Regional Operational Plan SF.2A.2016.15

Operational Plan: Crooked Creek Chinook Salmon Enhancement Project, 2016–2018

by

Jenny L. Cope

July 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

REGIONAL OPERATIONAL PLAN SF.2A.2016.15

OPERATIONAL PLAN: CROOKED CREEK CHINOOK SALMON ENHANCEMENT PROJECT 2016–2018

by

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Period Covered	2016 - 2018
Field Dates:	May 24 August 15
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Approval

Title	Name	Signature	Date
Project leader	Jenny L. Cope		4/28/16
Biometrician	Adam Reimer		4-28-16
Research Coordinator	Tim McKinley		7/29/16

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ABSTRACT

The Crooked Creek Chinook Salmon Enhancement Project is designed to monitor both naturally- and hatchery-produced Chinook salmon escapement as well as collect broodstock and conduct egg takes to provide additional sport fishing opportunities within the Kasilof River and other terminal fisheries on the Kenai Peninsula. This project will imprint Chinook salmon smolt for 7 to 10 days at the beginning of June. Additionally, age, sex, length, and genetic samples will be collected from returning naturally- and hatchery-produced Chinook salmon. The sustainable escapement goal for Crooked Creek is 650–1,700 naturally-produced Chinook salmon.

Key words: Crooked Creek, *Oncorhynchus tshawytscha*, Chinook salmon, weir, ASL composition, broodstock, egg take, smolt, imprinting, escapement, return, inriver run, digital video recorder, coded wire tag, adipose finclip, otolith marking, hatchery, hatchery-produced, naturally-produced, enhancement, escapement.

INTRODUCTION

PURPOSE

The overall goal of this research program is to reconstruct naturally- and hatchery-produced returns of Chinook salmon to Crooked Creek such that a biological escapement goal (BEG) can be established.

BACKGROUND

Crooked Creek is a tannin-stained stream flowing into the glacial waters of the Kasilof River approximately 11 kilometers (km) upstream of the Kasilof River's mouth in Cook Inlet. The Kasilof River (flowing from its outlet at Tustumena Lake) is approximately 31 km to Cook Inlet (Figure 1). Its origin in the glaciers of the Kenai Mountains makes it turbid throughout the year. Four species of Pacific salmon—Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), sockeye (*O. nerka*), and pink (*O. gorbuscha*) salmon—are present in the drainage, as well as anadromous and resident rainbow trout (*O. mykiss*), Dolly Varden (*Salvelinus malma*), resident lake trout (*S. namaycush*) and round whitefish (*Prosopium cylindraceum*) (Johnson and Weiss 2006). Sport fisheries exist for all Pacific salmon species present, although most of the sport fishing effort is directed at early-run Chinook salmon destined for Crooked Creek. This operational plan describes Alaska Department of Fish and Game (ADF&G) Chinook salmon enhancement, escapement enumeration, and biological sampling at the Crooked Creek Facility.

Crooked Creek Facility and Operations

Crooked Creek originally had a stock of wild Chinook salmon, which has been supplemented with hatchery-produced Chinook salmon smolt of Crooked Creek origin. The stocking program began in 1974 and since then (except 1997 and 1998) the annual escapement has been monitored through a weir at the Crooked Creek Facility (Todd *Unpublished*). Naturally-produced fish (fish from naturally spawning parents) made up 96% of the escapement in 1978, but these fish declined in proportion as hatchery production increased during the 1980s. Since 2002, the proportion of naturally-produced fish (fish denoted by the presence of an adipose fin) in the escapement has remained consistently higher than 50% and is likely to continue due to regulation changes affecting harvest in the Kasilof River sport fishery and the reduction of the enhanced component (numbers of hatchery-produced smolt released). The Crooked Creek Hatchery Facility was operated by ADF&G until 1995, when Cook Inlet Aquaculture Association (CIAA) assumed operations. Escapement monitoring continued until 1997, when the facility was returned to ADF&G. There was no escapement monitoring at the Crooked

Creek Facility during 1997 and 1998. During this time, smolt continued to be stocked despite inactivity at the facility. ADF&G resumed escapement monitoring in 1999. From 1988 to 1996, the number of naturally-produced Chinook salmon was held to approximately 700 fish in the spawning escapement of Crooked Creek upstream from the hatchery. The current management policy, adopted in 2001, requires ADF&G to achieve a sustainable escapement goal (SEG) at the Crooked Creek weir of 650–1,700 age-1.2+ naturally-produced adult Chinook salmon during the early run (Bue and Hasbrouck *Unpublished*).

