Fishery Data Series No. 10-52

Takotna River Salmon Studies, 2009

Annual Report for Study 08-304
USFWS Office of Subsistence Management
Fisheries Resource Monitoring Program

by

Robert Stewart,

Clinton Goods,

and

Christopher A. Shelden

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

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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Robert Stewart,
Clinton Goods,
and
Christopher A. Shelden
Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage

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

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Robb Stewart, (robb.stewart@alaksa.gov)

Clinton Goods, (clinton.goods@alaska.gov)

and

Christopher A. Shelden (chris.shelden@alaska.gov)

Alaska Department of Fish and Game, Division of Commercial Fisheries,
333 Raspberry Road, Anchorage, AK 99518-1599, USA

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ABSTRACT

The Takotna River, a tributary of the Kuskokwim River, produces Chinook *Oncorhynchus tshawytscha*, chum *O. keta*, and coho salmon *O. kisutch* that contribute to subsistence and commercial salmon fisheries downstream of its confluence. A weir has been operated annually on the Takotna River since 2000, and is part of an array of projects used to monitor salmon escapement in the Kuskokwim River drainage. Salmon were enumerated by species as they migrated through the weir to determine daily and annual escapements. Samples were collected to estimate the age, sex, and length composition of escapements using a live trap.

Total escapements of 311 Chinook, 2,487 chum, 4 sockeye *O. nerka*, and 2,708 coho salmon were determined for the target operational period 24 June to 20 September, 2009. Chinook and chum salmon escapements were below their historical medians, while coho salmon escapement was near its historical median. Age, sex, and length sampling in 2009 indicated the Chinook salmon escapement was 42% age-1.4, 30% age-1.3, and 28% age-1.2, with 42% female overall. The chum salmon escapement was 76% age-0.3, 18% age-0.4, 4% age-0.2, and 2% age-0.5, with 49% female overall. The coho salmon escapement was 92% age-2.1, 6% age-1.1, and 2% age-3.1, with 43% female overall. Escapement of age-1.3 Chinook and age-0.3 chum salmon in 2009 were low relative to historical levels at Takotna River weir. Despite low Chinook salmon escapement in 2009, the number of females was similar to more abundant years.

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

INTRODUCTION

Draining an area approximately 130,000 km^2 (11% of the total area of the state), the Kuskokwim River is the second largest river in Alaska (Figure 1; Brown 1983). Each year mature Pacific salmon *Oncorhynchus* spp. return to the river and its tributaries to spawn, supporting an annual average subsistence and commercial harvest of nearly 1 million salmon (Whitmore et al. 2008). The subsistence salmon fishery in the Kuskokwim Area is one of the largest in the state and remains a fundamental component of local culture (Coffing 1991; Coffing[1]; Coffing et al. 2000; Smith and Dull 2008; Whitmore et al. 2008). The commercial salmon fishery has been an important component of the market economy of lower Kuskokwim River communities (Buklis 1999; Whitmore et al. 2008). Salmon contributing to these fisheries spawn and rear in nearly every tributary of the Kuskokwim River basin.

Since 1960, management of Kuskokwim River subsistence, commercial, and sport fisheries has been the responsibility of the Alaska Department of Fish and Game (ADF&G), though other agencies contribute to the decision making process. Management authority for the subsistence fishery was broadened in October 1999 to include the federal government under Title VIII of the Alaska National Interest Lands Conservation Act (ANILCA). The U.S. Fish and Wildlife Service (USFWS) is the federal agency most involved within the Kuskokwim Area. In addition, numerous tribal groups such as the Takotna Tribal Council (TTC) are charged by their constituency to actively promote a healthy and sustainable subsistence salmon fishery. These groups, and others, have combined their resources in a common effort to promote sustainable management of Kuskokwim River salmon.

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

In the State of Alaska, salmon management seeks to provide for sustainable fisheries by ensuring that adequate numbers of salmon escape to the spawning grounds each year (5 AAC 39.222). This goal requires an array of long-term escapement monitoring projects that reliably measure annual escapement to key spawning systems as well as track temporal and spatial patterns in abundance, which influence management decisions. Over time and with sufficient data, escapement goals can be developed as a means to gauge escapement adequacy, but current spawner–recruit models for escapement goal development require many years of data. For much of ADF&G management history in the Kuskokwim Area, escapement monitoring has been limited to aerial surveys and 2 ground based escapement monitoring projects.

Salmon spawn in dozens of tributaries in the Kuskokwim drainage and the operation of only 2 escapement monitoring projects was not an adequate measure of the entire Kuskokwim River basin. This problem was answered with the addition of several escapement monitoring projects in the mid to late 1990s, including the Takotna River weir. The data provided by the current array of projects have much greater utility for fishery managers and have decreased their reliance on aerial stream surveys, which are known to be imprecise (Holmes and Burkett 1996; Molyneaux and Brannian 2006; Mundy 1998). In addition, main-river tagging studies rely on the expanded weir infrastructure to estimate inriver abundance and develop run reconstruction models for Kuskokwim River salmon. Run reconstruction models that result from these studies will be an important tool in answering questions of exploitation, distribution, abundance and travel time for Kuskokwim River salmon and may eventually lead to the development of escapement goals for the entire Kuskokwim River drainage. Such projects have since become deeply integrated components of Kuskokwim River salmon management.

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

BACKGROUND

Since monitoring began, Takotna River salmon escapements of all species have been relatively small; however, historical accounts suggest that salmon abundance was once much higher. In the early 1900s, salmon were harvested from the Takotna River by small bands of Athabaskans including residents of Tagholjitdochak', a now abandoned village site located near the confluence of Fourth of July Creek. The Takotna River also hosted immigration of residents from the Vinasale and Tatlawiksuk Athabaskan bands who maintained small seasonal camps in the Takotna River drainage (Figure 2; Anderson 1977; BLM 1984; Hosley 1966; Stokes 1983; Stokes 1985). The numbers of salmon these groups harvested is unknown, but Nikolai elders suggest that there were strong runs of Chinook *O. tshawytscha* and chum *O. keta* salmon in the Takotna River as recently as the early twentieth century (Stokes 1985).

The historical harvest method used by native Athabaskans was a weir constructed of spruce poles and fitted with a fish trap. According to Nikolai elders, at least 4 such weirs were located on the Takotna River (Figure 2; Stokes 1983). One of these was located on the Nixon Fork of the Takotna River near the confluence of the West Fork River. Other locations included a site on the main river a short distance above the current community of Takotna; one near Big Creek (lower); and another near or within Fourth of July Creek. The site near Fourth of July Creek is believed to have been operated by residents of Tagholjitdochak' (Stokes 1983). These sites were all abandoned by the mid 1920s (Stokes 1983).

The discovery of gold in the Innoko mining district in 1906 was a catalyst for social change and may have been a significant factor in the near extirpation of salmon in the Takotna River. The community of Takotna developed as a staging area for miners who used the Takotna River as an access route to mining operations that were mostly located in the Yukon River drainage (Brown 1983). The thousands of miners and related support personnel that migrated into the area were dependent on dog teams for winter transportation. The community of Takotna served as a major summer kenneling area and salmon was a common food source for the dogs.

Steamboats navigated as far upstream as the current community of Takotna and probably had an adverse effect on local salmon stocks. A Kusko Times article published in 1921 references the construction of small temporary dams on the Takotna River to facilitate steamboat passage (Kusko Times 1921). We have been unable to uncover any details about these dams, but they too may have contributed to salmon declines by altering stream habitat or creating obstructions to migration. Stokes (1985) conducted interviews with residents as part of a study of subsistence harvest activities in the upper Kuskokwim River, but residents were unclear about the cause and timing of declines in salmon harvest. Stokes (1985), after reviewing historical accounts, concluded that it was likely a combination of overfishing and habitat alteration associated with mining development, and not a result of traditional harvest practices, that led to the decline.

Area residents and local biologists described the Takotna River as being nearly void of salmon during the 1960s and 1970s (Molyneaux et al. 2000). By the 1980s, however, Takotna residents began to notice adult salmon in the river again. Around 1990 rod and reel fishermen began to catch coho salmon *O. kisutch* while fishing for northern pike *Esox lucius* (Dick Newton, local resident, Takotna; personal communication). During an aerial survey in 1994, an experienced ADF&G fishery biologist observed several thousand chum salmon and some Chinook salmon in Fourth of July Creek, but few salmon were observed elsewhere in the drainage (Burkey and Salomone 1999).

The perception of recovering salmon abundance inspired interest among ADF&G staff and local residents and prompted the development of a project designed to document the numbers of spawning salmon returning to the Takotna River. Initially, high school students built a salmon counting tower that they operated from 1995 to 1999, but success was limited because of poor water clarity, periodic high water levels, and organizational difficulties (Molyneaux et al. 2000). The monitoring project transitioned to a resistance board weir in 2000 (Schwanke et al. 2001) as one of several initiatives started in the late 1990s to improve salmon escapement monitoring in the Kuskokwim Area. The Takotna River weir has operated successfully every year since inception and is currently the farthest upstream ground-based salmon escapement monitoring project in the Kuskokwim River drainage. As such, the project is integrated into drainagewide initiatives to understand the dynamics of Kuskokwim River salmon.

The Takotna River weir is operated jointly by ADF&G Division of Commercial Fisheries and the Takotna Tribal Council (TTC). ADF&G staff help oversee inseason operations and serve as the principal agent for data management, data analysis, and report writing. The TTC provides most of the field crew and coordinates much of the preseason preparations and inseason operations.

OBJECTIVES

The annual objectives of the Takotna River escapement monitoring project (FIS 08-304) were to:

1. Determine daily and total escapements of male and female Chinook, chum, sockeye *O. nerka*, and coho salmon in the Takotna River upstream of the community of Takotna during the target operational period of 24 June to 20 September;
2. Estimate the age, sex, and length composition of annual Chinook, chum, and coho salmon escapements to the Takotna River such that 95% confidence intervals for the age composition are no wider than ±10% (α=0.05 and d=0.10);
3. Mentor high school students through the TTC high school internship program; and,
4. Facilitate other fisheries research projects by:
    a. Serving as a monitoring location for coho salmon equipped with radio transmitters and anchor tags deployed as part of *Kuskokwim River Coho Salmon Investigations*; and,
    b. Installing and monitoring air and stream thermographs at Takotna River weir as part of a broader *Temperature Monitoring* project.

METHODS

STUDY AREA

The Takotna River originates in the central Kuskokwim Mountains of the upper Kuskokwim River basin (Figure 1). Formed by the confluence of Moore Creek and Little Waldren Fork, the river flows northeasterly and passes the community of Takotna at river kilometer (rkm) 80, before turning southeasterly near the confluence of the Nixon Fork at rkm 24 (Figure 2; Brown 1983). The Tatalina River joins at rkm 4.8, and then the Takotna River empties into the Kuskokwim River across from McGrath at rkm 752 of the Kuskokwim River.

The Takotna River is about 160 km in length and drains an area of 5,646 sq km (Brown 1983). The river is shallow with many meanders from its headwaters to the community of Takotna, but gradually becomes deeper downstream of that point, especially after the confluence of the Nixon Fork. In the lower reaches, the current is sluggish and the channel width averages 122 to 152 m. The river's average slope is about 89 cm per km (Brown 1983).

At normal flow, the Takotna River has a nominal load of suspended materials, and the water is stained due to organic leaching. The Nixon Fork and Tatalina rivers drain extensive bog flats and swampy lowlands, but the remainder of the basin is primarily upland spruce-hardwood forest (Brown 1983; Selkregg 1976). White spruce *Picea glauca*, birch *Betula* spp., and aspen *Populus tremuloides* are common on moderate south-facing slopes; while black spruce *P. mariana* is more characteristic of northern exposures and poorly drained flat areas. The understory consists of spongy moss and low brush on the cool, moist slopes, grasses on the dry slopes, and willow *Salix* spp. and alder *Alnus* spp. in the higher open forest near the timberline.

A weir has been installed annually since 2000 at N 62° 58.1', W 156° 05.9', several hundred meters upstream of the Takotna River Bridge near the community of Takotna. This site captures nearly all the salmon spawning habitat in the Takotna River drainage excluding the Nixon Fork tributary. The river channel at this site is about 85 m wide and has a wetted depth of less than 1 m during normal summer flows. The substrate is composed mostly of gravel with sand and cobble also present.

