. From watershed area, the estimate of S_{eq} was 2,919, about one fifth (20%) that of the Ricker model. The estimate of S_{msy} was 1,067, also about one fifth (20%) that of the Ricker model.

Escapement Goal Recommendation

The team recommended no change in the current BEG (4,800 to 9,600). A Ricker model with additional brood years of data provided very similar escapement goal ranges as those adopted in 2001-2002. The team believed the spawner-recruit data provided a more accurate estimate of stock productivity than the habitat-based model.

SOCKEYE SALMON

Malina Lakes

The data available for the Malina Lakes sockeye salmon escapement goal analyses and the associated results of those analyses are located in Table 4 and Appendix C.

Stock Status

The current Malina Lake sockeye salmon SEG of 10,000 to 20,000 was adopted in 1988 (Table 1; Appendix C1). Prior to 1988 there was no published escapement goal for this system. Prior to 1992 the escapement estimates were derived from aerial counts and were highly variable ranging from 0 to 21,200 fish (Appendices C2 and C3). From 1991 to 2001 the Malina Lake system was enriched with a nutrient fertilizer and from 1992 to 1999 it was supplemented with juvenile sockeye salmon. In 1992 a weir was installed in Malina Creek and was operated through 2002. The escapement has averaged about 17,000 sockeye salmon from 1994 to 2003 (Appendix C3). In the past 6 year period, the escapements to the Malina Lake system have either met or exceeded the SEG (1998 to 2004).

Percentile Approach

An SEG for Malina Lakes sockeye salmon was estimated according to the percentile approach using 3 sets of escapement estimates (Bue and Hasbrouck 2001; Table 4). The first SEG estimate was based only on aerial survey estimates (1968-1991, 2003; Appendix C2). There was high contrast (42.4) in the escapement estimates and low exploitation resulting in an SEG of 300 to 6,000 (15^{th} to 75^{th} percentiles). Weir counts from 1992 to 2002 were used for the second SEG estimate. There was medium contrast (4.2) in the escapement estimates, which resulted in an SEG of 8,000 to 26,000 (15^{th} to 85^{th} percentiles). The last SEG estimate was determined using all available escapement data from 1968 to 2003. High contrast (64.4) in the escapement estimates and low exploitation of this stock resulted in an SEG of 1,000 to 9,000 (15^{th} to 75^{th} percentiles).

Euphotic Volume Model

The estimated average EV of $6.98 \times 10^6 m^3$ for Lower Malina Lake and $13.61 \times 10^6 m^3$ for Upper Malina Lake resulted in a combined average EV of $20.59 \times 10^6 m^3$ (Table 4). Based on the combined average EV, the escapement capcity of Malina Lakes is estimated at 16,000 to 18,000 sockeye salmon.

Smolt Biomass as a Function of Zooplankton Biomass

Dependent upon smolt size and the associated marine survival, the zooplankton models yielded escapement estimates of about 2,000 (2.9-g and 5.0-g smolt) and 5,000 (2.0-g smolt) sockeye salmon for the Malina Lakes (Table 4).

Spawning Habitat Model

Based on a total spawning habitat estimate within the Malina Lakes system, Kyle and Honnold (1991) estimated the adult carrying capacity of the Malina Lake system to be roughly 21,000 sockeye salmon. (Table 4).

Escapement Goal Recommendation

The team recommended changing the current Malina Lakes sockeye SEG to 1,000 to 10,000 sockeye salmon. This recommendation was based on the results of the percentile approach using all years of data (range 1,000 to 9,000) and the zooplankton model estimate (range 2,000 to 5,000; Table 4; Appendix C1). Although the EV and the spawning habitat support a higher goal (17,000 to 21,000), recent escapements (1999 to 2002) appear to have severely depressed the zooplankton biomass in the lakes. A lower goal with a wide range will allow management of escapement to promote the recovery of the rearing environment.

Pauls Bay Drainage

The data available for the Pauls Bay drainage sockeye salmon escapement goal analyses and the associated results of those analyses are located in Table 5 and Appendix D.

Stock Status

The current Pauls Bay drainage sockeye SEG of 20,000 to 40,000 was established in 1988 (Table 1; Appendix D1). Prior to 1978 the escapements were estimated by tributary surveys (Appendices D2 and D3). Escapements were within the SEG once (1976) based on these surveys (1969-1977; Appendix D3). Weir count estimates from 1978 to 2003 were within the SEG 12 of 27 years, meeting and exceeded the SEG goal only twice (1980 and 1996). The escapement has averaged about 25,000 sockeye salmon from 1994 to 2003.

Percentile Approach

An SEG for Pauls Bay sockeye salmon was estimated according to the percentile approach using 4 sets of escapement estimates (Bue and Hasbrouck 2001; Table 5; Appendix D1). The first SEG estimate was determined using tributary survey estimates and weir counts from 1969 to 2003. High contrast (15.7) in the escapement estimates and low exploitation of this stock resulted in an SEG of 8,000 to 23,000 (15^{th} to 75^{th} percentiles; Table 5). Weir counts from 1978 to 2003 were used for the second SEG estimate. The contrast remained the same (15.7), which resulted in an SEG of 11,000 to 26,000 (15^{th} to 75^{th} percentiles). The third SEG estimate was based only on tributary survey estimates from 1969 to 1977. There was medium contrast (5.0) in the escapement estimates resulting in an SEG of 7,000 to 16,000 (15^{th} to 85^{th} percentiles). The last SEG estimate was based on the 1978 to 1995 weir counts, which excluded years when returns were affected by rehabilitation efforts. These data had a high contrast (15.7) and low exploitation rate for an SEG of 8,000 to 20,000 (15^{th} to 75^{th} percentiles).

Euphotic Volume Model

Based on an average EV of $38.66\text{x}10^6\text{m}^3$ ($32.75\text{x}10^6\text{m}^3$ for Laura Lake and $5.91\text{x}10^6\text{m}^3$ Pauls Lake), the escapement capacity for the Pauls Bay drainage was estimated to be between 31,000 and 34,000 sockeye salmon (Table 5). Although this is a reasonable analysis of escapement capacity based on EV, data collected in October 2004 revealed that Pauls Lake had extremely poor light penetration and contained extraordinarily high levels of sulfur dioxide. Such a phenomenon would severely restrict if not inhibit sockeye salmon rearing in Pauls Lake.

Smolt Biomass as a Function of Zooplankton Biomass

Dependent upon smolt size and the associated marine survival, the zooplankton model yielded escapement estimates of 18,000 (5.0-g smolt), 21,000 (4.3-g smolt), and 26,000 (2.0-g smolt) sockeye salmon (Table 5). The larger estimate was based on 2.0-g smolt, whereas the Pauls Bay drainage sockeye salmon smolt have averaged 4.3-g. Thus, an escapement goal range between 18,000 and 21,000 is more appropriate.

Spawning Habitat Model

Based on a total spawning habitat within the Pauls Bay drainage, Honnold and Edmundson (1993) estimated the adult carrying capacity of the Pauls Bay system to be roughly 26,000 sockeye salmon. (Table 5).

Escapement Goal Recommendation

The team recommended changing the current Pauls Bay drainage SEG to 10,000 to 30,000 fish because all limnological models suggest lowering the upper end of the SEG (Table 5; Appendix D1). Results from the percentile method, which appeared to represent the long-term productivity of the system, supported this recommendation, including lowering the lower end of the SEG.

Afognak Lake

The data available for the Afognak Lake sockeye salmon escapement goal analyses and the associated results of those analyses are located in Table 6 and Appendix E.

Stock Status

The Afognak Lake sockeye salmon SEG of 40,000 to 60,000 was adopted in 1988 (Table 1; Appendix E1). The escapement has been enumerated with a counting weir annually since 1978. Since 1978, escapements were within the current SEG during 7 years, below the SEG during 6 years and have exceeded the upper goal range during 14 years (Appendices E2 and E3). Escapements averaged about 64,000 fish from 1995 to 2004; however, the run declined substantially after 2000, averaging about 22,000 fish. Escapement in 2004 was only 15,000 sockeye salmon. Commercial, sport and subsistence harvests of this stock were restricted in 2001 and closed in 2002 to 2004.

Spawner-Recruit Analysis

Afognak Lake sockeye salmon escapements averaged about 78,000 (approximate range: 26,000 to 129,000) fish, from 1982 to 1997 (Appendices E2-E4). Returns from these brood years averaged about 101,000 sockeye salmon. The contrast in the escapement data for this time period was 5.1, above the recommended minimum contrast level of 4.0 (CTC 1999).

Ricker and gamma spawner-recruit models were fit to the fully recruited brood year spawner-recruit data from 1982 to 1997. The Ricker model was significant (P=0.007) and resulted in an estimate of S_{msy} of about 34,000 spawners with an escapement range of approximately 22,000 to 48,000 spawners, while S_{eq} was estimated at about 90,000 sockeye salmon (Appendix E5). The lower bound on the range is lower than any observed escapement from this time period. No autocorrelation was found in the Ricker model residuals; however, there is a parabolic trend in the residuals by year (Appendices E6-E8). It is difficult to characterize the influence of the fertilization due to the dome shape of the residuals. The gamma model was also significant (P=0.03) and resulted in an estimate of S_{msy} of about 59,000 spawners with an escapement range of approximately 49,000 to 69,000 spawners, while S_{eq} was estimated at about 98,000 sockeye salmon (Appendix E5). No autocorrelation was found in the gamma model residuals, which are different than those of the Ricker model; however, there is a parabolic trend in the residuals by year (Appendices E8-E9). As with the residuals from the Ricker model, it is difficult to characterize the influence of the fertilization due to the dome shape of the residuals. The gamma model had an AIC of 35.5, while the Ricker model had an AIC of 39.0. The AIC estimates indicate that the gamma model is the better fit.

Percentile Approach

An SEG for Afognak Lake sockeye salmon was estimated according to the percentile approach using 4 sets of escapement estimates (Bue and Hasbrouck 2001; Table 6). The first SEG estimate was determined using weir counts (1921 to 1933, 1978 to 2004) and aerial survey estimates (1966 to 1977). High contrast (440) in the escapement estimates and low exploitation of this stock resulted in an SEG of 7,000 to 77,000 (15^{th} to 75^{th} percentiles). Weir escapement data were used from 1921-1933 and 1978-2004 for the second SEG estimate (contrast 21), resulting in an SEG of 18,000 to 86,000 (15^{th} to 75^{th} percentiles). The third SEG estimate was based on weir counts from 1978 to 2004. There was high contrast (8.7) in the escapement estimates, which resulted in an SEG of 27,000 to 92,000 (15^{th} to 75^{th} percentiles). The last SEG estimate was based on weir count data from 1978 to 1993. These data were used because a nutrient enrichment and supplemental juvenile sockeye salmon stocking project was implemented from 1990 to 2000, which could have artificially increased adult production. There was high contrast (19.7) in the escapement estimates resulting in an SEG of 11,000 to 79,000 (15^{th} to 75^{th} percentiles).

Euphotic Volume Model

Based on an average EV of $49.45x10^6m^3$, the adult escapement capacity of Afognak Lake is estimated to be from 39,000 to 44,000 sockeye salmon (Table 6).

Smolt Biomass as a Function of Zooplankton Biomass

Dependent upon smolt size and the associated marine survival, the zooplankton model using data from all years yielded escapement estimates of 49,000 (3.5-g smolt), 43,000 (5.0-g smolt), and 62,000 (2.0-g smolt) sockeye salmon (Table 6). When excluding fertilization and stocking affects from the model, estimates of escapement were 28,000 (3.5-g smolt), 25,000 (5.0-g smolt), and 36,000 (2.0-g smolt) sockeye salmon (Table 6). The latter estimates are more appropriate because there are no plans to fertilize this lake in the future and the zooplankton biomass has not responded to recent-year low escapement levels.

Spawning Habitat Model

Based on the estimate of the total spawning habitat within the Afognak Lake system, White et al. (1990) estimated the adult carrying capacity of Afognak Lake to be roughly 66,000 sockeye salmon. (Table 6).

Escapement Goal Recommendation

The team recommended changing the current Afognak Lake SEG to a BEG of 20,000 to 50,000 fish based on the Ricker spawner-recruit curve and the results of the zooplankton biomass assessment that excluded the years the lake was fertilized (Table 6; Appendix E1). The latter assessment suggested a lower lake rearing capacity, which was supported by recent escapement trends.

Little River

The data available for the Little River sockeye salmon escapement goal analyses and the associated results of those analyses are located in Appendix F.

Stock Status

The current SEG for Little River sockeye salmon is 15,000 to 25,000 (Table 1; Appendix F1). Aerial surveys were conducted from 1975 to 2000, and in 2004. Weir counts were available from 2001 to 2003 (Appendices F2 and F3). The average aerial survey peak escapement estimate was about 14,000, with a range of 2,800 to 35,500. The average weir count escapement estimate was about 37,000, with a range of 4,000 to 74,000. Peak aerial survey estimates tended to fall below the current SEG, while 2 of the 3 years with weir counts were above the SEG (Appendix F3).

Percentile Approach

There were 2 sets of SEGs estimated according to the percentile approach. The first SEG was estimated using peak aerial survey escapement estimates from 1975 to 2000 and 2004, and weir counts from 2001 to 2003 (weir and aerial surveys). The SEG was estimated using just the peak aerial survey escapement estimates from 1975 to 2000 and 2004 (aerial surveys only). High contrast in both sets of escapement estimates and low exploitation resulted in selection of the 15th and 75th percentiles to estimate the SEG (Bue and Hasbrouck 2001). Using the 15th and 75th percentiles resulted in an SEG of 5,100 to 18,500 (weir and aerial survey data only) and 4,900 to 17,000 (aerial survey data only).

Risk Analysis

The Little River sockeye salmon escapement counts from the weir and aerial surveys, and from aerial surveys only, were lognormally distributed with no autocorrelation. The percent difference between the mean and minimum escapement estimates was 83% for the weir and aerial surveys. An SEG of 9,900 resulted in a 5.5% risk of an unwarranted concern, and a 5.5% estimated risk that a drop in mean escapement of 83% would not be detected (Appendix F4). The percent difference between the mean and minimum escapement estimates was 79% for the aerial surveys only. An SEG of 9,100 resulted in a 5.1% risk of an unwarranted concern, and a 5.1% estimated risk that a drop in mean escapement of 79% would not be detected (Appendix F5).

Escapement Goal Recommendation

The team recommended eliminating the Little River sockeye SEG. This recommendation was based on the fact that reliable escapement estimates have not been consistently collected for this stock and, due to budget constraints, are not expected in the future. In addition, it is not possible to actively manage escapements to this system.

Uganik Lake

The data available for the Uganik Lake sockeye salmon escapement goal analyses and the associated results of those analyses are located in Table 7 and Appendix G.

Stock Status

The current Uganik Lake sockeye SEG of 40,000 to 60,000 fish was adopted in the late-1980s (Table 1; Appendix G1). Escapements, as indexed from aerial surveys, were generally within the range between 1974 and 1986 and generally fell below the lower end of the goal since 1987 (Appendices G2-G3). Escapement estimates, based on weir counts from 1990 to 1992, were above the current SEG suggesting that aerial surveys were only capturing a portion of the true escapement.

Percentile Approach

An SEG for Uganik Lake sockeye salmon was estimated according to the percentile approach using 4 sets of escapement estimates (Bue and Hasbrouck 2001). The first SEG estimate was determined using aerial survey estimates and weir counts from 1974 to 2003. High contrast (31.4) in the escapement estimates and high exploitation of this stock resulted in an SEG of 25,000 to 50,000 (25th to 75th percentiles; Table 7). Similar results were obtained using aerial survey estimates from 1974-1988. Medium contrast (7.1) in the escapement estimates resulted in selection of the 15th to 85th percentiles translating to an SEG of 21,000 to 53,000. The third SEG estimate was determined using aerial survey estimates and weir counts since 1989. This data set exhibited high contrast (31.4) resulting in selection of the 25th to 75th percentiles and an SEG of 24,000 to 48,000. Finally, when all weir count data (1928 to 1932 and 1990 to 1992) were used, the resulting SEG was 24,000 to 66,000 (contrast = 31.4; 25th to 75th percentiles).

Risk Analysis

The Uganik Lake observed escapement data (since 1974) were lognormally distributed with no autocorrelation. The percent difference between the mean and minimum escapement estimates was 92%. An SEG of 18,000 resulted in a 1.0% risk of an unwarranted concern, and a 1.0% estimated risk that a drop in mean escapement of 92% would not be detected (Table 7; Appendix G4).

The Uganik Lake observed escapement data, not including weir operation years, were lognormally distributed with no autocorrelation. The percent difference between the mean and minimum escapement estimates was 91%. An SEG of 16,000 resulted in a 1.0% risk of an unwarranted concern, and a 1.0% estimated risk that a drop in mean escapement of 91% would not be detected (Table 7; Appendix G4).

Euphotic Volume Model

Based on average EV of $58.87 \times 10^6 m^3$, Uganik Lake adult escapement capacity was estimated to be approximately 47,000 adult sockeye salmon annually, with an escapement goal range between of 47,000 and 53,000 sockeye salmon (Table 7).

Smolt Biomass as a Function of Zooplankton Biomass

Dependent upon smolt size and the associated marine survival, the zooplankton model yielded escapement estimates of 17,000 (5.0-g smolt), and 24,000 (2.0-g smolt) sockeye salmon (Table 7).

Escapement Goal Recommendation

The team recommended eliminating the Uganik sockeye salmon SEG (Table 1; Appendices G1). This recommendation was based on the fact that reliable escapement estimates have not been consistently collected for this stock and, due to budget constraints, are not expected in the future. In addition, it is not possible to actively manage escapements specific to this system. It is difficult to detect sockeye salmon, via aerial surveys, in this turbid glacially fed system until mid-July, when the darker colored sockeye start moving onto the spawning grounds in the Upper Uganik River.

In general, the EV model and the percentile approach yielded similar results when considering that the peak aerial survey escapement indices are likely underestimating the true escapement. The zooplankton model results were a little lower than the other methods, suggesting rearing limiting conditions in Uganik Lake for juvenile sockeye salmon. Glacial meltwater, which increases lake turbidity, was found to decrease the annual production of juvenile sockeye salmon in several Alaskan lakes (Lloyd et al. 1987). Despite any possible rearing limitations, Uganik Lake has been historically and is presently a healthy sockeye producing system; the 2004 peak aerial survey count estimated 84,000 sockeye in the Uganik Lake in July.

Karluk Lake

The data available for the Karluk Lake sockeye salmon escapement goal analyses and the associated results of those analyses are located in Table 8 and Appendix H.

Stock Status

Early Run

The Karluk Lake early-run sockeye BEG of 150,000 to 250,000 was adopted in 1992 (Table 1; Appendix H1). The escapement has been enumerated with a counting weir annually since 1922. Since 1985, escapements have been within the current BEG range during 4 years and have exceeded the goal during 15 years (Appendix H2 and H5). Stock-specific harvest estimates were available from 1985 to 2003.

Late Run

The Karluk Lake late-run sockeye BEG of 400,000 to 550,000 was adopted in 1992 (Table 8; Appendix H1). The escapement has been enumerated with a counting weir annually since 1922. Since 1985, escapements have been within the current BEG range during 7 years, fell below the goal during 5 years and have exceeded the goal during 7 years (Appendix H3 and H6). Stock-specific harvest estimates were available from 1985 to 2003.

Total Run

The sum of the early- and late-run goals for Karluk is 550,000 to 800,000 (Table 8; Appendix H1). Since 1985, combined-early and late-run escapements have been within the combined escapement goal range during 9 years and have exceeded the goal during 10 years (Appendix H4 and H7). Stock-specific harvest estimates were available from 1985 to 2003.

Spawner-Recruit Analysis

Early Run

Sockeye salmon escapements averaged about 254,000 (approximate range: 98,000 to 359,000) fish for the early run, from 1981 to 1996 (Appendix H2, H5, and H8). Returns from these brood years averaged about 473,000 sockeye salmon. The contrast in the early-run escapement data for this time period was 3.6, just below the recommended minimum contrast level of 4.0 (CTC 1999).

A Ricker spawner-recruit model was fit to the fully recruited brood year spawner-recruit data 1981 to 1996. The Ricker model was significant (P=0.001; Appendix H11; Table 8) and resulted in an estimate of S_{msy} of about 148,000 spawners with an escapement range of approximately 94,000 to 211,000 spawners, while S_{eq} was estimated at about 399,000 sockeye salmon. The lower bound on the range is lower than any observed escapement from this time period. No autocorrelation was found in the Ricker model residuals (Appendix H14).

The residuals for the Karluk early-run did not exhibit a trend; however, there seemed to be more variability in earlier years (Appendix H17). During years affected by fertilization, the residuals were lower and then increased (for the short time series), but there did not seem to be a linear trend (Appendix H17). During years affected by stocking, the residuals tended to be more variable (Appendix H18).

Late Run

Sockeye salmon escapements averaged about 436,000 (approximate range: 42,000 to 832,000) fish for the late run, from 1981 to 1996 (Appendix H3, H6, and H9). Returns averaged about 838,000 sockeye salmon for the late run during these years. The contrast in the late-run escapement data for this time period was 20.0, well above the recommended minimum contrast level of 4.0 (CTC 1999).

A Ricker spawner-recruit model was fit to the fully recruited brood year spawner-recruit data 1981 to 1996. The Ricker model was significant (P=0.0003; Appendix H12; Table 8) and resulted in an estimate of S_{msy} of about 266,000 spawners with an escapement range of approximately 169,000 to 381,000 spawners, while S_{eq} was estimated at about 736,000 sockeye salmon. No autocorrelation was found in the Ricker model residuals (Appendix H15).

The residuals for the Karluk late-run Ricker spawner-recruit model did not exhibit a trend; however, there seemed to be more variability in earlier years (Appendix H19). During years affected by fertilization, the residuals were lower and then increased (for the short time series), but there did not seem to be a linear trend (Appendix H19). During years affected by stocking, the residuals tended to be more variable (Appendix 20).

Total Run

Sockeye salmon escapements averaged about 691,000 (approximate range: 164,000 to 1,110,000) fish for the combined run, from 1981 to 1996 (Appendix H4, H7, and H10). Returns averaged about 1,310,000 sockeye salmon for the combined run during these years. The contrast in the combined-run escapement data for this time period was 6.8, above the recommended minimum contrast level of 4.0 (CTC 1999).

A Ricker spawner-recruit model was fit to the fully recruited brood year spawner-recruit data 1982 to 1996. The Ricker model was significant (P=0.0006; Appendix H13; Table 8) and resulted in an estimate of S_{msy} of about 463,000 spawners with an escapement range of approximately 296,000 to 655,000 spawners, while S_{eq} was estimated at about 1,210,000 sockeye salmon. No autocorrelation was found in the Ricker model residuals (Appendix H16).

The residuals for the Karluk combined run Ricker spawner-recruit model did not exhibit a trend; however, there seemed to be more variability in earlier years (Appendix H21 and H22). Since 1988, there seems to be a slight increasing trend (especially if you ignore 1992). However, with the short time period (< 10 years), it is difficult to be sure there is a true trend in the data.

There doesn’t seem to be strong correlation between the early- and late-run residuals from their respective Ricker models during either the years affected by fertilization (Appendix H23) or stocking (Appendix H24). However, since 1988 there does seem to be a positive correlation, which seems consistent with the overall increase in the residuals from the combined model (Appendix H21 and H22).

Euphotic Volume Model

Based on average EV, the adult escapement capacity of Karluk Lake is expected to be roughly 2,000,000 sockeye salmon resulting in an escapement goal range of about 670,000 to 754,000 (Table 8).

Smolt Biomass as a Function of Zooplankton Biomass

Depending on the size of the resultant smolt, the zooplankton model results in an escapement goal range of 1,484,000 (5.0-g smolt) to 2,119,000 (2.0-g smolt) sockeye salmon for Karluk Lake based on the biomass of smolt produced, smolt-to-adult survival, and a harvest exploitation rate of 0.65 (Table 8). Using the same zooplankton data with the predicted number of smolt the lake can produce was also used to back calculate how many adults are required to produce that number of smolt, based on fecundity and survival estimates specific to Karluk and resulted in an escapement goal range of 1,079,000 to 2,697,000 (Table 8).

Escapement Goal Recommendation

The team recommended changing the current Karluk Lake early-run BEG (150,000 to 250,000) to a BEG of 100,000 to 210,000 fish with a (S_{msy} = 150,000) fish based on the Ricker spawner-recruit curve (Table 1). The committee recommended changing the current Karluk Lake late-run BEG to a BEG of 170,000 to 380,000 (S_{msy} = 270,000) fish based on the Ricker spawner-recruit curve.

Several events relating to Karluk Lake sockeye salmon complicated analysis of the escapement goals. The estimated harvest assigned to Karluk prior to 1985 (completed brood year 1981) was considered by Barrett and Nelson (1995) to contain substantial errors. In addition, several Karluk Lake rehabilitation activities may have altered the natural state of the spawner-recruit relationship. From 1986 to 1990, Karluk Lake was fertilized to enhance juvenile sockeye salmon survival (Schrof and Honnold 2003). ADF&G also back stocked sockeye salmon fry into the Upper Thumb River in the Karluk Lake watershed after eggs were incubated at the Kitoi Bay Hatchery from 1979 to 1987. The data used for the spawner-recruit analysis includes 1981 to 1996 brood years (16 years) and the rehabilitation activities may have had an effect on brood years 1981 to 1995 (15 years).

Significant spawner-recruit relationships were found for the early run, late run, and both runs combined. Estimates for S_{msy} in all 3 cases were lower than the existing goals and lower than most recent escapements. The S_{msy} estimate (148,000) for the early run was similar to the lower end of the existing BEG range (150,000); however, there were few data points near that estimate and there was low contrast in the data. The late run data had sufficient contrast (20.0), and the estimate for S_{msy} (266,000) was below the current goal range of 400,000 to 550,000. The estimate for S_{msy} using the spawner-recruit relationship for the early and late runs combined was 463,000 spawners which was well below the goal range of 550,000 to 800,000 sockeye salmon. As with the early run, there were few recent escapements that occurred near the lower end of the 90% MSY estimate.

The escapement goal estimates that were calculated from smolt biomass as a function of zooplankton biomass model are larger than current goals and recent escapements. This provides evidence that, under current conditions and escapement levels, the rearing environment is not limiting production.

The resulting escapement goal range estimated using the EV model is similar to recent escapement levels providing additional evidence that Karluk Lake is not rearing limited at current escapement levels.

Previous analyses of spawner-recruit relationships for Karluk Lake sockeye salmon utilized harvests or indices of harvests from the west side of the Kodiak Archipelago. Results from the

Karluk Lake run reconstruction utilizing an age marker analysis (Barrett and Nelson 1994) indicate that the proportion of west-side Kodiak harvests that can be attributed to Karluk Lake is extremely variable. This may explain the substantial differences in results between this analysis and previous escapement goal analyses.

Caution must be used when interpreting the results of these analyses. Recent escapements however, have produced strong returns with large harvestable surpluses with a large range in parent-year escapements. Significant spawner-recruit relationships for the early and late runs indicate that S_{msy} can be achieved at escapements lower than the current goal ranges. Large escapements (average 905,000) during the past 5 years should provide evidence as to potential escapement goal modification in the near future when those brood years are fully recruited.

Ayakulik River

The data available for the Ayakulik River sockeye escapement goal analyses and the associated results of those analyses are located in Table 9 and Appendix I.

Stock Status

The current Ayakulik River sockeye SEG of 200,000 to 300,000 was adopted in 1983 (Table 1; Appendix I1). The escapement has been enumerated with a counting weir intermittently since 1929 and annually since 1962 (Appendix I2). Since 1984, escapements have been within the current SEG range during 9 years, have exceeded the goal during 11 years, and have been below the goal once (Appendix I3). Stock-specific harvest estimates were available from 1970 to 2004.

Spawner-Recruit Analysis

Sockeye salmon escapements averaged about 272,000 (approximate range: 34,000 to 774,000) fish for Ayakulik River, from 1966 to 1998 (Appendix I4). Returns from these brood years averaged about 591,000 sockeye salmon. The contrast in escapement data for this time period was 22.8, above the recommended minimum contrast level of 4.0 (CTC 1999).

Ricker and a gamma spawner-recruit models were fit to the fully recruited brood year spawner-recruit data 1966 to 1998. The Ricker model was not significant (P=0.34). The gamma model was significant (P=0.0002) and resulted in an estimate of S_{msy} of about 478,000 spawners with an escapement range of approximately 329,000 to 639,000 spawners, while S_{eq} was estimated at about 1,055,000 sockeye salmon (Table 9; Appendix I5). Significant autocorrelation was found in the gamma model residuals; before bias correction (Fair et al. 2004) the range was approximately 294,000 to 555,000 with a point estimate of 421,000.

Stock-Recruitment Yield Analysis

Different intervals were considered for Ayakulik River escapement and recruitment. The yield analysis tables had an escapement range from 0 to 500,000 fish, with intervals of 100,000 fish to create 5 intervals (Appendix I6). In addition, an escapement range from 50,000 to 450,000 fish was assessed with intervals of 100,000 fish. Analyses for both escapement ranges were performed with data sets from 1966 to 1998, resulting in 2 yield analyses. Neither analysis included the 2 points where the escapement was greater than 700,000 fish (1980 and 1989), though the average yield for these 2 points was 181,000 sockeye.

The smallest escapement interval (0 to100,000 and 0 to 50,000) in both methods included a relatively small number of years (< 5), and a low average and median yield (< 150,000). The highest average and median yield fell in the 350,000 to 450,000 escapement interval (Table 9;

Appendix I6). The second most productive escapement range was 300,000 to 400,000, however the median yield in this escapement interval was similar to that of the 200,000 to 300,000 interval.

Euphotic Volume Model

Based on average EV of 149.46x10^{6}m^3, Red Lake adult escapement capacity was estimated to be approximately 147,000 adult sockeye salmon annually, with an escapement goal range between of 119,000 and 134,000 sockeye salmon (Table 9).

Smolt Biomass as a Function of Zooplankton Biomass

Depending on the size of the resultant smolt (optimum 5.0-g smolt, or threshold 2.0-g smolt), the zooplankton model results in an estimated escapement goal range of 381,000 to 545,000 sockeye salmon for Red Lake based on the biomass of smolt produced, smolt-to-adult survival, and a harvest exploitation rate of 0.65 (Table 9). Using the larger than optimum size of Red Lake sockeye smolt sampled between 1990 and 1996 (8.7-g smolt), the escapement goal estimate was 365,000.

Escapement Goal Recommendation

After considering all analyses, the team recommended changing the current Ayakulik River SEG (200,000 to 300,000) to an SEG of 200,000 to 500,000 fish (Table 1). This modification would increase the current upper goal but leave the lower goal unchanged. The recommended escapement goal would be listed as an SEG, but was primarily based on a significant gamma spawner-recruit model and yield analyses. The new SEG range, which increases the upper bound and retains the lower bound, would achieve 3 objectives: 1) contain the estimate of S_{msy} resulting from the spawner-recruit model, 2) recognize the uncertainty in a model estimation of S_{msy} which is well removed from the majority of the data points, and 3) allow managers to increase escapement levels during years of high productivity, which will provide additional data necessary to remove the uncertainty associated with the estimate of S_{msy}.

The spawner-recruit, stock-recruitment yield, and zooplankton biomass analyses all suggested that an increase in the current SEG would increase the likelihood of the range containing the optimal level of escapement to maximize yield.

The EV model results indicate an optimal escapement goal range that was only one-third to one-half what historical escapement counts confirm is sustainable. This information, combined with the zooplankton biomass analysis, suggests that Red Lake is very productive, for its size. However, the EV model and the zooplankton biomass model should be viewed with caution due to the fact that limnology data were only collected from 1990 to 1996. Another consideration in determining the escapement goal for the Ayakulik River is that Red Lake is not the only spawning and rearing location in the watershed. Bare Lake is known to, and the 35-km mainstem Ayakulik River is believed to, support both spawning and rearing populations of sockeye salmon.

Akalura Lake

The data available for the Akalura Lake sockeye salmon escapement goal analyses and the associated results of those analyses are located in Table 10 and Appendix J.

Stock Status

The current Akalura Lake sockeye SEG of 40,000 to 60,000 was adopted in 1988 (Table 1; Appendix J1). From the 1920s through the 1940s, before the goal was implemented, escapement often exceeded the goal (Appendices J2 and J3). Thereafter, escapement fell below the SEG until 1989, when the Exxon Valdez oil spill occurred and, due to fishery closures, escapement substantially exceeded the upper end (Appendix J3). During the 14 years from 1990 to 2003, escapement has been within the range 4 times and exceeded the upper goal once (Appendix J3). The escapement has averaged 16,578 sockeye salmon from 1994 to 2003. Approximately 1,500 sockeye salmon were estimated from 1 aerial survey (8 August) in 2004; this count likely does not represent the total escapement.

Percentile Approach

An SEG for Akalura Lake sockeye salmon was estimated according to the percentile approach using 4 sets of escapement estimates (Bue and Hasbrouck 2001; Table 10). The first SEG estimate was determined using aerial survey estimates and weir counts from 1923 to 2003. High contrast (571.2) in the escapement estimates and high exploitation of this stock resulted in an SEG of 6,000 to 46,000 (25th to 75th percentiles; Table 10). Aerial survey estimates and weir counts from 1970 to 2003 were used for the second SEG estimate. These data were selected because the team agreed that they better represent current productivity of the system. There was high contrast (31.5) in the escapement estimates, which resulted in an SEG of 6,000 to 23,000 (25th to 75th percentiles). Weir count data were used for the remaining estimates due to perceived bias associated with aerial survey estimates. The third SEG estimate was based on weir count data from 1923 to 2003. Again, there was high contrast (571.2) in the escapement estimates resulting in an SEG of 7,000 to 48,000 (25th to 75th percentiles). The last SEG estimate was based on weir count data from 1970 to 2003, resulting in an SEG of 7,000 to 27,000 (contrast = 31.5; 25th to 75th percentiles).

Smolts-per-Spawner

Sockeye escapements to Akalura Lake of about 39,000 (8.8 SPS) and 31,000 (9.4 SPS) produced the most smolt (Table 10). Escapements from approximately 47,000 to 116,000 (1.5-2.3 SPS) produced the fewest smolt. An average escapement of about 35,000 produced the most smolt.

Euphotic Volume Model

Based on average EV of $50.47 \times 10^6 m^3$, Akalura Lake adult escapement capacity was estimated to be approximately 126,000 adult sockeye salmon annually, with an escapement goal range between of 40,000 and 45,000 sockeye salmon (Table 10).

Smolt Biomass as a Function of Zooplankton Biomass

Dependent upon smolt size and the associated marine survival, the zooplankton model yielded escapement estimates of 50,000 (5.0-g smolt), 53,000 (4.7-g smolt), and 72,000 (2.0-g smolt) sockeye salmon (Table 10). The larger estimate, however, was based on 2.0-g smolt, whereas Akalura Lake sockeye salmon smolt have averaged 4.7-g. Thus, an escapement goal range between 50,000 and 53,000 is more appropriate.

Spawning Habitat Model

Based on the estimate of the total spawning habitat within the Akalura Lake system, Edmundson et al. (1994) estimated the adult carrying capacity of Akalura Lake to be roughly 87,000 sockeye salmon. (Table 10).

Escapement Goal Recommendation

The team recommended eliminating the Akalura sockeye salmon SEG (Table 1; Appendices J1). This recommendation was based on the fact that reliable escapement estimates have not been consistently collected for this stock and, due to budget constraints, are not expected in the future. In addition, it is not possible to actively manage escapements specific to this system.

Upper Station (South Olga Lakes)

The data available for the Upper Station sockeye salmon escapement goal analyses and the associated results of those analyses are located in Table 11 and Appendix K.

Stock Status

Early Run

The current Upper Station early-run sockeye SEG of 50,000 to 75,000 was adopted in 1988 (Table 1; Appendix K1). An OEG of 25,000 was adopted by the BOF in 1999. The early run escapement has been enumerated with a counting weir annually since 1969 (Appendix K2). Since 1969, escapements have been within the goal range during 16 years and have exceeded the upper goal range during 5 years (Appendix K5). During this 35 year period, the OEG was met or exceeded during 31 years. In recent years (1994 to 2003), escapements have been within the goal range during 4 years and have exceeded the upper goal range once. During this 10 year period, the OEG was exceeded each year. Stock-specific harvest estimates are available from 1971 to 2003.

Late Run

The Upper Station late-run sockeye SEG of 150,000 to 200,000 was adopted in 1988 (Table 1; Appendix K1). The escapement has been enumerated with a counting weir annually since 1966 (Appendix K3). Since 1966, escapements have fallen within the SEG range during 8 years and have exceeded the goal during 14 years (Appendix K6). During this 38 year period, escapements were below the goal during 16 years. In recent years (1994 to 2003), escapements have fallen within the SEG range during 3 years and have exceeded the goal during 6 years (Appendix K6). Stock-specific harvest estimates are available from 1971 to 2003.

Total Run

The sum of the current early- and late-run Upper Station sockeye SEGs is 200,000 to 275,000 (Appendix K1). Since 1969, escapements have been within or above the goal during 21 years and below the goal during 14 years (Appendix K7). From 1994 to 2003, escapements have met or exceeded the upper end during 8 years. Stock-specific harvest estimates were available from 1971 to 2003.

Spawner-Recruit Analysis

Early Run

Upper Station sockeye salmon escapements averaged about 53,000 (approximate range: 10,000 to 171,000) fish for the early run, from 1969 to 1997 (Appendix K2, K5, and K8). Returns from these brood years averaged about 107,000 sockeye salmon. The contrast in the early-run escapement data for this time period was 16.5 (Appendix K1), well above the recommended minimum contrast level of 4.0 (CTC 1999).

A Ricker spawner-recruit model was fit to the fully recruited brood year spawner-recruit data from 1969 to 1997 (Table 11; Appendix K8). The Ricker model was not significant ($P>0.05$). Another Ricker spawner-recruit model was fit to the early-run data from 1975 to 1997. The selection of this time series was based on the major change in ocean climate (regime shift) in the GOA in 1976-1977. The contrast level of escapement for these years was 8.9, still above the recommended minimum contrast level of 4.0 (CTC 1999). However, the spawner-recruit relationship was not significant ($P>0.05$).

Late Run

Upper Station sockeye salmon escapements averaged about 172,000 (approximate range: 37,000 to 408,000) fish for the late run from 1969 to 1997 (Appendix K3, K6, and K9). Returns averaged about 498,000 sockeye salmon for the late run during these years. The contrast in the late-run escapement data for this time period was 11.1, well above the recommended minimum contrast level of 4.0 (CTC 1999).

A Ricker spawner-recruit model was fit to the fully recruited 1969 to 1997 brood year spawner-recruit data. The Ricker model was not significant ($P>0.05$). Another Ricker spawner-recruit model was fit to the late-run data from 1975 to 1997. The selection of this time series was based on the major change in ocean climate (regime shift) in the GOA in 1976-1977. The contrast level of escapement for these years was 10.7, well above the recommended minimum contrast level of 4.0 (Appendix K1; CTC 1999). The Ricker model was significant ($P=0.02$) and resulted in an estimate of S_{msy} of about 186,000 spawners with an escapement range of approximately 118,000 to 265,000 spawners, while S_{eq} was estimated at about 504,000 sockeye salmon (Table 11; Appendix K11). No autocorrelation was found in the Ricker model residuals (Appendix K12).

Total Run

Upper Station sockeye salmon escapements averaged about 225,000 (approximate range: 53,000 to 477,000) fish for the combined run from 1969 to 1997 (Appendix K4, K7, and K10). Returns averaged about 618,000 sockeye salmon for the combined run during these years. The contrast in the combined-run escapement data for this time period was 9.0, above the recommended minimum contrast level of 4.0 (CTC 1999).

A Ricker spawner-recruit model was fit to the fully recruited brood year 1969 to 1997 spawner-recruit data; however, it was not significant ($P>0.05$; Table 11). Another Ricker spawner-recruit model was fit to the combined-run data from 1975 to 1997. The selection of this time series was based on the major change in ocean climate (regime shift) in the GOA in

1976-1977. The contrast level of escapement for these years was 8.9 still above the recommended minimum contrast level of 4.0 (CTC 1999). However, the spawner-recruit relationship was not significant ($P>0.05$).

Percentile Approach

Upper Station early-run, late-run, and combined-run goals were estimated according to the percentile approach using weir counts from 1969 to 2003 (Bue and Hasbrouck 2001; Table 11). High contrast (16.5) in the early-run escapement estimates and high exploitation of this stock resulted in a goal range of 32,000 to 65,000 (25th to 75th percentiles). High contrast (11.1) in the late-run escapement estimates and high exploitation resulted a goal range of 76,000 to 226,000 (25th to 75th percentiles). High contrast (9.0) in the combined-run escapement estimates and high exploitation resulted in a goal range of 122,000 to 286,000 (25th to 75th percentiles).

Euphotic Volume Model

Based on average EV (combined for both lakes) of $156.0 \times 10^6 m^3$, Upper Station adult escapement capacity was estimated to be approximately 390,000 adult sockeye salmon annually, with an escapement goal range between of 125,000 and 140,000 sockeye salmon (Table 11).

Smolt Biomass as a Function of Zooplankton Biomass

Dependent upon smolt size and the associated marine survival, the zooplankton model yielded escapement estimates of 222,000 (6.6-g and 1.9-g smolt), 291,000 (5.0-g smolt), and 415,000 (2.0-g smolt) sockeye salmon (Table 11).

Spawning Habitat Model

Based on the estimate of the total spawning habitat within the Upper Station system, about 20,000 early-run (tributary) sockeye and 630,000 late-run (outlets and shoals) sockeye would be supported (Table 11). These spawner capacity estimates are based on a cursory survey of habitat and should be considered preliminary data; however, the estimates suggest spawning limitation for the early run and that the system is rearing limited for the late run.

Escapement Goal Recommendation

The team recommended changing the current Upper Station early-run sockeye SEG to an SEG of 30,000 to 65,000 fish based on the escapement percentile assessment (Table 1). The committee also recommended changing the current Upper Station late-run sockeye SEG to a BEG of 120,000 to 265,000 fish (S_{msy}=186,000) based on the significant Ricker spawner-recruit relationship. Combining the early- and late-run goals results in an overall goal of 150,000 to 330,000, which is similar to the range of lake rearing capacity based on zooplankton biomass.

Frazer Lake

The data available for the Frazer Lake sockeye salmon escapement goal analyses and the associated results of those analyses are located in Table 12 and Appendix L.

Stock Status

The current Frazer Lake sockeye salmon BEG of 140,000 to 200,000 was adopted in 1988 (Table 1; Appendix L1). Before the goal was implemented, escapements were generally below the BEG range except during the 1980s, when escapements substantially exceeded the goal 6 times (Appendices L2 and L3). Since the goal was implemented (1988 to 2003), escapements have averaged about 203,000 sockeye salmon. The 2004 escapement count was approximately 121,000 sockeye salmon.

Spawner-Recruit Analysis

Frazer Lake sockeye salmon escapements averaged about 161,000 (approximate range: 14,000 to 485,000) fish from 1966 to 1995 (Appendices L2-L4). Returns from these brood years averaged about 426,000 sockeye salmon. The contrast in the escapement data for this time period was 34.6, well above the recommended minimum contrast level of 4.0 (CTC 1999).

Ricker spawner-recruit models (with and without fertilization effects) were fit to the Frazer Lake fully recruited brood year spawner-recruit data from 1966 to 1995 (Table 12; Appendices L5-L9). For the spawner-recruit data including years of fertilization (1966-1995), the Ricker model with multiplicative error was significant (P=0.0003) and resulted in an estimate of S_{msy} of about 124,000 spawners with an escapement range of approximately 80,000 to 176,000 spawners, while S_{eq} was estimated at about 328,000 sockeye salmon. No autocorrelation was found in the Ricker model residuals (Appendix L7). For the spawner-recruit data not including years of fertilization (1966-1984 and 1992-1995), the Ricker model with multiplicative error was significant (P=0.0006) and resulted in an estimate of S_{msy} of about 105,000 spawners with an escapement range of approximately 68,000 to 149,000 spawners, while S_{eq} was estimated at about 272,000 sockeye salmon. No autocorrelation was found in the Ricker model residuals (Appendix L9).

The residuals for the Frazer Lake run exhibited a slight upward trend, with greater variability in the 1980s (Appendix L8). The residuals of years affected by fertilization are consistent with the residuals of years not affected by fertilization.

Percentile Approach

An SEG for Frazer Lake sockeye salmon was estimated according to the percentile approach using four sets of escapement estimates (Bue and Hasbrouck 2001; Table 12). The first SEG estimate was determined using weir counts from 1956 to 2003 or years during run development to the present. High contrast (>80,000) in the escapement estimates and high exploitation of this stock resulted in an SEG of 17,000 to 199,000 (25^{th} to 75^{th} percentiles). Weir counts from 1978 to 2003, after the run was developed to the present, were used for the second SEG estimate. These data were selected because the team agreed that they better represent current productivity of the system. There was high contrast (12) in the escapement estimates, which resulted in an SEG of 155,000 to 232,000 (25^{th} to 75^{th} percentiles). The third SEG estimate was based on weir count data from 1978 to 2003, excluding 1992 to 2002 when escapements were affected by fertilization. Again, there was high contrast (12) in the escapement estimates resulting in an SEG of 134,000 to 369,000 (25^{th} to 75^{th} percentiles).

Smolts per Spawner

Escapements to Frazer Lake of about 178,000 to 205,000 (34 SPS) produced the most smolt (Table 12). Escapements from approximately 196,000 to 234,000 (10 SPS) produced the fewest smolt. An average escapement of about 190,000 produced the most smolt.

Euphotic Volume Model

Based on 2 average EV estimates of $261.83 \times 10^6 m^3$ (1987-1997) and $272.41 \times 10^6 m^3$ (1989-1997; 2001, 2002), Frazer Lake adult escapement capacity (escapement goal range) was estimated to be about 236,000 to 245,000 sockeye salmon (Table 12).

Smolt Biomass as a Function of Zooplankton Biomass

Dependent upon smolt size and the associated marine survival, the zooplankton model yielded escapement estimates of 74,000 (5.1-g smolt), 122,000 (5.0-g smolt), and 174,000 (2.0-g smolt) sockeye salmon (Table 12). The larger estimate, however, was based on 2.0-g smolt, whereas Frazer Lake sockeye salmon smolt have averaged 5.1-g. Thus, an escapement goal range between 74,000 and 122,000 is more appropriate. Excluding years of fertilization, the zooplankton model yielded escapement estimates of 83,000 (5.1-g smolt), 137,000 (5.0-g smolt), and 196,000 (2.0-g smolt) sockeye salmon (Table 12). Again, the larger estimate was based on 2.0-g smolt, so an escapement goal range between 83,000 and 137,000 is more appropriate.

Spawning Habitat Model

Based on the estimate of the total spawning habitat within the Frazer Lake system, Blackett (1979) estimated the adult carrying capacity of Frazer Lake to be roughly 365,000 sockeye salmon. (Table 12).

Escapement Goal Recommendation

The team recommended changing the current Frazer Lake BEG (140,000 to 200,000) to 70,000-150,000 fish based on the Ricker spawner-recruit curve excluding years affected by fertilization (Table 1; Appendix L1 and L6). Contrast in the escapement data from brood years 1966-1995 was excellent and the data time series was fairly long and of relatively good quality. The subsequent spawner-recruit model was significant with no autocorrelation in the residuals.

Although the results of the EV model indicate that Frazer Lake can support escapements at or above the current goal, the escapement goal estimates that were calculated from smolt biomass as a function of zooplankton biomass model suggest that zooplankton biomass limits production in the system. The latter results corroborate the spawner-recruit analysis and further support lowering the goal.

Buskin Lake

The data available for the Buskin Lake sockeye salmon escapement goal analyses and the associated results of those analyses are located in Appendix M.

Stock Status

The current Buskin Lake sockeye salmon SEG is 8,000 to 13,000 fish (Table 1; Appendix M1). The goal range was established in 1996 (Nelson and Lloyd 2001) based on historical weir counts and the desire to maintain escapements similar to historical levels; 8 of the 14 years of escapements are within the current SEG range, with all escapements within or above the range (Appendices M2 and M3).

Spawner-Recruit Analysis

Buskin Lake sockeye salmon escapements averaged about 13,350 (approximate range: 9,500 to 23,900) fish from 1990 through 2003 and averaged about 11,050 (approximate range 9,500 to 15,500) for brood years 1990 through 1997 (Appendices M2 and M4). Total brood year returns averaged about 23,050 sockeye salmon. The contrast in escapement data was 1.6 from 1990 through 1997, below the recommended minimum contrast level of 4.0 (CTC 1999).

Although the data are of sufficient quality to develop a BEG, the data provide insufficient information to estimate MSY and a range of escapements that should produce maximum sustained yield (S_{msy}). The beta parameter from the traditional linear Ricker analysis was not significant (P = 0.21). In the Bayesian analysis, both the posterior distribution of the beta parameter and of S_{msy} were very wide. These results indicate the data provide insufficient information to accurately estimate MSY or S_{msy}.

Escapement Goal Recommendation

The team recommended no change in the current SEG. The current spawner-recruit data does not provide enough information to develop a BEG for this stock; although the estimates of S_{msy} in the Bayesian analyses had low precision, the data suggested point estimates of S_{msy} may be lower than the lower end of the current SEG range. The current SEG has always been obtained since 1990, has provided harvest (yield), and is sustainable. Assessment of this stock will continue, providing additional spawner-recruit data so that potentially a BEG can be developed in 3 years.

Pasagshak River

The data available for the Pasagshak River sockeye salmon escapement goal analyses and the associated results of those analyses are located in Appendix N.

Stock Status

The current Pasagshak River sockeye salmon SEG is 1,000 to 5,000 fish (Table 1; Appendix N1). The SEG was established in 1988 (Nelson and Lloyd 2001) based on historical aerial survey index counts and to some extent cursory spawning habitat evaluations. Nelson and Lloyd (2001) noted that there was some consideration that this goal may be too low; 18 of the 35 years of escapement indices are within the current SEG range, with most recent escapements within or above the range (Appendices N2 and N3).

Percentile Approach

An SEG for Pasagshak River sockeye salmon was estimated according to the percentile approach using aerial and foot survey escapement estimates from 1968-2003. High contrast in the escapement estimates (125) and high exploitation of this stock resulted in an SEG of 3,000 to 12,000 (approximately 25th to 75th percentiles).

Risk Analysis

The Pasagshak River sockeye salmon escapement index time series followed a lognormal distribution ($P > 0.15$). The log-transformed escapement time series had a significant ($P < 0.05$) lag-2 serial correlation. When the index count for either 1971 or 1973, the years with the 2 lowest index counts in the time series, were deleted there was no longer any significant serial correlation. Therefore, a truly meaningful serial correlation does not appear in the escapement indices.

An escapement threshold of 3,700 sockeye salmon resulted in a 7% estimated risk (once in 14 years) of a concern, and a 7% estimated risk that a drop in mean escapement of 90% would not be detected (Appendix N4). Detecting a 90% drop is between a 97% drop from a mean of 7,125 ($\hat{\mu}$; $\hat{\sigma}$ = 6,413) to the minimum observed escapement index of 200 using all the data, and an

87% drop ($\hat{\mu}$ = 7,995; $\hat{\sigma}$ = 6,536; minimum index = 1,000) observed using index values from 1974 to 2003 (i.e., delete 2 years early in the time series with the 2 lowest observed index values). 3 consecutive escapements of 3,700 or less have occurred 3 times (1971-1973, 1983 to 1985, and 1984 to 1986) in the 37 years of indexed sockeye salmon escapements since 1968 for an observed risk of 8%. Only 2 of 37 years (5%) had missing data (Appendix N2).

Escapement Goal Recommendation

The team recommended changing the Pasagshak River sockeye SEG to 3,000 to 12,000 based on the percentile approach which was corroborated by the risk analysis. This range of escapements has continued to provide desired escapement levels as well as surplus production.

Saltery Lake

The data available for the Saltery Lake sockeye salmon escapement goal analyses and the associated results of those analyses are located in Table 13 and Appendix O.

Stock Status

The current Saltery Lake sockeye salmon BEG of 15,000 to 30,000 was adopted in 2001 (Table 1; Appendix O1). Escapements were within or above the BEG range each year from 1976 to 2003 (Appendices O2 and O3). The current BEG was exceeded 20 times during this period; however the goal was 20,000 to 40,000 until 2001, and escapement levels were within this goal 14 years during this 25 year period. Since the BEG was implemented (2001 to 2003), escapements have averaged about 44,000 sockeye salmon. The 2004 escapement count was approximately 55,000 sockeye salmon.

Spawner-Recruit Analysis

Sockeye salmon escapements averaged about 41,000 (approximate range: 18,000 to 120,000) fish from 1976 to 1996 (Appendices O2 and O3). Returns from these brood years averaged about 61,000 sockeye salmon. The contrast in the escapement data for this time period was 6.7, above the recommended minimum contrast level of 4.0 (CTC 1999).

A Ricker spawner-recruit model was fit to the Saltery Lake fully recruited brood year spawner-recruit data from 1976 to 1996 (Appendices O4). The Ricker model with multiplicative error was significant (P=0.0003) and resulted in an estimate of S_{msy} of about 23,000 spawners with an escapement range of approximately 15,000 to 33,000 spawners, while S_{eq} was estimated at about 60,000 sockeye salmon (Appendix O5). No autocorrelation was found in the Ricker model residuals (Appendix O6).

Percentile Approach

An SEG for Saltery Lake sockeye salmon was estimated according to the percentile approach using 2 sets of escapement estimates (Bue and Hasbrouck 2001; Table 13). The first SEG estimate was determined using all data from 1976 to 2003. Medium contrast (6.7) in the escapement estimates resulted in an SEG of about 26,000 to 58,000 (15th to 85th percentiles). Weir counts from 1976 to 2003 were used for the second SEG estimate, which had a low contrast (3.4) in the escapement estimates, and resulted in an SEG of approximately 28,000 to 77,000 (15th percentile to the maximum escapement estimate).

Euphotic Volume Model

Based on average EV of $9.11x10^6m^3$, Saltery Lake adult escapement capacity was estimated to be approximately 23,000 adult sockeye salmon annually, with an escapement goal range between 7,000 and 8,000 sockeye salmon (Table 13).

Smolt Biomass as a Function of Zooplankton Biomass

Dependent upon smolt size and the associated marine survival, the zooplankton model yielded escapement estimates of 14,000 (5.1-g smolt), 14,000 (5.0-g smolt), and 20,000 (2.0-g smolt) sockeye salmon (Table 13). The larger estimate, however, was based on 2.0-g smolt, whereas Saltery Lake sockeye salmon smolt have averaged 5.1-g. Thus, an escapement goal of about 14,000 is more appropriate.

Spawning Habitat Model

Based on the estimate of the total spawning habitat within the Saltery Lake system, Honnold and Sagalkin (2001) estimated the adult carrying capacity of Saltery Lake to be roughly 39,000 sockeye salmon. (Table 13).

Escapement Goal Recommendation

The team recommended maintaining the current Saltery Lake sockeye salmon BEG of 15,000 to 30,000 sockeye salmon based on the Ricker spawner-recruit curve (Table 1; Appendix O1). The EV model suggested a lower goal for Saltery Lake; however, light penetration is limited in the lake due to glacial influence, making the EV model inappropriate. The escapement goal estimates that were calculated from smolt biomass as a function of zooplankton biomass model suggest that zooplankton biomass limits production in the system. Zooplankton biomass has declined in recent years, possibly due to high escapements. This warrants caution in the short term when using this goal for managing the stock. It may be prudent to target S_{msy} (23,000) or the lower end of the goal.

COHO SALMON

Road Systems

American River

The data available for the American River coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices P1-P4.

Stock Status

The current American River coho salmon SEG is 300 to 400 (Table 2; Appendix P1) and was established in 1999 (Nelson and Lloyd 2001). Coho salmon in the American River are enumerated by foot survey. Since 1980 the SEG range has never been achieved, but has been underachieved 11 times and exceeded 10 times (Appendices P2 and P3).

Theoretical Spawner-Recruit Analysis

The average foot survey escapement estimate from 1980 to 2003 was 504 fish and average harvest was 1,048 fish (Appendices P2 and P3). Assuming Ricker α for coho salmon ranges from 4 to 8 (ln(α) ranges from 1.4 to 2.1) and that the average survey count and average harvest represented an equilibrium exploitation rate of 0.68, 2 theoretical spawner-recruit relationships that have these same equilibrium values were calculated (Appendix P4). In addition, from the 2 theoretical spawner-recruit relationships, escapements (based on the surveys) that would produce MSY and a range of escapements that produce 90% or more of MSY were also calculated (see inset table below). These reference points were then compared to the average escapements based on surveys to help identify a potential SEG range that was robust to differences in the shape of the spawner-recruit relationship.

α	β	S_{msy} from $\overline{S}$	S_{msy} range from $\overline{S}$
4	5.19×10^{-4}	1,082	701 to 1,511
8	1.89×10^{-3}	390	247 to 561

True exploitation was likely to average somewhat less than 0.68 (surveys do not count all fish), given that mark-recapture experiments show that foot surveys average ~80% of the total escapement (Begich et al. 2000). However, the true exploitation rate was likely greater or within the range of what would produce MSY for a range of productivity parameter from 4 to 8. Given the uncertainty, in which relationship was more likely than another, it would appear that a conservative approach would be taken and the range of escapements that could produce at or near MSY be recommended.

Escapement Goal Recommendation

The team agreed that foot surveys of 400 to 900 would appear to theoretically provide for nearly 90% of MSY given α may actually range from 4 to 8 and average harvests and foot surveys represent an equilibrium situation (Appendix P4). Actual escapements have been below this range in 11, in this range in 6, and above this range in 4 of the 21 years (Appendix P3). Escapements have never been below 400 in 4 consecutive years, but have been below 400 in 3 consecutive years 3 times (1982 to 1984, 1994 to 1996, and 1999 to 2001).

The team recommendation is that the existing coho SEG for American River should be changed to an SEG of 400 to 900 fish by foot survey (Table 2). Current exploitation rate in the American River is likely at or slightly above the rate that produces MSY. Development of a BEG for this system is recommended. Development of a BEG would be facilitated by improved assessment of returns to the American River (age composition of escapement and harvests, continued validation of foot surveys, analysis of saltwater harvests to improve catch allocation).

Olds River

The data available for the Olds River coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices P5-P8.

Stock Status

The current Olds River SEG is 450 to 675 (Table 2; Appendix P5) and was established in 1999 (Nelson and Lloyd 2001). Coho salmon are enumerated by foot survey in the Olds River. Since

1980 the SEG range has been achieved once, has been underachieved 3 times and exceeded 16 times (Appendix P6 and P7).

Theoretical Spawner-Recruit Analysis

Average foot survey from 1980 to 2003 was 1,498 fish (Appendix P6 and P7) and average harvest was 2,566 fish (Appendix P6). Assuming Ricker α for coho salmon ranges from 4 to 8 ($\ln(\alpha)$ ranges from 1.4 to 2.1) and that the average survey count and average harvest represent an equilibrium exploitation rate of 0.63, 2 theoretical spawner-recruit relationships that have these same equilibrium values were calculated (Appendix P8). In addition, from the 2 theoretical spawner-recruit relationships escapements (based on the surveys) that would produce MSY and a range of escapements that produce 90% or more of MSY were also calculated (see inset table below). These reference points were then compared to the average escapements based on surveys to help identify a potential SEG range that was robust to differences in the shape of the spawner-recruit relationship.

α	β	S_{msy} from $\overline{S}$	S_{msy} range from $\overline{S}$
4	2.59×10^{-4}	2,167	1,403 to 3,027
8	7.22×10^{-4}	1,023	648 to 1,471

True exploitation was likely to average somewhat less than 0.63 (surveys do not count all fish), given that mark-recapture experiments show that foot surveys average ~80% of the total escapement (Begich et al. 2000). Moreover, the true exploitation rate was likely within or slightly lower than the range that would produce MSY for a range of productivity parameter from 4 to 8. Given the uncertainty in which relationship was more likely than another, it would appear that a conservative approach would be taken and a range of escapements that could produce at or near MSY be recommended.

Escapement Goal Recommendation

The team agreed that foot surveys of 1,000 to 2,200 would appear to theoretically provide for nearly 90% MSY given α may actually range from 4 to 8 and average harvests and foot surveys represent an equilibrium situation (Appendix P8). Actual escapements have been below this range in 8, in this range in 8, and above this range in 4 of the 20 years (Appendix P7). Escapements have never been below 1,000 in 4 consecutive years, but have been below 1,000 once (1992 to 1994) in 3 consecutive years.

The team recommendation is that the existing SEG for Olds River should be changed to an SEG of 1,000 to 2,200 fish by foot survey (Table 2). Current exploitation rate in the Olds River is likely at or approaching the rate that produces MSY. Development of a BEG for this system is also recommended. Development of a BEG would be facilitated by improved assessment of returns to the Olds River (age composition of escapement and harvests, continued validation of foot surveys, analysis of saltwater harvests to improve catch allocation).

Pasagshak River

The data available for the Pasagshak River coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices P9-P12.

Stock Status

The current Pasagshak River coho salmon SEG is 1,500 to 3,000 (Table 2; Appendix P9) and was established in 1999 (Nelson and Lloyd 2001). Coho salmon are enumerated by foot survey in Pasagshak River. This goal range since 1980 the SEG range has been achieved 9 times, has been underachieved twice and exceeded 6 times (Appendix P10).

Theoretical Spawner-Recruit Analysis

Average foot survey from 1980 to 2003 was 3,197 fish (Appendix P10 and P11) and average harvest was 2,965 fish (Appendix P10). Assuming Ricker α for coho salmon ranges from 4 to 8 ($\ln(\alpha)$ ranges from 1.4 to 2.1) and that the average survey count and average harvest represent an equilibrium exploitation rate of 0.48, 2 theoretical spawner-recruit relationships that have these same equilibrium values were calculated. In addition, from the 2 theoretical spawner-recruit relationships escapements (based on the surveys) that would produce MSY and a range of escapements that produce 90% or more of MSY were also calculated (see inset table below). These reference points were then compared to the average escapements based on surveys to help identify a potential SEG range that was robust to differences in the shape of the spawner-recruit relationship.

α	β	S_{msy} from $\overline{S}$	S_{msy} range from $\overline{S}$
4	2.28×10^{-4}	2,459	1,593 to 3,435
8	4.45×10^{-4}	1,659	1,051 to 2,385

True exploitation was likely to average somewhat less than 0.48 (surveys do not count all fish), given that area biologists judgments are that recent foot surveys averaged nearly 100% of the total escapement. Moreover, the true exploitation rate was likely lower than or within the range that would produce MSY for a range of productivity parameter from 4 to 8. Given the uncertainty, in which relationship was more likely than another, it would appear that an adaptive approach would be taken and a fairly wide range of escapements that could produce at or near MSY be recommended.

Local management biologists indicated that foot survey counts were improved during 1996 to 2003 resulting in much lower estimates of exploitation rate, so that this time period was analyzed separately from data gathered prior to this time to see if this changed the outcome based on this method. Average foot survey from 1996 to 2003 was 4,478 fish and average harvest was 1,816 fish for an exploitation rate of 0.29. Results from the two spawner-recruit relationships are shown below and in Appendix P12:

α	β	S_{msy} from $\overline{S}$	S_{msy} range from $\overline{S}$
4	2.34×10^{-4}	2,405	1,558 to 3,359
8	3.88×10^{-4}	1,901	1,204 to 2,733

Escapement Goal Recommendation

The team agreed with the analysis from 1996 to 2003 that foot surveys of 1,200 to 3,300 would appear to provide for MSY (Appendix P12). Actual escapements have been below this range in 1, in this range in 10, and above this range in 6 of the 17 years (Appendix P11). Escapements have never been below 1,200 in 4 consecutive years or 3 consecutive years.

The team recommendation is that the existing SEG for Pasagshak River should be changed to an SEG of 1,200 to 3,300 fish by foot survey (Table 2). Current exploitation rate in the Pasagshak River is likely below the rate that produces MSY.

Buskin River

The data available for the Buskin River coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices P13-P18.

Stock Status

The current Buskin River coho salmon SEG is 6,000 to 9,000 (Table 2; Appendix P13). Coho salmon escapement is enumerated through the use of a weir. This goal range was established in 1999 (Nelson and Lloyd 2001). Since 1985 the SEG range has been achieved 8 times, has been underachieved 3 times and exceeded 8 times.

Theoretical Spawner-Recruit Analysis

Average weir count from 1980 to 2003 was 9,270 fish (Appendix P14) and average harvest was 4,852 fish (Appendix P14). Escapements in the Buskin River are thought to be somewhat lower than the weir count due to sport harvest of coho salmon upstream of the weir. To account for this, escapements were estimated by subtracting 20% of the sport harvest from the weir count. Average escapement using this method was 8,684 fish (SD = 2,016, minimum = 5,918, maximum = 13,028 fish). Assuming Ricker α for coho salmon ranges from 4 to 8 ($\ln(\alpha)$ ranges from 1.4 to 2.1) and that the average escapement and average harvest represent an equilibrium exploitation rate of 0.36, 2 theoretical spawner-recruit relationships that have these same equilibrium values were calculated. In addition, from the 2 theoretical spawner-recruit relationships escapements (based on the surveys) that would produce MSY and a range of escapements that produce 90% or more of MSY were also calculated (see inset table below). These reference points were then compared to the average escapements based on surveys to help identify a potential BEG range that was robust to differences in the shape of the spawner-recruit relationship.

α	β	S_{msy} from $\overline{S}$	S_{msy} range from $\overline{S}$
4	1.09×10^{-4}	5,175	3,352 to 7,228
8	1.88×10^{-4}	3,920	2,482 to 5,636

Given the uncertainty, in which relationship was more likely than another, it would appear that an adaptive approach would be taken and a fairly wide range of escapements that could produce at or near MSY be recommended. Escapements of about 3,000 to 7,000 would appear to theoretically provide for MSY given α may actually range from 4 to 8 and average harvests and escapements represent an equilibrium situation. Actual escapements have never been below this range, within this range in 4, and above this range in 15 of the 19 years. Escapements have never been below 3,000 in 4 consecutive years.

Spawner-Recruit Analysis

An spawner-recruit analysis of return data arranged as a brood table (Appendix P15) indicate that: 1) estimated α for this stock was 4.65 (SE = 1.20); 2) MSY was produced with an escapement of 5,073 fish; and 3) 90% or more of MSY was produced with a range of escapement of 3,268 to 7,131. There was no significant autocorrelation of residuals of this regression analysis (Appendix P16). These results fall within the range of 2 previously discussed theoretical spawner-recruit relationships (Appendix P18).

Escapement Goal Recommendation

The team made a recommendation that the existing SEG for Buskin River should be changed to a BEG of 3,200 to 7,200 spawning fish (Table 2). The number of spawning fish must take into account 20% of the sport harvest that occurs upstream of the weir. This recommendation was based primarily on the updated brood table and spawner-recruit analysis, but is corroborated by the theoretical spawner-recruit relationships.

Saltery Creek

The data available for the Saltery Creek coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices P19-P20.

Stock Status

The current Saltery Creek coho salmon SEG is 3,000 to 5,000 coho salmon (Table 2; Appendix P21). This goal range was established in 1999 (Nelson and Lloyd 2001). Until 2004, coho salmon escapement was enumerated through the use of a weir. Since 1985 the SEG range has been achieved twice, has been underachieved 3 times and exceeded 3 times (Appendix P20).

Escapement Goal Recommendation

The team recommended that the SEG for this system be eliminated because of a lack of consistent and/or validated escapement assessment for coho salmon (Table 2). Based on years when the weir was operated for coho salmon, maximum exploitation rate likely varies from 15% to 52% and averages 30%.

Roslyn Creek

The data available for the Roslyn Creek coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices P21-P22.

Stock Status

The SEG range in Roslyn Creek is 600 to 1,200 and coho salmon are enumerated by foot survey (Table 2; Appendix P21). This goal range was established in 1999 (Nelson and Lloyd 2001). Since 1980 the SEG range has been achieved 6 times, has been underachieved 15 times and never exceeded (Appendix P22).

Escapement Goal Recommendation

The team recommended that the SEG for this system be eliminated because of a lack of reliable yield information from the recreational fishery and lack of validated foot surveys for coho salmon. (Table 2).

Remote Systems

Big Bay Creek

The data available for the Big Bay Creek coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices Q1-Q4.

Stock Status

The current Big Bay Creek coho salmon SEG is 600 to 1,300 by September 20 (Nelson and Lloyd 2001; Table 2; Appendix Q1). Aerial surveys were conducted from 1984 to 1985, 1989 to 1998, 2000 to 2002, and in 2004 (Appendices Q2 and Q3). The average peak escapement estimate was about 1,800, with a range of 100 to 5,000. The peak escapement estimates were usually were above, or within, the current SEG range. In only 1 year (2004) was the peak escapement estimate below the lower end of the current SEG (Appendix Q3).

Risk Analysis

The Big Bay Creek aerial survey peak escapement estimates were lognormally distributed and due to missing years in the survey data, autocorrelation could not be tested. The percent difference between the mean and minimum escapement estimates was 94%. An SEG of 800 resulted in a 2.0% risk of an unwarranted concern, and a 2.0% estimated risk that a drop in mean escapement of 94% would not be detected (Appendix Q4).

Percentile Approach

An SEG for Big Bay Creek coho salmon was according to the percentile approach using aerial survey peak escapement estimates. High contrast in escapement estimates and low exploitation resulted in selection of the 15^{th} and 75^{th} escapement estimate percentiles translating to an SEG estimate of 900 to 2,000.

Escapement Goal Recommendation

The team recommended eliminating the Big Bay Creek coho salmon SEG (Table 2, Appendix Q1). This recommendation was based on the fact that reliable escapement estimates have not been consistently collected for this stock and, due to budget constraints, are not expected in the future.

Bear Creek

The data available for the Bear Creek coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices Q5-Q7.

Stock Status

The current Bear Creek coho salmon SEG is 350 to 700 by September 20 (Nelson and Lloyd 2001; Table 2; Appendix Q5). Aerial surveys were conducted in 1985, 1989 to 1990, 1992, 1993, 1995 to 2000, and 2002 (Appendices Q6 - Q7). The average peak escapement estimate was about 1,200, with a range of 180 to 3,100. The peak escapement estimates were usually above the upper end of the current SEG. The peak escapement estimates fell within the current SEG range 4 times and below the lower end of the current SEG only once (2000) (Appendix Q7).

Risk Analysis

The Bear Creek aerial survey peak escapement estimates were not lognormally or normally distributed, and since a reasonable distribution could not be found, the risk analysis was not used.

Percentile Approach

An SEG for Bear Creek coho salmon was estimated according to the percentile approach using aerial survey peak escapement estimates. High contrast in escapement estimates and low exploitation resulted in selection of the 15th and 75th escapement estimate percentiles translating to an SEG of 170 to 1,800.

Escapement Goal Recommendation

The team recommended eliminating the Bear Creek coho salmon SEG (Table 2, Appendix Q5). This recommendation was based on the fact that reliable escapement estimates have not been consistently collected for this stock and, due to budget constraints, are not expected in the future. In addition, it is not possible to actively manage escapements specific to this system.

Portage Creek

The data available for the Portage Creek coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices Q8-Q10.

Stock Status

The current Portage Creek coho salmon SEG is 2,000 to 3,500 by September 15 (Nelson and Lloyd 2001; Table 2; Appendix Q8). Peak aerial survey estimates were available intermittently since 1968. Several foot surveys and 3 years of weir counts were also available (Appendix Q9). Escapement estimates have ranged from 100 to 15,300 and have been within or exceeded the current SEG range in 13 of the past 36 years (Appendices Q9 and Q10).

Percentile Approach

An SEG for Portage coho salmon was estimated according to the percentile approach (Bue and Hasbrouck 2001) using aerial survey estimates, foot surveys and weir counts from 1968 to 2003. High contrast in the escapement estimates and low exploitation of this stock resulted in an SEG of 200 to 3,500 (15th to 75th percentiles).

Escapement Goal Recommendation

The team recommended eliminating the Portage coho salmon SEG (Table 2, Appendix Q8). This recommendation was based on the fact that reliable escapement estimates have not been consistently collected for this stock and, due to budget constraints, are not expected in the future. In addition, it is not possible to actively manage escapements specific to this system.

Pauls Bay Drainage

The data available for the Pauls Bay drainage coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices Q11-Q13.

Stock Status

The current coho SEG is 6,500 to 9,000 coho salmon by September 15 (Nelson and Lloyd 2001; Table 2; Appendix Q11). Aerial surveys were conducted in 1991, 1992, 2002, and 2004. Weir counts were available from 1984 through 1990 and 1993 through 2001(Appendix Q12). Weir counts averaged 10,450 and ranged from 2,500 to 25,032 (Appendices Q12 and Q13). The escapement estimates have been within, or exceeded, the current SEG range during 14 of the past 20 years.

Percentile Approach

An SEG for Pauls Bay coho salmon was estimated according to the percentile approach using 4 sets of escapement estimates (Bue and Hasbrouck 2001). The first SEG estimate was determined using aerial survey estimates and weir counts from 1984 to 2003. High contrast in the escapement estimates (10.0) and low exploitation of this stock resulted in an SEG of 4,200 to 13,000 (15th to 75th percentiles). Weir counts from 1984 to 2003 were used for the second SEG estimate. There was medium contrast in the escapement estimates (6.8), which resulted in an SEG of 5,000 to 15,000 (15th to 85th percentiles). The third SEG estimate was based only on escapement data from 1984 to 1995, which were years without effects of fertilization. There was medium contrast in the escapement estimates (5.0) resulting in an SEG of 4,100 to 11,000 (15th to 85th percentiles). The last SEG estimate was based on the escapement counts from 1996 to 2003, which included years when returns were affected by rehabilitation efforts (1996 to 2003). This series of data had a medium contrast (6.3) resulting in an SEG of 8,400 to 16,000 (15th to 85th percentiles).

Escapement Goal Recommendation

The team recommended eliminating the Pauls Bay drainage coho salmon SEG (Table 2, Appendix Q11). This recommendation was based on the fact that reliable escapement estimates have not been consistently collected for this stock and, due to budget constraints, are not expected in the future. In addition, it is not possible to actively manage escapements specific to this system.

Afognak River

The data available for the Afognak River coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices Q14-Q18.

Stock Status

The current Afognak River SEG is 3,500 to 8,000 coho salmon by September 15 (Nelson and Lloyd 2001; Table 2; Appendix Q14). The average escapement estimate was about 9,700, with a range of 490 to 16,000 (Appendices Q15-Q16). The escapement estimates were usually above the upper end of the current SEG. The escapement estimates have been within the current SEG range only twice, and below the lower end of the current SEG 4 years (Appendix Q16).

Dates of weir removal ranged from August 7 to September 18. Escapement data from 2 time series were considered; weir counts through August 23 and 25 (Appendix Q15). In the 7 years where the weir was removed after September 15, the count through the weir by August 23 represented, on average, about 18% of the escapement, however it ranged from 1% to 46%. The escapement through August 25 is only slightly better, with an average of about 22% and a range of 2% to 48%.

Risk Analysis

The Afognak River escapement estimates through August 23, 1984 to 2003 were lognormally distributed with no autocorrelation. The percent difference between the mean and minimum escapement estimates was 93%. An SEG of 1,000 resulted in a 6.4% risk of an unwarranted concern, and a 6.4% estimated risk that a drop in mean escapement of 93% would not be detected (Appendix Q17).

