Fishery Data Series No. 06-29

George River Salmon Studies, 2005

Annual Report for Study 05-304

USFWS Office of Subsistence Management

Fisheries Information Services Division and

Bering Sea Fishermen's Association

by

Robert Stewart,

Douglas B. Molyneaux,

Daniel J. Costello,

and

David Orabutt

June 2006

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

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

FISHERY DATA SERIES NO. 06-29

GEORGE RIVER SALMON STUDIES, 2005

by
Robert Stewart, Douglas B. Molyneaux, Daniel J. Costello,
Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage
and
David Orabutt
Kuskokwim Native Association, Aniak

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

June 2006

Development and publication of this manuscript was partially financed by the USFWS Office of Subsistence Management (Project 05-304) Fisheries Resource Monitoring Program under Cooperative Agreement 701815J587 and a grant from the U.S. Bureau of Indian Affairs administered by the Bering Sea Fishermen's Association (#E00441023).

The Division of Sport Fish Fishery Data Series was established in 1987 for the publication of technically oriented results for a single project or group of closely related projects. Since 2004, the Division of Commercial Fisheries has also used the Fishery Data Series. Fishery Data Series reports are intended for fishery and other technical professionals. Fishery Data Series reports are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm This publication has undergone editorial and peer review.

Robert Stewart, Douglas B. Molyneaux, Daniel J. Costello,
Alaska Department of Fish and Game, Division of Commercial Fisheries,
333 Raspberry Road, Anchorage, AK 99518, USA
and
David Orabutt
Kuskokwim Native Association, P.O. Box 127, Aniak, AK 99557

This document should be cited as:
Stewart, R., D. B. Molyneaux, D. J. Costello, and D. Orabutt. 2006. George River salmon studies, 2005. Alaska Department of Fish and Game, Fishery Data Series No. 06-29, Anchorage.

The Alaska Department of Fish and Game administers all programs and activities free from discrimination based on race, color, national origin, age, sex, religion, marital status, pregnancy, parenthood, or disability. The department administers all programs and activities in compliance with Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972.

If you believe you have been discriminated against in any program, activity, or facility, or if you desire further information please write to ADF&G, P.O. Box 25526, Juneau, AK 99802-5526; U.S. Fish and Wildlife Service, 4040 N. Fairfax Drive, Suite 300 Webb, Arlington, VA 22203 or O.E.O., U.S. Department of the Interior, Washington DC 20240.

For information on alternative formats for this and other department publications, please contact the department ADA Coordinator at (voice) 907-465-6077, (TDD) 907-465-3646, or (FAX) 907-465-6078.

TABLE OF CONTENTS

Page

LIST OF TABLES iii
LIST OF FIGURES iii
LIST OF APPENDICES iv
ABSTRACT 1
INTRODUCTION 1
Background 2
Objectives 3
METHODS 4
Study Area 4
Weir Design 4
Installation Site 4
Construction 4
Maintenance 5
Escapement Monitoring 5
Passage Counts 5
Estimating Missed Passage 6
Carcass Counts 7
Age, Sex, and Length Composition 7
Sample Collection 7
Estimating Age, Sex, and Length Composition 8
Weather and Stream Observations 8
Related Projects 9
Inriver Abundance of Chinook Salmon in the Kuskokwim River 9
Kuskokwim River Sockeye Salmon Radiotelemetry Feasibility Study 9
Kuskokwim River Salmon Mark-recapture Project 9
Genetic Diversity of Chinook Salmon from the Kuskokwim River 10
RESULTS 10
Escapement Monitoring 10
Chinook Salmon 10
Chum Salmon 10
Coho Salmon 10
Other Species 11
Carcass Counts 11
Age, Sex, and Length Composition 11
Chinook Salmon 11
Chum Salmon 11
Coho Salmon 12
Weather and Stream Observations 12
Related projects 12

TABLE OF CONTENTS (Continued)

Page

Inriver Abundance of Chinook Salmon in the Kuskokwim River 12

Kuskokwim River Sockeye Salmon Radiotelemetry Feasibility Study 12

Kuskokwim River Salmon Mark-recapture Project 12

Genetic Diversity of Chinook Salmon from the Kuskokwim River 13

DISCUSSION 13

Escapement Monitoring 13

Chinook Salmon 13

Chum Salmon 14

Coho Salmon 15

Other Species 15

Carcass Counts 16

Age, Sex, and Length Composition 16

Chinook Salmon 16

Chum Salmon 17

Coho Salmon 18

Weather and Stream Observations 19

Related Fisheries Projects 20

Inriver Abundance of Chinook Salmon in the Kuskokwim River 20

Kuskokwim River Sockeye Salmon Radiotelemetry Feasibility Study 20

Kuskokwim River Salmon Mark-recapture Project 21

Chinook Salmon 21

Chum Salmon 21

Coho Salmon 22

Sockeye Salmon 23

Genetic Diversity of Chinook Salmon from the Kuskokwim River 23

CONCLUSIONS 23

Escapements 23

Age, Sex, and Length Composition 23

Weather and Stream Observations 23

Related Projects 24

RECOMMENDATIONS 24

Project Operation 24

Project Management 25

Weather and Stream Observations 25

ACKNOWLEDGEMENTS 26

REFERENCES CITED 26

TABLES AND FIGURES 31

APPENDIX A. OTHER PASSAGE 71

APPENDIX B. CARCASS COUNTS 75

APPENDIX C. WEATHER AND STREAM OBSERVATIONS 77

APPENDIX D. RIVER STAGE BENCHMARK 87

LIST OF TABLES

Table **Page**

1. Daily, daily cumulative, and daily cumulative percent passage for Chinook, chum, and coho salmon at George River weir with the median passage date and central 50% of the run, 2005.....32
2. Age and sex composition of the Chinook salmon escapement at the George River weir, 2005.....35
3. Mean length (mm) composition of the Chinook salmon escapement at the George River weir, 2005. 36
4. Age and sex composition of the chum salmon escapement at the George River weir, 2005. 37
5. Mean length (mm) composition of the chum salmon escapement at George River weir, 2005. 38
6. Age and sex composition of the coho salmon escapement at George River weir, 2005. 40
7. Mean length (mm) composition of the coho salmon escapement at George River weir, 2005. 41

LIST OF FIGURES

Figure **Page**

1. Kuskokwim Area salmon management districts and escapement monitoring projects.....42
2. George River, middle Kuskokwim River basin.....43
3. Historical Chinook salmon escapement into six Kuskokwim River tributaries, and the Kuskokwim River Chinook salmon escapement indices, 1991–2005. 44
4. Historical age distribution of annual Chinook and chum salmon escapements at George River weir. 45
5. Historical annual run timing of Chinook, chum, and coho salmon based on cumulative percent passage at George River weir. 46
6. Historical chum salmon escapements into seven Kuskokwim River tributaries, 1991–2005. 47
7. Historical coho salmon escapement into six Kuskokwim River tributaries, 1991–2005. 48
8. Historical intra-annual age composition of Chinook salmon at George River weir by sample date. 49
9. Historical intra-annual percent female Chinook, chum, and coho salmon at George River weir by sample date.....50
10. Historical annual average mean length at age of Chinook, chum, and coho salmon at George River weir.....51
11. Historical intra-annual mean length at age of male and female Chinook salmon by sample date at George River weir.....52
12. Historical intra-annual age composition of chum salmon by sample date at George River weir. 53
13. Historical intra-annual mean length at age of chum salmon by sample date at George River weir. 54
14. Historical age distribution of annual coho salmon escapements at George River weir.....55
15. Historical intra-annual percent of age-2.1 coho salmon by sample date at George River weir.....56
16. Historical intra-annual mean length of age-2.1 male and female coho by sample date salmon at George River weir.....56
17. Daily passage of Chinook, chum, and coho salmon relative to daily morning water temperature at George River weir, 2005. 57
18. Daily passage of Chinook, chum, and coho salmon relative to daily morning river stage at George River weir, 2005.....58
19. Daily morning water temperatures at George River weir in 2005 relative to historical average, minimum, and maximum morning readings from 1996–2004.....59
20. Daily morning river stage at George River weir in 2005 relative to historical average, minimum, and maximum morning readings from 2000–2004. 59
21. Daily detection and recovery of tagged Chinook, chum, and coho salmon with daily escapement at George River weir in 2005. 60
22. Migration of selected Chinook salmon stocks past the mainstem tagging site in 2002 and 2003, based on radio tagging studies.....61
23. Migration of selected Chinook salmon stocks past the mainstem tagging site in 2004 and 2005, based on radio tagging studies.....62
24. Migration of Chinook salmon stocks past the mainstem tagging site in 2005 based on tag recoveries at selected Kuskokwim River tributaries.....63
25. Migration of chum salmon stocks past the mainstem tagging site in 2002 and 2003 based on tag recoveries at selected Kuskokwim River tributaries. 64

LIST OF FIGURES (Continued)

Figure **Page**

26. Migration of chum salmon stocks past the mainstem tagging site in 2004 and 2005 based on tag recoveries at selected Kuskokwim River tributaries. 65
27. Migration of coho salmon stocks past the mainstem tagging site in 2002 and 2003 based on tag recoveries at selected Kuskokwim River tributaries. 66
28. Migration of coho salmon stocks past the mainstem tagging site in 2004 and 2005 based on tag recoveries at selected Kuskokwim River tributaries. 67
29. Migration of sockeye salmon stocks past the mainstem tagging site in 2002 and 2003 based on tag recoveries at selected Kuskokwim River tributaries. 68
30. Migration of sockeye salmon stocks past the mainstem tagging site in 2004 and 2005 based on tag recoveries at selected Kuskokwim River tributaries. 69

LIST OF APPENDICES

Appendix **Page**

A1. Daily passage of sockeye and pink salmon, and non-salmon species observed at George River weir, 2005. 72
B1. Daily carcass counts of Chinook, chum, and coho salmon at George River weir, 2005. 76
C1. Daily weather and stream observations at George River weir, 2005. 78
C2. Daily stream temperature summary from Hobo data logger at George River weir, 2005. 82
C3. Stream discharge measurement at George River weir on 26 June, 2005. 83
C4. Stream discharge measurement at George River weir on 17 August, 2005. 84
C5. Stream discharge measurement at George River weir on 27 September, 2005. 85
D1. Location and description of a benchmark installed in 2005 for measuring river stage at George River weir. 88

ABSTRACT

The George River is a tributary of the Kuskokwim River, and produces Chinook salmon *Oncorhynchus tshawytscha*, chum salmon *O. keta*, and coho salmon *O. kisutch* that contribute to intensive subsistence and commercial salmon fisheries downstream of its confluence. The George River weir is one of several projects operated in the Kuskokwim Area that form an integrated geographic array of escapement monitoring projects. Collectively, and in accordance with the State of Alaska Sustainable Fishery Policy (5 AAC 39.222), this array of projects is a tool to assure appropriate geographic and temporal distribution of spawning salmon, and provide a means to assess trends in escapement that should be monitored and considered in harvest management decisions. Towards this end, George River weir has been operated annually since 1996 to determine daily and total salmon escapements for the target operational period of 15 June through 20 September; to estimate age, sex, and length compositions of Chinook, chum, and coho salmon escapement; to monitor environmental variables that influence salmon productivity; and to provide part of an integrated platform in support of other Kuskokwim Area fisheries projects.

In 2005, a resistance board weir was operated on the George River from 15 June through 20 September. Escapements for the target operational period were estimated as 3,845 Chinook, 14,828 chum, and 8,200 coho salmon. Escapement goals have not been set for the George River. Chinook and chum salmon escapements were near average and coho salmon escapement was below average in 2005. Age, sex, and length data indicated a relatively strong return of age-1.3 Chinook salmon and age-0.3 chum salmon, similar to what was seen throughout the Kuskokwim River drainage in 2005. Information collected at the weir from fish tagged in the mainstem Kuskokwim River suggest George River salmon are a later component of runs migrating past the tagging site, located near the village of Kalskag.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, chum salmon, *O. keta*, coho salmon, *O. kisutch*, longnose suckers, *Catostomus catostomus*, escapement, age, sex, and length composition, George River, Kuskokwim River, resistance board weir, radiotelemetry, mark–recapture, genetic stock identification, stock specific run timing.

INTRODUCTION

The Kuskokwim River is the second largest river in Alaska, draining an area approximately 130,000 km^2, or 11% of the total area of Alaska (Figure 1; Brown 1983). Each year mature salmon return to the river to spawn, supporting an annual harvest averaging over 1 million salmon (Whitmore et al. 2005). The subsistence salmon fishery in the Kuskokwim Area is one of the largest and most important in the state (ADF&G 2005; Coffing 1991, *Unpublished* a, b; Coffing et al. 2001; Ward et al. 2003), and remains a fundamental component of local culture. 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; Ward et al. 2003).

Salmon that contribute to these fisheries spawn and rear in nearly every tributary of the Kuskokwim River basin; however, few spawning streams receive rigorous salmon escapement monitoring. Historically, only two long-term, ground-based escapement monitoring projects have operated in the Kuskokwim River basin: the Kogrukluk River weir and Aniak River sonar (Ward et al. 2003). These tributaries constitute a modest fraction of the total Kuskokwim River basin, and salmon populations in them are not representative of the diversity of salmon populations that contribute to subsistence, commercial, and sport harvests, nor do they take into account the overall ecosystem function in the Kuskokwim drainage. Other ground-based escapement monitoring projects have been developed within the Kuskokwim River basin, but these initiatives were short-lived (Ward et al. 2003). Aerial stream surveys are periodically conducted on many tributaries using fixed-wing aircraft, but these surveys serve only as abundance indices because they are flown only once each season, are subject to a high degree of variability, and are

geographically skewed towards lower Kuskokwim River tributaries (Ward et al. 2003). The inception of the George River weir in 1996, coupled with other initiatives begun in the late 1990s and beyond (Chythlook and Evenson 2003; Kerkvliet et al. 2003; Linderman et al. 2002; Schwanke et al. 2001; Stuby 2003) provides some of the additional escapement monitoring and abundance estimates required for management authorities to assess the adequacy of escapements and the effectiveness of management decisions (Holmes and Burtkett 1996; Mundy 1998).

The goal of salmon management is to provide for long-term sustainable fisheries by ensuring adequate numbers of salmon escape onto the spawning grounds each year. 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, tribal groups such as the Kuskokwim Native Association (KNA) are charged by their constituency to actively promote a healthy and sustainable subsistence salmon fishery. These and other groups have combined their resources to develop projects such as the George River weir to better achieve the common goal of providing for long-term sustainability of salmon fisheries in the Kuskokwim River.

Sustainable salmon fisheries require more than just adequate escapement numbers. Escapement projects such as the George River weir commonly serve as platforms for collecting other types of information useful for management and research. Collection of age, sex, and length (ASL) data is typically included in most escapement monitoring projects, including the George River weir (e.g., Costello et al. 2005, 2006; Jasper et al. *In prep*; Roettiger et al. 2005; Zabkar et al. *In prep*). Knowledge of ASL composition can provide insights into understanding fluctuations in salmon abundance and is essential in developing spawner-recruit relationships used in formulating escapement goals (DuBois and Molyneaux 2000). George River weir also serves as a platform for collecting information on habitat variables. Water temperature, water chemistry, and stream discharge (level) are fundamental variables of the stream environment that 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 such as mining, timber harvesting, or man-made impoundments (NRC 1996), or climatic changes (e.g., El Nino and La Nina events). Additionally, George River weir, along with other Kuskokwim River escapement projects, serves as a vital platform for collecting information used by other projects including *Inriver Abundance of Chinook Salmon in the Kuskokwim River* (FIS 02-015), *Kuskokwim River Mark–recapture Project* (FIS 04-308), genetics studies, and juvenile salmon studies.

BACKGROUND

George River is located in the middle Kuskokwim River basin (Figure 1) and provides spawning and rearing habitat for Chinook salmon *Oncorhynchus tshawytscha*, chum salmon *O. keta*, and coho salmon *O. kisutch* which contribute to subsistence, commercial, and sport fisheries of the Kuskokwim River (ADF&G 1998). The George River weir project has been operated cooperatively by ADF&G and KNA since its inception in 1996. George River weir has developed into a useful tool for salmon management, and both organizations make use of weir data during inseason salmon management deliberations. Oversight of field operations is shared between KNA and ADF&G. Generally, ADF&G takes the lead in data management, data analysis, and reporting; and KNA takes the lead in field operations. Part of the mission of this

project is to promote local involvement and to develop the capacity of KNA to engage effectively in salmon resource management. The project's crew consisted of two locally hired KNA technicians and one ADF&G technician. The project annually hosts several student interns from surrounding communities for a "hands-on" work experience at the weir.

Historically, the northern region of the Kuskokwim Mountains, including the George River drainage, supported a relatively high level of mining activity. Since the early 1900s, several small to moderate size mining camps operated intermittently in the middle and upper George River drainage (Brown 1983). A small tributary of George River named Julian Creek received intermittent mining activity since the early 1900s, and this activity continues at a recreational level today. Mining interest in the northern region of the Kuskokwim Mountains expanded in recent years with proposed large-scale open-pit gold mining operations at Donlin Creek in the Crooked Creek drainage, which borders the George River drainage. Development of Donlin Creek mine heightens interest and need for continued monitoring of George River salmon populations. Impacts of this proposed mine will likely include increased recreational and subsistence activities in the George River area because of a resulting increase in human population associated with development of Donlin Creek mine.

George River is popular for sport fishing, and the river is an access route for recreational and subsistence hunters. Professional guide operations based within and outside of the Kuskokwim Area use George River as an angling and hunting destination for their clients. In 2000, George River received some of the highest Chinook salmon sport fishing angler effort in the Middle Kuskokwim River area (Burr 2002). Escapement monitoring will help ensure continued wise management practices to provide sustainable harvest opportunity for these various user groups.

OBJECTIVES

1. Determine daily and annual escapements of Chinook, chum, and coho salmon to George River from 15 June through 20 September.
2. Estimate the age, sex, and length (ASL) composition of total Chinook, chum, and coho salmon escapements to George River from a minimum of 3 pulse samples, one collected from each third of the run, such that simultaneous 95% confidence intervals of age composition in each pulse are no wider than 0.20 ($\alpha = 0.05$ and $d = 0.10$).
3. Monitor habitat variables including daily water temperature and daily water level.
4. Participate in related fisheries projects:
    - Recover tag numbers and associated information from Chinook, chum, sockeye, and coho salmon in association with the mainstem *Kuskokwim River Salmon Mark–recapture Project* (FIS 04-308).
    - Serve as a monitoring site for Chinook salmon equipped with radio transmitters deployed as part of *Inriver Abundance of Chinook Salmon in the Kuskokwim River* (FIS 02-015).
    - Serve as a monitoring site for sockeye salmon equipped with radio transmitters deployed as part of *Kuskokwim River Sockeye Salmon Radiotelemetry Feasibility Study*.
    - Collect tissue samples for *Genetic Diversity of Chinook Salmon from the Kuskokwim River* (FIS 01-070).

METHODS

STUDY AREA

George River originates in the northern Kuskokwim Mountains within the middle Kuskokwim River basin and flows south for approximately 120 km to its confluence with the Kuskokwim River (Figures 1 and 2). George River drains an area of approximately 3,558 km² of mostly upland spruce-hardwood forest. Major tributaries include the East, South, and North Forks, and Michigan and Beaver Creeks. White spruce and scattered birch or aspen are common on south-facing slopes, and black spruce is characteristic on northern exposures and poorly drained areas. The understory consists of spongy moss and low brush in poorly drained areas, grasses in well-drained areas, and willow and alder in open forest near timberline.

WEIR DESIGN

Installation Site

The weir site is located at N61° 55.4' Latitude and W157° 41.9' Longitude, approximately 7 river kilometers (rkm) up the George River from its confluence with the Kuskokwim River and captures nearly all the salmon spawning habitat within the drainage (Figure 2). The weir has operated at this location since the project began in 1996. The river channel at this site is about 110 m wide and has a depth of about 1 m during normal summer operations. The substrate is composed mostly of gravel, with some sand and coble. Discharge measurements taken at the site over the years have ranged between 16 and 128 m^3/s, with velocities reaching 0.6 and 1.3 fm/s respectively in the thalweg. Discharge measurements have not been attempted during flood conditions.

Construction

Details of design and materials used to construct the George River resistance board weir are described in Tobin (1994) with panel modifications described by Stewart (2002). The weir was installed across the entire 110 m channel following the techniques described by Stewart (2003). The substrate rail and resistance board panels covered the middle 100-m portion of the channel, and fixed weir materials extended the weir 5 m to each bank. The pickets were 3.33 cm (1-5/16 in) in diameter and spaced at intervals of 6.67 cm (2-5/8 in) to leave a gap of 3.33 cm (1-5/16 in) between each picket.

A live trap and skiff gate were installed within the deeper portion of the channel. The live trap was designed as the primary means of upstream fish passage. The trap could be easily configured to pass fish freely upstream, capture individual fish for tag recovery, or trap numerous fish for collection of ASL or genetic samples. The skiff gate allowed boat operators to pass with little or no involvement by the weir crew as the weight of a boat submerged the passage panels and allowed boats to pass over the weir. Boats with jet-drive engines were the most common and could pass up or downstream over the skiff gate after reducing their speed to 5 miles per hour or less.

To accommodate downstream migration of longnose suckers *Catastomas catostomas* and other resident species, downstream passage chutes were incorporated into the weir once resident species were observed congregating just upstream. At locations where downstream migrants were most concentrated, chutes were created by releasing the resistance boards on one or two adjacent weir panels so the distal ends dipped slightly below the stream surface. The chute's

shallow profile guides downstream migrants while preventing upstream salmon passage. The chutes were monitored and adjusted to ensure salmon were not passing upstream. Downstream passage was not enumerated; however, few salmon have typically been observed passing downstream over these chutes, and these numbers are not considered significant.

Maintenance

The weir was cleaned several times each day, typically at the end of a counting shift. A technician walked across the weir partially submerging each panel, thereby allowing the current to wash any debris downstream. A rake was used to push larger debris loads off the weir. Each time the weir was cleaned, a visual inspection was made of weir panels, substrate rail, fish trap, and fixed weir sections to ensure no breaches would allow fish to pass upstream uncounted. If conditions prevented an adequate visual inspection, technicians used snorkel gear to complete their inspection.

ESCAPEMENT MONITORING

A "target operational period," spanning most of the salmon runs, was observed to provide for consistent comparisons of annual escapements among years. The target operational period for George River weir has been established as 15 June through 20 September, although actual operational dates may vary with stream conditions. Daily and total annual escapements consisted of the observed passage plus any estimated passage of Chinook, chum, or coho salmon missed during the target operational period. Counts of all other species were reported simply as observed passage.

Passage Counts

Passage counts were conducted periodically during daylight hours. Substantial delays in fish passage occurred only at night or during ASL sampling. Crew members visually identified each fish as it passed upstream and recorded it by species on a multiple tally counter. Counting continued for a minimum of 1 hour, or until passage waned. This schedule was adjusted as needed to accommodate the migratory behavior and abundance of fish, or operational constraints such as reduced visibility in evening hours late in the season. Crew members recorded the total upstream fish count in a designated notebook and zeroed the tally counter after each counting session. At the end of each day, total daily and cumulative seasonal counts were copied to logbook forms. These counts were reported each morning to ADF&G staff in Bethel via single side band radio or satellite telephone.

The live trap was used as the primary means of upstream fish passage so crew members could capture and recover information from fish tagged in the mainstem Kuskokwim River. A clear plastic viewing window was placed on the stream surface to improve visual identification of fish entering the trap. This allowed passage counts to be conducted from the downstream entrance of the trap, and enabled crew members to capture tagged fish once they entered the trap. A secondary passage gate could be employed if fish were hesitant to enter the live trap. Using the trap as a counting platform, a connecting picket would be removed between two neighboring panels. By folding the panels to stand on edge, an opening 6 feet wide would be created. A rigid aluminum weir panel would be lashed to the upstream ends of the panels to serve as an easily removable gate. When removed for counting, the gate would be placed on the river bottom in front of the opening to act as a flash panel for the identification of passing fish. Alternatively, a

weir panel could be removed from anywhere along the weir, and a crew member could wade next to the opening to conduct a passage count.

Estimating Missed Passage

Upstream salmon passage was estimated for days the weir was inoperable if adequate supporting data existed. Inoperable periods may have resulted from a breach in the weir, a delayed start date, or a premature end date. Estimates were assumed to be zero if passage was considered negligible based on historical data and run timing indicators. Otherwise, estimates for a single day were made using the "single day" method, calculated as the average observed passage 2 days before and after the inoperable day, minus any observed passage from the inoperable day.

Daily estimates for inoperable periods lasting 2 or more days were derived by one of several methods, depending on the situation. A "linear method" has commonly been used to interpolate daily estimates from average observed passage 2 days before an inoperable period to average observed passage 2 days after the inoperable period. This method resulted in a linear increase or decrease in daily estimates over the duration of the inoperable period. Daily estimates from this method were calculated using the formula:

$$\hat{n}_{d_i} = \alpha + \beta \cdot i \tag{1}$$

$$\alpha = \frac{n_{d_1-1} + n_{d_1-2}}{2}$$

$$\beta = \frac{\left(n_{d_I+1} + n_{d_I+2}\right) - \left(n_{d_1-1} + n_{d_1-2}\right)}{2\left(I+1\right)}$$

for (d_1, 2, …, d_i, …d_I)

where:

$\hat{n}_{d_i}$ = passage estimate for the ith day of the period (d_1, 2, …, d_i, …d_I) when the weir was inoperative;

n_{d_I+1} = observed passage of the first day after the weir was reinstalled;

n_{d_I+2} = observed passage of the second day after the weir was reinstalled;

n_{d_1-1} = observed passage of the day before the weir was washed out;

n_{d_1-2} = observed passage of the second day before the weir was washed out; and

I = the number of inoperative days.

A "proportion method" was used if evidence supporting similar fish passage characteristics existed between estimated and model data sets. A model data set could be from a different year at George River, or from the same year at a neighboring project. In either case, daily passage was based on a model data set's daily passage proportions, and was calculated using the formula:

$$n_{d_i} = \left(\frac{\left(n_{2d_i} \times n_{1t_1}\right)}{n_{2t_1}}\right) - n_{o_i} \tag{2}$$

where:

n_{d_i} = passage estimate for a given day (i) of the inoperable period;

n_{2d_i} = average passage for the ith-1, $i^{th,}$, and i^{th} +1 day in the model data set 2;

n_{1t_1} = known cumulative passage for the operational time period (t_1) from the estimated data set 1;

n_{2t_1} = known cumulative passage for the corresponding time period (t_1) from the model data set 2; and

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

Carcass Counts

The weir was cleaned several times each day, typically at the beginning and end of counting shifts. Spawned out salmon and carcasses of dead salmon (both hereafter referred to as carcasses) that washed up on the weir were counted by species and sex, and passed downstream. Daily and cumulative carcass counts were copied to logbook forms.

AGE, SEX, AND LENGTH COMPOSITION

The ASL composition of the total Chinook, chum, and coho salmon escapements were estimated by sampling a fraction of the fish passage and applying the ASL composition of those samples to the total escapement as described in DuBois and Molyneaux (2000).

Sample Collection

A pulse sampling design was used for Chinook, chum, and coho salmon ASL sampling, in which intensive sampling was conducted for 1 to 3 days followed by a few days without sampling. The goal for each pulse was to collect samples from 210 Chinook, 200 chum, and 170 coho salmon. These sample sizes were selected so that the simultaneous 95% confidence interval estimates of age and sex composition proportions would be no wider than 0.20 (Bromaghin 1993) per pulse for Chinook salmon assuming 10 age/sex categories, for chum salmon assuming 8 age/sex categories, and for coho salmon assuming 6 age/sex categories. Sample sizes for coho salmon were increased from 70 to 170 fish per pulse in 2005, which allowed the characterization of each third of the run. Sample sizes for all species were increased by about 10% from that recommended by Bromaghin (1993) to account for scales that could not be aged. The minimum acceptable number of pulse samples was 3 per species, one pulse sample from each third of the run, to account for temporal dynamics in the ASL composition. Salmon were sampled from the fish trap installed in the weir. The general practice was to open the entrance gate and leave the exit gate closed, which allowed fish to accumulate inside the holding pen. The holding pen was typically allowed to fill with fish and sampling was done during scheduled counting periods.

Scales were removed from the preferred area of the fish (INPFC 1963). Three scales were taken from each fish and mounted on numbered and labeled gum cards. Sex was determined by visually examining external morphology, keying in on the development of the kype, roundness of the belly, and the presence or absence of an ovipositor. Length was measured to the nearest millimeter from mideye to tail fork. After each fish was sampled, it was released into a recovery area upstream of the weir. After sampling was completed, relevant information such as sex,

length, date, and location was copied from hardcopy forms to computer mark-sense forms. The completed gum cards and data forms were sent to the Bethel and Anchorage ADF&G offices for processing. Further details of sampling procedures can be found in DuBois and Molyneaux (2000) and Linderman et al. (2003).

Weir crews conducted active sampling on Chinook salmon to increase sample sizes. Active sampling consisted of capturing and sampling Chinook salmon while actively passing and enumerating fish. Further details of active sampling procedures are described in Linderman et al. (2002).

Estimating Age, Sex, and Length Composition

ADF&G staff in Bethel and Anchorage aged scales, processed the ASL data, and generated data summaries (DuBois and Molyneaux 2000). These procedures generated 2 types of summary tables for each species; one described the age and sex composition and the other described length statistics. These summaries account for ASL composition changes over the season by first partitioning the season into temporal strata based on pulse sample dates, applying ASL composition of individual pulse samples to the corresponding temporal strata, and finally summing the strata to generate the estimated ASL composition for the season. This procedure ensured ASL composition of the total escapement was weighted by fish abundance in the escapement rather than fish abundance in the samples. Likewise, estimated mean length composition of total escapement was calculated by weighting sample mean lengths from each stratum by the escapement of salmon past the weir during that stratum. Ages were reported in tables using European notation, with total age reported in parenthesis. European notation is composed of 2 numerals separated by a decimal, where the first numeral indicates the number of winters spent by the juvenile fish in fresh water and the second numeral indicates the number of winters spent in the ocean (Groot and Margolis 1991). Total age is equal to the sum of these 2 numerals, plus 1 year to account for the winter when the egg was incubating in the gravel. For example, a Chinook salmon described as an age-1.4 fish under European notation has a total age of 6 years.

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.

WEATHER AND STREAM OBSERVATIONS

Daily weather and stream observations were taken in the morning and usually again in the late afternoon to monitor habitat variables. Air and water temperatures were measured using a thermometer calibrated in °C. Water temperature was determined by submerging the thermometer below the water surface until the temperature reading stabilized. Air temperature was obtained by placing the thermometer in a shaded location until the temperature reading stabilized. Temperature readings were recorded in the logbook, along with notations about cloud cover, wind direction and speed, and precipitation. Wind speed was estimated in miles per hour, and daily precipitation was measured using a rain gauge calibrated in millimeters.

Water level observations represented the river stage in centimeters above an arbitrary datum plane. Water levels were measured using a staff gage secured to a stake driven into the river bottom near the bank just downstream from the weir. The arbitrary datum plane was pegged to semi-permanent benchmarks intended to allow for consistency of measurements among years

(Appendix D1). Benchmarks consisted of steel pipe sections driven into the bank. These were driven nearly flush with the gravel to protect them from ice flows during break-up. Beginning in the 2005 season, a Hobo®[1] water temperature data logger was installed in midchannel and used to record water temperature every hour on the hour. These readings were used to calculate daily average, minimum, and maximum water temperatures.

Stream discharge measurements were conducted at several different water levels during the season using general methods described by the U.S. Geological Survey (Rantz 1982). Velocities were measured using a Price AA current-meter with top-setting wading rod. Stream discharge was calculated using the conventional current-meter method. Information collected for calculating discharge was recorded in the camp logbook.

RELATED PROJECTS

Inriver Abundance of Chinook Salmon in the Kuskokwim River

George River weir served as a monitoring site for radio tagged Chinook salmon as part of a mark–recapture study in the Kuskokwim River. This study was designed to incorporate escapement data from various projects (including George River weir) to estimate inriver abundance of Chinook salmon in the Kuskokwim River drainage above Kalskag. Methods for this project are presented in Stuby (*In prep*). The primary role of George River weir was to provide Chinook salmon escapement and ASL data for this project. The weir crew made no attempt to capture radio tagged Chinook salmon because these fish were monitored by a radio-tracking station located at the weir site.

