Special Publication No. 22-09

Characterization of Seasonal Habits, Migratory Timing, and Spawning Aggregations of Mainstem Yukon River Burbot and their Subsistence Use in the Communities of Pilot Station, Galena, and Fort Yukon, Alaska

Final Report for Study 16-251
USFWS Office of Subsistence Management
Fisheries Division

by

Lisa Stuby

Alida Trainor

Jeff Park

Helen Cold

and

David Koster

June 2022

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

SPECIAL PUBLICATION NO. 22-09

CHARACTERIZATION OF SEASONAL HABITS, MIGRATORY TIMING, AND SPAWNING AGGREGATIONS OF MAINSTEM YUKON RIVER BURBOT AND THEIR SUBSISTENCE USE IN THE COMMUNITIES OF PILOT STATION, GALENA, AND FORT YUKON, ALASKA

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

and

Alida Trainor
Jeff Park
Helen Cold
David Koster
Alaska Department of Fish and Game, Division of Subsistence, Fairbanks

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

June 2022

ADF&G Fishery Data Series was established in 1987 for the publication of Division of Sport Fish technically oriented results for a single project or group of closely related projects, and in 2004 became a joint divisional series with the Division of Commercial Fisheries. Fishery Data Series reports are intended for fishery and other technical professionals and are available through the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone editorial and peer review.

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

Alida Trainor, Jeff Park, Helen Cold, and David Koster
Alaska Department of Fish and Game, Division of Subsistence,
1300 College Road, Fairbanks, AK 99701-1599, USA

This document should be cited as follows:
Stuby, L., A. Trainor, J. Park, H. Cold, and D. Koster. 2022. Characterization of seasonal habits, migratory timing, and spawning aggregations of mainstem Yukon River burbot and their subsistence use in the communities of Pilot Station, Galena, and Fort Yukon, Alaska. Alaska Department of Fish and Game, Special Publication No. 22-09, Anchorage.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF APPENDICES

ABSTRACT

This 2-year interdisciplinary study was designed to examine life history characteristics and subsistence use and harvest patterns of burbot (*Lota lota*) in the Alaska portion of the Yukon River drainage. The primary objectives of this study were to describe seasonal distributions and migration timing, identify probable spawning areas, and estimate mean travel distances using radiotelemetry techniques. The key objectives for subsistence research were to document the traditional ecological knowledge related to the traditional and contemporary use patterns of burbot including methods and timing of harvest, gear types used, spatial mapping of harvest areas, and approximation of the relative size of subsistence harvests of burbot for the calendar year 2017 by Pilot Station, Galena, and Fort Yukon residents. Household harvest surveys were administered in study communities to active burbot fishers, and traditional ecological knowledge interviews were conducted with numerous residents in each community. Harvest mapping and participant observation were also used by research staff to contextualize quantitative survey data.

Overall, Yukon River burbot showed a high phenotypic plasticity with respect to migratory behavior. Most radiotagged burbot did not travel far from their tagging locations, although approximately 18% travelled over 805 km (500 miles). A statistically significant linear relationship was noted between length and travel distance. River burbot spawn during late January/early February throughout most of the mainstem Yukon River. Radiotagged burbot moved to their spawning locations primarily during late October to mid-January. Post-spawning movement primarily occurred during April–May. Summer movement was noted but to a much smaller degree. Of 24 mature burbot that were sampled during early February 2020 at a spawning location near the Dalton Highway, half exhibited post-spawning characteristics and the other half had not spawned. Results from each study community suggested slightly different harvest methods and distribution practices. Participation in burbot fishing varies with high levels of participation in Pilot Station and a more occasional approach to the practice in Fort Yukon. Harvest timing, however, did not vary because most respondents harvested burbot in the months of October, November, and December. Respondents in all 3 communities shared their concern for a changing climate that is leading to poor ice conditions and less predictable movements of burbot.

Keywords: Burbot, *Lota lota,* Yukon River, radiotelemetry, spawning habitat, spawning migration timing, subsistence, burbot harvest, Traditional Ecological Knowledge, Pilot Station, Fort Yukon, Galena, nonsalmon

INTRODUCTION

Burbot *Lota lota* are the only freshwater member of the Gadidae family and are distributed throughout the Holarctic region. In North America, burbot range eastward from the Seward Peninsula in Alaska (McPhail and Lindsey 1970) to New Brunswick on the Atlantic coast (Scott and Crossman 1973). Throughout their geographic distribution, burbot exist in both riverine and lacustrine forms and inhabit the large, cold-water rivers and lakes within north temperate regions (McPhail and Paragamian 2000; Hofmann and Fischer 2002). Two subspecies of burbot are found in North America: *Lota lota lota* is restricted to Alaska and the Yukon Territory, whereas *Lota lota maculosa* is fairly widespread across the remainder of the Nearctic and consists of three subclades (Elmer et al. 2008). Burbot are elongate, laterally compressed with a somewhat flattened head, and have a single barbel at the tip of the chin. Because of their long, cylindrical shape, burbot have low swimming endurance and even large fish cannot maintain themselves for more than 10 min in current velocities greater than 25 cm/s (Jones et al. 1974, McPhail and Paragamian 2000). Burbot are found throughout the Yukon River drainage. The Yukon River is one of the largest rivers in North America. It has headwaters in British Columbia, Canada, and empties an area of 832,700 km^2 into the Bering Sea. The Alaska portion of the Yukon River drainage encompasses an area of 508,900 km^2. Burbot in the Yukon River drainage typically spawn during late January and early February, although individual burbot may not spawn every year (Evenson 2000).

Burbot are ubiquitous throughout the Yukon River drainage and their life-history strategies exhibit a high phenotypic plasticity with respect to migratory behavior, which allows for them to be a potential year-round food source for Yukon River residents. Burbot are commonly referred to as

loche (lush) in Alaska and are primarily targeted in the mainstem Yukon River during fall and winter and are valued as a reliable source of fresh fish during the winter months. Historically in the Lower Yukon River, large, often square baited funnel traps were set on the river bottom to catch large numbers of burbot. Currently, Pilot Station uses such a large trap, and the catch is distributed throughout the community. Most Yukon River residents use set lines or setnets that are usually baited with blackfish *Dallia pectoralis* and are often set overnight (Brown et al. 2005). Burbot are a favorite food for many residents during fall and winter months prior to spawning (Brown et al. 2015), after which time, post-spawning liver size decreases (Evenson 2000). During 2010, Marshall, Nulato, Galena, and Ruby harvested a total of 5,868 lb. of burbot (Brown et al. 2015, Figure 1). For many of these villages, subsistence fishers harvested less nonsalmon fish in 2010 than in the past, except for burbot, where harvest amounts were unchanged since 1980 when the Alaska Department of Fish and Game (ADF&G) began estimating the harvest of nonsalmon fishes through the postseason salmon survey effort. The importance of burbot as a subsistence resource has been noted further upriver where in communities such as Rampart, 19% of the total nonsalmon harvest for 2014 was composed of burbot (Brown et al. 2016).

Burbot are also an important sport fish resource, with most harvests concentrated in the middle part of the drainage from Galena to Fort Yukon, and in the Tanana River near Fairbanks (Stuby 2018, Baker 2018). Most sport fishers capture burbot through the ice during the fall and winter months using baited set lines. Harvest values for the Tanana River have averaged 1,360 fish during 2009–2018 (Scannell and Baker 2021). Harvest values were relatively low for the remainder of the Yukon River, averaging 166 fish during this time period[1] (Stuby 2021a).

Overall, little research has been conducted on burbot within the Yukon River drainage, with most research focusing on the Tanana River population. Annual stock assessments occurred on Tanana River burbot during 1987–1998 using catch per unit effort (CPUE) indices and catch-age analyses (Stuby and Evenson 1999). Life history investigations were conducted on Tanana River burbot to examine fecundity, sexual maturity, age at length, and age validation (Clark et al. 1991, Evenson 2000, and Stuby 2008). Chen (1969) conducted morphometric measurements on burbot collected from Circle to Eagle in the Yukon River, and from Fairbanks to Tetlin Junction in the Tanana River. In the Yukon River, Evenson (1989) examined CPUE and length composition of burbot through limited sampling in the late 1980s using hoop traps deployed between the Dalton Highway and the mouth of the Tanana River.

Prior to this study, a few burbot radiotelemetry studies were conducted in limited areas of the Yukon River. Evenson (2000) radiotagged and tracked 55 burbot in the Tanana River between September 1992 and July 1993, and found that the radiotagged fish tended to remain in the fishery near Fairbanks year-round with only a few fish traveling distances greater than 100 km. During 2014, 56 burbot were radiotagged in the Upper Koyukuk River (Wuttig et al. 2015). These fish ranged throughout the drainage with concentrations noted during spawning (late January to early February). A radiotelemetry study conducted on the Kuskokwim River during 2011–2014 also showed concentrations at specific locations during spawning, and that this species was capable of long-distance seasonal migrations. Burbot that were radiotagged during fall between Aniak (rkm 307) and Sleetmute (rkm 488) were noted to travel over 550 km to a purported spawning location in the Upper Kuskokwim River, and post-spawning fish later travelled approximately 800 km to

[1] Stuby, L. 2021. Interim fishery management report for sport fisheries in the Yukon Management Area, 2019 and 2020. Unpublished report. Alaska Department of Fish and Game.

brackish waters in the Lower Kuskokwim River (Albert and Wuttig *In prep*). Long migrations suggest that these fish might be subject to exploitation in multiple fisheries that could have an effect on overall abundance and therefore are of great interest to managers.

This study addresses the 2015 Office of Subsistence Management Yukon Region Priority Information Need for burbot population assessments that support subsistence. Radiotelemetry techniques were used to examine and document seasonal distributions and location preferences, including probable spawning locations and migration timing into and out of these areas. Because of the size of the Yukon River, it was challenging to develop a meaningful yet cost-effective study with a sufficient quantity of radio transmitters to capture fish movements throughout the lower, middle, and upper portions of the Yukon River. Aerial tracking flights were conducted throughout the mainstem Yukon River and portions of major tributaries as fuel, daylight, and budget allowed. Radiotagged burbot were also tracked in the Tanana River through a concurrent sister project. Project leaders for both studies incorporated each other's frequencies into aerial tracking flights and stationary tracking stations, and movements of Yukon River burbot found in the Tanana River dataset are included in this report. These data will be essential in designing future stock assessment projects.

This study also documented traditional ecological knowledge (TEK) of mainstem Yukon River burbot held by residents of Pilot Station, Galena, and Fort Yukon, which corroborated what was learned about seasonal migration and timing from radiotagged burbot. Use of TEK has been increasingly recognized as significant to the priorities of natural resource management as a way of integrating important and long-term local observation and experience. The documentation of TEK in projects can be used by resource managers and biologists to provide a regional perspective on the nature and scope of nonsalmon fisheries (Godduhn et al. 2020). For example, the ethnographic investigation of customary and traditional practices associated with whitefish harvests contributes to a larger regional understanding of the seasonal movements and other biological aspects of whitefish life histories (Brown et al. 2010). Results will be shared to increase knowledge and support federal management of subsistence fisheries associated with the Yukon Delta, Koyukuk, Nowitna, Innoko, and Yukon Flats national wildlife refuges by integrating basic harvest assessments of burbot with holistic and analytical documentation of TEK.

INTERDISCIPLINARY PROJECT BACKGROUND

Lead researchers from the ADF&G Division of Subsistence and the Division of Sport Fish worked together to design a project that could explore the parameters of geographic ranges and spawning areas for burbot in the Yukon River while also gauging the human dimensions around burbot harvest. With the decline of salmon runs, a keystone species for Yukon River residents and subsistence users, understanding the harvest patterns and life history strategies of other fish species is critical for effective management of nonsalmon species. Radiotracking radiotagged burbot provided valuable information on run timing, probable spawning areas, and sizes of home ranges. These data allow mangers to examine the existence of discrete stocks or spawning aggregations, information critical to long-term, sustainable management. Pairing this information with household harvest surveys, harvest mapping, and an analysis of the TEK of burbot contributes to a holistic understanding of how these fish are understood locally and are being utilized in a time of change. TEK is increasingly being recognized as significant to the priorities of natural resource management as a way of integrating important and long-term local observation and experience. An interdicisplinary approach to this research has allowed for a more robust discussion of Yukon

River burbot that will contribute to the development of future research priorities that will support federal management of subsistence fisheries.

Concepts that emerged in results from both disciplines were examined. Exploring similar and divergent themes is a critcal component of interdicplinary research because it creates the opportunity to more fully evaluate each set of results while also identifying new research questions that will ultimately benefit the management of the resource and the subsistence users who rely on it. As Sillitoe (1998) explains, considering TEK and western scientific models side by side should not compel us to translate one into another's cultural conceptions or test TEK against the "canons of science." Instead, building interdisciplinary research teams that value different forms of knowledge without holding one above the other will ultimately result in a greater understanding of these complex socio-ecological systems.

REGULATORY CONTEXT

Burbot can be harvested year-round in the Yukon Management Area (5 AAC 01.210). The harvest of burbot, like other nonsalmon species in the Yukon River area, is not limited by season or bag limits. Fishers throughout the drainage can target burbot in open water conditions or catch them under the ice. Nonsalmon fish, including burbot, can be caught in the subsistence fishery using a set gillnet, drift gillnet, beach seine, fish wheel, longline, fyke net, dipnet, jigging gear, spear, hook and line attached to a rod or pole, handline, or lead (5 AAC 01.220 (f)). Some limitations to legal gear type do exist for other nonsalmon fish.

Limited harvest data exist for burbot. The ADF&G Division of Commercial Fisheries administers the postseason salmon survey in every Yukon River community each fall. Although this annual survey is focused on salmon, some questions ask participants to estimate their harvest of nonsalmon species; however, gear type, location, and timing information are not gathered for these species. Annual sport harvest estimates of burbot are included in the ADF&G Fishery Management Report series for the Yukon Management Area (excludes the Tanana River).

In 2019, the Alaska Board of Fisheries determined that freshwater fish species, including burbot, are associated with customary and traditional uses in the Yukon Management Area (6 AAC 01.236 (a)(2)). Although not codified in regulation, in 1997, the Board found that 133,000–2,850,000 lb of freshwater fishes was the amount reasonably necessary for subsistence (ANS) uses in the Yukon Area. This number is not specific to burbot but includes the estimated ANS harvest levels for sheefish (*Stenodus leucicthyes*), whitefish (*Coregonus, sp*), Arctic lamprey (*Lampetra camtschatica*), longnosed suckers (*Catostomus catostomus*), Arctic grayling (*Thymallus arcticus*), northern pike (*Esox lucius*), Dolly Varden (*Salvelinus malma*), and burbot. Without a more robust annual documentation of nonsalmon harvest levels on the Yukon River, ADF&G is not able to create an informed ANS that reflects the full extent of each species harvest rates.

OBJECTIVES

The objectives of this project for 2016–2018 were to:

- describe the seasonal distributions and their overlap for burbot that were radiotagged during fall of 2017 near Galena, Circle, and the Dalton Highway bridge, and during spring 2018 near Pilot Station and Circle;
- identify probable spawning areas of burbot in the mainstem of the Yukon River during late January/early February;

- examine seasonal timing past stationary tracking stations located at Russian Mission, Galena, Tanana, and the Dalton Highway when operable;
- estimate mean travel distances between aerial tracking surveys and the range of distances travelled between seasonal habitats;
- estimate the proportion of burbot located within each river section for each aerial tracking survey;
- estimate length categories for all burbot captured and measured;
- document traditional ecological knowledge related to traditional and contemporary patterns of subsistence harvest including methods and timing of harvest, gear types used, spatial mapping of harvest areas and other important habitats, and document fish-related place names and taxonomic lexicon; and
- using quantitative methods, approximate the relative size of subsistence harvests of burbot for the calendar year 2017 by season by Pilot Station, Galena, and Fort Yukon residents.

METHODS

RADIOTELEMETRY STUDY DESIGN

This 2-year study was designed to examine life history characteristics of burbot in the Alaska portion of the Yukon River drainage. Prior to this study, not much was known about the migratory nature of burbot in the Yukon River. However, the past radiotelemetry study on burbot in the Kuskokwim River suggested the potential for long distance migrations (Albert and Wuttig *In prep*), and potentially even larger migrations within the Yukon River given the larger size of this drainage. Therefore, during 2017 and 2018, an attempt was made to deploy 300 radio transmitters in the lower, middle, and upper portions of the Yukon River near Russian Mission, Pilot Station, Galena, Dalton Highway, and Circle. A certain number of transmitters would be deployed in each study section; however, catch rates dictated final tag deployment. Within each study section, radio transmitters were apportioned equally across 3 length strata of captured burbot: 550–649 mm, 650–749 mm, and >750 mm total length (TL). Because sampling could not be treated as representative of all Yukon River burbot, any inference beyond the tagged populations was purely suggestive. Internally implanted transmitters were used because results showed that this style of transmitter was less likely to adversely influence normal behavior than externally attached transmitters (Brown et al. 2002). Aerial tracking flights to locate radiotagged burbot took place during winter, spring, summer, and fall, and concentrated primarily on the mainstem Yukon River from the Canadian border to below Emmonak (Figure 1), with 80 km of the Lower Tanana, Nowitna, Koyukuk, and Innoko Rivers covered during each flight. Additional areas were covered as time, daylight, and fuel allowed. All flights were conducted using a fixed-wing aircraft. In addition, 5 stationary tracking stations located throughout the Yukon River drainage (Figure 1) recorded timing of upstream and downstream migrations related to spawning, feeding, and oversummering areas.

Capture and Tagging

A crew of 3 people captured burbot using hoop traps to deploy radio transmitters in each sampling area. Between 10–20 baited hoop traps were used for all sampling ventures except for Pilot Station, where the plan was to tag burbot collected from the community fish trap. Commercially made hoop traps were 3 m long with 7 hoops made of 6-mm diameter steel. Inside diameters of hoops

tapered from 61 cm at the entrance to 46 cm at the cod end. Hoop diameters tapered from 0.6 m at the entrance to 0.5 m at the cod end. Each trap had a double throat (tied to the second and fourth hoops) that narrowed to an opening 10 cm in diameter. Netting was knotted nylon woven into 25-mm bar mesh, bound with no. 15 cotton twine, and treated with an asphaltic compound. Traps were kept stretched with 2 sections of 19-mm polyvinyl chloride (PVC) pipe attached by snap clips to the end hoops. Because burbot are usually more active at night, the burbot traps were baited with whitefish or herring and soaked overnight. Hoop traps were moved periodically to increase catch efficiency.

All captured fish were placed into a sampling tub and sorted. Fish not selected for tagging were measured for length and returned to the water. For those fish that satisfied the length criteria and were deemed to be in healthy condition, a radio transmitter was surgically implanted following the basic surgical methods detailed by Brown et al. (2002). In addition to lengths, otoliths were collected for all mortalities and ages were later determined. Otoliths were thin-sectioned and aged using a compound microscope equipped with polarizing filters following instructions outlined in Stuby (2008).

Radiotracking Equipment and Procedures

Burbot were surgically implanted with 3V micro-coded radio transmitters that were 1.6 cm in diameter and 4.6 cm long. Transmitters had a 43.5 cm long wire antenna (Lotek model MCFT2-3A) and were programmed with 2.5 or 3 s burst rates. Each radio transmitter was uniquely distinguishable by 1 of 4 frequencies (149.630, 149.780, 149.820, and 149.900 MHz) and individually encoded pulse patterns. The transmitters also contained motion sensors that indicated if the radiotagged burbot exhibited little or no movement for at least 24 hours. Each transmitter had an estimated life of 750 days and operated continuously. Each frequency corresponded to 1 of the 4 sampling areas (Russian Mission and Pilot Station, Galena, Dalton Highway, and Circle). Transmitters weighed 16 g in air and were well below the criteria of 2% of the live weight of the fish recommended by Winter (1983). Lotek SRX 600 and SRX 800 receivers were used to record time and date of detections for the radiotagged fish.

Radiotagged burbot were tracked using an array of 4 tracking stations that were stationary throughout the project duration and were located near Russian Mission, Galena, Tanana, and the Dalton Highway. A fifth tracking station was located near Manley Hot Springs and was part of a concurrent project examining radiotagged burbot on the Tanana River. The frequencies of the Tanana River burbot radiotelemetry project were incorporated into the mainstem Yukon River tracking stations. The main purpose of the tracking stations was to record the upstream and downstream timing of radiotagged burbot movements.

For the tracking stations located near Tanana and the Dalton Highway, the SRX 600 receivers were powered by four 12V deep cycle batteries that were charged with two 85W or higher solar panels. The remaining stations near Russian Mission, Galena, and Manley Hot Springs were powered by six 6V batteries. It was hoped that the stations would remain operational during the coldest, darkest time of the year when burbot would travel to spawning areas. Water-resistant steel boxes covered with fitted tarps housed the components. Two 4-element Yagi antennas were mounted on a mast elevated 2–10 m above the ground depending on the elevation of the site above the river. One antenna was aimed upstream and the other downstream. The receivers were programmed to scan through the frequencies at 8 s intervals and receive from both antennas simultaneously. When a signal of sufficient strength was encountered, the receiver paused for 6 s on each antenna, and then

transmitter frequency, transmitter code, signal strength, date, time, and antenna number were recorded on the receiver. The relatively short cycle period minimized the chance that a radiotagged fish would migrate past the tracking stations without being detected. The tracking stations had satellite modems connected to the receivers that allowed the project biologist to remotely contact the receivers using a laptop computer with a standard telephone line.

Aerial tracking flights were conducted with 1 fixed-wing aircraft and 1 person in addition to the pilot. One Lotek SRX 600 or SRX 800 receiver was actively listened to by the project biologist and 1 SRX 600 or SRX 800 receiver passively scanned. Both receivers had an internal GPS that recorded time and location data for every radiotagged burbot detected. All frequencies were loaded into the receiver prior to each flight. Dwell time on each frequency was 4 s. Flight altitude ranged from 100 to 300 m above ground. Two H-antennas, 1 on each wing strut, were mounted such that the antennas received signals perpendicular to the direction of travel. Parts of the Yukon River are very wide (up to 5 km), especially between Stevens Village and Circle and in the lower river where numerous side-channels exist. Radiotracking these areas required constant crisscrossing with the aircraft. Whenever a signal was heard from a distance, the pilot would fly in the direction of the signal.

Conducting aerial tracking flights of the entire Alaska portion of the Yukon River was difficult due to its size and the length of daylight during winter. Nine aerial tracking flights were conducted during October and/or November (2017, 2018, 2019), late January/early February (2018, 2019), April (2018, 2019), and June and/or July (2018, 2019). The late January/early February flights were conducted during the time of spawning to document potential spawning areas. The timing of the remaining flights coincided before and after periods of major movements, which were anticipated to occur primarily during river freeze-up and breakup and were often associated with pre- and post-spawning behavior. According to Evenson (1993), the largest movements of burbot in the Tanana River occurred during freeze-up and ice-out. Additionally, he noted that localized movements occurred in association with active spawning during early to mid-February, or during midsummer.

Assessing whether a burbot was in a spawning area from aerial tracking flights and stationary tracking stations was subjective. In addition, visiting every potential spawning location to certify pre- and post-spawning characteristics for captured fish was not feasible given the size of the drainage. Therefore, the following criteria adapted from Stuby (2018) were considered when evaluating whether a burbot was in a spawning area:

- it was located during the likely time of spawning during late January/early February;
- it was located in habitat consistent with spawning areas described by observations from past research;
- it was located in close proximity to 1 or more other radiotagged burbot, especially those that were radiotagged from multiple areas; and
- there was a directed migration discernable with timing from the stationary tracking stations and/or aerial tracking data prior to being located during the January/early February aerial tracking flights.

Site Visit to Burbot Spawning Area

A site visit was made to a suspected burbot spawning location near the Dalton Highway based on the criteria adapted from Stuby (2018). Snow was cleared and holes were drilled in the ice to deploy set lines that had up to 3 hooks per line, were baited with herring, and were soaked

overnight. Each burbot was euthanized, sagittal otoliths were collected, sex was determined, total lengths were measured, and the gonads and livers were later weighed and visually inspected for signs of spawning and/or post-spawning characteristics to determine pre- and post-spawning condition. Spawning determination was based on Evenson (2000). Nonspawning burbot would have small gonads with sex not easily discernible with the naked eye; ovaries would be rounded and testes would be angular. For spawning burbot, roe and milt would run with slight pressure. For post-spawned fish, the genital aperture would be inflamed, ovaries would have the appearance of deflated sacs with a few residual eggs, and bluish blotches would be associated with partially spawned testes. Measurements of pH, dissolved oxygen (DO), conductivity, and temperature were also taken from the set line holes with a HACH multiprobe, and depth was recorded with a HawkEye DEPTHTRAX 1H.

SOCIAL SCIENCE RESEARCH METHODS

Ethical Principles for the Conduct of Research

The project was guided by the research principles outlined in the Alaska Federation of Natives *Guidelines for Research*[2] and by the National Science Foundation, Office of Polar Programs in its *Principles for the Conduct of Research in the Arctic*[3], the *Ethical Principles for the Conduct of Research in the North* (Association of Canadian Universities for Northern Studies 2003), and the Alaska confidentiality statute (AS 16.05.815). These principles stress community approval of research designs, informed consent, anonymity or confidentiality of study participants, community review of draft study findings, and the provision of study findings to each study community upon completion of the research.

Project Planning and Approvals

Lead researchers met with the three proposed study communities in the winter of 2017–2018 and gained project approval from each of the representative tribal councils (Table 1). Project staff and local research assistants hired for the subsistence portion of this project are listed in Table 2.

Systematic Household Surveys

The primary method for collecting subsistence harvest and use information in this project was a household survey. Following receipt of comments at the scoping meetings, ADF&G finalized the survey instrument in January 2018. The survey instrument was structured to collect demographic, resource harvest and use, and needs assessments comparable with information collected in other household surveys in the study communities and with data in the Community Subsistence Information System (CSIS[4]). Appendix A is an example of the survey instrument used in this project.

Sampling

Households to be included in this study were selected based on a snowball, or chain-referral, sampling approach. The goal of this strategy was to use local knowledge to identify and contact

---

[2] Alaska Federation of Natives, Alaska Native Knowledge Network. 2013. "Alaska Federation of Natives Guidelines for Research." Accessed December 2020. http://www.ankn.uaf.edu/IKS/afnguide.html

[3] National Science Foundation Interagency Social Science Task Force. 2012. "Principles for the Conduct of Research in the Arctic." Accessed December 2020. http://www.nsf.gov/od/opp/arctic/conduct.jsp

[4] Alaska Department of Fish and Game (ADF&G) Division of Subsistence, Juneau. "Community Subsistence Information System: CSIS." Accessed December 2020. https://www.adfg.alaska.gov/sb/CSIS. Hereinafter *ADF&G CSIS.*

100% of burbot fishers while reducing the burden on communities by avoiding contact with households that do not fish for burbot. Although a snowball sample is effective in maximizing contacts engaged in targeted activities, it also includes a risk of missing households who are unknown to previous respondents. Researchers mitigated the risk of missing households by relying on knowledgeable local research assistants to help curate the list.

Researchers developed an initial household list based on local research assistant knowledge of households that typically fish for burbot. Each respondent on the initial list was asked if they knew of other people who typically fish for burbot. Households were added to the list if they were identified in this way and were not already on the list. Households initially on the list that reported they were not usually burbot fishers or did not live in the community during the study period were removed from the list.

In Fort Yukon, researchers initially identified 20 households as likely burbot fishers (Table 3). Two of those households had moved prior to the study period and were removed from the list; 4 could not be reached; and none declined to be interviewed. While Division of Subsistence staff members were conducting this project in Fort Yukon, they were also administering a comprehensive subsistence survey that attempted a census of households. Through the administration of the comprehensive survey, researchers were able to identify additional burbot fishing households and administered the burbot survey to those households. The final list included 18 households, 14 of which were surveyed, resulting in a response rate of 77.8%. Surveys took an average of 14 minutes to complete; the shortest was 2 minutes and the longest was 53 minutes (Table 4).

In Galena, researchers identified 9 households as likely burbot fishers (Table 3). Only 1 household could not be reached, and no households declined to be interviewed, resulting in 8 surveys or an 88.9% response rate. Surveys took an average of 7 minutes to complete; the shortest was 3 minutes and the longest was 10 minutes (Table 4). In total, researchers contacted 22 of 27, or 81.5%, of burbot fishing households.

According to local contacts and members of the Pilot Station Traditional Village council, no burbot fishing occurred in 2017 because of poor ice conditions and the loss of elders who were esteemed burbot fishers. Without their knowledge, guidance, and gear, the community was unable to fish for burbot in 2017. As a result, household surveys were not administered in Pilot Station.

Mapping Locations of Subsistence Burbot Fishing

During household interviews, the researchers asked respondents to indicate the locations of their burbot fishing during the study year. In addition, interviewers asked the respondents to mark on maps the amounts harvested and the month(s) of harvest. ADF&G staff established a standard mapping method: points were generally used to mark harvest locations, and polygons were used to indicate broader harvest effort areas. However, sometimes points were also used to designate a harvest effort location, especially if fishing from a riverbank. Some lines were also drawn in order to depict when the harvesting activity did not occur at a specific point: for example, lines were used to depict an area of the river where drift gillnets were deployed.