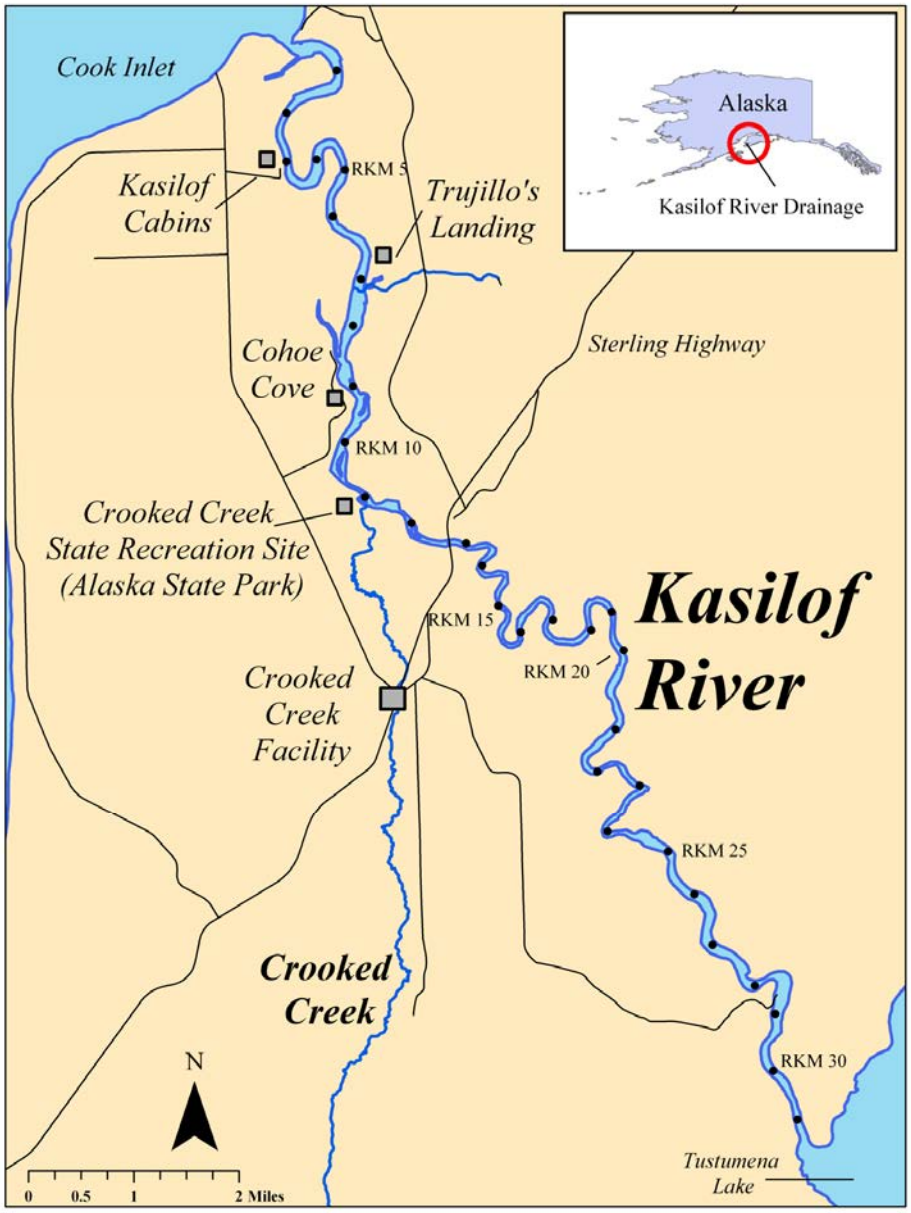

Figure 1.–Map showing Crooked Creek Facility, Kasilof River, and river access locations.

Historically, hatchery-produced smolt from Crooked Creek Chinook salmon stock have been stocked at different sites to create or enhance sport fisheries. Presently, this stock is used to

enhance Crooked Creek itself, 1 stocked lake on the Kenai Peninsula, and terminal fisheries in Resurrection Bay and Kachemak Bay. From 1974 through 1994, broodstock collection and egg takes were conducted at the Crooked Creek Hatchery. In 1995, broodstock collection moved to the Nick Dudiak Fishing Lagoon (Homer Spit) where progeny from Crooked Creek Chinook salmon were returning. Adult fish were captured at the Homer Spit, transported to Elmendorf Hatchery, and held for egg takes. Spawning success was low, varying from 34% in 1995 to 66% in 1996 (D. Keifer, ADF&G, Elmendorf Hatchery, personal communication). Hormone ripening tests were conducted in 1997 and 1998 (at the Homer Spit) with generally poor results. Because of these problems and incidences of straying in adult Chinook salmon, egg takes and smolt imprinting were moved back to the Crooked Creek Facility. Starting in 1999, smolt were held at the facility for imprinting to address straying problems, egg takes were conducted onsite to improve spawning success, and fertilized gametes were taken to Fort Richardson Hatchery for incubation. Beginning in 2011, gametes have been transported separately to the William Jack Hernandez Sport Fish Hatchery (WJHSFH) where they are later fertilized in a process called delayed fertilization and incubated.

Concerns about straying have resulted in other changes in stocking policy. Beginning in 2000, the stocking level was decreased from approximately 210,000 smolt in 1999 to approximately 105,000 smolt, and all smolt are marked with an adipose finclip (AFC), a coded wire tag (CWT), and a thermal otolith mark. In previous years, the marking rate was highly variable, ranging from 12.5% to 50.0%. Currently, it is estimated that the marking rate is 100% for each of the 3 marks. Coded wire tags were discontinued for a short period of time beginning with the 2011 smolt release year but were resumed with the 2015 smolt release year; however, adipose finclips and thermal marks were used for marking hatchery-produced fish during this time and these are still currently implemented. In 2014 due to increased hatchery capacity, the stocking level was increased to 140,500 smolt.

OBJECTIVES

PRIMARY OBJECTIVES

The annual primary objectives of this study during 2016–2018 are as follows:

1) Census the escapement of naturally- and hatchery-produced Chinook salmon in Crooked Creek that pass through the weir from late May to the middle of August.
2) Estimate the age composition, sex composition, and age-by-sex composition of the naturally- and hatchery-produced Chinook salmon in Crooked Creek, such that the estimated proportions are within 10 percentage points of the true value 90% of the time.

SECONDARY OBJECTIVES

Annual secondary objectives of this project are as follows:

1) Hold, imprint, and release approximately 140,500 Chinook salmon smolt at the Crooked Creek Facility in June.
2) Collect, hold, and artificially spawn a minimum of 101 male and 101 female naturally- and hatchery-produced Chinook salmon adults returning to Crooked Creek during July

to produce approximately 140,000 smolt to release into Crooked Creek and up to 315,000 smolt for other releases in 2017[1].

3) Monitor upstream migration of returning adult sockeye salmon during the Chinook salmon run from late May to the middle of August.

4) Summarize coded wire tags recovered from Chinook salmon stocked into Crooked Creek in previous years including recoveries found outside of the Kasilof River drainage.

5) Estimate the mean length-at-age of the naturally- and hatchery-produced Chinook salmon in Crooked Creek that pass through the weir from late May to the middle of August.

6) Collect axillary process tissue samples from age-1.2 and older naturally-produced and hatchery-produced Chinook salmon (target sample size of 200 each) migrating through the weir in 2016 [2].

7) Hatchery-produced jack Chinook salmon (ocean-age-1 salmon, typically under 20 inches in total length) will be culled opportunistically during broodstock collection days or biological sampling days[3].

METHODS

STUDY DESIGN

Escapement Sampling

ADF&G personnel will monitor the weir from late May until approximately the middle of August or until the daily count of Chinook salmon through the weir is less than 1% of the cumulative seasonal count for 3 consecutive days. Fish will be allowed unobstructed passage through a chute located and attached to the gate in Raceway 2 (Figure 2). The fish passage chute is approximately 6 inches wide at the exit end and reentry of fish is rare.

A digital video recorder (DVR) will be used to record fish passage through the Crooked Creek Facility (Figure 2). The digital video system will be located in Raceway 2 (Figure 2). One underwater video camera will be located inside a sealed video box that will be attached to the fish passage chute. The video box will be constructed of 3.2 mm aluminum sheeting and will be filled with filtered or bottled water to keep it submerged under the water in the raceway. One-half inch thick glass will be installed on the front of the video box to allow for a scratch free, clear surface through which video footage of passing fish will be captured. Video images will be recorded using a computer-based digital video recorder (DVR) located inside a building near the raceway. Two 12 V underwater pond lights will be mounted inside the video box to provide a consistent source of light during all hours of the day and night. The underwater pond lights are wired to an inverter located in the small building adjacent to the raceways and operates off of AC power.

