

**Susitna River Chinook and Coho Salmon Inriver
Abundance and Chinook Salmon Spawning
Distribution, 2015**

by

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and

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February 2016

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries



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Weights and measures (metric)		General		Mathematics, statistics	
centimeter	cm	Alaska Administrative Code	AAC	<i>all standard mathematical signs, symbols and abbreviations</i>	
deciliter	dL	all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.	alternate hypothesis	H_A
gram	g	all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.	base of natural logarithm	e
hectare	ha	at	@	catch per unit effort	CPUE
kilogram	kg	compass directions:		coefficient of variation	CV
kilometer	km	east	E	common test statistics	(F, t, χ^2 , etc.)
liter	L	north	N	confidence interval	CI
meter	m	south	S	correlation coefficient	
milliliter	mL	west	W	(multiple)	R
millimeter	mm	copyright	©	correlation coefficient (simple)	r
		corporate suffixes:		covariance	cov
Weights and measures (English)		Company	Co.	degree (angular)	$^\circ$
cubic feet per second	ft ³ /s	Corporation	Corp.	degrees of freedom	df
foot	ft	Incorporated	Inc.	expected value	E
gallon	gal	Limited	Ltd.	greater than	>
inch	in	District of Columbia	D.C.	greater than or equal to	≥
mile	mi	et alii (and others)	et al.	harvest per unit effort	HPUE
nautical mile	nmi	et cetera (and so forth)	etc.	less than	<
ounce	oz	exempli gratia	e.g.	less than or equal to	≤
pound	lb	(for example)		logarithm (natural)	ln
quart	qt	Federal Information Code	FIC	logarithm (base 10)	log
yard	yd	id est (that is)	i.e.	logarithm (specify base)	log ₂ , etc.
		latitude or longitude	lat or long	minute (angular)	'
Time and temperature		monetary symbols (U.S.)	\$, ¢	not significant	NS
day	d	months (tables and figures): first three letters	Jan, ..., Dec	null hypothesis	H_0
degrees Celsius	°C	registered trademark	®	percent	%
degrees Fahrenheit	°F	trademark	™	probability	P
degrees kelvin	K	United States (adjective)	U.S.	probability of a type I error (rejection of the null hypothesis when true)	α
hour	h	United States of America (noun)	USA	probability of a type II error (acceptance of the null hypothesis when false)	β
minute	min	U.S.C.	United States Code	second (angular)	"
second	s	U.S. state	use two-letter abbreviations (e.g., AK, WA)	standard deviation	SD
Physics and chemistry				standard error	SE
all atomic symbols				variance	
alternating current	AC			population sample	Var
ampere	A			sample	var
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				

REGIONAL OPERATIONAL PLAN ROP.SF.2A.2015.11

**SUSITNA RIVER CHINOOK AND COHO SALMON IN RIVER
ABUNDANCE AND CHINOOK SALMON SPAWNING DISTRIBUTION,
2015**

by
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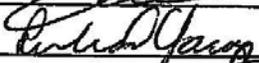
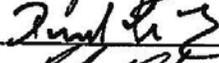
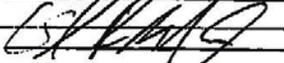
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ABSTRACT

The goals of this study are to estimate the abundance of spawning Chinook and coho salmon and the distribution of spawning Chinook salmon in the entire Susitna River in 2015. Independent, 2-event, mark–recapture experiments will be conducted on the mainstem Susitna River and Yentna River. In the mainstem Susitna River, fish wheels and gillnets will be operated at river mile (RM) 34 to capture Chinook salmon for marking with dart-PIT tags (a dart tag with an imbedded passive integrated transponder [PIT]). Recapture event sampling will occur at the Deshka River weir, Montana Creek weir, and at Sunshine (RM 83 Susitna River) with fish wheels and gillnets. Coho salmon abundance in the mainstem Susitna River will be estimated likewise, except gillnets will not be used for fish capture during either event. In the Yentna River, fish wheels and gillnets will be used at RM 6 to capture Chinook salmon for marking with dart tags (no PIT tag component). Recapture event sampling will occur at RM 18 of the Yentna River using fish wheels and gillnets. Coho salmon will be sampled and marked likewise, except gillnets will not be used in either event. Radio tags will be applied to a subsample of Chinook and coho salmon in the mainstem Susitna River and Yentna River to determine spawning distribution for Chinook salmon and handling effects for both species. Aerial telemetry surveys every 2 weeks and stationary telemetry receiver-loggers will be used to track movements of radiotagged salmon.

Key words: Chinook salmon, coho salmon, abundance, mark–recapture, Susitna River, Yentna River, spawning distribution, PIT tag, dart tag, gillnet, fish wheel, radio telemetry

PURPOSE

Recent Alaska-wide downturns in the productivity and abundance of Chinook salmon (*Oncorhynchus tshawytscha*) stocks have created social and economic hardships across many communities in rural and urban Alaska. There is a fundamental need to more precisely characterize productivity and abundance trends of Chinook salmon stocks across Alaska, gather essential information necessary to understand root causes of these widespread declines, and track population trends into the future (ADF&G Chinook Salmon Research Team 2013). The Alaska Department of Fish and Game (ADF&G) has selected the Susitna River Chinook salmon stock as an indicator stock and has recommended stock assessment projects and been allocated funds by the Alaska Legislature to estimate the inriver run size in the mainstem Susitna River and Yentna rivers. Use of radio tags in these abundance estimation projects will also allow estimation of spawner distribution. In addition, ADF&G has been allocated funds by the Alaska Legislature to estimate the escapement of coho salmon (*O. kisutch*) in the mainstem Susitna River and Yentna River.

In 2015, ADF&G will estimate the inriver abundance and spawner distribution of Chinook salmon and only the inriver abundance of coho salmon for both the Yentna and mainstem Susitna rivers. Data collected from these studies will supplement similar data collected in 2012–2014. The 2014 mainstem Susitna River Chinook salmon estimate was 68,225 (CI 53,473–94,240) above the Yentna River confluence and 22,042 (CI 17,286–28,325) within the Yentna River.

Data collected in 2015 from the Yentna and mainstem Susitna rivers stocks will enhance knowledge of the spawning distribution and habitat use of each species and quantify the annual variation in distribution and use. The 2015 abundance estimate for Chinook salmon in the entire Susitna River (mainstem Susitna River plus Yentna River) will be the third such study since the

1984 Susitna River hydroelectric project. These data will be useful for interpreting present and past stock assessments, choosing future assessments that are efficient and effective, providing new knowledge to fishery managers and users, advising the Alaska Board of Fisheries regulatory process, and for land use planning and permitting.

OBJECTIVES

PRIMARY OBJECTIVES

- 1) Estimate the abundance of Chinook salmon with length greater than or equal to 500 mm mid eye to tail fork (METF) in the mainstem Susitna River above the mouth of the Yentna River at RM 34¹, such that the estimate is within 25% of the true value 90% of the time.
- 2) Estimate the abundance of Chinook salmon with length greater than or equal to 500 mm METF in the Yentna River above RM 6², such that the estimate is within 40% of the true value 90% of the time.
- 3) Estimate the abundance of coho salmon with length greater than or equal to 400 mm METF in the mainstem Susitna River above the mouth of the Yentna River (RM 34) such that the estimate is within 40% of the true value 90% of the time.
- 4) Estimate the abundance of coho salmon with length greater than or equal to 400 mm METF in the Yentna River above RM 6, such that the estimate is within 40% of the true value 90% of the time.
- 5) Identify Chinook salmon spawning locations in the mainstem Susitna River by tagging site (fish wheel or gillnet) of radiotagged spawners so that any spawning location used by at least 5% of the tagged Chinook salmon spawners captured in a particular fish wheel or by drift gillnet will be detected (≥ 1 radio tag) with probability of at least 98%, and if spawners are distributed uniformly among 20 locations, the probability of detecting all 20 locations is at least 70%.
- 6) Identify Chinook salmon spawning locations in the Yentna River by tagging site (fish wheel or gillnet) of radiotagged spawners so that any spawning location used by at least 5% of the tagged Chinook salmon spawners captured with a gillnet or in a particular fish wheel will be detected (≥ 1 radio tag) with probability of at least 98%, and if spawners are distributed uniformly among 20 locations, the probability of detecting all 20 locations is at least 75%.
- 7) Estimate the proportions (based on radio tag locations and inriver spawning abundance estimates) of Chinook salmon spawning among 6 major tributaries (or groupings of minor tributaries) of the mainstem Susitna River, such that each proportion is within 7 percentage points of the true value 90% of the time.
- 8) Estimate the proportions (based on radio tag locations and inriver spawning abundance estimates) of Chinook salmon spawning among 7 major tributaries (or groupings of minor tributaries) of the Yentna River, such that each proportion is within 7 percentage points of the true value 90% of the time.

¹ Defined by Alaska Energy Authority, Watana Hydroelectric Studies

² Defined by the ADF&G Anadromous Waters Catalog

SECONDARY OBJECTIVES

1. Collect a tissue sample for genetic analysis from each Chinook salmon marked with a radio tag.
2. Collect lengths and tissue samples for genetic analysis from 200 coho salmon sampled at Montana Creek.
3. Collect scale samples from sockeye salmon at the mainstem Susitna River site.
4. Evaluate the effectiveness of the PIT tag readers at the Deshka River and Montana Creek weirs.

METHODS

STUDY DESIGN

Mark–recapture and radio telemetry techniques will be used to assess the abundance of Chinook and coho salmon in the Sustina River and the spawning distribution of Chinook salmon. Unfortunately, there are no sites on the Susitna River below the confluence with the Yentna River (RM 32) at which the entire salmon escapement is available to sampling; the channel is braided with many small islands and sand bars, and the water velocity is too slow to concentrate fish in any particular channel. Instead, the Chinook and coho salmon escapements and Chinook salmon distribution will be assessed independently in the mainstem Susitna River and the Yentna River (Figure 1).

Mainstem Susitna River

Chinook Salmon

A 2-event, capture–recapture experiment will be used to estimate the inriver abundance of Chinook salmon in the mainstem Susitna River. Fish wheels and gill nets will be used at RM 34 to capture Chinook salmon for marking with dart-PIT tags as the primary mark. Fish will be examined for marks at 3 recapture sites: weirs on the Deshka River and Montana Creek, and at fish wheels and gillnets at Sunshine (Susitna River RM 83; Figure 2). In 2014, second event Chinook salmon data was collected from the Deshka and Montana weirs and also with ARIS sonar in the Middle Fork Chulitna River; the latter site was not successful due to focus problems with the sonar unit. Because of these problems with the sonar, the Sunshine River site was chosen for second event data collection during 2015. The weirs at the Deshka River and Montana Creek provide very large sample sizes in the recapture events, and the Sunshine operations ensure that all remaining stocks, including the Talkeetna, Chulitna, and upper Susitna rivers stocks are sampled. The primary mark will be detected at the 2 recapture weirs using swim-through PIT tag antennas and visually by the crew at the Sunshine fish wheels. The PIT tags will allow for automated sampling of all fish at the Deshka and Montana weirs to maximize the sample size while avoiding the labor and run disruption necessary when hand sampling. Unlike radio tags, the low cost of dart-PIT tags also allows us to tag every fish greater than the prescribed size range, increasing the number of marks applied in the study. Radio tags will, however, also be deployed in a subsample of marked Chinook salmon to assess spawning distribution and to quantify the proportion of fish that drop out of the experiment. Examination of fish for secondary marks will occur for all the fish that are sampled for biological data at the 2 weirs, and for all fish captured in the fish wheels and gillnets at Sunshine.

All radiotagged Chinook salmon will be relocated using fixed tracking stations on major tributaries, at weir sites, and at fish wheel sites. For the Chinook salmon spawning distribution in each drainage, repeated aerial surveys will be flown over the major tributaries (Figure 2).

Coho Salmon

Coho salmon inriver abundance will be estimated in a nearly identical fashion, except that gill nets will not be used to capture fish at the marking or Sunshine recapture sites. Radio tags will be deployed on a small subsample of coho salmon only for quantifying the proportion of fish that drop out of the experiment; these tagged fish will not be followed to spawning grounds.

Yentna River

Chinook Salmon

Simultaneous with the mainstem Susitna River tagging, an independent, 2-event, capture–recapture experiment will be used to estimate the inriver abundance of Chinook salmon in the Yentna River. Fish wheels and gillnets will be used at RM 6 to capture Chinook salmon for marking with dart tags and a secondary mark. The recapture site will be fish wheels and gillnets at RM 18 (Figures 1 and 2). Radio tags will also be deployed in a subsample of marked Chinook salmon at RM 6 for assessing spawning distribution and quantifying the proportion of fish that drop out of the Yentna River experiment. Telemetry methods will be similar to those used for the mainstem study.

Coho Salmon

Coho salmon inriver abundance will be estimated in a nearly identical fashion, except that gill nets will not be used to capture fish at the marking or recapture sites. Radio tags will be deployed on a small subsample of coho salmon only for quantifying the proportion of fish that drop out of the Yentna River experiment. Spawner distribution for coho salmon will not be estimated in 2015.

SAMPLING METHODS

Marking Effort–Mainstem Susitna River

Dart-PIT tags

Chinook salmon tagging will occur approximately 22 May to 30 June 2015, and coho salmon tagging will occur approximately 7 July to 26 August 2015. Tagging will begin when water levels and debris loads allow for safe operations of fish wheels and gillnets.

At the mainstem Susitna River tagging site (Figure 3), 2 fish wheels, 1 on each bank, will each be operated for 12 h per day. A 2-person crew will operate both wheels for the first 6-h shift, followed by a different 2-person crew operating both wheels for the second 6-h shift (Table 1). Each fish wheel will be operated every day of the season, except for breakdowns, crew shortages, or unsafe weather.

Fish wheels will be aluminum, with 3 six-ft wide baskets webbed with knotless, nylon 1.5-in mesh netting (square measure). Captured fish will descend an aluminum basket chute to a fabric slide crossing above the float and exit into a live box. Live boxes will be 8-ft long, 2-ft wide, and 4-ft deep, with plywood sides with holes cut to allow water circulation. The configuration of the fish wheel axle, baskets, and floats make the fishing depth a maximum of 6.5 ft. Fish wheels will

be tied to the river bank and braced offshore with poles to position the wheels in sufficient current to make them spin. The axle height will be adjusted so that the baskets sweep as close to the river bottom as possible. A picket weir with 1.5-in gaps between pickets will be installed between shore and the fish wheel, to direct migrating salmon towards the fish wheel baskets.

In order to make sure all size categories of Chinook salmon are represented in the sample of all migrating Chinook salmon greater than or equal to 500 mm METF length, fish wheel samples will be supplemented by drift gillnets fished offshore of the fishwheels. In 2012, 2013, and 2014, Chinook salmon captured in gillnets had a larger average length than those captured in fish wheels; in 2014, the average length of Chinook salmon greater than or equal to 500 mm METF caught in fish wheels was 663 mm, while the average length of those caught in gillnets was 756 mm METF. Further, the average length of Chinook salmon caught in 2014 with the 5.5-in mesh was 726 mm METF, while the average length of those caught in the 7.5-in mesh was 788 mm METF. It is important to operate the drift gillnets as planned so that enough large fish can be tagged to provide a reasonably precise estimate of abundance in the larger size categories. Two drift net mesh sizes (5.5 in and 7.5 in, stretch measure) will be used. Nets will be 10–12 ft and 15–17 ft deep, respectively, for each mesh size. The desired capture technique will be to entangle fish by the snout to avoid gill injuries. The nets will be fished until the corks sink, indicating a fish is in the net, and the net will be immediately pulled in. One crew of 2 technicians will fish drift gillnets for up to 7.5 hours per day, with start times rotated daily until a cycle is completed each week to reduce bias due to the run timing of any individual stock (Table 2). No gillnets will be used for coho salmon tagging.

All captured healthy Chinook salmon greater than or equal to 500 mm METF length and coho salmon greater than or equal to 400 mm METF length will receive an orange dart-PIT tag (passive integrated transponder embedded dart tag, Model PDAT-PIT (HPT-12) from Hallprint Australia³) as the primary mark and a left operculum hole punch as the secondary mark to assess tag loss. Each dart-PIT tag will be associated with a unique dart tag number and unique PIT tag code. The dart number will be printed twice on each dart tag, so that when a fish is recaptured at the Sunshine site, the distal tag number can be cut off to aid in documentation of the recapture. The remaining portion of the dart tag in the fish will indicate the fish was previously sampled and thereby prevent double sampling.

