Regional Operational Plan SF.3F.2018.10

Seasonal Movements and Distributions of Radiotagged Burbot in the Mainstem Tanana River, 2018-2021

by

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and

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October 2018

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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SEASONAL MOVEMENTS AND DISTRIBUTIONS OF RADIOTAGGED BURBOT IN THE MAINSTEM TANANA RIVER, 2018-2021

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This document should be cited as follows:
Wuttig, K., and M. Tyers. 2018. Seasonal movements and distributions of radiotagged burbot in the mainstem Tanana River, 2018-2021. Alaska Department of Fish and Game, Regional Operational Plan ROP.SF.3F.2018.10, Anchorage.

SIGNATURE PAGE

Project Title:	Seasonal movements and distributions of radiotagged burbot in the mainstem Tanana River, 2018–2020.
Project leader(s):	Laura Gutierrez
Division, Region, and Area	Sport Fish, Region III, Tanana River Drainage
Project Nomenclature:	XXX
Period Covered	June 1, 2016–Dec 1, 2022
Field Dates:	September 1, 2018–May 1, 2021;
Plan Type:	Category II

Approval

Title	Name	Signature	Date
Project leader	Laura Gutierrez		
Biometrician	Matt Tyers		
Research Coordinator	James Savereide		
Regional Supervisor	Tim Viavant		

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ABSTRACT

A large-scale radiotelemetry project will be conducted on burbot in the mainstem Tanana River and in select tributaries to describe their seasonal distributions and movements. This information is needed to determine if discrete stocks exist, seasonally and spatially, that may be uniquely affected by harvest or habitat disturbances. Three hundred burbot will be surgically implanted with Lotek MCFT2-3A coded tags with motion sensors that will operate for approximately 2.75 years. Radio tags will be deployed into 3 sections (lower, middle, upper) of the Tanana River that correspond to harvest reporting strata. Stationary tracking stations and aerial surveys will be used to identify seasonal locations and movements from December 2018 to May 2021. Analyses for project objectives will be based on location data provided by tracking stations and aerial surveys. All fish judged to be alive when located will be plotted on maps using ArcGIS.

Key words: Burbot, *Lota lota*, lush, Tanana River, radio tag, telemetry.

PURPOSE

A radiotelemetry project on burbot in the mainstem Tanana River and select tributaries will be conducted to provide more comprehensive information on their seasonal migration timing, habitat occupancy, home ranges, and spawning areas. This information will be used to determine if discrete stocks exist, both temporally and spatially, that may be uniquely affected by regional (e.g. uppermost drainage vs Fairbanks vicinity) differences in harvest by sport fish anglers or habitat changes.

BACKGROUND

Burbot *Lota lota* support an important sport fishery along the entire length of the Tanana River, which is 912 km long. Research and management of this fishery to ensure sustainable yields was conducted from 1983 through 1996 with the objectives to determine biological characteristics such as size, age, and density distributions, identify migratory and reproductive behavior, examine spawning characteristics, monitor harvests, and determine characteristics of the sport fishery (Evenson 1993a and 1997).

Initially, this research sought to define individual stocks by examining movements throughout the system. This was accomplished through a rigorous sampling program that marked and subsequently recaptured burbot in the mainstream Tanana River and in several tributary streams. This information indicated that throughout the system movements were frequent and extensive enough that the entire drainage should be considered a single stock for management (Evenson 1989 and 1990). However, inferences from the recapture of tagged fish during the open-water period are very limited because they do not provide comprehensive data on movements to seasonal habitats. For example, a fish captured in consecutive years at the outlet of Sand Lake may make an extensive spawning (e.g. 200 km) migration to the Chisana River during winter.

