Fishery Data Series No. 23-29

Salmon Escapement Monitoring in the Kuskokwim Area, 2020

Note: Berry and Larson (2021) replaced the previous in-text reference in the last sentence of the Introduction; the full citation was added to References Cited. (11/15/2023)

Annual Report for Project No. 18-304 and 20-302

USFWS Office of Subsistence Management

Fisheries Resource Monitoring Program

by

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and

Sean Larson

October 2023

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

FISHERY DATA SERIES NO. 23-29

SALMON ESCAPEMENT MONITORING IN THE KUSKOKWIM AREA, 2020

by

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October 2023

This investigation was partially financed by USFWS Office of Subsistence Management (under Project Numbers 18-304 and 20-302), Fisheries Resource Monitoring Program under FWS Agreement Numbers F18AC00611 and F20AC00237. Additional funds were provided by the State of Alaska.

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This document should be cited as follows:
Dickerson, B. R., N. Buitrago, and S. Larson. 2023. Salmon escapement monitoring in the Kuskokwim Area, 2020. Alaska Department of Fish and Game, Fishery Data Series No. 23-29, Anchorage.

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ABSTRACT

The Alaska Department of Fish and Game (ADF&G), in collaboration with other entities, conducted aerial surveys and operated ground-based weir projects to monitor Pacific salmon *Oncorhynchus* spp., escapement throughout the Kuskokwim Area in 2020. This report presents the results of sampling activities and escapement monitoring from all aerial surveys and weir projects operated in 2020 by ADF&G and the following partner agencies: MTNT Ltd., Kuskokwim River Inter-Tribal Fish Commission (KRITFC), Native Village of Napaimute (NVN), and the National Park Service. Chinook salmon *O. tshawytscha* escapements were successfully enumerated on 5 tributaries with weirs and 14 tributaries using aerial surveys. Chinook salmon escapement was below the historical average at all locations except for 2 aerial surveys (which were slightly above the historical average). Of the 12 escapement goals for Chinook salmon, a total of 8 were successfully assessed. Of those, 6 goals were met, and 2 goals were slightly below their lower bounds. Chum salmon *O. keta* were successfully enumerated using weirs on 3 Kuskokwim River tributaries. Chum salmon escapements were below average. The only chum salmon tributary escapement goal was assessed and met. Sockeye salmon *O. nerka* were successfully enumerated on 3 tributaries using weirs and 2 tributaries using aerial surveys. Sockeye salmon escapement was above the historical average at 2 of the sites assessed and below average at the other 3. Two of the 4 escapement goals for sockeye salmon were successfully assessed. One escapement goal was met, and the other was exceeded. Coho salmon were successfully enumerated on 1 tributary using a weir. Coho salmon escapement were above average. There were no coho salmon escapement goals evaluated. There was no effort to monitor coho salmon escapement in Kuskokwim Bay due to funding constraints in 2020.

Keywords: Chinook salmon, *Oncorhynchus tshawytscha*, chum salmon, *Oncorhynchus keta*, sockeye salmon, *Oncorhynchus nerka*, coho salmon, *Oncorhynchus kisutch*, aerial survey, resistance board weir, fixed picket weir, escapement, age, sex, length, ASL, Kuskokwim River, North Fork Goodnews River, Middle Fork Goodnews River, Kanektok River, Kisaralik River, Aniak River, Salmon River (Aniak drainage), Kipchuk River, Holokuk River, Oskawalik River, George River, Holitna River, Kogrukluk River, Telaquana River, Cheeneetnuk River, Gagaryah River, Salmon River (Pitka Fork drainage), Bear Creek, Kuskokwim Bay, Kuskokwim Area

INTRODUCTION

Pacific salmon *Oncorhynchus* spp. fisheries throughout the Kuskokwim Area (5 AAC 07.100) are managed to provide escapements within ranges that will provide sustainable yields. The management area includes the Kuskokwim River and Kuskokwim Bay river systems (Figure 1). Long-term escapement monitoring projects are important tools for fishery management. Aerial surveys conducted during peak spawning and ground-based weirs are used throughout the area to monitor annual escapement to key spawning rivers (Figures 2 and 3) and track temporal and spatial patterns in abundance. Pacific salmon spawn in many tributaries throughout the Kuskokwim River drainage and contribute to subsistence, commercial, and sport fishery harvests. Because it is not feasible to monitor all tributaries of the Kuskokwim River, a subset of rivers distributed over a broad geographic area are monitored to provide an indicator of Kuskokwim River salmon escapement. The rivers monitored in Kuskokwim Bay are the primary spawning drainages and main producers of salmon harvested in commercial fishing Districts 4 and 5.

Formal total run or escapement estimates do not exist for all salmon species returning to the Kuskokwim Area. Available data indicate sockeye salmon *O. nerka* are the most abundant salmon species in the Kuskokwim Bay river systems, followed by chum *O. keta*, coho *O. kisutch*, and Chinook *O. tshawytscha* salmon (Lipka and Tiernan 2018). For the Kuskokwim River, in most years, data indicate chum salmon are the most abundant salmon species in the drainage, followed by sockeye, coho, and Chinook salmon. Pink salmon *O. gorbuscha* escapement within the area has not been estimated.

Subsistence, commercial, and sport fisheries contribute to an average annual harvest of approximately 181,000 salmon (2006–2015; Lipka et al. 2019). The subsistence salmon fishery in the area is one of the largest in Alaska and remains a fundamental component of local culture (Lipka et al. 2019). Although the subsistence salmon fishery occurs throughout the area, the majority of subsistence fishing effort occurs within the lower 320 rkm (200 mi) of the Kuskokwim River, Goodnews Bay, and the Kanektok River within Kuskokwim Bay (Lipka et al. 2019). Since 2016, the Kuskokwim River has been separated into 5 subsistence fishing zones (Figure 1). During times of restricted Chinook salmon subsistence fishing, each of these zones can be managed independently. Since 2001, the commercial salmon fishery has occurred in 3 districts within the management area (Lipka and Tiernan 2018). District 1 is in the lower portion of the Kuskokwim River, and Districts 4 and 5 encompass areas in Kuskokwim Bay near the Kanektok and Goodnews Rivers, respectively. From 2016 to 2019, due to a lack of interest, large-scale commercial fisheries ceased in the area, and commercial opportunity was limited to registered catcher–sellers (Lipka and Tiernan 2018). In 2020, commercial fishing opportunities were provided in Districts 4 and 5 (Figure 2). The sport fishery is the smallest of the 3 fisheries and occurs throughout the area.

Aerial surveys during peak salmon spawning have been conducted annually since 1959 in select rivers throughout the management area to index salmon escapement (Molyneaux and Brannian 2006). Aerial surveys flown on Kuskokwim Bay rivers provide an index of Chinook and sockeye salmon escapement. Kuskokwim River aerial surveys index only Chinook salmon escapement. A total of 145 individual rivers and lakes throughout the management area have been surveyed at least once (Brannian et al. 2006; AYKDBMS[1]). Although aerial surveys provide the most cost-effective means of monitoring salmon escapements, they are subject to limited reliability and high variability in precision depending on viewing conditions, the surveyor's experience, and the timing of the surveys (Burkey et al. 2001).

Weirs have been used annually since the late 1970s throughout the management area to estimate total escapement to specific spawning tributaries and collect age, sex, and length (ASL) data from Chinook, chum, sockeye, and coho salmon (AYKDBMS). Weir locations were chosen based on salmon abundance, ability to install and operate a weir, monitoring history in the area, availability of funding, and perceived local importance and interest. Pink salmon escapement data have been collected at escapement projects; however, the smaller body size of pink salmon has allowed some to pass through the weirs undetected, making complete counts impossible. In addition to Pacific salmon, many other resident fish species are commonly observed in monitored streams. Ground-based weir projects provide a dependable and rigorous approach to escapement monitoring. However, the relatively high costs of weir projects and the limitations of installing weirs in large or fast-flowing rivers limit the number of salmon-producing tributaries that can be monitored using this method.

There are several considerations when comparing weir and aerial survey data and when comparing data across years. Substantial effort has been made to standardize aerial survey and weir assessment methods so that data collected at a location may be compared to prior years and provide information about escapement trends over time. However, aerial survey indices and weir counts are different and are not directly comparable. Aerial surveys provided only an index of peak spawning abundance to a broad geographic area, but weir counts were used to estimate the total number of salmon that escaped past a specific location over the entire season. In addition, aerial survey indices are not directly comparable among monitored locations within the same year due

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[1] Arctic–Yukon–Kuskokwim Database Management System (AYKDBMS). 2006– . Alaska Department of Fish and Game, Division of Commercial Fisheries. Juneau, AK. https://www.adfg.alaska.gov/CF_R3/external/sites/aykdbms_website/Default.aspx (accessed: March 2021). Hereafter cited as AYKDBMS.

to differences in observation error, weather conditions, and survey area size. Conversely, weir counts may be compared among the various monitoring locations within the same year if the total annual escapement was estimated.

Formal escapement goals have been established for Chinook, chum, sockeye, and coho salmon in select monitored area tributaries (Liller and Savereide 2018; Table 1). Within the Kuskokwim River and Bay tributaries, Chinook salmon escapement goals were established on 12 tributaries; 4 goals were assessed using weirs, and 8 goals were assessed using aerial surveys. There were 2 weir-based escapement goals for chum salmon and 3 weir-based escapement goals for coho salmon. Sockeye salmon escapement goals were established on 3 tributaries; 1 goal was assessed using a weir, and 2 goals were assessed using aerial surveys.

Kuskokwim River Chinook salmon are the only species with an established drainagewide escapement goal (Hamazaki et al. 2012; Liller and Savereide 2018; Table 1). Estimates of total annual abundance are achieved using a maximum likelihood model that uses data collected from ground-based escapement monitoring projects, aerial surveys, and harvests (Table 2; Bue et al. 2012; Larson 2020). The model estimate is used to evaluate the drainagewide escapement goal for Chinook salmon (65,000–120,000 fish; e.g., Larson 2020).

This report presents the results of sampling activities and escapement monitoring from all aerial surveys and weir projects operated by the Alaska Department of Fish and Game (ADF&G) and partner organizations in 2020. Historical information for weirs and aerial surveys not operated this year can be found in the AYKDBMS. ADF&G was the lead on all aspects of the George and Kogrukluk River weirs. ADF&G worked in collaboration with MTNT Ltd. to operate the Salmon River (Pitka Fork) weir. ADF&G provided funding to the National Park Service (NPS) to operate the Telaquana River weir. Additionally, the Kuskokwim River Inter-Tribal Fish Commission (KRITFC) secured funding to independently operate the Takotna River weir. ADF&G helped facilitate these projects by providing infrastructure, sampling protocol, permitting, data analysis, and handling all reporting requirements. The projects discussed in this report provide information necessary for the annual assessment of escapement goals in the Kuskokwim Area, including estimating the total run size of Kuskokwim River Chinook salmon. The U.S. Fish and Wildlife Service (USFWS) typically operates a weir on the Kwethluk River; however, the weir did not operate in 2020. Historical escapement data for the Kwethluk River weir is in the AYKDBMS. Data collected to determine ASL compositions are reported in *Salmon age, sex, and length catalog for the Kuskokwim Area* (e.g., Berry and Larson 2021).

OBJECTIVES

1. Conduct aerial surveys of Chinook and sockeye salmon abundance under good or fair survey conditions between 17 July and 5 August on the following rivers in 2020:

   Kuskokwim Bay – Chinook and sockeye salmon

   - North Fork Goodnews River
   - Middle Fork Goodnews River
   - Kanektok River

   Kuskokwim River – Chinook salmon

   - Kwethluk River
   - Kisaralik River

- Aniak River
- Salmon River (Aniak drainage)
- Kipchuk River
- Holokuk River
- Oskawalik River
- Cheeneetnuk River
- Gagaryah River
- Salmon River (Pitka Fork drainage)
- Pitka Fork
- Bear Creek

2. Estimate daily and annual escapements of Pacific salmon species at weirs operated on the following rivers during a time that corresponds to each project's standard estimation range in 2020:

   Kuskokwim River

   - Salmon River (Aniak) – Chinook, chum, and sockeye salmon between 15 June and 15 August
   - George River – Chinook, chum, and coho salmon between 15 June and 20 September
   - Kogrukluk River – Chinook, chum, sockeye, and coho salmon between 26 June and 25 September
   - Telaquana River – sockeye salmon between 3 July and 26 August
   - Takotna River – Chinook and chum salmon between 24 June and 20 September
   - Salmon River (Pitka Fork) – Chinook salmon between 20 June and 15 August

3. Collect ASL data from adult salmon species using weir traps in 2020 such that minimum sample sizes meet or exceed the following:
   - Chinook salmon – Salmon River (Aniak) n = 260, Takotna n = 75, Salmon (Pitka Fork) n = 250, George and Kogrukluk n = 230
   - Sockeye salmon – Kogrukluk and Telaquana (sex and length data only) n = 250
   - Chum salmon – Kogrukluk n = 600, Salmon River (Aniak) and George n = 400
   - Coho salmon – George and Kogrukluk n = 400

METHODS

STUDY AREA

The Kuskokwim Area is defined in regulation (5 AAC 07.100) as all waters of Alaska between the latitude of the westernmost point of the Naskonat Peninsula and the latitude of the southernmost tip of Cape Newenham, including the waters of Alaska surrounding Nunivak and St. Matthews Island and those waters draining into the Bering Sea (Figure 1). For the purposes of this report, the area was divided into Kuskokwim Bay and the Kuskokwim River. Kuskokwim Bay includes mainland coastal streams (excluding the Kuskokwim River) and commercial fishing Districts 4 and 5. The Kuskokwim River includes the mainstem, all tributaries of the river, commercial fishing District 1, and subsistence Sections 1–5.

Escapement monitoring was conducted in select salmon spawning tributaries draining into the Kuskokwim Area. In 2020, ADF&G and its partners attempted to monitor escapement in 3 rivers draining into Kuskokwim Bay and 16 tributaries in the Kuskokwim River drainage (Figures 2 and 3). Chinook, chum, sockeye, and coho salmon were present at all monitored locations; however, not all species were present in large numbers at all locations.

Kuskokwim Bay Assessment Locations

Goodnews River

Monitoring efforts within the north and middle forks of the Goodnews River provided an index of salmon escapement to the entire Goodnews River drainage. The Goodnews River watershed drains an area of approximately 2,636 km^2 (Brown 1983). Originating on the north side of the Ahklun Mountains, the Goodnews River flows southwesterly for a distance of 127 river kilometers (rkm) until emptying into Goodnews Bay, nested within Kuskokwim Bay. The mainstem Goodnews River is the northernmost branch of the Goodnews River system and is referred to as the North Fork. Chinook and sockeye salmon escapement to the North Fork was monitored by aerial survey. The Middle Fork of the Goodnews River flows southwesterly for a distance of approximately 97 rkm before joining the North Fork a few miles upriver from Goodnews Bay (Buzzell 2011). Chinook and sockeye salmon escapement to the Middle Fork was monitored by aerial survey.

Kanektok River

Monitoring efforts within the Kanektok River provided an index of salmon escapement to the entire Kanektok River. The Kanektok River watershed drains an area of approximately 2,261 km^2 (Walsh et al. 2006). The Kanektok River originates from Kagati and Pegati Lakes, located between the Eek and Ahklun Mountains, and flows westerly for 147 rkm until emptying into Kuskokwim Bay near the village Quinhagak (Buzzell and Russell 2010). Chinook and sockeye salmon escapement to the Kanektok River was monitored by aerial survey.

Lower Kuskokwim River Assessment Locations

Kwethluk Canyon River

The Kwethluk River originates in the Kilbuck Mountains, one of the defining barriers separating Bristol Bay and Kuskokwim River drainages. The river flows northwest for approximately 261 rkm until entering Kuskokuak Slough (at rkm 6), which then flows into the Kuskokwim River (at rkm 131). Crooked Creek (also known as Canyon Creek) is a tributary in the upper reach of the drainage (Buzzell 2010a). This aerial survey was added in 2020 because USFWS was unable to operate the Kwethluk River weir due to COVID-19.

Kisaralik River

The Kisaralik River is located between the Tuluksak and Kwethluk Rivers, the latter of which was monitored by USFWS using a weir. Aerial surveys flown on the Kisaralik River were used to index Chinook salmon escapement to the Lower Kuskokwim River, a portion of the drainage where subsistence and sport fishing was common. The Kisaralik River originates from Kisaralik Lake in the Kilbuck Mountains and flows northwesterly for approximately 187 rkm until reaching Kuskokuak Slough at rkm 135 (Buzzell 2010b), and then flows into the Kuskokwim River at rkm 131.

Middle Kuskokwim River Assessment Locations

Aniak River Drainage

The mainstem Aniak River is a large tributary that drains the southern portion of the middle Kuskokwim River. The Aniak River originates from the Aniak Lake basin in the Kuskokwim Mountains and flows northerly for approximately 151 rkm until entering the Kuskokwim River at rkm 307 near the community of Aniak (Brown 1983). Chinook salmon escapement was monitored throughout the mainstem Aniak River by aerial survey.

The Salmon River is a tributary of the Aniak River, and the assessment provides an index of salmon abundance to the Aniak River. The Salmon River originates in the Kilbuck Mountains and flows northerly for approximately 71 rkm to its confluence with the Aniak River. Chinook salmon abundance was monitored using aerial surveys. In addition, Chinook, chum, and sockeye salmon escapement were monitored using a fixed picket weir. The weir was located approximately 1 km upstream of the confluence with the Aniak River at 61°03′46″N, 159°11′40″W. At the weir site, the river measures 35 m wide and 1.25 m deep during normal summer operations. Due to its proximity to the confluence, the weir accounts for nearly all salmon spawning within the Salmon River.

The Kipchuk River is a headwater tributary of the Aniak River, and the assessment provides an index of salmon abundance to the Kipchuk River. The Kipchuk River originates in the Kuskokwim Mountains, several kilometers northwest of Aniak Lake. The Kipchuk River flows northerly for approximately 106 rkm until reaching the Aniak River. Chinook salmon escapement was monitored using aerial surveys.

Holokuk and Oskawalik Rivers

The Holokuk and Oskawalik Rivers are relatively small tributaries that drain the southern portion of the middle Kuskokwim River. The Holokuk River flows northeasterly, approximately 72 rkm from its origins in the Buckstock Mountains, which separate the Holokuk River from the Aniak River. It joins the Kuskokwim River at rkm 362 near the community of Napaimute (Brown 1983). The Oskawalik River originates from streams draining the Chuilnuk Mountains, which separate the Oskawalik River from the Holitna River basin. This river flows north-northwesterly for approximately 89 rkm until reaching the Kuskokwim River at rkm 398 (Brown 1983). Aerial surveys flown on each river were used to index Chinook salmon escapement to the middle portion of the Kuskokwim River drainage.

George River

The George River is the only monitored tributary that drains the northern portion of the middle Kuskokwim River. The George River originates in the northern Kuskokwim Mountains and flows southerly for approximately 120 rkm to its confluence with the Kuskokwim River at rkm 446. (Brown 1983). Chinook, chum, and coho salmon escapement was monitored using a resistance board weir. The weir was located approximately 7 rkm upstream of its confluence with the Kuskokwim River at 61°55′24″N, 157°41′53″W. At the weir site, the river channel is about 110 m wide and has a depth of about 1 m during normal summer flow. Due to its proximity to the confluence, the weir accounts for nearly all salmon spawning within the George River.

Holitna River Drainage

The Holitna River watershed is one of the largest in the Kuskokwim basin, including the Kuskokwim, Kiokluk, and Chuilnuk Mountains to the west and the Shotgun and Nushagak Hills to the south. The Holitna River is formed from the confluence of the Chukowan and Kogrukluk Rivers and flows northerly for approximately 218 rkm until reaching the Kuskokwim River at rkm 491 near the community of Sleetmute (Brown 1983; ADNR 1988). The Holitna River drainage is a highly productive system that supports large numbers of spawning salmon (Molyneaux and Brannian 2006). Chinook salmon escapement was monitored throughout the mainstem of the Holitna River using aerial surveys. The Holitna River is also the single largest source of river-type sockeye salmon (Gilk et al. 2011).