Harvest locations and fishing areas were documented on iPads using the Collector application (ESRI, or Environmental Systems Research Institute) customized for Division of Subsistence data collection needs. The point, polygon, or line was drawn on a U.S. Geological Survey topographic relief map downloaded on the iPad. The iPad allowed the user to zoom in and out to the appropriate

scale and the ability to document harvesting activities wherever they occurred in the state of Alaska. Once a feature was accepted, an attribute box was filled out by the researcher that noted how the burbot were harvested, how many were harvested, the method of access to the resource, and the month(s) of harvest. Once data collection was complete, the data were uploaded through ArcGIS Online to the ESRI cloud server for storage.

Once a survey was complete, researchers conducted a quality control exercise by matching the map data to the survey form to ensure that all map data had been documented. This was completed in the field before the surveys were submitted to the community's lead researcher. Once the data had been uploaded, researchers also verified that the household data were logged into the server.

Key Respondent Interviews

While researchers were in the study communities they consulted with tribal governments, community councils, and local research assistants to identify key respondents to interview. The purpose of the key respondent interviews was to provide additional context for the quantitative data. Some of the topics explored in the key respondent interviews were the historical and contemporary burbot fisheries in each community; the way harvest occurs in relation to timing, methods, fishing groups, and means of access; local knowledge of the burbot lifecycle; identification of nearby spawning locations; and environmental changes that may be affecting this species. The number of key respondent interviews varied among communities. Key respondent interviews were semi-structured and directed by a key respondent interview protocol designed by Alida Trainor in consultation with co-PI (principal investigator) Lisa Stuby in order to intertwine both traditional ecological knowledge and biological understandings of burbot (see Appendix B). In addition to gathering qualitative data through the key respondent interview protocol, ADF&G staff took notes during interviews to provide additional context for this report. Researchers analyzed key respondent interviews and interview notes in preparation for this report. Key respondents were informed that, to maintain anonymity, their names would not be included in this report.

Household Survey Implementation

Pilot Station

Co-PI Alida Trainor worked with contacts at the Pilot Station Tribal Council to gain approval for this project on February 8, 2017. Unfortunately, fieldwork was delayed by poor weather conditions until the following winter, occurring between January 3 and January 15, 2018. This delay caused a reevaluation of the household snowball sample survey. In 2017, Pilot Station suffered the loss of 2 primary burbot fishers and community leaders. This loss impacted access to fishing gear, knowledge, and the capacity to organize new fishing groups. Consequently, no burbot fishing occurred in 2017. Because the subsistence harvest survey was designed to record harvest in the prior calendar year, the survey was not administered during fieldwork. Without the administration of households harvest surveys, no local research assistants were hired in Pilot Station. Division of Subsistence staff conducted ethnographic interviews and participated in burbot fishing activities that had resumed in early 2018.

Galena

Jeff Park, Subsistence Resource Specialist, gained community approval from Louden Tribal Council in Galena. Fieldwork occurred between April 23 and April 30, 2018. One local research

assistant was hired to help administer household harvest surveys and arrange ethnographic interviews. Mapping was conducted with all survey participants.

Fort Yukon

Fort Yukon approval and field work occurred in conjunction with an ADFG Division of Subsistence comprehensive survey project. Approval was gained on January 18, 2018, and fieldwork occurred between February 20 and March 2, 2018. Respondents who participated in the comprehensive survey and indicated that they fished for burbot were then administered the burbot survey for this project and were asked to identify other burbot fishers in the community. This allowed a more robust approach to the snowball sample and improved confidence that all Fort Yukon burbot fishers were being targeted in the sample. Six local research assistants were hired to help conduct surveys and arrange ethnographic interviews.

DATA ANALYSIS AND REVIEW

Survey Data Entry and Analysis

Surveys were coded for data entry by research staff and reviewed by the project leads in each community for consistency. Responses were coded following standardized conventions used by the Division of Subsistence to facilitate data entry. Information Management staff within the Division of Subsistence set up database structures in a Microsoft SQL Server at ADF&G in Anchorage to hold the survey data. The database structures included rules, constraints, and referential integrity to ensure that data were entered completely and accurately. Data entry screens were available on internal networks accessible by Division of Subsistence staff and further restricted to Information Management analysts and data entry personnel. Daily incremental backups of the database occurred, and transaction logs were backed up hourly. Full backups of the database occurred twice weekly. This ensured that no more than 1 hour of data entry would be lost in the unlikely event of a catastrophic failure. All survey data were entered twice, and the sets were compared in order to minimize data entry errors.

Once data were entered and confirmed, information was processed with the use of Statistical Package for the Social Sciences (SPSS) software, version 21. Initial processing included the performance of standardized logic checks of the data. Logic checks are often needed in complex data sets where rules, constraints, and referential integrity do not capture all of the possible inconsistencies that may appear. Harvest data collected as number of burbot were converted to pounds of usable weight using a standard conversion factor of 4.20 lb per fish to estimate edible weight.

ADF&G staff also used SPSS for analyzing the survey information. Analyses included review of raw data frequencies, cross tabulations, table generation, estimation of population parameters, and calculation of confidence intervals for the estimates. Missing information was dealt with on a case-by-case basis according to standardized practices, such as minimal value substitution or using an averaged response for similarly characterized households. Typically, missing data are an uncommon, randomly occurring phenomenon in household surveys conducted by the division. In unusual cases where a substantial amount of survey information was missing, the household survey was treated as a "non-response" and not included in community estimates. ADF&G researchers documented all adjustments.

Harvest estimates and responses to all questions were calculated based upon the application of weighted means (Cochran 1977). For a snowball sample, the mean among sampled households is

applied to only those uncontacted households identified in the snowball sample. These calculations are standard methods for extrapolating sampled data. As an example, the formula for harvest expansion is:

$$H_i = \bar{h}_i S_i \tag{1}$$

$$\bar{h}_i = \frac{h_i}{n_i} \tag{2}$$

where:

H_i = the total estimated harvest (numbers of resource or pounds) for the community *I;*

$\bar{h}_i$ = the mean harvest of returned surveys;

h_i = the total harvest reported in returned surveys;

n_i = the number of returned surveys; and

S_i = the number of burbot fishing households in a community.

As an interim step, the standard deviation (SD; or variance [V], which is the SD squared) was also calculated with the raw, unexpanded data. The standard error (SE), or SD of the mean, was also calculated for each community. This was used to estimate the relative precision of the mean, or the likelihood that an unknown value would fall within a certain distance from the mean. In this study, the relative precision of the mean is shown in the tables as a confidence limit (CL), expressed as a percentage. Once SE was calculated, the CL was determined by multiplying the SE by a constant that reflected the level of significance desired, based on a normal distribution. The value of the constant is derived from the student's *t* distribution and varies slightly depending upon the size of the community. Although there are numerous ways to express the formula below, it contains the components of a SD, V, and SE:

$$C.L.\%(\pm) = \frac{t_{a/2} \times \frac{s}{\sqrt{n}} \times \sqrt{\frac{N-n}{N-1}}}{\bar{x}} \tag{3}$$

where:

s = sample standard deviation;

n = sample size;

N = population size;

$t_{a/2}$ = student's *t* statistic for alpha level ($\alpha = 0.95$) with n–1 degrees of freedom; and

$\bar{x}$ = sample mean.

Small CL percentages indicate that an estimate is likely to be very close to the actual mean of the sample. Larger percentages mean that estimates could be further from the mean of the sample.

The corrected final data from the household survey will be added to the Division of Subsistence CSIS. This publicly accessible database includes community-level study findings.

Population Estimates and Other Demographic Information

As noted above, a goal of the research was to collect demographic information for all burbot fishing households in each study community. Although this information will not provide insight into overall community demographics, it is a useful tool in understanding how the demographics of burbot fishing households differ from the broader population of each community when compared to our earlier data on demographics for the same communities.

For this study, eligible households were defined as being domiciled in the community when the surveys took place and for at least six months during the study year 2017. Further, these households only included those that usually participate in burbot fishing. Because not all households were interviewed, population estimates for burbot fishing households in each community were calculated by multiplying the average household size of interviewed households by the total number of year-round burbot fishing households, as identified by Division of Subsistence researchers in consultation with community officials and other knowledgeable respondents.

Map Data Entry and Analysis

As discussed above, maps were generated based on data collected using an iPad or on 11x17-inch paper maps. All data were entered on the iPad, whether in the field during interviews or by ADF&G research staff while coding survey data. Map features were matched to the survey form to ensure that all harvest data were recorded accurately. Once all data were uploaded to the ESRI cloud server, ADF&G researchers created search and harvest location maps for burbot in ArcGIS 10.6.1 using a standard template for reports. To ensure confidentiality, the maps produced for the report do not distinguish between overall fishing areas and specific harvest locations. Maps were reviewed at a community review meeting to ensure accuracy and identify any data the community would like to keep confidential.

Community Review Meetings

Due to travel restrictions and concerns over the ongoing Covid-19 pandemic, PIs on this project decided not to hold in-person community reviews for this project. Instead, draft results were sent to tribal councils for review and comment. Any questions or concerns raised through this process by the communities were addressed prior to the publication of this report. The report was finalized after receipt of comments. ADF&G mailed a short summary of the study findings to every boxholder in the 3 study communities.

DATA ANALYSIS ADDRESSING OBJECTIVES

Objective 1

The GPS locations obtained during aerial tracking flights were taken from a moving aircraft and often multiple locations for each frequency/code combination were recorded. As a result, many of the recorded coordinates were not directly over the fish depending on the flight pattern. Coordinates with the highest signal strength for each radiotagged fish detected were used and adjusted to the nearest point on the river if needed. The accuracy of determining the true locations

of radiotagged fish from aerial tracking was variable (depending on aircraft speed, depth of the transmitter in the water column, and number of transmitters in the vicinity). However, within a river system, an accuracy of approximately 1 river km was considered achievable.

Recorded burbot spawning locations from the aerial tracking flights were consolidated, examined, and plotted using ArcGIS 10.6.1. Individual radiotagged burbot were assigned a "fate" (Table 5). Fates of all radiotagged burbot were determined from a combination of information collected from stationary tracking stations, aerial tracking flights, and harvested fish for which radio transmitters were returned. Given the vast size of the study area, the Yukon River was broken down into lower, middle, and upper sections, with subsections (Tables 5 and 6).

Seasonal distributions were expressed as ranges, which were defined as the minimum portions of the river network linking all observations for a given season or tracking flight, including tributaries if needed. Percent overlap was calculated for the ranges associated with each pair of tracking flights (i.e., fall and winter, winter and spring, etc.) for each tagging population (i.e., near Russian Mission/Pilot Station, Galena, Dalton Highway, and Circle), and each pair of tagging populations for each survey. Percent overlap between ranges A and B were calculated (1), in which $\cap$ and $\cup$ denote intersection and union, respectively.

$$O_{AB} = \frac{A \cap B}{A \cup B} \times 100\% \quad (1)$$

All range and range overlap calculations were completed in R using the riverdist package[5]. Linear range as an expression of distribution is inherently a minimum, and therefore any estimation of range overlap also represents a minimum. Because of this certain bias, the estimated range overlap was only used in descriptive and suggestive terms with no precision criteria.

Objective 2

Patterns in transmitter locations were used to infer fish behavior and habitat use, and aggregations of fish were used to characterize significant spawning and overwintering habitats. To accomplish this, fish locations were plotted for each aerial tracking survey and visually assessed using a linear kernel density. Aggregations were specifically identified for aerial tracking surveys known to coincide with spawning times, such as late January/early February, but evidence of aggregation times were also 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 were also performed using the riverdist package for R.

Objective 3

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

$$f(t) = \frac{R_t}{\sum_{t=1}^{T} R_t} \quad (2)$$

in which:

[5] Tyers, M. B. 2017. Riverdist: River Network Distance Computation and Applications. R package version 0.13.1.9000. https://cran.r-project.org/package=riverdist

$f(t)$ = 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 radiotagged burbot that migrate past the tracking stations during day t.

Objective 4

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

Objective 5

River sections were delineated as Lower, Middle, and Upper, with primary breakpoints at river km 853 (Galena) and 1,613 (Fort Yukon) from the Yukon River mouth. Tributaries were considered to belong to the same section as their respective confluences. Because the Alaska portion of the Yukon River drainage is 508,900 km^2, these 3 primary sections were further broken into 10 sections (Table 6). For each tagged population, the proportions of burbot in each river section were estimated for each flight survey with the proportion of burbot in river section I in survey j from tagged population k estimated as

$$\hat{p}_{ijk} = \frac{y_{ijk}}{n_{jk}} \tag{3}$$

with variance estimated as

$$\hat{V}(\hat{p}_{ijk}) = \frac{\hat{p}_{ijk}(1-\hat{p}_{ijk})}{n_{jk}-1} \tag{4}$$

in which 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 population j was estimated as

$$\hat{p}_{jk} = \frac{y_{lj}}{n_j} \tag{5}$$

with variance estimated as

$$\hat{V}(\hat{p}_{lj}) = \frac{\hat{p}_{lj}(1-\hat{p}_{lj})}{n_j-1} \tag{6}$$

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

Objective 7

Traditional ecological knowledge, related to traditional and contemporary patterns of subsistence harvest including methods and timing of harvest, gear types used, spatial mapping of harvest areas and other important habitats, and including fish-related place names and taxonomic lexicon, was documented by the Division of Subsistence by conducting and recording ethnographic interviews with long time burbot fishers. These ethnographic interviews were transcribed and then analyzed

through the use of Atlas.ti, a qualitative data analysis software program. Additionally, research staff participated in burbot harvesting activities and drew on these observations when describing local practices.

Objective 8

A subsistence harvest survey for burbot was developed and administered to all available burbot fishers in Galena and Fort Yukon. These surveys allowed researchers to estimate the approximate burbot harvest in the 2017 calendar year, by season. Additional information including harvest locations and the prevalence of sharing burbot was also established. Due to recent deaths in the community, this information was not gathered in Pilot Station because no burbot fishing occurred in 2017.

RESULTS

RADIOTELEMETRY RESULTS

A total of 293 burbot were captured and radiotagged in the lower, middle, and upper portions of the Yukon River. In the lower river, 10 radio transmitters were deployed during 3–6 June 2017 near Russian Mission, none were deployed during winter 2018 using the community burbot trap near Pilot Station due to low catches, and 65 were later deployed during 23–30 August 2018 near Pilot Station using commercially made baited hoop traps. For the middle Yukon River, 90 radio transmitters were deployed in burbot captured near Galena during 1–9 September 2017 and 90 burbot were captured and radiotagged near the Dalton Highway during 17–22 September 2017. In the upper river, 38 radio transmitters were deployed in burbot near Circle: 30 during 3–4 October 2017 and the remaining 8 on 8 October 2018.

Generally, more than 50% of radiotagged burbot were located during aerial tracking flights 2-8 that took place during January 2018–July 2019 (Table 7). The first flight was flown from 30 November to 1 December 2017 and encompassed the area from the Canadian border to the Dalton Highway but did not include the rest of the Yukon River due to inclement weather. The final flight occurred from 31 October and 3–5 November 2019, when most of the radio transmitters that were deployed in 2017 were at the end of their operational life and were no longer transmitting. The percentage of radiotagged burbot that were located during flights 2–8 ranged from 31% to 68%. An attempt was made to conduct one final aerial tracking flight during late January and early February 2020 to locate fish that were radiotagged near Pilot Station and Circle in 2018. The Yukon River was surveyed from approximately 25 miles above the Dalton Highway to above the Nowitna River, but no fish were located and inclement weather precluded tracking the remainder of the river. The lowest percentages of radiotagged burbot detected were during the 2018 and 2019 June and July radio tracking flights (39% and 31%, respectively; Table 7).

The majority of radiotagged burbot (234) survived tagging and handling and were noted to move during aerial tracking flights and/or between the tracking stations (Table 8). Smaller numbers were assumed tagging mortalities (14) or were not detected after the radio transmitters had been deployed (45). For the 14 assumed tagging mortalities, which were based on a relative lack of movement and perpetually inactive motion sensors, the radio transmitters remained operational throughout the study. The largest distance between locations for individual tagging mortalities recorded during aerial tracking flights ranged from 0.4 to 4.6 km with a median of 1.1 km, thus satisfying the assumption of achieving an accuracy of approximately 1 km distance between detections. Four radio transmitters were returned to the project biologist from burbot that were

captured near the Dalton Highway. Two burbot were harvested by a sport fisher approximately 2 weeks after tagging and were in good shape, and the remainder were harvested during June and September 2018. Movement data acquired prior to this harvest was included in the data analyses.

During the project duration, 38% of the 234 radiotagged burbot that survived tagging and handling were detected by the tracking stations. The tracking stations operated through most of the year, but some (such as the ones near Russian Mission and the Dalton Highway) ceased operating due to low battery power during the coldest and darkest months of December through late February (Table 9). The tracking station near Russian Mission was vandalized, the radio receiver was stolen, and there were no data past 4 March 2019. The tracking stations near Galena and Manley Hot Springs never ceased operating during the winter months. Most of the radiotagged burbot that swam by the tracking stations were recorded; however, some eluded detection (Appendix C).

Most radiotagged burbot did not travel far from their tagging locations or river section (Table 10). The burbot that were radiotagged near Russian Mission and Pilot Station were generally located in the Lower Yukon River and Yukon River Delta (Table 10, Appendices D2–D9). One of these burbot was located below Emmonak and another had travelled out and into Pastoliak Bay and was located at the mouth of the Pastoliak River. Burbot that were radiotagged near Galena and the Dalton Highway had a propensity for travelling longer distances and were seen in all sections of the Yukon River during the 9 radiotracking flights. The burbot that were radiotagged near Circle tended to stay in the upper and middle portions of the Yukon River (Table 10). Overall, a greater proportion of radiotagged burbot tended to move in a more downstream direction from the previous aerial tracking flight or tagging location during the October–December flights and upstream from the fall to spawning flights during late January/early February (Figure 2). Post-spawning burbot travelled in more downstream directions, which was noted during the spring and summer flights. Mean upstream and downstream distances were concurrent with numbers of migrating burbot (Figure 2).

Although most fish did not travel far from their tagging location, with a median net travel distance of 140 km, a small proportion of radiotagged burbot were seen to travel over half of the drainage (Figure 3, Appendices D2–D9). Forty radiotagged fish travelled cumulative distances of over 500 km (Table 8). The longest distance travelers consisted of a fish that was tagged near Russian Mission that travelled to Kaltag and then down below Russian Mission (448 km), and another fish that was radiotagged near Pilot Station and travelled up Bishop Creek in the Innoko Flats near Galena (624 km). A burbot that was radiotagged near Galena travelled downriver to Russian Mission, then upriver above the Dalton Highway, and then down to the Nowitna River (925 km). A burbot that was radiotagged near the Dalton Highway travelled upriver above Circle and then downriver near Russian Mission (1,299 km). Another burbot that was radiotagged near the Dalton Highway was located approximately 20 km upriver from Emmonak (1,194 km). The longest-distance traveler was a burbot that was captured and radiotagged near Circle and was later located near Kotlik (Figure 1), travelling approximately 1,700 km.

Probable spawning locations based on the spawning area criteria adapted from Stuby (2018) were noted throughout the Yukon River. Having pre- and/or post-spawning timing data from the tracking stations gave additional credence to areas where burbot were located during the time of spawning. However, with only 5 tracking stations located throughout a large drainage, and radiotagged burbot at times eluding detection due to swimming distance and depth and stations becoming inoperable due to low battery power during winter months, it can be assumed that many burbot without this timing data could have travelled to or resided at other spawning locations. Most

of the burbot that were radiotagged near Russian Mission and Pilot Station travelled down to the Yukon River Delta after tagging and many remained in the Lower Yukon River (Appendix D5). During the late January/early February aerial tracking flights, one fish travelled out to the mouth of the Pastoliak River (described above) and another fish was located below Emmonak (Figure 4). The Yukon River Delta is tidally influenced by marine waters; however, burbot are considered freshwater spawners and not known to spawn in brackish or marine water (McPhail and Paragamian 2000, Koporikov et al. 2017). Pilot Station is located just above tidal influence (https://alaska.usgs.gov/portal/project.php?project_id=203) and potential spawning locations were assumed above this location. Directed pre- and/or post-spawning migration timing to a potential spawning location was first noted at the beginning of Poltes Slough, above the Chuilnak River, where 2 burbot that were radiotagged near Galena and 1 near Pilot Station were located (Figure 4). A fish that was radiotagged near Pilot Station was located further upriver, below Russian Mission, and others below Kaltag and Galena. Three burbot that were radiotagged near the Dalton Highway travelled to potential spawning locations below Holy Cross and Russian Mission (Figure 4), over 870 km from where they were initially captured and radiotagged.

Most locations that met the criteria for probable spawning areas were found in the Middle Yukon River. Small groups of radiotagged burbot with timing data, and from various river sections, were found above and below Ruby and the Nowitna River, and above and below Rampart and the Dalton Highway (Figure 5, Appendices D2 and D6). The spawning area above and below the Nowitna River was composed of a mixture of burbot that were radiotagged near Pilot Station, Galena, Dalton Highway, and Circle. Two burbot that were radiotagged near Pilot Station were recorded by the Galena tracking station during January 2020, but inclement weather precluded conducting an aerial tracking flight below the Nowitna River. The most prolific spawning location was within an approximately 200 km area that began approximately 50 km below Rampart and ended above the Dalton Highway and showed a similar mixing of burbot that were radiotagged from Galena, Dalton Highway, and Circle (Figure 5). One burbot that was radiotagged in Galena travelled to a location approximately 8 km below Nenana during the time of spawning, and afterwards, migrated back to Galena.

Burbot spawning locations were also noted in the Upper Yukon River above and below Fort Yukon and below Eagle (Figure 6, Appendices D2 and D6). The majority of burbot that were radiotagged in Circle remained in the Upper Yukon River. A stationary tracking station was not deployed in this area because the Yukon Flats can be up to 5 km in width with numerous channels. Probable spawning locations were based on pre- and/or post-spawning timing from fish that swam past the Dalton Highway tracking station and from fish located during the January/February aerial tracking flights. For example, 2 burbot that were radiotagged near Circle travelled upriver and were considered spawning fish because they exhibited directed pre- and post-spawning travel during the 2018 and 2019 aerial tracking flights. Other fish that were radiotagged near Circle also exhibited upriver movements to additional spawning locations, especially those that were located with one or more additional fish, including those with timing data that were radiotagged near the Dalton Highway. The furthest upriver location was approximately 5 km above the Tatonduk River.

At least 80 radiotagged burbot with timing data, including the 2 Circle fish with clear pre- and post-spawning movements, were assumed to have travelled to a spawning location at least once and many were located in close proximity to one or more radiotagged fish (Table 11). Probable burbot spawning locations were noted throughout the Yukon River; however, burbot that did not show directed pre- and-post spawning travel could have resided in a spawning location, spawned,

and not migrated (Table 11). The majority of radiotagged burbot with timing data spawned between the Dalton Highway and Beaver (17), with fewer fish located between the Dalton Highway and Tanana (16, Table 11). Sixty-one and 21 radiotagged burbot exhibited directed migrations to spawning locations with timing data in 2018 and 2019/2020, respectively. Sixteen burbot met the criteria for spawning during both 2018 and 2019 (Table 12), and of these, 5 travelled to and spawned in similar locations each year, and 10 travelled to different locations. One burbot was noted to swim upriver of the tracking station near the Dalton Highway but was not detected during the aerial tracking flights and therefore could not be pinpointed to an exact location. Two radiotagged burbot spawned in 2018 and 2019 in different river sections that were separated by over half the distance of the Yukon River. One fish that was radiotagged in Galena spawned below the Nowitna River in 2018 and then above Beaver in 2019. The other fish was radiotagged near the Dalton Highway, spawned in the Upper Yukon River section below the Charley River in 2018, and then in the Lower Yukon River above Russian Mission in 2019.

Post-spawning behavior varied extensively. Post-spawning burbot remained at spawning locations, moved back to where they originated, or traveled to new locations (Table 13, Appendix D3 and D7). Most burbot without timing data from the stationary tracking stations lingered in place (Table 13), whereas fish with directed movements and/or timing data tended to travel to different locations after spawning. Of the 69 radiotagged burbot with timing data, 12 lingered at spawning locations as noted during the April 2018 aerial tracking flight, 5 remained at these locations 2–12 months later, and 25 moved to a different location. Of the 167 burbot without time signatures, 59 and 96 lingered at the same locations during 2018 and 2019, respectively, as noted from the late January/early February and April aerial tracking flights. A total of 116 fish did not move from their locations for 2–18 months (Table 13). These fish met the criteria for surviving tagging and handling, so it can be assumed that a proportion may have been non-spawners. The majority of fish that spawned during one year did not exhibit much movement during a probable non-spawning year. For example, a burbot that was radiotagged near Galena remained between Grayling and Anvik in 2018 for at least 6 months before being detected above Rampart in 2019. A burbot that was radiotagged near the Dalton Highway spawned upriver in 2018 but then travelled to a location between Galena and Ruby and showed little movement for 223 days before finally moving upriver. Lastly, a burbot that was radiotagged near Circle did not move from its tagging location for over 6 months, was undetected during the summer, and then travelled to a spawning location below Eagle in 2019.

Seasonal run-timing showed overall increases in movements past stationary tracking stations corresponding to pre- and post-spawning activities (Figures 7 and 8). Pre-spawning migrations usually occurred during the fall, especially during October–December, and post-spawning migrations usually occurred during April–June (Table 14). The earliest pre-spawning timing was a burbot that was radiotagged near Galena, passed by the tracking station on 24 September 2018, and travelled up the Tanana River to a location just below Nenana (~523 km). After spawning, this fish was recorded past Galena on 4 May 2019 (Appendix C2). The latest pre-spawning travel time was a burbot that was radiotagged near the Dalton Highway and spawned just below the tracking station on 31 January 2018; however, this fish did not have to travel very far to get to its spawning location (Appendix C1). In general, the further a burbot had to travel to reach its spawning location, the earlier it started its migration. For instance, burbot that spawned between Galena and the Nowitna River on average were recorded past the tracking station near Russian Mission on 12 November and past the Galena station, approximately 515 km upriver, on 20 January. Burbot that spawned between Fort Yukon and Circle, on average, migrated past Galena

on 16 November and past the Dalton Highway on 28 November. The average date of passage for all tracking stations for radiotagged burbot travelling to spawning locations was 11 December (Table 14). Unlike pre-spawning burbot, post-spawning travel times were more variable. The earliest post-spawning migration movement was recorded on 7 February past the Dalton Highway tracking station for a fish that had spawned a few kilometers downriver. Two pre-spawning burbot that were radiotagged near Pilot Station and spawned between Galena and the Nowitna River passed by the stationary tracking station near Galena within 20 minutes of each other on 12 January; however, after spawning they swam past Galena on 15 February and 9 June. The burbot that travelled from Circle to Kotlik travelled during the time of pre-spawning and was recorded past the stationary tracking stations from the Dalton Highway (1 October 2018) and Russian Mission (12 November 2018) but was not considered a spawning fish due to its final proximity to the tidally influenced marine environment.

By late spring and summer, post-spawning burbot with timing data from the tracking stations either travelled back to where their pre-spawning migration began or relocated to different sections of the river (Figures 9–11, Table 13). This movement was especially noticeable for radiotagged burbot with pre- and/or post-spawning timing data when placement of these fish as seen in Figures 4–6 are seen to move with Figures 9–11. During the summer, most radiotagged burbot were in the river section where they had been radiotagged (Table 15). Although burbot are usually more active in the winter, especially in the months prior to and after spawning (Figure 8), radiotagged burbot were recorded past the tracking stations throughout the year in much fewer numbers during the warmer months (Figures 7 and 8). During the June/July aerial tracking flights, lower percentages of burbot were located compared to previous flights, excluding the partial flight of November/December 2018 and the November/December 2019 flight where the majority of radio transmitters had ceased operating. Many burbot were in deeper eddies in the mainstem Yukon River during summer months, and the water depth compromised signal strength and created difficulties for the receiver to record the transmitter signals (Table 7).

A small proportion of burbot were located during all flights with no pattern of oversummering, overwintering, or demonstrating pre- and/or post-spawning movements. This was especially noted in areas off of the mainstem Yukon River such Kaiyuh Slough and the Khotol River in the Kaiyuh Flats where 5 radiotagged burbot were detected during the April and June/July 2019 flights (Figure 9). Of these, 3 were radiotagged near Galena and 2 near the Dalton Highway. Some burbot that were radiotagged near Pilot Station were located off the mainstem Yukon River in Bishop Creek in the Innoko National Wildlife Refuge near Galena and in sloughs within the Yukon River Delta and those near Alakanuk and Kotlik. Further upriver, a burbot that was radiotagged near Circle was located in Lower Beaver Creek (Figure 11).

Approximate swimming speed of radiotagged burbot was calculated for fish that migrated between the tracking stations (Table 16). Overall, swimming speed was faster for burbot travelling downriver with the current than upriver against the current. The fastest upriver swimming speed was 20.9 km/day for a burbot that travelled 249 km between the Galena and Tanana tracking stations. The fastest downriver speed recorded was 68.7 km/day for a fish that travelled 467 km from the Dalton Highway to Galena. The much lower swimming speeds were probably a result of burbot residing in place for unknown periods of time. No distinct diurnal timing patterns were noted past the stationary tracking stations during late fall and winter when water temperatures in Interior Alaska tend to be near 0^{o}C (Stuby 2016), or during spring and summer, thus implying that Yukon River burbot can be active at any time in a 24-hour period (Figure 12).