To obtain more comprehensive information about the distribution, and migratory and reproductive characteristics of Tanana River burbot, Evenson (1993a) radiotagged 55 burbot and followed their movements for one year. Transmitters were deployed in the Lower Chena River and in the Tanana mainstem between the Chena River and Willow Creek. These fish tended to remain in the fishery near Fairbanks year round with an average range of 57 km (range 5–225 km). Only a few fish traveled distances in excess of 100 km. These movements were in contrast to the range of movements observed by radiotagged burbot in the Kuskokwim River. During 2011-2014, 156 burbot were radiotagged during fall between Aniak and Sleetmute (Unpublished, ADF&G, Division of Sport Fish, Fairbanks). Nearly half of these fish migrated ~300 km upstream to one of several spawning areas near McGrath. During the following summer, these fish redistributed throughout the mainstem and tributaries, including several fish that spent the summer in brackish waters near the community of Eek (~ 800 km from McGrath) in the lower river.

Harvests in the Tanana Drainage are divided into the 3 survey areas: upper (upstream of the Goodpaster River), middle (Goodpaster River to Nenana River), and lower (Nenana River to its mouth). Harvest trends have been relatively stable since 2008 averaging ~1,800 burbot annually, and from 1998 to 2007 harvests averaged ~2,900 burbot annually[1]. Most (~60%–70%) of the harvest occurs in the middle section (which includes Fairbanks), ~20%–30% occurs in the upper section, and <10% in the lower section. There are no drainage-wide sustainability concerns, but localized depletions may occur affecting anglers catch rates and composition. For example, Evenson (1993b) identified a major spawning concentration downstream of Fairbanks near Rosie Creek. High catch rates of large mature burbot were commonly reported in this area, but in the last 4–5 year years, fish have been very difficult to catch. Questions remain as to whether this is a localized depletion or a change in spawning habitat associated with active channel meandering of the Tanana River.

Understanding fish movements and defining fish populations is essential for management of fisheries resources relative to habitat protections and ensuring sustainability. The goal of this project is to build on prior work by conducting a large-scale radiotelemetry project on Tanana River burbot that will provide more comprehensive information on their seasonal distributions and movements. This information is needed to determine if discrete stocks exist, seasonally and spatially, that may be uniquely affected by harvest or habitat perturbations.

OBJECTIVES

The objectives will be to:

1. Describe the seasonal distributions and their overlap for burbot radiotagged in each study section during fall of 2018 and spring 2019;
2. Identify probable spawning areas of burbot in the mainstem of the Tanana River during late January;
3. Describe run-timing of radiotagged burbot past stationary tracking stations positioned at Manley and Delta Junction when stations and radio tags are operable;
4. For each study section, estimate mean travel distances of fully recruited burbot between consecutive aerial surveys such that the estimates are within 20% of the true values 90% of the time and report the range of distances traveled between seasonal habitats;
5. For each aerial tracking survey, estimate the proportion of fully recruited burbot located within each river section such that the estimates are within 15 percentage points of the true values 95% of the time; and,
6. Estimate the length composition of fully recruited burbot.

[1] *Source*: Alaska Sport Fishing Survey database [Internet]. 1990–1996. Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish. Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/

METHODS

PROJECT DESIGN

During the fall of 2018 and late spring of 2019, 300 burbot will be radiotagged to collect temporal and spatial data over a 2.75 year period. Data will be collected using aerial surveys and 2 stationary tracking stations. Within the study area, radio tags will be apportioned across 3 geographic sections (Tables 1 and 2, Figure 1). Across and within sections, the tags will be apportioned based on locations of popular fishing areas, historical CPUE data, and interviews with current staff (Dave Stoller, ADF&G, Habitat Biologist, Fairbanks) and former staff (Matt Evenson, Fisheries Biologist, ADF&G, retired) who conducted prior CPUE and radiotelemetry studies.

The sections of the mainstem Tanana River include:

1) *Upper*: between the Goodpaster and Nabesna rivers;
2) *Middle:* between the Goodpaster and Nenana rivers, including the lower 72 km of the Chena River; and,
3) *Lower*: between the Nenana and Yukon rivers.

Within a study section, effort will be made to apportion tags equally across 2 length categories 650-749 mm, and ≥750 mm TL. The 2 length categories will help to account for any size-related differences in movements of mature burbot. This apportionment will likely be adjusted as sampling progresses because of localized differences in length compositions. The minimum size, 650 mm FL relates to the length at which 100% of burbot sampled in a previous study were mature (Evenson 1993b).

