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Escapement Goals for Salmon Stocks in Lower Cook Inlet, Alaska

by

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and

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October 2004

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

In 2001, following the Alaska Board of Fisheries adoption of two policies that affects development of escapement goals, the department revised all salmon escapement goals in Lower Cook Inlet. Salmon escapements are primarily monitored by single or multiple aerial and foot surveys of stream reaches that can be monitored. The resulting escapement indices do not provide absolute abundance estimates suitable for estimating biological escapement goals. Consequently, the department developed an algorithm to estimate sustainable escapement goals for each of the 3 Chinook salmon, 12 chum salmon, 24 pink salmon, and 8 sockeye salmon stocks the department monitors in Lower Cook Inlet. Escapements and escapement goals were recently reviewed again. Escapement performance relative to these new goals has been good during the past 4 years, with harvestable surpluses available in 87%-90% of the streams during most years. With the exception of four streams, the department does not recommend making any changes to the current escapement goals. The department recommends removing the goal of Anchor River Chinook salmon because a sonar and weir project begun in 2003 indicates the historical aerial surveys likely do not accurately index the total escapement. The new project will be a long-term program, allowing the department to more accurately estimate escapement and exploitation, and collect the spawner-recruit data needed to, in the future, estimate maximum sustained yield and a biological escapement goal. During the winter of 2006-2007 the department will examine the escapement and exploitation data to determine if a sustainable escapement goal can be developed to help manage fisheries until a biological escapement goal can be developed. Because no fishery targets Little or Big Kamishak River pink salmon, and escapement monitoring for these stocks is inconsistent, the department recommends removing the sustainable escapement goals for these systems. Additionally, the department recommends replacing the individual goals for pink salmon in Bear and Salmon Creeks in Resurrection Bay with a single sustainable escapement goal representing both streams. This is justified because Bear Creek is a tributary of Salmon Creek and the department has no means of managing the streams independently.

Key words: Lower Cook Inlet, sustainable escapement goals, Chinook salmon, chum salmon, pink salmon, sockeye salmon, escapement, Anchor River, Southern District, Outer District, Eastern District, Kamishak District, Alaska Board of Fisheries

INTRODUCTION

In this report we review the Lower Cook Inlet (LCI) salmon escapement goals that were revised in 2001 (Otis 2001) and present escapement information from the subsequent three years in the context of these new goals. Our objective is to provide historical and current information on LCI salmon escapements and to evaluate the appropriateness of the current and recommended new escapement goals for LCI salmon stocks. We also provide a brief summary of LCI stock assessment and management methods, along with a review of the methods used in 2001 to develop the escapement goals.

Following the adoption of the Alaska Department of Fish and Game's Salmon Escapement Goal Policy in 1992, Fried (1994) documented all the existing escapement goals for LCI. Under this policy, escapement goals were categorized as biological escapement goals, optimal escapement goals, or inriver goals. At that time all escapement goals in LCI, including 3 Chinook salmon, 13 chum salmon, 31 pink salmon, and 8 sockeye salmon, were considered biological escapement goals.

During 2000 and 2001, the Alaska Board of Fisheries (BOF) adopted two policies that govern escapement goals: the Policy for the Management of Sustainable Salmon Fisheries (sustainable fisheries policy; 5 AAC 39.222) and the Policy for Statewide Salmon Escapement Goals (escapement goal policy; 5 AAC 39.223). Under these policies sustainable escapement goals were added to those goals previously mentioned. Under sections (b) (2) and (3) of the escapement goal policy, the department is to:

> "(2) establish biological escapement goals (BEG) for salmon stocks for which the department can reliably enumerate salmon escapement levels, as well as total annual returns"; and
>
> "(3) establish sustainable escapement goals (SEG) for salmon stocks for which the department can reliably estimate escapement levels when there is not sufficient information to enumerate total annual returns and the range of escapements that are used to develop a BEG."

Section (f) of the sustainable fisheries policy provides definitions that are more detailed as follows:

> "(3) "biological escapement goal" or "(BEG)" means the escapement that provides the greatest potential for maximum sustained yield; BEG will be the primary management objective for the escapement unless an optimal escapement or inriver run goal has been adopted; BEG will be developed from the best available biological information and should be scientifically defensible on the basis of available biological information; BEG will be determined by the department and will be expressed as a range based on factors such as salmon stock productivity and data uncertainty; the department will seek to maintain evenly distributed salmon escapements within the bounds of a BEG"; and
>
> "(36) "sustainable escapement goal" or "(SEG)" means a level of escapement, indicated by an index or an escapement estimate, that is known to provide for sustained yield over a 5 to 10 year period, used in situations where a BEG cannot be estimated due to the absence of 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."

All escapement goals in LCI were reviewed in 2001 under the two BOF policies. The escapement goal review resulted in the establishment of 47 (3 Chinook salmon, 12 chum salmon, 24 pink salmon, and 8 sockeye salmon) new sustainable escapement goals (Bue and Hasbrouck 2001, Otis 2001).

METHODS

ASSESSING ESCAPEMENT AND HARVEST

The LCI management area is comprised of all waters west of the longitude of Cape Fairfield, north of the latitude of Cape Douglas, and south of the latitude of Anchor Point, and is divided into five fishing districts (Figure 1). Barren Islands District is the only non-fishing district, with the remaining four districts (Southern, Outer, Eastern, and Kamishak Bay) separated into approximately 30 sub-districts and sections to facilitate commercial management of discrete stocks of salmon (Hammarstrom and Dickson 2004). Sport fisheries in this management area also include the Anchor and Ninilchik rivers and Deep Creek, which flow into Cook Inlet along the west side of the lower Kenai Peninsula, and adjacent marine sport fisheries. Salmon streams in the management area (Figure 1) primarily produce pink and chum salmon, but also support runs of sockeye, coho, and Chinook salmon.

Escapement for most systems in LCI has been monitored by foot survey, aerial survey, or a combination of the two. Such surveys provide only an index of the escapement because we lack supporting data such as accurate estimates of stream life and of observer variability. The indices are a measurement on a numeric scale that provides information only about the relative level of the escapement. These measurements provide a ranking of escapement magnitude across years but in and of themselves provide no information on the total number of fish in the escapement. Escapement indices for stocks other than Chinook salmon are calculated by applying the area-under-the-curve method (Neilson and Geen 1981, Bue et al. 1998), which accounts for multiple sightings of the same fish during consecutive surveys by applying an average stream life factor.

Consistent weir data exist only for Ninilchik River Chinook salmon and Bear Lake sockeye salmon. Weir data provides a count or an estimate of the total number of fish in the escapement (i.e., total fish in the spawning population), expressed in units that are comparable to the estimates of total fish harvested for the same stock. Weir data exist for some other species-year-system combinations, but are not complete or consistent. LCI staff has also been developing and testing a digital time-lapse video recording system to remotely census fish returns in some small, clear streams (Otis and Dickson 2002). This technology may eventually allow replacement of aerial survey indices with escapement estimates more appropriate for developing and evaluating escapement goals.

