Fishery Data Series No. 23-30

Salmon Escapement Monitoring in the Kuskokwim Area, 2021

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

USFWS Office of Subsistence Management

Fisheries Resource Monitoring Program

by

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

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ABSTRACT

In collaboration with other entities, the Alaska Department of Fish and Game (ADF&G) conducted aerial surveys and operated ground-based weir projects to monitor Pacific salmon *Oncorhynchus* spp. escapement throughout the Kuskokwim Area in 2021. This report presents the results of sampling activities and escapement monitoring from all aerial surveys and weir projects operated in 2021 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 (NPS). Chinook salmon *O. tshawytscha* escapements were successfully enumerated on 5 tributaries using weirs and 3 tributaries using aerial surveys. Chinook salmon escapement was below the historical average at all locations except for 1 aerial survey (North Fork Goodnews River was slightly above the historical average). Of the 12 escapement goals for Chinook salmon, 4 were successfully assessed and met. Chum salmon *O. keta* were successfully enumerated using weirs on 3 Kuskokwim River tributaries. Chum salmon escapements were the lowest on record at all locations. Only 1 chum salmon tributary escapement goal was assessed and was not met. Sockeye salmon *O. nerka* were successfully enumerated on 3 tributaries using weirs and 3 tributaries using aerial surveys. Sockeye salmon escapement was above the historical average at 3 sites assessed and below average at the other 3. Of the 4 escapement goals for sockeye salmon, 3 were successfully assessed, 1 was met, and the other 2 were exceeded. Coho salmon were successfully enumerated on 2 tributaries using weirs, and 1 escapement goal was assessed and met. Coho salmon escapement was above average at 1 location and below average at the other. There was no effort to monitor coho salmon escapement in Kuskokwim Bay due to funding constraints in 2021.

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, contributing to subsistence, commercial, and sport fishery harvests. Because monitoring all tributaries of the Kuskokwim River is not feasible, 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 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; Tiernan and Gray 2020). The subsistence salmon fishery is one of the largest in Alaska and remains a fundamental component of local culture (Tiernan and Gray 2020). 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 (Tiernan and Gray 2020). 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 area commercial fisheries ceased, and commercial opportunity was limited to registered catcher–sellers (Lipka and Tiernan 2018). In 2020 and 2021, 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 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. Aerial surveys in the Kuskokwim River only index Chinook salmon escapement. A total of 145 individual rivers and lakes throughout the area have been surveyed at least once (Brannian et al. 2006).[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 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 Arctic–Yukon–Kuskokwim Database Management System).[1] 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. In contrast, weir counts were used to estimate the number of salmon migrating past a specific location over the entire season. In addition, aerial

[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 2022). Hereafter cited as AYKDBMS.

survey indices are not directly comparable among monitored locations within the same year due 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 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 are 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 2021). The model estimate is used to evaluate the drainagewide escapement goal for Chinook salmon (65,000–120,000 fish; e.g., Larson 2021).

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 2021. Historical information for weirs and aerial surveys not operated in 2021 can be found in the AYKDBMS. ADF&G led all aerial surveys in the area and 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 funded the National Park Service (NPS) to operate the Telaquana River weir. Additionally, the Native Village of Napaimute (NVN) and the Kuskokwim River Inter-Tribal Fish Commission (KRITFC) secured funding to independently operate the Salmon River (Aniak) and Takotna River weirs. 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 area, including estimating the total run size of Kuskokwim River Chinook salmon. The United States Fish and Wildlife Service (USFWS) typically operates a weir on the Kwethluk River; however, the weir did not operate in 2021. 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 2021:

   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 2021:

   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 1 July and 10 August
   - Salmon River (Pitka Fork) – Chinook salmon between 20 June and 15 August

3. Collect ASL data from adult salmon species using weir traps in 2021 such that minimum sample sizes meet or exceed the following:
   - Chinook salmon – Salmon River (Aniak) *n* = 260, Takotna River *n* = 75, Salmon River (Pitka Fork) *n* = 250, George and Kogrukluk Rivers *n* = 230
   - Sockeye salmon – Kogrukluk and Telaquana Rivers (sex and length data only) *n* = 250
   - Chum salmon – Kogrukluk River *n* = 600, Salmon (Aniak) and George Rivers *n* = 400
   - Coho salmon – George and Kogrukluk Rivers *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 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 area. In 2021, 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 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 the COVID-19 pandemic.

Kisaralik River

The Kisaralik River is located between the Tuluksak and Kwethluk Rivers. 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. Aerial surveys flown on the Kisaralik River indexed Chinook salmon escapement to the Lower Kuskokwim River, a portion of the drainage where subsistence fishing was common.

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 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 aerial surveys provide 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 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. The channel averages 70 m wide and 1.25 m deep at the weir site. 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 primarily 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.

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 Stony River, which then joins the Kuskokwim River at rkm 536. Escapement of sockeye salmon was assessed using a weir located on the Telaquana River approximately 1 rkm downstream of 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

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. 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). Aerial surveys were flown on the Cheeneetnuk and Gagaryah Rivers to index Chinook salmon escapement to the Swift River.

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 focus 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 the 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 Kuskokwim River tributaries and 3 rivers in Kuskokwim Bay in 2021 (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). Geographic coordinates defined index areas and often coincided with landmarks 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) to produce comparable indexes of escapement. Details about 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 live salmon and carcass counts 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

Depending on channel morphology and flow, a fixed picket or resistance board weir design with an integrated fish trap was used at all locations. 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 crew working in snorkel gear to attach weir components to the stream bed. Seasonal flooding occurs, 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 that 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 2021, ADF&G and its partners evaluated available funding and data needed to establish planned operational periods that would 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 River 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 the following morning and uploaded to the AYKDBMS that same day.

Missed Escapement Estimates

A variety of 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. The 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 between 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:

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

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 to be 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, conducted 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, variation in run timing, and to allow investigation of interannual changes in ASL composition. At 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 salmon 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, 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 corresponding to 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, all ASL data and metadata were copied to Microsoft Excel spreadsheets corresponding 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

Due to poor weather conditions and limited pilot availability, none of the aerial surveys were successfully flown on the Kuskokwim River tributaries in 2021. All 3 scheduled rivers in the Kuskokwim Bay were successfully flown once between 24 July and 25 July for Chinook and sockeye salmon, and escapement indices were determined for both species (Tables 6 and 7).

Weir Projects

Salmon River (Aniak) Weir

The Salmon River (Aniak) weir operated from 15 July to 19 August 2021. 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 29 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 19 August (Appendix C1).

George River Weir

The George River weir was operated from 18 June through 20 September 2021. The weir was out of operation for 2 partial days due to holes in the weir and high water (Table 8). The weir was installed 3 days late because the entire rail was pulled out of the river and moved upstream a short distance at the start of the season. Total escapement was estimated for all target species. Weather and stream observations were recorded between 12 June and 20 September (Appendix C2).

Kogrukluk River Weir

The Kogrukluk River weir was operated from 26 June through 25 September 2021. During this period, the weir was inoperable for 6 full days and 6 partial days due to holes in the weir and high water (Table 8). Postseason evaluation indicated that the actual operational dates were adequate to observe at least 60% of the escapement for all target species based on historical run timing. As such, there was sufficient data to generate a reliable estimate for all target species. Weather and stream observations were recorded between 26 June and 25 September (Appendix C3). Due to a broken thermometer, air and water temperatures were only recorded between 9 September and 25 September (Appendix C3).

Telaquana River Weir

The Telaquana River weir was operated from 5 July through 19 August 2021. During this period, there were 2 inoperable days due to holes in the weir (Table 8). 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 5 July and 21 August (Appendix C4).

Takotna River Weir

The Takotna River weir was operated from 4 July through 10 August 2021. During this period, the weir was inoperable for 8 full days and 4 partial days due to holes in the weir and high water (Table 8). 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 the low overall passage numbers and a failure to assess at least 60% of the run. Weather and stream observations were recorded between 5 July and 10 August (Appendix C5).

Salmon River (Pitka Fork) Weir

The Salmon River (Pitka Fork) weir was operated from 17 June through 15 August 2021. During this period, the weir was inoperable for 4 partial days due to holes in the weir (Table 8). 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. Weather and stream observations were recorded between 20 June and 15 August (Appendix C6).

ESCAPEMENT COUNTS

Chinook Salmon

Aerial Survey

Due to poor weather and pilot availability, Chinook salmon aerial escapement counts could only be performed in the Kuskokwim Bay area. The counts were below the historical average[2] in the Middle Fork Goodnews and Kanektok Rivers and above average in the North Fork Goodnews

[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 2020. The number of years represented in historical averages varies by project. A comprehensive record of operational years and escapement estimates contributing to historical averages are available in the AYKDBMS.

River (Table 6). Both the North Fork Goodnews and Kanektok River escapement counts were within the established sustainable escapement goals (SEG; Table 9).

Weir

Chinook salmon escapement was estimated at 5 weirs in 2021. Annual escapements were successfully estimated for Chinook salmon at the Salmon (Aniak; 1,303 fish), George (2,920 fish), Kogrukluk (6,969 fish), Takotna (323 fish), and Salmon (Pitka Fork; 3,992 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, the only 2 weir goals assessed in 2021 (Table 11). Weir counts indicated that, although low, Chinook salmon escapement was adequate to meet escapement needs in 2021.

Chinook salmon run timing was late at the Kuskokwim River weir projects in 2021 (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

Chum salmon escapements were very poor in 2021. Annual escapements were successfully estimated for chum salmon at the Salmon (Aniak; 537 fish), George (1,371 fish), and Kogrukluk (4,153 fish) weirs (Table 12). Escapements at these 3 weirs were the lowest on record (Table 13). The escapement at Kogrukluk River was ~11,000 fish below the lower bound of the SEG (Table 13).

Chum salmon run timing was late at the Kuskokwim River weir projects in 2021 (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.

Sockeye Salmon

Aerial Survey

Sockeye salmon aerial surveys were flown on 3 rivers in the Kuskokwim Bay area in 2021. The North Fork Goodnews River sockeye salmon aerial survey count was above average (95,020 fish) and more than 5 times the upper bound of the established SEG. The Middle Fork Goodnews (15,630 fish) and the Kanektok (53,960 fish) counts were below average. Although below average, escapement at the Kanektok River exceeded the upper bound of the established SEG (Table 14).

Weir

Annual escapements were successfully estimated for sockeye salmon at the Salmon (Aniak; 907 fish), Kogrukluk (13,534 fish), and Telaquana (123,958 fish) weirs (Table 15). Sockeye salmon escapement at the weirs indicated that escapement was above average at the Telaquana River weir and below average at the Salmon (Aniak) and Kogrukluk weirs in 2021 (Table 16). Escapement at the Kogrukluk River fell within the established SEG (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

Total escapement was successfully estimated for coho salmon at the George (31,491 fish) and Kogrukluk (14,373 fish) weirs (Table 17). Weir counts indicated that coho salmon escapement was below average at the Kogrukluk River weir and above average at the George River weir in 2021 (Table 18). The SEG was met at the Kogrukluk River weir (Table 18).

Coho salmon run timing was late at the Kogrukluk and George weirs in 2021 (Figure 7). Run timing at the weirs did not affect assessment. The planned operational period was adequate to observe the entire run past each weir.

Nontarget Species

Nontarget species were observed at all weir projects in 2021. Pink salmon, Arctic grayling *Thymallus arcticus*, and whitefish *Coregonus* spp. were observed at nearly all weir projects. Sockeye salmon were observed at the George, Salmon (Pitka Fork), and Takotna River weirs. Chum salmon were observed at the Telaquana and Salmon (Pitka Fork) weirs. Chinook salmon were observed at the Telaquana River 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; 161 fish), George (214 fish), Kogrukluk (224 fish), Takotna (70 fish), and Salmon (Pitka Fork; 252 fish) weirs. Sample goals were achieved at the Salmon River (Pitka Fork) weir and nearly achieved at the Kogrukluk, Takotna, and George weirs (Table 19). Samples were collected on a near-daily basis, spanning approximately the central 95% of the run, except at the Takotna River weir, where sampling spanned the central 52% of the run.

