Regional Information Report No. 3A07-09

Salmon Age, Sex, and Length Catalog for the Kuskokwim Area, 2006

Final Report for Project 04-307
USFWS Office of Subsistence Management
Fisheries Information Services Division

by

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and

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Alaska Department of Fish and Game **Division of 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 Regional Information 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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Appendix

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 04-307) provides the support required to process these ASL samples and compile the information into summary tables of use to managers, contributing project leaders, and other interested parties. The annual product of this project is a series of historical ASL summary tables (ASL Catalog) updated with current year results. This catalog is available at: http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2007.09Appendices.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 five species are harvested in area commercial, subsistence, and sport fisheries, as well as various interception 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 2000, 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. Tables from the ASL catalog are not incorporated into this document due to the large number and volume (994 pages representing 128 tables, referred to here as Appendices A through H). Tables are available electronically instead at: http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2007.09Appendices.pdf. This document represents an annual report for USFWS OSM project FIS 04-307.

OBJECTIVES

The objective for the USFWS OSM project FIS 04-307, *Kuskokwim Salmon Age-Sex-Length Assessment Continuation,* is to process, compile, and analyze salmon scales, and sex and length data collected in Kuskokwim Region fisheries and escapement projects. In 2006, this report consists of datasets from 9 escapement monitoring projects, 1 test fishery project, and catch sampling from the Kuskokwim River Chinook salmon subsistence fishery and commercial fisheries in three 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). 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, 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 at rkm 835 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. 2005; 2006a; 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 effectively extended through the coho salmon migration. The Tatlawiksuk weir project is conducted jointly by ADF&G CF and the Kuskokwim Native Association (Costello et al. 2006b; 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). 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 (Clark and Salomone 2002; Jasper and Molyneaux 2007; Shelden et al. 2004; 2005). 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 after 1995 due to the prevalence of reabsorbed scales among sockeye at this location (710 rkm from salt water). Historical data for sockeye salmon have not been included in catalog tables. The project is conducted by ADF&G CF (Jasper and Molyneaux 2007) 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 that allowed the operational period to be effectively extended through the coho salmon migration (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. 2005b; 2006). 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, as well as chum salmon ASL sampling with beach seines (Vania 1998). Methods changed again in 2004 to incorporate advances in Dual-frequency Identification Sonar (DIDSON) (McEwen 2005). 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 with 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 operated from mid June through mid-August. The project is conducted jointly by ADF&G CF and Kuskokwim Native Association. ASL samples have been collected from Chinook and chum salmon and 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, b, 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). 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 01-153 and FIS 04-302. 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 with funding provided by USFWS OSM (FIS 00-019). 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 04-304). 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). The current weir project is operated jointly by ADF&G CF and the Native Village of Kwinhagak with funding support from USFWS OSM (FIS 01-118 continued as FIS 04-305). ASL samples have been collected from Chinook, chum, sockeye, and coho salmon and 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 allowed for operation through the pink and coho salmon migrations (Estensen 2002b, 2003; Linderman 2005b; Menard 1998, 1999, 2000; Stewart 2004). ADF&G CF operates the project with funding support by USFWS OSM (FIS 00-027 continued as FIS 04-312). 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 four 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 fishers 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. Commercial fishers 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.

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[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.

BETHEL TEST-FISHERY

A drift gillnet test fishery was established on the mainstem Kuskokwim River near Bethel in 1984 to provide fishery managers with a daily index of salmon abundance and run timing (Bue 2005; Bue and Martz 2006; Molyneaux 1998). The project is located (rkm 106) near the midpoint of District 1. From early June through late August the crew conducts three or four systematic gillnet drifts beginning 1 hour after high tide. The drifts are done at three 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 two gillnets are rotated between the three 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-fish catch 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 some of the largest subsistence salmon harvests in the State of Alaska (ADF&G 2003). The subsistence fisheries in this area are prominent and vital elements of the culture and livelihood of many local residents (Coffing 1991, *Unpublished*; Oswalt 1990). 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 fishers include set gillnets, fish wheels, rod and reel, seines, and spears; however, drift gillnets are overwhelmingly the most common contemporary gear type used (Coffing *Unpublished*). Unlike commercial fishing, there is no restriction on the mesh size of subsistence gillnets, and many fishers choose 8.0 to 8.5-inch (20 to 22 cm) mesh sizes to target larger Chinook salmon. Chinook salmon are the only species sampled for ASL information from the subsistence harvest, and most sampling is limited to the lower Kuskokwim River (Figure 1).

Modest efforts to collect complete ASL data from subsistence caught Chinook salmon occurred in 1993, 1994, and 1995 as a pilot project (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). For 2001 through 2003, three projects were funded by OSM: FIS 01-023 for the upper river, FIS 01-225 for the middle river and FIS 01-132 for the lower river (Molyneaux et al. 2004a; b). In 2004, the upper and middle river projects were discontinued, leaving the lower Kuskokwim River subsistence sampling project intact in 2004 thru 2006 (Molyneaux et al. 2005; *In prep*). 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 four 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

Two methods of sample collection are employed in the Kuskokwim Area. The preferred method of sample collection attempts to distribute sampling effort evenly across the salmon run. This method, termed “pulse sampling”, is employed at locations that provide relatively consistent sampling opportunity, such as escapement projects. 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 three 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 three 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 than 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). The sample size goals for each pulse by species are: 210 Chinook, 210 sockeye, 200 chum, and 210 coho salmon. Sample sizes vary between species due to differences in the number of major age-sex groupings to be distinguished. These sample sizes were selected so that the 95% confidence intervals for simultaneous estimates of age composition proportions would be no wider than 0.10 (α = 0.05 and d = 0.10). Recommended sample sizes were increased by 8 to 9% to account for salmon for which age could not be determined due to sampling error or illegible scales. The need for achieving the 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 and often meet or exceed goals for precision.

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 the temporal changes in the 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 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: 210 Chinook, 210 sockeye, 200 chum and 210 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 the 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 often changes over the course of the season. Differences in migration timing exist within and between Kuskokwim River salmon stocks (Pawluk et al. 2006; Stuby 2006). 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 the 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 encompass 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. The data are presented in a manner that allows users to judge whether pooling strata with small sample sizes is suitable for the type of analysis being performed.

Generally, the seasonal ASL composition of harvest or escapement populations are estimated only when the distribution of samples allow. Samples must be distributed with a minimum of one stratum for each third of the annual harvest or passage. This “rule of thirds” is necessary due to the seasonal dynamics in the ASL composition of most species. When sample sizes and distribution do not meet the above criteria, sample results are recorded, but no season estimates are presented in the catalog. The rule of thirds does not apply to season estimates of commercial harvest for years in which fewer than three commercial fishing periods occurred in a season (e.g., District 1 chum salmon in 1993).

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 using a straight-edged meter stick. 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. The 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. Since 1993, 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 are taken several times (minimum goal of three) throughout the season to create a series of 'snap-shots' of ASL composition. Most project reports include a detailed description of ASL sampling protocols.

Commercial Catch Sampling

Commercial salmon harvest is sampled for ASL data as fishers 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's crews 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 two or three 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 fishers varies, but it is assumed to be within the legal range of specifications. Time and logistical constraints prohibit interviewing fishers 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 tables by footnotes.

Subsistence Catch Sampling

Until recently few samples from the subsistence Chinook harvest were taken each year. These few samples were procured from the harvests of a small number of subsistence fishers. 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 fishers were recruited and trained to collect ASL data from their catches. The fishers 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 fishers also recorded gear type (e.g., set net or drift gillnet), mesh size, date of capture and the location of capture. Fishers 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 through the present (Molyneaux et al. *In prep*). This project is operated in cooperation with non-government organizations, and non-agency participants that include subsistence fishers, 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 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[2]. Gilbert-Rich notation[3] 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 ages of absorbed or otherwise questionable scales, especially for Chinook salmon which tend to exhibit more pronounced length partitioning by age class. When the age of a fish is in question, the technician aging the scales may use associated length information to assist in deciding the proper age. The length of the fish from which the scale was removed is compared to historic length-at-age information for that project or district to decide the most likely age; however, scales with associated lengths that are common among multiple age classes are likely to be discarded because in this case the likelihood of incorrect age

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[2] 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.

[3] 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 the years of life after out-migration from freshwater.

assignment is increased. Occasionally this method is used when aging chum salmon, but it is not generally used for coho or sockeye salmon.

Computer Processing Format

Most ASL information from recent years is recorded on computer mark-sense forms that are processed through an OPSCAN machine to produce digital files in ASCII format. Portable data recorders were first used in 1998 and a more bulky fish measuring board has also been used in recent years. The data recorder produces an ASCII file similar to the OPSCAN raw data file. 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, 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. Where applicable, the information is applied to escapement and catch data to provide an estimate of the total age, sex, and length composition of those populations.

Summary Types

The ASL catalog consists of two types of tabular summaries, one that describes data by age and sex composition, and another that summarizes length data by age and sex. Each table 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 Tables

Age-sex tables 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 Tables

Data in the length tables are summarized by age-class and sex. Sample dates and stratum dates are usually identical to the age-sex tables. The length tables 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 consisted of an historical age-sex table and an historical length table. Each historical table includes data summaries for each year of sampling and includes the inseason temporal stratification. A "Grand Total" was calculated using only those years with sufficient ASL sampling. Years used in these summations are noted in table 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). Data are stored as individual fish. Currently, requests for data must be filled by Information Technology staff. Beginning in June 30, 2007 a web-based application will allow 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

Tables included in the 2006 ASL Catalog are organized into eight 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.2007.09Appendices.pdf). Within each species section, subsections are ordered by escapement projects, followed by commercial summaries, then test fishery samples, and finally subsistence summaries. Each of these categories is also organized by location, generally starting with the farthest interior and progressing towards the coast (river mouth), and south along Kuskokwim Bay. Some escapement, test-fish, 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 table precedes the historical length table.

As described in the preface, the summaries presented in the ASL Catalog are not exhaustive of all the data collected from the Kuskokwim Area (Table 2). For example, data sets are not included from the South Fork Salmon River (Pitka Fork drainage) where a weir was operated in 1981 and 1982 (Schneiderhan 1982a, b).[4] Also, many of the data summaries reported in the ASL Catalog are incomplete. As time and resources allow, it is the intention of the authors to continue adding the missing historical information to future catalog editions. Some available 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 (*Unpublished*), 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 generally differ from the methods used in this report.

[4] 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.

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 latter 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. 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 their 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 sometimes 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 tables from years prior to the 1990s have been re-stratified into a pulse sample format, therefore, results presented here may differ from those originally reported for those years.

Carcass Sampling

The use of carcasses for estimating the ASL composition of spawning escapements can be misleading. Male Chinook salmon, for example, 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).

By default, estimates based on stream bank carcass surveys would be 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.

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 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 the potential opposing bias of 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 (Figure 1). It is farther from marine waters than any other project where ASL data are collected (except the Takotna weir). 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 the decision in 1995 to discontinue sampling of sockeye salmon at that project. 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. Salmon harvested from commercial and subsistence fisheries in the lower Kuskokwim have recently left marine waters and have yet to fully develop external sexual characteristics.

External sex determination though reliable at escapement projects, is not as reliable when sampling from commercial and subsistence fisheries. 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 4 and 5 (Figure 3).

The sex of a salmon can be easily confirmed by cutting the fish and visually examining the gonads. Concerns about market quality generally limit the degree to which this can be done when sampling commercial catches. However, beginning in 1997 staff received permission from salmon buyers to make a small incision in fish for sex confirmation during ASL sampling. Nearly every fish sampled from the commercial catch was 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). Historically, commercial fishers harvest these three 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 from fishing periods with restricted mesh size averaged 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 fishers 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 fishers.

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. Given evidence of the genetic heritability of age of maturity (Hankin et al. 1993), high exploitation rates with large gillnet mesh sizes may exert enough selection pressure on the Chinook population to direct the evolution of the species towards smaller, younger fish if continued over many generations. Thus, it is in the interest of species conservation to continue to restrict the commercial fishery to smaller mesh sizes.

In their review of trends in salmon size throughout the North Pacific, 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. However, the authors based their conclusion solely on commercial catch data. They failed to note that in 1985, the Kuskokwim Area District 1 commercial fishery became restricted to a mesh size of 6 inches or less. Prior to this date, there was no restriction on mesh sizes used in the June Chinook fishery. Smaller mesh sizes typically capture smaller, younger fish. Therefore, the decrease in mean age of return noted by

Bigler et al. (1996) was probably 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 data sets as being the major obstacle to reaching definitive conclusions with respect to age of return. These examples stress both the importance of long-term consistent data collection over many years, and the importance of knowing how data was collected and thus knowing better how it may or may not be analyzed effectively.

In contrast to sampling of commercial and subsistence fisheries, the methods for sampling Chinook salmon at ground-based escapement projects is 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. These gear are not size selective. Samples taken from the escapement represent a population that has already undergone selection due to the subsistence and commercial fisheries. Therefore, despite the more random nature of escapement sampling, samples may be somewhat biased toward smaller and younger fish. Random sampling via weir trap should yield a close approximation of true age composition in escapements if sample sizes are adequate and well distributed temporally. These taken together with samples from the subsistence and commercial fisheries more closely approximate the age composition of overall Kuskokwim River salmon runs than any one set of samples viewed alone.

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 are generally less abundant than males in the Chinook salmon populations returning to the Kuskokwim Area. Female Chinook salmon at Kogrukluk River are estimated to comprise 30.7% of the escapement reported from 1984 to 2004. Information from other streams is less extensive, but the Takotna, Tatlawiksuk, Tuluksak, Kwethluk, Kanektok, and Middle Fork Goodnews Rivers averaged 27.2%, 34.5%, 25%, 19.1%, 29.6% and 35.8% females. Results from the George River show a more even ratio, with females comprising 48.3% of the returns. The female fraction of the commercial harvest in Districts 1, 4 and 5 average 28%, 34% 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 5). Data from subsistence harvests also tend to show fewer females in the catch even when large mesh gillnets are used. Generally, females are observed to arrive later than males on the spawning grounds (Figures 7 and 8).

The 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 8 and 9).

Sex ratios determined from the commercial harvest, however, 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 10). In samples collected without sex verification the fraction of age-1.2 Chinook reported as male has been as low as 30%. Similar trends were found in age-1.3 Chinook where the occurrence of males was 82% or greater when sex was verified, but as low as 32% in samples without verification (Figure 10).

On the encouraging side, these suspected errors are not persistent across all years or locations that lack visceral examinations of the fish. For the years examined, sex ratios reported for the District 1 commercial fishery have been near or within the range found in the verified samples (Figures 3 and 10). Escapement samples from Kogrukluk River were also near or within the expected range. Data from Districts 4 and 5, however, show considerable divergence from expected ratios, but not in all years.

The difference between the results from District 1 and those of Districts 4 and 5 are most probably due to 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 and periodically examine a small number of fish internally to verify sex. The findings of these occasional dissections are usually shared with other samplers as a training tool.

Kuskokwim Bay samplers have not been as fortunate. 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 much of the sampling responsibility shifted to Bethel where fish are sampled when delivered to local processors. Although logistically challenging, the quality and quantity of the data have improved. Additional training opportunities have been made available by rotating staff between Bethel and Kuskokwim Bay. In 2006, Coastal Villages Seafood in cooperation with ADF&G 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 shown a high degree of quality and consistency and it is the hope of Kuskokwim Area staff that the program will continue.

Length Composition

The length frequency distributions of the three most predominant Chinook salmon age classes (age-1.2, -1.3, and -1.4) overlap as illustrated in Figures 11, 12 and 13. 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 the District 1 males averaged 675 mm in length while females averaged 801 mm. The same trend is apparent in Distinct 4 where males averaged 694 mm and females averaged 802 mm. The lengths of age-1.4 males and females overlap broadly.

Trends in length among age-sex classes may vary with respect to time scale. For example, a comparison of lengths of age-1.4 male and female Chinook within a season shows a general increase in the lengths as the run progresses. This is a pattern commonly observed at Kuskokwim River escapement projects (Costello et al. 2006a; b; Jasper and Molyneaux 2007; Roettiger et al. 2005; Stewart et al. 2006; Zabkar et al. 2006).

Trends over years are more variable. A retrospective analysis of age-1.3 and -1.4 male and female Chinook at Kogrukluk weir showed general increases in length for each age-sex class between 1984 and 1997 (Figure 14). However, when observed over a longer time series (1985-2005) the overall trend for each of these age-sex classes was a general decrease in length (Figure 15). Similar trends were observed for Tuluksak and Kwethluk River weirs (Figure 14). 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 (Figure 15).

Bigler et al. (1996) reported a significant decrease ($P < 0.01$) in the average weight of Kuskokwim River Chinook salmon between 1975 and 1993. However this finding is flawed for the same reason described above regarding age composition. The authors relied on commercial catch statistics and did not account for mesh size restrictions first imposed in 1985. 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. 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. After the 1985 gear restriction, District 1 average weights became similar to those seen in District 4 (Figure 16). This supports the argument that the trend noted by Bigler et al. (1996) is more an artifact of commercial mesh size changes, and less likely due to actual size trends in the Chinook population. Furthermore, the weight trend noted in the commercial fishery does not match with length data from escapement projects for the same years. A review of escapement data from Kogrukluk River shows contrary trends with the average length of age-1.2 and -1.3 males generally increasing between 1984 and 1997, while females did not show much change (Figures 14 and 15).

