Regional Operational Plan SF.3F.2019.10

Seasonal Habitats and Migrations of Arctic Grayling of the Lower Colville River Relative to the Nuiqsut Subsistence Fishery Area

by

Andrew D. Gryska

September 2019

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

REGIONAL OPERATIONAL PLAN SF.3F.2019.10

SEASONAL HABITATS AND MIGRATIONS OF ARCTIC GRAYLING OF THE LOWER COLVILLE RIVER RELATIVE TO THE NUIQSUT SUBSISTENCE FISHERY AREA

by
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Alaska Department of Fish and Game
Division of Sport Fish

September 2019

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SIGNATURE PAGE

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Project leader(s):	*Andrew D. Gryska*
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Approval

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ABSTRACT

Arctic grayling *Thymallus arcticus* are an important component of subsistence fisheries of the Colville River drainage. Unfortunately, very little is known about this stock, and although the river and drainage are large, the available winter habitat may be limited. Arctic grayling, as well other fishes, are most vulnerable to declines in water quality and quantity during late winter. Identification of overwintering habitats and timing of migrations to and from all seasonal habitats is needed to avoid or greatly reduce impacts associated with development and narrowly directed fisheries at vulnerable times and places. To identify the important winter refuge areas, spawning areas, and fidelity to summer areas, 120 Arctic grayling will be radiotagged during late July when they are maximally distributed throughout the Colville River drainage, and an additional 30 Arctic grayling will be radiotagged adjacent to Nuiqsut during early winter to identify additional summering and spawning areas. Radiotelemetry surveys in a fixed wing aircraft will be conducted 7–12 times over the next 24 months to identify locations of radio tagged fish during each seasonal period.

Key words: Arctic grayling, *Thymallus arcticus,* Colville River, radiotelemetry.

PURPOSE

The purpose of this project is to describe the seasonal habitat usage of Arctic grayling in the Lower Colville River drainage during critical time periods including overwintering, spawning, and summer feeding. Movements and locations of mature Arctic grayling that inhabit the Lower Colville River drainage between the Killik River and the village of Nuiqsut from July 2019 through July 2021 will be documented. This project addresses the U.S. Fish and Wildlife Service Office of Subsistence Management Fisheries Resource Monitoring Program 2016 priority information need for “baseline information including abundance, distribution, movement, and health of Arctic Grayling in the Lower Colville River and its tributaries in the context of climate change and industrial uses of water.”

BACKGROUND

Arctic grayling *Thymallus arcticus* are an important component of subsistence fisheries of the Colville River drainage (Fall and Utermohle 1993; Holen et al. 2012). Because of the importance of these stocks to subsistence users, information on the movements of Arctic grayling and identification of critical habitat areas of the Colville River has been identified as a priority information need by members of the North Slope Regional Advisory Council.

Very little is known about the Arctic grayling stock of the Colville River drainage, but some generalizations can be applied. Arctic grayling are a resident fish which, in northern Alaska, reach maturity in 5–9 years and usually spawn annually thereafter (de Bruyn and McCart 1974; Craig and Poulin 1975; Neyme 2005). Arctic grayling can live for many years, some individuals for up to 29 years, and reproductive success expressed as recruitment to maturity can vary substantially, rarely yielding a strong year class (DeCicco and Brown 2006). Populations of Arctic grayling can therefore become dominated by older, larger fish and may be susceptible to large and sustained reductions in abundance if overharvested or critical habitat (e.g. winter habitat) are disrupted (DeCicco and Brown 2006).

Arctic grayling are a migratory fish utilizing habitats that are seasonally available for spring spawning, summer feeding, and winter refuge (Northcote 1997). As winter ends, Arctic grayling migrate to spawning areas, which may be located near or far, just before and after breakup (Gryska 2011; 2015; *In prep a, b*). Spawning areas which warm earliest in the spring and provide ideal conditions for young-of-year grayling may be located in the mainstem, tributaries, and often small, beaded tundra streams on the North Slope (Tack 1980; DeCicco and Gryska 2007; Gryska 2011, 2015, *In prep a, b*; Hiem et al. 2015). After spawning, adult Arctic grayling disperse widely throughout river drainages seeking foraging opportunities. With the onset of cooler fall weather, Arctic grayling, adults and juveniles, vacate many summer feeding areas because they become inhospitable during the long winter (Gryska 2011, 2015, *In prep a,b*; Heim et al. 2015). Winter refuge areas can be rare, and densities of Arctic grayling can become quite large (Gryska 2015, *In prep a*).