Of the 293 burbot that were captured and radiotagged in the lower, middle, and upper tagging locations, 27% were 550–649 mm, 30% were 650–749 mm, and 43% were ≥750 mm total length [TL]. For the individual tagging locations, a higher proportion of 550–649 mm burbot were radiotagged in the Lower Yukon River compared to the middle and upper tagging locations (Figure 13). For burbot that were radiotagged near Galena, Dalton Highway, and Circle, 54%, 48%, and 58% respectively were ≥750 mm TL. A total of 33 burbot were sacrificed during the study and the otoliths were aged. There was a positive relationship between length and age (Figure 14). For the 293 radiotagged burbot, lengths ranged from 530 to 1,050 mm, with an average TL of 736. Overall, larger radiotagged burbot had a propensity to travel longer net distances (Figure 15).

Site Visit to Burbot Spawning Area

During 4–7 February 2020, a crew of 4 people captured and examined 24 burbot from 5 sampling locations in the vicinity of the Dalton Highway to examine for pre- and post-spawning characteristics so this could be verified as a spawning location (Figure 16). Of the 24 fish captured, half had recently spawned, and the other half were non-spawners (Appendix E1). Liver to total weight was lower for post-spawned burbot than for non-spawners (Figure 17). The average liver weights for non-spawning and post-spawning fish were 187 g and 139 g, respectively. Of the 24 sampled burbot, 5 were males and all were non-spawning (Appendix E1). The average non-spawning liver weight was 169 g for males (5 fish) and 197 g for females (7 fish). The average length of non-spawning burbot was 716 mm and 835 mm for post-spawning fish (Appendix E1). The average length of non-spawning fish was 681 mm for males (5 fish) and 740 mm for females (7 fish).

Water quality sampling was also conducted using the ice holes where burbot were captured. Water temperature was 0.1° C at each of the 5 locations (Appendix E2). The pH varied from 6.9 at the most downstream site to 7.7 at the uppermost site above the Dalton Highway, with an average of 7.4 (Appendix E2). The DO values remained consistent over the 5 sites and averaged 8.2 mg/L. Similarly, conductivity was comparable amongst sites and averaged 333 µs/cm. Water depth, including ice thickness, ranged from 1.4–4.7 m, with an average of 2.5 m.

SUBSISTENCE USE AND HARVEST RESULTS

Pilot Station

In January 2018, two ADF&G Division of Subsistence researchers traveled to Pilot Station to administer a survey about burbot[6] harvest in 2017. However, researchers learned that 2017 was an anomalous year for burbot fishing in the community. Three experienced and primary burbot fishers, known for their active roles in leading the community fishing effort for burbot, passed away that year. As a result of these losses as well as financial constraints associated with lower-than-normal dividend payments, other fishers did not fish for burbot in 2017.[7] Because of the lack of harvest during the study year, researchers decided to not administer the survey. Instead, researchers interviewed 5 long-time burbot fishers and conducted participant observation. The 5 fishers interviewed for this project were all males ranging between 51 and 71 years of age. According to these respondents, burbot fishers in the community are predominantly middle-aged men, although youth are often encouraged to assist with group fishing efforts (01192018PQS1). Findings summarized in this section are sourced from the ethnographic interviews and field notes

[6] Locally known as "lush."

[7] A. Trainor, ADF&G Division of Subsistence, field notes, January 2018.

taken during participant observation. ADF&G Division of Subsistence has conducted 2 recent research projects in Pilot Station: a comprehensive survey of wild resources harvested by community residents during 2013 (Ikuta et al. 2016), and a survey focused specifically on nonsalmon fish resource use and harvest in 2014 and 2015, including burbot harvest and use patterns (Runfola et al. 2018). Information from these two surveys is included within this chapter to provide the reader with a better understanding of the social demographics as well as historical harvest and use practices for burbot of the community.

Community Background

Pilot Station is a remote Central Yup'ik community located on the northwest bank of the Lower Yukon River approximately 121 miles upstream of where the river meets the Bering Sea (Figure 1).[8] The American Community Survey (U.S. Census Bureau) estimated that there were 636 residents and 136 total households in Pilot Station for the year 2017.[9] Nearly all residents (98%) identified as Alaska Native, and the median age for residents was 23 years old. Its nearest neighboring communities are Marshall, 26 river miles to the east, and St. Mary's, 11 river miles to the west.[10] The community is located within the eastern portion of Yukon Delta National Wildlife Refuge, where flat, treeless coastal marshlands and tundra begin to merge with boreal forest and rolling hills (Runfola et al. 2018).[11] The contemporary townsite of Pilot Station is situated at the terminus of a small grouping of tundra valleys that form the southernmost end of the Nulato Hills. South of the community, expansive wetlands and tundra flats extend to the coastline and the Kuskokwim River delta. Pilot Station falls within a transitional climate zone and experiences long, cold winters and shorter, warm summers.[12] The Lower Yukon River is generally ice free from mid-June through October, although recent research indicates that warming temperatures throughout the Arctic in recent years may be expanding that timeframe (Brown et al. 2018).

Historically, the community of Pilot Station has moved among several nearby locations and been known by different names. In 1818, a Russian-American Company employee named Petr Korsakovskiy referred to the settlement as Anvychagmiut [Ankachak] (Korsakovskiy and Vasilev 1988). Later, the community relocated about one third of a mile upriver to a site known as Potiliuk.[13] Residents eventually moved back downriver to the original location, but it was not until 1916 that the community became known as Pilot Station. R. H. Sargent of the U.S. Geological Survey, the first to refer to the community with the new name, indicated that the name referred to the site's use as a checkpoint for riverboat pilots navigating the Yukon River.

A significant period in the history of many communities in the Yukon-Kuskokwim Delta, including Pilot Station, was the Bow and Arrow Wars. This generations-long series of conflicts among Yup'ik and Cup'ik people typically occurred between residents of coastal areas and those located further inland. These conflicts likely influenced the social dynamics of the region, including intertribal relations, trade networks, seasonal settlement, and subsistence harvest

---

[8] ADF&G. n.d. "Yukon (Pilot) River." Accessed December 9, 2020. http://www.adfg.alaska.gov/index.cfm?adfg=sonar.site_info&site=12

[9] U.S. Census Bureau, Washington D.C. n.d. "Explore Census Data: Pilot Station city, Alaska" Accessed December 9, 2020. https://data.census.gov/cedsci/

[10] Alaska Department of Commerce, Community, and Economic Development (ADCCED) Division of Community and Regional Affairs, Juneau. n.d. "Welcome to DCRA Open Data: Pilot Station" Accessed December 9, 2020. https://dcra-cdo-dcced.opendata.arcgis.com/ Hereinafter *ADCCED n.d.*

[11] Google Earth. 7.1.2.2041. "Pilot Station AK." 61°56′17″N 162°53′05″W. Digital Globe. Accessed January 2021.

[12] ADCCED n.d.

[13] ADCCED n.d.

patterns of residents (Funk 2010). Local oral histories indicate that people from Chevak (nearer the coast) and Pilot Station periodically fought when residents of Chevak traveled up the Kashunak River.[14] By the mid-19th century and the advent of increased Russian presence in the area, these conflicts had mostly subsided.

Pilot Station was incorporated as a second-class city in 1969. The community has a 2,500-foot gravel airstrip, a medical clinic, a kindergarten through grade 12 school, a post office, a city office and bingo hall, and two grocery stores. A local power plant provides electricity for the community, and a water treatment facility and locally operated landfill manage municipal water and waste products. Because there are no roads connecting Pilot Station with other communities, access to the community is primarily by boat or airplane. In cold-season months, residents use snowmachines to access neighboring communities on established trails. All-terrain vehicles are frequently used in warm-season months for local travel, and barges routinely deliver fuel and other bulk supplies during ice-free months via the Yukon River. Residents continue to rely heavily on annual subsistence harvests of a variety of wild resources and are especially dependent on large land mammals and both salmon and nonsalmon fish (Ikuta et al. 2016).

Beginning in 1989, ADF&G has run a sonar test-net project site near Pilot Station.[15] These sonar estimates provide Yukon River fisheries managers with the information necessary to make inseason management decisions.

Seasonal Round

Pilot Station's location provides residents with access to a diverse array of subsistence resources, because riverine, mountain, forest, tundra and marine ecosystems are all found adjacent the community (Runfola et al. 2018). As in many other rural communities in Alaska, subsistence harvest patterns follow a seasonal round as they have since historical times. In spring, many residents harvest migratory birds and replenish their winter-depleted food stores with nonsalmon fish, upland game birds, and small mammals. As summer nears, people begin to plan for the salmon fishing season by preparing and organizing gear and supplies. Some families in Pilot Station travel to summer fish camps, where they spend the summer months capturing and processing Chinook and summer chum salmon. Residents often participate in subsistence and commercial fishing simultaneously, and they reinvest profits in gear and fuel needed for next year's subsistence fishing efforts (Ikuta et al. 2016). Families collect blueberries and salmonberries as they ripen in the hills surrounding the community in early fall. In September, many hunters travel inland in search of moose in the vast wetlands and boreal forests north and east of Pilot Station, while others travel west and south toward the coastline to harvest beluga whales and seals. As fall transitions to winter, local fishers begin under-ice fishing for a variety of nonsalmon fish, including burbot, northern pike, inconnu (sheefish), and other whitefishes. Fishers use many different gear types, including under-ice nets, fish traps, and hook and line. In addition to fishing, some residents maintain traplines used to capture furbearers including foxes, lynx, wolverines, and marten. Some individuals capture snowshoe hares for food in winter months, and as spring nears once again, families prepare for another season of spring harvest opportunities.

[14] ADCCED n.d.

[15] ADF&G. n.d. "Yukon (Pilot) River." Accessed January 27, 2021. http://www.adfg.alaska.gov/index.cfm?adfg=sonar.site_info&site=12

Harvest and Use Patterns

Because no survey was conducted in Pilot Station, data about harvest and use levels during the study year are unavailable. However, information available in previous ADF&G Subsistence publications indicate that although burbot is not one of the top resources harvested by weight in the community, it contributes to both the wild food diets and the social structure of some Pilot Station residents. Runfola et. al. (2018) provides general information about burbot fishing and use in Pilot Station.

In 2014, fishers harvested a total of 346 burbot, which contributed an estimated 1,454 lb of edible weight to subsistence diets (Runfola et al. 2018). That year, 32% of households in Pilot Station reported using burbot and 18% said they harvested the resource, which indicates that successful burbot fishers shared their catch. In 2015, burbot harvesting declined: only 8% of households caught burbot, and 18% of households reported using them.

Burbot fishing in Pilot Station has changed over the years, but the practice has always played an important role in community social dynamics and intercommunity trade. Historically, burbot fishing in Pilot Station was based on family relationships. This social structure was particularly evident with the usage of large fish traps constructed specifically for capturing burbot. A fish trap would be owned and operated by one extended family that might consist of 3 to 4 households that shared the work of checking the trap and distributing the harvest (01192018PQS3). Burbot harvests would be shared among the participating households, each of which may then share or trade some of their allotted catch. One ethnographic respondent described past burbot fishing practices and the role of the resource in intercommunity trade:

> *Sometimes they had four or five fish traps that they put in the, during the fall, winter. There was always more than one fish trap 'cause there was a lot of dogs that they had to provide for…not just for people, it was for the whole, the whole community and people that were coming, coming from all over upriver, downriver. They come and they trade stuff for their dogs and coastal people that came, they trade lush fish for seal, you know, like seals and all the stuff that they had on the coast. (01192018PQS1)*

Although traditional burbot harvesting practices still exist today, fewer families are participating in the activity. Local knowledge of burbot behavior and fishing techniques are passed down generationally, and the transfer of knowledge between generations was especially apparent in this community. Several middle-aged key respondents spoke of learning how to fish for burbot from their fathers or from other older friends or relatives. One respondent learned to fish with his father when he was 9 or 10 years old with a large, wooden, hand-built trap (01172018PQS5). Another respondent learned how to set a burbot trap from an older mentor; now that the mentor has passed, he has become the teacher for other novice burbot fishers (01192018PQS3). Often, fishers shared their catches with family or other community members, especially elders. One key respondent mentioned sending fish to elders in Bethel (01192018PQS4), and another mentioned that often the fish caught in a community-managed fish trap were first given to local elders (01192018PQS1). Burbot are also eaten and shared at cultural events, such as community potlaches (01182018PQS2, 01192018PQS3).

Burbot harvests vary in timing and quantity year by year and are influenced by both environmental conditions and social circumstances. Ethnographic respondents indicated that there had been a general decline in both participation in the activity and the amount of fish harvested

(01192018PQS3, 01172018PQS5). Residents gave several explanations for the lack of fishing effort for the species. In recent years, 3 experienced resident burbot fishers died, and other fishers are just beginning to fill their roles as mentors for those with less experience. Some individuals cited lack of effort or desire to fish more generally as a cause for reduced participation in the burbot fishery. Key respondents mentioned that environmental changes such as later ice formation and warmer fall temperatures have shortened the length of the season in which fishers pursue burbot (01192018PS1, 01182018PS2, 01172018PQS5). One fisher mentioned how changing weather patterns have influenced his burbot fishing:

> *[I] used to fish between November and the end of February. When the water comes up, lush go into the lakes to feed on smaller fish. But now everything is so delayed. River freezing later, water warmer and the ice isn't as thick. Ice used to be five feet thick, now it's only two or three thick. Weather is different than it was 40 years ago. (01172018PQS5)*

Fishers described poor weather conditions and lack of an individual willing to lead group fishing efforts as the primary reasons for a lack of burbot fishing by Pilot Station residents in 2017, although other factors probably also influenced burbot fishing that year (01192018PQS3, 01172018PQS5).

Those people who do catch and consume burbot in Pilot Station say that they enjoy eating all parts of the fish, but they often prefer the fish's large, fatty liver and head. Fish kept for human consumption are processed and eaten in several ways, depending on individual tastes. Often, individuals boil and eat parts of the fish, or make a chowder. Others, especially elders, prefer to "age" the fish in a burlap sack set in a cool location for a while before consuming it either cooked or raw (01182018PQS2). One respondent mentioned his family's unique way of cooking burbot:

> *You cut the head off where the stomach is, and how I do it is how my mom taught me. The intestine, you clean it out, and you braid it along with the liver in there and the stomach and the head, and just throw it in the pot. (01192018PQS3)*

Some individuals spoke of burbot as "rich on the liver" and indicated that they would only consume fish caught if they judged their livers to be fatty and healthy (01182018PQS2, 01192018PQS1). Fishers target burbot in cold-season months primarily because "their liver content in the summer is [poor], nothin' on there just a long liver. But in winter their liver gets really good" (01182018PQS2). Another respondent mentioned seeing fish with "spotty" livers in fall before the weather cools and indicated that the spots went away as the weather cooled and the fish then developed better flavor (01192018PQS4).

Burbot Fishing Methods

Fishers interviewed in 2018 indicated that they primarily capture burbot during cold-season months using hook and line through the ice, under-ice nets, and large fish traps. Interannual variation influences the amount of use and success of each gear type, but all three methods can be effective (Runfola et al. 2018).

Hook and Line Through the Ice

Hook and line through the ice includes two different methods of fishing that are associated with fall and winter ice conditions: set lines and jigging (5 AAC 39.105(27)). Fishers create set lines by tying a braided cordage (such as paracord) to a stick or board that is wide enough to span the fishing hole the fisher created in the ice. They attach one or more hooks to the cord, and usually

tie a weight to the end of the cord to ensure baited hooks rest on or near the bottom of the water body. Fishers then place the board across the hole with the line suspended beneath it and cover the entire set with a thick layer of snow to insulate the hole and help prevent it from freezing closed. Set lines are left for a period of time (usually overnight) and checked at least every 24 hours. Jigging is a more active fishing method in which fishers tie monofilament or braided line to a handheld pole and use lures or bait and a rhythmic movement to actively attract fish.

Under-ice Nets

Under-ice nets can be used to capture a variety of fish species including burbot, whitefishes, inconnu, and northern pike. Fishers use nets of various lengths and mesh sizes to target specific species. Under-ice nets require a significant amount of work to install, but they can be checked by only one or two fishers once they are in place. Fishers generally return to the same locations year after year to set under-ice nets, and several individuals may set their own nets in the same general area of the river (01192018PQS4). Fishers check their nets every other day; if they are left longer during colder weather, thickening, refreezing ice makes them more difficult to remove (01192018PQS3).

Fish Trap

Burbot fishers from Pilot Station routinely use a large handmade fish trap specifically designed to capture burbot. The trap is a large box (approximately 4 feet by 4 feet) constructed of a wooden frame with panels of wire mesh and a wire mesh funnel aimed into the box on the side placed downstream. The funnel allows burbot to swim into the trap while preventing their escape. Before placing the trap, fishers push support poles into the river bottom and allow them to freeze in place. Then they lower the trap and secure it to the poles (Ikuta et al. 2016). Additionally, fishers cut a long line through the ice fanning downstream both out into the deeper channel and in towards the riverbank. They insert tall willow branches through this line to guide fish into the trap; fishers refer to this practice as "making trench" (01192018PQS1). Fishers check the trap several times each week for most of the winter, as explained by one key respondent:

> *We usually put 'em in as soon as it freeze up in November but we never freeze up, 'til last December. Second week, yeah, we finally freeze up. That's when we put our lush fish trap in. We usually take it out after end of February before March, end of March, you know, early March. (01192018PQS1)*

The location fishers choose to place the trap depends on river depth, distance from shore, and condition of the substrate. According to the same fisher, ice condition is predictive of substrate condition: "if [the substrate] underneath is smooth, the top [of the ice] will be smooth. If it's jagged, it will have jagged places" (01192018PQS1).

Although Pilot Station fishers indicated that these large fish traps have been used for many years by people in the community, recently they have not received as much use. Traps require a great deal of knowledge and skill to use and maintain, and they last over 10 years if well cared for. However, because of the size of the traps and the complexity of the method, several fishers must work in tandem to use one (01192018PQS1). Generally, one respected, experienced lead fisher (usually male) presides over group fishing efforts that use a large fish trap. That fisher uses the community VHF radio to announce that the trap needs to be checked, and anyone who would like to help can come and share the catch. Clearing the ice and removing the trap from the water usually takes at least 5 people. Fishers divide any burbot caught among those who are present, who then

may further distribute fish within and outside of the community.[16] The combination of the recent loss of mentors with traditional knowledge of the method, poor weather conditions, potentially declining numbers of burbot, and overall lack of interest in learning the method in younger generations have all contributed to the decline in use of burbot traps (01192018PQS3, 01192018PQS4, 01172018PQS5).

Regardless of the gear type used, fishers agreed that factors such as weather and burbot behavior influence catch rates. One ethnographic respondent explains:

> *There's times when we hit the fish. I don't know what, maybe the cold weather, maybe the, you know, those traps were, some days they're catch real, I mean, like, 20, 20s sometimes 40, sometimes 100. It all depends on what, you know, it might be the run of the fish or group, you know, like they maybe they do it like salmon, you know. They come up the river and sometimes there's lots and sometimes there's a few. But they're always running all year, all winter long. And there's days we catch whole bunch and there's days where we don't catch very much. (01192018PQS1)*

Another fisher that discussed using under-ice gillnets to catch burbot mentioned that "when it was warm, I catch only 2 or 3. But when it's cold I catch about 10, 15" (01192018PQS3). This respondent also indicated that fishers are less likely to capture burbot when water quality was silty or otherwise poor.

Harvest Areas of Burbot

Because Pilot Station burbot fishers did not fish for burbot in 2017, no maps were created for that season. However, interview respondents mentioned that burbot fishing locations have not changed significantly in recent years (01182018PQS2, 01192018PQS4). Most individuals are capturing fish in the channels and major sloughs of the Yukon River, often upriver of the community. In 2014 and 2015, Pilot Station fishers concentrated their efforts within 5 miles of the community, but some fished further upriver by about 30 miles, and others traveled as far as Emmonak and Alakanuk (Runfola et al. 2018). On a smaller scale, fishers may alter the locations of their nets or fish traps based on seasonal changes in catch abundance or water quality (01192018PQS3, 01192018PQS4).

Local Knowledge of the Burbot Life Cycle

Fishers in Pilot Station indicated that burbot move seasonally between the Yukon River and smaller lakes and tributaries (01182018PS2). Some individuals mentioned that burbot from downriver will migrate upriver, sometimes in big schools, even in winter (01192018PQS4, 01182018PQS2). Fishers rely on a network of contacts to inform them of the start of the migration inland so that they can better prepare for the fishing season before burbot arrive. One key respondent who is a mentor to other burbot fishers spoke of advice that his late mentor had given him:

> *Yeah, he would tell me, you know, like we watch news. He would say we heard there's fish downriver coming like from Emmo [Emmonak] or from the coastal area. If they know, if we know if they're coming up and we'll see how it is by December or November depends on the weather and the ice. We gotta get, we got fish trap ready 'cause we don't know when they'll get here. We can only wait 'til*

[16] A. Trainor, ADF&G Division of Subsistence, field notes, March 2017.

> *like his friend is from downriver. We call him and tell 'em that there's lush fish coming up and that's when he would tell us we needed to get ready to make fish trap. Or if somebody have net out …they would mention about catching lush fish. And that's when it's a good idea to make fish trap. (01192018PQS3)*

According to the most senior Pilot Station burbot fisher, historically between November and the end of February when the water level begins to rise, burbot traveled to sloughs and lakes to feed on smaller fish. In recent years with later river ice formation and warmer water conditions, that timeline has shortened (01172018PQS5).

Harvest Assessments

Fishers did not capture burbot in 2017, and most indicated that they would have liked to have done so. Although historically burbot is not one of the predominant subsistence resources on which the community relies, burbot do add variety to winter diets and are distributed to other community members by the fishers themselves and at potlaches (01192018PQS1, 01182018PQS2, 01192018PQS3, 01192018PQS4). While ADF&G researchers were present in the community, one fisher mentioned that he was currently fishing to provide burbot for an upcoming potlach (01192018PQS3). Because fishers are often harvesting other nonsalmon fish during cold-season months, it is likely that increased harvests of other species can make up for fewer burbot.

Observed Changes Over Time

Pilot Station's burbot fishers have noticed both a general decline in the numbers of burbot present and in the size of the fish captured (01182018PQS2, 01192018PQS4, 01172018PQS5). As one fisher noted: "Less of everything. Everything declining, including burbot" (01172018PQS5). Individual respondents attributed these declines to both social and environmental factors but highlighted the influence of environmental change on the health of the Yukon River aquatic ecosystem. Specifically, they cited thinning ice, warmer water, and pollution as contributing to burbot population decreases (01192018PQS3, 01172018PQS5). One fisher mentioned occasionally seeing burbot with lesions or tumors. Fish showing these signs of sickness would be removed from the catch when encountered (01192018PQS1). Several fishers noted possible declines in the numbers and average size of burbot (01192018PQS3, 01182018PQS2, 01172018PQS5):

> *I think they're a little bit smaller than they use to be. There's, there's [a] few large ones but now a days they're little, small. They're not as big as we used to get 'em long ago. [They used to be] probably about 36 inches maybe. Now they're like, maybe 15, 20 inches (01182018PS2).*

Overall, Pilot Station fishers indicated that these biological and ecological trends have affected the amount and quality of burbot they are able to capture.

Local Comments and Concerns

Environmental and social change is affecting rural Alaska communities, which depend on subsistence resources. Echoing the sentiments of many others from across the state, several key respondents expressed concern for the environmental changes they have witnessed in recent decades. Warmer winters, later freezes, and earlier thaws shorten the length of fishing seasons and make activities that depend on thick ice more dangerous (01172018PQS5). Fishers are also concerned that changes in weather may be affecting burbot behavior by altering their movements up and down the river and potentially affecting their health (01172018PQS5). Experienced fishers

worry about a lack of interest from younger residents, because they are eager to pass on the local and traditional ecological knowledge to the next generation so that it is not lost (01192018PQS3).

Galena

In April 2018, 2 Division of Subsistence researchers and 1 local research assistant conducted household surveys with burbot fishers to document subsistence harvests of Yukon River burbot in Galena. Researchers attempted to identify and survey all Galena residents who fished for burbot in 2017. Nine households were identified as having fished for burbot in 2017, and 8 surveys were completed. Household surveys included questions about demographic characteristics, burbot harvest estimates, gear types used to fish for burbot, and burbot fishing locations. Results from this survey are available online in the ADF&G Community Subsistence Information System (CSIS). In addition to the burbot harvest survey, researchers conducted interviews with 4 residents of the community who were identified as being particularly knowledgeable about burbot fishing. These ethnographic interviews focused on burbot life history, burbot fishing seasonality, fishing gear types, and changes in burbot fishing in Galena in over the respondent's lifetime.

Researchers attempted to identify all households that fished for burbot in 2017. A list of potential fishing households was compiled by consulting with Louden Tribal representatives, key respondents, survey respondents, and various Galena residents whom the researchers encountered during the project. This list grew to a total of 35 individuals who were mentioned by some Galena resident as people who may have fished for burbot in the past. Twenty-seven of these individuals were contacted, and nine of them confirmed that they had fished in 2017 (Tables 17 and 18). Eight of these nine fishers completed surveys for their household. The residents of these surveyed households averaged 31 years of age, and the average household size was three people.

Community Background

Galena is located in Interior Alaska on the north bank of the Yukon River approximately 270 air miles west of Fairbanks (Figure 1; Marcotte 1990). The area has traditionally been inhabited by the Koyukon Athabascan people, who moved seasonally throughout the region to access wild resources. The permanent community of Galena was established in 1918 at a site previously used for summer salmon fishing. During World War II, an airfield and the Galena Air Force Station was built. This station was eventually expanded with additional military facilities, and by 1986, the station housed 300 military personnel.

Galena now serves as a transportation, services, and educational hub for remote western Interior Alaska communities. The Air Force station closed in 1994, and many of the former Air Force facilities now house a large number of services including the Galena Interior Learning Academy, a boarding school that serves over 100 high school students from around Alaska.[17] The former Air Force facilities also currently contain a regional Bureau of Land Management fire facility and dorms, 2 airlines, Alaska Department of Transportation facilities, an Alaska Department of Fish and Game office, Alaska Court System offices, Alaska State Trooper housing, and a state of Alaska bunkhouse. Galena's population has decreased since 1986, when an estimated 998 people lived there (Figure 18). In 2010, the U.S. Census Bureau estimated that 69% of the 470 residents in Galena were Alaska Native, and in 2017, the American Community Survey estimated that 64% of the 5-year average population of 473 people were Alaska Native (Table 19; Figure 19). An

[17] Galena City School District. 2020. "Galena Interior Learning Academy: About GILA." Accessed December 10, 2020. https://www.galenaalaska.org/GILA/about-gila/

estimated 96% percent of the 9 burbot fishing households identified in this study are Alaska Native. This confirms that burbot fishing is predominantly a traditional subsistence activity that Galena's Alaska Native residents are continuing to engage in.

Galena experienced a massive flood during spring breakup of 2013. Much of the community was under 7 to 9 feet of water, and approximately 90% of Galena's structures were damaged including many community facilities (FEMA 2019). Some households lost their homes and nearly all their personal property. Many residents were evacuated, and some were never able to return to their home community. A Recovery Planning Committee was created, and Galena began rebuilding houses, roads, and infrastructure immediately. The recovery process continues to this day.

Galena is governed by the City of Galena and the Louden Tribal Council. Galena joined Koyukuk, Nulato, and Kaltag in creating Gana-A'yoo, a cooperative Alaska Native Claims Settlement Act (ANSCA) Native village corporation. Galena hosts a small amount of seasonal tourism by people traveling to access the nearby Nowitna, Koyukuk, and Innoko national wildlife refuges (Brown et al. 2015). Galena also experiences an influx of visitors every other winter for the Iditarod Sled Dog Race. A community building serves as both the city offices and the Edgar Nollner Health Center, a clinic operated by the Tanana Chiefs Conference. Finally, Galena has a senior center and residence facility, a post office, a regional U.S. Fish and Wildlife Service office, two grocery stores, and multiple bed and breakfasts.

Seasonal Round

Galena residents take advantage of seasonal opportunities to harvest wild resources throughout the year. Early spring, prior to breakup, trappers target beaver and muskrat (Marcotte 1990). Migratory waterfowl arrive to the region in May and hunters primarily target mallard, pintail, widgeons, Canada geese, and white-fronted geese. Fishers set gillnets in the Yukon River to harvest whitefishes, inconnu, northern pike, and Arctic grayling immediately after the ice goes out. Hunters may target black bears in the spring soon after they emerge from their dens. Residents also harvest new greens such as fiddlehead ferns and wild rhubarb at this time (Brown et al. 2015).

Summer involves travel to fish camp for many Galena households. Fishers target Chinook salmon with gillnets as they pass by the community on their spawning migration in June. Fall chum salmon typically arrive in August and are harvested with nets as well. Many people target nonsalmon fish such as Arctic grayling and northern pike with rod and reel in streams and sloughs off the Yukon River mainstem throughout the summer. Residents also pick blueberries, salmonberries, and raspberries in July and August.

Fall activities are centered around the hunting of large land mammals, the occasional harvest of smaller game birds, and berry picking. In September, many hunters focus on hunting moose, which provides more edible pounds of food to Galena residents than any other wild resource (Brown et al. 2015). Caribou, primarily from the Western Arctic herd, may also be hunted in September, depending on the herd's proximity to Galena as it travels through the region (Brown et al. 2004). Migratory waterfowl are hunted as they pass through in the fall on their return migration. Small land mammals such as snowshoe hare and porcupine and upland game birds such as spruce and ruffed grouse are also targeted or taken opportunistically in the fall. Highbush and lowbush cranberries are picked in the fall, as are other types of vegetation, such as rosehips. Galena fishers typically target burbot, locally known as lush, beginning in October once the river has frozen and continue until December.

