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Kogrukluk River Salmon Studies, 2010

by

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and

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

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by
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ABSTRACT

The Kogrukluk River weir has been operated since 1976 to estimate the return and age, sex and length compositions of salmon escapements, monitor environmental variables, and contribute to other Kuskokwim Area fisheries projects. In 2010, a fixed-picket weir was operated in the Kogrukluk River from 27 June through 22 September to estimate escapements of 4 species of Pacific salmon *Oncorhynchus* spp. The total annual Chinook salmon *O. tshawytscha* escapement of 5,690 fish fell within the sustainable escapement goal (SEG) range of 5,300 to 14,000 fish. The total annual chum salmon *O. keta* escapement of 63,583 exceeded the upper boundary of the SEG range of 15,000 to 49,000 fish. The total annual sockeye salmon *O. nerka* escapement of 13,995 was within the SEG range of 4,400 to 17,000 fish. The total annual coho salmon *O. kisutch* escapement of 13,971 was in the lower end of the SEG range of 13,000 to 28,000 fish. Age, sex and length samples taken from weir-trapped fish were used to describe the age-sex structure of the Chinook, chum, and coho salmon runs. Females comprised 26.2% of the Chinook salmon run, 45.3% of the chum salmon run, and 49.1% of the coho salmon run. The Chinook salmon run comprised 4 age classes, dominated by age-1.2 fish (44.0%). The chum salmon run comprised 4 age classes, dominated by age-0.3 fish (62.2%). The coho salmon run comprised 3 age classes, dominated by age-2.1 fish (87.4%).

The Kogrukluk River weir is one of several components which form an integrated array of escapement monitoring projects in the Kuskokwim Area. This array of projects provides a means to monitor and assess escapement trends that must be considered in harvest management decisions in accordance with the State of Alaska's Policy for the Management of Sustainable Salmon Fisheries (5 AAC 39.222).

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, chum salmon, *Oncorhynchus keta*, coho salmon, *Oncorhynchus kisutch*, sockeye salmon, *Oncorhynchus nerka*, pink salmon, *Oncorhynchus gorbuscha*, Dolly Varden, *Salvelinus malma* longnose suckers, *Catostomus catostomus*, escapement, age-sex-length, Kogrukluk River, Kuskokwim River, resistance board weir, radiotelemetry, mark–recapture, genetic stock identification, stock-specific run-timing.

INTRODUCTION

The Kuskokwim River is the second largest river in Alaska, draining an area approximately 130,000 km^2, or 11% of the total area of Alaska (Figure 1; Brown 1983). Each year mature Pacific salmon *Oncorhynchus* spp. return to the river and its tributaries to spawn, supporting an annual average subsistence and commercial harvest of nearly 650,000 salmon (Bavilla et al. 2010). The subsistence salmon fishery in the Kuskokwim Area is one of the largest in the state and remains a fundamental component of local culture (Coffing 1991; Coffing[1]; Coffing et al. 2000; Carroll and Patton 2010; Bavilla et al. 2010). The commercial salmon fishery, though modest in value compared to other areas of Alaska, has been an important component of the market economy of lower Kuskokwim River communities (Buklis 1999; Bavilla et al. 2010). Salmon contributing to these fisheries spawn and rear in most tributaries of the Kuskokwim River basin.

In the state of Alaska, salmon management seeks to provide for long-term sustainable fisheries by ensuring that adequate numbers of salmon escape to the spawning grounds each year (5 AAC 39.222). This goal requires an array of long-term escapement monitoring projects that reliably measure annual escapement to key spawning systems, as well as track temporal and spatial patterns in abundance, which influence management decisions. Over time and with sufficient data, escapement goals can be developed as a means to gauge escapement adequacy, but current models for escapement goal development require many years of data. For much of the Alaska Department of Fish and Game (ADF&G) management history in the Kuskokwim Area,

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[1] Coffing, M. Unpublished a. Kuskokwim area subsistence salmon harvest summary, 1996; prepared for the Alaska Board of Fisheries, Fairbanks, Alaska, December 2, 1997. Alaska Department of Fish and Game, Division of Subsistence, Bethel.

Coffing, M. Unpublished b. Kuskokwim area subsistence salmon fishery; prepared for the Alaska Board of Fisheries, Fairbanks, Alaska, December 2, 1997. Alaska Department of Fish and Game, Division of Subsistence, Bethel.

escapement monitoring has been limited to aerial surveys and two ground-based escapement monitoring projects.

Salmon spawn in dozens of tributaries in the Kuskokwim drainage and the operation of only two escapement monitoring projects was not an adequate measure of the entire Kuskokwim River basin. This problem was answered with the addition of several escapement monitoring projects in the mid- to late 1990s. The data provided by the current array of projects have much greater utility for fishery managers and have decreased their reliance on aerial stream surveys, which are known to be imprecise (Holmes and Burkett 1996; Molyneaux and Brannian 2006; Mundy 1998). In addition, main-river tagging studies rely on the expanded weir infrastructure to estimate inriver abundance and develop run reconstruction models for Kuskokwim River salmon. The models receive input data from escapement monitoring projects (weirs and aerial surveys) and harvest records (subsistence surveys and commercial catch tickets) to generate an estimate with confidence intervals of the number of salmon returning to the mainstem Kuskokwim River. Not only do the models allow for estimation of salmon returns in a current year, but also reaching back in time, giving managers another tool in making decisions to maximize exploitation while remaining sustainable. The results from these studies will be an important tool in answering questions of exploitation, distribution, abundance, and travel time for Kuskokwim River salmon and may eventually lead to the development of escapement goals for the entire Kuskokwim River drainage. The Kogrukluk River weir is an important project for the continuation of the run reconstruction models: due to the high productivity of the Holitna River system it contributes a larger portion of the fish returning to the Kuskokwim River than many of the other tributaries.

The Kogrukluk River weir also serves as a platform for collecting information on habitat variables, including water temperature, water chemistry, and stream discharge (level), which may directly or indirectly influence salmon productivity and timing of salmon migrations but do not yet figure prominently into management strategies (Hauer and Hill 1996; Kruse 1998; Quinn 2005). These variables can be affected by human activities (i.e., mining, timber harvesting, man-made impoundments, etc.; NRC 1996) or broader climatic variability (e.g., El Niño and La Niña events, climate change).

BACKGROUND

Regional

In the dialect of the middle Kuskokwim River Yupik people, *Kogrukluk* means “middle fork” (Evan Ignatti, elder, Kashegelok; personal communication). In the early 1800s, the Holitna River, along with the Nushagak River, formed a fur trade corridor between Bristol Bay and the Kuskokwim River (Oswalt 1990). Twice each year, Russian traders traveled this route, completing a 5-day portage between Shotgun Creek and the Chichitnok River (Brown 1983; Oswalt 1990). Until 1845, this route served as the primary supply conduit for the first Russian station on the Kuskokwim River, located at the mouth of the Holitna River. A number of communities were established along the Holitna River to service this route, including Kashegelok, Nogamut, and Itulilik. Residents of Holitna River communities relied heavily on the abundant Holitna River salmon runs, and supplemented their livelihoods through the fur trade.

As the fur trade declined and other opportunities arose, such as the opening of the Red Devil mercury mine in the 1930s, the Holitna River villages were slowly abandoned. Kashegelok, located just downstream from the Kogrukluk/Chukowan confluence, was the longest surviving

Native community along the Holitna River. Kashegelok harbored a sizable community until most of the dwellings were destroyed when the Holitna River shifted course to the east sometime between 1940 and 1960 (Evan Ignatti, elder, Kashegelok; personal communication). The village was abandoned in stages and the last resident of the village of Kashegelok, Evan Ignatti, passed away in September of 2010 in the village of Red Devil.

Today, most inhabitants of the Holitna River reside in a number of commercial lodges and private, homesteads along the lower Holitna River. At this writing, there are no known year-round residents of the Holitna drainage. However, this productive area continues to draw users from throughout the Kuskokwim River drainage and beyond, and remains an important location for subsistence fishing, sport fishing, and hunting.

Kogrukluk River Escapement Monitoring

Since the first aerial survey was flown in 1961, state managers have recognized the importance of the Holitna River drainage as a salmon spawning system (Burkey 1994; Schneiderhan[2]). Escapement monitoring began in 1969 when a salmon counting tower project was initiated on the Kogrukluk River upstream of the confluence of Shotgun Creek (Figure 2; Yanagawa 1972). The tower was relocated twice between 1970 and 1978 because of shifting river channels, but remained upstream of the mouth of Shotgun Creek. In order to more accurately assess salmon escapements, installation of a counting weir was attempted in 1971 near the counting tower site. This first weir was destroyed by high water early in the season (Yanagawa 1973). In 1976, a new weir was established not far downstream of the original weir and tower sites (Baxter 1979). Since the project's establishment, the Kogrukluk River weir has operated annually to monitor Chinook, chum, and sockeye salmon escapement to this system; and beginning in 1981, the weir operations were extended to include coho salmon (Baxter 1982).

Kogrukluk River salmon escapements constitute a fraction of the overall salmon escapements in the Kuskokwim River drainage; however, this tributary appears to support a relatively large number of spawning Chinook, chum, sockeye, and coho salmon when compared to other Kuskokwim River tributaries of similar size (Molyneaux and Brannian 2006). Of all the ground-based projects in the Kuskokwim River drainage, the Kogrukluk River weir is 1 of 4 with a formal escapement goal for Chinook salmon, 1 of 2 with a formal escapement goal for chum salmon, 1 of 2 with a formal escapement goal for coho salmon, and the only project with a formal escapement goal for sockeye salmon (Figure 1; Volk et al. 2009). The escapement goals set at the Kogrukluk River weir are sustainable escapement goals (SEG). This type of escapement goal is a target range for the number of salmon to return, and the range is developed from escapement estimates that are known to provide for sustained yield over a 5- to 10-year period. This type of escapement goal is used when levels of harvest of fish from a specific drainage cannot be estimated.

OBJECTIVES

The objectives of the Kogrukluk River escapement monitoring project in 2010 were to:

1. Determine the daily and total escapement of male and female Chinook, chum, sockeye, and coho salmon to the Kogrukluk River;

[2] Schneiderhan, D. J., editor. Unpublished. Kuskokwim stream catalog, 1954–1983. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage.

2. Estimate the age, sex, and length composition of Chinook, chum, and coho salmon escapements to the Kogrukluk River such that 95% confidence intervals for the age composition are no wider than ±10% ($\alpha = 0.05$ and $d = 0.10$);

3. Serve as a platform to facilitate current and future fisheries research projects (in 2010) by:

    a. Serving as a monitoring and recapture location for sockeye salmon equipped with anchor tags deployed as part of *Kuskokwim River Sockeye Salmon Run Reconstruction*;

    b. Serving as a collection site for Chinook and pink salmon genetic tissue;

    c. Collection of escapement and age, sex, length (ASL) data for run reconstruction models of the entire Kuskokwim River;

    d. Providing escapement context to assist in development and assessment of formal salmon escapement goals; and,

    e. Installing and monitoring air and stream thermographs at Kogrukluk River weir as part of a broader *Temperature Monitoring* project.

METHODS

STUDY AREA

The Kogrukluk River watershed drains about 2,073 km^2, formed by 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 near Nishlik Lake, the Kogrukluk River flows northerly for approximately 80 river kilometers (rkm). The Kogrukluk River weir is located near the abandoned village site of Kashegelok at the headwaters of the Holitna River (Figure 2). The confluence of the Chukowan and Kogrukluk Rivers forms the headwaters of the Holitna River which flows 218 rkm to its own ending in the Kuskokwim River. The Holitna River joins the Kuskokwim River at rkm 491.

The Kogrukluk River flood plain is poorly drained and is composed of soft sediments that erode easily. Over its course, the river descends approximately 250 m with an average drop of 3.2 m per km across a 1–5 km wide flood plain (Figure 3; Collazzi 1989). The river substrate is mostly gravel and cobble of assorted sizes. At normal flow, the Kogrukluk River has a nominal load of suspended materials and the water is clear; however, water clarity is reduced during periods of high flow when it can become stained from organic leaching. The Kogrukluk River and its tributaries are dynamic in that they can change course quickly. The resulting oxbows, sloughs, and large log jams form a complex mosaic of reproductive and rearing habitat suitable for salmon (Baxter[3]; Healy 1991).

Riparian areas consist of low-lying mixed spruce (*Picea* spp.), cottonwood (*Populus* sp.), willows (*Salix* spp.), and alders (*Alnus* spp.), interspersed with wet tundra. Uplands are typically spruce-hardwood forest, and terrain above 200 m is typically alpine tundra. White spruce (*P. glauca*), birch (*Betula* spp.), and aspen (*P. trenuloides*) are common on moderate south-facing slopes and black spruce (*P. mariana*) are common on north-facing slopes, in poorly

[3] Baxter, R. Unpublished a. Holitna Weir developmental project, 1976. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Salmon Escapement Report No. 11, Anchorage.

drained areas, and within pockets of permafrost. On cool moist slopes the understory consists of spongy moss and low brush, whereas on dry slopes the understory is mostly grasses and near timberline most under stories consist of willows, alders, and dwarf birch (*B. nana*).

Located approximately 220 rkm from the village of Sleetmute, 710 rkm from the mouth of the Kuskokwim River, and 212 km by air from the city of Bethel, the Kogrukluk River weir is the most remote ground-based escapement project in the Kuskokwim Area (Figure 1). Personnel and supplies are transported to and from the weir by floatplane. The weir has been at this location since 1976 (Figure 2; Baxter[4]).

WEIR DESIGN

The Kogrukluk River weir is a fixed-picket design, spans a 70 m channel and incorporates a fish trap and narrow boardwalk. The design and materials used to construct the Kogrukluk River weir in 2010 are the same as those described by Baxter (1981), with the exception of an improved fish trap (since 2001) and a tighter picket spacing (since 2005). The fish trap, which is about 2.4 m by 1.5 m, was modeled after the trap used at the George River weir since 2001 (Linderman et al. 2003). The picket spacing was narrowed after investigators observed small chum salmon passing through the pickets in 2004, a year that was characterized by an unusually high abundance of small, 3-year-old chum salmon. Picket intervals were reduced from 76.2 mm to 63.5 mm, which narrowed the gap from 49.0 to 36.5 mm (R. Stewart, Commercial Fisheries Technician, ADF&G, Anchorage; personal communication).

Boat traffic at the weir is uncommon, but when necessary, boats can be passed by removing weir pickets and pulling the boat through the opening (Baxter 1981). The use of a floating resistance board weir, which is generally better at accommodating debris and boat traffic, was considered for this site. But extensive site surveys indicated that the weir location lacked the necessary riverbed profile and substrate stability for proper installation and operation of a floating weir (Shelden et al. 2005).

ESCAPEMENT MONITORING

Annually, the weir is installed in late June, prior to the onset of the Chinook and chum salmon runs, and is operated into late September to encompass the bulk of the coho salmon run. Generally, no attempt is made to estimate missed passage prior to installation or after removal of the weir. High water events or damage to the weir occasionally result in inoperable periods, however estimates of salmon passage for inoperable periods help to provide consistent comparisons of escapements among years. Total annual escapement is determined from the total observed and estimated fish passage.

Passage Counts

Passage counts were conducted in 4 to 8 one-hour shifts per day between 0730 and 2400 hours. This schedule was adjusted as needed to accommodate variation in fish behavior and abundance. Crew members visually identified the species and sex of each fish observed passing upstream of the weir and recorded them on a tally counter. Following each shift, crew members recorded total counts in a logbook and zeroed the tally counter. At the end of each day, total daily and

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[4] Baxter, R. Unpublished b. Hoholitna River reconnaissance survey, 1977. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Salmon Resource Report No. 3, Anchorage.

cumulative seasonal counts were recorded in a designated logbook. These counts were reported each morning to ADF&G staff in Bethel via single sideband radio or satellite phone.

The live trap was used as the primary means of upstream fish passage. A clear plastic viewing window was placed on the stream surface to improve visual identification of fish entering the trap. Salmon were also enumerated by sex, from the visual characteristics of advanced sexual dimorphism apparent in adult salmon at Kogrukluk River weir. Other methods were occasionally used when salmon were reluctant to enter the fish trap, such as during periods of extreme low water (Liller et al. 2008).

Passage Estimates

In 2010, the inoperable period occurred at a time that affected the enumeration of all salmon species returning to the Kogrukluk River weir. Substantial portions of the waning end of the Chinook, chum, and sockeye salmon runs and the leading edge of the coho salmon run were not enumerated. In circumstances when the weir does not become operational until well into the one or more salmon runs, or when the weir ceases operating well before data suggest salmon runs are nearing completion, daily passage for inoperable days is interpolated using a proportional method.

In 2010, the proportional method used passage data from another year at the Kogrukluk River weir or from a neighboring project on the Kuskokwim River. The dataset used to model escapement for a particular situation was selected because it exhibited similar passage patterns to the incomplete dataset. Daily passage estimates were calculated using the following formula:

$$\hat{n}_{d_i} = \left(\frac{\left(n_{md_i} \times \sum n_{d_i} \right)}{\sum n_{md_i}} \right) - n_{o_i} \tag{1}$$

where

n_{md_i} = passage for the i^{th} day in the model data;

$\sum n_{d_i}$ = cumulative passage;

$\sum n_{md_i}$ = cumulative passage of the model data for the corresponding time period; and,

n_{o_i} = observed passage (if any) from the given day (i) being estimated.

When selecting potential surrogate data sets, investigators assumed that salmon runs closer in proximity and within the same year would show some similarities in migration characteristics. The closest monitored tributaries to select data from were George, Tatlawiksuk and Takotna River weir projects. If possible model data sets with little or no estimated passage were preferred, this excluded Tatlawiksuk River weir because it had considerable amounts of estimated passage for all species (Clark et al. 2011). For Chinook and chum salmon George River weir best fit the above criteria. For coho salmon George and Takotna River weirs both fit the above criteria, although both projects had some estimated passage it constituted a very small portion of the observed escapement. Finally 3 day moving averages of daily passage were generated for both surrogate data sets and observed data; they were then graphed alongside each other to make visual comparisons of similarities between the curves (Figure 4).

The Kogrukluk River weir is located at a much further distance away from the mainstem Kuskokwim River in comparison to the other monitoring projects; this resulted in run timing at the Kogrukluk River weir being later than the model data sets (Figure 4). To correct for this difference in run timing, the model data sets were shifted (i.e. data observed on day one would be moved to day two, and day two moved to day three and so on) until the trajectories of the moving average curves matched. It is important to note that the 3 day moving average was used to determine if the selected surrogate data was a good match to the incomplete observed data, and to determine how much and in which direction to shift the model data set to match the curve trajectories. When calculating the estimated daily passage with the above formula, actual daily counts from the model data set were used, not the 3 day average.

For Chinook and chum salmon, the passage data from the 2010 George River weir was chosen as the model data sets and shifted back 9 and 4 days respectively to match the run timing with Kogrukluk River weir (Smith and Shelden 2011). For coho salmon, the passage data from the 2010 Takotna River weir was chosen to model the estimated passage at the Kogrukluk River weir (Hansen and Shelden 2011). Similar to the other species, to match the run timing between the 2 projects the Takotna River data set was shifted back by 4 days (Figure 4).

Aside from Kogrukluk River weir, the only other escapement monitoring projects on the Kuskokwim River that receive any substantial number of sockeye salmon are the Telaquana and Kwethluk River weirs. The sockeye salmon observed at these projects are primarily lake spawning sockeye salmon whereas sockeye salmon observed at the Kogrukluk River weir are riverine spawners. Due to these differences in life history, we chose a surrogate data set from Kogrukluk River data from past years. Data sets with large amounts of estimated passage were excluded. Passage data from 1997 was chosen due to similarities with the 2010 run up until the inoperable period. As with other species, 3 day moving averages of daily passage were graphically compared to observed 2010 passage. Data was shifted 11 days earlier to better match the run timing between the 2 years (ADF&G 2010).

Carcass Counts

Each time the weir was cleaned, spawned-out salmon, or carcasses, that washed up on the weir were counted by species and discarded downstream. Daily and cumulative carcass counts were copied to a logbook. In some years, sex and species of all carcasses was determined; however, this practice has been discontinued.

AGE, SEX, AND LENGTH COMPOSITION

To estimate the age, sex, and length composition of Chinook, chum, and coho salmon escapements, live sampling was conducted as fish migrated upstream through the weir. Samples were collected throughout the season to account for temporal dynamics in ASL characteristics. Samples were stratified postseason to develop weighted estimates.

Sample Size and Distribution

A minimum sample size was determined for each species following conventions described by Bromaghin (1993) to achieve simultaneous 95% confidence intervals of age-sex composition no wider than ±10% (α = 0.05 and d = 0.10), assuming 10 age-sex categories for Chinook salmon (*n*=190), 8 age-sex categories for chum salmon (*n*=180), and 6 age-sex categories for coho salmon (*n*=168). These sample sizes were then increased by about 20% to account for unreadable scales or collection errors. This yielded a minimum collection goal for each sample of 230 Chinook, 220 chum, and 200 coho salmon.

