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Escapement Goal Review of Copper and Bering Rivers, and Prince William Sound Pacific Salmon Stocks, 2008

by

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November 2008

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

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

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ABSTRACT

This report is a summary of escapement goal reviews and recommendations for major salmon stocks of the Copper River, Bering River, and Prince William Sound area. Escapement goals were reviewed 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) adopted by the Alaska Board of Fisheries into regulation in 2001. The Escapement Goal Committee reviewed 17 existing escapement goals, including 1 Chinook salmon stock, 7 chum salmon stocks, 2 coho salmon stocks, 1 pink salmon stock (one goal for each even- and odd-year broodline), and 5 sockeye salmon stocks. Most of the existing goals were adopted in 2002 or 2005, while the 2 coho salmon goal ranges were adopted in 1991. The committee recommends that all goals for Chinook, chum, coho, and pink salmon remain the same. For sockeye salmon, it is recommended that the Eshamy Lake goal change from 20,000–40,000 to 13,000–28,000 and remain a biological escapement goal. This recommendation is derived from an updated and revised Ricker stock–recruitment model. The remaining 4 sockeye salmon goals would remain unchanged.

Key words: Copper River, Bering River, Prince William Sound, Eshamy Lake, escapement goal, biological escapement goal, sustainable escapement goal, Chinook salmon *Oncorhynchus tshawytscha*, chum salmon *O. keta*, sockeye salmon *O. nerka*, coho salmon *O. kisutch*, pink salmon *O. gorbuscha*.

INTRODUCTION

This report summarizes the escapement goal reviews and recommendations for the major salmon stocks of the Copper River, Bering River, and Prince William Sound areas. An interdivisional Escapement Goal Committee, including staff from the Divisions of Commercial Fisheries and Sport Fish, held a formal meeting to discuss and develop recommendations on March 18, 2008. Escapement goals were reviewed 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) adopted by the Alaska Board of Fisheries (BOF) into regulation in 2001 to ensure that the state's salmon stocks are conserved, managed, and developed using the sustained yield principle. The EGP states that it is Alaska Department of Fish and Game's responsibility to document existing salmon escapement goals for all salmon stocks that are currently managed for an escapement goal and to review existing, or propose new escapement goals on a schedule that conforms to the board's regular cycle of consideration of area regulatory proposals.

This was the fifth time an interdivisional team has reviewed escapement goals for stocks in this area. In 1994 and 1999, teams reviewed and recommended goals with guidance from Alaska Department of Fish and Game (ADF&G) Salmon Escapement Goal Policy adopted in 1992 (Fried 1994). The most recent escapement goal reviews were conducted in 2002 (Bue et al. 2002) and 2005 (Evenson et al. 2008). During the 2002 review, most of the escapement goals were revised to be compliant with the SSFP and EGP. Following extensive reviews and analyses in the 2002 review, 17 escapement goals were adopted, including 1 Chinook salmon *Oncorhynchus tshawytscha* stock, 7 chum salmon *O. keta* stocks, 2 coho salmon *O. kisutch* stocks, 1 pink salmon *O. gorbuscha* stock (one each for even- and odd–year broodlines), and 5 sockeye salmon *O. nerka* stocks. Fifteen of the goals were classified as sustainable escapement goals (SEG) while 2 were biological escapement goals (BEG). The SSFP defines biological and sustainable escapement goals as:

> *Biological Escapement Goal*: means the escapement that provides the greatest potential for maximum sustained yield (MSY); BEG will be the primary management objective for the escapement unless an optimal escapement or inriver run goal has been adopted; BEG will be developed from the best available biological information, and should be scientifically defensible on the basis of available biological information; BEG will be determined by the department and will be expressed as a range based on factors such as salmon stock

productivity and data uncertainty; the department will seek to maintain evenly distributed salmon escapements within the bounds of a BEG.

Sustainable Escapement Goal: means a level of escapement, indicated by an index or an escapement estimate, that is known to provide for sustained yield over a 5 to 10 year period, used in situations where a BEG cannot be estimated due to the absence of a stock specific catch estimate; the SEG is the primary management objective for the escapement, unless an optimal escapement or inriver run goal has been adopted by the board, and will be developed from the best available biological information; the SEG will be determined by the department and will be stated as a range that takes into account data uncertainty; the department will seek to maintain escapements within the bounds of the SEG.

Additional changes were made during the 2005 review. The 7 chum salmon goals were re-analyzed and changed and the Coghill Lake sockeye salmon goal was changed from a BEG to a SEG.

OBJECTIVES

Objectives of the 2008 review were to:

1) Review existing goals to determine whether they are still appropriate given (a) new data collected since the last review, (b) current assessment techniques, and (c) current management practices;
2) Review the methods used to establish the existing goals to determine whether alternative methods should be investigated;
3) Consider any new stocks for which there may be sufficient data to develop a goal; and,
4) Recommend new goals if appropriate.

METHODS

The team reviewed each of the existing escapement goals using updated escapement and harvest data collected since the 2005 review. Available escapement, catch, and age data for each stock were compiled from research reports, management reports, and unpublished historical databases. Escapement refers to the annual estimated size of the spawning salmon stock. Escapement is affected by a variety of factors including exploitation, predation, diseases, and physical and biological changes in the environment. The committee evaluated the type, quality, and quantity of data for each stock. This evaluation was used to determine the appropriate type of escapement goal as defined in regulation. Generally speaking, an escapement goal for a stock should provide escapement that produces sustainable yields. Escapement goals for salmon have typically been based on spawner–recruit relations (e.g., Beverton and Holt 1957; Ricker 1954), which represent the productivity of the stock and estimated carrying capacity. However, specific methods to determine escapement goals vary in their technical complexity. Thus, escapement goals should be evaluated and revised over time as improved methods of assessment and goal setting are developed, and when new and better information becomes available. In addition to the SSFP definition, an escapement goal for a stock was defined as a BEG if a sufficiently long time series of escapement, catch, and age estimates were available; the estimates were sufficiently accurate and precise; and the data were considered sufficient to provide a scientifically defensible estimate of MSY (as per rules and methods in Hilborn and Walters 1992; CTC 1999; Quinn and

Deriso 1999). A BEG is used when the reference points can be estimated and there is sufficient fishing power and inseason management capability to harvest annual runs to achieve the BEG. An escapement goal for a stock was defined as an SEG if a sufficiently long time series of escapement estimates were available, but there was concern about the spawner–return data (lack of age composition estimates and/or concern with stock–specific catch allocation) or there was a lack of information on stock productivity.

STUDY AREA

The Prince William Sound (PWS) management area encompasses all coastal waters and inland drainages entering the north Gulf of Alaska between Cape Suckling and Cape Fairfield (Figure 1). This area includes the Bering River, Copper River, and all Prince William Sound with a total adjacent land area of approximately 38,000 square miles.

The salmon management area is divided into 11 districts that correspond to local geography and distribution of the 5 species of salmon harvested by the commercial fishery. The management objective for all districts is the achievement of spawning escapement goals for the major stocks while allowing for the orderly harvest of fish surplus to spawning requirements.

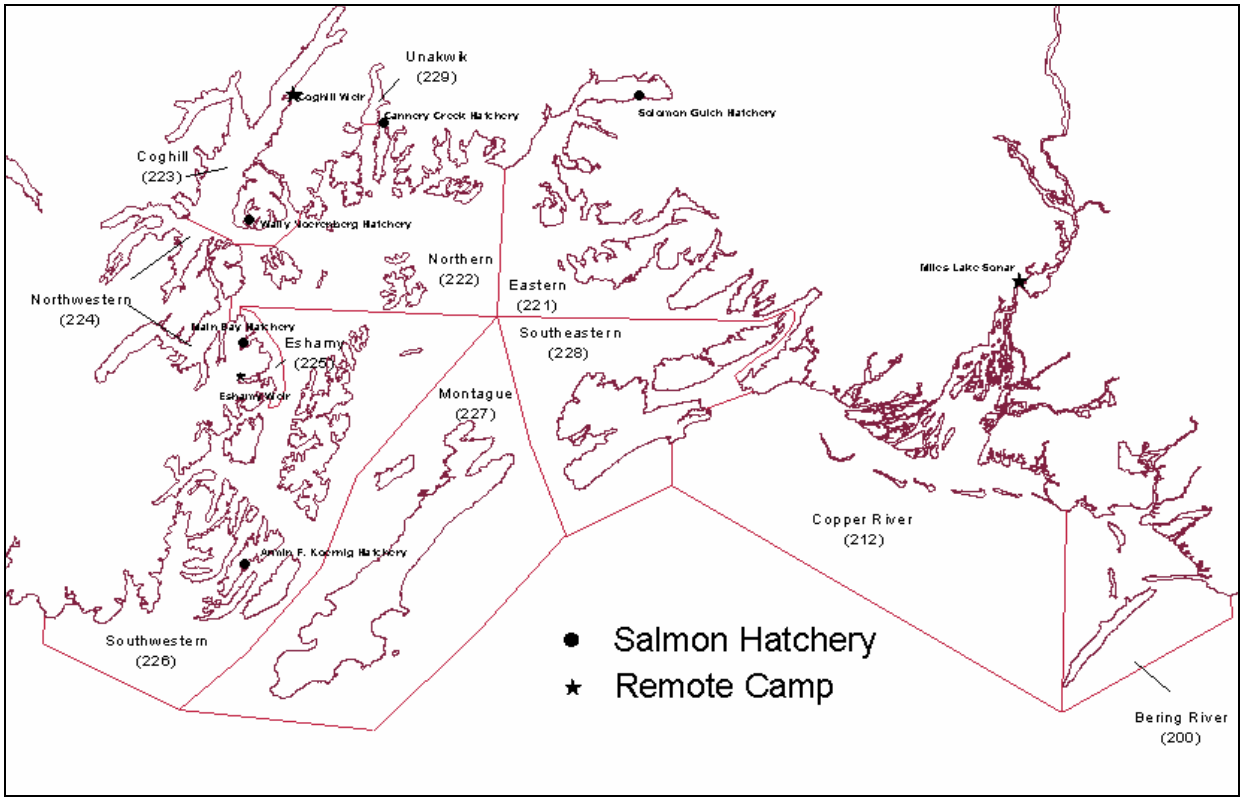

Figure 1.–Prince William Sound Management Area showing commercial fishing districts, salmon hatcheries, weir locations, and Miles Lake sonar camp.