The Kogrukluk River is a headwater tributary of the Holitna River, and the assessment provides an index of salmon abundance to the Holitna River. The Kogrukluk River forms a low plateau that divides the Tikchik Lakes system and Nushagak River basin to the south from the Holitna River basin to the north. From its headwaters, the Kogrukluk River flows northerly for approximately 80 rkm to its confluence with the Chukowan River to form the Holitna River (Brown 1983). Chinook, chum, sockeye, and coho salmon escapements were monitored with a fixed picket weir. The weir was located approximately 1.5 rkm from the confluence with the Holitna River at 60°50′28″N, 157°50′44″W. At the weir site, the channel averages 70 m wide and 1.25 m deep. Due to its proximity to the confluence, the weir accounts for nearly all salmon spawning within the Kogrukluk River.

Stony River Drainage

The Stony River joins the Kuskokwim River at rkm 536 and supports sockeye salmon and a modest return of Chinook salmon. Telaquana Lake and Two Lakes form the headwaters of the Stony River and are the largest lake systems in the Kuskokwim River drainage. Both lakes provide the requisite habitat for lake-spawning sockeye salmon and are the primary producers of lake-type sockeye salmon in the Kuskokwim River drainage.

Escapement of sockeye salmon was assessed using a weir located on the Telaquana River near the outlet of Telaquana Lake. The Telaquana River originates in the mountains above Telaquana Lake, located in Lake Clark National Preserve. The Telaquana River watershed is bounded by the Neacola Mountains to the east and a low plateau to the south, separating it from the Bristol Bay watershed. From its headwaters, the Telaquana River flows westerly for approximately 30 rkm before entering Telaquana Lake. From the mouth of the lake, the Telaquana River flows 50 rkm to its confluence with the Stony River, which then joins the Kuskokwim River at rkm 536. The Telaquana River weir was located approximately 1 rkm downstream of the Telaquana Lake outlet at 60°57′39″N, 154°02′40″W. The weir spans a 70 m channel, and the average channel depth is approximately 1.2 m with a maximum depth of 2.1 m. The weir accounts for all sockeye salmon spawning in Telaquana Lake, including those fish spawning in the lake outlet.

Swift River Drainage

The Swift River is a large tributary that flows northwesterly and joins the Kuskokwim River at rkm 560 (Brown 1983). The Cheeneetnuk and Gagaryah Rivers are parallel tributaries of the Swift River, and aerial surveys were flown on these rivers to index Chinook salmon escapement to the Swift River. The Cheeneetnuk River originates in the foothills of the Alaska Range and flows southwesterly for approximately 113 rkm before reaching the Swift River (at rkm 27). The

Gagaryah River originates in the Lyman Hills and flows southwesterly for approximately 100 rkm before joining the Swift River (at rkm 61).

Upper Kuskokwim River Assessment Locations

Takotna River Drainage

The Takotna River originates in the central Kuskokwim Mountains of the Upper Kuskokwim River basin. The Takotna River is approximately 160 rkm in length (Brown 1983). Formed by the confluence of Moore Creek and Little Waldren Fork, the Takotna River flows northeasterly and passes the community of Takotna at rkm 80 before turning southeasterly near the confluence of the Nixon Fork at rkm 24 and empties into the Kuskokwim River at rkm 752 across the river from the community of McGrath. Chinook and chum salmon escapement was monitored with a resistance board weir installed at 62°58′06″N, 156°05′54″W, upstream of the Takotna River Bridge near the community of Takotna. The river channel at this site is 85 m wide and less than 1 m deep during normal summer flow. This site allows for the enumeration of spawning salmon in the Takotna River drainage, excluding those in the Nixon Fork tributary.

Pitka Fork Drainage

The Pitka Fork originates in a piedmont area north of the Alaska Range and flows northerly 106 rkm before joining the Middle Fork (Brown 1983). The Middle Fork then flows northwesterly until reaching the Big River, which finally joins the Kuskokwim River at rkm 827 (Brown 1983), upstream from the community of McGrath. Tributaries of the Pitka Fork are the northernmost monitored systems within the Kuskokwim River drainage and provide an index of Chinook salmon escapement in the headwaters of the Kuskokwim River. Chinook salmon escapement was monitored on the Pitka Fork by aerial survey.

The Salmon River is a tributary of the Pitka Fork and flows northwesterly for approximately 47 rkm before joining the Pitka Fork 36 rkm upriver from its confluence with the Middle Fork. Chinook salmon escapement was monitored by aerial survey and a fixed picket weir. In 1981 and 1982, the weir was located on the South Fork of the Salmon River before being discontinued. In 2015, the weir was reestablished immediately downriver of the confluence of the north and south forks at 62°53′21″N, 154°30′35″W. The location change allowed a more complete assessment of Chinook salmon escapement to the Salmon River. At the weir site, the river measures approximately 45 m wide and 1 m deep during normal summer operations.

Bear Creek is a relatively small northwest-flowing tributary that joins the Pitka Fork approximately 44.8 rkm upriver from its confluence with the Middle Fork. The confluence of Bear Creek is located approximately 9.3 rkm southeast of the Salmon River with a nearly parallel flow direction. Chinook salmon escapement in Bear Creek was monitored by aerial survey.

ESCAPEMENT MONITORING

Aerial Surveys

Aerial surveys focused on Chinook salmon in Kuskokwim River tributaries but surveyed both Chinook and sockeye salmon in Kuskokwim Bay rivers (Table 3). On occasion, other salmon species were counted opportunistically during aerial surveys; however, those counts were not representative of spawning escapement and were considered ancillary. Aerial survey counts of live fish, carcasses, spawning redds, survey ratings, and observer comments were archived in the AYKDBMS.

Aerial surveys were planned on 13 tributaries in the Kuskokwim River and on 3 rivers in Kuskokwim Bay in 2020 (Table 3, Figures 2 and 3). Standardized index areas were flown within each river to allow for interannual comparisons of aerial survey counts (Appendix A; Schneiderhan 1988). Index areas were defined by geographic coordinates and often coincided with landmarks that were easily recognized from the air. For each river, lists of survey areas (Appendix A) and corresponding maps were created that depict index areas and highlight areas that must be surveyed (i.e., index objectives) in order to produce comparable indexes of escapement. Details regarding survey locations were archived in the AYKDBMS.

One-time peak aerial surveys were conducted following standardized procedures. Aerial surveys were conducted with fixed-winged aircraft at an altitude of 150–500 feet, dependent on both surveyor and pilot preference and weather conditions. Aerial survey operational standards required that all surveys be flown between the dates of 17 July and 5 August, which is believed to encompass peak spawning abundance for both Chinook and sockeye salmon across a range of locations and run timings. Observers rated survey conditions as being good (rating = 1), fair (rating = 2), or poor (rating = 3) based on criteria related to survey method, weather, and water conditions, time of the survey, and spawning stage (Schneiderhan 1988). During the flight, the surveyor recorded counts of live salmon and carcasses for each index area on a tally counter. Survey counts from only the objective index areas were summed to determine the escapement index. The escapement index was only reported if survey conditions were rated as good or fair for the entire survey.

Weir Projects

Weir Design and Installation

A fixed picket or resistance board weir design with an integrated fish trap was used at all locations depending on channel morphology and flow. A resistance board floating weir is designed to sink beneath flood waters, allowing debris to pass downstream with little obstruction. Resistance board weirs require a nearly level bottom profile and low enough water levels during the installation period to allow the crew working in snorkel gear to attach weir components to the stream bed. Seasonal flooding occurs in the area and resistance board weirs are preferred; however, not all rivers have conditions that allow the installation and operation of resistance board weirs. In such cases, fixed picket weirs were employed. Fixed picket weirs have a rigid structure that requires disassembly for debris to pass freely downstream. These weirs are more prone to damage and often require disassembly during flood conditions. However, fixed picket weirs can be installed at higher flows and in more variable channel conditions. All weirs utilized a live fish trap design capable of freely passing fish or trapping fish for sampling purposes. The live fish trap design was the same for all projects (Linderman et al. 2002). Additional details on the design and materials used for the construction of resistance board weirs can be found in Tobin (1994) and Stewart (2002 and 2003); and for fixed picket weirs in Molyneaux et al. (1997), Baxter (1981), and Jasper and Molyneaux (2007).

Slight differences in picket spacing existed between projects. Weirs on the George and Takotna Rivers had a gap of 3.3 cm between each picket, Salmon (Aniak) and Salmon (Pitka Fork) weirs had a gap of 3.6 cm, Kogrukluk River weir had a gap of 3.7 cm, and Telaquana River weir had a gap of 2.6 cm between each picket. Regardless of the spacing differences, all designs prevented most adult Pacific salmon from passing through the weirs undetected. However, pink salmon and other nonsalmon species have been observed passing between pickets.

Weirs were installed across the entire river channel. On tributaries with resistance board weirs, the substrate rail and resistance board panels covered the middle 90% of each channel, and fixed weir materials extended the weirs to each bank. Resistance board and fixed weir lengths were adjusted during the season based upon minor changes in the width and depth of the river. A boat gate and a downstream fish passage chute were installed following techniques described by Linderman et al. (2002). Additional details on techniques for weir installation can be found in Stewart (2003).

Operations

Each weir project has a planned operational period based on historical run timing information and available funding (Table 4). The planned operational period describes the dates the weir was scheduled to operate. The planned operational periods were intended to cover most of each target species escapement, representing either a subset or the entire standard estimation range. The term standard estimation range describes the date range for which total escapement is estimated so that escapements are comparable among years. The duration of the planned operational period ensured that high-quality estimates of total escapement could be generated for the standard estimation range.

In 2020, ADF&G and its partners evaluated available funding and data needed to establish planned operational periods to ensure estimates could be generated for target species at each site (Table 4). Projects that had available funding to operate for the entirety of the standard estimation range were the George, Kogrukluk, and Telaquana Rivers weirs. Takotna and Salmon (Aniak) weirs were operated for a subset of the standard estimation range due to funding constraints, which was adequate to assess escapement for all salmon species except coho salmon.

DATA COLLECTION AND ANALYSIS

Escapement Counts

Daily escapement counts were conducted at all weirs. Crew members visually identified all species of fish observed passing upstream of the weir and recorded them on a tally counter. Fish were counted for approximately 1 hour, 4 to 8 times daily, between 0700 and 2400 hours. This schedule was adjusted as needed to accommodate variations in fish behavior and abundance or operational constraints, such as reduced visibility in evening hours late in the season. The live trap was used as the primary means of upstream fish passage. A clear plastic viewing window was placed on the water surface to improve the visual identification of fish entering the trap. Fish were only allowed to pass freely through the weir when an observer was present and opened the passage gate. Following each counting shift, passage numbers were recorded in a designated logbook, and the weir was inspected for holes and cleaned of carcasses and debris. If holes were found, a note was made regarding the size, location, and if there was a potential for missed fish passage. Total daily and cumulative seasonal counts were reported along with operational details to ADF&G staff in Bethel or Anchorage by 10:00 AM daily and uploaded to the AYKDBMS that same day.

Missed Escapement Estimates

Various conditions can result in periods where fish can pass the weir site undetected. Conditions include, but are not limited to, (1) water levels preventing installation, requiring partial disassembly, or prompting the removal of the weir; (2) water levels exceeding the top of the weir; (3) holes created from scouring, debris, or wildlife; (4) maintenance requiring partial disassembly of the weir; or (5) the counting gate being left open unattended. Duration of time when a weir was not fully operational (i.e., inoperable) varied from a part of a single day to several days. Missed escapement of target species was estimated for all inoperable days within the standard estimation range. No missed escapement estimates were created for nontarget species.

Missed escapement was estimated using a hierarchical Bayesian estimation technique (Adkison and Su 2001; Jasper et al. 2018). All historical run timing was fitted to a log-normal distribution, in which each year's parameters were assumed to come from a common distribution (i.e., hierarchical parameters). Further, it was assumed that the distribution of daily run timing followed a log-normal distribution (i.e., log plus 1 transformed count or ln(daily count +1) was normally distributed).

Let y_{it} be the log plus 1 transformed count of year (i) and day (t) (y_{it} = ln(daily weir passage +1)), the +1 allows the avoidance of $In(0)$ the model removes the 1 after it is estimated; and assume that y_{it} is a random variable from a normal distribution of mean (θ_{it}) and standard deviation of day (t), σ_t. Then:

$$y_{it} \sim N(\theta_{it}, \sigma_t^2)$$

and

$$\theta_{it} = exp(a_i) exp\left(-\frac{(ln(t) - ln(\mu_i))^2}{2b_i^2}\right)$$

where:

$\sigma_t^2 > 0$, variance of daily passage of the day (t);

$a_i > 0$, the peak daily passage of the year (i);

$t \geq 1$, passage date;

$\mu_i > 0$, mean passage date of the year (i); and

$b_i^2 > 0$, variance of run timing of the year (i).

The starting passage date and number and range of years with data vary among projects (Table 5). At the upper hierarchical level, annual maximum daily passage (a_i), mean passage date (μ_i), and spread (b_i) were assumed to be a random sample from a normal distribution:

$$a_i \sim N(a_0, \sigma_a^2); \qquad \mu_i \sim N(\mu_0, \sigma_\mu^2); \qquad b_i \sim N(b_0, \sigma_b^2).$$

In most cases, prior distributions of the hyper-parameters for a_0, μ_0, and b_0 were derived from observed escapement, where:

a_0 = median(ob a_{is}) ; μ_0 = median(ob μ_{is}) ; b_0 = median(ob b_{is}) ;

σ_a = var(ob a_{is}) ; σ_μ = var(ob μ_{is}) ; σ_b = var (ob b_{is}) ;

σ_t was assumed to be uniformly distributed with the range of 0 to 50.

Markov-chain Monte Carlo (MCMC) methods (program JAGS [Plummer 2003] and Appendix B) were used to generate the joint posterior probability distribution of all unknowns in the model. Simulations were generated over 10,000 iterations, with the first 5,000 iterations discarded (burn-in period), and samples were taken every 2 iterations. This resulted in 2,500 samples, and the median sample value was used to represent the point estimate of daily missed passage. From those, Bayesian credible intervals (95%) were obtained from the percentiles (2.5 and 97.5) of the marginal posterior distribution. This was a slight deviation from historical methods. Prior to 2019, WinBUGS (Spiegelhalter et al. 1999) was used for the MCMC analysis. All historical estimates were reevaluated using JAGS.

Available historical data limited estimation of missed passage to the dates of each project's standard estimation range. All missed escapements for Chinook, chum, and sockeye salmon that occurred on or after 1 September through the end of each project's standard estimation range were assumed 0 based on historical information. Based on the evaluation of model fit, the Bayesian model provided accurate and precise estimates of total escapement if there was adequate count data to inform the timing and relative magnitude of the peak of annual spawning runs. Actual count data from a minimum of 60% of the run was expected to provide adequate information to inform annual estimates. The model performs best when it has good information about the peak passage; 60% of the run gives a high likelihood of informing peak passage. Therefore, if more than 40% of the entire run was missed, based on historical run timing, estimates of missed passage were not created, and total annual escapement was not imputed. The actual fit of the model is assessed by examining the curve created by the actual counts and the estimates.

Total annual escapement was estimated as the sum of the daily observed escapement counts and the daily estimates of missed escapement within the standard estimation range. Estimates of daily escapement were used for each day the weir was inoperable unless the estimate was less than the actual number of fish observed during partial operations. In these scenarios, the estimate was disregarded, and the observed escapement was considered a minimum daily escapement estimate.

WEATHER AND STREAM MEASUREMENTS

Weather and stream data were collected at all projects (Appendices C1–C6). Water and air temperatures were manually measured (°C) using handheld analog thermometers. Notations about cloud cover, precipitation, and river stage were also recorded. Daily precipitation was measured (mm) using a rain gauge, and water levels were measured (cm) using staff gauges installed approximately 150 meters from the weirs. The staff gauge was calibrated to a benchmark using a sight or line level. All data were collected in the morning and evening at all projects. In addition, water clarity observations were recorded at Kuskokwim River weir projects. Air and water temperature data were monitored year-round by Hobo data loggers as part of the Office of Subsistence Management Temperature Monitoring, contract number 140F0720P0029, operated by the Aquatic Restoration and Research Institute.

AGE, SEX, AND LENGTH SAMPLING

A minimum sample size was determined for each species to achieve 95% confidence intervals of age-sex composition estimates no wider than ±10% (α = 0.05 and d = 0.10; Bromaghin 1993). Sample size goals (n) were estimated based on 10 age-sex categories for Chinook salmon (n = 190), 14 age-sex categories for sockeye salmon (n = 205), 8 age-sex categories for chum salmon (n = 180), and 6 age-sex categories for coho salmon (n = 168). Sample size goals were increased to account for unreadable scales, collection errors, and variation in run timing and to allow investigation of interannual changes in ASL composition. For most project locations, the collection goal was 230 Chinook, 400 chum, 250 sockeye, and 400 coho salmon. The Chinook salmon sampling goal was increased to 250 fish at the Salmon River (Pitka Fork) weir because the percentage of unreadable scales was expected to be larger than in other locations because of scale reabsorption. At the Kogrukluk and Telaquana weirs, the sockeye salmon collection goal was 250 fish, but only sex and length data were collected. Sockeye scales were not collected from Kuskokwim River escapement projects because previous reports indicated that saltwater age could not be estimated from scales because of excessive deterioration of the scale margins (Liller et al. 2016). Sampling schedules were provided for each weir project. Schedules attempted to guide the collection of samples throughout the season in proportion to historical run timing and ensure an appropriate distribution of sampling effort across the run.

Age, sex, and length sample collection followed standardized procedures developed for the Arctic–Yukon–Kuskokwim Management Area (Eaton 2015). Salmon were captured for sampling using a trap integrated into the weir design. Following capture, crew members used safe handling techniques to place the fish into a partially submerged fish cradle. Scales were taken from the preferred area of the fish (INPFC 1963) and transferred to numbered gum cards. Sex was determined through a visual examination of the external morphology, focusing on the prominence of a kype, the roundness of the belly, and the presence or absence of an ovipositor. Length from the middle of the eye to the fork in the tail was measured to the nearest millimeter using a straight-edged meter stick. Sex and length data were recorded on standardized numbered data sheets that corresponded with numbers on the gum cards used for scale preservation. After sampling, each fish was released upstream of the weir. The procedure was repeated until the trap was emptied. Sampling procedures were not biased for size or sex and were designed to reduce stress caused by holding and handling time. Further details regarding trapping methods or fish handling techniques can be found in Liller et al. (2016).

After sampling was completed, all ASL data and metadata were copied to Microsoft Excel spreadsheets that corresponded to numbered gum cards. Completed Excel spreadsheets were sent in digital format to the Anchorage ADF&G office for processing. The original ASL gum cards, acetates, and paper forms were archived at the ADF&G office in Anchorage. Data were also archived in the AYKDBMS.

RESULTS AND DISCUSSION

OPERATIONS

Aerial Surveys

Aerial surveys were conducted on all 16 of the scheduled rivers in 2020. All surveyed rivers were flown once between 26 July and 3 August for Chinook salmon and on 3 August for sockeye salmon, except Kanektok (Tables 6 and 7). Kanektok was flown on 13 August, outside the date range that allows the escapement index to be determined. Gagaryah was flown, but weather conditions were too poor for an accurate count. The remaining Chinook and sockeye salmon escapement indices were successfully determined for all surveyed rivers (Tables 6 and 7).

Weir Projects

Salmon River (Aniak) Weir

The Salmon River (Aniak) weir operated from 5 July to 20 August 2020. The weir was out of operation for 3 partial days due to holes in the weir and high water (Table 8). The weir was installed 19 days late due to high water conditions, resulting in a shortened operational period. Postseason evaluation indicated that the actual operational dates were adequate to observe at least 60% of the escapement based on historical run timing. As such, there was sufficient data to generate a reliable estimate for Chinook, chum, and sockeye salmon. Weather and stream observations were recorded between 7 July and 20 August (Appendix C1).

George River Weir

The George River weir was operated from 15 June through 18 September 2020. The weir did not have any inoperable days (Table 8). Total escapement was estimated for all target species. Weather and stream observations were recorded between 15 June and 18 September (Appendix C2).

Kogrukluk River Weir

The Kogrukluk River weir was operated from 21 June through 7 September 2020. During this period, the weir was inoperable for 2 full days and 10 partial days due to holes in the weir and high water (Table 8). The weir was washed out by a flooding event and high waters preventing reinstalling it, resulting in the operational period being shortened by 18 days. Postseason evaluation indicated that the actual operational dates were adequate to observe at least 60% of the escapement for Chinook, chum, and sockeye salmon based on historical run timing. As such, there was sufficient data to generate a reliable estimate for Chinook, chum, and sockeye salmon. Total escapement for coho salmon could not be estimated due to excessive missed passage during the peak of the run and early weir removal due to flooding. Weather and stream observations were recorded between 20 June and 15 September (Appendix C3).