The number of radio tags deployed by section is considered sufficient to capture the range of movements likely to be encountered and to identify major spawning areas. For our objectives, the populations of inference will be limited to the populations inhabiting the 3 study sections during the times of sampling. Because sampling cannot be treated as representative of all Tanana River burbot, any inference beyond the tagged populations will be purely suggestive. Based on previous studies, it is believed that 85% of radiotagged burbot will be located during any given aerial survey.

Two-person crews will be sent to their respective sampling sections to deploy radio tags. Burbot will be captured in commercially available hoop traps. The hoop traps are 3 m long with seven 6-mm thick steel hoops. Hoop diameters taper from 0.6 m at the entrance to 0.5 m at the cod end. Each trap has a double throat (tied to the second and fourth hoops) that narrows to an opening 10 cm in diameter. All netting is knotted nylon woven into 25-mm bar mesh, bound with #15 cotton twine, and treated with an asphaltic compound. Traps will be kept stretched with 2 sections of 19-mm polyvinyl chloride (PVC) pipe attached by snap clips to the end hoops.

Each crew will fish 15–30 baited hoop traps depending on catch rates. Hoop traps will be set and fished overnight, and traps will be periodically moved to increase efficiency. All captured fish will be placed into an aerated sampling tub and sorted. Fish not selected for tagging will be sampled for length and returned to the water. For those fish that satisfy the length criteria, a radio tag will be surgically implanted following the basic surgical methods detailed by Brown (2006) and Morris (2003).

The transmitters selected for this project are Lotek™ model MCFT2-3A (coded tags). This coded transmitter with a motion or “mortality” sensor has an estimated life of 1,050 days when

Table 1.–Number of radio tags deployed by sampling area during 2018 and 2019.

Sampling locations by section	Number of tags	Sampling dates
Lower		
Mouth of Chitanana R. to Harpers Bend	15	Sept 15 – Oct 7, 2018
5 mile radius of Cosna R.	15	Sept 15 – Oct 7, 2018
5 mile radius of Zitziana R.	15	Sept 15 – Oct 7, 2018
5 mile downstream from Kantishna R.	15	Sept 15 – Oct 7, 2018
5 mile radius of Tolovana R.	10	Sept 15 – Oct 7, 2018
Tolovana River between mouth of Swanneck and Little Swanneck sloughs	10	May 15 – 30, 2019
5 mile radius from mouth of Totchaket Slough	10	May 15 – 30, 2019
Subtotal	**90**	
Middle		
Nenana River to Wood River	15	Sept 15 – Oct 7, 2018
Wood River To Chena River	17	May 15 – 30, 2019
Wood River To Chena River	18	Sept 15 – Oct 7, 2018
Chena River to Moose Creek	10	May 15 – 30, 2019
Chena River to Moose Creek	10	Sept 15 – Oct 7, 2018
Salcha to Shaw Creek	10	Sept 15 – Oct 7, 2018
Subtotal	**80**	
Chena R.		
Moose Creek Dike to Nordale Rd	15	May 15 – 30, 2019
Nordale Road to Mouth	15	May 15 – 30, 2019
Subtotal	**30**	
Upper		
Goodpaster to Volkmar River	10	Sept 15 – Oct 7, 2018
Healy Lake outlet (2 mile radius)	10	May 15 – 30, 2019
Healy Lake outlet (2 mile radius)	10	Sept 15 – Oct 7, 2018
Johnson River to Tok River (includes sand lake)	20	May 15 – 30, 2019
Johnson River to Tok River (includes sand lake)	20	Sept 15 – Oct 7, 2018
5 mile radius from Nabesna-Chisana Confluence	15	May 15 – 30, 2019
5 mile radius from Nabesna-Chisana Confluence	15	Sept 15 – Oct 7, 2018
Subtotal	**100**	

Table 2.–Major tributary confluences and bridge locations along the course of the Tanana River.