The problems with the findings of Bigler et al. (1996) are likely due to a failure to recognize an important factor governing the applicability of the data. Undoubtedly, the researchers assumed that there had been no change in sample collection over time. The introduction of a new gear restriction in 1985 did signify a change in sample collection, which introduced a new bias into the dataset. This underlines the importance of understanding the data being used in the analysis. 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. Recognizing these limitations provides important perspectives and helps to identify how best to apply the available information.

SOCKEYE SALMON

Age Composition

Eleven age classes have been reported for sockeye salmon returning to the Kuskokwim Area. Most age classes appear in small numbers. The predominant age-class among Kuskokwim Area sockeye salmon is age-1.3. The next most prevalent 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 17). 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 18). Commercial fisheries and escapement projects are similar with regard to sex ratio (Figure 18). 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 19). 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.

Commercial fisheries in each of the Kuskokwim Area districts are limited to 6 inch or less mesh gillnets. A comparison of commercial and escapement sample data from the Goodnews Area shows that age 1.2 and 1.3 female sockeye harvested in the commercial fishery tend to be larger than the same age-sex classes measured at the Middle Fork Goodnews weir (Figure 20). The sockeye salmon harvest for District 5 is estimated to represent 23% of sockeye salmon returning to the Goodnews river drainage (ADF&G 2004).

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 (Figure 6). 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 21). Conversely, the incidence of 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 in the historical data for the Tuluksak River (Figure 22) and similar patterns have been reported in streams of the Yukon drainage (Melegari 1996; Tobin and Harper 1995), Southcentral 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 23). Results from both escapement and commercial samples in 1999 show the same overall trend (Figure 24). These patterns are common in chum salmon populations (Bakkala 1970).

Kogrukluk River, however, does not follow this pattern. The annual percentage of females reported at the weir has always been less than 50% (Figures 9 and 25). Furthermore the percentage has been on a declining trend since 1981 with a record low in 1997 when females accounted for only 4% of the total run. It should be noted that in 1997, the Kogrukluk River weir showed the lowest overall passage of chum salmon yet recorded for the project. Still the low occurrence of females does not appear to be density dependent. The inseason trend in female chum salmon occurrence at Kogrukluk River is also often contrary to the norm. In 9 of 12 seasons reported the proportion of females either decreased or showed little change as the season progressed (Figure 26).

The cause of the sex ratio anomaly at Kogrukluk River is unknown. Commercial harvest is a potential factor; however, the sex ratio in the commercial fishery is only slightly higher for females than males (Figure 25), and other spawning stocks do not show such low percentages of females as the Kogrukluk River. Furthermore, the lowest proportion of females yet reported from the weir project occurred in 1997 when only one limited commercial fishing period was allowed for chum salmon (Burkey et al. 1997).

Another possible explanation is related to the location of the Kogrukluk River (Figure 1). The stream is found in the headwaters of the Holitna River drainage and there are abundant spawning grounds downstream of the Kogrukluk River, some of which are located in the main stem of the Holitna River. Schroder (1982) reported that male chum salmon remain sexually active for 10 to 14 days while most females complete their spawning in only 1 or 2 days. The longer effective breeding season typical of male chum may translate into continued upstream migration, with females remaining relatively stationary. If this proves true, it could account for the higher proportion of males seen passing the Kogrukluk River weir. The fact that the proportion of females rarely increases with the progression of the run further supports this explanation. Although plausible, this hypothesis fails to explain the trend of declining percentages observed over the past 17 years (Figures 9 and 26). Any clear determination on this issue would require directed study.

The 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 8 and 9).

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. Also, Kuskokwim Bay chum salmon (Kanektok and Goodnews Rivers) tend to be larger at age than Kuskokwim River fish as illustrated in Figure 27 for 1999. Also common among Kuskokwim Area (Figure 1) chum salmon stocks is a tendency for the average length of newly arriving fish to decrease as the migration progresses. This is true for all age-sex groupings. At Tuluksak River the average decrease in length over the course of the run was on the order of 56 mm (Figure 28).

It is important to note that low relative 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 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 29). Different levels of significance can be applied to each trend based on the 95% confidence intervals calculated with respect to sample size and passage. 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. Lengths recorded between years show significant differences and a higher level of certainty can be attributed to this trend. Age 0.4 females, typically represented by very low sample sizes, have broad overlapping confidence intervals (Figure 29). Lengths between years are not significantly different and trends in length cannot be attributed much certainty.

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 fishers 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 fishers 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 30).

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 when an atypically high percentage of age-3.1 coho returned to the Kuskokwim River. Age-3.1 comprised 13.2% of the harvest in District W1, 12.9% of the return to Tatlawiksuk River and 27.4% of the return to George River.

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 31). 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 8 and 9).

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. The mean lengths of District 1 samples with confirmed sex identification from 1997 and 1998 were pooled over all age classes by year and compared by sex. The mean length of females was found to be significantly greater in both years. In 1997 the mean length was 562 mm for males and 571 mm for females (two-tailed t-test; P = 0.00069, df 700). In 1998 the mean length was 567 mm for males and 574 mm for females (two-tailed t-test P =0.00026, df 1154). This pattern is not apparent in the historical database where sex was not confirmed, adding further question to 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 32). ASL data can be a helpful tool in identifying important areas of study, however, sample size and statistical significance should always be taken under consideration when making assertions about trends within ASL data.

CONCLUSIONS

- The objective for FIS 04-307 was fulfilled for 2006. ASL data were compiled across projects collecting samples in the Kuskokwim Area in 2006.
- The ASL catalog comprised of 138 tables, 994 pages and is available electronically from the Division of Commercial Fisheries, Kuskokwim Area web page at: http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2007.09Appendices.pdf.

- When using data from the Kuskokwim Area ASL catalog, users should consider: (1) the of 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.
- Improve how tables in the ASL catalog are compiled. Currently the compilation of the catalog, which represents 994 pages and 128 tables, is cumbersome. Automating the importation of Excel spreadsheet tables, preparation of the table of contents, and pagination in Adobe Acrobat would be a start.
- Update remaining figures to include data since 1999, as well as illustrations of other data sets.

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

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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 determined using a computer version (Garmin Topo MapSource) of U.S. Geological Survey 1:100,000 scale maps. Routing is 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^{o} 05.569, longitude W 162^{o} 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 2006 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	
	Aniak R.			X	
	Tulusak R.	X	X	X	X
	Kisaralik R.	X			
	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	X	X	X	X
Test Fish	Bethel Test Fish	X	X	X	
Subsistence	Kuskokwim R.	X			

Figure 1.–Kuskokwim salmon management area.

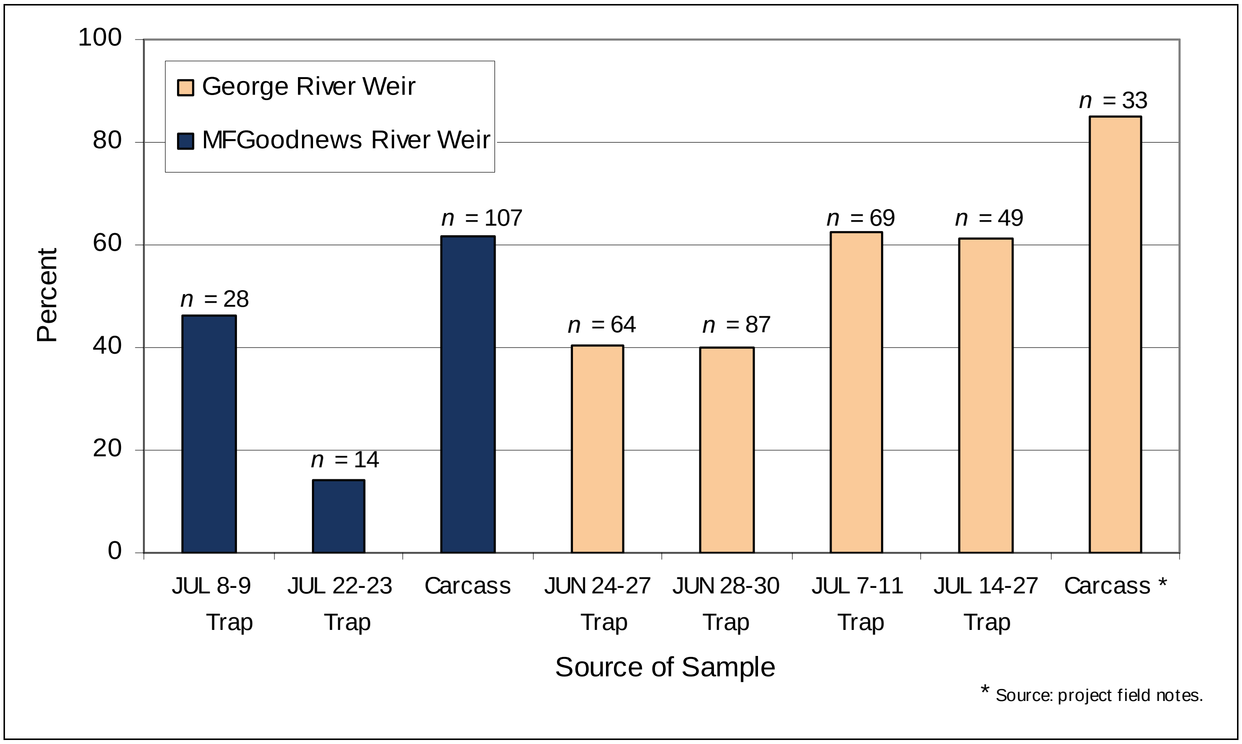

Figure 2.–Percentage of male Chinook salmon in trap and carcass samples from the Middle Fork Goodnews River weir in 1996 and the George River weir in 1997.

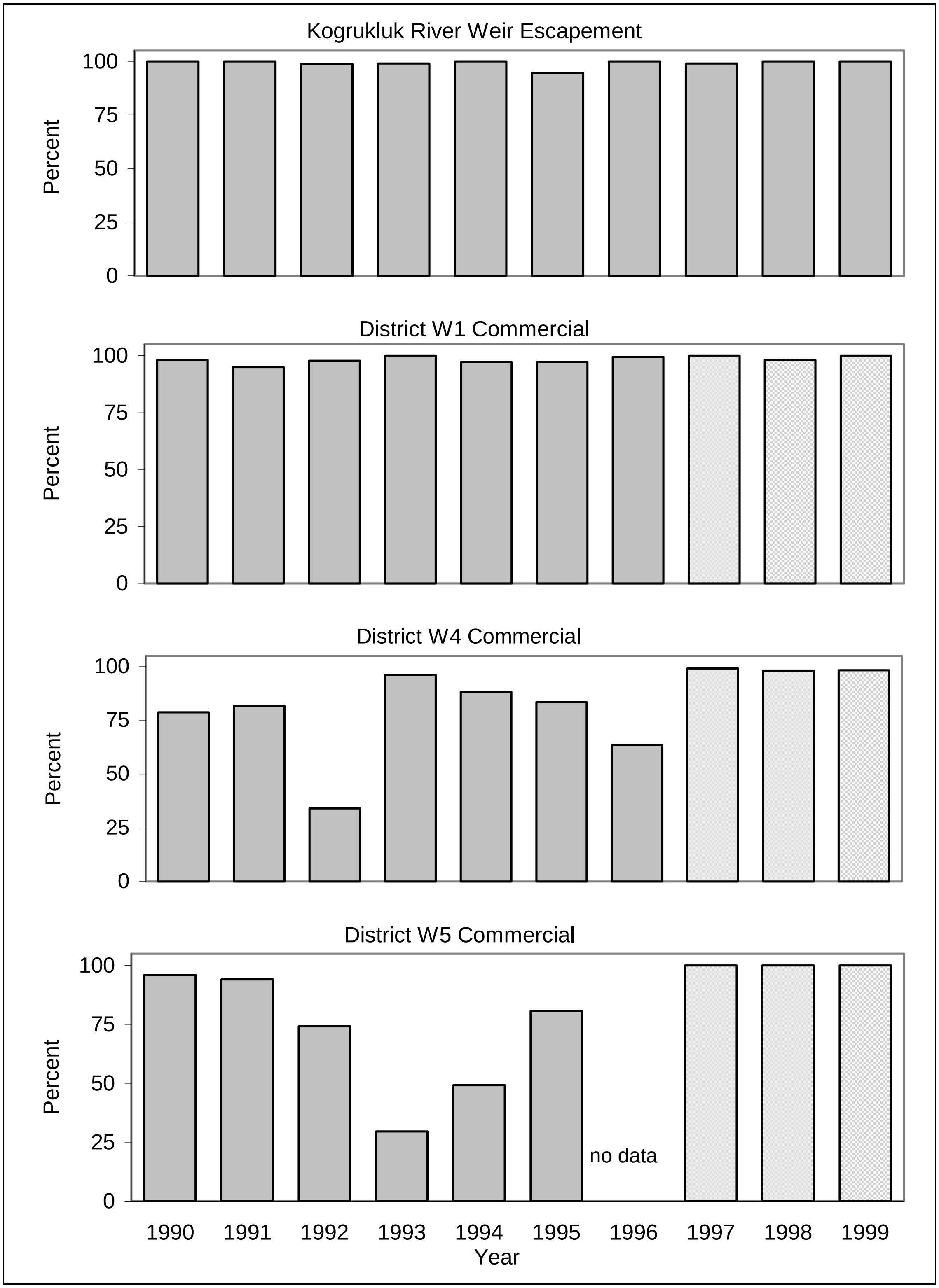

Figure 3.–Historical percentage of age-1.2 Chinook salmon reported as males from Kogrukluk River weir and Districts 1, 4 and 5, 1990–1999.

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

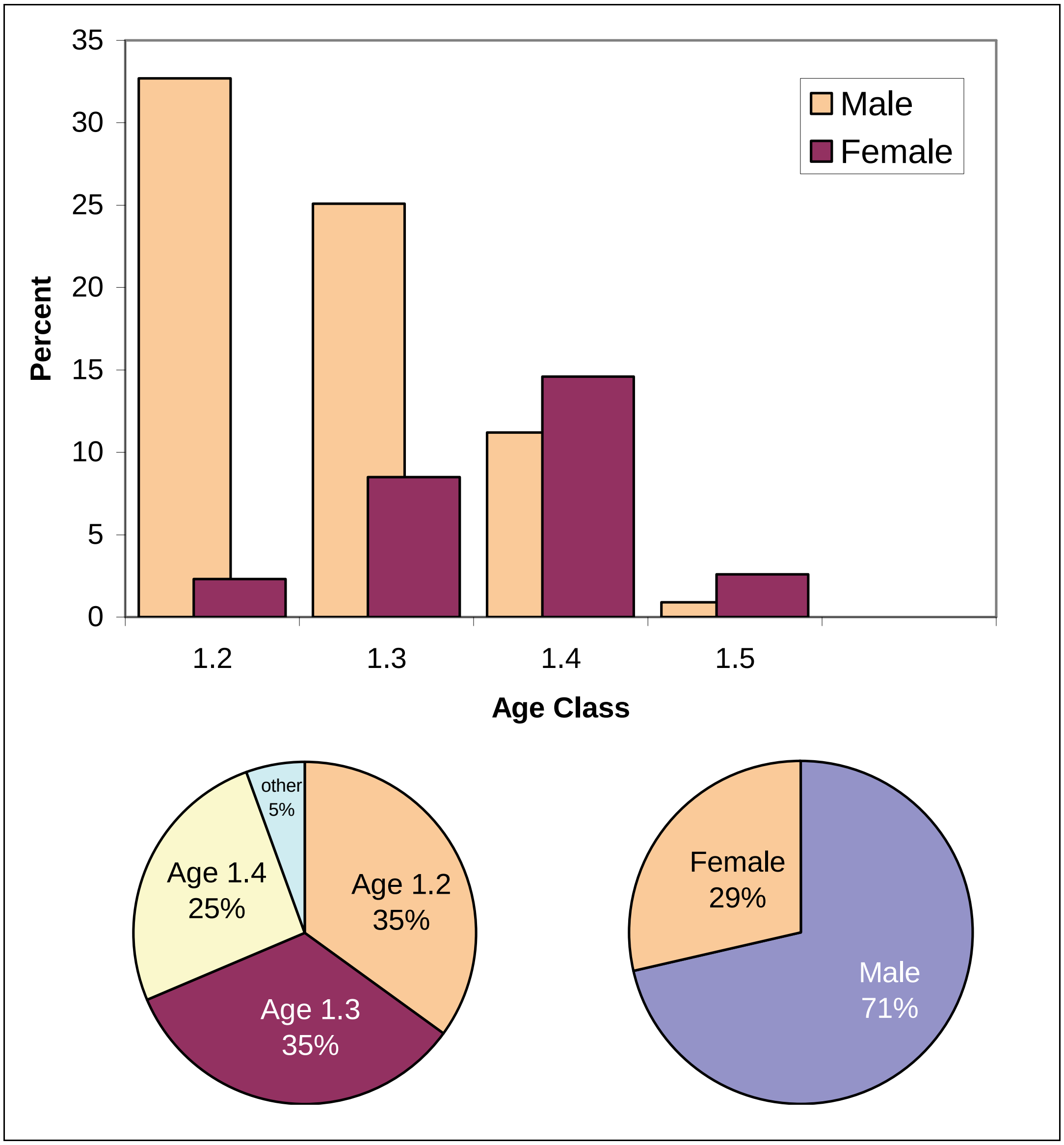

Figure 4.–Average age and sex composition of District W1 Chinook salmon harvested from commercial fishing periods in which gillnet mesh size was restricted to 6 inches or smaller, 1974–1999.