Kuskokwim River Sockeye Salmon Radiotelemetry Feasibility Study

George River weir served as a monitoring site for radio tagged sockeye salmon *O. nerka* as part of a pilot project to assess the feasibility of a large-scale radiotelemetry project on this species in the Kuskokwim River. The primary role of George River weir was to provide escapement data for sockeye salmon migrating into the drainage. Crew made no attempt to capture radio tagged sockeye salmon at the weir as these fish were monitored by a radio-tracking station nearby. Gilk (*Unpublished*) provides details.

Kuskokwim River Salmon Mark–recapture Project

George River weir served as a recovery site for salmon marked with Floy® anchor tags in support of a salmon tagging project conducted on the mainstem Kuskokwim River. The project was designed to estimate coho salmon abundance and identify stock specific run timing of Chinook, sockeye, chum, and coho salmon past the tagging site near Kalskag (Figure 1). Methods for this project are presented in Pawluk et al. (*In prep* b). At George River weir, tagged fish were captured as they passed through the live trap. Tag numbers were recorded along with the date, tag color, species, and presence or absence of an adipose clip used as a secondary mark. Any tags detected and not recovered (i.e. no tag number recorded) were recorded along with date, color, and species. To look for possible tag loss, all salmon sampled for ASL or otherwise captured in the trap were examined for an adipose clip used as a secondary mark.

[1] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

Genetic Diversity of Chinook Salmon from the Kuskokwim River

Crew members obtained tissue samples from 200 Chinook salmon at George River weir for a study examining genetic diversity of Kuskokwim River Chinook salmon. After ASL sampling, a piece of an axillary process was cut from the fish, wiped clean, and placed in a vial of isopropyl alcohol. Sampling instruments were cleaned after each fish to prevent cross contamination. Vials were numbered, and the corresponding sex, location, and sampling date were recorded. The tissue samples were sent to the ADF&G Division of Commercial Fisheries Gene Conservation Laboratory. Methods for this study are described in Templin et al. (*In prep*).

RESULTS

ESCAPEMENT MONITORING

The George River weir operated continuously from 0000 hours on 15 June through 1645 hours on 20 September in 2005. The weir was inoperable for several hours on 24 July with the occurrence of a hole, and again from 1645 to 2400 hours on 20 September due to early weir removal. Additionally, a portion of the weir was submerged several inches below the surface during high water conditions between 15 and 19 September. Crew observed no salmon passing upstream during monitoring efforts, and the weir was considered operational for this period.

Chinook Salmon

A total annual escapement of 3,845 Chinook salmon was determined for the target operational period in 2005 (Table 1). The total annual escapement consisted of an observed passage of 3,845 fish and an estimated passage of 31 fish. Passage missed during the 24 July inoperable period was estimated using the “single day” method. Passage missed during the 20 September inoperable period was considered negligible based on available passage and run timing data.

The first Chinook salmon was observed on 15 June, the first day of operation, and the last Chinook salmon was observed on 17 September. Based on the operational period and inclusive of estimated passage, the median passage date was 4 July and the central 50% of the run occurred between 29 June and 11 July.

Chum Salmon

A total annual escapement of 14,828 chum salmon was determined for the target operational period in 2005 (Table 1). The total annual escapement consisted of an observed passage of 14,654 fish and an estimated passage of 293 fish. Passage missed during the 24 July inoperable period was estimated using the “single day” method. Passage missed during the 20 September inoperable period was considered negligible based on available passage and run timing data.

The first chum salmon was observed on 15 June, the first day of operation, and the last chum salmon was observed on 20 September, the last day of operation. Based on the target operational period and inclusive of estimated passage, the median passage date was 14 July and the central 50% of the run occurred between 8 and 23 July.

Coho Salmon

A total annual escapement of 8,200 coho salmon was determined for the target operational period in 2005 (Table 1). The total annual escapement consisted of an observed passage of 8,197

fish and an estimated passage of 3 fish. Passage missed during the 24 July inoperable period was estimated using the "single day" method. Passage missed during the 20 September inoperable period was considered negligible based on available passage and run timing data.

The first coho salmon was observed on 26 July. Coho salmon were still passing upstream in small numbers before the weir was dismantled on 20 September. Based on the target operational period and inclusive of estimated passage, the median passage date was 31 August and the central 50% of the run occurred between 23 August and 7 September.

Other Species

Passage through the George River weir in 2005 included 272 sockeye salmon, 77 pink salmon *O. gorbuscha*, 2,046 longnose sucker, 184 Arctic grayling *Thymallus arcticus*, 23 whitefish *Coregonus spp*, and 2 Dolly Varden *Salvelinus malma* (Appendix A1). No estimates of unobserved passage were made for these species.

Carcass Counts

Carcass counts in 2005 included 39 Chinook salmon, 849 chum salmon, and 33 coho salmon during the target operational period (Appendix B1). The proportion of carcasses counted to total annual escapement was 1.0% for Chinook salmon and 5.7% for chum salmon.

AGE, SEX, AND LENGTH COMPOSITION

Samples were collected from 560 Chinook, 1,000 chum, and 524 coho salmon to determine ASL composition of escapements in 2005.

Chinook Salmon

Age, sex, and length were determined for 471 Chinook salmon, or 12.3% of the total escapement (Table 2). The run was partitioned into 3 temporal strata based on the distribution of sample dates. Sample sizes were 153, 165, and 153 fish per stratum. As applied to the total Chinook escapement, age 1.3 was the most abundant age class (43.9%), followed by age 1.4 (40.7%), and age 1.2 (10.6%). Female Chinook salmon composed 35.7% of the total escapement.

Male Chinook salmon ranged in length from 404 to 627 mm at age 1.2, 541 to 907 mm at age 1.3, and 697 to 1015 mm at age 1.4, with mean lengths of 543, 710, and 831 mm respectively. Female Chinook salmon ranged in length from 595 to 855 mm at age 1.3, and 725 to 980 mm at age 1.4, with mean lengths of 757 and 835 mm respectively (Table 3).

Chum Salmon

Age, sex, and length were determined for 985 chum salmon, or 6.6% of the total escapement (Table 4). The chum run was partitioned into 6 temporal strata based on sampling dates, with sample sizes of 199, 195, 186, 167, 179, 59 fish, respectively. As applied to the total chum escapement, age 0.3 was the most abundant age class (89.8%), followed by age 0.2 (5.2%), and age 0.4 (4.5%). Female chum salmon composed 46.8% of the total escapement.

Male chum salmon ranged in length from 455 to 580 mm at age 0.2, 420 to 660 mm at age 0.3, and 485 to 646 mm at age 0.4, with mean lengths of 513, 557, and 582 mm respectively. Female chum salmon ranged in length from 442 to 575 mm at age 0.2, 416 to 595 mm at age 0.3, and 472 to 559 mm at age 0.4, with mean lengths of 499, 522, and 520 mm respectively (Table 5).

Coho Salmon

Age, sex, and length were determined for 463 coho salmon, or 5.7% of the total escapement (Table 6). The run was partitioned into 3 temporal strata based on the distribution of sample dates. The coho run was partitioned into 3 temporal strata based on sampling dates, with sample sizes of 158, 154, and 151 fish, respectively. As applied to the total coho escapement, age 2.1 was the most abundant age class (80.2%), followed by age 3.1 (18.8%), and age 1.1 (1.0%). Female coho salmon composed 48.6% of the total escapement.

Male coho salmon ranged in length from 400 to 642 mm at age 2.1 and 405 to 630 mm at age 3.1, with mean lengths of 532 and 520 mm respectively. Female coho salmon ranged in length from 335 to 625 mm at age 2.1, and 448 to 625 mm at age 3.1, with mean lengths of 550 and 552 mm respectively (Table 7).

WEATHER AND STREAM OBSERVATIONS

A total of 167 complete weather and stream observations were recorded between 15 June and 20 September 2005 (Appendix C1). Water temperature was recorded hourly with the Hobo® data logger from 0000 hours on 1 July to 2300 hours on 20 September to calculate daily summaries (Appendix C2). During the target operational period, water temperatures ranged from 5.7°C on 20 September to 19.8°C on 23 July, and river stage ranged from 19 cm on 15 August to 101 cm on 17 September. Stream discharge measurements were taken three times during the season and ranged from 14.6 to 117.1 m^3/sec (Appendix C3–C5).

RELATED PROJECTS

Inriver Abundance of Chinook Salmon in the Kuskokwim River

Results of the Chinook salmon mark–recapture radiotelemetry study in 2005 are reported in Stuby (*In prep*). Six radio tagged Chinook salmon were detected past the receiving station at George River weir, and were later detected by aerial tracking upstream of the weir. Travel time over the 183 rkm from the tagging site to the George River weir ranged between 5.4 and 9.4 days and averaged 7.5 days.

Kuskokwim River Sockeye Salmon Radiotelemetry Feasibility Study

No radio tagged fish were detected among 272 sockeye salmon observed migrating past the George River weir in 2005. Results of study are reported in Gilk (*Unpublished*).

Kuskokwim River Salmon Mark–recapture Project

Results for the Chinook, chum, sockeye, and coho salmon tagging study in 2005 are reported in Pawluk et al. (*In prep* b). Tag recoveries at George River weir included 5 of 7 Chinook, 271 of 304 chum, 80 of 86 coho, and 16 of 18 sockeye salmon observed with tags. Of the 33 chum salmon tags that passed upstream not recovered, 16 were later collected on carcasses at the weir. A total of 526 Chinook, 73 sockeye, 1,689 chum, and 1,329 coho salmon were examined for secondary marks. Among untagged salmon examined, 1 of 521 Chinook, 0 of 58 sockeye, 1 of 1,425 chum, and 0 of 1,251 coho salmon were found with an adipose clip secondary mark.

Genetic Diversity of Chinook Salmon from the Kuskokwim River

Tissue samples were collected from 200 Chinook salmon for genetic analysis of population structure and genetic stock identification. Results of this study are reported in Templin et al. (*In prep*).

DISCUSSION

ESCAPEMENT MONITORING

The reported Chinook, chum, and coho escapements in 2005 are considered accurate representations of annual escapements to the George River. Moderate and low river levels permitted successful operation of the weir throughout the target operational period with only minimal interruptions on 24 July and 20 September. As a result, escapements were determined with little reliance on passage estimates. In addition, daily passage trends indicated few salmon passed the weir site before or after the operational period (Table 1).

Chinook Salmon

The George River Chinook salmon escapement of 3,845 fish in 2005 was intermediate to the higher escapements seen in 1996 and 1997 and the lower escapements seen in 2000 and 2002 (Figure 3). In contrast to other abundance indicators in the Kuskokwim drainage, where escapements increased or remained near the robust levels observed in 2004, the George River Chinook salmon escapement decreased about 25% in 2005. This may be the result of a poor escapement in 1999, since the return of age-1.4 fish to George River was about 40% lower in 2005 than in 2004 (Figure 4), and age-1.4 Chinook salmon tend to be more prominent in escapements to George River than to other Kuskokwim River tributaries (Molyneaux and Folletti 2005).

Run timing of Chinook salmon at the weir was earlier in 2005 than most previous years (Figure 5), with a median passage date of 4 July. Median passage dates at George River weir have typically occurred between 3 and 11 July. Other Kuskokwim River projects reported Chinook salmon run timing earlier or similar to previous years in 2005 (Costello et al. 2005, 2006; Jasper and Molyneaux *In prep*; Zabkar et al. *In prep*).

Currently, no escapement goal exists for George River Chinook salmon to serve as a benchmark for assessing adequacy of escapements. In tributaries where escapement goals have been established (ADF&G 2004), trends have improved since 2000, but to varying degrees. Escapement trends have generally remained within sustainable escapement goal (SEG) ranges at upper Kuskokwim River tributaries, but have increased sharply beyond SEG ranges at lower tributaries (Linderman et al. *In prep*). Overall, Chinook salmon escapements in 2005 were considered above average in the Kuskokwim River drainage. Escapement goals were met or exceeded in all tributaries where they have been established, and the Kuskokwim River Chinook salmon escapement index was only slightly lower than in 2004, which was the highest year on record (Linderman et al. *In prep*). Since 2001, Chinook salmon escapements to the Kuskokwim River have improved, but increases to George River escapements have been small in comparison to increases at other tributaries in the Kuskokwim River drainage.

Kuskokwim River Chinook salmon have been classified as a stock of yield concern by the Alaska Board of Fisheries (BOF) since September 2000 (Burkey et al. 2000 a, b), and have been managed more conservatively as a result. A subsistence fishing schedule implemented annually

since 2001 has observed a 3-day weekly closure to allow large pulses of salmon passage through the river, and has likely contributed to higher escapements in recent years (Bergstrom and Whitmore 2004). In response to adequate run strength indicators for Chinook and chum salmon in 2005, the subsistence schedule was lifted for the season on 19 June (Linderman et al. *In prep*). George River Chinook salmon likely benefited from the schedule because early June closures provided windows when fish could pass through the intensive lower Kuskokwim River subsistence fishery.

Chinook salmon are harvested incidentally during the June and July chum salmon commercial fishery in the Kuskokwim River. While the commercial fishery generally had some impact on Chinook escapement throughout most of the 1990's, its influence has likely been negligible in more recent years. Weak runs kept the commercial chum salmon fishery closed for most of 1999 and 2000, and all of 2001–2003. Improved runs permitted commercial chum salmon fishing in 2004 and 2005, but poor market conditions for Kuskokwim River chum salmon resulted in relatively small harvests. The commercial harvest of 4,784 Chinook salmon in 2005 was the highest since 1998, when the 10-year average commercial harvest was 27,238 Chinook salmon (Linderman et al. *In prep*). The impact of the subsistence fishery is likely much greater, but these harvests remain relatively consistent over years. Annual Chinook salmon subsistence harvest estimates in the Kuskokwim River range from 64,893 to 96,436 fish between 1994 and 2003 according to the most recent data available (Whitmore et al. 2005). These harvests are in comparison to the 145,373 Chinook salmon estimated to have migrated upstream of Aniak in 2005 (Stuby *In prep*).

Chum Salmon

Chum salmon escapement of 14,828 fish in 2005 to George River weir was intermediate to those in previous years (Figure 6), which have ranged from 3,492 fish in 2000 to 33,666 fish in 2003. The 2005 George River chum salmon escapement was near its historical average abundance of 13,605 fish. This was in contrast to record high abundances reported throughout the Kuskokwim River drainage in 2005.

Run timing for chum salmon at the weir in 2005 was intermediate relative to previous years (Figure 5), with a median passage date on 14 July. Historical median passage dates at George River weir have ranged between 7 and 21 July. Other Kuskokwim River projects observed median passage dates similar to previous years for chum salmon in 2005 (Costello et al. 2005, 2006; Jasper and Molyneaux *In prep*; McEwen *In prep*; Zabkar et al. *In prep*).

A formal escapement goal does not exist to evaluate the adequacy of chum salmon escapements into the George River. However, escapement goals have been established for chum salmon at Aniak River and Kogrukluk Rivers (ADF&G 2004). Comparisons between these projects show common years of low escapement in 1999 and 2000 when goals were not achieved, and significantly higher escapements in subsequent years when goals were achieved or nearly achieved (Figure 6). However, it is important to note that DIDSON (Dual-frequency Identification Sonar) equipment was newly deployed in 2004 at Aniak River Sonar. By allowing technicians to better distinguish fish swimming in close groups, it is believed the DIDSON produces a higher count than technologies in previous years (McEwen *In prep*). Historical escapements have been adjusted to the newer technology, but the current chum salmon escapement goal was determined using data produced by older sonar technologies.

Similar to Chinook salmon, Kuskokwim River chum salmon have been classified as a stock of yield concern by the Alaska BOF since September 2000 (Burkey et al. 2000 a, b), and have been managed more conservatively as a result. George River chum salmon likely benefited from the subsistence fishing schedule because early June closures provided windows when fish could pass through the lower Kuskokwim River subsistence fishery. The impact of the subsistence fishery is likely modest, however, since these harvests are small in proportion to the likely overall annual abundance of chum salmon to the Kuskokwim River. Annual subsistence harvest estimates for chum salmon in the Kuskokwim River range from 43,320 to 88,965 fish between 1994 and 2003 according to the most recent data available (Whitmore et al. 2005).

While the commercial fishery generally had some impact on chum escapement throughout most of the 1990s, its influence has been almost negligible in more recent years. Weak runs kept the commercial chum salmon fishery closed for most of 1999 and 2000, and all of 2001–2003. Improved runs permitted commercial chum salmon fishing in 2004 and 2005, but poor market conditions for Kuskokwim River chum salmon resulted in relatively small harvests. The commercial harvest of 69,139 chum salmon in 2005 was the highest since 1998, when the 10-year average commercial harvest was 334,029 chum salmon (Linderman et al. *In prep*).

Coho Salmon

Coho salmon escapement of 8,200 fish in 2005 was the second lowest in 8 years of observations at George River weir (Figure 7). Annual escapements have ranged between 6,759 fish in 2002 to 33,280 fish in 2003. Coho salmon escapements are monitored at 5 other weir projects in the Kuskokwim River drainage, and an escapement goal exists at Kogrukluk River weir (Jasper et al. *In prep*). Though escapement levels have been decreasing at each of these projects since 2003, the escapement goal was achieved at Kogrukluk River weir in 2005 (Linderman et al. *In prep*).

Coho salmon run timing at the weir in 2005 was intermediate to previous years (Figure 5), with a median passage date of 31 August. Historical median passage dates at George River weir have ranged from 21 August to 6 September, with an average date of 29 August. Other Kuskokwim River projects observed median passage dates variable to previous years for coho salmon in 2005 (Costello et al. 2005, 2006; Jasper and Molyneaux *In prep*; McEwen *In prep*; Zabkar et al. *In prep*).

The level of coho salmon escapement seen in the George River is influenced by harvest activity in the mainstem Kuskokwim River. Over 85% of coho salmon subsistence harvest and all commercial harvest occurs downstream of the George River confluence (Whitmore et al. 2005). This year's commercial harvest of 142,319 coho salmon was below the previous 10-year average of 300,280 fish (Linderman et al. *In prep*). Subsistence harvests in the Kuskokwim River have remained fairly consistent over the years, ranging from 24,864 to 36,277 fish between 1994 and 2003 (ADF&G 2005). Although below recent years, the 2005 commercial harvest may represent a higher exploitation rate considering the relatively low escapement observed at most projects in 2005 (Linderman et al. *In prep*). Kuskokwim River coho salmon have not been identified as a stock of concern, even though harvests and escapements have generally been below average since 1996 (Ward et al. 2003).

Other Species

Other salmon species observed historically at George River weir include small numbers of sockeye and pink salmon. The George River is not a primary spawning tributary for these

species; therefore, it is not surprising that few sockeye and pink salmon were observed in 2005 (Appendix A1). The passage of 272 sockeye salmon in 2005 was unusually high for George River weir, and reflects the record high passages observed at other Kuskokwim River weirs this year (Costello et al. 2005, 2006; Jasper and Molyneaux *In prep*; Zabkar et al. *In prep*). The 2005 sockeye salmon commercial harvest of 27,645 sockeye salmon was greater than the recent 10-year average of 23,763 fish (Linderman et al. *In prep*). Compared to other species in the drainage, little is known about sockeye salmon in the Kuskokwim River. No escapement goals exist for this species within the drainage.

Other species commonly observed at George River weir include longnose suckers, whitefish, and Arctic grayling (Appendix A1). Longnose suckers are historically the most abundant non-salmon species counted at George River weir; however, counts are likely incomplete because smaller individuals may be able to pass freely between pickets and upstream migration appears to start before weir operations typically begin. The highest recorded passage of this species was 15,840 in 2001. Longnose suckers have been reported as common in the Aniak, Tatlawiksuk, and Takotna rivers, but they appear to be uncommon or absent from the Kwethluk, Tuluksak, and Kogrukluk rivers.

Carcass Counts

Though not a project objective, carcass counts may provide a means for measuring nutrient retention and loss in the George River. Approximately 1.0% of the Chinook salmon escapement and 5.7% of chum salmon escapement was later observed as carcasses at the George River weir in 2005 (Appendix B1). The proportion of carcasses to escapement does not account for carcasses washed downstream during inoperable periods or removed by scavengers, and are likely higher than reported. Decreasing water levels throughout the Chinook and chum salmon run in 2005 likely resulted in a lower than historical proportion of carcasses at the weir. The protracted retention of salmon carcasses upstream of the weir in 2005 likely enhanced the absorption of marine derived nutrients, and further contributed to the productivity of the George River (Cederholm et al. 1999, 2000). No speculation is made from coho salmon carcass data because carcasses likely passed downstream unmonitored with debris loads that washed over the weir during high water conditions between 15 and 19 September. In addition, the weir was likely removed before the majority of coho salmon in the George River completed spawning.

AGE, SEX, AND LENGTH COMPOSITION

Chinook Salmon

ASL data collected from Chinook salmon in 2005 were adequate to describe the composition of the total escapement into the George River since sampling occurred throughout most of the run and total sample size met or exceeded the minimum goal for each pulse. ASL composition has been estimated for the total Chinook escapement in only 6 of 10 years the project has operated. Premature project termination or late start up was cited in some years, and problems collecting the minimum ASL sample size were cited in other years. Increased abundances and improved sampling techniques have resulted in adequate sample collections in recent years. Although “active sampling” has become an effective means of capturing adequate numbers of Chinook salmon for ASL collection, this strategy creates more crew activity around the weir, and as a result Chinook salmon sometimes move back downstream. This behavior is especially evident in low water conditions, and pulse sample collection must sometimes be abbreviated to prevent an abnormal delay in fish passage.

The abundance estimate for age-1.3 fish in 2005 was the highest on record at George River weir (Figure 4). This was anticipated by the high abundance of age-1.2 siblings in 2004, and is an indication of strong sibling relationships in Kuskokwim River Chinook salmon. Additionally, since age-1.4 is typically a prominent age class in the George River (Figure 4), a high return of Chinook salmon to the George River is expected for 2006. Similar age distribution, with relatively high abundances of age-1.2 fish in 2004 and age-1.3 fish in 2005, was observed throughout the Kuskokwim drainage (Costello et al. 2005, 2006; Jasper and Molyneaux *In prep*; Zabkar et al. *In prep*; Molyneaux and Folletti 2005). These strong returns contrasted with the poor escapements observed in the 2000 brood year, indicating favorable conditions for Kuskokwim Area Chinook salmon in recent years. Age increased over the run at George River weir in 2005. The percentage of age-1.2 and -1.3 Chinook salmon decreased and the percentage of age-1.4 Chinook salmon increased as the season progressed (Figure 8). This is consistent with George River Chinook salmon data combined over all years and with trends observed at other locations in the drainage (Costello et al. 2005, 2006; Jasper and Molyneaux *In prep*; Zabkar et al. *In prep*).

Comparisons among years indicate the sex ratio of 35.7% females in 2005 is near the lower end of the historical range of 33.0% to 53.9% for the George River weir (Molyneaux and Folletti 2005). This was expected because of the high proportion of age-1.3 fish in 2005 (Figure 4), which are predominantly male (Molyneaux and Folletti 2005). Most other projects observed a lower than average proportion of females in 2005 (Costello et al. 2005, 2006; Jasper and Molyneaux *In prep*; Zabkar et al. *In prep*). The ratio of females increased over the duration of the run at George River weir in 2005, which is consistent with data combined over all years (Figure 9). This finding was expected since male salmon are reported to migrate earlier than female salmon, and is commonly observed throughout the Kuskokwim River drainage (Molyneaux and Folletti 2005).

George River Chinook salmon exhibited length partitioning by age class for male and female fish in 2005 similar to previous years (Figure 10). Female Chinook salmon were generally longer at age than males and, as expected, length increased with age. This pattern is commonly observed throughout the Kuskokwim River drainage (Molyneaux and Folletti 2005). The numerous age/sex classes of Chinook salmon escapements generally result in sample sizes too small to adequately describe intra-annual changes in mean length at George River weir. When 2005 results were combined with historical data, the most apparent trends showed mean length of age-1.4 males increasing slightly, and age-1.4 females changing little over the run (Figure 11).

Chum Salmon

The ASL data collected from chum salmon in 2005 were adequate for describing the age composition for the total annual escapement into the George River. ASL composition of chum salmon has been estimated in 8 of 10 years that the project has operated. The project was terminated early in 1998 and began late in 1999.

In 2005, abundance estimates for both age-0.2 and -0.3 George River chum salmon were the second highest on record (Figure 4), indicating the potential for a strong run in 2006. In contrast, the return of age-0.4 fish was the weakest on record in 2005, possibly reflecting the poor escapement observed in the parent year 2000. Record high abundances of age-0.3 fish were observed in all other monitored tributaries in 2005 (Costello et al. 2005, 2006; McEwen *In prep*; Jasper and Molyneaux *In prep*; Zabkar et al. *In prep*). Abundances were above average for

age-0.2 fish, and below or near average for age-0.4 fish. Average age historically decreases over the run at George River weir (Figure 12), though a disproportionately high abundance of age-0.3 to -0.4 fish in 2005 likely masks this trend.

Comparisons among years indicate the sex ratio of 46.8% females at the George River weir in 2005 is well within the historical range of 42.8% to 53.8% (Molyneaux and Folletti 2005). Similar to previous years, estimates of the proportion of females were less than 50% early in the migration and greater than 50% later in the run (Figure 9). This finding was expected since male salmon are reported to migrate earlier than female salmon, as is commonly observed throughout the Kuskokwim River drainage (Molyneaux and Folletti 2005).

Length partitioning between sex and age class was similar to previous years at George River weir (Figure 10). Males tended to be longer than females, and mean lengths increased with age. Results of length partitioning in 2005 were likely skewed by small sample sizes of age-0.4 fish (Table 5). This pattern is commonly observed throughout the Kuskokwim River drainage (Molyneaux and Folletti 2005). Mean length appeared smaller overall in 2005 than in most previous years at George River weir (Figure 10), a pattern noted at Kogrukluk and Tatlawiksuk rivers as well (Costello et al. 2005; Jasper and Molyneaux *In prep*). Changes in mean length over the run in 2005 were similar to previous years at George River weir (Figure 13). Length appears to decrease over the run in all age/sex classes. This may indicate a correlation between migration speed and length of chum salmon.

Coho Salmon

The ASL data collected from coho salmon in 2005 were adequate for describing the age composition for the total annual escapement into the George River. ASL composition for coho salmon has been adequately estimated in 7 of 9 years the project has monitored this species. Early project termination from flooding was cited in 1998, and low water conditions delaying coho salmon passage was cited in 2002 for inadequate sample collections.

Coho salmon were predominantly age 2.1 in 2005 at George River weir (Figure 14). Age-2.1 coho salmon typically comprise over 80% of coho salmon at George River weir, with the remainder mostly age-3.1 and a few age-1.1 fish. Similar age composition is typically observed for coho salmon throughout the Kuskokwim River drainage (Molyneaux and Folletti 2005). Age composition remained fairly consistent over the 2005 season (Figure 15), similar to previous years at George River weir and similar to other locations in the Kuskokwim River drainage (Costello et al. 2005, 2006; Jasper and Molyneaux *In prep*; Zabkar et al. *In prep*).

Comparisons among years indicate the sex ratio of 48.6% female in 2005 is well within the historical range of 36.6% to 53.3% (Molyneaux and Folletti 2005). The ratio of female fish increased over the run in 2005 similar to previous years (Figure 9). The percentage of females is typically around 40–50% in Kuskokwim River tributaries where samples are routinely collected, and the percentages typically increase slightly throughout the run in most locations (Costello et al. 2005, 2006; Zabkar et al. *In prep*). One chronic exception is in the Kogrukluk River where the percentage of females is typically lower than other areas (30–40%) and the intra-seasonal sex composition is highly variable between years (Jasper and Molyneaux *In prep*; Molyneaux and Folletti 2005).

Length partitioning appeared stronger in 2005 between sexes in age-2.1 fish than in previous years (Figure 10). While females have tended to be slightly longer in most years at George River

weir, length partitioning does not appear strong between sexes at other locations in the Kuskokwim River (Molyneaux and Folletti 2005). Mean length of age-2.1 fish in 2005 was similar to 2004 and less than most other years at George River weir. Changes in mean length over the run in 2005 are similar to previous years at George River weir (Figure 16). Mean length of age-2.1 fish appears to increase slightly in males over the run and vary little in females.

WEATHER AND STREAM OBSERVATIONS

The weir crew maintained a nearly complete record of weather and stream observations in 2005. However, observations beyond 5 September were missing and a less complete set of observations was collected from radio log book forms for those dates.

Measured against historical stream data at George River weir, water temperature was above average throughout the season in 2005 (Figure 19). River stage was below average during Chinook and chum migration, and rose above average during coho migration in 2005 (Figure 20). Correlations of fish passage to water temperature and river stage are not easily discernable from the available data in 2005 (Figures 17 and 18). The most obvious correlation shows coho salmon passage increasing and decreasing with water levels between 23 August and 7 September (Figure 18). The effect of migration timing does change in relation to long term changes in freshwater water temperatures (Quinn 2005). The relation of water level to fish passage is less well understood and varies among sites and species (Quinn 2005).

Three stream discharge measurements were taken in 2005 (Appendices C3–C5). A stream discharge of 14.6 m^3/sec represented flow at a river stage of 20 cm, only 1 cm above the lowest river stage of the season. A discharge of 117.1 m^3/sec was measured at a river stage of 95 cm, and represented flow at the upper operational limits of the George River weir. These were the first measurements collected at the weir since 2002. Continued rigorous stream data collection might be used to estimate seasonal flow characteristics within the George River and identify instream flow needs to sustain fish population.

A new river stage benchmark was installed in 2005 to address the difficulty of maintaining benchmarks established in 2000 (Appendix D1). The 2000 benchmarks are located along the bank and have been damaged by ice in previous years. The new benchmark consists of a small rectangular aluminum plate fixed to the top of a tree stump located in the middle of the field camp, approximately 30 ft back from the riverbank. This benchmark represents a river stage of 300 cm, and was placed to correlate with benchmarks and stage measurements maintained since 2000. The new benchmark requires the use of a surveyor’s rod and level to calibrate the river gauge.

Knowledge of environmental conditions and a commitment to long-term monitoring may be valuable in understanding migration and survival. Quinn (2005) notes that migration in salmon is likely controlled by genetic factors as an adaptation to long-term average environmental conditions. Keefer et al. (2004) found a positive correlation between river discharge and run timing of Columbia River Chinook salmon stocks, and that Columbia River sockeye salmon have started their inriver migration 2 weeks earlier in response to warmer water conditions resulting from dam construction. We cannot begin to assess the affects of changing environmental conditions on Kuskokwim River salmon without the relatively complete weather and stream observations collected by crews such as at the George River weir. These measurements can easily be neglected in field camps and may seem like a low priority among project objectives, but incorporating weather and stream observations into the daily morning and

afternoon radio schedules with ADF&G staff in Bethel helps insure the data are gathered consistently throughout the season.

RELATED FISHERIES PROJECTS

Inriver Abundance of Chinook Salmon in the Kuskokwim River

The primary objective of the Chinook salmon radiotelemetry project was to estimate inriver abundance of Chinook salmon in the Kuskokwim River upstream of the tagging site near Lower Kalskag. Findings from 2005 are discussed in Stuby (*In prep*). The study was designed to incorporate escapement data from various projects (including George River weir) to estimate inriver abundance. Additionally, the radiotelemetry data offered an opportunity to study migration characteristics of George River Chinook salmon. A total of 6 radio tagged Chinook salmon were detected migrating past the weir in 2005 (Figure 21; L. Stuby, Sport Fish Biologist, ADF&G, Fairbanks; personal communication). The distance between the tagging site and the weir was 183 rkm and transit time averaged 7.5 days. The travel speed averaged 24.4 km/day. No radio tagged fish passed the weir site prior to the weir becoming operational on 15 June, though the first Chinook salmon was tagged near Kalskag on 13 June.

Radiotelemetry data from this study indicates the run timing of discreet Chinook salmon spawning aggregates past the Kalskag tagging site (Figures 22 and 23). George River Chinook salmon tend to migrate somewhat later than upper river stocks. A pattern of upper river populations migrating past the tagging site earlier than lower river populations is fairly consistent from past years (Stuby *In prep*), although Kogrukluk River fish tend to be an outlier and migrate later than this pattern would suggest.