The abundance of chum and coho salmon at the Kogrukluk River weir is high enough to collect a large sample size in a short period of time. A pulse sampling strategy was therefore employed to ensure adequate temporal distribution of chum and coho salmon samples. The term “pulse” is used to describe a sample that is collected over a short period of time and then used to characterize a longer time interval. Well-spaced pulse samples are thought to have greater power for detecting temporal changes in ASL composition than other sampling methods (Geiger and Wilbur 1990). Pulse sampling was conducted approximately every 7 to 10 days. The goal was to collect a minimum of one pulse sample from each third of the run.

The comparatively lower numbers of Chinook salmon running concurrently with large numbers of chum salmon and sockeye salmon at Kogrukluk River weir makes pulse sampling impractical. In 2010 sampling efforts followed a daily collection schedule based on historical run timing information using a sample size of 499 fish (Molyneaux et al. 2010). Daily sample sizes were proportional to average historical escapements by day to ensure a good distribution across the run. The overall sample size was selected to exceed the minimum necessary to meet precision and accuracy criteria for this location and was similar to average historical sampling success.

Sample Collection Procedures

Salmon were sampled from the fish trap installed in the weir. Salmon were trapped by opening the entrance gate while the exit gate remained closed. Fish were allowed to swim freely into the live trap, and the V-shape positioning of the entrance gate prevented them from easily escaping. The live trap was allowed to fill with fish until a reasonable number were inside. Crew members used a short-handled dip net to capture fish within the live trap. To obtain length data and aid in scale collection, fish were removed from the dip net and placed into a partially submerged fish “cradle.” Scales were taken from the preferred area of the fish (INPFC 1963) and transferred to numbered gum cards as described in Molyneaux et al. (2010). Sex was determined through 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. Mideye to fork (MEF) length was measured to the nearest millimeter using a straight-edged meter stick. Sex and length data were recorded on standardized numbered data sheets that correspond with numbers on the gum cards used for scale preservation. After sampling, each fish was released upstream of the weir. The procedure was repeated until the live trap was emptied to ensure no bias was introduced.

Chinook salmon samples were often collected through “active sampling,” which consisted of capturing and sampling fish individually while actively passing and counting all salmon. Further details of the active sampling procedures are described in Linderman et al. (2003). This method was also used for tag recoveries.

After sampling was completed, relevant information such as sex, length, sampling date, sampling location, and gum card number was entered into a computer spreadsheet. The completed gum cards and computer file were sent to the Bethel and/or Anchorage ADF&G offices for processing. The original ASL gum cards, acetates, and mark–sense forms were archived at the ADF&G office in Anchorage. The computer files were archived by ADF&G in the Anchorage and Bethel offices. Data was also loaded into the Arctic-Yukon-Kuskokwim (AYK) salmon database management system (Brannian et al. 2006). Further details of sampling procedures can be found in DuBois and Molyneaux (2000) and Linderman et al. (2003).

Data Processing and Reporting

Samples were aged and processed by ADF&G staff in Bethel and Anchorage following procedures describe by Molyneaux et al. (2010). Samples were partitioned into 2 to 4 temporal strata depending on samples sizes and distribution of samples within the run. The escapement in each stratum was divided into age-sex classes proportionately with strata sample composition. Mean length by age-sex class was determined for each stratum as well. Annual estimates were calculated as strata sums, weighted by the abundance in each stratum. When sample size or distribution was not considered adequate to estimate annual ASL composition, results were reported but not applied to annual escapements.

A table was generated for each species providing summary statistics for age-sex class and mean length-at-age by sex. The data is presented by stratum with season totals weighted by escapement in each stratum. Sample sizes and dates are included for each stratum. Age is reported in the European notation, composed of two numerals separated by a decimal. The first numeral represents the number of winters the juvenile spent in freshwater excluding the first winter spent incubating in the gravel, and the second numeral is the number of winters it spent in the ocean (Groot and Margolis 1991). The total age is therefore one year greater than the sum of these two numerals.

The practice of collecting complete ASL data from sockeye salmon was discontinued at Kogrukluk River weir in 1995 because of the prevalence of scale absorption, which confounds reliable aging (Burkey 1995; Cappiello and Burkey 1997). Crews continued to visually estimate sex composition during daily enumeration routines. Annual sex composition was determined by comparing the total annual escapement of males to the total annual escapement of females. ASL sampling of sockeye salmon was reinitiated at the Kogrukluk River weir in 2006 in support of *Kuskokwim River Sockeye Salmon Investigations*, although the project was completed in 2007 the practice of sampling has continued. The collected sockeye salmon ASL data, though insufficient to estimate total age or ocean life history, provides perspectives on juvenile life history strategies of riverine sockeye salmon populations in Western Alaska, which have previously been poorly understood (S. E. Gilk, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication).

To better assess sibling relationships, and visualize how abundance of a specific age class compares to historical values, investigators generated age-class abundance bubble graphs. These graphs take the observed abundance of each individual age-class and display it in the form of a bubble, wherein larger bubbles represent larger abundance values and vice versa. This allows the reader to see the historical range of abundance values for a given age-class and how abundance in a given year compares to that range, and assess the proportional contribution of an age class in a given year. Additionally, this allows the reader to track the abundance of a cohort over time and potentially make predictions about age specific run strength in subsequent years.

Visual Sex Determination

Sex was determined for every salmon passing upstream of the weir through observation of sexually dimorphic characteristics. Sex compositions derived visually and through ASL were compared to assess possible biases in each method and to test the potential of visual sex determination in clear water tributaries. Each ASL stratum was considered independently, with the sex composition determined by ASL compared to the sex composition determined visually for the same time period.

WEATHER AND STREAM OBSERVATIONS

Water and air temperatures were manually measured each day at approximately 1000 and 1700 hours. Water temperature was determined by submerging a calibrated thermometer below the water surface until the temperature reading stabilized. Air temperature was obtained from a thermometer attached to an outside wall of the cabin in a shaded location. Temperature readings were recorded in a designated logbook, along with notations about wind direction, estimated wind speed, cloud cover, and precipitation. Daily precipitation was measured using a rain gauge calibrated in millimeters. These manual techniques are consistent with past years at this project.

In addition to manual techniques, air and water temperature was monitored using 2 Hobo® Water Temp Pro V2 data loggers and one Hobo® Air Temperature R/H data logger. The water temperature loggers were anchored to the stream bed near mid-channel and the air temperature logger was installed in shaded area under a tent platform approximately 2 meters above ground level and 15 meters from the river. At the end of the field season all the data loggers were downloaded using a data shuttle, the data loggers were then reinstalled and left in the field to continue monitoring over the winter. The data shuttle, along with pictures and GPS coordinates of the data logger's location were returned to the ADF&G Anchorage office for data management, reporting, and storage.

Daily operations included monitoring river depth with a standardized staff gauge. The staff gauge consisted of a metal rod driven into the stream channel with a meter stick attached. The height of the water surface, as measured from the meter stick, represented the "stage" of the river in centimeters above an established datum plane. The staff gauge was calibrated (using a surveyor's level) to the datum plane with a semi-permanent benchmark to provide for consistent stage measurements between years. The benchmark consisted of a nail driven into the second step of a wooden staircase leading from the riverbank to the utility shed, which represents a measurement of 5 m above baseline and corresponds to the highest water level observed at the Kogrukluk River weir. Water stage was measured at approximately 1000 and 1700 hours.

RELATED FISHERIES PROJECTS

Kuskokwim River Salmon Run Reconstruction

The Kogrukluk River weir has served as a recovery site for several basinwide mark–recapture studies, including a currently ongoing study entitled *Kuskokwim River Sockeye Salmon Investigations*. Any questions regarding this study can be directed to the project investigator Kevin Schaberg at ADF&G Division of Commercial Fisheries. Salmon escapement and ASL information from the Kogrukluk River weir, in combination with data from other Kuskokwim River projects, serve as vital annual inputs to models used to estimate Chinook and coho salmon total abundance in the Kuskokwim River drainage. These estimates further help in determination of total exploitation rates and fluctuations in annual productivity.

Baseline Genetic Sample Collections

In 2010, the Kogrukluk River weir was used as a platform to collect genetic tissue from pink salmon. Pink salmon samples were collected on an opportunistic basis to contribute to existing baseline collections. These were sent to the ADF&G genetics lab in Anchorage for storage and processing.

In a separate study, tissues were harvested from 6 Chinook salmon for the purpose of isolating RNA. Heart, liver, muscle and gonad tissues were harvested from freshly killed males and placed in RNAlater® solution. These tissues were flown back to the ADF&G gene conservation laboratory where they will be used in a project intended to discover genetic markers for use in stock identification studies. The use of RNA samples makes it possible to scan areas of the genome that are likely under selection, thus increasing the chance of finding markers that vary among populations. The Kogrukluk River was chosen as a sample site for this study because it lies in an a broad region of coastal Western Alaskan drainages with Chinook salmon stocks that are currently difficult to distinguish from one another in mixed stock analyses.

RESULTS

WEIR OPERATIONS

In 2010, the Kogrukluk River weir was operated from 27 June through 22 September. Persistent rains and high water levels characterized the 2010 season, and resulted in a structural failure of the weir. The weir remained inoperable from 30 July to 26 August (Table 1). Estimates of missed salmon passage were generated using the proportional interpolation method described above. It should be noted that passage date statistics for all species are based on estimated passage during the inoperable period as such the actual dates could vary slightly; however they are considered to be good approximations.

ESCAPEMENT MONITORING

Chinook Salmon

Total Chinook salmon escapement upstream of the Kogrukluk River weir in 2010 was 5,690 fish, including an estimated 1,113 fish (19.6% of the total escapement) that passed while the weir was inoperable. The first fish passed through the weir on 27 June, daily passage peaked at 360 fish on 15 July, and the last Chinook salmon was observed on 7 September. The median passage date was 21 July and the central 50% of the passage occurred between 14 and 28 July (Table 1).

Chum Salmon

Total chum salmon escapement upstream of the Kogrukluk River weir in 2010 was 63,583 fish, of which 13,645 (21.5%) fish were estimated. The first chum salmon was observed on 27 June and daily passage peaked at 2,793 fish on 18 July, and the last chum salmon was observed on 22 September. The median passage date was 21 July and the central 50% of the passage occurred between 14 and 28 July (Table 1).

Coho Salmon

Total coho salmon escapement upstream of the Kogrukluk River weir in 2010 was 13,971 fish, which includes an estimated 1,452 (10.4%) fish that passed during inoperable periods. The first coho salmon was observed on 29 July, daily passage peaked at 907 fish on 5 September and on the last day of operations 84 coho salmon were observed. The median passage date was 5 September and the central 50% of the passage occurred between 30 August and 9 September (Table 1).

Sockeye Salmon

Total sockeye salmon escapement upstream of the Kogrukluk River weir in 2010 was 13,995 fish, of which 4,552 (32.5%) fish were estimated. The first sockeye salmon was observed on 4 July, observed daily passage peaked at 896 fish on 29 July, and the last sockeye salmon was observed on 22 September. The median passage date was 21 July and the central 50% of the passage occurred between 15 and 28 July (Table 1).

Other Species

It is assumed that small individuals such as pink salmon *O. gorbuscha* and non-salmon species may pass freely between weir pickets. Counts of these fish are therefore not considered a census of passage, but are reported here as anecdotal information. Observed pink salmon escapement upstream of the Kogrukluk River weir in 2010 was 148 fish (Appendix A). Pink salmon were observed passing upstream of the weir from 6 July to 7 September. Other species observed passing upstream of the Kogrukluk River weir during the 2010 field season include 399 char (*Salvelinus* spp.) and 2 whitefish (*Coregonus* sp.; Appendix A). Arctic grayling (*Thymallus arcticus*) and northern pike (*Esox lucius*) were also observed but total counts were not recorded. For a complete listing of fish species in the area, see Baxter[5].

Carcasses

A total of 5,293 salmon carcasses were recovered from the Kogrukluk River weir. Chum salmon were the most numerous (4,518), followed by pink (429), sockeye (304), Chinook (33), coho salmon (9). Other fish species recovered from the weir include Arctic grayling, char, northern pike, and whitefish (Appendix B).

Age, Sex, and Length Composition

Chinook Salmon

Chinook salmon ASL sampling at the Kogrukluk River weir was conducted on a daily basis from 5 July to 29 July, resulting in a total sample of 387 fish. Of those, age was successfully determined for 298 fish (77.0% of the total sample), or 5.2% of the escapement. The total escapement was partitioned into 2 temporal strata based on sample size and the temporal distribution of the sampling effort. Sample sizes were 154 and 144 fish, respectively. Overall, 95% confidence intervals for age composition proportions were no wider than ±5.5% (Table 2).

The Chinook salmon escapement past the weir was dominated by 3 age classes: age-1.2, -1.3, and -1.4. Age-1.2 fish were the most abundant (44.0%), followed by age-1.3 (28.8%) fish, and age-1.4 (25.6%). Female Chinook salmon comprised 26.2% of the total escapement (1,492 fish), and the method of visually identifying the sex of passing Chinook salmon yielded a sex ratio identical to that derived from ASL sampling. The length of female Chinook salmon ranged from 648 to 969 mm, and the length of males ranged from 413 to 917 mm. Average length of age-1.3 females was 819 mm, while the average length of age-1.4 females was 856 mm. Average lengths for male Chinook salmon age-1.2, -1.3, and -1.4 were 551, 704, and 773 mm, respectively. Female Chinook salmon were consistently larger at age than males (Table 2 and Figure 5).

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5 Baxter, R. Unpublished c. Holitna River salmon studies, 1977. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Salmon Escapement Report No. 13, Anchorage.

Chum Salmon

Chum salmon ASL sampling at the Kogrukluk River weir was conducted in 4 pulses, distributed between 5 July and 24 July, resulting in a total sample of 884 fish. Of those, age was successfully determined for 746 fish (84.4% of the total sample) or 1.2% of the total escapement. The total annual escapement was partitioned into 4 temporal strata based on the temporal distribution of sampling effort. Sample sizes were 198, 183, 223 and 142 aged fish for the first, second, third and fourth strata, respectively. Overall, 95% confidence intervals for age composition were no wider than ±4.6% (Table 3).

The chum salmon escapement past the weir was largely represented by 2 age classes, age-0.3, and -0.4. Age-0.3 was the most abundant age class (62.2%), followed by age-0.4 (34.1%), age-0.2 (2.8%), and age-0.5 (0.8%). Female chum salmon comprised 45.3% (28,830 fish) of the total annual escapement, and the method of visually identifying the sex of every passing chum salmon yielded a sex ratio similar to that derived through ASL sampling. The length of female chum salmon ranged from 478 to 620 mm and the length of males ranged from 480 to 688 mm. Males were generally larger at age than females, and average length generally increased with age for both males and females. Average lengths for female chum salmon age-0.2, -0.3, -0.4, and -0.5 were 523, 528, 540, and 547 mm. Average lengths for male age-0.2, -0.3, -0.4, and -0.5 chum salmon were 542, 557, 575, and 597 mm (Table 3 and Figure 5).

Coho Salmon

Coho salmon ASL sampling at the Kogrukluk River weir was conducted in 3 pulses, distributed between 31 August and 14 September, resulting in a total sample of 606 fish. Of those, age was successfully determined for 549 fish (90.6% of the total sample) or 3.9% of the escapement. The run was partitioned into 3 temporal strata based on the temporal distribution of sampling effort, which effectively encompassed each third of the run, sample sizes were 181, 184, and 184 aged fish, respectively. Overall, 95% confidence intervals for age composition were no wider than ± 2.8% (Table 4).

The coho salmon escapement past the weir was dominated by age-2.1 individuals, which comprised 87.4% of total escapement. Age-3.1 fish comprised 7.9% of the escapement and age-1.1 fish comprised 4.7% of the escapement. Females comprised 49.1% (6,858 fish) of the escapement and the method of visually identifying the sex of every passing coho salmon yielded a sex ratio that was similar to that derived through ASL sampling. The average length of female coho salmon ranged from 414 to 631 mm, and the average length of males ranged from 415 to 653 mm. Average lengths for age-1.1, -2.1, and -3.1 female fish were 568, 554, and 567 mm. Male fish had average lengths of 535, 546, and 561 mm for age-1.1, -2.1, and -3.1 fish (Table 4 and Figure 5).

Sockeye Salmon

Sockeye salmon ASL sampling at the Kogrukluk River weir was conducted on an opportunistic basis from 7 July to 29 July, resulting in a total sample of 185 fish. Of those, age was determined for 144 fish (77.8% of the total sample) or 1.0% of the total escapement. However, Kogrukluk River sockeye salmon scales are highly reabsorbed by the time they reach the weir site, making determination of salt water ages unreliable. Freshwater ages could still be determined: the majority of the sampled fish were age-1.X, but some age-0.X and age-2.X fish were also present. The method of visually identifying the sex of every passing sockeye salmon indicated that female sockeye salmon comprised 60.9% of the run, nearly identical to the percentage of females determined through ASL sampling (60.4%). The average length of female sockeye salmon ranged from 470 to 574 mm, and average length of males ranged from 528 to 632 mm (Table 5; Appendix A).

WEATHER AND STREAM OBSERVATIONS

A total of 176 complete observations of weather and stream conditions were recorded between 27 June and 22 September (Appendix C1). Based on twice-daily thermometer observations, water temperature at the weir ranged from 6.0 to 17.5°C, with an average water temperature of 9.9°C. Based on twice-daily thermometer observations, air temperature at the weir ranged from 1.5 to 25°C, with an average air temperature of 13.4°C (Appendix C1). Based on hourly data logger readings, air temperature ranged from -2.2 to 22.4°C with an average daily temperature of 10.9°C (Appendix C2). An hourly data logger was deployed to record water temperature, but the logger was only operational for a short duration. Successfully collected data is presented in Appendix C3 but will not be discussed in any further detail. A total of 269.0 mm of precipitation was recorded throughout the season. River stage ranged from 277 to 412 cm, with an average of 307 cm (Appendix C1).

DISCUSSION

OPERATIONS

In 2010, the Kogrukluk River weir was operated from 27 June through 22 September. Persistent rains and high water levels characterized the 2010 season; the resulting structural failure of the weir rendered it inoperable from 30 July to 26 August. Estimates of missed salmon passage were generated using the proportional interpolation method described above (Table 1).

In 2010, the Kogrukluk River weir operations were similar in duration and timing to the historical average. The inoperable period resulted in missed passage that accounted for approximately 19.6%, 21.5%, and 32.5% of the Chinook, chum and sockeye salmon escapements respectively. Historical run timing indicates that the inoperable period occurred at a time when Chinook, chum and sockeye salmon runs were diminishing. Thus, despite limitations, reported annual escapements for these species are considered reasonable approximations of actual escapement. The inoperable period had a lesser effect on coho salmon enumeration (10.4%), however the first 25% of the run could not be sampled for ASL data. Objectives for precision for these species were met in 2010, however objectives for sample distribution were not met for Chinook, chum, or coho salmon. Temporal variations in ASL composition typically observed may not have been captured in 2010. Conclusions about ASL composition should be viewed with this caveat in mind (Figure 6).

ESCAPEMENT MONITORING

Chinook Salmon

Chinook salmon escapement in 2010 fell near the lower end of the SEG range of 5,300–14,000 fish (Volk et al. 2009). The 2010 Chinook salmon run at the Kogrukluk River weir was the third latest on record, while the duration was just above average, and the median passage date was the second latest on record for the Kogrukluk River weir (Figures 7 and 8).

In 2010, ASL samples were not collected over the latter 20% of the run due to the weir being inoperable. Age-1.2 fish abundance in 2010 was near the historical average, while the abundance of the other age classes (-1.3, -1.4, and -1.5) were among the lowest on record (Molyneaux et al. 2010). The low abundance of the predominately female, age-1.4 fish accounted for one of the lowest abundance estimates of female Chinook salmon on record. The proportion of the Chinook salmon run was below average by 6%. The ASL sampling method yielded a female percentage identical to the visual method. The similarity between these methods supports the assumption that ASL sampling methods are random and effective. It is worth pointing out that older aged fish, and females in particular, tend to arrive as a later component of the run at Kogrukluk River, and poor sample distribution in 2010 likely missed a portion of these fish, causing proportions of females and older age fish to appear lower than they actually were. The degree to which this might have affected our results is unknown (Figures 5 and 9).

Mean lengths for each age-sex category in 2010 were within the historical range (Figure 10). Age-1.3 and age-1.4 Chinook salmon average lengths for both males and females were near the historical averages and have shown little variation since 2002. Female Chinook salmon tended to be longer than males of the same age, consistent with observations from past years at this project.

Chum Salmon

Chum salmon escapement in 2010 was the fifth largest escapement in the project's 35-year history, exceeding the SEG range of 15,000–49,000 fish (Volk et al. 2009). The chum salmon run at the Kogrukluk River weir was not as late as recent years but was 6 days later than the historical average. The median passage date was the third latest on record, and the run duration was of average length (Figures 7 and 11).