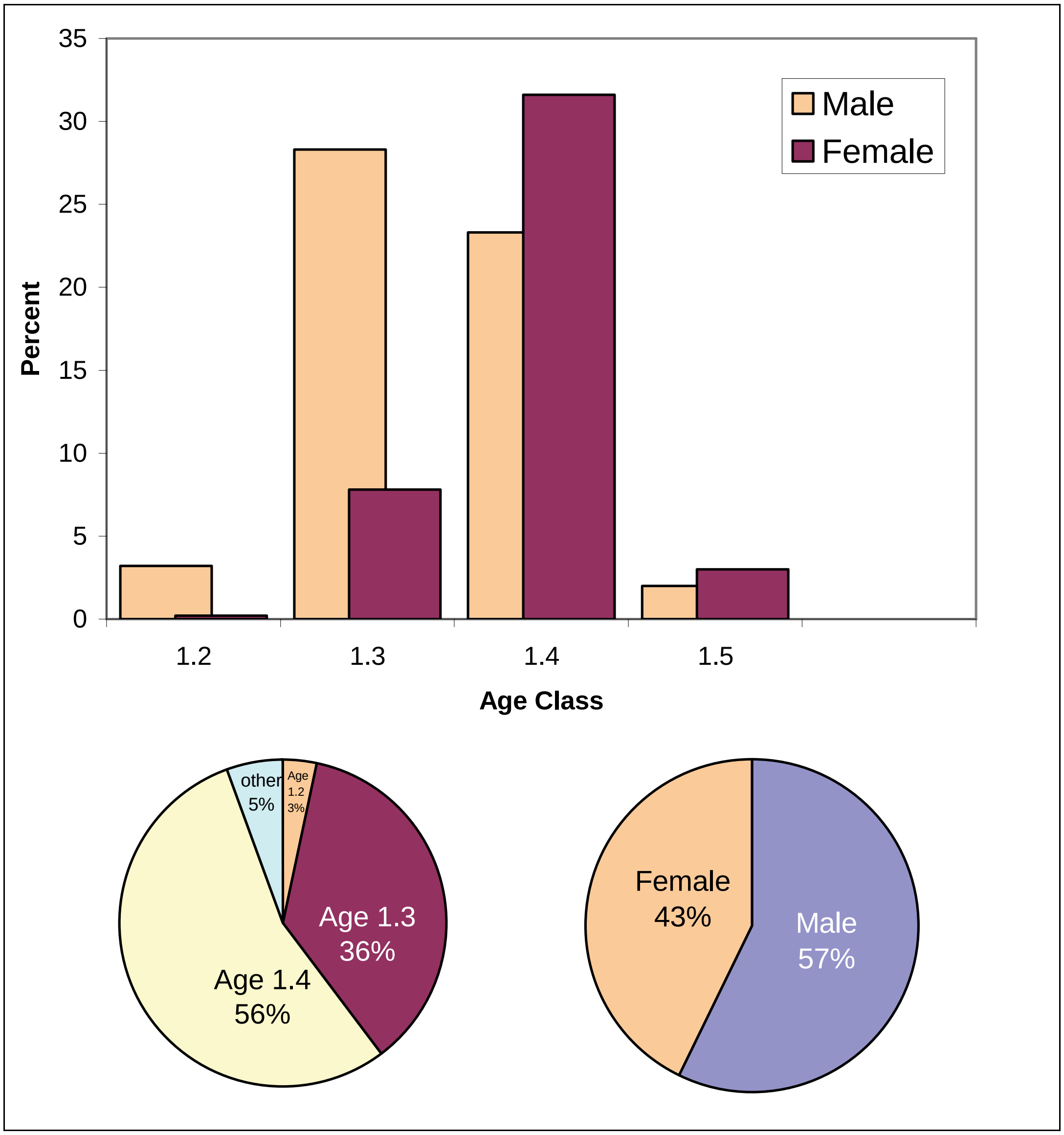

Figure 5.–Average age and sex composition of District W1 Chinook salmon harvested from commercial fishing periods in which gillnet mesh size was unrestricted, 1974–1984.

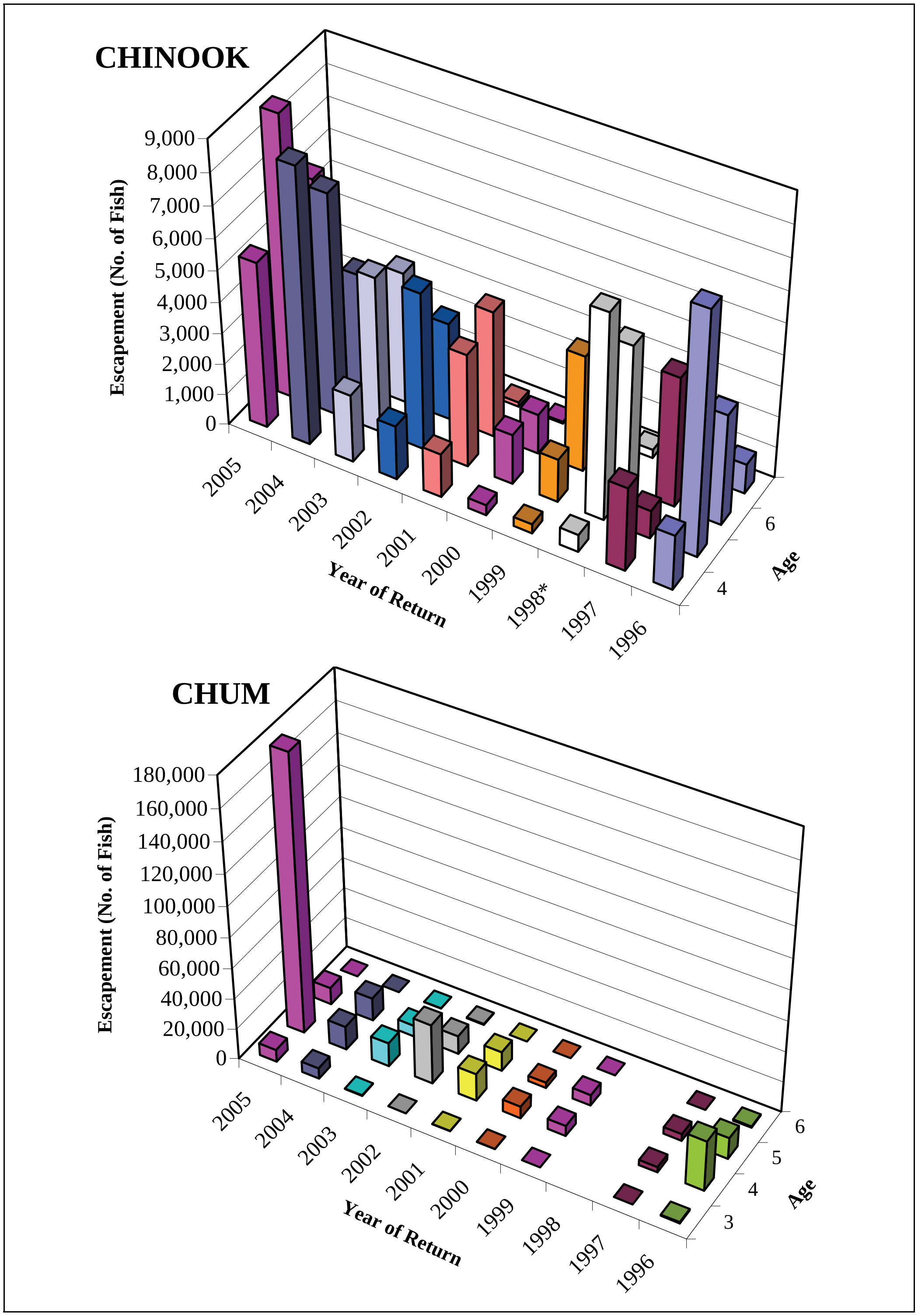

Figure 6.–Chinook and chum salmon age distribution over time at the Kogrukluk River weir.

Source: Jasper and Molyneaux 2007.

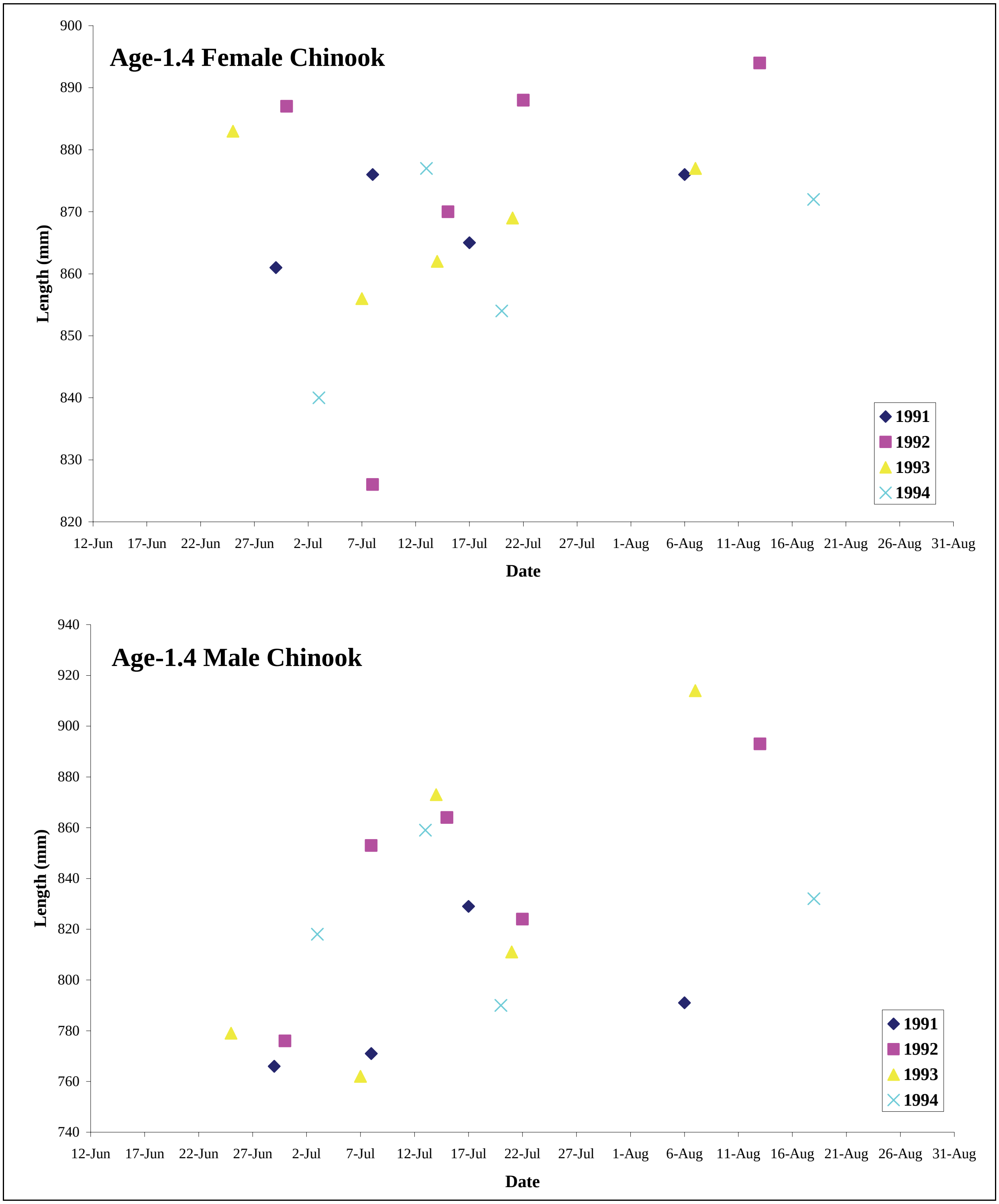

Figure 7.–Inseason changes in average length for age-1.4 Chinook observed at Tuluksak River weir.

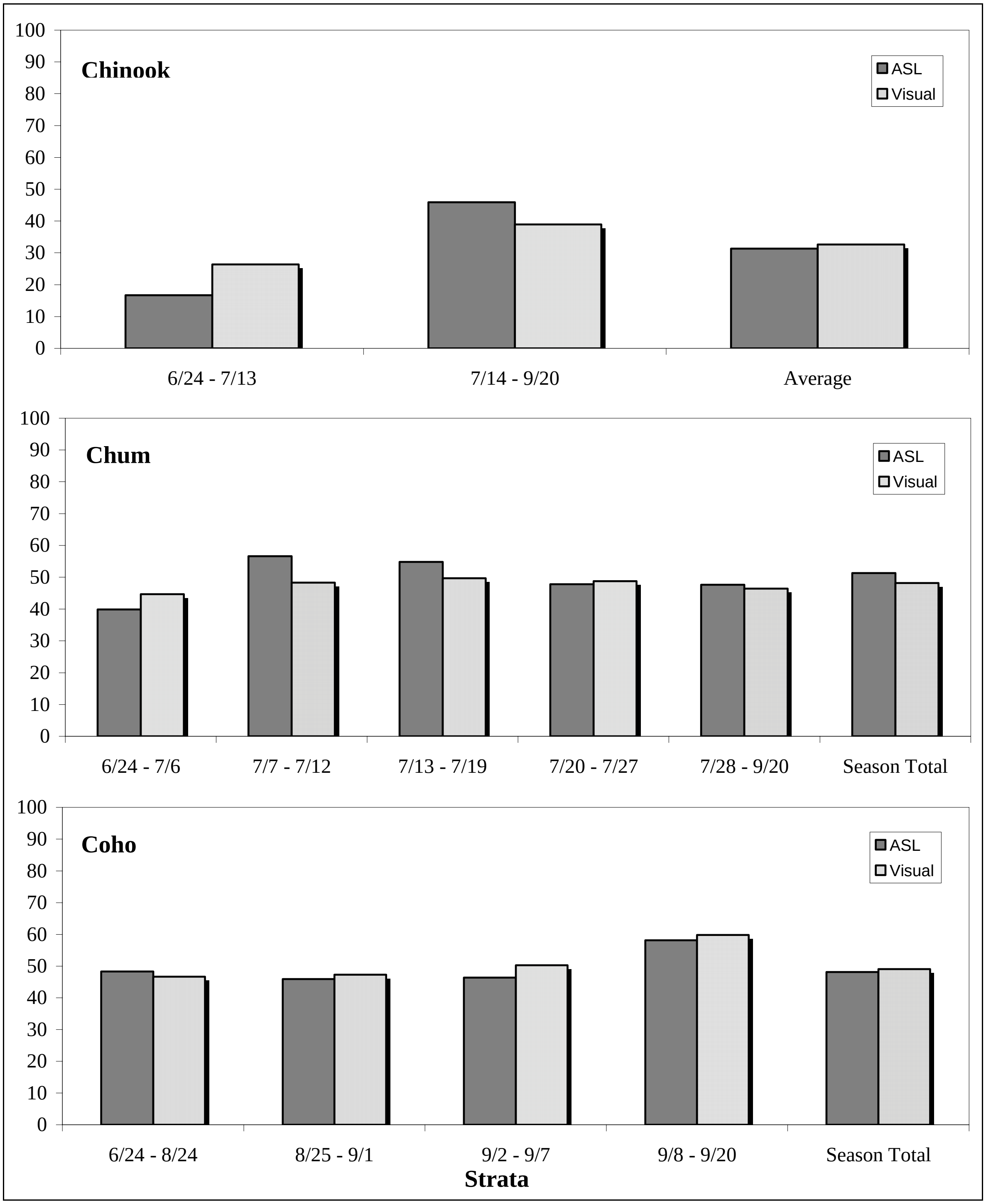

Figure 8.–Percentage of females per strata as determined by ASL sampling compared to visual identification at Takotna River weir, 2005.

Source: Costello et al. 2006a.