Chum Salmon

Age, sex, and length samples were collected from chum salmon at the Salmon (Aniak; 40 fish), George (71 fish), and Kogrukluk (230 fish) weirs. Sample goals for chum salmon were not achieved at any of the weirs in 2021 due to unprecedentedly low passage numbers (Table 19). Samples were collected on a near-daily basis, spanning approximately the central 80% of the run.

Sockeye Salmon

Sex and length samples were collected from the Kogrukluk (263 fish) and Telaquana (393 fish) weirs. Sample goals were achieved at both weirs (Table 19). Samples were collected on a near-daily basis, spanning approximately the central 95% of the run.

Coho Salmon

Age, sex, and length samples were collected from coho salmon at the George (409 fish) and Kogrukluk (401 fish) weirs. Sample goals were achieved at both weirs (Table 19). Samples were collected on a near-daily basis, spanning approximately the central 90% of the run.

CONCLUSIONS

- Chinook salmon were successfully enumerated on 5 tributaries using weirs and 3 tributaries using aerial surveys in 2021. Except for 1 aerial survey, which was above average, the weir and aerial survey assessments were below average. There were 11 escapement goals in 2021; 4 were assessed, and all 4 were met.
- Chum salmon were successfully enumerated on 3 tributaries using weirs in 2021, and escapements were the lowest on record for all projects. There was 1 chum salmon tributary escapement goal in 2021, and it was not met.
- Sockeye salmon were successfully enumerated on 3 tributaries using weirs and 3 tributaries using aerial surveys in 2021. Sockeye salmon escapement was above the historical average at 2 sites assessed and below average at the other 4 sites assessed. There were 3 escapement goals in 2021, and all 3 were assessed; 1 goal was met, and the other 2 goals were exceeded.
- Coho salmon were successfully enumerated on 2 tributaries using weirs in 2021. Coho salmon escapement was above average at the George River and below average at the Kogrukluk River. The escapement goal on the Kogrukluk River was met. There was no effort to monitor coho salmon escapement in Kuskokwim Bay due to funding constraints in 2021.

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TABLES AND FIGURES

Table 1.–Escapement goals for Kuskokwim Area salmon stocks, 2021.

		Escapement goal			
Stock unit	Assessment method	Goal	Type	Year established	Assessed in 2021
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	
Cheeneetnuk River	Aerial survey	340–1,300	SEG	2005	
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	
Kogrukluk River	Weir	4,800–8,800	SEG	2013	x
Kwethluk River	Weir	4,100–7,500	SEG	2013	
Salmon River (Pitka Fork)	Aerial survey	470–1,600	SEG	2005	
Salmon River (Aniak drainage)	Aerial survey	330–1,200	SEG	2005	
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	x
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	x
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 2021 and those used to inform the 2021 Chinook run reconstruction model.

Method	Location	Operated in 2021	Used in 2021
Weir	Kwethluk		
	Tuluksak		
	George	x	x
	Kogrukluk	x	x
	Tatlawiksuk		
	Takotna	x	x
Aerial survey	Kwethluk		
	Kisaralik		
	Tuluksak		
	Salmon (Aniak)		
	Kipchuk		
	Aniak		
	Holokuk		
	Oskawalik		
	Holitna		
	Cheeneetnuk		
	Gagaryah		
	Pitka		
	Bear		
	Salmon (Pitka)		
Harvest	Subsistence	x	x
	Commercial		
	Test fisheries	x	x
	Sport		

Table 3.–Kuskokwim Area aerial survey locations, 2021.

Project	Species targeted	
	Chinook salmon	Sockeye salmon
Kuskokwim Bay rivers		
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, 2021.

Project			Species targeted			
Kuskokwim River tributaries	Standard estimation range	2021 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 the Alaska Department of Fish and Game.

[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, 2021.

Project	Starting passage date	Weir passage years
Salmon (Aniak) River weir	15 June	2006–2009, 2012–2018, 2020
Salmon River (Pitka Fork) weir	20 Jun	2015–2020
George River weir	15 June	1996–2020
Kogrukluk River weir	26 June	1976–2020[a]
Telaquana River weir	3 July	2010–2020
Takotna River weir	24 June	2000–2013, 2017–2020

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 1981–2020.

Table 6.–Kuskokwim Area Chinook salmon aerial survey locations, survey dates, ratings, index objectives, and escapement indices, 2021.

River	Survey date	Overall survey rating	Index objective	Index area survey counts: 101	102	103	104	Supplemental	Escapement index
Kuskokwim Bay rivers									
North Fork Goodnews River	24 July	Good (1)	101,102,103	1,176	846	251	0	[a]	2,273
Middle Fork Goodnews River	24 July	Good (1)	101, 103, 104	579	[a]	3	25	[a]	607
Kanektok River	25 July	Good (1)	101, 102, 103	2,301	1,738	76	0	124	4,115

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 the survey occurred between the target date range of 17 July and 5 August.

[a] Index reach does not exist for river.

Table 7.–Sockeye salmon aerial survey escapement indices in the Kuskokwim Area, 2021.

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	24 July	Good (1)	101, 102, 103, 104	13,370	7,540	8,780	47,750	[a]	95,020
Middle Fork Goodnews River	24 July	Good (1)	101, 102, 103, 104	13,250	0	990	1,390	5,780	15,630
Kanektok River	25 July	Good (1)	101, 102, 103, 104	17,270	17,390	2,610	16,690	7,730	53,960

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 sockeye 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 the survey occurred between the target date range of 17 July and 5 August.

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

Table 8.–Target operational periods, actual operational periods, and missed passage days at Kuskokwim Area weir projects, 2021.

Project	Standard estimation range	2021 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	15 Jul–19 Aug[a]	15, 22 Jul; 19 Aug	
George River weir	15 Jun–20 Sep	15 Jun–20 Sep	18 Jun–20 Sep	13 Jul, 20 Sep	
Kogrukluk River weir	26 Jun–25 Sep	26 Jun–25 Sep	26 Jun–25 Sep	4, 10, 17, 21 Jul; 23 Aug; 14 Sep	11–16 Jul
Telaquana River weir	3 Jul–26 Aug	3 Jul–26 Aug	5 Jul–19 Aug	25, 27 Jul	
Takotna River Weir	24 Jun–20 Sep	24 Jun–10 Aug	4 Jul–10 Aug[a]	4, 12 Jul; 2, 4 Aug	5–11 Jul, 3 Aug
Salmon River (Pitka Fork) weir	20 Jun–15 Aug	20 Jun–15 Aug	17 Jun–15 Aug	17 Jun; 13, 15, 29 Jul	

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

Table 9.–Chinook salmon aerial survey escapement indices, Kuskokwim Area, 2002–2021.

	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
2021	2,273	632	4,239	–	–	–
Average	1,950	1,328	7,735	1,054	242	323
Median	1,349	1,222	5,980	943	192	210
Percentile rank	71%	13%	26%	–	–	–
Escapement goal	640–3,300	–	3,900–12,000	470–1,600	–	–

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	Middle Kuskokwim River							
Year	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	–
2021	–	–	–	–	–	–	–	–
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	–	–	–	–	–	–	–	–
Escapement goal	1,200–2,300	330–1,200	–	–	–	–	340–1,300	300–830

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Year	Lower Kuskokwim River	
	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
2021	–	–
Average	2,061	1,158
Median	1,722	673
Percentile rank	–	–
Escapement goal	–	400–1,200

Note: Average is derived from all aerial survey escapement indices on record for each river, except 2021, and may include indices prior to 2002. Data archived in the AYKDBMS. En dashes mean no data.

Table 10.–Observed, estimated, and total passage of Chinook salmon at Kuskokwim Area weirs, 2021.

Project	Observed passage[a]	Estimated passage	Total passage	95% Confidence interval
Salmon (Aniak) River weir	1,058	245	1,303	1,058–1,849
George River weir	2,920	0	2,920	2,920–2,953
Kogrukluk River weir	5,123	1,846	6,969	6,142–7,824
Takotna River weir	229	94	323	229–465
Salmon River (Pitka Fork) weir	3,641	351	3,992	3,641–4,585

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, 2002–2021.

	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
2021	[a]	[a]	1,303	2,920	6,969	[a]	323	3,992
Average	3,027	8,168	2,686	3,480	9,623	1,692	402	6,138
Median	2,549	6,729	2,314	3,318	8,468	1,857	368	5,863
Percentile rank	–	–	20%	36%	35%	–	35%	0%
Sustainable 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 2021, and may include escapements prior to 2002. Data archived in the AYKDBMS. 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, 2021.

Project	Observed passage[a]	Estimated passage	Total passage	95% Confidence interval
Salmon (Aniak) River weir	313	224	537	313–1,330
George River weir	1,283	88	1,371	1,283–1,575
Kogrukluk River weir	3,265	888	4,153	3,265–5,236
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, 2003–2021.

	Kuskokwim Bay		Kuskokwim River				
Year	Middle Fork Goodnews River	Kanektok River	Salmon River (Aniak)	George River	Kogrukluk River	Tatlawiksuk River	Takotna River
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]
2021	[a]	[a]	537	1,371	4,153	[a]	[b]
Average	27,068	49,569	11,159	23,894	46,246	31,686	5,280
Median	26,411	44,467	9,336	19,419	36,085	27,357	5,618
Percentile rank	–	–	0%	0%	0%	–	–
Sustainable escapement goal	>12,000	–	–	–	15,000–49,000	–	–

Note: Average, median, and percentile rank was derived from all annual escapements on record at each project, except 2021, and may include escapements prior to 2000. Data archived in the AYKDBMS. 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,2000–2021.

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	–
2021	95,020	15,630	53,960
Average	36,956	21,703	79,565
Escapement goal	9,600–18,000	–	15,000–41,000

Note: Average is derived from all aerial survey escapement indices on record for each river, except 2021, and may include indices prior to 2000. Data archived in the AYKDBMS. En dashes mean no data.

Table 15.–Observed, estimated, and total passage of sockeye salmon at Kuskokwim Area weirs, 2021.

Project	Observed passage[a]	Estimated passage	Total passage	95% Confidence interval
Salmon River (Aniak) weir	904	3	907	904–965
Kogrukluk River weir	13,144	390	13,534	13,144–14,122
Telaquana Lake weir	108,195	15,763	123,958	123,517–124,392

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, 2000-2021.

Year	Kuskokwim Bay Middle Fork Goodnews River	Kuskokwim Bay Kanektok River	Kuskokwim River Salmon River (Aniak)	Kuskokwim River Kogrukluk River	Kuskokwim 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
2021	[a]	[a]	907	13,738	123,958
Average	59,855	167,741	1,516	13,738	100,271
Median	39,344	128,588	1,181	9,203	82,710
Percentile rank	–	–	18%	62%	63%
Sustainable 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 2021, and may include escapements prior to 2000. Data 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, 2021.

Project	Observed passage[a]	Estimated passage	Total passage	95% Confidence interval
George River weir	31,338	153	31,491	31,338–31,666
Kogrukluk River weir	13,922	451	14,373	14,163–14,568

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 18.–Annual escapement of coho salmon past Kuskokwim Area weir projects, 2000–2021.

