Regional Information Report 3A21-02

2020 Kuskokwim River Chinook Salmon Run Reconstruction and 2021 Forecast

by

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Alaska Department of Fish and Game **Division of Commercial Fisheries**

Symbols and Abbreviations

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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

A maximum likelihood model was used to estimate the 2020 drainagewide run size and escapement of Kuskokwim River Chinook salmon (*Oncorhynchus tshawytscha*). The total run was estimated to be 124,486 fish (95% CI: 102,661–150,952) and escapement was estimated to be 88,285 fish (95% CI: 66,460–114,751). Model estimates were informed by direct observations of the 2020 escapement at 15 locations (3 weirs and 12 aerial surveys) and harvest, combined with historical observations of escapement (up to 6 weirs and 14 aerial surveys), harvest, test fishery, and mark–recapture data dating back to 1976. Model results are adequate to draw broad conclusions about the 2020 run and escapement. The 2020 total run of Chinook salmon was below the 1976–2019 average of 215,870 fish. The drainagewide sustainable escapement goal of 65,000–120,000 was met in 2020. The 2021 Kuskokwim River Chinook salmon forecast is for a range of 94,000–155,000 fish.

Key words: Chinook salmon *Oncorhynchus tshawytscha*, run reconstruction model, total run, total escapement, forecast, Kuskokwim River.

INTRODUCTION

This report describes methods used to estimate the drainagewide run size and escapement of Chinook salmon (*Oncorhynchus tshawytscha*) that returned to the Kuskokwim River in 2020. Because it is impossible to count all Chinook salmon that return to the Kuskokwim River, estimates of annual abundance and escapement were made using a maximum likelihood model. The model (Bue et al. 2012), with subsequent revisions (Liller et al. 2018), is an extension of the approach presented by Shotwell and Adkison (2004) and was specifically developed for use in data-limited situations. The model combines information about subsistence harvest, commercial catch and effort, sport harvest, test fishery harvest and catch per unit effort (CPUE) at Bethel, estimates of total inriver abundance, counts of salmon at 6 weirs, and peak aerial survey counts from 14 tributaries spread throughout the Kuskokwim River drainage (Figure 1). Each of these data sources provides an index of total abundance, and some data are more informative than others. The model provides an approach to combine and weight available information about Kuskokwim River Chinook salmon abundance to arrive at a scientifically defensible estimate of total run size and escapement. Estimates produced by the model represent the most likely run size given the observed data.

The run reconstruction model has become an important tool to guide the sustainable management of the Kuskokwim River Chinook salmon fishery. Model results from Bue et al. (2012) contributed to a spawner-recruit analysis used to establish a drainagewide escapement goal of 65,000–120,000 Kuskokwim River Chinook salmon (Hamazaki et al. 2012). The established escapement goal was reviewed in 2018, and it was determined that the existing goal range was appropriate for this stock (Liller and Savereide 2018). The run reconstruction model has been used annually since 2013 as a postseason tool to determine if the drainagewide escapement goal was achieved. Model results have also been used since 2012 to inform preseason management strategies to achieve escapement goals. Since 2014, a preseason forecast range has been developed based on the prior year's run size, as determined from the run reconstruction model.

The run reconstruction model has implications beyond the management of Kuskokwim River Chinook salmon fisheries. Since 2016, the Alaska Department of Fish and Game (ADF&G) has been required to provide the North Pacific Fishery Management Council (NPFMC) with a preliminary total run estimate of Kuskokwim River Chinook salmon abundance no later than October 1 of each year. The preliminary run abundance estimate is 1 component of a 3-system index (Upper Yukon, Unalakleet, and Kuskokwim Rivers) of Western Alaska Chinook salmon abundance used by NPFMC to guide Chinook salmon bycatch thresholds in the Bering Sea pollock trawl fishery. The preliminary 2020 3-system abundance estimate was provided to the NPFMC on September 18, 2020 (Appendix A), before final escapement and subsistence harvest estimates were available. The preliminary Kuskokwim River abundance estimate was based on model output from the run reconstruction model using preliminary escapement estimates and a prediction of total subsistence harvest. The final total run estimate was expected to change slightly from what was provided to NPFMC.

Given the significance of the run reconstruction model, it is important that the model is reviewed regularly and any changes are communicated in a timely and transparent manner. The model recently underwent a multi-year interagency peer review. The details of that review process and a description of the model changes that resulted from that review are documented in Liller et al. (2018) and Schindler et al. (2019). ADF&G adopted the revised model in 2018 (Smith 2019), and NPFMC also approved its use in the 3-system index[1]. There have been no changes to the run reconstruction model since that review.

OBJECTIVE

The project objective was to estimate the total run size and escapement of Kuskokwim River Chinook salmon in 2020.

METHODS

MODEL OVERVIEW

Drainagewide escapement (E_y) of Kuskokwim River Chinook salmon for year (y) is equal to the drainagewide run size (N_y) minus harvest (C_y),

$$E_y = N_y - C_y, \quad (1)$$

where C_y is the sum of harvest by subsistence, commercial, sport, and test fisheries. Each part of Equation 1 was known to different degrees. Total annual escapement was indexed by count data from weirs and aerial surveys of tributaries located throughout the lower, middle, and upper portions of the Kuskokwim River (Figure 1). Estimates of total abundance for scaling the model were derived from mark–recapture, escapement, and harvest data. Total abundance estimates were available for years 2003–2007 and 2014–2017 (Liller et al. 2018). Total annual harvests from commercial fish tickets and test fisheries were known to a high degree of confidence. Subsistence harvest was estimated from extensive postseason surveys, and the estimates were incorporated into the model without error (Shelden et al. 2016; Dave Koster, Research Analyst, Division of Subsistence, ADF&G, Anchorage; personal communication). Estimates of sport fish harvest were less precise, but the effect of a lower level of precision was assumed to be negligible because of the small annual sport harvest.

Total run and escapement of Kuskokwim River Chinook salmon were estimated using a maximum likelihood model (Appendix B) developed for data-limited situations, with subsequent revisions to the model configuration (summarized in Liller et al. 2018). The model simultaneously combined abundance data from multiple sources to estimate a time series of the most likely estimates of total annual run abundance. The methodology was divided into 3 components to simplify the description of the estimation process and was based on the type of data used in the model: (1)

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[1] NORTH PACIFIC FISHERY MANAGEMENT COUNCIL - File #: ID 18-064 (legistar.com)

escapement, (2) commercial catch and effort, and (3) direct estimates of total run size for model scaling.

Escapement Counts

Assuming annual escapement of Chinook salmon returning to each tributary and observed by a weir or aerial survey is a constant fraction of drainagewide escapement (E_y), the expected escapement ($\hat{e}$) in year (y) to tributary (i) observed by method (j: weir or aerial) is:

$$\hat{e}_{ijy}=E_y/k_{ij}, \quad (2)$$

where k_{ij} is a scaling parameter estimated by the model. The assumption of constant proportionality is tenuous and not supported by the tributary escapement data, but the revised model performance has been shown to be robust to violations of this assumption (Schindler et al. 2018).

Commercial Catch and Effort

Assuming commercial CPUE each week is proportional to the drainagewide run migrating during that week, the expected commercial catch CPUE ($\widehat{CPUE}_{wky}$) in week (w) with net configuration (k) is:

$$\widehat{CPUE}_{wky}=c_{wky}/f_{wky} = q_k\left(p_{wy}N_y\right), \quad (3)$$

where $\widehat{CPUE}_{wky}$ is the expected commercial catch CPUE at week (w) of net configuration (k), c_{wky} is the commercial catch at week (w) of net configuration (k), f_{wky} is the commercial efforts at week (w) of net configuration (k), p_{wy} is the proportion of Chinook salmon available at week (w) observed at Bethel test fishery, and q_k is the catchability coefficient of net configurations (k) (i.e., unrestricted, restricted).

Summing for all weeks and adjusting by the proportion of fish migrating through the harvest area during the weeks when fisheries occurred, the expected annual cumulative CPUE ($\widehat{CPUE}_{ky}$) is:

$$\widehat{CPUE}_{ky}=\frac{\sum_w(c_{wky}/f_{wky})}{\sum_w p_{wy}} = q_kN_y. \quad (4)$$

The proportion of Chinook salmon available for harvest each week and observed at Bethel test fishery included weeks 3–10. Data from weeks 8–10 were combined. Commercial catch and effort by week and net configuration included weeks 3–9. Data from weeks 8 and 9 were combined. Run timing from 1976 to 1983 was estimated using the average run timing from 1984 to 2020.

Model Scaling

Direct estimates of total run size ($\widehat{N}_y$) from 2003–2007 and 2014–2017 were derived using a combination of mark–recapture data, escapement estimates, extrapolation of escapement values to unmonitored areas, and harvests. Those estimates of the total run and associated uncertainties were used to scale the run reconstruction model. Measurement error associated with the model scalars was represented using the estimates of variance presented in Liller et al. (2018).

Likelihood Model

Assuming all observations follow lognormal distributions, negative log-likelihoods with omissions of constants were constructed as:

$$
L(\theta|data) = \begin{array}{l}
\text{Escapement Counts} \\
+\sum_{y}\sum_{i}\sum_{j}\left(ln(\sigma_j) + 0.5\left(\frac{ln(\hat{e}_{ijy}) - ln(e_{ijy})}{\sigma_j}\right)^2\right) \\
\text{Adjusted Commercial CPUE} \\
+\sum_{y}\sum_{k}\left(ln(\sigma_k) + 0.5\left(\frac{ln(\widehat{CPUE}_{ky}) - ln(CPUE_{ky})}{\sigma_k}\right)^2\right) \\
\text{Drainagewide Run} \\
+\sum_{y}\left(0.5\left(\frac{ln(\hat{N}_y) - ln(N_y)}{\sigma_y}\right)^2\right),
\end{array} \quad (5)
$$

where $\sigma_j^2 = ln(CV_j^2{+}1)$, $\sigma_k^2 = ln(CV_k^2{+}1)$, and $\sigma_y^2 = ln(CV_y^2{+}1)$, CV_j and CV_k were estimated from the model, and CV_y was the observed CV of drainagewide run sizes of 2003–2007 and 2014–2017.

The model was written in AD Model Builder and run using the computing environment R (Appendix B; Fournier et al. 2012; R Core Team 2019).

MODEL INPUTS

Large amounts of data were available to inform the model and estimate the total run and escapement in 2020. Model estimates in 2020 were informed by independent scalers using total run estimates from 2003–2007 and 2014–2017, which corresponded to years of relatively high and low run abundance (Appendix C). The model was also informed by commercial, subsistence, sport, and test fishery harvest and escapement at 6 weirs and 14 aerial surveys from 1979 to 2020 (Appendix C). Finally, the model was informed by the proportion of total annual Chinook salmon run in District W-1, by week, as estimated using data collected from the Bethel test fishery from 1984 to 2020 and harvest and effort, by week, for Kuskokwim River District W-1 from 1976 to 2020 (Appendix C). All model inputs were the best available data at the time of reporting and have been reviewed and finalized since the release of the preliminary run reconstruction estimate to NPFMC in September 2020.

The subsistence harvest estimate used to produce the preliminary run reconstruction estimate in September 2020 has changed. The preliminary run estimate relied on a "best guess" of 28,315 Chinook salmon harvested for subsistence purposes. Since that time, postseason subsistence harvest surveys have been completed, and the harvest was estimated to be 35,846 (95% CI 33,276–38,416; Dave Koster, Division of Subsistence, ADF&G; personal communication). The revised subsistence harvest estimate was used in this final run reconstruction analysis.

RESULTS AND DISCUSSION

The run reconstruction model was informed by 6 weirs and 14 aerial survey index locations (Table 1). In 2020, 3 of 6 weirs operated and 12 of 14 aerial surveys were successfully flown. Weirs located on George, Kogrukluk, and Takotna Rivers did not operate. Kwethluk River weir did not operate due to COVID-19 disruptions. Weirs located on Tuluksak and Tatlawiksuk Rivers have not operated in recent years due to funding limitations. Peak spawning aerial survey counts were flown between July 26 and July 29, 2020. Aerial surveys were attempted at all locations except the Tuluksak River. The Gagarahya River aerial survey was not used because the survey occurred before peak spawning. The Kwethluk River aerial survey was prioritized in 2020 because the weir did not operate. Of the 12 aerial surveys, 9 (75%) had good ratings, and 3 (25%) had fair ratings.

Harvest data came from subsistence and test fishery catches. The preliminary subsistence harvest of 35,846 (95% CI 33,276–38,416) Chinook salmon in 2020 is unlikely to change substantially and was below the amounts reasonably necessary for subsistence uses (ANS: 67,200–109,800) as defined by the Alaska Board of Fisheries (5 AAC 01.2086). A total of 355 Chinook salmon were caught in the Bethel test fishery. No commercial or sport fish harvest of Kuskokwim River Chinook salmon occurred during the 2020 season.

