Fishery Data Series No. 16-40

Unalakleet River Chinook Salmon Escapement Monitoring and Assessment, 2015

Annual Report for Project FIS 14-101

USFWS Office of Subsistence Management

Fisheries Resource Monitoring Program

by

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and

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September 2016

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

Symbols and Abbreviations

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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)

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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by
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ABSTRACT

Declining run sizes and ensuing state and federal restrictions and closures to Unalakleet River Chinook salmon *Oncorhynchus tshawytscha* fisheries highlighted the need to obtain more complete estimates of spawning escapement. In response, multiple agencies and entities began the Unalakleet River weir in 2010 funded by United States Fish and Wildlife Service's Office of Subsistence Management. The goal was to obtain estimates of the mainstem Chinook salmon escapement and age, sex, and length composition. An estimated 2,789 Chinook salmon were enumerated during the 2015 season. The central 50% of the Chinook salmon run was enumerated 7 July to 15 July in 2015. Interpolation was not needed in 2015 because there were only minor breaches that were repaired quickly. Female Chinook salmon comprised 37% of the fish sampled for age, sex, and length data and age composition of the samples was 40% age-1.3 and 35% age-1.4 Chinook salmon.

Key words: Chinook salmon *Oncorhynchus tshawytscha*, resistance board weir, North River, Unalakleet River.

INTRODUCTION

Unalakleet River Pacific salmon *Oncorhynchus* spp. stocks contribute heavily to Norton Sound Subdistricts 5 (Shaktoolik) and 6 (Unalakleet; Figure 1) subsistence and commercial salmon fisheries (Menard et al. 2012). Although most salmon stocks to the Unalakleet River are considered healthy, Chinook salmon *O. tshawytscha* runs to the Unalakleet River drainage have been chronically depressed since the late 1990s.

The Alaska Board of Fisheries (BOF) designated Unalakleet River Chinook salmon as a stock of yield concern in 2004 (Kent and Bergstrom 2015). A "yield concern" is a concern arising from a chronic inability, despite the use of specific management measures, to maintain expected yields, or harvestable surpluses, above a stock's escapement needs. As a result of this designation, the Alaska Department of Fish and Game (ADF&G) has implemented a restrictive management plan in an effort to increase escapements and restore Unalakleet River Chinook salmon runs to historic levels of abundance.

Until recently, ADF&G managed Unalakleet River Chinook salmon based primarily on inseason subsistence catch reports and counts of Chinook salmon observed at a counting tower located on the North River, a major tributary of the Unalakleet River. Radiotelemetry studies revealed that North River accounts for 34–55% of the overall drainagewide Chinook salmon escapement (Wuttig 1999; Joy and Reed 2014). Lower river test fishery set gillnet catches of Chinook salmon and spawning ground aerial surveys were also used, but were considered ancillary assessment tools. Further, collection of reliable Chinook salmon age, sex, and length (ASL) data from these existing projects was problematic due to funding limitations, small and poorly distributed annual sample sizes, and mesh-size selectivity bias (Kent 2010).

Beginning in 2010, a resistance board or "floating" weir was operated by ADG&G, Native Village of Unalakleet (NVU), United States Bureau of Land Management (BLM), and Norton Sound Economic Development Corporation (NSEDC) on the mainstem of the Unalakleet River. Resistance board weirs are more effective than traditional fixed picket weirs at withstanding flood conditions, require less maintenance, and ultimately result in shorter periods of unmonitored fish passage (Stewart et al. 2009, 2010). Therefore, escapement counts from resistance board weirs are considered more complete. Additionally, weir traps provide a more consistent platform for obtaining ASL data from live salmon.

The Unalakleet River weir project is funded by United States Fish and Wildlife Service Office of Subsistence Management (USFWS OSM) to provide 2 priority information needs: 1) reliable estimates of Chinook salmon escapement, and 2) unbiased ASL composition from the spawning escapement. This report provides an overview of the 2015 season of the Unalakleet River floating weir. Chinook salmon escapement, run timing, and ASL composition were estimated. Escapement, run timing, and ASL data on other salmon species are provided by year in the report series *Salmon escapements to the Norton Sound-Port Clarence Area*.