ESCAPEMENT AND HARVEST DATA

Estimates or indices of salmon escapement are obtained with a variety of methods such as aerial surveys, capture–recapture experiments, weir counts, and hydroacoustics (sonar). Differences in methods among years can affect the comparability and reliability of data. In the practical arena

of salmon management, fishery biologists try to determine the amount of harvestable surplus and the number of spawners necessary to perpetuate the stock or run, known as the escapement goal.

Escapements of Copper River Chinook salmon, the only Chinook salmon stock in the PWS management area, have been monitored by mark–recapture projects since 1999. Escapements from 1980–1998 were indexed using aerial surveys, but a total abundance estimate was not measured directly. The 1980–1998 estimates used to estimate the escapement goal were estimated using a catch–age model (Deriso et al. 1985; Savereide and Quinn 2004). Chinook salmon are primarily harvested commercially, but are also important for subsistence, personal use, and sport fishers. Annual harvest from the commercial fishery were determined from fish ticket receipts, personal use and subsistence harvests were determined from the return of fishery specific harvest permits, and harvests from the sport fishery were estimated from an annual statewide harvest survey.

Chum salmon escapements are based on expanded counts from aerial surveys that have been conducted since 1965. Streams were flown multiple times each year with escapement estimated through area–under–the–curve calculations adjusted with estimates of stream life (17.5 days; Bue et al. 1998). Catches of most chum salmon have been incidental to harvest of pink salmon throughout Prince William Sound except in terminal areas for returns to hatcheries. Reliable estimates of hatchery contributions to commercial harvests of chum salmon are unavailable before 2003. Likewise, there are no reliable estimates of district of origin for wild stock chum salmon with the possible exception of the Eastern and Southeastern districts.

Escapements have been measured as peak index counts from fixed–wing aerial surveys for 2 coho stocks. Although many streams have been surveyed for each stock over the years, only surveys conducted annually over the same streams were used to evaluate escapement goals: 17 streams in the Copper River Delta surveyed back to 1981 and 7 streams in the Bering River Delta surveyed back to 1984. Coho salmon are primarily harvested commercially, but are also used by subsistence, personal use, and sport fishers.

Since 1960, ADF&G has conducted aerial surveys of selected pink salmon streams to index the spawning escapement in PWS. There are approximately 1,000 pink salmon spawning systems in PWS, of which greater than 200 are surveyed annually. The 208 streams surveyed between 1960 and 1998 represent approximately 20–25% of the anadromous streams in each district and 75–85% of the total spawning escapement (Fried 1994; Fried et al. 1998). Beginning in 1999, additional streams were surveyed in some districts to make the proportion flown similar to other districts and the survey total is now 215 streams. Indices of spawning escapement are estimated using area–under–the–curve methodology and a 17.5–day stream life (Bue et al. 1998). Hatchery produced pink salmon have been returning to PWS since 1977 (Pirtle 1978). Hatchery pink salmon returns have been estimated using wild stock exploitation rates (1977–1986) or mark–recapture methods that employed either coded wire tags or otolith thermal marks (1987–present; Brady et al. 1987; Joyce and Riffe 1998). Since there are no methods to allocate commercial harvests to stream or even district of origin, all analyses were completed on the total wild return by brood line.

The Bering River sockeye salmon aerial index is estimated as the sum of the peak aerial counts from 5 survey sites. All sockeye salmon caught in the Bering River District are assumed to be of Bering River origin. Sockeye salmon escapements into Coghill Lake have been visually counted since 1960. From 1960–1973 escapements were counted using a partial weir and tower with a

full river weir coming into use in 1974. Age compositions from the commercial harvests and escapements have been collected since 1962. The Copper River Delta aerial index is estimated as the sum of the peak aerial counts for 17 index streams (Fried 1994). No adjustments were made for area–under–the–curve or stream life. Estimates of contribution by delta stocks to the Copper River harvests are unavailable. Escapement into Eshamy Lake has been visually counted through a weir since 1931 (Pirtle 1978), but reliable age composition data were not available until 1970; therefore, the spawner–recruit analysis used only complete brood years beginning with 1970 (Bue et al. 2002). Escapements to the Upper Copper River have been monitored at Miles Lake since 1978 with sonar. Beginning in 2005 on the south bank, after a period of comparison, the traditional Bendix side–scan sonar was replaced with dual–frequency identification sonar (DIDSON); this same replacement occurred in 2008 on the north bank. However, even with a reliable measure of escapement, the contribution of the upriver stock to the commercial fishery is not reliably known. Studies in the 1980s based on inherent differences in scale patterns attempted to estimate harvests by stock (Upper Copper River vs. Copper River Delta vs. Bering River stocks); these studies were discontinued because of imprecision in estimates (Marshall et al. 1987).

ESCAPEMENT GOAL RECOMMENDATION

Escapement goals were evaluated for PWS stocks using the following methods: (1) Stock–Recruitment Analysis; (2) Yield Analysis; (3) Percentile Approach; and (4) Risk Analysis. Spawner–return data was used to estimate escapement goals when the committee determined it had "good" estimates of total return (escapement and stock–specific harvest) for a stock. When "good" spawner–return data was available, escapement goals were estimated based on: (1) escapements producing average yields that were 90–100% of MSY from a stock–recruitment model, and (2) the Yield Analysis, explained below, which also estimates MSY with corresponding 90–100% yield range.

Stock–Recruitment Analysis

Complete spawner–return data exists for Eshamy and Coghill Lake sockeye salmon, and districtwide odd– and even–year pink salmon broodlines. Annual runs, the sum of escapements and harvests, were estimated and where quantifiable, sport and subsistence harvests were included in total return estimates.

Spawner–return data were analyzed using a Ricker (1954) stock–recruitment model to estimate MSY and the escapement goal range. Results were not used if the model fit the data poorly ($p \geq 0.20$) or model assumptions were violated. Hilborn and Walters (1992), Quinn and Deriso (1999), and the CTC (1999) provide good descriptions of the Ricker model and diagnostics to assess model fit. All stock–recruitment models were tested and corrected for serial correlation of residuals when necessary. Additionally, the Ricker alpha parameter was corrected for the logarithm transformation bias induced into the model as described in Hilborn and Walters (1992) from fitting a regression line to ln (recruits/spawners) versus spawners.

Yield Analysis

A Markov yield analysis (Hilborn and Walters 1992) was examined to further evaluate the escapement goal range for pink salmon. As in the original 2002 analysis, the yield table was constructed by partitioning the data into overlapping intervals of 200,000 spawners. The mean

number of spawners, mean return, mean return per spawner, mean yield, and the range of yields were calculated for each interval of spawner abundance.

Percentile Approach

The incorporation of contrast in the escapement data and exploitation of the stock to estimate an SEG range was first discussed in Bue and Hasbrouck (*Unpublished)*, referred to as the percentile approach by ADF&G. Percentile ranking is the percent of all escapement values that fall below a particular value. To calculate percentiles, escapement data are ranked from smallest to the largest value, with the smallest value the 0^{th} percentile (i.e., none of the escapement values are less than the smallest). The percentile of all remaining escapement values is a cumulative, or summation, of 1/(n–1), where n is the number of escapement values. Contrast in the escapement data is simply the maximum value divided by the minimum value. As contrast increased, the percentiles used to estimate the SEG were narrowed, primarily from the upper end, while still allowing the SEG to include a wide range of escapements. For exploited stocks with high contrast, the lower end of the SEG range was increased to the 25^{th} percentile as a precautionary measure for stock protection. The percentiles used at different levels of contrast were as follows (Bue and Hasbrouck *Unpublished*):

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

For this review, we re–evaluated the SEG ranges of all appropriate stocks using the percentile approach with updated or revised escapement data. If the estimated SEG range was consistent with the current goal (i.e., a high degree of overlap), the committee recommended no change to the goal.

Risk Analysis

The Risk Analysis was used to set PWS chum salmon SEG thresholds during the 2005 review. Three additional years of data since their inception did not warrant a re–analysis during this review. The Evenson et al. (2008) report fully describes the procedures employed to set these chum salmon goals following the methodology outlined in Bernard et al. (*In prep*). In essence, recommended escapement thresholds were chosen based on minimizing risk for triggering an unwarranted concern and an approximately equal risk of failing to detect the maximum percentage drop in mean escapement.

RESULTS AND DISCUSSION

The escapement goal changed for only one stock in the PWS area (Table 1). All of the data sets were updated (Appendix A) and most were re–evaluated using the methodology originally used in their establishment.

Table 1.–Summary of escapement goals for Copper and Bering rivers and Prince William Sound salmon stocks, 2008.

	Current Goal		Recommended Goal				
System	Goal	Year Adopted	Type	Range	No. Years	Escapement Data	Action
Chinook Salmon							
Copper River	>24,000	2002	SEG	>24,000	9	Mark Recapture	No Change
Coho Salmon							
Bering River	13,000 – 33,000	2002	SEG	13,000 – 33,000	27	Aerial Survey	No Change
Copper River Delta	32,000 – 67,000	2002	SEG	32,000 – 67,000	27	Aerial Survey	No Change
Sockeye Salmon							
Eshamy Lake	20,000 – 40,000	2002	BEG	13,000 – 28,000	32	Weir	Change in Range
Coghill Lake	20,000 – 40,000	2005	SEG	20,000 – 40,000	29	Weir	No Change
Bering River	20,000 – 35,000	2002	SEG	20,000 – 35,000	25	Aerial Survey	No Change
Copper River Delta	55,000 – 130,000	2002	SEG	55,000 – 130,000	27	Aerial Survey	No Change
Upper Copper River	300,000 – 500,000	2002	SEG	300,000 – 500,000	30	Sonar	No Change
Pink Salmon							
Even–Year Broodline (All Districts Combined)							
1,250,000 – 2,750,000		2002	SEG	1,250,000 – 2,750,000	24	Aerial Survey	No Change
Odd–Year Broodline (All Districts Combined)							
1,250,000 – 2,750,000		2002	SEG	1,250,000 – 2,750,000	24	Aerial Survey	No Change
Chum Salmon (by District)							
Coghill	8,000 and up	2005	SEG	8,000 and up	43	Aerial Survey	No Change
Eastern	50,000 and up	2005	SEG	50,000 and up	43	Aerial Survey	No Change
Northern/Unakwik	20,000 and up	2005	SEG	20,000 and up	43	Aerial Survey	No Change
Northwestern	5,000 and up	2005	SEG	5,000 and up	43	Aerial Survey	No Change
Southeastern	8,000 and up	2005	SEG	8,000 and up	38	Aerial Survey	No Change

CHINOOK SALMON

Copper River

We recommend the SEG of 24,000 or more spawners established in 2002 (Bue et al. 2002) remain unchanged. The review team recommends the fishery be managed for escapements that on average match the average escapement of 27,000 since 1980 as determined from model estimates using catch–age analysis and from mark–recapture estimates (Savereide and Evenson *In prep*). Since 1999, mark–recapture techniques along with estimates of inriver harvest have been used to estimate total drainage escapement to evaluate whether the escapement goal has been reached and to validate and refine model estimates of escapement. Escapement estimates have had low contrast (covered a narrow range), that indicates past escapements were within a

range too narrow to provide information sufficient for estimating a stock–recruitment relationship, and hence a BEG. However, the average escapement since 1980 (~27,000 salmon) has produced an average annual harvest near 48,000 salmon. No new information on production by this stock will be forthcoming until escapements move higher than observed in the recent past. Most estimates of escapement since 1980 have been less than 40,000 Chinook salmon. Recent measured estimates have ranged from 16,000–58,000 Chinook salmon and the escapement goal has been met six out of nine years since 1999 (Appendix A1). The threshold SEG was chosen to keep future escapements near the historical average without precluding the possibility that exceptionally large runs will provide new information with higher escapements. The review committee viewed this threshold as a minimum escapement to be met and not a management target. Without sufficient information regarding production from large escapements, no meaningful upper bound could be set for the SEG.

