Fishery Manuscript Series No. 15-06

Review of Salmon Escapement Goals in Bristol Bay, Alaska, 2015

by

Jack W. Erickson

Charles E. Brazil

Xinxian Zhang

Timothy R. McKinley

and

Robert A. Clark

November 2015

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

FISHERY MANUSCRIPT SERIES NO. 15-06

REVIEW OF SALMON ESCAPEMENT GOALS IN BRISTOL BAY, ALASKA, 2015

by

Jack W. Erickson

Charles E. Brazil

Xinxian Zhang

Timothy R. McKinley

and

Robert A. Clark

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

November 2015

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

Jack W. Erickson, Charles E. Brazil, and Xinxian Zhang
Alaska Department of Fish and Game, Division of Commercial Fisheries,
333 Raspberry Road, Anchorage, AK 99518, USA
and
Timothy R. McKinley and Robert C. Clark
Alaska Department of Fish and Game, Division of Sport Fish,
333 Raspberry Road, Anchorage, AK 99518, USA

This document should be cited as follows:
Erickson, J. W., C. E. Brazil, X. Zhang, T. R. McKinley, and R. A. Clark. 2015. Review of salmon escapement goals in Bristol Bay, Alaska, 2015. Alaska Department of Fish and Game, Fishery Manuscript Series No 15-06, Anchorage.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

The Alaska Department of Fish and Game (ADF&G) interdivisional escapement goal (EG) review committee reviewed Pacific salmon *Oncorhynchus* spp. escapement goals for the major river systems in Bristol Bay. The committee evaluated spawner-return data for sockeye salmon *O. nerka* in the Alagnak River, Chinook salmon *O. tshawytscha* in the Alagnak and Naknek rivers, and chum salmon *O. keta* in the Nushagak River. This review examined each of the existing 15 escapement goals.

Two significant events have occurred since the last review 3 years ago. In 2012, the majority of escapement goal recommendations for sockeye salmon presented to the Alaska Board of Fisheries (BOF) were not adopted. Secondly, an advisory panel was formed and tasked by the BOF to prepare recommendations relating to the development of optimal escapement goals for Bristol Bay salmon. In March 2015, the advisory committee reviewed a draft escapement analysis report and presentations prepared by scientists from the University of Washington School of Fisheries and Aquatic Sciences and LGL Alaska Research Associates, Inc. that evaluated EGs for Bristol Bay salmon, taking into account biological and economic factors. Likewise, since the 2012 Bristol Bay BOF, ADF&G participated in a series of meetings with the advisory committee, processors, and members of the Bristol Bay Science and Research Institute to evaluate, review and prepare recommendations for Bristol Bay salmon escapement goals that took into account biological and economic factors. During the March 2015 Statewide Miscellaneous Shellfish BOF meeting, ADF&G recommended increasing the upper bounds of the sockeye salmon goals to those that had been proposed at the 2012 Bristol Bay BOF meeting.

The EG review committee recommends the escapement goal for Alagnak River sockeye salmon be modified and that the Chinook salmon escapement goals for Alagnak and Naknek Rivers be discontinued. The committee recommends all other goals remain the same.

Key words: Pacific salmon *Oncorhynchus* spp., sockeye salmon *O. nerka*, Chinook salmon *O. tshawytscha*, chum salmon *O. keta*, coho salmon *O. kisutch*, pink salmon *O. gorbuscha*, Bristol Bay, Kvichak River, Alagnak River, Naknek River, Egegik River, Ugashik River, Wood River, Igushik River, Nushagak River, Togiak River, spawning escapement goal, Alaska Board of Fisheries.

INTRODUCTION

The purpose of this report is to inform the Alaska Board of Fisheries (BOF) and the public about the review of Bristol Bay salmon escapement goals by the interdivisional escapement goal review committee and their recommendations to the Division of Commercial Fisheries and Sport Fish directors. Many Bristol Bay salmon escapement goals have been set and evaluated at regular intervals since statehood. During the 2011–2012 BOF cycle, Bristol Bay escapement goals were reviewed, and recommended changes were presented to the BOF by the Alaska Department of Fish and Game (ADF&G; Fair et al. 2012). However, most of the recommendations were put on hold for 2 years until a task force formed by the BOF could prepare recommendations for optimal escapement goals for Bristol Bay sockeye salmon *Oncorhynchus nerka* that take into account biological and economic factors.

The Bristol Bay management area includes all coastal and inland waters east of a line from Cape Newenham to Cape Menshikof (Figure 1). The Bristol Bay area is divided into 5 management districts (Egegik, Naknek–Kvichak, Nushagak, Togiak, and Ugashik) that correspond to the major river systems. Bristol Bay supports some of the largest sockeye salmon runs in the world with combined runs to Bristol Bay averaging approximately 38.5 million fish since 1990. Nine major river systems produce more than 99% of the returning sockeye salmon: Alagnak, Egegik, Igushik, Kvichak, Naknek, Nushagak, Togiak, Ugashik, and Wood rivers (Table 1; Figure 1).

The primary management objective for each river is to achieve escapements within established ranges for the major salmon species while harvesting fish in excess of escapement goals through orderly fisheries. During the 2015 Statewide Miscellaneous Shellfish BOF meeting, ADF&G

introduced and the BOF approved regulatory language "to the extent practicable, manage for escapements to fall within the lower or upper portions of escapement goals proportional to the run size based on the preseason forecast and inseason assessment of the run size;" (5 AAC 06.355(d)(1). Regulatory management plans have been adopted for individual species in certain districts. Escapement refers to the annual estimated size of the spawning salmon stock and is affected by a variety of factors including exploitation, predation, disease, and physical and biological changes in the environment. Individual escapement goals for sockeye salmon have been in place for the major river systems since the early 1960s (Burgner et al. 1967; Fried 1994; Cross et al. 1997; Fair 2000; Fair et al. 2004; Baker et al. 2006, 2009; Fair et al. 2012). Bristol Bay also supports one of the largest runs of Chinook salmon *O. tshawytscha* in Alaska. The Chinook salmon run in the Nushagak River has averaged 215,000 since 1989 (Buck et al. 2012). Runs of chum *O. keta*, coho *O. kisutch*, and pink *O. gorbuscha* salmon are also found in many Bristol Bay rivers.

ADF&G reviews Bristol Bay escapement goals on a schedule that corresponds to the BOF's 3-year cycle for considering area regulatory proposals. This report describes the Bristol Bay salmon escapement goals that were reviewed in 2015.

In 2015, the committee reviewed and evaluated escapement goals for the following stocks:

- Chinook salmon: Alagnak, Naknek, and Nushagak, rivers;
- chum salmon: Nushagak River;
- coho salmon: Nushagak River;
- pink salmon: Nushagak River; and
- sockeye salmon:Alagnak, Egegik, Igushik, Kvichak, Naknek, Nushagak, Togiak, Ugashik, and Wood rivers.

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). The BOF adopted these policies into regulation during the winter of 2000–2001 to ensure that the state's salmon stocks are conserved, managed, and developed using the sustained yield principle. The EGP states that it is ADF&G'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 BOF's regular cycle of consideration of area regulatory proposals. For this review, there are 2 important terms defined in the SSFP:

> 5 AAC 39.222 (f)(3) "biological escapement goal or BEG" means the escapement that provides the greatest potential for maximum sustained yield; 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 ADF&G and will be expressed as a range based on factors such as salmon stock productivity and data uncertainty; ADF&G will seek to maintain evenly distributed salmon escapements within the bounds of a BEG; and,
>
> 5 AAC 39.222 (f)(36) "sustainable escapement goal or SEG" means a level of escapement, indicated by an index or an escapement estimate, that is known to provide for sustained

yield over a 5- to 10-year period, used in situations where a BEG cannot be estimated or managed for; the SEG is the primary management objective for the escapement, unless an optimal escapement or inriver run goal has been adopted by the BOF; the SEG will be developed from the best available biological information and should be scientifically defensible on the basis of that information; the SEG will be determined by ADF&G and will take into account data uncertainty and be stated as either an SEG range or lower bound SEG; ADF&G will seek to maintain escapements within the bounds of the SEG range or above the level of a lower-bound SEG.

During the spring of 2015, ADF&G established an interdivisional escapement goal review committee (committee). The committee consisted of 4 Division of Commercial Fisheries and 4 Division of Sport Fish personnel (Table 2). They provided analyses for recommending an escapement goal for each salmon stock. The committee formally met 28 January 2015 to review escapement goals and begin developing recommendations. Department regional and headquarters staff review all committee recommendations prior to adoption as escapement goals per the SSFP and EGP.

Of particular interest in evaluating or setting Bristol Bay escapement goals, the SSFP states that "salmon escapement goals should be established in a manner consistent with sustained yields; unless otherwise directed; ADF&G will manage Alaska's salmon fisheries, to the extent possible, for maximum sustained yield." In the 20 years prior to 2015, few Bristol Bay sockeye salmon escapement goals changed significantly. Evidence for raising them had existed for a number of years (estimates of escapement at maximum sustained yield are above the upper end of the goal). For some stocks, recent high productivity from larger escapements makes for an even stronger case in changing (i.e., raising) sockeye salmon escapement goal ranges. In the 2003 review, the escapement goal committee recommended raising the goals for Egegik, Igushik, Naknek, and Ugashik river sockeye salmon; however, Division of Commercial Fisheries and Division of Sport Fish directors did not approve those recommendations.

Two recent developments have contributed to changes in historical brood tables used in the 2012 and 2015 reviews. First, genetic techniques have greatly improved the ability to accurately determine sockeye salmon stock compositions of the harvest (Dann et al. 2011). In Bristol Bay, these data are currently available since 2006. The University of Washington Fisheries Research Institute, in cooperation with ADF&G, recently completed a study that isolated genetic information from previously collected scale samples from harvests dating back to the early 1960s (Smith et al. 2010). Cunningham et al. (2012), again in cooperation with ADF&G, used these genetic stock composition estimates, along with information about age composition and run timing, to reconstruct brood tables for each sockeye salmon stock, greatly improving our understanding of stock productivity. The second development was the transition of many statewide sonar-based salmon escapement projects from older systems to more modern technology. One such river is the Nushagak, where the Bendix sonar system estimated salmon passage since the late 1970s; it was replaced in 2005 with a dual-frequency identification sonar (DIDSON; Belcher et al. 2002). Recognizing that transitioning to more modern sonar equipment could alter the counts, ADF&G operated the Bendix and DIDSON sonar systems simultaneously at various times during the 2003–2005, 2007, and 2009 runs. From these side-by-side comparisons, Maxwell et al. (2011) and Buck et al. (2012) converted historical Bendix sonar counts to DIDSON-equivalent counts.

OBJECTIVES

Objectives of the 2015 review were as follows:

1) review existing goals (other than the sockeye salmon goals that were modified during the March 2015 Statewide Miscellaneous Shellfish BOF meeting) to determine whether they were still appropriate given (a) new data collected since the last review, (b) current assessment techniques, and (c) current management practices;
2) review the methods used to establish the existing goals to determine whether alternative methods should be investigated;
3) consider any new stocks for which there may be sufficient data to develop a goal; and,
4) recommend new goals if appropriate.

OVERVIEW OF STOCK ASSESSMENT METHODS

The committee reviewed each of the existing escapement goals using updated escapement and harvest data (if available) collected since the 2012 review. Available escapement, catch, and age data for each stock originated from research reports, management reports, and unpublished historical databases. Escapement goals for salmon are ideally based on spawner-recruitment relationships (e.g., Beverton and Holt 1957; Ricker 1954), which describe the productivity and carrying capacity of a stock. However, stock assessment data are often not suitable for describing a spawner-recruitment relationship (e.g., insufficient contrast in escapements, no stock-specific harvest data, short escapement time series, or inconsistent escapement monitoring). Therefore other evaluation methods that utilize a smaller set of stock assessment data are necessary. Thus, escapement goals are evaluated and revised over time as improved methods of assessment and goal setting are developed and when new and better information becomes available.

Available escapement, catch, and age data for each stock were compiled from research reports, management reports, and unpublished historical databases. The committee evaluated the type, quality, and quantity of data for each stock. Generally speaking, an escapement goal for a stock should provide escapement that produces sustainable yields. 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 estimate maximum sustained yield (MSY; Chinook Technical Committee 1999; Hilborn and Walters 1992; Quinn and Deriso 1999). 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 insufficient contrast in escapements) or there was a lack of information on carrying capacity or stock productivity.

ESCAPEMENT AND HARVEST DATA

Sockeye salmon escapements have been sampled by beach seine and visually counted using towers at Alagnak, Egegik, Igushik, Kvichak, Naknek, Togiak, Ugashik, and Wood rivers (West et al. 2012). ADF&G has estimated Alagnak River sockeye salmon escapement using a combination of aerial surveys and towers since its inception (Clark 2005). Escapements were sampled by gillnet or beach seine and estimated using sonar for all Nushagak River salmon

species beginning in the early 1980s (Brazil and Buck 2011). Prior to the implementation of sonar, Nushagak River Chinook and sockeye salmon escapement was assessed using aerial surveys. Also, tower counts prior to sonar from the Nuyakuk River, a major tributary of the Nushagak River, were combined with aerial counts for total sockeye salmon escapement. Age data have been collected from both the escapement and harvest for all of these stocks. Prior to this review, harvest allocation for each stock was estimated by harvest location and age composition (Bernard 1983). However, the run reconstruction model of Cunningham et al. (2012) estimated sockeye salmon stock-specific harvest contributions based on genetic markers, age composition, and run timing information beginning in 1959.

All other stocks (Alagnak and Naknek river Chinook salmon) whose escapements were estimated by aerial survey were not sampled for age composition, nor were their contributions to harvest (Salomone et al. 2009).

ESCAPEMENT GOAL DETERMINATION

In previous reviews, escapement goals were evaluated for Bristol Bay stocks using the following methods: (1) Stock-Recruitment Analysis, (2) Yield Analysis, (3) Smolt Information, and (4) Risk Analysis. Spawner-return data were generally used to estimate escapement goals when stock estimates of total return (escapement and stock-specific harvest) were reliable and there was sufficient contrast in escapements. Spawner-return data were used to estimate escapement goals based on the following: (1) escapements producing average yields that were 90–100% of MSY from a stock-recruitment model, and 2) the Yield Analysis, a visual examination of observed yield versus escapement. Recent smolt information is not available for any Bristol Bay data stocks. When the harvest of a stock was deemed coincidental (passively managed) to harvests and management of primary stocks (e.g., chum harvests are coincidental to the directed harvests of sockeye and Chinook salmon in the Nushagak District), the risk analysis approach was used to develop a lower bound SEG.

Stock-Recruitment Analysis

Complete spawner-return data exists for Nushagak River Chinook and chum salmon, and Alagnak, Egegik, Igushik, Kvichak, Naknek, Nushagak, Togiak, Ugashik, and Wood river sockeye salmon. For the 2012 review (Fair et al. 2012) stock-recruit models were used to analyze salmon spawner-return data for all available brood years. For that analysis, spawners were analogous to stock and return analogous to recruitment. Total returns were the sum of escapements and harvests. Sport and subsistence harvests were only included in total return estimates for the Nushagak River Chinook salmon, and were considered minor components for the other stocks.

The most commonly used stock-recruitment (S-R) model is the Ricker (1954).

$$R = \alpha S e^{-\beta S}, \tag{1}$$

where α and β are model parameters. After log-transforming both sides of the equation, the standard Ricker model was fit to the data using a linear regression equation

$$\ln(R/S) = \ln(\alpha) - \beta S \tag{2}$$

A Bayesian approach estimated these parameters in the model. Multiplicative-error Bayesian analysis has been previously used for Ricker stock-recruitment data analysis (Rivot et al. 2001).

ADF&G has applied the Bayesian approach to Ricker models in previous escapement goal studies (Fleischman et al. 2011).

In 2012, Fair et al. used approximate formulae given by Hilborn and Walters (1992) to estimate the fishery management parameters MSY, S_{msy}, and U_{msy}:

$$\begin{aligned} S_{msy} &\approx \frac{\ln(\alpha)}{\beta}\left(0.5 - 0.07\ln(\alpha)\right), \\ u_{msy} &\approx \ln(\alpha)\left[0.5 - 0.07\ln(\alpha)\right], \\ MSY &= \alpha S_{msy} e^{-\beta S_{msy}} - S_{msy} \end{aligned} \tag{3}$$

To reconstruct changes in productivity (recruits per spawner [R/S] at a given spawner abundance), they used historical spawner-return data along with a Kalman filter (Peterman et al. 2003) that included a time-varying Ricker α parameter for each of the sockeye salmon stocks.

Risk Analysis

For stocks that are passively managed and coincidentally harvested, lower bound SEGs are frequently developed (Bernard et al. 2009). Escapement goal analyses for 2 stocks, Nushagak River chum salmon and Alagnak River sockeye salmon, were updated during this review cycle using the risk analysis approach.