The Chinook salmon radiotelemetry project provides valuable data for fishery management. The timing of commercial fishery openings and the annual discontinuation of the subsistence fishing schedule is considered with respect to the stock-specific run timing evident through the tagging and tracking of Chinook salmon. By 24 June 2005, the date of the first commercial opening in District W-1 (Figure 1), 4 of the 6 radio tagged George River Chinook salmon had already passed the tagging site upstream of the district. (Figure 23; L. Stuby, Sport Fish Biologist, ADF&G, Fairbanks; personal communication). The timing of George River Chinook salmon through the lower river, coupled with the modest Chinook salmon harvest in 2005, made it unlikely that many George River Chinook salmon were harvested in the commercial fishery. Additionally, the subsistence fishing schedule likely benefited George River Chinook salmon stocks. In 2005, the schedule was implemented for 2 weeks beginning 5 and 12 June. In response to adequate run strength indicators for Chinook and chum salmon in 2005, the schedule was rescinded for the season on 19 June (Linderman et al. *In prep*). Based on run timing from the Chinook salmon radiotelemetry project, nearly half of the George River escapement would have entered the Kuskokwim River before the last day of subsistence closures on 14 June, assuming the estimated travel speed of 24.4 km/day remained constant throughout their migration.

Kuskokwim River Sockeye Salmon Radiotelemetry Feasibility Study

Findings for the Kuskokwim River sockeye radiotelemetry project are discussed in Gilk (*Unpublished*). Preliminary results suggest that Kuskokwim River sockeye salmon were distributed predominantly among the Holitna, Stony, and Aniak River drainages, and few were found upstream of the Stony River. This was a feasibility study, however, and a more extensive project proposed for 2006 will yield more solid conclusions.

Kuskokwim River Salmon Mark–recapture Project

Tag recovery efforts for *Kuskokwim River Salmon Mark–recapture Project* were successful in 2005 at George River weir, with 90% of tags recovered overall. Extremely low water conditions reduced tag recoveries for about 10 days in August when fish became reluctant to pass through the live trap. To prevent significant delays in migration during this period, fish passage was periodically conducted through another portion of the weir, making tag recovery more difficult. Data from the mark-recapture project afforded an opportunity to study migration characteristics of George River Chinook, chum, coho, and sockeye salmon in 2005. Findings from this study are presented in Pawluk et al. (*In prep* b).

Chinook Salmon

Tag numbers were recovered from 5 of 7 anchor tagged Chinook salmon observed passing the George River weir in 2005. The percentage of tagged fish in the total annual Chinook salmon escapement past the George River weir (0.2%) was similar to that reported for Tatlawiksuk River weir (0.3%), Kogrukluk River weir (0.3%), and Takotna River weir (0.4%; Pawluk et al. *In prep* b). The distribution of tags detected relative to passage at the weir indicates that the George River Chinook salmon run was well represented in the tagging sample, despite the few number of tags observed (Figure 21; Pawluk et al. *In prep* b).

Similar to the radiotelemetry data from Chinook salmon, anchor tagged George River Chinook salmon migrated past the Kalskag tagging site later than stocks spawning farther upstream in 2005 (Figure 24; Pawluk et al. *In prep* b). This finding further supports the notion that run timing of discreet Chinook salmon stocks through the lower river may be related to the distance to the spawning grounds. Tagging of George River Chinook salmon was concentrated more toward the early half of the run, suggesting migration past Kalskag was actually later than tag data indicate. Though sample size was small, average transit time between tagging and passage at George River weir (8.4 days) was similar to the radio tagged sample (9.7 days).

Chum Salmon

Results from Pawluk et al. (*In prep* b) indicate transit time between tagging and passage at George River weir ranged from 1 to 22 days, and averaged 6.1 days (Pawluk et al. *In prep* b). Travel speed of the anchor tagged fish averaged 32.5 km per day in 2005, which is slightly faster than estimates of 29.3, 27.4, and 29.0 km per day in 2002–2004 respectively (Kerkvliet et al. 2003, 2004; Pawluk et al. *In prep* a). Average travel speeds for George River chum salmon in 2005 were slightly slower than to the Tatlawiksuk (35.7 km per day), Kogrukluk (33.8 km per day), or Takotna (38.8 km per day) river weirs. This may indicate that the fish with the farthest distance to travel have greater average travel speeds.

Findings from 2005 show George River chum salmon migrated past the tagging site later than stocks returning to more distant tributaries in the Kuskokwim drainage, and earlier than fish bound for the Aniak River lower in the drainage (Figure 26). The distribution of tags relative to passage at the weir indicates tagged chum salmon were underrepresented early in the run and the likelihood of encountering a tagged fish became much greater as the run progressed (Figure 21). This suggests that actual run timing of George River chum salmon past Kalskag may have been earlier than the tagged sample indicates. However, even if the sample at Kalskag were shifted 6 days earlier to match the median passage date at George River weir, migration past Kalskag would still fall between adjacent upper and lower river stocks. These findings are similar to

previous years and suggest a relationship between run timing and distance to spawning grounds of chum salmon stocks in the Kuskokwim River drainage (Figures 25 and 26).

The tagging data provides an opportunity to study possible effects of fisheries and management decisions on the George River chum salmon escapement. Four commercial fishing periods were conducted for chum salmon in the lower river near Bethel between 24 June and 1 July 2005. Based on run timing of escapement at the weir, and assuming the estimated travel speed of 32.5 km/day remained constant throughout their migration, only the earlier half of the George River run would have been impacted by the commercial fishery. The subsistence fishery closures on 5 and 12 June likely had little impact on chum salmon returning to George River. Based on run timing at the weir, and assuming the estimated travel speed of 32.5 km/day remained constant throughout their migration, the majority of George River chum salmon would have migrated into the Kuskokwim River after these closures ended. Additionally, the overall impact of the subsistence fishery is likely minor, since chum salmon subsistence harvest estimates have only averaged 61,841 chum salmon in the Kuskokwim area between 1994 and 2003 (ADF&G 2005), and are small in proportion to the likely overall annual abundance of chum salmon to the Kuskokwim area.

Coho Salmon

Results from Pawluk et al. (*In prep* b) indicate transit time between tagging and passage at George River weir ranged from 5 to 24 days, and averaged 11.1 days in 2005 (Pawluk et al. *In prep* b). Travel speed of the anchor tagged fish averaged 19.9 km per day, which is similar to 2004 at 20.6 km/day but is 6 to 7 km/day faster than in other previous years (Kerkvliet et al. 2003, 2004; Pawluk et al. *In prep* a). Average travel speeds for George River coho salmon in 2005 were slightly slower than to Tatlawiksuk (22.3 km per day), Kogrukluk (23.7 km per day), or Takotna (26.1 km per day) river weirs. This may indicate that the fish with the farthest distance to travel have greater average travel speeds.

Findings in 2005 show George River chum salmon migrated past the tagging site later than stocks returning higher in the Kuskokwim drainage (Figure 28). The distribution of tags relative to passage at the weir indicates tagged coho salmon were underrepresented early in the run and the likelihood of encountering a tagged fish became greater as the run progressed (Figure 21). The median passage date of tags at the weir was 6 days later than median passage date for the run. This suggests that actual run timing of George River coho salmon past Kalskag may have been earlier than the tagged sample indicates. However, even if the tagged sample at Kalskag were shifted 6 days earlier, it would still be later than the other stocks examined. These findings are similar to previous years and suggest a relation between run timing and distance to spawning grounds of coho salmon stocks in the Kuskokwim River drainage (Figures 27 and 28).

The tagging data provides an opportunity to study possible effects of fisheries and management decisions on the George River coho salmon escapement. Eleven commercial fishing periods were conducted for coho salmon in 2005, all occurring between 2 August and 1 September in District W-1 (Figure 1). The commercial fishery likely had an impact on coho salmon escapement to George River in 2005. Based on run timing of escapement at the weir, and assuming the estimated travel speed of 19.9 km/day remained constant throughout their migration, the commercial fishing periods would have spanned a majority of George River coho salmon migration through the district. The impact of the subsistence fishery is likely minor. Subsistence harvest estimates averaged 33,664 coho salmon in the Kuskokwim area between

1994 and 2003 (ADF&G 2005), and are small in proportion to the likely overall annual abundance of coho salmon to the Kuskokwim area.

Sockeye Salmon

Sockeye salmon have been tagged at the mainstem Kuskokwim River Salmon Mark-recapture Project since 2002. Few sockeye salmon migrate annually into George River and sample sizes have been small. However, increasing escapements in 2004 and 2005, coupled with high proportions of tagged to total fish at the weir, have generated useful sample sizes. Results from these years show George River sockeye migrate very late in the overall catch sample at the mainstem tagging site (Figures 29 and 30). Transit time between tagging and passage at George River weir ranged from 5 to 22 days, and averaged 8.9 days in 2005 (Pawluk et al. *In prep* b). Travel speed of the anchor tagged fish averaged 24.4 km per day, which is similar to 2004 at 26.7 km/day (Pawluk et al. *In prep* a). Average travel speed for George River sockeye salmon in 2005 was similar to Tatlawiksuk (24.7 km per day), and Kogrukluk (26.2 km per day) river weirs, but much slower than at the Takotna River weir (40.2 km per day). This may indicate that the fish with the farthest distance to travel have greater average travel speeds.

Genetic Diversity of Chinook Salmon from the Kuskokwim River

Crew at the George River weir succeeded in collecting 200 Chinook salmon genetics samples to be added to the study of genetic diversity in the Kuskokwim River drainage. Based on microsatellite DNA and allozymes markers, past evaluations found evidence of genetic distinctions between upper, middle, and lower Kuskokwim River Chinook salmon populations (Templin et al. *In prep*).

CONCLUSIONS

ESCAPEMENTS

- The Chinook salmon escapement at George River in 2005 decreased about 25% from 2004 levels, in contrast to other abundance indicators in the Kuskokwim drainage where escapements increased or remained near the robust levels observed in 2004.
- The chum salmon escapement to George River in 2005 was near its historical average abundance, in contrast to other escapements monitored in the Kuskokwim drainage where record high abundances were reported.
- The coho salmon escapement to George River in 2005 was the second lowest abundance on record for the project, reflecting relatively low abundances reported elsewhere in the Kuskokwim River drainage.

AGE, SEX, AND LENGTH COMPOSITION

- The high return of age-1.3 Chinook salmon in 2005 indicates the potential for a strong return of age-1.4 fish in 2006.
- The unusually high return of age-0.3 chum salmon in 2005 indicates the potential for a high return of age-0.4 fish in 2006.

WEATHER AND STREAM OBSERVATIONS

- In general, water temperatures were warmer and river levels lower in 2005 than in previous years at George River weir.

RELATED PROJECTS

- The George River weir served as an important platform for several projects conducted in the Kuskokwim River drainage in 2005, including *Inriver Abundance of Chinook Salmon in the Kuskokwim River* (FIS 05-302), *Kuskokwim River Sockeye Salmon Radiotelemetry Feasibility Study, A Mark–Recapture Experiment of Kuskokwim River Chinook, Sockeye, Chum, and Coho Salmon* (FIS 04-308), and *Genetic Diversity of Chinook Salmon from the Kuskokwim River* (FIS 01-070).

RECOMMENDATIONS

PROJECT OPERATION

- Annual operation of the George River weir should continue indefinitely. The George River weir project has been a valuable addition to the array of well-distributed escapement monitoring projects throughout the Kuskokwim River drainage. Adequate monitoring of Kuskokwim River salmon escapements is one of many requirements needed for long-term sustainable management of Kuskokwim River salmon stocks. Discontinuation of the George River weir, or any other escapement monitoring project, would be a step backward from progress made in recent years toward collecting salmon stock assessment and information needs in the Kuskokwim River drainage. Additionally, the George River weir project serves as one of several data collection platforms critical to other Kuskokwim River salmon research projects. *Inriver Abundance of Chinook Salmon in the Kuskokwim River* project (FIS 05-302) is critically dependent on data collected from these weirs to generate total river abundance estimates. *Kuskokwim River salmon tagging project* (FIS 04-308) uses weir-recaptured spaghetti tagged Chinook, chum, sockeye, and coho salmon to develop and test total river abundance estimates, and these recaptures are critical for determining stock-specific run timing in the mainstem Kuskokwim River. George River is part of the genetic stock identification (GSI) baseline for Chinook, chum, and coho salmon, and plans are underway to use the weir for additional sample collection.

- Establish escapement goals for George River Chinook, chum, and coho salmon. ADF&G should continue seeking to establish biological escapement goals (BEG) to produce maximum sustainable yield (MSY) for these species at the George River, and in other Kuskokwim River spawning tributaries; however, determining MSY requires a rigorous level of stock specific spawner-recruit information still lacking. Alternatively, sustainable escapement goals (SEG) can be established, but require a 5 to 10 year data series of reliable escapement estimates that demonstrate sustainable yields. Recent deliberations on establishing escapement goals at the George River and other Kuskokwim River tributaries resulted in inaction because of inadequate historical escapement information (ADF&G 2004), heightening the need for uninterrupted continuation of the project.

PROJECT MANAGEMENT

- The George River weir should continue to be operated jointly by KNA and ADF&G. The partnership developed between KNA and ADF&G in the operation of fisheries projects, including the George River weir, has proven to be a successful strategy. Each organization compliments the partnership by providing an element the other cannot.

  KNA provides a communication link to help its constituents be more informed and less prone to the distrust and misinformation that can result when local organizations and their constituents are not directly involved. Active involvement of KNA adds an element of trust and acceptance toward the projects and ADF&G, which would not exist if ADF&G operated these projects alone. KNA is more effective at hiring technicians for these projects from the local area, and makes these jobs more acceptable and accessible for potential applicants. Additionally, the proximity of KNA facilities to these cooperatively managed projects provides logistical benefits for staging and for responding to various inseason project needs.

  Despite these attributes, KNA would have difficulty managing the George River weir and other jointly operated fisheries projects without ADF&G involvement. The fisheries staff of ADF&G has a greater depth of experience in fisheries project management; both in terms of on-site field experience, and broader aspects such as planning, data management and analysis, and report writing. The addition of a Partners Fisheries Biologist to the KNA staff has shifted some of these responsibilities to KNA, evident with the inclusion of a KNA biologist as a co-author of this report since 2003. However, the addition of one fisheries biologist to the KNA staff has not replaced all ADF&G personnel involved and the many years of fisheries management experience, scientific expertise, and understanding they contribute. Additionally, KNA's fisheries biologist has a myriad of other responsibilities, and is involved with multiple projects and multiple cooperative partners. This time limit reduces the direct attention KNA's biologist can contribute to individual project requirements.

  Partnership between KNA and ADF&G is a major contributing factor to success of the many fisheries projects for which these organizations are responsible. Dissolution of this partnership would result in a detrimental loss of continuity and support to both inseason and postseason project requirements, and increases the possibility of misunderstanding and mistrust between ADF&G, KNA, and the public. Continued joint operation will help to ensure the success of these projects in the future.

WEATHER AND STREAM OBSERVATIONS

- Continue the use of a water temperature data logger in the river channel to enable the determination of high, low, and mean daily measurements. This would provide more complete temperature documentation and enable better comparisons between years.

- Conduct additional stream discharge surveys to reestablish a link between flows and a new, more permanent benchmark. Several stream discharge surveys were conducted in previous years at George River weir, but these were never linked to a viable permanent benchmark.

ACKNOWLEDGEMENTS

The U.S. Fish & Wildlife Service, Office of Subsistence Management provided $71,979 in funding support for this project, in combination with the Takotna River weir project, through the Fisheries Resource Monitoring Program, under agreement number 701815J587. The salmon escapement monitoring program on George River is a cooperative project operated by the Kuskokwim Native Association (KNA) and the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries. Since inception of the project in 1996, operational funds have been provided to KNA from the U.S. Bureau of Indian Affairs through grants administered by the Bering Sea Fishermen's Association (BSFA) (#E00441023). In addition, other groups such as the Kuskokwim Corporation and the Sport Fish Division of ADF&G have provided in-kind support to the project in the form of free land-use for camp facilities, weir fabrication, and welding services. General Fund support from ADF&G included assistance from staff biologists, fish and wildlife technicians who served as crew leaders or crew members, and some operational costs. Additional funding for ADF&G's participation in this project was through a combination of state general funds and a grant from the Western Alaska Fishery Disaster Relief Program (NA 96FM0196) under the National Oceanic and Atmospheric Administration. USFWS OSM Resource Monitoring Program under Cooperative Agreement 701814J568 funded project FIS 04-307 which supported salmon age, sex, and length aging and data analysis for this project among others. In addition, other groups such as Kuskokwim Corporation and ADF&G Division of Sport Fish provided in-kind support to the project in the form of land-use authorization for the camp, and facilities for weir fabrication and welding services.

Many individuals contributed to the operation of the George River weir in 2005. Thanks to David Orabutt, and Karrina Wooderson of KNA who assisted with administrative needs and logistical support. Our greatest appreciation goes to crew members Cullan Lester, Harry Allain, and Brad Pensgard Jr. who did the bulk of the field work. Additionally, we would like to thank the Vanderpool family of Georgetown who provided winter storage facilities for equipment, assisted with and provided facilities for equipment repair and maintenance, and who provided the weir crew with many hours of Alaskan hospitality.

REFERENCES CITED

ADF&G (Alaska Department of Fish and Game). 1998. An atlas to the catalog of water important for spawning, rearing or migration of anadromous fishes. Region VI: Interior region resource management. Alaska Department of Fish and Game, Habitat and Restoration Division, Anchorage.

ADF&G (Alaska Department of Fish and Game). 2004. Escapement goal review of select AYK Region salmon stocks. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Informational Report No. 3A04-01, Anchorage.

ADF&G (Alaska Department of Fish and Game). 2005. Alaska subsistence fisheries, 2003 annual report. Alaska Department of Fish and Game, Division of Subsistence, Juneau.

Bergstrom, D. J. and C. Whitmore. 2004. Kuskokwim River Chinook and chum salmon stock status and action plan, a report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Informational Report No. 3A04-02, Anchorage.

Bromaghin, J. F. 1993. Sample size determination for interval estimation of multinomial probabilities. The American Statistician. 47(3): 203-206.

REFERENCES CITED (Continued)

Brown, C. M. 1983. Alaska's Kuskokwim River region: a history, draft. Bureau of Land Management, Anchorage.

Buklis, L. S. 1999. A description of economic changes in commercial salmon fisheries in a region of mixed subsistence and market economies. Arctic 52(1): 40-48.

Burkey, C. Jr., M. Coffing, D. B. Molyneaux, and P. Salomone. 2000 a. Kuskokwim River Chinook salmon stock status and development of management/action plan options, report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A00-40, Anchorage.

Burkey, C. Jr., M. Coffing, D. B. Molyneaux and P. Salomone. 2000 b. Kuskokwim River chum salmon stock status and development of management / action plan options, report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A00-41, Anchorage.

Burr, J. M. 2002. Middle Kuskokwim Chinook angler survey, 2000. Alaska Department of Fish and Game, Fishery Data Series No. 02-15, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds02-15.pdf

Cederholm, C. J., M. D. Kunze, T. Murota and A. Sibatani. 1999. Pacific salmon carcasses: essential contributions of nutrients and energy for aquatic and terrestrial ecosystems. Fisheries 24(10): 6-15.

Cederholm, C. J., D. H. Johnson, R. E. Bilby, L. G. Dominguez, A. M. Garrett, W. H. Graeber, E. L. Greda, M. D. Kunze, B. G. Marcot, J. F. Palmisano, W. G. Pearcy, C. A. Simenstad, and P. C. Trotter. 2000. Pacific salmon and wildlife–ecological contexts, relationships, and implications for management. Special Edition Technical Report, Prepared for D. H. Johnson and T. A. O'Neil (Managing Directors.). Wildlife-Habitat Relationships in Oregon and Washington. Washington Department of Fish and Wildlife, Olympia.

Chythlook, J. S. and M. J. Evenson. 2003. Assessment of Chinook, chum, and coho salmon escapements in the Holitna River drainage using radiotelemetry, 2002. Alaska Department of Fish and Game, Fishery Data Series No. 03-23, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds03-23.pdf

Coffing, M. 1991. Kwethluk subsistence: contemporary land use patterns, wild resource harvest and use, and the subsistence economy of a lower Kuskokwim River area community. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 157, Juneau.

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.

Coffing, M., L. Brown, G. Jennings, and C. Utermohle. 2001. The subsistence harvest and use of wild resources in Akiachak, Alaska, 1998. Alaska Department of Fish and Game, Division of Subsistence, Final Project Report to U.S. Fish and Wildlife Service, Office of Subsistence Management, FIS 00-009, Juneau.

Costello, D. J., S. E. Gilk, and D. B. Molyneaux. 2005. Takotna River salmon studies, 2004. Alaska Department of Fish and Game, Fishery Data Series No. 05-71, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds05-71.pdf

Costello, D. J., R. Stewart, D. B. Molyneaux, and D. E. Orabutt. 2006. Tatlawiksuk River salmon studies, 2005. Alaska Department of Fish and Game, Fishery Data Series No. 06-28, Anchorage. http://www.sf.adfg.state.ak.us/FedAidpdfs/fds06-28.pdf

DuBois, L. and D. B. Molyneaux. 2000. Salmon age, sex and length catalog for the Kuskokwim Area, 1999 progress report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A00-18, Anchorage.

Gilk, S. E. *Unpublished*. Kuskokwim River sockeye salmon radiotelemetry feasibility study, 2005. Located at: Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, Alaska.

REFERENCES CITED (Continued)

Groot, C. and L. Margolis, editors. 1991. Pacific salmon life histories. University of British Columbia Press, Vancouver, British Columbia.

Hauer, F. R. and W. R. Hill. 1996. Temperature, light and oxygen. Pages 93-106 in Methods in Stream Ecology. Academic Press, San Diego.

Holmes, R. A. and R. D. Burtkett. 1996. Salmon stewardship: Alaska's perspective. Fisheries 21(10): 36-38.

INPFC (International North Pacific Fisheries Commission). 1963. Annual report, 1961. International North Pacific Fisheries Commission, Vancouver, British Columbia.

Jasper, J. R. and D. B. Molyneaux. *In prep*. Kogrukluk River Salmon Studies, 2005. Alaska Department of Fish and Game, Division of Commercial Fisheries, Fishery Data Series, Anchorage.

Keefer, M. L., C. A. Peery, M. A. Jepson, K. R. Tolotti, and T. C. Bjornn. 2004. Stock-specific migration timing of adult spring-summer Chinook salmon in the Columbia River basin. North American Journal of Fisheries Management 24:1145-1162.

Kerkvliet, C. M., T. Hamazaki, K. E. Hyer, and D. Cannon. 2003. A mark–recapture experiment to estimate the abundance of Kuskokwim River chum, sockeye, and coho salmon, 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A03-25, Anchorage.

Kerkvliet, C. M., J. Pawluk, T. Hamazaki, K. E. Hyer, and D. Cannon. 2004. A mark–recapture experiment to estimate the abundance of Kuskokwim River chum, sockeye and coho salmon, 2003. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A04-14, Anchorage.

Kruse, G. H. 1998. Salmon run failures in 1997-1998: a link to anomalous ocean conditions? Alaska Fishery Research Bulletin 5(1): 55-63.

Linderman, J. C. Jr., D. B. Molyneaux, L. DuBois and W. Morgan. 2002. Tatlawiksuk River weir salmon studies, 1998–2001. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A02-11, Anchorage.

Linderman, J. C. Jr., D. B. Molyneaux, L. DuBois and D. J. Cannon. 2003. George River salmon studies, 1996 to 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A03-17, Anchorage.

Linderman, J. C., M. Martz, D. G. Bue, and R. L. Fisher. *In prep*. Annual management report for the subsistence and commercial fisheries of the Kuskokwim Area, 2005. Alaska Department of Fish and Game, Fishery Management Report, Anchorage.

McEwen, M. S. *In prep*. Sonar estimation of chum salmon passage in the Aniak River, 2005. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Molyneaux, D. B and D. Folletti. 2005. Salmon age, sex, and length catalog for the Kuskokwim Area, 2004. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A05-03, Anchorage.

Mundy, P. R. 1998. Principles and criteria for sustainable salmon management, a contribution to the development of a salmon fishery evaluation framework for the State of Alaska. Alaska Department of Fish and Game, Contract No. IHP-98-045, Anchorage.

NRC (National Research Council). 1996. Upstream: salmon and society in the Pacific Northwest, Committee on the Protection and Management of Pacific Northwest Salmonids. National Academy Press, Washington, D.C.

Pawluk, J., T. Hamazaki, K. E. Hyer, and D. Cannon. *In prep* a. Kuskokwim River sockeye, chum, and coho salmon tagging study, 2004. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Pawluk, J., J. Baumer, T. Hamazaki, and D. Orabutt. *In prep* b. A mark-recapture experiment of Kuskokwim River Chinook, sockeye, chum, and coho salmon, 2005. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

REFERENCES CITED (Continued)

Quinn, T. P. 2005. The behavior and ecology of Pacific salmon and trout. University of Washington Press, Seattle.

Rantz, S. E. and others 1982. Measurements and computation of streamflow: volume 1, measurements of stage and discharge. U.S. Geological Survey. Geological Survey Water-supply Paper 2175. Washington, D.C.: U.S. Government Printing Office.

Roettiger, T., F. G. Harris, and K. C. Harper. 2004. Abundance and run timing of adult Pacific salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2003. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series Number 2004-8, Kenai, Alaska

Schwanke, C. J., D. B. Molyneaux, L. DuBois, and C. Goods. 2001. Takotna River salmon studies and upper Kuskokwim River aerial surveys, 2000. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A01-02, Anchorage.

Stewart, R. 2002. Resistance board weir panel construction manual, 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A02-21, Anchorage.

Stewart, R. 2003. Techniques for installing a resistance board fish weir. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A03-26, Anchorage.

Stewart, R., D. B. Molyneaux, and D. Orabutt. 2005. George River salmon studies, 2004. Alaska Department of Fish and Game, Fishery Data Series No. 05-72, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds05-72.pdf

Stuby, L. 2003. Inriver abundance of Chinook salmon in the Kuskokwim River, 2002. Annual Report for Study 02-015, USFWS Office of Subsistence Management, Fishery Information Service Division. Alaska Department of Fish and Game, Fishery Data Series No. 03-22, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds03-22.pdf

Stuby, L. 2004. Inriver abundance of Chinook salmon in the Kuskokwim River, 2003. Alaska Department of Fish and Game, Fishery Data Series No. 04-30, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds04-30.pdf

Stuby, L. 2005. Inriver abundance of Chinook salmon in the Kuskokwim River, 2002-2004. Alaska Department of Fish and Game, Fishery Data Series No. 05-39, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/Fds05-39.pdf

Stuby, L. *In prep*. Inriver abundance of Chinook salmon in the Kuskokwim River, 2005. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Templin, W. D., C. T. Smith, D. B. Molyneaux, and L. W. Seeb. *In prep*. Genetic stock identification of Kuskokwim River Chinook salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report, Anchorage.

Tobin, J. H. 1994. Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Technical Report Number 22, Kenai, Alaska.

Ward, T. C., M. Coffing, J. L. Estensen, R. L. Fisher, and D. B. Molyneaux. 2003. Annual management report for the subsistence and commercial fisheries of the Kuskokwim Area, 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A03-27, Anchorage.

Whitmore, C., M. M. Martz, D. G. Bue, J. C. Linderman, and R. L. Fisher. 2005. Annual management report for the subsistence and commercial fisheries of the Kuskokwim Area, 2003. Alaska Department of Fish and Game, Fishery Management Report No. 05-72, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fmr05-72.pdf

Zabkar, L. M., F. G. Harris, and K. C. Harper. *In prep*. Abundance and run timing of adult Pacific salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 2005. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office. Alaska Fisheries Data Series, Kenai, Alaska.

TABLES AND FIGURES

Table 1.–Daily, daily cumulative, and daily cumulative percent passage for Chinook, chum, and coho salmon at George River weir with the median passage date and central 50% of the run, 2005.

	Chinook Salmon			Chum Salmon			Coho Salmon		
Date	Daily	Cumulative	%	Daily	Cumulative	%	Daily	Cumulative	%
6/15	6	6	0	5	5	0	0	0	0
6/16	3	9	0	1	6	0	0	0	0
6/17	14	23	1	7	13	0	0	0	0
6/18	12	35	1	4	17	0	0	0	0
6/19	4	39	1	15	32	0	0	0	0
6/20	6	45	1	2	34	0	0	0	0
6/21	3	48	1	8	42	0	0	0	0
6/22	56	104	3	18	60	0	0	0	0
6/23	21	125	3	15	75	1	0	0	0
6/24	106	231	6	59	134	1	0	0	0
6/25	72	303	8	35	169	1	0	0	0
6/26	60	363	9	23	192	1	0	0	0
6/27	143	506	13	65	257	2	0	0	0
6/28	114	620	16	61	318	2	0	0	0
6/29	392	1,012	26	270	588	4	0	0	0
6/30	202	1,214	32	228	816	6	0	0	0
7/1	108	1,322	34	151	967	7	0	0	0
7/2	122	1,444	38	340	1,307	9	0	0	0
7/3	404	1,848	48	719	2,026	14	0	0	0
7/4	336	2,184	57	436	2,462	17	0	0	0
7/5	202	2,386	62	350	2,812	19	0	0	0
7/6	92	2,478	64	440	3,252	22	0	0	0
7/7	140	2,618	68	368	3,620	24	0	0	0
7/8	61	2,679	70	508	4,128	28	0	0	0
7/9	102	2,781	72	430	4,558	31	0	0	0
7/10	61	2,842	74	518	5,076	34	0	0	0
7/11	111	2,953	77	459	5,535	37	0	0	0
7/12	108	3,061	80	755	6,290	42	0	0	0
7/13	77	3,138	82	597	6,887	46	0	0	0
7/14	52	3,190	83	733	7,620	51	0	0	0
7/15	86	3,276	85	478	8,098	55	0	0	0
7/16	61	3,337	87	501	8,599	58	0	0	0
7/17	83	3,420	89	497	9,096	61	0	0	0
7/18	43	3,463	90	240	9,336	63	0	0	0
7/19	25	3,488	91	274	9,610	65	0	0	0
7/20	41	3,529	92	512	10,122	68	0	0	0
7/21	23	3,552	92	527	10,649	72	0	0	0
7/22	26	3,578	93	347	10,996	74	0	0	0
7/23	27	3,605	94	362	11,358	77	0	0	0
7/24	31 a	3,636	95	293 a	11,651	79	3 a	3	0
7/25	36	3,672	96	206	11,857	80	0	3	0
7/26	6	3,678	96	257	12,114	82	10	13	0
7/27	22	3,700	96	226	12,340	83	8	21	0
7/28	19	3,719	97	210	12,550	85	5	26	0
7/29	15	3,734	97	157	12,707	86	8	34	0
7/30	14	3,748	97	163	12,870	87	7	41	1

-continued-

Table 1.–Page 2 of 3.

	Chinook Salmon			Chum Salmon			Coho Salmon		
Date	Daily	Cumulative	%	Daily	Cumulative	%	Daily	Cumulative	%
7/31	6	3,754	98	161	13,031	88	6	47	1
8/1	9	3,763	98	150	13,181	89	10	57	1
8/2	7	3,770	98	159	13,340	90	17	74	1
8/3	6	3,776	98	106	13,446	91	13	87	1
8/4	7	3,783	98	130	13,576	92	7	94	1
8/5	7	3,790	99	94	13,670	92	18	112	1
8/6	2	3,792	99	83	13,753	93	19	131	2
8/7	5	3,797	99	99	13,852	93	22	153	2
8/8	10	3,807	99	147	13,999	94	199	352	4
8/9	0	3,807	99	20	14,019	95	72	424	5
8/10	7	3,814	99	39	14,058	95	161	585	7
8/11	2	3,816	99	32	14,090	95	25	610	7
8/12	2	3,818	99	50	14,140	95	127	737	9
8/13	2	3,820	99	65	14,205	96	178	915	11
8/14	14	3,834	100	81	14,286	96	272	1,187	14
8/15	1	3,835	100	41	14,327	97	108	1,295	16
8/16	0	3,835	100	18	14,345	97	68	1,363	17
8/17	0	3,835	100	52	14,397	97	376	1,739	21
8/18	1	3,836	100	14	14,411	97	63	1,802	22
8/19	1	3,837	100	13	14,424	97	53	1,855	23
8/20	0	3,837	100	14	14,438	97	25	1,880	23
8/21	0	3,837	100	21	14,459	98	76	1,956	24
8/22	0	3,837	100	8	14,467	98	27	1,983	24
8/23	0	3,837	100	13	14,480	98	708	2,691	33
8/24	0	3,837	100	7	14,487	98	46	2,737	33
8/25	0	3,837	100	6	14,493	98	155	2,892	35
8/26	2	3,839	100	27	14,520	98	176	3,068	37
8/27	1	3,840	100	25	14,545	98	49	3,117	38
8/28	1	3,841	100	25	14,570	98	184	3,301	40
8/29	1	3,842	100	17	14,587	98	150	3,451	42
8/30	1	3,843	100	29	14,616	99	393	3,844	47
8/31	0	3,843	100	17	14,633	99	321	4,165	51
9/1	0	3,843	100	18	14,651	99	51	4,216	51
9/2	0	3,843	100	13	14,664	99	2	4,218	51
9/3	0	3,843	100	19	14,683	99	36	4,254	52
9/4	0	3,843	100	19	14,702	99	536	4,790	58
9/5	0	3,843	100	13	14,715	99	292	5,082	62
9/6	0	3,843	100	20	14,735	99	941	6,023	73
9/7	0	3,843	100	5	14,740	99	576	6,599	80
9/8	0	3,843	100	10	14,750	99	223	6,822	83
9/9	1	3,844	100	19	14,769	100	469	7,291	89
9/10	0	3,844	100	15	14,784	100	280	7,571	92
9/11	0	3,844	100	13	14,797	100	71	7,642	93
9/12	0	3,844	100	4	14,801	100	151	7,793	95
9/13	0	3,844	100	1	14,802	100	83	7,876	96
9/14	0	3,844	100	11	14,813	100	67	7,943	97
9/15	0	3,844	100	10	14,823	100	156	8,099	99

-continued-

Table 1.–Page 3 of 3.

