Fishery Data Series No. 10-24

Kogrukluk River Salmon Studies, 2008

by

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and

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April 2010

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)

Measures (fisheries)

fork length	FL
mideye to fork	MEF
mideye to tail fork	METF
standard length	SL
total length	TL

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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KOGRUKLUK RIVER SALMON STUDIES, 2008

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April 2010

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This document should be cited as:
Williams, D. L., and C. A. Shelden. 2010. Kogrukluk River weir salmon studies, 2008. Alaska Department of Fish and Game, Fishery Data Series No. 10-24, Anchorage.

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ABSTRACT

The Kogrukluk River weir has been operated since 1976 to estimate the return and age-sex-length compositions of salmon escapements, monitor environmental variables, and contribute to other Kuskokwim Area fisheries projects. In 2008, a fixed-picket weir was operated in the Kogrukluk River from 3 July through 13 September to estimate escapements of 4 species of Pacific salmon *Oncorhynchus* spp. The total annual Chinook salmon *O. tshawytscha* escapement of 9,730 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 44,978 was near the upper boundary of the SEG range of 15,000 to 49,000 fish. The total annual sockeye salmon *O. nerka* escapement of 19,675 was above the recent 10-year average (1998–2007) of 16,954 fish. The total annual coho salmon *O. kisutch* escapement of 29,661 surpassed the upper boundary of the SEG range of 13,000 to 28,000 fish. Age-sex-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 23.2% of the Chinook salmon run, 34.9% of the chum salmon run, and 55.1% of the coho salmon run. The Chinook salmon run was comprised of 6 age classes, dominated by age-1.3 fish (43.4%). The chum salmon run was comprised of 4 age classes, dominated by age-0.3 fish (53.8%). The coho salmon run was comprised of 3 age classes, dominated by age-2.1 fish (81.4%).

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, *O. keta*, coho salmon, *O. kisutch*, 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, sockeye salmon, *O. nerka*, pink salmon, *O. gorbuscha*, Dolly Varden, *Salvelinus malma*

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 1 million salmon (Whitmore et al. 2008). 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; Smith and Dull 2008; Whitmore et al. 2008). 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; Whitmore et al. 2008). Salmon contributing to these fisheries spawn and rear in most tributaries of the Kuskokwim River basin (Whitmore et al. 2008).

Management of Kuskokwim Area fisheries is primarily the jurisdiction of the State of Alaska, though other agencies contribute to the decision making process. Since 1960, management of Kuskokwim River subsistence, commercial, and sport fisheries has been the responsibility of the Alaska Department of Fish and Game (ADF&G). Management authority for the subsistence fishery was broadened in October 1999 to include the federal government under Title VIII of the Alaska National Interest Lands Conservation Act (ANILCA). The U.S. Fish and Wildlife Service (USFWS) is the federal agency most involved within the Kuskokwim Area. In addition,

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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.

numerous tribal groups are charged by their constituency to actively promote a healthy and sustainable subsistence salmon fishery. For years, these and other groups have combined their resources in an effort to achieve long-term sustainability of Kuskokwim River salmon.

In the state of Alaska, salmon management provides for sustainable fisheries by ensuring that adequate numbers of salmon escape to the spawning grounds each year. However, few Kuskokwim Area spawning streams have received rigorous salmon escapement monitoring. Consequently, critical long-term salmon escapement data are lacking for much of the drainage, limiting the ability of managers to assess the adequacy of escapements and the effects of management decisions.

The need for long-term escapement information in the Kuskokwim River drainage prompted the establishment of several weir projects in the late 1990s. Historically, only 2 long-term ground-based projects had operated in the drainage: the Aniak River sonar and the Kogrukluk River weir (Molyneaux and Brannian 2006). Currently, 8 ground-based escapement monitoring projects, including 7 weirs and one sonar project, are operated cooperatively by a variety of state, federal, and tribal organizations (Molyneaux and Brannian 2006). This array of projects allows managers to monitor the status of individual salmon stocks as well as track drainagewide trends that may reflect overall ecosystem health.

In the early 1980s fisheries management shifted from a strategy that emphasized guideline harvest levels to one emphasizing escapement, which was probably to the benefit of Kuskokwim River salmon populations (Buklis 1993). As a result, species-specific escapement goals were established for tributaries, like the Kogrukluk River, with sufficient historical baseline information. Now termed "sustainable escapement goals" or "SEGs", the escapement goals established for Kuskokwim River tributaries are levels of escapement, indicated by an index or an escapement estimate, which are known to provide for sustained yield over a 5–10 year period (Brannian et al. 2006b). The first formal escapement goals, expressed as thresholds, were established at the Kogrukluk River weir in 1983 for Chinook *O. tshawytscha* (10,000), chum *O. keta* (20,000), sockeye *O. nerka* (2,000), and coho salmon *O. kisutch* (20,000). In 1984, escapement goals were increased to 30,000 for chum and 25,000 for coho salmon. In January 2004, Kogrukluk River escapement goals were revised again and have since been expressed as ranges (ADF&G 2004). These revised escapement goals have been in effect since the 2005 season. For Chinook salmon the current SEG range is 5,300 to 14,000 fish, for chum salmon it is 15,000 to 49,000 fish, and for coho salmon it is 13,000 to 28,000 fish (Brannian et al. 2006b). Throughout most of the 1980s and into the 1990s sockeye salmon had an escapement goal as well; however, this goal was discontinued around 1995 because at that time sockeye salmon enumeration was considered ancillary to that of other species, and catch was considered incidental (Burkey et al. 1997).

During recent Alaska Board of Fisheries (BOF) meetings, Kuskokwim River Chinook and chum salmon have received considerable attention due to erratic run abundance patterns. In 2000, the BOF designated Kuskokwim River Chinook and chum salmon as "stocks of yield concern" after several years of lower than expected harvest levels (Burkey et al. 2000a-b). This "stock of yield concern" designation was upheld during the 2004 BOF meeting (Bergstrom and Whitmore 2004) but was rescinded in 2007 during the BOF meeting by recommendation of ADF&G following several years in which harvest levels and escapements met or exceeded department expectations (Linderman and Bergstrom 2006; Molyneaux and Brannian 2006). Between 2001 and 2006, subsistence and commercial fisheries were managed conservatively and in accordance with the

BOF "stocks of yield concern" designations. Efforts were focused on enumerating abundance of these species and obtaining enough data for escapement goal development. Several mainstem and drainagewide projects were initiated that utilized the existing weir infrastructure for data collection. Such projects have since become deeply integrated components of Kuskokwim monitoring program.

In 2008, the Kuskokwim River commercial fishing district (W-1) had a total of 20 commercial openings from 20 June to 25 August, with a 6-inch stretch mesh gear restriction. Processor interest faded in early July and compared to historical harvests, exploitation was below average. Commercial harvest of Chinook salmon in 2008 was 63% higher than the recent 10-year average (1998–2007). Sockeye salmon harvests were 15% above the 10-year average while chum harvests were 27% below. There were 10 coho salmon directed commercial openings between 4 and 25 August (J. C. Linderman, Jr., Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). Coho salmon harvests in 2008 were 22% below the recent 10-year average. Species-specific commercial fishing pressure varies with fluctuation in fish abundance, market value, and processing capabilities. In 2008 market interests were the limiting factor on harvest, prompting managers to reduce fishing time after 20 June.

The subsistence Chinook salmon fishery has always had a greater exploitation rate than the commercial fishery, and, in recent years, this has been true of chum and sockeye salmon as well (Smith and Dull 2008). Subsistence fishing pressure within the Kuskokwim River varies between species, with Chinook and chum salmon more heavily targeted. Throughout the 2008 season, subsistence fishing was allowed continuously with the exception of closed periods surrounding commercial fishing periods. Historically, subsistence harvests have been relatively consistent from year to year for all species (Smith and Dull 2008), despite considerable variation in abundance and escapements.

The utility of weirs extends beyond providing annual escapement estimates. Escapement projects, such as the Kogrukluk River weir, commonly serve as platforms for collecting other types of information useful for management and in other research initiatives. Collection of age, sex, and length (ASL) data is typically included in escapement monitoring projects (Molyneaux et al. 2008). Knowledge of ASL composition can improve understanding of fluctuations in salmon abundance and is essential for identifying spawner-recruit relationships that are integral to formulating escapement goals (Molyneaux and Brannian 2006).

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 (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 Nino and La Nina events, climate change).

BACKGROUND

Regional

In the dialect of the upper 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 last 2 individuals claiming ties to Kashegelok, Evan Ignatti and Ignatti Ignatti, relocated to Red Devil when a gravel bar formed across a portion of the channel favored as a floatplane landing site after the Chukowan River shifted course during the spring flood of 2003.

Today, most inhabitants of the Holitna River reside in a number of commercial lodges and private, usually single-family, homesteads along the lower Holitna River. Only one inhabitant, Elder Nastacia Nick, remains year round (Evan Ignatti, elder, Kashegelok; personal communication). The Holitna River drainage continues to draw users from throughout the Kuskokwim River drainage and beyond, and remains an important area 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]). In 1969, managers initiated a ground-based escapement monitoring program on the Kogrukluk River, which was found to support sizable populations of salmon and had geomorphic characteristics that facilitated salmon enumeration. Annual salmon escapement to the Kogrukluk River has been monitored since 1969, providing the longest and most consistent historical escapement dataset of all Kuskokwim Area projects.

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 always remained upstream of the mouth of Shotgun Creek. In order to more accurately assess salmon escapements, a counting weir was attempted in 1971 near the counting tower site. Unfortunately, this first weir was destroyed by high water early in the season (Yanagawa 1973). Both tower and weir operations in this section of the Kogrukluk River were hindered by log jams and shifting channels. Inadequacies of the existing tower sites and the absence of more suitable locations resulted in a transition from a counting tower to a weir between 1976 and 1978 (Baxter 1979). Because the weir was located below the confluence of Shotgun Creek, both tower and weir projects were operated concurrently from 1976 to 1978 to compare escapement estimates between projects.

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

The Kogrukluk River weir has a long and varied history as a platform for providing data for salmon research and management in the Kuskokwim Area. Since its inception in 1976, the Kogrukluk River weir (sometimes referred to as the Ignatti weir or Holitna River weir) has been operated annually to monitor Chinook, chum, and sockeye salmon escapements to this system. Beginning in 1981, the weir operations were extended later into the season to include coho salmon (Baxter 1982). Since the late 1990s, the Kogrukluk River weir has served several regional mark–recapture based projects including *Kuskokwim River coho salmon run reconstruction, Kuskokwim River Chinook salmon run reconstruction* (K. L. Schaberg, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication), *Inriver abundance of Chinook salmon in the Kuskokwim River* (Stuby 2007), *Kuskokwim River sockeye salmon investigations* (S. E. Gilk, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication), *Kuskokwim River salmon mark–recapture project* (Pawluk et al. 2006), and *Assessment of Chinook, chum, and coho salmon escapements in the Holitna River drainage using radiotelemetry* (Stroka and Brase 2004; Stroka and Reed 2005). Genetic tissue samples have been obtained from all species of Pacific salmon as well as Dolly Varden in support of various genetics-based large-scale studies. More recently, juvenile salmon and salmon otoliths have been collected in support of other fisheries studies.

Kogrukluk River salmon escapements are a relatively small percentage of the overall salmon escapement 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). The Kogrukluk River tributaries in the Kuskokwim River drainage with a formal escapement goal for Chinook salmon, one of only tributaries with a formal escapement goal for chum salmon, and the tributary with a formal escapement goal for coho salmon (Figure 1; Brannian et al. 2006b). The Kogrukluk River weir is the means by which these escapements are assessed.

OBJECTIVES

The objectives of the Kogrukluk River escapement monitoring project in 2008 were to:

1. Determine the daily and total annual escapement of male and female Chinook, chum, sockeye, and coho salmon to the Kogrukluk River;
2. Estimate the age, sex, and length (ASL) composition of annual Chinook, chum, and coho salmon escapements such that 95% confidence intervals for the total annual age composition are no wider than ±10% (α=0.05 and d=0.10);
3. Monitor habitat variables including daily water temperature and daily water level.
4. Serve as a platform to facilitate current and future fisheries research projects (in 2008):
    a. Serve as a monitoring and recapture location for Coho salmon equipped with radio transmitters and anchor tags deployed as part of *Kuskokwim River coho salmon run reconstruction*; (Arctic Yukon Kuskokwim Sustainable Salmon Initiative Project No; 565)
    b. Serve as a collection site for Dolly Varden (*Salvelinus malma*) genetic tissue samples as part of the *Baseline development for Dolly Varden in southwestern Alaska* project; and
    c. Serve as a collection site for pink salmon genetic tissue;

d. Serve as a collection site for the *Investigation of stable isotope and otolith elemental analyses as tools for salmon stock assessment* project;

e. Serve as a collection site for a *Productivity of Kuskokwim juvenile coho salmon* study;

f. Provide base of operations and assistance in a *Variation in AYK sockeye salmon stocks* study;

The primary goal of this report is to summarize and present the results for the 2008 field season at the Kogrukluk River weir. Secondary to this, we intend to provide a more holistic perspective of Kuskokwim Area fisheries by placing the 2008 findings into the broader spatial and temporal context. To do this we draw heavily on data from past years at this project to highlight inter-annual trends, and we draw on data from other escapement monitoring projects, related research projects, and the commercial and subsistence fisheries in order to highlight spatial trends. These goals are intended to enhance the utility of this report beyond simply archiving data. It is important to note that some of the data used to make these broader comparisons are preliminary. Effort was made to ensure that all preliminary data was reported as such. In addition, many of the referenced documents are currently being developed. Consequently, most of the reported trends for other projects were determined by the authors of this report based on data sets generously provided by other researchers. At the time of publication of this document all reported estimates and trends are as accurate as possible. However, the final results and conclusions for "*In prep*" documents may change. Therefore, readers should confirm via the specific project reports prior to referencing results from other projects, especially those listed as "*In prep*". Furthermore, unless stated, the statistical significance of the trends discussed for this and other escapement monitoring projects have not been determined. Many of these trends are subjective and based on low sample sizes with high variance. It is important to remember that sampling methodologies often differ across projects and over time leading to difficulty in comparisons. Throughout this document every effort was made to ensure sound comparisons.

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 form the headwaters of the Holitna River which flow 218 rkm to its own ending in the Kuskokwim River. The Holitna River joins the Kuskokwim River at rkm 491.

Over its course, the Kogrukluk 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 flood plain is poorly drained and is composed of soft sediments that erode easily. 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 (*Picea glauca*), birch (*Betula* spp.), and aspen (*Populus. trenuloides*) are common on moderate south-facing slopes and black spruce (*Picea mariana*) is common on north facing slopes, in poorly 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 understories consist of willows, alders, and dwarf birch (*B. nana*).

WEIR DESIGN

Installation Site

Located approximately 220 river kilometers (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]).

The river channel at the weir site is relatively stable, but lies on a dynamic floodplain that experiences relatively frequent changes in channel location and morphology. The weir is located within the confluence of 3 tributaries that form the headwaters of the Holitna River: about 1 rkm upstream from the confluence with the Chukowan River, and about 3 rkm downstream of the Shotgun Creek (Figure 2). Areas farther downstream are considered unsuitable due to excessive water depth, channel width, and braided stream morphology.

At the weir site, the Kogrukluk River is approximately 70 m wide and 3–4 m deep at full capacity. During normal summer operations, river depth is about 1.3 m in the deepest section. The weir is positioned in the center of a 2 km stretch of relatively straight channel that runs along the base of a southwest-facing hillside. The location's proximity to the hillside contributes to channel stability and provides a well drained campsite.

Construction

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 2008 are the same as those described by Baxter (1981), with the exception of an improved fish trap and a tighter picket spacing. The use of the new fish trap began in 1999 and the new picket spacing was first used in 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

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

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

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; however, extensive site surveys indicated that the weir location lacked the necessary homogenous riverbed profile and substrate stability for proper installation and operation of a floating weir (Shelden et al. 2005).

Maintenance

The weir was cleaned and inspected at least once each day. Small debris that accumulated around the weir pickets (sticks, leaves, fibrous root mats, small logs, algae, and fish carcasses) were removed and passed downstream. Large debris, such as large logs and root clumps, were removed using chainsaws, axes, and block and tackle. Sometimes larger debris requires partial dismantling of the weir.

The daily cleaning routine included a visual inspection of the weir for conditions that could compromise weir operations, such as substrate scouring or damaged pickets. Periodically the crew conducted more thorough inspections by snorkeling along the leading edge of the weir. Problems were addressed immediately. Incidences of substrate scouring were rectified with sandbags or comparable means.

Escapement Monitoring

The Kogrukluk River weir differs from other weir projects throughout the Kuskokwim River drainage in that it has not been operated based on a target operational period (see *Recommendations* section). Annually, the weir has been installed in late June, prior to the onset of the Chinook and chum salmon runs, and has been operated into late September to encompass the bulk of the coho salmon run. However, the annual operational period for the weir varies. Generally, no attempt has been made to estimate missed passage prior to installation and/or after removal of the weir. High water events or damage to the weir occasionally resulted in inoperable periods. 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 1-hour shifts 4 to 8 times 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 cumulative seasonal counts were recorded in a designated logbook. These counts were reported each morning to ADF&G staff in Bethel via single side band radio or satellite phone.

The live trap was used as the primary means of upstream fish passage. Fish were counted as they entered the downstream end of the trap. Proper identification was enhanced by use of a clear-bottom viewing box that reduced glare and water turbulence. In addition to aiding in species identification, this tool allowed observers to identify and trap tagged fish in support of tagging projects, such as *Kuskokwim River Coho Salmon Run Reconstruction* in 2008. 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) describes other methods.

Small fish that pass between the weir pickets were not enumerated. Since picket spacing was reduced in 2005 the occurrence of this type of passage has been considered negligible for all salmon species except pink salmon. Complete enumeration of pink salmon is not possible for this reason. Consequently, reported pink salmon abundance reflects only the number of fish observed passing the weir through the counting location during normal enumeration routines, and the reported escapements of pink salmon are known to be an under-representation of actual abundance. No effort is made to estimate pink salmon escapement during periods of inoperability.

Estimating Missed Passage

To better assess annual run size of each species of salmon and to facilitate comparison among years, upstream salmon passage was estimated for days when the weir was not operational within the season. When historical records indicate that passage of a particular species on an inoperable day was probably negligible, passage was assumed to be zero. However, when historical records indicate that passage of a particular species was probably significant, 1 of the 4 formulas listed below were used to calculate potential missed passage. The method used depended on the duration and timing of the inoperable periods.

Single Day

When the weir is not operational for part or all of one day, an estimate for the inoperable day is calculated using the following formula:

$$\hat{n}_{d_i} = \left(\frac{\left(n_{d_i-2} + n_{d_i-1} + n_{d_i+1} + n_{d_i+2}\right)}{4} \right) - n_{o_i} \tag{1}$$

where

n_{d_i-1}, n_{d_i-2} = observed passage of 1, 2 days before the weir was washed out;

n_{d_i+1}, n_{d_i+2} = observed passage of 1, 2 days after the weir was reinstalled; and,

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

Linear Method

When the weir is not operational for 2 or more days and later becomes operational, passage estimates for the inoperable days are calculated using the following formula:

$$\hat{n}_{d_i} = (\alpha + \beta \cdot i) - n_{o_i} \tag{2}$$

$$\alpha = \frac{n_{d_i-1} + n_{d_i-2}}{2}$$

$$\beta = \frac{\left(n_{d_i+I} + n_{d_i+I+1}\right) - \left(n_{d_i-1} + n_{d_i-2}\right)}{2\left(I+1\right)}$$

where

$I =$ number of inoperative days (I>2), and

$n_{d_i+I}, n_{d_i+I+1} =$ observed passage the first day after the weir was reinstalled.

Proportion Method

In circumstances when the weir does not first become operational until well into the one or more salmon runs, or when the weir ceases operating before data suggest salmon runs are nearing completion, daily passage for inoperable days is estimated using passage data from another year at the Kogrukluk River weir or from a neighboring project. The dataset used to model escapement for a particular situation is selected because it exhibits similar passage patterns to the incomplete dataset. With this method, daily passage estimates are calculated using the following formula:

$$\hat{n}_{d_i} = \left(\frac{\left(n_{md_i} \times \sum n_{d_i} \right)}{\sum n_{md_i}} \right) - n_{o_i} \tag{3}$$

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.

Exponential Method

When model data sets are not adequate to use the "proportion method" the "exponential method" can be used. This method uses non-linear regression to fit an exponential function to existing data. For estimating the beginning of a run, use the rising limb of the run curve to fit an exponential trend line. For estimating the end of a run, use the falling limb of the run curve to fit an exponential trend line. Using this method the trend line is fitted to the data using the exponential function:

$$\hat{n}_{d_i} = ae^{bi} \tag{4}$$

where

a = y-intercept of the fitted line

b = slope of the fitted line

i = day of the estimated portion of the run

Estimates Required in 2008

The "proportion method" was used to estimate missed coho passage, when high water levels prompted early removal of the weir in 2008, prior to coho salmon run completion as suggested by historical data. The "linear method" has been used more frequently in recent years since 2003 but varies from previous years. Clark and Salomone (2002) describe details of the methods used for estimating missed daily passages prior to 2003.

Carcasses

Each time the weir was cleaned, spawned-out salmon (hereafter referred to as carcasses) that washed up on the weir were counted by species and discarded downstream. Daily and cumulative carcass counts were copied to a logbook.

AGE, SEX, AND LENGTH COMPOSITION

The age, sex, and length (ASL) composition of the total annual Chinook, chum, and coho salmon escapements was estimated by live sampling a portion of the fish passage. Sampling was distributed throughout the season to account for temporal dynamics that occur as the run progresses upstream. These samples were then 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 0.20 (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 samples. The term "pulse" is used to describe an instantaneous sample, though in practice a pulse sample is typically collected over the period of a few days. 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 7–10 days. The goal was to collect a minimum of one pulse sample from each third of the run.

The comparatively low numbers of Chinook salmon running concurrently with large numbers of chum salmon and sockeye salmon at Kogrukluk River weir makes pulse sampling impractical. In 2008, sampling efforts followed a daily collection schedule based on historical run timing information using a sample size of 350 fish (Molyneaux et al. *In prep*). 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. The trap included an entrance gate, holding pen and exit gate. Salmon were trapped by opening the entrance gate while the exit gate remained closed. Fish were allowed to swim freely into a 2.4 by 1.5-m holding box. The entrance doors to the trap can be arranged in a V-shape, or fyke to prevent fish from easily escaping. The holding box was allowed to fill with fish until a reasonable number for sampling was inside. Short handled dip nets were used to capture fish within the holding box. 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 (DuBois and Molyneaux 2000). 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 of tail (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 holding box was emptied.

Chinook salmon samples were often collected through "active sampling," which consisted of capturing and sampling Chinook salmon 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, and sampling location was copied to computer mark–sense forms that correspond to numbered gum cards. The completed gum cards and mark–sense forms 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 were also loaded into the Arctic-Yukon-Kuskokwim (AYK) salmon database management system (Brannian et al. 2006a). 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. (2008). Samples were partitioned into a minimum of 3 temporal strata, based on overall distribution within the run in 2008. 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.

There were 2 summary tables generated for each species. The first table provides the escapement and percentage of each age-sex class by stratum, with season totals weighted by escapement in each stratum. The second table provides a summary of mean length-at-age by sex for each 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 (e.g. age-1.3). 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 continue 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*. The project was completed in 2007. 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).

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 0730 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 were consistent with past years at this project.

Beginning in 2006, water temperature was also measured using a Hobo® Water Temp Pro v.1 data logger remote temperature logger located near mid-channel just upstream from the weir. The data logger was programmed to record temperature every hour during the operational period. In 2008 air temperature was also measured using a remote data logger placed 30 ft from the stream bank in a shaded area. In 2008 two data loggers were deployed in each stream and air location, one stream and one air data logger were recovered at the end of annual weir operations, while the others were left in the field for winter data collection. The records were retrieved in the fall and compared to temperatures obtained using a thermometer.

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 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 5m above baseline and corresponds to the highest water level observed at the Kogrukluk River weir. Water stage was measured at approximately 0730 and 1700 hours.

RELATED FISHERIES PROJECTS

Kuskokwim River Coho Salmon Run Reconstruction

The Kogrukluk River weir served as a recovery site for a basin–wide mark–recapture and radiotelemetry study entitled *Kuskokwim River coho salmon investigations* (Project No. 803) lead by Kevin Schaberg, ADF&G, Anchorage. The project was designed to estimate coho salmon abundance, distribution, and run timing above the upper Kalskag tagging site (rkm 270), as well as produce a statistical model that would be used to compute historical annual abundance estimates from known escapement data. Coho salmon were captured at upper Kalskag and tagged using individually numbered Floy® anchor tags. A subset of tagged coho salmon received an individually coded radio-tag. Adipose fin clips were used as a secondary mark. Tagging methods are described by Stuby (2007).

Whenever possible, tagged coho salmon that passed through the weir's live trap were captured to recover tag information. Recorded data for "recovered" fish included the tag number, tag color, fish condition, presence of secondary mark, and recovery date. When a tagged fish was not captured it was recorded as "observed" along with the tag color and passage date. Tag loss was assessed at the weir by inspecting for secondary marks during routine ASL sampling.

This project built on an established network of telemetry tracking stations set up in support of Stuby (2007), and additional tracking stations were installed to increase the resolution of coho salmon distribution. The Kogrukluk River weir crew maintained the Kogrukluk River tracking station, including periodic data downloads. All data collected by the crew were transferred to the principal investigator on an opportunistic basis.

Baseline Genetic Sample Collections

In 2008, the Kogrukluk River weir was used as a platform to collect genetic tissue from pink salmon and Dolly Varden. Pink salmon samples were collected on an opportunistic basis to contribute to existing baseline collections, and were sent to the ADF&G genetics lab in Anchorage for storage and processing. Dolly Varden genetic tissue samples were collected in support of a USFWS project: *Baseline development for Dolly Varden in southwestern Alaska* (M. J. Lisac, Primary Investigator, USFWS Togiak National Wildlife Refuge, Dillingham). Dolly Varden samples, with associated sex and length data, were sent to the USFWS conservation genetics lab in Anchorage for storage and processing.

Otolith Collection

Otoliths were collected from chum and Chinook salmon carcasses in support of 2 pilot studies investigating the utility of micro-chemical analysis for stock identification. Crews collected carcasses from the weir on an opportunistic basis. Carcasses were examined to ensure that the fish had spawned above the weir, and these were assumed to belong to Kogrukluk River stocks. A goal was set to collect otoliths from 20 male and 20 female chum and Chinook salmon carcasses. Carcasses were rated 1 to 4 based on gill color, with red gills rated 1 and no color rated 4. Saggital otoliths were collected only from fish with a rating of 1 or 2. Plastic forceps were used to extract the samples to prevent contamination from foreign metals. Fresh forceps were used on each sample and then discarded to prevent contamination between samples. Otoliths from each fish were placed in separate envelopes with location, length, and sex information recorded on the outside. Samples were divided between investigators from USFWS (F. Harris, Principle Investigator, USFWS, Kenai Fisheries Resource Office, Kenai) and the University of Alaska Fairbanks (T. Sutton, Principle Investigator, UAF, Fairbanks).

Juvenile Coho Collection

Juvenile coho salmon were collected throughout the watershed in support of a *Productivity of Kuskokwim juvenile coho salmon* study, in an effort to develop scale radius-fish length relationships (Greg Ruggerone, Principle Investigator, Natural Resources Consultants, Seattle). Baited minnow traps were used to collect juvenile coho salmon. Traps were baited with cured salmon eggs and soaked for variable lengths of time (typically 0.5 to 1 hour) to maximize trapping efficiency. Traps were placed in pools, backwater areas, and along river and creek banks. Captured coho salmon juveniles were measured to determine size class. Fish were divided into size classes and placed in Whirlpacks® with buffered 10% formaline. A log book was used to record soak time, number of each species captured, and approximate size of juvenile coho salmon collected. Fish were collected throughout the summer or until a sample size of 100 juvenile coho salmon was collected with fish evenly distributed across the range of available size classes. Samples were sent to the principle investigator at the end of field operations.

Sockeye Ecotypic Variation Study

In 2008 the Kogrukluk River weir project acted as a platform for a study of *Ecotypic variation in AYK sockeye stocks* (Megan McPhee, Principle Investigator, Flathead Lake Biological Station University of Montana, Missoula). This 2 year study will assess biocomplexity among Kuskokwim River sockeye salmon stocks, determine the relationship between biocomplexity and run strength, and compare findings with Bristol Bay populations. In 2008, investigators located sockeye salmon spawning aggregates in the upper Holitna River drainage, quantified habitat characteristics, and collected morphology measurements, egg samples, fin clips for genotyping, and otoliths for aging. In support of this project, the Kogrukluk River weir crew provided a base camp to assist in sample collection.

RESULTS

ESCAPEMENT MONITORING

In 2008, the Kogrukluk River weir was operated from 3 July through 13 September. Large winter snowpack and late melting conditions resulted in prolonged high water and thus a later than average weir installation. Installation of the weir began on 24 June and the weir was fully operational by 1500 hours on 3 July. The weir remained fully operational throughout the above mentioned operational period. The weir was pulled prior to historical average extraction dates, due to several high water events. To prevent structural damage, the crew dismantled parts of the weir once water level or debris load exceeded a safe level. Persistent precipitation hindered efforts to reinstall the weir to characterize the end of the coho salmon run. Footnotes provided in Table 1 indicate when inoperable periods occurred and the estimation method used, if any.

Chinook Salmon

Total annual Chinook salmon escapement upstream of the Kogrukluk River weir in 2008 was 9,730 fish, of which 52 were estimated. The first Chinook salmon was observed on 4 July, daily passage peaked at 831 fish on 23 July, and the last Chinook salmon was observed on 30 August (Table 1). The median passage date was 23 July and the central 50% of the passage occurred between 18 and 26 July.

Chum Salmon

Total annual chum salmon escapement upstream of the Kogrukluk River weir in 2008 was 44,978 fish, of which 733 were estimated. The first chum salmon was observed on 3 July and daily passage peaked at 3,186 fish on 17 July (Table 1). Chum salmon were observed on the last day of operations, but daily passage was very low during the last 2 weeks of operation. The median passage date was 24 July and the central 50% of the passage occurred between 17 and 31 July.

Coho Salmon

Total annual coho salmon escapement upstream of the Kogrukluk River weir in 2008 was 29,661 fish, which includes an estimated 4,011 fish (13.5% of the total run) that passed during inoperable periods. The first coho salmon was observed on 25 July and daily passage peaked at 2,358 fish on 7 September (Table 1). Prior to early weir extraction significant numbers of coho salmon were still passing the weir, however passage numbers indicated the run was in decline. The median passage date was 4 September and the central 50% of the passage occurred between 29 August and 8 September.

Sockeye Salmon

Total annual sockeye salmon escapement upstream of the Kogrukluk River weir in 2008 was 19,675 fish, of which 117 were estimated. The first sockeye salmon was observed on 4 July, daily passage peaked at 1,783 fish on 17 July, and the last sockeye salmon was observed on 25 September (Table 1). The median passage date was 23 July and the central 50% of the passage occurred between 19 and 27 July.

Pink Salmon

Observed pink salmon escapement upstream of the Kogrukluk River weir in 2008 was 1,036 fish, of which 45 were estimated (Appendix A). Pink salmon were observed passing upstream of the weir from 5 July to 31 August. Passage estimates for inoperable periods are not considered accurate and will not be discussed in detail. Historic data, as well as daily observations, indicated that the run had diminished to negligible amounts at the time the inoperable period occurred. Furthermore, the number of individuals counted through the weir was assumed to represent an underestimate of the actual escapement because pink salmon are small enough to pass between the pickets uncounted.

Other Species

Several other species are routinely observed passing upstream and downstream of the weir by crew members during normal salmon enumeration routines. Other species observed passing upstream of the Kogrukluk River weir during the 2008 field season included 747 char (*Salvelinus spp.*) and 22 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 11,939 salmon carcasses were recovered from the Kogrukluk River weir (Appendix B), or 11.5% of the total annual escapement of all Pacific salmon species. A total of 1,426 Chinook salmon carcasses were recovered (14.7% of the annual escapement) from 7 July through 10 September. From 19 July through 13 September, 8,143 chum salmon carcasses were recovered, comprising 18.1% of the annual escapement. The 1,451 sockeye salmon carcasses recovered in 2008 comprised 7.4% of the observed annual escapement and were collected from 30 July through 13 September. Weir removal occurs well before the bulk of coho salmon carcasses return downstream resulting in only 23 coho salmon carcasses being recovered (less than 0.1% of the annual escapement) from 22 August through 11 September. A total of 896 pink salmon carcasses were recovered (86.5% of the observed annual escapement) from 30 July through 10 September. Other fish species recovered from the weir include Arctic grayling, char, northern pike, and whitefish.

AGE, SEX, AND LENGTH COMPOSITION

Chinook Salmon

Chinook salmon ASL sampling at the Kogrukluk River weir was conducted on a near daily basis from 7 July to 7 August, resulting in a total sample of 363 fish. Age, sex, and length were successfully determined for 296 fish (81.5% of the total sample) or 3.0% of the annual escapement (Table 2). The total annual escapement was partitioned into 3 temporal strata based on sample size and the temporal distribution of the sampling effort, which effectively encompassed each third of the run. The first, second and third sampling events occurred at 2%, 49%, and 93% of the run; sample sizes of the 3 strata were 72, 116, and 108 fish, respectively (Table 2). Overall, 95% confidence intervals for age composition proportions were no wider than ±6.0%.

Age Composition

The Chinook salmon escapement past the weir was dominated by 3 age classes: -1.2, -1.3, and -1.4 (Table 2). Combined, these 3 age classes composed 98.4% of the total annual escapement. Some variability across the dominate age classes was observed with age-1.3 (5-year-old) fish the most abundant, followed by age-1.2 (4-year-old) fish, and age-1.4 (6-year-old) fish. These age classes composed 43.4%, 35.9%, and 19.1% of the total run respectively. Age-1.1 and -1.5 fish were relatively few and composed only 0.5%, and 1.0% of annual escapement respectively. Rarely observed age-2.3 fish composed 0.2% of the total run. No other age classes were sampled although they are known to occur in the Kogrukluk River drainage (Molyneaux et al. 2008). The majority of age-1.2 and-1.3 fish were males, whereas most age-1.4 fish were females.

Temporal variations in age class percentages were observed. The proportion of age-1.2 fish in the escapement varied little as the run progressed, but lowest in the second stratum (33.6%) and

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

highest in the third stratum (40.7%). The percentage of age-1.3 fish continually decreased from the first stratum to the last whereas the percentage of age-1.4 fish generally increased (Figure 4). The first and second strata were dominated by age-1.3 fish (54.2%, 44.8% respectively), while the third stratum was dominated by age-1.2 fish (40.7%).

Sex Composition

Female Chinook salmon comprised 23.2% of the total annual escapement based on weighted ASL samples at the Kogrukluk River weir (Table 2). The percentage of females steadily increased over the course of the run: 11.1% in the first stratum, 21.6% in the second stratum, and 38.9% in the third stratum (Table 2, Figure 5). This correlated with an increasing proportion of the female dominated age-1.4 (6-year-old) fish and a decreasing proportion of the male-dominated age-1.3 (5-year-old) fish as the run progressed. The majority of female Chinook salmon were age-1.4 fish (62.3%). Male Chinook salmon were typically younger and divided nearly equally between age-1.2 and -1.3 fish (~46% each).

The method of visually identifying the sex of every passing Chinook salmon yielded a sex ratio similar to that derived from ASL sampling (Figure 6). Based on this method, female Chinook salmon composed 26.9% of the annual escapement. Male and female passage counts were stratified similarly to ASL samples for comparison, yielding per-stratum sex ratios that generally mimicked those derived from ASL sampling. As determined through regular passage counts, females composed 17.5%, 25.5%, and 39.1% of total Chinook salmon escapement during the first, second, and third stratum, respectively. Differences in total annual percent females between the 2 methods were negligible.

Length Composition

Analysis of length composition revealed partitioning by sex and age class. The length of female Chinook salmon ranged from 500 to 903 mm, and males ranged from 398 to 931 mm. In the 2 age classes that contained considerable numbers of both males and females (age-1.3 and-1.4), female Chinook salmon were larger at age than males and average length increased with age for both females and males (Figure 7). Average length of age-1.3 females was 781 mm while the average length of age-1.4 females was 846 mm and the average length of age-1.5 females was 889 mm. Average lengths for male age-1.2, -1.3, -1.4, and -1.5 Chinook salmon were 540 mm, 701 mm, 782 mm, and 862 mm respectively. Considering the variation within each age class, average lengths-at-age varied little during the run for both male and female Chinook salmon (Table 3; Figure 8).