Escapement time series were log-transformed and tested for autocorrelation using diagnostics of Chatfield (2004). There was a significant autocorrelation at lag one in log-escapements of Alagnak sockeye salmon (p-value < 0.001); however, there was no significant autocorrelation for the log-escapements of Nushagak chum salmon (p-value = 0.543). Normality tests were also done using the Shapiro-Wilk test. Both stocks followed a log-normal distribution (p-value = 0.08 for Alagnak sockeye salmon after removing autocorrelation; p-vlaue = 0.18 for Nushagak chum salmon).

Nushagak chum salmon

The current lower bound SEG of 200,000 chum salmon counted at the sonar was developed using the risk analysis approach (Baker et al. 2006). The escapement data used to establish the current goal began in 1980 from Nushagak River Bendix sonar estimates from early June through July 20, the ending date sonar operations ceased when the goal was developed.

For this review, we updated historical escapement data that had been converted from Bendix estimates to DIDSON equivalents (DIDSON:Bendix ratio of 1.27; Buck et al. 2012). Also, because of errors in escapements reported in the 2012 review, we reanalyzed the data using the risk analysis approach with data collected through 2015 (Appendix B1; and Figure 2). The log-escapement time series for Nushagak chum salmon is not serially correlated (p = 0.543, Figure 3).

For this review we continued to use cumulative escapements through July 20 even though in some years the sonar project operates until approximately August 20. This was done because (1) over 90% of the chum salmon escapement has passed the sonar site by July 20 and (2) for over 30% of the years since 1980, sonar operations ceased around July 20, allowing for a longer data set to evaluate the goal.

For Nushagak chum salmon, the log-normal model for estimating risk of an unwarranted restriction due to a management concern was estimated directly from the Student's *t*-distribution of the log-transformed mean, sample standard deviation, number of years in the time series, and the number of consecutive years to warrant a concern ($n = 3$) for various values of an escapement threshold (Figure 4) as per Bernard et al. (2009; Equations 1–8).

Alagnak sockeye salmon

The current lower bound SEG of 320,000 is based on tower counts established using the risk analysis approach (Baker et al. 2006). The escapement data used to establish the current goal was based on tower counts from 1956 to 1976 and expanded aerial surveys from 1977 to 1998 using an expansion factor of 2.7.

For this review we updated the historical aerial survey data from 1978 to 2008 (Appendix E1). Aerial survey data from 2009 to 2013 were not used for this analysis because it is not clear which streams in the drainage were flown by the biologist. Because the log-escapement time series for Alagnak sockeye salmon is serially correlated ($p < 0.001$; Figure 5), a lag-1 autoregressive model for estimated risk of an unwarranted restriction due to a management concern cannot be calculated directly, so a parametric simulation (per Bernard et al. 2009; equations 9–13) was conducted. One thousand lag-1 serially correlated escapements were generated. The risk of detecting a drop in mean escapement was calculated in the same way as risk of an unwarranted restriction, except that the risks of not detecting (1-risk) was estimated and mean escapement was changed by the desired drop in mean to be detected with the threshold (Figure 6).

Percentile Approach

Many salmon stocks throughout Alaska have an SEG developed using the percentile approach (Munro and Volk 2015); however, this approach has not previously been applied to Bristol Bay stocks. In 2001, Bue and Hasbrouck[1] developed an algorithm using percentiles of observed escapements, whether estimates or indices, that incorporated contrast in the escapement data and exploitation of the stock. Clark et al. (2014) evaluated this approach and recommended several modifications to the approach including consideration of the quality of the assessment data when deciding which percentiles are used to set the lower and upper bounds of the escapement goal. Percentile ranking is the percent of all escapement values that fall below a particular value. To calculate percentiles, escapement data are ranked from the smallest to the largest value, with the smallest value the 0th percentile (i.e., none of the escapement values are less than the smallest). The percentile of all remaining escapement values is cumulative, or a summation, of $1/(n\text{-}1)$, where n is the number of escapement values. Contrast in the escapement data is the maximum observed escapement divided by the minimum observed escapement. As contrast increases, meaning more information about the run size is known, the percentiles used to estimate the SEG are narrowed, primarily from the upper end, to better utilize the yields from the larger runs. Clark et al. (2014) recommended that the percentile approach not be used for stocks with average harvest rates greater than 0.40 or for stocks with very low contrast (4 or less) and high measurement error (aerial or foot surveys). For this review, the percentile approach was used to corroborate the Alagnak sockeye and Nushagak chum salmon goals, which were developed using the risk analysis approach.

[1] Bue, B. G. and J. J. Hasbrouck. *Unpublished*. Escapement goal review of salmon stocks of Upper Cook Inlet. Alaska Department of Fish and Game, Report to the Alaska Board of Fisheries, November 2001 (and February 2002), Anchorage. Subsequently referred to as Bue and Hasbrouck.

Escapement Contrast and Exploitation (from Clark et al. 2014)	SEG Range
High contrast (>8); and high measurement error (aerial and foot surveys) with low to moderate average harvest rates (<0.04)	20th to 60th Percentile
High contrast (>8); and low measurement error (weirs and towers) with low to moderate average harvest rates (<0.04)	15th to 65th Percentile
Low contrast (≤8) with low to moderate average harvest rates (<0.40)	5th to 65th Percentile

RESULTS AND DISCUSSION

A total of 15 escapement goals were reviewed for Bristol Bay. The committee updated the escapement goal analyses for Nushagak River chum salmon and Alagnak River sockeye salmon and recommends the Alagnak River sockeye salmon are changed to a lower-bound SEG of 125,000 that is based on a postseason aerial survey. The committee recommends no change to the Nushagak River chum salmon goal. The committee recommends 2 Chinook salmon goals be discontinued: Alagnak and Naknek rivers. There is no recommendation to establish any new goals in Bristol Bay.

The recommendation for each escapement goal follows by species and river.

CHINOOK SALMON

Alagnak River

The current risk-based lower-bound SEG of 2,700 for Alagnak River Chinook salmon is based on single aerial survey estimates begun in 1970 (Table 3; Appendix A1). Escapement averaged 4,855 Chinook salmon from 1970 to 2009 and was not surveyed in 1979 and from 2010 to 2014 (Appendix A1). ***The committee recommends this goal be discontinued for the following reasons:*** (1) the current assessment does not provide the area managers information to take inseason management actions; (2) this stock is passively managed and coincidentally harvested with the Kvichak River stock; harvest rates on this stock are probably low; (3) ADF&G has been unable to secure funding for conducting these surveys in 5 of the last 6 years; and (4) securing funding in the future for these surveys is unlikely. This stock is passively managed and coincidentally harvested with the Kvichak River stock; harvest rates on this stock are probably low.

Naknek River

The current risk-based lower bound SEG of 5,000 for Naknek River Chinook salmon is based on single aerial survey abundance estimates beginning in 1971 (Baker et al. 2006; Table 3; Appendix A2). Escapements have averaged 5,969 Chinook salmon from 1971 to 2008 (Appendix A2). Escapement was not estimated in 1999, 2005, 2006, and 2010–2014.

The committee recommends that this goal be discontinued for the following reasons: (1) the current assessment does not provide the area managers information to take inseason management actions; (2) this stock is passively managed and coincidentally harvested with the Kvichak River stock; harvest rates on this stock are probably low; (3) ADF&G has been unable to secure funding for conducting these surveys in 5 of the last 6 years; and (4) securing funding in the

future for these surveys is unlikely This stock is passively managed and coincidentally harvested with the Kvichak River stock; harvest rates on this stock are probably low.

Nushagak River

The current Nushagak River Chinook salmon SEG range is 55,000–120,000 (Table 3; Appendix A3). An ongoing study is estimating the proportion of Chinook salmon that travel in the non-ensonified midriver; preliminary findings suggest the proportion is relatively large although annual variability is unknown. From 2005 to 2014, 7 of 10 years experienced escapements (median of 96,468) within the recommended escapement goal range. Escapements averaged 166,089 Chinook salmon, total returns averaged 276,047, and return-per-spawner values averaged 2.12 from 1966 to 2007. We concluded that updating the stock recruit analysis would not probably result in a substantially different goal. ***The committee recommends no change to the Nushagak River Chinook salmon escapement goal: 55,000–120,000***.

CHUM SALMON

Nushagak River

The current lower bound SEG of 200,000 chum salmon counted at the sonar site was established in 2012 using the risk analysis approach (Fair et al. 2012). For this review, we corrected and updated historical escapement data and continued to use cumulative escapements through July 20 even though the sonar project in recent years has been extended into mid-August. July 20 was chosen as the cut-off date because (1) over 90% of the chum salmon escapement has passed the sonar site by this date, and (2) for over 30% of the years since 1980, sonar operations ceased around July 20, allowing for a larger time series to re-evaluate the goal.

Estimated risk for the current lower bound SEG based on the corrected and updated escapement data (Figure 4) (200,000) is 0.7% (less than once in 100 years) for an unwarranted concern, with 0.7% estimated risk that a consistent drop in mean escapement of 85% (from a mean of approximately 340,800 to the minimum observed escapement of 51,100) would not be detected in 3 consecutive years (Figure 4). The committee chose 3 consecutive years because this corresponds to the BOF regulatory cycle.

Three consecutive escapements of less than 200,000 have never occurred in 36 years of consecutive chum salmon escapements (1980–2015), and escapements less than 51,100 have never been experienced (Figure 2 and Appendix B1). The tier-two percentile method (high contrast and lower measurement error with moderate harvest) recommended by Clark et al. (2014) results in a lower bound SEG of approximately 187,000. ***Based on these results the committee recommends no change to the current lower bound SEG of 200,000 for this stock.***

COHO SALMON

Nushagak River

The review in 2006 discontinued an SEG of 50,000–100,000 for Nushagak River coho salmon (Baker et al. 2006). At that time, sonar operations had been reduced in duration (terminated on July 20), and no longer assessing coho salmon abundance. Beginning in 2012, the sonar project operated through August 20 to assess coho and pink salmon because both species are actively managed in the Nushagak District. During the previous review the SEG was changed to 60,000–120,000 to account for the transition from Bendix to DIDSON sonar.

For this review, we updated the historical escapement data (Appendix C1) but did not update the escapement goals analysis. The current escapement goal was met in 2012 and 2014. ***The committee recommends no change to the current SEG of 60,000–120,000*** (Table 3). Escapements averaged 127,7295 from 1980 to 2014 (Appendix C1), and this stock achieved the SEG twice in the last 11 years it has been assessed (median of 182,460; 1996–2014).

PINK SALMON

Nushagak River

The current lower bound SEG of 165,000 was established in 2012 (Fair et al. 2012) and is for even years only. The review in 2006 discontinued an SEG of 600,000–1,100,000 for Nushagak River pink salmon (Baker et al. 2006). At that time, sonar operations had been reduced in duration (terminated on July 20) and were no longer assessing pink salmon abundance. From 2012 to 2014, the sonar project operated through August 20 to assess pink and coho salmon because both species are actively managed in the Nushagak District.

For this review, we updated the historical escapement data (Appendix D1) but did not update the escapement goals analysis. The escapement goal was met in 2012 and 2014. ***The committee recommends no change to the lower bound SEG of 165,000*** for even-year pink salmon (Table 3). Escapements averaged 1,452,817 from 1958 to 2014 (Appendix D1), and this stock achieved the recommended goal for 8 of the last 10 even years (median of 484,919; 1990–2014).

SOCKEYE SALMON

Alagnak River

The estimated risk for the recommended lower bound SEG (125,000) based on aerial surveys from 1978 to 2008 is 4% (once in 25 years) for an unwarranted concern, with 3% estimated risk that a consistent drop in mean escapement of 95% (from a mean of approximately 528,369 to a minimum observed escapement of 26,468) would not be detected in 3 consecutive years (Figure 6). The committee chose 3 consecutive years because this corresponds to the BOF regulatory cycle for Bristol Bay.

Three consecutive escapements of less than 125,000 have never occurred in 31 years of aerial surveys (1978–2008) and escapements less 26,468 have never been experienced (Figure 7 and Appendix E1). ***Based on these results, the committee recommends a new lower bound SEG of 125,000 that is based on aerial counts.***

The Alagnak River sockeye salmon stock is passively managed and coincidentally harvested with the Kvichak River stock. ADF&G is not able to actively manage this stock. It is for this reason that a lower bound SEG was established in 2006.

Historically, the Alagnak River was not considered a large producer of sockeye salmon compared to the Kvichak River and many other Bristol Bay sockeye salmon stocks. However, since 2003, escapements based on tower counts and expanded aerial surveys averaged 2,076,096 (Appendix E1). While we do not yet know the total return from all of these large escapements, total runs since 2003 averaged approximately 3,500,000 fish (Table 1). We should not be surprised by the recent production increase for the Alagnak River. Schindler et al. (2006) used sediment cores to show that periods of high sockeye salmon abundance have occurred in the Alagnak River approximately every 100 years for the last 5 centuries.

Egegik River

The current Egegik River sockeye salmon SEG was implemented in March of 2015 (Table 3; Appendix E2). Given the recent change for this goal the review committee elected not to update the stock recruit analysis for this stock. ***The committee recommends no change to the Egegik River sockeye salmon SEG: 800,000–2,000,000 fish***.

From 2005 to 2014, each of the 10 years experienced escapements (median of 1,246,734) within the recommended escapement goal range. Escapements averaged 1,153,752 sockeye salmon, total returns averaged 6,495,459, and return-per-spawner values averaged 5.57 from 1959 to 2006.

Igushik River

The current Igushik River sockeye salmon SEG was implemented in March of 2015 (Table 3; Appendix E3). Given the recent change for this goal, the review committee elected not to update the stock recruit analysis for this stock. ***The committee recommends no change to the Igushik River sockeye salmon SEG: 150,000–400,000***.

From 2005 to 2014, 5 of 10 years experienced escapements (median of 401,244) within the recommended escapement goal range. Escapements averaged 345,333 sockeye salmon, total returns averaged 717,218, and return-per-spawner values averaged 5.57 from 1990 to 2006.

Kvichak River

Prior to the last review (Baker et al. 2009), the Kvichak River had 2 escapement goals: 1 for off-cycle years (pre-peak), and 1 for cycle years (peak). The SEG was 2,000,000–10,000,000 for off-cycle years and 6,000,000–10,000,000 for cycle years (Table 3; Appendix E4). A cycle year goal, largely composed of 5-year-old 2-ocean fish, was originally established in the 1960s (Rogers and Poe 1984) because it was believed that production differed from that of off-cycle years. Therefore, it was advantageous to separate them. In 2009, we updated the analysis for comparing production between cycle and off-cycle years and found statistical similarity in their underlying productivity. Additionally, it became difficult to identify off-cycle from cycle years as the runs declined in the 2000s. For these reasons, in the 2009 review we eliminated the cycle goal, leaving 1 goal, an SEG of 2,000,000–10,000,000 for all years.

Setting an escapement goal for Kvichak River sockeye salmon has proven difficult because of the perceived divergence in productivity between off-cycle and cycle years; weak evidence of density dependence found in the spawner-return data; and a subsequent lack of fit for stock-recruitment models. To help achieve escapements within the goal range and provide harvest opportunity, a maximum exploitation rate of 50% was established for Kvichak River runs of 4,000,000–20,000,000. For example, the management objective is to harvest 50% of the total inshore run, and escapements less than 2,000,000 or greater than 10,000,000 are avoided.

The change of the escapement goal in 2009 was also supported by an analysis completed by Ruggerone and Link (2006). Their analysis did not support the existing escapement goal policy of higher escapement levels during peak and pre-peak return years compared to other return years. They concluded that maintenance of the Kvichak River sockeye salmon cycle through management actions does not appear necessary for high salmon productivity and harvestable surpluses. A similar conclusion was also reached by Rogers and Poe (1984).

Fair et al. (2012) updated the Ricker stock-recruitment model with the newly reconstructed brood table through brood year 2005. Because of the similarity between the old brood and new brood tables (Appendix E4) for Kvichak River, they did not re-evaluate the test for differences in productivity between cycle and off-cycle years. Similar to previous reviews, fit of the Ricker model was poor. With inadequate information to reliably estimate β, and hence, S_{msy}, the goal will remain an SEG. Given the recent review of this goal in March of 2015, the review committee elected not to update the stock recruit analysis for this stock. ***The committee recommends no change to the Kvichak River sockeye salmon SEG: 2,000,000–10,000,000.*** From 2005 to 2014, each of 10 years experienced escapements (median of 2,784,060) within the escapement goal range. Escapements averaged 5,233,287 sockeye salmon, total returns averaged 10,705,266, and return-per-spawner values averaged 2.42 from 1959 to 2006.

Naknek River

The current Naknek River sockeye salmon SEG was implemented in March of 2015 (Table 3; Appendix E5). Given the recent change for this goal, the review committee elected not to update the stock recruit analysis for this stock. ***The committee recommends no change to the Naknek River sockeye salmon SEG: 800,000–2,000,000***.