WEIR DESIGN

The resistance board weir was installed across the entire 85 m channel following the techniques described by Stewart (2003). The substrate rail and resistance board panels covered the middle 75 m portion of the channel, and fixed weir materials extended the weir 5 m to each bank. Details of design and materials used to construct the weir are described in Tobin (1994) with panel modifications described by Stewart (2002). The Takotna River weir was designed with a gap of 4.29 cm (1-11/16 in) between each picket.

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

To accommodate downstream migration of longnose suckers and other non-salmon species, downstream passage chutes were installed into the weir. Chutes were created by releasing the resistance boards on 1 or 2 adjacent weir panels so the distal ends dipped slightly below the stream surface. The chute's shallow profile guided downstream migrants over the weir while preventing upstream salmon passage. The chutes were monitored and adjusted to ensure salmon were not passing upstream. Downstream passage was not enumerated; however, few salmon have been observed passing downstream over these chutes, and their numbers are considered negligible.

ESCAPEMENT MONITORING

A target operational period, spanning most of the salmon runs, was used to provide for consistent comparisons of annual escapements among years. The target operational period for Takotna River weir has been established as 24 June through 20 September, although actual operational dates may vary annually with stream conditions. Daily and total annual escapements consisted of the observed passage plus any estimated passage of Chinook, sockeye, chum, or coho salmon missed during the target operational period. Counts of all other species were reported simply as observed passage.

Passage Counts

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

Salmon were additionally enumerated by sex, from the visual characteristics of advanced sexual dimorphism apparent in adult salmon at Takotna River weir. This data is not considered a conclusive determination of sex, but instead may serve as a means of assessing bias in ASL sampling.

Passage Estimates

Passage missed during the occurrence of a hole in the weir was estimated by linier interpolation using the following formula:

$$\hat{n}_{d_i} = (\alpha + \beta \cdot i) - n_{o_i} \quad (1)$$

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

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

Where:

n_{d_i-1}, n_{d_i-2} = Observed passage of 1, 2 days before the weir was inoperable; and,

n_{d_i+1}, n_{d_i+2} = Observed passage of 1, 2 days after the inoperable period; and,

n_{o_i} = Observed passage (if any) from the given day (i) being estimated; and,

I = Number of inoperative days ($I \geq 2$); and,

n_{d_i+I}, n_{d_i+I+1} = Observed passage of 1, 2 days after the inoperable period.

Carcass Counts

The weir was typically cleaned and inspected after the first and last counts of each day. Dead or spawned out live salmon that washed up on the weir, both referred to hereafter as carcasses, were counted by species and sex and passed downstream during each cleaning. These counts are not considered a census, as both the skiff gate and downstream passage chutes installed to facilitate migration of non-salmon species provide a pathway for dead and dying salmon to pass downstream uncounted.

Age, Sex, and Length Composition

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

Sample Size and Distribution

A minimum sample size was determined for each species following conventions described by Bromaghin (1993) to achieve 95% confidence intervals of age-sex composition for each sample be no wider than ±10% (α=0.05 and d=0.10), assuming 10 age-sex categories for Chinook salmon (*n*=190), 8 age-sex categories for chum salmon (*n*=180), and 6 age-sex categories for coho salmon (*n*=168), and unknown population size. Because the Takotna River Chinook salmon population is small, the sample size of 190 was corrected for a population of 500 fish using the finite population correction:

$$n' = \frac{n}{1 + \left(\frac{n-1}{N} \right)} \tag{2}$$

Where:

n = sample size of unknown population size;

N = population size; and,

n' = sample size corrected for a known population size.

Minimum sample sizes for each species were then increased by about 20% to account for unreadable scales or collection errors. This yielded a minimum collection goal for each sample of 165 Chinook, 220 chum, and 200 coho salmon.

A pulse sampling strategy was employed to ensure adequate temporal distribution of chum and coho samples. The term "pulse" is used to describe a sample collected over a few days and applied to a longer period. Pulse sampling was conducted approximately every 7−10 days. The goal was to collect a minimum of one pulse sample from each third of the run. Well spaced pulse samples are thought to have greater power for detecting temporal changes in ASL composition than other sampling methods (Geiger and Wilbur 1990).

The relatively low abundance of Chinook salmon at Takotna River weir makes pulse sampling impractical. Instead, the sample was collected continuously over the run following a daily collection schedule based on historical run timing information. Daily sample sizes were proportional to average historical escapements by day to ensure a good distribution across the run. The overall sample size was selected to exceed the minimum necessary to meet precision and accuracy criteria for this location and was similar to average historical sampling success.

Sample Collection Procedures

Salmon were sampled using the live trap installed in the weir. Salmon were trapped by opening the entrance gate while the exit gate remained closed. Fish were allowed to swim freely into the live trap, and the V-shape positioning of the entrance gate prevented them from easily escaping. The live trap was allowed to fill with fish until a reasonable number was inside. Crew members used a short-handled dip net to capture fish within the live trap. To obtain length data and aid in scale collection, fish were removed from the dip net and placed into a partially submerged fish "cradle." Scales were taken from the preferred area of the fish (INPFC 1963) and transferred to numbered gum cards as described in Molyneaux et al. (2009). Sex was determined through visual examination of the external morphology, focusing on the prominence of a kype, roundness of the belly, and the presence or absence of an ovipositor. Mideye fork (MEF) length was measured to the nearest millimeter using a straight-edged meter stick. Sex and length data were recorded on standardized numbered data sheets that correspond with numbers on the gum cards used for scale preservation. After sampling, each fish was released upstream of the weir. The procedure was repeated until the live trap was emptied to ensure no bias was introduced.

Chinook salmon samples were often collected through "active sampling," which consisted of capturing and individually sampling while actively passing and counting all salmon. To prevent bias, active sampling was conducted on each Chinook salmon individual observed during the sampling/passing procedure. Further details of the active sampling procedures are described in Linderman et al. (2002).

After sampling was completed, relevant information such as sex, length, sampling date, and sampling location was copied to computer mark–sense forms that correspond to numbered gum cards. The completed gum cards and mark–sense forms were sent to the Bethel and/or Anchorage ADF&G offices for processing. The original ASL gum cards, acetates, and mark–sense forms were archived at the ADF&G office in Anchorage. The computer files were archived by ADF&G in the Anchorage and Bethel offices. Data were also loaded into the Arctic-Yukon-Kuskokwim (AYK) salmon database management system (Brannian et al. 2006).

Data Processing and Reporting

Samples were aged and processed by ADF&G staff in Bethel and Anchorage following procedures describe by Molyneaux et al. (2009). Samples were partitioned into temporal strata, based on overall distribution within the run. The escapement in each stratum was divided into age-sex classes proportionately with strata sample composition. Mean length by age-sex class was determined for each stratum as well. Annual estimates were calculated as strata sums, weighted by the abundance in each stratum. When sample size or distribution was not considered adequate to estimate annual ASL composition, results were reported, but not applied to annual escapements.

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

TTC High School Internship Program

Four local area high school students were employed by the Takotna Tribal Council to assist with daily weir operations during summer months. Under the supervision of project crew members, students participated in routine passage counts, ASL sample collections, and weather and stream measurements.

Weather and Stream Observations

Water and air temperatures (°C) were measured each day at approximately 0800 and 1700 hours. Water temperature was determined by submerging a calibrated thermometer below the water surface until the temperature reading stabilized. Air temperature was obtained by placing the thermometer in a shaded location until the temperature reading stabilized. Temperature readings were recorded in a designated logbook, along with notations about wind direction, estimated wind speed, cloud cover, and precipitation. Daily precipitation was measured using a rain gauge calibrated in millimeters.

Daily operations included monitoring river depth with a standardized staff gage. The staff gage consisted of a metal rod driven into the stream channel with a meter stick attached. The height of the water surface, as measured from the meter stick, represented the "stage" of the river above an established datum plane. The staff gage was calibrated to the datum plane by a semi-permanent benchmark located about 6 m from the river bank and consisted of a nail driven into a tree. The height of the nail corresponded to stage measurements of 300 cm relative to the datum plane. River stage was measured at approximately 0800 and 1700 hours each day.

RELATED FISHERIES PROJECTS

Kuskokwim River Coho Salmon Investigations

The Takotna River weir served as a recovery site for a basinwide mark–recapture and radiotelemetry study entitled *Kuskokwim River Coho Salmon Investigations* funded by the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative. The live trap was used as the primary means of upstream fish passage. Whenever possible, tagged coho salmon observed passing through the weir's live trap were captured to recover tag information. A clear plastic viewing window was placed on the stream surface to improve visual identification of fish entering the trap. Recorded data for "recovered" fish included the tag number, tag color, condition, presence of secondary mark, and recovery date. When a tagged fish was not captured it was recorded as "observed" along with the tag color and passage date. Tag loss was assessed at the weir by inspecting for secondary marks during routine ASL sampling. A secondary passage gate described in Costello et al. (2007) was employed during extreme low water conditions when fish showed reluctance to pass through the live trap.

Temperature Monitoring

The Takotna River weir served as a monitoring site for the *Temperature Monitoring* project (USFWS, Office of Subsistence Management, Project No. 08-701). An OSM contractor provided the monitoring equipment for installation at the weir site. Two Hobo® Water Temp Pro V2 data loggers and 2 Hobo® Air Temperature R/H data loggers were installed at the beginning of the field season. The water temperature loggers were anchored to the stream bed near mid-channel using a number 68 Duckbill® anchor. The air temperature loggers were installed using a solar shield attached to a small spruce tree approximately 2 meters above ground level and 50 meters from the river. At the end of the field season one water temperature logger and one air temperature logger were removed and the remaining temperature loggers were downloaded using the provided data shuttle and left to continue monitoring temperature. The removed temperature loggers and data shuttle were returned to the contractor for data management and reporting and logger maintenance, calibration, and storage.

Longnose Sucker Genetic Tissue Collection

Dorsal fin clips were collected opportunistically from mature longnose suckers in support of a genetic stock identification study. Takotna River is thought to have a distinct breeding population of longnose suckers that migrates upstream of the weir annually. Sampling occurred during regular ASL sampling events when longnose suckers were trapped, or when living individuals were found on the weir. A portion of the dorsal fin approximately 13 mm long and 6.5 mm wide was clipped from 30 longnose suckers and stored separately in vials containing Ethanol. Sex and total length were also recorded for each individual. Vials and data sheets were mailed to University of Michigan (Peter McIntyre, Principle Investigator, University of Michigan School of Natural Resources & Environment).

RESULTS

WEIR OPERATIONS

The weir was installed and operated from 20 June through 25 September in 2009, spanning the entire target operational period 24 June through 20 September. Passage counts were completed for all but 2 days, 11 and 12 September, when a hole was detected in the weir. Estimates of coho salmon passage missed during these 2 days were generated using the linear method described above. Estimates for any missed Chinook, sockeye, and chum salmon passage were assumed to be zero based on available passage data and run timing indicators for these 2 days.

ESCAPEMENT MONITORING

Chinook Salmon

A total escapement of 311 Chinook salmon was determined to have passed Takotna River weir during the target operational period in 2009. No Chinook salmon were estimated to have passed uncounted during this period, and one additional Chinook salmon was observed prior to the target operational period. The first Chinook salmon was observed on 21 June, daily passage peaked at 40 fish on 14 July, and the last Chinook salmon was observed on 25 August. Based on the target operational period, the median passage date was 14 July and the central 50% of the run occurred from 9 to 23 July (Table 1).

Chum Salmon

A total escapement of 2,487 chum salmon was determined to have passed Takotna River weir during the target operational period in 2009. No chum salmon were estimated to have passed uncounted during this period. An additional 27 chum salmon were observed prior to the target operational period, and 1 after. The first chum salmon was observed on 20 June, the first day of operation. Daily passage peaked at 144 fish on 20 July, and the last chum salmon was observed on 24 September. Based on the target operational period, the median passage date was 21 July and the central 50% of the passage occurred from 13 to 28 July (Table 1).