Escapement estimates and observations during 2020 indicated that the Chinook salmon escapement throughout the Kuskokwim River was generally less than prior years. In 2020, all projects reported lower escapements than the 2015–2019 average, and 13 out of 15 escapement projects reported lower escapements than the 2010–2019 averages. Escapement at 14 projects (93%) was lower than the long-term 1976–2019 averages (Table 1).

There were 9 tributaries with established escapement goals in 2020 (Liller and Savereide 2018). Of those, the Kwethluk River weir and Gagarayah River aerial survey goals were not assessed. Of the 7 goals assessed, 5 were within the goal range (weirs at George and Kogrukluk Rivers and aerial surveys at Aniak, Cheeneetnuk, and Salmon (Pitka Fork) Rivers), and 2 were below the lower bound of the goal range (aerial surveys at Kisaralik and Salmon (Aniak) Rivers).

MODEL RESULTS

The 2020 Kuskokwim River Chinook salmon drainagewide run was an estimated 124,486 (95% CI: 102,661–150,952) fish (Table 2; Figure 2). Based on the 2020 model run, the total run in 2020 was 42% less than the 1976–2019 average of 215,870 Chinook salmon. CV for the 2020 total run was estimated to be 10% and identical to the 1976–2019 average of 10% (range: 5–25%; Figure 3). The root mean square error was smaller for weirs compared to aerial surveys, which indicated the model fit weir data better than aerial survey data (Figure 4).

The 2020 Kuskokwim River Chinook salmon drainagewide escapement was an estimated 88,285 (95% CI: 66,460–114,751) fish (Table 2). Based on the 2020 model run, the total escapement in 2020 was 33% less than the 1976–2019 average of 131,509 Chinook salmon. The total escapement in 2020 was greater than 14 of 44 (32%) prior years. Acknowledging that uncertainty in the drainagewide escapement was relatively high, the 95% confidence range of 66,460–114,751 fish provided evidence that the drainagewide escapement goal of 65,000–120,000 fish was met (Table 2; Figure 2).

The run reconstruction model produces updated total run and escapement estimates for all years since 1976 each time the model is updated with new information. Results from prior year model runs represented the best available estimates based on information available at that time. The 2020 model run represents the most informed historical time series of total run and escapement and supersedes previous estimates. Estimates of total annual abundance from 1976 to 2019, generated by the 2020 model run, were compared against the estimates reported by Larson 2020 (Table 2). The difference between total annual run and escapement estimates did not change by more than 0.7% and 1.0%, respectively, across all years 1976–2019. The absolute difference between pairs of annual estimates ranged between 3 and 2,625 fish (average = 293). The long-term (1976–2019) averages for both total run and escapement differed by 81 fish between the 2020 and 2019 model runs.

Uncertainty in 2020 Model Estimates

There was an average level of uncertainty associated with the 2020 model run (Figure 3). Uncertainty about any individual year model estimate is generally related to the number of index projects that operated in that year and the similarity in the information about each project's total run. The number of index projects operated in 2020 (15 total projects) was at the 75th percentile (median 11; range: 2–20) over the 44 years (1976–2019) of available data, which would suggest a large amount of information to update the model and a relatively low level of uncertainty. However, each project provided a different picture of the total run. The model is specifically designed to accommodate "conflicting" data from a range of index projects; however, greater differences among projects result in greater uncertainty about the actual size of the total run and escapement. To illustrate this, the entire drainagewide escapement was estimated using data from 1 escapement project at a time (Figure 5). In 2020, estimates of drainagewide Chinook salmon escapements derived from individual weir projects were 78,000–117,000 fish, whereas estimates derived from individual aerial surveys were 54,000–170,000 fish (Table 3; Figure 5).

The sensitivity of the 2020 model results to parameter starting values was evaluated. Run estimates were compared across a range of 100 starting values for all model parameters independently (Table 4). The maximum observed difference between annual run estimates was less than 3 fish. Results for all parameter starting values confirmed the 2020 model run was not sensitive to starting values and the total run estimates presented represent the best fit model.

The sensitivity of model results to 2020 escapement data was explored (Figure 6). Specifically, the model was run using only weir data, only aerial survey data, with the removal of a single escapement project at a time, and with headwaters projects removed (i.e., Takotna River weir, Salmon (Pitka) Fork aerial, Upper Pitka Fork aerial, and Bear Creek aerial). The model was run with headwaters projects removed because early season management actions to close or heavily restrict Chinook salmon harvest during the early portion of the run (commonly referred to as the "front-end closure") have been implemented annually since 2014 (codified in regulation in 2016 5 AAC 07.365 *Kuskokwim River Salmon Management Plan*). These annual front-end-closures have resulted in disproportionately large escapements to the headwaters, compared to other areas in the drainage, and concern that the model may be overestimating total escapement when headwaters escapement data are included. All point estimates fell within the 95% confidence interval of the base model. Confidence intervals overlapped in all scenarios. Estimates of the total run were similar when the model was informed using only weir escapement data or only aerial escapement data (Figure 6). In aggregate, weir data suggested a total run of about 128,000 fish, and aerial data suggested a total run of about 122,000 fish. When headwaters data (1 weir; 3 aerial surveys) were removed from the model, the total run estimate of about 113,000 fish was less than the estimate produced using all available data. These comparisons are not meant to lend more or less credibility to specific escapement data sources but rather show the importance of having a comprehensive assessment program to inform the run reconstruction model.

2020 Run Reconstruction Model Conclusions

- The total run of Kuskokwim River Chinook salmon was estimated to be 124,486 (95% CI: 102,661–150,952) fish.

- Total run abundance was below the 1976–2019 average of 215,870 fish and below the range of run sizes necessary to meet at least the lower bound of the drainagewide escapement goal (65,000–120,000) and support at least the lower bound of ANS (67,200–109,800) as defined by the Alaska Board of Fisheries (5 AAC 01.2086). For example, a run of at least 132,200 fish would be needed to meet the lower bounds of the drainagewide escapement goal and ANS.
- Total escapement of Kuskokwim River Chinook salmon was estimated to be 88,285 (95% CI: 66,460–114,751) fish, and the drainagewide sustainable escapement goal of 65,000–120,000 was met.

2021 Chinook Salmon Run Forecast

The 2021 Kuskokwim River Chinook salmon forecast is for a range of 94,000–155,000 fish. The forecast range is equal to ±25% of the 2020 total run, as presented in this report. Uncertainty in the forecast (i.e., ±25%) is based on the 2014–2020 (7-year) average percent error between forecasted and actual run estimates. Interestingly, when using data from 1976 to 2020, the average percent error between forecasted and actual run estimates (24%) is nearly identical to the 7-year average percent error. Despite several years of similar run sizes since 2014, the 2019 run was well above forecast, and the 2020 run was well below forecast, both of which contributed to increased uncertainty in the 2021 forecast.

The forecast range is not based on probability and provides no insight into the most probable run size within the forecasted range. The value of the forecast is in preseason planning. For example, managers and stakeholders may choose to put equal effort into planning for all run size scenarios within the forecast range or focus their planning on a subset of the forecast. This forecast can be used alongside probability-based forecasts to identify run sizes with the highest probability to guide preseason planning.

Probability-based forecast methods like the P-star model[2] developed by Staton and Catalano (2019) have been explored for Kuskokwim River Chinook salmon. That model uses the same prior year method for defining the mean of the forecast range but uses the entire time series to describe forecast uncertainty. That model assumes uncertainty around the forecast expectation is lognormally distributed. A bias-corrected lognormal distribution is used to ensure the mean of the distribution is the same as the previous year's run size. Forecast uncertainty is quantified by calculating the errors the 'previous-year method' would have made, as though they were lognormal random variables, and calculating their standard deviation. The method described by Staton and Catalano (2019) produces forecast ranges based on any statistical confidence interval that is desired and can be used to describe the probability of different run sizes occurring. Probability-based forecasts necessitate proper interpretation and context to be useful for focusing preseason management planning discussions.

Probability-based methods like the P-star model can provide context to understand better the 2021 forecast produced by ADF&G and can be used to make explicit predictions about the 2021 run before the availability of inseason assessment data. The ADF&G 2021 forecast (based on the 7-year average percent error) represents approximately the central 60% of probable run size predictions identified through the P-star model. There is a 22% chance the 2021 run size will return

[2] https://bstaton.shinyapps.io/BayesTool

smaller than 94,000 and a 19% chance the run will return larger than 155,000. The P-star model indicated that there is a 98% chance the 2021 run size will be less than 213,000, which is a nearly average run size (1976–2019 average run size is 215,870). Stated more simply, there is a high probability that the 2021 run will be smaller than average. However, the P-star model provides considerable evidence that the 2021 run size will be large enough to meet the drainagewide escapement goal and allow some harvest. There is a 98% chance the 2021 run size will be equal to or exceed 66,000, which is a run size just larger than the lower bound of the escapement goal. There is a 50% chance (1 in 2) that the run will return larger than 119,000, which is a run size slightly smaller than the upper bound (120,000) of the drainagewide escapement goal[3] (Table 5).

Preseason expectations of Chinook salmon harvestable surplus in 2021 are highly uncertain. Simple subtraction of the drainagewide escapement goal (65,000–120,000) from the ADF&G forecast (94,000–155,000) would suggest a harvest outlook anywhere between 0–90,000 fish. However, run size probabilities from the P-star model provide considerable evidence that large run sizes suitable for supporting large harvests have a low chance of occurring in 2021. Actual harvest opportunities will be determined inseason based on run size assessments and expectations of achieving the drainagewide escapement goal range (65,000–120,000) and tributary escapement goals.

Successive years of achieving the drainagewide escapement goal provide some support for the notion that the 2021 Chinook salmon run will be large enough to meet escapement needs and provide for some harvest. The dominant brood years contributing to the 2021 run will be 2015–2017. These brood years will return fish that are age-4 (2017 brood), age-5 (2016 brood), and age-6 (2015 brood). The actual number of each age class that will return in 2021 is not known with certainty, but the drainagewide escapement goal was achieved in each of the contributing brood years. Drainagewide escapement was estimated to be 109,073 fish in 2015, 99,225 fish in 2016, and 114,860 fish in 2017 (Table 6). The drainagewide escapement goal on the Kuskokwim River was designed to maximize the probability that future run sizes are large enough to meet escapement and harvest needs.

Stock productivity trends should be considered when using this forecast to plan preseason management of the 2021 Chinook salmon run. Kuskokwim River Chinook salmon productivity, measured as recruits per spawner, has fluctuated through time (Figure 7). Relatively high productivity occurred during brood years 1982–1991 and again during brood years 1999–2001. Brood years 2004–2009 experienced low productivity (<1 recruit per spawner). Since that time, productivity has increased, and the 2011–2013 brood years have produced on average 3 recruits per spawner (Table 6; Figure 7).

FUTURE MODEL CONSIDERATIONS

Improvements to the Chinook salmon run reconstruction model are being explored. The model may benefit from time-varying scaling parameters that accommodate changes in management or spatial shifts in production that could affect the proportion of the total escapement observed at individual assessment locations. For example, headwaters stocks tend to have earlier run timing than middle river stocks (Clark and Smith 2019). Managers have heavily restricted fishing during the early portion of the Chinook salmon run since 2014, which has led to lower exploitation and higher escapements for headwater stocks than were observed before 2014. As a result, the observed

[3] Percentages presented in this text are rounded.

escapement at headwater assessment projects has tended to be higher than what the run reconstruction model predicted. This may be addressed by incorporating a time-variant scaler into the model. Also, the Kuskokwim River sonar is a new assessment tool that has been fully operational since 2018. This project provides valuable salmon passage data at a site approximately 20 km upriver from Bethel. The appropriateness of using sonar data as an additional model input will continue to be explored. ADF&G will engage and report out to stakeholders and ensure an appropriate level of review if any changes to the current model are adopted.

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TABLES AND FIGURES

Table 1.–Historical and recent year observations of Kuskokwim River Chinook salmon abundance used to inform the run reconstruction model.

Method	Location	Number of years of data (1976–2020)	Historical average (1976–2019)	10 yr average (2010–2019)	5 yr average (2015–2019)	2019	2020
Weir	Kwethluk	15	9,432	5,473	7,958	8,505	–
	Tuluksak	21	985	479	756	–	–
	George	22	3,557	2,506	3,068	3,828	2,418
	Kogrukluk	34	9,825	6,267	7,955	10,301	5,645
	Tatlawiksuk	18	1,692	1,525	2,323	–	–
	Takotna	21	416	258	359	554	357
Aerial survey	Kwethluk[a]	12	2,183	–	–	–	721
	Kisaralik	27	1,110	628	745	1,063	350
	Tuluksak	11	421	–	–	–	–
	Salmon (Aniak)	34	799	426	656	950	269
	Kipchuk	28	1,029	773	1,034	1,344	723
	Aniak	25	2,630	1,858	1,798	3,160	1,264
	Holokuk	19	346	178	240	719	99
	Oskawalik	24	290	162	128	638	169
	Holitna	24	1,510	853	970	1,377	854
	Cheeneetnuk	27	699	468	697	1,345	419
	Gagaryah	27	486	284	447	760	–
	Pitka	15	247	237	345	330	160
	Bear	21	259	350	541	542	321
	Salmon (Pitka)	34	1,062	1,150	1,520	1,918	1,150
Harvest	Subsistence	45	65,032	33,395	24,681	37,941	35,846
	Commercial	45	18,291	432	2	0	0
	Sport	44	430	93	0	0	0
	Test Fishery	45	618	396	463	563	355

Note: Not all projects operated in all years.

