Regional Information Report No. 3A09-06

Salmon Age, Sex, and Length Catalog for the Kuskokwim Area, 2008

Annual Report for Project 07-303
USFWS Office of Subsistence Management
Fisheries Resource Monitoring Program

by

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December 2009

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, Special Publications and the Division of Commercial Fisheries Regional Reports. 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

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December 2009

Development and publication of this manuscript were partially financed by the USFWS Office of Subsistence Management under Cooperative Agreement No. 701817J646.

The Regional Information Report Series was established in 1987 and was redefined in 2006 to meet the Division of Commercial Fisheries regional need for publishing and archiving information such as project operational plans, area management plans, budgetary information, staff comments and opinions to Board of Fisheries proposals, interim or preliminary data and grant agency reports, special meeting or minor workshop results and other regional information not generally reported elsewhere. Reports in this series may contain raw data and preliminary results. Reports in this series receive varying degrees of regional, biometric and editorial review; information in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author or the Division of Commercial Fisheries if in doubt of the level of review or preliminary nature of the data reported. Regional Information Reports are available through the Alaska State Library and on the Internet at: http://www.sf.adfg.ak.us/statewide/divreprots/htlm/intersearch.cfm.

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This document should be cited as:
Molyneaux, D. B., A. R. Brodersen, and C. A. Shelden. 2009. Salmon age, sex, and length catalog for the Kuskokwim Area, 2008. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 09-06, Anchorage.

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The full set of appendices A through H are available at:

http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2009.06Appendices.pdf

Chinook salmon appendices A and B are available at:
http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2009.06Chinook.pdf

Chum salmon appendices C and D are available at:
http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2009.06Chum.pdf

Coho salmon appendices E and F are available at:
http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2009.06Coho.pdf

Sockeye salmon appendices G and H are available at:
http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2009.06Sockeye.pdf

ABSTRACT

The Kuskokwim Area has the largest subsistence salmon fisheries in Alaska, and in support of these fisheries, numerous projects have been funded through the Fisheries Information Services (FIS) Division of the U.S. Fish and Wildlife Service, Office of Subsistence Management to monitor Pacific salmon *Oncorhynchus* spp. escapements and subsistence harvest in the region. These projects include collection of samples that are used to estimate age, sex, and length (ASL) composition of salmon escapement and subsistence harvest. The *Kuskokwim salmon age-sex-length assessment continuation* project (FIS 07-303) provides the support required to process these ASL samples and compile the information into summary reports of use to managers, contributing project leaders, and other interested parties. The annual product of this project is a series of historical ASL summary reports (ASL Catalog) updated with current year results. This catalog is available at: http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2009.06Appendices.pdf.

Key words: age-sex-length, ASL, Pacific salmon, *Oncorhynchus* sp., Kuskokwim River, age-class composition, sex composition, length composition.

INTRODUCTION

The Kuskokwim Area as defined by the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries (CF) encompasses marine waters from Cape Newenham to the Naskonat Peninsula, including waters around Nunivak and St. Matthew Islands (Figure 1). Primary salmon producing systems are the Kuskokwim, Kanektok, and Goodnews Rivers, which drain into Kuskokwim Bay and support runs of Chinook *Oncorhynchus tshawytscha*, sockeye *O. nerka*, chum *O. keta*, pink *O. gorbuscha*, and coho salmon *O. kisutch*. All 5 species are harvested in area commercial, subsistence, and sport fisheries, and may be intercepted in fisheries located outside of the formal management area.

Age, sex, and length (ASL) data are collected annually from commercial and subsistence harvests, escapement, run timing and abundance monitoring projects in the Kuskokwim Area. Age, sex, and length data have been collected in the Kuskokwim Area since 1961 (Brannian et al. 2005) and have been cataloged in historical summaries since 1995 (Anderson 1995; Molyneaux and Dubois 1996; Molyneaux and Samuelson 1992). In 2001, subsistence harvest and abundance monitoring projects were initiated within the Kuskokwim drainage. These projects were jointly funded and operated by federal, state, and local tribal groups, all of which participated in the collection of ASL data from Pacific salmon *Oncorhynchus* spp. The United States Fish and Wildlife Service (USFWS) Office of Subsistence Management (OSM) has assisted by funding the processing of ASL data collected in the Kuskokwim Area.

Annual summaries of ASL data have been incorporated into each project's annual report, as well as within this historical catalog maintained by ADF&G. This report functions to provide (1) an overview of the research projects that collect the data summarized in the ASL catalog, (2) a description of the methods employed in the collection of these data, and (3) results, and trends observed in these data throughout the Kuskokwim Area. Reports from the actual ASL catalog are not incorporated into this document due to the large number and volume referred to here as Appendices A through H. This narrative document represents an annual report for USFWS OSM project FIS 07-303.

Summary ASL reports are available electronically at:
http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2009.06Appendices.pdf

OBJECTIVES

The objective of the USFWS OSM project FIS 07-303, *Salmon Age-Sex-Length Catalog for the Kuskokwim Area,* is to process, compile and analyze salmon scales, sex and length data collected in Kuskokwim Region fisheries and escapement projects. In 2008, this report consists of datasets from 11 escapement monitoring projects and catch sampling from the Kuskokwim River Chinook salmon subsistence fishery and commercial fisheries in 2 Kuskokwim Area districts.

ESCAPEMENT MONITORING

Annual assessments of salmon spawning escapements are monitored in the Kuskokwim Area with weirs, counting towers, sonar, and aerial surveys (Whitmore et al. 2005 2008; Linderman and Bergstrom 2006). Ground-based weir, tower (currently none in the Kuskokwim drainage), and sonar projects typically include ASL sampling. Samples are collected from salmon captured with beach seines, live traps, or by hook and line. Ground-based projects are typically operated from mid-June through mid-September, which encompasses the majority of the Chinook, chum, sockeye, and coho salmon migrations. Ground-based projects have been established throughout the drainage (Figure 1) ranging from 216 to 835 river kilometers (rkm) from the mouth (Table 1) of the Kuskokwim River.

Takotna River

The Takotna River joins the Kuskokwim River at rkm 752 (Table 1; Figure 1). Ground-based salmon escapement monitoring began in 1995 with a counting tower located near the community of Takotna (rkm 832), but no ASL sampling was conducted (Molyneaux et al. 2000). The tower project was replaced in 2000 with a resistance board weir located 83 rkm from the confluence of the Kuskokwim River, a total of 835 rkm from Kuskokwim Bay, and project objectives were broadened to include ASL sampling (Schwanke et al. 2001; Schwanke and Molyneaux 2002). The Takotna weir project is conducted jointly by ADF&G CF and the Takotna Tribal Council (Clark and Molyneaux 2003; Costello et al. 2008; Gilk and Molyneaux 2004). ASL samples have been collected from Chinook, chum, and coho salmon and are summarized in the ASL catalog.

Tatlawiksuk River

The Tatlawiksuk River joins the Kuskokwim River at rkm 563 (Table 1; Figure 1). Ground-based salmon escapement monitoring began in 1998 with a fixed-panel aluminum weir installed on the Tatlawiksuk River, 5 rkm upstream of its confluence with the Kuskokwim River (Linderman et al. 2004a). The fixed-panel weir was replaced with a resistance board design in 1999 that allowed the operational period to be extended through the coho salmon migration. The Tatlawiksuk weir project is conducted jointly by ADF&G CF and the Kuskokwim Native Association (Elison et al. 2009; Linderman et al. 2002; 2003a; 2004a; Stewart and Molyneaux 2005a) with funding assistance from USFWS OSM beginning in 2000 (project FIS 00-007 and FIS 04-310 continued as FIS 07-304). ASL samples have been collected from Chinook, chum, and coho salmon and are summarized in the ASL catalog.

Kogrukluk River

The Holitna River joins the Kuskokwim River at rkm 491 (Table 1; Figure 1). The Kogrukluk River is located in the upper reaches of the Holitna River drainage, 218 rkm upstream of the confluence of the Kuskokwim and Holitna Rivers. The weir is located on the Kogrukluk River, approximately 1 rkm upstream of the confluence of the Kogrukluk and Holitna Rivers and 710 rkm from Kuskokwim Bay (Table 1; Figure 1). Kogrukluk River weir has the most extensive history of ground-based salmon escapement monitoring in the Kuskokwim Area. Counting tower projects were operated on the Kogrukluk River from 1969 through 1978 (Baxter 1976, 1977; Kuhlmann 1973, 1974, 1975; Yanagawa 1972a, b). Both a weir and tower were operated from 1976 through 1979. The Kogrukluk River escapement project has been operated solely as a fixed picket weir from 1980 until present (Shelden et al. 2005; Williams and Sheldon *In prep*). ASL sampling of Chinook salmon began in 1972 (Yanagawa 1973). Chum and sockeye salmon were not regularly included in ASL sampling until 1976 when a fixed picket weir was first installed (Baxter 1976). Sampling of coho salmon started in 1981 when the operational period of the weir was extended into August and September (Baxter 1982). Sampling sockeye salmon for ASL information was discontinued in 2007 due to the high frequency of reabsorbed scales at this location (710 rkm from salt water); however, collection began again in 2008, to focus specifically on fresh water growth. Historical data for sockeye salmon have not been included in catalog reports. The project is conducted by ADF&G CF (Williams and Sheldon *In prep*) and supplemented with technicians from Orutsararmiut Native Council. The ASL samples collected from Chinook, chum, and coho salmon are summarized in the ASL catalog.

George River

The George River joins the Kuskokwim River at rkm 446 (Table 1; Figure 1). Ground-based salmon escapement monitoring began in 1996 with a fixed-panel aluminum weir established 7 rkm upstream of the confluence. The fixed-panel weir was replaced with a resistance board design in 1999, which allowed the operational period to be effectively extended through the coho salmon migration (Stewart et al. 2009; Linderman et al. 2003b; 2004b; Molyneaux et al. 1997). The project is conducted jointly by ADF&G CF and Kuskokwim Native Association (Stewart et al. 2009). ASL samples have been collected from Chinook, chum, and coho salmon and are summarized in the ASL catalog.

Aniak River

The Aniak River joins the Kuskokwim River at rkm 307 (Table 1; Figure 1). Ground-based salmon escapement monitoring began in 1980 with the use of non-configurable sonar, which was deployed approximately 16 rkm upstream of the Kuskokwim River confluence (Schneiderhan 1981). The project was redesigned in 1996 to incorporate user-configurable sonar technology and chum salmon ASL sampling with beach seines (Vania 1998). Methods changed again in 2004 to incorporate advances in Dual-frequency Identification Sonar (DIDSON) (McEwen *In prep*). The reported passage estimates are a mix of species; chum salmon dominate during most of the annual operational period, but the sonar counts are not apportioned by species. The project is conducted by ADF&G CF. ASL samples collected from chum salmon are summarized in the ASL catalog and sonar type descriptions are included to mitigate inappropriate comparisons.

Salmon River

The Salmon River is located in the upper reaches of the Aniak River, about 96 rkm from the confluence of the Kuskokwim and Aniak Rivers and 403 rkm from Kuskokwim Bay (Table 1; Figure 1). Ground-based salmon escapement monitoring began in 2006 and continues through the present, using a fixed-panel aluminum weir that was installed approximately 1 rkm upstream of the confluence of the Aniak and Salmon Rivers (Table 1; Figure 1). The weir operates from mid June through mid-August. This project is conducted jointly by ADF&G CF and Kuskokwim

Native Association as a component of several mark–recapture studies. ASL samples have been collected from Chinook and chum salmon and are summarized in the ASL catalog.

Kalskag Fishwheels

The Kalskag Fishwheels site is located upstream of the village of Kalskag at river mile 168 (Table 1; Figure 1). This location was chosen during a feasibility study conducted in 2001, focused on providing a total abundance estimate of Kuskokwim River coho salmon using mark–recapture methods. In 2002, a project was funded by the Western Alaska Salmon Fisheries Disaster Mitigation Research Plan (WASFDP) and was expanded to include tagging initiatives for sockeye and chum salmon (Pawluk et al. 2006). Since 2001, the Kalskag Fishwheels have proven to be a valuable platform for a variety of short-term cooperative research projects, including:

- Chinook salmon (2002–2007): abundance estimates (Stuby 2007) and run reconstruction (AYK SSI Project No. 45554) based on radiotelemetry;
- Chum salmon (2004): genetic and morphological sampling to determine the stock composition and run-timing of Kuskokwim River fall chum (Gilk et al. 2005);
- Sockeye salmon (2005–2007): combining radiotelemetry and juvenile salmon sampling and scale analysis to address information gaps regarding distribution and biology of this species in the Kuskokwim River drainage (Gilk and Molyneaux *In prep*);
- Broad whitefish (2004–*present*): assistance with a USFWS radiotelemetry to chart migration within the Kuskokwim River drainage from the upper river to near shore marine waters (Ken Harper, USFWS KNWR FRO, Kenai);
- Coho salmon (2008–2009): mark–recapture to provide abundance estimates as a basis for run reconstructions and radiotelemetry to determine distribution within the Kuskokwim River drainage (AYK SSI Project No. 45565);
- Sockeye salmon (to be conducted 2010–2012): mark–recapture to provide abundance estimates as a basis for run reconstructions and radiotelemetry to determine distribution within the Kuskokwim River drainage (AK SSF);

Most of the above mentioned projects collect ASL samples from fish captured during tagging operations, and the objective of sample collection is to collect paired data on tagged fish, rather than to determine composition of the run at that location. Therefore, ASL statistics from this project are not considered representative of the migration of a given species past this location. Samples taken from the Chinook, sockeye, and coho radiotelemetry projects are summarized in the ASL catalog.

Tuluksak River

The Tuluksak River joins the Kuskokwim River at rkm 192 (Table 1; Figure 1). Ground-based salmon escapement monitoring occurred from 1991 through 1994 when USFWS operated a weir at approximately rkm 264 (Harper 1995a-c, 1997). With support from the Tuluksak IRA Council, weir operations began again in 2001 under the management of the USFWS using a resistance-board weir (Gates and Harper 2002; Zabkar and Harper 2004; Zabkar et al. 2005, 2006). A new site was chosen 16 rkm downstream from the previous site (rkm 248). For all years of operations, staff from ADF&G CF has processed ASL samples and provided data summaries to USFWS for inclusion in annual project reports for FIS 07-307. ASL samples have been collected from Chinook, chum, sockeye, and coho salmon and are summarized in the ASL catalog.

Kwethluk River

The Kwethluk River joins the Kuskokwim River at rkm 131 (Table 1; Figure 1). Ground-based salmon escapement monitoring occurred for 1 year in 1992 when the USFWS operated a weir at approximately rkm 30 of the Kwethluk River (Harper 1998). The Association of Village Council Presidents (AVCP) in cooperation with ADF&G operated a counting tower in place of the weir at a nearby location from 1996 through 1999, but success was limited (Cappiello and Sundown 1998; Chris and Cappiello 1999; Hooper 2001). Weir operations were reinitiated in 2000 by USFWS in cooperation with the Organized Village of Kwethluk and funding provided by USFWS OSM (FIS 07-306). Since 2000 a resistance board weir has been operated within the vicinity of rkm 216 (Roettiger et al. 2004). In 2005, the Kwethluk River weir did not operate due to early and prolonged flood conditions that prevented installation and made later season operation impractical (T. Roettiger, USFWS Yukon Delta National Wildlife Refuge, Bethel; personal communication). For all years of operations, staff from ADF&G CF has processed Kwethluk ASL data, and since 2000 has provided summaries to USFWS for inclusion in annual project reports (FIS 00-019 continued as FIS 07-306). ASL samples have been collected from Chinook, chum, sockeye, and coho salmon and are summarized in the ASL catalog.

Kanektok River

The Kanektok River joins the marine waters of Kuskokwim Bay near the community of Quinhagak (Figure 1). The Kanektok River is the main salmon spawning stream in District 4. Various efforts have been made to incorporate ground-based salmon escapement monitoring in the Kanektok River (tower: ADF&G 1960, 1961, 1962; sonar: Huttunen 1984a, 1985, 1986, 1988; Schultz and Carey 1982; Schultz and Williams 1984), but all were discontinued due to site limitations, technical obstacles, and budget reductions. Monitoring initiatives commenced again in 1996 with a counting tower, but success was limited (Fox 1997). Improvements in 1997 allowed for moderate success that year (Menard and Caole 1998), but the tower was inoperable in 1998 and 1999. Escapement monitoring efforts transitioned to a resistance board weir in 2000 at a new site located near rkm 68; however, success was limited the first 2 years (Estensen 2002a; Estensen and Diesinger 2003, 2004; Linderman 2000, 2005a; Pawluk et al. 2007; Clark et al. 2007). The current weir project is operated jointly by ADF&G CF and the Native Village of Quinhagak with funding support from USFWS OSM (FIS 01-118 continued as FIS 07-305).

In 2008, due to a late spring thaw and flooding conditions, the Kanektok River weir did not become operational until 23 July, by which most of the Chinook salmon run had already passed up river. ASL information was collected from all species, but because samples were weighted more heavily towards the middle and end of the runs, data are presented in summary format only, and not included in grand totals. All data from past years in which ASL samples were collected from Chinook, chum, sockeye, and coho salmon are summarized in the ASL catalog.

Middle Fork Goodnews River

The Middle Fork Goodnews River joins the Goodnews River at about rkm 10 (Figure 1). The Goodnews River in turn drains into the marine waters of Goodnews Bay, which further drains into the larger Kuskokwim Bay. Ground-based salmon escapement monitoring began in 1981 with the establishment of a counting tower at about rkm 5 of the Middle Fork Goodnews River[1] (Menard 1998; Schultz 1985, 1987; Schultz and Burkey 1989). Annual operating procedures began to include some form of ASL sampling by 1985, with methods including carcass sampling and beach seining. The tower project was replaced with a fixed panel aluminum weir in 1991, and then with a resistance board weir in 1997, which allows for operation through the pink and coho salmon migrations (Estensen 2002b, 2003; Linderman 2005b; Menard 1998, 1999, 2000; Pawluk and Jones 2007; Stewart 2004, Clark et al. 2007). ADF&G CF operates the project with funding support from USFWS OSM (FIS 00-027 continued as FIS 07-305). ASL samples have been collected from Chinook, chum, sockeye, and coho salmon and are summarized in the ASL catalog.

COMMERCIAL FISHERIES

The Kuskokwim Salmon Management Area is currently divided into 4 commercial fishing districts (Figure 1). The boundaries of these districts have changed over the years as described in annual management reports (e.g., Burkey et al. 1998; 1999; Ward et al. 2003; Whitmore et al. 2005). District 1 is located in the lower Kuskokwim River and currently extends from Kuskokwim Bay to Bogus Creek, a distance of 203 rkm. District 2 spans a distance of approximately 60 rkm starting in the middle Kuskokwim River, from near Kalskag to Chuathbaluk. District 4 is located in the marine waters of Kuskokwim Bay near the community of Quinhagak and is managed as a terminal fishery supported by the salmon production of the Kanektok River, the principle salmon-producing stream draining into that district. District 5 is located in Goodnews Bay and is managed as a terminal fishery supported by the salmon production of the Goodnews River.

Drift gillnets are currently the principal gear type used in all Kuskokwim Area commercial salmon fisheries (Whitmore et al. 2005). Set gillnets were once common in some locations during the early development of the fisheries but this practice has largely disappeared (Whitmore et al. 2005). Prior to 1985 commercial fishermen in the Kuskokwim River were unrestricted as to the gillnet mesh size they used during the June Chinook fishery, and many used 8 or 8.5 inch (20 or 22 cm) mesh sizes. Typically, in late June and early July, chum salmon would become the focus of the commercial fishery, at which point, mesh sizes would be restricted to 6 inches (15.2 cm) or smaller.

Since 1985 all Kuskokwim Area Commercial fishing districts have been restricted to gillnet mesh sizes of 6 inches (15.2 cm) or smaller (Whitmore et al. 2005). Commercial fishermen in Kuskokwim Bay districts have always been restricted to the smaller mesh sizes. Results from commercial catch sampling described in this catalog are from restricted mesh openings unless stated otherwise. ASL samples collected from Chinook, chum, sockeye, and coho salmon from Districts 1, 4 and 5 are summarized in the ASL catalog.

BETHEL TEST-FISHERY

A drift gillnet test fishery was established on the main stem Kuskokwim River near Bethel in 1984 to provide fishery managers with a daily index of relative salmon abundance and run timing (Bue 2005; Bue and Martz 2006; Molyneaux 1998). The project is located at rkm 106,

[1] In the literature the Middle Fork Goodnews River weir /tower are often misleadingly referred to as the “Goodnews River weir/tower”; in actuality the project has always been located on the middle fork of the Goodnews River.

near the geographic midpoint of District 1. From early June through late August the crew conducts 3 or 4 systematic gillnet drifts beginning 1 hour after high tide. The drifts are done at 3 stations distributed across the width of the channel. Each drift is 20 minutes in duration. Two 50 fathom gillnets are used, one net is hung with 5 3/8-inch mesh and the other with 8-inch mesh. The 2 gillnets are rotated between the 3 stations following a systematic schedule. Both mesh sizes are employed from early June through about 10 July when Chinook, sockeye and chum salmon are present. Use of the 8-inch mesh is discontinued after about 10 July when Chinook abundance diminishes. Test fishing with the 5 3/8-inch mesh continues until late August. Collection of ASL information from the test fishery catches has been sporadic and limited to more recent years. ASL data from Chinook, chum, sockeye, and coho salmon are summarized in the ASL catalog.

Historically, other test fisheries have been attempted in the Kuskokwim River: Kwegooyuk test fishery, 1966–1983 (Baxter 1970; Huttunen 1984b); Eek test fishery, 1988 to 1994 (unpublished); Kuskokwim River subsistence test fishery, 1988 to 1990 (Kuskokwim Fishermen's Cooperative 1991); Aniak test fishery, 1992 to 1995 (unpublished); Chuathbaluk test fishery, 1992 to 1993 (unpublished); and the Lower Kuskokwim River test fishery, 1995 (unpublished). Most test fisheries were initiated at the prompting of groups other than ADF&G, and all were eventually discontinued. Some of the projects incorporated salmon ASL sampling, but the results are not currently reported in our ASL catalog.

SUBSISTENCE FISHERIES

The Kuskokwim Area supports one of the largest subsistence salmon harvests in the State of Alaska (ADF&G 2003). Subsistence fisheries in this area are prominent and vital elements of the culture and livelihood of many local residents. Subsistence harvest occurs throughout the Kuskokwim Area, but most effort and harvest occurs in the lower 203 rkm of the Kuskokwim River in District 1 (Table 1; Figure 1). Gear types used by subsistence salmon fishermen include set gillnets, fish wheels, rod and reel, seines, and spears; however, drift gillnets are overwhelmingly the most common contemporary gear type used (Coffing 1991[2]; Oswalt 1990).

Unlike the commercial fishery, there are no restrictions on mesh size for subsistence gillnets. Fishermen have traditionally preferred 8.0 to 8.5-inch (20 to 22 cm) mesh sizes which target the larger Chinook salmon; however in 2008, subsistence fishermen broke from tradition by using more then one mesh size during their harvest, and of the 46 fishermen contracted by ADF&G to collect ASL from their catch, 55.6% used mesh sizes 7.5-inch or smaller (Table 3). Chinook salmon are the only species sampled for ASL information from the subsistence harvest and as of 2004 sampling has been limited to the lower Kuskokwim River (Figure 1).

A pilot project conducted by ADF&G to collect complete ASL data from subsistence caught Chinook salmon occurred in 1993, 1994, and 1995 (DuBois and Molyneaux 2000). The initiative was discontinued due to a lack of resources to execute the program. The program was re-established and expanded in 2001 through resources provided by the OSM in coordination with ADF&G CF and various Tribal organizations (DuBois et al. 2002). Between 2001 and 2003, 3 projects were funded by OSM: FIS 01-023 (upper river), FIS 01-225 (middle river), and FIS 01-132 (lower river). The last was continued as FIS 08-302. In 2004, the upper and middle river

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[2] Coffing, M. Unpublished. 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.

projects were discontinued, leaving only the lower Kuskokwim River subsistence sampling project intact from 2004 through 2008 (Molyneaux et al. *In prep*). In 2008, USFWS initiated a project to study the effects of subsistence fishing on the Tuluksak River (FIS 08-351), and those data were included in subsistence ASL totals. The ASL catalog contains summaries for subsistence Chinook salmon samples collected from 1993 through 1995 and more complete summaries for data collected since 2001.

SPORT FISHERIES

Sport fishing activity is relatively low in the Kuskokwim Area. Moderate effort does occur in a few specific locations, such as the Kanektok, Goodnews, Kisaralik, and Aniak Rivers (Howe et al. 1996). Professional sport fishing guides focus mostly on these 4 river systems, but there are a growing number of guides expanding into other locations such as the Holitna, George, Oskawalik, and Holokuk Rivers. Collection of ASL information from sport harvest is limited and not reported in the catalog.

METHODS

SAMPLING STRATEGIES

In the Kuskokwim Area, the basic sample design for ASL is a stratified random sample using one of 3 collection methods. The preferred method of sample collection attempts to distribute sampling effort evenly across the salmon run in discreet events with sample sizes sufficient to determine ASL composition in 3 or more snap shots. This method, termed “pulse sampling”, is employed for species and at locations that provide relatively consistent sampling opportunity (e.g. chum and coho at escapement projects). Pulse sampling has proven to be impractical for several Chinook salmon escapements because of issues of relative abundance; consequently, a “daily sampling” method is used. Commercial and subsistence fisheries tend to provide fewer and less consistent opportunities for sample collection. Samples are collected from these fisheries on an opportunistic basis using a “grab sampling” method (Geiger and Wilbur 1990).

Pulse Sampling

The pulse sampling method is essentially a stratified random sampling technique, in which ASL samples are collected periodically over the duration of the migration to account for temporal changes in ASL composition. Ideally, a series of temporally well-distributed pulse samples are collected for each species as the population passes through an access point, such as a weir or test fishery, over time. These samples are used to characterize each escapement or catch.

Each population is sampled a minimum of 3 times during a season, representing the early, middle, and late portions of the run. However, variability exists in salmon run timing between years. Therefore, samples are usually collected in more than 3 pulses within a season to ensure sampling of each portion of the run. The collection of additional pulse samples also improves accuracy and resolution for detecting temporal changes in the ASL composition of the escapement or catch. Well spaced pulse samples have greater power for detecting temporal changes in the ASL composition over other methods, such as random sampling, systematic sampling, or closely spaced grab sampling (Geiger and Wilbur 1990).

