Regional Operational Plan SF.2A.2018.12

Operational Plan: Mortality of Chinook Salmon Caught and Released Using Sport Tackle in the Nushagak River, 2018

by

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and

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May 2018

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.2018.12

OPERATIONAL PLAN: MORTALITY OF CHINOOK SALMON CAUGHT AND RELEASED USING SPORT TACKLE IN THE NUSHAGAK RIVER, 2018

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SIGNATURE/TITLE PAGE

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Approval

Title	Name	Signature	Date
Project leader	Jason Dye		
Biometrician	David Evans		
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ABSTRACT

In 2018, the Alaska Department of Fish and Game will conduct the second and final year of a study to estimate catch-and-release mortality of Chinook salmon ≥500 mm mid eye to tail fork length captured in the lower Nushagak River. Chinook salmon will be caught with sport fishing gear commonly used in the inriver fishery and tagged with radio transmitters. Fixed telemetry stations, and aerial and boat surveys will be used to track tagged fish to determine fates. Mortality rates will be estimated using a Kaplan Meier model and the effect of fishery and biological variables on mortality will be estimated using a Cox proportional hazards model.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, catch-and-release mortality, Nushagak River, radio telemetry

INTRODUCTION

PURPOSE

On average from 2011 to 2016, anglers caught and released an estimated 25% of the total run of Chinook salmon to the Nushagak River. The fate of these released fish is largely unknown, and most are assumed to spawn and form part of the estimated escapement. However, if a substantial portion of these catch-and-release fish do not spawn, estimates of escapement would be biased upward. This study will estimate the proportion of catch-and-release Chinook salmon that succumb to catch-and-release injuries within 5 days after capture. This information will be useful in assessing the validity of the estimated escapement. The effects of fishery and biological variables on mortality will also be assessed, and these data may be useful in future management decisions.

BACKGROUND

The Nushagak River is located in Southwestern Alaska and flows approximately 390 km from its headwaters into Bristol Bay (Figure 1). The Nushagak River drainage has 2 main tributaries: the Nuyakuk River, draining Tikchik lakes from the west, and the Mulchatna River, which flows into the Nushagak River from the east. The Nushagak River supports one of the largest Chinook salmon runs in Alaska with an average (1989–2016) annual total run of approximately 178,000 and a spawning escapement of approximately 117,000 fish.

Chinook salmon stocks in the Nushagak–Mulchatna drainage have had variable runs in recent years. The 2009, 2010, 2011, and 2014 runs were well below average and did not achieve the inriver goal. The 2012, 2013, 2015 and 2016 runs were above average and exceeded the inriver goal. Total runs of Nushagak and Mulchatna rivers Chinook salmon averaged 128,417 fish from 2011 through 2016, ranging from 90,717 to 166,006 fish (Table 1).

Total harvest by commercial, subsistence, and sport fisheries averaged 40,811 Chinook salmon from 2011 through 2016 (calculated from Table 1). Based on this average, the majority (54%) of the harvest was taken by the commercial fishery, 30% was taken by the subsistence fishery, and 16% by sport anglers (calculated from Table 1). Sport harvest of Chinook salmon averaged 6,561 fish from 2011 through 2016 (calculated from Table 1). Sport catch (both harvested and released fish) of Chinook salmon averaged 35,869 fish from 2011 through 2016 (Table 1).