Commercial harvest data were obtained from tallies from the fishticket database. Estimates of sport harvest were from the postal survey conducted annually by the Division of Sport Fish.

HISTORICAL DEVELOPMENT OF ESCAPEMENT GOALS

Chinook salmon escapements have been monitored at the Anchor and Ninilchik rivers and at Deep Creek since 1962 using a combination of foot and aerial surveys. Starting in 1976, single helicopter surveys were used to index Chinook salmon escapements. Escapement goals of the three stocks were first adopted in 1993 and were the average of the escapement indices in each system (Fried 1994). In 1999 the point goals were changed to ranges by multiplying the respective point goal by 0.8 and 1.6 (Eggers 1993).

Chum salmon escapement surveys began in the early 1970's. Escapement goals were established from these indices beginning in 1979. Many of the original goals were based on a subjective assessment of the quality of available spawning habitat and the level of commercial harvests resulting from various levels of escapement indices (Fried 1994).

Pink salmon escapement surveys began during the 1960s with many starting in either 1960 or 1962. Pink salmon escapement goals for some systems were first established in 1970, while goals for many other systems were established in either 1976 or 1982. Origins of these goals are not well documented. Those in the Outer and Eastern districts were based on quantitative estimates of available spawning areas, assuming an optimal density of 1.5-2.0 spawners per square meter (Fried 1994).

Aerial surveys to index sockeye salmon escapements began in 1960. In the case of Bear Lake, a complete count or estimate of escapements has been monitored through a weir since 1960. Although escapement goals were first established for sockeye salmon in 1982, goals for additional systems were added throughout the 1980s. Methods and rationales for setting these goals were generally not well documented.

Yuen (1992) documented the history of escapement goals in LCI and used a Ricker (1975) analysis to assess many of these goals. He concluded, "The suitability of Ricker curves to estimate optimum escapement have not been demonstrated for LCI salmon stocks." In many cases, Ricker analyses of pink salmon data were not meaningful because there was insufficient spawner-recruit data to produce a dome-shaped curve. In cases where the Ricker analyses were meaningful, the results were consistent with the existing goals in some cases, but not in others. Yuen (1992) attempted to fit Ricker curves to two sockeye salmon stocks (Aialik Lake and Nuka Bay), one chum salmon stock (McNeil River), and two aggregated chum salmon stocks (Cottonwood –Iniskin). He again found that the results were not meaningful, because either the Ricker model was not dome-shaped or the model estimated an optimal escapement that was well below the range of observed escapements.

CURRENT DEVELOPMENT OF ESCAPEMENT GOALS

Virtually all escapement goals in LCI are based on foot or aerial surveys. The surveys typically observe less than 100% of the spawning habitat due to practical constraints (e.g., overhanging riparian vegetation). In addition, different people have conducted the surveys over the years under a wide variety of conditions. While the commercial fisheries in LCI primarily occur in terminal areas, stock mixing does take place, especially in areas such as Port Dick and Resurrection Bay. Lack of stock identification prevents allocating commercial harvest to specific stocks and adds to the uncertainty in determining total return of many stocks. In 2001, with the definitions of escapement goals adopted into policy by the Board of Fish, and the uncertainties in accurately determining escapements and stock-specific commercial harvests, the department recommended all goals of LCI stocks be changed to sustainable escapement goals (SEGs).

In 2001 the SEG of all stocks was developed using percentiles of observed escapement estimates or indices that also incorporated contrast in the escapement data (Bue and Hasbrouck 2001, Otis 2001). To calculate the percentiles, we first ranked the escapement data from the smallest to the largest value, with the smallest value the 0^{th} percentile (i.e., none of the escapement values are less than the smallest). The percentile of all remaining escapement values is 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 range were narrowed, primarily from the upper range, to allow 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:

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

All resulting SEG ranges were rounded to the nearest 50 fish. Percentiles were calculated for nearly all stocks using aerial and foot survey escapement indices from 1976 through 2001

(through 2000 for Chinook salmon stocks). Aerial and foot survey data prior to 1976 were excluded due to inconsistencies in data collection methods. Survey data since 1976 were not used for three stocks: Ninilchik River Chinook salmon, Tutka Creek pink salmon, and Bear Lake sockeye salmon.

The Ninilchik River Chinook salmon SEG was based on the estimated number of naturally produced Chinook salmon observed at a weir between 8 – 24 July from 1994-2000. This river has been stocked since the early 1990s with hatchery produced Chinook salmon from Ninilchik River brood stock (Begich *in prep*). Hatchery stocked fish have been marked with an adipose fin clip and coded wire tag. Early in the stocking program only a portion of each release group was marked, but beginning in 1995 all stocked fish were marked. During 1994-2000 a weir was consistently in place from 8 – 24 July for use in collecting brood stock. All fish that were passed through the weir were counted and examined for a missing adipose fin. Based on the marking and mark recovery data, the number of hatchery-stocked fish in the escapement between 8 – 24 July could be estimated. The number of naturally produced fish was then estimated by subtracting the estimated number of hatchery fish from the total number of fish observed between 8 – 24 July. This was considered an index because it does not account for all Chinook salmon in the escapement. Weir data were used to develop the SEG because they were considered more reliable than the aerial surveys.

For Tutka Creek pink salmon, survey data from 1959 to 1975 were used to exclude years with hatchery supplementation. For Bear Lake sockeye salmon, weir data from 1985 to 2001 were used because prior to 1985 the lake was managed to limit sockeye salmon production in favor of coho salmon.

RESULTS AND DISCUSSION

Based on this review, the department recommends most escapement goals not be changed. The department recommends removing the sustainable escapement goal (SEG) of Anchor River Chinook salmon based on recent availability of better data. The department also recommends removing the SEG for Big Kamishak River and Little Kamishak River pink salmon stocks because these stocks do not receive commercial fishing pressure and no longer receive consistent escapement monitoring. Finally, the department recommends combining the SEGs for Bear Creek and Salmon Creek pink salmon as these are managed as one stock. The following provides additional details on these recommendations and reviews recent salmon escapements relative to the goals developed in 2001.

CHINOOK SALMON

The department recommends changing one of the three Chinook salmon goals (Table 1); removing the escapement goal of Anchor River Chinook salmon. The current SEG for this stock is based on aerial survey escapement indices from 1976-2000 (Bue and Hasbrouck 2001). Based in part on a declining trend of these indices and that in 2001 the Board of Fish designated this stock as a stock of management concern, the department initiated a sonar and weir project in 2003. The goal of the project is to more accurately assess Chinook salmon escapements to the Anchor River. Estimated escapements generated by this new project confirm the aerial survey indices measure only a small proportion, less than 10%, of the actual escapement. The Chinook salmon escapements estimated by the sonar and weir project were a minimum of 8,678 in 2003 and approximately 11,885 in 2004 (Kerkvliet et al. 2004), as opposed to survey indices of 680 in

2003 and 834 in 2004 (Table 1). Thus, the escapement indices and trends in these indices likely do not accurately reflect the true escapements.