[1] These numbers are provided by William Jack Hernandez Sport Fish Hatchery staff and may change in response to stocking demands and production at other broodstock collection sites.

[2] The target sample size was provided by the ADF&G Gene Conservation Laboratory. Genetic samples will be collected for the next 5 consecutive years.

[3] This is a new secondary objective for 2016. Hatchery-produced jacks will be culled as time permits without sacrificing other project objectives.

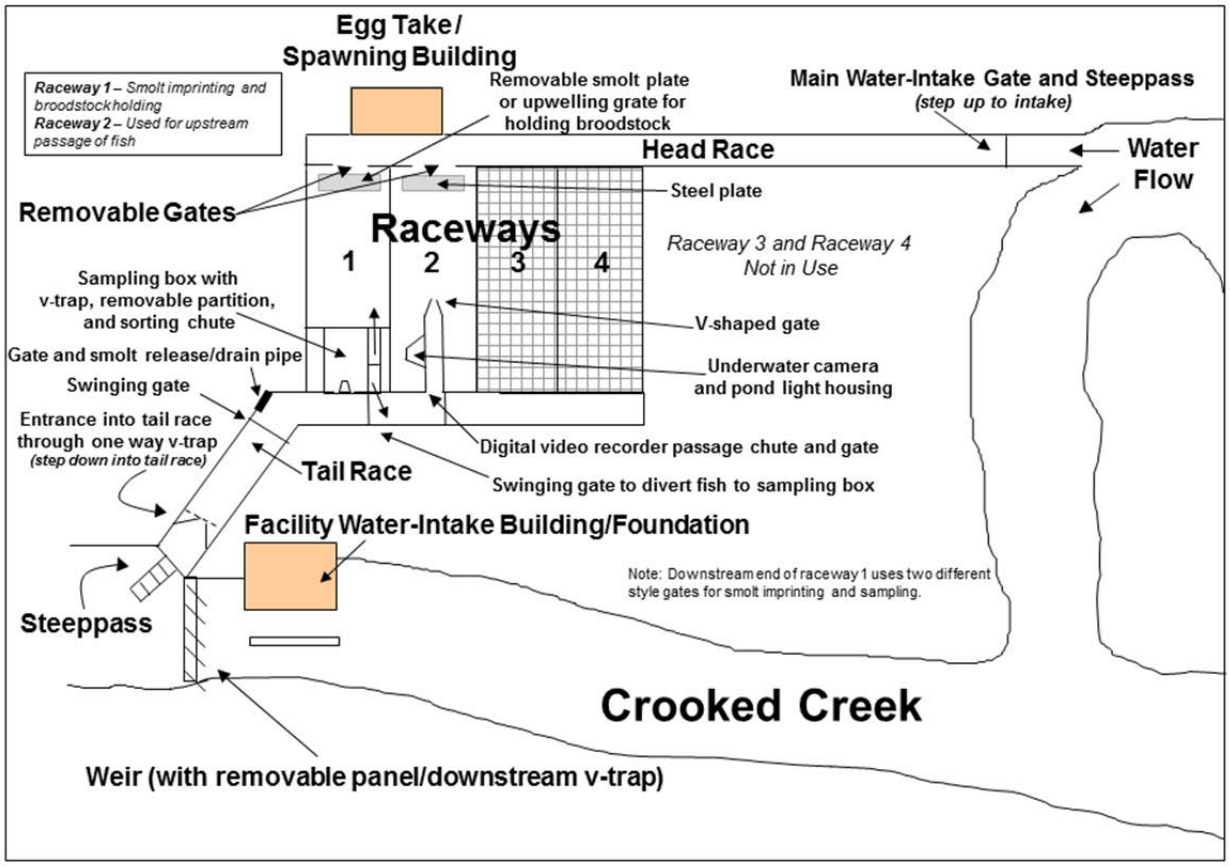

Figure 2.–Diagram of the layout of the Crooked Creek Facility, weir, and passage chute.

Video information will be reviewed on weekdays by ADF&G personnel. All Chinook salmon will be examined for the presence of an AFC from recorded video footage. The hatchery contribution to the adult escapement into Crooked Creek can be obtained directly from the count of AFC Chinook salmon counted at the weir each year because all returning adults are from stocking release groups that were 100% marked, and all Chinook salmon are inspected for AFC marks by examining recorded video footage. Other species of adult fish such as Dolly Varden, rainbow or steelhead trout, pink salmon, sockeye salmon, and coho salmon will be enumerated. Occasionally, Pacific lamprey also pass through the weir and will be noted. Juvenile salmonids will not be identified or enumerated. All observed data will be recorded on the DVR Passage Data Form (Appendix A1). Chinook salmon longer than a 20-inch reference mark located within the DVR passage chute will be considered ocean-age-2+ fish; those shorter than the mark will be considered jacks (ocean-age-1 Chinook salmon)[4]. Limited historical data from 1999 indicate that mid eye to tail fork (METF) lengths of ocean-age-1 fish were within a range of 311–428 mm (20 inches = 508 mm). We feel that the 20-inch reference mark used to enumerate jack Chinook salmon is a valid assumption for the length cutoff.

All mortalities that occur within the facility before the DVR (i.e., within the V-trap within the tail raceway) will be recorded in the comments sections of the DVR Passage Data Form

[4] Sport fishing regulations define bag limits for Chinook salmon shorter or longer than 20 inches of length. Because of this, we consider Chinook salmon less than 20 inches to be jacks or ocean-age-1 Chinook salmon.

(Appendix A1). Any mortalities that occur upstream of the DVR system in Pond 2 or the head raceway will also be recorded on this data form. These mortalities will either be added or subtracted from the escapement. Although rare, other situations, such as physically moving fish by net upstream of the facility, will also be recorded on the DVR Passage Data Form.

In the event of a DVR malfunction, the gate to the upstream DVR passage chute and the swinging gate at the sampling structure will be closed as soon as possible. All fish will be held in the tail race and diverted to the sampling structure box (Figure 2) for biological sampling or broodstock collection; fish will be counted and passed upstream manually each day until the DVR is operable. Staff will not be stationed at the weir after normal working hours or on weekends, but in the case of an electrical malfunction, a battery backup and alarm system will be connected to a power source at the Crooked Creek Facility. This system will ensure a minimal amount of data is lost in the event of a power outage. An alarm system will automatically call ADF&G personnel and notify them of the problem and corrective measures will be taken immediately. The battery backup system should provide power to the DVR system until someone can get to the weir.