Coho Salmon

A total escapement of 2,708 coho salmon was determined to have passed Takotna River weir during the target operational period in 2009. Estimates for missed passage accounted for 86 fish, or 3.2% of the total. An additional 23 coho salmon were counted after the target operational period, during 21–25 September. The first coho salmon was observed on 24 July, daily passage peaked at 416 fish on 18 September, and the last coho salmon was observed on 25 September, the last day of operation. Based on the target operational period, the median passage date was 2 September and the central 50% of the run occurred from 22 August to 2 September (Table 1).

Sockeye Salmon

A total escapement of 4 sockeye salmon was determined to have passed Takotna River weir during the target operational period in 2009 (Table 1). No sockeye salmon were estimated to have passed uncounted during this period. The first sockeye salmon was observed on 27 July and the last was observed on 29 August. No sockeye salmon were observed outside the target operational period.

Other Species

It is likely that small individuals such as pink salmon *O. gorbuscha* and non-salmon species may pass freely between weir pickets. Counts of these fish are therefore not considered a census of passage, but are reported here as anecdotal information. In 2009, 1 pink salmon was observed passing upstream of the Takotna River on 24 July (Appendix A1). Other species observed passing upstream of Takotna River weir in 2009 included 988 longnose suckers, 12 northern pike, 2 whitefish *Coregonus* spp. and 1 Arctic grayling *Thymallus arcticus* (Appendix A1). Passage missed during inoperable periods at the weir was not estimated for these species.

Carcass Counts

A total of 114 salmon carcasses were recovered at Takotna River weir in 2009 (Appendix B1). Chum salmon were the most numerous (100), followed by Chinook (10), coho (3), and pink salmon (1). Males comprised 74% of chum and 90% of Chinook salmon carcasses. Non-salmon carcasses consisted of longnose sucker (42), northern pike (3), and whitefish (1).

AGE, SEX, AND LENGTH COMPOSITION

Chinook Salmon

Samples were collected from 137 Chinook salmon between 5 July and 9 August. Of those, age was determined for 104 (76% of the total sample), or 33% of Chinook salmon escapement (Tables 2 and 3). The escapement was partitioned into 3 temporal strata based on sampling dates, with sample sizes of 40, 38, and 26 in the first, second, and third strata, respectively (Table 2). Sample size and distribution resulted in 95% confidence intervals for age composition no wider than ±8% (Table 2).

The sample was composed of 3 age classes. As applied to escapement, age-1.4 was the most abundant age class (41.9%), followed by age-1.3 (29.7%), and -1.2 (28.4%). Females composed 40.7% of the total. Age-1.2 and -1.3 fish were predominately males, while age-1.4 fish were predominately females (Table 2).

Sampled fish ranged between 488 mm and 915 mm in length and sample sizes ranged from 24 to 35 fish among the 3 dominant age-sex categories. Mean lengths of female Chinook salmon were 816 mm at age-1.3, and 847 mm at age-1.4. Mean lengths of male age-1.2, -1.3, and -1.4 fish were 572, 673, and 784 mm, respectively. Female Chinook salmon were consistently larger at age than males (Table 3).

Chum Salmon

Samples were collected from 972 chum salmon between 5 July and 18 August. Of those, age was determined for 948 (98% of the total sample), or 38% of chum salmon escapement (Tables 4 and 5). The escapement was partitioned into 3 temporal strata based on sampling dates, with 313, 216, and 419 samples in each stratum, respectively. Sample size and distribution resulted in 95% confidence intervals for age composition no wider than ±2% (Table 4).

The sample was composed of 4 age classes. As applied to escapement, age-0.3 was the most abundant age class (75.8%), followed by age-0.4 (18.3%), age-0.2 (3.6%), and age-0.5 (2.4%). Females composed 49.4% of the total (Table 4). Sampled fish ranged between 458 mm and 655 mm in length and sample sizes ranged from 78 to 361 fish among the 4 dominant age-sex categories. Mean lengths of female chum salmon were 544 mm at age-0.3, and 547 mm at age-0.4. Mean lengths of male age-0.3 and -0.4 fish were 565 and 573 mm, respectively. Male chum salmon were consistently larger at age than females (Table 5).

Coho Salmon

Samples were collected from 443 coho salmon between 16 August and 5 September. Of those, age was determined for 349 (79% of the total sample), or 13% of annual coho salmon escapement (Tables 6 and 7). The escapement was partitioned into 2 temporal strata based on sampling dates, with 164 and 185 samples in each stratum, respectively (Table 6). Sample size and distribution resulted in 95% confidence intervals for age composition no wider than ±2.8% (Table 4).

The sample was composed of 3 age classes. As applied to escapement, coho salmon were predominately age-2.1 (92.4%), followed by age-1.1 (6.2%), and age-3.1 (1.5%). Females composed 42.6% of the total (Table 6). Sampled fish ranged between 390 mm and 695 mm in length and sample sizes ranged from 2 to185 fish among the 6 age-sex categories (Table 7). Mean lengths of age-2.1 coho salmon were 551 mm for males and 562 mm for females.

WEATHER AND STREAM OBSERVATIONS

A total of 193 complete weather and stream observations were recorded between 21 June and 25 September, 2009 (Appendix C1). Based on twice-daily thermometer observations, water temperature at the weir ranged from 4°C to 21°C, with an average of 13.0°C. A total of 78.9 mm of precipitation was recorded throughout the season. River stage ranged from 35 cm to 75 cm, with an average of 44 cm.

TTC HIGH SCHOOL INTERNSHIP PROGRAM

Four local area high school students participated in the TTC Internship Program in 2009. Interns assisted crew members in daily counting, sampling, and tag recovery efforts throughout the summer. Three interns worked 20 hours per week and a fourth worked as an alternate, to fill in on an as needed basis.

RELATED FISHERIES PROJECTS

Kuskokwim River Coho Salmon Investigations

Takotna River weir crew recaptured 6 coho salmon tagged at the Kalskag project site, which represented all tags visually detected passing the weir in 2009. No coho salmon were examined for adipose fin clips, apart from recaptures. Tag information was recorded and sent to the project investigators postseason.

Temperature Monitoring

Results for temperature monitoring will be reported under USFWS, Office of Subsistence Management, Project No. 08-701.

Longnose Sucker Genetic Tissue Collection

Tissue samples were collected from 30 longnose suckers at Takotna River weir, and mailed to University of Michigan (Peter McIntyre, Principle Investigator, University of Michigan School of Natural Resources & Environment).

DISCUSSION

OPERATIONS

Low water throughout the season contributed to relatively trouble free weir operation in 2009. All project objectives were achieved with only one exception. The Takotna River weir crew was instructed to examine each sampled coho salmon for an adipose fin clip to help determine tag retention for *Kuskokwim River Coho Salmon Investigations*. Because this was a somewhat minor objective at the weir, it was overlooked by the weir crew and went unnoticed by project staff until after the field season. This oversight is expected to have minimal impact for estimating tag retention because coho salmon were inspected for secondary marks at 4 other weir locations.

As in years past, collecting the optimal ASL sample size for Takotna River Chinook salmon was problematic, given the small population. The need to collect samples was weighed against the need to allow efficient passage through the weir. The 2009 sample (n=104) fell slightly below the sample design size (n'=118, N=311) for 10 age-sex categories, however, the sample represented a third of the total population. Therefore, considering that the sample was well distributed, and 95% confidence intervals were within the project objective of ±10%, the objective for precision and accuracy was achieved (Tables 2 and 3).

A sudden increase in passage of coho salmon (416) that occurred 18 September (Table 1) resulted from a change in project operations. The 2009 coho salmon season was characterized by historically low river levels and high water temperatures at Takotna River weir (Figures 3 and 4), factors thought likely to affect spawning migration (Sandercock 1991). By mid September fish became increasingly hesitant to pass through the narrow trap entrance. An accumulation of coho salmon observed for several days below the weir prompted the decision to forgo tag recovery in favor of unimpeded fish passage. An alternate passage gate was employed on 18 September which provided a 2 m wide opening, which facilitated the increased passage observed on that day. Though the alternate passage gate offered no means to capture tagged fish, their occurrence could still be observed and recorded. For the remainder of the season, passage counts were conducted primarily through the wider gate. Counts declined precipitously over the next week following the initial increase (Appendix A1), indicating passage was no longer impeded. The weir was operated 5 days past the end of the target operational period, to ensure that any delayed migration was accounted for and to accommodate the coho salmon tagging project.

ESCAPEMENTS

Salmon escapement has been monitored at Takotna River weir since 2000 (Figures 5, 6, 7). Chinook and chum escapements were determined in 1996 and 97 using a counting tower near the same location.

Chinook Salmon

Escapement in 2009 was the lowest reported at Takotna River weir and was 75% of the historical median (Figure 5). Run timing at the weir was slightly later than the historical median, but similar in duration (Figure 6).

Takotna River Chinook salmon return primarily as age-1.2, -1.3, and -1.4 fish (Figure 7), which is common among Kuskokwim Area stocks (Molyneaux et al. 2009). The strong return of predominantly female age-1.4 fish in 2009 resulted in high female abundance (Figure 8), despite low escapement overall.

Chum Salmon

Escapement in 2009 was below the historical median (Figure 5). Run timing at the weir was later and protracted compared to all other years on record (Figure 6).

Takotna River chum salmon return primarily as age-0.3 and -0.4 fish (Figure 7), which is common among Kuskokwim Area stocks (Molyneaux et al. 2009). Historically, age-0.3 fish have tended to outnumber age-0.4 fish at Takotna River weir, as in 2009.

Coho Salmon

Escapement in 2009 was near the historical median (Figure 5), and run timing at the weir was much later and more protracted than in previous years (Figure 6). Run timing may have been affected by low water combined with tag recovery efforts, as described above.

In 2009, similar to historical observations, Takotna River coho salmon returned almost entirely as age-2.1 (Figure 7). In some years, unusually large numbers of age-1.1 and -3.1 fish may occur.

TTC High School Internship Program

The Takotna River weir has hosted internships for local area high school students annually since 2000. These internships serve to foster student career interest and improve local understanding of fisheries management and research activities. Past interns have been employed as technicians at the weir and taken positions with ADF&G in Bethel and Kuskokwim Native Association in Aniak. The TTC crew leader at the weir in 2009 was a former intern. These internships benefit both students and the weir project. Students gain exposure to fisheries research and management, while the weir project gains a much needed level of community involvement and support. The authors look forward to continued involvement with this program.

ACKNOWLEDGEMENTS

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TABLES AND FIGURES

Table 1.–Daily, cumulative, and cumulative percent passage of Chinook, sockeye, chum, and coho salmon at Takotna River weir, 2009.

