Fishery Data Series No. 17-17

Unalakleet River Chinook Salmon Escapement Monitoring and Assessment, 2016

Annual Report for Project FIS 14-101

USFWS Office of Subsistence Management

Fisheries Resource Monitoring Program

by

Jenefer Bell

and

Larry Neff

April 2017

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

FISHERY DATA SERIES NO. 17-17

UNALAKLEET RIVER CHINOOK SALMON ESCAPEMENT MONITORING AND ASSESSMENT, 2016

by
Jenefer Bell and Larry Neff
Alaska Department of Fish and Game, Division of Commercial Fisheries, Nome

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

April 2017

This investigation was funded by the U.S. Fish and Wildlife Service, Office of Subsistence Management (Project No. FIS 14-101), Fisheries Resource Monitoring Program under agreement number 70181AJ019.

ADF&G Fishery Data Series was established in 1987 for the publication of Division of Sport Fish technically oriented results for a single project or group of closely related projects, and in 2004 became a joint divisional series with the Division of Commercial Fisheries. Fishery Data Series reports are intended for fishery and other technical professionals and are available through the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone editorial and peer review.

Jenefer Bell and Larry Neff
Alaska Department of Fish and Game, Division of Commercial Fisheries,
Box 1148, Nome, AK, 99762, USA

This document should be cited as follows:
Bell, J., and L. Neff. 2017. Unalakleet River Chinook salmon escapement monitoring and assessment, 2016. Alaska Department of Fish and Game, Fishery Data Series No. 17-17, Anchorage.

TABLE OF CONTENTS

Page

LIST OF TABLES ii

LIST OF FIGURES ii

LIST OF APPENDICES ii

ABSTRACT 1

INTRODUCTION 1

OBJECTIVES 2

METHODS 2

Study Area 2
Resistance Board Weir Design, Installation, and Operation 3
Data Collection 5
Weather and Stream Observations 5
Interpolating Unmonitored Weir Passage 5
Age, Sex, and Length Data Collection 5
  Chinook Salmon Capture Methods 5
  Distribution and Sample Sizes 6
  Sample Collection Procedures 6

RESULTS 6

Weir Operations 6
Chinook Salmon Escapement and Run Timing 7
Age, Sex, and Length Composition 8

DISCUSSION 8

ACKNOWLEDGEMENTS 9

REFERENCES CITED 9

APPENDICES 11

LIST OF TABLES

Table **Page**

1 Chinook salmon ASL sampling intervals and daily collection goals at Unalakleet River weir, 2016. 6
2 Chinook salmon age, sex, and mean length, Unalakleet River weir, 2016. 8

LIST OF FIGURES

Figure **Page**

1 Commercial salmon fishing subdistricts and major salmon producing watersheds in the Norton Sound District. 2
2 Salmon stock assessment projects within the Unalakleet River drainage. 3
3 Unalakleet River weir boat gate panel with HDPE pipe sections to safeguard PVC weir pickets against propeller strikes. 4
4 Daily Chinook salmon passage and daily relative river depth, Unalakleet River weir, 2016..........................7

LIST OF APPENDICES

Appendix **Page**

A1 Daily and cumulative Chinook salmon passage at Unalakleet River weir, 2016. 12
A2 Relative water depth at Unalakleet River weir, 2016. 13

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 (ASL) composition. An estimated 505 Chinook salmon were enumerated during the 2016 season. High water and numerous pink salmon *O. gorbuscha* contributed to an incomplete count of Chinook salmon in 2016; therefore, the escapement estimate should be considered a minimum count, and run timing could not be determined. A total of 25 ASL samples were collected but did not meet minimum sample size requirements and could not be used to estimate female percentage or age composition. Despite issues with operations in 2016, the Unalakleet River weir is an important tool for fishery managers, and increased oversight and training will ensure it remains a viable option for monitoring Chinook salmon in the Unalakleet River.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, resistance board weir, Unalakleet River, North 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. 2015). 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 a stock of yield concern in 2004 and it has continued under that designation since (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 these 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 ADF&G, Native Village of Unalakleet (NVU), United States Bureau of Land Management (BLM), and Norton Sound Economic Development Corporation (NSEDC) on 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 consistent platform for obtaining ASL data from live salmon.