[a] Aerial survey was flown for the first time since 2013 because the Kwethluk River weir did not operate in 2020.

Table 2.–Annual drainagewide run and escapement of Kuskokwim River Chinook salmon from the 2020 run reconstruction model.

Year	2020 Model run Total run estimate	Lower 95% CI	Upper 95% CI	Previously published total run estimate[a]	2020 Model run Total esc. estimate	Lower 95% CI	Upper 95% CI	Previously published total esc. estimate[a]
1976	206,588	159,441	267,676	206,672	116,041	68,894	177,129	116,125
1977	326,025	232,442	457,286	324,860	232,318	138,735	363,579	231,153
1978	237,858	189,352	298,790	237,518	154,386	105,880	215,318	154,046
1979	236,265	169,517	329,297	236,554	139,963	73,215	232,995	140,252
1980	364,915	225,931	589,397	362,290	267,947	128,963	492,429	265,322
1981	310,624	225,191	428,470	311,309	200,225	114,792	318,071	200,910
1982	143,849	126,174	164,000	143,957	36,848	19,173	56,999	36,956
1983	148,494	122,332	180,251	148,051	66,349	40,187	98,106	65,906
1984	175,454	136,872	224,911	175,501	86,278	47,696	135,735	86,325
1985	145,166	117,769	178,936	145,163	63,239	35,842	97,009	63,236
1986	124,134	93,927	164,057	123,817	53,522	23,315	93,445	53,205
1987	182,733	146,792	227,474	182,967	78,490	42,549	123,231	78,724
1988	207,057	179,116	239,357	206,619	79,294	51,353	111,594	78,856
1989	215,249	178,117	260,122	214,473	89,096	51,964	133,969	88,320
1990	268,125	230,109	312,422	267,793	103,939	65,923	148,236	103,607
1991	215,904	181,949	256,196	215,518	102,756	68,801	143,048	102,370
1992	260,912	225,324	302,122	260,878	129,812	94,224	171,022	129,778
1993	272,597	223,762	332,090	272,385	172,930	124,095	232,423	172,718
1994	397,965	305,228	518,879	398,188	275,861	183,124	396,775	276,084
1995	371,818	300,813	459,583	371,220	237,089	166,084	324,854	236,491
1996	323,418	251,055	416,637	323,884	217,843	145,480	311,062	218,309
1997	262,514	216,939	317,664	262,498	171,180	125,605	226,330	171,164
1998	254,394	194,704	332,383	254,674	154,422	94,732	232,411	154,702
1999	160,317	129,544	198,400	160,332	81,724	50,951	119,807	81,739
2000	122,173	107,546	138,789	122,228	53,964	39,337	70,580	54,019
2001	192,403	163,385	226,576	192,625	113,763	84,745	147,936	113,985
2002	238,306	204,285	277,992	238,337	156,458	122,437	196,144	156,489
2003	231,941	207,652	259,072	231,825	163,236	138,947	190,367	163,120
2004	365,280	322,647	413,547	365,368	264,639	222,006	312,906	264,727
2005	327,123	294,662	363,159	326,910	235,347	202,886	271,383	235,134
2006	323,790	287,494	364,668	324,338	229,405	193,109	270,283	229,953
2007	248,548	225,006	274,553	248,762	151,688	128,146	177,693	151,902
2008	214,918	189,339	243,951	214,991	116,013	90,434	145,046	116,086
2009	194,763	169,448	223,861	195,102	106,829	81,514	135,927	107,168

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Table 2.–Page 2 of 2.

Year	2020 Model run Total run estimate	Lower 95% CI	Upper 95% CI	Previously published total run estimate[a]	2020 Model run Total esc. estimate	Lower 95% CI	Upper 95% CI	Previously published total esc. estimate[a]
2010	115,951	104,941	128,115	116,048	45,287	34,277	57,451	45,384
2011	114,453	102,531	127,761	114,599	50,424	38,502	63,732	50,570
2012	74,992	61,890	90,868	75,010	51,500	38,398	67,376	51,518
2013	88,496	79,048	99,072	88,515	41,008	31,560	51,584	41,027
2014	82,216	70,868	95,380	82,096	70,450	59,102	83,614	70,330
2015	125,677	110,832	142,510	125,578	109,073	94,228	125,906	108,974
2016	130,443	113,437	149,998	130,475	99,225	82,219	118,780	99,257
2017	131,530	112,600	153,642	131,677	114,860	95,930	136,972	115,007
2018	136,076	107,945	171,539	136,135	113,345	85,214	148,808	113,404
2019	226,835	183,061	281,077	226,987	188,331	144,557	242,573	188,483
2020	124,486	102,661	150,952		88,285	66,460	114,751	
Average (1976–2019)	215,870			215,789	131,509			131,428

Note: The run reconstruction model produces estimates for all years every time the model is updated with new information. Previously published estimates of total run and escapement associated with prior year model runs are shown for reference.

[a] Prior year model run from Larson (2020). Based on the prior year model run, the 1976–2019 average total run and escapement was larger than the 2019 model run average by 81 fish (0.03%) and 81 fish (0.05%), respectively.

Table 3.–Parameter estimates derived from the 2020 run reconstruction model.

	Parameter estimate (*k*)	95% Bound Lower	95% Bound Upper	Observed escapement	Total escapement[a]
Weir projects (*k*)					
Kwethluk weir	2.74	2.54	2.94		
Tuluksak weir	5.04	4.87	5.22		
George weir	3.55	3.37	3.72	2,418	83,999
Kogrukluk weir	2.62	2.46	2.78	5,645	77,543
Tatlawiksuk weir	4.19	4.00	4.38		
Takotna weir	5.79	5.61	5.97	357	117,216
Aerial survey (*k*)					
Kwethluk River	4.44	4.10	4.78	721	61,129
Kisaralik River	5.16	4.92	5.40	350	61,002
Tuluksak River	6.12	5.76	6.48		
Salmon (Aniak River)	5.36	5.14	5.58	269	57,168
Kipchuk River	5.00	4.77	5.24	723	107,761
Aniak River	4.05	3.80	4.30	1,264	72,749
Holokuk River	6.31	6.04	6.58	99	54,302
Oskawalik River	6.48	6.23	6.73	169	110,613
Holitna River	4.54	4.28	4.79	854	79,713
Cheeneetnuk River	5.40	5.16	5.64	419	93,054
Gagaryah River	5.84	5.60	6.07		
Pitka Fork	6.40	6.10	6.71	160	96,614
Bear River	6.27	6.01	6.53	321	169,784
Salmon(Pitka Fork)	4.80	4.58	5.02	1,150	139,627
Catchability (*q*)					
Unrestricted	-9.51	-9.79	-9.22		
Restricted	-10.04	-10.21	-9.88		

Note: Parameter values (*k*) are presented as natural logarithms (ln).

[a] Expected drainagewide total escapement = observed escapement*EXP(*k*).

Table 4.–Starting values used for the 2020 run reconstruction model sensitivity analysis and associated results.

Parameter	Starting values range	Average difference[a]	Max difference[b]
Total run (N_y)	100,000–400,000	0.003	0.013
Weir escapement scaling (k_{ij})	0.01–10	0.043	0.200
Aerial escapement scaling (k_{ij})	0.01–10	0.003	0.017
Catchability (q_k)	-20–1	0.015	0.096
Weir coefficient of variation[c]	-20–20	0.584	2.974
Aerial coefficient of variation[c]	-20–20	0.584	2.974
Catchability coefficient of variation[c]	-20–20	0.584	2.974

[a] Average difference in numbers of fish among all 1976–2020 total run estimates across a range of 100 different starting values for each parameter.

[b] Maximum difference in numbers of fish among all 1976–2020 total run estimates across a range of 100 different starting values for each parameter.

[c] Weir, aerial, and catchability coefficient of variation starting values were evaluated simultaneously.

Table 5.–Kuskokwim River Chinook salmon forecast produced using the P-star model, 2021.

Run size	Percent chance of being below run size	Percent chance of being above run size
66,000	2.5%	97.5%
81,000	10.0%	90.0%
97,000	25.0%	75.0%
119,000	50.0%	50.0%
145,000	75.0%	25.0%
174,000	90.0%	10.0%
213,000	97.5%	2.5%

Note: The model assumes the probability of outcomes between any 2 intervals is not uniform, that is, values closer to the mean (124,000 fish) have higher probabilities of being the correct run size than values farther from the mean. Statistical methodology is described in Staton and Catalano (2019) and the P-star model can be accessed athttps://bstaton.shinyapps.io/BayesTool. Model code can be accessed at https://github.com/bstaton1/kusko-bayes-tool.

Table 6.–Brood table for Kuskokwim River Chinook salmon.

Brood year	Escapement	Return by age class (0.2)	(1.1)	(0.3)	(1.2)	(2.1)	(0.4)	(1.3)	(2.2)	(1.4)	(2.3)	(1.5)	(2.4)	(1.6)	(2.5)	Return	R/S
1976	116,041	0	64	6	65,831	6	0	105,707	34	82,456	85	6,097	260	91	0	260,637	2.25
1977	232,318	0	66	6	23,724	6	0	44,268	32	77,385	70	7,484	515	67	0	153,623	0.66
1978	154,386	0	668	5	11,444	5	0	39,427	26	61,319	498	4,833	52	5	0	118,283	0.77
1979	139,963	0	209	4	24,443	4	32	76,921	159	61,065	64	6,428	60	6	0	169,396	1.21
1980	267,947	0	693	5	28,122	5	0	51,888	176	46,231	74	3,478	80	7	0	130,759	0.49
1981	200,225	0	372	4	27,015	4	0	59,225	28	83,003	99	12,064	85	7	0	181,906	0.91
1982	36,848	0	48	5	11,309	5	0	53,005	37	69,163	104	6,585	1,062	10	0	141,331	3.84
1983	66,349	0	698	6	42,957	6	0	95,876	39	103,354	733	5,714	130	33	302	249,849	3.77
1984	86,278	0	74	7	29,688	7	0	67,186	1,579	72,724	161	5,273	841	8	0	177,547	2.06
1985	63,239	0	78	7	34,482	7	0	130,325	60	107,609	1,274	5,044	219	8	90	279,206	4.42
1986	53,522	0	90	10	56,129	10	0	72,278	1,925	91,564	235	10,280	716	10	0	233,247	4.36
1987	78,490	0	2,927	7	26,214	7	0	87,114	620	99,500	778	6,098	1,634	9	0	224,908	2.87
1988	79,294	76	82	8	69,654	8	0	83,070	210	130,390	1,977	4,119	359	16	0	289,968	3.66
1989	89,096	0	6,190	8	77,457	8	179	211,665	1,418	194,434	388	35,995	116	7	0	527,866	5.92
1990	103,939	0	419	10	42,985	10	0	107,868	56	113,620	716	3,142	95	7	0	268,928	2.59
1991	102,756	90	736	9	64,630	9	0	138,825	359	124,043	117	5,108	97	7	0	334,031	3.25
1992	129,812	0	144	9	33,527	9	0	64,250	44	86,455	120	3,103	87	6	0	187,755	1.45
1993	172,930	0	130	7	70,582	7	0	125,990	45	95,210	107	3,958	81	0	0	296,118	1.71
1994	275,861	0	88	7	35,672	7	0	47,842	166	55,377	99	7,729	81	0	0	147,069	0.53
1995	237,089	0	284	7	13,536	7	0	47,300	37	101,055	0	8,138	0	0	0	170,364	0.72
1996	217,843	0	230	6	15,182	6	0	63,614	0	94,760	0	9,738	0	0	0	183,536	0.84
1997	171,180	0	100	0	19,707	0	0	84,856	61	75,922	0	4,627	0	0	0	185,273	1.08
1998	154,422	0	0	0	50,205	0	0	102,314	0	106,568	0	4,411	172	0	0	263,670	1.71
1999	81,724	0	204	0	43,423	0	0	111,304	427	110,191	549	14,790	91	0	0	280,979	3.44
2000	53,964	0	381	0	141,251	0	0	152,665	10	126,127	182	5,209	1,100	0	0	426,926	7.91
2001	113,763	0	1,207	0	58,804	0	0	98,019	91	90,373	470	4,767	180	0	0	253,910	2.23

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Table 6.–Page 2 of 2.