Similar to Chinook, the chum salmon ASL samples in 2010 were temporally well distributed over a large portion of the fish passage, except for the latter 20% of the run, due to the weir being inoperable. Regardless of the lack of samples characterizing the end of the run, sampling goals and objectives for precision and accuracy were achieved. The 2010 escapement past the Kogrukluk River weir was typical in terms of age structure proportions, with age-0.3 fish dominating the run followed by age-0.4 fish (Molyneaux et al. 2010). The brood year for the abundant age-0.3 fish was 2006, the second highest escapement on record. The percentage of female chum salmon at the Kogrukluk River weir in 2010 was above the historical average (Figure 9). Beginning in 2005, the percentage of females rose to a record high for the project and has remained high. The above average proportion of female chum salmon estimated by ASL sampling in 2010 was supported by the visual sex determination, which produced values almost identical to those from the ASL sampling (Figure 5). Possible reasons for the observed changes in sex ratios are detailed in Williams and Shelden (2010).

Mean lengths of chum salmon for all age-sex categories were below the historical averages. Male lengths were near project history lows that occurred in 2006-2007 while female lengths were the lowest on record (Figure 12). A retrospective analysis of age-0.3 and-0.4 chum salmon at this project shows a general decrease in length-at-age from 1997 through 2007 (Molyneaux et al. 2010; Jasper and Molyneaux 2007). This decrease is most obvious among age-0.3 and -0.4 males. The tighter picket spacing that has been used in recent years (2005 to 2010) may be partially responsible for the lower mean lengths-at-age in recent years; prior to 2005 smaller fish were occasionally observed passing between the pickets, but there have been no reports of this occurring between 2005 and 2010. However, the chum length frequency has been decreasing since 1996, well before picket spacing was adjusted, indicating that the decreased picket spacing may be only one of several contributing factors.

Coho Salmon

Coho salmon escapement in 2011 was below the historical average, but within the current SEG range of 13,000–28,000 fish (Volk et al. 2009). The run exhibited later than average run timing and the duration of the run was 3 days shorter than average for this project. The median passage date of 5 September was 4 days later than the historical median date (Figures 13 and 14).

ASL samples for coho salmon in 2010 missed the front 25% of the run, but because of the low amount of temporal variation in coho age classes this likely had little effect on reported age distribution. The degree to which this poor sample distribution influenced sex and length compositions is unknown. Sampling goals and objectives for precision and accuracy were achieved in 2010 indicating that reported ASL values are reasonable approximations. Kogrukluk River coho salmon are predominantly age-2.1 (4-year-old) fish, and 2010 was no exception. The proportion of female coho salmon at the weir was above the historical average by 7%, although abundance of females in 2010 was below average. The ASL sampling method yielded a female proportion similar to the visual method (Figures 5 and 9).

Mean lengths of male and female age-2.1 coho salmon at the Kogrukluk River weir have generally been declining since the late 1990s (Figure 15). Mean lengths in 2010 increased from recent years but were still below the historical average. Female fish tended to be slightly larger than males of the same age.

Sockeye Salmon

In 2010, Kogrukluk River sockeye salmon escapement was above the historic median and fell in the upper half of the escapement goal range of 4,400–17,000 fish (Figure 13; Volk et al. 2009). In recent years sockeye salmon escapements have been unusually high; this comes after consistently low escapements that occurred between 1999 and 2003. The timing of the 2010 sockeye salmon run at the Kogrukluk River weir was the latest on record, while the duration of the run was average (Figure 16). A table of ASL compositions was generated for sockeye salmon in 2010 that included saltwater ages, but it is important to note that personnel aging the scales gave a certainty of only 40% on the reliability of the presented salt water age (Dan Warnke, Commercial Fisheries Biologist, ADF&G; personal communication, Anchorage).

Pink Salmon

Accurate enumeration of spawning pink salmon at the Kuskokwim Area weirs is not possible due to their small size, which allows some individuals to pass between weir pickets undetected. Historically, the contribution of pink salmon to the overall salmon escapement at the Kogrukluk River weir has been negligible, often crews sometimes counting fewer than 10 individuals in a year. The passage of 88 pink salmon in 2010 was neither the largest or smallest count in the history of monitoring at the Kogrukluk River weir. Annual passage counts are higher in even years than in odd years. It appears that the contribution of pink salmon to this and other Kuskokwim River systems is greater than previously believed with the presence of a distinct population and recurring run timing events. It is notable that the pink salmon spawning in upper Kuskokwim River tributaries are among the farthest known migrating pink salmon in the world (Morrow 1980; Heard 1991). Pink salmon make less extensive spawning migrations into freshwater than other Pacific salmon species (Heard 1991) and, given the spatial orientation of the Kogrukluk River weir (approximately 710 rkm from the mouth of the Kuskokwim River), the small escapements observed at this site are not surprising.

Carcass Counts

The number of salmon carcasses found on the weir is not a complete census of the number of carcasses that drifted downstream of the weir site (Appendix B). Water levels in 2010 caused a washout of the weir in the month of August, a time at the Kogrukluk River weir when the bulk of carcass deposition occurs. Carcass washout rates are closely tied to water level, making it impossible to standardize the data, and analysis among years is unreliable. Some remainder of the spawned-out fish were invariably retained in or near the river upstream of the weir for a protracted period of time, possibly contributing to the productivity of the system through the introduction of marine derived nutrients (Cederholm et al. 1999).

WEATHER AND STREAM OBSERVATIONS

During the first third of the weir operations water levels were near average, but in August water levels rose above the upper boundary of levels observed in 2002–2009 by over 50 cm (Figure 17). Water temperature derived from thermometer measurements was near average and within the historical range (Appendix C1, Figure 18). It is unclear whether water temperature affected salmon passage, because changes in water temperature at Kogrukluk River weir usually occur concurrently with fluctuations in water level.

RELATED FISHERIES PROJECTS

Kuskokwim River Sockeye Salmon Run Reconstruction

The results for each of the related fisheries projects to which the Kogrukluk River weir contributed will be reported separately in reports for those projects. Results for the Chinook and coho salmon run reconstructions are currently in development. The project *Kuskokwim River Sockeye Salmon Investigations* is currently ongoing; any questions regarding these studies can be directed to the project investigator Kevin Schaberg, at ADF&G, Division of Commercial Fisheries. The Chinook salmon RNA genetic tissue study is also an ongoing project; questions regarding this study can be directed to the project investigator Nick Decovich, at ADF&G, Division of Commercial Fisheries.

CONCLUSIONS

- Total escapements of Chinook, chum, sockeye and coho salmon in 2010 were 5,690; 63,583; 13,995; 13,971 respectively.
- Run timing of Chinook, chum, and sockeye and coho salmon at the Kogrukluk River weir were all later than average.
- Female Chinook salmon made up approximately 26% of the total annual run.
- Average length increased with age for all Chinook, chum and coho. Females were longer than males at age for Chinook, and vice versa for chum salmon.
- Female chum salmon made up approximately 45% of the total annual run. The percentage of female chum salmon observed in the last 6 years is considerably higher than that observed since the late 1980s.
- Female coho salmon made up approximately 49% of the total annual run.
- Female sockeye salmon made up approximately 61% of the total annual run based on the non-ASL sex-determination method.

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TABLES AND FIGURES

Table 1.–Daily, cumulative, and cumulative percent passage of Chinook, chum, coho, and sockeye salmon at the Kogrukluk River weir, 2010.

	Chinook			Chum			Coho			Sockeye		
Date	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%
6/27	1	1	0	1	1	0	0	0	0	0	0	0
6/28	2	3	0	1	2	0	0	0	0	0	0	0
6/29	0	3	0	10	12	0	0	0	0	0	0	0
6/30	0	3	0	15	27	0	0	0	0	0	0	0
7/1	0	3	0	23	50	0	0	0	0	0	0	0
7/2	1	4	0	14	64	0	0	0	0	0	0	0
7/3	2	6	0	123	187	0	0	0	0	0	0	0
7/4	8	14	0	326	513	1	0	0	0	1	1	0
7/5	24	38	1	730	1,243	2	0	0	0	5	6	0
7/6	12	50	1	700	1,943	3	0	0	0	6	12	0
7/7	82	132	2	1,163	3,106	5	0	0	0	46	58	0
7/8	150	282	5	1,601	4,707	7	0	0	0	181	239	2
7/9	51	333	6	1,910	6,617	10	0	0	0	68	307	2
7/10	72	405	7	1,750	8,367	13	0	0	0	78	385	3
7/11	277	682	12	2,399	10,766	17	0	0	0	354	739	5
7/12	262	944	17	2,470	13,236	21	0	0	0	247	986	7
7/13	144	1,088	19	1,907	15,143	24	0	0	0	129	1,115	8
7/14	314	1,402	25	1,881	17,024	27	0	0	0	237	1,352	10
7/15	360	1,762	31	2,120	19,144	30	0	0	0	334	1,686	12
7/16	272	2,034	36	2,599	21,743	34	0	0	0	360	2,046	15
7/17	216	2,250	40	2,726	24,469	38	0	0	0	302	2,348	17
7/18	133	2,383	42	2,793	27,262	43	0	0	0	183	2,531	18
7/19	139	2,522	44	1,969	29,231	46	0	0	0	227	2,758	20
7/20	289	2,811	49	2,055	31,286	49	0	0	0	475	3,233	23
7/21	296	3,107	55	2,277	33,563	53	0	0	0	836	4,069	29
7/22	344	3,451	61	2,188	35,751	56	0	0	0	880	4,949	35
7/23	101	3,552	62	2,138	37,889	60	0	0	0	513	5,462	39
7/24	198	3,750	66	2,044	39,933	63	0	0	0	640	6,102	44
7/25	73	3,823	67	1,604	41,537	65	0	0	0	322	6,424	46
7/26	238	4,061	71	2,293	43,830	69	0	0	0	860	7,284	52
7/27	124	4,185	74	2,042	45,872	72	0	0	0	739	8,023	57
7/28	120	4,305	76	1,935	47,807	75	0	0	0	501	8,524	61
7/29	263	4,568	80	2,028	49,835	78	1	1	0	896	9,420	67
7/30 [a]	220	4,788	84	1,496	51,331	81	0	1	0	923	10,343	74
7/31 [a]	80	4,868	86	1,476	52,807	83	0	1	0	644	10,986	78
8/1 [a]	8	4,876	86	1,211	54,018	85	0	1	0	596	11,582	83
8/2 [a]	118	4,993	88	997	55,015	87	0	1	0	289	11,871	85
8/3 [a]	103	5,096	90	1,269	56,284	89	0	1	0	538	12,409	89
8/4 [a]	91	5,187	91	1,070	57,354	90	0	1	0	160	12,569	90
8/5 [a]	34	5,221	92	912	58,266	92	0	1	0	136	12,705	91
8/6 [a]	103	5,324	94	695	58,961	93	0	1	0	203	12,908	92
8/7 [a]	49	5,373	94	686	59,647	94	0	1	0	170	13,078	93
8/8 [a]	19	5,392	95	554	60,201	95	0	1	0	192	13,269	95
8/9 [a]	65	5,457	96	377	60,578	95	0	1	0	134	13,403	96
8/10 [a]	46	5,502	97	528	61,106	96	0	1	0	94	13,497	96
8/11 [a]	15	5,518	97	372	61,478	97	0	1	0	94	13,591	97
8/12 [a]	42	5,559	98	374	61,853	97	0	1	0	65	13,656	98

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Table 1.–Page 2 of 2.

Date	Chinook			Chum			Coho			Sockeye		
	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%
8/13 [a]	0	5,559	98	221	62,074	98	9	10	0	57	13,713	98
8/14 [a]	4	5,563	98	173	62,247	98	13	23	0	39	13,752	98
8/15 [a]	4	5,567	98	270	62,516	98	4	28	0	40	13,792	99
8/16 [a]	19	5,586	98	185	62,701	99	27	54	0	43	13,835	99
8/17 [a]	4	5,590	98	163	62,864	99	53	107	1	17	13,852	99
8/18 [a]	8	5,597	98	143	63,008	99	53	160	1	27	13,879	99
8/19 [a]	4	5,601	98	85	63,093	99	13	173	1	16	13,895	99
8/20 [a]	19	5,620	99	53	63,146	99	93	266	2	15	13,910	99
8/21 [a]	15	5,635	99	102	63,248	99	194	460	3	21	13,931	100
8/22 [a]	11	5,647	99	67	63,315	100	208	668	5	34	13,965	100
8/23 [a]	19	5,666	100	55	63,370	100	163	831	6	0	13,965	100
8/24 [a]	8	5,673	100	44	63,414	100	141	973	7	0	13,965	100
8/25 [a]	0	5,673	100	32	63,446	100	243	1,216	9	4	13,969	100
8/26 [a]	8	5,681	100	34	63,480	100	265	1,481	11	5	13,974	100
8/27	2	5,683	100	14	63,494	100	414	1,895	14	3	13,977	100
8/28	1	5,684	100	13	63,507	100	631	2,526	18	2	13,979	100
8/29	3	5,687	100	4	63,511	100	595	3,121	22	0	13,979	100
8/30	0	5,687	100	12	63,523	100	369	3,490	25	0	13,979	100
8/31	0	5,687	100	13	63,536	100	969	4,459	32	2	13,981	100
9/1	0	5,687	100	9	63,545	100	809	5,268	38	2	13,983	100
9/2	2	5,689	100	0	63,545	100	317	5,585	40	1	13,984	100
9/3	0	5,689	100	3	63,548	100	282	5,867	42	0	13,984	100
9/4	0	5,689	100	4	63,552	100	716	6,583	47	2	13,986	100
9/5	0	5,689	100	4	63,556	100	907	7,490	54	0	13,986	100
9/6	0	5,689	100	2	63,558	100	652	8,142	58	1	13,987	100
9/7	1	5,690	100	4	63,562	100	844	8,986	64	1	13,988	100
9/8	0	5,690	100	0	63,562	100	762	9,748	70	1	13,989	100
9/9	0	5,690	100	0	63,562	100	713	10,461	75	0	13,989	100
9/10	0	5,690	100	4	63,566	100	476	10,937	78	0	13,989	100
9/11	0	5,690	100	0	63,566	100	396	11,333	81	0	13,989	100
9/12	0	5,690	100	0	63,566	100	531	11,864	85	0	13,989	100
9/13	0	5,690	100	2	63,568	100	420	12,284	88	1	13,990	100
9/14	0	5,690	100	2	63,570	100	307	12,591	90	1	13,991	100
9/15	0	5,690	100	0	63,570	100	241	12,832	92	1	13,992	100
9/16	0	5,690	100	1	63,571	100	180	13,012	93	0	13,992	100
9/17	0	5,690	100	2	63,573	100	262	13,274	95	0	13,992	100
9/18	0	5,690	100	3	63,576	100	170	13,444	96	1	13,993	100
9/19	0	5,690	100	4	63,580	100	154	13,598	97	1	13,994	100
9/20	0	5,690	100	2	63,582	100	173	13,771	99	0	13,994	100
9/21	0	5,690	100	0	63,582	100	116	13,887	99	0	13,994	100
9/22	0	5,690	100	1	63,583	100	84	13,971	100	1	13,995	100

Note: Elongated boxes delineate the central 50% of the run and the bold box delineates the median passage date.

[a] The weir was inoperable for all or part of the day, daily passage was estimated using the "proportional" method.

Table 2.–Age and sex composition of Chinook salmon at the Kogrukluk River weir in 2010 based on escapement samples collected with a live trap.

			Brood Year (Age)													
			2007		2006		2005		2004		2003		2002			
Sample Dates	Sample		(1.1)		(1.2)		(1.3)		(1.4)		(1.5)		(1.6)		Total	
(Stratum Dates)	Size		N	%	N	%	N	%	N	%	N	%	N	%	N	%
7/05 - 7/17	154	Male	0	0.0	1,286	57.1	526	23.4	117	5.2	0	0.0	0	0.0	1,929	85.7
(6/27-7/17)		Female	0	0.0	0	0.0	88	3.9	219	9.7	15	0.6	0	0.0	321	14.3
		Subtotal	0	0.0	1,286	57.1	614	27.3	336	14.9	15	0.6	0	0.0	2,250	100.0
		Male Mean Length	-		541		709		762		-		-			
		SE	-		4		14		32		-		-			
		Range	-		413-639		526-864		629-904		-		-			
		n	-		88		36		8		-		-			
		Female Mean Length	-		-		801		832		875		-			
		SE	-		-		27		22		-		-			
		Range	-		-		669-849		648-932		-		-			
		n	-		-		6		15		1		-			
7/18 - 7/29	144	Male	0	0.0	1,218	35.4	788	22.9	239	6.9	24	0.7	0	0.0	2,269	66.0
(7/18-7/29)		Female	0	0.0	0	0.0	239	6.9	884	25.7	48	1.4	0	0.0	1,171	34.0
		Subtotal	0	0.0	1,218	35.4	1,027	29.9	1,123	32.6	72	2.1	0	0.0	3,440	100.0
		Male Mean Length	-		557		701		781		878		-			
		SE	-		8		15		31		-		-			
		Range	-		436-700		516-845		546-917		-		-			
		n	-		51		33		10		1		-			
		Female Mean Length	-		-		830		871		872		-			
		SE	-		-		13		7		28		-			
		Range	-		-		783-904		786-969		844-899		-			
		n	-		-		10		37		2		-			

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Table 2.–Page 2 of 2.

Sample Dates (Stratum Dates)	Sample Size		Brood Year (Age) 2007 (1.1) N	%	2006 (1.2) N	%	2005 (1.3) N	%	2004 (1.4) N	%	2003 (1.5) N	%	2002 (1.6) N	%	Total N	%
Season	298	Male	0	0.0	2,504	44.0	1,314	23.1	356	6.3	24	0.4	0	0.0	4,198	73.8
		Female	0	0.0	0	0.0	327	5.7	1,103	19.4	62	1.1	0	0.0	1,492	26.2
		Total	0	0.0	2,504	44.0	1,641	28.8	1,459	25.6	86	1.5	0	0.0	5,690	100.0
		Male Mean Length	-		551		704		773		878		-			
		SE	-		5		10		23		-		-			
		Range	-		413-700		516-864		546-917		-		-			
		n	-		139		69		18		1		-			
		Female Mean Length	-		-		819		856		873		-			
		SE	-		-		14		10		28		-			
		Range	-		-		669-904		648-969		844-899		-			
		n	-		-		16		52		3		-			

Note: Other potential age classes were not included because there were no individuals observed in these age classes in 2010.

Table 3.–Mean length (mm) of Chinook salmon at the Kogrukluk River weir in 2010 based on escapement samples collected with a live trap.

			Brood Year (Age)									
			2007		2006		2005		2004			
Sample Dates	Sample		(0.2)		(0.3)		(0.4)		(0.5)		Total	
(Stratum Dates)	Size		N	%	N	%	N	%	N	%	N	%
7/05-7/07	198	Male	16	0.5	769	24.7	1,365	43.9	47	1.5	2,196	70.7
(6/27-7/07)		Female	31	1.0	282	9.1	533	17.2	63	2.0	910	29.3
		Subtotal	47	1.5	1,051	33.8	1,898	61.1	110	3.5	3,106	100.0
		Male Mean Length	518		570		593		589			
		SE	-		4		3		11			
		Range	-		522-667		508-665		575-610			
		n	1		49		87		3			
		Female Mean Length	539		536		564		575			
		SE	5		5		4		16			
		Range	534-544		497-577		516-608		536-603			
		n	2		18		34		4			
7/10-7/12	183	Male	0	0.0	3,377	33.3	2,823	27.9	0	0.0	6,200	61.2
(7/08-7/12)		Female	0	0.0	1,882	18.6	1,937	19.1	111	1.1	3,930	38.8
		Subtotal	0	0.0	5,259	51.9	4,761	47.0	111	1.1	10,130	100.0
		Male Mean Length	-		548		566		-			
		SE	-		3		4		-			
		Range	-		480-622		485-631		-			
		n	-		61		51		-			
		Female Mean Length	-		529		550		539			
		SE	-		5		4		29			
		Range	-		478-586		508-595		510-567			
		n	-		34		35		2			
7/17-7/19	223	Male	143	0.9	5,236	32.7	3,730	23.3	72	0.4	9,181	57.4
(7/13-7/19)		Female	143	0.9	4,304	26.9	2,367	14.8	0	0.0	6,814	42.6
		Subtotal	287	1.8	9,540	59.6	6,097	38.1	72	0.4	15,995	100.0
		Male Mean Length	541		553		578		561			
		SE	5		3		5		-			
		Range	536-545		510-638		510-688		-			
		n	2		73		52		1			
		Female Mean Length	532		528		545		-			
		SE	12		3		5		-			
		Range	520-543		479-573		499-620		-			
		n	2		60		33		-			

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Table 3.–Page 2 of 3.

