Fishery Data Series No. 18-18

Unalakleet River Chinook Salmon Escapement Monitoring and Assessment, 2017

by

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and

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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)

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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ABSTRACT

Declining run sizes and ensuing state and federal restrictions and closures to Unalakleet River Chinook salmon *Oncorhynchus tshawytscha* fisheries have 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 Office of Subsistence Management. The goal was to obtain estimates of the Chinook salmon escapement and age, sex, and length composition. An estimated 2,934 Chinook salmon were enumerated during the 2017 season. The central 50% of the Chinook salmon run was enumerated between July 4 and July8, which was earlier and of a shorter duration than the average run timing of all project years. Female Chinook salmon accounted for 49% of the fish sampled. Age composition of the sampled fish was 49% age-1.3 and 31% age-1.2 Chinook salmon.

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 and 6 (Shaktoolik and Unalakleet; Figure 1) subsistence and commercial salmon fisheries (Menard et al. 2015). Chinook salmon *O. tshawytscha* runs to the Unalakleet River drainage have been chronically depressed since the late 1990s (Kent and Bergstrom 2015), although chum *O. keta*, coho *O. kisutch*, and pink *O. gorbuscha* salmon stocks to the Unalakleet River are considered healthy. The drainage also supports a small run of sockeye salmon *O. nerka*.

The Alaska Board of Fisheries (BOF) designated Unalakleet River Chinook salmon as a stock of yield concern in 2004 and it has since continued under that designation (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 to increase escapements and restore Unalakleet River Chinook salmon runs to historic levels of abundance.

Prior to the weir, 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. Collection of reliable Chinook salmon age, sex, and length (ASL) data from these 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 weir funded by United States Fish and Wildlife Service Office of Subsistence Management (USFWS OSM), 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 may result in shorter periods of unmonitored fish passage (Stewart et al. 2009, 2010). Therefore, escapement counts from resistance board weirs may be more consistent from year to year than other methods of enumeration.

The Unalakleet River weir project provides 2 priority data needs: 1) reliable estimates of Chinook salmon escapement, and 2) unbiased ASL composition from the spawning escapement. This report provides an overview of the 2017 season Unalakleet River weir project and describes Chinook salmon escapement, run timing, and ASL composition. Escapement, run timing, and ASL data about other salmon species are provided by year in the report series *Salmon escapements to the Norton Sound-Port Clarence Area*.

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 the age and sex composition of Unalakleet River Chinook salmon such that the estimate of age composition is within 20% of the actual estimates 90% of the time and the estimate of sex composition is within 10% of the actual estimate 95% of the time.

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 the 5 species of 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* (Sloan et al. 1986). The weir was 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).

WEIR DESIGN AND INSTALLATION

Weir design and materials followed those described by Tobin (1994) with modifications described 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 carabiner 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 continual 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. Large traffic cones topped with flashing strobe lights were affixed on either side of the boat pass to facilitate safe boat passage during low light periods.

The weir was routinely inspected for breaches to prevent unmonitored passage of Chinook salmon. Cleaning the weir consisted of raking debris and spawned-out fish carcasses from the upstream surface of the weir and walking across panels to submerge them so the current could wash debris downstream.

WEATHER AND STREAM OBSERVATIONS

Stream and ambient air temperature (°C), atmospheric observations (e.g., percent cloud cover) were measured twice daily at approximately 0800 hours and 2000 hours. A style “C” 4-foot tall staff gauge with graduation marks every 1/100th foot was installed on the live trap to measure relative water levels. A rain gauge provided precipitation data. Additionally, a HOBO[1] Pro v2 data logger (Onset Computer Corporation) was secured several inches off the bottom just upstream of the weir to record daily water temperatures. Weather conditions, air and water temperatures, and hydrological observations were recorded in a climatological and stream observation logbook.

BIOLOGICAL 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 and through the live trap. 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 LED 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, except Arctic grayling *Thymallus arcticus* and whitefish species, were identified to species and recorded on multiple tally counters. Counts were recorded in waterproof field 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 daily to the ADF&G Nome office.