Fishers travel to nearby lakes to harvest Alaska blackfish, which is primarily used for burbot fishing bait, in October and November:

> *You just chip a hole in the ice and, usually the ice is not very thick, and just run the trap down…The best spots to put them are the little channels between lobes on lakes and they'll funnel through those little channels. And a lot of times there's a beaver trail that goes through those too and will make it nice and deep and you can just set them in those. We'll usually put that in probably two days maybe three if we're not catching enough. (04252018GAL3)*

Furbearer trappers target marten, river otter, lynx, red fox, wolf, and wolverine starting in November once the pelts are in prime condition and the river and lakes are frozen. Finally, fishers place gillnets under the river ice to catch whitefishes throughout the winter.

Harvest and Use Patterns of Burbot

Galena burbot fishers harvested an estimated 454 lb (108 individual fish) of burbot in 2017 (Table 20). This amounts to 50 lb (12 fish) per fishing household. Inquiries in the community indicated that there are approximately 6 to 8 primary fishers in the community who are likely to target burbot in a given year.[18] Three of these primary fishers were not surveyed because they did not fish in 2017. However, researchers did conduct key respondent interviews with these 3 fishers in addition to 1 fisher who did harvest in 2017. These fishers all indicated that they typically fish every year, and they regretted not being able to fish in 2017. Two of these fishers said they could not fish in 2017 because they did not have time during the fishing season, and one said he did not fish because of jagged ice at the fishing location, which makes fishing more labor intensive.

Key respondents provided a number of reasons why burbot fishing continues to be important to their households. One key respondent indicated that they fish for burbot because burbot are a good supplement to their subsistence diet, especially in years when the household is not able to harvest enough salmon:

> *It was a household staple every most, almost daily 'cause it's easy to fish for. And that time of year you know if you had a bad salmon year we supplemented a lot of our diets with burbot…Fifteen to twenty is pretty good cause we had other fish resources and it was a good change of diet too. So, you're not eating just the same fish then moose meat back and forth. It was always good to us to eat burbot. (04252018GAL4)*

Another key respondent described burbot fishing as an important tradition and a fun family activity:

> *It's one of those things we just love doing with our kids… 'cause it's one of those things we grew up doing it, my family, and I don't know why, but it's really fun. The kids really like it. It's almost like trapping. It's not like normal fishing where you have a pole and you're waiting for a bite you know. You set your hooks and then you let it freeze up and come back the next day and check your line. Pulling up the pole, kids love doing that. And once you get them out you got to get the hook out of the mouth and that's always kind of an adventure...So, it's just a whole lot of fun. And then we really like the fish. That's one of my favorite fish to eat. And the kids really like it too. (04252018GAL3)*

[18] J. Park, ADF&G Division of Subsistence, field notes, April 2018.

Finally, one respondent said that burbot fishing is important to him because he shares his catch with the community: "I'll get what I want, and I'll share whatever I have left over. I just go around town, pass 'em out. Couple at the Elders Center. Just ask around anybody wants one. They've been cleaned…See the idea is to try to feed people, you know" (04272018GAL1).

Nearly all burbot were harvested from October through December (Figure 20; Table 21). Key respondents indicated that burbot are present in the river and may be harvested throughout the year; however, early winter is the primary burbot fishing season. Immediately after freeze-up, cutting fishing holes in the ice is easier because the ice is still thin: "Yeah, because the ice is shallower then, so it's not a whole lot of work to get through it, to get through the ice. You can fish just about any time, I think. But the ice starts getting thick, and keeping the hole open becomes kind of a nuisance" (04252018GAL3). Therefore, the season begins in October as soon as the Yukon River ice is thick enough to walk on:

> *Well, it's safe enough to be out there when it's six inches or so…Two years ago the river froze up on the 18th of October, which was great. And it was safe enough to go out on the ice and set hooks. And the lakes froze up well enough that we could get back and put in our fish traps for the blackfish that we use for bait for the lush. (04272018GAL1)*

Fishers may even begin fishing through the ice shelf that forms along the sides of the river during freeze-up before the river has completely frozen over: "We fish for them in the fall during freeze-up. So, before the ice stops, but while there's still when the shelf of the ice forms on the edge of the river" (04252018GAL3).

Key respondents reported that early winter is the primary burbot fishing season also because the burbot are more active leading up to their spawning, which occurs later in winter:

> *[In October] it seems when you get your best migration to…once [the ice] stops and you get out there and you can see a change when the, all of a sudden it will really pick up and it will get really consistent. Out of 20, 25 hooks on the line I'll come up with 20 or 22 fish every time. That's pretty consistent, you know. Then all of a sudden it will drop off to about half that after about right around the first week of December it gets really slow and then you come up with four or five at a time. (04272018GAL1)*

Later in the winter the river tends to slow down, and overflow is likely to encroach on the fishing area, making it difficult to maintain the fishing holes:

> *When the river stopped moving we usually pull our sets. Or if it starts to really slow down we'll pull our sets because once the river stops it will flood the site. So, the water will come up in that spot once the river stops. 'Cause it will have the pans of ice will be forming, and the ice will be moving and going. And then it will start to slow and down it gets slower, and slower and so we can. So it starts backing up 'cause it disrupts the flow of the river. When the ice stops then the water will come up and flood the sites and there be a little bit of overflow. It's just we've had that happen a couple of times where we were like, "Oh we got some time," and then we end up out there in hip boots, you know, trying to pull our poles up. (04252018GAL3)*

Burbot fishing occurs immediately after moose hunting and before trapping season when there are few other subsistence harvesting opportunities. It also occurs at a time of year when travel to target more distant resources is not possible: "It's just lush fishing. It's 'cause you can't travel. You can't

go out in a boat because it's freeze-up, and you can't use your snowmachine yet cause there's not enough snow. So, we're kind of stuck" (04252018GAL3).

Ease of preservation also makes winter the ideal burbot fishing time: "It's colder and they're easier to put up. Hence why nobody does it in September, 'cause they don't freeze" (04252018GAL4). None of the key respondents could remember anyone preserving burbot in any way other than freezing: "I don't ever remember them being dried or pickled…or salted. Because the time of year, it's freeze-up. So, the smokehouses aren't going or anything. And they're easy to freeze. You just butcher them up and freeze them" (04252018GAL3).

Finally, the milder weather and longer days of October and November make fishing easier than in mid-winter: "…towards the later part of the year in November, December you have to worry about daylight, blowing snow and everything else. It's hard to work with. But in the end of October, November it's perfect for fishing 'cause the days are still long enough" (04272018GAL1).

Burbot Fishing Methods

Figure 21 shows the percentage of burbot caught by each gear type, by edible weight. Ninety-six percent of the burbot harvest was caught using a pole setline, or pole set. To construct a pole set, a fisher drills or chips a hole in the ice and jams a long willow pole into the river bottom. The fisher attaches 1 to 3 hooked and baited lines along a larger line that is connected to the bottom of the pole. Fishers typically place a series of pole sets extending in a line along the fishing area. These sets are left overnight and checked daily. A key respondent described fishing with pole sets:

> *I make a big hole 16 inches in diameter so it's easier to chip out. And then I take a big long pole or willow of sort: 18 feet, 15 feet long. And I have my line tied at the bottom about a foot up 'cause you want to shove that pole in the ground and then your line will get close to the bottom [of the river]. And there's some current on that sandbar side, and that's what pulls your line downriver. And it just strings it out, so when you set it, you just feed the line back in, and when you're pulling it, you walk it back out and your whole line just tracks with you. I use multiple hooks. Sometimes I try up to five, but they tangle. So, I've been pretty good with about three hooks on each pole. One main line and just small tag lines off. I can run anywhere between four and six poles. Sometimes every day you'll get three or four [burbot]. (04252018GAL4)*

Another key respondent explained the function of the pole in this fishing method:

> *Usually people cut a big thick willow that's close by so you don't have to walk a mile. And the reason you need a pole because you need to chop out, the hole will freeze every night it will freeze within an hour, so you need to chop it out. So, you can chop out a line. Right, that's why you need the stick. Otherwise you could just trail a line. It works mechanically: the line is on the bottom, the bait is on the bottom or very close to the bottom. The line is tied to the very bottom of the pole. The burbot are bottom feeders and they hunt really close to the bottom. And so the pole also gets the gear down there and away from where at the surface of the ice that could be stuff traveling. Big chunks of ice floating by, drift going by, so it's safest on the bottom. And stuff is freezing, the ice is freezing down from the surface as it's thickening. So, if you had a line trailing with the current sweeping it, it would be freezing into the ice. (04262018GAL2)*

This respondent also explained that poles must be braced at the surface to prevent losing the set:

> *You can nail a cross piece, conceivably, but usually you just jam it with a piece of ice that you chopped out. It can pull it away. People normally use two or three hooks a pole, and a lot of times all the hooks get filled up. So, there could be a team of burbot pulling, pulling it away. (04262018GAL2)*

Three percent of the reported 2017 burbot harvest was caught using a rod and reel (Figure 21). A key respondent said that he sometimes catches burbot with rod and reel while targeting inconnu (sheefish) in the summer: "Well sometimes I catch them with a rod and reel by accident because I like to let my hook go way down for when I'm targeting sheefish 'cause they're in the deep water" (04272018GAL1).

One percent of burbot was harvested by jigging through the ice (Figure 21). A key respondent indicated that this fishing method was common in the past, especially with elders, because it does not require distant travel or a great amount of effort. This respondent explained that although a few people continue to jig through the ice for burbot today, jigging is less common than using pole sets because it is more time consuming: "[An elder relative] used to do that all the time. But we've never done it. We always talk about it how cool and fun it would be but we're always kind of busy" (04252018GAL3).

Respondents described other fishing methods that were used in the past, but are no longer common in Galena. One key respondent described setting an open water trotline in the past. This respondent described anchoring one end of the trotline to the shore and extending the gear in into the river. The trotline is composed of a long line and shorter lines with baited hooks set at intervals: "In September I tried it, you know, it's not frozen. I put a stake in the ground. I have a premade line and it could be 30 feet long with 10 hooks and a small weight at the end. I just back the boat up and add bait to every hook and drop it out there. Then I come back to check it" (04252018GAL4).

A key respondent described another open water method of setting lines that he has used in past summers. A milk jug is used as a buoy that trails a line with a baited hook:

> *You take a milk jug and you wrap line on it. Say you are estimating the water at 10 feet. So, you put 12, 13 feet of line around a jug, you have a weight, and then off the weight you have a foot or two of line, then you have your bait and your hook…I've tried it and I've gotten burbot in the summer. (04252018GAL4)*

Unlike respondents in other Yukon River communities, Galena burbot fishers do not use fish traps. As one key respondent explained:

> *Yeah, they look like just pretty deadly, you know. But we don't have a good place for that around here. It just wouldn't work out for lush [burbot]…Because we just don't have the right water conditions for that…No, it's too deep. Water's too swift. And it just be, it would be quite the ordeal. (04272018GAL1)*

All respondents indicated that they exclusively use Alaska blackfish for burbot bait. Alaska blackfish were once an important food resource to people living in the region:

> *The Indian name for blackfish is oonyeeyh, which means life. Because when they were starving that was their fallback food, because it's so high in oil and fats. And they would also, when they adopted a baby or a baby's mother couldn't nurse, they would make a broth out of the fish. (04252018GAL3)*

Although modern-day Galena residents do not harvest large amounts of Alaska blackfish for human consumption, they are needed to fish for burbot. Key respondents reported that blackfish has always been the primary bait used for burbot fishing: "We've just always used blackfish and that's what my parents used, and it works every time" (04252018GAL3). Another respondent explained that Alaska blackfish are effective burbot bait because they will remain alive and active for a long time on the hook (04262018GAL2).

Harvest Areas of Burbot

All burbot fishing in 2017 took place on the mainstem of the Yukon River near a gravel bar directly in front of the community (Figure 22). A key respondent explained that this has always been a primary location used by Galena fishers: "Right on the river from town because of ease of accessibility. Just drive a truck out and pull your little jet sled out there…our pole sets are traditionally the same place as far back as I remember" (04252018GAL4).

Respondents explained that the gravel bottom, water depth, and current at this location create an ideal fishing spot:

> *I like to fish right in front of town. It's the strongest current right there, and it's consistent bottom, nice smooth bottom, and it's flat…And I try to find no more than 15 feet of water cause it's really hard to set a pole with that much current and that deep of water. (04272018GAL1)*

> *It has a gravel bottom, which is really nice 'cause you can just twist the poles in and they will hold steadier…And there's no mud. And it's pretty steady current through there over that bar so it's, it doesn't usually have the, the layers of ice that we have to deal with. (04252018GAL3)*

Local Knowledge of Burbot Life Cycle

Respondents provided information about aspects of burbot biology and life history with which they had experiential knowledge. Key respondents who have observed burbot stomach contents said that they most often find that the burbot have been eating least ciscos and the fry of other fish species:

> *As far as I can tell from the stomach contents, they target smaller whitefish. Ciscos and all the young of all the other. It's not uncommon to, when you are fishing a very small mesh net to pull a cisco with a burbot holding onto it…Yeah, large burbot target the adults. (04262018GAL2)*

> *When I open them up they'll have small whitefish in them. Like ciscos, I think they call them. Little guys. They're migrating about that time, too [early winter]. So, they're just mowing 'em down…sometimes grayling. I see grayling in there too. (04272018GAL1)*

One key respondent has observed that burbot caught during early winter tend to be larger than those caught prior to freeze-up:

> *Later in the year October, November we get the bigger fish. So, you get more bang for your buck. After freeze-up is when we tend to get bigger fish. Thirty-six-, thirty-eight-inch range. They get pretty sizeable. But in the early season they're 20, 24 [inches]. That's what I found when I did it. (04252018GAL4)*

No respondents were able to provide firsthand observations regarding burbot spawning habits or locations.

Harvest Assessments

Researchers asked respondents to assess their burbot harvests in two ways: whether they used more, less, or about the same amount of burbot in 2017 compared to recent years, and whether they got "enough" burbot in 2017. Households also were asked to provide reasons if their use was different or if they were unable to get enough burbot. If they did not get enough of a resource, they were asked to evaluate the severity of the impact to their household as a result of not getting enough. This section discusses responses to those questions.

Six burbot fishing households (75%) reported that they used less burbot in 2017 compared to recent years (Table 22). Two households (25%) used about the same amount, and no surveyed households used more burbot in 2017. Of the 6 households that reported using less burbot, 3 reported that they did not fish for burbot as much as they have in recent years because they did not have enough time (Table 23). Two households used less burbot because they put less effort into fishing, and 1 household used less burbot because they did not need as much as in recent years.

Seven households (88%) reported getting enough burbot in 2017 (Table 24). Only 1 household (13%) reported not getting enough burbot. This household indicated that they were not noticeably impacted by a lack of burbot in 2017 (Table 24).

Changes in the harvest of burbot by Galena residents can also be discerned through comparisons with findings from other study years and through information provided by key respondents in this study. In 2006 an estimated 16% of Galena households harvested 1,844 lb of burbot (Brown et al. 2010). Also, in 2010, 16% of Galena households harvested an estimated 725 lb of burbot (Brown et al. 2015). These data, compared to an estimated harvest of 454 lb by 5% of households in 2017, suggest a decrease in burbot fishing over the past 15 years. This is supported by key respondents who indicated that elders who used to fish for burbot have passed away and other burbot fishers have moved away from town: "Between now and then a lot of folks have passed on who were fishermen, who was out, and our population changed. That's a big part of it…But I do see a lot of folks that used to fish aren't here anymore. A lot of elders and a lot of other folks" (04252018GAL4). This key respondent also explained that a recent increase in the availability of salmon may have resulted in less need for burbot compared to recent years: "Over the last few years we had a pick-up in king [Chinook] salmon and fall chum. So, we had a more plentiful amount of that available to us" (04252018GAL4).

Observed Change Over Time

Respondents said that they have not noticed a change in burbot numbers over time: "I've never seen a change in population. We always have been able to get what we need" (04252018GAL4). Also, key respondents indicated that they have not seen any significant change in the size of burbot over time: "The size, they are always about the same. We always get the small ones and the big ones, you know, a good mix of each size" (04252018GAL4). Key respondents did indicate that later freeze-ups are causing a change in the timing of burbot fishing: "It's getting later. We used to always count on being able to do it mid-to-late October and now it's, I think, mid-November" (04252018GAL3).

Local Comments and Concerns

Respondent comments indicated that burbot population and availability have been stable over time, and that burbot are a resource that can be harvested reliably with a predictable amount of effort.

As one key respondent summarized, "They're one of those things that, man, you put poles out and you're going to have fish the next day. It's pretty consistent, pretty reliable" (04252018GAL3).

Fort Yukon

In February and March of 2017, 6 Division of Subsistence researchers and 6 local research assistants conducted household surveys with burbot fishers to document subsistence harvests of Yukon River burbot by Fort Yukon residents. Researchers attempted to identify and survey all Fort Yukon residents who fished for burbot in 2017. Eighteen households were identified as having fished for burbot in 2017, and 14 surveys were completed (Table 3). This section summarizes findings from household surveys including demographic characteristics of burbot-fishing households, responses to harvest assessment questions, burbot harvest estimates, and responses to food security questions. In addition to the comprehensive survey, researchers and assistants conducted five ethnographic interviews with select survey respondents who actively fished for burbot. By providing a better understanding of the seasonal round, local history, and subsistence activities in the area, the ethnographic interviews contextualize the quantitative harvest and use data collected in the surveys. Results from this survey are available online in the ADF&G Community Subsistence Information System (CSIS).

For this project, researchers sampled 14 households of 18 eligible households (78%; Table 25). All surveyed households identified as Alaska Native. Out of a total of 203 households in Fort Yukon, 8.9% were identified as burbot fishing households (Table 26). The estimated 44 individuals that were part of burbot fishing households constituted 7.8% of the total estimated community population of 560 individuals.

Community Background[19]

Fort Yukon is a Gwichyaa Gwich'in Athabascan community located in northeastern Interior Alaska near the center of the Yukon Flats and just north of the Arctic Circle (Figure 1; Slobodin 1981). The community lies within an alluvial basin bordered to the north by the Brooks Range and to the south by the White Mountains. It is the largest Athabascan community in Alaska, with a population of 560 residents and 307 households in 2017[20] (Sumida and Andersen 1990). The town of Fort Yukon is situated on the northern bank of the Yukon River at its confluence with the Porcupine River, about 145 miles northeast of Fairbanks.[21] Yukon Flats National Wildlife Refuge and Alaska Native Interest Lands Conservation Act (ANILCA) allotments surround the community, and people and supplies move to and from the community via water or air transportation. The region has a continental subarctic climate characterized by long, cold winters and short, warm summers: extended periods of -50° F to -60° F in the winter are common, and summer temperatures can average above 70° F. In recent history, the Yukon River near Fort Yukon has generally been ice-free from the end of May through mid-September, although information provided by residents and local weather stations over the last several decades indicate a steady increase in ice-free days during both spring and fall seasons (Brown et al. 2018).

The environment around Fort Yukon is characterized by a complex mosaic of upland subarctic boreal forest and wetland ecosystems. Braided channels and sloughs of the Yukon and Porcupine

---

[19] This section is drawn from Trainor et al. (2020) and modified by the author of this chapter.

[20] U.S. Census Bureau, Washington, D.C., n.d. "American FactFinder: Fort Yukon." Accessed March 28, 2019. http://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml

[21] Alaska Department of Commerce, Community, and Economic Development (ADCCED) Division of Community and Regional Affairs, Juneau. n.d. "Alaska Community Database Online: Community Information." Accessed June 6, 2019. https://dcra-cdo-dcced.opendata.arcgis.com/

Rivers weave across the landscape to create an intricate network of forest and both shrub-scrub and herbaceous wetlands. Oxbows of different ages form sinuous scars in various levels of vegetative regrowth. Tree species include black spruce, white spruce, tamarack, paper birch, quaking aspen, and balsam poplar. Willows, alders, and dwarf birch are the dominant shrubs in the region, and herbaceous wet meadows can be found in oxbow scars and around lake perimeters.[22] Ecosystem characteristics are heavily influenced by regular environmental disturbances including floods and forest fires, both of which reset vegetative succession and maintain ecosystem heterogeneity.

Subsistence use patterns of the residents of Fort Yukon are shaped by the environment and associated seasonal cycles. Large mammals and salmon are the predominant subsistence food resources for the community (Trainor et al. 2020). A variety of nonsalmon fish species also contribute to local food resources, and many small mammal species are harvested for both meat and fur. Migratory birds frequent the surrounding wetlands during spring and fall migrations, and residents hunt sandhill cranes and a wide array of waterfowl during both seasons. Fort Yukon residents supplement fish and wildlife resources with edible wild greens and several species of berries and mushrooms, and locally obtained timber is used for both fuel and building materials.

Oral histories and archaeological evidence indicate that the site where Fort Yukon now lies has long been used as a Gwich'in gathering place. Prior to contact with western European explorers, inhabitants were mobile hunter-gatherers who traversed the landscape to harvest seasonally accessible resources (Nelson 1974). Dispersing into small bands, usually consisting of family groups, allowed residents to access low-density and seasonally abundant resources and ensure that those resources were not overharvested (McKennan 1965; Slobodin 1981).

The city of Fort Yukon is the oldest settlement of the Upper Yukon River region. From the 1950s to 2018, Fort Yukon's population has remained mostly stable (Figure 23). With 583 individuals making up 246 households, Fort Yukon is one of the largest communities in the Yukon Flats (Table 27; Figure 24).[23] A. H. Murray, an employee of the Hudson Bay Co., founded Fort Yukon in 1847. Since that time, the community has served as a regional trading, supply, administrative, and transportation center (Slobodin 1981). William West Kirby established an Anglican mission school in 1862 (Mishler 1990). Around the turn of the 20th century, economic activity for the community centered around the fur trade, the whaling boom on the Arctic Coast, and the Klondike Gold Rush. The U.S. military established a White Alice radar site and Air Force station in the 1950s, just prior to the city's incorporation in 1959 (Sumida and Andersen 1990). Fort Yukon is home to the Council of Athabascan Tribal Governments (CATG), an organization under the authority of tribal governments from ten communities in the Yukon Flats.[24] CATG manages many collective natural resources, health care, government, and economic activities in the region. Contemporary Fort Yukon provides its residents with most major conveniences. A diesel generator managed by the Gwichyaa Zhee Utility Company provides electricity. Water is drawn from groundwater, and wastewater and sewage are either contained in outhouses or private septic systems or treated at the water treatment facility. There is a laundromat, several stores, a coffee shop, a radio broadcasting station, a bed and breakfast, a kindergarten through grade 12 school, a

[22] U.S. Fish and Wildlife Service, 2019. "National Wetlands Inventory: Wetlands Mapper." Accessed December 10, 2019. https://www.fws.gov/wetlands/Data/Mapper.html

[23] Alaska Department of Commerce, Community, and Economic Development (ADCCED) Division of Community and Regional Affairs, Juneau. n.d. "Welcome to DCRA Open Data: Fort Yukon." Accessed January 26, 2021. https://dcra-cdo-dcced.opendata.arcgis.com

[24] Council of Athabascan Tribal Governments, n.d. "Council of Athabascan Tribal Governments." Accessed December 11, 2019. https://www.catg.org/

state-run public health office, and the Yukon Flats Health Center, which is a federally qualified health center managed under CATG. Additionally, Fort Yukon is one of 9 Interior Alaskan communities served by the Yukon Flats Center, an extension of the University of Alaska Fairbanks Interior Alaska Campus that provides opportunities to pursue select professional certificates and degrees to local residents.[25] Freight arrives via barge during summer months or via airplane year-round. A state-owned, lighted, gravel airstrip is available, and a lake adjacent to the airport is used by float planes. Harvesting, sharing, and trading of subsistence resources remains an integral part of the mixed cash-subsistence economy of the community. Prior to this research, Alaska Department of Fish and Game (ADF&G) Division of Subsistence had conducted 5 different studies in Fort Yukon. These include 1 comprehensive examination of all subsistence resource use in the community (Sumida and Andersen 1990), surveys targeting specific resources (Andersen and Jennings 2001; Koskey and Mull 2011; Van Lanen et al. 2012), and 1 study specifically investigating customary trade and barter practices (Brown et al. 2017).

Seasonal Round[26]

The harvest of wild resources in Fort Yukon follows seasonal cycles of abundance. A variety of natural and cultural factors influence subsistence activities, including fluctuations in fish and wildlife populations, changes in climate, type and availability of employment opportunities, and regulatory changes.

Winter can be a time of scarcity for residents of Fort Yukon, who depend on subsistence resources. As the days continually increase in length and temperatures gradually warm, stores of food gathered during the previous summer and fall begin to run low. During this season, some residents augment their diets with a variety of nonsalmon fish species, including burbot, captured from under the ice until conditions no longer allow fishing. Other individuals trap small mammals for both fur and food, and many also gather firewood in preparation for heating homes the following year using sleds and snowmachines.

Breakup of the Yukon River at the end of April and beginning of May allows residents to travel by boat, and activity increases in the community. Hunters navigate the newly opened rivers and sloughs in search of spring waterfowl during their migration towards breeding grounds. Fishers set nets for nonsalmon species and prepare fish wheels and gillnets and seine nets for salmon fishing.

Salmon, the predominant subsistence resource harvested by residents of Fort Yukon, are caught all summer. Families often move to fish camps, locations used seasonally to process and preserve fish through smoking and drying near to where they are being harvested. Chinook and fall chum salmon are the 2 types of salmon most commonly available to residents who fish near Fort Yukon. Chinook salmon are the first salmon species to travel upriver towards spawning grounds, and they generally pass the community from early June through the end of July. Fall chum salmon generally move past the community during their migration from the beginning of August through the time the river freezes. This run coincides with the harvest of blueberries, lowbush and highbush cranberries, and cloudberries.

During the month of September while leaves begin to change color, temperatures cool, and days quickly grow shorter, the people of Fort Yukon turn their attention to the pursuit of large land

[25] University of Alaska Fairbanks. "Interior Alaska Campus." Accessed December 11, 2019. https://www.uaf.edu/iac/centers/yukon-center/

[26] This section is drawn from Trainor et al. (2020) and modified by the author of this chapter.

mammals such as moose and caribou. Throughout the month of September hunters travel up and down the Yukon and Porcupine Rivers in search of bulls of both species. Hunters harvest caribou, black bears, and the occasional Dall sheep from late summer through fall. As the snow begins to fall and water bodies freeze, trapping resumes once again, as does under-ice fishing. Although burbot can be harvested at any point in the year, Fort Yukon burbot fishers capture the most fish in late fall and early winter, soon after river ice is thick enough for safe travel.

Harvest and Use Patterns of Burbot

In 2017, fishers harvested a total of 310 burbot that contributed an estimated 1,301 lb of edible weight to subsistence diets (Table 28). For the households that harvested burbot, the total weight equated to an average of 72 lb per household (30 lb per capita). Most fishers caught burbot using handlines under the ice (67%, or 207 individual fish); but fishers also captured 45 burbot in fish wheels (15%), 41 burbot in setnets (13%), and 17 (5%) via rod and reel (Figure 25; Table 28). Handline fishing occurred in the months of October and November; and rod and reel was used in July, September, and October (Figure 26; Table 29). Burbot captured in fish wheels were incidental captures: fish wheels target salmon during the summer months.

Although relatively few individuals fish for burbot in Fort Yukon, those who do are enthusiastic about it.[27] Even when burbot are captured incidentally, they are usually used as food for people or dogs (02272018FYU2). Burbot fishers in Fort Yukon were primarily young to middle-aged adult men that fished both for their families and for elders in the community that requested burbot. One interview respondent indicated that his uncle and other elders always asked him for burbot (02282018FYU5); another respondent mentioned that elders would always ask him when he was going to go burbot fishing, and they were happy to accept burbot after a successful fishing trip (02272018FYU2).

Some burbot fishers noted that most people did not participate in burbot fishing. One interview respondent stated: "A lot of people don't know how to fish for these and…if they catch one, to them it's a surprise" (02272018FYU2). The respondent mentioned that in particular, younger individuals had little interest in the activity. They attributed such indifference to a lack of knowledge about the fish and its value as a food source: "I figure they don't know they're eating-fish. Nice, good eating-fish I would say. You know they don't know. They don't know what it is. This generation now is different" (02272018FYU2).

Although burbot are not the target of heavy harvest, for some people the fish add variety to a local diet that is predominantly based on a couple of main resources. One interview respondent elaborated: "It's a different thing when you're eating straight salmon all summer and moose meat all winter. It's like you need something different to eat" (02282018FYU6).

Many people compare the taste and texture of burbot to lobster, and locals reportedly enjoy both the meat and the large, fatty livers boiled or fried. One individual mentioned a family recipe involving burbot livers fried with wild berries: "I like the liver. They [family members] cook it with berries. They fry it in a frying pan and then mix berries in there with it" (02272018FYU2).

Other cooking methods included frying, boiling, and baking; and occasionally burbot are also fed to dogs (02272018FYU2). Although burbot are captured and eaten year-round, they are particularly sought after in the fall when they have prime fat stores and rich, oily flesh.

[27] A. Trainor, ADF&G Division of Subsistence, field notes, March 2018.