Based on data collected by the new sonar and weir project, the department also recommends that Anchor River Chinook salmon no longer be designated as a stock of concern (Kerkvliet et al. 2004). Using a liberal estimate of total harvest of approximately 2,200 fish (average freshwater and marine harvest since 1997 is approximately 1,500 fish), these authors stated that the current exploitation rate on this stock of less than 25% is sustainable and exploitation can be increased some and still be sustainable. They recommend taking a cautious incremental approach to changing the current regulatory structure until the department has more information on stock productivity.

The sonar and weir project will be a long-term program and will aid in collecting spawner-recruit data needed to, in the future, estimate maximum sustained yield and a BEG for this stock. This project will allow the department to more accurately estimate escapement and exploitation annually and monitor trends in both. During the winter of 2006-2007, the department will examine the escapement and exploitation data collected to date and determine if a SEG can be developed to help manage fisheries until a BEG can be estimated. Aerial surveys will also continue in an attempt to improve the surveys by increasing the proportion of the escapement observed.

Recent Chinook salmon escapement indices at Deep Creek and the Ninilchik River have mostly been within or above the respective SEGs (Table 1). The 2003 escapement index of Ninilchik River Chinook salmon was below the SEG but only by seven fish.

CHUM SALMON

The department recommends no changes to the 12 chum salmon goals (Table 2). Recent chum salmon escapement indices have been sufficient, relative to the current SEGs, to provide a harvestable surplus for most stocks (Appendix A). During 2001-2004, only 10% of LCI chum stocks had escapement indices below the current SEG range, while 63% of chum stocks had indices above the current SEG range (Figure 2). Low prices, relatively modest returns, and lack of tender service have all contributed to diminished commercial fishing effort, particularly in the Kamishak Bay District. This in turn has contributed to many chum salmon systems realizing escapement indices above the existing SEG range.

PINK SALMON

The department recommends changes to four of the 24 pink salmon goals (Table 3). The department recommends removing escapement goals for Little and Big Kamishak River pink salmon because no fishery targets these stocks and escapement monitoring for these stocks is inconsistent (Table 3). Additionally, the department proposes to replace the individual goals for Bear and Salmon creeks in Resurrection Bay with a single SEG representing both streams. This is justified because Bear Creek is a tributary of Salmon Creek and the department has no means for managing the streams independently. To remain consistent with the methods used to develop SEGs for all other salmon stocks in LCI, the individual escapement indices for Bear and Salmon Creeks from 1976-2001 were combined, and the proper percentiles (Bue and Hasbrouck 2001) were determined to recommend a new SEG range (Appendix B). The resulting SEG range (5.0-23.5 thousand fish) is very similar to the sum of the two streams' individual SEG ranges (4.8-21.7 thousand fish), resulting in very little real change affected by this revision.

Recent pink salmon escapement indices have been sufficient, relative to the current SEGs, to provide a harvestable surplus for most stocks (Appendix A). During 2001-2004, only 12% of LCI pink salmon stocks had escapement indices below the current SEG range, while 41% of pink salmon stocks had indices above the current SEG range (Figure 3). Low prices, relatively modest returns, and lack of tender service have all contributed to diminished commercial fishing effort for pink salmon, particularly in the Kamishak Bay District. This in turn has contributed to many pink salmon systems realizing escapement indices above the existing SEG range.

SOCKEYE SALMON

The department recommends no changes to the eight sockeye salmon goals (Table 4). Recent sockeye salmon escapement indices have been sufficient, relative to the current SEGs, to provide a harvestable surplus for most stocks (Appendix A). During 2001-2004, only 13% of LCI sockeye stocks had escapement indices below the current SEG range, while 56% of sockeye stocks had indices above the current SEG range (Figure 4). Sockeye salmon runs in Lower Cook Inlet are modest in size compared to Upper Cook Inlet, largely due to limited number and size of accessible lakes in LCI, which juvenile sockeye require for rearing. As such, only a few of the larger systems receive consistent commercial fishing effort. Thus, some of the smaller systems' entire return escapes into the lakes to spawn.

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Table 1.– Current escapement goals, escapements observed from 2001 through 2004, and escapement goal recommendations in 2004 for Chinook salmon stocks of Lower Cook Inlet, Alaska.

System	Escapement Data[a]	Escapement Goal Type (BEG, SEG)	Escapement Goal Range	Escapements[b] 2001	2002	2003	2004	Recommendation[c]
Anchor River[d]	SAS	SEG	750-1,500	414	748	680	834	Remove
Deep Creek	SAS	SEG	350-800	551	696	1,008	1075	NC
Ninilchik River[e]	Weir	SEG	400-850	710	655	393	416	NC

[a] SAS = Single Aerial Survey.

[b] NS = No Survey.

[c] NC = No Change.

[d] Aerial survey indices. Sonar and weir project estimated minimum escapement of 8,678* in 2003, and approximately 11,885 in 2004 (Kerkvliet et al. 2004).

[e] Escapement of naturally produced fish through the weir between 8-24 July which is basis for SEG.

* corrected from the original version of this report, which read 8,8,678)

Table 2.– Current escapement goals, escapements observed from 2001 through 2004, and escapement goal recommendations in 2004 for chum salmon stocks of Lower Cook Inlet, Alaska.

System	Escapement Data[a]	Escapement Goal Type (BEG, SEG)	Escapement Goal Range	Escapements[b] 2001	2002	2003	2004	Recommendation[c]
Port Graham River	MFS	SEG	1,450-4,800	6,037	5,253	2,925	1,177	NC
Dogfish Lagoon	MFS	SEG	3,350-9,150	6,068	10,062	13,287	3,617	NC
Rocky River	MFS	SEG	1,200-5,400	2,990	5,655	5,549	17,159	NC
Port Dick Creek	MAS or MFS	SEG	1,900-4,450	1,801	12,321	5,595	8,620	NC
Island Creek	MAS or MFS	SEG	6,400-15,600	6,270	15,251	16,274	15,135	NC
Big Kamishak River	MAS	SEG	9,350-24,000	36,341	17,350	16,357	57,897	NC
Little Kamishak River	MAS	SEG	6,550-23,800	27,184	16,400	22,194	45,342	NC
McNeil River	MAS	SEG	13,750-25,750	16,997	11,293	23,275	11,203	NC
Bruin River	MAS	SEG	6,000-10,250	21,782	9,852	13,080	15,886	NC
Ursus Cove	MAS	SEG	6,050-9,850	37,699	17,144	30,410	15,988	NC
Cottonwood Creek	MAS	SEG	5,750-12,000	15,868	42,194	72,764	16,277	NC
Iniskin Bay	MAS	SEG	7,850-13,700	13,754	28,486	18,709	22,044	NC

[a] MAS = Multiple Aerial Survey, MFS = Multiple Foot Survey.

