**Regional Operational Plan No. ROP.SF.3F.2021.07**

# Beaver and Nome Creeks Arctic Grayling Radiotelemetry, 2021–2022

**by**

**Lisa Stuby**

**July 2021**

**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, $\chi^2$, 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 NO. ROP.SF.3F.2021.07*

# BEAVER AND NOME CREEKS ARCTIC GRAYLING RADIOTELEMETRY, 2021-2022

by
Lisa Stuby
Alaska Department of Fish and Game Division of Sport Fish, Fairbanks

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

July 2021

The Regional Operational Plan Series was established in 2012 to archive and provide public access to operational plans for fisheries projects of the Divisions of Commercial Fisheries and Sport Fish, as per joint-divisional Operational Planning Policy. Documents in this series are planning documents that may contain raw data, preliminary data analyses and results, and describe operational aspects of fisheries projects that may not actually be implemented. All documents in this series are subject to a technical review process and receive varying degrees of regional, divisional, and biometric approval, but do not generally receive editorial review. Results from the implementation of the operational plan described in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author if you have any questions regarding the information provided in this plan. Regional Operational Plans are available on the Internet at: http://www.adfg.alaska.gov/sf/publications/.

Product names used in this publication are included for completeness and do not constitute product endorsement. The Alaska Department of Fish and Game does not endorse or recommend any specific company or their products.

*Lisa Stuby,*
*Alaska Department of Fish and Game, Division of Sport Fish,*
*1300 College Road, Fairbanks, AK 99701-1599, USA*

*This document should be cited as follows:*
*Stuby, L. 2021. Beaver and Nome Creeks Arctic grayling radiotelemetry, 2021-2022. Alaska Department of Fish and Game, Division of Sport Fish, Regional Operational Plan No. ROP.SF.3F.2021.07, Anchorage.*

## SIGNATURE PAGE

| | |
|---|---|
| Project Title: | Beaver and Nome Creeks Arctic grayling radiotelemetry, 2021–2022. |
| Project leader(s): | Lisa Stuby, Fishery Biologist III |
| Division, Region, and Area | Sport Fish, Region III, Fairbanks |
| Project Nomenclature: | L21AS00302 |
| Period Covered | July 2021–August 2024 |
| Field Dates: | July 2021–July 2023 |
| Plan Type: | Category II |

**Approval**

| Title | Name | Signature | Date |
|---|---|---|---|
| Project leader | Lisa Stuby | | |
| Biometrician | Matt Tyers | | |
| Research Coordinator | James Savereide | | |
| Regional Supervisor | Jeffrey Estensen | | |

# TABLE OF CONTENTS

**Page**

LIST OF TABLES ..... ii
LIST OF FIGURES ..... ii
ABSTRACT ..... 1
PURPOSE ..... 3
BACKGROUND ..... 3
OBJECTIVES ..... 3
METHODS ..... 3
Project Design ..... 3
Radiotelemetry Project ..... 4
Radiotracking Equipment and Tracking Procedures ..... 5
Data Collection and Reduction ..... 6
Data Analysis ..... 6
Objective 1: ..... 6
Objective 2: ..... 7
Objective 3: ..... 8
Objective 4: ..... 8
SCHEDULE AND DELIVERABLES ..... 9
RESPONSIBILITIES ..... 10
Project Staff and Primary Assignments ..... 10
REFERENCES CITED ..... 11

# LIST OF TABLES

**Table** **Page**

1. Aerial tracking flights to be conducted in 2021-2023. ..... 16
2 List of possible fates for radiotagged Arctic grayling in Beaver and Nome Creeks ..... 16

# LIST OF FIGURES

**Figure** **Page**

1. Outline of the Fairbanks nonsubsistence area within the YMA and containing the WMNRA. ..... 14
2. Map of the Beaver Creek drainage within the WMNRA and referenced sampling locations. ..... 15

# ABSTRACT

This project plan outlines a 2-year radiotelemetry study for Arctic grayling *Thymallus arcticus* in the Beaver Creek drainage. Information on life history, migration timing, and habitat use is needed to better understand the distribution of Arctic grayling during critical time periods and to inform a future population assessment. Radio transmitters with a 2-year operational life will be surgically implanted into 150 Arctic grayling in parts of the drainage that are most susceptible to sport fishing pressure. Aerial tracking flights to locate radiotagged Arctic grayling will be conducted during winter, spring, summer, and fall in order to identify, document, and characterize overwintering, spring spawning, and summer feeding areas. Location data will also be used to examine seasonal fidelity to these areas. Seasonal migration timing between Beaver Creek and its Nome Creek tributary will be determined with a stationary tracking station located near the confluence. Results from the radiotelemetry study will be used to select an appropriate index area and time for a mark-recapture experiment that will be conducted during summer 2023.

Keywords: Arctic grayling, *Thymallus arcticus*, radiotelemetry, Beaver Creek, Nome Creek, aerial tracking flight, seasonal movements, spawning areas, radio transmitter, stationary tracking station

# PURPOSE

Because Nome Creek is road accessible and attracts a large number of visitors, sport fishing for Arctic grayling *Thymallus arcticus* is catch-and-release only. Concerns were recently brought to the Federal Subsistence Board by the Eastern Interior Regional Advisory Council (EIRAC) about the possibility that catch-and-release mortality may be adversely affecting the Arctic grayling population in Beaver and Nome Creeks. Alaska Department of Fish and Game (ADF&G) and Bureau of Land Management (BLM) managers requested information on the seasonal movements and distributions of Arctic grayling in the Beaver Creek drainage during overwintering, spring spawning, and summer feeding to better understand critical habitat areas and the availability of Arctic grayling to sport anglers. Resulting data will be used to inform a future population assessment, which is needed to evaluate current use trends and respond to the concerns posed by the EIRAC. The BLM will also use this information to address current management objectives, such as determining the status of important native species and habitat as it relates to the Outstanding Remarkable Values defined by the Wild and Scenic Rivers Act.