Burbot Fishing Methods

Most Fort Yukon fishers target burbot using handlines during late fall and early winter after water bodies have frozen and ice is thick enough for safe travel. Handlines include 2 different methods of fishing, both of which are associated with fall and winter ice conditions: setlines and jigging (5 AAC 399.105(27)). To make a set line, a fisher ties a braided cordage (such as paracord) to a stick or board that is wide enough to span the fishing hole the fisher created in the ice. One or more hooks are attached to the cord, and a weight is usually tied to the end of the cord to ensure baited hooks rest on or near the bottom of the water body. Fishers then place the board across the hole with the line suspended beneath and cover the entire set with a thick layer of snow to insulate the hole and help prevent it from freezing closed. Setlines sit for a period of time (usually overnight), and fishers check sets every 24 hours. Jigging is a more active fishing method: fishers tie monofilament or braided line to a handheld pole and use lures or bait and a rhythmic movement to actively attract fish. When jigging, fishers use baited or unbaited lures or baited hooks, ideally placed about 6 inches to 1 foot above the bottom of the water column (02272018FYU2).

Fishers begin handlining as soon as ice has reached a safe thickness, which is often in October (02282018FYU6). When using handlines, fishers often have more success catching burbot in colder temperatures. One fisher explained that he usually concentrates his efforts "in the fall time when it gets cold, about 30 below [zero, Fahrenheit]," because "when it's cold out there that's when they start moving around" (02272018FYU2). Key respondents also observe that burbot are more active nocturnally, so fishers are most successful at night. As one interview respondent explained:

> *[We] catch 'em at night because there's dark water, they can see their prey better at night, you know. Like well after it starts to get dark we have this white bait and we put it in [the] water. They see that, yeah, that's the difference right there. You start catching in the dark. (02272018FYU2)*

In addition to eyesight, burbot also rely on their sense of smell to capture prey.[28] Because burbot are often present in cloudy water, fishers often find success in using large pieces of bait as attractants. Bait can either be attached to a large plain hook or attached to a hook on a lure. One fisher described their use of bait when fishing for burbot under the ice:

> *I always use the lush[29] belly. It's like a big chunk of fat. The bigger, to me the bigger the bait the more curious the fish would be, and then they grab it. They just grab it and hang on. (02272018FYU2)*

This fisher explained how traditional burbot ice fishing lures may have been attractive both visually and by scent:

> *Long time ago that's all they had. They didn't have no hook, you had to make your own. And now, I was very surprised about how they made that and the lush would just grab it. You know, [they] didn't use bait, nothing, just that [lure]. It was white I guess, or that bone had a smell to it 'cause they use caribou bone you know. (02272018FYU2)*

During summer and fall months when fishers use fish wheels to capture salmon, they also sometimes incidentally capture burbot. Although these fish not the primary target of this fishing

---

[28] ADF&G, n.d.

[29] "Lush" or "lush fish" is a common local term for burbot.

method, fishers often keep the burbot and either consume them or use them to supplement commercial feed for dogs.

Similarly, fishers occasionally capture burbot in setnets used to catch salmon in summer months. Fishers place setnets at strategic locations in rivers, often eddies or the junctions of creeks or sloughs to a main channel, and fish become trapped by their gills in the net mesh. Burbot captured in setnets are consumed by people or by dogs; however, some people prefer to consume burbot caught in cold months because as one fisher put it, "In the fall time they're fat, you know. Rich" (02272018FYU2). Fishers in Fort Yukon capture few burbot using a rod and reel. Because rod and reel fishing often involves repetitive casting and reeling in of baits, this method is often meant to target fish that feed actively by sight during daylight hours in warm-weather months. However, some individuals described using this gear type in a manner similar to handlines, but in summer and early fall months. Fishers attach a large bait to a hook, cast the bait out, and let it sink to the bottom of the water body (02272018FYU2, 02282018FYU6). This provides an opportunity for burbot to smell the bait and seek it out in the location within the water column where they most often forage.[30]

Harvest Areas of Burbot

Fishers targeting burbot attempt to capture the fish along the mainstems of the Yukon and Porcupine Rivers, often in areas where sloughs connect to larger river channels (Figure 27). Additionally, some individuals search for burbot in lakes adjacent to the northern braids of the Yukon River. One resident who fished for burbot in sloughs of the Porcupine River mentioned that he looked for waters that were "calmer but still along the current, the big current of the Porcupine [River]" (02282018FYU6). Another fisher indicated that they look for burbot where creeks merge with the mainstems of rivers, because burbot are attracted to the small fish that originate and shelter in tributary waters (02272018FYU2). Most fishing locations are within 20 miles of the community of Fort Yukon, although some fishers travel as far southwest as Lower Birch Creek Slough (about 45 miles from Fort Yukon) in search of burbot.

Local Knowledge of the Burbot Life Cycle

Burbot living in river systems have been known to move considerable distances annually (Evenson 1990), and fishers also report seasonal movements for the species. One interview respondent indicated that "they're around here but there's not a lot, and then they, like, make a big run during wintertime or like the October season. November, I suppose" (02282018FYU6). The same individual mentioned that he believes burbot residing in the Yukon and Porcupine Rivers are moving upstream during that time period, possibly to locations where they will spawn in mid- to late winter.

Harvest Assessments

Of the 14 households surveyed in 2017, 14% indicated that they did not get enough burbot (Table 30). The remaining 86% of surveyed households did get enough burbot that year. The impact of harvesting fewer burbot on those households was minimal: 50% said it was not noticeable, and the other half said fewer burbot had a minor impact on their household. Households that did not get enough burbot did not report changing any behaviors to accommodate for the lack of the resource.

[30] ADF&G, n.d.

Compared to recent years, most surveyed households (54%) used the same amount of burbot in 2017 as they usually do (Table 31). Thirty-one percent of households reported using more burbot in 2017, and 15% of households used less. The households that used less said that they did so due to lack of effort and the need to work or lack of time (Table 32). Households that used more increased their fishing efforts, had more success when fishing, or did not specify a reason (Table 33).

The Division of Subsistence has conducted 3 prior studies in Fort Yukon that provide historical points of comparison for burbot harvests in the community. A 1987 study of all subsistence resources used in Fort Yukon indicated that about 17% of Fort Yukon residents attempted to harvest burbot and 16% succeeded, resulting in a community harvest of 948 fish (3,793 lb; Sumida and Andersen 1990). In 2005, an ADF&G Subsistence study documenting nonsalmon fish harvest information indicated that 13% of households in Fort Yukon captured an estimated 344 fish (Koskey and Mull 2011). A comprehensive survey of all subsistence resources used by Fort Yukon residents during the 2017 calendar year reported that 10% of households harvested 228 fish (959 lb; Trainor et al. 2020). The decline in the number of burbot harvested from 1987 to 2005, then again from 2005 to 2017, suggest that the species was more heavily harvested in previous decades.

Although separate, distinct survey instruments were used for both 2017 studies, information for the comprehensive study and the burbot study were collected during the same time period. This provided an opportunity to compare harvest and use information for the same species at all community households with the information for only those households identified as burbot fishers. The general community harvested fewer burbot overall (228 fish)[31] than the narrower population targeted for the burbot-specific study (310 fish; Table 28). This discrepancy may be an artifact of survey methodologies. ADF&G researchers and their community counterparts attempted to survey all households in Fort Yukon, but inevitably some households may not have been contacted for a variety of reasons, including household members not being present during contact attempts or declining to provide information. It is possible that a burbot-harvesting household or households did not provide information for the comprehensive survey but were available for the species-specific survey. Additionally, burbot use levels are consistently low in Fort Yukon, and the resource is not widely exchanged. In 2005, 16% of households used burbot and 4% gave away the resource (Koskey and Mull 2011); and in 2017, 12% of households used the resource and 3% gave it away (Trainor et al. 2020).

Observed Changes Over Time

Respondents indicated that they have not noticed any significant changes in burbot populations, sizes of individual fish or fish health over time (02272018FYU2, 02282018FYU5). Fishers are usually able to get what they need, provided they invest the appropriate amount of time and effort.

Local Comments and Concerns

As mentioned previously, burbot are not a fish species widely used by residents of Fort Yukon. However, those fishers that do target burbot generally expressed satisfaction with the availability of the species in the region (02282018FYU6, 02272018FYU2, 02282018FYU5). Several survey respondents provided comments that illustrated the variety of relationships Fort Yukon households had with burbot.[32] One survey respondent mentioned that although they did not personally fish for

[31] ADF&G CSIS.

[32] ADF&G Division of Subsistence household surveys, 2018.

burbot, they had received some in 2017. Another respondent, who did fish for burbot, provided a detailed description of how they liked to process and consume the species, indicating that when boiled in sugar water and dipped in butter it closely resembled crab meat. A third community resident indicated that they also fish for burbot but primarily as a catch-and-release leisure activity during the winter months.

DISCUSSION

RADIOTELEMETRY DISCUSSION

The radiotagged burbot in this study showed variation among fish with respect to tagging location, migration behavior to purported spawning locations, consecutive and nonconsecutive spawning, travel distances to and final locations of oversummering areas, and a possible degree of semi-anadromy for some fish. This illustrates the phenotypic plasticity of this long-lived species. This plasticity has been noted in other river and lake systems in North America. Paragamian and Wakkinen (2008) reported multiple burbot movement patterns in the Kootenai River, and similar to the Yukon River burbot, they showed behavior patterns during the spawning seasons that ranged from active to sedentary with lotic/lentic migrations.

The physical characteristics of a river can influence tracking success. Radiotracking burbot in the Yukon River was challenging due to the relative vastness of this system. Although the highest percentage of radiotagged fish were located during the January/February 2018 flight, 32% were still not detected. These fish may have been missed due to river conditions, in particular river depth and width. Radiotagged fish swimming deep will be more difficult to detect due to reduced reception range (Eiler 2012). Additionally, there is a strong nonlinear relationship between the distance to the transmitter and received signal strength (Heim et al. 2018), so distance as well as depth can attenuate the radio transmitter's signal. Water depth in the Yukon River can be shallow, as was noted when burbot were sampled near the Dalton Highway, to depths of ~40 m near the Rampart Rapids (http://rapidsresearch.com/html/yukon_river_panel.html). Overall, much of the Upper Yukon River tends to be shallower, with depth and width progressively increasing below major tributaries towards the Bering Sea (Brabets et al. 2000). Radiotagged burbot may have been missed over wide sections of the river where crisscrossing during the aerial tracking flights was required to sufficiently cover these areas, such as the Yukon Flats and sections with numerous side channels and/or sloughs. Several fish also swam past the tracking stations without being detected, which was attributed to fish swimming deep and/or far away from the stations. This project was designed to focus primarily on the mainstem Yukon River because the number of tributaries, changing weather conditions, fuel requirements, and associated costs made it unfeasible to cover the entire system. Additional areas not in the project design, such as the Middle and Upper Koyukuk River, Lower Porcupine River, Middle and Upper Innoko River, Kaiyuh Flats, Yukon River Delta sloughs near Alakanuk and Kotlik, and Lower Beaver Creek, were surveyed when time and conditions allowed. However, the number of additional burbot located in these areas was minimal. The sister project on the Tanana River incorporated the frequencies from this project during their aerial tracking flights, which broadened our scope of finding transmitters in this major Yukon River tributary.

Spawning Season Movements, Characteristics, and Conditions

The radiotagged burbot in this study exhibited pre- and post-spawning migration timing similar to what has been noted for other northern rivers. Similar to this project, Evenson (2000) found

movements of large burbot in the Tanana River were greatest during October and November, coinciding with river freeze-up, and May and June, coinciding with river ice break-up. Similarly, Breeser et al. (1988) noted that movements were longest during the period of November–March, which were attributed to spawning activities. Evenson (2000) also observed that most fish spawned between 15 January and 5 February, with the first spent burbot collected on 28 January. This relatively short spawning season is consistent with broadcast spawners who require a high degree of synchronism among individuals for reproduction (McPhail and Paragamian 2000). Burbot have been known to spawn during late February–March in Copper and Tanada Lakes (Scannell 2016), and pre- and post-spawning burbot have been observed as late as mid-March (Corey Schwanke, ADF&G research biologist, personal communication, Glennallen AK). Burbot in the Kootenay Lake, B. C., begin spawning in early April and continue into late May or early June[33], which suggests that lacustrine burbot may have later spawning schedules than river burbot.

Spawning duration of burbot has been noted to last from 1 to 3 weeks (Evenson 2000, Boag 1989). The post-spawning burbot that were collected near the Dalton Highway during 5–7 February 2020 had clearly spawned the week prior to sampling, and this timing was consistent with Evenson's (2000) observations in the Tanana River. The sample size was small (24), so it was unknown whether burbot in this or other areas of the Yukon River were still engaged in spawning activities.

The Yukon River burbot radiotelemetry project was designed to radiotag mature burbot over a range of sizes. Evenson (2000) noted that the onset of maturity for Tanana River burbot was estimated at age 5 (~400 mm) for females and age 3 (~340 mm) for males, 50% maturity was attained at age 8 by females (~580 mm TL) and age 7 (~540 mm TL) by males, and complete maturity for Tanana River burbot was attained at age 14 by females (~760 cm TL) and age 15 (~730 mm TL) for males. The majority of burbot in this study were considered mature because 40% were ≥760 mm, 7% of radiotagged burbot were <580 mm, and the average length was 736 mm. Burbot exhibit a low level of sexual dimorphism (Cott et al. 2014), although for Yukon River burbot, males reach maturity and senescence earlier than females (Chen 1969). Northern populations have been noted to reach maturity later than southern populations by 1–3 years (Boag 1989). Because the Tanana River is a major tributary of the Yukon River, it can be assumed that ages and lengths at maturity would be similar for both systems. Similar to this study, Evenson (2000) found smaller (younger) burbot moved shorter net distances than larger (older) burbot in the Tanana River.

This study suggested that some mature burbot may not spawn annually. The propensity for mature burbot to not spawn every year has been noted throughout their range. Pulliainen and Korhonen (1990) estimated that approximately 30% of adult burbot from Bothnian Bay in northern Finland did not spawn every year. Arndt and Hutchinson (2000) noted non-consecutive spawning for burbot that spawned in a tributary of Columbia Lake in British Columbia, Canada. Chen (1969) suggested that Yukon River burbot may not spawn every year due to the failure to accumulate nutrients necessary for gonad development. Evenson (2000) noted Tanana River burbot that achieved ages and lengths representative of up to 50% maturity did not spawn annually but suggested that they may do so after reaching complete maturity. For this project, average lengths of the nonspawning burbot that were sampled near the Dalton Highway in early February 2020 were lower than those observed for post-spawning burbot. However, several of these fish had attained complete maturity with respect to size and/or age and the remaining fish had attained 50%

[33] Martin, A. D. 1977. Kootenay Lake burbot fishery. Unpublished report. British Columbia Fish and Wildlife, Nelson.

maturity. Also, many burbot that did not exhibit clear pre- and/or post-spawning migration timing data were fully mature and therefore may not have spawned during 2018 and 2019, although this was not conclusive. Therefore, it can be assumed that a proportion of non-spawning fish in this study were fully mature in contrast to Evenson (2000).

For the burbot that were suspected to spawn during both 2018 and 2019, most did not show fidelity to a particular section of the Yukon River. Arndt and Hutchinson (2000) noted that burbot that had consecutively spawned in a tributary of Columbia Lake in British Columbia, Canada, had moved in different locations. This is not too surprising because, unlike whitefish that spawn in very few and discrete locations, most of the mainstem Yukon River is spawning habitat. According to Evenson (2000), spawning sites were located throughout the mainstream Tanana River and in the Lower Chena River, a major tributary, with no overwhelming preference of burbot to move into tributary streams to spawn.

The majority of post-spawning burbot with timing data in this study stayed in place for several months before they exhibited post-spawning movements, and movements were not necessarily back to their original locations. Other burbot were mostly sedentary for the duration of the study or traveled a significant distance after months of residing in one location. This was also noted for burbot that spawned in the Goat River, a tributary of the Kootenai River. According to Paragamian and Wakkinen (2008), burbot that spawned during January–February later moved to oversummering locations in the Goat River during March–April and many of these fish did not show fidelities for home pools. Evenson (1993) and Bressler et al. (1988) noted little or no movement for several months of burbot in the Tanana River soon after spawning.

Burbot spawning activity is energetically expensive. During the spawning period, burbot can be found in writhing balls composed of many individuals (McPhail and Paragamian 2000). Burbot spawn in relatively low light conditions, especially in northern latitudes like Alaska. Liver lipids are important for the reproductive success of lean fish such as the codfishes (Marshall et al. 1999). Cott et al. (2013) found a significant seasonal pattern in liver size and lipid concentrations that was most pronounced in females. Similar to other cods, burbot females produce thousands of eggs during spawning, with estimates up to 3,477,699 eggs per female for Tanana River burbot (Roach and Evenson 1993). Ovary development seems to require more lipids than the development of testes, as burbot have small nonadhesive eggs that contain a large oil globule (Chen 1969). However, male burbot have significantly larger Gonadal Somatic Indices than females (percentage of gonad weight to total weight), which may be indicative of sperm competition during spawning (Cott et al. 2013). The male burbot sampled near the Dalton Highway were all nonspawning, so we were unable to compare them with post-spawning fish. However, the post-spawning livers of female burbot were much more shrunken as would be expected compared to those that did not spawn.

Spawning Habitat and Environmental Needs

Burbot have been documented to spend up to several months in brackish water, but no population is known to spawn in brackish water (McPhail and Paragamian 2000). Therefore, in this study it was assumed that burbot would not spawn below Pilot Station, which is located just above tidal influence (https://alaska.usgs.gov/portal/project.php?project_id=203). Most burbot that were radiotagged in the Lower Yukon River were noted to travel further downriver into the Yukon River Delta, where some spent over a year in the brackish/marine environment. Several burbot that were radiotagged in the Middle and Upper Yukon River did similarly. This behavior was similarly noted in the Gulf of Bothnia in Finland and Sweden and the Mackenzie River Delta in northern Canada

where burbot were found in estuaries and brackish lagoons (Pulliainen et al. 1992, Percy 1975). Because estuaries are documented to be marginal environments for spawning, it was assumed that the Yukon River Delta would not be a suitable spawning location. The longest distance traveler in this study was a burbot that was radiotagged in Circle and later located near Kotlik. This burbot was not considered a spawner because it travelled to an area that is subjected to marine influence, even though the travel occurred when other burbot were making pre-spawning migrations. Burbot in Irtysh River in Western Siberia have been observed migrating distances of up to 700 km to optimal foraging areas in estuarine areas but spawning in freshwater (Koporikov et al. 2017). The Yukon River Delta, like many estuaries, is an important transition zone with rearing habitat for anadromous and resident species (Howard et al. 2017). The 5 species of juvenile Pacific salmon *Oncorhynchus spp.* utilize the estuarine conditions to transition from freshwater to the marine environment, as do Arctic lamprey, nine-spined stickleback *Pungitius pungitius*, and rainbow smelt *Osmerus mordax*. These fish can be a rich food source for burbot, and similar to burbot in the Irtysh River, burbot from this study may have been exhibiting foraging behavior. However, this remains speculative without examination of samples during the time of spawning from the Yukon River Delta.

Although limited water quality data were collected during this study, overall, the data were comparable to previous observations and corroborated reported trends. Spawning is triggered by specific environmental conditions, with water temperature being one of the most critical cues. Burbot spawn during the dead of winter, often under ice. Ideal water temperatures in the Kootenai River reported by Paragamian and Wakkinen (2008) were usually between 0.5°C and 4°C, and temperature should not exceed 5ºC during spawning and egg incubation according to Terrazas et al. (2017). The temperatures recorded near the Dalton Highway were at the lower end of this range at 0.1°C. However, the Kootenai River is at a much lower latitude than the Yukon River in Alaska, so a lower winter temperature for the Yukon River was expected. The DO levels at the Dalton Highway sampling stations were consistent and >8 mg/L. According to Chambers et al. (2000), dissolved oxygen levels <6 mg/L may extend the spawning period of burbot by up to 5 weeks, and burbot have an acute intolerance of levels below 2 mg/L. Oxygen levels this low are unlikely in a large river system such as the Yukon River but are possible in a lake environment. Specific conductivity at the Dalton Highway was 281 µs/cm during late July 2019, and the average across all sampling stations was 333 µs/cm during the first week of February 2020. During the months when the Yukon River is primarily covered with ice, glacial and surface runoff is minimal and baseflow predominates (Brabets et al. 2000). As was observed during July and February sampling, this results in higher specific conductivity during winter months. Conductance has also been found to increase from Eagle to Pilot Station by almost 100 µs/cm (Brabets et al. 2000), thus implying a seasonal and spatial tolerance for varying levels by Yukon River burbot. The pH levels recorded at the Dalton Highway were also consistent with those reported throughout the drainage and between seasons (Brabets et al. 2000).

As broadcast spawners, burbot spawn in low-velocity areas in the main channels of the glacially influenced Tanana River (Breeser et al. 1988) and in channels behind deposition bars (Sorokin 1971). Burbot spawn over a variety of substrates from silt and sand to coarse gravel and cobble (McPhail and Paragamian 2000). Yukon River substrate near Pilot Station varies from silt and fine sand on the left bank to a rocky bottom on the right bank, and it can be assumed that these substrate types are characteristic upriver of Pilot Station (Dreese and Lozori 2019). Lower-velocity spawning areas with differentially sized gravel and sand substrate are also preferred by other broadcast spawners, such as sheefish, and may enable fertilized eggs to lodge into the substrate (Alt 1987). Burbot aggregate in shallow water only while spawning under the ice in winter (Scott

and Crossman 1973), which may be why burbot were easier to locate during the January and February aerial tracking flights. Burbot spawning areas were also assumed to start upriver of Pilot Station because the river near Pilot Station is fairly deep and only 1,000 m wide, with an approximately 25 m thalweg (Dreese and Lozori 2019). Off-channel habitats may be important to the early life history of immature burbot (Fisher 2000). Several radiotagged burbot were in these areas such as the Kaiyuh Flats, Lower Beaver Creek, and Yukon River Delta sloughs. From the air, these off-channel sloughs and rivers appeared slow moving with fine sediments without the differentially sized gravel and sand that characterizes burbot spawning habitat.

Oversummering Behavior and Needs

Despite the seemingly inhospitable environment of glacial rivers during summer when flow, turbidity, and scouring are at relatively high levels, radiotagged Yukon River burbot appeared to prefer the main channels. This trend was similarly noted by Breeser et al. (1988) for burbot in the Tanana River. Except for pre- and post-spawning spawning migrations, burbot in both rivers and lakes appear to be relatively sedentary (McPhail and Paragamian 2000). Dunnigan and Sinclair (2008) noted that many burbot in the Koocanusa Reservoir in Montana were sedentary during the spring to early autumn period. According to Tyulpanov (1967), at summer temperatures feeding is practically arrested, and fish may even enter a state of summer torpor. During this study, burbot exhibited some movement past tracking stations during the summer months, but not to the extent noted during fall and winter pre-spawning and spring post-spawning periods.

During the summer aerial tracking flights, locating radiotagged burbot was more difficult because many fish were in deep pools. This observed proclivity of adult burbot for deeper habitats, particularly during summer months, is likely due to the maximization of physiological performance at cold water temperatures. The pumping capacity of the burbot heart and food intake have been shown to decline with increasing water temperature, while both oxygen consumption and gastric evacuation rates increase (Paakkonen et al. 2003). For burbot to tolerate warmer water they must down regulate their metabolism, resulting in lower food consumption and reduced energy expenditures (Hardewig et al. 2004). Given the physiological responses of burbot to warm water, particularly in summer, it is not surprising that much of the existing data has shown that this species is commonly found in cooler waters at deeper depths (Scannell 2016).

Adult burbot prefer cold water temperatures even during nonspawning months. Burbot prefer temperatures between 10°C and 14°C, although thermal maximum temperatures have been reported at 26.8°C–31.7°C based on different acclimation temperatures (Hofmann and Fischer 2002). During late July 2019, record high water temperatures were recorded throughout the Yukon River, with temperatures above 22°C during 14–19 July near Emmonak and 19.5°C on 24 July under the Dalton Highway bridge (Stuby 2021). Terrazas et al. (2017) conducted a burbot thermal maximum trial and demonstrated the ability of burbot to withstand temperatures as high as 31.5°C. For many river systems there may be areas of hyporheic exchange where fish can find thermal refuge, even when temperatures reach peak levels for the day or season (Terrazas et al. 2017). Global warming is a cause for concern for temperature-sensitive species such as burbot, because increases in temperature may affect winter spawning success and oversummering survival.

Burbot Movements

Burbot can travel long distances, although burbot are documented to have low swimming endurance and difficulty swimming against a 25 cm/s current (Jones et al. 1974, McPhail and Paragamian 2000). In this study, 18% of the radiotagged burbot were noted to travel net

cumulative distances of over 500 km with varying swimming speeds. This was not too surprising considering radiotagged burbot in the Kuskokwim River were noted to travel over 800 km, which was also related to pre- and post-spawning migrations (Albert and Wuttig *In prep*). Similarly, radiotagged burbot that were tracked in the Koyukuk River were found to travel ~120 km prior to spawning (Wuttig et al. 2015). Long-distance travels have also been noted outside of Alaska. Paragamian and Whitman (1998) reported that some radiotagged burbot were seen to move up to 280 km in the Slave River in Canada and over 450 km in the Kootenai River in Idaho. Semi-anadromous burbot in Irtysh River in Western Siberia were also observed migrating distances of up to 700 km (Koporikov et al. 2017).

For this study, yearly net movements in the Yukon River tended to be primarily downriver, except prior to spawning. Evenson (1989) noted that burbot that were Floy tagged and later recovered on the Tanana River moved predominantly upstream, with downstream movements infrequent and short ranging. However, a few years later, when he incorporated radiotelemetry techniques, Evenson (1993) noted that downstream movements were common and that net movement of all burbot was slightly downstream. A similar trend was noted by Paragamian and Wakkinen (2008) for the Kootenai River, with post-spawning burbot also tending to move downstream. However, these studies were short-term, and it is unknown what the long-term movements might be or if net upstream and downstream movements may vary from year to year.

The radiotagged Yukon River burbot did not show distinct diurnal movements. Kavaliers (1980) showed that under constant darkness, burbot displayed a rhythm of free-running circadian locomotor activities. However, for this study radiotagged fish swam past the stationary tracking stations during all hours, including during the warmest months. In contrast, lacustrine burbot are more active at night during summer months, when ambient conditions are cooler (Cott et al. 2015). For example, Scannell (2016) noted that burbot from both Tanada and Copper Lakes occupied shallow depths at night and deeper depths during the day, and showed that water temperature primarily influenced seasonal occupancy depth selection. This lack of distinct diurnal movement could be a characteristic of the Yukon River burbot population.

No genetic analysis has been conducted on burbot within the Yukon River to decipher if genetically distinct subgroups exist within the *Lota lota lota* subspecies that is found in Alaska and the Yukon Territory, Canada. Most burbot in this study travelled within their tagging sections, although smaller proportions travelled long distances, particularly those radiotagged near Galena and the Dalton Highway. Many burbot that were radiotagged in Russian Mission and Pilot Station stayed in the lower river or travelled to the Yukon River Delta, and very few were noted to travel into the Middle Yukon River. Given the relatively short duration of this study, it is unknown whether more burbot that were radiotagged in the lower river would have eventually migrated upriver. However, with the large travel distances noted from this study, multiple spawning locations throughout the Yukon River and some radiotagged fish located in one spawning area during one year and a different one the following year is suggestive of a single stock. Behavioral differences have been noted between lake and river burbot such as spawning timing and diurnal movements, which is suggestive of multiple subspecies within the state of Alaska.

SUBSISTENCE USE AND HARVEST DISCUSSION

Although burbot are not a keystone species like salmon, these fish are an important subsistence resource to residents living along the Yukon River, particularly because they offer a change in diet

in the early winter months of October and November. In particular, their livers are considered a delicacy because of a high fat content and are enjoyed by many people throughout the drainage.

Traditional ecological knowledge holders accumulate their knowledge over a time period that exceeds a typical scientific study period, and the spatial scale that TEK (traditional ecological knowledge) holders utilize often differs from a targeted study area. These discrepancies are commonly encountered during interdisciplinary projects. Consequently, it can be easy to conclude that the results of TEK and western science methodologies are incompatible. However, as Huntington et al. (2013) note, "Consistent results may increase confidence, but inconsistent results may point the way to new insights or promising new research." In addition to a variety of interview topics, ethnographic respondents in this study were asked about their knowledge of the burbot life cycle. Specifically, respondents were asked if they knew of nearby burbot spawning locations, whether burbot are present in smaller tributaries, if they had observed patterns related to burbot behavior and migration, etc. Answers to these questions were limited: respondents knew little about burbot spawning or migration. Instead, respondents shared their understanding of what burbot eat and when they are most active. That fishers shared knowledge related to their experience of fishing rather than that of burbot life cycle details is consistent with the experiential characteristics of traditional knowledge (Carothers et al. 2014). Fishers had more to say about their observations of burbot during the fishing season because that is when they encounter those fish. Because the radiotelemetry results also explored these topics, they are discussed together in the following section.