[b] NS = No Survey.

[c] NC = No Change.

Table 3.– Current escapement goals, escapements observed from 2001 through 2004, and escapement goal recommendations in 2004 for pink salmon stocks of Lower Cook Inlet, Alaska.

System	Escapement Data[a]	Escapement Goal Type (BEG, SEG)	Escapement Goal Range	Escapements[b] 2001	2002	2003	2004	Recommendation[c]
Humpy Creek	MFS	SEG	21,650-85,550	30,463	37,051	90,853	28,945	NC
China Poot Creek	MFS	SEG	2,900-8,200	6,639	6,543	6,694	3,335	NC
Tutka Creek	MFS	SEG	6,500-17,000	4,451	15,884	30,866	17,846	NC
Barabara Creek	MFS	SEG	1,900-8,950	2,287	3,241	5,062	5,395	NC
Seldovia Creek	MFS	SEG	19,050-38,950	12,259	26,938	35,135	56,763	NC
Port Graham River	MFS	SEG	7,700-19,850	10,260	58,527	14,916	44,010	NC
Port Chatham	MFS	SEG	7,800-21,000	17,921	18,078	34,979	26,375	NC
Windy Creek Right	MFS	SEG	3,350-10,950	10,300	14,401	23,341	11,974	NC
Windy Creek Left	MFS	SEG	3,650-29,950	61,813	28,946	82,814	23,286	NC
Rocky River	MFS	SEG	9,350-54,250	72,951	112,527	287,443	53,760	NC
Port Dick Creek	MAS or MFS	SEG	18,550-58,300	44,692	108,072	107,575	13,323	NC
Island Creek	MAS or MFS	SEG	7,200-28,300	81,764	44,105	118,637	33,573	NC
S. Nuka Island Creek	MAS or MFS	SEG	2,700-14,250	20,654	14,811	41,366	6,432	NC
Desire Lake	MAS	SEG	1,900-20,200	67,480	78,410	34,766	24,258	NC
Bear Creek	MFS	SEG	2,950-8,450	2,728	1,326	3,372	547	Combine Bear and Salmon creeks. New SEG = 5,000 - 23,500
Salmon Creek	MFS	SEG	1,900-13,250	297	1,363	1,063	689	
Thumb Cove	MFS	SEG	2,350-8,850	3,121	3,694	5,050	4,250	NC
Humpy Cove	MFS	SEG	900-3,200	330	1,832	2,563	990	NC
Tonsina Creek	MFS	SEG	500-5,850	2,780	6,949	5,180	3,450	NC
Big Kamishak River	MAS	SEG	3,500-11,000	NS	NS	NS	NS	Remove
Little Kamishak River	MAS	SEG	600-3,700	NS	3,400	NS	3,000	Remove
Bruin River	MAS	SEG	18,650-155,750	18,522	1,598,454	138,674	66,494	NC
Sunday Creek	MAS	SEG	4,850-28,850	26,231	81,949	346,657	31,497	NC
Brown's Peak Creek	MAS	SEG	2,450-18,800	19,166	27,480	285,049	18,100	NC

[a] MAS = Multiple Aerial Survey, MFS = Multiple Foot Survey.

[b] NS = No Survey.

[c] NC = No Change.

Table 4.– Current escapement goals, escapements observed from 2001 through 2004, and escapement goal recommendations in 2004 for sockeye salmon stocks of Lower Cook Inlet, Alaska.

System	Escapement Data[a]	Escapement Goal Type (BEG, SEG)	Escapement Goal Range	Escapements[b] 2001	2002	2003	2004	Recommendation[c]
English Bay[d]	PAS,Weir	SEG	6,000-13,500	10,508	15,277	19,422	15,352	NC
Delight Lake	PAS,Weir	SEG	5,950-12,550	10,110	19,555	7,538	7,262	NC
Desire Lake	PAS,Weir	SEG	8,800-15,200	5,470	16,000	8,400	10,700	NC
Bear Lake[d]	Weir	SEG	700-8,300	8,606	8,441	9,498	8,061	NC
Aialik Lake	PAS	SEG	3,700-8,000	5,100	6,100	5,370	10,100	NC
Mikfik Lake	PAS	SEG	6,300-12,150	5,350	16,650	12,830	14,020	NC
Chenik Lake	PAS,Weir	SEG	1,880-9,300	250	4,650	13,825	17,006	NC
Amakdedori Creek	PAS	SEG	1,250-2,600	2,690	3,200	11,800	7,200	NC

[a] PAS = Peak Aerial Survey.

[b] NS = No Survey.

[c] NC = No Change.

[d] Bear Lake and English Bay Lake escapements include only those fish allowed past the weir to spawn naturally in the lake, not those removed for broodstock.