	Chinook Salmon			Chum Salmon			Coho Salmon		
Date	Daily	Cumulative	%	Daily	Cumulative	%	Daily	Cumulative	%
9/16	0	3,844	100	2	14,825	100	64	8,163	100
9/17	1	3,845	100	1	14,826	100	19	8,182	100
9/18	0	3,845	100	0	14,826	100	9	8,191	100
9/19	0	3,845	100	0	14,826	100	3	8,194	100
9/20	0 [b]	3,845	100	2 [b]	14,828	100	6 [b]	8,200	100

Note: The boxes represent the median passage date and central 50% of the run.

[a] Daily passage was estimated due to the occurrence of a hole in the weir.

[b] Partial day count, missed passage assumed to be zero.

Table 2.–Age and sex composition of the Chinook salmon escapement at the George River weir, 2005.

Sample and	Sample		Age 1.2		Age 1.3		Age 1.4		Age 2.3		Age 1.5		Age 2.4		Total	
(Stratum) Dates	Size	Sex	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%
6/24-29	153	M	151	12.4	611	50.3	206	17.0	0	0.0	0	0.0	0	0.0	968	79.7
(6/15-30)		F	0	0.0	87	7.2	143	11.8	8	0.7	8	0.7	0	0.0	246	20.3
		Subtotal[a]	151	12.4	698	57.5	349	28.8	8	0.7	8	0.7	0	0.0	1,214	100.0
7/1-3,6,9-13	165	M	198	10.3	560	29.1	373	19.4	12	0.6	35	1.8	12	0.6	1,189	61.8
(7/1-13)		F	24	1.2	163	8.5	490	25.4	11	0.6	47	2.4	0	0.0	735	38.2
		Subtotal[a]	222	11.5	723	37.6	863	44.8	23	1.2	82	4.2	12	0.6	1,924	100.0
7/15-17,22-23,25,	153	M	37	5.2	143	20.3	111	15.7	0	0.0	23	3.3	0	0.0	314	44.4
27,29,31,8/1-2		F	0	0.0	125	17.6	240	34.0	14	2.0	14	1.9	0	0.0	393	55.6
(7/14-9/20)		Subtotal[a]	37	5.2	268	37.9	351	49.7	14	2.0	37	5.2	0	0.0	707	100.0
Season[b]	471	M	386	10.0	1,314	34.2	690	18.0	12	0.3	58	1.5	12	0.3	2,472	64.3
		F	23	0.6	375	9.7	873	22.7	33	0.9	69	1.8	0	0.0	1,373	35.7
		Total	409	10.6	1,689	43.9	1,563	40.7	45	1.2	127	3.3	12	0.3	3,845	100.0

[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 escapement that occurred in each strata.

Table 3.–Mean length (mm) composition of the Chinook salmon escapement at the George River weir, 2005.

Sample and (Stratum) Dates	Sex		Age Class 1.2	1.3	1.4	2.3	1.5	2.4
6/24-29	M	Mean Length	559	711	806			
(6/15-30)		SE	13	7	13			
		Range	420- 625	579- 907	700- 960			
		Sample Size	19	77	26	0	0	0
	F	Mean Length		764	823	829	910	
		SE		11	8	-	-	
		Range		720- 822	767- 884	829- 829	910- 910	
		Sample Size	0	11	18	1	1	0
7/1-3,6,9-13	M	Mean Length	541	708	836	715	828	897
(7/1-13)		SE	10	9	12	715- 715	16	-
		Range	466- 606	541- 901	697-1015	1	805- 858	897- 897
		Sample Size	17	48	32		3	1
	F	Mean Length	606	757	844	789	821	
		SE	21	14	8	789- 789	42	
		Range	585- 626	629- 842	735- 980	1	720- 905	
		Sample Size	2	14	42		4	0
7/15-17,22-23,25,	M	Mean Length	492	709	859		836	
27,29,31,8/1-2		SE	26	12	15		43	
(7/14-9/20)		Range	404- 627	572- 883	725- 990		729- 928	
		Sample Size	8	31	24	0	5	0
	F	Mean Length		753	825	786	888	
		SE		10	7	30	50	
		Range		595- 855	725- 970	754- 846	834- 987	
		Sample Size	0	27	52	3	3	0
Season[a,b]	M	Mean Length	543	710	831	715	831	897
		Range	404- 627	541- 907	697-1015	715- 715	729- 928	897- 897
		Sample Size	44	156	82	1	8	1
	F	Mean Length	606	757	835	797	845	
		Range	585- 626	595- 855	725- 980	754- 846	720- 987	
		Sample Size	2	52	112	5	8	0

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

[b] "Season" mean lengths are simple averages of number of fish sampled.

Table 4.–Age and sex composition of the chum salmon escapement at the George River weir, 2005.

Sample and	Sample		Age 0.2		Age 0.3		Age 0.4		Age 0.5		Total	
(Stratum) Dates	Size	Sex	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%
7/1-3,6,8	199	M	23	0.5	2,245	49.2	183	4.0	23	0.5	2,474	54.3
(6/15-7/9)		F	92	2.0	1,832	40.2	138	3.0	23	0.5	2,084	45.7
		Subtotal[a]	115	2.5	4,077	89.4	321	7.0	46	1.0	4,558	100.0
7/11-13	195	M	42	1.1	2,280	56.4	124	3.1	21	0.5	2,466	61.0
(7/10-16)		F	41	1.0	1,533	38.0	0	0.0	0	0.0	1,575	39.0
		Subtotal[a]	83	2.1	3,813	94.4	124	3.1	21	0.5	4,041	100.0
7/18-20	186	M	65	2.7	1,263	52.7	103	4.3	0	0.0	1,430	59.7
(7/17-22)		F	90	3.8	850	35.5	13	0.5	13	0.5	967	40.3
		Subtotal[a]	155	6.5	2,113	88.2	116	4.8	13	0.5	2,397	100.0
7/25-27	167	M	46	3.0	530	34.1	10	0.6	0	0.0	586	37.7
(7/23-28)		F	177	11.4	754	48.5	37	2.4	0	0.0	968	62.3
		Subtotal[a]	223	14.4	1,284	82.6	47	3.0	0	0.0	1,554	100.0
7/29-8/2	179	M	27	1.7	622	39.1	44	2.8	9	0.6	702	44.1
(7/29-8/12)		F	106	6.7	781	49.2	0	0.0	0	0.0	888	55.9
		Subtotal[a]	133	8.4	1,403	88.3	44	2.8	9	0.6	1,590	100.0
8/29-9/1,4	59	M	0	0.0	222	32.2	12	1.7	0	0.0	233	33.9
(8/13-9/20)		F	58	8.5	396	57.6	0	0.0	0	0.0	455	66.1
		Subtotal[a]	58	8.5	618	89.8	12	1.7	0	0.0	688	100.0
Season[b]	985	M	202	1.4	7,161	48.3	476	3.2	52	0.4	7,891	53.2
		F	565	3.8	6,148	41.5	188	1.3	36	0.2	6,937	46.8
		Total	767	5.2	13,309	89.8	664	4.5	88	0.6	14,828	100.0

[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 escapement that occurred in each strata.

Table 5.–Mean length (mm) composition of the chum salmon escapement at George River weir, 2005.

Sample and (Stratum) Dates	Sex		Age Class 0.2	0.3	0.4	0.5
7/1-3,6,8	M	Mean Length	553	567	593	575
(6/15-7/9)		SE	-	3	12	-
		Range	553- 553	498- 645	539- 646	575- 575
		Sample Size	1	98	8	1
	F	Mean Length	514	534	528	570
		SE	9	4	10	-
		Range	493- 530	450- 595	500- 559	570- 570
		Sample Size	4	80	6	1
7/11-13	M	Mean Length	565	556	568	580
(7/10-16)		SE	15	3	13	-
		Range	550- 580	460- 622	515- 615	580- 580
		Sample Size	2	110	6	1
	F	Mean Length	530	521		
		SE	45	3		
		Range	485- 575	435- 580		
		Sample Size	2	74	0	0
7/18-20	M	Mean Length	508	558	604	
(7/17-22)		SE	5	4	11	
		Range	497- 524	427- 660	554- 642	
		Sample Size	5	98	8	0
	F	Mean Length	510	522	490	512
		SE	7	4	-	-
		Range	488- 546	419- 577	490- 490	512- 512
		Sample Size	7	66	1	1
7/25-27	M	Mean Length	480	535	485	
(7/23-28)		SE	8	4	-	
		Range	455- 500	486- 606	485- 485	
		Sample Size	5	57	1	0
	F	Mean Length	490	504	502	
		SE	5	3	15	
		Range	456- 536	447- 592	472- 532	
		Sample Size	19	81	4	0
7/29-8/2	M	Mean Length	470	540	554	537
(7/29-8/12)		SE	15	4	11	-
		Range	455- 500	420- 600	520- 590	537- 537
		Sample Size	3	70	5	1
	F	Mean Length	493	512		
		SE	6	4		
		Range	462- 540	416- 595		
		Sample Size	12	88	0	0

-continued-

Table 5.–Page 2 of 2.

Sample and (Stratum) Dates	Sex		Age Class 0.2	0.3	0.4	0.5
8/29-9/1,4	M	Mean Length		542	560	
(8/13-9/20)		SE		9	-	
		Range		486- 626	560- 560	
		Sample Size	0	19	1	0
	F	Mean Length	480	524		
		SE	12	4		
		Range	442- 513	456- 569		
		Sample Size	5	34	0	0
Season[a,b]	M	Mean Length	513	557	582	571
		Range	455- 580	420- 660	485- 646	537- 580
		Sample Size	16	452	29	3
	F	Mean Length	499	522	520	549
		Range	442- 575	416- 595	472- 559	512- 570
		Sample Size	49	423	11	2

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

[b] "Season" mean lengths are simple averages of number of fish sampled.

Table 6.–Age and sex composition of the coho salmon escapement at George River weir, 2005.

Sample and	Sample		Age 1.1		Age 2.1		Age 3.1		Total	
(Stratum) Dates	Size	Sex	Esc.	%	Esc.	%	Esc.	%	Esc.	%
8/14-19,21,23	158	M	34	1.3	1,226	45.6	238	8.9	1,499	55.7
(6/15-8/23)		F	0	0.0	903	33.5	290	10.7	1,192	44.3
		Subtotal[a]	34	1.3	2,129	79.1	528	19.6	2,691	100.0
8/24-29	154	M	0	0.0	783	51.3	109	7.1	892	58.4
(8/24-9/2)		F	20	1.3	476	31.2	139	9.1	635	41.6
		Subtotal[a]	20	1.3	1,259	82.5	248	16.2	1,527	100.0
9/4-6	151	M	26	0.7	1,530	38.4	264	6.6	1,820	45.7
(9/3-20)		F	0	0.0	1,661	41.7	501	12.6	2,162	54.3
		Subtotal[a]	26	0.7	3,191	80.1	765	19.2	3,982	100.0
Season[b]	463	M	60	0.7	3,539	43.1	611	7.5	4,211	51.4
		F	20	0.3	3,040	37.1	930	11.3	3,989	48.6
		Total	80	1.0	6,579	80.2	1,541	18.8	8,200	100.0

[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 escapement that occurred in each strata.

Table 7.–Mean length (mm) composition of the coho salmon escapement at George River weir, 2005.

Sample and (Stratum) Dates	Sex		Age Class 1.1	2.1	3.1
8/14-19,21,23 (6/15-8/23)	M	Mean Length	435	512	540
		SE	15	7	18
		Range	420- 450	400- 630	410- 630
		Sample Size	2	72	14
	F	Mean Length		548	551
		SE		4	12
		Range		470- 625	448- 625
		Sample Size	0	53	17
8/24-29 (8/24-9/2)	M	Mean Length		541	539
		SE		6	19
		Range		410- 642	410- 615
		Sample Size	0	79	11
	F	Mean Length	508	546	535
		SE	13	6	10
		Range	495- 520	455- 616	474- 604
		Sample Size	2	48	14
9/4-6 (9/3-20)	M	Mean Length	468	543	493
		SE	-	6	17
		Range	468- 468	420- 642	405- 569
		Sample Size	1	58	10
	F	Mean Length		552	558
		SE		6	9
		Range		335- 614	485- 612
		Sample Size	0	63	19
Season[a,b]	M	Mean Length	449	532	520
		Range	420- 468	400- 642	405- 630
		Sample Size	3	209	35
	F	Mean Length	508	550	552
		Range	495- 520	335- 625	448- 625
		Sample Size	2	164	50

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

[b] "Season" mean lengths are simple averages of number of fish sampled.

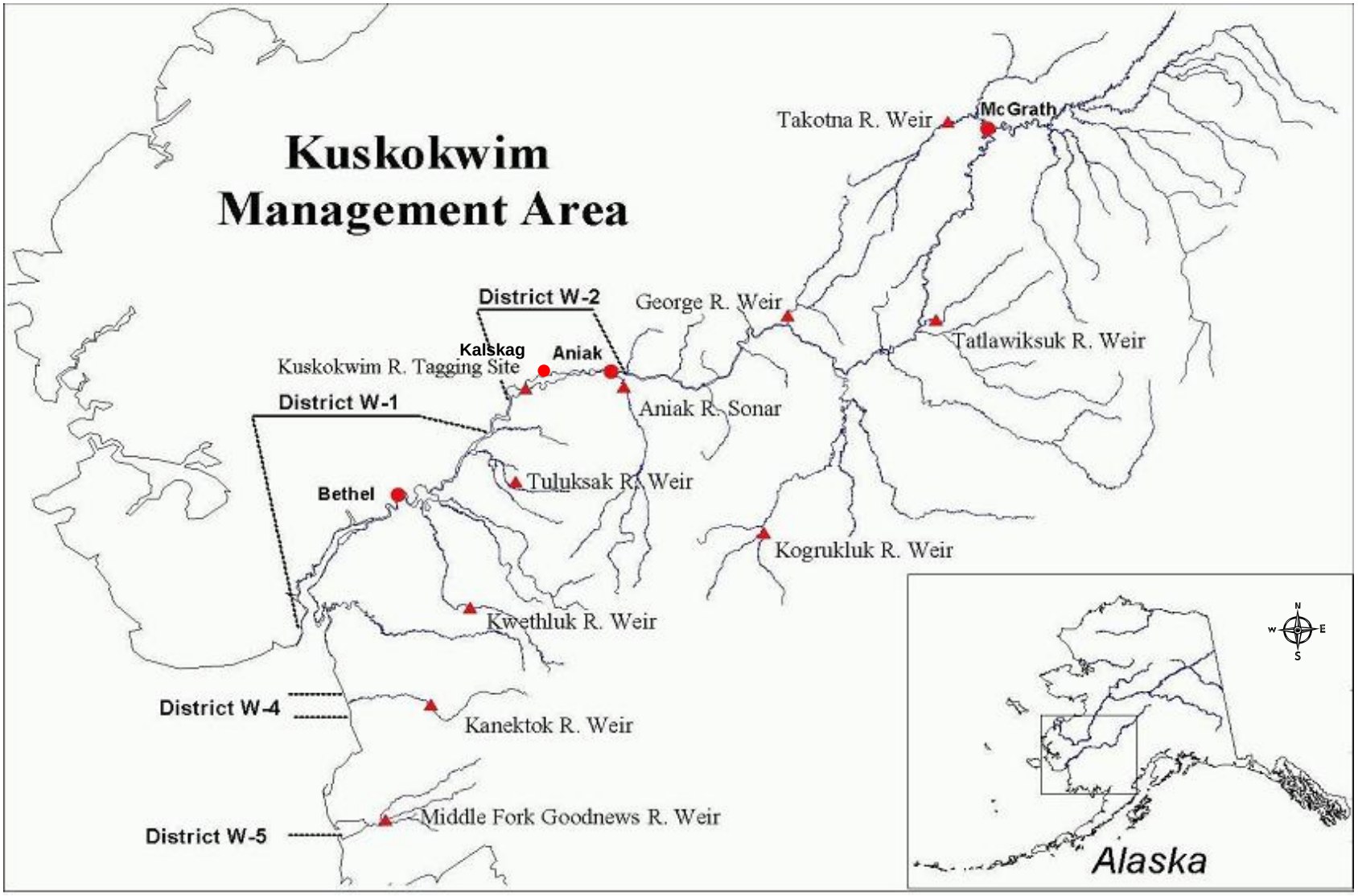


Figure 1.–Kuskokwim Area salmon management districts and escapement monitoring projects.

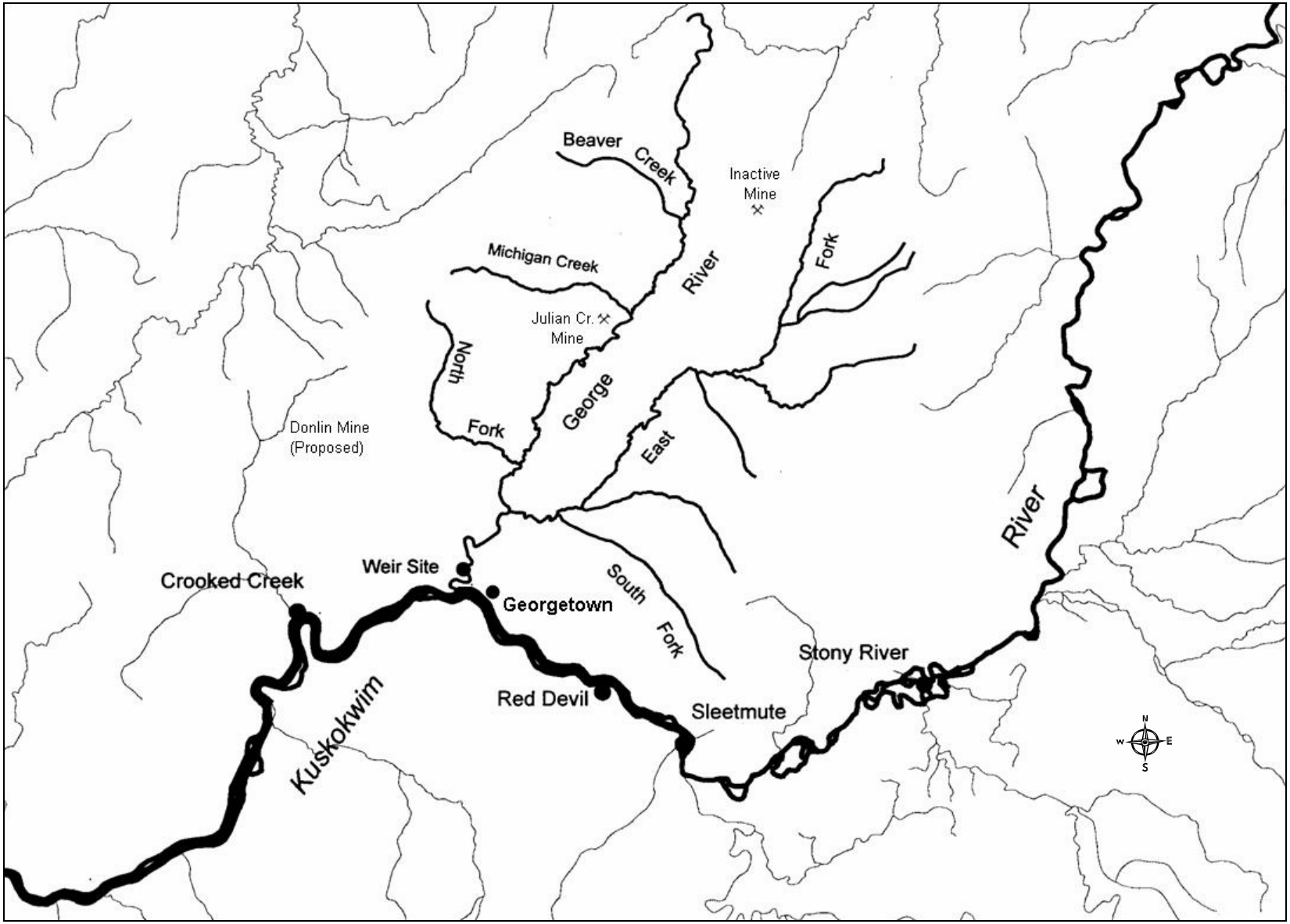
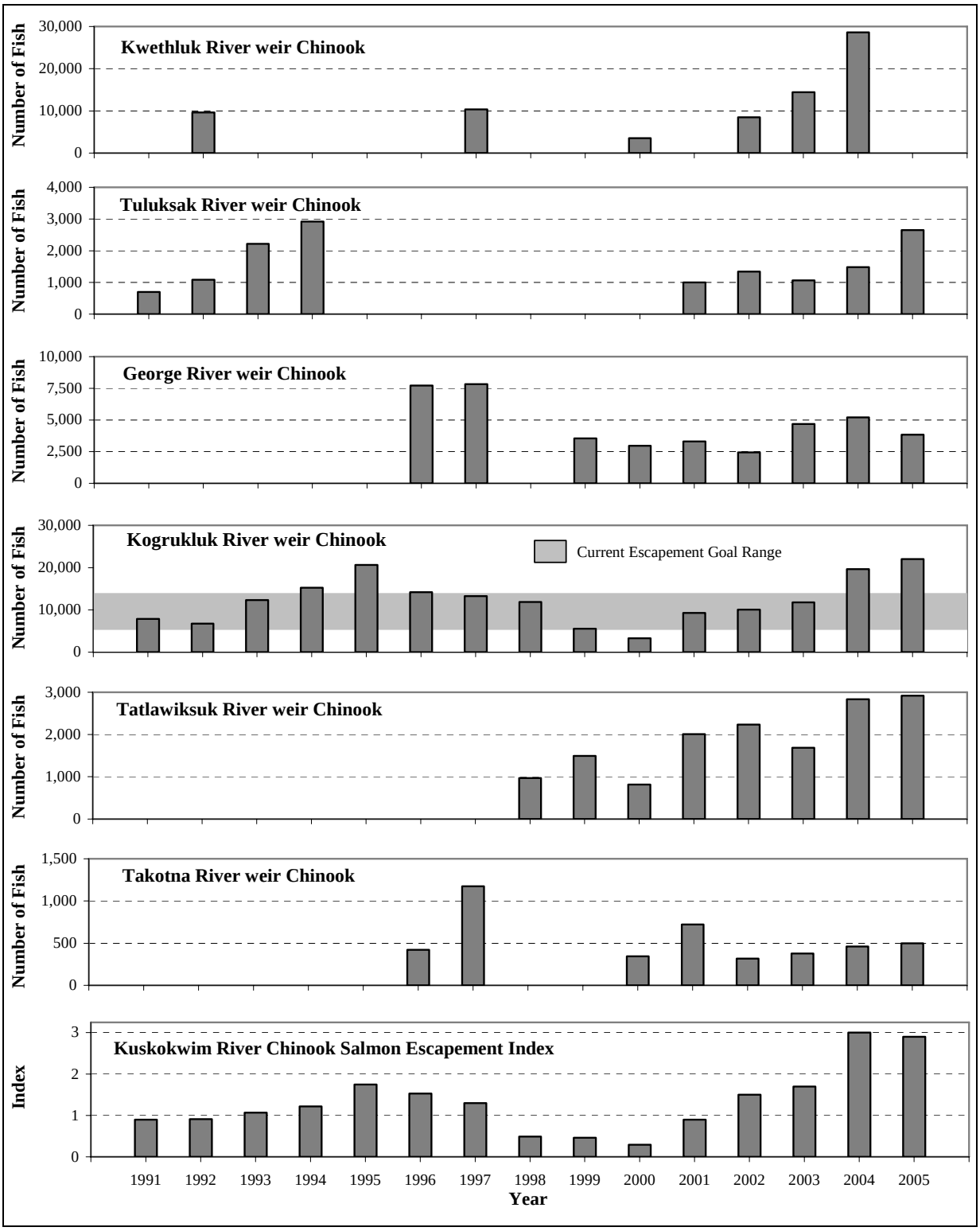
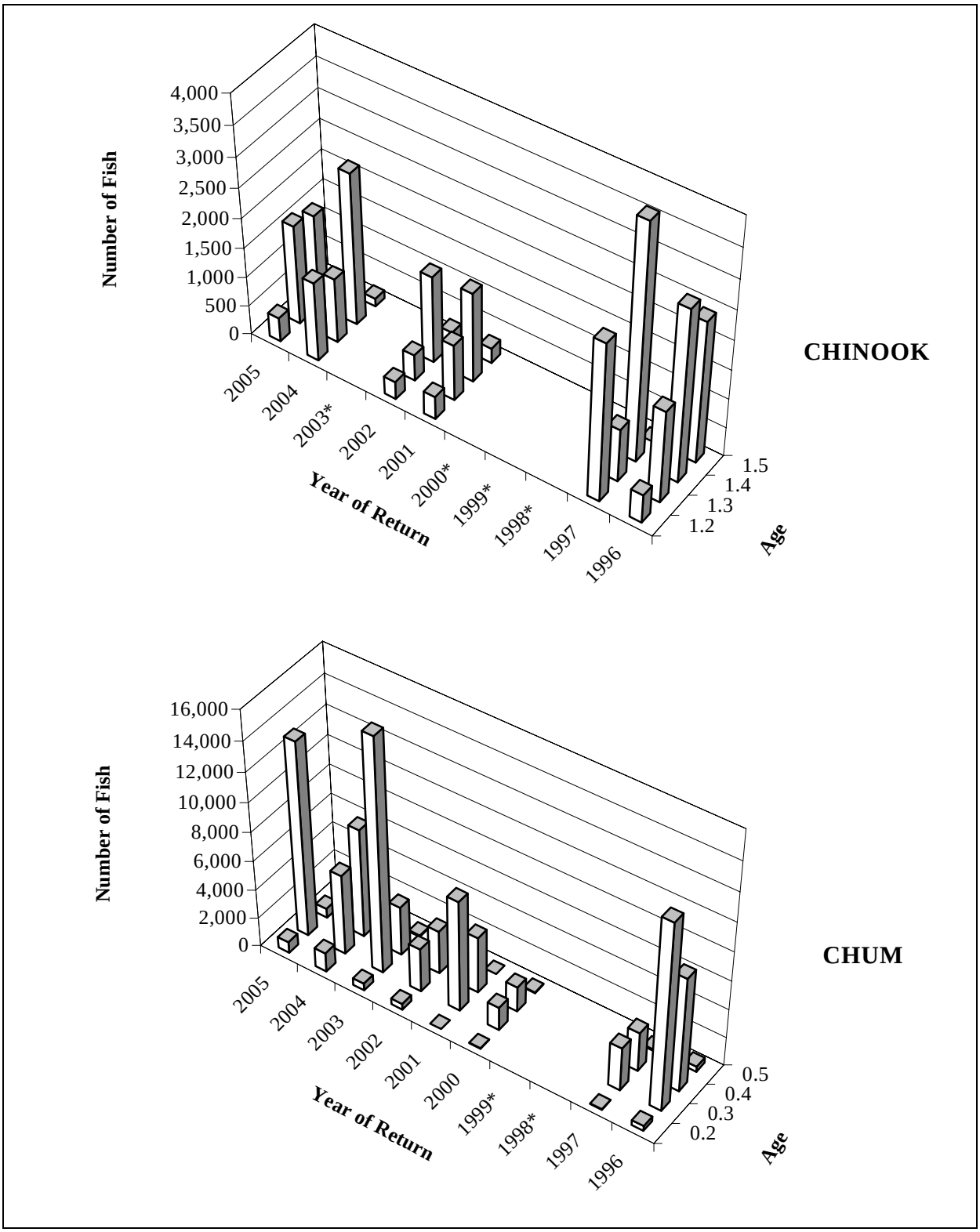


Figure 2.–George River, middle Kuskokwim River basin.



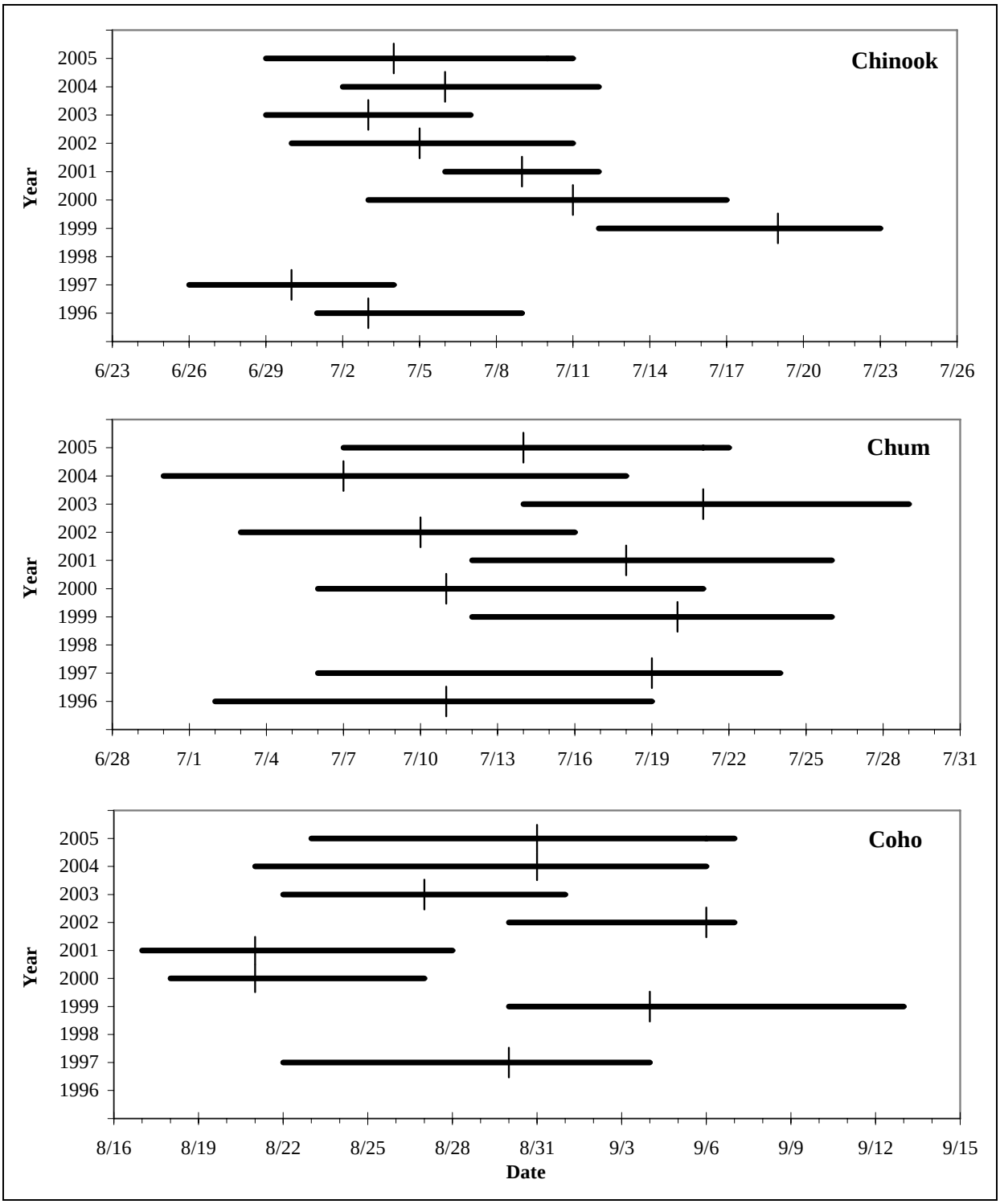
Source: Linderman et al. *In prep*.