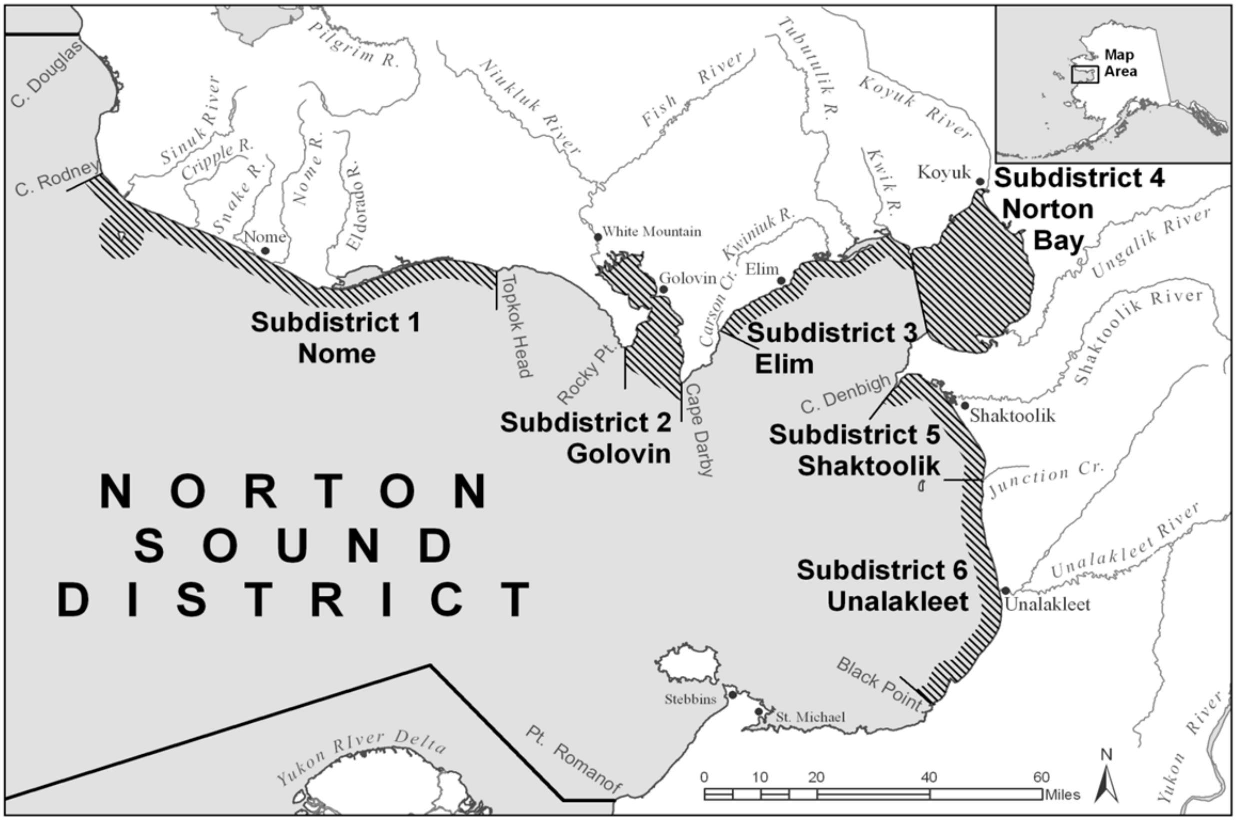

Figure 1.–Commercial salmon fishing subdistricts and major salmon producing watersheds in the Norton Sound District.

OBJECTIVES

Objectives for the Unalakleet River weir project were as follows:

1. Estimate daily and total Chinook salmon escapement during the target operational period.
2. Describe timing of Chinook salmon migration within the Unalakleet River.
3. Estimate ASL composition of the Unalakleet River Chinook salmon spawning escapement.