	Kuskokwim Bay	Kuskokwim River		
Year	Middle Fork Goodnews River	George River	Kogrukluk River	Tatlawiksuk River
2000	[a]	11,280	33,100	[a]
2001	18,300	15,224	19,926	[a]
2002	27,643	6,759	14,516	11,192
2003	52,504	33,741	74,903	[a]
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	[a]
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	[a]	14,844	13,462	8,001
2013	[a]	14,823	23,800	12,724
2014	[a]	35,771	54,001	19,822
2015	[a]	35,790	32,900	17,669
2016	[a]	[a]	[a]	11,719
2017	[a]	25,338	[a]	[a]
2018	[b]	8,993	8,169	[b]
2019	[a]	13,277	16,470	[b]
2020	[b]	21,426	[a]	[b]
2021	[b]	31,491	14,373	[b]
Average	26,634	18,624	23,486	11,851
Median	25,478	14,050	22,300	11,192
Percentile rank	–	81%	27%	–
Sustainable 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 2021, and may include escapements prior to 2000. Data archived in the AYKDBMS. En dashes mean no data.

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

[b] Weir did not operate.

Table 19.–Age, sex, and length sample collection at Kuskokwim Area weir projects, 2021.

Species	Project	Season sample goal	Scales per fish sampled	Season total number of samples collected	Dates samples collected
Chinook	Salmon (Aniak)	260	3	161	16 July–10 August
	George	230	3	214	5 July–20 August
	Kogrukluk	230	3	224	7 July–17 August
	Takotna	75	3	70	12–28 July
	Salmon (Pitka Fork)	250	3	252	30 June–5 August
Chum	Salmon (Aniak)	400	1	40	16 July–10 August
	George	400	1	71	5 July–20 August
	Kogrukluk	600	1	230	29 June–25 August
Sockeye	Kogrukluk [a]	250	0	263	30 June–7 August
	Telaquana [a]	250	0	393	17 July–19 August
Coho	George	400	3	409	6 August–13 September
	Kogrukluk	400	3	401	12 August–19 September

[a] Only length and sex information was collected from sockeye salmon in 2021.

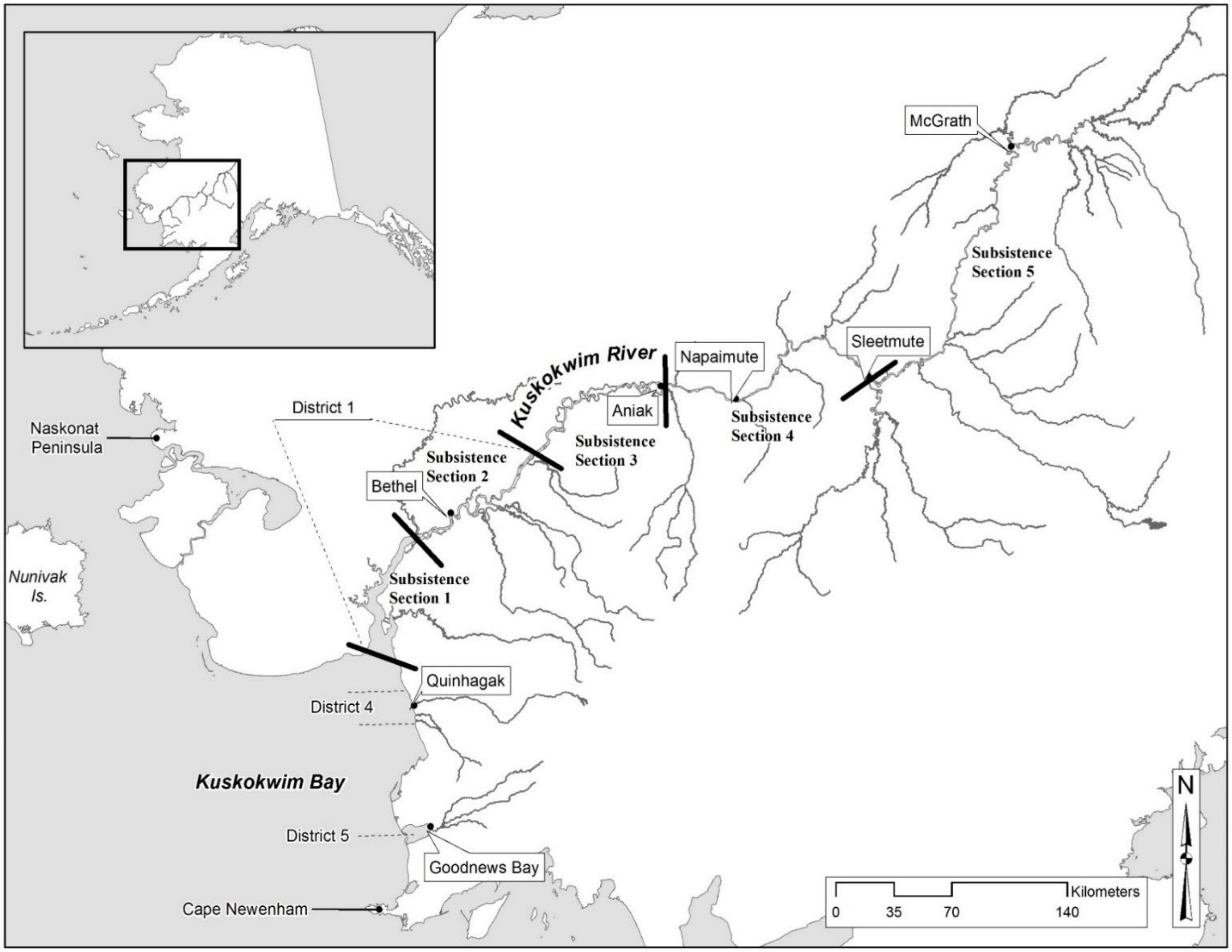

Figure 1.–The Kuskokwim Area, including Kuskokwim Bay, the Kuskokwim River, subsistence fishing sections, and select commercial fishing districts.

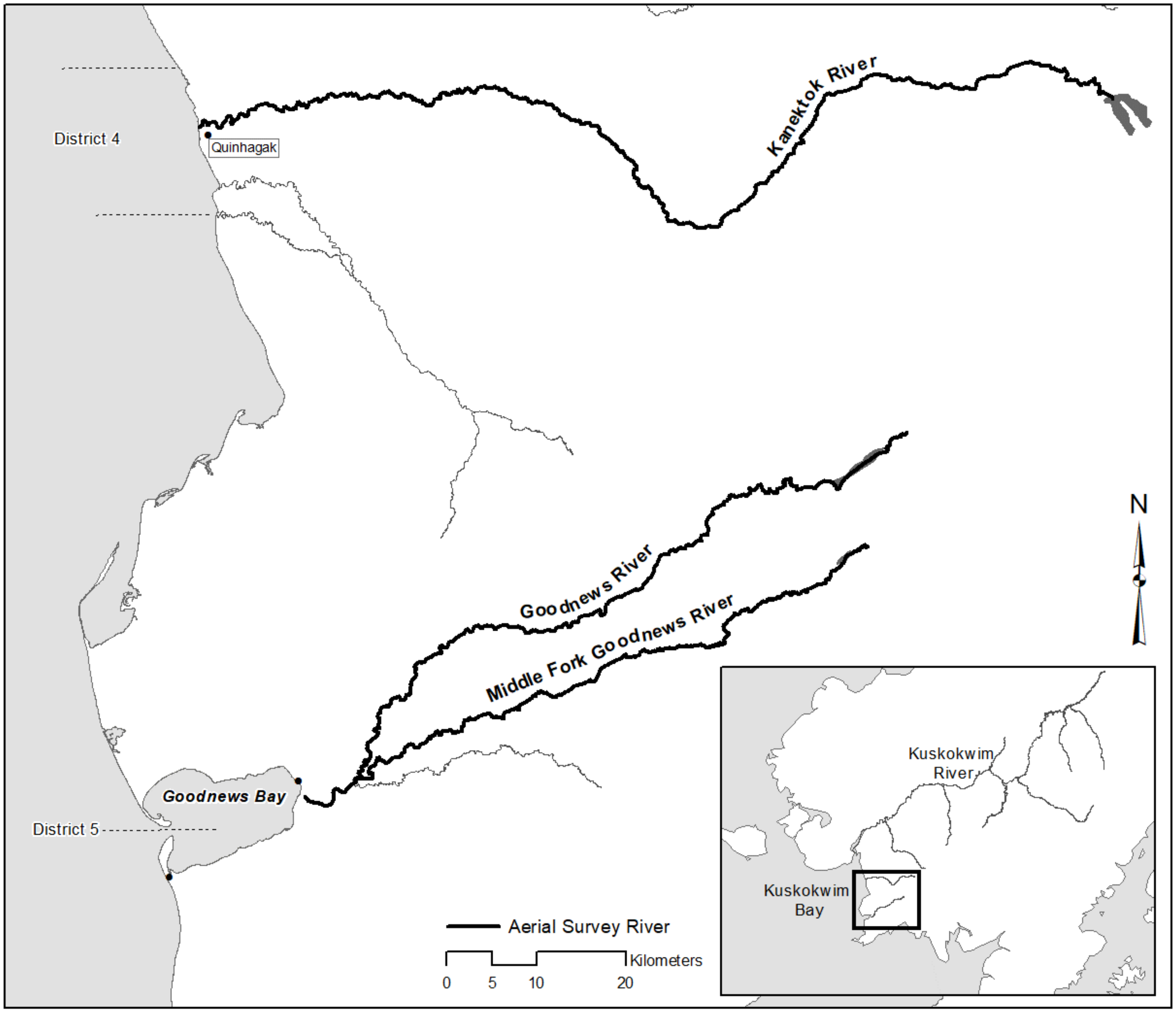

Figure 2.–Kuskokwim Bay rivers where salmon escapement was monitored in 2021.