Telaquana River Weir

The Telaquana River weir was operated from 12 July through 24 August 2020. During this period, the weir did not have any inoperable days (Table 8). The weir was installed 11 days late due to travel restrictions imposed by COVID-19 concerns. Postseason evaluation indicated that the actual operational dates were adequate to observe at least 60% of the escapement based on historical run timing. As such, there was sufficient data to generate a reliable estimate for sockeye salmon. Weather and stream observations were recorded between 10 July and 24 August (Appendix C4).

Takotna River Weir

The Takotna River weir was operated from 12 July through 10 August 2020. During this period, the weir was inoperable for 3 full days and 3 partial days due to holes in the weir and high water (Table 8). The weir was installed 16 days late due to high water conditions, resulting in a shortened operational period. Postseason evaluation indicated that the actual operational dates were adequate to observe at least 60% of the escapement for Chinook salmon based on historical run timing. As such, there was sufficient data to generate a reliable estimate for Chinook salmon. Total escapement could not be estimated for chum salmon due to greater than 40% missed passage. Weather and stream observations were recorded between 1 July and 10 August (Appendix C5).

Salmon River (Pitka Fork) Weir

The Salmon River (Pitka Fork) weir was operated from 19 June through 15 August 2020, and the weir had no inoperable days (Table 8). Total escapement was estimated for Chinook salmon. Weather and stream observations were recorded between 19 June and 15 August (Appendix C6).

Escapement Counts

Chinook Salmon

Aerial Survey

Aerial escapement counts were generally below the historical average[2] but were within escapement goal ranges for most of the management area. The Kanektok River aerial count was completed outside of the target dates for that river, and an escapement index was not produced. Although this count was done late, the number of fish counted in the survey was within the established sustainable escapement goal (SEG) and can be considered a minimum count (Table 6). The Middle Fork Goodnews River aerial count was slightly above average (Table 9). The North Fork Goodnews River aerial count was below average but within the established SEG (Table 9). All aerial survey indices in the lower and middle sections of the Kuskokwim River were below the averages (Table 9). In the upper portion of the Kuskokwim River, aerial survey indices were below average in 2 of the 3 rivers surveyed (Table 9). In 2020, 5 SEGs were assessed within the Kuskokwim River drainage. Of these 5 SEGs, 3 were met, and 2 were below the lower bound (Kisaralik and Salmon [Aniak] Rivers).

Weir

Chinook salmon escapement was estimated at 5 weirs in 2020. Annual escapements were successfully estimated for Chinook salmon at the Salmon (Aniak; 1,228 fish), George (2,418 fish), Kogrukluk (5,645 fish), Takotna (357 fish), and Salmon (Pitka Fork; 4,825 fish) weirs (Table 10). Chinook salmon escapements were below average throughout the Kuskokwim River (Table 11). The SEGs were met at the Kogrukluk and George weirs, which were the only 2 weir goals assessed in 2020 (Table 11). Weir counts indicated that, although low, Chinook salmon escapement was adequate to meet escapement needs in 2020.

Chinook salmon run timing was late at the Kuskokwim River weir projects in 2020 (Figure 4). Run timing at the weirs did not affect assessment. The operational periods were adequate to observe the entire escapement past each weir.

Chum Salmon

Weir counts indicated that chum salmon escapements were below average in 2020. Annual escapements were successfully estimated for chum salmon at the Salmon (Aniak; 1,995 fish), George (8,943 fish), and Kogrukluk (19,020 fish) weirs (Table 12). Escapements at these 3 weirs ranked between 10–19% of their historical escapements (Table 13). Although escapements were low in 2020, the SEG was met on the Kogrukluk River (Table 13).

Chum salmon run timing was late at the Kuskokwim River weir projects in 2020 (Figure 5). Run timing at the weirs did not affect assessment. The planned operational period was adequate to observe the entire run past each weir.

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[2] Unless otherwise noted, the term "average" refers to the historical average of all available annual escapement estimates for a given project through project year 2019. The number of years represented in historical averages varies by project. A comprehensive record of operational years and escapement estimates contributing to historical averages can be found in the Arctic-Yukon-Kuskokwim Database Management System.

Sockeye Salmon

Aerial Survey

Sockeye salmon aerial surveys were flown on 3 rivers in the Kuskokwim Bay area. The North Fork Goodnews River sockeye salmon aerial survey count was above average (55,110 fish) and more than triple the upper bound of the established SEG. The Middle Fork Goodnews River count was below average (18,390 fish; Table 14). The aerial survey on the Kanektok River was flown outside the target dates and an escapement index was not produced; however, the count taken exceeded the SEG (Table 7).

Weir

Annual escapements were successfully estimated for sockeye salmon at the Salmon (Aniak; 234 fish), Kogrukluk (9,923 fish), and Telaquana (177,509 fish) weirs (Table 15). Sockeye salmon weir escapement estimates indicated that escapement was well above average at the Telaquana River weir and below average at the Salmon (Aniak) and Kogrukluk weirs in 2020. Escapement at the Kogrukluk River fell within the established SEG. Escapement past the Telaquana River weir, although lower than the last 2 years, was the third largest on record and almost twice the average (2010–2019; Table 16).

Run timing was late at the Kogrukluk and Telaquana weirs (Figure 6). Run timing at the Salmon River (Aniak) weir was early (Figure 6). Run timing at the weirs did not affect assessment, and the planned operational period was adequate to observe the entire run past each weir.

Coho Salmon

The George River weir was the only assessment project that successfully estimated coho salmon escapement in 2020. Total escapement at the George River weir was above average in 2020 (21,426 fish; Table 17). Coho salmon run timing was late at the George River weir (Figure 7). Run timing at the George River weir did not affect assessment, and the operational period was adequate to observe nearly the entire run past the weir.

There are 3 SEGs for coho salmon, Middle Fork Goodnews, Kwethluk, and Kogrukluk Rivers, none of which could be assessed in 2020. Due to funding constraints, the Middle Fork Goodnews weir did not operate. The Kwethluk River weir was not operated by USFWS due to COVID-19. The estimates from the Kogrukluk River weir were unreliable (Table 18).

The Kogrukluk River weir was operated in 2020, but a reliable total escapement estimate for coho salmon could not be made. The established methods were applied to the available data to produce an estimate, but that estimate was deemed untrustworthy and was excluded. There were 3 days of counts that were very influential data points. These data were collected following a period of 4 days when the weir did not operate due to high water and just prior to the weir being removed 19 days early for the season in response to continued high water conditions. The concern is that these 3 daily counts were relatively low and had a substantial influence on model output and conclusions about the 2020 coho salmon escapement. At face value, and with no additional context, these 3 data points provided evidence that the run past the weir was nearing an end. However, staff were unable to determine with confidence if the weir was fish tight and if these counts were reliable. Furthermore, there was concern that the 3 low counts were not representative of the number of fish still moving upriver.

The sensitivity of model results to those 3 data points was explored by running the model with those data included and excluded. Including those data, per standard methods, resulting in an estimated model escapement of 12,797 (below SEG), and the cumulative daily passage estimate indicated that run timing was early. When these data were excluded, the result was an escapement estimate of 27,284 (within SEG), and the cumulative daily passage estimate indicated that run timing was late. Under this late timing scenario, the remaining data did not meet prior criteria for using the model to estimate missed passage because more than 40% of the run was estimated.

Information from other locations supported the decision not to use the model estimate based on standard methods. George River coho salmon run timing was late, and escapement was above average. Historically, coho salmon escapement at the George and Kogrukluk Rivers has been strongly correlated with run timing and abundance trends. It was unlikely that the 2020 coho escapements at these 2 locations would diverge substantially from historical patterns. Furthermore, in 2020, the Bethel test fishery (BTF) project was operated by ADF&G in the Lower Kuskokwim River to index coho salmon run timing. The BTF indicated late run timing. It is unlikely that the total run past Bethel was late, and the Kogrukluk River component arrived on the spawning ground early.

Nontarget Species

Nontarget species were observed at all weir projects in 2020. Pink salmon, Arctic grayling *Thymallus arcticus*, and whitefish *Coregonus* spp. were observed at nearly all weir projects. Sockeye salmon were observed at the George and Takotna weirs, and chum salmon were observed at the Telaquana and Salmon (Pitka Fork) weirs. Chinook salmon were observed at the Telaquana weir. Longnose suckers *Catostomus catostomus*, Dolly Varden *Salvelinus malma*, northern pike *Esox Lucius*, and rainbow trout *O. mykiss* were observed at multiple projects (Appendices D1–D6).

AGE, SEX, AND LENGTH COLLECTION

Chinook Salmon

Age, sex, and length samples were collected from Chinook salmon at the Salmon (Aniak; 174 fish), George (220 fish), Kogrukluk (231 fish), Takotna (74 fish), and Salmon (Pitka Fork; 259 fish) weirs. Sample goals were achieved at the Salmon (Pitka Fork) and Kogrukluk weirs and came very close to the goals for Takotna and George weirs (Table 19). Samples were collected on a near-daily basis spanning approximately the central 90% of the run, except at the Takotna River weir, where sampling spanned the central 80% of the run.

Chum Salmon

Age, sex, and length samples were collected from chum salmon at the Salmon (Aniak; 290 fish), George (417 fish), and Kogrukluk (602 fish) weirs. Sample goals were achieved at the George and Kogrukluk weirs (Table 19). Samples were collected on a near-daily basis, spanning approximately the central 92% of the run.

Sockeye Salmon

Sex and length samples were collected from the Kogrukluk (250 fish) and Telaquana (421 fish) weirs. Sample goals were achieved at both weirs (Table 19). Samples were collected on a near-daily basis, spanning approximately the central 94% of the run.

Coho Salmon

Age, sex, and length samples were collected from coho salmon at the George (408 fish) and Kogrukluk (203 fish) weirs. The coho salmon sample size goal was achieved at the George River weir but not at the Kogrukluk River weir (Table 19). Samples were collected on a near-daily basis, spanning approximately the central 72% of the run.

CONCLUSION

- Chinook salmon were successfully enumerated on 5 tributaries using weirs and 14 tributaries using aerial surveys in 2020. Except for 2 aerial surveys (which were slightly above average), weir and aerial survey assessments were below average. There were 11 escapement goals in 2020, of which 8 were assessed, 6 were met, and 2 were slightly below the lower bound.
- Chum salmon were successfully enumerated on 3 tributaries using weirs in 2020, and escapements were below average at all projects. The only chum salmon tributary escapement goal was assessed and met.
- Sockeye salmon were successfully enumerated on 3 tributaries using weirs and 2 tributaries using aerial surveys in 2020. Sockeye salmon escapement was above the historical average at 2 sites assessed and below average at 3 sites assessed. There were 3 escapement goals in 2020, of which 2 were assessed, 1 goal was met, and 1 goal was exceeded.
- Coho salmon were successfully enumerated on 1 tributary using a weir in 2020. Coho salmon escapement was above average. The escapement goal on the Kogrukluk River could not be assessed due to missed passage and perceived run timing at the project. There was no effort to monitor coho salmon escapement in Kuskokwim Bay due to funding constraints in 2020.

ACKNOWLEDGMENTS

Kuskokwim salmon escapement monitoring projects are only successful due to the hard work and diligence of all individuals who have contributed to the development and operations of each project.

The USFWS Office of Subsistence Management (OSM), provided funding support for George and Salmon River (Pitka Fork) weirs under agreement numbers F18AC00612 (Project No. 18-304) and F20AC00237 (Project No. 20-302), respectively, through the Fisheries Resource Monitoring Program. This report was submitted as the technical project report to USFWS OSM, Subsistence Fisheries Resource Monitoring Program for Project Numbers 18-304 and 20-302.

We thank all our collaborators: U.S. Fish and Wildlife Service, National Park Service (NPS), Native Village of Napaimute (NVM), Bering Sea Fisherman's Association, and MTNT Ltd. Administrative and logistic support was provided by Ben Gray (ADF&G), Nick Smith (ADF&G), Lily Reichard (AFG&G), and Dan Young (NPS). The authors thank ADF&G project crew leaders Rob Stewart, Charles Grammer, Mike Oexner, and Storm Phillips. A special thanks to all the technicians and interns from ADF&G, NPS, MTNT Ltd., and NVN. Toshihide Hamazaki (ADF&G Commercial Fisheries Biometrician) provided support with model code and equations, Zachary Liller (ADF&G Commercial Fisheries Research Supervisor) provided an editorial report review, and Bobby Hsu (ADF&G Biometrician) provided biometric review.

A big thank you goes out to the hard work put in by Tim Barnum at MTNT Ltd., and Kevin Whitworth at Kuskokwim River Inter-Tribal Fish Commission for their efforts to carry on the operation of the Salmon (Pitka Fork) and Takotna River weirs in 2020.

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TABLES AND FIGURES

Table 1.–Escapement goals for Kuskokwim Area salmon stocks, 2020.

Stock unit	Assessment method	Escapement goal: Goal	Type	Year established	Assessed in 2020
Chinook salmon (13 goals)					
Kuskokwim Bay rivers					
Kanektok River	Aerial survey	3,900–12,000	SEG	2016	x
Middle Fork Goodnews River	Weir	1,500–3,600	SEG	2019	
North Fork Goodnews River	Aerial survey	640–3,300	SEG	2005	x
Kuskokwim River / tributaries					
Kuskokwim River drainage[a]	Run reconstruction	65,000–120,000	SEG	2013	x
Aniak River	Aerial survey	1,200–2,300	SEG	2005	x
Cheeneetnuk River	Aerial survey	340–1,300	SEG	2005	x
Gagarayah River	Aerial survey	300–830	SEG	2005	
George River	Weir	1,800–3,300	SEG	2013	x
Kisaralik River	Aerial survey	400–1,200	SEG	2005	x
Kogrukluk River	Weir	4,800–8,800	SEG	2013	x
Kwethluk River	Weir	4,100–7,500	SEG	2013	x
Salmon River (Pitka Fork)	Aerial survey	470–1,600	SEG	2005	x
Salmon River (Aniak Drainage)	Aerial survey	330–1,200	SEG	2005	x
Chum salmon (2 goals)					
Kuskokwim Bay rivers					
Middle Fork Goodnews River	Weir	>12,000	SEG	2005	
Kuskokwim River tributaries					
Kogrukluk River	Weir	15,000–49,000	SEG	2005	x
Sockeye salmon (4 goals)					
Kuskokwim Bay rivers					
Kanektok River	Aerial survey	15,300–41,000	SEG	2016	
Middle Fork Goodnews River	Weir	22,000–43,000	SEG	2019	
North Fork Goodnews River	Aerial survey	9,600–18,000	SEG	2016	x
Kuskokwim River / tributaries					
Kogrukluk River	Weir	4,400–17,000	SEG	2010	x
Coho salmon (3 goals)					
Kuskokwim Bay rivers					
Middle Fork Goodnews River	Weir	>12,000	SEG	2005	
Kuskokwim River / tributaries					
Kogrukluk River	Weir	13,000–28,000	SEG	2005	
Kwethluk River	Weir	>19,000	SEG	2010	

[a] Run reconstruction is conducted postseason using a model to estimate total run from harvest and escapement monitoring projects.

Table 2.–Projects operated in 2020 and those used to inform the 2020 Chinook run reconstruction model.

Method	Location	Operated in 2020	Used in 2020
Weir	Kwethluk		
	Tuluksak		
	George	x	x
	Kogrukluk	x	x
	Tatlawiksuk		
	Takotna	x	x
Aerial survey	Kwethluk	x	x
	Kisaralik	x	x
	Tuluksak		
	Salmon (Aniak)	x	x
	Kipchuk	x	x
	Aniak	x	x
	Holokuk	x	x
	Oskawalik	x	x
	Holitna	x	x
	Cheeneetnuk	x	x
	Gagaryah	x	
	Pitka	x	x
	Bear	x	x
	Salmon (Pitka)	x	x
Harvest	Subsistence	x	x
	Commercial		
	Test fisheries	x	x
	Sport		

Table 3.–Kuskokwim Area aerial survey locations, 2020.

Project	Species targeted	
Kuskokwim Bay rivers	Chinook salmon	Sockeye salmon
North Fork Goodnews River	x	x
Middle Fork Goodnews River	x	x
Kanektok River	x	x
Kuskokwim River tributaries		
Kwethluk Canyon Creek	x	
Kisaralik River	x	
Aniak River	x	
Salmon River (Aniak)	x	
Kipchuk River	x	
Holokuk River	x	
Oskawalik River	x	
Holitna River	x	
Cheeneetnuk River	x	
Gagaryah River	x	
Salmon River (Pitka Fork)	x	
Pitka Fork	x	
Bear Creek	x	

Table 4.–Target operational period and species targeted at Kuskokwim Area weir projects, 2020.

Project			Species targeted			
Kuskokwim River tributaries	Standard estimation range	2020 Planned operational period	Chinook salmon	Chum salmon	Sockeye salmon	Coho salmon
Salmon River (Aniak) weir[a]	15 June–20 September	15 June–15 August[b]	x	x	x	
George River weir	15 June–20 September	15 June–20 September	x	x	x	x
Kogrukluk River weir	26 June–25 September	26 June–25 September	x	x	x	x
Telaquana River weir	3 July–26 August	3 July–26 August			x	
Takotna River weir	24 June–20 September	1 July–15 August[b]	x	x		
Salmon River (Pitka Fork) weir	20 June–15 August	20 June–15 August	x			

Note: The “x” indicates that salmon species is monitored in notable numbers, and the planned operational period covers a majority of the run.

[a] Salmon River (Aniak) weir was operated by the Native Village of Napaimute. All data was transferred to and reported by ADF&G.

[b] The operational period was reduced compared to past years due to a lack of funding.

Table 5.–Starting passage dates and years used in the hierarchical Bayesian estimation technique to estimate missed escapement at Kuskokwim Area weir projects, 2020.

Project	Starting passage date	Weir passage years
Salmon River (Aniak) weir	15 June	2006–2009, 2012–2018
Salmon River (Pitka Fork) weir	20 Jun	2015–2019
George River weir	15 June	1996–2019
Kogrukluk River weir	26 June	1976–2019[a]
Telaquana River weir	3 July	2010–2019
Takotna River weir	24 June	2000–2013, 2017–2019

Note: Starting passage dates and weir passage years only apply to target species at each project.

[a] Weir passage years are for Chinook, chum, and sockeye salmon only. Coho salmon passage years are 1981–2019.

Table 6.–Kuskokwim Area Chinook salmon aerial survey locations, survey dates, ratings, index objectives, and escapement indices, 2020.

River	Survey date	Overall survey rating	Index objective	Index area survey counts					Escapement index
				101	102	103	104	Supplemental	
Kuskokwim Bay rivers									
North Fork Goodnews River	3 Aug	Good (1)	101,102,103	187	286	625	0	[a]	1,098
Middle Fork Goodnews River	3 Aug	Good (1)	101, 103, 104	1,352	[a]	50	0	[a]	1,402
Kanektok River	13 Aug	Good (1)	101, 102, 103	2,872	1,332	201	0	0	[b]
Kuskokwim River tributaries									
Kwethluk Canyon Creek	26 Jul	Good (1)	102, 103, 104	[a]	263	329	129	[a]	721
Kisaralik River	26 Jul	Good (1)	102, 103	[a]	317	33	[a]	[a]	350
Aniak River	28 Jul	Good (1)	102, 103, 104	[a]	303	893	68	[a]	1,264
Salmon River (Aniak)	28 Jul	Good (1)	101, 102, 103	211	46	12	[a]	[a]	269
Kipchuk River	28 Jul	Good (1)	101, 102, 103	453	135	135	[a]	[a]	723
Holokuk River	29 Jul	Good (1)	101, 102, 103, 104	38	38	14	9	[a]	99
Oskawalik River	29 Jul	Fair (2)	101, 102, 103	10	84	75	[a]	[a]	169
Holitna River	29 Jul	Fair (2)	102, 103	217	29	825	554	[a]	854
Cheeneetnuk River	29 Jul	Good (1)	101, 102	187	232	[a]	[a]	[a]	419
Salmon River (Pitka Fork)	27 Jul	Good (1)	102, 103, 104	175	306	41	803	[a]	1,150
Pitka Fork	27 Jul	Fair (2)	101	160	[a]	[a]	[a]	[a]	160
Bear Creek	27 Jul	Good (1)	101	321	[a]	[a]	[a]	[a]	321

Note: Survey ratings were based on criteria related to survey method, weather and water conditions, time of survey, and spawning stage (Schneiderhan 1988). The index objective defines the specific index areas that must be surveyed to produce a Chinook salmon escapement index count. Survey counts are not adjusted or expanded in any way. Escapement index is only reported when index objectives were achieved, survey conditions were rated good (1) or fair (2), and survey occurred between the target date range of 17 July and 5 August.