The sample size of each pulse is determined following conventions described by Bromaghin (1993). To achieve 95% confidence intervals for an age sex composition, no wider then ±10% (α=0.05 and d=0.10), we assume 10 age-sex categories for Chinook salmon (n=190), 10 age-sex categories for sockeye salmon (n=190), 8 age-sex categories for chum salmon (n=180), and 6 age-sex categories for coho salmon (n=168). To account for unreadable scales and collection errors we increased sample sizes by 20%, providing a minimum sample goal for each species: 230 Chinook, 230 sockeye, 220 chum, and 200 coho salmon. The need for achieving these sample goals are weighed against the need for collecting each pulse sample over a relatively brief period of time. Consequently, the sample goals serve as guidelines rather than rigid requirements. Therefore, sample sizes are usually adequate to meet goals for precision.

Daily Sampling

The daily sampling method is a stratified random sample, in which ASL samples are collected in small numbers on a near daily basis throughout the duration of the migration. Samples are temporally well distributed and sufficient to describe the ASL composition of the annual migration to the desired confidence (95% CI no greater than ±10%). Samples are stratified post season similar to pulse sampling to demonstrate the possibility of intra annual trends in composition; however, sample sizes are generally too small to provide the desired confidence on the stratum level.

Daily sampling is the preferred method for sampling Chinook salmon because of their small run sizes relative to other salmon species. Appropriate sample sizes are determined by following conventions described by Bromaghin (1993) which are mentioned above in Pulse Sampling. Sample sizes vary slightly between projects based on relative abundance of salmon and feasibility of sample collection. At projects where larger samples are realistic, sample sizes are increased to allow the possibility of greater confidence within strata (e.g. Kogrukluk River). At projects with relatively small Chinook salmon populations, the finite population correction is used to determine sample size (e.g. Takotna River, Elison et al. 2009). Sample sizes for Chinook salmon at each of the Kuskokwim River escapement projects are as follows: Takotna River weir, 169, Tatlawiksuk River weir, 228, Kogrukluk River weir, 499, and George River weir, 348 fish.

Grab Sampling

The grab sample method is essentially a random sampling technique in which ASL samples are collected opportunistically over the duration of the migration to account for temporal changes in ASL composition. The grab sampling method (Geiger and Wilbur 1990) is employed at locations and projects where there is no guarantee that each salmon in the harvest has an equal chance of selection (random sample) or that every i^{th} fish can be sampled (systematic sample). The grab sampling method is used to collect information from Kuskokwim Area commercial salmon and from Kuskokwim River subsistence Chinook salmon harvests where sampling opportunity is often inconsistent.

ASL samples from commercially caught Chinook, chum, sockeye, and coho salmon in the Kuskokwim Area are collected by ADF&G staff. Sampling goals for commercial fisheries are similar to those for escapement projects and follow conventions described by Bromaghin (1993). The sample size goals for each sample by species are: 230 Chinook, 230 sockeye, 220 chum and 200 coho salmon. As with pulse sampling, an effort is made to collect one grab sample from each third of the run for each salmon species. Due to the often inconsistent nature of commercial fishing schedules, these grab samples may not be well distributed across the run.

ASL samples from subsistence harvested Chinook salmon in the Kuskokwim Area are most often collected by individuals recruited from various local communities to sample their subsistence catch through time. It is assumed that sampling effort is proportional to subsistence salmon harvest and representative of the overall subsistence harvest. An effort is made to recruit as many participants as possible to ensure representative coverage of the Chinook salmon subsistence harvest. An overall ASL sampling goal of 2000 samples has been established for the lower Kuskokwim River Chinook salmon subsistence fishery. However, individual samplers are encouraged to collect as many samples as possible throughout the Chinook salmon subsistence fishing season in order to ensure that the goal is met. Due to the often inconsistent nature of subsistence fishing schedules, these grab samples may not be well distributed across the run.

Strata Determination

Viewed from a fixed location, such as an escapement-monitoring project or a fishing district, the ASL composition of an upstream-migrating salmon population may change over the course of the season; i.e. differences in migration timing exist within and between Kuskokwim River salmon stocks (Pawluk et al. 2006; Stuby 2007). Quinn (2005) describes an often observed pattern of older or larger fish preceding smaller fish within the migration of particular stocks and across larger mixed stock migrations. Each year, salmon are sampled at such fixed locations to estimate ASL compositions of the respective escapement or catch.

The term "stratum" is used here to describe an interval of time during which fish pass a given point such as a weir or tower project, or are harvested from a given location such as a commercial fishing district. The time interval usually spans approximately 7 days, but the duration may vary from one stratum to the next based on abundance and/or sampling opportunity. For example, the first stratum for chum salmon at a weir project may extend from 18 through 30 June, while the second stratum may extend from 1 to 6 July. The yearly migration is partitioned postseason into several strata based on the number and temporal distribution of ASL samples compared with the volume of observed fish passage. Collectively, the strata set for a given species encompasses the entire annual passage or harvest at a given location.

The ASL composition of a stratum is estimated from fish that are sampled at some time within that stratum. The samples may have been taken evenly throughout the stratum, from the midpoint, or weighted towards one end of the time interval. In practice, the sample distribution is driven by fish abundance and the availability of resources to sample the fish. For example, early in the migration, the relative abundance of a given species is low. Although small numbers of fish may be noted daily, densities may be too low to feasibly collect a pulse sample. Therefore, the first stratum of the season may span 10 to 20 days with the representative samples collected only in the last few days of the stratum. For clarity, appendices that make up this catalog list both the sample dates and the stratum dates.

Although samples are collected with a strata framework in mind, the final partitioning occurs postseason. Postseason partitioning allows the distribution of samples to be viewed in context with the overall distribution of the population. Sample sizes often fall short of weekly pulse sampling goals, thus strata partitioning is subjective in order to allow adequate numbers of samples to be applied to each third of the run.

A well distributed sample of Chinook salmon provided through daily sampling is treated as a single sample or stratum for statistical analysis. However, post season stratification is applied to allow researchers to look for general intra annual trends in ASL composition and for comparison across projects and across years. Presenting data in this manner also allows researchers to make reasonable comparisons with data from previous years.

In past years the seasonal ASL composition of harvest or escapement populations was estimated only when the distribution of samples would allow a minimum of one stratum for each third of the annual harvest or passage. This "rule of thirds" helped account for seasonal dynamics in the ASL composition of most species. When sample sizes and distribution did not meet the above criteria, sample results were recorded, but no season estimates were presented in the catalog. Due to the smaller run size of Chinook salmon at some Kuskokwim Area escapement projects, technicians were seldom able to collect enough samples to accurately characterize the run based upon the "rule of thirds" objective. Sample collection design and sampling expectations were adjusted to account for these limitations while meeting the objective of providing an estimate of ASL composition that takes intra annual variation into account.

Age, Sex and Length Sampling Procedures

The Age, Sex and Length sampling protocol consists of removing scales from the preferred area of the fish for use in age determination (INPFC 1963). Generally 1 scale is taken from each sockeye and chum salmon. Three scales are taken from Chinook and coho salmon to account for a high incidence of regenerated freshwater annuli. At some escapement projects, where scale absorption can be problematic, multiple scales are taken from chum salmon. All scales are mounted on gum cards. Except where noted, sex is determined by visually examining external morphological characteristics such as development of the kype, roundness of the belly, presence or absence of an ovipositor, and overall size. Length is measured to the nearest millimeter from mid eye to the fork of the tail. Examples of measuring equipment include calipers, meter stick, fish cradle, and computerized fish measuring board. Some data sets, especially commercial samples prior to about 1991, may include measurements taken with cloth tapes, which include the body curvature and are therefore slightly longer than those taken with rigid measuring apparatus. Data are recorded in field notebooks, on tally sheets, on computer mark–sense forms, or logged electronically on a computerized fish measuring board or hand held data logger. The original scale cards, acetates and data forms are archived at the ADF&G office in Anchorage.

Escapement Sampling

Pulse sampling is used to collect escapement ASL data from salmon passing weirs, counting towers, and tributary sonar sites. The goal is to estimate the seasonal ASL composition of the spawning population within a given tributary. Weir samples are generally obtained from traps built into the weir. Beach seines or gillnets are used at counting towers and sonar sites. Sample sizes and sampling frequency have varied over the years. During some years, a small number of fish were sampled each day, in others a larger daily sample was taken until a pre-determined sample size was achieved for the week. From 1993 through 2007 area staff has employed the latter method where fish are sampled in pulse samples over a short time interval (i.e., 1 to 7 days) followed by a number of days without sampling. Pulse samples or daily samples are taken throughout the season to create a series of 'snap-shots' of ASL composition.

Commercial Catch Sampling

Commercial salmon harvest is sampled for ASL data as fishermen deliver their catch to floating and shore-based processors located in or near the villages of Bethel, Quinhagak, and Goodnews Bay. The goal is to estimate the seasonal ASL composition of the population of salmon harvested in the District 1, 4, and 5 commercial fisheries. Commercial catch sampling is similar to pulse sampling in design and practice. However, inconsistent sampling opportunity qualifies commercial catch ASL as grab sampling. Sampling occurs after the salmon are off-loaded from fishing boats. Off-loading crews assist by depositing salmon in species-specific totes without regard to sex, size or stage of maturity; ADF&G staff then sample fish from these totes. In Kuskokwim Bay fisheries, crews sometimes obtain samples from an offshore tender or individual boats as deliveries are made. In either case, the sample from each day generally includes fish from several boats, but this variable is not monitored and in some instances a sample may come from as few as 2 or 3 boats. Samples from Kuskokwim Bay have a greater likelihood of coming from small numbers of deliveries because of the limited resources available for collecting samples. The mesh size used by fishermen varies, but it is assumed to be within the legal range of specifications. Time and logistical constraints prohibit interviewing fishermen for information regarding mesh size or the exact location fish were caught. Department crews are instructed to sample in a manner which guards against size or sex bias. This usually entails sampling all the fish from an individual tote, particularly for Chinook salmon.

Sex has been confirmed for most salmon sampled from the commercial fishery starting in 1997. Sex identification is done by making a small incision into the abdominal cavity of each fish to visually inspect for the presence of ovaries or testes. Strata with confirmed-sex fish are identified in the appropriate reports by footnotes.

Subsistence Catch Sampling

Until recently few samples from the subsistence Chinook harvest were taken each year. These few samples were collected from the harvests of a small number of subsistence fishermen. Most samples were collected from the Bethel area, but in a few instances samples were also collected from the Aniak area. Prior to 1992, samples were limited to scales removed from fish that were hanging on drying racks. Sex and length could not be determined and details about the harvest method were lacking. In 1992, fish were sampled in the round and included sex and length information. From 1993 through 1995, a small number of subsistence fishermen were recruited and trained to collect ASL data from their catches. The fishermen collected 3 scales from each fish, and recorded sex as determined by internal examination of gonads, and length as determined with a meter stick. The fishermen also recorded gear type (e.g., set net or drift gillnet), mesh size, date of capture and the location of capture. Fishermen received monetary compensation for the samples. The program was discontinued in 1996 due to the time required for training and inseason follow-ups, and the difficulties in recruiting participants.

A second ASL sampling program for subsistence caught Chinook salmon was initiated in 2001 and continues thru to the present (Molyneaux et al. *In prep*). This project is operated in cooperation with non-government organizations, and non-agency participants that include subsistence fishermen, subsistence household members, or other community members who sample fish caught near their local communities or fish camps (DuBois et al. 2002; Molyneaux et al. 2004a; b, 2005). Participants are trained in sampling technique by technicians and biologists from ADF&G or one of several non-government cooperating groups including Orutsararmiut Native Council. Participants collect samples using a grab sampling method from their own catch. Sample limits (number of fish samples) were not placed on individual participants and participants were selected based on a willingness to sample all season and sample all fish caught during each sampling event. Participants were also encouraged to seek permission to sample from neighboring fish camps. Participants collected 3 scales from each fish, and recorded sex as determined by internal examination of gonads, and length as determined with a meter stick. Participants also recorded gear type (e.g., set net or drift gillnet), mesh size, date of capture and the location of capture. Participants received monetary compensation for the samples.

DATA PROCESSING AND REPORTING

Age Determination

Age is determined by examining the annuli of scales taken from the preferred area of the fish (INPFC 1963). The scales, which are mounted on gum cards, are impressed in a cellulose acetate using methods described by Clutter and Whitesel (1956). The scale impressions are magnified with a microfiche reader and age is determined through visual identification of annuli. Ages are reported on data forms or directly entered into computer ASCII files. Since 1985, all ages have been recorded using European notation[3]. Gilbert-Rich notation[4] was typically used prior to 1985. In this report and the associated appendices, all ages are reported in European notation, including those determined prior to 1985.

Length information is helpful in determining the age of absorbed or otherwise questionable scales, especially for Chinook salmon which exhibit pronounced length partitioning by age class. When the age of a fish is in question, the technician aging the scales can use a length range to help decide the proper age of the fish. Length ranges are determined by taking the mean of all fish sampled within that age-class for that specific project, and then selecting a length range of 2 standard deviations above and below the mean. This creates a length range that is 95% accurate for that age-class. If the age of a scale and its corresponding length, fall within the appropriate length range for that age-class, then the ager is reassured they are aging correctly. If the age of the scale and the corresponding length do not fall within the appropriate length range, both should be rechecked for correctness.

Computer Processing Format

ASL data is typically digitized from hand recorded forms or electronic recorders. Most commonly, data is recorded on computer mark–sense forms, which are processed into ASCII files using an optical scanner. Other methods for data recording in the field include portable data recorders (first used in 1998), and more bulky electronic fish measuring boards. The data recorder produces an ASCII file similar to that provided by optically scanner. Data from the fish measuring board must be parsed to produce a comparable ASCII file. The resulting data files are then processed using one or more custom programs (i.e. KEdit), depending on the origin of the data. Two types of summary reports are generated: one focusing on age and sex composition of the sample, the other on length statistics by age and sex. The resulting age compositions are applied to the corresponding escapement or catch data to provide an estimate of the total age, sex, and length composition of those populations.

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3 In European notation two digits are separated by a decimal and refer to the number of freshwater and marine annuli respectively. The first digit represents the freshwater age minus one. The second digit represents the number of annuli formed during the marine residency. Total age from brood year is the sum of the two ages plus one.

4 In Gilbert-Rich notation two digits are listed without a decimal. The first digit represents the total years of life at maturity and the second number, which is usually subscripted, denotes years of fresh water residence, after emerging from the gravel.

Summary Types

The ASL catalog consists of 2 types of tabular summaries, one that describes data by age and sex composition, and another that summarizes length data by age and sex. Each report lists the year, sample dates, the stratum dates, and the number of fish sampled in each stratum. Sample dates are footnoted for samples in which the sex of fish was confirmed through examination of the gonads.

Age-Sex Reports

Age-sex reports describe the age and sex composition for each temporal stratum as a percentage based on the stratum sample. These percentages are used to estimate the number of fish in each age-sex category for the escapement or catch that occurred during the stratum.

Season estimates are weighted by the abundance of fish passage or harvest in each temporal stratum. The escapement or harvest numbers listed in the season summaries are the sum of the stratum estimates. The sums are in turn used to calculate the season percentages. Grand total escapement or harvest estimates are the sum of the annual season estimates. The grand total sums are then used to derive the grand total percentages.

Length Reports

Data in the length reports are summarized by age-class and sex. Sample dates and stratum dates are usually identical to the age-sex reports. The length reports include statistics on mean length, standard error, and the range of lengths in each age-sex category. The mean length reported for the season is weighted by fish abundance in each stratum. The weighting is derived by multiplying the mean length of each stratum by the estimated catch or escapement for that stratum. These numbers are summed for all strata in the season then divided by the total estimated catch or escapement for the season. The resulting number is the estimated season mean length for each age-sex category. The mean length reported in the grand total is the average of the annual season mean lengths.

Age, Sex, and Length Catalog

The ASL catalog (Appendices) was created from a series of Excel spreadsheets, which were converted into an Adobe PDF file. Each Excel spreadsheet consists of a historical age-sex report and an historical length report. Each historical report includes data summaries for each year of sampling and includes the inseason temporal stratification. Grand totals are calculated using only those years with sufficient ASL sampling. Years used in these summations are noted in report specific footnotes. The composition of the grand total was calculated after summing across each yearly total by age and sex category. Grand totals were used to calculate total percentages by age-sex category. Because of the volume of the catalog it was our intent to minimize paper versions, automate the yearly updates, and post the catalog to the ADF&G Kuskokwim Area web site. This manuscript is intended to be a readily available, hard copy guide and companion to the online catalog.

Age, Sex, and Length Database

Historical data from ASL sampling now reside in a database within the AYK salmon database management system (Brannian et al. 2004; 2005; 2006; 2007). Data are stored as individual fish. Currently, requests for data must be filled by Information Technology staff. Beginning in June 2007, a web-based application allows the general public to access and extract ASL data. OSM funding for project 04-701 partially supports the construction of the database management system and web applications.

RESULTS

Reports included in the 2008 ASL Catalog are organized into 8 major sections based on species: Chinook (Appendices A, B), chum (Appendices C, D), coho (Appendices E, F), and sockeye salmon (Appendices G, H) (http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2009.06Appendices.pdf). Within each species section, subsections are ordered by escapement project summaries, followed by commercial fishery summaries, test fishery summaries and subsistence summaries. Each category is also organized by location, starting with the farthest interior, progressing to the coast (river mouth), and south along Kuskokwim Bay. Some escapement, test fishery, and subsistence samples are also arranged by gear type such as 8.0-inch mesh drift gillnets or 6.0-inch mesh set gillnets. For each species/project type/project location combination the historical age composition report precedes the historical length report.

As described above, the summaries presented in the ASL Catalog are not exhaustive of all the data collected from the Kuskokwim Area. For example, data sets are not included from the South Fork Salmon River (Pitka Fork drainage) weir, operated in 1981 and 1982 (Schneiderhan 1982a, b).[5] Also, some of the data summaries reported in the ASL Catalog are incomplete. As time and resources allow, authors intend to continue adding missing historical information to future catalog editions. Additional sources of information include annual management reports, annual project reports, and the Catch and Escapement Statistics Report series. Partial summaries of sport caught fish and carcass samples can be found in Marino[6], Lisac and MacDonald (1995), Dunaway (1997), and MacDonald (1997). These documents are generally limited to individual years and the methods used to expand the ASL information into escapement and catch estimates may differ from the methods used in this report.

Users of the historical Catch and Escapement Report series (e.g. Andersen 1995; Huttunen 1989) should be cautioned that the season summaries listed in those reports are weighted by the number of fish sampled. This is not consistent with this catalog in which season summaries are weighted by the escapement or catch totals, not the number of fish sampled. Therefore, direct comparisons of summaries should not be made. The method used here is considered an improvement in that it better accounts for seasonal changes in ASL compositions relative to sampling effort and fish abundance.

DISCUSSION

TRENDS IN AGE, SEX, AND LENGTH COMPOSITION

This section is intended to provide examples of data concerns and common trends found in salmon ASL information in the Kuskokwim Area. Our analysis is not intended to be exhaustive.

5 In the literature the South Fork Salmon River weir is misleadingly referred to as the "Salmon River weir"; in actuality the weir was located on the south fork of the Salmon River.

6 Marino, T. *Unpublished*. Length, sex, and age distribution of Chinook salmon (*Oncorhynchus tshawytscha*), and silver salmon (*Oncorhynchus kisutch*) sampled on the Kwethluk River, Yukon Delta National Wildlife Refuge, 1989. U.S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge, Bethel.

Project leaders are encouraged to use the examples described herein as the basis for expanding ASL discussions in annual reports specific to their projects.

SOURCES OF BIAS

Sampling Design

Salmon populations often demonstrate distinctive and dynamic trends in ASL composition over the course of a single season. It is vital that sampling designs recognize and account for both temporal and spatial variability (Clutter and Whitesel 1956). Sampling effort should be temporally distributed across the migration and results weighted in a manner that accounts for fish abundance.

Resources or sampling conditions sometime prevent adequate sampling effort. Therefore, the available data should not be used to characterize the entire population unless there is clear and justifiable reason to do so. Such incomplete data sets may not be representative of the overall population, but have been retained within the ASL Catalog in the interest of providing a complete record of all ASL data collected within the Kuskokwim Area. Retaining these data may provide perspectives by which sampling and data analysis procedures may be improved. Incomplete datasets are clearly marked to prevent confusion.

Pulse sampling was first implemented in the Kuskokwim Area in the early 1990s as a means of accounting for temporal variability in populations. Much of the ASL data reported in the summary reports from years prior to the 1990s have been reanalyzed through post season stratification, therefore, results presented here may differ from those originally reported. Similarly, with sampling objectives for Chinook salmon escapements no longer requiring a desired confidence (95% CI within ±10% annually) be reached on the stratum level, some past years previously not included in the grand totals are now being used. Footnotes for each data set indicate where the data is coming from, how it has been collected, and how it is being used.

Carcass Sampling

The use of carcasses for estimating the ASL composition of spawning escapements can be misleading. For example, male Chinook salmon tend to drift downstream in a moribund state after spawning while females tend to remain near their nests, or redds (Kissner and Hubartt 1986). As a result, estimates of ASL composition based on Chinook carcasses collected at weirs tend to be biased towards males (McPherson et al. 1997). Data collected at the Middle Fork Goodnews River weir in 1996 and George River weir in 1997 support this conclusion (Figure 2).

Therefore, it would be reasonable to assume that estimates based on stream bank carcass surveys are biased towards female Chinook salmon. The likelihood of this happening is enhanced by the large size of females, which makes them more visible than smaller males. Evenson (1991) and Skaugstad (1990) found that when rigorous sampling designs are employed, as in their stream bank surveys of the Chena and Salcha Rivers (Yukon River drainage), the above sex bias did not appear. The findings of Evenson (1991) and Skaugstad (1990) not withstanding, collection and interpretation of ASL sample data from Chinook carcasses should be done with caution. Casual or opportunistic sampling is especially likely to be prone to bias.

For salmon species other than Chinook, the differential arrival time to spawning grounds that occur between sex and age groups is a potential source of bias in carcass sampling. Temporal dynamics in age composition can be pronounced in sockeye and chum salmon (Quinn 2005).

Likewise, changes in sex composition can be pronounced in chum and coho salmon. Other temporal and spatial variations in ASL composition exist in salmon species as well. In general, carcass sampling is not recommended as a means of estimating the ASL composition of escapement populations unless sampling designs can account for the inherent dynamics of populations.

Aging Scales

There has been concern in recent years about the consistency and accuracy of aging Chinook salmon scales within the AYK region. Recent studies, anecdotal information, and indigenous knowledge suggest that the proportion of older and larger Chinook salmon may have declined in recent decades in Yukon and Kuskokwim River Chinook salmon populations. This has led to concerns about the consistency of Chinook salmon age estimates by ADF&G. Since ADF&G began aging Chinook salmon scales in the 1960s many different readers have interpreted scale growth patterns and assigned ages. Inconsistent age estimation may lead to artificial changes in age composition over time.

DuBois and Liller (*In prep*) conducted a study to investigate whether ADF&G has consistently aged Yukon River Chinook salmon from scales over a 43-year period (1964–2006). Scales from over 7,000 fish were aged by 3 independent readers and compared to ADF&G's ages. In general, the differences in the age estimates between ADF&G and the independent readers were small and likely not biologically significant. However, this study did identify a considerable difference between ADF&G and the independent readers with respect to freshwater age-2 fish and to a lesser extent saltwater age-5 fish. In conclusion, this study found that Yukon River Chinook salmon have been aged consistently (Larry Dubois, Fishery Biologist, ADF&G, Anchorage; personal communication). Although this study did not rule out aging inconsistencies for the Kuskokwim River, historically and at present there has been considerable interaction between Kuskokwim and Yukon staff in regard to salmon scale aging, so it is reasonable to assume that they share similar bias patterns.

Scale Absorption

The phenomenon of scale absorption can make aging of escapement samples unreliable. The outer margin of a salmon scale is absorbed by the fish as an energy reserve during the last few weeks of life (Clutter and Whitesel 1956). Absorption is most prominent along the lateral edges of a scale, but in advanced absorption there may be little or no remnant of the outer annulus. The general convention is to avoid collection of scales from fish with advanced scale absorption, and to determine age only using observable annuli; however, on the rare occasion when there is reason to believe a full annulus has been absorbed, the technician or biologist may add an additional year for the missing annulus. In these instances, length information is used to help decide the correct age, particularly with Chinook salmon. The potential bias associated with this practice is recognized but considered in balance with a potential opposing bias caused by discarding every scale of questionable age because such scales are often more prominent among older age classes.

Scale absorption in Kuskokwim Area salmon, particularly sockeye salmon, is most problematic in fish sampled from the Kogrukluk River. The Kogrukluk River is located approximately 710 rkm from the mouth of the Kuskokwim River (Table 1, Figure 1). Scale absorption generally appears more advanced at Kogrukluk River weir than elsewhere in the area. Consequently the uncertainty of age estimates is heightened.

In their study of British Columbia sockeye salmon, Clutter and Whitesel (1956) reported that the degree of scale absorption varied between individuals and was most pronounced in males. This appears to be true of Kogrukluk River sockeye salmon as well. The high degree of scale absorption observed in Kogrukluk River sockeye salmon contributed to a decision in 1995 to discontinue sampling of sockeye salmon at that project. In 2006, collection of sockeye salmon ASL resumed on the Kogrukluk River, in association with a study that looked into the freshwater growth of juvenile salmon (Gilk and Molyneaux *In prep*). Scale absorption is more moderate elsewhere in the Kuskokwim Area. Therefore the confidence of age determination is greater.

Sex Determination

Secondary sexual characteristics become progressively more obvious in salmon as they near their spawning grounds. An experienced technician at an escapement project can easily and reliably identify the sex of fish without internal examination of gonads. However, sex determination by visual inspection only is less reliable earlier in the migration.

Salmon harvested in commercial and subsistence fisheries in the lower Kuskokwim have recently left marine waters and have yet to fully develop external sexual characteristics. Male Chinook salmon in commercial and subsistence harvest may lack a prominent kype. Female coho salmon sometimes have recognizable kype development. Both cases are contrary to the common perception that fish with kypes are males while those without are females. In 1997, the method of gonad examination was instituted to confirm the sex of fish sampled in the commercial fishery. It is believed that prior to that year, many age-1.2 male Chinook salmon were incorrectly identified as female, compromising the reliability of sex compositions described for the commercial Chinook harvests in Districts 1, 4 and 5 (Figure 3).

The sex of a harvested salmon can be easily confirmed by cutting the fish and visually examining the gonads. Concerns about market quality may limit the degree to which this can be done when sampling commercial catches. Beginning in 1997, and thru to the present, Kuskokwim Area staff have received permission from salmon buyers to make a small incision in the fish for sex confirmation during ASL sampling. Nearly every fish sampled from the commercial catch is examined in this way. These ‘sex-confirmed’ samples are identified in the appendices with footnotes. The sex of Chinook salmon sampled from the subsistence harvest in the Kuskokwim River since 2001 are also determined by examination of gonads (Molyneaux et al. 2005).