The Unalakleet River weir project, funded by United States Fish and Wildlife Service Office of Subsistence Management (USFWS OSM), provides 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 2016 season Unalakleet River floating weir project. Attempts were made to estimate Chinook salmon escapement, run timing, and ASL composition. 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*.

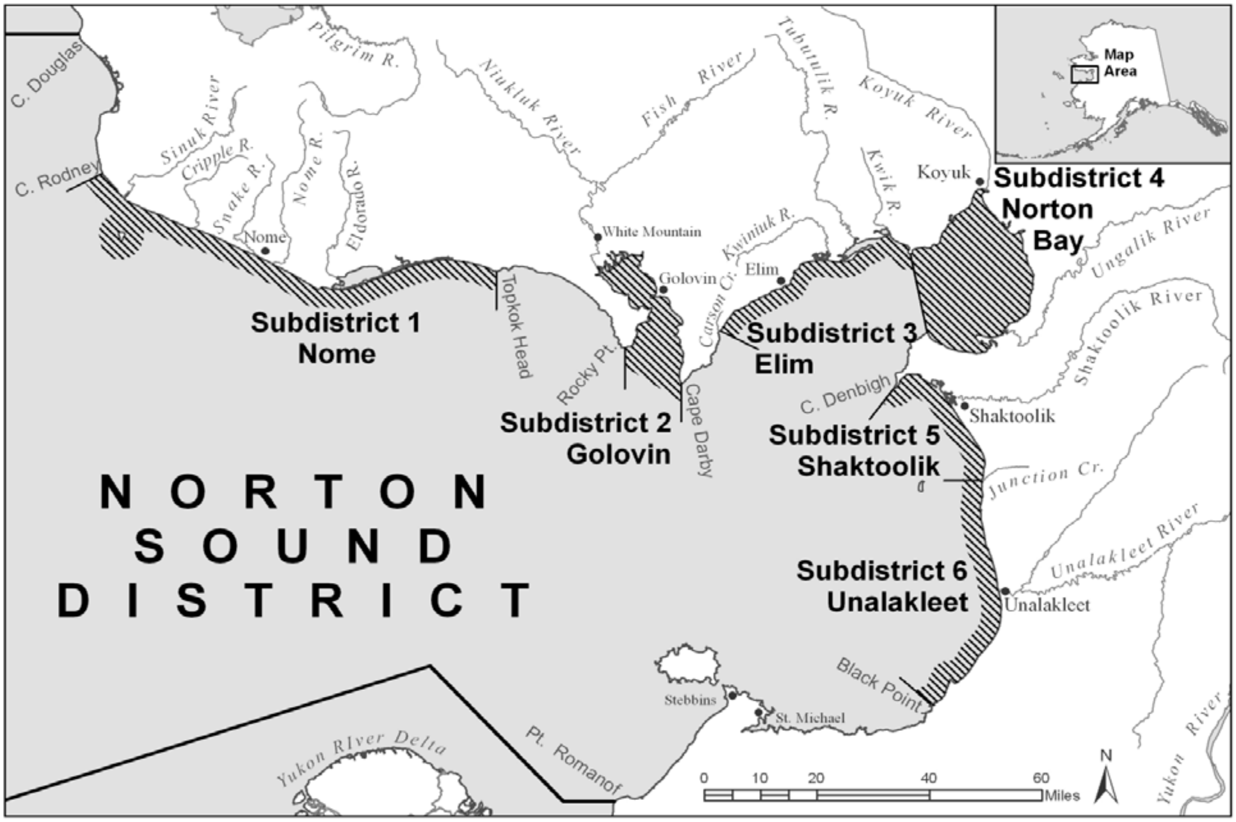

Figure 1.–Commercial salmon fishing subdistricts and major salmon-producing watersheds in the Norton Sound District.

OBJECTIVES

Objectives for the Unalakleet River weir project were as follows:

1. To estimate daily and total Chinook salmon escapement during the target operational period;
2. To describe timing of Chinook salmon migration within the Unalakleet River; and
3. To estimate the ASL composition of Unalakleet River Chinook salmon escapement to achieve 90% and 95% confidence intervals of age and sex composition, respectively.