Chum Salmon

Chum salmon ASL sampling at the Kogrukluk River weir was conducted in 3 pulses, distributed between 6 July and 4 August, resulting in a total sample of 660 fish. Age-sex-length were successfully determined for 524 fish (79.4% of the total sample) or 1.2% of the total annual escapement (Table 4). The total annual escapement was partitioned into 3 temporal strata based on the temporal distribution of sampling effort. Sample sizes were 196, 163 and 165 aged fish for the first, second, and third strata, respectively (Table 4). Sampling events were well distributed occurring at 4%, 41% and 80% of the run respectively. Overall, 95% confidence intervals for age composition were no wider than ±5.0%.

Age Composition

The chum salmon escapement past the weir was largely represented by 2 age classes, age-0.3, and -0.4 (Table 4). Combined, these 2 age classes composed over 95% of the annual escapement. Age-0.3 was the most abundant age class (53.8%), followed by age-0.4 (42.0%), age-0.5 (2.6%), and age-0.2 (1.5%). All predicted age-sex categories were found in 2008, and were predominantly male.

Relative age composition changed considerably over the course of the run. The percentage of age-0.3 chum salmon continually increased during the run, while the percentage of age-0.4 chum salmon continually decreased (Figure 9). Age-0.5 fish exhibited a slight decrease toward the end of the run, while -0.2 fish remained the same in the final 2 strata.

Sex Composition

Female chum salmon comprised 34.9% of the total annual escapement based on weighted ASL samples (Table 4). Sex composition varied slightly during the run but no consistent trends were apparent (Figure 5). The percentages of females in the first and third strata were the lower (32.7, 32.1 respectively) and highest during the second (38.0%). Both the male and female escapements were dominated by age-0.3 individuals (50.4% for males, 60.2% for females).

The method of visually identifying the sex of every passing chum salmon yielded a sex ratio that slightly deviated from that derived thru ASL sampling. Based on this method, female chum salmon composed 40.3% of the annual escapement (Figure 6). Male and female passage counts were stratified similarly to ASL samples for comparison, yielding per-stratum sex ratios similar to those derived from ASL sampling, with the exception of the third strata. In the third stratum, the percent females by visual determination continued to rise while the ASL determined percentage of females fell. Visually determined through regular passage counts, females composed 33.1%, 40.3%, 44.0% of total chum salmon escapement during the first, second, and third strata, respectively. Differences in total annual percent females between the 2 methods were negligible.

Length Composition

Analysis of length composition revealed partitioning by sex and age class (Table 5). The length of female chum salmon ranged from 459 to 677 mm and males ranged from 448 to 680 mm. Males were generally larger at age than females, and average length generally increased with age for both males and females (Figure 7). Average lengths for female age-0.2, -0.3, -0.4, and -0.5 chum salmon were 475, 536, 565, and 581 mm, respectively. Average length for male age-0.2, -0.3, -0.4, and -0.5 chum salmon was 536, 556, 575, and 574 mm, respectively. For both males and females, average length-at-age varied little during the run (Table 5, Figure 10).

Coho Salmon

Coho salmon ASL sampling at the Kogrukluk River weir was conducted in 3 pulses, distributed between 20 August and 11 September, resulting in a total sample of 597 fish. Age, sex, and length were successfully determined for 455 fish (76.2% of the total sample) or 1.5% of the annual escapement (Table 6). The run was partitioned into 3 temporal strata based on the temporal distribution of sampling effort, with sample sizes of 155, 156, and 144 aged fish for each stratum. Sampling was well distributed with the first, second and third strata occurring at

12%, 35%, and 81%. Overall, 95% confidence intervals for age composition were no wider than ±4.0%.

Age Composition

The coho salmon escapement past the weir was dominated by age-2.1 individuals, which composed 81.4% of total escapement (Table 6). Age-3.1 fish composed 15.7% of the escapement and age-1.1 fish composed 2.9% of the escapement. No individuals from other age classes were found in the sample.

Slight variations in age class percentage occurred over the course of the run in 2008. The proportion of age-2.1 fish decreased over time while age-3.1 fish increased throughout the run (Figure 11). Proportions of age-1.1 fish showed little change as the run progressed.

Sex Composition

Females composed 55.1% of the total annual escapement based on weighted ASL samples (Table 6). The percentage of females steadily increased over the course of the run, composing 44.5% in the first stratum, 49.4% in the second stratum, and 66.0% in the last stratum (Figure 5). This change in percentage of females was largely attributable to an increasing abundance of age-3.1 females and decrease of age-2.1 males as the run progressed.

The method of visually identifying the sex of every passing coho salmon yielded a sex ratio that deviated from that derived thru ASL sampling. Based on this method, female coho salmon comprised 43.9% of the annual escapement (Figure 6). Male and female passage counts were stratified similarly to ASL samples for comparison, yielding per-strata sex ratios similar to those derived from ASL sampling. Visually determined through regular passage counts, females comprised 47.1%, 40.9%, and 45.8% of total coho salmon escapement during the first, second, and third stratum, respectively. The difference between the 2 methods was small, the total annual percent female as determined through ASL sampling was approximately 11% higher than determined visually (Figure 6).

Length Composition

Analysis of length composition revealed partitioning by sex and age class. The length of female coho salmon ranged from 466 to 594 mm, and males ranged from 397 to 615 mm. Female fish tended to be slightly larger than males of the same age, but differences were minor (Figure 7). Average lengths for age-1.1, -2.1, and -3.1 female fish were 537, 538, and 554 mm, respectively. Average lengths for age-1.1, -2.1, and -3.1 male fish were 465, 533, and 538 mm, respectively. Average length at age varied little during the run (Figure 12).

Sockeye Salmon

ASL Composition

Sockeye salmon ASL sampling at the Kogrukluk River weir was conducted on an opportunistic basis from 23 July to 8 August, resulting in a total sample of 228 fish. Age, sex, and length were not determined for any of the sampled fish because scale samples were lost in transit between the weir camp and Bethel. The lack of data precludes any age and length analysis for the 2008 season.

Sex Composition

We estimated through visual observations that female sockeye salmon accounted for 52.9% of the run.

WEATHER AND STREAM OBSERVATIONS

A total of 191 complete observations of weather and stream conditions were recorded between 21 June and 25 September (Appendix C1). Based on twice-daily thermometer observations, water temperature at the weir ranged from 4.0° to 14.0°C, and averaged 9.3°C. Based on hourly data logger readings, daily average water temperature ranged from 4.7°C to 11.4°C, and averaged 9.7°C (Appendix C2). Based on twice-daily thermometer observations, air temperature at the weir ranged from 0° to 27°C, and averaged 11.6°C (Appendix C1). A total of 244.3 mm of precipitation was recorded throughout the season. River stage ranged from 272 to 356 cm, and averaged of 303.4 cm (Appendix C1).

RELATED FISHERIES PROJECTS

Kuskokwim River Coho Salmon Run Reconstruction

Telemetry data from the tracking station at the Kogrukluk River weir along with telemetry data from aerial tracking efforts and tag passage data through the weir revealed that 91 tagged coho salmon passed upstream of the weir site. Of these, 24 were radio tagged, of which 21 were hand recovered by crew members. In addition to the radio tags, the weir crew also hand recovered 63 of the 67 anchor tags observed passing the weir.

The 2008 estimates of coho salmon abundance provided by this study are preliminary at the time of writing. Information regarding this study can be obtained from K. L. Schaberg (Fishery Biologist, ADF&G, Anchorage; Principle Investigator).

Genetic Sample Collections

Approximately 30 pink salmon and 20 Dolly Varden genetic samples were collected from the Kogrukluk River weir in 2008.

Otolith Collection

A total of 10 chum salmon and 58 Chinook salmon otolith samples were collected from the Kogrukluk River weir in 2008. Information regarding the collection, processing, and results can be obtained from T. Sutton (Principle Investigator, UAF, Fairbanks) and F. Harris (Principle Investigator, USFWS, Kenai Fisheries Resource Office, Kenai).

Juvenile Coho Salmon Collection

Approximately 40 juvenile coho salmon were sampled from the Kogrukluk River in 2008. Information regarding the collection, processing and results can be obtained from Greg Ruggerone (Principle Investigator, Natural Resources Consultants, Seattle).

Sockeye Ecotypic Variation

Information regarding the *Ecotypic variation in AYK sockeye stocks* project can be obtained from Megan McPhee (Principle Investigator, Flathead Lake Biological Station University of Montana, Missoula).

DISCUSSION

ESCAPEMENT MONITORING

In 2008, the Kogrukluk River weir operated from 3 July to 13 September. These dates and duration were sufficient to properly encompass the run timing of Kogrukluk River Chinook, chum, sockeye, and pink salmon runs. Operations were similar in duration and timing to the historical average (Figure 13). Salmon passage was low to moderate for several days following weir installation (Table 1), indicating that relatively few fish escaped upstream of the weir site prior to installation. No attempt was made to estimate passage for these species prior to weir installation. Historical data corroborate a tendency toward low passage numbers in late June and early July for these species (ADF&G 2009). The weir remained fully operational for the remainder of the Chinook, chum and sockeye salmon runs, and provided reliable escapement numbers.

Although the weir was removed because of high water before the coho salmon migration had fully diminished, we estimated that 88% of the run had already passed by that time. The rate of decline in passage at the time of removal (Table 1), along with historical comparisons (Figure 14), indicated that escapement after weir removal was probably low.

The reported escapement value for pink salmon is not considered reliable. The Kogrukluk River weir is not designed to accommodate pink salmon, which have been observed passing between weir pickets. We consider pink salmon counts an index of abundance at best and species detection at least. It is important to recognize these caveats when using pink salmon escapement data from this project.

We estimated above-average abundances of chum, sockeye, and coho salmon, while the escapement Chinook salmon was near the project average. Escapements of those species for which an escapement goal has been developed (Chinook, chum, and coho) were within or exceeded the escapement goal ranges (Figures 15 and 16). During the 2–3 years immediately preceding 2007, annual escapements of Chinook and chum salmon exceeded the upper boundary of the escapement goal ranges by tens of thousands, and the escapement of sockeye salmon have remained above the historical average (Jasper and Molyneaux 2007; Liller et al. 2008; Shelden et al. 2005). Annual coho salmon escapements have generally been within or above the escapement goal range since 2000, except in 2003 when the escapement was anomalously high (Shelden et al. 2004). Coho salmon escapements at the Kogrukluk River weir have only been below the lower boundary of the escapement goal 3 times in the past 17 years (Figure 16). This recent pattern of strong salmon escapement has been similarly observed other weir projects and escapement indices in the Kuskokwim River drainage (Elison et al. 2009 a-b; Miller and Harper *In prep* a-b; Stewart et al. 2009).

Chinook Salmon

Abundance

Since there were no inoperable days in the 2008 season, investigators are extremely confident that reported annual escapement accurately reflects actual escapement, making it a valuable indicator of run condition and adequate to reasonably investigate inter-annual differences and historical trends.

Considerable variation in abundance of Chinook salmon has been observed throughout the 33-year history of escapement monitoring at the Kogrukluk River (Figure 15). Escapement in 2008 was in the middle of the current SEG range (5,300–14,000 fish), a decrease from 2007 and a considerable decline from the record setting escapement in 2005 (Jasper and Molyneaux 2007; Liller et al. 2008). Chinook salmon escapements to the Kogrukluk River have exhibited a distinct sinusoidal pattern of increase and decrease throughout most of project history (Figure 15), perhaps resulting from climatic shifts such as El Nino/La Nina events. The "crest" observed in recent years was reflective of similar periods that occurred in the early 1980s and mid 1990s. The regularity of this sinusoidal trend has predictive potential and suggests 2009 escapement may be as low as or lower than 2008.

This persistent trend reveals that high returns from brood years with low abundance and low returns from brood years with high abundance, though counterintuitive, are not uncommon. For example, the record-high escapements observed at the Kogrukluk River weir in 2004, 2005, and 2006 consisted of the return from parent years of low abundance (1999 and 2000). Appendix E1 shows a brood table generated from the available Kogrukluk River data, which can be used to assess the above mentioned sibling relationships and cohort strength, but it does not account for the fraction of Kogrukluk River bound fish taken in the harvest that occurred downstream of the weir.

Overall, the total Kuskokwim River Chinook salmon escapement was considered average to below average in 2008; most Area projects reported a decrease in Chinook salmon escapement from 2007 and annual escapements have declined steadily since 2005, with the exception of George River Weir. (Figure 17; Elison et al. 2009 a-b; Miller and Harper *In prep* a-b; Stewart et al. 2009). The most notable disparities in annual abundance occurred at the George River and the Kwethluk River (2008 escapement was the second lowest on record) (Miller and Harper *In prep* a; Stewart et al. 2009). There are only 4 ground-based escapement monitoring projects with formal SEGs for Chinook salmon, and of these the Kogrukluk River was the only monitored river in which escapement was within its SEG (Figure 17). The Kuskokwim River drainagewide index for 2008 is the lowest since 2001. However, drainagewide Chinook salmon escapement in 2008 was higher than in 1999 and 2000; years which motivated the BOF decision to designate Kuskokwim River Chinook and chum salmon as "stocks of yield concern."

While there was a commercial fishery in 2008, it likely had little impact on Kogrukluk River Chinook salmon runs, as well as other Kuskokwim River Chinook salmon stocks, owing to the small harvest size. When compared to the recent 10-year average (3,287 fish), the 2008 harvest (8,865 fish) seems large, however in the past 10 years there have been very few commercial openings prior to the beginning of August. The 2008 Chinook salmon harvest pales in comparison to the historical average of 25,058 fish (1960–2007); this difference in harvest sizes is primarily a function of processor interest rather than abundance. The harvest of 8,865 Chinook salmon is small, especially when compared to the subsistence harvest. The commercial harvest only composes 11% of the total combined commercial and subsistence harvests (J. C. Linderman, Jr., Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication).

The total subsistence harvest for 2008 has not yet been estimated; however, the annual subsistence harvest of Chinook salmon has remained relatively constant through history, despite varying abundance. Therefore, the most recent 10-year average (1998–2007) of 70,984 fish (Smith and Dull 2008) is probably a reasonable approximation of the 2008 harvest, although this estimate is preliminary. The subsistence harvest and commercial harvest sum to an approximate harvest of 80,000 in 2008. In terms of size, the subsistence harvest represents a substantial component of the total run.

Run Timing at Weir

The 2008 Chinook salmon run at the Kogrukluk River weir was the latest on record, while the duration was just below average (Figure 18). The central 50% passage in 2008 occurred from 18 to 26 July, compared to the historical average of 7 to 17 July. The 2008 median passage date of 23 July was the latest on record for the Kogrukluk River weir. The earliest median passage date at the project is 7 July (1981 and 1996), the average date is 12 July, and the latest date before the 2008 season is 20 July (1999) (Figure 18). The Chinook salmon run timing at the Kogrukluk River weir has been successively later since 2004, which may be part of the sinusoidal pattern seen with Chinook salmon, but will only be apparent with more years of data collection. All other Kuskokwim River escapement monitoring projects exhibited late run timing; some projects were the latest on record in 2008, while run durations were average (Elison et al. 2009 a-b; Miller and Harper *In prep* a-b; Stewart et al. 2009).

Chum Salmon

Abundance

Researchers are confident that reported annual escapement in 2008 accurately reflected actual escapement, as no inoperable periods occurred during the majority of chum salmon passage. The earlier than average withdrawal date had no effect since only a few individuals every few days were being counted at the date of removal. Therefore, 2008 escapement data will be a valuable indicator of run condition and are adequate to reasonably investigate inter-annual differences and historical trends.

Considerable variation in abundance of chum salmon has been observed throughout the 33-year history of escapement monitoring for this project (Figure 15). Although annual chum salmon escapement in 2008 was far below the large escapements in 2005 and 2006 (Jasper and Molyneaux 2007; Liller et al. 2008), it was among the 10 largest escapements in the project's history and approached the upper limit of the SEG range.

Overall, Kuskokwim River chum salmon escapement was considered average in 2008. With the exception of the below average escapement at the Kwethluk River weir, all other projects reported escapements near or above average (Elison et al. 2009 a-b; McEwen *In prep*; Miller and Harper *In prep* a-b; Stewart et al. 2009). The only other Kuskokwim area project where a chum salmon escapement goal has been developed is the Aniak River sonar, which in 2008 exceeded the upper limit (Figure 19; McEwen *In prep*). Aniak River sonar and Kogrukluk River weir have shown similar trends in chum salmon escapement in recent years, both having record highs in 2005 and 2006 (Figure 19; McEwen *In prep*). Every monitoring project in the Kuskokwim River in 2008 reported chum salmon escapements lower than 2007. Regardless of how they differ among recent years, chum salmon escapements throughout the drainage have remained well above the relatively poor levels observed in 1999 and 2000.

The commercial fishery in 2008 harvested 30,516 chum salmon throughout the season. Compared to historical catches this was a small harvest relative to the total run, and likely had little impact on Kogrukluk and other Kuskokwim River chum salmon stocks. The 2008 chum harvest was slightly below the recent 10-year average (39,272 fish) and is nominal when compared to the historical average of 197,285 fish (1960–2007) (J. C. Linderman, Jr., Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication).

As with the commercial fishery, the effect of the subsistence fishery on individual Kuskokwim River chum salmon stocks was probably negligible. The total subsistence harvest for 2008 has not yet been estimated; however, the most recent 10-year average (1998–2007) of 53,571 fish (Carroll and Patton 2010) is probably a reasonable approximation of the 2008 harvest, although this number is subject to change. This subsistence harvest and the small commercial harvest of 30,516 sums to a total harvest of less than 85,000 in 2008, a small amount compared to the escapement of 144,107 fish observed across all Kuskokwim River weir projects combined, and the 427,911 estimated in the Aniak River via sonar (McEwen *In prep*).

Run Timing at Weir

The timing of the 2008 chum salmon run at the Kogrukluk River weir was the latest on record, but had an above average duration (Figure 20). The central 50% passage in 2008 passed between 17 to 31 July, compared to the historical average of 8 to 20 July. The 2008 median passage date was 24 July. The earliest median passage date at the project is 9 July (1981, 1988, and 1996), the average is 14 July, and the latest date before the 2008 season was 20 July (2005) (Figure 20). Though some variability in run timing existed among Kuskokwim River escapement monitoring projects, overall most projects observed later than average run timing based on median passage dates, as well as average run durations (Elison et al. 2009 a-b; Miller and Harper *In prep* a-b; Stewart et al. 2009).

Coho Salmon

Abundance

High water and debris loads affected the Kogrukluk River weir at the end of the season, requiring an early termination of weir operations. Daily passage prior to weir extraction indicated that the coho salmon run was in decline. Some coho salmon passage continued past the project end date as indicated by a few radio-tagged salmon detected by the nearby receiver station up to a week following weir removal (K. L. Schaberg, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). The timing and duration of the high water event had minor effects on enumeration of the 2008 coho salmon run, with 13.5% of the run requiring estimation. Consequently, the reported escapement of 29,661 fish is considered an accurate estimate of the total annual escapement past the weir (Appendix D). Combined with historical data, escapement values for 2008 will provide an important reference for constructing future estimates, models, and management initiatives.

Considerable variation in abundance has been observed throughout the 28-year history of coho salmon escapement monitoring at this project (Figure 16). Although annual coho salmon escapement in 2008 was far below the exceptional escapement recorded in 2003, it was the 6th highest on record and exceeded the upper boundary of the current SEG range. Escapement in 2008 was considerably above the pre-2004 escapement goal (threshold), which has only been achieved 10 other times throughout coho salmon monitoring history.

Generally, Kuskokwim River coho salmon escapement was considered to be average in 2008. Currently, the Kogrukluk River is the only tributary in the drainage that has an escapement goal established for coho salmon, which limits investigators' ability to assess overall (whole Kuskokwim River) escapement adequacy. Nearly all the drainagewide projects recorded increased escapement over the 2007 season with the exception of the George River and Takotna River weirs. Although reporting a decrease from 2007, the 2008 escapement at the George River weir was the third highest on record for the project. Regardless of inter-annual inconsistencies in recent years, Kuskokwim River coho salmon did not exhibit the spatially-consistent low abundances in the late 1990s that chum and Chinook salmon did; consequently, they were not subjected to the conservative management practices imposed on Chinook and chum salmon. Furthermore, coho salmon escapements in the Kuskokwim River have not exhibited periodic cycles of increase or decrease like those observed with Chinook salmon.

The 2008 commercial harvest of 142,862 coho salmon in 2008 (J. C. Linderman, Jr., Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication) seems relatively low when compared to historical harvests in the 1980s and 1990s, when commercial harvests frequently exceeded 600,000 fish with a recorded high of 937,299 fish harvested in 1996. When compared to the ground-based escapements observed in 2008, the commercial harvest may represent more of a moderate exploitation rate.

Estimates are not yet available for the 2008 coho salmon subsistence harvest, but the preliminary 1998–2007 average harvest estimate of 30,894 fish (Smith and Dull 2008) is probably a reasonable approximation because annual subsistence harvests have not varied greatly in the past 10 years of available data. Compared to the number of coho salmon captured in the commercial fishery, and recognizing that escapements were near average to above average, a subsistence harvest of approximately 31,000 coho salmon probably had little impact on escapements of individual stocks.

Run Timing at Weir

The 2008 coho salmon run at the Kogrukluk River weir exhibited slightly later-than-average run timing and a shorter-than-average duration for this project (Figure 14); however, the integrity of the analysis is limited by the early weir extraction. The central 50% passage in 2008 occurred from 23 August to 8 September, compared to the historical average of 25 August to 8 September. In 2008, the median passage date was 4 September. The earliest median passage date at the project is 25 August (1996), the average is 1 September, and the latest date is 10 September (1983) (Figure 14). All Kuskokwim River escapement monitoring projects observed near average run timing based on median passage dates and average run durations (Elison et al. 2009 a-b; Miller and Harper *In prep* a-b; Stewart et al. 2009).

Sockeye Salmon

Abundance

The early termination of weir operations in 2008 had no effect on sockeye salmon enumeration. No individuals had been counted for more than 2 weeks prior to weir removal. The absence of inoperable periods throughout sockeye salmon passage gave investigators high confidence that reported annual escapement accurately reflects actual escapement. The reported 2008 escapement is a valuable indicator of run condition and is adequate to reasonably investigate inter-annual differences and historical trends.

Considerable variation in abundance of sockeye salmon has been observed throughout the 33-year history of escapement monitoring at this project (Figure 16). Although 2008 escapement was not as high as in 2005 and 2006, it was the fourth highest escapement for this project. No distinct inter-annual patterns are obvious for Kogrukluk River sockeye salmon.

Sockeye salmon escapements have been unusually high in recent years, following a period of relatively low escapements between 1999 and 2004. There is currently no sockeye salmon escapement goal established for any Kuskokwim River tributary, which precludes a formal assessment of the adequacy of the escapements (Figure 22).

Little is known about the distribution and abundance of Kuskokwim River sockeye salmon. Sockeye salmon have been observed in several tributaries throughout the drainage (Burkey and Salomone 1999). Only the Kogrukluk and Kwethluk river weirs have a consistent history of enumerating large numbers of sockeye salmon; however, aerial surveys flown in the Stony River drainage have indicated significant numbers of sockeye escape to this tributary as well. Recent investigations have reviled previously unknown spawning aggregates in several middle and upper Kuskokwim tributaries. Of these, the largest concentrations of sockeye salmon occur in the Holitna River system, of which the Kogrukluk River is a tributary (S. E. Gilk, Fisheries Geneticist, ADF&G, Anchorage; personal communication). Of particular interest in these systems is the general lack of lentic habitat. Preliminary results of this study suggest that the ecological contribution of these "river type" sockeye salmon to the Kuskokwim drainage is larger than previously believed.

Sockeye salmon harvests coincide with the Chinook and chum salmon harvests because they share similar run timing. Like the Chinook salmon, the 2008 commercial sockeye harvest of 15,601 fish was an increase from recent 10-year average of 13,318 fish (J. Linderman; Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). The effect of the combined harvest pressure of subsistence and incidental commercial fisheries on Kogrukluk River sockeye salmon is unknown. At time of writing, subsistence harvest estimates are unavailable for sockeye salmon in the Kuskokwim River for 2008; however, the most recent 10-year average of 35,699 fish is a reasonable estimate (Smith and Dull 2008). The subsistence harvest combined with the modest commercial harvest results in an estimate of an approximate harvest of 49,000 Kuskokwim River sockeye salmon. These harvest estimates cannot be properly compared to weir abundance estimates because most monitored tributaries do not see large escapements of sockeye salmon (Elison et al. 2009 a-b; Miller and Harper *In prep* a-b; Stewart et al. 2009).

Run Timing at Weir

The timing of the 2008 sockeye salmon run at the Kogrukluk River weir was the latest on record for this project (Figure 23). However, the duration of the run was near average. The central 50% passage in 2008 occurred from 19 to 27 July, compared to the historical average from 10 to 19 July. The 2008 median passage date was 23 July. The earliest median passage date at the project is 9 July (1981), the average is 15 July, and the latest date prior to the 2008 season is 22 July (1999, 2007) (Figure 23). The only Kuskokwim area projects that enumerate significant numbers of sockeye salmon are the Kogrukluk and the Kwethluk River weirs. The sockeye salmon run at the Kwethluk River weir was later than average by only 3 days compared to 8 days at Kogrukluk River weir. The duration of the run at both projects was slightly below to near average in 2008. Other Kuskokwim River drainage projects reported near average run timing and duration; however, the integrity of these spatial comparisons is limited, as few monitored tributaries support considerable numbers of sockeye salmon.

Pink Salmon

No tributary system in the middle to upper Kuskokwim River drainage has a history of enumerating large escapements of pink salmon. Escapements of pink salmon at Kuskokwim River escapement projects have never been large and are more a matter of curiosity than a measure of an important resource. Therefore, estimates of missed escapement are not typically reported.

However, we can make a few general comments regarding the biology of these stocks. Kuskokwim River pink salmon migrations show a bi-annual pattern of greater and lesser abundance which is likely a result of the life history strategy of the species: namely, that pink salmon exhibit a fixed 2-year life span resulting in even- and odd-year spawning aggregates that are reproductively isolated (Heard 1991). More interestingly, the relatively few pink salmon that pass the Kogrukluk River weir represent one of the farthest known freshwater migrations of pink salmon in the world (Morrow 1980; Heard 1991). Continued monitoring of this species has potential to help track the evolution of the Kuskokwim River ecosystem and productivity.

Historically, the contribution of pink salmon to the overall salmon escapement at the Kogrukluk River weir has been negligible, often contributing less than 10 individuals per year. Generally, 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.

The successful weir operations in 2008 provided a record escapement estimate for pink salmon at the Kogrukluk River weir (1,036 fish). This record surpassed the previous record in 2006 of 933, which in turn surpassed the 2005 record of 106. Prior to these years the greatest number of pink salmon counted at the Kogrukluk River weir had been 23 in 1988.

The small size of pink salmon makes estimating passage difficult as they have the ability to pass up and down stream between the pickets freely and uncounted. Thus, pink salmon escapement data from 2008 are considered incomplete and all reported escapement values under-represent daily passage. This issue was partially remedied in 2005 when the weir structure was modified with new components that reduced picket spacing (Jasper and Molyneaux 2007). Even so, the passage of pink salmon through weir pickets is probably still substantial, but it does appear that the contribution of pink salmon to this system, though small, is greater than previously believed.

The remarkable increases in recorded passage in recent years are likely a combination of the improved weir design and operation, and greater relative abundance. The George and Tatlawiksuk River weir crews also reported increases in pink salmon (Costello et al. 2007; Hildebrand et al. 2007). Historically (pre-2006), the George River weir averaged 181 individuals per year and the Tatlawiksuk River weir averaged only one fish per year. Only 2 pink salmon have been observed at the Takotna River weir throughout its history. The George River weir crew enumerated 2,444 pink salmon in 2008, which greatly exceeded the 2007 escapement of 325 fish. (Stewart et al. 2009). In addition, the Tatlawiksuk River weir crew observed 19 pink salmon (Elison et al. 2009 a). Consistent with past years, no pink salmon were observed at Takotna River weir (Elison et al. 2009 b). The picket spacing used at the George and Tatlawiksuk River weirs has not changed in recent years, which supports the conclusion that the observed increase in pink salmon escapements at Kogrukluk River weir is not due solely to changes in picket spacing, but also an actual increase in abundance. The reason for the increased abundance in upper river tributaries is unknown. Further monitoring is necessary to determine the relevance and possible implications of this observed increase in returns of pink salmon to the Kuskokwim River drainage.

Carcasses

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. Water levels influence reported carcass deposition in 2 ways. First, high water levels probably increase the rate of carcass washout and vice versa. Second, carcass deposition was not estimated for inoperable periods; thus, the reported number of carcasses is an underestimate. Water levels in 2008 steadily declined throughout late August, when carcass deposition was at its peak. Since carcass washout rates are so closely tied to water level, it is impossible to standardize the data, making any attempt at trend analysis among years difficult and unreliable. Despite these limitations, 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, contributing to the productivity of the system through the introduction of marine derived nutrients as described by Cederholm et al. (1999).

AGE, SEX, AND LENGTH COMPOSITION

Chinook Salmon

The low ratio of Chinook salmon to chum salmon at the Kogrukluk River weir makes sampling Chinook salmon in 3–5 day pulses difficult and impractical. In recent years, Kogrukluk River weir crews have sampled Chinook salmon opportunistically throughout the run and have not adhered to a strict pulse-sample protocol. In 2008, the crew's objective to sample a fraction of escapement every day was met, and sampling events and sizes mirrored the escapement curve. As a result, the sample met the objective for confidence interval widths, indicating these data are a good representation of the run.

Age Composition

The assortment of age classes seen at the Kogrukluk River weir in 2008 (age-1.2, -1.3, -1.4 and -1.5) are similar to past years, and similar to what has been observed elsewhere in the Kuskokwim Area (Molyneaux et al. *In prep*). In 2008, each dominant age class (age-1.2, -1.3, and -1.4) composed 35.9%, 43.4%, 19.1% of the run respectively (Table 2). This composition deviated from recent years and the historical norm in which proportions were nearly equal (Figure 24). At the Kogrukluk River weir age-1.2 fish historically constitute only about 24% of annual escapement, whereas age-1.3 and age-1.4 fish typically constitute about 36% each of escapement. Age-1.2 fish were relatively abundant and constituted a larger than average proportion of the run in 2008 (Figure 24). In contrast, the percentage of age-1.3 fish was above average, but of average abundance in actual numbers, while age-1.4 fish were far below average both in proportion and abundance. This pattern of age abundances suggests that the subsistence fishery impacted the Kogrukluk River Chinook salmon stock, while the commercial fishery had limited affect. The commercial fishery, restricted to a maximum of 6-inch stretch mesh gillnets in 2008, targets the smaller and thus younger fish while the subsistence fishery generally utilizes 8-inch stretch mesh, which targets larger and thus older fish. If the commercial fishery had a pronounced effect on Kogrukluk River stocks, one would expect to have seen lower abundances of younger fish. This however is not substantiated and is merely a suggestion of a possible mechanism for the recently observed trend.

The age composition of Chinook salmon at the Kogrukluk River weir was not consistent with other Kuskokwim Area projects in 2008; the age compositions across all other projects were remarkably similar to one another although inevitably showed a small degree of variability. While similar age composition was persistent across all other projects, there was variability in how these projects compared to their respective historical averages. All projects, including Kogrukluk had one trend in common: the proportion of age-1.3 fish at each project in 2008 was higher than the respective historical average for that project. George River weir's age composition was the most similar to that of Kogrukluk River weir, in that there was an increase in the proportion of age-1.3 fish and a decrease in age-1.4 fish. The trend of increased proportions of age-1.3 fish throughout the Kuskokwim drainage is not surprising considering that the percentage of age-1.2 fish was high at most projects in 2007 (Molyneaux et al. *In prep*).

Additional forecasting value comes from the relatively strong sibling relationship that Kuskokwim River Chinook salmon tend to show, wherein the relative strength of each age class produced from a given brood year is often mirrored in subsequent year escapements of sibling age classes in subsequent years (Figure 24; Appendix E1). By this relationship, it is possible to make limited predictions about age-specific run strength in subsequent years based on past sibling returns. For instance, average to above average abundance of age-1.2 and -1.3 Chinook salmon in the Kogrukluk River in 2008 would suggest an above average return of their age-1.3 and -1.4 siblings in 2009, but how this pertains to total escapement will remain to be seen. It is important to note that these are limited predictions that do not take into account the fraction of fish harvested down river.

The age composition of Kuskokwim River Chinook salmon escaping to the Kogrukluk River drainage varied throughout the 2008 run. As the run progressed, the percentage of age-1.3 individuals continually decreased while the percentage of older (age-1.4) individuals slightly increased (Figure 4). The proportion of age-1.2 fish changed little as the run progressed. The age-1.3 individuals dominated the early two thirds of the run while age-1.2 individuals dominated the final third. During most years, intra-annual trends among age classes are not well-defined. Upon examination of graphs generated from historical data (Figure 4), no defined trends were evident. This is consistent with other escapement monitoring projects throughout the Kuskokwim River drainage (Elison et al. 2009 a-b; Miller and Harper *In prep* a-b; Stewart et al. 2009).

Sex Composition

At 23.2% of the total 2008 escapement (Table 2), the percentage of female Chinook salmon at Kogrukluk River weir was only slightly below the historical average of 32.3%. The percentage of females in 2008 was well within the historical range of 16.4 (2004) to 53.2% (1999) (Figure 25). The number of females in the Chinook salmon escapement (2,262) was also below the historical average (3,636). The sex composition was attributable to both a relatively high abundance of age-1.2 and age-1.3 fish, which are predominantly male, and a relatively low abundance of age-1.4 fish which are predominantly female. Elsewhere in the Kuskokwim River drainage, percentages and abundances of female Chinook salmon were generally low (Molyneaux et al. *In prep*). As mentioned above, it is uncertain what role the commercial and subsistence fisheries played in the recently observed trends.

At the Kogrukluk River weir, as with most others, the percentage of females tends to increase as the run progresses past the weir, and this trend remained consistent in 2008 (Figure 5, Molyneaux et al. *In prep*). Since the majority of females are age-1.4 fish, and the majority of males are age-1.2 or age-1.3 fish, the timing of each sex through the weir influences the age composition at that time (Table 2, Figure 4). Consequently, the intra-annual increase in the proportion of females corresponded to the observed increase in age-1.4 individuals during later phases of the run. However, consistent intra-annual trends in sex composition do not translate into consistent intra-annual trends in age composition throughout much of the Kuskokwim River drainage.

Sex composition of the fish sampled for ASL information typically serves as the basis for characterizing the sex composition of the annual escapement. However, concerns are sometimes raised that the physical process required to capture fish for ASL sampling could be selective for or against specific components of the population (e.g. the nature of fish trapping might encourage or discourage discrete age or sex classes through inter- and intraspecific interactions within the weir trap). In order to assess potential bias, the crew at the Kogrukluk River weir has visually recorded the sex of every Chinook salmon observed passing upstream of the weir throughout project history. In each year that paired data have been collected, the ASL sampling method has yielded a female percentage similar to the visual method, and the difference has usually been less than 5 percentage points (Figure 26).

To assess whether a sampling bias was present in 2008, the 95% confidence interval was determined for the season total proportion of female Chinook salmon passage derived from ASL sampling data. The percent female value, as determined by visual inspection, fell well within the confidence bounds of the ASL derived data, indicating differences between the methods were minute. As the run progressed, variability occurred between percent females determined visually and thru ASL sampling with largest difference, less than 7% (also the smallest sample size of 72 fish), observed in the first stratum (Figure 6). Though perhaps present, the potential bias between the 2 methods is not great enough to concern investigators.

Length Composition

Mean lengths for each age-sex category in 2008 were within the historical range (Figure 27). Age-1.3 Chinook salmon average lengths were very similar to the previous year, and lengths for both males and females have shown little variation since 2002. Similarly, age-1.4 fish showed little variation from the previous year: males were identical to the 2007 average length, while females were slightly small, and both males and females were smaller than the historical average.

A retrospective analysis of age-1.3 and -1.4 males and females at this project suggests a general increase in length-at-age between 1984 and 1991, and then a general decrease through 2007 (Figure 28; Molyneaux et al. 2008, Jasper and Molyneaux 2007). The increasing trend in mean length from 1984 to 1991 is most pronounced for age-1.3 fish, but for age-1.4 fish the trend is weak at best (Figure 27). Furthermore, with each successive year of data collection, the decreasing trend in mean length of Chinook salmon in recent years has faded and mean lengths-at-age have remained relatively consistent since about 1999.