CHINOOK SALMON

Age Composition

Most Chinook salmon return to the Kuskokwim Area at age-1.2, -1.3, or -1.4 (Molyneaux and DuBois 1999), and historically, commercial fishermen harvest these 3 age classes in fairly even proportions when gillnets are restricted to mesh sizes of 6 inches or smaller. From 1974 to 1999, the age composition of the District 1 commercial harvest, with restricted mesh gear, had an average harvest composition of: 35% age-1.2, 35% age-1.3 and 25% age-1.4 fish (Figure 4). Prior to 1985, the Chinook salmon directed commercial fishing was unrestricted. Most commercial fishermen used an 8-inch mesh size to target the larger Chinook salmon. The age composition prior to 1985 was 3% age-1.2, 36% age-1.3 and 56% age-1.4 (Figure 5). Larger mesh sizes continue to be popular among subsistence fishermen (Table 3). The age composition of the commercial harvest with restricted mesh size and the subsistence harvest with unrestricted mesh size, together probably more closely approximate the true age composition of returning Chinook salmon than either fishery separately.

A review of trends in salmon size throughout the North Pacific by Bigler et al. (1996) reported that the mean age at return for Chinook salmon in the Kuskokwim River decreased significantly ($P<0.01$) between 1975 and 1993. This study has been criticized because the authors based their conclusion solely on commercial catch data and failed to note that in 1985, the Kuskokwim Area District 1 commercial fishery became restricted to a mesh size of 6 inches or less. Smaller mesh sizes typically capture smaller, younger fish; and the decrease in mean age of return noted by Bigler et al. (1996) may have been an artifact of this gear change. The same study showed no change in the mean age of Yukon River Chinook salmon, and an increase in the mean age of the Kenai River population for the same years. A similar retrospective analysis of Yukon River Chinook salmon by Hyer and Schleusner (2005) was less conclusive with regards to finding basin-wide trends in ASL composition among Yukon River Chinook salmon stocks. The authors noted the relatively short time series of comparable datasets as being the major obstacle to reaching definitive conclusions with respect to age of return. These examples stress the importance of both long-term consistent data collection over several years and good maintenance and dissemination of metadata.

In contrast to the sampling of commercial and subsistence harvests, the methods for sampling Chinook salmon at ground-based escapement projects are believed to provide a random and representative sample of stocks reaching Kuskokwim Area spawning grounds. Escapement projects most often use fish traps and beach seines to capture salmon for ASL sampling which are not size selective methods for capturing fish; however, the escapement represents a population that has already undergone selection due to the subsistence and commercial fisheries. Despite the more random nature of escapement sampling, samples may be somewhat biased by selection. Therefore, escapement samples should be viewed together with samples from the subsistence and commercial fisheries for a closer approximation of the age composition of overall Kuskokwim River salmon runs.

Not all Chinook salmon from a particular spawning year will return in the same season. By observing a relatively high or low abundance of a particular age-class within a particular year's migration, it is possible to make limited predictions about the age composition of subsequent returns. For example, a high abundance of age-1.2 (4 year old) Chinook salmon in a given year may indicate a similarly strong return of age-1.3 (5 year old) Chinook the following year (Figure 6).

Sex Composition

Females generally arrive later, (Figure 7) and are less abundant than males in Chinook salmon populations returning to the Kuskokwim Area. This is most notable at escapement projects, where females constituted 20–40% of the return between 1984 and 2004 (Appendix A). The female fraction of the commercial harvest in Kuskokwim Area Districts 1, 4 and 5 averaged between 28 and 43% for fishing periods with gillnet mesh size restricted to 6 inches or smaller. For District 1 periods with unrestricted mesh size (prior to 1985), the percentage of females was higher (43%, Figure 8, Appendix B). Data from subsistence harvests collected between 2004 and 2008 also tend to show fewer females in the catch even when large mesh gillnets are used (Figure 10, Appendix B).

The sex ratios reported by escapement projects are considered reliable due to advanced development of sexual dimorphism among salmon approaching spawning grounds. At those projects furthest from marine waters, it is often possible to get a rough estimate of sex composition while observing fish passage from the weirs. Visual assessment of sex composition at Takotna and Kogrukluk River weirs has been similar to the percent females estimated by direct examination and handling during ASL sampling (Figures 9 and 10). Deviation between ASL determined and visually determined sex ratios vary somewhat from year to year and are not consistent, thus visual sexing is not a substitute for ASL determined sex ratios (Figure 11). However, the variation is frequently low enough to allow for rough inseason estimates of sex composition based on visual assessment.

Sex ratios determined from the commercial harvest, may not be as reliable due to less pronounced dimorphism. Most of the Chinook salmon sampled from commercial catches between 1997 and 1999 were investigated internally to verify the sex (Dubois and Molyneaux 2000). Considering only those fish in which the sex was confirmed (*N*=3,704), age-1.2 Chinook salmon were found to be overwhelmingly male; ≥98% (Figure 3). In samples collected without sex verification the fraction of age-1.2 Chinook salmon reported as male has been as low as 30%. Similar trends were found in age-1.3 Chinook salmon where the occurrence of males was 82% or greater when sex was verified, but as low as 32% in samples without verification (Figure 12).

These suspected errors are not persistent across all years or locations that lack visceral examinations of the fish. For the years examined here, sex ratios reported for the District 1 commercial fishery have been near or within the range found in the verified samples (Figures 3 and 12). Escapement samples from Kogrukluk River were also near or within the expected range (Appendix A). Data from Districts 4 and 5, however, show considerable divergence from expected ratios, but not in all years (Appendix B).

The difference between the results from District 1 and those of Districts 4 and 5 may have more to do with the level of experience and training provided to the people who are collecting the samples. The sampling crews in District 1 typically include one or more experienced biologists who closely monitor the sampling routine. Since 1997, all ASL samples collected from fish during the commercial harvest have been internally examined to verify sex; this verification, also helps samplers learn what external features to recognize when visually identifying sex. Technicians sampling in Districts 4 and 5 have traditionally been more isolated and rarely had the benefit of a biologist in attendance. These fisheries are also more remote, crew size is usually smaller, sampling conditions more difficult, and crewmembers often have much less experience or training to draw on.

Efforts to resolve some of these problems began in 1997 when additional training opportunities were allowed by rotating staff between Bethel and Kuskokwim Bay.

In 2006–2008 Coastal Villages Seafood in cooperation with ADF&G has supported the hiring and training of technicians to collect ASL samples from the commercial harvest in their Quinhagak village processing plant. Samples provided via this program have usually shown a high degree of quality and consistency, but staffing changes in 2008 translated into a reduction in quality and quantity of samples.

Length Composition

The length frequency distributions of the 3 most predominant Chinook salmon age classes (age-1.2, -1.3, and -1.4) overlap as illustrated in (Figures 13, 14 and 15). The most distinctive group is the age-1.2 fish. This age class is comprised mostly of males and the relatively small size of the fish is one of the external morphological characteristics that can help in sex determination. The age-1.3 group contains a few more females, however female lengths tend to be limited to the upper half of the range for that age-class (Molyneaux and DuBois 1999); for example, in 1999 District 1 age 1.3 males averaged 675 mm in length while females averaged 801 mm. This same trend is apparent in District 4 where males averaged 694 mm and females averaged 802 mm. The lengths of age-1.4 males and females overlap more broadly.

Another commonly seen trend in Chinook salmon is a decreasing pattern in fish length over the course of a season. This is best observed at Kuskokwim River escapement projects (Costello et al. 2008; Elison et al. 2009; Stewart et al 2009; Williams and Sheldon *In prep)*. Similar comparisons have been made for Chinook salmon in Kuskokwim Area commercial fisheries, but trends are less consistent. Figure 16 compares age-1.4 male and age-1.4 female Chinook salmon during the 2005 and 2008 W-1 commercial fishing seasons. This figure illustrates a weak decreasing trend in the lengths of females in 2005, but no real trend in the lengths of male salmon. In 2008, that trend reversed and there was a decrease in the size of male Chinook salmon over the season, but no decrease in the length of females. Trends observed in a single year but not consistent across years probably do not have any bearing on long-term fisheries management strategies.

Trends among years are more variable. A retrospective analysis of Kogrukluk River Chinook salmon has shown a general increase in length for each age-sex class between 1984 and 1991 (Figure 17). Since 1991, the average length has become more stable, but there has been a slight decrease in recent years (Figure 17). Similar trends were observed at the Kogrukluk, Kwethluk, and Tuluksak River weirs (Figure 18). It is important to note that due to the overall size of the run and difficulty in procuring samples, Chinook salmon sample sizes from escapement projects are often low, and length trends may not be statistically significant.

Bigler et al. (1996) reported a significant decrease ($P<0.01$) in the average weight of Kuskokwim River Chinook salmon between 1969 and 2003 (Figure 19); however, that study relied on commercial catch statistics and did not account for mesh size restrictions first imposed in 1985. Prior to 1985, the average weight of Chinook salmon captured in the District 1 commercial fishery was typically much greater than those caught incidentally in the District 4 fishery (Figure 20). After the 1985 gear restriction, District 1 average weights became similar to those seen in District 4 (Figure 20). The commercial fishery in District 4 is a sockeye directed fishery and has always been restricted to a mesh size of 6 inches or less, thus has little value for comparison with District W1. This supports the argument that the trend noted by Bigler et al. (1996) may have been an artifact of commercial mesh size changes. However, the weight trend noted in the commercial fishery does seem to correlate with length data from escapement projects. A review of escapement data from Kogrukluk River shows trends in the average length of -1.4 males generally decreasing between 1975 and 1985, and remaining consistent at their current lower length range (Figure 21).

Uncertainties such as those suggested above underline the importance of understanding the sources, potentials, and limitations of the data being analyzed (Hyer and Schleusner 2005; JTC

2006). The availability of good metadata will help ensure that analysis takes mitigating factors into account. The introduction of a new gear restriction in 1985 equated to a change in sample collection, which introduced a new bias into the dataset that was not adequately accounted for.

Gathering data from multiple sources (commercial fisheries, subsistence fisheries, and escapement projects) over many years is extremely important in understanding the dynamics of Kuskokwim River salmon populations. However, data collected from each type of project is likely to come with unique limitations based on the methodologies of capture and sample collection. Being able to recognize these limitations and properly documenting them helps to provide important perspective when applying this information.

SOCKEYE SALMON

Age Composition

Eleven age classes have been reported for sockeye salmon returning to the Kuskokwim Area, and most appear in small numbers. The predominant age-class among Kuskokwim Area sockeye salmon is age-1.3 (Appendix G and H). The next most common age-classes vary depending on location. Among Kuskokwim Bay fisheries and escapements, the second most prevalent age-class is age-1.2, while among Kuskokwim River stocks, it is age-2.3. Samples from 1999 show that age-1.3 fish tend to be in greatest proportion early in the season in Kuskokwim Bay and the occurrence of age-1.2 sockeye salmon may increase slightly as the season progresses (Figure 22). Similar patterns are apparent for previous years (Molyneaux and DuBois 1998, 1999).

Sex Composition

The overall annual sex ratio of most Kuskokwim Area sockeye salmon populations is approximately 1 male to 1 female (Figure 23). Commercial fisheries and escapement projects are similar with regard to sex ratio (Figure 23). No clear inseason temporal pattern for the arrival of male and female sockeye salmon is apparent based on Kuskokwim Area sampling data.

Length Composition

The range of lengths found in the various sockeye salmon age classes overlap broadly, however escapement data collected from the Kanektok River in 1997 show the average length for age-1.3 fish to be consistently greater than age-1.2 fish (Figure 24). Furthermore, males tend to average about 20 mm greater in length than females of the same age class. The average length of age-1.3 sockeye salmon was fairly uniform in the Kanektok River escapement throughout the 1997 season, whereas age-1.2 fish were generally smaller at the start of the season.

A comparison of commercial and escapement sample data from the Goodnews area shows that age 1.2 and 1.3 female sockeye salmon harvested in the commercial fishery tend to be larger than the same age-sex classes measured at the Middle Fork Goodnews weir (Figure 25, Appendix G and H). The sockeye salmon harvest for District 5 is estimated to represent 23% of sockeye salmon returning to the Goodnews River drainage (ADF&G 2004). Commercial fisheries in each of the Kuskokwim Area districts are limited to 6-inch or less mesh gillnets.

CHUM SALMON

Age Composition

Chum salmon return to the Kuskokwim Area at age-0.2, -0.3, -0.4, and -0.5, with age-0.3 and -0.4 most predominant (Appendix C and D). The older fish tend to arrive earlier in the season with younger fish becoming more prominent as the season progresses. The daily incidence of age-0.2 chum salmon early in the season is near 0% but may rise to as much as 40% at some escapement projects by the end of August (Figure 26). Conversely, the incidence of age-0.4 chum salmon may be as high as 90% early in the season and less than 10% near the end of the season. This pattern is well illustrated at the Tuluksak River weir from 1991 thru 1994 (Figure 27) and similar patterns have been reported in streams of the Yukon drainage (Melegari 1996; Tobin and Harper 1995), South Central Alaska (Helle 1979), Southeast Alaska (Clark and Weller 1986), British Columbia (Beacham 1984; Beacham and Starr 1982), and Washington (Salo and Noble 1953). This pattern appears to be common among chum salmon populations. Occasional inconsistencies seen in historical age summaries of the Kuskokwim Area are suspect and should be viewed with some skepticism. Ideally the scales collected from such data sets should be reviewed to confirm the age determinations.

Sex Composition

The overall annual sex ratio of most Kuskokwim Area chum salmon populations approximates 1 male to 1 female. At any given location, males tend to be more predominant early in the season whereas the proportion of females increases as the season progresses. Results from Tuluksak River weir illustrate the point well with the daily percentage of females showing a steady increase as the season progresses from 25 to about 75% in each of 4 consecutive years (Figure 28). Results from both escapement and commercial samples in 1999 show the same overall trend (Figure 29). These patterns are common in chum salmon populations (Bakkala 1970).

Contrary to traditional inseason patterns, data from the Kogrukluk River weir showed a decreasing trend in its percentages of female chum salmon between 1981 and 1999 (Figure 30). Since 1976 the percentage of upriver migrating females has been <50% of the total returning chum salmon population. In 2005, there was a record return of chum salmon to the Kogrukluk River, with age 0.3 fish making up a majority of the returning age composition. Also in 2005 and continuing to 2007, the observed percentage of female chum salmon has increased dramatically from between 10 and 20% to nearly 50% (Figure 30). It is not known what caused this decreasing trend in the percentage of female chum salmon between 1987 and 2005 or the sharp increase in recent years.

One possible cause for this increase could be changes made preseason in 2005 to decrease weir picket spacing in response to a previously observed leakage of smaller chum salmon. The sudden upswing in percent females in that year lead to concerns that past leakage of smaller fish through the weir might have resulted in erroneous sex ratios (Jasper and Molyneaux 2007). Although certainly a factor, examination of length frequency data from past years showed that smaller fish were well represented in ASL collections, and that the observed anomalous sex ratios were not accounted for by picket spacing alone (Jasper and Molyneaux 2007). Potential factors that could contribute to this unusual population dynamic are discussed in Jasper and Molyneaux 2007. Whatever the cause, sex ratios reported for Kogrukluk River salmon escapements are believed to be reliable due to the advanced sexual dimorphism that occurs the further fish get from marine waters.

Length Composition

The length frequencies of chum salmon overlap broadly by age and sex groupings; however, the average length of females is generally less than males of the same age-class (Figure 31). Also, Kuskokwim Bay (District W4, W5 and Goodnews River weir) chum salmon tend to be larger at age than Kuskokwim River fish (District W1 and Aniak River weir) as illustrated in (Figure 32) for 1999. Also common among Kuskokwim Area (Figure 1) chum salmon stocks is a tendency for the average length of arriving fish to decrease as the migration progresses. This is true for all age-sex groupings. At Tuluksak River the average decrease in length of age-0.3 and -0.4 chum salmon over the course of the run between years 1991 thru 1994 was on the order of 56 mm (Figure 33).

Low sample sizes reduce the statistical significance of trends, so it is important to use only those years that provide adequate sample sizes to properly characterize the run. Years with inadequate samples sizes are footnoted and not included in grand totals (Appendix C and D). For example, when comparing average lengths for different age-sex classes of chum salmon sampled at Kogrukluk River weir, it is possible to identify an overall decline in length at age for all age-sex classes (Figure 34); however, age-0.3 male chum salmon show the clearest trend with the tightest confidence intervals due to an abundance of samples for this age group.

Kuskokwim River chum salmon stocks were among the North Pacific chum salmon stocks reported by Bigler et al. (1996) to have had significant decreases in the average weight-at-age between 1975 to 1993 ($P<0.05$). As with Chinook salmon, the authors' conclusion generally relies on commercial catch statistics that, for the Kuskokwim River, contain some confounding influences. First, prior to 1985 there were no restrictions on the mesh size fishermen used and their tendency to use larger mesh sizes for targeting Chinook salmon would have also resulted in a higher proportion of larger chum salmon in the catch. Beginning in 1985 the mesh size was restricted to 6 inches or smaller (Burkey et al. 1999), which would have reduced the average size of chum salmon in the harvest. Second, beginning in the late 1980s there was a tendency to extend the commercial fishing season for chum salmon into the second half of July. During July, the average size of chum salmon tends to decrease due to higher proportions of younger age classes and females in the catch. Also, as noted above, all age-sex classes show lesser length-at-age later in the season. Third, as the value of chum salmon has decreased over the past several years (Burkey et al. 1999), some fishermen are beginning to use smaller mesh sizes, which tend to be more effective in catching the higher valued sockeye salmon (author's observation). In contrast to the findings of Bigler et al. (1996), chum salmon data from Kogrukluk River escapements and the District 1 commercial harvests both show variable average lengths-at-age over the years, but no strong decreasing trend (Figure 35).

COHO SALMON

Age Composition

Coho salmon return to Kuskokwim Area streams at age-1.1, -2.1 and -3.1. Age-2.1 fish usually account for more than 90% of the return. Age-3.1 fish normally comprise 5% or less of the return. An exception to this trend occurred in 1999 and in 2008, when an atypically high percentage of age-3.1 coho returned to the Kuskokwim River (Appendix E and F).

Sex Composition

Since 1997, sex has been confirmed through internal examination for most coho salmon sampled from commercial harvests. Samples generally exhibited an increasing proportion of females in the catch as the season progressed (Figure 36). This pattern is not always obvious in other databases, possibly due to errors in sexing the fish. Female coho salmon may exhibit some level of kype development, which can confound sexing by external characteristics alone.

Similar to Chinook and chum salmon, coho salmon sex ratios reported by escapement projects are generally believed to be reliable due to advanced development of sexual dimorphism. At those projects furthest from marine waters, it is often possible to get a rough estimate of sex composition while observing fish passage from the weirs. Visual assessment of sex composition at Takotna and Kogrukluk River weirs is similar to the percent female estimated by direct examination and handling during ASL sampling (Figures 37 and 38).

Length Composition

Among coho salmon, no consistent pattern is obvious in the average length-at-age composition. Overall, the mean length of fish does tend to increase as the season progresses, but the pattern is not consistent for all years. There is a tendency for female coho salmon to be larger than males. This pattern was not apparent in the historical database before 1997, calling into question the reliability of sex determination of coho salmon when the sex is not confirmed.

It is important to note that low sample sizes reduce the statistical significance of observed trends. Relative abundance of age-sex classes within the run yield different levels of certainty with respect to trends in length-at-age. When comparing average lengths for different age-sex classes of coho salmon sampled at Kogrukluk River weir, it is difficult to identify any significant trend with regard to size. Sample sizes are typically small in relation to abundance and 95% confidence intervals tend to overlap broadly (Figure 39). ASL data can be a helpful tool in identifying important areas of study, however, sample size and statistical significance should always be taken into consideration when making assertions about trends within ASL data.

CONCLUSIONS

- The objective for FIS 07-303 was fulfilled for 2008. ASL data were compiled across projects which collected samples from the Kuskokwim Area in 2008.

The ASL catalog is available electronically from the Division of Commercial Fisheries, Kuskokwim Area web page at:
http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2009.06Appendices.pdf

- When using data from the Kuskokwim Area ASL catalog, users should consider: (1) the method of data procurement, (2) the possibility and nature of bias, and (3) the applicability of the data.

RECOMMENDATIONS

- Stabilize and standardize collection and processing of salmon ASL data to ensure that an adequate time series of data is maintained that will facilitate retrospective analysis.
- Facilitate retrospective data analysis by continuing to report the salmon ASL time series in a manner that allows for broad and easy access to the data sets.
- Continue to process ASL samples in a centralized location with consistent aging criteria and data processing methods.
- Continue to archive scale cards, paper data collection forms, and electronic data in a centralized location.
- Continue to add historical data summaries to the catalog with the goal of summarizing all data historically collected in the Kuskokwim Area.
- Continue to improve methods for compiling and reporting ASL data, including a reduction in the number and complexity of reports in the online catalog.
- To this point, online versions of this catalog have been replaced each year. From now on catalogs will be stored online indefinitely. In future versions of this catalog, the number of years represented should be reduced to save server space. Older datasets will remain accessible and can be referenced.
- Update figures to include present year data where fitting, and add illustrations of other data sets.

ACKNOWLEDGMENTS

The USFWS OSM provided funding support for project (FIS 07-303) through the Fisheries Resource Monitoring Program, under agreement number 701817J646. This project supports processing, analyzing, and reporting of salmon ASL data collected in Kuskokwim Area subsistence and commercial fisheries, test fisheries, and escapement projects, many of which were funded in part or in full through the Fisheries Resource Monitoring Program. Additional funding was provided through the State of Alaska. We wish to thank Larry DuBois and Chris Shelden for their preparation of many of the figures in this report. We also wish to thank Chris Shelden, Dani Evenson, and Donald Rivard for the review and editing of this report.

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

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TABLES AND FIGURES

Table 1.–Distance to selected locations from the mouth of the Kuskokwim River or Bethel.[a]

Location [b]	Distance From River Mouth [c]		Distance from Bethel	
	Kilometer	Miles	Kilometer	Miles
Popokamiut (Downstream boundary District 1)	(3)	(2)	(109)	(68)
Kuskokwim River Mouth [c]	0	0	(106)	(66)
Apokak Slough (Downstream boundary District 1)	5	0	(106)	(66)
Eek River	13	8	(93)	(58)
Eek (community)	46	29	(60)	(37)
Kwegooyuk	22	13	(85)	(53)
Kinak River	32	20	(74)	(46)
Tuntutuliak (community)	45	28	(61)	(38)
Kialik River	50	31	(56)	(35)
Fowler Island	68	42	(39)	(24)
Johnson River	77	48	(29)	(18)
Napakiak (community)	87	54	(19)	(12)
Napaskiak (community)	97	60	(10)	(6)
Oscarville (community)	97	60	(10)	(6)
Bethel (community)	106	66	0	0
Gweek River	135	84	29	18
Kwethluk River	131	82	25	16
Kwethluk (community)	132	82	26	16
Kwethluk River Weir	216	134	109	68
Akiachak (community)	143	89	37	23
Kasigluk River	150	93	43	27
Kisaralik River	151	94	45	28
Akiak (community)	161	100	55	34
Mishevik Slough,	183	114	77	48
Tuluksak River	192	119	85	53
Tuluksak (community)	192	120	86	54
Tuluksak River Weir	248	154	142	88
Nelson Island	190	118	84	52
Bogus Creek (Upstream Boundary District 1)	203	126	97	60
High Bluffs	233	145	127	79
Downstream Boundary District 2	262	163	156	97
Mud Creek Slough	267	166	161	100
Lower Kalskag (community)	259	161	153	95
Kalskag (community)	263	163	157	97
Lower Kalskag Fishwheel (2004)	249	155	143	89
Kalskag Fishwheel (2002, 2003, 2005, and 2006)	270	168	163	102
Birchtree Fishwheel (2001 to 2004)	294	183	187	117

-continued-

Table 1.–Page 2 of 3.

Location [b]	Distance From River Mouth [c]		Distance from Bethel	
	Kilometer	Miles	Kilometer	Miles
Aniak (community)	307	191	201	125
Aniak River	307	191	201	125
Doestock	320	199	214	133
Aniak Sonar Site	323	201	217	135
Buckstock	370	230	264	164
Salmon River	403	250	296	184
Salmon River Weir	404	251	298	185
Kipchuck	407	253	301	187
Chuathbaluk (community)	323	201	217	135
Upstream Boundary District 2	322	200	216	134
Kolmakof River	344	214	238	148
Napaimiut (community)	359	223	253	157
Holokuk River	362	225	256	159
Sue Creek	381	237	275	171
Oskawalik River	398	247	291	181
Crooked Creek (community)	417	259	311	193
Georgetown (community)	446	277	340	211
George River	446	277	340	211
George River Weir	453	281	347	215
Red Devil (community)	472	293	365	227
Sleetmute (community)	488	303	381	237
Holitna River	491	305	385	239
Hoholitna River	538	334	432	268
Chukowan River	709	441	603	375
Kogrukluk River	709	441	603	375
Kogrukluk River Weir	710	441	604	375
Stony River (community)	534	332	428	266
Stony River	536	333	430	267
Lime Village (community)	644	400	538	334
Telaquana River	727	452	621	386
Telaquana Lake (outlet)	772	480	666	414
Necons River	760	472	653	406
Swift River	560	348	454	282
Cheeneetnuk River	587	365	481	299
Gagarayah River	634	394	528	328
Babel River	660	410	554	344
Moose Creek	533	331	426	265

-continued-

Table 1.–Page 3 of 3.

Location [b]	Distance From River Mouth [c]		Distance from Bethel	
	Kilometer	Miles	Kilometer	Miles
Nunsatuk River	620	385	513	319
Selatna River	663	412	557	346
Little Selatna River	669	416	563	350
Black River	679	422	573	356
Katitna River	719	447	613	381
Blackwater River	838	521	732	455
Tatlawiksuk River	563	350	457	284
Tatlawiksuk River Weir	568	353	462	287
Devil's Elbow	599	372	492	306
Vinasale (abandoned community)	665	413	558	347
Takotna River	752	467	645	401
Takotna (community)	832	517	726	451
Takotna River Weir	835	519	729	453
McGrath (community)	753	468	647	402
Middle Fork	806	501	700	435
Big River	827	514	721	448
Pitka Fork	845	525	739	459
Salmon River	880	547	774	481
Windy Fork	901	560	795	494
Medfra (community)	863	536	756	470
South Fork	869	540	763	474
Nikolai (community)	941	585	835	519
East Fork	882	548	776	482
North Fork	884	549	777	483
Swift Fork	1,078	670	972	604
Telida (community)	1,128	701	1,022	635
Highpower Creek	1,151	715	1,044	649
Headwaters South Fork	1,292	803	1,186	737
Headwaters North Fork	1,548	962	1,442	896

[a] Distances are determoned using a computer version (Garmin Topo MapSource) of U.S. Geological Survey 1:100,000 scale map. Routing as if traveling by boat.