For the winter, Arctic grayling seek out habitat that minimizes energy expenditure (e.g. low velocity water), has physiochemically suitable water (e.g. adequate depth, oxygen, and no frazzle ice), and provides cover from predators (e.g. overhead ice; Cunjak 1996). These habitat requirements may be found in a limited number of areas, and, in conjunction with reduced metabolism (i.e. less feeding and competition for food and space), large congregations of fish can occur among normally competitive fish (Cunjak 1996; Gryska 2015, *In prep a*). During winter, some of these locations may also become isolated refugia from which fish cannot migrate. For these reasons, Arctic grayling, as well other fishes, are most vulnerable to declines in water quality and quantity during late winter. Identification of overwintering habitats and timing of migrations to and from all seasonal habitats is needed to avoid or greatly reduce impacts associated with development and narrowly directed fisheries at vulnerable times and places. In addition, alterations of the hydrologic regime (e.g. droughts limiting migration corridors) due to climate change or withdrawals for oil industry uses may impact the population.

Arctic grayling of the Colville River drainage have not been studied to any great extent, and although the generalizations above likely apply, the Colville River is a unique river that may affect aspects of behavior, population dynamics, and life history. The Colville River is the largest river on Alaska's North Slope having a length of ~600 km, drainage area of 59,756 km^2, and annual discharge of 19.7 km^3 (McClelland et al. 2014). The Colville River basin is entirely laid across permafrost and the duration of winter is 8–10 months per year. These characteristics greatly influence features of its annual discharge. For example, spring thaw and breakup occur for about 2–3 weeks during late May and early June when on average 53% of annual discharge occurs (McClelland et al. 2014). During summer, some tributaries may become intermittent while other tributaries may flood and become silt laden when storms occur in the Brooks Range. Meanwhile, September through April accounts for only 9% of annual discharge (McClelland 2014). As winter progresses, river current and discharge cease and some streambeds go dry while others freeze to the bottom (Williams 1970; Bendock 1979; Walker and Hudson 2003). Without flow, saltwater from the ocean may intrude at least 60 km from the mouth into the delta and lower river (Walker and Hudson 2003). Although the river and drainage are large, the available winter habitat is likely limited (Bendock 1979). Information resulting from this study will identify habitats utilized by Arctic grayling during critical time periods under these unique conditions.

OBJECTIVES

The objective of this project is to use radiotelemetry to describe the seasonal movements and locations of mature Arctic grayling that inhabit the Lower Colville River drainage between the Killik River and the village of Nuiqsut from July 2019 through July 2021.

The primary objectives will be to:

1. Identify overwintering areas of Arctic grayling that summer in the tributaries of the Lower Colville River drainage;
2. Identify summering areas of Arctic grayling that overwinter near Nuiqsut;

3. Identify spawning areas of Arctic grayling that summer in the tributaries of the Lower Colville River drainage or overwinter near Nuiqsut;
4. Describe all migration timing; and,
5. Estimate the mean proportion across sites of Arctic grayling that exhibit fidelity to summering sites from summer 2019–summer 2020, such that the estimated proportion is within 13 percentage points of the true value 95% of the time.

METHODS

STUDY AREA

The 600 km Colville River with a drainage basin of approximately 53,000 km^2 is the largest river on the North Slope of Alaska. For approximately 400 km it flows east along the north slopes of the Brooks Range from which numerous tributaries make contributions, and just downstream of Umiat it turns to the north and flows nearly 200 km to the delta on the Arctic Ocean. Nuiqsut is a small village located on the west bank near the beginning of the delta, where many residents participate in subsistence hunting and fishing activities. This study will focus on the lower 290 km of the Colville River and its tributaries (Figure 1) between the Killik River and Nuiqsut where 150 fish will be radiotagged in 30–50 locations. The search area for this study will primarily focus on the Lower Colville River and its tributaries; however, tagged Arctic grayling could potentially relocate anywhere in the drainage beyond the search area. Other areas may be covered as time allows; however, it is recognized that the potential search area is far too large to be feasibly and comprehensively covered during this study.