Sample Dates (Stratum Dates)	Sample Size		2007 (0.2) N	2007 (0.2) %	2006 (0.3) N	2006 (0.3) %	2005 (0.4) N	2005 (0.4) %	2004 (0.5) N	2004 (0.5) %	Total N	Total %
			Brood Year (Age)									
7/22-7/24	142	Male	726	2.1	11,612	33.8	4,596	13.4	242	0.7	17,176	50.0
(7/20-9/22)		Female	726	2.1	12,096	35.2	4,354	12.7	0	0.0	17,176	50.0
		Subtotal	1,451	4.2	23,708	69.0	8,951	26.1	242	0.7	34,352	100.0
		Male Mean Length	545		560		574		615			
		SE	16		5		8		-			
		Range	513-565		506-657		531-649		-			
		n	3		48		19		1			
		Female Mean Length	517		526		532		-			
		SE	20		3		7		-			
		Range	484-552		478-576		490-594		-			
		n	3		50		18		-			
	746	Male	885	1.4	20,993	33.0	12,514	19.7	361	0.6	34,753	54.7
Season		Female	901	1.4	18,564	29.2	9,192	14.5	173	0.3	28,830	45.3
		Total	1,785	2.8	39,557	62.2	21,706	34.1	534	0.8	63,583	100.0
		Male Mean Length	542		557		575		597			
		SE	11		3		4		11			
		Range	513-565		480-667		485-688		561-615			
		n	6		231		209		5			
		Female Mean Length	523		528		540		547			
		SE	13		2		4		22			
		Range	484-552		478-586		490-620		510-603			
		n	7		162		120		6			

Note: Other potential age classes were not included because no individuals were observed in these age classes in 2010.

Table 4.–Age and sex composition of chum salmon at the Kogrukluk River weir in 2010 based on escapement samples collected with a live trap.

			Brood Year (Age)							
			2007		2006		2005			
Sample Dates	Sample		(1.1)		(2.1)		(3.1)		Total	
(Stratum Dates)	Size		N	%	N	%	N	%	N	%
8/31-9/02	181	Male	154	2.8	2,654	47.5	185	3.3	2,993	53.6
(6/27-9/02)		Female	123	2.2	2,253	40.3	216	3.9	2,592	46.4
		Subtotal	278	5.0	4,906	87.8	401	7.2	5,585	100.0
		Male Mean Length	537		543		562			
		SE	21		4		15			
		Range	473-580		427-614		510-604			
		n	5		86		6			
		Female Mean Length	545		554		561			
		SE	10		4		9			
		Range	527-567		470-620		529-607			
		n	4		73		7			
9/07-9/09	184	Male	80	1.6	2,279	46.7	159	3.3	2,518	51.6
(9/03-9/09)		Female	53	1.1	1,988	40.8	318	6.5	2,359	48.4
		Subtotal	133	2.7	4,267	87.5	477	9.8	4,876	100.0
		Male Mean Length	570		554		574			
		SE	9		5		23			
		Range	560-587		415-653		506-647			
		n	3		86		6			
		Female Mean Length	602		558		574			
		SE	19		4		8			
		Range	583-621		469-631		526-612			
		n	2		75		12			
9/13, 9/14	184	Male	134	3.8	1,316	37.5	153	4.3	1,602	45.7
(9/10-9/22)		Female	114	3.3	1,717	48.9	76	2.2	1,908	54.3
		Subtotal	248	7.1	3,033	86.4	229	6.5	3,510	100.0
		Male Mean Length	484		540		543			
		SE	19		4		13			
		Range	415-553		452-636		497-596			
		n	7		69		8			
		Female Mean Length	558		549		567			
		SE	16		4		13			
		Range	488-597		414-627		532-596			
		n	6		90		4			

-continued-

Table 4.–Page 4 of 4.

Sample Dates (Stratum Dates)	Sample Size		Brood Year (Age) 2007 (1.1) N	%	2006 (2.1) N	%	2005 (3.1) N	%	Total N	%
Season	549	Male	367	2.6	6,249	44.7	497	3.6	7,113	50.9
		Female	291	2.1	5,957	42.6	610	4.4	6,858	49.1
		Total	658	4.7	12,206	87.4	1,107	7.9	13,971	100.0
		Male Mean Length	535		546		561			
		SE	10		3		11			
		Range	415-587		415-653		497-647			
		n	15		241		20			
		Female Mean Length	568		554		567			
		SE	9		2		6			
		Range	488-621		414-631		526-612			
		n	12		238		23			

Table 5.–Age, sex and length (mm) composition of coho salmon at the Kogrukluk River weir in 2010 based on escapement samples collected with a live trap.

			Brood Year (Age)															
			2007				2006				2005							
Sample Dates	Sample		(0.2)		(1.1)		(0.3)		(1.2)		(0.4)		(1.3)		(2.2)		Total	
(Stratum Dates)	Size		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
7/07-7/09, 7/11-7/25	144	Male	97	0.7	194	1.4	0	0.0	4,568	32.6	0	0.0	292	2.1	389	2.8	5,540	39.6
		Female	97	0.7	0	0.0	0	0.0	5,054	36.1	0	0.0	3,110	22.2	194	1.4	8,455	60.4
(6/27-9/22)		Subtotal	194	1.4	194	1.4	0	0.0	9,622	68.8	0	0.0	3,402	24.3	583	4.2	13,995	100.0
		Male Mean Length	596		568		-		577		-		615		555			
		SE	-		28		-		3		-		10		7			
		Range	-		540-595		-		528-617		-		596-632		534-567			
		n	1		2		-		47		-		3		4			
		Female Mean Length	526		-		-		519		-		535		533			
		SE	-		-		-		3		-		3		10			
		Range	-		-		-		470-574		-		479-569		523-543			
		n	1		-		-		52		-		32		2			
Season	144	Male	97	0.7	194	1.4	0	0.0	4,568	32.6	0	0.0	292	2.1	389	2.8	5,540	39.6
		Female	97	0.7	0	0.0	0	0.0	5,054	36.1	0	0.0	3,110	22.2	194	1.4	8,455	60.4
		Total	194	1.4	194	1.4	0	0.0	9,622	68.8	0	0.0	3,402	24.3	583	4.2	13,995	100.0
		Male Mean Length	596		568		-		577		-		615		555			
		SE	-		28		-		3		-		10		7			
		Range	-		540-595		-		528-617		-		596-632		534-567			
		n	1		2		-		47		-		3		4			
		Female Mean Length	526		-		-		519		-		535		533			
		SE	-		-		-		3		-		3		10			
		Range	-		-		-		470-574		-		479-569		523-543			
		n	1		-		-		52		-		32		2			

Note: Other potential age classes were not included because no individuals were observed in these age classes in 2010.

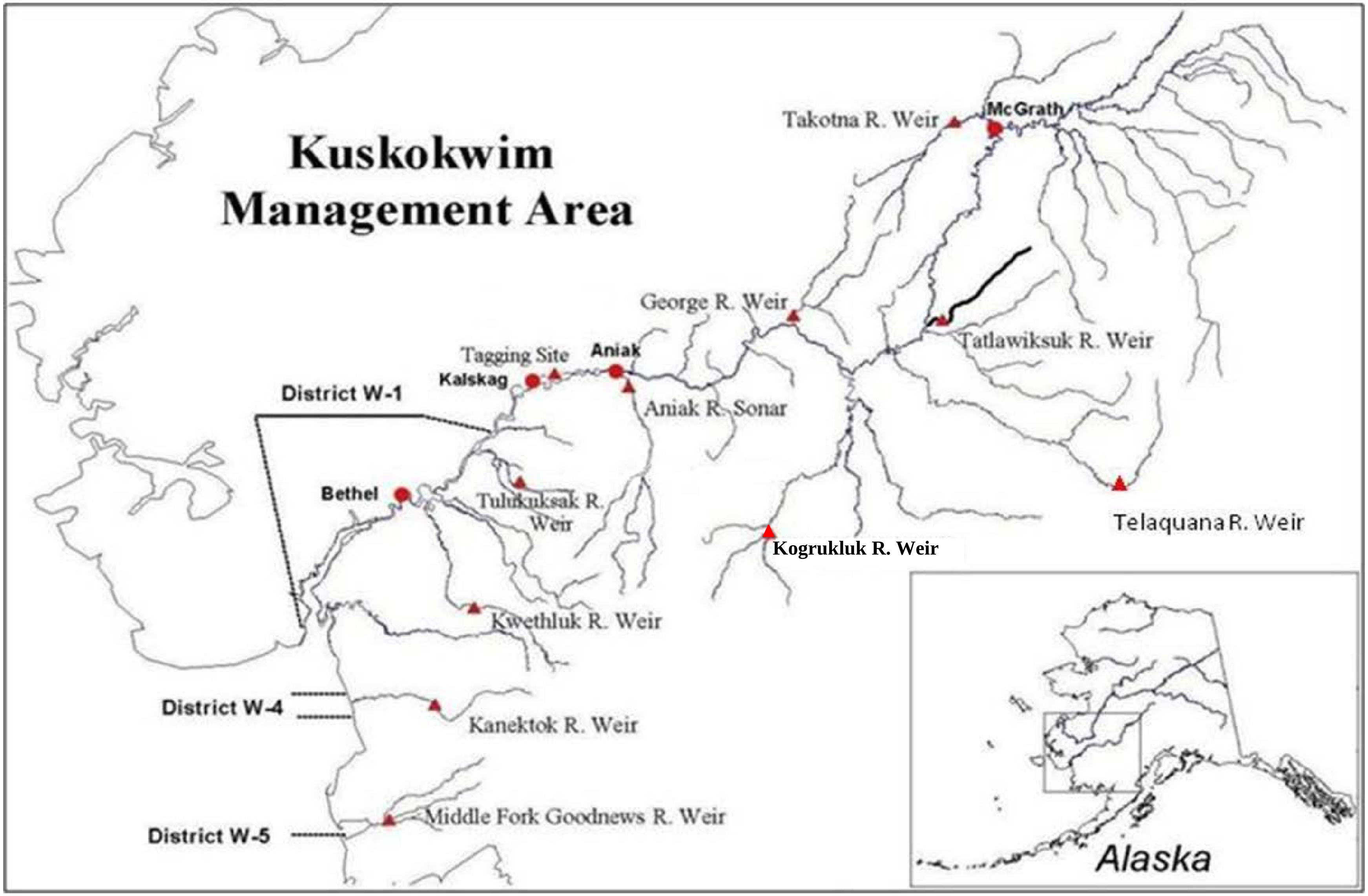


Figure 1.–Kuskokwim Area salmon management districts and escapement monitoring projects with emphasis on the Kogrukluk River weir.

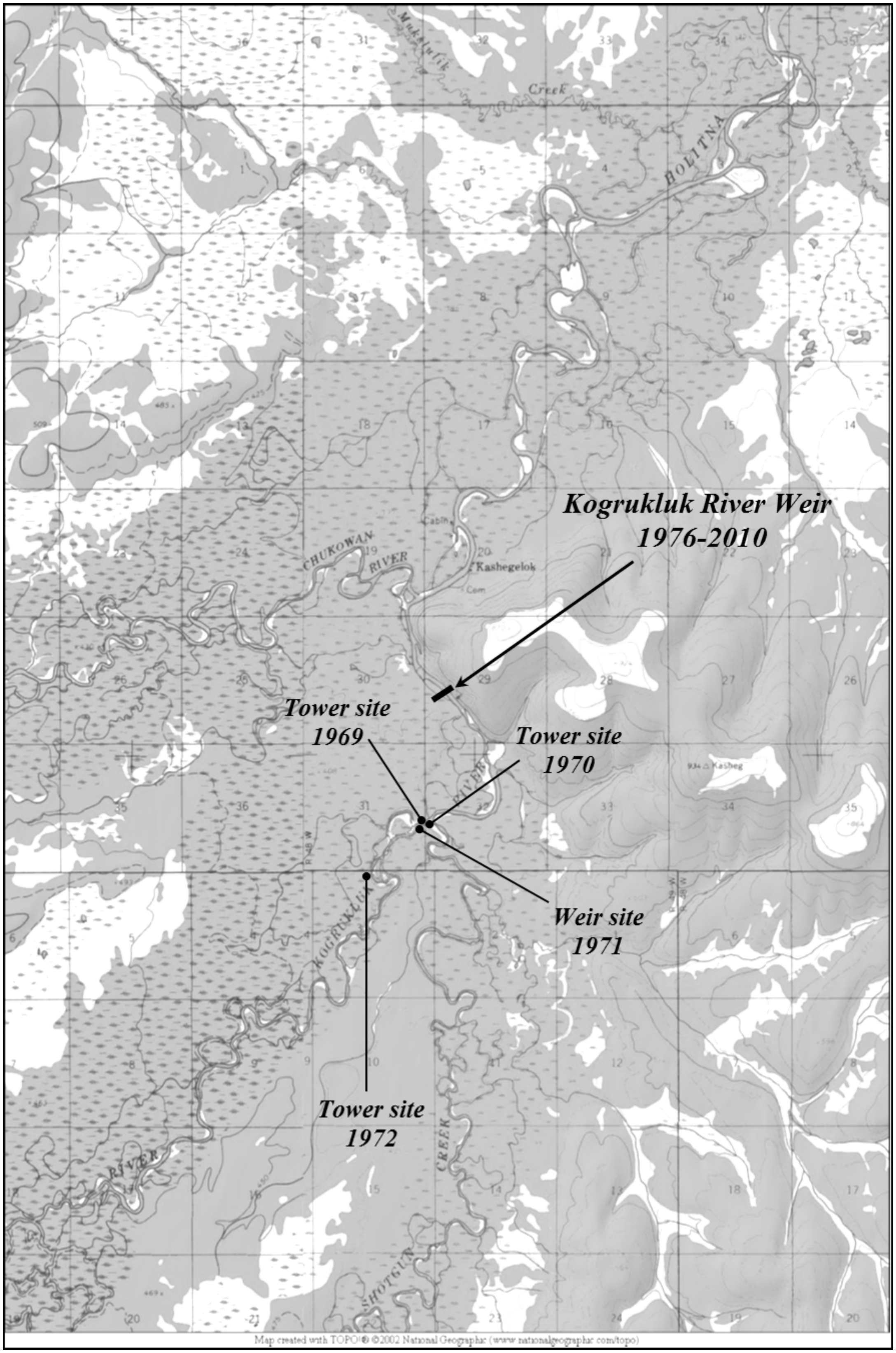


Figure 2.–Kogrukluk River study area and location of historical escapement monitoring projects.

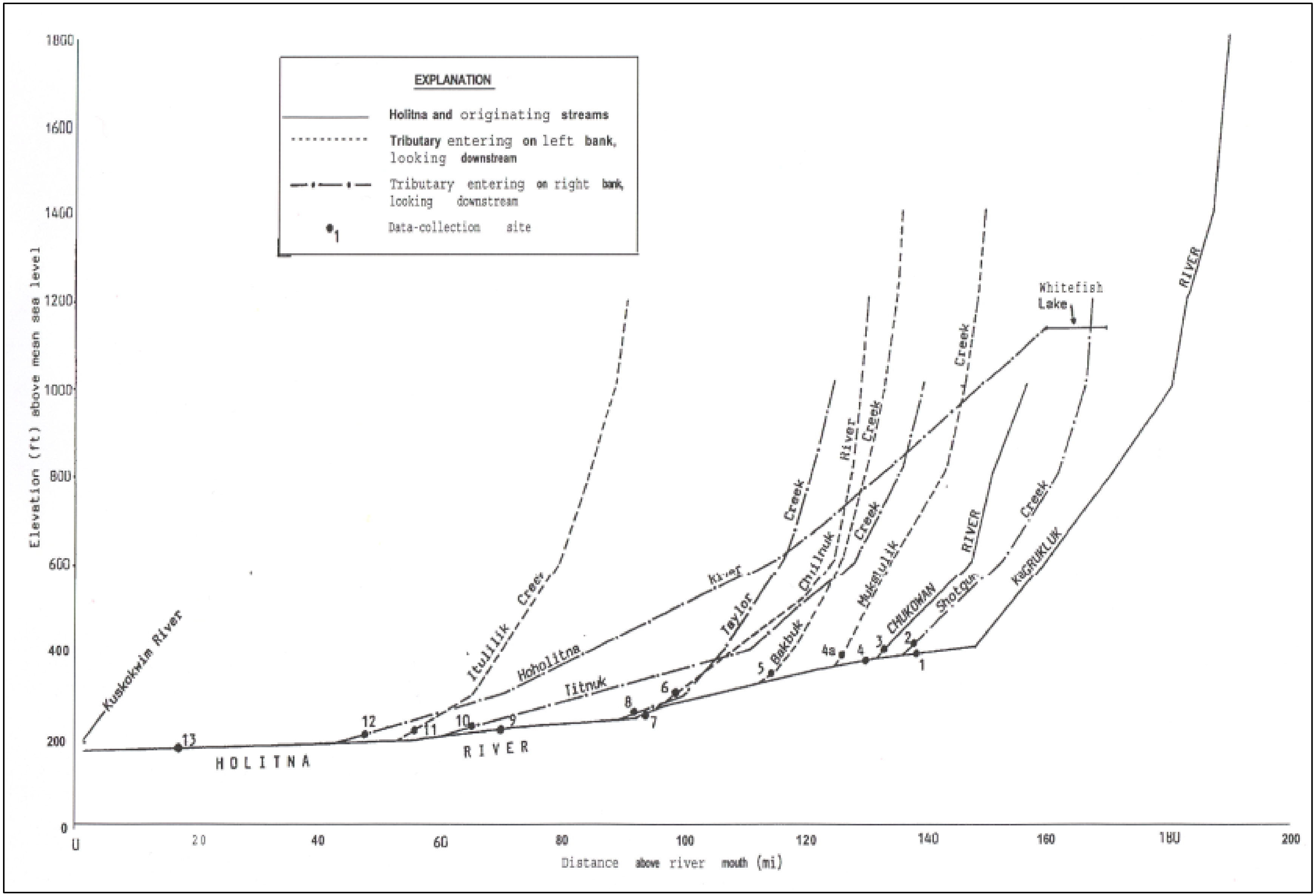
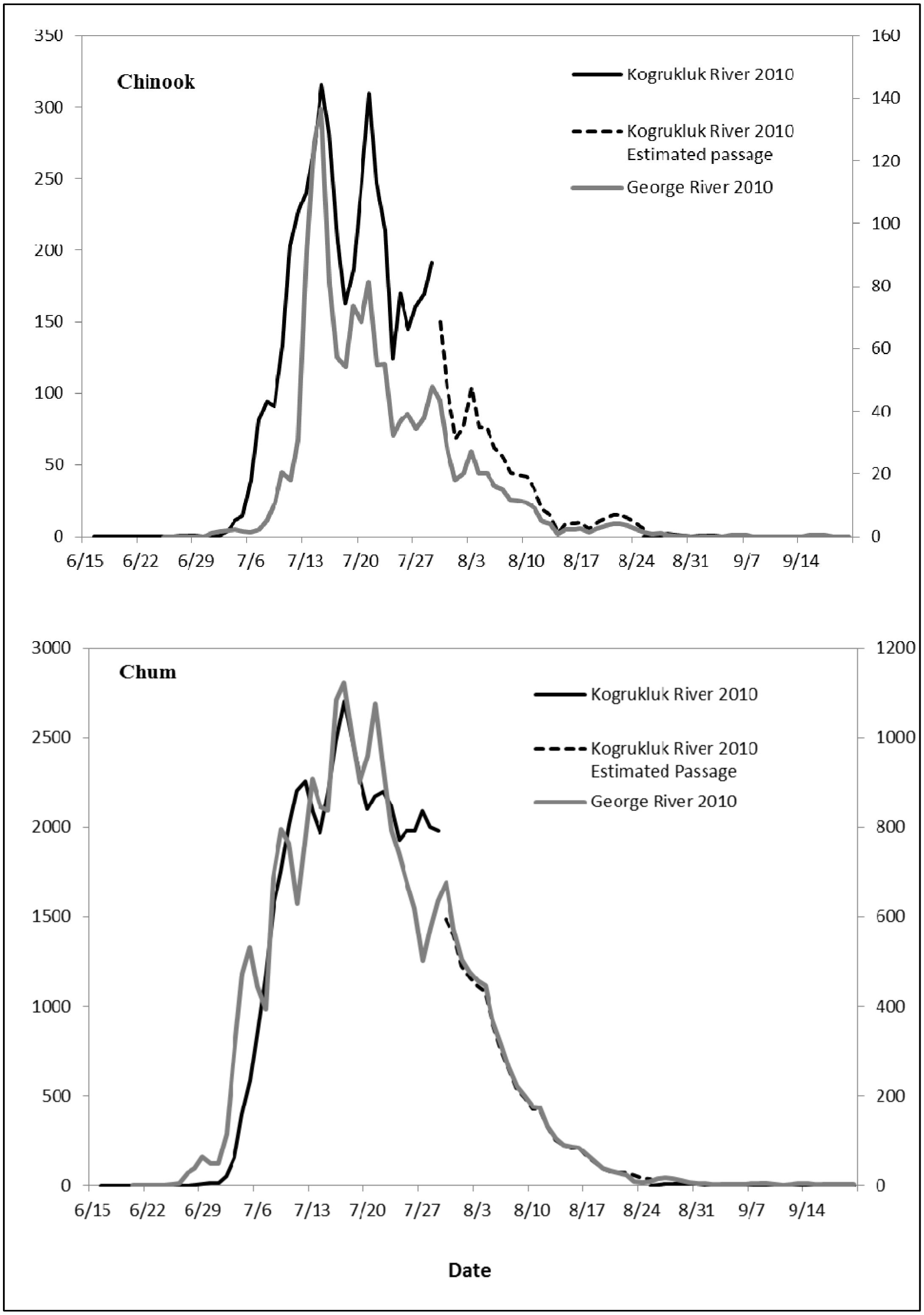
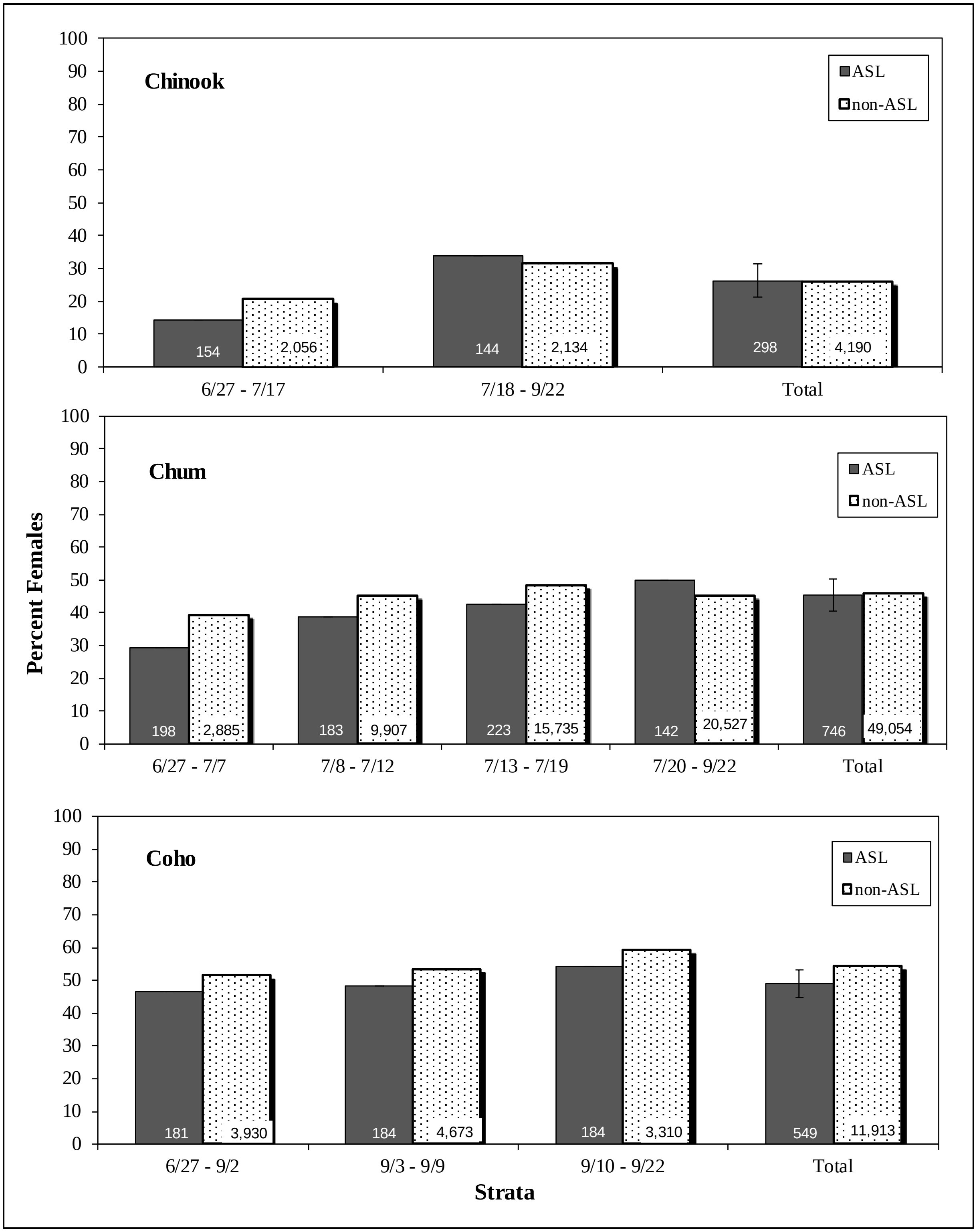