The Afognak River escapement estimates through August 25, 1984 to 2002 were lognormally distributed with no autocorrelation. The percent difference between the mean and minimum escapement estimates was 93%. An SEG of 1,300 resulted in a 4.7% risk of an unwarranted concern, and a 4.7% estimated risk that a drop in mean escapement of 93% would not be detected (Appendix Q18).

Percentile Approach

An SEG for Afognak River coho salmon was estimated according to the percentile approach using weir counts through August 23 from 1984 through 2003 as well as weir counts through August 25 from 1984 through 2002. High contrast in escapement estimates and low exploitation resulted in selection of the 15th and 75th escapement estimate percentiles in both cases. The resulting SEG through August 23 was 300 to 2,700, while the resulting SEG through August 25 was 300 to 3,900.

Escapement Goal Recommendation

The team recommended eliminating the Afognak River coho salmon SEG (Table 2, Appendix Q14). This recommendation was based on the fact available consistent escapement estimates represent <20% of the total escapement. Moreover, due to budget constraints, complete escapement estimates will likely not to be collected in the future. In addition, it is not possible to actively manage escapements specific to this system.

Karluk River

The data available for the Karluk River coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices Q19-Q22.

Stock Status

The current Karluk River coho salmon SEG is 10,000 to 20,000 by September 20 (Nelson and Lloyd 2001; Table 2; Appendix Q19). The average escapement estimate, based on weir counts, from 1974 through 2004 was about 18,000, with a range of 1,000 to 42,000 (Appendices Q20 and Q21). Estimated escapements have been above or within the current SEG range during most years since 1974, with only 7 years falling below the goal (Appendix Q21).

Dates of weir removal ranged from September 8 to October 18. The weir was removed after September 16 from 1974 to 2003 (except in 1980 and 1990, Appendix Q20). In the 7 years where the weir was removed after September 30, the count through the weir by September 16 represented, on average, about 25% of the escapement, with a range of 10% to 48%.

Risk Analysis

The Karluk River escapement estimates from September 16, 1974 to 2003 were lognormally distributed with no autocorrelation. The percent difference between the mean and minimum escapement estimates was 97%. An SEG of 2,200 resulted in a 1.4% risk of an unwarranted concern, and a 1.4% estimated risk that a drop in mean escapement of 97% would not be detected (Appendix Q22).

Percentile Approach

An SEG for Karluk River coho salmon was estimated according to the percentile approach using weir counts through September 16 from 1974 to 2003, except 1980 and 1990. High contrast in escapement estimates and low exploitation resulted in selection of the 15th and 75th escapement percentiles translating to an SEG of about 2,000 to 10,000 by September 16.

Escapement Goal Recommendation

The team recommended eliminating the Karluk River coho salmon SEG (Table 2, Appendix Q19). This recommendation was based on the fact available consistent escapement estimates represent, on average, only 25% of the total escapement. Moreover, due to budget constraints, complete escapement estimates will likely not to be collected in the future. In addition, it is not possible to actively manage escapements specific to this system.

Ayakulik River

The data available for the Ayakulik River coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices Q23-Q25.

Stock Status

The current Ayakulik River coho salmon SEG is 12,000 to 18,000 by September 10 (Nelson and Lloyd 2001; Table 2; Appendix Q23). The average escapement estimate, based on weir counts, was about 9,600, with a range of 40 to 34,000 (Appendices Q24-Q25). The estimated escapements have usually been below the current SEG. The estimated escapements have fallen within the current SEG range only 4 times and were above the current SEG only twice (Appendix Q25).

Dates of weir removal ranged from August 11 to September 7. The weir was removed after August 19 from 1978 to 2004 (except 1979 to 1982, 1991, and 2003; Appendix Q24). By extending 2 more days (August 21) there was only 1 less year (1998) for the analysis, but often provided a substantially greater number (>1,000) of coho to escape (Appendix Q24). In the 9 years where the weir was removed after August 30, the count through the weir by August 21 represented, on average, about 18% of the escapement, with a range of 7% to 37%.

Risk Analysis

The Ayakulik River coho escapements were not lognormally or normally distributed, and since a reasonable distribution could not be found, the risk analysis was not used.

Percentile Approach

An SEG for Ayakulik River coho salmon was estimated according to the percentile approach using weir counts as of August 19 and 21 from 1978 to 2004 (except 1979 to 1982, 1991, and 2003). High contrast in escapement estimates and low exploitation resulted in selection of the 15th and 75th percentiles to estimate the goal range (Bue and Hasbrouck 2001). The 15th and 75th percentiles resulted in an escapement goal range of 900 to 2,300 and 1,500 to 3,700, using the August 19 and August 21 weir removal dates, respectively.

Escapement Goal Recommendation

The team recommended eliminating the Ayakulik River coho salmon SEG (Table 2, Appendix Q23). This recommendation was based on the fact available consistent escapement estimates represent, on average, only 18% of the total escapement. Moreover, due to budget constraints, complete escapement estimates will likely not to be collected in the future. In addition, it is not possible to actively manage escapements specific to this system.

Akalura Creek

The data available for the Akalura Creek coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices Q26-Q30.

Stock Status

The current Akalura Creek coho salmon SEG is 1,500 to 3,500 coho salmon by September 15 (Nelson and Lloyd 2001; Table 2; Appendix Q26). Weir counts were available intermittently from 1974 through 2003. The average escapement estimate was about 3,700, with a range of 50 to 7,700 (Appendices Q27-Q28). The escapement estimates were above or within the current SEG range in all but 2 years (Appendix Q28).

Dates of weir removal ranged from August 26 to October 27. The weir was removed after September 7 for most years from 1974 to 2003 (except in 1978 to 1985, Appendix Q27). In the 9 years where the weir was removed after September 20, the count through the weir by September 7 represented, on average, about 35% of the escapement, with a range of 8% to 83%.

Risk Analysis

The Akalura Creek coho escapement estimates through September 7, 1974 to 1977 and 1986 to 2003, were lognormally distributed with no autocorrelation (though autocorrelation was difficult to assess with the many missing years). The percent difference between the mean and minimum escapement estimates was 84%. An SEG of 800 resulted in a 8.8% risk of an unwarranted concern, and a 8.8% estimated risk that a drop in mean escapement of 84% would not be detected (Appendix Q29).

The Akalura escapement estimates through September 7, 1986 to 2003 were lognormally distributed with no autocorrelation. The percent difference between the mean and minimum escapement estimates was 85%. An SEG of 900 resulted in a 6.6% risk of an unwarranted concern, and a 6.6% estimated risk that a drop in mean escapement of 85% would not be detected (Appendix Q30).

Percentile Approach

An SEG for Akalura Creek coho salmon was estimated according to the percentile approach using weir counts as of September 7 from 1974 to 2003 (except 1978 to 1985) and 1986 to 2003. High contrast in escapement estimates and low exploitation resulted in selection of the 15th and 75th percentiles. The resulting SEGs (through September 7), were 300 to 1,800 using the 1974 to 2003 time series and 400 to 1,800 using the 1986 to 2003.

Escapement Goal Recommendation

The team recommended eliminating the Akalura Creek coho salmon SEG (Table 2, Appendix Q26). This recommendation was based on the fact that reliable escapement estimates have not been consistently collected for this stock and, when available, only represent 35% of the total escapement on average. Moreover, due to budget constraints, complete escapement estimates will likely not to be collected in the future. In addition, it is not possible to actively manage escapements specific to this system.

Upper Station (South Olga Lakes)

The data available for the Upper Station coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices Q31-Q34.

Stock Status

The current Upper Station coho salmon SEG is 3,500 to 5,500 by September 15 (Nelson and Lloyd 2001; Table 2; Appendix Q31). Escapement estimates based on weir counts were available from 1974 through 2004 (Appendix Q32). The average escapement estimate was about 5,400, with a range of 2,200 to 13,000. Escapement estimates have been within, or above, the current SEG range during 25 of these 31 years (Appendix Q33).

Dates of weir removal ranged from September 6 to October 2. The weir was removed after September 5 from 1974 to 2004 (Appendix Q32). In the 11 years where the weir was removed after September 15, the count through the weir by September 5 represented, on average, about 60% of the escapement, with a range of 36% to 93%.

Risk Analysis

The Upper Station coho salmon escapement estimates through September 5, 1974 to 2004 were lognormally distributed with no autocorrelation. The percent difference between the mean and minimum escapement estimates was 63%. An SEG of 2,900 resulted in a 6.3% risk of an unwarranted concern, and a 6.3% estimated risk that a drop in mean escapement of 63% would not be detected (Appendix Q34).

Percentile Approach

An SEG for Upper Station coho salmon was estimated The goal was estimated according to the percentile approach using weir counts as of September 5 from 1974 to 2004. Medium contrast in escapement estimates resulted in selection of the 15th and 85th escapement percentiles resulting in an SEG of about 1,900 to 5,600 by September 5.

Escapement Goal Recommendation

The team recommended eliminating the Upper Station coho salmon SEG (Table 2, Appendix Q31). This recommendation was based on the fact that escapement estimates only represent 60% of the total escapement on average. Moreover, due to budget constraints, complete escapement estimates will likely not to be collected in the future. In addition, it is not possible to actively manage escapements specific to this system.

Dog Salmon Creek

The data available for the Dog Salmon Creek coho salmon escapement goal analysis and the associated results of those analyses are located in Appendices Q35-Q38.

Stock Status

The current Dog Salmon Creek coho salmon SEG is 3,500 to 5,500 by September 15 (Nelson and Lloyd 2001; Table 2; Appendix Q35). Escapement estimates based on weir counts were available from 1983 through 2004 (Appendix Q36). The average escapement estimate was about 4,100, with a range of 20 to 7,900 (Appendix Q37). The escapement estimates were usually within the current SEG range between 1983 and 1999; however, since 2000 the escapement estimates have been below the lower end of the current SEG (Appendix Q37).

Dates of weir removal ranged from August 8 to September 17. The weir was removed after August 24 from 1983 to 2002; however, in 2003 and 2004 it was removed much earlier, August 12 and 8, respectively (Appendix Q36). In the 6 years when the weir was removed after September 10, the count through the weir by August 24 represented, on average, about 6% of the escapement, with a range of 1% to 9%.

Risk Analysis

The Dog Salmon Creek escapement estimates through August 24, 1983 to 2002 were lognormally distributed with no autocorrelation. The percent difference between the mean and minimum escapement estimates was 92%. An SEG of 300 resulted in a 2.4% risk of an unwarranted concern, and a 2.4% estimated risk that a drop in mean escapement of 92% would not be detected (Appendix Q38).

Percentile Approach

An SEG for Dog Salmon Creek coho salmon was estimated according to the percentile approach using weir counts through August 24 from 1983 to 2002. High contrast in escapement estimates and low exploitation resulted in selection of the 15th and 75th escapement percentiles resulting in an SEG of about 200 to 800 through August 24.

Escapement Goal Recommendation

The team recommended eliminating the Dog Salmon Creek coho salmon SEG (Table 2, Appendix Q35). This recommendation was based on the fact that escapement estimates only represent 6% of the total escapement on average. Moreover, due to budget constraints, complete escapement estimates will likely not to be collected in the future. In addition, it is not possible to actively manage escapements specific to this system.

PINK SALMON

The data available for the pink salmon escapement goal analysis and the associated results of those analyses are located in Appendices R1-R6.

Kodiak Archipelago

Stock Status

The current pink salmon SEG is 2,140,000 to 5,230,000 for even years and 790,000 to 2,380,000 for odd years when all individual Kodiak archipelago district goals are summed (Table 14; Appendix R1). Estimated total even-year escapements were usually below the lower range of the current even-year goal in the late-1960s through mid-1970s, but were usually within the current even-year escapement goal range from the mid-1970s to present (Table 15; Appendices R2 and R3). Estimated total odd-year escapements were within the current odd-year escapement goal from the late-1960s through early-1970s, but have usually been above the upper range of the current odd-year escapement goal since the mid-1980s (Appendices R2 and R3)

Data and most parameter estimates are given in Appendix R2 and in Figures 4 and 5. Escapement indices and harvests by calendar year are given in the Appendix R2. "Maximum" harvest rates are plotted in Figure 4, and values for μ'_δ and s^2_δ for the logits of these rates are also listed as part of that figure. Figure 5 contains log-log plots of indices against harvests along with parameter estimates and pertinent statistics for regressions. The regression showed no sign of serial correlation among residuals. Censoring years with large harvests or large escapement counts had little effect on fits or parameter estimates. The estimated variances of the log transformations of the indices $v[\ln(\hat{S})]$ is 0.369 for the Kodiak archipelago stock (as calculated from data given in Appendix R2, 1989 excluded). Dividing $v[\ln(\hat{S})]$ into $\sigma^2_{\gamma(\min)} \leq \sigma^2_\gamma \leq \sigma^2_{\gamma(\max)}$ indicates that random measurement error represented somewhere between 26 and 51% of variation in the index.

Even a cursory inspection of Table 16 shows that expected yields are positive for all current Kodiak escapement goals, that is, all current escapement goals meet the criterion as being SEGs as set out in 5 AAC 39.333(f)(36). Potential yields in this table are conditioned on extreme values (smallest and largest possible) for random measurement error in escapement indices for both stocks. Potential yields are also conditioned on the largest possible value of *p* for both stocks. Reducing values of p only increased potential yields. Indices were within even-year goals in 12 even years and 8 odd years all of which spanned the data for the archipelago stock from early to recent years. Odd-year goals for this stock were met in 5 odd years and 2 even years, however, all instances were earlier than 1984. The paucity of data relative to odd-year goals was the reason for not distinguishing between subpopulations for the Kodiak archipelago stock. Restricting calculations only to data taken prior to 1984 had limited effect on potential yield and no effect on the judgment of sustainability. Interestingly, conditional yields from the even-year goals were considerably higher for both odd- and even-year brood lines than were yields projected from the odd-year goals for the archipelago stock (Table 16). Such a difference is the reason the department is proposing to raise the odd-year goals to match the even-year goals for this stock.

Recommendation

The team recommended an aggregate SEG of 2 million to 5 million pink salmon for both even- and odd-years. This recommendation was based on the projected yield for both even- and odd-year pink salmon using the conditional sustained yield analysis. Escapement objectives by district will be assigned from the aggregate goal according to the relationship of indices averaged across the years (Appendix R1)

Mainland District

Stock Status

The current district-wide pink salmon SEG is 256,000 to 768,000 in even years and 215,000 to 645,000 pink salmon in odd years (Tables 3 and 14; Appendix R4). The 2 goals are similar, with a wider range in odd years. Estimated total escapements were usually below or at the lower range of the current goal in the late-1960s through the mid-1970s, but was usually within the current escapement goal range, though sometimes above, from the mid-1970s to present (Appendices R5 and R6).

Conditional Sustained Yields

Data and most parameter estimates are given in Appendix R5 and in Figures 1 and 2. Escapement indices and harvests by calendar year are given in the Appendix R5. "Maximum" harvest rates are plotted in Figure 4, and values for μ'_δ and s^2_δ for the logits of these rates are also listed as part of that figure. Figure 5 contains log-log plots of indices against harvests along with parameter estimates and pertinent statistics for regressions on both stocks. The regression showed no sign of serial correlation among residuals. Censoring years with large harvests or large escapement counts had little effect on fits or parameter estimates. The estimated variances of the log transformations of the indices $v[\ln(\hat{S})]$ is 0.622 for the mainland stock (as calculated from data given in Appendix R5, 1989 excluded). Dividing $v[\ln(\hat{S})]$ into $\sigma^2_{\gamma(\min)} \le \sigma^2_\gamma \le \sigma^2_{\gamma(\max)}$ indicates that random measurement error represented somewhere between 28 and 53% for the Mainland District stock.

Even a cursory inspection of Table 16 shows that expected yields are positive for all current escapement goals, that is, all current escapement goals meet the criterion as being SEGs as set out in 5 AAC 39.333(f)(36). Potential yields in this table are conditioned on extreme values (smallest and largest possible) for random measurement error in escapement indices for both stocks. Potential yields are also conditioned on the largest possible value of p for both stocks.

Reducing values of p only increased potential yields. Odd- and even-year goals were so similar for the Mainland District pink salmon subpopulation that conditional yields for that stock were calculated based on an amalgam of these two goals. This amalgam was met in 10 odd and 12 even years spanning the data on this stock from early to recent years.

Recommendation

The team recommended an SEG of 250,000 to 750,000 pink salmon for both even- and odd-years for the Mainland District. This recommendation was based on the projected yield for both even- and odd-year pink salmon using the conditional sustained yield analysis (Appendix R4).

CHUM SALMON

The data available for the chum salmon escapement goal analysis and the associated results of those analyses are located in Appendices S1-S26.

Northwest Kodiak District

Stock Status

The current Northwest Kodiak District chum salmon SEG is 46,000 to 138,000 (Nelson and Lloyd 2001; Table 2; Appendix S1). Aerial surveys were conducted from 1967 to 2004 (Appendices S2-S3). The average aggregate peak escapement estimate was about 80,000, with a range of 2,500 to 417,000. The aggregate peak escapement estimates tended to fall below the lower end of the current SEG in the early and mid-1970s, but have usually been within the current SEG range since 1975 (Appendix S3). The average harvest (1970 to 2004) for the Northwest Kodiak District was about 218,000 chum salmon for an approximate harvest rate of 73% (Appendix S2).

Risk Analysis

The Northwest Kodiak District peak escapements were non-stationary and autocorrelated for escapement years 1967 to 2004. However, for 1977 to 2004 the peak escapement estimates were lognormally distributed and not autocorrelated. The percent difference between the mean and minimum escapement estimates was 71%. An SEG of 74,000 resulted in an 8.9% risk of an unwarranted concern, and an 8.9% estimated risk that a drop in mean escapement of 71% would not be detected (Appendix S4).

Percentile Approach

An SEG was estimated according to the percentile approach using peak aerial survey estimates from 1967 to 2004 and 1977 to 2004. High contrast in both time series of escapement estimates and high exploitation resulted in an SEG of 42,000 to 103,000 (25th and 75th percentiles) using the time series 1967 to 2004 and an SEG of 53,000 to 126,000 (25th and 75th percentiles) using the time series 1977 to 2004.

Escapement Goal Recommendation

The team recommended an aggregate peak aerial survey SEG of 53,000 (Table 2, Appendix S1). This recommendation was based on the percentile approach using the most recent (1977 to 2004) aggregate peak aerial surveys. This escapement level is associated with a low risk of unneeded action or mistaken inaction, since the aggregate peak aerial survey escapement estimate has never been below 53,000 chum salmon for 3 consecutive years since 1977 (Appendix S5). The risk analysis estimate of 74,000 was considered too restrictive, since the aggregate peak aerial survey escapement estimate has been below this value for 3 consecutive years 9 different times since 1967 and 4 different times since 1977, yet the stock appears to be healthy. The team did not feel that they could develop a defensible upper end goal and did not feel that one was biologically necessary.

Southwest Kodiak District

Stock Status

The current Southwest Kodiak District chum salmon SEG is 25,000 to 75,000 (Nelson and Lloyd 2001; Table 2; Appendix S5). Aerial surveys were conducted from 1967 to 2004 (Appendix S6). The average aggregate peak escapement estimate was about 46,000, with a range of 1,500 to 160,000. The aggregate peak escapement estimates were within the current SEG 11 times, above the SEG 10 times and below the SEG 17 times (Appendix S7). The average harvest for the Southwest Kodiak District was about 30,000 chum salmon for an approximate harvest rate of 43%.

Risk Analysis

The Southwest Kodiak District peak escapements were not lognormally or normally distributed, and since a reasonable distribution could not be found, the risk analysis was not used.

Percentile Approach

An SEG was estimated according to the percentile approach using peak aerial survey estimates from 1967 to 2004 and 1977 to 2004. High contrast in both time series of escapement estimates and low exploitation resulted in selection of the 15th and 75th percentiles resulting in a peak escapement SEG of 7,200 to 79,000 and 7,300 to 87,000, using the time series 1967 to 2004 and 1977 to 2004, respectively.

Escapement Goal Recommendation

The team recommended an aggregate peak aerial survey SEG of 7,300 (Table 2, Appendix S5). This recommendation was based on the percentile approach using the most recent (1977 to 2004) aggregate peak aerial survey data. This escapement level is associated with a low risk of unneeded action or mistaken inaction, since the aggregate peak aerial survey escapement estimate has never been below 7,300 chum salmon for 3 consecutive years from 1967 to 2004 (Appendix S6). The team did not feel that they could develop a defensible upper end goal and did not feel that one was biologically necessary.

Alitak Bay District

Stock Status

The current Alitak Bay District chum salmon SEG is 26,000 to 78,000 (Nelson and Lloyd 2001; Table 2; Appendix S8). Aerial surveys were conducted from 1967 to 2004 (Appendices S9-S10). The average aggregate peak escapement estimate was about 39,000, with a range of 3,200 to 122,000. The aggregate peak escapement estimates tended to be below the lower end of the current SEG in the late-1960s and early-1970s, but since about 1975 the escapement estimates were usually within the current SEG range (Appendix S10). Average harvest (1970 to 2004) for the Alitak Bay District was about 67,000 chum salmon for an approximate harvest rate of 62% (Appendix S9).

Risk Analysis

The Alitak Bay District peak escapement estimates were non-stationary and autocorrelated for escapement years 1967 to 2004. However, for 1977 to 2004 the peak escapement estimates were lognormally distributed and not autocorrelated. The percent difference between the mean and minimum escapement estimates was 83%. An SEG of 28,000 resulted in a 5.3% risk of an unwarranted concern, and a 5.3% estimated risk that a drop in mean escapement of 83% would not be detected (Appendix S11).

Percentile Approach

An SEG was estimated according to the percentile approach using peak aerial survey estimates from 1967 to 2004 and 1977 to 2004. High contrast in both time series of escapement estimates and high exploitation resulted in selection of the 25th and 75th percentiles resulting in an SEG of about 22,000 to 54,000 (1967 to 2004 data) and 33,000 to 60,000 (1977 to 2004 data).

Escapement Goal Recommendation

The team recommended an aggregate peak aerial survey SEG of 28,000 based on the risk analysis (Table 2, Appendix S8). This escapement level is associated with a low empirical risk of unneeded action or mistaken inaction, since the aggregate peak aerial survey escapement estimate has never been below 28,000 chum salmon for 3 consecutive years since 1977 (Appendix S9). The team did not feel that they could develop a defensible upper end goal and did not feel that one was biologically necessary.

Eastside Kodiak District

Stock Status

The current Eastside Kodiak District chum salmon SEG is 35,000 to 105,000 (Nelson and Lloyd 2001; Table 2; Appendix S12). Aerial surveys were conducted from 1967 to 2004 (Appendices S13-S14). The average aggregate peak escapement estimate was about 78,000, with a range of 6,200 to 224,000. The aggregate peak escapement estimates tended to be below the SEG in the late-1960s, above the SEG in the 1970s and early-1980s, and generally within the SEG since the mid-1980s (Appendix S14). Average harvest (1970 to 2004) for the Eastside Kodiak District was about 206,000 chum salmon for an approximate harvest rate of 70% (Appendix S13).

Risk Analysis

The Eastside Kodiak District peak escapement estimates seem reasonably stationary and autocorrelated for escapement years 1967 to 2004 (Appendix S15) and 1977 to 2004 (Appendix S17). Both could be modeled as an AR(1), with lognormal error. The percent difference between the mean and minimum escapement estimates was 92% for the 1967 to 2004 escapement data. An SEG of 30,000 resulted in a 4.0% risk of an unwarranted concern, and a 4.0% estimated risk that a drop in mean escapement of 92% would not be detected (Appendix S16).

The percent difference between the mean and minimum escapement estimates was 80% for the 1977 to 2004 escapement data. An SEG of 50,000 resulted in a 10.3% risk of an unwarranted concern, and a 10.3% estimated risk that a drop in mean escapement of 80% would not be detected (Appendix S18).

Percentile Approach

An SEG was estimated according to the percentile approach using peak aerial survey estimates from 1967 to 2004 and 1977 to 2004. High contrast in both time series of escapement estimates and high exploitation resulted in selection of the 25th and 75th resulting in an SEG of about 27,000 to 125,000 using the 1967 to 2004 time series and an SEG of 42,000 to 133,000 using the 1977 to 2004 time series.

Escapement Goal Recommendation

The team recommended an aggregate peak aerial survey SEG of 50,000 based on the risk analysis using the 1977 to 2004 time series (Table 2, Appendix S12). This escapement level is associated with a low empirical risk of unneeded action or mistaken inaction, since the aggregate peak aerial survey escapement estimate has been below 50,000 chum salmon for 3 consecutive years only 3 times since 1977 (Appendix S13). The team did not feel that they could develop a defensible upper end goal and did not feel that one was biologically necessary.

Northeast Kodiak District

Stock Status

The current Northeast Kodiak District chum salmon SEG is 8,000 to 24,000 (Nelson and Lloyd 2001; Table 2; Appendix S19). Aerial surveys were conducted from 1967, and 1969 to 2003 (Appendices S20-S21). The average aggregate peak escapement estimate was about 14,000, with a range of 450 to 51,000. The aggregate peak escapement estimates were below the current SEG in the late-1960s and early-1970s; but since the mid-1970s, escapement estimates have usually been within or above the SEG (Appendix S21). Average harvest (1970 to 2004) for the Northeast Kodiak District was about 14,000 chum salmon for an approximate harvest rate of 55% (Appendix S20).

Risk Analysis

The Northeast Kodiak District peak escapement estimates were non-stationary and autocorrelated for escapement years 1969 to 2003. However, for 1977 to 2003 the peak escapement estimates were lognormally distributed and not autocorrelated. The percent difference between the mean and minimum escapement estimates was 87%. An SEG of 9,000 resulted in a 3.9% risk of an unwarranted concern, and a 3.9% estimated risk that a drop in mean escapement of 87% would not be detected (Appendix S22).

Percentile Approach

An SEG was estimated according to the percentile approach using peak aerial survey estimates from 1967 to 2004 and 1977 to 2004. High contrast in both time series of escapement estimates and high exploitation resulted in selection of the 25th and 75th percentiles resulting in an SEG of about 4,200 to 17,000 using the 1967 to 2004 time series and 7,800 to 21,000 using the 1977 to 2004 time series.

Escapement Goal Recommendation

The team recommended an aggregate peak aerial survey SEG of 9,000 based on the risk analysis. (Table 2, Appendix S19). This escapement level is associated with a low empirical risk of unneeded action or mistaken inaction, since the aggregate peak aerial survey escapement estimate has been below 9,000 chum salmon for 3 consecutive years only 3 times since 1977

(Appendix S20). The team did not feel that they could develop a defensible upper end goal and did not feel that one was biologically necessary.

Mainland District

Stock Status

The current Mainland District chum salmon SEG is 133,000 to 339,000 (Nelson and Lloyd 2001; Table 2; Appendix S23). Aerial surveys were conducted from 1967 to 2004 (Appendices S24 and S25). The average aggregate peak escapement estimate was about 173,000, with a range of 7,000 to 453,000. The aggregate peak escapement estimates fell below the lower end of the current SEG from the late-1960s through the mid-1970s. Since that time escapement estimates have been within or above the SEG in all but 5 years (Appendix S25). Average harvest (1970 to 2004) for the Mainland District was about 188,000 chum salmon for an approximate harvest rate of 50% (Appendix S24).

Risk Analysis

The Mainland District peak escapement estimates were non-stationary and autocorrelated for escapement years 1967 to 2004. However, for 1977 to 2004 the peak escapement estimates were lognormally distributed and not autocorrelated. The percent difference between the mean and minimum escapement estimates was 76%. An SEG of 153,000 resulted in a 3.6% risk of an unwarranted concern, and a 3.6% estimated risk that a drop in mean escapement of 76% would not be detected (Appendix S26).

Percentile Approach

An SEG was estimated according to the percentile approach using peak aerial survey estimates from 1967 to 2004 and 1977 to 2004. High contrast in both time series of escapement estimates and high exploitation resulted in selection of the 25th and 75th percentiles resulting in an SEG of about 75,000 to 241,000 using the 1967 to 2004 time series and 151,000 to 251,000 using the 1977 to 2004 time series.

Escapement Goal Recommendation

The team recommended an aggregate peak aerial survey SEG of 153,000 based on the risk analysis (Table 2, Appendix S23). This escapement level is associated with a low empirical risk of unneeded action or mistaken inaction, since the aggregate peak aerial survey escapement estimate has never been below 153,000 chum salmon for 3 consecutive years since 1977 (Appendix S24). The team did not feel that they could develop a defensible upper end goal and did not feel that one was biologically necessary.

SUMMARY OF RECOMMENDATIONS

This comprehensive review of the 46 existing salmon escapement goals in the KMA resulted in recommendations to leave 4 goals unchanged, change 21 goals, create 1 goal that would replace 6 goals, and eliminate 21 goals.

The team recommended that no changes in the current biological escapement goals (BEGs) were warranted for the 2 Chinook salmon systems in the KMA. Both the Karluk and Ayakulik chinook BEGs were reevaluated in 2001 and additional data available for this review did not change the results significantly.

Following the evaluation of escapement goals for 15 sockeye salmon stocks, the team recommended that 2 of these goals should remain unchanged. While there was not enough compelling evidence to change the current Buskin sockeye salmon sustainable escapement goal (SEG) at this time, the team recommended that assessment of this stock should continue, so that a BEG could potentially be developed in 3 years. The current Saltery Lake sockeye salmon BEG was established in 2001 and additional data available for this review did not change the results significantly.

The team recommended changing 10 sockeye salmon escapement goals. These changes included reducing the SEGs for Malina Lakes and Pauls Bay drainage sockeye salmon based on limnological models that indicated that the lake rearing capacity for both systems is less than the current escapement goals suggest. Based on a Ricker spawner-recruit analysis and the results of the zooplankton biomass assessment, the team also recommended reducing the current Afognak Lake SEG to a BEG of 20,000 to 50,000 fish. The team recommended reducing the current Karluk early- and late-run BEGs based on significant spawner-recruit relationships that indicated that Smsy can be achieved at escapements lower than the current goal ranges. The recommended change to the early-run goal was relatively minor (100,000 to 210,000 vs. 150,000 to 250,000); however, the team recommended a substantial decrease in the late-run goal (170,000 to 380,000 vs. 400,000 to 550,000). After considering all analyses, the team also recommended changing the current Ayakulik River escapement goal range to 200,000-500,000, which would increase the current upper goal but leave the lower goal unchanged. The spawner-recruit, yield analysis and zooplankton biomass analyses all suggested that an increase in the current Ayakulik SEG would increase the likelihood of maximizing yield.

The team recommended reducing the current Upper Station early-run sockeye SEG to 30,000-65,000 fish based on the escapement percentile approach. It should be noted that the Alaska Board of Fisheries adopted an OEG of 25,000 for Upper Station early-run sockeye in 1999, which is still lower than the recommended SEG. The team also recommended reducing the current Upper Station late-run sockeye SEG to a BEG of 120,000 to 265,000 fish based on the significant Ricker spawner-recruit relationship. Combining the recommended early- and late-run goals resulted in an overall goal of 150,000 to 330,000, which falls within the range of lake rearing capacity based on zooplankton biomass, corroborating the recommendation. The team recommended changing the current Frazer Lake BEG (140,000 to 200,000) to 70,000-150,000 fish based on a Ricker spawner-recruit curve. This recommendation was corroborated by the estimates that were calculated from smolt biomass as a function of zooplankton biomass. The team recommended increasing the current sockeye SEG for Pasagshak (1,000 to 5,000) to 3,000-12,000. This recommendation was based on the percentile approach, which was corroborated by Risk analysis.

A total of 16 coho salmon escapement goals (6 road systems and 10 remote systems) were evaluated during this review. The team made a recommendation to change the current Buskin River coho SEG to a BEG of 3,200 to 7,200 spawning fish. The number of spawning fish must take into account 20% of the sport harvest that occurs upstream of the weir. This recommendation was based primarily on the updated brood table and a Ricker spawner-recruit analysis, but was corroborated by a theoretical spawner-recruit relationship. The team recommended changing 3 road system coho escapement goals based on theoretical spawner recruit analyses. The recommended coho salmon SEG for the American River was 400 to 900, for the Olds River 1,000 to 2,200, and for Pasagshak River 1,200 to 3,300. The team recommended that the coho SEGs for Roslyn and Saltery Creeks be eliminated because of a lack of consistent and/or validated escapement assessment. The team recommended eliminating all 10 remote system coho SEGs based on the fact that reliable escapement estimates have not been consistently collected for this stock and, due to budget constraints, are not expected in the future.

The team recommended replacing the current Afognak, Northwest Kodiak, Southwest Kodiak, Alitak Bay, Eastside Kodiak and Northeast Kodiak district-wide pink salmon SEGs (6 even- and odd-year SEGs) with 1 Kodiak Archipelago aggregate SEG of 2 million to 5 million pink salmon for both even- and odd-years. This recommendation was based on the projected yield for both even- and odd-year pink salmon using the conditional sustained yield analysis. Management objectives by district will be determined based on the relationship of escapement indices averaged across years. The team recommended changing the Mainland District pink salmon SEG to 250,000-750,000 for both even- and odd-years (changing 2 SEGs). This recommendation was based on the projected yield for both even- and odd-year pink salmon using the conditional sustained yield analysis and is similar to the current Mainland District even-year pink salmon SEG.

It was the recommendation of the team to change all 6 district-wide chum salmon SEGs based on the percentile approach and risk analyses. In each case the recommended goal is a single number representing the lower end of the SEG. In the case of chum salmon the team did not feel that they could develop a defensible upper end goal and did not feel that one was biologically necessary. The recommended chum salmon SEG for the Northwest Kodiak District was 53,000, for the Southwest Kodiak District 7,300, for the Alitak Bay District 28,000, for the Eastside Kodiak District 50,000, for the Northeast Kodiak District 9,000, and for the Mainland District 153,000.

REFERENCES CITED

Abraham and Ledolter. 1983. Statistical methods for forecasting. John Wiley. New York.

Agresti, A. 1990. Categorical data analysis. John Wiley & Sons. New York.

Barrett, B. M. and P. A. Nelson. 1995. Estimation of Karluk Lake early and late run sockeye returns based on scale age data, 1985-1994. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 4K95-44, Kodiak.

Barrett, B.M. and P.A. Nelson. 1994. Estimated run timing of selected sockeye salmon stocks on the west and east sides of Kodiak Island. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 4K94-6, Kodiak.

Begich, R.N., L.J. Schwarz and T. Motis. 2000. Sport effort, harvest and escapement of coho salmon in selected Kodiak Management Area streams, 1997 and 1998. Alaska Department of Fish and Game, Fishery Data Series No. 00-9, Anchorage.

Bernard, D.R., J.J. Hasbrouck, and B. G. Bue. *In prep.* Using risk of management error to set precautionary reference points (PRPs) for non-targeted salmon stocks. North American Journal of Fisheries Management.

Blackett, R.F. 1979. Establishment of sockeye (*Oncorhynchus nerka*) and chinook (*O. tshawytscha*) salmon runs at Frazer Lake, Kodiak Island, Alaska. Journal of Fisheries Research Board of Canada 36:1265-1277.

Booth, J.A. 1993. Migration timing and abundance of adult salmonids in the Uganik River, Kodiak National Wildlife, Alaska, 1990 and 1991. U.S. Fish and Wildlife Service, Kenai Fishery Assistance Office. Alaska Fisheries Progress Report Number 93-1. Kenai, Alaska.

Brennan, K. 1998. The Alitak Bay District commercial salmon fishery, 1998. Report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report 4K98-55, Kodiak.

Bue, B.G., and J.J. Hasbrouck. 2001. Escapement goal review of salmon stocks of Upper Cook Inlet. Alaska Department of Fish and Game, Report to the Board of Fisheries, 2001, Anchorage.

Burgner, R.L., C. J. Di Costanzo, RJ. Ellis, G. Y. Harry Jr., W. L. Hartman, O. E. Kerns Jr., O. A. Mathison, and W. F. Royce. 1969. Biological studies and estimates of optimum escapements of sockeye salmon in the major river systems in southwestern Alaska. U.S. Fish and Wildlife Service, Fisheries Bulletin 67(2):405-459.

Burnham, K.P. and D.R. Anderson. 1985. Model Selection and Inference: A Practical Information-Theoretic Approach. Springer, New York, 353 p.

Chatfield, C. 1984. The Analysis of Time Series: An Introduction 3rd Ed. Chapman and Hall, New York, p. 286.

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

Clapsadl, M. 2002. Age composition and spawning escapement of Chinook salmon in the Karluk, Ayakulik, and Chignik rivers, Alaska, 1997 and 1998. Alaska Department of Fish and Game, Fishery Data Series No. 02-02, Anchorage.

Coggins, L.G. Jr., and N.H. Sagalkin. 1999. Akalura Lake sockeye salmon restoration, Exxon Valdez Oil Spill Restoration Final Report (Restoration Project 97251), Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska.

Conover, W.J. 1980. Practical Nonparametric Statistics, 2nd Ed. John Wiley and Sons, New York p. 493.

Edmundson, J.A., L.E. White, S.G Honnold, and G.B. Kyle. 1994. Assessment of sockeye salmon production in Akalura Lake. Alaska Department of Fish and Game, Division of Commercial Fisheries, Management, and Development, Regional Information Report 4J94-17, Juneau.

Eggers, D.M. 2001. Biological escapement goals for Yukon River fall chum salmon. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report 3A01-10, Anchorage.

Eggers, D. M. 1993. Robust harvest policies for Pacific salmon fisheries. Pages 85 to 106 *in* G. Kruse, D.M. Eggers, R.J. Marasco, C. Pautzke, and T.J. Quinn II, editors. Proceedings of the International Symposium on Management Strategies for Exploited Fish Populations. Alaska Sea Grant College Program Report No. 93-02, University of Alaska Fairbanks.

Eicher, G.J., Jr. 1953. Aerial methods of assessing red salmon populations in western Alaska. Journal of Wildlife Management 17:521-528.

Fair, L. F., B. G. Bue, R. A. Clark, and J. J. Hasbrouck. 2004. Spawning escapement goal review of Bristol Bay salmon stocks. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report, 2A04-17, Kodiak.

Hander, R.F. 1997. Spawning substrate and adequate escapement for coho salmon in the Ayakulik River, Kodiak National Wildlife Refuge. M.S. thesis, University of Alaska Fairbanks.

Hasbrouck, J.J., and R.A. Clark. *In prep*. Escapement goal review of Chinook salmon in the Ayakulik, Chignik, and Karluk Rivers. Alaska Department of Fish and Game, Fishery Manuscript Series, Anchorage.

Heard, W.R. 1991. Life history of pink salmon (*Oncorhynchus gorbuscha*), pages 119-230 in C. Groot and L. Margolis, ed. Pacific Salmon Life Histories, UBC Press, Vancouver, B.C., Canada.

Hilborn, R. and C.J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics and uncertainty. Chapman and Hall, New York, NY.

Honnold, S.G. and N.H. Sagalkin. 2001. A review of Limnology and Fishery Data and a Sockeye Salmon Escapement Goal Evaluation for Saltery Lake on Kodiak Island. Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K01-37, Kodiak.

Honnold, S.G. and J.A. Edmundson. 1993. Limnological and fisheries assessment of sockeye salmon (*Oncorhynchus nerka*) production in the Laura Lake system. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development, Regional Information Report 130, Kodiak.

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001 a. Revised edition: Harvest, catch, and participation in Alaska sport fisheries during 1996. Alaska Department of Fish and Game, Fishery Data Series No. 97-29 (Revised), Anchorage.

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001 b. Revised edition: Harvest, catch, and participation in Alaska sport fisheries during 1997. Alaska Department of Fish and Game, Fishery Data Series No. 98-25 (Revised), Anchorage.

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001 c. Revised edition: Participation, catch, and harvest in Alaska sport fisheries during 1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-41 (Revised), Anchorage.

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001 d. Participation, catch, and harvest in Alaska sport fisheries during 1999. Alaska Department of Fish and Game, Fishery Data Series No. 01-8, Anchorage.

Howe, A. L., G. Fidler, A. E. Bingham, and M. J. Mills. 1996. Harvest, catch, and participation in Alaska sport fisheries during 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-32, Anchorage.

Howe, A. L., G. Fidler, and M. J. Mills. 1995. Harvest, catch, and participation in Alaska sport fisheries during 1994. Alaska Department of Fish and Game, Fishery Data Series No. 95-24, Anchorage.

Jennings, G. B., K. Sundet, A. E. Bingham, and D. Sigurdsson. *In prep* a. Participation, catch, and harvest in Alaska sport fisheries during 2002. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Jennings, G. B., K. Sundet, A. E. Bingham, and D. Sigurdsson. *In prep* b. Participation, catch, and harvest in Alaska sport fisheries during 2003. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Jennings, G. B., K. Sundet, A. E. Bingham, and D. Sigurdsson. 2004. Participation, catch, and harvest in Alaska sport fisheries during 2001. Alaska Department of Fish and Game, Fishery Data Series No. 04-11, Anchorage.

Jones, E.L. III, T.J. Quinn II, and B.W. Van Alen. 1998. Observer accuracy and precision in aerial and foot survey counts of pink salmon in a southeast Alaska stream. North American Journal of Fisheries Management 18:832-846.

Kirk, J.T.O. 1994. Light and photosynthesis in aquatic systems. Cambridge. 509 p.

Koenings, J.P, and G.B. Kyle. 1997. Consequences to juvenile sockeye salmon and the zooplankton community resulting from intense predation. Alaska Fisheries Research Bulletin 4(2):120-135.

Koenings, J.P, and J.A. Edmundson. 1991. Secchi disk and photometer estimates of light regimes in Alaskan lakes: effects of yellow color and turbidity. Limnology and Oceanography 36:91-105.

Koenings, J.P., and R.B. Burkett. 1987. Population characteristics of sockeye salmon (*Oncorhynchus nerka*) smolts relative to temperature regimes, euphotic volume, fry density, and forage base within Alaskan lakes. In H.D. Smith, L. Margolis, and C.C, Wood, editors. Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Canadian Special Publications in Fisheries and Aquatic Sciences 96.

Koenings, J.P, H.J. Geiger, and J.J. Hasbrouck. 1993. Smolt-to-adult survival patterns of sockeye salmon (*Oncorhynchus nerka*): effects of smolt length and geographic latitude when entering the sea . Can. J. Fish. Aquat. Sci. 50: 600-611.

Kuriscak, P.A. , and C. Bond. *In press.* Kodiak Management Area salmon escapement daily cumulative counts for fish weirs, 1995-2004. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak.

Kyle, G.B. and S.G. Honnold. 1991. Limnology and fisheries evaluation of sockeye salmon production (*Oncorhynchus nerka*) in Malina Lakes for fisheries development. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development, Regional Information Report 110, Kodiak.

Kyle, G.B., J.P. Koenings, and B.M. Barrett. 1988. Density-dependent, trophic level responses to an introduced run of sockeye salmon (*Oncorhynchus nerka*) at Frazer Lake, Kodiak Island, Alaska. Can. J. Fish. Aquat. Sci. 45: 856-867.

Lloyd, D. S., J.P. Koenings, and J.D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management 7:18-33.

Malloy, L.M., and D.L. Prokopowich. 1992. Kodiak management area annual finfish management report 1988. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report 4K92-7, Kodiak.

Mills, M. J. 1994. Harvest, catch, and participation in Alaska sport fisheries during 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-28, Anchorage.

Mills, M. J. 1993. Harvest, catch, and participation in Alaska sport fisheries during 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-42, Anchorage.

Mills, M. J. 1992. Harvest, catch, and participation in Alaska sport fisheries during 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-40, Anchorage.

Mills, M. J. 1991. Harvest, catch, and participation in Alaska sport fisheries during 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-58, Anchorage.

Mills, M. J. 1990. Harvest and participation in Alaska sport fisheries during 1989. Alaska Department of Fish and Game, Fishery Data Series No. 90-44, Anchorage.

Mills, M. J. 1989. Alaska statewide sport fisheries harvest report 1988. Alaska Department of Fish and Game. Fishery Data Series No. 122, Juneau.

Mills, M. J. 1988. Alaska statewide sport fisheries harvest report. Alaska Department of Fish and Game, Fishery Data Series No. 52, Juneau.

Mills, M. J. 1987. Alaska statewide sport fisheries harvest report. Alaska Department of Fish and Game, Fishery Data Series No. 2, Juneau.

Mills, M. J. 1986. Alaska statewide sport fish harvest studies, 1985 data. Alaska Department of Fish and Game. Federal Aid in fish Restoration, Annual Performance Report, 1985-1986, Project F-9-18, 27(SW-1-A): 90 pp.

Mills, M. J. 1985. Alaska statewide sport fish harvest studies, 1984 data. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1984-1985, Project F-9-17, 26(SW-1-A): 88 pp.

Mills, M. J. 1984. Alaska statewide sport fish harvest studies, 1983 data. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1983-1984, Project F-9-16, 25(SW-1-A): 122 pp.

Mills, M. J. 1983. Alaska statewide sport fish harvest studies, 1982 data. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1982-1983, Project F-9-15, 24(SW-1-A): 118 pp.

Motis, T. 1997. Age composition and spawning escapement of Chinook salmon in the Karluk, Ayakulik, and Chignik rivers, Alaska, 1995 and 1996. Alaska Department of Fish and Game, Fishery Data Series No. 97-40, Anchorage.

Nelson, P.A., and D.S. Lloyd. 2001. Escapement goals for Pacific salmon in the Kodiak, Chignik, and Alaska Peninsula/Aleutian Islands Areas of Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K01-66, Kodiak.

Noakes, D., D. W. Welch, and M. Stocker. 1987. A time series approach to stock-recruitment analysis: transfer function noise modeling. Natural Resource Modeling 2:213-233.

Pankratz, A. 1991. Forecasting with dynamic regression models. John Wiley. New York.

Pappas, G.E., M.J. Diagneault, and M. LaCroix. 2003. Chignik Management Area annual finfish management report, 2000. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report, 4K03-62, Kodiak.

Parken, C. Unpublished. A habitat-based method for developing escapement goals for chinook salmon. Oral report to the Chinook Technical Committee of the Pacific Salmon Commission, November 19, 2003.

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

Reish, R.L., R. B. Deriso, D. Ruppert, and R. J. Carroll. 1985. An investigation of the population dynamics of Atlantic menhaden (Brevoortia tyrannus). Can. J. Fish. Aquat. Sci. 42: 147-157.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 pp.

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

Sagalkin, N.H. *In prep*. A sockeye salmon escapement goal evaluation for Frazer Lake. Alaska Department of Fish and Game, Division of Commercial Fisheries, Fishery Manuscript 4K00-XX, Kodiak.

Sagalkin, N. 1999. Frazer Lake fish pass sockeye salmon smolt and adult research, 1997 and 1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4K99-59, Kodiak.

Shardlow, T., R. Hilborn, and D. Lightly. 1987. Components analysis of instream escapement methods for Pacific salmon (*Oncorhynchus spp*.) Canadian Journal of Fisheries and Aquatic Sciences 44:1031-1037.

Schmidt, J. S., D. Evans, and D. Tracy. *In prep*. Stock assessment of sockeye salmon of the Buskin River, 2000-2003. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Schrof, S.T. and S.G. Honnold. 2003. Salmon enhancement, rehabilitation, evaluation, and monitoring efforts conducted in the Kodiak Management Area through 2001. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4K03-41, Kodiak.

Schrof, S., S.G. Honnold, C. Hicks and J. Wadle. 2000. A summary of salmon enhancement, rehabilitation, evaluation, and monitoring efforts conducted in the Kodiak Management Area through 1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K00-57, Kodiak.

Schwarz, L. 1996. Age composition and spawning escapement of Chinook salmon in the Karluk, Ayakulik, and Chignik rivers, Alaska, 1993 and 1994. Alaska Department of Fish and Game, Fishery Data Series No. 96-6, Anchorage.

Schwarz, L., D. Tracy, and S. Schmidt. 2002. Area management report for the recreational fisheries of the Kodiak and Alaska Peninsula/Aleutian Islands regulatory areas, 1999 and 2000. Alaska Department of Fish and Game, Fishery Management Report No. 02-02, Anchorage.

Sheng, M. D., M. Foy, et al. 1990. Coho salmon enhancement in British Columbia (Canada) using improved groundwater-fed side channels. Canadian Manuscript Report Of Fisheries And Aquatic Sciences(2071): 1-81.

Swanton, C.O. 1992. Stock interrelationships of sockeye salmon runs, Alitak Bay District, Kodiak Island, Alaska. Masters Thesis, University of Washington, Seattle.

Tracy, D. J. S. Schmidt, and S. Fleischman. *In prep*. Age composition and spawning escapement of Chinook salmon in the Karluk, Ayakulik, and Chignik rivers, Alaska, 1999-2003. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Tyler, R.W., L. Malloy, D. Prokopowich, and K. Manthey. 1981. Migration of sockeye salmon in the Kodiak Archipelago, 1981. Alaska Department of Fish and Game, Commercial Fish Division, Finfish Data Report No. 1-85, Kodiak.

Wadle, J. 2004. Kodiak Management Area annual finfish management report, 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report, 4K04-01, Kodiak.

Walker, R.J., C. Olnes, K. Sundet, A. L. Howe, and A. E. Bingham. 2003. Participation, catch, and harvest in Alaska sport fisheries during 2000. Alaska Department of Fish and Game, Fishery Data Series No. 03-05, Anchorage.

White, L.E., G.B. Kyle, S.G. Honnold, and J.P. Koenings, 1990. Limnological and fisheries assessment of sockeye salmon (*Oncorhynchus nerka*) production in Afognak Lake. Alaska Department of Fish and Game. FRED Division Report 103, Juneau.

TABLES & FIGURES

Table 1.–Current and recommended Chinook and sockeye salmon escapement goals by spawning system in the Kodiak Management Area.

Species System (stock)	Stream Number	Current Escapement Goal Lower	Upper	Type	Recommended Escapement Goal Lower	S_{msy}	Upper	Type	Action
Chinook									
Karluk	255-101	3,600	7,300	BEG	3,600	4,492	7,300	BEG	no change
Ayakulik	256-201	4,800	9,600	BEG	4,800	6,638	9,600	BEG	no change
Sockeye									
Malina	251-105	10,000	20,000	SEG	1,000		10,000	SEG	change
Pauls	251-831	20,000	40,000	SEG	10,000		30,000	SEG	change
Afognak	252-342	40,000	60,000	SEG	20,000	34,000	50,000	BEG	change
Little River	253-115	15,000	25,000	SEG					eliminate
Uganik Lake	253-122	40,000	60,000	SEG					eliminate
Karluk	255-101								
Early run		150,000	250,000	BEG	100,000	150,000	210,000	BEG	change
Late run		400,000	550,000	BEG	170,000	270,000	380,000	BEG	change
Ayakulik	256-201	200,000	300,000	SEG	200,000		500,000	SEG	change
Akalura	257-302	40,000	60,000	SEG					eliminate
Upper Station	257-304								
Early run[a]		50,000	75,000	SEG	30,000		65,000	SEG	change
Late run		150,000	200,000	SEG	120,000	186,000	265,000	BEG	change
Frazer	257-403	140,000	200,000	BEG	70,000	105,000	150,000	BEG	change
Buskin	259-211	8,000	13,000	SEG	8,000		13,000	SEG	no change
Pasagshak	259-411	1,000	5,000	SEG	3,000		12,000	SEG	change
Saltery	259-415	15,000	30,000	BEG	15,000		30,000	BEG	no change

[a] Upper Station early run has the only optimal escapement goal (OEG; 25,000) in the KMA established by the BOF in 1999.

Table 2.–Current and recommended coho salmon escapement goals by spawning system and chum salmon escapement goals by district, in the Kodiak Management Area.

Species	Stream	Current Escapement Goal			Recommended Escapement Goal			
System (stock) / District	Number	Lower	Upper	Type	Lower	Upper	Type	Action
Coho								
road systems								
American	259-231	300	400	SEG	400	900	SEG	change
Olds (Sid Olds)	259-242	450	675	SEG	1,000	2,200	SEG	change
Pasagshak	259-411	1,500	3,000	SEG	1,200	3,300	SEG	change
Buskin	259-211	6,000	9,000	SEG	3,200	7,200	BEG	change
Saltery	259-415	3,000	5,000	SEG				eliminate
Roslyn	259-251	600	1,200	SEG				eliminate
remote systems								
Big Bay	251-601	600	1,300	SEG				eliminate
Bear Cr.	251-705	350	700	SEG				eliminate
Portage (Perenosa)	251-825	2,000	3,500	SEG				eliminate
Pauls	251-831	6,500	9,000	SEG				eliminate
Afognak	252-342	3,500	8,000	SEG				eliminate
Karluk	255-101	10,000	20,000	SEG				eliminate
Ayakulik	256-201	12,000	18,000	SEG				eliminate
Akalura	257-302	1,500	3,500	SEG				eliminate
Upper Station	257-304	3,500	5,500	SEG				eliminate
Dog Salmon	257-403	3,500	5,500	SEG				eliminate
Chum								
N.W. Kodiak District		46,000	138,000	SEG	53,000		SEG	change
S.W. Kodiak District		25,000	75,000	SEG	7,300		SEG	change
Alitak Bay District		26,000	78,000	SEG	28,000		SEG	change
Eastside Kodiak District		35,000	105,000	SEG	50,000		SEG	change
N.E. Kodiak District		8,000	24,000	SEG	9,000		SEG	change
Mainland District		133,000	399,000	SEG	153,000		SEG	change

Table 3.–Current and recommended pink salmon escapement goals by district, in the Kodiak Management Area.

	Current Escapement Goal					Recommended Escapement Goal			
Species	Even Year		Odd Year			Even and Odd year			
District	Lower	Upper	Lower	Upper	Type	Lower	Upper	Type	Action
Pink									
Afognak District	145,000	435,000	80,000	240,000	SEG				eliminate
N.W. Kodiak District	315,000	945,000	220,000	660,000	SEG				eliminate
S.W. Kodiak District	1,250,000	2,550,000	30,000	90,000	SEG				eliminate
Alitak Bay District	162,000	486,000	212,000	636,000	SEG				eliminate
Eastside Kodiak District	150,000	450,000	140,000	420,000	SEG				eliminate
N.E. Kodiak District	120,000	360,000	110,000	330,000	SEG				eliminate
Kodiak Archepelago						2,000,000	5,000,000	SEG	establish
Mainland District	256,000	768,000	215,000	645,000		250,000	750,000	SEG	change

Table 4.–Summary of the results of the Malina Lakes sockeye salmon escapement goal evaluation.

CURRENT ESCAPEMENT GOAL: 10,000 - 20,000 (SEG)

UPPER LAKE FERTILIZED FROM 1991-2001; LOWER LAKE FERTILIZED FROM 1996-2001; STOCKING FROM 1992-1999

Evaluation Method	Pertinent Data	Low	Point Estimate	High	Comments
Escapement Percentiles	1968-2003 aerial survey data only (n=25; contrast 42.4) 15%-75% percentile	300		6,000	contains highly variable data; low exploitation
	1992-2002 weir data only (n=11; contrast 4.2) 15%-85% percentile	8,000		26,000	low exploitation
	1968-2003 all available data (n=36; contrast 64.4) 15%-75% percentile	1,000		9,000	low exploitation
Euphotic Volume	Upper Lake euphotic volume = 13.61 10^6 m^3 (average 1989-2003)	11,000		12,000	
	Lower Lake euphotic volume = 6.98 10^6 m^3	5,000		6,000	
	Total euphotic volume = 20.59 10^6 m^3	16,000		18,000	
Zooplankton Biomass		Average 2.9 g	Optimum 5.0 g	Threshold 2.0 g	
	Upper lake mean zooplankton biomass 1989, 1990, 2002-2004 = 66.5 mg m^2; supports 58,000 avg. (2.9 g) smolt (12% survival); supports 34,000 optimum (5.0 g) smolt (21% survival); supports 84,000 threshold (2.0 g) smolt (12% survival).	2,000	2,000	4,000	Data from years without fertilization
	Lower lake mean zooplankton biomass 1989-1995,2002, 2003 = 17.9 mg m^2; supports 9,000 avg. (2.9 g) smolt (12% survival); supports 5,000 optimum (5.0 g) smolt (21% survival); supports 13,000 threshold (2.0 g) smolt (12% survival).	400	400	600	Data from years without fertilization
	Total both lakes	2,400	2,400	4,600	
Spawning Habitat	Total habitat estimate 20,876 m^2 (Kyle and Honnold 1991); supports 1 spawning pair per m^2 (Burgner et al. 1969)		21,000		
Recommendation	System is rearing limited and is expected to have depressed zooplankton biomass without fertilization. Upper range of current goal was exceeded from 1999-2002, which likely impacted zooplankton levels.	1,000		10,000	Lower EG (1,000 to 10,000).

Table 5.–Summary of the results of the Pauls Bay drainage sockeye salmon escapement goal evaluation.

CURRENT ESCAPEMENT GOAL: 20,000 - 40,000 (SEG)	LAKE WAS FERTILIZED FROM 1993-2001; STOCKED FROM 1994-1996 and in 1999				
Evaluation Method	Pertinent Data	Low	Point Estimate	High	Comments
Escapement Percentiles	1969-2003 all years data (n=35; contrast 15.7) 15%-75% percentile	8,000		23,000	low exploitation
	1978-2003 weir data (n=26; contrast 15.7) 15%-75% percentile	11,000		26,000	low exploitation
	1969-1977 tributary surveys (n=9; contrast 5.0) 15%-85% percentile	7,000		16,000	low exploitation
	1978-1995 weir data (n=18; contrast 15.7) 15%-75% percentile	8,000		20,000	years without fertilization/stocking effects; low exploitation
Euphotic Volume	Laura Lake euphotic volume = 32.75 10^6 m^3 (average 1990-2003)	26,000		29,000	
	Pauls Lake euphotic volume = 5.91 10^6 m^3 (1994)	5,000		5,000	
	Total euphotic volume = 38.66 10^6 m^3	31,000		34,000	
Zooplankton Biomass		Average 4.3 g	Optimum 5.0 g	Threshold 2.0 g	
	Laura Lake mean zooplankton biomass 1990-1992 2002, 2003 = 138 mg m^2; supports 284,000 avg. (4.3 g) smolt (21% survival); supports 245,000 optimum (5.0 g) smolt (21% survival); supports 611,000 threshold (2.0 g) smolt (12% survival).	21,000	18,000	26,000	Data from years without fertilization
Spawning Habitat	Total habitat estimate 26,452 m^2 (Honnold and Edmundson 1993); supports 1 spawning pair per m^2 (Burgner et al. 1969)		26,000		
Recommendation	All methods result in lower upper range for EG; percentiles support lowering goal	10,000		30,000	

Table 6.–Summary of the results of the Afognak Lake sockeye salmon escapement goal evaluation.

CURRENT ESCAPEMENT GOAL: 40,000 - 60,000 (SEG)

LAKE WAS FERTILIZED FROM 1990-2000; STOCKED IN 1992, 1994, AND FROM 1996-1998

Evaluation Method	Pertinent Data	Low	Point Estimate[a]	High	Comments
Spawner-Recruit	Ricker BY1982-1997 data (P=0.007)	22,000	34,000	48,000	
	Gamma BY1982-1997 data (P=0.03)	49,000	59,000	69,000	
Escapement Percentiles	1921-1933, 1966-2004 all available data (n=49; contrast 440.2) 15%-75% percentile	7,000		77,000	low exploitation
	1921-1933, 1978-2004 all weir data (n=39; contrast 21.2) 15%-75% percentile	18,000		86,000	low exploitation
	1978-2004 recent weir data (n=27; contrast 8.7) 15%-75% percentile	27,000		92,000	low exploitation
	1978-1993 recent weir data from non-fertilized years (n=28; contrast 19.7) 15%-75% percentile	11,000		79,000	low exploitation
Euphotic Volume	Euphotic volume = 49.45 10^6 m^3 (1987-2003)	39,000		44,000	
Zooplankton Biomass		Average 3.5 g	Optimum 5.0 g	Threshold 2.0 g	
	Mean zooplankton biomass 1987-2004 = 264 mg m^2; supports 0.844 million avg. (3.5 g) smolt (16.5% survival); supports 0.590 million optimum (5.0 g) smolt (21% survival); supports 1.476 million threshold (2.0 g) smolt (12% survival).	49,000	43,000	62,000	includes years of fertilization/stocking
	Mean zooplankton biomass 1987-2004 excluding fert. years (1990-2000) = 153 mg m^2; supports 0.489 million avg. (3.5 g) smolt (16.5% survival); supports 0.342 million optimum (5.0 g) smolt (21% survival); supports 0.856 million threshold (2.0 g) smolt (12% survival).	28,000	25,000	36,000	
Spawning Habitat	Total habitat estimate 66,307 m^2 (White et al. 1990); supports 1 spawning pair per m^2 (Burgner 1969)		66,000		
Recommendation		20,000		50,000	system is rearing limited and zooplankton biomass likely limits production.

[a] Point estimate refers to S_{msy} for Spawner-Recruit.

Table 7.–Summary of the results of the Uganik Lake sockeye salmon escapement goal evaluation.

CURRENT ESCAPEMENT GOAL: 40,000 - 60,000 (SEG)

Evaluation Method	Pertinent Data	Low	Point Estimate	High	Comments
Escapement Percentiles	1974-2003 all data (n=28; contrast 31.4) 25%-75% percentile	25,000		50,000	
	1974-1988 all data (n=13; contrast 7.1) 15%-85% percentile	21,000		53,000	
	1989-2003 all data (n=15; contrast 31.4) 25%-75% percentile	24,000		48,000	USFWS operated weir on Uganik River from 1990 to 1992
	1928-1932; 1990-1992 weir data (n=5; contrast 31.4) 25%-75% percentile	24,000		66,000	U.S. Bureau of Fisheries operated weir from 1928 to 1932.
Risk Analysis	1974-2003 all data and all data (peak aerial survey only)		18,000		1.0% risk of an unwarranted concern
	1974-2003 (peak aerial survey only)		16,000		1.0% risk of an unwarranted concern
Euphotic Volume	Euphotic volume = 58.87 10^6 m^3 (data collected in 1990, 1991, and 1996)	47,000		53,000	
Zooplankton Biomass		Optimum 5.0 g		Threshold 2.0 g	
	Mean zooplankton biomass 1990, 1991, 1996 = 138 mg m^2; ; supports 228 thousand optimum (5.0 g) smolt (21% survival - Low escapement estimate); supports 571 thousand threshold (2.0 g) smolt (12% survival - High escapement estimate)	17,000		24,000	
Recommendation		Eliminate Goal			This deep, glacially fed lake has turbid water resulting in poor aerial survey accuracy until later in the summer.

Table 8.–Summary of the results of the Karluk Lake sockeye salmon escapement goal evaluation.

CURRENT ESCAPEMENT GOAL: EARLY RUN: 150,000 - 250,000 (BEG)

CURRENT ESCAPEMENT GOAL: LATE RUN: 400,000 - 550,000 (BEG)

CURRENT ESCAPEMENT GOAL: EARLY AND LATE RUNS COMBINED: 550,000 - 800,000 (BEG)

Evaluation Method		Lower	Point Estimate[a]	Upper	Comments
Spawner-Recruit	BY 1981-1996 Early Run	94,000	148,000	211,000	Years included for which run reconstruction is available. 15 of 16 BYs affected by egg stocking or fertilization.
	BY 1981-1996 Late Run	169,000	266,000	381,000	Years included for which run reconstruction is available. 15 of 16 BYs affected by egg stocking or fertilization.
	BY 1981-1996 Early and Late Runs combined	296,000	463,000	655,000	Years included for which run reconstruction is available. 15 of 16 BYs affected by egg stocking or fertilization.
Euphotic Volume	Euphotic volume = 838.04 10^6 m^3	670,000		754,000	
Zooplankton Biomass		Optimum 5.0 g		Threshold 2.0 g	
	Mean zooplankton biomass 1981-2004 = 1,214 mg m^2; supports 20.2 million optimum (5.0 g) smolt (21% survival - Lower escapement estimate); supports 50.5 million threshold (2.0 g) smolt (12% survival - Upper escapement estimate)	1,484,000		2,119,000	
Zooplankton Biomass (Saltery Method)	Smolt estimates from zooplankton biomass used to back calculate spawning adults using fry-to smolt survival, fecundity, and prespawn mortality.	1,079,000		2,697,000	Methods described in Honnold and Sagalkin (2001)
Recommendation	Significant spawner recruit curves provide an estimate of $S_{msy.}$				Establish new BEGs.
	Early Run	100,000	150,000	210,000	
	Late Run	170,000	270,000	380,000	
	Early and Late Runs combined	270,000	420,000	590,000	

[a] Point estimate refers to S_{msy} for Spawner-Recruit.

Table 9.–Summary of the results of the Ayakulik River sockeye salmon escapement goal evaluation.

CURRENT ESCAPEMENT GOAL: 200,000 - 300,000 (SEG)

Evaluation Method	Pertinent Data	Lower	Point Estimate[a]	Upper	Comments
Gamma Multiplicative Spawner-Recruit	Brood Years 1966 to 1998	329,000	478,000	639,000	Significant relationship, P=0.0002; however significant first-order autocorrelation. Uncorrected range is: 294,000 to 555,000.
Ricker Multiplicative Spawner-Recruit	Brood Years 1966 to 1998				Relationship NOT Significant P=0.34
Yield Analysis	Brood Years 1966 to 1998. Intervals assessed between 0 and 500,000; 50,000 to 450,000 (intervals of 100,000 fish).	350,000		450,000	Highest average and median yield was in the range between 350,000 and 450,000. The next highest average and median was in the interval between 300,000 and 400,000 fish.
Euphotic Volume	Euphotic volume = 149.46 10^6 m^3	119,000		134,000	
Zooplankton Biomass		Optimum 5.0 g	Average 8.7 g	Threshold 2.0 g	
	Mean zooplankton biomass 1990-1996 = 1,464 mg m^2; supports 13.0 million (2.0 g) threshold smolt (12% survival - Upper escapement estimate); supports 5.2 million (5.0 g) smolt (21% survival - Lower escapement estimate); supports 3.0 million (8.7 g) avg. size smolt (35% survival - Point escapement estimate).	381,000	365,000	545,000	Many sockeye are believed to spawn upriver of Red Lake in the Ayakulik mainstem as well as a small spawning population in Bare Lake.
Recommendation	Need more escapement data between 400 and 700 thousand fish. However, data clearly suggests S_{msy} is much higher than the current escapement goal.				
	Ayakulik River Sockeye Run	200,000		500,000	Raise SEG

[a] Point estimate refers to S_{msy} for Spawner-Recruit and estimate from average smolt size for zooplankton biomass model.

Table 10.–Summary of the results of the Akalura Lake sockeye salmon escapement goal evaluation.

CURRENT ESCAPEMENT GOAL: 40,000 - 60,000 (SEG)

Evaluation Method	Pertinent Data	Low	Point Estimate	High	Comments
Escapement Percentiles	1923-2003 all data (n=61; contrast 571.2) 25%-75% percentile	6,000		46,000	high production years (1920s-1940s) and lower production years (1970s to present)
	1970-2003 all data (n=32; contrast 31.5) 25%-75% percentile	6,000		23,000	lower production years - represents current productivity
	1923-2003 weir data (n=50; contrast 571.2) 25%-75% percentile	7,000		48,000	high production years (1920s-1940s) and lower production years (1970s to present)
	1970-2003 weir data (n=22; contrast 31.5) 25%-75% percentile	7,000		27,000	lower production years - represents current productivity
Euphotic Volume	Euphotic volume = 50.47 10^6 m^3 (1990-1996)	40,000		45,000	
Zooplankton Biomass		Average 4.7 g	Optimum 5.0 g	Threshold 2.0 g	
	Mean zooplankton biomass 1987-1996 = 330 mg m^2; supports 0.726 million avg. (4.7 g) smolt (21% survival); supports 0.682 million optimum (5.0 g) smolt (21% survival); supports 1.71 million threshold (2.0 g) smolt (12% survival).	53,000	50,000	72,000	avg. biomass excludes years with < 4 samples (1986, 1988, and 1996)
Spawning Habitat	Total habitat estimate 87,015 m^2 (Edmundson et al. 1994); supports 1 spawning pair per m^2 (Burgner et al. 1969)		87,000		
Smolt per Spawner (SPS)	~9 SPS at 31,000 to 39,000 escapement - highest 9.4 SPS@ 30,692	31,000	35,000	39,000	brood years 1988-1993; point estimate is avg. of Low and High estimates
	~2 SPS at 47,000 to 116,000 escapement - lowest 1.5 SPS@ 47,181				
Recommendation		Eliminate Goal			Escapement data in recent years are suspect and reliable data are not expected to be collected in the future; the run is not managed

Table 11.–Summary of the results of the Upper Station (South Olga Lakes) sockeye salmon escapement goal evaluation.

CURRENT ESCAPEMENT GOAL: EARLY RUN 50,000 -75,000; LATE RUN 150,000 - 200,000

Evaluation Method	Pertinent Data	Low	Point Estimate[a]	High	Comments
Spawner-Recruit	Early run brood table - brood year data 1969 to 1997; 1975 to 1997 (regime shift data)				no significant S-R relationships
	Late run brood table - brood year data 1969 to 1997; 1975 to 1997 (regime shift data)	118,000	186,000	265,000	significant S-R relationship for 1975-1997 data
	Early/Late combined brood table - brood year data 1969 to 1997; 1975 to 1997 (regime shift data)				no significant S-R relationships
Escapement Percentiles	Early run 1969-2003 weir data (n=35; contrast 16.5) 25%-75% percentile	32,000		65,000	high exploitation
	Late run 1969-2003 weir data (n=35; contrast 11.1) 25%-75% percentile	76,000		226,000	high exploitation
	Combined runs 1969-2003 weir data (n=35; contrast 9.0) 25%-75% percentile	122,000		286,000	high exploitation
Euphotic Volume	Upper Lake euphotic volume = 150.1 10^6 m^3 (average 90-93,95,99,00)	120,000		135,000	
	Lower Lake euphotic volume = 5.9 10^6 m^3	5,000		5,000	Total lake volume=EV
	Total euphotic volume = 156.0 10^6 m^3	125,000		140,000	
Zooplankton Biomass		Average 6.6 g	Optimum 5.0 g	Threshold 2.0 g	
	Upper lake mean zooplankton biomass 1990-1993,1995,1999,2000 = 1,184 mg m^2; supports 2.99 million avg. (6.6 g) smolt (21% survival); supports 3.95 million optimum (5.0 g) smolt (21% survival); supports 9.87 million threshold (2.0 g) smolt (12% survival)	220,000	290,000	414,000	
	Lower lake mean zooplankton biomass 1990-1993,1995,1999,2000 = 7.6 mg m^2; supports 37,000 avg. (1.9 g) smolt (12% survival); supports 14,000 optimum (5.0 g) smolt (21% survival); supports 35,000 threshold (2.0 g) smolt (12% survival)	2,000	1,000	1,000	Average size of lower lake smolt (0-checks) is 1.9 g
	Total both lakes	222,000	291,000	415,000	
Spawning Habitat	Early run - total habitat (tributaries) estimate 20,008 m^2 (Sagalkin, ADFG, personal communication)		20,000		1 spawning pair per m^2 (Burgner et al. 1969)
	Late run - total habitat (shoals and outlets) estimate 629,918 m^2 (Sagalkin, ADFG, personal communication)		630,000		1 spawning pair per m^2 (Burgner et al. 1969)
Recommendation Early Run	SEG	30,000		65,000	based on escapement percentile method
Recommendation Late Run	SEG to BEG	120,000		265,000	based on significant spawner-recruit curve
Recommendation Both Runs	Zooplankton biomass model (optimum and avg size smolt) supports current goal	150,000		330,000	

[a] Point estimate refers to S_{msy} for Spawner-Recruit.

Table 12.–Summary of the results of the Frazer Lake sockeye salmon escapement goal evaluation.

CURRENT ESCAPEMENT GOAL: 140,000 - 200,000 (BEG) **FERTILIZED FROM 1988-1992**

Evaluation Method	Pertinent Data	Low	Point Estimate[a]	High	Comments
Spawner-Recruit	Brood table - brood year data 1966 to 1995	80,000	124,000	176,000	described in detail in Sagalkin *in press*
	Brood table - brood year data 1966 to 1995; excluding 1985-1991 (fert. effected years)	68,000	105,000	149,000	described in detail in Sagalkin *in press;* strongest analysis
Escapement Percentiles	1956-2003 all weir data (n=48; contrast 80,973.5) 25%-75% percentile	17,000		199,000	includes years of run development
	1978-2003 weir data (n=26; contrast 12.0) 25%-75% percentile	155,000		232,000	years when run was developed
	1978-2003 weir data (excluding 1992-2002) (n=15; contrast 12.0) 25%-75% percentile	134,000		369,000	escapements from 1992-2002 included fish that reared during fertilization
Euphotic Volume	Euphotic volume = 261.83 10^6 m^3 (1987-1997) - Low estimate	236,000		245,000	
	Euphotic volume = 272.41 10^6 m^3 (1989-1997; 2001, 2002) - High estimate				
Zooplankton Biomass		Average 5.1 g	Optimum 5.0 g	Threshold 2.0 g	
	Mean zooplankton biomass 1985-2003 = 236 mg m^2; supports 1.61 million avg. (5.1 g) smolt (13% survival); supports 1.65 million optimum (5.0 g) smolt (21% survival); supports 4.13 million threshold (2.0 g) smolt (12% survival)	74,000	122,000	174,000	
	Mean zooplankton biomass 1985-2003 excluding fert. years (1988-1992) = 267 mg m^2; supports 1.83 million avg. (5.1 g) smolt (13% survival); supports 1.87 million optimum (5.0 g) smolt (21% survival); supports 4.68 million threshold (2.0 g) smolt (12% survival)	83,000	137,000	196,000	
Spawning Habitat	Total habitat estimate 365,000 m^2 (Blackett 1979; Kyle et al. 1988)		365,000		
Smolts per Spawner (SPS)	~34 SPS at 178,000 to 205,000 escapement - highest 51.9 SPS@ 185,825	178,000	190,000	205,000	Brood years 1992-1998; point estimate is avg. of Low and High estimates
	~10 SPS at 196,000 to 234,000 escapement - lowest 5.5 SPS@ 216,565				
Recommendation	Spawner-recruit analysis (exluding fertilizaton years) provides most reliable results; corroborated by result of Zooplankton biomass model using avg. size smolt and actual survival	70,000		150,000	system is rearing limited and zooplankton biomass likely limits production.

[a] Point estimate refers to S_{msy} for Spawner-Recruit.

Table 13.–Summary of the results of the Saltery Lake sockeye salmon escapement goal evaluation.

CURRENT ESCAPEMENT GOAL: 15,000 - 30,000 (BEG)

Evaluation Method	Pertinent Data	Low	Point Estimate[a]	High	Comments
Spawner-Recruit	Brood table - brood year data 1976 to 1996	15,000	23,000	33,000	
	Brood table - brood year data 1976 to 1993	16,000	19,000	31,000	previous S-R analysis described in Honnold and Sagalkin (2001)
Escapement Percentiles	1976-2003 all data (n=28; contrast 6.7) -15%-85% percentile	26,000		58,000	
	1976-2003 weir data (n=17; contrast 3.4) -15%-Max percentile	28,000		77,000	
Euphotic Volume	Euphotic volume = 9.11 10^6 m^3 (1994-1999)	7,000		8,000	glacial influence reduces light penetration
Zooplankton Biomass		Average 5.1 g	Optimum 5.0 g	Threshold 2.0 g	
	Mean zooplankton biomass 1994-2004 = 439 mg m^2; supports 191,000 avg. (5.1 g) smolt (21% survival); supports 195,000 optimum (5.0 g) smolt (21% survival); supports 486,000 threshold (2.0 g) smolt (12% survival)	14,000	14,000	20,000	
Spawning Habitat	Total habitat estimate 39,064 m^2 (Honnold and Sagalkin 2001); supports 1 spawning pair per m^2 (Burgner et al. 1969)		39,000		
Recommendation	Updated Spawner-Recruit analysis was similar to 2001 analysis; avg. of limnological analyses corroborates				No change to current EG based on data; however, reliable escapement data may not be available in the future

[a] Point estimate refers to S_{msy} for Spawner-Recruit.