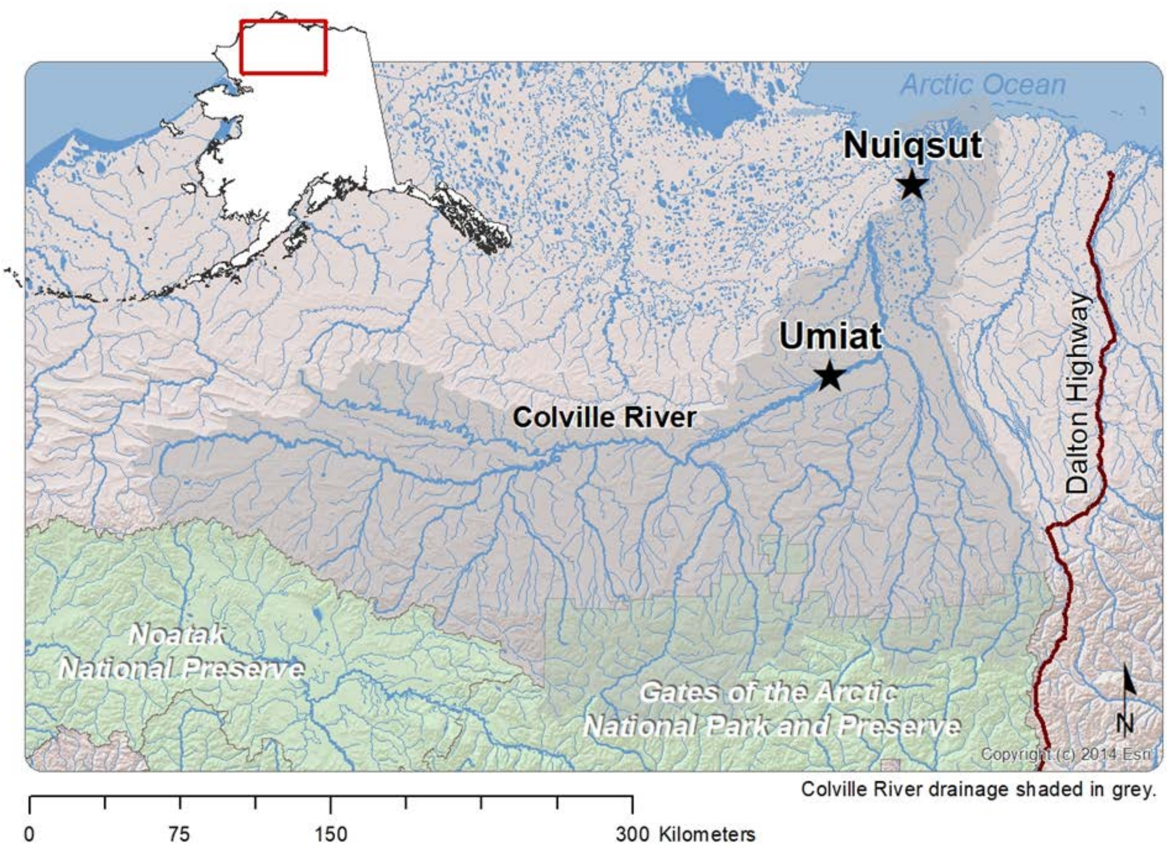

Figure 1.–Map of the Colville River drainage.

STUDY DESIGN

Radiotelemetry techniques will be used to collect location and movement data to describe seasonal locations and migrations of Arctic grayling that occupy the Lower Colville River drainage. Radio tags will be surgically implanted in 150 Arctic grayling ≥330 mm FL captured throughout the lower drainage, of which 120 radio tags will be deployed during late July while grayling occupy summer habitats in the vicinity (~55km radius) of Umiat. The remaining 30 radio tags will be deployed in the Colville River adjacent to Nuiqsut during early winter (late October or November). The wide distribution of radio tags during summer will reveal overwinter locations, while the distribution of radio tags in the Nuiqsut fishery during winter will reveal summer residence locations of fish that overwinter adjacent to Nuiqsut. In addition, spawning locations, fidelity to seasonal locations, and timing of migrations will be investigated. Results will be evaluated relative to the Nuiqsut subsistence fishery and oil field development.

Although there are numerous tributaries in the Lower Colville River, not all are sufficiently large to reasonably expect catches of appropriate size fish (Bendock 1979; Bendock and Burr 1985, 1986). Fifty-five locations in 16 larger tributaries and in the mainstem Colville River (from Killik River to Nuiqsut) were selected for the distribution of tags (Table 1; Figure 2). These sample areas have not had previous stock assessments, but several of them have been sampled to determine presence of fish species (Bendock 1979; Bendock and Burr 1985, 1986; Alaska Freshwater Fish Inventory 2019). While these data indicate presence of Arctic grayling, they do not adequately describe densities, particularly of larger fish (≥330 mm FL), and therefore, it is unknown what catches may be expected at any particular sample site. It is expected that among the 55 potential sample locations only a portion (~30) will be utilized or yield taggable fish.