To minimize handling stress, only Chinook and coho salmon that have been held in the live box less than 1 h will be tagged. Radio telemetry data for coho salmon in the Kenai River indicates that fish that were tagged immediately upon capture experience a mortality rate half that of fish that were held for variable times in the fish wheel live box before tagging (10% vs. 20% mortality; Carlon and Evans, 2007). Other salmon telemetry studies have also documented adverse effects for salmon that were held in live boxes prior to tagging (Adam et al. 2012). Identical holding time practices at Flathorn (mainstem Susitna River RM 29) in 2010 showed that 12% of coho salmon and 9.5% of chum salmon did not continue upstream (Cleary et al. 2013). In 2014, we found that only 7% of radio tags applied to Chinook salmon in the mainstem Susitna River at RM 34 were assigned a tag-induced mortality fate. Given that 1 crew is tasked with operating 2 fish wheels simultaneously, deploying the scheduled number of radio tags each day, and sorting, dart-tagging, and measuring other fish, we feel a 1-h holding time is a reasonable compromise. Live box holding time for all tagged fish will be recorded.

³ Product names used in this publication are included for completeness but do not constitute product endorsement.

Two person crews will process selected salmon quickly to reduce handling time. Fish will be in a holding tank on board a boat during tagging. A bucket will be used to frequently add water to the tank. A padded, aluminum cradle (Larson 1995) will be slipped around the fish to restrain it during tagging. One person will restrain the fish, while the second will insert a dart-PIT tag and record data. Dart-PIT tags will be inserted with stainless steel applicator needles immediately below the dorsal fin on the fish's left side, anchoring in the dorsal pterigiophores. A paper punch will be used to punch a hole in the lower left operculum as a secondary mark.

Radio Tags

Three hundred of the dart-PIT tagged Chinook salmon greater than or equal to 500 mm METF length will also be radiotagged at the mainstem tagging site. Radio tags will be deployed systematically, in proportion to the historical run timing of fish greater than or equal to 500 mm METF length (Tables 1 and 2). Radiotagging the first available, healthy fish should avoid selection bias by the crews. Analysis of 2014 Deshka weir data shows that tagging small fish (500–585 mm METF) at one-third the rate of larger fish with a fishwheel:gillnet radiotagging ratio of 4:1 resulted in insufficient radio tags placed on large fish (≥ 785 mm METF). As described earlier, we found that fish caught in gillnets were significantly larger than those caught by fish wheels. We plan to tag fish in the 500–585 mm METF category at one-quarter the rate of larger fish and to decrease the fishwheel:gillnet radiotagging ratio to 2:1, such that we will apply 100 radio tags at each of the fishwheels and 100 radio tags to fish caught in the gillnets. This strategy should increase the proportion of radio tags applied to larger fish. We will stratify the spawner distribution estimate should the Deshka weir recapture:capture length composition plots show uneven tagging among size categories.

A total of 100 coho salmon greater than or equal to 400 mm METF length will be radiotagged at the fish wheels (50 per fish wheel); these will be deployed systematically, in proportion to the historical run timing (Table 3). Methods for deploying leftover tags, fish handling, and radiotagging are described in the Data Collection section below. No gillnets will be used to capture coho salmon in this study.

Once the scheduled number of radio tags has been deployed for a particular fish wheel shift (both species), the wheels will still run for the duration of the shift to continue with dart-PIT tagging. Similarly, once the scheduled number of radio tags has been deployed for a particular gillnet shift, netting will continue for the full duration of the shift, to maximize the number of dart-PIT tags deployed on Chinook salmon.

Procedures to sample fish for radiotagging and to minimize handling stress will be identical to those described above for dart-PIT tagging. Radio tags will be inserted through the esophagus and into the upper stomach using a 0.38-in (outside diameter), 12-in long plastic tube. The antenna of the radio transmitter will be threaded through the tube and pinched by hand at the end of the tube such that the radio transmitter is held tightly against the opposite end of the tube. A paper punch will be used to punch a hole in the lower left operculum as a secondary mark. The crew will measure METF length and remove and preserve the distal 0.5 cm of the left axillary process of any radiotagged salmon.

Marking Effort–Yentna River

Dart tags

At the RM 6 site of the Yentna River (Figure 3), Chinook salmon tagging will occur approximately 22 May to 25 June 2015, and coho salmon tagging will occur approximately 7 July to 26 August 2015. Chinook salmon tagging will cease on 25 June to accommodate personnel moving to other projects. Tagging will begin when water levels and debris loads allow for safe operations of fish wheels and gillnets. Two crews will work 9-h shifts each day to operate 2 fish wheels, 1 on each bank, during daylight hours. Total effort for each fish wheel will be 16 h per day (8 h/shift for 2 shifts). Each fish wheel will be operated every day of the season, except for breakdowns, crew shortages, or unsafe weather.

The RM 6 fish wheels on the Yentna River are similar to the mainstem Susitna River fish wheels, except for having 2 baskets instead of 3, live boxes 4-ft long, 4-ft wide, and 4-ft deep instead of $8 \times 2 \times 4$ ft, and a maximum fishing depth of 4.5 ft instead of 6.5 ft. Gillnet methods will be identical to those at the mainstem Susitna River site described above.

At the Yentna River tagging site, all healthy captured Chinook salmon greater than or equal to 500 mm METF and coho salmon greater than or equal to 400 mm METF length will receive a yellow dart tag (model FT-1-94 from Floy Tag, Seattle, WA) as the primary mark and a hole punch in the adipose fin as a secondary mark to allow assessment of tag loss. Each dart tag will be associated with a unique tag number, which will be printed twice on the tag, so when a fish is recaptured upriver, the distal tag number can be cut off to aid in documentation of the recapture. The remaining portion of the dart tag will serve to identify it as a previously caught fish and thereby will prevent double sampling.

Radio Tags

A total of 300 dart-tagged Chinook salmon greater than or equal to 500 mm METF length will be tagged with radio tags at Yentna River RM 6. The target distribution for radio tags will be 100 per fish wheel and 100 with drift gillnets. A total of 100 coho salmon (50 per fish wheel) greater than or equal to 400 mm METF will also be tagged with radio tags. Identical to the mainstem Susitna River, radio tags will be deployed in Chinook and coho salmon systematically, in proportion to the historical run timing (Tables 4–6), and following the same insertion method. Methods for deploying leftover tags are described in the Data Collection section, below. Analysis of the 2014 Chinook salmon data from the Yentna River experiment shows no size stratification was needed in the mark–recapture experiment and that no substantial differences were found in the length composition of radiotagged versus dart-tagged fish. We will therefore mimic the 2014 methodology as closely as possible; however, additional training of radiotagging crews will occur to correct crew-dependent radio tag drop-out rates observed in 2014.

Once the scheduled number of radio tags has been deployed for a particular fish wheel shift, the wheels will still be run for the duration of the shift to continue with dart tagging. Similarly, once the scheduled number of radio tags has been deployed for a particular gill net shift, netting will continue at Yentna River RM 6 for the full duration of the shift, to maximize the number of dart tags deployed.

Spawning Location

For both the mainstem Susitna River and Yentna River, movements of radiotagged Chinook salmon will be monitored from time of release by a combination of aerial surveys and tracking stations on important migratory corridors and recapture sites. Four tracking stations will be placed in the Yentna drainage and 8 tracking stations will be placed upstream of Susitna River RM 34 (Table 7, Figure 2). All tracking stations will consist of at least 2 antennae: a receiver–logger and a self-contained power system. Radiotagged fish within reception range of the stations will be identified and recorded. Collected information will include the date and time each radiotagged fish is present at the site, the signal strength and activity pattern of the transmitter (active or inactive), and the location of the fish in relation to the station (i.e., upriver or downriver from the site). Information on tracking station operations (i.e., voltage levels for the station components and whether the reference transmitter at the site is being properly recorded) will also be collected.

A fixed-wing aircraft will be used for aerial surveys, following the major tributaries at about 1,000 ft above ground level. Two Yagi antennas, 1 on each side of the plane, will be mounted on a wing strut with the antenna oriented forward and slightly downward, and the elements oriented vertically to maximize the reception. Both antennae will be combined into 1 line to the receivers. An Advanced Telemetry Systems (ATS) R4520C radio receiver–logger with an internal global positioning system (GPS) receiver will be programmed to continuously scan all frequencies and create a log of the detected tags and the concurrent latitude and longitude.

Tracking flights will be made approximately every 2 weeks from 22 June through 7 August to locate radiotagged fish, weather permitting. The flights will cover major tributaries throughout the entire Susitna River drainage. Each transmitter will be located approximately to the nearest 2 mi. Any transmitters signaling a mortality pulse will be noted. A handheld GPS, set to automatically record a track, will be operated for the full duration of each flight to document the extent of each survey.

For both salmon species, the radio transmitters will be manufactured by ATS and will operate on several frequencies within the 150.000–152.999 MHz range. Eight frequencies will have 100 pulse codes resulting in 800 uniquely identifiable transmitters. Each transmitter will be equipped with a mortality indicator mode that activates when the tag is motionless for approximately 24 h. All Chinook salmon will receive the ATS F1845B transmitters, which will be 52-mm long, 19 mm in diameter, have a mass of 26 g, have a 30-cm external whip antenna, and a nominal battery capacity life of 311 d. The first Chinook salmon radio tag is scheduled to be deployed 22 May 2015; all aerial surveys are scheduled to be completed approximately 77 days later (7 August), and the fixed radiotracking stations are scheduled to be shut down for the season approximately 131 days later (30 September), so battery life should not be a factor in tracking tags. Coho salmon will receive the ATS F1840B transmitters, which are 56-mm long, 17 mm in diameter, have a mass of 20 g, have a 30-cm external whip antenna, and a battery capacity life of 126 days. The first coho salmon radio tag is scheduled to be deployed 9 July 2015; the fixed radio tracking stations are scheduled to be shut down for the season approximately 83 days later (30 September), so battery life should not be a factor in tracking tags. Both the Chinook and coho salmon radio tags will be programmed to stop transmitting 180 days after activation to prevent long-lived tags from transmitting into 2016 and confounding the next season's tracking.

Recapture Events–Mainstem Susitna River

A fixed radio tracking station located at the mouth of the Deshka River will be used as the gateway station to define radiotagged fish that have entered the abundance experiment (Figure 2). The product of the number of all tags applied and the proportion of radiotagged fish that entered the experiment will be used to estimate valid tags in the mark–recapture study. Recapture events for the mainstem Susitna River mark–recapture experiments consist of weirs and fishwheels and gillnets (Chinook salmon only) at Sunshine.

Weirs

Floating weirs will be operated at the Deshka River and Montana Creek. Two types of recapture technology will exist at each of the Deshka and Montana weirs. The first involves fixed radio tracking stations, installed at the Deshka River and Montana Creek weirs to record the radio frequency and pulse code of radiotagged Chinook and coho salmon as they migrate upstream of the weirs. Fixed radiotracking stations will be checked periodically to confirm their proper operation and to download data.

The second type of recapture technology involves PIT-tag readers, deployed upstream of the weir traps to record dart-PIT-tagged fish as they swim through the antennae (Appendix C1). Two antennae will be operated at each weir to ensure detection. At each weir, 3 tests will be run to verify proper operation of the PIT-tag detection array (Appendix C1). A trap incorporated into the weir at each site will allow capture of fish for sampling. METF length will be measured on a subsample of marked or unmarked Chinook and coho salmon at the Deshka River and Montana Creek weirs. Fish sampled for METF length will also be examined for secondary marks to assess tag loss, although the test will be very weak given that only about 350 fish will have been sampled for ASL at the weirs. Tissue samples will be collected from coho salmon at the Deshka River and Montana Creek weirs in support of other ADF&G studies. Other species counted through the weirs will be tallied.

Fishwheels-Sunshine

Fish wheels will be used at Sunshine (Susitna River RM 83) to sample Chinook and coho salmon for tags and secondary marks. Drift gillnets will also be used at Sunshine to sample only Chinook salmon. All captured Chinook and coho salmon will be examined for the presence of a dart-PIT tag and an operculum punch. Found dart-PIT tags will be scanned electronically for the PIT-tag number and visually examined for the dart number, which will be recorded on field forms. The upper portion of the dart tag attached to recaptured salmon will be cut off (containing the tag number). All marked Chinook and coho salmon will be measured for METF length. Fish sampled with half a tag will not be sampled further; their presence will be recorded however. All Chinook salmon and a subsample of caught coho salmon will be measured for METF length each shift. All untagged Chinook salmon measured for length will be given a tertiary mark (dorsal fin punch) to identify previously sampled salmon.

Recapture Events–Yentna River

A fixed radiotracking station will be installed at RM 18 of the Yentna River to be used as the gateway station to define fish that have entered the abundance experiment (Figure 2). Recapture event sampling data will be collected by fish wheels operated in the Yentna River at RM 18 using similar methods to those used at Yentna River RM 6. Drift gill nets will be used to sample Chinook salmon only. All Chinook and coho salmon captured will be examined for the

presence of a dart tag and an operculum punch. The upper portion of the dart tag (containing the tag number) attached to recaptured fish will be cut off. All marked fish will be measured for METF length. Fish sampled with half a tag will not be sampled further; however, their presence will be recorded. All Chinook salmon and a subsample of coho salmon will be measured for METF length each shift. All untagged Chinook salmon measured for length will be given a tertiary mark (dorsal fin punch) to identify previously sampled salmon.

MARK–RECAPTURE

Abundance–Assumptions and Testing

Ideally, Chinook and coho salmon abundance will be estimated with a Petersen-type estimator. For these estimates of abundance to be unbiased, certain assumptions must be met (Seber 1982). These assumptions, expressed in the circumstances of this study, along with their respective design considerations and test procedures will be as follows:

Assumption I: the population is closed to births, deaths, immigration, and emigration.

Considering the life histories of Chinook and coho salmon, there should be no recruitment (births, immigration) between sampling events. First event sampling (marking) will begin prior to any significant passage of fish past the tagging sites and will continue through the run until passage has dropped to near zero. With respect to emigration, some fish marked at each of the mainstem Susitna River and Yentna River marking sites will leave the system where they were marked and migrate to the other. Also, some marked fish may fail to enter the experiment due to handling stress. For both the mainstem Susitna River and Yentna River experiments, losses of fish due to either reason will be estimated from a sample of marked fish that are also instrumented with radio tags, and marked fish will be adjusted accordingly.

Assumption II: there is no trap induced behavior.

There is no explicit test for this assumption because the behavior of unhandled fish cannot be observed. We will attempt to meet this assumption by minimizing holding and handling time of all captured fish. Any obviously stressed or injured fish will not be tagged. Examples would be fresh seal bites that penetrate into the muscle, capture injuries such as torn opercula, large skin wounds or broken snouts, or being dropped in the boat while tagging.

Assumption III: tagged fish will not lose their marks between sampling events and all marks are recognizable.

Failure of tagged fish to remain in the experiment will be estimated for the abundance experiments as described under Assumption I. Chinook and coho salmon sampled at the Yentna River and Sunshine second event fishwheels and Sunshine gillnets will be examined for a secondary mark. A fish with a secondary mark but no dart(-PIT) tag will indicate the dart(-PIT) tag (primary mark) has been lost.

Assumption IV: 1 of the following 3 conditions will be met:

- 1) all Chinook and coho salmon will have the same probability of being caught in the first event, or
- 2) all Chinook and coho salmon will have the same probability of being captured in the second event, or
- 3) marked fish will mix completely with unmarked fish between samples.

In this experiment, it is impossible that marked and unmarked fish will mix completely. Marking fish wheels and gillnets will be operated continuously during the run, with marked fish never having the opportunity to mix with unmarked fish from later stages of the run by the time they are sampled in the second event.

For the Yentna River marking and recapture events and the mainstem Sustina River marking event, consistent use of fishwheels and gillnets provides a possibility that the populations are sampled uniformly. However, uniform sampling is not guaranteed. Fluctuations in water levels can affect the efficiency of fish wheels, resulting in variation in probability of capture over time. Also, the probabilities of capture by fish wheels may vary between banks due to differences in channel morphology and water flow (Yanusz et al. 2007). Further, uneven fishing efficiency and effort between gillnets and fishwheels may also result in uneven probability of capture between midriver and bank-oriented populations, and probability of capture may differ among size categories.

For the second event in the mainstem Susitna River experiment, weirs at Deshka River and Montana Creek and fish wheels and gillnets at Sunshine will be used. While the entire population is exposed to sampling, there is little chance that probability of capture will be uniform. All (100%) of the Deshka River and Montana Creek populations will be sampled, while only a fraction of the remaining stocks will be sampled in the Sunshine fishwheels and gillnets.

The diagnostic tests described below will identify appropriate remedial measures for departures from uniform sampling and will provide direction in selecting the most appropriate model(s) to estimate abundance.