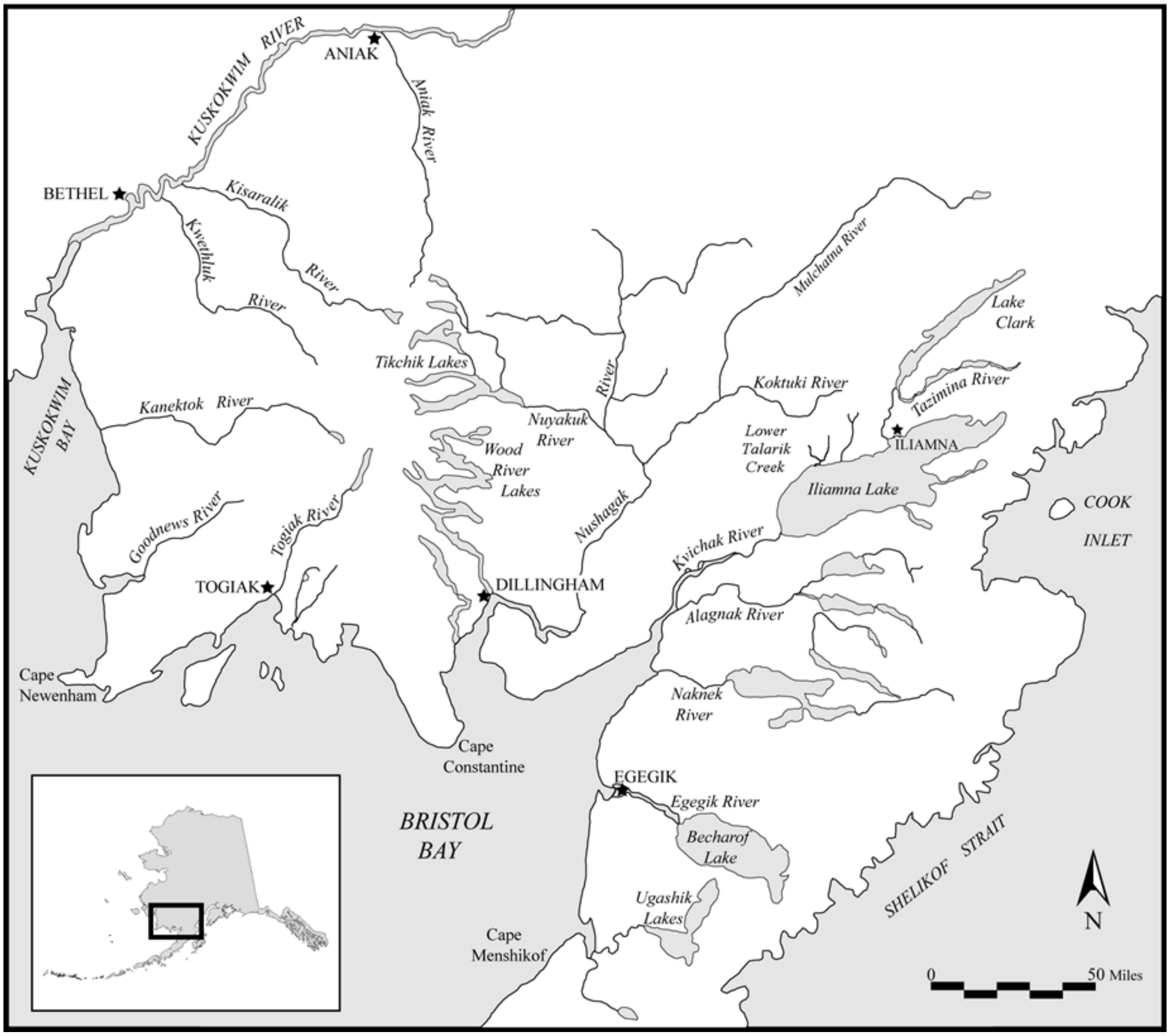

Figure 1.–Nushagak River drainage.

Table 1.–Chinook salmon harvest and escapement (1989–2016) and sport catch (2004–2016) for the Nushagak River drainage.

		Harvests below sonar			Inriver	Harvests above sonar		Spawning escapement		
Year	Total run [a]	Commercial harvest [b]	Subsistence harvest [c]	Sport harvest [d]	sonar estimate	Subsistence harvest [e]	Sport harvest [f]	Sonar estimate [g]	Aerial survey estimate	Sport catch
1989	102,241	17,637	4,898	1,404	78,302	2,217	2,210	73,875		
1990	85,792	14,812	6,228	797	63,955	3,325	2,689	57,941		
1991	132,769	19,718	6,907	1,793	104,351	3,127	3,758	97,466		
1992	139,943	47,563	7,688	1,844	82,848	2,499	2,911	77,438		
1993	173,747	62,976	10,552	2,408	97,812	2,919	3,492	91,401		
1994	332,388	119,480	8,829	4,436	199,643	6,661	6,191	186,792		
1995	268,137	79,943	7,810	2,238	178,146	5,891	2,713	169,542		
1996	192,011	72,123	9,086	2,346	108,456	6,855	3,045	98,557		
1997	156,052	64,390	8,731	931	170,610	6,587	2,567		82,000	
1998	370,908	117,820	6,987	1,640	244,461	5,271	4,188	235,003		
1999	147,530	11,178	5,732	934	129,686	4,325	3,304	122,058		
2000	136,194	12,120	5,398	1,389	117,288	4,072	4,628	108,588		
2001	212,037	11,746	6,703	1,600	191,988	5,057	4,299	182,632		
2002	228,969	40,039	6,430	1,193	181,307	4,851	2,500	173,956		
2003	222,846	43,485	10,651	2,203	166,507	8,035	3,752	154,720		
2004	350,407	96,759	8,898	2,567	242,183	6,712	4,339	231,132		69,278
2005	306,892	62,764	7,142	2,863	234,123	5,387	5,702	223,034		65,089
2006	218,413	84,881	5,683	3,166	124,683	4,288	4,307	116,088		50,756
2007	121,959	51,831	7,598	3,581	60,464	5,732	6,088	48,644		53,633
2008	126,301	18,968	7,387	3,305	96,641	5,573	3,395	87,673		45,181
2009	115,884	24,693	7,260	2,451	81,480	5,477	3,903	72,100		33,102
2010	69,556	26,056	5,216	1,659	36,625	3,935	2,248	30,443		18,572
2011	95,300	26,927	7,103	1,542	59,728	5,358	3,302	51,068		40,139
2012	129,282	11,952	7,711	1,833	107,786	2,639	4,098	101,049		37,476
2013	133,246	10,213	6,613	1,971	113,709	4,989	4,714	104,746		32,154
2014	90,717	11,448	6,418	2,369	70,482	4,842	3,891	61,749		26,158
2015	155,948	48,803	6,612	2,514	98,019	4,352	4,720	88,947		32,952
2016	166,006	23,783	13,802	3,053	125,368	1,933	5,358	118,077		46,333

-continued-

Year	Total run [a]	Harvests below sonar: Commercial harvest [b]	Harvests below sonar: Subsistence harvest [c]	Harvests below sonar: Sport harvest [d]	Inriver sonar estimate	Harvests above sonar: Subsistence harvest [e]	Harvests above sonar: Sport harvest [f]	Spawning escapement: Sonar estimate [g]	Spawning escapement: Aerial survey estimate	Sport catch
1989–2016										
Average	177,910	44,075	7,503	2,144	127,380	4,747	3,868	117,212		42,371
Percent		70%	12%	3%		8%	6%			
2011–2016										
Average	128,417	21,188	8,043	2,214	95,849	4,019	4,347	87,606		35,869
Percent		54%	20%	5%		10%	11%			
2017	98,689	NA	NA	NA	56,961	NA	NA	NA		NA