New weir designs were implemented during the 2009 and 2010 field seasons to allow for improved juvenile fish and emigrating steelhead kelt passage. A daily count will be kept of any steelhead or other fish mortalities as well as for emigrating fish that may be trapped, requiring assistance to pass the weir. The daily count data will be recorded on the Weir Mortalities and Trapped Emigrating Fish Data Form (Appendix A2). The weir will be cleaned to remove debris as necessary to ensure adequate water flow.

Due to gravel movement in an upstream braided channel above the Crooked Creek Facility, the water flow into the main water intake gate may be greatly diminished. In 2004, 2005, 2008, and 2011–2015, ADF&G personnel obtained an ADF&G, Division of Habitat, Fish Habitat Permit and dredged this area to a depth of approximately 4 feet using a large track hoe. This dredging has increased the water flow into the main water intake gate, head trough, and subsequently into Raceways 1 and 2 (Figure 2). The creek inspection will be completed by late April and if it is needed, dredging will be completed by early May if snow depth and spring weather permits and if the Department of Transportation spring road restrictions do not limit heavy equipment transportation. Other measures will be taken to divert water as well. In the event of low water levels, a fence made with specialty fabric will be installed in Crooked Creek at a slight angle such that it parallels the current. It will divert water from the main channel to the channel that feeds water to the facility. An ADF&G, Division of Habitat, Fish Habitat Permit will be obtained for this activity as well.

Other changes were made to sampling operation and facility maintenance in 2009. Because the tail race wall was identified as a life safety hazard in 2008, necessary measures were taken to enable the safety of personnel while handling and sampling fish. Instead of sampling and sorting fish in the tail trough, a sampling box and V-trap attached to the gate were installed in Raceway 1. The sampling box has an attached chute that provides ease in sorting fish. Fish will be passed into the broodstock collection area or back into the tail race wall and through the DVR passage chute to be enumerated during video review. Although this system minimizes the amount of time individuals spend in the immediate vicinity of the tail race wall, it does not keep people from working in the area. Some sorting and crowding does occur in the trail race in order to move fish into the sampling box area on broodstock collection days and sampling days. Other changes were also made which included moving the gate near the DVR box closer to the sliding

gate at the downstream edge of Raceway 1. This helps direct Chinook salmon into the sampling box for entrapment (Figure 2). All incorporated structures will be utilized in the upcoming field seasons, although an updated sampling structure will be installed in 2016.

Smolt Imprinting and Release

Dependent on spring weather and in preparation of DVR installation and smolt delivery, Raceways 1 and 2 at the Crooked Creek Facility will have remaining ice removed and be cleaned using high-pressure water hoses or by running a small amount of creek water through the raceways and manually sweeping sediment out of the facility in late May. Once debris and sediment are removed, the raceways will be disinfected with a water and Betadyne[5] solution of 200 parts per million (A. Tesch, ADF&G, WJHSFH, personal communication). Preferably, this will be done on a sunny day to increase the effectiveness of the microbicide treatment. The raceway will then be flooded with water such that the water level is maintained within 1 ft of the top. One technician and the project biologist will be involved in the preparation. The DVR system will be operational during the smolt imprinting period.

Chinook salmon smolt (approximately 140,500 fish with an expected 100% AFC, CWT, and thermal otolith marks) will be transported from WJHSFH to the Crooked Creek Facility during the first week of June. A network of ultraviolet stabilized polyethylene fabric panels will be hung over the raceway to protect the imprinting smolt from feeding activities of birds and sun burn. ADF&G personnel will be on duty to feed the smolt a minimum of twice daily and monitor operations. Smolt will be held for approximately 7 to 10 days for imprinting. A daily smolt mortality census will be conducted and recorded on a Smolt Imprinting and Release Data Form (Appendix A3). Dead smolt will be examined for an AFC and will be measured (total length in millimeters). If mortality levels become a concern, smolt may be released sooner. Other information including water temperature, dissolved oxygen content, and quantity of food fed will be recorded on a Smolt Imprinting and Release Data Form (Appendix A3). Water quality recordings will be taken for the inlet and outlet of the raceway. If ADF&G personnel encounter any problems with water flow into Raceway 1 during the 7 to 10 days of imprinting, the gate to the DVR passage chute and the fish ladder located downstream of the weir will be closed allowing increased flow into Raceway 1 but restricting adult passage until imprinting is complete.

After the smolt are released, Raceway 1 will be dewatered, cleaned, and disinfected in preparation for biological sampling and holding adult Chinook salmon for broodstock. Raceway 2 will not be drained and the DRV system will remain in place during this time.

Biological Sampling

Sample size for estimation of the age and sex composition of the escapement of naturally-produced adult Chinook salmon was determined by applying a finite population correction (FPC) factor (Cochran 1977) to the sample size given by Thompson (1987) as follows:

$$n_a = \frac{n_o}{1 + \frac{n_o - 1}{N}}, \tag{1}$$

[5] Product names used in this publication are included for completeness but do not constitute product endorsement.

where

n_o = sample size goal without the FPC, (101 adult Chinook salmon via Thompson [1987]), and

N = total number of adult Chinook salmon expected to migrate past the weir.

Assuming that approximately 1,581 age-1.2+ naturally-produced Chinook salmon migrate to the weir during 2016[6], then 95 valid ages are required. Given that age cannot be determined on approximately 15% of the scale samples, sampling 112 adult Chinook salmon (about 7% or a sampling rate of 1:14 fish in the run) would meet the stated objective criterion.

Assuming that approximately 756 age-1.2+ hatchery-produced Chinook salmon migrate to the weir during 2016[7], then 89 valid ages are required. Given that age cannot be determined on approximately 15% of the scale samples, sampling 105 adult Chinook salmon (about 14% or a sampling rate of 1:7 fish in the run) would meet the stated objective criterion.