From 2005 to 2014, 7 of the 10 years experienced escapements (median of 1,469,178) within the recommended escapement goal range. From 1959 to 2006, escapements averaged 1,351,244 sockeye salmon, total returns averaged 4,072,397, and return-per-spawner values averaged 3.27.

Nushagak River

The current Nushagak River sockeye salmon SEG was implemented in March of 2015 (Table 3; Appendix E6). Given the recent change for this goal the review committee elected not to update the stock recruit analysis for this stock. ***The committee recommends no change to the Nushagak River sockeye salmon SEG: 370,000–900,000***.

From 2005 to 2014, 9 of 10 years experienced escapements (median of 505,294) within the recommended escapement goal range. Escapements averaged 539,328 sockeye salmon, total returns averaged 1,481,327, and return-per-spawner values averaged 3.77 from 1959 to 2006.

Togiak River

The current Togiak River sockeye salmon SEG is 120,000–270,000 (Table 3; Appendix E7). During the previous review, Fair et al. (2012) standardized the escapement time series by removing all aerial surveys and updating the brood table accordingly. This means the current goal is strictly a tower-based goal.

The committee recommends no change to the Togiak River sockeye salmon escapement goal. The committee recommends keeping the goal as an SEG due to catch allocation issues within the Togiak District (Dann et al. 2011). From 2005 through 2014, 8 of 10 years experienced escapements (median of 197,059) within the recommended escapement goal range. Escapements averaged 164,418 sockeye salmon, total returns averaged 560,491, and return-per-spawner values averaged 3.77 from 1959 to 2005.

Ugashik River

The current Ugashik River sockeye salmon SEG was implemented in March of 2015 (Table 3; Appendix E8). Given the recent change for this goal the review committee elected not to update

the stock recruit analysis for this stock. ***The committee recommends no change to the Ugashik River sockeye salmon SEG: 500,000–1,400,000***.

From 2005 through 2014, 9 of the 10 years experienced escapements (median of 864,498) within the recommended escapement goal range. Escapements averaged 887,255 sockeye salmon, total returns averaged 3,077,841, and return-per-spawner values averaged 4.31 from 1959 to 2006.

Wood River

The current Wood River sockeye salmon SEG was implemented in March of 2015 (Table 3; Appendix E9). Given the recent change for this goal the review committee elected not to update the stock recruit analysis for this stock. ***The committee recommends no change to the Wood River sockeye salmon SEG: 700,000–1,800,000***.

From 2005 to 2014, 7 of 10 years experienced escapements (median of 1,512,318) within the recommended escapement goal range. Escapements averaged 1,238,888 sockeye salmon, total returns averaged 4,050,626, and return-per-spawner values averaged 3.40 from 1959 to 2006.

ACKNOWLEDGEMENTS

The authors wish to thank the members of the escapement goal committee and participants in the escapement goal review. Special thanks go to Fred West and Greg Buck for their thorough review of data quality and analysis.

REFERENCES CITED

Baker, T. T., L. F. Fair, R. A. Clark, and J. J. Hasbrouck. 2006. Review of salmon escapement goals in Bristol Bay, Alaska, 2006. Alaska Department of Fish and Game, Fishery Manuscript No. 06-05, Anchorage.

Baker, T. T., L. F. Fair, F. W. West, G. B. Buck, X. Zhang, S. Fleishman, and J. Erickson. 2009. Review of salmon escapement goals in Bristol Bay, Alaska, 2009. Alaska Department of Fish and Game, Fishery Manuscript No. 09-05, Anchorage.

Belcher, E. O., W. Hanot, and J. Burch. 2002. Dual-frequency identification sonar. Pages 187–192 [*In*] Proceedings of the 2002 International Symposium on Underwater Technology, April 16–19. Tokyo, Japan.

Bernard, D. R. 1983. Variance and bias of catch allocations that use the age composition of escapements. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet No. 227, Anchorage.

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

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

Brazil, C., and G. B. Buck. 2011. Sonar enumeration of Pacific salmon escapement into the Nushagak River, 2006. Alaska Department of Fish and Game, Fishery Data Series No. 11-14 Anchorage.

Buck, G. B., C. Brazil, F. West, L. Fair, X. Zhang, and S. L. Maxwell. 2012. Stock assessment of Chinook, sockeye, and chum salmon in the Nushagak River. Alaska Department of Fish and Game, Fishery Manuscript Series No. 12-05, Anchorage.

Burgner, R. L., C. J. DiCostanzo, R. L. Ellis, G. Y. Harry, Jr., W. L. Hartman, O. E. Kerns, Jr., O. A. Mathisen, and W. F. Royce. 1967. Biological studies and estimates of optimum escapement s of sockeye salmon in the major river systems in Southwestern Alaska. Fishery Bulletin 67:405–459. United States Fish and Wildlife Service, Washington, D.C.

Chatfield, C. 2004. The analysis of time series, an introduction, sixth edition. Chapman & Hall. New York.

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

Clark, J. H. 2005. Abundance of sockeye salmon in the Alagnak River system of Bristol Bay Alaska. Alaska Department of Fish and Game, Fishery Manuscript No. 05-01, Anchorage.

Clark R. A., D. M. Eggers, A. R. Munro, S. J. Fleischman, B. G. Bue, and J. J. Hasbrouck. 2014. An evaluation of the percentile approach for establishing sustainable escapement goals in lieu of stock productivity information. Alaska Department of Fish and Game, Fishery Manuscript No. 14-06, Anchorage.

Cross, B. A., D. C. Gray, and D. L. Crawford. 1997. Report to the Alaska Board of Fisheries on spawning escapement goal evaluations for Bristol Bay salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A97-30, Anchorage.

Cunningham, C. J., R. Hilborn, J. Seeb, and T. Branch. 2012. Reconstruction of Bristol Bay sockeye salmon returns using age and genetic composition of catch. University of Washington, School of Aquatic and Fishery Sciences: AFS-UW-1202.

Dann, T. H., C. Habicht, H. A. Hoyt, T. T. Baker, and F. W. West. 2011. Genetic stock composition of the commercial harvest of sockeye salmon in Bristol Bay, Alaska, 2009. Alaska Department of Fish and Game, Fishery Data Series No. 11-21, Anchorage.

Fair, L. F. 2000. Report to the Alaska Board of Fisheries on spawning escapement goal evaluations for Bristol Bay salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A00-38, Anchorage.

REFERENCES CITED (Continued)

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

Fair, L. F., C. E. Brazil, X. Zhang, R. A. Clark, and J. W. Erickson. 2012. Review of salon escapement goals in Bristol Bay, Alaska, 2012. Alaska Department of Fish and Game, Fishery Manuscript Series No. 12-04, Anchorage.

Fleischman, S. J., J. A. Der Hovanisian, and S. A. McPherson. 2011. Escapement goals for Chinook salmon in the Blossom and Keta rivers. Alaska Department of Fish and Game, Fishery Manuscript No. 11-05, Anchorage.

Fried, S. M. 1994. Pacific salmon spawning escapement goals for the Prince William Sound, Cook Inlet, and Bristol Bay areas of Alaska. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Special Publication No. 8, Juneau.

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

Maxwell, S. L., A. V. Faulkner, L. Fair, and X. Zhang. 2011. A comparison of estimates from 2 hydroacoustic systems used to assess sockeye salmon escapement in 5 Alaska Rivers. Alaska Department of Fish and Game, Fishery Manuscript Series No. 11-02, Anchorage.

Munro, A. R., and E. C. Volk. 2015. Summary of Pacific salmon escapement goals in Alaska with a review of escapements from 2006 to 2014. Alaska Department of Fish and Game, Fishery Manuscript Series No. 15-04, Anchorage.

Peterman, R. M., B. J. Pyper, and B. W. MacGregor. 2003. Use of the Kalman filter to reconstruct historical trends in productivity of Bristol Bay sockeye salmon (*Oncorhynchus nerka*). Canadian Journal of Fisheries and Aquatic Sciences 60: 809–824.

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

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

Rivot, E., E. Prévost, and E. Parent. 2001. How robust are Bayesian posterior inferences based on a Ricker model with regards to measurement errors and prior assumptions about parameters? Canadian Journal of Fisheries and Aquatic Sciences 58:2284–2297.

Rogers D. E., and P. H. Poe. 1984. Escapement goals for the Kvichak River system. Final Report to the Alaska Department of Fish and Game, Contract No. 84-0324. Fisheries Research Institute, School of Fisheries, University of Washington, FRI-UW-8407. Seattle.

Ruggerone, G. T., and M. R. Link. 2006. Collapse of Kvichak sockeye salmon production brood years 1991–1999: Population characteristics, possible factors, and management implications. Unpublished report prepared by Natural Resources Consultants, Inc. and LGL Alaska Research Associates, Inc. for the North Pacific Research Board, Anchorage, AK.

Salomone P., S. Morstad, T. Sands, and M. Jones. 2009. Salmon spawning ground surveys in the Bristol Bay Area, Alaska, 2008. Alaska Department of Fish and Game, Fishery Management Report No. 09-42, Anchorage.

Schindler, D. E., P. R. Leavitt, S. P. Johnson, and C. S. Brock. 2006. A 500-year context for the recent surge in sockeye salmon (*Oncorhynchus nerka*) abundance in the Alagnak River, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 63:1439–1444.

Smith, M. J. 2010. Genetics provide a forty-five year retrospective of sockeye salmon (*Oncorhynchus nerka*) harvest compositions in Bristol Bay, Alaska. Master's thesis. University of Washington, Seattle.

West, F., T T. Baker, S. Morstad, K. Weiland, P. Salomone, T. Sands, and C. Westing. 2012. Abundance, age, sex, and size statistics for Pacific salmon in Bristol Bay, 2005. Alaska Department of Fish and Game, Fishery Data Series No. 12-02, Anchorage.

TABLES AND FIGURES

Table 1.–Bristol Bay sockeye salmon total runs by system, 1990–2014.

Year	Alagnak	Egegik	Igushik	Kvichak	Naknek	Nushagak	Togiak	Ugashik	Wood	Total
1990	1,701,649	12,637,915	876,172	18,189,966	8,163,457	1,804,526	367,224	2,712,067	3,195,123	49,648,099
1991	1,737,583	9,251,071	1,645,838	8,611,675	9,688,700	1,628,967	829,268	5,958,772	4,506,271	43,858,145
1992	1,489,221	17,899,123	470,348	10,627,883	5,188,655	1,888,874	868,259	6,341,101	3,071,690	47,845,154
1993	2,512,409	24,268,431	717,075	8,063,207	5,501,841	2,580,049	701,900	6,216,394	4,748,132	55,309,438
1994	2,195,065	12,777,526	906,828	21,588,688	3,535,600	1,436,463	522,040	5,569,307	3,696,594	52,228,111
1995	2,338,713	15,416,175	1,184,425	28,422,825	3,266,372	810,995	771,293	5,912,259	4,938,613	63,061,670
1996	2,410,081	12,424,020	942,696	4,473,942	4,629,505	1,623,169	586,181	5,370,520	5,959,844	38,419,958
1997	824,652	7,932,989	208,759	2,394,703	1,897,379	817,647	264,324	2,508,869	3,879,034	20,728,356
1998	1,208,943	4,696,477	426,034	3,810,384	2,336,117	991,560	313,124	1,892,158	4,421,018	20,095,815
1999	3,103,292	6,501,522	859,318	13,202,982	4,608,730	451,807	565,235	5,223,624	7,403,081	41,919,591
2000	2,247,374	8,174,785	982,740	3,582,461	3,892,043	1,344,618	1,126,843	2,300,669	6,541,118	30,192,651
2001	1,298,362	3,567,026	818,733	1,978,264	5,843,560	2,093,785	1,109,141	1,469,530	4,644,099	22,822,500
2002	991,581	5,543,847	199,684	915,974	2,746,786	691,785	406,290	2,499,988	3,859,722	17,855,657
2003	4,269,058	3,216,304	492,184	2,041,843	4,714,012	2,409,660	897,566	2,542,318	6,233,372	26,816,317
2004	7,602,372	11,653,816	268,354	8,103,494	3,968,470	2,062,469	507,677	4,203,288	6,430,417	44,800,357
2005	5,396,064	9,403,191	801,087	2,926,045	8,538,432	3,672,976	581,328	3,093,000	5,881,534	40,293,657
2006	2,959,105	8,611,295	730,987	5,212,193	6,244,656	3,182,432	906,036	3,769,197	12,186,375	43,802,276
2007	4,192,470	7,871,418	856,587	5,010,550	9,438,712	2,499,070	1,066,972	7,408,795	7,930,681	46,275,255
2008	4,625,323	7,892,592	1,685,397	6,132,383	9,249,393	1,548,644	868,540	2,722,282	7,366,573	42,091,127
2009	2,411,665	13,014,336	915,844	6,899,793	4,438,134	1,674,977	856,127	3,605,013	7,745,923	41,561,812
2010	2,857,063	5,156,493	1,540,795	10,931,213	5,270,545	1,035,601	741,034	4,953,525	8,847,397	41,333,666
2011	2,333,170	4,503,430	1,297,732	7,587,656	5,109,389	1,123,579	858,018	4,273,505	4,711,499	31,797,978
2012	2,380,017	5,915,261	730,319	12,217,291	3,218,808	948,971	832,938	2,926,170	2,563,505	31,733,281
2013	2,013,751	5,303,258	829,687	6,380,982	2,929,308	1,977,312	592,763	2,459,882	3,181,502	25,668,445
2014	1,575,995	5,255,860	1,470,641	17,708,088	5,201,164	1,545,643	533,288	1,034,323	7,095,983	41,420,984
Mean	2,666,999	9,155,526	874,331	8,680,579	5,184,791	1,673,823	706,936	3,878,662	5,641,564	38,463,212
Median	2,338,713	7,932,989	856,587	6,899,793	4,714,012	1,623,169	741,034	3,605,013	4,938,613	41,420,984
Min	824,652	3,216,304	199,684	915,974	1,897,379	451,807	264,324	1,034,323	2,563,505	17,855,657
Max	7,602,372	24,268,431	1,685,397	28,422,825	9,688,700	3,672,976	1,126,843	7,408,795	12,186,375	63,061,670

Note: Small runs (less than 1% of total Bristol Bay) of sockeye salmon not shown here occur in the Kulukak, Matogak, Osviak, and Snake rivers.

Table 2.–List of members on the Alaska Department of Fish and Game (ADF&G) Bristol Bay salmon escapement goal committee and other participants who assisted with the escapement goal review.

Name	Position	Affiliation
Escapement Goal Committee:		
Charles Brazil	Area Research Biologist	ADF&G, Division of Commercial Fisheries
Robert Clark	Fisheries Advisor	ADF&G, Division of Sport Fish
Jack Erickson	Regional Research Coordinator	ADF&G, Division of Commercial Fisheries
Steve Fleischman	Fisheries Scientist	ADF&G, Division of Sport Fish
James Hasbrouck	Chief Fisheries Scientist	ADF&G, Division of Sport Fish
Timothy McKinley	Regional Research Coordinator	ADF&G, Division of Sport Fish
Andrew Munro	Fisheries Scientist	ADF&G, Division of Commercial Fisheries
Xinxian Zhang	Regional Biometrician	ADF&G, Division of Commercial Fisheries
Other Participants:		
Tim Baker	Regional Management Biologist	ADF&G, Division of Commercial Fisheries
Daniel Bosch	Regional Management Biologist	ADF&G, Division of Sport Fish
Greg Buck	Asst. Area Research Biologist	ADF&G, Division of Commercial Fisheries
Jason Dye	Area Management Biologist	ADF&G, Division of Sport Fish
Travis Elison	Area Management Biologist	ADF&G, Division of Commercial Fisheries
Ian Fo	Asst. Area Management Biologist	ADF&G, Division of Sport Fish
Matt Jones	Asst. Area Management Biologist	ADF&G, Division of Commercial Fisheries
Bert Lewis	Regional Management Biologist	ADF&G, Division of Commercial Fisheries
Tracy Lingnau	Regional Supervisor	ADF&G, Division of Commercial Fisheries
Paul Salomone	Area Management Biologist	ADF&G, Division of Commercial Fisheries
Timothy Sands	Area Management Biologist	ADF&G, Division of Commercial Fisheries
Thomas Vania	Regional Supervisor	ADF&G, Division of Sport Fish
Erik Volk	Chief Fisheries Scientist	ADF&G, Division of Commercial Fisheries
Fred West	Asst. Area Research Biologist	ADF&G, Division of Commercial Fisheries

Table 3.–Summary of current escapement goals and recommended escapement goals for salmon stocks in Bristol Bay, 2015.