# BACKGROUND

Arctic grayling (*Thymallus arcticus*) are a salmonid that are distinguished by their brilliant iridescent coloration and large sail-like dorsal fin. They have a Holarctic distribution and are fairly ubiquitous throughout most Alaskan drainages, with the exception of Kodiak Island, portions of the Kenai Peninsula, the islands in Southeast Alaska, and along the Alaska Peninsula west of Ugashik Lake (Swanton and Wuttig 2014). Arctic grayling are distributed throughout the entire 3,190 km long Yukon River drainage from the headwaters in Canada to streams that originate in the Yukon Delta (Stuby *In press*). Beaver Creek is a major tributary of the Yukon River that is 452 km in length. The first 204 km of Beaver Creek has been designated a wild and scenic river with the majority flowing through the White Mountains National Recreation Area (WMNRA), which is managed by the BLM.

Some populations of Arctic grayling in Alaska show distinct seasonal migrations from overwintering to spring spawning and summer feeding areas. Mature Arctic grayling travel to spring spawning locations soon after ice-out (at temperatures near 4$^{o}$C) between mid-May and mid-June, with some fish migrating as early as the end of April and others as late as July (Armstrong 1986). In rivers and streams, Arctic grayling spawn mostly in riffles with pea-sized gravel (Tack 1971), although other substrate types such as large rubble and vegetated silt have also

been noted (Bendock 1979). Embryonic development is rapid, and hatching and emergence of juvenile Arctic grayling generally takes 2–3 weeks (Armstrong 1982). Mature post-spawning fish will travel to summer feeding areas, which are often located in the headwaters (Gryska 2006, 2011), where they remain between mid-June and mid-August (Tack 1980). Arctic grayling are visual predators that feed opportunistically on drifting invertebrates like crustaceans, insects, and fish eggs. During feeding, territorial older Arctic grayling select stream positions in dominance hierarchies that maximize their net energy intake rate (Hughes 1992), usually in deep depressions near the center of the current. Mature Arctic grayling show site fidelity to summer feeding and spring spawning areas (Ridder 1998); however, Arctic grayling are also known to quickly colonize new habitats that may become available from fluvial changes or after removal of stream obstructions (Wuttig 1997). In fall, Arctic grayling migrate out of tributaries as streambeds freeze to the bottom or dry up (Gryska 2011). During the winter, they seek habitat with a low velocity current that will minimize energy usage with adequate depth, oxygen, and no frazil ice (Cunjak 1996).

Arctic grayling are a popular sport and subsistence species throughout the Yukon River drainage. They readily strike a lure and therefore are one of the most sought-after species by sport anglers in Alaska. Within the ADF&G, Division of Sport Fish (DSF) Yukon Management Area (YMA, Yukon River drainage, excluding the Tanana River), Arctic grayling accounted for 45% of total harvest and 47% of the total catch (harvest + catch-and-release) during 2009–2018 (Stuby *In press*). Beaver Creek is located within the YMA and the Fairbanks nonsubsistence area (Figure 1), and supports a popular Arctic grayling sport fishery. Nome Creek, a road-accessible tributary of Beaver Creek, is approximately 90 km (56 miles) northeast of Fairbanks and accessed from the Steese Highway. Highway improvements in the early 1990s allowed for easier access to Beaver and Nome Creeks and the creation of 2 campgrounds along a road that parallels Nome Creek. Increased visitation to this area, and subsequent fishing pressure, prompted the Board of Fish to adopt a catch-and-release only regulation in 1994 for Arctic grayling in Nome Creek. For the remainder of Beaver Creek, the sport fish regulation is 5 fish per day, 5 in possession. People frequently float and fish from the lowermost accessible point of Nome Creek to the Victoria Creek confluence on Beaver Creek. Nome Creek is closed to federal subsistence harvests of Arctic grayling; however, subsistence harvests of 5 Arctic grayling per day are allowed along Beaver Creek from the mouth of Nome Creek to O'Brien Creek, and harvests of 10 fish per day are allowed below O'Brien Creek (Figure 2).

Little work has been conducted on Arctic grayling in the Beaver Creek drainage. The BLM has periodically conducted fisheries surveys on Beaver Creek within the WMNRA since 1988, with an emphasis on Arctic grayling because of their recreational value as a sport fish species (Carufel 1990). Radiotelemetry techniques were used in 1992 to locate Arctic grayling during the winter within the WMNRA and examine winter habitat needs (Lubinski 1995). During 2000, a mark-recapture (M-R) experiment was conducted in a 30-mile section of Beaver Creek and a separate M-R study was conducted in Nome Creek (Fleming and McSweeny 2001). During the 2000 M-R experiment, Fleming and McSweeny (2001) estimated 1,325 Arctic grayling per river mile in Beaver Creek. However, for the separate M-R effort in Nome Creek they reported an inability to maintain geographic closure within the lower 5 miles of Nome Creek that resulted in inconclusive results and large errors. This was attributed to conducting the M-R experiment too soon after spawning before the fish had completed post-spawning migrations to their summer feeding areas.