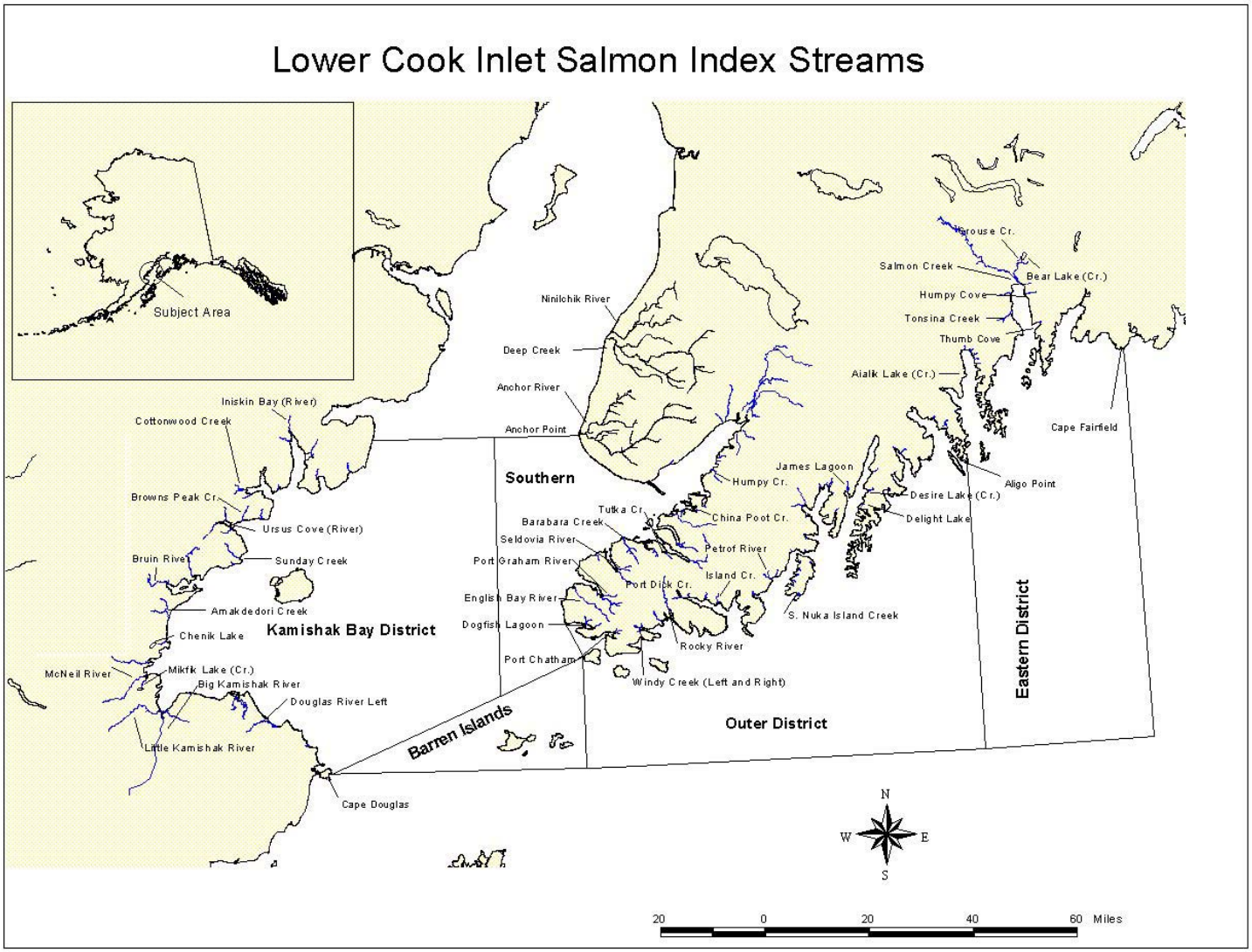


Figure 1.-Salmon producing streams of stocks with an escapement goal by district in the Lower Cook Inlet management area.

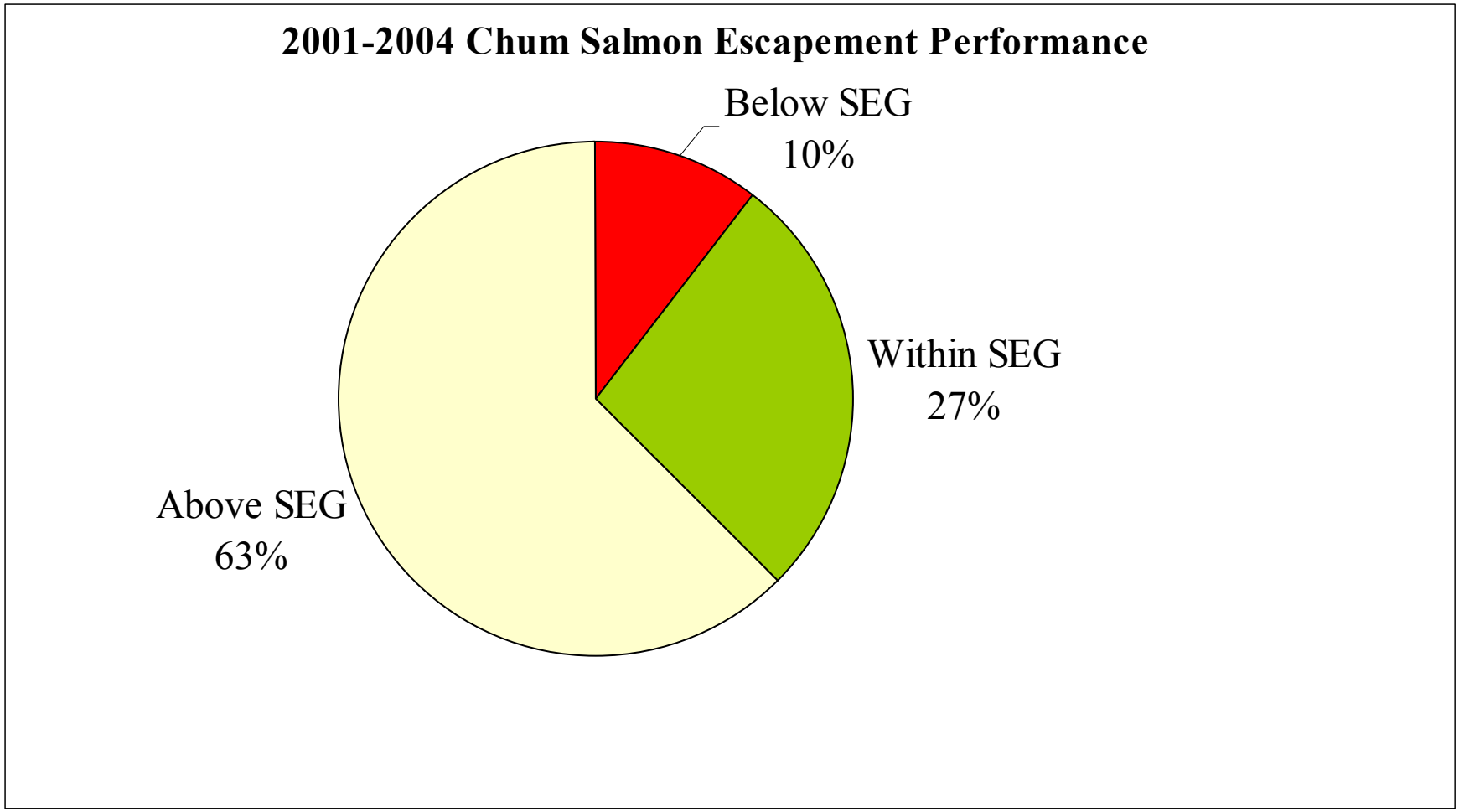


Figure 2.–2001-2004 Lower Cook Inlet chum salmon escapement performance relative to the current sustainable escapement goal ranges.