METHODS

STUDY AREA

The Unalakleet River and its 6 major tributaries have a drainage area of 2,815 square km, extending from the Nulato Hills. The river runs for approximately 210 km before emptying into the Bering Sea at the village of Unalakleet. The upper 81 river miles (130 rkm) of the mainstem Unalakleet River have been designated a National Wild River. Riparian vegetation throughout much of the drainage includes various assemblages of sedge grasses, muskeg bog flats, willow *Salix* spp., alder *Alnus* spp., western cottonwood *Populus fremontii*, black spruce *Picea mariana*, and white birch *Betula papyrifera*. Shale, clay, and loose soils characterize the majority of bank substrate of the Unalakleet River mainstem and its tributaries. In addition to Pacific salmon, the Unalakleet River supports resident populations of arctic grayling *Thymallus arcticus*, whitefish (*Coregonus* and *Prosopium* spp.), Dolly Varden char *Salvelinus malma*, and burbot *Lota lota*.

In 2001, ADF&G personnel identified a suitable resistance board weir site located approximately 22 kilometers upstream from the mouth on the Unalakleet River (63°53.32′N, 160°29.41′W; Figure 2; Menard 2001; Todd 2003). This site was selected because of its favorable physical characteristics, including channel width (91 m), water depth (0.9–1.2 m), optimal stream velocity (0.9–1.2 m/s), and even bottom profile with gravel and small cobble substrate to provide stable anchoring of the weir. Additionally, radiotelemetry data have shown this site is located well downstream of the entire mainstem Chinook salmon spawning distribution (Wuttig 1999; Joy and Reed 2014).

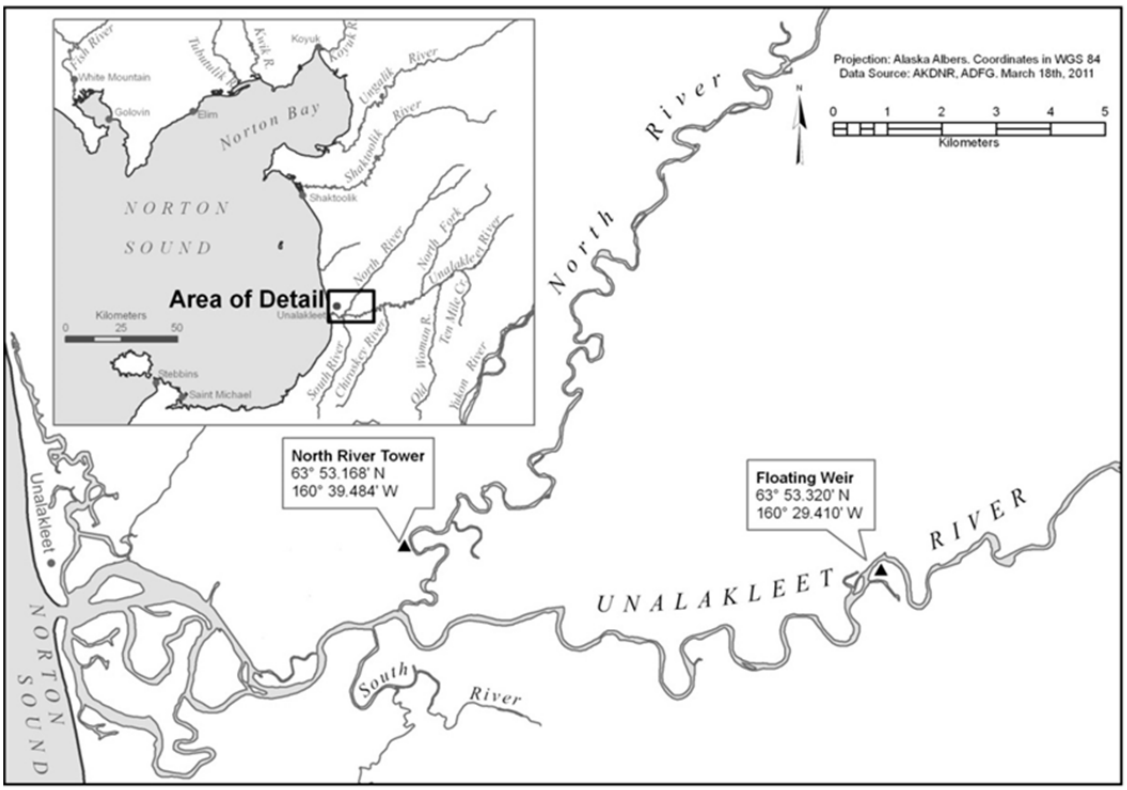

Figure 2.–Salmon stock assessment projects within the Unalakleet River drainage.