[b] Locations not on the mainstem of the Kuskokwim River are listed as subordinate to the point of departure from the mainstem.

[c] The "mouth" of the Kuskokwim River is defined as the southern most tip of Eek Island (Latitude N 60° 05.569, longitude W 162° 19.054), and is one of three points that define the downstream boundry of District 1.

Table 2.–Projects and salmon species for which age sex, and length data are summarized in the 2008 Kuskokwim Area ASL Catalog.

		Salmon Species (ASL Summaries Present = X)			
Project Type	Location	Chinook	Sockeye	Chum	Coho
Escapement	Takotna R.	X		X	X
	Tatlawiksuk R.	X		X	X
	Kogrukluk R.	X		X	X
	George R.	X		X	X
	Salmon R.	X		X	
	Kalskag Fishwheels				X
	Aniak R.			X	
	Tulusak R.	X	X	X	X
	Kisaralik R.				
	Kwethluk R.	X	X	X	X
	Kanektok R.	X	X	X	X
	Goodnews R.	X	X	X	X
Commercial	District 1	X	X	X	X
	District 4	X	X	X	X
	District 5				
Test Fish	Bethel Test Fish				
Subsistence	Kuskokwim R.	X			

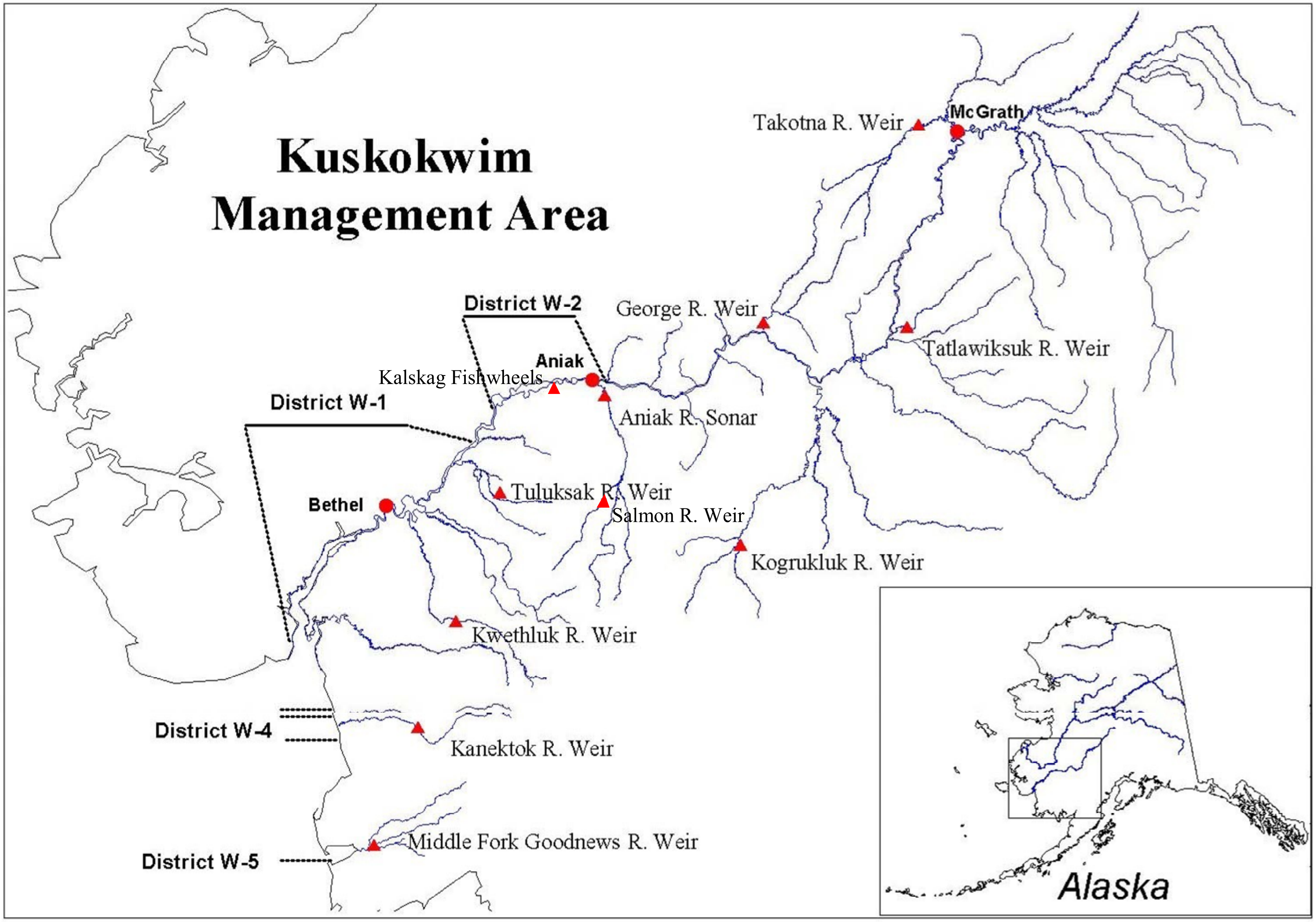


Figure 1.–Kuskokwim salmon management area.

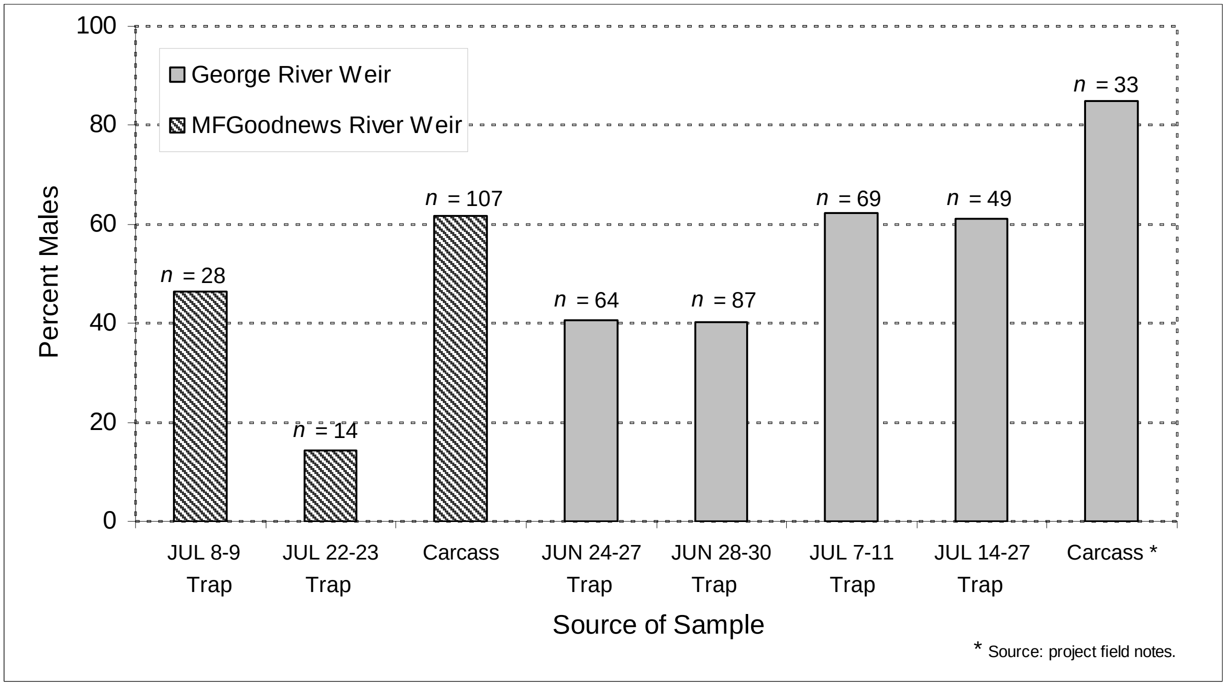
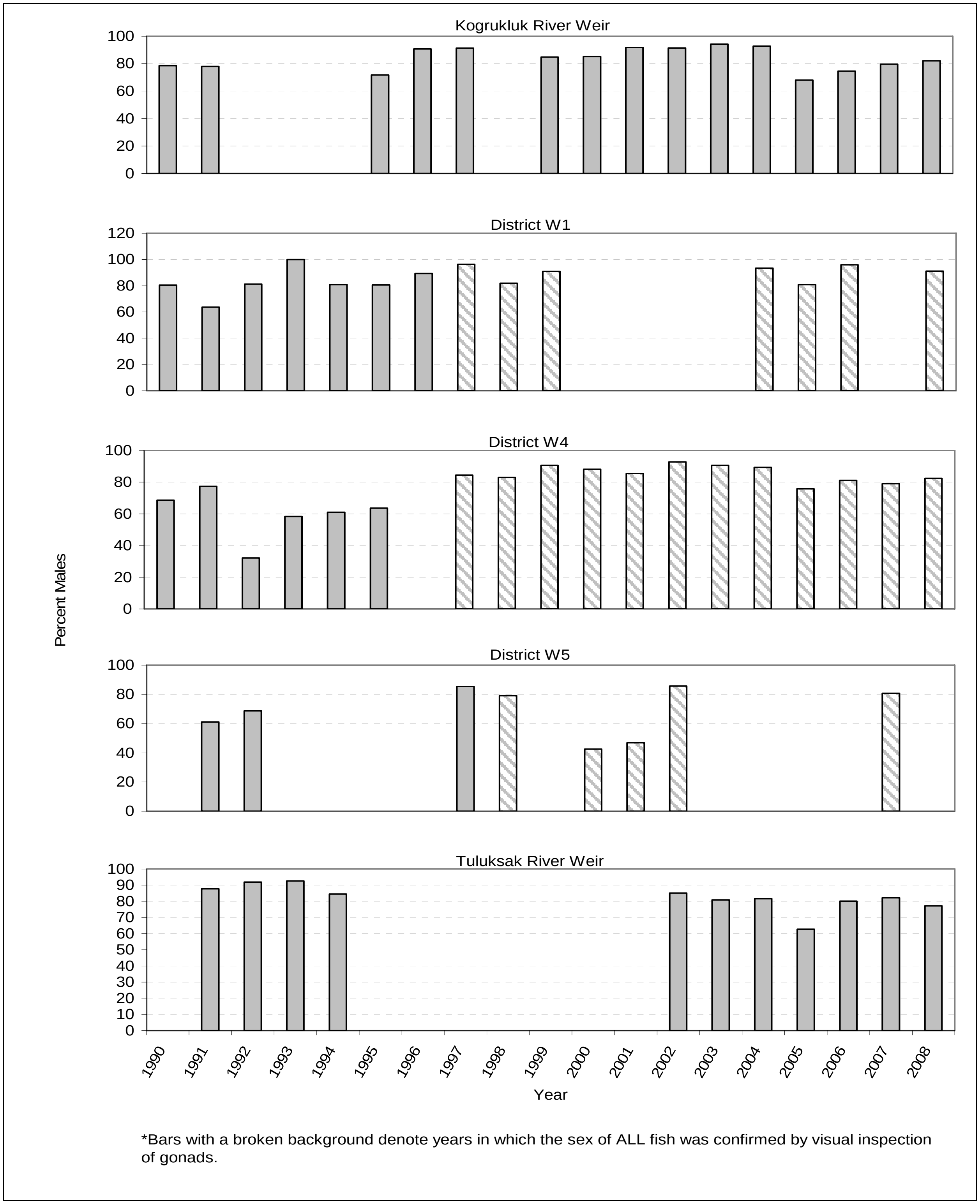


Figure 2.–Percentage of male Chinook salmon in trap and carcass samples from the Middle Fork Goodnews River weir in 1996 and the George River weir in 1997.



Note: Hatch-marked bars only include data for fish with confirmed sex identification.

Figure 3.–Percentage of male age-1.2 Chinook salmon documented during ASL sampling between 1990 and 2008.

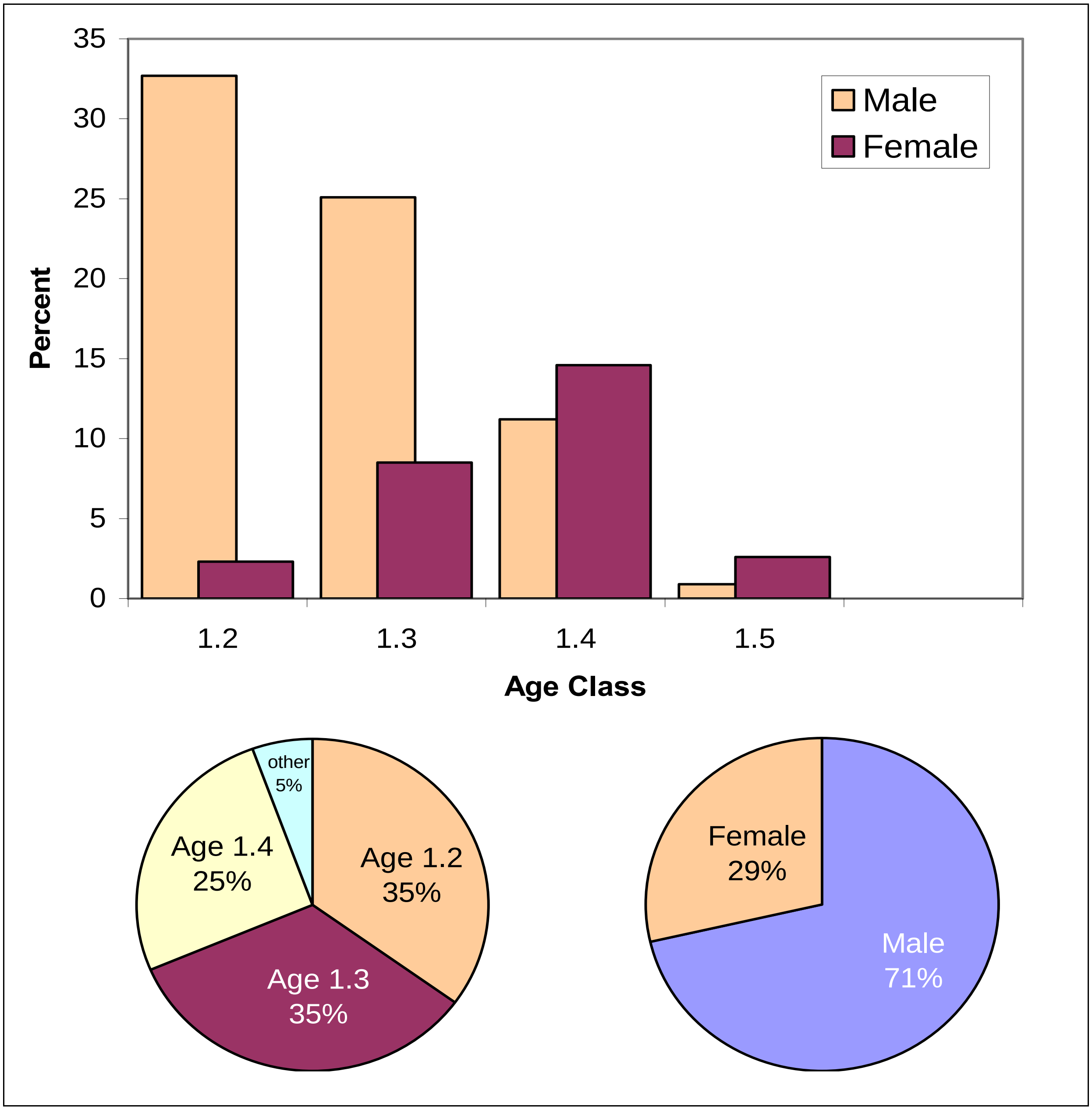


Figure 4.–Average age and sex composition of District W1 Chinook salmon harvested from commercial fishing periods in which gillnet mesh size was restricted to 6 inches or smaller, 1974–1999.

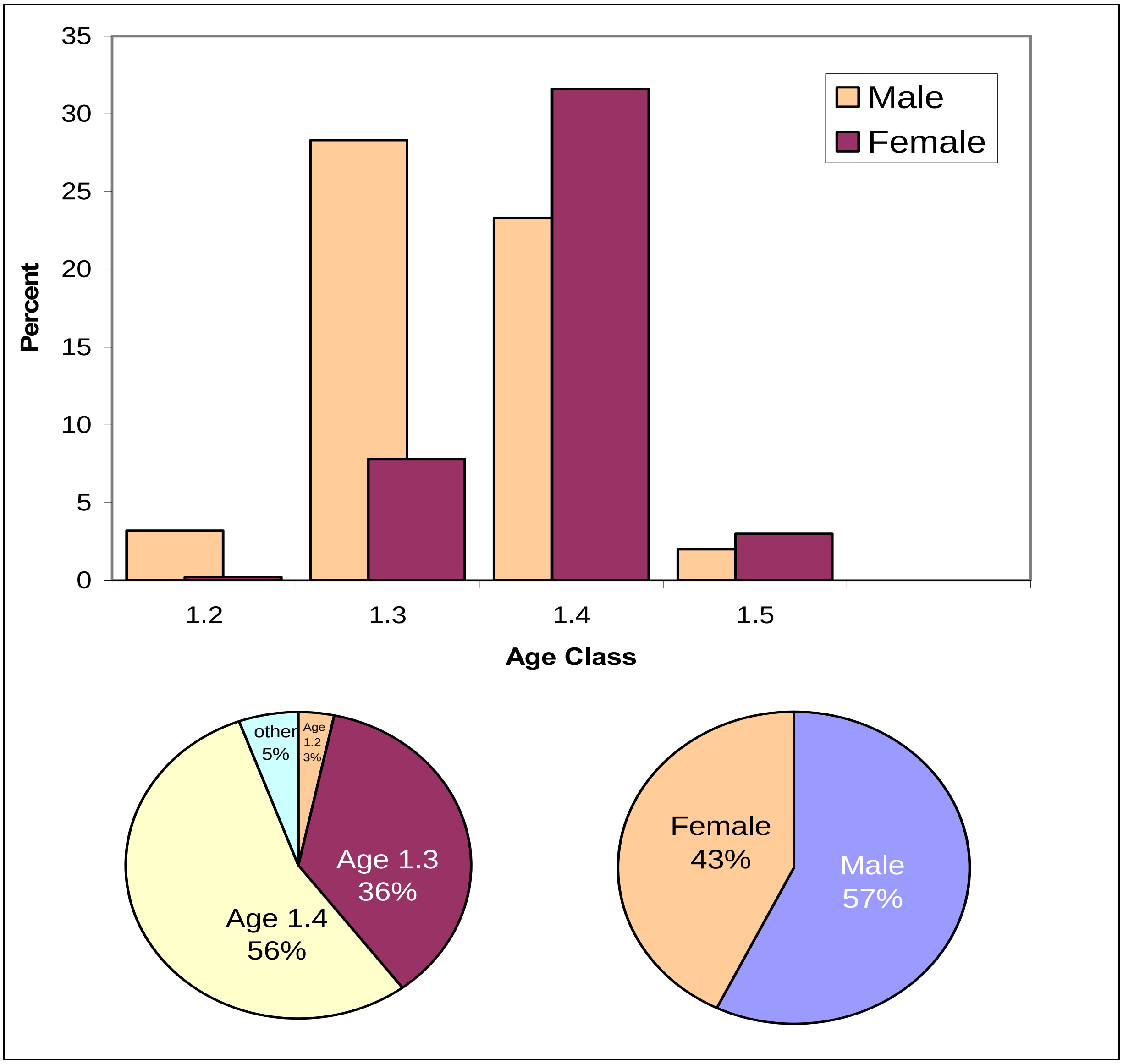
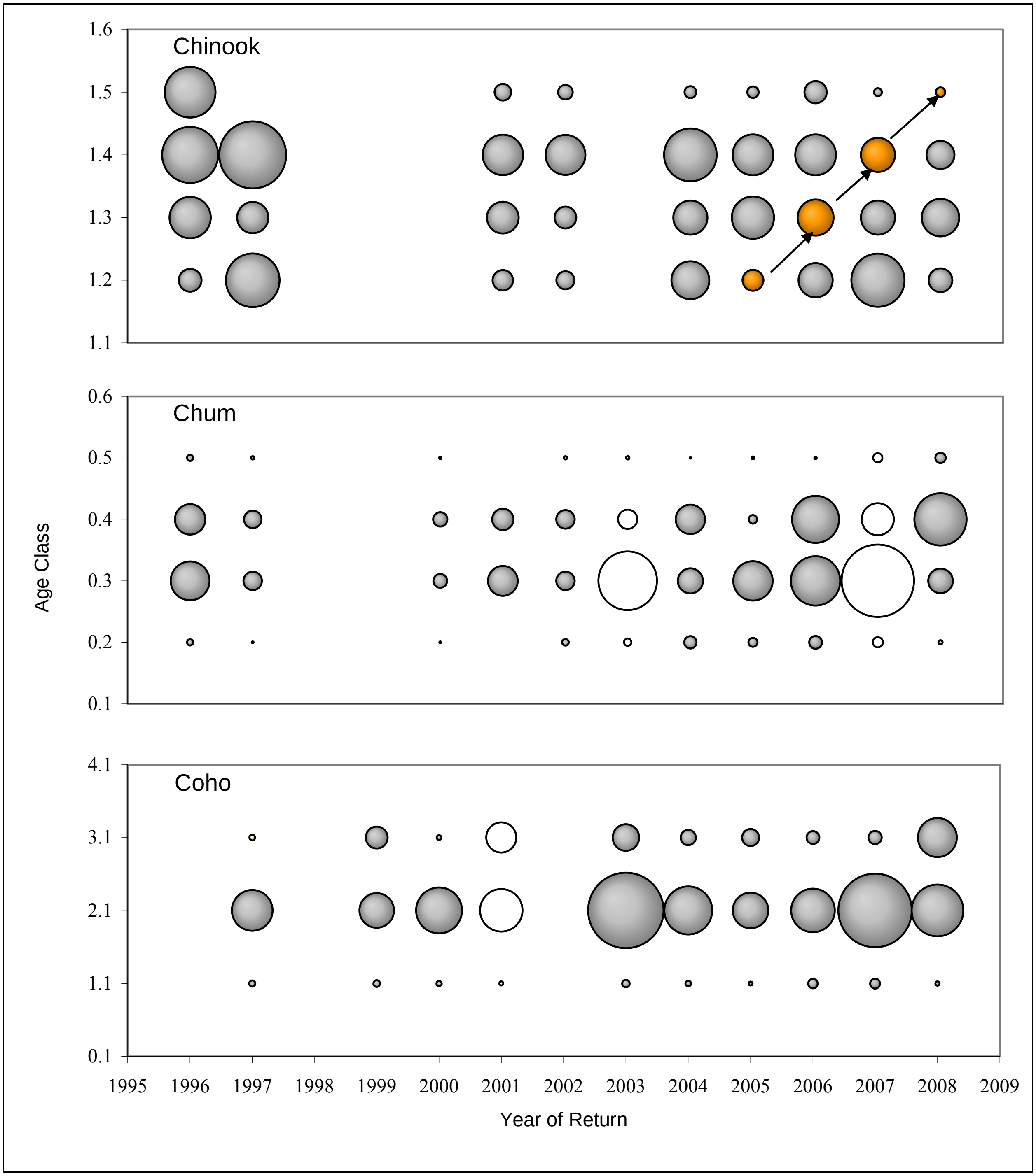


Figure 5.–Average age and sex composition of District W1 Chinook salmon harvested from commercial fishing periods in which gillnet mesh size was unrestricted, 1974–1984.

Gear Type	Number of Mesh Sizes Used, By Year							
	2001	2002	2003	2004	2005	2006	2007	2008
Large Mesh Gillnets (≥8-inch mesh)								
8-3/4 inch mesh		1						
8-1/2 inch mesh		3	1			1		1
8-1/4 inch mesh		6	6	3	7	5	4	3
8-1/8 inch mesh		4	1	1				
8.0 inch mesh		17	25	19	19	16	22	24
Subtotal		31 62.0%	33 68.8%	23 82.1%	26 66.7%	22 84.6%	26 63.4%	28 **44.4%**
Intermediate Mesh Gillnets (>6-inch but <8-inch mesh)								
7-7/8 inch mesh		1	1		1			
7-3/4 inch mesh					1		2	
7-5/8 inch mesh						1		
7-1/2 inch mesh		1	2	1	3	2	1	9
7-1/4 inch mesh		2				1	2	6
7-3/8 inch mesh							1	
7.0 inch mesh		2	1					4
Subtotal		6 12.0%	4 8.3%	1 3.6%	5 12.8%	4 15.4%	6 14.6%	19 **30.2%**
Small Mesh Gillnets (≤6-inch mesh)								
6-3/4 inch mesh								1
6-1/2 inch mesh		1		1	2			
6.0 inch mesh		3	3	1	3		4	4
5-7/8 inch mesh		1			1		1	
5-3/4 inch mesh					1		2	1
5-1/2 inch mesh		2	3	2	1		2	6
5-1/4 inch mesh			1					
5-3/8 inch mesh		1						1
5.0 inch mesh			1					1
4-1/2 inch mesh		1						
4.0 inch mesh		4	3					1
3-1/2 inch mesh								1
Subtotal		13 26.0%	11 22.9%	4 14.3%	8 20.5%	0 0.0%	9 22.0%	16 **25.4%**
Total		50 100.0%	48 100.0%	28 100.0%	39 100.0%	26 100.0%	41 100.0%	63 100.0%
Number of Participant Samplers		34	37	21	31	20	25	46
Number of Samplers using Multipul Mesh Sizes		16	11	7	8	6	16	17

Table 3.–Historical mesh size distribution from the Kuskokwim River Subsistence Fishery.



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

Source: Stewart et al. 2008, *In prep*.

Figure 6.–Relative age-class abundance of Chinook, chum, and coho salmon by return year at George River weir.