Section	Landmark	River Kilometer [a]
Lower		
	Chitanana River	54
	CosnaRiver	64
	ManleyHotSpringsSlough	98
	Kantishna River	154
	TolovanaRiver	168
	NenanaRiver	267
	Parks Highway Bridge	267
Middle		
	Wood River	298
	Chena River	358
	Moose Creek	392
	Salcha River	429
	Little Delta River	462
	Shaw Creek	498
	Delta River	515
	Richardson Hwy Bridge	515
Upper		
	Goodpaster River	530
	Volkmar River	568
	HealyLakeOutlet	587
	GeorgeLakeOutlet	619
	JohnsonRiver	630
	Robertson River	696
	Tok River	795
	AlaskaHighwayBridge	816
	Chisana-Nabesna River confluence	902

[a] MeasuredupstreamfromtheTananaRiverconfluencewiththeYukonRiver.

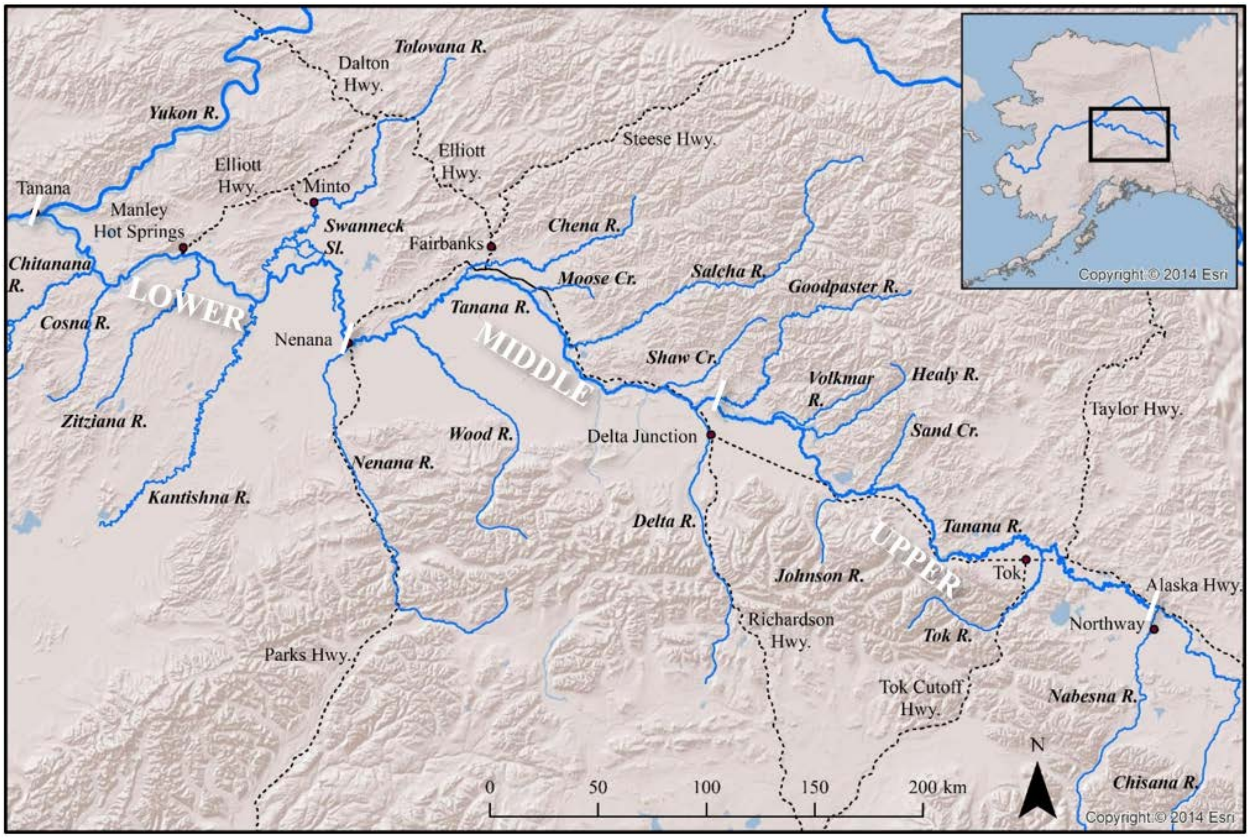

Figure 1.–Tanana River drainage and geographic Upper, Middle, and Lower study sections.

operated 12 h per day using a 3-s pulse interval. Radio tags will operate on 3 frequencies between 149.500 and 149.999 MHz (each frequency will correspond to 1 of the 3 sampling areas) with individual transmitters digitally coded for identification. Motion sensors will indicate when there is no movement for 24 hours or more, which would be indicative of a non-viable tag (fish died or tag expelled).