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 before and after the missed days. If greater than 10 days were missed, then 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:

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

$$\hat{N}_i = \frac{\sum_{j=i-k}^{i+k} I_j \hat{N}_j}{\sum_{j=i-k}^{i+k} I_j},$$

where:

$$I_j = \begin{cases} 1 & \text{if counting was successfully conducted on day } j \\ 0 & \text{otherwise} \end{cases}.$$

AGE, SEX AND LENGTH COMPOSITION

Distribution and Sample Sizes

Minimum ASL sample sizes were determined following Bromaghin (1993) such that the estimate of age composition was within 20% of the actual estimates 90% of the time and the estimate of sex composition was within 10% of the actual estimate 95% of the time assuming 5 age classes and 2 sex categories (n = 230 in 2017). To ensure adequate temporal distribution, ASL samples were collected following a daily collection schedule in proportion to average historical escapement by day (Table 1). The 2010–2016 Unalakleet River Chinook salmon run timing was used to establish collection schedules.

Sample Collection Procedures

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 live trap the front and rear gates were closed to trap the fish. During periods of high numbers of pink salmon passage, conditions required 2 people for sampling. One crew member trapped and sampled fish, while a second technician enumerated passing salmon through the open weir panels.

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 mideye to tail fork (METF), to the nearest 1 mm. 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; Eaton 2015). Scales were cleaned of slime and debris, 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

In 2017, installation of the weir began on June 7 and the weir was fish tight the evening of June 8. Counting continued through the morning of August 10. Two days of counting were missed, August 4 and 5, when enumeration ceased due to high water. The average river height during weir operations was 0.35 m and ranged between 0.11 m and 1.18 m (Figure 3). Water temperature during weir operations averaged 12.6°C and daily average temperature ranged between 8.8°C and 17.0°C (Figure 3).

In 2017, a large number of pink salmon (6,094,350) contributed to occasional breaches forming under the weir rail that were plugged immediately with sand bags. During peak pink salmon passage days, the weir was inspected nearly every hour for breaches. Although a minor number of pink salmon may have passed through small breaches undetected, unmonitored passage of chum and Chinook salmon was unlikely due to the size of the holes. Additionally, Chinook and chum salmon passage following repair of these breaches did not increase, suggesting that unmonitored passage was minimal.

Chinook Salmon Escapement and Run Timing

During the 2017 season, an estimated 2,934 Chinook salmon passed through the Unalakleet River weir. The first Chinook salmon passed on June 11, which was 4 days earlier than the earliest recorded date of June 15, 2016. The central 50% of Chinook salmon run was July 4–8, the earliest and the shortest passage timing since the beginning of the project in 2010. In 2017, the median passage date was July 7 and the third quarter point date was July 9. Daily passage peaked on July 8 (548 Chinook salmon; Figure 4; Appendix A1).

Age, Sex, and Length Composition

The 2017 sampling objective was 230 Chinook salmon distributed evenly through quarterly intervals between June 25 and July 23, based on average historical escapements from 2010 to 2016 (Table 1). A total of 174 samples were collected from June 24 to July 26. Although the minimum ASL sample size requirements were met for the season (n = 125 for age composition, and n = 71 for sex composition), samples were not collected evenly throughout the run. Specifically, 47% of the samples (n = 63) were collected during the first quarter of the run (June 25 to July 3), 16% of the samples (n = 28) were collected from the central 50% of Chinook salmon run from July 4–8, and 37% of the samples (n = 80) were collected during the last quarter, July 10–15.

Mean length for all sampled fish was 588 mm (SD = 131). Females averaged 651 mm (SD = 143) in length and made up 49.3% of the total fish sampled. Mean length of male Chinook salmon was 532 mm (SD = 89; Table 2). In the first quarter of the run, females made up 23.8 % of the passage and average length was 510 mm (SD = 93) for males and 683 mm (SD = 157) for females. The last quarter of the run was dominated by females (67.1%) and average length was 542 mm (SD = 53) for males and 640 mm (SD = 140) for females. Age-1.3 were the predominant age class (48.6%) and age-1.2 was the second most abundant (31.0%; Table 2).