[a] Index reach does not exist for the river.

[b] Due to the late timing of this flight the escapement index is not official, although the escapement goal was met.

Table 7.–Sockeye salmon aerial survey escapement indices in the Kuskokwim Area, 2020.

River	Survey date	Overall survey rating	Index objective	Index area survey counts 101	102	103	104	Supplemental	Escapement index
Kuskowkim Bay rivers									
North Fork Goodnews River	3 Aug	Good (1)	101, 102, 103, 104	3,010	1,710	2,640	47,750	[a]	55,110
Middle Fork Goodnews River	3 Aug	Good (1)	101, 102, 103, 104	5,280	0	1,590	11,520	[a]	18,390
Kanektok River	13 Aug	Good (1)	101, 102, 103, 104	7,606	11,240	3,550	30,490	7,730	[b]

Note: Survey ratings were based on criteria related to survey method, weather and water conditions, time of survey, and spawning stage (Schneiderhan 1988). The index objective defines the specific index areas that must be surveyed to produce a Chinook salmon escapement index count. Survey counts are not adjusted or expanded in any way. Escapement index is only reported when index objectives were achieved, survey conditions were rated good (1) or fair (2), and survey occurred between the target date range of 17 July and 5 August.

[a] Index reach does not exist for th river.

[b] Due to the late timing of this flight the escapement index is not official, although the escapement goal was exceeded.

Table 8.–Target operational periods, actual operational periods, and missed passage days at Kuskokwim Area weir projects, 2020.

Project	Standard estimation range	2020 Planned operational period[a]	Actual operational period	Partial missed passage days during actual operational period	Full missed passage days during actual operational period
Salmon River (Aniak) weir	15 Jun–20 Sep	15 Jun–15 Aug	5 Jul–20 Aug[a]	7, 13, 19 Jul	
George River weir	15 Jun–20 Sep	15 Jun–20 Sep	15 Jun–18 Sep		
Kogrukluk River weir	26 Jun–25 Sep	26 Jun–25 Sep	21 Jun–7 Sep	14, 17, 27, 29 July; 1,6, 11, 31 Aug; 3, 7 Sep	1, 2 Sep
Telaquana River weir	3 Jul–26 Aug	3 Jul–26 Aug	12 Jul–24 Aug		
Takotna River weir	24 Jun–20 Sep	1 Jul–15 Aug	12 Jul–10 Aug[a]	19, 23, 30 Jul	20–22 July
Salmon River (Pitka Fork) weir	20 Jun–15 Aug	20 Jun–15 Aug	19 Jun–15 Aug		

[a] Planned operational period was reduced due to lack of funding.

Table 9.–Chinook salmon aerial survey escapement indices, Kuskokwim Area, 2002–2020.

	Kuskokwim Bay			Upper Kuskokwim River		
Year	North Fork Goodnews	Middle Fork Goodnews	Kanektok	Salmon (Pitka Fork)	Pitka Fork	Bear Creek
2002	1,470	1,195	–	–	165	211
2003	3,935	2,131	6,206	–	197	176
2004	7,482	2,617	28,375	1,138	290	206
2005	–	–	12,780	1,801	744	367
2006	–	–	–	862	170	347
2007	–	–	–	943	131	165
2008	2,155	2,190	–	1,033	242	245
2009	–	–	–	632	187	209
2010	–	–	1,208	135	67	75
2011	853	–	–	767	85	145
2012	378	355	–	670	–	–
2013	–	–	2,277	469	–	64
2014	630	612	1,840	1,865	–	–
2015	991	515	4,919	2,016	–	1,381
2016	1,120	1,301	5,631	1,578	–	580
2017	–	–	–	687	234	492
2018	–	–	4,246	1,399	471	550
2019	2,462	–	7,212	1,918	330	542
2020	1,098	1,402	–	1,150	160	321
Average	1,841	1,347	7,748	1,054	242	323
Median	1,228	1,222	6,172	943	192	210
Percentile rank	43%	68%	–	70%	28%	65%
Escapement goal	640–3,300	–	3,900–12,000	470–1,600	–	–

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Table 9.–Page 2 of 3.

Year	Middle Kuskokwim River							
	Aniak	Salmon (Aniak)	Kipchuk	Holokuk	Oskawalik	Holitna	Cheeneetnuk	Gagaryah
2002	–	1,236	1,615	513	295	733	730	–
2003	3,514	1,242	1,493	1,096	844	–	810	1,093
2004	5,362	2,177	1,868	539	293	4,051	918	670
2005	–	4,097	1,679	510	582	1,760	–	–
2006	5,639	–	1,618	705	386	1,866	1,015	531
2007	3,984	1,458	2,147	–	–	–	–	1,035
2008	3,222	589	1,061	418	213	–	290	177
2009	–	–	–	565	379	–	323	303
2010	–	–	–	229	–	–	–	62
2011	–	79	116	61	26	–	249	96
2012	–	49	193	36	51	–	229	178
2013	754	154	261	–	38	532	138	74
2014	3,201	497	1,220	80	200	–	340	359
2015	–	810	917	77	–	662	–	19
2016	718	–	898	100	47	1,157	217	135
2017	1,781	423	889	140	136	676	660	453
2018	1,534	442	1,123	162	–	980	565	438
2019	3,160	950	1,344	719	638	1,377	1,345	760
2020	1,264	269	723	99	169	854	419	–
Average	2,561	762	1,018	333	294	1,522	709	460
Median	2,184	586	1,061	231	197	1,267	660	392
Percentile rank	24%	23%	29%	27%	45%	36%	44%	–
Escapement goal	1,200–2,300	330–1,200	–	–	–	–	340–1,300	300–830

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Table 9.–Page 3 of 3.

	Lower Kuskokwim River	
Year	Kwethluk	Kisaralik
2002	1,795	1,727
2003	2,661	654
2004	6,801	5,157
2005	5,059	2,206
2006	–	4,734
2007	–	692
2008	487	1,074
2009	–	–
2010	–	235
2011	–	534
2012	–	588
2013	1,165	599
2014	–	622
2015	–	709
2016	–	622
2017	–	–
2018	–	584
2019	–	1,063
2020	721	350
Average	2,061	1,158
Median	1,722	673
Percentile rank	27%	12%
Escapement goal	–	400–1,200

Note: Average, median, and percentile rank was derived from all annual escapements on record at each project, except 2020, and may include escapements prior to 2000. Escapement data for all projects are archived in the AYKDBMS. En dashes mean no data.

Table 10.–Observed, estimated, and total passage of Chinook salmon at Kuskokwim Area weirs, 2020.

Project	Observed passage[a]	Estimated passage	Total passage	95% Confidence interval
Salmon River (Aniak) weir	1,028	200	1,228	1,028–1,535
George River weir	2,418	0	2,418	2,418–2,446
Kogrukluk River weir	4,925	720	5,645	5,338–5,946
Takotna River weir	198	159	357	208–503
Salmon River (Pitka Fork) weir	4,825	0	4,825	4,825–4,825

Note: Percent of run missed was determined by calculating the current year's run timing, then using similar historical run timings to determine the percent of the run missed on each day of missed passage.

[a] Observed passage does not include partial day counts when estimates were made.

Table 11.–Annual escapement of Chinook salmon past Kuskokwim Area weir projects, 2002–2020.

	Kuskokwim Bay		Kuskokwim River					
Year	Middle Fork Goodnews River	Kanektok River	Salmon River (Aniak)	George River	Kogrukluk River	Tatlawiksuk River	Takotna River	Salmon River (Pitka Fork)
2002	3,001	5,288	[a]	2,445	9,830	2,237	326	[a]
2003	2,245	8,158	[a]	[b]	11,751	[b]	378	[a]
2004	4,550	19,602	[a]	5,392	19,880	2,833	461	[a]
2005	4,591	13,281	[a]	3,845	21,686	2,858	499	[a]
2006	4,558	[a]	6,901	4,359	19,305	1,700	537	[a]
2007	3,874	13,965	6,214	4,972	[b]	2,058	412	[a]
2008	2,329	[b]	2,376	3,383	9,740	1,194	413	[a]
2009	1,632	7,000	1,823	3,664	9,201	1,071	311	[a]
2010	1,968	6,457	[a]	1,500	5,160	554	183	[a]
2011	2,181	5,195	[a]	1,605	6,926	1,011	149	[a]
2012	1,131	1,495	[b]	2,362	[b]	1,116	238	[a]
2013	1,263	3,569	711	1,267	1,919	495	104	[a]
2014	750	3,594	1,722	2,988	3,726	2,050	[a]	[a]
2015	1,543	10,416	2,401	2,301	8,333	2,131	[a]	7,156
2016	1,659	[a]	[b]	2,218	7,034	2,693	[a]	6,371
2017	6,775	[a]	2,611	3,669	7,787	2,146	318	8,298
2018	[a]	[a]	2,252	3,322	6,292	[a]	205	5,354
2019	6,039	[a]	[a]	3,828	10,301	[a]	554	4,823
2020	[a]	[a]	1,228	2,418	5,645	[a]	357	4,825
Average	3,027	8,168	3,001	3,557	9,712	1,692	409	6,400
Median	2,549	6,729	2,376	3,322	8,468	1,857	378	6,371
Percentile rank	–	–	11%	28%	21%	–	47%	20%
Escapement goal	1,500–3,600	–	–	1,800–3,300	4,800–8,800	–	–	–

Note: Average, median, and percentile rank was derived from all annual escapements on record at each project, except 2020, and may include escapements prior to 2000. Escapement data for all projects are archived in the AYKDBMS. En dashes mean no data.

[a] Weir did not operate.

[b] Historical run timing indicates that more than 40% of the run was missed; annual escapement was not determined.

Table 12.–Observed, estimated, and total passage of chum salmon at Kuskokwim Area weirs, 2020.

Project	Observed passage[a]	Estimated passage	Total passage	95% confidence interval
Salmon River (Aniak) weir	1,896	99	1,995	1,896–2,305
George River weir	8,943	0	8,943	8,943–9,952
Kogrukluk River weir	16,716	2,304	19,020	18,599–19,470
Takotna River weir	[b]	[b]	[b]	[b]

Note: Percent of run missed was determined by calculating the current year's run timing, then using similar historical run timings to determine the percent of the run missed on each day of missed passage.

[a] Observed passage does not include partial day counts when estimates were made.

[b] Historical run timing indicates that more than 40% of the run was missed; annual escapement was not determined.

Table 13.–Annual escapement of chum salmon past Kuskokwim Area weir projects, 2002–2020.

	Kuskokwim Bay		Kuskokwim River				
Year	Middle Fork Goodnews River	Kanektok River	Salmon River (Aniak)	George River	Kogrukluk River	Tatlawiksuk River	Takotna River
2002	29,905	41,809	[a]	6,530	52,912	24,539	4,454
2003	21,664	40,063	[a]	30,944	23,708	[b]	3,292
2004	32,447	45,894	[a]	14,172	24,429	21,245	1,633
2005	26,411	54,218	[a]	14,847	194,896	55,432	6,488
2006	54,599	[a]	41,159	41,596	183,743	32,303	12,643
2007	48,973	132,319	25,228	62,681	53,064	82,821	8,906
2008	39,821	[b]	9,459	29,616	44,717	30,354	5,704
2009	18,503	54,987	9,336	7,940	81,829	19,975	2,528
2010	24,794	69,236	[a]	26,187	63,612	36,710	3,995
2011	19,974	53,202	[a]	45,257	76,649	85,723	8,562
2012	9,512	26,425	[b]	33,277	[b]	44,573	6,039
2013	27,692	43,040	7,685	37,945	65,648	32,253	6,516
2014	11,518	18,586	2,777	17,183	30,697	12,453	[a]
2015	11,475	15,048	5,511	17,554	33,091	10,382	[a]
2016	33,671	[a]	1,691	19,469	45,234	10,849	[a]
2017	44,876	[a]	9,754	39,971	85,793	30,174	6,557
2018	[a]	[a]	18,770	48,915	52,937	[a]	6,007
2019	38,072	[a]	[a]	43,072	71,006	[a]	5,618
2020	[a]	[a]	1,995	8,943	19,020	[a]	[b]
Average	27,068	49,569	13,137	25,524	48,171	31,686	5,280
Median	26,411	44,467	9,398	19,469	38,752	27,357	5,618
Percentile rank	–	–	10%	17%	19%	–	–
Escapement goal	SEG: >12,000	–	–	–	SEG: 15,000–49,000	–	–

Note: Average, median, and percentile rank was derived from all annual escapements on record at each project, except 2020, and may include escapements prior to 2000. Escapement data for all projects are archived in the AYKDBMS. En dashes mean no data.

[a] Weir did not operate.

[b] Historical run timing indicates that more than 40% of the run was missed; annual escapement was not determined.

Table 14.–Sockeye salmon aerial survey escapement indices, Kuskokwim Area, 2000–2020.

Year	North Fork Goodnews River	Middle Fork Goodnews River	Kanektok River
2000	–	–	–
2001	–	–	–
2002	–	2,627	–
2003	50,140	29,150	21,335
2004	31,695	33,670	77,780
2005	–	–	95,900
2006	–	–	–
2007	–	–	–
2008	32,500	13,935	–
2009	–	–	–
2010	–	–	16,180
2011	14,140	–	–
2012	16,710	–	–
2013	–	–	51,517
2014	–	12,262	136,400
2015	38,390	24,780	39,970
2016	90,060	68,978	80,160
2017	–	–	–
2018	–	–	326,200
2019	162,930	–	349,073
2020	55,110	18,390	–
Average	35,888	21,958	79,565
Escapement goal	9,600–18,000	–	15,000–41,000

Note: Average, median, and percentile rank was derived from all annual escapements on record at each project, except 2020, and may include escapements prior to 2000. Escapement data for all projects are archived in the AYKDBMS. En dashes mean no data.

Table 15.–Observed, estimated, and total passage of sockeye salmon at Kuskokwim Area weirs, 2020.

Project	Observed passage[a]	Estimated passage	Total passage	95% Confidence interval
Kogrukluk River weir	8,391	1,532	9,923	9,556–10,309
Salmon River (Aniak) weir	232	2	234	232–376
Telaquana Lake weir	176,480	1,029	177,509	177,000–178,002

Note: Percent of run missed was determined by calculating the current year's run timing, then using similar historical run timings to determine the percent of the run missed on each day of missed passage.

[a] Observed passage does not include partial day counts when estimates were made.

Table 16.–Sockeye salmon escapement past Kuskokwim Area tributary weirs, 2000–2020.

	Kuskokwim Bay		Kuskokwim River		
Year	Middle Fork Goodnews River	Kanektok River	Salmon River (Aniak)	Kogrukluk River	Telaquana River
2000	37,358	[a]	[a]	2,870	[a]
2001	21,008	[b]	[a]	7,536	[a]
2002	21,127	58,619	[a]	4,035	[a]
2003	37,882	128,415	[a]	9,203	[a]
2004	53,131	103,150	[a]	6,895	[a]
2005	115,167	235,450	[a]	37,684	[a]
2006	126,734	[a]	5,190	60,507	[a]
2007	74,111	305,356	2,114	16,798	[a]
2008	41,228	[b]	1,181	19,663	[a]
2009	26,197	294,212	1,366	22,216	[a]
2010	37,273	208,300	[a]	13,306	71,932
2011	20,188	87,303	[a]	8,079	35,099
2012	30,352	99,604	950	[b]	23,002
2013	24,117	128,761	966	7,793	28,058
2014	41,473	256,970	934	6,479	24,292
2015	54,757	106,751	1,504	6,647	95,570
2016	169,544	[a]	310	20,108	82,710
2017	182,043	[a]	[b]	24,696	145,281
2018	[a]	[a]	2,537	21,343	197,368
2019	162,711	[a]	[a]	32,116	198,485
2020	[a]	[a]	234	9,923	177,509
Average	55,741	167,741	1,705	13,328	90,180
Median	37,882	128,588	1,274	8,383	77,321
Percentile rank	–	–	0%	52%	80%
Escapement goal	18,000–40,000	–	–	4,400–17,000	–

Note: Average, median, and percentile rank was derived from all annual escapements on record at each project, except 2020, and may include escapements prior to 2000. Escapement data for all projects are archived in the AYKDBMS. En dashes mean no data.

[a] Weir did not operate.

[b] Historical run timing indicates that more than 40% of the run was missed; annual escapement was not determined.

Table 17.–Observed, estimated, and total passage of coho salmon at Kuskokwim Area weirs, 2020.

Project	Observed passage[a]	Estimated passage	Total passage	95% Confidence interval
George River weir	19,633	1,793	21,426	21,016–21,848
Kogrukluk River weir	[b]	[b]	[b]	[b]

Note: Percent of run missed was determined by calculating the current year's run timing, then using similar historical run timings to determine the percent of the run missed on each day of missed passage.

[a] Observed passage does not include partial day counts when estimates were made.

[b] Historical run timing indicates that more than 40% of the run was missed; annual escapement was not determined.

Table 18.–Annual escapement of coho salmon past Kuskokwim Area weir projects, 2000–2020.

	Kuskokwim Bay	Kuskokwim River		
Year	Middle Fork Goodnews River	George River	Kogrukluk River	Tatlawiksuk River
2000	[b]	11,280	33,100	[b]
2001	18,300	15,224	19,926	[b]
2002	27,643	6,759	14,516	11,192
2003	52,504	33,741	74,903	[b]
2004	42,049	12,499	26,078	16,448
2005	20,168	8,296	25,313	7,294
2006	26,909	12,693	22,300	[b]
2007	19,442	28,513	26,798	8,434
2008	37,690	21,931	29,300	11,037
2009	19,123	12,491	22,544	10,148
2010	26,287	12,866	14,558	3,940
2011	24,668	31,900	21,950	15,635
2012	[b]	14,844	13,462	8,001
2013	[b]	14,823	23,800	12,724
2014	[b]	35,771	54,001	19,822
2015	[b]	35,790	32,900	17,669
2016	[b]	[b]	[b]	11,719
2017	[b]	25,338	[b]	[b]
2018	[a]	8,993	8,169	[a]
2019	[b]	13,277	16,470	[a]
2020	[a]	21,426	[b]	[a]
Average	26,634	17,877	23,486	11,851
Median	25,478	13,277	22,300	11,192
Percentile rank	–	66%	–	–
Escapement goal	>12,000	–	13,000–28,000	–

Note: Average, median, and percentile rank was derived from all annual escapements on record at each project, except 2020, and may include escapements prior to 2000. Escapement data for all projects are archived in the AYKDBMS. En dashes mean no data.

[a] Weir did not operate.

[b] Historical run timing indicates that more than 40% of the run was missed; annual escapement was not determined.

Table 19.–Age, sex, and length sample collection at Kuskokwim Area weir projects, 2020.

Species	Project	Season sample goal	Scales per fish sampled	Season total number of samples collected	Dates samples collected
Chinook	Salmon (Aniak)	260	3	174	12 July–14 August
	George	230	3	220	27 June–13 August
	Kogrukluk	230	3	231	1 July–11 August
	Takotna	75	3	74	12 July–8 August
	Salmon (Pitka Fork)	250	3	259	11 July–5 August
Chum	Salmon (Aniak)	400	1	290	13 July–16 August
	George	400	1	417	28 June–7 August
	Kogrukluk	600	1	602	1 July–14 August
Sockeye	Kogrukluk [a]	250	0	250	7 July–10 August
	Telaquana [a]	250	0	421	14 July–22 August
Coho	George	400	3	408	10 August–12 September
	Kogrukluk	400	3	203	8 August–6 September

[a] Only length and sex information was collected from sockeye salmon in 2020.