Figure 3.–Historical Chinook salmon escapement into six Kuskokwim River tributaries, and the Kuskokwim River Chinook salmon escapement indices, 1991–2005.



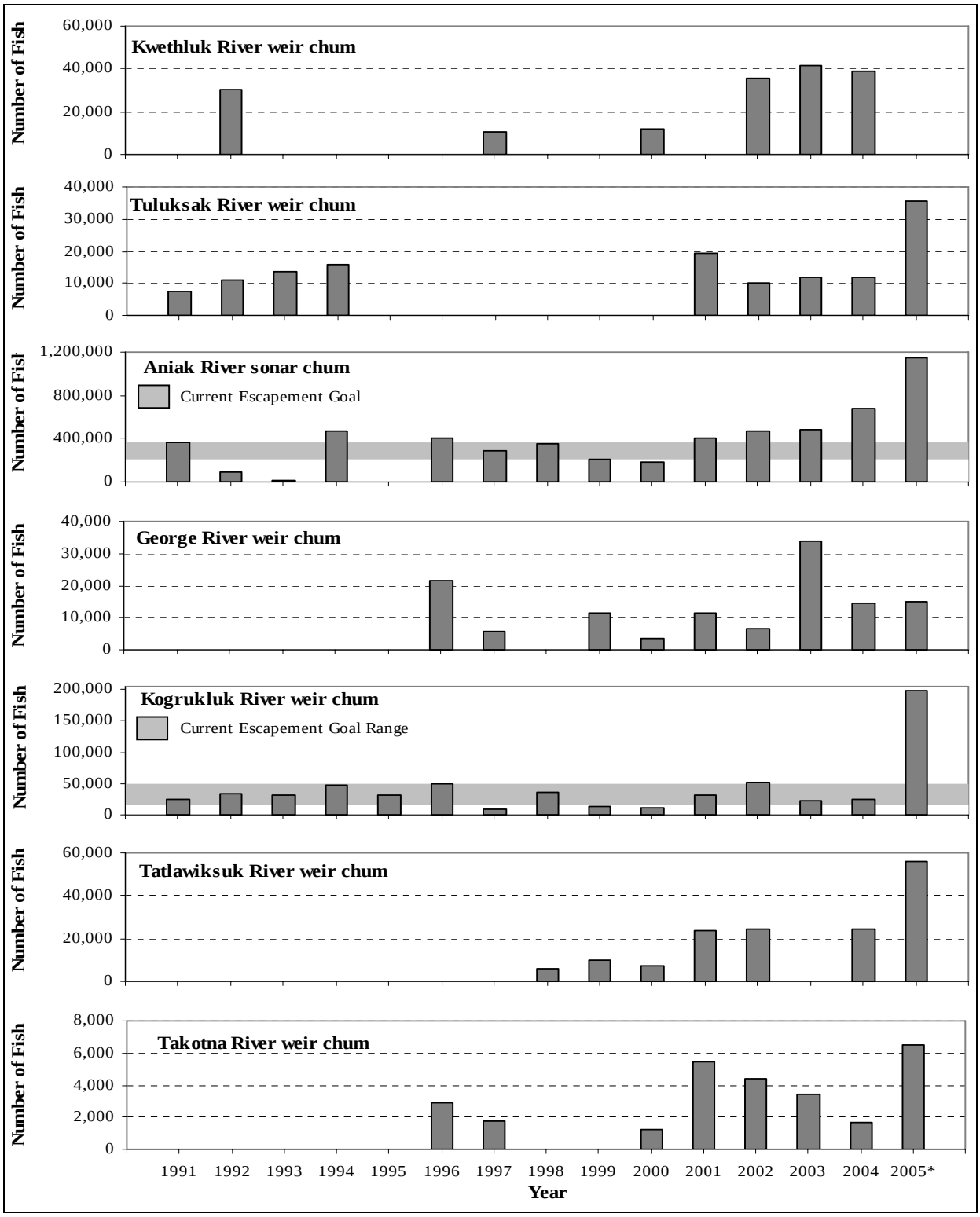
Source: Molyneaux and Folletti 2005.
Note: An asterisk (*) denotes years with incomplete sampling or escapement estimates.

Figure 4.–Historical age distribution of annual Chinook and chum salmon escapements at George River weir.



Note: Solid lines represent central 50% of the run; cross-bars represent the median passage date.

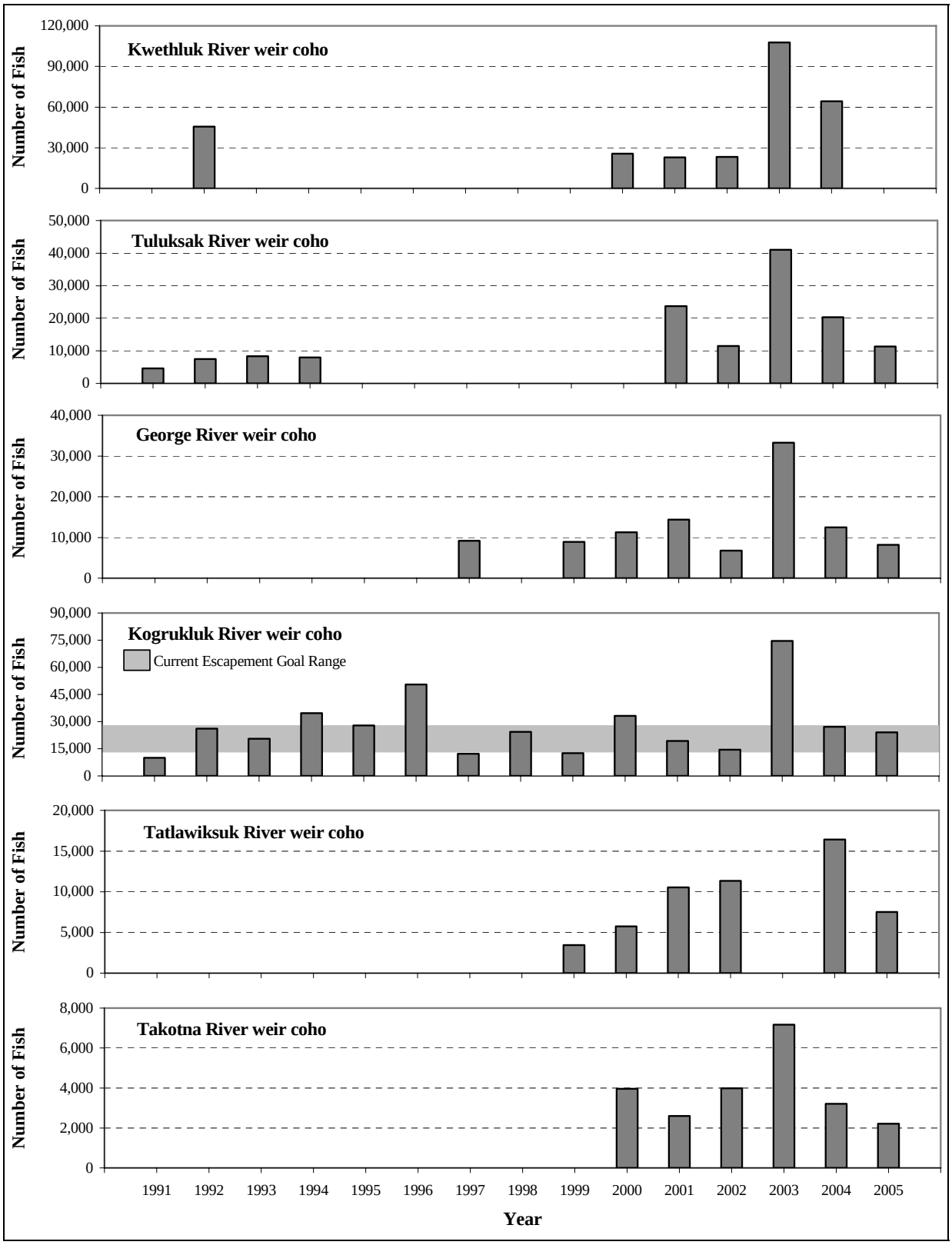
Figure 5.–Historical annual run timing of Chinook, chum, and coho salmon based on cumulative percent passage at George River weir.



Source: Linderman et al. *In prep*.

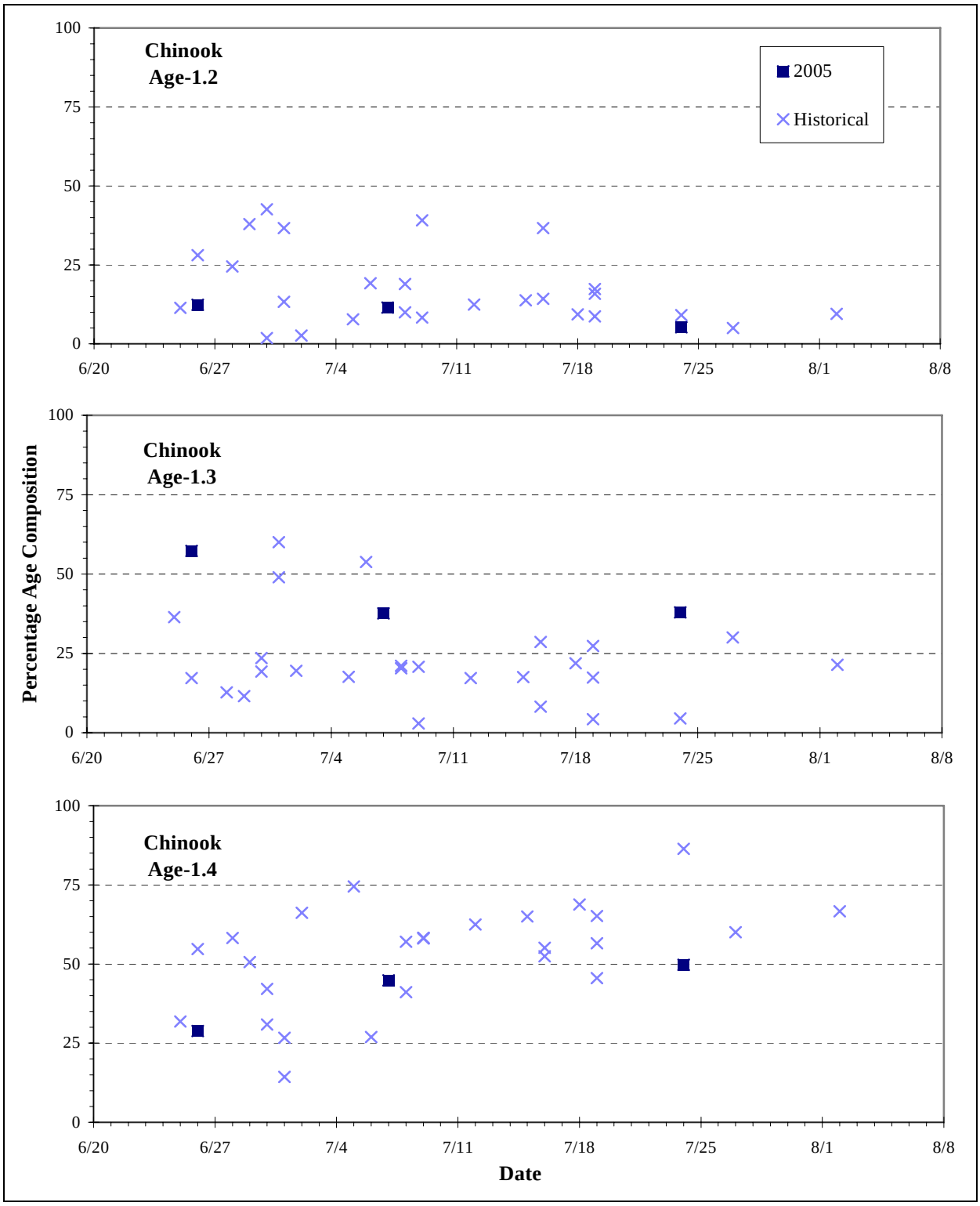
Note: Aniak River sonar has utilized several different sonar systems since the project began. In 2005 historical escapement values were adjusted to be congruous between the systems. Therefore, the values published in this report may vary slightly from those published in previous years or in other reports.

Figure 6.–Historical chum salmon escapements into seven Kuskokwim River tributaries, 1991–2005.



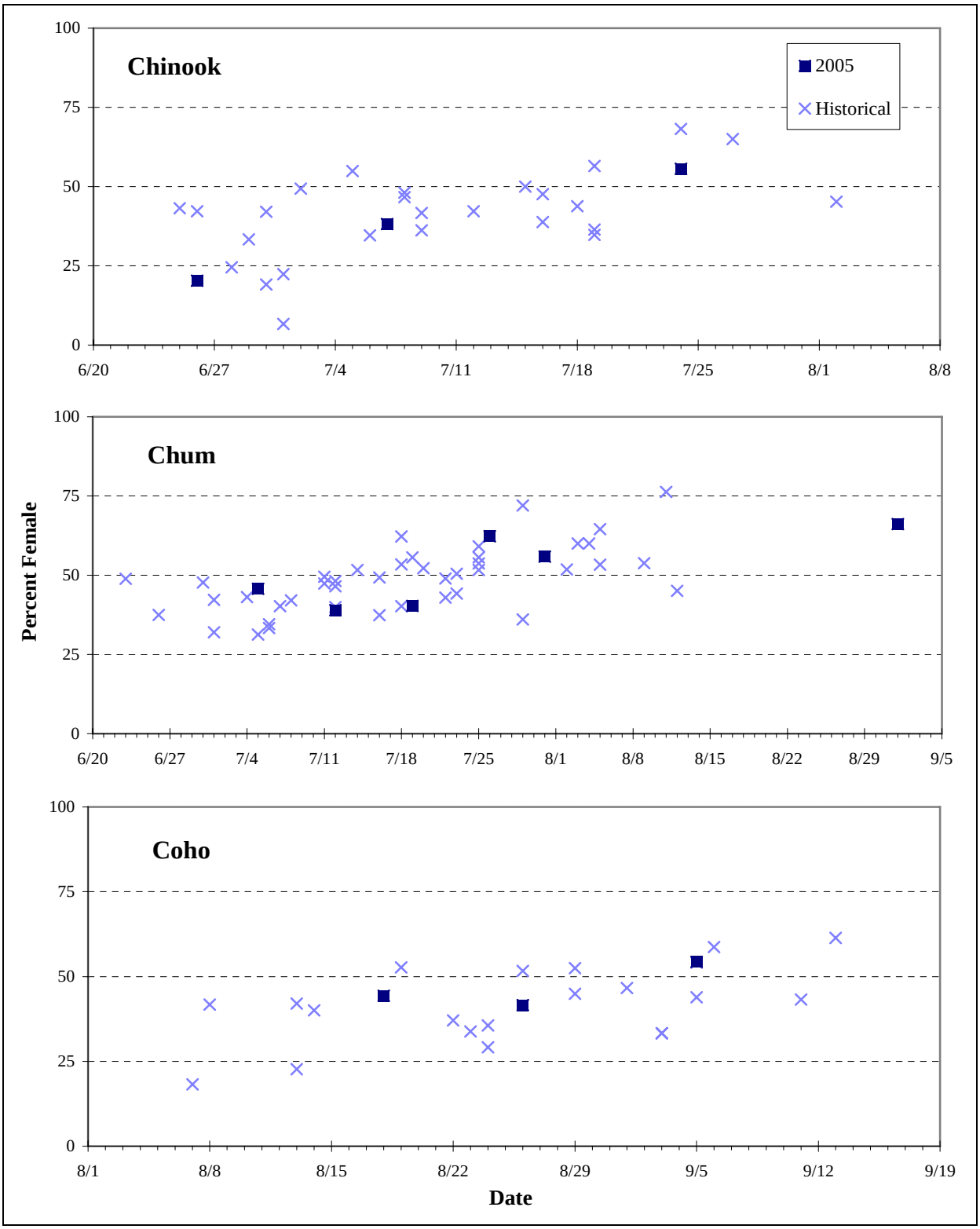
Source: Linderman et al. *In prep*.

Figure 7.–Historical coho salmon escapement into six Kuskokwim River tributaries, 1991–2005.



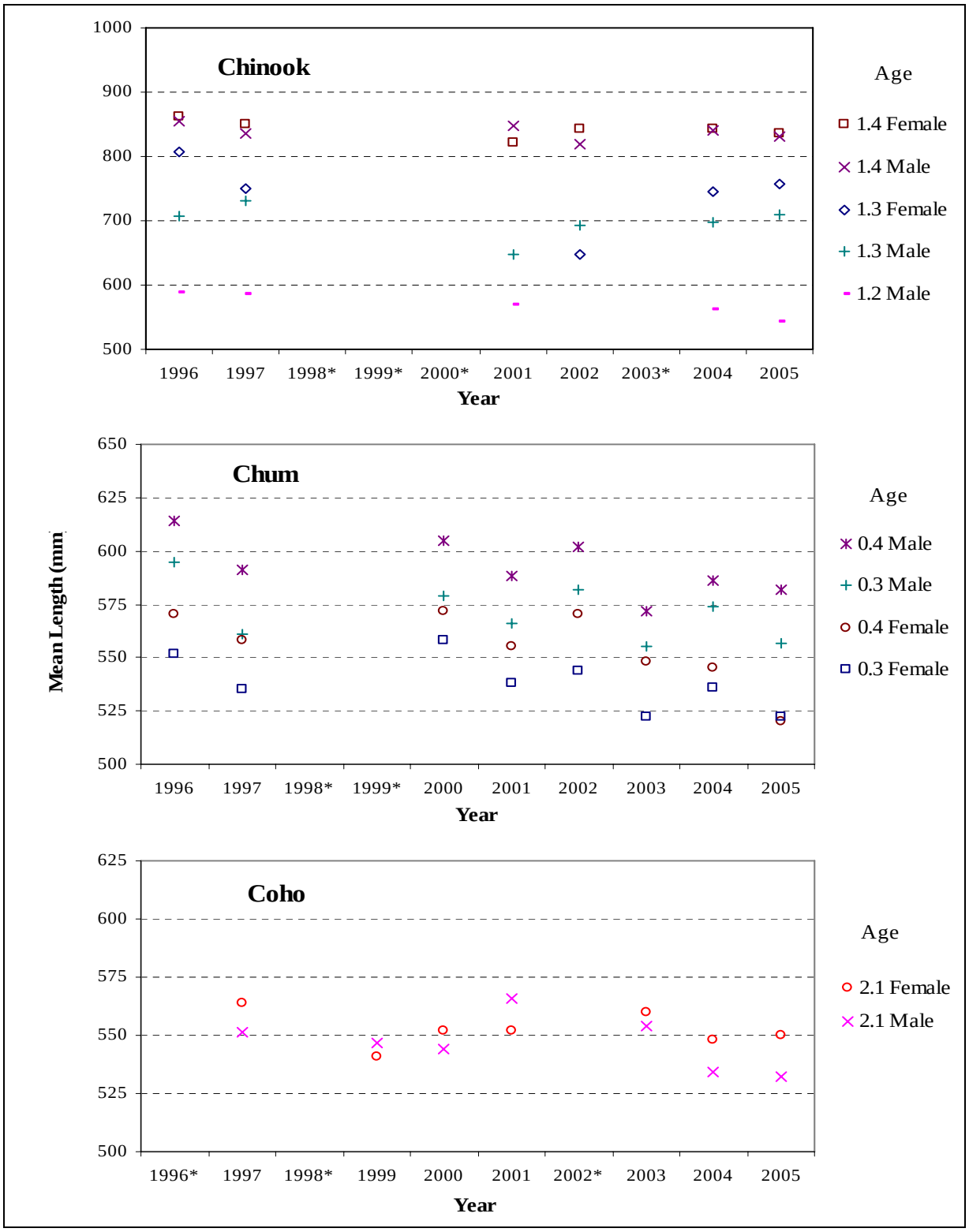
Source: Molyneaux and Folletti 2005.

Figure 8.–Historical intra-annual age composition of Chinook salmon at George River weir by sample date.



Source: Molyneaux and Folletti 2005.

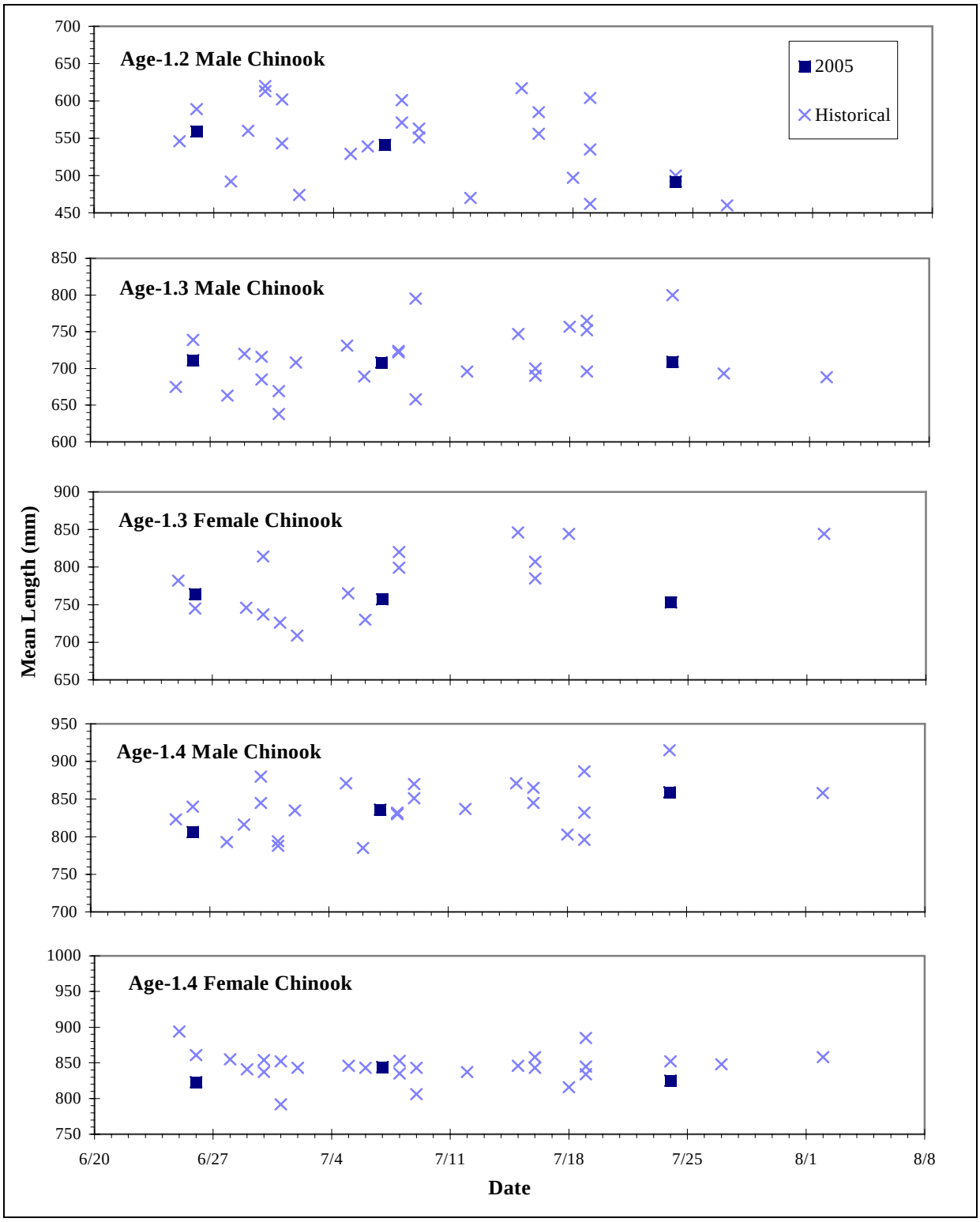
Figure 9.–Historical intra-annual percent female Chinook, chum, and coho salmon at George River weir by sample date.



Source: Molyneaux and Folletti 2005.

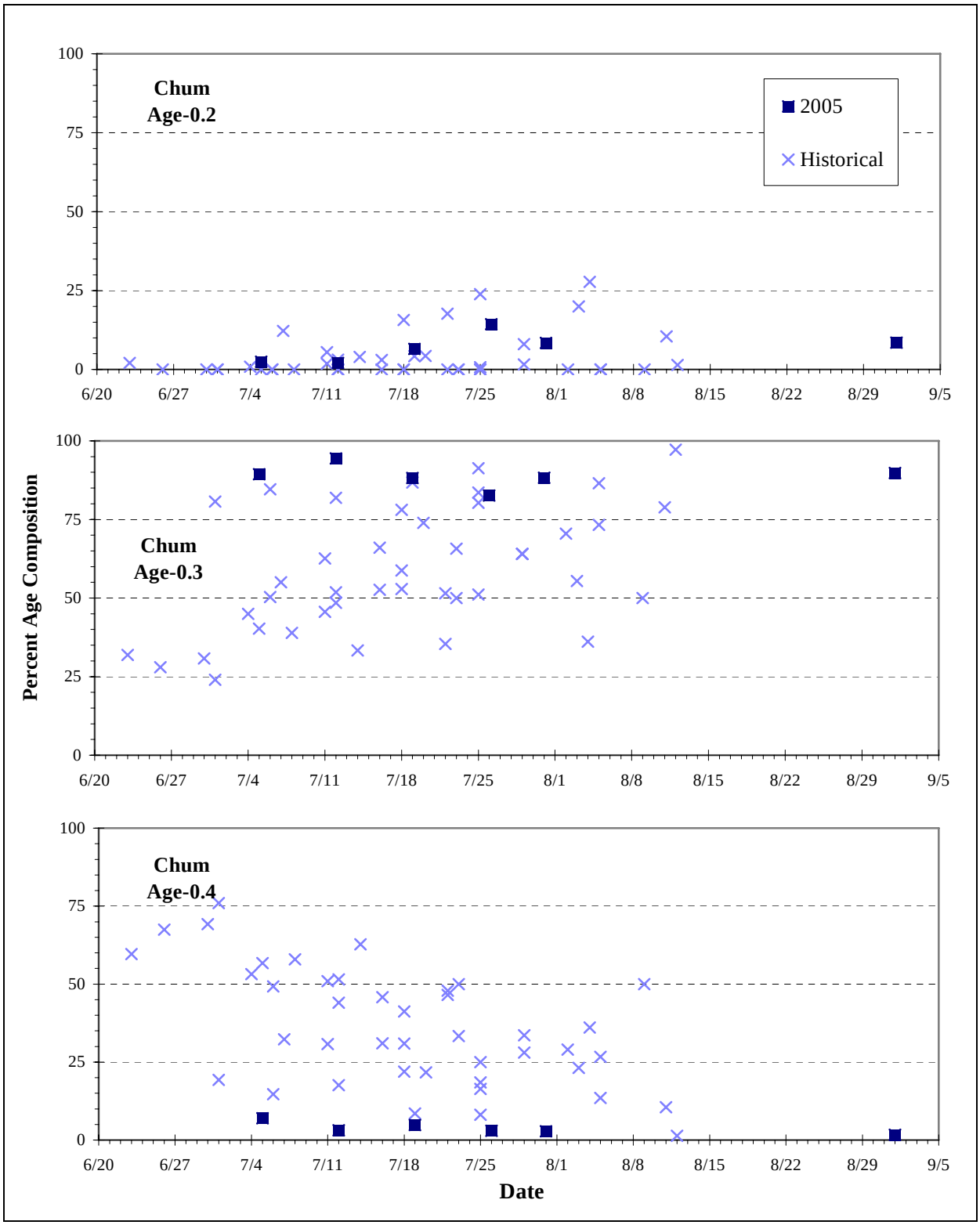
Note: An asterisk (*) denotes years with incomplete sampling or escapement estimates.

Figure 10.–Historical annual average mean length at age of Chinook, chum, and coho salmon at George River weir.



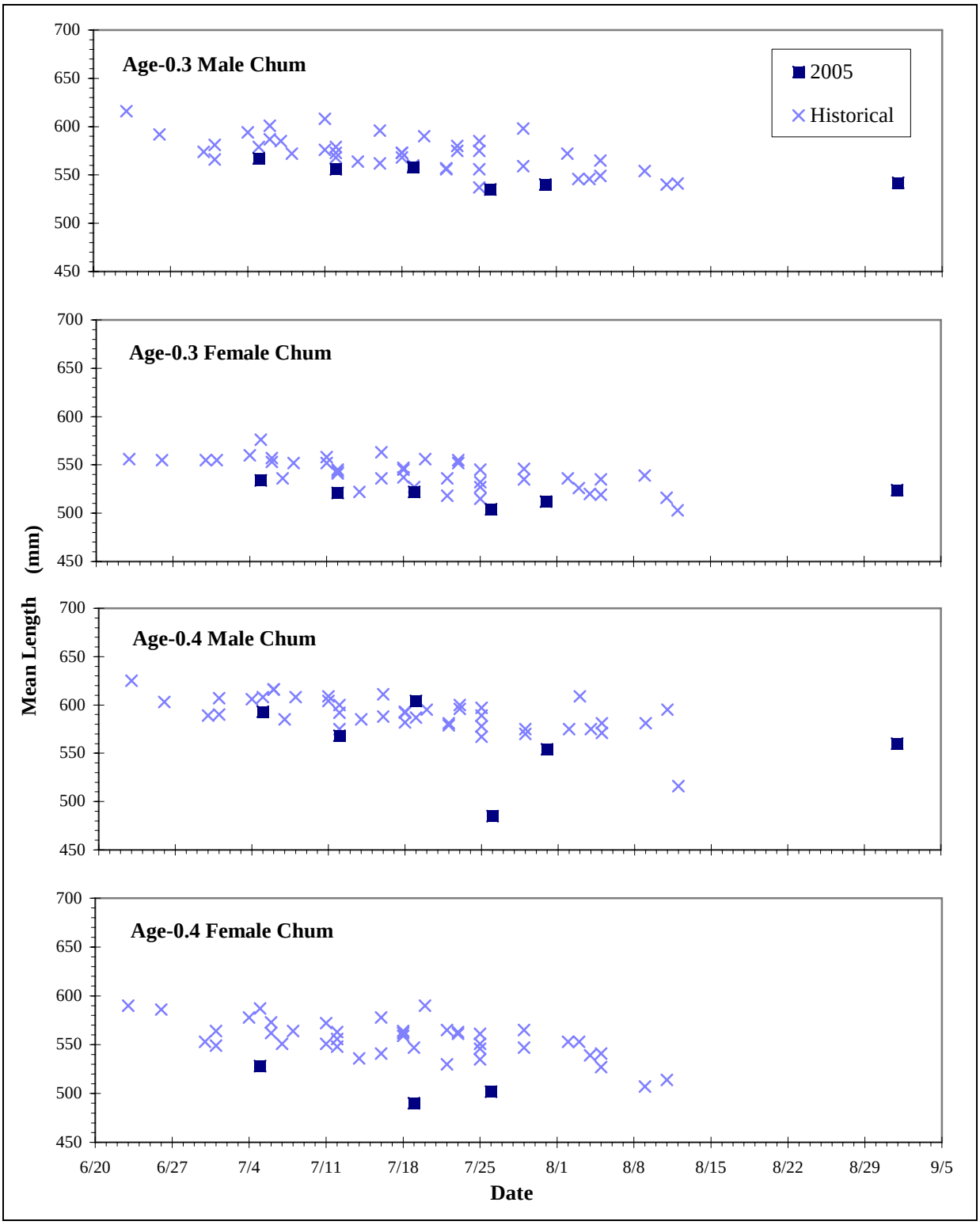
Source: Molyneaux and Folletti 2005.

Figure 11.–Historical intra-annual mean length at age of male and female Chinook salmon by sample date at George River weir.



