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Review of Salmon Escapement Goals in Bristol Bay, Alaska, 2018

by

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

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ABSTRACT

The Alaska Department of Fish and Game interdivisional escapement goal review committee reviewed Pacific salmon *Oncorhynchus* spp. escapement goals for the major river systems in Bristol Bay. There were 15 escapement goals examined in the Bristol Bay management area for this review. The committee evaluated spawner-return data for most Bristol Bay sockeye salmon *O. nerka* and Chinook salmon *O. tshawytscha* stocks with escapement goals.

For this escapement goal review, the committee recommends modifying the tower-assessed sustainable escapement goal and discontinuing the aerial survey-assessed sustainable escapement goal for Alagnak River sockeye salmon. The committee recommends the sustainable escapement goal for Alagnak River Chinook salmon assessed via aerial survey be discontinued, and that all other escapement goals in the Bristol Bay management area remain the same. The committee also recommends that, prior to the next regulatory cycle, a run reconstruction and spawner-recruit analysis be conducted for Nushagak River Chinook salmon that accounts for errors in harvest data used to develop the current escapement goal, and uncertainty in the proportion of Chinook salmon indexed by sonar identified by recent tagging and capture-recapture studies.

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*, spawning escapement goal, Alaska Board of Fisheries, Kvichak River, Alagnak River, Naknek River, Egegik River, Ugashik River, Wood River, Igushik River, Nushagak River, Togiak River, Bristol Bay

INTRODUCTION

This report describes the review of Bristol Bay salmon escapement goals by the interdivisional escapement goal review committee and their recommendations to the Alaska Department of Fish and Game (ADF&G) Division of Commercial Fisheries and Division of Sport Fish directors. Many Bristol Bay salmon escapement goals have been set and evaluated at regular intervals since statehood.

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 *Oncorhynchus nerka* runs in the world with combined runs to Bristol Bay averaging approximately 38 million fish since 1998 (Table 1). 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 while harvesting fish in excess of escapement goals through orderly fisheries. During the 2015 Statewide Miscellaneous Shellfish Alaska Board of Fisheries (BOF) meeting the Alaska Department of Fish and Game (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, which is affected by a variety of factors including harvest, predation, disease, and physical and biological changes in the environment. 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; Erickson et al. 2015). Bristol Bay also contains 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). Substantial 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 reviewed in 2018.

The committee reviewed and evaluated escapement goals for the following stocks:

- Chinook salmon: Alagnak and Nushagak rivers;
- 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 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 the department and will be expressed as a range based on factors such as salmon stock productivity and data uncertainty; the department will seek to maintain evenly distributed salmon escapements within the bounds of a BEG; and
>
> 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 board; 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 the department and will take into account data uncertainty and be stated as either an "SEG range" or "lower bound SEG"; the department will seek to maintain escapements within the bounds of the SEG range or above the level of a lower bound SEG.

An escapement goal for a stock was defined as a BEG if a sufficiently long time series of escapement, harvest, 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 (e.g.,

lack of age composition estimates, concern with stock-specific harvest allocation, and insufficient contrast in escapements).

During 2018, ADF&G established an interdivisional escapement goal review committee (committee). The committee consisted of Division of Commercial Fisheries and Division of Sport Fish personnel (Table 2). The committee met formally for the first time in February of 2018 to review escapement goals and begin developing recommendations. As per the SSFP and EGP, ADF&G regional and headquarters staff reviewed all committee recommendations prior to adoption as escapement goals.

OBJECTIVES

Objectives of the 2018 review were as follows:

1) Review existing goals 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 discontinuing existing goals;
4) Consider any new stocks for which there may be sufficient data to develop a goal; and
5) Recommend new goals, if appropriate.

OVERVIEW OF STOCK ASSESSMENT METHODS

The committee reviewed each of the existing escapement goals using escapement and harvest data (if available), including data collected since the 2015 review. 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, available fisheries 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). In these cases, other evaluation methods are necessary. Escapement goals are evaluated and revised over time as improved methods are developed, and when new and better information becomes available.

Available escapement, harvest, 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. Escapements within an escapement goal range for a stock should produce sustainable yields.

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 assessed Alagnak River sockeye salmon escapement using a combination of aerial surveys and towers since its inception (Clark 2005). Salmon 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 escapements were assessed using aerial surveys. Age data have been collected from both the escapement and harvest for all of these stocks. Prior to the 2012 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 going back to 1959. For the current review, the Bristol Bay sockeye salmon run reconstruction was updated retroactively for the length of the data set (brood years 1959–2009) to incorporate the best, most current understanding of genetic baselines in Bristol Bay. The total returns for all sockeye salmon stocks in this review were taken from the 2017 run reconstruction.

Alagnak River Chinook salmon escapements were estimated by aerial survey; age composition data was not collected for this stock for escapements or commercial harvests (Salomone et al. 2009).

ESCAPEMENT GOAL SETTING

In previous reviews, escapement goals were evaluated for Bristol Bay salmon stocks using the following methods: (1) spawner-recruitment analysis; (2) yield analysis; (3) smolt information; and (4) risk analysis. Spawner-return data were generally used to estimate escapement goals when stock-specific 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: (1) escapements producing average yields that were 90–100% of MSY from a spawner-recruit model, and 2) the yield analysis, a visual examination of observed yield versus escapement. Recent smolt information is not available for any Bristol Bay salmon stocks. The risk analysis approach (Bernard et al. 2009) was used to develop a lower bound SEG when the harvest of a stock was deemed incidental (passively managed) to harvests and management of primary stocks (e.g., chum salmon harvests are incidental to the directed harvests of sockeye and Chinook salmon in the Nushagak District).

Spawner-Recruit Analysis

Complete spawner-recruit data exists for Nushagak River Chinook and chum salmon, and Alagnak, Egegik, Igushik, Kvichak, Naknek, Nushagak, Togiak, Ugashik, and Wood River sockeye salmon. For this review spawner-recruit models were used to analyze salmon spawner-recruit data for all available brood years. Although total returns are the sum of escapements and harvests, sport and subsistence harvests were only included in total return estimates for the Nushagak River Chinook salmon but were considered minor components for the sockeye salmon stocks.

The Bristol Bay analyses used the standard Ricker spawner-recruit (S-R) model (Ricker 1954) written as:

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

where R is recruitment (i.e., brood year return) and S is brood year escapement, α and β are model parameters.

The model was log transformed to the linearized form:

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

and its parameters were estimated using a simple linear regression analysis (Hilborn and Walters 1992). For Nushagak River Chinook salmon and Egegik sockeye salmon the parameters were estimated using a Bayesian approach of the same model because of additional uncertainties associated with data. For most data, both regression and Bayesian approaches provide nearly identical parameter estimates.

Fishery management parameters S_{eq}, S_{msy}, and MSY were estimated from:

$$S_{eq} = \frac{ln(\alpha)}{\beta}, \tag{3}$$

$$S_{msy} \approx S_{eq}(0.5\text{-}0.07\, ln(\alpha)), \tag{4}$$

$$MSY = \alpha S_{msy} e^{-\beta S_{msy}} - S_{msy}. \tag{5}$$

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 the Alagnak River sockeye salmon were updated during this review cycle using the risk analysis approach. The risk analysis approach estimates 2 types of management errors: 1) the risk of taking an unneeded management action and; 2) the risk of not taking action when management action was warranted (mistaken inaction).

There are currently 2 lower bound SEGs for Alagnak River sockeye salmon. A lower bound SEG of 320,000 assessed with tower counts was established in 2007 utilizing the risk analysis approach (Baker et al 2006); and a lower bound SEG of 125,000 assessed with aerial surveys was established in 2015 utilizing the risk analysis approach (Erickson et al. 2015).

For this review, we updated the historical aerial survey and tower data from 1955–1957 and 1959–2017. The escapement data used to establish the current tower-based escapement goal used tower counts from 1956 to 1976 and expanded aerial surveys from 1977 to 1998 with an expansion factor of 2.7 (Erickson et al. 2015). For this review, we corrected (for an historical error) and updated the expansion factor (by including additional years of data) for Alagnak River sockeye salmon. Escapement time series were log-transformed and tested for autocorrelation using diagnostics of Chatfield (2004). Because the log-escapement time series for Alagnak River sockeye salmon based on tower counts (and aerial survey counts expanded to tower counts) is serially correlated ($p < 0.001$; Figure 2), a lag-1 autoregressive model for estimated risk (π_k, where $k = 3$) of an unwarranted restriction due to a management concern cannot be calculated directly. To address this, a parametric simulation was conducted and 1,000 lag-1 serially correlated escapements were generated (Equations 9–13 in Bernard et al 2009).

The risk of detecting 50–95% declines in mean escapement were calculated in the same way as risk of an unwarranted concern, except risk of not detecting ($1\text{-}\pi_k$) was estimated and the mean escapement was changed by the desired percentage drop in mean to be detected with the threshold. A 95% decline in mean escapement was selected based on the observed percent difference between the mean escapement and minimum escapement.

Percentile Approach

Many salmon stocks throughout Alaska have an SEG developed using the percentile approach (Munro and Volk 2017). In 2001, Bue and Hasbrouck[1] (unpublished) 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 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 0^{th} 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*-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 variability of the run size are 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) and high measurement error (aerial or foot surveys). For this review the percentile approach was used to corroborate the Alagnak River sockeye salmon goal, which was developed using the risk analysis approach.

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 (<0.4)	20^{th} to 60^{th} Percentile
High contrast (>8); and low measurement error (weirs and towers) with low to moderate average harvest rates (<0.4)	15^{th} to 65^{th} Percentile
Low contrast (≤8) with low to moderate average harvest rates (<0.40)	5^{th} to 65^{th} Percentile

RESULTS AND DISCUSSION

A total of 15 escapement goals were reviewed for Bristol Bay. The committee updated the escapement goal analyses for all Bristol Bay sockeye salmon stocks except for 1 recommended to be discontinued (Alagnak River SEG assessed with single aerial surveys). The committee recommends the tower-based lower bound SEG for Alagnak River sockeye salmon be reduced to a lower bound SEG of 210,000, and that the aerial survey-assessed lower bound SEG for this stock be discontinued. The committee recommends the Alagnak River Chinook salmon SEG be discontinued. There is no recommendation to establish any new goals in Bristol Bay. Although results of the updated spawner-recruit analysis for Nushagak River Chinook salmon could indicate a higher SEG, the committee recommends no change be made to the goal until further analysis can be conducted that incorporates the component of the run that is undetected by the sonar.

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

[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.

CHINOOK SALMON

Alagnak River

The current risk analysis-based lower bound SEG of 2,700 Alagnak River Chinook salmon is based on single aerial survey estimates that began in 1970. Surveys were not conducted in 1979 or 2010–2014. A survey was conducted in 2015 but due to poor water conditions it was considered not representative. From 1970 through 2018 (excluding 2015), mean Chinook salmon escapement was 4,573; from 2016 through 2018 it was 902 (Appendix A1).