Radio tags will be located using a combination of ground based tracking stations and aerial tracking surveys. Two tracking stations will collect movement information by recording fish passage, one near Manly, and one near Delta Junction. In general, the stations are positioned on elevated ground and consist of a Lotek™ SRX 800 receiver, a solar array, a battery bank, steel housing, and a satellite modem for remote communications. Each receiver will monitor the frequencies continuously and receive from all antennas simultaneously. When a signal of sufficient strength is encountered, the receiver will pause for 8 s on each antenna, and then tag frequency, tag code, signal strength, date, time, and antenna number will be recorded on the data logger. Because radio tags will only operate on a 12 hour on/off cycle, only a portion of the radiotagged fish will be recorded.

Several tracking surveys are scheduled (Table 3). Each flight will require ~9 hours of flight time. A survey of the entire river may be broken into 2 or more days to account for daylight,

Table 3.–Approximate dates of aerial surveys and associated movement or habitat information.

Survey date	Information
15-Jan-2019	Winter spawning
1-Feb-2019	Winter spawning
20-May-2019	Post break-up and spring feeding locations
1-Aug-2019	Mid-summer feeding habitats
1-Oct-2019	Fall movements and feeding habitats (e.g. white fish spawning)
15-Jan-2020	Winter spawning
1-Feb-2020	Winter spawning
20-May-2020	Post break-up and feeding
15-Jul-2020	Mid-summer feeding habitats
1-Oct-2020	Fall movements and feeding habitats (e.g. white fish spawning)
1-Jan-2021	Winter spawning
1-Feb-2021	Winter spawning

weather, and pilot availability. Additional surveys may be added pending funding. The timing of the flights is set to coincide before and after periods of major movements, which are anticipated to occur primarily during freeze-up and break-up. For example, Evenson (1993b) found the largest movements of burbot in the Tanana River occurred during freeze-up and ice-out, and more localized movements only occurred in association with active spawning.

SAMPLE SIZE

Based on previous studies from the Kuskokwim and Tanana rivers, we anticipate that at least 75% of the transmitters will be operating in live burbot throughout the study. Deploying a minimum of 90 radio tags per population will provide at least a 96.6% chance of detecting (finding at least one radio in) a specific seasonal use area (winter, spawning habitat, etc.) used by at least 5% of the fish. This assumes the transmitters were randomly distributed throughout each population and the number of radiotagged fish in a seasonal use area are Poisson distributed with a mean equal to the expected number of radiotagged fish in that area (Manly et al. 1993). Similarly, we have an 81.5% chance of detecting an individual seasonal use area used by at least 2.5% of the fish.

In addition to tag loss due to mortality, it is expected that not all tags in live fish will be located during every aerial survey due to the long distances and demanding nature of survey flights. If 85% of the transmitters are located in live burbot during each survey flight, a sample size of 90 tagged individuals per population will meet the stated precision criteria for Objective 5 (Thompson 1987).

If 85% of transmitters are expected to be located in live burbot during a given flight, then we expect 72.25% of transmitters to be located in live burbot during sequential flights. Using this as an estimate of data loss, and the range of travel distances documented by Evenson (1993b) of $4 \times SD$ providing an estimated coefficient of variation, 90 tagged individuals per tagged population will meet the stated precision criteria for Objective 4 (Cochran 1977). However, it should be noted that the probabilities of live detection in sequential observations are not independent, and the probability of live detection in a given flight is likely to be more than 85% conditional on live detection in the previous flight. Because of this, actual data loss will likely be less than estimated above.