Brood		Return by age class															
year	Escapement	(0.2)	(1.1)	(0.3)	(1.2)	(2.1)	(0.4)	(1.3)	(2.2)	(1.4)	(2.3)	(1.5)	(2.4)	(1.6)	(2.5)	Return	R/S
2002	156,458	0	485	0	83,284	0	0	81,558	0	61,495	1,254	2,163	312	0	0	230,552	1.47
2003	163,236	0	1,084	0	69,495	0	0	104,910	66	83,946	274	3,208	41	64	0	263,086	1.61
2004	264,639	0	194	0	41,762	0	0	72,029	771	40,063	0	1,647	53	0	0	156,520	0.59
2005	235,347	0	448	0	35,188	0	0	49,001	79	37,315	272	872	1	0	0	123,177	0.52
2006	229,405	0	81	68	23,254	68	0	45,912	106	23,113	450	830	95	0	0	93,976	0.41
2007	151,688	0	202	0	28,784	0	0	40,882	0	47,094	236	815	0	0	0	118,013	0.78
2008	116,013	0	262	0	9,622	0	0	27,057	75	30,131	353	445	1	0	0	67,946	0.59
2009	106,829	45	0	0	12,857	75	0	32,892	483	24,041	360	5	1	0	77	70,836	0.66
2010	45,287	0	95	0	14,526	0	122	44,246	766	16,890	358	17	99	0	0	77,119	1.70
2011	50,424	0	2,862	0	54,791	2	0	74,539	233	28,650	205	112	0	0	0	161,393	3.20
2012	51,500	65	804	0	36,502	0	0	59,896	165	22,403	53	77	470	0	0	120,434	2.34
2013	41,008	0	1,914	0	41,285	0	124	59,358	124	30,224	1,635	862	111	0	0	135,638	3.31
2014	70,450	0	1,056	0	50,665	0	234	74,049	2,313	27,814	4	0	0	0	0	156,135	–
2015	109,073	0	3,195	239	105,210	88	0	51,803	46	0	0	0	0	0	0	160,582	–
2016	99,225	30	12,444	0	42,244	0	0	0	0	0	0	0	0	0	0	54,718	–
2017	114,860	0	1,211	0	0	0	0	0	0	0	0	0	0	0	0	1,211	–
2018	113,345	0	0	0	0	0	0	0	0	0	0	0	0	0	0	–	–
2019	188,331	0	0	0	0	0	0	0	0	0	0	0	0	0	0	–	–
2020	88,285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	–	–

Note: The number of recruits returning from brood year escapement are shown as R/S. Brood years 2014–2020 are incomplete.

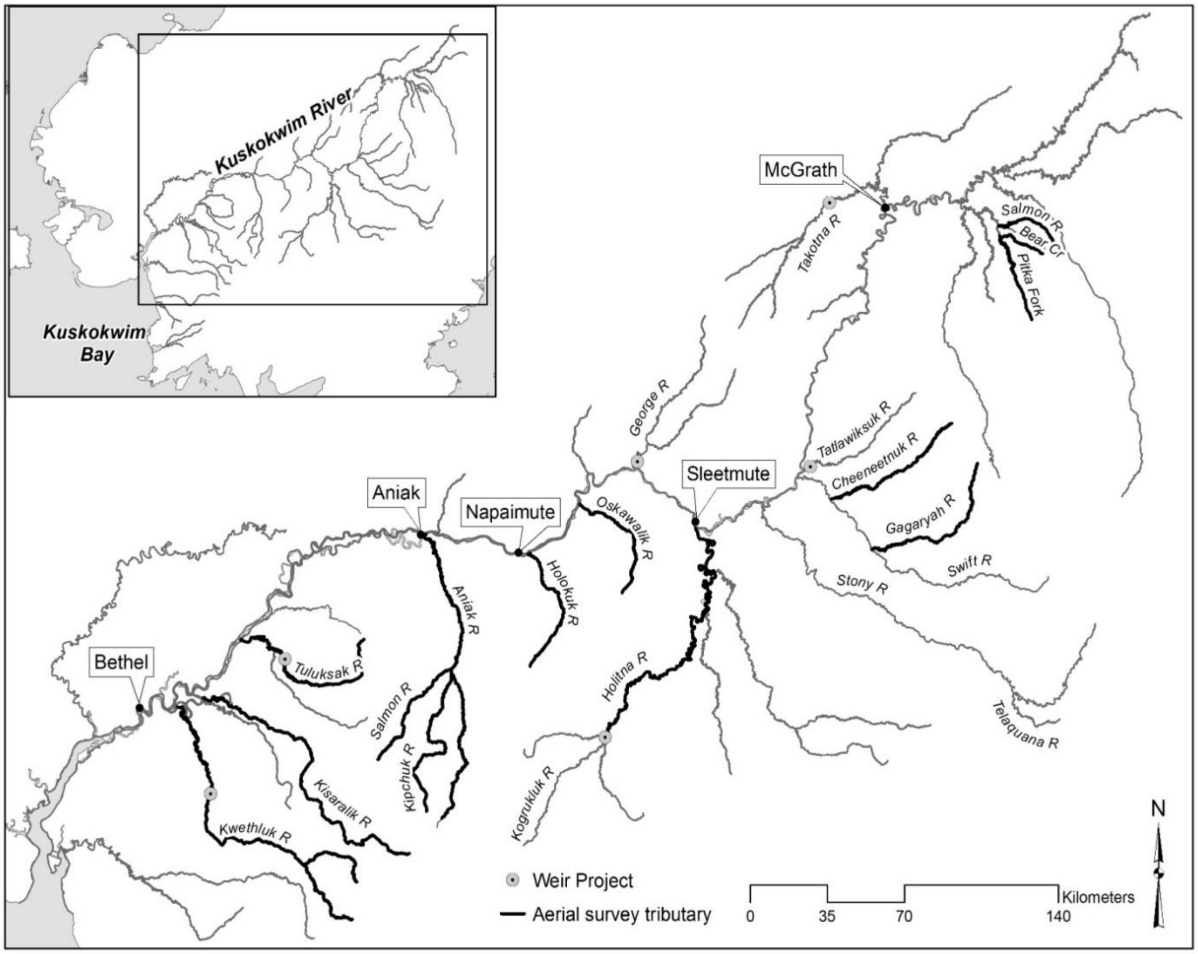

Figure 1.–Kuskokwim River Chinook salmon escapement monitoring projects used to inform the run reconstruction model.

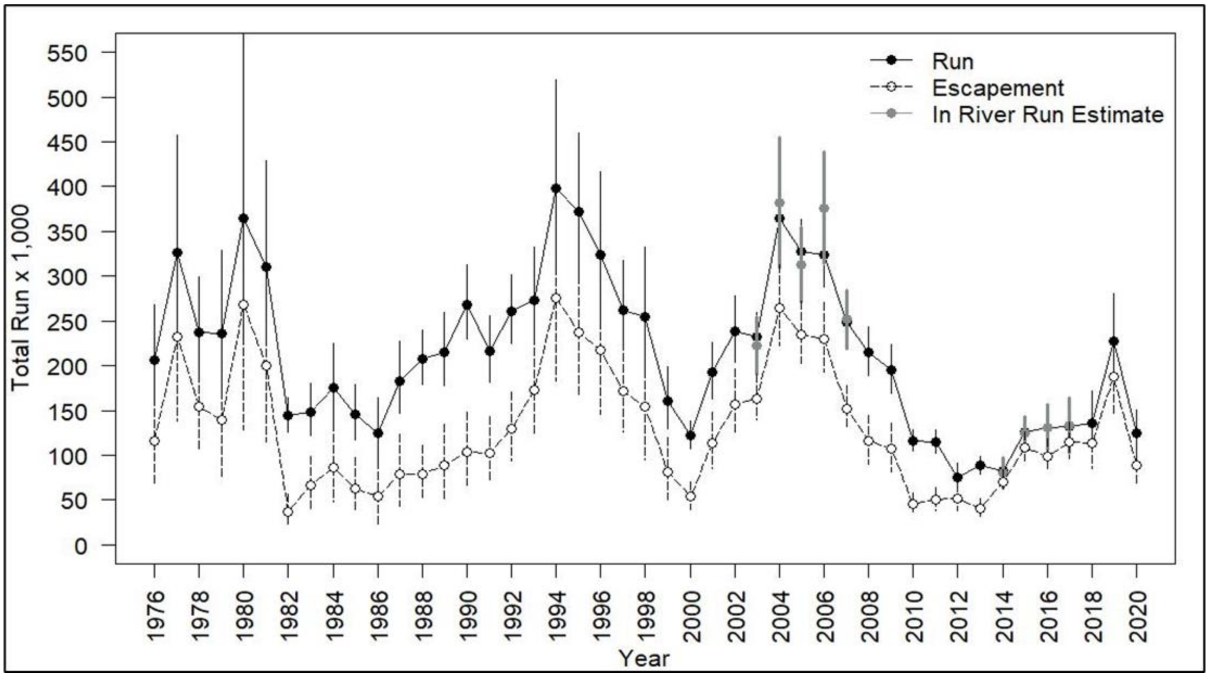

Figure 2.–Annual run (black) and escapement (white) estimates with 95% confidence intervals estimated from the 2020 run reconstruction model.

Note: Gray dots are drainagewide run size and 95% confidence intervals for years 2003–2007 and 2014–2017 used to scale the model. Model scalars are direct estimates of total run derived from a combination of mark–recapture data, escapement estimates, extrapolation of escapement values to unmonitored areas, and harvests (Liller et al. 2018).

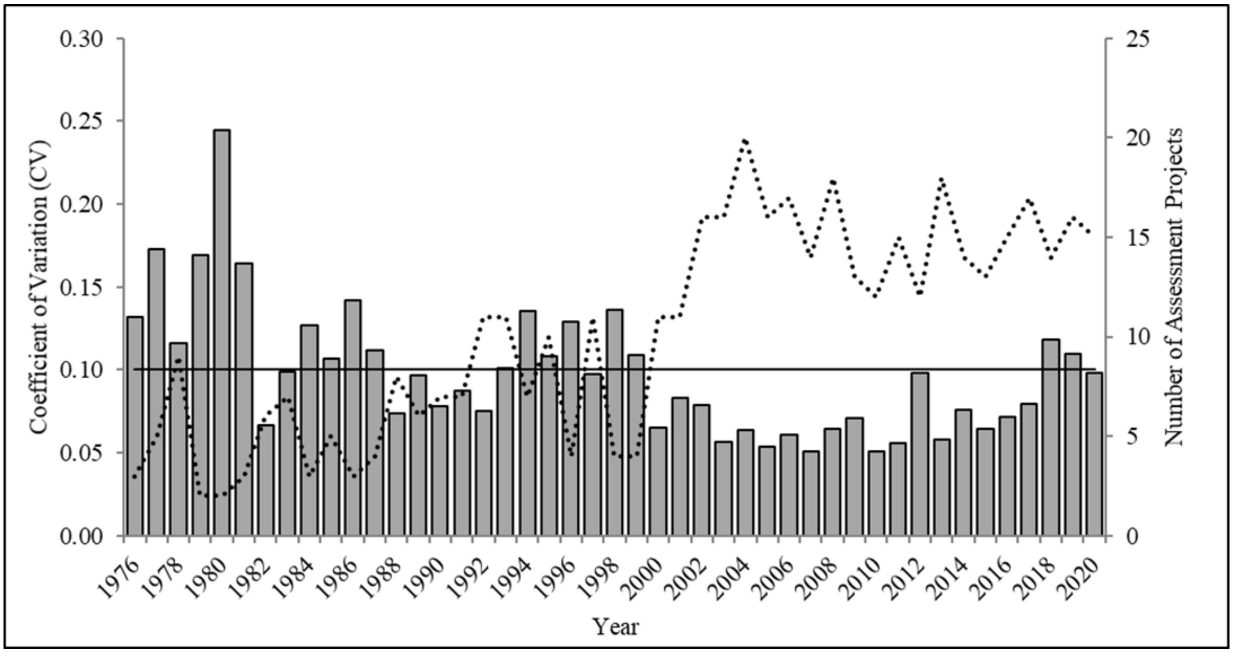

Figure 3.–Annual uncertainty (coefficient of variation; grey bars) of the run reconstruction model estimate of total run size and the number of assessment projects (dotted black line) used to inform the model in each year.

Note: The solid black line is the average coefficient of variation (10%) across years 1976–2019.