Figure 3.–Profile of the Holitna River and major tributaries, Alaska (Collazzi 1989).



Note: Kogruluk River data is plotted on the left vertical axis other rivers plotted on the right vertical axis. Surrogate data sets are in grey and have been shifted to match the trajectory of observed 2010 data.

Figure 4.–Three day moving average of daily passage of Chinook, chum, sockeye, and coho salmon.



Note: The number at the base of each column is sample size (*n*). ASL determined sex ratios were estimated with confidence intervals; visually counted fish are considered a census.

Figure 5.–Comparison of the percentage of female salmon passing upstream of the Kogrukluk River weir in 2010 as determined from standard ASL sampling using a fish trap, and from visual inspection of non-ASL sampled fish using standard fish passage procedures.

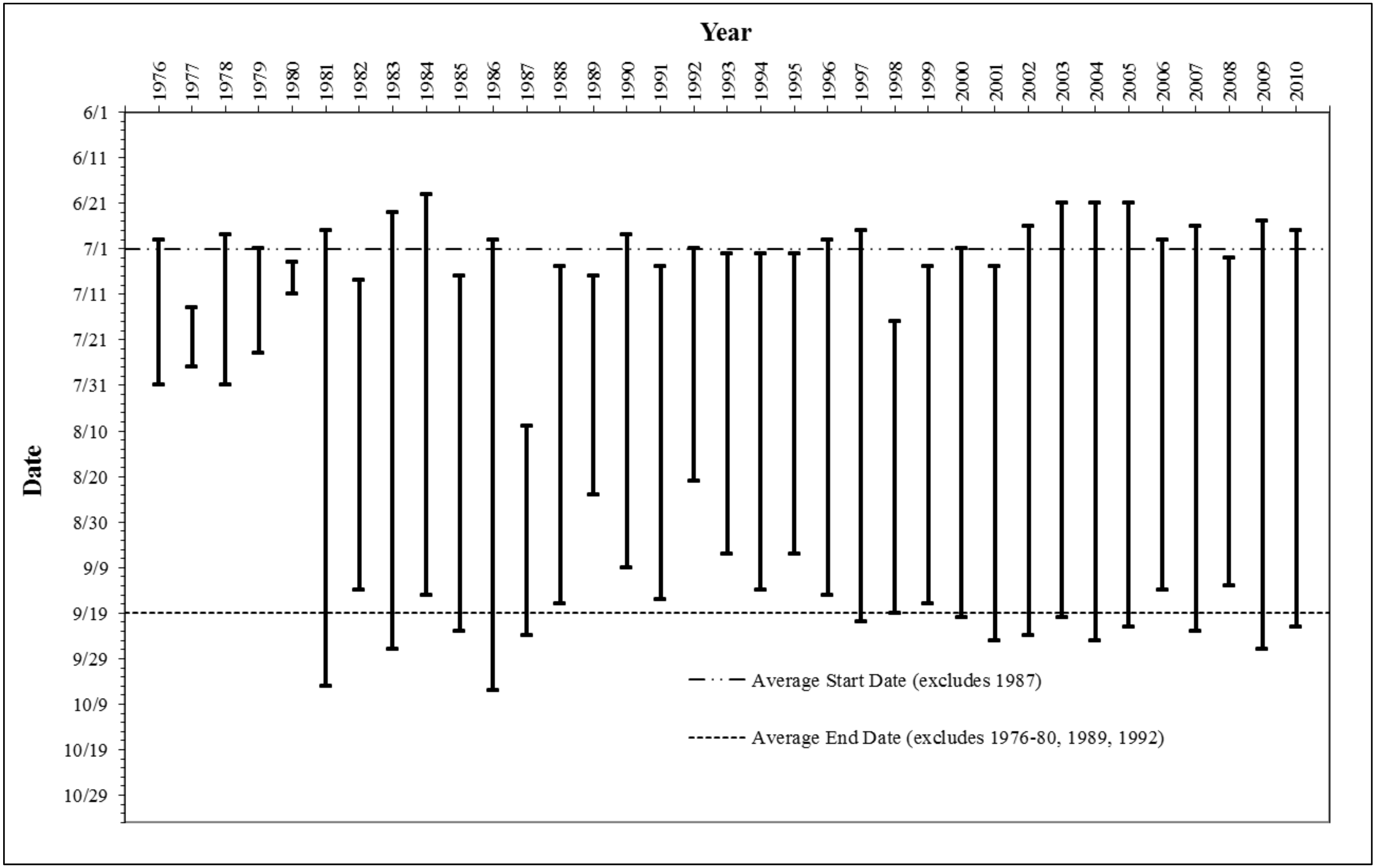
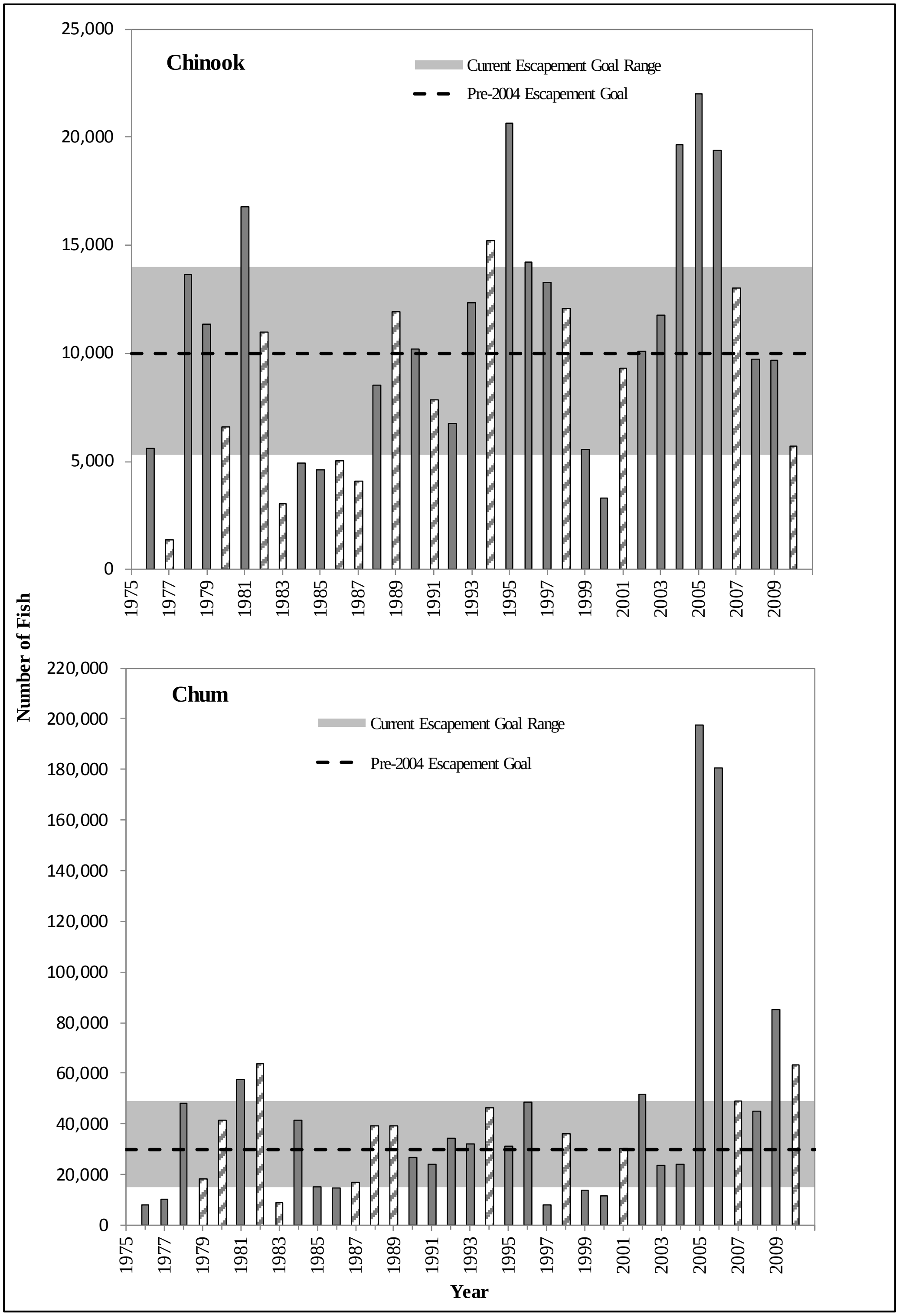
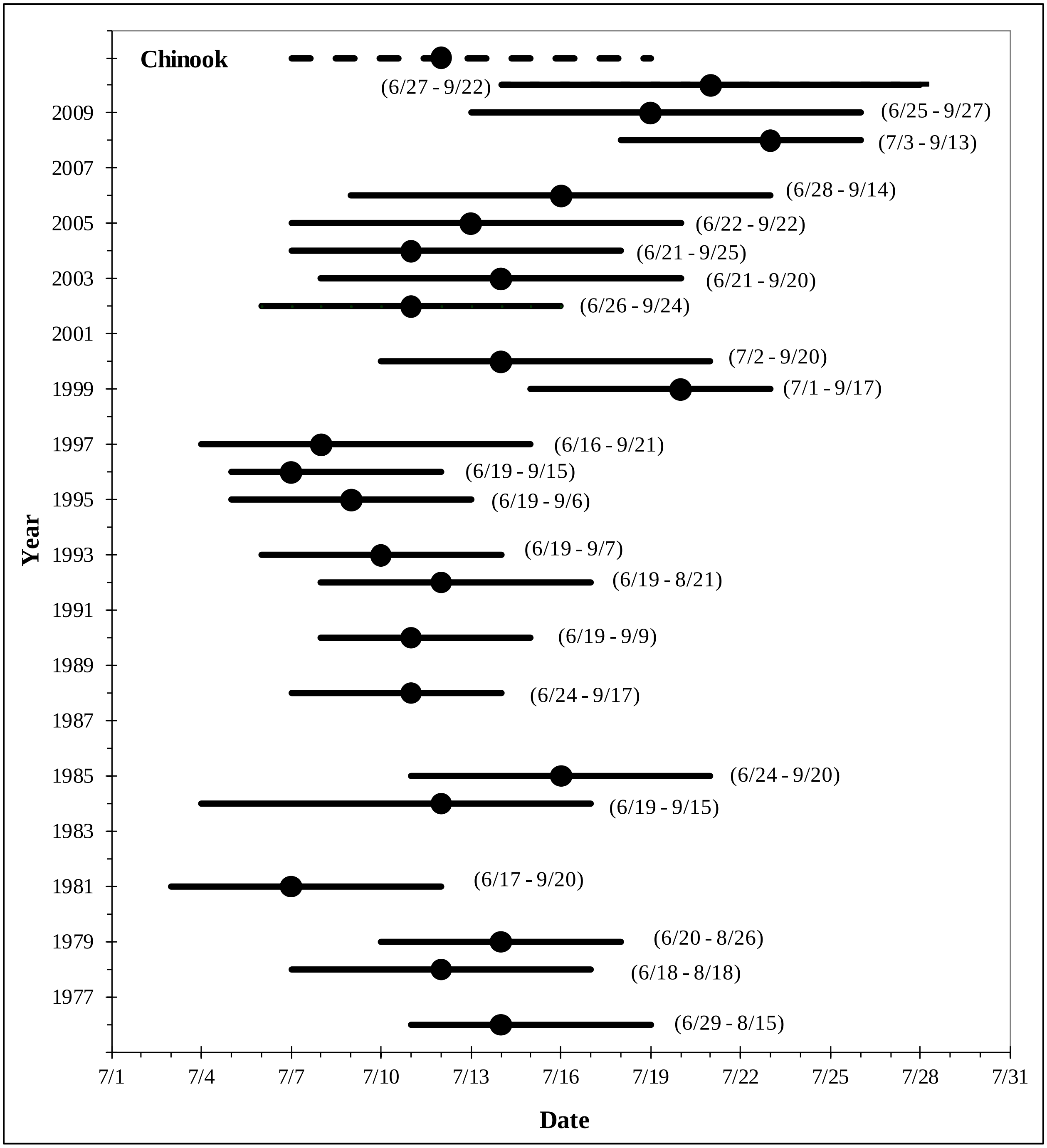


Figure 6.–Historical operational dates for the Kogrukluk River weir.



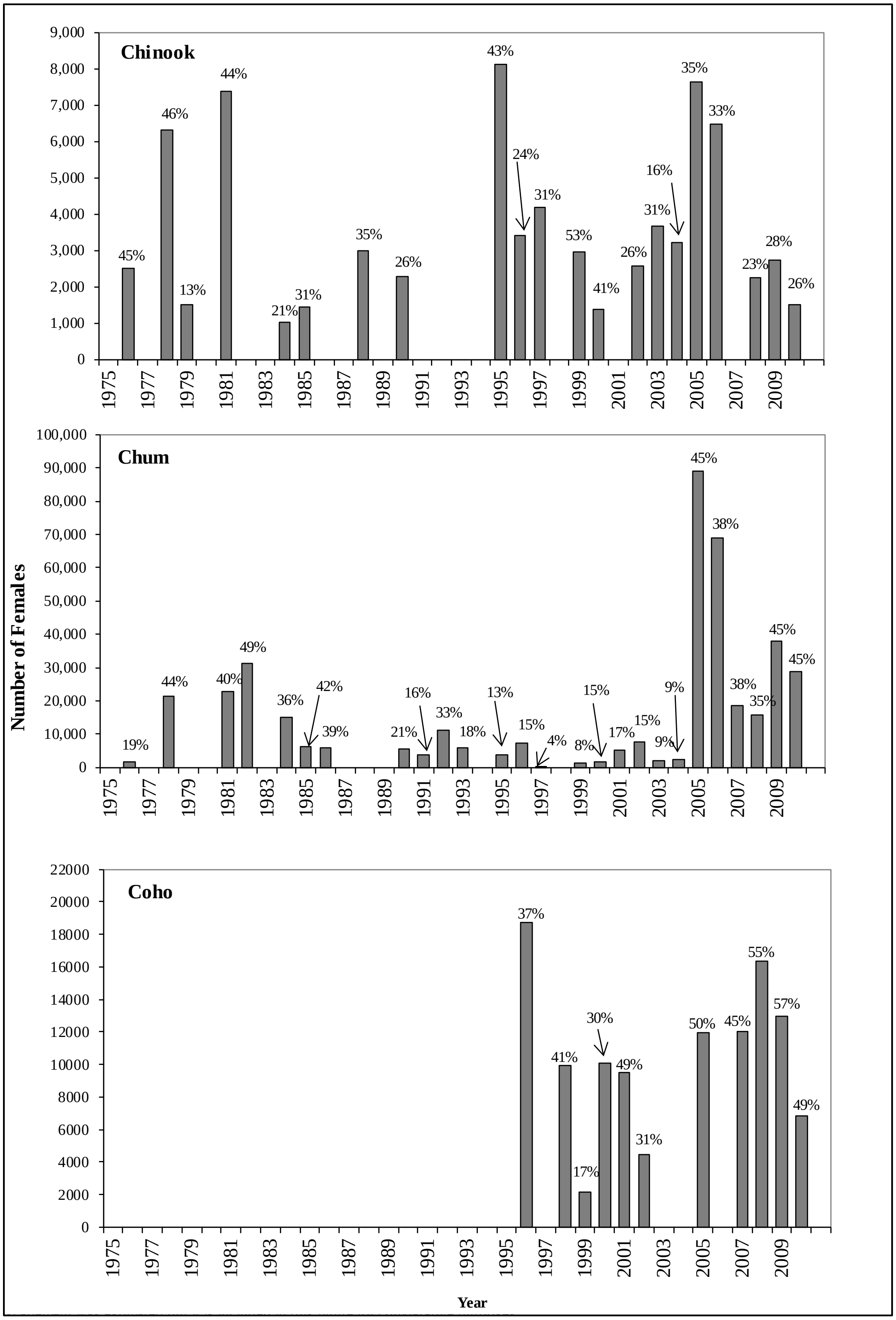
Note: Hatched bars represent years when more than 20% of the escapement was calculated through estimation methods.

Figure 7.–Historical Chinook and chum salmon escapement with the pre-2004 minimum escapement goal and the current escapement goal range at the Kogrukluk River weir.