Table 14.–Current escapement goals in millions of pink salmon for stocks in the Kodiak Management Area. Goals are ranges representing the maximum counts of pink salmon observed in a stream then summed over surveys of streams in each district.

	Odd Years		Even Years	
	From:	**To:**	**From:**	**To:**
Kodiak Archipelago (all districts combined)	0.79	2.38	2.14	5.23
Afognak	0.08	0.24	0.15	0.44
Northwestern	0.22	0.66	0.32	0.95
Southwest	0.03	0.09	1.25	2.55
Alitak	0.21	0.64	0.16	0.49
Eastside	0.14	0.42	0.15	0.45
Northeastern	0.11	0.33	0.12	0.36
Mainland	0.22	0.65	0.26	0.77

Table 15.–Escapement indices and harvests for the Kodiak archipelago and the Mainland District aggregated stocks of pink salmon in the Kodiak Management Area.

	ARCHIPELAGO		MAINLAND	
Calendar Year	Summed Peak Counts (millions)	Harvest (millions)	Summed Peak Counts (millions)	Harvest (millions)
1966	2.10			
1967	0.70			
1968	2.56	8.39	0.26	0.38
1969	1.32	12.44	0.31	0.06
1970	3.13	11.75	0.31	0.29
1971	0.97	3.95	0.11	0.38
1972	1.09	2.44	0.05	0.05
1973	0.56	0.50	0.07	0.02
1974	2.01	2.62	0.07	0.03
1975	0.91	2.67	0.19	0.27
1976	2.97	11.03	0.13	0.05
1977	1.77	5.90	0.54	0.35
1978	4.78	14.77	0.23	0.24
1979	2.51	10.45	0.55	0.63
1980	5.94	16.73	0.53	0.29
1981	2.66	9.36	0.54	0.27
1982	4.85	7.32	0.52	0.59
1983	1.85	4.29	0.24	0.18
1984	4.03	10.23	0.50	0.35
1985	2.77	3.61	0.44	0.26
1986	3.52	10.36	0.59	0.81
1987	1.96	3.90	0.53	0.23
1988	3.51	12.21	0.90	1.75
1989	10.67	0.18	3.98	0.00
1990	5.38	4.57	0.65	0.88
1991	3.18	14.14	1.14	1.17
1992	3.10	2.42	0.42	0.19
1993	3.83	20.58	0.46	1.37
1994	3.65	5.92	0.35	0.19
1995	9.73	37.64	0.77	0.70
1996	2.92	2.46	0.43	0.05
1997	2.41	9.10	0.84	0.73
1998	6.19	15.23	0.90	0.56
1999	3.46	7.46	0.62	0.38
2000	3.82	6.14	0.69	0.12
2001	2.99	6.04	0.41	0.40
2002	7.49	11.31	0.90	0.32
2003	4.09	8.36	1.01	0.17

Table 16.–Estimated average escapements and averages of observed harvests (in millions of fish) associated with odd- and even–year brood years with parent escapements indexed to have been within even- and odd-year index goals. Statistics are conditioned on extremes for random measurement error and p.

	$\overline{N}_{by}$	$\overline{N}_{by+2}$	$\overline{H}_{by+2}$	**Potential Yield**
Archipelago Even-Year Goals: $2.14 \le \hat{S}_{cy} \le 5.23$				
–Random measurement error set at 51% of variation of the log index, *p* ← 1.487–				
Even Years	7.4	11.5	9.8	14.0
Odd Years	5.2	10.7	12.2	17.7
–Random measurement error set at 26% of variation of the log index, *p* ← 1.487–				
Even Years	9.0	14.0	9.8	14.8
Odd Years	6.4	13.0	12.2	18.8
Archipelago Odd-Year Goals: $0.79 \le \hat{S}_{cy} \le 2.38$				
–Random measurement error set at 51% of variation of the log index, *p* ← 1.487–				
All Years	0.7	1.4	5.4	6.1
–Random measurement error set at 26% of variation of the log index, *p* ← 1.487–				
All Years	0.8	1.6	5.4	6.2
Mainland Goals: $0.22 \le \hat{S}_{cy} \le 0.77$				
–Random measurement error set at 53% of variation of the log index, *p* ← 0.535–				
Even Years	0.43	0.64	0.45	0.66
Odd Years	0.48	0.66	0.45	0.58
–Random measurement error set at 28% of variation of the log index, *p* ← 0.535–				
Even Years	0.57	0.86	0.40	0.74
Odd Years	0.65	0.90	0.45	0.64

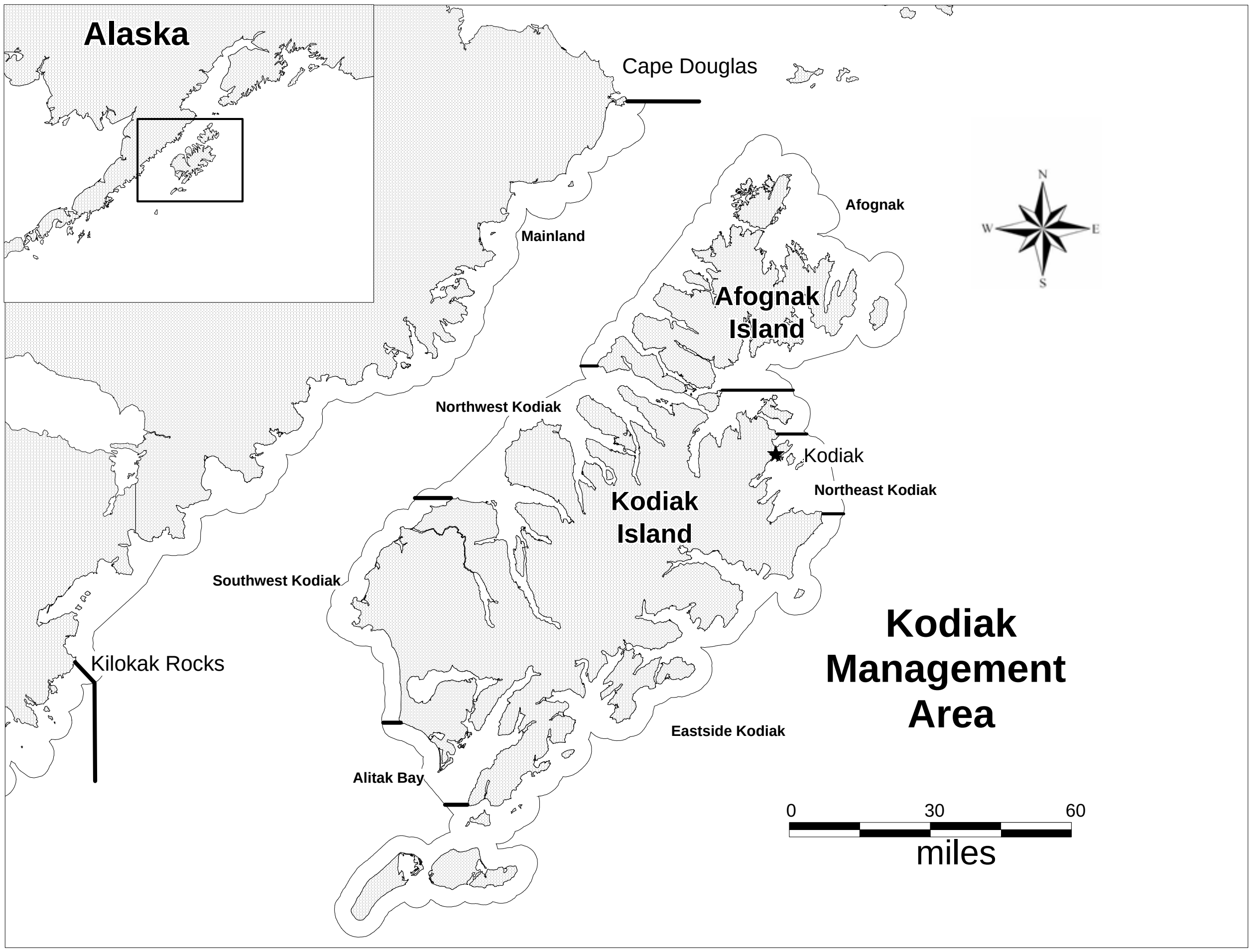


Figure 1.–The Kodiak Management Area showing the commercial salmon fishing districts.

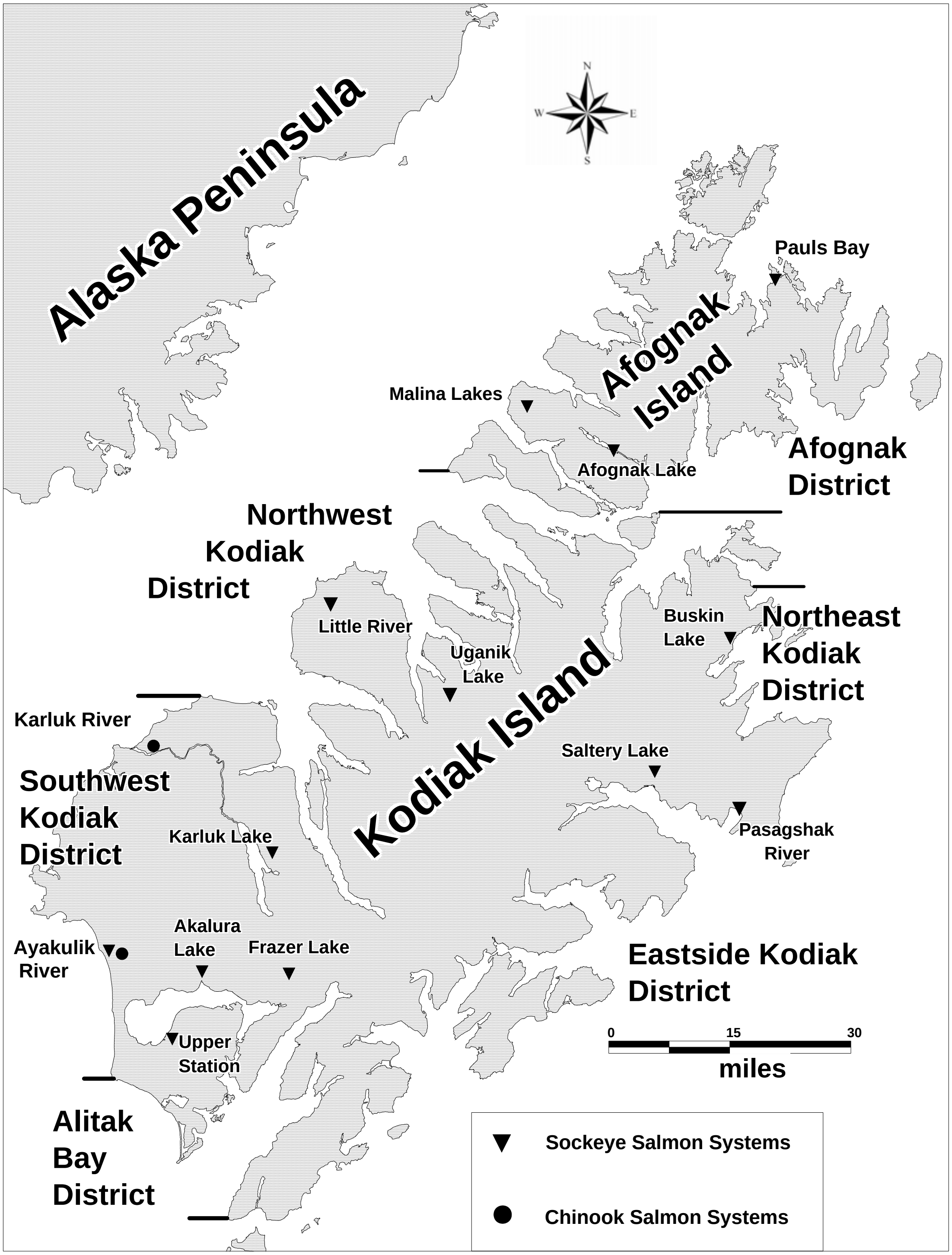


Figure 2.–Map of the Kodiak Management Area showing locations of sockeye and Chinook salmon systems.

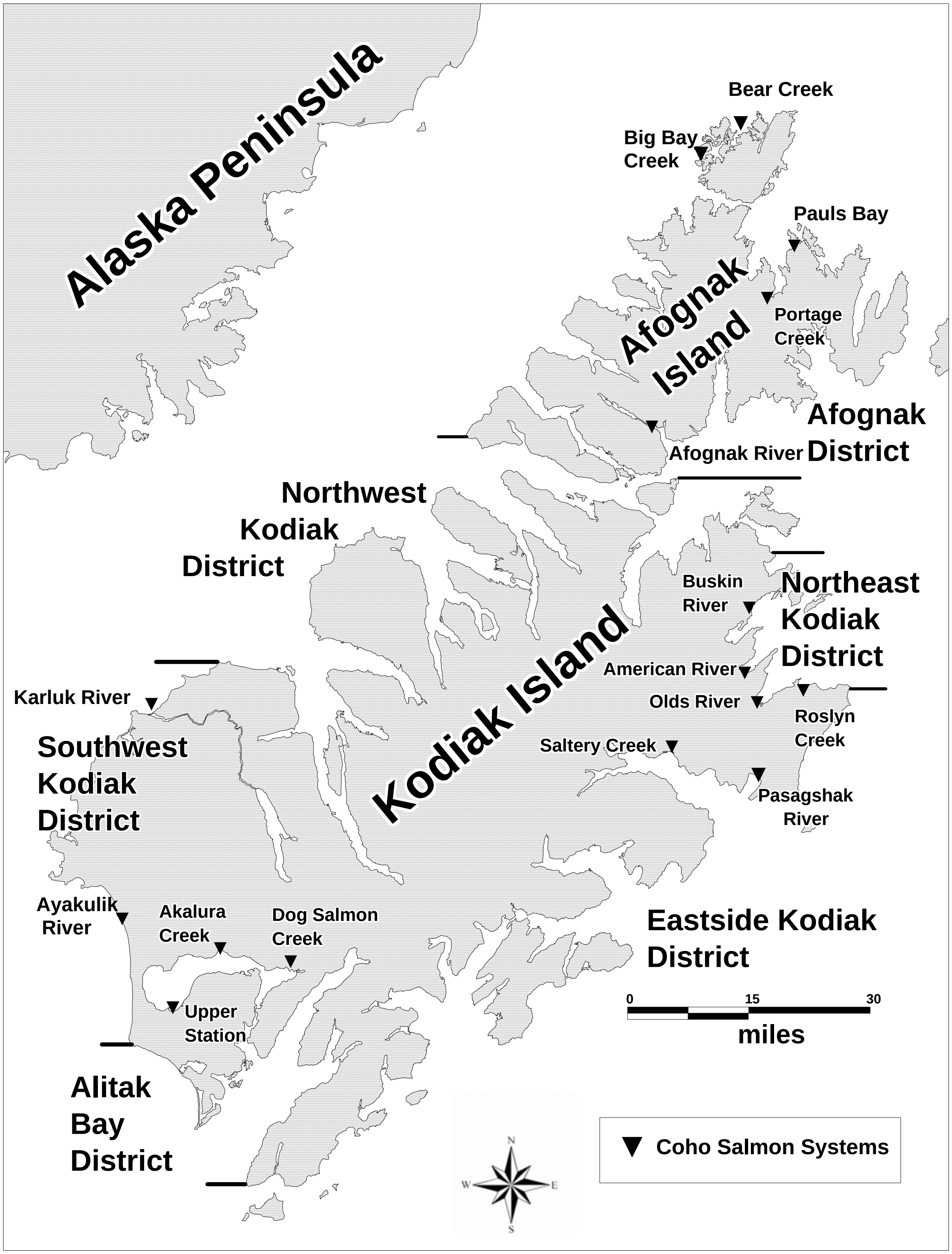


Figure 3.–Map of the Kodiak Management Area showing locations of coho salmon systems

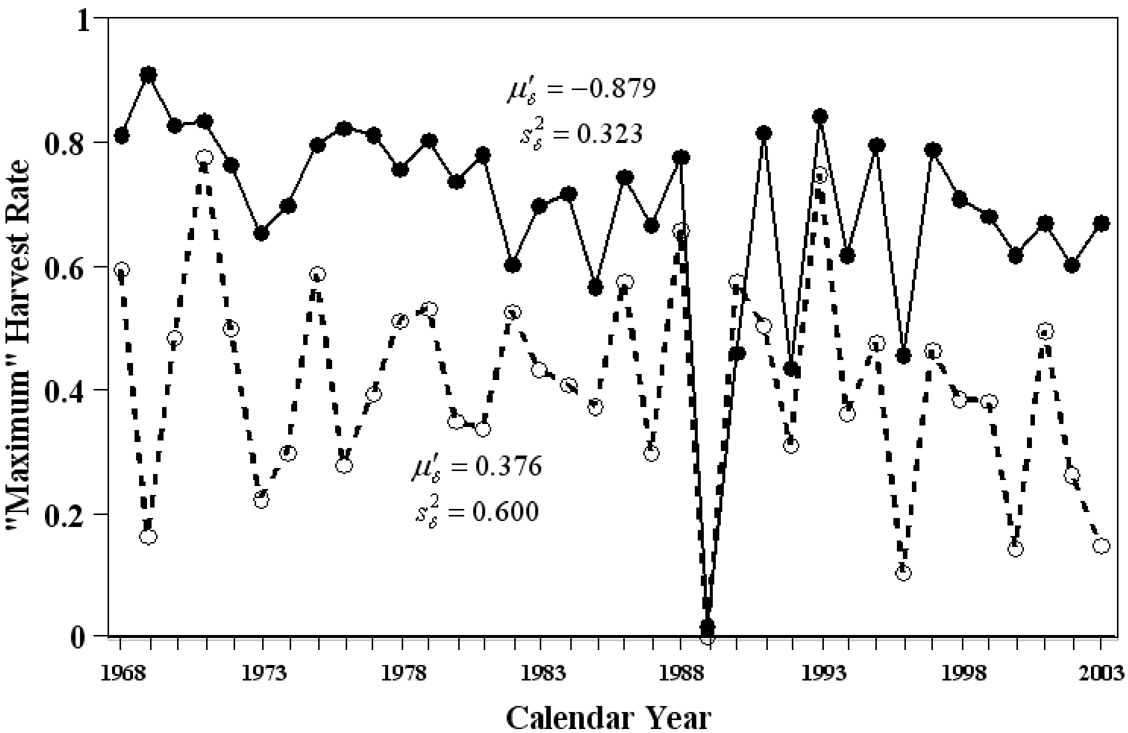


Figure 4.–"Maximum" harvest rates for pink salmon of the Kodiak Archipelago (solid line) and the Mainland District stocks (dashed line).

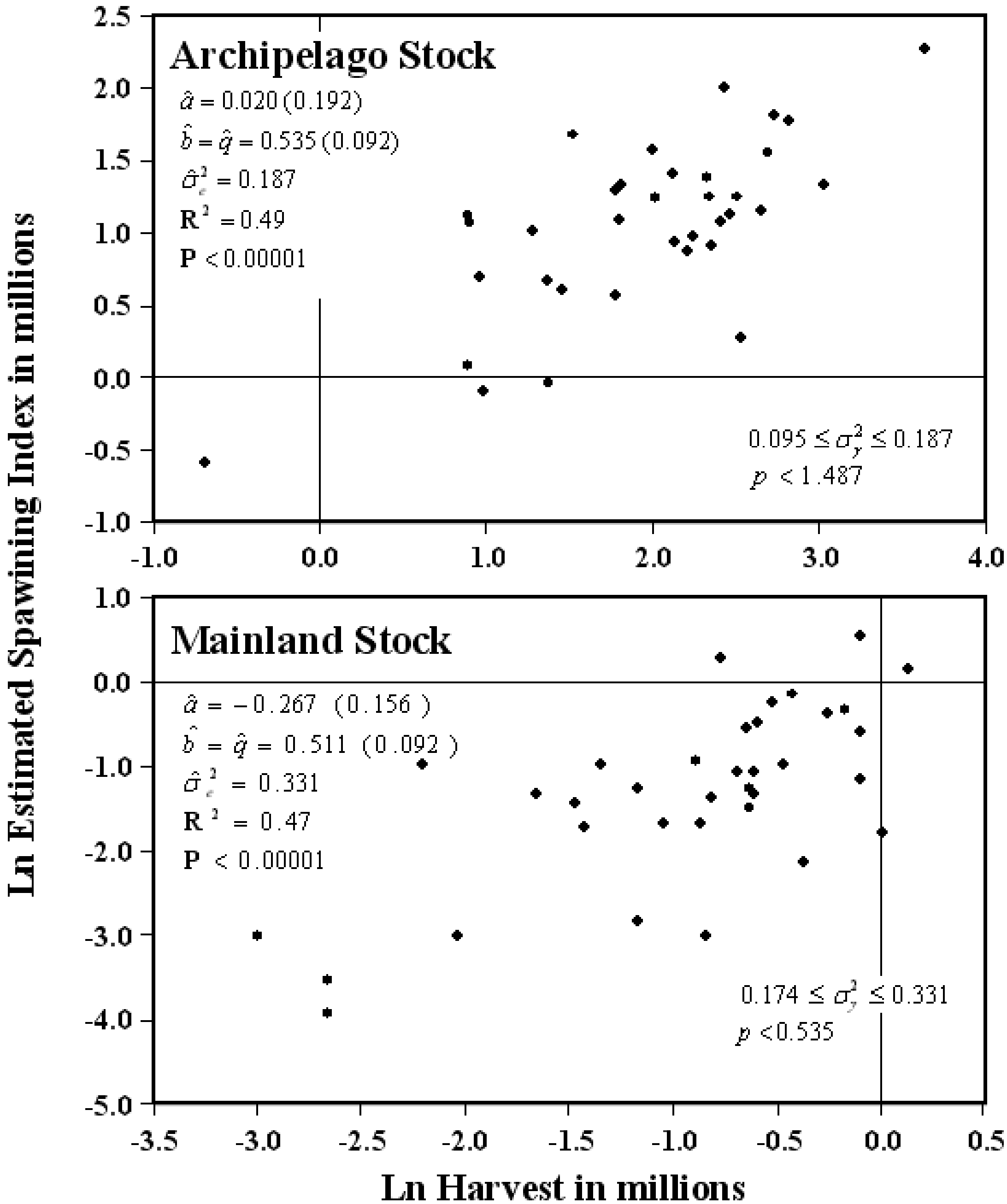


Figure 5.–Log-log regressions of the spawning index against harvest as per (5) and related statistics for the archipelago and the mainland pink salmon stocks. Standard errors for parameter estimates are in parentheses.

APPENDIX A. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR KARLUK RIVER CHINOOK SALMON

Appendix A1.-Description of stock and escapement goals for Karluk River Chinook salmon.

System: **Karluk River**

Species: **Chinook salmon**

Description of stock and escapement goals

Regulatory Area:	Kodiak Management Area – Westward Region
Management Division:	Sport Fish and Commercial Fish
Primary Fishery:	Recreational, Commercial, and Subsistence
Previous Escapement Goal:	BEG: 3,600 – 7,300
Recommended Escapement Goal:	BEG: 3,600 – 7,300
Optimal Escapement Goal:	None
Inriver Goal:	None
Action Points:	None
Escapement Enumeration:	Weir counts since 1976; 21 years of complete spawner-recruit data
Data summary:	
Data quality:	Excellent escapement data; good harvest and age data.
Data type:	Weir counts, harvests, ages
Contrast:	4.4 for all years; 3.2 for complete brood years.
Methodology:	Ricker spawner-recruit
Criteria for BEG:	Low contrast, but very precise escapement data.
S_{msy} and S_{msy} range:	4,492; 3,594 – 7,187 using (0.8 and 1.6 of S_{msy}); 2,926 – 6,227 using 90%-100% of MSY.
Years within recommended BEG:	7
Comments:	Although data show moderately low contrast, weir counts represent actual escapements over a fairly long time series. Goal represents total spawner abundance.
Recommendations:	Recommend BEG of 3,600 to 7,300.

Appendix A2.-Data available for analysis of escapement goal by run year, Karluk River Chinook salmon.

System: Karluk River

Species: Chinook salmon

Description of stock and escapement goals

Run Year	Commercial Harvest[a] +	Subsistence Harvest +	Inriver Run[b] =	Total Run	Recreational Harvest[c]	Escapement[d]
1976	2	0	6,897	6,899	0	6,897
1977	0	0	8,434	8,434	0	8,434
1978	35	0	9,795	9,830	0	9,795
1979	0	0	9,555	9,555	0	9,555
1980	0	0	4,810	4,810	0	4,810
1981	0	0	7,575	7,575	0	7,575
1982	0	0	7,489	7,489	796	6,693
1983	0	0	11,746	11,746	304	11,442
1984	2	0	7,747	7,749	175	7,572
1985	5	0	5,362	5,367	472	4,890
1986	542	0	4,429	4,971	122	4,307
1987	313	0	7,930	8,243	199	7,731
1988	3	0	13,337	13,340	819	12,518
1989	0	0	10,484	10,484	559	9,925
1990	0	0	14,442	14,442	700	13,742
1991	0	0	14,022	14,022	1,599	12,423
1992	264	0	9,601	9,865	856	8,745
1993	3,082	5	13,944	17,031	1,634	12,310
1994	5,114	13	12,049	17,176	1,483	10,566
1995	1,794	31	12,657	14,482	1,284	11,373
1996	1,662	4	10,051	11,717	1,695	8,356
1997	1,445	17	13,443	14,905	1,574	11,869
1998	252	4	10,239	10,495	1,173	9,066
1999	1,067	7	13,063	14,137	1,766	11,297
2000	693	22	10,460	11,175	2,581	7,879
2001	2,588	24	4,453	7,065	1,304	3,149
2002	1,262	165	7,175	8,602	601	6,574
2003	1,336	0	7,256	8,592	294	6,962

[a] Commercial harvest is the commercial harvest of Chinook salmon from the Inner and Outer Karluk statistical areas (statistical areas 255-10 and 255-20) taken during June 1 through July 15. Harvests obtained from runs of the fish ticket database located at the Division of Commercial Fisheries Westward Region, Kodiak. Some harvests also reported by Schwarz (1996) and Tracy et al. (*in prep*).

[b] Inriver return is the weir count of Chinook salmon (Schwarz et al. 2002).

[c] Recreational harvest is from the Statewide Harvest Survey for 1982-2003 (Mills 1983-1994; Howe et al. 2001a-d; Walker et al. 2003; Jennings et al. 2004, *in prep* a, b).

[d] Escapement is inriver run minus recreational harvest.

Appendix A3.-Data available for analysis of escapement goal by brood year, Karluk River Chinook salmon.

System: Karluk River

Species: Chinook salmon

Description of stock and escapement goals

Brood Year	Escapement	Age 3 Return +	Age 4 Return +	Age 5 Return +	Age 6 Return +	Age 7 Return =	Total Return	Yield[a]	Return/ Spawner
1976	6,897	143	514	2,194	4,033	580	7,465	568	1.08
1977	8,434	72	810	2,169	6,326	382	9,760	1,326	1.16
1978	9,795	114	801	3,403	4,173	265	8,755	-1,040	0.89
1979	9,555	112	1,256	2,245	2,890	245	6,749	-2,806	0.71
1980	4,810	176	829	1,555	2,677	407	5,644	834	1.17
1981	7,575	116	574	1,440	4,439	658	7,228	-347	0.95
1982	6,693	81	532	2,388	7,184	517	10,702	4,009	1.60
1983	11,442	75	882	3,864	5,646	713	11,180	-262	0.98
1984	7,572	124	1,427	3,037	7,778	692	13,057	5,485	1.72
1985	4,890	200	1,121	4,183	7,552	487	13,544	8,654	2.77
1986	4,307	157	1,545	4,062	5,313	77	11,154	6,847	2.59
1987	7,731	217	1,500	2,858	10,360	1,098	16,031	8,300	2.07
1988	12,518	210	1,055	5,165	10,317	1,484	18,232	5,714	1.46
1989	9,925	148	1,352	3,417	8,642	913	14,472	4,547	1.46
1990	13,742	77	1,692	2,021	5,959	882	10,630	-3,112	0.77
1991	12,423	653	1,891	2,751	6,922	0	12,218	-205	0.98
1992	8,745	444	1,921	5,271	7,866	820	16,322	7,577	1.87
1993	12,310	115	1,237	1,210	6,051	168	8,781	-3,529	0.71
1994	10,566	592	1,343	5,980	7,063	721	15,698	5,132	1.49
1995	11,373	77	1,216	3,464	4,854	421	10,032	-1,341	0.88
1996	8,356	71	358	1,491	3,458	95	5,472	-2,884	0.65
1997[b]	11,869	123	0	2,985	2,122				
1998[b]	9,066	0	1,652	4,725					
1999[b]	11,297	86	1,572						
2000[b]	7,879	77							
2001[b]	3,149								
2002[b]	6,574								
2003[b]	6,962								

[a] Yield is total return minus escapement.

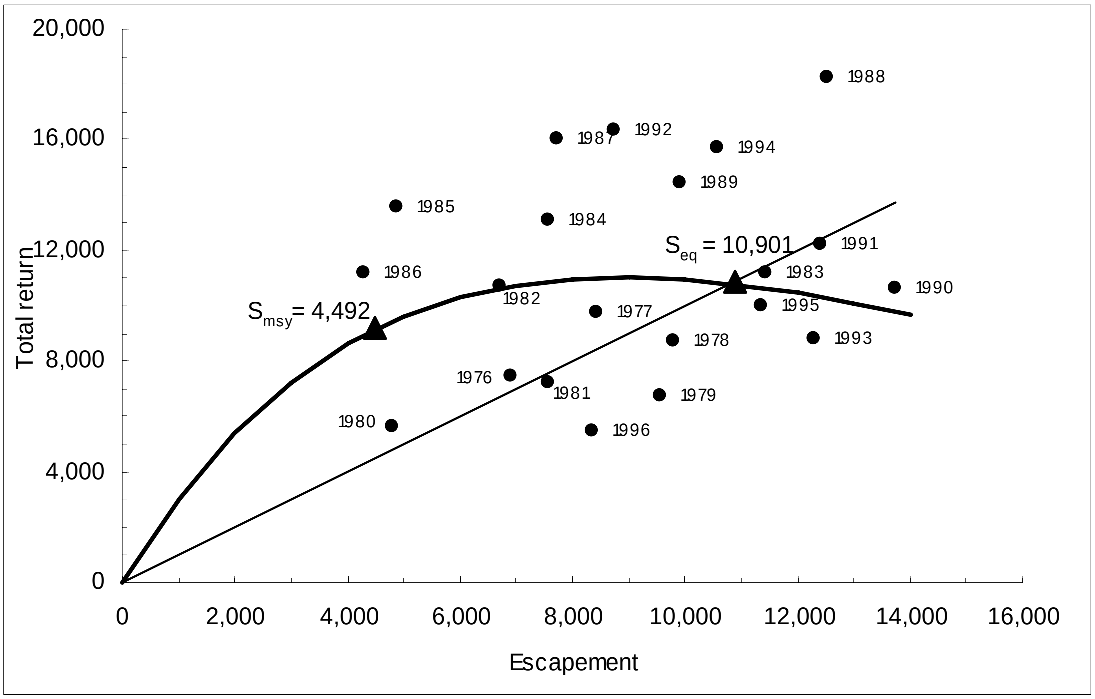
[b] Complete age data not yet available for all components of the run this year.

Appendix A4.-Fitted Ricker curve, line of replacement, and actual data for Karluk River Chinook salmon.

System: **Karluk River**

Species: **Chinook salmon**

Description of stock and escapement goals

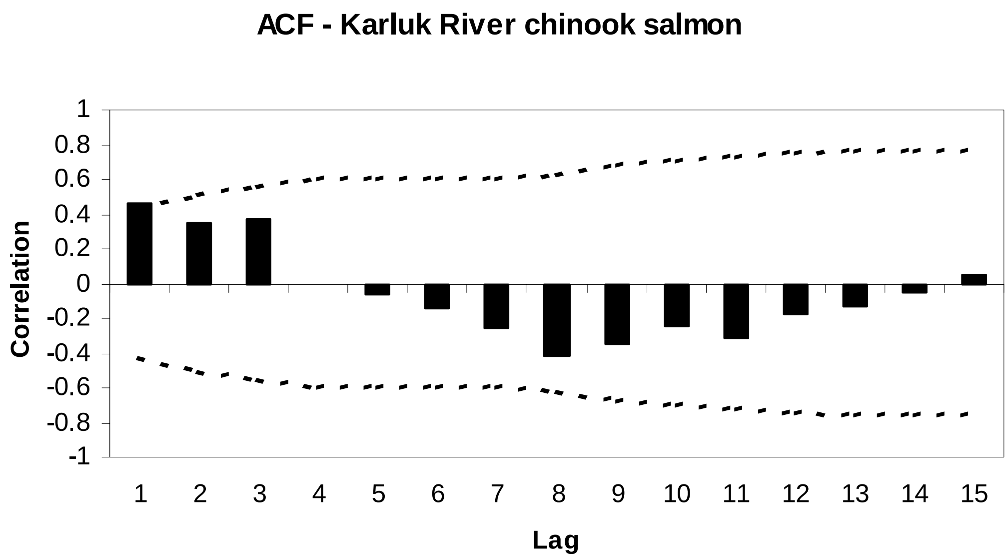


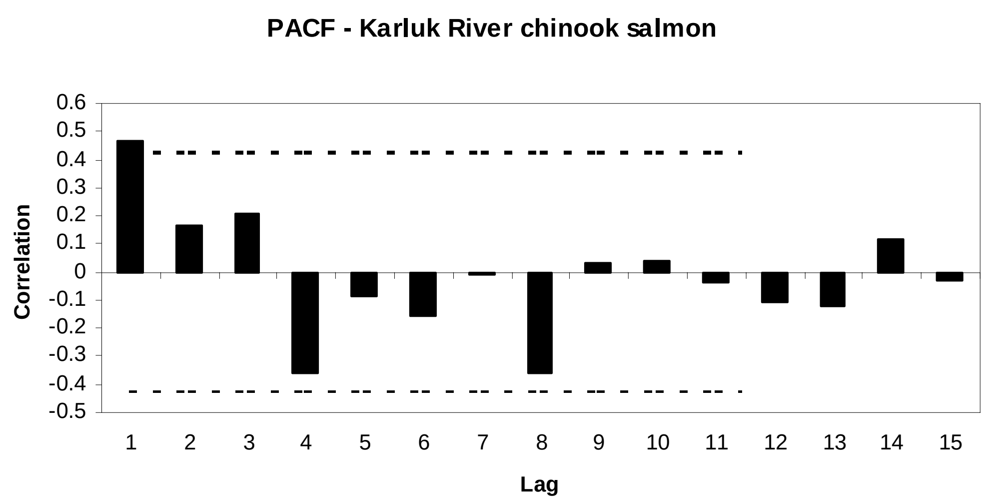
Appendix A5.-Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals of the Ricker model for Karluk River Chinook salmon.

System: **Karluk River**

Species: **Chinook salmon**

ACF and PACF of residuals from the Ricker model





APPENDIX B. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR AYAKULIK RIVER CHINOOK SALMON

Appendix B1.-Description of stock and escapement goals for Ayakulik River Chinook salmon.

System: Ayakulik River

Species: Chinook salmon

Description of stock and escapement goals

Regulatory Area:	Kodiak Management Area – Westward Region
Management Division:	Sport Fish and Commercial Fish
Primary Fishery:	Recreational, Commercial, and Subsistence
Previous Escapement Goal:	BEG: 4,800 – 9,600
Recommended Escapement Goal:	BEG: 4,800 – 9,600
Optimal Escapement Goal:	None
Inriver Goal:	None
Action Points:	None
Escapement Enumeration:	Weir counts since 1977; 20 years of complete spawner-recruit data
Data summary:	
Data quality:	Excellent escapement data; good harvest and age data.
Data type:	Weir counts, harvests, ages
Contrast:	9.6 for all years; 9.6 for complete brood years.
Methodology	Ricker spawner-recruit
Criteria for BEG:	
S_{msy} and S_{msy} range:	6,638; 5,311 – 10,621 using (0.8 and 1.6 of S_{msy}); 4,297 – 9,279 using 90%-100% of MSY
Years within recommended BEG:	9
Comments:	Goal represents total spawner abundance.
Recommendation:	Recommend BEG of 4,800 to 9,600.

Appendix B2.-Data available for analysis of escapement goal by run year, Ayakulik River Chinook salmon.

System: Ayakulik River

Species: Chinook salmon

Description of stock and escapement goals

Run Year	Commercial Harvest[a] +	Inriver Run[b] =	Total Run	Subsistence Harvest	Recreational Harvest[c]	Escapement[d]
1977	361	5,163	5,524	0	0	5,163
1978	615	4,739	5,354	0	0	4,739
1979	70	4,833	4,903	0	0	4,833
1980	0	2,164	2,164	0	0	2,164
1981	473	8,018	8,491	0	0	8,018
1982	83	14,043	14,126	0	0	14,043
1983	662	15,511	16,173	0	145	15,366
1984	1,409	6,502	7,911	0	437	6,065
1985	3,043	8,151	11,194	0	76	8,075
1986	1,785	6,371	8,156	0	76	6,295
1987	729	15,636	16,365	0	126	15,510
1988	2,257	21,370	23,627	0	600	20,770
1989	0	15,432	15,432	0	390	15,042
1990	5,332	11,251	16,583	0	252	10,999
1991	4,685	12,988	17,673	0	563	12,425
1992	4,909	9,135	14,044	0	776	8,359
1993	2,708	7,819	10,527	0	1,004	6,815
1994	0	9,138	9,138	3	948	8,187
1995	2,367	17,701	20,068	4	200	17,497
1996	3,722	10,344	14,066	0	419	9,925
1997	812	14,357	15,169	0	1,190	13,167
1998	3,722	14,038	17,760	0	259	13,779
1999	3,366	13,503	16,869	26	609	12,868
2000	3,206	20,527	23,733	38	803	19,686
2001	6,715	13,929	20,644	5	568	13,356
2002	63	12,552	12,615	37	362	12,153
2003	0	17,557	17,557	0	451	17,106

[a] Commercial harvest is the harvest of Chinook salmon from the Inner and Outer Ayakulik Sections (statistical areas 256-15 and 256-20) taken during June 1 through July 15. Some harvests also reported by Schwarz (1996) and Tracy et al. (*in prep*).

[b] Inriver run is the weir count of Chinook salmon (Schwarz et al. 2002). For 1980 and 1982, weir counts were expanded to account for days weir was non-operational.

[c] Recreational harvest is from the Statewide Harvest Survey for 1983-2003 (Mills 1983-1994; Howe et al. 2001a-d; Walker et al. 2003; Jennings et al. 2004, *in prep* a, b).

[d] Escapement is inriver run minus recreational harvest.

Appendix B3.-Data available for analysis of escapement goal by brood year, Ayakulik River Chinook salmon.

System: Ayakulik River

Species: Chinook salmon

Description of stock and escapement goals

Brood Year	Escapement	Age 3 Return +	Age 4 Return +	Age 5 Return +	Age 6 Return +	Age 7 Return =	Total Return	Yield[a]	Return/ Spawner
1977	5,163	99	1,309	4,146	7,440	367	13,361	8,198	2.59
1978	4,739	390	2,178	4,747	3,639	519	11,473	6,734	2.42
1979	4,833	649	2,493	2,322	5,150	378	10,992	6,159	2.27
1980	2,164	743	1,219	3,285	3,752	759	9,759	7,595	4.51
1981	8,018	363	1,726	2,394	7,529	1,096	13,107	5,089	1.63
1982	14,043	514	1,257	4,803	10,870	716	18,160	4,117	1.29
1983	15,366	375	2,523	6,934	7,100	769	17,700	2,334	1.15
1984	6,065	752	3,642	4,529	7,629	819	17,372	11,307	2.86
1985	8,075	1,085	2,379	4,867	8,130	651	17,113	9,038	2.12
1986	6,295	709	2,556	5,187	6,461	1,695	16,608	10,313	2.64
1987	15,510	762	2,724	4,122	4,092	170	11,869	-3,641	0.77
1988	20,770	812	2,165	1,815	4,767	1,534	11,092	-9,678	0.53
1989	15,042	645	2,857	2,239	12,054	559	18,354	3,312	1.22
1990	10,999	69	974	2,630	6,095	834	10,601	-398	0.96
1991	12,425	988	2,813	3,351	8,732	627	16,511	4,086	1.33
1992	8,359	1,037	3,503	2,934	12,869	202	20,546	12,187	2.46
1993	6,815	559	1,537	2,030	4,774	71	8,972	2,157	1.32
1994	8,187	1,133	1,405	8,232	10,585	454	21,809	13,622	2.66
1995	17,497	827	3,306	12,412	12,634	1,047	30,227	12,730	1.73
1996	9,925	354	641	3,654	3,154	70	7,873	-2,052	0.79
1997[b]	13,167	24	1,693	4,655	3,950				
1998[b]	13,779	2,209	3,179	10,130					
1999[b]	12,868	580	3,353						
2000[b]	19,686	53							
2001[b]	13,356								
2002[b]	12,153								
2003[b]	17,106								

[a] Yield is total return minus escapement.

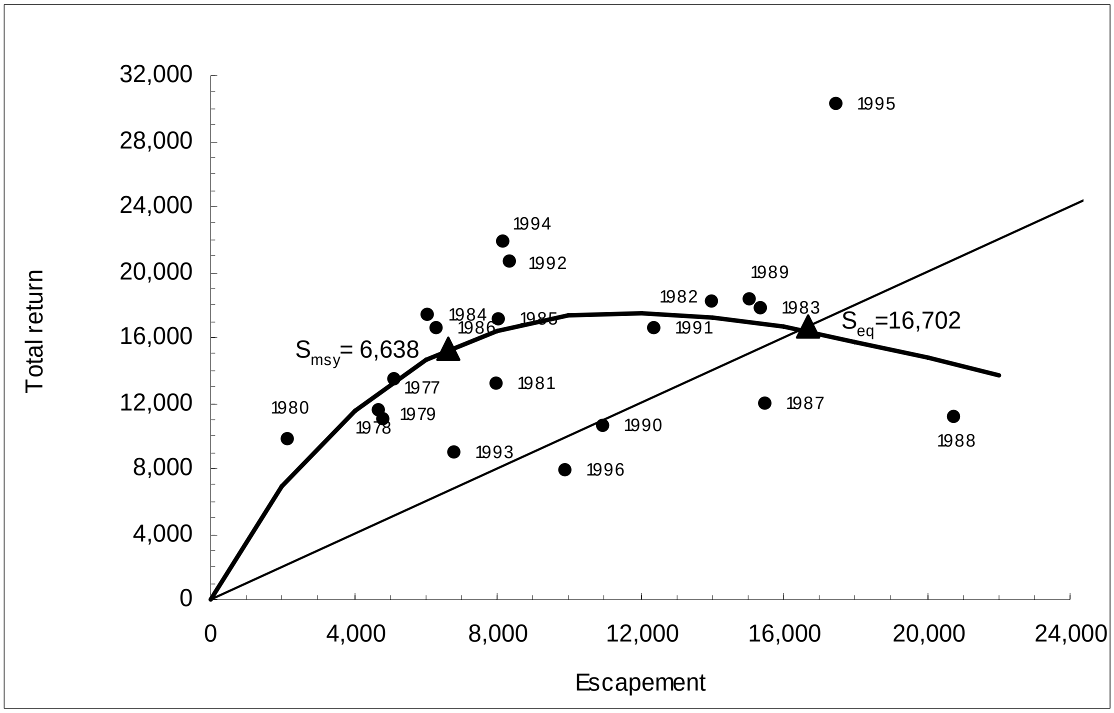
[b] Complete age data not yet available for all components of the run this year.

Appendix B4.-Fitted Ricker curve, line of replacement, and actual data for Ayakulik River Chinook salmon.

System: **Ayakulik River**

Species: **Chinook salmon**

Description of stock and escapement goals

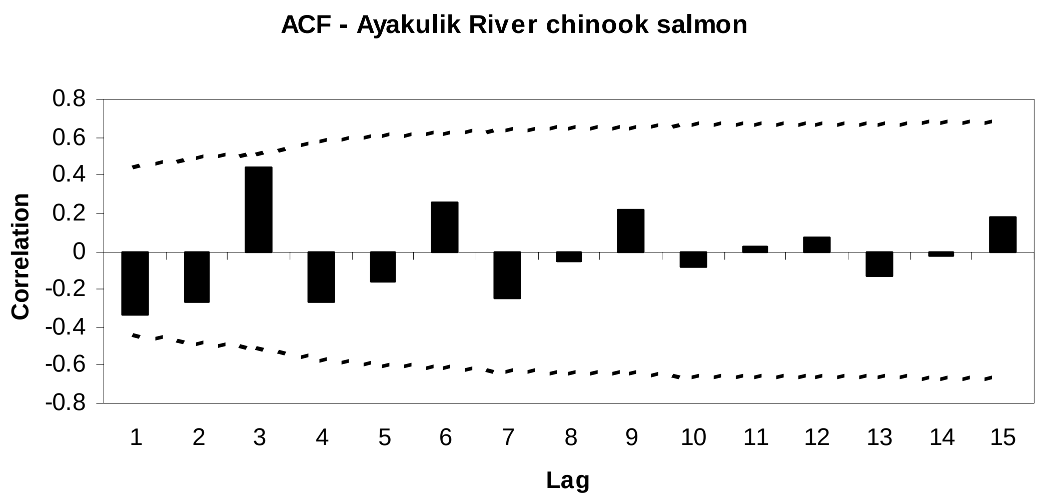


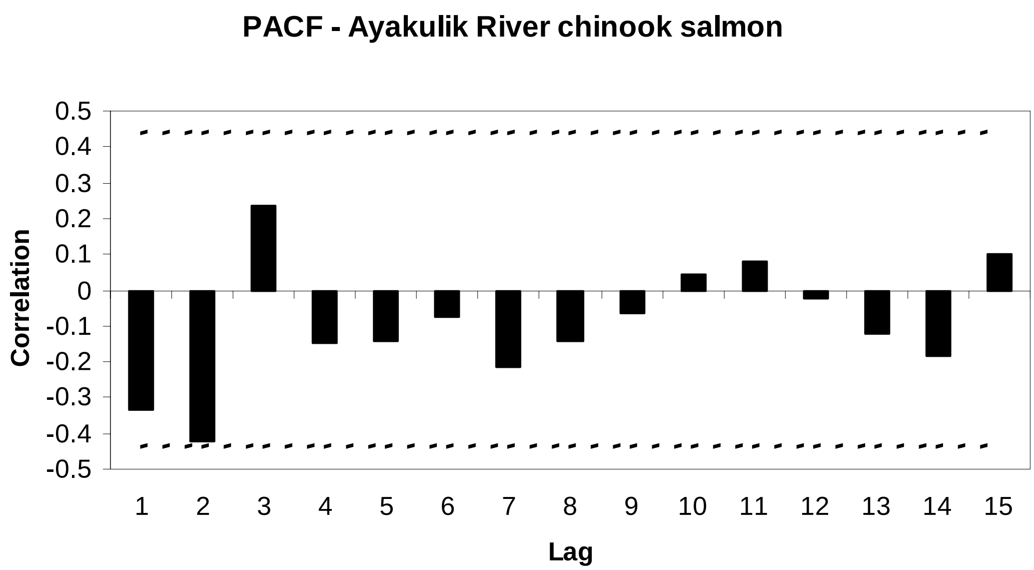
Appendix B5.-Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals of the Ricker model for Ayakulik River Chinook salmon.

System: Ayakulik River

Species: Chinook salmon

ACF and PACF of residuals from the Ricker model





APPENDIX C. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR MALINA LAKES SOCKEYE SALMON

Appendix C1.–Description of stock and escapement goal for Malina Lakes sockeye salmon.

System: Malina Lakes

Species: sockeye salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine
Previous escapement goal:	SEG: 10,000 to 20,000 (1988)
Recommended escapement goal:	SEG: 1,000 to 10,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial counts, 1968 – 1991, 2003-2004
	Weir counts, 1992 – 2002
Data summary:	
Data quality:	Fair to poor for aerial counts, excellent for weir counts
Data type:	Aerial counts from 1968 through 1991 and 2003, weir counts from 1992 through 2002 include escapement age data. No stock-specific harvest information is available.
Data contrast:	Peak aerial surveys 1968–2003: 42.4
	Weir data 1992–2002: 4.2
	All available weir and survey data 1968-2003: 64.4
Methodology:	Percentile, euphotic volume analysis, spawning habitat, smolt biomass as a function of zooplankton biomass
Criteria for SEG:	Low exploitation
Percentiles:	15th to 75th (all available data and aerial survey data)
	15th to 85th (weir data only)
Comments:	Lake was stocked with indigenous juvenile sockeye salmon from 1992-1999 and fertilized from 1991-2001.
Recommendation:	Euphotic volume and spawning habitat methods approximate the upper range of the current SEG; however, the escapement percentiles (all data) suggest a lower escapement and the zooplankton biomass suggests that system is rearing rather than spawning limited, therefore, we recommend lowering the current goal to 1,000 to 10,000.

Appendix C2.–Malina Lakes sockeye salmon escapement, 1968-2003.

System: Malina Lake

Species: sockeye salmon

Data available for analysis of escapement goals

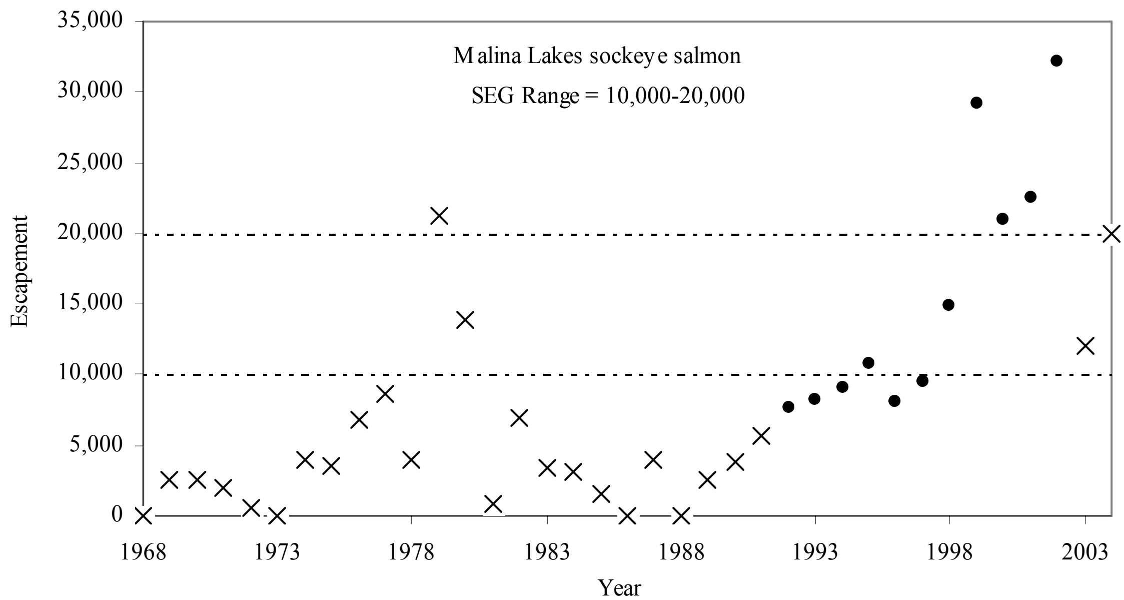
Year	Peak Aerial Survey	Weir Counts
1968	0	
1969	2,500	
1970	2,600	
1971	2,000	
1972	500	
1973	0	
1974	4,000	
1975	3,500	
1976	6,800	
1977	8,667	
1978	4,000	
1979	21,200	
1980	13,900	
1981	900	
1982	7,000	
1983	3,400	
1984	3,100	
1985	1,600	
1986	0	
1987	4,000	
1988	0	
1989	2,570	
1990	3,800	
1991	5,650	
1992		7,610
1993		8,273
1994		9,042
1995		10,803
1996		8,030
1997		9,455
1998		14,917
1999		29,171
2000		21,006
2001		22,490
2002		32,214
2003	12,000	
2004	20,000	

Appendix C3.–Malina Lakes sockeye salmon escapement, 1968-2003 and current escapement goal ranges.

System: **Malina Lakes**

Species: **sockeye salmon**

Observed escapement by year (Xs for aerial surveys, solid circles for weir counts) and current SEG range (dashed lines).



APPENDIX D. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR PAULS BAY DRAINAGE SOCKEYE SALMON

Appendix D1.–Description of stock and escapement goal for Pauls Bay drainage sockeye salmon.

System: Pauls Bay drainage

Species: sockeye salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine
Previous escapement goal:	SEG: 20,000 – 40,000 (1988)
Recommended escapement goal:	SEG: 10,000 – 30,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Tributary surveys, 1969 – 1977
	Weir counts, 1978 – 2004
Data summary:	
Data quality:	Fair for tributary surveys, excellent for weir counts
Data type:	Tributary surveys from 1969 to 1977, weir counts from 1978 to 2003. Escapement age data are available from 1992 to 2002 and cursory harvest age data are available from 1970 to 2004.
Data contrast:	All available data 1968-2004: 15.7
	Tributary surveys 1968-1977: 5.0
	Weir data 1978-2004: 15.7
	Weir data excluding rehabilitation years 1978-1995: 15.7
Methodology:	Percentile approach, euphotic volume analysis, spawning habitat, smolt biomass as a function of zooplankton biomass.
Criteria for SEG:	Low exploitation
Comments:	Laura Lake was stocked with indigenous juvenile sockeye salmon from 1994 through 1996 and 1999 and was fertilized from 1993 through 2001.
Recommendation:	Lower the escapement goal to an SEG of 10,000 to 30,000 and continue monitoring the system for further analysis.

Appendix D2.–Pauls Bay drainage sockeye salmon escapement, 1968-2004.

System: Pauls Bay drainage

Species: sockeye salmon

Data available for analysis of escapement goals

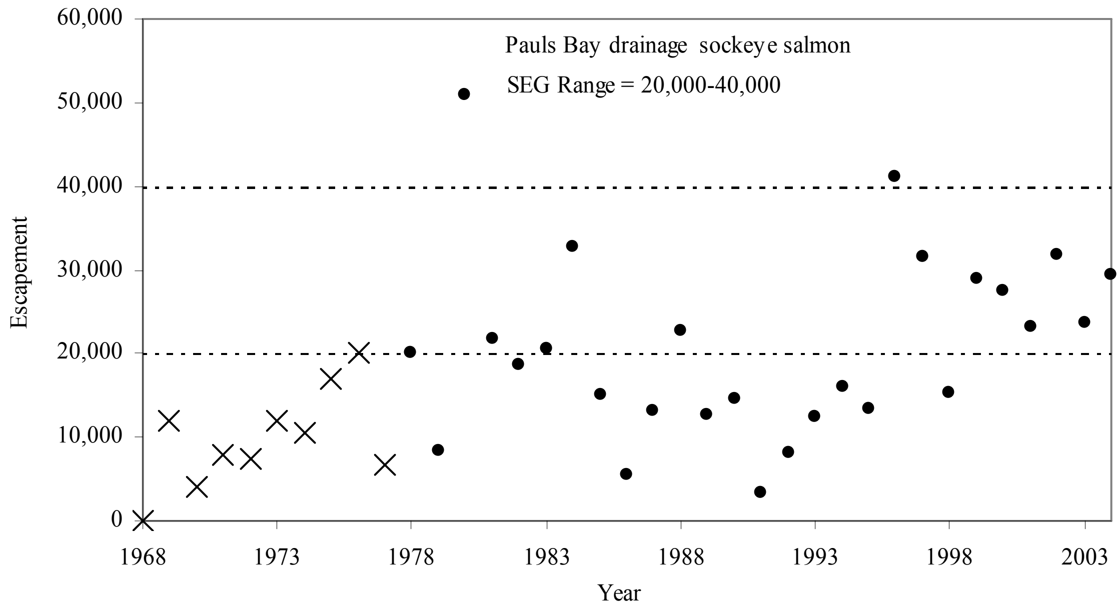
Year	Peak Tributary Survey	Weir Counts
1968	0	
1969	12,000	
1970	4,000	
1971	8,000	
1972	7,500	
1973	12,000	
1974	10,500	
1975	17,000	
1976	20,000	
1977	6,650	
1978		20,043
1979		8,415
1980		50,933
1981		21,806
1982		18,574
1983		20,625
1984		32,659
1985		14,941
1986		5,402
1987		13,122
1988		22,794
1989		12,605
1990		14,510
1991		3,237
1992		8,033
1993		12,442
1994		16,100
1995		13,480
1996		41,145
1997		31,456
1998		15,343
1999		28,884
2000		27,373
2001		23,230
2002		31,911
2003		23,594
2004		29,289

Appendix D3.–Pauls Bay drainage sockeye salmon escapement, 1968-2004 and current escapement goal ranges.

System: Pauls Bay drainage

Species: sockeye salmon

Observed escapement by year (Xs for foot surveys, solid circles for weir counts) and current SEG range (dashed lines).



APPENDIX E. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR AFOGNAK LAKE SOCKEYE SALMON

Appendix E1.–Description of stock and escapement goal for Afognak Lake sockeye salmon.

System: Afognak Lake

Species: sockeye salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine
Previous escapement goal:	SEG: 40,000-60,000 (1988)
Recommended escapement goal:	BEG: 20,000-50,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir counts, 1921-1933; 1978-2004
	Aerial survey, 1966-1977
Data summary:	
Data quality:	Excellent for weir enumeration 1978-2004; fair for weir counts 1921-1933 and aerial surveys; good for harvest and age data.
Data type:	Weir counts from 1978-2004 with escapement age data during weir counts, 1985-2004. Fixed-wing aerial surveys from 1966 to 1977. Commercial, subsistence, sport fish harvest data from Afognak Bay (252-34) from 1978-2004.
Data contrast:	Weir and aerial data, all years: 440
	Weir data, all years: 21
	Recent weir data, 1978-2004: 9
	Recent weir data from pre-fertilization years, 1978-1993: 3
Methodology:	Ricker and gamma spawner-recruit models, percentiles, euphotic volume analysis, smolt biomass as a function of zooplankton biomass, and available spawning habitat.
Autocorrelation:	None
Criteria for BEG:	Ricker spawner-recruit model.

Comments:	The BEG estimate was based on a significant relationship (P=0.007) from the spawner-recruit data fit to the Ricker model. Limnological data collected from 1987-2004 and applied to the zooplankton biomass model indicates the system is rearing limited. The lake was enriched with a liquid fertilizer from 1990-2000 and back stocked with juveniles in 1991, 1993, and 1996-1998. Thus, a comparison of zooplankton data from non-fertilized years vs. all years was performed. With no plan to fertilize the lake in the future, utilizing the unfertilized data seemed more appropriate and will more accurately reflect zooplankton production.
Recommendation:	Based on the Ricker spawner-recruit analysis and the zooplankton biomass model, a BEG of 20,000 to 50,000 is recommended.

Appendix E2.–Afognak Lake sockeye salmon escapement, 1921-2004.

System: Afognak Lake

Species: sockeye salmon

Data available for analysis of escapement goals

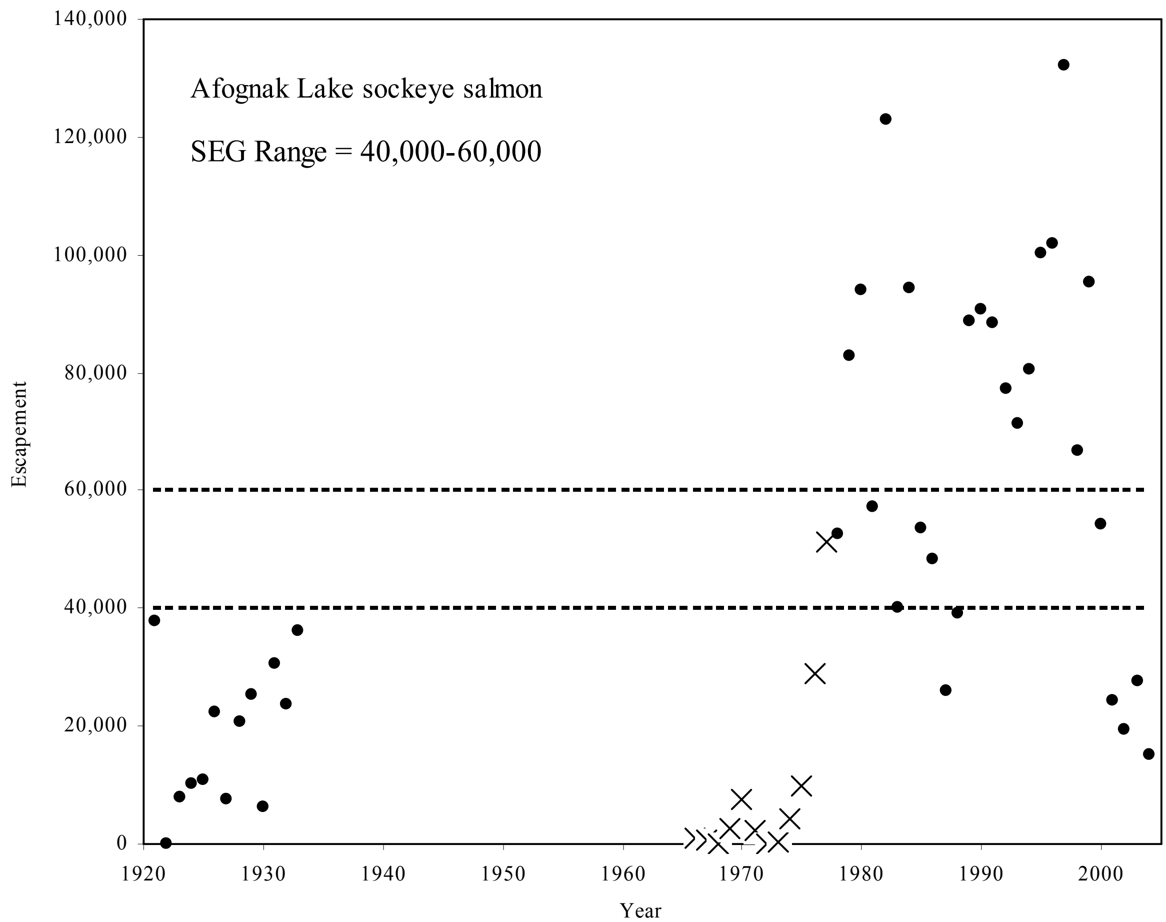
Year	Weir Counts	Peak Aerial Survey	Year	Weir Counts	Peak Aerial Survey
1921	37,653		1978	52,701	
1922	0		1979	82,703	
1923	8,025		1980	93,861	
1924	10,317		1981	57,267	
1925	11,000		1982	123,055	
1926	22,250		1983	40,049	
1927	7,491		1984	94,463	
1928	20,862		1985	53,563	
1929	25,428		1986	48,328	
1930	6,238		1987	25,994	
1931	30,515		1988	39,012	
1932	23,574		1989	88,825	
1933	36,144		1990	90,666	
1966		950	1991	88,557	
1967		550	1992	77,260	
1968		-	1993	71,460	
1969		2,600	1994	80,570	
1970		7,500	1995	100,131	
1971		2,200	1996	101,718	
1972		-	1997	132,050	
1973		300	1998	66,869	
1974		4,300	1999	95,361	
1975		10,000	2000	54,064	
1976		29,000	2001	24,271	
1977		51,300	2002	19,520	
1977			2003	27,766	
1978	52,701		2004	15,181	

Appendix E3.–Afognak Lake sockeye salmon escapement, 1921-2004 and current escapement goal ranges.

System: Afognak Lake

Species: sockeye salmon

Observed escapement by year (solid circles for weir counts, Xs for aerial surveys) and current SEG range (dashed lines).



Appendix E4.–Afognak Lake sockeye salmon brood table.

System: Afognak Lake

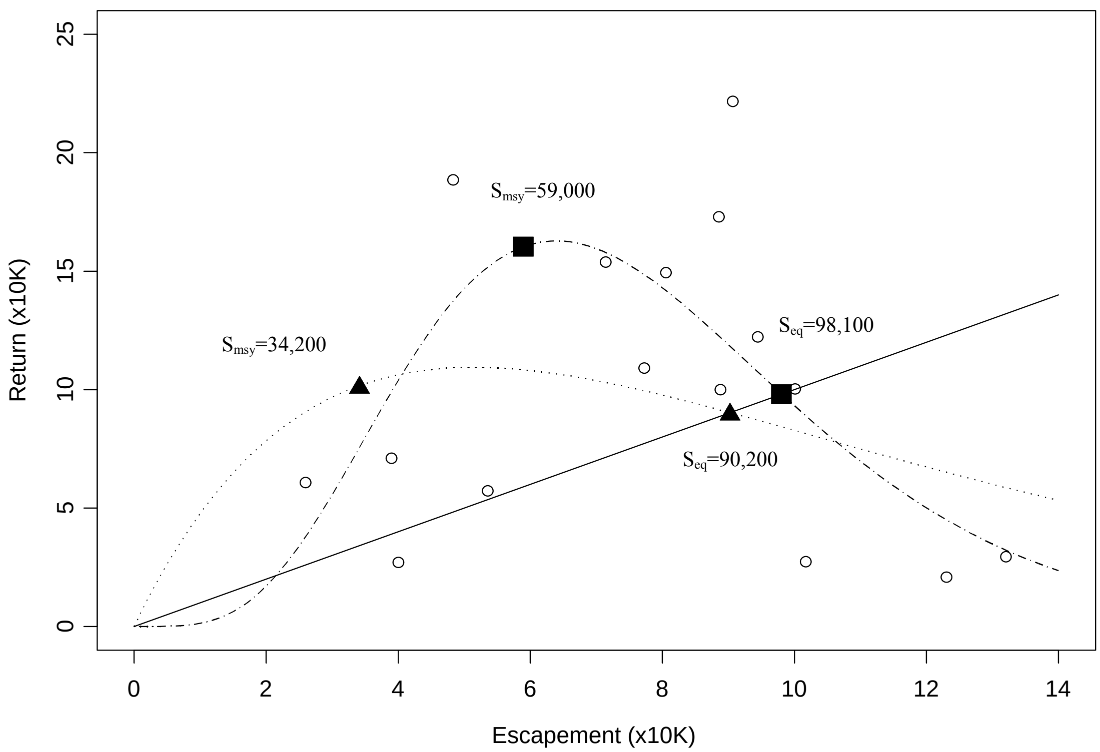
Species: sockeye salmon

Data available for analysis of escapement goals

Brood		Age of Returns																Total	
Year	Escapement	0.1	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	4.1	2.4	3.3	Return	R/S
1982	123,055		0	17	113	5,557	113	0	13,865	763	0	0	376	0	0	0	0	20,804	0.2
1983	40,049	0	0	340	0	9,842	297	0	10,140	4,686	0	0	1,717	0	0	35	0	27,022	0.7
1984	94,463	0	0	1,590	54	24,946	1,324	0	47,376	22,487	0	340	24,186	0	0	0	0	122,303	1.3
1985	53,563	36	98	276	0	10,642	2,918	0	26,660	10,075	0	0	6,592	0	0	66	0	57,297	1.1
1986	48,328	0	0	8,068	35	54,981	720	0	108,895	4,976	0	431	10,444	0	0	0	0	188,550	3.9
1987	25,994	0	0	776	0	20,966	314	0	25,318	3,220	100	0	9,837	178	0	0	0	60,709	2.3
1988	39,012	0	0	473	0	18,761	8,419	0	23,785	9,672	57	78	9,737	80	0	0	0	71,062	1.8
1989	88,825	0	0	17,934	0	8,377	13,517	0	35,862	10,504	158	254	13,415	0	0	397	0	100,021	1.1
1990	90,666	0	0	12,989	0	31,138	4,216	0	97,222	18,583	0	397	56,932	175	0	0	199	221,652	2.4
1991	88,557	0	281	9,731	278	37,577	1,445	0	96,391	4,512	0	48	22,660	0	0	0	0	172,923	2.0
1992	77,260	0	0	3,936	175	20,245	4,704	0	71,132	3,099	0	367	5,406	0	0	0	0	109,064	1.4
1993	71,460	0	0	35,199	0	40,201	10,239	0	48,179	10,420	223	331	8,950	74	649	0	687	153,816	2.2
1994	80,570	0	0	7,893	0	7,884	6,996	74	12,891	58,045	74	0	52,940	2,558	0	0	209	149,355	1.9
1995	100,131	0	0	18,669	0	52,730	721	0	12,015	4,571	0	0	11,602	0	77	0	0	100,308	1.0
1996	101,718	0	0	1,469	0	1,909	267	0	6,911	942	4,289	0	1,066	6,504	0	0	3,998	27,355	0.3
1997	132,050	0	30	1,588	0	3,260	1,820	0	7,506	5,054	192	0	8,219	777	0	179	843	29,468	0.2
1998	66,869	0	0	406	0	235	746	0	222	7,136	0	3	4,073						
1999	95,361	0	0	21	0	6,275	56	0	2,888	280	0								
2000	54,064	0	0	1,138	0	6,720	25												
2001	24,271	0	0	170															
2002	19,520																		
2003	27,766																		
2004	15,181																		

Appendix E5.–Fitted Ricker and gamma stock-recruitment curves, line of replacement, and actual data Afognak Lake sockeye salmon.

System: Afognak Lake
Species: sockeye salmon
Stock-recruitment relationship for brood years, 1982-1997. The dotted line represents the Ricker curve, the dashed line represents the gamma curve, and the solid line represents replacement.

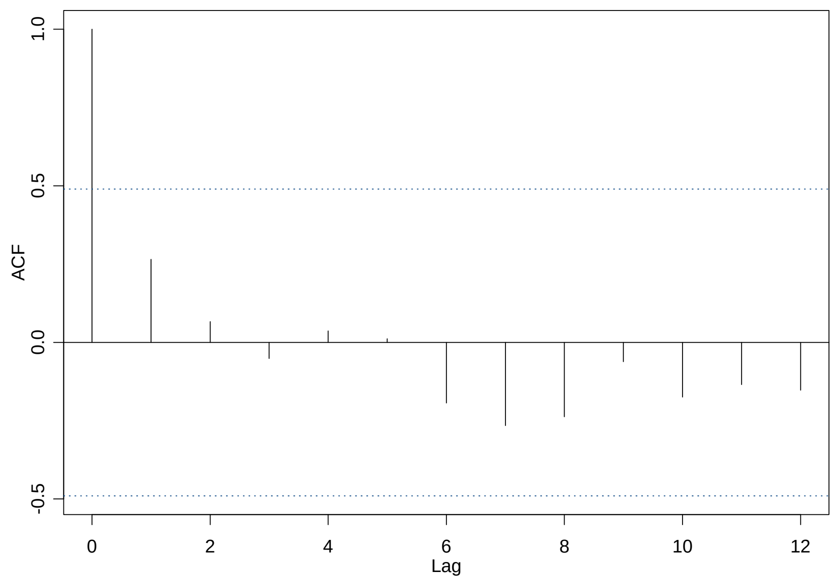


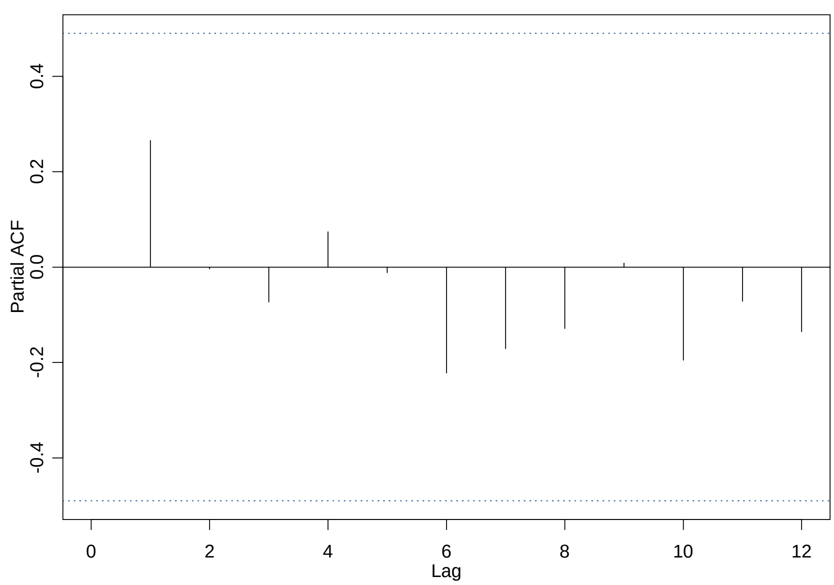
Appendix E6.–Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals of the Ricker model for Afognak Lake sockeye salmon.

System: Afognak Lake

Species: sockeye salmon

ACF and PACF of residuals from the Ricker model



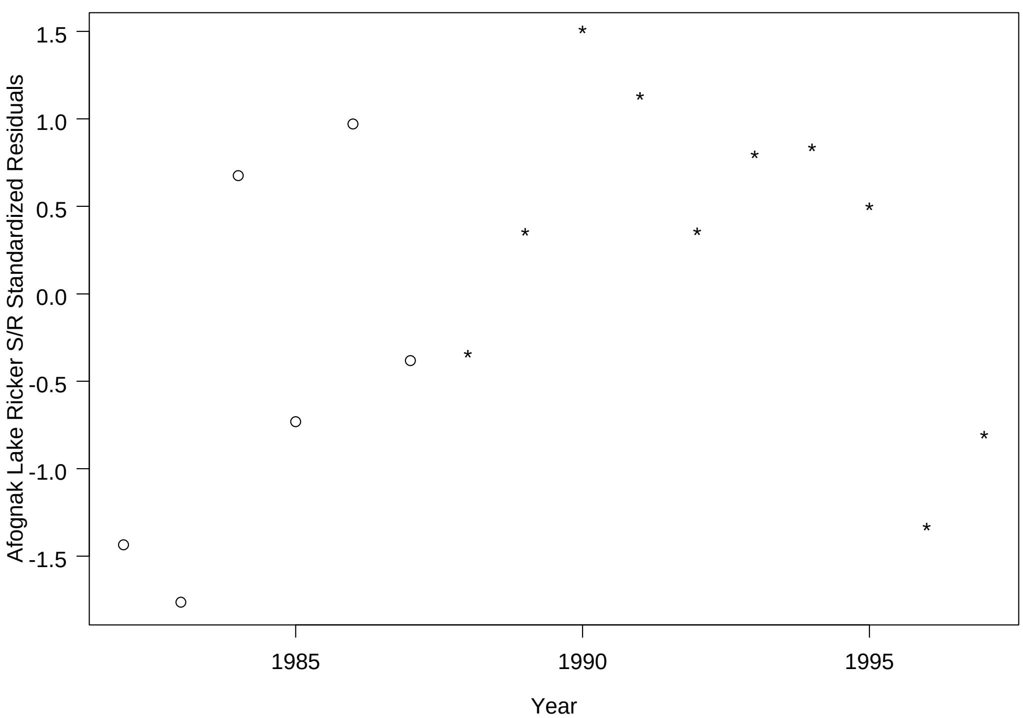


Appendix E7.–Standardized residuals from the Afognak Lake Ricker model, with asterisks (*) identifying the years of fertilization.