Equal probability of capture will be evaluated by time, area, and size. The procedures to analyze length data for statistical bias due to gear selectivity are described in Appendix E1. If different probabilities of capture by size are indicated, data will be fully stratified into size groups where probability of capture is homogeneous within groups, and abundance estimates will be calculated for each size group and summed.

Contingency table analyses recommended by Seber (1982) and described in Appendix E2 will be used to detect significant temporal or geographic violations of assumptions of equal probability of capture. The test for complete mixing (Test I in Appendix E2) will not be performed. We expect the complete mixing condition will be violated geographically because a strong tendency for bank orientation by coho salmon at the Flathorn tagging site was demonstrated during the 2009 and 2010 radiotelemetry studies (Merizon et al. 2010; Cleary et al. 2013.) Examination of Chinook salmon data collected in 2012 suggested some bank orientation at the mainstem tagging sites by Chinook salmon spawning above the Deshka River weir because a larger proportion of fish captured on the west bank entered the Deshka River than fish captured on the east bank ($P = 0.21$). Also, the complete mixing condition cannot be satisfied temporally due to experimental design and the timing of movements of fish being investigated. Tests II and III in Appendix E2 will be performed. Based on previous experience, it is anticipated that geographic and possibly temporal violations of these assumptions will be detected and that a Petersen-type model would yield a biased estimate. Therefore, abundance will most likely be estimated using models developed by Darroch (1961) for a 2-event mark–recapture experiment on a closed population when temporal or spatial distributions of fish affect their probabilities of capture.

SAMPLE SIZES

Abundance–Mainstem Susitna River Chinook Salmon (Objective 1)

Assessment of sampling effort necessary to achieve our precision criteria for Objective 1 will be based largely on experience gained during the 2010–2014 experiments. We expect sampling rates (the proportions of the population passing each sampling site that are captured) will be similar in 2015 to that experienced in 2014.

The approach of Robson and Regier (1964) was used to provide baseline sample sizes for a given population size and precision criteria, under the assumption a Petersen type estimator will be used. These sample sizes are interpreted in the context of likely violations of assumptions required for the Petersen estimator.

Given results from the 2013–2014 mainstem Susitna River Chinook salmon studies, we expect that size stratification and possibly Darroch-type models (Darroch 1961) may be needed rather than a Petersen-type model. There was, however, no indication Darroch-type models were needed in 2014. The following sample size calculations consider only one or the other type of model (size-stratified or Darroch) will be required.

In reviewing several salmon mark–recapture experiments where a Darroch-type model was required to estimate abundance, we observed that the unbiased CV for abundance estimates was 1.3 to 2.3 times as large as it might have been if necessary assumptions were satisfied and a Petersen-type model were appropriate. In 2010, the CV of our estimate of chum salmon abundance based on a Darroch model with correction for handling loss was approximately 1.6 times larger than would have been realized using a Chapman estimator with no correction for handling loss for a similar population size and sampling effort. Similarly, the CV of our coho salmon abundance estimate based on a Darroch model with correction for handling loss was approximately 2.0 times larger than provided by a Chapman model. With respect to size stratification, the 2013 and 2014 mainstem Chinook salmon estimates had to be stratified; the cost of the stratification ranged from increased CV of the abundance estimate from 1.4 (2013 studies) to 1.9 (2014).

For these experiments, we assume that the CVs of our final estimates of abundance, using either the Darroch model or size stratification, will be 2 times as large as we would see if no adjustments were necessary and a Petersen-type model were appropriate. The methods of Robson and Regier (1964) were used to calculate the necessary sample sizes, for different potential population sizes, to estimate abundances of Chinook salmon in the Susitna River drainage above the mouth of the Yentna River within 12.5% (half of specified relative precision for Objective 1) of the true values 90% of the time with a Petersen-type model. We expect that these same sample sizes will allow us to estimate abundances of Chinook salmon within 25% of the true values 90% of the time. Based on average rates from the 2013–2014 radiotagging experiments, we expect approximately 20% of the fish tagged at the mainstem Susitna River will be censored from the experiment. About 6–7% are expected to not be detected at all or will only be detected downstream of the tagging site, plus up to 14–15% will spawn in the Yentna River system.

The minimum sample size requirements and numbers of Chinook salmon expected to be sampled during first and second event sampling to estimate population sizes between 40,000 and 120,000 are presented in Appendix E3. The range of population sizes that were examined span the 95%

confidence intervals of the 2012–2014 mainstem Susitna River Chinook salmon estimates. In 2014, about 1,500 Chinook salmon greater than 500 mm METF were caught in fishwheels and drift gillnets from an estimated population of 68,000. In 2015, all fish greater than 500 mm will be tagged with dart-PIT tags. Appendix E3 shows that about 20% of the population needs to be sampled in the worst case (population of 40,000) in the second event to meet objective criteria. In 2013 and 2014, about 20% of the population of Chinook salmon greater than 500 mm passed through the Deshka weir alone. Given that the second event samples comprise all Desha weir and Montana Creek fish, along with fishwheel and gillnet samples from Sunshine on the Susitna River, we are confident that more than 20% of the population will be sampled. Reducing the marking rate for the largest population in Appendix E4 to 50% of the 2014 rate (depensatory sampling) means that we would need to sample 14% of the population (vs 7.5%); this rate is below the 20% expected.

Abundance–Mainstem Susitna River Coho Salmon (Objective 3)

Similarly for mainstem Susitna River coho salmon (Objective 3), the methods of Robson and Regier (1964) were used to calculate the necessary sample sizes, for different potential population sizes, to estimate abundance within 20% of the true value 90% of the time with a Petersen-type model. We expect that these sample sizes will allow us to estimate abundances of coho salmon within 40% of the true values 90% of the time, assuming similar mitigation for violations of assumptions as described above by using a Darroch (1961) model or due to size stratification. Based on results of our 2013 and the 2014 experiments, we expect approximately 20% of the coho salmon radiotagged at the mainstem wheels will not be detected at all, will only be detected downstream of the tagging site, or will be detected in the Yentna River system.

The minimum sample size requirements and numbers of coho salmon expected to be sampled during first and second event sampling to estimate population sizes from 40,000 to 200,000 are presented in Appendix E4. The range of population sizes that were examined span the 95% confidence intervals of the 2010–2014 mainstem coho salmon estimates.

The spawning distribution estimates from the 2010 coho salmon experiment (Cleary et al. 2013) suggest that about 9% of the coho salmon spawning in the mainstem spawned in the Deshka River and Montana Creek drainages. The preliminary 2012 results suggest approximately 12% of the mainstem spawners were in these 2 systems where second event sampling for coho salmon will be conducted. In both 2013 and 2014, approximately 18% of the mainstem coho salmon spawned above the second event sampling sites. In the worst case scenario (population of 40,000), we will need to inspect about 9% of the spawning population above the mainstem tagging site during second event sampling to achieve the precision criteria for Objective 3. Our sampling design will be adequate if spawning distribution is similar to that estimated in recent years. Reducing the marking rate in Appendix E4 for the largest population to 50% of the 2014 rate (depensatory sampling) means that we would need to sample 5% of the population (vs 2.4%); this rate is below the expected rates.

Abundance–Yentna River Chinook Salmon (Objective 2)

Based on the Yentna River Chinook salmon mark–recapture experiment in 2014, we expect the abundance of Chinook salmon in 2015 to be in the range of 15,000 to 30,000. Of the 694 Chinook salmon radiotagged at the Yentna River RM 6 fishwheels in 2013, 77 (11.1%) were not detected later, failed to enter the experiment area, or did not spawn upstream of the tagging site. In 2014, we observed 2 distinct drop-out rates for radiotagged Chinook salmon, dependent on

which one of 2 crews were tagging. One crew experienced a drop-out rate of 36%, while the other experienced a rate of only 16%, similar to that found in 2013, and also of the same magnitude of that observed in the mainstem Susitna River experiment in 2014. We will assume that the crew-specific problems will be solved in 2015 and that a drop-out rate of 15% is reasonable for the Yentna River marking effort.

Assuming a loss of marked fish of 15%, a 2014 Yentna River Chinook escapement between 15,000 and 30,000 fish, and catch rates similar to that in 2014 (approximately 1,500 per 22,000), we need to capture about 1,100 salmon during the second sampling event to achieve the precision criteria for Objective 2, assuming similar mitigation of violation of assumptions as used for the mainstem experiments (Appendix E5). In 2014, the second event fishwheels and gillnets captured about 1,400 Chinook salmon greater than or equal to 500 mm. Objective 2 criteria should be met. It is noted that in 2014, no size-stratified or Darroch model was needed; if only a simple Petersen model is again needed in 2015, then catch rates in the first event for the highest population (depensatory sampling) can be reduced appreciably (30% of that seen in 2014) while still meeting Objective 2 criteria.

Abundance–Yentna River Coho Salmon (Objective 4)

Yentna River coho salmon abundance was estimated to be 122,777 (SE 22,697) in 2010; 85,851 (SE 10,148) in 2011; 93,932 (SE 10,630) in 2012; and 73,819 (SE 6,569) in 2014, with catches at the lower Yentna River fishwheels (RM 6) of 6,134; 2,030; 4,395; and 3,300, for those years respectively. Based on 95% confidence intervals of the 2010 through 2014 estimates, we present sample sizes for populations from 70,000 through 180,000. In 2014, about 25% of the radiotagged fish failed to enter the mark–recapture experiment.

Appendix E6 shows required sample sizes meeting precision criteria for Objective 4. Assuming a loss of marked fish of 25%, escapements ranging from 70,000 to of 180,000, and a capture rate similar to that seen in 2014 (about 3,250 per 74,000), we will need to capture about 2,000 salmon during the second sampling event. In 2014, we sampled 10,500 coho salmon in the second event fish wheels, and we are confident that we can meet Objective 4 criteria. If catch rates are reduced by 50% for the highest population (depensatory sampling) cited in Appendix E6, then about 4,000 need to be sampled in the second event.

Spawning Location–Mainstem Susitna River Chinook Salmon (Objective 5)

For Chinook salmon, the project will deploy 100 radio tags per fish wheel at RM 34, and 100 radio tags on fish caught from drift gillnets, and we expect a 20% mark loss for Chinook salmon. Assuming tag loss is independent of spawning location, then any spawning location used by at least 5% of the spawners passing a fish wheel tagging site or drift gillnet should be detected (≥ 1 radio tag) with a probability greater than 98%, and if spawners are distributed uniformly among 20 locations, the probability of detecting all 20 locations is greater than 71%, meeting Objective 5 criteria.

Spawning Location–Yentna Chinook Salmon (Objective 6)

For Chinook salmon, the project will deploy 100 radio tags per fish wheel at Yentna River RM 6, and 100 from drift gillnets, and we expect a 15% mark loss for Chinook salmon. Assuming tag loss is independent of spawning location, then any spawning location used by at least 5% of the spawners passing a fish wheel tagging site or drift gillnet should be detected (≥ 1 radio tag) with a 98% probability, and if spawners are distributed uniformly among 20 locations, the probability

of detecting all 20 locations is 76%, meeting Objective 6 criteria. The probability of detecting all 20 locations is greater than 75%.

Spawning Distribution–Mainstem Susitna Chinook Salmon (Objective 7)

The required sample size of radiotagged Chinook salmon in the mainstem Susitna River experiment, assuming 20% tag loss and uniform application of tags is 257, with 205 functioning tags (Objective 7; Thompson 1987). We will be applying 300 radio tags and expect to have 240 functional tags, so Objective 7 criteria should be met. The additional 35 functional tags provides some leeway should we detect uneven application of radio tags (e.g., through R:C plots and contingency table analysis from Deshka River and Montana Creek weirs and Sunshine fish wheels). If uneven tagging is detected, then abundance estimates may be stratified accordingly and the spawning distribution weighted accordingly. It is noted that this stratification may be different to the stratifications that may be required for the dart-PIT tag abundance estimates. These weighted observations can be combined (see Data Analysis section) to provide unbiased or minimally biased estimates of the proportions of Chinook salmon spawning in different tributaries.

Projecting the precision of estimates of proportions based on weighted tag observations, as described above, is very difficult. Empirical results from our 2013 mainstem Susitna River Chinook salmon experiments provide an indication of the precision we might expect to see for estimates of spawning distribution for the 2015 Chinook salmon experiments. For Chinook salmon in 2013, the value in the longer tail of the 90% confidence interval deviated from the point estimates by less than 5 percentage points in 6 out of 6 proportions estimated.

Spawning Distribution–Yentna River Chinook Salmon (Objective 8)

The required sample size of radiotagged Chinook salmon in the mainstem Susitna River experiment, assuming 15% tag loss and uniform application, is 242, with 205 functioning tags (Objective 8; Thompson 1987). We will be applying 300 radio tags, and expect to have 255 functional tags, so Objective 8 criteria should be met. The additional 50 functional tags provides some leeway should we detect uneven application of radio tags (e.g., through R:C plots and contingency table analysis from the RM 18 Yentna River fishwheels), although no stratification was required in the 2014 study. If uneven tagging is detected, then abundance estimates may be stratified accordingly and the spawning distribution weighted accordingly. It is noted that this stratification may be different to the stratifications that may be required for the dart-PIT tag abundance estimates. These weighted observations can be combined (see Data Analysis section) to provide unbiased or minimally biased estimates of the proportions of Chinook salmon spawning in different tributaries.

DATA COLLECTION

Each sampling site will provide a daily summary of catch, effort, tags deployed or recovered, weir counts, environmental conditions, and any operational changes, to a biologist at the Palmer Division of Sport Fish (SF) office via telephone 5 days per week. Division of Commercial Fisheries (CF), Soldotna will operate the Yentna River RM 6 site. RM 6 crews will maintain daily contact with the Soldotna ADF&G office for camp logistical needs, and will contact the Palmer office directly to relay daily summaries.

Abundance

Marking Events–Mainstem Susitna River RM 34 and Yentna River RM 6 Sites

At each site, tag deployment data will be recorded on Rite-In-Rain data sheets and entered in Microsoft Excel spreadsheets at camp. Fish wheel catch and effort data will be recorded on the 2015 Catch and Effort Data Form (Appendix A1). The form will be filled out with the following: date, crew initials, total fish wheel operation time, shift, start and stop times, crew arrival and departure time, and the total number of Chinook and coho salmon tagged and untagged. In addition, the total number of other species captured during the shift will be recorded.

Marking Event–Mainstem Susitna River

During Chinook salmon tagging, a total of 6 people will be used: 2 crews of 2 people to run the fish wheels for 2 shifts each day, and 1 crew of 2 people to sample with drift gillnets, in a split shift. During coho salmon tagging, only fishwheels will be operated. All Chinook salmon greater than or equal to 500 mm METF length and all coho salmon greater than or equal to 400 mm METF length will be tagged with a dart-PIT tag. The number of radio tags deployed each day for Chinook and coho salmon will occur according to a daily schedule (Tables 1–3). Each fish wheel will be operated for a total of 12 h each day in 2 shifts. Sampling effort will begin when the live box door is installed to hold captured fish, approximately 1 h after the crew starts its shift, allowing for sampling preparation and travel time. The first shift will begin at 0500 and will end at 1300 daily, and the second shift will be from 1400 to 2200 daily. After 6 h of effort for the shift, the live box door will be pulled so captured fish can escape. The fish wheel will be allowed to run in order to prevent debris from building up on the submerged basket. The crew will spend the remainder of its shift performing data compilation and equipment maintenance.

The number of radio tags to be deployed will be evenly split between the first and second shifts and river banks, with odd numbers of tags alternating between the shifts and river banks (Tables 1–3). The exact sequence of radio tag frequency-pulse codes to be deployed will follow Appendix A1. If the scheduled number of radio tags for a given species cannot be deployed at a given wheel due to low catch during that shift, the leftover tags will be deployed by the next shift, even if it is the following day. The next shift will deploy its regularly scheduled tags first, then the leftover tags. This will continue until the leftover tags are deployed and the crew can get back on the original schedule. To enhance the chance that radio tags are deployed in proportion to the run, the number of tags deployed from each wheel may be adjusted depending on catch rates. Actual deployment of tags will be recorded in Tag Deployment and Tag Deviation Logs (Appendix A1).

In order to minimize fish wheel injuries, closed-cell foam padding will be placed where appropriate to prevent injuries as fish exit fish wheel basket chutes.

Fish wheel operations-Mainstem Susitna River

- 1) Each fish wheel will be visited every 1 hr or less. When a fish wheel has been untended for more than 1 hr, all the fish in the live box shall be counted, measured if due, and released, but not tagged.
- 2) Fish with large, fresh injuries, that are bleeding, or that have dropped in the boat, will be measured and released without being tagged.
- 3) No tagging will occur without first placing the fish in water.