Source: Commercial harvest (total Nushagak District): 1989-1993 Jones et al. (2012: Appendix A19); 1994–2014 Elison et al. (2015: Appendix A19). Subsistence harvests above and below sonar: ADF&G Subsistence Division, Subsistence Database from Charles Utermohle, Program Coordinator, Subsistence Division, Region II, Anchorage, Nov. 20, 2000. Data for 2000–2008 provided by James Fall, Subsistence Division, Region II, Anchorage. Sport harvests above and below the sonar: Alaska Sport Fishing Survey database [Intranet]. 1996– . Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish (cited April 20, 2018). Available from: https://intra.sf.adfg.state.ak.us/swhs_est/ (custom query details available upon request from ADF&G, Division of Sport Fish, Research and Technical Services). Sonar estimates: 1989–1993 Jones et al. (2012: Appendix A19); 1994–2014 Elison et al. (2015: Appendix A19).

[a] Run refers to an aggregation of salmon of all ages returning from ocean feeding grounds to spawn in any given calendar year.

[b] Total Nushagak District commercial harvest.

[c] Includes Nushagak Bay and Igushik.

[d] Sport harvest total for 1989 to 1996 is 50% of the Nushagak River system sport harvest. Sport harvest total for 1997 to 2016 is Nushagak River sport harvest from Black Point to sonar (Figure 2).

[e] Includes Ekwok area, Iowithla River, Klutuk River, Koliganek area, New Stuyahok area, Portage Creek area, Kokwok area, Mulchatna River, and an unknown Nushagak River watershed site.

[f] Sport harvest total for 1989 to-1996 is 50% of the Nushagak River system sport harvest plus the Mulchatna River system, Tikchik-Nuyakuk rivers, and Koktuli River sport harvests. Sport harvest total for 1997 to 2001 is 50% of the Nushagak River harvest plus the, Nushagak River upstream of Iowithla River, Mulchatna River system, Tikchik–Nuyakuk rivers and the Koktuli River harvests. Sport harvest total for 2002 to 2016 is Nushagak River excluding Black Point to sonar.

[g] Sonar estimates for 1989 to 1996, and 1998 to 2016 are sonar estimates minus subsistence and sport harvest above sonar.

Based on Alaska Department of Fish and Game (ADF&G) Statewide Harvest Survey (SWHS) data, annual sport fishing effort on the Nushagak River averaged 18,940 angler-days from 2011 to 2016[1]. Based on Freshwater Logbook Data[2] from 2006 through 2016 (Sigurdsson and Powers 2009-2014, *In prep*; Powers and Sigurdsson 2016), guided angler effort downstream of the Mulchatna River has been variable, with a low of 3,920 angler-days in 2010 and a high of 8,559 angler-days in 2006 and averaging 6,647 angler-days.

Nushagak River Chinook salmon are managed under the guidelines of the *Nushagak–Mulchatna King Salmon Management Plan*, adopted into regulation in 1992. This management plan was modified in the mid- and late 1990s and again in 2012 to account for the conversion of Bendix sonar counts to dual frequency identification sonar (DIDSON) counts in terms of historical escapement numbers (Maxwell et al. 2011). The current sustainable escapement goal (SEG) is 55,000 to 120,000 fish with an inriver goal of 95,000 (Fair et al. 2012).

ADF&G estimates inriver abundance of Chinook salmon at the Portage Creek sonar site located on the lower Nushagak River, approximately 53 km upstream from the terminus of the Nushagak commercial fishing district and 5 km downstream from the village of Portage Creek (Figures 1 and 2). Although the sonar project is not designed to assess Chinook salmon, it does produce an index of abundance that is used for inseason management of commercial and sport fisheries. The Chinook salmon sonar count has always been considered an index of abundance rather than a measure of total abundance because an unknown proportion of Chinook salmon are presumed to migrate upriver beyond the range of the sonar.

Due to the large Chinook salmon return to the Nushagak River and relatively conservative sport fishing harvest regulations, the practice of catch-and-release fishing for Chinook salmon is common in the Nushagak River drainage. From 2011 through 2016, the catch of Chinook salmon in the sport fishery averaged 35,869 fish. An average of approximately 29,300 of the catch were released (calculated from Table 1), representing about 25% of the 2011–2016 average total run. Because so many fish are released, users have raised concerns regarding the fate of Chinook salmon caught and released in the sport fishery. Few catch-and-release mortality studies have been conducted previously on Chinook salmon sport fisheries in freshwater. Bendock and Alexandersdottir (1991) estimated the mortality rate of catch-and-release Chinook salmon in the Kenai River sport fishery averaged 8.8% and 5.8% for early and late runs, respectively, and Lindsay et al. (2004) estimated the overall mortality rate of wild catch-and-release Chinook salmon in the Willamette River sport fishery at 12.2%. However, there are significant differences between the Kenai, Willamette, and Nushagak river Chinook salmon stocks and associated sport fisheries, and the primary purpose of this project is to estimate the short-term mortality rate of catch-and-release Chinook salmon in the lower Nushagak River sport fishery. The results of this project will be used to assist fisheries managers with future management strategies and assessment of harvest and escapement goals for Nushagak River Chinook salmon.