CHUM SALMON

In 2002, all escapement goals for PWS chum salmon were changed from BEGs to SEGs (Bue et al. 2002), and two goals, Montague and Southwestern District chum salmon, were removed from the list of existing goals. The Unakwik District (part of the Northern District until 1989) does not contain any chum salmon index streams and no goal was created. Current goals exist for Coghill, Eastern, Northern/Unakwik, Northwestern, and Southeastern districts.

Precautionary reference points, known as sustainable escapement goal (SEG) thresholds, were estimated using risk analysis as described in Bernard et al. (*In prep*) during the 2005 review (Evenson et al. 2008) for Coghill, Eastern, Northern/Unakwik, Northwestern, and Southeastern districts using historical aerial indices of escapement. The risk analysis approach worked well for PWS chum salmon because of the inability to determine district of origin for wild–stock harvests, the lack of hatchery contribution estimates before 2003, and because most fisheries do not target and are not managed for chum salmon. The nature of the risk analysis approach does not lend itself to a necessary update with every 3 years of additional data (Appendix A2); therefore we did not re–analyze the data for this review.

COHO SALMON

Copper River Delta and Bering River

We recommend the SEG of 13,000–33,000 spawners for Bering River and the SEG of 32,000–67,000 spawners for Copper River Delta established in 1991 (Fried 1994) and adopted as an SEG in 2002 (Bue et al. 2002) remain unchanged. With updated information through 2007 (Appendices A3–A4) and using the traditional percentile approach, the Bering River percentile range is similar (18,000–32,000) to the existing SEG. Likewise, the updated Copper River Delta percentile range is similar (32,000–64,000) to the existing SEG. Lack of stock–specific harvest information and index measurements of escapement (peak aerial survey counts) preclude development of a spawner–recruit relationship and hence a BEG.

PINK SALMON

No changes to the PWS pink salmon SEGs are recommended for 2008. In 2002, escapement goals for PWS pink salmon were changed from BEGs to SEGs, and a Sound–wide goal of 1,250,000–2,750,000 for both the even- and odd–year brood lines was established (Bue et al. 2002). Although a Sound–wide goal was established, the fishery will be managed to distribute

the goal to the fishing districts similar to the historical escapement distribution. An extensive review of data and methodology was conducted in 2002, and the goals established were based on examination of Markov yield tables for each brood line (Bue et al. 2002). In the 2008 review, no new analytical methods were suggested so we only updated the Markov yield tables for each brood line (Appendices A5–A6). Based on the yield analysis, there does not appear to be evidence for a change in the SEG.

SOCKEYE SALMON

Bering River

No change in the Bering River sockeye salmon SEG is recommended for 2008. The SEG of 20,000–35,000 aerial index points was established in 2002 using the method of Bue and Hasbrouck (*Unpublished*). With updated information through 2007 and using the traditional percentile approach, the Bering River percentile range is similar (21,000–32,000) to the existing SEG (Appendix A7).

Coghill Lake

We recommend the escapement goal of 20,000–40,000 spawners established in 2002 (Bue et al. 2002) as a BEG and modified to an SEG in 2005 (Evenson et al. 2008) remain the same. A series of large escapements greater than 100,000 from 1980–1982 produced returns per spawner greater than 3.0. However, escapements from brood years 1985–1989, including some additional escapements >100,000 spawners, did not replace themselves (less than 1.0 return per spawner). Edmundson et al. (1992) suggests that poor production from the 1985–1989 brood years was due to grazing pressure of high densities of sockeye salmon fry resulting in low densities of cyclopoid copepods. Because of the apparent reduced productivity, the lake was fertilized (1993–1996) to increase the zooplankton abundance. Additionally, the outmigrating smolt abundance was estimated in 1989–1991 and 1993–1997. Although the mean number of smolt increased significantly after fertilization (from ~263 thousand before fertilization to ~940 thousand after fertilization), the mean size of the outmigrating smolt remained less than 1.5 g (Edmundson et. al. 1997). Multiple studies suggest that the Ricker model estimate of spawners required for maximum sustained yield (S_{MSY}) may be too high for the forage base (Edmundson et al. 1997; Koenings and Kyle 1997).

For this review we updated the available brood data (Appendix A8) but did not re–analyze stock–recruitment or yield models, since they were not used to derive the existing SEG.

Copper River Delta

No change in the Copper River Delta sockeye salmon SEG is recommended for 2008. The current SEG of 55,000–130,000 aerial index points was established in 2002 (Bue et al. 2002) using the method of Bue and Hasbrouck (*Unpublished*). In 2002, the review team recommended that the fishery be managed for escapements that on average match the historical average escapement of 84,500. With updated information through 2007 and using the percentile approach, the Copper River Delta percentile range is similar (58,000–98,000) to the existing SEG (Appendix A9). Although the difference for the upper bound of the range between the current goal (130,000) and the updated goal (98,000) is 32,000 fish, the committee does not believe the goal should be changed at this time since such a change will have little, if any, impact on the management of the fishery because (a) escapements greater than 100,000 have not been

realized since 1985 and (b) since Copper River Delta sockeye salmon are assessed by aerial survey throughout the season, a final estimate of escapement will not occur until late in the fishery or after it has closed.

Eshamy Lake

We recommend the BEG of 20,000–40,000 spawners established in 2002 (Bue et al. 2002) be modified to a range of 13,000–28,000. Since the 2005 review, three additional brood years (2000–2002) produce a substantial change in S_{MSY} using a Ricker stock–recruitment model. As such, the estimate of S_{MSY} (19,622) has dropped below the lower range of the current BEG. To develop a revised BEG range based on the most recent stock–recruitment information we bootstrapped (1,000 replications) the residuals of the Ricker model to estimate the uncertainty of all parameters and calculations, including the range that produces 90% or more of MSY. The outcome is an estimate of the probability of achieving 90% or more of MSY for a range of escapements (Appendix A10). Given the strong defining shape of the 90% probability curve and the desire to include S_{MSY} within the range, we believe that an appropriate BEG is 13,000–28,000. Escapements within this range have a probability greater than 50% of producing returns at least 90% of MSY.

Upper Copper River

No change in the upper Copper River sockeye salmon SEG is recommended for 2008. The SEG of 300,000–500,000 spawners was established in 2002 using the method of Bue and Hasbrouck (*Unpublished*). In 2002, the review team recommended that the fishery be managed for escapements that on average match the historical average escapement of 361,000. With updated information through 2007 and using the traditional percentile approach, the Upper Copper River percentile range is similar (306,000–547,000) to the existing SEG (Appendix A11). The large runs from 2005 to 2007 resulted in escapements greater than 500,000, which increased the upper range bound of the updated goal. However, this effect of the recent large runs does not warrant a revision to the goal at this juncture.

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APPENDIX A: SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR SALMON STOCKS IN THE COPPER RIVER, BERING RIVER, AND PRINCE WILLIAM SOUND AREA

Appendix A1.–Supporting information for analysis of escapement goal for Copper River Chinook salmon.

System: Copper River
Species: Chinook salmon

Data available for analysis of escapement goals.

Brood Year	Measured Escapement[a]	Modeled Escapement[b]	Total Return[c]
1980	ND	22,951	37,682
1981	ND	17,895	42,458
1982	ND	20,280	69,678
1983	ND	22,066	84,204
1984	ND	31,667	74,096
1985	ND	8,481	56,541
1986	ND	36,396	82,371
1987	ND	28,054	74,827
1988	ND	22,310	59,762
1989	ND	45,747	79,020
1990	ND	28,753	54,848
1991	ND	28,346	72,264
1992	ND	14,509	63,223
1993	ND	17,517	59,240
1994	ND	20,002	79,350
1995	ND	14,115	94,101
1996	ND	32,461	99,471
1997	ND	49,761	115,090
1998	ND	33,938	118,624
1999	16,294	ND	95,895
2000	24,492	ND	70,741
2001	28,208	ND	81,063
2002	21,502	ND	72,958
2003	34,034	ND	94,271
2004	30,628	ND	80,405
2005	21,607	ND	66,039
2006	58,489	ND	99,639
2007	34,634	ND	87,675

[a] Estimated by mark–recapture experiment.