- 4) For healthy Chinook salmon greater than or equal to 500 mm METF length, radio tags will be deployed (Table 1) at a rate of every fourth fish that is less than 585 mm METF and every fish greater than or equal to 585 mm METF until the scheduled number is deployed.
- 5) The actual number of tags deployed will be compared to the scheduled number to be deployed every 5 d (Tables 1–2) on 26 and 31 May, and 5, 10, 15, and 20 June, in order to adjust the tagging rates if tags are being deployed too quickly or slowly. If tags at a particular fish wheel are being deployed too slowly (i.e., the tag surplus keeps building), the surplus may be reassigned to another fish wheel or the gill nets in order to utilize all tags by 30 June.
- 6) For healthy coho salmon greater than or equal to 400 mm METF, radio tags will be deployed (Table 3) until the scheduled number have been applied.
- 7) If tags at a particular fish wheel fall behind schedule (i.e., surplus tags build), the surplus may be reassigned to the other fish wheel in order to utilize all coho salmon tags by 17 August.
- 8) Every radiotagged Chinook and coho salmon will have the distal 0.5 in of the left axillary process removed and preserved in a uniquely-numbered vial with ethanol (Appendix B2).
- 9) A dart-PIT tag will be applied to every healthy Chinook salmon greater than or equal to 500 mm METF and coho salmon greater than or equal to 400 mm METF, including radiotagged fish. The lower left operculum of each dart-PIT tagged fish will have a hole punched in it with a paper punch.
- 10) After the dart-PIT is successfully imbedded in the salmon, a handheld PIT tag reader will be used to record the PIT tag number.
- 11) All Chinook and coho salmon (both tagged and not tagged) will be measured for METF length (Appendix B1), tallied, and released.
- 12) Every second sockeye salmon will be measured for METF length and have a scale sample taken (Appendix D1) in support of another ADF&G project.
- 13) Other fish species will be tallied on the data form and the fish released.
- 14) If the radio tags scheduled for a shift cannot be deployed to low catches, those tags shall be deployed on the next shift(s).

Tags will not be shared between the mainstem Susitna River and Yentna River.

Drift net operations–Mainstem Susitna River

Drift gillnetting for Chinook salmon will take place midchannel, if possible, and between the fish wheel sites to sample fish not susceptible to fish wheel capture. Prior to using new drift nets, old nets will be used to practice drift fishing and locate fishing sites that do not have snags. Drift net mesh sizes (5.5 in and 7.5 in, stretch measure) will be used. Nets will be 10–12 ft and 15–17 ft deep for each mesh size, respectively. Drift locations, duration, and net depth will be changed accordingly to depth or when net snags are found at fishing sites. One mesh size will be used per split shift, and each split shift will use a different mesh size so that each mesh size gets approximately an equal amount of effort each day. Two technicians will make as many drifts as possible during each split shift to achieve a total of 6 hours per day of fishing effort for both shifts combined. After the scheduled Chinook salmon radio tags are deployed (Table 2) for each shift, drift net operations will continue to deploy dart-PIT tags.

The desired capture technique will be to entangle fish by the snout, to avoid injuries to gills. The net will be watched continuously until corks sink, then the net will be pulled in immediately.

Chinook salmon captured in drift nets will be processed as described for fishwheels above.

Marking Event–Yentna River

At the Yentna River RM 6 site, 6 individuals will make up 2 crews of 2 to run the fish wheels for 2 shifts each day, and 1 crew of 2 will sample with drift gillnets. At the Yentna tagging site, each fish wheel will be operated for a total of 16 h total each day in two 9-hr shifts. Sampling effort will begin when the live box door is installed to hold captured fish, approximately 1 h after the crew starts its shift, allowing for sampling preparation and travel time. The first shift will begin at 0300 and will end at 1200 (Table 4). The second shift will start at 1400 and end at 2300.

Radio tags will be evenly split between the first and second shifts, with odd numbers of tags alternating between the shifts (Table 4). The next shift will deploy its regularly scheduled tags first, then the leftover tags. This will continue until the leftover tags are deployed, and the crew can get back on the original schedule. To enhance the chance that radio tags are deployed in proportion to the run, the number of tags deployed from each wheel may be adjusted depending on catch rates. Actual deployment of tags will be recorded in Tag Deployment and Tag Deviation Logs (Appendix A1).

Fish wheel operations-Yentna River

- 1) Each fish wheel will be visited every 1 hr or less. When a fish wheel has been untended for greater than 1 hr, all Chinook and coho salmon in the live box shall be counted, measured, and released, but not tagged.
- 2) Fish with large, fresh injuries, are bleeding, or that have dropped in the boat will be measured and released.
- 3) No tagging will occur without first placing the fish in water.
- 4) The scheduled number of radio tags (Tables 4–5) will be deployed to the first healthy (without fresh or recent injuries and not having fallen in the boat) Chinook salmon greater than 500 mm METF caught during each shift. The fish will be placed in a water-filled tote with a cradle and tagged with a radio transmitter in addition to a dart tag and an operculum punch.
- 5) The actual number of tags deployed will be compared to the scheduled number to be deployed every 5 d (Tables 4–5) on 26 and 31 May, and 5, 10, 15, and 20 June, in order to adjust the tagging rates if tags are being deployed too quickly or slowly. If tags at a particular fish wheel are being deployed too slowly (i.e., the tag surplus keeps building), the surplus may be reassigned to another fish wheel or the gillnets in order to utilize all tags by 30 June.
- 6) The scheduled number of radio tags (Table 6) will be deployed to the first healthy coho salmon greater than or equal to 400 mm METF caught during each shift. Fish will be placed in a water-filled tote with a cradle and tagged with a radio transmitter in addition to a dart tag and an operculum punch.
- 7) For coho salmon, if tags at a particular fish wheel fall behind schedule (i.e., the surplus tags keep building), the surplus may be reassigned to the other fish wheel in order to utilize all coho salmon tags by 17 August.

- 8) Every radiotagged fish will have the distal 0.5 in of the left axillary process removed and preserved in a uniquely-numbered vial with ethanol (Appendix B2).
- 9) A dart tag will also be applied to every healthy Chinook salmon greater than or equal to 500 mm METF and coho salmon greater than or equal to 400 mm METF, including radiotagged fish that are caught during the shift. The operculum will have a hole punched in it with a paper punch.
- 10) All Chinook and coho salmon, both tagged and untagged, will be measured for METF length (Appendix B1).
- 11) Other fish species will be tallied on the data form and released.
- 12) If the scheduled number of radio tags cannot be deployed during a shift due to low catches, those tags shall be deployed on the next shift(s).
- 13) Tags will not be shared between the mainstem Susitna River and Yentna River.

Drift net operations-Yentna River

Drift gillnetting will take place midchannel, if possible, and between the fish wheel sites to sample Chinook salmon not susceptible to fish wheel capture. Prior to using new drift nets, old nets will be used to practice drift fishing and locate fishing sites that do not have snags. Drift net mesh sizes (5.5 in and 7.5 in, stretch measure) will be used. Nets will be 10–12 ft and 15–17 ft deep for each mesh size, respectively. Drift locations, duration, and net depth will be changed accordingly to depth or when net snags are found at fishing sites. One mesh size will be used per split shift, and each split shift will use a different mesh size, so that each mesh size gets approximately an equal amount of effort each day. Two technicians will make as many drifts as possible during each split shift. Gillnets will be fished continuously at the Yentna River deployment site to achieve 8 hours per day of fishing effort, to maximize the dart tag deployment and to deploy radio tags as scheduled.

The desired capture technique will be to entangle fish by the snout, to avoid injuries to the gills. The net will be watched continuously until corks sink, then the net will be pulled in immediately.

Salmon captured in drift nets and will be processed as described for fishwheels above.

Recapture Events–Mainstem Susitna River and Yentna River

Recapture Events Mainstem Deshka River and Montana Creek weirs

A resistance board floating weir will be operated at RM 7 of the Deshka River from approximately 21 May to 3 September, 2015. Sampling at the Deshka River weir will be conducted by an independent project, and will follow a separate operational plan (Hayes 2014). A dual antenna, PIT-tag detection array will be attached to the upstream exit of the weir's sampling cage (Appendix C1). One additional crew member will be at camp to regularly test the PIT array's detection rate, troubleshoot it immediately, and download the data file. System checks of the PIT tag array are described in Appendix C1.

The weir at Montana Creek will be identical in construction and operation to the Deshka River weir. The crew at the Montana Creek weir will record data on a 2015 Weir Daily Reporting Form (Appendix A1). Tasks will be as follows:

- 1) Clean and maintain the weir as needed to ensure its integrity.
- 2) Count and record all salmon, by species, through the weir.

- 3) For Chinook salmon, measure 350 fish for METF length (to the nearest 5 mm; Appendix B1) for the season. Daily, every third Chinook salmon will be sampled, based on the 2014 weir count of 1,217 Chinook salmon at Montana Creek (1,217 per 350, rounded down to be conservative), and assuming a similar, low run size.
- 4) For coho salmon, 200 METF (to the nearest 5 mm) measurements will be made for the season. Up to 40 coho salmon will be sampled per week.
- 5) Dart-PIT tagged fish will be counted and the time of the count will be recorded, only if capturing a tagged fish and reading the dart tag number may be done without disrupting the movement of other fish.
- 6) Upon request, ensure fixed radio stations have power and are scanning.
- 7) Record water level and temperature.

A PIT-tag detection array identical to the Deshka River weir's will be operated at the Montana Creek weir in identical fashion by the weir technician.

Recapture Event–Mainstem Sunshine (Susitna River RM 83)

Chinook salmon will be sampled for marks at Susitna River RM 83 using fish wheel and drift gillnet effort, and coho salmon will be sampled using fish wheel effort only, following schedules nearly identical to those used at Susitna River RM 34. Drift gillnetting will cease approximately 7 July, and only fish wheel effort will continue until approximately 30 August. All Chinook and coho salmon will be examined for a left operculum punch to detect dart tag loss and given a dorsal fin punch to prevent double sampling of untagged fish. All Chinook salmon and the first 3 coho salmon captured each shift on each wheel every day will be measured for METF length (i.e., 3 coho salmon \times 2 wheels \times 2 shifts = 12 total coho salmon per day). All untagged salmon measured for length will be given a tertiary mark (dorsal fin punch) to identify previously sampled salmon. Every tagged fish recaptured will be measured for METF length, the dart-PIT tag number recorded, and also scanned to record the PIT tag number. The distal half of the dart tag will be cut off and saved.

Recapture Event–Yentna River RM 18

Chinook salmon will be sampled for marks at RM 18 of the Yentna River using fish wheel and drift gillnet effort, and coho salmon will be sampled using fish wheel effort only, following schedules nearly identical to those used at RM 6 of the Yentna River. Drift gillnetting will cease approximately 7 July, and only fish wheel effort will continue until approximately 30 August. All Chinook and coho salmon will be examined for an operculum punch to detect dart tag loss and given a dorsal fin punch to prevent double sampling of untagged fish. All Chinook salmon and the first 3 coho salmon captured each shift on each wheel every day will be measured for METF length (i.e., 3 coho salmon \times 2 wheels \times 2 shifts = 12 total coho salmon per day). All untagged salmon measured for length will be given a tertiary mark (dorsal fin punch) to identify previously sampled salmon. Every tagged fish that is recaptured will be measured for METF length and the dart tag number recorded. The distal half of the dart tag will be cut off and saved in a plastic bag as documentation of the tag number

GENETICS SAMPLES

At both the mainstem Susitna River and Yentna River marking sites, the tissue samples from each radiotagged Chinook and coho salmon will be placed in a uniquely-numbered (radio tag number) vial and preserved in ethyl alcohol following methods in Appendix B2. In addition, at

least 200 coho salmon genetic samples will be collected at Montana Creek when sampling as described above. The radio tag number will be used to link the spawning location and genetic data for individual salmon. These samples will be archived for use in possible future genetics studies. All salmon samples and relevant collection data will be shipped to the ADF&G Division of Commercial Fisheries (CF) Gene Conservation Lab in Anchorage at the end of the season.

SPAWNING LOCATION

Radio receivers (ATS Model R4500C) at each stationary tracking site will be visited and downloaded twice a month. Each record will contain the following fields: year, Julian day, hour, minute, antenna, frequency, pulse code, signal strength, and duplicate counts in ASCII text format. A laptop computer will be connected to the radio receiver with a serial cable and ATS software will be used to transfer the data file to the laptop. A logbook will be maintained at each station to note the date, staff, settings, and battery voltage for each visit. A checklist with radio receiver settings and the download steps will be available at each site. Each downloaded file will be transferred to the Palmer local area network (LAN), uploaded to Docushare at the ADF&G Region II office (<http://docushare.sf.adfg.state.ak.us/dsweb/HomePage>), and eventually appended into a SQL telemetry database.

Each record in the file will contain the site code, download date and time, radio frequency and pulse code, date and time of detection, antenna number, period, and signal strength (ATSunpublished).

Aerial telemetry surveys will be conducted on the mainstem Susitna River and Yentna River as well as the primary tributaries, to verify data collected at tracking stations and identify the locations of radiotagged fish during the likely spawning period. Spawning sites will be inferred by maximum upstream locations of radio tags. Automatically recorded data will include the date and time of decoding, and the frequency, pulse code, latitude and longitude, signal strength, and activity status of each decoded transmitter. Decisions to continue or terminate any given survey will be made real time as the number of tags found becomes apparent.

When the radio receiver operator hears a tag, the “HOLD” button will be pressed, and the receiver will lock on the frequency to identify the pulse code. When the “HOLD” button is pressed, the frequency, pulse code, mortality indicator, signal strength, and latitude-longitude will be automatically written to the internal memory of the receiver. The data in the internal memory will be downloaded daily to a Microsoft Windows–based personal computer after each survey. The flight path will be automatically recorded on a handheld GPS (Garmin, Oregon) and then downloaded, using Minnesota Department of Natural Resources DNRGPS software, to a Microsoft Windows–based personal computer after each survey to document the drainages surveyed. Each downloaded file will be transferred to the Palmer local area network (LAN), and uploaded to Docushare at the ADF&G Region II office (<http://docushare.sf.adfg.state.ak.us/dsweb/HomePage>).

DATA REDUCTION

All data collected by SF and CF tagging and recapture crews (Appendix A1) will be entered into Excel spreadsheets as they become available inseason, consolidated into 1 master Microsoft Excel file (Master_Susitna_2015_Chinook_Coho_Abundance_telemetry.xlsx) with separate worksheets for each data type (e.g. tagging, recovery, fishing effort, etc.), and stored in a dedicated subdirectory on the Palmer ADF&G local area network (LAN) and uploaded to

Docushare at the ADF&G Region II office (<http://docushare.sf.adfg.state.ak.us/dsweb/HomePage>). All data files (.csv format) that are used in analyses by the R software package (R Core Team 2014) will be directly created from the master Excel file. Raw data files downloaded from ATS radio receiver-loggers and GPS instruments will eventually be appended into a structured query language (SQL) telemetry database as they become available inseason.

Raw telemetry data will be imported into a SQL Server telemetry project database that contains all aerial and station telemetry and fish tag data from 2006 through present. Database reports will be generated throughout the season in order to track progress. Queries for standard data analysis (i.e., tables and figures for reports) will be available to project personnel for data retrieval. Custom queries will be written upon request for dissemination of data to biologists and biometricians.

The SQL database and master Excel file will serve as the basis for all data analysis required to achieve the study objectives. After all data are edited and analyzed, a final copy of the database (in comma delimited ASCII format) will be e-mailed, along with a data map, to Research and Technical Services (RTS) in the Anchorage ADF&G office for archiving on the SF intranet site.

DATA ANALYSIS

ABUNDANCE

A 2-sample mark-recapture model will be used to estimate the number of Chinook and coho salmon passing by the first event sampling sites. The appropriate abundance estimator will depend on the results of the aforementioned tests of mark-recapture assumptions. If stratification is not needed, Chapman's (1951) version of Petersen's abundance estimator for closed populations (see Seber 1982) will be used:

$$\hat{N} = \frac{(\hat{M}_U + 1)(\hat{C} + 1)}{(R + 1)} - 1 \quad (1)$$

where \hat{N} is the estimated number of Chinook or coho salmon, \hat{M}_U is the estimated number of marked Chinook or coho salmon moving upstream of the mainstem Susitna River or Yentna River tagging sites, \hat{C} is the estimated number of Chinook or coho salmon greater than or equal to 500 mm and 400 mm METF length, respectively, that are inspected for marks at the second event sampling sites, and R is the number of marked Chinook or coho salmon recaptured during second event sampling.