	Current Escapement Goal			Escapement	Recommended Escapement Goal		
System	Goal	Type	Year Adopted and History	Data	Action	Goal	Type
Chinook Salmon							
Alagnak	2,700 minimum	SEG	2007	Aerial	Discontinued		
Naknek	5,000 minimum	SEG	2007	Aerial	Discontinued		
Nushagak	55,000–120,000	SEG	2007; Changed to SEG in 2007; range changed in 2013	Sonar	No Change		
Chum Salmon							
Nushagak	200,000 minimum	SEG	2007; range changed in 2013	Sonar	No Change		
Coho Salmon							
Nushagak	60,000–120,000	SEG	2013	Sonar	No Change		
Pink Salmon							
Nushagak (even years)	165,000 minimum		2013	Sonar	No Change		
Sockeye Salmon							
Alagnak	320,000 minimum	SEG	2007	Tower	Change in range based on aerial survey	125,000 lower bound	SEG
Egegik	800,000–2,000,000	SEG	1995; Changed to SEG in 2007; range changed in 2015	Tower	No Change		
Igushik	150,000–400,000	SEG	2001; Changed to SEG in 2007; range changed in 2015	Tower	No Change		
Kvichak	2,000,000–10,000,000	SEG	One goal for all years in 2010	Tower	No Change		
Naknek	800,000–2,000,000	SEG	1983; Changed to SEG in 2007; range changed in 2015	Tower	No Change		
Nushagak	370,000–900,000	SEG	1998; Changed to SEG in 2007; range changed in 2013; range changed in 2015	Sonar	No Change		
Togiak	120,000–270,000	SEG	2007; Changed from a BEG in 2010	Tower	No Change		
Ugashik	500,000–1,400,000	SEG	1995; Changed to SEG in 2007; range changed in 2015	Tower	No Change		
Wood	700,000–1,800,000	SEG	2001; Changed to SEG in 2007; range changed in 2015	Tower	No Change		

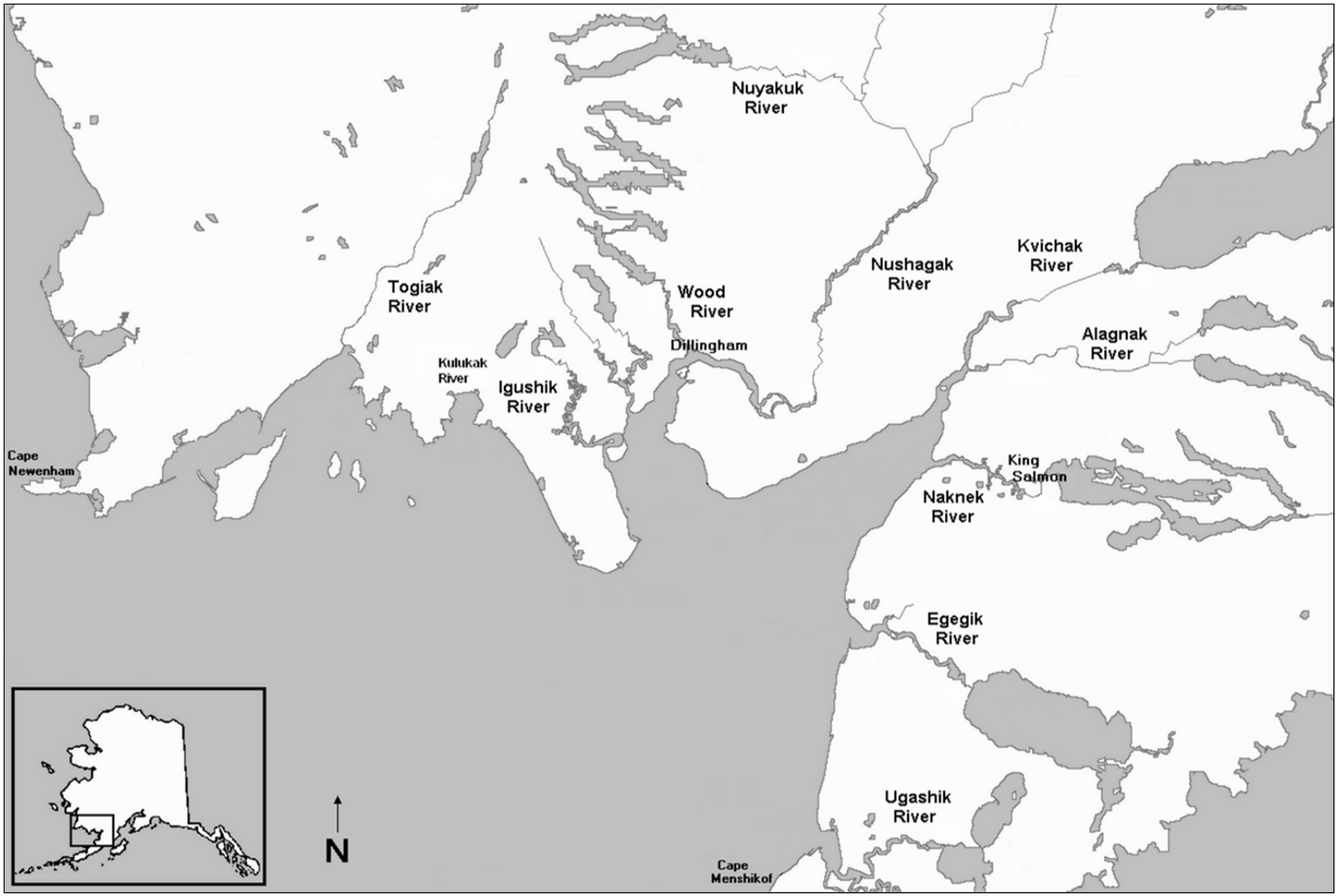

Figure 1.–Map of Bristol Bay showing major rivers.

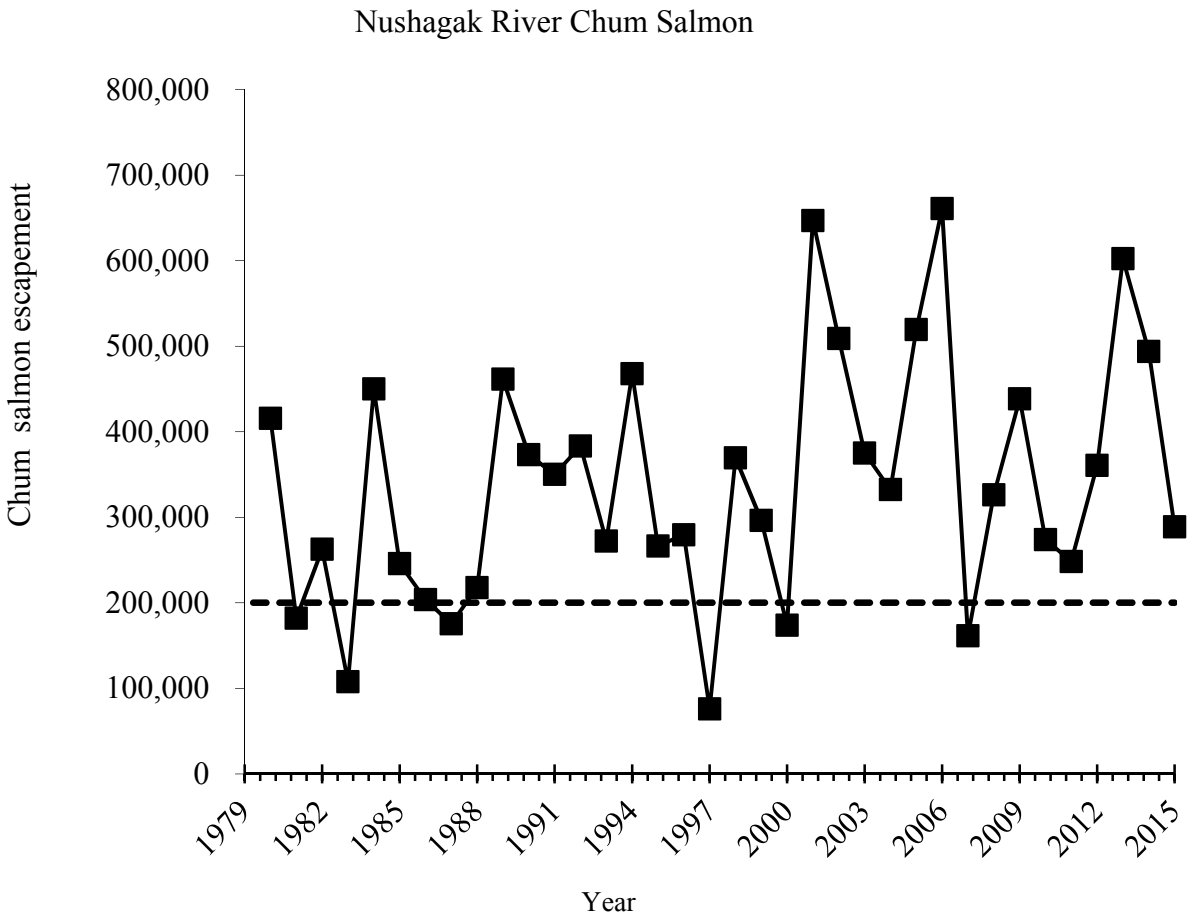

Figure 2.–Escapement of chum salmon in the Nushagak River (1980–2015; solid line) and the current lower bound sustainable escapement goal (SEG; dashed line).

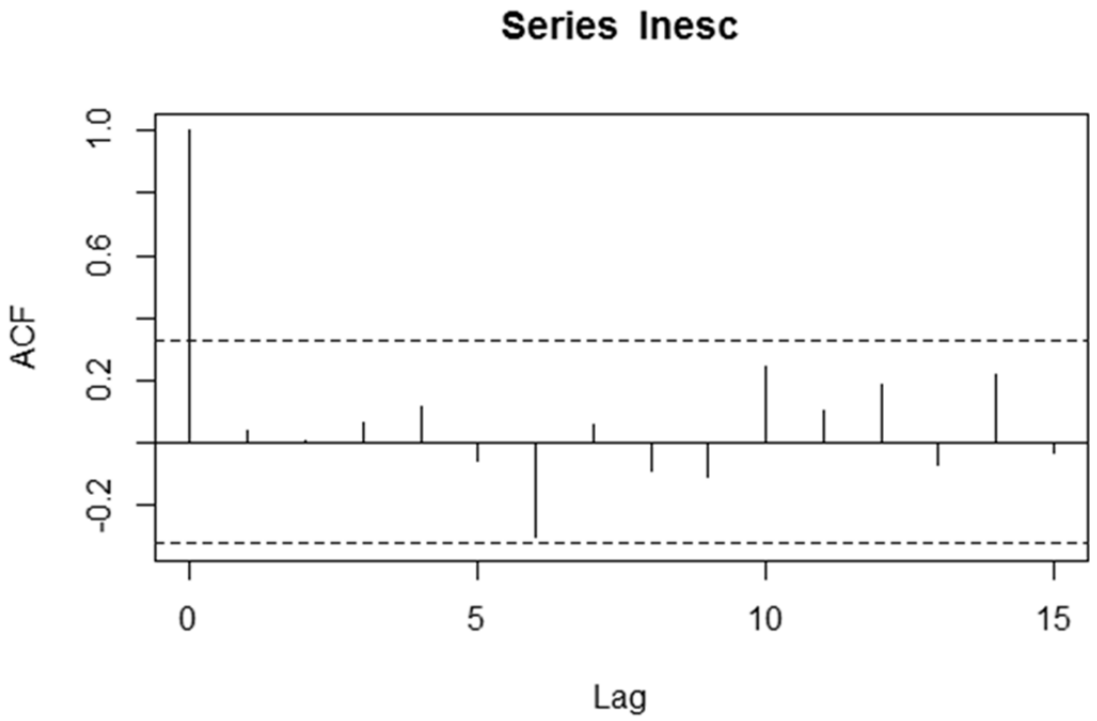

Figure 3.–Autocorrelations (ACF) for log escapements of annual spawning abundance for chum salmon in the Nushagak River (1980–2015).

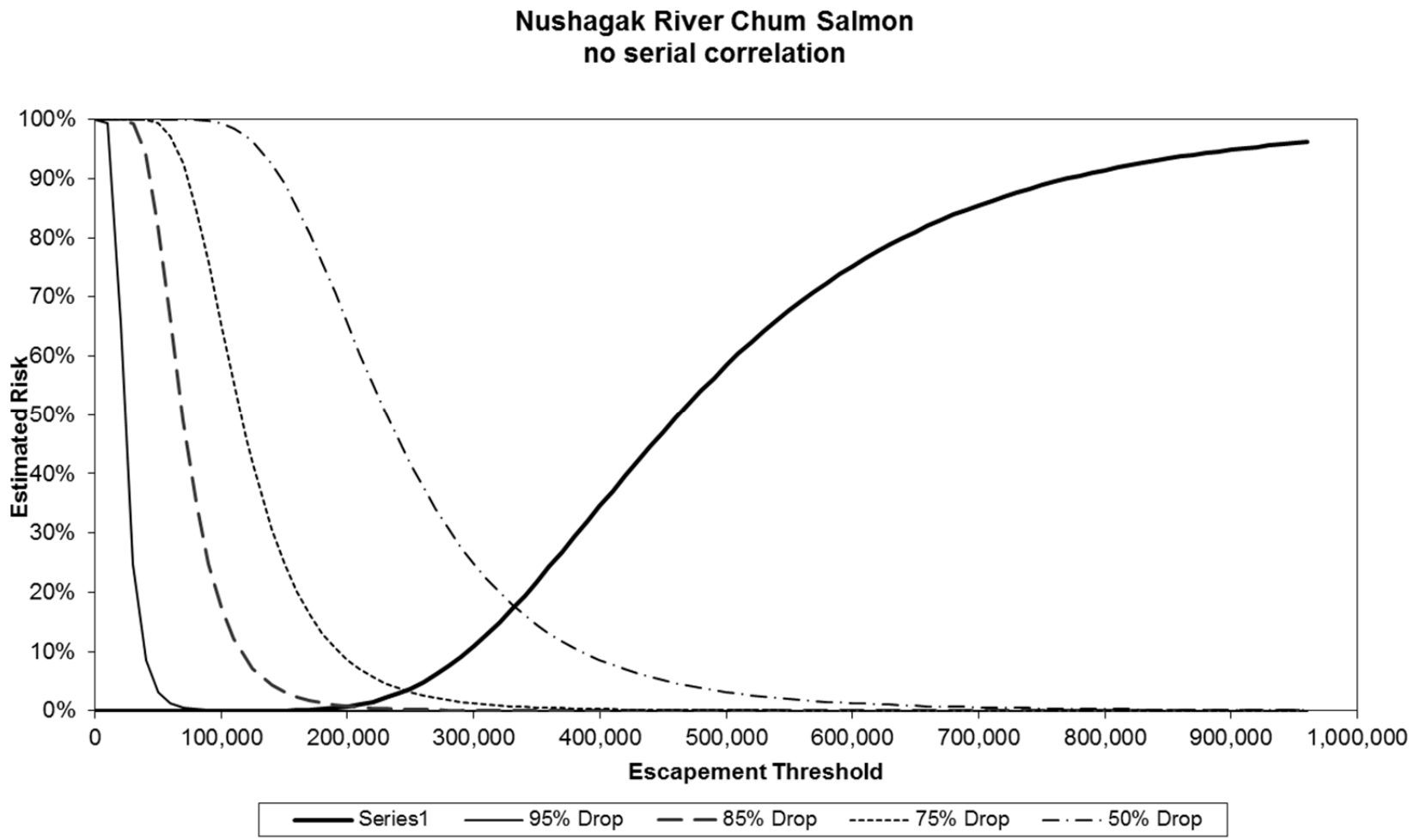

Figure 4.–Estimated risk of an unwarranted management concern and risk of not detecting various percentage drops in mean log-transformed escapement for a range of possible escapement thresholds for Nushagak River chum salmon.

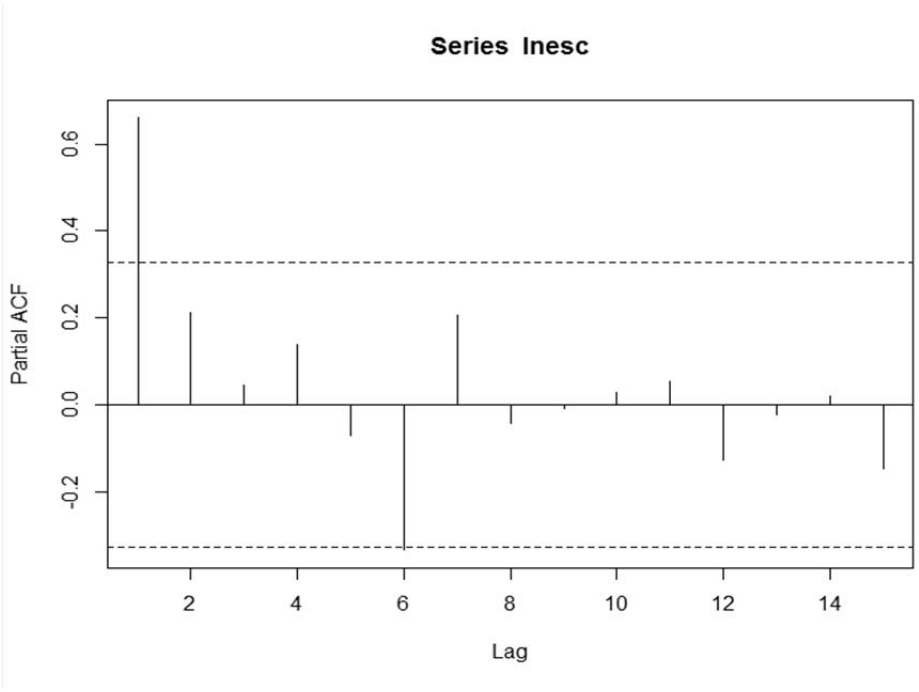

Figure 5.–Partial autocorrelations (PACF) for log escapements of annual spawning abundance for sockeye salmon in the Alagnak River (1978–2008).