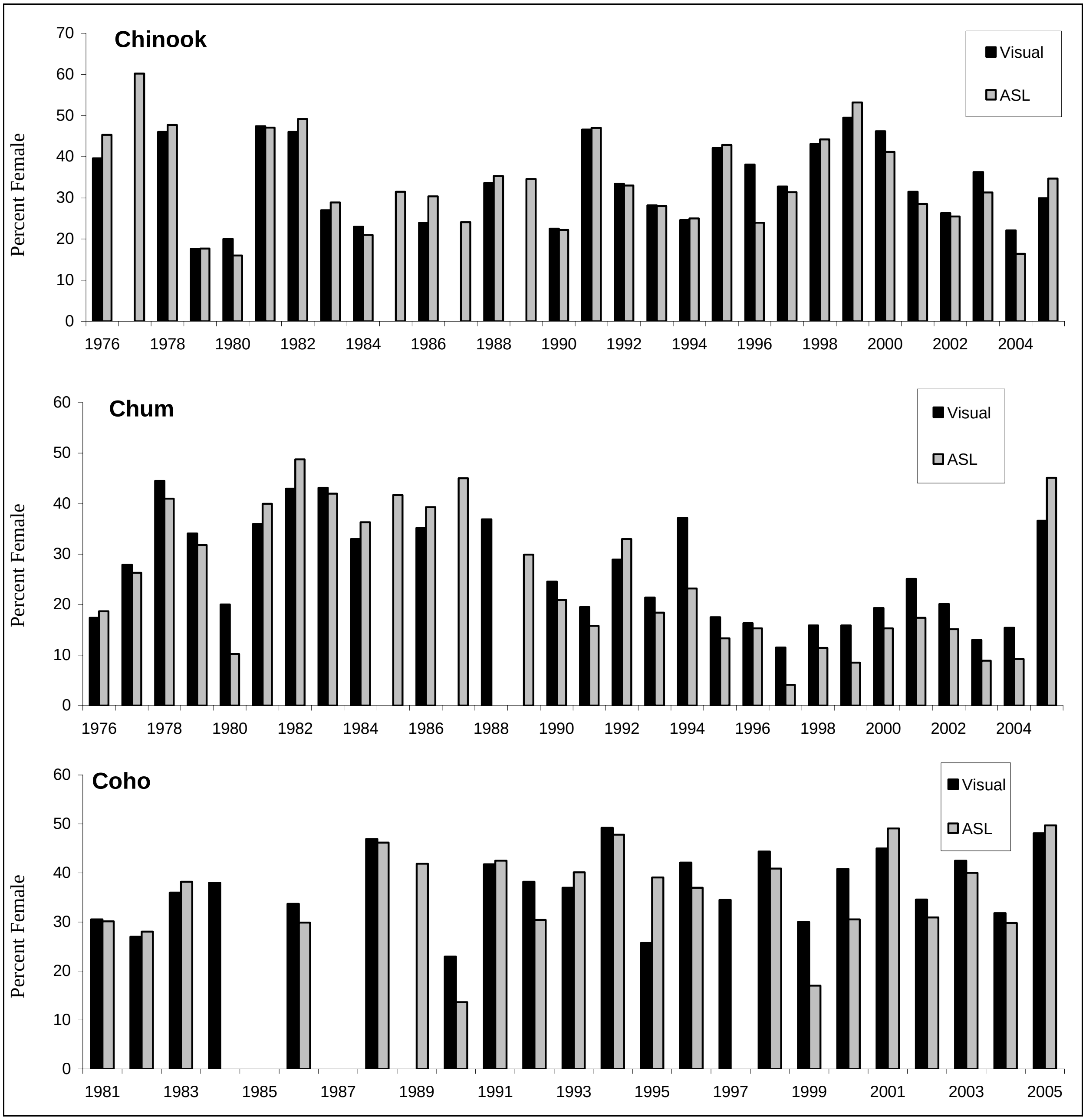

Figure 9.–Historical annual percentage of female salmon as determined by weighted ASL sampling and visual identification at the Kogrukluk River weir.

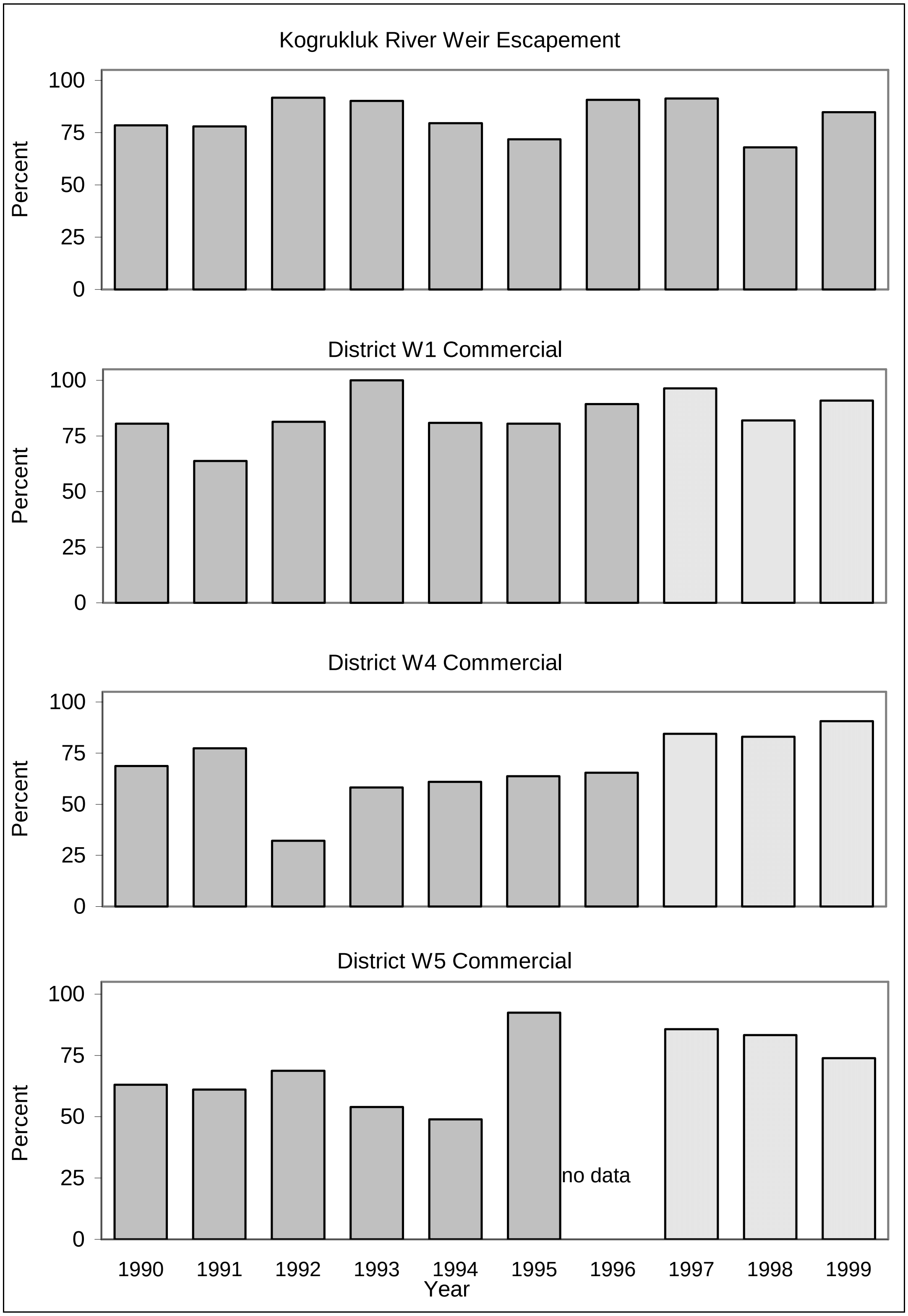

Figure 10.–Historical percentage of age-1.3 Chinook salmon reported as males from Kogrukluk River weir and Districts 1, 4 and 5, 1990–1999.

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

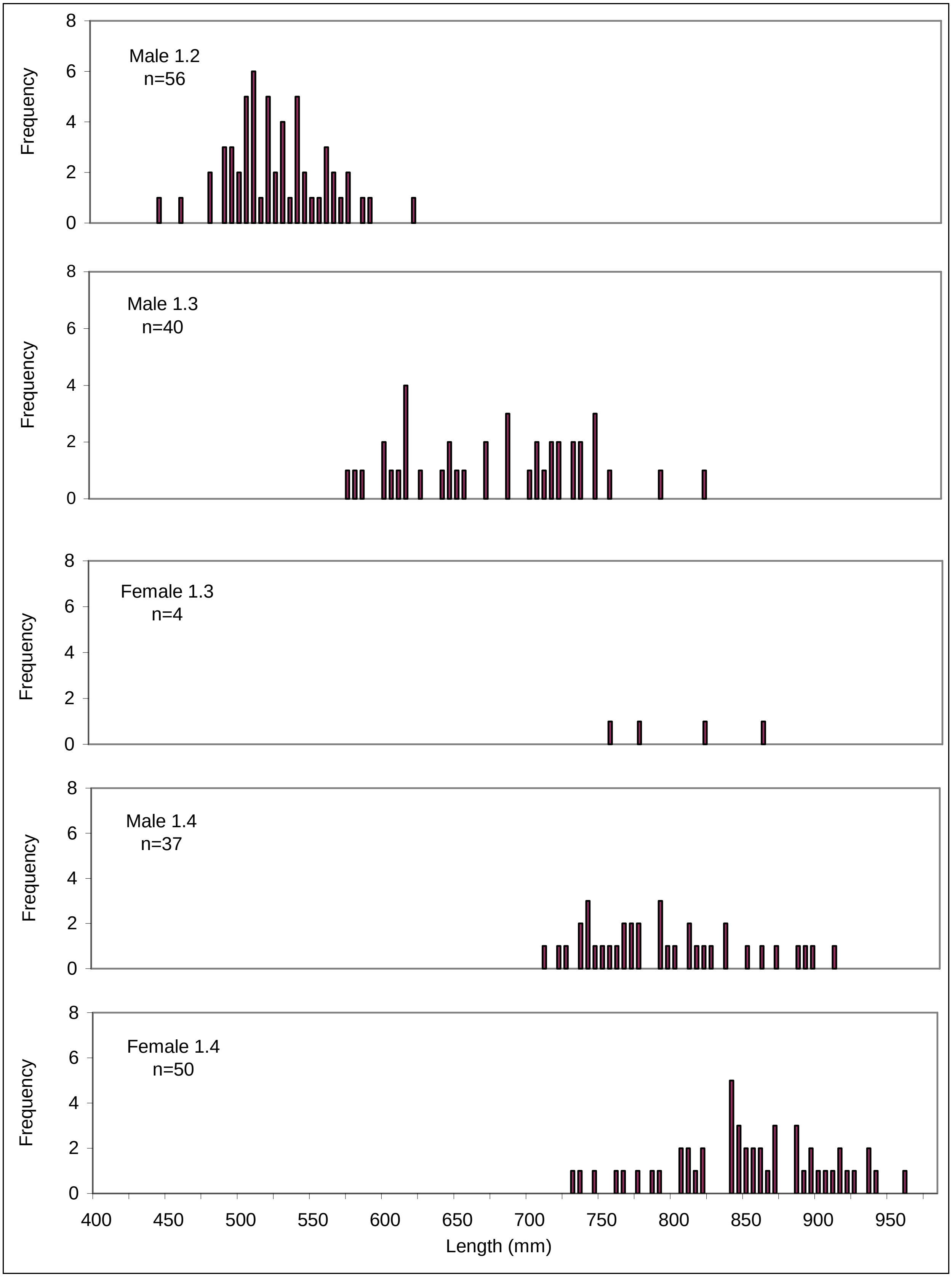

Figure 11.–Length frequency of District 1 Chinook salmon by age and sex, 1999.

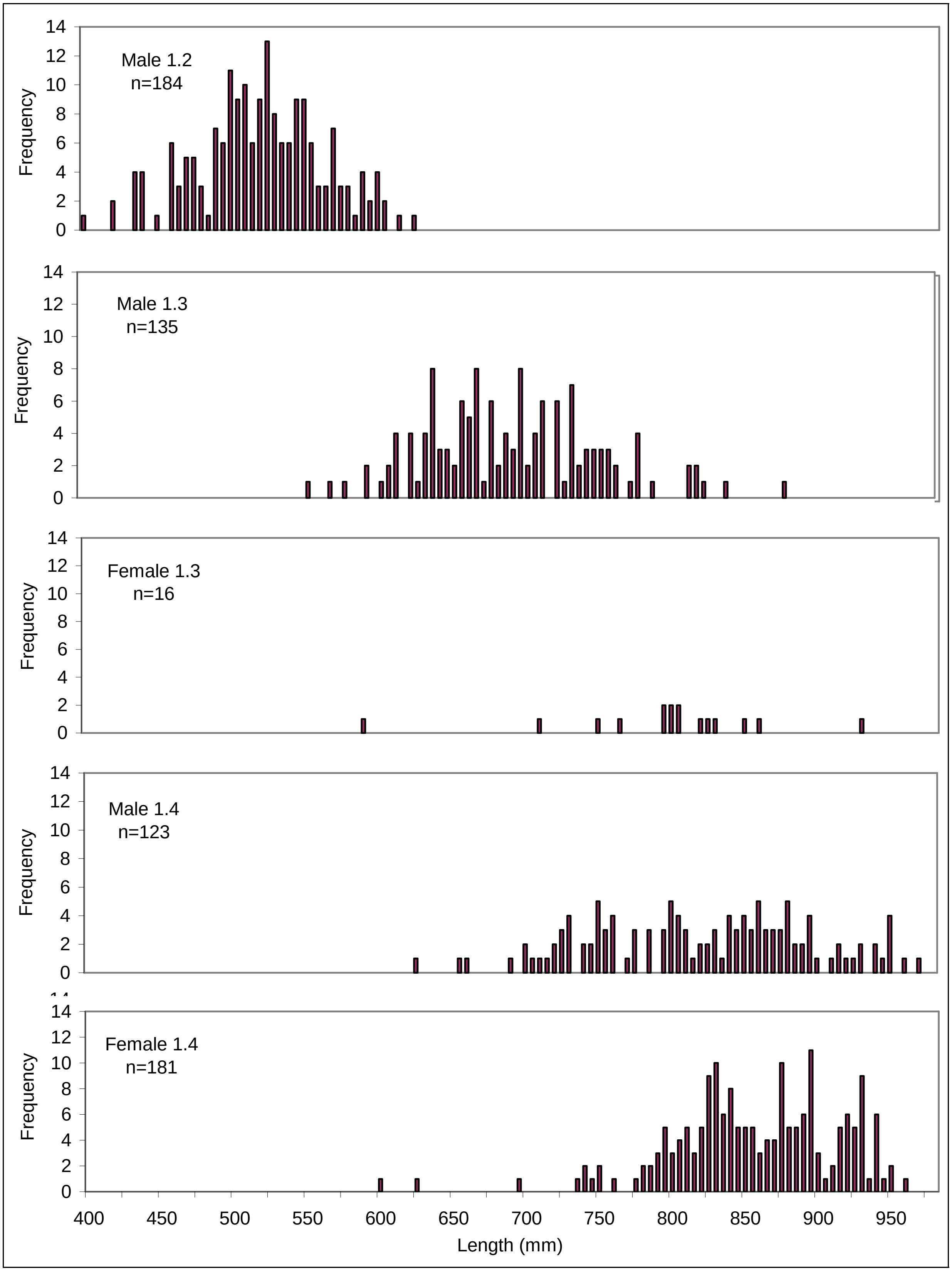

Figure 12.–Length frequency of District 4 Chinook salmon by age and sex, 1999.