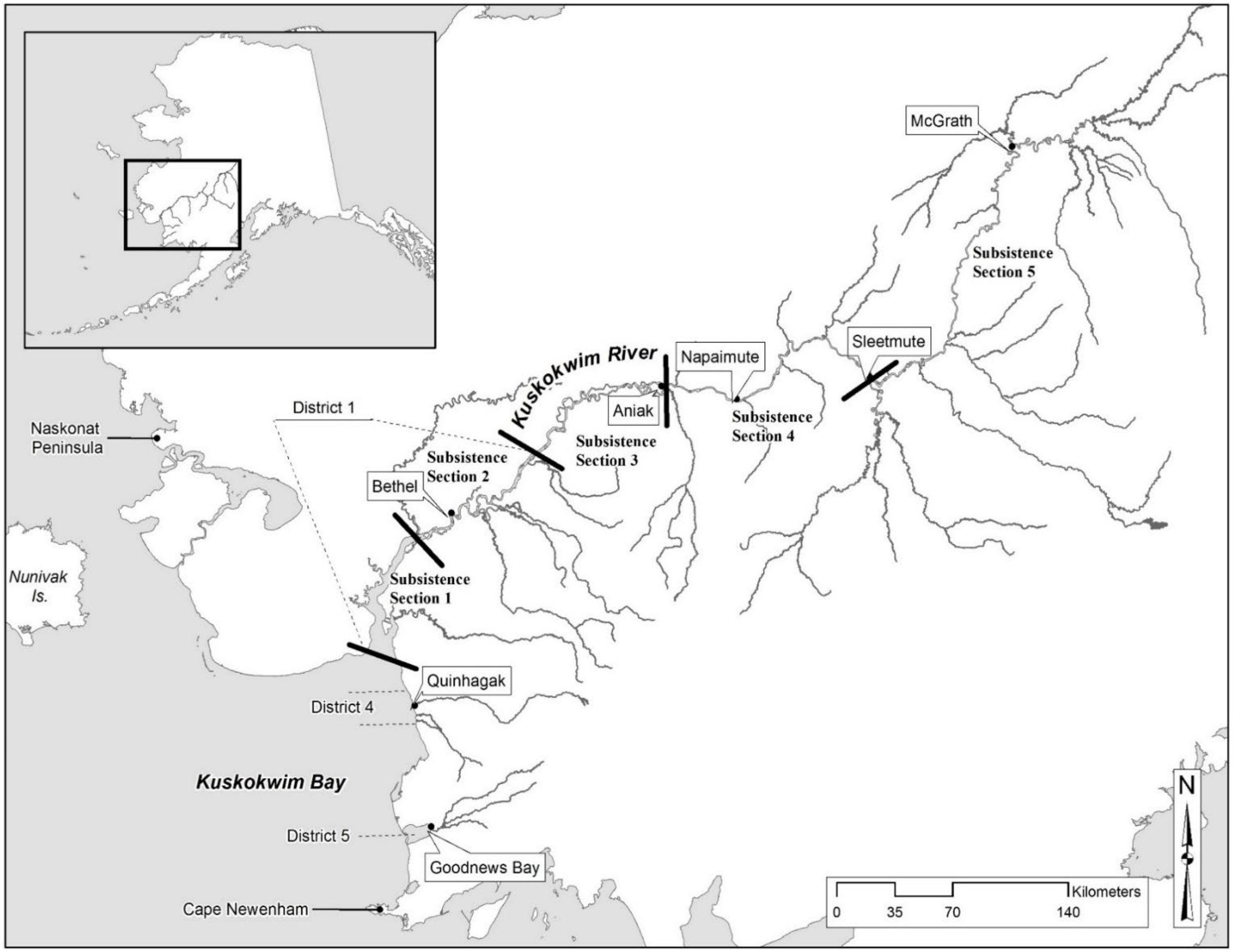

Figure 1.–The Kuskokwim Area, including Kuskokwim Bay, the Kuskokwim River, subsistence fishing sections, and select commercial fishing districts.

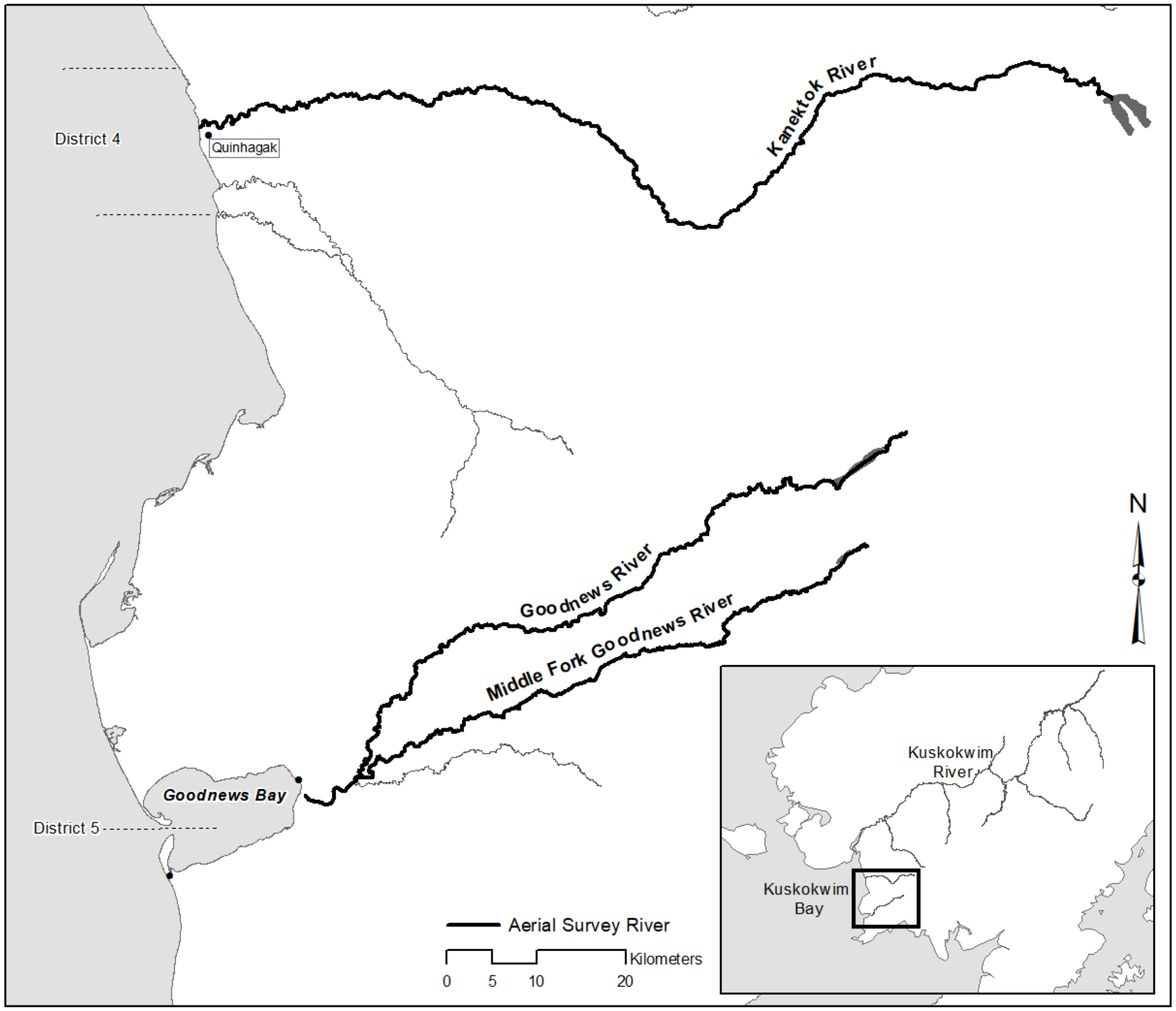

Figure 2.–Kuskokwim Bay rivers where salmon escapement was monitored in 2020.

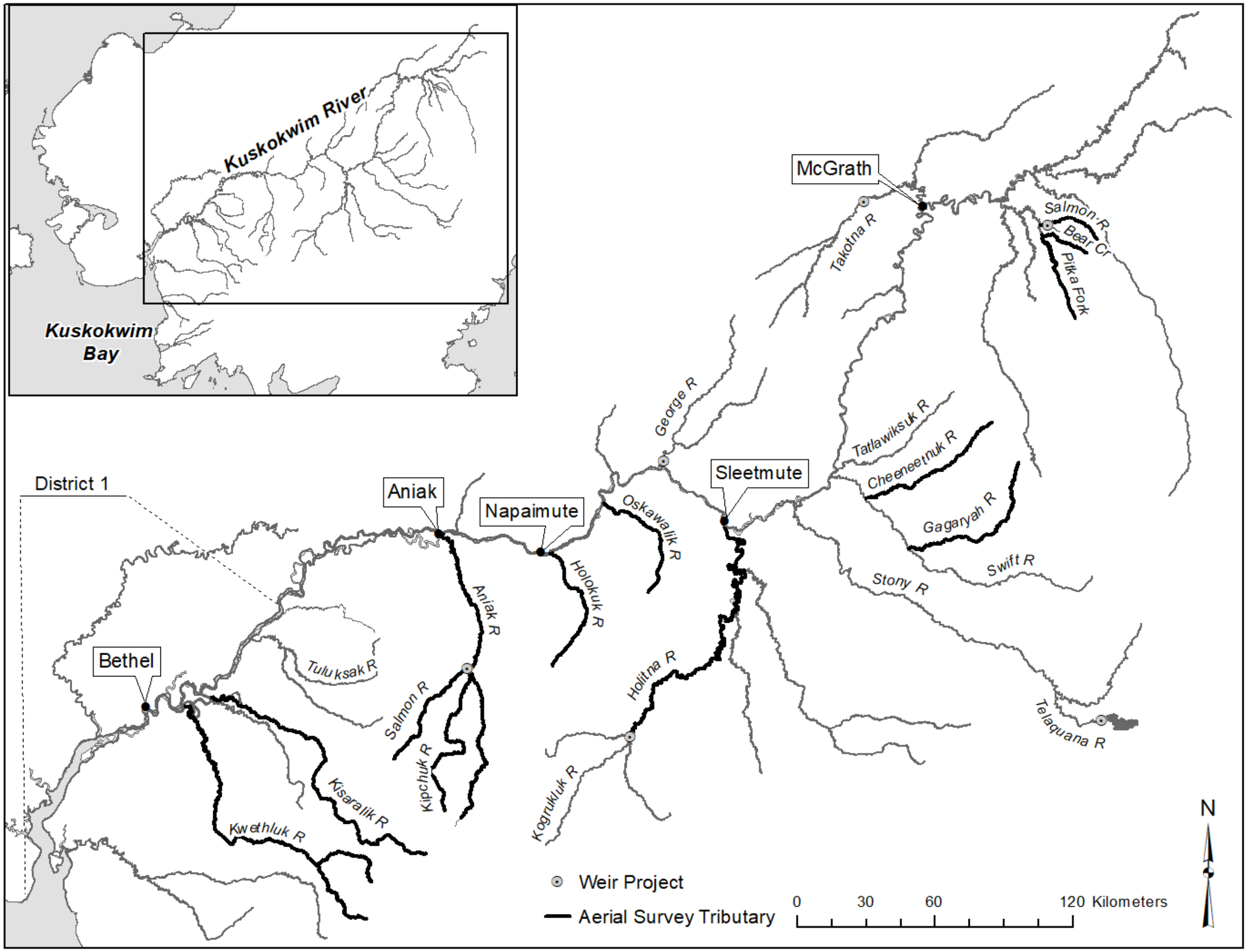

Figure 3.–Kuskokwim River tributaries where salmon escapement was monitored by ADF&G and partners, 2020.

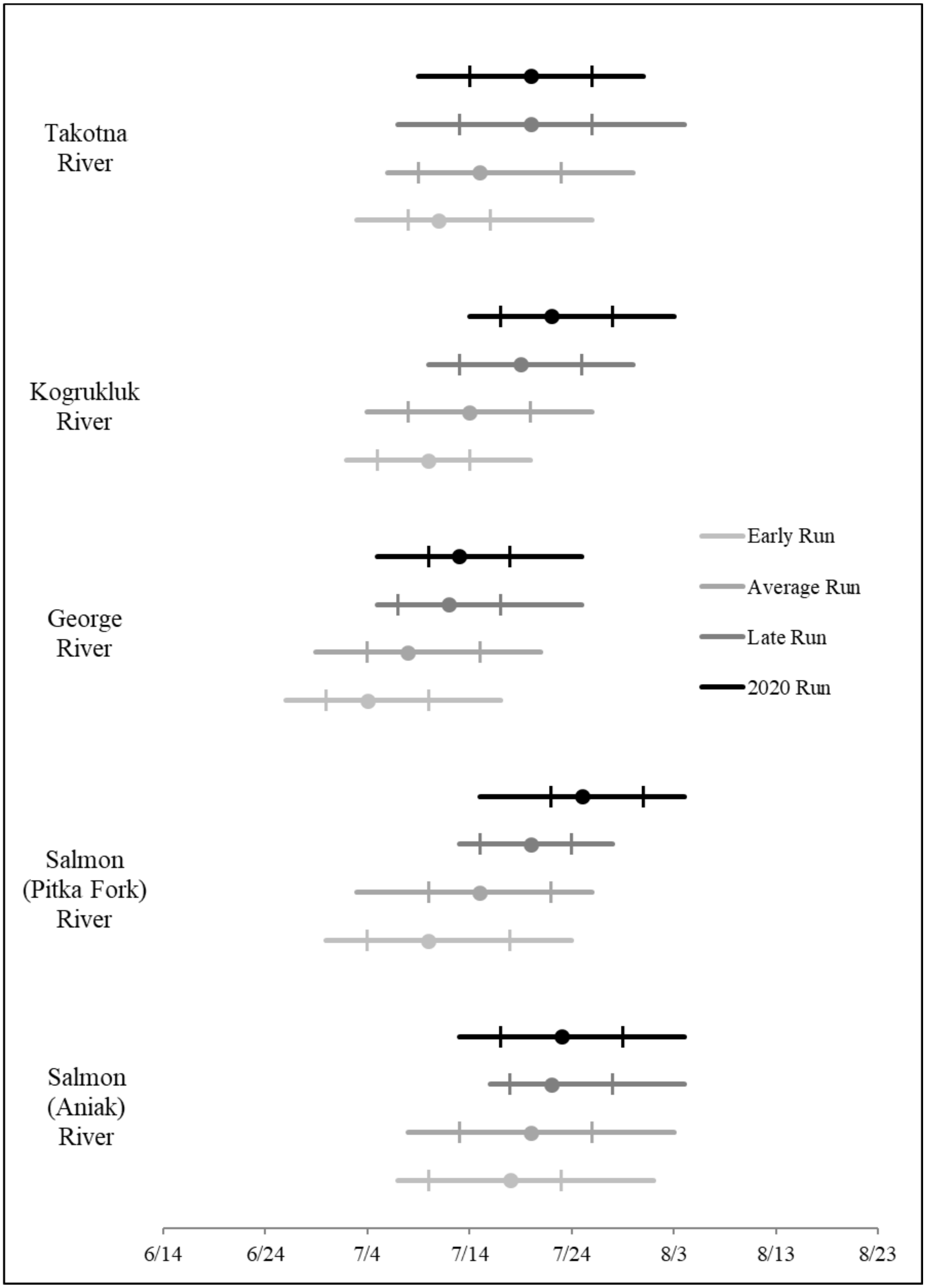

Figure 4.–Early, average, late, and 2020 run timings of Chinook salmon at Kuskokwim Area weirs.

Note: Lines represent the central 80% of the salmon run with the 25 and 75 percentile represented as vertical bars and the median with a solid circle. Early, average, and late run timing are based on historical observations at the specific weir.

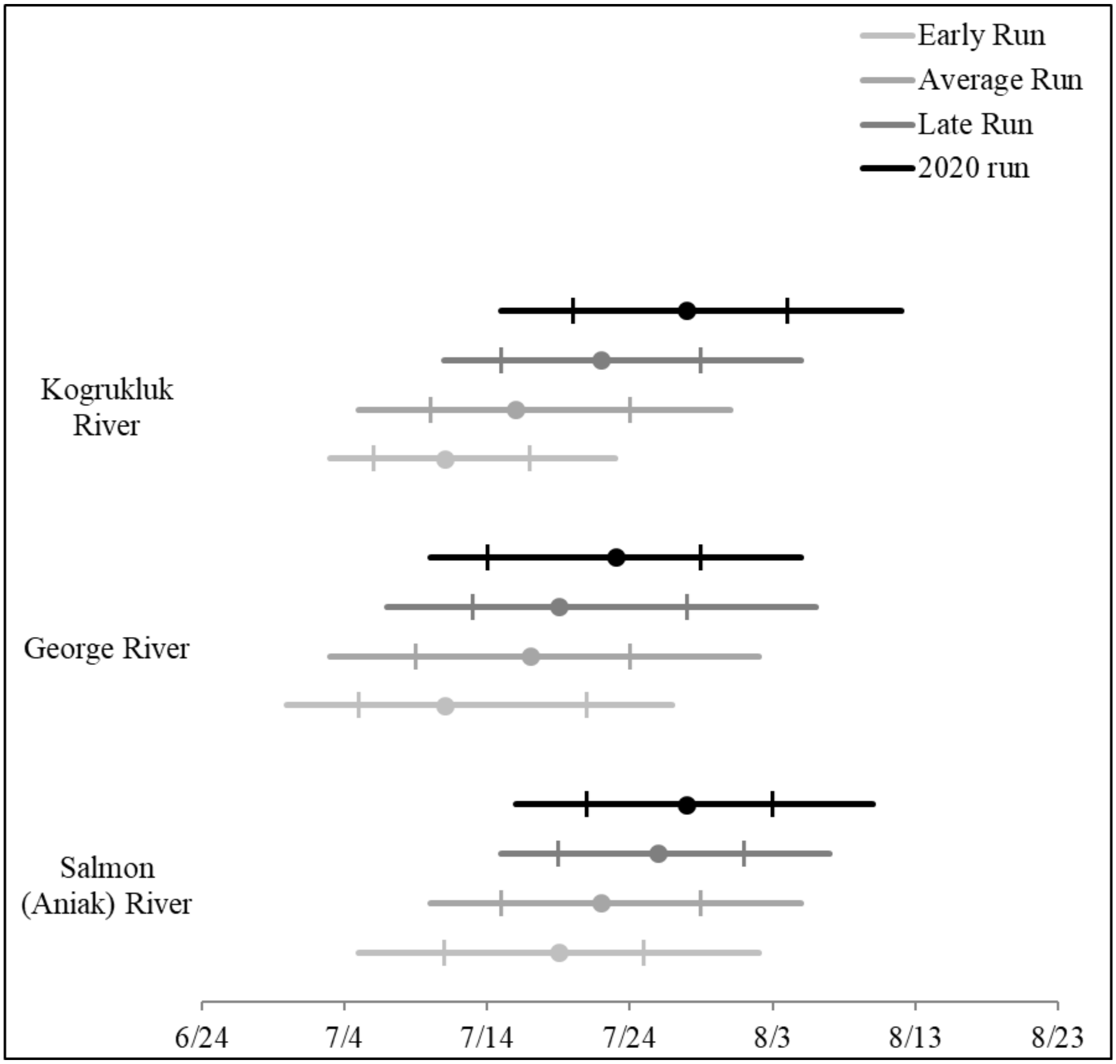

Figure 5.–Early, average, late, and 2020 run timings of chum salmon at Kuskokwim Area weirs.

Note: Lines represent the central 80% of the salmon run with the 25 and 75 percentiles represented as vertical bars and the median with a solid circle. Early, average, and late run timing are based on historical observations at the specific weir.