The observation that female Chinook salmon tended to be longer than males of the same age (Figure 7) was a common pattern throughout the Kuskokwim River drainage in 2008 (Molyneaux et al. *In prep*). Mean length increased with age, and the length ranges of female age-1.3 and male age-1.4 fish overlapped broadly. Chinook salmon rarely show an obvious intra-annual trend in length by age class over the course of the season, and apparent trends tend to be weak (Figure 8). The length of fish in each age-sex category did not change appreciably between the temporal strata in 2008, which is typical for Chinook salmon at Kogrukluk River weir and elsewhere in the Kuskokwim River drainage (Figure 8, Molyneaux et al. 2008).

Management Implications

Salmon are harvested in both subsistence and commercial fisheries that occur in the main-stem Kuskokwim River far downstream from the Kogrukluk River and other spawning areas (Smith and Dull 2008; Whitmore et al. 2008). Most harvest is taken with gillnets which are size-selective for discrete components of the returning salmon population. The potential impact of the size-selective harvest is perhaps most consequential to Chinook salmon because they exhibit a wide range of size at maturity (Molyneaux et al. *In prep*).

Subsistence fishermen tend to favor using gillnets composed of large-mesh web (e.g., 8-inch mesh; Smith and Dull 2008), so their harvest is selective for larger and older Chinook salmon. This is the same segment of the population in which females are most common (Molyneaux et al. *In prep*). The exploitation rate of the subsistence fishery was estimated to range between 22% and 32% of the total Kuskokwim River Chinook salmon runs in the years 2002–2005 (Molyneaux and Brannian 2006).

In contrast, commercial fishers are usually limited to using 6-inch or smaller mesh sizes (Whitmore et al. 2008), and harvest is selective for smaller Chinook salmon in a size range dominated by males (Molyneaux et al. *In prep*). The timing of the commercial fishery tends to occur during the second half of the Chinook salmon run through the lower Kuskokwim River; however, in recent years low market interest has resulted in very limited commercial harvest (Whitmore et al. 2008). Exploitation rates from the commercial fishery are estimated to have been no more than 1.6% in the 2002 to 2005 run reconstructions (Molyneaux and Brannian 2006).

The selectivity of the Kuskokwim River Chinook salmon harvests influence the resulting age, sex, and length composition as well as the size of the escapement. In 2008, the subsistence fishery likely had a greater effect on tributary escapement composition than the commercial fishery, with 89% of the harvest of Chinook salmon occurring in the subsistence fishery, though overall exploitation rates were low.

Chum Salmon

The chum salmon sampling effort in 2008 was considered successful. The sampling distribution effectively encompassed each third of the run as it progressed and sample sizes were sufficient to achieve the desired confidence interval width.

Age Composition

The assortment of age classes seen at the Kogrukluk River weir in 2008 (age-0.2, -0.3, -0.4, and -0.5) was similar to past years at the Kogrukluk River and elsewhere in the Kuskokwim Area (Molyneaux et al. *In prep*). The percentages of age-0.2, -0.3, -0.4 and -0.5 fish were 1.5%, 53.8%, 42.0%, and 2.6% of the run respectively. Age-0.2, and -0.3 fish each composed a lower than average proportion of the total run, while the age-0.4 and -0.5 proportions were well above average. Historically (and in 2008), age-0.3 fish composed the majority of the escapement at the Kogrukluk River weir (Figure 28). Age-0.3 is typically the dominant age class at all projects throughout the Kuskokwim River drainage (Molyneaux et al. *In prep*); however, in 2008 with the exception of the Kogrukluk River weir, all projects in 2008 were all heavily dominated by age-

0.4 fish, ranging from 61.3% at the Takotna River weir to 78.8% at the George River (Elison et al. 2009 a-b; Miller and Harper *In prep* a-b; Stewart et al. 2009). Historical trends in age composition tend to vary spatially and temporally throughout the Kuskokwim River drainage; however, age-0.3 and -0.4 fish have consistently composed the majority of the run at all escapement projects. The 2008 season was no exception, age-0.3 and -0.4 fish combined composed over 93% of the total annual escapement at every Kuskokwim River escapement project (Molyneaux et al. *In prep*).

The lower than average abundance of age-0.3 chum salmon in 2008 suggests the possibility of a relatively smaller return of their age-0.4 siblings in 2009. Likewise, the relatively low abundance of age-0.2 chum salmon in the Kogrukluk River weir and most other projects in 2008 indicates the potential for an average to lower than average return of age-0.3 fish in 2009. Unfortunately, sibling relationships for chum salmon are not as reliable as with Chinook salmon, despite the relatively small and stable commercial harvest that has occurred since 1999 (Figure 28; Appendix E2; Smith and Dull 2008). Moderate abundances of age-0.3 and low abundances of age-0.4 chum salmon expected in 2009 at the Kogrukluk River weir and other projects will probably equate to an average overall escapement.

Age composition of the chum salmon escapement showed a consistent trend as the 2008 run progressed past the Kogrukluk River weir. The proportion age-0.3 fish continually increased while the proportions of age-0.4 and -0.5 continually decreased. The 2008 trend is consistent with the common historical trend seen at the Kogrukluk River weir where there is an inverse relationship between the percentage of age-0.3 and -0.4 chum salmon (Figure 9).

Brood tables provide the tools to investigate potential cohort survival and assess the number of returns per spawner (Appendix E2). Total return is calculated as the sum of all individuals returning from a specific brood year, 6 years of escapement analysis are required to provide perspectives into spawner-recruit relationships. With the available data, we can begin to examine these relationships starting in the 1996 brood year. However, conclusions are limited by the absence of stock specific harvest data from downstream fisheries. The number of fish Kogrukluk River fish harvested in the subsistence fishery is unknown, but may be large enough to noticeably affect escapement, so the return values presented in Appendix E2 underestimate actual returns. However, since subsistence harvests of chum salmon tend to vary with abundance, the values presented in this report are probably reasonable indexes of total returns to the Kogrukluk River.

Consistent ASL sampling effort has allowed calculation of return for all brood years between 1996 and 2002 and return per spawner (R/S) can be calculated for all but 1998 (Appendix E2). Historically, R/S values have ranged from 0.43 for the 1996 brood year to 8.26 for the 2001 brood year. The 2.69 returns per spawner determined for the 2002 brood year, the most recent for which it can be calculated, is well within the range and third highest return per spawner calculated at this time. There are only a few years available from which to draw comparisons, which limits the validity of conclusions.

Sex Composition

At 34.9% of the total 2008 escapement (Table 4), the percentage of female chum salmon at the Kogrukluk River weir was slightly above the historical average of 32.4%. The percentage of females in 2008 was well within the historical range, which reached a high of 45.1% in 2005 and a low of 4% in 1997 (Molyneaux et al. *In prep*). From 1990 through 2004, the percentage of females at this project had generally been low and averaged only 13.8% annually. In contrast, the percentage of female chum salmon has been near 50% in most other Kuskokwim Area data sets (Molyneaux et al. *In prep*). Like the Kogrukluk River weir, all other Kuskokwim Area escapement monitoring projects in 2008 reported a proportion of females consistent with past years (Elison et al. 2009 a-b; Miller and Harper *In prep* a-b; Stewart et al. 2009).

Historically low female percentages observed at the Kogrukluk River (Figure 25) weir may have been the consequence of weir location and differences in spawning behavior between males and females. The Kogrukluk River weir differs from others in the Kuskokwim River area in that it is located upstream from a large stretch of spawning habitat. Because of differences in spawning behavior between male and female chum salmon, the location of the weir relative to spawning habitat may influence the percentage of females passing through the weir. Schroder (1982) reports observations of male chum salmon that continued upstream a considerable distance after initial spawning, while females tended to remain near their redds; therefore, males may concentrate in greater proportions higher in the drainage than females. This may equate to a higher proportion of males being counted through the weir. If this is true, then the percentage of females counted through the Kogrukluk River weir in a given year may be more closely tied to abundance. In years of high abundance, such as 2005 and 2006, downstream spawning habitat may have been saturated with redds, inducing more females to migrate further upstream and through the weir. The percentage of females in 2005 may have been high (45.1%) as a consequence of the exceptionally high abundance of chum salmon in the Holitna River system that year (197,723 fish were counted through the weir; Jasper and Molyneaux 2007). However a strong correlation between chum salmon abundance and the percentage of females is not apparent. The recent 2 years have contradicted this possible mechanism, 2007 and 2008 had escapement levels similar to those seen in the 1980s and 1990s but the percent females remained high.

An alternate explanation for the greater percentage of female chum salmon in recent years is the adoption of a tighter picket spacing in the weir design in 2005. Investigators considered the possibility that the extreme sex ratios during the 1990s and early 2000s were biased and the wider picket spacing employed during these years may have allowed the passage of smaller females but prevented the passage of larger males. Examination of length frequency histograms does not indicate that smaller fish have been underrepresented to such a degree as to account for the anomalous sex ratios observed in those years (Jasper and Molyneaux 2007; Liller et al. 2008).

Stratified sampling at the Kogrukluk River weir revealed only slight changes in sex composition as the run progressed and no consistent trends were apparent. Historically, Kogrukluk River chum salmon sex composition tends to change little during the run and intra-annual variation does not generally follow a positive or negative trend (Figure 5). At some monitoring projects it is common for the percentage of females to continually increase during the run (Molyneaux et al. *In prep*). Since most female chum salmon are 4-year-old fish (age-0.3) intra-annual changes in sex composition tend to equate to intra-annual changes in age composition.

Length Composition

In 2008 at the Kogrukluk River weir, annual mean lengths of chum salmon for all age-sex categories were below the historical averages and near project history lows in 2006 (Liller et al. 2008) (Figure 29). A retrospective analysis of age-0.3 and -0.4 male and female chum salmon at this project shows a general increase in length-at-age between 1984 and 1996, and then a general decrease through 2007 (Molyneaux et al. 2008; Jasper and Molyneaux 2007). This decreasing trend is most obvious among age-0.3 and -0.4 males. The 2008 mean lengths were fairly consistent with the last 3–4 years, depicting a leveling off from the continual decreasing pattern starting in the mid 1990s. The tighter picket spacing that has been used in recent years (2005 to 2008) 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 2008. However, the decreasing length frequency trend has been occurring since 1996, well before picket spacing was adjusted, indicating that the decreased picket spacing is not the sole reason. Furthermore, the Tatlawiksuk, Takotna, and George River weirs all displayed similar decreasing trends for all age-sex categories (Elison et al. 2009 a-b; Stewart et al. 2009). More likely, the decreasing size trend among chum salmon may have allowed increasing numbers of fish to pass between pickets over the years, until the picket spacing was adjusted in 2005. This also suggests that any effect picket spacing may have had on escapement and ASL estimation may not have been constant over time.

Although length-at-age was generally less than average in 2008 at Kogrukluk River weir, males were larger than females of the same age (Figure 7). Both occurrences are fairly consistent trends at this project (Figure 29) and throughout the Kuskokwim River drainage (Molyneaux et al. *In prep*). Chum salmon rarely exhibit a strong intra-annual trend in length-at-age over the course of the season, but a slight decrease in length-at-age as the run progresses has been consistently observed at this and other Kuskokwim Area projects (Figure 10; Molyneaux et al. *In prep*). In summary, as the run progressed, the overall age and length composition shifted from older and larger fish to smaller and younger individuals.

Coho Salmon

Sampling goals for Kogrukluk River coho salmon were achieved in 2008. Confidence interval widths were met and sampling effort was sufficiently distributed for analysis of ASL composition.

Age Composition

Kuskokwim River coho salmon are predominantly age-2.1 (4-year-old) fish. At escapement projects throughout the drainage, age-2.1 coho salmon typically compose about 90% of annual escapement (Molyneaux et al. *In prep*). Other age classes historically fluctuate in terms of relative contribution, but percentages are always low compared to age-2.1 fish (Molyneaux et al. *In prep*). At the Kogrukluk River weir in 2008, age-2.1 coho salmon composed 81.4% of the total run. Age-3.1 and -1.1 made up 15.7% and less than 3% respectively (Table 6). Though numbers were small compared to age-2.1 fish, the abundance of age-3.1 fish was considerably above average, the second highest on record, whereas the abundance of age-1.1 fish was just below average in 2008.

Age composition of the coho salmon escapement exhibited slight variability as the 2008 run progressed past the Kogrukluk River weir. Age-2.1 individuals dominated the entire run (Figure 11), but continually decreased as the run progressed, composing 90.3%, 83.3%, 75% of each stratum respectively. While the proportion of age-1.1 fish remained fairly constant, the proportion of age-1.3 individuals increased from 7.1% in the first stratum to 22.9% in the last.

The practice of considering the abundance of an age class in a given year to predict the abundance of fish spawned in the same year within subsequent escapements (sibling relationships) has limited utility when applied to coho salmon. First, nearly all Kuskokwim River coho return as age-2.1 individuals, so deviations in the abundance of other age-classes will have little effect on total annual escapement. Second, historical data do not show that such predictions are reliable for coho salmon (Figure 24). Furthermore, the total return of the Kogrukluk River stocks cannot be determined because it is not known how many Kogrukluk River coho salmon are harvested in downstream fisheries. However, a record-high abundance of age-1.1 fish observed in the 2006 escapement at Kogrukluk River weir (1,812 fish), followed by a higher-than-average abundance of age-2.1 fish in 2007 (24,527 fish) continued in 2008 with the second highest escapement of age-3.1 fish (4,665) in the project history. The strong returns of age-1.1, -2.1 and -3.1 fish in the last 3 years may be the result of the exceptional abundance of spawners observed during the 2003 season.

A Brood table was constructed for coho salmon to investigate potential cohort survival and the number of returns per spawner (Appendix E3). As with other projects in the Kuskokwim River drainage, return data for the Kogrukluk River do not include the number of Kogrukluk River coho salmon harvested annually in downstream fisheries. For coho salmon, the number of fish harvested in the commercial fisheries may be large enough to noticeably affect escapement, so the return values presented in Appendix E3 underestimate actual returns. However, the values presented in this report are probably reasonable indices of total returns to the Kogrukluk River. Consistent ASL sampling effort has allowed the calculation of return per spawner for 1990, 1991, and every brood year between 1995 and 2003 (Appendix E3).

Return per spawner values have ranged from 0.42 for the 2003 brood year to 5.33 for the 1990 brood year. The broods from 1990 and 1999 exhibited exceptional survival and were responsible for the extremely large coho salmon escapements observed at the Kogrukluk River weir in 1994 and 2003 (Burkey 1995; Shelden et al. 2004). The high R/S values calculated for the 1990 and 1999 brood years (5.33 and 5.08) are obvious outliers; R/S values have not exceeded 1.84 in any other years of project history. The R/S value for the 2002 brood year (1.22) was higher than that of most other years and, though modest in comparison to 1990 and 1999, indicates that the total number of surviving offspring from the 2002 brood year were 22% more abundant than their parents.

Sex Composition

At 55.1% of the total 2008 escapement (Table 6), the percentage of female coho salmon at the Kogrukluk River weir was well above the historical average (38.1%). The percentage of females among Kuskokwim River coho salmon stocks was spatially variable in 2008 and ranged from 38.4% at the Tuluksak River weir (Miller and Harper *In prep*, b) to 58% at the Kwethluk River weir (Miller and Haper *In prep*, a). Similar to the Kogrukluk River, deviations from historical averages were minimal (Molyneaux et al. *In prep*). Historically, the percentage of female coho salmon has been near 50% in most Kuskokwim Area data sets.

The annual percentage of female coho salmon at the Kogrukluk River weir has ranged from a low of 17% in 1999 to a high of 49.7% in 2005 (Molyneaux et al. *In prep*). The extremely high percentage of female coho salmon that occurred in 2008 equated to a relatively high abundance of females (16,337) rather than a lower abundance of males (Figure 25). Though considerable annual variation has been observed at this project, the proportion of females has been generally increasing since the start of coho salmon monitoring in 1981. This trend has not been observed elsewhere in the Kuskokwim River drainage. The reason for the increase in the proportion of females is unknown, but does not generally appear to correlate with abundance.

Stratified sampling at the Kogrukluk River weir in 2008 revealed considerable changes in sex composition during the coho salmon run. In 2008, the percentage of female coho salmon increased continually from the first stratum to the last (Figure 5), a trend that is historically consistent at the Kogrukluk River weir and consistent with Kwethluk and George River weirs in 2008 (Molyneaux and Brodersen *In prep*). However, this trend has not occurred often enough throughout the Kuskokwim River drainage to be considered the norm. In most years, the percentage of female coho salmon is higher in the last stratum than in the first, but percentages tend to vary widely between strata.

Length Composition

Annual 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 30). Mean lengths in 2008 were below those in most years between 1990 and 2003. Coho salmon escapement in 2006 was marked by abnormally short fish; mean lengths for both male and female age-2.1 fish were far below any other year including 2008 (Liller et al. 2008). This pattern of decreasing length for both male and female age-2.1 fish has been observed throughout the Kuskokwim River drainage, but usually to a lesser degree (Elison et al. 2009 a-b; Molyneaux et al. *In prep*; Stewart et al. 2009). Similar to past years for this project, no consistent intra-annual pattern was obvious in the average length composition (Figure 12). Across all Kuskokwim River datasets mean length tends to increase as the season progresses (Molyneaux et al. *In prep*), but this pattern is highly variable and was not observed at the Kogrukluk River weir in 2008. It is important to note that low sample sizes and the absence of long term escapement monitoring at Kuskokwim River projects may preclude accurate inter-annual trend analysis.

Sockeye Salmon

Sockeye salmon ASL data have not been collected since 1995, because investigators realized that the high incidence and magnitude of scale re-absorption inhibited reliable aging (Burkey 1995; Cappiello and Burkey 1997). Still, records of annual sex composition have been maintained because crews continue to estimate sex composition visually as the fish migrate past the weir. Comprehensive ASL sampling of sockeye salmon was reinitiated at the Kogrukluk River weir in 2006 in support of *Kuskokwim River Sockeye Salmon Investigations*. ASL data collected from sockeye salmon in 2006 through 2008 were intended to assess life history strategies of “river type” sockeye salmon, including fresh water residency. In 2008, the samples collected were lost in transit between the project and Bethel. Collection of sockeye salmon ASL samples will continue in order to provide perspectives on length frequency, sex ratio, and freshwater residency.

Sex Composition

Ensuing discussion of sockeye salmon sex composition will be based on the female percentage derived from the non-ASL (visual) method rather than that provided through ASL sampling for 2 reasons. First, ASL data were not collected in 2008. Second, for most of project history comprehensive ASL data were not collected for sockeye salmon; hence, data are lacking for historical comparisons. In 10 out of 12 years of paired data, the female percentage derived from ASL sampling was less than the percentage different from the non-ASL method (Figure 26).

The percentage of female sockeye salmon as determined through regular counts (i.e. not ASL sampling) in 2008 (52.9%) was slightly higher than 2007 (47.7%) and above the historical (1976–2007) average of 40.8%. Annual percentages of female sockeye salmon (based on non-ASL methods) have ranged from a minimum of 14% in 1976 to 69% in 1983. This range was corroborated by ASL sampling conducted simultaneously during these years. The annual percentage of female sockeye salmon tended to decline throughout most of the 1990s. Since about 2000, annual percentages have been highly variable but do seem to be increasing. The cause of the decline in females during the 1990s is unknown, but does not appear to be correlated to abundance. Of all escapement monitoring projects operated in the Kuskokwim River drainage, only the Kogrukluk and Kwethluk River weirs have a history of enumerating large escapements of sockeye salmon (Miller and Harper *In prep*, b). Hence, spatial comparisons involving other projects are impaired by a lack of data. However, sources of sockeye salmon sex data do not suggest a clear inseason temporal pattern for sex composition (Molyneaux et al. *In prep*).

WEATHER AND STREAM OBSERVATIONS

Water levels were varied while water temperatures were below average throughout most the Chinook, chum, and sockeye salmon runs (Figures 31 and 32). Overall, water level was unusually high in the early season, steadily declined to seasonal lows in August and swelled to above average throughout September. The 2008 average water temperature of 9.3°C derived from thermometer measurements was slightly lower than the historical average of 10.2°C (Appendix C1, Figure 32). The average water temperature determined by the Hobo® Water Temp Pro v.1 data logger (9.7°C) was also below the historical average (Appendix C2). 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. Generally, no obvious relationship between fish passage and water temperature has been reported for this project.

Similar to past years at this project, no obvious relationship was observed between Chinook, chum, sockeye or coho salmon passage through the weir and local weather conditions. However, peak coho salmon escapement dates of the 2008 year did seem to coincide with an increase in water level (Table 1; Figure 33), but this behavior is more pronounced in coho and has been observed in other stocks of coho salmon throughout their range (Sandercock 1991). Additionally this effect could be produced from complementary timing of the salmon run and water level increase, which is supported by the observation that after peak coho passage water levels continued to climb in late September while passage numbers were in decline.

RELATED FISHERIES PROJECTS

In 2008 the Kogrukluk River weir was successful in its support of the *Kuskokwim River Coho Salmon Investigations, Baseline development for Dolly Varden in southwestern Alaska, Productivity of Kuskokwim Juvenile Coho, Ecotypic variation in AYK sockeye stocks,* and several pilot Otolith Studies. At the time of publication, all studies are still in progress, results and discussion of success will be reported in separate publications that will be written upon completion. To obtain information regarding any of these studies, contact the primary authors as listed above beginning on page 14.

CONCLUSIONS

ESCAPEMENT MONITORING

- The weir was installed on 3 July and was operated through 13 September.
- The weir was not operated through the historical average end date due to high water and heavy debris load.
- Total annual escapement of 9,730 Chinook salmon in 2008 was below recent years; however, it was an average run at the median of the SEG range.
- Similar to the Kogrukluk River weir, most escapement monitoring projects witnessed an average Chinook salmon escapement.
- Run timing of Chinook salmon at the Kogrukluk River weir was later than average, which was similar to most other projects.
- Total annual escapement of 44,978 chum salmon in 2008 was substantially less than the record escapement in 2005 and 2006; however it was a strong run near the upper boundary of the SEG range.
- Similar to the Kogrukluk River weir, most escapement monitoring projects witnessed a slightly lower than average chum salmon escapement.
- Exploitation rates in both the commercial and subsistence fisheries were low and likely had little effect on Kogrukluk River chum salmon escapement.
- Run timing of chum salmon at the Kogrukluk River weir was later than average, which was similar to most other projects.
- Total annual escapement of 29,661 coho salmon in 2008 was the sixth highest escapement on record and exceeded the SEG range.
- The relative strength of the 2008 coho salmon escapement when compared to past years was highly variable among projects; still, most projects reported average or near average escapements.
- Run timing of coho salmon at the Kogrukluk River weir was average, which was similar to most other projects.
- Total annual escapement of 19,675 sockeye salmon in 2008 was the fourth highest escapement on record.
- Run timing of sockeye salmon at the Kogrukluk River weir was later than average.

AGE, SEX, AND LENGTH COMPOSITION

- ASL sample collections for Chinook, chum, and coho salmon were sufficient for estimating the age, sex, and length composition of total annual escapement.
- The Chinook salmon run was predominately represented by age-1.2, -1.3, and -1.4 fish. The percentage of age-1.3 fish decreased throughout the run, while the percentage of older (age-1.4) fish increased and the percentage of age-1.2 fish showed little change.

- Assuming consistency in ocean survival, the high abundance of age-4 Chinook salmon in 2008 suggests that a high abundance of age-5 Chinook salmon will return in 2009. Similarly, the average abundance of age-5 and low abundance of age-6 Chinook salmon in 2008 forecasts average and low abundances of age-6 and age-7 fish in 2009, respectively.
- Female Chinook salmon made up approximately 23% of the total annual run. The percentage of females increased as the run progressed.
- The Chinook salmon run showed length partitioning by sex and age class, and females were longer than males at age.
- The chum salmon run was primarily represented by age-0.3 and -0.4 fish. The percentage of age-0.4 fish decreased as the run progressed while the percentage of age-0.3 fish increased.
- Female chum salmon made up approximately 35% of the total annual run. The percentage of females increased slightly as the run progressed. The percentage of female chum salmon observed in the last 3 years was considerably higher than that observed since the late 1980s.
- The chum salmon run showed length partitioning by sex and age class. Average length increased with age, and males were larger than females at age.
- Mean lengths-at-age of male and female chum salmon have remained consistent over the past 4–5 years.
- The coho salmon run was dominated by age-2.1 fish. The percentage of age-2.1 fish continually decreased while the percentage of age-3.1 fish increased as the run progressed.
- Female coho salmon made up approximately 55% of the total annual run. The percentage of females increased slightly as the run progressed.
- The coho salmon run showed length partitioning by sex. Females were larger than males of the same age.
- Mean lengths-at-age of male and female coho salmon were below average, and continued the recent trend of decreasing lengths.
- Female sockeye salmon made up approximately 53% of the total annual run based on the non-ASL sex determination method, which is greater than the average of 41% for this project and method.

WEATHER AND STREAM OBSERVATIONS

- For the 2008 season, daily water levels were higher than average at the Kogrukluk River weir. Low water conditions occurred in late August and early September and high water conditions occurred throughout most of September.
- Daily water temperatures at the Kogrukluk River weir in 2008 were slightly below average.

- No obvious relationship was observed between fish passage and water level or water temperature.

RECOMMENDATIONS

WEIR OPERATIONS

- Adopt a target operational period (TOP) of 24 June to 20 September. Considerable variability in start and stop dates for the Kogrukluk River weir confound between-year comparisons of summary statistics such as total annual escapement. Circumstances that dictate start and stop dates are often beyond the control of project leaders or crews, but comparability can be enhanced by adopting a TOP across all years. Investigators have been reluctant to adopt a "formal" TOP because weir operations during the 1970s–1990s were inconsistent in timing, duration, and operational success; one implication of developing a TOP is that escapement within the TOP would need to be determined for each year of weir operation. For most years, this would require that statistically-defensible estimates be calculated for inoperable days within the TOP. Until recently, funding for staff time to pursue this endeavor has not been available. To our benefit, Jim Jasper, a University of Alaska Fairbanks (UAF) graduate student and a former crew leader (Jasper and Molyneaux 2007), is currently working to develop estimates for the TOP for each year of operations. Hopefully, the next project report (expected date of completion in late 2009) will include results from his work.
- Develop a method to estimate the extent of fish "leakage" through the pre-2005 weir design in order to correct previous years' escapement estimates. Picket spacing has changed as weir sections have been replaced over the years, resulting in a weir that incorporated panels of up to 3 different picket widths. The estimation method would require: 1) quantifying the amount of fish leakage through each type of panel, 2) determining the composition of species and age-sex classes successfully passing each panel type, and 3) estimating the surface area of each type of panel in each year's weir design. The first and second criteria would entail installing older panels into the new weir design and enumerating fish passage through the pickets using some kind of retaining structure and allowing for ASL sampling of the "leaking" sub population. The last criterion would be more difficult as the design changes over time were poorly documented. An alternative method may be to examine length frequency histograms for each year by age group to determine the extent to which smaller fish have been excluded from the ASL data. If smaller fish were passing through the pickets to a large degree, one would expect a positive skew in the length frequency histograms of all age groups, especially younger fish.
- Investigate the benefit and utility of using the methods suggested by Jasper and Short (*In prep*) for providing reliable estimates of Chinook salmon escapement in years of project failure.

FISH PASSAGE

- Reestablish a SEG for sockeye salmon. The escapement goal of 2,000 sockeye salmon was discontinued around 1995 because sockeye enumeration was considered ancillary to enumeration of other species, and sockeye catch was considered incidental (Burkey et al.

1997). In recent years record high escapements of sockeye salmon have been recorded at the Kogrukluk River weir, increased commercial interest in this species among Kuskokwim River commercial fishers and processors. In addition, ongoing large-scale sockeye salmon investigations have suggested that the Kogrukluk River supports a considerable portion of the Kuskokwim River sockeye salmon population (S. E. Gilk, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). Escapement goals are essential tools for evaluating the adequacy of salmon escapements to spawning tributaries. The lack of an established sockeye salmon SEG for the Kogrukluk River inhibits sustainable management of this stock. Based on the percentile approach of Bue and Hasbrouck[6] we recommend the establishment of a weir-based SEG of 4,400 to 17,000 sockeye salmon. The prescribed SEG rates as excellent based on data quality and quantity. This estimate was generated from 29 years of weir escapement data. This stock is characterized by a high spawning contrast and a moderate exploitation rate. The prescribed SEG range was rounded up from the 25th to 75th percentiles (4,359 to 16,526 fish) based on rounding convention used for escapement goal recommendation. An SEG was recommended because stock-specific harvest data are lacking, precluding the development of a Biological Escapement Goal.

- Develop a method to test the reliability of visual sexing of sockeye salmon. Currently, there is no systematic ASL data collection for sockeye salmon. The only measure of sex ratios for sockeye is visual sexing. One method that comes to mind would be to count fish into a closed trap for a specific period of time. Fish could then be dipped out and species and sex could be determined through close examination. Comparison of the methods side by side would provide an error rate for visual sexing and determine the utility of the method. Testing would inherently determine success rates of visual sexing of other species as well.

SALMON AGE, SEX, AND LENGTH COMPOSITION

- Weir crews continue collection of ASL information from Kogrukluk River sockeye salmon.
- Future project reports for the Kogrukluk River weir should continue and enhance inclusion of detailed figures depicting trends in age, sex, and length composition. Kogrukluk River has the longest history of salmon escapement monitoring in the Kuskokwim Area, but inquiry into the rich history of data collected at this project is elusive because of the limited historical perspective provided by the standard project report. Future project reports for the Kogrukluk River weir should continue to include historical perspectives such as the following:
    - Brood Tables and three dimensional graphics that illustrate the number of fish by age class for the recent past,
    - Inter-seasonal differences in sex composition as determined from weighted ASL samples and visual crew counts (both percent and total number),
    - Inter-seasonal trends in the number and percent of females in the escapement, and

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[6] Bue, B. G., and J. J. Hasbrouck. Unpublished. Escapement goal review of salmon stocks of Upper Cook Inlet. Alaska Department of Fish and Game, Report to the Alaska Board of Fisheries, November 2001 (and February 2002), Anchorage.

- Inter-seasonal trends in average length-at-age and sex.

WEATHER AND STREAM OBSERVATIONS

- Continue monitoring environmental conditions indefinitely. It is clear that environmental stimuli can and do influence migration of Pacific salmon (Quinn 2005). Kuskokwim Area escapement monitoring projects are not specifically designed to evaluate environmental cues to upstream migration, but knowledge of environmental conditions and a commitment to long-term monitoring is valuable to understanding migration and survival of Pacific salmon (Quinn 2005). Even though annual relationships between environmental conditions and salmon migration and abundance are not always clear, long-term data sets may prove valuable to understanding the biology and ecology of these species. We cannot begin to assess the effects of changing environmental conditions on Kuskokwim River salmon without sufficient baseline data consisting of complete and accurate measures of environmental variables. Escapement projects must continue to be diligent in the collection of weather and stream data. Perhaps with sufficient data, researchers and managers will be able to assess relationships between migration and environmental factors relevant in the broader spatial-temporal context.

- Stream gauging stations should be installed strategically throughout the Holitna basin in order to establish baseline hydrologic data for the purpose of establishing water reservations. ADF&G is charged with the responsibility to "…manage, protect, maintain, improve, and extend the fish, game, and aquatic plant resources of the state in the interest of the economy and general well-being of the state" (AS 16.05.020). Toward this end, Alaskan State law (AS 16.05.050) allows ADF&G to acquire water rights based on data and analysis that substantiates the need for the amount of water being requested (Estes 1996). A water reservation is a legal right (or appropriation of water) to maintain a specific flow rate or level in a given body of water for one or a combination of purposes: 1) protection of fish and wildlife habitat, migration, and propagation; 2) recreation and parks purposes; 3) navigation and transportation purposes; and 4) sanitary and water quality purposes (Estes 1996). Based on the high ecologic and resource value and current and proposed uses of the Holitna watershed, water reservations would be directed at nearly all of the above-mentioned purposes. To date, sufficient hydrologic data for the establishment of water rights on Holitna River, in part or in its entirety, is currently lacking. Multiple gauging stations will likely be needed to adequately describe instream flow characteristics, due to variation in hydrology and geology throughout drainage. We recommend installing a minimum of 3 gauging stations near: 1) the Kogrukluk River weir to describe the upper Holitna; 2) the mouth of the Holitna; and 3) the mouth of Holitna near its confluence with the Kuskokwim River.

  In addition, for most readers, the utility in reporting river stage in cm above an arbitrary datum, as determined annually by the crew (see *Methods*) is limited. Installation of a gauging station combined with the systematic discharge measurements needed for calibration would allow project leaders to convert river stage data to a more meaningful measure of discharge in m^3/sec.

- Cooperate with USFWS OSM in their effort to collect reliable, consistent, and scientifically-defensible baseline data on weather and stream conditions at weir sites. A thermograph was first installed in the Kogrukluk River in 2007 and will continue to be installed annually until battery life expires. If the Kogrukluk River weir crew is selected to assist in this effort, project managers' are willing to add this thermograph to a pool of equipment that is shared among all projects involved.

- Create an appendix of historical weather data from the Kogrukluk River weir. These data will give the reader more of a historical perspective of the climate at this location as well as provide a better understanding of climate variation and how it pertains to fish passage.

SPAWNER-RECRUIT ANALYSIS

- Continue to develop a spawner-recruit analysis for Kogrukluk River salmon. One of the caveats in undertaking this initiative in the past was accounting for the unknown fraction of Kogrukluk River fish harvested in the commercial and subsistence fisheries. Preliminary findings from the mark–recapture projects operated in 2002, 2003, and 2004 provide insight into the timing of Kogrukluk River salmon stocks in the lower Kuskokwim River, which may allow for some reasonable assumptions of the temporal fraction of the harvest likely to contain fish bound for the Kogrukluk River. Isolating harvest during that time period and applying an estimated spawning stock apportionment to account for Kogrukluk River fish may provide the resolution required for identifying a reasonable spawner-recruit relationship.

ACKNOWLEDGMENTS

The success of the 2008 field season is attributed to the diligence and ability of the crew members Sergio Santillanes of ADF&G, Ashley Fairbanks of ADF&G, and Justin Crow ONC. Amy Brodersen and Dave Folletti analyzed the ASL data collected at the project. Special thanks go to Kashegelok elders Evan Ignatti and Ignatti Ignatti for their continued support of this project and field crew, and to Nick Mellick Jr. (1932–2003) for his invaluable input and life-long commitment to protecting and maintaining the health and dignity of the fisheries, wildlife, people, and culture of the Kuskokwim and Holitna Rivers. Funding for this project was provided primarily by the State of Alaska.

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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, 2008.