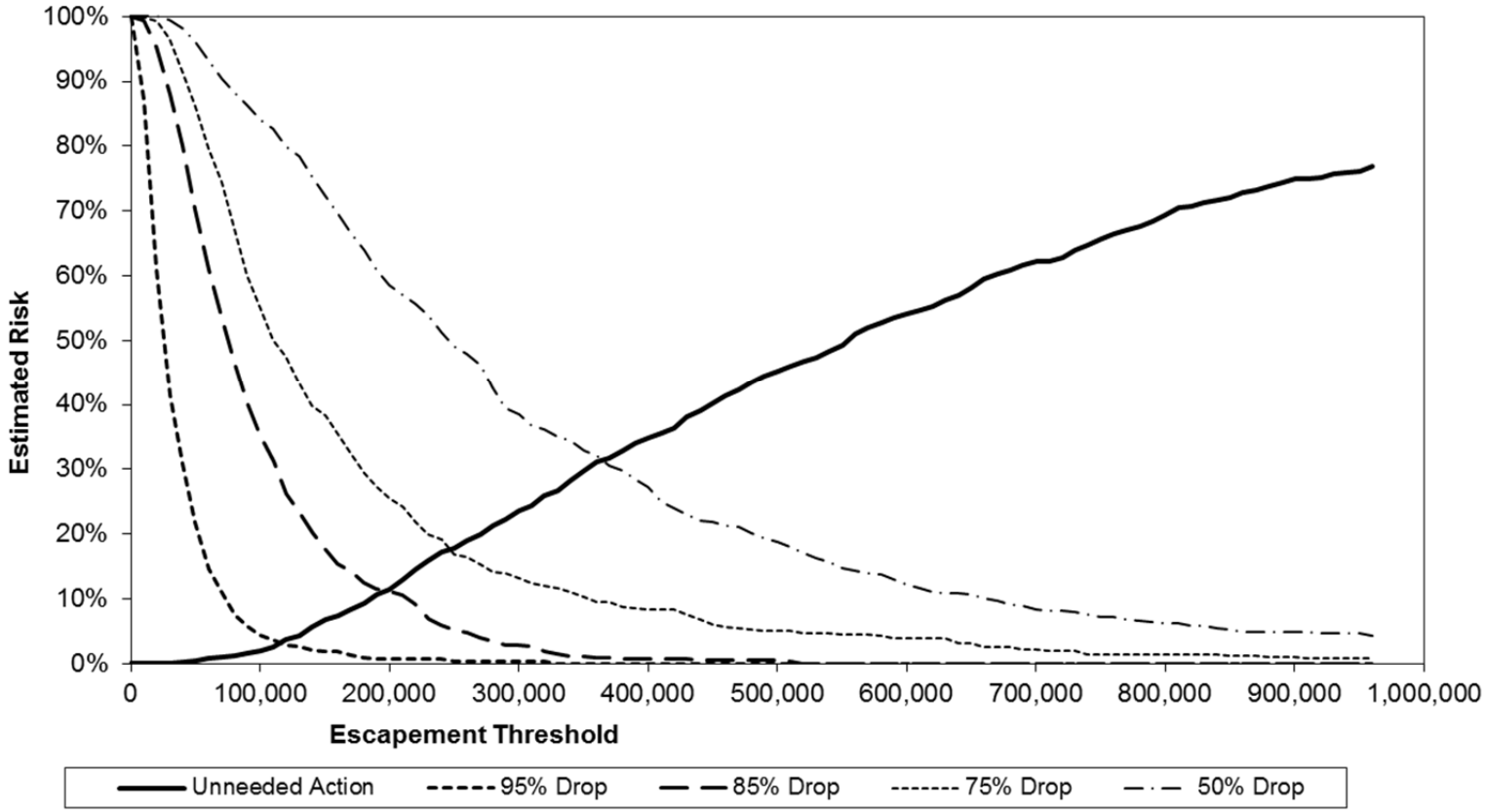

Figure 6.–Estimated risk of an unwarranted management concern and risk of not detecting various percentage drops in mean log-transformed escapement for a range of possible escapement thresholds for Alagnak River sockeye salmon.

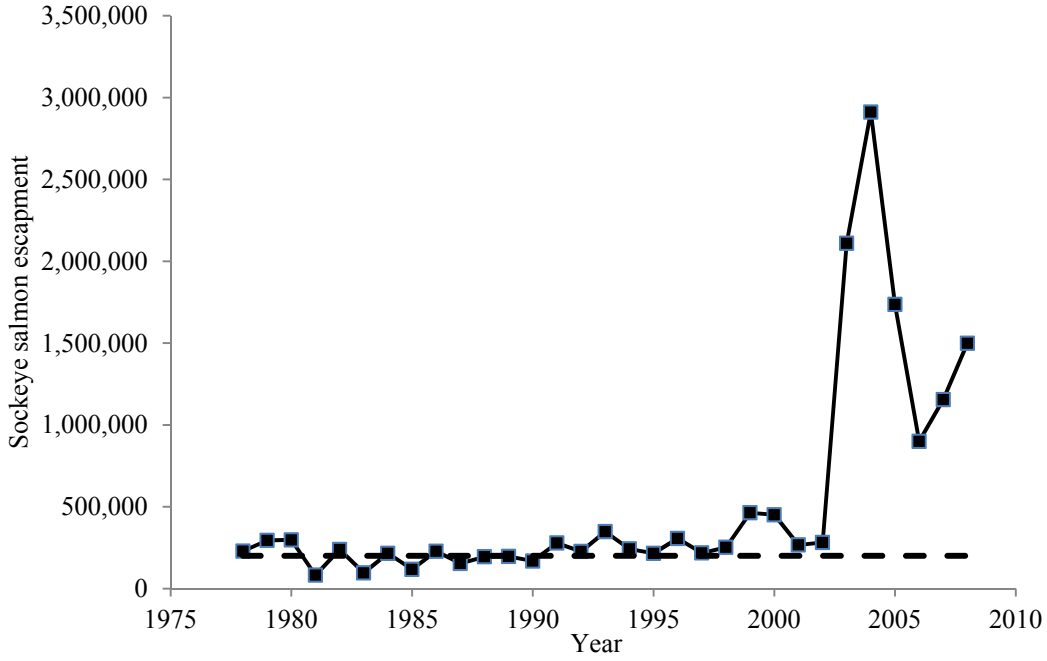

Figure 7.–Escapement of sockeye salmon based on aerial surveys of the Alagnak River (1978–2008; solid line) and the recommended lower bound sustainable escapement goal (SEG; dashed line).

APPENDIX A. CHINOOK SALMON

Appendix A1.–Escapement goal for Alagnak River Chinook salmon.

System:	Alagnak River
Species:	Chinook salmon
Description of stock and escapement goals	
Management Division:	Sport Fish
Current Escapement Goal:	2,700 lower bound SEG
Inriver Goal:	None
Optimal Escapement Goal:	None
Recommended Escapement Goal:	No change
Escapement Estimation:	Aerial survey counts since 1970
Summary:	
Data Quality	Fair
Data Type	Aerial survey; limited age data
Methodology	Risk analysis
Years within recommended goal	7 out of last 11 years (1999–2009) – no surveys since 2009

-continued-

Appendix A1.–Page 2 of 3.

Year	Escapement	ln(Escapement)
1970	5,250	8.57
1971	1,475	7.30
1972	2,256	7.72
1973	824	6.71
1974	1,596	7.38
1975	6,620	8.80
1976	7,593	8.93
1977	9,425	9.15
1978	11,650	9.36
1979	[a]	
1980	2,930	7.98
1981	2,430	7.80
1982	3,400	8.13
1983	2,980	8.00
1984	6,090	8.71
1985	3,920	8.27
1986	3,090	8.04
1987	2,420	7.79
1988	4,600	8.43
1989	3,650	8.20
1990	1,720	7.45
1991	2,531	7.84
1992	3,042	8.02
1993	10,170	9.23
1994	8,480	9.05
1995	6,860	8.83
1996	9,885	9.20
1997	15,210	9.63
1998	4,148	8.33
1999	2,178	7.69

-continued-

Appendix A1.–Page 3 of 3.

Year	Escapement	ln(Escapement)
2000	2,220	7.71
2001	5,458	8.60
2002	3,675	8.21
2003	8,209	9.01
2004	6,755	8.82
2005	5,084	8.53
2006	4,278	8.36
2007	3,455	8.15
2008	1,825	7.51
2009	1,957	7.58
2010	[a]	
2011	[a]	
2012	[a]	
2013	[a]	
2014	[a]	
1970–2009		
Average	4,855	8.28
St. dev.	3,239	0.66
Median	3,675	8.21
No. of Years	39	39

[a] No surveys were flown in 1979, 2010–2014.

Appendix A2.–Escapement goal for Naknek River Chinook salmon.

System:	Naknek River
Species:	Chinook salmon
Description of stock and escapement goals	
Management Division:	Sport Fish
Previous Escapement Goal:	5,000 lower bound SEG
Inriver Goal:	None
Optimal Escapement Goal:	None
Recommended Escapement Goal:	No change
Escapement Estimation:	Aerial survey counts since 1971
Summary:	
Data Quality	Fair
Data Type	Aerial survey and Big Creek weir; limited age data
Methodology	Risk analysis
Years within recommended goal	6 out of 7 years (2000–2004; 2007–2008); no escapement estimates in 1999, 2005–2006, and 2009–2011

-continued-

Appendix A2.–Page 2 of 3.

Year	Escapement	ln(Escapement)
1971	2,885	7.97
1972	2,791	7.93
1973	2,536	7.84
1974	[a]	
1975	3,452	8.15
1976	7,131	8.87
1977	[a]	
1978	[a]	
1979	[a]	
1980	[a]	
1981	4,271	8.36
1982	8,610	9.06
1983	7,830	8.97
1984	4,995	8.52
1985	[a]	
1986	3,917	8.27
1987	4,450	8.4
1988	11,730	9.37
1989	2,710	7.9
1990	7,000	8.85
1991	4,391	8.39
1992	2,691	7.9
1993	8,016	8.99
1994	9,678	9.18
1995	4,960	8.51
1996	5,010	8.52
1997	10,453	9.25
1998	5,505	8.61
1999	[a]	

-continued-

Appendix A2.–Page 3 of 3.

Year	Escapement	ln(Escapement)
2000	3,233	8.08
2001	6,340	8.75
2002	7,503	8.92
2003	6,081	8.71
2004	12,878	9.46
2005	[a]	
2006	[a]	
2007	5,498	8.61
2008	6,559	8.79
2009	3.305 [b]	
2010	[a]	
2011	[a]	
2012	[a]	
2013	[a]	
2014	[a]	
1971–2008		
Average	5,969	8.59
St. dev.	2,781	0.46
Median	5,498	8.61
No. of Years	29	29

[a] Escapement not available.

[b] Partial count.

Appendix A3.–Escapement goal for Nushagak River Chinook salmon.

System:	Nushagak River
Species:	Chinook salmon
Description of stock and escapement goals	
Management Division:	Commercial Fisheries
Current Escapement Goal:	55,000–120,000 SEG
Previous Escapement Goal:	40,000–80,000 BEG (2007); changed to SEG in 2007
Inriver Goal:	90,000
Optimal Escapement Goal:	None
Escapement Estimation:	Expanded aerial survey counts plus Nuyakuk tower from 1966–1979; sonar counts from 1980 to present; converted Bendix to DIDSON 1966 to 2005; DIDSON counts uncorrected since 2006; 40 years of complete return data available
Summary:	
Data Quality	Good
Data Type	Aerial survey, tower, and sonar escapement estimates; sport, subsistence, and commercial harvests; age data
Methodology	Ricker stock-recruitment, yield analysis
Years within recommended goal	8 of last 10 years (2005–2014)

-continued-

Appendix A3.–Page 2 of 3.

Year	Spawning escapement [a]	Total return	Return per spawner
1966	83,224	206,417	2.48
1967	135,240	207,822	1.54
1968	145,643	228,162	1.57
1969	72,821	102,029	1.40
1970	104,030	288,555	2.77
1971	83,224	363,524	4.37
1972	52,015	477,250	9.18
1973	72,821	422,771	5.81
1974	145,643	260,059	1.79
1975	145,643	833,159	5.72
1976	208,061	585,648	2.81
1977	135,240	989,404	7.32
1978	270,479	322,448	1.19
1979	197,658	448,355	2.27
1980	293,366	218,931	0.75
1981	312,091	289,258	0.93
1982	305,849	138,241	0.45
1983	336,497	153,865	0.46
1984	168,404	123,079	0.73
1985	240,768	188,210	0.78
1986	81,456	219,125	2.69
1987	169,510	283,382	1.67
1988	112,971	315,081	2.79
1989	158,504	315,727	1.99

-continued-

Appendix A3.–Page 3 of 3.

Year	Spawning escapement [a]	Total return	Return per spawner
1990	126,708	145,103	1.15
1991	210,282	281,973	1.34
1992	166,915	251,785	1.51
1993	197,038	367,493	1.87
1994	190,063	151,351	0.80
1995	172,962	166,918	0.97
1996	102,317	178,538	1.74
1997	165,013	184,497	1.12
1998	235,773	283,161	1.20
1999	123,868	330,945	2.67
2000	110,647	311,763	2.82
2001	184,261	157,237	0.85
2002	174,651	119,881	0.69
2003	158,259	178,879	1.13
2004	233,404	78,551	0.34
2005	224,106	110,236	0.49
2006	117,364	126,724	1.08
2007	50,960	188,420	3.70
2008	91,364	[b]	
2009	74,781	[b]	
2010	56,088	[b]	
2011	101,572	[b]	
2012	167,618	[b]	
2013	107,602	[b]	
2014	70,482	[b]	
1966–2007			
Average	166,089	276,047	2.12
No. of Years	42	42	42

[a] DIDSON conversion factor of 2.08 applied to all years prior to 2005. Escapement estimate for 2005 used strata- and species-specific correction factors applied to the Bendix north bank counting stratum. Counts from 2006 through 2014 are uncorrected DIDSON counts.

[b] Incomplete returns from brood year escapement.

APPENDIX B. CHUM SALMON

Appendix B1.–Escapement goal for Nushagak River chum salmon.

System: Nushagak River

Species: chum salmon

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Current Escapement Goal	200,000 lower bound SEG
Previous Escapement Goal:	190,000 lower bound SEG (2007)
Inriver Goal:	None
Optimal Escapement Goal:	None
Escapement Estimation:	Sonar counts since 1980; converted Bendix to DIDSON 1980 to 2005; DIDSON counts uncorrected since 2006; 36 years of escapement data available; converted Bendix counts to DIDSON-equivalent counts in 2012. Escapement counts presented are through July 20th.
Summary:	
Data Quality	Good
Data Type	Sonar escapement estimates; commercial harvest; age data
Methodology	Risk analysis
Years within recommended goal	9 out of last 10 years (2006–2015)

-continued-

System: Nushagak River

Species: chum salmon

Data available for analysis of escapement goals

Year	Escapement [a]	ln(Escapement)	Year	Escapement [a]	ln(Escapement)
1980	415,727	12.94	2001	646,984	13.38
1981	182,021	12.11	2002	509,106	13.14
1982	262,597	12.48	2003	375,175	12.84
1983	107,780	11.59	2004	332,347	12.71
1984	450,031	13.02	2005	569,034	13.25
1985	245,797	12.41	2006	661,002	13.40
1986	203,810	12.22	2007	161,483	11.99
1987	175,551	12.08	2008	326,300	12.70
1988	217,772	12.29	2009	438,481	12.99
1989	461,456	13.04	2010	273,914	12.52
1990	373,126	12.83	2011	248,278	12.42
1991	350,186	12.77	2012	395,162	12.89
1992	383,303	12.86	2013	628,134	13.35
1993	272,278	12.51	2014	525,797	13.17
1994	467,930	13.06	2015	288,929	12.57
1995	266,432	12.49	1980-2015		
1996	279,406	12.54	Mean	344,748	12.65
1997	76,034	11.24	St. dev.	148,961	0.49
1998	369,447	12.82	Median	329,324	12.70
1999	296,408	12.60	No. of Years	36	36
2000	173,712	12.07			

[a] DIDSON conversion factor of 1.27 applied to all years prior to 2005. Escapement estimate for 2005 used strata- and species-specific correction factors applied to the Bendix north bank counting stratum. Counts from 2006 through 2015 are uncorrected DIDSON counts. Escapement counts presented are through July 20.