For Chinook and coho salmon, we will estimate \hat{M}_U as follows:

$$\hat{M}_U = \hat{p}_{UP} M \quad (2)$$

where M is the total number of Chinook or coho salmon marked, and

$$\hat{p}_{UP} = \frac{r_{up}}{r} \quad (3)$$

where r is the number of radio tags applied and r_{up} is the number of radio tags that entered the mark–recapture experiment.

For the mainstem and Yentna River Chinook and coho salmon experiments, we will estimate \hat{C} as follows:

$$\hat{C} = \sum_i^I C_{Ti} \hat{p}_{SZ+,i} \quad (4)$$

where C_{Ti} is the total number of Chinook or coho salmon counted past second event sampling site i and $\hat{p}_{SZ+,i}$ is the estimated proportion of Chinook or coho salmon at site i with size (SZ) greater than or equal to 500 mm METF (Chinook salmon) or 400 mm METF (coho salmon).

For the mainstem experiment, i is an index for the sampling sites: Deshka River weir, Montana Creek weir and Sunshine (Susitna River RM 83). For the Yentna River experiment, i is an index for the RM 18 recapture location. The proportion $\hat{p}_{SZ+,i}$ will be known for the Sunshine and Yentna River Chinook salmon recapture events because all Chinook salmon are measured for METF length at these locations. For the Deshka River and Montana Creek weir recapture sites (Chinook and coho salmon) and for the Yentna River coho salmon recapture sites, the proportion $\hat{p}_{SZ+,i}$ is estimated from length composition data:

$$\hat{p}_{SZ+,i} = \frac{n_{SZ+,i}}{n_i} \quad (5)$$

where n_i is the total number of Chinook or coho salmon sampled at site i , and $n_{SZ+,i}$ is those members of n_i with size (SZ) greater than or equal to 500 mm METF (Chinook salmon) or 400 mm METF (coho salmon).

If temporal or geographic stratification is not required but stratification by size or sex is (see Appendix E1), the data will be fully stratified and estimates for each stratum will be generated using Equations 1–4. Stratum estimates of abundance and variance (see below) will be summed over size strata for estimates pertinent to the entire population.

An estimate of the variance for \hat{N} within a size stratum will be obtained through simulation. The estimated number of marks continuing upstream will be simulated as a binomial variable ($\hat{M}_U^* \sim \text{bin}(M, \hat{p}_{Up})$), and the number of recaptures R will be modeled as a binomial variable ($R^* \sim \text{bin}(\hat{C}, \hat{M}_U^* / \hat{N})$). The number of Chinook or coho salmon greater than or equal to 500 mm or 400 mm METF, respectively, at recapture location i will be modeled as binomial variables $\text{bin}(C_{Ti}, \hat{p}_{SZ+,i})$, and simulated values \hat{C}^* will be calculated using Equation 4. A large number of simulated values R^* , \hat{M}_U^* , and \hat{C}^* will be generated and simulated samples of the abundance estimate, \hat{N}^* , will be calculated using Equation 1.

A minimum of 1,000,000 simulations (B) will be drawn. The approximate variance of \hat{N} will be calculated as follows:

$$\text{var}(\hat{N}) = \frac{\sum_{b=1}^B (\hat{N}_b^* - \hat{N}^*)^2}{B-1} \quad (6)$$

where \hat{N}^* is the average of the \hat{N}_b^* .

Size stratification tests will be conducted first and the data partitioned into appropriate size classes. Geographic and temporal stratification tests will then be conducted within each size stratum. Should these tests (Appendix E2) indicate that the Chapman-Petersen model is inadequate, estimation of abundance within size strata will follow procedures described by Darroch (1961). The computer program SPAS-2 (Carl Schwarz, Simon Fraser U., personal communication) will be used. SPAS-2 currently requires square matrices; the contingency tables described in Appendix E2 will be analyzed to identify marking and recapture strata that can be pooled to provide the necessary square matrices. Temporal categories generally will consist of groupings of sample data collected by week, and may reflect known changes in tagging or recapture sampling effort. Stratification will also be guided by environmental conditions encountered during data collection (river stage height and rainfall) and by previous experience gained when conducting mark-recapture experiments on this system.

A series of SPAS-2 models will be fitted, differing in pooling structures. Reasonable pooling strategies will be used as described above. Akaike information criterion (AIC) will be the main guide in choosing the best model. (SPAS-2 is able to present AIC because the original data structure is preserved over all models, with parameters being set in the model-fitting phase that control whether stratum probabilities of capture are equal or not). Future renditions of SPAS-2 will accommodate nonsquare data structures and restrictions on movement parameters. The SPAS-2 software will provide an underestimate of the true variance of the abundance estimate, due to unaccounted-for uncertainty regarding the estimates of valid marks across marking strata and numbers of inspected fish across recapture strata. Simulation will be used with the chosen model structure to accommodate these uncertainties. Marked fish entering the experiment will be simulated by tagging stratum as will inspected fish meeting size criteria by recapture strata; simulation techniques will be similar to those described earlier for these quantities. Recaptures will be simulated as multinomial variables across recapture strata. The chosen model will be fitted in SPAS-2 with each generated data structure to provide a simulated estimate of abundance; simulated variance will be provided as in Equation 6. Tagging-stratum specific estimates of abundance are provided, which may be useful in spawning distribution estimation.

SPAWNING LOCATION

The fixed telemetry stations at the lower Yentna River and 1 mile upstream of the mainstem Susitna River fish wheel site will be used as gateways to the experiment for determining spawning location of all species. Fish that do not pass the gateways will be noted and will not be used to characterize spawning location. Prior to determining spawning sites, all “lost” (including harvested fish and fish spawning in a different system) radiotagged fish will be identified and censored (removed from analysis). Tag loss or fish mortality will be assumed for any tag that transmits an “inactive” code and for which upstream movement has ceased prior to reaching

potential spawning areas. All tags that move downstream immediately after tagging and are not later detected moving upstream will be assumed to be handling mortalities; i.e., they do not pass a gateway. Significant variations in fish mortality or tag loss over time and tagging site will be used to identify possible needs for changes in fish handling; such differences were observed for the Yentna River system in 2014 and will be addressed before the 2015 tagging season through additional training for the field crews and by changing the slides on the Yentna River RM 6 fish wheels from wood to fabric.

Following removal of “lost” tags, a final location will be determined for each tagged fish using the telemetry data. Radio tags deployed and relocated by date, species, and fish wheel (also gillnet for Chinook salmon) will be tabulated. In most cases, the farthest upstream locations of a radiotagged fish will be assumed to be the actual spawning site or spawning drainage. However, in very few circumstances some judgment may be exercised to deviate from this guideline. For example, if following the farthest upstream location, a fish is later observed to spend more than 2 weeks (anticipated interval between aerial surveys) in a more downstream location or another tributary in the presence of other spawning fish, the latter site will be used rather than the farthest upstream location.

A map of the final locations of tagged fish by species and fish wheel will be constructed. Visually comparing final locations between fish wheels may be useful in detecting bank orientation, which must be considered when planning future experiments, especially for Chinook salmon.

SPAWNING DISTRIBUTION

The diagnostic procedures described in Appendix E2 will be used on radiotagged Chinook salmon to detect evidence of geographic or temporal variability in probability of capture during the marking event. The test results will guide stratification of groups of marked fish into S temporally and geographically contiguous strata, such that little or no evidence of variation in probability of capture is detectable within strata. A Darroch (1961) model will be used to estimate the total number of fish passing the marking sites within each marking stratum \hat{N}_s (as described above). These estimates will not be mutually independent. It is noted that the stratification appropriate for radiotagged fish may not be the same as that used for the main abundance estimate.

For each marking stratum, radiotagging data will be used to estimate spawning distribution:

$$\hat{p}_{l,s} = \frac{n_{l,s}}{n_s} \quad (7)$$

where $\hat{p}_{l,s}$ is the estimated proportion of salmon from stratum s spawning in location l , n_s is the number of fish radiotagged in stratum s that travelled to a spawning location, and $n_{l,s}$ is the number of fish from n_s that travelled to location l .

The total number of salmon spawning in location l can be estimated as follows:

$$\hat{N}_l = \sum_{s=1}^S \hat{N}_s \hat{p}_{l,s} \quad (8)$$

and the proportion of salmon spawning in each location estimated as

$$\hat{p}_l = \hat{N}_l / \sum_{s=1}^S \hat{N}_s. \quad (9)$$

Variance for these parameters will be estimated using simulated variation in estimates of spawning distribution parameters within each of S strata that will be modeled using multinomial distributions and the observed data described in Equation 7.

Equations 8 and 9 will then be used to provide simulated estimates of spawning distribution proportions. Variance for each of these parameters will then be estimated using methods analogous to Equation 6.

GENETICS SAMPLES

Tissue samples will be collected by SF personnel and transported to the genetics lab in Anchorage. All genetics sample processing, data storage, and data analysis will be the responsibility of the ADF&G Gene Conservation Lab in Anchorage.

SCHEDULE AND DELIVERABLES

- 1) Deploy fixed radiotracking stations 19 May–10 June 2015.
- 2) Download fixed radiotracking stations approximately every 1–3 weeks, 1 June–30 September 2015.
- 3) Conduct radiotelemetric aerial surveys approximately every 2 weeks, 23 June–7 August 2015.
- 4) Conduct marking operations at mainstem Susitna River and Yentna River RM 6 sites approximately 22 May–30 August 2015.
- 5) Conduct recapture sampling at Sunshine (Susitna River RM 83) approximately 10 May–30 August 2015.
- 6) Conduct recapture sampling at the Yentna River RM 18 site approximately 22 May–30 August 2015.
- 7) Conduct weir sampling at Deshka River and Montana Creek approximately 19 May (Deshka River) and 10 June (Montana Creek) through 5 September 2015.
- 8) Reduce and analyze data 15 September–31 December 2015.
- 9) Finalize 2014 Fishery Data Series Report 30 November 2016.
- 10) Genetics results will be reported separately, to be determined by ADF&G Gene Conservation Lab.

RESPONSIBILITIES

Pete Cleary (Fishery Biologist II):

Supervise mainstem Susitna River and Yentna River operations and Montana Creek weir and Sunshine recapture site. Oversee all SF fish wheel portions of the project: planning, budgeting, hiring and training field staff, data collection, editing and analysis, supervision, and purchasing. Coordinate with John Campbell on radio tag deployment. Lead author on operational plan and report.

John Campbell (Fishery Biologist II):

Lead all radio telemetry and PIT data recovery and tracking portions of the project: planning, budgeting, data collection, data analysis, purchasing, reporting, crew training, radiotracking station setup and downloads, and aerial surveys. Assist with hiring and training and writing the operational plan. Coauthor on report.

David Evans (Biometrician III):

Advise all portions of the biometrics: planning, sample sizes, statistical methods, and data analysis.

Gayle Horner-Neufeld (Research Analyst III):

Import raw telemetry and tag data into SQL database, data quality control, provide queries, construct maps.

Andy Barclay (Geneticist):

Advise portions of the genetics: planning, sample sizes, statistical methods, data analysis, and reporting. Supply tissue collection materials and instructions.

Mark Willette (Fishery Biologist III):

Oversee budget, operations, purchasing, and hiring for CF crew at Yentna River RM 6.

Bill Glick (Fishery Biologist II):

Oversee daily operations and logistics for CF crew at Yentna River RM 6. Provide sampling data from RM 6.

Richard Yanusz (Fishery Biologist III):

Review all aspects of project: planning, budget, data collection, data analysis, and reporting.

Steve Dotomain (Fishery Biologist I):

Assist with all aspects at the mainstem Susitna River, and Yentna River RMs 6 and 18 sites: planning, hiring and training field staff, data collection, data analysis, supervision, and purchasing.

Taylor Hendricks (Fishery Biologist I):

Assist with all aspects of the Sunshine (Susitna Rive RM 83) and Montana Creek recapture sites: planning, hiring and training field staff, data collection, data analysis, supervision, and purchasing. Assist with radio telemetry data collection as needed.

James Stribny (Fish and Wildlife Technician III):

Conduct field camp supervision and field sampling at the mainstem Susitna River camp according to operational plan and verbal instructions.

Luke Warta (Fish and Wildlife Technician III):

Conduct field camp supervision and field sampling at the Yentna River RM 6 recapture camp according to operational plan and verbal instructions.

Technicians (Fish and Wildlife Technician II or III, College Intern II):

Conduct field sampling at Yentna River and mainstem Susitna River sites according to operational plan and verbal instructions.

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TABLES

Table 1.–Fish wheel radiotagging schedule for Chinook salmon at the mainstem Susitna River, 2015.

Date	Morning shift 05:00–13:00			Afternoon shift 14:00–22:00			Total radio tags
	Crew	Radio tags		Crew	Radio tags		
		East bank	West bank		East bank	West bank	
22 May	1	0	1	2	0	0	1
23 May	1	0	0	2	1	0	1
24 May	1	1	0	2	0	1	2
25 May	1	0	1	2	1	0	2
26 May	1	1	1	2	1	1	4
27 May	1	1	1	2	1	1	4
28 May	1	2	1	2	1	2	6
29 May	1	1	2	2	2	1	6
30 May	1	2	1	2	1	2	6
31 May	1	1	2	2	2	1	6
1 Jun	2	2	1	3	1	2	6
2 Jun	2	1	2	3	2	1	6
3 Jun	2	2	1	3	1	2	6
4 Jun	2	1	2	3	2	1	6
5 Jun	2	2	1	3	1	2	6
6 Jun	2	2	2	3	2	2	8
7 Jun	2	2	2	3	2	2	8
8 Jun	2	2	3	3	3	2	10
9 Jun	2	3	2	3	2	3	10
10 Jun	2	2	3	3	3	2	10
11 Jun	3	3	3	1	3	3	12
12 Jun	3	3	3	1	3	3	12
13 Jun	3	3	2	1	2	3	10
14 Jun	3	2	3	1	3	2	10
15 Jun	3	3	2	1	2	3	10
16 Jun	3	2	2	1	2	2	8
17 Jun	3	1	2	1	2	1	6
18 Jun	3	1	1	1	1	1	4
19 Jun	3	1	0	1	0	1	2
20 Jun	3	0	1	1	1	0	2
21 Jun	1	0	0	2	0	1	1
22 Jun	1	1	0	2	0	0	1
23 Jun	1	0	1	2	0	0	1
24 Jun	1	0	0	2	1	0	1
25 Jun	1	0	0	2	0	1	1
26 Jun	1	1	0	2	0	0	1
27 Jun	1	0	1	2	0	0	1
28 Jun	1	0	0	2	1	0	1
29 Jun	1	0	0	2	0	1	1
30 Jun	1	1	0	2	0	0	1
Total tags		50	50		50	50	200

Table 2.–Gillnet radiotagging schedule for Chinook salmon at the mainstem Susitna River tagging site by shift, 2015.

Date	Morning			Afternoon			Total radios
	Start	Stop	Radio tags	Start	Stop	Radio tags	
22 May	9:00	12:45	0	17:00	20:45	1	1
23 May	8:00	11:45	0	16:00	19:45	0	0
24 May	7:00	10:45	1	15:00	18:45	0	1
25 May	6:00	9:45	0	14:00	17:45	1	1
26 May	7:00	10:45	1	15:00	18:45	1	2
27 May	8:00	11:45	1	16:00	19:45	1	2
28 May	9:00	12:45	1	17:00	20:45	2	3
29 May	10:00	13:45	2	18:00	21:45	1	3
30 May	11:00	14:45	1	19:00	22:45	2	3
31 May	12:00	15:45	2	20:00	23:45	1	3
1 Jun	11:00	14:45	1	19:00	22:45	2	3
2 Jun	10:00	13:45	2	18:00	21:45	1	3
3 Jun	9:00	12:45	1	17:00	20:45	2	3
4 Jun	8:00	11:45	2	16:00	19:45	1	3
5 Jun	7:00	10:45	1	15:00	18:45	2	3
6 Jun	6:00	9:45	2	14:00	17:45	2	4
7 Jun	7:00	10:45	2	15:00	18:45	2	4
8 Jun	8:00	11:45	3	16:00	19:45	2	5
9 Jun	9:00	12:45	2	17:00	20:45	3	5
10 Jun	10:00	13:45	3	18:00	21:45	2	5
11 Jun	11:00	14:45	3	19:00	22:45	3	6
12 Jun	12:00	15:45	3	20:00	23:45	3	6
13 Jun	11:00	14:45	2	19:00	22:45	3	5
14 Jun	10:00	13:45	3	18:00	21:45	2	5
15 Jun	9:00	12:45	2	17:00	20:45	3	5
16 Jun	8:00	11:45	2	16:00	19:45	2	4
17 Jun	7:00	10:45	2	15:00	18:45	1	3
18 Jun	6:00	9:45	1	14:00	17:45	1	2
19 Jun	7:00	10:45	0	15:00	18:45	1	1
20 Jun	8:00	11:45	1	16:00	19:45	0	1
21 Jun	9:00	12:45	1	17:00	20:45	0	1
22 Jun	10:00	13:45	0	18:00	21:45	0	0
23 Jun	11:00	14:45	0	19:00	22:45	1	1
24 Jun	12:00	15:45	0	20:00	23:45	0	0
25 Jun	11:00	14:45	1	19:00	22:45	0	1
26 Jun	10:00	13:45	0	18:00	21:45	0	0
27 Jun	9:00	12:45	0	17:00	20:45	1	1
28 Jun	8:00	11:45	0	16:00	19:45	0	0
29 Jun	7:00	10:45	1	15:00	18:45	0	1
30 Jun	6:00	9:45	0	14:00	17:45	0	0
Total			50			50	100

Table 3.–Fish wheel radiotagging schedule for coho salmon at the mainstem Susitna River tagging site, 2015.