To aid in the management of Arctic grayling resources in the Beaver Creek drainage, we have developed a two-phase integrated approach to understand Arctic grayling movements, seasonal distribution, and abundance using radiotelemetry and M-R techniques. A radiotelemetry study will be conducted in 2021–2022 to identify critical habitat areas used for overwintering, spring spawning, and summer feeding, yearly fidelity to these areas, and migration timing between Beaver and Nome Creeks. Resulting movement and timing data will be used to identify an appropriate index area to conduct a M-R experiment in 2023 in both Beaver and Nome Creeks. The M-R experiment will estimate abundance, length, and age composition of Arctic grayling residing in the selected index area and will be detailed in a separate operational plan.

# OBJECTIVES

The objectives of the 2021–2022 radiotelemetry study are to:

1) describe seasonal movements, run-timing, and spatial distributions of Arctic grayling during fall 2021 to summer 2023 in the Beaver Creek drainage;
2) identify and examine spawning, overwintering, and summer feeding areas;
3) calculate travel distances of radiotagged Arctic graying between tracking flights; and,
4) identify an appropriate index area to monitor Arctic grayling abundance in 2023.

# METHODS

## PROJECT DESIGN

Radiotelemetry techniques will be used to locate and describe seasonal overwintering, spring spawning, and summer feeding areas of Arctic grayling within the Beaver Creek drainage, with an emphasis on the portion of Beaver and Nome Creeks that lie within the WMNRA. Radio transmitters will be distributed primarily in areas that incur the majority of sport fishing pressure. Concurrent to this study, BLM will be conducting habitat and water quality analyses on spawning, feeding, and overwintering areas. ADF&G personnel will assist the BLM in the collection of habitat and water quality data, and likewise, the BLM will assist the ADF&G with field operations during the radiotelemetry study.

***Year 1:*** One hundred fifty radio transmitters will be surgically implanted into Arctic grayling captured throughout the accessible headwaters of Beaver Creek downriver to the confluence with Victoria Creek, which is near the WMNRA border (Figure 2). This number of transmitters is considered sufficient to capture the range of seasonal movements of Arctic grayling. Radio transmitters will have a 2-year operational life. A stationary tracking station will be installed near the confluence of Beaver and Nome Creeks to provide seasonal timing data for radiotagged Arctic grayling and 9 aerial tracking flights will be conducted to locate radiotagged fish during critical time periods.

***Year 2:*** Movements of the Arctic grayling that were radiotagged in 2021 will be recorded during winter-fall 2022. In addition, ADF&G will assist BLM in collecting water quality data and conducting habitat analysis on spring, summer, and overwintering areas within Beaver and Nome Creeks.

***Year 3:*** Results gathered from the radiotelemetry study will be used to identify an appropriate index area and determine the best timing for the 2023 M-R study.

## RADIOTELEMETRY PROJECT

During July and August 2021, 150 radio transmitters will be distributed in Arctic grayling from the upper tributaries of Beaver Creek to the confluence with Victoria Creek (Figure 2). Transmitters will be systematically distributed throughout the study area with a proportion of radio transmitters allocated to each reach that is accessible by road, all-terrain vehicles (ATV), or raft. Deployment will occur primarily in 1) Beaver Creek headwater tributaries including Champion, Little Champion, and Quartz Creeks that are accessible off of the 16-mile Quartz Creek trail by ATVs; 2) Road-accessible Nome Creek from above the Mount Prindle Campground down to the Put-in Point at the end of Nome Creek Road; and, 3) by floating Nome Creek from the Put-in Point to mainstem Beaver Creek, down to Victoria Creek (Figure 2). Most floaters take-out at Victoria Creek, and beyond this point is outside of the WMNRA. The proportion of radio transmitters in each area will be roughly based on the length of each reach, sport fishing pressure due to accessibility, and on ease of capturing Arctic grayling as determined from feasibility sampling that occurred during late July 2020. Of the 150 available transmitters, 20 will be deployed in Arctic grayling that are captured in tributaries off of the Quartz Creek trail. Nome Creek is accessible and fishable for approximately 16 miles and 40 transmitters will be deployed in this section with 5 transmitters deployed approximately every 2 miles. The float from the Nome Creek Road Put-in Point to Victoria Creek is 177 km and the remaining 90 radio transmitters will be deployed in this area with approximately 10 transmitters to be deployed each 20 km. Distances for radio transmitter deployment will be estimated using a GPS. Due to tagging uncertainties that can result from inclement weather and reaches not having as many Arctic grayling as predicted, undeployed transmitters will be redistributed to other reaches and locations if needed. The systematic distribution of the transmitters will maximize the opportunity to identify seasonal habitats and migratory behavior.

Arctic grayling will be captured with hook-and-line gear. Single, barbless hooks will be used, along with soft landing nets, to minimize stress and ensure tagging success. Only fish that appear healthy will receive a radio transmitter. Warm water is stressful to Arctic grayling (LaPerriere and Carlson 1973, Lohr et al. 1996), so an attempt will be made to tag fish when water temperature is less than 15°C. Radio transmitters will be surgically implanted following the methods detailed by Brown et al. (2002). Lengths and locations of all Arctic grayling that are surgically implanted with a radio transmitter will be recorded. Each fish will be measured from snout to fork of tail to the nearest mm. All attempts will be made to prevent tagging mortality, but in the event of a mortality, otoliths will be collected for later aging and ages will be determined as described by Brown (2000).

Capture and radiotagging Arctic grayling off of Quartz Creek trail and floating from the Nome Creek Put-in Point to Victoria Creek will take place during July 2021. Three to 4 personnel will use ATVs to access sample locations off the Quartz Creek trail over 4–5 days. Champion, Little Champion, and Quartz Creeks will be fished along the banks and sampling will be constrained to areas that are walkable. The float trip from the Put-in Point to Victoria Creek will take 9–10 days to complete and 4–6 ADF&G and BLM personnel will float this portion of the drainage in 2–3 rafts.