There are indications that the aerial surveys conducted since 2015 may not index escapement the same as, or similar to, previous surveys used to develop the escapement goal. Although recent index counts have been some of the lowest on record, other indicators of relative Chinook salmon abundance in the Alagnak River (e.g., Statewide Harvest Survey estimates of catch, personal communication with anglers and guide businesses) are on par with years when historical aerial survey index counts were greater than 3,000 fish (Figure 3). The exact reason(s) for these differences are unknown, in part because there are only 2 years (2016 and 2017) of recent aerial survey data under good counting conditions where Statewide Harvest Survey data are available, and the aerial surveys have been conducted in a different manner than in the past (i.e., the peak count of 2 observers per survey and multiple surveys per year beginning in 2016, but 1 observer flying single aerial surveys historically). ADF&G currently lacks the information needed to understand the relationship between aerial survey data and the existing escapement goal, as well as reported sport fishing data. This goal was recommended to be discontinued in 2015 during the previous BOF cycle for this area. However, the goal was kept in place because a new management plan was developed that included a stipulation that the Alagnak River Sockeye Salmon Special Harvest Area only be opened if the Chinook salmon SEG was met in the previous year. ***The committee recommends the Chinook salmon goal for the Alagnak River stock be discontinued.*** By discontinuing this goal, the *Alagnak River Sockeye Salmon Special Harvest Area Management Plan* (5 AAC 06.373 (c)) will need to be updated. This stock is passively managed and incidentally harvested along with the Kvichak River sockeye salmon stock; total harvest rates on Alagnak River Chinook salmon are probably low.

Nushagak River

The current Nushagak River Chinook salmon SEG range is 55,000–120,000 (Table 3; Appendix A2). In this review, we updated the Ricker spawner-recruitment model with the 3 most recent complete brood years (2008–2010). Additionally, corrections were made to historical harvest estimates that had been mistakenly expanded during the Bendix to DIDSON conversion in 2012 (Fair et al. 2012). Similar to previous reviews, the Ricker spawner-recruitment model fit the data well based on a relatively small regression standard deviation (0.50), and a relatively small 95% credible interval for *Smsy* (79,000–115,000) (Tables 4 and 5). The updated median point estimate of *Smsy* (91,700) is well within the current SEG (55,000–120,000) (Figure 4) but is greater than the point estimate of *Smsy* (85,000) that the existing goal was developed from (Fair et al. 2012).

The Nushagak River is approximately 300 m wide at the sonar site and it is not possible to ensonify the middle of the channel. A 2011–2014 acoustic tagging study estimated that the sonar beam covered less than a third of the channel. Preliminary results from the 2011–2014 acoustic tagging study estimated the proportion of Chinook salmon traveling outside the sonar beam

range was 47–65% with a mean of 57%.[2] Similarly, a 2014–2016 mark–recapture study estimated the abundance of adult Chinook salmon in the Nushagak River independently from the sonar estimate. Preliminary results from the 2014–2016 mark–recapture study enumerated 76–81% of the adult Chinook salmon passing the sonar (data on file with Central Region Research Group, ADF&G, Division of Commercial Fisheries, Soldotna). Both studies indicated that a substantial number of Chinook salmon are not enumerated by the existing sonar assessment and that the current sonar assessment is an index of abundance. At this time, ADF&G has not quantified the consistency of the sonar index.

The committee recommends no change be made to the existing escapement goal and that a spawner-recruit model be developed prior to the next Bristol Bay regulatory cycle that will incorporate the corrected harvest data and the uncertainty in Chinook salmon abundance that has been identified by the 2 recent tagging studies. The committee also recommends that the updated analysis and preliminary recommendation from this analysis be presented to subsistence, sport and commercial interests well in advance of the deadline for submitting regulatory proposals.

CHUM SALMON

Nushagak River

The current lower bound SEG of 200,000 chum salmon based on sonar site data was established in 2012 using the risk analysis approach (Fair et al. 2012). For that review, historical escapement data through July 20 was used to develop the escapement goal even though the sonar project in recent years has been extended into mid-August. July 20 was chosen as the cut-off date because over 90% of the chum salmon escapement has passed the sonar site by this date; and for 12 of the 38 years since 1980, sonar operations ceased around July 20, allowing for a larger time series to re-evaluate the goal.

Recent escapements from 2015 to 2017 were above the lower bound SEG and well within the range of historical escapements (Appendix B1); therefore, the committee concluded updating the analysis for this stock would not result in a substantially different escapement goal. ***The committee recommends no change to the current lower bound SEG of 200,000 for Nushagak River chum salmon.***

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 assessed 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 2012 review, the SEG was changed to 60,000–120,000 to account for the difference between Bendix and DIDSON sonar estimation.

The Nushagak River sonar has not operated after July 20 since 2014, so no new information was available for the committee to examine since the 2015 review (Appendix C1). ***The committee***

[2] On file with ADF&G Division of Commercial Fisheries: Expanding Nushagak River Chinook salmon escapement indices to inriver abundance estimates using acoustic tags, 2011–2014, Soldotna; unpublished report.

recommends no change to the current SEG of 60,000–120,000 for Nushagak River coho salmon.

PINK SALMON (EVEN-YEAR)

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 no longer assessed 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.

The sonar project was not operated during the month of August since the previous review, therefore no new information was available to update the escapement goals analysis (Appendix D1). ***The committee recommends no change to the lower bound SEG of 165,000 for even-year pink salmon*** (Table 3).

SOCKEYE SALMON

Alagnak River

The Alagnak River sockeye salmon stock is passively managed and incidentally harvested with Kvichak River sockeye salmon. ADF&G is not able to actively manage this stock. It is for this reason that a lower bound SEG was established in 2007.

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 productivity appears to have increased and escapement estimates based on tower counts and expanded aerial surveys averaged 2,271,581 (Appendix E1). Although we do not yet know the total return from these large escapements, total runs since 2003 averaged approximately 4,000,000 fish (Table 1). 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; hence recent increased production is not completely unexpected.

The risk-based approach was used to develop the initial lower bound SEG for Alagnak River sockeye salmon in 2007 (Baker et al. 2006). The escapement goal committee chose to update the risk-based analysis for the tower-assessed escapement goal because it was not reviewed during the 2012 or 2015 reviews. The estimated risk of an unwarranted concern is 5% (approximately once in 20 years) for the recommended lower bound SEG (210,000) based on tower counts and expanded aerial surveys from 1959 to 2017 (Figure 5). There is a 4.5% estimated risk that a 95% decline in mean escapement over 3 consecutive years would not be detected (from a mean of approximately 879,777 to a minimum observed escapement of 35,280). These levels of risk are similar to the levels of estimated risk that were used in setting this goal in 2006. The committee chose 3 consecutive years because this corresponds to the BOF regulatory cycle.

Estimated mean annual total run for the past 20 years (1998–2017) is approximately 3,473,590 fish (Table 1) and mean escapement for the same period of record is 1,914,786 (Appendix E1). The estimated harvest rate (55%) is greater than the harvest rate (<40%) recommended by Clark

et al. (2014) for using the Percentile Approach. For stocks with harvest rates greater 40%, Clark et al. (2014) suggested the option of setting the lower bound no lower than the 25th percentile to avoid overfishing. The 25th percentile for this stock is approximately 195,000 (Appendix E1) which is less than the recommended lower bound SEG (210,000).

Three consecutive escapements of less than 210,000 (based on tower counts) have not occurred since 1977 and escapements less than 43,989 (5% of mean historical escapement) have occurred only once since 1955 (Figure 6 and Appendix E1). Based on these results, ***the committee recommends the current lower bound SEG of 320,000 Alagnak River sockeye salmon assessed using tower counts be changed to a lower bound SEG of 210,000. The committee also recommends the companion lower bound SEG of 125,000 assessed using a single aerial survey be eliminated*** in deference to the tower-based lower bound SEG.

Other Bristol Bay sockeye salmon stocks

For this review, we updated the sockeye salmon genetic harvest allocations for each stock to better account for mixed stock harvest in each district and to more accurately represent the true production of the primary stocks. Even though the escapement goals were thoroughly reviewed and updated in 2015, the committee elected to update the spawner-recruit analyses (Tables 4 and 5, Figure 7) to determine if the updated harvest allocations and extension of the times series would result in appreciable changes to the spawner-recruit relationships developed in 2012. The committee concluded there were insufficient changes to the spawner recruit analyses to warrant modifying the escapement goals. ***The committee recommends no changes for the Egegik, Igushik, Kvichak, Naknek, Nushagak, Ugashik, Togiak, and Wood river sockeye salmon escapement goals.***

ACKNOWLEDGEMENTS

The authors wish to thank the members of the escapement goal committee and participants in the escapement goal review.

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TABLES AND FIGURES

Table 1.–Bristol Bay sockeye salmon total runs by system, 1998–2017.

Year	Alagnak	Egegik	Igushik	Kvichak	Naknek	Nushagak	Togiak	Ugashik	Wood	Total
1998	1,185,591	4,689,597	426,034	3,811,021	2,365,116	991,560	771,293	1,892,275	4,421,018	20,553,504
1999	3,028,937	6,481,074	859,318	13,203,152	4,701,484	451,807	586,181	5,223,881	7,403,081	41,938,914
2000	2,189,170	8,168,699	982,740	3,569,959	3,967,486	1,344,618	264,324	2,300,098	6,541,118	29,328,214
2001	1,186,913	3,566,444	818,733	1,940,225	5,991,185	2,093,785	313,124	1,467,575	4,644,099	22,022,082
2002	941,301	5,544,322	199,684	897,874	2,813,598	691,785	565,235	2,499,049	3,859,722	18,012,567
2003	4,157,797	3,217,356	492,184	2,001,790	4,861,853	2,409,660	1,126,843	2,540,240	6,233,372	27,041,094
2004	7,525,884	11,642,565	268,354	8,091,208	4,066,682	2,062,469	1,109,141	4,202,791	6,430,417	45,399,511
2005	5,224,716	9,402,204	801,087	2,867,679	8,765,371	3,672,976	406,290	3,090,002	5,881,534	40,111,860
2006	3,342,879	8,613,842	727,744	5,715,390	5,342,241	2,731,826	897,566	3,779,176	12,640,215	43,790,879
2007	4,771,233	7,395,032	1,022,675	5,917,492	8,438,492	2,469,463	507,677	7,399,703	7,794,243	45,716,011
2008	4,704,660	7,825,252	1,888,898	6,030,620	9,127,188	1,908,901	581,328	2,929,895	6,802,770	41,799,512
2009	2,369,160	12,269,671	1,585,348	6,961,784	4,912,920	2,077,746	906,036	3,851,254	6,673,679	41,607,597
2010	2,815,554	5,145,650	1,407,871	10,779,329	5,436,898	1,206,251	1,066,972	4,988,743	8,809,667	41,656,936
2011	2,249,302	4,604,185	1,015,858	7,228,364	5,520,113	1,167,743	868,540	4,203,387	4,949,206	31,806,699
2012	2,226,527	5,923,046	507,046	12,263,919	3,321,536	1,037,757	856,127	2,920,818	2,698,060	31,754,837
2013	1,929,767	5,124,466	692,485	6,324,295	3,074,128	2,009,704	741,034	2,633,700	3,286,043	25,815,621
2014	1,620,274	5,078,503	1,436,176	17,600,068	5,320,300	1,510,012	858,018	1,154,017	7,166,061	41,743,430
2015	8,244,526	8,508,004	1,643,379	23,104,927	6,090,738	2,475,985	832,938	4,249,070	5,019,839	60,169,408
2016	4,957,298	9,036,510	1,912,626	12,669,029	5,358,304	3,360,041	592,763	8,831,921	5,382,715	52,101,208
2017	4,800,305	12,379,291	1,228,467	7,783,316	6,514,161	8,156,817	710,468	6,625,230	11,316,072	59,514,127
Mean	3,473,590	7,230,786	995,835	7,938,072	5,299,490	2,191,545	728,095	3,839,141	6,397,647	38,094,201
Median	2,922,245	6,938,053	921,029	6,643,040	5,331,271	2,036,086	756,164	3,434,589	6,331,895	41,632,266
Min	941,301	3,217,356	199,684	897,874	2,365,116	451,807	264,324	1,154,017	2,698,060	18,012,567
Max	8,244,526	12,379,291	1,912,626	23,104,927	9,127,188	8,156,817	1,126,843	8,831,921	12,640,215	60,169,408