Harvest and use patterns of burbot vary widely, and these differences were noted when comparing the results of the 3 study communities included in this project. In Pilot Station, although no harvest survey was conducted for the study year, ethnographic respondents describe harvesting large quantities of burbot in fish traps. Fishing for burbot is an organized community activity in Pilot Station, and fishers from many families join the communal harvesting effort. Fishing participants divide burbot and then share their portion with numerous households throughout town. Large harvests are announced publicly on the VHF radio and arrangements are made to get fish to anyone who wants them (Trainor field notes, 2017). In Galena, fishing is less of a communal activity but sharing burbot with nonfishers still occurs. Sixty-three percent of households reported giving some of their burbot to others. Because this survey used a snowball sample instead of a census, the rate of sharing is possibly much higher. In Fort Yukon, far fewer residents fish for burbot. Ethnographic respondents in Fort Yukon noted that burbot fishing is done by a small number of individuals, inconsistently. Only 21 percent of fishing households reported giving burbot away to others, which suggests that burbot is less ingrained in the social norms associated with sharing as it is in other study communities.

Another possible explanation for the lower rates of harvest and use in middle and upriver study communities as compared to Pilot Station is that the gear type used in Pilot Station requires a group of individuals, working cooperatively, to deploy successfully. The fish traps used in Pilot Station are very large and cumbersome when empty. When full of burbot, they are heavy and unwieldy and require numerous individuals to lift from the water. In contrast, in Galena and Fort Yukon, where the preferred gear type is a set line or a jigging hook attached to a line and pole, residents are able to fish easily without help from others. Additionally, fishing can occur opportunistically when someone has the time or desire to go out, with little planning or maintenance of gear. This convenient gear type and fishing pattern is easier to use and participate in but results in smaller harvests. In the absence of large, frequent harvests, fishers do not have the numbers of fish

necessary to share widely throughout the community. Consequently, burbot are not as central to the seasonal harvest or use patterns in Fort Yukon and Galena as they are in Pilot Station.

Although burbot are available to subsistence fishers year-round, they are most often targeted in the winter months. Subsistence fishers in all study communities fished though the ice for burbot. Accessing these fish through the river ice gave respondents a unique perspective on the ice itself. Consequently, respondents in Pilot Station and Galena shared concerns related to environmental change and ice conditions. In Pilot Station, where burbot fishing is a communal event that occurs in October and November, thick, safe ice is critical. Unfortunately, in recent years warmer weather and later freeze-up of the Yukon River have delayed or even prohibited burbot fishing. These changes are causing some in Pilot Station to view burbot fishing, especially with a fish trap, as an unsafe activity (01192018PQS3, 01172018PQS5). In Galena, residents expressed similar sentiments. Key respondents shared that freeze-up of the mainstem Yukon River is occurring later in the year (04252018GAL3). Burbot fishing used to occur as soon as the river froze, usually in mid- to late October. Now fishing occurs in mid- to late November. Fort Yukon fishers did not mention these environmental changes when discussing burbot. However, recent subsistence division publications that have included Fort Yukon as a study community have discussed environmental changes including those associated with late freeze-up and unpredictable ice and river conditions (Trainor et al. 2020; Trainor et al. 2019).

Other Subsistence division studies documented the use and harvest levels of burbot in Pilot Station and Galena, as well as numerous other Yukon River communities (Runfola et al. 2018; Brown et al. 2015). Fort Yukon had never participated in a nonsalmon fish study prior to this one. In these past reports, information about fishing patterns was gathered, such as timing, gear, and composition of fishing groups. Over the 3-year study period documented in Runfola et al. 2018, burbot were one of the most heavily relied on nonsalmon species other than whitefish; however, burbot's contribution to the total nonsalmon harvest varied year to year and ranged from 9% to 2%. During a 2010 study year, burbot accounted for 5% of the total community wild food harvest and 20% of the nonsalmon harvest (Brown et al. 2015).

INTERDISCIPLINARY DISCUSSION

Seasonal Movement and Locations

Yukon River residents have long understood the fall pre-spawning and spring post-spawning movements of burbot, and the radiotelemetry study has corroborated that TEK. Residents of Pilot Station, Galena, and Fort Yukon reported fishing for burbot primarily during the fall to early winter because of the quality of the fish and as a welcome source of fresh fish after the salmon runs had concluded. The TEK documented from residents of these three villages helped inform project biologists on tagging locations and possible locations to include on flight paths for the radiotelemetry portion of this project.

Lower Yukon River

Prior studies have documented that residents of Pilot Station concentrated their efforts within 5 miles of the community, although some fished further upriver by about 30 miles (~48 km) and others traveled downriver as far as Emmonak and Alakanuk, which were approximately 100 miles (~161 km) from Pilot Station (Runfola et al. 2018). Approximately 30 miles upriver of Pilot Station is the beginning of Poltes Slough, where 2 burbot that were radiotagged near Galena were located and assumed to be at a spawning location. These fish were recorded swimming past the stationary

tracking station located near Russian Mission during early and late October 2017. As broadcast spawners, burbot will congregate in large numbers, which would make this a good fishing location. Burbot may not feed much during spawning (Patrick Moore, personal communication, subsistence fisherman from Tanana), but can travel and congregate months ahead of spawning. Areas near the Yukon River Delta communities of Emmonak and Alakanuk are not assumed to be appropriate locations for spawning due to tidal influence and brackish water. However, because burbot may not spawn in consecutive years and the Yukon River Delta can be good habitat for young salmon and other species, it is conceivable that some nonspawning burbot would travel here because it is a potentially good food source.

Schooling behavior was not noted from the radiotelemetry study; however, some residents of Pilot Station have reported that burbot from downriver will sometimes migrate upriver in big schools, and the fishers will rely on a network of friends to inform them of the start of the migration (01192018PQS4, 01182018PQS2). Given the vastness of the Yukon River, it is conceivable that the spread of 293 radio transmitters that were surgically emplaced in burbot from near Pilot Station to Circle would have been too diluted relative to the population of burbot to have shown clear schooling behavior. However, because local information suggests that schooling does occur, further research on how burbot move through the Yukon River may be warranted.

Middle Yukon River

Key respondents from Galena reported that early winter is the primary burbot fishing season because the burbot are more active leading up to spawning, which occurs during late January and early February. Nearly all burbot were harvested from October through December. In the radiotelemetry study, burbot were noted to move all year. However, a substantial increase in movements was noted from October–December, with much of that attributed to pre-spawning activity. In addition, this study has shown that larger burbot have a propensity to travel longer distances, similar to what was noted years ago in the Tanana River (Evenson 2000). Also, burbot moved throughout the drainage and could travel various distances and directions to spawning locations, which were located throughout most of the drainage.

In Galena, fishing for burbot takes place on the mainstem of the Yukon River near a gravel bar directly in front of the community. Respondents explained that the gravel bottom, water depth, and current at this location create an ideal fishing spot that is devoid of mud. Respondents have described the differentially sized gravel and sand that would be preferable to a broadcast spawner like burbot. Also, the radiotelemetry study showed that burbot travelled to areas above and below Galena prior to and during the time of spawning, among them burbot that were radiotagged near the Dalton Highway and Pilot Station. This area met all of the criteria of a burbot spawning location. Because burbot are broadcast spawners that can congregate months before spawning during late January and early February, there would be numerous opportunities to capture burbot at these locations.

Upper Yukon River

Subsistence fishers in Fort Yukon had more success catching burbot during the fall in colder temperatures. One interview respondent indicated that “they’re around here but there’s not a lot, and then they, like, make a big run during wintertime or, like, the October season. November, I suppose” (02282018FYU6). Burbot are fairly ubiquitous throughout the mainstem Yukon River. During the radiotelemetry study burbot moved some during the warmer months, but not nearly to the degree that they did during the fall, and these were considered to be pre-spawning fish.

Spawning locations based on the criteria were noted above and below Fort Yukon and included fish that were radiotagged from the Dalton Highway, Galena, and Circle. Both river and lacustrine burbot from Alaska and other northern latitude areas have been documented to be more active during cooler months and fairly sedentary during the warmer months of spring to early fall (Scannell 2016, Tyulpanov 1967, McPhail and Paragamian 2000).

Key respondents also observed that burbot are more active nocturnally, so fishers are most successful at night (02272018FYU2). Diurnal migration has been documented in the literature for other northern areas and lakes (Cott et al. 2015, Scannell 2016). However, from the results of the radiotelemetry study, Yukon River burbot do not appear to engage in more active nocturnal behavior and were noted to move past the stationary tracking stations during all hours of the day.

A respondent mentioned that he believes that burbot residing in the Yukon and Porcupine Rivers are moving upstream during the fall, possibly to locations where they will spawn in mid- to late winter (02282018FYU6). After hearing from this key respondent, a flight was added to the itinerary. During the late April 2019 aerial tracking flight, researchers flew up the Porcupine River to the Sheenjek River and covered a few tributaries such as the Draanjik River for a few miles. A radiotagged burbot was located in the Lower Porcupine River, where there were finer sediments and a slower current. Upriver of where this fish was located, sediments were more characteristic of salmon spawning areas. We did not fly above the Sheenjek River. Therefore, it is possible that radiotagged burbot could have travelled into the upper reaches of the Porcupine River, beyond our scope of tracking. Some burbot were not detected at all. Burbot that were radiotagged near Galena and the Dalton Highway migrated above and below Fort Yukon prior to spawning. However, there was some pre-spawning downriver migration past Fort Yukon of burbot that were radiotagged near Circle. During the summer aerial tracking flights, the burbot from Galena and the Dalton Highway that had migrated upriver and downriver of Fort Yukon were seen to travel back downriver after spawning.

Lifecycle Data

Residents of all 3 study communities considered burbot prime eating in late fall, around November, when their livers, a favored delicacy, were enlarged and the flesh contained more oil. Fishers from Pilot Station have reported targeting burbot in cold-season months primarily because “their liver content in the summer is [poor], nothin’ on there just a long liver” (01182018PQS2). Similarly, Fort Yukon fishers have reported that although burbot are captured and eaten year-round, they are particularly sought after in the fall when they have prime fat stores and rich, oily flesh. This study did not capture and evaluate liver weight to total weight of burbot during the summer months as was done for the 24 burbot that were sampled during early February near the Dalton Highway. However, burbot are fairly sedentary during the warmer months of spring to early fall with much lower feeding activity (Tyulpanov 1967, McPhail and Paragamian 2000). Burbot, like most gadids, store fat in their livers and use this fat to produce eggs and milt in preparation for spawning. Brown et al. (2005) documented that anadromous Arctic lampreys migrate up the Yukon River during October–December, and Galena residents have reported seeing burbot stomachs that are full of this fatty prey, in addition to the least cisco and the fry of other fish species (04262018GAL2). Many of the post-spawning burbot that were captured near the Dalton Highway bridge had shrunken livers and appeared emaciated. Because burbot do not spawn every year, there will be opportunities after the time of spawning to harvest burbot in better eating condition, if ice conditions allow.

The Yukon River Is cloudy 54hroughhout the drainage, and a respondent from Fort Yukon reported that in addition to eyesight, burbot also rely on their sense of smell to capture prey (02272018FYU2). Like all cod, burbot have a barbel, which is a whisker-like sensory organ located below its mouth. Barbels house the taste buds and are used to search for food in murky water. Because burbot are often present in cloudy water, fishers often find success in using large pieces of bait as attractants. Burbot also have good hearing, and according to Cott et al. 2014, they also vocalize utilizing their swim bladders similar to other cod species that have sensitive hearing, which probably aids spawning in murky water.

Burbot Presence off the Mainstem Yukon River

The radiotelemetry project was designed to track radiotagged burbot in the mainstem Yukon River, with short 50 mile (~80 km) or less flights up major tributaries of the Nowitna, Innoko, Koyukuk, and Tanana Rivers. When daylight and fuel allowed for exploration of some other areas, often a few radiotagged burbot were located. Capture and radiotagging of burbot often took place at the mouths of sloughs, which were good places to deploy the baited hoop traps.

The residents of Pilot Station who reported travelling to and harvesting burbot near the communities of Alakanuk and Emmonak may have utilized sloughs; burbot that were radiotagged near Pilot Station were located in or near some of these sloughs. Also, as was elaborated above, 2 burbot that were radiotagged near Galena were located during the January/February aerial tracking flights upriver of Pilot Station approximately 30 miles (~48 km) at a purported spawning location and a burbot harvest location that fishers from Pilot Station have used.

Across from Galena are numerous sloughs that community members utilize for burbot fishing within the Innoko National Wildlife Refuge and Kaiyuh Flats. While flying over this area to locate radiotagged burbot, the project biologist noted numerous snowmachine tracks and what she thought were drilled holes in the ice that may have been used for burbot set lines. Unfortunately, these flights occurred after the subsistence field work occurred, so researchers were unable to confirm what species were being targeted. Burbot that were radiotagged near Pilot Station, Galena, and the Dalton Highway were located in this area.

In the upper river during the study year, most fishing locations were within 20 miles of the community of Fort Yukon, although some fishers travelled as far southwest as Lower Ikhèenjik River Slough (Birch Creek; about 45 miles from Fort Yukon) in search of burbot. Radiotagged burbot were located within the mainstem Porcupine River, as well as in sloughs near the upper and lower mouths of the river. The Lower and Upper Ikhèenjik River mouths as well as the Ikhèenjik River Slough were covered during the June/July 2019 aerial tracking flight, but no radiotagged burbot were located. However, one burbot that was radiotagged near Circle was located in Lower Beaver Creek near the confluence with Beaver Slough during this flight. The habitat in this area is similar to that located in the nearby Ikhèenjik River system. Given that 293 radio transmitters were deployed to represent burbot throughout a huge drainage and not all of these off-mainstem areas were covered during each flight, it is conceivable that a radiotagged burbot may have visited the Ikhèenjik River and slough at some time during the 2-year project.

Size

Respondents from Galena reported that burbot caught during early winter tend to be larger than those caught prior to freeze-up. One respondent noted, “Later in the year October, November we get the bigger fish” (04252018GAL4). In the early 1990s, Matt Evenson, a retired ADF&G

fisheries biologist, conducted a radiotelemetry study on Tanana River burbot and showed that larger burbot have a propensity to travel longer distances (Evenson 2000). A similar pattern was also shown in this radiotelemetry study. So, not only were burbot noted to move more during fall, mostly associated with pre-spawning migrations, but larger burbot tended to move greater net distances over the 2-year study. Because larger burbot seem to travel further distances, the burbot Galena respondents were describing could have come from anywhere in the drainage. Radiotagged burbot from all tagging locations were noted to migrate upriver and/or downriver of Galena. Taken together, the TEK observations of size and timing and the radiotelemetry results suggest a strong correlation between size and distance traveled.

Temperature

The radiotelemetry study has shown that burbot are active year-round but are far more active in the fall and much less so during the warmest months of spring, summer, and early fall where movements and feeding activity are significantly lower (Tyulpanov 1967, McPhail and Paragamian 2000). Burbot will try to avoid warm water during the warmest months of the year by relocating to deeper areas of a river or lake, and this was noted during the June/July aerial tracking flights (Scannell 2016, Hardewig et al. 2004). Studies have also shown that their physiological performance is maximized at cold water temperatures (Paakkonen et al. 2003). In the Yukon River, burbot spawn during the coldest, darkest time of the year, and the temperature at the Dalton Highway was recorded at 0.1°C during the first week of February 2020. Preferred spawning temperatures have been noted between 0.5°C and 4°C for burbot that spawn in southern Canada (Paragamian and Wakkinen 2008).

Several key respondents from Pilot Station expressed concern for the environmental changes they have witnessed in recent decades. Fishers are also concerned that changes in weather may be affecting burbot behavior by altering their movements up and down the river and potentially affecting their health. In addition, key respondents from Galena indicated that later freeze-ups are causing a change in the timing of burbot fishing from mid-late October to mid-November. Information provided by residents and local weather stations over the last several decades indicates a steady increase in ice-free days during both spring and fall seasons for residents of Fort Yukon (Brown et al. 2018). Climate change is a concern for burbot as well as other important fish species that subsistence users depend on. Because burbot prefer colder temperatures, especially during the time of spawning, it is uncertain what effect warmer summers will have on oversummering behavior and winter spawning. As ice conditions become less predictable, subsistence fishers are having a more difficult time accessing their traditional winter fishing locations. This creates a risk to fishers themselves and to their food supply. Record warm water temperatures were recorded near Emmonak of 22°C during 14–19 July 2019 and 19.5°C at the Dalton Highway on 24 July 2019. Burbot prefer summer temperatures between 10°C and 14°C, although thermal maximum temperatures have been reported at 26.8–31.7°C (Hofmann and Fischer 2002). It is unknown what thermal maximum Yukon River burbot could tolerate.

CONCLUSION

Taken together, the TEK and radiotelemetry results gathered for this study improved our understanding of burbot in the Yukon River. The localized TEK that was documented in Pilot Station, Galena, and Fort Yukon not only corroborated the results from the radiotelemetry study, but also informed expansion of the aerial tracking efforts when time and funding allowed. This was especially valuable given the challenges and logistics of working in a large river drainage.

Ethnographic respondents shared their understanding of other facets of burbot biology such as diets, movement, and behavior in addition to their fishing practices. Fishing practices throughout the 3 study communities varied, but all respondents described targeted harvesting efforts that took place in the fall and winter when ice was present and fish were fatty. Respondents are concerned how changing ice conditions will impact how they access burbot fishing locations. Burbot are a slow-growing, long-lived species that have a high phenotypic plasticity with respect to migration behavior. During this 2-year study a variety of behaviors were documented, among these that some burbot travel extensively throughout the drainage to spawn and feed, whereas others occupy a more localized range.

Although much was learned about the life history of Yukon River burbot, this study also raises additional questions for future research. How are burbot impacted by changing ice conditions in winter months? If declines in Yukon River salmon abundance continue, will subsistence harvest of burbot increase enough to warrant closer monitoring of this species? Do burbot in the Yukon River make up a single stock, and if so, do they follow similar spawning and migration patterns of other burbot from the same stock? Exploring these questions in the future will contribute to a better understanding of the biological nature of these fish and the extent they are relied on by Yukon River residents.

ACKNOWLEDGMENTS

The U.S. Fish and Wildlife Service, Office of Subsistence Management, provided $380,464 in funding support for the duration of this project (2017–2021) through the Fisheries Resource Monitoring Program under agreement F16AC00718. Heather Scannell initiated the radiotelemetry portion of this project, and her primary project crew leader was Loren St. Amand. In addition, field assistance was provided from James Savereide, Laura Gutierrez, April Behr, Rick Queen, Dave Stoller, Matt Stoller, Matt Albert, Joe Spencer, and John Chythlook. Matt Tyers wrote the riverdist software package, and Jordy Bernard implemented it and performed other biometric support. April Behr, James Savereide, and Matt Tyers proofread the report and provided valuable edits and comments.

Co-PI Trainor would like to express gratitude to the residents of Pilot Station, Galena, and Fort Yukon for their interest and participation in the 2017 study. During fieldwork residents were generous with their time and hospitable to the Division of Subsistence researchers who spent a week in each community, often sharing food and inviting researchers into their homes. Special thanks go to the elders and other residents that contributed their time and wisdom through participation as key respondents. Division of Subsistence staff would like to thank Martin Kelly of Pilot Station, who has been critical to the success of research projects in Pilot Station and can now be counted as a friend. In Galena, the Louden Tribal Council was instrumental in helping to identify local research assistants and possible burbot fishing households. This author is very thankful to Yvonne Carlo, our local research assistant in Galena, who, in addition to helping us with surveys, showed us around town, fed us, and made us laugh. In Fort Yukon, this research, along with numerous other Subsistence Division publications, would not have been possible without the attention, care, and knowledge that Andrew Firmin shared so passionately. He will be missed.

This report was submitted as the final technical project report to U.S Fish and Wildlife Service, Office of Subsistence Management, Subsistence Fisheries Resource Monitoring Program for project number 16-251.

REFERENCES CITED

Albert, M., and K. Wuttig. *In prep*. Movements of northern pike, burbot, and Arctic grayling in the middle Kuskokwim and Holitna rivers, 2011-2014. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Alt, K. T. 1987. Review of Sheefish (*Stenodus leucichthys*) Studies in Alaska. Alaska Department of Fish and Game, Fishery Manuscript No. 3. Juneau.

Andersen, David B., and Gretchen Jennings. 2001. The 2000 harvest of migratory birds in ten Upper Yukon River communities, Alaska. Final report no. 1 to USFWS under cooperative agreement no. 701810J252. Alaska Department of Fish and Game Division of Subsistence Technical Paper No. 268. http://www.adfg.alaska.gov/techpap/Tp268.pdf.

Arndt, S. K. A., and J. Hutchinson. 2000. Characteristics of burbot spawning in a tributary of Columbia Lake, British Columbia, over a four-year period. Pages 48-60 [*In*] V. L. Paragamian and D. W. Willis, editors. Burbot biology, ecology, and management. American Fisheries Society, Fisheries Management Section, Publication 1, Bethesda, Maryland.

Association of Canadian Universities for Northern Studies. 2003. *Ethical Principles for the Conduct of Research in the North*. Ottawa: The Association = L'Association. https://acuns.ca/wp-content/uploads/2010/09/EthicsEnglishmarch2003.pdf.

Baker, B. 2018. Fishery management report for recreational fisheries in the Tanana River management area, 2017. Alaska Department of Fish and Game, Fishery Management Report No. 18-33, Anchorage.

Boag, T. D. 1989. Growth and fecundity of burbot, Lota lota L., in two Alberta lakes. Master's Thesis, University of Alberta, Edmonton.

Brabets, T. P., B. Wang, and R. H. Meade. 2000. Environmental and hydrologic overview of the Yukon River basin, Alaska and Canada. U. S. Geological Survey, Water-Resources Investigations Report 99-4204.

Breeser, W. W., F. D Searns, M. W. Smith, R. L. West, and J. B. Reynolds. 1988. Observations of movements and habitat preference of burbot in an Alaskan glacial river system. Transactions of the American Fisheries Society 117(6): 506-509.

Brown, C., D. Koster, and P. Koontz. 2010. Traditional ecological knowledge and harvest survey of nonsalmon fish in the Middle Yukon Region, Alaska, 2005-2008. Final report to the U.S. Fish and Wildlife Service Office of Subsistence Management to fullfill olbligations for Study No. FIS 06-253. Alaska Department of Fish and Game Division of Subsistence Technical Paper No. 358, Fairbanks.

Brown, C. L., A. Brenner, H. Ikuta, E. H. Mikow, B. Retherford, L. J. Slayton, A. Trainor, J. Park, D. Koster, and M. L. Kostick. 2015. The harvest and uses of wild resources in Mountain Village, Marshall, Nulato, Galena, and Ruby, Alaska, 2010. Alaska Department of Fish and Game, Division of Subsistence Technical Paper No. 410, Fairbanks.

Brown, C. L., J. Burr, K. Elken, and R. J. Walker. 2005. Contemporary subsistence uses and population distribution of non-salmon fish in Grayling, Anvik, Shageluk and Holy Cross. Federal Subsistence monitoring Program, Fishery Information Service, Anchorage, Alaska.

Brown, C. L., N. M. Braem, M. L. Kostick, A. Trainor, L. J. Slayton, D. M. Runfola, E. H. Mikow, H. Ikuta, C. R. McDevitt, J. Park, and J. J. Simon. 2016. Harvests and uses of wild resources in 4 Interior Alaska communities and 3 Arctic Alaska communities, 2014. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 426.

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

Brown, C. L., B. M. McDavid, C. F. Moncrieff, A. Trainor, and J. S. Magdanz. 2017. Customary trade and barter as part of a continuum of exchange practices in 3 Upper Yukon River Region communities: Fort Yukon, Manley Hot Springs, and Venetie. Alaska Department of Fish and Game, Division of Subsistence Technical Paper No. 437, Fairbanks.

REFERENCES CITED (Continued)

Brown, C. L., R. J. Walker, and S. B. Vanek. 2004. The 2002–2003 harvest of moose, caribou, and bear in Middle Yukon and Koyukuk River communities. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 280.

Brown, D. R. M., T. J. Brinkman, D. L. Verbyla, C. L. Brown, H. S. Cold, and T. N. Hollingsworth. 2018. Changing river ice seasonality and impacts on interior Alaskan communities. Weather, Climate and Society 10(4):625–640.

Carothers, C., M. Moritz, and R. Zarger. 2014. Introduction: Conceptual, methodological, practical, and ethical challenges in studying and applying indigenous knowledge. Ecology and Society 19(4): 43.

Chambers, P. A., S. Brown, J. M. Culp, R. B. Lowell, and A. Pietroniro. 2000. Dissolved oxygen decline in ice-covered rivers of northern Alberta and its effects on aquatic biota. Journal of Aquatic Ecosystem Stress and Recovery 8(1):27-38.

Chen, L. C. 1969. The biology and taxonomy of the burbot, *Lota lota leptura*, in interior Alaska. University of Alaska, Biological Paper 11, Fairbanks.

Clark, J. H., M. J. Evenson, and R. R. Riffe. 1991. Ovary size, mean egg diameters, and fecundity of Tanana River burbot. Alaska Department of Fish and Game, Fishery Data Series No. 91-64, Anchorage.

Cochran, W. G. 1977. Sampling techniques. John Wiley and Sons, New York, New York, USA. Equations 4.3 & 4.5 (pages 76-77).

Cott, P. A., M. M. Guzzo, A. J. Chapelsky, S. W. Milne, and P. J. Blanchfield. 2015. Diel bank migration of burbot (*Lota lota*). Hydrobiologia 757(1): 3-20.

Cott, P. A., A. D. Hawkins, D. Zeddies, B. Martin, T. A. Johnston, J. D. Reist, J. M. Gunn, and D. M. Higgs. 2014. Song of the burbot: under-ice acoustic signaling by a freshwater gadoid fish. Journal of Great Lakes Research 40(2):435-440.

Cott, P. A., T. A. Johnston, and J. M. Gunn. 2013. Sexual dimorphism in an under-ice spawning fish: the burbot (*Lota lota*). Canadian Journal of Zoology 91(10):732-740.

Dreese, L. M., and J. D. Lozori. 2019. Sonar estimation of salmon passage in the Yukon River near Pilot Station, 2018. Alaska Department of Fish and Game, Fishery Data Series No. 19-16, Anchorage.

Dunnigan, J. L., and C. L. Sinclair. 2008. Home range and movement patterns of burbot in Koocanusa Reservoir, Montana, USA. Pages 43-54 [*In*] V. L. Paragamian and D. H. Bennett, editors. Burbot: ecology, management, and culture. American Fisheries Society, Symposium 59, Bethesda, Maryland.

Eiler, J. H. 2012. Tracking aquatic animals with radio telemetry. Pages 163-204 [*In*] N. S. Adams, J. W. Beeman, and J. H. Eiler, editors. Telemetry techniques: a user guide for fisheries research. American Fisheries Society, Bethesda, Maryland.

Efron, B., and R. J. Tibshirani. 1994. An introduction to the bootstrap. CRC Press.

Elmer, K. R., J. K. J. Van Houdt, A. Meyer, and F. A. M. Volckaert. 2008. Population genetic structure of North American burbot (*Lota lota maculosa*) across the Nearctic and at its contact zone with Eurasian burbot (*Lota lota lota*). Canadian Journal of Fisheries and Aquatic Science 65(11): 2412-2426.

Evenson, M. J. 1989. Biological characteristics of burbot in rivers of Interior Alaska during 1988. Alaska Department of Fish and Game, Fishery Data Series No. 109.

Evenson, M. J. 1990. Movement, abundance, and length composition of burbot in rivers of interior Alaska during 1989. Alaska Department of Fish and Game, Fishery Data Series No. 90-3, Anchorage.

Evenson, M. J. 1993. Seasonal movements of radio-implanted burbot in the Tanana River drainage. Alaska Department of Fish and Game, Fishery Data Series No. 93-47, Anchorage.

Evenson, M. J. 2000. Reproductive traits of burbot in the Tanana River, Alaska. Pages 61-70 [*In*] V. L. Paragamian and D. W. Willis, editors. Burbot biology, ecology, and management. American Fisheries Society, Fisheries Management Section, Publication 1, Bethesda, Maryland.

REFERENCES CITED (Continued)

Federal Emergency Management Agency (FEMA). 2019. Community flood risk reduction: Galena, Alaska flood recovery. Federal Emergency Management Agency. https://www.fema.gov/sites/default/files/2020-09/galena-risk-reduction_case-study.pdf.

Fisher, S. 2000. Early life history observations of burbot utilizing two Missouri River backwaters. Pages 96-101 [*In*] V. L. Paragamian and D. W. Willis, editors. Burbot biology, ecology, and management. American Fisheries Society, Fisheries Management Section, Publication 1, Bethesda, Maryland.

Funk, C. 2010. The bow and arrow war days on the Yukon-Kuskokwim Delta of Alaska. Ethnohistory 57(4):523–569.

Godduhn, A. R., C. R. McDevitt, M. L. Kostick, C. L. Brown, and D. M. Runfola. 2020. Subsistence harvest and use of nonsalmon fish in coastal Yukon-Kuskokwim Delta communities, 2017. Alaska Department of Fish and Game, Division of Subsistence Technical Paper No. 458, Fairbanks.

Hardewig, I., O. Portner, and P. V. Dijk. 2004. How does the cold stenothermal gadoid *Lota lota* survive high water temperatures during the summer? Journal of Comparative Physiology B 174(2): 149-156.

Heim, K. C., M. E. Steeves, T. E. McMahon, B. D. Ertel, and T. M. Koel. 2018. Quantifying uncertainty in aquatic telemetry: using received signal strength to estimate telemetry error. North American Journal of Fisheries Management 38(5): 979-990.