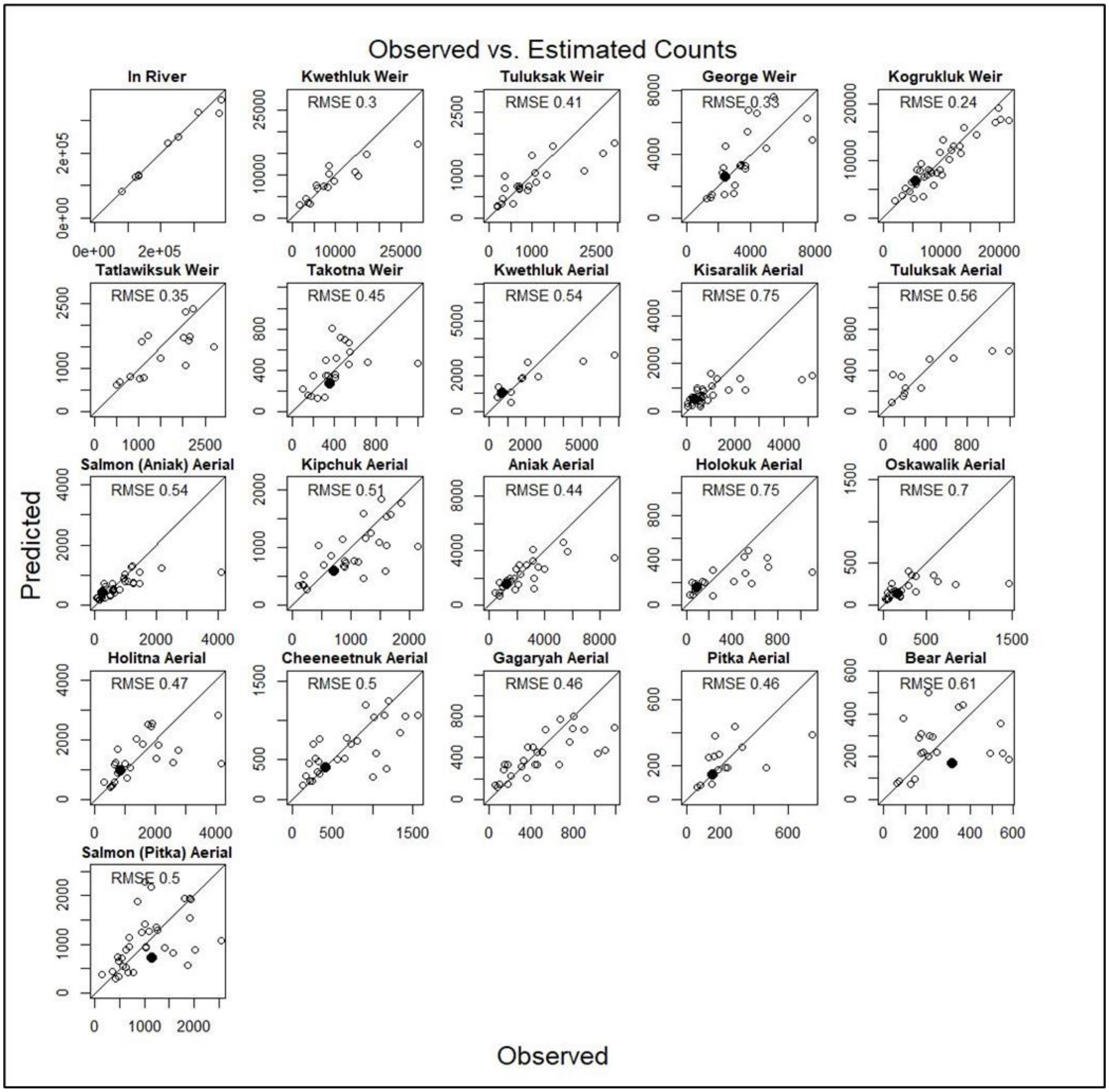

Figure 4.–Observed versus model estimated escapement counts.

Note: The diagonal line within each subplot represents the 1:1 line, which is the point at which observed and estimated escapements are equal. Hollow dots are the prior year observations and solid dots are the 2020 observations. Dots that fall below the 1:1 line indicate that the observed counts are higher than the model estimates, and the opposite is also true. The top left subplot titled "Inriver" is the 2003–2007 and 2014–2017 total run estimates used to scale the model.

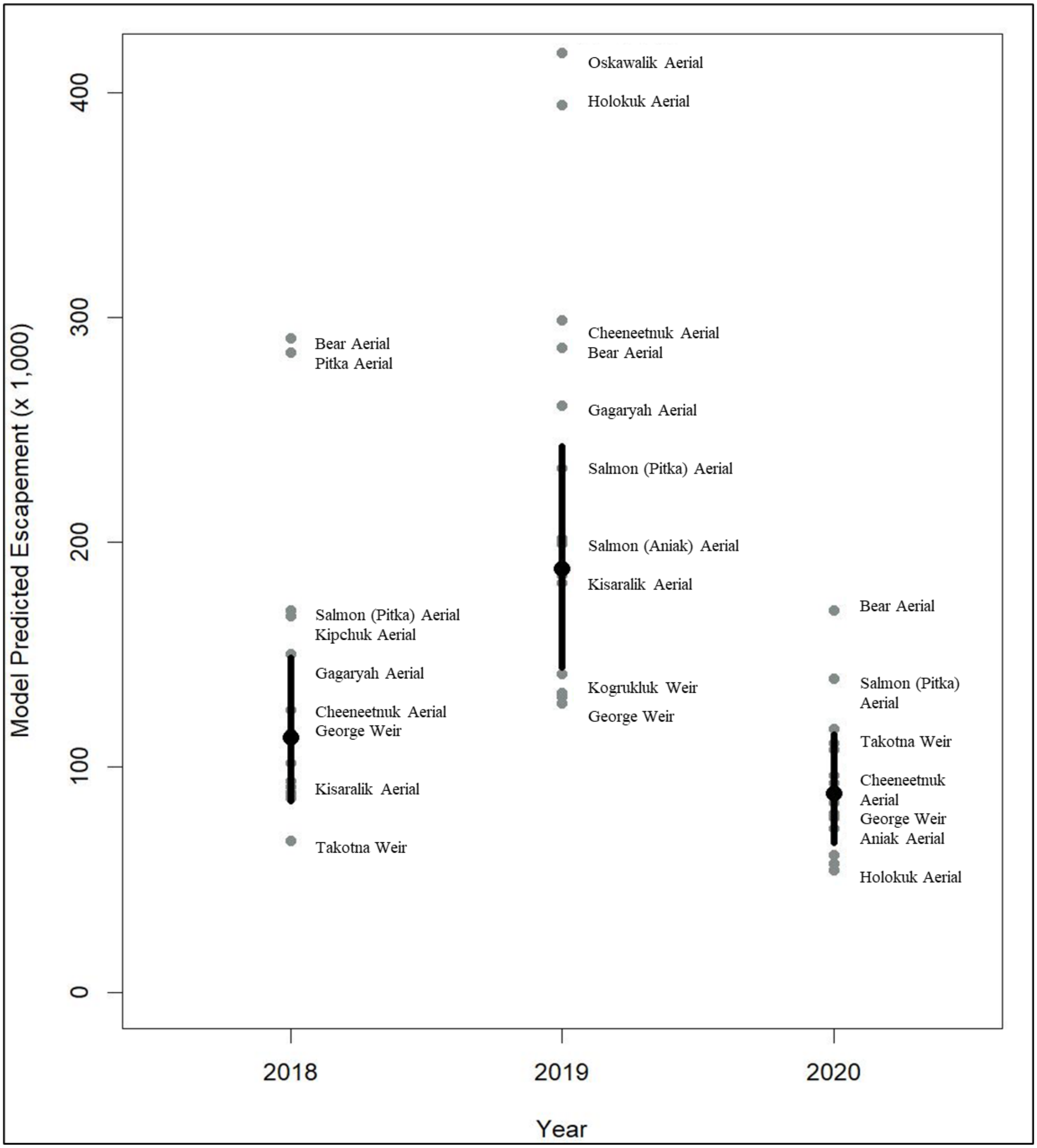

Figure 5.–Range of drainagewide escapement estimates produced by the model based on each escapement project.

Note: Grey dots are individual project estimates of the total run based on the model estimated scaling factor. Black dots and lines show the model derived drainagewide escapement and 95% confidence interval after simultaneously combining the information from all escapement monitoring projects. Estimates for years 2018 and 2019 are shown to provide context for 2020 results.

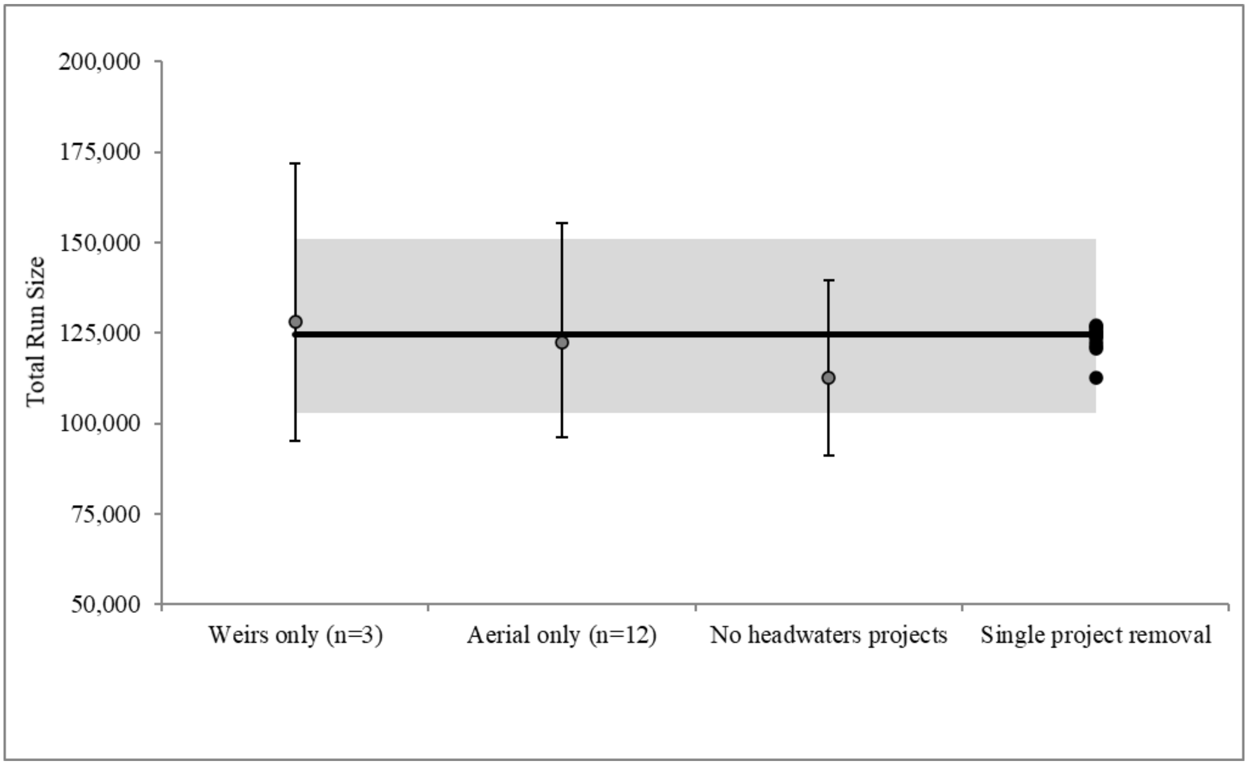

Figure 6.–Sensitivity of 2020 Chinook salmon total run size estimates using weir data only, aerial survey data only, exclusion of headwaters project data, and removal of single escapement monitoring projects (black dots).

Note: The solid black line is the point estimate of the ADF&G base model and the grey shaded area is the 95% confidence interval. Alternative estimates (gray dots) and 95% confidence intervals are shown for comparison. The amount of overlap with the grey shaded area indicates the degree of similarity between estimates.