[1] Alaska Sport Fishing Survey database [Intranet]. 1996–2016. Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish. Available from: https://intra.sf.adfg.state.ak.us/swhs_est/ (custom query details available upon request from ADF&G, Division of Sport Fish, Research and Technical Services)

[2] Alaska Department of Fish and Game, Division of Sport Fish. 2006 to present [URL not publicly available as some information is confidential. Contact Research and Technical Services for data requests.]

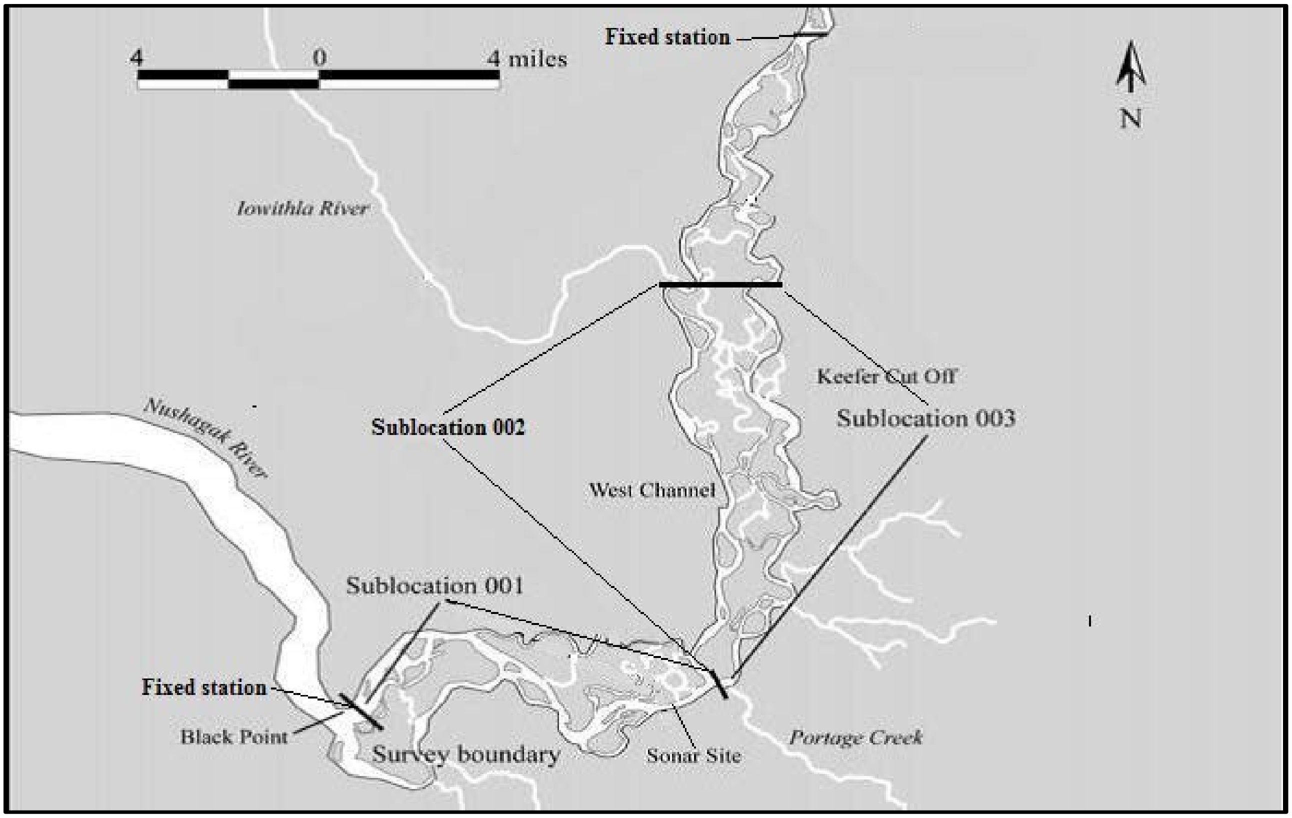

Figure 2.–Map of the lower Nushagak River drainage demarcating capture sublocations and locations of fixed tracking stations.

The first year of this project was completed in the summer of 2017. A total of 107 tags were deployed but 1 tag was never seen via telemetry and 1 tag will be removed from the study due to its unknown date of mortality. Of the 105 uncensored tags, 7 were confirmed mortalities whereas 98 were tracked alive for the full 5-day study period. This preliminary data produces a rate of mortality of 6.7%.

This study will continue to estimate the short-term mortality rate of catch-and-release Chinook salmon in the lower Nushagak River and will concurrently examine the influence of various biological and fishery related variables on mortality rates.

OBJECTIVES

PRIMARY OBJECTIVE

Estimate the short-term (5 d) mortality rate for Chinook salmon ≥500 mm mid eye to tail fork (METF) length caught and released in the lower Nushagak River such that the estimate is within 5%[3] of the true value 90% of the time.

[3] Within d % of the true value A% of the time implies $P(p - d/100 \leq \hat{p} \leq p + d/100) = A/100$, where p denotes the population proportion.

SECONDARY OBJECTIVES

1) Estimate the effects of selected biological and sport fishery related variables on mortality rates of catch-and-release Chinook salmon.
2) Estimate length and sex composition of Chinook salmon captured in the lower Nushagak River.
3) Examine all captured Chinook salmon for previously applied marks.