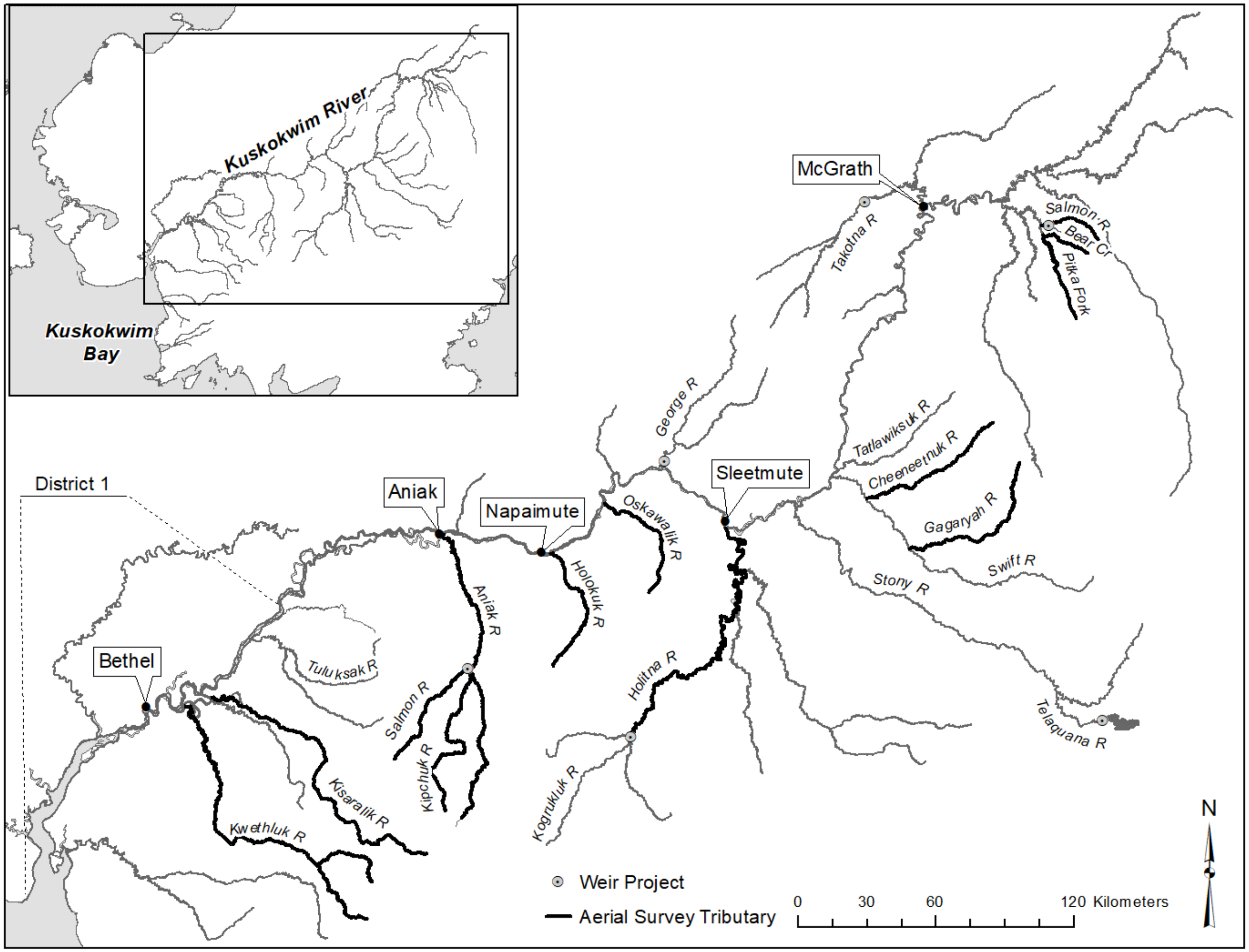

Figure 3.–Kuskokwim River tributaries where salmon escapement was monitored by the Alaska Department of Fish and Game and partners, 2021.

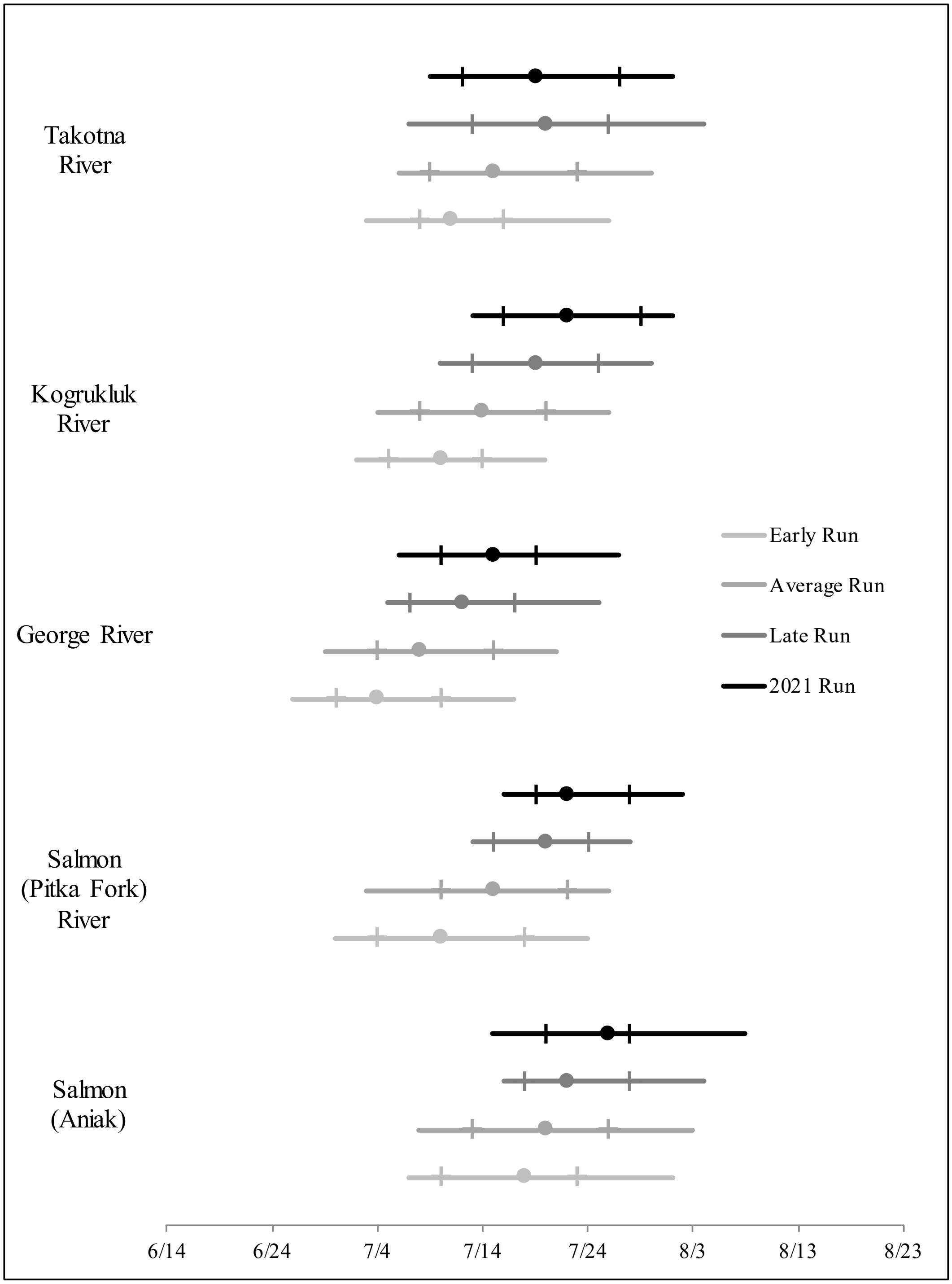

Figure 4.–Early, average, late, and 2021 run timings of Chinook salmon at Kuskokwim Area weirs.

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.

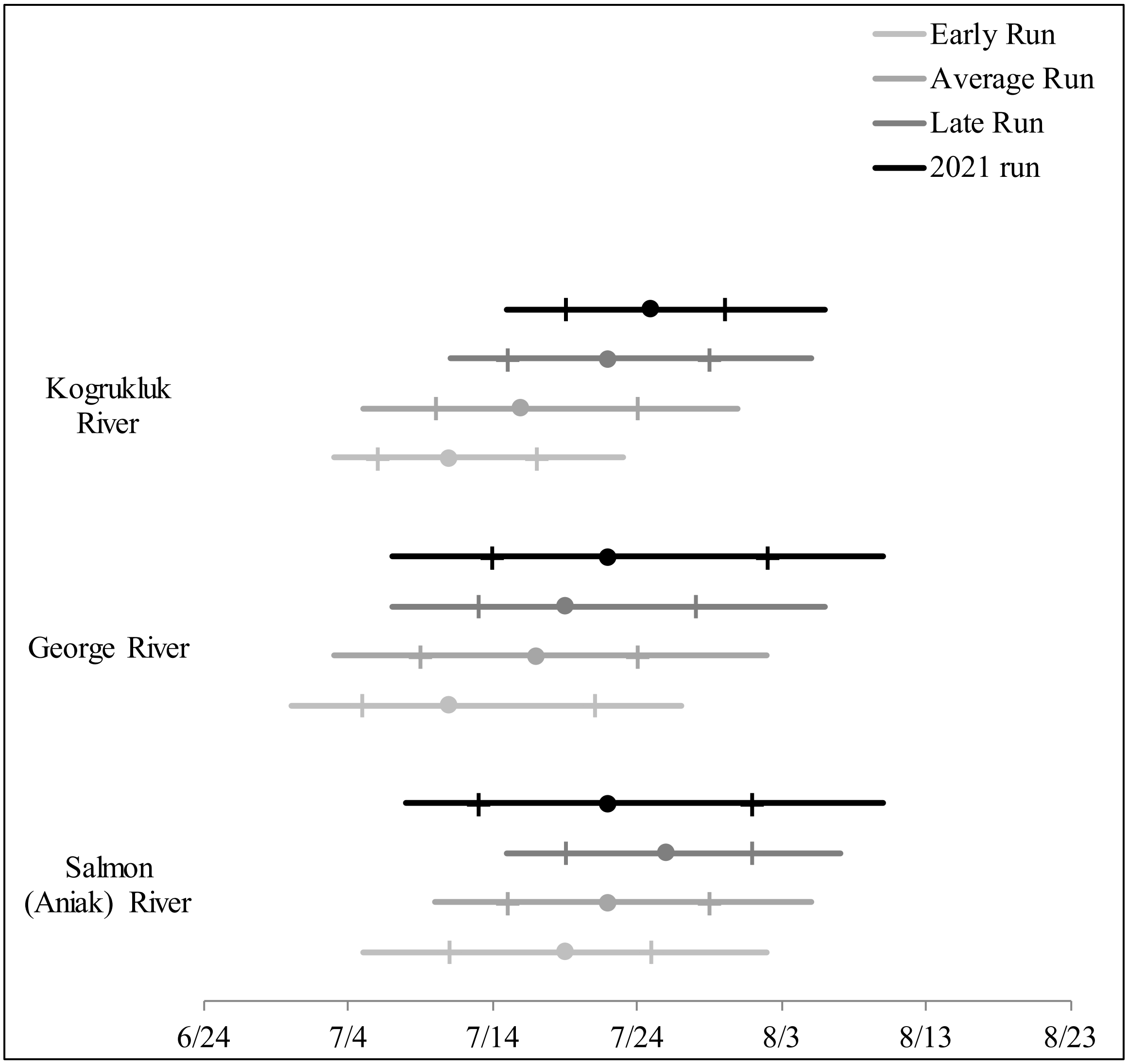

Figure 5.–Early, average, late, and 2021 run timings of chum salmon at Kuskokwim Area weirs.

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.