Date	Chinook			Sockeye			Chum			Coho		
	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%
6/24	0	0	0	0	0	0	2	2	0	0	0	0
6/25	0	0	0	0	0	0	13	15	1	0	0	0
6/26	2	2	1	0	0	0	30	45	2	0	0	0
6/27	0	2	1	0	0	0	21	66	3	0	0	0
6/28	1	3	1	0	0	0	18	84	3	0	0	0
6/29	1	4	1	0	0	0	28	112	5	0	0	0
6/30	1	5	2	0	0	0	11	123	5	0	0	0
7/1	0	5	2	0	0	0	21	144	6	0	0	0
7/2	2	7	2	0	0	0	19	163	7	0	0	0
7/3	9	16	5	0	0	0	24	187	8	0	0	0
7/4	0	16	5	0	0	0	35	222	9	0	0	0
7/5	4	20	6	0	0	0	28	250	10	0	0	0
7/6	13	33	11	0	0	0	27	277	11	0	0	0
7/7	36	69	22	0	0	0	44	321	13	0	0	0
7/8	6	75	24	0	0	0	43	364	15	0	0	0
7/9	18	93	30	0	0	0	27	391	16	0	0	0
7/10	6	99	32	0	0	0	54	445	18	0	0	0
7/11	22	121	39	0	0	0	76	521	21	0	0	0
7/12	10	131	42	0	0	0	77	598	24	0	0	0
7/13	5	136	44	0	0	0	47	645	26	0	0	0
7/14	40	176	57	0	0	0	79	724	29	0	0	0
7/15	3	179	58	0	0	0	55	779	31	0	0	0
7/16	20	199	64	0	0	0	37	816	33	0	0	0
7/17	7	206	66	0	0	0	56	872	35	0	0	0
7/18	1	207	67	0	0	0	80	952	38	0	0	0
7/19	3	210	68	0	0	0	99	1,051	42	0	0	0
7/20	1	211	68	0	0	0	144	1,195	48	0	0	0
7/21	19	230	74	0	0	0	96	1,291	52	0	0	0
7/22	3	233	75	0	0	0	98	1,389	56	0	0	0
7/23	6	239	77	0	0	0	116	1,505	61	0	0	0
7/24	17	256	82	0	0	0	109	1,614	65	1	1	0
7/25	1	257	83	0	0	0	43	1,657	67	0	1	0
7/26	0	257	83	0	0	0	91	1,748	70	0	1	0
7/27	7	264	85	1	1	25	75	1,823	73	1	2	0
7/28	1	265	85	0	1	25	72	1,895	76	0	2	0
7/29	14	279	90	0	1	25	100	1,995	80	0	2	0
7/30	6	285	92	0	1	25	81	2,076	83	0	2	0
7/31	8	293	94	0	1	25	112	2,188	88	0	2	0
8/1	2	295	95	0	1	25	44	2,232	90	1	3	0
8/2	1	296	95	0	1	25	14	2,246	90	0	3	0
8/3	6	302	97	1	2	50	26	2,272	91	0	3	0
8/4	2	304	98	0	2	50	53	2,325	93	1	4	0
8/5	0	304	98	1	3	75	28	2,353	95	2	6	0
8/6	0	304	98	0	3	75	33	2,386	96	8	14	1
8/7	0	304	98	0	3	75	31	2,417	97	8	22	1
8/8	1	305	98	0	3	75	15	2,432	98	11	33	1
8/9	2	307	99	0	3	75	12	2,444	98	23	56	2

-continued-

Table 1.–Page 2 of 2.

Date	Chinook			Sockeye			Chum			Coho		
	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%
8/10	0	307	99	0	3	75	6	2,450	99	18	74	3
8/11	1	308	99	0	3	75	2	2,452	99	15	89	3
8/12	0	308	99	0	3	75	5	2,457	99	36	125	5
8/13	0	308	99	0	3	75	4	2,461	99	17	142	5
8/14	1	309	99	0	3	75	0	2,461	99	63	205	8
8/15	0	309	99	0	3	75	4	2,465	99	75	280	10
8/16	0	309	99	0	3	75	3	2,468	99	87	367	14
8/17	0	309	99	0	3	75	3	2,471	99	91	458	17
8/18	0	309	99	0	3	75	2	2,473	99	41	499	18
8/19	0	309	99	0	3	75	0	2,473	99	44	543	20
8/20	0	309	99	0	3	75	1	2,474	99	54	597	22
8/21	0	309	99	0	3	75	4	2,478	100	32	629	23
8/22	0	309	99	0	3	75	0	2,478	100	45	674	25
8/23	1	310	100	0	3	75	1	2,479	100	38	712	26
8/24	0	310	100	0	3	75	1	2,480	100	67	779	29
8/25	1	311	100	0	3	75	1	2,481	100	19	798	29
8/26	0	311	100	0	3	75	0	2,481	100	16	814	30
8/27	0	311	100	0	3	75	1	2,482	100	116	930	34
8/28	0	311	100	0	3	75	0	2,482	100	20	950	35
8/29	0	311	100	1	4	100	1	2,483	100	111	1,061	39
8/30	0	311	100	0	4	100	1	2,484	100	59	1,120	41
8/31	0	311	100	0	4	100	0	2,484	100	14	1,134	42
9/1	0	311	100	0	4	100	0	2,484	100	64	1,198	44
9/2	0	311	100	0	4	100	1	2,485	100	158	1,356	50
9/3	0	311	100	0	4	100	0	2,485	100	281	1,637	60
9/4	0	311	100	0	4	100	1	2,486	100	100	1,737	64
9/5	0	311	100	0	4	100	0	2,486	100	50	1,787	66
9/6	0	311	100	0	4	100	0	2,486	100	50	1,837	68
9/7	0	311	100	0	4	100	0	2,486	100	23	1,860	69
9/8	0	311	100	0	4	100	0	2,486	100	22	1,882	70
9/9	0	311	100	0	4	100	0	2,486	100	11	1,893	70
9/10	0	311	100	0	4	100	0	2,486	100	44	1,937	72
9/11	0 [a]	311 [a]	100	0 [a]	4 [a]	100	1 [a]	2,487 [a]	100	41 [a]	1,978 [a]	73
9/12	0 [a]	311 [a]	100	0 [a]	4 [a]	100	0 [a]	2,487 [a]	100	54 [a]	2,032 [a]	75
9/13	0	311	100	0	4	100	0	2,487	100	94	2,126	79
9/14	0	311	100	0	4	100	0	2,487	100	40	2,166	80
9/15	0	311	100	0	4	100	0	2,487	100	36	2,202	81
9/16	0	311	100	0	4	100	0	2,487	100	22	2,224	82
9/17	0	311	100	0	4	100	0	2,487	100	10	2,234	82
9/18	0	311	100	0	4	100	0	2,487	100	416	2,650	98
9/19	0	311	100	0	4	100	0	2,487	100	25	2,675	99
9/20	0	311	100	0	4	100	0	2,487	100	33	2,708	100

[a] Partial day count. Passage was estimated.

Table 2.–Age and sex composition of Chinook salmon at Takotna River weir in 2009 based on escapement samples collected with a live trap.

			Age Class																	
Sample Dates	Sample		1.1		1.2		2.2		1.3		1.4		2.3		1.5		2.4		Total	
(Stratum Dates)	Size	Sex	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%
7/5–7, 10, 11	40	M	0	0.0	45	37.5	0	0.0	36	30.0	6	5.0	0	0.0	0	0.0	0	0.0	88	72.5
(6/24–7/11)		F	0	0.0	0	0.0	0	0.0	0	0.0	33	27.5	0	0.0	0	0.0	0	0.0	33	27.5
		Subtotal[a]	0	0.0	45	37.5	0	0.0	36	30.0	39	32.5	0	0.0	0	0.0	0	0.0	121	100.0
7/12–14, 16, 19	38	M	0	0.0	24	28.2	0	0.0	11	12.8	6	7.7	0	0.0	0	0.0	0	0.0	42	48.7
(7/12–7/18)		F	0	0.0	0	0.0	0	0.0	15	18.0	29	33.3	0	0.0	0	0.0	0	0.0	44	51.3
		Subtotal[a]	0	0.0	24	28.2	0	0.0	26	30.8	35	41.0	0	0.0	0	0.0	0	0.0	86	100.0
7/19–22, 27,	26	M	0	0.0	11	10.7	0	0.0	26	25.0	15	14.3	0	0.0	0	0.0	0	0.0	52	50.0
8/2–4, 9		F	0	0.0	8	7.2	0	0.0	4	3.6	41	39.3	0	0.0	0	0.0	0	0.0	52	50.0
(7/19–9/20)		Subtotal[a]	0	0.0	19	17.9	0	0.0	30	28.6	56	53.6	0	0.0	0	0.0	0	0.0	104	100.0
Season[b]	104	M	0	0.0	81	26.0	0	0.0	73	23.6	27	8.8	0	0.0	0	0.0	0	0.0	182	58.4
		F	0	0.0	7	2.4	0	0.0	19	6.1	103	33.1	0	0.0	0	0.0	0	0.0	129	41.6
		Total	0	0.0	88	28.4	0	0.0	92	29.7	130	41.9	0	0.0	0	0.0	0	0.0	311	100.0
		95% C.I. (%)				(±7.2)				(±7.5)		(±8.0)								-

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

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

Table 3.–Mean length (mm) of Chinook salmon at Takotna River weir in 2009 based on escapement samples collected with a live trap.

Sample Dates (Stratum Dates)	Sex		Age Class 1.2	1.3	1.4	2.3	1.5
7/5–7/7, 7/10	M	Mean Length	566	674	827		
(6/24–7/10)		SE	10	18	25		
		Range	503-635	568-810	802-852		
		Sample Size	15	12	2		
	F	Mean Length			860		
		SE			12		
		Range			793-915		
		Sample Size	0	0	11		
7/11–7/19	M	Mean Length	578	656	727		
(7/11–7/19)		SE	13	19	71		
		Range	488-632	615-720	656- 97		
		Sample Size	11	5	2		
	F	Mean Length		822	824		
		SE		22	14		
		Range		745-911	725-879		
		Sample Size	0	7	13		
7/20–8/9	M	Mean Length	588	680	786		
(7/20–9/20)		SE	22	20	18		
		Range	556-629	567-732	738-822		
		Sample Size	3	7	4		
	F	Mean Length	580	794	853		
		SE	-	-	11		
		Range	580-580	794-794	805-913		
		Sample Size	1	1	11		
Season[a]	M	Mean Length	572	673	781		
		SE[b]	6	10	13		
		Range	488-635	567-810	656-852		
		Sample Size	29	24	8		
	F	Mean Length	580	816	847		
		SE[b]	-	-	6		
		Range	580-580	745-911	725–915		
		Sample Size	1	8	35		

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

[b] Standard error was not calculated for small sample sizes.

Table 4.–Age and sex composition of chum salmon at Takotna River weir in 2009 based on escapement samples collected with a live trap.

Sample Dates (Stratum Dates)	Sample Size	Sex	0.2 Esc.	0.2 %	0.3 Esc.	0.3 %	0.4 Esc.	0.4 %	0.5 Esc.	0.5 %	Total Esc.	Total %
7/5–7/14	313	M	8	0.9	240	29.4	123	15.0	32	3.8	401	49.2
(6/24–7/16)		F	10	1.3	281	34.5	104	12.8	18	2.3	415	50.8
		Subtotal[a]	18	2.2	521	63.9	227	27.8	50	6.1	816	100.0
7/18–7/22	216	M	16	1.8	339	40.3	47	5.6	4	0.5	405	48.1
(7/17–7/25)		F	23	2.8	350	41.6	58	6.9	4	0.4	436	51.9
		Subtotal[a]	39	4.6	689	81.9	105	12.5	8	0.9	841	100.0
7/26–8/18	419	M	14	1.7	361	43.4	77	9.3	0	0.0	452	54.4
(7/26–9/20)		F	18	2.1	313	37.7	46	5.5	2	0.2	378	45.6
		Subtotal[a]	32	3.8	674	81.1	123	14.8	2	0.2	830	100.0
Season[b]	948	M	37	1.5	939	37.8	247	9.9	35	1.4	1,258	50.6
		F	52	2.1	945	38.0	208	8.4	24	1.0	1,229	49.4
		Total	89	3.6	1,884	75.8	455	18.3	59	2.4	2,487	100.0
		95% C.I. (%)		(±1.0)		(±2.2)		(±2.0)		(±0.8)		-

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

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

Table 5.–Mean length (mm) of chum salmon at Takotna River weir in 2009 based on escapement samples collected with a live trap.

Sample Dates (Stratum Dates)	Sex		Age Class 0.2	0.3	0.4	0.5
7/5–7/14 (6/24–7/16)	M	Mean Length	566	563	569	575
		SE	15	3	5	7
		Range	541-594	506-624	498-634	539-625
		Sample Size	3	92	47	12
	F	Mean Length	547	541	546	547
		SE	12	2	4	10
		Range	514-568	485-626	502-597	501-580
		Sample Size	4	108	40	7
7/18–7/22 (7/17–7/25)	M	Mean Length	549	569	578	612
		SE	15	3	9	-
		Range	519-587	487-633	517-626	612-612
		Sample Size	4	87	12	1
	F	Mean Length	533	547	548	583
		SE	10	3	5	-
		Range	492-563	491-631	521-585	583-583
		Sample Size	6	90	15	1
7/26–8/18 (7/26–9/20)	M	Mean Length	543	563	576	
		SE	11	2	5	
		Range	516-593	489-641	525-655	
		Sample Size	7	182	39	0
	F	Mean Length	525	542	547	562
		SE	9	2	4	-
		Range	497-572	458-619	514-579	562-562
		Sample Size	9	158	23	1
Season[a]	M	Mean Length	550	565	573	579
		SE[b]	-	1	3	-
		Range	516-594	487-641	498-655	539-625
		Sample Size	14	361	98	13
	F	Mean Length	533	544	547	554
		SE[b]	-	1	2	-
		Range	492-572	458-631	502-597	501-583
		Sample Size	19	356	78	9

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

[b] Standard error was not calculated for small sample sizes.