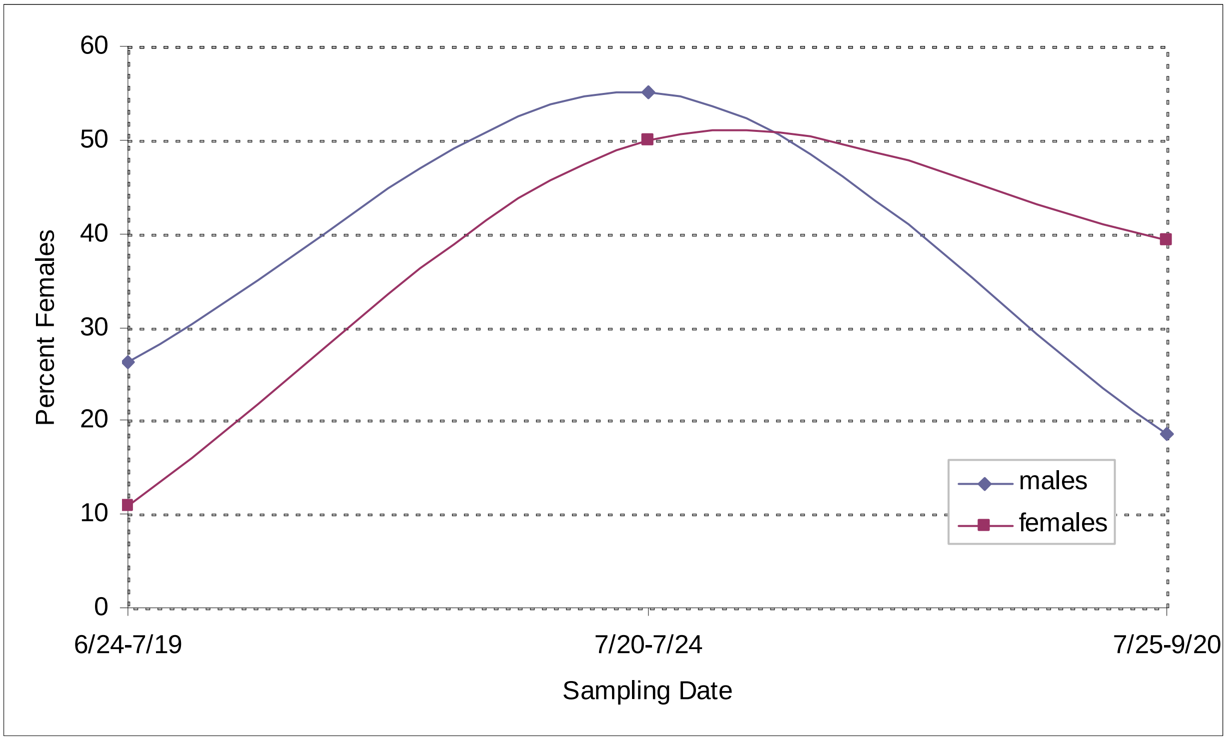


Figure 7.–Percent of total male and female Chinook salmon by date at Takotna River weir.

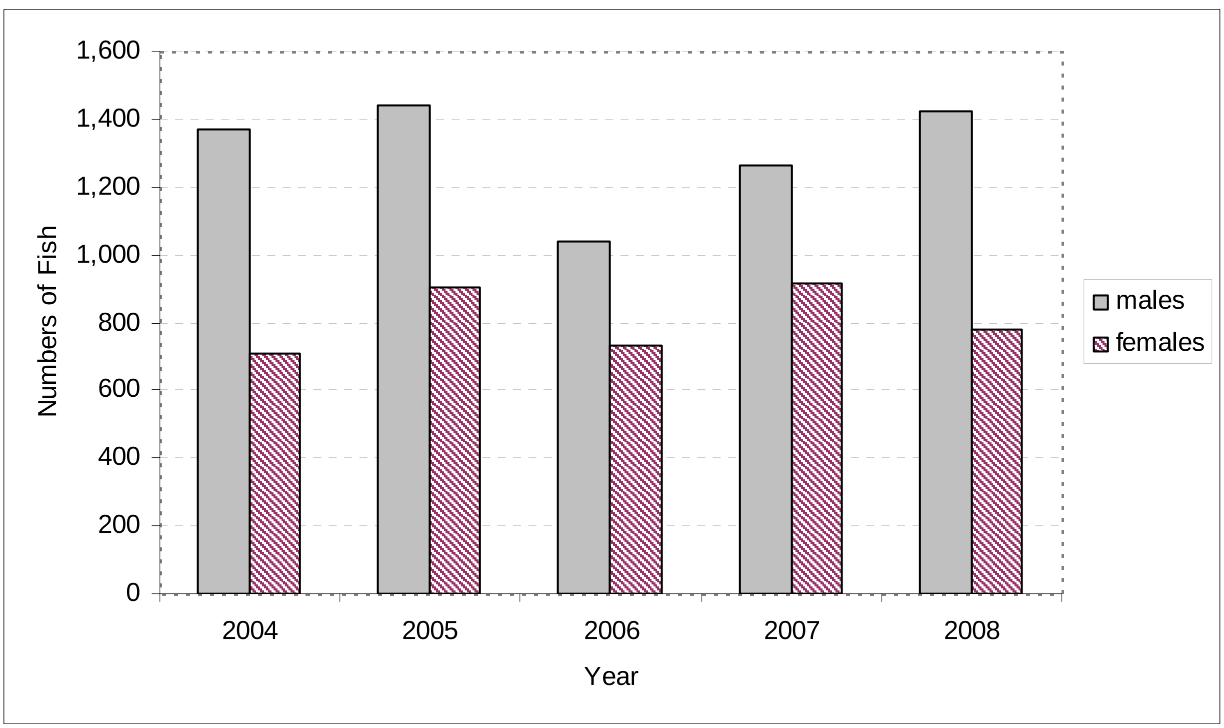


Figure 8.–Numbers of male and female Chinook salmon caught in 8-inch mesh gill nets between 2004 and 2008 during the subsistence harvest.

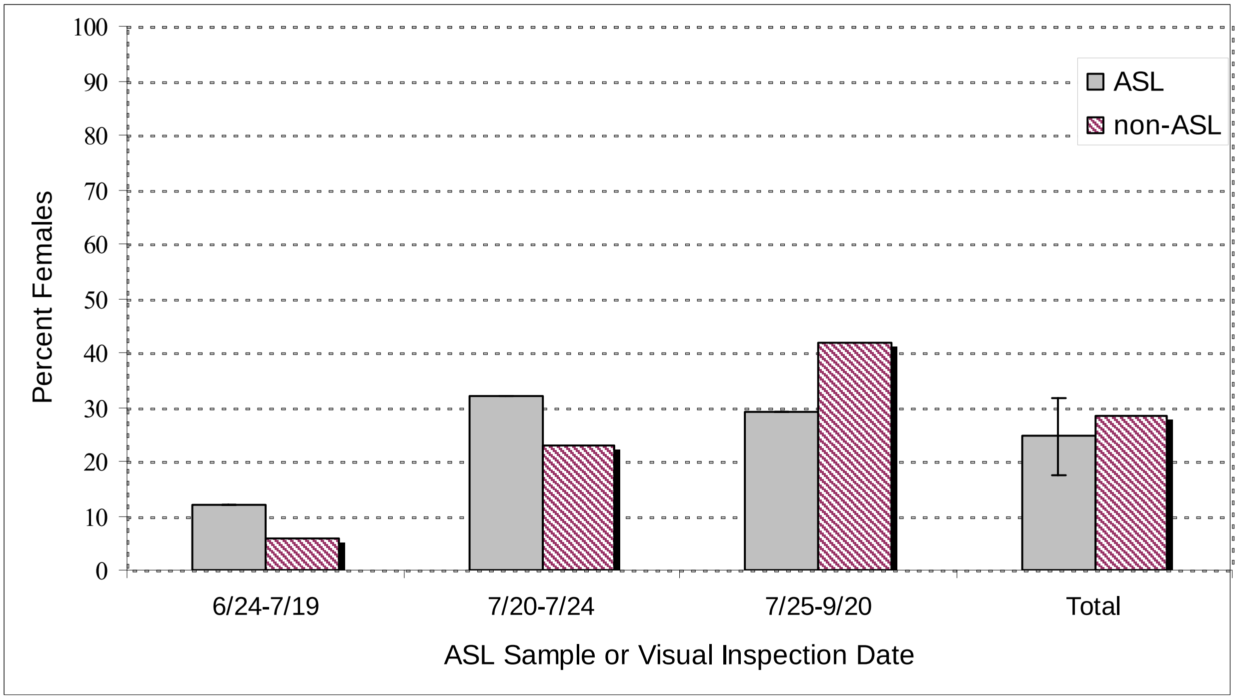


Figure 9.–Comparison of the percentage of female Chinook salmon passing upstream of the Takotna River weir as determined from standard ASL sampling using a fish trap, and from visual inspection of non-ASL sampled fish using standard fish passage procedures.

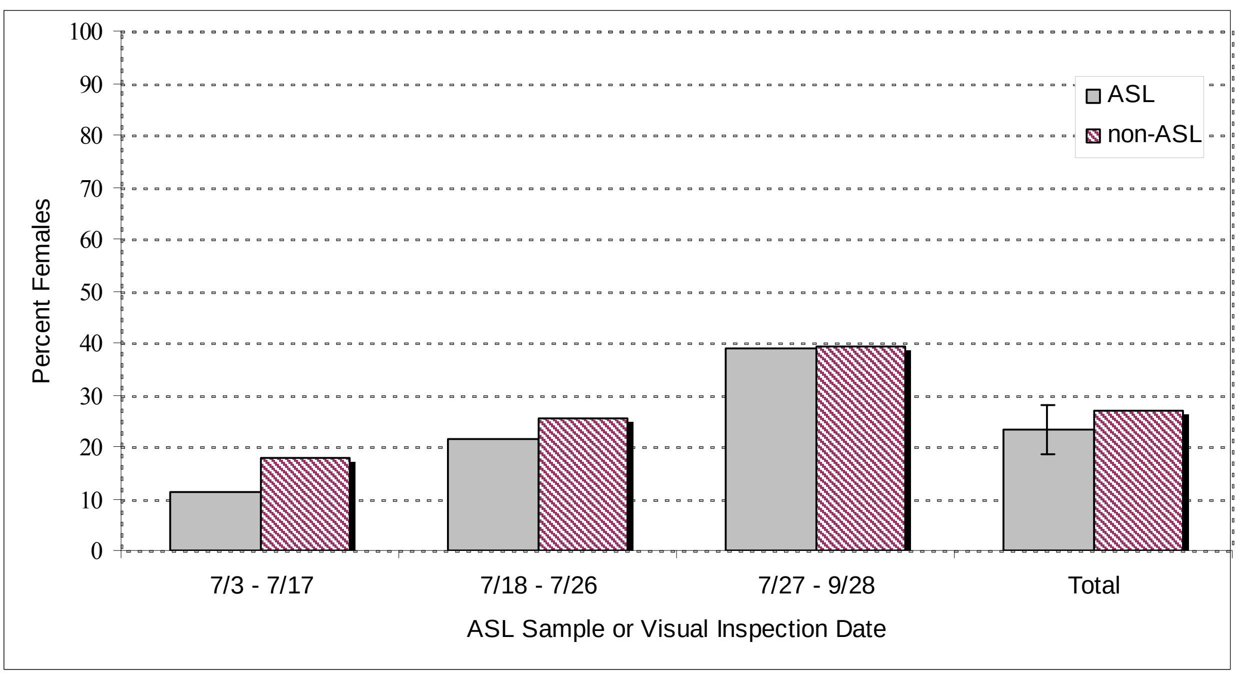
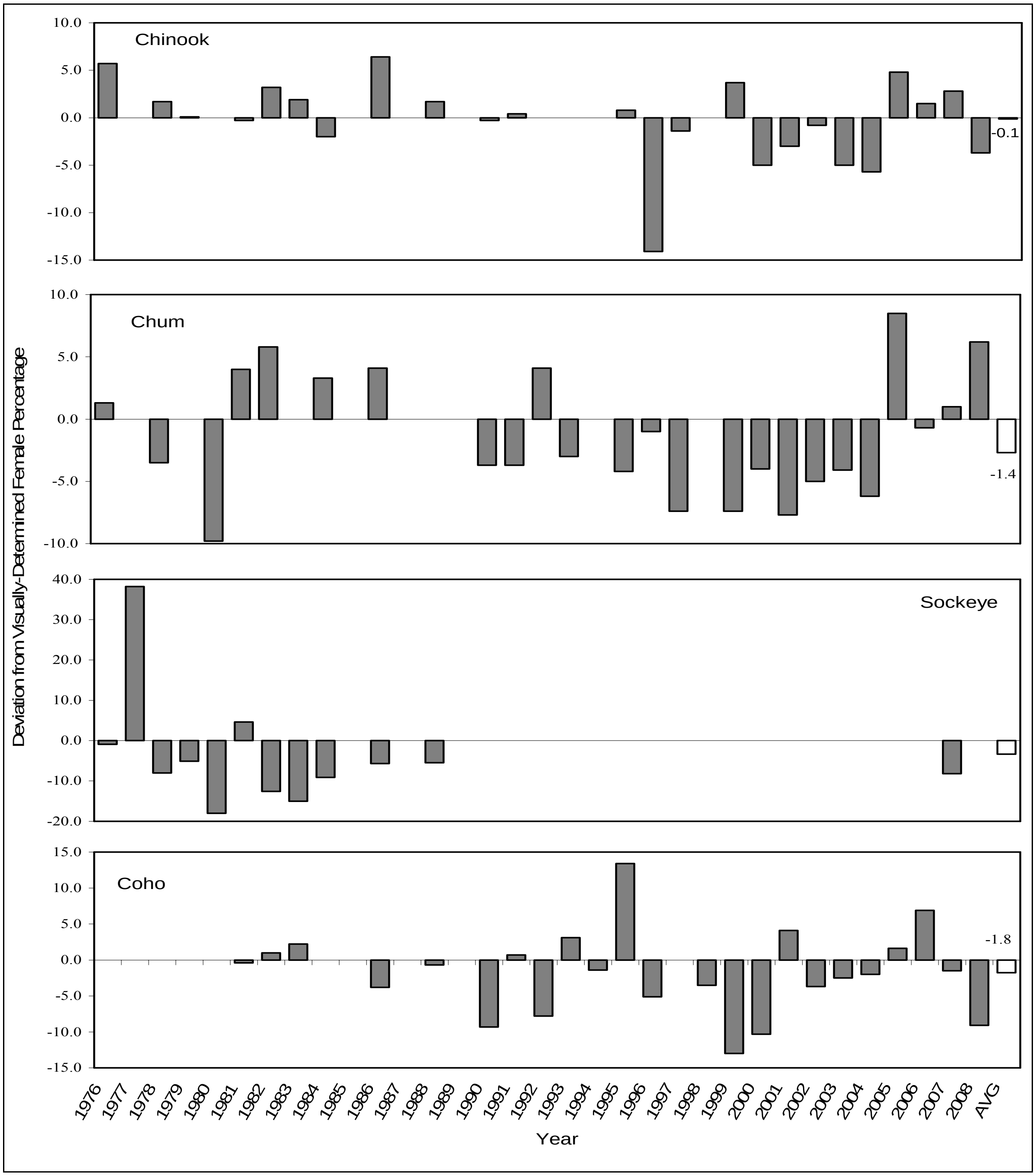


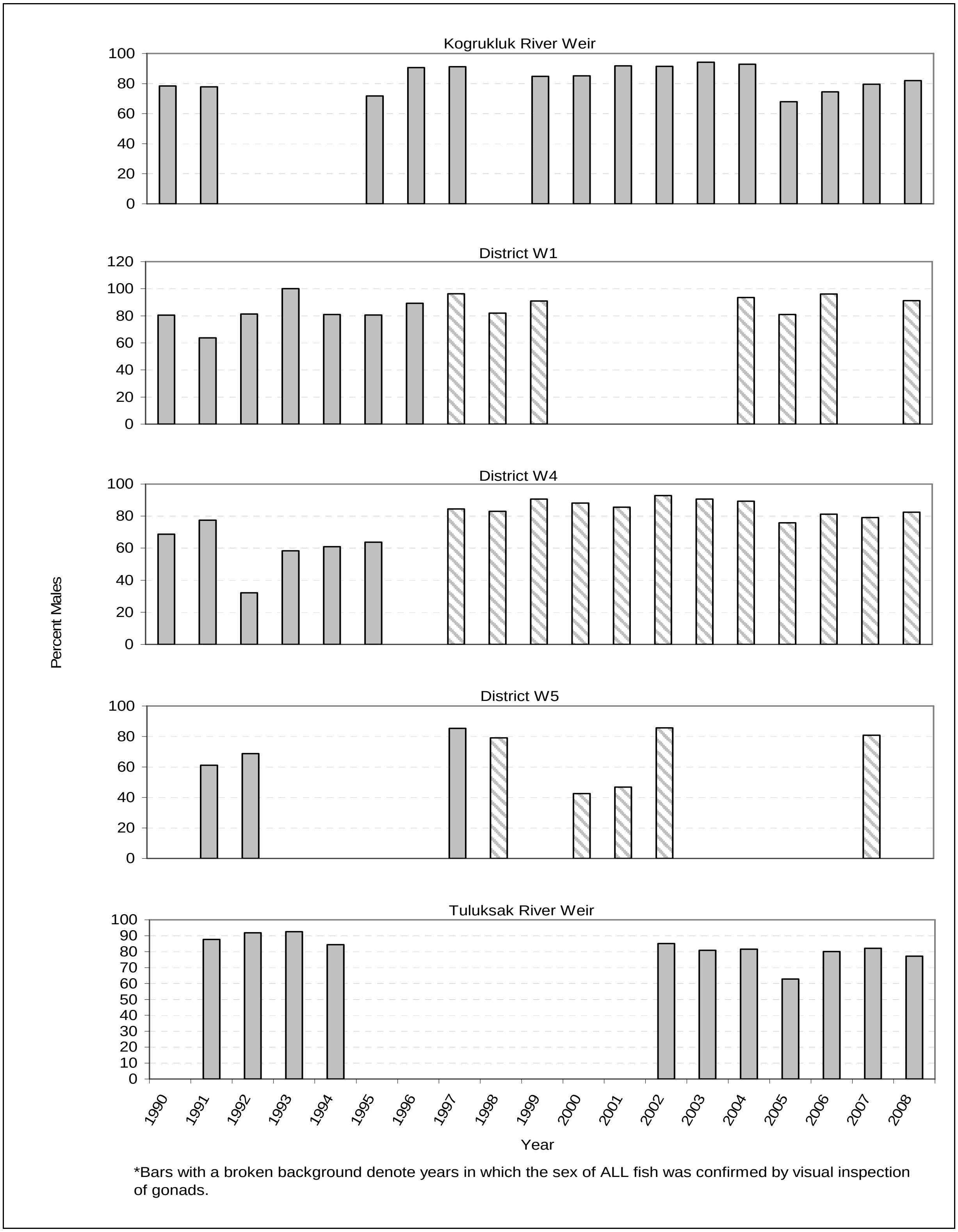
Figure 10.–Comparison of the percentage of female Chinook salmon passing upstream of the Kogrukluk River weir in 2008 as determined from standard ASL sampling using a fish trap, and from visual inspection of non-ASL sampled fish using standard fish passage procedures.



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

Source: Williams et al. 2008, Williams and Sheldon *In prep.*

Figure 11.–Annual deviation of percent females at Kogrukluk River weir, as determined by ASL sampling methods from the percentage determined through standard escapement counts.



Note: Hatch-marked bars only include data for fish with confirmed sex identification.

Figure 12.–Percentage of male age-1.3 Chinook salmon documented during ASL sampling between 1990 and 2008.

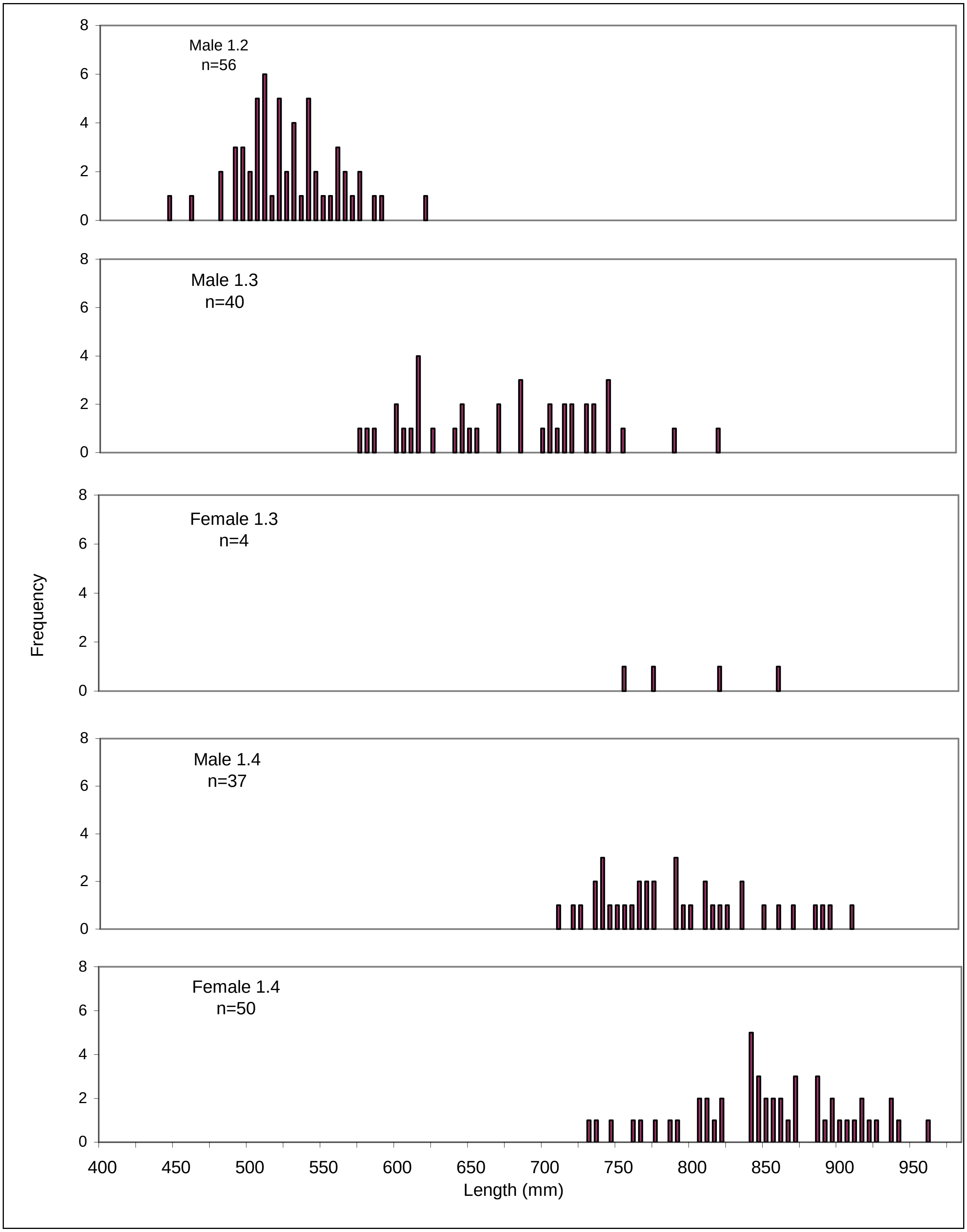


Figure 13.–Length frequency of District 1 Chinook salmon by age and sex, 1999.

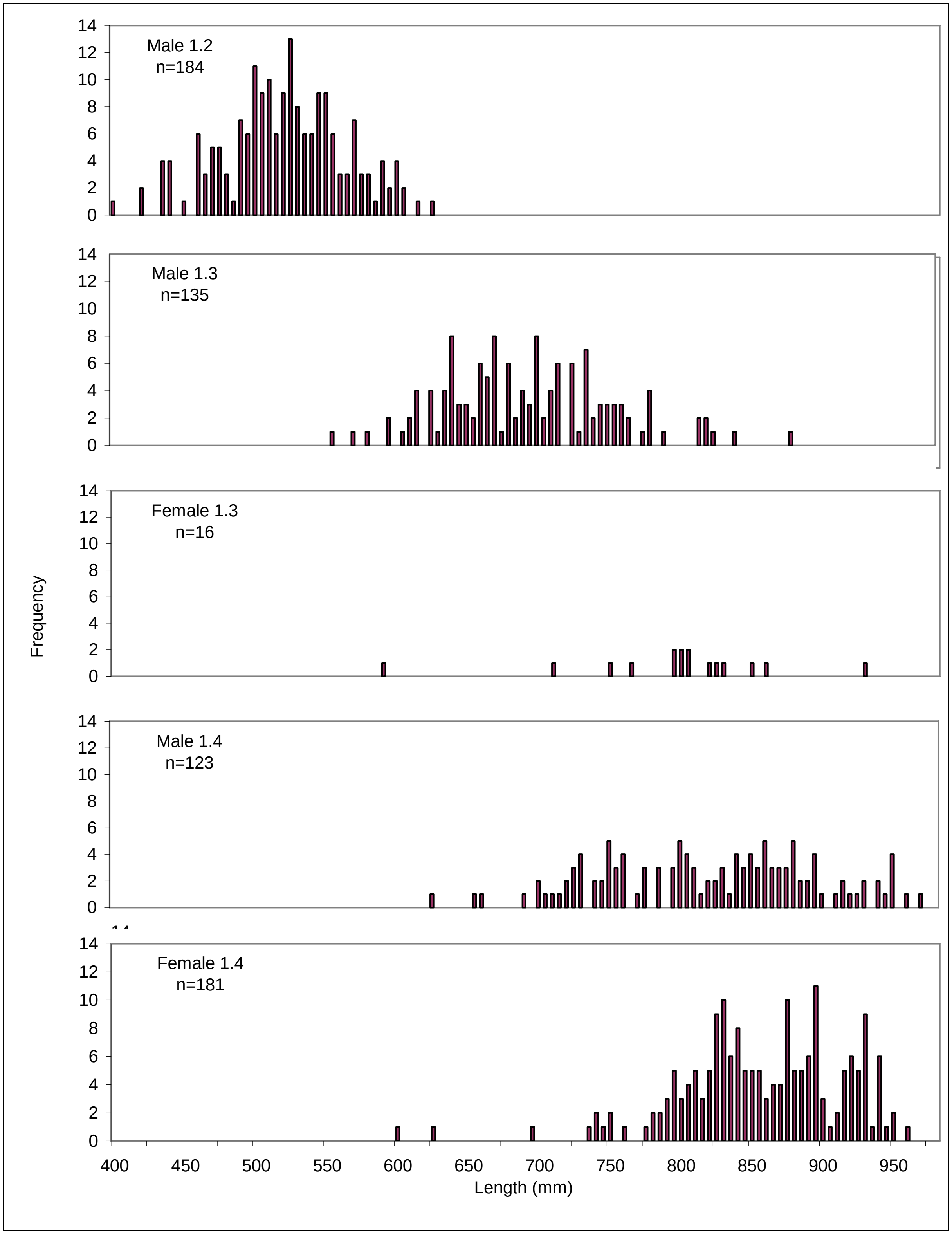


Figure 14.–Length frequency of District 4 Chinook salmon by age and sex, 1999.