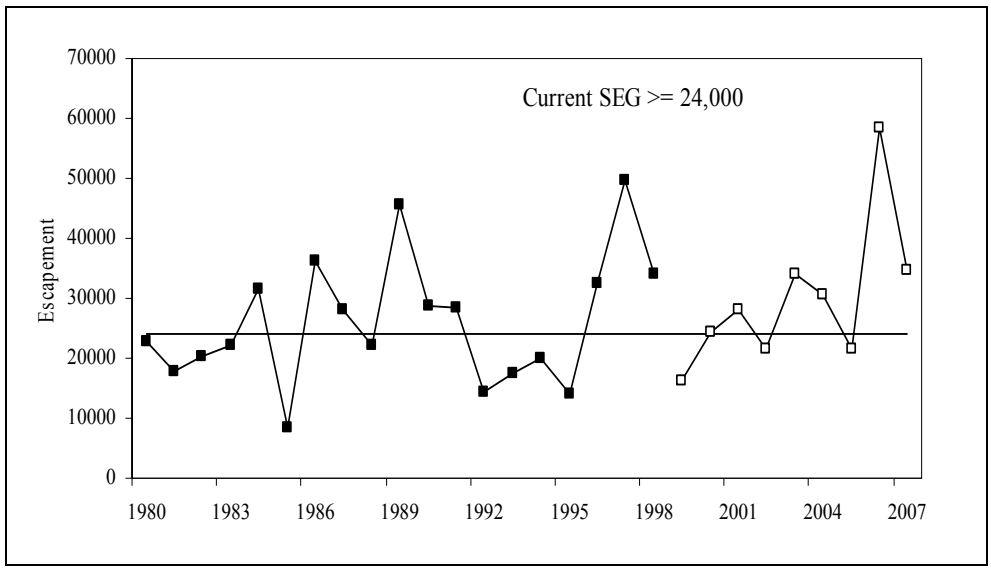
[b] From age–structured model.

[c] Total return estimated by age–structured model from 1980–1998 and from mark–recapture estimates of escapement and subsistence, sport, and commercial harvest information since 1999.

–continued–

System: Copper River
Species: Chinook salmon

Estimated escapement by year, estimated with an age–structured model (closed boxes) and mark–recapture experiment (open boxes), and current SEG (solid line).



Appendix A2.–Supporting information for analysis of escapement goal for Prince William Sound chum salmon.

System: Prince William Sound
Species: chum salmon

Data available for analysis of escapement goals.

	Wild Escapements [a]				
Year	Eastern	Northern	Coghill	Northwestern	Southeastern
1965	69,180	20,980	20,768	18,907	ND
1966	75,690	24,870	10,540	5,770	ND
1967	74,570	23,270	7,450	1,670	ND
1968	48,960	10,620	8,780	800	ND
1969	58,690	17,340	8,410	780	ND
1970	34,430	4,020	11,880	2,720	7,950
1971	49,730	11,870	6,600	5,600	6,450
1972	112,950	70,760	28,160	22,980	26,990
1973	213,170	140,030	72,610	13,250	48,080
1974	72,010	55,510	29,280	6,580	3,200
1975	30,040	8,910	3,640	430	2,850
1976	16,260	29,430	25,670	8,300	770
1977	47,880	48,600	43,940	10,090	8,280
1978	90,250	27,480	18,160	12,940	6,550
1979	42,630	17,320	6,330	8,770	5,140
1980	26,720	27,880	23,340	3,060	6,710
1981	71,560	28,670	2,050	15,130	16,010
1982	146,120	68,580	22,130	21,880	25,260
1983	143,800	85,720	61,410	31,660	21,410
1984	129,190	59,080	19,690	7,920	8,650
1985	111,310	33,410	22,140	13,290	4,470
1986	126,690	50,740	13,140	17,420	8,830
1987	183,620	38,700	24,510	26,460	44,020
1988	258,560	75,420	39,240	40,780	66,930
1989	112,080	46,470	22,680	27,430	22,640
1990	115,100	112,480	26,020	37,020	7,275
1991	86,360	19,080	6,070	8,960	9,203
1992	48,804	12,903	10,003	11,072	3,881
1993	54,102	24,975	8,430	18,966	19,172
1994	40,476	23,942	14,176	12,992	4,057
1995	75,655	28,899	11,596	4,883	23,200
1996	137,908	55,568	19,669	24,405	47,334
1997	93,146	19,429	3,101	8,387	43,274
1998	86,227	28,867	22,764	7,553	52,103
1999	242,713	36,691	5,057	4,544	36,181
2000	196,253	23,655	20,488	10,150	34,969
2001	198,683	75,473	13,388	6,373	37,526
2002	94,046	30,531	7,430	16,194	104,906
2003	198,921	44,272	19,729	12,736	116,131
2004	108,833	42,456	9,685	10,371	42,344
2005	113,135	30,657	11,979	12,696	25,547
2006	109,403	52,069	15,900	25,860	26,739
2007	123,814	49,669	14,052	10,778	60,464

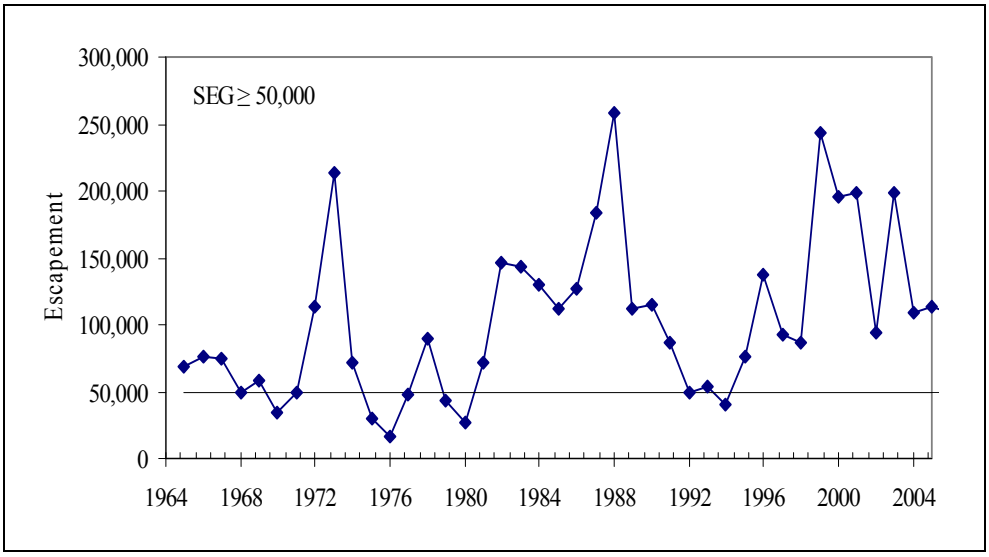
[a] The chum salmon escapement index is the area under the curve of weekly aerial survey counts adjusted for 17.5 days stream life.

–continued–

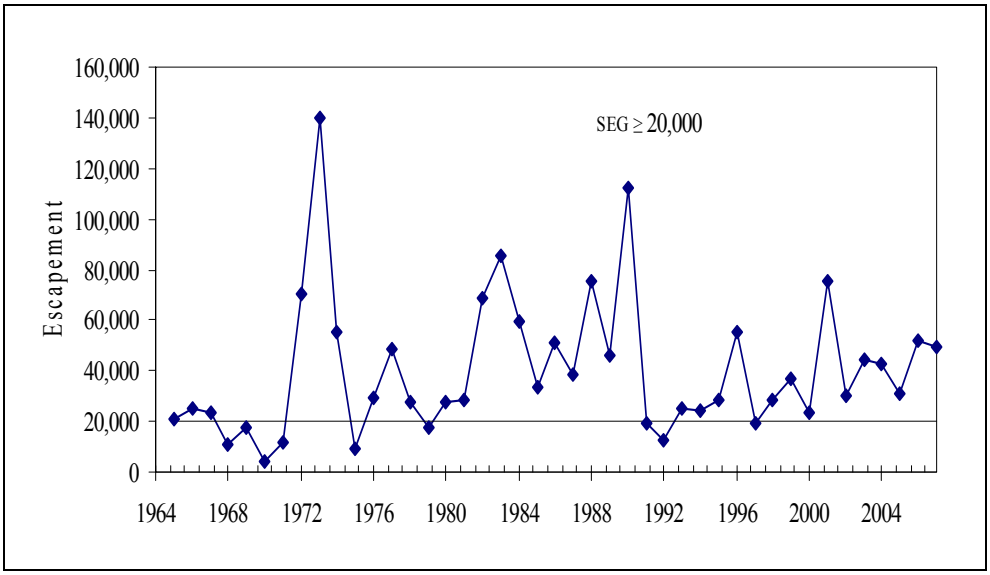
System: (a) Eastern District; (b) Northern; (c) Coghill; (d) Northwestern; (e) Southeastern
Species: chum salmon

Observed escapement by year (blocked line) and current SEG range (solid line).

(a)



(b)



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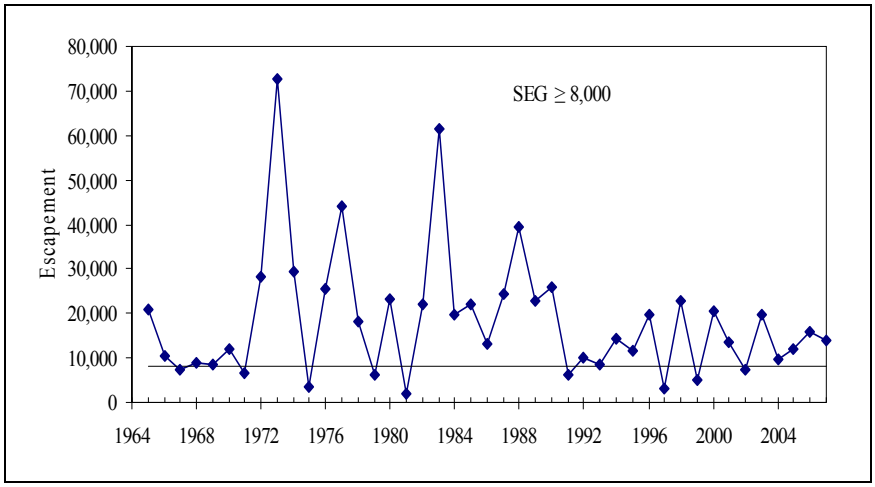
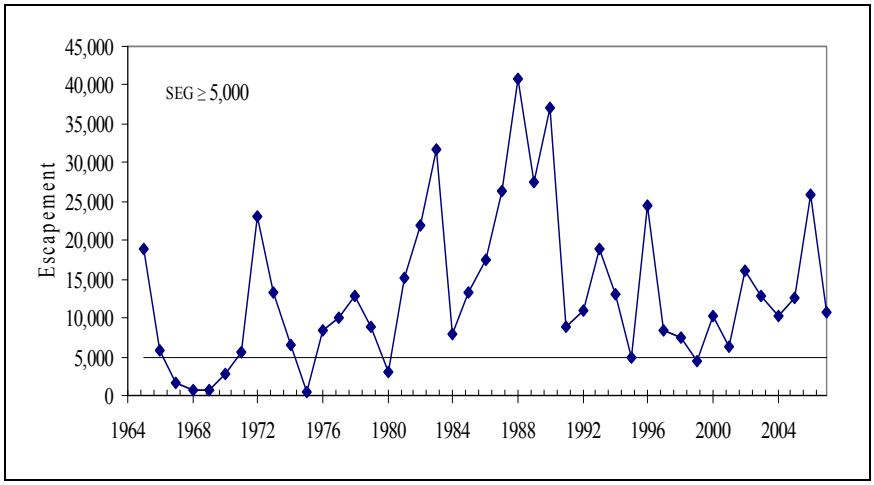
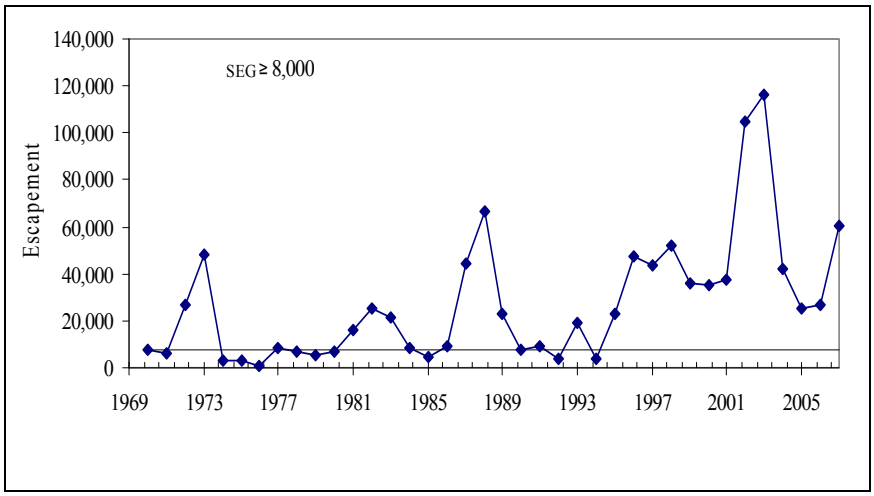
(c)