RESISTANCE BOARD WEIR DESIGN, INSTALLATION, AND OPERATION

Weir design and materials followed those described by Tobin (1994) with modifications outlined by Stewart (2002). Picket spacing was 3.2 cm, which imparted flexibility to the panels and allowed for a complete census of all but the smallest returning salmon.

Following methods outlined by Stewart (2003), a tethering cable system upstream of the substrate rail was used to guide weir panels into position on the rail in deep sections of the river. Snorkelers would use a knotted rope with a carabineer attached to the substrate rail to hold them in position in the deepest swiftest part of the river during installation.

For the first 4 years of the project, a single enclosed passage chute and live trap were installed upstream of the weir to serve as a platform for enumeration and ASL sampling of migrating salmon. However, to further reduce unmonitored periods during high water events, a second passage chute/live trap assembly was added during the 2014 season. This second chute/trap assembly was situated near shore to provide continued enumeration and ASL sampling during periods of high murky water that prohibited enumeration and sampling near the thalweg. Live traps were constructed from aluminum angle and channel stock and measured 1.5 m x 2.4 m x 1.5 m. The trap floor was made of sandbags. A collapsible hinged entrance and removable exit gate (16 inches wide) were also installed on the trap. During periods of high water and or diminished clarity, an angled insert covered with high visibility flash panel material was deployed into the exit door slot. This forced the salmon into the upper portion of the water column facilitating speciation and enumeration. To expedite passage of high numbers of pink salmon *O. gorbuscha* during the 2015 season a nearshore panel picket would be pulled and 1 entire panel would be opened temporarily. A piece of flash panel material placed on the upstream side of the opened panel would help with speciation and enumeration.

Boat passage/gate systems have undergone continual refinement since the project's inception. Beginning in 2014, bisected sections of 8 inch high density polyethylene (HDPE) drain pipe were installed as covers on the downstream half of the boat pass panels. This configuration was a good balance between boat strike defense and salmon containment and was in place in 2015 (Figure 3). Large traffic cones topped with flashing net lights were also affixed on either side of the boat pass to facilitate safe boat passage during low light periods.

For the 2015 season, the desired target operational period was mid-June to mid-August. This ensured even the latest Chinook salmon runs, like those observed from 2010 to 2012, were fully enumerated at the weir.

Figure 3.–Example of Unalakleet River weir boat gate panel with HDPE pipe sections to safeguard PVC weir pickets against propeller strikes.

DATA COLLECTION

The weir was closed to fish passage except during onsite counting periods. Hourly or bi-hourly counts were conducted based on fish movement behind the weir. Counting schedules were adjusted for changes in diurnal migratory patterns or operational constraints such as less favorable viewing conditions caused by high water levels. Flood lamps were used at night to aid in salmon identification. The weir was open to migrating salmon for at least an hour or until fish passage diminished; all fish were identified to species and recorded on multiple tally counters.

Counts were recorded in *Rite in the Rain* notebooks before being transferred to hourly count forms. Total and cumulative daily counts were calculated and transferred to radio log forms, and inseason estimates were relayed to fishery managers in the Nome Area office.

WEATHER AND STREAM OBSERVATIONS

Stream and ambient air temperature (°C), relative water levels, and atmospheric observations (e.g., percent cloud cover, wind speed and direction) were measured twice daily. Additionally, a HOBO® Pro v2 data logger (Onset Computer Corporation) was secured several inches off the bottom just upstream of the weir.[1] Weather, temperature, and hydrological observations were recorded in *Rite in the Rain* data forms and entered into Microsoft Excel spreadsheets.