Site visits may be opportunistically attempted in late-winter and spring 2022 and/or 2023 to locate radiotagged Arctic grayling in suspected overwintering and spring spawning areas if the areas can be easily and safely reached. If the Arctic grayling can be fished, attempts will be made to capture

approximately 5 fish per location. For fish captured during spring, attempts will be made to express gametes with light finger pressure. Extrusion of gametes will confirm spawning readiness and fish will be released alive after handling. If gametes cannot be extruded, the Arctic grayling will be sacrificed and spawning readiness will be evaluated through visual inspection of the gonads. Additional data may be gathered at suspected spawning and overwintering locations to characterize habitat, including channel characteristics, spawning substrate type, dissolved oxygen (DO), pH, temperature, conductivity, turbidity, and flow rate. These data will be shared with BLM, who will be gathering and processing more detailed habitat data concurrent with this study at suspected Arctic grayling overwintering, spawning, and feeding areas.

## Radiotracking Equipment and Tracking Procedures

Arctic grayling will be implanted with Lotek NTFD-6-2 series transmitters that are 25 mm long x 9 mm in diameter and weigh 4 g. The radio transmitters will be programmed with a 4 s burst rate and operate for 12 hours on and 12 hours off to extend battery longevity. These radio transmitters are estimated to operate for 835 days and have a 668-day warranty, which will enable a 2-year operational life. Only fish >300 mm will be radiotagged, so the weight of the transmitter does not exceed 2% of the total weight of the fish (Winter 1983). Most Arctic grayling $\geq$ 300 mm will be sexually mature (Gryska 2019). The radio transmitters will have 1 frequency (149.340 MHz) and 150 uniquely identifiable encoded pulse patterns (codes). Transmitter burst intervals will be staggered by 0.1 seconds from 4.0 to 4.5 seconds, which will minimize code collision. Code collision can occur when fish congregate in a small area and the receiver cannot detect and download each individual code.

One stationary tracking station will be located on Nome Creek near the confluence with Beaver Creek to record pre-and post-spawning and/or feeding timing data as radiotagged Arctic grayling migrate between Beaver and Nome Creeks. The stationary tracking station will have an SRX600 receiver with a satellite modem so the project biologist can remotely download data. This station will be powered by two 12 V deep cycle batteries that will be charged with an 85W solar panel. A water-resistant steel box covered with a fitted tarp will house the components. Two 4-element Yagi antennas will be mounted on a mast elevated 2–10 m above the ground depending on the elevation of the site above the river. One antenna will be aimed upstream and the other downstream. The receiver will be programmed to scan through the frequencies at 8 s intervals and receive from both antennas simultaneously. When a signal of sufficient strength is encountered, the receiver will pause for 6 s on each antenna, and then transmitter frequency and code, signal strength, date, time, and antenna number will be recorded on the receiver. The relatively short cycle period will minimize the chance that a radiotagged fish will migrate past the tracking station without being detected. Although the radio transmitters will operate on a 12 hour on/off cycle, a sufficient number of radiotagged Arctic grayling should migrate past the tracking station during the on cycle to characterize seasonal migration timing between Beaver and Nome Creeks.

Nine aerial tracking flights will be conducted beginning in fall 2021 and concluding in summer 2023 to document locations of radiotagged fish. Tracking flights will be conducted with 1 fixed-wing aircraft, 1 person (in addition to the pilot), and utilize 2 Lotek SRX800 or SRX1200 receiver/scanners. The pilot and project biologist will actively listen to 1 receiver for tag detections and an additional receiver will passively scan and record any Arctic grayling that the project biologist may have missed. The frequency will be loaded into the receiver prior to each flight. Flight altitude will range from 100–300 m above the ground. Two H-antennas, 1 on each wing strut, will be mounted such that the antennas will receive signals perpendicular to the direction of

travel. The 9 aerial tracking flights will occur during time periods critical for overwintering, summer feeding, spring spawning, and fall transition (Table 1).

## DATA COLLECTION AND REDUCTION

For each Arctic grayling that will be radiotagged, the date, location, length, radio transmitter frequency and code, and any noteworthy comments (like condition of fish upon release) will be recorded. Arctic grayling that are collected from spawning locations will be documented similarly, including date, location, length, spawning readiness, and gender. Habitat data gathered at the overwintering, spawning, and feeding areas will be recorded including date, time, location, DO, pH, temperature, conductivity, turbidity, and flow rate. All data will be recorded on field forms or in Rite in the Rain books.

Radio transmitters from harvested Arctic grayling will be obtained by voluntary returns from sport and subsistence fishers. The project biologist will post informational flyers describing the radiotelemetry project at the campgrounds and picnic areas along Nome Creek Road with her contact information. The project biologist will contact each fisher who reports a captured Arctic grayling with a radio transmitter and let them know what has been learned from the captured fish. Date, time, location, radio transmitter number, method of capture, gender of fish, and type of fishery will be asked of the fisher and the data recorded. An attempt will be made to redeploy returned transmitters. Data from tag recoveries will be entered into the Excel file as they become available.

The stationary tracking station will record date, time, frequency and code, signal strength, and upstream or downstream antenna each time a signal of sufficient strength is encountered. Data will be stored in the receiver in an ASCII format. Data from the stationary tracking station will be periodically downloaded to a laptop computer and saved as an Excel spreadsheet file (.xls). Data for each unique radio transmitter will be inspected and the temporal pattern of signal strength recordings by antenna will be used to select the most appropriate date/time stamp for when the radiotagged fish swam past the tracking station.