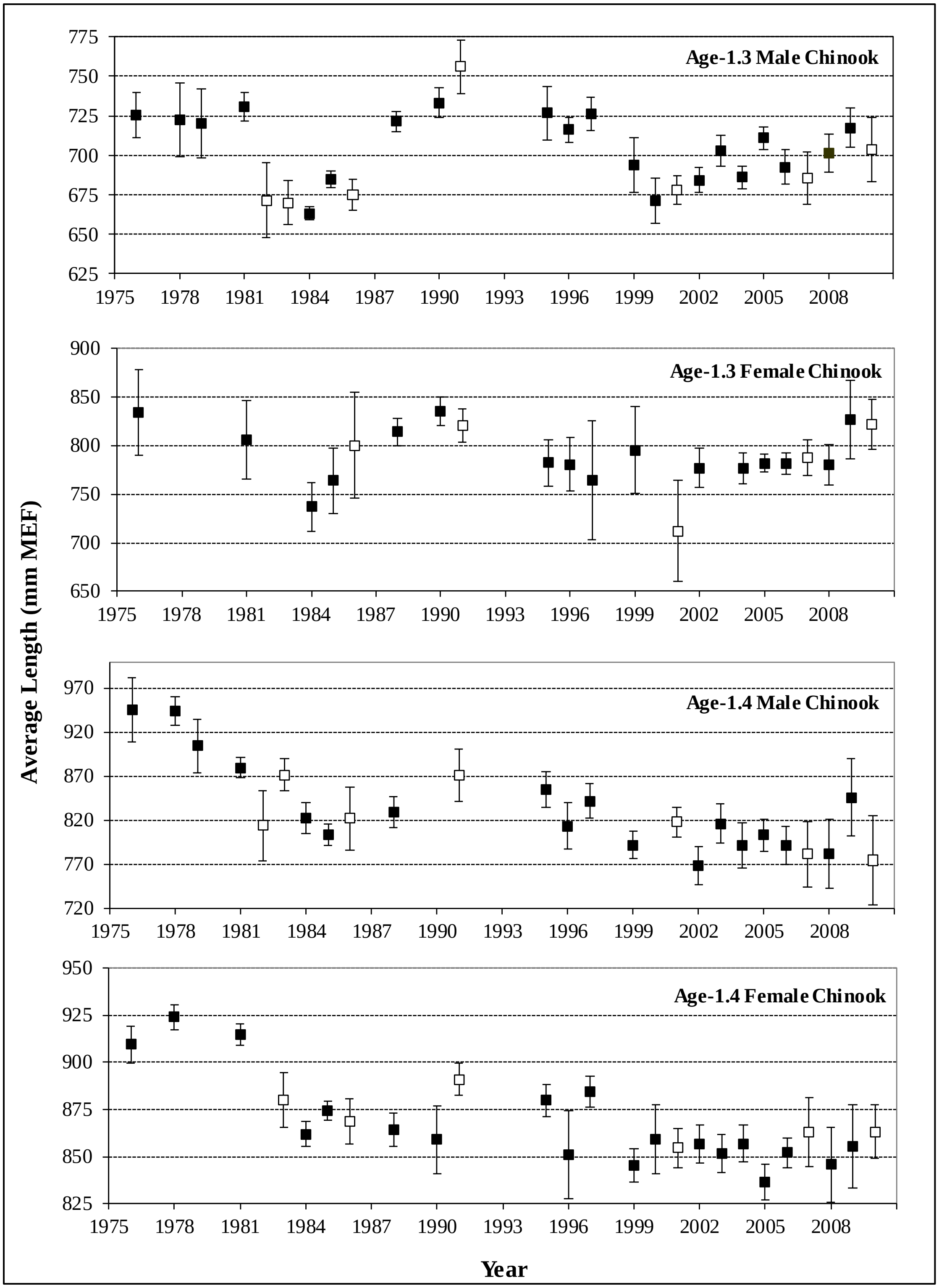
Note: Solid black lines represent dates the central 50% of annual escapement passed in years with at least 80% observed passage. Circles represent median passage dates. As a means to gauge the comparability of the run timing estimates, operational date ranges are in parentheses beside each annual line. The dashed line represents the average passage dates of the graphed years.

Figure 8.–Historical annual run timing of Chinook salmon based on cumulative percent passage at Kogrukluk River weir, from 1976 to 2010.



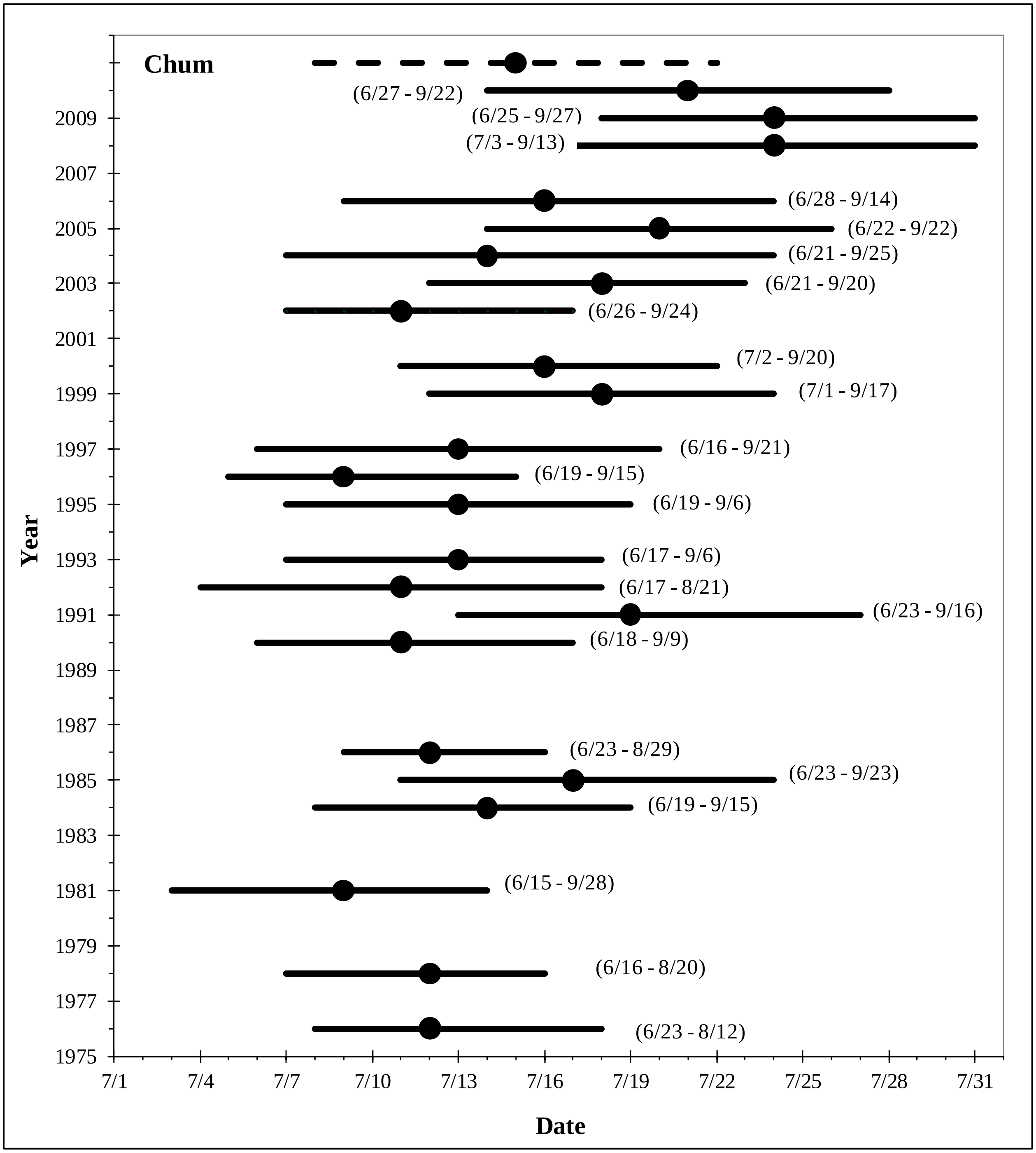
Note: Years in which 20% or more of annual escapement is estimated are omitted. In 2010, 20% of annual Chinook and chum salmon escapement was estimated but it is included in this figure for comparative purposes.

Figure 9.–Historical female escapement of Chinook, chum, and coho salmon relative to percent composition of female salmon.



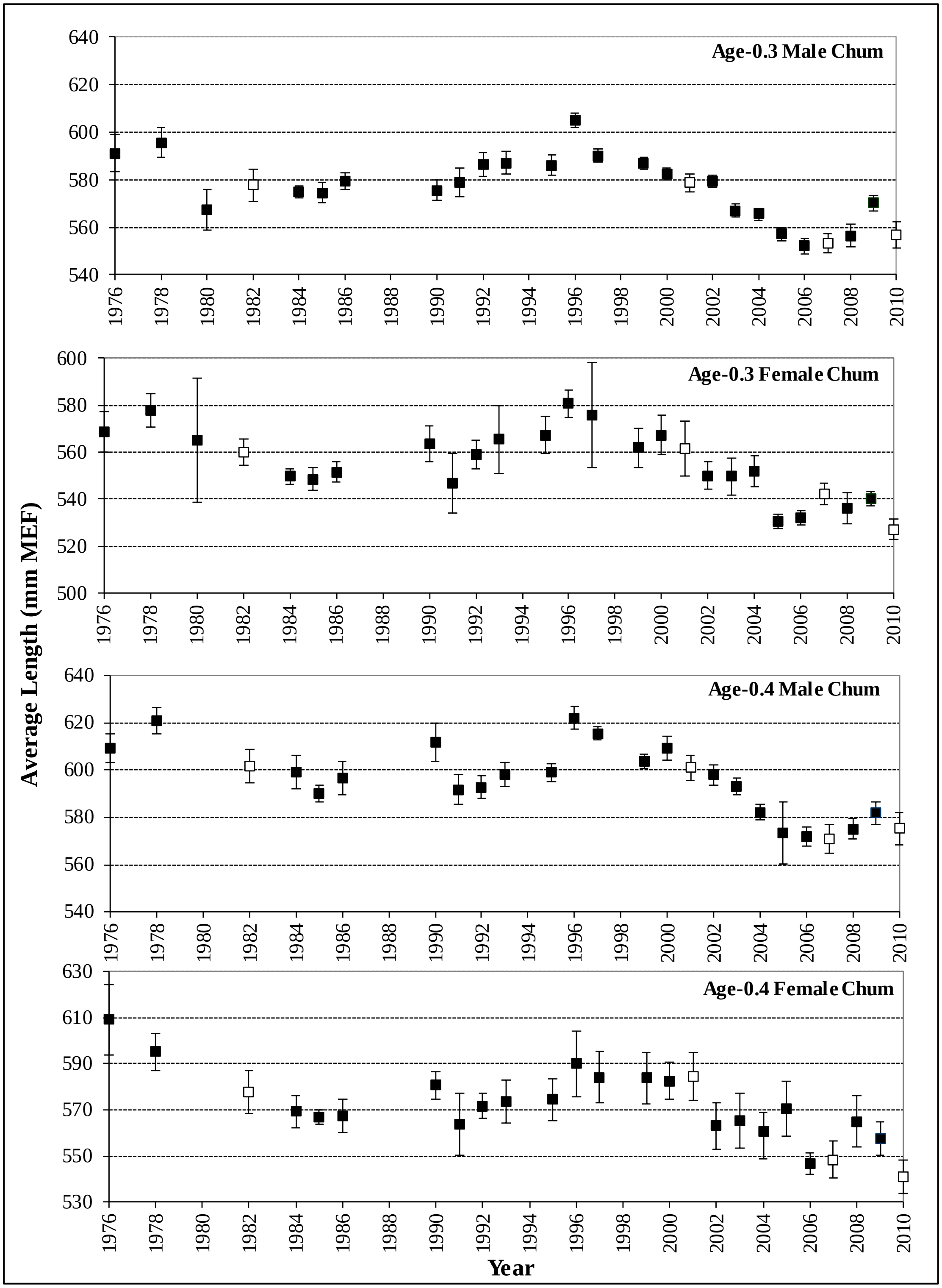
Note: Years when sampling effort was not well distributed throughout the run were omitted. Years for which annual escapement consisted of greater than 20% estimated passage are delineated with white squares.

Figure 10.–Historical average annual length for Chinook salmon with 95% confidence intervals at the Kogrukluk River weir.



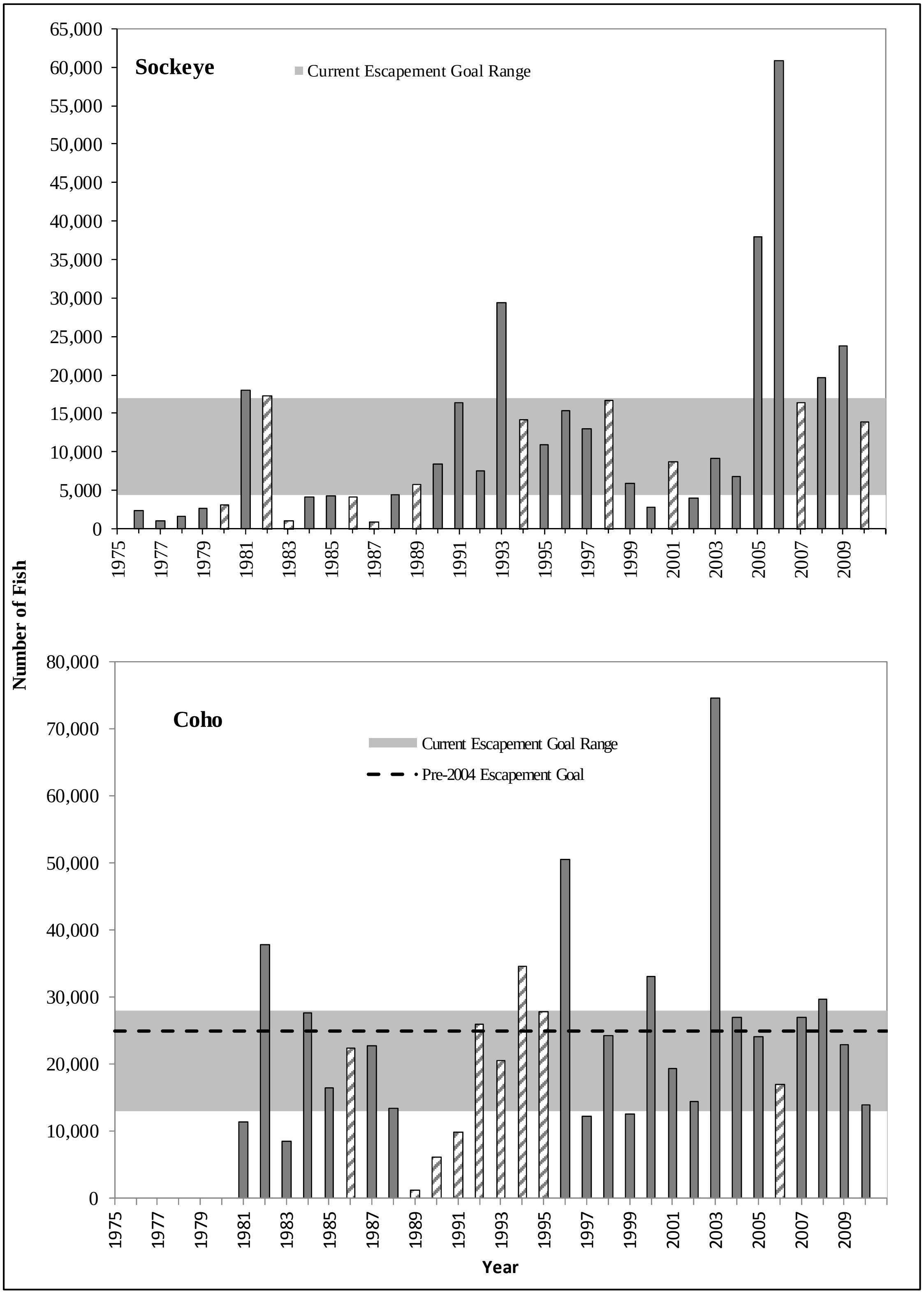
Note: Solid black lines represent dates the central 50% of annual escapement passed in years with at least 80% observed passage. Circles represent median passage dates. As a means to gauge the comparability of the run timing estimates, operational date ranges are in parentheses beside each annual line. The dashed line represents the average passage dates of the graphed years.

Figure 11.–Historical annual run timing of chum salmon based on cumulative percent passage at Kogrukluk River weir, from 1976 to 2010.



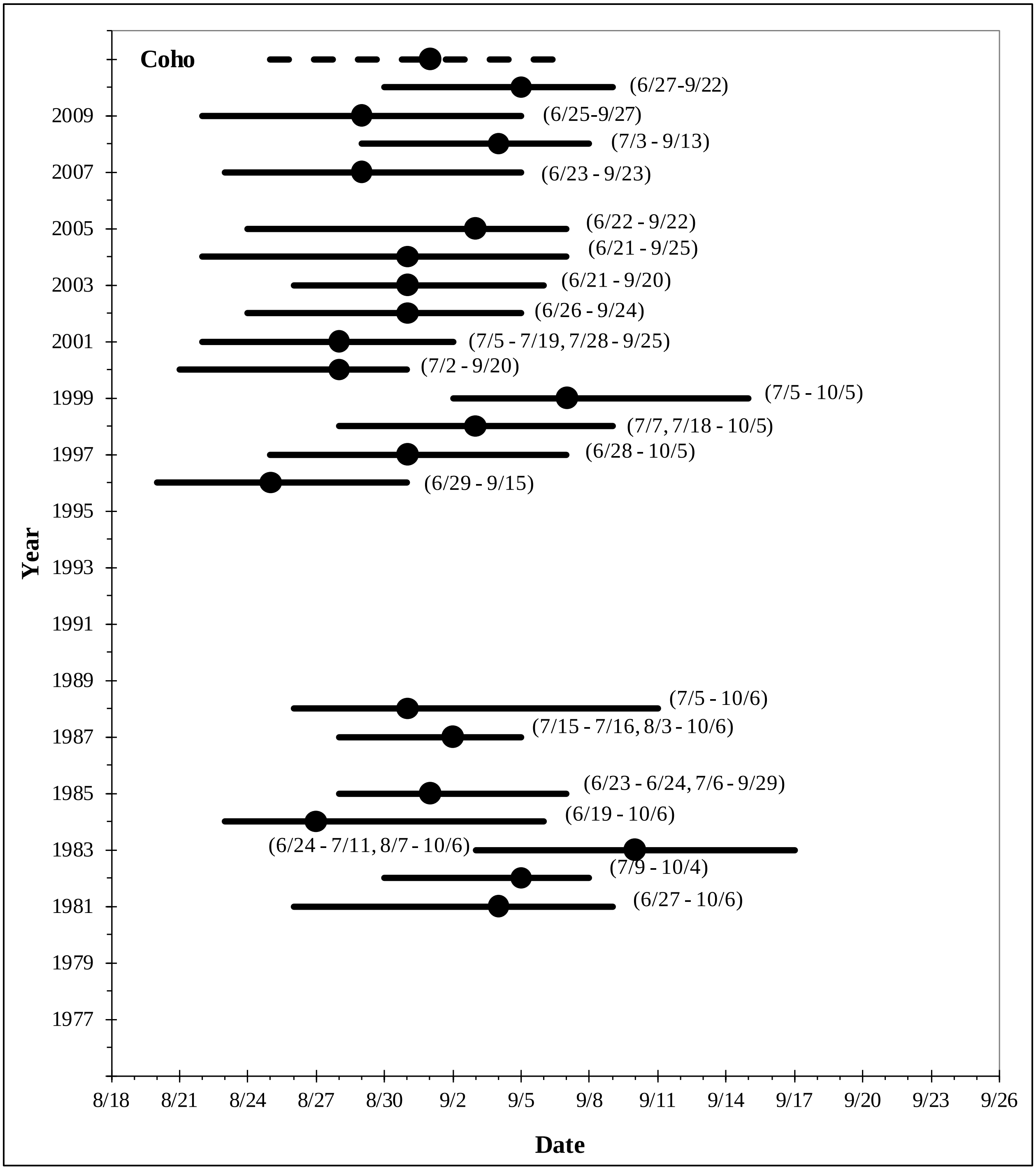
Note: Years when sampling effort was not well distributed throughout the run were omitted. Years for which annual escapement consisted of greater than 20% estimated passage are delineated with white squares.

Figure 12.–Historical average annual length for chum salmon with 95% confidence intervals at the Kogrukluk River weir.