INTERPOLATING UNMONITORED WEIR PASSAGE

Missing daily counts were interpolated using the moving average method described in Perry-Plake and Antonovich (2009). Partial-count days were considered days of minimum passage, and therefore were not used to interpolate missed passage for days when the weir was not operational. When counts for consecutive days (*k*) were missed, the moving average estimate for the missing day (*i*) was calculated as

$$\hat{N}_i = \frac{\sum_{j=i-k}^{i+k} I(\textit{counting was successfully conducted on day } j)\hat{N}_j}{\sum_{j=i-k}^{i+k} I(\textit{counting was successfully conducted on day } j)},$$

where $I(\cdot) = \begin{cases} 1 & \textit{when the condition is true} \\ 0 & \textit{otherwise} \end{cases}$ is an indicator function.

AGE, SEX, AND LENGTH DATA COLLECTION

Chinook Salmon Capture Methods

Active sampling, consisting of capturing and sampling Chinook salmon individually or in small numbers while actively passing and counting all salmon (Linderman et al. 2002) was used in 2015. To further increase the likelihood of capturing Chinook salmon, the enclosed bulkhead of the fish passage chute was connected to the live trap to obscure personnel positioned near the rear trap gate from the view of Chinook salmon. Consequently, Chinook salmon entered the trap less hesitantly and at a much slower speed, which led to improved capture and sampling of Chinook salmon.

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

Distribution and Sample Sizes

Minimum ASL sample sizes were determined following Bromaghin (1993) to achieve 95% confidence intervals of age-sex composition to be no wider than ±10% (α = 0.05 and d = 0.10), assuming 10 age-sex categories (n = 190). To ensure adequate temporal distribution, ASL samples were collected during the 2015 seasons following a daily collection schedule in proportion to average historical escapement by day (Table 1). Mainstem Chinook salmon run timing was used to establish collection schedules, but sampling distributions and schedules were adjusted inseason to address differences between expected and observed run abundance and timing.

Table 1.–Chinook salmon ASL sampling intervals and daily collection goals at Unalakleet River weir, 2015.

	Passage date	Expected sampling dates	Expected sample size	Samples/ day
First quarter point	7 Jul	June 25–July 7	48	4
Midpoint	13 Jul	July 8–July 13	48	8
Third quarter point	19 Jul	July 14–July 19	47	8
95% cumulative passage	24 Jul	July 20–July 24	47	10
Season total			190	

Sample Collection Procedures

Three scales were collected from each Chinook salmon for age determination. Sex was determined by visually examining external characteristics (such as body symmetry, kype development and presence of an ovipositor), and length was measured to the nearest 1 mm from mid eye to tail fork (METF). Scales were removed from the left side of the fish in an area 2–3 scale rows above the lateral line crossed by a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (INPFC 1963). Scales were cleansed of slime and debris, mounted on gummed cards, and impressions were later made in cellulose acetate cards for age determination following methods described by Clutter and Whitesel (1956). Impressions were read with a microfiche reader and ages were determined from reading annuli as described by Mosher (1969). European notation was used to report ages in which the first digit refers to the freshwater age, not including the year spent in the gravel, and the second digit refers to the ocean age (Koo 1962).

RESULTS

WEIR OPERATIONS

Personnel and supplies were transported to the weir site on 13 June. Installation of the weir began on 14 June and due to extremely low water levels, complete installation of the weir was achieved by 17 June. Several small brief breaches were discovered and repaired by weir personnel between 25 June and 28 July. Breaches were generally due to misaligned weir panels or scouring beneath the substrate rail from large numbers of milling pink salmon. The crew leader ascertained these breaches were only large enough to allow for passage of pink salmon and the smallest of chum salmon *O. keta*. Breaches were repaired quickly and it is believed only a small number of pink and chum salmon passed unmonitored. As further evidence, Chinook salmon passage did not increase drastically following repair of these small breaches suggesting unmonitored Chinook salmon was unlikely. Water levels remained low until 19 July when they rose several centimeters and then dropped off beginning on 27 July (Figure 4; Appendix A1). Field notes indicate that counting operations were only limited by poor conditions on 19 July. However, the integrity of the weir was maintained on this day and there was no unmonitored salmon passage. Between 20 July and July 27, counting operations were performed at the nearshore passage chute/weir trap where improved water clarity allowed for accurate enumeration of migrating salmon. The use of this additional weir trap/passage chute facilitated counting operations that were not possible under high water levels in prior years.