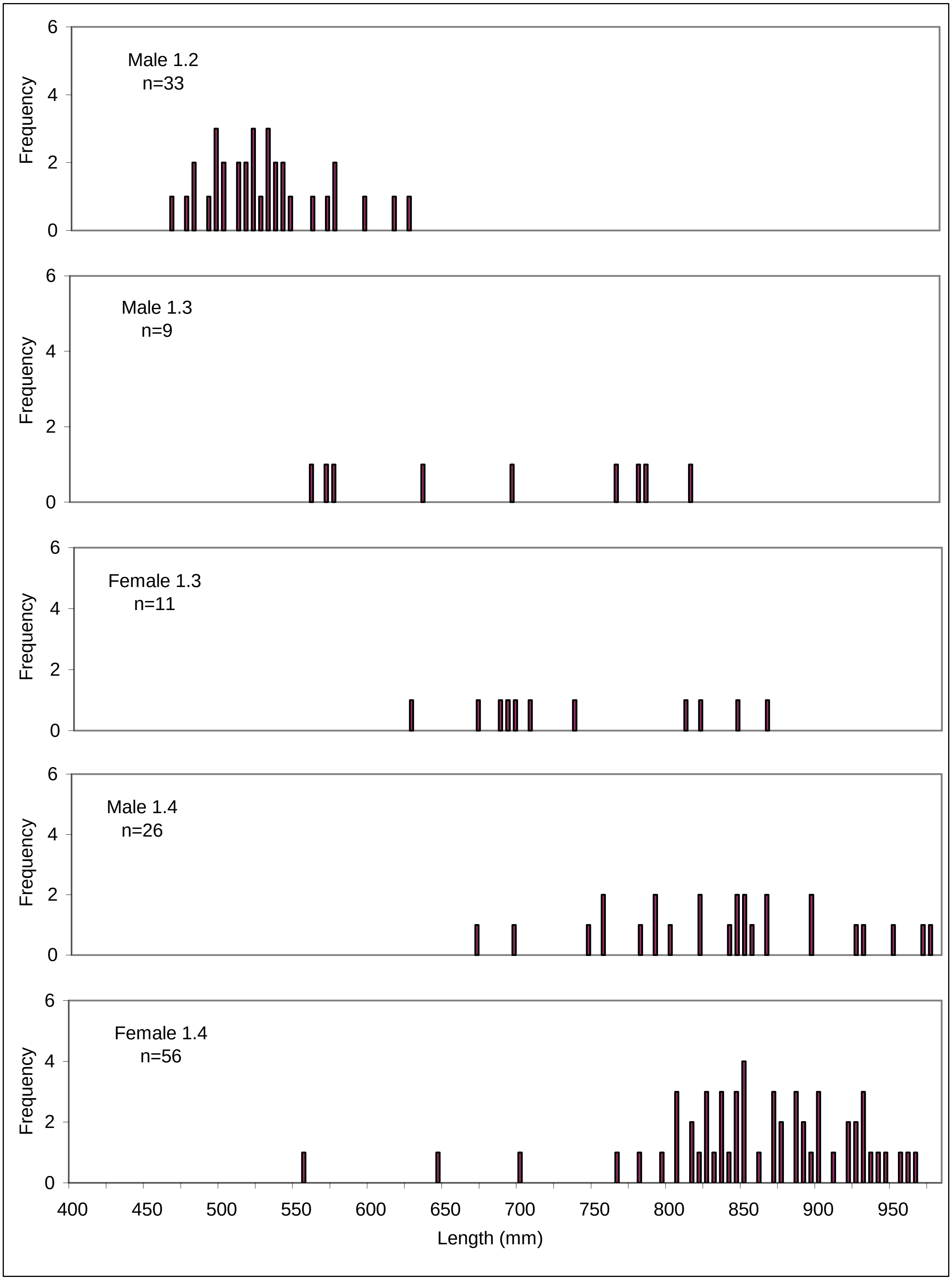

Figure 13.–Length frequency of District 5 Chinook salmon by age and sex, 1999.

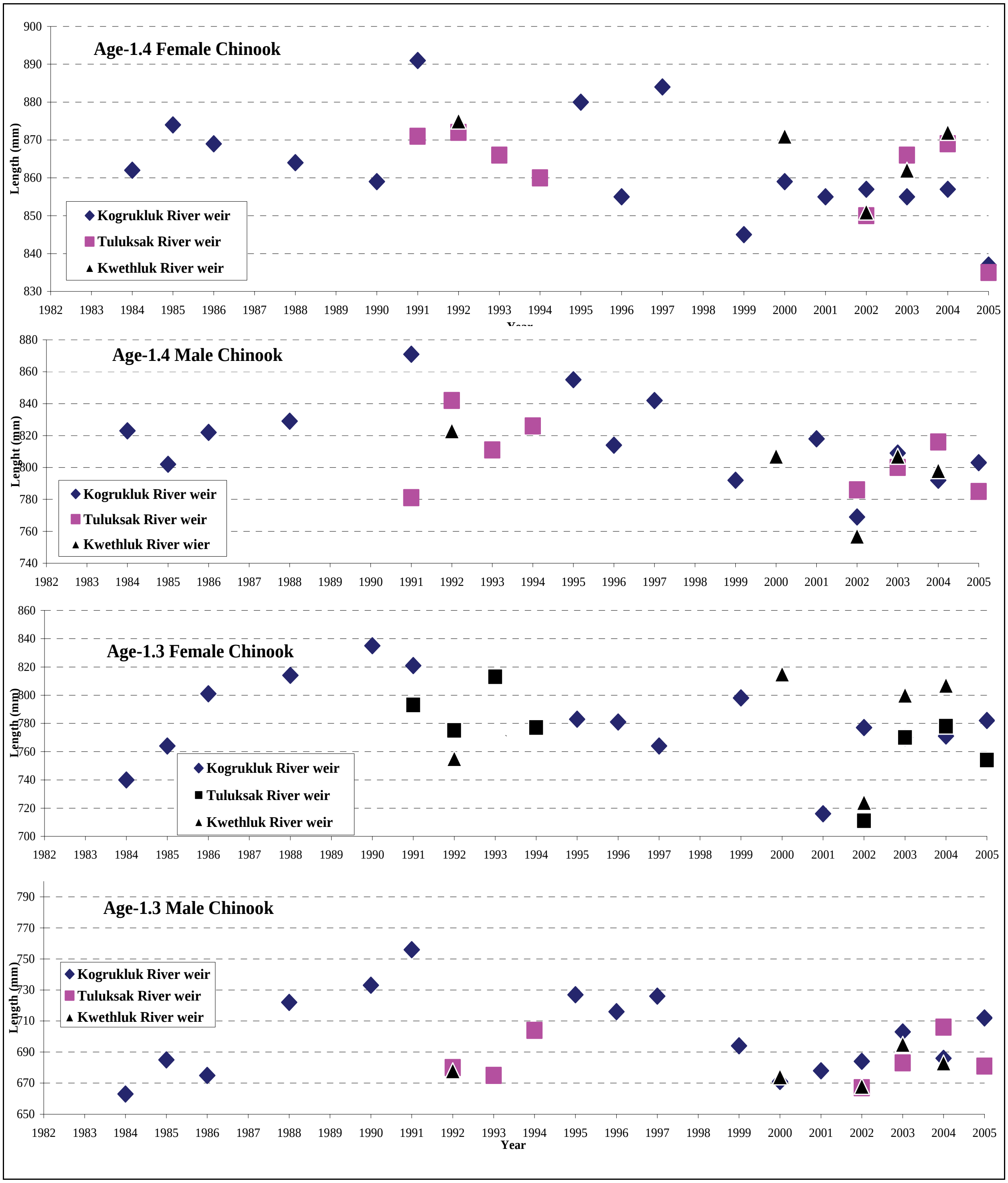

Figure 14.–Length-at-age for Chinook salmon at three Kuskokwim River tributary escapement projects.

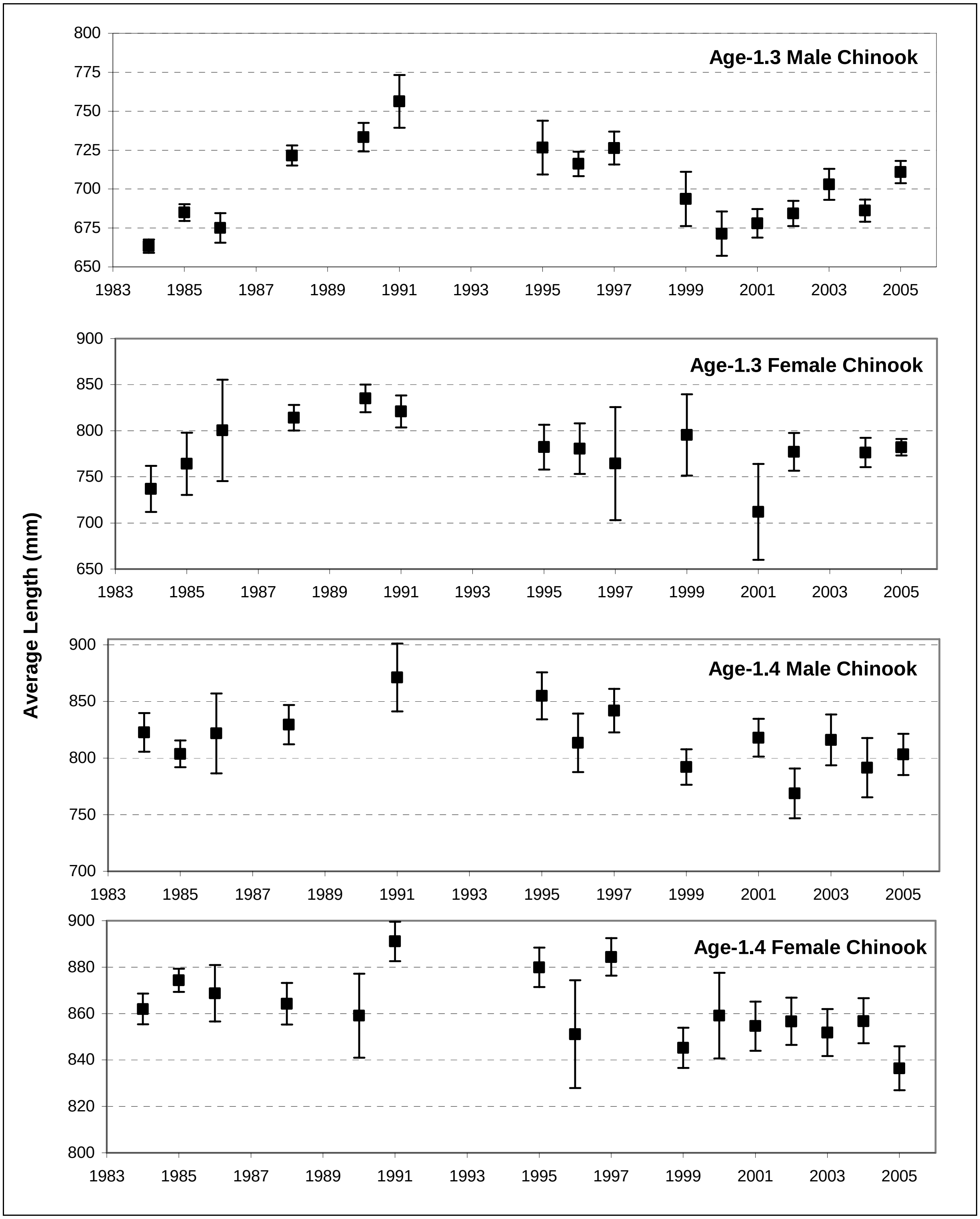

Figure 15.–Historical average annual length with 95% confidence intervals for Chinook salmon at Kogrukluk River weir.

Source: Jasper and Molyneaux 2007.

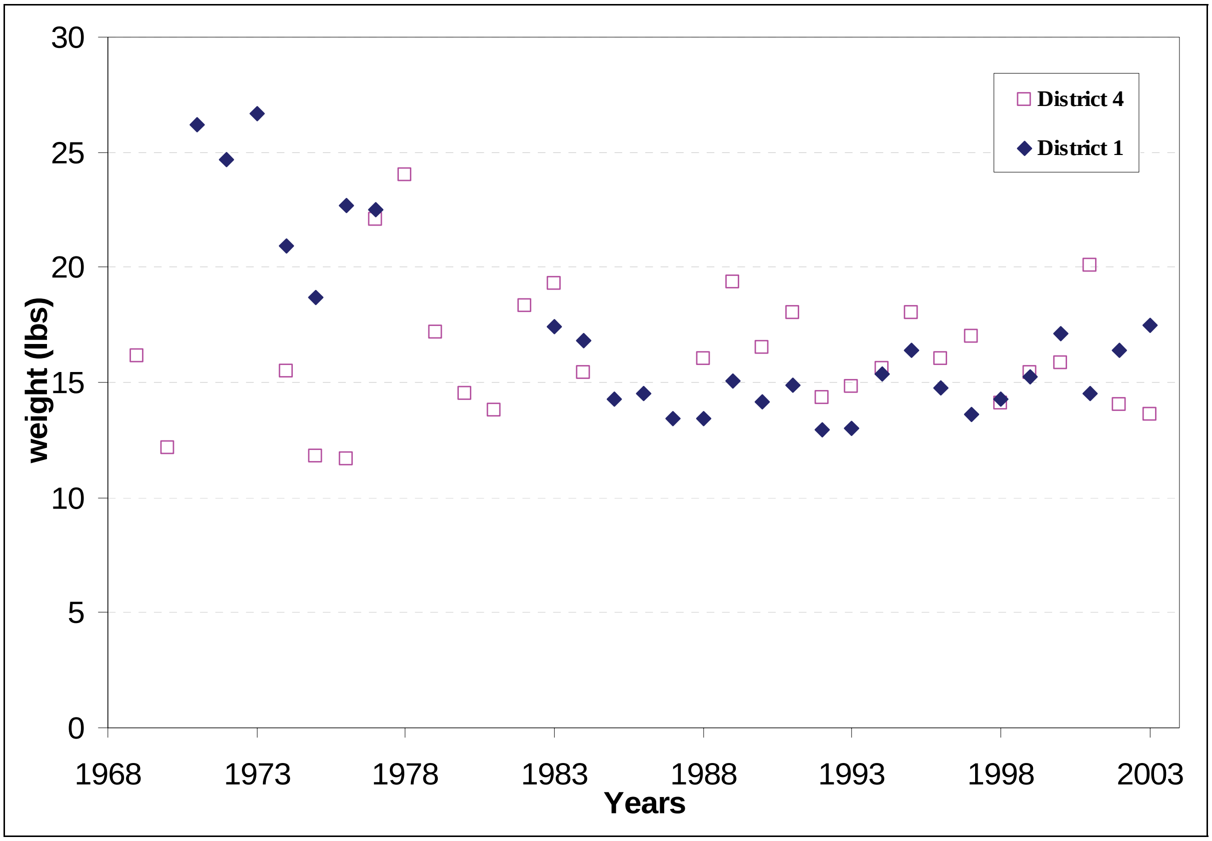

Figure 16.–Average weight by year of commercially caught Chinook salmon in Kuskokwim area fishing Districts 1 and 4.

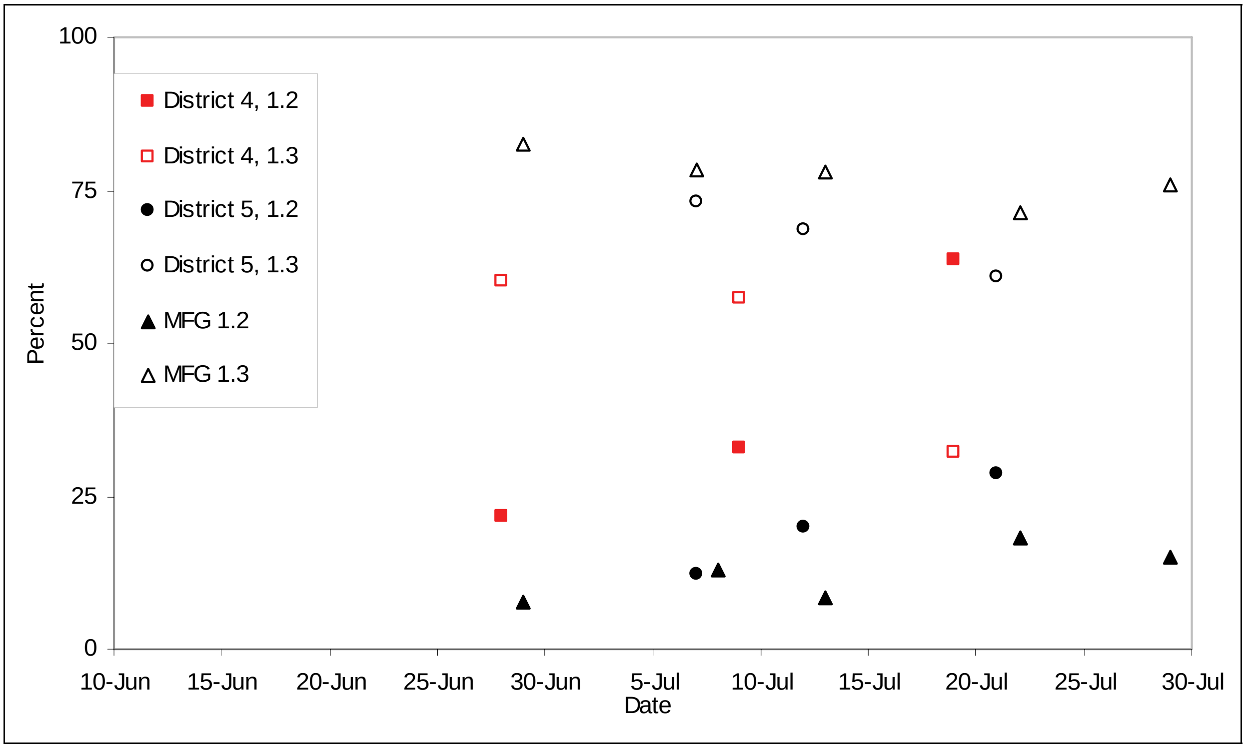

Figure 17.–Percentage of age-1.2 and -1.3 sockeye salmon by sample date from the Middle Fork Goodnews River weir (MFG) escapement and the District 4 and District 5 commercial catches, 1999.