DISCUSSION

The 2017 season was completed successfully, beginning and ending consistent with most other years and with only a few days of missed counts. Despite meeting the minimum ASL sample goal in 2017, the distribution of ASL data was not considered representative of the entire run. Compressed and early run timing was partially responsible for the inadequate number of ASL samples collected. The central 50% of the run (n = 1,616) occurred in under 5 days and 74.2% of the run (n = 2,178) passed in 8 days. Further, in 2017, the median passage date was July 7 and the third quarter point date was July 9; both were earlier than the 5-year historical median passage date of July 11 and the third quarter point date of July 17 (Kent et al. 2016; Bell and

Leon[2]). An additional issue that has made it challenging to obtain samples from Chinook salmon was the large number of pink salmon returning to the Unalakleet River in recent years. There were times during the 2017 season when daily salmon passage was so large that additional people were needed to maintain the weir and were not available to conduct sampling. Further, to accommodate passage of pink salmon, panels of the weir were removed, which made it nearly impossible to capture Chinook salmon for sampling.

To alleviate the issues created by large numbers of pink salmon such as scouring along the rail and removing panels to count, it has been proposed to adjust the picket spacing on the weir panels. Wider picket spacing that allows unmonitored pink salmon passage (4.8 cm – inside edge to inside edge) has been extensively used by projects where Chinook salmon monitoring and management is a priority and where large pink salmon runs occur (Stewart 2003; Mears 2014; Miller et al. 2015). Furthermore, weirs with larger picket spacing can withstand higher water levels (Miller et al. 2015) which will increase the likelihood that the weir remains operational during high water events. As existing weir panels need replacing, we will incorporate new panels with increased picket spacing. It is expected that panels will not need to be removed and salmon will be directed through the weir using the live traps, which will allow for more comprehensive sampling of the run.

In addition to changing picket spacing, the crew lead and fishery managers will work more closely to monitor daily passage to evaluate run strength and timing. Working together we can provide additional staff and adjust sampling protocols as needed. Although the 2017 Chinook salmon run timing was atypical in the relatively short history of the project, as the project continues to operate we will get a clearer understanding of variability of run timing and be able to apply the information inseason to adjust sampling schedules more effectively.

The Unalakleet River weir project is a crucial assessment tool for Chinook salmon run strength and timing in Subdistricts 5 and 6 (Shaktoolik and Unalakleet) in Norton Sound. Chinook salmon run timing and abundance data from this project are major contributors to inseason management of commercial, subsistence and sport fisheries in southern Norton Sound. The Unalakleet River weir project allows for Chinook salmon subsistence openings early in the season. With the eighth year completed, the project is still several years away from having enough data to develop scientifically defensible escapement goals. However, the project has clarified assumptions about Chinook salmon in the drainage. For example, telemetry studies completed in 1997–1998 and 2009–2010 suggested North River accounted for approximately 40% of the Chinook salmon returning to the drainage in any year (Wuttig 1999; Joy and Reed 2014). Comparisons between the weir and a long running tower project on North River now suggest the proportion of Chinook salmon migrating up the North River may not be consistent across years. Although we need to collect several more years of data before we can consider escapement goals, the Unalakleet River weir project continues to provide critical information for evaluating the effect of harvest practices and management strategies on the size and composition of the Chinook salmon spawning escapement to the Unalakleet River drainage.

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[2] Bell, J., and J. M. Leon. *In prep*. Salmon escapements to the Norton Sound-Port Clarence Area, 2015–2016. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

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TABLES AND FIGURES

Table 1.–Chinook salmon age, sex, and length sampling intervals and daily collection goals at Unalakleet River weir, 2017.

	Quartile date	Sampling period dates	Number of samples collected /day	Cumulative sample total
Quarter point	6 Jul	6/25–7/06	5	60
Midpoint	11 Jul	7/07–7/11	12	120
Three-quarter point	17 Jul	7/12–7/17	10	180
~90% point	23 Jul	7/18–7/23	10	240

Table 2.–Chinook salmon age, sex, mean length data (METF in mm), and standard deviation (SD) of length, Unalakleet River weir, 2017.