DATA COLLECTION

During the fieldwork, data will be recorded into all-weather field notebooks. For each fish captured, data collected will include: measurement of burbot (TL) to the nearest millimeter, and location (section, GPS coordinate, and date). For those fish receiving a radio tag, additional data will include the radio tag frequency and code.

Stationary tracking stations will record date, time, frequency, code, signal strength, and antenna number each time a signal of sufficient strength is encountered. Data from each station will be periodically downloaded to a laptop computer and later saved as an Excel spreadsheet file (.xls). All data files for each tracking station download will be combined into a single file (one for each station) at the end of the season. Data in these files will be sorted by transmitter frequency, code, and date/time. Data for each unique radio transmitter will be inspected, and based on the temporal pattern of signal strength recordings by antenna, a single date/time stamp will be selected for the date and time the radiotagged fish swam past a particular station. During each aerial survey, data collected for each fish will include frequency, code, latitude, longitude, and a general description of its location (e.g. approximately 1 km upstream from the George Lake outlet).

All data recorded from the captured and radiotagged burbot, stationary tracking stations, and aerial tracking flights will be combined into one master Excel spreadsheet. Excel column headers will be labeled as follows: radio transmitter frequency, code, date of capture, capture location, gear type, TL, and any other pertinent information ("Comments"). There is one column for each of the 2 tracking stations and a date and time stamp will be entered for every station that records a particular transmitter. There will be 3 columns for each tracking flight, the first will include a date and time stamp for each survey that a particular transmitter was located, and the second and third columns will list the latitude and longitude location of the fish. The GPS coordinates from aerial tracking flights will later be copied from the Excel worksheet into ArcGIS® software (ArcMap) and the locations will be plotted on maps.

The master spreadsheet and others pertinent to this project will be archived on the Sport Fish Division Intranet Docushare site and on the project leader's personal work computer at ADF&G Sport Fish Division in Fairbanks, Alaska. The filename, a description of data contained in the file, and the files location on the Docushare site will be given in the final report for this project.

DATA ANALYSIS

Objective 1

Because the GPS locations obtained in the field will be taken from a moving aircraft and multiple locations for each frequency/code combination will likely be recorded, there is a possibility that the coordinates recorded will not be within the stream course or directly over the fish. Therefore, the coordinates with the highest signal strength for each fish will be adjusted to the nearest point on the river. The accuracy of determining the true locations of radiotagged fish from aerial radio tracking is variable (depending on the speed of the aircraft, depth of the tag, and the number of tags in the vicinity), but an accuracy of 1 km can be easily achieved.

Locations of seasonal distributions of fish will be presented and summarized by plotting coordinates of all located fish deemed to be alive at the time of each survey onto a digitized map of the drainage using ArcGIS®. Seasonal distributions will be expressed as ranges, defined as the minimum portions of the river network linking all observations for a given season or survey, including tributaries if needed. Percent overlap will be calculated for the ranges associated with each pair of surveys for each tagging population, and each pair of tagging populations for each survey. Percent overlap between ranges A and B will be calculated according to the form below, in which ∩ and ∪ denote intersection and union, respectively.

$$O_{AB} = \frac{A \cap B}{A \cup B} \times 100\%$$

All range and range overlap calculations will be done in R using the riverdist package (Tyers 2017). Linear range as an expression of distribution is inherently a minimum, therefore any estimation of range overlap also represents a minimum. Because of this certain bias, the estimated range overlap will only be used in descriptive and suggestive terms, and no precision criteria will be used.

Objective 2

Patterns in transmitter locations will be used to infer fish behavior and habitat use, and aggregations of fish will be used to characterize significant spawning and overwintering habitats. To accomplish this, fish locations will be plotted for each aerial tracking survey, and visually assessed using a linear kernel density. Aggregations will be specifically identified for aerial tracking surveys known to coincide with spawning times, such as late January, but evidence of aggregation times will also be assessed using an adaptation of Ripley's K-function (Ripley 1977) with a bootstrap envelope (Efron & Tibshirani 1994). Linear kernel density and k-function analysis will also be performed using the riverdist package for R (Tyers 2017).