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:		
Greg Buck	Area Research Biologist	Division of Commercial Fisheries
Jack Erickson	Regional Research Coordinator	Division of Commercial Fisheries
Hamachan Hamazaki	Biometrician	Division of Commercial Fisheries
James Hasbrouck	Fisheries Scientist	Division of Sport Fish
Katie Howard	Fisheries Scientist	Division of Sport Fish
Timothy McKinley	Regional Research Coordinator	Division of Sport Fish
Andrew Munro	Fisheries Scientist	Division of Commercial Fisheries
Adam St. Saviour	Regional Research Biologist	Division of Sport Fish
Bill Templin	Fisheries Scientist	Division of Commercial Fisheries
Xinxian Zhang	Biometrician	Division of Commercial Fisheries
Other Participants:		
Lee Borden	Asst. Area Management Biologist	Division of Sport Fish
Dan Bosch	Regional Management Biologist	Division of Sport Fish
Rich Brenner	Statewide Fisheries Biologist	Division of Commercial Fisheries
Jason Dye	Area Management Biologist	Division of Sport Fish
Travis Elison	Area Management Biologist	Division of Commercial Fisheries
Jordan Head	Asst. Area Research Biologist	Division of Commercial Fisheries
Bert Lewis	Regional Supervisor	Division of Commercial Fisheries
Aaron Poetter	Regional Management Biologist	Division of Commercial Fisheries
Paul Salomone	Area Management Biologist	Division of Commercial Fisheries
Tim Sands	Area Management Biologist	Division of Commercial Fisheries
Katie Sechrist	Asst. Area Research Biologist	Division of Commercial Fisheries
Tom Vania	Regional Supervisor	Division of Sport Fish

Table 3.–Summary of current escapement goals and recommended escapement goals for salmon stocks in Bristol Bay, 2018.

	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	Discontinue		
Nushagak	55,000–120,000	SEG	2007; Changed to SEG in 2007; range changed in 2012	Sonar	No Change		
Chum salmon							
Nushagak	200,000 minimum	SEG	2007; range changed in 2012	Sonar	No Change		
Coho salmon							
Nushagak	60,000–120,000	SEG	2012	Sonar	No Change		
Pink salmon							
Nushagak (even years)	165,000 minimum		2012	Sonar	No Change		
Sockeye salmon							
Alagnak (tower count)	320,000 minimum	SEG	2007	Tower	Update	210,000 lower-bound	SEG
Alagnak (single aerial survey)	125,000 minimum	SEG	2015	Single aerial survey	Discontinue		
Egegik	800,000–2,000,000	SEG	1995; Changed to SEG in 2007; range changed in March 2015	Tower	No Change		
Igushik	150,000–400,000	SEG	2001; Changed to SEG in 2007; range changed in March 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 March 2015	Tower	No Change		
Nushagak	370,000–900,000	SEG	1998; Changed to SEG in 2007; range changed in 2012; range changed in March 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 March 2015	Tower	No Change		
Wood	700,000–1,800,000	SEG	2001; Changed to SEG in 2007; range changed in March 2015	Tower	No Change		

Table 4.–Current escapement goals and updated estimates of S_{msy}, escapement at 90–100% of *MSY*, and S_{eq} for Bristol Bay salmon.

		Current escapement goal (x thousands)					S_{msy} 95% CI				Escapement at 90–100% of *MSY*		S_{eq}
Sockeye salmon	Goal type	Lower	Upper	Spawner-return data	*n*	Model	Median	CV	Lower	Upper	Lower	Upper	($\ln\alpha$ / β) Median
Alagnak	SEG	320		1959–2009	51	Ricker	1,338	0.47	914	2,813	880	1,855	3,176
Egegik	SEG	800	2,000	1959–2009	51	Ricker	5,252	6.31	1,466	11,984	3,417	7,484	13,485
Igushik	SEG	150	400	1959–2009	51	Ricker	294	0.14	236	400	195	415	737
Kvichak	SEG	2,000	10,000	1959–2009	51	Ricker	12,309	18.6	5,772	148,400	9,295	19,035	27,734
Naknek	SEG	800	2,000	1959–2009	51	Ricker	1,752	2.09	1,174	4,171	1,140	2,460	4,415
Nushagak	SEG	370	900	1959–2009	51	Ricker	815	1.65	582	1,509	535	1,150	2,034
Ugashik	SEG	500	1,400	1959–2009	51	Ricker	2,175	19.66	1,002	27,828	1,610	3,420	5,261
Togiak	SEG	120	270	1959–2009	51	Ricker	205	0.27	150	351	135	290	536
Wood	SEG	700	1,800	1959–2009	51	Ricker	1,925	6.6	1,203	6,514	1,245	2,690	4,817
Chinook salmon													
Nushagak	SEG	55	120	1966–2010	45	Ricker	91.7	0.10	79	115	68.5	117.7	214

Note: A Bayesian analysis estimated stock-recruitment parameters for a Ricker model with multiplicative error. Median parameter estimates are given with CVs and lower and upper 95% credible intervals (CI).

Table 5.–Updated estimates of spawner-recruitment parameters (α, β, and σ) for Bristol Bay salmon.

	Spawner-return			α 95% CI				β 95% CI			σ 95% CI		
Sockeye salmon	data	*n*	Model	Lower	Median	ln Median	Upper	Lower	Median	Upper	Lower	Median	Upper
Alagnak	1959–2009	51	Ricker	2.32	3.04	1.11	3.98	1.49E-07	3.50E-07	5.57E-07	0.62	0.77	0.92
Egegik	1959–2009	51	Ricker	3.74	4.89	1.61	7.59	4.80E-09	1.17E-07	4.86E-07	0.71	0.77	0.94
Igushik	1959–2009	51	Ricker	2.95	4.14	1.42	5.83	1.22E-06	1.92E-06	2.65E-06	0.65	0.79	0.93
Kvichak	1959–2009	51	Ricker	1.67	2.2	0.79	2.94	1.81E-09	2.79E-08	7.00E-08	0.51	0.79	1.08
Naknek	1959–2009	51	Ricker	3.06	4.32	1.46	6.12	1.16E-07	3.31E-07	5.67E-07	0.42	0.53	0.65
Nushagak	1959–2009	51	Ricker	3.16	4.07	1.4	5.27	3.37E-07	6.90E-07	1.05E-06	0.47	0.62	0.79
Togiak	1959–2009	51	Ricker	3.84	5.38	1.81	7.49	1.59E-03	3.14E-06	4.74E-03	0.42	0.5	0.58
Ugashik	1959–2009	51	Ricker	2.41	3.49	1.25	5.2	1.55E-08	2.34E-07	5.91E-07	0.78	0.95	1.12
Wood	1959–2009	51	Ricker	3.02	4.19	1.43	5.93	7.37E-08	2.96E-07	5.44E-07	0.46	0.55	0.63
Chinook salmon													
Nushagak	1966–2010	45	Ricker	2.79	3.97	1.38	5.71	4.39E-06	6.47E-06	8.53E-06	0.41	0.50	0.63

Note: A Bayesian analysis estimated stock-recruitment parameters for a Ricker model with multiplicative error. Median parameter estimates are given with CVs and lower and upper 95% credible intervals (CI).

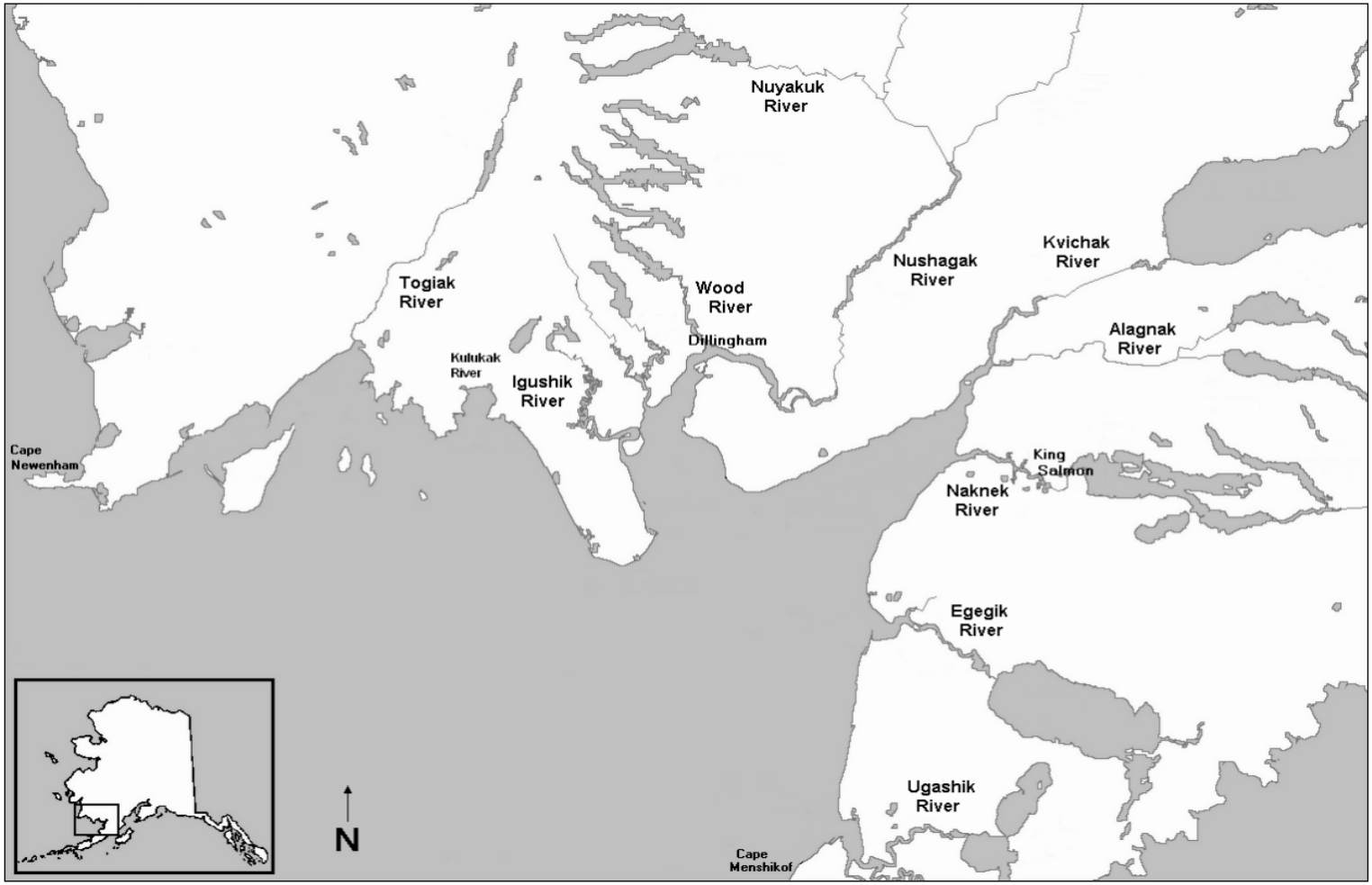

Figure 1.–Map of Bristol Bay showing major rivers.