Biological samples will be collected in proportion to passage through the weir. Early and late in the season (when fish passage is low), the gate to the DVR passage chute will be closed overnight no less than twice weekly, tentatively scheduled for Mondays and Thursdays, to collect fish for biological sampling the following day (Tuesdays and Fridays). A conservative sampling rate for each group (1:10 for naturally-produced fish and 1:5 for hatchery-produced fish) will be applied to the weir passage for each group since the last sampling day to set the daily sampling goal. If the sampling goal is not reached during a sampling period then extra fish will be sampled the following sampling day to make up the deficit. During the middle of the run (when fish passage is high), the same procedure will be employed, although the gate to the DVR passage chute will be closed every day (or every weekday) to allow a large number of broodstock to be collected. After a fish is sampled, it will either be placed into Raceway 1 for holding as broodstock or into the tail race (via the sampling chute) for upstream passage through the DVR. Fish that are not sampled, will be sorted into Raceway 1 for holding as broodstock or into the tail race for upstream passage depending on broodstock collection needs. All fish will be given an anal fin hole-punch mark so that duplicate sampling doesn't occur on days when the tail raceway gate is opened for unobstructed fish passage. Some fish do not immediately leave the facility and hold in the tail raceway. The sampling equipment prevents selective sampling of fish within the sampling chute. All fish are crowded into the sampling chute prior to sampling, the net is the width of the sampling chute and the water is opaque so that fish cannot be observed prior to netting. The water flow at the main water intake gate will be reduced during sampling (Figure 2). The same method will be used to generate samples sizes in 2017 and 2018 after adjusting the sampling rate to account for recent escapements.

Adult Chinook salmon collected for sampling will be examined for sex, measured for length (mid eye to tail fork to the nearest 1 mm), and examined for the presence of an AFC. Scales will be removed from each collected fish and all data will be recorded on the Scale Sampling Data Form (Appendix A4). Three scales from the preferred area[8] will be collected from each adult Chinook salmon selected for age sampling (Welander 1940). Scales will be mounted on

[6] The average of 2014–2015 naturally-produced fish to the weir was 1,581.

[7] The average of 2014–2015 hatchery-produced fish to the weir was 756.

[8] The preferred area for scale sampling is on the left side of the fish at a point on a diagonal line from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin, 2 rows above the lateral line.

adhesive coated scale cards; the scales will be pressed such that impressions are made on acetate cards to allow aging postseason, following procedures described by Mosher (1969). After each fish is sampled for age, sex, length, and genetics, a hole punch will be administered to the anal fin. This anal fin hole punch will mark each fish and help prevent field technicians from sampling fish twice in the event the fish doesn't move through the DVR system and remains in the tail race. Fish collected for broodstock and all mortalities will be recorded by sex and tallied on the Broodstock Collection Data Form (Appendix A5).

Ocean-age-1.1 hatchery-produced Chinook salmon, easily identified by their small size (less than 20 inches total length), will be culled as they are encountered. This will be either on sampling days and broodstock collection days or while crowding the tail race to move fish into the sampling structure. Naturally-produced jack Chinook salmon will not be sampled and will be passed back into the tail race for passage upstream through the DVR system.

Axillary process tissue samples will be collected from naturally- and hatchery-produced Chinook salmon captured for biological sampling or broodstock. Every effort will be taken to collect genetic samples throughout the entire run so that samples are collected representatively. This may require samples to be taken on every other or every third fish depending on the number of fish that have migrated to the weir on that particular day and the date when samples are being collected (i.e., earlier versus later in the run). Historically, tissue samples have been taken on a biennial basis, as recommended by the ADF&G Division of Commercial Fisheries Gene Conservation Laboratory. Beginning in 2016, samples will be taken every year for the next 5 consecutive years. Sampling protocol will be followed as outlined in in the *Adult Finfish Tissue Sampling for DNA Analysis* directions provided by the ADF&G Gene Conservation Laboratory.

Broodstock Collection and Egg Takes

Broodstock collection will begin in approximately late June or as soon as semiripe fish start returning to the weir. Raceway 1 will be used to hold naturally-produced and hatchery-produced broodstock, and the tail raceway and Raceway 2 will be used for passing nonripe fish upstream. Any bright fish encountered during broodstock collection days will be immediately passed upstream because they have higher mortality rates when held. A minimum of 101 males and 101 females (WJHSFH request) will be used for the egg takes that will occur 2 or 3 times throughout the middle to later part of July. This request may change in response to other remote egg-take locations and the ability to meet broodstock requests due to available fish in the escapement as well as the run of available fish at Crooked Creek. While fish are being held, Raceway 1 will be partially covered by a network of polyethylene, ultraviolet stabilized fabric panels to provide shelter from environmental conditions. Water temperature, mortalities, and dissolved oxygen content will be recorded daily on the Broodstock Holding Hydrology and Mortality Data Form (Appendix A6).

Only naturally-produced Chinook salmon will be used as broodstock to support Crooked Creek stocking demands while both naturally- and hatchery-produced Chinook salmon will be used as broodstock to support stocking demands in other drainages. If small numbers of naturally-produced Chinook salmon return, collection of naturally-produced broodstock will be reduced in an attempt to exceed the lower bound of the SEG (650). Hatchery-produced Chinook salmon progeny will not be used for restocking Crooked Creek in years when naturally-produced

Chinook salmon runs are low. Consequently, Crooked Creek may not be stocked with the total requested number of smolt in subsequent years.

Adult Chinook salmon being held for broodstock will be examined to determine sexual maturity; this will assist in setting dates for eggtakes. If fish are not ripening during sorting and if sufficient numbers of fish are returning, select broodstock will be released upstream. This will be recorded on the in the comments section of the Broodstock Collection Data Form (Appendix A5). Egg takes are tentatively scheduled to begin in the middle of July and will be conducted weekly until desired numbers of fish have been artificially spawned. WJHSFH staff and Soldotna staff will conduct the egg takes. WJHSFH staff will provide necessary equipment for collecting gametes from broodstock. Eggs will be taken on site following a limited Chinook salmon egg-take protocol (ADF&G 1983). Fish used for the egg take will be sacrificed and recorded on the Egg-Take Data Form (Appendix A7). The abdomen of the fish will be wiped with Betadyne before removing the eggs. Separate gametes will be placed in sealed plastic bags. The gametes will be placed on ice in coolers for transport to WJHSFH the same day. The gametes will be fertilized at WJHSFH. Fish used for egg takes will be sampled for Infectious Hematopoietic Necrosis Virus (IHNV) and sampled for Bacterial Kidney Disease (BKD) by collecting ovarian fluid samples from females, and liver-kidney samples from males. These samples will be sent to the ADF&G Fish Pathology Laboratory for testing.