Hoffman, N., and P. Fischer. 2002. Temperature preference and critical limits of burbot: implications for habitat selections and ontogenetic habitat shift. Transactions of the American Fisheries Society 131(6): 1164-1172.

Howard, K. G., K. M. Miller, and J. Murphy. 2017. Estuarine fish ecology of the Yukon River Delta, 2014-2015. Alaska Department of Fish and Game, Fishery Data Series No. 17-16, Anchorage

Huntington, H. P., N. M. Braem, C. L. Brown, E. Hunn, T. M. Krieg, P. Lestenkof, G. Noongwook, J. Sepez, M. F. Sigler, F. K. Wiese, and P. Zavadil. 2013. Local and traditional knowledge regarding the Bering Sea ecosystem: Selected results from five indigenous communities. Deep Sea Research Part II: Topical Studies in Oceanography 94: 323–32.

Ikuta, H., D. M. Runfola, J. J. Simon, and M. L. Kostick. 2016. Subsistence harvests in 6 communities on the Bering Sea, in the Kuskokwim River drainage, and on the Yukon River, 2013. Alaska Department of Fish and Game, Division of Subsistence Technical Paper No. 417, Fairbanks. http://www.adfg.alaska.gov/techpap/TP417.pdf.

Jones, D. R., J. W. Kiceniuk, and O. S. Bamford. 1974. Evaluation of the swimming performance of several species of fish from the Mackenzie River. Journal of the Fisheries Research Board of Canada 31(10): 1641-1647.

Kavaliers, M. 1980. Circadian locomotor activity rhythms of the burbot, *Lota lota*: seasonal differences in period length and the effect of pinealectomy. Journal of Comparative Physiology 136(3): 215-218.

Koporikov, A. R., V. D. Bogdanov, L. E. Yalkovskaya, S. B. Rakitin, Y. Y. Khrunyk, A. S. Aldokhin, A. A. Chemagin, T. K. Tuneva, and A. V. Borodin. 2017. Russian Journal of Ecology 48(5):449-458.

Korsakovskiy, P., and I. Y. Vasilev. 1988. Russian exploration in Southwest Alaska: The travel journals of Petr Korsakovskiy (1818) and Ivan Ya Vasilev (1829). Edited by J. W. VanStone. Translated by D. H. Kraus. The Rasmuson Library Historical Translation Series, v. 4. Fairbanks: University of Alaska Press.

Koskey, M., and K. Mull. 2011. Traditional ecological knowledge and biological sampling of nonsalmon fish species in the Yukon Flats Region, Alaska. Final Report for Study 06-252. Alaska Department of Fish and Game, Division of Subsistence Technical Paper No. 362, Fairbanks. http://www.subsistence.adfg.state.ak.us/TechPap/TP362.pdf.

Marcotte, J. R. 1990. Subsistence harvest of fish and wildlife by residents of Galena, Alaska, 1985-86. Technical Paper 155. Alaska Department of Fish and Game, Division of Subsistence, Juneau.

Marshall, C. T., N. A. Yaragina, Y. Lambert, and O. S. Kjesbu. 1999. Total lipid energy as a proxy for total egg production by fish stocks. Nature 402(6759): 288–290.

McKennan, Robert A. 1965. The Chandalar Kutchin. Arctic Institute of North America. Technical Paper No. 17. Montreal.

REFERENCES CITED (Continued)

McPhail, J. D, and C. C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Fisheries Research Board Canada, Bulletin 173, Ottowa.

McPhail, J. D., and V. L. Paragamian. 2000. Burbot biology and life history. Pages 11-23 [*In*] V. L. Paragamian and D. W. Willis, editors. Burbot biology, ecology, and management. American Fisheries Society, Fisheries Management Section, Publication 1, Bethesda, Maryland.

Mishler, C. 1990. Missionaries in collision: Anglicans and oblates among the Gwich'in, 1861–68. ARCTIC 43(2): 121–26.

Nelson, R. K. 1974. Relationships between Eskimo and Athapaskan cultures in Alaska: An ethnographic perspective. Arctic Anthropology 11 (Supplement: Festschrift issue in honor of Chester S. Chard): 48–53.

Pakkonen, J. P., O. Tikkanen, and J. Karjalainen. 2003. Development and validation of a bioenergetics model for juvenile and adult burbot. Journal of Fish Biology 63(4):956-969.

Paragamian, V. L. and V. D. Wakkinen. 2008. Seasonal movement of burbot in relation to temperature and discharge in the Kootenai River, Idaho, USA and British Columbia, Canada. Pages 55-77 [*In*] V. L. Paragamian and D. H. Bennett, editors. Burbot: ecology, management, and culture. American Fisheries Society, Symposium 59, Bethesda, Maryland.

Paragamian, V. L., and V. Whitman. 1998. Kootenai River inventory, stock status of burbot in the Kootenai River. Idaho Department of Fish and Game, Bonneville Power Administration. Annual Progress Report, Project 88-65, Boise.

Percy, R. 1975. Fishes of the outer Mackenzie Delta. Environment Canada, Beaufort Sea Project, Technical Report No. 8, Winnipeg.

Pulliainen, E., and K. Korhonen. 1990. Seasonal changes in condition indices in adult mature and non-maturing burbot. *Lota lota* (L.), in the north-eastern Bothnian Bay, northern Finland. Journal of Fish Biology 36(2):251-259.

Pulliainen, E., K. Korhonen, L. Kankaanranta, and K. Maeki. 1992. Non-spawning burbot on the northern coast of the Bothnian Bay. Ambio 21(2): 170-175.

Ripley, B. D. 1977. Modelling spatial patterns. Journal of the Royal Statistical Society Series B 39(2): 172–212.

Roach, S. M., and M. J. Evenson. 1993. A geometric approach for estimating and predicting fecundity of Tanana River burbot. Alaska Department of Fish and Game, Fishery Data Series No. 93-38, Anchorage.

Runfola, D. M. A. R. Godduhn; C. R. McDevitt, and M. L. Kostick. 2018. Subsistence Harvest and Use of Nonsalmon Fish in 6 Lower Yukon River Communities, 2014 and 2015. ADF&G Division of Subsistence, Technical Paper No. 438.

Scannell, H. S and B. Baker. 2021. Fishery Management Report for sport fisheries in the Area, 2019. Alaska Department of Fish and Game, Fishery Management Report, Fairbanks.

Scannell, H. S. 2016. Seasonal thermal habitat use and bathymetric distribution of burbot in Tanada and Copper lakes, Alaska. Master's Thesis, University of Alaska, Fairbanks.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board Canada, Bulletin 173, Ottawa.

Sillitoe, P. 1998. The development of indigenous knowledge: a new applied anthropology. Current Anthropology 39(2): 223-252.

Slobodin, Richard. 1981. Kutchin. [*In*] Handbook of North American Indians. Vol. 6: Subarctic. Washington D.C.: Smithsonian Institution Press.

Sorokin, V. N. 1971. The spawning and spawning grounds of the burbot, *Lota lota* (L.). Journal of Ichthyology 11(6):907-916.

REFERENCES CITED (Continued)

Stuby, L. 2008. An evaluation of precision in age assessment of thin-sectioned and whole otoliths and the efficacy of using oxytetracycline as an aid in validating otolith annuli in burbot. Pages 235-247 [*In*] V. L. Paragamian and D. H. Bennett, editors. Burbot: ecology, management, and culture. American Fisheries Society, Symposium 59, Bethesda, Maryland.

Stuby, L. 2016. Status of sheefish in Highpower Creek and Upper Kuskokwim River, 2012-2015. Alaska Department of Fish and Game, Fishery Data Series No. 16-42, Anchorage.

Stuby, L. 2018. Contributions to the life history of Kuskokwim River inconnu. Transactions of the American Fisheries Society 147(5):879-890.

Stuby, L. 2021. Fishery management report for sport fisheries in the Yukon Management area, 2019. Alaska Department of Fish and Game, Fishery Management Report No. 21-27, Anchorage.

Stuby, L., and M. J. Evenson. 1999. Burbot research in rivers of the Tanana River drainage, 1998. Alaska Department of Fish and game, Fishery Data Series No. 99-36, Anchorage.

Sumida, V. A., and D. B. Andersen. 1990. Patterns of fish and wildlife use for subsistence in Fort Yukon, Alaska. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 179. http://www.adfg.alaska.gov/techpap/tp179.pdf.

Terrazas, M. M., J. R. Adams, P. S. Sudheesh, and K. D. Cain. 2017. Effects of diel temperature fluctuation on growth, stress response, and immune function of burbot. Transactions of the American Fisheries Society 146(5): 996-1007.

Trainor, A., H. S. Cold, and M. L. Kostick. 2020. The harvest and uses of wild resources in Fort Yukon, Alaska, 2017. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 461. http://www.adfg.alaska.gov/techpap/TP461.pdf.

Trainor, A., B. M. McDavid, L. A. Sill, and L. S. Naaktgeboren. 2019. Local traditional knowledge of the freshwater life stages of Yukon River Chinook and chum salmon in Anvik, Huslia, Allakaket, and Fort Yukon." Fairbanks: Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 447. http://www.adfg.alaska.gov/techpap/TP 447.pdf.

Tyulpanov, M. A. 1967. Investigations of the biology of the burbot in the basin of River Ob (in Russian). Uchenye Zapiski Tomskogo Universiteta 53: 133-152.

Van Lanen, J. M., C. Stevens, C. L. Brown, K. B. Maracle, and D. S. Koster. 2012. Subsistence land mammal harvests and uses, Yukon Flats, Alaska: 2008–2010 Harvest report and ethnographic update. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 377.

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. G., M. L. Albert, A. E. Behr, and J. W. Savereide. 2015. Fishery investigations along the proposed Ambler Road corridor, 2014. Alaska Department of Fish and Game, Fishery Data Series No. 15-37, Anchorage.

TABLES

Table 1.–Community meetings, study communities, 2015–2016.

Community	Community approval meeting	Fieldwork	Community data review meeting
Pilot Station	February 8, 2017	January 3, 2018–January 15, 2018	August, 2021[a]
Galena	February 21, 2017	April 23, 2018–April 30, 2018	May 10, 2021
Fort Yukon	January 18, 2018	February 20, 2018–March 2, 2018	August, 2021[a]

Source: ADF&G Division of Subsistence, 2021.

[a] Due to COVID-19 concerns, draft reports were sent to these communities for review and comment.

Table 2.–Division of Subsistence project staff.

Task/role	Name	Organization
Northern Regional Program Manager	Caroline Brown	ADF&G Division of Subsistence
Principal Investigator	Alida Trainor	ADF&G Division of Subsistence
Administrative support	Pam Amundson	ADF&G Division of Subsistence
	Tamsen Coursey-Willis	ADF&G Division of Subsistence
	Deanne Lincoln	ADF&G Division of Subsistence
Data Management Lead	David Koster	ADF&G Division of Subsistence
Programmer	Margaret Cunningham	ADF&G Division of Subsistence
Data Entry	Margaret Cunningham	ADF&G Division of Subsistence
	Halia Janssen	ADF&G Division of Subsistence
	Alexandra DePue	ADF&G Division of Subsistence
Data Cleaning/Validation	Margaret Cunningham	ADF&G Division of Subsistence
Data Analysis	David Koster	ADF&G Division of Subsistence
Cartography	Gayle Neufeld	ADF&G Division of Subsistence
Editorial Review Lead	Rebecca Dunne	ADF&G Division of Subsistence
Production Lead	Rebecca Dunne	ADF&G Division of Subsistence
Field Research Staff	Alida Trainor	ADF&G Division of Subsistence
	Kathleen Roush	ADF&G Division of Subsistence
	Jeff Park	ADF&G Division of Subsistence
	Helen Cold	ADF&G Division of Subsistence
	Brooke McDavid	ADF&G Division of Subsistence
	Seth Wilson	ADF&G Division of Subsistence
	Daniel Gonzalez	ADF&G Division of Subsistence
Local Research Assistant	Yvonne Carlo	Galena
	John L Alexander	Fort Yukon
	Michael S Peter	Fort Yukon
	Judy Alexander	Fort Yukon
	Vicky Thomas	Fort Yukon
	Travis Wayne Wilson	Fort Yukon
	Paul Shewfelt	Fort Yukon

Source: ADF&G Division of Subsistence, 2021.

Table 3.–Sample achievement, study communities, 2017.

Sample information	Community	
	Fort Yukon	Galena
Number of dwelling units	20	9
Households surveyed	14	8
Households failed to be contacted	4	1
Households declined to be surveyed	0	0
Households moved or occupied by nonresident	2	0
Total households attempted to be surveyed	18	9
Refusal rate	0.0%	0.0%
Final estimate of permanent households	18	9
Percentage of total households surveyed	77.8%	88.9%
Interview weighting factor	1.29	1.13
Sampled population	34	27
Estimated population	43.7	30.4

Source: ADF&G Division of Subsistence household surveys, 2018.

Note: Only burbot fishing households were contacted; this sample is a subset of the total population.

Table 4.–Survey length, study communities, 2017.

Community	Survey length (minutes)		
	Average	Minimum	Maximum
Fort Yukon	14	2	53
Galena	7	3	10

Source: ADF&G Division of Subsistence household surveys, 2018.

Table 5.–List of possible fates of radiotagged burbot in the Yukon River.

Fate	Fate Description
Tagging Survival and Mortality	
Not detected since deployed	Burbot that were not detected during aerial tracking flights and with the stationary tracking stations since being captured and radiotagged.
Tagging mortality	Burbot not noted to move within 1 or more years after being captured and radiotagged.
Harvest mortality	Project biologist contacted by fisher that a radiotagged burbot has been harvested.
Survived tagging and handling	Post-tagging movement detected in radiotagged burbot.
Total Locations Detected	
Lower	Mouth of Yukon River to Galena
Lower Lower	Mouth of Yukon River to Grayling
Upper Lower	Grayling to Galena
Middle	Galena to Fort Yukon
Lower Middle	Galena to Dalton Highway
Upper Middle	Dalton Highway to Fort Yukon
Upper	Fort Yukon to Eagle
Cumulative Distance Travelled	
<200 km	Distance travelled across all aerial tracking flights
200-500	Distance travelled across all aerial tracking flights
>500	Distance travelled across all aerial tracking flights

Table 6.–Distances at and between locations on the Yukon River.

Location	River mile	River kilometer	River section
Locations			
Grayling	336	541	
Galena	530	853	
Nowitna River	612	985	
Tanana	695	1,118	
Rampart	763	1,228	
Dalton Highway	820	1,320	
Beaver	932	1,500	
Fort Yukon	1,002	1,613	
Circle	1,061	1,708	
Charley River	1,124	1,809	
Eagle	1,213	1,952	
Distance between locations			
Yukon River mouth to Grayling	336	541	Lower
Grayling to Galena	194	312	Lower
Galena to Nowitna River	82	132	Middle
Nowitna River to Tanana	83	134	Middle
Tanana to Rampart	68	109	Middle
Rampart to Dalton Highway	57	92	Middle
Dalton Highway to Beaver	112	180	Middle
Beaver to Fort Yukon	70	113	Middle
Fort Yukon to Circle	59	95	Upper
Circle to Charley River	63	101	Upper
Charley River to Eagle	89	143	Upper

Table 7.–Radiotagged burbot located during the 9 aerial tracking flights during 2017–2019.

Aerial tracking flight dates	Number of radiotagged burbot	Number of radiotagged burbot located	Percent of radiotagged burbot located
30 Nov–1 Dec 2017[a]	220	39	18%
27 Jan–4 Feb 2018	220	149	68%
13–15 Apr 2018	220	146	66%
14–17 Jun 2018	220	85	39%
13–29 Oct 2018	293	138	47%
28 Jan–15 Feb 2019	293	168	57%
27–29 Apr 2019	293	169	58%
30 Jun–2 Jul 2019	293	91	31%
31 Oct, 3–5 Nov 2019[b]	293	32	11%

[a] Due to inclement weather, only 1 flight was conducted from the Canadian border to Dalton Highway.

[b] Aerial tracking flight conducted to record movement of burbot that were radiotagged near Pilot Station and Circle in fall 2018. Few burbot were located because transmitters deployed in 2017 were no longer operating.

Table 8.–Fates of Yukon River radiotagged burbot during 2017–2020.

						Areas located within the Yukon River							
						Lower		Middle		Upper	Cumulative Distance Travelled (km)[a]		
Tagging location	Total burbot radiotagged	Survived tagging and handling	Not detected since deployed	Tagging mortality	Harvest mortality	Below Grayling	Grayling to Galena	Galena to Dalton Hwy	Dalton Hwy to Ft. Yukon	Ft. Yukon to Eagle	<200	200-500	>500
Russian Mission/ Pilot Station	75	47	25	3	0	47	5	3	0	0	32	11	3
Galena	90	67	15	8	0	24	59	29	5	1	23	17	20
Dalton Hwy	90	85	3	2	4	8	15	83	31	5	50	18	15
Circle	38	35	2	1	0	1	1	3	11	35	26	7	2
Total	293	234	45	14	4	80	80	118	47	41	131	53	40

[a] The number of burbot noted to travel do not add up to the total that survived tagging and handling because some were not detected during the aerial tracking flights but were detected by the stationary tracking stations.

Table 9.–Dates when the stationary tracking stations were not operational because of low battery power incurred due to cold and dark winter conditions.

		Dates not operational (Winters)		
Stationary tracking stations	Setup dates	2017–2018	2018–2019	2019–2020
Russian Mission	15-Jun-17	31-Jan-17 to 14-Feb-18	27-Dec-18 to 11-Jan-19	Stationary tracking station vandalized and receiver missing. No data past 4 March 2019.
Galena	19-Oct-17	Did not shut off	Did not shut off	Did not shut off
Below Tanana	11-Jul-18	–	Did not shut off	3-Jan-20 to 17-Jan-20
Dalton Highway Bridge	7-Nov-17	22-Dec-17 to 23 Jan-18	23-Dec-18 to 21 Feb-19	19-Dec19 to 01-Feb-20
Manley Hot Springs	17-Jan-19	–	–	Did not shut off

Table 10.–Proportions of radiotagged burbot located in the lower, middle, and upper river sections for each aerial tracking flight by tagging location. Estimated SEs in parentheses.

River Section	30 Nov-1 Dec 2017	27 Jan-4 Feb 2018	13–15 Apr 2018	14–17 Jun 2018	13-29 Oct 2018	28–31 Jan; 5, 14 Feb 2019	27–29 Apr 2019	30 Jun-2 Jul 2019	31 Oct, 3–5 Nov 2019
Russian Mission/Pilot Station									
Below Grayling	–	0.8 (0.04)	1	1	1	0.97(0.001)	0.95(0.001)	0.95(0.003)	1
Grayling to Galena	–	0.2 (0.04)	0	0	0	0.03(0.001)	0.05(0.001)	0.05(0.003)	0
Galena to Dalton Hwy	–	0	0	0	0	0	0	0	0
Dalton Hwy to Ft. Yukon	–	0	0	0	0	0	0	0	0
Ft Yukon to Eagle	–	0	0	0	0	0	0	0	0
Galena									
Below Grayling	–	0.19 (0.003)	0.23(0.004)	0.26(0.009)	0.25(0.008)	0.19(0.004)	0.26(0.005)	0.07(0.005)	0.5(0.25)
Grayling to Galena	–	0.36 (0.005)	0.45(0.005)	0.65(0.01)	0.58(0.011)	0.51(0.007)	0.54(0.007)	0.71(0.016)	0
Galena to Dalton Hwy	–	0.43(0.005)	0.3(0.005)	0.09(0.004)	0.17(0.006)	0.27(0.005)	0.15(0.003)	0.21(0.013)	0.5(0.25)
Dalton Hwy to Ft Yukon	–	0	0	0	0	0.03(0.001)	0.05(0.001)	0	0
Ft Yukon to Eagle	–	0.02 (<0.000)	0.02(<0.000)	0	0	0	0	0	0
Dalton Highway									
Below Grayling	0	0.03(<0.000)	0.05(0.001)	0.07(0.002)	0.04(0.001)	0.05(0.001)	0.04(0.001)	0.07(0.002)	0
Grayling to Galena	0	0.05 (0.001)	0.05(0.001)	0	0.02	0.05(0.001)	0.08(0.001)	0.03(0.001)	0
Galena to Dalton Hwy	0.67 (0.005)	0.59 (0.004)	0.58(0.004)	0.82(0.005)	0.86(0.002)	0.75(0.003)	0.77(0.003)	0.83(0.005)	1
Dalton Hwy to Ft Yukon	0.33 (0.005)	0.27(0.003)	0.29(0.003)	0.11(0.004)	0.08(0.001)	0.12(0.002)	0.12(0.002)	0.07(0.002)	0
Ft Yukon to Eagle	0	0.06(0.001)	0.03(0.001)	0	0	0.03(0.001)	0	0	0
Circle									
Below Grayling	0	0	0	0	0	0	0.03(0.001)	0.04(0.002)	0
Grayling to Galena	0	0	0	0	0	0	0	0	0
Galena to Dalton Hwy	0.06 (0.003)	0.05(0.002)	0.04(0.002)	0.09(0.004)	0.07(0.002)	0.07(0.003)	0.03(0.001)	0.04(0.002)	0
Dalton Hwy to Ft Yukon	0.06 (0.003)	0.1 (0.004)	0.17(0.006)	0.22(0.008)	0.17(0.005)	0.11(0.004)	0.17(0.005)	0.13(0.005)	0.17(0.28)
Ft Yukon to Eagle	0.89 (0.006)	0.86(0.006)	0.79(0.007)	0.7(0.01)	0.77(0.006)	0.81(0.006)	0.76(0.007)	0.78(0.008)	0.83(0.28)

Table 11.–Radiotagged burbot that were detected during the time of spawning, 2018–2020.

	Tagging locations											
	2018						2019/2020					
Yukon River Sections	Russian Mission	Pilot Station[a]	Galena	Dalton Hwy	Circle	Total	Russian Mission	Pilot Station	Galena	Dalton Hwy	Circle	Total
	With timing data											
Below Grayling	0	N/A	3	2	0	5	0	1	0	1	0	2
Grayling to Galena	1	N/A	1	0	0	2	0	1	1	0	0	2
Galena to Nowitna R.	0	N/A	5	2	0	7	0	2	2	1	0	5
Nowitna R. to Tanana	0	N/A	4	0	0	4	0	0	0	0	0	0
Tanana to Rampart	0	N/A	6	0	1	7	0	0	0	0	0	0
Rampart to Dalton Hwy	0	N/A	4	1	0	5	0	0	3	0	1	4
Dalton Hwy to Beaver	0	N/A	1	13	0	14	0	0	0	3	0	3
Beaver to Fort Yukon	0	N/A	0	6	0	6	0	0	1	0	0	1
Fort Yukon to Circle	0	N/A	1	1	0	2	0	0	0	2	0	2
Circle to Charley R.	0	N/A	0	2	0	2	0	0	0	0	0	0
Charley R. to Eagle	0	N/A	0	1	0	1	0	0	0	0	0	0
Above Dalton Hwy Infer	0	N/A	1	4	1	6	0	0	0	1	0	1
Tanana R. (below Nenana)	0	N/A	0	0	0	0	0	0	1	0	0	1
Total	1	N/A	26	32	2	61	0	4	8	8	1	21

-continued-

Table 11.–Page 2 of 2.

Yukon River Sections	Tagging locations: 2018 Russian Mission	2018 Pilot Station[a]	2018 Galena	2018 Dalton Hwy	2018 Circle	2018 Total	2019/2020 Russian Mission	2019/2020 Pilot Station	2019/2020 Galena	2019/2020 Dalton Hwy	2019/2020 Circle	2019/2020 Total
	Without timing data											
Below Grayling	4	N/A	6	0	0	10	4	27	6	3	0	40
Grayling to Galena	0	N/A	15	2	0	17	0	1	16	2	0	19
Galena to Nowitna R.	0	N/A	1	3	0	4	0	0	3	6	1	10
Nowitna R. to Tanana	0	N/A	0	5	0	5	0	0	1	8	0	9
Tanana to Rampart	0	N/A	0	15	0	15	0	0	2	17	0	19
Rampart to Dalton Hwy	0	N/A	0	12	0	12	0	0	1	12	0	13
Dalton Hwy to Beaver	0	N/A	0	1	1	2	0	0	0	5	1	6
Beaver to Fort Yukon	0	N/A	0	0	1	1	0	0	0	0	2	2
Fort Yukon to Circle	0	N/A	0	0	8	8	0	0	0	0	15	15
Circle to Charley R.	0	N/A	0	0	8	8	0	0	0	0	5	5
Charley R. to Eagle	0	N/A	0	0	2	2	0	0	0	0	2	2
Tanana R.	0	N/A	0	1	0	1	0	0	0	0	0	0
Kaiyuh Flats	0	N/A	0	0	0	0	0	0	1	1	0	2
Koyukuk R.	0	N/A	0	0	0	0	0	0	1	0	0	1
Total	4	N/A	22	39	20	85	4	28	31	54	26	143

[a] Burbot were not captured and radiotagged from Pilot Station until late summer 2018.

[b] Burbot noted to swim upriver past stationary tracking station near Dalton Highway but not detected during the January/February aerial tracking flights.

Table 12.–Repeat spawning noted for the 16 burbot that met the criteria outlined in Stuby (2008).

Tagging location	Yukon River section		Repeat spawning locations	
	2018	2019	Similar	Different
Galena	Grayling to Galena	Galena to Nowitna River		Yes
Galena	Galena to Nowitna River	Beaver to Fort Yukon		Yes
Galena	Galena to Nowitna River	Grayling to Galena		Yes
Galena	Galena to Nowitna River	Galena to Nowitna River	Yes	
Galena	Rampart to Dalton Hwy	Rampart to Dalton Hwy	Yes	
Dalton Hwy	Rampart to Dalton Hwy	Dalton Hwy to Beaver		Yes
Dalton Hwy	Dalton Hwy to Beaver	Dalton Hwy to Beaver	Yes	
Dalton Hwy	Dalton Hwy to Beaver	Dalton Hwy to Beaver	Yes	
Dalton Hwy	Dalton Hwy to Beaver	Above Dalton Hwy (inferred)[a]	N/A	N/A
Dalton Hwy	Beaver to Fort Yukon	Fort Yukon to Circle		Yes
Dalton Hwy	Charley River to Eagle	Fort Yukon to Circle		Yes
Dalton Hwy	Below Grayling	Galena to Nowitna River		Yes
Dalton Hwy	Circle to Charley River	Below Grayling		Yes
Circle	Tanana to Rampart	Rampart to Dalton Hwy		Yes
Circle	Dalton Hwy to Beaver	Beaver to Fort Yukon		Yes
Circle	Circle to Charley River	Circle to Charley River	Yes	
Total spawning locations			5	10

[a] Burbot noted to swim upriver past the tracking station near the Dalton Highway but not detected during the January/February aerial tracking flights.

Table 13.–Dates and times purported pre- and post-spawning burbot travelled past the tracking stations.

Radiotagged burbot with timing data											
						Pre- and post-spawning lingering times (months)					
				Lingered at spawning location in April		Remained at spawning location			Different location		
Tagging location	#[a]	Spawned 2018 and 2019	Movement noted throughout 2018–2019[a]	2018	2019	2-5	6-9	10-12	2-5	6-9	10-12
Russian Mission	1	0	1	0	0	0	0	0	0	0	0
Pilot Station[b]	4	–	1	–	0	0	0	0	0	0	0
Galena	29	5	16	3	0	0	1	0	2	5	3
Dalton Hwy	33	8	17	9	0	3	0	1	2	7	5
Circle	2	1	1	0	0	0	0	0	0	1	0
Total	69	14	36	12	0	3	1	1	4	13	8

Radiotagged burbot without timing data											
						Lingering Times (Months)					
		Located during time of spawning 2018 and 2019	Seen 2018 and 2019 spawning areas	Located within 5 miles of 2018 and 2019 spawning areas	Movement noted throughout 2018–2019[a]	Lingered at spawning location in April		Longest time noted not to move			
Tagging Location	#					2018	2019	2-5	6-9	10-12	13-18
Russian Mission	6	2	2	1	2	0	2	1	1	0	1
Pilot Station[b]	27	–	–	–	5	–	17	7	7	6	0
Galena	40	14	14	8	1	18	19	8	6	2	7
Dalton Hwy	63	30	29	23	3	33	38	12	7	12	11
Circle	31	15	10	3	2	8	20	9	12	4	3
Total	167	61	55	35	13	59	96	37	33	24	22

[a] Includes burbot that showed time signatures during one but not both spawning years, and two burbot with spawning time signatures from 2020.

[a] Pilot Station burbot were radiotagged during August 2018, so there was no location information for January/February 2018.

Table 14.–Dates and times of pre- and post-spawning burbot that travelled past tracking stations to reach their spawning locations in one of the 10 river sections.