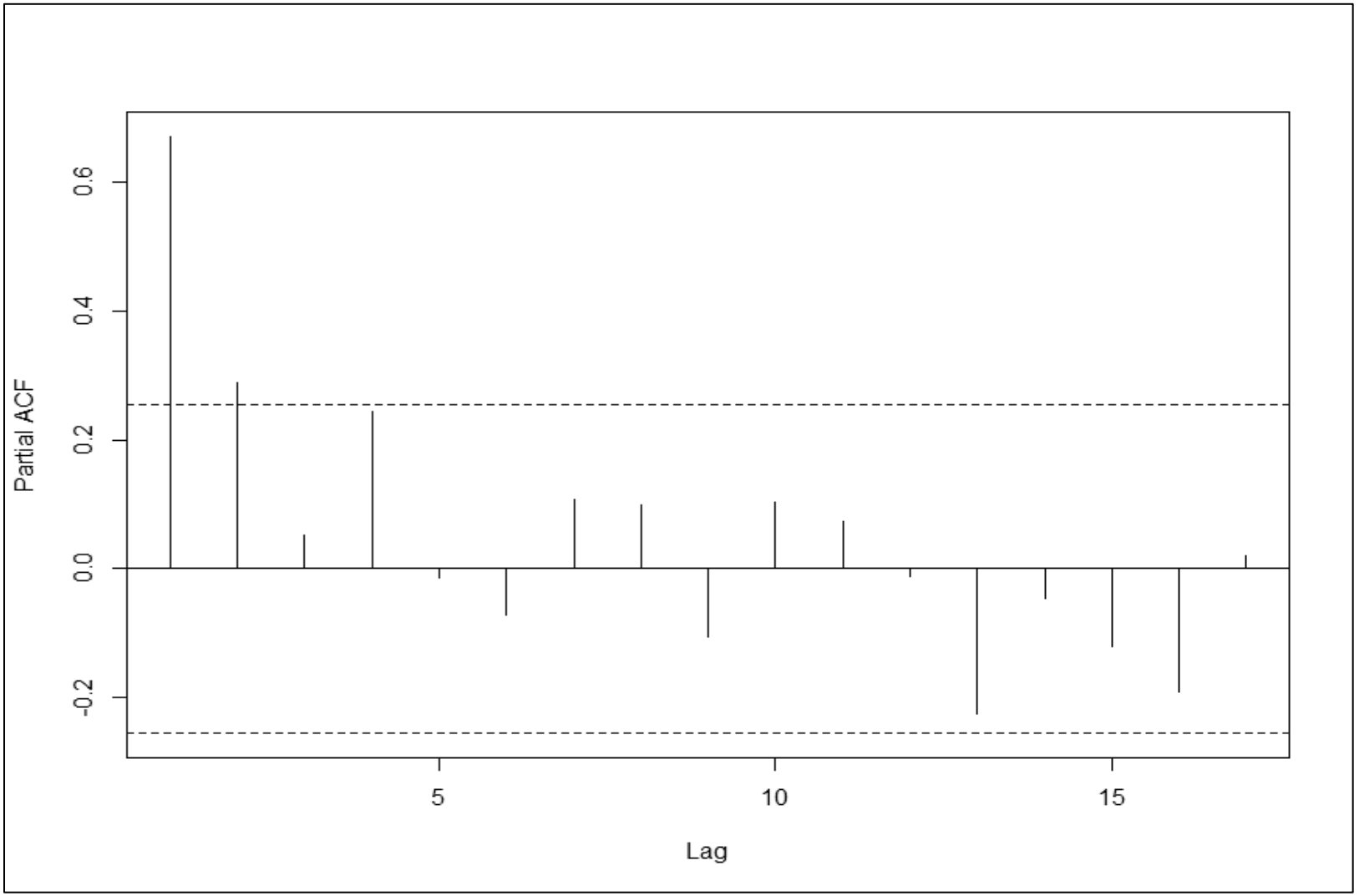

Figure 2.–Partial autocorrelations (PACF) for log escapements of annual spawning abundance for sockeye salmon in the Alagnak River (1959–2017).

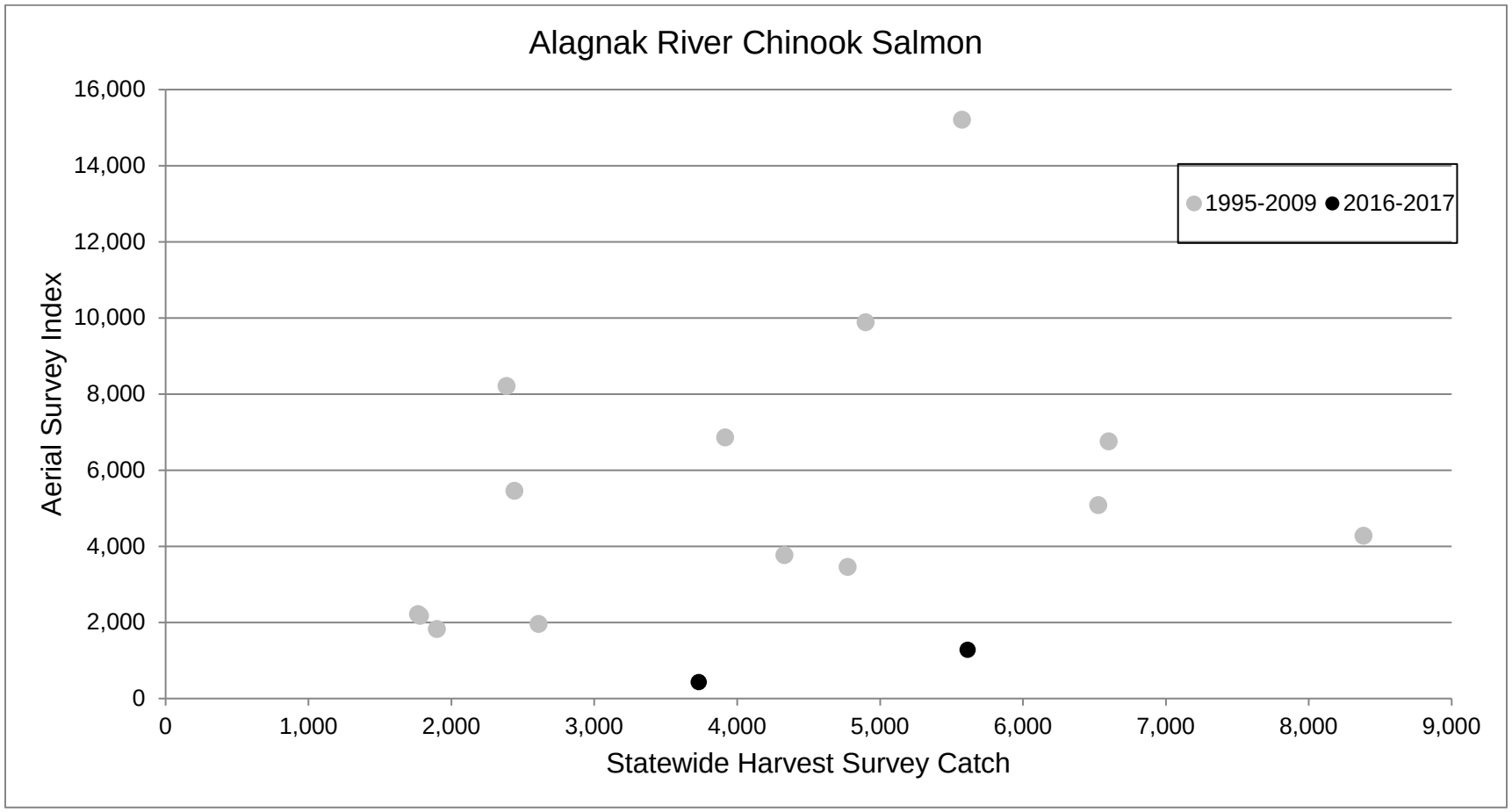

Figure 3.–Aerial survey index counts and Statewide Harvest Survey (SWHS) estimates of catch of Alagnak River Chinook salmon, 1995–2009 and 2016–2017.

Note: The aerial survey index counts reported for 2016 and 2017 are the peak counts of all observers and days surveyed.

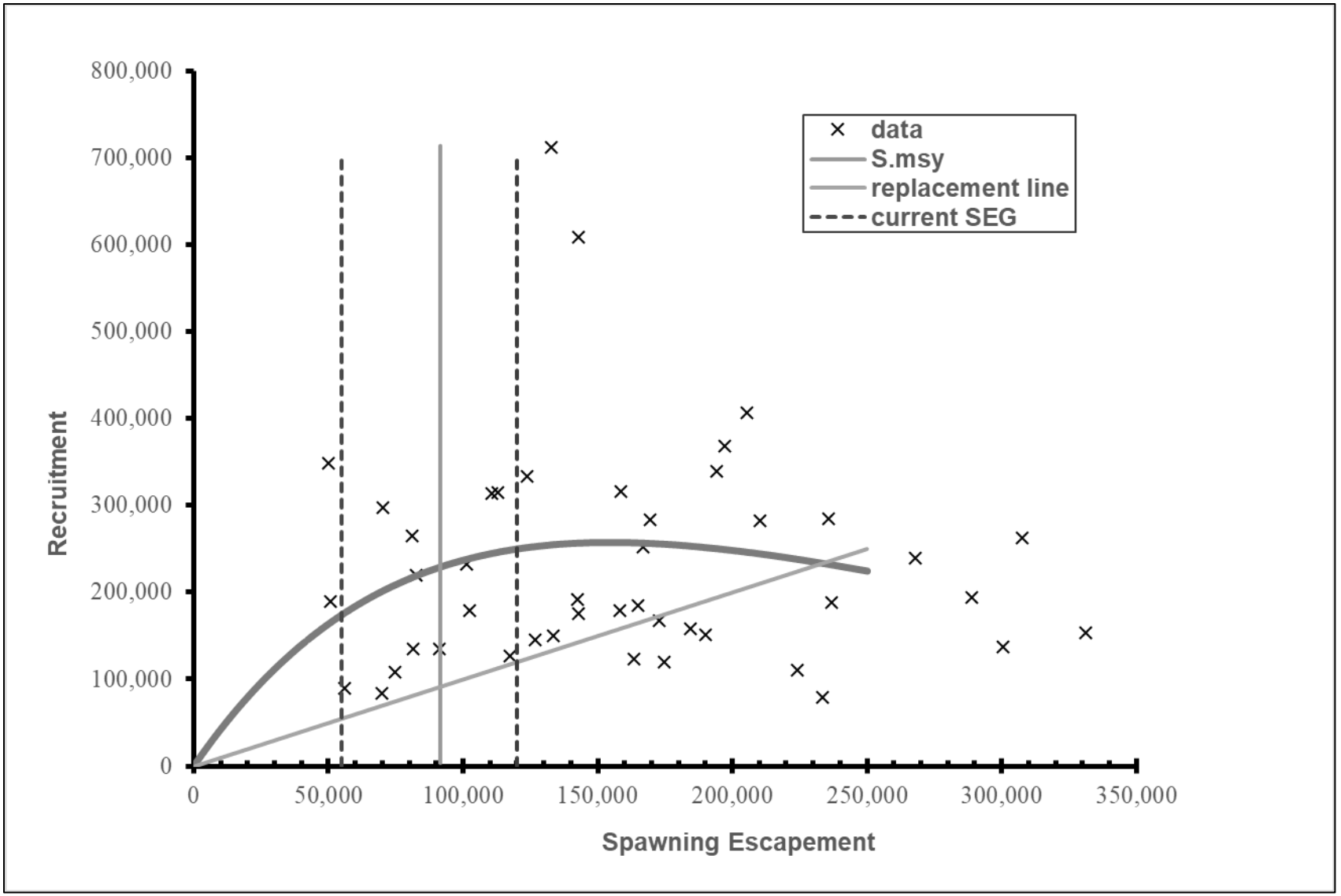

Figure 4.–Ricker spawner-recruit curve for Nushagak River Chinook salmon (brood years 1966–2010).