SEG ≥ 8,000
Escapement
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
2004

(d)


SEG ≥ 5,000
Escapement
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
2004

(e)


SEG ≥ 8,000
Escapement
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005

Appendix A3.–Supporting information for analysis of escapement goal for Bering River Delta coho salmon.

System: Bering River Delta
Species: coho salmon

Data available for analysis of escapement goals.

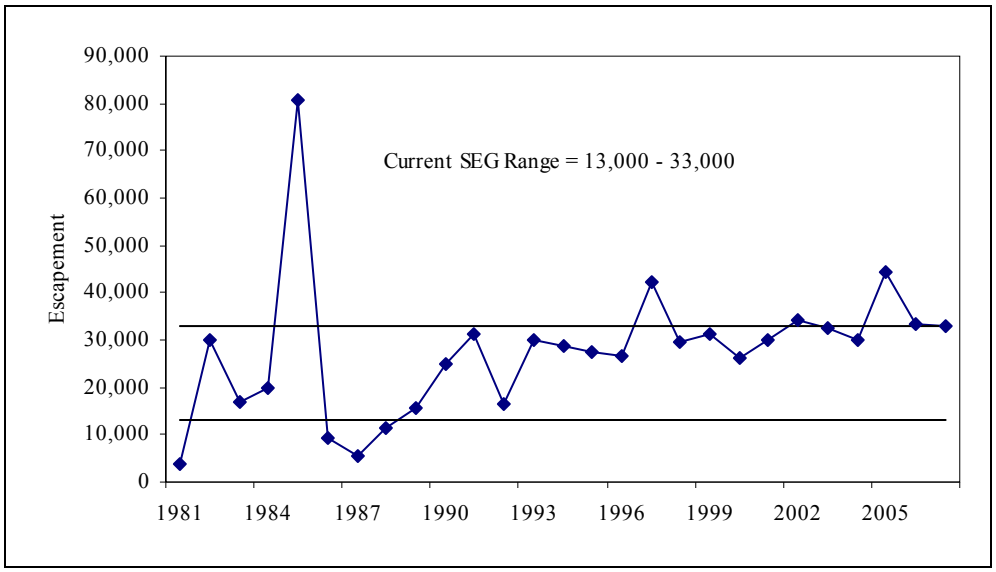
Return Year	Wild Escapement[a]	Harvest		Total Run[c]
		Commercial	Sport[b]	
1981	3,600	82,626	ND	86,226
1982	30,000	144,752	ND	174,752
1983	16,700	117,669	ND	134,369
1984	20,000	214,632	ND	234,632
1985	80,500	419,276	ND	499,776
1986	9,420	115,809	ND	125,229
1987	5,585	15,864	ND	21,449
1988	11,415	86,539	ND	97,954
1989	15,535	26,952	ND	42,487
1990	24,800	42,952	ND	67,752
1991	31,300	110,951	ND	142,251
1992	16,300	125,616	ND	141,916
1993	30,050	115,833	ND	145,883
1994	28,550	259,003	ND	287,553
1995	27,450	282,045	ND	309,495
1996	26,800	93,763	ND	120,563
1997	42,400	97	ND	42,497
1998	29,750	12,284	ND	42,034
1999	31,290	9,852	ND	41,142
2000	26,380	56,329	ND	82,709
2001	30,007	2,715	ND	32,722
2002	34,200	108,522	ND	142,722
2003	32,475	59,481	ND	91,956
2004	30,185	95,595	ND	125,780
2005	44,542	43,0301	ND	87,572
2006	33,192	56,713	ND	89,905
2007	32,962	9,305	ND	42,267

[a] Calculated as peak aerial survey from the 7 primary index systems.
[b] There are no sport fish harvest estimates for the Bering River drainage.
[c] Escapement plus total harvest.

–continued–

System: Bering River Delta
Species: coho salmon

Observed escapement by year (blocked line) and current SEG range (solid line).



Appendix A4.–Supporting information for analysis of escapement goal for Copper River Delta coho salmon.

System: Copper River Delta
Species: coho salmon

Data available for analysis of escapement goals.

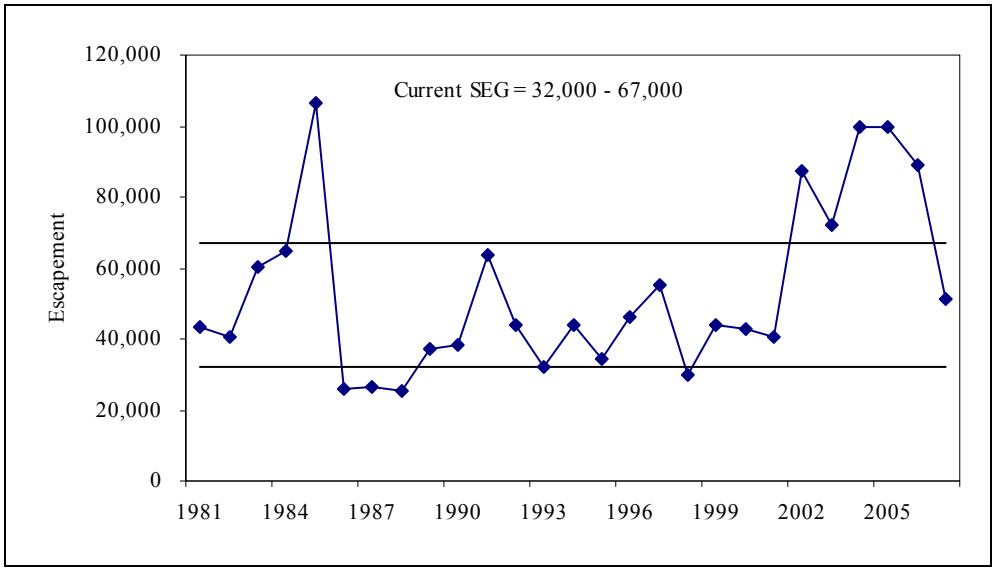
Return Year	Wild Escapement[a]	Harvest		Total Run[c]
		Commercial	Sport[b]	
1981	43,300	225,299	ND	268,599
1982	40,325	310,154	ND	350,479
1983	60,050	454,763	84	514,897
1984	64,525	234,243	1,780	300,548
1985	106,410	382,432	649	489,491
1986	25,790	295,980	2,969	324,739
1987	26,465	111,599	1,010	139,074
1988	25,220	315,568	1,492	342,280
1989	37,036	194,454	2,118	233,608
1990	38,436	246,797	1,778	287,011
1991	63,656	385,086	1,941	450,683
1992	44,013	291,627	3,854	339,494
1993	31,870	281,469	4,139	317,478
1994	43,955	677,633	4,293	725,881
1995	34,480	542,658	2,543	579,681
1996	46,110	193,042	5,750	244,902
1997	55,360	18,656	2,825	76,841
1998	30,000	108,232	4,230	142,462
1999	43,725	153,061	6,978	203,764
2000	42,830	304,944	4,479	352,253
2001	40,331	251,473	12,144	303,948
2002	87,415	504,223	6,909	598,547
2003	72,055	363,489	14,443	449,987
2004	99,505	467,859	14,643	582,007
2005	99,682	263,465	10,240	373,387
2006	89,070	318,285	5,745	413,100
2007	51,215	117,182	7,823	176,220

[a] Calculated as peak aerial survey from the 17 primary index systems.
[b] From state–wide harvest survey.
[c] Escapement plus total harvest.

–continued–

System: Copper River Delta
Species: coho salmon

Observed escapement by year (blocked line) and current SEG range (solid line).



Appendix A5.–Supporting information for analysis of escapement goal for Prince William Sound pink salmon even–year broodline (all districts combined).

System:	Prince William Sound
Species:	pink salmon
Stock Unit:	even year

Data available for analysis of escapement goals.