METHODS

STUDY DESIGN

This study will estimate the short-term (5 d) mortality rate of Chinook salmon ≥500 mm METF length caught and released in the Nushagak River sport fishery. Chinook salmon will be captured with hook and line in the lower Nushagak River from Black Point upstream to its confluence with the Iowithla River, where the majority of the sport fishery occurs (Figure 2). Capture will be conducted during the peak of the run from June 18 through July 9. Gear and terminal tackle similar to that utilized in the sport fishery will be used. Captured Chinook salmon will be implanted with a radio tag. Length and sex data and other biological and fishery related variables will also be collected for all captured and tagged Chinook salmon. Survival and movement of radiotagged salmon will be tracked by daily aerial surveys, boat surveys, and 2 stationary tracking stations to determine fate. Tracking will continue for 5 days beyond the date of the last tag deployment; tracking may be continued for an additional 2 days should we observe tagged fish with uncertain fates. A 5-day tracking period was chosen to ensure this study is comparable to previous Chinook salmon catch-and-release mortality studies.

Capture

Three 2-person crews will capture Chinook salmon in the lower Nushagak River (Figure 2) during the historical average peak of the run from June 18 through July 9, 2018. Capture will occur 6 days per week. The capture area will be divided into 3 sublocations: 1) Black Point to the downstream confluence of the west channel and the Keefer Cutoff near Portage Creek (recorded as sublocation 001), 2) downstream confluence of the west channel and the Keefer Cutoff near Portage Creek to the confluence with the Iowithla River in the west channel (recorded as sublocation 002), and 3) downstream confluence of the west channel and the Keefer cutoff near Portage Creek to 25 km upstream of the confluence in the Keefer cutoff (recorded as sublocation 003) (Figure 2).

Chinook salmon will be captured using standard catch-and-release techniques as outlined by ADF&G (Appendix A1). Strong test monofilament or braided line (25–40 lb) will be used along with a heavy spinning or casting rod-and-reel so as to bring in the catch quickly in a manner similar to that encouraged by guides. Landing time will be varied in an attempt to emulate the sport fishery. Four combinations of terminal tackle and angling methods used commonly in the Nushagak River Chinook salmon sport fishery will be used to capture fish. The combinations are as follows: backtrolling plugs, drifting salmon eggs, downtrolling spinners, and setting sideplaners from shore with either salmon eggs or plugs. Past creel surveys conducted on the lower Nushagak River Chinook salmon sport fishery have estimated that approximately 60% of anglers used bait and that sport fishing effort was equally distributed between sublocations 001, 002, and 003 (Dye 2005; Cappiello and Dye 2006; and Dye 2012). In order to distribute the catch by terminal tackle in a similar proportion to the sport fishery, 60% (144) of the radio tags will be implanted in fish caught using bait and the remaining 40% (96) will be implanted in fish caught without the use of bait. The overall sport fish catch of Chinook salmon from shore using sideplaners is probably much lower than for other angling methods; therefore, only 10 percent (24) of the tags will be implanted in fish caught with the use of sideplaners from shore. Finally, to ensure fish are caught and released proportionally to the sport fishery by location, approximately 33% (80) of the tags will be implanted in fish caught in each of the three capture sublocations.

Chinook salmon captured from a boat will be restrained in a tagging cradle or landing net. The tagging cradle or landing net will be positioned alongside the boat to allow the fish to be processed without removal from the water. The tagging cradle is a rigid, padded device that immobilizes captured fish. Landing nets will be of typical design and comparable to those used in the sport fishery. All captured Chinook salmon will be examined for previous marks (i.e., radio tag antenna). Mortalities as a result of this study will be kept and donated to local subsistence users, if possible.

Tagging and Telemetry

Approximately 80 esophageal radio tags will be inserted into Chinook salmon captured by hook and line in each of 3 capture sublocations (241 total tags) in the lower Nushagak River from Black Point to the confluence with the Iowithla River approximately 28 km upstream of the Portage Creek sonar site (Figure 2). A hand-held GPS will be used to identify the exact tagging locations. All Chinook salmon over 500 mm METF length will receive a radio tag unless severely injured, bleeding profusely, or clearly a mortality. Such fish will be included in the study as mortalities. Chinook salmon less than 500 mm METF length will not be sampled to ensure that fish are large enough to safely carry a radio transmitter. According to Winter (1983), transmitters should weigh no more than 2% of the body weight of a fish in air or 1.25% of the weight in water. With these criteria, Chinook salmon need to weigh at least 2.5 lb to be safely tagged.

Advanced Telemetry Systems[4] (ATS) high frequency pulse encoded transmitters (radio tags) that are 5.5 cm long, 1.9 cm in diameter, and weigh 26 g in air with a 41 cm external whip antenna will be used for tracking fish in this study. Each radio tag is distinguishable by a unique frequency and encoded pulse pattern. Fifteen frequencies spaced approximately 30 kHz apart in the 151 and 153 MHz range with approximately 12 encoded pulse patterns per frequency will be used for a total of 174 uniquely identifiable tags. Transmitters will have a mortality option that changes the pulse rate of the signal if a transmitter has been sedentary for 4 hours. This will be used to identify mortalities.

Radio tags will be inserted through the esophagus and into the upper stomach using a 41 cm plastic tube with a diameter equal to that of the radio tags. The radio transmitter will be pushed through the esophagus such that the antenna end of the radio tag will be seated 0.5 cm posterior to the base of the pectoral fin. Tagging will be performed without the use of anesthesia. In order to simulate proper catch-and-release practices, with exception of insertion of radio tags, handling will be kept to a minimum. Sex will be noted only if this can be easily determined from external morphology. Each Chinook salmon will be measured for length from mid eye to tail fork while it is in the holding cradle. No scales will be taken for aging. For each fish that receives a radio tag,

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

river location, tag frequency and code, and several fishery and biological variables will be recorded as described in the next section below.