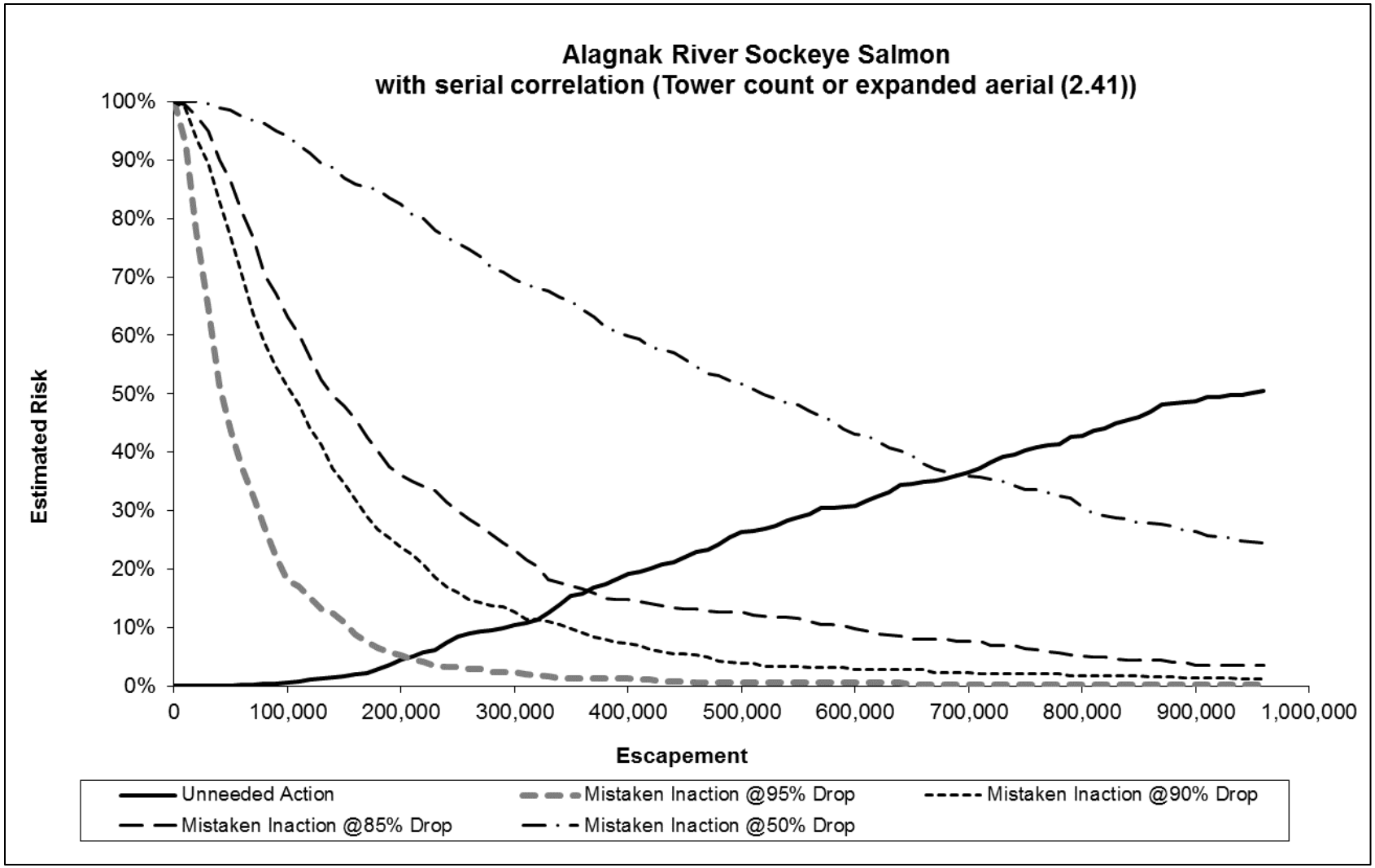

Figure 5.–Estimated risk of an unwarranted management concern and risk of not detecting various percentage drops in mean log-transformed escapement for a range of possible escapements for Alagnak River sockeye salmon (1959–2017).

Note: Time series from 1955 to 1957 was excluded from the time series because there was not assessment in 1958.

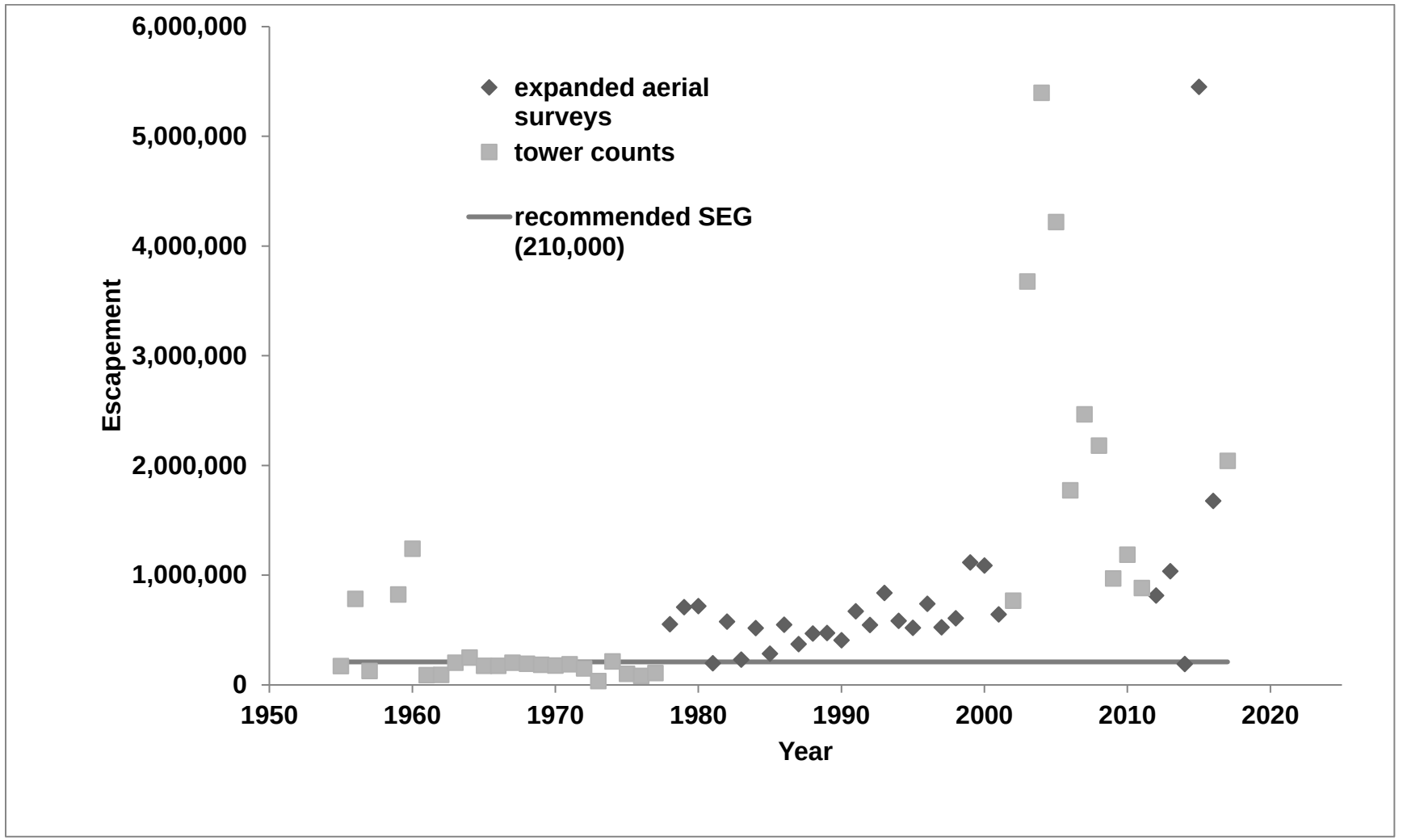

Figure 6.–Escapement of sockeye salmon based on tower counts of the Alagnak River (1955–1957 and 1959–2017) and the recommended lower bound sustainable escapement goal.

Note: No assessment was conducted in 1958.

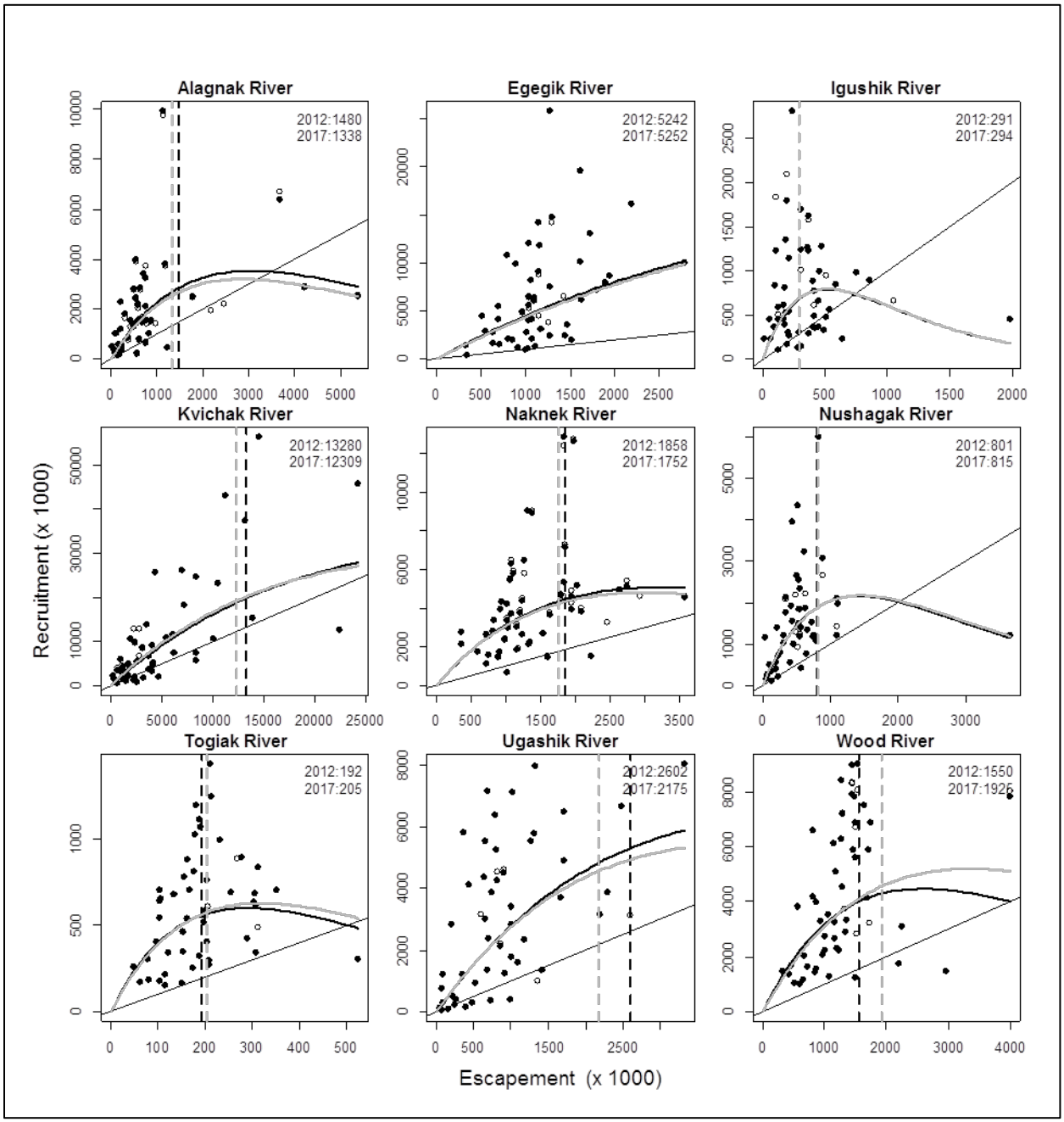

Figure 7.–Comparison of 2012 (light gray) and 2017 (black) Ricker spawner-recruit analyses for Bristol Bay sockeye salmon.