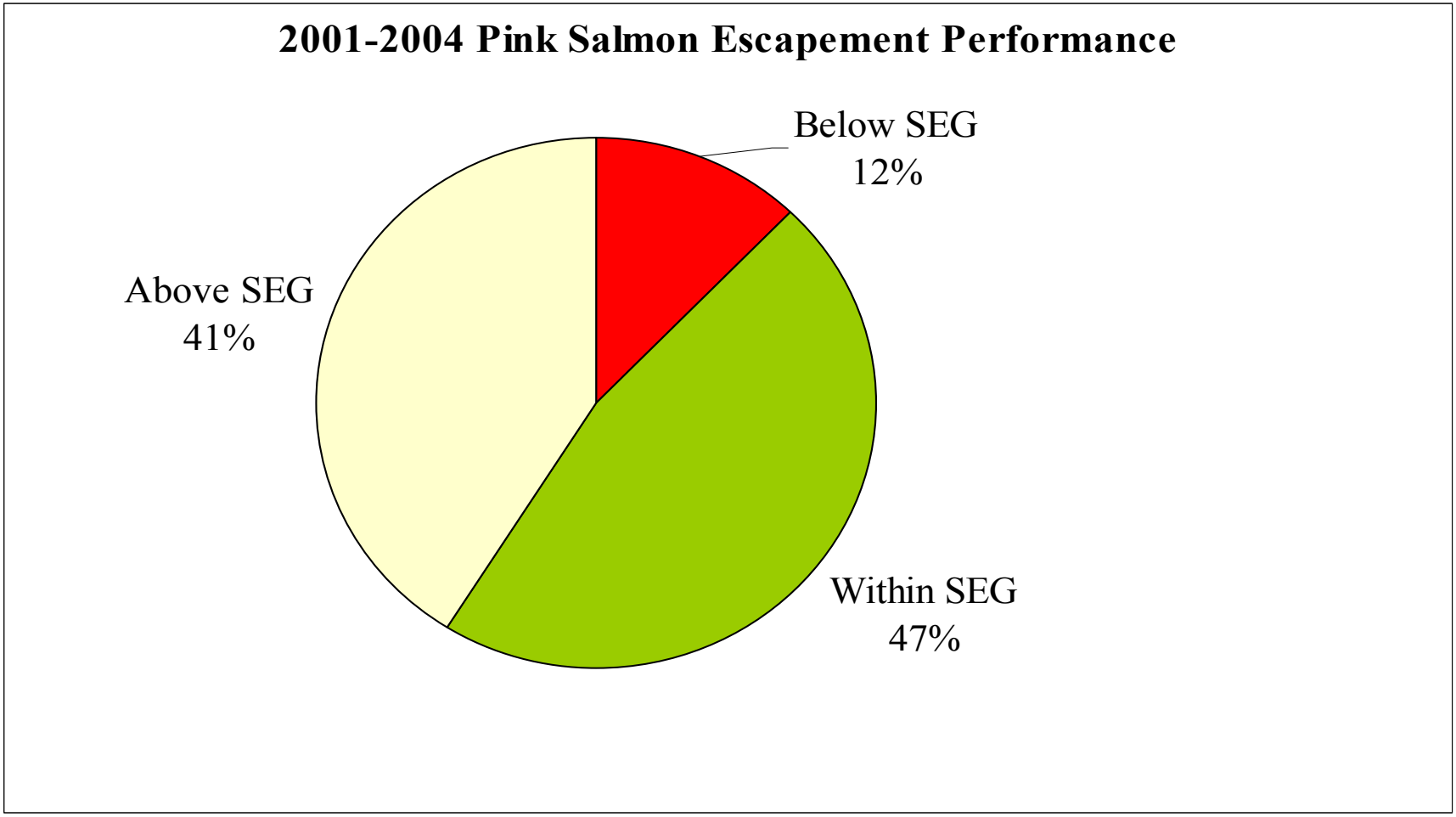


Figure 3.–2001-2004 Lower Cook Inlet pink salmon escapement performance relative to the current sustainable escapement goal ranges.

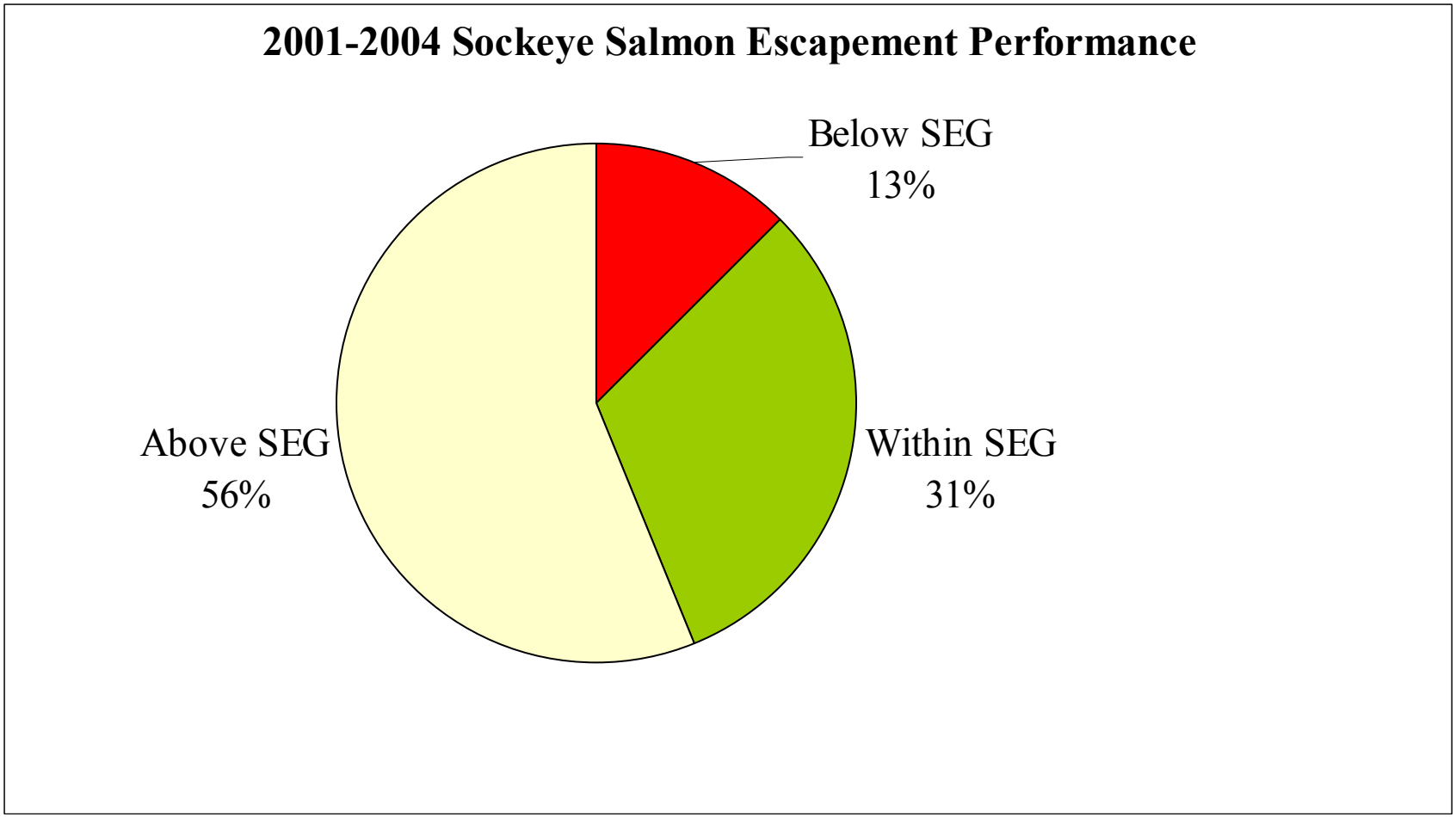


Figure 4.–2001-2004 Lower Cook Inlet sockeye salmon escapement performance relative to the current sustainable escapement goal ranges.