Brood Year	Wild Escapement[a]	Intertidal Fry Density[b]	Yield[c]
1960	1,350,722	ND	7,409,604
1962	2,018,010	146.74	4,030,566
1964	1,841,680	116.71	2,280,908
1966	1,423,170	80.98	2,185,508
1968	1,156,510	187.38	2,632,706
1970	979,220	123.10	(283,257)
1972	641,180	99.20	765,713
1974	958,120	157.30	2,987,135
1976	926,260	179.90	2,897,594
1978	1,145,010	237.23	13,067,293
1980	1,671,940	164.73	14,671,058
1982	2,274,570	327.37	19,571,165
1984	4,031,860	200.67	1,764,097
1986	960,220	221.61	906,716
1988	964,530	242.97	13,454,166
1990	1,325,852	176.72	862,358
1992	555,105	61.60	8,889,016
1994	1,413,184	221.24	6,240,973
1996	1,483,336	ND	4,257,643
1998	1,420,105	ND	6,086,528
2000	1,659,028	ND	(393,986)
2002	943,177	ND	3,957,586
2004	1,996,223	ND	908,317
2006	1,187,595	ND	936,366

[a] The pink salmon escapement index is estimated from the area under the curve of weekly aerial survey counts adjusted for 17.5 days stream life.

[b] Intertidal fry density was measured as the number of live eggs and fry per m2 of intertidal stream bottom. Fry densities were last estimated in spring, 1995.

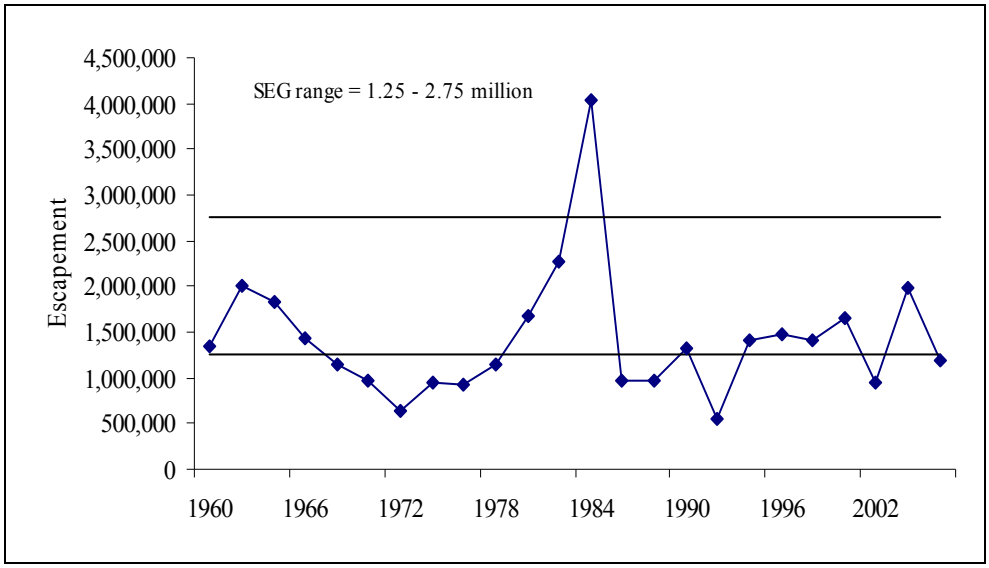
[c] Yield is total brood year return minus brood year escapement. Total wild pink salmon harvest was estimated by subtracting coded–wire tag (CWT) and thermally marked otolith hatchery estimates from total CPF harvest.

–continued–

System: Prince William Sound
Species: pink salmon
Stock Unit: even year

(a) Observed escapement by year (blocked line) and recommended SEG range (solid line)
(b) Markov yield table

(a)



(b)

Even Brood Years (1960–2004)

Escapement Interval	n	Average Escapement	Average Returns	Average R/S	Average Yield
0.50–1.00	8	0.87	5.06	6.28	4.20
0.75–1.25	8	1.00	5.96	5.84	4.95
1.00–1.50	8	1.34	6.68	5.12	5.34
1.25–1.75	8	1.47	6.63	4.47	7.03
1.50–2.00	4	1.79	5.90	3.43	4.11
1.75–2.25	3	1.95	4.01	2.06	2.06
> 2.00	3	2.77	11.23	4.68	8.46

Appendix A6.–Supporting information for analysis of escapement goal for Prince William Sound pink salmon–odd year broodline (all districts combined).

District:	Prince William Sound
Species:	pink salmon
Stock Unit:	odd year

Data available for analysis of escapement goals.

Brood Year	Wild Escapement[b]	Intertidal Fry Density[c]	Yield[d]
1961	2,198,980	285.09	4,452,138
1963	1,355,740	251.38	2,080,687
1965	975,956	197.98	2,492,644
1967	842,260	136.81	4,390,889
1969	404,570	254.65	8,018,944
1971	1,112,550	118.07	2,169,338
1973	1,225,010	162.85	4,493,355
1975	1,265,560	311.24	4,120,507
1977	1,298,170	305.21	15,977,422
1979	2,217,280	356.67	18,009,653
1981	1,713,080	537.15	9,148,037
1983	2,163,100	364.75	18,051,533
1985	2,621,330	372.96	10,860,291
1987	1,466,240	285.81	5,338,102
1989 [a]	1,272,770	270.56	8,022,686
		330.00	
1991	1,837,165	212.54	1,029,203
1993	1,066,469	220.30	2,325,832
1995	1,190,184	242.75	3,199,402
1997	1,422,688	ND	7,991,096
1999	2,462,871	ND	6,364,497
2001	2,000,386	ND	5,389,311
2003	2,857,289	ND	1,675,119
2005	4,745,377	ND	7,551,127
2007	1,509,133	ND	8,537,763

[a] Two rounds of fry digs were completed due to the *Exxon Valdez* oil spill.

[b] The pink salmon escapement index is the area under the curve of weekly aerial survey counts adjusted for 17.5 days stream life.

[c] Intertidal fry density was measured as the number of live eggs and fry per m^2 of intertidal stream bottom. Fry densities were last estimated in spring, 1995.

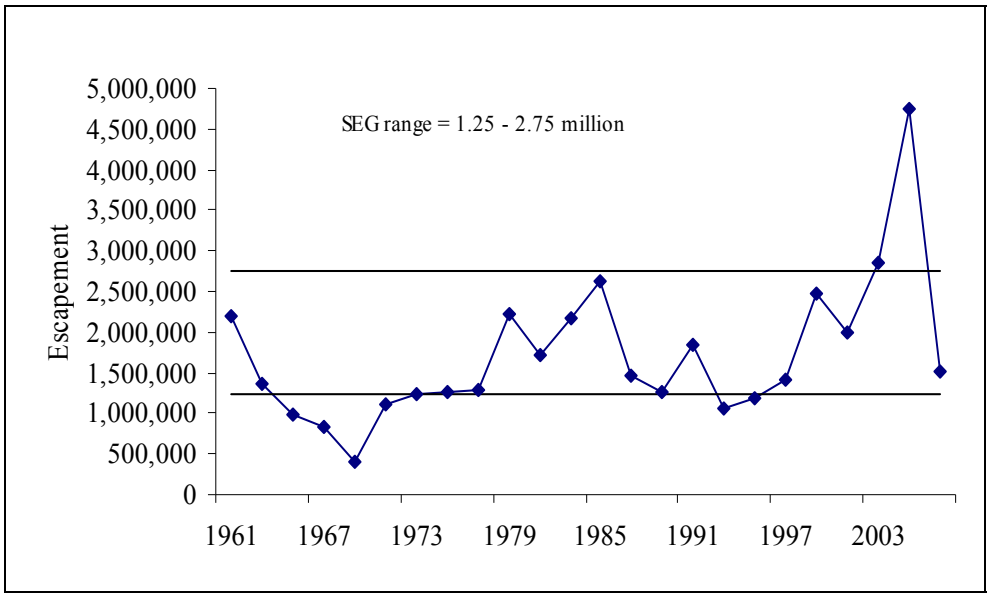
[d] Yield is total brood year return minus brood year escapement. Total wild pink salmon harvest was estimated by subtracting coded–wire tag (CWT) and thermally marked otolith hatchery estimates from total CPF harvest.

–continued–

District: Prince William Sound
Species: pink salmon
Stock Unit: odd year

(a) Observed escapement by year (blocked line) and recommended SEG range (solid line)
(b) Markov yield table

(a)



(b)

Odd Brood Years (1961–2005)

Escapement Interval	n	Average Escapement	Returns	R/S	Yield
0.0–1.00	3	0.74	5.71	10.20	4.97
0.75–1.25	6	1.07	4.25	4.04	3.18
1.00–1.50	10	1.27	6.84	5.31	5.57
1.25–1.75	7	1.40	8.92	6.43	7.53
1.50–2.00	3	1.85	7.04	3.86	5.19
1.75–2.25	5	2.08	11.47	5.35	9.39
2.00–2.50	5	2.21	12.66	5.75	10.45
> 2.25	4	3.17	12.32	4.21	9.15

Appendix A7.–Supporting information for analysis of escapement goal for Bering River sockeye salmon.

System: Bering River
Species: sockeye salmon

Data available for analysis of escapement goals.

Return Year	Wild Escapement[b]	CPF Harvest	Total Run[c]
1983 [a]	41,200	179,273	–
1984 [a]	48,500	91,784	–
1985 [a]	24,300	26,561	–
1986	18,975	19,038	38,013
1987	26,525	16,926	43,451
1988	13,330	7,152	20,482
1989	23,300	9,225	32,525
1990	19,741	8,332	28,073
1991	32,220	19,181	51,401
1992	55,895	19,721	75,616
1993	27,725	33,951	61,676
1994	26,550	27,926	54,476
1995	33,450	21,585	55,035
1996	27,310	37,712	65,022
1997	13,065	9,651	22,716
1998	23,400	8,439	31,839
1999	46,195	13,697	59,892
2000	24,220	1,279	25,499
2001	8,423	5,450	13,873
2002	24,715	235	24,950
2003	32,840	18,266	51,106
2004	25,135	13,165	38,300
2005	30,890	77,465	108,355
2006	14,671	36,867	51,538
2007	21,170	16,470	37,640

[a] Before 1986 Kayak Island Subdistrict was included in total harvest inflating total run estimates. Therefore, total run data is only shown since 1986.