Sample dates:	6/24–7/26	Brood year and age class					
Aged samples:	142	2014	2013	2012	2011	2010	
		1.1	1.2	1.3	1.4	1.5	Total
Male	Percent of sample	1.4	21.8	24.6	1.4	1.4	50.7
	Number of samples	2	31	35	2	2	72
	Mean length (mm)	338	515	538	746	701	532
	SD (length)	20	60	73	64	46	89
Female	Percent of sample	0.0	9.2	23.9	12.0	4.2	49.3
	Number of samples	–	13	34	17	6	70
	Mean length (mm)	–	534	572	812	874	651
	SD (length)	–	52	58	78	38	143
Total	Percent of sample	1.4	31.0	48.6	13.4	5.6	100.0
	Number of samples	2	44	69	19	8	142
	Mean length (mm)	338	521	55	805	831	588
	SD (length)	20	58	67	78	88	131

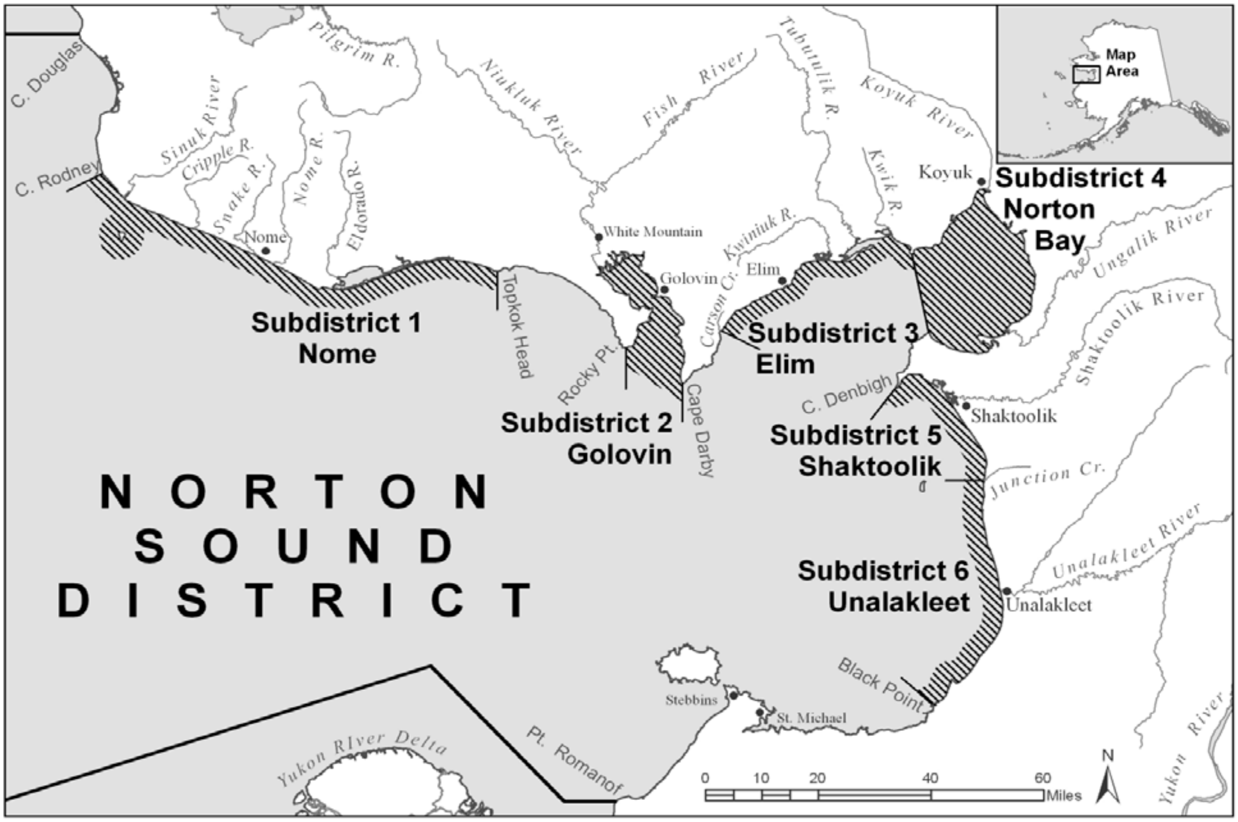

Figure 1.–Commercial salmon fishing subdistricts and major salmon-producing watersheds in the Norton Sound District.