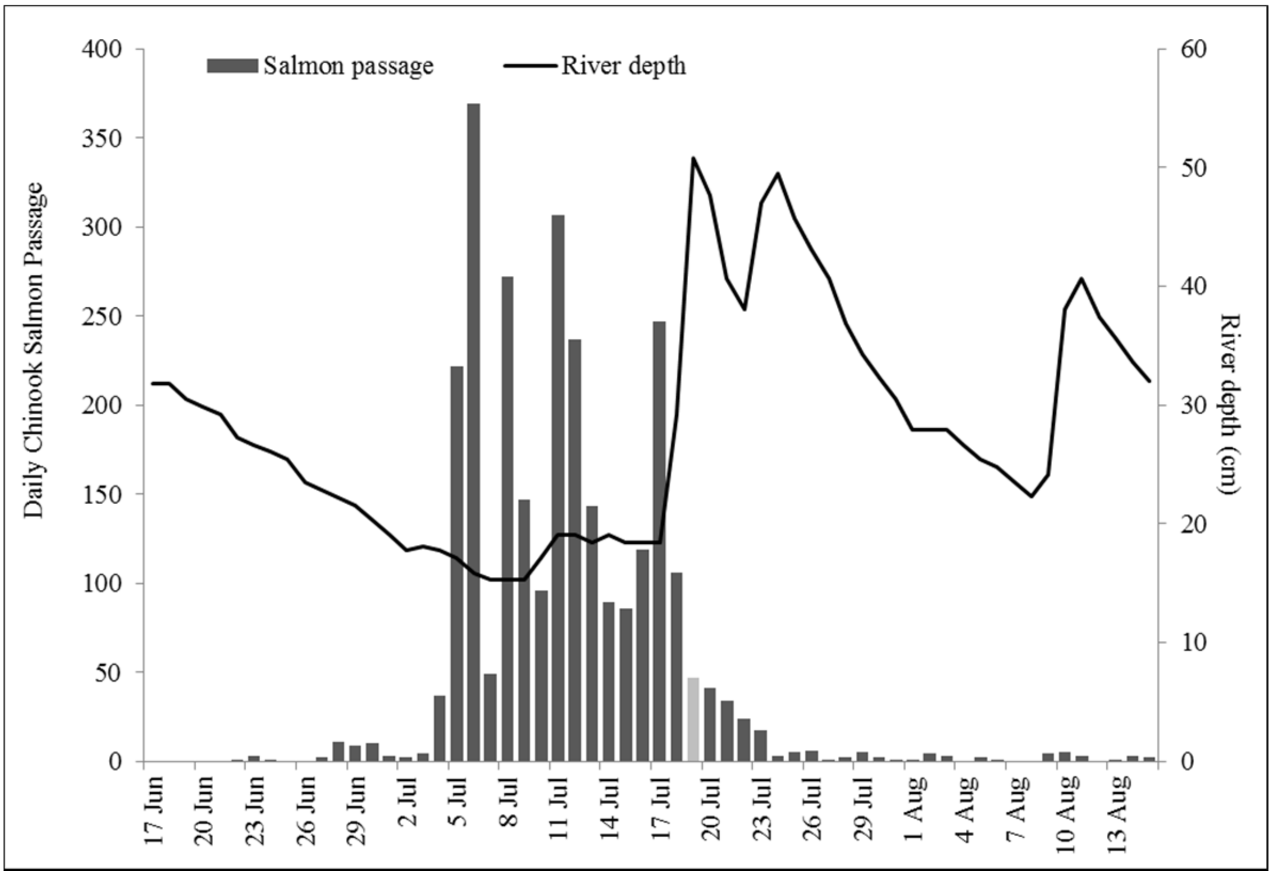

Figure 4.–Daily Chinook salmon passage and daily relative river depth (cm), Unalakleet River weir, 2015.