Radio tags will be distributed throughout the study area systematically; each sample site will be allocated 3 to 5 radio tags (Table 1; Figure 2). Due to uncertainties, some sites may be devoid of Arctic grayling and tags for those reaches may be redistributed to other sites. Unbiased total population inferences cannot be estimated for the L:ower Colville River because radio tags cannot be allocated by abundance and size composition of Arctic grayling in each sample reach. However, the systematic distribution of the tags through the drainage will minimize bias and maximize identification of seasonal habitats and migratory behavior for the majority of the population for the period from July 2019 through July 2021.

Nearly all sample reaches are extremely remote. Areas around Umiat will be reached using helicopter transport and areas adjacent to Nuiqsut will be accessed by snow machine. As stated above, some reaches may not hold Arctic grayling, or may not have suitable landing terrain. The chosen sample reaches will be aerially inspected, and modifications to the distribution of tags and of the sample reaches will occur as needed. To efficiently sample, the designated sample sites adjacent to each other will be grouped together for sampling during a particular day (Table 1; Figure 2). Each 2-person crew (3 crews) will sample 2–3 sample locations for a range of 6–9 sample sites per day.

Table 1.–Proposed sample locations for Arctic grayling radio tag deployment around Umiat and Nuiqsut during August and October–November 2019.

Site	Area	Name	Sample Site	Latitude[a]	Longitude[a]	Distance from Umiat (km)
1	A	Kog C2	Kogosukruk River	69.49885	-152.33707	16.3
2	A	Kog 4	Kogosukruk River	69.54036	-152.36987	21
3	A	Kog C1	Kogosukruk River	69.56054	-152.22449	21.4
4	A	Kog 3	Kikiakrorak River	69.58556	-152.17172	24
5	A	Kik 6	Kikiakrorak River	69.59732	-152.73000	34.3
6	A	Kik 5	Kikiakrorak River	69.63090	-152.69250	36.2
7	A	Kik 3	Kikiakrorak River	69.69025	-152.37945	36.9
8	A	Kik 4	Kikiakrorak River	69.66545	-152.59753	37.5
9	B	Kog B2	Kogosukruk River	69.54451	-151.97474	20.5
10	B	Kog A2	Kogosukruk River	69.53187	-151.82572	21.8
11	B	Kog B1	Kogosukruk River	69.62182	-151.93691	29.2
12	B	Kog 2	Kogosukruk River	69.64302	-151.85944	30.3
13	B	Kog A1	Kogosukruk River	69.62576	-151.86977	30.4
14	B	Kog 1	Kogosukruk River	69.71735	-151.74849	41.6
15	B	Kik 2	Kikiakrorak River	69.76605	-152.05305	44.3
16	B	Kik A1	Kikiakrorak River	69.84010	-152.07058	52.5
17	B	Kik 1	Kikiakrorak River	69.85019	-151.88902	54.4
18	B	Lake	Unnamed Lake	69.981788	-151.064897	79.9
19	B	Itk 1	Itkillik River	70.009718	-150.861409	86.8
20	C	Col 3	Colville River 3	69.424475	-151.74130	16.8
21	C	Ch 1	Chandler River 1	69.436748	-151.461584	27.7
22	C	Col 4	Colville River 4	69.522106	-151.443318	32.1
23	C	Itk 2	Itkillik River 2	69.605463	-151.036478	50.3
24	C	Ck	Itkillik Tributary	69.766164	-150.652514	72.9
25	D	Ch 2	Chandler River 2	69.292245	-151.418498	16.1
26	D	UnN 3	Unnamed Trib 3	69.327179	-151.31606	17.7
27	D	Kut 2	Kutchik River 2	69.297043	-151.734179	18
28	D	UnN 2	Unamed Trib 2	69.246937	-151.340367	18.6
29	D	Kut 1	Kutchik River 1	69.31422	-151.460901	27.4
30	D	Out	Outpost Creek	69.194367	-151.360619	36.5
31	D	Anak	Anaktuvak River	69.246922	-151.013763	46.5
32	D	Tul 1	Tuluga River 1	69.133898	-151.156376	47
33	D	Itk 3	Itkillik River 3	69.352788	-150.611995	60.2
34	E	Kut 3	Kutchik River 3	69.283091	-151.903376	13.5

-continued-

Table 1.–Page 2 of 2.