Note: Circle points represent run reconstruction. Numeric values in upper right corner are point estimates of S_{MSY}. Vertical hashed lines represent S_{MSY}. Lines represent Ricker spawner-recruit curve. Diagonal lines are replacement lines.

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 (2007)
Inriver Goal:	None
Optimal Escapement Goal:	None
Recommended Escapement Goal:	Discontinue; was previously recommended to be discontinued in 2015
Escapement Estimation:	Aerial survey counts since 1970
Summary:	
Data Quality	Poor
Data Type	Aerial survey; limited age data
Methodology	Risk analysis
Years within recommended goal	0 out of last 10 years (2009–2018) – no surveys 2010–2014; 2015 poor water conditions

-continued-

Appendix A1.–Page 2 of 3.

Year	Aerial survey index [a]	SWHS [b] catch	SWHS harvest	Guide logbook harvest
1970	5,250	–	–	–
1971	1,475	–	–	–
1972	2,256	–	–	–
1973	824	–	–	–
1974	1,596	–	–	–
1975	6,620	–	–	–
1976	7,593	–	–	–
1977	9,425	–	–	–
1978	11,650	–	–	–
1979	–	–	–	–
1980	2,930	–	–	–
1981	2,430	–	–	–
1982	3,400	–	–	–
1983	2,980	–	–	–
1984	6,090	–	–	–
1985	3,920	–	–	–
1986	3,090	–	–	–
1987	2,420	–	–	–
1988	4,600	–	–	–
1989	3,650	–	–	–
1990	1,720	–	–	–
1991	2,531	–	–	–
1992	3,042	–	–	–
1993	10,170	–	–	–
1994	8,480	–	–	–
1995	6,860	3,916	891	–
1996	9,885	4,899	931	–
1997	15,210	5,573	972	–
1998	4,148	9,087	1,531	–
1999	2,178	1,780	592	–

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Year	Aerial survey index [a]	SWHS [b] catch	SWHS harvest	Guided logbook harvest
2000	2,220	1,766	501	–
2001	5,458	2,440	508	–
2002	3,675	4,331	305	–
2003	8,209	2,386	334	–
2004	6,755	6,600	1,146	–
2005	5,084	6,526	1,008	–
2006	4,278	8,383	1,052	693
2007	3,455	4,772	1,007	540
2008	1,825	1,898	394	308
2009	1,957	2,609	199	150
2010	NS	2,842	405	254
2011	NS	4,416	1,317	345
2012	NS	1,249	572	290
2013	NS	3,502	823	284
2014	NS	4,265	983	349
2015	917[c]	4,299	206	410
2016	1,283	5,613	385	229
2017	435	3,731	403	N/A
2018	988	–	–	–
Average	4,573	4,212	726	350
SD.	3,285	2,074	381	152
Median	3,553	4,265	708	308
No. of Years	42	23	23	11

Note: NS = No Survey; N/A = Not Available.

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

[b] Statewide Harvest Survey.

[c] Poor water conditions.

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

System: Nushagak River	
Species: Chinook salmon	
Description of stock and escapement goals	
Management Division:	Commercial Fisheries
Previous Escapement Goal:	40,000–80,000 BEG (2004); changed to SEG in 2007
Inriver Goal:	90,000
Optimal Escapement Goal:	None
Current Escapement Goal:	55,000–120,000 SEG
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; 45 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 (2008–2017)

-continued-

Appendix A2.–Page 2 of 3.

Year	Spawning escapement	Total return	Return per spawner
1966	81,462	134,612	1.65
1967	133,477	149,545	1.12
1968	142,951	175,766	1.23
1969	69,970	83,614	1.19
1970	101,435	231,916	2.29
1971	81,237	264,749	3.26
1972	50,156	348,613	6.95
1973	70,130	297,988	4.25
1974	142,535	191,584	1.34
1975	142,791	608,763	4.26
1976	205,273	406,882	1.98
1977	132,907	711,779	5.36
1978	268,046	239,702	0.89
1979	194,335	339,512	1.75
1980	289,040	194,006	0.67
1981	307,527	262,576	0.85
1982	300,656	137,337	0.46
1983	331,270	153,904	0.46
1984	163,544	123,105	0.75
1985	236,899	188,254	0.79
1986	82,777	219,175	2.65
1987	169,562	283,448	1.67
1988	113,006	315,142	2.79
1989	158,551	315,785	1.99

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Year	Spawning escapement [a]	Total return	Return per spawner
1990	126,747	145,148	1.15
1991	210,346	282,200	1.34
1992	166,965	252,253	1.51
1993	197,098	368,161	1.87
1994	190,121	151,532	0.80
1995	173,014	167,131	0.97
1996	102,348	178,919	1.75
1997	165,062	185,066	1.12
1998	235,845	284,846	1.21
1999	123,906	333,343	2.69
2000	110,682	313,369	2.83
2001	184,317	157,799	0.86
2002	174,704	120,174	0.69
2003	158,307	179,363	1.13
2004	233,475	78,789	0.34
2005	223,950	110,791	0.49
2006	117,364	127,187	1.08
2007	50,960	188,943	3.71
2008	91,364	134,339	1.47
2009	74,781	108,640	1.45
2010	56,092	89,454	1.59
2011	101,995	[b]	
2012	167,618	[b]	
2013	104,746	[b]	
2014	62,532	[b]	
2015	90,974	[b]	
2016	122,637	[b]	
2017	53,819	[b]	
1966–2017			
Average	150,794	229,671	1.79
No. of Years	52	45	45

[a] Spawning escapement is defined as escapement count minus sport fish and subsistence harvest occurring above the counting sonar (Buck et al 2012).

[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; 38 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	10 out of last 10 years (2008–2017)

-continued-

System: Nushagak River
Species: chum salmon
Data available for analysis of escapement goals

Year	Escapement	ln(Escapement)
1980	415,727	12.94
1981	182,021	12.11
1982	262,597	12.48
1983	107,780	11.59
1984	450,031	13.02
1985	245,797	12.41
1986	203,810	12.22
1987	175,551	12.08
1988	217,772	12.29
1989	461,456	13.04
1990	373,126	12.83
1991	350,186	12.77
1992	383,303	12.86
1993	272,278	12.51
1994	467,930	13.06
1995	266,432	12.49
1996	279,406	12.54
1997	76,034	11.24
1998	369,447	12.82
1999	296,408	12.60
2000	173,712	12.07
2001	646,984	13.38
2002	509,106	13.14
2003	375,175	12.84
2004	332,347	12.71
2005	569,034	13.25
2006	661,002	13.40
2007	161,483	11.99
2008	326,300	12.70
2009	438,481	12.99
2010	273,914	12.52
2011	248,278	12.42
2012	395,162	12.89
2013	628,134	13.35
2014	525,797	13.17
2015	288,929	12.57
2016	419,810	12.95
2017	415,488	12.94
1980-2017		
Mean	348,585	12.66
SD	145,816	0.48
Median	341,267	12.74
No. of Years	38	38

[a] Conversion factor of 1.27 was applied to all years prior to 2005 to convert from Bendix to DIDSON count equivalents. Escapement estimate for 2005 used strata- and species-specific correction factors applied to the Bendix north bank counting stratum. Counts from 2006 through 2017 are DIDSON counts. Escapement index 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 discontinued 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	6 out of last 10 years assessed (1997-2017)

-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	NS		
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		
2003	NS		
2004	193,819		
2005	NS		
2006	NS		
2007	NS		
2008	NS		
2009	NS		
2010	NS		
2011	NS		
2012	329,946		
2013	207,222		
2014	478,198		
2015	NS		
2016	NS		
2017	NS		
1980–2017 Average	127,729	130,172	1.64
No. of Years	26	17	17

Note: NS = no survey

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

APPENDIX D. PINK SALMON

Appendix D1.–Escapement goal for Nushagak River pink salmon (even-year).

System: Nushagak River

Species: pink salmon (even-year)

Description of stock and escapement goals

Management Division:	Commercial Fisheries
Previous Escapement Goal:	600,000 to 1,100,000 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 [a]
Years within recommended goal	8 out of last 10 assessments (1990–2016)

-continued-

System: Nushagak River
Species: pink salmon
Data available for analysis of escapement goals

Year	Escapement[b]
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
2016	NS
Average	1,452,817
Median	753,410
Contrast	157

Note: NS = No survey.

[a] 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.

[b] 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:	210,000 lower bound SEG; based on tower counts; recommend aerial-based goal be discontinued
Current Escapement Goal:	320,000 lower bound SEG based on tower counts; 125,000 lower bound SEG based on aerial survey
Escapement Estimation:	Tower counts from 1955–1977, 2002–2011, and 2017; expanded aerial survey counts from 1978–2001 and 2012–2016
	Recommended goal is based on tower counts and expanded aerial surveys (1955–2017)
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	Recommended escapement goal minimum would have 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	Aerial survey count	Expanded aerial survey [a]	Tower counts	Observed expansion factor	Year valid for expansion?	Tower count or expanded aerial survey (2.41)
1955	57,400		172,000		No, Nanuktuk not surveyed	172,000
1956	235,000		784,000	3.34	Yes	784,000
1957	85,000		126,595		No, Nanuktuk & Moraine not surveyed	126,595
1959	no flights		825,431			825,431
1960	no flights		1,240,530			1,240,530
1961	no flights		90,036			90,036
1962	6,400		90,630		No, Nanuktuk not surveyed	90,630
1963	63,125		203,304	3.22	Yes	203,304
1964	no flights		248,700			248,700
1965	no flights		175,020			175,020
1966	110,300		174,336	1.58	Yes	174,336
1967	128,030		202,626		No, Nanuktuk not surveyed	202,626
1968	74,350		193,872	2.61	Yes	193,872
1969	42,066		182,490	4.34	Yes	182,490
1970	no flights		177,060			177,060
1971	no flights		187,302			187,302
1972	no flights		151,188			151,188
1973	no flights		35,280			35,280
1974	no flights		214,848			214,848
1975	35,325		100,480	2.84	Yes	100,480
1976	84,440		81,822	0.97	Yes	81,822
1977	no flights		108,911			108,911
1978	229,400	552,671				552,671
1979	294,200	708,788				708,788
1980	297,900	717,702				717,702
1981	82,210	198,061				198,061
1982	239,300	576,522				576,522
1983	96,220	231,814				231,814
1984	215,470	519,111				519,111
1985	118,030	284,358				284,358
1986	228,180	549,732				549,732
1987	154,210	371,523				371,523
1988	194,630	468,903				468,903

-continued-

Appendix E1.–Page 3 of 3.