Note: Light gray bar indicates a partial day count.

CHINOOK SALMON RUN TIMING AND ESCAPEMENT

During the 2015 season, counting operations were 17 June to 15 August and 2,789 Chinook salmon were counted at Unalakleet River weir. Daily Chinook salmon passage peaked on 6 July (369 Chinook salmon; Figure 4; Appendix A2). The central 50% of Chinook salmon escapement was 7–15 July and the median passage date was 11 July (Figure 4; Appendix A2). The weir was not inoperable for more than a few hours throughout the target operational period and the small breaches mentioned previously were of an unknown, but likely short duration.

AGE, SEX, AND LENGTH COMPOSITION

In 2015, the sampling objective was 190 Chinook salmon distributed between 25 June and 24 July. A total of 194 samples were collected from 23 June to 23 July and 177 (94%) of these samples were successfully aged. The age composition was age-1.2 (22%), age-1.3 (40%), age-1.4 (35%), and age-1.5 (3%); sex composition was 37% female. Average lengths ranged from 521 mm (SD = 57) for age-1.2 Chinook salmon to 840 mm (SD = 46) for age-1.5 fish. Mean length for all sampled fish was 680 mm (SD = 136). Females averaged 775 mm (SD = 102) in length and the mean length of male Chinook salmon was 624 mm (SD = 121; Table 2).

Table 2.–Chinook salmon age, sex, and mean length (METF in mm), Unalakleet River weir, 2015.

Sample dates:	6/23-7/23	Brood year and age class					
		2012	2011	2010	2009	2008	
Number of aged samples:	177	1.1	1.2	1.3	1.4	1.5	Total
Male	Percent of sample	0.6	19.2	31.1	11.3	0.6	62.7
	Number of samples	1	34	55	20	1	111
	Mean length (mm)	365	516	635	776	836	624
	SD (Length)	–	56.9	80.9	94.0	–	120.8
Female	Percent of sample	0.0	2.3	9.0	23.7	2.3	37.3
	Number of samples	0	4	16	42	4	66
	Mean length (mm)	–	564	697	818	841	775
	SD (Length)	–	49.1	92.4	63.7	52.7	102.4
Total	Percent of sample	0.6	21.5	40.1	35.0	2.8	100.0
	Number of samples	1	38	71	62	5	177
	Mean length (mm)	365	521	649	805	840	680
	SD (Length)	–	57.4	86.9	76.6	45.7	135.5

DISCUSSION

The 2015 Unalakleet River Chinook salmon run was slightly later than the 2014 run despite an even milder winter and warm spring temperatures (Kent et al. 2016). The first Chinook salmon was not enumerated until 22 June in 2015, whereas Chinook salmon were observed upstream of the weir site on 17 June, the day the weir was installed in 2014. One explanation for this is persistent low water levels and warm weather in June and July, which produced very warm riverine water temperatures in 2015. As a result, salmon exhibited prolonged milling behavior in the nearshore coastal waters where water temperatures remained relatively cool.

Unlike previous years, peak Chinook salmon passage days were not correlated with rising stream levels in 2015; periods of high water occurred after 94% of the Chinook salmon passage had already occurred. Counting conditions were only severely affected on 19 July when water levels rose sharply and water clarity diminished even at the nearshore counting station. Additionally, the majority of the Chinook salmon escapement had already been enumerated by July 19.

Therefore only a small proportion of the escapement counts were affected by poor counting conditions.

Chinook salmon passage at the weir in 2015 was the highest in 6 years of estimates and greatly exceeded forecasted run expectations. Additionally, unlike the 2014 estimate, the 2015 count is considered to be a reliable estimate of the spawning escapement because the weir was fully installed 5 days prior to encountering the first Chinook salmon. We also believe few if any Chinook salmon escaped through the small breaches beneath the substrate rail that occurred throughout the season.