During aerial tracking flights, the Lotek SRX800 or SRX1200 receivers will automatically record and store GPS coordinates of detected radiotagged fish as waypoints.

All tagging and tracking data will be incorporated into a master spreadsheet. The spreadsheet and other files pertinent to this project will be archived in a Region III Division of Sport Fish network drive and on the project leader's computer at ADF&G Division of Sport Fish in Fairbanks, Alaska. All data will be available to the public on request.

## DATA ANALYSIS

### Objective 1:

During the aerial tracking flights, multiple GPS coordinates will be recorded for each frequency/code combination and the coordinate with the largest signal strength will be mapped in ArcGIS. The accuracy of locations of radiotagged Arctic grayling from aerial tracking data will be variable depending on the speed of the aircraft, depth of the transmitter in the water column, and number of other radiotagged fish in the vicinity. However, an accuracy of 0.5 km can be achieved. Locations recorded by aerial tracking methods will be consolidated, examined, and plotted using ArcGIS 10.6.1 and movements to overwintering, spring spawning, and summer feeding areas will be examined and compared between seasons.

Each radiotagged Arctic grayling will be assigned a "fate" (Table 2). Fates will be determined from a combination of information collected from the stationary tracking station, aerial tracking flights, and harvested fish for which radio transmitters are returned. Final fates will be determined at the end of the 2-year study.

Stationary tracking station data will be used to construct cumulative frequency distribution plots to describe the timing of Arctic grayling movements during their upriver and downriver migrations to spawning and overwintering areas. Data from the stationary tracking station will be utilized to construct run-timing curves and describe other behavior such as upriver or downriver migrations to spawning and overwintering areas.

Run-timing profiles will be described as time-density functions, where the relative abundance of Arctic grayling located upstream and downstream of the recording station during time interval *t* will be described by (Mundy 1979):

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

where:

*f(t)* = the empirical temporal probability distribution over the total span of migrations (upstream and downstream) for Arctic grayling in Nome Creek; and,

$R_t$ = the subset of tagged Arctic grayling that migrate past the recording station during day t.

The mean date of passage ($\bar{t}$) past the recording station (upstream and downstream) will be estimated as:

$$\bar{t} = \sum_t t f(t), \quad (2)$$

with variance:

$$\hat{V}(\bar{t}) = \frac{\sum_{t=1}^{T} (t-\bar{t})^2 f(t)}{\sum_{t=1}^{T} R_t}.$$

With n=150 instrumented fish and assuming 90% survival, the time interval described by the range of tracking station passage dates will have an expected value of 1 – 2/(n+1) = 98.5% of the total migration.

## Objective 2:

Locations of radiotagged Arctic grayling will be examined between aerial tracking flights (seasons) over the 2-year project duration utilizing ArcGIS. Aggregations of more than 2 radiotagged fish located within 0.5 km of each other will be specifically identified from the aerial tracking flights known to coincide with overwintering, spring spawning, and summer feeding times.

Assessing if radiotagged Arctic grayling are in a spawning area from aerial tracking flights and stationary tracking station data will be subjective. Visiting potential spawning location(s) to confirm pre-and post-spawning characteristics may not be feasible due to spring river break up conditions and the proximity of spawning locations to established trails, although an attempt will be made to visit at least 1 spawning location to examine Arctic grayling for spawning readiness.

The following criteria adapted from Stuby (2018) will be considered when evaluating whether an Arctic grayling will be in a spawning area:

1) it was located during the likely time of spawning during mid-to-late April to early May;
2) it was located in habitat consistent with spawning areas described by observations from past research;
3) it was located in close proximity to 1 or more other radiotagged Arctic grayling; and,
4) there was a directed migration discernable with timing from the stationary tracking station and/or aerial tracking data prior to being located during the April/May aerial tracking flights.

A sample size of 150 surviving instrumented radiotagged Arctic grayling will provide a 99.9% chance of detecting (observing at least 1 radiotagged fish) a seasonal use area used by 5% of the sampled population, assuming a binomial distribution with a probability parameter equal to the use fraction multiplied by a 90% survival rate, and a 99% chance of detecting an aggregation (observing at least 2 radiotagged fish) representing a seasonal use area used by 5% of the sampled population.

## Objective 3:

Travel distances between aerial tracking flights will be calculated for each individual fish, as well as net travel direction and directional (upstream and/or downstream) distance, using the riverdist package for R (Tyers 2017, R Core Team 2016) and ArcGIS. The mean travel and directional travel distances will be estimated for all radiotagged Arctic grayling observed in each sequential pair of surveys.

## Objective 4:

In addition to learning more about the life history strategies of Arctic grayling in Beaver and Nome Creeks, the radiotelemetry study will aid in identifying an appropriate index area for the 2023 M-R project. This area will need to satisfy the conditions for a consistent Peterson estimator (Seber 1982). The 2023 M-R experiment will take place during the summer feeding period after post- and non-spawning migrations are complete, generally during June–August (Tack 1980), thus satisfying the condition that the population will be closed to immigration and emigration. Due to the inability to maintain geographic closure within the lower 5 miles of Nome Creek during the 2000 M-R experiment, Nome Creek was stratified into upper and lower portions. For the upper portion, findings suggested unequal mixing and unequal recapture rates. Results for both the upper and lower portions of Nome Creek were inconclusive or large errors were associated with the estimates. Fleming and McSweeny (2001) postulated that the 2000 M-R study on Nome Creek might have been conducted too soon after spawning before the Arctic grayling moved to their summer feeding locations. The radiotelemetry project will help pinpoint the most appropriate timing to conduct this study. Also, identifying concentrations of Arctic grayling at their summer feeding areas will assist in designing a M-R experiment that will help satisfy the assumption of equal probability of capture between both events.