APPENDIX C. COHO SALMON

Appendix C1.–Escapement goal for Nushagak River coho salmon.

System: Nushagak River

Species: coho salmon

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Previous Escapement Goal:	50,000 to 100,000 SEG dropped in 2007
Inriver Goal:	None
Optimal Escapement Goal:	None
Current Escapement Goal:	60,000 to 120,000 SEG
Escapement Estimation:	Sonar counts since 1980; converted Bendix to DIDSON 1980 to 2002; 26 years of complete escapement data available; converted Bendix counts to DIDSON-equivalent counts in 2012
Summary:	
Data Quality	Good
Data Type	Sonar escapement estimates; commercial harvest; age data
Methodology	Ricker stock-recruitment, yield analysis
Years within recommended goal	3 out of last 10 years assessed (1997, 1998, and 2001)

-continued-

System: Nushagak River

Species: coho salmon

Data available for analysis of escapement goals

Year	Spawning Escapement [a]	Total Return	Return per Spawner
1980	95,411	407,100	4.27
1981	141,468	96,740	0.68
1982	294,151	148,150	0.50
1983	36,885	49,151	1.33
1984	140,804	165,050	1.17
1985	82,258	188,273	2.29
1986	45,483	152,472	3.35
1987	21,268	63,074	2.97
1988	130,171	86,853	0.67
1989	81,107	77,353	0.95
1990	140,500	81,822	0.58
1991	37,584	58,024	1.54
1992			
1993	42,161	61,619	1.46
1994	80,470	125,739	1.56
1995	45,137	43,677	0.97
1996	182,460	305,932	1.68
1997	55,882	101,893	1.82
1998	103,194		
1999	33,991		
2000	200,938		
2001	72,388		
2002	48,054		
2004	193,819		
2012	329,946		
2013	207,222		
2014	478,198		
1980–2014			
Average	127,729	130,172	1.64
No. of Years	26	17	17

[a] DIDSON conversion factor of 1.27 applied to all years.

APPENDIX D. PINK SALMON

Appendix D2.–Escapement goal for Nushagak River pink salmon.

System: Nushagak River

Species: pink salmon

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Previous Escapement Goal:	600,000 to 1,100,000 SEG dropped in 2007
Inriver Goal:	None
Optimal Escapement Goal:	None
Current Goal:	165,000 lower bound SEG
Escapement Estimation:	Expanded aerial survey in 1958; Nuyakuk tower counts from 1960–1979; sonar counts from 1980–2004; converted Bendix to DIDSON 1958 to 2004; 26 years of escapement data available, even years only
Summary:	
Data Quality	Good
Data Type	Sonar escapement estimates; commercial harvest; age data
Methodology	Percentile approach (Bue and Hasbrouck)
Years within recommended goal	8 out of last 10 assessments (1990–2014)

-continued-

System: Nushagak River

Species: pink salmon

Data available for analysis of escapement goals

Year	Escapement [a]
1958	4,440,000
1960	111,000
1962	555,016
1964	1,008,435
1966	1,601,091
1968	2,398,839
1970	169,364
1972	64,975
1974	590,871
1976	928,269
1978	10,169,580
1980	3,052,218
1982	1,788,461
1984	3,145,032
1986	80,130
1988	549,017
1990	889,587
1992	209,429
1994	212,867
1996	911,656
1998	146,966
2000	150,166
2002	352,604
2004	617,233
2006	NS
2008	NS
2010	NS
2012	1,348,606
2014	2,281,831
Average	1,452,817
Median	753,410
Contrast	157

[a] DIDSON conversion factor of 1.11 applied to years prior to 2006.

APPENDIX E. SOCKEYE SALMON

Appendix E1.–Escapement goal for Alagnak River sockeye salmon.

System: Alagnak River

Species: sockeye salmon

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Previous Escapement Goal:	320,000 lower bound SEG (2007); based on tower counts
Inriver Goal:	None
Optimal Escapement Goal:	None
Recommended Escapement Goal:	125,000 lower bound SEG; based on aerial surveys
Escapement Estimation:	Tower counts from 1956–1976 and 2001–2011; expanded aerial survey counts from 1977–2008
	Recommended goal is based on aerial surveys (1978-2008)
Summary:	
Data Quality	Fair to Good
Data Type	Tower counts; aerial surveys; commercial harvest; age data
Methodology	Escapement goal based on risk analysis
Years within recommended goal	Escapement goal minimum has been met 19 of the last 20 years; this stock is passively managed and coincidentally harvested; the department is not able to actively manage to obtain an escapement goal range

-continued-

System: Alagnak River

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Escapement (towers)	Escapement (aerial survey)	Total return	Return per spawner
1959	825,431		1,009,100	1.22
1960	1,240,530		448,154	0.36
1961	90,036		294,559	3.27
1962	90,630		252,129	2.78
1963	203,304		414,873	2.04
1964	248,700		381,900	1.54
1965	175,020		259,729	1.48
1966	174,336		565,584	3.24
1967	202,626		389,349	1.92
1968	193,872		249,192	1.29
1969	182,490		180,185	0.99
1970	177,060		145,642	0.82
1971	187,302		324,752	1.73
1972	151,188		124,168	0.82
1973	35,280		512,940	14.54
1974	214,848		2,290,909	10.66
1975	100,480		1,022,274	10.17
1976	81,822		344,709	4.21
1977	108,911		1,002,659	9.21
1978	584,970	229,400	2,175,018	3.72
1979	750,210	294,200	2,108,944	2.81
1980	759,645	297,900	649,461	0.85
1981	209,636	82,210	1,189,250	5.67
1982	610,215	239,300	783,215	1.28
1983	245,361	96,220	519,999	2.12
1984	549,194	215,470	2,395,855	4.36
1985	300,977	118,030	1,782,638	5.92
1986	586,959	228,180	2,129,631	3.63
1987	393,236	154,210	843,196	2.14
1988	496,307	194,630	1,376,837	2.77
1989	501,738	196,760	2,796,371	5.57

-continued-

Appendix E1.–Page 3 of 3.

Year	Escapement (towers)	Escapement (aerial survey)	Total return	Return per spawner
1990	430,338	168,760	1,532,335	3.56
1991	707,852	278,589	3,402,940	4.81
1992	577,940	226,643	226,603	0.39
1993	887,336	347,975	1,523,485	1.72
1994	618,464	242,595	1,585,492	2.56
1995	550,068	215,713	3,989,777	7.25
1996	782,213	306,750	1,549,878	1.98
1997	556,193	218,115	1,467,972	2.64
1998	643,110	252,200	2,851,140	4.43
1999	1,182,180	463,600	3,790,191	3.21
2000	1,150,815	451,300	9,915,981	8.62
2001	680,850	267,000	1,464,957	2.15
2002	766,962	282,100	3,234,177	4.22
2003	3,676,146	2,110,000	6,387,177	1.74
2004	5,396,592	2,911,600	2,548,096	0.47
2005	4,218,990	1,736,000	2,899,649	0.69
2006	1,773,966	900,000	2,520,964	1.42
2007	2,466,414 [a]	1,155,000		
2008	2,180,502 [a]	1,499,000		
2009	970,818 [a]			
2010	1,187,730 [a]			
2011	883,794 [a]			
2012	861,747 [a]			
2013	1,095,950 [a]			
2014	200,500 [a]			
1959–2006				
Average	734,840	528,369	1,663,626	3.44
No. of years	48	31	48	48

[a] Incomplete returns from brood year escapement.

Appendix E2.–Escapement goal for Egegik River sockeye salmon.

System: Egegik River

Species: sockeye salmon

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Previous Escapement Goal:	800,000–1,400,000 SEG (1995); changed to SEG in 2007
Inriver Goal:	None
Optimal Escapement Goal:	None
Current Escapement Goal:	800,000–2,000,000 SEG
Escapement Estimation:	Tower counts from 1959 to present; smolt data from 1983–2001; 48 years of escapement data available
Summary:	
Data Quality	Excellent
Data Type	Tower counts; commercial harvest; smolt data; age data
Methodology	Escapement goal based on Ricker stock-recruitment and yield analysis
Years within recommended goal	10 out of last 10 years (2005–2014)

-continued-

System: Egegik River

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Escapement	Total return	Return per Spawner
1959	1,072,459	2,122,136	1.98
1960	1,798,764	7,118,837	3.96
1961	701,538	1,487,493	2.12
1962	1,027,482	1,093,256	1.06
1963	997,602	993,872	1.00
1964	849,576	1,937,882	2.28
1965	1,444,608	2,388,485	1.65
1966	804,246	2,058,271	2.56
1967	636,864	1,631,431	2.56
1968	338,654	377,056	1.11
1969	1,015,554	2,755,728	2.71
1970	919,734	1,202,584	1.31
1971	634,014	2,700,676	4.26
1972	546,402	2,909,902	5.33
1973	328,842	1,451,686	4.41
1974	1,275,630	2,441,308	1.91
1975	1,173,840	3,040,169	2.59
1976	509,160	4,480,475	8.80
1977	692,514	4,167,610	6.02
1978	895,698	9,914,904	11.07
1979	1,032,042	4,039,957	3.91
1980	1,060,860	8,224,600	7.75
1981	694,680	5,444,111	7.84
1982	1,034,628	6,441,614	6.23
1983	792,282	10,829,622	13.67
1984	1,165,345	11,792,825	10.12
1985	1,095,192	6,401,009	5.84
1986	1,152,180	14,229,272	12.35
1987	1,273,553	25,748,671	20.22
1988	1,612,745	19,484,271	12.08
1989	1,611,566	10,167,814	6.31
1990	2,191,582	16,096,303	7.34

-continued-

Appendix E2.–Page 3 of 3.

Year	Escapement	Total return	Return per Spawner
1991	2,786,925	9,957,467	3.57
1992	1,945,632	8,673,758	4.46
1993	1,517,000	1,939,491	1.28
1994	1,897,977	7,996,226	4.21
1995	1,266,692	7,532,365	5.95
1996	1,076,460	4,161,538	3.87
1997	1,104,004	6,062,442	5.49
1998	1,110,938	1,270,197	1.14
1999	1,728,397	13,014,334	7.53
2000	1,032,138	11,992,735	11.62
2001	968,872	4,904,532	5.06
2002	1,036,092	5,590,048	5.40
2003	1,152,120	9,110,326	7.91
2004	1,290,144	14,704,858	11.40
2005	1,621,734	6,147,475	3.79
2006	1,465,158	3,550,421	2.42
2007	1,432,500 [a]		
2008	1,259,568 [a]		
2009	1,146,276 [a]		
2010	927,054 [a]		
2011	961,200 [a]		
2012	1,233,900 [a]		
2013	1,113,630 [a]		
2014	1,382,466 [a]		
1959–2006			
Average	1,153,752	6,495,459	5.57
No. of Years	48	48	48

[a] Incomplete returns from brood year escapement.

Appendix E3.–Escapement goal for Igushik River sockeye salmon.

System: Igushik River

Species: sockeye salmon

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Previous Escapement Goal:	150,000–300,000 SEG (2001); changed to SEG in 2007
Inriver Goal:	None
Optimal Escapement Goal:	None
Current Goal:	150,000–400,000 SEG
Escapement Estimation:	Tower counts from 1956 to present; 47 years of complete return data available
Summary:	
Data Quality	Excellent
Data Type	Tower counts; commercial harvest; age data
Methodology	Ricker stock-recruitment, yield analysis
Years within recommended goal	5 out of last 10 years (2005–2014)

-continued-

Appendix E3.–Page 2 of 3.

Year	Escapement	Total return	Return per spawner
1959	643,808	227,626	0.35
1960	495,087	324,150	0.65
1961	294,252	300,743	1.02
1962	15,660	229,117	14.63
1963	92,184	368,205	3.99
1964	128,532	583,060	4.54
1965	180,840	810,920	4.48
1966	206,360	301,093	1.46
1967	281,772	125,745	0.45
1968	194,508	158,923	0.82
1969	512,328	476,722	0.93
1970	370,920	287,436	0.77
1971	210,960	259,415	1.23
1972	60,018	232,049	3.87
1973	59,508	452,000	7.60
1974	358,752	1,267,130	3.53
1975	241,086	2,810,903	11.66
1976	186,120	1,354,667	7.28
1977	95,970	830,426	8.65
1978	536,154	562,275	1.05
1979	859,560	896,476	1.04
1980	1,987,530	443,803	0.22
1981	591,144	838,645	1.42
1982	423,768	346,608	0.82
1983	180,438	391,104	2.17
1984	184,872	522,953	2.83
1985	212,454	1,138,951	5.36
1986	307,728	1,700,597	5.53
1987	169,236	445,515	2.63
1988	170,454	614,898	3.61
1989	461,610	991,784	2.15

-continued-

Appendix E3.–Page 3 of 3.

Year	Escapement	Total return	Return per spawner
1990	365,802	1,229,498	3.36
1991	756,126	983,939	1.30
1992	304,920	139,561	0.46
1993	405,564	358,174	0.88
1994	445,920	659,953	1.48
1995	473,382	1,278,256	2.70
1996	400,746	886,426	2.21
1997	127,704	99,345	0.78
1998	215,904	536,354	2.48
1999	445,536	362,488	0.81
2000	413,316	767,881	1.86
2001	409,596	490,207	1.20
2002	123,156	448,204	3.64
2003	194,088	1,799,058	9.27
2004	109,650	1,227,254	11.19
2005	365,712	1,623,044	4.44
2006	305,268	1242884	4.07
2007	415,452 [a]		
2008	1,054,704 [a]		
2009	514,188 [a]		
2010	518,040 [a]		
2011	421,380 [a]		
2012	193,326 [a]		
2013	387,036 [a]		
2014	340,590 [a]		
1959–2006			
Average	345,333	717,218	3.31
No. of Years	48	48	48

[a] Incomplete returns from brood year escapement.

Appendix E4.–Escapement goal for Kvichak River sockeye salmon.

System: Kvichak River

Species: sockeye salmon

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Previous Escapement Goal:	2,000,000–10,000,000 SEG (2010)
Inriver Goal:	None
Optimal Escapement Goal:	None
Recommended Escapement Goal:	No change
Escapement Estimation:	Tower counts from 1959 to present; smolt data from 1971–2000; 47 years of complete return data available
Summary:	
Data Quality	Excellent
Data Type	Tower counts; smolt data; commercial harvest; age data
Methodology	Escapement goal based on Ricker stock-recruitment, yield analysis
Years within recommended goal	10 out of last 10 years (2005–2014)

-continued-

System: Kvichak River

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Escapement	Total return	Return per spawner
1959	673,811	453,641	0.67
1960	14,602,360	56,411,705	3.86
1961	3,705,849	3,580,935	0.97
1962	2,580,884	5,506,892	2.13
1963	338,760	1,388,216	4.10
1964	957,120	5,763,515	6.02
1965	24,325,926	45,820,689	1.88
1966	3,755,185	6,522,062	1.74
1967	3,216,208	1,784,048	0.55
1968	2,557,440	635,324	0.25
1969	8,394,204	5,513,626	0.66
1970	13,935,306	15,363,872	1.10
1971	2,387,392	2,036,285	0.85
1972	1,009,962	3,248,671	3.22
1973	226,554	2,203,241	9.73
1974	4,433,844	25,784,407	5.82
1975	13,140,450	37,439,011	2.85
1976	1,965,282	10,716,323	5.45
1977	1,341,144	3,089,502	2.30
1978	4,149,288	5,055,228	1.22
1979	11,218,434	43,049,711	3.84
1980	22,505,268	12,597,129	0.56
1981	1,754,358	2,048,731	1.17
1982	1,134,840	1,509,147	1.33
1983	3,569,982	13,774,175	3.86
1984	10,490,670	23,284,320	2.22
1985	7,211,046	18,311,756	2.54
1986	1,179,322	4,113,937	3.49
1987	6,065,880	11,646,723	1.92
1988	4,065,216	9,204,227	2.26
1989	8,317,500	24,796,919	2.98

-continued-

Year	Escapement	Total return	Return per spawner
1990	6,970,020	26,294,888	3.77
1991	4,222,788	4,636,825	1.10
1992	4,725,864	1,876,573	0.40
1993	4,025,166	3,131,830	0.78
1994	8,355,936	7,304,603	0.87
1995	10,038,720	10,647,375	1.06
1996	1,450,578	2,300,492	1.59
1997	1,503,732	842,686	0.56
1998	2,296,074	1,280,847	0.56
1999	6,196,914	7,397,614	1.19
2000	1,827,780	4,277,407	2.34
2001	1,095,348	3,860,432	3.52
2002	703,884	3,470,460	4.93
2003	1,686,804	4,607,129	2.73
2004	5,500,134	10,923,565	1.99
2005	2,320,332	9,793,959	4.22
2006	3,068,226 [a]	8,552,138	2.79
2007	2,810,208 [a]		
2008	2,757,912 [a]		
2009	2,266,140 [a]		
2010	4,207,410 [a]		
2011	2,264,352 [a]		
2012	4,164,444 [a]		
2013	2,088,576 [a]		
2014	4,458,540 [a]		
1959–2006			
Average	5,233,287	10,705,266	2.42
No. of Years	48	48	48

[a] Incomplete returns from brood year escapement.