Table 6.–Age and sex composition of coho salmon at Takotna River weir in 2009 based on escapement samples collected with a live trap.

Sample Dates (Stratum Dates)	Sample Size	Sex	1.1 Esc.	1.1 %	2.1 Esc.	2.1 %	3.1 Esc.	3.1 %	Total Esc.	Total %
8/16–21	164	M	23	2.4	527	56.7	6	0.6	556	59.8
(6/24–8/27)		F	0	0.0	369	39.6	5	0.6	374	40.2
		Subtotal[a]	23	2.4	896	96.3	11	1.2	930	100.0
8/30–9/5	185	M	96	5.4	884	49.7	19	1.1	1,000	56.2
(8/28–9/20)		F	48	2.7	721	40.6	10	0.5	778	43.8
		Subtotal[a]	144	8.1	1,605	90.3	29	1.6	1,778	100.0
Season[b]	349	M	119	4.4	1,412	52.1	25	0.9	1,555	57.4
		F	48	1.8	1,089	40.3	15	0.6	1,153	42.6
		Total	167	6.2	2,501	92.4	40	1.5	2,708	100.0
		95% C.I. (%)		(±2.6)		(±2.8)		(±1.2)		-

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

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

Table 7.–Mean length (mm) of coho salmon at Takotna River weir in 2009 based on escapement samples collected with a live trap.

Sample Dates (Stratum Dates)	Sex		Age Class 1.1	2.1	3.1
8/16–21	M	Mean Length	526	554	483
(6/24–8/27)		Std. Error	28	5	-
		Range	475-606	453-695	483-483
		Sample Size	4	93	1
	F	Mean Length		555	553
		Std. Error		4	-
		Range		390-599	553-553
		Sample Size	0	65	1
8/30–9/5	M	Mean Length	500	550	577
(8/28–9/20)		Std. Error	12	4	9
		Range	423-570	412-635	568-586
		Sample Size	10	92	2
	F	Mean Length	528	566	573
		Std. Error	16	3	-
		Range	480-575	486-624	573-573
		Sample Size	5	75	1
Season[a]	M	Mean Length	505	551	556
		Std. Error	-	3	-
		Range	423-606	412-695	483-586
		Sample Size	14	185	3
	F	Mean Length	528	562	566
		Std. Error	-	2	-
		Range	480-575	390-624	553-573
		Sample Size	5	140	2

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

[b] Standard error was not calculated for small sample sizes.

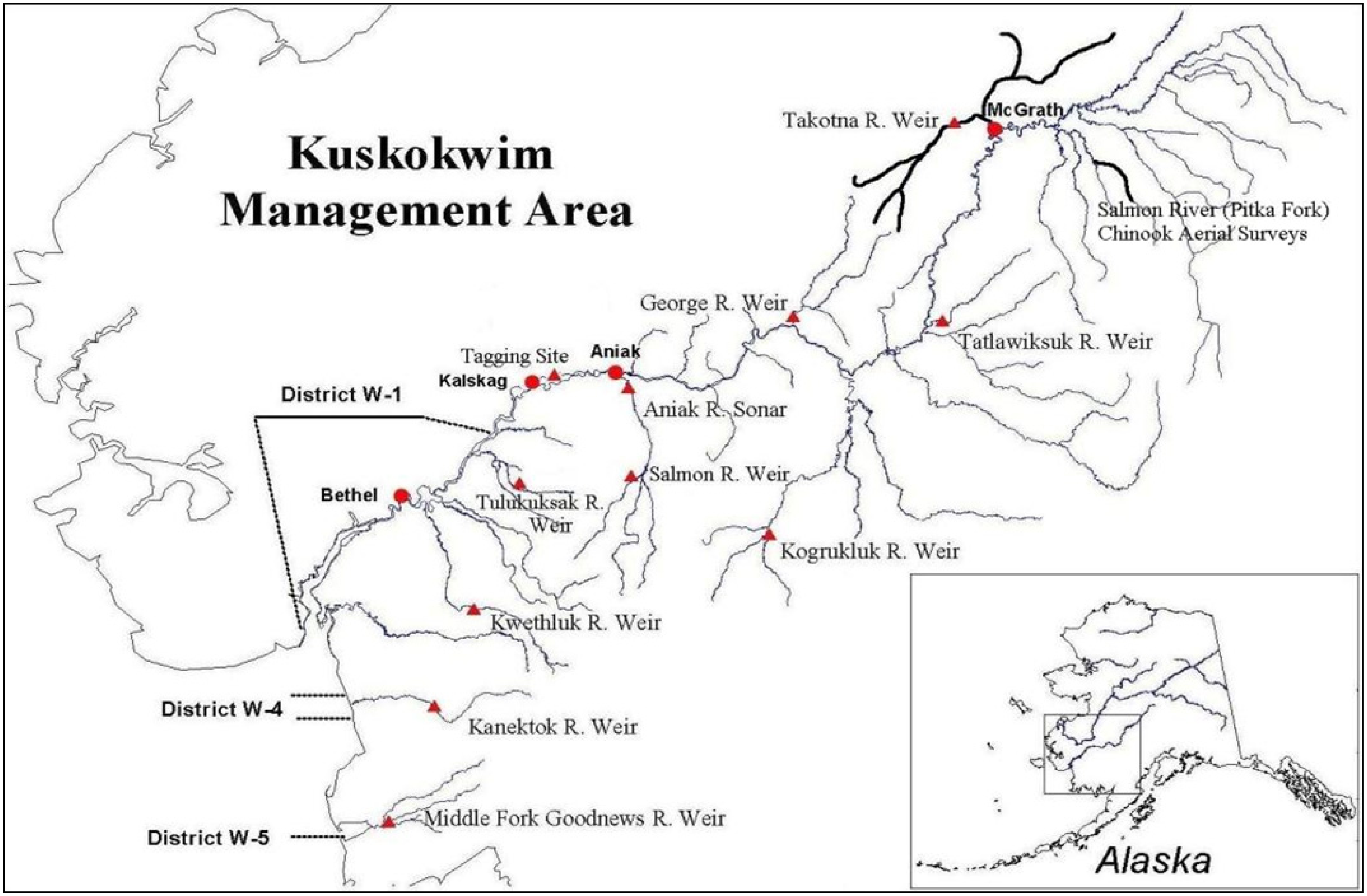


Figure 1.–Kuskokwim Area salmon management districts and escapement monitoring projects with emphasis on the Takotna River.

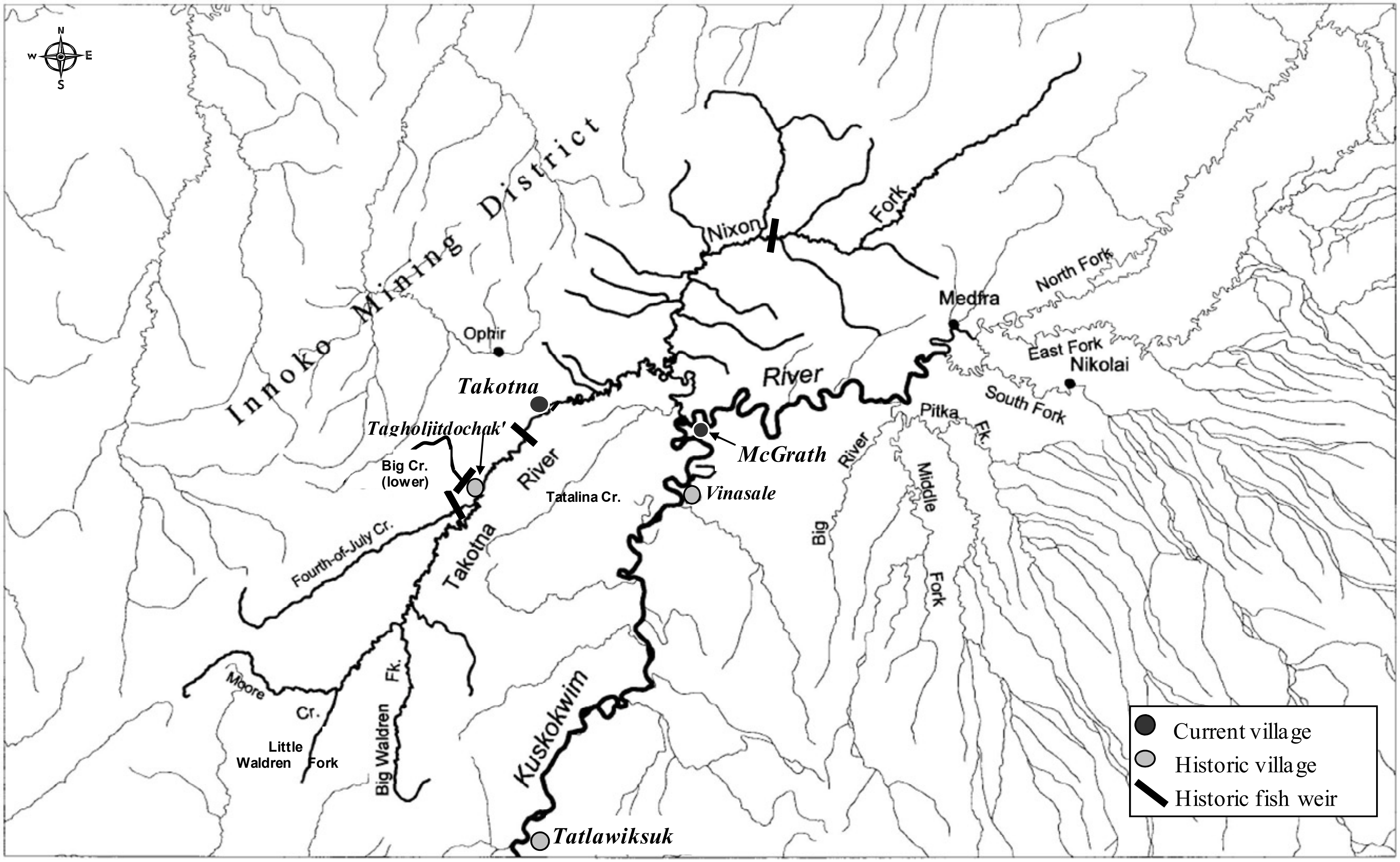


Figure 2.–Takotna River drainage and location of historic native communities and fish weirs.