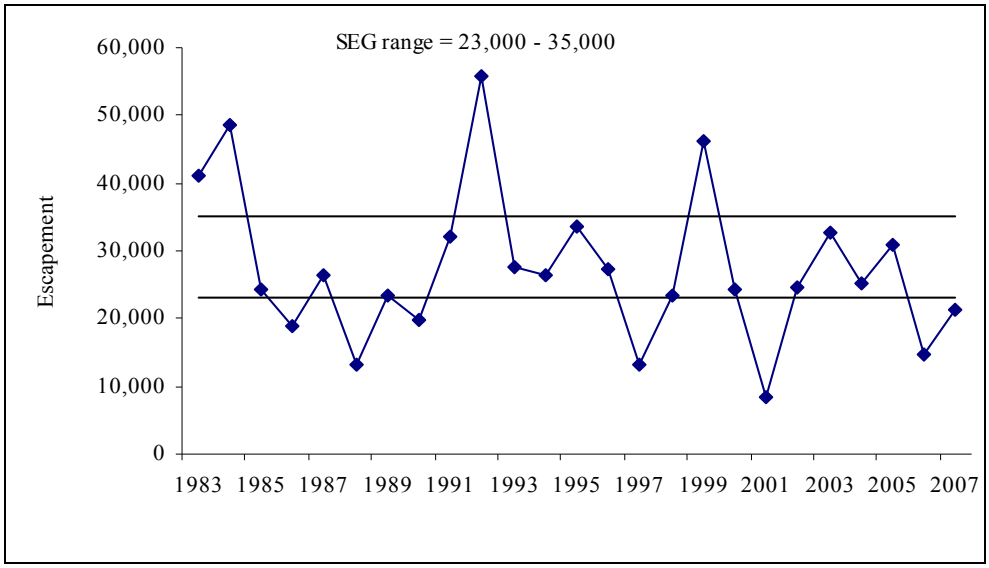
[b] Calculated as peak aerial survey from the 7 primary index systems.

[c] Wild escapement plus CPF harvest.

–continued–

System: **Bering River**
Species: **sockeye salmon**

Observed escapement by year (blocked line) and current SEG range (solid line).



Appendix A8.–Supporting information for analysis of escapement goal for Coghill Lake sockeye salmon.

System: Coghill Lake
Species: sockeye salmon

Data available for analysis of escapement goals.

Brood Year	Wild Escapement	BY Total Return[b]	R/S	Yield[c]
1962 [a]	26,866	54,521	2.0	27,655
1963 [a]	63,984	63,949	1.0	(35)
1964 [a]	22,200	163,131	7.3	140,931
1965 [a]	62,500	77,666	1.2	15,166
1966 [a]	82,500	86,158	1.0	3,658
1967 [a]	33,000	153,333	4.6	120,333
1968 [a]	11,800	137,509	11.7	125,709
1969 [a]	81,000	91,749	1.1	10,749
1970 [a]	35,200	220,867	6.3	185,667
1971 [a]	15,000	46,728	3.1	31,728
1972 [a]	51,000	218,569	4.3	167,569
1973 [a]	55,000	233,689	4.2	178,689
1974	22,334	110,825	5.0	88,491
1975	34,855	191,529	5.5	156,674
1976	9,056	173,531	19.2	164,475
1977	31,562	1,251,048	39.6	1,219,486
1978	42,284	70,303	1.7	28,019
1979	48,281	150,407	3.1	102,126
1980	142,253	473,656	3.3	331,403
1981	156,112	496,238	3.2	340,126
1982	180,314	612,159	3.4	431,845
1983	38,783	106,297	2.7	67,514
1984	63,622	203,086	3.2	139,464
1985	163,342	16,598	0.1	(146,744)
1986	74,135	26,918	0.4	(47,217)
1987	187,263	60,053	0.3	(127,210)
1988	72,023	50,495	0.7	(21,528)
1989	36,881	9,410	0.3	(27,471)
1990	8,250	26,127	3.2	17,877
1991	9,701	153,809	15.9	144,108
1992	29,642	114,128	3.9	84,486
1993	9,232	67,501	7.3	58,269
1994	7,264	27,940	3.8	20,676
1995	30,382	317,501	10.5	287,119
1996	38,693	133,377	3.4	94,684
1997	35,010	44,736	1.3	9,726
1998	27,050	89,490	3.3	62,440
1999	59,311	234,831	4.0	175,520
2000	28,446	143,849	5.1	115,403
2001	38,547	15,616	0.4	(22,931)
2002	28,323	177,343	6.3	149,020
2003	75,427	–	–	–
2004	30,569	–	–	–
2005	30,313	–	–	–
2006	23,479	–	–	–
2007	70,001	–	–	–

[a] A partial weir and tower were used to enumerate sockeye salmon escapement into Coghill Lake.

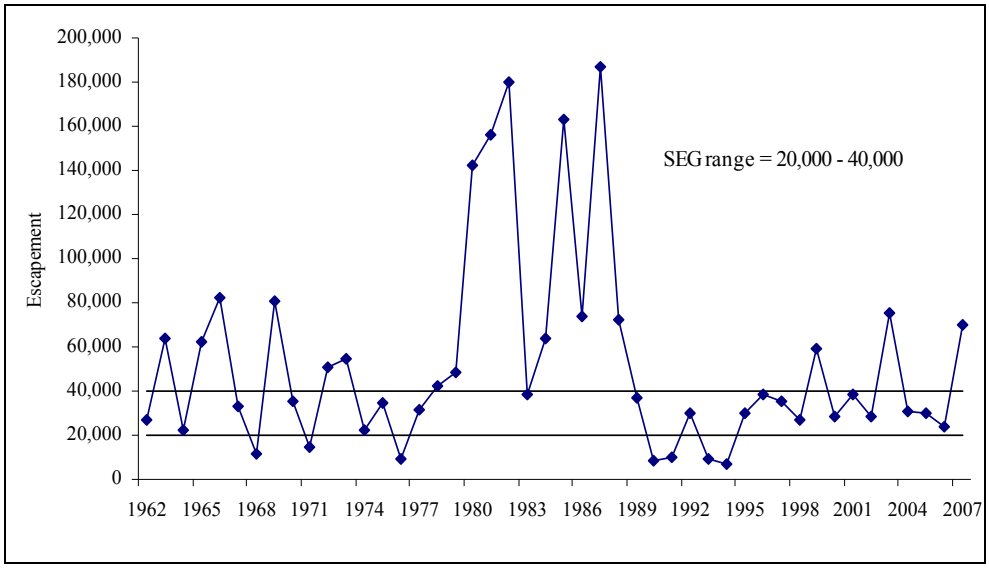
[b] Total return was calculated as Coghill Lake weir escapement plus total Coghill District CPF harvest wild contributions plus sockeye salmon harvested in the Eshamy District prior to the timing of Eshamy Lake wild sockeye salmon.

[c] Yield is total brood year return minus brood year escapement.

–continued–

System: Coghill Lake
Species: sockeye salmon

Observed escapement by year (blocked line) and current SEG range (solid line)



Appendix A9.–Supporting information for analysis of escapement goal for Copper River Delta sockeye salmon.

System:	Copper River Delta
Species:	sockeye salmon

Data available for analysis of escapement goals.

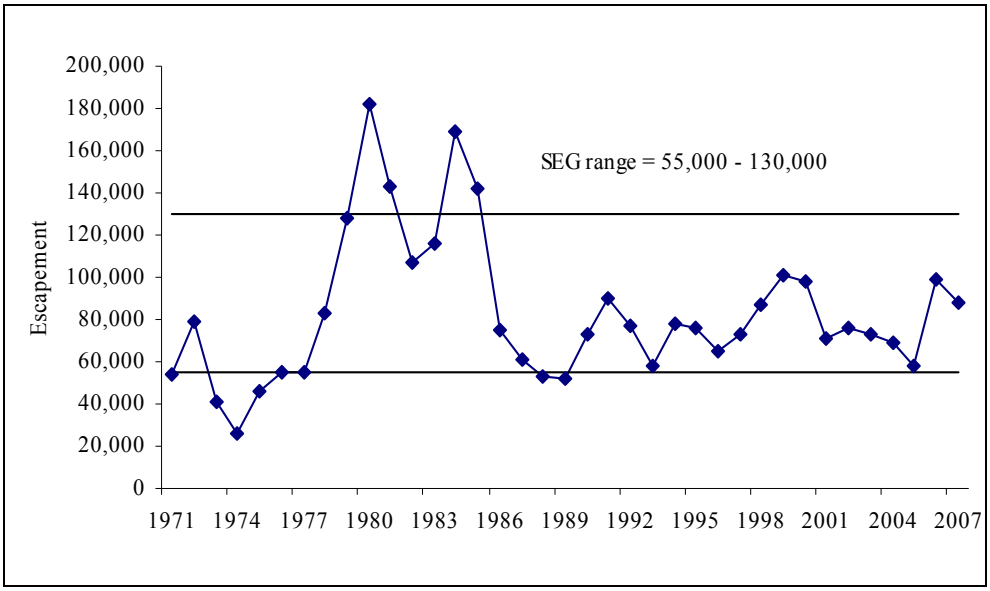
Brood Year	Escapement[a]
1971	53,647
1972	78,942
1973	40,970
1974	25,651
1975	46,475
1976	55,450
1977	55,144
1978	83,469
1979	127,900
1980	181,750
1981	143,050
1982	106,770
1983	115,750
1984	168,840
1985	142,050
1986	75,295
1987	60,698
1988	53,315
1989	51,700
1990	73,345
1991	90,500
1992	76,827
1993	57,720
1994	78,370
1995	76,370
1996	65,470
1997	72,563
1998	87,500
1999	100,925
2000	98,045
2001	71,065
2002	75,735
2003	73,150
2004	69,385
2005	58,406
2006	98,896
2007	88,285

[a] Escapement calculated as the peak aerial counts from 17 survey sites.

–continued–

System: Copper River Delta
Species: sockeye salmon

Observed escapement by year (blocked line) and current SEG range (solid line)



Appendix A10.–Supporting information for analysis of escapement goal for Eshamy Lake sockeye salmon.

System: Eshamy Lake
Species: sockeye salmon

Data available for analysis of escapement goals.