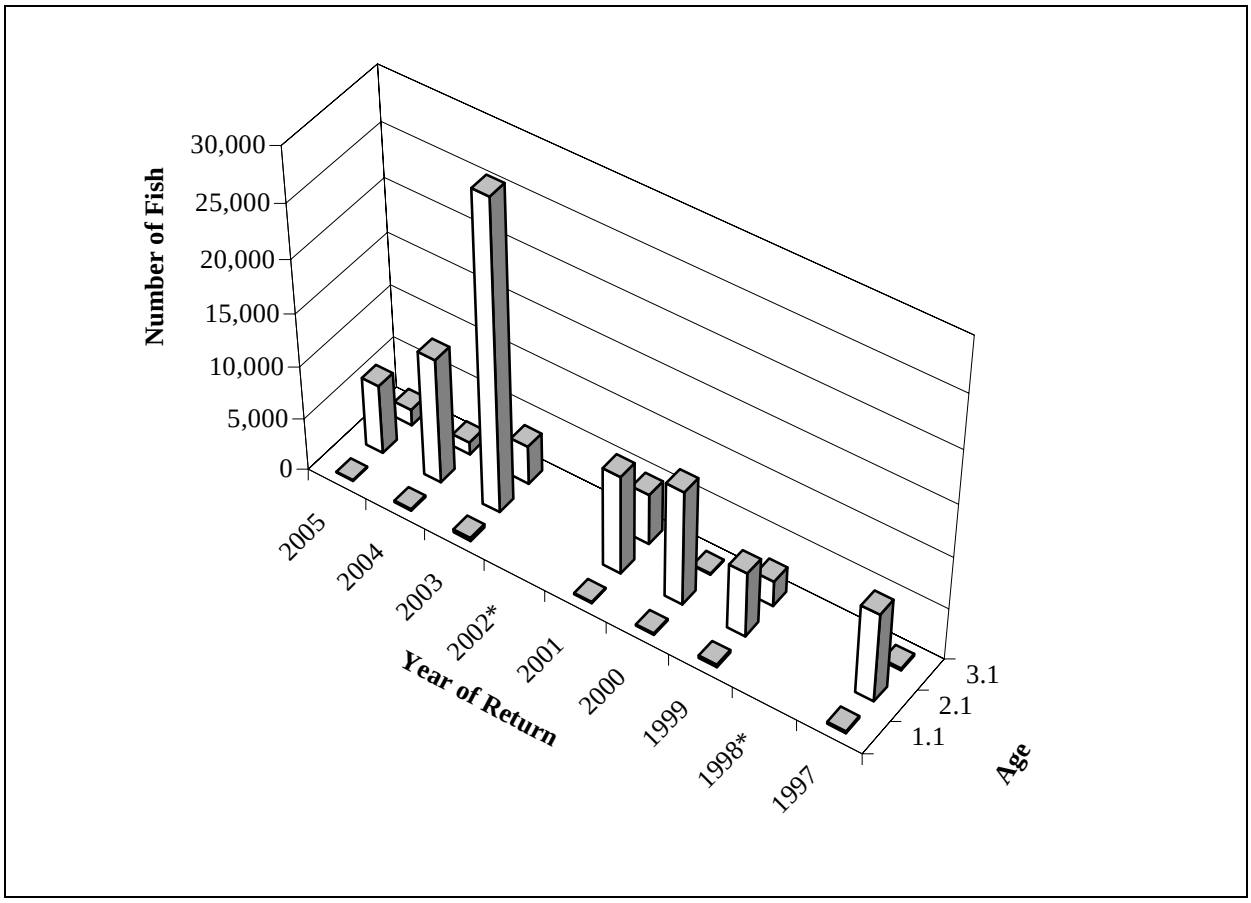
Source: Molyneaux and Folletti 2005.

Figure 12.–Historical intra-annual age composition of chum salmon by sample date at George River weir.



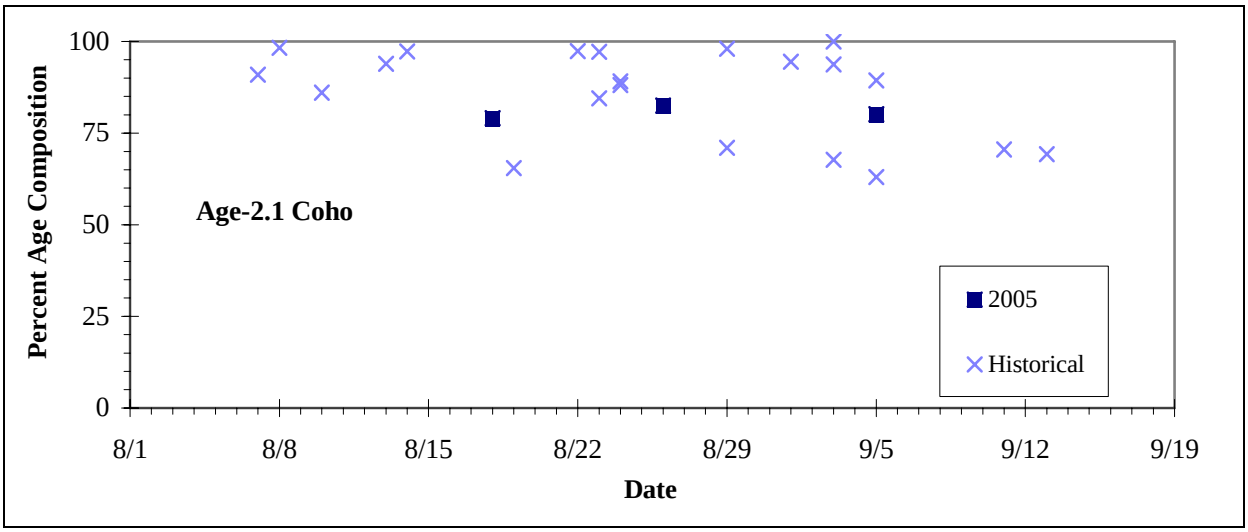
Source: Molyneaux and Folletti 2005.

Figure 13.–Historical intra-annual mean length at age of chum salmon by sample date at George River weir.



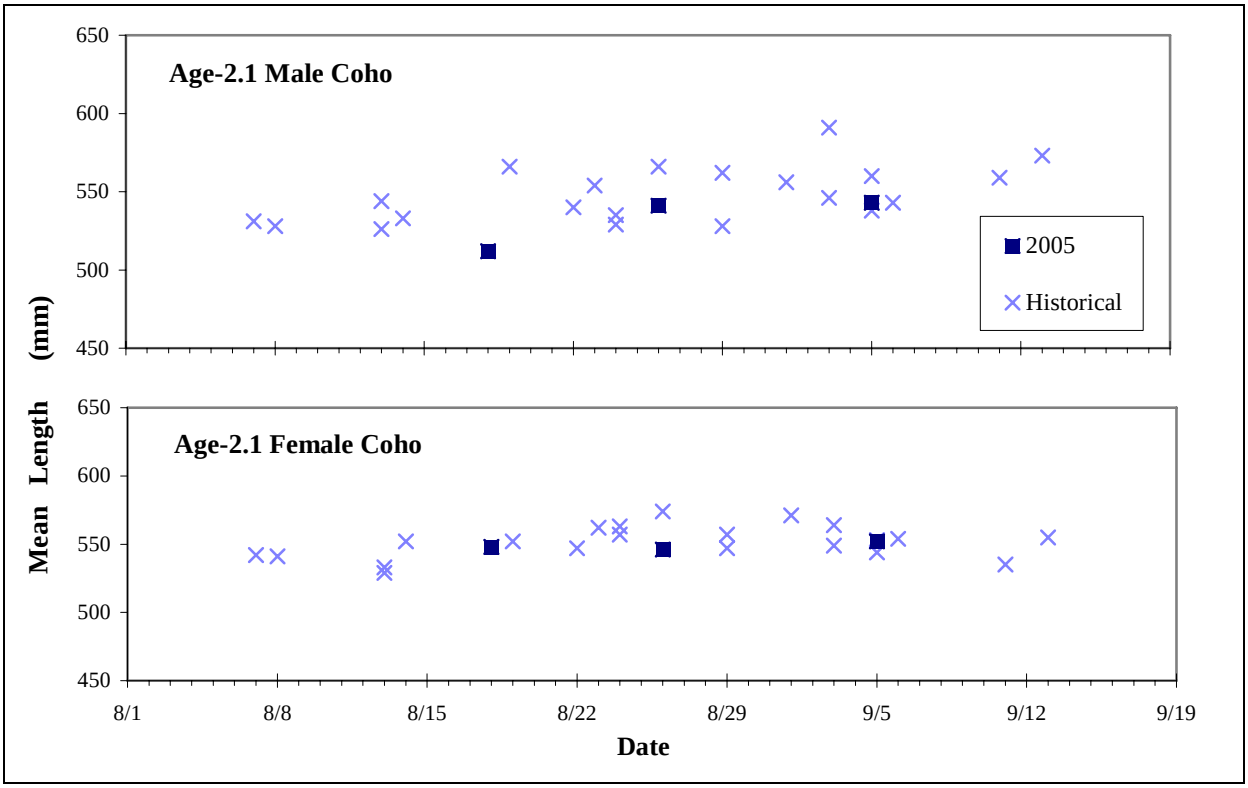
Source: Molyneaux and Folletti 2005.

Figure 14.–Historical age distribution of annual coho salmon escapements at George River weir.



Source: Molyneaux and Folletti 2005.

Figure 15.–Historical intra-annual percent of age-2.1 coho salmon by sample date at George River weir.



Source: Molyneaux and Folletti 2005.

Figure 16.–Historical intra-annual mean length of age-2.1 male and female coho by sample date salmon at George River weir.

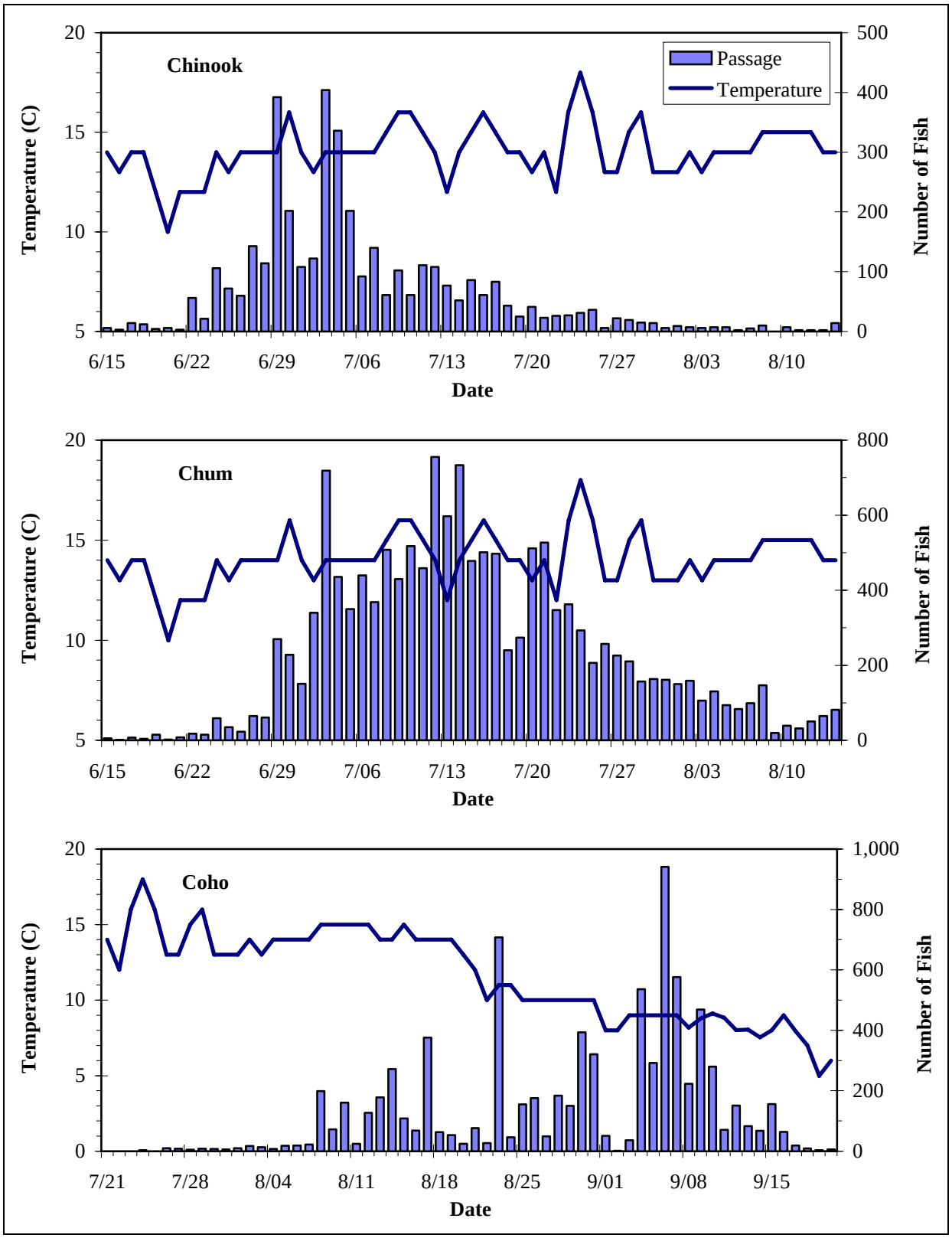


Figure 17.–Daily passage of Chinook, chum, and coho salmon relative to daily morning water temperature at George River weir, 2005.

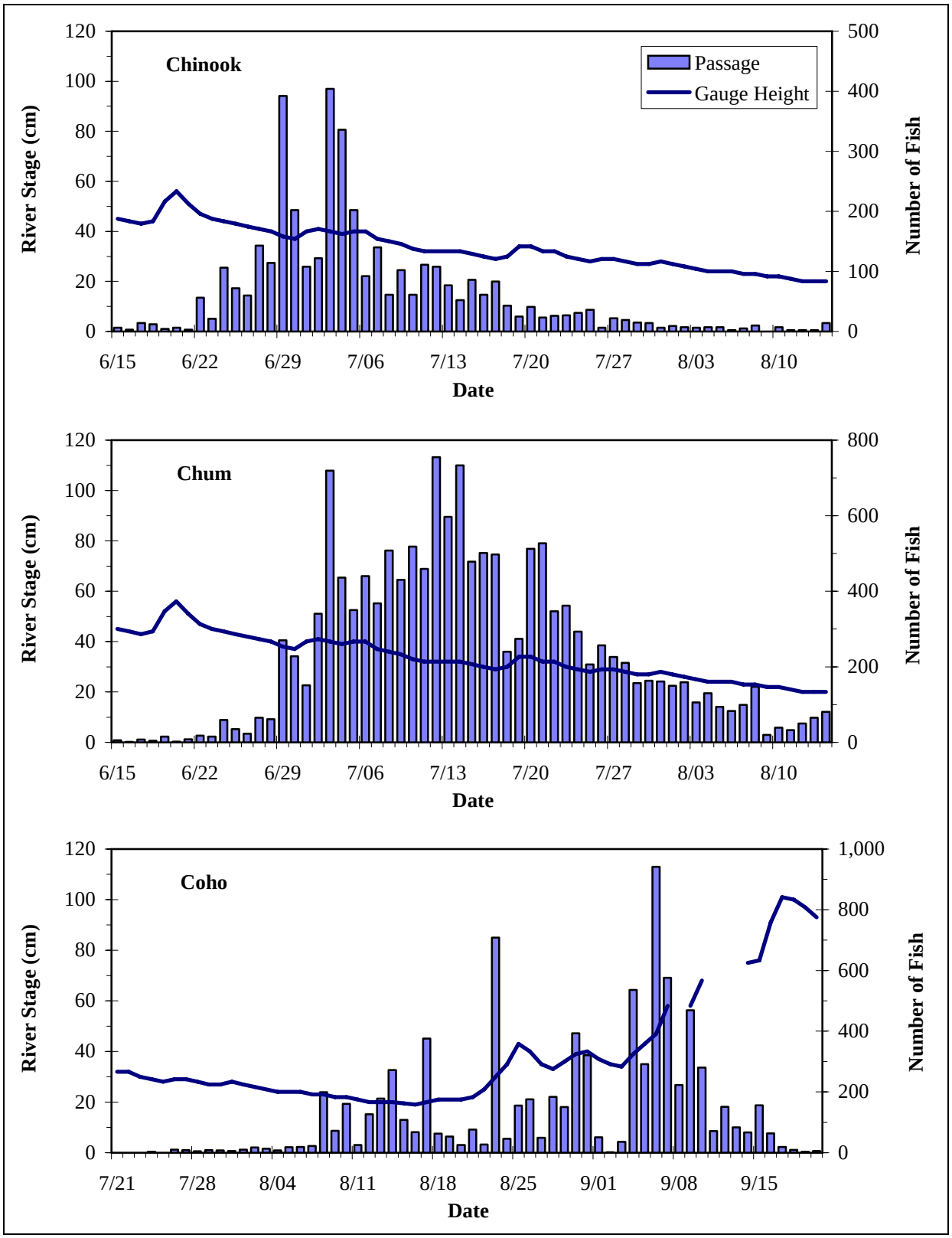
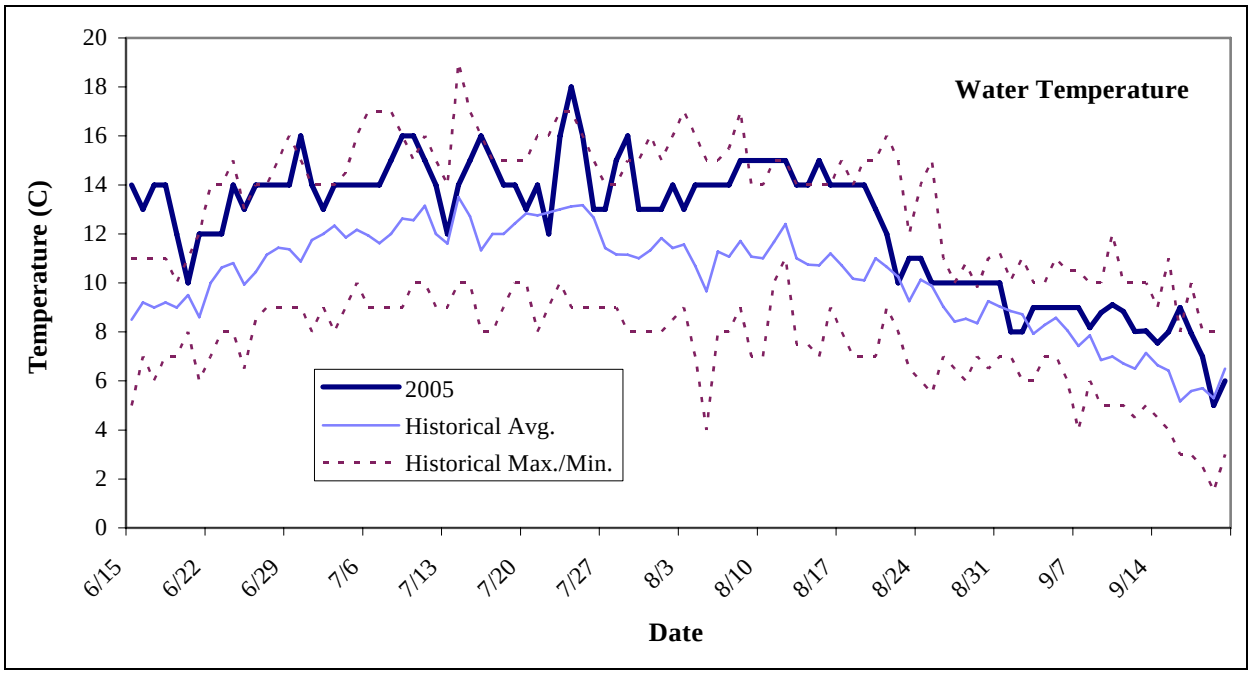
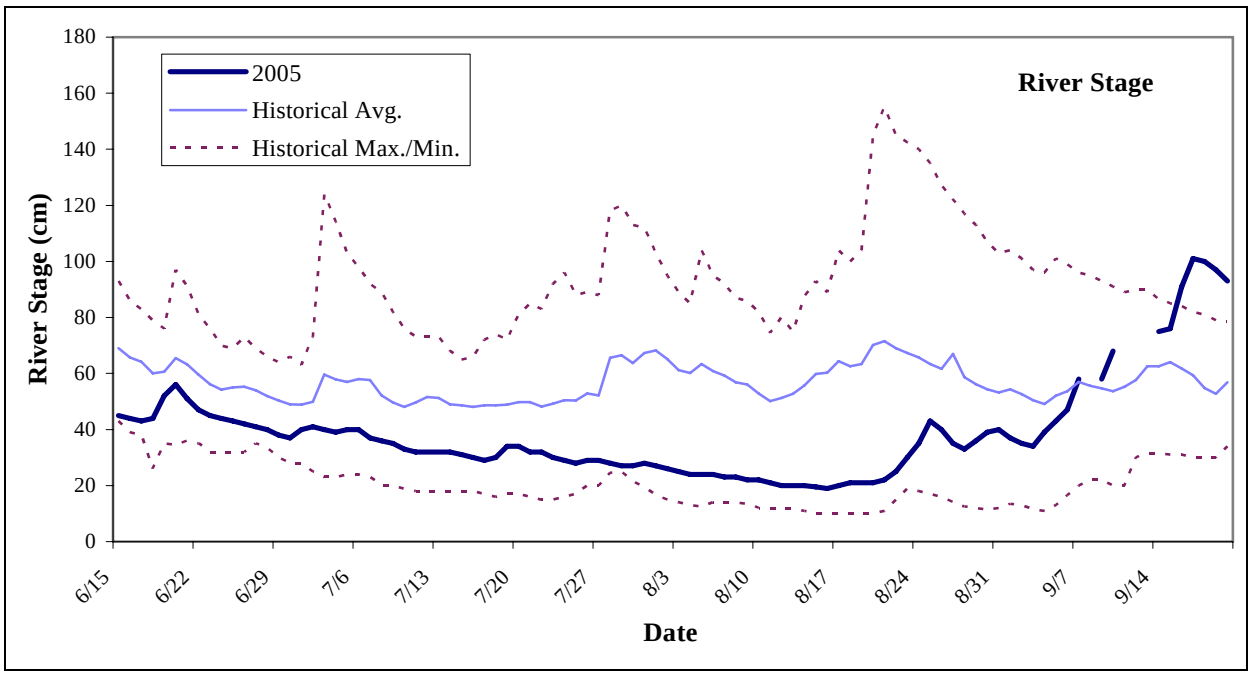


Figure 18.–Daily passage of Chinook, chum, and coho salmon relative to daily morning river stage at George River weir, 2005.



Source: Stewart et al. 2005.

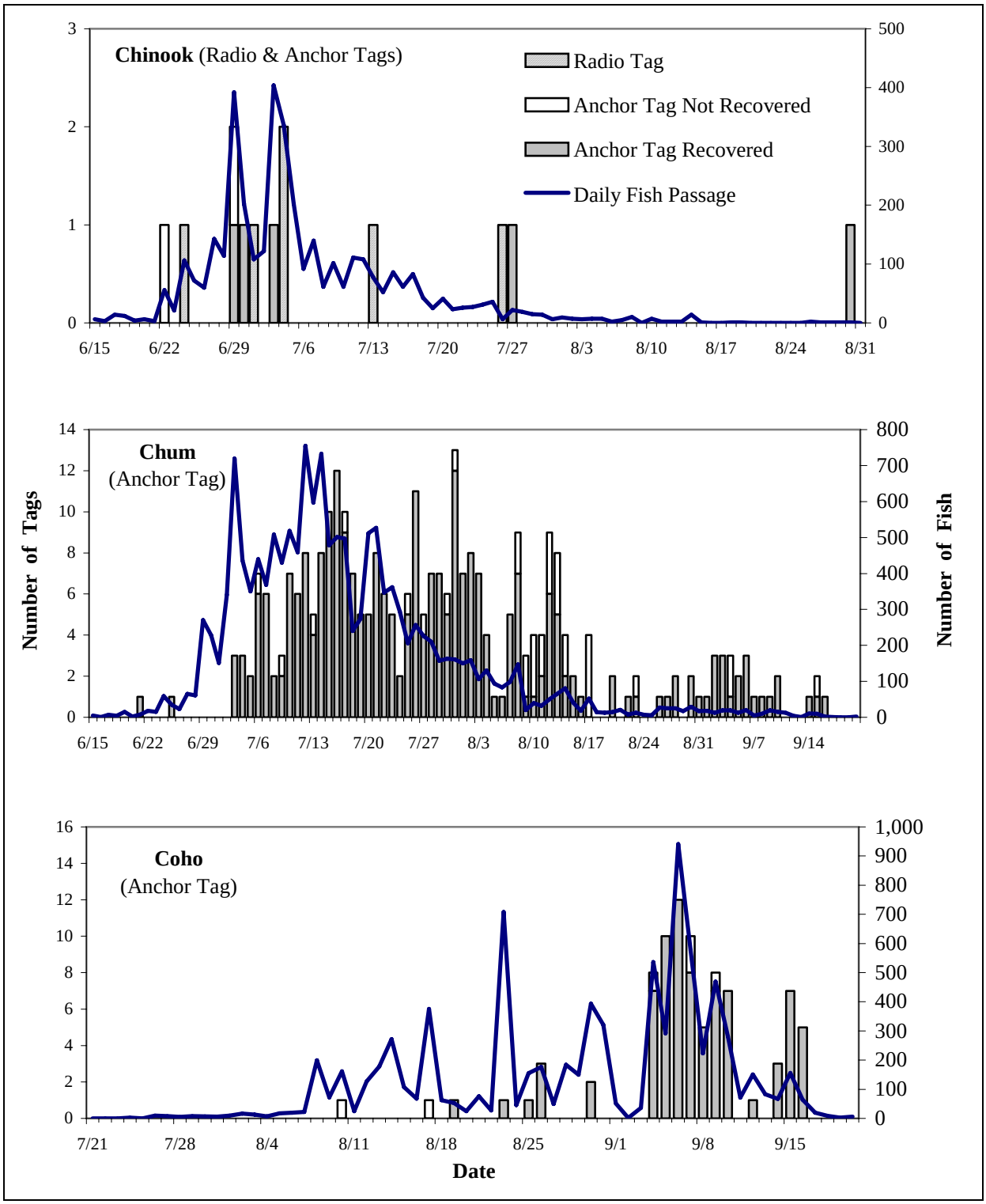
Figure 19.–Daily morning water temperatures at George River weir in 2005 relative to historical average, minimum, and maximum morning readings from 1996–2004.



Source: Stewart et al. 2005.

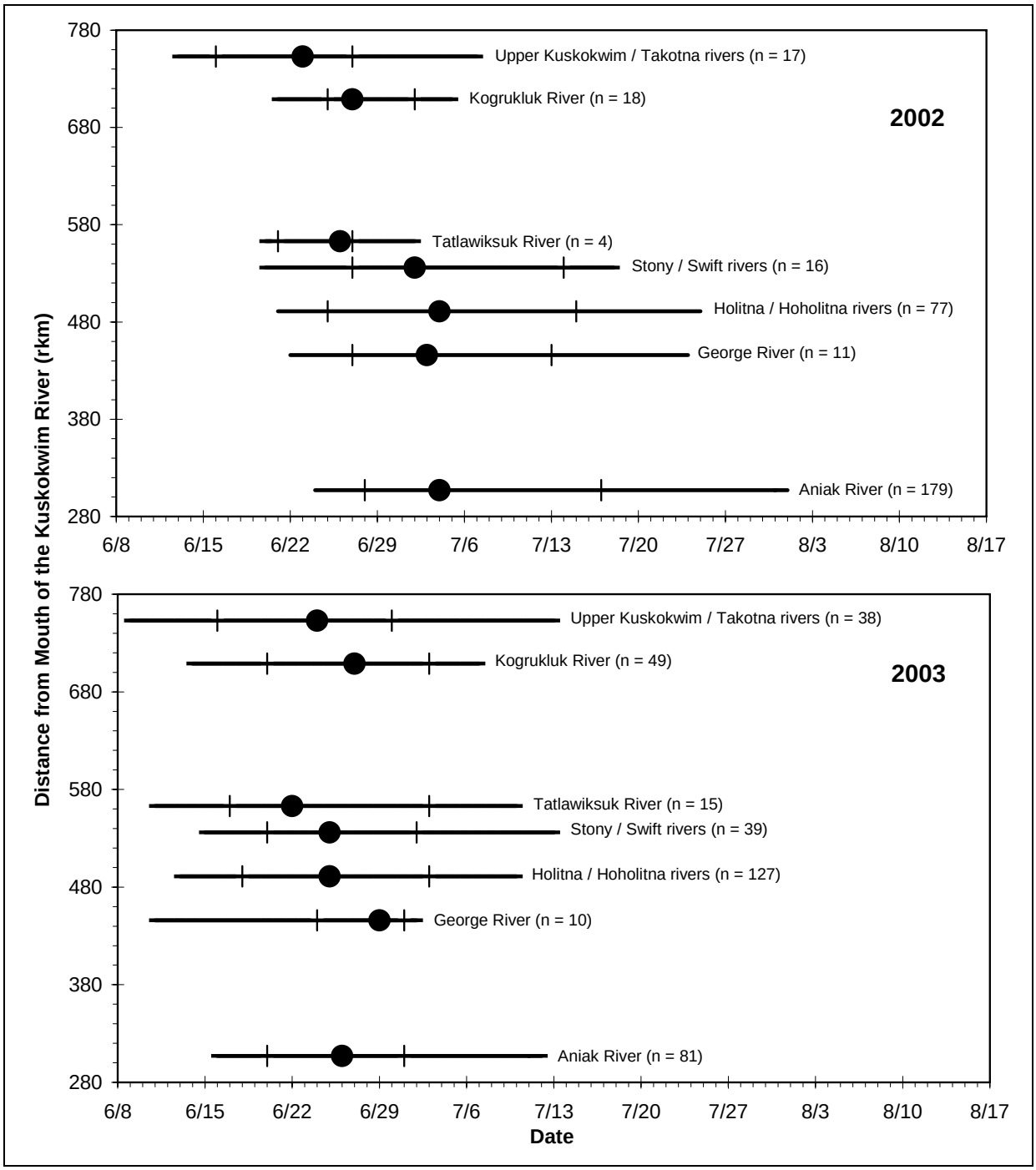
Note: Data before 2000 were excluded as they do no correlate with benchmarks maintained since.

Figure 20.–Daily morning river stage at George River weir in 2005 relative to historical average, minimum, and maximum morning readings from 2000–2004.



Source: Pawluk et al. *In prep* b.

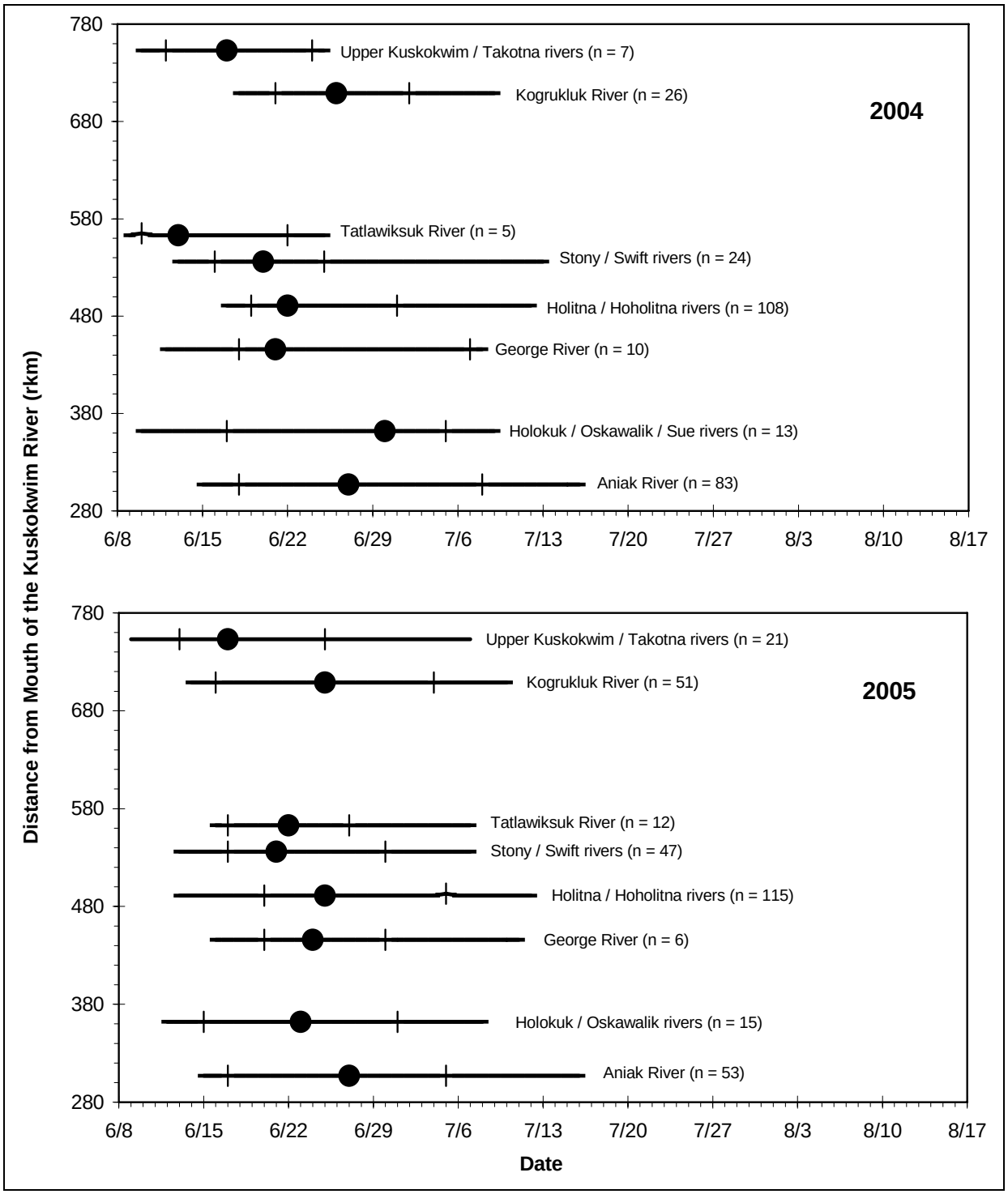
Figure 21.–Daily detection and recovery of tagged Chinook, chum, and coho salmon with daily escapement at George River weir in 2005.