Following radio tag insertion, the inriver migrations of radiotagged salmon will be tracked by aerial and boat surveys and 2 fixed stations. Fixed stations will be located at the upstream confluence of the mainstem and Keefer Cutoff, approximately 50 km upstream of the Portage Creek sonar site, and at Black Point approximately 15 km downstream of the sonar site (Figure 2). Each station will include 2 deep-cycle batteries, an ATS Model 5041 data collection computer (DCC II), an ATS Model 4000 receiver, a housing box, and 1 Yagi antenna. The receiver and DCC II will be programmed to scan the frequencies at 3 s intervals. When a signal of sufficient strength is encountered, the receiver will pause for 5 s, and tag frequency, tag code, signal strength, date, and time will be recorded on the data logger. The relatively short cycle period will help minimize the chance that a radiotagged fish will swim past the receiver site without being detected. Recorded data will be downloaded to a laptop computer every 7–10 days. Aerial surveys of the mainstem will be conducted daily from 19 June through 15 July. During each aerial survey, date, tag frequency, GPS coordinates, and signal type (alive or mortality) will be recorded (Appendix B1). A reference tag will be placed in a location unknown to the surveyor and it will be moved to a new location every other day to verify that the tracking equipment is working properly during each aerial survey. Boat surveys will be conducted periodically as needed during the study to locate tags and possibly recover tags indicating mortality. This level of coverage should allow the determination of the numbers of tagged fish that die within 5 days of release, exit the survey area downriver, or travel upstream of the confluence.

Biological and Sport Fishery Related Variables

Biological and fishery related variables will be recorded for each capture event (Appendices B2 and B3). All Chinook salmon captured during the duration of the project will be sampled for sex and length. Sex will be determined when possible based on external sexual characteristics. METF length will be recorded to the nearest 5 mm. Additionally, several fishery related variables will be recorded including water temperature, angling method, terminal tackle, hooking location, landing time, handling time, bleeding severity, swimming away characteristics, and external condition of fish at release. For the latter, scale and slime loss will be noted. The hook locations and bleeding descriptions will be based on Falk and Gillman (1975) (Appendix B2). Water temperature will be collected at the capture site with the use of a handheld thermometer placed in the water column approximately 0.3 m below the water surface.

Fates of Radiotagged Chinook Salmon

All radiotagged salmon will be assigned 1 of 4 distinct fates (Table 2). These fates define whether catch-and-release Chinook salmon died from injuries associated with capture and handling or were harvested or lost completely.

The aerial surveys, boat surveys, and fixed tracking stations will monitor movements that will define the fates of radiotagged Chinook salmon. Aerial tracking will take place throughout and after the tagging period to determine whether the tags are working, whether the fish have recovered from handling, where they are, and whether fish have survived for 5 days following release. The first aerial tracking survey will commence one day after the first tag has been deployed and continue daily until 5 days after the last tag is deployed. Tracking may be continued for an additional 2 days should we observe tagged fish with uncertain fates.

Approximately 25 flights will be conducted over a 4-week period. Following completion of aerial surveys on the lower river, 1 aerial tracking survey will also be used to locate tags upstream of the upper tracking station. This flight will locate fish that the tracking stations failed to record and validate records of upstream migration from the upper tracking station.

Based on historical aerial surveys, nearly all Chinook salmon spawning occurs upstream of the confluence of the Nushagak and Iowithla rivers, and documented spawning has not commenced prior to July 25. Therefore, tagged Chinook salmon are not likely to spawn within the tagging area and possibly signal a false mortality.

Table 2.–List of fates of radiotagged Chinook salmon from the Nushagak River, 2018.

Fate	Description
1 Hooking survivor	Fish that move upstream past the upstream tracking station (near upstream confluence of mainstem and Keefer Cutoff) at any time after release or Fish are located with their transmitter in active mode at least 5 days after release
2 Hooking mortality	Fish that die immediately after capture (such fish will not be radio-tagged) or Fish that never passed the upstream tracking station and whose carcasses are found dead within 5 days of release or Fish that never passed the upstream tracking station and are located either upstream or downstream of the tagging site with their transmitter in inactive mode on 2 consecutive aerial surveys within 5 days of release or Fish that never passed the upstream tracking station and move downstream past the lower tracking station near Black Point and are never located again
3 Fishery mortality	Fish that are harvested in either the sport, commercial, or subsistence fishery within 5 days of release.
4 Unknown	Fish that are never located after release. Such fish will not be used for estimation of hooking mortality.

Sample Sizes

Sample size was calculated assuming a simple binomial model for mortality. For the estimated mortality to be within 5% of the true mortality 90% of the time, we need 173 radiotagged Chinook salmon, assuming a worst case mortality rate of 20%. We plan on using 241 radio tags to meet Objective 1 criteria. The binomial model is a simplification of the methods that we will use to estimate mortality (Kaplan Meier model), but it should give a reasonable approximation for planning purposes.

DATA COLLECTION AND REDUCTION

Catch and Release Mortality and Biological and Sport Fishery Variables

All data will be recorded on field forms described in Appendices B1–B3. Data will be edited for errors and entered into an Excel worksheet at the end of the sampling day. These data will be later analyzed and archived as described in the Archiving section below.