System: Afognak Lake

Species: sockeye salmon

Standardized residuals from the Ricker model by year (open circles unfertilized years and asterisks fertilized years)

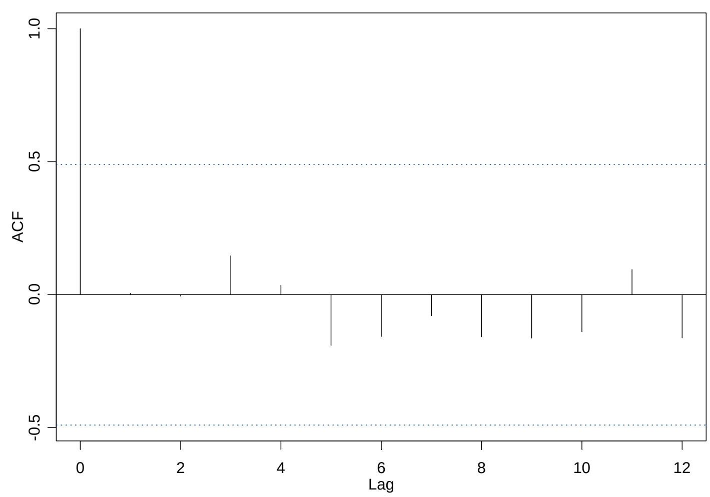


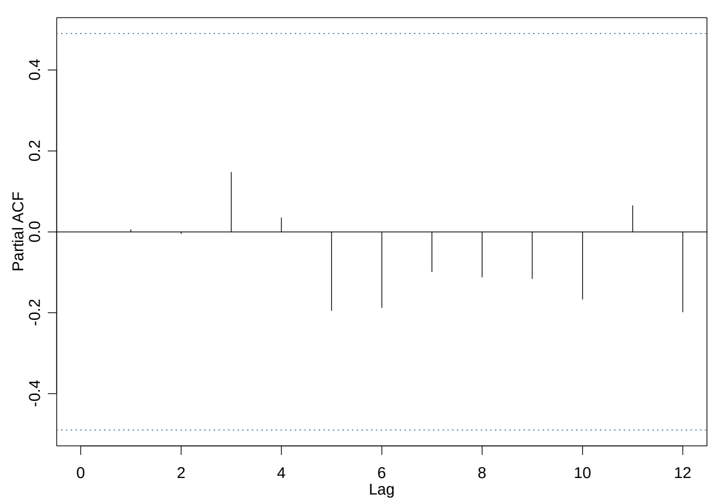
Appendix E8.–Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals of the gamma model for Afognak Lake sockeye salmon.

System: Afognak Lake

Species: sockeye salmon

ACF and PACF of residuals from the gamma model



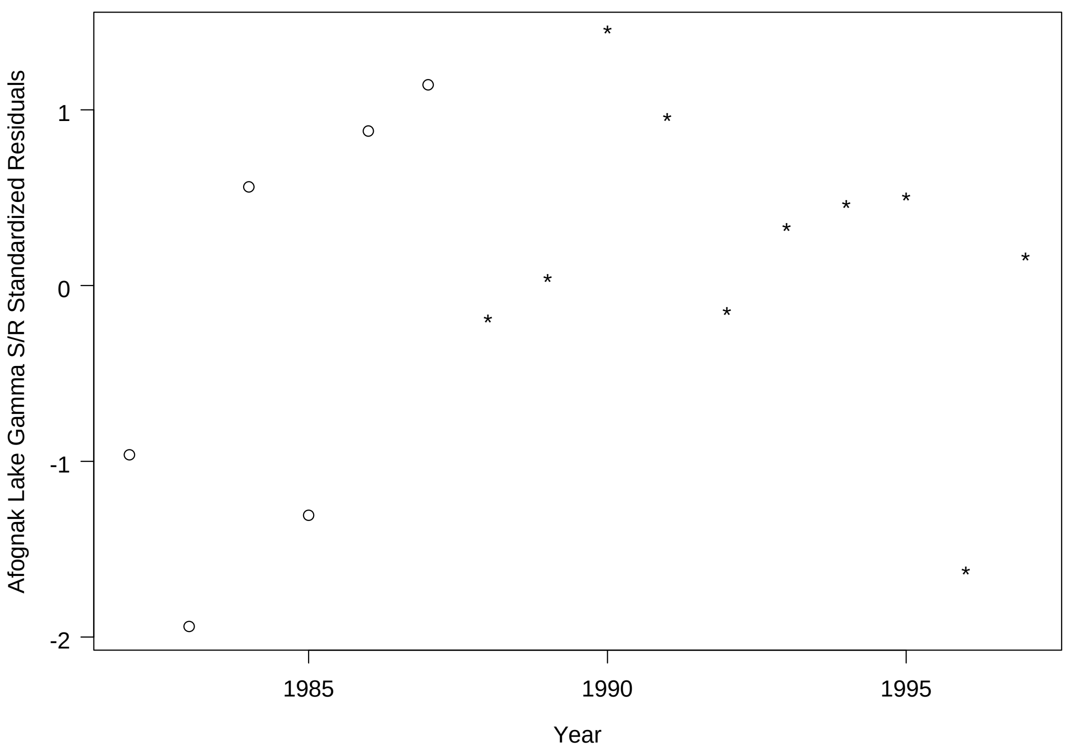


Appendix E9.–Standardized residuals from the Afognak Lake gamma model, with asterisks (*) identifying the years of fertilization.

System: Afognak Lake

Species: sockeye salmon

Standardized residuals from the gamma model by year (open circles unfertilized years and asterisks fertilized years)



APPENDIX F. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR LITTLE RIVER SOCKEYE SALMON

Appendix F1.–Description of stocks and escapement goals for Little River sockeye salmon.

System: Little River

Species: sockeye salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	SEG: 15,000 to 25,000 (1988)
Recommended escapement goal:	None (remove)
Optimal escapement goal:	Eliminate goal
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial surveys: 1975-2000, and 2004, weir counts 2001-2003
Data summary:	
Data quality:	Fair for aerial surveys, good for weir counts
Data type:	Fixed-wing aerial surveys with peak surveys from 1975-2000 and 2004, and weir counts 2001-2003. Used all data and aerial surveys only. No stock-specific harvest information is available.
Contrast:	All surveys and aerial surveys: 26.4 and 12.7, respectively
Methodology:	Risk analysis and percentile approach
Comments:	None
Recommendations:	Eliminate the current escapement goal.

Appendix F2.–Little River sockeye salmon escapement, 1975-2004

System: Little River

Species: sockeye salmon

Data available for analysis of escapement goals

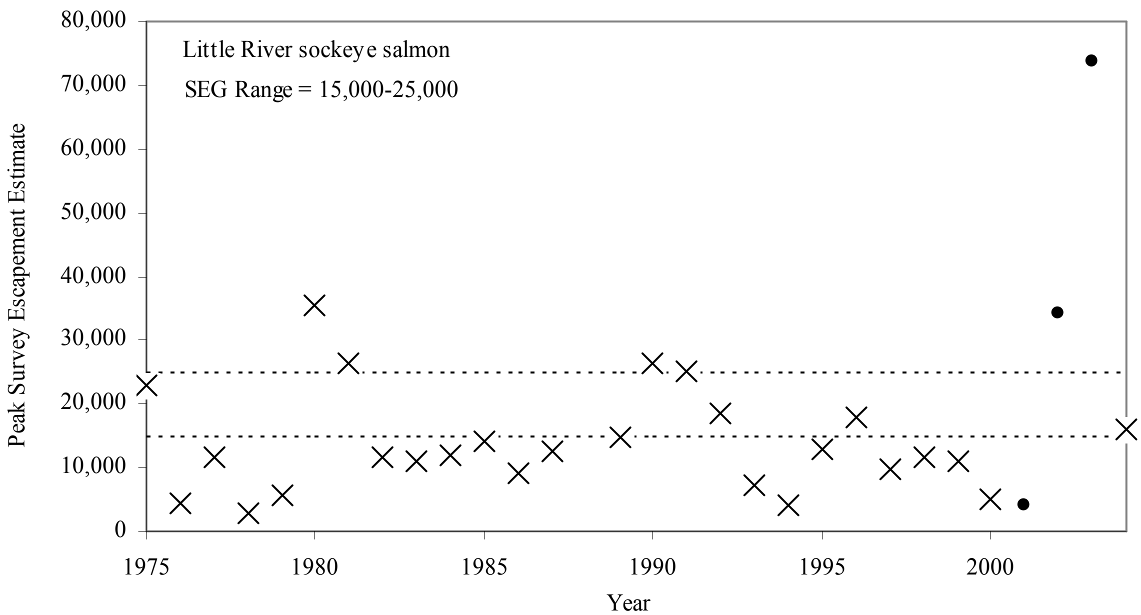
Year	Peak Aerial Survey	Weir Counts
1975	23,000	
1976	4,500	
1977	11,500	
1978	2,800	
1979	5,500	
1980	35,500	
1981	26,500	
1982	11,500	
1983	11,000	
1984	12,000	
1985	14,000	
1986	9,000	
1987	12,500	
1989	14,700	
1990	26,300	
1991	24,960	
1992	18,500	
1993	7,200	
1994	4,200	
1995	13,000	
1996	18,000	
1997	9,800	
1998	11,500	
1999	11,000	
2000	5,000	
2001		3,994
2002		34,064
2003		73,856
2004	16,000	

Appendix F3.–Little River sockeye salmon escapement, 1975-2004 and current escapement goal ranges.

System: Little River

Species: sockeye salmon

Observed escapement by year (Xs circles for aerial surveys and solid circles for weir counts) and current SEG range (dashed lines).

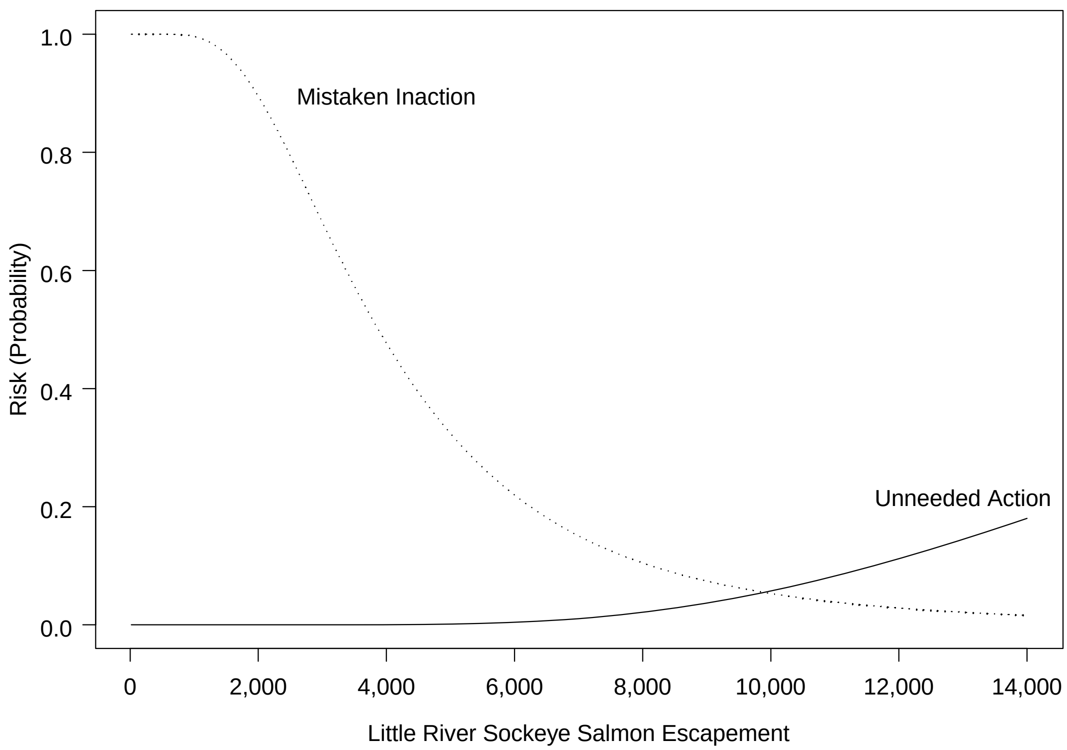


Appendix F4.–Risk analysis for Little River sockeye salmon, 1975-2004 using all data.

System: Little River

Species: sockeye salmon

Little River sockeye salmon, 1975-2004 risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).

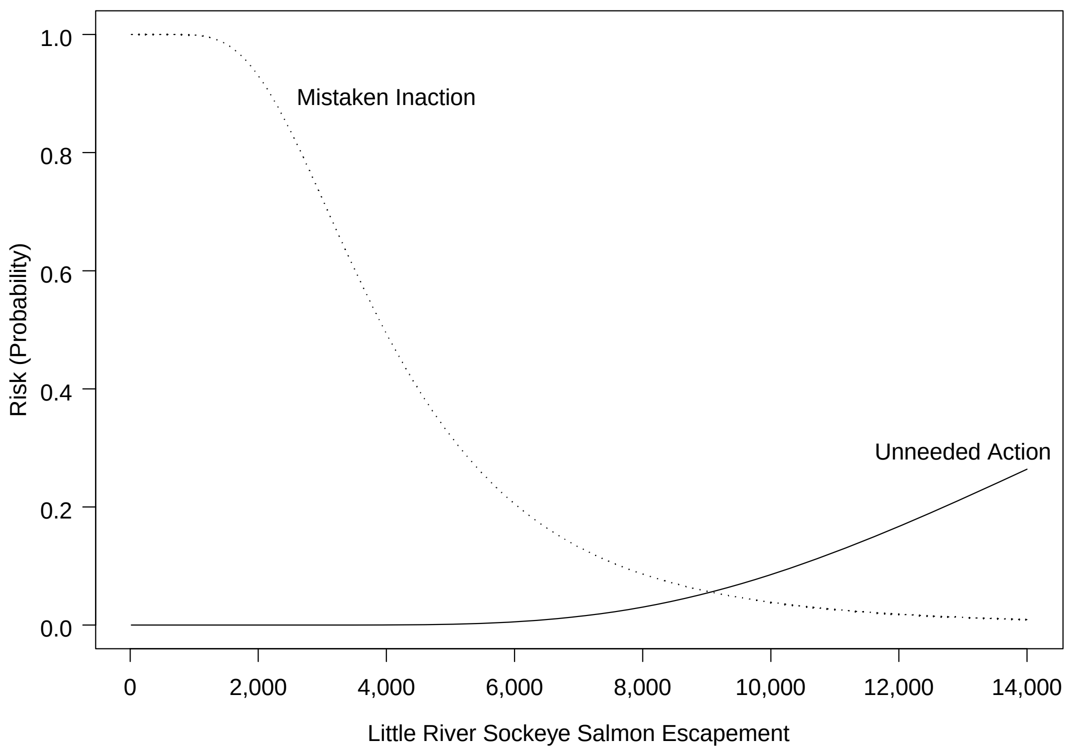


Appendix F5.–Risk analysis for Little River sockeye salmon, 1975-2000 and 2004 using aerial survey data only.

System: **Little River**

Species: **sockeye salmon**

Little River sockeye salmon, 1975-2000, and 2004 risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).



APPENDIX G. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR UGANIK LAKE SOCKEYE SALMON

Appendix G1.–Description of stock and escapement goal for Uganik Lake sockeye salmon.

System: **Uganik Lake**

Species: **sockeye salmon**

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial set gillnet and purse seine
Previous escapement goal:	SEG: 40,000 to 60,000 (late 1980s)
Recommended escapement goal:	Eliminate
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir counts, 1928-1932, 1990-1992.
	Aerial surveys, 1974,1976-1977, 1979-2003.
Data summary:	
Data quality:	Fair for aerial surveys (glacially fed lake has variable water visibility); good for weir enumeration.
Data type:	Fixed-wing aerial surveys, weir escapement estimates from 1990 to 1992 include some escapement age data. No stock-specific harvest information is available.
Contrast:	Peak aerial surveys (1974-2003) 31.4.
Methodology:	Analysis of escapement percentiles from peak aerial survey estimates, euphotic volume analysis, smolt biomass as a function of zooplankton biomass.
Autocorrelation:	None
Comments:	There is currently no timely means of estimating escapement into this system. There is not a weir operation or plans for one in the future.
Recommendations:	Recommendation is to eliminate the current SEG.

Appendix G2.–Uganik Lake sockeye salmon escapement, 1928-2003.

System: Uganik Lake

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Weir Counts	Peak Aerial Survey
1928	15,732	
1929	24,893	
1930	9,823	
1931	6,791	
1932	25,808	
No Data Between 1933 and 1973		
1974		9,000
1976		53,000
1977		42,000
1979		55,000
1980		26,000
1981		64,000
1982		50,000
1983		23,000
1984		40,000
1985		40,000
1986		45,000
1987		35,000
1988		12,000
1989		38,000
1990	65,551	97,300
1991	89,304	29,100
1992	69,015	25,000
1993		33,000
1994		22,600
1995		29,000
1996		33,200
1997		45,900
1998		14,250
1999		29,000
2000		20,310
2001		3,100
2002		25,400
2003		51,000

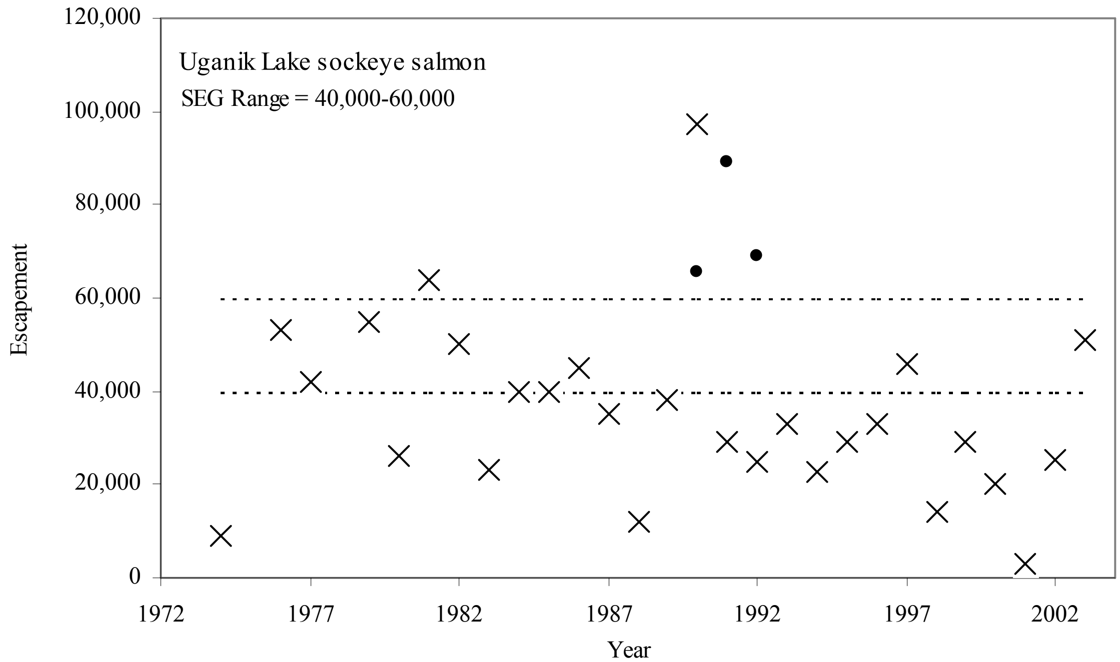
Note: All data from ADF&G database except 1928 to 1932 from Booth (1993). Weirs operated during variable timeframes. No data available for 1975 and 1978.

Appendix G3.–Uganik Lake sockeye salmon escapement, 1974-2003 and current escapement goal ranges.

System: **Uganik Lake**

Species: **sockeye salmon**

Observed escapement by year (Xs for peak aerial surveys and solid circles for weir counts) and current SEG (dashed lines).

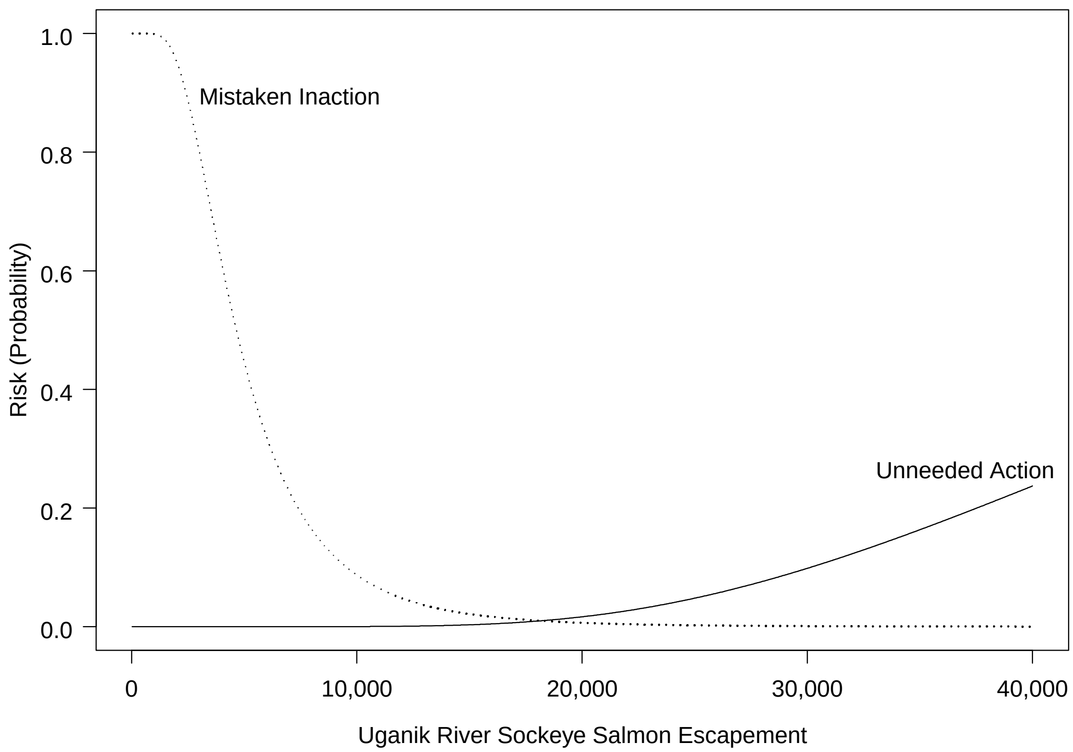


Appendix G4.–Risk analysis results for Uganik Lake sockeye salmon.

System: Uganik Lake

Species: sockeye salmon

Risk analysis for Uganik Lake, as analyzed from all data.

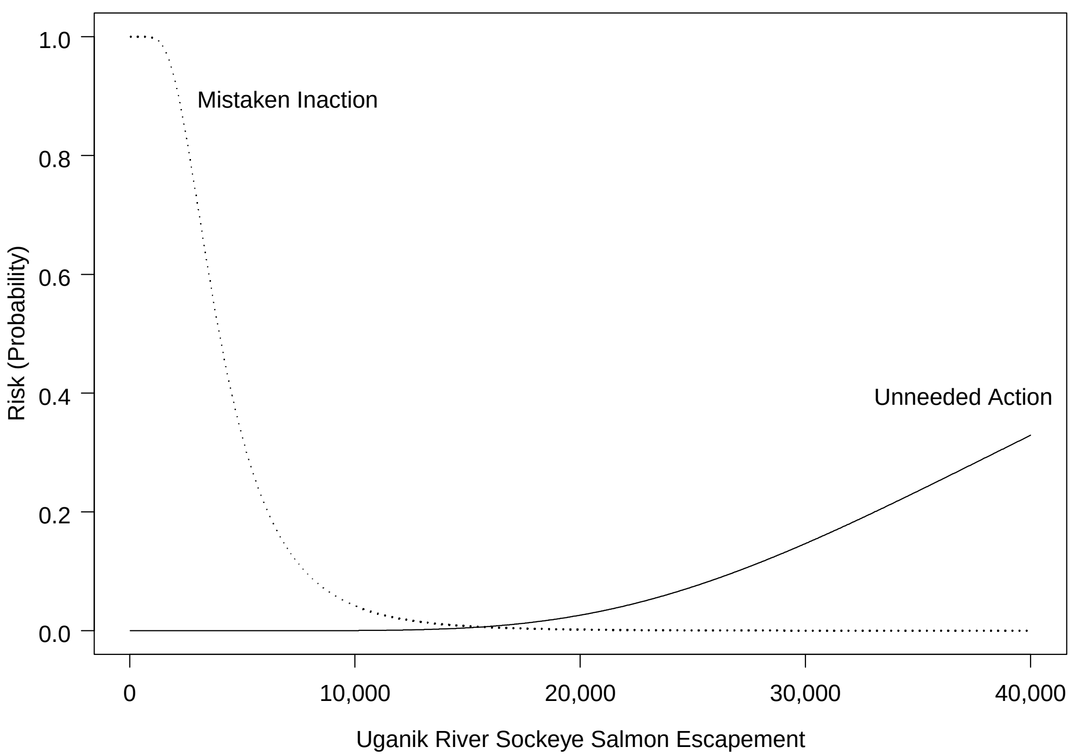


-continued-

System: **Uganik Lake**

Species: **sockeye salmon**

Risk analysis for Uganik Lake, as analyzed from aerial survey data only.



APPENDIX H. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR KARLUK LAKE SOCKEYE SALMON

Appendix H1.–Description of stock and escapement goals for Karluk Lake sockeye salmon.

System: Karluk Lake

Species: sockeye salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	Early run: BEG: 150,000-250,000 (1992)
	Late run: BEG: 400,000-550,000 (1992)
Recommended escapement goal:	Early run: BEG: 100,000-210,000
	Late run: BEG: 170,000-380,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir counts, 1922-2004
Data summary:	
Data quality:	Good
Data type:	Weir counts from 1922 to 2004. Age compositions and stock-specific harvest 1985-2003. Rough estimates of harvest attributed to both runs combined, 1922-2003. Smolt outmigration estimates 1961-68, 1980-84, 1991-92, and 1999-2003. Limnology information 1981-2004.
Data contrast:	1981-2003: early (2.3), late (2.9), both (2.0)
Methodology:	Ricker spawner-recruit, EV model, zooplankton model
Comments:	Brood years 1981-1995 may be affected by fertilization (1986-1990) and egg stocking (1979-1987).
Recommendations:	Recommend new BEGs based on individual significant spawner-recruit curves:
	Early run: 100,000 – 210,000
	Late run: 170,000 – 380,000

Appendix H2.–Karluk Lake early-run sockeye salmon escapement, 1981-2004.

System: Karluk Lake early run

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Weir Count
1981	97,937
1982	122,705
1983	215,620
1984	288,422
1985	316,688
1986	358,756
1987	354,094
1988	296,510
1989	349,753
1990	196,197
1991	243,069
1992	217,152
1993	261,169
1994	260,771
1995	238,079
1996	250,357
1997	252,859
1998	252,298
1999	392,419
2000	291,351
2001	338,799
2002	456,842
2003	451,856
2004	393,468

Appendix H3.–Karluk Lake late-run sockeye salmon escapement, 1981-2004.

System: **Karluk Lake late run**

Species: **sockeye salmon**

Data available for analysis of escapement goals

Year	Weir Count
1981	124,769
1982	41,702
1983	220,795
1984	131,846
1985	679,260
1986	528,415
1987	412,157
1988	282,306
1989	758,893
1990	541,891
1991	831,970
1992	614,262
1993	396,288
1994	587,258
1995	504,977
1996	323,969
1997	311,902
1998	384,848
1999	589,119
2000	445,393
2001	524,739
2002	408,734
2003	626,854
2004	326,735

Appendix H4.–Karluk Lake early- and late-runs combined sockeye salmon escapement, 1981-2004.

System: Karluk Lake early and late runs combined

Species: sockeye salmon

Data available for analysis of escapement goals

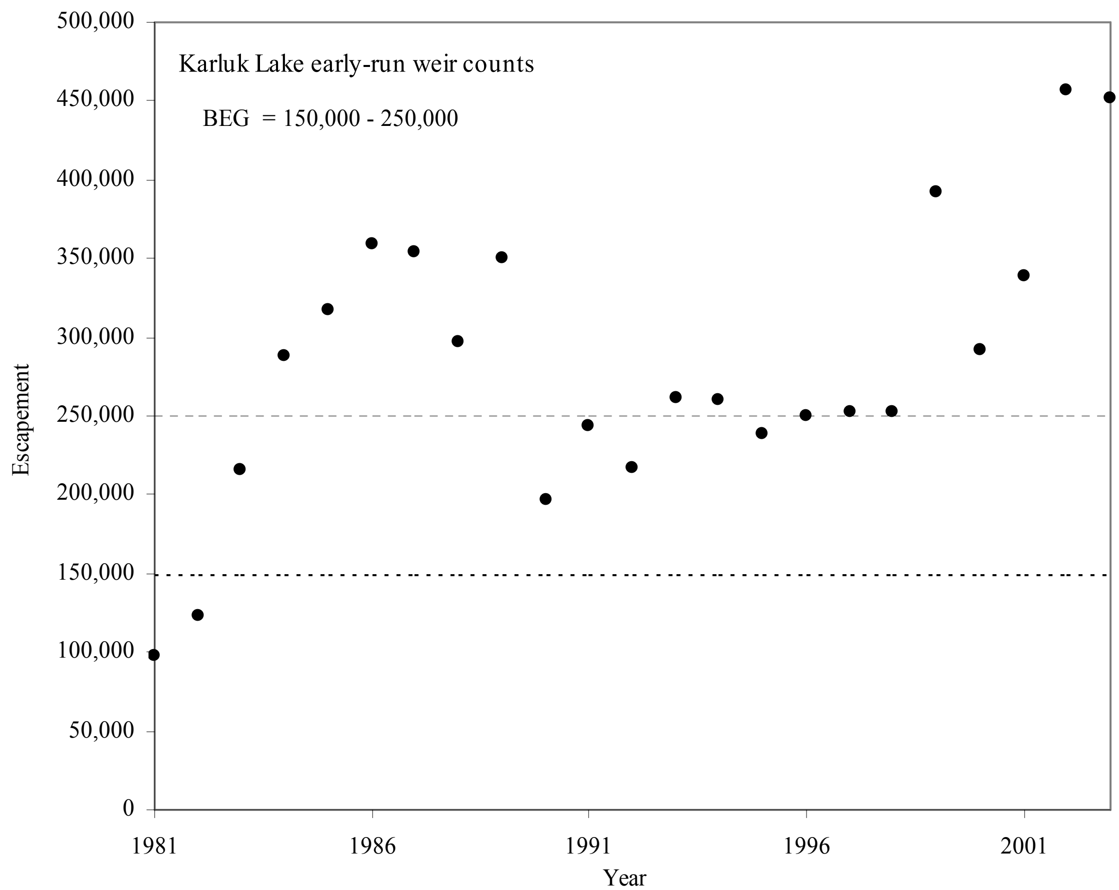
Year	Weir Count
1981	222,706
1982	164,407
1983	436,415
1984	420,268
1985	995,948
1986	887,171
1987	766,251
1988	578,816
1989	1,108,646
1990	738,088
1991	1,075,039
1992	831,414
1993	657,457
1994	848,029
1995	743,056
1996	574,326
1997	564,761
1998	637,146
1999	981,538
2000	736,744
2001	863,538
2002	865,576
2003	1,078,710
2004	720,203

Appendix H5.–Karluk Lake early-run sockeye salmon escapement, 1981-2003 and current escapement goal range.

System: **Karluk Lake early run**

Species: **sockeye salmon**

Observed escapement by year (black circles) and current BEG (dashed lines).

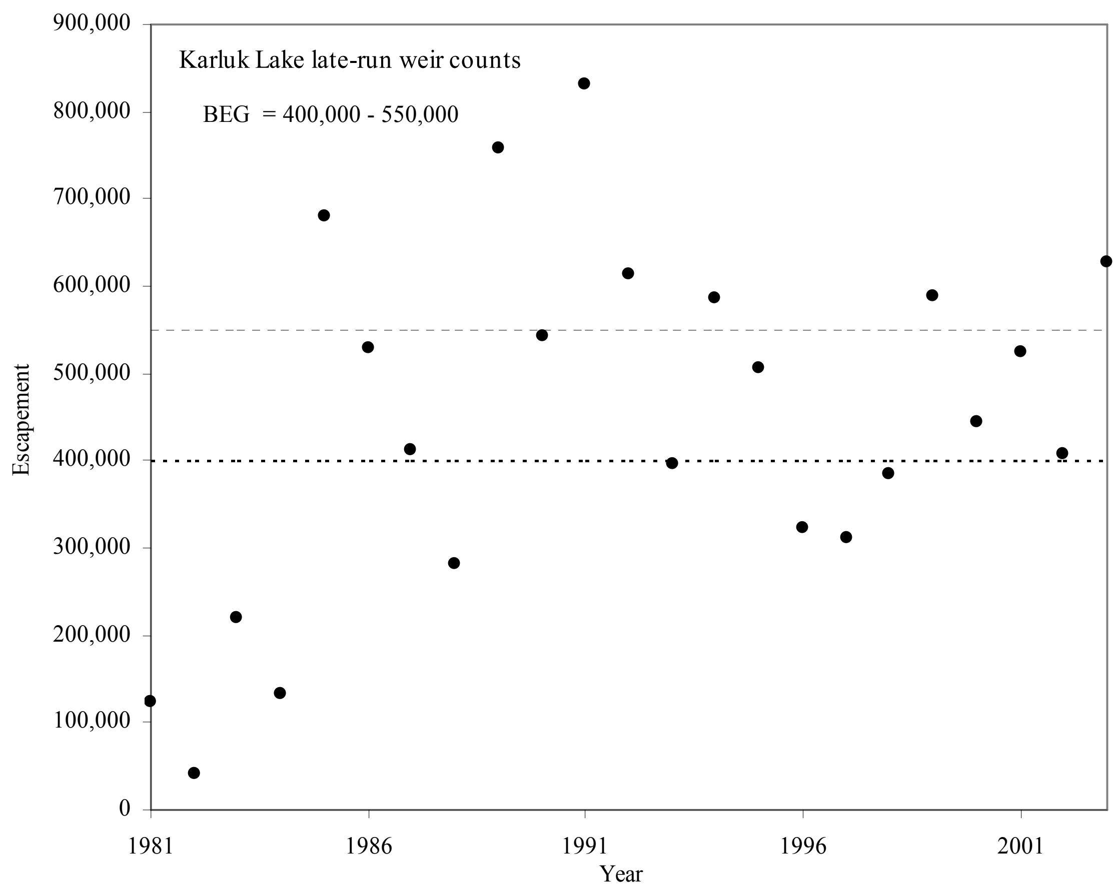


Appendix H6.–Karluk Lake late-run sockeye salmon escapement, 1981-2003 and current escapement goal range.

System: Karluk Lake late run

Species: sockeye salmon

Observed escapement by year (black circles) and current BEG (dashed lines).

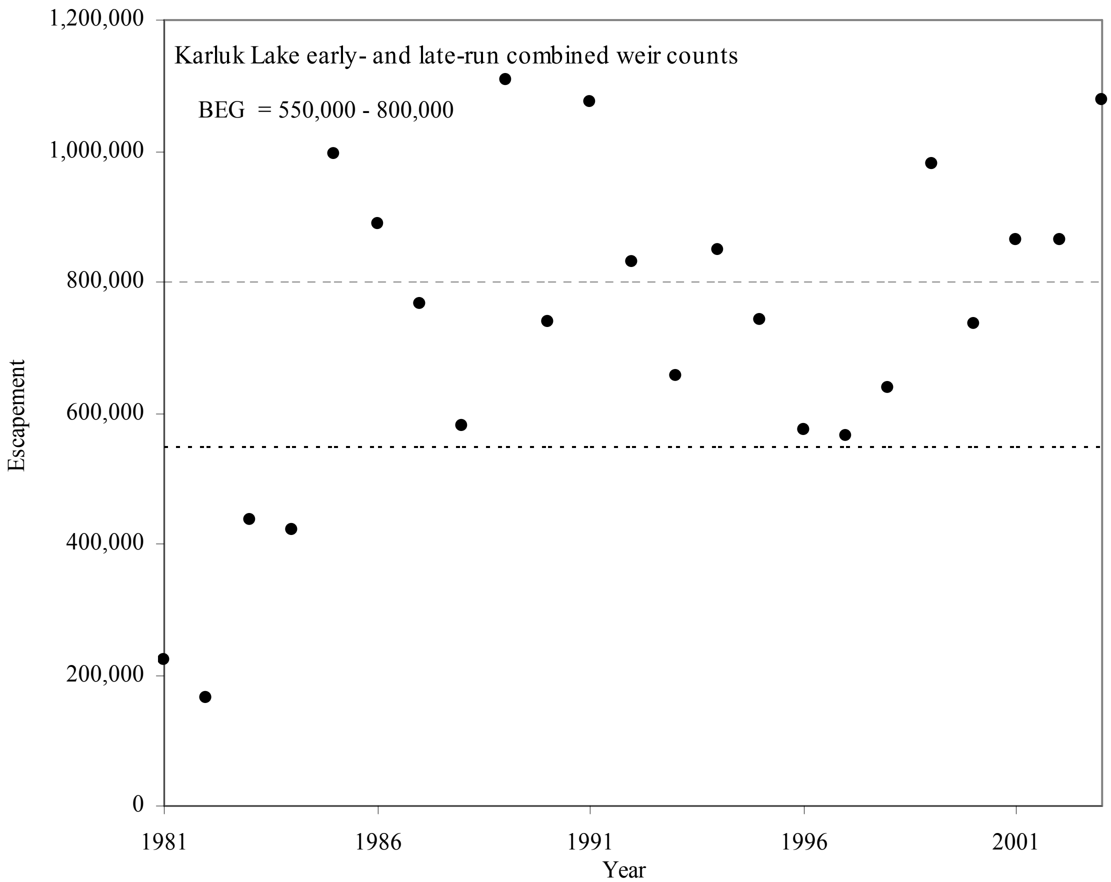


Appendix H7.–Karluk Lake early- and late-runs combined sockeye salmon escapement, 1981-2003 and current escapement goal range.

System: Karluk Lake early and late runs combined

Species: sockeye salmon

Observed escapement by year (black circles) and current BEG (dashed lines)



Appendix H8.–Karluk Lake early-run sockeye salmon brood table.

System: Karluk Lake early run

Species: sockeye salmon

Data available for analysis of escapement goals

Brood Year	Escap.	Ages 0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	4.1	2.4	3.3	4.2	3.4	4.3	4.4	Total Return
1976	204,037																			0	
1977	185,312																	0	0	0	
1978	248,741														0	10,989	0	0	0	0	
1979	212,872										0	50,484	45,654	0	641	14,673	0	0	0	0	
1980	132,396						0	11,635	193,760	4,085	0	103,899	60,395	0	0	37,689	0	0	0	0	
1981	97,937			0	8,558	18,604	0	3,735	278,831	1,672	0	117,158	38,129	0	272	22,433	0	0	0	0	489,391
1982	122,705	0	1,244	841	4,650	5,466	0	21,058	197,293	4,169	0	93,560	37,079	0	0	20,728	0	0	0	320	386,408
1983	215,620	0	143	564	8,159	7,032	0	14,244	149,947	1,728	0	183,829	33,945	0	337	14,082	0	0	0	0	414,009
1984	288,422	0	0	0	4,090	8,393	0	5,830	97,537	738	0	94,258	30,589	0	908	19,634	0	0	0	0	261,977
1985	316,688	0	0	24	4,258	2,842	0	3,969	72,857	3,010	0	88,599	57,934	0	1,955	40,331	0	38	30	0	275,847
1986	358,756	24	0	337	6,152	2,201	346	6,443	87,691	4,031	94	129,381	131,218	0	479	61,223	1,508	235	113	0	431,475
1987	354,094	427	0	1,456	958	2,884	0	8,503	114,504	19,876	416	44,051	337,905	0	285	60,244	2,309	690	1,969	0	596,477
1988	296,510	0	0	0	8,383	6,297	0	9,708	84,322	13,770	0	37,096	202,729	0	320	70,357	231	39	2,906	0	436,159
1989	349,753	0	1,621	0	8,492	7,624	0	13,979	104,564	5,517	0	167,751	101,296	0	1	69,709	5,362	0	1,713	0	487,630
1990	196,197	0	181	0	18,149	2,780	0	50,649	79,156	6,586	652	146,751	97,063	0	269	70,863	760	0	0	0	473,858
1991	243,069	0	1,224	1,062	26,661	12,015	0	83,430	326,422	7,087	0	127,809	81,364	809	107	12,113	2,476	0	247	0	682,826
1992	217,152	0	2,669	4	9,627	9,642	0	13,159	52,730	14,935	0	42,891	58,375	0	769	36,603	0	79	0	0	241,483
1993	261,169	2	1,534	350	3,309	18,252	0	7,718	226,377	2,275	0	128,158	35,029	0	1,752	42,563	437	288	0	0	468,044
1994	260,771	0	1,017	0	8,956	7,266	0	41,179	294,780	1,857	427	182,133	54,148	0	587	33,887	1,781	1,042	0	0	629,059
1995	238,079	0	218	0	23,268	13,106	0	33,004	231,809	3,463	0	245,934	83,559	0	1,405	52,470	835	492	0		689,562
1996	250,357	0	0	0	2,063	5,959	0	2,217	253,847	2,326	0	215,129	84,029	0	61	42,035	0				607,666
1997	252,859	0	0	1,838	3,930	11,696	0	6,691	233,964	3,274	0	131,879	63,748	0							
1998	252,298	0	574	0	4,258	19,885	0	5,410	531,206	4,517											
1999	392,419	0	898	0	15,382	28,948															
2000	291,351	0	939																		
2001	338,799																				
2002	456,842																				
2003	451,856																				

Appendix H9.–Karluk Lake late-run sockeye salmon brood table.

System: Karluk Lake late run

Species: sockeye salmon

Data available for analysis of escapement goals

Brood Year	Escap.	Ages 0.1	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	4.2	3.4	4.3	Total Return
1976	319,459																			
1977	366,936																	0	0	
1978	112,194														0	6,728	0	0	0	
1979	248,908											0	54,171	167,426	0	85,143	0	0	0	
1980	14,227							0	446	596,053	4,476	0	156,074	177,587	1,190	25,537	0	0	0	
1981	124,769				0	5,158	13,129	0	0	402,872	2,521	0	187,293	49,557	0	14,077	0	0	0	674,607
1982	41,702		0	0	0	0	1,261	0	5,239	290,631	606	0	110,997	34,711	0	19,631	0	0	0	463,075
1983	220,795	0	0	0	4,079	4,160	12,830	0	480	241,803	1,268	31	213,452	42,156	2,070	47,370	0	0	0	569,699
1984	131,846	0	885	0	0	445	6,246	0	30,516	424,123	0	937	303,542	271,018	471	71,764	651	0	0	1,110,598
1985	679,260	169	0	0	1,084	30,165	212	189	60,235	784,914	494	595	493,743	421,972	462	43,998	0	42	0	1,838,274
1986	528,415	0	893	0	15,519	39,109	978	105	57,974	835,214	1,162	0	114,862	655,219	563	60,240	325	147	1,623	1,783,933
1987	412,157	106	5,976	201	17,067	24,703	1,737	0	550	226,552	2,373	0	23,389	320,723	79	54,451	1,600	0	0	679,507
1988	282,306	0	2,531	111	2,424	4,649	1,512	0	3,127	189,196	7,249	0	71,078	212,649	0	16,740	0	0	9	511,274
1989	758,893	0	3,555	799	3,717	5,909	12,607	0	3,302	308,439	6,233	0	151,212	214,110	0	12,030	950	0	0	722,863
1990	541,891	0	3,591	971	6,292	16,995	3,241	0	10,310	447,371	1,085	18	52,479	80,226	591	62,392	1,095	0	64	686,721
1991	831,970	0	7,113	340	2,879	16,292	3,023	0	8,568	340,535	4,731	52	191,311	85,334	952	13,107	659	111	0	675,007
1992	614,262	0	1,567	1,923	0	3,880	6,759	0	12,234	57,188	5,043	0	76,196	138,987	513	28,379	0	0	0	332,669
1993	396,288	0	0	1,501	2,860	3,550	17,168	0	11,541	412,758	1,362	36	202,913	75,591	0	23,523	0	0	0	752,802
1994	587,258	0	0	198	1,192	24,718	4,323	0	17,261	616,350	1,008	0	159,094	109,890	551	41,274	821	128	0	976,808
1995	504,977	0	1,156	0	3,219	48,766	8,685	0	1,839	353,857	5,252	0	390,880	129,216	424	28,253	405	284	1,384	973,619
1996	323,969	0	540	633	0	2,970	108	0	469	283,071	2,817	0	149,445	139,820	0	83,431	0			663,304
1997	311,902	0	0	407	0	1,473	21,821	0	291	494,043	18,682	0	268,631	235,707						
1998	384,848	0	0	136	0	586	33,787	1,399	2,716	923,141	8,407									
1999	589,119	0	0	0	0	25,117	41,401													
2000	445,393	155	669	51																
2001	524,739	0																		
2002	408,734																			
2003	626,854																			

Appendix H10.–Karluk Lake early- and late-runs combined sockeye salmon brood table.

System: Karluk Lake early and late runs combined

Species: sockeye salmon

Data available for analysis of escapement goals

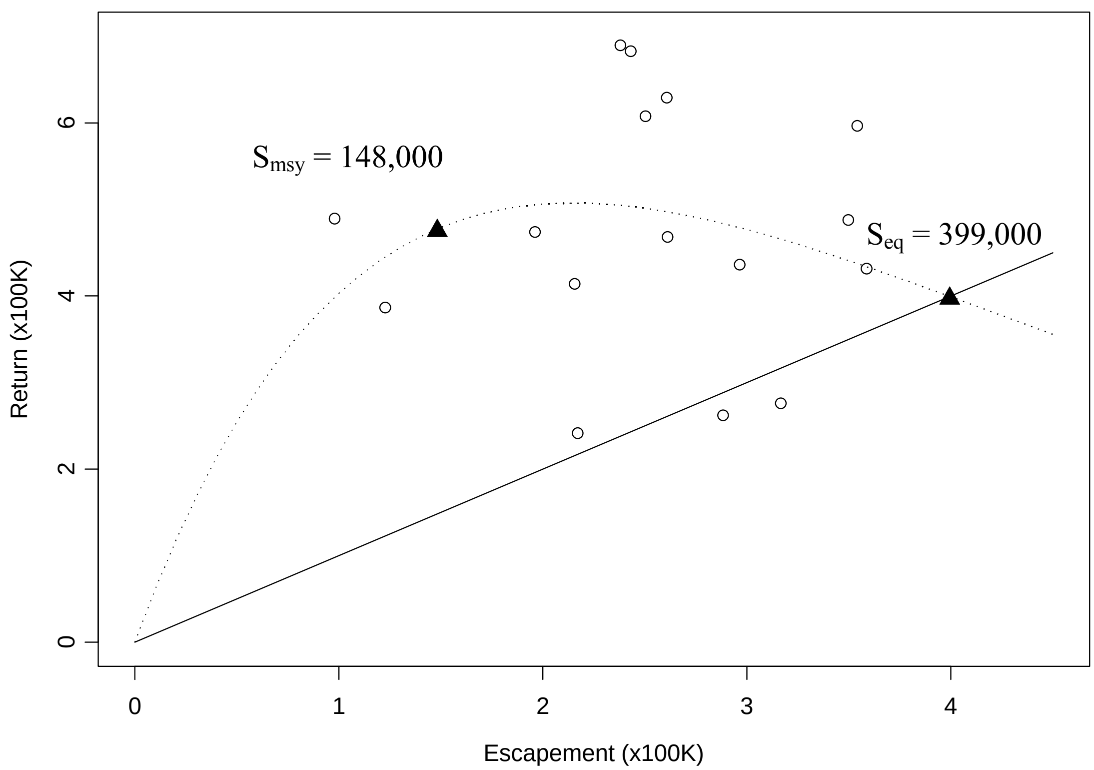
Brood		Ages																				Total
Year	Escap.	0.1	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	4.1	2.4	3.3	4.2	3.4	4.3	4.4	Return
1976	523,496																					
1977	552,248																				0	
1978	360,935															0	17,718	0	0	0	0	
1979	461,780											0	104,655	213,080	0	641	99,816	0	0	0	0	
1980	146,623							0	12,082	789,813	8,561	0	259,973	237,982	0	1,190	63,226	0	0	0	0	
1981	222,706				0	13,716	31,733	0	3,735	681,702	4,193	0	304,451	87,686	0	272	36,510	0	0	0	0	1,163,999
1982	164,407		0	1,244	841	4,650	6,727	0	26,297	487,924	4,775	0	204,557	71,789	0	0	40,359	0	0	0	320	849,483
1983	436,415	0	0	143	4,643	12,319	19,862	0	14,724	391,750	2,996	31	397,281	76,101	0	2,407	61,452	0	0	0	0	983,708
1984	420,268	0	885	0	0	4,535	14,639	0	36,346	521,660	738	937	397,801	301,607	0	1,379	91,398	651	0	0	0	1,372,575
1985	995,948	169	0	0	1,108	34,423	3,054	189	64,204	857,770	3,504	595	582,343	479,906	0	2,417	84,329	0	80	30	0	2,114,121
1986	887,171	0	917	0	15,855	45,260	3,179	451	64,417	922,905	5,193	94	244,243	786,438	0	1,042	121,463	1,833	382	1,736	0	2,215,407
1987	766,251	106	6,403	201	18,523	25,661	4,621	0	9,053	341,056	22,249	416	67,440	658,628	0	364	114,695	3,909	690	1,969	0	1,275,984
1988	578,816	0	2,531	111	2,424	13,032	7,809	0	12,835	273,518	21,019	0	108,174	415,378	0	320	87,097	231	39	2,915	0	947,433
1989	1,108,646	0	3,555	2,420	3,717	14,401	20,231	0	17,281	413,003	11,750	0	318,963	315,406	0	1	81,739	6,312	0	1,713	0	1,210,493
1990	738,088	0	3,591	1,152	6,292	35,144	6,021	0	60,959	526,527	7,671	670	199,230	177,289	0	860	133,255	1,855	0	64	0	1,160,579
1991	1,075,039	0	7,113	1,564	3,941	42,953	15,038	0	91,998	666,957	11,818	52	319,120	166,698	809	1,058	25,220	3,135	111	247	0	1,357,833
1992	831,414	0	1,567	4,592	4	13,507	16,401	0	25,393	109,918	19,978	0	119,087	197,361	0	1,282	64,982	0	79	0	0	574,152
1993	657,457	0	2	3,035	3,210	6,859	35,420	0	19,259	639,135	3,637	36	331,071	110,620	0	1,752	66,085	437	288	0	0	1,220,845
1994	848,029	0	0	1,215	1,192	33,674	11,589	0	58,440	911,130	2,865	427	341,227	164,038	0	1,138	75,161	2,602	1,170	0	0	1,605,867
1995	743,056	0	1,156	218	3,219	72,034	21,791	0	34,842	585,666	8,715	0	636,813	212,775	0	1,829	80,723	1,240	776	1,384		1,663,181
1996	574,326	0	540	633	0	5,033	6,066	0	2,686	536,918	5,143	0	364,573	223,849	0	61	125,466	0				1,270,970
1997	564,761	0	0	407	1,838	5,403	33,517	0	6,982	728,007	21,956	0	400,510	299,455	0							
1998	637,146	0	0	709	0	4,843	53,672	1,399	8,126	1,454,347	12,924											
1999	981,538	0	0	898	0	40,499	70,349															
2000	736,744	155	669	990																		
2001	863,538	0																				
2002	865,576																					
2003	1,078,710																					

Appendix H11.–Fitted Ricker curve, line of replacement, and actual data for Karluk Lake early-run sockeye salmon.

System: **Karluk Lake early run**

Species: **sockeye salmon**

Ricker stock-recruitment relationship, 1981 – 1996. The dashed line represents the Ricker curve, and the solid straight line represents replacement.

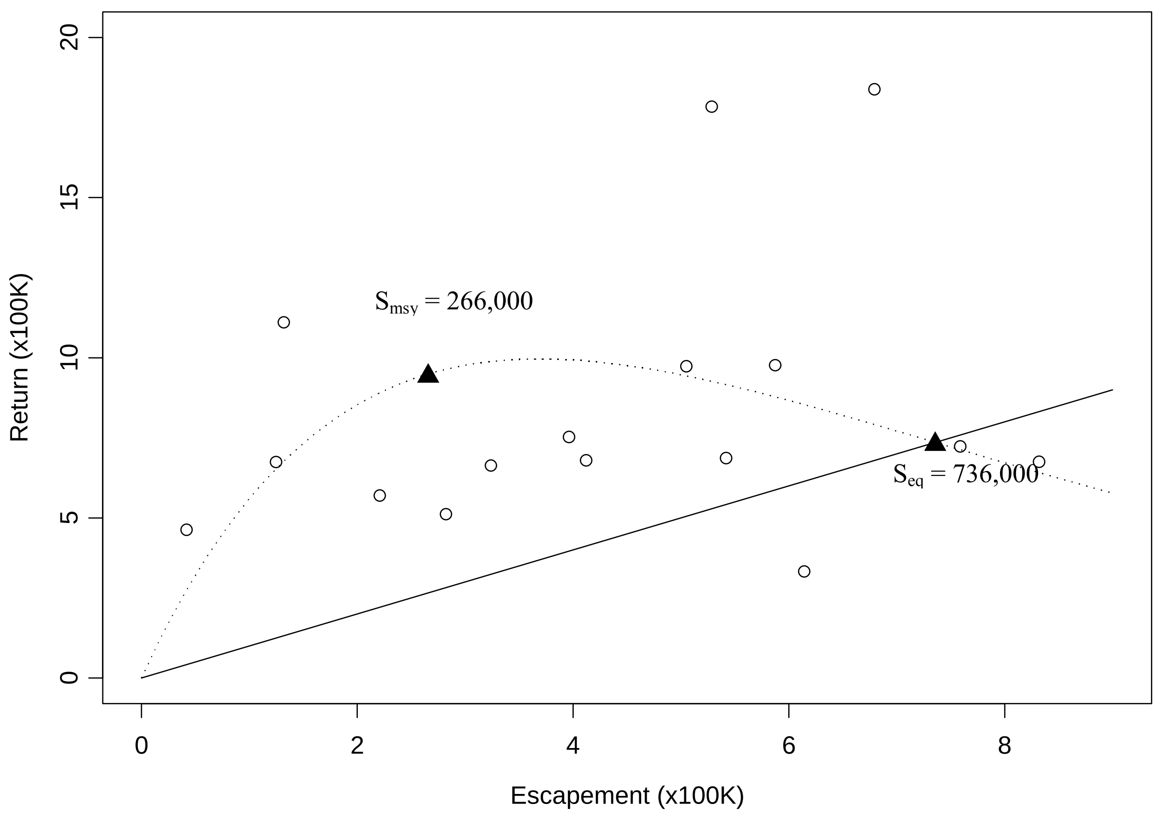


Appendix H12.–Fitted Ricker curve, line of replacement, and actual data for Karluk Lake late-run sockeye salmon.

System: Karluk Lake late run

Species: sockeye salmon

Ricker stock-recruitment relationship, 1981 – 1996. The dashed line represents the Ricker curve, and the solid straight line represents replacement.

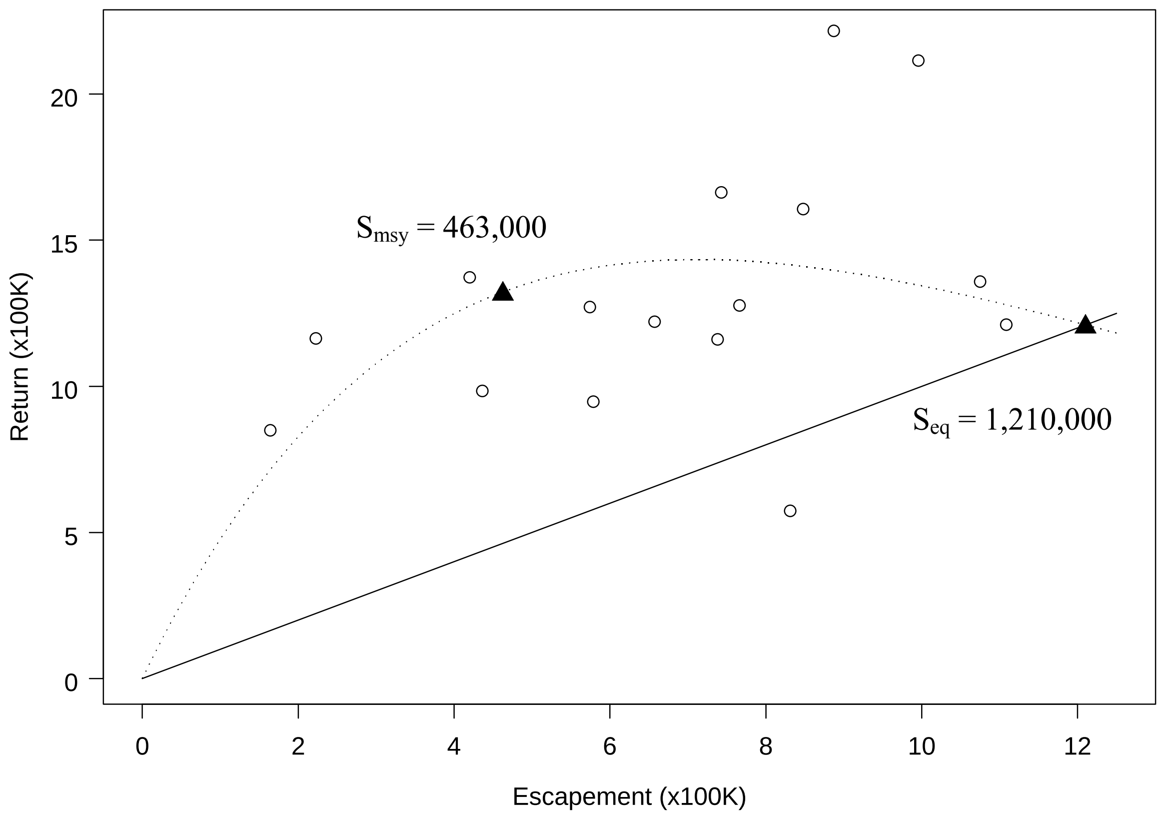


Appendix H13.–Fitted Ricker curve, line of replacement, and actual data for Karluk Lake early- and late-runs combined sockeye salmon.

System: **Karluk Lake early and late runs combined**

Species: **sockeye salmon**

Ricker stock-recruitment relationship, 1981 – 1996. The dashed line represents the Ricker curve, and the solid straight line represents replacement.

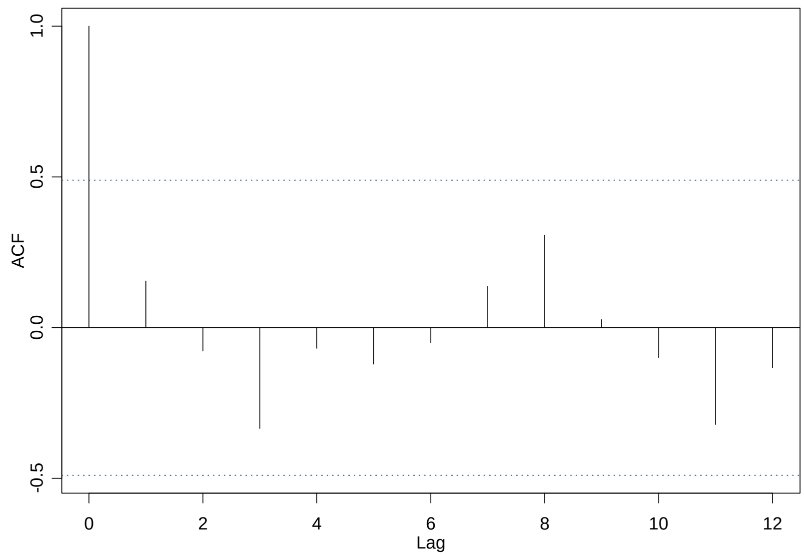


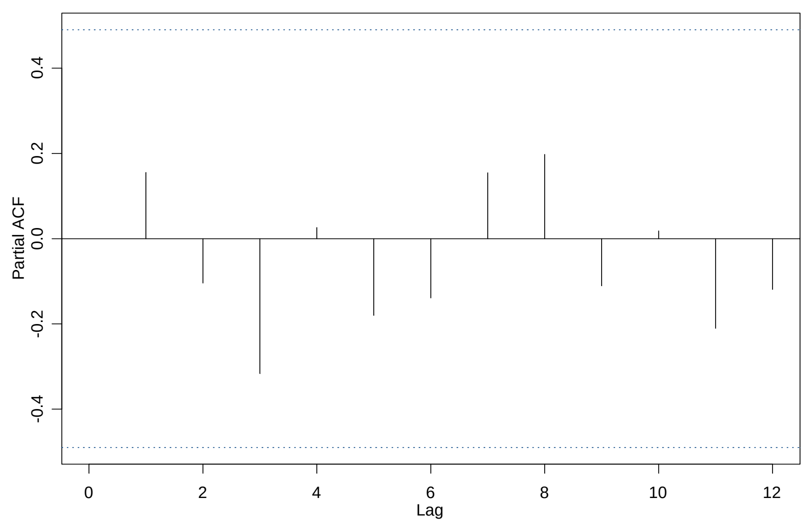
Appendix H14.–Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals of the Ricker model for Karluk Lake early-run sockeye salmon.

System: Karluk Lake early run

Species: sockeye salmon

ACF and PACF of residuals from the early-run Ricker model





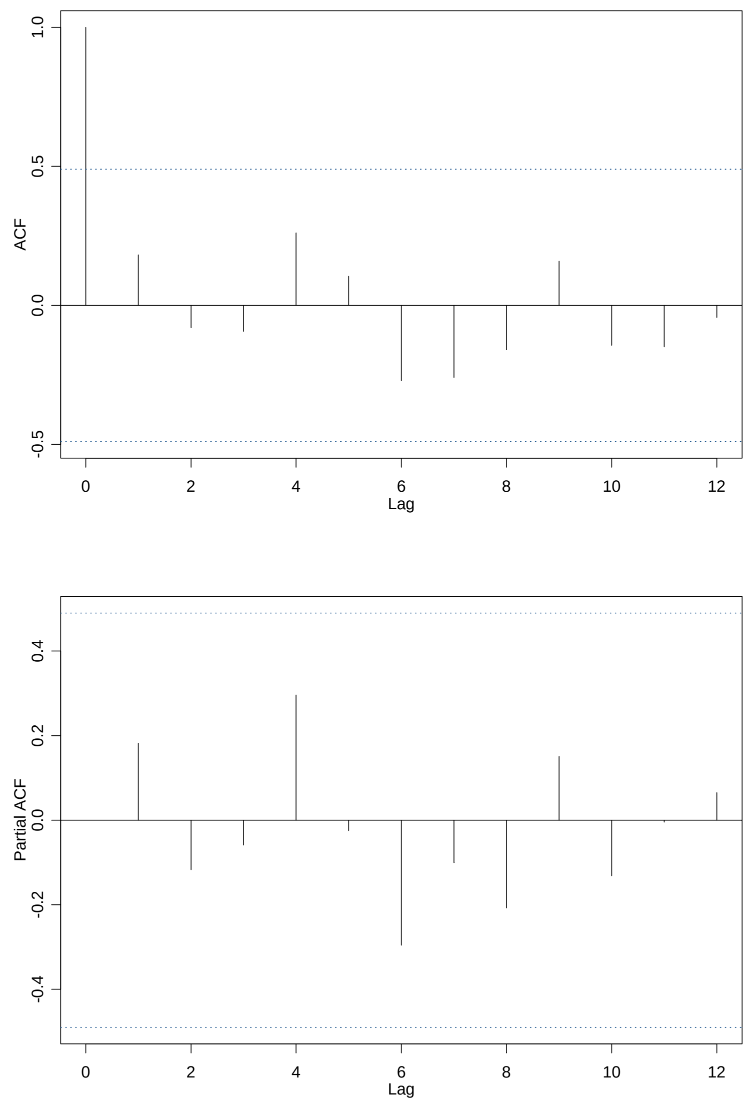
Appendix H15.–Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals of the Ricker model for Karluk Lake late-run sockeye salmon

---

System: Karluk Lake late run

Species: sockeye salmon

ACF and PACF of residuals from the late-run Ricker model

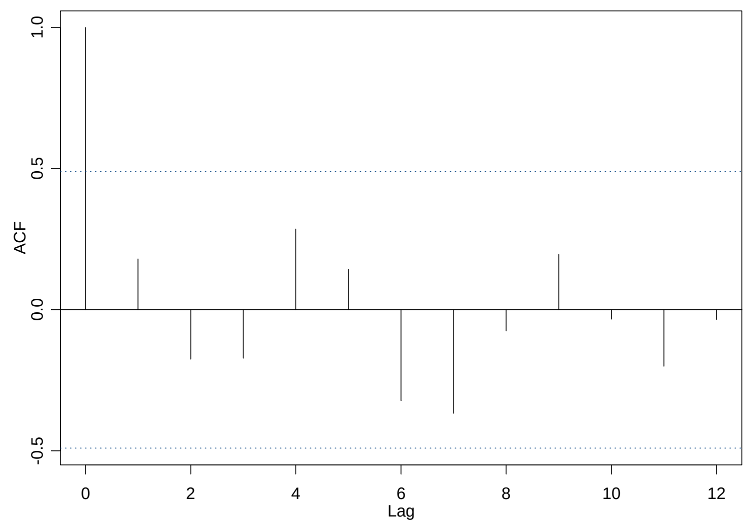


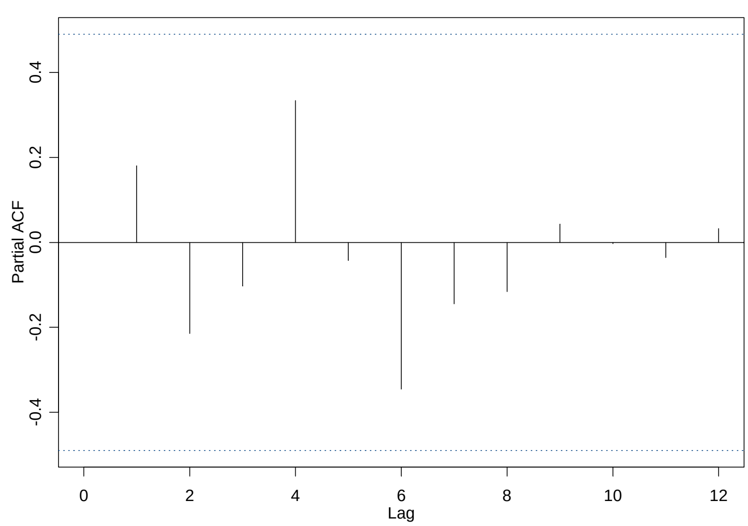
Appendix H16.–Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals of the Ricker model for Karluk Lake early- and late-runs combined sockeye salmon.

System: Karluk Lake early and late runs combined

Species: sockeye salmon

ACF and PACF of residuals from the combined Ricker model



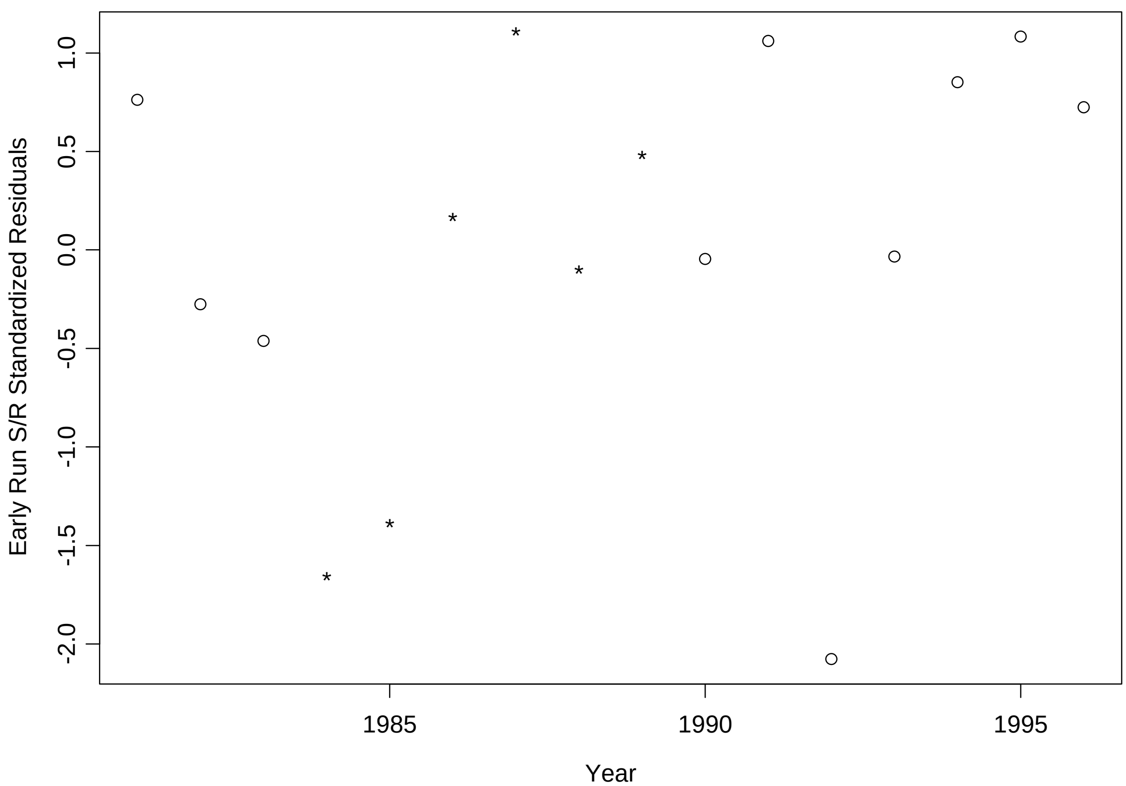


Appendix H17.–Standardized residuals from the Karluk Lake early-run Ricker model, with asterisks (*) identifying the years of fertilization.

System: **Karluk Lake early run**

Species: **sockeye salmon**

Standardized residuals from the Ricker model by year (open circles unfertilized years and asterisks fertilized years)

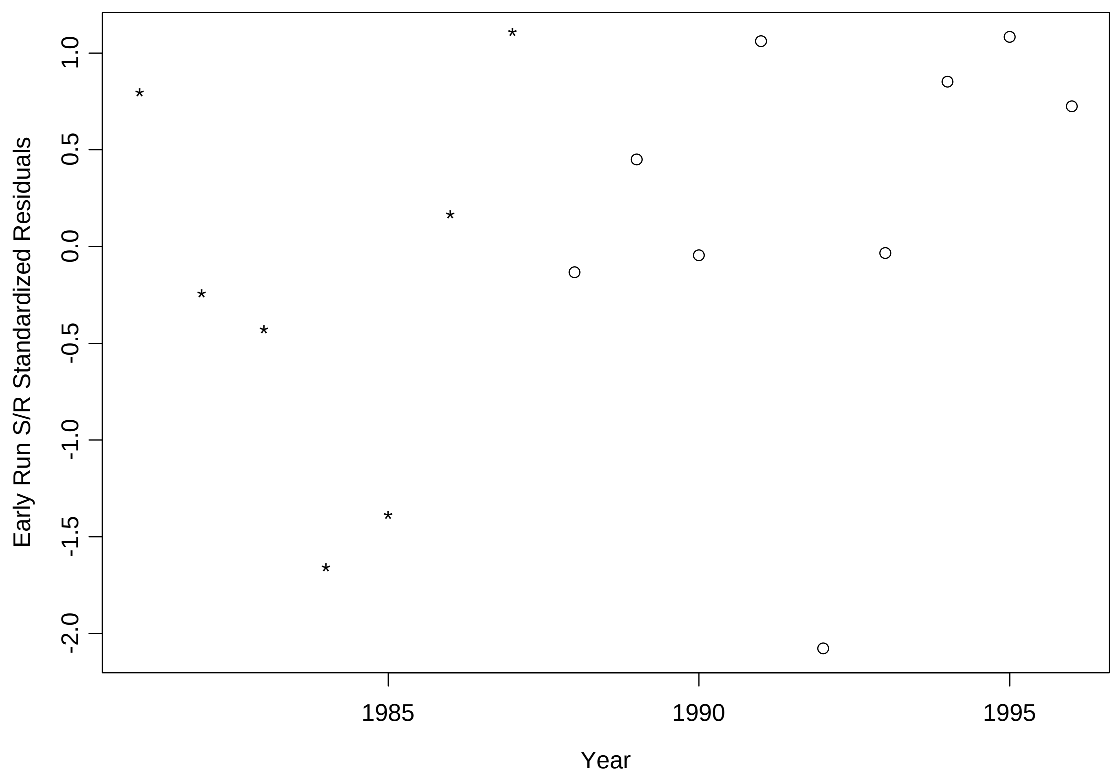


Appendix H18.–Standardized residuals from the Karluk Lake early-run Ricker model, with asterisks (*) identifying the years of stocking.

System: **Karluk Lake early run**

Species: **sockeye salmon**

Standardized residuals from the Ricker model by year (open circles years not stocked and asterisks years stocked)

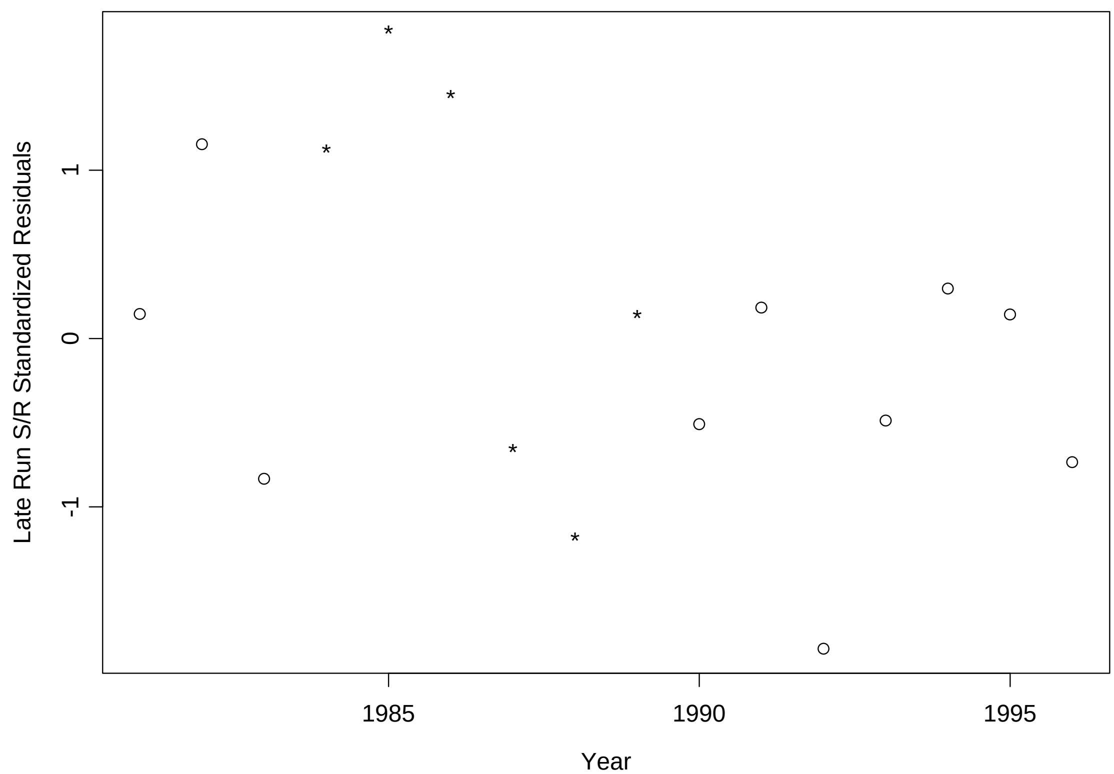


Appendix H19.–Standardized residuals from the Karluk Lake late-run Ricker model, with asterisks (*) identifying the years of fertilization.