APPENDIX A

Appendix A1.–Commercial salmon catch in numbers of fish by species in the Southern District, Lower Cook Inlet, 1983 – 2003.

Year	Chinook	Sockeye	Coho	Pink	Chum	Total
1983	858	133,671	3,433	690,254	14,281	842,497
1984	661	160,654	3,193	336,595	8,065	509,168
1985	1,007	84,149	4,258	518,889	5,513	613,816
1986	776	36,838	3,095	542,521	5,560	588,790
1987	1,158	89,662	2,163	90,522	5,030	188,535
1988	1,655	105,302	2,987	852,382	7,742	970,068
1989	1,889	98,052	6,667	987,488	3,141	1,097,237
1990	1,546	82,412	1,552	178,087	2,433	266,030
1991	1,399	170,224	9,415	253,962	1,962	436,962
1992	1,852	106,793	1,277	417,021	1,885	528,828
1993	2,162	159,747	4,431	692,794	2,788	861,922
1994	1,230	64,531	1,373	1,589,709	2,631	1,659,474
1995	2,289	164,798	5,161	2,475,312	4,530	2,652,090
1996	1,180	358,163	9,543	444,236	3,511	816,633
1997	1,262	188,413	5,597	2,685,764	4,260	2,885,296
1998	1,070	196,262	2,243	1,315,042	3,956	1,518,534
1999	1,760	243,444	2,757	1,105,267	4,624	1,357,852
2000	1,184	123,574	768	1,070,065	5,340	1,200,931
2001	986	155,411	2,706	542,975	3,789	705,867
2002	1,553	218,203	3,769	953,960	4,803	1,182,288
2003	1,179	556,037	5,408	563,043	5,730	1,131,397
20-Year Avg.	1,374	147,015	3,819	887,142	4,792	1,044,143
1983-92 Avg.	1,280	106,776	3,804	486,772	5,561	604,193
1993-2002 Avg.	1,468	187,255	3,835	1,287,512	4,023	1,484,093
2003 % of Total	0.10%	49.15%	0.48%	49.77%	0.51%	100.00%

Source: Hammarstrom and Dickson 2004.

Appendix A2.–Commercial salmon catch in numbers of fish by species in the Kamishak Bay District, Lower Cook Inlet, 1983 – 2003.

Year	Chinook	Sockeye	Coho	Pink	Chum	Total
1983	1	11,207	7,138	1,405	142,901	162,652
1984	3	24,600	13,027	138,145	70,736	246,511
1985	6	78,250	2,024	194	8,139	88,613
1986	14	146,496	9,935	423,774	61,670	641,889
1987	7	123,654	8,079	72,684	108,412	312,836
1988	33	183,952	4,471	61,080	218,299	467,835
1989	3	46,395	4	256,669	7,809	310,880
1990	12	96,397	26	2,448	3,597	102,480
1991	17	136,612	2,337	47,833	7,853	194,652
1992	39	68,847	1,488	2,594	20,051	93,019
1993	4	67,650	3	4,205	600	72,462
1994	0	35,296	1,897	33	14	37,240
1995	2	36,427	6,084	169,054	10,302	221,869
1996	1	31,604	1	35	27	31,668
1997	0	11,733	0	293	7	12,033
1998	0	27,502	0	1,776	29	29,307
1999	0	46,913	0	807	23	47,743
2000	1	31,636	7	6,214	66,072	103,930
2001	2	39,712	9	1,397	84,766	125,886
2002	0	33,921	54	446,146	34,641	514,762
2003	0	51,253	4	12,005	29,800	93,062
20-Year Avg.	7	63,940	2,829	81,839	42,297	190,913
1983-92 Avg.	14	91,641	4,853	100,683	64,947	262,137
1993-2002 Avg.	1	36,239	806	62,996	19,648	119,690
2003 % of Total	0.00%	55.07%	0.00%	12.90%	32.02%	100.00%

Source: Hammarstrom and Dickson 2004.

Appendix A3.–Commercial salmon catch in numbers of fish by species in the Outer District, Lower Cook Inlet, 1983 – 2003.

Year	Chinook	Sockeye	Coho	Pink	Chum	Total
1983	14	16,835	54	199,794	27,203	243,900
1984	3	29,276	41	89,085	3,204	121,609
1985	19	91,957	3,210	618,222	11,844	725,252
1986	6	48,472	5,052	401,755	11,701	466,986
1987	14	31,845	2,481	23,890	28,663	86,893
1988	5	9,501	2	6,094	71,202	86,804
1989	1	10,286	72	52,677	43	63,079
1990	2	17,404	74	191,320	614	209,414
1991	2	6,408	12	359,664	14,337	380,423
1992	0	572	1	146	181	900
1993	2	4,613	119	159,159	970	164,863
1994	0	5,930	993	13,200	32	20,155
1995	12	17,642	1,272	192,098	474	211,498
1996	0	14,999	96	7,199	3	22,297
1997	0	6,255	63	128,373	1,575	136,266
1998	0	15,991	45	102,172	611	118,819
1999	3	51,117	1,482	32,484	2,062	87,148
2000	2	21,623	20	306,555	302	328,502
2001	0	7,339	5	48,559	408	56,311
2002	0	21,154	74	569,955	3,810	594,993
2003	1	26,615	4	281,663	137	308,420
20-Year Avg.	4	21,461	758	175,120	8,962	206,306
1983-92 Avg.	7	26,256	1,100	194,265	16,899	238,526
1993-2002 Avg.	2	16,666	417	155,975	1,025	174,085
2003 % of Total	0.00%	8.63%	0.00%	91.32%	0.04%	100.00%

Source: Hammarstrom and Dickson 2004.

Appendix A4.–Commercial salmon catch in numbers of fish by species in the Eastern District, Lower Cook Inlet, 1983 – 2003.