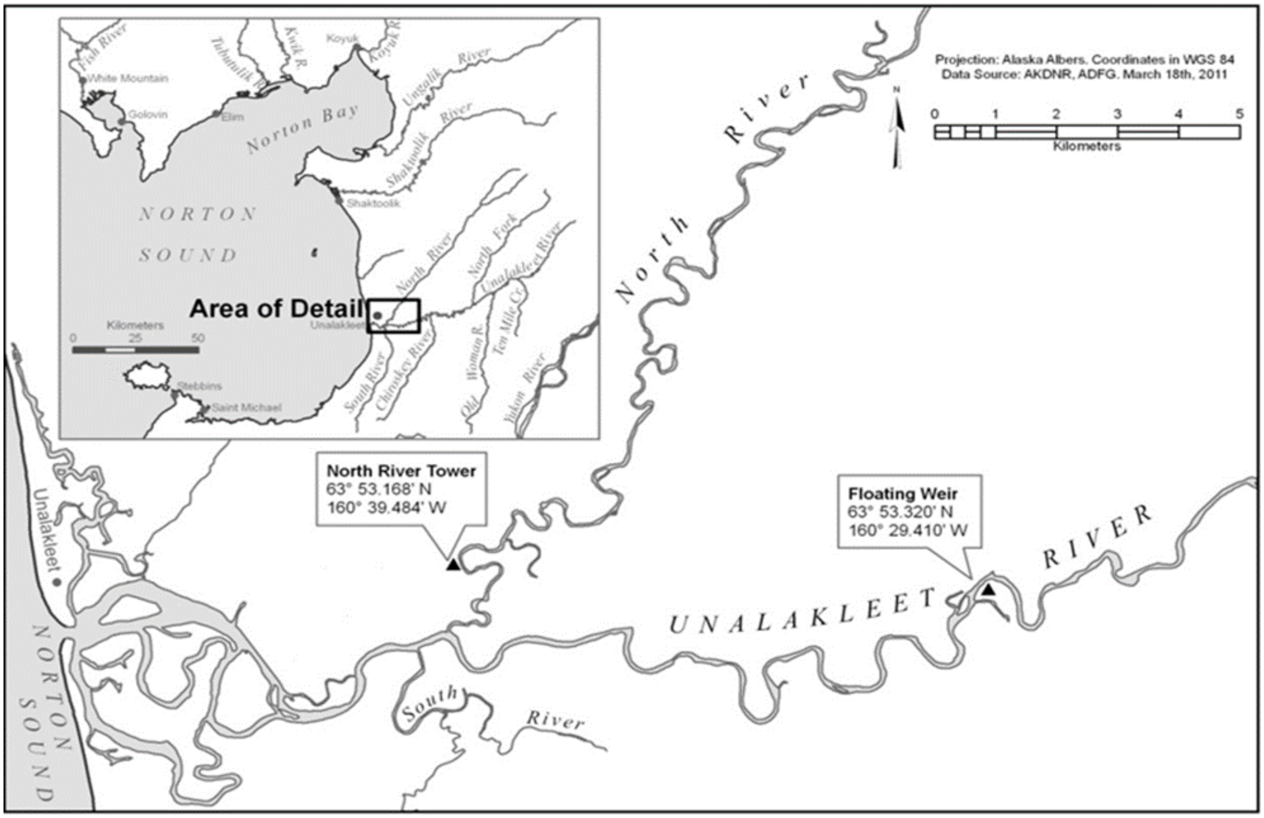

Figure 2.–Salmon stock assessment projects within the Unalakleet River drainage.