Date	Morning shift 05:00–13:00			Afternoon shift 14:00–22:00			Daily total radio tags
	Crew	Radio tags		Crew	Radio tags		
		East bank	West bank		East bank	West bank	
9 Jul	2	0	1	1	1	0	2
10 Jul	2	1	0	1	0	1	2
11 Jul	2	0	1	1	1	0	2
12 Jul	2	1	0	1	0	1	2
13 Jul	2	0	1	1	1	0	2
14 Jul	2	1	0	1	0	1	2
15 Jul	2	0	1	1	1	0	2
16 Jul	2	1	0	1	0	1	2
17 Jul	2	0	1	1	1	0	2
18 Jul	2	1	0	1	0	1	2
19 Jul	1	1	1	2	1	1	4
20 Jul	1	0	1	2	1	0	2
21 Jul	1	1	0	2	0	1	2
22 Jul	1	0	1	2	1	0	2
23 Jul	1	1	1	2	1	1	4
24 Jul	1	1	0	2	0	1	2
25 Jul	1	1	1	2	1	1	4
26 Jul	1	1	1	2	1	1	4
27 Jul	1	1	2	2	2	1	6
28 Jul	1	1	1	2	1	1	4
29 Jul	2	1	0	1	0	1	2
30 Jul	2	1	1	1	1	1	4
31 Jul	2	1	1	1	1	1	4
1 Aug	2	0	1	1	1	0	2
2 Aug	2	1	1	1	1	1	4
3 Aug	2	1	1	1	1	1	4
4 Aug	2	1	0	1	0	1	2
5 Aug	2	1	1	1	1	1	4
6 Aug	2	1	1	1	1	1	4
7 Aug	2	0	1	1	1	0	2
8 Aug	1	1	0	2	0	1	2
9 Aug	1	0	1	2	1	0	2
10 Aug	1	1	0	2	0	1	2
11 Aug	1	0	1	2	1	0	2
12 Aug	1	0	0	2	0	1	1
13 Aug	1	1	0	2	0	0	1
14 Aug	1	0	1	2	0	0	1
15 Aug	1	0	0	2	1	0	1
16 Aug	1	0	0	2	0	1	1
17 Aug	1	1	0	2	0	0	1
Total		25	25		25	25	100

Table 4.–Fish wheel radiotagging schedule for Chinook salmon at the Yentna River RM 6 tagging site, 2015.

Date	Morning shift 03:00–12:00			Afternoon shift 14:00–23:00			Total radio tags
	Crew	Radio tags		Crew	Radio tags		
		North bank	South bank		North bank	South bank	
22 May	1	0	1	2	0	0	1
23 May	1	0	0	2	0	0	0
24 May	1	0	0	2	1	0	1
25 May	1	1	0	2	0	1	2
26 May	1	0	1	2	1	0	2
27 May	1	1	1	2	1	1	4
28 May	1	1	1	2	1	1	4
29 May	1	1	1	2	1	1	4
30 May	1	1	1	2	1	1	4
31 May	1	1	1	2	1	1	4
1 Jun	2	1	1	3	1	1	4
2 Jun	2	1	1	3	1	1	4
3 Jun	2	2	1	3	1	2	6
4 Jun	2	2	3	3	3	2	10
5 Jun	2	3	2	3	2	3	10
6 Jun	2	2	3	3	3	2	10
7 Jun	2	3	2	3	2	3	10
8 Jun	2	3	3	3	3	3	12
9 Jun	2	3	3	3	3	3	12
10 Jun	2	3	3	3	3	3	12
11 Jun	3	3	3	1	3	3	12
12 Jun	3	2	3	1	3	2	10
13 Jun	3	3	2	1	2	3	10
14 Jun	3	2	2	1	2	2	8
15 Jun	3	2	1	1	1	2	6
16 Jun	3	1	2	1	2	1	6
17 Jun	3	2	1	1	1	2	6
18 Jun	3	1	2	1	2	1	6
19 Jun	3	1	1	1	1	1	4
20 Jun	3	1	1	1	1	1	4
21 Jun	1	1	1	2	1	1	4
22 Jun	1	1	1	2	1	1	4
23 Jun	1	0	0	2	0	1	1
24 Jun	1	1	0	2	0	0	1
25 Jun	1	0	1	2	1	0	2
Total tags		50	50		50	50	200

Table 5.—Gillnet radiotagging schedule for Chinook salmon at the Yentna River RM 6 tagging site, 2015.

Date	Morning			Afternoon			Total radios
	Start	Stop	Radio tags	Start	Stop	Radio tags	
22 May	9:00	12:45	0	17:00	20:45	0	0
23 May	8:00	11:45	1	16:00	19:45	0	1
24 May	7:00	10:45	0	15:00	18:45	0	0
25 May	6:00	9:45	0	14:00	17:45	1	1
26 May	7:00	10:45	1	15:00	18:45	0	1
27 May	8:00	11:45	1	16:00	19:45	1	2
28 May	9:00	12:45	1	17:00	20:45	1	2
29 May	10:00	13:45	1	18:00	21:45	1	2
30 May	11:00	14:45	1	19:00	22:45	1	2
31 May	12:00	15:45	1	20:00	23:45	1	2
1 Jun	11:00	14:45	1	19:00	22:45	1	2
2 Jun	10:00	13:45	1	18:00	21:45	1	2
3 Jun	9:00	12:45	1	17:00	20:45	2	3
4 Jun	8:00	11:45	3	16:00	19:45	2	5
5 Jun	7:00	10:45	2	15:00	18:45	3	5
6 Jun	6:00	9:45	3	14:00	17:45	2	5
7 Jun	7:00	10:45	2	15:00	18:45	3	5
8 Jun	8:00	11:45	3	16:00	19:45	3	6
9 Jun	9:00	12:45	3	17:00	20:45	3	6
10 Jun	10:00	13:45	3	18:00	21:45	3	6
11 Jun	11:00	14:45	3	19:00	22:45	3	6
12 Jun	12:00	15:45	3	20:00	23:45	2	5
13 Jun	11:00	14:45	2	19:00	22:45	3	5
14 Jun	10:00	13:45	2	18:00	21:45	2	4
15 Jun	9:00	12:45	1	17:00	20:45	2	3
16 Jun	8:00	11:45	2	16:00	19:45	1	3
17 Jun	7:00	10:45	1	15:00	18:45	2	3
18 Jun	6:00	9:45	2	14:00	17:45	1	3
19 Jun	7:00	10:45	1	15:00	18:45	1	2
20 Jun	8:00	11:45	1	16:00	19:45	1	2
21 Jun	9:00	12:45	1	17:00	20:45	1	2
22 Jun	10:00	13:45	1	18:00	21:45	1	2
23 Jun	11:00	14:45	0	19:00	22:45	0	0
24 Jun	12:00	15:45	1	20:00	23:45	0	1
25 Jun	11:00	14:45	0	19:00	22:45	1	1
Total			50			50	100

Table 6.–Fishwheel radiotagging schedule for coho salmon at the Yentna River RM 6 tagging site, 2015.

Date	Morning shift 03:00–12:00			Afternoon shift 14:00–23:00			Daily total radio tags
	Crew	Radio tags		Crew	Radio tags		
		North bank	South bank		North bank	South bank	
9 Jul	2	0	1	1	1	0	2
10 Jul	2	1	0	1	0	1	2
11 Jul	2	0	1	1	1	0	2
12 Jul	2	1	0	1	0	1	2
13 Jul	2	0	1	1	1	0	2
14 Jul	2	1	0	1	0	1	2
15 Jul	2	0	1	1	1	0	2
16 Jul	2	1	0	1	0	1	2
17 Jul	2	0	1	1	1	0	2
18 Jul	2	1	0	1	0	1	2
19 Jul	1	1	1	2	1	1	4
20 Jul	1	0	1	2	1	0	2
21 Jul	1	1	0	2	0	1	2
22 Jul	1	0	1	2	1	0	2
23 Jul	1	1	1	2	1	1	4
24 Jul	1	1	0	2	0	1	2
25 Jul	1	1	1	2	1	1	4
26 Jul	1	1	1	2	1	1	4
27 Jul	1	1	2	2	2	1	6
28 Jul	1	1	1	2	1	1	4
29 Jul	2	1	0	1	0	1	2
30 Jul	2	1	1	1	1	1	4
31 Jul	2	1	1	1	1	1	4
1 Aug	2	0	1	1	1	0	2
2 Aug	2	1	1	1	1	1	4
3 Aug	2	1	1	1	1	1	4
4 Aug	2	1	0	1	0	1	2
5 Aug	2	1	1	1	1	1	4
6 Aug	2	1	1	1	1	1	4
7 Aug	2	0	1	1	1	0	2
8 Aug	1	1	0	2	0	1	2
9 Aug	1	0	1	2	1	0	2
10 Aug	1	1	0	2	0	1	2
11 Aug	1	0	1	2	1	0	2
12 Aug	1	0	0	2	0	1	1
13 Aug	1	1	0	2	0	0	1
14 Aug	1	0	1	2	0	0	1
15 Aug	1	0	0	2	1	0	1
16 Aug	1	0	0	2	0	1	1
17 Aug	1	1	0	2	0	0	1
Total		25	25		25	25	100

Table 7.–Fixed radiotracking station locations throughout the mainstem Susitna River and Yentna River drainages, 2015.

Drainage	Site name	Latitude	Longitude
Yentna	Lower Yentna	61.66359	-150.62567
	RM 18	61.74118	-150.69383
	Skwentna	61.87268	-151.35259
	Upper Yentna	62.19382	-151.58783
Susitna	Deshka Mouth	61.69127	-150.30632
	Sunshine Camp	62.12740	-150.11540
	Talkeetna	62.34754	-150.01463
	Chulitna (Princess Lodge)	62.55397	-150.23167
	Deshka Weir	61.78585	-150.34572
	Montana Creek Weir	62.10556	-150.04861
	Middle Fork Chulitna Weir	63.05900	-149.58222
	Middle Susitna	62.455387	-150.126907

Note: Datum is WGS84.

FIGURES

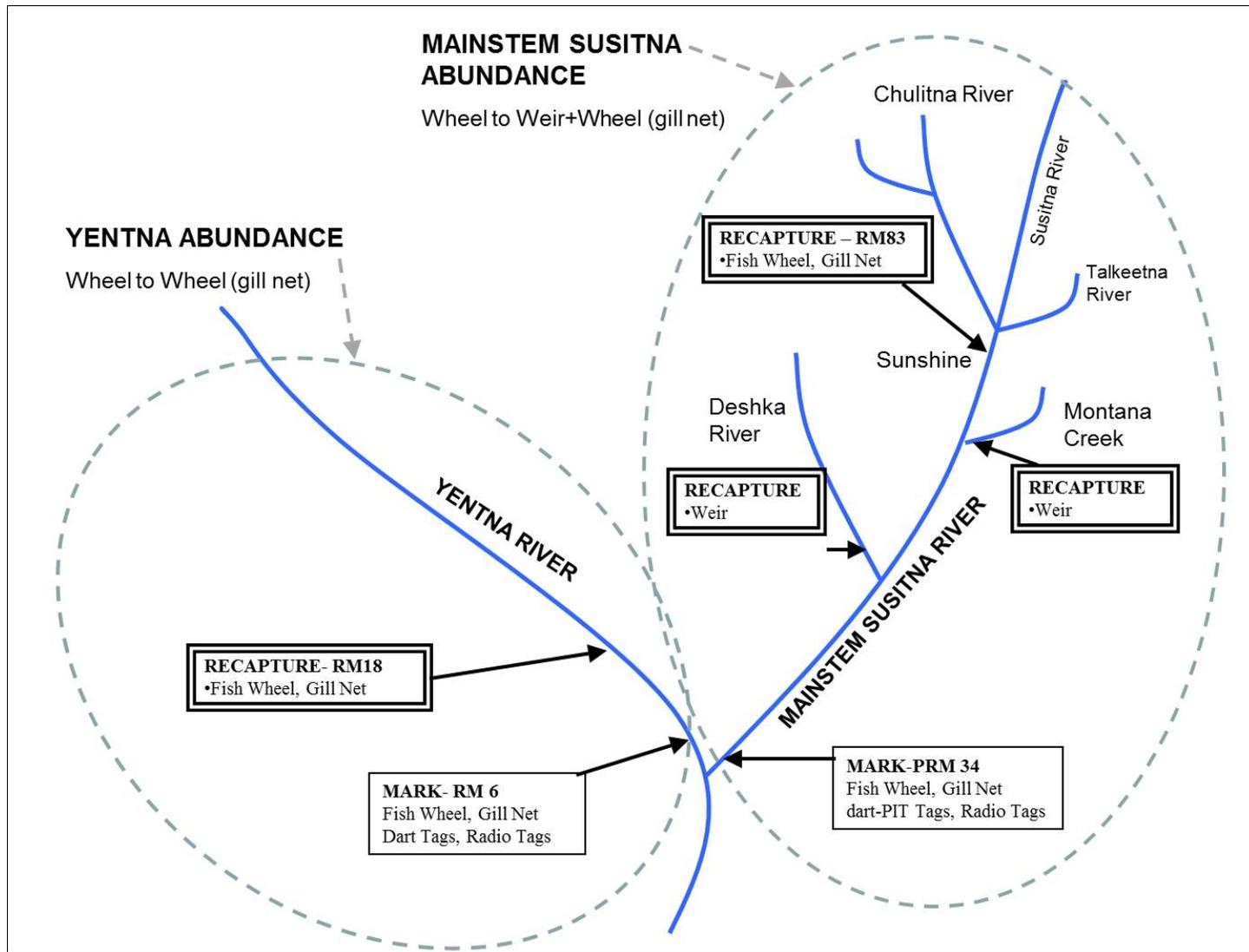


Figure 1.—Sampling design for the mainstem Susitna and Yentna rivers mark–recapture experiments.

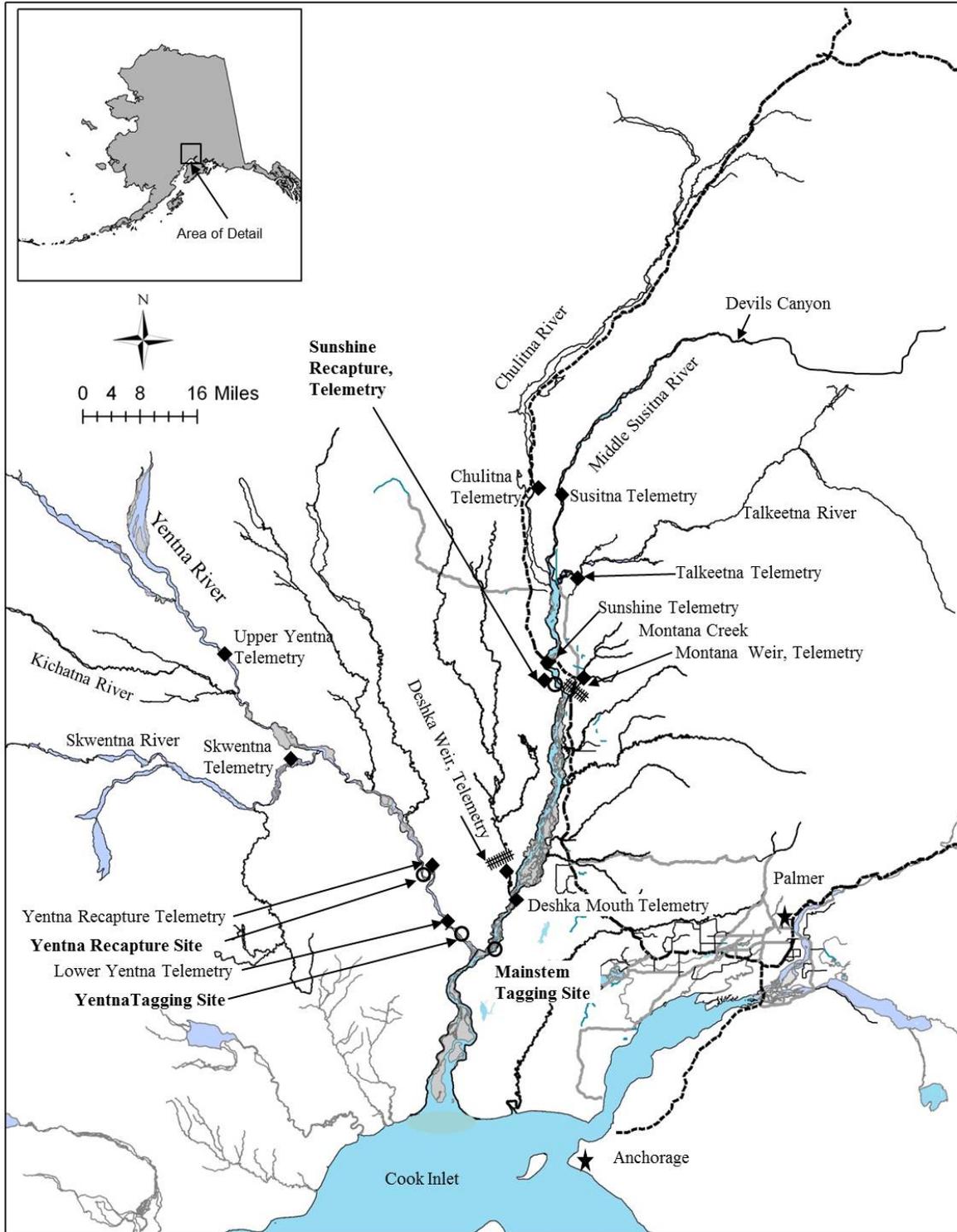


Figure 2.—Locations of fish wheel (open circles), fixed telemetry station (diamonds), and weir (fences) sites in the Susitna River drainage, Alaska.