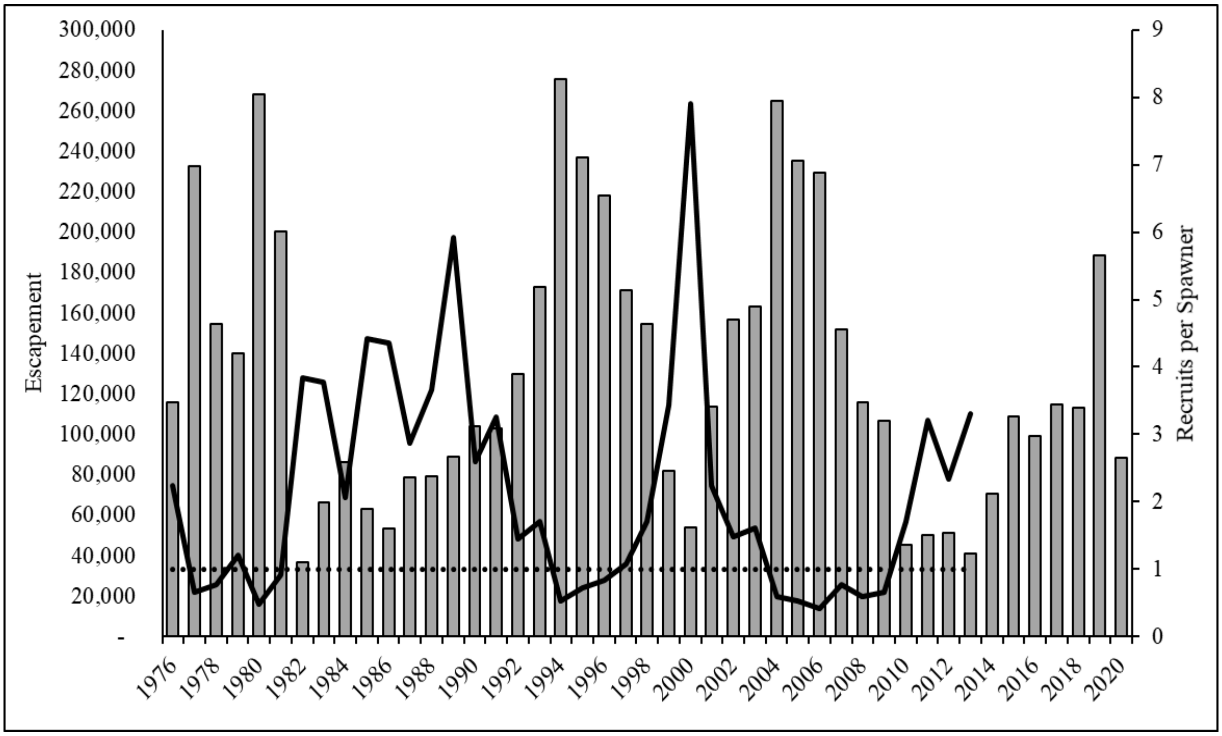

Figure 7.–Escapement (bars), recruits per spawner (solid line), and the 1:1 replacement line for recruits per spawner (dotted line) for Kuskokwim River Chinook salmon, 1976–2020.

APPENDIX A: 2020 NPFMC 3-SYSTEM INDEX LETTER

Appendix A1.–2020 NPFRMC 3-system index letter.

THE STATE of ALASKA

GOVERNOR MIKE DUNLEAVY

Department of Fish and Game

Division of Commercial Fisheries
Headquarters Office

1255 West 8th Street
P.O. Box 115526
Juneau, Alaska 99811-5526
Main: 907.465.4210
Fax: 907.465.2604

September 18, 2020

Dr. James Balsiger, Administrator
NOAA Fisheries, Alaska Region
PO Box 21668
Juneau, Alaska 99802-1668

Dear Dr. Balsiger:

In April 2015, the North Pacific Fishery Management Council (Council) adopted an action that lowers Chinook salmon bycatch caps in the Bering Sea pollock fishery when Chinook salmon abundance in Western Alaska is at historically low levels.[1] The Council's action identifies historically low Western Alaskan Chinook salmon abundance using a three-system index of inriver adult Chinook salmon run sizes from the Unalakleet, Upper Yukon, and Kuskokwim rivers combined at or below the threshold level of 250,000 fish. The Council's action also specified a process by which the Alaska Department of Fish and Game (department) would provide postseason abundance estimates to the National Marine Fisheries Service (NMFS) by October 1, following the salmon season each year. If the threshold is not met, the performance standard and hard cap applicable to the Bering Sea pollock fishery would be lowered in the following year.

Methods and analyses used by the department to estimate the postseason run size for each of the three systems have been approved by the Council, and there were no changes to those methods in 2020. The methods used for the Unalakleet and Upper Yukon rivers are consistent with what is outlined in the Council's public review analysis.[2] Methods used for the Kuskokwim River were approved by the Council in June 2018[3].

The 2020 three-system index of inriver adult Chinook salmon run sizes from the Unalakleet, Upper Yukon, and Kuskokwim rivers is 173,416 and is below the threshold level of 250,000. The following details the preliminary total run estimates for each system:

Unalakleet River
The preliminary postseason run size estimate of Unalakleet River Chinook salmon is **5,215,** based on the sum of reported commercial harvest, expected subsistence harvest, and estimated total escapement. A total of 475 Chinook salmon were commercially harvested in Norton Sound Subdistrict 6 (Unalakleet Subdistrict), and the total catch was assumed to be bound for the Unalakleet River. The department expects approximately 1,500 Unalakleet River Chinook salmon were harvested for subsistence uses in 2020, which is based on a modest increase to the 2019 subsistence harvest (i.e., 1,459) and informed by a relative increase in fishing opportunity and positive inseason catch reports. The preliminary total escapement of Chinook salmon to the Unalakleet River is estimated to be 3,240. The North River Tower was installed 10 days late, and the Unalakleet River weir did not operate, due to high water. Standard methods were used to estimate the number of fish that passed the North River Tower during inoperable periods. The resulting North River

---

1 https://npfmc.legistar.com/LegislationDetail.aspx?ID=2237783&GUID=89E4DA9C-19B8-4BDE-8643-B19D68DD9EE3

2 Public Review draft Environmental Assessment/ Regulatory Impact Review/ Initial Regulatory Flexibility Analysis for Proposed Amendment to the Fishery Management Plan for Bering Sea Aleutian Islands Groundfish Bering Sea Chinook and Chum salmon bycatch management measures, March 2015.

3 https://npfmc.legistar.com/LegislationDetail.aspx?ID=3486558&GUID=81056FD0-C9E8-4376-BD59-C2F6084C82E9&Options=ID|Text|&Search=Kuskokwim

-continued-

Tower escapement was expanded to the total Unalakleet River, based on the average[4] contribution of the North River to the total escapement. The expansion methods used in 2020 were consistent with those used to develop the 3-system index.

Upper Yukon River

The preliminary postseason run size estimate of Upper Yukon River Chinook salmon is **52,005,** based on the preliminary assessment of total passage into Canada and expectations of the total harvest in Alaska. Chinook salmon passage into Canada was based on a sonar project operated near the U.S./Canada border, downriver from Eagle, Alaska. The preliminary sonar count is 33,005 (90% CI[5]: 32,649–33,361). The preliminary sonar count does not include one day of right-bank passage estimates. The total harvest of Upper Yukon River Chinook salmon in Alaska is expected to be about 19,000, based on the 2018 harvest (i.e., 19,266) which resulted from similar conservative management strategies. Nearly all harvest occurred in the Alaskan subsistence fishery, and minimal harvest occurred in test fisheries operated by the department. Subsistence fishing restrictions were implemented throughout the Chinook salmon run in 2020, and high-water conditions likely further reduced subsistence harvest relative to the opportunities provided. There was no sale of Chinook salmon harvested incidentally in summer chum salmon commercial fisheries, and all commercially harvested Chinook salmon were retained for subsistence uses. The preliminary total run size of Upper Yukon River Chinook salmon was smaller than expected but generally consistent with the lower end of the preseason run forecast (i.e., 59,000) and the lower end of the inseason run projections (i.e., 63,000).

Kuskokwim River

The preliminary postseason run size estimate of Kuskokwim River Chinook salmon is **116,196** fish (95% CI: 95,000–143,000), based on preliminary results of a maximum likelihood model. The total run estimate was informed by direct observations of escapement and an expectation of drainagewide harvest. Escapement was successfully monitored at 15 locations, and there were no operational issues. The total harvest of Kuskokwim River Chinook salmon is expected to be 28,315. No commercial harvest of Kuskokwim River Chinook salmon occurred during the 2020 season. Nearly all harvest occurred in the subsistence fishery, and minimal harvest occurred in test fisheries operated by the department and collaborators. Subsistence fishing restrictions were implemented throughout the Chinook salmon run in 2020. U.S. Fish and Wildlife Service (USFWS) estimated that approximately 23,000 Chinook salmon were harvested within a portion of the Yukon Delta National Wildlife refuge during subsistence fishing openers announced by Federal Special Actions. A preliminary estimate of drainagewide subsistence harvest was generated using a four-year relationship between partial harvest estimates developed inseason by USFWS and drainagewide estimates developed postseason by the department. The preliminary total run size of Kuskokwim River Chinook salmon was smaller than expected given the preseason run forecast of 193,000–261,000. However, the preliminary model estimate is consistent with an independent partial run estimate of 106,152 (90% CI: 90,231–122,073) Chinook salmon, based on a sonar project operated near Bethel, Alaska.

Sincerely,

Sam Rabung
Director, Division of Commercial Fisheries

cc: Anne Marie Eich, NMFS AKR
David Witherell, NPFMC

[4] The average contribution of the North River escapement to the total Unalakleet River escapement was based on years 2015, 2017, and 2019, which were the most recent three years with complete escapement assessment. The contribution of North River in prior years was not used, because there is evidence that the proportional contribution of the North River to the total Unalakleet River escapement has declined modestly over time.