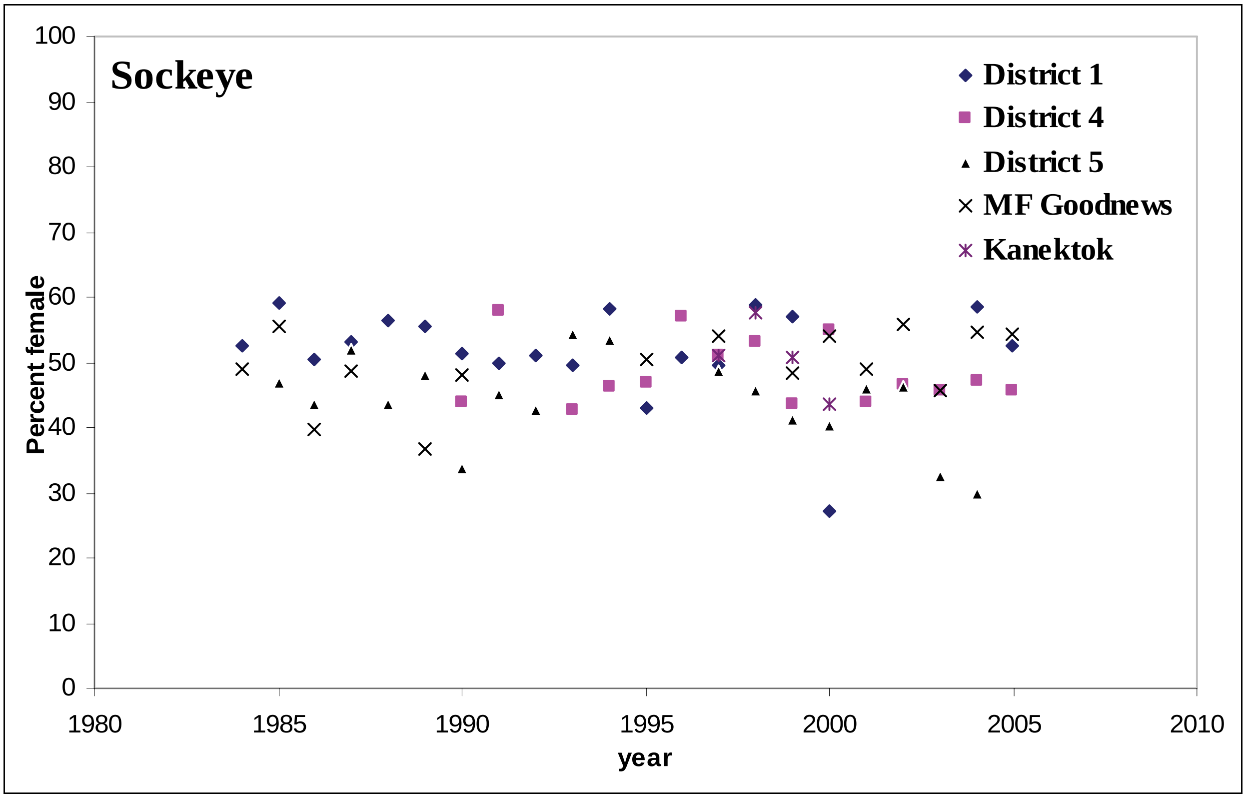

Figure 18.–Percent female of sockeye salmon sampled from three commercial fishing districts and two associated escapement projects.

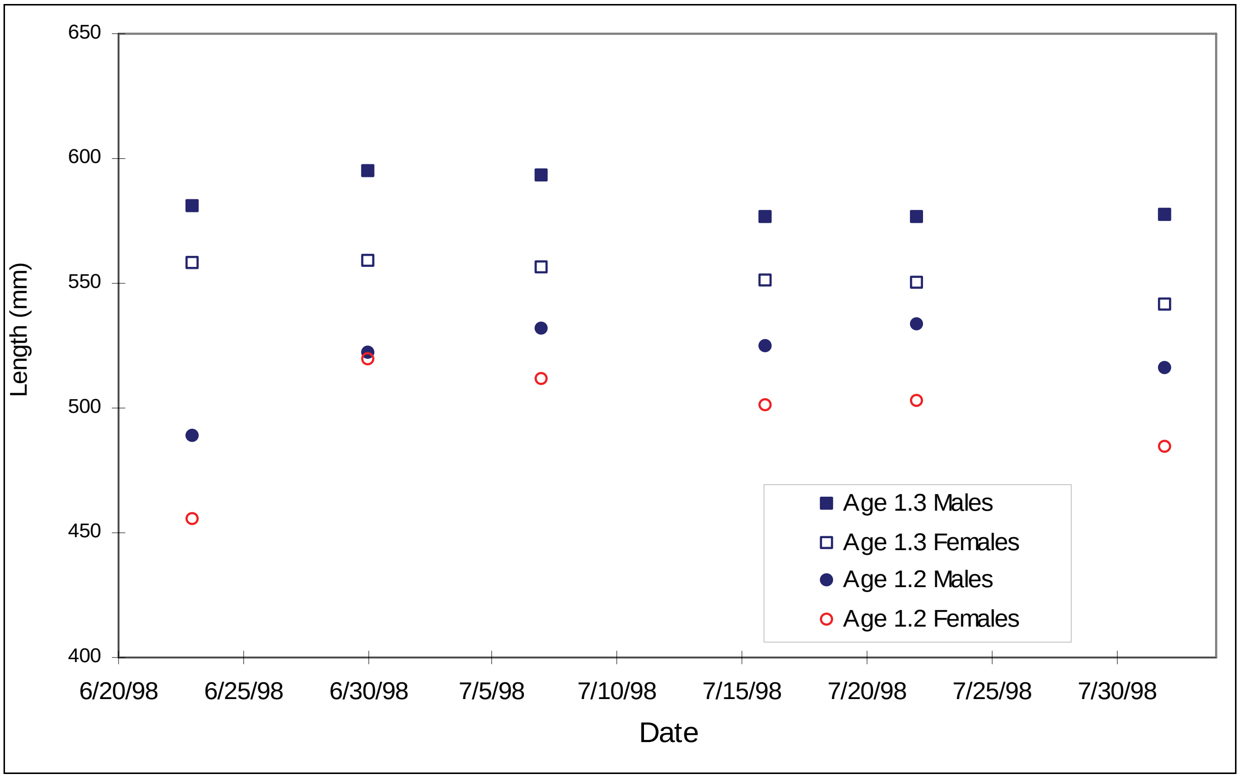

Figure 19.–Average length by sample date for Kanektok River sockeye salmon in 1997.

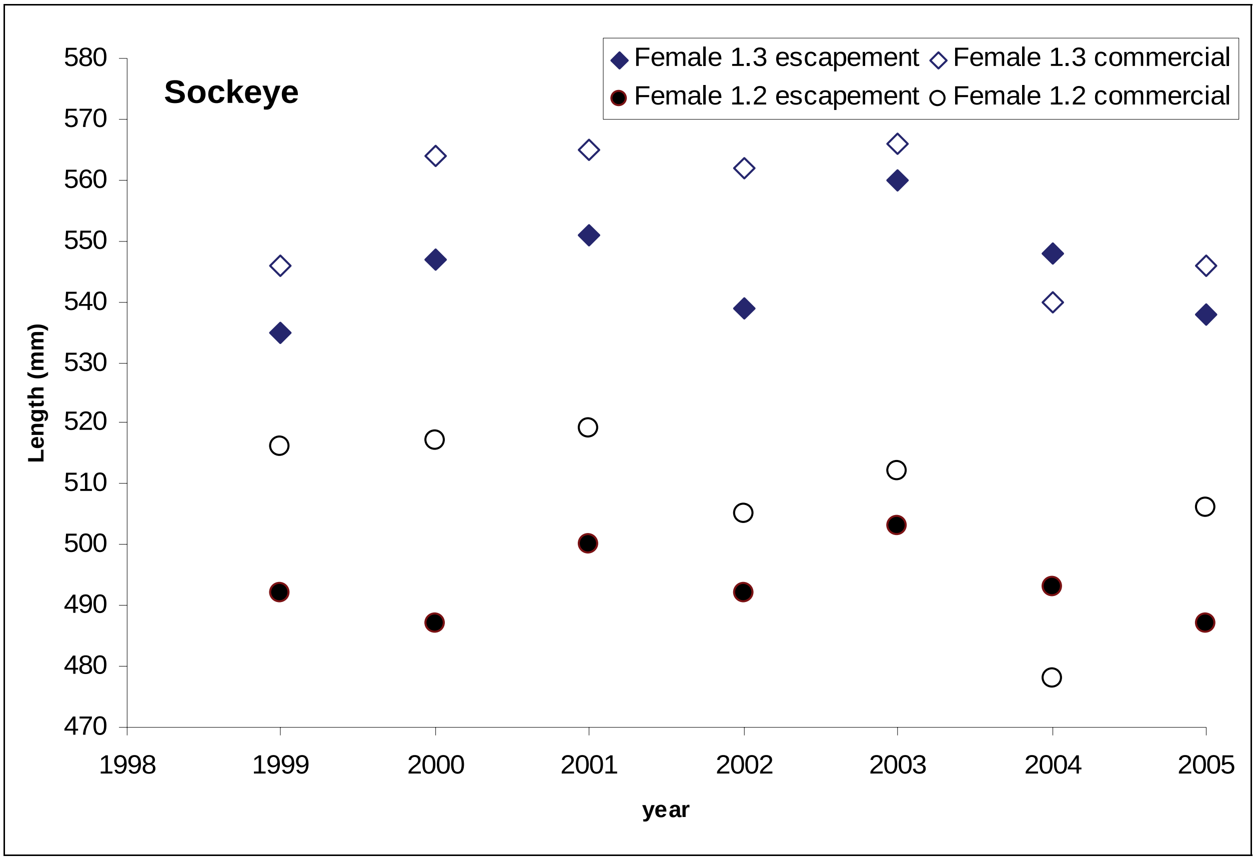

Figure 20.–Comparison of average length by year of female sockeye salmon sampled from the W5 commercial fishery and at the Middle Fork Goodnews River weir.

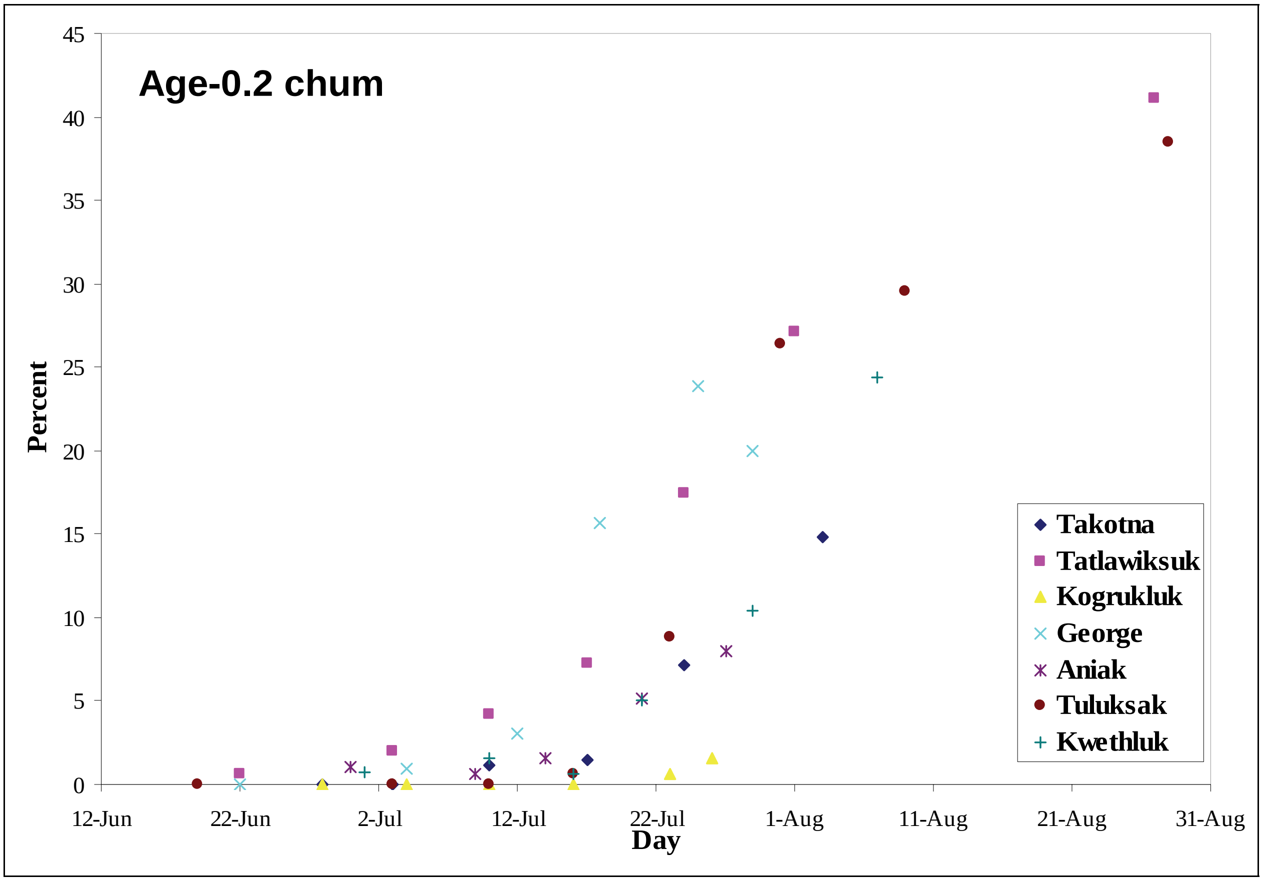

Figure 21.–Percent of the chum salmon migration composed of age-0.2 fish in 2002 at Kuskokwim Area tributary escapement projects.

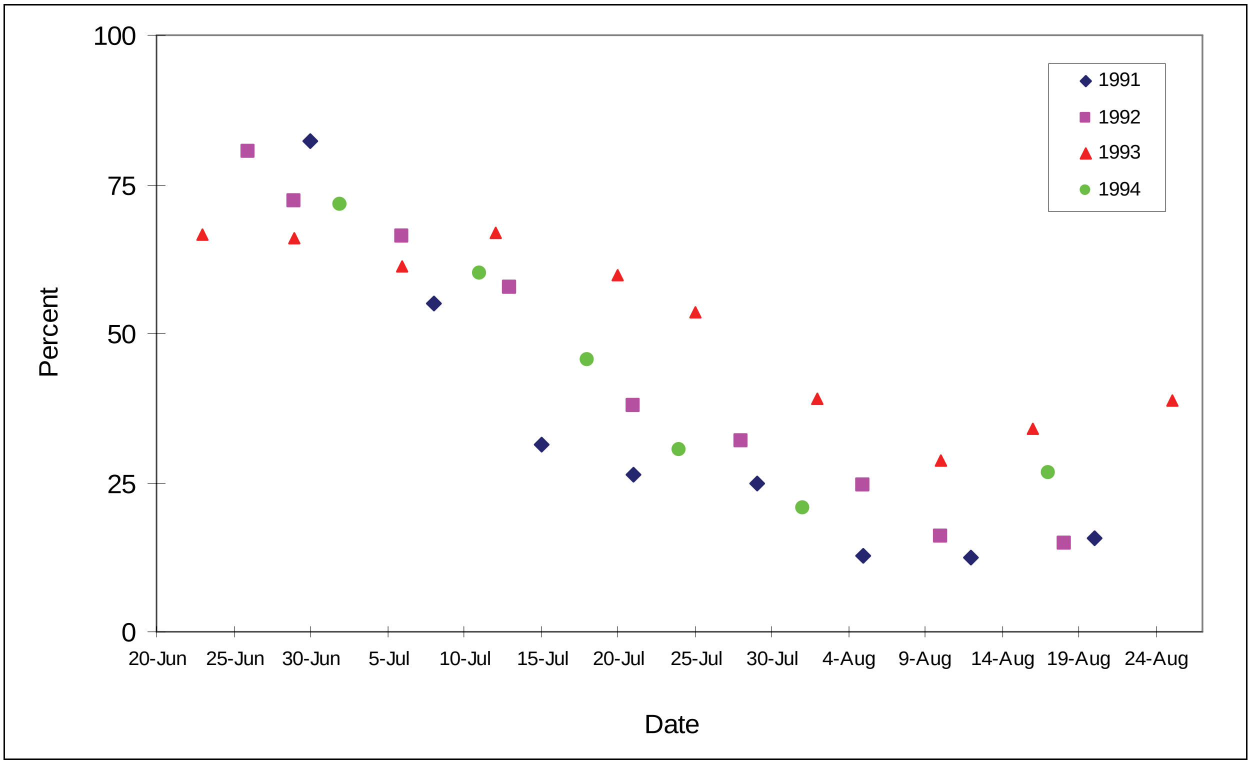

Figure 22.–Percent of the chum salmon migration composed of age-0.4 fish in 2002 at Tuluksak River weir.