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 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 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*.

The weir is located approximately 22 kilometers upstream from the mouth of the Unalakleet River (63°53.32′ N, 160°29.41′ W; Figure 2). This site was selected because of its favorable physical characteristics (Menard 2001; Todd 2003) and location well downstream of the Chinook salmon spawning distribution (Wuttig 1999; Joy and Reed 2014).

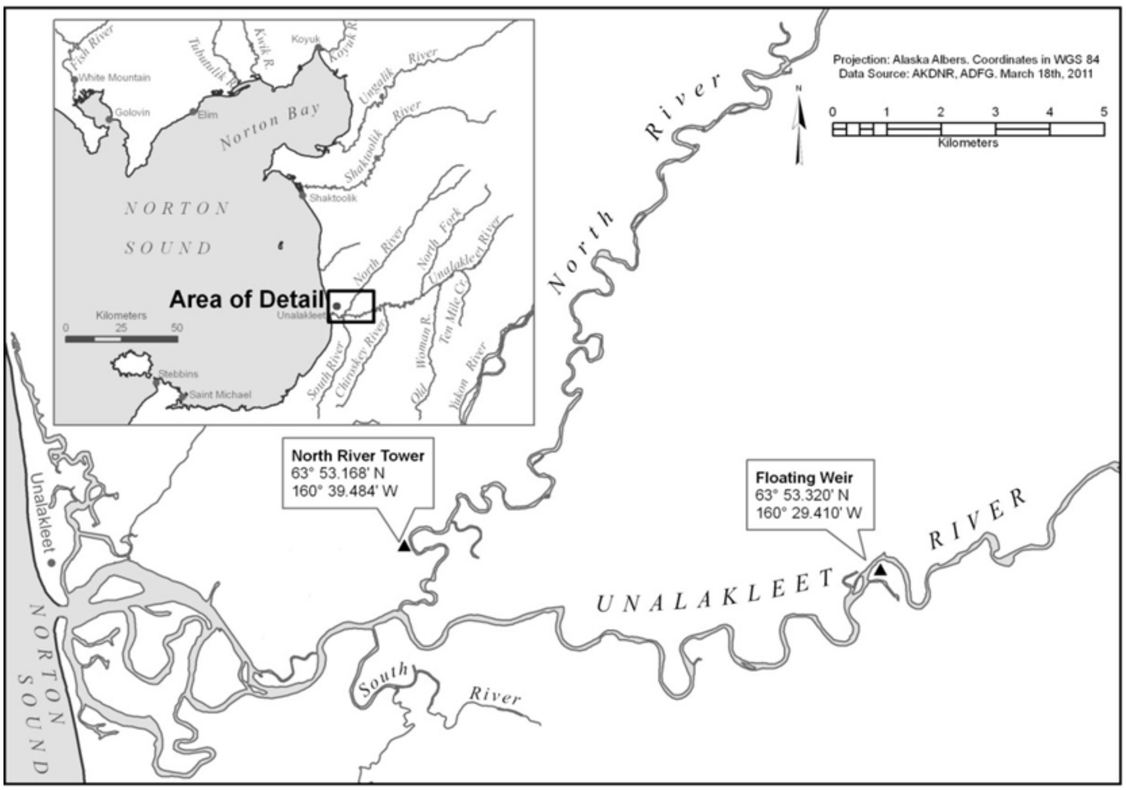

Figure 2.–Salmon stock assessment projects within the Unalakleet River drainage.

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 used 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.

Two enclosed passage chutes and live traps were installed to serve as platforms for enumeration and ASL sampling of migrating salmon. One passage 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 at the second passage chute/trap situated near the thalweg of the river. 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 up of white flash panel material and sandbags. A collapsible hinged entrance and removable 16-inch-wide exit gate were also installed on the trap. During periods of high water or increased turbidity, an angled insert covered with high-visibility white flash panel material was placed 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 2016 season, a nearshore panel picket was pulled and one entire panel was opened temporarily. A 0.9 m x 1.8 m piece of flash panel material, anchored with sandbags, placed on the upstream side of the opened panel helped 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 2016 (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 2016 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.–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 every hour for at least 5 minutes 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[1] 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. 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. Interpolation of missed daily counts was completed when 10 or fewer days were missed and there were at least 9 days of full counts after the missed days. If greater than 10 days were missed, there was no interpolation for that time period and the escapement estimate should be considered a minimum count. 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