System: **Karluk Lake late run**

Species: **sockeye salmon**

Standardized residuals from the Ricker model by year (open circles unfertilized years and asterisks fertilized years)

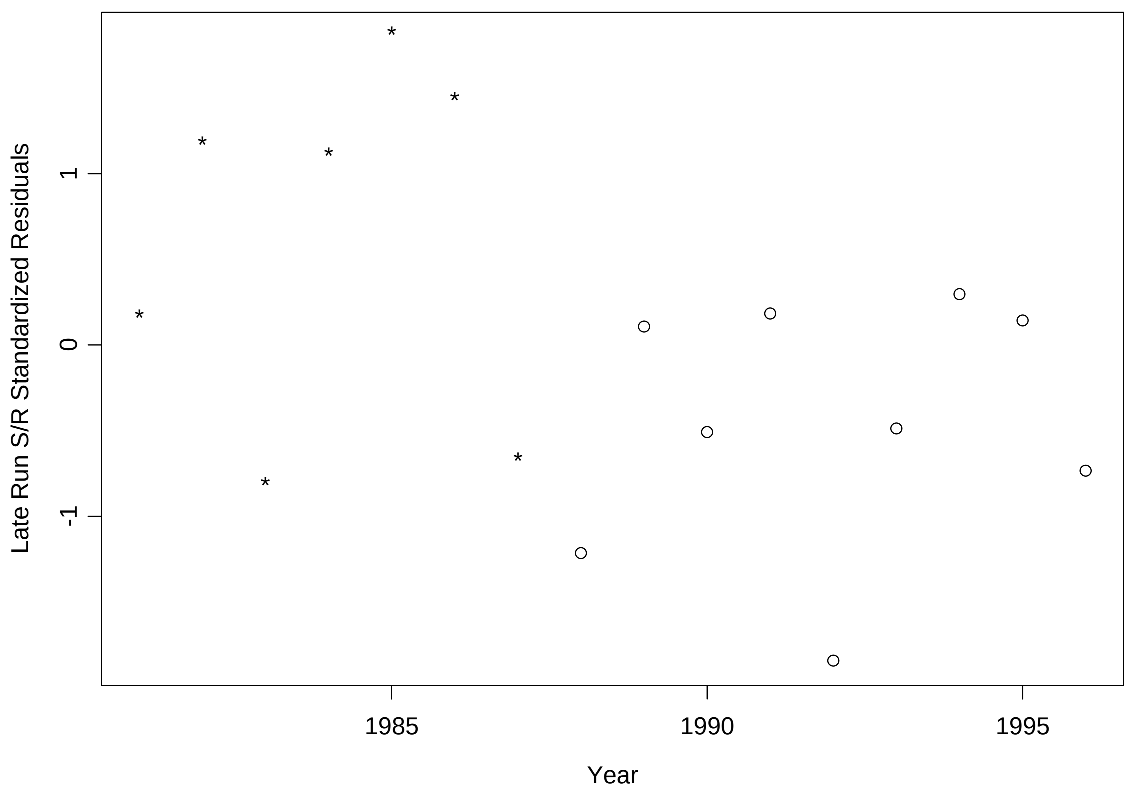


Appendix H20.–Standardized residuals from the Karluk Lake late-run Ricker model, with asterisks (*) identifying the years of stocking.

System: **Karluk Lake late run**

Species: **sockeye salmon**

Standardized residuals from the Ricker model by year (open circles years not stocked and asterisks years stocked)

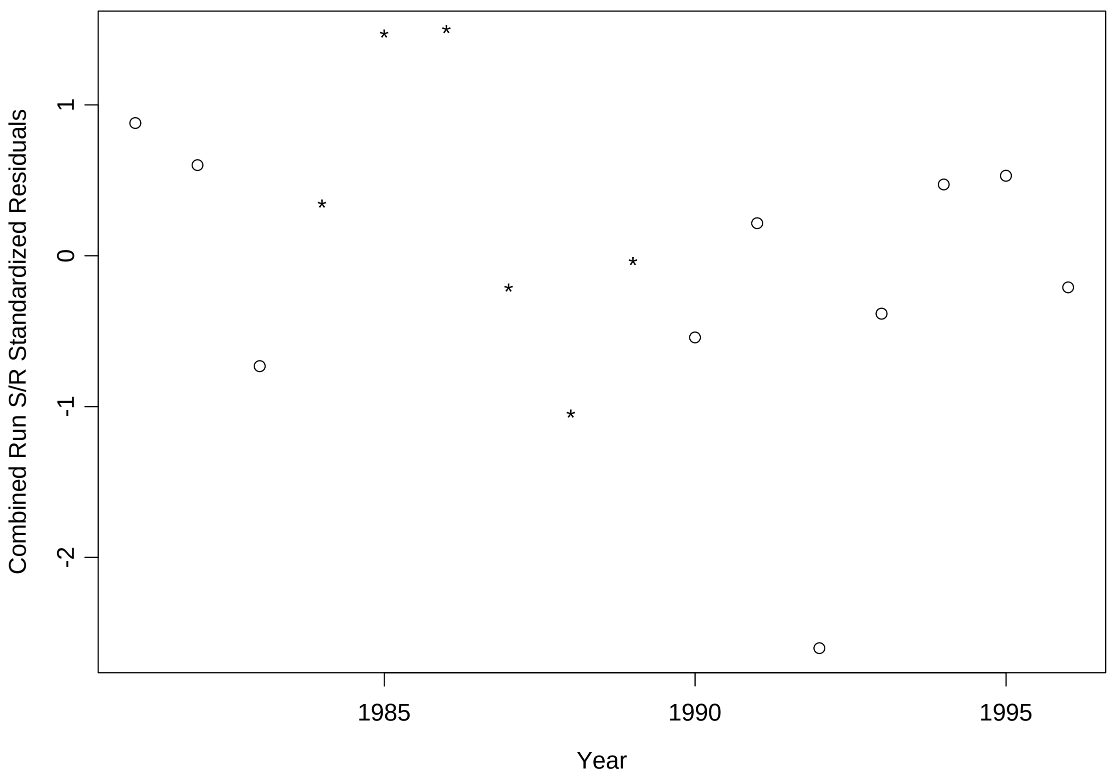


Appendix H21.–Standardized residuals from the Karluk Lake early- and late-runs combined Ricker model, with asterisks (*) identifying the years of fertilization.

System: **Karluk Lake early and late runs combined**

Species: **sockeye salmon**

Standardized residuals from the Ricker model by year (open circles unfertilized years and asterisks fertilized years)

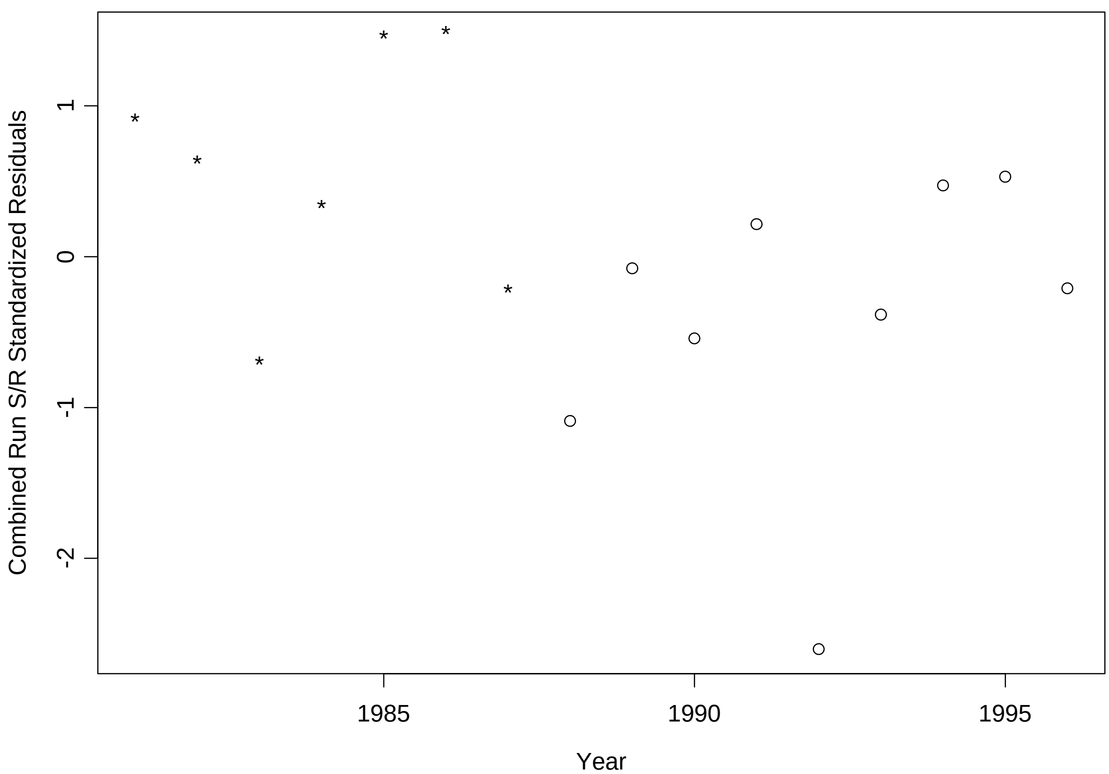


Appendix H22.–Standardized residuals from the Karluk Lake early- and late-runs combined Ricker model, with asterisks (*) identifying the years of stocking.

System: Karluk Lake early and late runs combined

Species: sockeye salmon

Standardized residuals from the Ricker model by year (open circles years not stocked and asterisks years stocked)

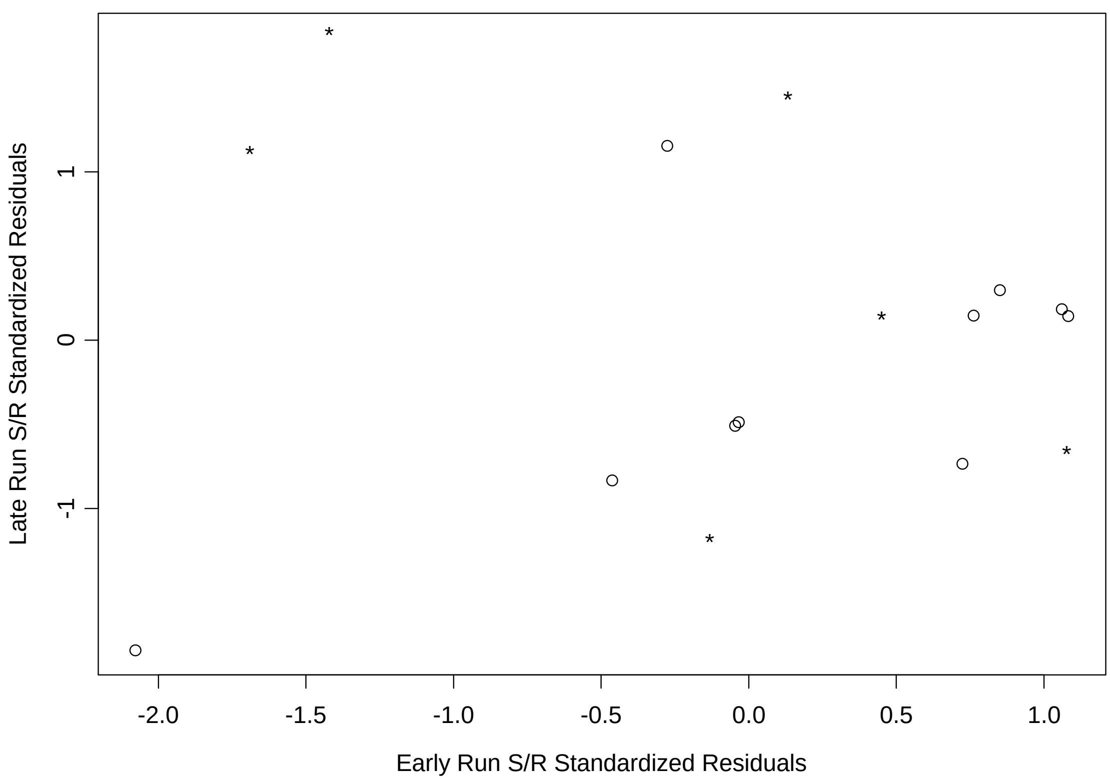


Appendix H23.–Karluk Lake early-run versus late-run standardized residuals from their respective Ricker models, with asterisks (*) identifying the years of fertilization.

System: Karluk Lake

Species: sockeye salmon

Ricker model standardized residuals of the early versus late run (open circles unfertilized years and asterisks fertilized years)

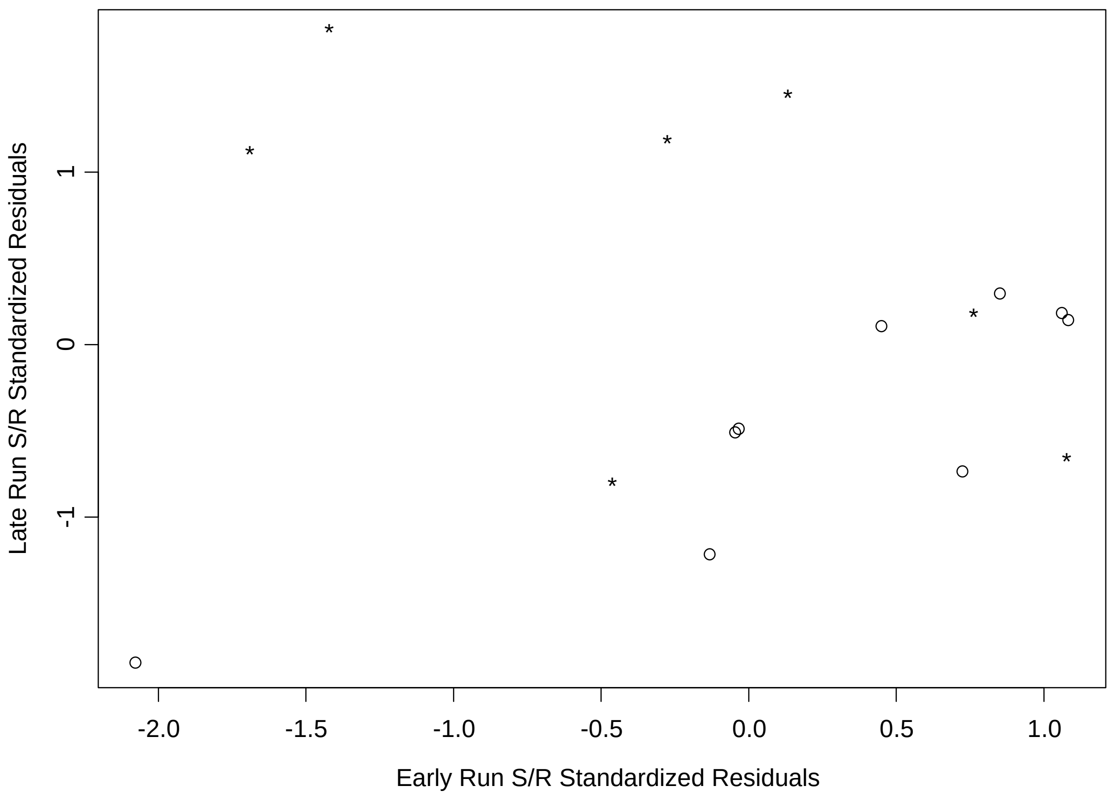


Appendix H24.–Karluk early-run versus late-run standardized residuals from their respective Ricker models, with asterisks (*) identifying the years of stocking.

System: **Karluk Lake**

Species: **sockeye salmon**

Ricker model standardized residuals of the early versus late run (open circles years of not stocking and asterisks years of stocking)



APPENDIX I. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR AYAKULIK RIVER SOCKEYE SALMON

Appendix I1.–Description of stock and escapement goal for Ayakulik River sockeye salmon.

System: Ayakulik River

Species: sockeye salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine
Previous escapement goal:	SEG: 200,000 to 300,000 (1983)
Recommended escapement goal:	SEG: 200,000 to 500,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir counts, 1929-1932, 1934-1942, 1945-1946,1948-1950, 1953-1960, 1962-2004.
Data summary:	
Data quality:	Good for escapement enumeration, Good for harvest estimates.
Data type:	Weir escapement estimates from 1970-2004 include escapement age data. Stock-specific harvest information is available from 1970-2004. Limnology information 1990-1996.
Contrast:	Escapement counts (1929-2004) 67.0
Methodology:	Ricker and Gamma spawner-recruit analysis (multiplicative error) euphotic volume analysis, smolt biomass as a function of zooplankton biomass.
Autocorrelation:	Significant (P=0.005) first-order autocorrelation; No significant second-order autocorrelation.
Comments:	Ricker model is not statistically significant (P=0.34), however, the gamma model is significant (P=0.0002) with an S_{msy} estimate of 478,000.
Recommendations:	Recommendation is to increase the current SEG from 200,000 - 300,000 to 200,000 - 500,000.

Appendix I2.–Ayakulik River sockeye salmon escapement, 1929-2004.

System: Ayakulik River

Species: sockeye salmon

Data available for analysis of escapement goals

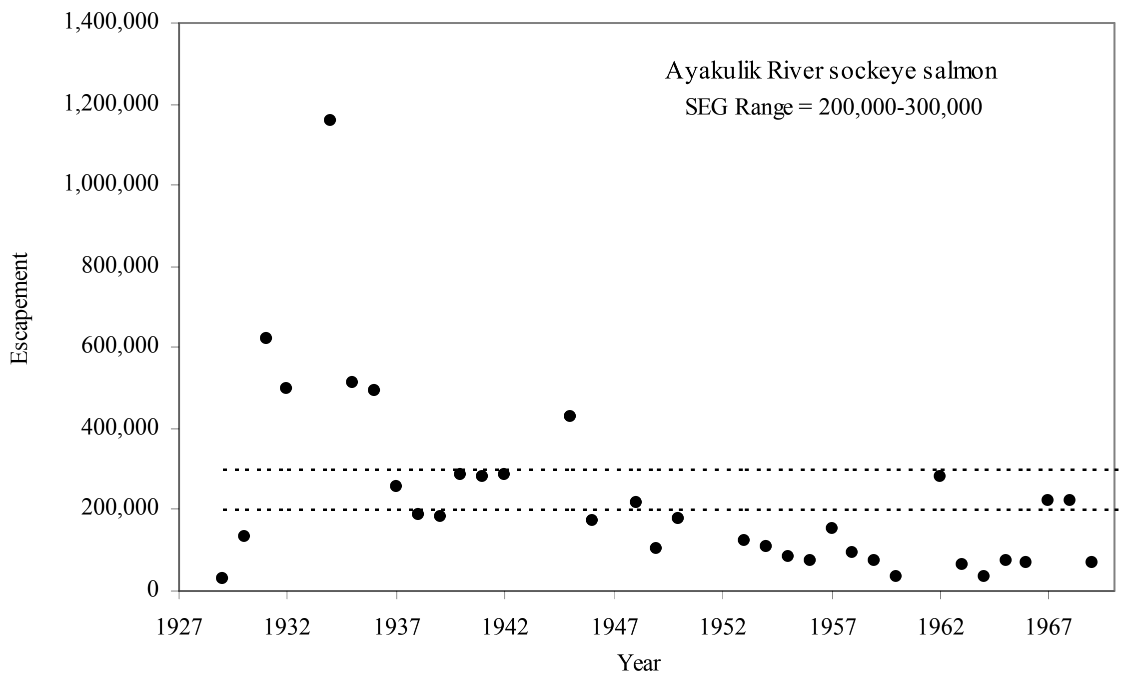
Year	Weir Counts	Year	Weir Counts
1929	28,867	1971	109,199
1930	133,786	1972	113,733
1931	620,993	1973	119,993
1932	498,523	1974	181,631
1934	1,160,296	1975	94,517
1935	514,967	1976	219,047
1936	491,372	1977	306,982
1937	253,994	1978	132,864
1938	186,503	1979	222,270
1939	184,507	1980	774,328
1940	284,633	1981	279,200
1941	280,836	1982	169,678
1942	285,045	1983	171,415
1945	429,883	1984	283,215
1946	170,355	1985	388,759
1948	218,229	1986	318,135
1949	101,625	1987	261,913
1950	176,619	1988	291,774
1953	121,654	1989	768,101
1954	107,369	1990	371,282
1955	85,832	1991	384,859
1956	71,573	1992	344,184
1957	154,895	1993	286,170
1958	94,855	1994	380,181
1959	75,100	1995	317,832
1960	34,614	1996	337,155
1962	278,954	1997	308,214
1963	63,563	1998	427,208
1964	36,342	1999	295,717
1965	75,356	2000	208,651
1966	71,159	2001	218,892
1967	224,200	2002	229,292
1968	220,850	2003	197,892
1969	71,160	2004	275,238
1970	33,868		

Appendix I3.–Ayakulik River sockeye salmon escapement, 1929-2004 and current escapement goal ranges.

System: Ayakulik River

Species: sockeye salmon

Observed escapement by year (black circles) and current SEG (dashed lines).

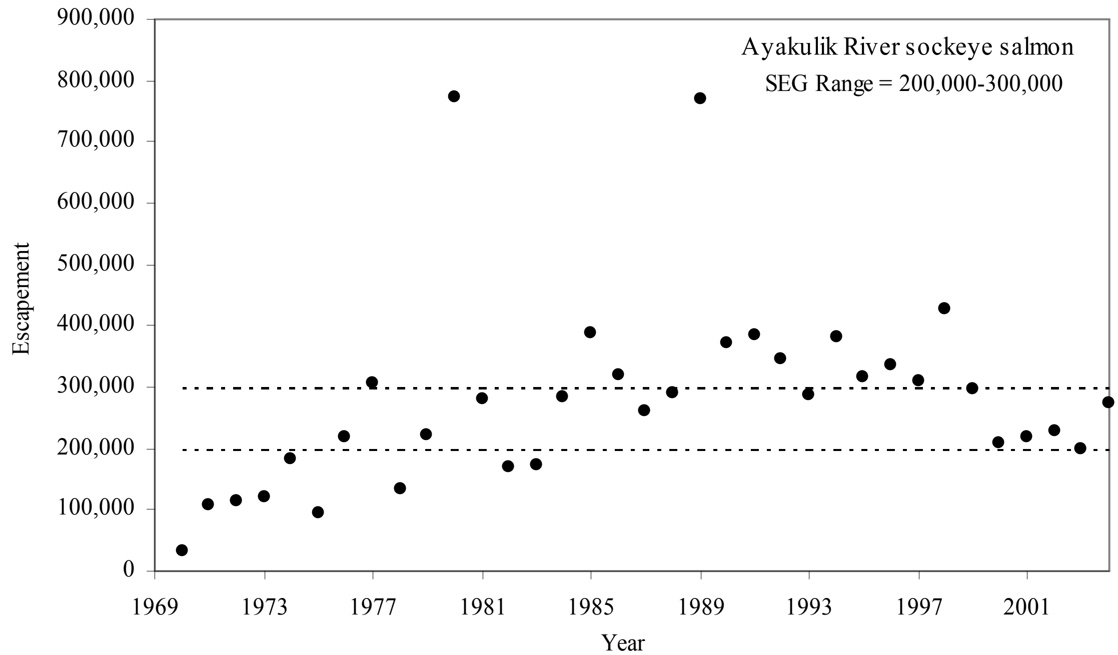


-continued-

System: **Ayakulik River**

Species: **sockeye salmon**

Observed escapement by year (black circles) and current SEG (dashed lines).



Appendix I4.–Ayakulik River sockeye salmon brood table.

System: Ayakulik River
Species: sockeye salmon
Data available for analysis of escapement goals

Ayakulik River sockeye salmon brood table.

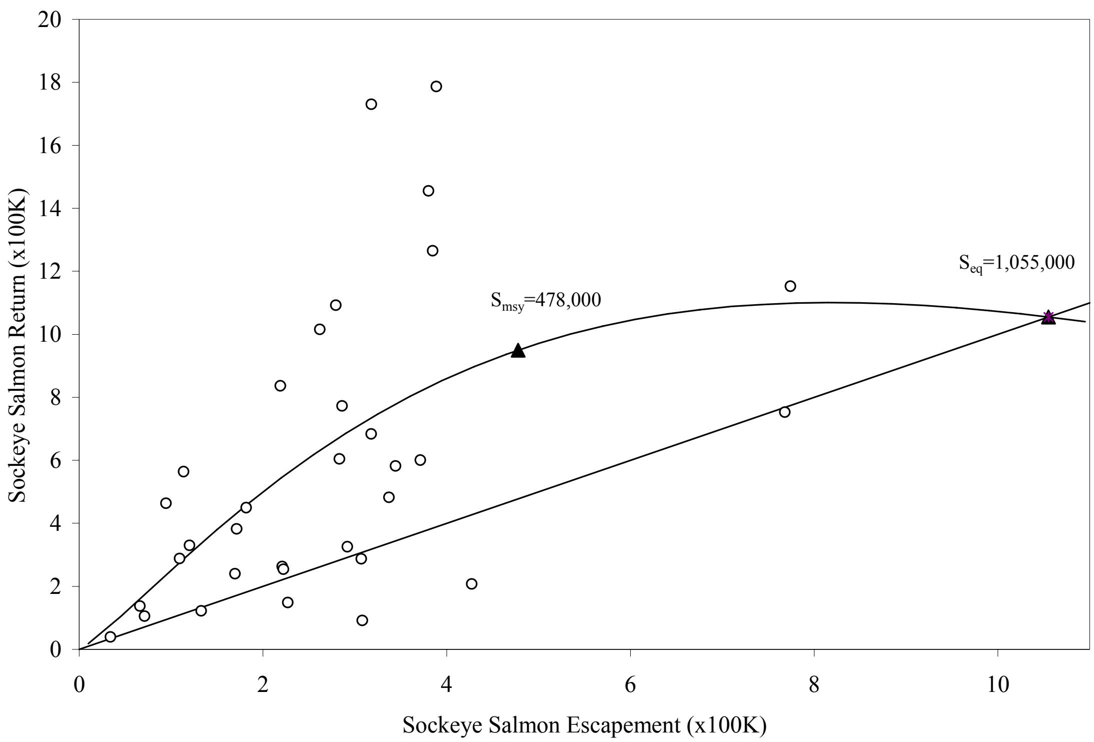
Brood		Ages																Total	Return/
Year	Escap.	0.1	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	3.4	Return	Spawner
1963	63,563											0	58,667	6,268	0	0	0		
1964	36,342							0	158	50,206	0	0	5,705	3,375	0	0	0		
1965	76,456				0	158	3,470	0	0	33,522	0	0	13,150	5,534	0	0	0		
1966	66,057		0	315	0	1,173	16,622	0	3,285	57,850	0	0	51,109	7,031	0	0	0	137,384	2.1
1967	227,089	0	0	1,772	0	24,013	3,338	0	16,469	78,834	0	0	23,976	0	0	0	0	148,402	0.7
1968	220,850	0	0	83	0	4,199	2,825	0	34,463	89,549	0	0	123,053	8,493	0	0	0	262,665	1.2
1969	71,160	0	0	0	0	4,756	3,703	0	3,704	78,972	0	0	13,734	652	0	0	0	105,523	1.5
1970	33,863	0	0	0	0	1,084	6,325	0	2,052	17,543	0	0	9,152	3,274	0	0	0	39,429	1.2
1971	109,174	0	0	3,251	0	35,919	18,925	0	26,505	184,053	0	0	16,736	3,364	0	0	0	288,753	2.6
1972	113,733	0	0	5,080	0	121,160	6,723	0	99,681	260,325	0	0	71,225	0	0	0	0	564,194	5.0
1973	119,993	0	0	986	1,395	79,993	7,548	0	82,532	110,906	0	0	45,469	1,393	0	0	0	330,221	2.8
1974	181,631	0	0	3,364	0	46,281	0	0	45,109	129,000	0	0	221,923	3,892	0	0	0	449,570	2.5
1975	94,517	0	0	0	1,393	10,982	14,989	0	30,950	308,251	0	0	96,141	858	0	0	0	463,563	4.9
1976	219,047	0	0	5,835	3,855	405,330	8,408	0	164,495	187,009	0	0	61,395	0	0	0	0	836,328	3.8
1977	306,982	0	0	0	0	5,060	3,431	0	18,656	170,721	0	0	85,541	3,940	0	0	0	287,349	0.9
1978	132,864	0	0	0	0	1,556	15,799	0	14,937	45,081	0	0	42,151	2,747	0	0	0	122,273	0.9
1979	222,270	0	0	3,625	441	16,345	18,352	0	40,958	131,539	0	0	41,815	1,438	0	0	0	254,511	1.1
1980	774,328	0	0	11,780	13,347	402,761	24,781	0	232,583	305,083	0	0	159,440	2,762	0	0	0	1,152,537	1.5
1981	279,200	0	0	17,149	0	310,784	7,450	0	230,889	328,622	0	0	168,527	28,564	0	0	0	1,091,984	3.9
1982	169,678	0	0	6,857	7,500	1,626	2,596	0	16,351	123,667	0	0	77,129	4,751	0	0	0	240,476	1.4
1983	171,415	0	0	548	1,171	20,198	15,116	0	72,231	168,055	0	0	104,765	0	0	0	0	382,085	2.2
1984	283,215	0	0	7,779	3,311	138,185	78,899	0	72,319	197,026	0	0	103,450	3,347	0	0	0	604,316	2.1
1985	388,759	0	0	61,345	3,903	365,489	18,971	0	589,731	513,314	0	0	229,750	4,276	0	0	0	1,786,779	4.6
1986	318,135	0	0	4,480	38,326	571,371	6,489	0	506,463	365,644	0	0	231,471	5,967	0	0	0	1,730,211	5.4
1987	261,913	0	0	12,991	15,380	173,341	13,602	0	103,512	317,142	0	0	341,728	32,807	0	5,063	0	1,015,566	3.9
1988	291,774	0	0	2,822	3,351	81,584	2,832	0	62,159	126,124	0	0	27,783	10,655	0	8,225	0	325,535	1.1
1989	768,101	0	0	2,571	5,565	26,297	29,189	0	18,318	310,379	0	0	254,557	59,553	0	46,238	0	752,667	1
1990	371,282	0	0	1,028	8,047	3,618	14,638	0	59,035	295,167	0	0	202,600	16,202	0	102	38	600,475	1.6
1991	384,859	0	640	22,371	17,118	145,925	36,123	0	393,249	482,187	0	19	158,923	5,779	64	2,796	112	1,265,306	3.3
1992	344,184	0	4,591	2,578	9,900	65,889	24,694	205	10,135	200,817	2,188	2,685	230,460	19,788	1,983	6,010	112	582,035	1.7
1993	286,170	0	0	3,093	3,678	2,504	16,283	400	176,539	409,718	516	8,075	138,504	7,591	344	5,426	0	772,671	2.7
1994	380,181	0	465	42,711	7,275	555,246	35,908	17,036	338,728	344,937	546	79	102,628	7,224	401	1,737	0	1,454,921	3.8
1995	317,832	0	0	4,711	4,707	101,292	18,181	516	53,759	227,822	3,186	0	240,294	22,068	1,125	6,135	0	683,795	2.2
1996	337,155	0	269	1,770	17,050	16,902	8,589	332	93,851	198,161	364	0	143,934	802	291	244	0	482,559	1.4
1997	308,214	0	5	1,250	4,810	14,447	5,395	597	11,767	34,814	330	0	16,169	727	0	1,490		91,802	0.3
1998	427,208	62	0	4,554	597	29,683	2,929	0	12,657	97,574	1,470	602	46,305	10,818				207,252	0.5
1999	295,717	0	0	2,953	4,818	53,015	8,754	353	124,906	192,030	0								
2000	208,651	130	0.0	2,261	7,074	56,453	5,858												
2001	218,892	0	0.0	97															
2002	229,292	0																	
2003	197,892																		

Appendix I5.–Gamma stock-recruitment curve, line of replacement, and actual data for Ayakulik River sockeye salmon.

System: Ayakulik River

Species: sockeye salmon

Gamma stock-recruitment relationship, 1966 – 1998 all brood years. The solid line represents the multiplicative error gamma curve, and the solid straight line represents replacement.



Appendix I6.–Yield analysis table for Ayakulik River sockeye salmon.

System: Ayakulik River

Species: sockeye salmon

Ayakulik River sockeye salmon spawner-recruit yield analysis table, with escapements in 100 thousand intervals starting with 0, and returns in 200 thousand intervals starting with 0, 1966-1998 (excluding brood years 1980 and 1989).

	Escapement (in thousands)				
Return (in thousands)	0-100	100-200	200-300	300-400	400-500
0-200	75.0%	14.3%	11.1%	10.0%	
200-400		57.1%	33.3%	10.0%	100.0%
400-600	25.0%	28.6%		20.0%	
600-800			22.2%	20.0%	
800-1,000			11.1%		
1,000-1,200			22.2%		
1,200-1,400				10.0%	
1,400-1,600				10.0%	
1,600-1,800				20.0%	
Escapement Summary					
Number of Years per Interval	4	7	9	10	1
Average Yield per Interval	120,076	197,012	335,606	550,765	-219,956
Median Yield per Interval	52,845	210,228	321,101	301,907	-219,956

-continued-

System: **Ayakulik River**

Species: **sockeye salmon**

Ayakulik River sockeye salmon spawner-recruit yield analysis table, with escapements in 100 thousand intervals starting with 50, and returns in 200 thousand intervals starting with 0, 1966-1998 (excluding brood years 1980 and 1989).

	Escapement (in thousands)				
Return (in thousands)	0-50	50-150	150-250	250-350	350-450
0-200	100.0%	42.9%	14.3%	9.1%	
200-400		28.6%	57.1%	18.2%	20.0%
400-600		28.6%	14.3%	18.2%	
600-800				27.3%	20.0%
800-1,000			14.3%		
1,000-1,200				18.2%	
1,200-1,400					20.0%
1,400-1,600					20.0%
1,600-1,800				9.1%	20.0%
Escapement Summary					
Number of Years per Interval	1	7	7	11	5
Average Yield per Interval	5,566	186,345	166,008	393,914	672,489
Median Yield per Interval	5,566	179,579	70,798	321,101	880,447

APPENDIX J. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR AKALURA LAKE SOCKEYE SALMON

Appendix J1.–Description of stock and escapement goal for Akalura Lake sockeye salmon.

System: Akalura Lake

Species: sockeye salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial set gillnet and purse seine
Previous escapement goal:	SEG: 40,000 – 60,000 (1988)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir counts, 1923-1942, 1944-1946, 1948-1950, 1952-1958, 1968-1972, 1974-1977, 1986-1997, 2000-2003
	Aerial surveys, 1967, 1978-1985, 1998-1999
Data summary:	
Data quality:	Fair for aerial surveys, unknown for weir counts prior to 1970, good for weir enumeration after 1970
Data type:	Fixed-wing aerial surveys, weir escapement estimates from 1986 to 1997 include some escapement age data. No stock-specific harvest information is available.
Data contrast:	Peak aerial surveys and weir counts, all years (1923-2003): 571.2
	Peak aerial surveys and weir counts, recent years (1970-2003): 31.5
	Weir counts, all years (1923-2003): 571.2
	Weir counts, recent years (1970-2003): 31.5
Methodology:	Percentile, smolt per spawner, euphotic volume analysis, smolt biomass as a function of zooplankton biomass, spawning habitat
Comments:	Exploratory analyses indicate current SEG is too high; however, reliable escapement estimates are not expected in the future and managers will not actively manage the stock.
Recommendations:	Eliminate the goal.

Appendix J2.–Akalura Lake sockeye salmon escapement, 1923-2003.

System: Akalura Lake

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Peak Aerial Survey[a]	Weir Counts[a]	Year	Peak Aerial Survey[a]	Weir Counts[a]
1923		15,855	1963		
1924		19,867	1964		
1925		40,910	1965		
1926		105,142	1966		
1927		87,949	1967	2,000	
1928		72,550	1968		442
1929		18,094	1969		539
1930		9,907	1970		3,992
1931		30,186	1971		3,618
1932		67,544	1972		8,591
1933		90,448	1973		
1934		69,614	1974		34,812
1935		85,024	1975		16,127
1936		94,507	1976		10,693
1937		252,469	1977		6,800
1938		97,417	1978	2,500	1,014
1939		59,447	1979	7,500	
1940		73,507	1980	4,000	
1941		46,229	1981	5,000	
1942		48,521	1982	15,000	
1943			1983	3,300	
1944		54,628	1984	20,350	
1945		105,077	1985	3,000	
1946		48,018	1986		9,800
1947			1987		6,116
1948		39,856	1988		38,618
1949		19,888	1989		116,029
1950		6,180	1990		47,181
1951			1991		44,189
1952		16,793	1992		63,296
1953		23,917	1993		30,692
1954		3,445	1994		13,681
1955		2,128	1995		2,010
1956		1,828	1996		7,898
1957		1,411	1997		18,140
1958		5,658	1998	46,000	
1959			1999	37,000	
1960			2000		12,425
1961			2001		13,772
1962			2002	8,000	7,635
			2003	3,500	7,220

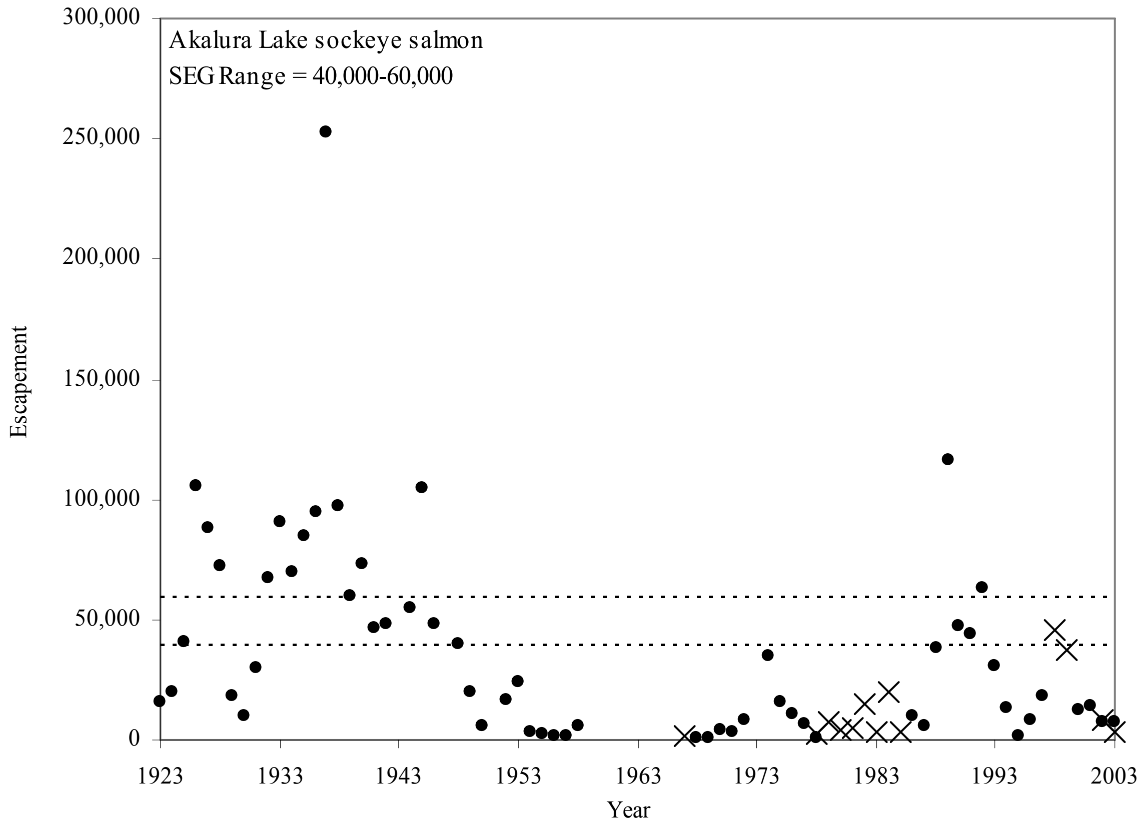
[a] Weir counts and peak aerial surveys are from ADF&G database (Rbase) for all years except: 1923-1929 from Edmundson et al. (1994), 1969,1970 from Blackett (1971); weir counts used to estimate escapement when available; aerial survey count was used for 1978 because it was substantially higher than weir count.

Appendix J3.–Akalura Lake sockeye salmon escapement, 1923-2003 and current escapement goal ranges.

System: Akalura Lake

Species: sockeye salmon

Observed escapement by year (Xs for aerial surveys, solid circles for weir counts) and current SEG range (dashed lines).



APPENDIX K. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR UPPER STATION (SOUTH OLGA LAKES) SOCKEYE SALMON

Appendix K1.–Description of stock and escapement goal for Upper Station (South Olga Lakes) sockeye salmon.

System: Upper Station

Species: sockeye salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	Early run: SEG: 50,000-75,000 (1988)
	Late run: SEG: 150,000-200,000 (1988)
Recommended escapement goal:	Early run: SEG: 30,000-65,000
	Late run: BEG: 120,000-265,000
Optimal escapement goal:	Early run: 25,000 (1999)
Inriver goal:	none
Action points:	none
Escapement enumeration:	Early run: Weir counts, 1969-2003
	Late run: Weir counts, 1966-2003
Data summary:	
Data quality:	Excellent
Data type:	Weir counts from 1969 to 2003. Age compositions and stock-specific harvest from 1971-2003. Limnology data 1990-1993, 1995, 1999, and 2000.
Data contrast:	1969-2003: early (16.5), late (11.1), both (9.0)
Methodology:	Ricker spawner-recruit, escapement percentiles, EV model, zooplankton model, spawning habitat.
Comments:	Set new late-run BEG based on significant spawner-recruit analysis; set SEG for early run based on percentile method; zooplankton biomass supports current overall goal; however, lower lake likely supports more than model suggest due to age 0. component utilization of non-zooplankton forage.
Recommendations:	Change the early run to an SEG: 30,000 – 65,000
	Change the late run to a BEG: 120,000 – 265,000

Appendix K2.–Upper Station early-run sockeye salmon escapement, 1969-2003.

System: Upper Station early run

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Weir Counts
1969	22,509
1970	16,168
1971	32,529
1972	39,613
1973	26,892
1974	35,319
1975	10,325
1976	28,567
1977	26,380
1978	66,157
1979	53,115
1980	37,866
1981	77,042
1982	170,610
1983	115,890
1984	96,798
1985	27,408
1986	100,812
1987	74,747
1988	56,724
1989	64,582
1990	56,159
1991	50,026
1992	19,076
1993	34,852
1994	37,645
1995	41,492
1996	58,686
1997	47,655
1998	30,713
1999	36,521
2000	55761
2001	66,795
2002	36802
2003	76,175

Appendix K3.–Upper Station late-run sockeye salmon escapement, 1966-2003.

System: Upper Station late run

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Weir Counts
1966	36,154
1967	66,999
1968	15,743
1969	74,150
1970	36,833
1971	95,150
1972	68,351
1973	67,826
1974	251,234
1975	74,456
1976	48,650
1977	49,001
1978	38,126
1979	134,579
1980	77,718
1981	118,900
1982	306,161
1983	179,741
1984	239,608
1985	408,409
1986	367,922
1987	156,274
1988	247,647
1989	221,706
1990	198,287
1991	242,860
1992	199,067
1993	187,229
1994	221,675
1995	203,659
1996	235,727
1997	230,793
1998	171,214
1999	210,016
2000	176,783
2001	74,408
2002	150,349
2003	200,894

Appendix K4.–Upper Station early and late-runs combined sockeye salmon escapement, 1969-2003.

System: Upper Station early and late runs combined

Species: sockeye salmon

Data available for analysis of escapement goals

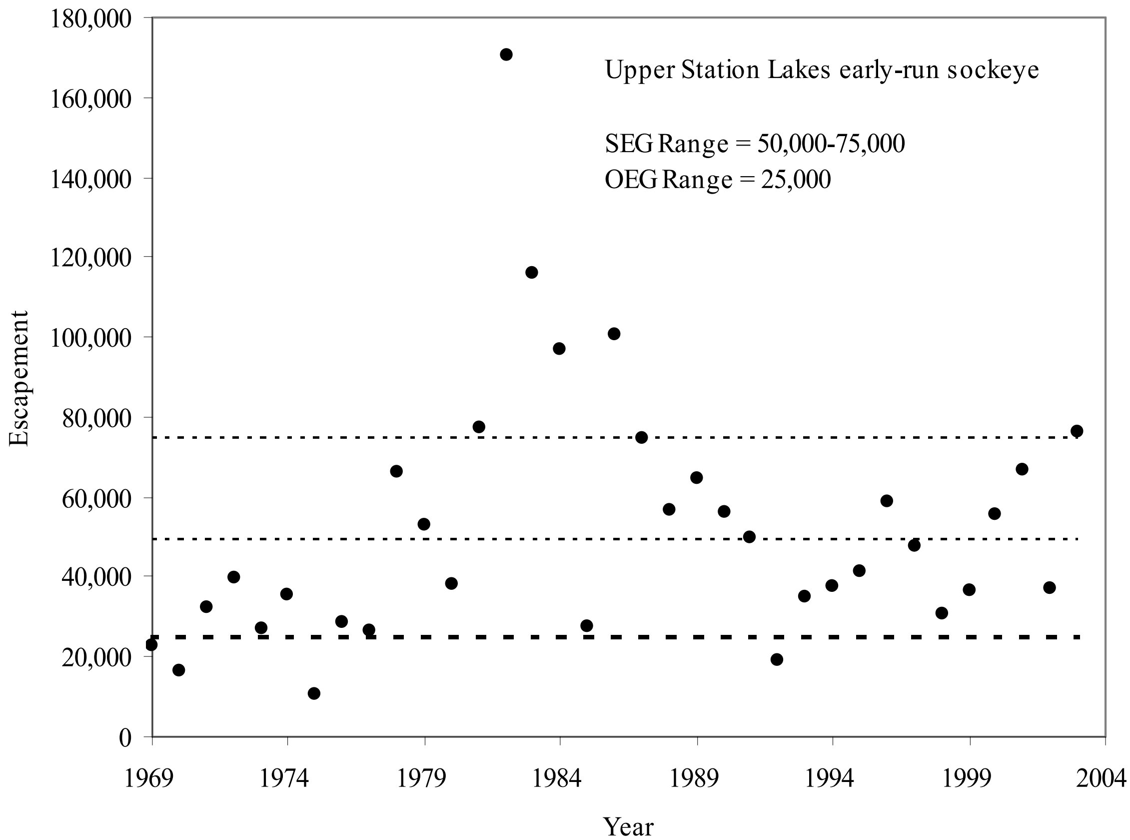
Year	Weir Counts
1969	96,659
1970	53,001
1971	127,679
1972	107,964
1973	94,718
1974	286,553
1975	84,781
1976	77,217
1977	75,381
1978	104,283
1979	187,694
1980	115,584
1981	195,942
1982	476,771
1983	295,631
1984	336,406
1985	435,817
1986	468,734
1987	231,021
1988	304,371
1989	286,288
1990	254,446
1991	292,886
1992	218,143
1993	222,081
1994	259,320
1995	245,151
1996	294,413
1997	278,448
1998	201,927
1999	246,537
2000	232,544
2001	141,203
2002	187,151
2003	277,069

Appendix K5.–Upper Station early-run sockeye salmon escapement, 1969-2003 and current escapement goal ranges.

System: Upper Station early run

Species: sockeye salmon

Observed escapement by year (solid circles for weir counts), the current SEG range (dashed lines), and the current OEG (bold dashed line)

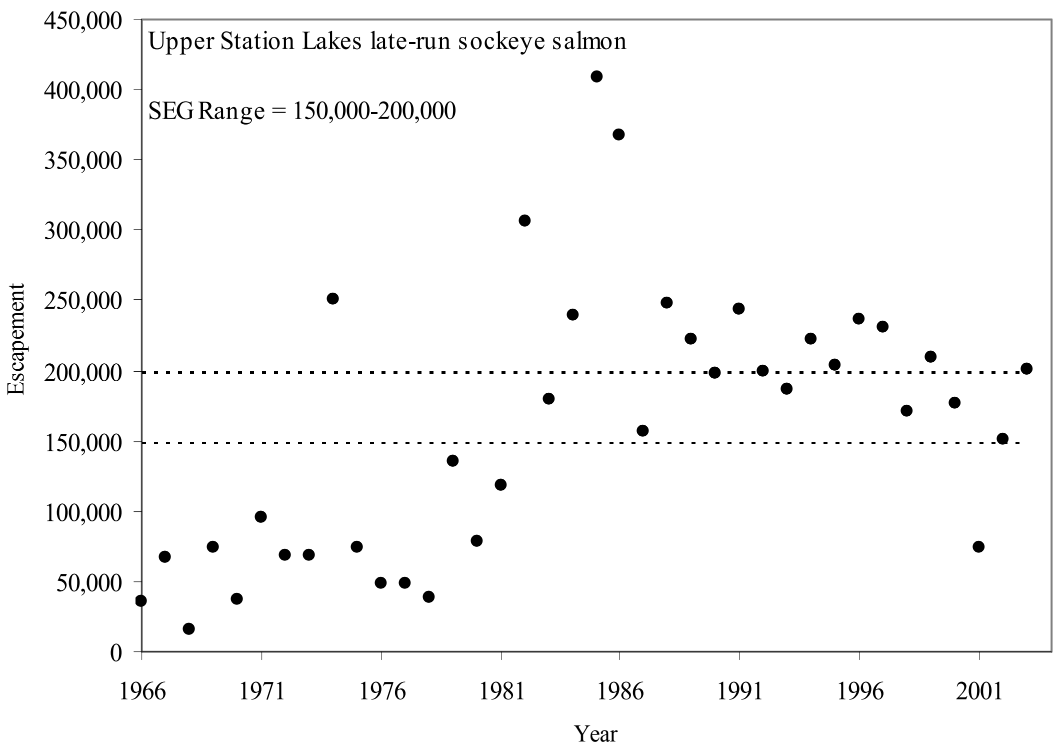


Appendix K6.–Upper Station late-run sockeye salmon escapement, 1966-2003 and current escapement goal ranges.

System: **Upper Station late run**

Species: **sockeye salmon**

Observed escapement by year (solid circles for weir counts) and current SEG range (dashed lines)

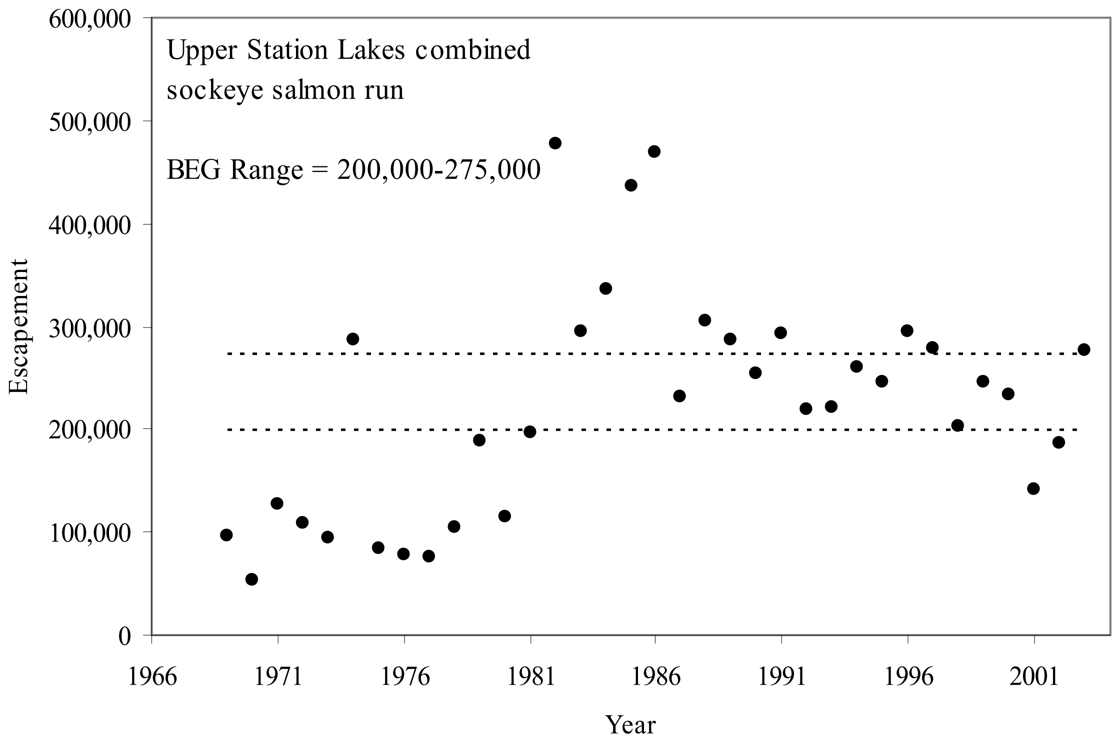


Appendix K7.–Upper Station early- and late-runs combined sockeye salmon escapement, 1969-2003 and current escapement goal ranges.

System: Upper Station early and late runs combined

Species: sockeye salmon

Observed escapement by year (solid circles for weir counts) and current BEG range (dashed lines)



Appendix K8.–Upper Station early-run sockeye salmon brood table.

System: Upper Station early run
Species: sockeye salmon

Data available for analysis of escapement goals

Brood Year	Escapement	Ages 0.1	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	3.3	2.4	Total Return
1969	22,509	0	317	0	1,406	3,094	281	263	9,979	11,554	0	62	3,516	62	0	0	30,534
1970	16,168	0	375	188	788	2,889	263	0	1,850	3,269	0	0	1,469	367	0	0	11,458
1971	32,529	0	0	0	185	1,234	370	0	5,876	15,976	0	0	2,263	0	0	0	25,904
1972	39,613	0	185	62	1,102	5,693	184	0	3,482	18,977	0	0	8,603	574	208	0	39,070
1973	26,892	0	0	0	174	522	696	0	3,728	41,006	0	208	7,289	0	0	133	53,756
1974	35,319	0	0	522	0	26,382	0	0	16,660	38,317	0	0	11,720	133	0	0	93,734
1975	10,325	0	0	0	0	1,458	208	0	6,393	14,783	0	0	8,738	485	0	0	32,065
1976	28,567	0	0	0	133	9,722	0	0	10,438	47,090	0	0	27,139	0	0	0	94,522
1977	26,380	0	0	0	0	32,041	243	0	48,850	94,081	0	0	35,526	634	0	0	211,375
1978	66,157	0	243	243	1,809	28,948	0	0	32,354	70,735	0	0	19,660	0	37	0	154,029
1979	53,115	0	0	0	0	4,124	0	0	17,554	65,300	0	46	14,870	38	142	0	102,074
1980	37,866	0	317	0	2,341	11,937	0	0	4,000	7,165	38	0	7,259	0	25	0	33,082
1981	77,042	0	0	0	542	2,832	1,498	0	4,370	85,872	0	43	23,861	0	0	0	119,018
1982	170,610	0	2,472	234	1,006	113,439	781	0	75,684	37,220	0	360	18,131	70	0	0	249,398
1983	115,890	0	285	1,220	1,181	5,491	1,205	0	11,396	87,555	0	0	41,723	217	0	0	150,273
1984	96,798	0	109	0	3,443	2,118	66	0	1,792	46,879	0	0	14,103	113	60	0	68,683
1985	27,408	0	1,476	4	2,865	2,314	22,466	0	6,714	86,949	0	0	42,895	633	64	0	166,380
1986	100,812	0	35	5,680	449	51,361	936	0	36,048	83,179	60	18	8,248	340	408	0	186,763
1987	74,747	0	2,134	46	1,022	2,027	3,849	0	726	30,417	27	0	25,242	779	57	0	66,326
1988	56,724	0	17	0	71	82	852	0	1,607	35,640	210	206	7,282	1,072	0	0	47,038
1989	64,582	0	450	404	5,823	8,751	6,313	0	5,539	67,810	0	0	34,127	0	0	0	129,217
1990	56,159	0	1,497	578	0	6,275	3,414	0	19,145	82,269	0	0	6,839	361	6	0	120,384
1991	50,026	0	407	3,258	20,467	46,391	6,815	0	57,478	131,931	0	0	27,274	0	0	0	294,021
1992	19,076	52	2,338	223	5,878	5,959	3,583	0	3,435	24,099	0	0	7,268	0	0	0	52,835
1993	34,852	219	669	605	2,423	5,189	2,741	0	11,812	31,749	0	0	5,168	1,229	0	62	61,866
1994	37,645	0	229	994	4,887	53,607	1,320	0	7,176	33,104	0	0	17,361	570	0	0	119,248
1995	41,492	0	185	2,467	5,857	33,691	1,497	360	44,415	44,608	0	492	20,938	689	92	0	155,291
1996	58,686	0	79	177	2,723	30,487	1,973	0	81,164	51,987	4	25	15,238	281	0	0	184,138
1997	47,655	0	422	45	0	972	2,438	0	558	11,566	34	0	7,233	795			24,063
1998	30,713	0	0	6	0	145	6,264	0	418	45,950	0						
1999	36,521	0	0	2,598	328	27,894	6,080										
2000	55,761	0	780	10912													
2001	66,795	0															
2002	36802																
2003	76,175																

Appendix K9.–Upper Station late-run sockeye salmon brood table.

System: Upper Station late run

Species: sockeye salmon

Data available for analysis of escapement goals

		Return Ages															
Yr.	Escapement	0.1	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	3.3	2.4	Total
1966	36,154							0	37,120	109,124	0	0	1,579	0	0	0	147,823
1967	66,999				24,598	21,467	447	0	5,265	51,076	0	0	2,249	112	0	0	105,214
1968	15,743		1,342	0	3,686	12,111	526	0	6,859	18,778	0	0	44,305	0	0	0	87,607
1969	74,150	0	8,425	2,106	9,221	14,056	10,682	0	25,475	115,193	0	0	2,843	6,950	475	0	195,427
1970	36,833	0	675	12,594	9,969	81,964	4,431	0	9,161	30,644	632	0	6,171	1,424	0	0	157,663
1971	95,150	450	5,538	21,045	632	10,109	1,895	0	16,613	40,346	0	0	8,105	901	0	0	105,635
1972	68,351	3,323	10,425	11,689	17,563	39,397	3,797	0	8,105	58,539	0	0	4,027	0	0	0	156,866
1973	67,826	1,580	1,424	2,373	1,801	10,807	2,702	0	6,041	77,528	0	0	7,926	0	0	0	112,182
1974	251,234	0	0	23,416	0	107,734	1,007	0	22,645	294,387	0	0	7,680	7,040	0	0	463,908
1975	74,456	901	3,021	0	0	61,142	1,132	0	36,479	76,157	0	0	5,228	0	0	0	184,060
1976	48,650	0	10,190	0	36,479	38,399	2,560	0	11,501	141,154	0	0	10,336	940	0	0	251,559
1977	49,001	0	640	0	3,137	52,279	1,046	0	66,714	312,897	0	0	9,732	0	0	0	446,444
1978	38,126	0	82,601	1,046	90,205	134,367	4,698	0	55,146	217,342	0	0	26,755	2,638	0	0	614,798
1979	134,579	0	31,947	0	63,256	71,366	0	0	103,020	339,950	0	736	10,850	360	280	0	621,765
1980	77,718	0	124,890	0	56,178	35,951	2,131	0	21,758	55,472	399	0	16,555	965	223	0	314,522
1981	118,900	0	1,294	0	17,853	157,249	12,280	1,007	149,158	345,506	0	0	14,809	0	0	879	700,035
1982	306,161	0	644,017	5,129	324,600	364,312	5,029	117	92,824	231,963	0	0	5,168	2,042	0	0	1,675,201
1983	179,741	4,867	182,514	0	135,177	23,242	1,682	0	53,195	92,799	0	0	30,036	0	1,488	0	525,000
1984	239,608	3,012	37,733	528	89,721	187,451	5,064	0	21,543	224,033	0	0	23,712	4,642	0	0	597,438
1985	408,409	2,313	562,757	1,958	309,775	34,924	12,374	0	40,759	179,839	0	578	45,289	6,140	0	0	1,196,706
1986	367,922	1,449	72,415	1,953	94,380	291,815	5,610	678	116,039	451,917	0	0	17,721	1,579	1,289	6	1,056,851
1987	156,274	0	68,016	495	113,821	12,899	127	0	17,053	104,995	0	225	27,470	15,072	39	0	360,212
1988	247,647	0	9,222	216	27,793	76,583	1,000	0	71,330	80,102	177	133	4,037	1,244	0	0	271,836
1989	221,706	401	169,158	1,125	85,530	83,807	12,864	142	53,928	184,067	308	0	21,693	0	0	0	613,023
1990	198,287	1,432	56,992	3,904	115,907	27,747	7,728	444	17,591	237,284	0	0	4,315	0	67	0	473,411
1991	242,860	6,744	51,810	4,858	163,283	73,541	6,484	160	44,507	712,676	31	0	20,546	0	0	0	1,084,640
1992	199,067	4,913	61,018	1,108	15,733	58,923	12,611	79	6,302	279,349	0	0	7,189	156	192	26	447,599
1993	187,229	5,186	46,015	5,688	114,817	35,842	45,256	444	10,769	199,820	191	278	27,883	5,350	0	0	497,539
1994	221,675	1,417	10,206	6,322	23,167	90,488	17,439	44	25,603	293,322	80	0	6,069	968	0	0	475,125
1995	203,659	233	3,020	3,340	3,349	179,562	24,492	0	13,017	251,855	0	254	14,264	307	247	20	493,960
1996	235,727	277	1,972	6,536	1,335	35,606	4,057	0	15,478	88,856	121	1	4,856	2,282	0	1,500	162,877
1997	230,793	0	347	0	916	2,842	11,901	0	1,932	129,206	1,984	130	8,502	17,554			175,314
1998	171,214	0	0	89	0	2,511	13,979	0	3,281	219,890	25,325						
1999	210,016	0	279	2,323	672	80,315	15,939										
2000	176,783	96	34,433	5,197													
2001	74,408	0															
2002	150,349																
2003	200,894																

Appendix K10.–Upper Station early- and late-runs combined sockeye salmon brood table.

System: Upper Station early and late runs combined
Species: sockeye salmon
Data available for analysis of escapement goals

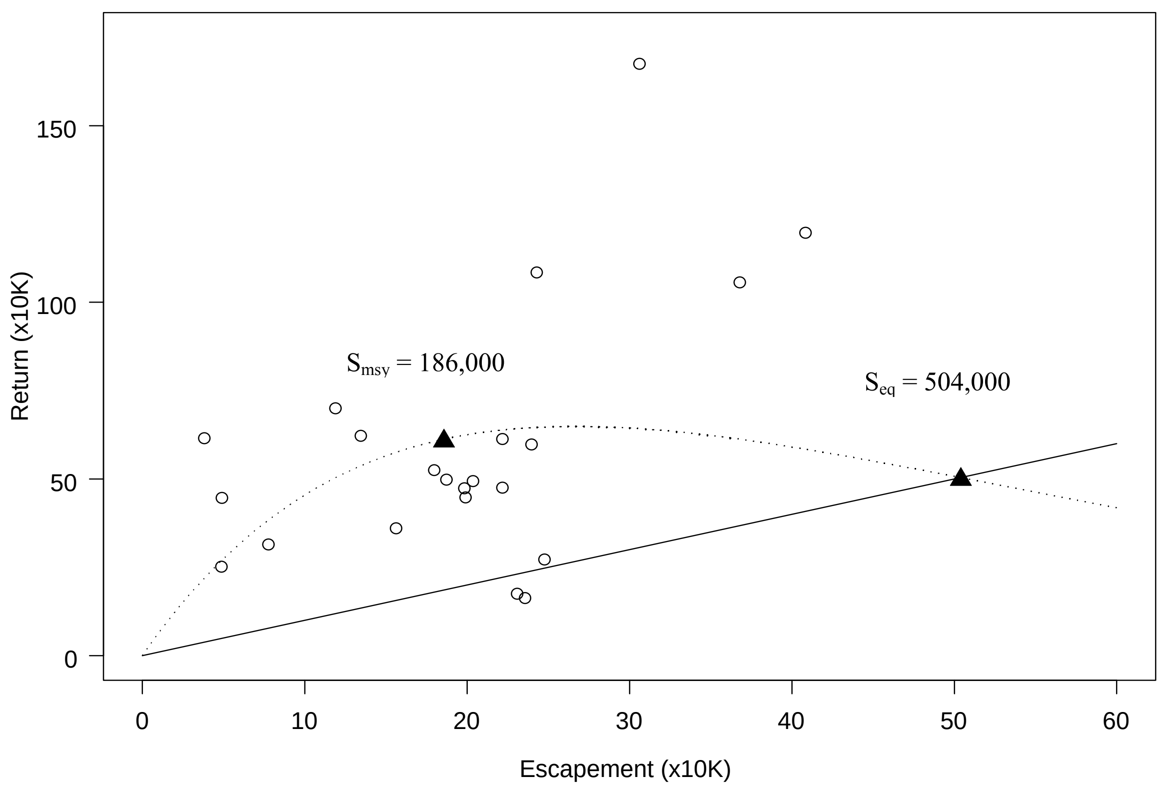
		Return Ages															
Yr.	Escapement	0.1	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	3.3	2.4	Total
1969	96,659	0	8,742	2,106	10,627	17,150	10,963	263	35,454	126,747	0	62	6,359	7,012	475	0	225,961
1970	53,001	0	1,050	12,782	10,757	84,853	4,694	0	11,011	33,913	632	0	7,640	1,791	0	0	169,121
1971	127,679	450	5,538	21,045	817	11,343	2,265	0	22,489	56,322	0	0	10,368	901	0	0	131,539
1972	107,964	3,323	10,610	11,751	18,665	45,090	3,981	0	11,587	77,516	0	0	12,630	574	208	0	195,936
1973	94,718	1,580	1,424	2,373	1,975	11,329	3,398	0	9,769	118,534	0	208	15,215	0	0	133	165,938
1974	286,553	0	0	23,938	0	134,116	1,007	0	39,305	332,704	0	0	19,400	7,173	0	0	557,642
1975	84,781	901	3,021	0	0	62,600	1,340	0	42,872	90,940	0	0	13,966	485	0	0	216,125
1976	77,217	0	10,190	0	36,612	48,121	2,560	0	21,939	188,244	0	0	37,475	940	0	0	346,081
1977	75,381	0	640	0	3,137	84,320	1,289	0	115,564	406,978	0	0	45,258	634	0	0	657,819
1978	104,283	0	82,844	1,289	92,014	163,315	4,698	0	87,500	288,077	0	0	46,415	2,638	37	0	768,827
1979	187,694	0	31,947	0	63,256	75,490	0	0	120,574	405,250	0	782	25,720	398	422	0	723,839
1980	115,584	0	125,207	0	58,519	47,888	2,131	0	25,758	62,637	437	0	23,814	965	248	0	347,604
1981	195,942	0	1,294	0	18,395	160,081	13,778	1,007	153,528	431,378	0	43	38,670	0	0	879	819,053
1982	476,771	0	646,489	5,363	325,606	477,751	5,810	117	168,508	269,183	0	360	23,299	2,112	0	0	1,924,599
1983	295,631	4,867	182,799	1,220	136,358	28,733	2,887	0	64,591	180,354	0	0	71,759	217	1,488	0	675,272
1984	336,406	3,012	37,842	528	93,164	189,569	5,130	0	23,335	270,912	0	0	37,815	4,755	60	0	666,121
1985	435,817	2,313	564,233	1,962	312,640	37,238	34,840	0	47,473	266,787	0	578	88,184	6,773	64	0	1,363,087
1986	468,734	1,449	72,450	7,633	94,830	343,176	6,546	678	152,087	535,096	60	18	25,969	1,919	1,697	6	1,243,614
1987	231,021	0	70,150	541	114,843	14,926	3,976	0	17,779	135,412	27	225	52,712	15,851	96	0	426,537
1988	304,371	0	9,239	216	27,863	76,665	1,852	0	72,937	115,742	387	339	11,319	2,316	0	0	318,874
1989	286,288	401	169,607	1,529	91,353	92,558	19,177	142	59,467	251,877	308	0	55,820	0	0	0	742,239
1990	254,446	1,432	58,489	4,482	115,907	34,022	11,142	444	36,736	319,553	0	0	11,154	361	73	0	593,795
1991	292,886	6,744	52,217	8,116	183,750	119,932	13,299	160	101,985	844,607	31	0	47,820	0	0	0	1,378,661
1992	218,143	4,965	63,356	1,331	21,611	64,882	16,194	79	9,737	303,448	0	0	14,457	156	192	26	500,434
1993	222,081	5,405	46,684	6,293	117,240	41,031	47,997	444	22,581	231,569	191	278	33,051	6,579	0	62	559,405
1994	259,320	1,417	10,435	7,316	28,054	144,095	18,759	44	32,779	326,426	80	0	23,430	1,538	0	0	594,373
1995	245,151	233	3,205	5,807	9,206	213,253	25,989	360	57,432	296,463	0	746	35,202	996	339	20	649,251
1996	294,413	277	2,051	6,713	4,058	66,093	6,030	0	96,642	140,843	125	26	20,094	2,563	0	1,500	347,015
1997	278,448	0	347	0	916	2,842	11,901	0	1,932	129,206	1,984	130	8,502	17,554			
1998	201,927	0	0	89	0	2,511	13,979	0	3,281	219,890	25,325						
1999	246,537	0	279	2,323	672	80,315	15,939										
2000	232,544	96	34,433	5,197													
2001	141,203	0															
2002	187,151																
2003	277,069																

Appendix K11.–Fitted Ricker curve, line of replacement, and actual data for Upper Station late-run sockeye salmon.

System: **Upper Station late run**

Species: **sockeye salmon**

Ricker stock-recruitment relationship, 1975 – 1997. The dashed line represents the Ricker curve, and the solid straight line represents replacement.

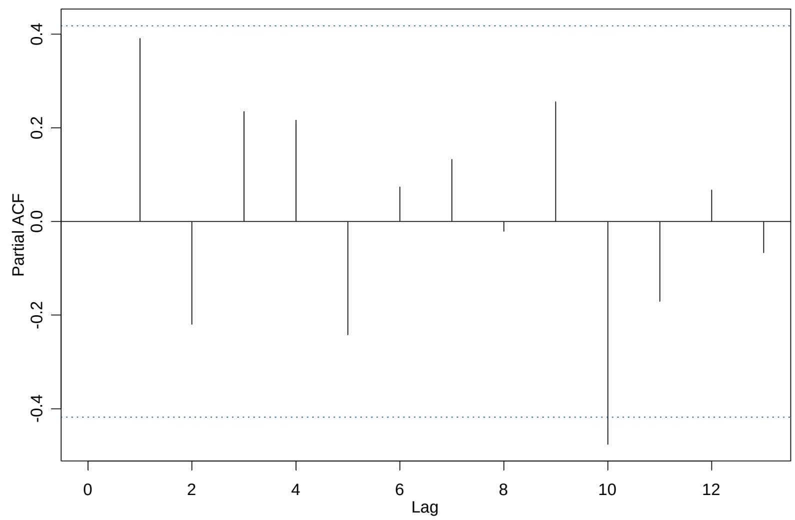


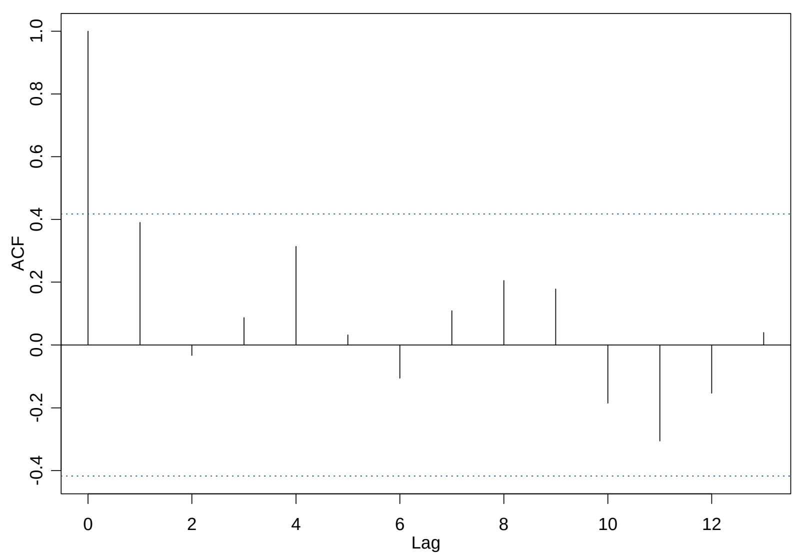
Appendix K12.–Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals of the Ricker model for Upper Station late-run sockeye salmon.

System: Upper Station late run

Species: sockeye salmon

ACF and PACF of residuals from the late-run Ricker model





APPENDIX L. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR FRAZER LAKE SOCKEYE SALMON

Appendix L1.–Description of stock and escapement goal for Frazer Lake sockeye salmon.

System: Frazer Lake

Species: sockeye salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet (with some area-specific restrictions)
Previous escapement goal:	BEG: 140,000 – 200,000 (1988)
Recommended escapement goal:	BEG: 70,000 – 150,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	Escapement through the Dog Salmon Creek weir:
	90,000 – 170,000
Escapement enumeration:	Weir counts (1956-2003)
Data summary:	
Data quality:	Excellent
Data type:	Escapement counts from fish pass (1956-2003) and through the Dog Salmon weir (1985-2003). Harvest information obtained through fish tickets and catch apportionment (1966-2003).
Data contrast:	Weir data, all years (1956-2003): 80,973
	Weir data, years after run established (1978-2003): 12
	Weir data, years after run established, excluding fertilization effected years (1978-1991, 2003): 12
Methodology:	Ricker spawner-recruit model, percentile approach, smolt per spawner, euphotic volume analysis, smolt biomass as a function of zooplankton biomass, spawning habitat
Autocorrelation:	None

-continued-

Appendix L1.–Page 2 of 2.

Comments:	Ricker spawner-recruit models suggest a lower goal than the current BEG. Previous escapement goal analysis influenced by brood year affected by fertilization. Action point at the Dog Salmon weir necessary due to the extended migration time from saltwater to the Frazer fish pass. Lake was fertilized from 1988-1992.
Recommendations:	Change current BEG from 140,000 to 200,000 to a BEG of 70,000 to 150,000

Appendix L2.–Frazer Lake sockeye salmon escapement, 1956-2003.