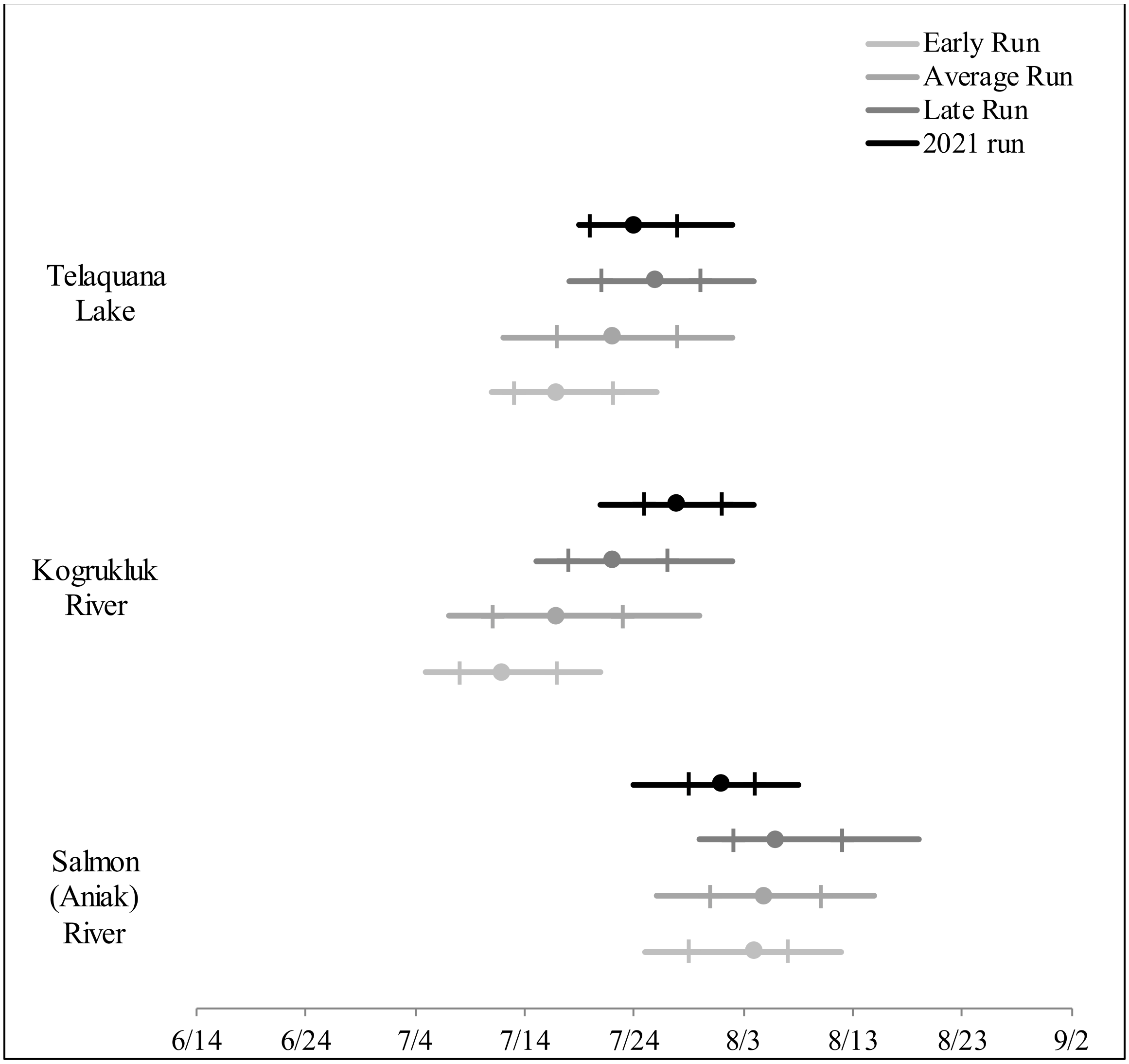

Figure 6.–Early, average, late, and 2021 run timings of sockeye salmon at Kuskokwim Area weirs.

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.

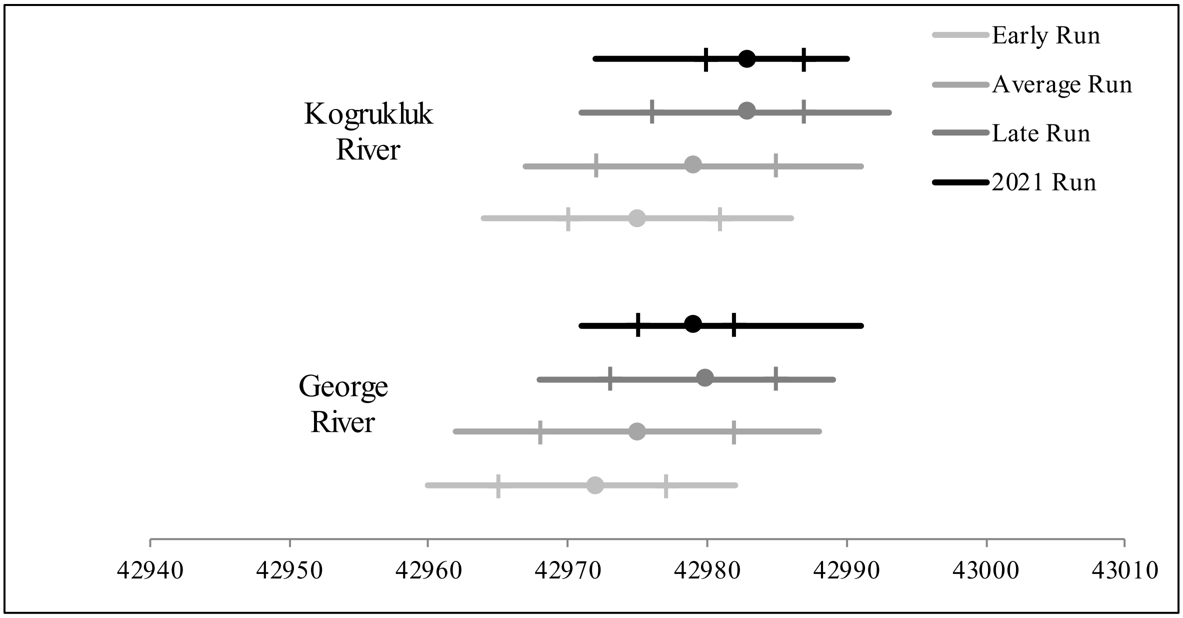

Figure 7.–Early, average, late, and 2021 run timings of coho salmon at Kuskokwim Area weirs.

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 mi. upstream of confluence w/ Goodnews Bay	
	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.	Chinook: 101, 102, 103 Sockeye: 101,102,103,104
	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 miles 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.	
	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	Chinook: 101, 103, 104 Sockeye: 101,102,103,104
	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	
	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)	Chinook: 101, 102, 103 Sockeye: 101, 102, 103, 104
	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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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, 103, 104
	102 (60.32.27 N, 161.06.23 W)	Three Step Mountain	
	103 (60.17.76 N, 160.57.16 W)	Elbow Mountain	
	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, 103
	102 (60.44.52 N, 160.22.75 W)	Confluence w/ Nukluk Cr.	
	103 (60.21.11 N, 159.56.63 W)	Upper falls	
	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, 103, 104
	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)	
	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.	101, 102, 103
	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.	
	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.	101, 102, 103
	102 (60.46.67 N, 159.19.14 W)	Confluence w/ small creek 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 river	
	STOP (60.30.83 N, 159.14.37 W)	Lake outlet at end of East Fork in upper reach	

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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	

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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, 2021

Appendix C1.–Daily weather and stream observations at the Salmon River (Aniak) weir, 2021.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
7/8	AM	4	0.0	8	8	65	1
7/8	PM	4	0.0	11	9	64	1
7/9	AM	4	4.8	8	7	64	1
7/9	PM	4	7.0	10	8	68	1
7/10	AM	3	0.7	9	8	69	1
7/10	PM	3	0.0	15	10	69	1
7/11	AM	3	0.0	8	7	67	1
7/11	PM	2	0.0	18	10	66	1
7/12	AM	1	0.0	9	8	66	1
7/12	PM	3	0.0	24	11	65	1
7/13	AM	4	0.0	14	8	64	1
7/13	PM	2	0.0	25	13	64	1
7/14	AM	2	1.2	12	10	64	1
7/14	PM	1	0.0	21	13	63	1
7/15	AM	1	0.0	10	10	63	1
7/15	PM	1	0.0	22	14	60	1
7/16	AM	1	0.0	10	11	59	1
7/16	PM	1	0.0	24	13	58	1
7/17	AM	2	0.0	10	12	55	1
7/17	PM	1	0.0	22	14	55	1
7/18	AM	1	0.0	11	12	53	1
7/18	PM	1	0.0	26	15	53	1
7/19	AM	1	0.0	15	12	50	1
7/19	PM	2	0.0	27	15	50	1
7/20	AM	3	3.5	13	13	50	1
7/20	PM	4	2.0	16	13	57	1
7/21	AM	4	5.0	12	11	57	1
7/21	PM	4	3.0	14	12	56	1
7/22	AM	4	1.2	12	11	54	1
7/22	PM	4	0.7	16	12	54	1
7/23	AM	4	0.0	11	11	52	1
7/23	PM	4	0.0	15	12	50	1
7/24	AM	4	0.0	9	11	49	1
7/24	PM	3	0.1	16	12	48	1
7/25	AM	2	0.0	11	11	48	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
7/25	PM	4	0.0	15	11	47	1
7/26	AM	2	0.0	11	11	46	1
7/26	PM	3	0.0	16	11	47	1
7/27	AM	4	0.0	11	10	47	1
7/27	PM	4	0.1	16	11	46	1
7/28	AM	4	0.0	11	10	46	1
7/28	PM	4	0.0	17	11	46	1
7/29	AM	4	0.0	13	11	42	1
7/29	PM	4	0.0	17	11	42	1
7/30	AM	4	0.5	13	10	45	1
7/30	PM	4	0.0	16	12	45	1
7/31	AM	4	0.2	15	12	44	1
7/31	PM	4	1.6	16	12	44	1
8/1	AM	4	0.5	15	11	48	1
8/1	PM	3	0.3	21	15	48	1
8/2	AM	1	0.0	22	15	45	1
8/2	PM	1	0.0	25	15	44	1
8/3	AM	1	0.0	10	11	43	1
8/3	PM	1	0.0	29	15	40	1
8/4	AM	1	0.0	15	14	38	1
8/4	PM	2	0.0	29	16	38	1
8/5	AM	4	5.2	13	12	38	1
8/5	PM	4	10.0	14	13	42	1
8/6	AM	4	1.2	10	11	45	1
8/6	PM	3	0.0	15	12	45	1
8/7	AM	4	0.0	10	11	44	1
8/7	PM	3	0.0	15	11	43	1
8/8	AM	4	9.5	11	10	43	1
8/8	PM	4	12.5	12	11	50	1
8/9	AM	4	0.5	9	10	51	1
8/9	PM	3	0.0	15	12	51	1
8/10	AM	2	0.5	11	10	46	1
8/10	PM	3	0.0	17	13	44	1
8/11	AM	4	1.0	10	11	44	1
8/11	PM	4	5.0	13	11	44	1
8/12	AM	3	5.0	8	10	52	1

-continued-

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	3	0.7	13	11	53	1
8/13	AM	4	0.6	8	9	49	1
8/13	PM	4	0.1	13	11	49	1
8/14	AM	4	0.5	7	9	46	1
8/14	PM	4	0.1	11	9	46	1
8/15	AM	4	0.7	11	10	46	1
8/15	PM	4	0.5	12	10	46	1
8/16	AM	4	0.2	9	9	46	1
8/16	PM	4	0.0	14	10	46	1
8/17	AM	3	0.0	5	9	46	1
8/17	PM	4	0.0	12	9	46	1
8/18	AM	2	0.0	1	7	46	1
8/18	PM	3	0.0	19	11	46	1
8/19	AM	4	1.0	9	9	47	1
8/19	PM	–	–	–	–	–	–
Average	–	–	1.0	13.8	10.9	50.8	–

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, 2021.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
6/12	AM	3	5.5	9	8	66	1
6/12	PM	2	0.5	18	11	67	1
6/13	AM	1	0.0	14	9	68	1
6/13	PM	2	0.0	22	11	68	1
6/14	AM	–	–	–	–	–	–
6/14	PM	2	0.0	21	12	64	1
6/15	AM	–	–	–	–	–	–
6/15	PM	–	–	–	–	–	–
6/16	AM	1	0.0	10	11	62	1
6/16	PM	–	–	–	–	–	–
6/17	AM	4	0.7	10	10	62	1
6/17	PM	1	4.0	9	9	64	1
6/18	AM	1	0.7	5	8	66	1
6/18	PM	1	0.0	21	12	66	1
6/19	AM	4	3.5	12	10	67	1
6/19	PM	3	4.0	18	12	68	1
6/20	AM	3	6.0	12	10	68	1
6/20	PM	3	0.3	15	12	69	1
6/21	AM	4	0.5	12	10	69	1
6/21	PM	4	1.5	18	12	70	1
6/22	AM	3	0.0	12	10	71	1
6/22	PM	3	1.5	18	12	70	1
6/23	AM	3	0.0	8	10	70	1
6/23	PM	4	0.5	17	11	70	1
6/24	AM	4	2.0	10	10	69	1
6/24	PM	4	1.5	16	10	69	1
6/25	AM	4	1.8	9	10	68	1
6/25	PM	3	0.5	15	12	69	1
6/26	AM	4	0.0	10	9	69	1
6/26	PM	4	0.0	12	9	69	1
6/27	AM	3	0.0	10	9	67	1
6/27	PM	3	0.0	16	11	68	1
6/28	AM	3	0.0	9	9	64	1
6/28	PM	3	0.5	18	12	64	1
6/29	AM	2	0.0	11	10	63	1
6/29	PM	3	0.5	14	11	62	1