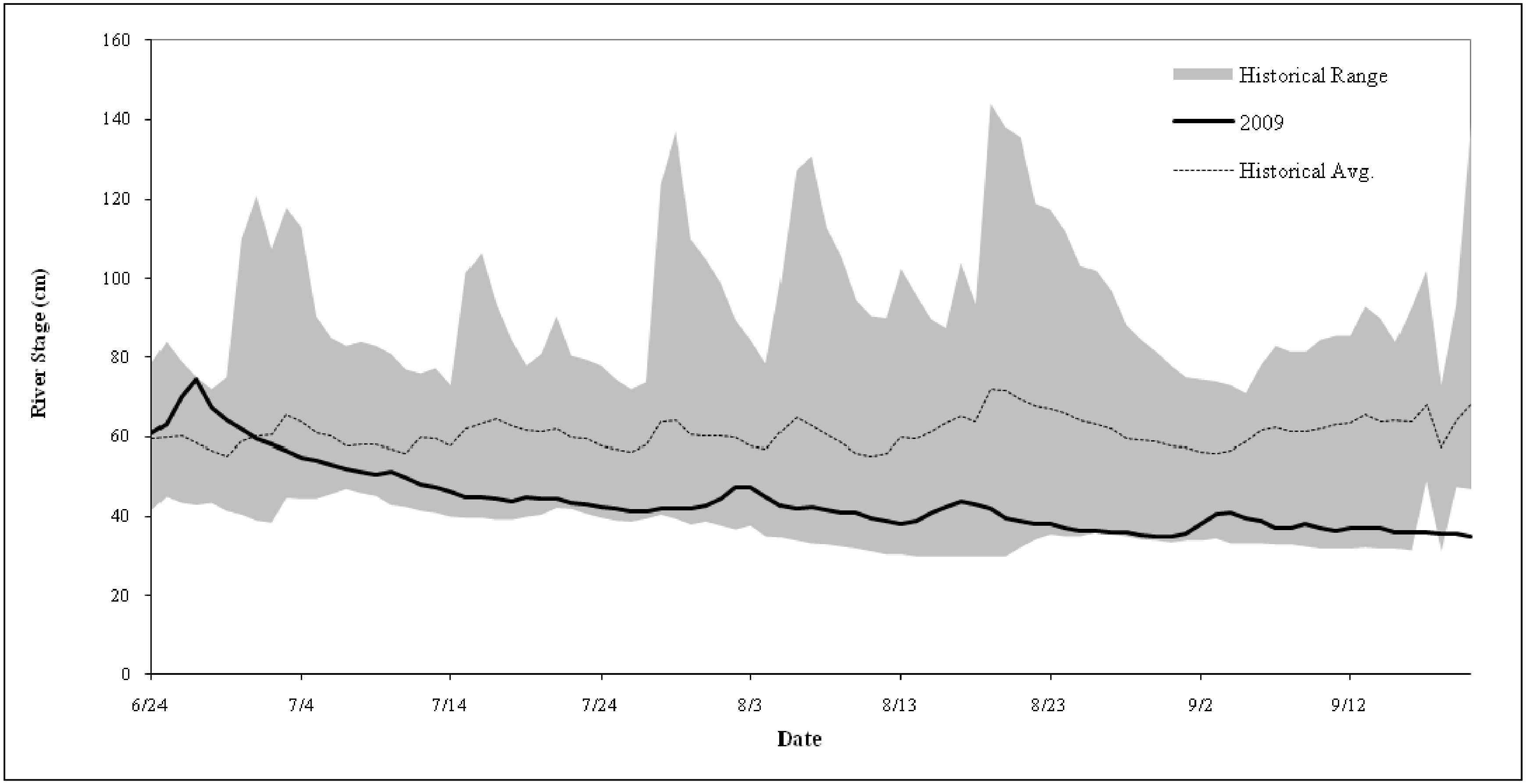


Figure 3.–Daily water level at the Takotna River weir in 2009 relative to its historical average and range since 2000.

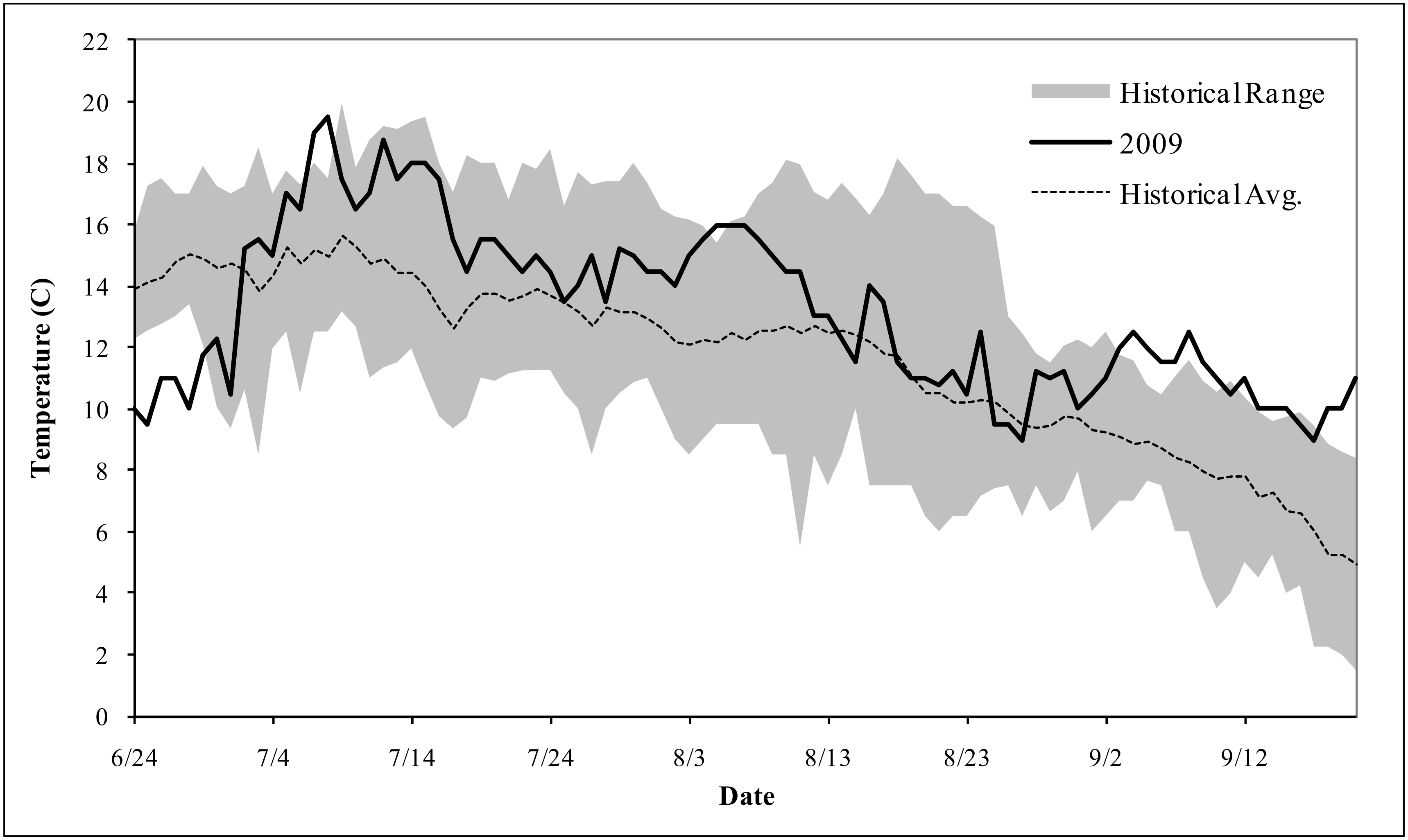


Figure 4.–Daily water temperature at Takotna River weir in 2009 relative to its historical average and range since 2000.

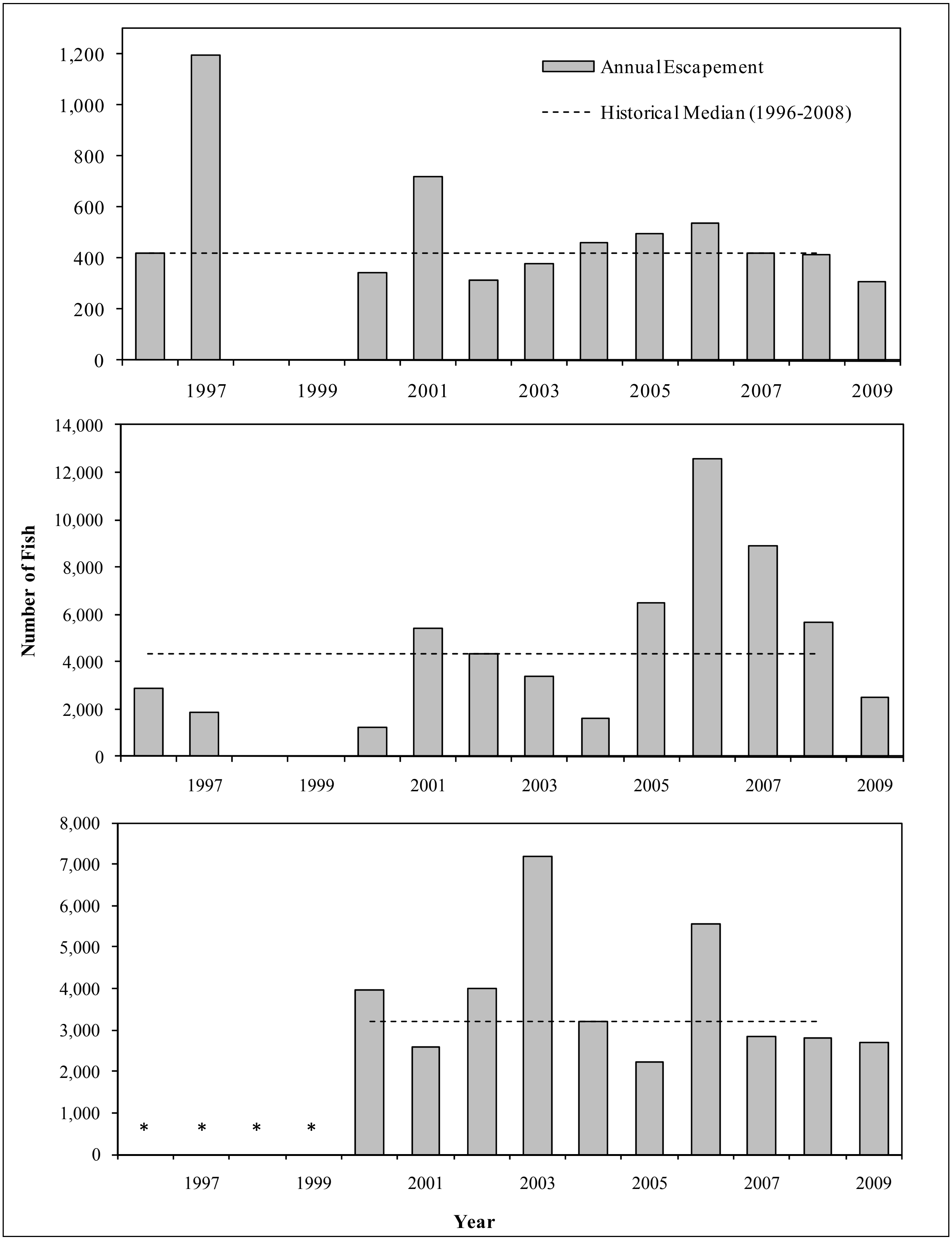
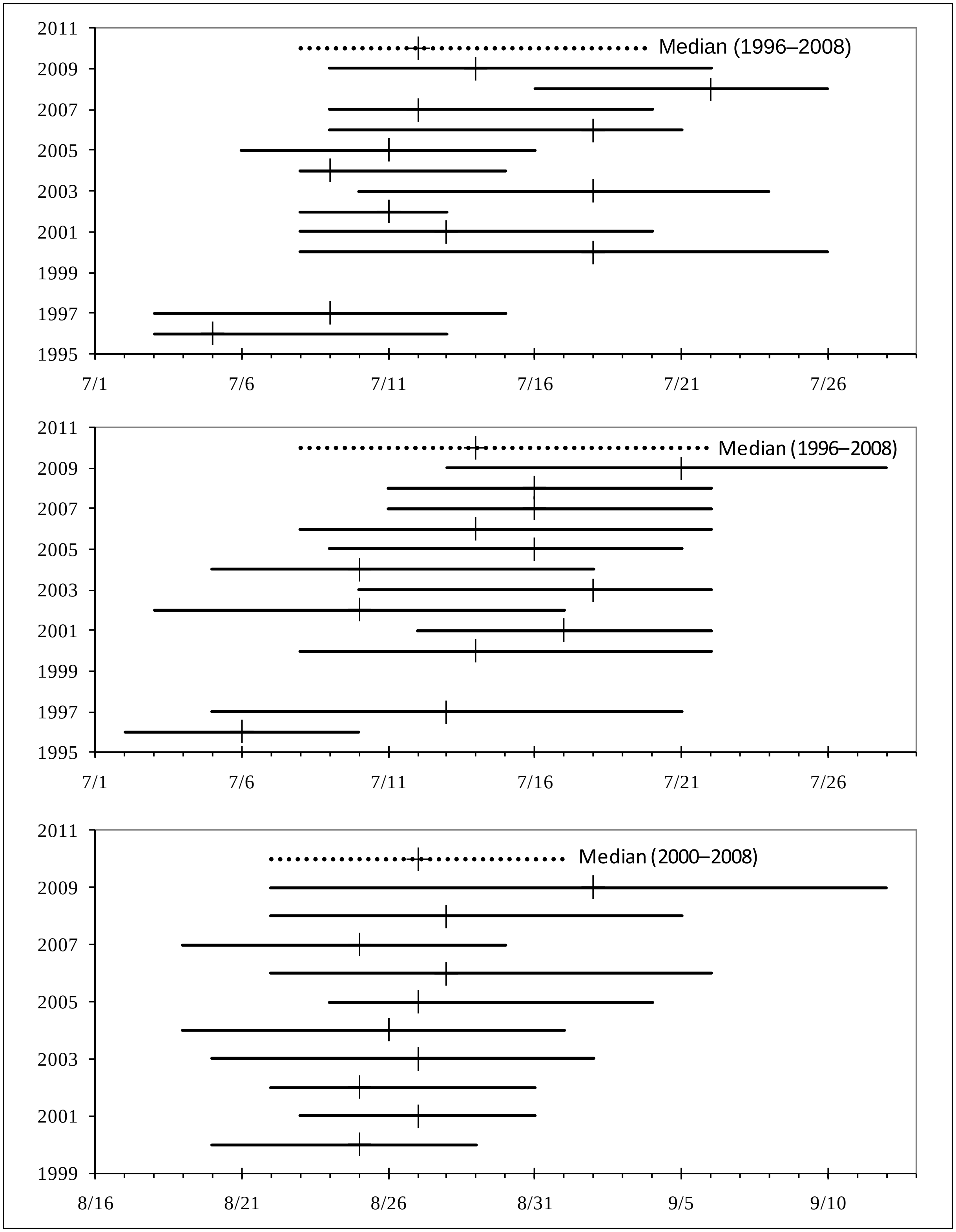
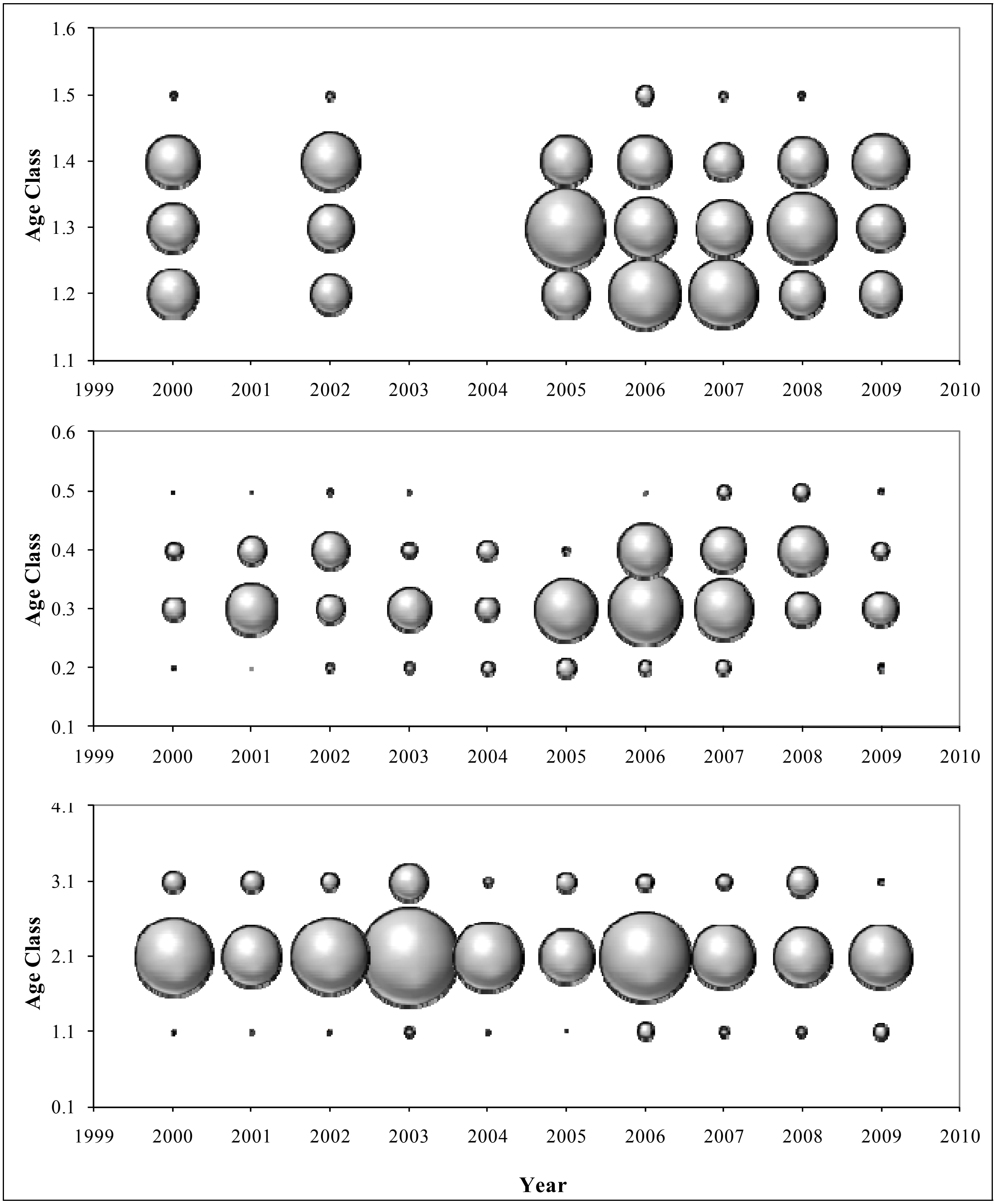