Site	Area	Name	Sample Site	Latitude[a]	Longitude[a]	Distance from Umiat (km)
35	E	Ch 3	Chandler River 3	69.075756	-151.943573	33.8
36	E	Trb	Trouble Creek	69.096908	-151.653052	36
37	E	Tul 2	Tuluga River 2	68.957878	-151.523416	52.1
38	E	Ayi 1	Ayiyak River 1	68.87931	-152.05900	54.8
39	E	Ch 4	Chandler River 4	68.861471	-151.925789	57.4
40	F	FS1	Fossil Creek	69.24992	-152.48483	19.2
41	F	FS2	Fossil Creek	69.20442	-152.49046	23.2
42	F	Nin 3	Ninuluk Creek	69.05290	-152.84405	45.1
43	F	Ayi 2	Ayiyak River 2	68.95303	-152.31452	47
44	F	Nin SF	SF Ninuluk Creek	68.97977	-153.05826	56.9
45	G	Prince M	Prince Creek\Colville	69.307512	-152.426149	13.3
46	G	Prince 1	Prince Creek	69.32039	-152.48047	14.5
47	G	Prince 2	Prince Creek	69.32772	-152.59932	18.8
48	G	UnN1	Unnamed Trib 1	69.23668	-152.64254	24.8
49	G	Prince 3	Prince Creek	69.31220	-152.79726	26.7
50	G	Col 2	Colville River 2	69.162197	-153.209136	48.3
51	G	Nin 1	Ninuluk Creek	69.14490	-153.19604	48.8
52	G	Nin 2	Ninuluk Creek	69.04987	-153.08413	51.8
53	G	Col 1	Colville River 1	69.02527	-153.921885	80.5
54	U	Um	Colville River Umiat	69.37393	-152.11342	0
55	U	CB	Sea Bee Creek	69.36078	-152.12077	0

[a] Latitude and longitude expressed in decimal degrees, WGS84 datum.