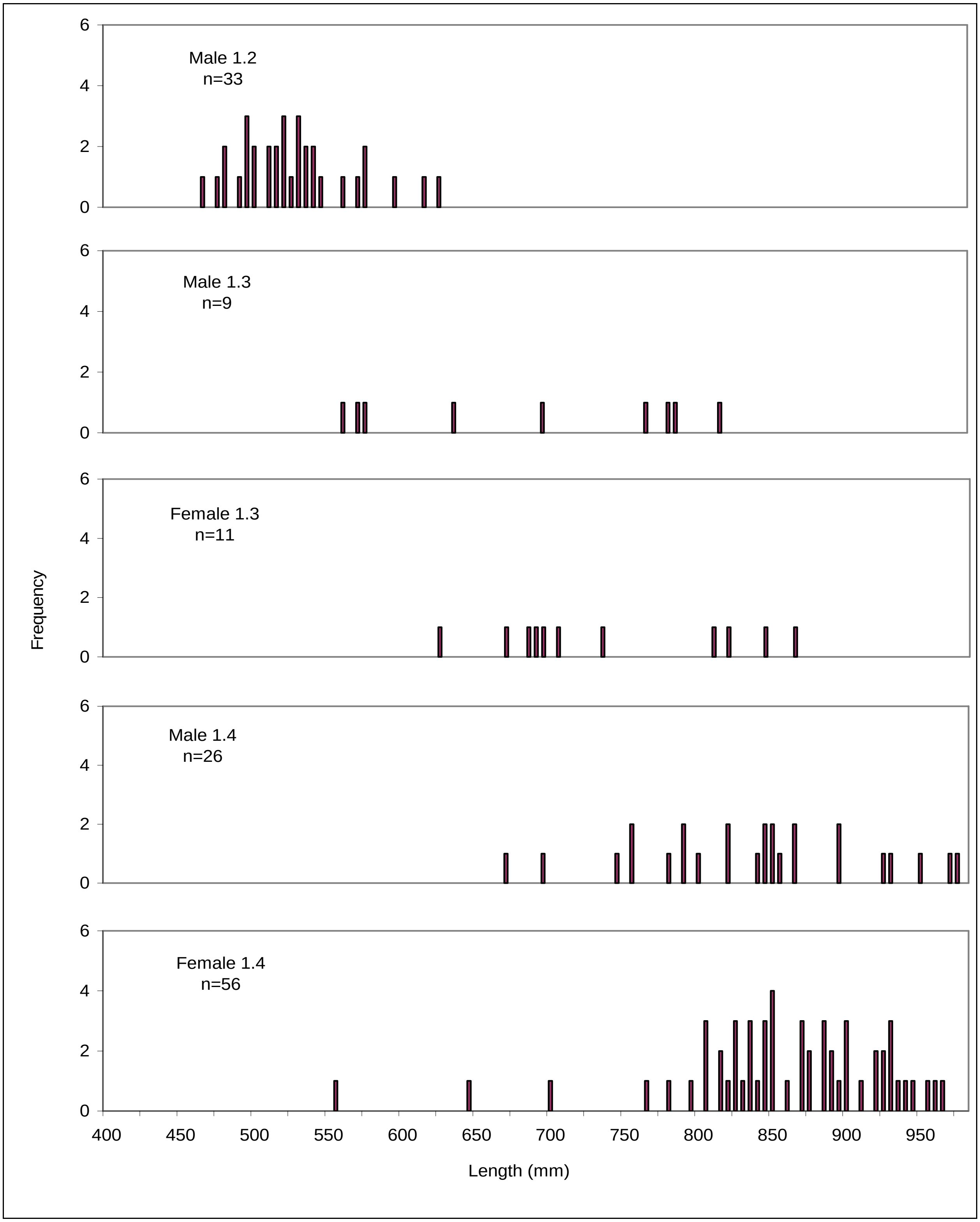


Figure 15.–Length frequency of District 5 Chinook salmon by age and sex, 1999.

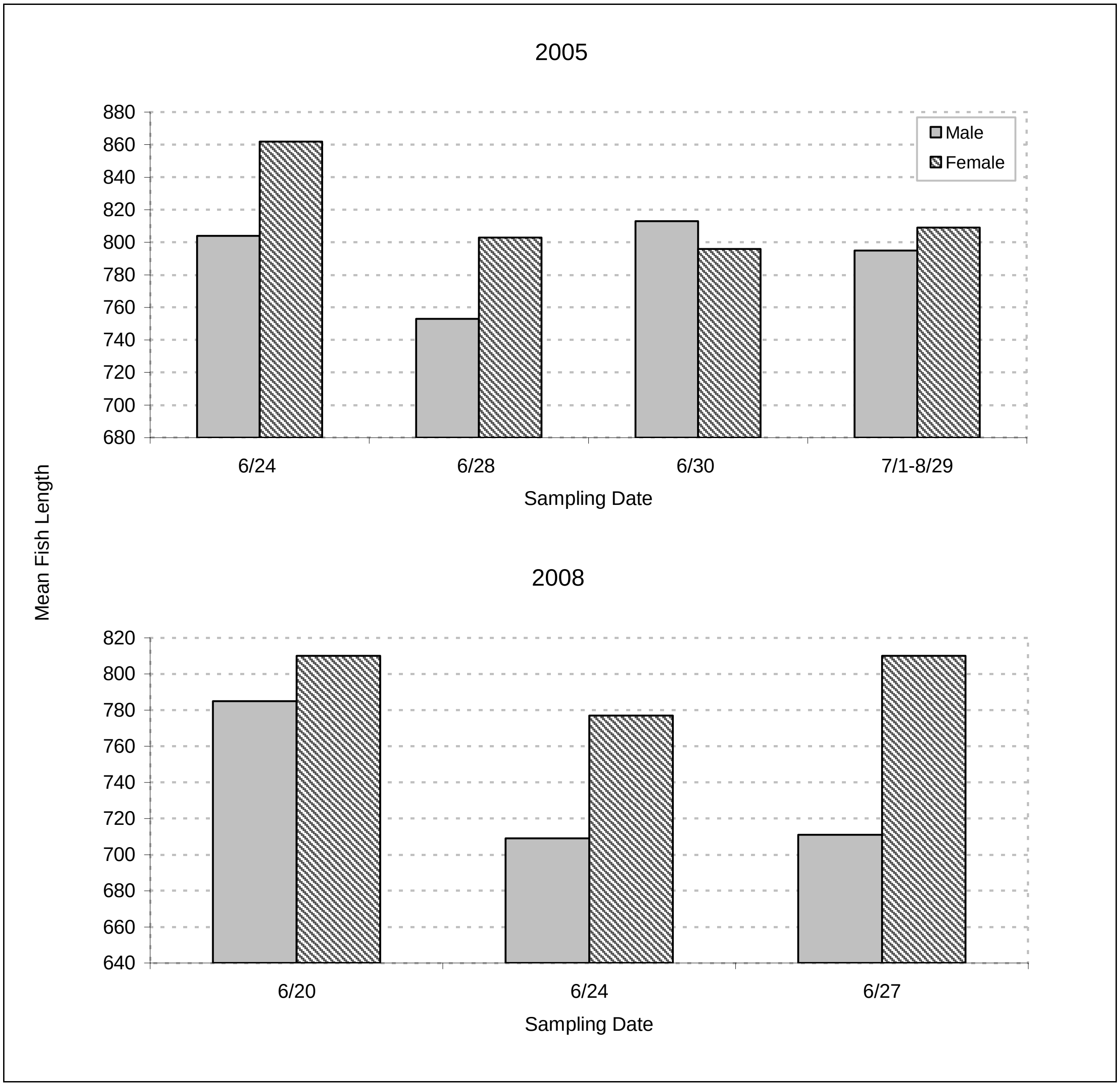


Figure 16.–Length composition of age-1.4 Chinook salmon in the 2005 and 2008 W1 commercial harvest.

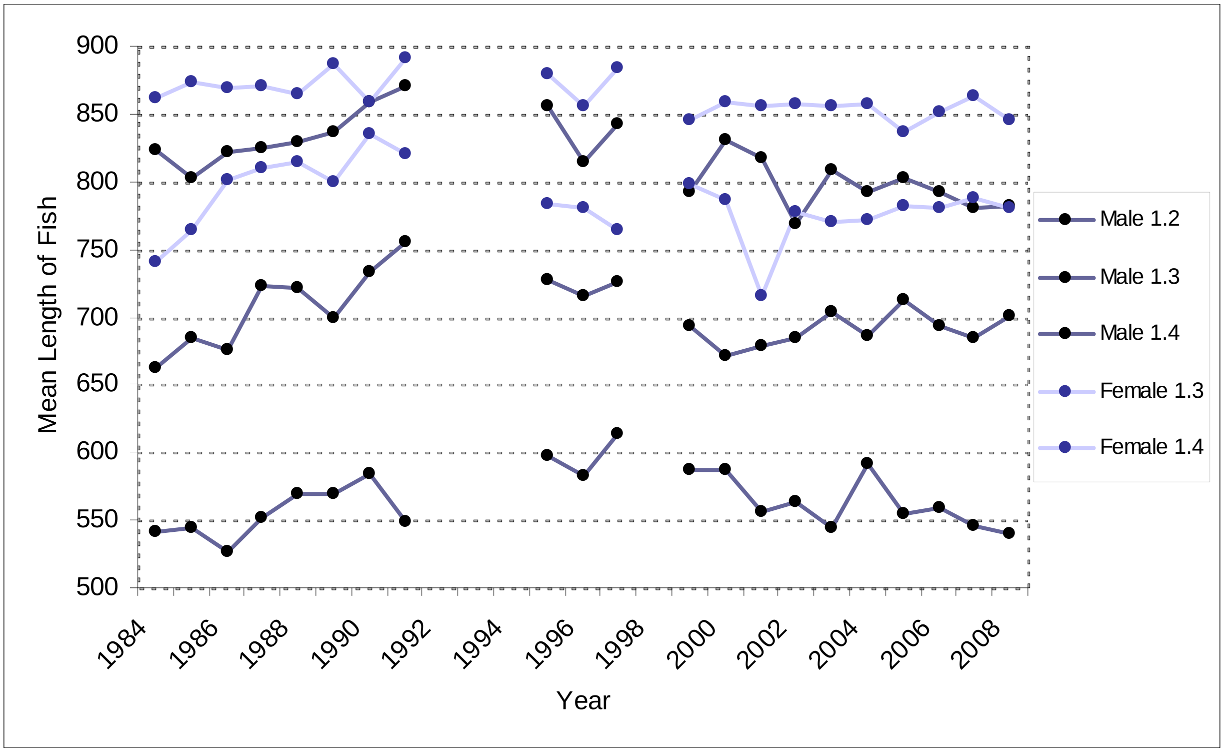


Figure 17.–Historical trends in the average length of Chinook salmon at Kogrukluk River weir, 1984-2008.

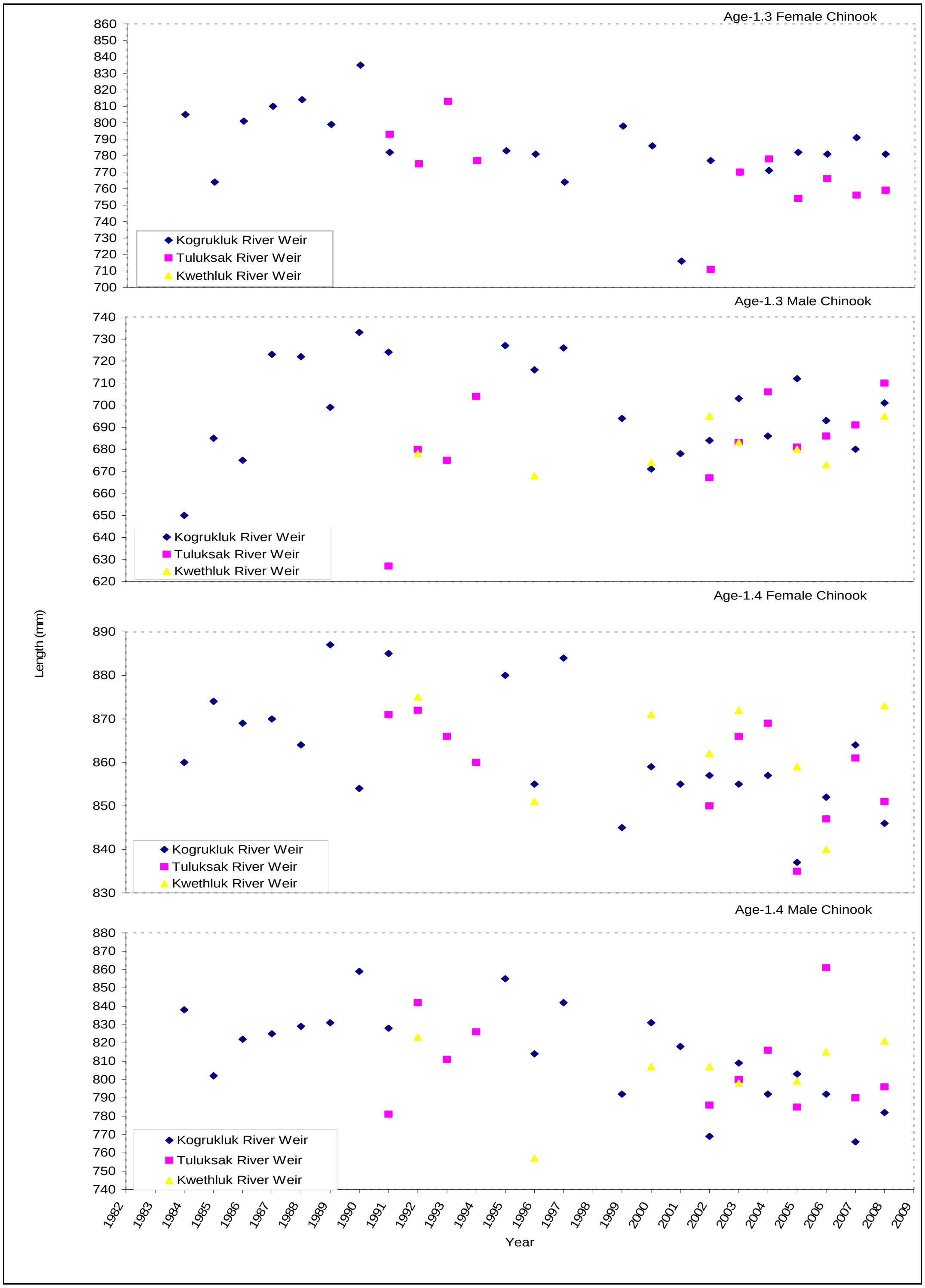


Figure 18.–Length at age of Chinook salmon from the Kogrukluk, Kwethluk, and Tuluksak River weirs.

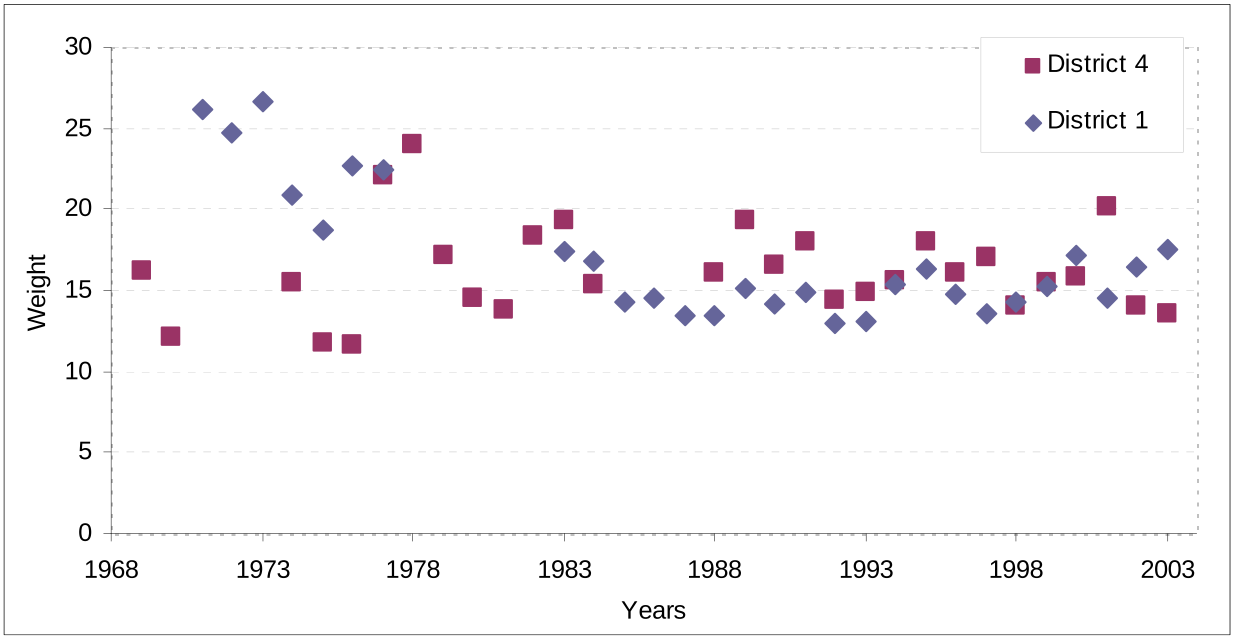


Figure 19.–Average weight by year of commercially caught Chinook salmon in Kuskokwim area fishing Districts 1 and 4.

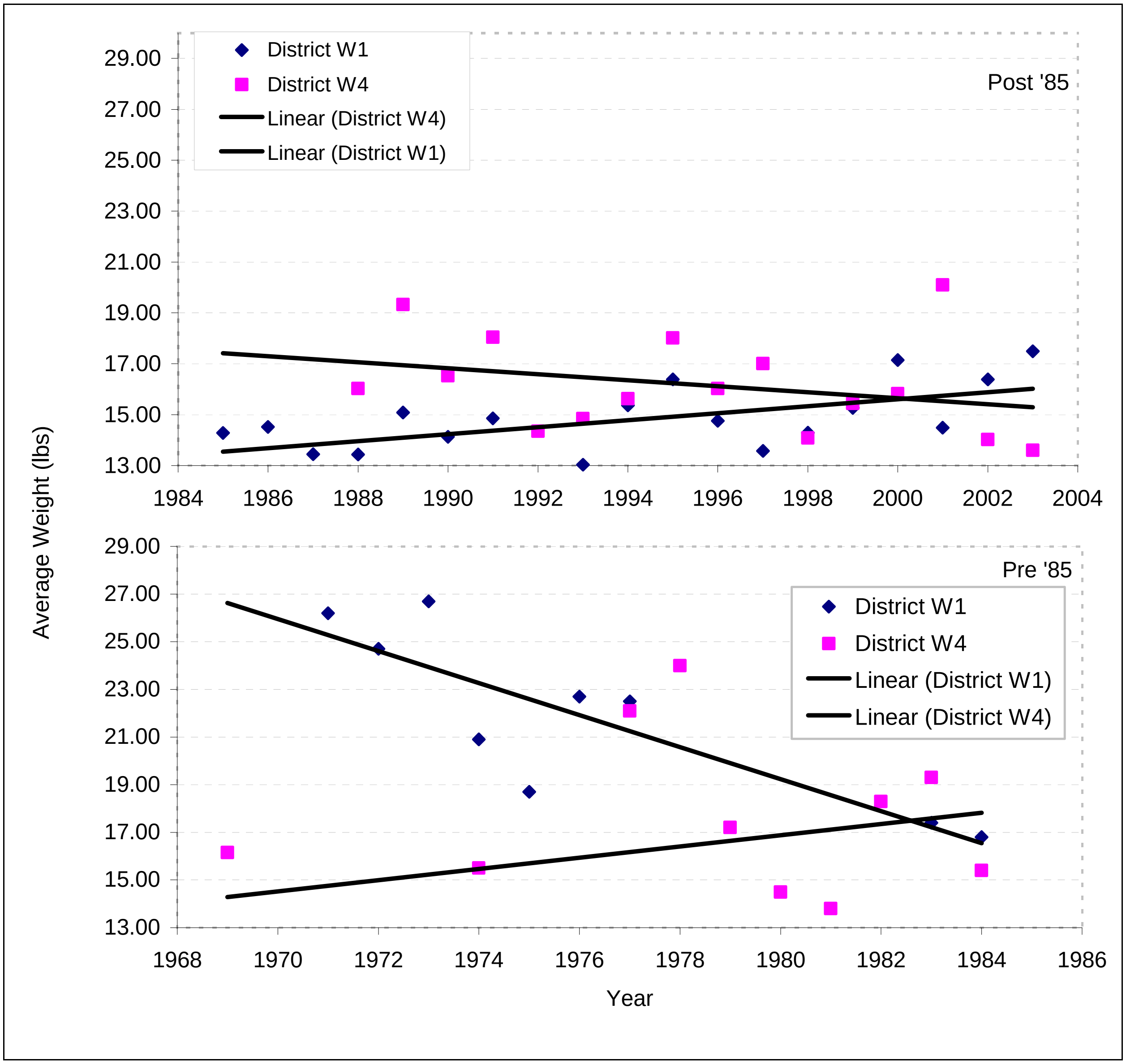
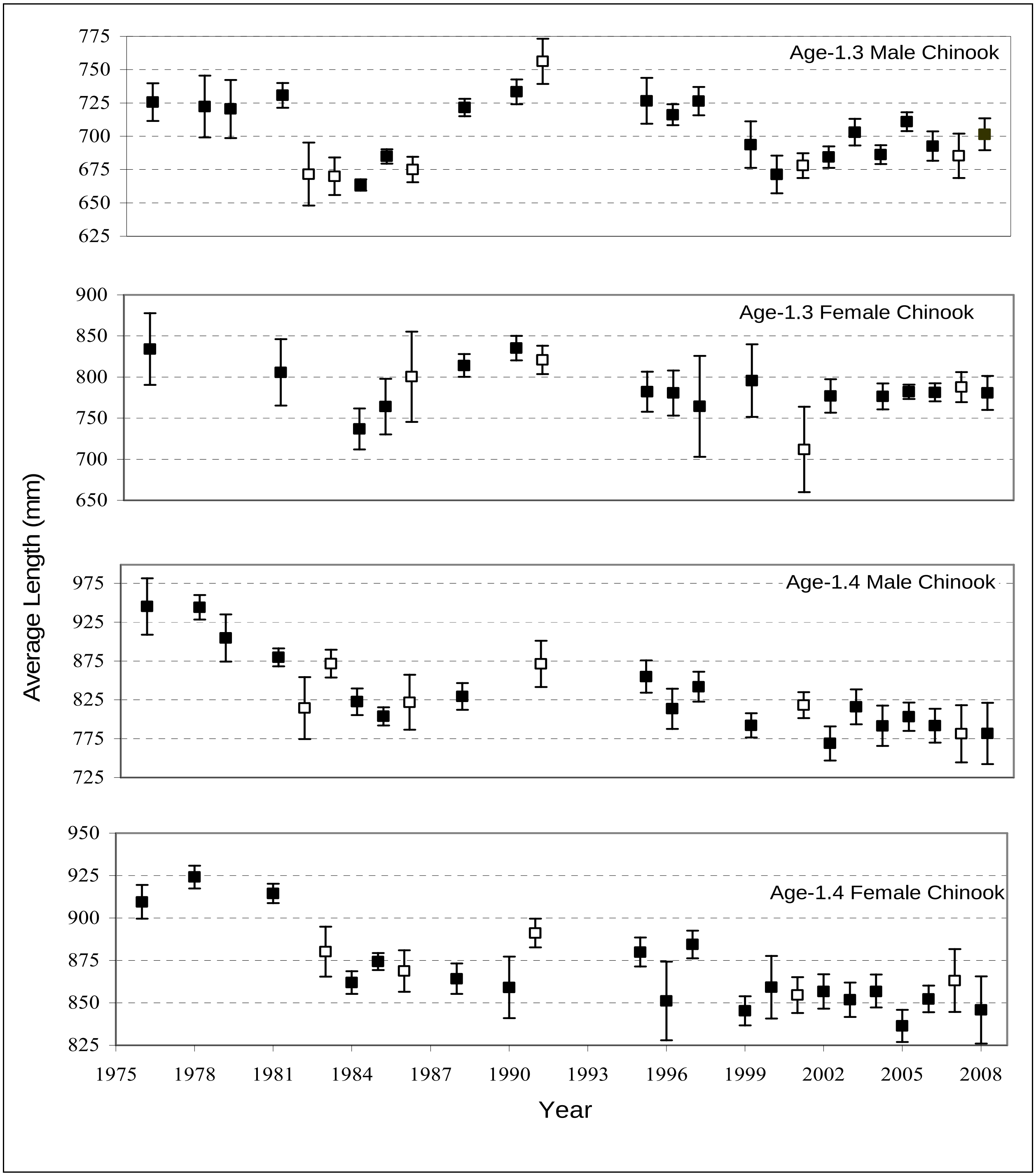


Figure 20.–Average weight of Chinook salmon in District W1 and District W4 before and after 1985 (restricted and unrestricted mesh harvest).



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

Source: Williams et al. 2008, Williams and Sheldon *In prep.*

Figure 21.–Historical average annual length for Chinook salmon with 95% confidence intervals at Kogrukluk River weir.