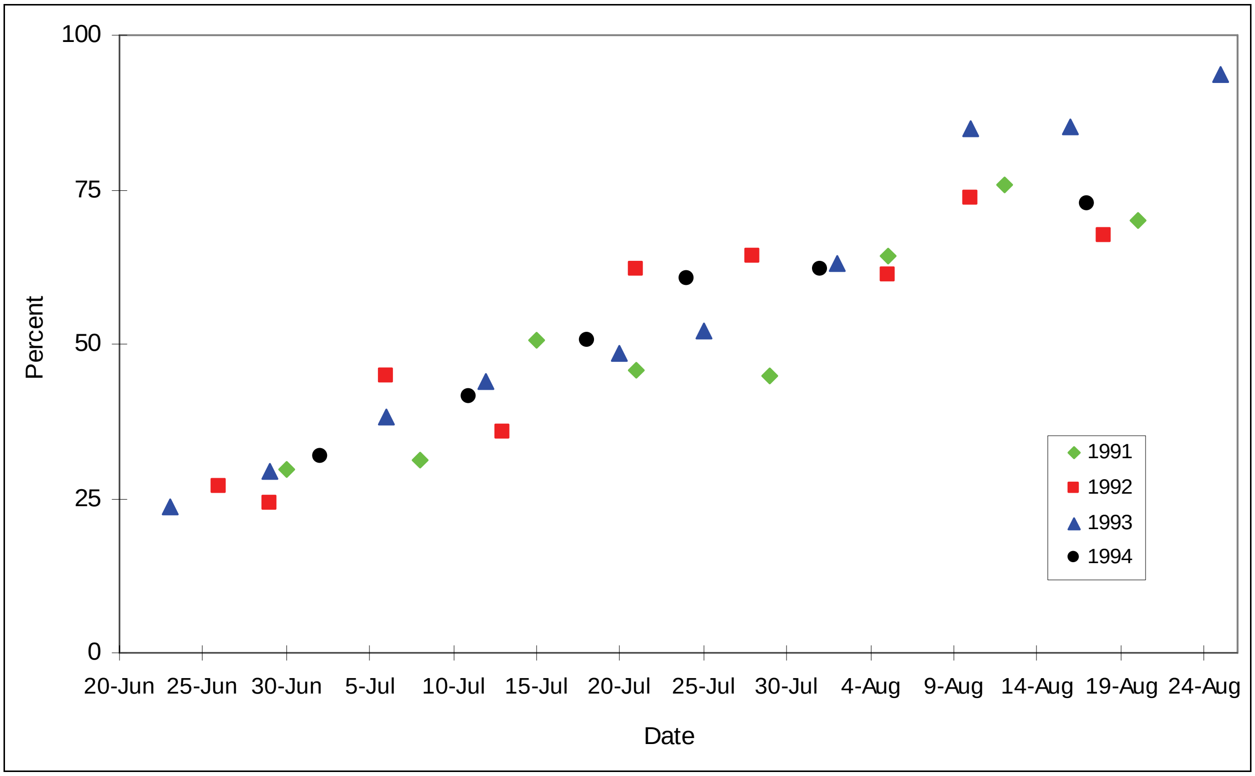

Figure 23.–Percentage of female chum salmon by sample date at Tuluksak River weir, 1991–1994.

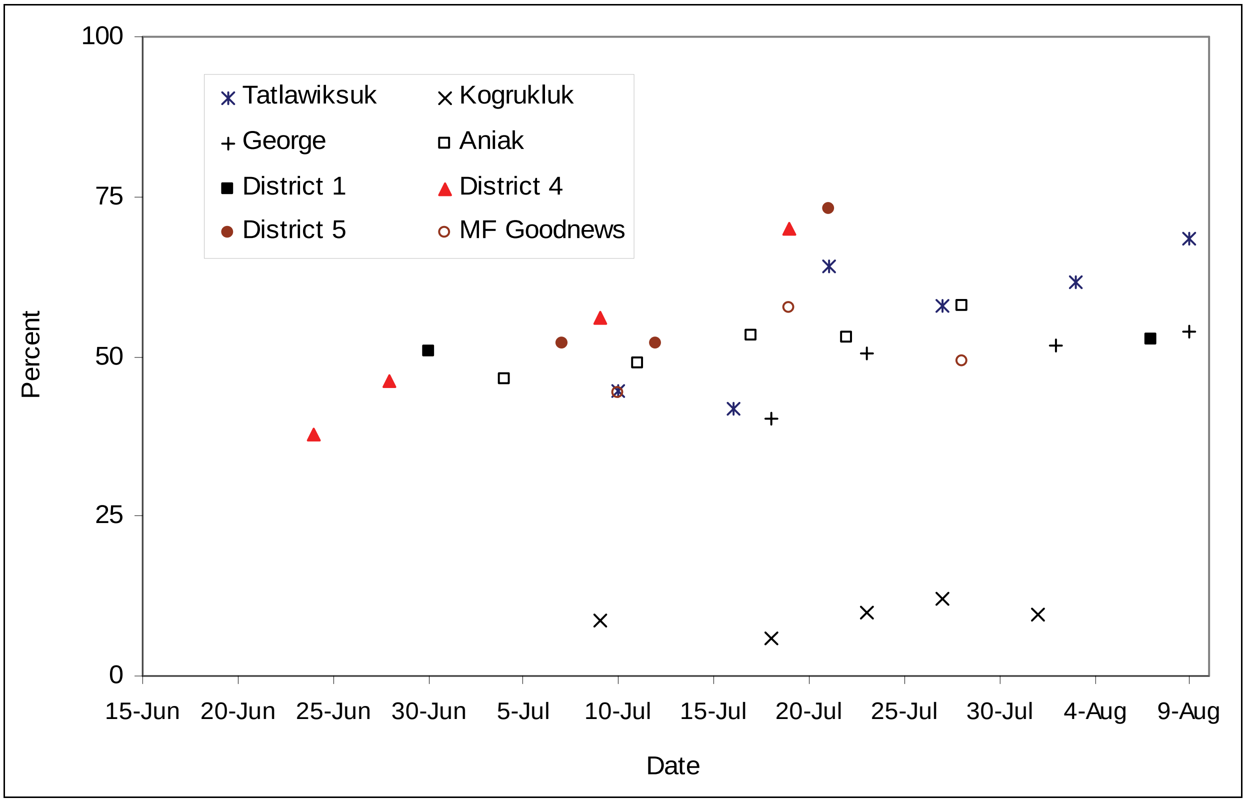

Figure 24.–Percentage of female chum salmon by sample date from Kuskokwim Area tributary escapements and commercial catches, 1999.

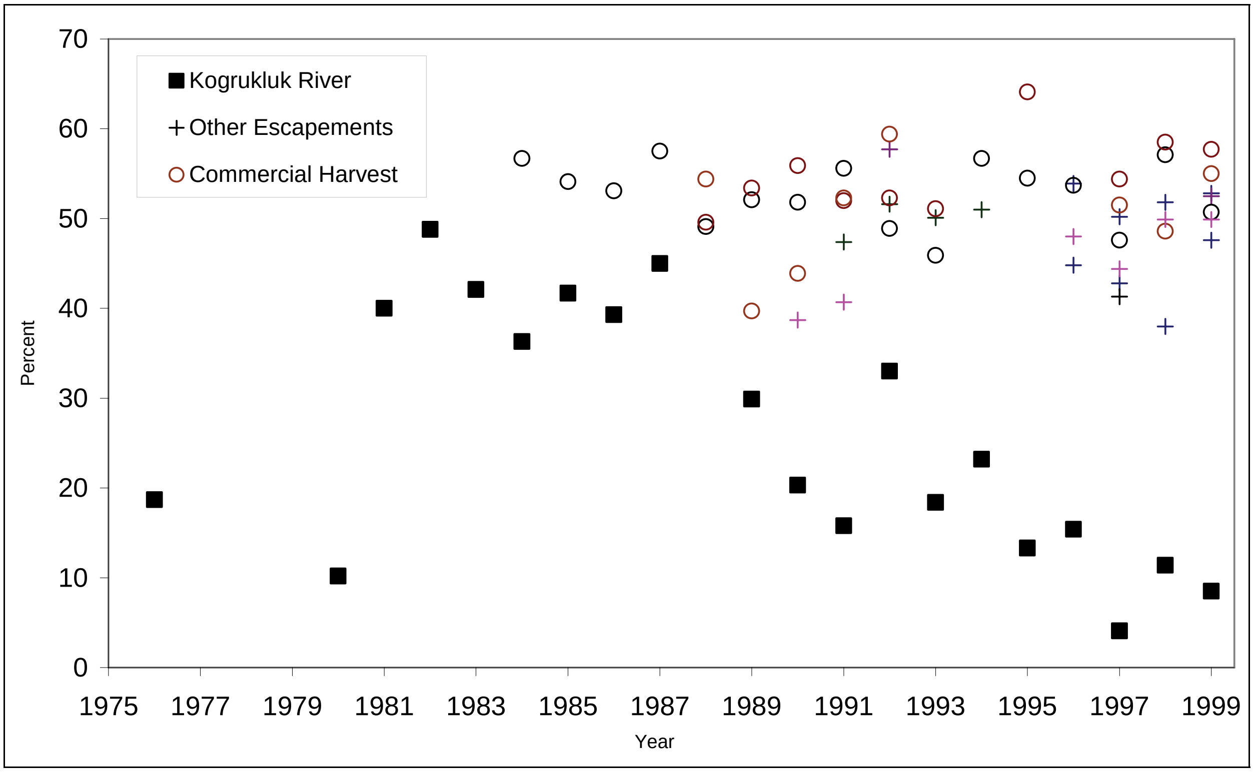

Figure 25.–Historical percentage of female chum salmon in Kuskokwim Area escapement and commercial catch populations, 1976–1998.

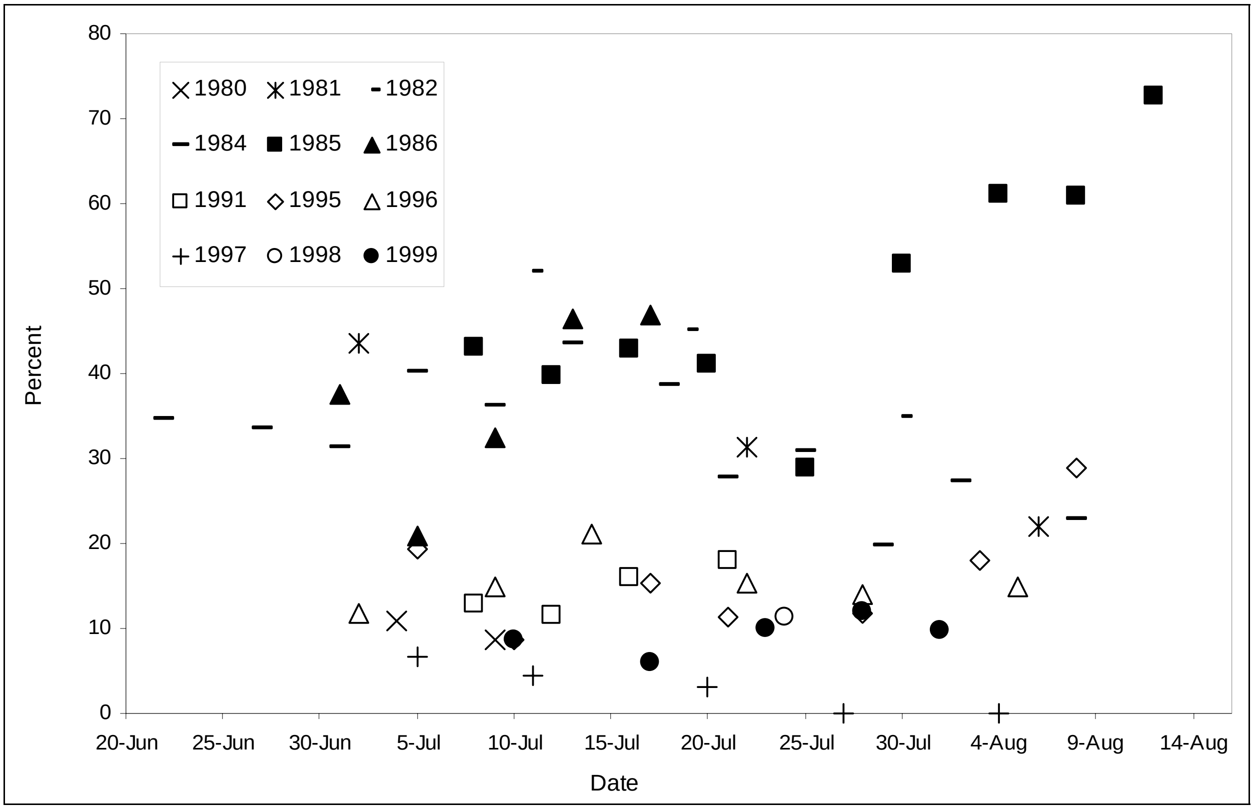

Figure 26.–Historical percentage of female chum salmon by sample date at Kogrukluk River weir, 1980–1999.

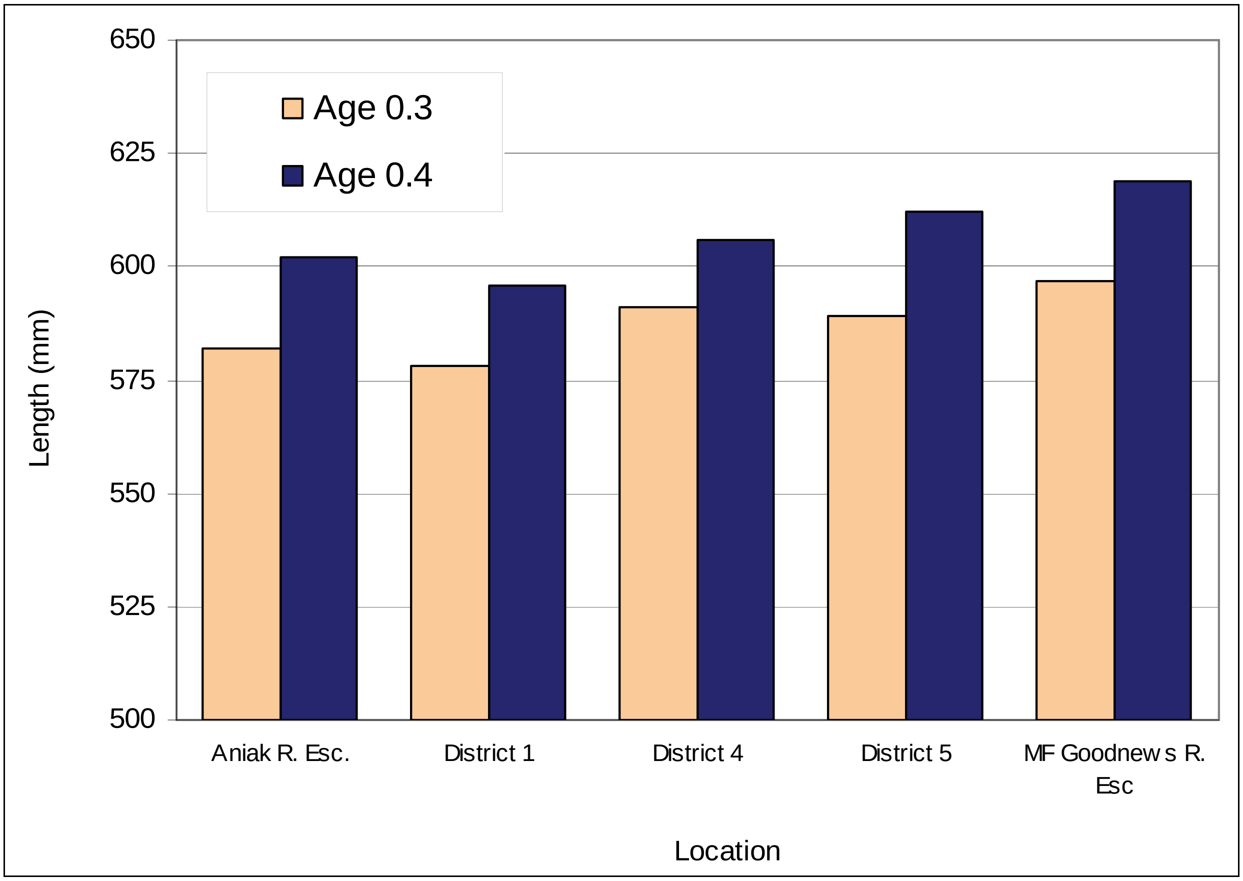

Figure 27.–Average length of male chum salmon from escapements and commercial catches in the Kuskokwim Area, 1999.