[5] CI: confidence interval

APPENDIX B: 2020 ADMB-CODE WITH ANNOTATIONS

Appendix B1.–2020 ADMB-code with annotations.

```
//=============================================================================
//DATA SECTION
//=============================================================================
DATA_SECTION

  init_int nyear; // number of years with datae
  init_int nweek; // number of weeks for harvest data
  init_int nweir; // number of weir sites
  init_int nair;  // number of aerial survey sites

  init_matrix testf(1,nyear,1,nweek); //Estimates of run proportion by week

  init_matrix ceff(1,nyear,1,nweek);  // Weekly effort commercial fishery
  init_matrix ccat(1,nyear,1,nweek);  // Weekly catch commercial fishery
  init_matrix creg(1,nyear,1,nweek);  // Weekly indicator of fishery regulation

  init_vector inriv(1,nyear);        // Annual in-river run estimate
  init_vector inriv_sd(1,nyear);      // SD of annual in-river run estimate

  init_vector tcatch(1,nyear);         // Total harvest across all fishery sectors
  init_matrix esc_w(1,nyear,1,nweir);   // Weir escapement indices
  init_matrix esc_a(1,nyear,1,nair);    // Aerial escapement indices

  init_vector minesc(1,nyear);            // Minimum annual escapement
  init_vector minrun(1,nyear);            // Minimum annual run size
  init_vector ubrun(1,nyear);             // Upper bounds for annual run size estimation

//========================================================
// Parameter Section
//========================================================
PARAMETER_SECTION
  init_bounded_number_vector log_trun(1,nyear,minrun,ubrun,1);  // log drainage-wide run
  init_bounded_vector log_wesc(1,nweir,0,7,1);   // log slope for weir counts
  init_bounded_vector log_aesc(1,nair,0,7,1);    // log slope for aerial counts
  init_bounded_vector log_q(1,2,-12,-9,1);        // log Catchability for different fishery sectors
  init_bounded_number log_cvw(-10,1,1);    // log cv for weir counts
  init_bounded_number log_cva(-10,1,1);     // log cv for aerial counts
  init_bounded_number log_cvq(-10,1,1);     // log cv for commercial cpue
  vector t_run(1,nyear);              // storage for untransformed total runs
  vector wesc(1,nweir);               // storage for untransformed weir escapement slopes
  vector aesc(1,nair);                // storage for untransformed aerial escapement slopes
  vector q(1,2);                      // storage for untransformed catchabilities
  number cvw;                // storage for untransformed weir cv parameters
  number cva;                // storage for untransformed aerial cv parameters
  number cvq;                                       // storage for untransformed fishery cv parameters
  matrix wk_est(1,nyear,1,nweek);     // storage matrix for the estimated number of fish available for harvest 
each week
  number tfw;                       // likelihood for weir counts
  number tfa;                       // likelihood for aerial counts
```

```
  vector tfc(1,3);                    // likelihood for commercial CPUE
  number tft;                        // likelihood for in-river run estimates
  vector esc(1,nyear);                // vector of total escapement estimates
  number var1;                       // storage for Weir Escapement variance parameter
  number var2;                       // storage for Aerial Escapement variance parameter
  number var3;                                        // storage for CPUE variance parameter
  matrix cpue(1,3,1,nyear);                           // storage matrix for annual CPUE by fishery
  matrix testp(1,3,1,nyear);                  // testfish weekly run proportion

  objective_function_value objf;

INITIALIZATION_SECTION
  log_trun  12.5;
  log_wesc  5.0;
  log_aesc  4.0;
  log_q  -11.0;
  log_cvw  1.0;
  log_cva  1.0;
  log_cvq  1.0;

//=======================================================
// Calculate Annual run adjusted CPUE
//=======================================================
PRELIMINARY_CALCS_SECTION
   int i,j,k;
  for (i=1;i<=nyear;i++)
  {
  for (j=1;j<=nweek;j++)
        {
// Unrestricted mesh catch
    if(creg(i,j)==1)
          {
                        cpue(1,i) += ccat(i,j)/ceff(i,j);
                        testp(1,i) += testf(i,j);
          }
// Restricted mesh catch
    if(creg(i,j)==2)
          {
                        cpue(2,i) += ccat(i,j)/ceff(i,j);
                        testp(2,i) += testf(i,j);
                        }
// Mono-filament mesh catch
    if(creg(i,j)==3 or creg(i,j)==5)
          {
                        cpue(3,i) += ccat(i,j)/ceff(i,j);
                        testp(3,i) += testf(i,j);
                              }
        }
  }

//=========================================================
```

```
// Procedure Section
//===========================================================
PROCEDURE_SECTION

  objf = 0.0;

  convert_parameters_into_rates();

  evaluate_obj_func();

RUNTIME_SECTION
  maximum_function_evaluations 200000000
  convergence_criteria 1.e-30  //was 1.e-20 //low converge was .000001

//===========================================================
// Function convert_parameters_into_rates
//===========================================================
FUNCTION convert_parameters_into_rates

   t_run=exp(log_trun);
   wesc=exp(log_wesc);
   aesc=exp(log_aesc);
   q=exp(log_q);
   cvw=exp(log_cvw);
   cva=exp(log_cva);
   cvq=exp(log_cvq);
   var1 = log(square(cvw)+1);
   var2 = log(square(cva)+1);
   var3 = log(square(cvq)+1);

//===========================================================
// Function evaluate_obj_func
//===========================================================
FUNCTION evaluate_obj_func
   int i,j,k,l,ctr1,ctr2,ctr3;

   tfw= 0.0;
   tfa= 0.0;
   tft= 0.0;
   tfc=0.0;


   for (i=1;i<=nyear;i++)
   {
    esc(i)=t_run(i)-tcatch(i);

    if(inriv(i)>0)
    {
     tft+= 0.5*square(log(inriv(i))-log(t_run(i)))/log(square(inriv_sd(i)/inriv(i))+1);
           // In-River run estimate likelihood
    }
```

```
    // Weir likelihoods
    for(j=1;j<=nweir;j++)
    {
      if(esc_w(i,j)>0)
      {
        tfw += log(sqrt(var1))+0.5*square(log(esc_w(i,j))-log(esc(i)/wesc(j)))/var1;
      }
    }

// Aerial likelihoods
    for(k=1;k<=nair;k++)
    {
     if(esc_a(i,k)>0)
     {
      tfa += log(sqrt(var2))+0.5*square(log(esc_a(i,k))-log(esc(i)/aesc(k)))/var2;
     }
    }

//===  Calculate annual run adjusted CPUE ==================================

            if(cpue(1,i)>0)
            {
            tfc(1) += log(sqrt(var3))+0.5*square(log(cpue(1,i)/testp(1,i))-log(q(1)*t_run(i)))/var3;
            }
// Remove CPUE during the Restricted Period
//          if(cpue(2,i)>0)
//          {
//          tfc(2) += log(sqrt(var3))+0.5*square(log(cpue(2,i)/testp(2,i))-log(q(2)*t_run(i)))/var3;
//          }
            if(cpue(3,i)>0)
            {
            tfc(3) += log(sqrt(var3))+0.5*square(log(cpue(3,i)/testp(3,i))-log(q(2)*t_run(i)))/var3;
            }

   }

   objf+= tft+tfw+tfa+sum(tfc);

//============================================================================
======
// Report Section
//============================================================================
======
REPORT_SECTION

   report<<"Total Run"<< endl << t_run << endl;
   report<<"ObjFunc"<< endl << objf << endl;
   report<<"tfc"<<endl<< tfc <<endl;
   report<<"tft"<<endl<< tft <<endl;
   report<<"tfa"<<endl<< tfa <<endl;
```

```
   report<<"tfw"<<endl<< tfw <<endl;
   report<<"cvw"<<endl<< cvw << endl;
   report<<"cva"<<endl<< cva << endl;
   report<< "q" << endl << q << endl;
   report<< "wesc" <<endl<< wesc << endl;
   report<< "aesc" <<endl<< aesc << endl;
   report<<"tcatch"<<endl<< tcatch<<endl;
   report<<"TotalEscapement"<<endl<< esc << endl;

//==========================================================================
=======
// Globals Section
//==========================================================================
=======
GLOBALS_SECTION
  #include <df1b2fun.h>
  #include <math.h>
  #include <time.h>
  #include <statsLib.h>
  #include <adrndeff.h>
  #include <admodel.h>
  time_t start,finish;
  long hour,minute,second;
  double elapsed_time;

TOP_OF_MAIN_SECTION
  arrmblsize = 100000000;
  gradient_structure::set_MAX_NVAR_OFFSET(30000000);
  gradient_structure::set_GRADSTACK_BUFFER_SIZE(3000000);
  gradient_structure::set_CMPDIF_BUFFER_SIZE(100000000);
  time(&start);

FINAL_SECTION
 // Output summary stuff
  time(&finish);
  elapsed_time = difftime(finish,start);
  hour = long(elapsed_time)/3600;
  minute = long(elapsed_time)%3600/60;
  second = (long(elapsed_time)%3600)%60;
  cout << endl << endl << "Starting time: " << ctime(&start);
  cout << "Finishing time: " << ctime(&finish);
  cout << "This run took: " << hour << " hours, " << minute << " minutes, " << second << " seconds." <<
endl << endl;
```

APPENDIX C: MODEL INPUT DATA

Appendix C1.–Independent estimates of Kuskokwim River Chinook salmon abundance, used to scale the run reconstruction model.

Conventional name:	Year	Total run	Standard error
	2003	222,145	16,055
	2004	381,958	36,322
	2005	312,353	21,083
	2006	376,291	31,094
	2007	251,781	16,315
	2014	80,399	8,605
	2015	124,421	9,362
	2016	131,090	12,632
	2017	133,292	15,702

Appendix C2.–Harvest of Kuskokwim River Chinook salmon.

Var name:	Year	H.Com	H.Sub	H.Sports	H.Test
Conventional name:	Year	Commercial	Subsistence	Sport	Testfish
	1976	30,735	58,606		1,206
	1977	35,830	56,580	33	1,264
	1978	45,641	36,270	116	1,445
	1979	38,966	56,283	74	979
	1980	35,881	59,892	162	1,033
	1981	47,663	61,329	189	1,218
	1982	48,234	58,018	207	542
	1983	33,174	47,412	420	1,139
	1984	31,742	56,930	273	231
	1985	37,889	43,874	85	79
	1986	19,414	51,019	49	130
	1987	36,179	67,325	355	384
	1988	55,716	70,943	528	576
	1989	43,217	81,175	1,218	543
	1990	53,502	109,778	394	512
	1991	37,778	74,820	401	149
	1992	46,872	82,481	367	1,380
	1993	8,735	87,830	587	2,515
	1994	16,211	102,817	1,139	1,937
	1995	30,846	101,921	541	1,421
	1996	7,419	96,477	1,432	247
	1997	10,441	79,334	1,227	332
	1998	17,359	80,969	1,434	210
	1999	4,705	73,538	252	98
	2000	444	67,596	105	64
	2001	90	78,174	290	86
	2002	72	81,169	319	288
	2003	158	67,737	401	409
	2004	2,305	96,788	857	691
	2005	4,784	85,863	572	557
	2006	2,777	90,812	444	352
	2007	179	94,898	1,478	305
	2008	8,865	88,912	708	420
	2009	6,664	79,896	904	470
	2010	2,732	67,286	354	292
	2011	747	62,366	579	337
	2012	627	22,544	0	321
	2013	174	47,113	0	201
	2014	35	11,234	0	497
	2015	8	16,124	0	472
	2016	0	30,693	0	525
	2017	0	16,380	0	290
	2018	0	22,266	0	465
	2019	0	37,941	0	563
	2020	0	35,846	0	355

Appendix C3.–Weir escapement counts of Kuskokwim River Chinook salmon.

Var name:	Year	w.kwe	w.tul	w.geo	w.kog	w.tat	w.tak
Conventional name:	Year	Kwethluk	Tuluksak	George	Kogrukluk	Tatlawiksuk	Takotna
	1976				5,822		
	1977						
	1978				13,436		
	1979				11,437		
	1980						
	1981				16,075		
	1982						
	1983						
	1984				4,922		
	1985				4,479		
	1986						
	1987						
	1988				8,603		
	1989						
	1990				10,093		
	1991		697		7,602		
	1992	9,675	1,083		6,471		
	1993		2,218		12,157		
	1994		2,932				
	1995				20,249		540
	1996			7,501	13,900		423
	1997			7,810	13,116		1,197
	1998						
	1999				5,567	1,484	
	2000	3,547		2,956	3,254	808	345
	2001		924	3,313	8,151	2,013	718
	2002	8,543	1,346	2,445	9,830	2,237	326
	2003	14,475	1,067		11,751		378
	2004	28,801	1,475	5,392	19,880	2,833	461
	2005		2,653	3,845	21,686	2,858	499
	2006	17,019	1,008	4,359	19,305	1,700	537
	2007	15,112	374	4,972		2,058	412
	2008	5,642	707	3,383	9,740	1,194	413
	2009	5,826	362	3,664	9,201	1,071	311
	2010	1,716	201	1,500	5,160	554	183
	2011	4,056	284	1,605	6,926	1,011	149
	2012		559	2,362		1,116	238
	2013		198	1,267	1,919	495	104
	2014	3,191	325	2,988	3,726	2,050	
	2015	8,163	711	2,301	8,333	2,131	
	2016		909	2,218	7,062	2,693	
	2017	7,207	648	3,669	7,787	2,146	318
	2018			3,322	6,292		205
	2019	8,505		3,828	10,301		554
	2020			2,418	5,645		357

Appendix C4.–Peak aerial survey index counts of Kuskokwim River Chinook salmon.

Var name:	Year	a.kwe	a.kis	a.tul	a.sla	a.kip	a.ank	a.hlk	a.osk	a.hlt	a.che	a.gag	a.pit	a.ber	a.slp
Conventional name:	Year	Kwethluk	Kisaralik	Tuluksak	Salmon (Aniak)	Kipchuk	Aniak	Holokuk	Oskawalik	Holitna	Cheeneetnuk	Gagaryah	Pitka	Bear	Salmon (Pitka)
	1976									2,571		663		182	
	1977	2,075		439							1,407	897			1,930
	1978	1,722	2,417		289					2,766	268	504		227	1,100
	1979														682
	1980			1,035	1,186										
	1981						9,074							93	
	1982		81		126					521				127	413
	1983	471		186	231		1,909			1,069	173				572
	1984										1,177				545
	1985		63								1,002				620
	1986				336		424			650					
	1987				516	193			193		317	205			
	1988	622	869	195	244		954		80						474
	1989	1,157	152		631	1,598	2,109								452
	1990		631	205	596	537	1,255		113						
	1991		217	358	583	885	1,564								
	1992				335	670	2,284		91	2,022	1,050	328			2,536
	1993				1,082	1,248	2,687	233	103	1,573	678	419			1,010
	1994		1,021		1,218	1,520					1,206	807			1,010
	1995		1,243		1,446	1,215	3,171		326	1,887	1,565	1,193			1,911
	1996				985										
	1997		439		980	855	2,187		1,470	2,093	345	364			
	1998		457		557	443	1,930								
	1999								98	741					
	2000				238	182	714		62	301			151		362
	2001				598			52		4,156		143		175	1,033
	2002	1,795	1,727		1,236	1,615		513	295	733	730	452	165	211	1,255

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Var name:	Year	a.kwe	a.kis	a.tul	a.sla	a.kip	a.ank	a.hlk	a.osk	a.hlt	a.che	a.gag	a.pit	a.ber	a.slp
Conventional name:	Year	Kwethluk	Kisaralik	Tuluksak	Salmon (Aniak)	Kipchuk	Aniak	Holokuk	Oskawalik	Holitna	Cheeneetnuk	Gagaryah	Pitka	Bear	Salmon (Pitka)
	2003	2,661	654	94	1,242	1,493	3,514	1,096	844		810	1,095	197	176	1,242
	2004	6,801	5,157	1,196	2,177	1,868	5,362	539	293	4,051	918	670	290	206	1,138
	2005	5,059	2,206	672	4,097	1,679		510	582	1,760	1,155	788	744	367	1,801
	2006		4,734			1,618	5,639	705	386	1,866	1,015	531	170	347	862
	2007		692	173	1,458	2,147	3,984					1,035	131	165	943
	2008	487	1,074		589	1,061	3,222	418	213		290	177	242	245	1,033
	2009							565	379		323	303	187	209	632
	2010		235					229		587		62	67	75	135
	2011				79	116		61	26		249	96	85	145	767
	2012		588		49	193		36	51		229	178			670
	2013	1,165	599	83	154	261	754		38	532	138	74		64	469
	2014		622		497	1,220	3,201	80	200		340	359			1,865
	2015		709		810	917		77		662					2,016
	2016		622			898	718	100	47	1,157	217	135		580	1,578
	2017				423	889	1,781	140	136	676	660	453	234	492	687
	2018		584		442	1,123	1,534	162		980	565	438	471	550	1,399
	2019		1,063		950	1,344	3,160	719	638	1,377	1,345	760	330	542	1,918
	2020	721	350		269	723	1,264	99	169	854	419		160	321	1,150

Note: Only surveys rated good or fair were used. Only surveys flown between July 17 and August 5, inclusive, were used. Chinook salmon live and carcass counts were combined.