	Chinook			Chum			Coho			Sockeye		
Date	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%
7/03	0	0	0	3	3	0	0	0	0	0	0	0
7/04	14	14	0	120	123	0	0	0	0	2	2	0
7/05	5	19	0	110	233	1	0	0	0	5	7	0
7/06	18	37	0	171	404	1	0	0	0	0	7	0
7/07	19	56	1	378	782	2	0	0	0	2	9	0
7/08	27	83	1	450	1,232	3	0	0	0	34	43	0
7/09	21	104	1	365	1,597	4	0	0	0	22	65	0
7/10	12	116	1	339	1,936	4	0	0	0	22	87	0
7/11	51	167	2	451	2,387	5	0	0	0	50	137	1
7/12	24	191	2	372	2,759	6	0	0	0	40	177	1
7/13	710	901	9	876	3,635	8	0	0	0	399	576	3
7/14	364	1,265	13	664	4,299	10	0	0	0	433	1,009	5
7/15	220	1,485	15	1,078	5,377	12	0	0	0	291	1,300	7
7/16	303	1,788	18	2,553	7,930	18	0	0	0	522	1,822	9
7/17	420	2,208	23	3,186	11,116	25	0	0	0	1,783	3,605	18
7/18	379	2,587	27	1,593	12,709	28	0	0	0	634	4,239	22
7/19	427	3,014	31	2,069	14,778	33	0	0	0	1,160	5,399	27
7/20	492	3,506	36	1,897	16,675	37	0	0	0	1,259	6,658	34
7/21	746	4,252	44	1,766	18,441	41	0	0	0	1,267	7,925	40
7/22	488	4,740	49	1,397	19,838	44	0	0	0	871	8,796	45
7/23	831	5,571	57	1,619	21,457	48	0	0	0	1,467	10,263	52
7/24	534	6,105	63	1,537	22,994	51	0	0	0	1,142	11,405	58
7/25	740	6,845	70	1,789	24,783	55	1	1	0	1,620	13,025	66
7/26	604	7,449	77	1,742	26,525	59	1	2	0	1,259	14,284	73
7/27	361	7,810	80	1,795	28,320	63	0	2	0	753	15,037	76
7/28	411	8,221	84	1,856	30,176	67	5	7	0	1,064	16,101	82
7/29	286	8,507	87	1,623	31,799	71	5	12	0	885	16,986	86
7/30	180	8,687	89	955	32,754	73	14	26	0	507	17,493	89
7/31	193	8,880	91	1,446	34,200	76	9	35	0	437	17,930	91
8/1	122	9,002	93	945	35,145	78	7	42	0	353	18,283	93
8/2	120	9,122	94	950	36,095	80	12	54	0	163	18,446	94
8/3	105	9,227	95	1,102	37,197	83	34	88	0	232	18,678	95
8/4	82	9,309	96	1,143	38,340	85	34	122	0	239	18,917	96
8/5	88	9,397	97	1,112	39,452	88	69	191	1	222	19,139	97
8/6 [a]	64	[b] 9,461	97	940	[b] 40,392	90	45	[b] 236	1	155	[b] 19,294	98
8/7	58	9,519	98	666	41,058	91	27	263	1	89	19,383	99
8/8	29	9,548	98	840	41,898	93	50	313	1	69	19,452	99
8/9	36	9,584	98	460	42,358	94	54	367	1	32	19,484	99
8/10	25	9,609	99	495	42,853	95	23	390	1	34	19,518	99
8/11	28	9,637	99	399	43,252	96	83	473	2	37	19,555	99
8/12	24	9,661	99	376	43,628	97	210	683	2	33	19,588	100
8/13	15	9,676	99	264	43,892	98	117	800	3	13	19,601	100
8/14	14	9,690	100	209	44,101	98	189	989	3	15	19,616	100
8/15	8	9,698	100	153	44,254	98	175	1,164	4	15	19,631	100
8/16	7	9,705	100	147	44,401	99	273	1,437	5	11	19,642	100
8/17	3	9,708	100	89	44,490	99	165	1,602	5	8	19,650	100
8/18	4	9,712	100	119	44,609	99	368	1,970	7	3	19,653	100

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Table 1.–Page 2 of 2.

Date	Chinook			Chum			Coho			Sockeye		
	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%
8/19	4	9,716	100	60	44,669	99	287	2,257	8	9	19,662	100
8/20	1	9,717	100	53	44,722	99	246	2,503	8	0	19,662	100
8/21	4	9,721	100	83	44,805	100	461	2,964	10	7	19,669	100
8/22	0	9,721	100	18	44,823	100	137	3,101	10	2	19,671	100
8/23	1	9,722	100	30	44,853	100	675	3,776	13	1	19,672	100
8/24	3	9,725	100	26	44,879	100	436	4,212	14	1	19,673	100
8/25	2	9,727	100	21	44,900	100	615	4,827	16	2	19,675	100
8/26	0	9,727	100	25	44,925	100	917	5,744	19	0	19,675	100
8/27	2	9,729	100	17	44,942	100	327	6,071	20	0	19,675	100
8/28	0	9,729	100	4	44,946	100	981	7,052	24	0	19,675	100
8/29	0	9,729	100	9	44,955	100	881	7,933	27	0	19,675	100
8/30	1	9,730	100	5	44,960	100	590	8,523	29	0	19,675	100
8/31	0	9,730	100	4	44,964	100	681	9,204	31	0	19,675	100
9/01	0	9,730	100	2	44,966	100	2,069	11,273	38	0	19,675	100
9/02	0	9,730	100	0	44,966	100	947	12,220	41	0	19,675	100
9/03	0	9,730	100	0	44,966	100	757	12,977	44	0	19,675	100
9/04	0	9,730	100	4	44,970	100	2,090	15,067	51	0	19,675	100
9/05	0	9,730	100	1	44,971	100	2,256	17,323	58	0	19,675	100
9/06	0	9,730	100	2	44,973	100	353	17,676	60	0	19,675	100
9/07	0	9,730	100	1	44,974	100	2,358	20,034	68	0	19,675	100
9/08	0	9,730	100	0	44,974	100	2,188	22,222	75	0	19,675	100
9/09	0	9,730	100	1	44,975	100	863	23,085	78	0	19,675	100
9/10	0	9,730	100	0	44,975	100	986	24,071	81	0	19,675	100
9/11	0	9,730	100	0	44,975	100	468	24,539	83	0	19,675	100
9/12	0	9,730	100	1	44,976	100	597	25,136	85	0	19,675	100
9/13	0	9,730	100	2	44,978	100	545	25,681	87	0	19,675	100
9/14 [c]	0 [d]	9,730	100	0 [e]	44,978	100	511 [f]	26,192	88	0 [d]	19,675	100
9/15 [c]	0 [d]	9,730	100	0 [e]	44,978	100	453 [f]	26,645	90	0 [d]	19,675	100
9/16 [c]	0 [d]	9,730	100	0 [e]	44,978	100	407 [f]	27,052	91	0 [d]	19,675	100
9/17 [c]	0 [d]	9,730	100	0 [e]	44,978	100	369	27,421	92	0 [d]	19,675	100
9/18 [c]	0 [d]	9,730	100	0 [e]	44,978	100	359 [f]	27,780	94	0 [d]	19,675	100
9/19 [c]	0 [d]	9,730	100	0 [e]	44,978	100	326 [f]	28,106	95	0 [d]	19,675	100
9/20 [c]	0 [d]	9,730	100	0 [e]	44,978	100	317 [f]	28,423	96	0 [d]	19,675	100
9/21 [c]	0 [d]	9,730	100	0 [e]	44,978	100	281 [f]	28,704	97	0 [d]	19,675	100
9/22 [c]	0 [d]	9,730	100	0 [e]	44,978	100	243 [f]	28,947	98	0 [d]	19,675	100
9/23 [c]	0 [d]	9,730	100	0 [e]	44,978	100	188 [f]	29,135	98	0 [d]	19,675	100
9/24 [c]	0 [d]	9,730	100	0 [e]	44,978	100	150 [f]	29,285	99	0 [d]	19,675	100
9/25 [c]	0 [d]	9,730	100	0 [e]	44,978	100	105 [f]	29,390	99	0 [d]	19,675	100
9/26 [c]	0 [d]	9,730	100	0 [e]	44,978	100	72 [f]	29,462	99	0 [d]	19,675	100
9/27 [c]	0 [d]	9,730	100	0 [e]	44,978	100	57 [f]	29,519	100	0 [d]	19,675	100
9/28 [c]	0 [d]	9,730	100	0 [e]	44,978	100	52 [f]	29,571	100	0 [d]	19,675	100
9/29 [c]	0 [d]	9,730	100	0 [e]	44,978	100	47 [f]	29,618	100	0 [d]	19,675	100
9/30 [c]	0 [d]	9,730	100	0 [e]	44,978	100	43 [f]	29,661	100	0 [d]	19,675	100

[a] Incomplete or partial daily count.
[b] Daily passage was estimated using the "single day" method.
[c] The weir was inoperable for all or part of the day.
[d] Daily passage was assumed zero based on historical run timing data.
[e] Daily passage was assumed zero based on run timing indicators.
[f] Weir was inoperable; passage estimated using "proportion" method.

Table 2.–Age and sex composition of Chinook salmon at the Kogrukluk River weir in 2008 based on escapement samples collected with a live trap.

Sample Dates (Stratum Dates)	Sample Size	Sex	1.1 Esc.	1.1 %	1.2 Esc.	1.2 %	1.3 Esc.	1.3 %	2.2 Esc.	2.2 %	1.4 Esc.	1.4 %	2.3 Esc.	2.3 %	1.5 Esc.	1.5 %	2.4 Esc.	2.4 %	Total Esc.	Total %
7/7-14,16	72	M	0	0.0	797	36.1	1,073	48.6	0	0.0	92	4.2	0	0.0		0.0	0	0.0	1,963	88.9
(7/3-17)		F	0	0.0	0	0.0	123	5.6	0	0.0	92	4.1	0	0.0	31	1.4	0	0.0	245	11.1
		Subtotal[a]	0	0.0	797	36.1	1,196	54.2		0.0	184	8.3		0.0	31	1.4		0.0	2,208	100.0
7/19-25	116	M	45	0.9	1,762	33.6	1,988	37.9	0	0.0	316	6.0	0	0.0	0	0.0	0	0.0	4,111	78.4
(7/18-26)		F	0	0.0	0	0.0	361	6.9	0	0.0	768	14.7	0	0.0	0	0.0	0	0.0	1,130	21.6
		Subtotal[a]	45	0.9	1,762	33.6	2,349	44.8		0.0	1,084	20.7		0.0		0.0		0.0	5,241	100.0
7/27-8/5,7	108	M	0	0.0	908	39.8	401	17.6		0.0	42	1.8		0.0	42	1.9		0.0	1,394	61.1
(7/27-9/28)		F	0	0.0	21	0.9	275	12.0	0	0.0	549	24.1	21	0.9	21	0.9	0	0.0	887	38.9
		Subtotal[a]	0	0.0	929	40.7	676	29.6	0	0.0	591	25.9	21	0.9	63	2.8	0	0.0	2,281	100.0
Season[b]	296	M	45	0.5	3,468	35.7	3,462	35.6		0.0	451	4.6		0.0	42	0.5		0.0	7,468	76.8
		F	0	0.0	21	0.2	759	7.8	0	0.0	1,409	14.5	21	0.2	52	0.5	0	0.0	2,262	23.2
		Total	45	0.5	3,489	35.9	4,221	43.4	0	0.0	1,860	19.1	21	0.2	94	1.0	0	0.0	9,730	100.0
		95% C.I. (%)		(±0.9)		(±5.7)		(±5.9)				(±4.6)		(±0.4)		(±0.9)				

[a] The number of fish in each stratum age and sex category are derived from the sample percentages; discrepancies in sums are attributed to rounding errors.

[b] The number of fish in "Season" summaries are the strata sums; "Season" percentages are derived from the sums of the estimated escapement that occurred in each stratum.

Table 3.–Mean length (mm) of Chinook salmon at the Kogrukluk River weir in 2008 based on escapement samples collected with a live trap.

Sample Dates (Stratum Dates)	Sex		Age Class 1.1	1.2	1.3	1.4	2.3	1.5
7/7-14,16 (7/3-17)	M	Mean Length		544	696	787		
		Std. Error		9	11	53		
		Range		403-623	552-842	708-888		
		Sample Size	0	26	35	3	0	0
	F	Mean Length			770	805		880
		Std. Error			22	27		-
		Range			715-812	754-845		880-880
		Sample Size	0	0	4	3	0	1
7/19-25 (7/18-26)	M	Mean Length	422	543	707	781		
		Std. Error	-	8	9	18		
		Range	422-422	467-679	564-825	684-841		
		Sample Size	1	39	44	7	0	0
	F	Mean Length			790	852		
		Std. Error			16	16		
		Range			722-852	722-951		
		Sample Size	0	0	8	17	0	0
7/27-8/5,7 (7/27-9/28)	M	Mean Length		531	691	775		862
		Std. Error		8	12	5		69
		Range		398-636	625-802	770-779		793-931
		Sample Size	0	43	19	2	0	2
	F	Mean Length		500	773	845	745	903
		Std. Error		-	13	9	-	-
		Range		500-500	683-852	777-945	745-745	903-903
		Sample Size	0	1	13	26	1	1
Season[a]	M	Mean Length	422	540	701	782		862
		Std. Error[b]	-	5	6	17		-
		Range	422-422	398-679	552-842	684-888		793-931
		Sample Size	1	108	98	12	0	2
	F	Mean Length		500	781	846	745	889
		Std. Error[b]		-	10	10	-	-
		Range		500-500	683-852	722-951	745-745	880-903
		Sample Size	0	1	25	46	1	2

Note: The sum of the sample sizes in each stratum equal the total sample size reported for that stratum in Table 2.

[a] "Season" mean lengths are weighted by the escapement passage in each stratum.

[b] Standard error was not calculated for small samples.

Table 4.–Age and sex composition of chum salmon at the Kogrukluk River weir in 2008 based on escapement samples collected with a live trap.

			Age Class									
			0.2		0.3		0.4		0.5		Total	
Sample Dates (Stratum Dates)	Sample Size	Sex	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%
7/6-12	196	M	0	0.0	971	12.3	4,086	51.5	283	3.6	5,341	67.3
(6/15-7/16)		F	0	0.0	890	11.2	1,497	18.9	203	2.5	2,589	32.7
		Subtotal[a]	0	0.0	1,861	23.5	5,583	70.4	486	6.1	7,930	100.0
7/19-24	163	M	375	1.8	7,130	35.0	4,754	23.3	375	1.9	12,634	62.0
(7/17-27)		F	0	0.0	4,629	22.7	3,002	14.7	125	0.6	7,756	38.0
		Subtotal[a]	375	1.8	11,759	57.7	7,756	38.0	500	2.5	20,390	100.0
7/31-8/4	165	M	202	1.2	6,663	40.0	4,341	26.0	101	0.6	11,307	67.9
(7/28-9/20)		F	101	0.6	3,938	23.6	1,212	7.3	101	0.6	5,351	32.1
		Subtotal[a]	303	1.8	10,601	63.6	5,553	33.3	202	1.2	16,658	100.0
Season[b]	524	M	577	1.3	14,764	32.8	13,181	29.3	760	1.7	29,282	65.1
		F	101	0.2	9,456	21.0	5,711	12.7	428	0.9	15,696	34.9
		Total	678	1.5	24,220	53.8	18,892	42.0	1,188	2.6	44,978	100.0
		95% C.I. (%)		(±1.2)		(±4.5)		(±4.4)		(±1.4)	-	-

[a] The number of fish in each stratum age and sex category are derived from the sample percentages; discrepancies in sums are attributed to rounding errors.

[b] The number of fish in "Season" summaries are the strata sums; "Season" percentages are derived from the sums of the estimated escapement that occurred in each stratum.

Table 5.–Length Summary of chum salmon at the Kogrukluk River weir in 2008 based on escapement samples collected with a live trap.

Sample Dates (Stratum Dates)	Sex		Age Class 0.2	0.3	0.4	0.5
7/6-12 (6/15-7/16)	M	Mean Length		561	579	564
		Std. Error		6	3	11
		Range		515-624	522-680	522-595
		Sample Size	0	24	101	7
	F	Mean Length		546	559	565
		Std. Error		7	4	6
		Range		488-607	500-611	555-588
		Sample Size	0	22	37	5
7/19-24 (7/17-27)	M	Mean Length	555	558	579	572
		Std. Error	15	4	4	18
		Range	530-583	503-654	529-646	549-607
		Sample Size	3	57	38	3
	F	Mean Length		545	576	635
		Std. Error		5	10	-
		Range		501-632	506-677	635-635
		Sample Size	0	37	24	1
7/31-8/4 (7/28-9/20)	M	Mean Length	503	554	567	607
		Std. Error	35	3	4	-
		Range	468-537	448-612	510-617	607-607
		Sample Size	2	66	43	1
	F	Mean Length	475	523	546	545
		Std. Error	-	4	8	-
		Range	475-475	459-587	497-595	545-545
		Sample Size	1	39	12	1
Season[a]	M	Mean Length	536	556	575	574
		Std. Error[b]	-	2	2	-
		Range	468-583	448-654	510-680	522-607
		Sample Size	5	147	182	11
	F	Mean Length	475	536	565	581
		Std. Error[b]	-	3	5	-
		Range	475-475	459-632	497-677	545-635
		Sample Size	1	98	73	7

Note: The sum of the sample sizes in each stratum equal the total sample size reported for that stratum in Table 4.

[a] "Season" mean lengths are weighted by the escapement passage in each stratum.

[b] Standard error was not calculated for small samples.

Table 6.–Age and sex composition of coho salmon at the Kogrukluk River weir in 2008 based on escapement samples collected with a live trap.

			Age Class							
			1.1		2.1		3.1		Total	
Sample Dates (Stratum Dates)	Sample Size	Sex	Esc.	%	Esc.	%	Esc.	%	Esc.	%
8/20-25	155	M	79	1.3	2,997	49.0	313	5.2	3,368	55.5
(7/3-8/27)		F	78	1.3	2,506	41.3	118	1.9	2,703	44.5
		Subtotal[a]	157	2.6	5,483	90.3	431	7.1	6,071	100.0
8/29,31,9/1,3	156	M	372	3.2	4,612	39.7	893	7.7	5,877	50.6
(8/28-9/6)		F	74	0.6	5,059	43.6	595	5.1	5,728	49.4
		Subtotal[a]	446	3.8	9,671	83.3	1,488	12.8	11,605	100.0
9/9-11	144	M	0	0.0	3,413	28.5	666	5.5	4,078	34.0
(9/7-30)		F	250	2.1	5,576	46.5	2,081	17.4	7,907	66.0
		Subtotal[a]	250	2.1	8,989	75.0	2,747	22.9	11,985	100.0
Season[b]	455	M	450	1.5	11,001	37.1	1,872	6.3	13,324	44.9
		F	403	1.4	13,142	44.3	2,793	9.4	16,337	55.1
		Total	853	2.9	24,143	81.4	4,665	15.7	29,661	100.0
		95% C.I. (%)		(±1.6)		(±3.8)		(±3.5)	-	-

[a] The number of fish in each stratum age and sex category are derived from the sample percentages; discrepancies in sums are attributed to rounding errors.

[b] The number of fish in "Season" summaries are the strata sums; "Season" percentages are derived from the sums of the estimated escapement that occurred in each stratum.

Table 7.–Mean length (mm) of coho salmon at the Kogrukluk River weir in 2008 based on escapement samples collected with a live trap.

Sample Dates (Stratum Dates)	Sex		Age Class 1.1	2.1	3.1
8/20-25	M	Mean Length	523	527	539
(7/3-8/27)		Std. Error	6	5	16
		Range	517-528	397-615	440-590
		Sample Size	2	76	8
	F	Mean Length	533	532	530
		Std. Error	4	3	10
		Range	529-536	466-574	509-540
		Sample Size	2	64	3
8/29,31,9/1,3	M	Mean Length	453	536	536
(8/28-9/6)		Std. Error	28	4	9
		Range	400-540	409-607	470-574
		Sample Size	5	62	12
	F	Mean Length	519	532	547
		Std. Error	-	3	9
		Range	519-519	471-572	502-576
		Sample Size	1	68	8
9/9-11	M	Mean Length		534	540
(9/7-30)		Std. Error		5	11
		Range		428-591	497-587
		Sample Size	0	41	8
	F	Mean Length	544	545	557
		Std. Error	18	3	4
		Range	509-566	490-594	514-591
		Sample Size	3	67	25
Season[a]	M	Mean Length	465	533	538
		Std. Error[b]	-	3	6
		Range	400-540	397-615	440-590
		Sample Size	7	179	28
	F	Mean Length	537	538	554
		Std. Error[b]	-	2	4
		Range	509-566	466-594	502-591
		Sample Size	6	199	36

Note: The sum of the sample sizes in each stratum equal the total sample size reported for that stratum in Table 6.

[a] "Season" mean lengths are weighted by the escapement passage in each stratum.

[b] Standard error was not calculated for small samples.

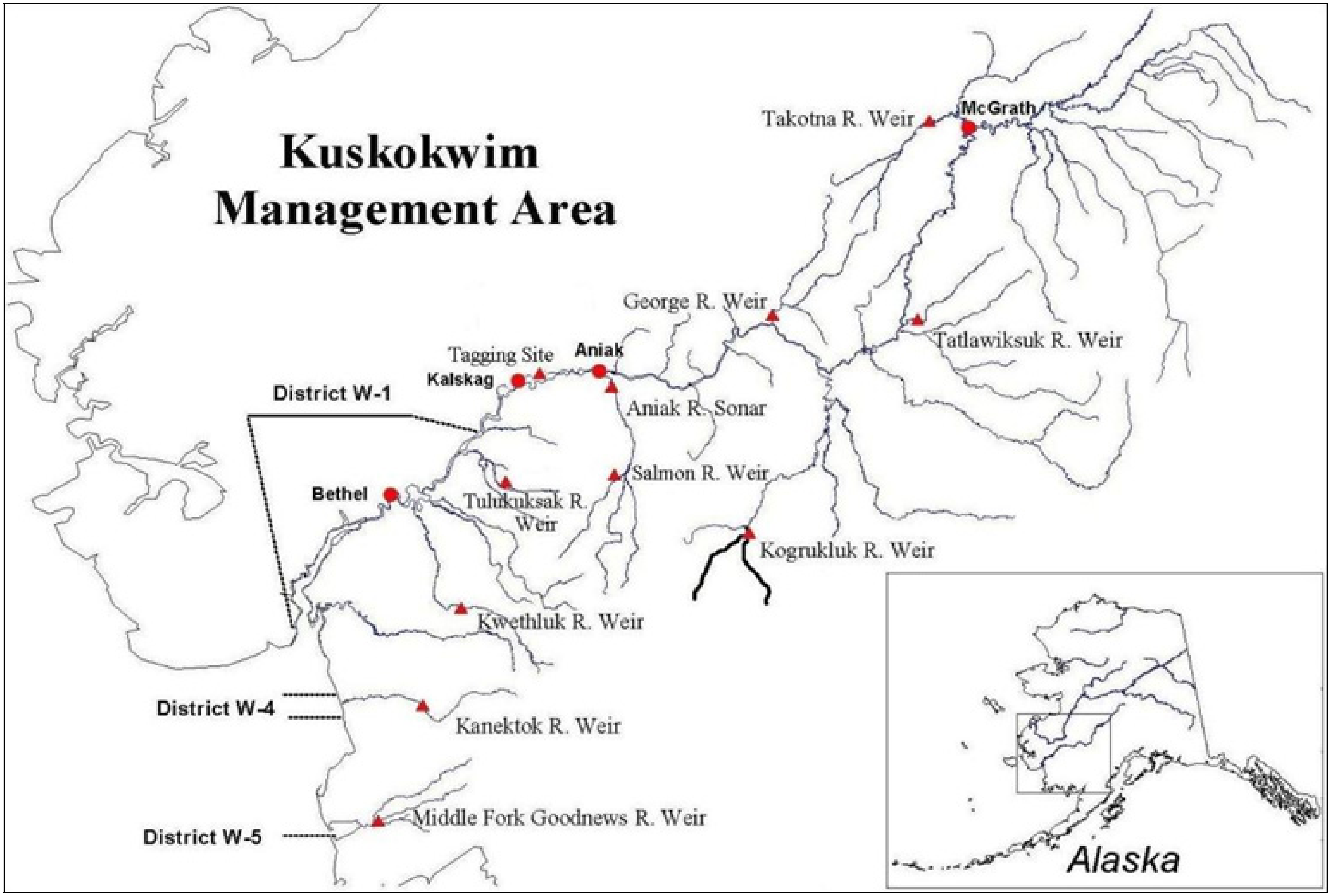


Figure 1.–Kuskokwim Area salmon management districts and escapement monitoring projects with emphasis on the Kogrukluk River weir.

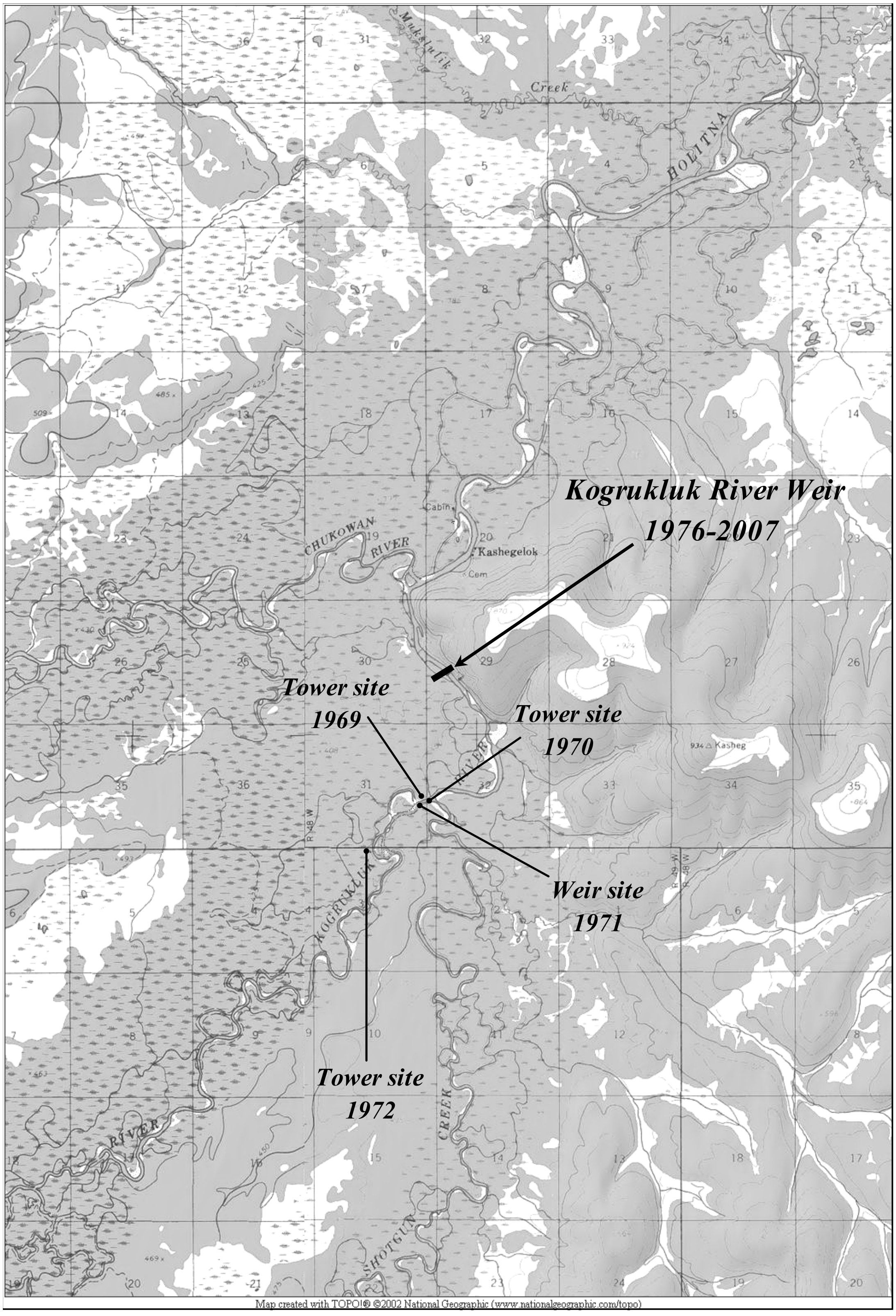
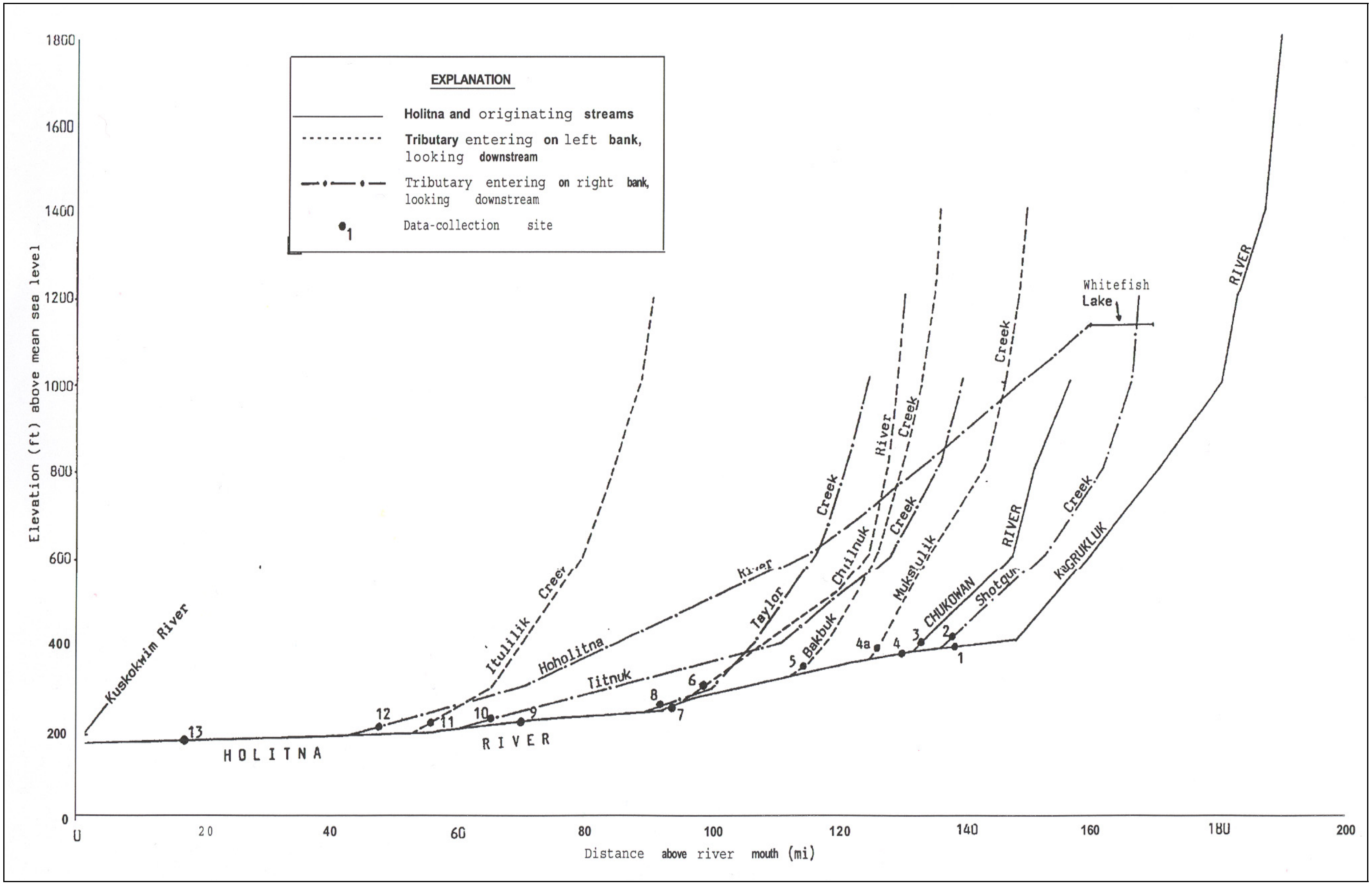
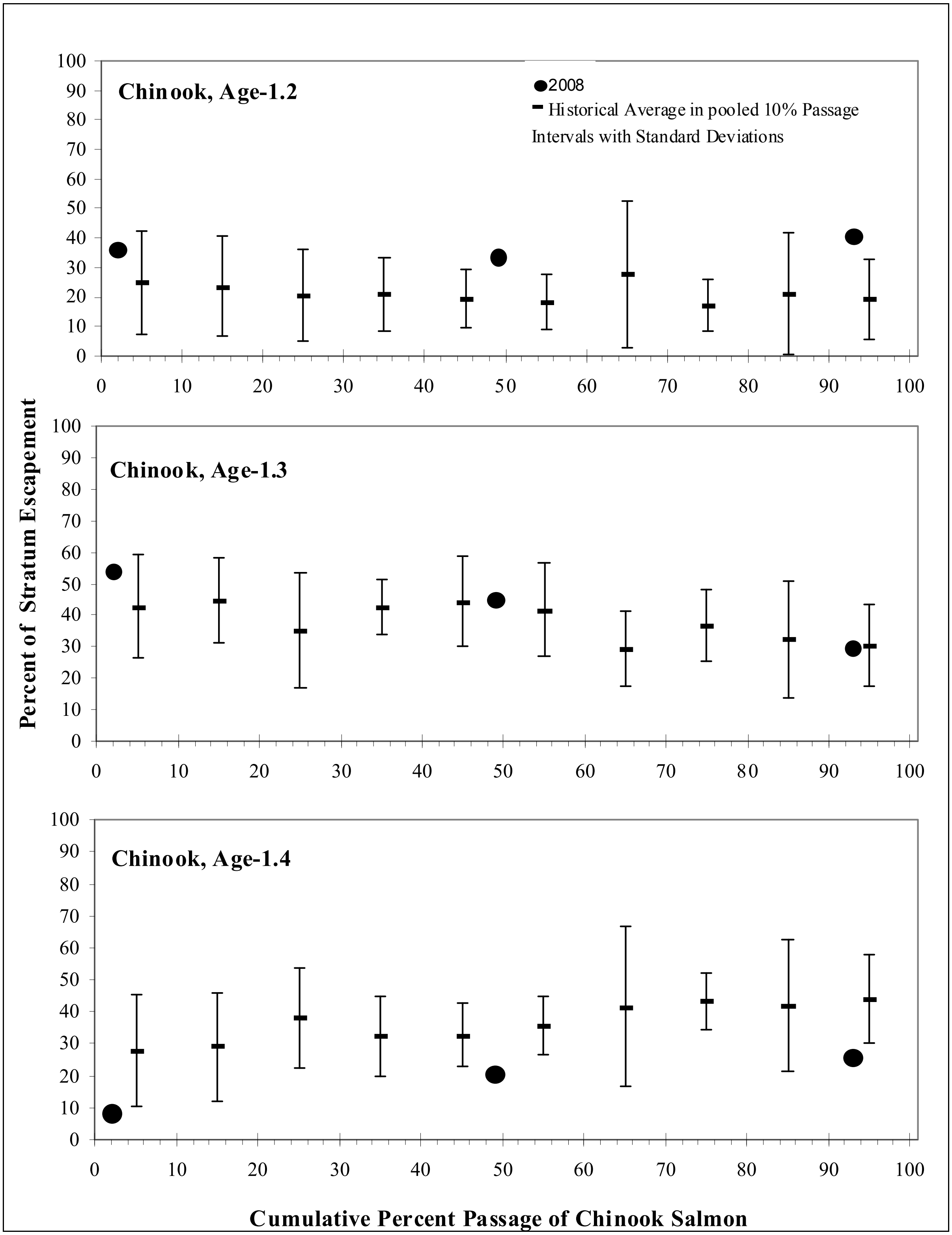


Figure 2.–Kogrukluk River study area and location of historical escapement monitoring projects.



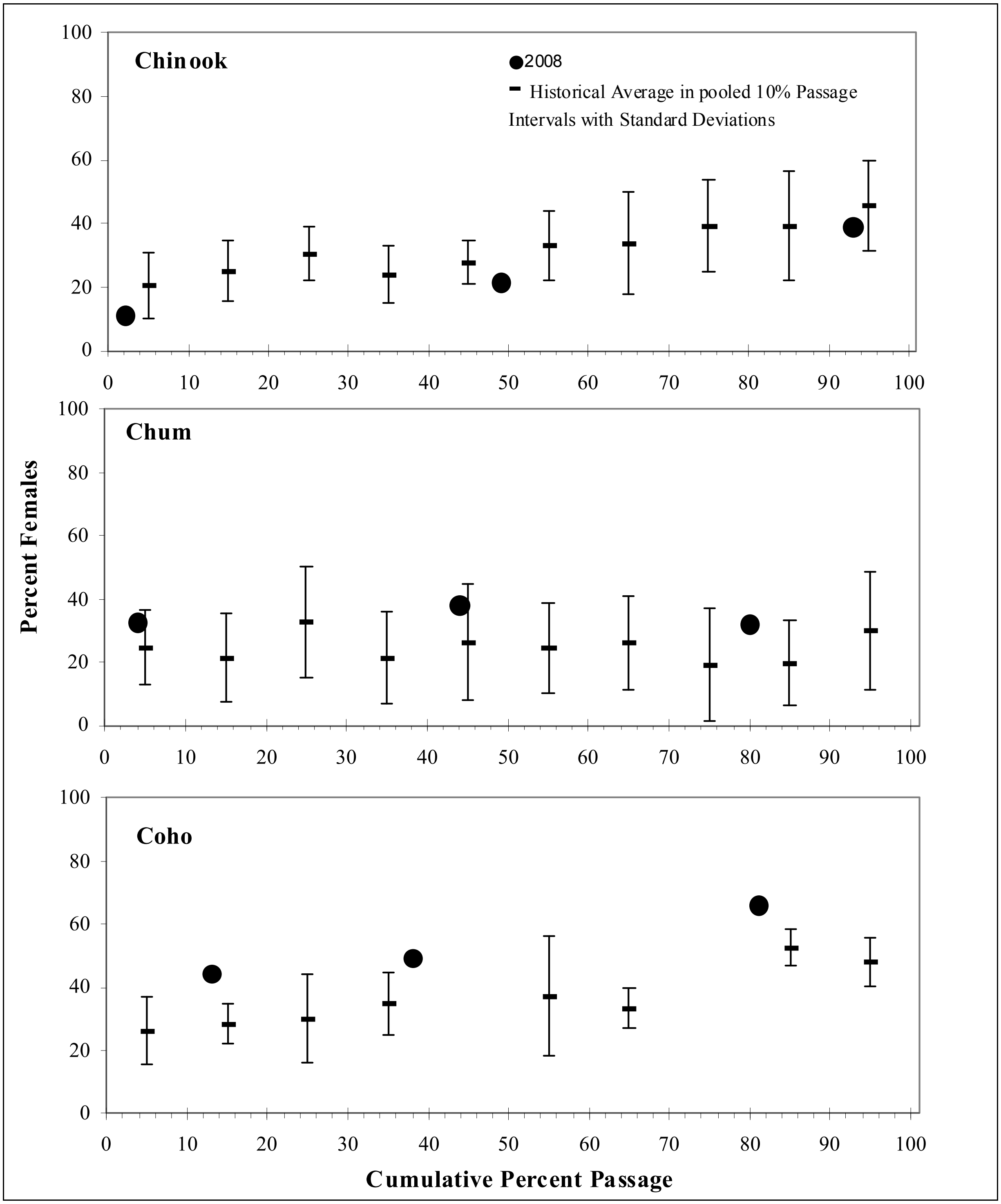
Source: Collazzi 1989.