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Appendix C2.–Page 2 of 6.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
6/30	AM	2	0.0	9	10	61	1
6/30	PM	2	0.0	23	12	60	–
7/1	AM	4	0.0	14	11	60	1
7/1	PM	4	0.0	19	13	58	1
7/2	AM	3	0.5	11	11	58	1
7/2	PM	4	0.0	13	11	58	1
7/3	AM	4	1.5	9	10	57	1
7/3	PM	4	0.5	13	11	56	1
7/4	AM	4	0.0	11	10	54	1
7/4	PM	3	1.0	14	11	53	1
7/5	AM	4	12.5	10	9	55	1
7/5	PM	4	10.0	10	10	58	1
7/6	AM	4	9.0	8.5	8.5	70	1
7/6	PM	3	2.0	13	8.5	78	1.5
7/7	AM	4	1.2	8	9	82	2
7/7	PM	4	2.0	10	9.5	85	2
7/8	AM	4	0.5	8	8	77	2
7/8	PM	3	0.5	13	10	78	1
7/9	AM	4	3.5	7	8	75	1
7/9	PM	4	6.0	9	8	78	1
7/10	AM	2	0.7	8.5	8	87	1
7/10	PM	3	0.0	17	11	96	1
7/11	AM	3	0.0	7	8	90	1
7/11	PM	2	0.0	20	12	90	1
7/12	AM	1	0.0	12	9	90	1
7/12	PM	2	0.0	23	11	89	1
7/13	AM	3	0.0	15	10	86	1
7/13	PM	3	0.0	22	12	84	1
7/14	AM	1	0.0	12	10	83	1
7/14	PM	–	–	–	–	–	–
7/15	AM	4	0.0	10	10	80	1
7/15	PM	3	0.0	16	11	79	1
7/16	AM	5	0.0	7	9	78	1
7/16	PM	1	0.0	23	12	77	1
7/17	AM	4	0.0	12	10	74	1
7/17	PM	2	0.0	21	12	73	1

-continued-

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
7/18	AM	3	0.0	13	10	70	1
7/18	PM	–	–	–	–	–	–
7/19	AM	5	0.8	11	10	68	1
7/19	PM	2	0.0	27	14	68	1
7/20	AM	4	6.5	12	10	67	1
7/20	PM	4	4.5	14	13	68	1
7/21	AM	5	3.0	12	11	70	1
7/21	PM	4	2.0	14	12	72	1
7/22	AM	5	1.8	12	9	70	1
7/22	PM	2	0.5	17	12	71	1
7/23	AM	4	0.0	12	10	69	1
7/23	PM	4	0.0	15	12	67	1
7/24	AM	4	0.0	10	10	62	1
7/24	PM	4	0.0	14	11	63	1
7/25	AM	4	0.0	6	9	60	1
7/25	PM	3	0.0	18	11	60	1
7/26	AM	4	0.0	11	9	59	1
7/26	PM	4	0.0	16	11	59	1
7/27	AM	4	0.5	10	10	58	1
7/27	PM	4	1.5	14	10	57	1
7/28	AM	3	2.8	10	9.5	57	1
7/28	PM	4	0.8	16	11	59	1
7/29	AM	4	0.5	12.5	10	58	1
7/29	PM	4	0.0	16	10	58	1
7/30	AM	4	2.0	14	10	56	1
7/30	PM	4	0.0	15	11	56	1
7/31	AM	4	1.0	12	10	55	1
7/31	PM	4	5.5	15	11	58	1
8/1	AM	4	1.0	15	10	58	1
8/1	PM	3	0.0	20	13	63	1
8/2	AM	3	0.0	13	10.5	68	2
8/2	PM	1	0.0	24	14	70	2
8/3	AM	5	0.0	8	12	66	1
8/3	PM	2	0.0	28	15	62	1
8/4	AM	1	0.0	13	13	61	1
8/4	PM	2	0.0	27	15	60	1

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Appendix C2.–Page 4 of 6.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River stage (cm)	Water clarity[b]
8/5	AM	4	4.4	13	14	66	2
8/5	PM	4	0.8	10	14	72	3
8/6	AM	4	1.5	9	11	67	2
8/6	PM	3	0.0	14	12	66	2
8/7	AM	5	0.0	5	10	64	1
8/7	PM	3	0.0	14	11	62	1
8/8	AM	4	4.5	10	10	63	1
8/8	PM	3	9.0	13	10	67	1
8/9	AM	4	3.0	10	9	68	1
8/9	PM	3	0.0	15	10	70	1
8/10	AM	4	1.0	8	9	69	1
8/10	PM	4	0.0	14	11	69	1
8/11	AM	3	0.0	8	9	67	1
8/11	PM	3	0.0	13	10	66	1
8/12	AM	4	3.0	8	9	65	1
8/12	PM	4	0.0	14	10	64	1
8/13	AM	4	0.0	6	8	65	1
8/13	PM	4	0.5	9	9	65	1
8/14	AM	4	0.5	5	8	63	1
8/14	PM	4	0.0	12	9	63	1
8/15	AM	4	0.8	10	8	62	1
8/15	PM	4	0.0	12	8	62	1
8/16	AM	4	0.0	10	8	61	1
8/16	PM	4	0.0	12	8	61	1
8/17	AM	4	0.0	7	8	60	1
8/17	PM	4	0.8	11	9	62	1
8/18	AM	5	0.0	-1	6	61	1
8/18	PM	3	0.0	12	9	59	1
8/19	AM	5	2.0	7	7	58	1
8/19	PM	4	1.5	9	7	58	1
8/20	AM	4	1.8	7	6	58	1
8/20	PM	3	0.8	11	8	59	1
8/21	AM	4	0.0	3	6	59	1
8/21	PM	3	0.0	13	8	59	1
8/22	AM	4	2.0	6	7	57	1
8/22	PM	4	5.0	12	8	59	1

-continued-

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River stage (cm)	Water clarity[b]
8/23	AM	4	0.0	8	7	59	1
8/23	PM	4	1.2	13	8	59	1
8/24	AM	5	0.0	5	7	60	1
8/24	PM	3	0.0	15	9	61	1
8/25	AM	4	4.0	11	8	61	1
8/25	PM	3	2.5	13	9	61	1
8/26	AM	5	0.0	3	8	61	1
8/26	PM	4	2.3	8	7	66	1
8/27	AM	4	4.5	0	6	67	1
8/27	PM	3	0.0	8	7	67	1
8/28	AM	5	0.0	-1	5	67	1
8/28	PM	4	0.0	11	7	67	1
8/29	AM	4	2.8	9	7	66	1
8/29	PM	3	0.8	11	8	66	1
8/30	AM	4	0.0	8	7	67	1
8/30	PM	4	0.0	14	8	67	1
8/31	AM	5	0.0	5.5	7	67	1
8/31	PM	3	0.0	15	8	66	1
9/1	AM	5	0.0	7.5	7	67	1
9/1	PM	3	0.0	17	9	65	1
9/2	AM	4	0.0	8	7	64	1
9/2	PM	4	3.0	12	9	65	1
9/3	AM	4	9.5	10	7.5	69	1
9/3	PM	3	2.5	13	9	68	1
9/4	AM	4	6.0	9	8	69	1
9/4	PM	–	–	–	–	–	–
9/5	AM	3	0.0	5	7	67	1
9/5	PM	3	1.0	9	9	68	1
9/6	AM	3	0.0	4	7	66	1
9/6	PM	3	0.0	13	8	65	1
9/7	AM	4	1.0	9	7	64	1
9/7	PM	4	0.8	11	8	63	1
9/8	AM	5	4.0	7	7	62	1
9/8	PM	3	3.5	12	8	63	1
9/9	AM	5	0.5	7.5	7	65	1
9/9	PM	4	0.0	12	8	67	1

-continued-

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River stage (cm)	Water clarity[b]
9/10	AM	5	2.8	7	7	67	1
9/10	PM	2	0.0	12	8	66	1
9/11	AM	4	4.0	1	6.5	67	1
9/11	PM	3	3.0	8	6.5	67	1
9/12	AM	4	0.0	2	5	67	1
9/12	PM	4	0.5	10	6	67	1
9/13	AM	5	2.0	3	5	66	1
9/13	PM	3	0.8	9	7	66	1
9/14	AM	5	1.8	5.5	5.5	65	1
9/14	PM	4	3.8	7	6	67	1
9/15	AM	4	4.0	6	6	69	1
9/15	PM	3	0.0	9	6	74	2
9/16	AM	5	0.0	-1.5	5	75	2
9/16	PM	2	0.0	13	6	76	2
9/17	AM	3	0.0	-2	4	75	1
9/17	PM	3	0.0	9	5	73	1
9/18	AM	3	0.0	-1.5	4	74	1
9/18	PM	4	0.0	6	4	72	1
9/19	AM	5	0.0	-1	4	73	1
9/19	PM	1	0.0	9	5	74	1
9/20	AM	3	0.0	-2.5	4	72	1
9/20	PM	3	0.0	5	4	72	1
Average	–	–	1.2	11.2	9.1	66.7	-

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, 2021.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
6/26	AM	4	0.0	–	–	316	1
6/26	PM	4	0.0	–	–	316	1
6/27	AM	4	0.8	–	–	324	1
6/27	PM	4	0.3	–	–	336	1
6/28	AM	4	0.0	–	–	330	1
6/28	PM	3	0.0	–	–	330	1
6/29	AM	3	0.0	–	–	320	1
6/29	PM	4	0.0	–	–	318	1
6/30	AM	3	0.0	–	–	316	1
6/30	PM	2	0.0	–	–	312	1
7/1	AM	4	0.0	–	–	306	1
7/1	PM	4	0.0	–	–	306	1
7/2	AM	4	3.0	–	–	306	1
7/2	PM	3	9.0	–	–	314	1
7/3	AM	4	10.0	–	–	329	1
7/3	PM	4	0.7	–	–	332	1
7/4	AM	4	0.6	–	–	328	1
7/4	PM	4	3.8	–	–	324	1
7/5	AM	4	6.5	–	–	316	1
7/5	PM	4	5.5	–	–	318	1
7/6	AM	4	1.2	–	–	330	1
7/6	PM	4	1.5	–	–	330	1
7/7	AM	3	15.0	–	–	326	1
7/7	PM	3	1.0	–	–	324	1
7/8	AM	4	2.8	–	–	320	1
7/8	PM	3	1.5	–	–	320	1
7/9	AM	4	5.8	–	–	320	1
7/9	PM	4	7.0	–	–	323	1
7/10	AM	4	3.0	–	–	340	1
7/10	PM	2	1.0	–	–	355	2
7/11	AM	4	0.5	–	–	345	2
7/11	PM	–	–	–	–	–	–
7/12	AM	2	0.0	–	–	332	1
7/12	PM	3	0.0	–	–	330	1
7/13	AM	4	0.0	–	–	325	1
7/13	PM	3	0.0	–	–	323	1