System: Frazer Lake

Species: sockeye salmon

Data available for analysis of escapement goals

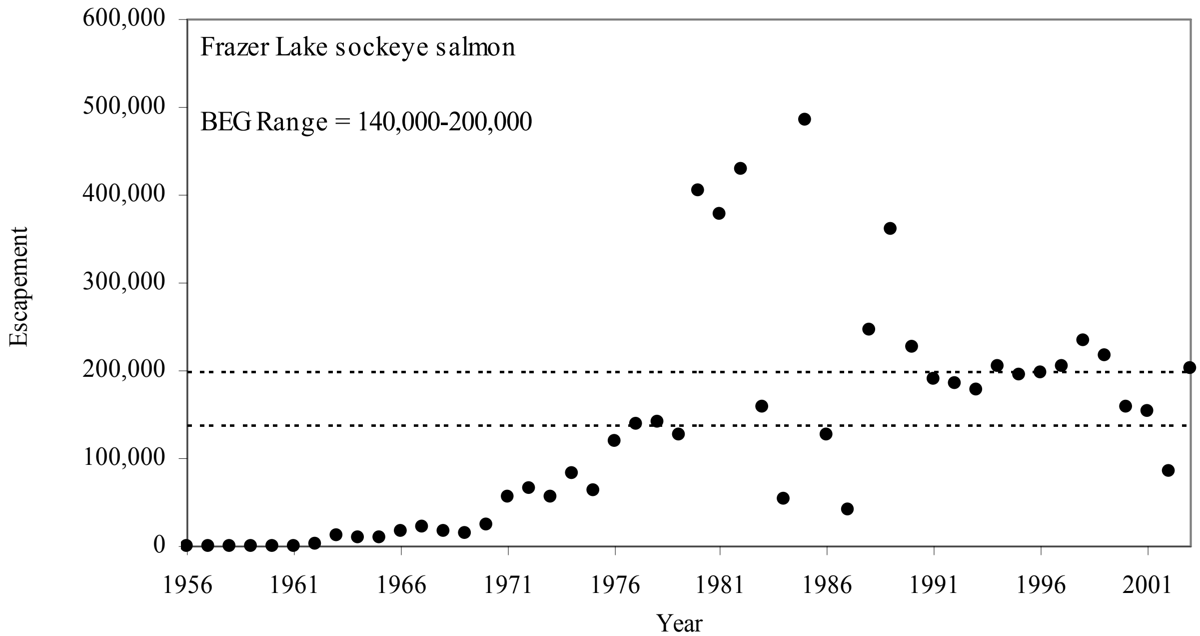
Year	Weir Counts	Year	Weir Counts
1956	6	1980	405,535
1957	165	1981	377,716
1958	71	1982	430,423
1959	62	1983	158,340
1960	440	1984	53,524
1961	873	1985	485,835
1962	3,090	1986	126,529
1963	11,857	1987	40,544
1964	9,966	1988	246,704
1965	9,074	1989	360,373
1966	16,456	1990	226,707
1967	21,834	1991	190,358
1968	16,738	1992	185,825
1969	14,041	1993	178,391
1970	24,039	1994	206,071
1971	55,366	1995	196,323
1972	66,419	1996	198,695
1973	56,255	1997	205,264
1974	82,609	1998	233,755
1975	64,199	1999	216,565
1976	119,321	2000	158,044
1977	139,548	2001	154,349
1978	141,981	2002	85,317
1979	126,742	2003	201,679

Appendix L3.–Frazer Lake sockeye salmon escapement, 1956-2003 and current escapement goal ranges.

System: **Frazer Lake**

Species: **sockeye salmon**

Observed escapement by year (solid circles for weir counts) and current BEG range (dashed lines).



Appendix L4.–Frazer Lake sockeye salmon brood table.

System: Frazer Lake
Species: sockeye salmon
Data available for analysis of escapement goals

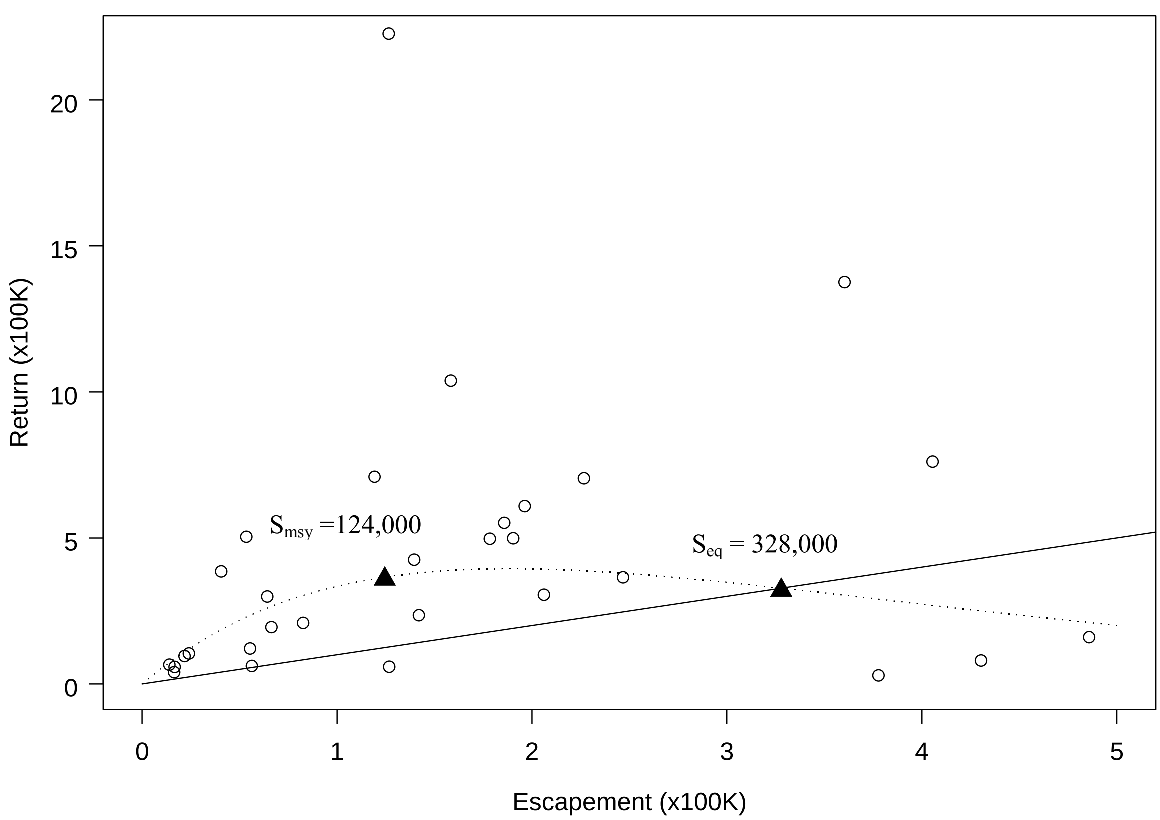
		Ages													Total	Return/
Year	Escp.	0.2	1.1	0.3	1.2	2.1	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	Return	Spawner
1962	3,090												0	385		
1963	11,857									0	4,009	589	0	0		
1964	9,966						0	16,173	204	0	279	0	0	66		
1965	9,074			0	0	1,291	475	12,518	0	0	2,571	66	0	0		
1966	16,456	0	0	0	11,820	1,732	7,580	16,149	0	0	2,629	0	0	0	39,910	2.4
1967	21,834	0	1,118	0	38,626	395	38,395	11,553	0	0	5,114	0	0	0	95,202	4.4
1968	16,738	0	461	0	15,565	899	15,228	14,998	0	0	10,757	0	0	0	57,910	3.5
1969	14,041	0	138	0	14,654	5,229	9,306	30,137	0	0	6,007	0	0	512	65,984	4.7
1970	24,039	0	2,241	0	17,672	16,989	1,687	51,299	0	0	9,351	3,074	0	1,691	104,005	4.3
1971	55,366	0	512	0	1,417	6,345	769	92,226	0	0	20,151	0	0	0	121,419	2.2
1972	66,419	0	742	0	10,888	11,016	8,032	91,876	0	0	71,167	345	0	0	194,066	2.9
1973	56,255	0	256	0	2,677	5,637	4,825	31,706	345	0	15,969	0	0	0	61,415	1.1
1974	82,609	0	10,850	0	53,591	9,305	28,713	75,084	154	461	30,407	461	0	0	209,026	2.5
1975	64,199	0	1,034	0	22,571	8,906	20,732	173,687	0	0	72,701	0	0	0	299,631	4.7
1976	119,321	0	2,150	0	223,444	8,753	73,677	257,625	0	0	143,383	0	0	393	709,424	5.9
1977	139,548	0	2,764	0	73,189	2,928	92,211	107,917	0	0	146,064	393	0	0	425,466	3.0
1978	141,981	0	7,807	0	162,130	507	24,148	22,970	0	0	16,844	0	0	638	235,043	1.7
1979	126,742	0	507	0	1,374	982	2,965	24,323	0	0	26,791	0	0	2,165	59,106	0.5
1980	405,535	0	0	0	6,064	16,305	7,654	589,393	0	0	141,065	684	46	52	761,264	1.9
1981	377,716	0	876	0	12,120	0	2,455	7,748	0	172	5,239	0	0	862	29,471	0.1
1982	430,423	0	1,276	0	23,647	431	28,624	3,735	24	754	10,870	10,812	0	0	80,172	0.2
1983	158,340	0	10	26	8,935	9,729	13,438	380,531	1,604	0	586,833	0	0	36,986	1,038,092	6.6
1984	53,524	0	1,001	0	5,771	33,628	7,437	386,832	0	0	67,142	2,046	0	0	503,856	9.4
1985	485,835	0	192	0	16,502	4,399	49,290	53,978	151	0	22,578	9,032	1,595	2,694	160,412	0.3
1986	126,529	1,393	67,475	0	727,658	40,794	230,893	972,290	0	0	168,815	9,129	0	8,584	2,227,031	17.6
1987	40,544	0	1,787	1,851	3,019	26,596	3,902	187,581	0	0	159,822	104	156	882	385,701	9.5
1988	246,704	0	1,886	0	21,073	7,793	30,096	210,586	133	0	64,565	20,510	16	7,994	364,652	1.5
1989	360,373	0	16,191	208	327,929	12,847	153,078	373,277	5,752	0	300,182	145,325	0	40,754	1,375,543	3.8
1990	226,707	0	1,096	0	18,217	12,986	33,393	400,750	1,678	0	210,744	15,341	455	9,340	704,000	3.1
1991	190,358	0	621	0	2,031	57,463	1,728	330,834	302	0	105,361	630	0	0	498,970	2.6
1992	185,825	0	3,545	0	20,513	78,168	27,471	211,959	4,666	0	185,148	18,141	0	2,209	551,819	3.0
1993	178,391	0	2,529	45	12,677	41,759	56,178	291,218	4,831	0	64,155	17,867	256	5,830	497,344	2.8
1994	206,071	0	2,056	0	23,034	17,688	39,741	112,849	1,048	0	77,546	15,427	187	15,733	305,309	1.5
1995	196,323	0	10,106	0	59,574	39,574	77,223	152,287	1,251	0	251,356	11,284	815	5,387	608,857	3.1
1996	198,695	0	20,062	0	41,983	22,276	81,667	32,786	26	1,641	50,325	101	191	201	251,259	1.3
1997	205,264	0	626	0	8,327	1,639	9,831	14,560	231	630	15,665	2,251				
1998	233,755	0	367	0	1,374	24,808	14,710	87,861	16,454							
1999	216,565	0	1,152	0	3,507	136,968										
2000	158,044	0	35,476													
2001	154,349															
2002	85,317															
2003	201,679															

Appendix L5.–Fitted Ricker curve, line of replacement, and actual data for Frazer Lake sockeye salmon, 1966-1995 brood years.

System: **Frazer Lake**

Species: **sockeye salmon**

Ricker stock – recruitment relationship, 1966-1995 brood years. The dotted line represents the Ricker curve and the solid line represents replacement.

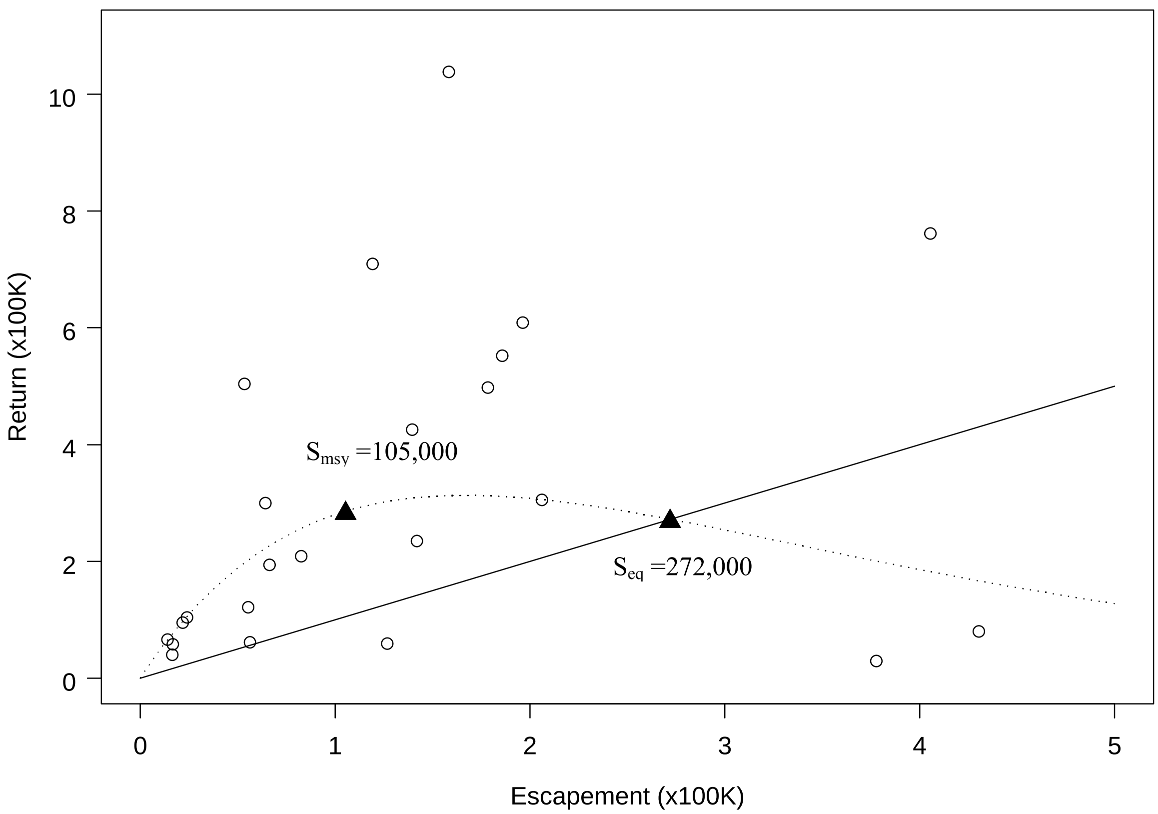


Appendix L6.–Fitted Ricker curve, line of replacement, and actual data for Frazer Lake sockeye salmon, 1966-1995 brood years (excluding years affected by fertilization 1985-1991).

System: **Frazer Lake**

Species: **sockeye salmon**

Ricker stock – recruitment relationship, 1966-1995 brood years, excluding year affected by fertilization (1985-1991). The dotted line represents the Ricker curve and the solid line represents replacement.

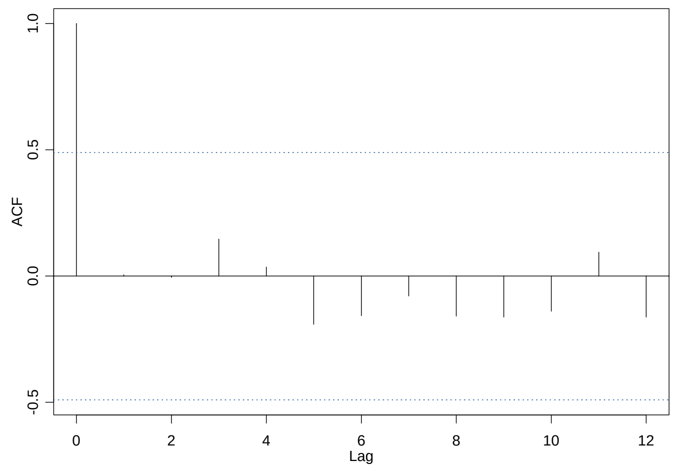


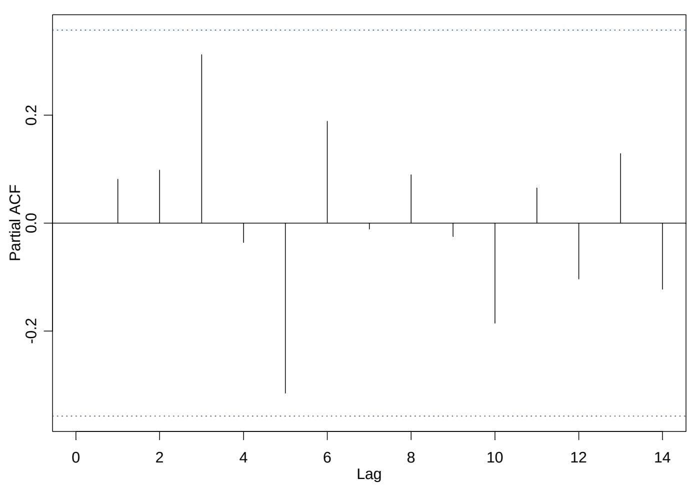
Appendix L7.–Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals of the Ricker model for Frazer Lake sockeye salmon.

System: Frazer Lake

Species: sockeye salmon

ACF and PACF of residuals from the Ricker model (all data)



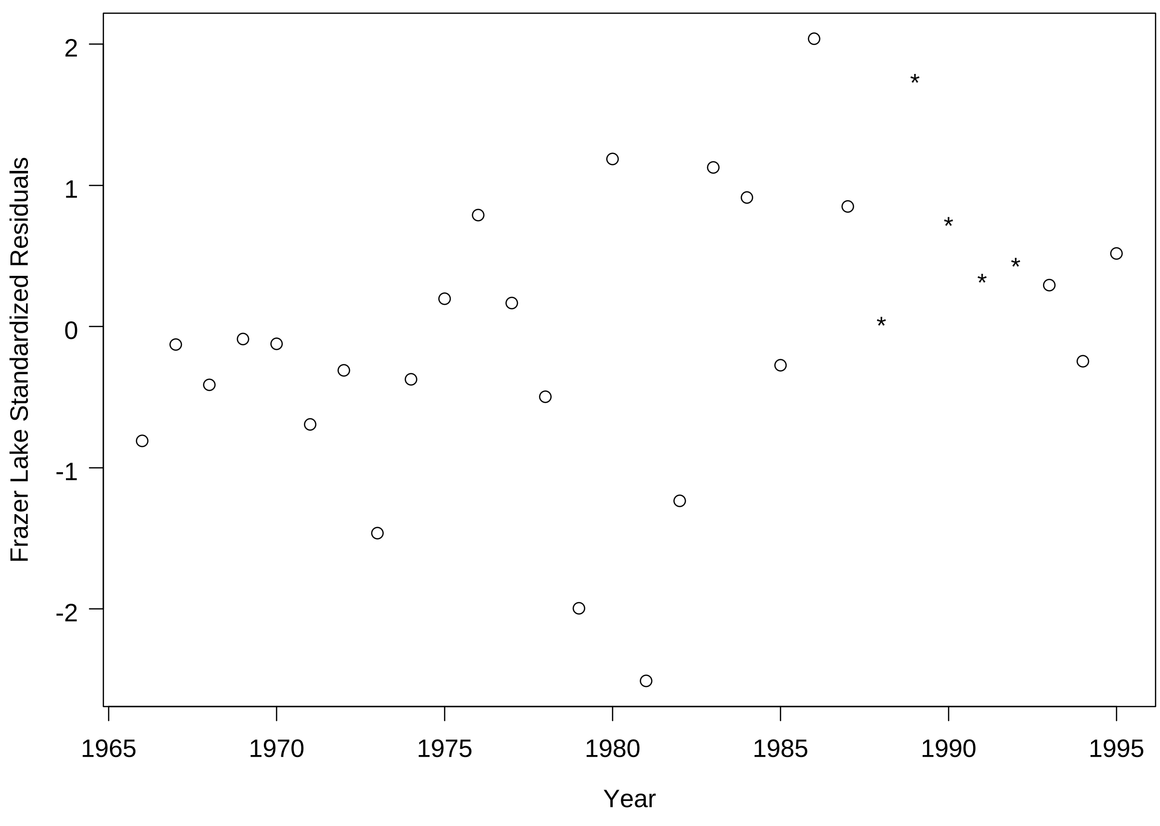


Appendix L8.–Standardized residuals from the Frazer Lake sockeye salmon Ricker model, with asterisks (*) identifying the years of fertilization.

System: Frazer Lake

Species: sockeye salmon

Standardized residuals from the Ricker model by year indicating the years affected by fertilization (asterisks) and those unaffected by fertilization (open circles)

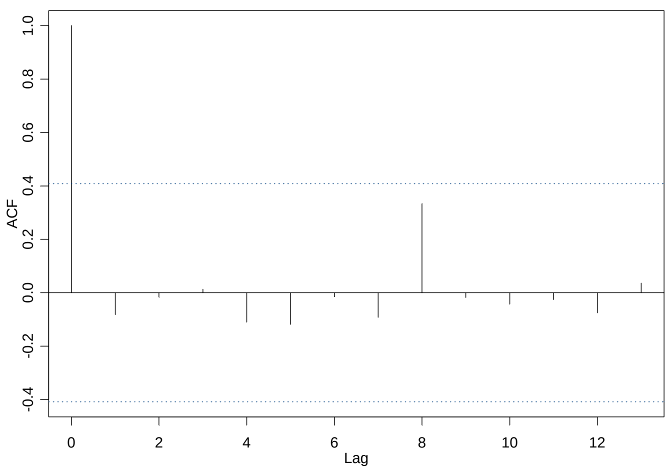


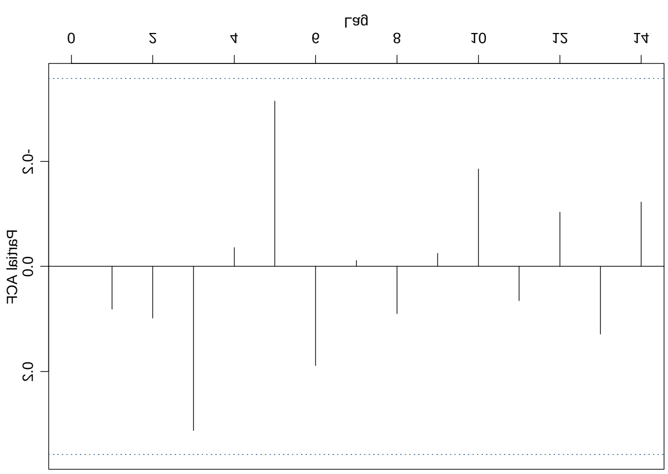
Appendix L9.–Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals of the Ricker model for Frazer Lake sockeye salmon (without fertilization).

System: **Frazer Lake**

Species: **sockeye salmon**

ACF and PACF of residuals from the Ricker model (without fertilization data)





APPENDIX M. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR BUSKIN LAKE SOCKEYE SALMON

Appendix M1.–Description of stock and escapement goal for Buskin Lake sockeye salmon.

System: Buskin Lake

Species: sockeye salmon

Description of stock and escapement goals.

Regulatory area	Kodiak Management Area, Northeast Kodiak District
Management division:	Sport Fish and Commercial Fisheries
Primary fishery:	Subsistence, with some sport and commercial harvest
Previous escapement goal:	SEG: 8,000 to 13,000 (1996)
Recommended escapement goal:	SEG: 8,000 to 13,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir counts, 1985-2003
Data summary:	
Data quality:	Good to excellent.
Data type:	Annual weir counts of escapement for 1985-2003, but weir location moved to outlet of Buskin Lake beginning in 1990. Subsistence harvest estimated annually from permit returns with, in general, most permits returned. Inriver harvests of the sport fishery estimated annually through the Statewide Harvest Survey. Although there is no stock-specific harvest information for commercial fisheries, annual catch data are available from Woman's Bay (statistical area 259-22). Age data collected from the escapement and subsistence harvest since 1990.
Data contrast:	Weir counts, all years since 1990: 2.5
	Weir counts, brood years (1990-1997): 1.6

-continued-

Methodology:	Ricker spawner-recruit analysis was utilized using both traditional linear and Bayesian approaches.
Autocorrelation:	No significant autocorrelation of weir counts.
Comments:	Neither the traditional linear or Bayesian spawner-recruit models provided estimates of escapement(s) that produce maximum sustained yield. The current escapement goal range has provided surplus yield and is sustainable. The SEG range represents escapements based on weir counts.
Recommendations:	Recommend SEG of 8,000 to 13,000

Appendix M2.-Weir counts of escapement and harvests of Buskin Lake sockeye salmon.

System: Buskin Lake

Species: sockeye salmon

Data available for analysis of escapement goals.

Year	Commercial Harvest [a]	Subsistence Harvest [b]	Weir Count [c]		Estimated Sport fishing Effort [d]		
			Buskin Lake	Louise Lake	Harvest	Catch	Angler Days [e]
1990	17	3,576	10,528	-	998	1,405	19,151
1991	16	4,525	9,787	-	1,575	2,122	21,991
1992	0	4,441	9,782	-	1,981	3,279	15,482
1993	4	4,779	9,526	-	1,544	2,520	17,072
1994	3	4,915	13,146	-	2,573	3,630	16,534
1995	80	5,563	15,520	-	1,087	2,159	14,089
1996	0	5,403	10,277	-	1,881	3,015	14,159
1997	0	5,892	9,838	-	1,843	2,524	10,734
1998	2	6,011	14,767	-	1,983	2,533	14,332
1999	1	7,985	10,812	-	1,467	2,284	19,382
2000	0	7,315	11,226	-	2,041	3,322	21,002
2001	0	10,282	20,556	-	827	1,488	9,539
2002	0	13,432	17,174	3,541	2,201	3,794	18,450
2003	6	11,857	23,870	4,488	n/a	n/a	n/a
Average	9	13,344	13,344	4,015	1,693	2,621	16,301

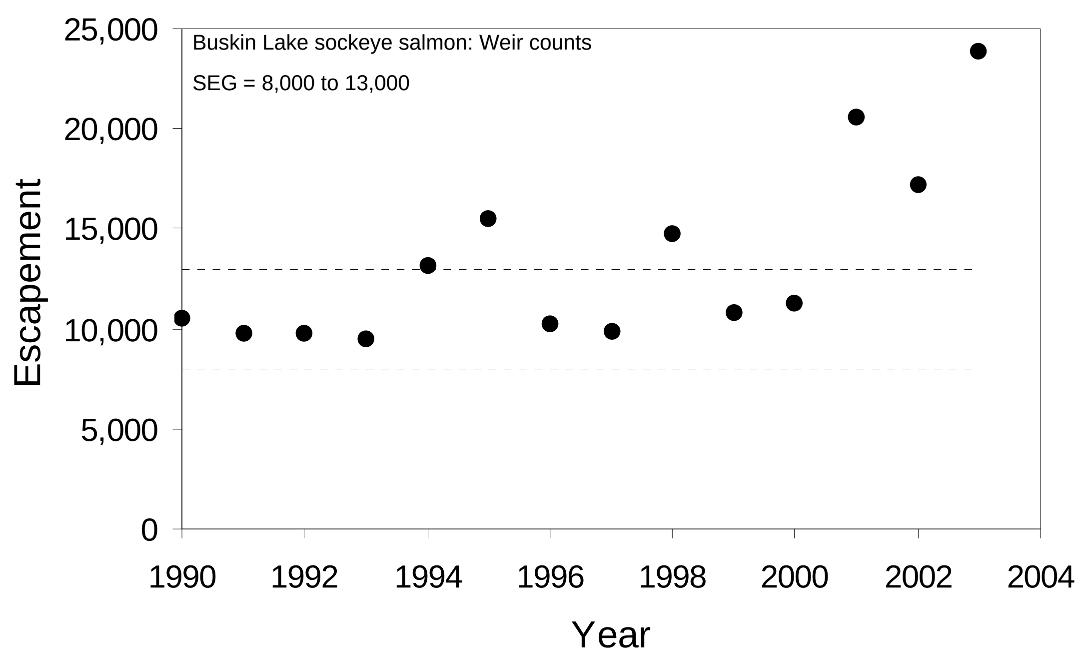
[a] Source: ADF&G Commercial Fish Division Statewide Harvest Receipt (fish ticket) database; includes all sockeye salmon harvested in Woman's Bay section (statistical area 259-22).
[b] Source: ADF&G Commercial Fish Division Westward Region.
[c] Source: Brodie 2001; Kuriscak *In prep*.
[d] Source: Mills 1991-1994; Howe et al. 2001a-d; Walker et al. 2003; Jennings et al. 2004, I*n prep a-b*.
[e] Defined as anglers' days. Includes effort directed toward all species.

Appendix M3.–Weir counts of escapement of sockeye salmon into Buskin Lake, 1990-2003 and current escapement goals.

System: **Buskin Lake**

Species: **sockeye salmon**

Observed escapement by year (solid circles for weir counts) and current SEG (dashed lines).



Appendix M4.-Brood table and spawner-recruit plot for Buskin Lake sockeye salmon.

System: **Buskin Lake**

Species: **sockeye salmon**

Data available for analysis of escapement goal.

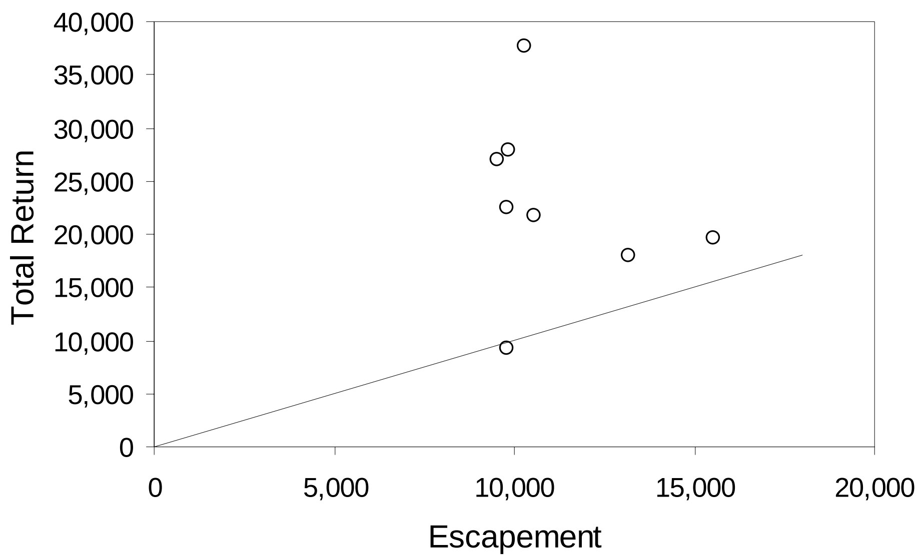
Brood		Age at Retuurn					Total
Year	Escapement	Age 3	Age 4	Age 5	Age 6	Age 7	Return
1990	10,528	12	2,425	10,668	8,483	192	21,780
1991	9,789	174	2,282	8,320	11,322	431	22,529
1992	9,782	15	597	3,397	5,187	192	9,388
1993	9,526	11	2,662	15,670	8,685	54	27,083
1994	13,146	0	1,386	9,451	7,002	203	18,042
1995	15,520	88	1,886	11,196	6,602	0	19,772
1996	10,277	51	2,329	23,082	12,032	247	37,741
1997	9,838	0	1,759	17,354	8,876		27,989
1998	14,767	19	3,314	18,329			
1999	10,812	110	7,170				
2000	11,226	223					
2001	20,556						
2002	17,174						
2003	23,870						

Appendix M5.–Spawner-recruit plot for Buskin Lake sockeye salmon.

System: Buskin Lake

Species: sockeye salmon

Data available for analysis of escapement goal.



APPENDIX N. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR PASAGSHAK RIVER SOCKEYE SALMON

Appendix N1.–Description of stock and escapement goal for Pasagshak River sockeye salmon.

System: Pasagshak River

Species: sockeye salmon

Description of stock and escapement goals.

Regulatory area:	Kodiak Management Area, Eastside Kodiak District
Management division:	Commercial Fisheries
Primary fishery:	Commercial, subsistence, sport
Previous escapement goal:	SEG: 1,000 to 5,000 (1988)
Recommended escapement goal:	SEG: 3,000 to 12,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Peak aerial survey counts, 1968-2003
Data summary:	
Data quality:	Fair
Data type:	Fixed-wing peak aerial survey escapement index counts for 1968-2003. Subsistence harvest estimated annually since 1993 from permit returns. Inriver sport harvests estimated annually since 1977 through the Statewide Harvest Survey. No stock-specific harvest information for commercial fisheries, though total annual catch data are available from Outer Ugak Bay Section (statistical area 259-42). Commercial harvests include sockeye salmon from the Pasagshak River and other nearby systems. No age data collected from the escapements or harvests.
Data contrast:	Peak survey counts, all years: 125.0
	Peak survey counts, 1974-2003: 25.0

-continued-

Methodology:	Percentile approach.
Autocorrelation:	Significant ($P < 0.05$) autocorrelation at lag-2. Deleting survey index for either 1971 or 1973, the years with the two lowest indices in the time series, resulted in no significant autocorrelation; therefore, meaningful autocorrelation does not exist.
Comments:	The recommended escapement goal is based on the percentile approach and corroborated by Risk analysis.
Recommendations:	Recommend SEG of 3,000 – 12,000

Appendix N2.-Peak aerial survey counts of escapement and harvests of Pasagshak River sockeye salmon.

System: Pasagshak River

Species: sockeye salmon

Data available for analysis of escapement goals.

Year	Peak aerial Survey	Harvest Commercial [a]	Subsitence [b]	Sport [c]
1968	3,000			
1969	4,500			
1970		4,847		
1971	700	8,483		
1972	2,000	5,035		
1973	200	1,227		
1974	4,000	1,560		
1975	1,000	451		
1976	4,500	4,302		
1977		2,577		176
1978	5,470	7,436		85
1979	12,000	16,079		236
1980	3,484	315		284
1981	2,759	21,792		205
1982	5,400	2,747		199
1983	3,458	5,727		192
1984	3,700	16,937		374
1985	1,500	25,941		185
1986	3,200	16,203		428
1987	14,000	3,405		417
1988	20,000	13,597		819
1989	14,300	0		1,244
1990	4,680	12,595		1,018
1991	25,000	6,787		815
1992	3,590	5,900		427
1993	16,000	34,638	329	543
1994	2,400	11,903	1,554	861
1995	12,500	19,591	2,099	571
1996	21,500	3,574	2,854	723
1997	13,200	1,946	2,759	1,009
1998	1,850	598	1,089	614
1999	9,800	38,806	2,996	1,241
2000	6,000	28,996	4,520	2,721
2001	3,800	10,189	6,650	701
2002	4,750	29,320	4,576	1,062
2003	8,000	35,418	5,910	492

[a] Source: ADF&G Commercial Fish Division Statewide Harvest Receipt (fish ticket) database; includes all sockeye salmon harvested in Outer Ugak Bay section (statistical area 259-42).

[b] Source: ADF&G Commercial Fish Division Westward Region.

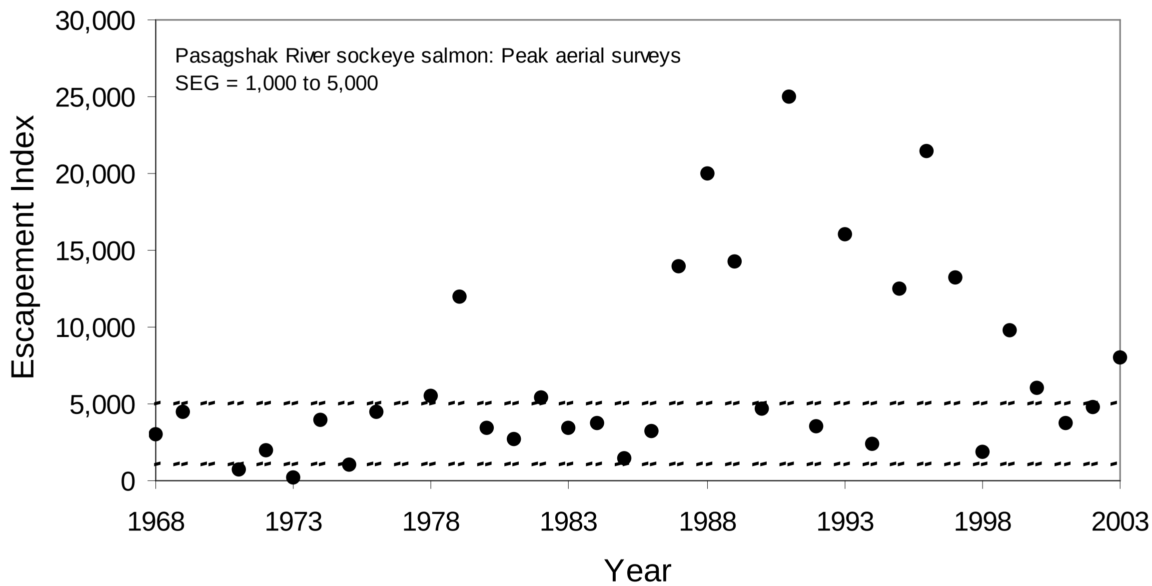
[c] Source: Mills 1979-1994; Howe et al. 2001a-d; Walker et al. 2003; Jennings et al. 2004, *In prep a-b*).

Appendix N3.–Peak aerial survey counts of escapement of sockeye salmon into the Pasagshak River with existing escapement goals depicted.

System: Pasagshak River

Species: sockeye salmon

Observed escapement by year (solid circles for weir counts) and current SEG (dashed lines).

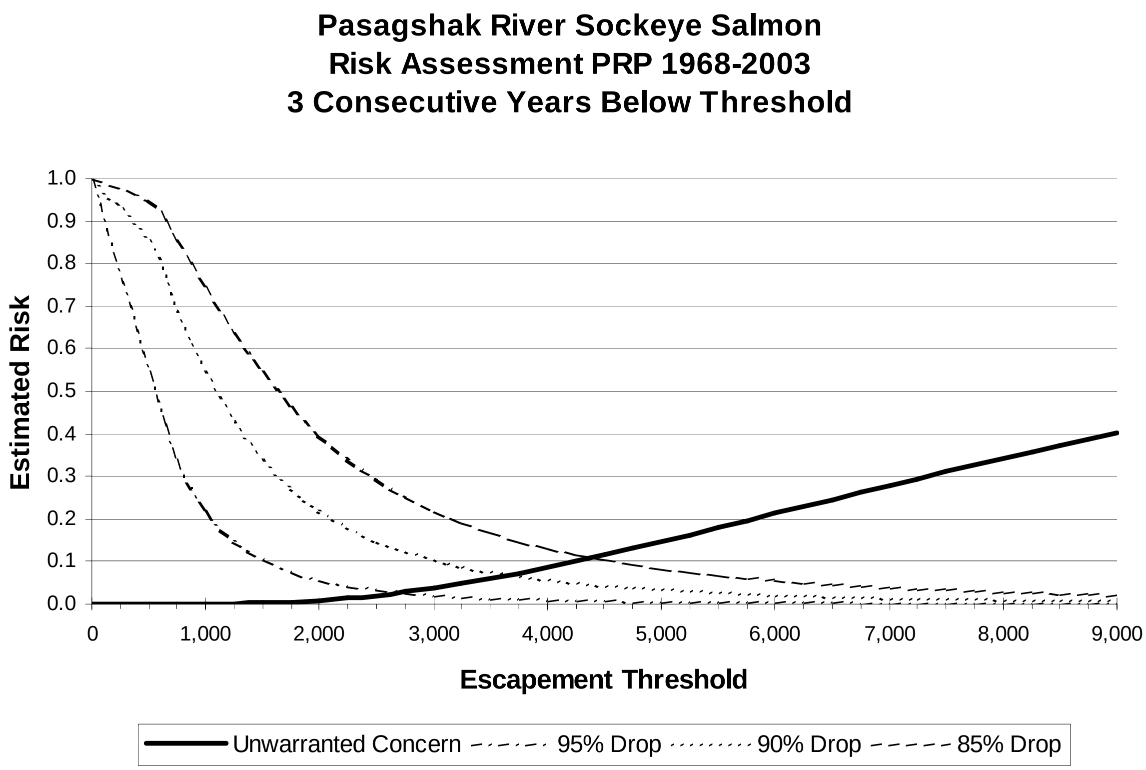


Appendix N4.-Risk analysis for Pasagshak River sockeye salmon.

System: Pasagshak River

Species: sockeye salmon

Data available for analysis of escapement goal



APPENDIX O. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR SALTERY LAKE SOCKEYE SALMON

Appendix O1.–Description of stock and escapement goal for Saltery Lake sockeye salmon.

System: Saltery Lake

Species: sockeye salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine
Previous escapement goal:	SEG: 15,000 – 30,000 (2001)
Recommended escapement goal:	SEG: 15,000 – 30,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial surveys and weir counts (1976 – 2003)
Data summary:	
Data quality:	Fair for aerial surveys, excellent for weir counts
Data type:	Aerial surveys from 1976 to 1985, 1992, weir counts from 1986 to 1991 and 1993 to 2003. Harvest data are available from 1976 to 2003.
Data contrast:	All available data 1976-2003: 6.7
	Weir data 1976-2003: 3.4
Methodology:	Ricker spawner-recruit analysis, percentile approach, euphotic volume analysis, spawning habitat, smolt biomass as a function of zooplankton biomass.
Criteria for SEG:	Low exploitation
Comments:	Updated spawner-recruit curve resulted in similar S_{msy} as found from previous analysis (2001); weir operation is doubtful for future years.
Recommendation:	No change to the current escapement goal of 15,000 to 30,000.

Appendix O2.–Saltery Lake sockeye salmon escapement, 1976-2003.

System: Saltery Lake

Species: sockeye salmon

Data available for analysis of escapement goals

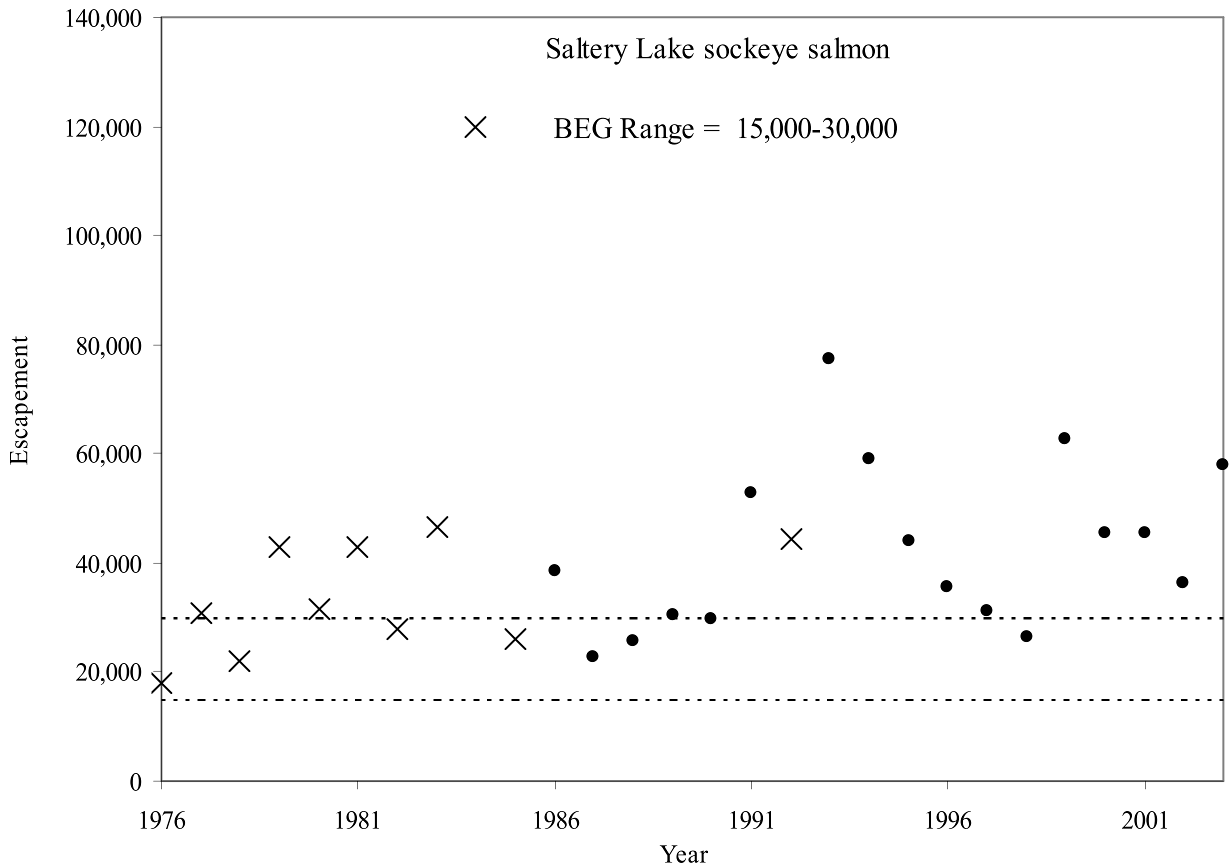
Year	Peak Aerial Survey	Weir Counts
1976	18,000	
1977	30,800	
1978	22,000	
1979	43,000	
1980	31,600	
1981	43,000	
1982	28,000	
1983	46,400	
1984	120,000	
1985	26,000	
1986		38,314
1987		22,705
1988		25,654
1989		30,237
1990		29,767
1991		52,592
1992	44,450	
1993		77,186
1994		58,975
1995		43,859
1996		35,488
1997		31,016
1998		26,263
1999		62,821
2000		45,604
2001		45,608
2002		36,336
2003		57,993

Appendix O3.–Saltery Lake sockeye salmon escapement, 1976-2003 and current escapement goal ranges.

System: Saltery Lake

Species: sockeye salmon

Observed escapement by year (solid circles for weir counts, Xs for aerial counts) and current SEG range (dashed lines).



Appendix O4.–Saltery Lake sockeye salmon brood table.

System: Saltery Lake

Species: sockeye salmon

Data available for analysis of escapement goals

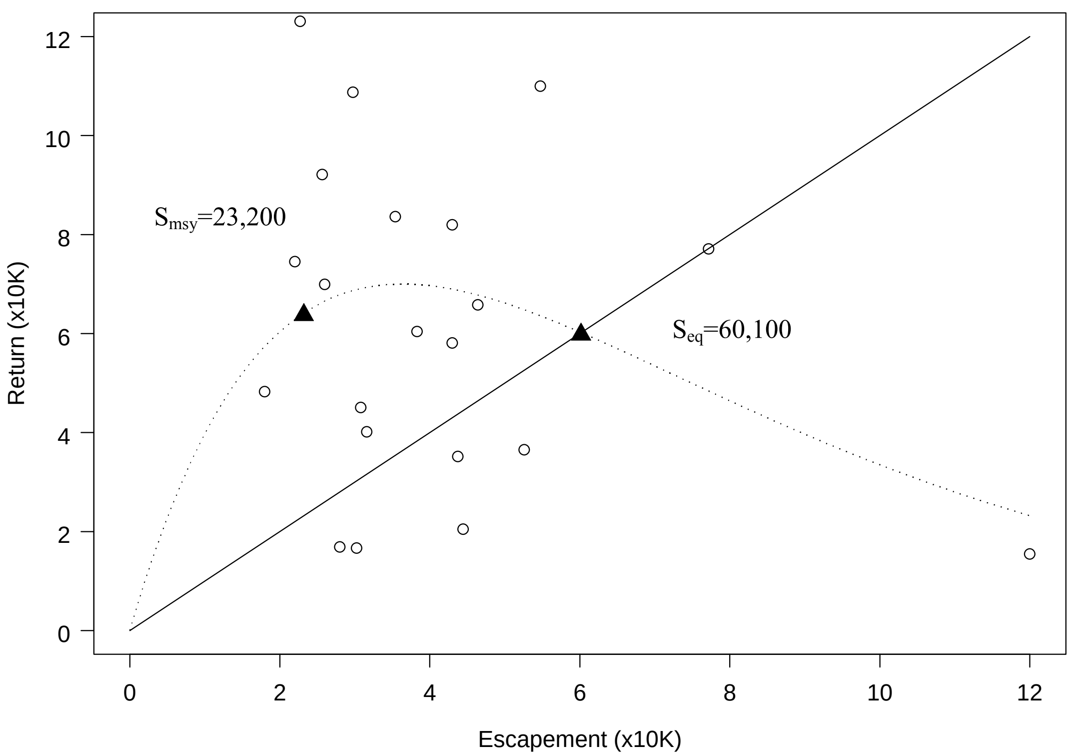
Brood	Brood Year	Age Class Returns															Total	Return-per-
Year	Escapement	0.2	1.1	2.1	0.3	1.2	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	3.4	Return	Spawner
1976	18,000	117	117	190	158	4,329	52	23,661	8,633	0	61	9,335	338	103	1,188	0	48,282	2.68
1977	30,800	63	63	384	320	8,761	138	11,362	4,146	0	103	15,706	568	275	3,166	0	45,054	1.46
1978	22,000	128	128	184	154	4,207	0	19,115	6,975	0	275	41,841	1,514	0	0	0	74,520	3.39
1979	43,000	61	61	310	258	7,078	0	50,925	18,581	0	0	4,691	0	0	0	0	81,965	1.91
1980	31,600	103	103	826	688	18,856	0	14,188	2,231	0	301	2,825	0	0	0	0	40,122	1.27
1981	43,000	275	275	0	0	7,781	0	48,834	201	0	0	707	0	0	0	0	58,073	1.35
1982	28,000	57	0	0	1,240	1,463	0	9,643	1,161	0	0	3,335	0	0	0	0	16,899	0.60
1983	46,400	0	279	0	202	14,137	54	31,369	2,993	0	0	16,464	239	54	0	0	65,791	1.42
1984	120,000	101	202	0	0	1,120	0	7,476	3,579	0	108	2,252	0	611	0	0	15,450	0.13
1985	26,000	0	0	0	0	3,261	78	18,972	10,833	0	0	34,819	0	156	1,797	0	69,916	2.69
1986	38,314	0	80	0	922	8,850	0	22,602	2,443	0	156	23,753	859	0	743	0	60,409	1.58
1987	22,705	0	0	0	0	611	0	28,910	10,548	0	0	82,248	0	178	583	0	123,078	5.42
1988	25,654	0	0	469	391	10,704	0	13,378	29,233	0	0	37,932	0	0	0	0	92,106	3.59
1989	30,237	156	156	248	248	991	0	3,082	6,218	0	462	5,087	0	0	0	0	16,648	0.55
1990	29,767	0	0	59	206	23,235	0	55,341	4,933	0	284	24,483	0	0	232	0	108,774	3.65
1991	52,592	147	0	0	462	1,079	0	11,911	1,702	0	232	20,573	349	0	54	0	36,509	0.69
1992	44,450	0	0	0	0	1,134	0	7,904	5,812	0	0	5,615	0	0	0	0	20,464	0.46
1993	77,186	0	0	349	116	1,046	0	5,642	4,509	162	0	13,757	17,345	577	33,088	514	77,105	1.00
1994	54,737	0	116	2,388	27	9,692	0	18,697	50,605	0	0	27,761	0	672	0	0	109,958	2.01
1995	43,737	715	135	0	299	5,580	0	5,903	10,789	0	0	11,738	0	0	0	0	35,158	0.80
1996	35,385	0	0	0	0	5,204	0	32,066	11,022	0	182	33,700	985	450	0		83,610	2.36
1997	28,316	0	0	0	714	1,705	0	4,725	8,199	0	0	21,539	178					
1998	23,703	0	395	1,102	0	19,422	0	49,648	14,888	0								
1999	58,503	0	182	272	258	10,092												
2000	43,022	356	0															
2001	44,763																	
2002	34,336																	
2003	53,818																	

Appendix O5.–Fitted Ricker curve, line of replacement, and actual data for Saltery Lake sockeye salmon, 1976-1996 brood years.

System: **Saltery Lake**

Species: **sockeye salmon**

Ricker stock – recruitment relationship, 1976-1996 brood years. The dotted line represents the Ricker curve and the solid line represents replacement.

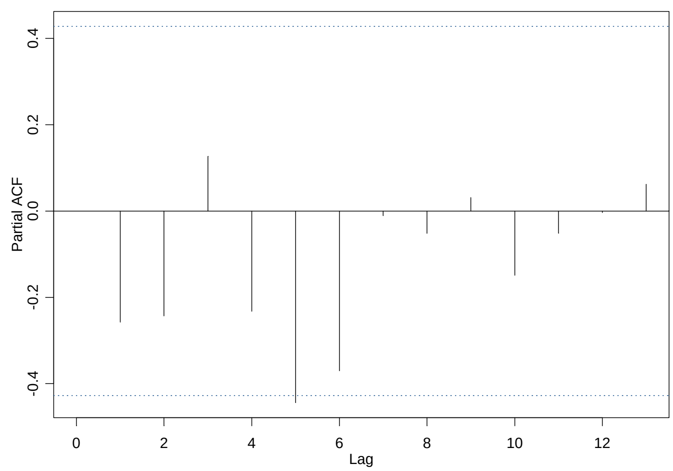


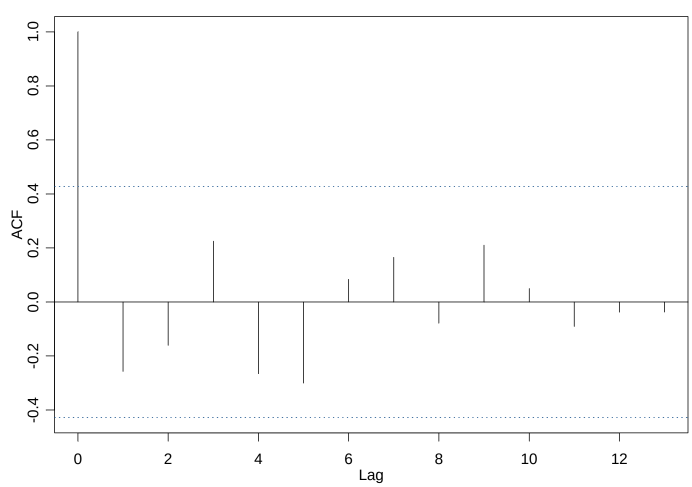
Appendix O6.–Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals of the Ricker model for Saltery Lake sockeye salmon.

System: Saltery Lake

Species: sockeye salmon

ACF and PACF of residuals from the Ricker model





APPENDIX P. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR COHO SALMON ON THE KODIAK ARCHIPELAGO ON THE ROAD SYSTEM

Appendix P1.–Description of stock and escapement goal for American River coho salmon.

System: American River

Species: coho salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area, Northeast Kodiak District
Management division:	Sport Fish and Commercial Fisheries
Primary fishery:	Recreational, Commercial, and Subsistence
Previous escapement goal:	SEG: 300 to 400 (1999)
Recommended escapement goal:	SEG: 400 to 900
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Foot survey, 1980-2003 with no surveys in 1988-1989 and 1991
Data summary:	
Data quality:	Mark-recapture work conducted in 1997 and 1998 (Begich et al. 2000) indicated that foot surveys in the American River represent 62% to 108% of point estimates of abundance and are within the 95% confidence interval of estimated abundance.
Data type:	Foot surveys are conducted annually and inriver harvests of the recreational fishery are estimated annually through the Statewide Harvest Survey (Jennings et al. 2004). Although there are no stock-specific harvest information available for subsistence and commercial fisheries, annual catch data are available from Middle Bay (statistical area 259-23).
Data contrast:	Foot survey counts, all years: 31.9

-continued-

Methodology:	Theoretical stock-recruit analysis was utilized with average foot survey and average harvest (recreational, commercial and subsistence) from 1980-2003 to specify the SEG range that potentially maximizes yield given uncertainty in the productivity of this stock. α-parameter values used in the stock-recruit analysis ranged from 4 to 8.
Autocorrelation:	No significant autocorrelation of foot survey counts.
Comments:	Assuming foot surveys represent the majority of actual escapement, maximum exploitation rate on this stock has averaged 68% since 1980. If stock productivity ranges from 4 to 8 returns-per-spawner at low stocks sizes, exploitation rate should range from 56% to 74% at MSY, indicating that harvests are at or approaching MSY for this stock. The SEG range represents escapements based on unexpanded foot surveys.
Recommendations:	Recommend SEG of 400 to 900

Appendix P2.–American River coho salmon foot surveys and harvests, 1980-2003.

System: American River

Species: coho salmon

Data available for analysis of escapement goals

		Harvest:			
Year	Foot Survey	Recreational[a]	Subsistence[b]	Commercial[c]	Total
1980	903		8	433	
1981	627		1	30	
1982	266		95	121	
1983	114	378	43	73	494
1984	277	486	0	2	488
1985	439	349	15	298	662
1986	221	826	2	71	899
1987	555	435	33	359	827
1988		1,710	0	89	1,799
1989		1,500	0	0	1,500
1990	419	849	14	1	864
1991		722	60	4	786
1992	167	583	0	0	583
1993	412	2,340	3	73	2,416
1994	194	642	0	0	642
1995	169	794	2	1,303	2,099
1996	69	549	15	0	564
1997	2,204	1,749	6	31	1,786
1998	1,360	700	0	129	829
1999	284	1,090	0	29	1,119
2000	133	480	0	0	480
2001	233	860	18	0	878
2002	1,034	1,195	5	0	1,200
2003	511	1,051	42	4	1,097
N	21	21	24	24	21
Avg	504	918	15	127	1,048
SD	510	523	24	278	560
Min	69	349	0	0	480
Max	2,204	2,340	95	1,303	2,416

[a] Recreational harvests from the Statewide Harvest Survey (Jennings et al. 2004).

[b] Subsistence harvests from Commercial Fisheries Division data base.

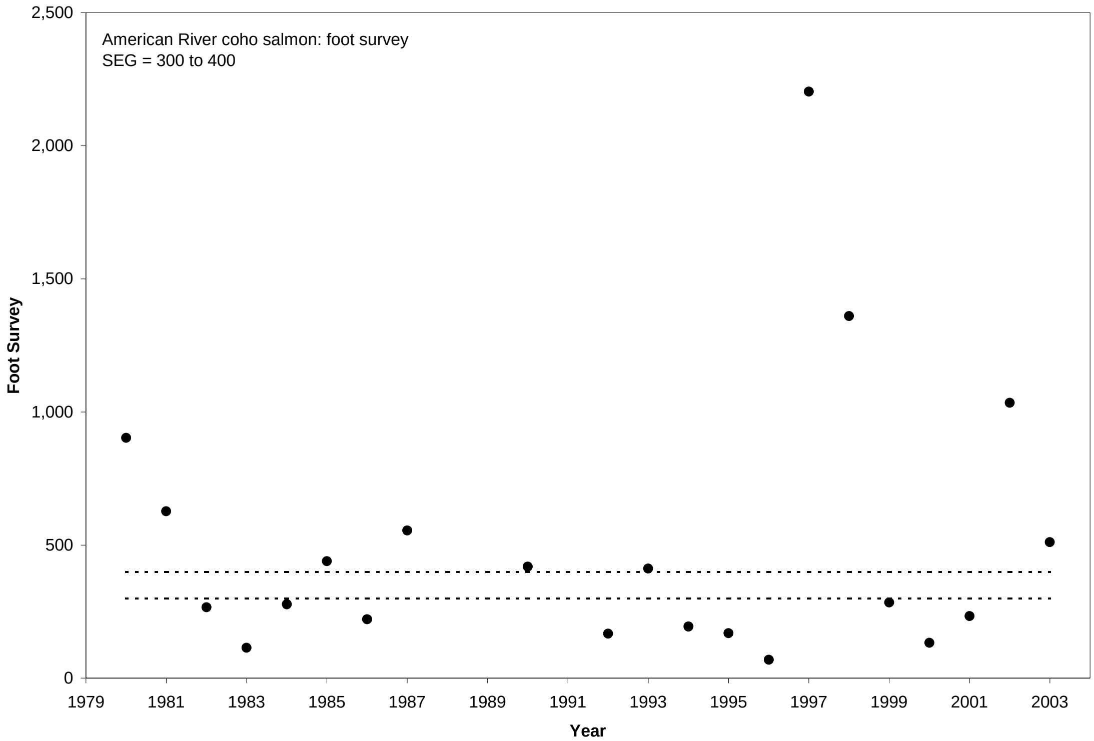
[c] Commercial harvests from Commercial Fisheries Division data base for statistical area 259-23.

Appendix P3.–American River coho salmon foot surveys and the current escapement goal.

System: American River

Species: coho salmon

Observed escapement by year (solid circles for foot surveys) and current SEG (dashed lines).

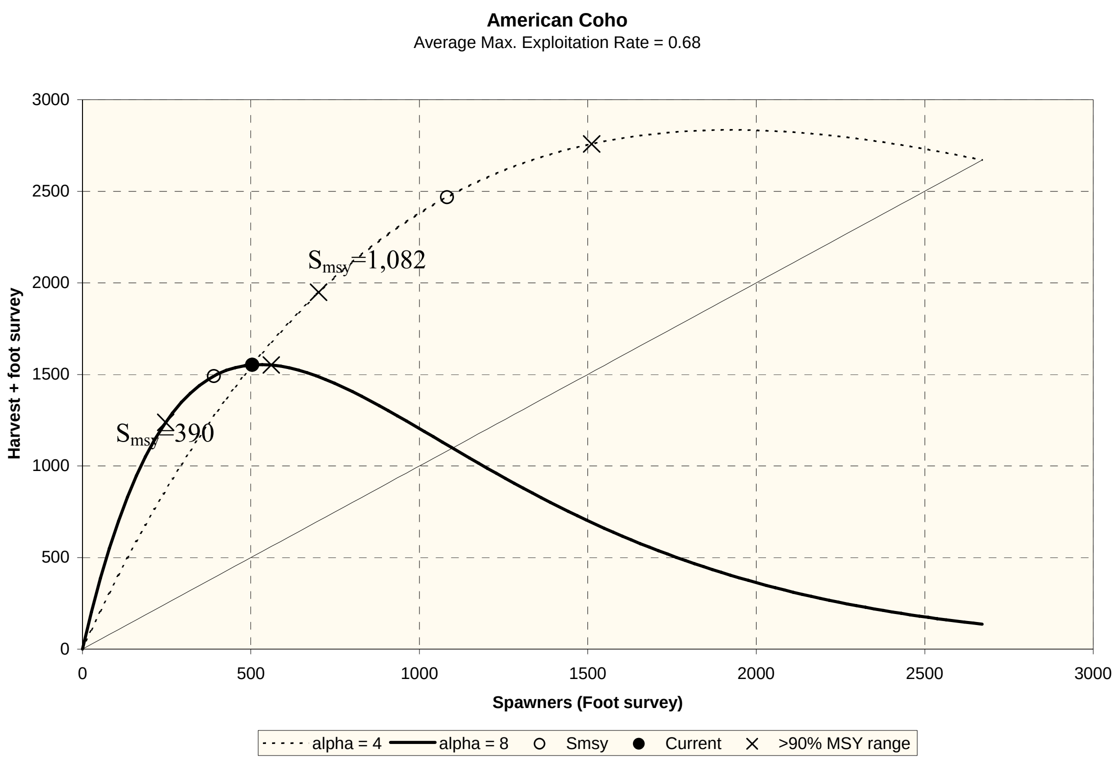


Appendix P4.–Theoretical Ricker stock-recruitment relationships for American River coho salmon.

System: American River

Species: coho salmon

Theoretical Ricker stock-recruitment relationships based on an average foot survey of 504 and average harvest of 1,048 coho salmon (1980-2003; •). The dotted line represents the Ricker curve with an α-parameter of 4; the solid line represents the Ricker curve with an α-parameter of 8, and the solid straight line represents replacement. S_{msy} (○) and escapements that produce 90% of MSY (×) are also shown.



Appendix P5.–Description of stock and escapement goal for Olds River coho salmon.

System: Olds River

Species: coho salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area, Northeast Kodiak District
Management division:	Sport Fish and Commercial Fisheries
Primary fishery:	Recreational, Commercial, and Subsistence
Previous escapement goal:	SEG: 450 to 675 (1999)
Recommended escapement goal:	SEG: 1,000 to 2,200
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Foot survey, 1980-2003 with no surveys in 1981, 1983, 1988 and 1991
Data summary:	
Data quality:	Mark-recapture work conducted in 1997 and 1998 (Begich et al. 2000) indicated that foot surveys in the Olds River represent 69% to 104% of point estimates of abundance and were within the 95% confidence interval of estimated abundance in 1998.
Data type:	Foot surveys are conducted annually and inriver harvests of the recreational fishery are estimated annually through the Statewide Harvest Survey (Jennings et al. 2004). Although there are no stock-specific harvest information available for subsistence and commercial fisheries, annual catch data are available from Kalsin Bay (statistical area 259-24).
Data contrast:	Foot survey counts, all years: 13.2

-continued-

Appendix P5.–Page 2 of 2.

Methodology:	Theoretical stock-recruit analysis was utilized with average foot survey and average harvest (recreational, commercial and subsistence) from 1980-2003 to specify the SEG range that potentially maximizes yield given uncertainty in the productivity of this stock. α-parameter values used in the stock-recruit analysis ranged from 4 to 8.
Autocorrelation:	No significant autocorrelation of foot survey counts.
Comments:	Assuming foot surveys represent the majority of actual escapement, maximum exploitation rate on this stock has averaged 63% since 1980. If stock productivity ranges from 4 to 8 returns-per-spawner at low stocks sizes, exploitation rate should range from 56% to 74% at MSY, indicating that harvests are at or approaching MSY for this stock. The SEG range represents escapements based on unexpanded foot surveys.
Recommendations:	Recommend SEG of 1,000 to 2,200

Appendix P6.–Olds River coho salmon foot surveys and harvests, 1980-2003.

System: Olds River

Species: coho salmon

Data available for analysis of escapement goals

		Harvest:			
Year	Foot Survey	Recreational[a]	Subsistence[b]	Commercial[c]	Total
1980	780		0	6,069	
1981			152	1,366	
1982	1,375		279	1,839	
1983		31	64	766	861
1984	325	611	445	4,252	5,308
1985	1,648	304	337	332	973
1986	1,849	1,651	312	447	2,410
1987	842	307	379	3,310	3,996
1988		1,273	209	1,773	3,255
1989	743	2,571	143	0	2,714
1990	1,706	948	379	7	1,334
1991		1,778	247	178	2,203
1992	308	1,085	276	0	1,361
1993	525	1,876	82	40	1,998
1994	395	1,083	225	2	1,310
1995	2,642	833	116	3,988	4,937
1996	2,200	864	305	0	1,169
1997	4,064	1,519	363	3,011	4,893
1998	2,296	951	269	10	1,230
1999	1,382	1,349	258	320	1,927
2000	1,097	1,712	383	0	2,095
2001	3,454	1,268	295	4,948	6,511
2002	790	1,346	215	0	1,561
2003	1,534	1,233	595	9	1,837
N	20	21	24	24	21
Avg	1,498	1,171	264	1,361	2,566
SD	1,031	591	132	1,868	1,628
Min	308	31	0	0	861
Max	4,064	2,571	595	6,069	6,511

[a] Recreational harvests from the Statewide Harvest Survey (Jennings et al. 2004).

[b] Subsistence harvests from Commercial Fisheries Division data base.

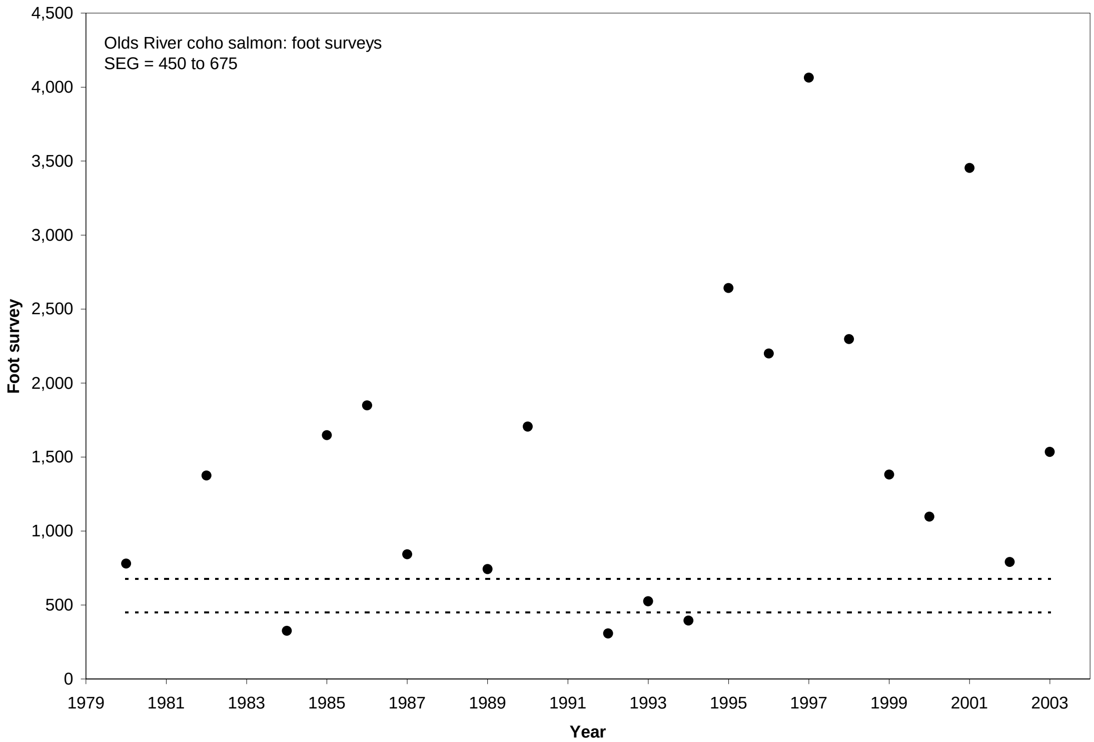
[c] Commercial harvests from Commercial Fisheries Division data base for statistical area 259-24.

Appendix P7.–Olds River coho salmon foot surveys and current escapement goal ranges.

System: Olds River

Species: coho salmon

Observed escapement by year (solid circles for foot surveys) and current SEG (dashed lines).

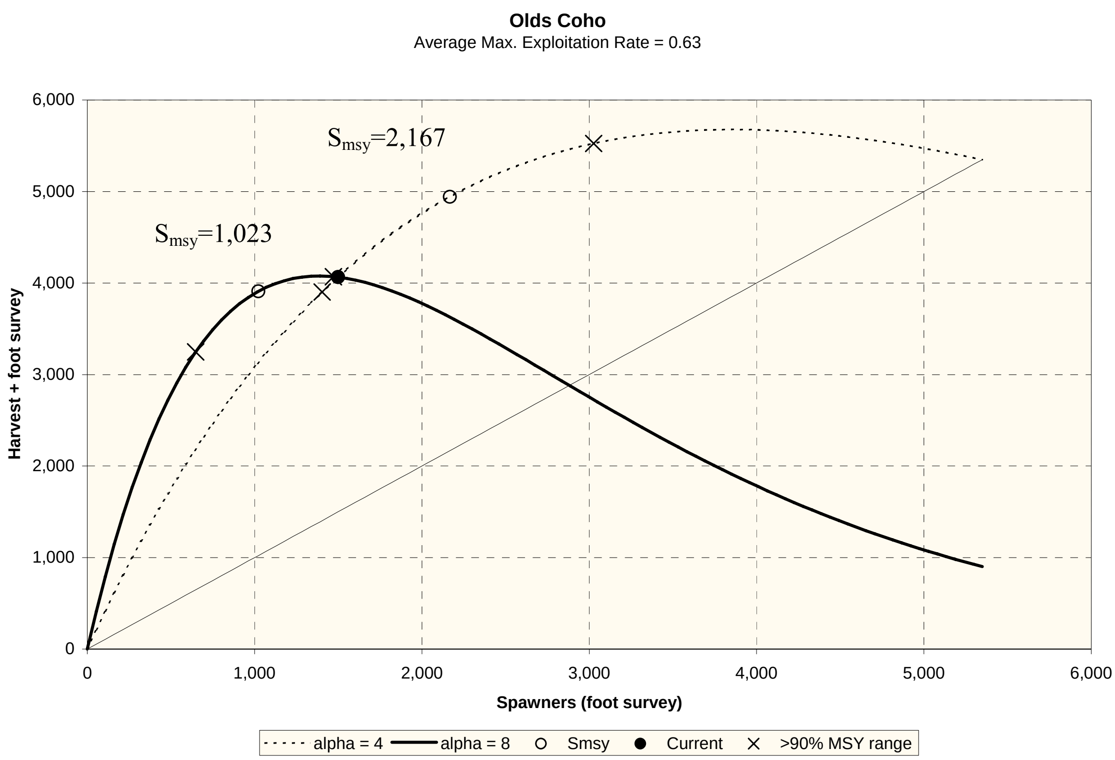


Appendix P8.–Theoretical Ricker stock-recruitment relationships for Olds River coho salmon.

System: Olds River

Species: coho salmon

Theoretical Ricker stock-recruitment relationships based on an average foot survey of 1,498 and average harvest of 2,566 coho salmon (1980-2003; •). The dotted line represents the Ricker curve with an α-parameter of 4; the solid line represents the Ricker curve with an α-parameter of 8, and the solid straight line represents replacement. S_{msy} (○) and escapements that produce 90% of MSY (×) are also shown.



Appendix P9.–Description of stock and escapement goal for Pasagshak River coho salmon.

System: Pasagshak River

Species: coho salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area, Eastside Kodiak District
Management division:	Sport Fish and Commercial Fisheries
Primary fishery:	Recreational, Commercial, and Subsistence
Previous escapement goal:	SEG: 1,500 to 3,000 (1999)
Recommended escapement goal:	SEG: 1,200 to 3,300
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Foot survey, 1980-2003 with no surveys in 1985, 1988-1989, and 1991-1992
Data summary:	
Data quality:	Fishery managers have indicated that foot surveys in the Pasagshak River since 1996 likely represent most of the actual escapement to that system.
Data type:	Foot surveys are conducted annually and inriver harvests of the recreational fishery are estimated annually through the Statewide Harvest Survey (Jennings et al. 2004). Although there are no stock-specific harvest information available for subsistence and commercial fisheries, annual catch data are available from statistical area 259-41.
Contrast:	Foot survey counts, all years: 50.8
Methodology:	Theoretical stock-recruit analysis was utilized with average foot survey and average harvest (recreational, commercial and subsistence) from 1980-2003 to specify the SEG range that potentially maximizes yield given uncertainty in the productivity of this stock. α-parameter values used in the stock-recruit analysis ranged from 4 to 8.

-continued-

Autocorrelation:	Significant autocorrelation of foot survey counts at lag 1 (0.55).
Comments:	Assuming foot surveys since 1996 represent the majority of actual escapement, maximum exploitation rate on this stock has averaged 29% since 1996. If stock productivity ranges from 4 to 8 returns-per-spawner at low stocks sizes, exploitation rate should range from 56% to 74% at MSY, indicating that harvests are below MSY for this stock. The SEG range represents escapements based on unexpanded foot surveys.
Recommendations:	Recommend SEG of 1,200 to 3,300

Appendix P10.–Pasagshak River coho salmon foot surveys and harvests, 1980-2003.