Appendix E5.–Escapement goal for Naknek River sockeye salmon.

System: Naknek River

Species: sockeye salmon

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Previous Escapement Goal:	800,000–1,400,000 SEG (1983)); changed to SEG in 2007
Inriver Goal:	None
Optimal Escapement Goal:	2,000,000
Current Escapement Goal:	800,000–2,000,000 BEG
Escapement Estimation:	Tower counts from 1959 to present; 48 years of complete return data available
Summary:	
Data Quality	Excellent
Data Type	Tower counts; commercial harvest; age data
Methodology	Escapement goal based on Ricker stock-recruitment, yield analysis
Years within recommended goal	7 out of last 10 years (2005–2014)

-continued-

System: Naknek River

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Escapement	Total return	Return per spawner
1959	2,231,807	1,524,714	0.68
1960	828,381	3,360,315	4.06
1961	351,078	2,151,891	6.13
1962	723,066	1,106,335	1.53
1963	905,358	1,706,836	1.89
1964	1,349,604	2,223,531	1.65
1965	717,798	2,654,768	3.70
1966	1,016,445	4,205,622	4.14
1967	755,640	1,552,168	2.05
1968	1,023,222	638,312	0.62
1969	1,331,202	2,143,778	1.61
1970	732,502	2,535,306	3.46
1971	935,754	4,350,422	4.65
1972	586,518	1,715,207	2.92
1973	356,676	2,742,669	7.69
1974	1,241,058	2,642,513	2.13
1975	2,026,686	5,195,705	2.56
1976	1,320,750	8,991,732	6.81
1977	1,085,856	3,721,059	3.43
1978	813,378	2,788,295	3.43
1979	925,362	3,963,916	4.28
1980	2,644,698	4,922,134	1.86
1981	1,796,220	4,683,500	2.61
1982	1,155,552	1,820,719	1.58
1983	888,294	1,451,803	1.63
1984	1,242,474	4,384,278	3.53
1985	1,849,938	7,147,411	3.86
1986	1,977,645	12,634,896	6.39
1987	1,061,806	5,472,177	5.15
1988	1,037,862	2,972,686	2.86
1989	1,161,984	3,006,870	2.59

-continued-

Appendix E5.–Page 3 of 3.

Year	Escapement	Total return	Return per spawner
1990	2,092,578	3,824,685	1.83
1991	3,578,508	4,574,329	1.28
1992	1,606,650	1,469,491	0.91
1993	1,535,658	2,671,487	1.74
1994	990,810	2,351,000	2.37
1995	1,111,140	5,810,346	5.23
1996	1,078,098	6,316,443	5.86
1997	1,025,664	3,360,610	3.28
1998	1,202,172	3,764,484	3.13
1999	1,625,364	3,663,375	2.25
2000	1,375,488	8,902,997	6.47
2001	1,830,360	5,351,531	2.92
2002	1,263,918	6,474,702	5.12
2003	1,831,170	12,843,690	7.01
2004	1,939,674	3,946,527	2.03
2005	2,744,622	5,119,004	1.87
2006	1,953,228	4,618,763	2.36
2007	2,945,304 [a]		
2008	2,472,690 [a]		
2009	1,169,466 [a]		
2010	1,463,928 [a]		
2011	1,177,074 [a]		
2012	900,312 [a]		
2013	938,160 [a]		
2014	1,474,428 [a]		
1959–2006 Average	1,351,244	4,072,397	3.27
No. of Years	48	48	48

[a] Incomplete returns from brood year escapement.

Appendix E6.–Escapement goal for Nushagak River sockeye salmon.

System: Nushagak River

Species: sockeye salmon

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Previous Escapement Goal:	340,000–760,000 SEG (1998)); changed to SEG in 2007
Inriver Goal:	None
Optimal Escapement Goal:	260,000
Current Escapement Goal:	370,000–900,000 SEG
Escapement Estimation:	Nuyakuk tower and expanded aerial survey counts from 1959–1984; sonar counts from 1985 to present; converted Bendix to DIDSON 1980 to 2005; DIDSON counts uncorrected since 2006; 48 years of complete return data available
Summary:	
Data Quality	Good
Data Type	Tower, aerial survey, and sonar counts; commercial harvest; age data
Methodology	Ricker stock-recruitment, yield analysis
Years within recommended goal	9 out of last 10 years (2005–2014)

-continued-

System: Nushagak River

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Escapement [a]	Total return	Return per spawner
1959	67,553	251,110	3.72
1960	201,161	554,162	2.75
1961	110,369	466,173	4.22
1962	51,273	152,649	2.98
1963	234,821	214,841	0.91
1964	134,853	93,342	0.69
1965	255,794	779,754	3.05
1966	233,578	701,566	3.00
1967	74,003	227,033	3.07
1968	142,360	344,179	2.42
1969	95,805	493,692	5.15
1970	452,892	988,764	2.18
1971	312,699	1,010,999	3.23
1972	39,851	1,147,980	28.81
1973	210,601	1,380,189	6.55
1974	204,190	383,623	1.88
1975	832,093	5,995,149	7.20
1976	520,303	4,351,924	8.36
1977	611,588	3,236,089	5.29
1978	734,040	1,513,725	2.06
1979	551,272	1,846,153	3.35
1980	3,669,136	1,210,266	0.33
1981	1,118,873	1,976,757	1.77
1982	664,580	1,335,148	2.01
1983	446,845	1,548,738	3.47
1984	655,739	761,247	1.16
1985	551,319	1,416,870	2.57
1986	1,095,241	2,092,574	1.91
1987	429,182	1,905,456	4.44
1988	534,460	2,557,339	4.78
1989	567,863	1,398,722	2.46

-continued-

Year	Escapement [a]	Total return	Return per spawner
1990	752,513	1,189,247	1.58
1991	544,748	1,491,482	2.74
1992	768,816	1,212,574	1.58
1993	790,927	1,074,278	1.36
1994	563,334	425,915	0.76
1995	311,136	1,198,477	3.85
1996	557,057	2,335,512	4.19
1997	412,591	544,302	1.32
1998	507,532	2,665,496	5.25
1999	344,972	1,753,716	5.08
2000	446,286	3,956,541	8.87
2001	897,112	3,076,644	3.43
2002	349,155	2,121,281	6.08
2003	642,093	1,863,316	2.90
2004	543,872	1,463,695	2.69
2005	1,102,833	1,210,008	1.10
2006	548,410	1,185,006	2.16
2007	518,041 [b]		
2008	492,546 [b]		
2009	484,149 [b]		
2010	468,696 [b]		
2011	428,191 [b]		
2012	432,438 [b]		
2013	894,148 [b]		
2014	618,477 [b]		
1959–2006			
Average	539,328	1,481,327	3.77
No. of Years	48	48	48

[a] DIDSON conversion factor of 1.11 applied to all years prior to 2005. Escapement estimate for 2005 used strata- and species-specific correction factors applied to the Bendix north bank counting stratum. Counts from 2006 through 2011 are uncorrected DIDSON counts.

[b] Incomplete returns from brood year escapement.

Appendix E7.–Escapement goal for Togiak River sockeye salmon.

System: Togiak River

Species: sockeye salmon

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Previous Escapement Goal:	120,000–270,000 SEG (2007); changed to SEG in 2007
Inriver Goal:	None
Optimal Escapement Goal:	None
Current Escapement Goal	120,000–270,000 SEG
Escapement Estimation:	Tower counts from 1959 to present; 48 years of complete return data available
Summary:	
Data Quality	Good; data quality would be excellent except for concerns with regard to stock-specific harvest
Data Type	Tower counts; commercial harvest; age data
Methodology	Ricker stock-recruitment, yield analysis
Years within recommended goal	8 out of last 10 years (2005–2014)

-continued-

System: Togiak River

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Escapement	Total return	Return per spawner
1959	178,740	284,478	1.59
1960	162,810	490,021	3.01
1961	95,454	323,897	3.39
1962	47,352	159,716	3.37
1963	102,396	135,835	1.33
1964	95,574	145,179	1.52
1965	88,486	381,239	4.31
1966	91,098	610,132	6.70
1967	69,330	169,033	2.44
1968	42,918	242,379	5.65
1969	109,266	187,658	1.72
1970	192,096	362,266	1.89
1971	190,842	519,148	2.72
1972	74,070	284,762	3.84
1973	95,730	607,520	6.35
1974	82,992	670,282	8.08
1975	160,962	1,137,264	7.07
1976	158,190	975,806	6.17
1977	133,734	829,373	6.20
1978	273,576	646,977	2.36
1979	171,138	532,695	3.11
1980	461,850	272,164	0.59
1981	208,080	317,516	1.53
1982	244,734	401,789	1.64
1983	191,520	1,204,548	6.29
1984	95,448	152,706	1.60
1985	136,542	332,161	2.43
1986	168,384	748,532	4.45
1987	249,676	886,753	3.55
1988	276,612	610,191	2.21
1989	84,480	524,119	6.20

-continued-

Year	Escapement	Total return	Return per spawner
1990	141,977	669,580	4.72
1991	254,683	657,996	2.58
1992	199,134	254,771	1.28
1993	177,185	294,488	1.66
1994	154,752	243,963	1.58
1995	185,718	1,377,953	7.42
1996	156,954	1,101,047	7.02
1997	131,682	450,361	3.42
1998	153,576	807,711	5.26
1999	155,898	514,498	3.30
2000	311,970	702,280	2.25
2001	296,676	636,824	2.15
2002	162,402	1,029,368	6.34
2003	232,302	998,817	4.30
2004	129,462	680,764	5.26
2005	149,178	776,533	5.21
2006	312,126 [a]		
2007	269,646 [a]		
2008	205,680 [a]		
2009	313,946 [a]		
2010	188,298 [a]		
2011	190,970 [a]		
2012	203,148 [a]		
2013	128,000 [a]		
2014	151,934 [a]		
1959–2005			
Average	164,418	560,491	3.77
No. of Years	47	47	47

[a] Incomplete returns from brood year escapement.

Appendix E8.–Escapement goal for Ugashik River sockeye salmon.

System: Ugashik River

Species: sockeye salmon

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Previous Escapement Goal:	500,000–1,200,000 SEG (1995)
Inriver Goal:	None
Optimal Escapement Goal:	None
Current Escapement Goal:	500,000–1,400,000 SEG
Escapement Estimation:	Tower counts from 1956 to present; 48 years of complete return data available
Summary:	
Data Quality	Excellent
Data Type	Tower counts; commercial harvest; age data
Methodology	Ricker stock-recruitment and yield analysis
Years within recommended goal	9 of last 10 years (2005–2014)

-continued-

System: Ugashik River

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Escapement	Total return	Return per spawner
1959	219,228	496,911	2.27
1960	2,304,200	3,867,461	1.68
1961	348,639	1,220,755	3.50
1962	255,426	407,565	1.60
1963	388,254	132,741	0.34
1964	472,770	274,733	0.58
1965	996,612	392,954	0.39
1966	704,436	2,388,187	3.39
1967	238,830	230,351	0.96
1968	70,896	45,088	0.64
1969	160,380	89,243	0.56
1970	735,024	355,709	0.48
1971	529,752	935,802	1.77
1972	79,428	276,170	3.48
1973	38,988	102,308	2.62
1974	61,854	757,907	12.25
1975	429,336	4,125,834	9.61
1976	356,308	5,801,029	16.28
1977	201,520	2,853,151	14.16
1978	82,435	1,194,448	14.49
1979	1,706,904	6,480,877	3.80
1980	3,335,284	8,062,907	2.42
1981	1,327,699	7,976,367	6.01
1982	1,185,551	2,359,880	1.99
1983	1,001,364	1,789,090	1.79
1984	1,270,318	5,529,343	4.35
1985	1,006,407	2,823,431	2.81
1986	1,015,582	7,142,245	7.03
1987	686,894	7,164,093	10.43
1988	654,412	5,544,390	8.47
1989	1,713,287	4,912,515	2.87

-continued-

Year	Escapement	Total return	Return per spawner
1990	749,478	3,858,144	5.15
1991	2,482,016	6,680,530	2.69
1992	2,194,927	3,149,052	1.43
1993	1,413,454	1,357,576	0.96
1994	1,095,068	1,586,369	1.45
1995	1,321,108	5,774,021	4.37
1996	692,167	1,355,916	1.96
1997	656,641	3,026,473	4.61
1998	924,853	1,248,478	1.35
1999	1,662,042	3,675,007	2.21
2000	638,420	4,360,152	6.83
2001	866,368	2,133,622	2.46
2002	905,584	4,500,313	4.97
2003	790,202	6,369,928	8.06
2004	815,104	4,260,305	5.23
2005	799,612	5,244,674	6.56
2006	1,003,158	3,422,310	3.41
2007	2,599,186 [a]		
2008	596,332 [a]		
2009	1,364,338 [a]		
2010	830,886 [a]		
2011	1,029,853 [a]		
2012	695,018 [a]		
2013	898,110 [a]		
2014	640,158 [a]		
1959–2006 Average	887,255	3,077,841	4.31
No. of Years	48	48	48

[a] Incomplete returns from brood year escapement.

Appendix E9.–Escapement goal for Wood River sockeye salmon.

System: Wood River

Species: sockeye salmon

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Previous Escapement Goal:	700,000–1,500,000 BEG (2001)); changed to SEG in 2007
Inriver Goal:	None
Optimal Escapement Goal:	None
Current Escapement Goal:	700,000–1,800,000 SEG
Escapement Estimation:	Tower counts from 1959 to present; 48 years of complete return data available
Summary:	
Data Quality	Excellent
Data Type	Tower counts; commercial harvest; age data
Methodology	Ricker stock-recruitment, yield analysis
Years within recommended goal	8 of last 10 years (2005–2014)

-continued-

System: Wood River

Species: sockeye salmon

Data available for analysis of escapement goals

Year	Escapement	Total return	Return per spawner
1959	2,209,266	1,738,125	0.79
1960	1,016,073	2,748,924	2.71
1961	460,737	1,685,024	3.66
1962	873,888	1,550,870	1.77
1963	721,404	1,632,836	2.26
1964	1,076,112	1,286,903	1.20
1965	675,156	2,021,719	2.99
1966	1,208,682	2,290,780	1.90
1967	515,772	1,054,264	2.04
1968	649,344	1,154,367	1.78
1969	604,338	989,848	1.64
1970	1,161,964	2,648,102	2.28
1971	851,202	1,425,140	1.67
1972	430,602	1,338,679	3.11
1973	330,474	1,460,260	4.42
1974	1,708,836	5,893,430	3.45
1975	1,270,116	6,290,687	4.95
1976	817,008	6,590,536	8.07
1977	561,828	3,824,313	6.81
1978	2,267,238	3,117,207	1.37
1979	1,706,352	4,154,669	2.43
1980	2,969,040	1,471,792	0.50
1981	1,233,318	2,231,913	1.81
1982	976,470	2,085,371	2.14
1983	1,360,968	3,326,753	2.44
1984	1,002,792	2,218,822	2.21
1985	939,000	3,304,167	3.52
1986	818,652	4,176,305	5.10
1987	1,337,172	2,897,914	2.17
1988	866,778	3,978,870	4.59
1989	1,186,410	5,106,291	4.30

-continued-

Appendix E9.–Page 3 of 3.

Year	Escapement	Total return	Return per spawner
1990	1,069,440	3,555,678	3.32
1991	1,159,920	6,110,265	5.27
1992	1,286,250	4,539,123	3.53
1993	1,176,126	3,267,339	2.78
1994	1,471,890	5,887,328	4.00
1995	1,482,162	7,844,736	5.29
1996	1,649,598	7,529,945	4.56
1997	1,512,396	1,237,317	0.82
1998	1,755,768	6,866,961	3.91
1999	1,512,426	5,621,078	3.72
2000	1,300,026	7,214,553	5.55
2001	1,458,732	7,908,115	5.42
2002	1,283,682	8,414,497	6.55
2003	1,459,782	8,971,062	6.15
2004	1,543,392	9,037,345	5.86
2005	1,496,550	6,884,016	4.60
2006	4,008,102	7,845,825	1.96
2007	1,528,086 [a]		
2008	1,724,676 [a]		
2009	1,319,232 [a]		
2010	1,804,344 [a]		
2011	1,098,006 [a]		
2012	764,211 [a]		
2013	1,183,348 [a]		
2014	2,764,614 [a]		
1959–2006			
Average	1,238,808	4,050,626	3.40
No. of Years	48	48	48

[a] Incomplete returns from brood year escapement.