Sampling consisted of capturing and sampling salmon individually or in small numbers while actively passing and counting all salmon (Linderman et al. 2002). When Chinook salmon entered the trap, the front and rear gates were closed to trap the fish. During periods of low and clear water, one crew member, while sitting at the downstream end of the trap, could actively trap Chinook salmon while counting all salmon species. Periods of high or turbid water

---

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

conditions required two people for sampling. One crew member counted fish at the upstream end of the trap while a second crew member sat at the back of the trap. Careful and quick handling of all Chinook salmon sampled was emphasized, to minimize stress and injury.

Distribution and Sample Sizes

Minimum ASL sample sizes were determined following Bromaghin (1993) to achieve simultaneous 90% and 95% confidence intervals for age and sex composition assuming 5 age categories and 2 sex (*n* = 230 in 2016). To ensure adequate temporal distribution, ASL samples were collected following a daily collection schedule in proportion to average historical escapement by day (Table 1). Unalakleet River 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, 2016.

	Quartile date	Sampling period dates	Number of samples collected/day	Cumulative sample total
Quarter point	7/07	6/25–7/07	5	52
Midpoint	7/13	7/08–7/13	10	112
Three-quarter point	7/19	7/14–7/19	10	172
~90% point	7/24	7/20–7/24	11	227

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 MEF (mideye to fork of tail). 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 cleaned of slime and debris and mounted on gummed cards, and impressions were 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 this notation, 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 June 5, 2016. Installation of the weir began on June 6 and due to low water levels, the weir was fish tight by late afternoon on June 10. On July 7 breaches were noticed under the weir rail; however, it was unclear how long the breaches persisted and how many salmon passed through unmonitored. Mid-day on July 13 the camp coordinator arrived at the weir and noted salmon were backed up approximately one-half mile downstream of the weir and the weir was one third underwater due to the weight of gravel swept up on the panels by large numbers of pink salmon. Salmon were passing unmonitored over the weir: in 2 minutes of observation 12 chum salmon, 1 Chinook salmon, and hundreds of pink salmon went over the boat gate. As part of the site visit, the rail was inspected and numerous breaches where pink and chum salmon were passing unmonitored under the weir rail were identified. The crew leader estimated the weir had been in this condition for approximately 9–12 hours. The gravel was removed from the weir, the breaches were plugged with rocks and sandbags, and a panel was opened to count and pass the backup of pink salmon. The weir remained operational for another 9 days until July 22 when counting was halted because of high water levels. The field camp retained minimum personnel to monitor the camp and weir. The weir remained submerged when personnel were removed from the field camp in mid-August. Water levels dropped enough to begin dismantling the weir on September 9, and it was completely removed from the river 4 days later.

CHINOOK SALMON ESCAPEMENT AND RUN TIMING

During the 2016 season, counting operations were June 10 to July 22 and 505 Chinook salmon were counted at Unalakleet River weir. Abundant pink salmon and high water made counting difficult, and ultimately the weir was fully submerged on July 22 and counting ceased (Figure 4; Appendices A1 and A2). Because the target operational period was not fully monitored, Unalakleet River Chinook salmon escapement estimate should be considered a minimum and run timing could not be determined.