Source: Stuby 2003, 2004.

Note: Horizontal lines represent central 80%, cross bars represent central 50%, and circles represent median passage date of each sample. Sample number is given in parentheses.

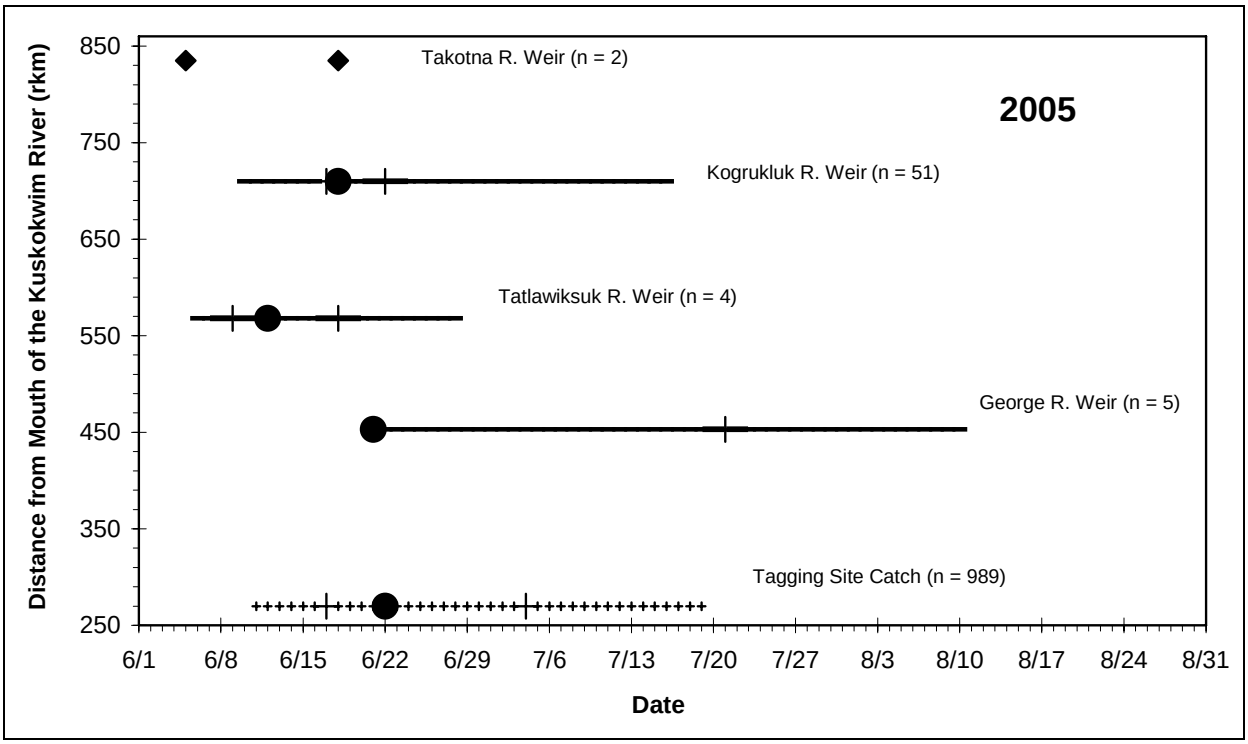
Figure 22.–Migration of selected Chinook salmon stocks past the mainstem tagging site in 2002 and 2003, based on radio tagging studies.



Source: Stuby 2005, *In prep*.

Note: Horizontal lines represent central 80%, cross bars represent central 50%, and circles represent median passage date of each sample. Sample number is given in parentheses.

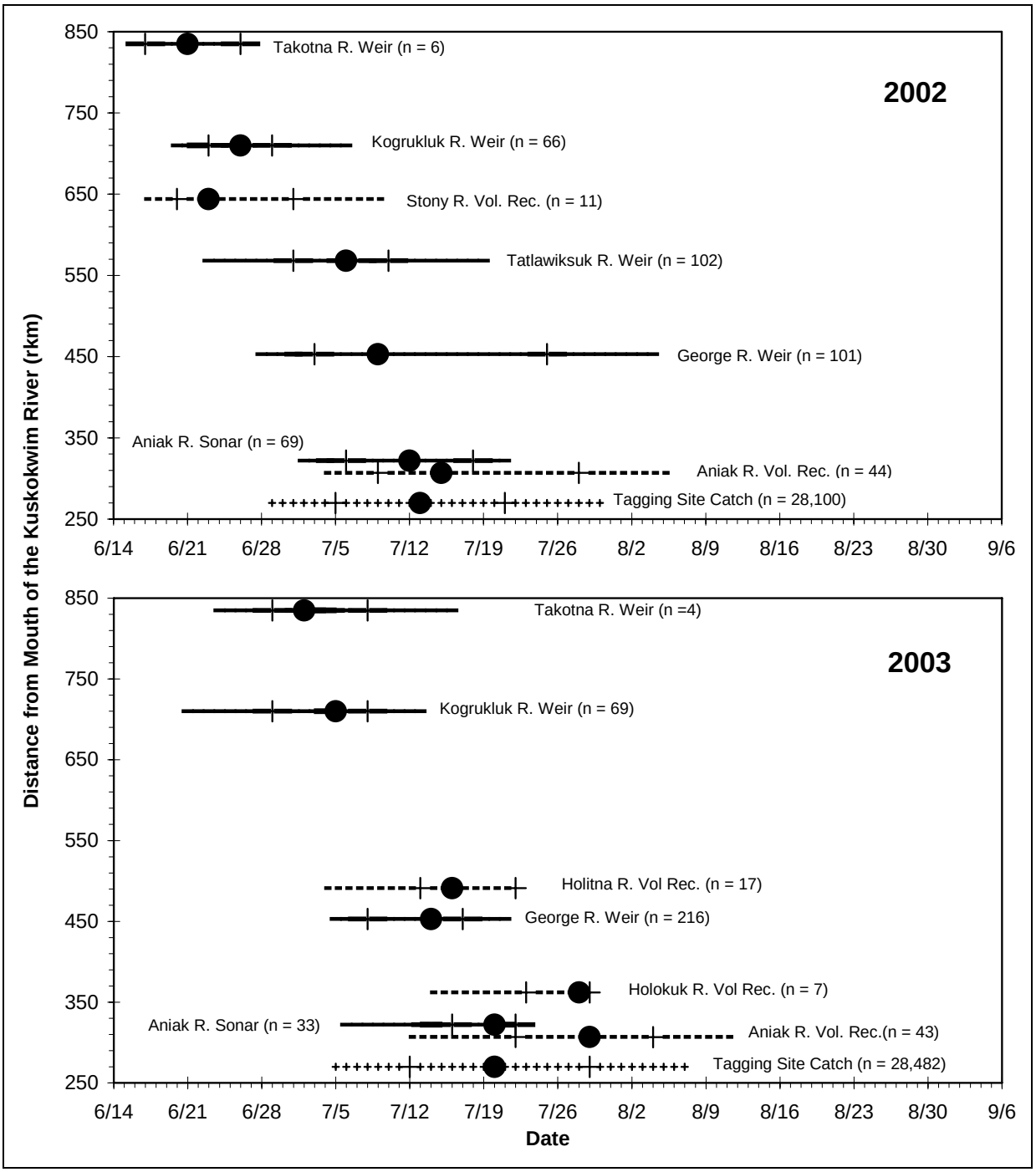
Figure 23.–Migration of selected Chinook salmon stocks past the mainstem tagging site in 2004 and 2005, based on radio tagging studies.



Source: Pawluk et al. *In prep* b.

Note: Horizontal lines represent central 80%, cross bars represent central 50%, and circles represent median passage date of each sample. Sample numbers are given in parentheses.

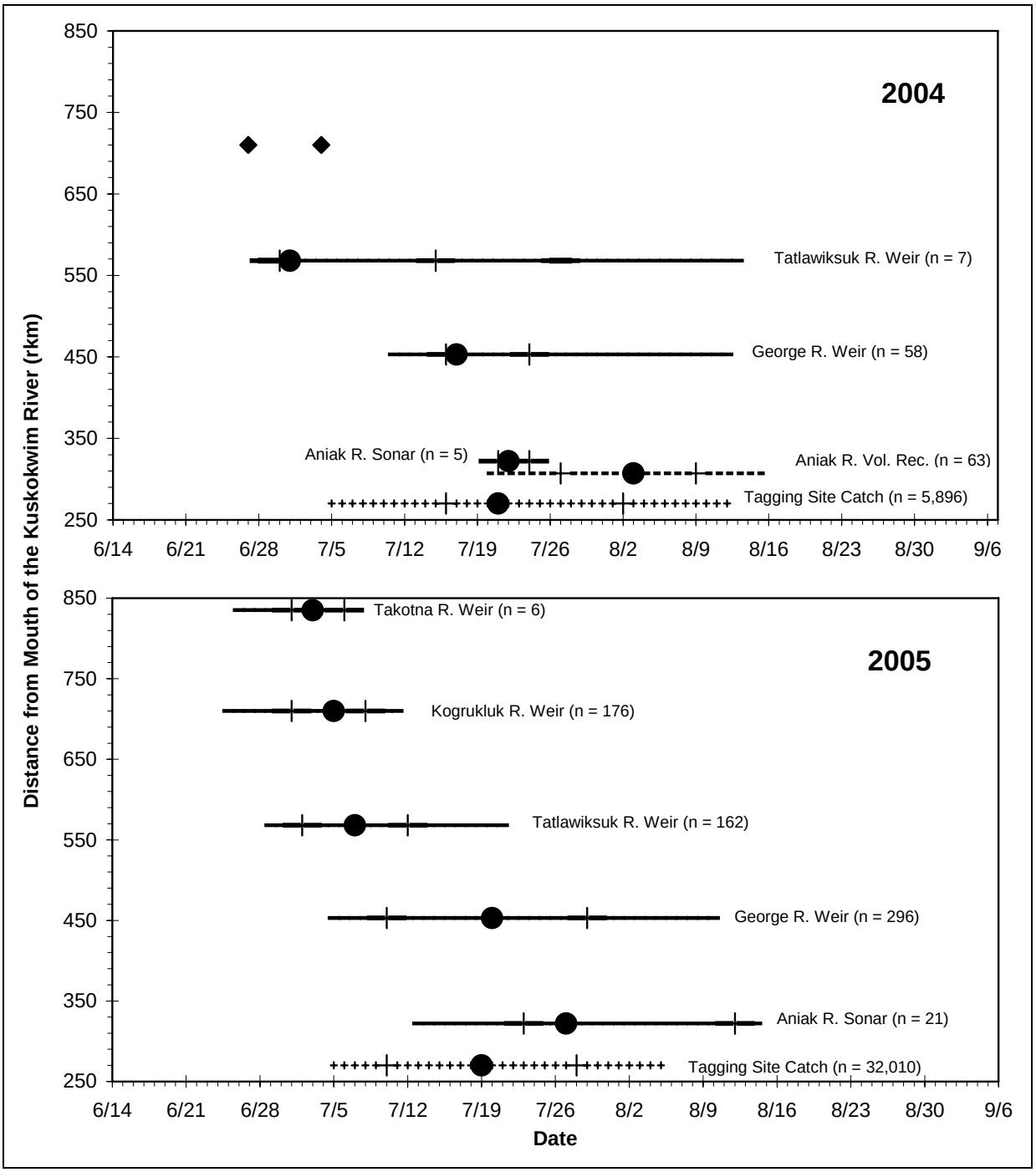
Figure 24.–Migration of Chinook salmon stocks past the mainstem tagging site in 2005 based on tag recoveries at selected Kuskokwim River tributaries.



Source: Kerkvliet et al 2003, 2004.

Note: Horizontal lines represent central 80%, cross bars represent central 50%, and circles represent median passage date of each sample. Sample numbers are given in parentheses.

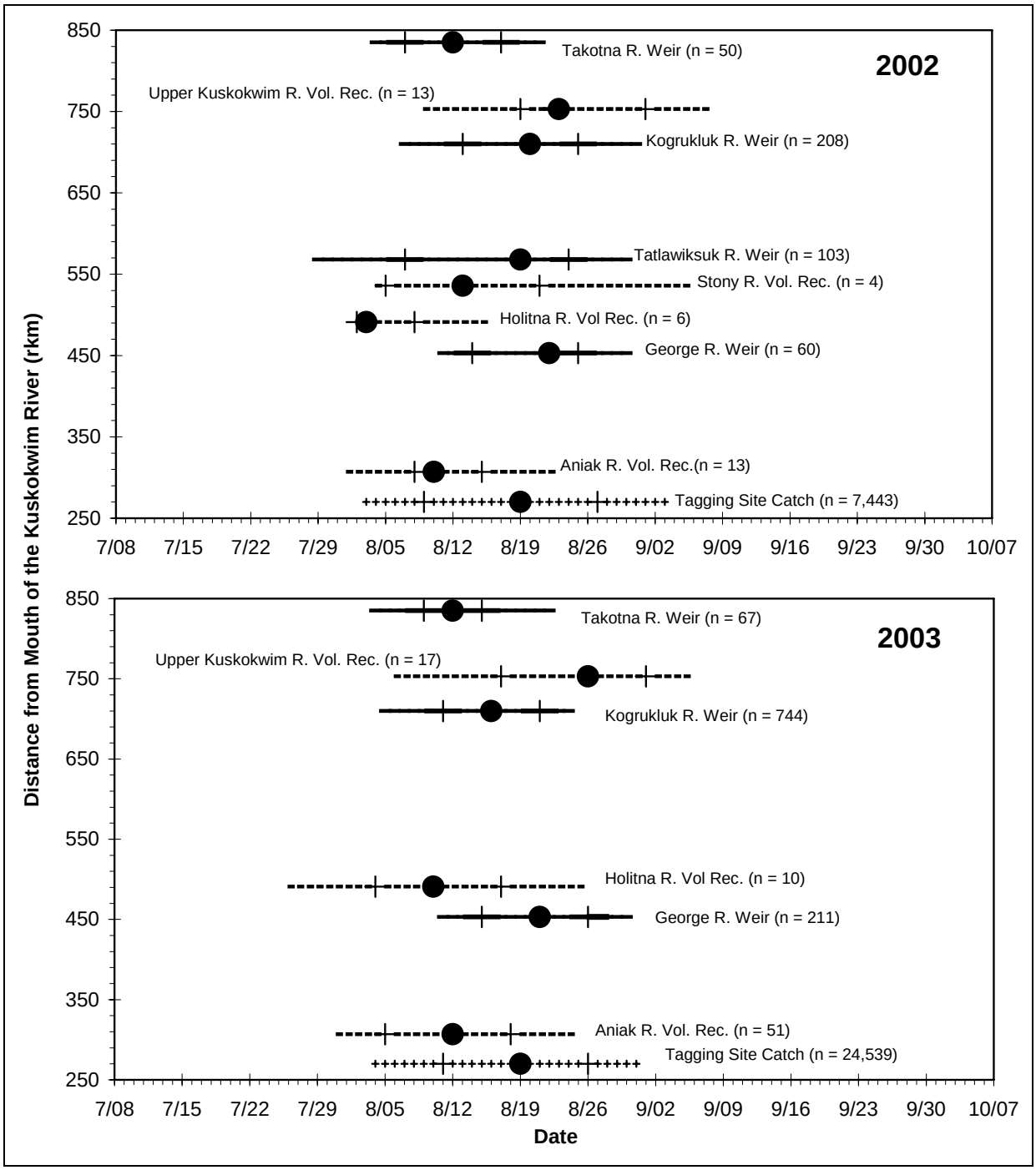
Figure 25.–Migration of chum salmon stocks past the mainstem tagging site in 2002 and 2003 based on tag recoveries at selected Kuskokwim River tributaries.



Source: Pawluk et al. *In prep* a, b.

Note: Horizontal lines represent central 80%, cross bars represent central 50%, and circles represent median passage date of each sample. Sample numbers are given in parentheses.

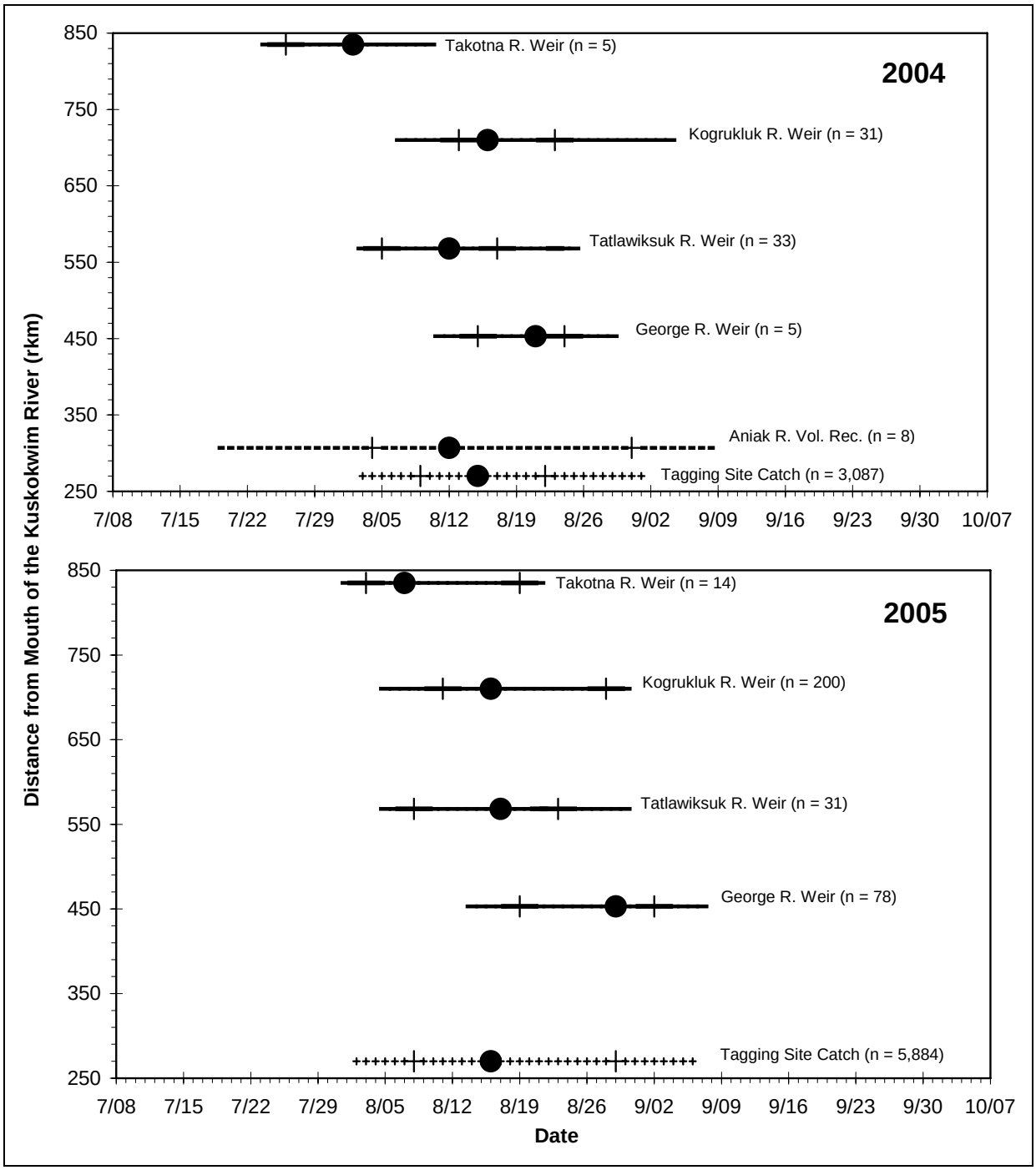
Figure 26.–Migration of chum salmon stocks past the mainstem tagging site in 2004 and 2005 based on tag recoveries at selected Kuskokwim River tributaries.



Source: Kerkvliet et al 2003, 2004.

Note: Horizontal lines represent central 80%, cross bars represent central 50%, and circles represent median passage date of each sample. Sample numbers are given in parentheses.

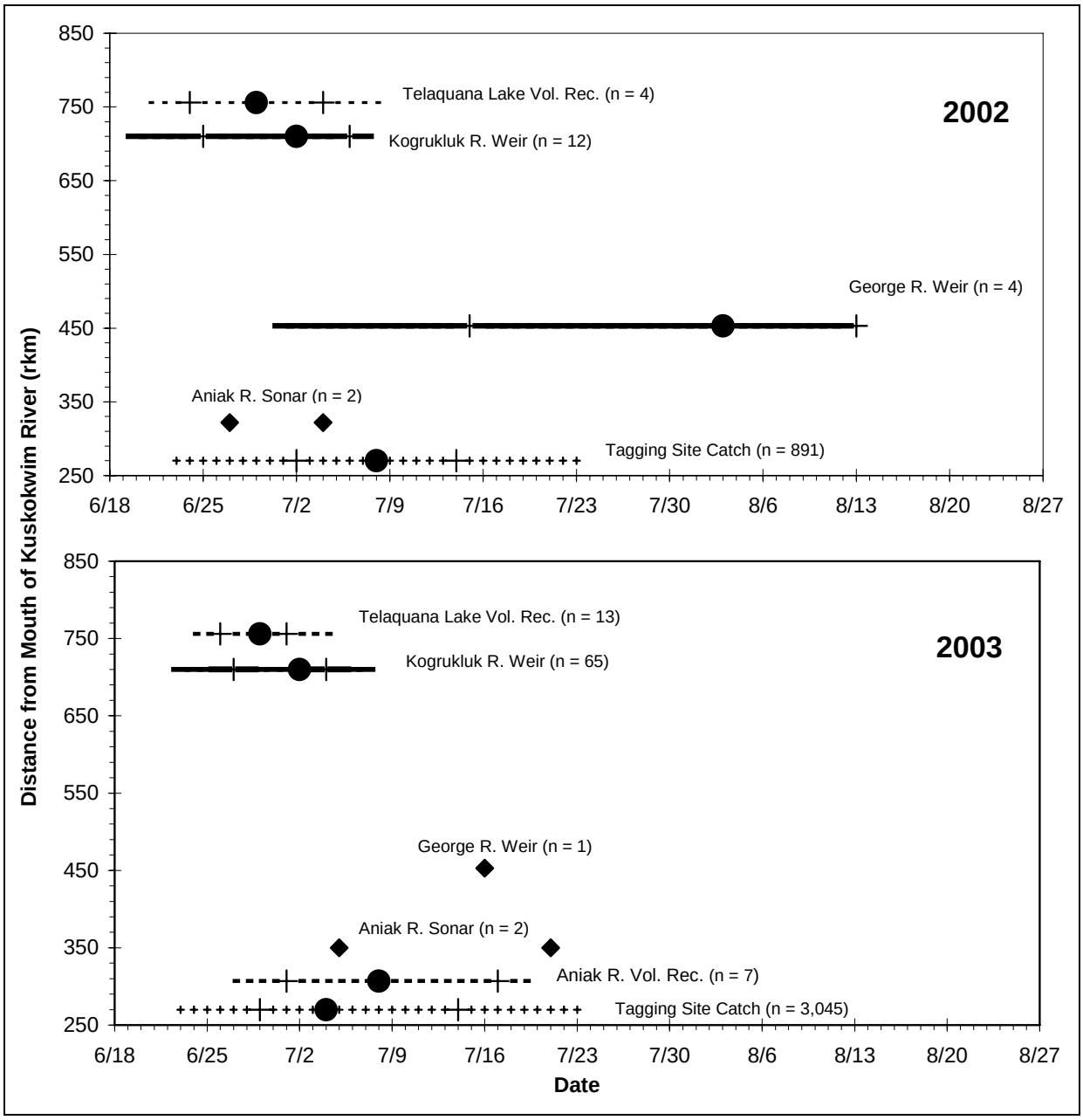
Figure 27.–Migration of coho salmon stocks past the mainstem tagging site in 2002 and 2003 based on tag recoveries at selected Kuskokwim River tributaries.



Source: Pawluk et al. *In prep* a, b.

Note: Horizontal lines represent central 80%, cross bars represent central 50%, and circles represent median passage date of each sample. Sample numbers are given in parentheses.

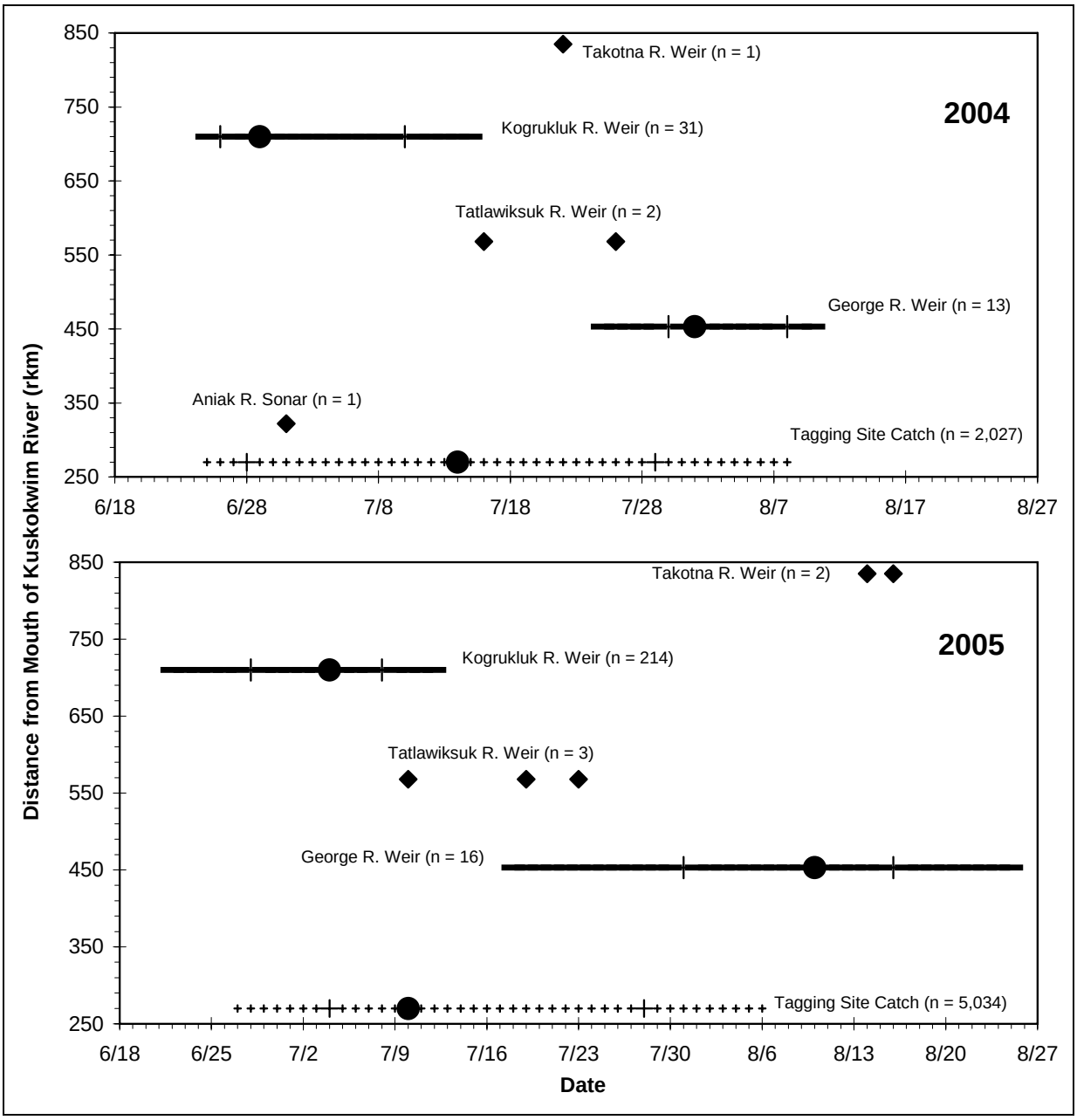
Figure 28.–Migration of coho salmon stocks past the mainstem tagging site in 2004 and 2005 based on tag recoveries at selected Kuskokwim River tributaries.



Source: Kerkvliet et al 2003, 2004.

Note: Horizontal lines represent central 80%, cross bars represent central 50%, and circles represent median passage date of each sample. Sample numbers are given in parentheses.

Figure 29.–Migration of sockeye salmon stocks past the mainstem tagging site in 2002 and 2003 based on tag recoveries at selected Kuskokwim River tributaries.



Source: Pawluk et al. *In prep* a, b.

Note: Horizontal lines represent central 80%, cross bars represent central 50%, and circles represent median passage date of each sample. Sample numbers are given in parentheses.

Figure 30.–Migration of sockeye salmon stocks past the mainstem tagging site in 2004 and 2005 based on tag recoveries at selected Kuskokwim River tributaries.

APPENDIX A. OTHER PASSAGE

Appendix A1.–Daily passage of sockeye and pink salmon, and non-salmon species observed at George River weir, 2005.

Date	Sockeye Salmon	Pink Salmon	Longnose Sucker	Whitefish	Arctic Grayling	Dolly Varden
6/15	0	0	725	3	31	0
6/16	0	0	264	0	5	0
6/17	0	0	211	0	5	0
6/18	0	0	25	0	3	0
6/19	0	0	16	1	7	0
6/20	0	0	15	0	1	0
6/21	0	0	7	3	2	0
6/22	1	0	9	0	4	0
6/23	0	0	6	1	2	0
6/24	2	0	2	4	7	0
6/25	0	0	1	1	3	0
6/26	0	0	42	0	6	0
6/27	0	0	131	0	4	0
6/28	0	0	95	2	10	0
6/29	1	0	161	0	9	0
6/30	0	0	12	1	1	0
7/01	0	0	24	2	5	0
7/02	0	0	28	0	0	0
7/03	0	0	39	0	8	0
7/04	0	0	79	1	18	0
7/05	0	0	8	1	0	1
7/06	1	0	7	0	3	0
7/07	1	2	8	0	3	0
7/08	1	1	15	0	4	0
7/09	2	3	3	3	6	0
7/10	1	1	14	0	6	0
7/11	1	0	15	0	2	0
7/12	0	4	5	0	6	0
7/13	0	0	3	0	6	0
7/14	2	8	17	0	1	0
7/15	0	6	2	0	1	0
7/16	3	3	1	0	0	0
7/17	4	8	4	0	1	0
7/18	2	1	2	0	1	0
7/19	2	0	2	0	0	0
7/20	3	11	0	0	2	0
7/21	8	7	7	0	1	0
7/22	5	1	0	0	0	0
7/23	3	2	1	0	5	0
7/24	0 [a]	0 [a]	0 [a]	0 [a]	0 [a]	0 [a]
7/25	4	2	0	0	0	0
7/26	5	1	0	0	3	0
7/27	7	0	2	0	0	1
7/28	6	0	0	0	0	0
7/29	1	1	0	0	0	0
7/30	12	1	0	0	0	0
7/31	6	1	0	0	2	0

-continued-

Appendix A1.–Page 2 of 3.