When a tag is identified during aerial-tracking and boat surveys, frequency, code, signal, and location information will be recorded (Appendix B3). All information will be subsequently entered into an Excel spreadsheet after the survey is completed. Biological data will be recorded on the form described in Appendix B1 and then later transcribed into the project Excel workbook.

Each tracking station will record all transmitter signals of sufficient strength. Stations record date, time, frequency, code, signal strength, and antenna number for each time a signal of sufficient strength is encountered. Data will be stored in the data collection computer in ASCII format. Data from each station will be downloaded to a laptop computer at least once every 7–10 days with use of PROCOM PLUS software provided by ATS.

Recoveries of tagged Chinook salmon harvested in various fisheries will be obtained by voluntary tag returns from users of subsistence, commercial, and sport fisheries. The local and visiting public and commercial sport fishing operations will be made aware of the study via a guide meeting, e-mail, and a news release and will be asked to turn in any tags they encounter and note the date of harvest. Date, time, location, tag number, method of capture, and type of fishery will be recorded. Tag numbers will link the fish to the original capture data. Data from tag recoveries will be entered into the Excel file as they become available. Imprinted on each radio tag will be the Dillingham ADF&G office address and a contact phone number.

Archiving

Final edited copies of the data (MS Excel spreadsheet and ASCII file), along with a data map describing the data files, will be sent to Division of Sport Fish (SF) Research and Technical Services (RTS) in Anchorage for archiving on the SF intranet site ("Docushare") at http://docushare.sf.adfg.state.ak.us/. Archiving will be completed by end of winter 2018–2019. The specific location within Docushare has yet to be determined.

DATA ANALYSIS

Assumptions

The assumptions of this radiotracking study are as follows:

1) There is no tagging or natural mortality within the 5-day period.
2) There is no tag loss within the 5-day period.
3) Tags that are removed by various fisheries or that we fail to relocate are a random subset of the total sample and do not bias the study results.

Chi-square statistics and loglinear methods will be used to test Assumption 3 that tag removal by any factors other than hook-and-release mortality is independent of biological and fishery variables (see Appendix B1). Loglinear methods for categorical data (Agresti 1990) will be used for the analysis of association in contingency tables of 3 or higher dimensions. These methods test whether there is interaction between any of the included variables, particularly between "fate" and the biological or fishery explanatory variables. The categorical procedure GENMOD in SAS (SAS 2010) will be used to generate maximum-likelihood estimates for fitting loglinear models to the data. The size distributions of tagged fish removed by the sport, commercial, or subsistence fisheries will be compared to the distribution of the total released sample using the nonparametric Kolmogorov–Smirnov statistic (Conover 1980). All statistical tests will be conducted at the Type-1 error rate (alpha) of 0.1, unless otherwise noted.

Estimation of Catch and Release Mortality

The methods of survival analysis will be used to estimate hook-and-release mortality (Cox and Oakes 1984). For this analysis, we define hook-and-release mortality as a failure event and the time to that event as the failure time. In this experiment, censored individuals are those removed by a fate other than hook-and-release mortality (e.g., removals by sport fishery). Five days after release, all fish still surviving are automatically censored (removed) from the experiment. This method computes the percent dying on each day of the experiment from all fish available on that day. The fish available are those available the previous day minus both those dying and those censored the previous day. The nonparametric Kaplan-Meier estimator will be used to estimate the survivor function $F(t)$, which is the probability of surviving to time t and is estimated as follows (Cox and Oakes 1984):

$$\hat{F}(t) = \prod_{j<t} 1 - \hat{h}_j \tag{1}$$

where $\hat{h}_j$ is the hazard function, or the probability of dying at time j, and is estimated by

$$\hat{h}_j = \frac{d_j}{r_j} \tag{2}$$

where

d_j = number of individuals dying at time j, and

r_j = number available or alive just of individuals dying at time j.

The number alive just before time j, r_j, includes those individuals censored at time j. The variance for the survivor function is estimated using Greenwood's formula (Cox and Oakes 1984):

$$\text{var}(\hat{F}(t)) = \hat{F}(t)^2 \sum_{j<t} \frac{d_j}{r_j(r_j - d_j)} \tag{3}$$

Explanatory Variables

The influence of explanatory variables on hook-and-release mortality will be estimated using Cox's proportional hazards (Cox and Oakes 1984):

$$h(t,z) = h_0(t)\, w(z;b) \tag{4}$$

where h_0(t) is a baseline hazard function; in this case, the Kaplan-Meier function will be used. The function $w(z;b)$ is a parametric shift function of the vector of explanatory variables, z, and the parametric vector b. The shift function will adjust the baseline hazard function dependent on the effect of the explanatory variables included in the model. Typically, $w(z;b)$ is an exponential function (Steinberg and Colla 1988) and the hazard at time t is described as follows:

$$h(t,z) = h_0(t)\, e^{(z;b)} \tag{5}$$

The survival analysis is carried out using the procedure LIFETEST (SAS 2010). For these analyses, the day of release is defined as day 1 of the experiment and the date of release is assumed not to have an effect. In order to test the assumption that there is no change in censoring rates or mortality rates by actual date of release, a test of independence will be carried out for fates by week of release.

Length and Sex Composition

Mean length of Chinook salmon captured in the Nushagak River and its variance will be estimated using standard sample summary statistics (Cochran 1977).

The proportion (p_i) of Chinook salmon of length or sex class *i*, and its variance, will be estimated as a binomial proportion as follows (Cochran 1977):

$$\hat{p}_i = \frac{x_i}{x}, \tag{6}$$

where

x_i = number of Chinook salmon of length or sex class *i*, and

x = total number of Chinook salmon sampled.