Figure 5.–Historical annual Chinook, chum, and coho escapements at Takotna River weir.



Note: Solid lines represent the dates when the central fifty percent of the run passed and cross-bars represent the median passage date.

Figure 6.–Annual run timing of Chinook, chum, and coho salmon based on cumulative percent passage at the Takotna River weir, 1996–2009.



Note: Size of bubbles is relative to abundance within each species plot, but not across plots. Years when sample objectives were not achieved contain no data plots.

Figure 7.–Relative age-class abundance in annual Chinook, chum, and coho salmon escapements at Takotna River weir.

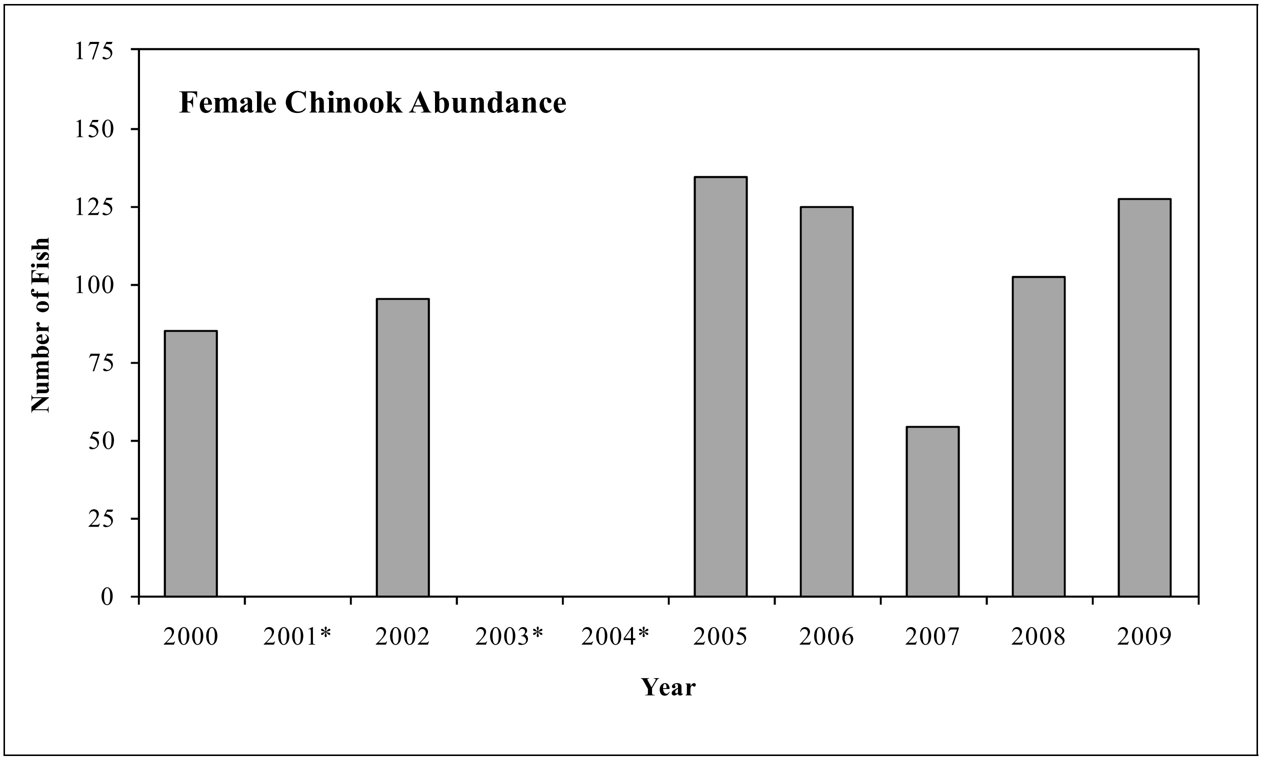


Figure 8.–Historical abundance of female Chinook salmon at Takotna River weir.

APPENDIX A: DAILY FISH PASSAGE COUNTS

Appendix A1.–Daily fish passage counts at Takotna River weir in 2009.

Date	Chinook Salmon		Sockeye Salmon		Chum Salmon		Coho Salmon		Longnose
	Male	Female	Male	Female	Male	Female	Male	Female	Suckers
6/20	0	0	0	0	6	0	0	0	134
6/21	1	0	0	0	6	2	0	0	74
6/22	0	0	0	0	4	4	0	0	112
6/23	0	0	0	0	2	3	0	0	76
6/24	0	0	0	0	2	0	0	0	25
6/25	0	0	0	0	12	1	0	0	6
6/26	1	1	0	0	23	7	0	0	14
6/27	0	0	0	0	12	9	0	0	78
6/28	1	0	0	0	14	4	0	0	12
6/29	1	0	0	0	17	11	0	0	4
6/30	0	1	0	0	9	2	0	0	1
7/1	0	0	0	0	11	10	0	0	57
7/2	2	0	0	0	11	8	0	0	89
7/3	8	1	0	0	15	9	0	0	83
7/4	0	0	0	0	14	21	0	0	65
7/5	4	0	0	0	17	11	0	0	55
7/6	13	0	0	0	13	14	0	0	16
7/7	21	15	0	0	24	20	0	0	4
7/8	5	1	0	0	16	27	0	0	23
7/9	12	6	0	0	14	13	0	0	2
7/10	5	1	0	0	29	25	0	0	6
7/11	12	10	0	0	37	39	0	0	2
7/12	5	5	0	0	33	44	0	0	14
7/13	3	2	0	0	26	21	0	0	6
7/14	27	13	0	0	31	48	0	0	4
7/15	2	1	0	0	31	24	0	0	3
7/16	9	11	0	0	16	21	0	0	5
7/17	6	1	0	0	34	22	0	0	5
7/18	1	0	0	0	41	39	0	0	0
7/19	2	1	0	0	50	49	0	0	0
7/20	1	0	0	0	64	80	0	0	4
7/21	9	10	0	0	32	64	0	0	2
7/22	2	1	0	0	48	50	0	0	1
7/23	2	4	0	0	57	59	0	0	0
7/24	12	5	0	0	56	53	0	0	1
7/25	1	0	0	0	25	18	0	0	0
7/26	0	0	0	0	47	44	0	0	1
7/27	3	4	1	0	38	37	0	0	1
7/28	1	0	0	0	35	37	0	0	1
7/29	6	8	0	0	48	52	0	0	0
7/30	6	0	0	0	40	41	0	0	1
7/31	5	3	0	0	59	53	0	0	0
8/1	0	2	0	0	18	26	1	0	0
8/2	0	1	0	0	9	5	0	0	0
8/3	4	2	0	1	18	8	0	0	0
8/4	1	1	0	0	32	21	1	0	0
8/5	0	0	1	0	13	15	1	1	0
8/6	0	0	0	0	24	9	2	6	0
8/7	0	0	0	0	18	13	3	5	0
8/8	0	1	0	0	8	7	7	4	0
8/9	1	1	0	0	7	5	16	7	0

APPENDIX B: DAILY FISH CARCASS COUNTS

Appendix B1.–Daily fish carcass counts at Takotna River weir in 2009.