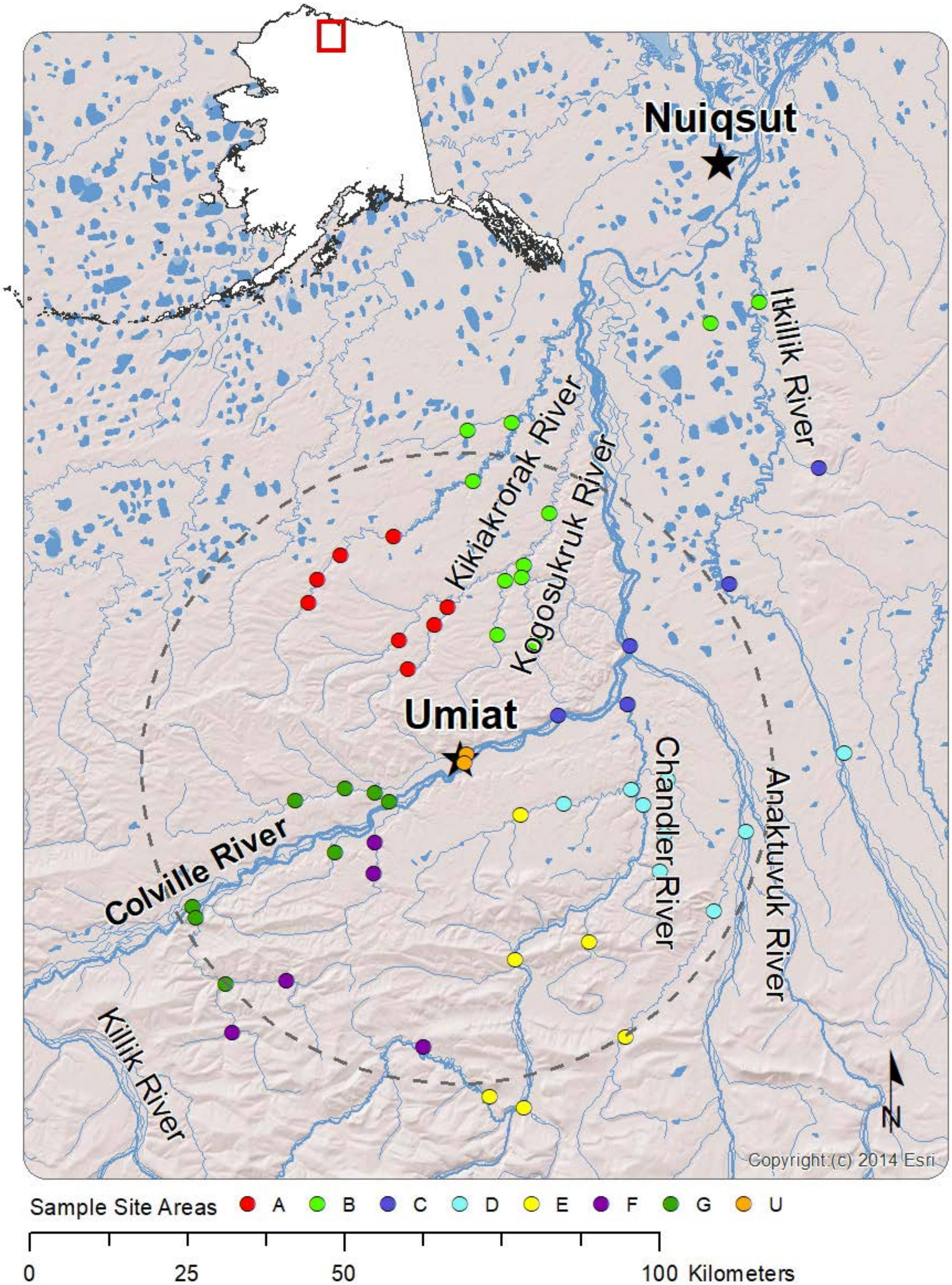

Figure 2.–Proposed sample locations for Arctic grayling radio tag deployment around Umiat and Nuiqsut during August and October–November 2019 with designated sampling areas. The dashed line depicts a 50-kilometer radius circle around Umiat from which most locations will be sampled via helicopter.

SAMPLE SIZE

Radio transmitters will be implanted into 120 Arctic grayling during the late July 2019 sampling period and 30 Arctic grayling during the late October/early November sampling period. It is assumed that 25% of radiotagged fish will experience either radio tag failure or fish mortality each year. Only Arctic grayling ≥330 mm FL will be tagged because it is expected that they are mature and will spawn. In addition, Arctic grayling ≥330 mm FL are large enough to accommodate the radio tag.

Because the primary focus of this study is the identification of seasonal use areas, there are no associated precision criteria. However, it is still possible to make probabilistic statements about what can be expected given the number of radio tags that will be deployed. If movements of summer-tagged fish were independent of one another and assuming 25% mortality or tag failure, the expected 90 remaining fish would yield a 95% chance of detecting (observing at least one fish in) an overwintering area used by 3.5% of the tagged population, assuming a binomial distribution. Similarly, 90 independent fish would yield a 95% chance of detecting an aggregation (observing more than one fish in) an overwintering area used by 5.5% of the tagged population.

Statistical independence is unlikely if fish tagged in the same summering area have an increased probability of using the same overwintering area, however, it is unlikely this is true for all tagged grayling, especially fish tagged in different streams or in different areas of a stream. A worst-case scenario can be considered, in which the number of summer tagging areas is treated as the effective sample size. If 120 radio tags were deployed evenly among 30 areas, each area would retain a 99.6% chance of being represented by at least one surviving fish, again assuming 25% mortality or tag failure; therefore, there is very little chance of a summer sampling area not to be represented. An effective sample size of 30 would still yield a 95% chance of detecting (observing at least one fish in) an overwintering area used by 10% of the tagged population, and 95% chance of detecting an aggregation (observing more than one fish) in an overwintering area used by 15% of the tagged population, again assuming a binomial distribution. Even this worst-case scenario will almost certainly be adequate for inference, because we expect overwintering aggregations to represent very large proportions of the population. The 30 radio tags deployed in the winter will yield a 95% chance of independently detecting a spawning or summering area used by 13% of the tagged population, assuming 25% mortality or tag failure.

The precision criteria for Objective 5 will be satisfied if there are at least 30 summering locations sampled with 3 fish surviving from each, assuming the maximum-variance case of all proportions equaling 0.5.

SAMPLING METHODS

Fish Capture and tagging

During late summer sampling, remote locations will be accessed from Umiat via helicopter. Arctic grayling will be captured using angling methods. Both spin and fly gear will be used to capture fish ≥330 mm FL. Terminal spin gear will consist of rubber-bodied jigs of varied size (1/16–1/4 oz and size 2–6 hooks) and fly gear will consist of an assortment of flies (e.g., Adams fly, Blue Dunn fly, or bead-head nymphs). The late summer sample period was selected so Arctic grayling will be captured when they remain in their upper river summer resident locations and water temperatures are beginning to cool as fall approaches. Warm water is stressful to Arctic grayling, and by avoiding it, it is expected that healing and survival will be enhanced. Only fish that appear to be healthy will be surgically implanted with a radio tag. Sex and maturity will be difficult to verify because fish will be captured 10 months prior to spawning. To ensure that most fish sampled are mature, only fish ≥330 mm FL will be radiotagged (Clark 1992).