The variance of this proportion will be estimated by (Cochran 1977):

$$var(\hat{p}_i) = \frac{\hat{p}_i(1-\hat{p}_i)}{x-1} \tag{7}$$

SCHEDULE AND DELIVERABLES

The objectives of this project will be completed within 1 calendar year (1 field season). A 2018 time schedule for initiating and completing the Nushagak River Chinook salmon catch and release mortality project is summarized below.

Dates	Activity
March–April 2018	Procurement of equipment (Borden)
June–July 2018	Capture and tagging (Technicians)
November–December 2018	Editing of mark–sense data (Borden)
January–February 2019	Data analysis (Borden/Evans)
March 2019	Report describing results (Borden/Dye)

Results from the 2017 and 2018 field seasons will be documented in an Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series Report. Analysis and reporting will be completed by March 2019.

RESPONSIBILITIES

Lee Borden, Assistant Area Management Biologist

Duties: Overall project supervisor. Write operational plan. Develop and administer project budget and hire seasonal staff. Assist with collection of field data. Primary author responsible for writing the final project reports.

Jason Dye, Area Management Biologist

Duties: Assist with collection of field data. Review final project reports.

David Evans, Biometrician II

Duties: Review operational plan, provide sample size determination and estimation procedures, advise project leader regarding statistical procedures. Review Fishery Data Series report describing analyses and results of 2018 fieldwork.

Stephen Warta, Fishery Technician III

Duties: Assist with procurement of equipment. Ensure sampling activities and schedules are in accordance with methods prescribed in the operational plan. Edit and organize data before being sent to Anchorage for genetic processing. Assist in the writing of the final project reports.

Research and Technical Staff

Duties: Process mark–sense forms and archive data files.

BUDGET SUMMARY

Projected FY17 and FY18 costs:

Line item	Category	Budget ($K)
100	Personal Services	239.4
200	Travel	0.0
300	Contractual	51.6
400	Commodities	70.8
500	Equipment	0.0
Total		361.8

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APPENDIX A: STANDARD ADF&G CATCH-AND-RELEASE GUIDELINES

Tackle

- Use appropriate line strength to land catch in a timely manner.
- Fish caught with flies or lures typically survive at a higher rate than fish caught with bait.
- Hooks appropriate to the size of the fish should be used. Overly large hooks can damage mouth parts or eyes and small hooks can be taken deeply.
- Barbless hooks can make releasing fish easier.

Landing the catch

- Fish should be landed as quickly as possible.
- Fish should not be removed from the water.
- Fish should not be allowed to flop in shallow water, over rocks, on dry land, or in the bottom of a boat.
- Knotless or rubber landing nets should be used.

Handling the catch

- Fish should be kept in the water
- Fish should be cradled gently with both hands: one under its belly near the pectoral fins and one near its tail.
- Fingers should be kept out of and away from the eyes and gills.
- Hands should be wet when handling fish.
- Fish should never be squeezed.
- Fish should be supported in the water prior to picture taking.
- Never hold a fish vertically.

Removing the hook

- Long-nosed pliers should be used to back the hook out.
- Hook should be removed quickly and gently while fish is held underwater.
- If a fish is hooked deeply, then line near hook should be cut.
- Avoid stainless steel hooks. If a hook has to be left in the fish, it should be able to quickly rust out.

Reviving the catch

- Fish should be pointed into a slow current or gently moved back and forth until gills are working properly and balance is maintained.
- Let fish go after it recovers and attempts to swim away.
- Large fish may take longer to revive.

APPENDIX B: FIELD DATA FORMS AND CODES

Appendix B1.–Lower Nushagak River Chinook salmon radiotracking data form.

Transportation mode:______________ Personnel:_______________________

Date:___________________________ Weather conditions:_______________

Frequency	Mortality (Y or N)	GPS Coordinates		Frequency	Mortality (Y or N)	GPS Coordinates

Appendix B2.–Nushagak River Chinook salmon hooking and handling mortality data form, 2018.

Date:

Tagging coordinates and sublocation	Tag Frequency and Code	Sex (M or F)	Fork length (mm)	Water temp.	Angling method	Terminal tackle	Hook location (1 - 8)	Landing time (min:sec)	Handling time (min:sec)	Bleeding (0-3)	Swimming away (0 - 3)	Overall external condition (0 - 3)

Appendix B3.–Codes for Nushagak River Chinook salmon hooking and handling mortality data form, 2018.

Hook location	Bleeding severities	Swimming away	Overall external appearance
1 Upper Jaw	0 None, no evidence of external bleeding	0 No apparent effects from handling. Fish easily and readily swam away	0 Fish shows no apparent handling effects. Loses little slime and scales still intact.
2 Roof of Mouth	1 Slight, a small amount of bleeding generally localized near the point of hook entry	1 Fish shows some handling stress, but swims off soon fairly soon after release	1 Some slime loss, scales remain intact
3 Esophagus	2 Moderate, a greater amount of external bleeding generally localized around the point of hook entry	2 Fish held in quiet water for a while. Takes some time to recover, but finally swims away	2 Slime and some scale loss
4 Gills	3 Severe, copious amounts of blood, staining the water in the holding tub and generally surrounding and obscuring the point of hook entry	3 Assumed mortality	3 Heavy slime and scale loss.
5 Tongue			
6 Lower Jaw			
7 Snag			
8 Eye			

Source: Adapted from Stuby and Taube 1998(1998) and Falk and Gillman (1975).