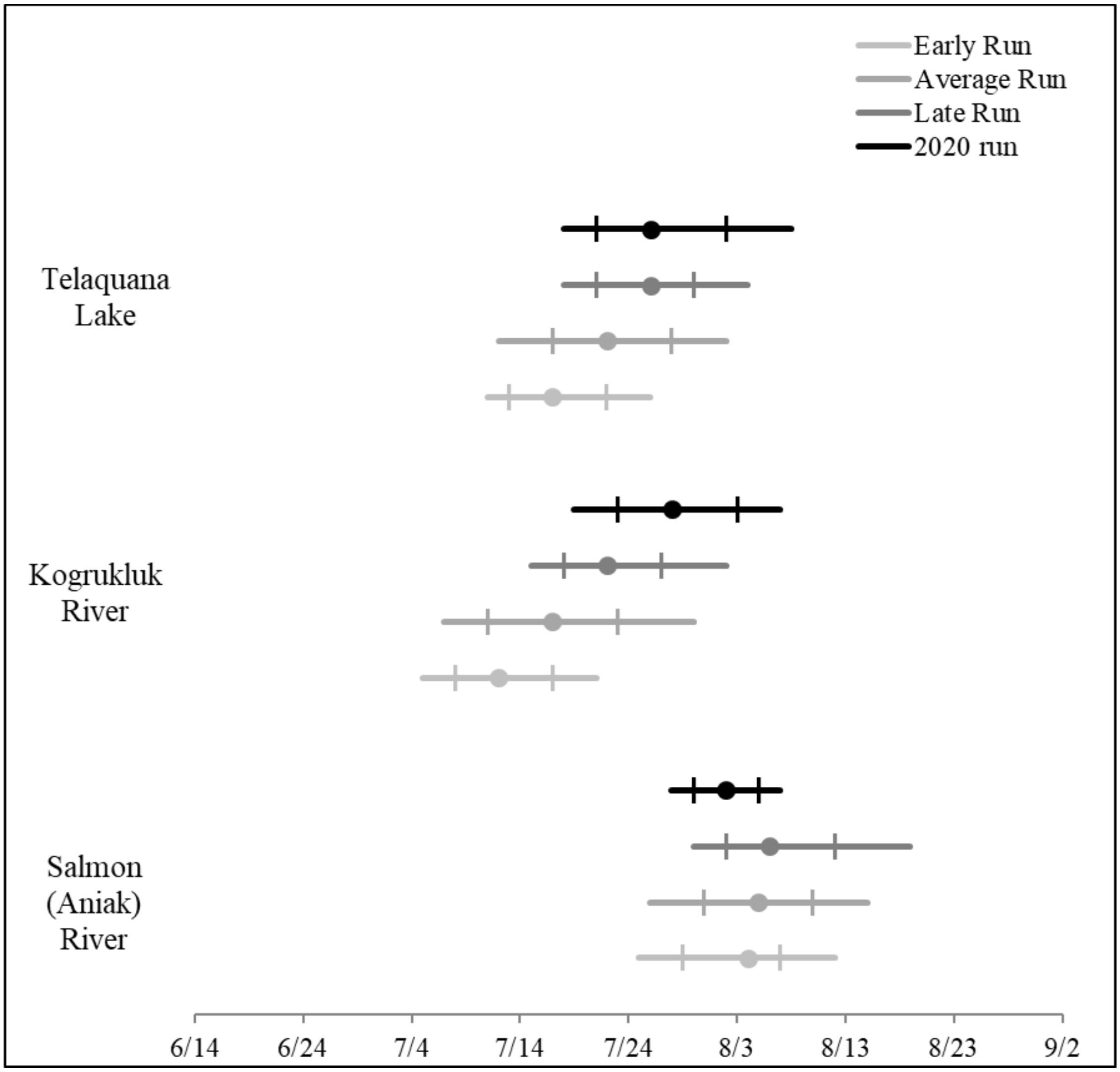

Figure 6.–Early, average, late, and 2020 run timings of sockeye salmon at Kuskokwim Area weirs.

Note: Lines represent the central 80% of the salmon run with the 25 and 75 percentiles represented as vertical bars and the median with a solid circle. Early, average, and late run timing are based on historical observations at the specific weir.

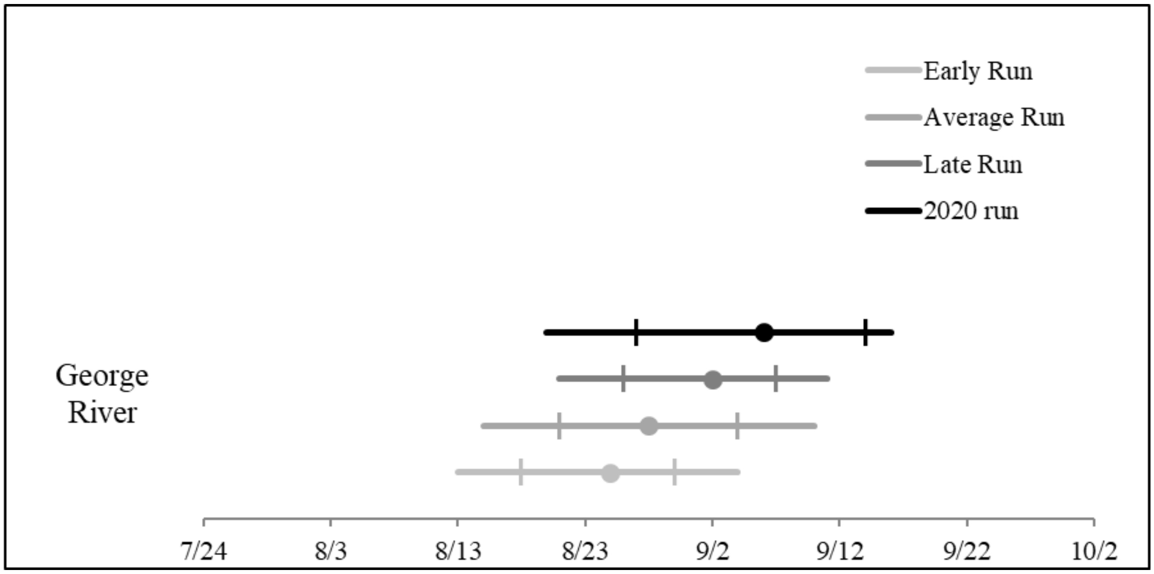

Figure 7.–Early, average, late, and 2020 run timings of coho salmon at Kuskokwim Area weirs.

Note: Lines represent the central 80% of the salmon run with the 25 and 75 percentiles represented as vertical bars and the median with a solid circle. Early, average, and late run timing are based on historical observations at the specific weir.

APPENDIX A: KUSKOKWIM AREA AERIAL SURVEY INDEX REACHES

Appendix A1.–Index areas and objectives for survey rivers in the Kuskokwim Area.

River	Index areas [a]	Description/Landmark	Index objective[b]
North Fork Goodnews [c]	101 (59.17.55 N, 161.15.62 W)	Approx. 1 mile upstream of confluence w/ Goodnews Bay	Chinook: 101, 102, 103 Sockeye: 101, 102, 103, 104
	102 (59.27.00 N, 160.47.09 W)	Confluence w/ Slate Cr.	
	103 (59.28.57 N, 160.35.13 W)	Confluence w/ Nimgun Cr.	
	104 (59.28.56 N, 160.35.16 W)	Outlet of Goodnews Lake (survey lake and river at east end of Lakes	
	STOP (59.31.69 N, 160.28.23 W)	Approx. 3 mi. upriver at east end of Goodnews Lake (Goodnews to Igmiumanik R.)	
Middle Fork Goodnews [c]	101 (29.07.77 N, 161.28.00 W)	Confluence w/ Goodnews R.	Chinook: 101, 103, 104 Sockeye: 101, 102, 103, 104
	102 (59.21.30 N, 160.41.11 W)	Confluence w/ North Lake Cr.	
	102 STOP (59.24.63 N, 160.35.74 W)	Outlet of North L. (survey lake and creek at east end of lake)	
	103 (59.21.30 N, 160.41.11 W)	Confluence between North L., North Lake Cr., and Middle Fork Goodnews River	
	103 STOP (59.23.56 N, 160.34.25 W)	Outlet of Middle Fork Lake (survey lake and creek at east end of lake)	
	104 (59.17.65 N, 160.51.15 W)	Confluence w/ Kukaktlik R.	
	104 STOP (59.20.17 N, 160.29.72 W)	Outlet of Kukatlim L. (survey lake and all connected outlying lakes)	
Kanektok [c]	101 (59.44.90 N, 161.55.75 W)	Confluence w/ Kuskokwim Bay	Chinook: 101, 102, 103 Sockeye: 101, 102, 103, 104
	102 (59.42.54 N, 160.58.40 W)	Confluence w/ Nukluk Cr.	
	103 (59.52.28 N, 160.28.37 W)	Confluence w/ Kanuktik Cr.	
	104 (59.52.49 N, 160.07.35 W)	Outlet of Kagati/Pegati Lakes (survey lakes and creeks at south ends of lakes)	
	105 (59.53.50 N, 160.17.07 W)	Small chain of lakes west of Katati/Pegati L.	
	Supp. (59.44.28 N, 160.19.64 W)	Kanuktik Cr. and Kanuktik Lake	

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Appendix A1.–Page 2 of 4.

River	Index areas[a]	Description/Landmark	Index objective[b]
Kwethluk Canyon Creek	101 (60.48.78 N, 161.27.08 W)	Confluence w/ Kuskokwim R.	
	102 (60.32.27 N, 161.06.23 W)	Three Step Mountain	
	103 (60.17.76 N, 160.57.16 W)	Elbow Mountain	102, 103, 104
	104 (60.15.12 N, 160.15.82 W)	Confluence w/ Crooked Cr.	
	STOP (60.17.92 N, 159.56.55 W)	Crooked Cr. confluence w/ Swift Cr.	
Kisaralik	101 (60.51.43 N, 161.14.31 W)	Confluence w/ Kuskokwim R.	
	102 (60.44.52 N, 160.22.75 W)	Confluence w/ Nukluk Cr.	
	103 (60.21.11 N, 159.56.63 W)	Upper falls	102, 103
	STOP (60.20.04 N, 159.24.40 W)	Outlet of Kisaralik Lake	
Aniak	101 (61.34.49 N, 159.29.35 W)	Confluence w/ Kuskokwim R.	
	102 (61.20.33 N, 159.13.57 W)	Confluence w/ Buckstock R.	
	103 (61.03.88 N, 159.10.93 W)	Confluence w/ Salmon R. (to West)	102, 103, 104
	104 (60.37.44 N, 159.05.20 W)	Start of island adj. to Gemuk Mountain	
	STOP (60.29.28 N, 159.09.28 W)	Outlet of Aniak Lake	
Salmon (Aniak)	101 (61.03.88 N, 159.10.93 W)	Confluence w/ Aniak R.	
	102 (60.57.55 N, 159.23.68 W)	Confluence w/ Dominion Cr.	
	103 (60.52.91 N, 159.31.15 W)	Confluence w/ Eagle Cr.	101, 102, 103
	STOP (60.47.11 N, 159.32.85 W)	Confluence w/ Cripple Cr. adj. to landing strip	
Kipchuk	101 (61.02.66 N, 159.10.50 W)	Confluence w/ Aniak R.	
	102 (60.46.67 N, 159.19.14 W)	Confluence w/ small cr. from South at beginning of Horseshoe Canyon	
	103 (60.43.44 N, 159.20.53 W)	Confluence w/ trib. from South at East bend in R.	101, 102, 103
	STOP (60.30.83 N, 159.14.37 W)	Lake outlet at end of East Fork in upper reach	

-continued-

River	Index areas[a]	Description/Landmark	Index objective[b]
Holokuk	101 (61.32.15 N, 158.35.35 W)	Confluence w/ Kuskokwim R.	101, 102, 103, 104
	102 (61.26.00 N, 158.27.07 W)	Between Ski Cr. and Gold Run Cr.	
	103 (61.21.93 N, 158.17.54 W)	Confluence w/ Chineekluk Cr.	
	104 (61.16.06 N, 158.16.86 W)	Island at confluence w/ Egozuk Cr.	
	STOP (61.12.89 N, 158.18.45 W)	Confluence w/ Boss Cr.	
	2ND STOP (61.08.62 N, 158.27.39 W)	Upper reach Tri Fork	
Holitna	101 (61.00.95 N, 157.41.37 W)	Nogamut	102, 103
	102 (60.58.24 N, 157.40.75 W)	1 mi. above Nogamut adj. to bluff	
	103 (60.57.52 N, 157.41.59 W)	Slough/confluence w/ Kiknik Cr.	
	104 (60.51.24 N, 157.50.22 W)	Kasheglok (downstream of Chukowan/Kogrukluk R. confluence)	
	STOP (60.50.32 N, 157.50.87 W)	Kogrukluk R. weir	
Oskawalik	101 (61.44.30 N, 158.11.30 W)	Confluence w/ Kuskokwim R.	101, 102, 103
	102 (61.41.40 N, 157.52.47 W)	Confluence w/ 1st large South tributary	
	103 (61.38.79 N, 157.42.71 W)	Confluence w/ 1st large North tributary	
	STOP (61.32.05 N, 157.40.43 W)	Fork adjacent to Henderson Mountain	
Cheeneetnuk	101 (61.48.62 N, 156.00.64 W)	Confluence w/ Swift R.	101, 102
	102 (61.51.57 N, 155.44.49 W)	Major South tributary below 1st major hills	
	STOP (61.57.28 N, 155.18.45 W)	Confluence w/ Shoeleather Cr.	
Gagaryah	101 (61.37.42 N, 155.38.61 W)	Confluence w/ Swift R.	101, 102
	102 (61.39.48 N, 155.21.07 W)	Head of island adj. to 1st hills	
	STOP (61.39.30 N, 155.03.41 W)	Major fork adj. to high hills	

-continued-

Appendix A1.–Page 4 of 4.

River	Index areas[a]	Description/Landmark	Index objective[b]
Salmon (Pitka Fork)	101 (62.53.45 N, 154.34.86 W)	Salmon R. index area 101 start	
	102 (62.53.37 N, 154.30.49 W)	Salmon R. index area 102/104 start	
	102 STOP (62.55.02 N, 154.17.08 W)	Salmon R. index area 102 stop	
	103 (62.53.11 N, 154.28.93 W)	Salmon R. index area 103 start	102, 103, 104
	103 STOP (62.51.62 N, 154.19.82 W)	Salmon R. index area 103 end	
	104 (62.52.03 N, 154.30.27 W)	Salmon R. index area 103 start	
	104 STOP (62.51.00 N, 154.19.28 W)	Salmon R. index area 104 end	
Pitka Fork	101 (62.46.28 N, 154.28.66 W)	Mouth of Pitka Fork	101
	STOP (62.40.35 N, 154.23.28 W)	Headwaters of Pitka Fork	
Bear Creek	101 (62.51.08N, 154.32.94 W)	Mouth of Bear Creek	101
	STOP (62.48.24 N, 154.13.66 W)	Headwaters of Bear Cr.	

[a] Parenthesis following the index areas contain the start point in latitude and longitude (degrees.minutes.seconds). Index area stop points coincide with the following sequential index area start point unless otherwise designated. For the last index area of a stream, the stop point is designated with STOP.

[b] The index objective defines the specific index area(s) that must be surveyed in order to produce a comparable index of escapement. Index objectives are for all target species unless otherwise noted.

[c] Index areas may include lakes. Lakes are not surveyed for Chinook salmon even if the index area is required for the index objective.

APPENDIX B: CODE USED TO RUN THE MARKOV-CHAIN MONTE CARLO (MCMC) METHODS

Appendix B1.–R code used to run the Markov-chain Monte Carlo (MCMC) methods which generated the joint posterior probability distribution of all unknowns in the model.

```
jag.model.n <- function(){
  for(j in 1:nyrs) {
    for(i in 1:ndays){
      # Likelihood
      y[j,i] ~ dnorm(theta[j,i],tausqd[i])
        # Log-normal run timing
      theta[j,i] <- exp(a[j])*exp(-0.5*pow(log(i/mu[j])/b[j],2))
    }
  }
# Priors
  for(j in 1:nyrs) {
    # Normal distribution Positive only
    a[j] ~ dnorm(a0,a0.prec)%_%T(1,)
    b[j] ~ dnorm(b0,b0.prec)%_%T(0.2,)
    mu[j] ~ dnorm(mu0,mu0.prec)%_%T(1,)
  }
  # Rule of thumb prior
  # a log of the highest passage
  # b 1/(log(total passage))
  # m peak passage date.
 # Hyper parameter
  a0 ~ dnorm(a0m,a0tau)
  b0 ~ dnorm(b0m,b0tau)
  mu0 ~ dnorm(mu0m,mu0tau)
## This assumes that variance of each year is independent.
  for(i in 1:ndays) {
    sigmad[i] ~ dunif(0,sigma0)
    tausqd[i] <-pow(sigmad[i],-2)
  }                          }
```

APPENDIX C: DAILY WEATHER AND STREAM OBSERVARIONS, 2020

Appendix C1.–Daily weather and stream observations at the Salmon River (Aniak) weir, 2020.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River stage (cm)	Water clarity[b]
7/7	AM	4	0.0	9	9	35	1
7/7	PM	4	0.0	13	10	34	1
7/8	AM	4	3.0	10	9	33	1
7/8	PM	4	0.1	12	10	33	1
7/9	AM	4	0.0	11	10	32	1
7/9	PM	4	0.0	15	11	32	1
7/10	AM	1	0.0	10	12	29	1
7/10	PM	1	0.0	23	14	29	1
7/11	AM	4	0.0	14	13	29	1
7/11	PM	3	10.0	17	14	27	1
7/12	AM	2	0.0	13	11	28	1
7/12	PM	2	7.5	20	15	28	1
7/13	AM	4	2.0	14	13	28	1
7/13	PM	3	1.0	19	15	28	1
7/14	AM	3	0.0	16	14	29	1
7/14	PM	3	0.0	20	16	29	1
7/15	AM	4	0.0	15	12	27	1
7/15	PM	4	0.0	24	18	26	1
7/16	AM	4	0.0	18	16	25	1
7/16	PM	4	0.0	23	14	25	1
7/17	AM	4	0.8	12	11	26	1
7/17	PM	4	0.5	17	12	26	1
7/18	AM	4	3.1	14	12	28	1
7/18	PM	3	9.5	17	13	29	1
7/19	AM	4	6.3	12	11	39	2
7/19	PM	4	1.9	16	11	39	2
7/20	AM	4	0.4	11	9	39	2
7/20	PM	3	0.0	14	11	39	2
7/21	AM	4	0.0	11	9	37	2
7/21	PM	4	0.9	13	10	37	2
7/22	AM	4	11.5	9	9	38	2
7/22	PM	4	0.5	12	10	40	2
7/23	AM	3	0.0	6	8	38	1
7/23	PM	2	0.0	17	12	38	1
7/24	AM	4	0.2	12	10	38	1
7/24	PM	4	3.1	15	11	39	1
7/25	AM	3	1.8	11	10	40	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
7/25	PM	4	3.7	13	11	41	1
7/26	AM	4	0.0	12	9	42	2
7/26	PM	4	0.0	15	12	41	2
7/27	AM	4	0.2	13	9	39	1
7/27	PM	3	0.0	19	13	39	1
7/28	AM	3	0.0	10	8	38	1
7/28	PM	1	0.0	23	12	37	1
7/29	AM	2	0.0	15	10	36	1
7/29	PM	4	0.0	19	11	35	1
7/30	AM	4	1.3	14	10	35	1
7/30	PM	4	0.1	14	11	35	1
7/31	AM	4	5.0	12	11	35	1
7/31	PM	4	2.0	13	11	37	1
8/1	AM	3	0.5	8	8	40	2
8/1	PM	3	0.0	18	11	40	2
8/2	AM	3	0.0	14	12	36	2
8/2	PM	3	1.6	20	12	36	2
8/3	AM	3	0.3	11	9	36	1
8/3	PM	3	0.0	20	12	35	1
8/4	AM	1	0.0	7	9	34	1
8/4	PM	3	0.0	21	13	34	1
8/5	AM	4	0.0	11	9	32	1
8/5	PM	4	0.0	17	13	32	1
8/6	AM	4	5.0	12	11	31	1
8/6	PM	3	0.1	16	12	30	1
8/7	AM	4	0.2	12	10	30	1
8/7	PM	4	11.0	14	12	31	1
8/8	AM	3	0.0	7	10	31	1
8/8	PM	3	0.0	16	12	30	1
8/9	AM	2	0.5	4	8	29	1
8/9	PM	4	0.0	15	10	28	1
8/10	AM	4	0.2	9	9	29	1
8/10	PM	3	2.4	14	11	29	1
8/11	AM	4	0.5	8	9	29	1
8/11	PM	2	0.0	22	13	29	1
8/12	AM	1	0.0	5	9	30	1

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Appendix C1.–Page 3 of 3.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
8/12	PM	1	0.0	21	12	30	1
8/13	AM	1	0.3	5	9	29	1
8/13	PM	2	0.0	20	12	27	1
8/14	AM	1	0.0	7	9	26	1
8/14	PM	1	0.0	21	12	24	1
8/15	AM	1	0.0	6	9	23	1
8/15	PM	1	0.0	20	12	23	1
8/16	AM	3	0.0	6	9	23	1
8/16	PM	1	0.0	24	13	22	1
8/17	AM	1	0.0	7	9	22	1
8/17	PM	3	0.0	22	14	21	1
8/18	AM	1	0.0	10	11	21	1
8/18	PM	2	0.0	23	13	20	1
8/19	AM	3	3.1	11	9	24	1
8/19	PM	2	2.0	20	13	24	1
8/20	AM	4	0.0	12	11	22	1
8/20	PM	–	–	–	–	–	–
Average	–	–	1.2	14.1	11.1	31.6	–

Note: En dash means no data.