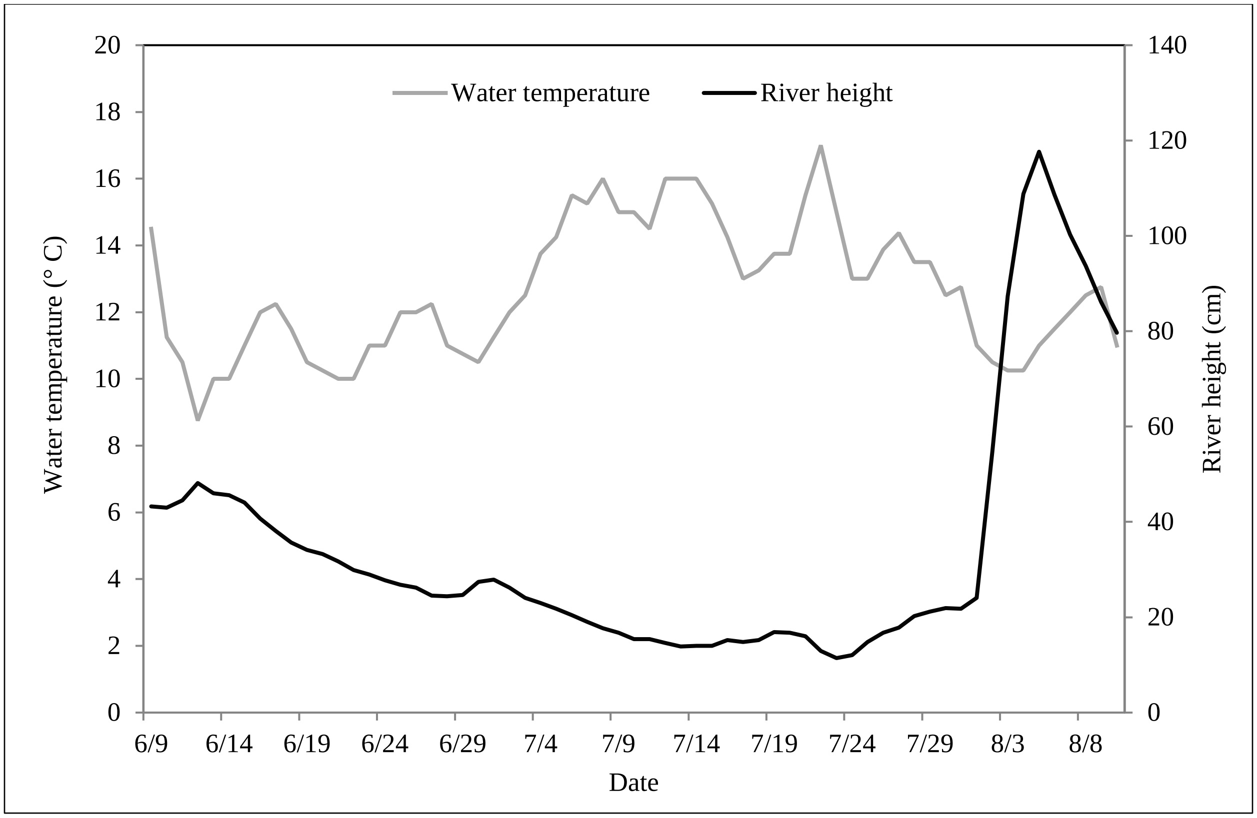

Figure 3.–Average daily water temperature (°C) and average daily river height (cm) at Unalakleet River weir, 2017.