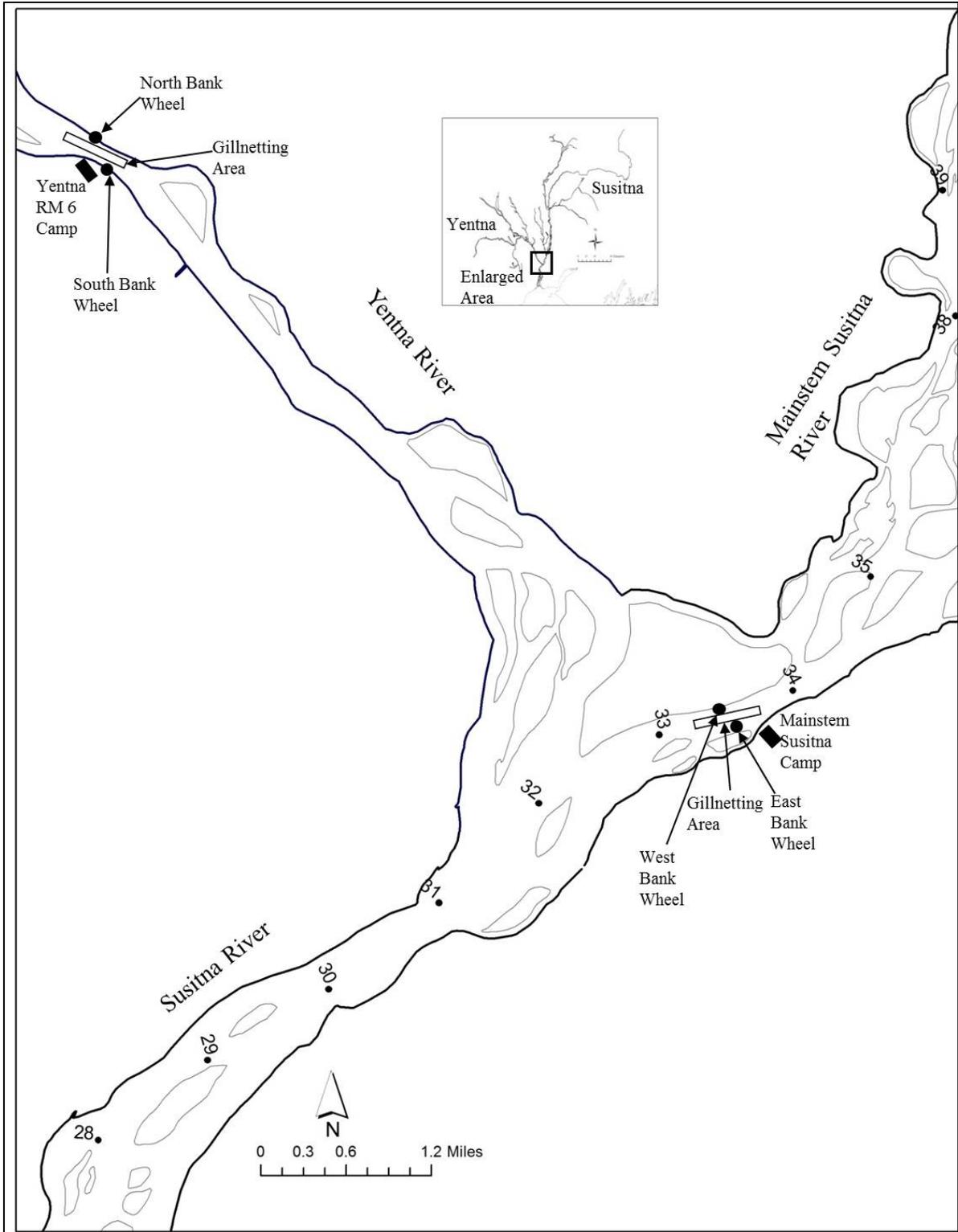


Figure 3.—Tagging sites and river miles for the mainstem Susitna River and the location of RM 6 sampling site of the Yentna River.

APPENDIX A: FIELD DATA FORMS

Appendix A1.–List of field data forms in preparation.

Fish wheel catch and effort field data form

Fish Tagging Form

Gillnet Catch and Tagging Form

Fishwheel Untagged Lengths

Recapture Wheel Catch, Effort, and Tags

Gillnet Recapture Effort and Tags

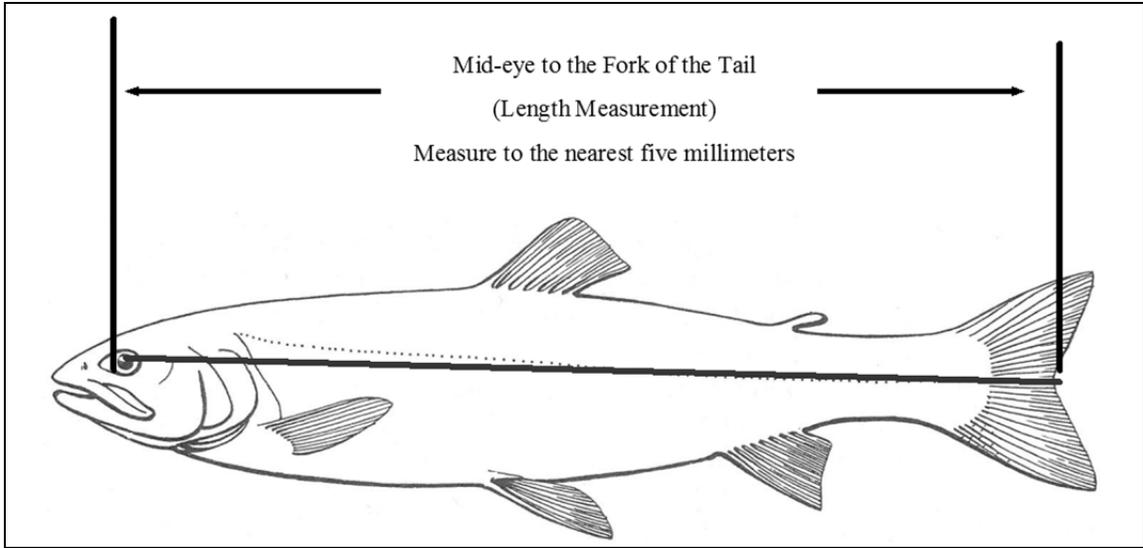
Weir Sampling Form

Radio tag deployment sequence

Radio Tag deployment field data form

Radio Tag Deviation Log

APPENDIX B: BIOLOGICAL SAMPLING PROCEDURES



Appendix B1.—Measuring salmon for length (mid eye to tail fork, METF).

Appendix B2.–Genetic tissue sample collection procedures.

Non-lethal Sampling of Finfish Tissue for DNA Analysis

ADF&G Gene Conservation Lab, Anchorage

I. General Information

We use axillary process samples from individual fish to determine the genetic characteristics and profile of a particular run or stock of fish. This is a non-lethal method of collecting tissue samples from adult fish for genetic analysis. The most important thing to remember in collecting samples is that **only quality tissue samples give quality results**. If sampling from carcasses: tissues need to be as “fresh” and as cold as possible and recently moribund, do not sample from fungal fins.

Sample preservative: Ethanol (ETOH) preserves tissues for later DNA extraction without having to store frozen tissues. Avoid extended contact with skin.

II. Sample procedure:

- 1) Tissue type: Axillary process, clip axillary process from each fish (Figure B2).
- 2) Data to record: Record each vial number to paired data information.
- 3) Prior to sampling, fill the tubes half way with ETOH from the squirt bottle. Fill only the tubes that you will use for a particular sampling period.
- 4) To avoid any excess water or fish slime in the vial, wipe the axillary process dry prior to sampling. Using the dog toe nail clipper or scissors, clip off axillary process (**1/2 -1” max**) to fit into the cryovial.
- 5) Place axillary process into ETOH. The tissue/ethanol ratio should be **slightly less than 1:3** to thoroughly soak the tissue in the buffer.
- 6) Top up tubes with ETOH and screw cap on securely. Invert tube twice to mix ETOH and tissue. Periodically, wipe the dog toe nail clippers or scissor blade so not to cross contaminate samples.
- 7) Discard remaining ethanol from the 500ml bottle before returning samples. **Tissue samples must remain in 2ml ethanol** after sampling. HAZ-MAT paperwork will be required for return shipment. Store vials containing tissues at cool or room temperature, away from heat in the white sample boxes provided. In the field: keep samples out of direct sun, rain and store capped vials in a dry, cool location. Freezing not required.

III. Supplies included with sampling kit:

- 1) (1) – Dog toe nail clipper - used for cutting the axillary process
- 2) (1) – Scissors can be used to cut a portion axillary process – if clippers don’t work for your crew
- 3) Cryovial- a small (2ml) plastic vial, pre-labeled.
- 4) Caps – with or without gasket to prevent evaporation of ETOH.
- 5) Cryovial rack- white plastic rack with holes for holding cryovials while sampling
- 6) Ethanol (ETOH) – in (2) 500 ml plus (1) – 125 ml Nalgene bottle
- 7) Squirt bottle – to fill or “top off” each cryovial with ETOH
- 8) Paper towels – use to blot any excess water or fish slime off axillary process
- 9) Printout of sampling instructions
- 10) (3) – three pair of lab gloves (size large)
- 11) Laminated “return address” label

IV. Shipping: HAZMAT paperwork is required for return shipment of these samples and is included in the kit.

Ship samples to: ADF&G – Genetics
333 Raspberry Road

Lab staff: 1-907-267-2247

Judy Berger: 1-907-267-2175

-continued-

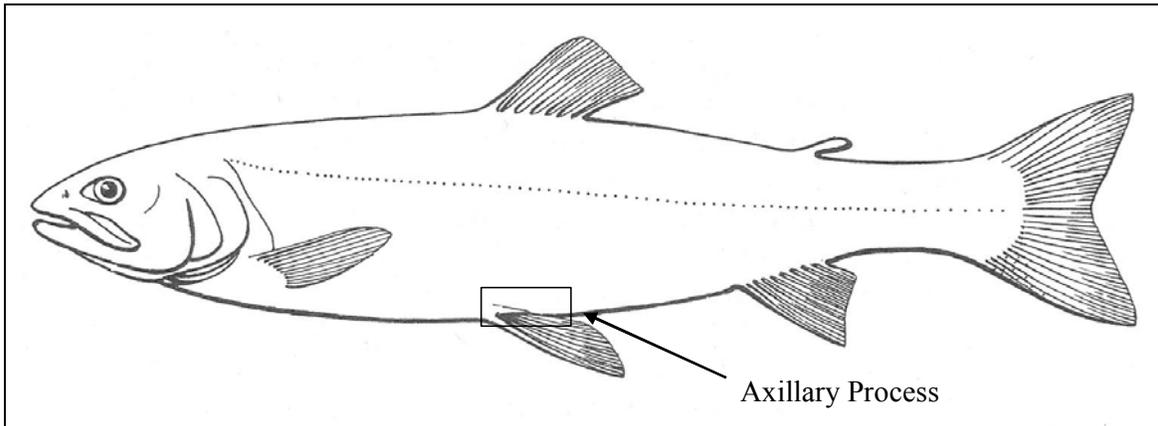


Figure B2.–Location of axillary process.

APPENDIX C: PIT TAG METHODS

All healthy Chinook salmon greater than or equal to 500 mm METF length and coho salmon greater than or equal to 400 mm METF length that are captured at the Mainstem Susitna site will be tagged with an orange, 14-cm long, vinyl, dart-PIT tag (model PDAT-PIT (HPT-12) from Hallprint Australia). Each dart-PIT tag (Figure C1) is associated with a unique number (10,000–25,000) printed on the tag twice (bottom and top portions), contact information for the researchers, and an embedded Biomark (Biomark Inc) High performance FDX-B glass PIT tag (HPT-12). Each tag will be applied beneath the dorsal fin with a hollow 8-gauge stainless steel applicator needle. In addition to the dart tag, each fish will also receive a left operculum punch to estimate tag loss at the recapture sites. Instructions, quoted from the tag manufacturer, are as follows:

**HALLPRINT TECHNICAL NOTES 2
APPLICATION INSTRUCTIONS FOR PLASTIC TIPPED DART TAGS - TUNA**

This information is for guidance to the first-time user. Procedures will vary, depending on the species to be tagged, size of tag, fish and field conditions.

Always check correct location of the dart head etc. before engaging in actual tagging operations (see over).

Tag description

Plastic tipped dart tags are constructed from a cylindrical printed and numbered marker, moulded to a plastic barbed head. Several sizes/shapes of dart head are used in combination with various length/diameter markers.

Loading of applicator

It is a good idea to keep a pre-loaded one, with the tags, your measure, notes and a pen, in a handy place so that the fish does not have to wait too long for you to find them.

Load tag with only the barb exposed at the pointed end.

If the tag does not slide easily out of applicator then it is either choked with debris or bent. This must be rectified otherwise you will probably get a hung-up tag.

Loosely fitting tags can be secured by making a slight bend in the printed marker – do not alter the applicator.

Some researchers prefer to use a handle which can be made from a short length of 20 mm diameter dowel with a hole drilled in one end. Retractable and non retractable fabricated handles are available (other than for PDX/PDXL needles) from Hallprint if needed.

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Insertion of tags into fish

Minimize trauma and damage to fish. Keep it under control. If it has noticeably suffered by capture do not waste time tagging it. Release gently, or keep if legal and you intend to eat.

Anglers and fisherman should carefully observe the procedures for recording of fish details etc. issued by the NSW Gamefish Tagging Program organisers and ensure that these are reported promptly.

1. Remove a scale with the applicator point just below the base of a dorsal spine on the second dorsal fin (see over). Avoid placing the tag too deeply into muscle.
2. Hold needle with exposed tag barb in line with fish, with barb facing head. Turn needle so barb is on the fish side.
3. Start inserting the needle at a shallow angle under the scales until you feel it pierce the skin, then raise the needle to an angle of 45 degrees so making clearance for the barb.
4. When barb is below skin, return to a shallow angle and insert until the barb is just beyond the fin spine. A slight “click” can be felt as the barb slides over the bone and locks behind it.
5. Pause for a second then withdraw the needle smoothly. A slight tug will help “set” the tag. Particularly with small tags/small fish do not place any undue strain on either tag or fish after insertion.
6. The fish should then be gently released. Fish showing undue stress, damage or inability to swim should not be released if tagged.

Prior to deployment, all dart-PIT tags will be scanned with a 134.2 kHz signal from a Biomark 601 handheld reader to ensure that the PIT tag is operating properly and to determine its unique code. The code will be recorded along with the corresponding dart tag number. The same process will be performed independently by a different person to insure that each code and corresponding dart tag number is correct.