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Appendix C3.–Page 2 of 5.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River stage (cm)	Water clarity[b]
7/14	AM	3	0.0	–	–	320	1
7/14	PM	3	0.0	–	–	319	1
7/15	AM	1	0.0	–	–	316	1
7/15	PM	1	0.0	–	–	315	1
7/16	AM	1	0.0	–	–	311	1
7/16	PM	1	0.0	–	–	310	1
7/17	AM	1	0.0	–	–	308	1
7/17	PM	1	0.0	–	–	304	1
7/18	AM	2	0.0	–	–	303	1
7/18	PM	3	0.0	–	–	302	1
7/19	AM	3	0.0	–	–	301	1
7/19	PM	–	–	–	–	–	–
7/20	AM	4	5.0	–	–	299	1
7/20	PM	3	1.8	–	–	298	1
7/21	AM	4	5.0	–	–	301	1
7/21	PM	4	3.0	–	–	302	1
7/22	AM	4	25.0	–	–	305	1
7/22	PM	4	1.0	–	–	304	1
7/23	AM	3	0.8	–	–	303	1
7/23	PM	2	0.0	–	–	300	1
7/24	AM	1	0.0	–	–	299	1
7/24	PM	2	0.0	–	–	296	1
7/25	AM	4	0.0	–	–	294	1
7/25	PM	2	0.0	–	–	291	1
7/26	AM	4	0.0	–	–	290	1
7/26	PM	3	0.0	–	–	290	1
7/27	AM	4	0.0	–	–	289	1
7/27	PM	4	0.0	–	–	288	1
7/28	AM	4	0.0	–	–	287	1
7/28	PM	4	0.0	–	–	286	1
7/29	AM	4	0.0	–	–	285	1
7/29	PM	4	0.0	–	–	284	1
7/30	AM	4	1.8	–	–	284	1
7/30	PM	4	0.0	–	–	283	1
7/31	AM	4	1.8	–	–	282	1
7/31	PM	4	4.0	–	–	283	1

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Appendix C3.–Page 3 of 5.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
8/1	AM	4	2.4	–	–	287	1
8/1	PM	4	0.0	–	–	292	1
8/2	AM	3	0.0	–	–	292	1
8/2	PM	1	0.0	–	–	290	1
8/3	AM	1	0.0	–	–	285	1
8/3	PM	1	0.0	–	–	285	1
8/4	AM	1	0.0	–	–	285	1
8/4	PM	1	0.0	–	–	280	1
8/5	AM	4	3.4	–	–	279	1
8/5	PM	4	2.7	–	–	280	1
8/6	AM	3	0.6	–	–	283	1
8/6	PM	4	0.0	–	–	284	1
8/7	AM	4	0.0	–	–	283	1
8/7	PM	4	0.3	–	–	280	1
8/8	AM	4	12.5	–	–	280	1
8/8	PM	4	0.7	–	–	283	1
8/9	AM	3	2.8	–	–	292	1
8/9	PM	4	0.2	–	–	295	1
8/10	AM	3	2.0	–	–	291	1
8/10	PM	3	0.0	–	–	289	1
8/11	AM	4	0.0	–	–	287	1
8/11	PM	4	2.1	–	–	287	1
8/12	AM	4	6.5	–	–	288	1
8/12	PM	4	0.6	–	–	293	1
8/13	AM	3	1.0	–	–	294	1
8/13	PM	3	0.4	–	–	292	1
8/14	AM	4	0.0	–	–	289	1
8/14	PM	4	0.0	–	–	287	1
8/15	AM	3	0.0	–	–	284	1
8/15	PM	3	0.3	–	–	284	1
8/16	AM	4	0.0	–	–	283	1
8/16	PM	4	0.0	–	–	282	1
8/17	AM	3	0.0	–	–	280	1
8/17	PM	4	0.0	–	–	280	1
8/18	AM	2	0.0	–	–	279	1
8/18	PM	2	0.0	–	–	279	1

-continued-

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
8/19	AM	4	1.0	–	–	278	1
8/19	PM	4	4.0	–	–	277	1
8/20	AM	1	8.0	–	–	280	1
8/20	PM	2	0.5	–	–	280	1
8/21	AM	3	0.2	–	–	278	1
8/21	PM	3	0.0	–	–	276	1
8/22	AM	4	5.4	–	–	277	1
8/22	PM	4	1.5	–	–	277	1
8/23	AM	4	0.5	–	–	280	1
8/23	PM	3	4.4	–	–	280	1
8/24	AM	3	0.0	–	–	280	1
8/24	PM	3	0.0	–	–	278	1
8/25	AM	4	4.0	–	–	278	1
8/25	PM	2	0.6	–	–	277	1
8/26	AM	3	0.0	–	–	277	1
8/26	PM	4	0.0	–	–	277	1
8/27	AM	3	1.0	–	–	276	1
8/27	PM	3	0.8	–	–	276	1
8/28	AM	3	0.0	–	–	274	1
8/28	PM	3	0.0	–	–	273	1
8/29	AM	4	0.0	–	–	272	1
8/29	PM	2	0.0	–	–	272	1
8/30	AM	4	0.0	–	–	271	1
8/30	PM	2	0.0	–	–	270	1
8/31	AM	3	0.0	–	–	270	1
8/31	PM	3	0.0	–	–	270	1
9/1	AM	3	0.0	–	–	270	1
9/1	PM	4	0.0	–	–	270	1
9/2	AM	4	2.6	–	–	270	1
9/2	PM	4	1.4	–	–	271	1
9/3	AM	4	5.4	–	–	275	1
9/3	PM	4	0.3	–	–	275	1
9/4	AM	4	3.4	–	–	277	1
9/4	PM	3	0.3	–	–	276	1
9/5	AM	2	0.2	–	–	277	1
9/5	PM	2	0.0	–	–	275	1
9/6	AM	3	0.0	2	8	273	1
9/6	PM	3	0.0	10	7	272	1

-continued-

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
9/7	AM	3	0.0	4	5	270	1
9/7	PM	3	1.4	11	8	270	1
9/8	AM	4	3.0	6	7	270	1
9/8	PM	3	2.2	10	8	270	1
9/9	AM	4	1.6	7	8	270	1
9/9	PM	4	3.2	10	8	270	1
9/10	AM	3	5.0	5	7	272	1
9/10	PM	2	0.0	14	9	276	1
9/11	AM	4	0.3	2	7	276	1
9/11	PM	4	3.4	11	7	276	1
9/12	AM	3	0.0	7	7	274	1
9/12	PM	4	2.8	7	7	274	1
9/13	AM	4	16.0	5	6	280	1
9/13	PM	4	6.5	9	7	290	3
9/14	AM	4	3.2	3	6	308	2
9/14	PM	4	3.6	6	7	303	2
9/15	AM	4	0.5	3	6	297	1
9/15	PM	3	0.0	10	7	295	1
9/16	AM	1	0.7	0	6	291	1
9/16	PM	1	0.0	14	8	290	1
9/17	AM	1	0.0	0	5	289	1
9/17	PM	3	0.0	8	6	288	1
9/18	AM	1	0.0	-3	4	286	1
9/18	PM	1	0.0	10	6	285	1
9/19	AM	1	0.0	0	4	285	1
9/19	PM	1	0.0	13	5	284	1
9/20	AM	1	0.0	-1	4	283	1
9/20	PM	1	0.0	4	5	283	1
9/21	AM	4	0.0	-2	4	281	1
9/21	PM	1	0.0	5	5	281	1
9/22	AM	4	30.0	-1	4	280	1
9/22	PM	5	3.6	2	4	280	1
9/23	AM	1	0.0	-3	4	280	1
9/23	PM	2	0.5	5	4	280	1
9/24	AM	1	0.0	-4	2	280	1
9/24	PM	1	0.0	8	4	280	1
9/25	AM	1	0.0	-5	2	280	1
9/25	PM	1	0.0	8	3	280	1
Average	–	–	1.7			292	–

Note: En dash means no data. Due to a malfunctioning recording tool the accuracy of air and water temperatures for some dates are questionable, therefore they will not be included this year.

[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, 2021.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
7/5	AM	–	–	–	–	–	–
7/5	PM	4	0.0	13	12	12	1
7/6	AM	4	0.0	10	11	12	1
7/6	PM	4	0.1	11	12	12	1
7/7	AM	4	0.2	8	10	13	1
7/7	PM	3	0.3	12	12	13	1
7/8	AM	3	0.2	10	10	13	1
7/8	PM	3	0.2	10	11	13	1
7/9	AM	4	0.0	9	10	13	1
7/9	PM	4	0.0	11	11	13	1
7/10	AM	3	0.01	10	10	10	1
7/10	PM	3	0.0	15	12	10	1
7/11	AM	1	0.0	12	11	8	1
7/11	PM	3	0.0	17	12	7	1
7/12	AM	3	0.0	11	11	7	1
7/12	PM	4	0.0	18	13	6	1
7/13	AM	3	0.1	12	12	6	1
7/13	PM	3	0.0	15	12	6	1
7/14	AM	3	0.0	11	12	5	1
7/14	PM	3	0.0	18	13	5	1
7/15	AM	2	0.0	14	13	5	1
7/15	PM	2	0.0	20	14	5	1
7/16	AM	3	0.0	16	11	6	1
7/16	PM	2	0.0	17	13	6	1
7/17	AM	3	0.0	15	12	6	1
7/17	PM	2	0.0	22	15	7	1
7/18	AM	2	0.0	15	11	9	1
7/18	PM	3	0.0	22	14	9	1
7/19	AM	1	0.0	19	12	11	1
7/19	PM	3	0.0	20	15	12	1
7/20	AM	4	0.1	13	14	14	1
7/20	PM	4	0.6	13	14	16	1
7/21	AM	4	0.2	11	14	18	1
7/21	PM	4	0.1	12	12	18	1
7/22	AM	5	0.0	10	11	19	1
7/22	PM	4	0.0	17	13	19	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
7/23	AM	4	0.0	13	12	19	1
7/23	PM	3	0.0	19	12	18	1
7/24	AM	4	0.0	10	10	19	1
7/24	PM	4	0.0	15	11	19	1
7/25	AM	4	0.0	12	12	19	1
7/25	PM	4	0.0	16	13	19	1
7/26	AM	4	0.0	13	12	18	1
7/26	PM	4	0.0	15	14	18	1
7/27	AM	4	0.0	12	13	18	1
7/27	PM	4	0.0	17	14	18	1
7/28	AM	4	0.0	12	13	17	1
7/28	PM	3	0.0	13	16	16	1
7/29	AM	4	0.0	13	12	16	1
7/29	PM	3	0.0	14	12	16	1
7/30	AM	4	0.0	13	12	15	1
7/30	PM	4	0.0	15	14	15	1
7/31	AM	4	0.1	14	14	15	1
7/31	PM	4	0.0	16	14	15	1
8/1	AM	4	0.0	14	14	16	1
8/1	PM	1	0.0	24	16	17	1
8/2	AM	1	0.0	13	14	17	1
8/2	PM	1	0.0	24	16	17	1
8/3	AM	1	0.0	13	14	17	1
8/3	PM	1	0.0	30	16	17	1
8/4	AM	1	0.0	16	16	18	1
8/4	PM	3	0.0	26	18	18	1
8/5	AM	4	2.1	15	16	28	1
8/5	PM	4	0.0	13	13	27	1
8/6	AM	4	0.0	10	12	27	1
8/6	PM	4	0.0	13	11	27	1
8/7	AM	4	0.0	10	10	27	1
8/7	PM	4	0.0	14	11	26	1
8/8	AM	4	0.3	9	12	26	1
8/8	PM	4	0.2	10	13	27	1
8/9	AM	3	0.0	9	12	27	1
8/9	PM	4	0.0	15	12	27	1

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
8/10	AM	4	0.2	9	12	26	1
8/10	PM	3	0.1	14	12	28	1
8/11	AM	4	0.0	8	12	28	1
8/11	PM	4	0.0	12	12	28	1
8/12	AM	4	0.2	9	12	28	1
8/12	PM	3	0.2	12	12	28	1
8/13	AM	4	0.0	7	12	28	1
8/13	PM	3	0.0	12	12	26	1
8/14	AM	4	0.0	5	10	25	1
8/14	PM	3	0.0	11	10	24	1
8/15	AM	4	0.0	6	10	23	1
8/15	PM	4	0.0	12	10	22	1
8/16	AM	4	0.0	8	10	20	1
8/16	PM	4	0.0	12	12	19	1
8/17	AM	4	0.1	8	10	19	1
8/17	PM	4	0.0	12	11	18	1
8/18	AM	3	0.0	5	10	17	1
8/18	PM	2	0.0	16	12	17	1
8/19	AM	3	0.0	9	10	16	1
8/19	PM	4	0.2	8	12	14	1
8/20	AM	4	0.6	7	10	16	1
8/20	PM	2	0.1	11	11	17	1
8/21	AM	4	0.0	2	9	16	1
8/21	PM	–	–	–	–	–	–
Average	–	–	0.1	13	12	17	–

Note: En dash means no data. Due to a malfunctioning recording tool the accuracy of air and water temperatures for some dates are questionable, therefore they will not be included this year.