System: Pasagshak River

Species: coho salmon

Data available for analysis of escapement goals

		Harvest:			
Year	Foot Survey	Recreational[a]	Subsistence[b]	Commercial[c]	Total
1980	2,664	2,480	18	1,832	4,330
1981	2,621	1,015	16	1,048	2,079
1982	175	1,100	17	2,787	3,904
1983	1,920	1,322	20	2,316	3,658
1984	1,540	1,870	76	1,485	3,431
1985		2,292	117	1,691	4,100
1986	3,571	2,951	35	1,184	4,170
1987	2,519	3,459		9,425	12,884
1988		2,601	0	778	3,379
1989		2,065	28	0	2,093
1990	2,173	2,105	60	46	2,211
1991		1,296	216	94	1,606
1992		1,765	118	222	2,105
1993	1,337	2,274	276	714	3,264
1994		994	112	106	1,212
1995		1,215	65	927	2,207
1996	2,248	1,458	196	0	1,654
1997	2,813	1,468	88	41	1,597
1998	1,906	969	140	48	1,157
1999	3,409	1,195	75	226	1,496
2000	4,526	2,691	348	374	3,413
2001	6,209	804	181	44	1,029
2002	5,825	945	112	81	1,138
2003	8,886	2,547	353	143	3,043
N	17	24	23	24	24
Avg	3,197	1,787	116	1,067	2,965
SD	2,123	745	103	1,954	2,373
Min	175	804	0	0	1,029
Max	8,886	3,459	353	9,425	12,884

[a] Recreational harvests from the Statewide Harvest Survey (Jennings et al. 2004).

[b] Subsistence harvests from Commercial Fisheries Division data base.

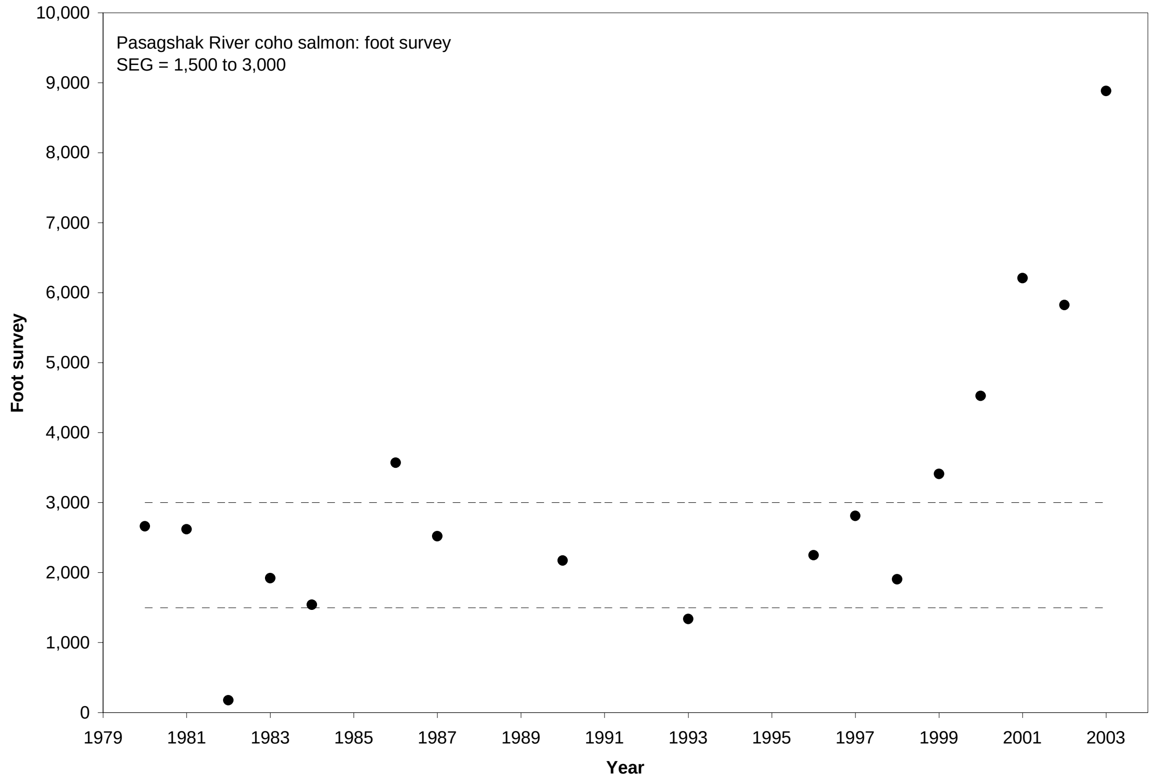
[c] Commercial harvests from Commercial Fisheries Division data base for statistical area 259-41.

Appendix P11.–Pasagshak River coho salmon foot surveys and current escapement goal ranges.

System: **Pasagshak River**

Species: **coho salmon**

Observed escapement by year (solid circles for foot surveys) and current SEG (dashed lines).

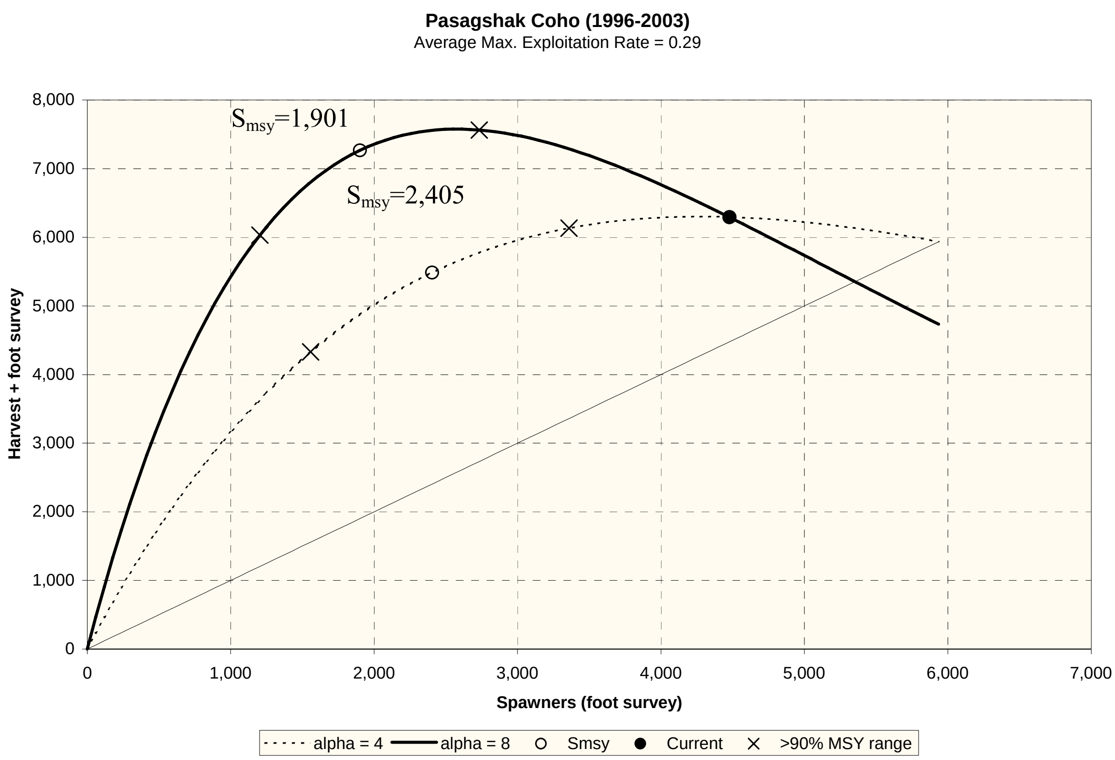


Appendix P12.–Theoretical Ricker stock-recruitment relationships for Pasagshak River coho salmon.

System: **Pasagshak River**

Species: **coho salmon**

Theoretical Ricker stock-recruitment relationships based on an average foot survey of 4,478 (1996-2003) and average harvest of 2,965 coho salmon (1996-2003; •). The dotted line represents the Ricker curve with an α-parameter of 4; the solid line represents the Ricker curve with an α-parameter of 8, and the solid straight line represents replacement. S_{msy} (o) and escapements that produce 90% of MSY (×) are also shown.



Appendix P13.–Description of stock and escapement goal for Buskin River coho salmon.

System: Buskin River

Species: coho salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area, Northeast Kodiak District
Management division:	Sport Fish and Commercial Fisheries
Primary fishery:	Recreational, Commercial, and Subsistence
Previous escapement goal:	SEG: 6,000 to 9,000 (1999)
Recommended escapement goal:	BEG: 3,200 to 7,200
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir, 1985-2003
Data summary:	
Data quality:	Good to excellent. Age composition is available for escapement, recreational, subsistence, and commercial catch for most years.
Data type:	Weir counts are conducted annually and inriver harvests of the recreational fishery are estimated annually through the Statewide Harvest Survey (Jennings et al. 2004). Although there are no stock-specific harvest information available for subsistence and commercial fisheries, annual catch data are available from statistical area 259-22.
Contrast:	Weir counts, all years: 2.2

-continued-

Methodology:	A Ricker stock-recruit analysis was conducted on brood table information from escapements in 1990-1999 and returns in 1993-2003. Also a theoretical stock-recruit analysis was utilized with average foot survey and average harvest (recreational, commercial and subsistence) from 1985-2003 to specify the BEG range that potentially maximizes yield given uncertainty in the productivity of this stock. α-parameter values used in the stock-recruit analysis ranged from 4 to 8.
Autocorrelation:	No significant autocorrelation of residuals of the Ricker stock-recruit analysis. Significant autocorrelation of escapements at lag 2 (0.50).
Comments:	Estimated S_{msy} from the Ricker analysis is 5,073 fish with escapements that produce at least 90% of MSY ranging from 3,268 to 7,131 fish. Exploitation rate on this stock has averaged 36% since 1985. If stock productivity ranges from 4 to 8 returns-per-spawner at low stocks sizes, exploitation rate should range from 56% to 74% at MSY, indicating that harvests are below MSY for this stock. The BEG range represents escapements based on weir counts minus 20% of the recreational harvest.
Recommendations:	Recommend BEG of 3,200 to 7,200.

Appendix P14.–Buskin River coho salmon escapement and harvest, 1980-2003.

System: **Buskin River**

Species: **coho salmon**

Data available for analysis of escapement goals

		Harvest:			
Year	Weir Count	Recreational[a]	Subsistence[b]	Commercial[c]	Total
1980		2,643			
1981		2,269			
1982		2,431			
1983		2,307			
1984		1,871			
1985	9,474	2,178	2,554	666	5,398
1986	9,939	4,098	2,618	1,065	7,781
1987	11,103	3,133	1,747	2,334	7,214
1988	6,782	3,474	1,556	254	5,284
1989	9,930	4,782	1,301	0	6,083
1990	6,222	1,521	1,821	1	3,343
1991	8,929	4,149	1,473	15	5,637
1992	6,535	1,474	1,563	0	3,037
1993	6,813	4,125	1,723	7	5,855
1994	8,146	2,429	2,193	15	4,637
1995	8,694	2,132	1,309	224	3,665
1996	8,439	2,481	1,372	0	3,853
1997	10,926	2,864	1,445		4,309
1998	9,062	2,669	1,555	9	4,233
1999	9,794	3,422	1,467	3	4,892
2000	8,048	2,631	2,011	0	4,642
2001	13,494	2,332	1,430	0	3,762
2002	10,646	2,497	1,514	0	4,011
2003	13,150	3,302	1,247	6	4,555
N	19	24	19	18	19
Avg	9,270	2,801	1,679	256	4,852
SD	2,042	854	400	592	1,259
Min	6,222	1,474	1,247	0	3,037
Max	13,494	4,782	2,618	2,334	7,781

[a] Recreational harvests from the Statewide Harvest Survey (Jennings et al. 2004).

[b] Subsistence harvests from Commercial Fisheries Division data base.

[c] Commercial harvests from Commercial Fisheries Division data base for statistical area 259-22.

Appendix P15.–Brood table and Ricker stock-recruit parameters for Buskin River coho salmon production.

System: **Buskin River**

Species: **coho salmon**

Data available for analysis of escapement goals

Brood Year	Escapement (S)	Age 3 Return	Age 4 Return	Age 5 Return	Total Return (R)	R/S
1988	5,487			940		
1989	8,974		9,073	281		
1990	5,918	1,829	9,547	344	11,720	1.98
1991	8,105	2,469	9,220	930	12,619	1.56
1992	6,240	2,368	8,019	1,529	11,916	1.91
1993	5,988	2,847	10,215	1,276	14,338	2.39
1994	7,660	2,919	9,155	3,099	15,173	1.98
1995	8,268	2,330	11,709	952	14,991	1.81
1996	7,943	2,985	9,149	22	12,156	1.53
1997	10,353	2,131	7,843	427	10,401	1.00
1998	8,528	8,924	11,481	1,456	21,861	2.56
1999	9,110	2,250	11,963	1,023[a]	15,236	1.67

[a] Assumed from average of age 5 returns from 1988-1998.

Results of regression of ln(R/S) on S:

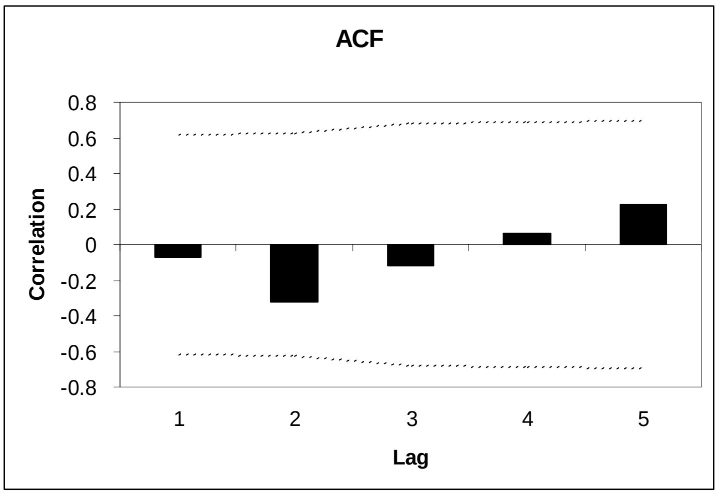
Parameter	Estimate	SE	p-value
ln(α')	1.54	0.39	0.005
β	1.19×10^{-4}	4.90×10^{-5}	0.042
σ	0.21		
Adjusted r^2	0.35		

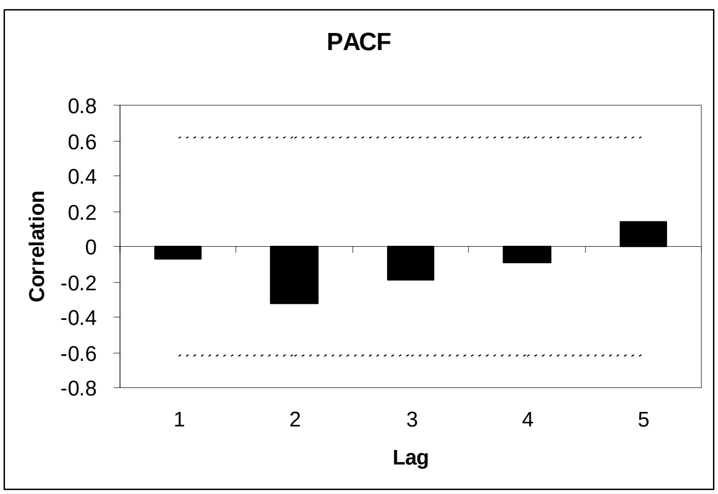
Appendix P16.–Autocorrelation (ACF) and partial-autocorrelation (PACF) plots for the first five lags of residuals of regression of ln(Return/Escapement) on escapement of Buskin River coho salmon.

System: Buskin River

Species: coho salmon

Bars are estimates of correlation at lag; dotted lines are ± 2 SE's.



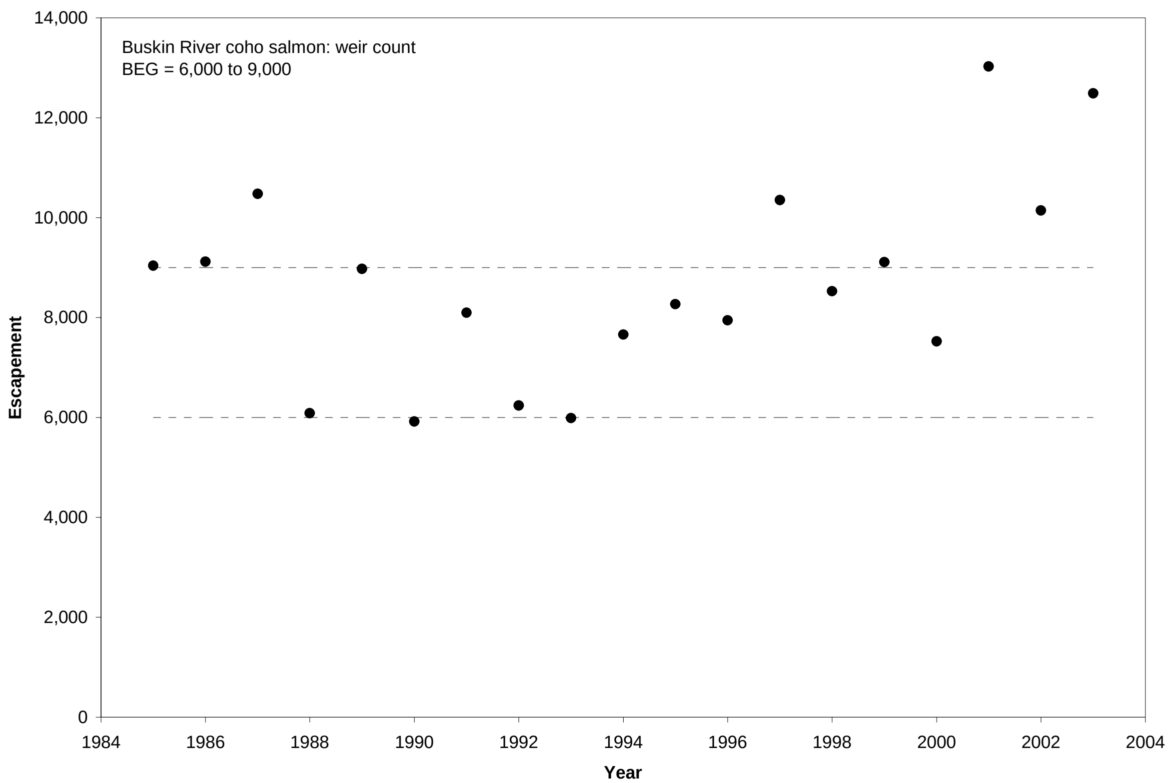


Appendix P17.–Buskin River coho salmon escapement and current escapement goals ranges.

System: **Buskin River**

Species: **coho salmon**

Observed escapement by year (solid circles weir counts minus 20% for recreational harvest) and current BEG (dashed lines).

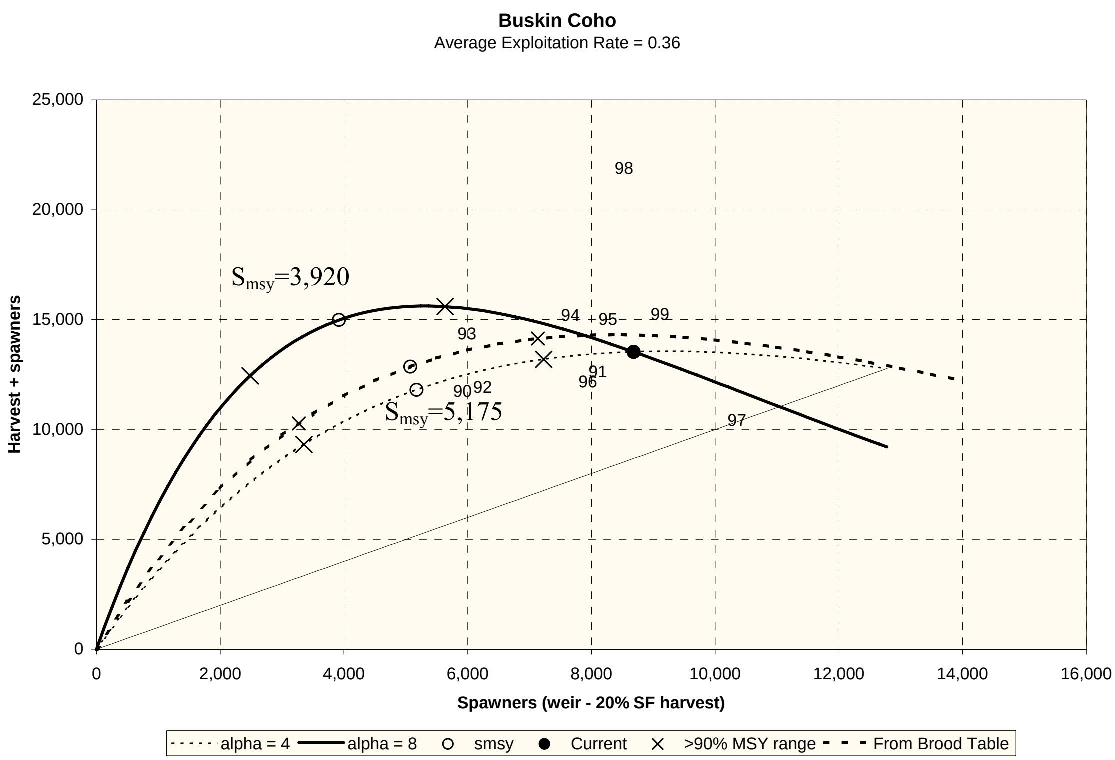


Appendix P18.–Theoretical Ricker stock-recruitment relationships and a Ricker stock-recruitment relationship from the 1990-1999 brood years for Buskin River coho salmon.

System: Buskin River

Species: coho salmon

Theoretical Ricker stock-recruitment relationships based on an average escapement of 8,684 and average harvest of 4,852 coho salmon (1980-2003; •). The dotted line represents the Ricker curve with an α-parameter of 4; the solid line represents the Ricker curve with an α-parameter of 8, and the solid straight line represents replacement. S_{msy} (○) and escapements that produce 90% of MSY (×) are also shown. The heavy dotted line represents the Ricker stock-recruitment relationship from the 1990-1999 brood table (data indicated by brood years).



Appendix P19.–Description of stock and escapement goal for Saltery Creek coho salmon.

System: Saltery Creek

Species: coho salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area, Eastside Kodiak District
Management division:	Sport Fish and Commercial Fisheries
Primary fishery:	Recreational, Commercial, and Subsistence
Previous escapement goal:	SEG: 3,000 to 5,000 (1999)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial survey: 1980, 1982-1984, 1992-1993, 1995, 1997-1998. Weir (run through 9/12 or later): 1985-1990, 1994, 2002
Data summary:	
Data quality:	Fair
Data type:	A combination of weir counts and aerial surveys are available to estimate escapement. Inriver harvests of the recreational fishery are estimated annually through the Statewide Harvest Survey (Jennings et al. 2004). Although there are no stock-specific harvest information available for subsistence and commercial fisheries, annual catch data are available from statistical area 259-41.
Data contrast:	Weir counts: 8.7 Aerial surveys: 23.6

-continued-

Methodology:	None
Autocorrelation:	N/A
Comments:	The escapement goal for this system is recommended to be eliminated because of a lack of consistent and/or validated escapement assessment for coho salmon. Based on years when the weir was operated for coho salmon, maximum exploitation rate likely varies from 15% to 52% and averages 30%.
Recommendations:	Eliminate goal

Appendix P20.–Saltery Creek coho salmon aerial surveys, weir counts, and harvests.

System: Saltery Creek

Species: coho salmon

Data available for analysis of escapement goals

	Weir	Aerial	Harvest:			
Year	Count[a]	Survey	Recreational[b]	Subsistence[c]	Commercial[d]	Total
1980		212		0	1,832	
1981				1	1,048	
1982		3,500		42	2,787	
1983		700	556	4	2,316	2,876
1984		2,100	1,035	44	1,485	2,564
1985	4,022		608	82	1,691	2,381
1986	9,200		336	91	1,184	1,611
1987	11,376		417	67	9,425	9,909
1988	4,702		1,073	17	778	1,868
1989	5,332		1,247	0	0	1,247
1990	2,847		617	7	46	670
1991			750	3	94	847
1992		1,000	745	0	222	967
1993		1,500	466	33	714	1,213
1994	2,173		544	110	106	760
1995		5,000	685	73	927	1,685
1996			333	0	0	333
1997		1,500	928	33	41	1,002
1998		1,200	960	184	48	1,192
1999			1,098	44	226	1,368
2000			686	68	374	1,128
2001			1,088	91	44	1,223
2002	1,306		1,266	70	81	1,417
2003			1,112	34	143	1,289
N	8	9	21	24	24	21
Avg	5,150	1,857	788	46	1,067	1,788
SD	3,497	1,504	298	45	1,954	9,909
Min	1,306	212	333	0	0	333
Max	11,376	5,000	1,266	184	9,425	1,963

[a] Only includes years where weir counting operations were run through September 12 or later.

[b] Recreational harvests from the Statewide Harvest Survey (Jennings et al. 2004).

[c] Subsistence harvests from Commercial Fisheries Division data base.

[d] Commercial harvests from Commercial Fisheries Division data base for statistical area 259-41.

Appendix P21.–Description of stock and escapement goal for Roslyn Creek coho salmon.

System: Roslyn Creek

Species: coho salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area, Northeast Kodiak District
Management division:	Sport Fish and Commercial Fisheries
Primary fishery:	Recreational, Commercial, and Subsistence
Previous escapement goal:	SEG: 600 to 1,200 (1999)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Foot survey: 1980-2003, except 1982 and 1988.
Data summary:	
Data quality:	Fair
Data type:	Foot surveys are conducted annually, but inriver harvests of the recreational fishery are not estimated. Although there is no stock-specific harvest information available for subsistence and commercial fisheries, annual catch data are available from statistical area 259-25.
Data contrast:	Foot survey all years: 173.8
Methodology:	None
Comments:	There is little yield information from the recreational fishery and no validated foot surveys for coho salmon.
Recommendations:	Eliminate goal.

Appendix P22.–Roslyn Creek coho salmon foot surveys and harvests.

System: Roslyn Creek

Species: coho salmon

Data available for analysis of escapement goals

Year	Foot Survey	Harvest: Recreational[a]	Subsistence[b]	Commercial[c]	Total
1980	628		137	75	212
1981	314		88	644	732
1982			245	700	945
1983	49		20	2,068	2,088
1984	168		100	192	292
1985	189		221	3	224
1986	405		188	0	188
1987	280		311	235	546
1988			299	345	644
1989	235		262	0	262
1990	676		249	0	249
1991	882		160	5,630	5,790
1992	70		236	6,604	6,840
1993	148		148	969	1,117
1994	130		0	2,317	2,317
1995	322		120	748	868
1996	6		76	94	170
1997	1,043		85	4,202	4,287
1998	57		14	3	17
1999	537		52	2,547	2,599
2000	205		36	626	662
2001	832		129	1,374	1,503
2002	660		115	4,367	4,482
2003	497		133	120	253
N	22		24	24	48
Avg	379		143	1,411	1,554
SD	299		91	1,926	2,017
Min	6		0	0	0
Max	1,043		311	6,604	6,915

[a] Recreational harvests not estimated.

[b] Subsistence harvests from Commercial Fisheries Division data base.

[c] Commercial harvests from Commercial Fisheries Division data base for statistical area 259-25.

APPENDIX Q. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR COHO SALMON ON THE KODIAK ARCHIPELAGO OFF THE ROAD SYSTEM

Appendix Q1.–Description of stocks and escapement goals for Big Bay Creek coho salmon.

System: Big Bay Creek

Species: coho salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine
Previous escapement goal:	SEG: 600 to 1,300 by September 20 (1988)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial surveys, 1984-1985, 1989-1998, 2000-2002, and 2004
Data summary:	
Data quality:	Fair
Data type:	Fixed-wing aerial surveys with peak surveys from 1984-1985, 1989-1998, 2000-2002, and 2004. No stock-specific harvest information is available.
Data contrast:	Aerial surveys:39.6
Methodology:	Risk analysis and percentile approach
Comments:	None
Recommendations:	Eliminate the current escapement goal.

Appendix Q2.–Big Bay Creek coho salmon escapement, 1984-2004.

System: **Big Bay Creek**

Species: **coho salmon**

Data available for analysis of escapement goals

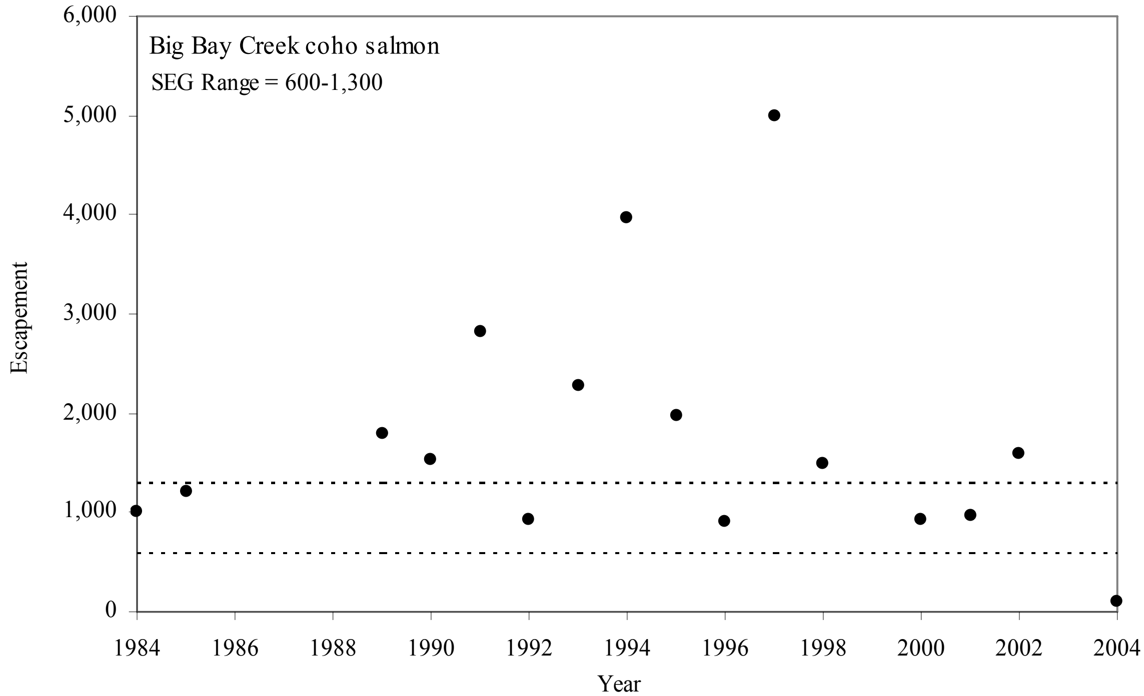
Year	Peak Aerial Survey
1984	1,000
1985	1,200
1989	1,799
1990	1,535
1991	2,823
1992	931
1993	2,281
1994	3,960
1995	1,971
1996	896
1997	5,000
1998	1,494
2000	928
2001	966
2002	1,582
2004	100

Appendix Q3.–Big Bay Creek coho salmon escapement, 1984-2004 and current escapement goal ranges.

System: Big Bay Creek

Species: coho salmon

Observed escapement by year (solid circles for aerial surveys) and current SEG range (dashed lines).

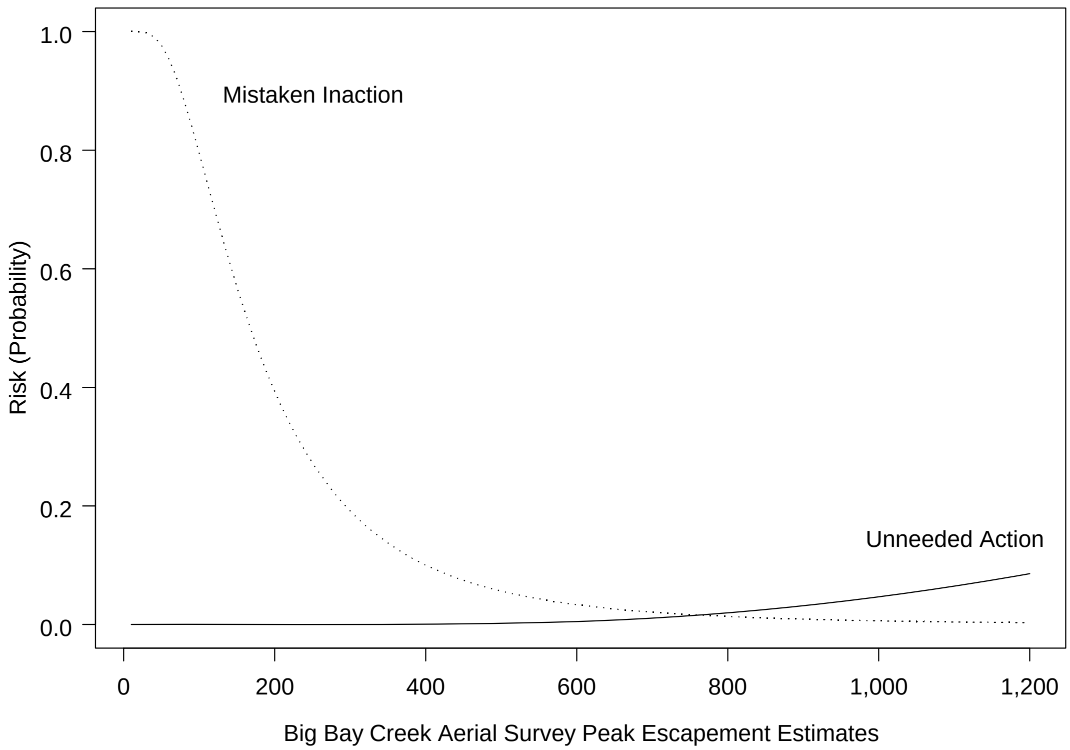


Appendix Q4.–Risk analysis for Big Bay Creek coho salmon.

System: Big Bay Creek

Species: coho salmon

Big Bay Creek coho salmon risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).



Appendix Q5.–Description of stocks and escapement goals for Bear Creek coho salmon.

System: Bear Creek

Species: coho salmon

Description of stock and escapement goals

Regulatory area:	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and sport hook and line
Previous escapement goal:	SEG: 350 to 700 by September 20 (1988)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial surveys, 1985, 1989-1990, 1992, 1994-2000, and 2002
Data summary:	
Data quality:	Fair
Data type:	Fixed-wing aerial surveys with peak surveys from 1985, 1989-1990, 1992-1993, 1995-2000, and 2002. No stock-specific harvest information is available.
Data contrast:	Peak aerial surveys: 17.2
Methodology:	Percentile approach
Comments:	None
Recommendation:	Eliminate the current escapement goal.

Appendix Q6.–Bear Creek coho salmon escapement, 1985-2002.

System: Bear Creek

Species: coho salmon

Data available for analysis of escapement goals

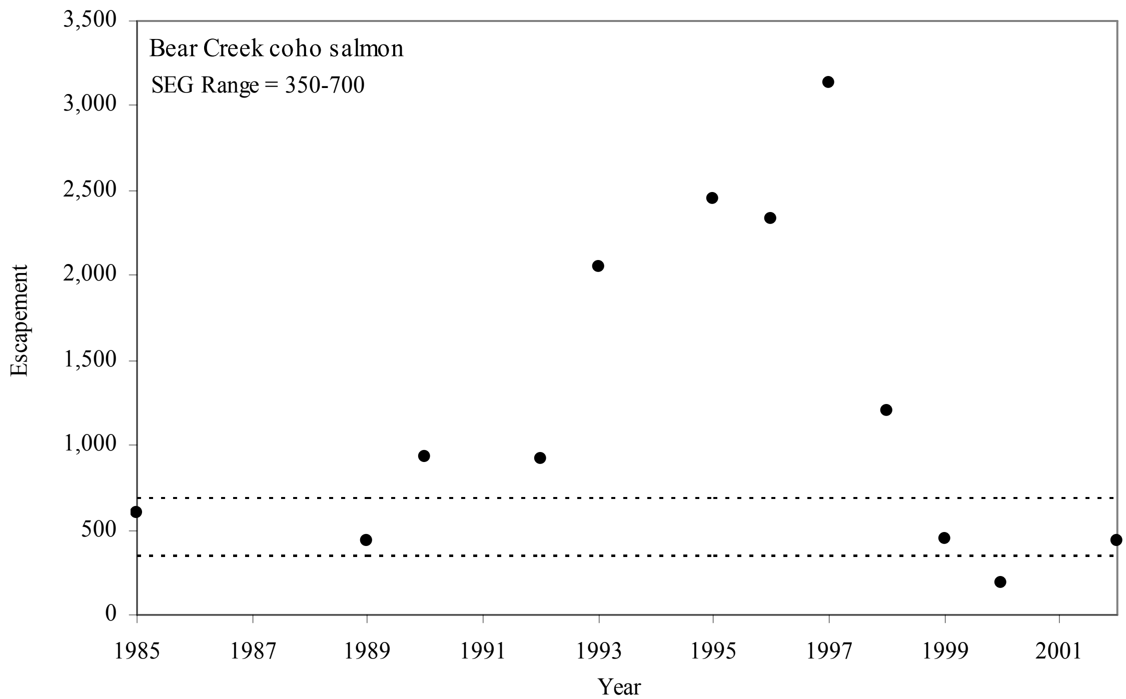
Year	Peak Aerial Survey
1985	600
1989	441
1990	926
1992	925
1993	2,048
1995	2,456
1996	2,332
1997	3,138
1998	1,202
1999	450
2000	183
2002	440

Appendix Q7.–Bear Creek coho salmon escapement, 1985-2002 and current escapement goal ranges.

System: Bear Creek

Species: coho salmon

Observed escapement by year (solid circles for aerial surveys) and current SEG range (dashed lines).



Appendix Q8.–Description of stocks and escapement goals for Portage Creek coho salmon.

System: Portage Creek

Species: coho salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and sport hook and line
Previous escapement goal:	SEG: 2,000 to 3,500 by September 15 (1988)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial surveys, foot surveys, and weir counts 1968-2003
Data summary:	
Data quality:	Fair for aerial surveys, and good for foot surveys and weir counts
Data type:	Aerial surveys in 1968-1970, 1972-1973, 1975, 1978-1986, 1989, 1993-1994, 1997-2001d 2003. Foot surveys in 1971,1974, 1976, 1991-1992, 1995-1996, Weir counts in 1987-1988, and 1990
Data contrast:	All available data 1968-2003: 153
Methodology:	Percentile approach
Criteria for SEG:	Low exploitation
Comments:	Reliable escapement data are not expected to be available in the future.
Recommendation:	Eliminate the current escapement goal.

Appendix Q9.–Portage Creek coho salmon escapement, 1968-2003.

System: Portage Creek

Species: coho salmon

Data available for analysis of escapement goals

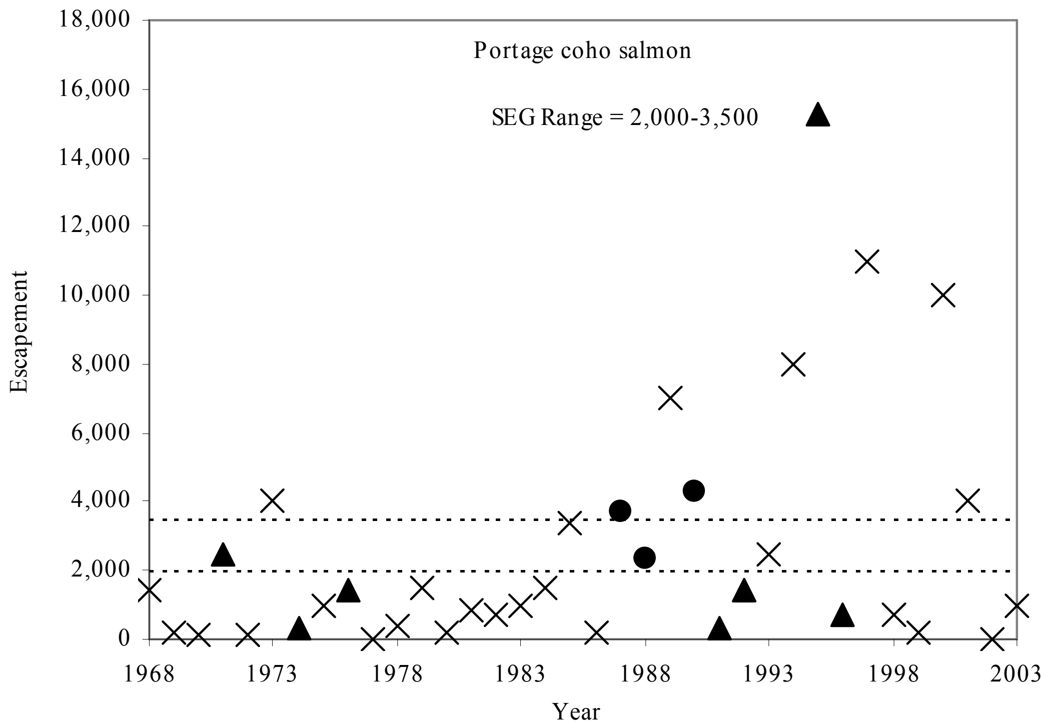
Year	Peak Aerial Survey	Foot Survey	Weir Counts
1968	1,456		
1969	200		
1970	150		
1971		2,500	
1972	100		
1973	4,000		
1974		300	
1975	1,000		
1976		1,400	
1977			
1978	400		
1979	1,480		
1980	192		
1981	849		
1982	739		
1983	1,000		
1984	1,500		
1985	3,400		
1986	200		
1987			3,710
1988			2,354
1989	7,000		
1990			4,277
1991		350	
1992		1,400	
1993	2,500		
1994	8,000		
1995		15,300	
1996		697	
1997	11,000		
1998	700		
1999	200		
2000	10,000		
2001	4,000		
2002			
2003	1,000		

Appendix Q10.–Portage Creek coho salmon escapement, 1968-2003 and current escapement goal ranges.

System: **Portage Creek**

Species: **coho salmon**

Observed escapement by year (solid circles for weir counts, X for aerial surveys and solid triangles for foot surveys) and current SEG range (dashed lines).



Appendix Q11.–Description of stocks and escapement goals for Pauls Bay drainage coho salmon.

System: **Pauls Bay drainage**

Species: **coho salmon**

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and sport hook and line
Previous escapement goal:	SEG: 6,500 to 9,000 by September 15 (1988)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	
Data quality:	Fair for aerial surveys, excellent for weir counts
Data type:	Aerial surveys in 1991, 1992, 2002 and 2003, weir counts from 1984 through 1990 and 1993 through 2001.
Data contrast:	All available data 1984-2003: 10.0
	Weir data 1984-2003: 6.8
	All data 1984-1995 (without effects of fertilization): 5.0
	All data 1996-2003 (with effects of fertilization): 6.3
Methodology:	Percentile approach, spawning habitat
Criteria for SEG:	Low exploitation
Comments:	Reliable escapement data are not expected to be available in the future.
Recommendation:	Eliminate the current escapement goal.

Appendix Q12.–Peak aerial surveys and weir counts of Pauls Bay drainage coho salmon, 1984-2003.

System: Pauls Bay drainage

Species: coho salmon

Data available for analysis of escapement goals

Year	Peak Aerial Survey	Weir Counts[a]
1984		4,274
1985		9,535
1986		9,403
1987		4,767
1988		5,563
1989		7,919
1990		3,668
1991	2,500	
1992	11,700	
1993		10,664
1994		12,538
1995		10,663
1996		15,491
1997		8,280
1998		15,514
1999		11,206
2000		12,676
2001		25,032
2002	15,000	
2003	4,000	

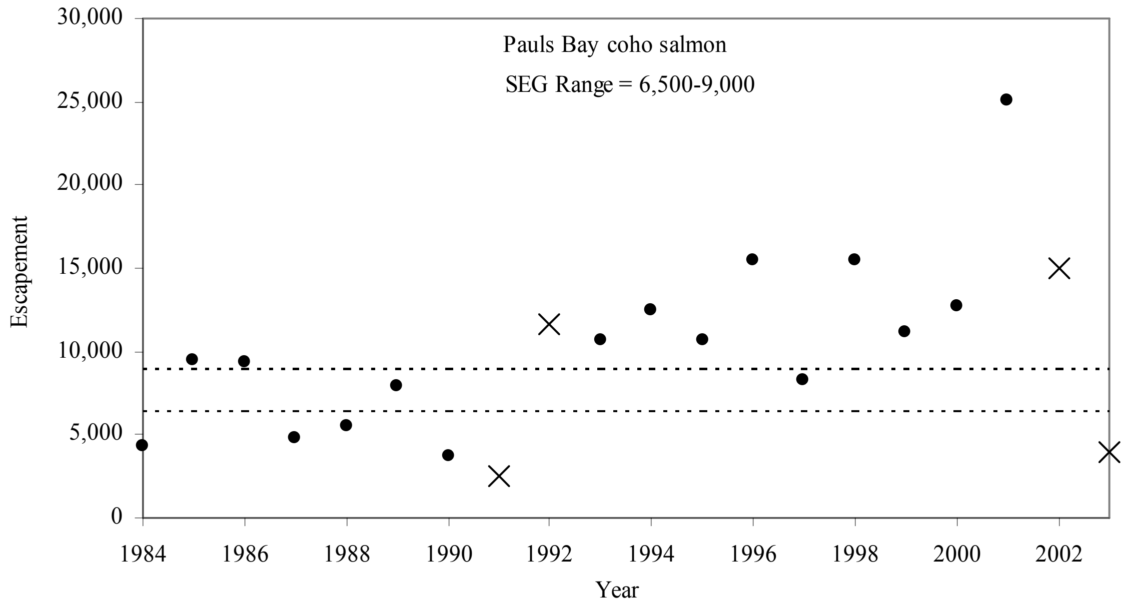
[a] Escapement estimates were adjusted in some years for an estimated build-up of coho below the weir or in the bay.

Appendix Q13.–Pauls Bay drainage coho salmon escapement, 1984-2003, and current escapement goal ranges.

System: Pauls Bay drainage

Species: coho salmon

Observed escapement by year (solid circles for weir counts, Xs for aerial surveys) and current SEG range (dashed lines).



Appendix Q14.–Description of stocks and escapement goals for Afognak River coho salmon.

System: **Afognak River**

Species: **coho salmon**

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine
Previous escapement goal:	SEG: 3,500 to 8,000 by September 15 (1988)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir counts, 1984-2003
Data summary:	
Data quality:	Good
Data type:	Weir counts with estimated total escapement from 1984-2003. Estimated total escapement is computed from weir counts plus estimated build-up below the weir, in the lagoon, in the bay or near-shore when the weir is removed. Unadjusted weir counts through August 23, 1984-2003 were available, and unadjusted weir counts through August 25, 1984-2002 were available. No stock-specific harvest information is available.
Contrast:	Weir counts August 23: 30.2, and August 25: 50.5
Methodology:	Risk analysis and percentile approach
Comments:	None
Recommendations:	Eliminate the current escapement goal.

Appendix Q15.–Afognak River coho salmon total estimated escapement and escapement through August 23 and 25, 1984-2004.

System: **Afognak River**

Species: **coho salmon**

Data available for analysis of escapement goals

Year	Estimated Escapement[a]	Weir Counts through August 23	August 25
1984	2,463	1,229	2,463
1985	11,347	858	968
1986	5,082	918	922
1987	11,469	170	484
1988	9,772	2,660	6,499
1989	13,050	2,538	4,287
1990	13,380	4,564	5,316
1991	14,409	2,743	3,424
1992	16,415	7,624	7,873
1993	6,637	1,214	2,313
1994	11,965	192	192
1995	10,542	1,221	1,346
1996	9,456	1,339	2,327
1997	10,908	342	354
1998	16,374	2,007	2,239
1999	12,092	2,453	2,526
2000	2,036	151	741
2001	12,981	1,794	2,565
2002	8,654	5,235	8,654
2003	3,256	3,256	
2004	492		

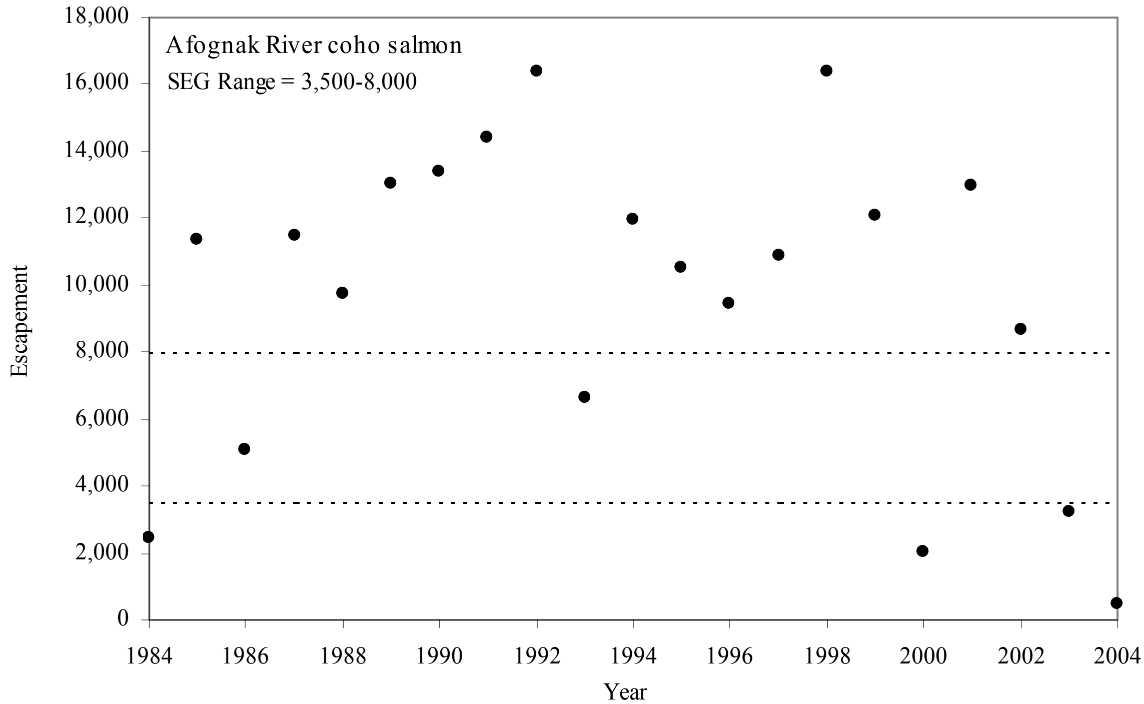
[a] Escapement estimates were adjusted in some years for an estimated build-up of coho below the weir, in the lagoon, bay, or near-shore.

Appendix Q16.–Afognak River coho salmon escapement, 1984-2004 and current escapement goal ranges.

System: Afognak River

Species: coho salmon

Observed escapement by year (solid circles for estimated escapement) and current SEG range (dashed lines).

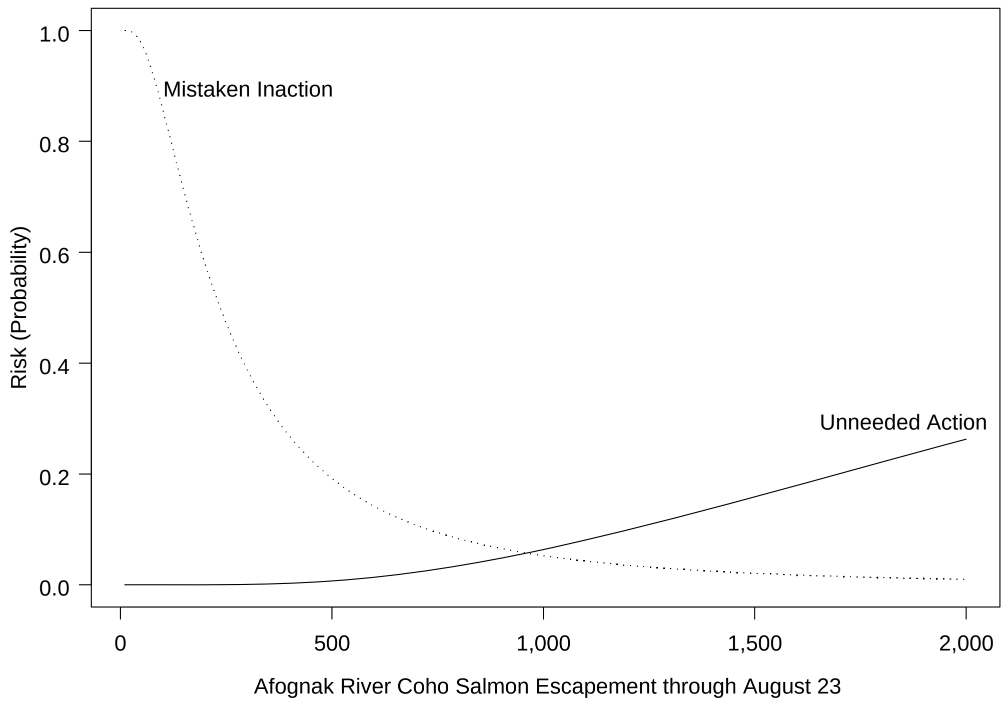


Appendix Q17.–Risk analysis for Afognak River coho salmon through August 23.

System: Afognak River

Species: coho salmon

Afognak River coho salmon (through August 23) risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).

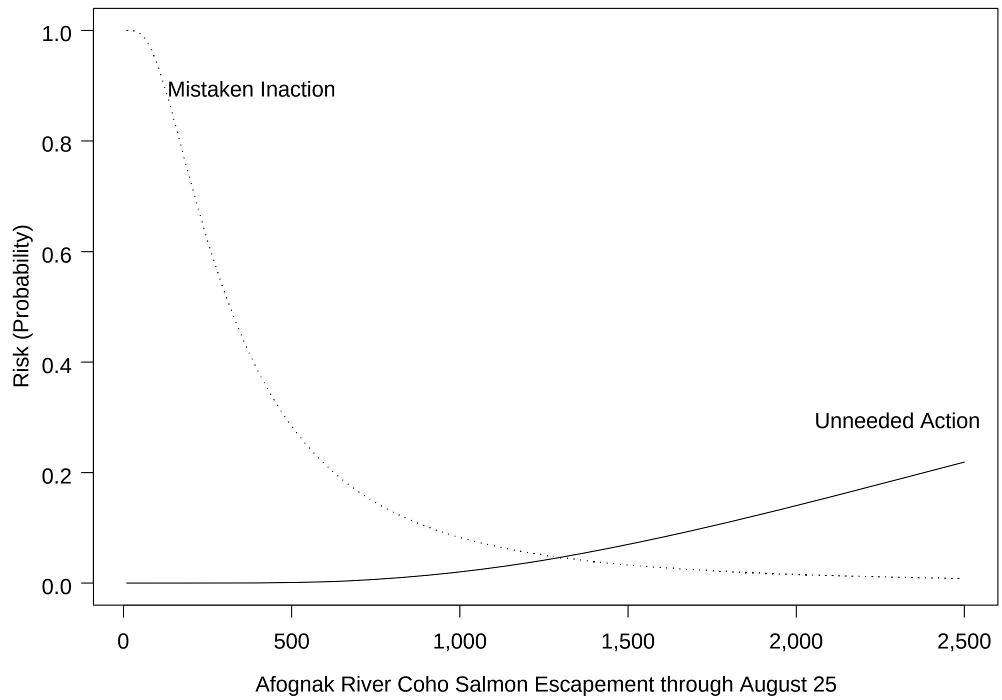


Appendix Q18.–Risk analysis for Afognak River coho salmon through August 25.

System: Afognak River

Species: coho salmon

Afognak River coho salmon (through August 25) risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).



Appendix Q19.–Description of stocks and escapement goals for Karluk River coho salmon.

System: Karluk River

Species: coho salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet, Sport fishery
Previous escapement goal:	SEG: 10,000 to 20,000 by September 20 (1988)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir counts, 1974-2004
Data summary:	
Data quality:	Good
Data type:	Weir counts with estimated total escapement from 1974-2004. Estimated total escapement is computed from weir counts plus estimated build-up below the weir, in the lagoon, in the bay or near-shore when the weir is removed. Unadjusted weir counts through September 16, 1974-2004 were available for all years, except 1980 and 1990. No stock-specific harvest information is available.
Contrast:	Weir counts through September 16: 162.3
Methodology:	Risk analysis and percentile approach
Comments:	None
Recommendations:	Eliminate the current escapement goal.

Appendix Q20.–Karluk River coho salmon total estimated escapement and escapement through September 16, 1974-2004.

System: **Karluk River**

Species: **coho salmon**

Data available for analysis of escapement goals

Year	Estimated Escapement[a]	Estimated Escapement through September 16
1974	2,587	563
1975	1,478	171
1976	13,515	7,198
1977	18,537	6,785
1978	12,085	4,528
1979	42,262	4,204
1980	5,739	
1981	24,792	20,541
1982	14,901	9,568
1983	34,778	8,221
1984	12,365	3,974
1985	37,221	20,462
1986	22,836	3,916
1987	37,634	7,462
1988	2,083	2,083
1989	16,852	16,852
1990	1,010	
1991	18,426	5,365
1992	5,411	2,622
1993	19,362	10,121
1994	23,263	12,092
1995	26,914	12,992
1996	24,802	13,744
1997	28,198	15,408
1998	20,115	2,796
1999	22,375	1,552
2000	13,876	3,841
2001	17,660	2,127
2002	14,251	2,011
2003	6,995	3,202
2004	11,186	1,647

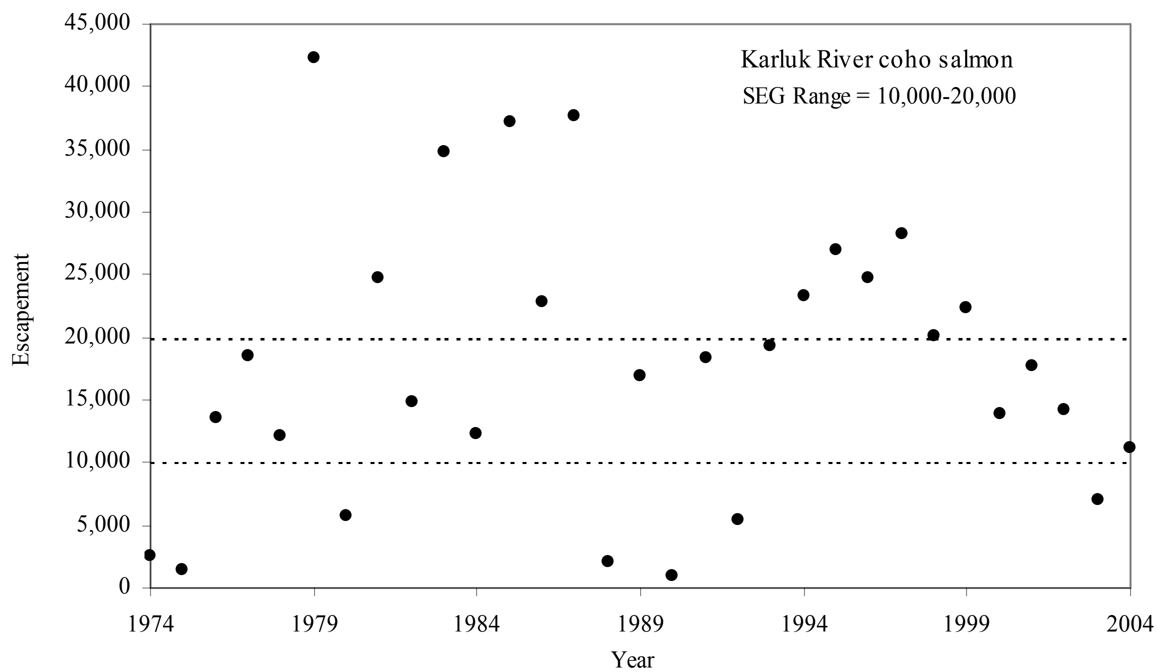
[a] Escapement estimates were adjusted in some years for an estimated build-up of coho below the weir, in the lagoon, or near-shore.

Appendix Q21.–Karluk River coho salmon escapement, 1974-2004 and current escapement goal ranges.

System: Karluk River

Species: coho salmon

Observed escapement by year (solid circles for estimated escapement) and current SEG range (dashed lines).

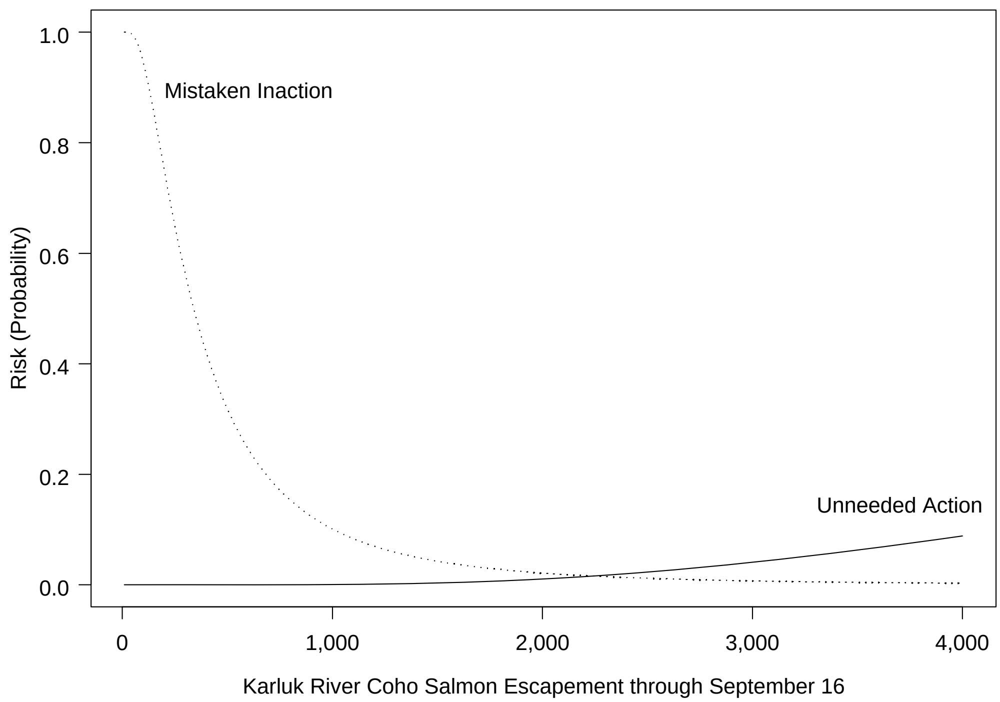


Appendix Q22.–Risk analysis for Karluk River coho salmon through September 16.

System: Karluk River

Species: coho salmon

Karluk River coho salmon risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).



Appendix Q23.–Description of stocks and escapement goals for Ayakulik River coho salmon.

System: Ayakulik River

Species: coho salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine
Previous escapement goal:	SEG: 12,000 to 18,000 by September 10 (1988)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir counts, 1978-2004
Data summary:	
Data quality:	Good
Data type:	Weir counts with estimated total escapement from 1978-2004. Estimated total escapement is computed from weir counts plus estimated build-up below the weir, or near-shore when the weir is removed. Unadjusted weir counts through August 19, 1978, 1983-1990, 1992-2002, and 2004 were available. Unadjusted weir counts through August 21, 1978, 1983-1990, 1992-1997, 1999-2002, and 2004 were available. No stock-specific harvest information is available.
Contrast:	Weir counts through August 19 and 21: 203.4 and 207.9, respectively
Methodology:	Percentile approach
Comments:	None
Recommendations:	Eliminate the current escapement goal.

Appendix Q24.–Ayakulik River coho salmon total estimated escapement and weir counts through August 19 and 21, 1978-2004.

System: Ayakulik River

Species: coho salmon

Data available for analysis of escapement goals

Year	Estimated Escapement	Estimated Escapement through August 19	August 21
1978	2,905	925	1,705
1979	1,747		
1980	511		
1981	2,392		
1982	5,011		
1983	16,665	7,728	10,602
1984	11,951	5,823	7,475
1985	29,085	2,019	3,819
1986	12,215	3,884	4,483
1987	16,242	2,021	2,610
1988	19,476	2,610	3,605
1989	8,242	1,270	2,048
1990	22,539	1,062	1,603
1991	414		
1992	4,640	1,228	1,740
1993	2,154	38	51
1994	33,658	2,257	3,524
1995	8,887	1,730	2,113
1996	8,153	2,982	4,773
1997	8,451	1,088	2,024
1998	2,043	2,043	
1999	203	146	203
2000	5,798	1,039	2,009
2001	5,064	1,777	1,831
2002	26,331	1,410	2,626
2003	41		
2004	4,783	651	936

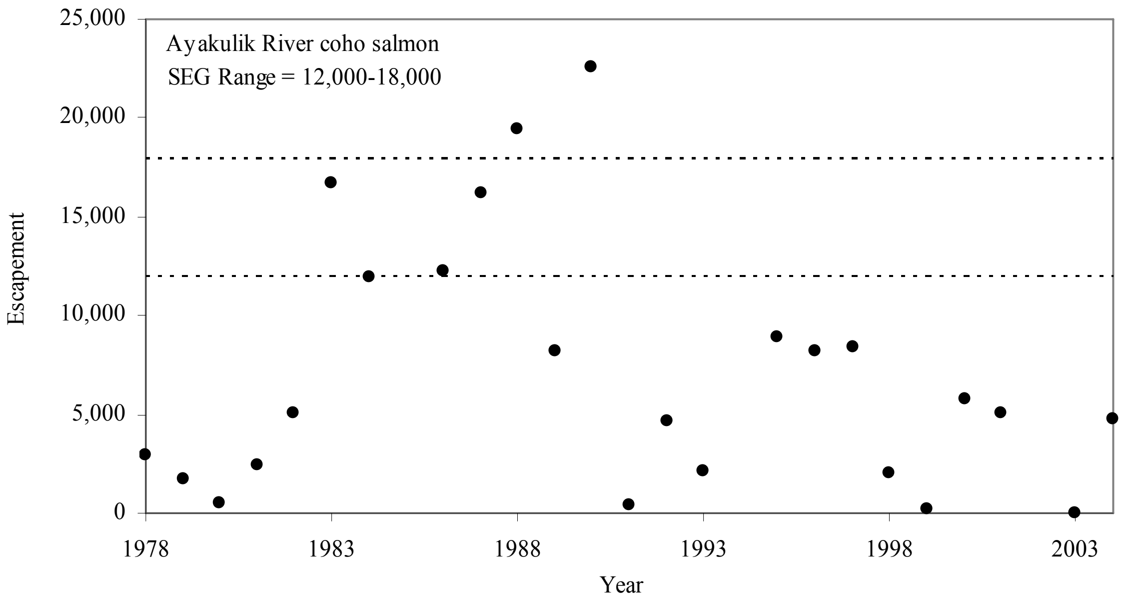
[a] Escapement estimates were adjusted in some years for an estimated build-up of coho below the weir or near-shore

Appendix Q25.–Ayakulik River coho salmon escapement, 1978-2004 and current escapement goal ranges.

System: **Ayakulik River**

Species: **coho salmon**

Observed escapement by year (solid circles for estimated escapement) and current SEG range (dashed lines).



Appendix Q26.–Description of stocks and escapement goals for Akalura Creek coho salmon.

System: Akalura Creek

Species: coho salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	SEG: 1,500 to 3,500 by September 15 (1988)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir counts, 1974-1978, 1986-2003
Data summary:	
Data quality:	Good
Data type:	Weir counts with estimated total escapement from 1974-1978 and 1986-2003. Estimated total escapement is computed from weir counts plus estimated build-up below the weir, in the lagoon, in the bay or near-shore when the weir is removed. Unadjusted weir counts through September 7, 1974-1977 and 1986-2003 were available for all years. Unadjusted weir counts through September 7, 1986-2003 were also used separately. No stock-specific harvest information is available.
Contrast:	Weir counts September 7 1974-1977 and 1986-2003, and just 1986-2003: 22.9
Methodology:	Risk analysis and percentile approach
Comments:	None
Recommendations:	Eliminate the current escapement goal.

Appendix Q27.–Akalura Creek coho salmon estimated escapement and weir counts through September 7, 1974-2003.

System: **Akalura Creek**

Species: **coho salmon**

Data available for analysis of escapement goals

Year	Estimated Escapement	Estimated Escapement through September 7
1974	5,107	2,320
1975	5,988	398
1976	1,877	777
1977	47	223
1978	2,100	
1986	1,480	574
1987	6,115	765
1988	4,001	5,082
1989	4,232	2,001
1990	7,672	779
1991	2,198	1,615
1992	4,405	2,182
1993	1,785	4,105
1994	750	1,785
1995	5,150	284
1996	2,409	1,078
1997	2,803	222
2000	2,709	336
2001	4,528	1,169
2002	6,025	785
2003	6,025	498

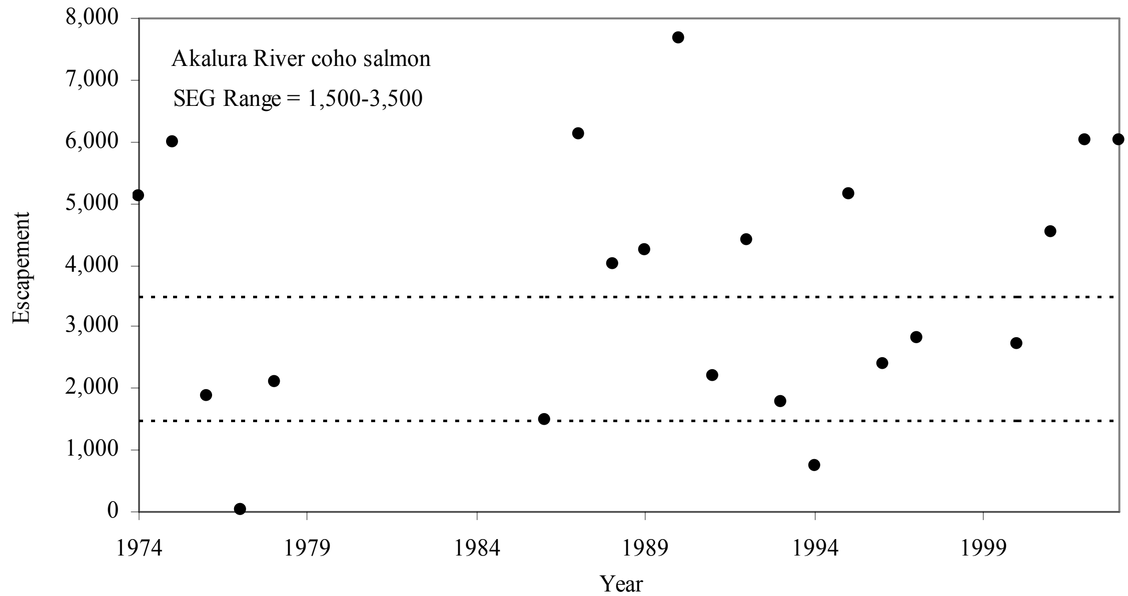
[a] Escapement estimates were adjusted in some years for an estimated build-up of coho below the weir, in the lagoon, or in the bay.

Appendix Q28.–Akalura Creek coho salmon escapement, 1974-2003 and current escapement goal ranges.

System: Akalura Creek

Species: coho salmon

Observed escapement by year (solid circles for estimated escapement) and current SEG range (dashed lines).

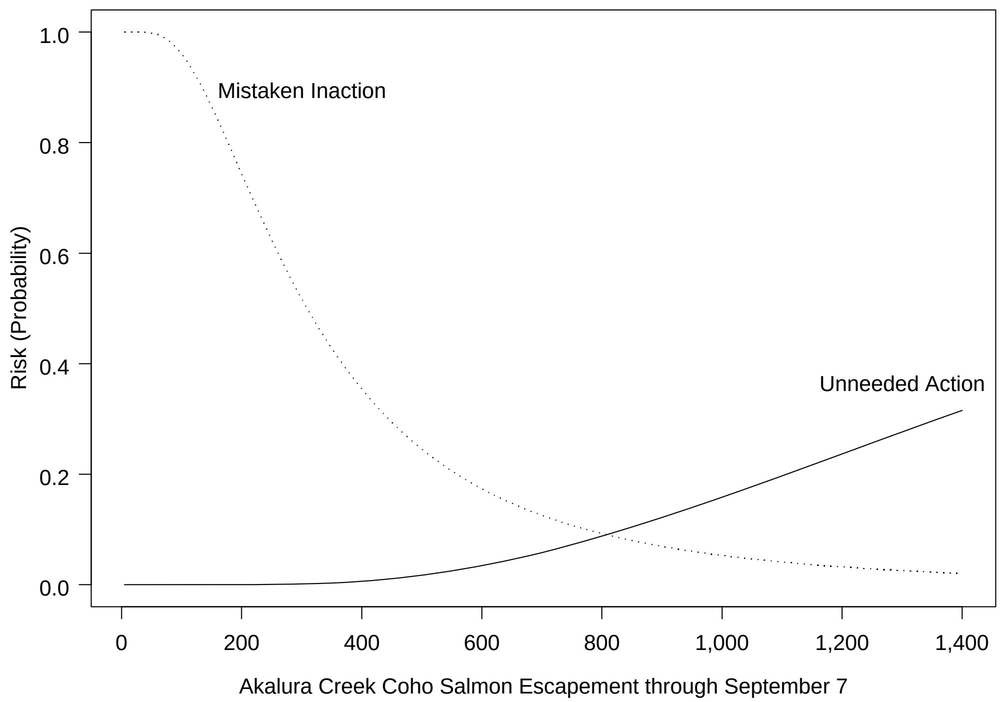


Appendix Q29.–Risk analysis for Akalura Creek coho salmon through September 7, 1974-1977 and 1986-2003.

System: Akalura Creek

Species: coho salmon

Akalura Creek coho salmon risk analysis, 1974-1977 and 1986-2003 (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).

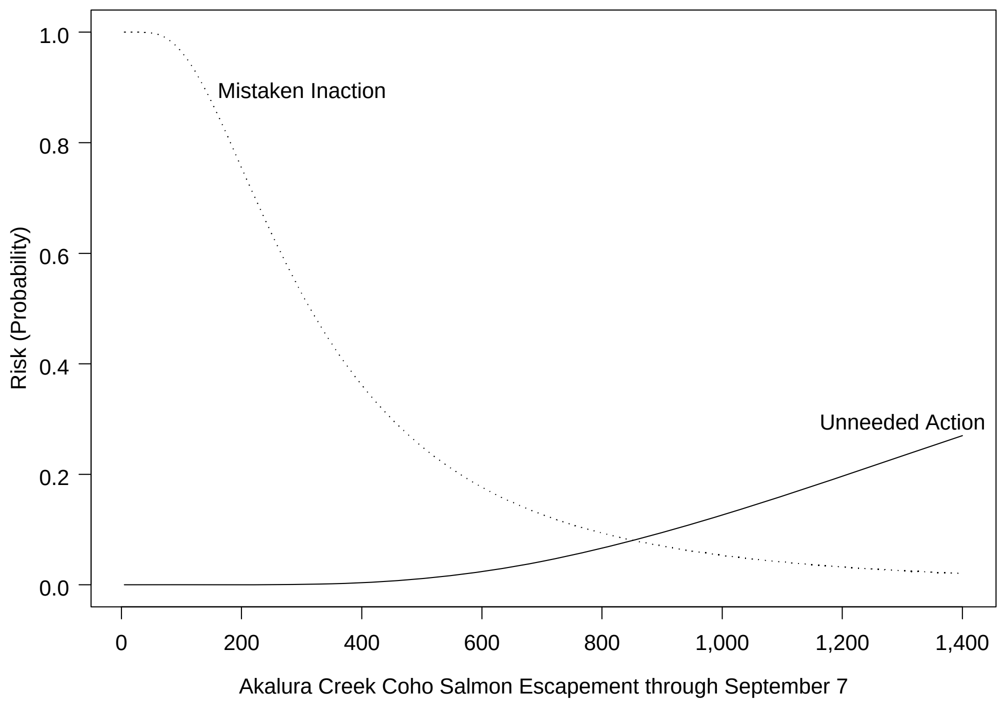


Appendix Q30.–Risk analysis for Akalura Creek coho salmon through September 7, 1986-2003.