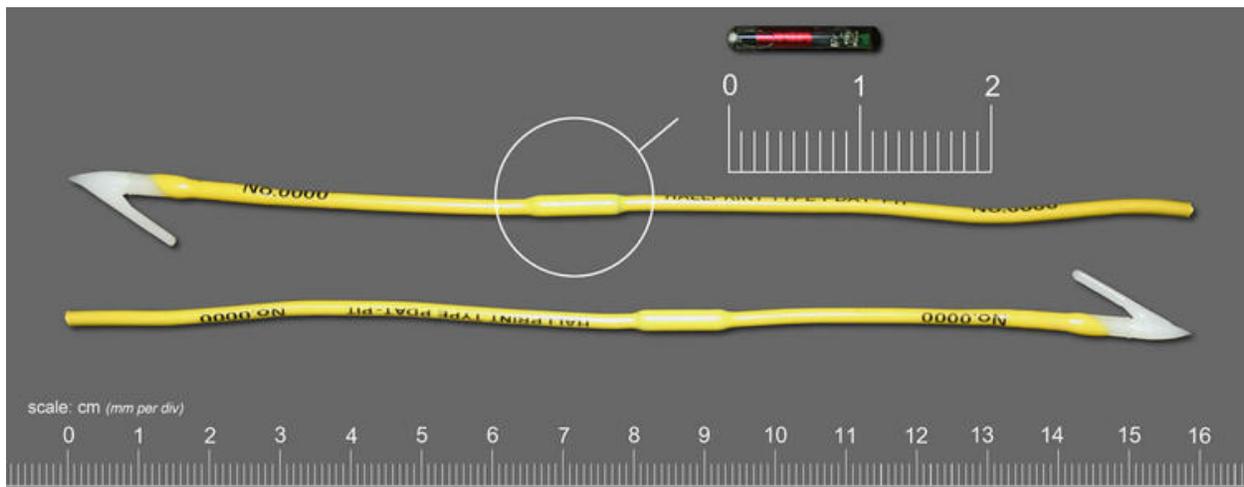


Figure C1.–Example of Hallprint PDAT-PIT tag

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Appendix C1.–Page 3 of 5.

Antenna Setup

A double antenna, Biomark PIT detection system will be installed immediately upstream of the fish cage at the Deshka River and Montana Creek floating weirs. The system will be set up to resemble the systems that were successfully used for detecting PIT tags in 2014 on the Iowithla and New Stuyahok Rivers in southwest Alaska (Charles Brazil, ADF&G personal communication). Each system will consist of a 6-m long, 1-m wide, and 1.5-m tall U-shaped chute constructed of 2.5-cm mesh size, polyethylene netting, that will force fish that have passed through the weir cage to swim through two, 1.2-m × 1.5-m Biomark antennas located 3 m and 6 m upstream of the weir.



Figure C2.–PIT detection antennas above the Iowithla floating weir and cage, 2013.

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Chest Enclosure

Antennas will have 30-m Biomark antenna exciter cables attached to them and will be routed along the stream bed to the stream bank where they will be connected to a Biomark IS1001 chest enclosure, which will contain two Biomark IS1001 24V control nodes, a Biomark IS1001 data logger, a Biomark IS1001 Data Logger board, and two 12V, 75AH, maintenance-free batteries. The system will be kept charged by a 200 W solar panel mounted 1 to 2 m above the chest enclosure in an area that receives direct sunlight. A 24-V charge controller will be used to control the voltage being supplied to the batteries and prevent the batteries from being drained during low light periods.



Figure C3.–Biomark IS1001 chest enclosure showing the components and the 2 antenna exciter cables.

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System Checks

In order to ensure that the system is operational and the antennas are working properly, 3 tests will be performed daily. In addition to daily checks of the battery voltage, tests will be performed to ensure that any PIT tags passing through the antennas are being recorded.

The first test will be performed every morning and afternoon. It will consist of testing the antennas by using a test PIT tag mounted to a 2-m long, 2-cm diameter wooden dowel. During periods of time when the trap door is closed on the weir (no fish passing) the PIT tag will be moved through all areas of each antenna to ensure that there are no 'dead spots' where the tag is not being detected. If dead spots are detected, the systems will be configured until there are no dead spots.

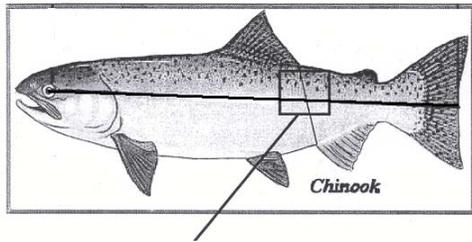
The second test will take place as opportunities arise. At both sites, crews will be sampling fish for ASL data and after necessary data has been collected, a subsample of those fish will be tagged with a dart-PIT tag and then each fish will be released into the chute so that it swims through the antennas. Either during or after the fish swims through the antennas, the system will be checked to insure that the tag was detected.

The third test will also take place as conditions allow. As the weir crews are passing fish, they will record the time they observe an orange dart-tagged fish passing through the weir. At the end of the shift, the PIT detection data will be downloaded and the crew will assess whether a PIT tag was detected during the time period that the dart-tagged fish was observed passing through the weir. The system has real time indicators for when a tag is detected, and if circumstances allow, this test can be used to provide immediate evaluation of the system.

Because the potential exists for Yentna River tagged fish (i.e., fish with a yellow dart tag) to pass through the weirs, for this test to be beneficial, the crew will need to demonstrate they can distinguish a yellow dart tag from an orange tag at the beginning of each shift. The fresh crew will attempt to positively identify separate orange and yellow dart tags placed in the counting area by the previous crew. This test will need to be performed by each shift every day because water conditions constantly change.

APPENDIX D: SCALE COLLECTION PROCEDURE

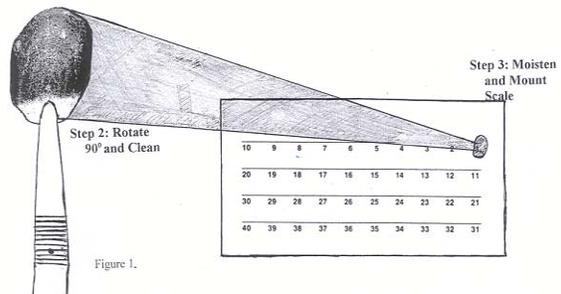
Appendix D1.–Scale collection procedure.



A “preferred scale” is located on the left side of the fish, 2 rows above the lateral line along a diagonal line from the back (posterior) of the dorsal fin to the front (anterior) of the anal fin.

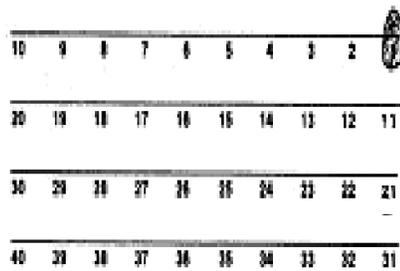
Pluck the preferred scale from the fish using forceps. Pliers may be necessary to remove scales if the fish has been in freshwater for an extended period, as happens during late season sampling.

Remove all slime, grit, and skin from the scale by moistening and rubbing between thumb and forefinger. Moisten the clean scale and mount it on the gummed card directly on top of the number “1”.



A good scale has a well-rounded shape. Hold the scale up to light and examine for overall size, shape, regeneration, deformities, etc.

Continuing, mount the second and third scales from fish number 1 onto the numerals “11” and “21”, filling in each column. Only 10 fish will fit on a card, 1 fish per column.



**APPENDIX E: TESTS OF MARK-RECAPTURE
ASSUMPTIONS AND SAMPLE SIZES**

Appendix E1.–Detection of size and sex selective sampling during a 2-sample mark–recapture experiment and its effects on estimation of population size and population composition.

Size-selective sampling

The Kolmogorov-Smirnov 2-sample test (Conover 1980) is used to detect significant evidence that size-selective sampling occurred during the first or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test compares M and C and is used to evaluate the results of the first 2 tests when sample sizes are small. Guidelines for small sample sizes are less than 30 for R and less than 100 for M or C.

Sex-selective sampling

A Contingency table analysis (χ^2 -test) is generally used to detect significant evidence that sex-selective sampling occurred during the first or second sampling events. The ratios of the counts of observed males to females are compared between M and R, C and R, and M and C using the null hypothesis that the probability that a sampled fish is male or female is independent of the sample. If the proportions by gender are estimated for a sample (usually C), rather than observed for all fish in the sample, contingency table analysis is not appropriate, and the proportions of females (or males) are then compared between samples using a 2-sample test (e.g. Student's *t*-test).

Case	M vs. R	C vs. R	M vs. C	Conclusion
I	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0	There is no size or sex selectivity detected during either sampling event.
II	Reject H_0	Fail to reject H_0	Reject H_0	There is no size or sex selectivity detected during the first event, but there is during the second event.
III	Fail to reject H_0	Reject H_0	Reject H_0	There is no size or sex selectivity detected during the second event, but there is during the first event.
IV	Reject H_0	Reject H_0	Either result	There is size or sex selectivity detected during both sampling events.
Evaluation required:				
	Fail to reject H_0	Fail to reject H_0	Reject H_0	Sample sizes and powers of tests must be considered (see below).

Cases where evaluation is required

- A. If sample sizes for M vs. R and C vs. R tests are not small and sample sizes for the M vs. C test are very large, the M vs. C test is likely detecting small differences, which have little potential to result in bias during estimation. *Case I* is appropriate.
- B. If a) sample sizes for M vs. R are small, b) the M vs. R *P*-value is not large (~0.20 or less), and c) the C vs. R sample sizes are not small or the C vs. R *P*-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size or sex selectivity during the second event, which the M vs. R test was not powerful enough to detect. *Case I* may be considered, but *Case II* is the recommended, conservative interpretation.

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C. If a) sample sizes for C vs. R are small, b) the C vs. R *P*-value is not large (~ 0.20 or less), and c) the M vs. R sample sizes are not small or the M vs. R *P*-value is fairly large (~ 0.30 or more), the rejection of the null in the M vs. C test was likely the result of size or sex selectivity during the first event, which the C vs. R test was not powerful enough to detect. *Case I* may be considered, but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for C vs. R and M vs. R are both small, and b) both the C vs. R and M vs. R *P*-values are not large (~ 0.20 or less), the rejection of the null in the M vs. C test may be the result of size or sex selectivity during both events, which the C vs. R and M vs. R tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation.

Estimation of population size and composition under different cases

Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

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Weighted estimation formulae

If stratification by sex or length is necessary prior to estimating composition parameters, then an overall composition parameter (p_k) is estimated by combining within-stratum composition estimates using the following:

$$\hat{p}_k = \sum_{i=1}^j \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik} \quad (\text{E1})$$

and variance

$$\hat{V}[\hat{p}_k] \approx \frac{1}{\hat{N}_\Sigma^2} \sum_{i=1}^j \left(\hat{N}_i^2 \hat{V}[\hat{p}_{ik}] + (\hat{p}_{ik} - \hat{p}_k)^2 \hat{V}[\hat{N}_i] \right) \quad (\text{E2})$$

where

j	=	the number of sex or size strata,
\hat{p}_{ik}	=	the estimated proportion of fish that were age or size or sex k among fish in stratum i ,
\hat{N}_i	=	the estimated abundance in stratum i , and
\hat{N}_Σ	=	sum of the \hat{N}_i across strata.

Of the following conditions, at least 1 must be fulfilled to meet assumptions of a Petersen estimator:

- 1) Marked fish mix completely with unmarked fish between events.
- 2) Every fish has an equal probability of being captured and marked during event 1.
- 3) Every fish has an equal probability of being captured and examined during event 2.

To evaluate these 3 assumptions, a chi-square test of independence will be performed for each of the following contingency tables, as recommended by Seber (1982). At least 1 null hypothesis needs to be accepted for assumptions of the Petersen model (Bailey 1951, 1952; Chapman 1951) to be valid. If all 3 tests are rejected, a temporally or geographically stratified estimator (Darroch 1961) will be used to estimate abundance. Terminology (M, C, R) is defined in the Data Analysis section of the plan.

I.–Test For Complete Mixing^a

Area/Time Where Marked	Area/Time Where Recaptured				Not Recaptured (M-R)
	1	2	...	t	
1					
2					
...					
s					

II.–Test For Equal Probability of capture during the first event^b

	Area/Time Where Examined			
	1	2	...	t
Recaptured (R)				
Unmarked (C-R)				

III.–Test for equal probability of capture during the second event^c

	Area/Time Where Marked			
	1	2	...	s
Recaptured (R)				
Not Recaptured (M-R ₂)				

^a Tests the hypothesis that movement probabilities (θ) from time or area i ($i = 1, 2, \dots, s$) to section j ($j = 1, 2, \dots, t$) are the same among sections: $H_0: \theta_{ij} = \theta_j$.

^b Tests the hypothesis of homogeneity on the columns of the 2-by- t contingency table with respect to the marked to unmarked ratio among time or area designations: $H_0: \sum_i a_i \theta_{ij} = k U_j$, where k = total marks released/total unmarked in the population, U_j = total unmarked fish in stratum j at the time of sampling, and a_i = number of marked fish released in stratum i . For the Petersen estimator to be unbiased, k must also equal total marks released/total unmarked in the population; this condition is satisfied if there is equal closure over tagging strata ($\sum_j \theta_{ij} = \text{constant}$); i.e., the proportion of the run in each tagging stratum moving to inspected second event strata is the same for all tagging strata. The hypothesis can also be satisfied through mixing ($\theta_{ij} = \theta_j$), but since mixing is unlikely due to experimental design, the test is one of equal probability of capture in the first event.

^c Tests the hypothesis of homogeneity on the columns of this 2-by- s contingency table with respect to recapture probabilities among time or area designations: $H_0: \sum_j \theta_{ij} p_j = d$, where p_j is the probability of capturing a fish in section j during the second event, and d is a constant. The hypothesis can also be satisfied through mixing ($\theta_{ij} = \theta_j$), but since mixing is unlikely due to experimental design the test is one of equal probability of capture in the second event.

Appendix E3.—Anticipated sampling rates and sample sizes necessary to estimate abundance of Chinook salmon in the mainstem Susitna River within $\pm 25\%$, 90% of the time using a Darroch model (or $\pm 12.5\%$ using a Petersen model) and adjusting for 20% loss of marked fish.

Population size (N)	Marks deployed	Mark loss	Valid marks	2 nd Event	
				Sample size needed	Sample % of N
120,000	2,647	20%	2,118	9,019	7.5
100,000	2,206	20%	1,765	8,885	8.9
80,000	1,765	20%	1,412	8,692	10.9
60,000	1,324	20%	1,059	8,388	14
40,000	882	20%	709	7,813	19.5

Note: marks are deployed based on estimated capture rate in 2014 (~1,500/68,000).

Appendix E4.–Anticipated sampling rates and sample sizes necessary to estimate abundance of coho salmon in the mainstem Susitna River within $\pm 40\%$, 90% of the time using a Darroch model (or $\pm 20\%$ using a Petersen model) and adjusting for 20% loss of marked fish.

Population size (N)	Marks deployed	Mark loss	Valid marks	2nd Event	
				Sample size needed	Sample % of N
200,000	3,529	20%	2,824	4,766	2.4
160,000	2,824	20%	2,259	4,738	3
120,000	2,118	20%	1,694	4,692	4
80,000	1,412	20%	1,129	4,604	5.8
40,000	706	20%	565	3,547	8.9

Note: marks are deployed based on estimated capture rate in 2014 (~1,500/85,000).

Appendix E5.—Anticipated sampling rates and sample sizes necessary to estimate abundance of Chinook salmon in the Yentna River within $\pm 40\%$, 90% of the time using a Darroch model (or $\pm 20\%$ using a Petersen model) and adjusting for 15% loss of marked fish.

Population size (N)	Marks deployed	Mark loss	Valid marks	2nd Event sample size needed
30,000	2,045	15%	1,739	1,095
25,000	1,705	15%	1,449	1,087
20,000	1,364	15%	1,159	1,076
15,000	1,023	15%	869	1,057

Note: marks are deployed based on estimated capture rate in 2014 (~1,500/22,000).

Appendix E6.—Anticipated sampling rates and sample sizes necessary to estimate abundance of coho salmon in the Yentna River within $\pm 40\%$, 90% of the time using a Darroch model (or $\pm 20\%$ using a Petersen model) and adjusting for 15% loss of marked fish.

Population size (N)	Marks deployed	Mark loss	Valid marks	2nd Event sample size needed
180,000	7,922	25%	5,942	2,025
150,000	6,602	25%	4,951	2,021
130,000	5,722	25%	4,291	2,017
100,000	4,401	25%	3,301	2,007
70,000	3,081	25%	2,311	1,990

Note: marks are deployed based on estimated capture rate in 2014 (~3,250/74,000).