Year	Chinook	Sockeye	Coho	Pink	Chum	Total
1983	0	25,932	594	36,154	7,934	70,614
1984	47	54,420	536	136,797	10,535	202,335
1985	11	24,338	835	92,403	5,144	122,731
1986	0	3,055	770	40,243	3,757	47,825
1987	0	3,687	1,631	14,333	14,913	34,564
1988	1	20,253	486	1,740	24,668	47,148
1989	0	8,538	5,346	92	312	14,288
1990	0	7,682	7,645	11,815	307	27,449
1991	1	4,703	7,283	167,250	80	179,317
1992	0	432	3,136	60,007	86	63,661
1993	0	1,824	8,924	10,616	9	21,373
1994	1	9,661	10,410	44,987	2,792	67,851
1995	0	46,556	5,192	12,000	330	64,078
1996	0	44,919	3,932	36	223	49,110
1997	0	33,783	5,344	1	66	39,194
1998	1	44,274	14,365	38,829	51	97,520
1999	1	135,305	3,794	1,930	1,232	142,262
2000	1	64,099	7,408	4,473	1,540	77,521
2001	0	13,809	3,947	0	6	17,762
2002	0	17,376	4,432	0	5	21,813
2003	0	10,352	5,886	0	19	16,257
20-Year Avg.	3	28,232	4,801	33,685	3,700	70,421
1983-92 Avg.	6	15,304	2,826	56,083	6,774	80,993
1993-2002 Avg.	0	41,161	6,775	11,287	625	59,848
2003 % of Total	0.00%	79.66%	20.32%	0.00%	0.02%	100.00%

Source: Hammarstrom and Dickson 2004.

APPENDIX B

Appendix B1.–Sustainable escapement goal for Bear and Salmon Creek pink salmon.

The following page (Appendix B2) contains a table, a chart, and a text box, formatted exactly the same as the 2001 BOF report that created the revised SEG ranges now in place. The table contains relevant inputs to and results from the SEG analysis, such as: the maximum and minimum escapements observed, the contrast between those two data points, the percentiles used to calculate the SEG range, and the number of data points (i.e., years of escapement data) used in the analysis. The table also contains summaries, by decade, of the average escapement, harvest, and total return for each stream (units are thousands of fish). This information, along with estimated return per spawner ratios, puts the SEG range into the proper context and illustrates the stream-specific fishery and productivity trends the department has documented over the years. The sum of the individual SEGs for Bear and Salmon Creeks is also listed in the table for comparative purposes.

The chart illustrates the return per spawner relationship for Bear/Salmon Creek combined. Spawners (thousands of fish) are plotted on the x-axis and returning fish (thousands) on the y-axis. Points plotted below the diagonal 'replacement line' represent brood years where the total return, over all year classes, was less than the escapement that produced that return. The sum of the individual SEGs for Bear and Salmon Creek and new SEG ranges are also depicted on the chart.

Finally, the text box captures the remaining information relevant to the analysis, such as: the source for the escapement data (e.g., aerial survey), the times series used for the analysis, the rationale for selecting that time series, and a brief statement regarding any special history associated with that stream, if available.

Appendix B2.–Sustainable escapement goal evaluation for Bear/Salmon Creek (combined) pink salmon.

Sustainable Escapement Goal Evaluation for: Bear/Salmon Creek (combined) **Species: pink salmon**

Esc. Goals:	Current SEGs (summed)	Recommended SEG	% diff.
Low	4.8	5.0	
Mid-Pt	13.3	14.2	7%
High	21.7	23.5	

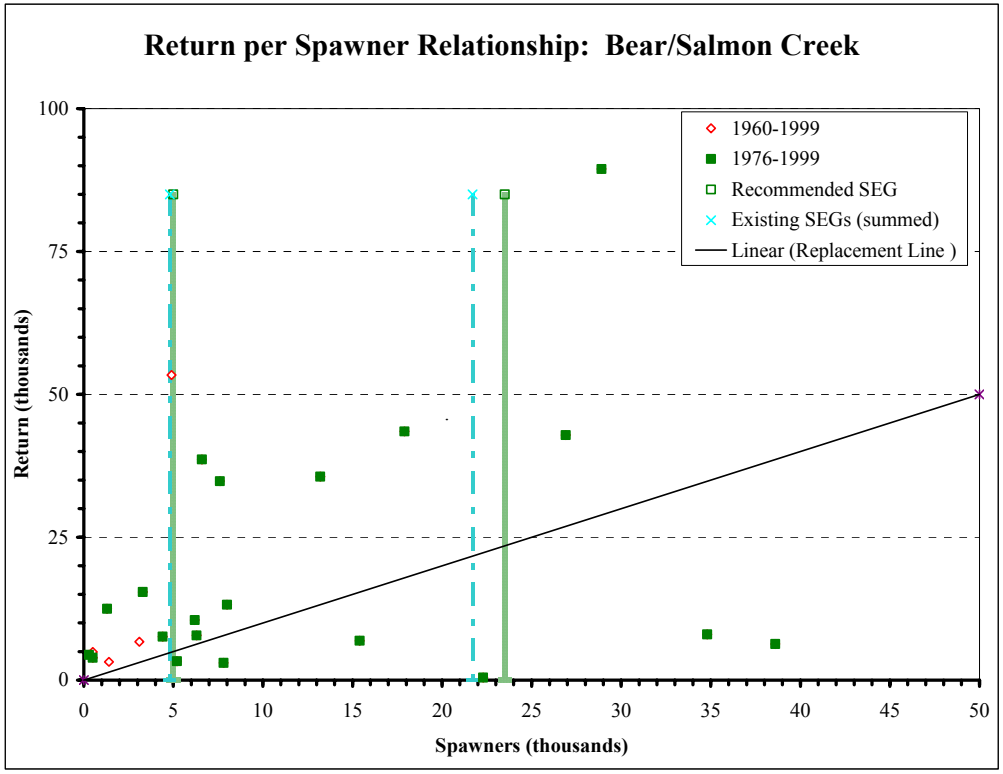
Avg. Escap.	All Years (thousands)
Last 5 Yrs	13.2
Last 10 Yrs	16.2
1982-91	10.5
1972-81	13.4
1962-71	4.2
All Years	12.0

1976-2001 Escapement Data	
Max:	38.6
Min:	0.3
Contrast:	129
Exploitation:	Yes
SEG Range:	25-75%
Data points used in analysis:	24

Avg. Harvest	All Years (thousands)
Last 5 Yrs	0.0
Last 10 Yrs	0.0
1982-91	21.0
1972-81	33.3
1962-71	6.6
All Years	15.4

Avg. Tot. Ret.	All Years (thousands)
Last 5 Yrs	13.2
Last 10 Yrs	16.2
1982-91	29.4
1972-81	46.7
1962-71	10.8
All Years	25.9

R/S	All Years R/S
Last 5 Yrs	1.4
Last 10 Yrs	2.1
1982-91	3.9
1972-81	7.0
1962-71	2.2
All Years	3.9



Time Series Used for SEG Analysis: 1976-2001 **Escapemenent Monitoring Method(s):** Ground survey **Comments:** All escapements from 1976-2001 were based on area-under-the-curve estimates derived from multiple ground surveys using a 17.5 day streamlife estimate.

History: NA