Appendix C5.–Proportion of total annual Chinook salmon run in District W-1, by week, as estimated by Bethel test fishery.

Var name:	Year	rpw.3	rpw.4	rpw.5	rpw.6	rpw.7	rpw.8	rpw.9	rpw.10
Conventional name:	Year	6/10/ - 6/16	6/17 - 6/23	6/24 - 6/30	7/1 - 7/7	7/8 - 7/14	7/15 - 7/21	7/22 - 7/28	7/29 - 8/26
	1976								
	1977								
	1978								
	1979								
	1980								
	1981								
	1982								
	1983								
	1984	0.2243	0.2903	0.1488	0.1633	0.0509	0.0522	0.0090	0.0173
	1985	0.0000	0.0930	0.2427	0.4306	0.1504	0.0247	0.0175	0.0410
	1986	0.1503	0.4039	0.1656	0.1399	0.0488	0.0097	0.0241	0.0000
	1987	0.1988	0.3070	0.2368	0.1137	0.0210	0.0344	0.0130	0.0094
	1988	0.2080	0.3086	0.1786	0.0852	0.0218	0.0419	0.0145	0.0192
	1989	0.1769	0.2780	0.3474	0.0976	0.0258	0.0190	0.0119	0.0112
	1990	0.1434	0.2095	0.3325	0.1492	0.0609	0.0136	0.0266	0.0256
	1991	0.0593	0.2965	0.2942	0.1994	0.0337	0.0430	0.0000	0.0000
	1992	0.3466	0.1791	0.2132	0.1085	0.0542	0.0554	0.0000	0.0118
	1993	0.2148	0.4172	0.1270	0.0328	0.0273	0.0097	0.0000	0.0000
	1994	0.2883	0.3098	0.1396	0.1009	0.0138	0.0122	0.0000	0.0061
	1995	0.1566	0.3066	0.3005	0.0988	0.0300	0.0050	0.0097	0.0050
	1996	0.4007	0.2138	0.0963	0.0288	0.0214	0.0000	0.0066	0.0033
	1997	0.1913	0.5295	0.1196	0.0533	0.0357	0.0119	0.0079	0.0059
	1998	0.1166	0.2199	0.3866	0.1513	0.0378	0.0116	0.0055	0.0000
	1999	0.1360	0.1349	0.2469	0.1462	0.1903	0.0297	0.0754	0.0297
	2000	0.2089	0.3896	0.1530	0.0461	0.0205	0.0410	0.0000	0.0183
	2001	0.0791	0.4157	0.2510	0.1036	0.0528	0.0367	0.0000	0.0156
	2002	0.3547	0.2245	0.1601	0.1034	0.0337	0.0137	0.0089	0.0132
	2003	0.2764	0.2748	0.1433	0.0662	0.0351	0.0255	0.0112	0.0042
	2004	0.2130	0.2927	0.2513	0.0693	0.0406	0.0537	0.0160	0.0021
	2005	0.2335	0.2851	0.1876	0.1601	0.0768	0.0062	0.0000	0.0168
	2006	0.1299	0.3054	0.2935	0.1675	0.0535	0.0114	0.0142	0.0105
	2007	0.0996	0.2000	0.3114	0.2472	0.0754	0.0316	0.0095	0.0032

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Var name:	Year	rpw.3	rpw.4	rpw.5	rpw.6	rpw.7	rpw.8	rpw.9	rpw.10
Conventional name:	Year	6/10/ - 6/16	6/17 - 6/23	6/24 - 6/30	7/1 - 7/7	7/8 - 7/14	7/15 - 7/21	7/22 - 7/28	7/29 - 8/26
	2008	0.1524	0.2931	0.3057	0.1183	0.0431	0.0334	0.0083	0.0139
	2009	0.1955	0.2830	0.3460	0.0753	0.0323	0.0164	0.0000	0.0049
	2010	0.2190	0.3755	0.1517	0.1335	0.0556	0.0185	0.0113	0.0103
	2011	0.1188	0.2976	0.1996	0.1695	0.0818	0.0130	0.0000	0.0031
	2012	0.0508	0.2964	0.3308	0.2114	0.0627	0.0201	0.0088	0.0127
	2013	0.1681	0.3708	0.2654	0.0963	0.0743	0.0108	0.0000	0.0000
	2014	0.2834	0.2370	0.1217	0.0771	0.0148	0.0146	0.0000	0.0029
	2015	0.1859	0.2292	0.1520	0.1316	0.0625	0.0591	0.0338	0.0238
	2016	0.1696	0.1830	0.2085	0.1385	0.0722	0.0296	0.0197	0.0112
	2017	0.0899	0.2067	0.3202	0.1459	0.1117	0.0473	0.0266	0.0265
	2018	0.1979	0.1706	0.3085	0.174	0.0539	0.0231	0.0175	0.0108
	2019	0.1478	0.3298	0.2459	0.0473	0.0591	0.0165	0.0106	0.0000
	2020	0.1327	0.1895	0.2331	0.1599	0.1398	0.0435	0.0073	0.0124

Appendix C6.–Chinook salmon catch and effort (permit-hours) for Kuskokwim River District W-1.

		Week 3 6/10 - 6/16			Week 4 6/17 - 6/23			Week 5 6/24 - 6/30		
Var name:	Year	chw.3	cew.3	cfw.3	chw.4	cew.4	cfw.4	chw.5	cew.5	cfw.5
Conventional name:	Year	Catch	Effort	Net	Catch	Effort	Net	Catch	Effort	Net
	1976	0	0	0	20,010	5,724	1	4,143	2,088	2
	1977	12,458	2,802	1	16,227	2,904	1	1,841	4,722	2
	1978	18,483	3,972	1	10,066	2,004	1	3,723	5,346	2
	1979	24,633	6,432	1	5,651	3,012	2	3,860	6,438	2
	1980	9,891	2,814	1	21,698	5,364	4	1,460	2,448	2
	1981	29,882	6,180	1	3,830	3,066	2	4,563	5,952	2
	1982	4,912	2,784	1	24,628	5,970	1	12,555	5,176	4
	1983	13,406	5,634	1	8,063	5,544	2	4,925	5,958	2
	1984	0	0	0	17,181	5,562	1	5,643	5,616	2
	1985	0	0	0	6,519	2,538	3	19,204	5,880	3
	1986	0	0	0	0	0	0	11,986	6,540	3
	1987	0	0	0	19,126	4,734	3	0	0	0
	1988	12,640	4,816	3	11,708	3,672	3	15,060	7,518	3
	1989	0	0	0	15,215	5,208	3	11,094	6,144	3
	1990	0	0	0	16,690	3,780	3	25,459	7,536	3
	1991	0	0	0	13,813	3,606	3	12,612	3,696	3
	1992	0	0	0	24,334	9,488	3	16,307	8,628	3
	1993	0	0	0	0	0	0	8,184	4,976	3
	1994	0	0	0	0	0	0	14,221	4,608	3
	1995	0	0	0	6,895	2,276	3	14,424	4,532	3
	1996	0	0	0	4,091	1,056	3	666	360	3
	1997	0	0	0	10,023	2,118	3	0	0	0
	1998	0	0	0	0	0	0	12,771	4,584	3
	1999	0	0	0	0	0	0	4,668	2,454	3
	2000	0	0	0	0	0	0	0	0	0
	2001	0	0	0	0	0	0	0	0	0
	2002	0	0	0	0	0	0	0	0	0
	2003	0	0	0	0	0	0	0	0	0
	2004	0	0	0	0	0	0	520	104	3
	2005	0	0	0	0	0	0	3,531	1,189	3
	2006	0	0	0	0	0	0	2,493	1,038	3
	2007	0	0	0	0	0	0	0	0	0
	2008	0	0	0	6,415	1,026	3	2,362	783	3
	2009	0	0	0	3,003	668	3	2,539	752	3
	2010	0	0	0	0	0	0	1,724	1,324	5
	2011	0	0	0	0	0	0	0	0	0
	2012	0	0	0	0	0	0	0	0	0
	2013	0	0	0	0	0	0	0	0	0
	2014	0	0	0	0	0	0	0	0	0
	2015	0	0	0	0	0	0	0	0	0
	2016	0	0	0	0	0	0	0	0	0
	2017	0	0	0	0	0	0	0	0	0
	2018	0	0	0	0	0	0	0	0	0
	2019	0	0	0	0	0	0	0	0	0
	2020	0	0	0	0	0	0	0	0	0

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		Week 6 7/1 - 7/7			Week 7 7/8 - 7/14			Week 8 7/15 - 7/21			Week 9 7/22-7/28		
Var name:	Year	chw.6	cew.6	cfw.6	chw.7	cew.7	cfw.7	chw.8	cew.8	cfw.8	chw.9	cew.9	cfw.9
Conventional name:	Year	Catch	Effort	Net	Catch	Effort	Net	Catch	Effort	Net	Catch	Effort	Net
	1976	1,550	2,490	2	1,238	4,548	2	236	1,590	2	0	0	0
	1977	673	4,194	2	153	2,310	2	0	0	0	0	0	0
	1978	2,354	8,676	2	153	2,310	2	0	0	0	0	0	0
	1979	1,233	3,252	2	470	3,120	2	0	0	0	0	0	0
	1980	498	2,298	2	445	2,586	2	0	0	0	0	0	0
	1981	2,795	5,520	2	941	2,640	2	0	0	0	0	0	0
	1982	1,970	3,968	2	1,055	4,734	2	0	0	0	0	0	0
	1983	2,415	5,634	2	633	2,796	2	0	0	0	0	0	0
	1984	3,206	5,454	2	2,069	5,592	2	744	2,238	2	0	0	0
	1985	9,942	5,844	3	0	0	0	0	0	0	0	0	0
	1986	5,029	6,852	3	1,156	3,192	3	0	0	0	0	0	0
	1987	9,606	6,948	3	1,910	3,582	3	2,758	6,720	3	0	0	0
	1988	5,871	6,954	3	5,270	10,794	3	1,728	6,636	3	662	6,276	3
	1989	7,911	7,092	3	6,043	10,962	3	868	2,622	3	210	3,372	3
	1990	4,071	3,546	3	4,931	8,534	3	0	0	0	0	0	0
	1991	8,068	7,308	3	904	3,426	3	452	3,408	3	419	7,522	3
	1992	3,250	4,696	3	0	0	0	0	0	0	0	0	0
	1993	0	0	0	0	0	0	0	0	0	0	0	0
	1994	0	0	0	578	1,984	3	441	3,000	3	538	6,348	3
	1995	4,368	3,824	3	1,452	3,716	3	568	3,488	3	0	0	0
	1996	861	836	3	408	896	3	251	1,195	3	307	6,398	3
	1997	0	0	0	0	0	0	0	0	0	0	0	0
	1998	2,277	1,780	3	1,127	1,668	3	0	0	0	816	4,296	3
	1999	0	0	0	0	0	0	0	0	0	0	0	0
	2000	357	896	3	0	0	0	0	0	0	0	0	0
	2001	0	0	0	0	0	0	0	0	0	0	0	0
	2002	0	0	0	0	0	0	0	0	0	0	0	0
	2003	0	0	0	0	0	0	0	0	0	0	0	0
	2004	1,107	446	3	0	0	0	0	0	0	127	360	3
	2005	874	604	3	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	0	0	0	0	0	0
	2007	0	0	0	0	0	0	0	0	0	0	0	0
	2008	19	4	3	1	6	3	0	6	0	0	12	0
	2009	762	519	3	113	436	3	83	672	3	58	752	3
	2010	290	522	3	271	686	3	186	958	3	176	1,632	3
	2011	361	634	5	227	996	5	129	1,226	5	24	1,668	5
	2012	0	0	0	45	604	5	195	1,616	5	39	1,464	5
	2013	0	0	0	0	0	0	139	2,018	5	21	1,556	5
	2014	0	0	0	14	584	5	14	2,276	5	0	0	0
	2015	0	0	0	0	0	0	0	0	0	0	0	0
	2016	0	0	0	0	0	0	0	0	0	0	0	0
	2017	0	0	0	0	0	0	0	0	0	0	0	0
	2018	0	0	0	0	0	0	0	0	0	0	0	0
	2019	0	0	0	0	0	0	0	0	0	0	0	0
	2020	0	0	0	0	0	0	0	0	0	0	0	0

Note: Key to column net:

1 = Gillnet mesh size unrestricted
2 = Gillnets were restricted to 6" or less - old gear
3 = Gillnets were restricted to 6" or less - new gear
4 = Both unrestricted and restricted mesh size periods in the week
5 = Personal use harvest also included in catch and effort calculations - 6" or less new gear