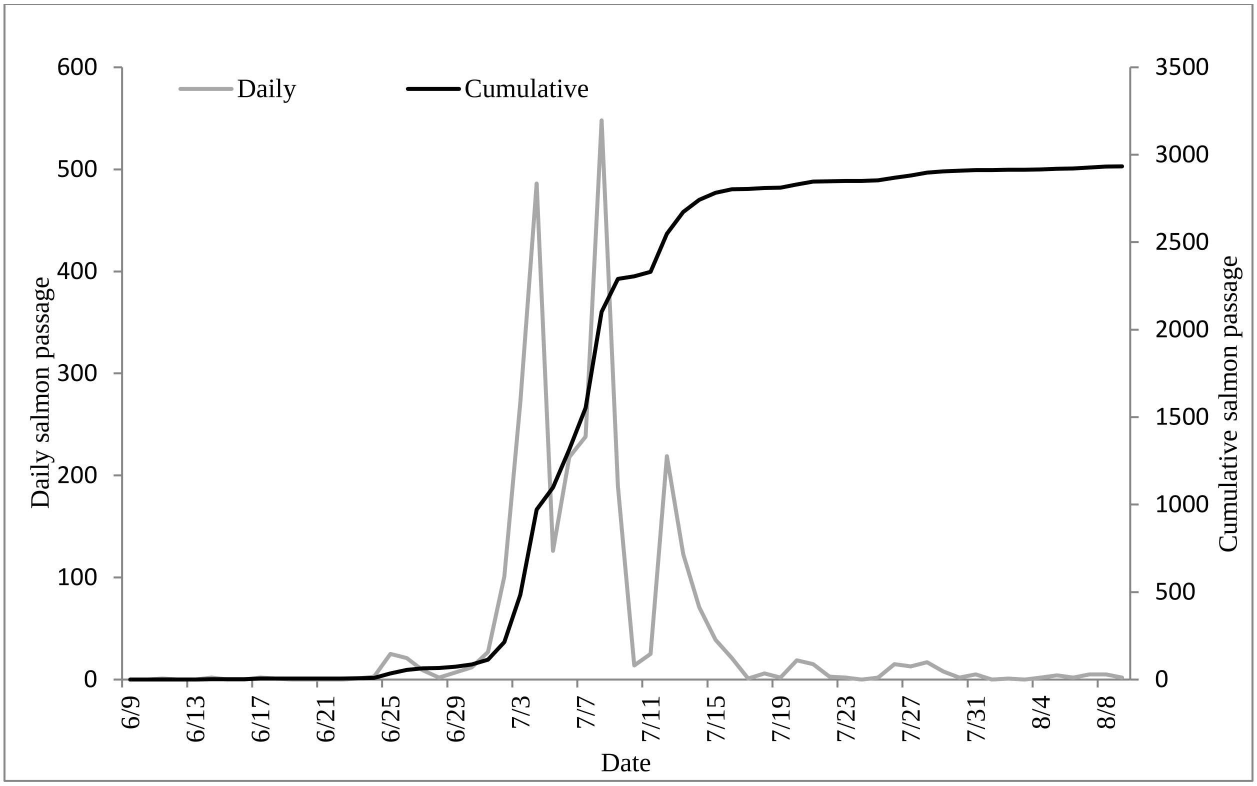

Figure 4.–Daily and cumulative Chinook salmon escapement, Unalakleet River weir, 2017.

APPENDIX A

Appendix A1.–Daily and cumulative estimates of Chinook salmon passage at Unalakleet River weir, 2017.

Date	Daily	Cumulative
6/09	0	0
6/10	0	0
6/11	1	1
6/12	0	1
6/13	0	1
6/14	2	3
6/15	0	3
6/16	0	3
6/17	2	5
6/18	1	6
6/19	0	6
6/20	0	6
6/21	0	6
6/22	0	6
6/23	1	7
6/24	3	10
6/25	25	35
6/26	21	56
6/27	9	65
6/28	2	67
6/29	7	74
6/30	12	86
7/01	27	113
7/02	101	214
7/03	272	486
7/04	486	972
7/05	126	1,098
7/06	218	1,316
7/07	238	1,554
7/08	548	2,102
7/09	189	2,291
7/10	14	2,305
7/11	25	2,330
7/12	219	2,549
7/13	123	2,672
7/14	71	2,743
7/15	39	2,782
7/16	21	2,803
7/17	1	2,804

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Date		Daily	Cumulative
7/18		6	2,810
7/19		2	2,812
7/20		19	2,831
7/21		15	2,846
7/22		3	2,849
7/23		2	2,851
7/24		0	2,851
7/25		2	2,853
7/26		15	2,868
7/27		13	2,881
7/28		17	2,898
7/29		8	2,906
7/30		2	2,908
7/31		5	2,913
8/01		0	2,913
8/02		1	2,914
8/03	[a]	0	2,914
8/04	[b]	2	2,916
8/05	[b]	4	2,920
8/06	[a]	2	2,922
8/07		5	2,927
8/08		5	2,932
8/09		2	2,934
8/10	[a]	0	2,934

Note: Inner box indicates median passage date and outer box delineates the central 50% of the run.

[a] Partial-day count.

[b] Interpolated count.

Appendix A2.–Daily river height and water and air temperatures at Unalakleet River weir, 2017.