# SCHEDULE AND DELIVERABLES

The final Fisheries Data Series report will be completed in 2024, and project updates and results will be shared with the Eastern Interior Regional Advisory Council (EIRAC) during their bi-yearly meetings.

| Activity | Start Date | Completion Date |
|---|---|---|
| Deploy 150 radio transmitters into Arctic grayling in the Beaver and Nome Creek drainages and assist BLM in recording habitat data | 7/1/2021 | 8/31/2021 |
| Set up 1 stationary tracking station near the confluence of Beaver and Nome Creeks | 7/1/2021 | 8/31/2021 |
| Conduct 9 aerial tracking flights to document seasonal movements | 10/1/2021 | 6/30/2023 |
| Visit overwintering areas and record habitat needs | 2/15/2022 | 3/25/2022 |
| Visit spring spawning areas to verify spawning readiness and record habitat needs | 4/15/2022 | 5/31/2022 |
| Conduct two-event M-R | 7/1/2023 | 8/31/2023 |
| Conduct data analysis | 9/1/2023 | 11/31/2023 |
| Draft FDS report submitted to supervisors | | 4/30/2024 |
| Final FDS report submitted | | 8/31/2024 |

# RESPONSIBILITIES

## PROJECT STAFF AND PRIMARY ASSIGNMENTS

Lisa Stuby, *Fisheries Biologist III*. YMA Management Biologist and Project Leader. Responsible for supervision of all aspects of the Beaver and Nome Creeks Arctic grayling radiotelemetry project, managing the project budget, and writing the annual and final reports.

April Behr, *Fisheries Biologist III*. Resident Species Supervisor. Assist with capture and tagging of Arctic grayling and review all reports.

James Savereide, *Fisheries Biologist IV*. Regional Research Supervisor. Final report editing and project support.

Matt Tyers, *Biometrician IV*. Sport Fish Division Biometric Supervisor. Assist in statistical design of field investigation for the operational plan and review data analysis and final report.

Brian Collyard, *Fish & Wildlife Technician IV*. Crew leader. Project mobilization, oversees day-to-day project tasks, all aspects of field work, and demobilization.

Matt Stoller, *Fish & Wildlife Technician III*. Assistant crew leader. Assists project biologist and crew leader with project mobilization and day-to-day project tasks.

Rick Queen, *Fish & Wildlife Technician V*. Crew Member. Assist with capture and tagging.

Dave Stoller, *Habitat Biologist I*. Assist with capture and tagging.

Chris Clark, *BLM Fisheries Biologist*. Crew Member. Assist with capture and tagging.

TBD, *BLM Fisheries Biologist*. Crew Member. Assist with capture and tagging.

# REFERENCES CITED


Armstrong, R. H. 1986. A review of the Arctic grayling studies in Alaska, 1952-1982. Biological Papers of the University of Alaska. 23: 3-17.

Armstrong, R. H. 1982. A review of Arctic grayling studies in Alaska, 1952-1982. Biological Papers of the University of Alaska No. 23.

Bendock, T. N. 1979. Inventory and cataloging of Arctic area waters Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1978-1979, Project F-9-11, 20 (G-I-I), Juneau.

Brown, R. J. 2000. Migratory patterns of Yukon River inconnu as determined with otolith microchemistry and radio telemetry. Master's Thesis, University of Alaska Fairbanks.

Brown, R. J., C. Lunderstadt, and B. Schultz. 2002. Movement patterns of radio-tagged adult Humpback Whitefish in the Upper Tanana River drainage. U. S. Fish and Wildlife Service, Alaska Fisheries Data Series 2002-1, Fairbanks.

Carufel, L. 1990. Fisheries investigations I the Beaver Creek drainage, White Mountains National Recreation Area, Alaska, 1989. BLM-Alaska Open File Report 31.

Cunjak, R. A. 1996. Winter habitat of selected stream fishes and potential impacts from land-use activity. Canadian Journal of Fisheries and Aquatic Sciences 53: 267-282.

Fleming, D. F. and I. McSweeney. 2001. Stock assessment of Arctic grayling in Beaver and Nome Creeks. Alaska Department of Fish and Game, Fishery Data Series No. 01.28, Anchorage.

Gryska, A. D. 2006. Vulnerability of Arctic grayling to the Brushkana Creek sport fishery. Alaska Department of Fish and Game, Fishery Data Series No. 06-73, Anchorage.

Gryska, A. D. 2011. Salcha River Arctic grayling stock assessment, 2003-2004. Alaska Department of Fish and Game, Fishery Data Series No. 11-42, Anchorage.

Gryska, A. D. 2019. Seasonal distributions and migrations of Arctic grayling in the Goodpaster River. Alaska Department of Fish and Game, Fishery Data Series No. 19-11, Anchorage.

Hughes, N. F. 1992. Ranking of feeding positions by drift-feeding Arctic grayling (Thymallus arcticus) in dominance hierarchies. Canadian Journal of Fisheries and Aquatic Sciences. 49: 1994-8.

LaPerriere, J. D., and R.F. Carlson. 1973. Thermal tolerances of interior Alaskan Arctic grayling (*Thymallus arcticus*). University of Alaska, Institute of Water Resources.

Lohr, S. C., P. A. Byorth, C. M. Kaya, W. P. Dwyer. 1996. High-temperature tolerances of fluvial Arctic grayling and comparisons with summer river temperatures of the Big Hole River, Montana. Transactions of the American Fisheries Society 125(6):933-939.