[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, 2021.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
7/5	AM	–	–	–	–	–	–
7/5	PM	4	0.6	13	12	81	2
7/6	AM	4	0.22	9	11	84	2
7/6	PM	4	0.3	10	11	94	3
7/7	AM	4	0.2	13	12	131	3
7/7	PM	3	0.05	13	11	130	3
7/8	AM	1	0.05	11	10	131	3
7/8	PM	1	0.0	13	11	131	3
7/9	AM	4	1.5	9	10	132	3
7/9	PM	4	0.12	11	9	132	3
7/10	AM	1	0.15	9	9	132	3
7/10	PM	1	0	18	12	132	3
7/11	AM	1	0	9	10	132	3
7/11	PM	1	0	20	13	131	3
7/12	AM	1	0.0	11	10	130	3
7/12	PM	1	0.0	22	15	98	2
7/13	AM	1	0.0	18	13	–	3
7/13	PM	1	0.0	19	15	–	2
7/14	AM	1	0.0	14	12	78	2
7/14	PM	1	0.0	22	13	76	2
7/15	AM	1	0.0	12	13	75	2
7/15	PM	1	0.0	20	14	75	2
7/16	AM	1	0.0	11	12	75	2
7/16	PM	1	0.0	23	17	75	2
7/17	AM	1	0.0	14	12	74	1
7/17	PM	1	0.0	21	17	74	1
7/18	AM	1	0.0	15	14	74	1
7/18	PM	2	0.0	23	27	73	1
7/19	AM	1	0.0	13	15	73	1
7/19	PM	1	0.0	26	19	73	1
7/20	AM	4	0.2	13	14	74	2
7/20	PM	4	0.1	15	13	74	2
7/21	AM	4	0.0	14	14	74	2
7/21	PM	4	0.1	18	14	74	2
7/22	AM	5	0.3	14	13	74	2
7/22	PM	3	0.0	18	13	74	2

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
7/23	AM	4	0.0	17	12	78	2
7/23	PM	3	0.0	19	13	74	2
7/24	AM	4	0.0	12	12	73	2
7/24	PM	3	0.0	16	12	73	2
7/25	AM	–	–	–	–	–	–
7/25	PM	3	0.0	16	13	73	2
7/26	AM	4	0.0	13	12	73	2
7/26	PM	3	0.0	16	13	73	2
7/27	AM	4	0.0	15	12	73	2
7/27	PM	4	0.1	15	12	74	2
7/28	AM	4	0.2	12	10	73	2
7/28	PM	4	0.0	14	12	73	2
7/29	AM	4	0.0	13	12	73	2
7/29	PM	4	0.0	15	12	73	2
7/30	AM	4	0.1	13	11	73	2
7/30	PM	4	0.0	14	11	73	2
7/31	AM	4	0.2	13	10	74	2
7/31	PM	4	0.1	15	12	74	2
8/1	AM	4	0.2	15	11	75	2
8/1	PM	2	0.0	19	12	80	2
8/2	AM	4	0.2	15	12	85	3
8/2	PM	4	0.2	16	11	87	3
8/3	AM	4	0.1	14	12	80	3
8/3	PM	4	0.0	15	11	80	2
8/4	AM	1	0.0	16	14	80	2
8/4	PM	1	0.0	25	15	80	2
8/5	AM	3	0.0	16	13	79	2
8/5	PM	4	0.0	22	12	75	2
8/6	AM	4	0.3	14	14	75	2
8/6	PM	3	0.1	16	15	74	2
8/7	AM	1	0.0	16	15	74	2
8/7	PM	4	0.0	18	13	74	2
8/8	AM	4	0.1	14	12	74	2
8/8	PM	4	0.4	14	12	72	2
8/9	AM	4	0.3	17	12	72	2
8/9	PM	2	0.3	16	13	72	2

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
8/10	AM	2	0.0	8	11	74	2
8/10	PM	4	0.1	14	12	79	3
Average	–	–	0.1	15	13	85	–

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, 2021.

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River stage (cm)	Water clarity[b]
6/20	AM	3	17.5	14	12	30	2
6/20	PM	–	–	–	–	–	–
6/21	AM	–	–	–	–	–	–
6/21	PM	3	1.6	19	17	29	1
6/22	AM	3	0.3	16	14	29	1
6/22	PM	2	0.1	23	18	29	1
6/23	AM	2	0	18	13	28	1
6/23	PM	4	0	19	15	28	1
6/24	AM	3	0.5	17	13	28	1
6/24	PM	3	0	19	16	28	1
6/25	AM	3	0.5	10	12	27	1
6/25	PM	1	0	20	15	28	1
6/26	AM	3	0	13	12	27	1
6/26	PM	3	0	16	15	27	1
6/27	AM	3	0.2	13	13	27	1
6/27	PM	3	0	16	16	29	1
6/28	AM	3	0	13	13	28	1
6/28	PM	2	0.5	18	16	29	1
6/29	AM	3	0	13	13	29	1
6/29	PM	1	0	19	16	30	1
6/30	AM	1	0	12	13	29	1
6/30	PM	2	0	24	17	30	1
7/1	AM	2	0	20	15	30	1
7/1	PM	4	0	24	17	30	1
7/2	AM	4	0	17	14	30	1
7/2	PM	–	–	–	–	–	–
7/3	AM	3	2	11	13	34	1
7/3	PM	3	0.3	14	12	37	1
7/4	AM	4	0	10	11	34	1
7/4	PM	4	0	15	14	34	1
7/5	AM	4	2.6	13	13	34	1
7/5	PM	4	12	13	12	39	1
7/6	AM	4	0.9	10	10	46	1
7/6	PM	3	0.3	14	13	46	1
7/7	AM	3	0	11	11	43	1
7/7	PM	2	0.3	14	14	42	1

-continued-

Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C)		River stage (cm)	Water clarity[b]
				Air	Water		
7/8	AM	2	2	13	12	42	1
7/8	PM	2	1.2	13	14	44	1
7/9	AM	4	0	11	11	50	1
7/9	PM	2	0.1	11	12	48	1
7/10	AM	1	0	15	11	46	1
7/10	PM	1	0	16	15	44	1
7/11	AM	1	0	15	12	42	1
7/11	PM	–	–	–	–	–	–
7/12	AM	1	0	18	11	42	1
7/12	PM	2	0	23	16	42	1
7/13	AM	1	0	17	14	41	1
7/13	PM	2	0	20	16	42	1
7/14	AM	2	0	17	14	42	1
7/14	PM	2	0	23	18	42	1
7/15	AM	2	0	13	15	41	1
7/15	PM	1	0	22	17	42	1
7/16	AM	2	0	14	14	42	1
7/16	PM	1	0	17	18	42	1
7/17	AM	1	0	15	15	42	1
7/17	PM	2	0	–	17	42	1
7/18	AM	3	0	16	15	42	1
7/18	PM	1	0	23	19	42	1
7/19	AM	1	0	17	15	43	1
7/19	PM	3	0.1	19	19	44	1
7/20	AM	3	0	18	16	48	1
7/20	PM	4	6	13	14	50	1
7/21	AM	4	0.3	14	13	51	1
7/21	PM	4	2	15	14	52	1
7/22	AM	3	0.4	15	13	52	1
7/22	PM	3	0	18	16	52	1
7/23	AM	3	0	16	14	50	1
7/23	PM	3	0	16	16	50	1
7/24	AM	4	0	13	13	50	1
7/24	PM	4	0	14	14	50	1
7/25	AM	1	0	13	13	50	1
7/25	PM	3	0	19	14	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]
7/26	AM	3	0	14	13	50	1
7/26	PM	3	0	14	13	50	1
7/27	AM	3	0	15	12	50	1
7/27	PM	4	2.2	14	12	52	1
7/28	AM	4	2	12	11	54	1
7/28	PM	3	0.1	15	14	54	1
7/29	AM	3	0	15	13	51	1
7/29	PM	4	0	17	13	52	1
7/30	AM	4	1.4	14	13	52	1
7/30	PM	4	0.2	16	13	51	1
7/31	AM	3	2.4	15	13	54	1
7/31	PM	–	–	–	–	–	–
8/1	AM	4	6	15	12	60	1
8/1	PM	3	1	21	16	64	1
8/2	AM	1	0	19	15	61	1
8/2	PM	1	0	23	18	60	1
8/3	AM	1	0	15	15	58	1
8/3	PM	1	0	28	18	58	1
8/4	AM	1	0	18	17	56	1
8/4	PM	1	0	24	19	56	1
8/5	AM	2	0	18	17	56	1
8/5	PM	3	0	16	16	56	1
8/6	AM	3	0	14	15	56	1
8/6	PM	4	0	14	15	56	1
8/7	AM	3	0	11	13	56	1
8/7	PM	3	0	15	13	56	1
8/8	AM	4	0.8	11	12	56	1
8/8	PM	4	5	12	12	58	1
8/9	AM	4	12.5	10	11	66	1
8/9	PM	4	0.6	12	13	71	1
8/10	AM	3	0.2	11	12	68	1
8/10	PM	3	0.5	13	13	66	1
8/11	AM	3	0	11	12	65	1
8/11	PM	4	0.6	12	12	64	1
8/12	AM	4	1.4	11	11	64	1
s	PM	4	6.4	11	12	68	1

-continued-

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Date	Time	Sky conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River stage (cm)	Water clarity[b]
8/13	AM	3	0.5	9	10	70	1
8/13	PM	3	0.1	11	11	69	1
8/14	AM	3	0	7	11	68	1
8/14	PM	4	0	11	11	67	1
8/15	AM	4	2.6	10	10	66	1
8/15	PM	4	1	11	10	66	1
Average	–	–	0.9	15	14	47	–

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, 2020, and 2021.

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
2021	7	18	0	1	7	0
Average	157	127	161	16	13	4

Appendix D2.–Yearly observed passage of nontarget species at George River weir, 2012–2021.

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
2021	937	694	675	0	113	16	0
Average	1,107	1,479	6,371	5	120	40	2

Appendix D3.–Yearly observed passage of nontarget species at Kogrukluk River weir, 2012–2021.

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
2021	38	58	6	14	1
Average	1,182	326	9	46	1

Appendix D4.–Yearly observed passage of nontarget species at Telaquana River weir, 2012–2021.

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
2021	63	31	15	1,780	108	42	1	10
Average	91	89	4	1,185	62	46	5	7

Appendix D5.–Yearly observed passage of nontarget species at Takotna River weir, 2013 and 2017–2021.

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
2021	34	0	3	2	1
Average	15	0	21	7	2

Appendix D6.–Yearly observed passage of nontarget species at Salmon River (Pitka Fork) weir, 2015–2021.

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
2021	148	84	135	0	9	2
Average	24	120	122	2	18	2