Sockeye Salmon

Small numbers of sockeye salmon arrive at the Crooked Creek weir in July. Some sockeye salmon may pass upstream of the weir while the DVR is operating. Infectious hematopoietic necrosis virus (IHNV) is commonly found in sockeye salmon (Meyers 2003). High densities of sockeye salmon on Chinook salmon spawning grounds can increase the potential spread of IHNV to Chinook salmon. Should Crooked Creek Chinook salmon stocks become infected with IHNV, the ability to use them for broodstock for Chinook salmon enhancement projects would be compromised. Because run timing of Crooked Creek sockeye salmon and Chinook salmon differ slightly, concerns of disease transmittal during broodstock collection periods are reduced (Meyers, Fish Pathology Laboratory, ADF&G, personal communication).

Sockeye salmon will be able to pass through the Crooked Creek Facility freely although their passage will be recorded and enumerated using the DVR. On sampling days and broodstock collection days, any sockeye salmon encountered will be enumerated and destroyed. End of season sockeye salmon escapement summaries will be given to ADF&G Fish Pathology Laboratory and hatchery personnel for evaluation and programmatic recommendations will be solicited.

Straying of Crooked Creek Chinook Salmon of Hatchery Origin

In past years, CWT Chinook salmon stocked into Crooked Creek have been recovered at locations outside of the Crooked Creek and Kasilof River drainages. In the fall following the field season, the ADF&G Coded Wire Tag Laboratory database will be queried for all CWT recoveries of Chinook salmon originally released at Crooked Creek. These records will provide information about the location of the fish at the time of tag recovery and about potential straying into other systems.

DATA REDUCTION

Crooked Creek DVR counts, weir mortalities, smolt imprinting, broodstock collection, broodstock holding hydrology, egg take, and ASL information will be recorded on specialized field data forms (Appendices A1–A7). Technicians will return data forms to the Soldotna office daily. The Project Biologist will examine all data forms for errors and enter the data electronically. The Project Biologist will convert the data to fixed width, comma separated values (.csv), modified mark sense format for analysis.

Data maps for all of the information collected in this project are shown in Appendices B1–B2. The project biologist will edit Crooked Creek biological and escapement data to ensure values of counts, age, and length-at-age are within regular bounds. The biologist will also prepare inseason data summaries daily, conduct postseason data analyses, and write the Division of Sport Fish Fishery Data Series report. All Crooked Creek data will be entered into computer files and edited by 1 November. A final edited copy of all data files along with a data map will be sent to the Alaska Department of Fish and Game Research and Technical Services (RTS) for archiving.

DATA ANALYSIS

Separate analyses will be conducted for naturally- and hatchery-produced fish. All (100%) hatchery-produced fish are marked; therefore, the number of marked Chinook salmon counted in the escapement is equal to the contribution of hatchery releases to the escapement.

The number of ocean-age-1 Chinook salmon (jacks) in the escapement will be determined by examining recorded footage and comparing all passing fish to a 20-inch reference mark. The number of adult Chinook salmon in the escapement (N^{adult}) will be calculated by subtracting the number of jacks (N^{jack}) from the total number of Chinook salmon that passed through the weir (N^{weir})[9]:

$$N^{adult} = N^{weir} - N^{jack} \quad (1)$$

The total number of adults that returned to the weir will be the sum of escapement (N^{adult}), the number of adult Chinook salmon that died during holding or in the facility downstream of the DVR, and the number used for egg takes.

The sampling protocol attempts proportional sampling of the total escapement. If proportional sampling is achieved or age compositions do not differ between temporal strata then samples will be pooled and unstratified estimates will be calculated. To test if a stratified estimator is required, the run will be split into 4 temporal strata based on the daily escapement counts such that each stratum represents approximately a quarter of the total run, and a likelihood ratio test (G-test, $\alpha = 0.05$) will be applied to age-by-time contingency tables. The likelihood ratio test statistic, the G-statistic, will be calculated as follows:

$$G = 2\sum_i f_i \ln\left(\frac{f_i}{\hat{f}_i}\right) \quad (2)$$

[9] Minor adjustments will be made if mortalities are observed within the facility upstream of the DVR.

where f_i is the observed number of fish in the *i*th cell of the age-by-time contingency table, and $\hat{f}_i$ is the expected number of fish in the *i*th cell calculated under the assumption that age proportions don't change over time (Sokal and Rohlf 1995). The G-statistic has an approximate χ^2 distribution with (*r*-1)(*c*-1) degrees of freedom, where *r* is the number of rows and *c* the number of columns in the table.

For clarity, the following description and formula were developed to estimate the age composition; however, estimating the sex or age-by-sex composition is treated similarly with appropriate substitutions. The proportion of adult (ocean-age-.2 and older) Chinook salmon that belong to age class *z* will be estimated separately for each group (naturally- versus hatchery-produced salmon). The age proportions of adult salmon in the escapement by sampling stratum will be estimated as follows:

$$\hat{p}_{tz} = \frac{n_{tz}}{n_t} \tag{3}$$

where $\hat{p}_{tz}$ is the estimated proportion of adult salmon passing the weir during sampling stratum *t* from age category *z*, n_{tz} is the number of fish sampled during sampling stratum *t* that were classified as age category *z*, and n_t is the number of salmon sampled for age determination during sampling stratum *t*.

The sampling variance of $\hat{p}_{tz}$ will be calculated by

$$\text{var}\left[\hat{p}_{tz}\right] = \left(1 - \frac{n_t}{N_t^{adult}}\right) \frac{\hat{p}_{tz}\left(1-\hat{p}_{tz}\right)}{n_t - 1} \tag{4}$$

where N_t^{adult} is the number of adult Chinook salmon passing the weir during sampling stratum *t*.

The estimates of escapement by age category in each sampling stratum will be calculated by

$$\hat{N}_{tz}^{adult} = N_t^{adult}\,\hat{p}_{tz} \tag{5}$$

with variance estimated as

$$\text{var}\left[\hat{N}_{tz}^{adult}\right] = N_t^{adult^2} * \text{var}\left[\hat{p}_{tz}\right]. \tag{6}$$

The total adult escapement by age category and its variance will then be estimated by summation:

$$\hat{N}_z^{adult} = \sum_{t=1}^{L} \hat{N}_{tz}^{adult} \tag{7}$$

and

$$\text{var}\left[\hat{N}_z^{adult}\right] = \sum_{t=1}^{L} \text{var}\left[\hat{N}_{tz}^{adult}\right] \tag{8}$$

where L equals the number of sampling strata.