[a] Sky condition codes:
1 = clear or mostly clear; <10% cloud cover
2 = partly cloudy; <50% cloud cover
3 = mostly cloudy; >50% cloud cover
4 = complete overcast
5 = thick fog

[b] Water clarity codes:
1 = visibility greater than 1 meter
2 = visibility between 0.5 and 1 meter
3 = visibility less than 0.5 meter

Appendix C2.–Daily weather and stream observations at the George River weir, 2020.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River stage (cm)	Water clarity[b]
6/15	AM	1	0.0	12	11	70	2
6/15	PM	2	0.0	21	12	76	2
6/16	AM	3	0.0	11	11	73	2
6/16	PM	1	0.0	21	14	70	2
6/17	AM	3	0.0	12	12	69	2
6/17	PM	3	0.0	20	13	68	2
6/18	AM	2	0.0	10	11	67	1
6/18	PM	2	0.0	18	14	65	1
6/19	AM	2	0.0	12	11	65	1
6/19	PM	4	4.0	14	13	64	1
6/20	AM	2	12.5	10	11	67	1
6/20	PM	4	0.5	15	13	70	2
6/21	AM	4	8.0	10	11	73	2
6/21	PM	3	0.5	18	13	73	2
6/22	AM	3	1.0	9	11	71	2
6/22	PM	4	0.5	13	12	73	2
6/23	AM	3	1.0	11	10	70	2
6/23	PM	3	0.0	17	12	70	1
6/24	AM	4	0.0	10	10	69	1
6/24	PM	–	–	–	–	–	–
6/25	AM	4	3.0	8	9	68	1
6/25	PM	4	0.5	12	10	67	1
6/26	AM	4	1.0	9	10	68	1
6/26	PM	3	0.5	13	11	68	1
6/27	AM	1	0.0	6	9	67	1
6/27	PM	4	0.0	14	11	66	1
6/28	AM	4	0.5	9	9	64	1
6/28	PM	4	0.0	14	11	64	1
6/29	AM	4	8.0	8	9	64	1
6/29	PM	3	0.5	14	11	66	1
6/30	AM	1	0.0	6	9	72	1
6/30	PM	3	0.0	18	11	71	1
7/1	AM	4	0.0	10	10	68	1
7/1	PM	4	0.0	17	12	66	1
7/2	AM	4	0.0	12	10	66	1
7/2	PM	4	0.5	18	12	63	1
7/3	AM	4	0.0	10	11	62	1

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Appendix C2.–Page 2 of 5.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
7/3	PM	2	0.0	16	13	62	1
7/4	AM	1	0.0	7	10	62	1
7/4	PM	2	0.0	23	14	61	1
7/5	AM	3	0.0	15	13	62	1
7/5	PM	3	0.0	20	14	61	1
7/6	AM	4	9.0	14	13	62	1
7/6	PM	4	3.0	13	13	62	1
7/7	AM	4	0.0	10	11	63	1
7/7	PM	4	0.0	10	11	63	1
7/8	AM	4	1.0	9	10	62	1
7/8	PM	4	2.0	11	11	63	1
7/9	AM	4	0.0	9	9	62	1
7/9	PM	3	0.0	16	11	62	1
7/10	AM	2	0.0	12	10	61	1
7/10	PM	2	0.0	21	13	60	1
7/11	AM	4	7.0	9	13	59	1
7/11	PM	4	4.5	13	13	58	1
7/12	AM	4	0.0	10	12	60	1
7/12	PM	2	0.0	17	14	60	1
7/13	AM	3	0.0	11	12	61	1
7/13	PM	4	0.3	16	14	60	1
7/14	AM	2	0.0	14	13	59	1
7/14	PM	3	0.0	20	14	59	1
7/15	AM	3	0.0	10	12	57	1
7/15	PM	3	0.0	21	15	56	1
7/16	AM	3	0.0	9	12	55	1
7/16	PM	3	0.0	20	15	54	1
7/17	AM	4	0.0	12	13	54	1
7/17	PM	3	2.0	17	15	54	1
7/18	AM	4	1.0	12	13	54	1
7/18	PM	3	2.0	20	15	55	1
7/19	AM	4	0.0	13	13	58	1
7/19	PM	3	0.0	17	15	60	1
7/20	AM	4	2.0	11	13	61	1
7/20	PM	3	0.0	13	14	64	1
7/21	AM	4	0.0	10	12	65	1
7/21	PM	4	1.0	13	12	64	1
7/22	AM	4	7.0	9	10	64	1
7/22	PM	3	1.0	12	11	63	1
7/23	AM	3	0.0	8	10	65	1

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Appendix C2.–Page 3 of 5.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
7/23	PM	2	0.0	20	13	64	1
7/24	AM	4	0.5	10	12	63	1
7/24	PM	4	6.0	12	12	63	1
7/25	AM	5	12.5	11	11	63	1
7/25	PM	3	2.8	14	12	67	1
7/26	AM	3	0.0	11	10	70	2
7/26	PM	2	4.0	12	12	69	2
7/27	AM	5	0.0	6	10	68	2
7/27	PM	3	0.0	20	14	66	1
7/28	AM	3	0.0	8	11	64	1
7/28	PM	4	0.0	16	11	63	1
7/29	AM	5	0.0	7	10	62	1
7/29	PM	4	0.0	19	12	61	1
7/30	AM	4	4.0	10	10	60	1
7/30	PM	4	4.0	13	10	61	1
7/31	AM	4	2.0	11	10	62	1
7/31	PM	4	0.0	14	11	61	1
8/1	AM	5	0.0	9	10	60	1
8/1	PM	4	0.5	15	11	60	1
8/2	AM	3	0.0	12	10	60	1
8/2	PM	4	6.0	17	12	60	1
8/3	AM	4	0.5	12	11	60	1
8/3	PM	3	0.0	20	14	59	1
8/4	AM	4	0.5	11	12	58	1
8/4	PM	3	0.0	21	14	58	1
8/5	AM	5	0.0	8	12	58	1
8/5	PM	4	0.0	18	14	56	1
8/6	AM	4	2.0	12	12	55	1
8/6	PM	4	0.0	15	13	55	1
8/7	AM	5	3.0	8	11	55	1
8/7	PM	3	3.5	15	13	56	1
8/8	AM	4	0.5	9	11	56	1
8/8	PM	4	0.0	13	13	55	1
8/9	AM	2	0.0	6	11	54	1
8/9	PM	3	0.0	16	13	54	1
8/10	AM	1	0.0	3	10	53	1
8/10	PM	2	0.0	18	12	51	1
8/11	AM	3	0.0	8	10	50	1
8/11	PM	3	0.0	15	13	50	1
8/12	AM	1	0.0	3	10	50	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
8/12	PM	2	0.0	19	13	50	1
8/13	AM	5	0.0	4	10	49	1
8/13	PM	2	0.0	20	13	49	1
8/14	AM	1	0.0	5	11	48	1
8/14	PM	2	0.0	21	14	47	1
8/15	AM	1	0.0	4	11	46	1
8/15	PM	1	0.0	20	15	45	1
8/16	AM	1	0.0	4	11	45	1
8/16	PM	1	0.0	23	15	45	1
8/17	AM	1	0.0	6	11	44	1
8/17	PM	2	0.0	22	14	44	1
8/18	AM	2	0.0	7	11	43	1
8/18	PM	2	0.0	23	14	43	1
8/19	AM	5	0.0	7	12	43	1
8/19	PM	–	–	–	–	–	–
8/20	AM	3	0.0	11	12	42	1
8/20	PM	3	0.0	18	14	42	1
8/21	AM	1	0.0	8	11	41	1
8/21	PM	1	0.0	21	14	41	1
8/22	AM	4	1.0	10	12	42	1
8/22	PM	3	0.0	14	13	41	1
8/23	AM	4	4.0	11	12	42	1
8/23	PM	3	0.0	15	14	42	1
8/24	AM	4	1.0	14	11	43	1
8/24	PM	3	6.0	11	12	45	1
8/25	AM	3	1.0	8	10	44	1
8/25	PM	2	0.0	14	12	44	1
8/26	AM	4	0.0	5	10	44	1
8/26	PM	4	1.0	14	12	44	1
8/27	AM	4	0.0	9	10	43	1
8/27	PM	4	3.0	12	12	44	1
8/28	AM	4	10.0	9	10	43	1
8/28	PM	4	1.0	13	12	45	1
8/29	AM	5	2.0	5	10	44	1
8/29	PM	4	2.0	12	11	44	1
8/30	AM	3	1.5	10	10	43	1
8/30	PM	4	12.5	9	10	45	1
8/31	AM	4	3.0	8	9	46	1
8/31	PM	3	0.5	13	11	48	1
9/1	AM	4	1.0	10	10	50	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
9/1	PM	4	0.0	10	10	53	2
9/2	AM	2	0.0	5	8	53	1
9/2	PM	4	0.0	8	9	50	1
9/3	AM	4	0.0	5	8	49	1
9/3	PM	3	0.0	10	9	48	1
9/4	AM	1	0.0	0	7	47	1
9/4	PM	3	0.0	9	8	45	1
9/5	AM	5	0.0	-2	6	44	1
9/5	PM	1	0.0	13	8	44	1
9/6	AM	4	0.0	4	6	44	1
9/6	PM	4	3.5	8	7	44	1
9/7	AM	3	0.0	11	7	44	1
9/7	PM	4	4.0	13	8	48	1
9/8	AM	3	0.0	10	7	48	1
9/8	PM	2	1.0	12	9	49	1
9/9	AM	4	3.5	7	7	49	1
9/9	PM	3	1.0	9	9	50	1
9/10	AM	2	0.0	-1	6	49	1
9/10	PM	3	0.0	10	8	49	1
9/11	AM	5	0.0	-2	5	50	1
9/11	PM	1	0.0	12	7	50	1
9/12	AM	1	0.0	-3	5	48	1
9/12	PM	1	0.0	13	7	48	1
9/13	AM	3	0.0	0	5	47	1
9/13	PM	4	0.0	13	8	47	1
9/14	AM	3	0.0	3	6	47	1
9/14	PM	4	0.0	10	7	46	1
9/15	AM	4	10.0	9	7	49	1
9/15	PM	2	4.0	11	8	49	1
9/16	AM	3	0.0	5	7	55	2
9/16	PM	4	0.0	9	8	60	3
9/17	AM	4	8.0	8	7	65	3
9/17	PM	4	6.0	8	8	65	3
9/18	AM	4	0.5	8	7	68	3
9/18	PM	3	0.0	11	8	72	3
Average	–	–	1.2	11.7	10.9	56.5	–

Note: En dash means no data.

[a] Sky condition codes:
1 = clear or mostly clear; <10% cloud cover
2 = partly cloudy; <50% cloud cover
3 = mostly cloudy; >50% cloud cover
4 = complete overcast
5 = thick fog

[b] Water clarity codes:
1 = visibility greater than 1 meter
2 = visibility between 0.5 and 1 meter
3 = visibility less than 0.5 meter

Appendix C3.–Daily weather and stream observations at the Kogrukluk River weir, 2020.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
6/20	AM	–	–	–	–	–	–
6/20	PM	1	11.5	15	10	289	1
6/21	AM	1	0.5	5	8	290	1
6/21	PM	3	0.5	15	10	285	1
6/22	AM	2	0.0	8	8	285	1
6/22	PM	3	0.0	15	9	282	1
6/23	AM	3	0.0	9	8	280	1
6/23	PM	3	0.0	15	10	280	1
6/24	AM	4	0.0	7	8	280	1
6/24	PM	4	3.5	9	8	278	1
6/25	AM	4	5.8	7	7	279	1
6/25	PM	4	2.5	12	8	279	1
6/26	AM	4	4.0	7	7	281	1
6/26	PM	4	5.0	10	7	280	2
6/27	AM	3	1.0	5	6	280	1
6/27	PM	4	0.0	9	8	279	2
6/28	AM	4	0.5	6	7	279	1
6/28	PM	4	0.5	12	9	279	1
6/29	AM	4	0.3	7	7	280	1
6/29	PM	3	0.0	16	10	280	2
6/30	AM	3	0.0	7	7	279	1
6/30	PM	4	0.0	14	10	277	2
7/1	AM	3	0.0	8	8	276	1
7/1	PM	4	0.0	15	9	275	1
7/2	AM	3	0.0	11	9	274	1
7/2	PM	4	2.5	14	9	273	2
7/3	AM	3	1.0	11	9	274	1
7/3	PM	3	0.0	19	10	273	1
7/4	AM	3	0.0	11	9	273	1
7/4	PM	2	0.0	–	–	272	1
7/5	AM	3	0.0	15	10	270	1
7/5	PM	4	11.0	15	11	270	1
7/6	AM	4	23.5	12	10	274	1
7/6	PM	4	1.0	12	9	276	1
7/7	AM	3	0.3	9	9	278	1
7/7	PM	4	0.0	15	10	278	1
7/8	AM	4	0.0	9	9	275	1
7/8	PM	4	0.0	9	8	273	1
7/9	AM	2	0.1	9	8	271	1
7/9	PM	3	0.0	15	10	270	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River stage (cm)	Water clarity[b]
7/10	AM	2	0.0	9.5	8.5	269	1
7/10	PM	2	0.0	22	13	268	1
7/11	AM	2	0.0	8.5	10	267	1
7/11	PM	4	11.0	12	8.5	267	1
7/12	AM	0	1.0	9	8.5	269	1
7/12	PM	2	3.5	20	12	269	1
7/13	AM	2	0.3	9	9.5	275	1
7/13	PM	3	0.0	17	12.5	276	1
7/14	AM	2	0.0	8.5	9	270	1
7/14	PM	3	0.0	19	12.5	269	1
7/15	AM	2	0.0	9.5	9.5	268	1
7/15	PM	3	0.0	17.5	12	266	1
7/16	AM	4	0.0	10	10	265	1
7/16	PM	3	0.0	19	12.5	265	1
7/17	AM	3	0.0	11	10	264	1
7/17	PM	3	8.2	16	12	268	1
7/18	AM	4	0.8	10	10	268	1
7/18	PM	3	6.5	16	11	270	1
7/19	AM	4	5.5	11	10	274	1
7/19	PM	4	15.0	12	12	276	1
7/20	AM	4	3.6	9	10	276	1
7/20	PM	2	0.5	14	12	282	2
7/21	AM	4	0.0	9	10	280	1
7/21	PM	4	0.0	12	10	276	1
7/22	AM	4	5.3	7	9	275	1
7/22	PM	3	0.5	12	10	277	1
7/23	AM	3	0.0	5	8	280	1
7/23	PM	3	0.0	17	11	280	1
7/24	AM	4	0.0	10	9	275	1
7/24	PM	3	0.3	17	10.5	272	1
7/25	AM	4	28.5	9	9	276	1
7/25	PM	3	8.0	15.5	10	282	1
7/26	AM	3	7.2	8	9	296	2
7/26	PM	3	0.5	17	11	296	2
7/27	AM	4	0.0	9	10	290	2
7/27	PM	3	0.0	15	12	285	1.5
7/28	AM	2	0.0	8	10	282	1
7/28	PM	3	0.0	20	12	280	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River stage (cm)	Water clarity[b]
7/29	AM	1	0.0	4	9	276	1
7/29	PM	3	0.0	18	12	275	1
7/30	AM	4	0.5	8	10	274	1
7/30	PM	4	0.2	13	11	274	1
7/31	AM	4	5.0	9	9	275	1
7/31	PM	4	11.5	12	11	288	1
8/1	AM	4	4.0	9	9	296	1
8/1	PM	3	0.7	15	10	300	2
8/2	AM	2	0.0	8	9	302	2
8/2	PM	3	0.0	19	11	299	2
8/3	AM	3	0.0	11	10	295	2
8/3	PM	3	0.0	15	11	280	1
8/4	AM	1	0.0	3	9	288	1
8/4	PM	2	0.0	19	11	286	1
8/5	AM	1	0.0	4	9	284	1
8/5	PM	4	0.0	14	9	284	1
8/6	AM	4	1.0	9	9	280	1
8/6	PM	4	2.5	12	9	280	1
8/7	AM	4	0.8	9	9	287	1
8/7	PM	4	13.0	11	10	290	1
8/8	AM	4	1.4	7	9	290	1
8/8	PM	4	1.2	9	9	292	1
8/9	AM	1	0.3	2	7	290	1
8/9	PM	3	0.0	15	11	289	1
8/10	AM	3	0.0	8	9	286	1
8/10	PM	2	0.0	13	10	283	1
8/11	AM	3	8.3	9	9	286	1
8/11	PM	2	0.3	12	10	285	1
8/12	AM	1	0.2	3	9	286	1
8/12	PM	2	0.0	21	12	285	1
8/13	AM	1	0.0	3	9	283	1
8/13	PM	1	0.0	22	12	281	1
8/14	AM	1	0.0	3	9	280	1
8/14	PM	1	0.0	20	13	279	1
8/15	AM	1	0.0	7	10	278	1
8/15	PM	2	0.0	23	12	276	1
8/16	AM	1	0.0	5	10	276	1
8/16	PM	1	0.0	24	13	274	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
8/17	AM	1	0.0	5	10	274	1
8/17	PM	1	0.0	25	13	272	1
8/18	AM	1	0.0	5	10	272	1
8/18	PM	2	0.0	23	12	272	1
8/19	AM	1	7.0	6	10	272	1
8/19	PM	1	0.0	25	13	272	1
8/20	AM	1	0.0	8	10	270	1
8/20	PM	1	0.0	22	13	269	1
8/21	AM	1	0.0	7	10	270	1
8/21	PM	2	0.0	22	12	269	1
8/22	AM	3	0.0	10	10	269	1
8/22	PM	4	0.0	15	11	268	1
8/23	AM	4	6.4	10	10	269	1
8/23	PM	3	15.0	15	10	269	1
8/24	AM	4	0.2	8	10	269	1
8/24	PM	3	8.0	12	10	270	1
8/25	AM	3	0.7	7	9	273	1
8/25	PM	4	0.1	15	11	272	1
8/26	AM	4	0.0	7	9	272	1
8/26	PM	3	0.0	16	11	270	1
8/27	AM	4	7.0	7	9	270	1
8/27	PM	3	0.2	14	11	269	1
8/28	AM	3	0.8	7	9	270	1
8/28	PM	3	0.1	14	12	270	1
8/29	AM	5	0.0	3	7	268	1
8/29	PM	5	3.5	11	9	268	1
8/30	AM	4	5.6	8	7	270	1
8/30	PM	5	14.0	7	8	278	1
8/31	AM	4	6.5	3	3	294	2
8/31	PM	4	1.0	7	4	315	3
9/1	AM	4	1.0	3	3	320	3
9/1	PM	2	0.1	7	4	310	2
9/2	AM	2	0.0	–	3	300	2
9/2	PM	2	0.0	3	3	298	1
9/3	AM	4	0.0	3	3	290	1
9/3	PM	4	5.0	–	–	289	1
9/4	AM	3	0.6	–	–	288	1
9/4	PM	3	0.0	10	6	288	1
9/5	AM	1	0.0	-5	4	285	1
9/5	PM	2	0.0	9	6	285	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
9/6	AM	4	0.1	3	5	283	1
9/6	PM	4	11.4	6	2	286	1
9/7	AM	4	3.2	6	5	295	1
9/7	PM	2	0.0	9	6	325	3
9/8	AM	3	0.0	5	6	330	2
9/8	PM	2	0.0	15	9	320	2
9/9	AM	2	0.0	3	5	311	1
9/9	PM	2	0.0	14	6	309	1
9/10	AM	1	0.0	-4	4	300	1
9/10	PM	1	0.0	17	9	300	1
9/11	AM	1	0.0	-5	4	297	1
9/11	PM	2	0.0	15	6	296	1
9/12	AM	1	0.0	-4	4	293	1
9/12	PM	2	0.0	14	6	292	1
9/13	AM	2	0.0	0	4	291	1
9/13	PM	3	0.0	16	6	290	1
9/14	AM	4	0.0	4	5	289	1
9/14	PM	4	7.0	6	4	290	2
9/15	AM	4	11.0	7	5	290	1
9/15	PM	–	–	–	–	–	–
Average	–	–	2.0	11	9	281	–

Note: En dash means no data.