Date	Sockeye Salmon	Pink Salmon	Longnose Sucker	Whitefish	Arctic Grayling	Dolly Varden
8/01	6	2	0	0	0	0
8/02	2	0	0	0	0	0
8/03	2	0	0	0	0	0
8/04	0	1	0	0	0	0
8/05	1	0	0	0	0	0
8/06	2	0	0	0	0	0
8/07	5	0	2	0	0	0
8/08	18	0	0	0	0	0
8/09	3	1	0	0	0	0
8/10	1	1	1	0	0	0
8/11	2	0	0	0	0	0
8/12	4	1	0	0	0	0
8/13	4	0	0	0	0	0
8/14	9	0	0	0	0	0
8/15	6	0	0	0	0	0
8/16	5	0	0	0	0	0
8/17	15	2	0	0	0	0
8/18	3	1	0	0	0	0
8/19	2	0	0	0	0	0
8/20	0	2	0	0	0	0
8/21	5	0	0	0	0	0
8/22	1	0	0	0	0	0
8/23	21	0	0	0	0	0
8/24	7	0	0	0	0	0
8/25	3	0	0	0	0	0
8/26	9	0	0	0	0	0
8/27	3	0	0	0	0	0
8/28	9	0	0	0	0	0
8/29	1	0	2	0	0	0
8/30	6	1	0	0	0	0
8/31	2	0	0	0	0	0
9/01	2	0	0	0	0	0
9/02	0	0	0	0	0	0
9/03	0	0	0	0	0	0
9/04	2	0	0	0	0	0
9/05	1	0	0	0	0	0
9/06	1	0	0	0	0	0
9/07	1	0	18	0	0	0
9/08	3	0	6	0	0	0
9/09	5	1	0	0	0	0
9/10	5	0	4	0	0	0
9/11	0	0	2	0	0	0
9/12	2	0	0	0	0	0
9/13	3	0	0	0	0	0
9/14	3	0	0	0	0	0
9/15	2	0	3	0	0	0
9/16	0	0	0	0	0	0
9/17	0	0	0	0	0	0

-continued-

Appendix A1.–Page 3 of 3.

Date	Sockeye Salmon	Pink Salmon	Longnose Sucker	Whitefish	Arctic Grayling	Dolly Varden
9/18	0	0	0	0	0	0
9/19	1	0	0	0	0	0
9/20	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]
Total	272	77	2,046	23	184	2

[a] Count is incomplete due to the occurrence of a hole in the weir.

[b] Partial day count.

APPENDIX B. CARCASS COUNTS

Appendix B1.–Daily carcass counts of Chinook, chum, and coho salmon at George River weir, 2005.

Date	Chinook	Chum	Coho	Date	Chinook	Chum	Coho
6/15	0	0	0	8/04	2	13	0
6/16	0	0	0	8/05	2	11	0
6/17	0	0	0	8/06	1	11	0
6/18	0	0	0	8/07	0	18	0
6/19	0	0	0	8/08	1	10	0
6/20	0	0	0	8/09	2	0	0
6/21	0	0	0	8/10	0	10	1
6/22	0	0	0	8/11	0	7	0
6/23	0	0	0	8/12	0	8	0
6/24	0	1	0	8/13	0	9	0
6/25	0	0	0	8/14	0	1	0
6/26	0	0	0	8/15	0	6	0
6/27	0	0	0	8/16	0	3	0
6/28	0	0	0	8/17	0	5	2
6/29	0	1	0	8/18	0	4	1
6/30	0	1	0	8/19	0	3	0
7/01	0	1	0	8/20	0	3	1
7/02	0	0	0	8/21	0	1	0
7/03	0	2	0	8/22	0	3	1
7/04	0	0	0	8/23	0	2	2
7/05	0	3	0	8/24	0	2	0
7/06	0	3	0	8/25	0	1	1
7/07	0	4	0	8/26	0	0	0
7/08	0	1	0	8/27	0	2	2
7/09	0	7	0	8/28	0	2	0
7/10	0	7	0	8/29	0	3	1
7/11	1	14	0	8/30	0	3	0
7/12	0	10	0	8/31	1	0	0
7/13	1	14	0	9/01	0	0	0
7/14	0	9	0	9/02	0	0	0
7/15	0	29	0	9/03	0	0	0
7/16	1	15	0	9/04	0	1	0
7/17	1	33	0	9/05	0	1	1
7/18	1	20	0	9/06	0	1	0
7/19	0	21	0	9/07	0	1	1
7/20	1	28	0	9/08	0	1	0
7/21	0	30	0	9/09	0	2	0
7/22	0	27	0	9/10	0	1	1
7/23	1	57	0	9/11	0	1	2
7/24	0	25	0	9/12	0	2	2
7/25	1	34	0	9/13	0	0	3
7/26	4	51	0	9/14	0	2	2
7/27	0	45	0	9/15	1	0	0
7/28	2	28	0	9/16	0	2	1
7/29	0	30	0	9/17	0	3	4
7/30	3	40	0	9/18	0	2	0
7/31	4	30	2	9/19	0	0	2
8/01	1	30	0	9/20	0	0	0
8/02	4	12	0	Season Total	39	849	33
8/03	3	25	0				

APPENDIX C. WEATHER AND STREAM OBSERVATIONS

Appendix C1.–Daily weather and stream observations at George River weir, 2005.

		Sky	Precipitation			Temperature		River
Date	Time	Code	Code	Amount	Wind	Air	Water	Stage (cm)
6/15	7:30	4	B	17.5	0	16	14	45
6/15	17:00	2	n.a.	0.0	0	23	16	47
6/16	7:30	1	n.a.	2.5	0	10	13	44
6/16	17:00	2	n.a.	0.0	NW10	23	16	45
6/17	7:30	1	n.a.	0.0	0	11	14	43
6/17	17:00	4	n.a.	0.0	S10	22	17	43
6/18	7:30	4	B	9.0	0	10	14	44
6/18	17:00	4	A	0.0	0	12	14	45
6/19	7:30	4	n.a.	7.5	0	9	12	52
6/19	18:00	3	n.a.	0.0	SW10	14	12	56
6/20	7:30	1	n.a.	1.0	0	8	10	56
6/20	17:00	2	n.a.	0.0	0	20	13	55
6/21	7:30	4	n.a.	0.0	0	10	12	51
6/21	17:00	3	n.a.	0.0	N5	19	13	50
6/22	7:30	3	n.a.	0.0	0	10	12	47
6/23	7:30	3	n.a.	0.0	0	10	12	45
6/23	17:00	3	n.a.	0.0	V5	19	14	44
6/24	7:30	4	n.a.	0.0	0	13	14	44
6/24	17:00	2	n.a.	0.0	0	22	16	43
6/25	7:30	4	A	0.5	0	9	13	43
6/25	17:00	2	n.a.	0.0	N5	23	16	43
6/26	7:30	1	n.a.	0.0	0	11	14	42
6/26	17:00	3	n.a.	0.0	NE10	23	16	41
6/27	7:30	2	n.a.	0.0	0	10	14	41
6/27	17:00	2	n.a.	0.0	N20	26	17	40
6/28	7:30	1	n.a.	0.0	0	9	14	40
6/28	17:00	3	n.a.	0.0	N15	27	17	39
6/29	7:30	3	n.a.	0.0	0	17	14	38
6/29	17:00	2	n.a.	0.0	N15	25	17	37
6/30	7:30	4	A	0.6	0	14	16	37
6/30	17:00	4	A	0.0	0	14	15	37
7/01	7:30	4	n.a.	1.2	0	13	14	40
7/01	17:00	3	n.a.	0.0	0	18	14	41
7/02	7:30	4	n.a.	0.0	0	13	13	41
7/02	17:00	1	n.a.	0.0	S15	22	15	41
7/03	7:30	3	n.a.	0.0	0	13	14	40
7/03	17:00	3	A	0.0	0	19	15	39
7/04	10:00	3	n.a.	0.3	0	15	14	39
7/04	17:00	2	n.a.	0.0	NW5	21	17	39
7/05	7:30	5	n.a.	0.0	0	9	14	40
7/05	17:00	3	A	0.0	0	22	17	41
7/06	7:30	1	n.a.	7.5	0	9	14	40
7/06	17:00	1	n.a.	0.0	V5	24	18	39
7/07	7:30	1	n.a.	0.0	0	16	14	37
7/07	17:00	2	n.a.	0.0	N5	23	18	37
7/08	7:30	2	n.a.	0.0	0	12	15	36
7/08	17:00	2	n.a.	0.0	N5	25	18	35
7/09	7:30	3	n.a.	0.0	0	18	16	35
7/09	10:00	2	n.a.	0.0	S10	25	19	34

-continued-

Appendix C1.–Page 2 of 3.

Date	Time	Sky Code	Precipitation Code	Precipitation Amount	Wind	Temperature Air	Temperature Water	River Stage (cm)
7/10	7:30	2	n.a.	0.0	S20	17	16	33
7/10	17:00	1	n.a.	0.0	W30	24	18	33
7/11	7:30	4	n.a.	0.0	0	11	15	32
7/11	17:00	2	n.a.	0.0	S5	20	17	32
7/12	7:30	4	A	0.5	0	11	14	32
7/12	17:00	4	A	0.0	S5	15	15	32
7/13	7:30	5	n.a.	0.0	0	9	12	32
7/13	17:00	3	n.a.	0.0	0	21	16	32
7/14	7:30	5	n.a.	0.0	N5	9	14	32
7/14	17:00	2	n.a.	0.0	N5	27	19	31
7/15	7:30	1	n.a.	0.0	0	10	15	31
7/15	17:00	2	n.a.	0.0	N5	23	19	31
7/16	10:00	3	n.a.	0.0	S5	16	16	30
7/16	17:00	4	n.a.	0.0	0	19	17	30
7/17	10:00	4	n.a.	0.0	0	16	15	29
7/17	17:00	3	A	0.0	0	20	17	30
7/18	7:30	3	n.a.	2.5	0	12	14	30
7/18	17:00	4	A	0.0	0	16	17	31
7/19	7:30	4	B	0.1	0	11	14	34
7/19	17:00	4	n.a.	0.0	0	15	14	35
7/20	7:30	2	n.a.	1.0	0	14	13	34
7/20	17:00	4	B	0.0	N5	13	16	34
7/21	7:30	1	n.a.	3.0	0	8	9	32
7/21	17:00	1	n.a.	0.0	S5	24	18	33
7/22	7:30	1	n.a.	0.0	0	9	12	32
7/22	17:00	3	n.a.	0.0	S10	25	19	31
7/23	7:30	3	n.a.	0.3	0	14	16	30
7/23	17:00	2	n.a.	0.0	S5	26	20	29
7/24	10:00	1	n.a.	0.0	0	19	18	29
7/24	17:00	3	n.a.	0.0	S5	20	18	29
7/25	7:30	2	n.a.	0.0	0	10	16	28
7/25	17:00	4	n.a.	0.0	0	19	18	29
7/26	7:30	5	n.a.	0.0	0	9	13	29
7/26	17:00	3	n.a.	0.0	S5	22	17	29
7/27	7:30	1	n.a.	0.0	0	8	13	29
7/27	17:00	2	n.a.	0.0	N30	26	18	29
7/28	7:30	1	n.a.	0.0	0	14	15	28
7/28	17:00	1	n.a.	0.0	S10	24	18	27
7/29	7:30	4	A	2.0	0	14	16	27
7/29	17:00	3	n.a.	0.0	N5	18	17	27
7/30	7:30	1	n.a.	3.0	0	9	13	27
7/30	17:00	1	n.a.	0.0	N10	22	17	27
7/31	7:30	4	n.a.	3.0	0	9	13	28
7/31	17:00	2	n.a.	0.0	N5	20	18	27
8/01	7:30	1	n.a.	0.0	0	3	13	27
8/01	17:00	2	n.a.	0.0	S5	22	17	26
8/02	7:30	1	n.a.	0.0	0	4	14	26
8/02	17:00	2	n.a.	0.0	S10	21	18	25
8/03	7:30	5	n.a.	0.0	0	7	13	25

-continued-

Appendix C1.–Page 3 of 4.

		Sky	Precipitation			Temperature		River
Date	Time	Code	Code	Amount	Wind	Air	Water	Stage (cm)
8/03	17:00	2	n.a.	0.0	N15	23	17	24
8/04	7:30	1	n.a.	0.0	0	8	14	24
8/04	17:00	2	n.a.	0.0	V5	23	17	24
8/05	7:30	5	n.a.	0.0	0	8	14	24
8/05	17:00	4	n.a.	0.0	0	19	17	24
8/06	10:00	3	n.a.	0.0	0	19	14	24
8/06	17:00	4	n.a.	0.0	S5	19	17	23
8/07	7:30	4	n.a.	0.0	0	13	14	23
8/07	17:00	4	n.a.	0.0	S5	18	15	23
8/08	7:30	2	n.a.	0.0	0	12	15	23
8/08	17:00	1	n.a.	0.0	0	25	18	23
8/09	7:30	1	n.a.	0.0	0	6	15	22
8/09	17:00	1	n.a.	0.0	S10	29	19	22
8/10	7:30	1	n.a.	0.0	0	11	15	22
8/10	17:00	2	n.a.	0.0	SW10	19	19	22
8/11	7:30	2	n.a.	0.0	0	7	15	21
8/11	17:00	1	n.a.	0.0	NE5	25	17	20.5
8/12	7:30	5	n.a.	0.0	0	6	15	20
8/12	17:00	1	n.a.	0.0	N5	28	17	20
8/13	7:30	5	n.a.	0.0	0	7	14	20
8/13	17:00	5	n.a.	0.0	0	25	16	20
8/14	7:30	5	n.a.	0.0	0	12	14	20
8/14	17:00	5	n.a.	0.0	0	25	16	20
8/15	7:30	5	n.a.	0.0	0	10	15	19.5
8/15	17:00	5	n.a.	0.0	S10	22	16	19
8/16	7:30	4	n.a.	0.0	0	10	14	19
8/17	7:30	4	B	2.8	0	12	14	20
8/17	17:00	4	n.a.	0.0	0	19	16	20
8/18	7:30	4	n.a.	0.0	0	12	14	21
8/18	17:00	3	n.a.	0.0	N5	21	16	21
8/19	7:30	5	n.a.	0.0	0	9	14	21
8/19	17:00	5	n.a.	0.0	NW5	20	15	22
8/20	7:30	4	n.a.	0.0	SW10	10	13	21
8/20	17:00	4	n.a.	0.0	S5	13	13	21
8/21	7:30	4	B	10.0	S5	10	12	22
8/21	17:00	4	n.a.	0.0	S5	13	13	23
8/22	7:30	5	n.a.	1.0	0	5	10	25
8/22	17:00	4	A	0.0	SE20	12	11	26
8/23	7:30	4	A	8.5	S15	13	11	30
8/23	17:00	4	A	0.0	S20	13	12	32
8/24	7:30	4	B	7.4	0	11	11	35
8/24	17:00		A	0.0	W10	12	12	38
8/25	7:30	5	n.a.	2.0	0	5	10	43
8/25	17:00	3	n.a.	0.0	NW5	14	11	43
8/26	7:30	3	n.a.	0.0	0	3	10	40
8/26	17:00	3	n.a.	0.0	W5	13	10	37
8/27	7:30	4	n.a.	0.0	0	8	10	35
8/28	7:30	4	n.a.	8.0	0	10	10	33
8/29	7:30	4	n.a.	4.6	0	10	10	36

-continued-

Appendix C1.–Page 4 of 4.

		Sky	Precipitation			Temperature		River
Date	Time	Code	Code	Amount	Wind	Air	Water	Stage (cm)
8/29	17:00	4	n.a.	0.0	0	12	11	37
8/30	7:30	5	n.a.	1.8	0	8	10	39
8/30	17:00	3	n.a.	0.0	N5	15	11	41
8/31	7:30	3	n.a.	2.2	0	8	10	40
8/31	17:00	2	n.a.	0.0	W10	13	11	38
9/01	7:30	1	n.a.	0.0	0	-3	8	37
9/01	17:00	1	n.a.	0.0	0	14	11	36
9/02	7:30	2	n.a.	0.0	0	-2	8	35
9/02	17:00	4	n.a.	0.0	S10	12	9	34
9/03	7:30	4	B	1.6	S10	9	9	34
9/03	17:00	4	A	0.0	S10	11	9	35
9/04	7:30	4	n.a.	3.5	0	9	9	39
9/04	17:00	4	n.a.	0.0	0	14	10	41
9/05	7:30	4	A	0.1	0	10	9	43
9/06	7:30	4	n.a.	13.0	0	10	9	47
9/07	7:30	5	n.a.	0.0	ND	ND	9	58
9/08	7:30	ND	ND	ND	ND	ND	8	ND
9/09	7:30	ND	n.a.	9.0	ND	ND	9	58
9/10	10:00	ND	n.a.	0.0	ND	ND	9	68
9/10	17:00	ND	ND	0.0	ND	ND	ND	69
9/11	7:30	ND	n.a.	0.0	ND	ND	9	ND
9/12	7:30	ND	ND	ND	ND	ND	8	ND
9/13	7:30	ND	ND	ND	ND	ND	8	ND
9/14	10:00	4	n.a.	3.0	S5	ND	8	75
9/15	10:15	4	B	2.0	E15	11	8	76
9/16	10:00	3	n.a.	3.5	ND	7	9	91
9/16	17:00	ND	ND	0.0	ND	ND	ND	99
9/17	10:00	ND	n.a.	ND	ND	ND	8	101
9/17	17:00	3	n.a.	0.0	ND	ND	ND	100
9/18	10:30	3	n.a.	0.5	ND	6	7	100
9/18	17:00	3	n.a.	0.0	ND	ND	ND	99
9/19	10:00	4	n.a.	0.0	0	3	5	97
9/20	10:00	4	n.a.	0.0	0	7	6	93
9/20	17:00	4	n.a.	0.0	ND	ND	ND	91

Note: ND = No Data, n.a. = Not applicable.

[a] Sky condition codes:
0 = no observation
1 = < 1/10 cloud cover
2 = partly cloudy; < 1/2 cloud cover
3 = mostly cloudy; > 1/2 cloud cover
4 = complete overcast
5 = thick fog

[b] Precipitation Codes:
A = intermittent rain
B = continuous rain
C = snow
D = snow and rain
E = hail
F = thunder

Appendix C2.–Daily stream temperature summary from Hobo data logger at George River weir, 2005.

	Temperature (°C)				Temperature (°C)		
Date	**Avg.**	**Min.**	**Max.**	**Date**	**Avg.**	**Min.**	**Max.**
6/15	ND	ND	ND	8/03	16.0	14.5	17.7
6/16	ND	ND	ND	8/04	15.9	14.7	17.0
6/17	ND	ND	ND	8/05	15.4	14.3	16.3
6/18	ND	ND	ND	8/06	15.0	13.8	15.9
6/19	ND	ND	ND	8/07	14.9	14.2	15.5
6/20	ND	ND	ND	8/08	15.9	14.0	18.7
6/21	ND	ND	ND	8/09	17.5	15.6	19.4
6/22	ND	ND	ND	8/10	17.8	16.2	19.3
6/23	ND	ND	ND	8/11	16.9	15.7	18.0
6/24	ND	ND	ND	8/12	16.0	14.7	17.1
6/25	ND	ND	ND	8/13	15.4	14.3	16.5
6/26	ND	ND	ND	8/14	15.5	14.4	16.7
6/27	ND	ND	ND	8/15	15.9	15.1	16.7
6/28	ND	ND	ND	8/16	15.9	14.7	17.3
6/29	ND	ND	ND	8/17	15.7	15.0	16.5
6/30	ND	ND	ND	8/18	15.5	14.7	16.4
7/01	13.8	13.3	14.7	8/19	14.8	14.1	15.9
7/02	14.0	12.8	15.9	8/20	13.3	12.8	14.2
7/03	15.0	14.0	15.9	8/21	12.2	11.7	12.7
7/04	15.6	14.2	17.2	8/22	11.3	10.9	12.3
7/05	15.9	14.5	16.9	8/23	11.4	11.0	12.1
7/06	16.1	14.4	18.0	8/24	11.1	10.8	11.6
7/07	16.6	15.3	18.0	8/25	10.7	9.7	11.6
7/08	16.8	15.1	18.7	8/26	10.4	9.8	10.9
7/09	17.7	16.2	19.1	8/27	10.1	9.5	10.5
7/10	17.3	15.8	18.6	8/28	10.5	9.9	11.5
7/11	16.3	15.2	17.8	8/29	10.5	10.1	11.0
7/12	15.2	14.7	16.0	8/30	10.2	9.7	10.8
7/13	15.0	13.3	16.7	8/31	10.5	9.7	11.5
7/14	16.4	14.5	18.5	9/01	9.5	8.1	10.5
7/15	17.1	15.4	18.6	9/02	8.4	7.4	9.6
7/16	16.9	16.1	18.0	9/03	8.4	8.1	8.7
7/17	16.1	15.4	16.7	9/04	8.8	8.2	9.7
7/18	15.4	14.6	16.3	9/05	9.4	9.0	9.7
7/19	14.4	13.9	15.9	9/06	9.4	9.1	9.8
7/20	14.9	13.6	16.4	9/07	9.1	8.5	9.7
7/21	16.2	14.5	18.1	9/08	8.8	8.0	9.3
7/22	17.4	15.8	19.2	9/09	9.2	8.8	10.1
7/23	18.2	16.7	19.8	9/10	9.4	9.0	9.7
7/24	18.0	16.7	19.1	9/11	9.0	8.7	9.5
7/25	17.2	16.2	18.2	9/12	8.4	7.9	8.9
7/26	16.7	15.1	18.2	9/13	8.2	7.9	8.6
7/27	16.6	14.9	18.3	9/14	7.8	7.5	8.1
7/28	17.1	15.9	18.6	9/15	8.3	8.1	8.7
7/29	16.5	15.6	17.8	9/16	8.4	7.9	8.8
7/30	16.0	14.5	17.9	9/17	8.1	7.9	8.5
7/31	16.4	14.9	17.6	9/18	7.1	6.6	7.8
8/01	15.7	13.8	17.5	9/19	6.4	5.9	6.8
8/02	15.8	14.0	17.7	9/20	6.0	5.7	6.4

Appendix C3.–Stream discharge measurement at George River weir on 26 June, 2005.

Location: George River weir **Date:** 06/26/05

Description: Approx. 10 m upstream of weir rail **Gauge Height:** 42 cm

Crew: Rob Stewart, Cullan Lester

Comments: Water level is within a normal range for date. **Meter Type:** AA

Station Dist. (m)	Stream Depth (m)	Meter Height (m)	Substrate Description	Velocity (m/sec) Point	Mean Vert.	Mean Cell	Cell Depth (m)	Width (m)	Area (m^2)	Flow (m^3/sec)
0	0.00	0.00	river right bank	0.00	-	-	-	-	-	-
5	0.55	0.22	gravel	0.32	-	0.16	0.28	5.00	1.38	0.22
10	0.69	0.28	gravel	0.41	-	0.37	0.62	5.00	3.10	1.14
15	0.70	0.28	gravel	0.44	-	0.43	0.70	5.00	3.48	1.49
20	0.75	0.30	gravel	0.47	-	0.46	0.73	5.00	3.63	1.65
25	0.80	0.32	gravel	0.49	-	0.48	0.78	5.00	3.88	1.85
30	0.87	0.35	gravel	0.43	-	0.46	0.84	5.00	4.18	1.91
35	0.87	0.35	gravel	0.53	-	0.48	0.87	5.00	4.35	2.08
40	0.90	0.36	gravel	0.48	-	0.51	0.89	5.00	4.43	2.24
45	0.90	0.36	gravel	0.50	-	0.49	0.90	5.00	4.50	2.21
50	0.83	0.33	gravel	0.54	-	0.52	0.87	5.00	4.33	2.24
55	0.80	0.32	gravel	0.57	-	0.56	0.82	5.00	4.08	2.27
60	0.74	0.30	gravel	0.52	-	0.55	0.77	5.00	3.85	2.10
65	0.69	0.28	gravel	0.51	-	0.51	0.72	5.00	3.58	1.83
70	0.65	0.26	gravel	0.49	-	0.50	0.67	5.00	3.35	1.68
75	0.59	0.24	gravel	0.47	-	0.48	0.62	5.00	3.10	1.50
80	0.54	0.22	gravel	0.45	-	0.46	0.57	5.00	2.83	1.30
85	0.53	0.21	gravel	0.38	-	0.42	0.54	5.00	2.68	1.11
90	0.49	0.20	gravel	0.41	-	0.40	0.51	5.00	2.55	1.01
95	0.48	0.19	gravel	0.36	-	0.39	0.49	5.00	2.43	0.94
100	0.49	0.20	gravel	0.37	-	0.37	0.49	5.00	2.43	0.89
105	0.91	0.36	gravel	0.18	-	0.27	0.70	5.00	3.50	0.96
107	0.50	0.20	river left bank	0.00	-	0.09	0.71	2.00	1.41	0.12

Avg. Depth: 0.66 m Avg. Velocity: 0.41 m/sec

Max. Depth: 0.91 m Max.Velocity: 0.57 m/sec

Total Discharge: 32.8 m^3/sec

Appendix C4.–Stream discharge measurement at George River weir on 17 August, 2005.

Location: George River weir **Date:** 8/17/05

Description: 50 meters upstream of weir **Gauge Height:** 20 cm

Crew: R. Stewart

Comments: seasonal low water **Meter Type:** AA

Station **Dist.** (m)	Stream **Depth** (m)	Meter **Height** (m)	Substrate Description	**Velocity** (m/sec) Point	Mean Vert.	Mean Cell	Cell Depth (m)	Width (m)	Area (m^2)	Flow (m^3/sec)
0	0.00	0.00	river right	0.000						
5	0.45	0.18		0.196		0.10	0.23	5.00	1.13	0.11
15	0.60	0.24		0.275		0.24	0.53	10.00	5.25	1.24
25	0.79	0.32		0.335		0.31	0.70	10.00	6.95	2.12
35	0.81	0.32		0.315		0.33	0.80	10.00	8.00	2.60
45	0.75	0.30		0.384		0.35	0.78	10.00	7.80	2.73
55	0.60	0.24		0.344		0.36	0.68	10.00	6.75	2.46
65	0.47	0.19		0.301		0.32	0.54	10.00	5.35	1.73
75	0.30	0.12		0.224		0.26	0.39	10.00	3.85	1.01
85	0.19	0.08		0.186		0.21	0.25	10.00	2.45	0.50
95	0.00	0.00	river left	0.000		0.09	0.10	10.00	0.95	0.09

Avg. Depth: 0.45 m Avg. Velocity: 0.23 m/sec

Max. Depth: 0.81 m Max.Velocity: 0.38 m/sec

Total Discharge: 14.6 m^3/sec

Appendix C5.–Stream discharge measurement at George River weir on 27 September, 2005.

Location: George River weir

Date: 9/27/2005

Description: 100 ft upstream of weir site

Gauge Height: 95 cm

Crew: Dan Costello, Caroline Kvamme

Comments: High Water. This water level is near the upper limit of weir operation.

Meter Type: AA

Station **Dist.** (m)	Stream **Depth** (m)	Meter **Height** (m)	Substrate Description	**Velocity** (m/sec) Point	Mean Vert.	Mean Cell	Cell Depth (m)	Width (m)	Area (m^2)	Flow (m^3/sec)
0.0	0.00		Right Bank	0.000						
2.0	0.55	0.22		0.453		0.23	0.28	1.98	0.54	0.12
11.9	1.25	0.50		0.891		0.67	0.90	9.90	8.91	5.99
21.8	1.45	0.58		0.973		0.93	1.35	9.90	13.37	12.46
31.7	1.60	0.64		1.170		1.07	1.53	9.90	15.10	16.18
41.6	1.60	0.64		1.180		1.18	1.60	9.90	15.84	18.61
51.5	1.40	0.56		1.130		1.16	1.50	9.90	14.85	17.15
61.4	1.30	0.52		0.977		1.05	1.35	9.90	13.37	14.08
71.3	1.15	0.46		0.913		0.95	1.23	9.90	12.13	11.46
81.2	0.95	0.38		0.875		0.89	1.05	9.90	10.40	9.29
91.1	0.80	0.32		0.758		0.82	0.88	9.90	8.66	7.07
101.0	0.65	0.26		0.490		0.62	0.73	9.90	7.18	4.48
104.0	0.00	0.00	Left Bank	0.000		0.25	0.33	2.97	0.97	0.24

Avg. Depth: 0.98 m

Max. Depth: 1.60 m

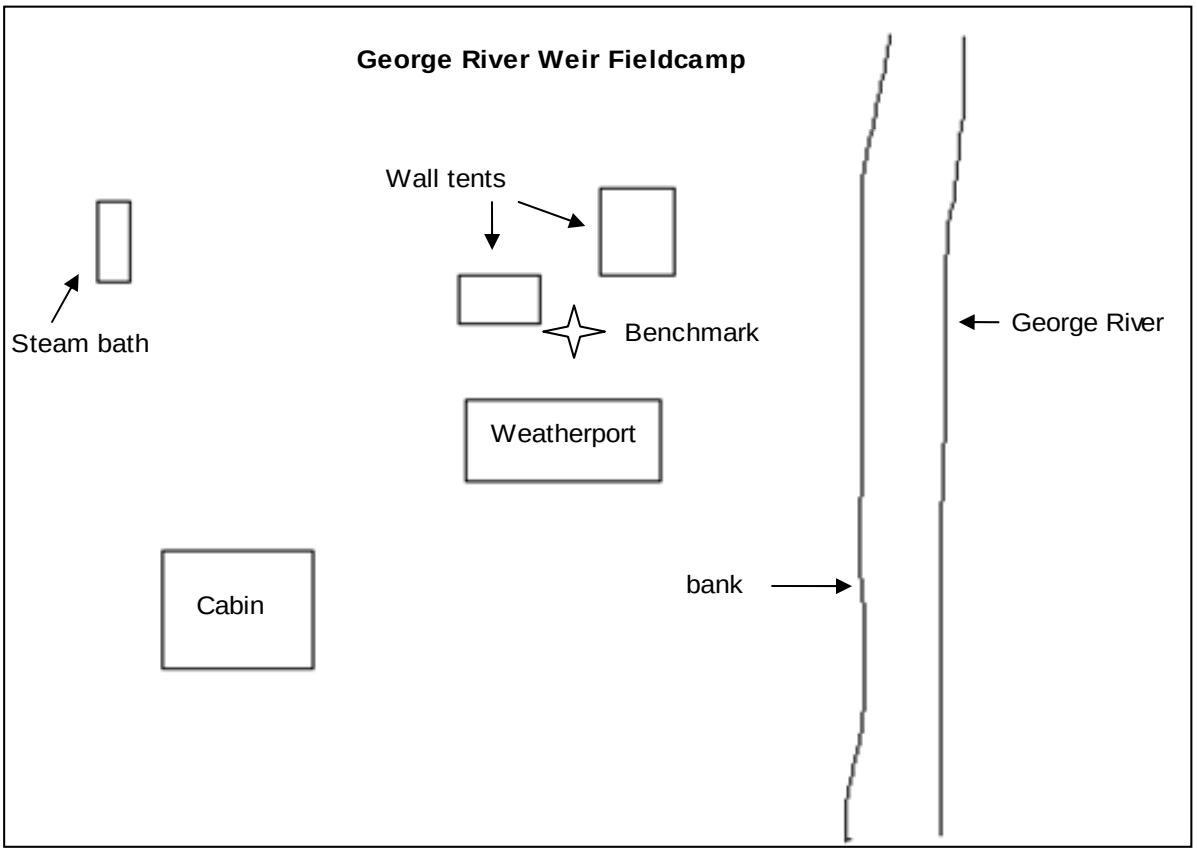
Avg. Velocity: 0.75 m/sec

Max.Velocity: 1.18 m/sec

Total Discharge: 117.1 m^3/sec

APPENDIX D. RIVER STAGE BENCHMARK

Appendix D1.–Location and description of a benchmark installed in 2005 for measuring river stage at George River weir.



Note: This benchmark consists of a 5 by 8 cm aluminum plate mounted on top of a tree stump approximately 20 cm in diameter, and represents a river stage of 300 cm. This benchmark was installed in 2005 as a stable alternative to benchmarks located along the river bank subject to ice damage, and correlates to benchmarks and river stage measurements maintained since 2000.