Year	Aerial survey count	Expanded aerial survey [a]	Tower counts	Observed expansion factor	Year valid for expansion?	Tower count or expanded aerial survey (2.41)
1989	196,760	474,035				474,035
1990	168,760	406,577				406,577
1991	278,589	671,177				671,177
1992	226,643	546,029				546,029
1993	347,975	838,342				838,342
1994	242,595	584,461				584,461
1995	215,713	519,696				519,696
1996	306,750	739,023				739,023
1997	218,115	525,483				525,483
1998	252,200	607,601				607,601
1999	463,600	1,116,907				1,116,907
2000	451,300	1,087,273				1,087,273
2001	267,000	643,257				643,257
2002	no flights		766,962			766,962
2003	2,110,000		3,676,146	1.74	Yes	3,676,146
2004	2,911,600		5,396,592	1.85	Yes	5,396,592
2005	1,736,000		4,218,990	2.43	Yes	4,218,990
2006	900,000		1,773,966	1.97	Yes	1,773,966
2007	1,155,000		2,466,414	2.14	Yes	2,466,414
2008	1,499,000		2,180,502	1.45	Yes	2,180,502
2009	no flights		970,818			970,818
2010	no flights		1,187,730			1,187,730
2011	no flights		883,794			883,794
2012	337,940	814,435				861,747
2013	429,784	1,035,780				1,095,950
2014	78,637	189,452				189,452
2015	2,263,000	5,452,026				5,452,026
2016	696,400	1,677,769				1,677,769
2017	629,200		2,041,825	3.25	Yes	2,041,825
Average	479,008	796,845	1,008,254	2.41		879,777
n	44	29	30	14		62
Minimum	6,400		35,280	0.97		35,280
Maximum	2,911,600		5,396,592	4.34		5,452,026
Std. deviation	650,349	947,636	1,370,807	0.91		1,155,380

[a] Aerial survey expansion factor of 2.41.

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 BEG (1997); changed to SEG in 2007
Inriver Goal:	None
Optimal Escapement Goal:	None
Current Escapement Goal:	800,000–2,000,000 SEG (2015)
Escapement Estimation:	Tower counts from 1959 to present; smolt data from 1983–2001; 59 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 (2008–2017)

-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	9,914,902	11.07
1979	1,032,042	4,039,741	3.91
1980	1,060,860	8,222,418	7.75
1981	694,680	5,441,586	7.83
1982	1,034,628	6,435,075	6.22
1983	792,282	10,811,633	13.65
1984	1,165,345	11,766,356	10.10
1985	1,095,192	6,382,683	5.83
1986	1,152,180	14,207,134	12.33
1987	1,273,553	25,731,443	20.20
1988	1,612,745	19,465,142	12.07
1989	1,611,566	10,134,483	6.29

-continued-

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Year	Escapement	Total return	Return per spawner
1990	2,191,582	16,060,318	7.33
1991	2,786,925	9,948,962	3.57
1992	1,945,632	8,668,647	4.46
1993	1,517,000	1,936,034	1.28
1994	1,897,977	7,979,479	4.20
1995	1,266,692	7,522,881	5.94
1996	1,076,460	4,161,328	3.87
1997	1,104,004	6,063,053	5.49
1998	1,110,938	1,270,508	1.14
1999	1,728,397	13,004,488	7.52
2000	1,032,138	12,037,958	11.66
2001	968,872	4,786,180	4.94
2002	1,036,092	5,292,059	5.11
2003	1,152,120	8,800,152	7.64
2004	1,290,144	14,138,820	10.96
2005	1,621,734	6,185,018	3.81
2006	1,465,158	3,573,363	2.44
2007	1,432,500	6,440,136	4.50
2008	1,259,568	3,830,060	3.04
2009	1,146,276	4,505,950	3.93
2010	927,054	[a]	
2011	961,200	[a]	
2012	1,233,900	[a]	
2013	1,113,630	[a]	
2014	1,382,466	[a]	
2015	2,160,792	[a]	
2016	1,837,260	[a]	
2017	2,600,982	[a]	
1959–2017 Average	1,210,775	6,374,840	5.45
No. of Years	59	51	51

[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 BEG (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 1963 to present; 51 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	10 of last 10 years (2008–2017)

-continued-

System: Igushik River

Species: sockeye salmon

Data available for analysis of escapement goals

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-

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	767,785	1.86
2001	409,596	490,103	1.20
2002	123,156	495,201	4.02
2003	194,088	2,087,759	10.76
2004	109,650	1,835,271	16.74
2005	365,712	1,579,838	4.32
2006	305,268	1,005,262	3.29
2007	415,452	608,855	1.47
2008	1,054,704	663,700	0.63
2009	514,188	941,767	1.83
2010	518,040	[a]	
2011	421,380	[a]	
2012	193,326	[a]	
2013	387,666	[a]	
2014	340,590	[a]	
2015	651,172	[a]	
2016	469,230	[a]	
2017	578,700	[a]	
1959–2017			
Average	345,333	731,441	3.32
No. of Years	59	51	51

[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:	Prior to current goal (which this is) there was the off-cycle and pre- or peak-cycle goals. The current goal is the off-cycle which numerically was established in 1997 and changed from BEG to SEG in 2006 the pre, peak-cycle goal was also established in 1997 as BEG and was 6-10 million, changed to SEG in 2006 and eliminated in 2015.
Inriver Goal:	None
Optimal Escapement Goal:	None
Current Escapement Goal:	2,000,000–10,000,000 SEG
Escapement Estimation:	Tower counts from 1963 to present; smolt data from 1971–2000; 51 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 of last 10 years (2008–2017)

-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	43,049,770	3.84
1980	22,505,268	12,597,313	0.56
1981	1,754,358	2,048,789	1.17
1982	1,134,840	1,509,246	1.33
1983	3,569,982	13,775,451	3.86
1984	10,490,670	23,287,185	2.22
1985	7,211,046	18,314,833	2.54
1986	1,179,322	4,114,460	3.49
1987	6,065,880	11,648,130	1.92
1988	4,065,216	9,205,714	2.26
1989	8,317,500	24,800,933	2.98

-continued-

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Year	Escapement	Total return	Return per spawner
1990	6,970,020	26,298,686	3.77
1991	4,222,788	4,637,250	1.10
1992	4,725,864	1,875,603	0.40
1993	4,025,166	3,130,470	0.78
1994	8,355,936	7,303,050	0.87
1995	10,038,720	10,636,782	1.06
1996	1,450,578	2,260,607	1.56
1997	1,503,732	816,242	0.54
1998	2,296,074	1,254,499	0.55
1999	6,196,914	7,378,782	1.19
2000	1,827,780	4,261,658	2.33
2001	1,095,348	4,421,265	4.04
2002	703,884	3,881,251	5.51
2003	1,686,804	4,966,281	2.94
2004	5,500,134	10,918,274	1.99
2005	2,320,332	9,582,839	4.13
2006	3,068,226	8,319,191	2.71
2007	2,810,208	12,795,126	4.55
2008	2,757,912	6,577,118	2.38
2009	2,266,140	12,889,440	5.69
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]	
2015	7,348,572	[a]	
2016	4,462,728	[a]	
2017	3,163,404	[a]	
1959–2017			
Average	4,935,425	10,723,008	2.54
No. of Years	59	51	51

[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 BEG (1983); changed to SEG in 2007
Inriver Goal:	None
Optimal Escapement Goal:	2,000,000
Current Escapement Goal:	800,000–2,000,000 SEG
Escapement Estimation:	Tower counts from 1959 to present; 51 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	9 of last 10 years (2008–2017)

-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	3,965,088	4.28
1980	2,644,698	4,930,476	1.86
1981	1,796,220	4,703,787	2.62
1982	1,155,552	1,849,206	1.60
1983	888,294	1,482,526	1.67
1984	1,242,474	4,489,760	3.61
1985	1,849,938	7,264,391	3.93
1986	1,977,645	12,744,734	6.44
1987	1,061,806	5,533,716	5.21
1988	1,037,862	3,025,871	2.92
1989	1,161,984	3,133,263	2.70

-continued-

Year	Escapement	Total return	Return per spawner
1990	2,092,578	3,997,626	1.91
1991	3,578,508	4,629,239	1.29
1992	1,606,650	1,481,553	0.92
1993	1,535,658	2,704,804	1.76
1994	990,810	2,396,222	2.42
1995	1,111,140	5,927,766	5.33
1996	1,078,098	6,473,144	6.00
1997	1,025,664	3,457,636	3.37
1998	1,202,172	3,869,572	3.22
1999	1,625,364	3,762,439	2.31
2000	1,375,488	9,024,550	6.56
2001	1,830,360	4,633,413	2.53
2002	1,263,918	5,780,190	4.57
2003	1,831,170	12,396,541	6.77
2004	1,939,674	4,303,688	2.22
2005	2,744,622	5,386,596	1.96
2006	1,953,228	4,907,171	2.51
2007	2,945,304	4,634,052	1.57
2008	2,472,690	3,266,706	1.32
2009	1,169,466	1,914,527	1.64
2010	1,463,928	[a]	
2011	1,177,074	[a]	
2012	900,312	[a]	
2013	938,160	[a]	
2014	1,474,428	[a]	
2015	1,920,954	[a]	
2016	1,691,910	[a]	
2017	1,899,972	[a]	
1959–2017			
Average	1,405,321	4,039,636	3.19
No. of Years	59	51	51

[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 BEG (1998); changed to SEG in 2007
Inriver Goal:	None
Optimal Escapement Goal:	260,000 (5AAC 6.358)
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; 51 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 of last 10 years (2008–2017)

-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	3,938,655	8.83
2001	897,112	2,662,843	2.97
2002	349,155	2,083,211	5.97
2003	642,093	2,196,683	3.42
2004	543,872	1,836,096	3.38
2005	1,102,833	1,418,239	1.29
2006	548,410	1,237,549	2.26
2007	518,041	911,789	1.76
2008	492,546	2,169,246	4.40
2009	484,149	1,284,511	2.65
2010	468,696	[b]	
2011	428,191	[b]	
2012	432,438	[b]	
2013	894,148	[b]	
2014	618,477	[b]	
2015	796,684	[b]	
2016	680,513	[b]	
2017	2,852,306	[b]	
1959–2017			
Average	585,660	1,585,999	3.76
No. of Years	59	51	51

[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:	120,000–200,000 BEG (1997); changed to 120,000-270,000 BEG (2007); changed to SEG in 2010
Inriver Goal:	None
Optimal Escapement Goal:	None
Current Escapement Goal	120,000–270,000 SEG
Escapement Estimation:	Tower counts from 1959 to present; 47 years of complete return data available
Summary:	
Data Quality	Good (some 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	28,118	[a]	
2014	151,934	[a]	
2015	218,700	[a]	
2016	200,046	[a]	
2017	195,330	[a]	
1959–2017			
Average	174,671	560,491	3.77
No. of Years	59	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 BEG (1995); changed to SEG 2007
Inriver Goal:	None
Optimal Escapement Goal:	None
Current Escapement Goal:	500,000–1,400,000 SEG
Escapement Estimation:	Tower counts from 1959 to present; 51 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	8 of last 10 years (2008–2017)