[a] Sky condition codes:
1 = clear or mostly clear; <10% cloud cover
2 = partly cloudy; <50% cloud cover
3 = mostly cloudy; >50% cloud cover
4 = complete overcast
5 = thick fog

[b] Water clarity codes:
1 = visibility greater than 1 meter
2 = visibility between 0.5 and 1 meter
3 = visibility less than 0.5 meter

Appendix C4.–Daily weather and stream observations at the Telaquana River weir, 2020.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River stage (cm)	Water clarity[b]
7/10	PM	2	0.0	14	12	31	1
7/11	AM	2	0.0	13	11	31	1
7/11	PM	4	0.3	12	11	32	1
7/12	AM	4	0.2	11	12	33	1
7/12	PM	4	0.4	12	13	33	1
7/13	AM	1	0.6	11	13	33	1
7/13	PM	2	0.0	16	13	32	1
7/14	AM	2	0.0	12	12	31	1
7/14	PM	2	0.0	23	15	31	1
7/15	AM	2	0.0	15	14	30	1
7/15	PM	2	0.0	22	15	29	1
7/16	AM	1	0.0	15	13	29	1
7/16	PM	3	0.0	20	15	28	1
7/17	AM	3	0.1	15	15	29	1
7/17	PM	4	0.0	15	15	29	1
7/18	AM	4	0.0	12	14	30	1
7/18	PM	3	0.2	17	16	29	1
7/19	AM	4	0.1	15	15	29	1
7/19	PM	3	0.0	16	18	28	1
7/20	AM	4	0.0	13	14	29	1
7/20	PM	4	0.0	16	12	30	1
7/21	AM	2	0.0	10	11	32	1
7/21	PM	2	0.0	18	13	31	1
7/22	AM	4	0.1	10	12	31	1
7/22	PM	3	0.3	12	11	31	1
7/23	AM	4	0.0	10	11	34	1
7/23	PM	2	0.0	22	12	34	1
7/24	AM	4	0.0	11	12	34	1
7/24	PM	4	0.0	15	12	33	2
7/25	AM	4	0.2	10	13	34	2
7/25	PM	3	0.1	16	13	33	2
7/26	AM	4	0.2	10	12	34	2
7/26	PM	2	0.0	18	13	33	2
7/27	AM	4	0.0	10	12	32	2
7/27	PM	2	0.0	20	14	32	2
7/28	AM	3	0.0	13	12	31	2
7/28	PM	2	0.0	19	13	31	2
7/29	AM	2	0.0	10	14	30	2
7/29	PM	2	0.0	23	15	30	2
7/30	AM	3	0.0	18	15	31	2
7/30	PM	3	0.0	18	15	30	2
7/31	AM	3	0.0	13	14	28	2
7/31	PM	3	0.0	18	14	27	2
8/1	AM	4	0.1	10	14	27	2
8/1	PM	4	0.2	17	16	27	2

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River stage (cm)	Water clarity[b]
8/2	AM	4	0.0	12	14	26	2
8/2	PM	4	0.4	12	15	27	2
8/3	AM	5	0.1	11	14	27	1
8/3	PM	3	0.0	20	15	27	1
8/4	AM	5	0.0	8	14	26	1
8/4	PM	2	0.0	20	15	27	1
8/5	AM	1	0.0	10	14	27	1
8/5	PM	3	0.0	20	15	28	1
8/6	AM	4	0.0	13	15	28	1
8/6	PM	3	0.0	14	14	28	1
8/7	AM	3	0.0	10	14	27	1
8/7	PM	2	0.0	18	15	26	1
8/8	AM	4	0.0	10	14	25	1
8/8	PM	4	0.3	11	14	25	1
8/9	AM	4	0.2	10	14	24	1
8/9	PM	3	0.0	14	13	24	1
8/10	AM	2	0.0	5	10	24	1
8/10	PM	3	0.0	15	12	24	1
8/11	AM	3	0.0	8	12	23	2
8/11	PM	3	0.0	18	13	22	1
8/12	AM	1	0.0	4	13	21	1
8/12	PM	1	0.0	20	14	20	1
8/13	AM	1	0.0	6	12	19	1
8/13	PM	2	0.0	20	13	20	1
8/14	AM	1	0.1	8	13	21	1
8/14	PM	1	0.0	16	14	20	1
8/15	AM	1	0.0	8	13	20	1
8/15	PM	1	0.0	23	15	20	1
8/16	AM	1	0.0	6	15	19	1
8/16	PM	1	0.0	24	17	18	1
8/17	AM	1	0.0	9	15	17	1
8/17	PM	1	0.0	23	17	17	1
8/18	AM	4	0.0	11	15	17	1
8/18	PM	1	0.0	19	17	17	1
8/19	AM	3	0.2	10	16	18	1
8/19	PM	2	0.0	19	18	17	1
8/20	AM	4	0.0	10	15	17	1
8/20	PM	1	0.0	20	15	18	1
8/21	AM	4	0.0	9	15	17	1
8/21	PM	1	0.0	20	16	17	1
8/22	AM	2	0.0	7	15	17	1
8/22	PM	4	0.0	16	16	16	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
8/23	AM	4	0.1	10	15	16	1
8/23	PM	2	0.2	16	16	16	1
8/24	AM	4	0.0	9	13	16	1
8/24	PM	3	0.0	16	12	16	1
Average	–	–	0.1	14	14	26	–

Note: En dash means no data.

[a] Sky condition codes:

1 = clear or mostly clear; <10% cloud cover
2 = partly cloudy; <50% cloud cover
3 = mostly cloudy; >50% cloud cover
4 = complete overcast
5 = thick fog

[b] Water clarity codes:

1 = visibility greater than 1 meter
2 = visibility between 0.5 and 1 meter
3 = visibility less than 0.5 meter

Appendix C5.–Daily weather and stream observations at the Takotna River weir, 2020.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
7/1	AM	2	0.0	–	–	89	2
7/1	PM	–	–	–	–	–	–
7/2	AM	2	0.1	–	–	87	2
7/2	PM	–	–	–	–	–	–
7/3	AM	2	0.0	–	–	86	2
7/3	PM	–	–	–	–	–	–
7/4	AM	1	0.0	–	–	85	2
7/4	PM	–	–	–	–	–	–
7/5	AM	–	–	–	–	–	–
7/5	PM	2	–	–	–	84	–
7/6	AM	–	–	–	–	–	–
7/6	PM	1	–	–	–	80	1
7/7	AM	–	–	–	–	–	–
7/7	PM	1	–	–	–	79	–
7/8	AM	–	–	–	–	–	–
7/8	PM	3	0.1	–	–	79	–
7/9	AM	–	–	–	–	–	–
7/9	PM	–	–	–	–	–	–
7/10	AM	–	–	–	–	–	–
7/10	PM	–	–	–	–	–	–
7/11	AM	–	–	–	–	–	–
7/11	PM	–	–	–	–	–	–
7/12	AM	4	0.1	–	–	82	1
7/12	PM	–	–	–	–	–	–
7/13	AM	3	–	–	–	86	1
7/13	PM	2	0.0	–	–	87	2
7/14	AM	4	–	–	–	86	1
7/14	PM	2	0.0	–	–	85	2
7/15	AM	3	0.0	–	–	85	1
7/15	PM	1	–	–	–	81	1
7/16	AM	4	0.0	–	–	81	1
7/16	PM	1	0.1	13	15	81	1
7/17	AM	4	0.1	10	13	78	1
7/17	PM	4	0.3	15	14	79	1
7/18	AM	1	0.3	14	12	82	1
7/18	PM	3	1.2	15	12	89	3
7/19	AM	5	0.0	13	14	97	3
7/19	PM	2	0.2	16	15	98	3
7/20	AM	–	0.0	0	0	102	3
7/20	PM	3	0.0	15	0	102	3
7/21	AM	2	0.0	14	0	102	3
7/21	PM	3	0.0	0	0	102	3

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
7/22	AM	4	0.0	0	0	102	3
7/22	PM	–	–	–	–	–	–
7/23	AM	1	0.0	8	0	95	2
7/23	PM	3	0.0	16	12	91	2
7/24	AM	4	0.0	11	12	89	2
7/24	PM	4	0.3	12	12	90	2
7/25	AM	3	0.5	11	12	89	2
7/25	PM	2	0.0	15	11	92	2
7/26	AM	1	0.0	14	12	96	3
7/26	PM	2	0.0	19	13	96	3
7/27	AM	2	0.0	10	11	93	3
7/27	PM	1	0.0	17	14	92	3
7/28	AM	4	0.0	12	13	91	2
7/28	PM	4	0.0	14	13	91	2
7/29	AM	3	0.0	12	9	89	2
7/29	PM	4	0.0	19	13	87	1
7/30	AM	4	0.0	14	12	87	1
7/30	PM	2	0.1	14	11	86	1
7/31	AM	2	0.0	18	12	86	1
7/31	PM	1	0.0	16	13	84	1
8/1	AM	3	0.0	14	13	83	1
8/1	PM	3	0.0	16	13	85	1
8/2	AM	4	0.0	12	12	86	1
8/2	PM	4	0.0	16	14	86	1
8/3	AM	3	0.0	15	13	87	1
8/3	PM	1	0.0	16	14	86	1
8/4	AM	4	0.0	14	13	86	1
8/4	PM	2	0.0	16	14	86	1
8/5	AM	–	–	–	–	–	–
8/5	PM	4	0.0	15	15	82	1
8/6	AM	4	0.4	13	14	82	1
8/6	PM	2	0.0	11	13	82	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
8/7	AM	4	0.0	10	13	82	1
8/7	PM	2	0.1	13	13	82	1
8/8	AM	3	0.0	12	12	81	1
8/8	PM	3	0.0	14	14	81	1
8/9	AM	4	0.0	11	13	79	1
8/9	PM	1	0.0	10	13	79	1
8/10	AM	2	0.0	8	–	79	1
8/10	PM	2	0.0	11	13	79	–
Average	–	–	0.1	13	11	87	–

Note: En dash means no data.

[a] Sky condition codes:
1 = clear or mostly clear; <10% cloud cover
2 = partly cloudy; <50% cloud cover
3 = mostly cloudy; >50% cloud cover
4 = complete overcast
5 = thick fog

[b] Water clarity codes:
1 = visibility greater than 1 meter
2 = visibility between 0.5 and 1 meter
3 = visibility less than 0.5 meter

Appendix C6.–Daily weather and stream observations at the Salmon River (Pitka Fork) weir, 2020.

		Sky	Precipitation	Temperature (°C)		River	Water
Date	Time	conditions[a]	(mm)	Air	Water	stage (cm)	clarity[b]
6/19	PM	4	2.0	15	13	40	1
6/20	AM	1	2.0	11	11	45	1
6/20	PM	4	0.8	15	14	45	1
6/21	AM	4	4.0	12	13	47	1
6/21	PM	1	0.0	14	16	47	1
6/22	AM	4	0.0	12	13	47	1
6/22	PM	4	0.0	11	14	47	1
6/23	AM	4	3.0	12	11	50	1
6/23	PM	4	0.0	13	11	48	1
6/24	AM	4	0.5	12	11	48	1
6/24	PM	4	0.2	13	12	48	1
6/25	AM	4	3.0	11	13	52	1
6/25	PM	4	0.0	12	14	51	1
6/26	AM	4	0.6	11	13	52	1
6/26	PM	3	0.0	10	12	51	1
6/27	AM	4	0.1	12	13	50	1
6/27	PM	3	0.0	13	11	50	1
6/28	AM	4	0.0	13	11	50	1
6/28	PM	3	2.0	14	12	51	1
6/29	AM	4	3.0	11	13	52	1
6/29	PM	3	6.0	15	13	56	1
6/30	AM	3	0.0	10	10	58	1
6/30	PM	4	0.0	10	11	58	1
7/1	AM	4	0.5	10	12	55	1
7/1	PM	3	0.0	15	13	56	1
7/2	AM	4	0.5	13	14	55	1
7/2	PM	4	0.1	15	15	55	1
7/3	AM	4	1.0	15	14	56	1
7/3	PM	1	0.0	20	15	59	1
7/4	AM	4	1.4	11	13	58	1
7/4	PM	0	0.0	12	13	58	1
7/5	AM	2	0.0	13	14	57	1
7/5	PM	1	0.0	25	19	57	1
7/6	AM	2	0.0	16	16	57	1
7/6	PM	–	–	–	–	–	–

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River stage (cm)	Water clarity[b]
7/7	AM	4	0.2	13	15	59	1
7/7	PM	4	0.0	15	15	60	1
7/8	AM	4	6.0	10	12	62	1
7/8	PM	3	0.0	11	13	66	1
7/9	AM	3	0.8	13	12	66	1
7/9	PM	3	0.0	20	14	65	1
7/10	AM	2	0.1	13	13	64	1
7/10	PM	2	0.0	20	16	64	1
7/11	AM	3	0.0	12	14	64	1
7/11	PM	1	0.0	16	16	64	1
7/12	AM	4	0.0	13	14	63	1
7/12	PM	2	0.0	25	16	64	1
7/13	AM	4	3.4	13	14	64	1
7/13	PM	2	0.0	19	15	64	1
7/14	AM	4	0.0	14	14	64	1
7/14	PM	3	0.0	21	16	64	1
7/15	AM	3	0.3	14	15	64	1
7/15	PM	3	0.0	20	16	65	1
7/16	AM	4	0.0	10	14	64	1
7/16	PM	4	0.0	15	15	64	1
7/17	AM	4	0.0	13	14	65	1
7/17	PM	4	1.0	15	15	66	1
7/18	AM	4	1.6	14	13	67	1
7/18	PM	3	0.0	21	15	68	1
7/19	AM	4	0.3	14	15	67	1
7/19	PM	3	1.8	19	15	67	1
7/20	AM	3	0.0	15	15	71	1
7/20	PM	4	0.3	18	15	73	1
7/21	AM	4	0.7	11	13	72	1
7/21	PM	3	0.0	16	14	73	1
7/22	AM	4	0.2	11	13	72	1
7/22	PM	1	0.0	12	14	70	1
7/23	AM	2	0.0	10	13	70	1
7/23	PM	3	0.0	20	15	70	1
7/24	AM	3	0.0	12	14	70	1
7/24	PM	4	2.3	13	14	71	1
7/25	AM	4	9.0	11	11	79	1
7/25	PM	4	0.4	18	13	82	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
7/26	AM	4	14.0	12	13	84	1
7/26	PM	3	10.0	15	15	90	1
7/27	AM	3	1.4	11	14	92	2
7/27	PM	–	–	–	–	–	–
7/28	AM	3	0.0	13	14	85	2
7/28	PM	4	0.0	15	13	83	2
7/29	AM	–	–	–	–	–	–
7/29	PM	3	0.0	24	14	82	1
7/30	AM	3	0.0	15	14	80	1
7/30	PM	4	0.0	14	13	80	1
7/31	AM	4	0.3	12	12	79	1
7/31	PM	2	0.0	13	14	80	1
8/1	AM	4	3.0	14	14	80	1
8/1	PM	4	0.0	18	13	82	1
8/2	AM	4	1.6	14	13	81	1
8/2	PM	4	0.4	18	14	81	1
8/3	AM	4	0.0	15	14	81	1
8/3	PM	4	0.0	14	13	81	1
8/4	AM	4	0.1	13	13	81	1
8/4	PM	4	7.2	15	14	83	1
8/5	AM	3	1.2	8	12	81	1
8/5	PM	–	–	–	–	–	–
8/6	AM	4	3.0	13	14	92	2
8/6	PM	4	2.4	18	13	90	2
8/7	AM	4	9.0	12	12	88	2
8/7	PM	3	0.6	18	14	88	2
8/8	AM	3	0.1	13	14	86	2
8/8	PM	4	0.3	16	14	85	1
8/9	AM	4	0.3	11	13	85	1
8/9	PM	4	0.0	15	13	85	1
8/10	AM	4	0.0	10	13	85	1
8/10	PM	3	0.0	13	13	84	1
8/11	AM	4	0.1	10	12	83	1
8/11	PM	2	0.0	13	13	83	1
8/12	AM	4	1.0	8	11	83	1
8/12	PM	1	0.0	18	13	84	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
8/13	AM	1	0.0	5	11	83	1
8/13	PM	1	0.0	20	12	83	1
8/14	AM	2	0.0	5	12	83	1
8/14	PM	–	–	–	–	–	–
8/15	AM	1	0.0	8	13	83	1
8/15	PM	1	0.0	24	14	82	1
Average	–	–	1.0	14	13	68	–

Note: En dash means no data.

[a] Sky condition codes:
1 = clear or mostly clear; <10% cloud cover
2 = partly cloudy; <50% cloud cover
3 = mostly cloudy; >50% cloud cover
4 = complete overcast
5 = thick fog

[b] Water clarity codes:
1 = visibility greater than 1 meter
2 = visibility between 0.5 and 1 meter
3 = visibility less than 0.5 meter

APPENDIX D: HISTORICAL SUMMARY OF NONTARGET SPECIES PASSAGE AT KUSKOKWIM AREA WEIRS

Appendix D1.–Yearly observed passage of nontarget species at Salmon River (Aniak) weir, 2012–2018 and 2020.

Year	Pink salmon	Longnose sucker	Dolly Varden	Arctic grayling	Rainbow trout	Whitefish
2012	62	37	311	8	3	–
2013	17	50	86	11	22	2
2014	116	154	127	3	11	8
2015	126	288	491	13	22	9
2016	77	146	5	5	0	3
2017	525	74	100	57	8	10
2018	436	354	324	40	46	0
2020	48	22	5	6	0	0
Average	176	141	181	18	14	5

Note: En dashes mean no data.

Appendix D2.–Yearly observed passage of nontarget species at George River weir, 2012–2020.

Year	Sockeye salmon	Pink salmon	Longnose sucker	Dolly Varden	Arctic grayling	Whitefish	Northern pike
2012	79	6,271	2,900	2	0	1	1
2013	150	278	21,808	3	32	80	9
2014	156	906	2,294	4	45	49	0
2015	159	703	9,584	6	345	106	2
2016	2,807	1,708	4,941	9	172	34	0
2017	912	1,404	4,046	1	206	16	4
2018	1,615	1,752	4,832	24	141	36	5
2019	3,973	312	11,567	1	44	34	0
2020	281	766	1,067	3	106	31	3
Average	1,126	1,567	7,004	6	121	43	3

Appendix D3.–Yearly observed passage of nontarget species at Kogrukluk River weir, 2012–2020.

Year	Pink salmon	Dolly Varden	Arctic grayling	Whitefish	Northern pike
2012	237	259	0	35	0
2013	13	84	0	13	0
2014	288	319	4	56	0
2015	88	381	2	117	1
2016	1,237	11	0	0	0
2017	299	38	1	17	0
2018	3,977	1,092	24	89	3
2019	99	236	24	74	2
2020	5,542	777	27	49	0
Average	1,309	355	9	50	1

Appendix D4.–Yearly observed passage of nontarget species at Telaquana River weir, 2012–2020.

Year	Chinook salmon	Chum salmon	Pink salmon	Longnose sucker	Arctic grayling	Whitefish	Northern pike	Lake trout
2012	5	5	2	990	54	105	4	11
2013	17	83	0	348	72	17	10	5
2014	67	72	4	1,361	4	21	6	12
2015	101	92	4	115	34	1	0	1
2016	119	103	1	1,251	54	84	7	7
2017	202	157	7	1,590	85	40	5	8
2018	149	152	0	3,169	71	87	5	9
2019	130	166	2	947	70	28	3	7
2020	52	32	3	299	64	33	9	0
Average	94	96	3	1,119	56	46	5	7

Appendix D5.–Yearly observed passage of nontarget species at Takotna River weir, 2013 and 2017–2020.

Year	Sockeye salmon	Pink salmon	Arctic grayling	Whitefish	Northern pike
2013	0	0	48	2	1
2017	6	0	9	8	1
2018	4	1	58	27	1
2019	36	0	7	2	2
2020	7	0	0	0	4
Average	11	0	24	8	2

Appendix D6.–Yearly observed passage of nontarget species at Salmon River (Pitka Fork) River weir, 2015–2020.

Year	Sockeye salmon	Chum salmon	Longnose sucker	Arctic grayling	Whitefish	Northern pike
2015	0	54	38	4	0	0
2016	0	55	324	2	36	3
2017	17	393	300	8	41	3
2018	1	121	40	1	22	1
2019	1	18	17	0	18	1
2020	0	118	2	2	2	1
Average	3	127	120	3	20	2