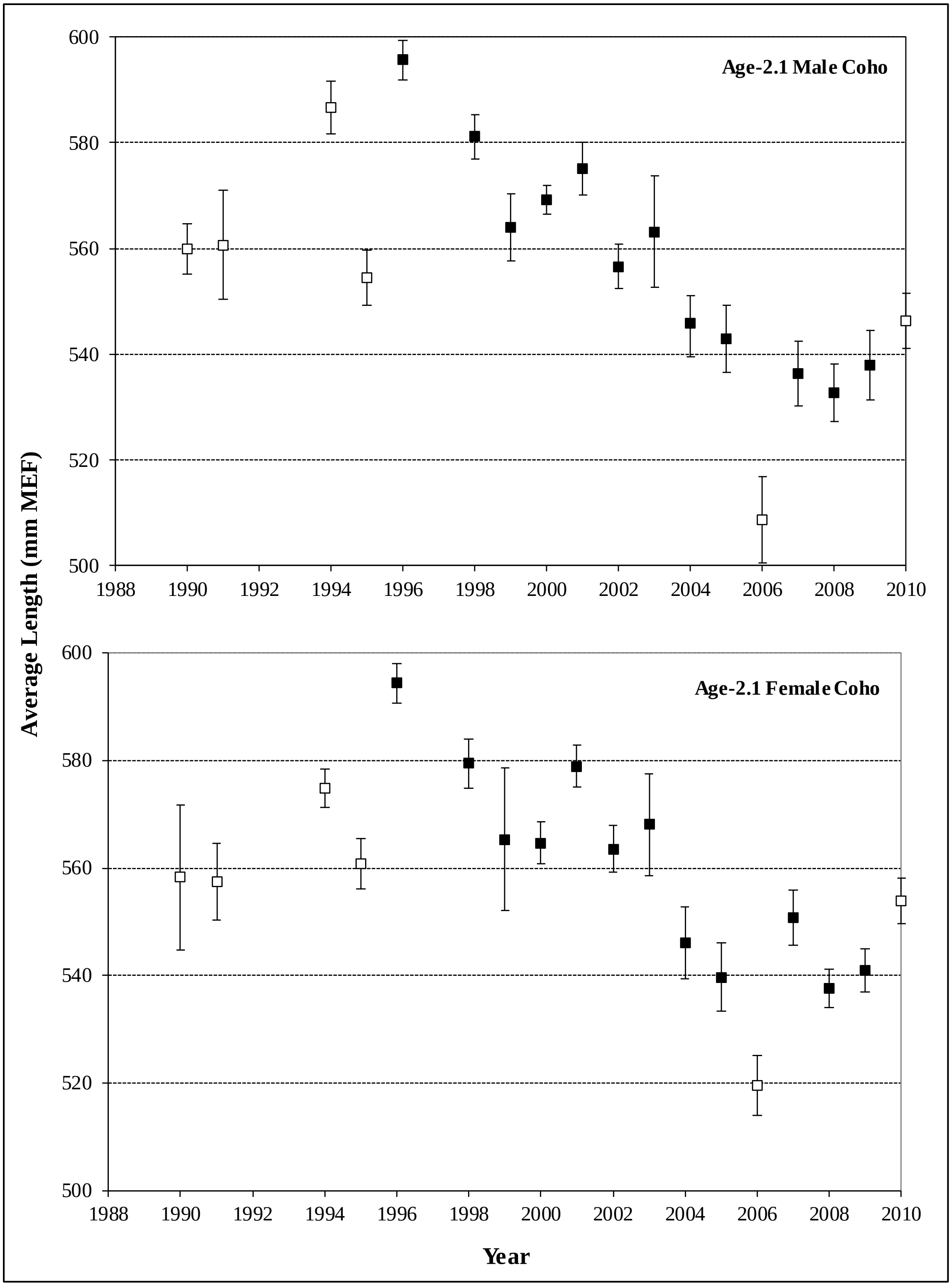
Note: Hatched bars represent years when more than 20% of the escapement was calculated through estimation methods.

Figure 13.–Historical sockeye and coho salmon escapement with the pre-2004 minimum escapement goal and the current escapement goal range at the Kogrukluk River weir.



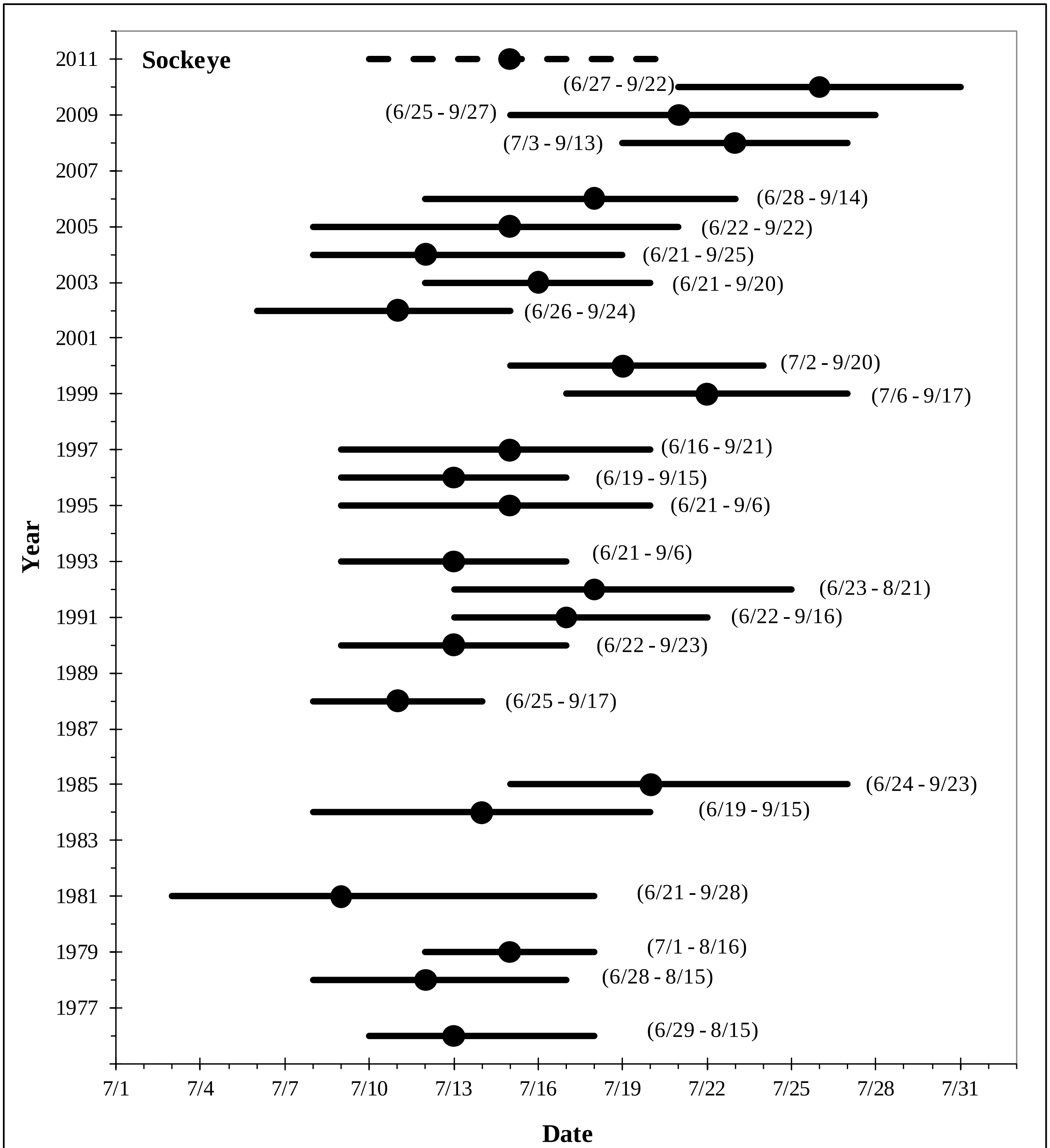
Note: Solid black lines represent dates the central 50% of annual escapement passed in years with at least 80% observed passage. Circles represent median passage dates. As a means to gauge the comparability of the run timing estimates, operational date ranges are in parentheses beside each annual line. The dashed line represents the average passage dates of the graphed years.

Figure 14.–Historical annual run timing of coho salmon based on cumulative percent passage at Kogrukluk River weir, from 1976 to 2010.



Note: Years when sampling effort was not well-distributed throughout the run were omitted. Years for which annual escapement consisted of greater than 20% estimated passage are delineated with white squares.

Figure 15.–Historical average annual length for coho salmon with 95% confidence intervals at Kogrukluk River weir.



Note: Solid black lines represent dates the central 50% of annual escapement passed in years with at least 80% observed passage. Circles represent median passage dates. As a means to gauge the comparability of the run timing estimates, operational date ranges are in parentheses beside each annual line. The dashed line represents the average passage dates of the graphed years.

Figure 16.–Historical annual run timing of sockeye salmon based on cumulative percent passage at Kogrukluk River weir, from 1976 to 2010.

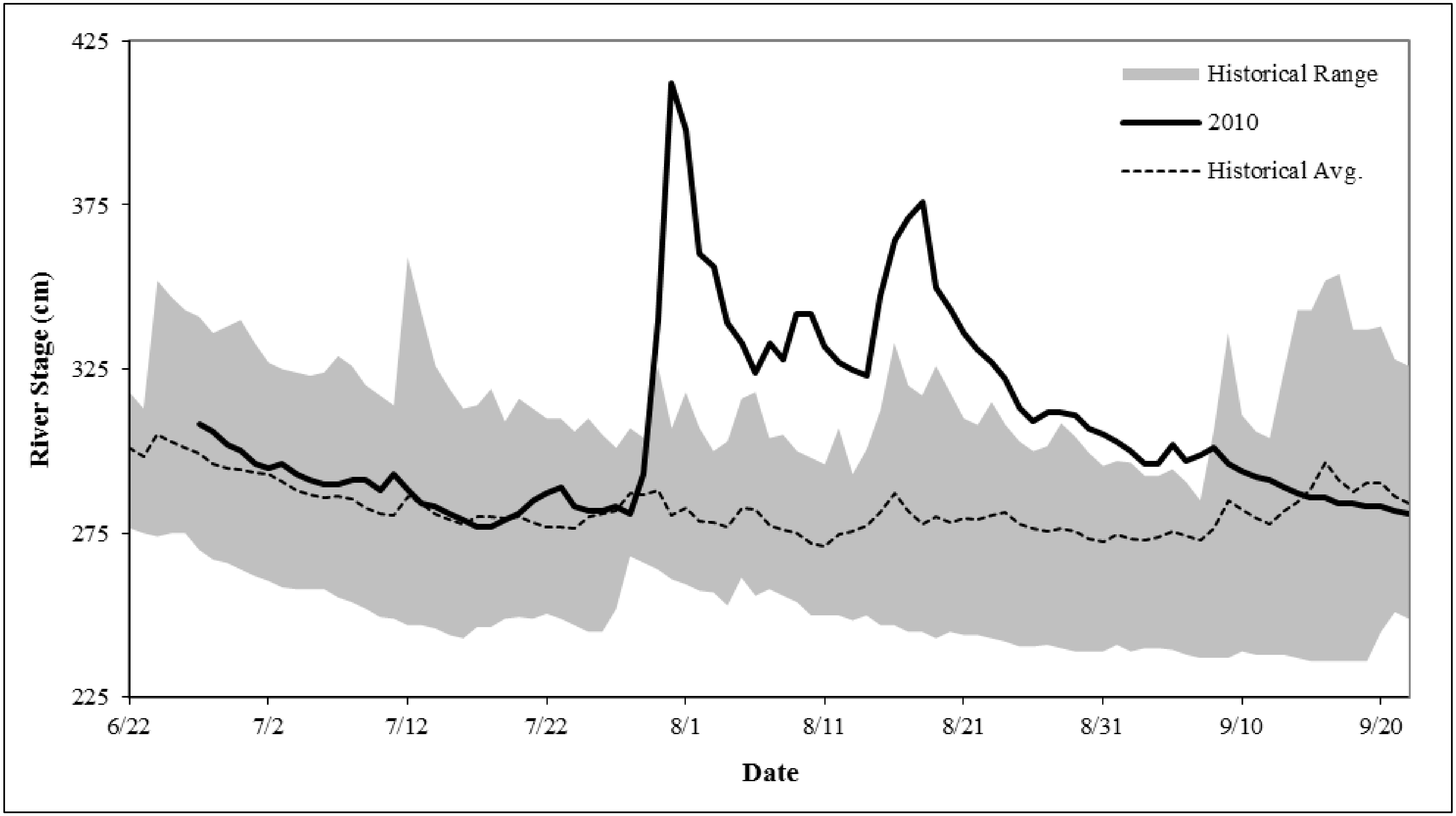


Figure 17.–Daily morning river stage at Kogrukluk River weir in 2010 relative to historical average, minimum, and maximum morning readings from 2002 to 2009.

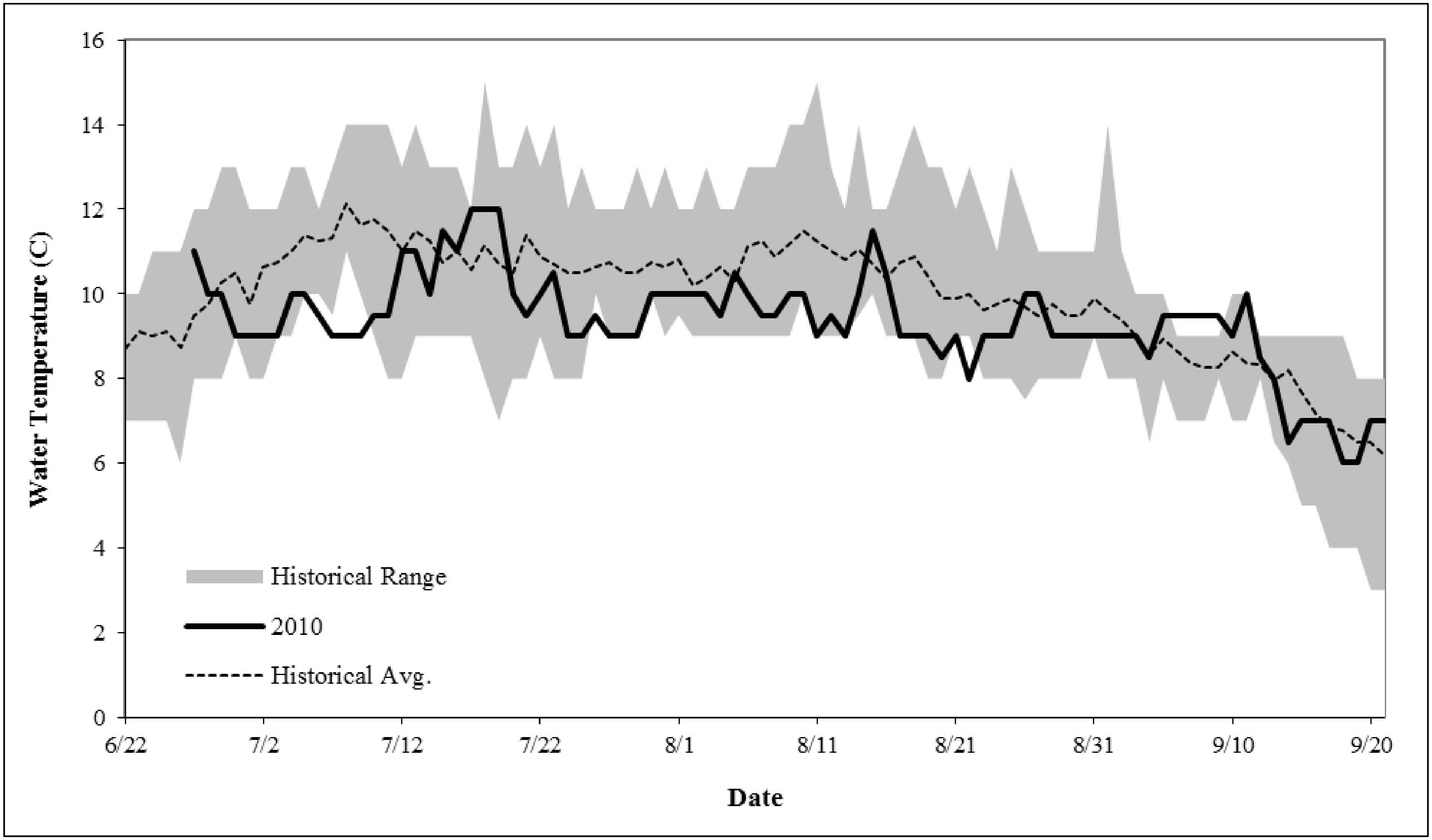


Figure 18.–Daily morning water temperature at Kogrukluk River weir in 2010 relative to historical average, minimum, and maximum morning readings from 2002 to 2009.

APPENDIX A

Appendix A1.–Daily passage counts by species at Kogrukluk River weir, 2010.

	Chinook Salmon		Sockeye Salmon		Chum Salmon		Pink Salmon		Coho Salmon		Dolly	
Date	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Varden[a]	Other[b]
6/27	0	1	0	0	0	1	0	0	0	0	0	0
6/28	0	2	0	0	0	1	0	0	0	0	1	0
6/29	0	0	0	0	4	6	0	0	0	0	6	0
6/30	0	0	0	0	8	7	0	0	0	0	0	0
7/1	0	0	0	0	11	12	0	0	0	0	0	0
7/2	1	0	0	0	7	7	0	0	0	0	2	0
7/3	2	0	0	0	72	51	0	0	0	0	2	0
7/4	5	3	1	0	176	150	0	0	0	0	1	0
7/5	16	8	3	2	433	297	0	0	0	0	0	0
7/6	11	1	4	2	442	258	1	1	0	0	0	0
7/7	53	29	18	28	755	408	2	2	0	0	0	0
7/8	108	42	55	126	946	655	0	0	0	0	1	0
7/9	40	11	14	54	1,098	812	0	1	0	0	1	0
7/10	54	18	30	48	1,010	740	2	2	0	0	0	0
7/11	215	62	105	249	1,272	1,127	5	5	0	0	1	0
7/12	195	67	60	187	1,250	1,220	0	0	0	0	0	0
7/13	121	23	46	83	962	945	4	4	0	0	0	0
7/14	259	55	73	164	948	933	4	2	0	0	1	0
7/15	287	73	114	220	1,092	1,028	4	2	0	0	0	0
7/16	240	32	107	253	1,311	1,288	2	4	0	0	2	0
7/17	190	26	101	201	1,429	1,297	3	2	0	0	0	0
7/18	109	24	74	109	1,467	1,326	8	5	0	0	2	0
7/19	116	23	67	160	1,072	897	0	0	0	0	0	0
7/20	222	67	180	295	1,167	888	1	3	0	0	2	0
7/21	210	86	373	463	1,278	999	3	1	0	0	1	0
7/22	224	120	355	525	1,221	967	2	2	0	0	0	0
7/23	76	25	210	303	1,098	1,040	2	0	0	0	0	0
7/24	146	52	237	403	1,093	951	0	0	0	0	0	0
7/25	57	16	137	185	881	723	0	0	0	0	0	0
7/26	142	96	345	515	1,264	1,029	1	0	0	0	0	0
7/27	82	42	331	408	1,130	912	0	0	0	0	2	0
7/28	78	42	248	253	1,000	935	0	0	0	0	2	0
7/29	115	148	405	491	1,176	852	0	0	1	0	0	0
7/30 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/31 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/1 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/2 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/3 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/4 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/5 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/6 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/7 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/8 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/9 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/10 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/11 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/12 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/13 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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Appendix A1.–Page 2 of 2.

Date	Chinook Salmon		Sockeye Salmon		Chum Salmon		Pink Salmon		Coho Salmon		Dolly	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Varden[a]	Other[b]
8/14 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/15 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/16 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/17 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/18 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/19 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/20 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/21 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/22 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/23 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/24 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/25 [c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/26 [c]	0	0	1	1	0	0	0	0	10	18	0	0
8/27	1	1	2	1	6	8	1	0	207	207	63	0
8/28	0	1	1	1	8	5	0	0	293	338	43	0
8/29	1	2	0	0	1	3	1	1	274	321	50	0
8/30	0	0	0	0	6	6	3	0	182	187	29	0
8/31	0	0	0	2	6	7	1	0	508	461	10	0
9/1	0	0	2	0	6	3	0	0	392	417	15	0
9/2	2	0	0	1	0	0	0	0	153	164	6	0
9/3	0	0	0	0	3	0	0	0	128	154	3	0
9/4	0	0	0	2	1	3	0	0	360	356	11	0
9/5	0	0	0	0	1	3	0	0	442	465	20	0
9/6	0	0	1	0	1	1	0	0	329	323	11	0
9/7	1	0	1	0	2	2	1	0	392	452	11	0
9/8	0	0	1	0	0	0	0	0	328	434	18	0
9/9	0	0	0	0	0	0	0	0	305	408	7	2 WF
9/10	0	0	0	0	2	2	0	0	210	266	8	0
9/11	0	0	0	0	0	0	0	0	170	226	4	0
9/12	0	0	0	0	0	0	0	0	237	294	4	0
9/13	0	0	0	1	0	2	0	0	184	236	4	0
9/14	0	0	0	1	1	1	0	0	121	186	2	0
9/15	0	0	0	1	0	0	0	0	88	153	2	0
9/16	0	0	0	0	0	1	0	0	63	117	4	0
9/17	0	0	0	0	1	1	0	0	94	168	22	0
9/18	0	0	1	0	1	2	0	0	73	97	4	0
9/19	0	0	0	1	2	2	0	0	60	94	2	0
9/20	0	0	0	0	1	1	0	0	60	113	8	0
9/21	0	0	0	0	0	0	0	0	49	67	5	0
9/22	0	0	0	1	0	1	0	0	32	52	6	0
Total	3,379	1,198	3,703	5,740	27,122	22,816	51	37	5,745	6,774	399	2

Note: ND = no data.

[a] Counts represent sexually mature fish only.

[b] WF = White Fish.

[c] Incomplete or partial daily count.

APPENDIX B

Appendix B1.–Daily carcass counts at Kogrukluk River weir, 2010.