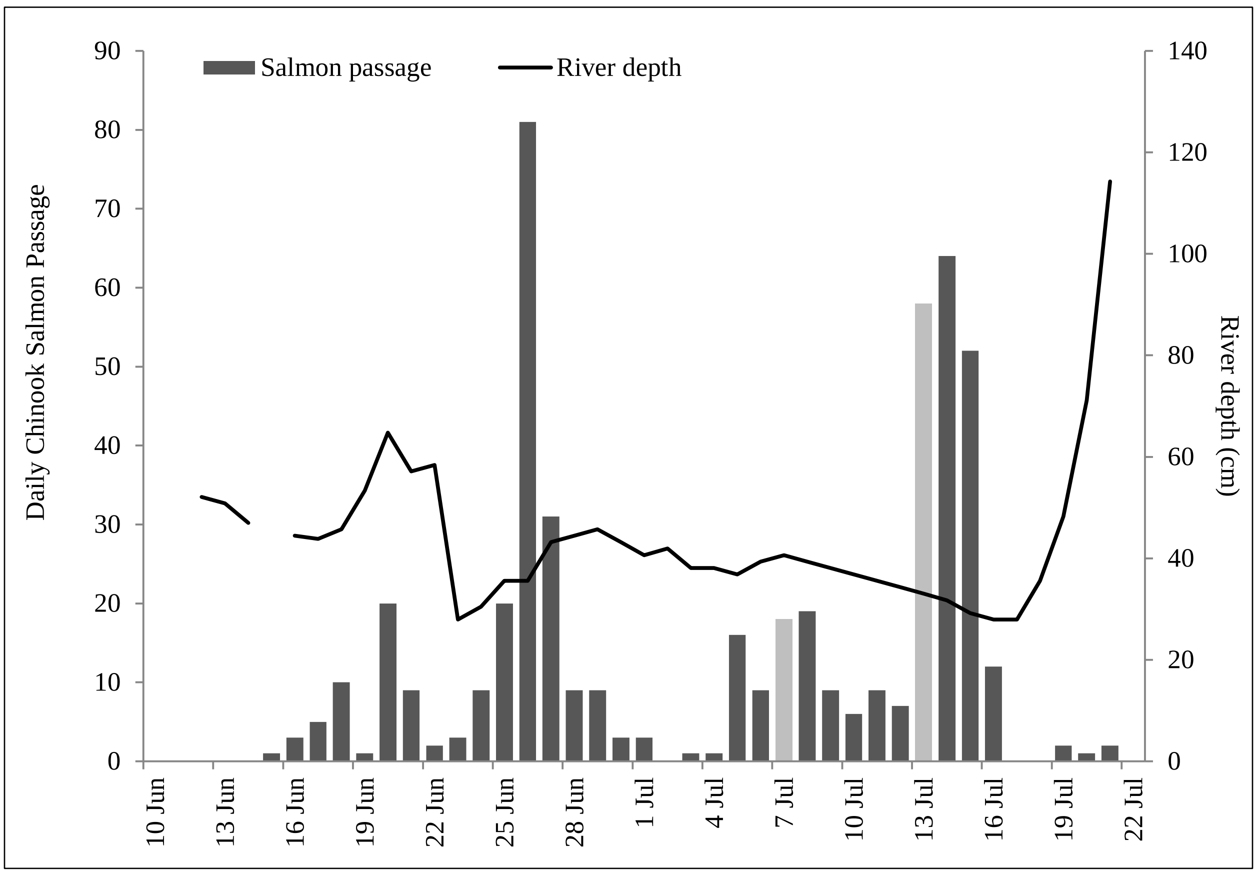

Figure 4.–Daily Chinook salmon passage and daily relative river depth (cm), Unalakleet River weir, 2016.

Note: Light gray bar indicates a partial day count.

AGE, SEX, AND LENGTH COMPOSITION

In 2016, the sampling objective was 230 Chinook salmon distributed between June 25 and July 24. A total of 25 samples were collected from June 26 to July 14; 18 (72%) of these samples were successfully aged, and age-1.3 male Chinook salmon made up 50% of all aged samples (Table 2). Sample size requirements were not met; therefore, sex and age composition of the Unalakleet River Chinook salmon run could not be determined.

Table 2.–Chinook salmon age, sex, and mean length (MEF in mm), Unalakleet River weir, 2016.

Sample Date	Sex	Length	Age
6/26	M	673	1.3
6/26	F	754	1.4
6/27	M	715	1.5
6/27	F	761	1.4
6/27	F	801	1.4
6/27	F	821	1.4
6/28	M	613	1.3
6/28	F	760	1.3
7/05	M	576	1.3
7/07	M	720	1.3
7/07	M	735	1.3
7/07	F	788	1.4
7/09	M	656	1.3
7/10	M	548	1.2
7/10	M	602	1.3
7/10	M	774	1.3
7/12	M	693	1.3
7/12	F	798	1.3

Note: Samples sizes for age and sex composition were not met. Therefore, use of this data for analysis is limited.