Age, sex, and length sampling objectives were achieved for the second consecutive season. Unlike 2014, in which samples were poorly distributed across the run, ASL samples collected in 2015 were distributed evenly across of the entire Chinook salmon run. The strong contribution of age-1.4 (6-year-old) Chinook salmon from the 2009 brood year was expected but the good contributions of age-1.3 and age-1.2 Chinook salmon by the 2010 and 2011 brood years were somewhat surprising considering the low escapements observed in those years.

The Unalakleet River weir is critical for collecting data to evaluate the effect of harvest practices and management strategies on the size and composition of the Chinook salmon spawning escapement. The 2016 Unalakleet River Chinook salmon run is expected to have a small harvestable surplus based on year class strength of the 2010 and 2011 brood years observed in escapement ASL samples and the last 2 years of better than expected escapements.

ACKNOWLEDGEMENTS

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APPENDICES

Appendix A1.–Relative stream depth observations as indicated by stream gauge measurements, Unalakleet River weir, 2015.

Date	Water depth (cm)
6/17	31.8
6/18	31.8
6/19	30.5
6/20	29.8
6/21	29.2
6/22	27.3
6/23	26.7
6/24	26.0
6/25	25.4
6/26	23.5
6/27	22.9
6/28	22.2
6/29	21.6
6/30	20.3
7/1	19.1
7/2	17.8
7/3	18.1
7/4	17.8
7/5	17.1
7/6	15.9
7/7	15.2
7/8	15.2
7/9	15.2
7/10	17.1
7/11	19.1
7/12	19.1
7/13	18.4
7/14	19.1
7/15	18.4
7/16	18.4
7/17	18.4
7/18	29.2
7/19	50.8
7/20	47.6
7/21	40.6
7/22	38.1
7/23	47.0
7/24	49.5
7/25	45.7
7/26	43.2
7/27	40.6
7/28	36.8
7/29	34.3
7/30	32.4
7/31	30.5

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Date	Water depth (cm)
8/1	27.9
8/2	27.9
8/3	27.9
8/4	26.7
8/5	25.4
8/6	24.8
8/7	23.5
8/8	22.4
8/9	24.1
8/10	38.1
8/11	40.6
8/12	37.5
8/13	35.6
8/14	33.7
8/15	32.0

Appendix A2.–Daily and cumulative Chinook salmon passage, Unalakleet River weir, 2015.

Date	Daily Chinook salmon	Cumulative Chinook salmon
6/17	0	0
6/18	0	0
6/19	0	0
6/20	0	0
6/21	0	0
6/22	1	1
6/23	3	4
6/24	1	5
6/25	0	5
6/26	0	5
6/27	2	7
6/28	11	18
6/29	9	27
6/30	10	37
7/1	3	40
7/2	2	42
7/3	4	46
7/4	37	83
7/5	222	305
7/6	369	674
7/7	49	723
7/8	272	995
7/9	147	1,142
7/10	96	1,238
7/11	307	1,545
7/12	237	1,782
7/13	143	1,925
7/14	89	2,014
7/15	86	2,100
7/16	119	2,219
7/17	247	2,466
7/18	106	2,572
7/19 [a]	47	2,619
7/20	41	2,660
7/21	34	2,694
7/22	24	2,718
7/23	17	2,735
7/24	3	2,738
7/25	5	2,743
7/26	6	2,749
7/27	1	2,750
7/28	2	2,752
7/29	5	2,757

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Date	Daily Chinook salmon	Cumulative Chinook salmon
7/30	2	2,759
7/31	1	2,760
8/1	1	2,761
8/2	4	2,765
8/3	3	2,768
8/4	0	2,768
8/5	2	2,770
8/6	1	2,771
8/7	0	2,771
8/8	0	2,771
8/9	4	2,775
8/10	5	2,780
8/11	3	2,783
8/12	0	2,783
8/13	1	2,784
8/14	3	2,787
8/15	2	2,789

Note: Grey shaded box indicates median passage date and the enclosed box delineates the central 50% of the run.

[a] Partial day count.