During early winter sampling, Arctic grayling will be captured in and near the Colville River delta adjacent to Nuiqsut. Sample areas will be accessed via snow machine when travel becomes safe. Arctic grayling will be captured using ice fishing methods, primarily jigging rubber-bodied jigs of varied size (1/16–1/4 oz and size 2–6 hooks).

Radiotelemetry

Radio tags will be surgically implanted following the surgical methods detailed by Brown (2006) and Morris (2003). During winter, a small portable tent will be utilized to provide a relatively warm and windless environment for surgeries. The radio tags are model MCFT2-3BM manufactured by Lotek™, which are small (11 mm x 43 mm), lightweight (8 g), and have at least a 24-month operational life as programmed for this project. Each tag will emit an individual code for each fish on a single radio frequency (151.400 MHz), at either 4 or 4.5s burst rates to avoid code collision if numerous fish congregate. The radio tags will emit a signal 24 h/day during designated periods important to seasonal activities (Table 2). Radio tags have a warranty life of 741 days and an estimated life of 1,000 days.

Table 2.–Radio tag function schedule for tags deployed in Arctic grayling in the Colville River drainage. Warranty life of radio tags is 741 days and estimated life is 1000 days.

Period	Function	Days	Start Date	End Date	Cumulative Days
1	OFF	63	July 22, 2019	September 22, 2019	63
2	ON	28	September 23, 2019	October 20, 2019	91
3	OFF	161	October 21, 2019	March 29, 2020	252
4	ON	28	March 30, 2020	April 26, 2020	280
5	OFF	28	April 27, 2020	May 24, 2020	308
6	ON	84	May 25, 2020	August 16, 2020	392
7	OFF	35	August 17, 2020	September 20, 2020	427
8	ON	28	September 21, 2020	October18, 2020	455
9	OFF	161	October 21, 2020	March 28, 2021	616
10	ON	28	March 29, 2021	April 25, 2021	644
11	OFF	28	April 26, 2021	May 23, 2021	672
12	ON	84	May 24, 2021	August 15, 2021	756
13	OFF	35	August 16, 2021	September 19, 2021	791
14	ON	28	September 20, 2021	October 17, 2021	819
15	OFF	161	October 18, 2021	March 27, 2022	980
12	ON	28	March 28, 2022	April 24, 2022	1008

Locations of radiotagged Arctic grayling will be determined using periodic flights in a fixed wing aircraft in the Lower Colville River drainage. Additional search areas may be considered based on survey data from previous flights. Timing and direction of migrations will be monitored to make intuitive decisions about additional search areas. Tracking flights will utilize a Lotek SRX 600 receiver with an internal GPS that will record time and location data (WGS84 datum). Flights will occur during a 24-month period primarily to determine locations of winter refuge, pre-spawning, spawning, and subsequent summer feeding habitats (Table 2). The periodicity of flights will vary dependent upon typical Arctic grayling behavior and weather conditions (e.g. timing of breakup affecting timing of spawning).

To facilitate data analysis, all radiotagged Arctic grayling will be assigned a "fate" during each tracking survey (Table 3). Fates (e.g. tagging mortality, post-tagging mortality, alive, and at-large) will be assigned based on information collected from aerial surveys as well as any harvested fish for which tags are returned. Following fate assignment and description, seasonal locations, and migratory periods will be described and depicted on maps.

DATA COLLECTION

During the fieldwork, data will be recorded in all-weather field notebooks and on field data forms. For each Arctic grayling captured, data collected will include:

1) date;
2) radio tag frequency and code;
3) measurement of fish length to the nearest 1 mm FL;
4) location as a coordinate (longitude and latitude in decimal degrees WGS84 datum) determined by a GPS;
5) water temperature (°C); and,
6) sex (if possible).

During each aerial tracking survey, data collected for each fish will include:

1) radio tag frequency and code;
2) location as a coordinate (longitude and latitude in decimal degrees WGS84 datum) determined by the receiver; and,
3) general description of its location (e.g. approximately 1 km upstream from Umiat).

Following all fieldwork, data will be transcribed into an EXCEL workbook with column headings corresponding to the field data form and comments. A brief project description in a text box will be provided for added clarity. Locations of radio tagged fish will be plotted on USGS maps using ArcGIS software. Final copies of the Excel and ArcGIS files will be provided with the completed report when it is submitted for review to be archived in the Division of Sport Fish Docushare website. The file name and directory location will be presented in the final report.

DATA ANALYSIS

Data analysis will consist of plotting locations of radiotagged Arctic grayling on maps and constructing a data profile of each radiotagged fish. Maps will be constructed using ArcGIS and R software, and will depict locations of interest: tagging, summer residence, spawning, and over-winter residence. Final fates of each tagged fish will be fully determined by project completion.