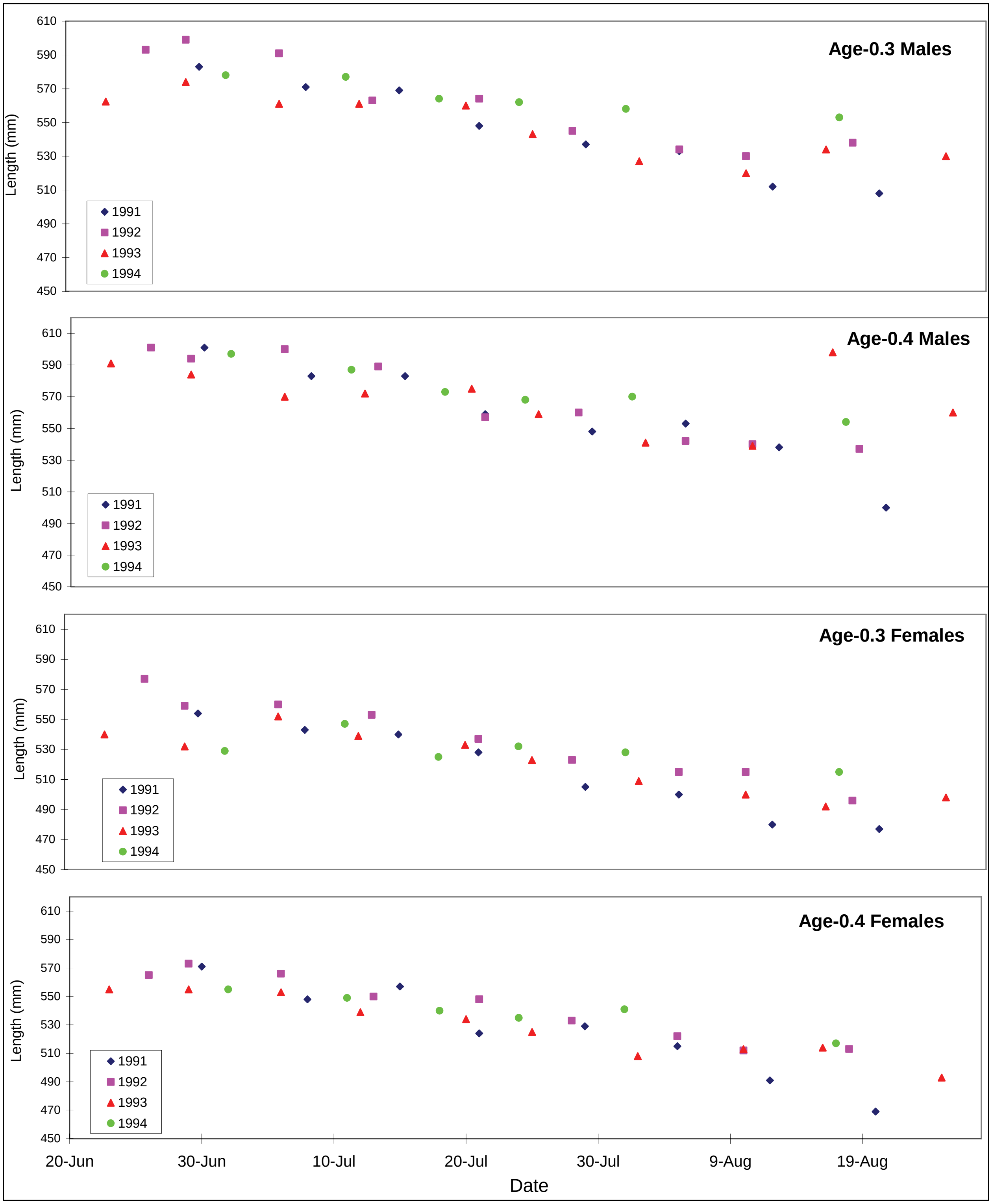

Figure 28.–Average length of chum salmon by sample date in the Tuluksak River, 1991–1994.

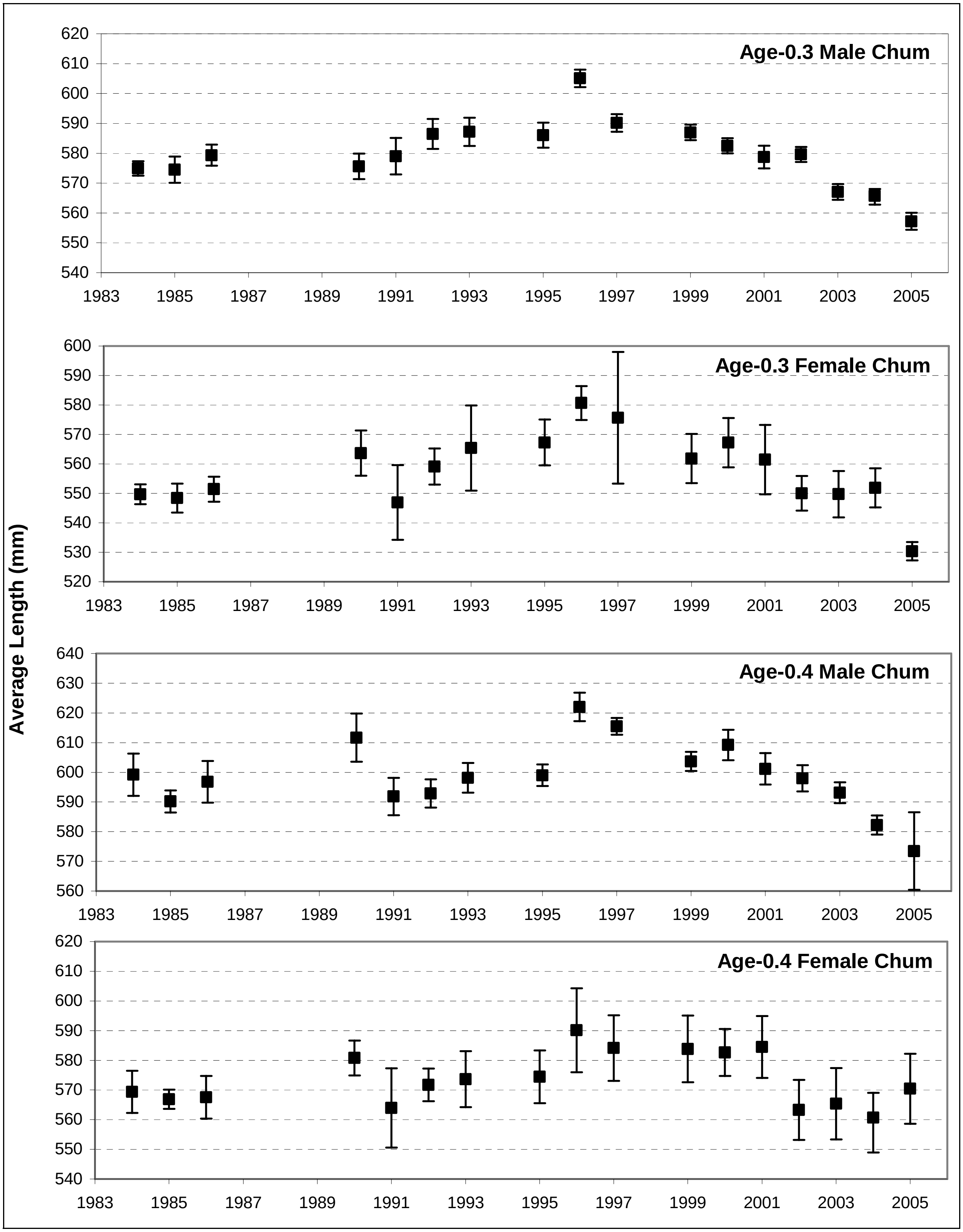

Figure 29.–Historical average annual length with 95% confidence intervals for chum salmon at Kogrukluk River weir.

Source: Jasper and Molyneaux 2007.

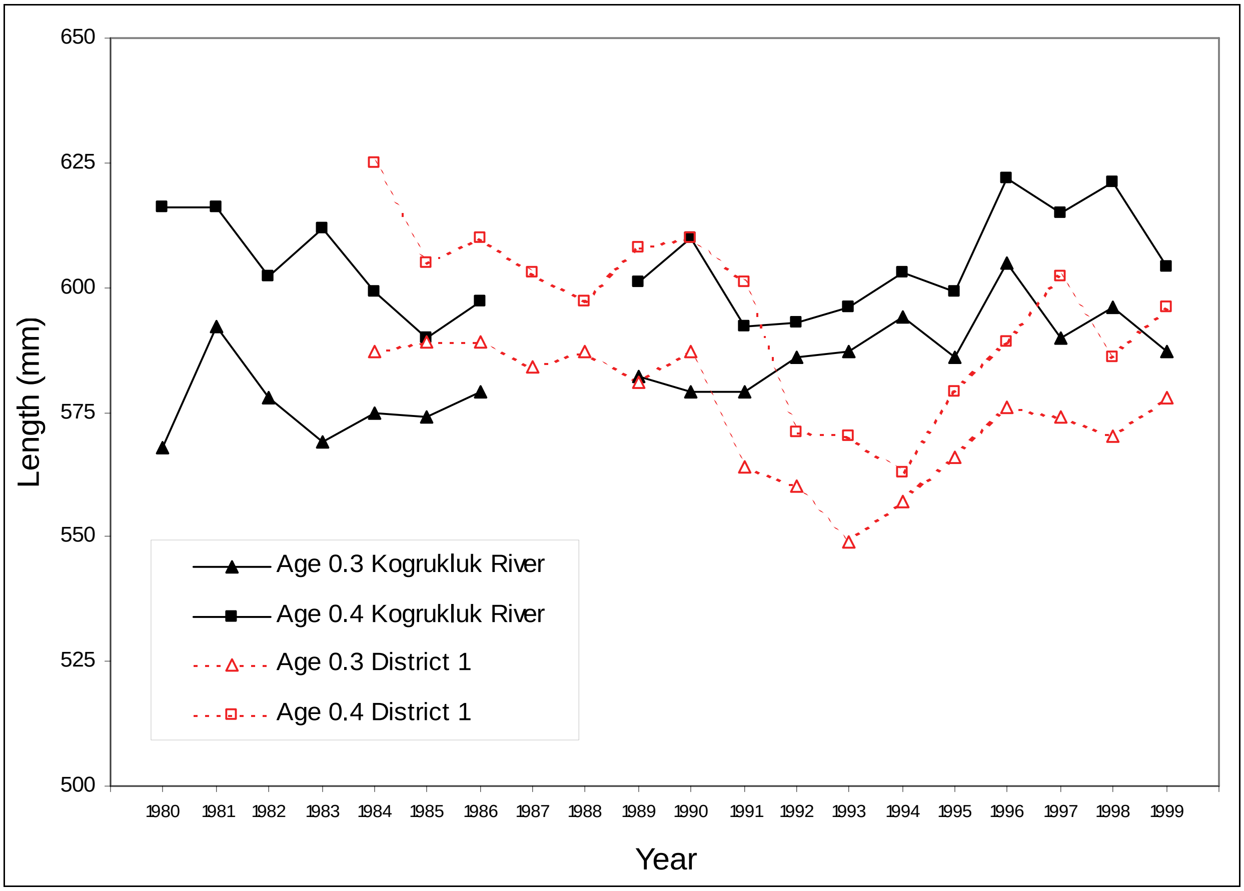

Figure 30.–Historical average length of male chum salmon from Kogrukluk River and District 1 by age, 1980–1999.

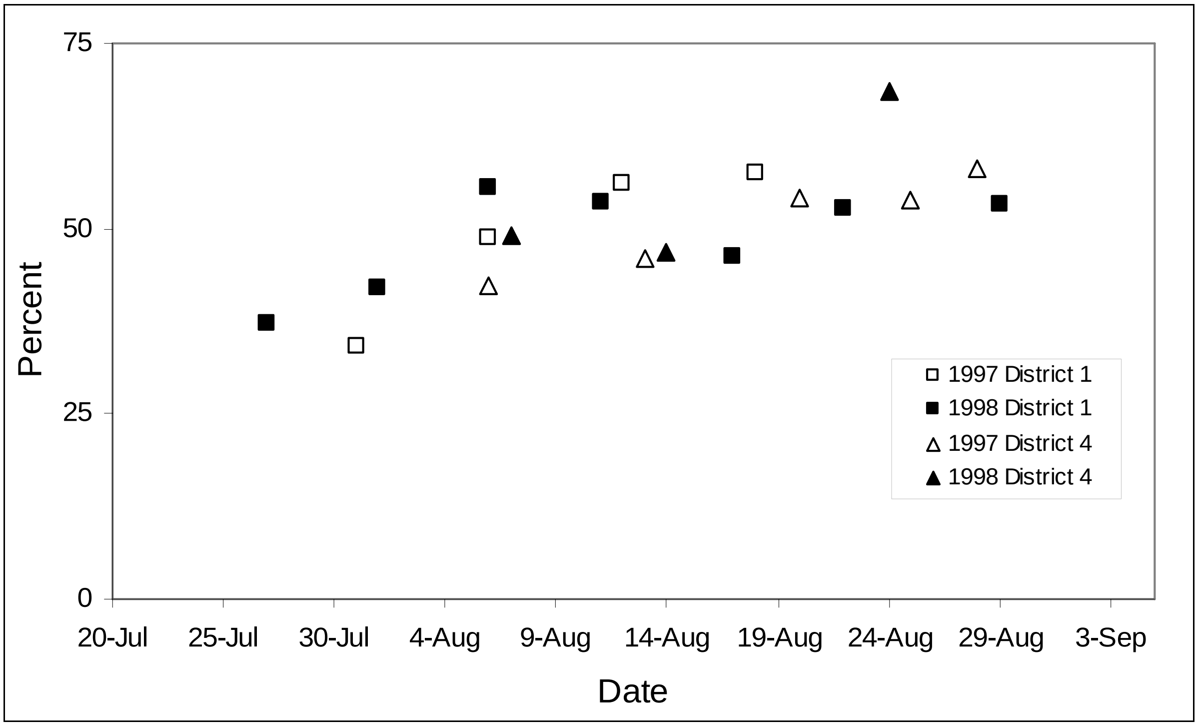

Figure 31.–Percentage of female coho salmon by sample date from Districts 1 and 4 commercial catch populations, 1997 and 1998.

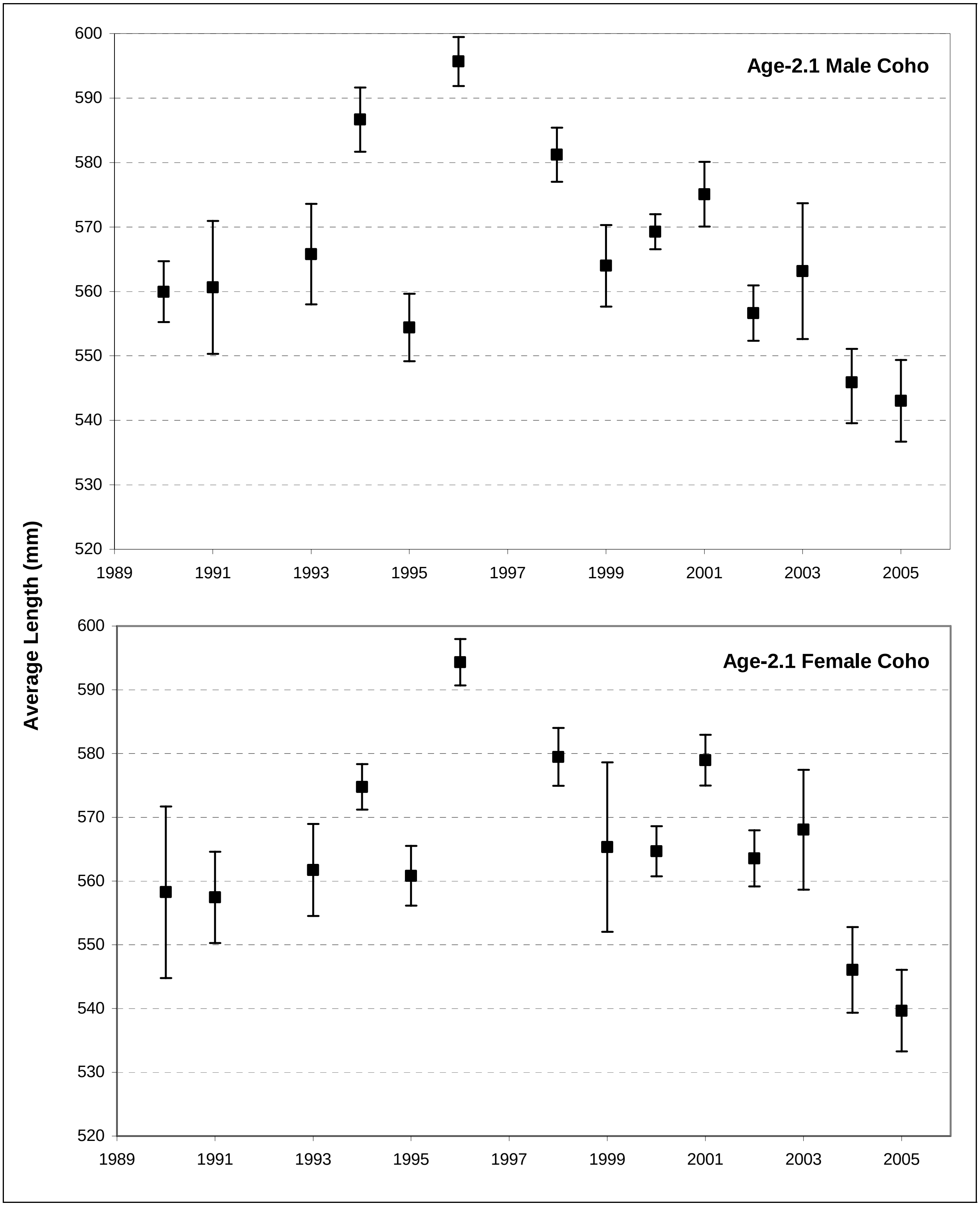

Figure 32.–Historical average annual length with 95% confidence intervals for chum salmon at Kogrukluk River weir.

Source: Jasper and Molyneaux 2007.