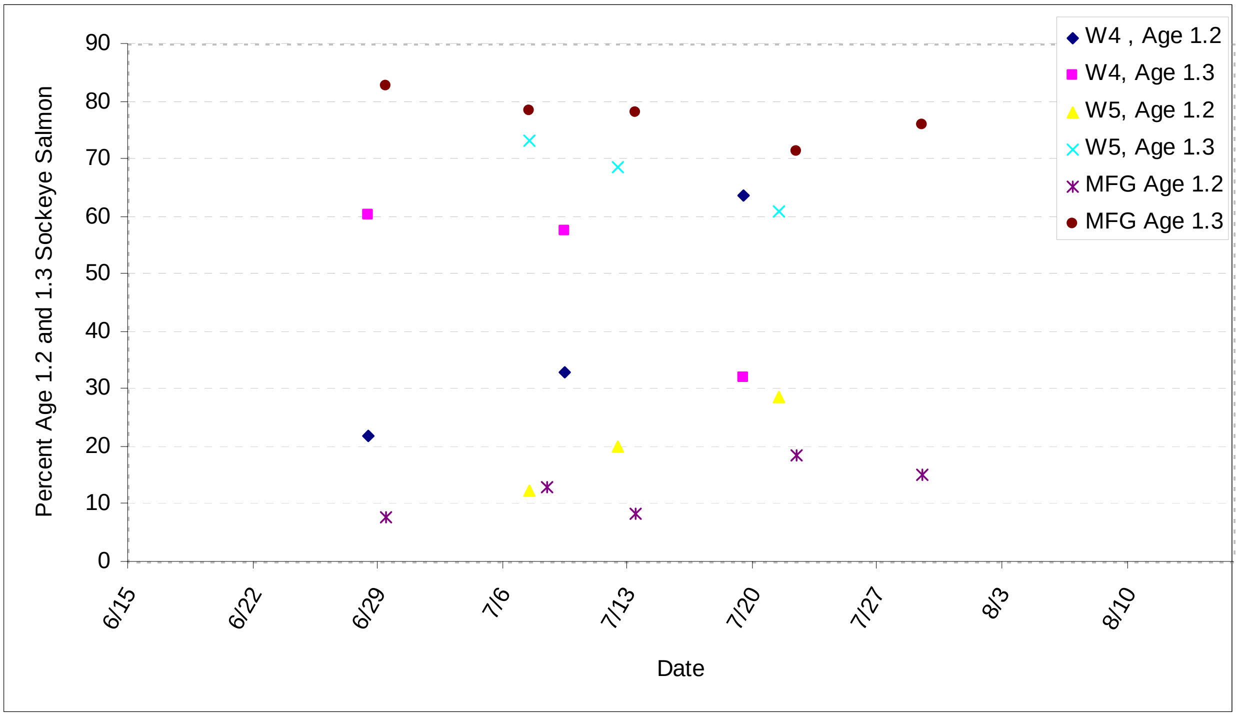


Figure 22.–Percentage of age-1.2 and 1.3 sockeye salmon by sample date from the Middle Fork Goodnews River weir (MFG) escapement and the District 4 and District 5 commercial catches, 1999.

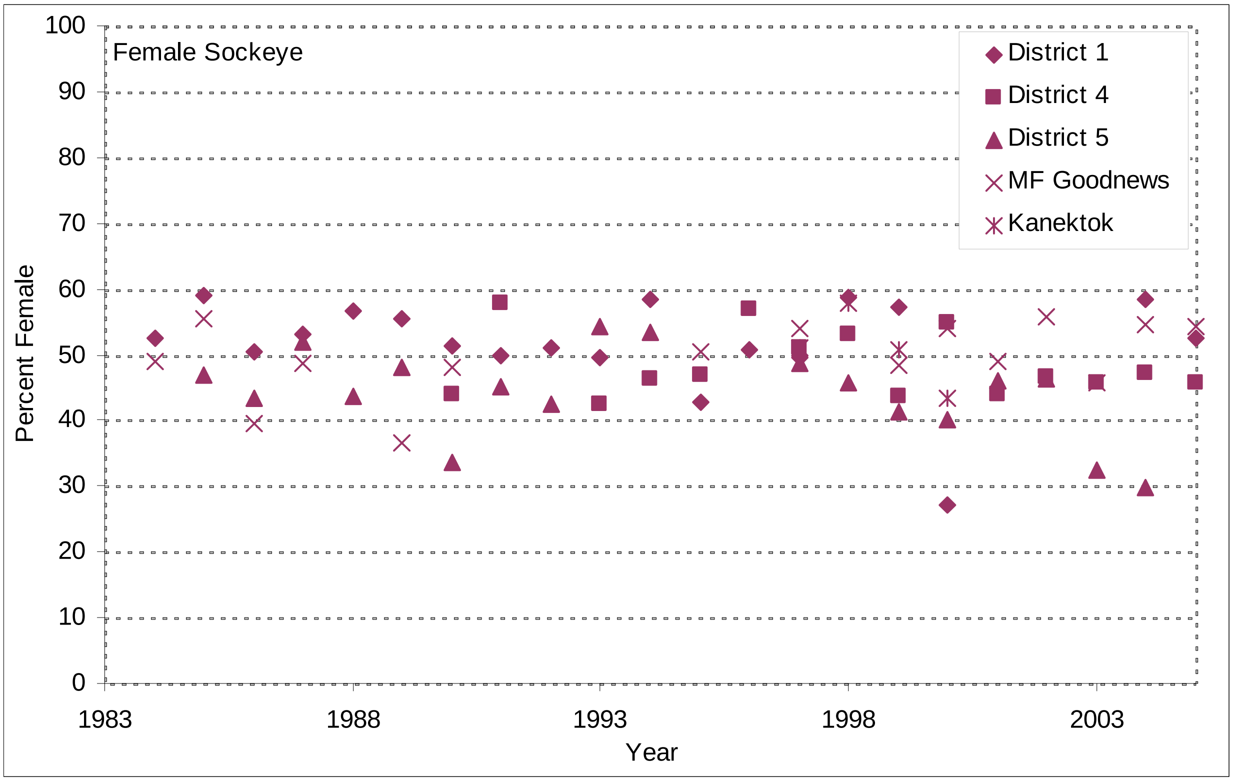


Figure 23.–Percent female sockeye salmon sampled from 3 commercial fishing districts and 2 associated escapement projects.

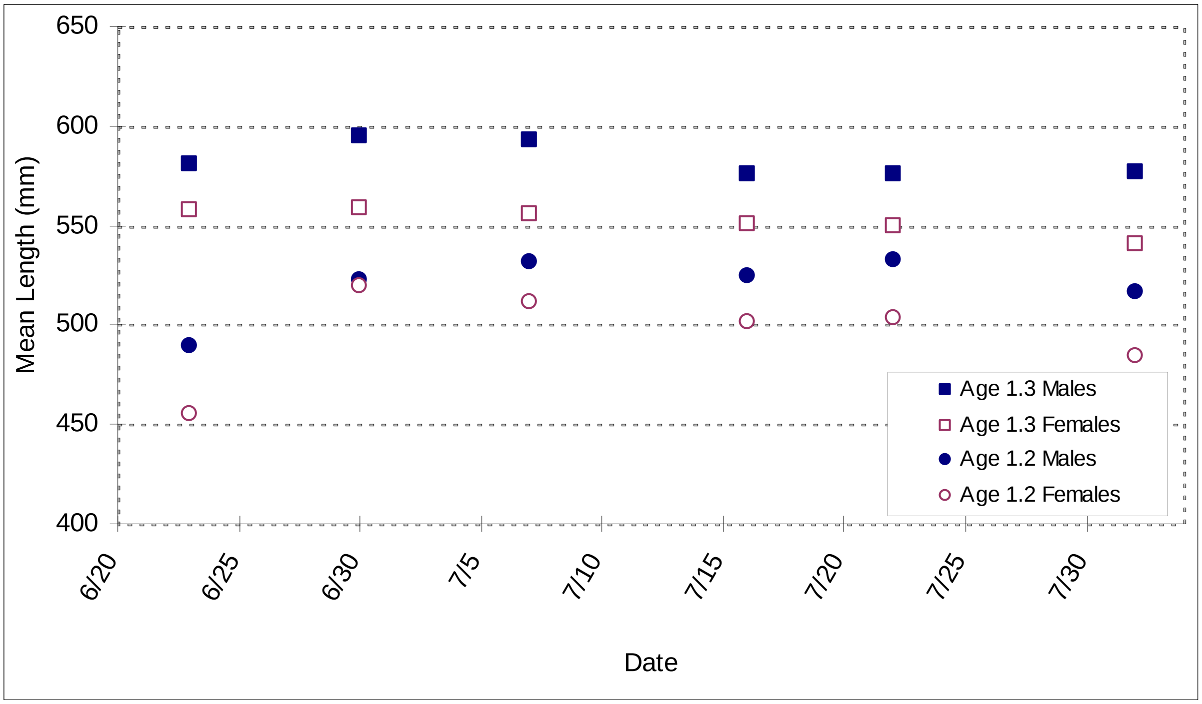


Figure 24.–Average length by sample date for Kanektok River sockeye salmon in 1997.

Figure 25.–Comparison of average length by year of female sockeye salmon sampled from the W5 Commercial fishery and at the Middle Fork Goodnews River weir.

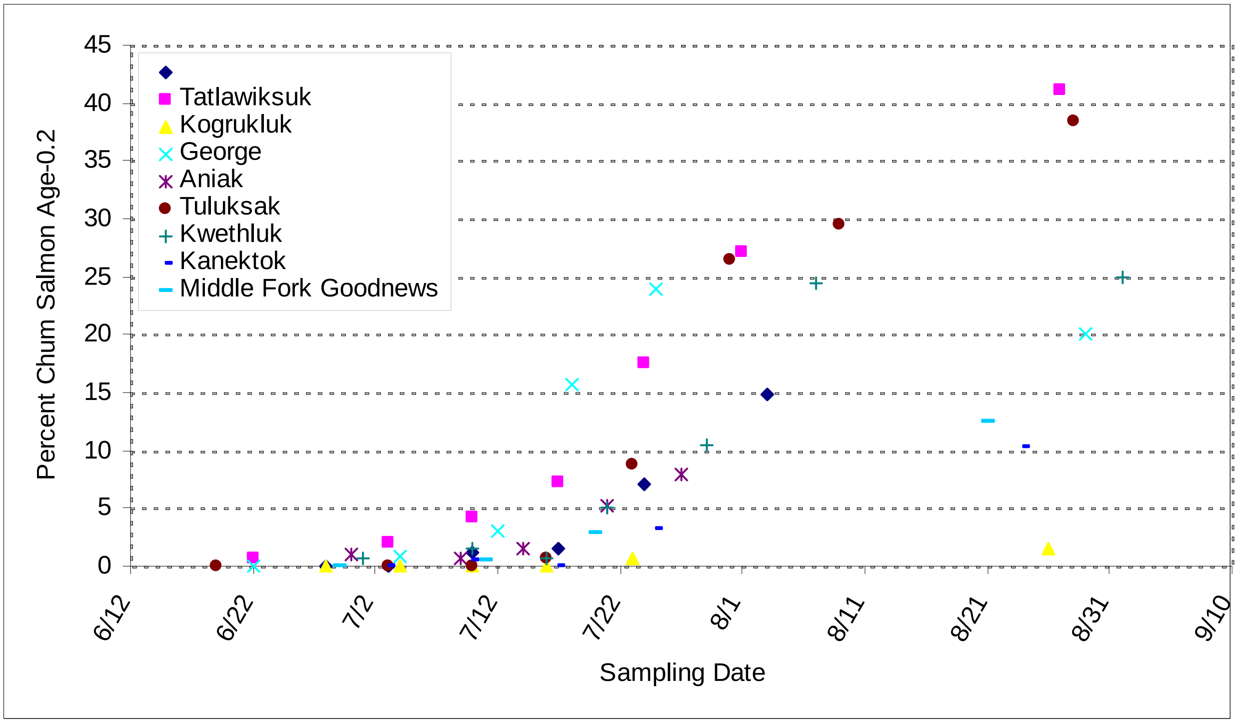


Figure 26.–Percent 0.2 age chum salmon by sample date in escapement projects.

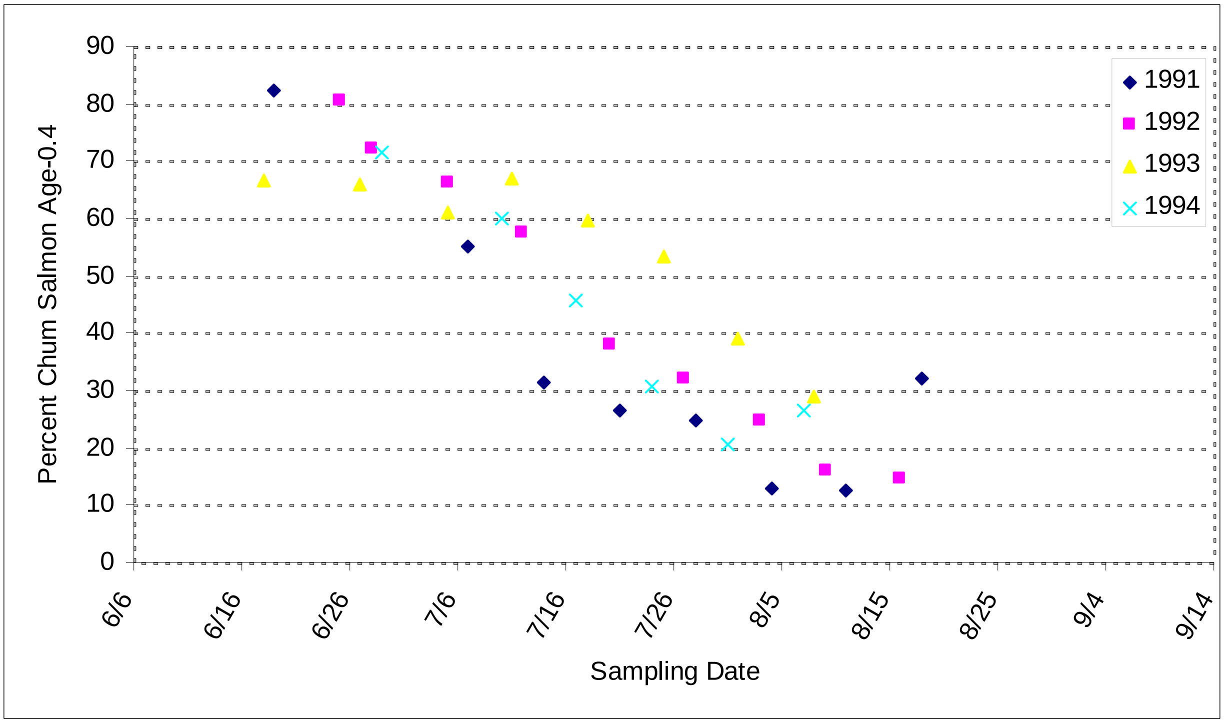


Figure 27.–Percentage of age-0.4 chum salmon by sample date in the Tuluksak River, 1991–1994.

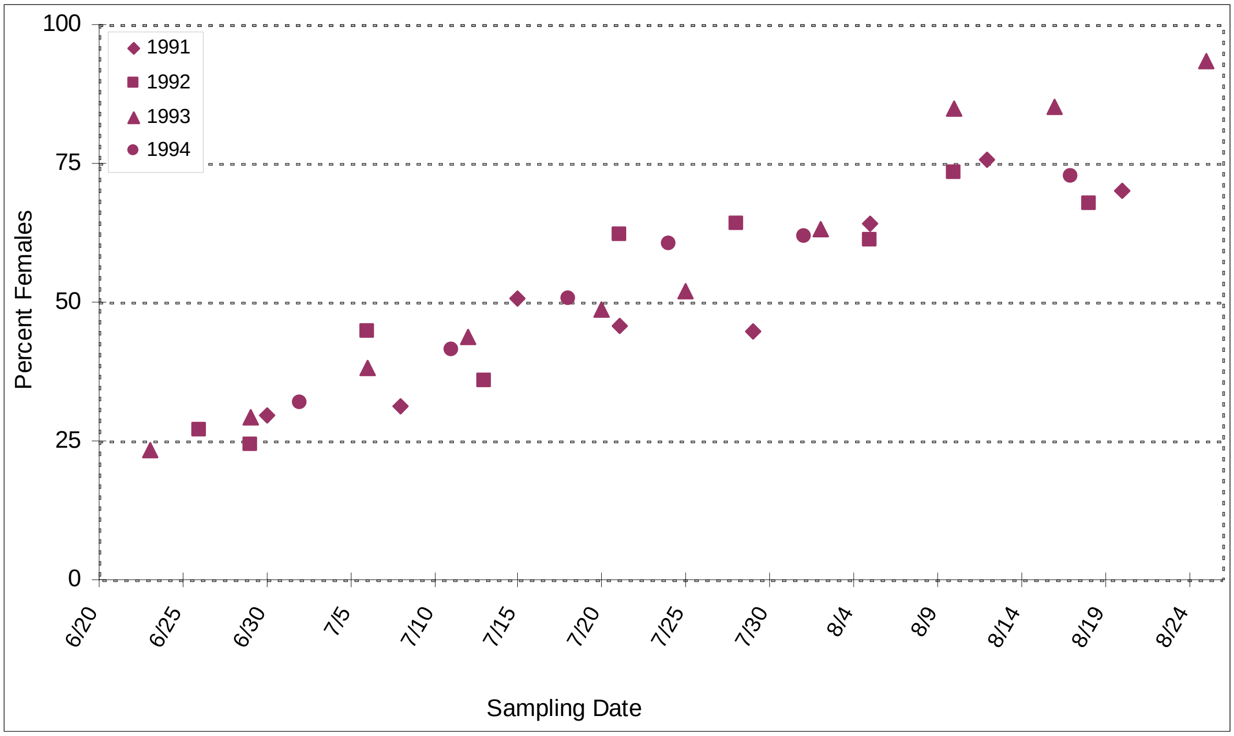


Figure 28.–Percentage of female chum salmon by sample date at Tuluksak River weir, 1991–1994.

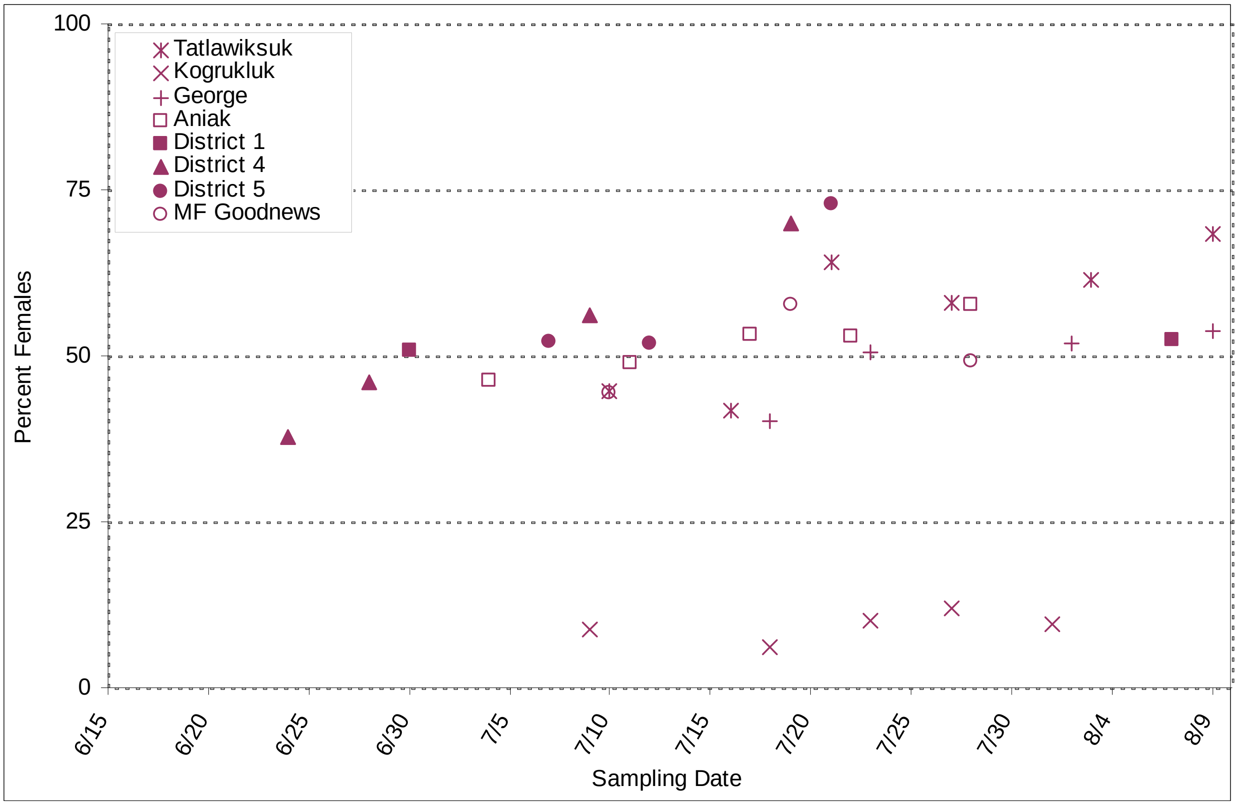


Figure 29.–Percentage of female chum salmon by sample date from Kuskokwim Area escapements and commercial catches, 1999.

Figure 30.–Historical percentage of female chum salmon in Kuskokwim Area escapement and commercial catch populations, 1976–2008.

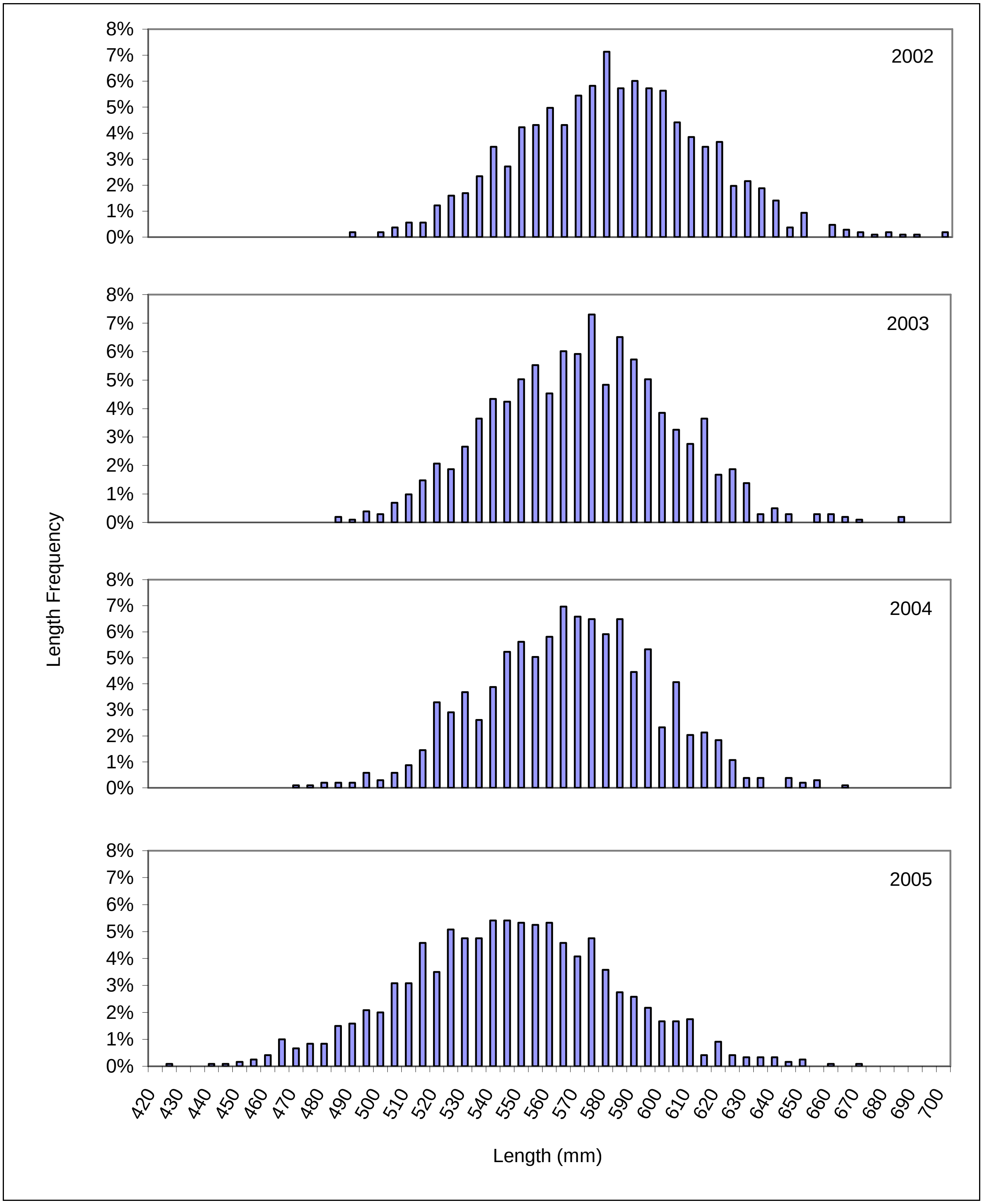


Figure 31.–Length frequency histograms for chum salmon at Kogrukluk River weir for 2002–2005.

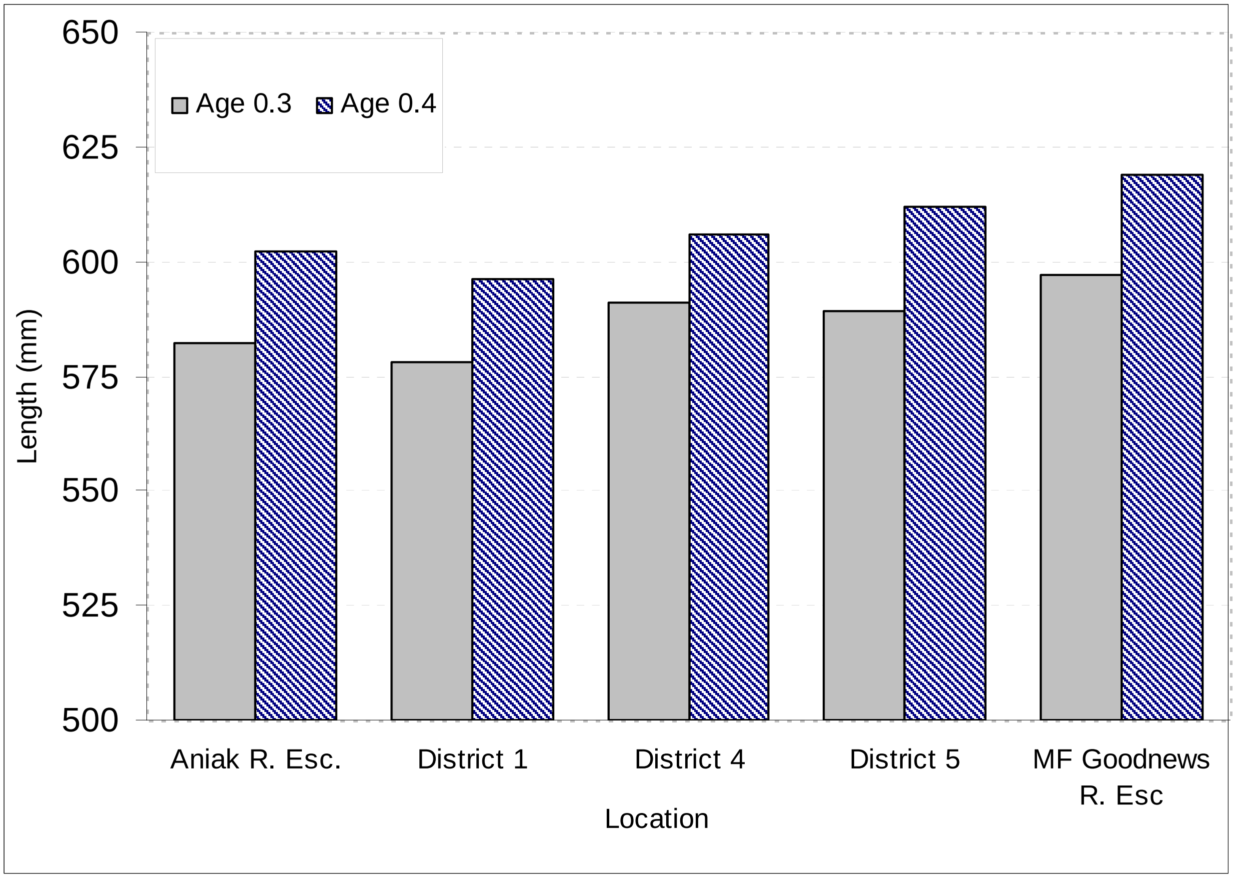


Figure 32.–Average length of male chum salmon from escapement and commercial catches in the Kuskokwim Area 1999.