APPENDIX F. ESCAPEMENT MEMOS AND RECORD COPIES PRESENTED TO THE ALASKA BOARD OF FISHERIES

Appendix F1.–2013 Final Escapement goal memo for Bristol Bay

THE STATE of ALASKA
GOVERNOR SEAN PARNELL

Department of Fish and Game

DIVISIONS OF SPORT FISH & COMMERICAL FISHERIES
Central Region Office
333 Raspberry Road
Anchorage, AK 99518-1565
Main: 907.267.2105
Fax: 907.267.2442

MEMORANDUM

TO: Jeff Regnart, Director
Division of Commercial Fisheries

Charles O. Swanton, Director
Division of Sport Fish

THRU: Tracy Lingnau, Regional Supervisor
Division of Commercial Fisheries, Region II

James J. Hasbrouck, Regional Supervisor
Division of Sport Fish, Region II

FROM: Lowell Fair, Regional Research Coordinator
Division of Commercial Fisheries, Region II

Jack W. Erickson, Regional Research Coordinator
Division of Sport Fish, Region II

DATE: January 31, 2013

SUBJECT: Final Escapement Goal Recommendations for Select Bristol Bay Management Area Salmon Stocks

---

The purpose of this memo is to formally recommend to you additions, deletions, and changes to escapement goals for the Bristol Bay Management Area (BBMA) and to solicit your final approval to include these recommendations as ADF&G salmon escapement goals. In February 2012, an interdivisional salmon escapement goal committee, including staff from the divisions of Commercial Fisheries and Sport Fish, initially met to discuss Bristol Bay salmon escapement goals. This review was based on the *Policy for the Management of Sustainable Salmon Fisheries* and the *Policy for Statewide Salmon Escapement Goals*.

The escapement goal review process was atypical this cycle. Unforeseen delays prevented us from having escapement goal recommendations completed prior to the board's October Work Session. Two significant events occurred since the last escapement goal review three years ago. The first was the transition from Bendix sonar to DIDSON for the Nushagak River, affecting goals for Chinook, chum, and sockeye salmon by applying a correction factor to historical escapements to put them in terms of DIDSON-equivalent counts. The second was an extensive run reconstruction of historical Bristol Bay sockeye salmon brood tables using comprehensive genetic stock composition estimates since 2006, along with older genetic estimates gathered from select sets of scale DNA dating back to the early 1960s. The review committee evaluated spawner-return data for sockeye salmon *O. nerka* in the Alagnak, Egegik, Igushik, Kulukak, Kvichak, Naknek, Nushagak, Togiak, Ugashik, and Wood rivers; Chinook salmon *O.*

-continued-

tshawytscha in the Alagnak, Egegik, Naknek, Nushagak, and Togiak rivers; and chum salmon *O. keta* in the Nushagak River. There are no escapement goals for coho salmon *O. kisutch* or pink salmon *O. gorbuscha* for any Bristol Bay rivers. This review examined the existing 16 escapement goals and two others that were eliminated in the 2006 review: Nushagak River coho and pink salmon (Table 1).

The committee recommended changing the ranges for eight escapement goals (Nushagak River Chinook and chum salmon, and Egegik, Igushik, Naknek, Nushagak, Ugashik, and Wood rivers sockeye salmon). Four of those goals would also change in type: Igushik, Naknek, Nushagak, and Wood rivers changing from sustainable escapement goals (SEG) to biological escapement goals (BEG). Three goals were eliminated: Egegik and Togiak rivers Chinook salmon, and Kulukak Bay sockeye salmon. Finally, two new goals were established: Nushagak River coho and pink salmon.

At the Alaska Board of Fisheries (board) meeting in December 2012, it was decided that not all recommended escapement goals will go into effect for the 2013 salmon season. Recommendations for all nonsockeye salmon escapement goals will be implemented in 2013 (Table 2). Most of the sockeye salmon goals will not be implemented until 2015, with two exceptions. In 2013, the Kulukak Bay goal will be dropped and the Nushagak River goal will be modified to account for the conversion of Bendix sonar to DIDSON: 370,000 to 840,000. All other sockeye salmon escapement goals recommended in Fair et al. (2012), including the Nushagak River sockeye salmon goal of 400,000 to 900,000, will go into effect in 2015 (Table 3).

In summary, this comprehensive review of the 16 existing salmon escapement goals in BBMA resulted in eight modifications for the 2013 season and six modifications for the 2015 season. For the 2013 goals, there will be two added, three dropped, one change in range, and two changes in range and type. For the 2015 goals, there will be two changed in range and four changed in range and type. For the December 2012 board meeting, the department submitted an oral and written report (Fair et al. 2012) concerning escapement goals and specific recommendations for numerous Bristol Bay stocks. These reports listed all current and recommended escapement goals for Bristol Bay, as well as detailed descriptions of the methods used to reach these recommendations. Therefore, we respectfully seek your signatures for approval to establish these recommendations as ADF&G salmon escapement goals.

Literature Cited

Fair, L. F., C. E. Brazil, X. Zhang, R. A. Clark, and J. W. Erickson. 2012. Review of salmon escapement goals in Bristol Bay, Alaska, 2012. Alaska Department of Fish and Game, Fishery Manuscript Series No. 12-04, Anchorage.

-continued-

Bristol Bay Escapement Goal Memo

By signing this memo you will officially adopt the respective escapement goals summarized here.

2/15/13

Jeff Regnart
Director, Commercial Fisheries Division

Date

2/7/13

Charles O. Swanton
Director, Sport Fish Division

Date

-continued-

Bristol Bay Escapement Goal Memo

Table 1.–Summary of current escapement goals and recommended escapement goals for salmon stocks in Bristol Bay, 2012 [From Fair et al. (2012)].

	Current Escapement Goal				Recommended Escapement Goal		
System	Goal	Type	Year Adopted	Escapement Data	Action	Goal	Type
Chinook Salmon							
Alagnak	2,700 minimum	SEG	2007	Aerial	No Change		
Egegik	450 minimum	SEG	2007	Aerial	Drop		
Naknek	5,000 minimum	SEG	2007	Aerial	No Change		
Nushagak	40,000–80,000	SEG	2007; Changed to SEG in 2007	Sonar	Change in range	55,000–120,000	SEG
Togiak	9,300 minimum	SEG	2007	Aerial	Drop		
Chum Salmon							
Nushagak	190,000 minimum	SEG	2007	Sonar	Change in range	200,000 minimum	SEG
Coho Salmon							
Nushagak	50,000–100,000	SEG	2007	Sonar	New Goal	60,000–120,000	SEG
Pink Salmon							
Nushagak				Sonar	New Goal	165,000 minimum	SEG
Sockeye Salmon							
Alagnak	320,000 minimum	SEG	2007	Tower	No Change		
Egegik	800,000–1,400,000	SEG	1995; Changed to SEG in 2007	Tower	Change in range	900,000–2,000,000	SEG
Igushik	150,000–300,000	SEG	2001; Changed to SEG in 2007	Tower	Change in range and type	200,000–400,000	BEG
Kvichak	2,000,000–10,000,000	SEG	One goal for all years in 2010	Tower	No Change		
Kulukak Bay	8,000 minimum	SEG	2007	Aerial	Drop		
Naknek	800,000–1,400,000	SEG	1983; Changed to SEG in 2007	Tower	Change in range and type	900,000–2,000,000	BEG
Nushagak	340,000–760,000	SEG	1998; Changed to SEG in 2007	Sonar	Change in range and type	400,000–900,000	BEG
Togiak	120,000–270,000	SEG	2007; Changed from a BEG in 2010	Tower	No Change		
Ugashik	500,000–1,200,000	SEG	1995; Changed to SEG in 2007	Tower	Change in range	600,000–1,400,000	SEG
Wood	700,000–1,500,000	SEG	2001; Changed to SEG in 2007	Tower	Change in range and type	800,000–1,800,000	BEG

Page 4 of 5

-continued-

Bristol Bay Escapement Goal Memo

Table 2.–Recommended changes to escapement goals for Bristol Bay salmon stocks that will go into effect in 2013.

	Current Escapement Goal			Recommended Escapement Goal		
System	Goal	Type	Escapement Data	Action	Goal	Type
Chinook Salmon						
Egegik	450 minimum	SEG	Aerial	Drop		
Nushagak	40,000–80,000	SEG	Sonar	Change in range	55,000–120,000	SEG
Togiak	9,300 minimum	SEG	Aerial	Drop		
Chum Salmon						
Nushagak	190,000 minimum	SEG	Sonar	Change in range	200,000 minimum	SEG
Coho Salmon						
Nushagak	50,000–100,000	SEG	Sonar	New Goal	60,000–120,000	SEG
Pink Salmon						
Nushagak			Sonar	New Goal	165,000 minimum	SEG
Sockeye Salmon						
Kulukak Bay	8,000 minimum	SEG	Aerial	Drop		
Nushagak	340,000–760,000	SEG	Sonar	Change in range	370,000–840,000	SEG

Table 3.–Recommended changes to escapement goals for Bristol Bay salmon stocks that will go into effect in 2015.

	Current Escapement Goal			Recommended Escapement Goal		
System	Goal	Type	Escapement Data	Action	Goal	Type
Sockeye Salmon						
Egegik	800,000–1,400,000	SEG	Tower	Change in range	900,000–2,000,000	SEG
Igushik	150,000–300,000	SEG	Tower	Change in range and type	200,000–400,000	BEG
Naknek	800,000–1,400,000	SEG	Tower	Change in range and type	900,000–2,000,000	BEG
Nushagak	340,000–760,000	SEG	Sonar	Change in range and type	400,000–900,000	BEG
Ugashik	500,000–1,200,000	SEG	Tower	Change in range	600,000–1,400,000	SEG
Wood	700,000–1,500,000	SEG	Tower	Change in range and type	800,000–1,800,000	BEG

Appendix F2.–2015 Escapement goal recommendations for Bristol Bay sockeye salmon.

RC 013

THE STATE of ALASKA
GOVERNOR BILL WALKER

Department of Fish and Game
DIVISIONS OF COMMERICAL FISHERIES
AND SPORT FISH
Headquarters

333 Raspberry Road
Anchorage, Alaska 99518-1565
Office: 907.267.2376

16 March 2015

Mr. Thomas Kluberton – Chairman
Alaska Board of Fisheries

Dear Chairman Kluberton and members of the Board of Fisheries:

Since the December 2012 Bristol Bay Board of Fisheries (board) meeting in Naknek, the Alaska Department of Fish and Game (department) has participated in a series of meetings with a committee of users, processors, and members of the Bristol Bay Science and Research Institute. This committee was charged by the board to prepare recommendations relating to the development of optimal escapement goals for Bristol Bay sockeye salmon. As a part of this effort, the committee reviewed a draft escapement analysis report and presentations prepared by scientists from the School of Fisheries and Aquatic Sciences at the University of Washington and LGL Alaska Research Associates, Inc. that evaluated escapement goals for Bristol Bay sockeye salmon taking into account biological and economic factors. Based on the biological and economic analysis, and the escapement goal analysis conducted by the department in 2012 (Fair et al. 2012), the department recommends the lower bounds of the existing sustainable escapement goals (SEGs) and the upper bounds of the escapement goals following the recommendations from Fair et al. 2012 (Table 1). The department intends to implement these recommendations prior to the 2015 fishing season.

In addition, the department is developing umbrella language for Bristol Bay sockeye salmon management as guidelines for managers. This regulatory language will be introduced during the statewide miscellaneous shellfish board meeting in March of 2015 for the department to manage escapements to fall within the lower or upper half of the adopted river-specific escapement goal ranges, proportionate with pre-season and inseason assessments of run strength to fishing districts.

-continued-

Table 1. - Recommended Bristol Bay sockeye salmon escapement goals (in thousands).

	Current SEG		SEG recommendations from Fair, et al. 2012		Recommended SEG	
River	Lower	Upper	Lower	Upper	Lower	Upper
Egegik	800	1,400	900	2,000	800	2,000
Igushik	150	300	200	400	150	400
Kvichak	2,000	10,000	2,000	10,000	2,000	10,000
Naknek	800	1,400	900	2,000	800	2,000
Nushagak	370	840	400	900	370	900
Ugashik	500	1,200	600	1,400	500	1,400
Wood	700	1,500	800	1,800	700	1,800

Citations:

Fair, L.F., C.E. Brazil, X. Zhang, R.A. Clark, and J.W. Erickson. 2012. Review of salmon escapement goals in Bristol Bay, Alaska, 2012. Alaska Department of Fish and Game, Fishery Manuscript Series No. 12-04, Anchorage.

Sincerely,

Jeff Regnart, Director
Division of Commercial Fisheries
Anchorage

Tom Brookover, Acting Director
Division of Sport Fish
Anchorage

Appendix F3.–2015 Escapement goal evaluations for Bristol Bay sockeye salmon from the Bristol Bay Advisory Panel.

RC 6

Bristol Bay Science And Research Institute

March 10, 2015

Tom Kluberton
Chairman, Alaska Board of Fisheries

RE: Evaluation of escapement goals for Bristol Bay

Dear Mr. Kluberton,

Following up on my letter of 19 January 2015, please find attached two draft reports from a study of alternative escapement goals for Bristol Bay.

Analysis of Escapement Goals for Bristol Bay Sockeye Salmon taking into Account Biological and Economic Factors

An evaluation of biological escapement goals for sockeye salmon of Bristol Bay, Alaska.

The study's Advisory Panel (AP) met in Seattle on March 5, 2015 to review the study's results and conclusions. Here in this letter, the AP unanimously puts forward for the Board of Fisheries and ADF&G consideration at the March 17-20 meeting in Anchorage the following.

Conclusions

- A combination of existing and proposed SEGs (Dec. 2012) addresses biological and economic concerns of the industry.
- If the escapement goals proposed here are adopted by ADF&G *and* the Board of Fisheries makes the change below to management plan (s), the AP believes OEGs for these stocks are not necessary.

Recommendations

- ADF&G adopt as SEGs (or BEGs) the lower bound from the existing escapement goals and the upper bound of the proposed goals (Table 1 below).
- The Board of Fisheries implements regulatory language in district-specific management plans as to where generally within the adopted SEG range the Department should manage. For example:
    - *The Department will manage for escapement to fall within the lower or upper half of the adopted river-specific escapement goal ranges, commensurate with pre-season and ongoing in-season assessment of run strength to the fishing district.*

Bristol Bay Science and Research Institute, P.O. Box 1464, Dillingham, AK 99576
Phone: 907-842-4370 Fax: 907-842-4336

-continued-

For illustration purposes, Table 1 also provides the ranges of the lower and upper half of its proposed escapement goal ranges. With this recommended language for management plans, the AP does not envision that the Department be held accountable for falling tightly within these ranges as a function of run size, in all years. Instead, the AP believes the proposed language (above) provides sufficient guidance and flexibility for the Department to achieve higher escapements at times of large runs to the Bay.

Table 1. Current, previously proposed, and Advisory Panel proposed escapement goal ranges for six sockeye salmon stocks in Bristol Bay, Alaska.

	Development of Recommended Ranges				
Stock	Current SEGs	ADF&G proposed (Dec. 2012)	**Advisory Panel (March 2015)**	Lower half of EG range	Upper half of EG range
Ugashik					
Lower	500	600	**500**	500	950
Upper	1,200	1,400	**1,400**	950	1,400
Mid/*Median*	850	1,000	-	725	1,175
Egegik					
Lower	800	900	**800**	800	1,400
Upper	1,400	2,000	**2,000**	1,400	2,000
Mid/*Median*	1,100	1,450		1,100	1,700
Igushik					
Lower	150	200	**150**	150	275
Upper	300	400	**400**	275	400
Mid/*Median*	225	300		213	338
Naknek					
Lower	800	900	**800**	800	1,400
Upper	1,400	2,000	**2,000**	1,400	2,000
Mid/*Median*	1,100	1,450		1,100	1,700
Wood					
Lower	700	800	**700**	700	1,250
Upper	1,500	1,800	**1,800**	1,250	1,800
Mid/*Median*	1,100	1,300		975	1,525
Nushagak					
Lower	370	400	**370**	370	635
Upper	840	900	**900**	635	900
Mid/*Median*	655	700		503	768
Kvichak					
Lower	2,000	----------no change----------			
Upper	10,000				

-continued-

We will have at least three members from the AP available for the March 17-20 meeting in Anchorage (Regnart, Webster, Link), and if you like, I am willing to make an evening presentation to Board members and interested public.

On behalf of the Study's Advisory Panel,

Michael R. Link
Project Manager and AP member for the OEG study, and Chief Scientist, BBSRI

cc.
Advisory Panel: J. Regnart, F. Johnson, M. Luck, A. Williams, V. Webster, B. Monroe, J. Heins, J. Boggs, M. Reimer

Keggie Tubbs, BBSRI Executive Director

Sue Aspelund, Executive Director, BBRSDA