-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	6,480,880	3.80
1980	3,335,284	8,062,937	2.42
1981	1,327,699	7,976,426	6.01
1982	1,185,551	2,359,985	1.99
1983	1,001,364	1,789,220	1.79
1984	1,270,318	5,529,834	4.35
1985	1,006,407	2,823,866	2.81
1986	1,015,582	7,142,617	7.03
1987	686,894	7,164,347	10.43
1988	654,412	5,544,646	8.47
1989	1,713,287	4,913,114	2.87

-continued-

Year	Escapement	Total return	Return per spawner
1990	749,478	3,858,559	5.15
1991	2,482,016	6,680,927	2.69
1992	2,194,927	3,149,041	1.43
1993	1,413,454	1,357,580	0.96
1994	1,095,068	1,586,318	1.45
1995	1,321,108	5,773,750	4.37
1996	692,167	1,353,867	1.96
1997	656,641	3,025,123	4.61
1998	924,853	1,247,104	1.35
1999	1,662,042	3,674,140	2.21
2000	638,420	4,355,261	6.82
2001	866,368	2,184,180	2.52
2002	905,584	4,599,316	5.08
2003	790,202	6,372,603	8.06
2004	815,104	4,531,213	5.56
2005	799,612	5,265,096	6.58
2006	1,003,158	3,402,149	3.39
2007	2,599,186	3,139,804	1.21
2008	596,332	3,162,448	5.30
2009	1,364,338	982,677	0.72
2010	830,886	[a]	
2011	1,029,853	[a]	
2012	670,578	[a]	
2013	898,110	[a]	
2014	640,158	[a]	
2015	1,564,638	[a]	
2016	1,635,270	[a]	
2017	1,186,446	[a]	
1959–2017 Average	942,441	3,047,792	4.20
No. of Years	59	51	51

[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; 51 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	6 of last 10 years (2008–2017)

-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

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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	7,238,890	5.57
2001	1,458,732	8,311,690	5.70
2002	1,283,682	8,408,970	6.55
2003	1,459,782	8,339,222	5.71
2004	1,543,392	8,064,892	5.23
2005	1,496,550	6,718,864	4.49
2006	4,008,102	8,034,958	2.00
2007	1,528,086	2,825,544	1.85
2008	1,724,676	3,220,111	1.87
2009	1,319,232	3,719,532	2.82
2010	1,804,344	[a]	
2011	1,098,006	[a]	
2012	764,211	[a]	
2013	1,166,508	[a]	
2014	2,764,614	[a]	
2015	1,941,474	[a]	
2016	1,309,707	[a]	
2017	4,274,224	[a]	
1959–2017			
Average	1,373,970	3,981,124	3.32
No. of Years	59	51	51

[a] Incomplete returns from brood year escapement.

APPENDIX F. RECENT ESCAPEMENT MEMOS AND RECORD COPIES PRESENTED TO THE 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.*

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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.

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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

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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

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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

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.

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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

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THE STATE of ALASKA
GOVERNOR BILL WALKER

Department of Fish and Game

DIVISIONS OF SPORT FISH & COMMERCIAL FISHERIES
333 Raspberry Road
Anchorage, AK 99518

MEMORANDUM

TO: Forrest R. Bowers, Acting Director
Division of Commercial Fisheries

Thomas Brookover, Director
Division of Sport Fish

DATE: October 3, 2018

THRU: Bert Lewis, Regional Supervisor BL
Division of Commercial Fisheries, Region II

Thomas Vania, Regional Supervisor TV
Division of Sport Fish, Region II

SUBJECT: Bristol Bay Escapement Goal Memo

FROM: Jack Erickson, Regional Research Coordinator JWE
Division of Commercial Fisheries, Region II

Timothy McKinley, Regional Research Coordinator TRM
Division of Sport Fish, Region II

The purpose of this memo is to report our progress reviewing and recommending escapement goals for the Bristol Bay Management Area (BBMA). The *Policy for Statewide Salmon Escapement Goals* (5 AAC 39.223) recognizes the establishment of salmon escapement goals as a joint responsibility of the Alaska Department of Fish and Game (department) and the Alaska Board of Fisheries (board) and describes the concepts, criteria, and procedures for establishing and modifying salmon escapement goals. Under the policy, the board recognizes and describes the department's responsibility for establishing and modifying biological escapement goals (BEG) and sustainable escapement goals (SEG).

Beginning in February 2018, an interdivisional salmon escapement goal committee, including staff from the divisions of Commercial Fisheries and Sport Fish, initially met to discuss salmon escapement goals in the BBMA. Escapement goals for this area have been set and evaluated at regular intervals since statehood and many of these stocks have long-term historical datasets. The review was based on the *Policy for the Management of Sustainable Salmon Fisheries* (5 AAC 39.222) and the *Policy for Statewide Salmon Escapement Goals* (5 AAC 39.223). Two important terms are:

> 5 AAC 39.222 (f)(3) *"Biological Escapement Goal* (BEG): the escapement that provides the greatest potential for maximum sustained yield (MSY);" and

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5 AAC 39.222 (f)(36) *"Sustainable Escapement Goal* (SEG): a level of escapement, indicated by an index or an escapement estimate, that is known to provide for sustained yield over a 5 to 10 year period, used in situations where a BEG cannot be estimated or managed for."

The committee determined the appropriate goal type (BEG or SEG) for each salmon stock with an existing goal and reviewed other monitored stocks without an existing goal. Using available data, we determined the most appropriate methods to develop each escapement goal.

Currently 15 escapement goals are evaluated in BBMA (Table 1). Due to the comprehensive previous analyses in Cross et al. (1997), Fair (2000), Fair et al. (2004), Baker et al. (2006 and 2009), Fair et al. (2012), and Erickson et al. (2015) this review committee only considered reanalyzing goals with recent (2015–2017) escapements that might result in a substantially different escapement goal from the last review, or those that should be eliminated or newly established.

Sockeye salmon

For this review, we updated the sockeye salmon genetic harvest allocations to better account for mixed-stock harvest in each district, and to more accurately represent the true production of the primary stocks (Alagnak, Egegik, Igushik, Kvichak, Naknek, Nushagak, Ugashik, and Wood rivers) in Bristol Bay. The committee reviewed the updated stock-recruit analyses for each of these stocks and recommends no changes for Egegik, Igushik, Kvichak, Naknek, Nushagak, Ugashik, and Wood River sockeye salmon escapement goals.

For this review, the expansion factor (aerial counts to tower counts) for Alagnak River sockeye salmon was updated to include recent aerial surveys and tower counts, and corrections made to the aerial survey data. The committee recommends that the lower-bound SEG of 320,000 Alagnak River sockeye salmon assessed using tower counts be changed to a lower-bound SEG of 210,000. The committee also recommends that the companion lower-bound SEG of 125,000 assessed using a single aerial survey be eliminated in deference to the tower-based lower-bound SEG. Allocative implications associated with a change in this escapement goal are found within the *Alagnak River Sockeye Salmon Special Harvest Area Management Plan* (5 AAC 06.373).

King salmon

For this review, the time series for Nushagak River king salmon was updated to include recent harvest and escapement, and corrections made to the harvest data. The updated stock-recruit analysis resulted in a greater estimate of spawner abundance that maximizes sustained yield (S_{msy}) but the new S_{msy} estimate is well within the current goal. In addition, results from sonic-tagging (2011–2014) and capture-recapture (2014–2016) studies show that substantial numbers of king salmon are not enumerated by the existing sonar assessment. The escapement goal committee recommended no change be made to the existing goal and that a stock-recruit model be developed prior to the next Bristol Bay regulatory-cycle which incorporates the corrected harvest data and uncertainty in king salmon abundance estimated by the sonar.

The committee recommends the king salmon goal for the Alagnak River stock be discontinued because there are indications that aerial surveys conducted since 2015 may not index escapement the same as, or similar to, previous surveys used to develop the escapement goal. This goal was

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recommended to be discontinued during the last board cycle, because funding was unavailable and uncertainty over the current survey observer efficiency in relation to historic aerial survey numbers.

Other recent indicators of relative king salmon abundance in the Alagnak River (e.g., Statewide Harvest Survey estimates of catch, guide logbook data, personal communication with anglers and guide businesses) are on par with years when historical survey index counts were greater than 3,000 fish. The exact reason(s) for these differences are unknown, in part because surveys have been conducted in a different manner (i.e., two observers per survey and multiple surveys per year since 2015 but one observer flying single aerial surveys historically). The department currently lacks the information needed to understand the relationship between current aerial survey data and the existing escapement goal, as well as reported sport fishing data. By discontinuing this goal, the *Alagnak River Sockeye Salmon Special Harvest Area Management Plan* (5 AAC 06.373 (c)) will need to be updated.

Pink, coho, and chum salmon

The committee concluded that updating the analyses for these stocks would not likely result in a substantially different escapement goals; therefore, the committee recommends no changes at this time.

In summary, this comprehensive review of the 15 existing salmon escapement goals in the BBMA resulted in recommendations to update 1 existing sockeye salmon escapement goal and discontinuing 2 escapement goals (one for sockeye salmon, one for king salmon). It is also recommended that a concerted effort be made by the department to develop a run reconstruction and stock-recruit analysis for Nushagak River king salmon that accounts for errors in harvest data used to develop the current escapement goal, and the uncertainty in proportion of king salmon counted by sonar that was identified by recent tagging and capture-recapture studies. Oral and written reports (Erickson et al. *In prep.*) concerning BBMA escapement goals and stock status will be presented to the board in December 2018. These reports will list current escapement goals for BBMA, detailed descriptions of the methods used to develop the goals, and annual escapements through 2018.

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Table 1. – Summary of escapement goals and recommendations for salmon stocks in Bristol Bay Management Area.

System	Escapement Goal	Enumeration Method	Goal Type	Initial Year	Recommendation
KING SALMON					
Nushagak River	55,000 – 120,000	sonar	SEG	2013	No change
Alagnak River	2,700	single aerial survey	lower-bound SEG	2007	discontinue
CHUM SALMON					
Nushagak River	200,000	sonar	lower-bound SEG	2013	No change
COHO SALMON					
Nushagak River	60,000 – 120,000	sonar	SEG	2013	No change
PINK SALMON					
Nushagak River (even years only)	165,000	sonar	lower-bound SEG	2013	No change
SOCKEYE SALMON					
Kvichak River	2,000,000 – 10,000,000	tower count	SEG	2010	No change
Alagnak River	320,000	tower count	lower-bound SEG	2007	correct & update to 210,000
Alagnak River	125,000	single aerial survey	lower-bound SEG	2015	discontinue
Naknek River	800,000 – 2,000,000	tower count	SEG	2015	No change
Egegik River	800,000 – 2,000,000	tower count	SEG	2015	No change
Ugashik River	500,000 – 1,400,000	tower count	SEG	2015	No change
Wood River	700,000 – 1,800,000	tower count	SEG	2015	No change
Igushik River	150,000 – 400,000	tower count	SEG	2015	No change
Nushagak River	370,000 – 900,000	sonar	SEG	2015	No change
	260,000 – 760,000	sonar	OEG	2012	NA
Togiak River	120,000 – 270,000	tower count	SEG	2007	No change

-continued-

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