	Water temperature (°C)		Water height (cm)		Air temperature (°C)	
Date	AM	PM	AM	PM	AM	PM
6/09	-	14.5	-	43.3		20.0
6/10	11.5	11.0	43.3	42.7	15.0	15.0
6/11	10.0	11.0	43.3	45.7	11.0	15.0
6/12	9.0	8.5	48.8	47.5	11.0	10.0
6/13	8.5	11.5	45.7	46.3	9.5	20.0
6/14	9.0	11.0	45.4	45.7	12.0	22.0
6/15	10.0	12.0	45.1	43.0	10.0	19.0
6/16	11.0	13.0	41.5	39.9	13.0	17.0
6/17	11.5	13.0	39.0	37.2	12.0	14.0
6/18	11.0	12.0	36.0	35.4	9.8	13.0
6/19	10.0	11.0	34.7	33.5	9.0	12.0
6/20	10.0	10.5	33.5	32.9	10.0	11.0
6/21	10.0	10.0	32.3	31.1	9.0	10.0
6/22	9.0	11.0	30.5	29.3	8.5	12.0
6/23	9.0	13.0	29.3	28.7	10.0	15.0
6/24	10.0	12.0	28.0	27.4	9.0	13.0
6/25	10.0	14.0	27.4	26.2	7.0	22.0
6/26	12.0	12.0	26.2	26.2	15.0	13.0
6/27	12.0	12.5	24.7	24.4	11.0	17.0
6/28	11.0	11.0	24.4	24.4	12.0	11.5
6/29	10.0	11.5	24.4	25.0	11.0	14.5
6/30	10.0	11.0	27.4	27.4	10.5	17.0
7/01	11.0	11.5	27.7	28.0	11.5	14.0
7/02	11.0	13.0	26.8	25.6	11.0	11.0
7/03	12.5	12.5	24.4	23.8	11.5	13.0
7/04	12.5	15.0	23.5	22.6	11.5	19.0
7/05	13.0	15.5	22.3	21.3	7.0	22.0
7/06	15.0	16.0	20.7	20.1	14.5	24.0
7/07	13.5	17.0	19.8	18.3	13.5	24.0
7/08	15.0	17.0	17.7	17.7	13.5	20.0
7/09	15.0	15.0	17.1	16.5	14.0	20.0
7/10	13.0	17.0	15.5	15.2	11.5	21.0
7/11	14.0	15.0	15.2	15.5	14.0	15.0
7/12	15.0	17.0	14.6	14.6	14.0	16.0
7/13	15.0	17.0	14.0	13.7	13.0	19.0
7/14	-	17.0	-	14.0	-	-
7/15	15.0	15.5	13.1	14.9	14.0	15.0
7/16	14.0	14.5	15.5	14.9	13.0	18.0

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	Water temperature C°		Water height		Air temperature C°	
Date	AM	PM	AM	PM	AM	PM
7/17	13.0	13.0	14.6	14.9	14.5	14.5
7/18	12.0	14.5	14.9	15.5	13.5	18.0
7/19	12.5	15.0	17.1	16.8	13.0	19.0
7/20	13.5	14.0	16.8	16.8	15.0	16.0
7/21	15.0	16.0	16.8	15.2	14.0	17.0
7/22	17.0	17.0	13.7	12.2	14.0	17.0
7/23	15.5	14.5	11.9	11.0	15.0	13.5
7/24	13.0	13.0	11.6	12.5	12.0	15.0
7/25	12.0	14.0	14.3	15.2	13.0	14.0
7/26	12.8	15.0	16.5	17.1	13.0	18.0
7/27	13.8	15.0	17.4	18.3	10.0	18.0
7/28	14.0	13.0	20.7	19.8	13.0	15.0
7/29	12.0	15.0	21.0	21.3	13.0	19.0
7/30	12.0	13.0	21.9	21.9	11.0	15.0
7/31	13.0	12.5	21.6	21.9	15.0	14.0
8/01	11.0	11.0	22.6	25.6	12.5	15.0
8/02	10.0	11.0	46.9	62.5	12.0	17.0
8/03	10.0	10.5	82.9	91.7	13.0	17.0
8/04	10.0	10.5	105.5	112.2	13.0	19.0
8/05	10.0	12.0	118.3	117.0	17.0	23.0
8/06	10.0	13.0	112.2	105.2	12.0	23.0
8/07	11.0	13.0	104.5	96.0	11.0	19.0
8/08	11.0	14.0	93.0	94.5	12.0	20.0
8/09	10.5	15.0	89.9	82.3	11.5	20.0
8/10	11.0	11.0	79.9	79.6	13.0	-