Figure 3.–Profile of the Holitna River and major tributaries, Alaska.



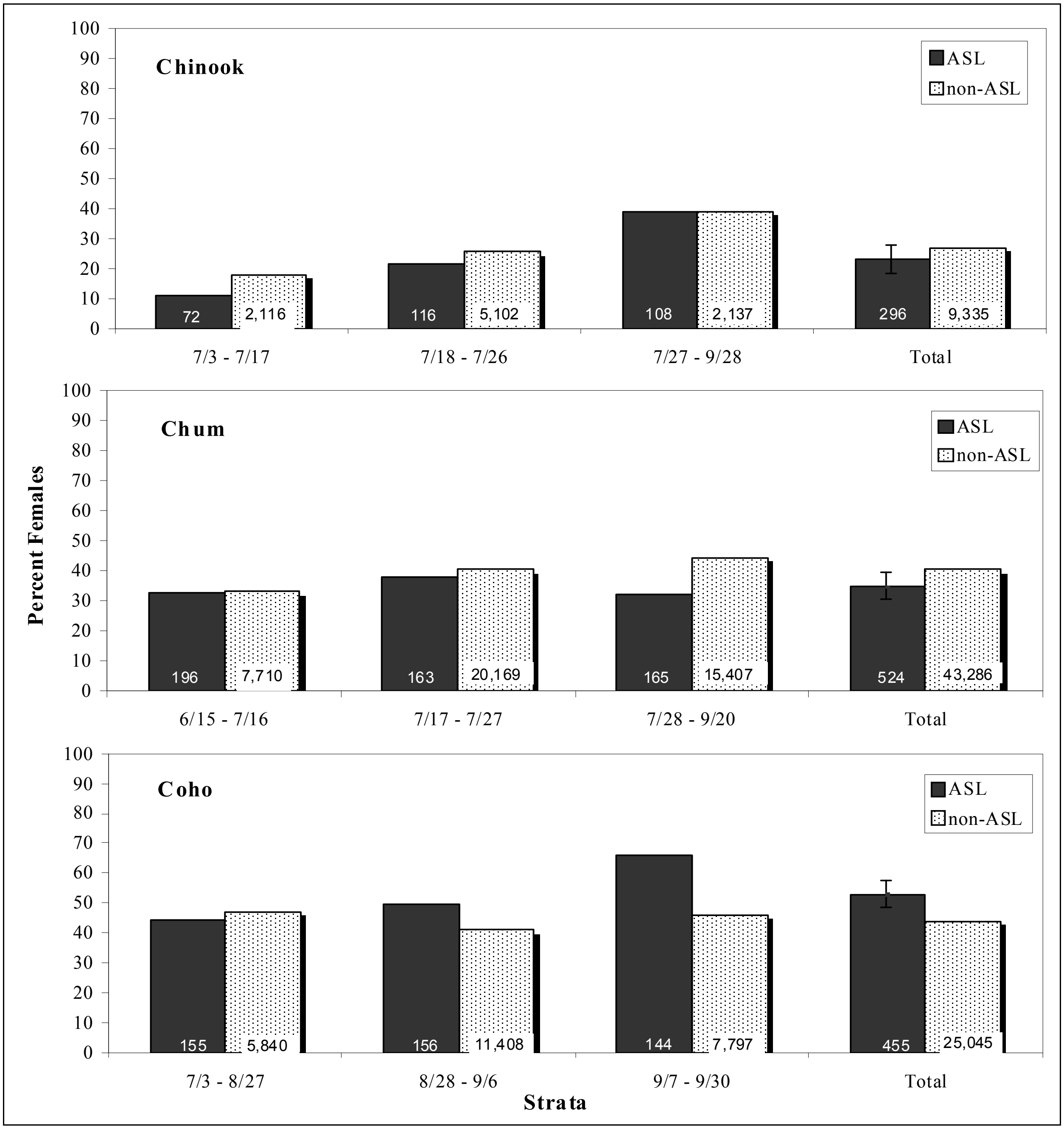
Note: Years were omitted when annual escapement contained considerable passage estimates (greater than 20%) and/or sample sizes were not large enough for temporal stratification.

Figure 4.–Chinook salmon age composition by cumulative percent passage at the Kogrukluk River weir, with historical averages in pooled 10% passage intervals.



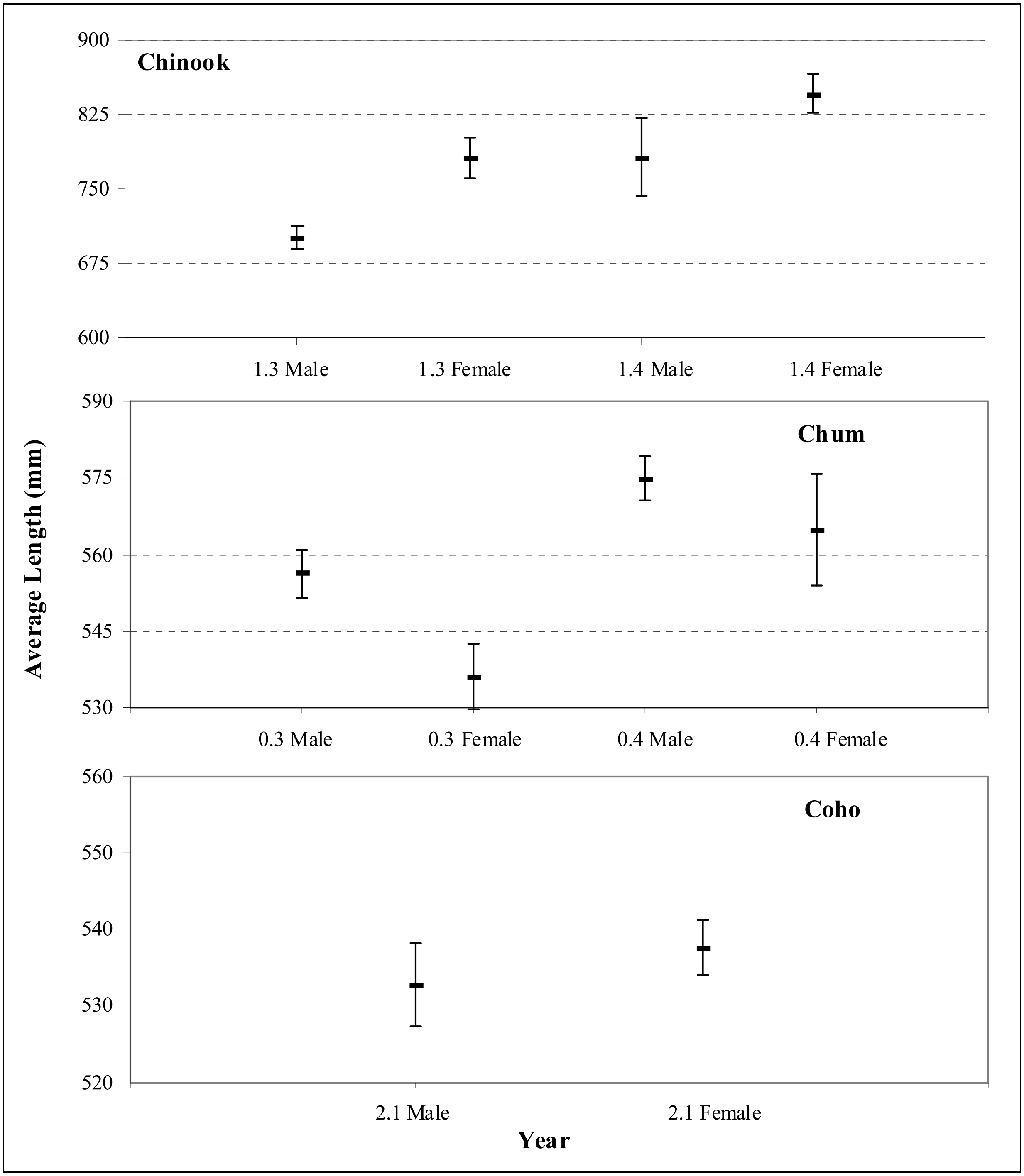
Note: Years were omitted when annual escapement contained passage estimates greater than 20% and/or sample sizes were not large enough for temporal stratification.

Figure 5.–Percent of female Chinook, chum, and coho salmon by cumulative percent passage at the Kogrukluk River weir, with historical averages in pooled 10% passage intervals.



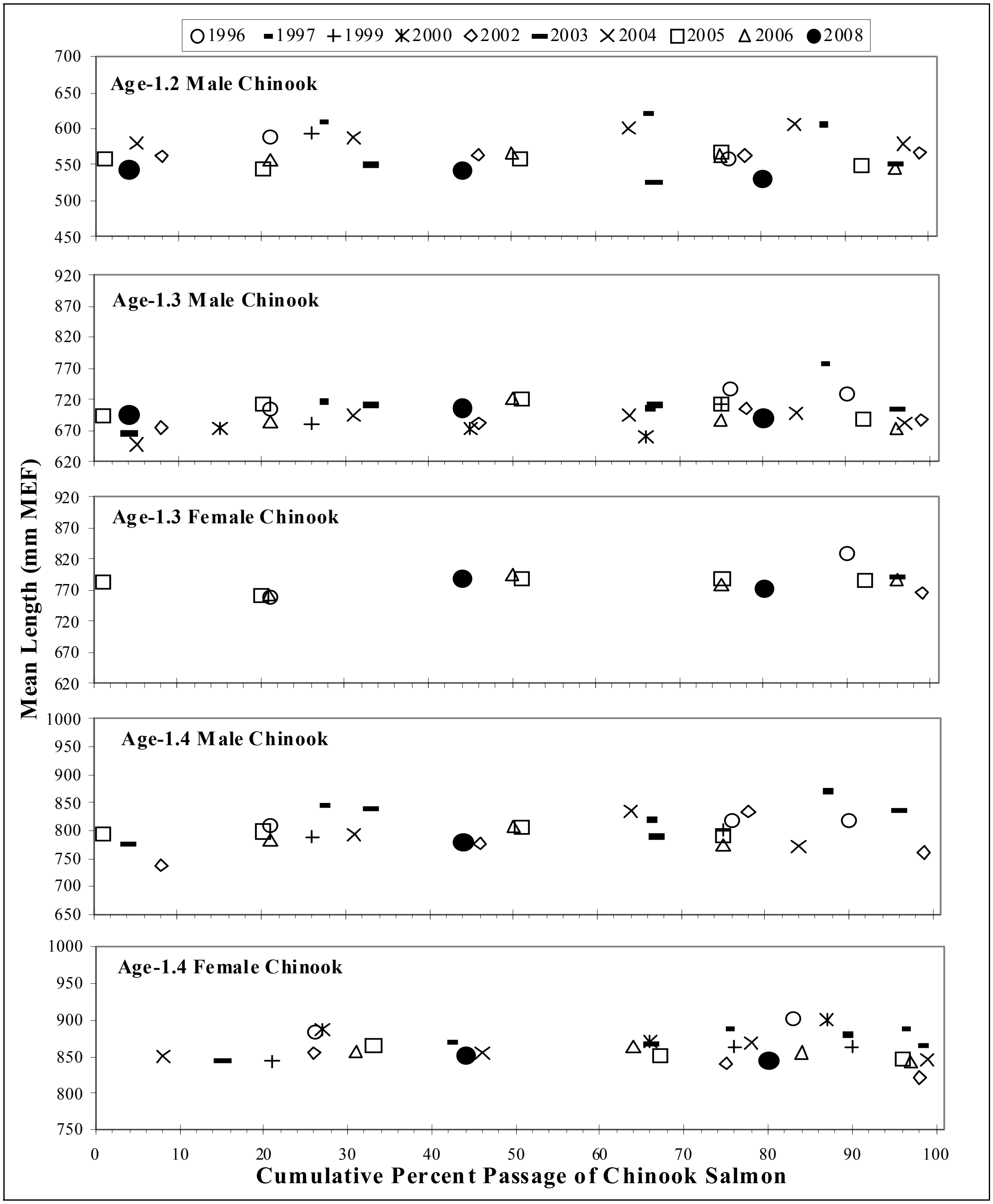
Note: The number at the base of each column is samples size (n). ASL determined sex ratios were estimated, with confidence intervals; visually counted fish are considered a census.

Figure 6.–Comparison of the percentage of female salmon passing upstream of the Kogrukluk River weir in 2008 as determined from standard ASL sampling using a fish trap, and from visual inspection of non-ASL sampled fish using standard fish passage procedures.



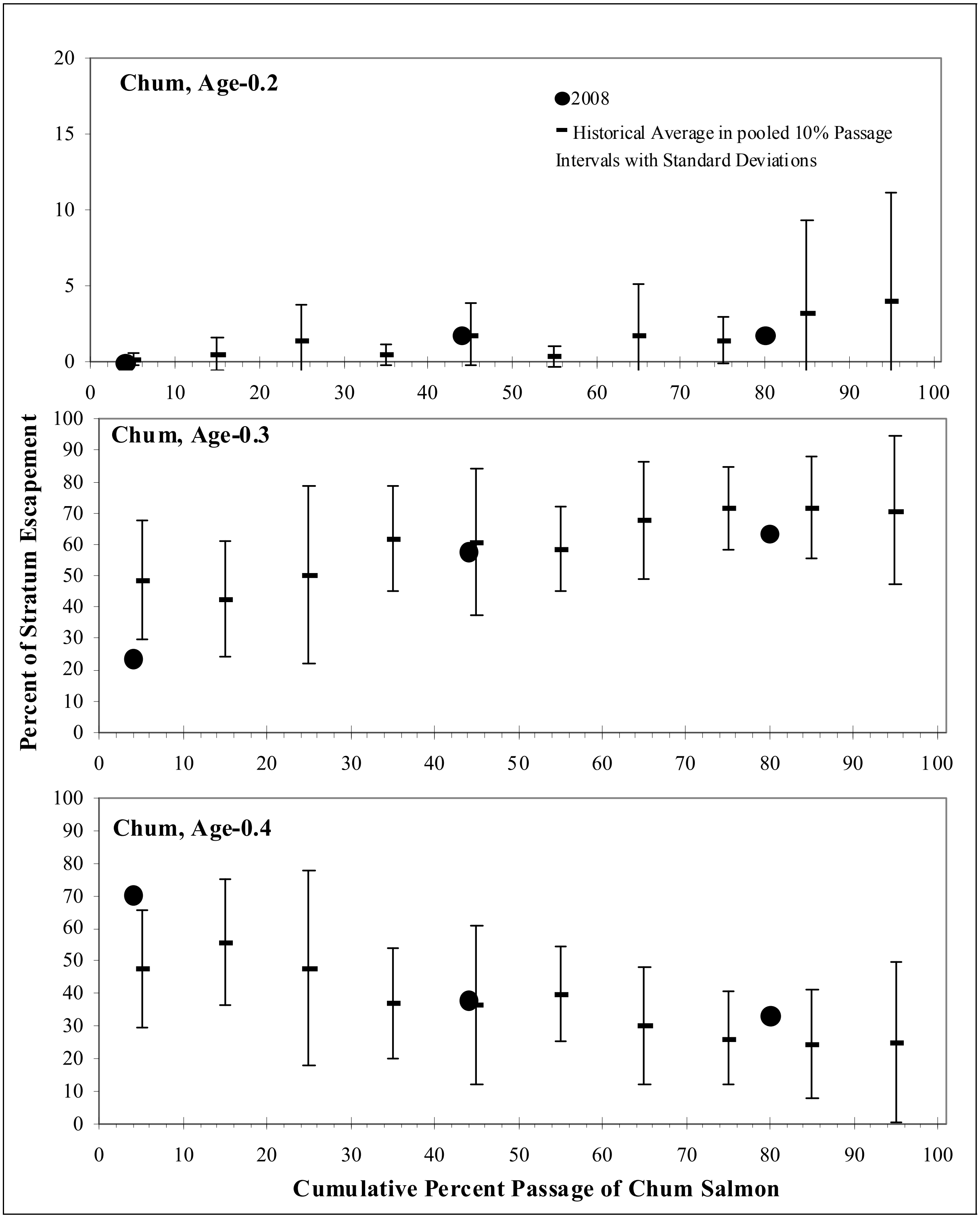
Note: Years were omitted when annual escapement contained considerable passage estimates (greater than 20%) and/or sample sizes were not large enough for temporal stratification.

Figure 7.–Average length of Chinook, chum, and coho salmon by age and sex in 2008 at the Kogrukluk River weir with 95% confidence intervals.



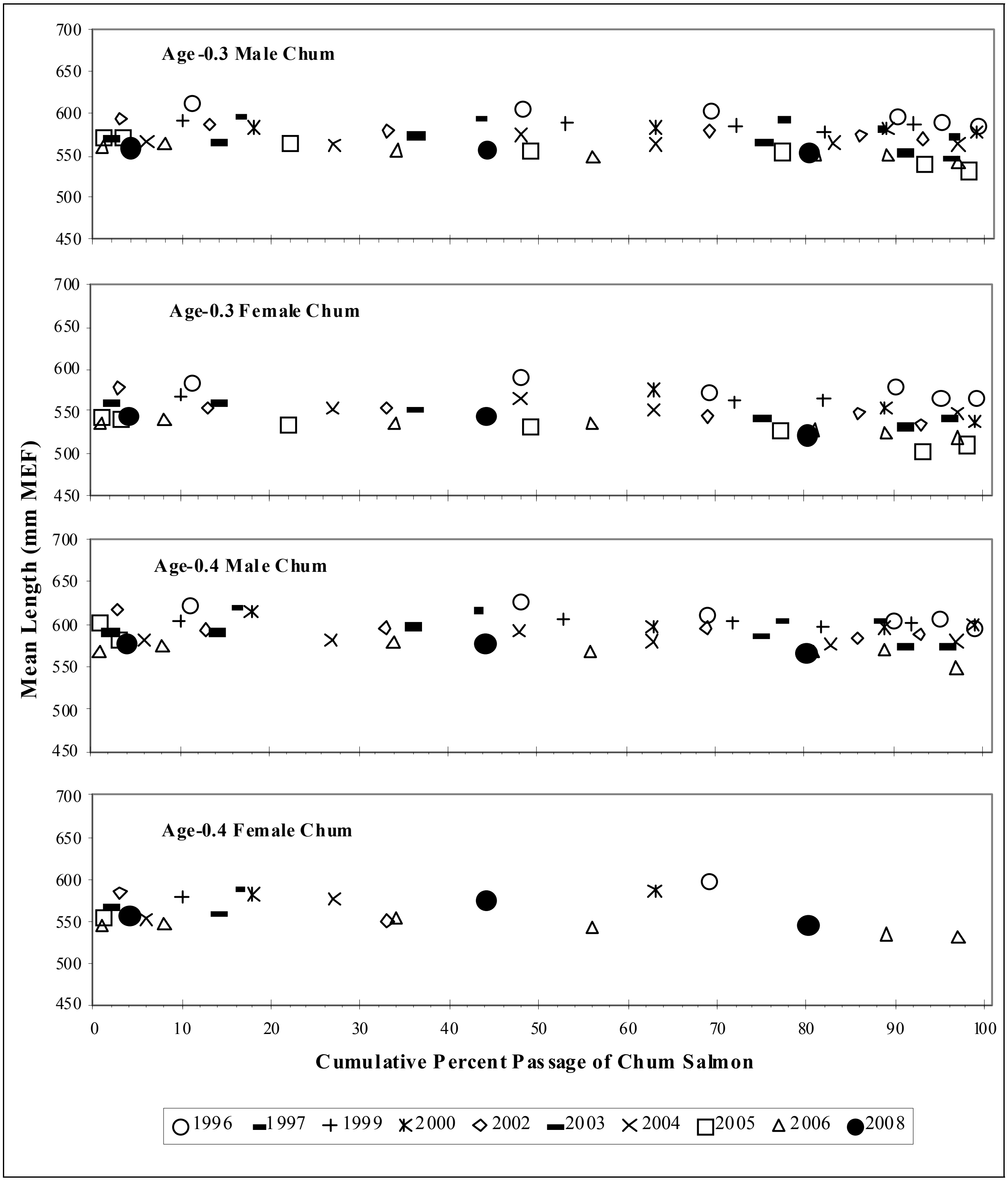
Note: Only sample sizes greater than 6 fish were included in this figure.

Figure 8.–Historical intra-annual mean length at age of male and female Chinook salmon by cumulative percent passage at Kogrukluk River weir.



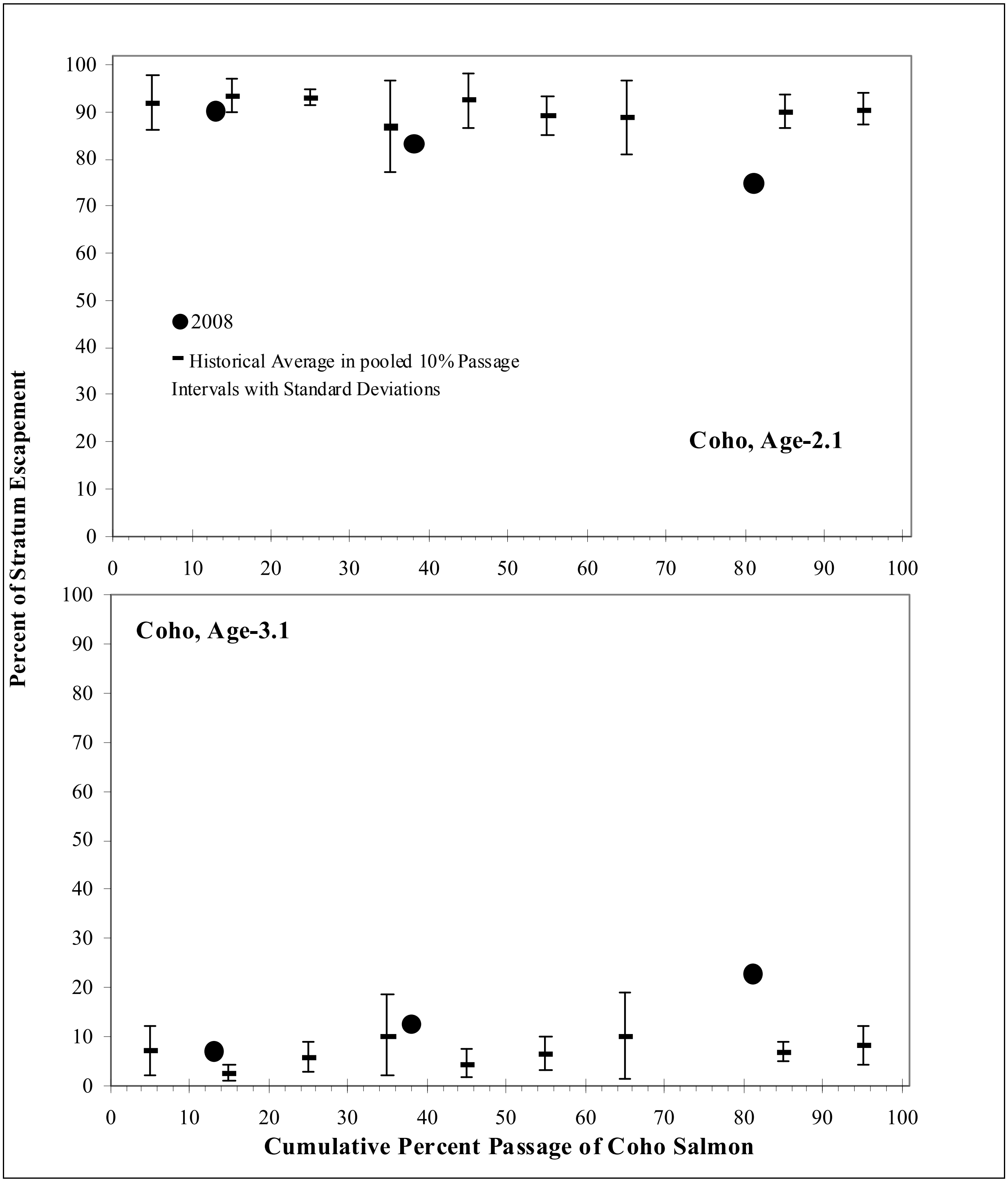
Note: Years were omitted when annual escapement contained considerable passage estimates (greater than 20%) and/or sample sizes were not large enough for temporal stratification.

Figure 9.–Chum salmon age composition by cumulative percent passage at Kogrukluk River weir with historical averages in pooled 10% passage intervals.



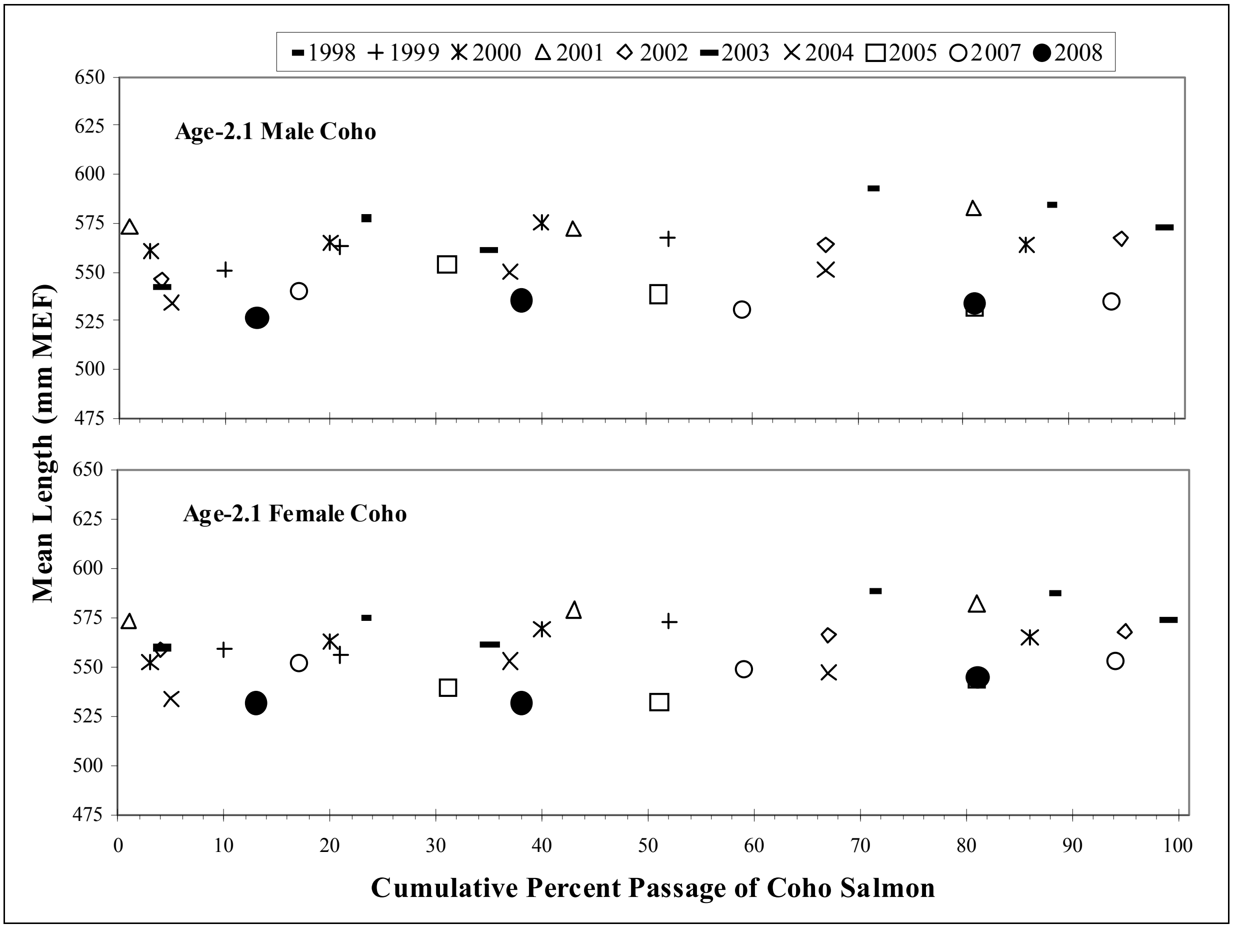
Note: Years were omitted when annual escapement contained considerable passage estimates (greater than 20%) and/or sample sizes were not large enough for temporal stratification. Only means from samples greater than 6 fish were included in this figure.

Figure 10.–Historical intra-annual mean length at age of male and female chum salmon by cumulative percent passage at the Kogrukluk River weir.



Note: Years were omitted when annual escapement contained considerable passage estimates (greater than 20%) and/or sample sizes were not large enough for temporal stratification.

Figure 11.–Coho salmon age composition by cumulative percent passage at the Kogrukluk River weir, with historical averages in pooled 10% passage intervals.



Note: Years were omitted when annual escapement contained considerable passage estimates (greater than 20%) and/or sample sizes were not large enough for temporal stratification.

Figure 12.–Historical intra-annual mean length at age of male and female coho salmon by cumulative percent passage at the Kogrukluk River weir.

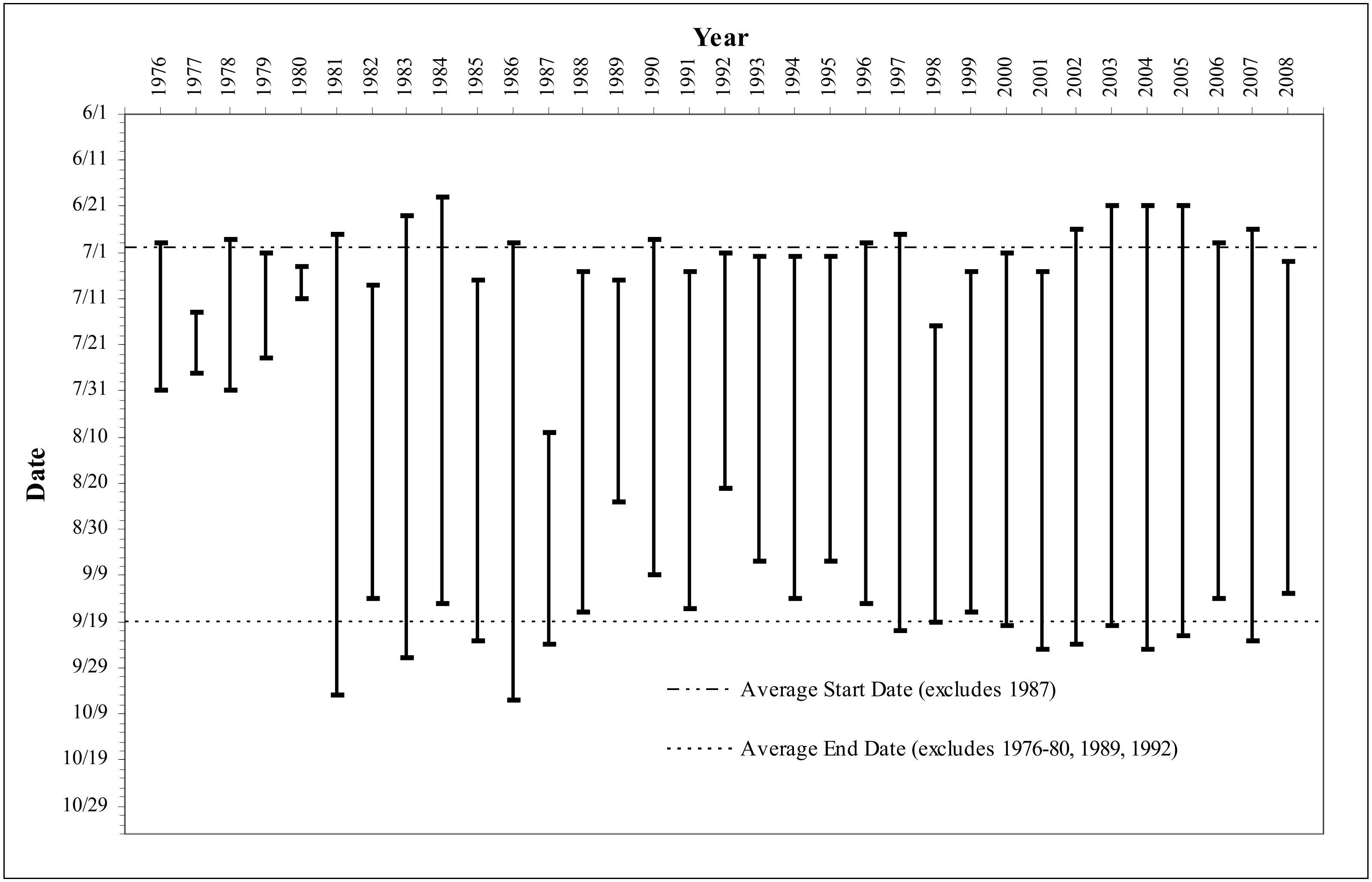
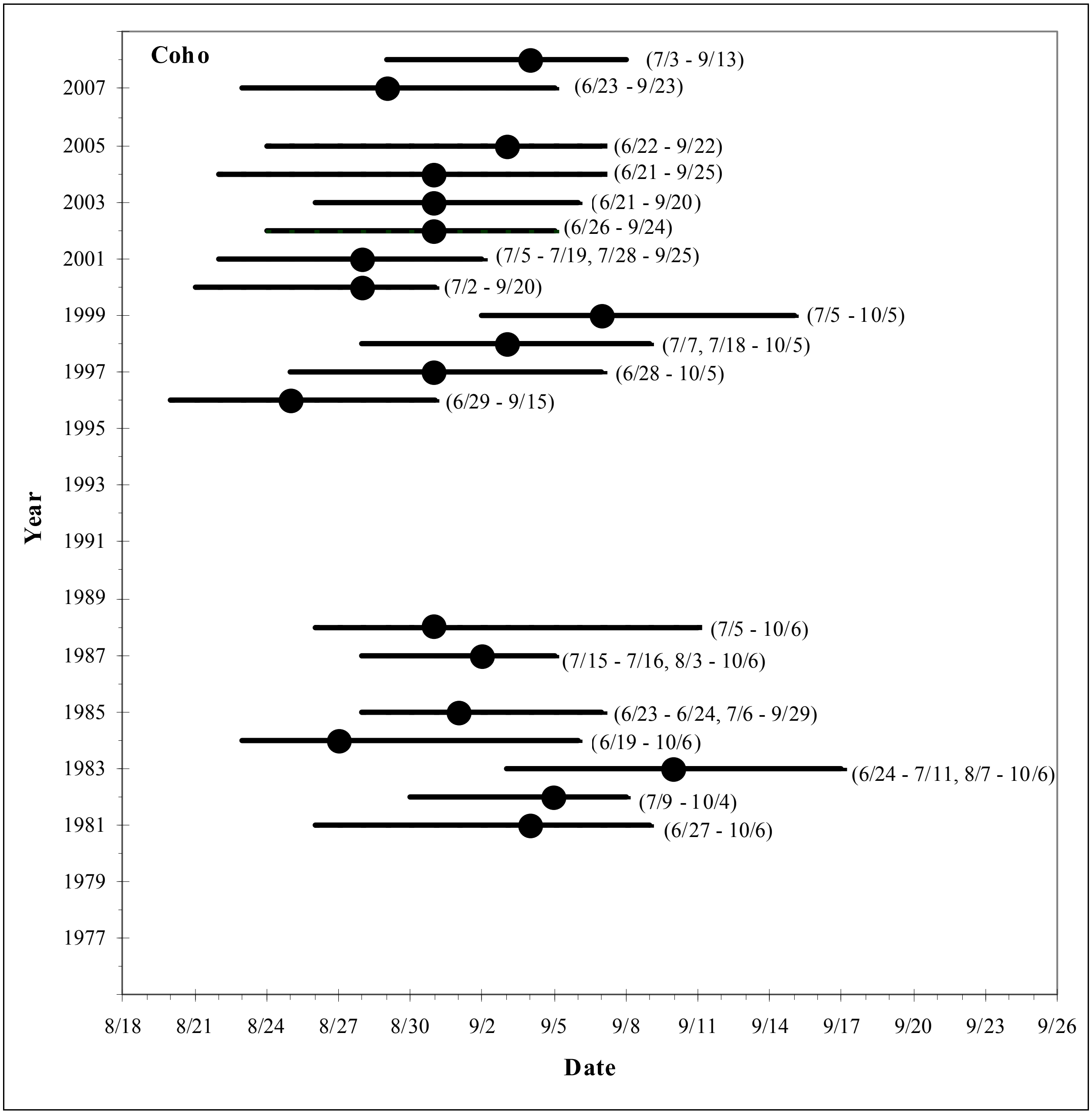
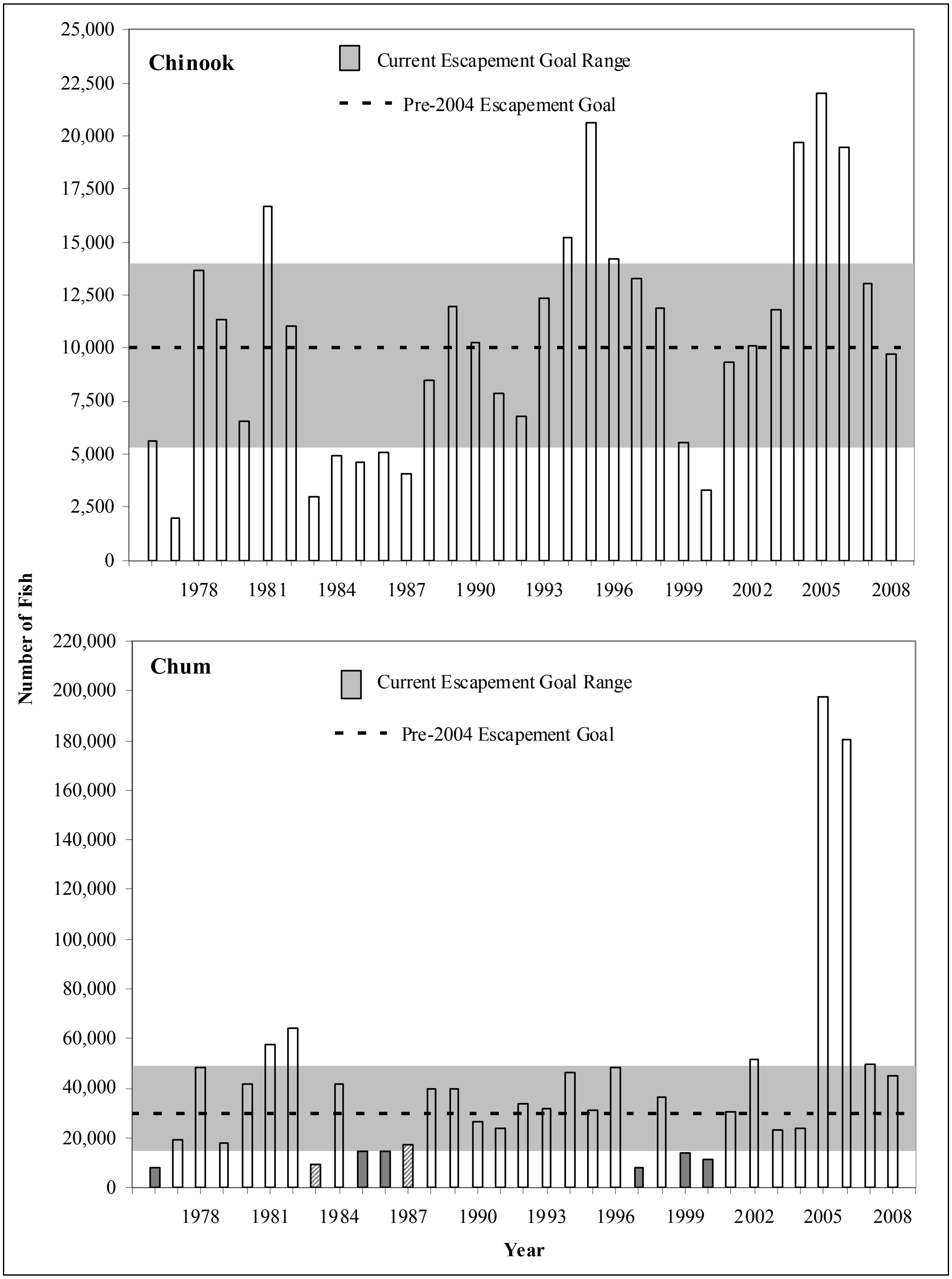


Figure 13.–Historical operational dates for the Kogrukluk River weir.