Profiles will include all relevant data collected from each radiotagged fish: length at capture, capture location, GPS location during each survey, and the status (fate) of each fish during each survey. Fates will be determined from information collected during aerial tracking surveys (Table 3). Because Arctic grayling are highly migratory, mortality can be easily inferred if an Arctic grayling is located more than once and fails to move a significant distance (5 km) over a period of one month or greater. The unknown fate is usually a temporary designation for radiotagged fish for which there is insufficient data to determine if the fish is alive or not. For example, if a fish is tagged during August and not located again until spawning surveys amongst a spawning aggregation during the following spring, then it would have been temporarily assigned an unknown fate until found spawning, when it would be designated a spawner. At the end of the 24-month study, final fates will be determined.

Table 3.–List of possible fates of radiotagged Arctic grayling.

Fate	Description
Unknown (U)	A fish that that may be dead or alive but its status cannot be determined because there is insufficient data (e.g., a fish was not located or moved very little).
Mortality (M)	A fish that dies in response to tag implantation, fishing, or natural causes.
Alive (A)	A fish that is alive and displayed an obvious migration pattern towards an overwinter, spawning, or summer area in conjunction with other radio tagged Arctic grayling.

Transmitter distribution patterns will be used to infer fish behavior and habitat use, and aggregations of fish will be used to characterize significant spawning and seasonal 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, but evidence of aggregation times will also be assessed using an adaptation of Ripley’s K-function (Ripley 1977) with a bootstrap envelope (Efron and Tibshirani 1994). Linear kernel density and k-function analysis will be performed using the riverdist package for R (Tyers 2017, R Core Team 2016). Finally, to refine our understanding of the spatial extent of each spawning area, the minimum regions containing 75%, 90%, and 100% of the individuals in each spawning aggregation will be determined.

Temporal patterns in migration will also be described by calculating travel distances between aerial surveys for each individual fish, as well as net travel direction and directional (upstream) distance. The mean travel and directional travel distances will be estimated between surveys for each spawning and summering population.

Even though summer sampling cannot be treated as allocated proportional to abundance, it is still possible to estimate mean summer site fidelity across sites. This can be estimated as:

$$\bar{p} = \frac{\sum_i \hat{p}_i}{m}$$

$$V(\bar{p}) = \frac{1}{m^2}\sum_i \frac{\hat{p}_i(1-\hat{p}_i)}{n_i - 1}$$

In which $\hat{p}_i = {x_i}/{n_i}$, for x_i representing the number of fish tagged in summer area *i* showing site fidelity out of n_i surviving fish with operating radio tags, out of *m* total summer areas.

SCHEDULES AND REPORTS

A Fisheries Data Series (FDS) Report will be submitted to the research coordinator by December 31, 2022. This report will summarize all capture and tagging information and telemetry data from aerial survey flights from July 2019 through July 2021. Probable dates for sampling activities are summarized below.

Date	Activity
July 1–19, 2019	Mobilization
July 21–30, 2019	Sampling from Umiat
October 26–November 30, 2019	Sampling for 1 week from Nuiqsut
September 23, 2019–July 31, 2021	Periodic Flights
December 2021	Analysis
May 31, 2021	Draft Report
December 1, 2021	Final FDS Report

RESPONSIBILITIES

PROJECT STAFF AND PRIMARY ASSIGNMENTS

Andrew Gryska, *Fisheries Biologist II*. Project Leader. Responsible for supervision of all aspects of this project, data analysis, managing the project budget, and writing the final report.

Matt Tyers, *Biometrician III*, Assist with project design and data analysis.

April Behr, *Fishery Biologist III*. Report editing and general project support for all aspects of field work.

James Savereide, *Fishery Biologist IV*. Final report editing and project support and all aspects of field work.

Matt Stoller, *Fish & Wildlife Technician III*. Mobilization, day-to-day project tasks, all aspects of field work, and demobilization.

Brian Collyard, *Fish & Wildlife Technician III*. Mobilization, day-to-day project tasks, all aspects of field work, and demobilization.

Dave Stoller, *Habitat Biologist I*. Mobilization, day-to-day project tasks, all aspects of field work, and demobilization.

Rick Queen, *Fish & Wildlife Technician IV*. Mobilization, day-to-day project tasks, all aspects of field work, and demobilization.

Eugene Peltola, *ANSEP student intern*. Mobilization, day-to-day project tasks, all aspects of field work, and demobilization.

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