Objective 3

Run timing profiles of burbot will be constructed for each tracking station for the periods they are operable. Run timing profiles will be described as time-density functions, where tagged fish moving upstream and downstream of the tracking stations during time interval t will be described by

$$f(t) = \frac{R_t}{\sum_{t=1}^{T} R_t}$$

in which:

f (t)	=	the empirical temporal probability distribution over the total span of movements (upstream or downstream) past a given tracking station; and,
R_t	=	the subset of radio-tagged burbot that migrate past the tracking stations during day *t*.

Objective 4

Travel distances between aerial surveys will be calculated for each individual fish, as well as net travel direction and directional (upstream and downstream) distance, using the riverdist package for R (Tyers 2017). The mean travel and directional travel distances will be estimated for each tagged population of burbot.

Objective 5

River sections will be delineated as Lower, Middle, and Upper, with breakpoints at 267 and 515 river km from the Tanana River mouth, with any tributaries considered to belong to the same section as their respective confluences. For each tagged population, the proportions of burbot in each river section will be estimated for each flight survey, with the proportion of burbot in river section i in survey j from tagged population *k* estimated as:

$$\hat{p}_{ijk} = \frac{y_{ijk}}{n_{jk}}$$

with variance estimated as:

$$\hat{V}\left(\hat{p}_{ijk}\right) = \frac{\hat{p}_{ijk}(1 - \hat{p}_{ijk})}{n_{jk} - 1}$$

where y_{ijk} and n_{jk} denote the number of tagged burbot in river section *i* in survey *j* from tagged population *k*, and the total number of tagged burbot in survey *j* from tagged population *k*, respectively.

Objective 6

The proportion of burbot of length category *l* for tagged *j* will be estimated as:

$$\hat{p}_{jk} = \frac{y_{lj}}{n_j}$$

with variance estimated as:

$$\hat{V}\left(\hat{p}_{lj}\right) = \frac{\hat{p}_{lj}(1 - \hat{p}_{lj})}{n_j - 1}$$

where y_{lj} and n_j denote the number of tagged burbot of length category *l* in tagged population *j*, and total number of tagged burbot in tagged population *j*, respectively.

SCHEDULE AND DELIVERABLES

Dates of sampling events in 2018 and 2019 and reporting deadlines are summarized below. All research results will be compiled in a State of Alaska Fisheries Data Series (FDS) report.

Dates	Activity
August 2018	Field preparations
September 15–30, 2018	Deploy fall radio tags
May 15–30, 2019	Deploy spring radio tags
January 2019–February 2021	Conduct 12 aerial survey flights (Table 3)
May 2021	Radio battery life nearly gone, last potential aerial survey
December 2021	Survey data edited
May 2022	Data analyzed and completion of map figures
December 2022	Draft of FDS submitted to research supervisor

RESPONSIBILITIES

Project Staff and Primary Assignments

April Behr, *Fishery Biologist III*.	Project Supervisor. Responsible for project budget, support, report editing, and overseeing planning, logistics, surveys, and report writing.
Laura Gutierrez, *Fisheries Biologist I*	Project Leader. Responsible for logistics, conducting surveys, budgets, and writing the final report.
Matt Tyers, *Biometrician III.*	Assist in preparation of statistical design of field investigation for operational plan, and review data analysis and final report.
James Savereide, *Fishery Biologist IV*.	Final report editing and project support.
Brian Collyard, *F&W Technician IV*.	Assist with all field preparation and sampling.
Rick Queen, *F&W Technician IV*.	Assist with all field preparation and sampling.
Mike McNulty, *F&W Technician II*.	Assist with burbot capture and tagging.
Kirsten Duran, *F&W Technician II*.	Assist with burbot capture and tagging.
Brandy Baker, *Fishery Biologist II*.	Assist with burbot capture and tagging
Andy Gryska, *Fishery Biologist II*.	Assist with burbot capture and tagging.
Dave Stoller, *Habitat Biologist I*.	Assist with burbot capture and tagging.

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