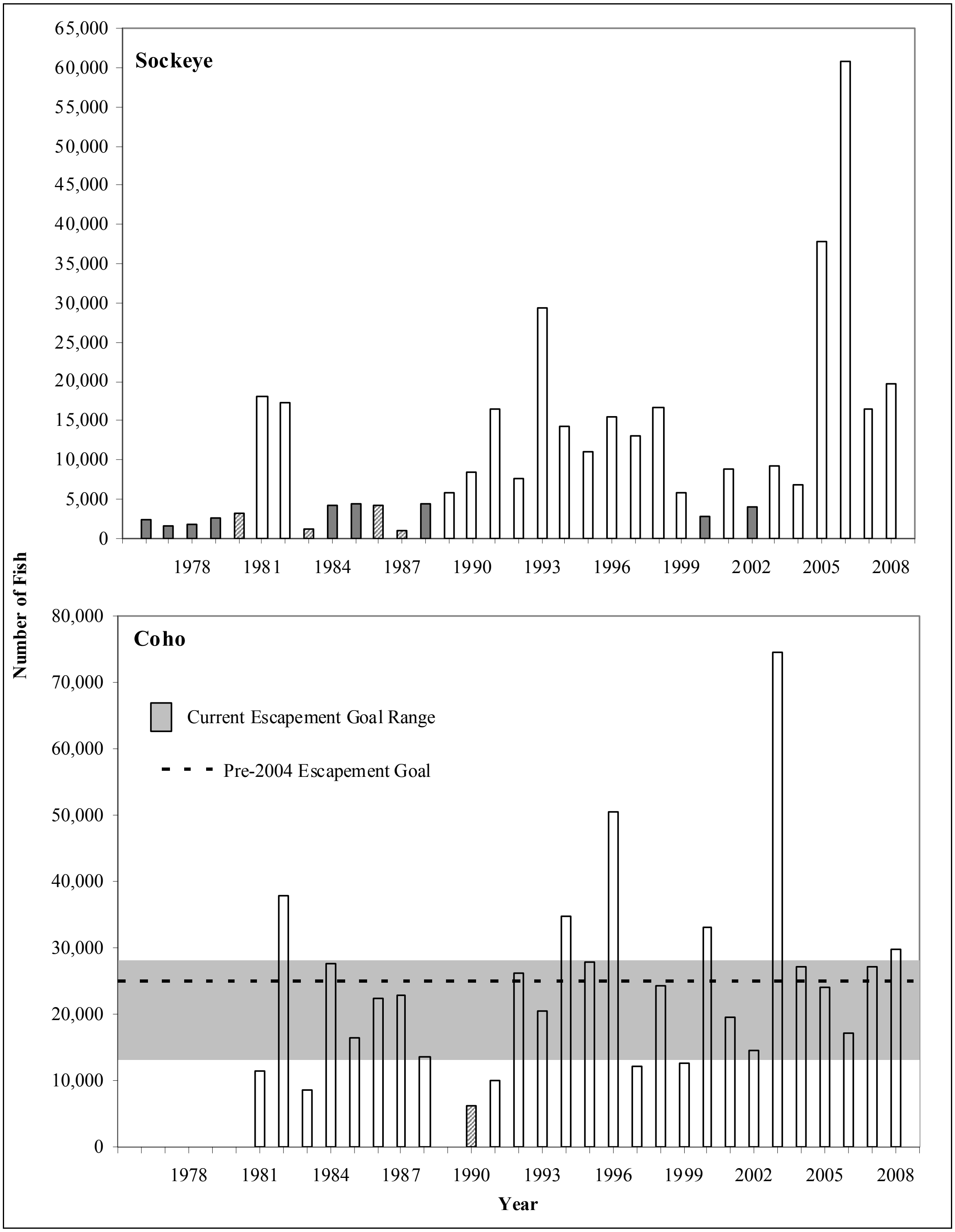
Note: Solid black lines represent dates the central 50% of annual escapement passed in years with at least 80% observed passage. Circles represent median passage dates. As a means to gauge the certainty of the run timing estimates, date ranges with escapement information (observed passage plus passage estimates) are in parentheses beside each annual line.

Figure 14.–Historical annual run timing of coho salmon based on cumulative percent passage at Kogrukluk River weir, 1976–2008.



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

Figure 15.–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: Hatched bars represent years when more than 20% of the escapement was calculated through estimation methods.

Figure 16.–Historical sockeye and coho salmon escapement with the pre-2004 minimum escapement goal and the current escapement goal range at the Kogrukluk River weir.

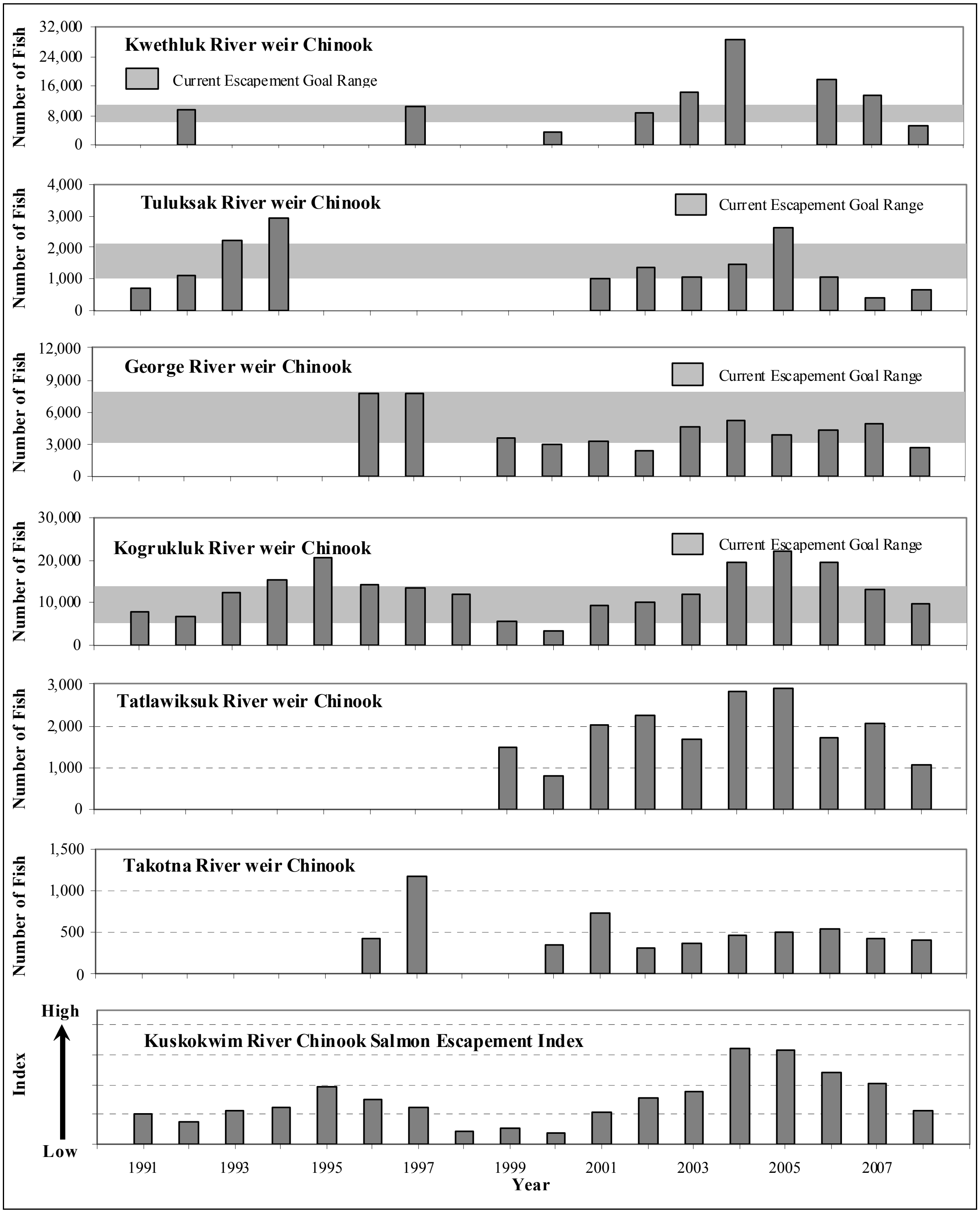
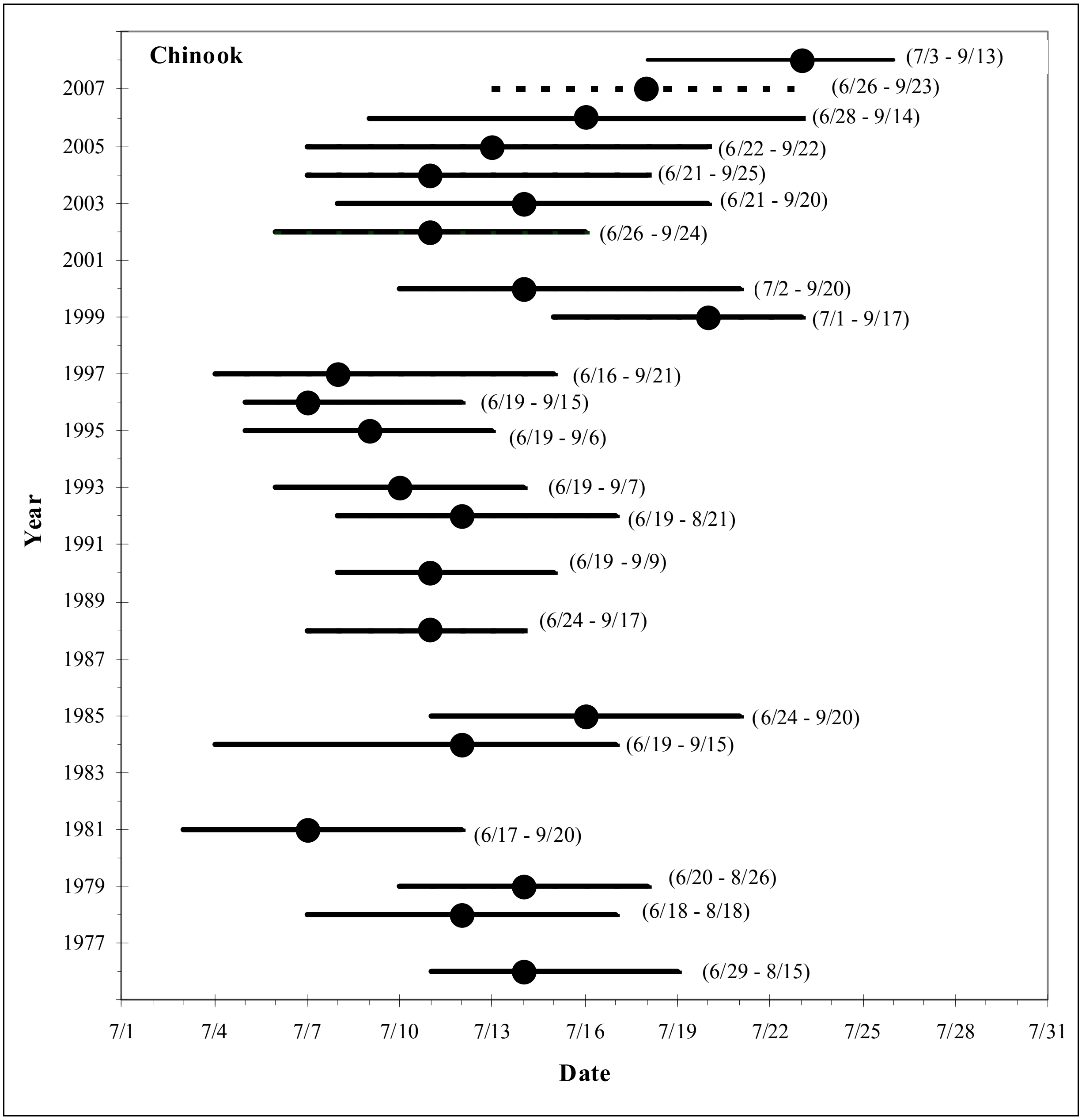


Figure 17.–Historical annual Chinook salmon escapement into 6 Kuskokwim River tributaries and annual Kuskokwim River Chinook salmon escapement indices, 1991–2008.



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. The 2007 annual escapement consists of only 53% observed passage but is included for comparison and denoted with a dashed line. As a means to gauge the certainty of the run timing estimates, date ranges with escapement information (observed passage plus passage estimates) are in parentheses beside each annual line.

Figure 18.–Historical annual run timing of Chinook salmon based on cumulative percent passage at Kogrukluk River weir, 1976–2008.

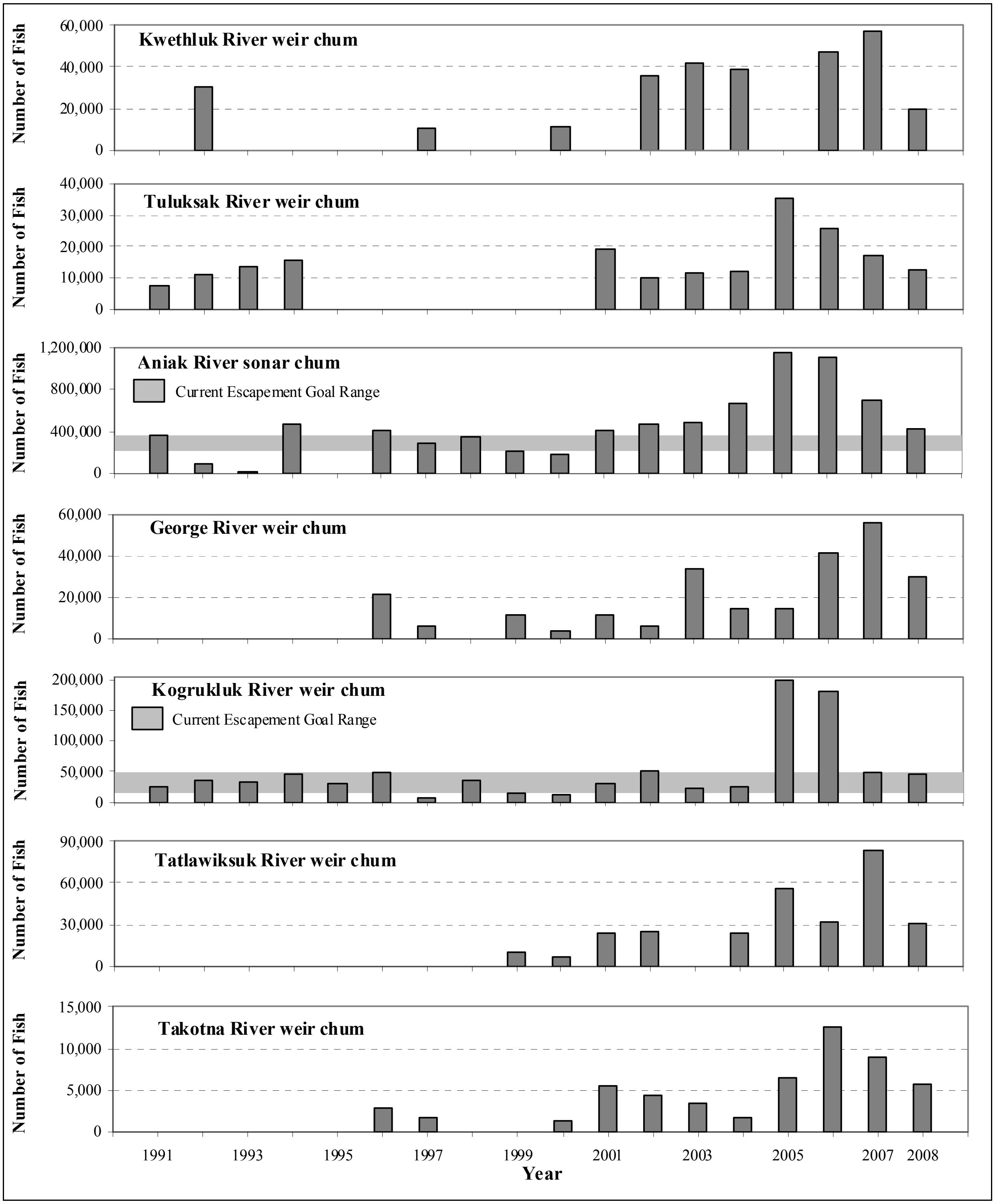
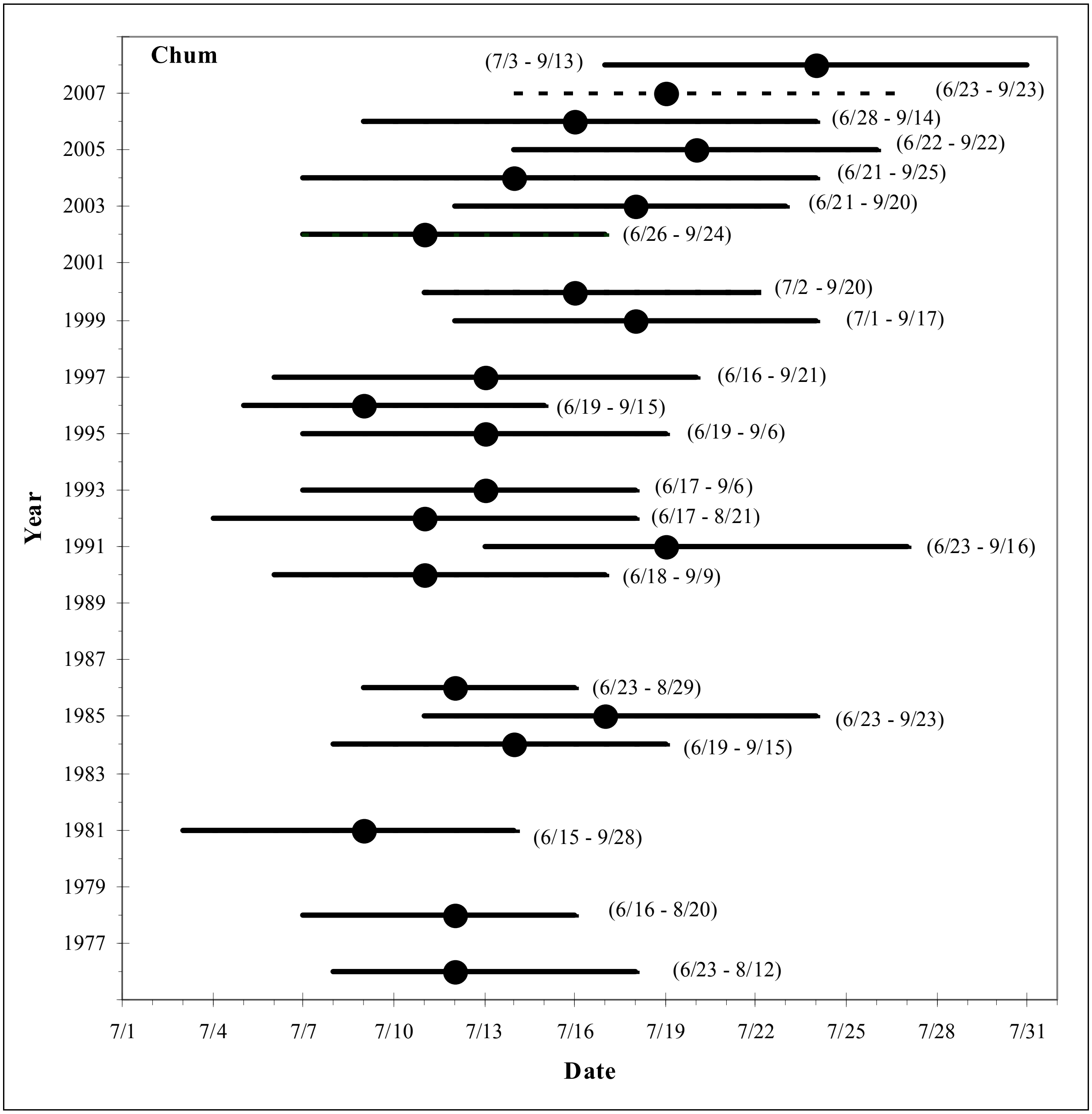


Figure 19.–Historical annual chum salmon escapement into 7 Kuskokwim River tributaries, 1991–2008.



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. The 2007 annual escapement consists of only 63% observed passage but is included for comparison and denoted with a dashed line. As a means to gauge the certainty of the run timing estimates, date ranges with escapement information (observed passage plus passage estimates) are in parentheses beside each annual line.

Figure 20.–Historical annual run timing of chum salmon based on cumulative percent passage at Kogrukluk River weir, 1976–2008.

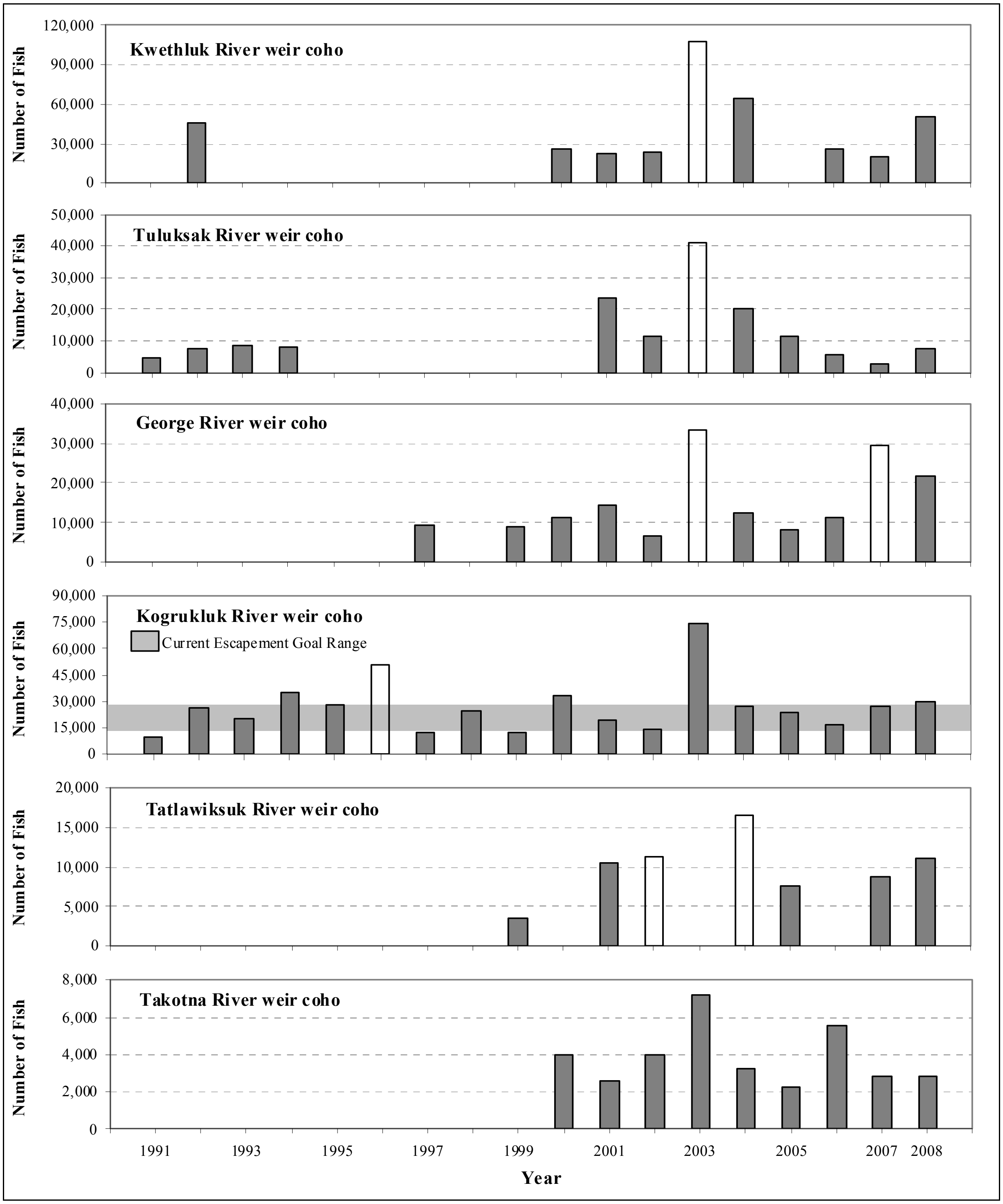
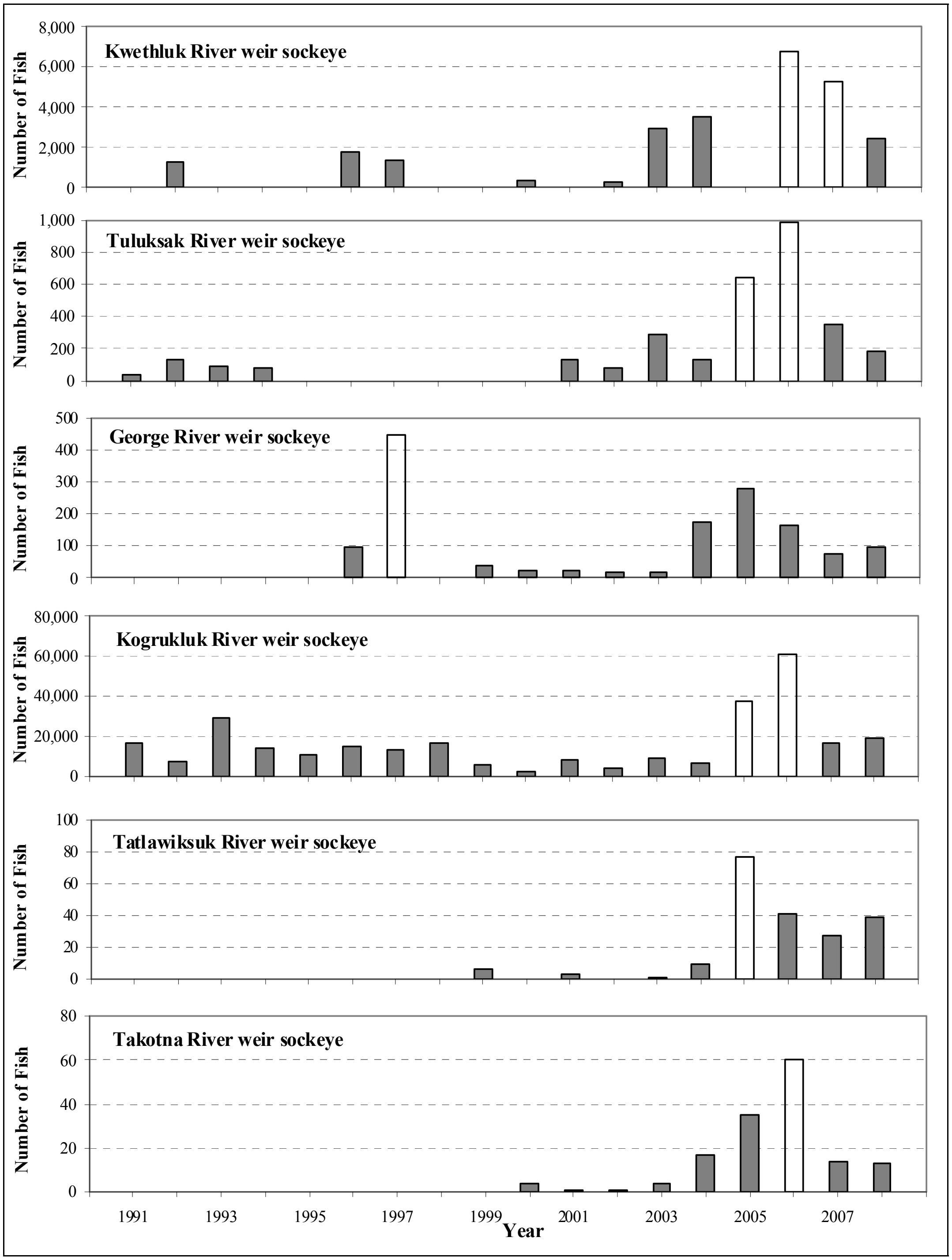
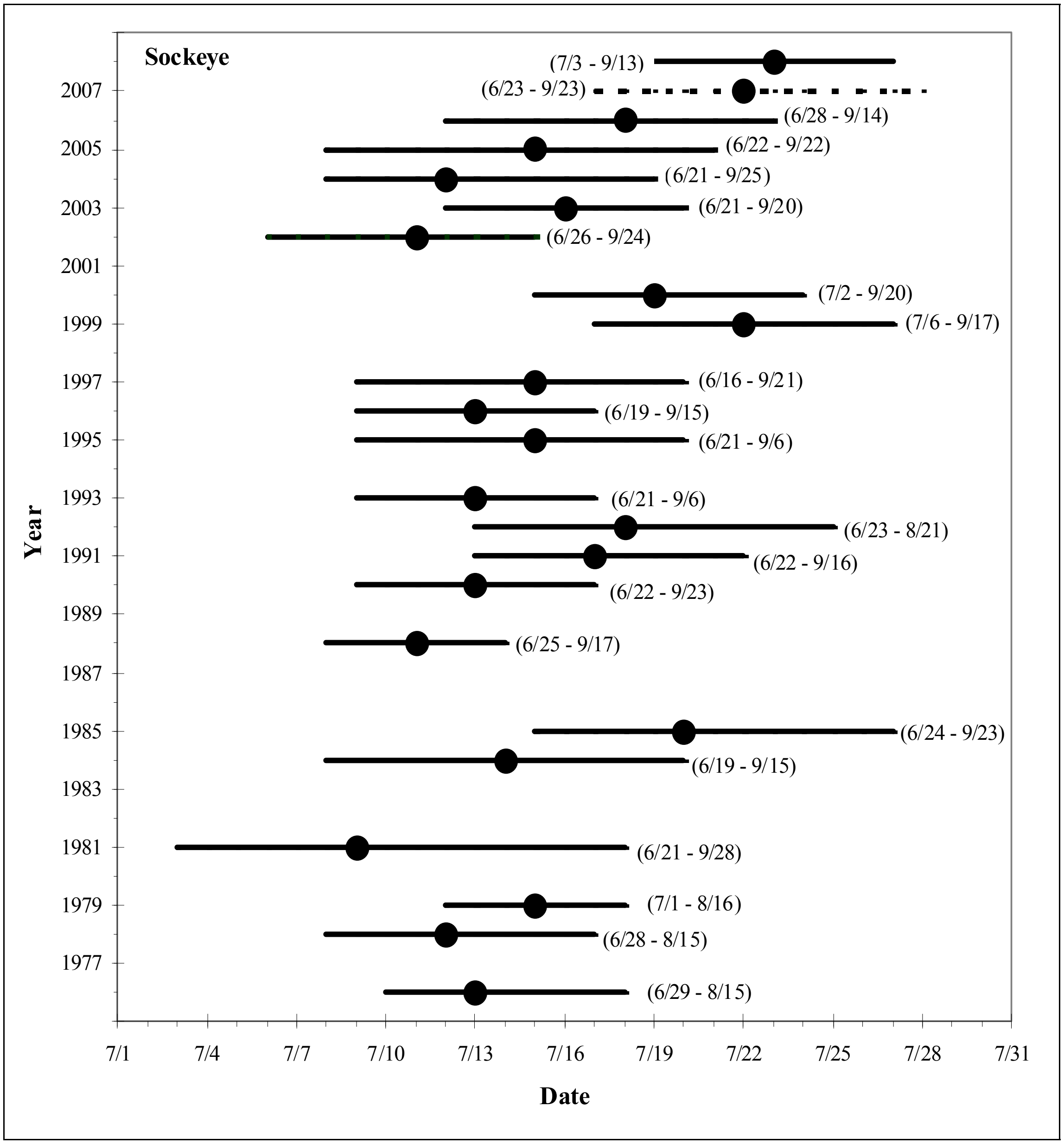


Figure 21.–Historical annual coho salmon escapement into 6 Kuskokwim River tributaries, 1991–2008.