Lubinski, B. R. 1995. Winter habitat of Arctic grayling in an interior Alaska stream. M. Sc. Thesis, University of Alaska.

Mundy, P. R. 1979. A quantitative measure of migratory timing illustrated by application to management of commercial salmon fisheries. Ph.D. Dissertation. University of Washington

R Core Team. 2016. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ridder, W. P. 1998. Radiotelemetry of Arctic grayling in the Delta Clearwater River 1995 to 1997. Alaska Department of Fish and Game, Fishery Data Series No. 98-37, Anchorage.

Seber, G. A. F. 1982. On the estimation of animal abundance and related parameters. Second edition. Griffin and Company, Ltd. London.

Stuby, L. *In prep*. Fishery management report for sport fisheries in the Yukon Management area, 2019. Alaska Department of Fish and Game, Fishery Management Report, Anchorage.

Stuby, L. 2018. Contributions to the life history of Kuskokwim River inconnu. Transactions of the American Fisheries Society 147:879-890.

# REFERENCES CITED (Cont.)

Tack, S. L. 1971. Distribution, abundance, and natural history of Arctic grayling in the Tanana River drainage. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1970-1971, Project F-9-3, 12 (R-I).

Tack, S. L. 1980. Migrations and distributions of Arctic grayling *Thymallus arcticus* (pallas), in Interior and Arctic Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1979-1980, Project F-9-12, 21 (R-I), Juneau.

Swanton, C. O., and K. G. Wuttig. 2014. A management plan and policies for Arctic grayling fisheries within the Arctic-Yukon-Kuskokwim Region. Alaska Department of Fish and Game, Fishery Management Report No. 14-06, Anchorage.

Tyers, M. B. 2017. riverdist: River Network Distance Computation and Applications. R package version 0.14.0. https://cran.r-project.org/package=riverdist

Winter. J. D. 1983. Underwater biotelemetry. Pages 371–395 in L. A. Nielsen and D. L. Johnson, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Wuttig, K. 1997. Successional changes in the hydrology, water quality, primary production and growth of juvenile Arctic grayling of blocked Tanana River Sloughs, Alaska. M. S. Thesis. University of Alaska Fairbanks.

# TABLES AND FIGURES

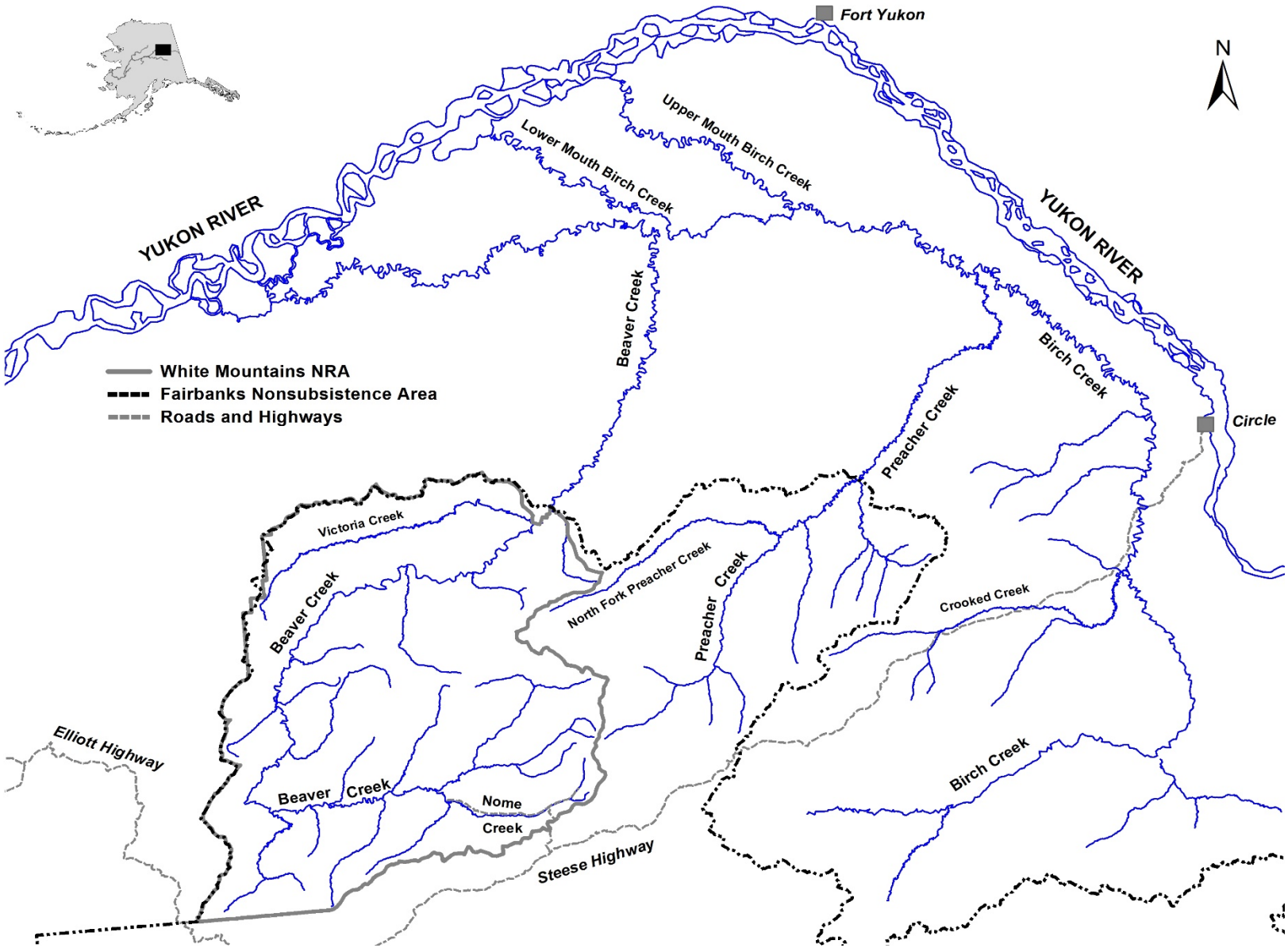


Figure 1.–Outline of the Fairbanks nonsubsistence area within the YMA and containing the WMNRA.