Brood Year	Wild Escapement	BY Total Return[b]	R/S	Yield[c]
1970	11,460	11,690	1.02	230
1971	954	6,667	6.99	5,713
1972	28,683	59,976	2.09	31,293
1973	10,202	34,411	3.37	24,209
1974	633	15,946	25.19	15,313
1975	1,724	31,355	18.19	29,631
1976	19,367	178,061	9.19	158,694
1977	11,746	38,453	3.27	26,707
1978	12,580	36,904	2.93	24,324
1979	12,169	39,724	3.26	27,555
1980	44,263	270,623	6.11	226,360
1981	23,048	30,841	1.34	7,793
1982	6,782	51,290	7.56	44,508
1983	10,348	51,162	4.94	40,814
1984	36,121	117,761	3.26	81,640
1985	26,178	58,163	2.22	31,985
1986	6,949	39,946	5.75	32,997
1987[a]	ND	–	–	–
1988	31,747	93,876	2.96	62,129
1989	57,106	70,390	1.23	13,284
1990	14,191	58,447	4.12	44,256
1991	45,814	23,930	0.52	–21,884
1992	30,627	24,468	0.80	–6,159
1993	34,657	61,820	1.78	27,163
1994	23,910	54,750	2.29	30,840
1995	15,292	27,986	1.83	12,694
1996	5,271	65,804	12.48	60,533
1997	41,299	64,513	1.56	23,214
1998[a]	ND	91,903	–	–
1999	27,057	40,521	1.50	13,464
2000	22,153	51,753	2.34	29,600
2001	55,187	49,830	0.90	–5,357
2002	40,478	66,089	1.63	25,611
2003	39,845	–	–	–
2004	13,443	–	–	–
2005	23,523	–	–	–
2006	41,823	–	–	–
2007	16,646	–	–	–

[a] Eshamy Lake weir was not in place in 1987 and 1998.

[b] Total return was calculated as the wild escapement contribution estimates plus the Eshamy and Southwestern District CPF harvests minus hatchery contribution estimates from sockeye salmon returning to Main Bay Hatchery and the estimate of Coghill Lake sockeye salmon in the harvest.

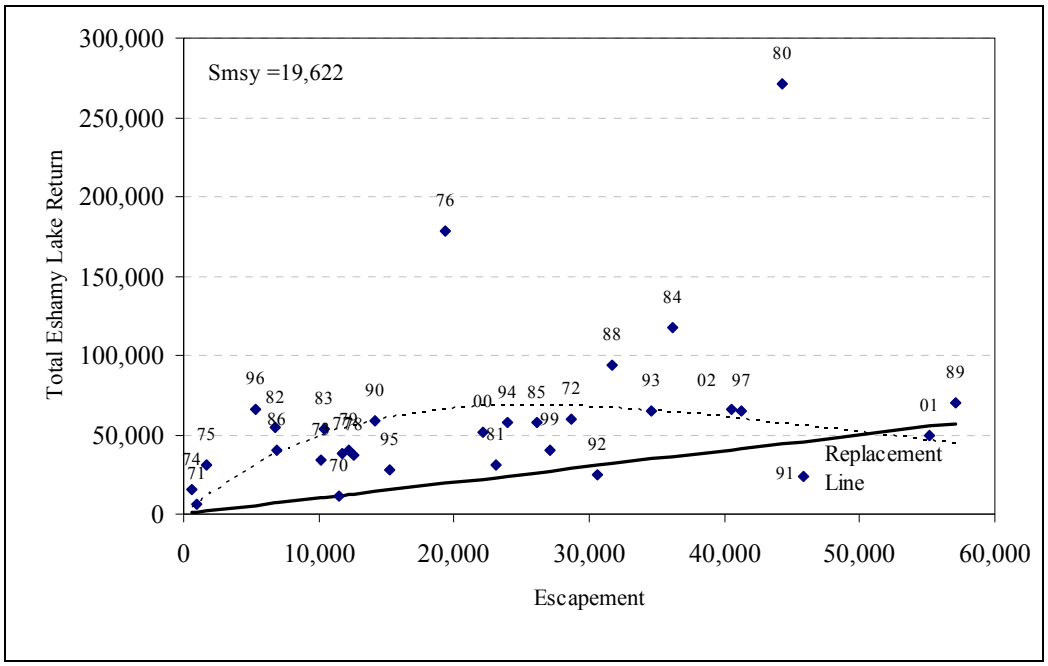
[c] Yield is total brood year return minus brood year escapement.

–continued–

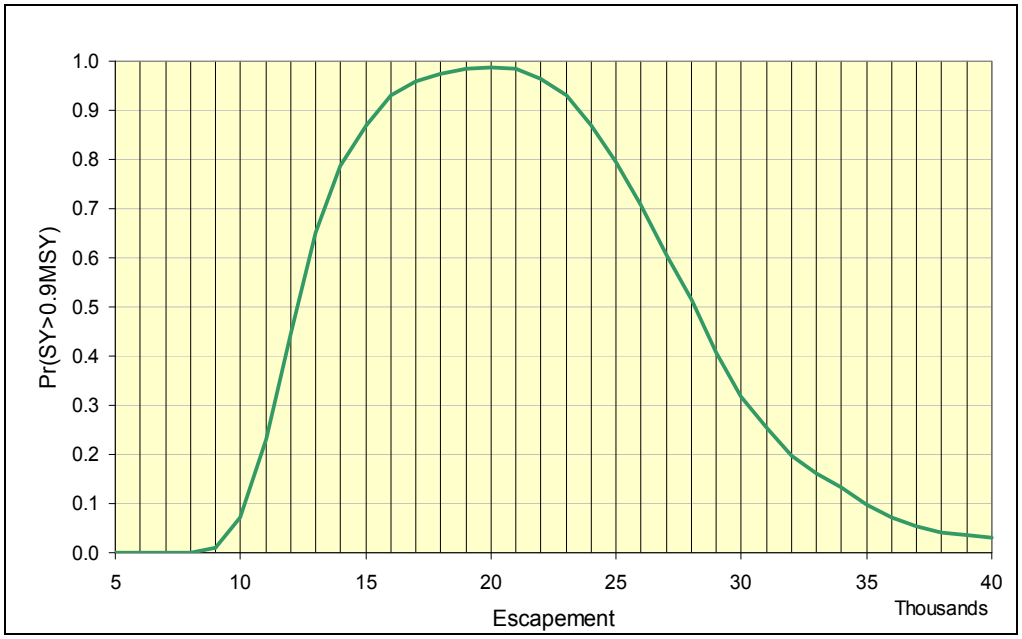
System: Eshamy Lake
Species: sockeye salmon

(a) Fitted Ricker curve, line of replacement, and actual data labeled by year for Eshamy Lake sockeye salmon.
(b) Probability that sustained yields are greater than 90% MSY at various levels of escapement using a Ricker stock–recruitment model.

(a)



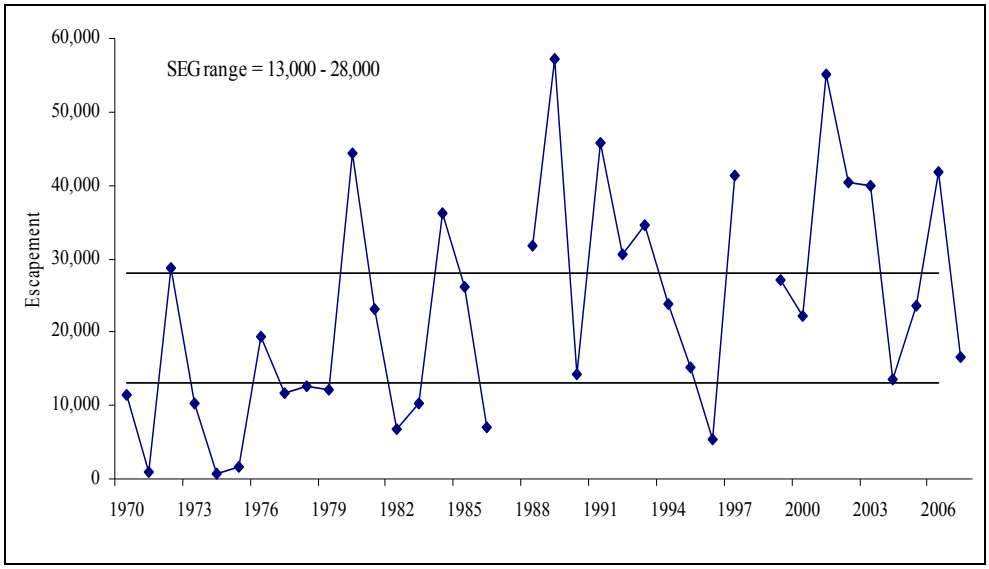
(b)



–continued–

System: Eshamy Lake
Species: sockeye salmon

Observed escapement by year (blocked line) and current SEG range (solid line)



Appendix A11.–Supporting information for analysis of escapement goal for Upper Copper River sockeye salmon.

System: Upper Copper River
Species: sockeye salmon

Data available for analysis of escapement goals.

Brood Year	Wild Escapement[a]	Harvest[b]		Yield[c]
		Sport	Sub/PU	
1978	65,583	1,606	28,061	1,178,377
1979	166,095	1,599	35,734	1,582,763
1980	196,787	2,109	33,984	914,122
1981	432,225	1,523	67,897	443,163
1982	335,003	3,343	108,611	1,428,779
1983	381,690	2,619	116,988	390,301
1984	431,026	3,267	76,177	834,603
1985	327,719	4,752	61,551	709,961
1986	383,377	4,129	68,495	1,226,368
1987	350,372	4,876	76,598	1,362,580
1988	291,856	3,038	71,525	1,364,070
1989	373,169	4,509	84,138	1,711,296
1990	397,085	3,569	98,197	1,385,891
1991	353,718	5,511	117,189	2,522,509
1992	371,149	4,560	131,956	2,566,873
1993	551,920	5,288	146,724	1,863,050
1994	441,745	6,533	162,302	1,211,633
1995	342,729	6,068	131,522	913,373
1996	536,387	11,851	147,059	923,109
1997	748,029	12,293	231,534	850,319
1998	463,572	11,184	201,624	1,193,712
1999	450,301	11,101	219,027	1,120,917
2000	294,351	12,361	167,353	1,604,010
2001	494,107	8,169	215,895	1,585,806
2002	572,514	7,761	144,281	1,939,457
2003	452,159	7,108	142,597	–
2004	434,628	6,464	177,386	–
2005	539,270	8,135	182,955	–
2006	605,832	14,297	174,554	–
2007	652,304	8,753	190,384	–

[a] Wild spawning escapements after 1977 were estimated as the Miles Lake sonar index minus subsistence, personal use and sport harvests in addition to the Gulkana Hatchery broodstock and excess brood escapement.

[b] The sport and subsistence/personal use harvests include both wild and hatchery stocks. Prior to 1995, no scanning for coded–wire tags was completed in the upper Copper River subsistence or personal use fisheries.

[c] Yield is total brood year return minus brood year escapement. Shown is the total yield for both upper Copper River and the Copper River Delta because currently we have no method to separate the stock groups in the commercial harvest.

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System: Upper Copper River
Species: sockeye salmon

Observed escapement by year (blocked line) and current SEG range (solid line)