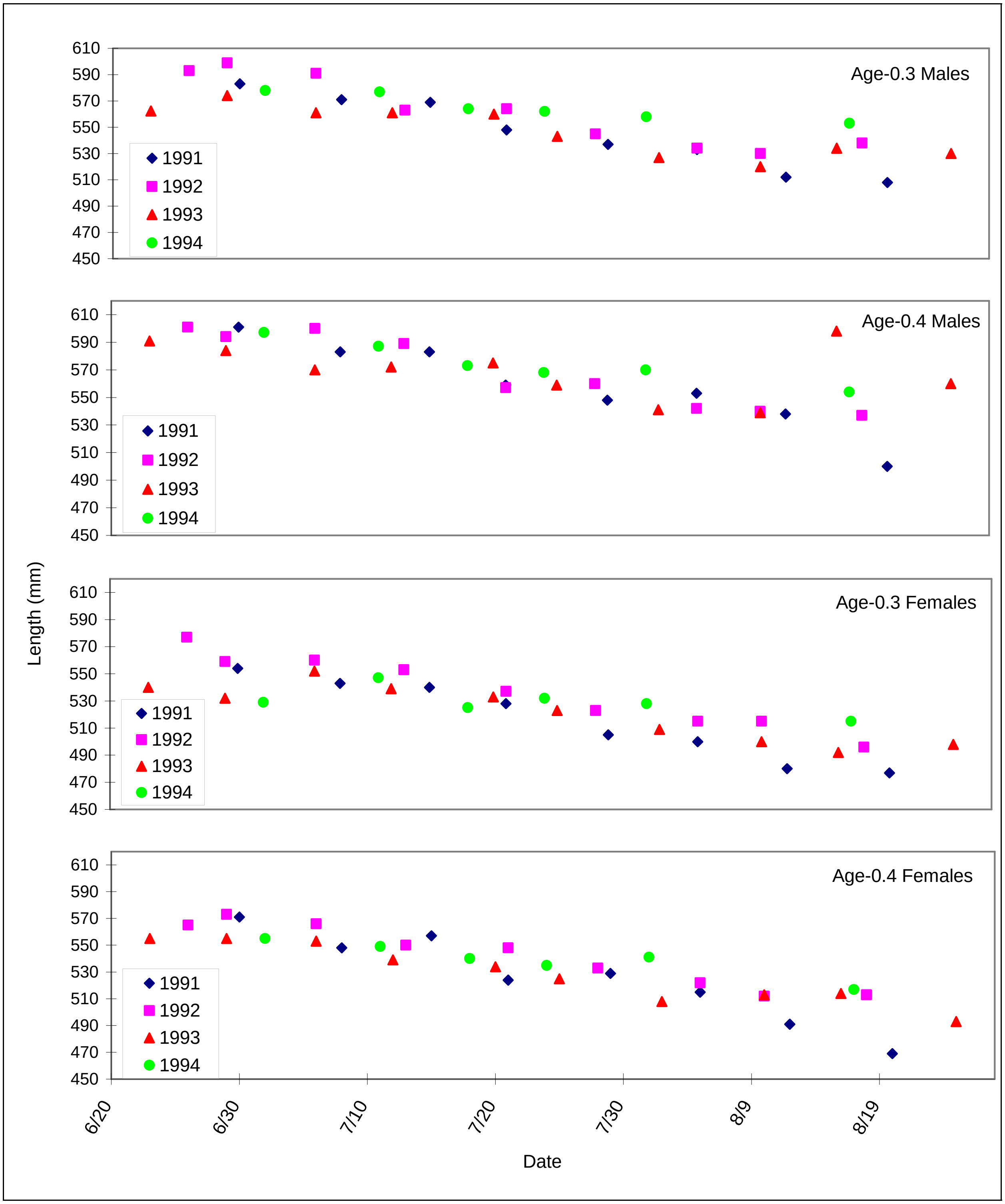
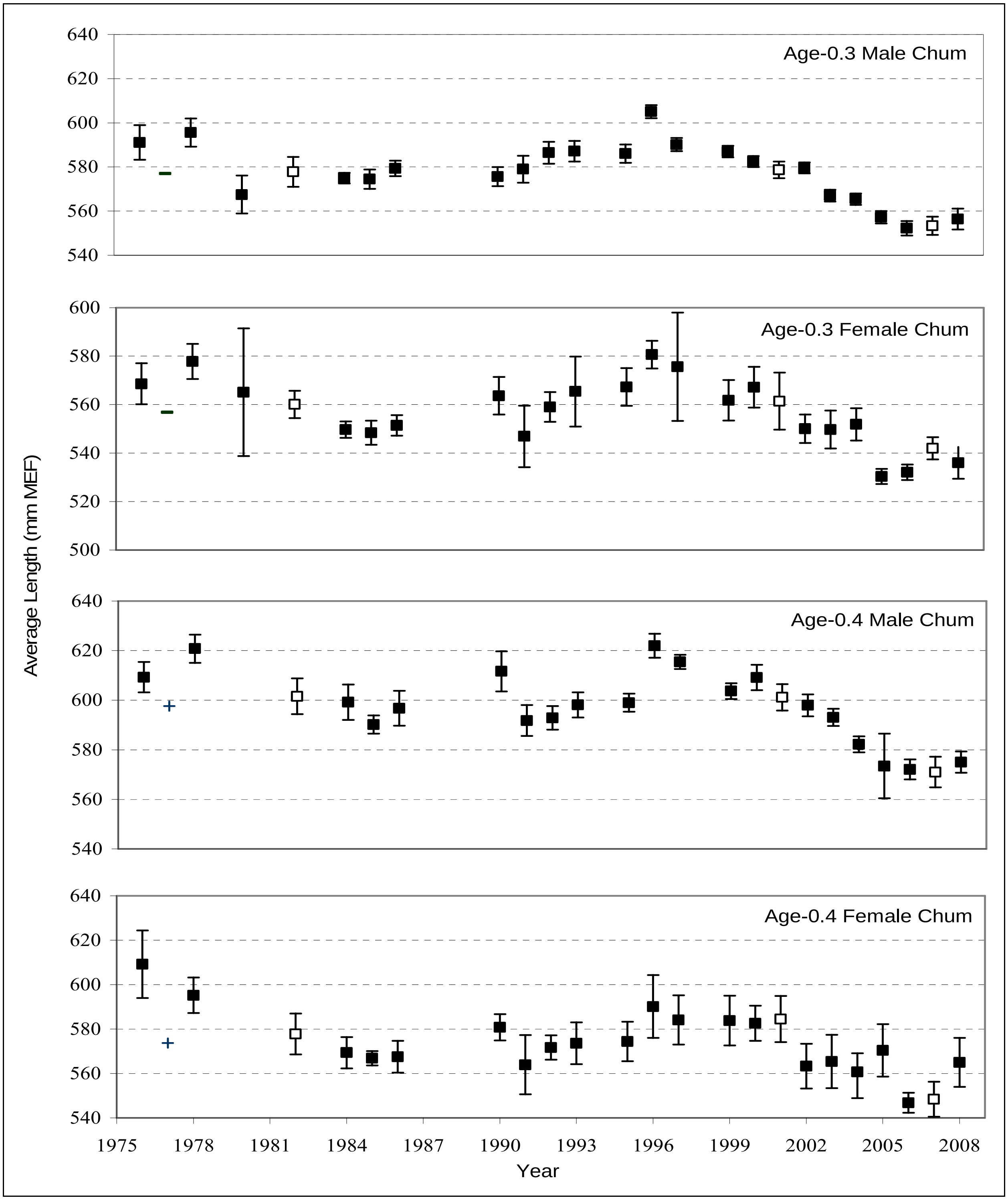


Figure 33.–Average length of chum salmon by sample date in the Tuluksak River, 1991–1994.



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

Source: Williams et al. 2008, Williams and Sheldon *In prep*.

Figure 34.–Historical average annual length for chum salmon with 95% confidence intervals at the Kogrukluk River weir.

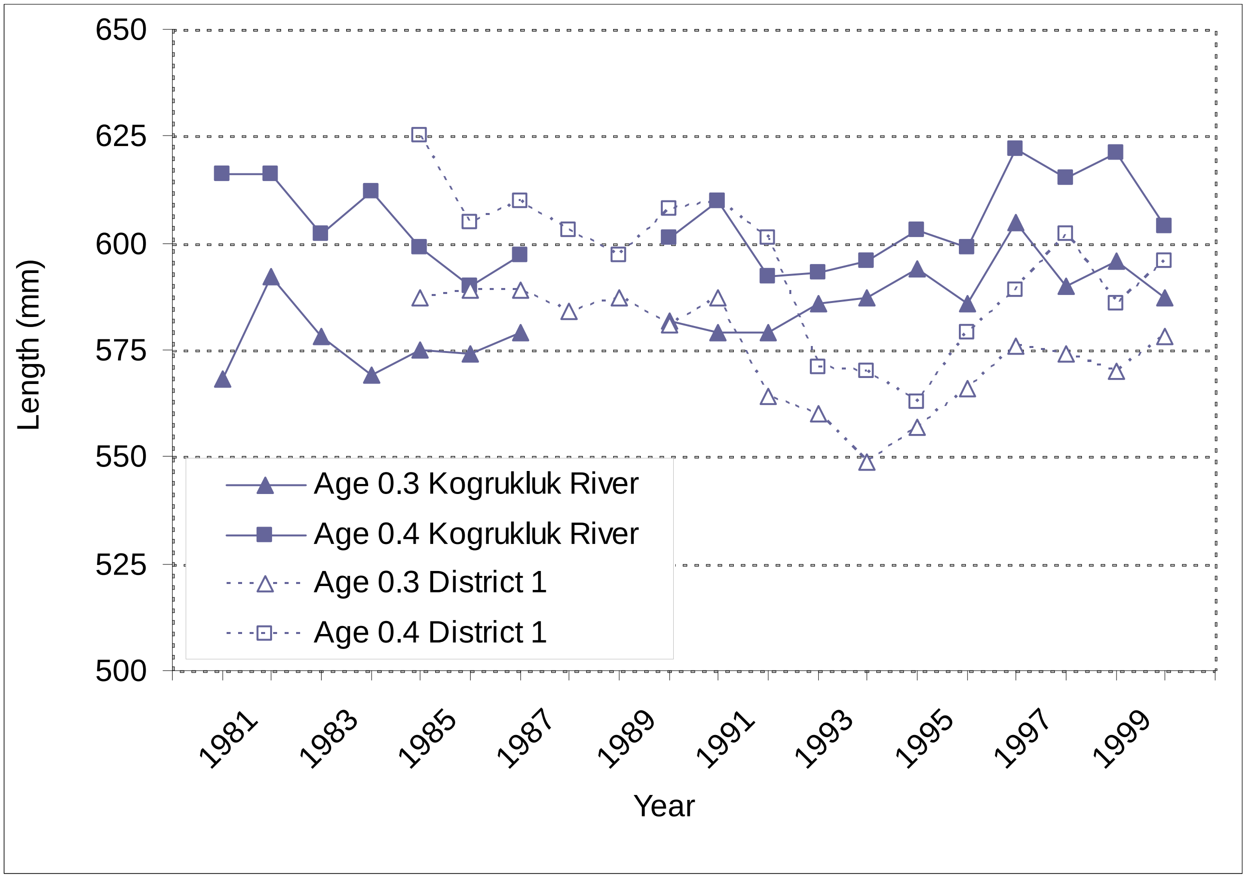


Figure 35.–Historical average length of male chum salmon from Kogrukluk River escapement and District 1 commercial harvests by age 1980–1999.

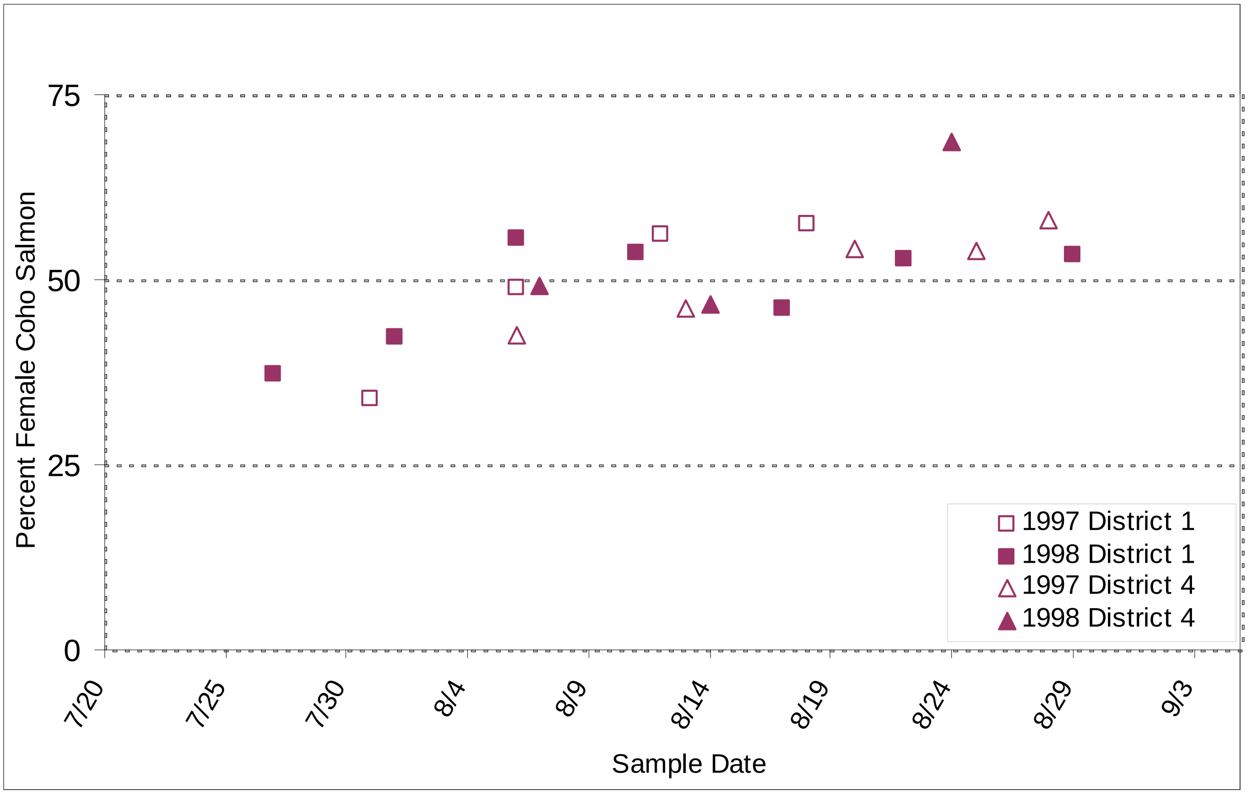
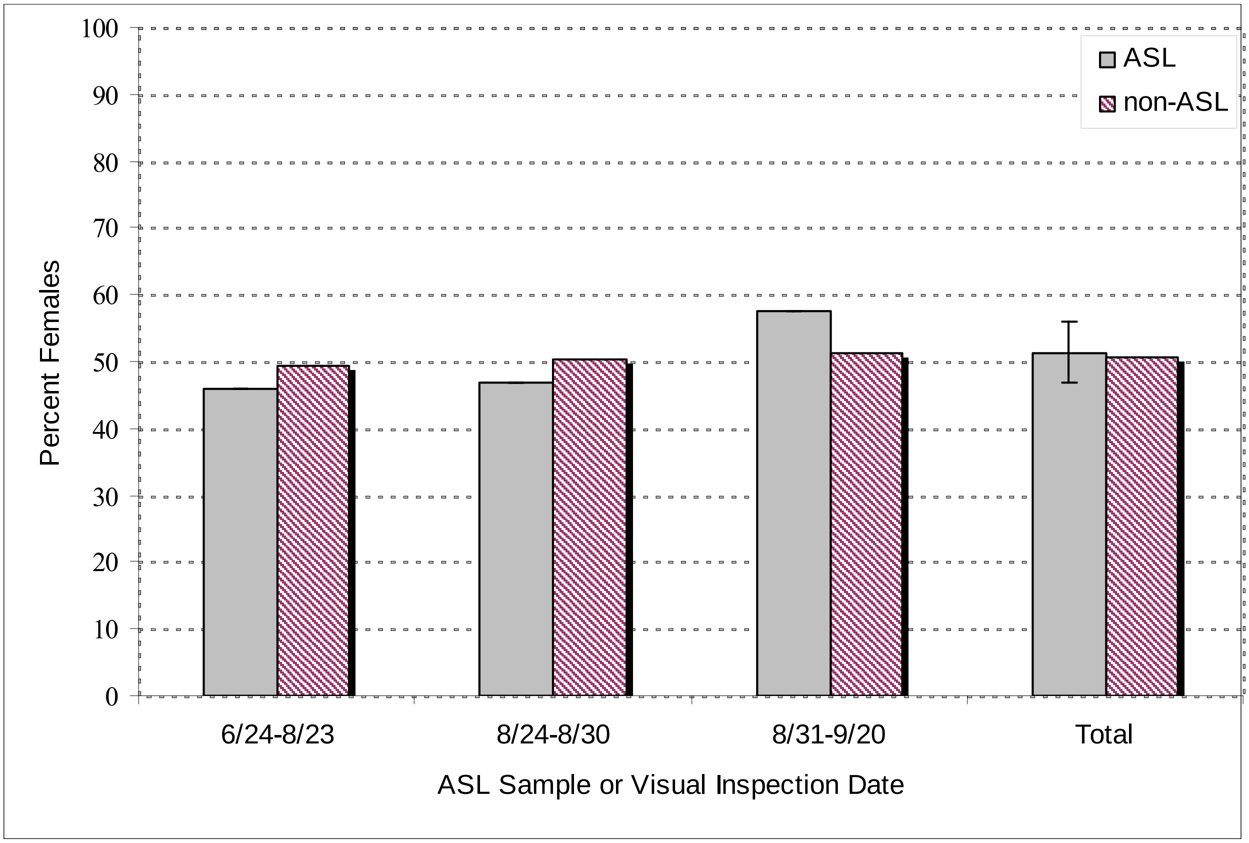
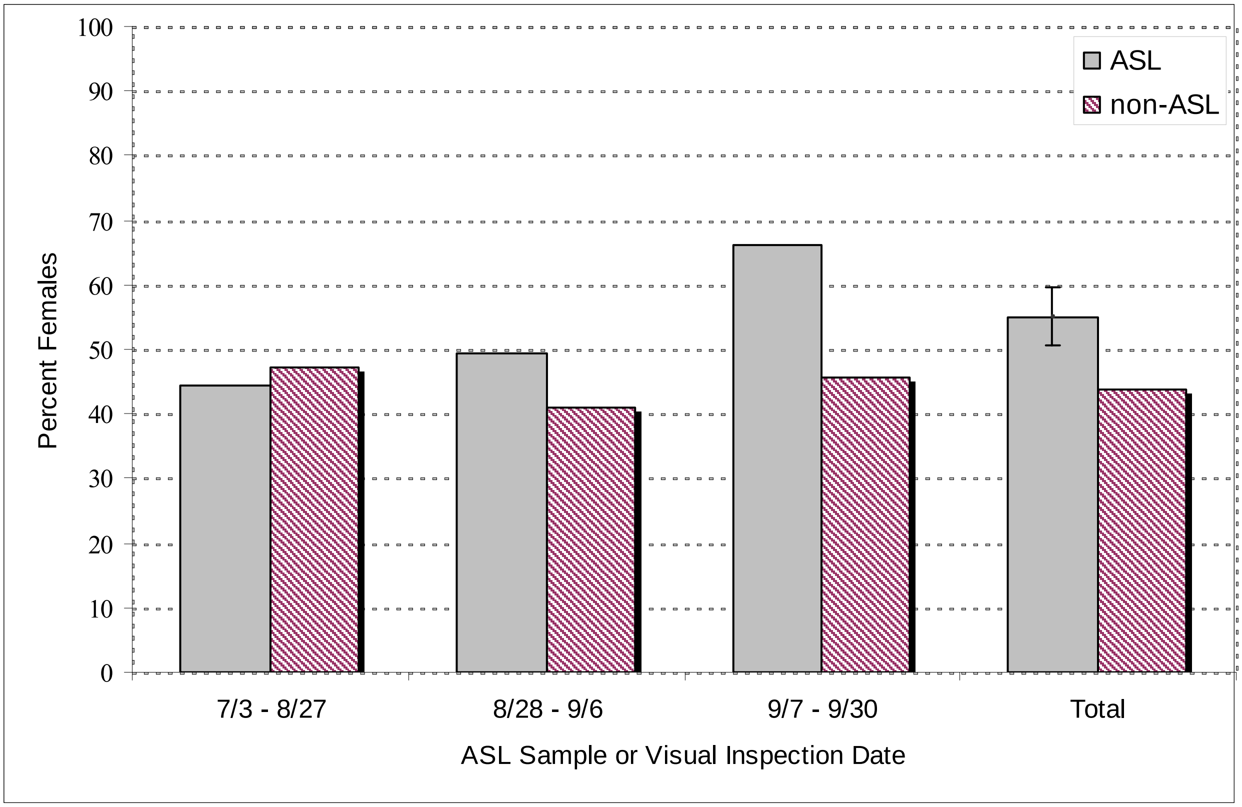


Figure 36.–Percentage of female coho salmon by sample date from Districts 1 and 4 catch populations 1997 and 1998.



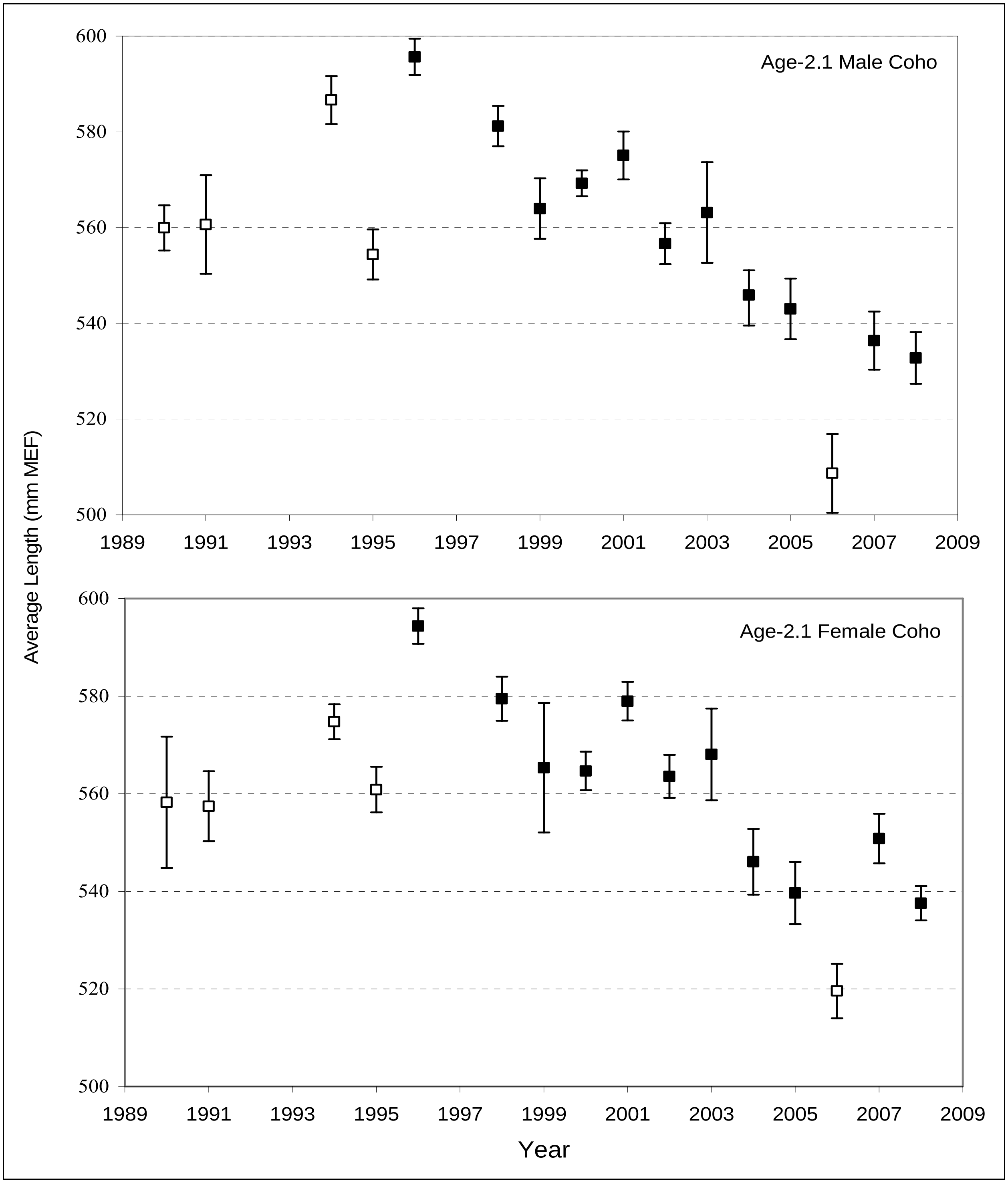
Note: ASL determined sex ratios were estimated with confidence intervals; visually counted fish are considered a census.

Figure 37.–Comparison of the percentage of female coho salmon passing upstream of the Takotna River weir as determined from standard ASL sampling using a fish trap and from visual inspection of non-ASL sampled fish using standard fish passage procedures.



Note: ASL determined sex ratios were estimated with confidence intervals; visually counted fish are considered a census.

Figure 38.–Comparison of the percentage of female coho salmon passing upstream of the Kogrukluk River weir in 2008 as determined from standard ASL sampling using a fish trap and from visual inspection of non-ASL sampled fish using standard fish passage procedures.



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

Figure 39.–Historical average annual length for coho salmon with 95% confidence intervals at Kogrukluk River weir.