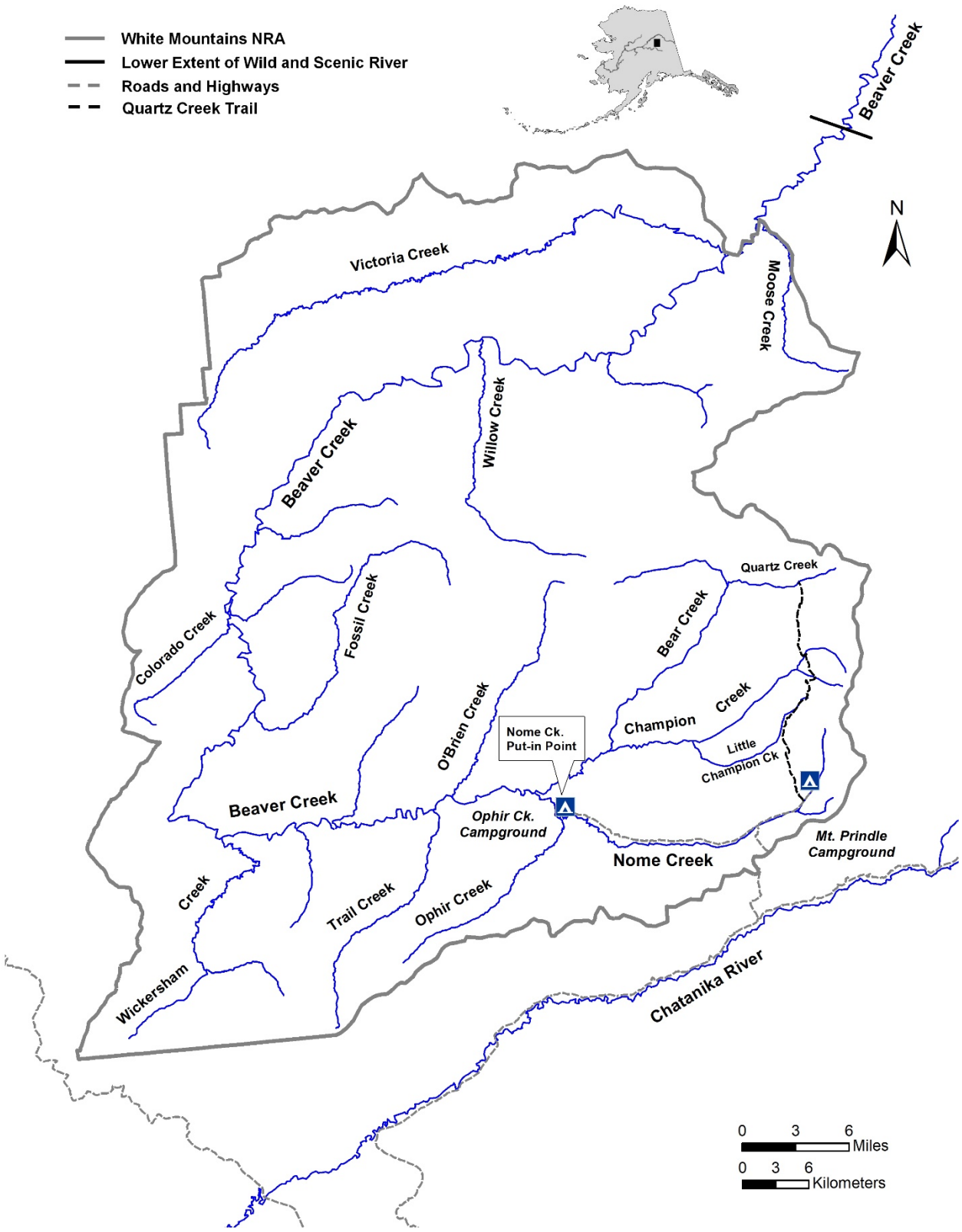


Figure 2.–Map of the Beaver Creek drainage within the WMNRA and referenced sampling locations.

Table 1.–Aerial tracking flights to be conducted in 2021-2023.

| Season | 2021 | 2022 | 2023 |
|---|---|---|---|
| Fall | X | X | |
| Winter | | X | X |
| Spring | | XX | X |
| Summer | | X | X |

Table 2–List of possible fates for radiotagged Arctic grayling in Beaver and Nome Creeks.

| Fate | Fate Description |
|---|---|
| Tagging Mortality | Arctic grayling did not move within one or more years after being captured and radiotagged. |
| Harvest Mortality | Project biologist was contacted by a fisher and informed that the radiotagged Arctic grayling was harvested. |
| Survived Tagging and Handling | Post-tagging movement detected in radiotagged Arctic grayling. |
| Spawner | An Arctic grayling that displayed an obvious migration pattern towards a spawning area during early spring in conjunction with other radiotagged fish. A sub-fate will be assigned to each of these fish indicating the specific areas where the fish spawned. |
| Non-Spawner | An Arctic grayling that did not display an obvious migration pattern towards a known or suspected spawning habitat in conjunction with other radiotagged Arctic grayling. |