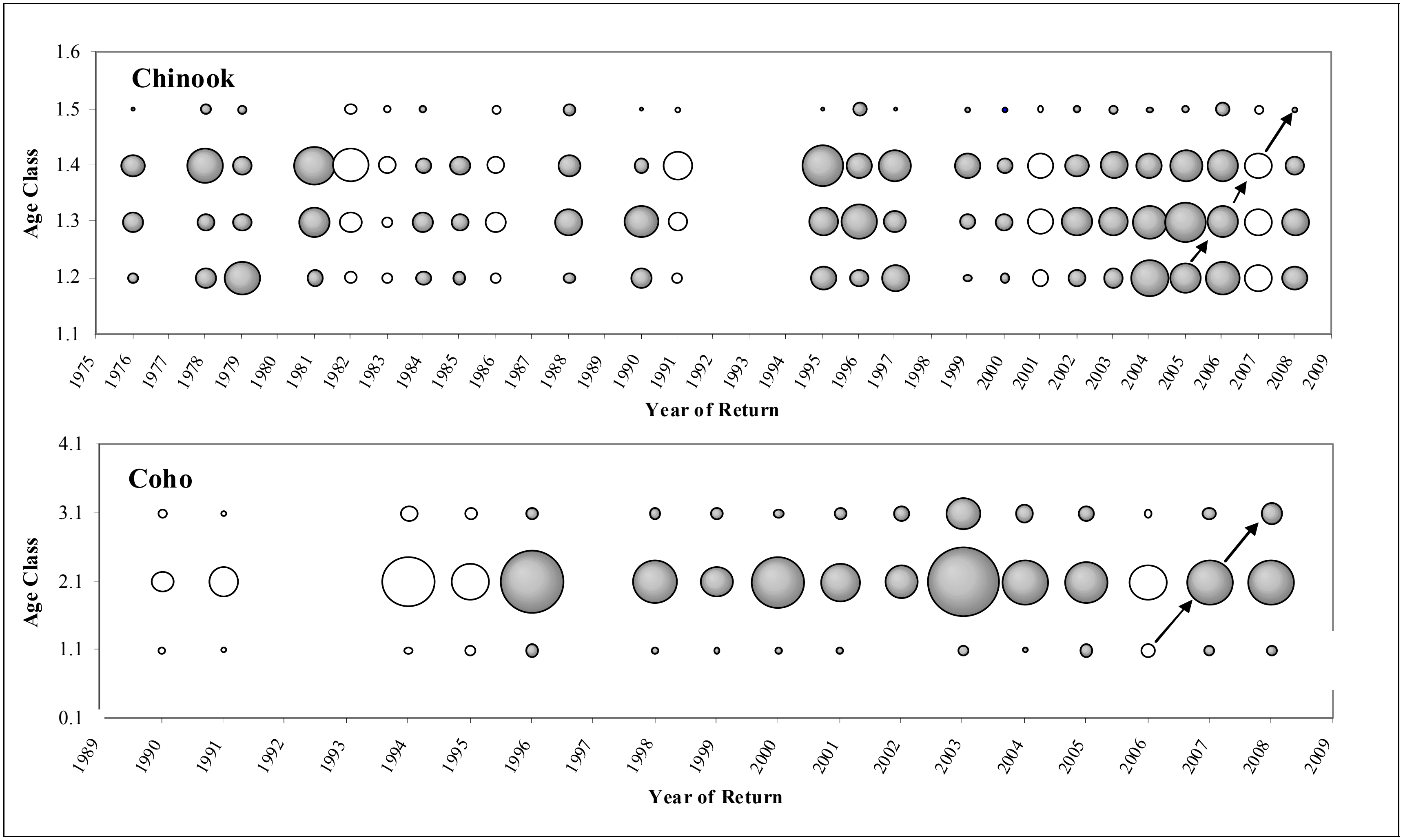
Note: Sockeye salmon escapement at the George River weir in 1997 may be incorrect; investigators suspect possible species misidentification.

Figure 22.–Historical annual sockeye salmon escapement into 6 Kuskokwim River tributaries, 1991–2008.



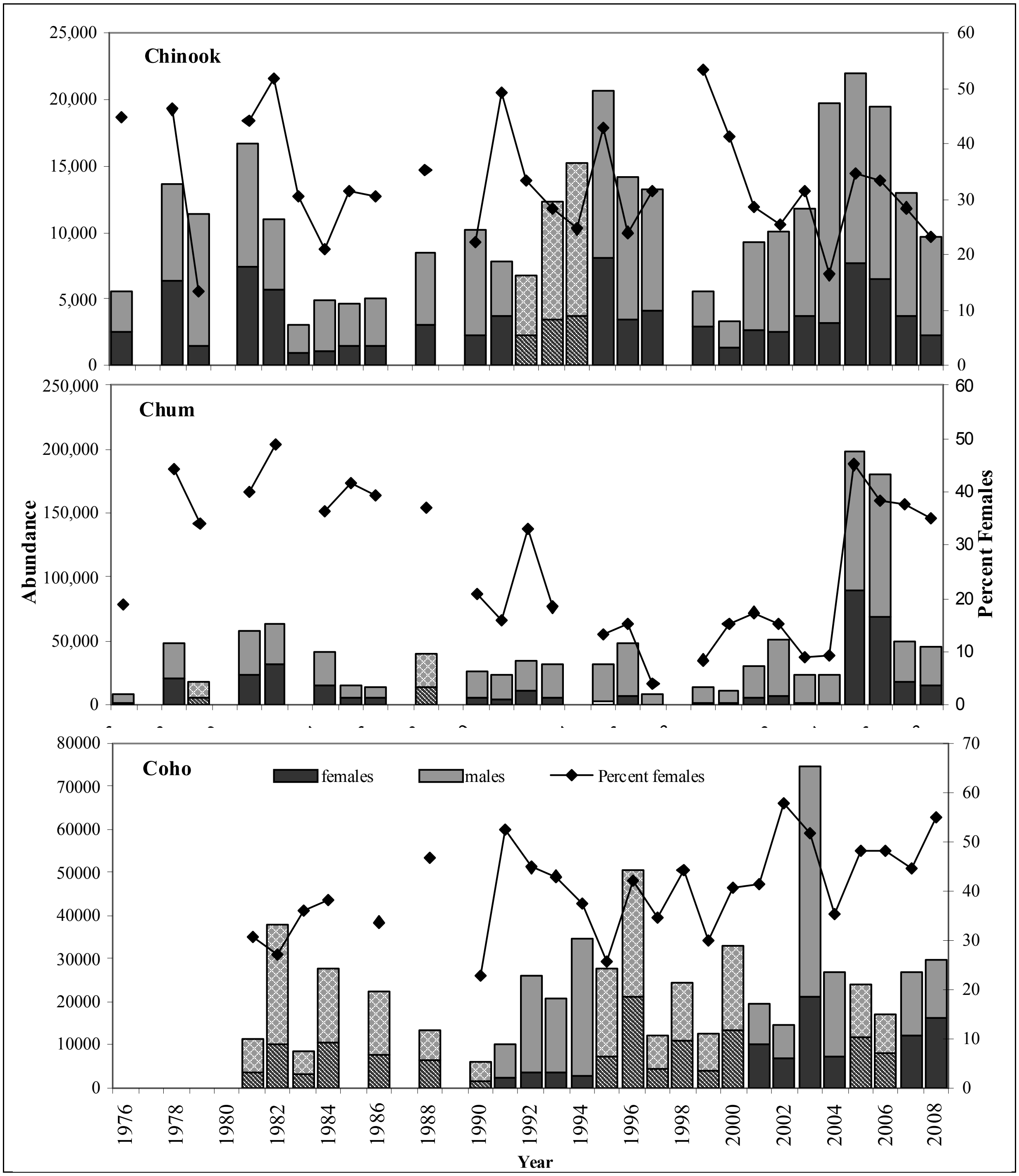
Note: Solid black lines represent dates the central 50% of annual escapement passed in years with at least 80% observed passage. Circles represent median passage dates. The 2007 annual escapement consists of only 60% observed passage but is included for comparison and denoted with a dashed line. As a means to gauge the certainty of the run timing estimates, date ranges with escapement information (observed passage plus passage estimates) are in parentheses beside each annual line.

Figure 23.–Historical annual run timing of sockeye salmon based on cumulative percent passage at Kogrukluk River weir, 1976–2008.



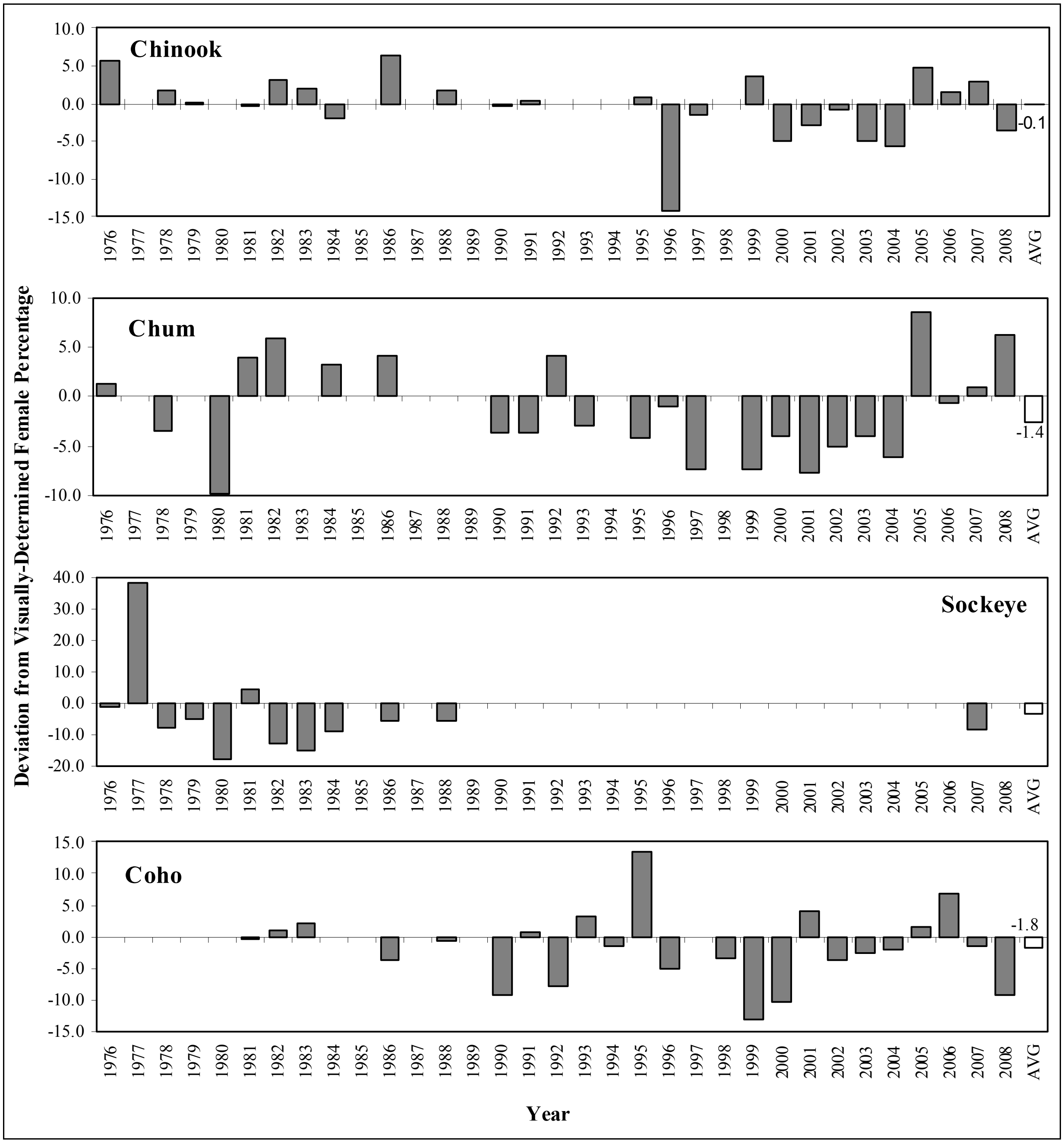
Note: Size of circles represents relative abundance and arrows illustrate a cohort group. Plots that appear empty (white) correspond to years when greater than 20% of reported escapement was derived from daily passage estimates. Years when sample objectives were not achieved contain no data plots.

Figure 24.–Relative age-class abundance of Chinook (1976–2008) and coho salmon (1990–2008) by return year at the Kogrukluk River weir.



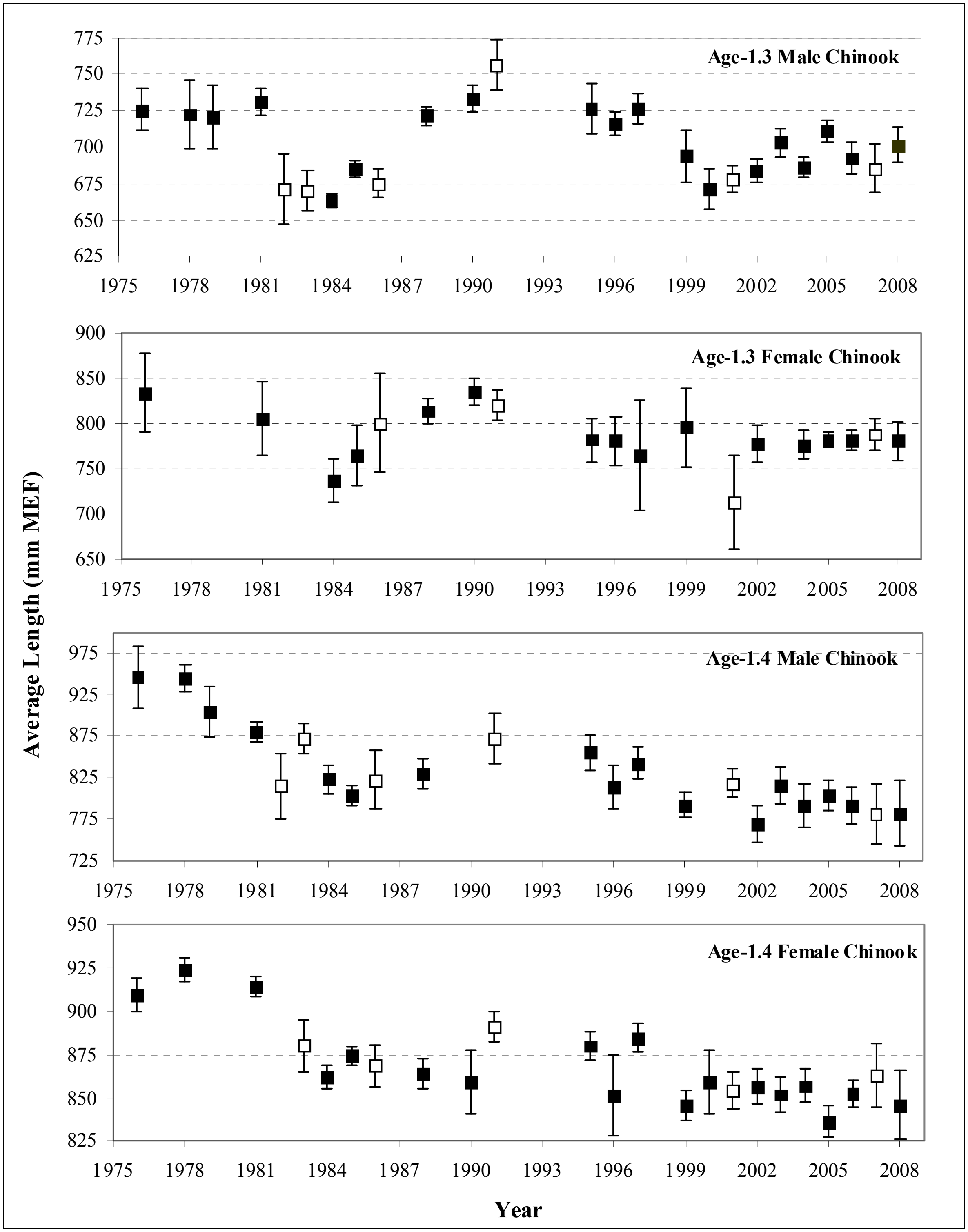
Note: Hatched bars represent years in which female salmon composition was determined from non ASL data due to insufficient ASL data. Lines represent the annual proportion of female salmon.

Figure 25.–Historical Chinook, chum, and coho salmon escapement by sex relative to percent composition of female salmon.



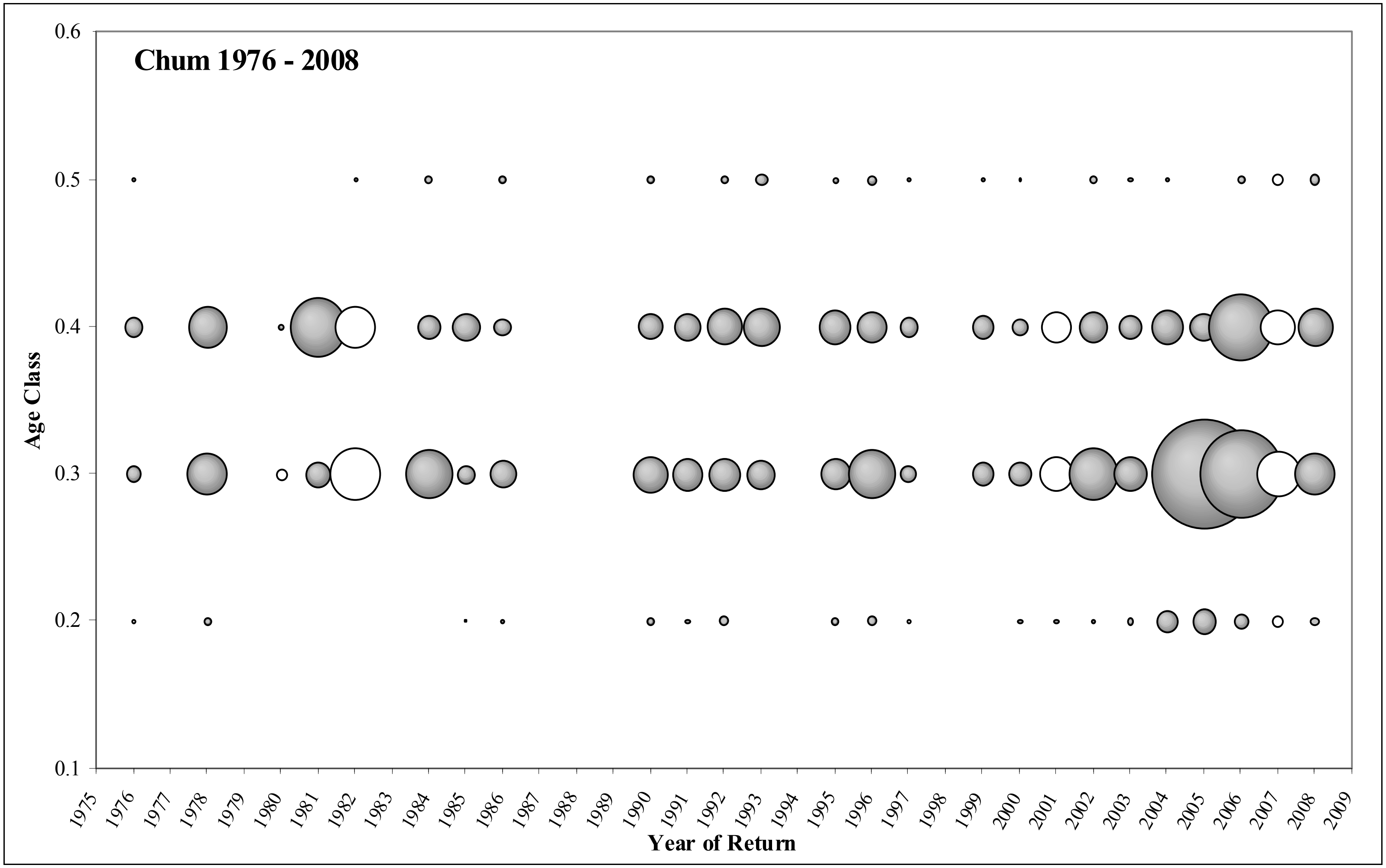
Note: The horizontal line bisecting the plot area at y = 0 represents the visually-determined female percentage during a given year. Columns dropping below this line are instances when the female percentage derived from ASL sampling was less than that of the visual method; columns rising above this line are instances when the female percentage derived from ASL sampling was more than that of the visual method.

Figure 26.–Annual deviation of percent females as determined by ASL sampling methods from the percentage determined through standard escapement counts.



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



Note: Size of circles represents relative abundance. Plots that appear empty (white) correspond to years when greater than 20% of reported escapement was derived from daily passage estimates. Years when sample objectives were not achieved contain no data plots.

Figure 28.–Relative age-class abundance of chum salmon by return year at Kogrukluk River weir.

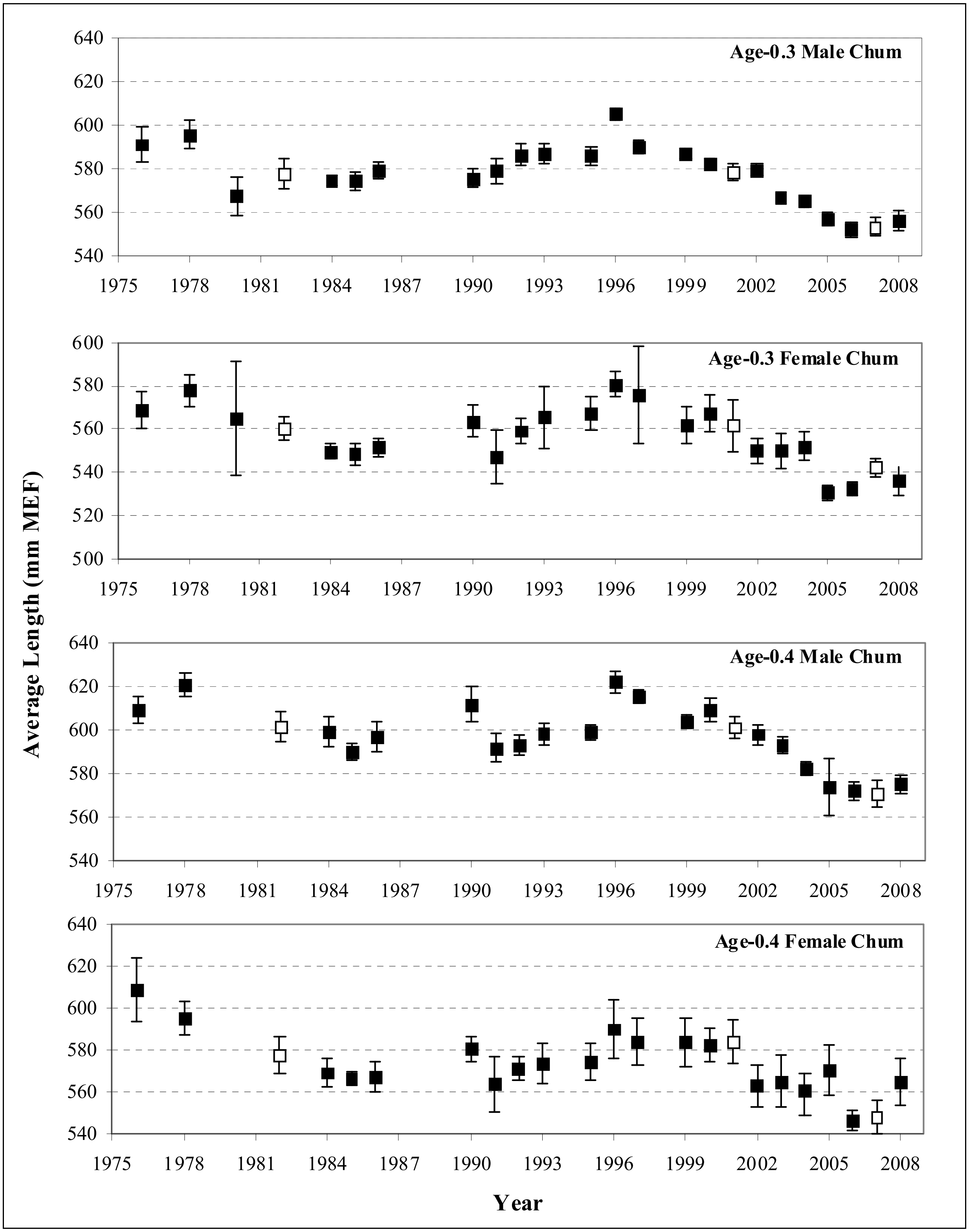
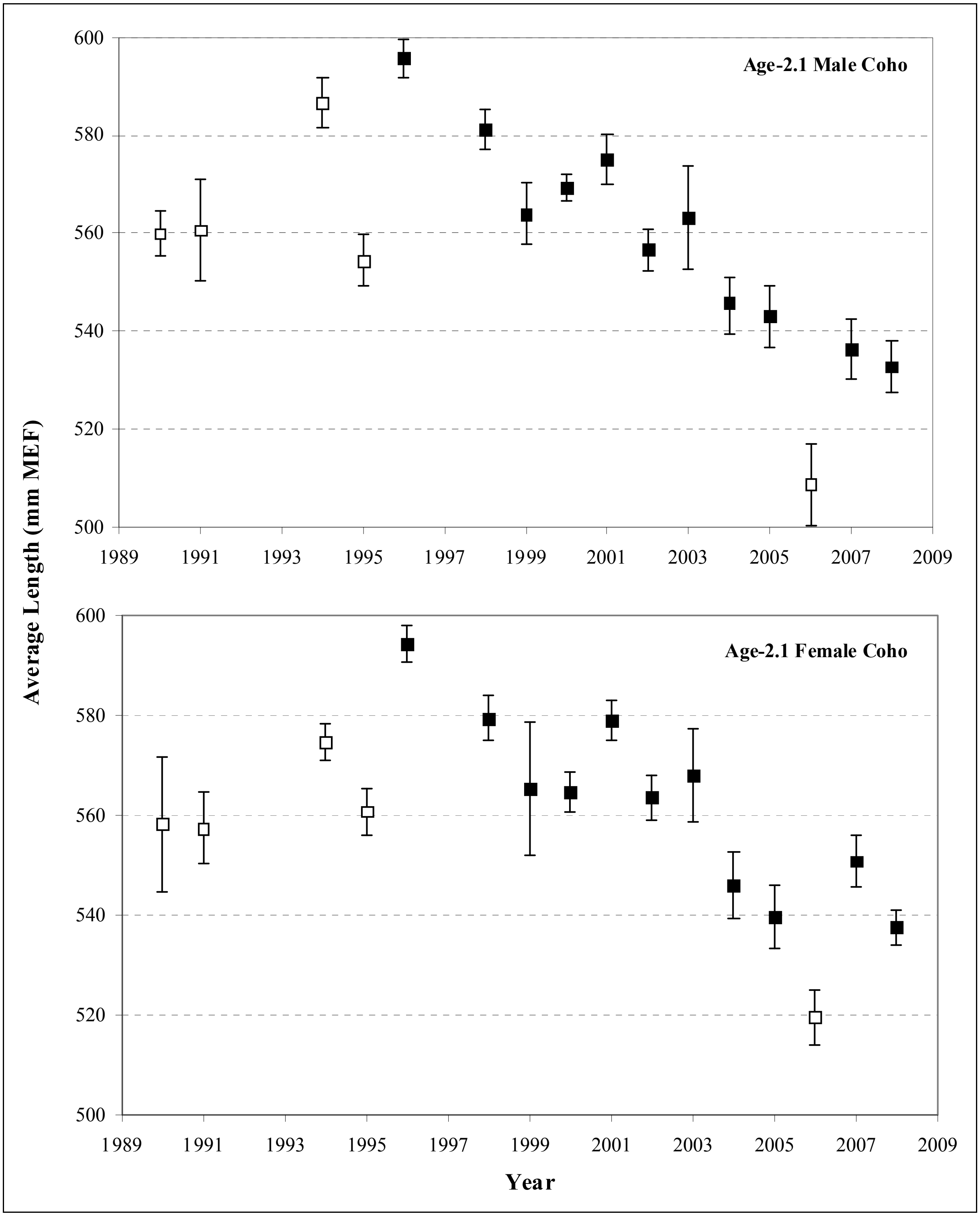


Figure 29.–Historical average annual length for chum salmon with 95% confidence intervals at the Kogrukluk River weir.



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

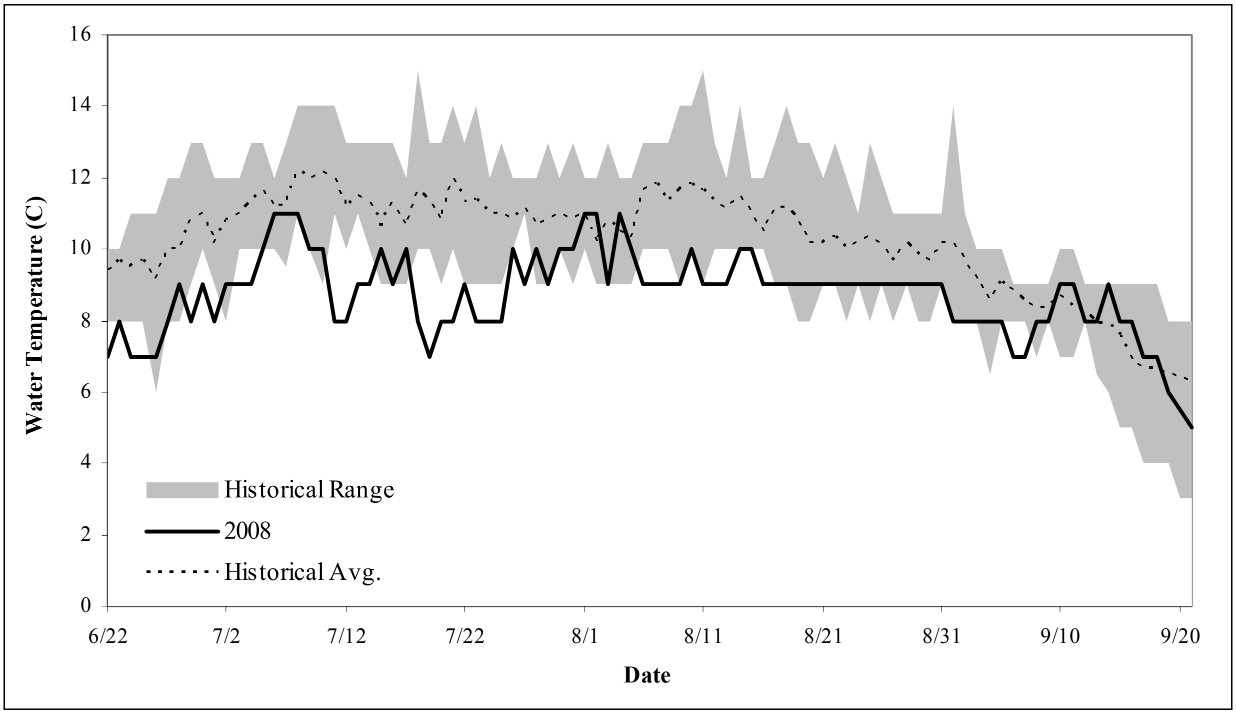


Figure 31.–Daily morning water temperature at Kogrukluk River weir in 2008 relative to historical average, minimum, and maximum morning readings from 2002–2007.

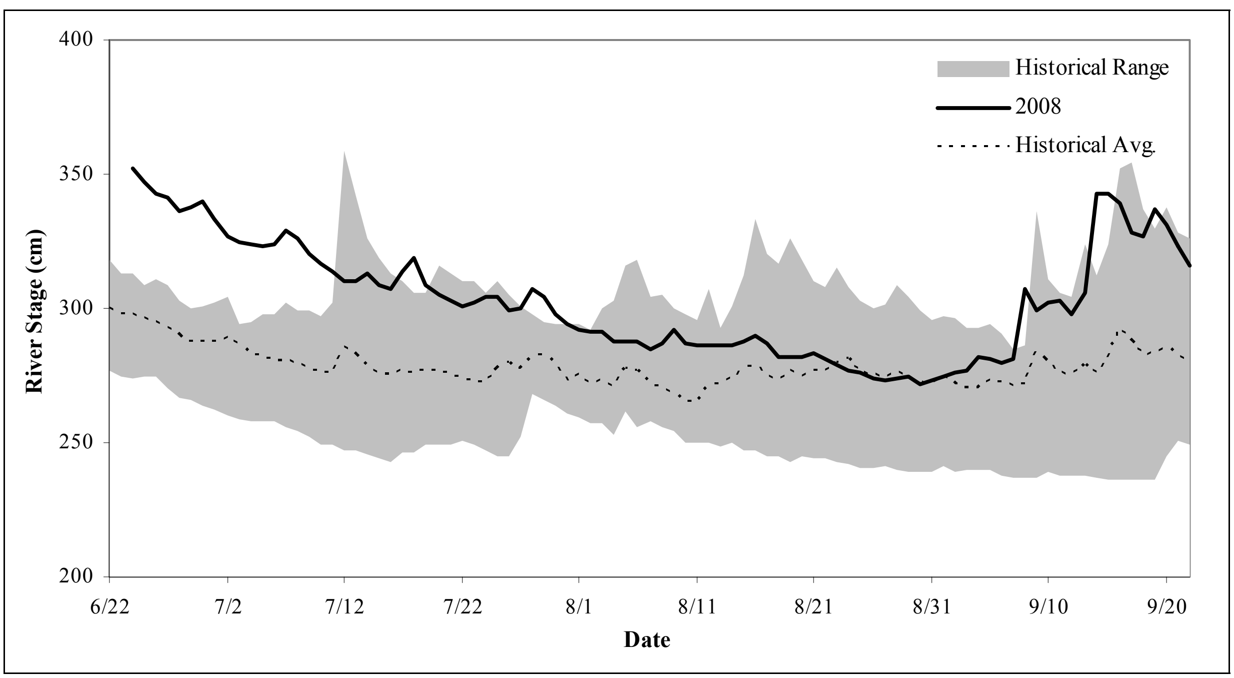


Figure 32.–Daily morning river stage at Kogrukluk River weir in 2008 relative to historical average, minimum, and maximum morning readings from 2002–2007.

APPENDIX A

Appendix A1.–Daily passage counts by species at Kogrukluk River weir, 2008.

Date	Chinook Salmon		Sockeye Salmon		Chum Salmon		Pink Salmon		Coho Salmon		Dolly	White-	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Varden[a]	fish	Other[b]
7/03	0	0	0	0	2	1	0	0	0	0	0	0	0
7/04	9	5	0	2	86	34	0	0	0	0	0	0	0
7/05	3	2	2	3	72	38	1	0	0	0	2	1	1 G
7/06	10	8	0	0	114	57	0	0	0	0	0	0	0
7/07	10	9	2	0	256	122	0	0	0	0	0	0	0
7/08	19	8	17	17	282	168	0	0	0	0	0	0	0
7/09	11	10	10	12	234	131	1	0	0	0	0	0	0
7/10	11	1	7	15	235	104	0	0	0	0	0	0	0
7/11	38	13	21	29	302	149	1	0	0	0	2	0	0
7/12	14	10	23	17	274	98	1	0	0	0	1	0	0
7/13	619	91	130	269	655	221	1	2	0	0	0	0	0
7/14	307	57	139	294	467	197	6	0	0	0	0	0	0
7/15	184	36	152	139	701	377	3	1	0	0	0	0	0
7/16	246	57	244	278	1,625	928	7	1	0	0	1	0	0
7/17	340	80	865	918	2,073	1,113	6	1	0	0	2	0	0
7/18	290	89	334	300	1,002	591	5	1	0	0	1	0	0
7/19	348	79	560	600	1,141	928	2	0	0	0	4	0	0
7/20	407	85	541	718	1,072	825	11	0	0	0	0	0	0
7/21	573	173	504	763	970	796	5	1	0	0	8	0	0
7/22	378	110	383	488	775	622	8	1	0	0	6	0	0
7/23	645	186	694	773	939	680	6	1	0	0	3	0	0
7/24	371	163	512	630	903	634	4	0	0	0	2	0	0
7/25	534	206	701	919	1,140	649	2	1	1	0	0	0	0
7/26	357	247	624	635	1,066	676	2	4	1	0	5	0	0
7/27	237	124	366	387	1,086	709	4	0	0	0	4	0	0
7/28	257	154	547	517	1,153	703	13	0	4	1	3	0	0
7/29	146	140	420	465	950	673	5	1	4	1	1	0	0
7/30	112	68	283	224	563	392	15	6	9	5	0	0	0
7/31	127	96	217	220	891	555	15	6	6	3	1	0	0
8/01	71	51	218	135	680	265	11	1	6	1	1	0	0
8/02	68	52	93	70	622	328	16	3	9	3	0	0	0
8/03	60	45	149	83	725	377	27	4	16	18	0	0	0

-continued-

Appendix A1.–Page 2 of 3.