Date	Chinook Salmon	Sockeye Salmon	Chum Salmon	Pink Salmon	Coho Salmon	Dolly Varden	White-fish	Other[a]
6/27	0	0	0	0	0	0	0	0
6/28	0	0	0	0	0	1	0	0
6/29	0	0	0	0	0	0	0	0
6/30	0	0	0	0	0	0	0	0
7/1	0	0	0	0	0	0	0	0
7/2	0	0	0	0	0	0	0	0
7/3	0	0	0	0	0	0	0	0
7/4	0	0	0	0	0	0	0	0
7/5	0	0	0	0	0	0	0	0
7/6	0	0	0	0	0	0	0	0
7/7	0	0	0	0	0	0	1	1 AG
7/8	0	0	1	0	0	0	0	0
7/9	0	0	1	0	0	0	0	0
7/10	0	0	0	0	0	0	0	0
7/11	1	0	1	0	0	0	0	0
7/12	0	0	5	0	0	0	0	0
7/13	0	0	6	0	0	0	0	0
7/14	0	0	8	0	0	1	0	0
7/15	0	0	18	0	0	0	0	0
7/16	0	0	34	0	0	0	0	0
7/17	0	0	45	0	0	0	0	0
7/18	0	0	58	0	0	0	0	1 AG
7/19	0	0	137	0	0	0	0	0
7/20	0	0	220	0	0	0	0	0
7/21	0	0	332	0	0	0	0	0
7/22	0	2	414	0	0	0	0	0
7/23	0	0	461	0	0	0	0	0
7/24	0	0	398	0	0	0	0	0
7/25	0	0	383	2	0	0	1	0
7/26	0	0	383	0	0	0	0	0
7/27	0	1	345	2	0	0	0	0
7/28	3	0	381	0	0	0	0	0
7/29	3	0	788	1	0	0	0	0
7/30 [b]	ND	ND	ND	ND	ND	ND	ND	ND
7/31 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/1 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/2 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/3 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/4 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/5 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/6 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/7 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/8 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/9 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/10 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/11 [b]	ND	ND	ND	ND	ND	ND	ND	ND

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Appendix B1.–Page 2 of 2.

Date	Chinook Salmon	Sockeye Salmon	Chum Salmon	Pink Salmon	Coho Salmon	Dolly Varden	White-fish	Other[a]
8/12 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/13 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/14 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/15 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/16 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/17 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/18 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/19 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/20 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/21 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/22 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/23 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/24 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/25 [b]	ND	ND	ND	ND	ND	ND	ND	ND
8/26 [b]	1	8	1	6	0	0	0	0
8/27	6	28	7	126	0	0	0	0
8/28	1	23	12	74	0	0	0	0
8/29	3	40	12	44	0	1	0	0
8/30	2	31	9	58	0	0	0	0
8/31	4	36	7	37	0	0	1	0
9/1	3	24	8	36	0	1	1	0
9/2	1	18	0	11	0	0	0	0
9/3	0	18	4	10	0	0	0	0
9/4	0	0	0	0	0	0	0	0
9/5	2	33	8	20	0	0	0	0
9/6	0	2	0	0	0	0	0	0
9/7	0	6	3	0	0	1	0	0
9/8	0	4	3	0	0	2	2	0
9/9	0	3	2	1	0	0	0	0
9/10	3	8	5	0	1	1	0	0
9/11	0	6	2	0	1	0	0	0
9/12	0	5	4	0	2	0	1	1 AG
9/13	0	2	1	0	0	0	0	0
9/14	0	0	0	0	0	0	0	1 NP
9/15	0	0	0	0	0	0	0	0
9/16	0	1	1	1	1	1	0	0
9/17	0	2	1	0	0	0	1	0
9/18	0	0	4	0	2	1	0	0
9/19	0	0	0	0	0	0	0	0
9/20	0	2	4	0	2	1	1	1 NP
9/21	0	1	1	0	0	2	0	0
9/22	0	0	0	0	0	0	0	0
Total	33	304	4,518	429	9	13	9	3AG, 2 NP

Note: ND = no data.

[a] AG = Arctic grayling; NP = Northern pike.

[b] Weir inoperable for all or part of the day.

APPENDIX C

Appendix C1.–Daily weather and stream observations at Kogrukluk River weir, 2010.

Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River Stage (cm)[b]	Water Clarity[c]
6/27	10:00	4	2.6	12	11	308	1
	17:00	4	0.8	15	11.5	307	1
6/28	10:00	4	0.3	11	10	306	1
	17:00	3	0.0	20	11	305	1
6/29	10:00	4	1.1	13	10	302	1
	17:00	4	0.0	14	10.5	301	1
6/30	10:00	4	0.0	10	9	300	1
	17:00	4	0.0	18	10	299	1
7/1	10:00	4	0.0	13	9	296	1
	17:00	4	0.0	14	9.5	296	1
7/2	10:00	4	0.6	10	9	295	1
	17:00	4	3.2	14	9.5	295	1
7/3	10:00	3	0.3	12	9	296	1
	17:00	3	0.0	20	10	296	1
7/4	10:00	4	0.0	13	10	293	1
	17:00	3	0.0	20	11	293	1
7/5	9:00	4	5.0	10	10	291	1
	17:00	4	1.5	14	10.5	290	1
7/6	10:00	4	3.0	9	9.5	290	1
	17:00	4	0.6	13	10	290	1
7/7	10:00	3	0.7	10	9	290	1
	17:00	3	3.0	13	9.5	290	1
7/8	9:00	3	0.2	11	9	291	1
	17:00	2	2.8	22	11.5	293	1
7/9	10:00	2	0.4	11	9	291	1
	17:00	4	0.0	16	11	290	1
7/10	10:00	4	4.8	11	9.5	288	1
	17:00	4	0.0	15	10	288	1
7/11	10:00	2	0.0	15	9.5	293	1
	18:00	2	0.0	22	12	291	1
7/12	9:00	1	0.0	9	11	288	1
	17:00	2	0.0	23	12.5	286	1
7/13	10:00	4	2.1	12	11	284	1
	17:00	1	0.0	14	10	284	1
7/14	10:00	1	0.0	11	10	283	1
	17:00	3	0.0	23	12	282	1
7/15	10:00	3	0.0	13	11.5	281	1
	17:00	2	0.0	21	13	280	1
7/16	10:00	1	0.0	13	11	279	1
	17:00	1	0.0	25	15	278	1
7/17	9:00	1	0.0	11	12	277	1
	17:00	3	0.0	22	17.5	277	1
7/18	10:00	4	2.6	14	12	277	1
	17:00	4	0.8	16	12	277	1
7/19	10:00	4	5.5	13	12	279	1
	17:30	4	0.9	15	11	279	1
7/20	10:00	4	3.2	12	10	281	1
	17:25	4	8.5	15	10.5	281	1
7/21	10:00	3	1.7	12	9.5	285	1
	17:00	4	0.2	16	11	285	1

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Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River Stage (cm)[b]	Water Clarity[c]
7/22	7:30	4	4.4	11	10	287	1
	17:00	3	0.0	14	12	286	1
7/23	7:30	4	0.9	9	10.5	289	1
	18:00	4	0.0	10	10	283	1
7/24	7:30	5	0.6	9	9	283	1
	18:30	4	0.5	13	10	280	1
7/25	7:30	4	1.2	10	9	282	1
	17:00	4	1.2	12	10	279	1
7/26	10:00	3	1.6	10	9.5	282	1
	17:00	3	0.0	17	11	280	1
7/27	10:00	4	0.0	10	9	283	1
	17:00	4	1.2	12	10	284	1
7/28	10:00	4	5.8	11	9	281	1
	17:00	4	2.8	12	10	284	1
7/29	10:00	4	10.5	11	9	293	1
	17:00	4	10.1	14	9	297	2
7/30	10:00	4	35.0	11	10	340	3
	17:00	4	6.5	15	10	359	3
7/31	10:00	4	6.8	13	10	ND	3
	17:00	4	3.0	17	11	412	3
8/1	10:00	3	0.2	12.5	10	398	3
	17:00	4	0.0	19	11	371	3
8/2	10:00	3	0.0	15	10	360	3
	17:00	3	0.0	19	10.5	358	3
8/3	10:00	4	0.0	14	10	356	3
	17:00	4	0.0	12	10.5	346	3
8/4	10:00	3	5.2	13	9.5	339	3
	17:00	3	0.2	20	12	337	2
8/5	10:00	4	0.0	15	10.5	333	2
	17:00	4	0.0	17	11	330	2
8/6	10:00	4	7.5	12	10	324	2
	17:00	4	0.9	15	10	326	2
8/7	10:00	4	3.6	11	9.5	333	2
	17:00	4	0.6	16	10	330	2
8/8	10:00	4	1.0	11	9.5	328	2
	17:00	4	12.5	14	10	329	3
8/9	10:00	4	2.9	11	10	342	3
	17:00	3	0.0	17	10	349	3
8/10	10:00	4	0.0	11	10	342	3
	17:00	4	0.2	13	10	337	3
8/11	10:00	4	3.4	10	9	332	2
	17:00	3	0.4	17	10	331	2
8/12	10:00	4	1.6	12	9.5	327	2
	17:00	3	1.7	16	10	325	2
8/13	10:00	4	0.2	12	9	325	2
	17:00	4	0.0	17	10	324	2
8/14	10:00	3	10.0	17	10	323	2
	17:00	3	0.0	19	12	329	3

-continued-

Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River Stage (cm)[b]	Water Clarity[c]
8/15	10:00	4	3.9	15	11.5	347	3
	17:00	4	1.8	14	11.5	341	3
8/16	10:00	4	0.0	11	10.5	364	3
	17:00	4	8.3	13	9.5	367	3
8/17	10:00	3	8.5	10	9	371	3
	17:00	3	0.6	13	9.5	380	3
8/18	10:00	4	0.0	10	9	376	3
	17:00	2	0.0	16	10	363	2
8/19	10:00	4	0.0	9	9	350	2
	17:00	4	0.0	15	10	348	2
8/20	10:00	3	0.0	9	8.5	343	2
	17:00	4	0.0	15	9.5	340	2
8/21	10:00	4	0.0	10	9	336	2
	17:00	4	0.0	15	10	332	2
8/22	10:00	4	1.5	10	8	331	2
	17:00	3	0.0	17	9.5	330	2
8/23	10:00	2	0.0	10	9	327	1
	17:00	2	0.0	19	12	326	1
8/24	10:00	1	0.0	11	9	322	1
	17:00	1	0.0	19	11	316	1
8/25	10:00	4	0.0	5	9	313	1
	17:00	2	0.0	18	11	312	1
8/26	10:00	4	0.0	11	10	309	1
	17:00	4	0.8	13	10	311	1
8/27	10:00	4	2.1	12	10	312	1
	17:00	4	2.0	15	10	312	1
8/28	10:00	4	9.5	10	9	312	1
	17:00	4	1.9	14	9.5	309	1
8/29	10:00	4	0.0	10	9	311	1
	17:00	3	0.0	17	9.5	309	1
8/30	10:00	4	3.7	9	9	307	1
	17:00	2	0.0	15	10	305	1
8/31	10:00	2	3.4	12	9	305	1
	17:00	3	0.0	17	10	304	1
9/1	10:00	2	0.0	9	9	303	1
	17:00	2	0.0	14	10.5	302	1
9/2	10:00	4	0.0	8	9	300	1
	17:00	4	0.6	13	9.5	299	1
9/3	10:00	4	1.7	10	9	296	1
	17:00	4	0.1	14	9	296	1
9/4	10:00	4	5.6	11	8.5	296	1
	17:00	3	0.0	16	9	297	1
9/5	10:00	4	0.6	12	9.5	302	1
	17:00	3	0.0	17	10.5	301	1
9/6	10:00	4	0.0	12	9.5	297	1
	17:00	4	1.5	14	10	297	1
9/7	10:00	2	4.6	13	9.5	299	1
	17:00	3	0.0	14	11	299	1
9/8	10:00	4	0.2	11	9.5	301	1
	17:00	4	1.2	13	10	299	1

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Appendix C1.–Page 4 of 4.

Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River Stage (cm)[b]	Water Clarity[c]
9/9	10:00	3	4.3	10	9.5	296	1
	17:00	3	0.0	14	10	295	1
9/10	10:00	3	0.0	12	9	294	1
	17:00	2	0.0	20	11	294	1
9/11	10:00	3	0.0	10	10	292	1
	17:00	3	0.0	19	11	291	1
9/12	10:00	1	0.0	6	8.5	291	1
	17:00	1	0.0	21	12	290	1
9/13	10:00	1	0.0	4.5	8	289	1
	17:00	1	0.0	23	10	288	1
9/14	10:00	1	0.0	4	6.5	287	1
	17:00	1	0.0	22	10	287	1
9/15	10:00	1	0.0	3	7	286	1
	17:00	1	0.0	20	9	286	1
9/16	10:00	1	0.0	3	7	286	1
	17:00	1	0.0	19	9	285	1
9/17	10:00	1	0.0	4	7	284	1
	17:00	1	0.0	18.5	9	284	1
9/18	10:00	1	0.0	1.5	6	284	1
	17:00	1	0.0	18	8	284	1
9/19	10:00	1	0.0	3	6	283	1
	17:00	1	0.0	22	8	283	1
9/20	10:00	1	0.0	6	7	283	1
	17:00	4	0.0	13	7	282	1
9/21	10:00	4	0.0	10	7	282	1
	17:00	4	0.0	14	8	282	1
9/22	10:00	4	0.0	8	7	281	1
	17:00	4	0.0	12	8	281	1
		Mode	Total	Average[d]	Average[d]	Average[d]	Mode
Season Statistics		4	269.0	13.4	9.9	307	1

[a] Sky condition codes are: 0 = no observation; 1 = mostly clear (< 10% cloud cover); 2 = partly cloudy (< 50% cloud cover); 3 = mostly cloudy (> 50% cloud cover); 4 = complete overcast (100% cloud cover); 5 = thick fog

[b] In previous reports water level was reported in millimeters. Note this distinction when comparing to past years.

[c] Water clarity codes are: 1 = visibility is greater than 1.0 m; 2 = visibility is 0.5 to 1.0 m; 3 = visibility is less than 0.5 m

[d] Calculated from days in which two observations were made: one between 0730 and 1100 hours and one between 1700 and 1900 hours.

Appendix C2.–Daily air temperature summary from Hobo® data logger at the Kogrukluk River weir, 2010.

	Temperature (°C)		
Date	Avg.	Max.	Min.
7/2	10.2	13.2	7.7
7/3	11.9	17.0	7.0
7/4	13.0	17.5	10.3
7/5	9.7	12.2	6.6
7/6	9.4	11.6	7.4
7/7	10.2	14.1	7.0
7/8	13.1	20.2	6.4
7/9	10.8	17.6	4.7
7/10	11.6	16.1	8.7
7/11	14.8	20.7	8.7
7/12	14.6	20.8	7.7
7/13	12.8	16.0	9.7
7/14	14.4	20.7	7.8
7/15	14.3	19.5	8.9
7/16	15.8	22.4	9.8
7/17	14.4	19.3	7.5
7/18	12.6	14.6	11.2
7/19	12.0	15.7	10.1
7/20	11.2	12.7	10.1
7/21	10.5	14.0	7.1
7/22	11.8	16.5	9.2
7/23	9.0	10.3	7.2
7/24	10.2	13.6	8.5
7/25	9.4	10.6	8.1
7/26	11.4	17.3	7.6
7/27	9.7	12.3	5.5
7/28	9.8	11.4	8.1
7/29	10.2	11.7	9.0
7/30	11.5	13.8	9.6
7/31	13.2	15.9	11.3
8/1	13.3	16.6	9.6
8/2	14.1	17.4	11.7
8/3	12.8	14.8	10.9
8/4	13.6	17.7	10.6
8/5	13.1	16.5	9.9
8/6	10.8	13.5	8.6
8/7	11.5	13.9	9.8
8/8	10.6	12.7	8.9
8/9	11.8	15.0	10.6
8/10	10.7	11.9	9.9
8/11	11.1	15.2	8.6
8/12	11.3	14.8	9.1
8/13	11.8	15.5	6.8
8/14	14.9	18.1	11.6
8/15	13.2	15.6	11.0
8/16	9.6	11.6	7.9
8/17	10.0	12.4	8.0
8/18	10.2	14.4	7.4
8/19	9.8	13.4	6.8
8/20	10.0	16.1	3.9
8/21	9.7	13.9	6.7
8/22	10.9	16.3	7.1
8/23	12.4	20.0	5.1
8/24	13.0	20.3	6.7
8/25	10.2	19.4	2.3
8/26	10.9	13.2	8.8
8/27	11.4	14.5	9.2
8/28	9.4	12.7	7.6
8/29	10.7	14.5	8.2
8/30	10.6	15.6	8.4
8/31	10.8	15.3	8.0
9/1	8.8	14.0	4.7
9/2	7.2	11.0	2.7
9/3	9.1	11.9	6.5
9/4	11.4	14.3	9.0
9/5	12.3	17.3	9.5
9/6	10.9	12.2	8.6
9/7	12.4	15.0	9.9
9/8	9.9	11.3	8.5
9/9	10.0	14.1	7.0
9/10	12.4	19.2	8.1
9/11	12.8	20.1	6.9
9/12	11.2	21.3	3.4
9/13	10.4	21.0	1.7
9/14	9.8	20.5	0.7
9/15	9.5	19.9	1.3
9/16	9.5	19.9	0.6
9/17	9.3	18.5	2.5
9/18	7.9	18.6	-0.6
9/19	8.4	20.7	-0.4
9/20	8.3	12.3	4.2
9/21	9.5	12.9	6.9
9/22	7.7	11.4	3.4
9/23	6.0	10.8	2.7
9/24	4.0	13.4	-2.2
9/25	1.8	8.6	-1.8
Average:	10.9	15.5	7.1
Minimum	1.8	8.6	-2.2
Maximum	15.8	22.4	11.7

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Appendix C3.–Daily stream temperature summary from Hobo® data logger at the Kogrukluk River weir, 2010.

	Temperature (°C)		
Date	Avg.	Min.	Max.
7/5	10.4	11.4	9.9
7/6	9.5	10.2	9.2
7/7	9.3	10.2	8.4
7/8	10.0	11.4	8.8
7/9	10.2	11.0	9.3
7/10	9.8	10.6	9.2
7/11	10.7	12.4	9.4
7/12	11.8	12.7	10.9
7/13	11.2	12.3	10.7
7/14	11.0	12.7	9.6
7/15	12.1	13.9	10.9
7/16	13.1	15.0	11.5
7/17	13.2	14.2	11.9
7/18	12.2	13.3	11.8
7/19	11.0	11.7	10.7
7/20	10.5	10.8	10.2
7/21	10.3	10.9	9.7
7/22	10.7	12.1	9.7
7/23	10.4	11.4	9.5
7/24	9.4	10.1	8.9
7/25	9.3	9.7	9.0
7/26	9.7	11.4	8.5
7/27	9.8	10.6	9.3
7/28	9.4	9.8	9.0
7/29	9.2	9.5	9.0
7/30	9.4	9.8	9.2
7/31	10.1	10.9	9.6
8/1	10.6	10.8	10.2
8/2	10.3	10.7	9.8
8/3	9.9	10.4	9.6
8/4	9.8	10.6	9.2
8/5	10.3	10.8	9.8
8/6	9.7	10.3	9.3
8/7	ND	ND	ND
8/8	ND	ND	ND
8/9	ND	ND	ND
8/10	ND	ND	ND
8/11	ND	ND	ND
8/12	ND	ND	ND
8/13	ND	ND	ND
8/14	ND	ND	ND
8/15	ND	ND	ND
8/16	ND	ND	ND
8/17	ND	ND	ND
8/18	ND	ND	ND
8/19	ND	ND	ND
8/20	ND	ND	ND
8/21	ND	ND	ND
8/22	ND	ND	ND
8/23	ND	ND	ND
8/24	ND	ND	ND
8/25	ND	ND	ND
8/26	ND	ND	ND
8/27	ND	ND	ND
8/28	ND	ND	ND
8/29	ND	ND	ND
8/30	ND	ND	ND
8/31	ND	ND	ND
9/1	ND	ND	ND
9/2	ND	ND	ND
9/3	ND	ND	ND
9/4	ND	ND	ND
9/5	ND	ND	ND
9/6	ND	ND	ND
9/7	ND	ND	ND
9/8	ND	ND	ND
9/9	ND	ND	ND
9/10	ND	ND	ND
9/11	ND	ND	ND
9/12	ND	ND	ND
9/13	ND	ND	ND
9/14	ND	ND	ND
9/15	ND	ND	ND
9/16	ND	ND	ND
9/17	ND	ND	ND
9/18	ND	ND	ND
9/19	ND	ND	ND
9/20	ND	ND	ND
9/21	ND	ND	ND
9/22	7.6	8.1	7.1
9/23	7.1	7.6	6.6
9/24	5.5	6.5	4.9
9/25	4.0	4.8	3.4
Average:	10.0	10.8	9.3
Minimum	4.0	4.8	3.4
Maximum	13.2	15.0	11.9

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