System: Akalura Creek

Species: coho salmon

Akalura Creek coho salmon risk analysis, 1986-2003 (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).



Appendix Q31.–Description of stocks and escapement goals for Upper Station coho salmon.

System: Upper Station

Species: coho salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	SEG: 3,500 to 5,500 by September 15 (1988)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir counts, 1974-2004
Data summary:	
Data quality:	Good
Data type:	Weir counts with estimated total escapement from 1974-2004. Estimated total escapement is computed from weir counts plus estimated build-up below the weir, in the lagoon, in the bay or near-shore when the weir is removed. Unadjusted weir counts through September 5, 1974-2004 were available for all years. No stock-specific harvest information is available.
Contrast:	Weir counts September 5: 5.8
Methodology:	Risk analysis and percentile approach
Comments:	None
Recommendation:	Eliminate the current escapement goal.

Appendix Q32.–Upper Station coho salmon estimated escapement and weir counts through September 5, 1974-2004.

System: Upper Station

Species: coho salmon

Data available for analysis of escapement goals

Year	Estimated Escapement	Estimated Escapement through September 5
1974	5,105	1,820
1975	8,172	2,988
1976	5,792	4,092
1977	4,885	4,356
1978	2,717	1,854
1979	10,555	6,370
1980	2,200	2,200
1981	8,233	6,124
1982	4,839	4,107
1983	4,521	3,040
1984	3,240	3,000
1985	4,314	2,654
1986	2,469	1,496
1987	2,560	1,316
1988	3,813	2,842
1989	5,319	2,008
1990	7,467	2,883
1991	4,250	1,937
1992	7,179	3,812
1993	6,580	5,555
1994	4,836	3,266
1995	5,243	3,565
1996	3,929	3,629
1997	7,359	4,566
1998	7,024	6,453
1999	4,098	3,234
2000	3,455	2,957
2001	3,530	2,197
2002	13,065	7,661
2003	3,318	3,318
2004	7,477	5,623

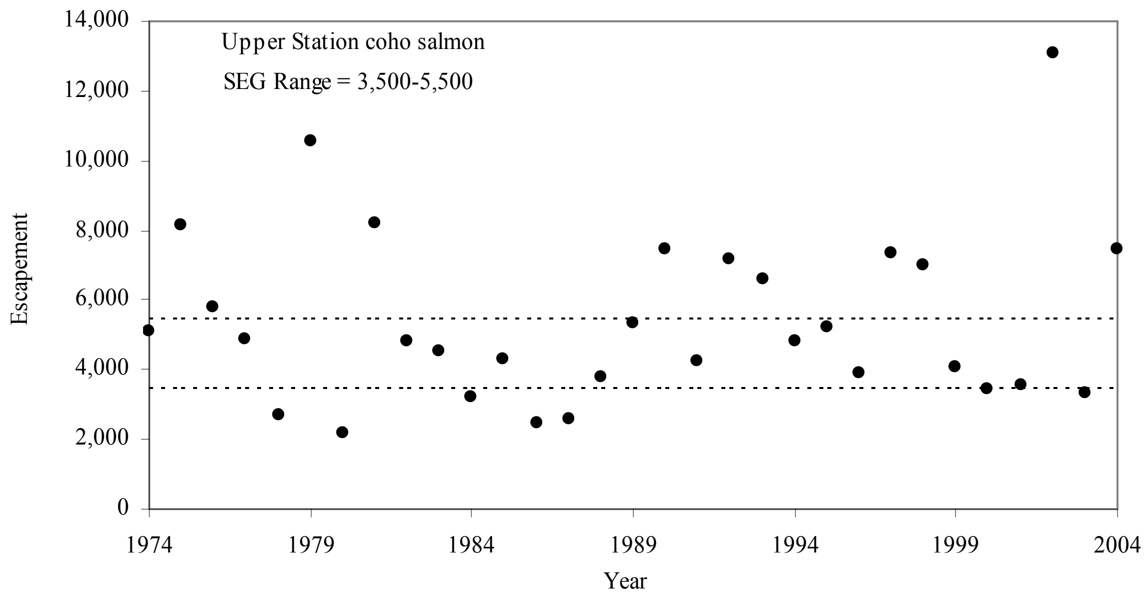
[a] Escapement estimates were adjusted in some years for an estimated build-up of coho below the weir, in the lagoon, or in the bay.

Appendix Q33.–Upper Station coho salmon escapement, 1974-2004 and current escapement goal ranges.

System: **Upper Station**

Species: **coho salmon**

Observed escapement by year (solid circles for estimated escapement) and current SEG range (dashed lines).

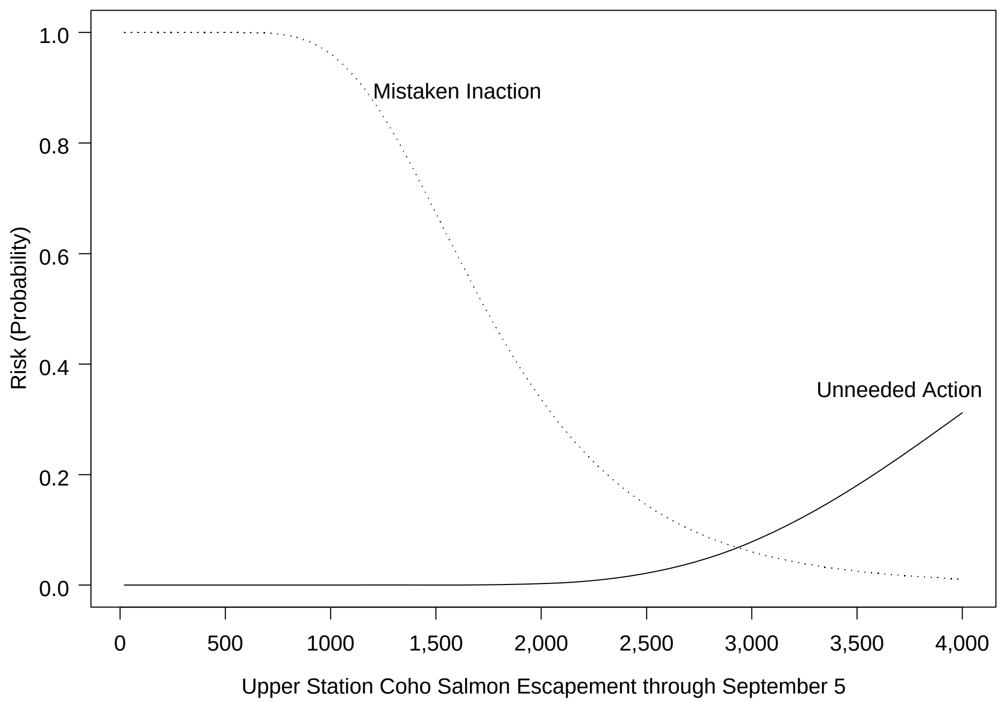


Appendix Q34.–Risk analysis for Upper Station coho salmon through September 5.

System: Upper Station

Species: coho salmon

Upper Station coho salmon risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).



Appendix Q35.–Description of stocks and escapement goals for Dog Salmon Creek coho salmon.

System: **Dog Salmon Creek**

Species: **coho salmon**

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	SEG: 3,500 to 5,500 by September 15 (1988)
Recommended escapement goal:	Eliminate goal
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Weir counts, 1983-2004
Data summary:	
Data quality:	Good
Data type:	Weir counts with estimated total escapement from 1983-2004. Estimated total escapement was computed from weir counts plus estimated build-up below the weir, in the lagoon, in the bay or near-shore when the weir is removed. Unadjusted weir counts through August 24, 1983-2002 were available for all years. No stock-specific harvest information is available.
Contrast:	Weir counts through August 24: 54.9
Methodology:	Risk analysis and percentile approach
Comments:	None
Recommendation:	Eliminate the current escapement goal.

Appendix Q36.–Dog Salmon Creek coho salmon estimated escapement and weir counts through August 24, 1983-2004.

System: Dog Salmon Creek

Species: coho salmon

Data available for analysis of escapement goals

Year	Estimated Escapement	Estimated Escapement through 24-Aug
1983	5,033	433
1984	1,340	1,340
1985	4,000	366
1986	5,394	3,456
1987	6,223	63
1988	3,543	177
1989	5,668	831
1990	6,484	482
1991	5,158	573
1992	7,940	2,137
1993	4,985	263
1994	4,944	502
1995	4,172	369
1996	4,382	786
1997	3,733	248
1998	5,042	709
1999	4,139	102
2000	3,168	833
2001	1,505	530
2002	3,052	1,249
2003	29	
2004	20	

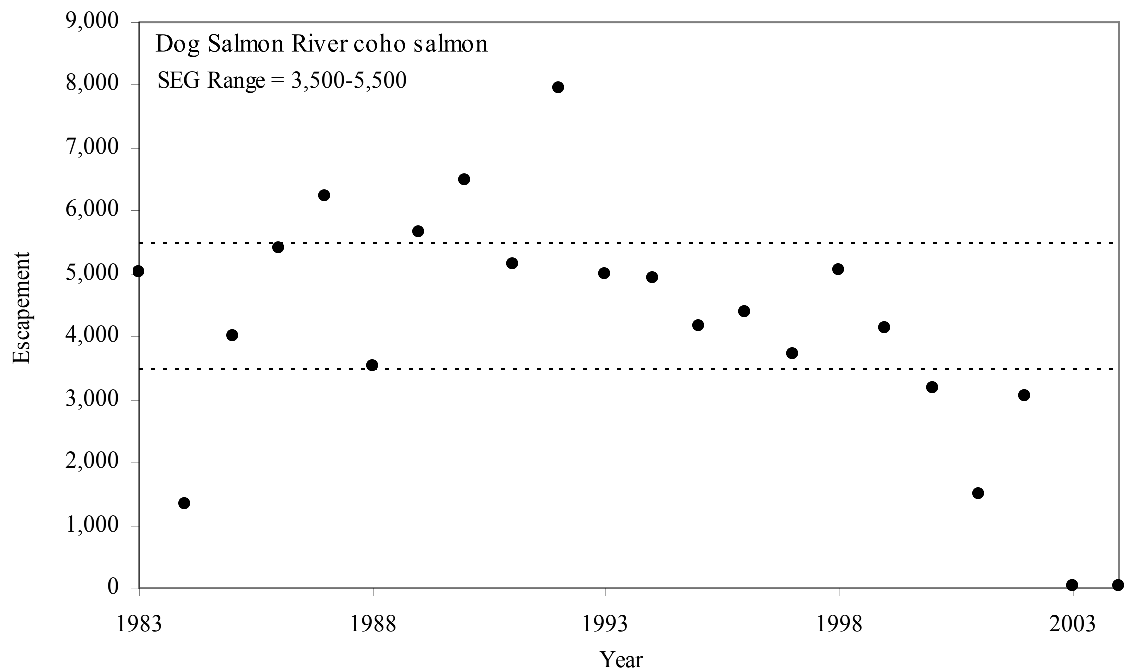
[a] Escapement estimates were adjusted in some years for an estimated build-up of coho below the weir, in the lagoon, or in the bay.

Appendix Q37.–Dog Salmon Creek coho salmon estimated escapement, 1983-2004 and current escapement goal ranges.

System: Dog Salmon Creek

Species: coho salmon

Observed escapement by year (solid circles for estimated escapement) and current SEG range (dashed lines).

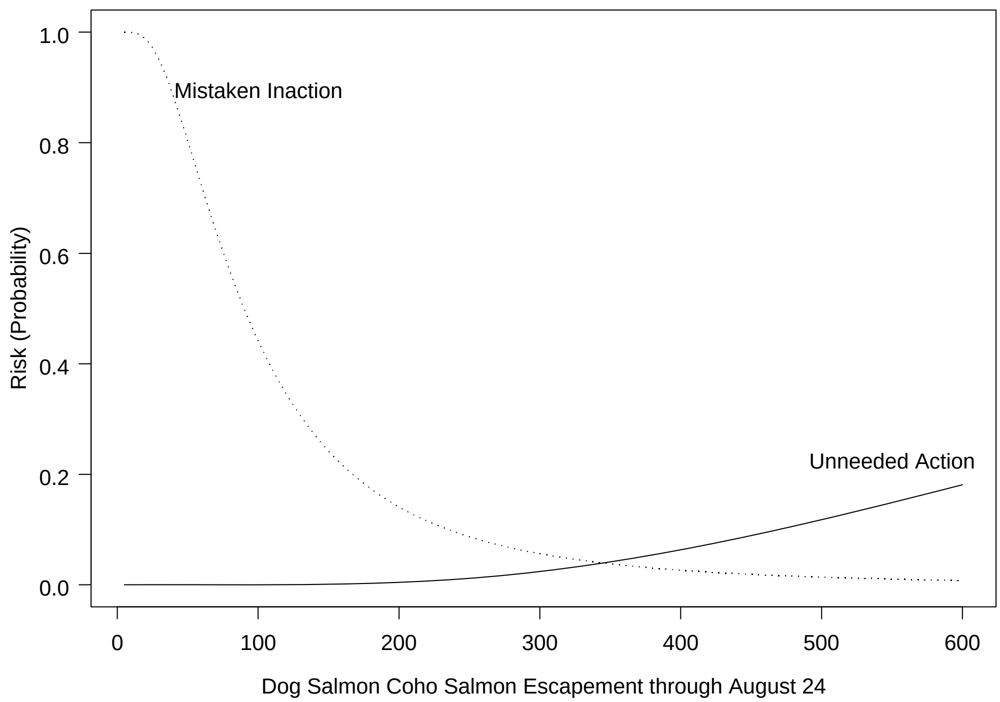


Appendix Q38.–Risk analysis for Dog Salmon Creek coho salmon through August 24.

System: Dog Salmon Creek

Species: coho salmon

Dog Salmon Creek coho salmon risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).



APPENDIX R. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR PINK SALMON ON THE KODIAK ARCHIPELAGO AND MAINLAND DISTRICT

Appendix R1.–Description of stocks and escapement goals: Kodiak Archipelago pink salmon.

System: Archipelago Districts –Afognak, Northwest Kodiak, Southwest Kodiak, Alitak Bay, Eastside Kodiak, Northeast Kodiak

Species: pink salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	SEG: even years: 2,140,000 to 5,230,000 in index
	odd years: 790,000 to 2,380,000 in index
Recommended escapement goal:	SEG: even years: 2,000,000 to 5,000,000 in index
	SEG: odd years: 2,000,000 to 5,000,000 in index
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial Survey, 1964-2003
Data summary:	
Data quality:	Fair
Data type:	Fixed-wing aerial surveys from 1964 to 2003 with peak counts used as an index of spawning escapement. 34 streams are flown annually with peak counts from streams summed annually to produce a single index for the archipelago.
Contrast:	Peak aerial surveys, all years: 18.1
	Peak aerial surveys, even years: 6.9
	Peak aerial surveys, odd years: 18.1

-continued-

Methodology:	Comparison of past yields of progeny associated with different values of the escapement index for their parents. Estimated returns (harvests plus estimated escapements of progeny) were averaged over escapements (of parents) for brood years within escapement goal ranges to show that yields have been sustainable (estimated escapement of parents subtracted from the estimated return of progeny), and that the higher range of escapement goals (2 to 5 million as an index) have resulted in greater sustained yields for both odd- and even-year brood lines than did lower goals. Estimates of those potential yields are:

Old SEGs (as an index in millions)	Estimated Sustained Yield (in millions)
2.14 to 5.23	15.3 to 16.4
0.79 to 2.38	6.7 to 7.0

Range in estimated sustained yields in above table represents the range in possible random measurement error in the escapement index. Because the linear component in the relationship between the escapement index and escapement is unknown, that component was arbitrarily set to one for estimating return. Setting the component to some other value would change estimates of sustained yields, but would not affect their relative magnitudes.

Comments:	Management objectives for individual districts were prorated from the archipelago SEG (2.0 to 5.0 million as an index) based on the averages (since 1989) of the relative values of indices across all districts for each brood line, even-year and odd-year.
Recommendations:	Establish management objectives

District	Management Objective (as an index in millions)	
	Odd Years	Even Years
Afognak	0.21 to 0.52	0.18 to 0.44
Northwest Kodiak	0.54 to 1.36	0.42 to 1.06
Southwest Kodiak	0.07 to 0.16	0.82 to 2.05
Alitak Bay	0.50 to 1.25	0.28 to 0.69
Eastside Kodiak	0.45 to 1.13	0.18 to 0.45
Northeast Kodiak	0.23 to 0.57	0.13 to 0.32

Appendix R2.–Peak counts from annual aerial surveys and annual harvest: of Kodiak Archipelago pink salmon, 1964-2003.

System: Archipelago Districts –Afognak, Northwest Kodiak, Southwest Kodiak, Alitak Bay, Eastside Kodiak, Northeast Kodiak

Species: pink salmon

Data available for analysis of escapement goal

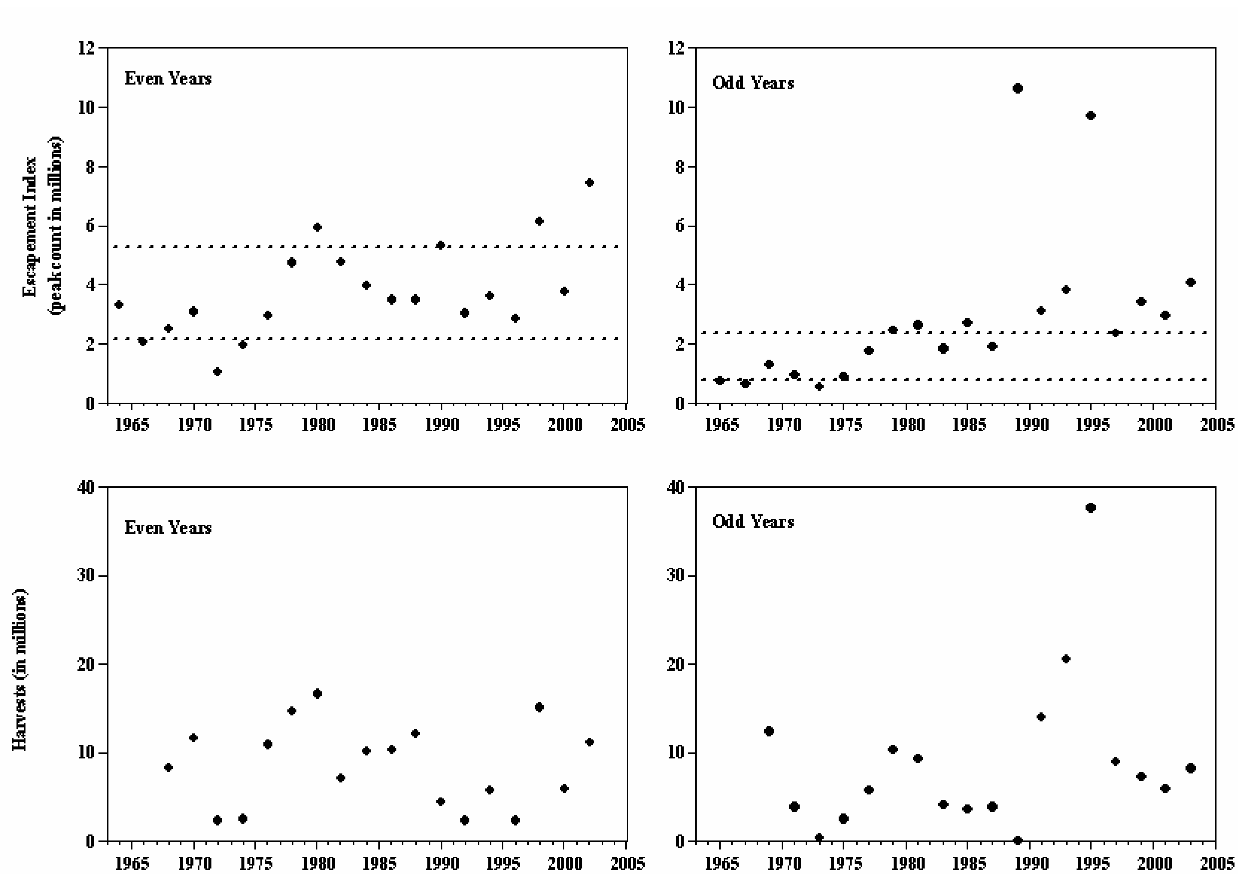
Year	Peak Count (millions)	Harvest (millions)
1964	3.36	
1965	0.77	
1966	2.1	
1967	0.7	
1968	2.56	8.39
1969	1.32	12.44
1970	3.13	11.75
1971	0.97	3.95
1972	1.09	2.44
1973	0.56	0.5
1974	2.01	2.62
1975	0.91	2.67
1976	2.97	11.03
1977	1.77	5.9
1978	4.78	14.77
1979	2.51	10.45
1980	5.94	16.73
1981	2.66	9.36
1982	4.85	7.32
1983	1.85	4.29
1984	4.03	10.23
1985	2.77	3.61
1986	3.52	10.36
1987	1.96	3.9
1988	3.51	12.21
1989	10.67	0.18
1990	5.38	4.57
1991	3.18	14.14
1992	3.1	2.42
1993	3.83	20.58
1994	3.65	5.92
1995	9.73	37.64
1996	2.92	2.46
1997	2.41	9.1
1998	6.19	15.23
1999	3.46	7.46
2000	3.82	6.14
2001	2.99	6.04
2002	7.49	11.31
2003	4.09	8.36

Appendix R3.–Kodiak Archipelago pink salmon escapement, 1964-2003 and current escapement goal ranges and Kodiak Archipelago pink salmon harvest.

System: Archipelago Districts –Afognak, Northwest Kodiak, Southwest Kodiak, Alitak Bay, Eastside Kodiak, Northeast Kodiak

Species: pink salmon

Range of proposed SEG (as an escapement index) represented by dashed lines.



Appendix R4.–Description of stocks and escapement goals: Mainland District pink salmon.

System: Mainland District

Species: pink salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine
Previous escapement goal:	SEG: even years: 256,000 to 768,000 in index
	odd years: 215,000 to 645,000 in index
Recommended escapement goal:	SEG: even years: 250,000 to 750,000 in index
	SEG: odd years: 250,000 to 750,000 in index
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial Survey, 1968-2003
Data summary:	
Data quality:	Fair.
Data type:	Fixed-wing aerial surveys from 1968 to 2003 with peak counts used as an index of spawning escapement. 16 streams are flown annually with peak counts from streams summed annually to produce a single index for the district.
Contrast:	Peak aerial surveys, all years: 79.6
	Peak aerial surveys, even years: 18.0
	Peak aerial surveys, odd years: 56.9
Methodology:	Comparison of past harvests against the values of past escapements as indices. Comparison showed that keeping escapement indices within existing SEGs resulted in sustained yields.
Comments:	The SEGs for both brood lines (even and odd years) for the district were equated and rounded to simplify management objectives.
Recommendations:	Change even and odd year goals to a SEG: 250,000 to 750,000 in index

Appendix R5.–Peak counts from annual aerial surveys and annual harvest: of Mainland District pink salmon.

System: Mainland District

Species: pink salmon

Data available for analysis of escapement goal

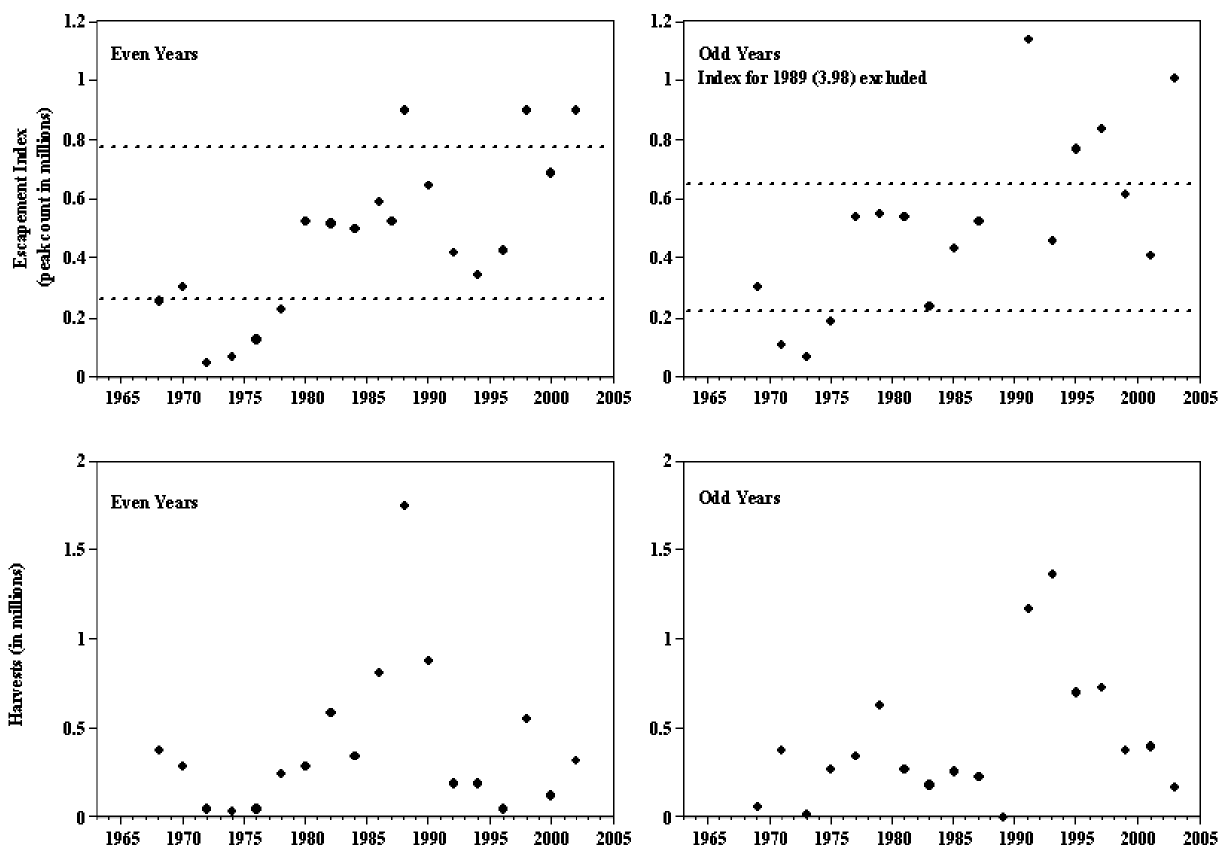
Year	Peak Count (millions)	Harvest (millions)
1968	0.26	0.38
1969	0.31	0.06
1970	0.31	0.29
1971	0.11	0.38
1972	0.05	0.05
1973	0.07	0.02
1974	0.07	0.03
1975	0.19	0.27
1976	0.13	0.05
1977	0.54	0.35
1978	0.23	0.24
1979	0.55	0.63
1980	0.53	0.29
1981	0.54	0.27
1982	0.52	0.59
1983	0.24	0.18
1984	0.5	0.35
1985	0.44	0.26
1986	0.59	0.81
1987	0.53	0.23
1988	0.9	1.75
1989	3.98	0
1990	0.65	0.88
1991	1.14	1.17
1992	0.42	0.19
1993	0.46	1.37
1994	0.35	0.19
1995	0.77	0.7
1996	0.43	0.05
1997	0.84	0.73
1998	0.9	0.56
1999	0.62	0.38
2000	0.69	0.12
2001	0.41	0.4
2002	0.9	0.32
2003	1.01	0.17

Appendix R6.–Mainland pink salmon escapement, 1964-2003 and current escapement goal ranges and Mainland pink salmon harvest.

System: Mainland District

Species: Pink salmon

Range of proposed SEG (as an escapement index) represented by dashed lines.



APPENDIX S. SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR CHUM SALMON ON THE KODIAK ARCHIPELAGO

Appendix S1.–Description of stocks and escapement goals for Northwest Kodiak District chum salmon.

System: Northwest Kodiak District

Species: chum salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	46,000 to 138,000 (1988)
Recommended escapement goal:	SEG: 53,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial surveys, 1967-2004
Data summary:	
Data quality:	Fair
Data type:	Fixed-wing aerial surveys with peak surveys from 1967-2004. Harvest information from 1970-2004.
Contrast:	Aerial surveys 1967-2004 and 1977-2004: 108.2
Methodology:	Risk analysis and percentile approach
Comments:	None
Recommendation:	Change the current escapement goal from a range to a minimum escapement goal of 53,000 chum salmon.

Appendix S2.–Northwest Kodiak District chum salmon peak aerial surveys, 1967-2004 and commercial harvest, 1970-2004.

System: Northwest Kodiak District

Species: chum salmon

Data available for analysis of escapement goals

Year	Aggregate Peak Aerial Survey	Harvest
1967	43,000	
1968	6,800	
1969	6,445	
1970	2,500	115,772
1971	21,000	128,609
1972	90,340	174,577
1973	45,848	45,872
1974	15,600	29,849
1975	38,350	33,796
1976	8,000	67,993
1977	57,602	108,802
1978	47,700	111,408
1979	75,200	58,231
1980	43,050	90,174
1981	99,100	232,110
1982	147,700	412,671
1983	169,225	366,163
1984	75,600	135,013
1985	61,600	214,752
1986	162,890	497,530
1987	76,950	228,783
1988	192,550	536,483
1989	417,100	34

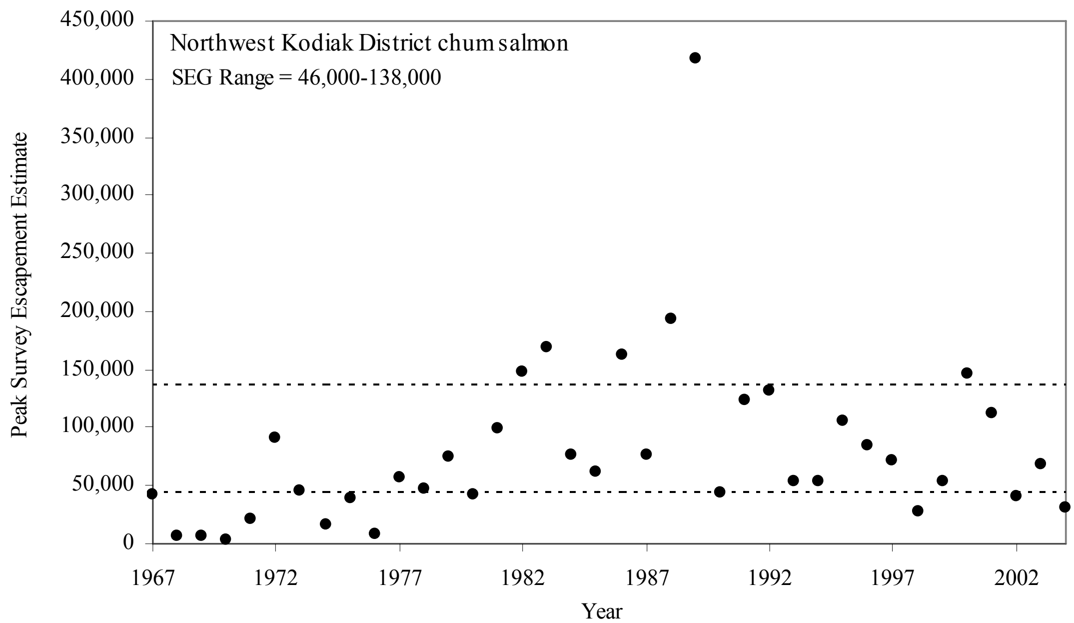
Year	Aggregate Peak Aerial Survey	Harvest
1990	43,920	167,773
1991	123,503	283,582
1992	131,710	225,973
1993	53,825	219,003
1994	52,950	250,938
1995	104,800	574,665
1996	84,900	248,993
1997	70,900	181,730
1998	28,250	121,412
1999	53,300	189,509
2000	145,800	302,753
2001	112,550	317,701
2002	41,200	204,303
2003	67,700	262,436
2004	30,700	477,039

Appendix S3.–Northwest Kodiak District chum salmon peak aerial surveys, 1967-2004 and current escapement goal range.

System: Northwest Kodiak District

Species: chum salmon

Observed escapement by year (solid circles for aerial surveys) and current SEG range (dashed lines).

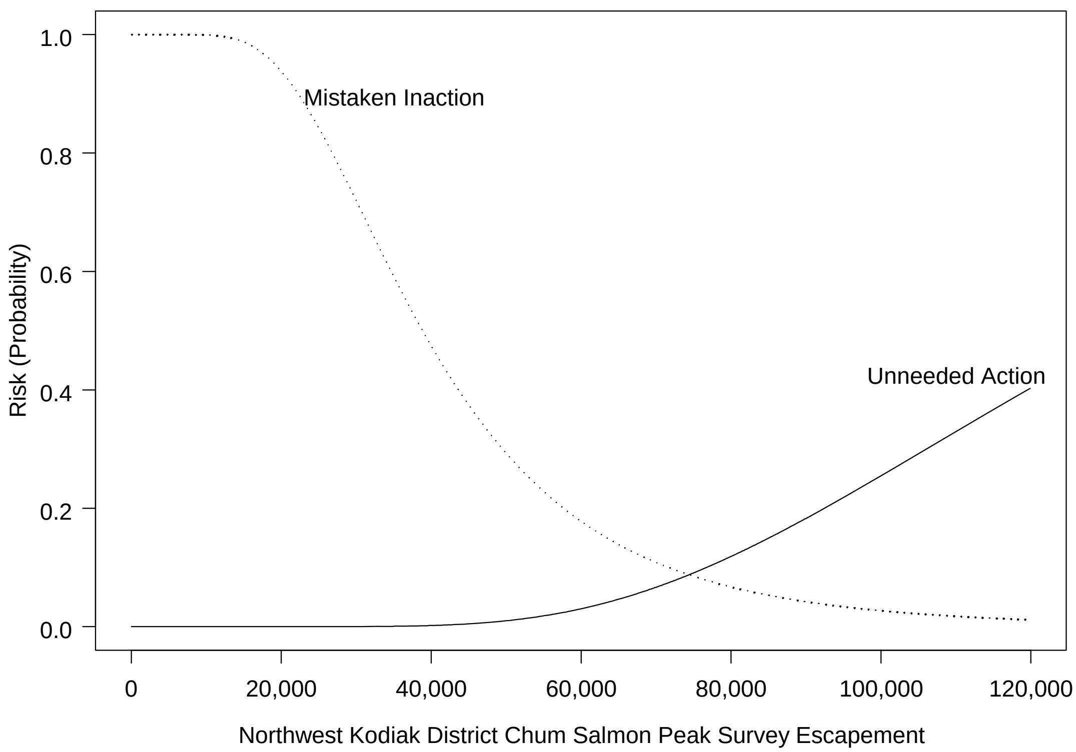


Appendix S4.–Risk analysis for Northwest Kodiak District chum salmon.

System: **Northwest Kodiak District**

Species: **chum salmon**

Northwest Kodiak District chum salmon risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).



Appendix S5.–Description of stocks and escapement goals for Southwest Kodiak District chum salmon.

System: **Southwest Kodiak District**

Species: **chum salmon**

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	SEG: 25,000 to 75,000 (1988)
Recommended escapement goal:	SEG: 7,300
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial surveys, 1967-2004
Data summary:	
Data quality:	Fair
Data type:	Fixed-wing aerial surveys with peak surveys from 1967- 2004. Harvest information from 1970-2004.
Contrast:	Aerial surveys 1967-2004 and 1977-2004: 108.2
Methodology:	Risk analysis and percentile approach
Comments:	None
Recommendation:	Change the current escapement goal from a range to a minimum escapement goal of 7,300 chum salmon.

Appendix S6.–Southwest Kodiak District chum salmon escapement, 1967-2004 and commercial harvest, 1970-2004.

System: **Southwest Kodiak District**

Species: **chum salmon**

Data available for analysis of escapement goals

Year	Aggregate Peak Aerial Survey	Harvest
1967	45,000	
1968	71,000	
1969	9,500	
1970	5,000	10,782
1971	101,000	138
1972	21,500	6,644
1973	9,120	496
1974	13,500	2,679
1975	45,574	209
1976	7,132	9,653
1977	99,446	1,352
1978	160,339	16,000
1979	97,141	632
1980	96,108	38,943
1981	97,000	1,518
1982	63,675	29,471
1983	85,189	920
1984	80,172	24,228
1985	1,502	11,053
1986	92,218	56,580
1987	12,200	25,321
1988	58,900	28,716
1989	7,279	19

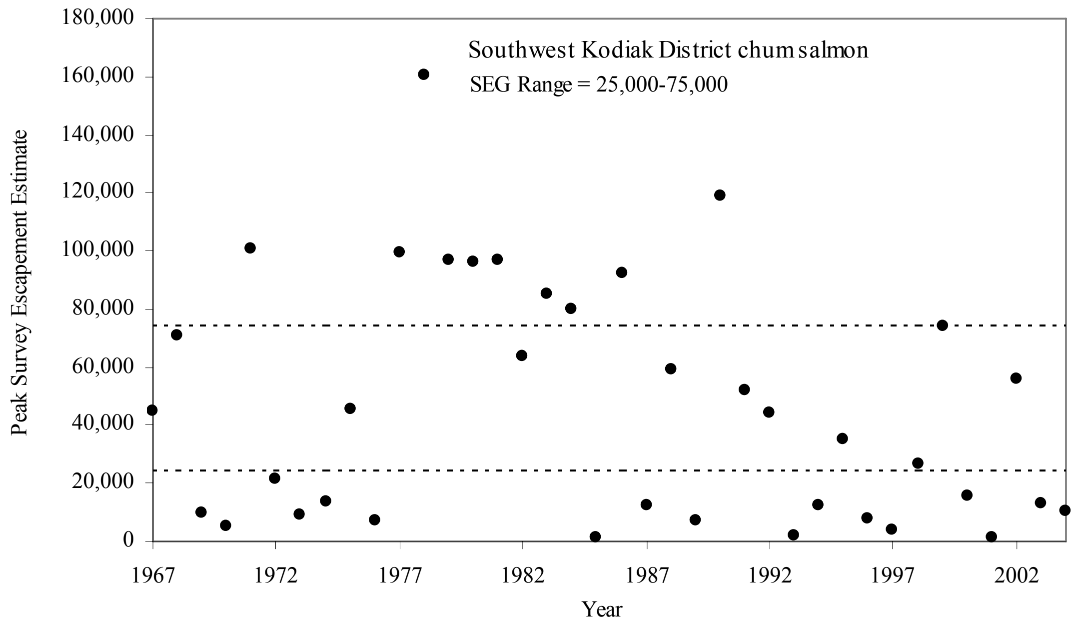
Year	Aggregate Peak Aerial Survey	Harvest
1990	118,657	32,355
1991	51,765	33,763
1992	43,874	59,592
1993	1,978	46,896
1994	12,538	58,075
1995	35,191	96,766
1996	7,757	80,218
1997	3,778	12,033
1998	26,596	52,081
1999	73,850	71,630
2000	15,697	69,010
2001	1,482	50,937
2002	55,838	23,988
2003	12,900	28,503
2004	10,100	69,870

Appendix S7.–Southwest Kodiak District chum salmon peak aerial surveys, 1967-2004 and current escapement goal ranges.

System: **Southwest Kodiak District**

Species: **chum salmon**

Observed escapement by year (solid circles for aerial surveys) and current SEG range (dashed lines).



Appendix S8.–Description of stocks and escapement goals for Alitak Bay District chum salmon.

System: Alitak Bay District

Species: chum salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	SEG: 26,000 to 78,000 (1988)
Recommended escapement goal:	SEG: 28,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial surveys, 1967-2004
Data summary:	
Data quality:	Fair
Data type:	Fixed-wing aerial surveys with peak surveys from 1967- 2004. Harvest information from 1970-2004.
Contrast:	Aerial surveys 1967-2004 and 1977-2004: 42.3 and 13.3, respectively.
Methodology:	Risk analysis and percentile approach
Comments:	None
Recommendation:	Change the current escapement goal from a range to a minimum escapement goal of 28,000 chum salmon.

Appendix S9.–Alitak Bay District chum salmon peak aerial surveys, 1967-2004 and commercial harvest, 1970-2004.

System: Alitak Bay District

Species: chum salmon

Data available for analysis of escapement goals

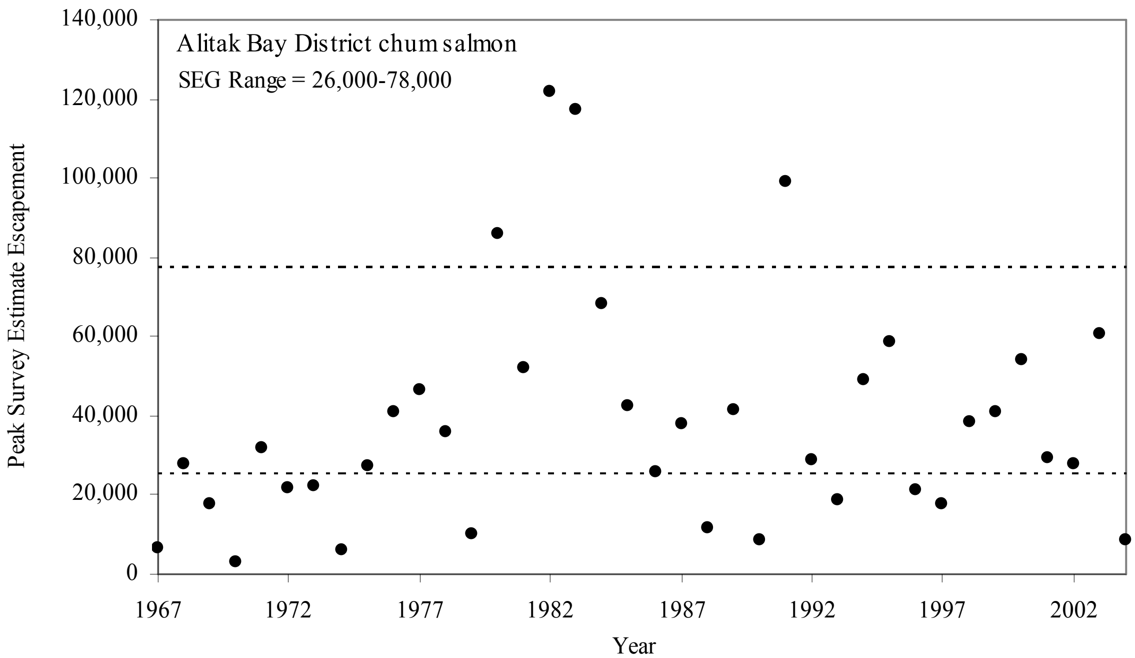
Year	Aggregate Peak Aerial Survey	Harvest
1967	6,735	
1968	28,000	
1969	17,785	
1970	3,200	93,320
1971	31,700	191,437
1972	21,570	95,135
1973	22,100	24,408
1974	6,000	23,939
1975	27,240	2,853
1976	41,041	68,132
1977	46,500	70,969
1978	36,059	72,166
1979	10,165	22,462
1980	86,075	67,659
1981	52,310	61,513
1982	121,900	101,543
1983	117,317	107,786
1984	68,075	84,924
1985	42,268	84,760
1986	25,634	75,643
1987	38,000	59,727
1988	11,600	93,401
1989	41,599	19,919
1990	8,721	50,306
1991	99,187	83,017
1992	28,772	34,599
1993	18,912	53,639
1994	48,827	112,196
1995	58,661	105,224
1996	21,381	65,272
1997	17,474	85,775
1998	38,656	40,554
1999	40,778	79,000
2000	53,843	67,223
2001	29,086	52,560
2002	27,642	10,198
2003	60,525	31,908
2004	8,500	38,356

Appendix S10.–Alitak Bay District chum salmon peak aerial surveys and current escapement goal ranges.

System: Alitak Bay District

Species: chum salmon

Observed escapement by year (solid circles for aerial surveys) and current SEG range (dashed lines).

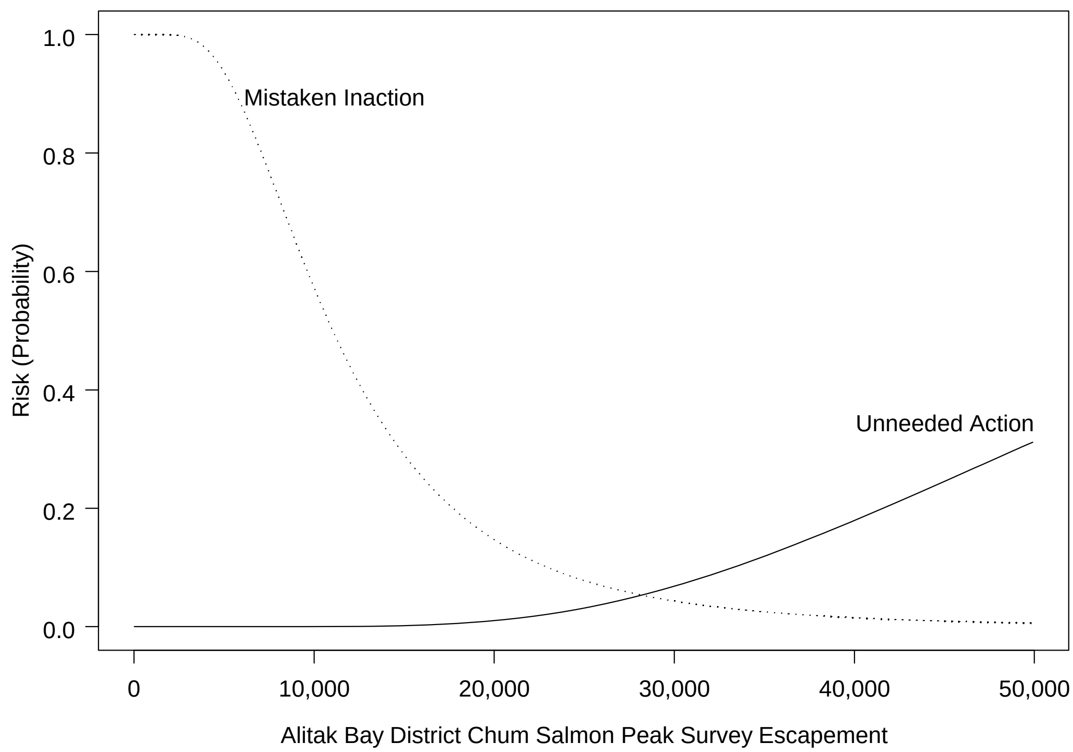


Appendix S11.–Risk analysis for Alitak Bay District chum salmon.

System: **Alitak Bay District**

Species: **chum salmon**

Alitak Bay District chum salmon risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).



Appendix S12.–Description of stocks and escapement goals for Eastside Kodiak District chum salmon.

System: Eastside Kodiak District

Species: chum salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	SEG: 35,000 to 105,000 (1988)
Recommended escapement goal:	SEG: 50,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial surveys, 1967-2004
Data summary:	
Data quality:	Fair
Data type:	Fixed-wing aerial surveys with peak surveys from 1967- 2004. Harvest information from 1970-2004.
Contrast:	Aerial surveys 1967-2004 and 1977-2004: 35.9 and 12.5, respectively.
Methodology:	Risk analysis and percentile approach
Autocorrelation:	AR(1) for both 1967-2004 and 1977-2004
Comments:	None
Recommendation:	Change the current escapement goal from a range to a minimum escapement goal of 50,000 chum salmon.

Appendix S13.–Eastside Kodiak District chum salmon peak aerial surveys, 1967-2004 and commercial harvest, 1970-2004.

System: **Eastside Kodiak District**

Species: **chum salmon**

Data available for analysis of escapement goals

Year	Aggregate Peak Aerial Survey	Harvest
1967	6,225	
1968	18,600	
1969	22,300	
1970	13,150	280,976
1971	14,050	677,127
1972	142,315	600,173
1973	112,380	143,588
1974	49,860	106,118
1975	23,725	18,418
1976	66,250	251,937
1977	129,775	322,497
1978	65,139	349,116
1979	169,495	172,886
1980	165,510	348,124
1981	204,070	479,621
1982	144,720	321,418
1983	150,657	304,875
1984	110,360	158,942
1985	129,500	43,858
1986	62,973	57,267
1987	42,600	90,606
1988	44,080	216,093
1989	223,645	0

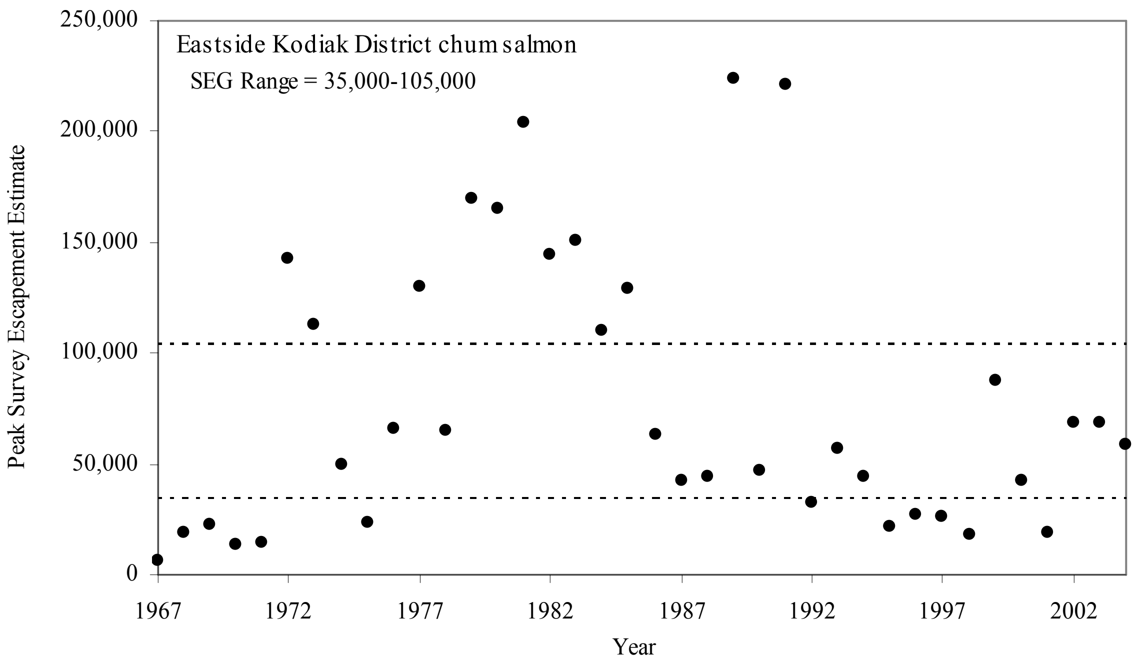
Year	Aggregate Peak Aerial Survey	Harvest
1990	46,870	86,743
1991	220,951	306,857
1992	32,085	184,350
1993	56,650	107,900
1994	44,170	168,128
1995	21,353	321,838
1996	27,365	42,924
1997	26,525	134,584
1998	17,925	27,138
1999	87,705	179,946
2000	42,100	218,195
2001	18,750	179,601
2002	68,400	181,857
2003	68,700	80,898
2004	58,500	51,869

Appendix S14.–Eastside Kodiak District chum salmon peak aerial surveys, 1967-2004 and current escapement goal ranges.

System: Eastside Kodiak District

Species: chum salmon

Observed escapement by year (solid circles for aerial surveys) and current SEG range (dashed lines).

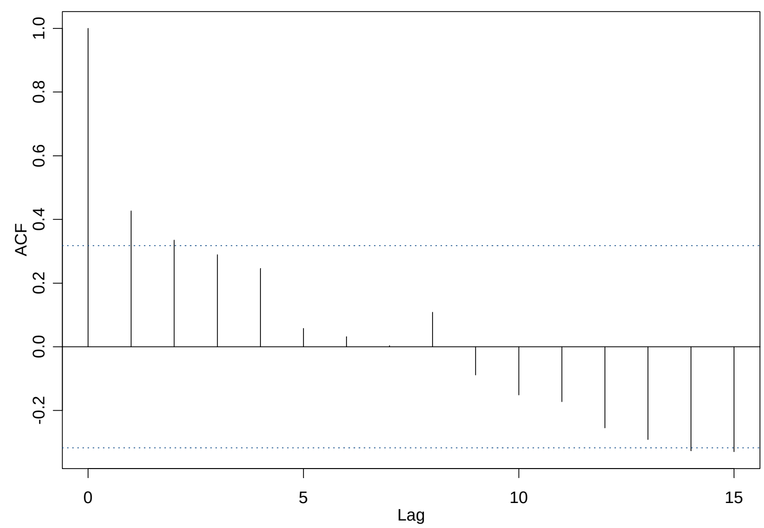


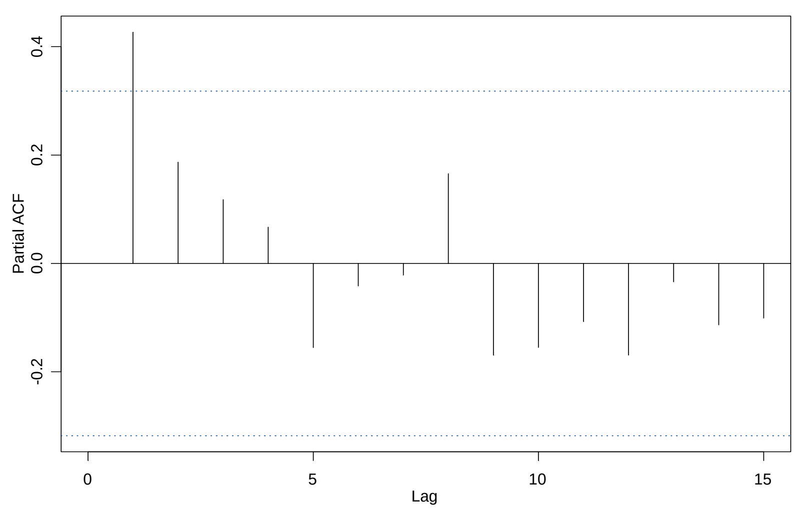
Appendix S15.–Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals Eastside Kodiak District chum salmon, peak escapement survey, 1967-2004.

System: Eastside Kodiak District

Species: chum salmon

ACF and PACF of natural log-transformed escapement data, 1967-2004



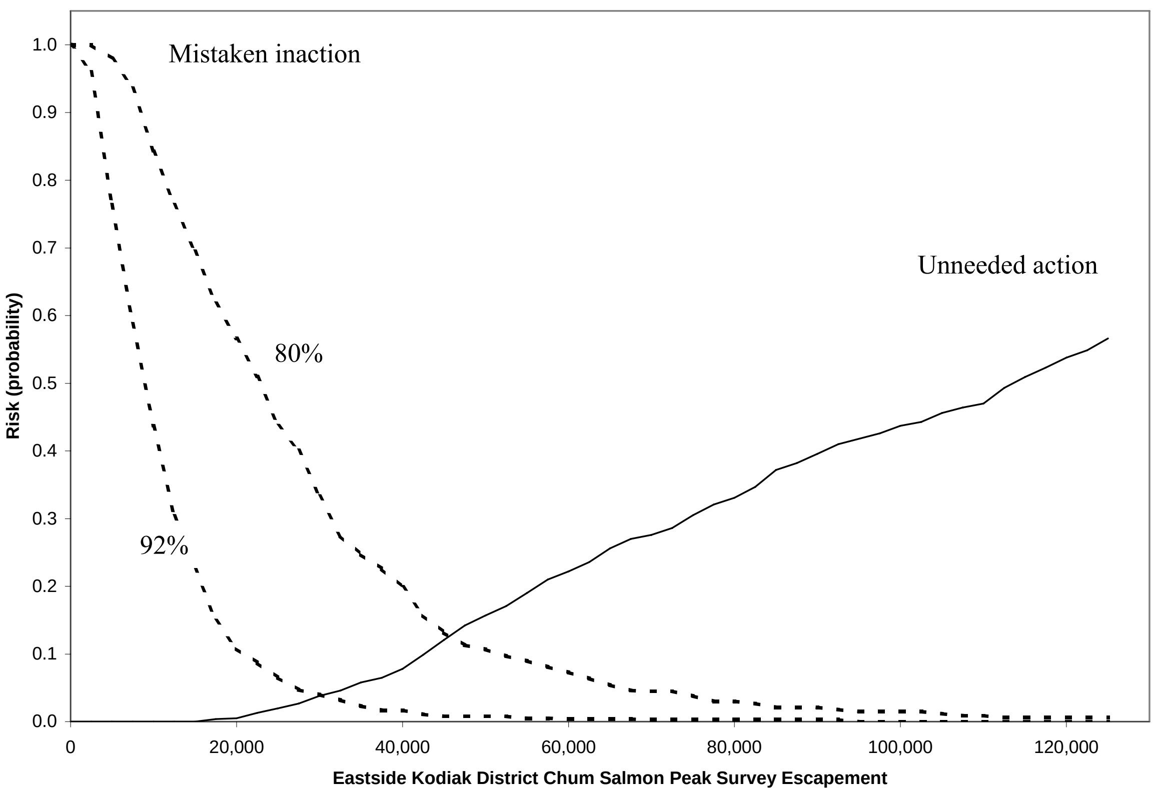


Appendix S16.–Risk analysis for Eastside Kodiak District chum salmon, 1967-2004

System: Eastside Kodiak District

Species: chum salmon

Eastside Kodiak District chum salmon 1967-2004 risk analysis (solid line the risk of unneeded action and dashed lines the risk of mistaken inaction).

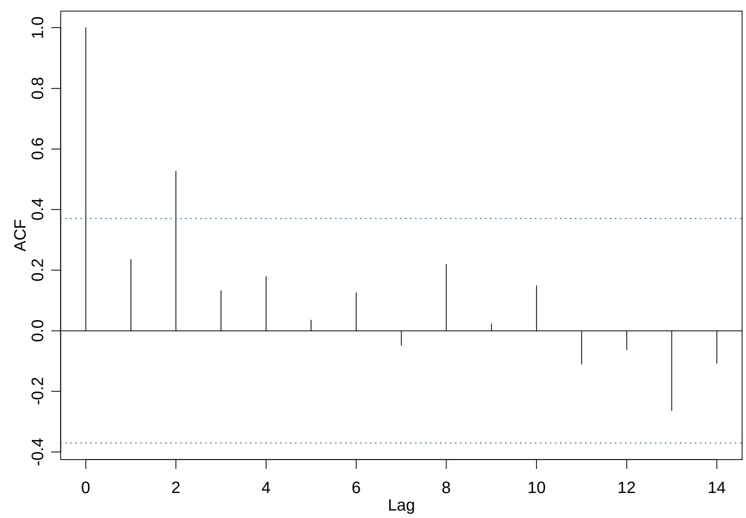


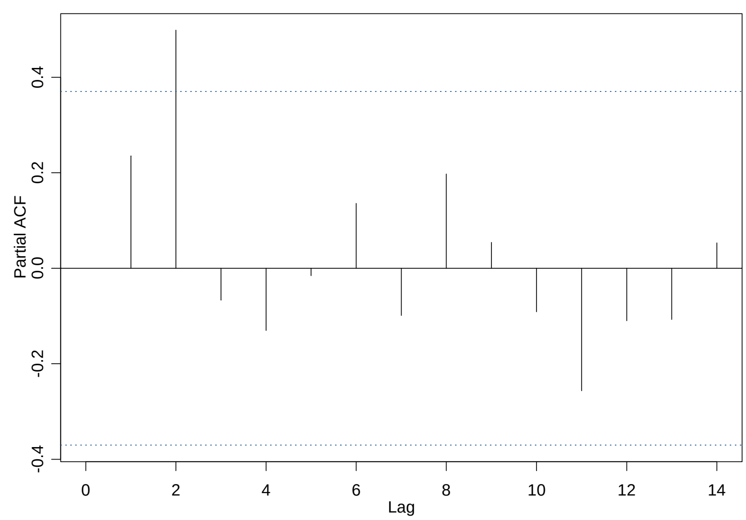
Appendix S17.–Autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals Eastside Kodiak District chum salmon, peak escapement survey, 1977-2004.

System: Eastside Kodiak District

Species: chum salmon

ACF and PACF of natural log-transformed escapement data, 1977-2004



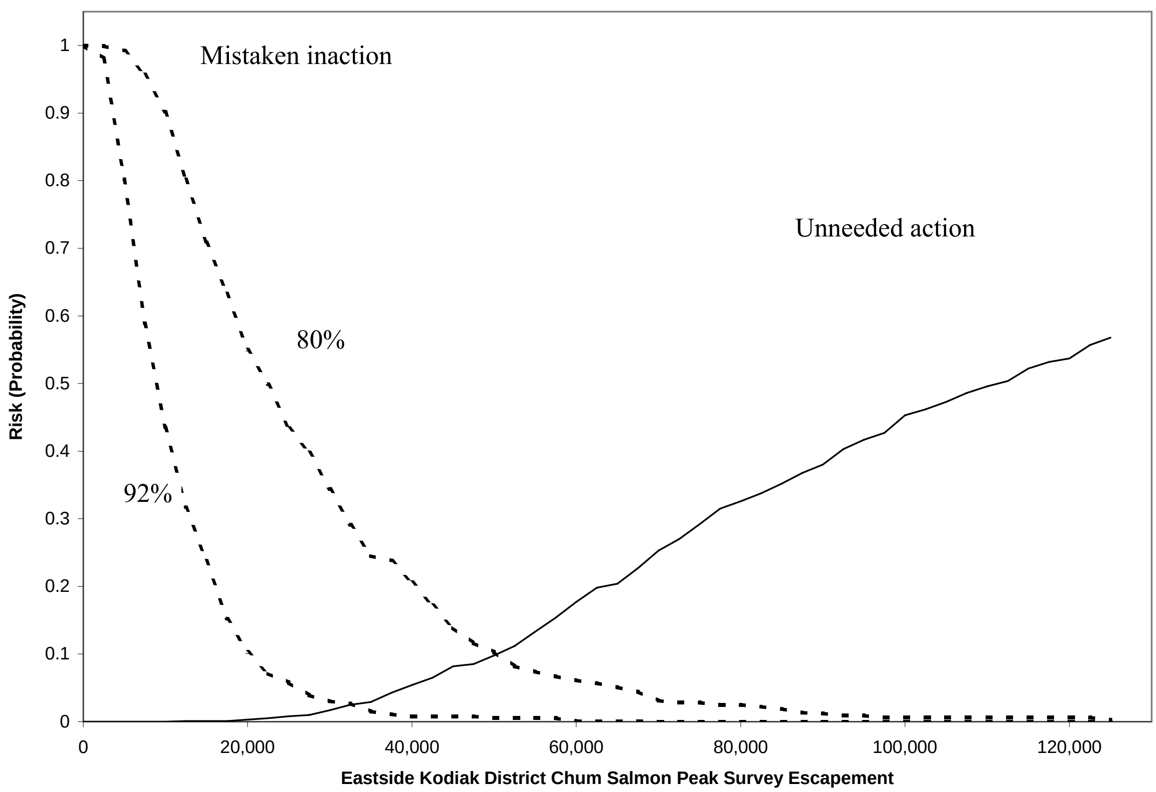


Appendix S18.–Risk analysis for Eastside Kodiak District chum salmon, 1977-2004.

System: **Eastside Kodiak District**

Species: **chum salmon**

Eastside Kodiak District chum salmon 1977-2004 risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).



Appendix S19.–Description of stocks and escapement goals for Northeast Kodiak District chum salmon.

System: **Northeast Kodiak District**

Species: **chum salmon**

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	SEG: 8,000 to 24,000 (1988)
Recommended escapement goal:	SEG: 9,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial surveys, 1967, 1969-2003
Data summary:	
Data quality:	Fair
Data type:	Fixed-wing aerial surveys with peak surveys from 1967, 1969-2003. Harvest information from 1970-2004.
Contrast:	Aerial surveys 1967-2003 and 1977-2003: 25.3
Methodology:	Risk analysis and percentile approach
Comments:	None
Recommendation:	Change the current escapement goal from a range to a minimum escapement goal of 9,000 chum salmon.

Appendix S20.–Northeast Kodiak District chum salmon peak aerial surveys, 1967-2004 and commercial harvest, 1970-2004.

System: Northeast Kodiak District

Species: chum salmon

Data available for analysis of escapement goals

Year	Aggregate Peak Aerial Survey	Harvest
1967	5,224	
1969	450	
1970	2,500	38,288
1971	2,007	56,144
1972	2,920	15,823
1973	13,215	1,589
1974	2,500	5,095
1975	10,950	2,230
1976	11,835	34,515
1977	34,200	42,714
1978	10,261	31,757
1979	11,750	6,324
1980	17,900	35,397
1981	3,710	41,887
1982	50,715	36,488
1983	24,100	11,805
1984	30,600	10,804
1985	37,110	20,364
1986	21,002	11,223
1987	7,643	29,413
1988	31,501	71,680
1989	17,679	0

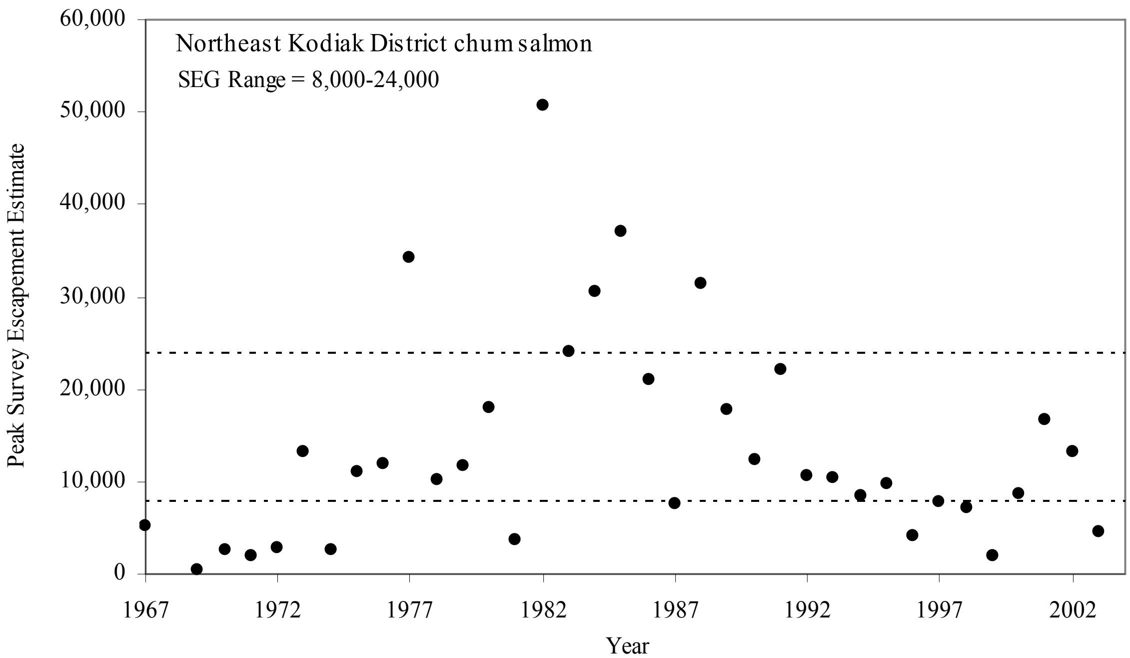
Year	Aggregate Peak Aerial Survey	Harvest
1990	12,300	5,683
1991	22,116	27,217
1992	10,605	17,226
1993	10,422	2,994
1994	8,450	18,631
1995	9,843	33,595
1996	4,100	2,333
1997	7,808	29,741
1998	7,250	902
1999	2,031	15,077
2000	8,600	10,075
2001	16,600	1,334
2002	13,200	16,519
2003	4,500	15,112
2004		24,638

Appendix S21.–Northeast Kodiak District chum salmon peak aerial surveys, 1967-2004 and current escapement goal ranges.

System: Northeast Kodiak District

Species: chum salmon

Observed escapement by year (solid circles for aerial surveys) and current SEG range (dashed lines).

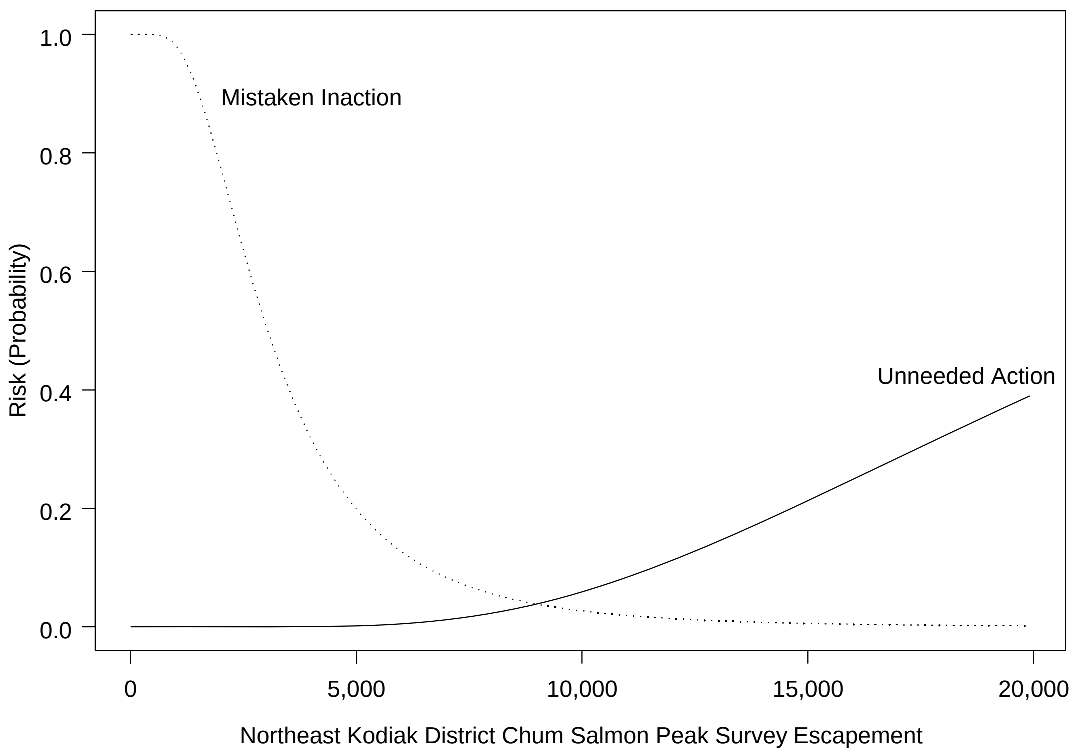


Appendix S22.–Risk analysis for Northeast Kodiak District chum salmon.

System: Northeast Kodiak District

Species: chum salmon

Northeast Kodiak District chum salmon risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).



Appendix S23.–Description of stocks and escapement goals for Mainland District chum salmon.

System: Mainland District

Species: chum salmon

Description of stock and escapement goals

Regulatory area	Kodiak Management Area – Westward Region
Management division:	Commercial Fisheries
Primary fishery:	Commercial purse seine and set gillnet
Previous escapement goal:	SEG: 133,000 to 339,000 (1988)
Recommended escapement goal:	SEG: 153,000
Optimal escapement goal:	none
Inriver goal:	none
Action points:	none
Escapement enumeration:	Aerial surveys, 1967-2004
Data summary:	
Data quality:	Fair
Data type:	Fixed-wing aerial surveys with peak surveys from 1967- 2004. Harvest information from 1970-2004.
Contrast:	Aerial surveys 1967-2004 and 1977-2004: 64.7 and 8.7, respectively.
Methodology:	Risk analysis and percentile approach
Comments:	None
Recommendation:	Change the current escapement goal from a range to a minimum escapement goal of 153,000 chum salmon.

Appendix S24.–Mainland District chum salmon peak aerial surveys, 1967-2004 and commercial harvest, 1970-2004.

System: Mainland District

Species: chum salmon

Data available for analysis of escapement goals

Year	Aggregate Peak Aerial Survey	Harvest
1967	19,250	
1968	7,000	
1969	22,200	
1970	61,500	271,272
1971	53,710	373,979
1972	38,800	192,965
1973	89,450	90,651
1974	15,300	57,526
1975	31,720	9,423
1976	125,910	214,567
1977	392,440	426,419
1978	119,850	152,548
1979	177,310	73,137
1980	367,250	413,884
1981	238,850	437,784
1982	453,148	316,010
1983	238,810	273,858
1984	246,450	220,760
1985	263,100	48,189
1986	245,175	400,469
1987	225,600	231,232
1988	185,800	392,154
1989	346,200	0

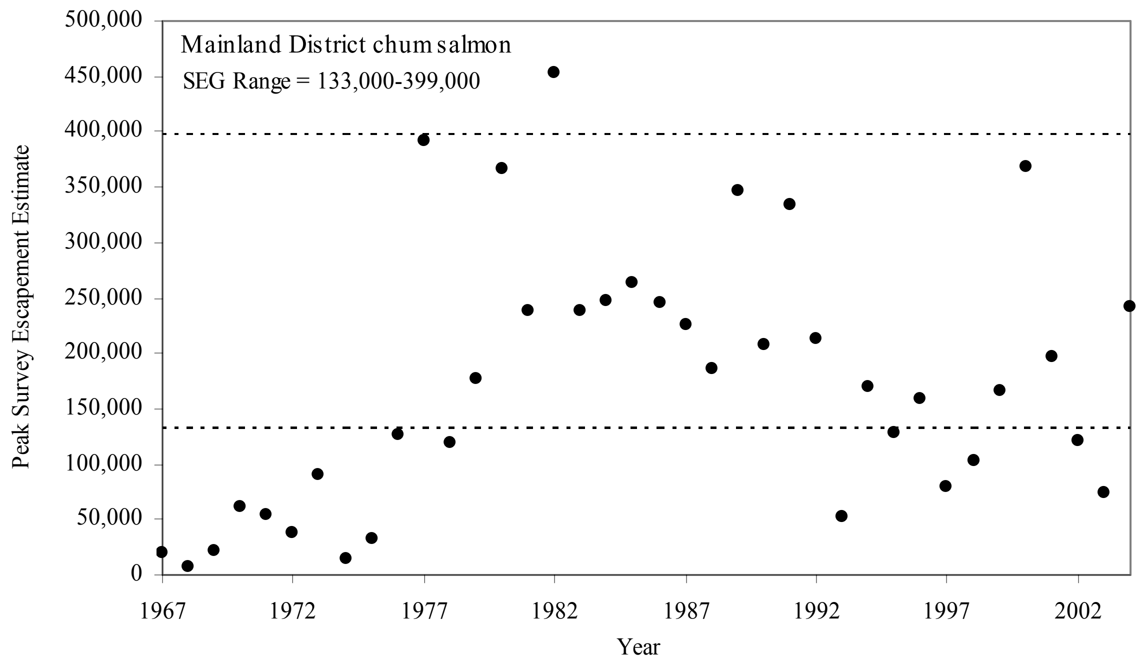
Year	Aggregate Peak Aerial Survey	Harvest
1990	207,200	200,648
1991	334,100	222,548
1992	213,100	114,080
1993	51,790	84,237
1994	169,100	90,965
1995	127,900	100,874
1996	158,650	40,358
1997	80,300	34,928
1998	103,050	25,264
1999	166,200	210,072
2000	367,650	195,024
2001	196,100	208,445
2002	120,975	89,677
2003	73,800	204,526
2004	241,645	149,393

Appendix S25.–Mainland District chum salmon peak aerial surveys, 1967-2004 and the current escapement goal ranges.

System: Mainland District

Species: chum salmon

Observed escapement by year (solid circles for aerial surveys) and current SEG range (dashed lines).



Appendix S26.–Risk analysis for Mainland District chum salmon.

System: Mainland District

Species: chum salmon

Mainland District chum salmon risk analysis (solid line the risk of unneeded action and dashed line the risk of mistaken inaction).