DISCUSSION

The Unalakleet River weir project began about 7 days earlier in 2016 than 2015, and the first Chinook salmon passed about 7 days earlier in 2016 as well (Kent et al. 2016). Despite the apparent ease with which the season started compared to the previous year, large numbers of pink salmon, relative inexperience of the crew leader, and high water contributed to season-long difficulties culminating in the weir becoming inoperable about a month earlier than expected. Because of the issues with the weir, the escapement estimate of 505 Chinook salmon that passed the Unalakleet River weir are not considered representative of escapement. The average median passage date for Chinook salmon is July 21 (Bell and Leon 2017), which is around the same time the weir became inoperable in 2016. In addition to the shortened season, there were concerns about the integrity of the weir earlier in the season. Breaches along the bottom rail were noticed on July 7, but it was unclear how long the holes had been there and there were no attempts to estimate missed passage of salmon. The weir was also inundated with pink salmon on July 12–13 that allowed for unmonitored passage of all species, further adding to the uncertainty of the

Chinook salmon escapement estimate. Given these issues, it is conceivable that greater than half of the Chinook salmon run was not enumerated.

In prior years, comparisons between the weir and North River tower have been useful as indicators of relative abundance. That is, large disagreements between escapement estimates between projects might be indicative of operational issues such as misidentification of species or unmonitored passage. In 2016, the North River tower was not operational from July 20 to August 19 and may have missed a large segment of Chinook salmon passage (Bell and Leon 2017), so drawing conclusions about escapement is challenging. There are no apparent concerns with species identification because ASL samples from Chinook salmon collected at the weir were all the correct species. Thus, there is a high level of certainty Chinook salmon were accurately identified and the 505 Chinook salmon escapement estimate is indeed a minimum count.

Despite issues with operations in 2016, 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 to the Unalakleet River drainage. The breaches and issues with pink salmon in 2016 were a consequence of inexperienced crew and too little oversight. In subsequent years, the project leader and field camp coordinator will complete more frequent site visits to ensure all weir personnel are familiar with and competent in operating the floating weir. Even with these issues, the persistent high water experienced in 2016 is a part of any long-term monitoring project and little can be done to mitigate the effects of extreme environmental events.

ACKNOWLEDGEMENTS

The authors would like to acknowledge personnel from organizations who contributed time and resources to make the Unalakleet River weir a success. The authors would like to thank all field crew who assisted with the installation and operation of the weir in 2016: Peter Nanouk, Bradley Russel, Anvil Boeckman, Ruslan Grigoriev, Mike McGowan, Nolan Horner, John Ivanoff, Ethan Kelso, Jeff Slwooko, Barb Kehrberg, Ben Stratton, Jessica Mute, and Merlyn Schelske. USFWS OSM provided funding for this project (FIS 14-101) through the Fisheries Resource Monitoring Program, under agreement number 70181AJ019.

REFERENCES CITED

Bell, J., and J. M. Leon. 2017. Salmon escapements to the Norton Sound-Port Clarence Area, 2015–2016. Alaska Department of Fish and Game, Fishery Data Series No. 17-14, Anchorage.

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

Clutter, R., and L. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. Bulletin of International Pacific Salmon Fisheries Commission No. 9. Vancouver, British Columbia.

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

Joy, P., and D. J. Reed. 2014. Estimation of Chinook salmon abundance and spawning distribution in the Unalakleet River, 2010. Alaska Department of Fish and Game, Fishery Data Series No. 14-38, Anchorage.

Kent, S. 2010. Unalakleet River salmon studies, 2002-2008. Alaska Department of Fish and Game, Fishery Data Series No. 10-83, Anchorage.

REFERENCES CITED (Continued)

Kent, S. M., and D. J. Bergstrom. 2015. Norton Sound Subdistrict 5 (Shaktoolik) and Subdistrict 6 (Unalakleet) king salmon stock status and action plan, 2016; a report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Special Publication No. 15-19, Anchorage.

Kent, S. M., J. Bell, and L. Neff. 2016. Unalakleet River Chinook salmon escapement monitoring and assessment, 2013–2014. Alaska Department of Fish and Game, Fishery Data Series No. 16-39, Anchorage.