Finally, the proportion of the adult escapement by age category and its variance will be estimated by

$$\hat{p}_z = \frac{\hat{N}_z^{adult}}{N^{adult}} \tag{9}$$

and

$$\text{var}\left[\hat{p}_z\right] = \frac{\text{var}\left[\hat{N}_z^{adult}\right]}{N^{adult\,2}}. \tag{10}$$

If age composition is independent of time, age proportions for the escapement ($\hat{p}_z$), as well as the number of fish by age ($\hat{N}_z^{adult}$) and their estimated variances, will be calculated using Equations 3–6 with the pooled data and ignoring subscripts for temporal strata.

Mean length-at-age of naturally- and hatchery-produced Chinook salmon will be estimated by standard statistical techniques.

SCHEDULE AND DELIVERABLES

Dates	Activity
May 24, 2016	Install Crooked Creek weir (Cope, Vacant)
May 24–31, 2016	Clean and disinfect raceways prior to smolt delivery (Cope, Vacant)
June 1–7 through 10, 2016	Hold Chinook salmon smolt for imprinting and release (Cope, Vacant, Vacant)
June 7–August 10, 2016	Census all fish passed upstream of weir and sample adult Chinook salmon (Cope, Vacant, Vacant)
August 1–August 10, 2016	Crooked Creek Facility cleanup, winterization, and monitor weir (Cope, Vacant, Vacant)
August 15, 2016	Weir removal (Cope, Vacant)
September 1, 2016	Scale ageing (Cope)
November 1, 2016	Data analysis and results (Cope)
December 31, 2016	Crooked Creek Chinook salmon escapement project FDS report (Cope)
April 30, 2017	Review operational plan (Cope)

The result of this project will be presented in an Alaska Department of Fish and Game, Division of Sport Fish (SF), Fishery Data Series (FDS) Report.

RESPONSIBILITIES

Jenny Cope, Fishery Biologist I

Duties: The Principal Investigator is responsible for overseeing project development, data quality, data analysis, and report preparation. This position is responsible for hiring and training any new personnel, supervising 2 technicians, inseason data editing and reduction, postseason data analysis, and a summary of the enhancement program to be reported in an FDS report. This position will also be responsible for submitting Chinook salmon heads and associated paperwork to the CWT Lab and will

also ensure that all data are in proper format for SF Research and Technical Services (RTS) and are archived with RTS at the completion of the field season. Inseason duties include entering Crooked Creek weir data into ADF&G's Internet "DocuShare", Region II Inseason Data, entitled: "Crooked Creek Weir Summary." This position is responsible for informing their supervisor of any problems with equipment or personnel affecting the completion of this project. At the end of the season, this position will supervise crew activities involved with winterizing field equipment and the Crooked Creek Facility. This position will write the project operational plan, FDS report, performance report and synopsis as well as manage the budget, prepare budget requests, perform midyear audits, write performance evaluations for technicians, apply for and renew fish transport permits, and apply for fish habitat permits. This position also interacts with Anchorage hatchery staff in evaluation of the Crooked Creek enhancement program and coordinates activities associated with the Chinook salmon smolt release and the adult egg takes at Crooked Creek.

Adam Reimer, Biometrician I

Duties: The Biometrician is responsible for review, consultation, and approval of design and analytical procedures.

Vacant, Fish and Wildlife Technician II, (June 1–August 8)

Duties: Assist with 1) conducting a census of fish passed upstream of the weir at Crooked Creek and 2) biological sampling adult Chinook salmon. This individual will be responsible for conducting inseason Crooked Creek escapement counts either manually or using a DVR, pre- and postseason cleaning and disinfecting of raceways, and preparation of the Crooked Creek Facility for winter. As time allows, this individual may be involved in some facility maintenance activities, such as painting buildings and vegetation control.

Vacant, Fish and Wildlife Technician II, (May 24 –August 15)

Duties: Assist with 1) conducting a census of fish passed upstream of the weir at Crooked Creek and 2) biological sampling adult Chinook salmon. This individual will be responsible for conducting inseason Crooked Creek escapement counts either manually or using a DVR, pre- and postseason cleaning and disinfecting of raceways, and preparation of the Crooked Creek Facility for winter. As time allows, this individual may be involved in some facility maintenance activities, such as painting buildings and vegetation control.

BUDGET SUMMARY

Crooked Creek stock assessment (11229581)

Line item	Category	FY16 Budget ($K)	FY17 Budget ($K)
100	Personal Services	81.0	84.4
200	Travel	0	0.6
300	Contractual	12.3	12.3
400	Commodities	2.4	2.4
500	Equipment	0	0
Total		95.7	99.7

Crooked Creek egg take and stocking (11229591)

Line item	Category	FY16 Budget ($K)	FY17 Budget ($K)
100	Personal Services	17.0	17.4
200	Travel	0.1	0
300	Contractual	1.1	1.1
400	Commodities	0.6	0.6
500	Equipment	0	0
Total		18.8	19.1

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APPENDIX A: FISH ENUMERATION DATA FORMS

Appendix A1.–Crooked Creek Chinook salmon enhancement project digital video recorder (DVR) Passage Data Form.

DVR Passage

		Video Time	Video Time	Age 2+		Jacks						
Date	Observer	Start	Stop	Non-AFC	AFC	Non-AFC	AFC	DV	STHL/RT	Sockeye	Coho	Comments

Appendix A2.–Crooked Creek Chinook salmon enhancement project Weir Mortalities and Trapped Emigrating Fish Data Form.

Weir Mortalities and Trapped Emigrating Fish

Date	Time	Observer	Species	Daily Total	Comments

Appendix A3.–Crooked Creek Chinook salmon enhancement project Smolt Imprinting and Release Data Form.

Smolt Imprinting and Release

Raceway #1

Smolt arrival date: _____

No. of smolt: _____

Page _____ of _____

Smolt release date: _____

			Water Temp (C)		Water DO (%)			Mortalities in Raceway # 1				
Date	Time	Observer	Inlet	Oulet	Inlet	Outlet	Food (No. Scoops)	Non-AFC	AFC	Daily Total	Cumulative Total	Comments
Total:												

Appendix A4.–Crooked Creek Chinook salmon enhancement project Scale Sampling Form for recording biological sampling of age, sex, and length.