	Chinook Salmon		Chum Salmon		Coho Salmon		Longnose		
Date	Male	Female	Male	Female	Male	Female	Suckers	Other[a]	Comments
6/20							1		
6/21							2		
6/22									
6/23									
6/24									
6/25									
6/26									
6/27			1	1			10		
6/28									
6/29			2						
6/30			1						
7/1							4		
7/2									
7/3				1					
7/4									
7/5			2	1					
7/6			2						
7/7			1						
7/8	1		2						
7/9			3						
7/10			5	1					
7/11								2NP	
7/12									
7/13									
7/14			4	3					
7/15									
7/16		1							
7/17									
7/18									
7/19									
7/20			2	1					
7/21									
7/22									
7/23									
7/24			2				1		
7/25			6	1					
7/26			1					1PS	male
7/27			1	1					
7/28			8	2			2		
7/29									
7/30			3				1		
7/31									
8/1			1						
8/2			4	3			2		
8/3			2						
8/4			1						
8/5			4	2					
8/6	1		1	1					
8/7							2		
8/8			3	1					
8/9			3	1					
8/10				3			2		
8/11	1						1		

APPENDIX C: DAILY WEATHER AND STREAM OBSERVATIONS

Appendix C1.–Daily weather and stream observations at Takotna River weir, 2009.

Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River Stage (cm)	Water Clarity[b]
6/21	17:00	3	0.0	20	11	64	1
6/22	8:00	3	0.0	11	11	63	1
	17:00	4	0.0	16	12	63	1
6/23	8:00	4	0.0	9	10	62	1
	17:00	3	0.0	13	10	62	1
6/24	8:00	3	0.0	9	10	60	1
	17:00	4	0.0	9	10	62	1
6/25	8:00	4	10.0	8	9	63	1
	17:00	4	1.0	13	10	63	1
6/26	8:00	1	0.0	11	10	70	2
	17:00	3	0.0	18	12	70	2
6/27	8:00	1	0.0	8	9	75	3
	17:00	3	0.0	15	13	74	3
6/28	8:00	4	0.0	8	9	68	3
	17:00	3	0.0	17	11	67	3
6/29	8:00	4	0.0	8	11	65	2
	17:00	2	0.0	23	13	63	2
6/30	8:00	2	0.0	10	11	62	1
	17:00	2	0.0	23	14	62	1
7/1	8:00	1	0.0	10	11	60	1
	17:00	1	0.0	31	11	59	1
7/2	8:00	1	0.0	12	13	58	1
	17:00	1	0.0	30	18	58	1
7/3	8:00	1	0.0	17	14	57	1
	17:00	1	0.0	26	17	56	1
7/4	8:00	1	0.0	15	15	55	1
	17:00	1	0.0	25	15	55	1
7/5	8:00	1	0.0	4	16	54	1
	17:00	3	0.0	25	18	54	1
7/6	8:00	2	0.0	15	15	53	1
	17:00	2	0.0	29	18	53	1
7/7	8:00	2	0.0	16	18	52	1
	17:00	1	0.0	28	20	52	1
7/8	8:00	4	0.2	18	18	51	1
	17:00	4	6.0	13	21	52	1
7/9	8:00	2	0.5	11	16	51	1
	17:00	2	0.0	18	19	50	1
7/10	8:00	1	0.0	9	15	52	1
	17:00	1	0.0	25	18	52	1
7/11	8:00	1	0.0	11	14	50	1
	17:00	1	0.0	27	20	50	1
7/12	8:00	1	0.0	15	18	49	1
	17:00	1	0.0	28	20	47	1
7/13	8:00	1	0.0	14	17	48	1
	17:00	2	0.0	24	18	47	1
7/14	8:00	3	0.0	17	18	47	1
	17:00	3	0.0	22	18	46	1
7/15	8:00	3	0.0	15	18	45	1
	17:00	4	0.0	19	18	45	1
7/16	8:00	4	0.0	14	16	45	1
	17:00	4	0.0	20	19	45	1

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Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C)		River Stage (cm)	Water Clarity[b]
				Air	Water		
7/17	8:00	4	0.0	11	13	45	1
	17:00	4	0.0	17	18	45	1
7/18	8:00	4	1.0	12	14	44	1
	17:00	4	0.0	18	15	44	1
7/19	8:00	4	7.0	12	16	45	1
	17:00	4	0.0	17	15	45	1
7/20	8:00	2	0.0	12	14	45	1
	17:00	3	0.0	22	17	45	1
7/21	8:00	1	1.0	12	14	45	1
	17:00	4	0.0	20	16	45	1
7/22	8:00	2	0.0	14	14	44	1
	17:00	2	0.0	18	15	43	1
7/23	8:00	1	0.0	11	14	43	1
	17:00	2	0.0	17	16	43	1
7/24	8:00	3	0.0	10	14	43	1
	17:00	3	0.0	16	15	42	1
7/25	8:00	4	0.0	9	13	42	1
	17:00	4	0.0	20	14	42	1
7/26	8:00	4	0.5	11	13	42	1
	17:00	4	0.0	17	15	42	1
7/27	8:00	1	0.0	11	15	42	1
	17:00	3	0.0	18	15	42	1
7/28	8:00	1	3.0	13	13	42	1
	17:00	3	0.0	19	14	42	1
7/29	8:00	3	1.0	15	15	42	1
	17:00	3	0.0	19	16	42	1
7/30	8:00	2	0.3	10	13	42	1
	17:00	4	0.0	19	17	42	1
7/31	8:00	3	7.0	10	15	43	1
	17:00	3	0.0	13	14	43	1
8/1	8:00	5	0.5	5	12	44	1
	17:00	3	0.0	14	17	45	1
8/2	8:00	1	0.0	8	12	47	1
	17:00	4	0.0	11	16	48	1
8/3	8:00	3	0.0	11	13	48	1
	17:00	1	0.0	22	17	47	1
8/4	8:00	0	0.0	11	15	45	1
	17:00	4	0.0	22	16	45	1
8/5	8:00	3	0.0	14	15	43	1
	17:00	4	0.0	18	17	43	1
8/6	8:00	4	0.0	13	16	42	1
	17:00	3	0.0	18	16	42	1
8/7	8:00	4	0.1	13	15	43	1
	17:00	3	0.0	20	17	43	1
8/8	8:00	4	0.0	13	15	42	1
	17:00	1	0.0	18	16	42	1
8/9	8:00	2	0.0	14	14	41	1
	17:00	1	0.0	20	16	41	1
8/10	8:00	1	0.0	5	13	41	1
	17:00	1	0.0	19	16	41	1

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Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C) Air	Temperature (°C) Water	River Stage (cm)	Water Clarity[b]
8/11	8:00	1	0.0	5	13	40	1
	17:00	1	0.0	20	16	40	1
8/12	8:00	1	0.0	8	12	39	1
	17:00	1	0.0	16	14	39	1
8/13	8:00	4	2.0	9	13	38	1
	17:00	4	1.0	11	13	38	1
8/14	8:00	5	2.0	11	11	39	1
	17:00	3	0.0	14	14	39	1
8/15	8:00	4	0.0	11	10	40	1
	17:00	4	4.0	15	13	42	1
8/16	8:00	2	0.0	9	13	42	1
	17:00	1	0.0	19	15	43	1
8/17	8:00	1	0.0	2	12	44	1
	17:00	1	0.0	20	15	44	1
8/18	8:00	4	0.0	10	11	43	1
	17:00	4	0.5	11	12	43	1
8/19	8:00	1	0.6	2	10	42	1
	17:00	2	0.0	15	12	42	1
8/20	8:00	1	0.0	0	10	40	1
	17:00	1	0.0	17	12	40	1
8/21	8:00	5	0.0	4	11	39	1
	17:00	4	0.0	15	11	39	1
8/22	8:00	4	0.0	8	11	38	1
	17:00	4	0.0	14	12	38	1
8/23	8:00	3	0.2	14	10	38	1
	17:00	4	0.5	9	11	38	1
8/24	8:00	3	0.5	5	10	37	1
	17:00	3	0.0	12	15	37	1
8/25	8:00	1	0.0	-1	8	37	1
	17:00	2	0.0	14	11	36	1
8/26	8:00	1	0.0	0	7	37	1
	17:00	1	0.0	15	12	36	1
8/27	8:00	1	0.0	2	8	36	1
	17:00	1	0.0	20	10	36	1
8/28	8:00	1	0.0	4	10	36	1
	17:00	1	0.0	19	13	36	1
8/29	8:00	1	0.0	4	9	36	1
	17:00	1	0.0	11	13	35	1
8/30	8:00	4	0.0	10	11	35	1
	17:00	4	0.0	12	12	35	1
8/31	8:00	4	0.0	10	10	35	1
	17:00	4	1.0	10	10	35	1
9/1	8:00	4	1.0	9	10	36	1
	17:00	4	5.0	10	11	36	1
9/2	8:00	5	0.0	8	9	37	1
	17:00	4	5.0	14	13	39	1
9/3	8:00	4	0.2	7	12	41	1
	17:00	1	0.0	20	12	41	1
9/4	8:00	1	0.0	9	12	41	1
	17:00	1	0.0	22	13	41	1

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Date	Time	Sky Conditions[a]	Precipitation (mm)	Temperature (°C) Air	Water	River Stage (cm)	Water Clarity[b]
9/5	8:00	1	0.0	5	11	40	1
	17:00	1	0.0	23	13	40	1
9/6	8:00	1	0.0	17	10	39	1
	17:00	1	0.0	19	13	39	1
9/7	8:00	4	0.0	8	10	37	1
	17:00	3	0.0	18	13	37	1
9/8	8:00	5	0.0	11	10	37	1
	17:00	1	0.0	18	15	37	1
9/9	8:00	4	0.0	11	10	38	1
	17:00	4	0.0	17	13	38	1
9/10	8:00	1	0.0	4	9	37	1
	17:00	1	0.0	20	13	37	1
9/11	8:00	3	0.0	6	10	37	1
	17:00	3	0.0	14	11	37	1
9/12	8:00	5	7.0	5	9	37	1
	17:00	5	2.0	10	13	37	1
9/13	8:00	5	0.5	8	7	37	1
	17:00	4	0.0	15	13	37	1
9/14	8:00	2	0.0	10	8	37	1
	17:00	1	0.0	17	12	37	1
9/15	8:00	1	0.0	5	9	36	1
	17:00	1	0.0	10	11	36	1
9/16	8:00	2	0.0	1	8	36	1
	17:00	4	0.0	13	11	36	1
9/17	8:00	1	0.0	4	7	36	1
	17:00	1	0.0	16	11	36	1
9/18	8:00	4	0.0	8	8	36	1
	17:00	4	0.0	14	12	36	1
9/19	8:00	4	0.0	5	8	36	1
	17:00	1	0.0	14	12	36	1
9/20	8:00	2	0.0	10	11	35	1
	17:00	2	0.0	12	11	35	1
9/21	8:00	4	0.0	5	8	35	1
	17:00	4	3.0	6	8	35	1
9/22	8:00	3	0.0	0	5	36	1
	17:00	4	1.5	4	6	36	1
9/23	8:00	3	0.0	0	5	35	1
	17:00	4	0.8	3	4	36	1
9/24	8:00	4	0.0	0	6	35	1
	17:00	3	0.0	6	7	35	1
9/25	8:00	4	0.0	3	4	35	1
	17:00	4	1.5	4	4	37	1
Season			Total = 78.9	Avg. = 13	Avg. = 13	Avg. = 44	

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

[b] Water clarity codes:
1 = visibility greater than 1 meter
2 = visibility 0.5 to 1 meter
3 = visibility less than 0.5 meter