Koo, T. S. Y. 1962. Age designation on salmon. Pages 37-48 [*In*] T.S.Y. Koo, editor, Studies of Alaska red salmon. University of Washington Publications in Fisheries, New Series, Volume I, Seattle.

Linderman, J. C. Jr., D.B. Molyneaux, L. DuBois and W. Morgan. 2002. Tatlawiksuk River weir salmon studies, 1998–2001. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A02-11, Anchorage.

Menard, J. 2001. Norton Sound weir site investigation report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A01-33, Anchorage.

Menard, J., J. Soong, S. M. Kent, L. Harlan, and J. Leon. 2015. 2014 annual management report Norton Sound, Port Clarence, and Kotzebue. Alaska Department of Fish and Game, Fishery Management Report No. 15-39, Anchorage.

Mosher, K. H. 1969. Identification of Pacific salmon and steelhead trout by scale characteristics. United States Department of the Interior, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Washington D.C., Circular 317.

Perry-Plake, L. J., and A. B. Antonovich. 2009. Chinook salmon escapement in the Gulkana River, 2007-2008. Alaska Department of Fish and Game, Fishery Data Series 09-35, Anchorage.

Stewart, R. 2002. Resistance board weir panel construction manual. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A02-21, Anchorage.

Stewart, R. 2003. Techniques for installing a resistance board fish weir. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A03-26, Anchorage.

Stewart, R., J. M. Thalhauser, and C. A. Shelden. 2009. George River salmon studies, 2008. Alaska Department of Fish and Game, Fishery Data Series No. 09-70, Anchorage.

Stewart, R., C. Goods, and C. A. Shelden. 2010. Takotna River salmon studies, 2009. Alaska Department of Fish and Game, Fishery Data Series No. 10-52, Anchorage.

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

Todd, G. L. 2003. Norton Sound weir site investigations. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A03-19, Anchorage.

Wuttig, K. G. 1999. Escapement of Chinook salmon in the Unalakleet River in 1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-10, Anchorage.

APPENDIX

Appendix A1.–Daily and cumulative Chinook salmon passage at Unalakleet River weir, 2016.

Date	Daily Chinook	Cumulative Chinook
6/10	0	0
6/11	0	0
6/12	0	0
6/13	0	0
6/14	0	0
6/15	1	1
6/16	3	4
6/17	5	9
6/18	10	19
6/19	1	20
6/20	20	40
6/21	9	49
6/22	2	51
6/23	3	54
6/24	9	63
6/25	20	83
6/26	81	164
6/27	31	195
6/28	9	204
6/29	9	213
6/30	3	216
7/01	3	219
7/02	0	219
7/03	1	220
7/04	1	221
7/05	16	237
7/06	9	246
7/07 [a]	18	264
7/08	19	283
7/09	9	292
7/10	6	298
7/11	9	307
7/12	7	314
7/13 [a]	58	372
7/14	64	436
7/15	52	488
7/16	12	500
7/17	0	500
7/18	0	500
7/19	2	502
7/20	1	503
7/21	2	505
7/22 [a]	0	505

[a] Partial count day.

Appendix A2.–Relative water depth (cm) at Unalakleet River weir, 2016.

Date	Water depth (cm)
6/10	48.3
6/11	ND
6/12	52.1
6/13	50.8
6/14	47.0
6/15	ND
6/16	44.5
6/17	43.8
6/18	45.7
6/19	53.3
6/20	64.8
6/21	57.2
6/22	58.4
6/23	27.9
6/24	30.5
6/25	35.6
6/26	35.6
6/27	43.2
6/28	44.5
6/29	45.7
6/30	43.2
7/01	40.6
7/02	41.9
7/03	38.1
7/04	38.1
7/05	36.8
7/06	39.4
7/07	40.6
7/08	39.4
7/09	38.1
7/10	36.8
7/11	35.6
7/12	34.3
7/13	33.0
7/14	31.8
7/15	29.2
7/16	27.9
7/17	27.9
7/18	35.6
7/19	48.3
7/20	71.1
7/21	114.3
7/22	ND