Scale Sampling

Date: ______________________________

Collectors: ______________________________

Scale Card No.	Fish No.	Sex		AFC		Length	Age	Vial No.
	1	M	F	Y	N			
	2	M	F	Y	N			
	3	M	F	Y	N			
	4	M	F	Y	N			
	5	M	F	Y	N			
	6	M	F	Y	N			
	7	M	F	Y	N			
	8	M	F	Y	N			
	9	M	F	Y	N			
	10	M	F	Y	N			

Scale Card No.	Fish No.	Sex		AFC		Length	Age	Vial No.
	1	M	F	Y	N			
	2	M	F	Y	N			
	3	M	F	Y	N			
	4	M	F	Y	N			
	5	M	F	Y	N			
	6	M	F	Y	N			
	7	M	F	Y	N			
	8	M	F	Y	N			
	9	M	F	Y	N			
	10	M	F	Y	N			

Scale Card No.	Fish No.	Sex		AFC		Length	Age	Vial No.
	1	M	F	Y	N			
	2	M	F	Y	N			
	3	M	F	Y	N			
	4	M	F	Y	N			
	5	M	F	Y	N			
	6	M	F	Y	N			
	7	M	F	Y	N			
	8	M	F	Y	N			
	9	M	F	Y	N			
	10	M	F	Y	N			

Scale Card No.	Fish No.	Sex		AFC		Length	Age	Vial No.
	1	M	F	Y	N			
	2	M	F	Y	N			
	3	M	F	Y	N			
	4	M	F	Y	N			
	5	M	F	Y	N			
	6	M	F	Y	N			
	7	M	F	Y	N			
	8	M	F	Y	N			
	9	M	F	Y	N			
	10	M	F	Y	N			

Appendix A5.–Crooked Creek Chinook salmon enhancement project Broodstock Collection Data Form.

Brood Stock Collection

Date: _____

Collectors: _____

Raceway #1 *(Chinook brood stock)*			
Non-AFC		**AFC**	
M	F	M	F
Upstream Released:			
Mortalities:			

Appendix A6.–Crooked Creek Chinook salmon enhancement project Broodstock Holding, Hydrology, and Mortality Data Form.

Brood Stock Holding Hydrology and Mortality

				Mortalities in Raceway # 1				
Date	Observer	Water Temp (C)	Water DO	Non-AFC	AFC	Daily Total	Cumulative Total	Comments
Total:								

Appendix A7.–Crooked Creek Chinook salmon enhancement project Egg-take Data Form for recording counts of artificially spawned fish.

Egg Take

Date:

Personnel:

Non-AFC		**AFC**		**COMMENTS**
M	F	M	F	
Mortalities:				

APPENDIX B: CROOKED CREEK CHINOOK SALMON WEIR AND ASL DATA MAPS

Appendix B1.–Crooked Creek Chinook salmon weir and escapement data map.

Data field Name	Width	Start column	End column	Comma column	Codes and Comments
Date code	8	1	8	9	
Year	4	1	4		Four digit year
Month	2	5	6		Two digit month
Day	2	7	8		Two digit day
Var1	3	10	12	13	DVR count: Non-AFC ocean age 2+
Var2	3	14	16	17	DVR count: AFC ocean age 2+
Var3	3	18	20	21	DVR count: Non-AFC jacks
Var4	3	22	24	25	DVR count: AFC jacks
Var5	3	26	28	29	Upstream released or sampled: Non-AFC ocean age 2+
Var6	3	30	32	33	Upstream released or sampled: AFC ocean age 2+
Var7	3	34	36	37	Upstream released or sampled: Non-AFC jacks
Var8	3	38	40	41	Upstream released or sampled: AFC jacks
Var9	3	42	44	45	Downstream of DVR mortalities: Non-AFC ocean age 2+
Var10	3	46	48	49	Downstream of DVR mortalities: AFC ocean age 2+
Var11	3	50	52	53	Downstream of DVR mortalities: Non-AFC jacks
Var12	3	54	56	57	Downstream of DVR mortalities: AFC jacks
Var13	3	58	60	61	Upstream of DVR mortalities: Non-AFC ocean age 2+
Var14	3	62	64	65	Upstream of DVR mortalities: AFC ocean age 2+
Var15	3	66	68	69	Upstream of DVR mortalities: Non-AFC jacks
Var16	3	70	72	73	Upstream of DVR mortalities: AFC jacks
Var17	3	74	76	77	Brood stock collected: Non-AFC ocean age 2+
Var18	3	78	80	81	Brood stock collected: AFC ocean age 2+
Var19	3	82	84	85	Brood stock collected: Non-AFC jacks
Var20	3	86	88	89	Brood stock collected: AFC jacks

-continued-

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Data field Name	Width	Start column	End column	Comma column	Codes and Comments
Var21	3	90	92	93	Broodstock released: Non-AFC ocean age 2+
Var22	3	94	96	97	Broodstock released: AFC ocean age 2+
Var23	3	98	100	101	Broodstock released: Non-AFC jacks
Var24	3	102	104	105	Broodstock released: AFC jacks
Var25	3	106	108	109	Broodstock mortalities: Non-AFC ocean age 2+
Var26	3	110	112	113	Broodstock mortalities: AFC ocean age 2+
Var27	3	114	116	117	Broodstock mortalities: Non-AFC jacks
Var28	3	118	120	121	Broodstock mortalities: AFC jacks
DV	3	122	124	125	Dolly Varden
STH	3	126	128	129	Steelhead trout
RT	3	130	132	133	Rainbow trout
PS	4	134	137	138	Pink salmon
SS	4	139	142	143	Coho salmon
RS	4	144	147	end	Sockeyes salmon

Appendix B2.–Crooked Creek Chinook salmon ASL data map.

Data field Name	Width	Start column	End column	Comma column	Codes and Comments
Date code	8	1	8	9	
Year	4	1	4		Four digit year
Month	2	5	6		Two digit month
Day	2	7	8		Two digit day
(Blank)	2	10	11	12	
(Blank)	1	13	13	14	
Survey area code	2	15	16	17	P0 = Kenai Peninsula fresh water
Site code	3	18	20	21	160 = Crooked Creek
(Blank)	2	22	23	24	
(Blank)	2	25	26	27	
Species	3	28	30	31	410 = Chinook
(Blank)	3	32	34	35	
(Blank)	3	36	38	39	
(Blank)		40	57	43,45,47,49,58	
(Blank)	2	59	60	61	
Sex	1	62	62	63	= M or F
AFC or Non-AFC	1	64	64	65	0 = Non-AFC, 1 = AFC
(Blank)	4	66	69	70	Length (mm)
(Blank)		71	86	76,81,84,87	
(Blank)	2	88	89	90	
(Blank)	5	91	95	96	
Scale card number	3	97	99	100	
Fish number	1	101	102	103	Number on scale card (Values 1–10)
Age	2	104	105	106	Column 104 = freshater age, column 105 = marine age
Age error	1	107	107	end	R = Regen, M = Missing, I = Inverted, A = Absorbed, U = Unreadable, D = Dirty