Date	Chinook Salmon		Sockeye Salmon		Chum Salmon		Pink Salmon		Coho Salmon		Dolly	White-	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Varden[a]	fish	Other[b]
8/4	43	39	125	114	614	529	39	11	14	20	0	0	0
8/5	52	36	116	106	618	494	55	30	28	41	7	0	0
8/6 [c]	10	2	20	18	104	103	14	6	8	6	2	0	0
8/7	50	8	33	56	290	376	43	21	10	17	3	0	0
8/8	18	11	31	38	261	279	43	17	22	28	5	0	0
8/9	27	9	19	13	230	230	45	13	25	29	4	0	0
8/10	16	19	20	14	249	246	24	15	10	13	4	0	0
8/11	15	13	19	18	144	255	62	17	49	34	15	0	0
8/12	18	6	17	16	176	200	58	21	97	113	4	0	0
8/13	12	3	6	7	76	188	56	16	57	60	18	0	0
8/14	11	3	7	8	54	155	48	19	86	103	15	0	0
8/15	8	0	7	8	49	104	30	14	79	96	7	0	0
8/16	5	2	5	6	71	76	15	5	152	121	9	0	0
8/17	2	1	5	3	44	45	15	8	100	65	12	0	0
8/18	2	2	2	1	41	78	14	2	199	169	15	0	0
8/19	4	0	5	4	23	37	11	2	169	118	16	0	0
8/20	1	0	0	0	13	40	7	0	139	107	6	0	0
8/21	2	2	5	2	34	49	8	0	246	215	25	0	0
8/22	0	0	2	0	5	13	5	1	78	59	12	0	0
8/23	1	0	1	0	13	17	3	1	357	318	23	0	0
8/24	3	0	0	1	13	13	1	0	216	220	23	0	0
8/25	2	0	1	1	5	16	0	1	329	286	20	0	0
8/26	0	0	0	0	13	12	2	0	485	432	37	0	0
8/27	2	0	0	0	9	8	3	0	190	137	13	0	0
8/28	0	0	0	0	2	2	1	0	581	400	34	0	0
8/29	0	0	0	0	2	9	0	0	578	303	17	0	0
8/30	0	0	0	0	2	3	0	0	357	233	26	0	0
8/31	0	0	0	0	1	3	0	1	372	309	9	0	0

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Appendix A1.–Page 3 of 3.

	Chinook Salmon		Sockeye Salmon		Chum Salmon		Pink Salmon		Coho Salmon		Dolly	White-	
Date	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Varden[a]	fish	Other[b]
9/01	0	0	0	0	1	1	0	0	1,222	847	24	0	0
9/02	0	0	0	0	0	0	0	0	567	380	21	0	0
9/03	0	0	0	0	0	0	0	0	436	321	15	0	0
9/04	0	0	0	0	2	2	0	0	1,223	867	38	0	0
9/05	0	0	0	0	0	1	0	0	1,283	973	36	0	0
9/06	0	0	0	0	1	1	0	0	231	122	10	0	0
9/07	0	0	0	0	0	1	0	0	1,382	976	49	0	0
9/08	0	0	0	0	0	0	0	0	1,171	1,017	33	1	0
9/09	0	0	0	0	0	1	0	0	429	434	23	0	0
9/10	0	0	0	0	0	0	0	0	502	484	11	7	0
9/11	0	0	0	0	0	0	0	0	217	243	10	0	0
9/12	0	0	0	0	0	1	0	0	311	286	19	8	0
9/13	0	0	0	0	0	2	0	0	284	261	30	5	0

[a] Counts represent sexually mature fish only

[b] G = Arctic grayling; P = Northern pike. Counts may not correspond to actual day observed

[c] Incomplete or partial daily count

APPENDIX B

Appendix B1.–Daily carcass counts at Kogrukluk River weir, 2008.

Date	Chinook Salmon	Sockeye Salmon	Chum Salmon	Pink Salmon	Coho Salmon	Dolly Varden	White-fish	Other[a]
7/03	0	0	0	0	0	0	0	0
7/04	0	0	0	0	0	0	0	0
7/05	0	0	0	0	0	0	0	0
7/06	0	0	0	0	0	0	0	0
7/07	5	0	0	0	0	0	0	0
7/08	0	0	0	0	0	0	0	0
7/09	0	0	0	0	0	0	0	0
7/10	0	0	0	0	0	0	0	0
7/11	0	0	0	0	0	0	0	0
7/12	0	0	0	0	0	0	0	0
7/13	0	0	0	0	0	0	0	0
7/14	0	0	0	0	0	0	0	0
7/15	0	0	0	0	0	0	0	0
7/16	0	0	0	0	0	0	0	0
7/17	0	0	0	0	0	0	0	0
7/18	0	0	0	0	0	0	0	0
7/19	0	0	46	0	0	0	0	0
7/20	0	0	0	0	0	0	0	0
7/21	0	0	45	0	0	0	0	0
7/22	0	0	31	0	0	0	0	0
7/23	0	0	51	0	0	0	0	0
7/24	0	0	62	0	0	0	0	0
7/25	0	0	82	0	0	0	1	0
7/26	0	0	0	0	0	0	0	0
7/27	0	0	279	0	0	1	0	0
7/28	0	0	225	0	0	0	1	0
7/29	1	0	149	0	0	0	0	0
7/30	0	2	187	2	0	0	0	0
7/31	0	0	254	0	0	0	0	0
8/01	1	2	194	5	0	2	0	0
8/02	3	2	274	0	0	0	0	0
8/03	4	0	320	0	0	0	0	0
8/04	18	3	318	4	0	0	0	0
8/05	19	2	356	6	0	1	0	0
8/06	0	0	0	0	0	0	0	0
8/07	13	5	252	4	0	0	0	0
8/08	46	21	394	4	0	0	0	0
8/09	84	30	514	10	0	0	0	0
8/10	118	27	500	9	0	0	0	0
8/11	118	29	484	12	0	0	0	1 G
8/12	157	33	550	9	0	0	0	0
8/13	0	0	0	0	0	0	0	0
8/14	114	74	501	38	0	0	0	1 G
8/15	115	68	392	42	0	0	0	0

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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]
8/16	112	71	383	25	0	0	0	0
8/17	105	307	57	0	0	0	0	0
8/18	0	0	0	0	0	0	0	0
8/19	83	89	260	105	0	1	0	0
8/20	68	90	199	34	0	1	0	0
8/21	57	75	145	78	0	0	0	0
8/22	67	78	130	85	1	0	0	0
8/23	31	87	100	83	0	0	0	0
8/24	26	62	92	93	0	0	0	0
8/25	15	61	70	68	0	0	0	0
8/26	0	0	0	0	0	0	0	0
8/27	17	92	87	70	0	0	0	0
8/28	0	0	0	0	0	0	0	0
8/29	21	47	58	55	2	1	0	0
8/30	0	0	0	0	0	0	0	0
8/31	3	39	49	38	0	0	0	0
9/01	0	0	0	0	0	0	0	0
9/02	2	25	38	11	1	0	0	3 P
9/03	1	15	7	3	1	0	0	0
9/04	0	0	0	0	0	0	0	0
9/05	0	0	0	0	0	0	0	0
9/06	0	0	0	0	0	0	0	0
9/07	0	0	0	0	0	0	0	0
9/08	0	0	0	0	0	0	0	0
9/09	0	0	0	0	0	0	0	0
9/10	2	7	3	3	8	0	0	0
9/11	0	3	0	0	10	1	0	0
9/12	0	0	0	0	0	0	0	0
9/13	0	5	5	0	0	20	0	0
Total	1,426	1,451	8,143	896	23	28	2	5

[a] G = Arctic grayling; P = Northern pike; B = burbot

APPENDIX C

Appendix C1.–Daily weather and stream observations at Kogrukluk River weir, 2008.

Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River Stage (cm)[b]	Water Clarity[c]
6/21	7:30	1	0.0	4	7	ND	3
6/22	7:30	1	0.0	5	7	ND	2
6/23	7:30	4	0.5	9	8	ND	2
	17:00	3	0.0	15	9	356	2
6/24	7:30	2	0.0	4	7	352	2
	17:00	2	0.0	15	9	350	2
6/25	7:30	2	0.0	7	7	347	2
	17:00	4	0.0	16	8	345	2
6/26	7:30	4	0.0	8	7	343	2
	17:00	4	0.0	16	9	344	1
6/27	7:30	3	0.5	8	8	341	1
	20:00	2	9.0	17	10	339	1
6/28	10:30	4	3.0	10	9	336	1
	17:00	4	3.0	14	9	337	1
6/29	10:30	4	3.0	9	8	338	1
	17:00	4	2.0	13	8	339	1
6/30	7:30	4	0.0	8	9	340	1
	17:00	2	0.0	ND	ND	339	1
7/01	7:30	2	0.0	5	8	333	1
	17:00	2	0.0	21	11	330	1
7/02	7:30	4	0.0	9	9	327	1
	17:00	1	0.0	ND	10	326	1
7/03	7:30	4	0.0	9	9	325	1
	17:00	4	0.5	15	10	325	1
7/04	10:30	3	0.5	13	9	324	1
	17:00	2	0.0	18	10	323	1
7/05	10:30	3	0.0	16	10	323	1
	17:00	2	0.0	27	14	322	1
7/06	10:30	1	2.0	14	11	324	2
	17:00	2	0.0	22	14	328	2
7/07	7:30	4	0.5	15	11	329	2
	17:00	2	0.0	22	13	327	1
7/08	7:30	4	0.0	14	11	326	1
	17:00	3	2.0	19	11	323	1
7/09	7:30	4	0.0	12	10	320	1
	17:00	4	0.0	16	11	318	1
7/10	7:30	4	0.0	12	10	317	1
	17:00	4	0.0	14	10	316	1
7/11	7:30	4	0.0	10	8	314	1
	18:00	4	0.0	15	9	312	1
7/12	10:30	4	0.0	11	8	310	1
	17:30	4	2.5	ND	9	309	1
7/13	10:30	4	2.0	13	9	310	1
	18:00	2	0.0	18	10	313	1
7/14	7:30	3	0.0	12	9	313	1
	17:00	3	0.0	18	11	310	1

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Appendix C1.–Page 2 of 5.

Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C)		River Stage (cm)[b]	Water Clarity[c]
				Air	Water		
7/15	7:30	4	0.0	12	10	309	1
	17:00	4	3.0	14	10	306	1
7/16	7:30	4	7.0	11	9	307	1
	17:00	4	7.0	13	10	310	1
7/17	7:30	4	0.0	7	10	314	1
	18:00	3	0.0	ND	ND	323	2
7/18	7:30	4	0.0	8	8	319	2
	18:00	3	0.0	14	10	313	1
7/19	10:30	4	0.0	10	7	309	1
	17:30	3	3.0	16	9	307	1
7/20	10:30	3	0.0	13	8	305	1
	17:00	4	0.0	16	10	303	1
7/21	7:30	3	3.0	9	8	303	1
	17:30	2	0.0	18	10	302	1
7/22	7:30	2	0.0	5	9	301	1
	17:00	4	6.0	12	9	300	1
7/23	7:30	4	2.0	8	8	302	1
	17:00	4	1.0	13	9	303	1
7/24	7:30	4	25.0	8	8	304	1
	17:00	1	0.0	19	10	306	1
7/25	7:30	1	0.0	5	8	304	1
	17:00	1	0.0	22	11	301	1
7/26	7:30	4	3.0	12	10	299	1
	17:00	4	0.0	15	10	298	1
7/27	7:30	4	5.0	9	9	300	1
	18:00	3	3.0	16	11	301	1
7/28	7:30	1	4.0	8	10	307	2
	18:30	1	0.0	19	12	307	2
7/29	7:30	1	0.0	7	9	304	1
	18:00	1	0.0	17	11	299	1
7/30	7:30	1	0.0	10	10	298	1
	18:00	2	0.0	17	ND	296	1
7/31	7:30	1	0.0	5	10	294	1
	18:00	1	0.0	24	14	292	1
8/01	7:30	1	0.0	5	11	292	1
	17:00	1	0.0	25	14	292	1
8/02	10:00	4	0.0	13	11	291	1
	17:00	3	0.0	16	14	291	1
8/03	10:00	1	0.0	6	9	291	1
	17:00	1	0.0	20	13	288	1
8/04	7:30	4	0.0	11	11	288	1
	17:00	3	0.0	15	12	286	1
8/05	7:30	2	0.0	7	10	288	1
	17:00	1	0.0	22	12	286	1
8/06	7:30	2	0.0	5	9	288	1
	17:00	4	0.0	ND	ND	288	1

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Appendix C1.–Page 3 of 5.

Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River Stage (cm)[b]	Water Clarity[c]
8/07	7:30	4	0.0	8	9	285	1
	19:00	4	0.0	16	10	285	1
8/08	7:30	5	0.0	3	9	287	1
	19:00	1	0.0	20	ND	285	1
8/09	7:30	1	0.0	8	9	292	1
	19:00	2	0.0	18	ND	282	1
8/10	10:30	2	0.0	11	10	287	1
	17:00	2	0.0	18	12	280	1
8/11	7:30	2	1.0	8	9	286	1
	18:00	3	0.0	ND	ND	283	1
8/12	7:30	1	1.0	6	9	286	1
	14:00	1	0.0	ND	ND	279	1
8/13	7:30	4	0.5	8	9	286	1
	16:30	4	0.0	17	11	278	1
8/14	7:30	4	1.5	12	10	286	1
	17:00	4	1.0	17	11	281	1
8/15	7:30	4	0.0	9	10	288	1
	17:00	4	0.0	15	11	284	1
8/16	10:00	3	0.0	8	9	290	1
	17:00	3	0.0	17	11	282	1
8/17	10:30	3	0.0	8	9	287	1
	17:00	3	0.0	17	11	281	1
8/18	7:30	1	0.0	5	9	282	1
	17:00	1	0.0	15	12	279	1
8/19	7:30	3	0.0	6	9	282	1
	16:00	4	0.0	14	11	278	1
8/20	7:30	5	17.5	9	9	282	1
	17:00	4	0.5	16	11	281	1
8/21	7:30	2	0.0	8	9	283	1
	19:00	2	0.0	17	11	280	1
8/22	7:30	5	2.0	5	9	281	1
	19:00	2	5.0	15	11	278	1
8/23	10:30	1	0.0	8	9	279	1
	17:00	1	0.0	21	11	278	1
8/24	10:30	1	0.0	8	9	277	1
	17:30	1	0.0	20	11	276	1
8/25	7:30	1	0.0	0	9	276	1
	17:00	1	0.0	19	12	274	1
8/26	7:30	1	0.0	7	9	274	1
	17:00	4	0.0	17	11	274	1
8/27	7:30	5	0.0	5	9	273	1
	17:00	4	7.0	15	11	273	1
8/28	8:30	3	0.0	6	9	274	1
	17:00	2	0.0	16	11	274	1
8/29	7:30	1	0.0	3	9	275	1
	18:00	3	0.0	15	ND	273	1

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Appendix C1.–Page 4 of 5.

Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River Stage (cm)[b]	Water Clarity[c]
8/30	10:30	4	0.0	9	9	272	1
	17:00	4	0.0	14	10	272	1
8/31	10:30	4	3.0	9	9	273	1
	17:00	4	0.0	13	10	273	1
9/01	10:30	1	0.8	6	8	275	1
	17:30	4	0.0	15	10	276	1
9/02	10:30	4	4.0	8	8	276	1
	17:00	4	1.0	10	8	276	1
9/03	9:30	4	6.0	9	8	277	1
	17:30	4	1.0	11	9	279	1
9/04	10:30	4	3.0	9	8	282	1
	17:00	3	0.0	16	10	282	1
9/05	10:30	4	2.0	9	8	281	1
	17:00	3	0.0	15	12	281	1
9/06	10:30	5	0.0	5	7	280	1
	17:00	4	1.0	10	8	279	1
9/07	10:30	4	10.0	9	7	281	1
	17:00	4	1.5	12	9	285	1
9/08	10:30	4	3.0	9	8	307	3
	18:00	4	0.0	ND	9	301	3
9/09	10:30	4	5.0	9	8	299	2
	18:45	4	3.0	12	9	300	2
9/10	10:30	4	3.0	11	9	302	3
	18:00	4	1.0	14	10	303	3
9/11	10:30	4	0.0	11	9	303	3
	18:00	4	3.0	13	10	301	2
9/12	10:30	4	1.0	9	8	298	2
	17:00	4	2.0	12	8	298	2
9/13	10:30	4	8.0	10	8	306	2
	18:00	4	1.0	12	9	315	3
9/14	10:30	4	0.0	9	9	343	3
	18:00	3	0.0	10	9	340	3
9/15	10:30	4	1.0	9	8	343	3
	18:30	4	2.0	12	9	342	3
9/16	17:00	4	1.0	9	8	339	3
	10:30	3	0.0	14	8	330	2
9/17	17:00	3	0.0	5	7	328	2
	10:30	4	0.5	9	8	327	2
9/18	10:30	4	11.0	7	7	327	3
	17:00	4	2.0	9	7	331	3
9/19	10:30	4	5.0	5	6	337	3
	17:00	3	0.0	11	7	338	3
9/20	10:30	2	0.0	3	5.5	331	2
	17:00	4	0.0	9	6	328	2
9/21	10:30	4	0.0	4	5	323	2
	17:00	3	0.0	8	6	319	2

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Appendix C1.–Page 5 of 5.

Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River Stage (cm)[b]	Water Clarity[c]
9/22	10:30	4	0.0	3	4	316	2
	20:00	4	6.0	6	5	314	2
9/23	10:30	4	5.0	7	5	316	2
	17:00	4	4.5	11	6	319	2
9/24	10:30	4	2.0	7	6	320	2
	20:30	3	0.5	7	7	320	2
9/25	10:30	1	0.5	4	6	321	2
Seasonal mode[d]:		4	-	-	-	-	1
Seasonal average[e]:		-	1.3	11.6	9.3	303.4	-

[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 = visiblity is greater than 1.0 m; 2 = visibility is 0.5 to 1.0 m; 3 = visibility is less than 0.5 m

[d] The most frequent occurrence.

[e] Calculated from days in which 2 observations were made: one between 0730 and 1100 hours and one between 1700 and 1900 hours.

Appendix C2.–Daily stream temperature summary from Hobo® data logger at Kogrukluk River weir, 2008.

Date	Temperature (°C)		
	Avg.	Min.	Max.
6/30	8.3	7.4	9.7
7/01	9.1	7.9	10.7
7/02	9.8	8.9	10.8
7/03	9.3	8.8	10.1
7/04	9.1	8.1	10.4
7/05	10.6	9.3	12.4
7/06	12.1	10.8	13.6
7/07	12.4	11.3	13.5
7/08	11.4	10.8	12.5
7/09	10.7	10.4	11.3
7/10	9.6	9.1	10.5
7/11	8.9	8.4	9.3
7/12	8.6	8.4	9.0
7/13	9.1	8.0	11.0
7/14	10.6	9.7	11.8
7/15	10.3	9.7	11.3
7/16	9.2	8.9	9.7
7/17	9.3	8.6	10.0
7/18	8.8	8.3	9.4
7/19	8.5	7.6	9.4
7/20	9.2	8.4	9.9
7/21	9.7	8.7	10.9
7/22	9.2	8.8	10.5
7/23	8.6	7.8	9.3
7/24	10.0	8.4	12.0
7/25	11.1	9.5	12.9
7/26	11.0	10.4	12.0
7/27	10.3	9.5	11.1
7/28	10.7	9.5	12.2
7/29	10.9	9.8	11.8
7/30	11.1	10.1	12.5
7/31	11.7	10.2	13.5
8/01	12.2	10.6	14.0
8/02	12.0	11.4	13.1
8/03	11.2	9.5	12.9
8/04	11.4	10.8	12.1
8/05	11.5	10.1	13.1
8/06	10.9	9.9	12.1
8/07	10.8	9.7	12.5
8/08	10.9	9.2	12.7
8/09	11.0	9.4	12.8
8/10	10.8	9.8	11.8
8/11	11.0	9.8	12.2
8/12	11.4	10.1	13.2
8/13	11.0	10.4	11.6
8/14	10.8	10.2	11.6
8/15	10.4	9.7	11.3
8/16	10.1	9.1	11.4
8/17	10.0	8.8	11.2

-continued-

Date	Temperature (°C)		
	Avg.	Min.	Max.
8/18	10.7	9.5	12.7
8/19	10.9	10.1	11.5
8/20	10.5	9.8	11.2
8/21	10.7	9.5	12.3
8/22	10.9	9.7	12.2
8/23	11.2	9.5	13.0
8/24	11.2	9.4	13.3
8/25	10.6	8.8	12.6
8/26	10.5	9.6	11.7
8/27	10.0	9.1	10.8
8/28	10.2	9.1	11.6
8/29	9.4	8.1	10.7
8/30	9.3	8.7	10.0
8/31	9.5	8.9	10.2
9/01	9.5	8.4	10.9
9/02	8.8	8.4	9.6
9/03	8.9	8.3	10.0
9/04	9.3	8.9	10.1
9/05	9.0	8.3	9.8
9/06	8.1	7.7	9.0
9/07	8.1	7.8	8.6
9/08	8.8	8.2	9.5
9/09	9.2	8.9	9.4
9/10	9.3	8.7	10.1
9/11	9.5	9.0	10.2
9/12	8.9	8.6	9.5
9/13	8.7	8.5	9.0
9/14	8.6	8.4	8.9
9/15	8.6	8.3	9.0
9/16	8.5	8.1	8.9
9/17	7.9	7.4	8.4
9/18	7.3	7.2	7.7
9/19	7.1	6.8	7.5
9/20	6.7	6.3	7.1
9/21	6.1	5.7	6.7
9/22	5.1	4.7	5.9
9/23	5.5	5.1	6.1
9/24	6.4	6.0	6.8
Average:	9.7	8.9	10.8
Minimum	5.1	4.7	5.9
Maximum	12.4	11.4	14.0

APPENDIX D

Appendix D1.–Summary of annual passage estimates for Kogrukluk River 1976–2008.

	Chinook				Chum				Sockeye				Coho[a]			
Year	Obs.[b]	Est.[c]	Total[d]	[e]	Obs.[b]	Est.[c]	Total[d]	%[e]	Obs.[b]	Est.[c]	Total[d]	%[e]	Obs.[b]	Est.[c]	Total[d]	%[e]
1976	5,507	93	5,600	% 1.7	8,046	71	8,117	0.9	2,302	24	2,326	1.0				
1977[f]	1,385	0	1,385	n.a.	10,388	0	10,388	n.a.	1,112	0	1,112	n.a.				
1978	13,132	535	13,667	3.9	47,099	1,026	48,125	2.1	1,646	24	1,670	1.4				
1979	10,125	1,213	11,338	10.7	13,966	4,633	18,599	24.9	2,432	196	2,628	7.5				
1980	843	0	843	87.2	6,323	0	6,323	84.9	404	0	404	87.4				
1981	16,070	737	16,807	4.4	56,271	1,101	57,372	1.9	17,702	374	18,076	2.1	11,450	5	11,455	0.0
1982	5,325	5,668	10,993	51.6	41,204	20,655	61,859	33.4	11,729	5,568	17,297	32.2	35,582	2,214	37,796	5.9
1983	1,082	1,943	3,025	64.2	3,248	837	4,085	65.5	375	0	375	68.1	8,327	211	8,538	2.5
1984	4,928	0	4,928	0.0	41,484	0	41,484	0.0	4,133	0	4,133	0.0	25,304	2,291	27,595	8.3
1985	4,287	332	4,619	7.2	13,843	1,162	15,005	7.7	4,344	15	4,359	0.3	14,618	1,823	16,441	11.1
1986	2,922	2,116	5,038	42.0	12,041	2,652	14,693	18.1	3,255	992	4,247	23.4	14,717	7,789	22,506	34.6
1987[g]	770	3,293	4,063	81.1	2,365	15,057	17,422	86.4	284	689	973	70.8	19,756	3,065	22,821	13.4
1988	7,665	855	8,520	10.0	28,499	11,044	39,543	27.9	4,240	162	4,402	3.7	11,722	1,790	13,512	13.3
1989[h]	4,911	7,029	11,940	58.9	15,543	24,004	39,547	60.7	2,599	3,211	5,810	55.3	1,272	0	1,272	n.a.
1990	10,097	121	10,218	1.2	26,555	210	26,765	0.8	8,383	24	8,407	0.3	2,736	3,396	6,132	55.4
1991	5,868	1,982	7,850	25.3	22,369	1,819	24,188	7.5	13,737	2,718	16,455	16.5	7,059	2,905	9,964	29.2
1992	6,397	358	6,755	5.3	31,902	2,202	34,104	6.5	7,344	195	7,539	2.6	2,712	23,519	26,231	89.6
1993	10,516	1,817	12,333	14.7	26,764	5,137	31,901	16.1	27,148	2,218	29,366	7.6	4,395	16,122	20,517	78.6
1994	8,305	6,922	15,227	45.5	23,147	23,488	46,635	50.4	5,695	8,497	14,192	59.9	27,057	7,638	34,695	22.0
1995	18,877	1,774	20,651	8.6	28,460	2,805	31,265	9.0	10,582	414	10,996	3.8	17,492	10,370	27,862	37.2
1996	13,764	435	14,199	3.1	47,095	1,383	48,478	2.9	15,222	164	15,386	1.1	47,011	3,544	50,555	7.0
1997	13,111	173	13,284	1.3	7,902	56	7,958	0.7	13,059	18	13,077	0.1	11,611	627	12,238	5.1
1998	3,009	9,098	12,107	75.1	13,013	23,428	36,441	64.3	5,321	11,452	16,773	68.3	22,614	1,734	24,348	7.1
1999	5,472	98	5,570	1.8	13,497	323	13,820	2.3	5,777	87	5,864	1.5	10,094	2,515	12,609	20.0
2000	3,180	130	3,310	3.9	11,077	414	11,491	3.6	2,776	89	2,865	3.1	32,875	260	33,135	0.8
2001	6,572	2,726	9,298	29.3	22,551	8,019	30,570	26.2	6,637	2,139	8,776	24.4	18,308	1,079	19,387	5.6
2002	9,590	514	10,104	5.1	49,494	2,076	51,570	4.0	3,913	137	4,050	3.4	14,501	15	14,516	0.1
2003	11,585	186	11,771	1.6	22,514	899	23,413	3.8	8,986	178	9,164	2.0	68,718	5,886	74,604	7.9
2004	19,432	219	19,651	1.1	24,174	27	24,201	0.1	6,767	8	6,775	0.1	26,078	963	27,041	3.6
2005	21,731	269	22,000	1.2	191,588	6,135	197,723	3.1	37,465	474	37,939	1.2	23,102	1,014	24,116	4.2
2006	19,184	230	19,414	1.2	176,508	4,086	180,594	2.3	59,773	1,034	60,807	1.7	12,811	4,200	17,011	24.7
2007	6,923	6,106	13,029	46.9	31,421	18,084	49,505	36.5	10,004	6,521	16,525	39.5	23,796	3,237	27,033	12.0
2008	9,678	52	9,730	99.5	44,245	733	44,978	98.4	19,558	117	19,675	99.4	25,650	4,011	29,661	86.5

-continued-

[a] Coho migrations were not monitored prior to 1981.

[b] The sum of annual observed passage.

[c] The sum of annual estimated passage (i.e. passage estimates that were calculated for inoperable periods).

[d] The sum of total observed passage and total estimated passage.

[e] The percentage of total passage that was estimated (i.e. not observed).

[f] Estimates were made from counting tower data and are not included in the "Estimated Total".

[g] Chinook, chum, and sockeye salmon escapements were estimated from a ratio of unknown 1987 escapement and known 1987 aerial assessments to known 1988 weir escapement and known 1988 aerial assessment. Coho salmon escapements were estimated using time series techniques.

[h] Heavy rain and high river levels allowed only 2 days of counts during the coho migration. As a result, total escapement was not estimated.

APPENDIX E

Appendix E1.–Brood table for Kogrukluk River Chinook salmon.

Brood Years	Escapement (spawners)	Number by Age in Return Year 3	4	5	6	7	8	Returns[a]	Return per Spawner[a]
1968	ND	ND	ND	ND	ND	ND	0	-	-
1969	- [b]	ND	ND	ND	ND	24	ND	-	-
1970	- [b]	ND	ND	ND	2,847	ND	0	-	-
1971	- [b]	ND	ND	2,301	ND	2,054	0	-	-
1972	- [b]	ND	428	ND	7,830	352	-	-	-
1973	- [b]	0	ND	1,433	1,851	-	0	-	-
1974	- [b]	ND	2,327	1,630	-	649	0	-	-
1975	- [b]	24	7,505	-	9,774	597	0	-	-
1976	5,600	0	-	5,096	7,106	128	4	-	-
1977	1,385	-	1,243	2,588	1,690	171	5	5,692 [c]	4.11
1978	13,667	45	698	594	1,301	148	0	2,741	0.20
1979	11,338	4	606	2,341	2,072	365	-	5,384 [d]	0.47
1980	6,572 [e]	7	1,106	1,647	1,652	-	0	-	-
1981	16,809	4	746	2,563	-	678	-	-	-
1982	10,993	0	433	-	2,672	-	0	-	-
1983	3,025	22	-	4,479	-	30	0	-	-
1984	4,928	-	678	-	1,148	83	-	-	-
1985	4,625	0	-	6,288	4,677	-	-	-	-
1986	5,038	-	2,463	2,264	-	-	-	-	-
1987	4,063 [f]	293	479	-	-	-	0	-	-
1988	8,520	0	-	-	-	48	0	-	-
1989	11,940 [f]	-	-	-	10,427	964	0	-	-
1990	10,214	-	-	4,827	3,639	55	-	-	-
1991	7,850	-	3,614	7,801	6,034	-	0	-	-
1992	6,755 [e]	0	1,788	2,715	-	86	0	-	-
1993	12,332 [e]	0	4,481	-	3,749	59	0	-	-
1994	15,227 [e]	0	-	1,418	1,294	143	0	-	-
1995	20,630	-	303	1,630	4,070	143	0	6,146 [c]	0.30
1996	14,499	14	327	3,656	3,149	330	0	7,462	0.53
1997	13,286	0	1,425	5,054	4,234	121	0	10,834	0.82
1998	12,107 [e]	0	1,754	5,011	3,643	207	0	10,615	0.88
1999	5,570	0	2,196	7,105	6,172	831	0	16,304	2.93
2000	3,310	0	8,782	10,228	5,707	380	0	25,097	7.58
2001	9,297	0	5,337	5,998	4,137	94	ND	-	-
2002	10,099	56	6,776	4,301	1,881	ND	ND	-	-
2003	11,771	102	4,212	4,221	ND	ND	ND	-	-
2004	19,651	0	3,489	ND	ND	ND	ND	-	-
2005	22,000	45	ND	ND	ND	ND	ND	-	-
2006	19,414	ND	ND	ND	ND	ND	ND	ND	ND
2007	13,029	ND	ND	ND	ND	ND	ND	ND	ND
2008	9,730	ND	ND	ND	ND	ND	ND	ND	ND

[a] Returns do not include downstream harvest.

[b] Escapement was monitored with a counting tower; annual escapement data are not comparable to weir data.

[c] Does not include any possible 3-year-old fish

[d] Does not include any possible 8-year-old fish

[e] Insufficient age data.

[f] Insufficient escapement data.

Appendix E2.–Brood table for Kogrukluk River chum salmon.

Brood Years	Escapement (spawners)		Number by Age in Return Year				Returns[a]		Return per Spawner[a]	
			3	4	5	6				
1969	-	b	ND	ND	ND	ND	-		-	
1970	-	b	ND	ND	ND	113	-		-	
1971	-	b	ND	ND	4,913	ND	-		-	
1972	-	b	ND	3,072	ND	0	-		-	
1973	-	b	22	ND	23,716	ND	-		-	
1974	-	b	ND	24,031	ND	0	-		-	
1975	-	b	378	ND	157	368	-		-	
1976	8,117		ND	1,487	48,390	39	-		-	
1977	10,388		0	8,607	25,656	-	-	c	-	
1978	48,125		0	38,382	-	534	-		-	
1979	18,599		0	-	7,205	75	-		-	
1980	6,323		-	33,754	10,703	343	-		-	
1981	57,372		0	4,188	3,774	-	-		-	
1982	61,859		37	10,513	-	ND	-		-	
1983	4,094		69	-	ND	-	-		-	d
1984	41,484		-	ND	-	378	-		-	
1985	15,005		ND	-	8,477	0	-		-	
1986	14,693		-	17,532	10,066	277	-		-	
1987	2,365		378	14,013	18,320	1,587	34,297		-	d
1988	39,543		105	14,617	19,452	-	-	c	-	
1989	39,547		906	10,860	-	246	-	c	-	d
1990	26,765		0	-	15,088	788	-		-	
1991	24,188		-	13,355	13,953	51	-		-	
1992	34,104		411	32,893	4,448	-	-		-	
1993	31,901		860	3,404	-	47	-		-	
1994	46,635		34	-	6,965	35	-	c	-	
1995	31,265		-	6,807	3,565	0	-		-	
1996	48,494		0	7,750	12,542	551	20,843		0.43	
1997	7,958		141	17,874	11,912	136	30,063		3.78	e
1998	36,441		148	39,028	7,426	41	46,643		-	d
1999	13,820		79	15,431	14,952	0	30,462		2.20	e
2000	11,491		420	15,182	11,002	471	27,075		2.36	
2001	30,570		6,939	178,882	65,060	1,479	252,360		8.26	
2002	51,570		7,839	112,256	17,291	1,188	138,574		2.69	
2003	23,413		2,811	29,321	18,892	ND	-		-	
2004	24,201		1,415	24,220	ND	ND	-		-	
2005	197,723		678	ND	ND	ND	-		-	
2006	180,594		ND	ND	ND	ND	ND		ND	
2007	49,505		ND	ND	ND	ND	ND		ND	
2008	44,978		ND	ND	ND	ND	ND		ND	

[a] Returns do not include downstream harvest.
[b] Escapement was monitored with a counting tower; annual escapement data are not comparable to weir data.
[c] Insufficient age data.
[d] Insufficient escapement data.
[e] Does not include any possible 3-year-old fish.

Appendix E3.–Brood table for Kogrukluk River coho salmon.

Brood Years	Escapement (spawners)	Number by Age in Return Year			Returns[a]	Return per Spawner[a]
		3	4	5		
1981	11,455	ND	ND	ND	- [b]	-
1982	37,796	ND	ND	ND	- [b]	-
1983	8,538	ND	ND	ND	- [b]	-
1984	27,595	ND	ND	ND	- [b]	-
1985	16,441	ND	ND	604	- [b]	-
1986	22,506	ND	5,169	223	- [b]	-
1987	22,821	357	9,565	ND	- [b]	-
1988	13,512	175	ND	134	- [b]	-
1989	1,272 [c]	ND	4,071	2,880	-	-
1990	6,132	108	31,259	1,320	32,687	5.33
1991	9,964	504	16,743	1,068	18,315	1.84
1992	26,057 [c]	775	47,970	ND	-	-
1993	20,517	1,511	ND	1,029	-	-
1994	34,695	ND	22,915	1,184	-	-
1995	27,862	401	11,109	680	12,190	0.44
1996	50,555	317	32,117	1,395	33,829	0.67
1997	12,238	338	17,699	1,967	20,004 [b]	1.63
1998	24,348	293	12,550	12,585	25,428	1.04
1999	12,609	0	60,942	3,175	64,117	5.08
2000	33,135	1,227	23,700	2,201	27,128	0.82
2001	19,387	166	20,470	485	21,121	1.09
2002	14,516	1,445	14,715	1,560	17,720	1.22
2003	74,604	1,812	24,527	4,665	31,004	0.42
2004	27,041	946	24,143	ND	-	-
2005	24,116	853	ND	ND	-	-
2006	17,011	ND	ND	ND	ND	ND
2007	27,033	ND	ND	ND	ND	ND
2008	29,661	ND	ND	ND	ND	ND

Note: Escapement monitoring at Kogrukluk River weir dates back to 1969; however, coho salmon monitoring did not begin until 1981.

[a] Returns do not include downstream harvest.

[b] Insufficient age data.

[c] Insufficient escapement data.