River sections	Tracking station	Pre-spawning migration timing				Tracking station	Post-spawning migration timing			
		#	Minimum	Maximum	Average		#	Minimum	Maximum	Average
Below Grayling	Russian Mission	6	3-Oct 15:41	25-Dec 0:18	30 Oct 18:19	Russian Mission	3	19-Apr 23:04	3-Jul 8:49	29-May 2:00
	Galena	1	22-Oct 3:03	22-Oct 3:03	22-Oct 3:03					
Grayling to Galena	Russian Mission	4	2-Dec 7:52	28-Dec 16:38	11-Dec 4:27	Russian Mission	1	12-May 3:15	12-May 3:15	12-May 3:15
Galena to Nowitna River	Russian Mission	3	12-Oct 19:57	30-Nov 9:02	12-Nov 3:50					
	Galena	13	8-Jan 6:40	30-Jan 14:54	20-Jan 20:13	Galena	11	8-Feb 23:13	9-Jun 23:29	28-Mar 20:33
Nowitna River to Tanana	Russian Mission	1	7-Dec 17:03	7-Dec 17:03	7-Dec 17:03					
	Galena	4	23-Nov 19:40	18-Jan 16:56	20-Dec 14:04	Galena	3	12-May 19:59	9-Jun 18:10	24-May 8:01
Tanana to Rampart	Galena	6	26-Nov 11:13	7-Jan 15:46	25-Dec 4:36	Galena	3	6-Mar 5:48	23-May 22:40	25-Apr 18:37
	Dalton Hwy	1	12-Nov 14:14	12-Nov 14:14	12-Nov 14:14					
Rampart to Dalton Hwy	Galena	7	28-Nov 12:10	12-Jan 17:28	20-Dec 23:01	Galena	5	26-Apr 23:36	22-May 18:29	13-May 7:29
	Dalton Hwy	1	31-Jan 23:38	31-Jan 23:38	31-Jan 23:38	Dalton Hwy	4	7-Feb 6:17	21-May 13:41	6-Apr 13:04
Dalton Hwy to Beaver	Galena	1	29-Nov 7:55	29-Nov 7:55	29-Nov 7:55					
	Dalton Hwy	10	19-Nov 16:09	21-Dec 14:18	27-Nov 20:14	Dalton Hwy	12	13-Feb 20:04	5-Jun 14:49	19-Apr 8:10
Beaver to Fort Yukon	Galena	1	19-Nov 9:13	19-Nov 9:13	19-Nov 9:13	Galena	3	29-May 4:07	6-Jun 21:27	1-Jun 3:35
	Dalton Hwy	2	15-Nov 14:04	15-Dec 14:04	30-Nov 14:04	Dalton Hwy	4	28-Feb 7:02	26-May 19:58	30-Apr 23:10
Fort Yukon to Circle	Galena	2	3-Nov 2:08	30-Nov 6:09	16-Nov 16:08	Galena	3	28-May 2:27	2-Jun 7:50	30-May 16:22
	Dalton Hwy	2	16-Nov 9:37	10-Dec 9:22	28-Nov 9:30	Dalton Hwy	3	7-May 1:17	26-May 12:53	19-May 0:08
Circle to Charley River	Dalton Hwy	1	17-Dec 11:30	17-Dec 11:30	17-Dec 11:30	Dalton Hwy	2	7-Jun 17:11	11-Jun 21:38	9-Jun 19:25

-continued-

Table 14.–Page 2 of 2.

River sections	Tracking station	Pre-spawning migration timing #	Minimum	Maximum	Average	Tracking station	Post-spawning migration timing #	Minimum	Maximum	Average
Circle to Charley River	Dalton Hwy	1	17-Dec 11:30	17-Dec 11:30	17-Dec 11:30	Dalton Hwy	2	7-Jun 17:11	11-Jun 21:38	9-Jun 19:25
Charley River to Eagle						Dalton Hwy	1	5-Jun 15:52	5-Jun 15:52	5-Jun 15:52
Above Dalton Hwy (inferred)[a]	Galena	1	29-Nov 8:23	29-Nov 8:23	29-Nov 8:23	Galena	2	28-May 17:00	4-Jun 0:15	31-May 20:37
	Dalton Hwy	6	16-Nov 6:07	30-Jan 20:53	9-Dec 10:44	Dalton Hwy	6	4-May 1:34	29-May 8:47	18-May 18:03
Above Nenana	Galena	1	24-Sep 23:45	24-Sep 23:45	24-Sep 23:45	Manley HS	1	4-May 19:42	4-May 19:42	4-May 19:42
						Galena	1	28-May 18:16	28-May 18:16	28-May 18:16
Total	All	74	24-Sep 23:45	31-Jan 23:38	11-Dec 3:21	All	68	7-Feb 6:17	3-Jul 8:49	3-May 8:37

[a] Burbot noted to swim upriver past stationary tracking station near Dalton Highway but not detected during the January/February aerial tracking flights.

Table 15.–Locations of radiotagged burbot from aerial tracking flights conducted during June–July 2018–2019.

	Tagging Locations											
	2018						2019					
Oversummering Locations	Russian Mission	Pilot Station[a]	Galena	Dalton Hwy	Circle	Total	Russian Mission	Pilot Station	Galena	Dalton Hwy	Circle	Total
Below Grayling	4	N/A	5	2	0	11	2	16	0	2	1	21
Grayling to Galena	0	N/A	15	0	0	15	0	0	8	0	0	8
Galena to Nowitna R.	0	N/A	2	2	0	4	0	0	1	4	1	6
Nowitna R. to Tanana	0	N/A	0	7	1	8	0	0	0	8	0	8
Tanana to Rampart	0	N/A	1	8	0	9	0	0	1	5	0	6
Rampart to Dalton Hwy	0	N/A	0	5	1	6	0	0	1	7	0	8
Dalton Hwy to Beaver	0	N/A	0	3	1	4	0	0	0	1	2	3
Beaver to Fort Yukon	0	N/A	0	0	4	4	0	0	0	1	1	2
Fort Yukon to Circle	0	N/A	0	0	11	11	0	0	0	0	14	14
Circle to Charley R.	0	N/A	0	0	5	5	0	0	0	0	3	3
Charley R. to Eagle	0	N/A	0	0	0	0	0	0	0	0	0	0
Other Locations												
Kaiyuh Flats	0	N/A	0	0	0	0	0	1	2	1	0	4
Lower Porcupine R.	0	N/A	0	0	0	0	0	0	0	0	1	1
Lower Tanana R.	0	N/A	0	1	0	1	0	0	0	0	0	0
Total	4	N/A	23	28	23	78	2	17	13	29	23	84
Detected during 2018 and 2019							1	–	8	17	16	42
Within 5 miles of 2018–2019 locations							1	–	5	12	7	25

[a] Pilot Station burbot were radiotagged during August 2018, so there is no location information for summer 2018.

Table 16.–Swimming speed of radiotagged burbot recorded during upriver and downriver migrations past the stationary tracking stations located near Russian Mission (RUS), Galena (GAL), Tanana (TAN), Dalton Highway (DHW), Circle (CIR), and Manley Hot Springs (MAN).

Frequency-code	Tagging location	Length (mm)	Tracking stations	Distance (km)	Time (days)	Swimming speed (km/day)
Upriver						
149.820-15	Galena	683	GAL-TAN	249	23.3	10.7
149.820-23	Galena	892	RUS-GAL	510	99.2	5.1
149.820-39	Galena	725	GAL-TAN	249	15.0	16.7
149.820-41	Galena	895	RUS-GAL	510	58.0	8.8
149.820-63	Galena	735	GAL-TAN	249	16.9	14.8
			TAN-DHW	217	17.0	12.8
	Total distance (149.780-63)[a]		GAL-DHW	467	33.9	13.8
149.820-71	Galena	686	GAL-DHW	467	62.5	7.5
149.820-91	Galena	820	GAL-TAN	249	12.0	20.9
149.820-93	Galena	830	RUS-GAL	510	42.0	12.1
149.780-19	Dalton Hwy	680	RUS-GAL	510	59.4	8.6
149.780-43	Dalton Hwy	690	GAL-TAN	249	18.6	13.4
			TAN-DHW	217	18.7	11.6
	Total distance (149.780-43)[a]		GAL-DHW	467	37.3	12.5
Downriver						
149.820-15	Galena	683	DHW-TAN	217	3.5	61.3
			TAN-GAL	249	10.2	24.5
	Total distance (149.820-15)[a]		DHW-GAL	467	13.7	34.0
149.820-52	Galena	790	MAN-TAN	129	9.5	13.6
			TAN-GAL	249	14.5	17.2
	Total distance (149.820-52)[a]		MAN-GAL	378	24	15.8
149.820-53	Galena	715	DHW-GAL	467	6.8	68.7
149.820-71	Galena	686	DHW-GAL	467	7.7	60.7
149.820-91	Galena	820	DHW-TAN	217	9.9	21.9
149.780-43	Dalton Hwy	690	DHW-GAL	467	15.6	29.9
149.820-94	Galena	967	DHW-GAL	467	104.5	4.5
149.780-50	Dalton Hwy	805	DHW-GAL	468	7.2	65.0
149.780-70	Dalton Hwy	645	DHW-GAL	467	15.6	29.9
149.900-10	Circle	607	DHW-TAN	217	16.1	13.5
			TAN-GAL	249	6.1	40.8
			GAL-RUS	510	20.2	25.3
	Total distance (149.900-10)[a]		DHW-RUS	977	42	23.1
Average upriver						11.9
Average downriver						34.1

[a] Burbot recorded during upriver and/or downriver movements on multiple stationary tracking stations.

Table 17.–Comparison of burbot fishing households to total population, Galena, 2010 and 2017.

	5-year American Community Survey (2013–2017)	Households identified as burbot fishing households	
	Estimate	Estimate	Percentage of total[a]
Total population			
Households	171.0	9.0	5.3%
Population	473.0	30.4	6.4%
Alaska Native			
Population	301.0	29.3	9.7%

Source: U.S. Census Bureau (2011) for 2010 estimate; U.S. Census Bureau for American Community Survey (ACS) 2017 estimate (5-year average); and ADF&G Division of Subsistence household surveys, 2018, for 2017 estimate.

[a] Percentage of estimated number of households and population from the 2013–2017 ACS survey.

Table 18.–Sample and demographic characteristics, Galena, 2017.

Characteristics	Community: Galena
Sampled households	8
Eligible households	9
Percentage sampled	88.9%
Sampled population	27
Estimated community population	30.4
Household size	
Mean	3.4
Minimum	2
Maximum	5
Age	
Mean	31.4
Minimum[a]	1
Maximum	77
Median	28
Alaska Native	
Estimated households[b]	
Number	9.0
Percentage	100.0%
Estimated population	
Number	29.3
Percentage	96.3%

Source ADF&G Division of Subsistence household surveys, 2018.

[a] A minimum age of zero is used for infants who are less than one year of age.

[b] The estimated number of households in which at least one head of household is Alaska Native.

Table 19.–Population estimates, Galena, 2010 and 2017.

	Census (2010)	5-year American Community Survey (2003–2017)		This study (2017)[a]	
		Estimate	Range[b]	Estimate	Range[c]
Total population					
Households	190	171.0	141–201	9.0	
Population	470	473.0	420–526	30.4	27–34
Alaska Native					
Population	324	301.0	257–345	29.3	26–32
Percentage	68.9%	63.6%	54.3–72.9%	96.3%	86.7–105.9%

Source: U.S. Census Bureau (2011) for 2010 estimate; U.S. Census Bureau for American Community Survey (ACS) 2017 estimate (5-year average); and ADF&G Division of Subsistence household surveys, 2018, for 2017 estimate.

[a] Burbot fishing households only for ADF&G Division of Subsistence surveys.

[b] ACS data range is the reported margin of error.

[c] No range of households is estimated for Division of Subsistence surveys.

Table 20.–Estimated harvests of burbot by gear type, Galena, 2017.

Resource	Percentage of households: Using	Attempting harvest	Harvesting	Receiving	Giving away	Harvest weight (lb): Total	Mean per household	Per capita	Harvest amount: Total	Unit	Mean per household	95% confidence limit (±) harvest
All gear types	100.0	100.0	100.0	0.0	62.5	453.6	50.4	14.9	108.0	ind	12.0	31.8
Handline (under ice)	–	–	–	–	–	4.7	0.5	0.2	1.1	ind	0.1	78.8
Rod and reel	–	–	–	–	–	14.2	1.6	0.5	3.4	ind	0.4	78.8
Pole setline	–	–	–	–	–	434.7	48.3	14.3	103.5	ind	11.5	34.2

Source: ADF&G Division of Subsistence household surveys, 2018.

Table 21.–Estimated burbot harvests by gear type and month, Galena, 2017.

Gear Type	Estimated harvest by month (individual fish): Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Unknown	Total
All gear types	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	27.0	48.4	31.5	0.0	108.0
Handline (under ice)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.1
Rod and reel	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	3.4
Pole setline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.8	48.4	30.4	0.0	103.5

Source: ADF&G Division of Subsistence household surveys, 2018.

Table 22.–Changes in household uses of burbot compared to recent years, Galena, 2017.

Sampled households	Valid responses[a]	Households reporting use: Total households Number	Total households Percentage	Less Number	Less Percentage	Same Number	Same Percentage	More Number	More Percentage	Households not using Number	Households not using Percentage
8	8	8	100.0%	6	75.0%	2	25.0%	0	0.0%	0	0.0%

Source: ADF&G Division of Subsistence household surveys, 2018.

[a] Valid responses do not include households that did not provide any response.

Table 23.–Reasons for less household use of burbot compared to recent years, Galena, 2017.

Valid responses[a]	Households reporting reasons for less use	Family/ personal		Resources less available		Too far to travel		Lack of equipment	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
8	6	0	0.0%	0	0%	0	0.0%	0	0%

Valid responses[a]	Households reporting reasons for less use	Less sharing		Lack of effort		Unsuccessful		Weather/ environment	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
0	0	0	0%	2	33%	0	0.0%	0	0.0%

Valid responses[a]	Households reporting reasons for less use	Other reasons		Working/ no time		Regulations		Small/ diseased animals	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
8	6	1	17%	3	50.0%	0	0.0%	0	0.0%

Valid responses[a]	Households reporting reasons for less use	Did not need		Equipment/ fuel expense		Used other resources		Competition	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
0	0	1	16.7%	0	0.0%	0	0.0%	0	0.0%

Source: ADF&G Division of Subsistence household surveys, 2018.

[a] Valid responses do not include households that did not provide any response and households that reported never using burbot.

Table 24.–Reported impacts to households reporting they did not get enough burbot, Galena, 2017.

Sample households	Households not getting enough burbot			
	Valid responses[a]		Did not get enough	
	Number	Percentage	Number	Percentage
8	8	100.0%	1	12.5%

Sample households	Impact to those not getting enough burbot									
	No response		Not noticeable		Minor		Major		Severe	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
8	0	0.0%	1	100.0%	0	0.0%	0	0.0%	0	0.0%

Source: ADF&G Division of Subsistence household surveys, 2018.

[a] Includes households failing to respond to the question and those households that reported never using burbot.

Table 25.–Sample and demographic characteristics, Fort Yukon, 2017.

Characteristics	Community: Fort Yukon
Sampled households	14
Eligible households	18
Percentage sampled	77.8%
Sampled population	34
Estimated community population	43.7
Household size	
Mean	2.4
Minimum	1
Maximum	7
Age	
Mean	32.9
Minimum[a]	2
Maximum	94
Median	35.5
Alaska Native	
Estimated households[b]	
Number	18.0
Percentage	100.0%
Estimated population	
Number	43.7
Percentage	100.0%

Source: ADF&G Division of Subsistence household surveys, 2018.

[a] A minimum age of 0 is used for infants who are less than 1 year of age.

[b] The estimated number of households in which at least one head of household is Alaska Native.

Table 26.–Comparison of burbot fishing households to total population, Fort Yukon, 2010 and 2017.

	5-year American Community Survey (2013–2017)	Households identified as burbot fishing households	
	Estimate	Estimate	Percentage of total[a]
Total population			
Households	203.0	18.0	8.9%
Population	560.0	43.7	7.8%
Alaska Native			
Population	495.0	43.7	8.8%

Source: U.S. Census Bureau (2011) for 2010 estimate; U.S. Census Bureau for American Community Survey (ACS) 2017 estimate (5-year average); and ADF&G Division of Subsistence household surveys, 2018, for 2017 estimate.

[a] Percentage of estimated number of households and population from the 2013–2017 ACS survey.

Table 27.–Population estimates, Fort Yukon, 2010 and 2017.

		5-year American Community Survey (2013–2017)		This study (2017)[a]		
	Census (2010)	Estimate	Range[b]	Estimate	Range[c]	Percentage of total[d]
Total population						
Households	246	203.0	183–223	18.0	–	8.9%
Population	583	560.0	492–628	43.7	35–53	7.8%
Alaska Native						
Population	530	495.0	429–561	43.7	35–53	8.8%
Percentage	90.9%	88.4%	76.6–100.2%	100.0%	79.5–120.5%	–

Source: U.S. Census Bureau (2011) for 2010 estimate; U.S. Census Bureau for American Community Survey (ACS) 2017 estimate (5-year average); and ADF&G Division of Subsistence household surveys, 2018, for 2017 estimate.

[a] Burbot fishing households only for ADFG Division of Subsistence surveys

[b] ACS data range is the reported margin of error.

[c] No range of households is estimated for division surveys.

[d] Percent of selected burbot fishing households and people compared to 5-year ACS estimate.

Table 28.–Estimated harvests of burbot by gear type, Fort Yukon, 2017.

Resource	Percentage of households: Using	Attempting harvest	Harvesting	Receiving	Giving away	Harvest weight (lb): Total	Mean per household	Per capita	Harvest amount: Total	Unit	Mean per household	95% confidence limit (±) harvest
All gear types	92.9	85.7	85.7	21.4	21.4	1,301.4	72.3	29.8	309.9	ind	17.2	32.4
Setnet	–	–	–	–	–	172.8	9.6	4.0	41.1	ind	2.3	95.2
Fish wheel	–	–	–	–	–	189.0	10.5	4.3	45.0	ind	2.5	70.0
Handline (under ice)	–	–	–	–	–	869.4	48.3	19.9	207.0	ind	11.5	36.3
Rod and reel	–	–	–	–	–	70.2	3.9	1.6	16.7	ind	0.9	80.0

Source: ADF&G Division of Subsistence household surveys, 2018.

Note: Resources for which the percentage using is greater than the combined received and harvested indicate use from resources obtained during a previous year.

Table 29.–Estimated burbot harvests by gear type and month, Fort Yukon, 2017.

Gear Type	Estimated harvest by month (individual fish): Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Unknown	Total
All gear types	0.0	0.0	0.0	0.0	0.0	0.0	23.1	38.6	9.0	128.6	110.6	0.0	0.0	309.9
Setnet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.6	2.6	0.0	0.0	0.0	0.0	41.1
Fish wheel	0.0	0.0	0.0	0.0	0.0	0.0	19.3	0.0	0.0	0.0	25.7	0.0	0.0	45.0
Handline (under ice)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	122.1	84.9	0.0	0.0	207.0
Rod and reel	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	6.4	6.4	0.0	0.0	0.0	16.7

Source: ADFG Division of Subsistence household surveys, 2018.

Table 30.–Reported impact to households reporting that they did not get enough burbot, Fort Yukon, 2017.

Sample households	Households not getting enough burbot			
	Valid responses[a]		Did not get enough	
	Number	Percentage	Number	Percentage
14	14	100.0%	2	14.3%

Sample households	Impact to those not getting enough burbot									
	No response		Not noticeable		Minor		Major		Severe	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
14	0	0.0%	1	50.0%	1	50.0%	0	0.0%	0	0.0%

Source: ADF&G Division of Subsistence household surveys, 2018.

[a] Includes households failing to respond to the question and those households that reported never using burbot.

Table 31.–Changes in household uses of burbot compared to recent years, Fort Yukon, 2017.

Sampled households	Valid responses[a]	Households reporting use								Households not using	
		Total households		Less		Same		More			
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
14	13	13	100.0%	2	15.4%	7	53.8%	4	30.8%	0	0.0%

Source: ADF&G Division of Subsistence household surveys, 2018.

[a] Valid responses do not include households that did not provide any response.

Table 32.–Reasons for less household uses of burbot compared to recent years, Fort Yukon, 2017.

Valid responses[a]	Households reporting reasons for less use	Family/ personal		Resources less available		Too far to travel		Lack of equipment	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
13	1	0	0.0%	0	0%	0	0.0%	0	0%

Valid responses[a]	Households reporting reasons for less use	Less sharing		Lack of effort		Unsuccessful		Weather/ environment	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
13	1	0	0%	1	100%	0	0.0%	0	0.0%

Valid responses[a]	Households reporting reasons for less use	Other reasons		Working/ no time		Regulations		Small/ diseased animals	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
13	1	0	0%	1	100.0%	0	0.0%	0	0.0%

Valid responses[a]	Households reporting reasons for less use	Did not need		Equipment/ fuel expense		Used other resources		Competition	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
13	1	0	0.0%	0	0.0%	0	0.0%	0	0.0%

Source: ADF&G Division of Subsistence household surveys, 2018.

[a] Valid responses do not include households that did not provide any response and households reporting never using burbot.

Table 33.–Reasons for more household uses of burbot compared to recent years, Fort Yukon, 2017.

Valid responses[a]	Households reporting reasons for more use	Personal		Increased availability		Used other resources		Favorable weather	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
13	4	0	0.0%	0	0.0%	0	0.0%	0	0.0%

-continued-

Table 33.–Continued.

Valid responses[a]	Households reporting reasons for more use	Received more		Needed more		Increased effort		Regulations	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
13	4	0	0.0%	0	0.0%	3	75.0%	0	0.0%

-continued-

Table 33.–Continued.

Valid responses[a]	Households reporting reasons for more use	Traveled farther		More success		Had more time		Store-bought expense	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
13	4	0	0.0%	1	25.0%	0	0.0%	0	0.0%

-continued-

Table 33.–Continued.

Valid responses[a]	Households reporting reasons for more use	Got/ fixed equipment		Substitute for unavailable resource(s)		Had more help		Other	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
13	4	0	0.0%	0	0.0%	0	0.0%	1	25.0%

Source: ADF&G Division of Subsistence household surveys, 2018.

[a] Valid responses do not include households that did not provide any response and households reporting never using burbot.

FIGURES

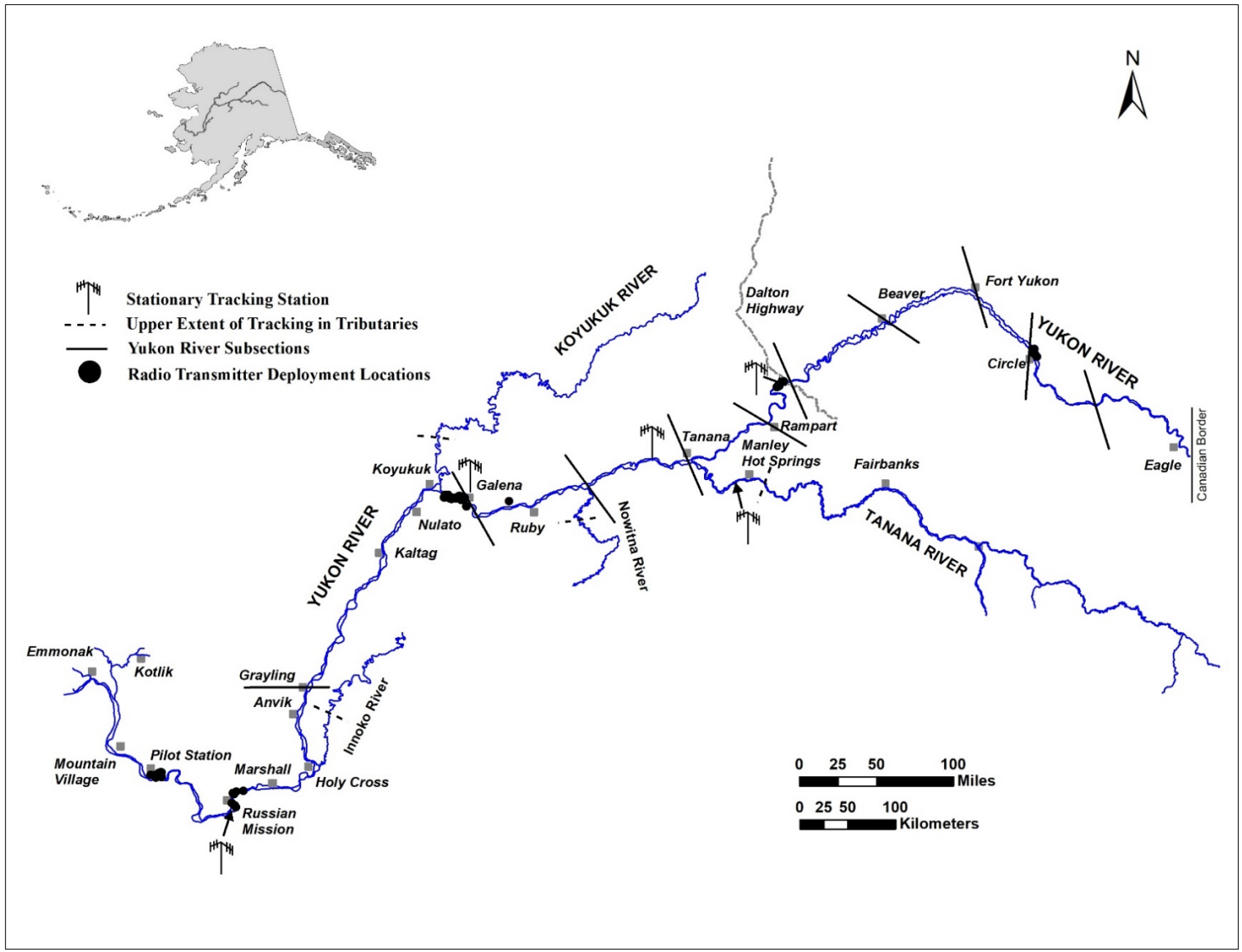


Figure 1.–Map of the Yukon River showing tracking station locations used during 2017–2020, upper extent of aerial tracking in the 4 major tributaries that were covered during each flight, areas of radio transmitter deployment, and subsections.

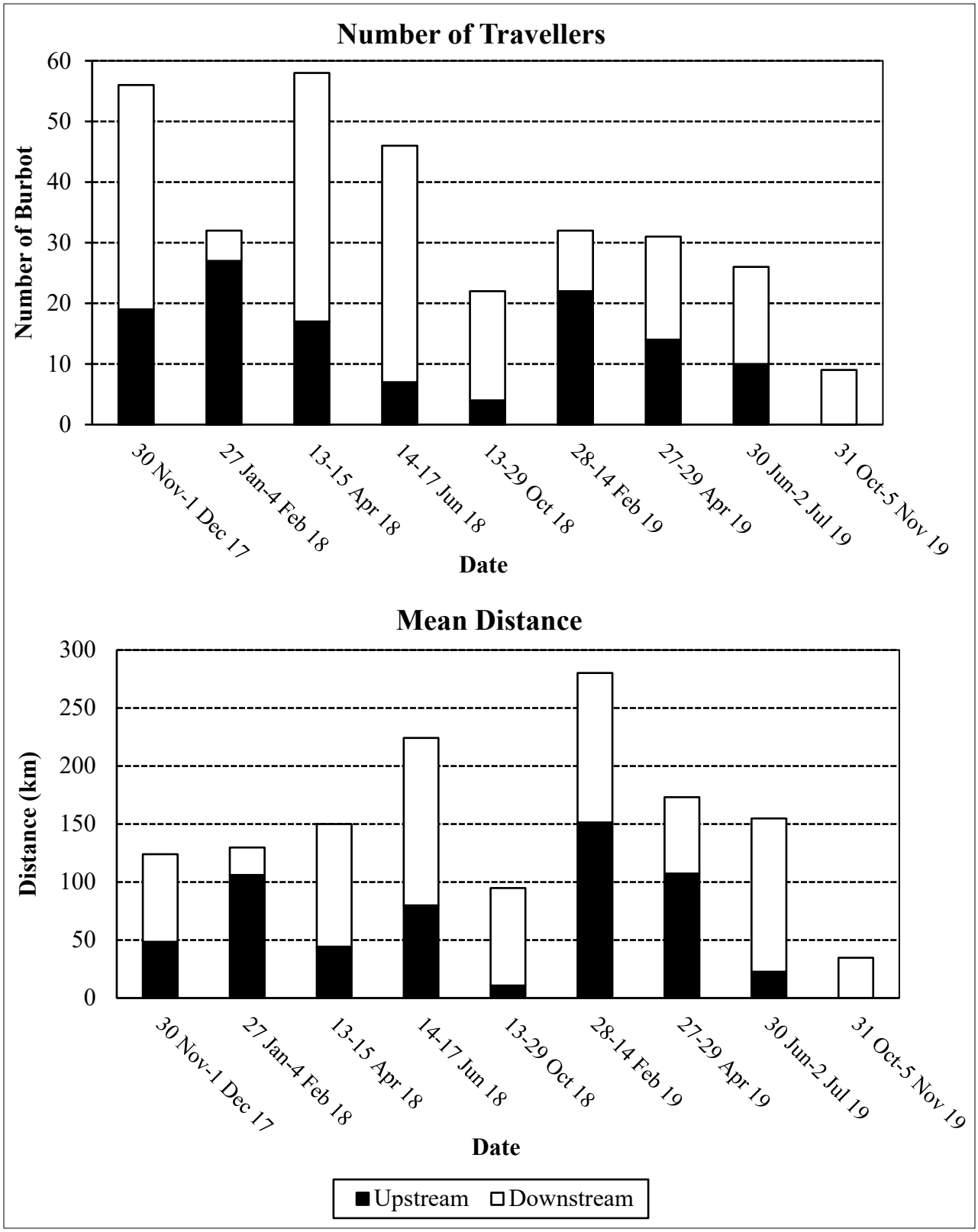


Figure 2.–Number of upstream and downstream radiotagged burbot and mean travel distances noted during the aerial tracking flights from the previous flight.

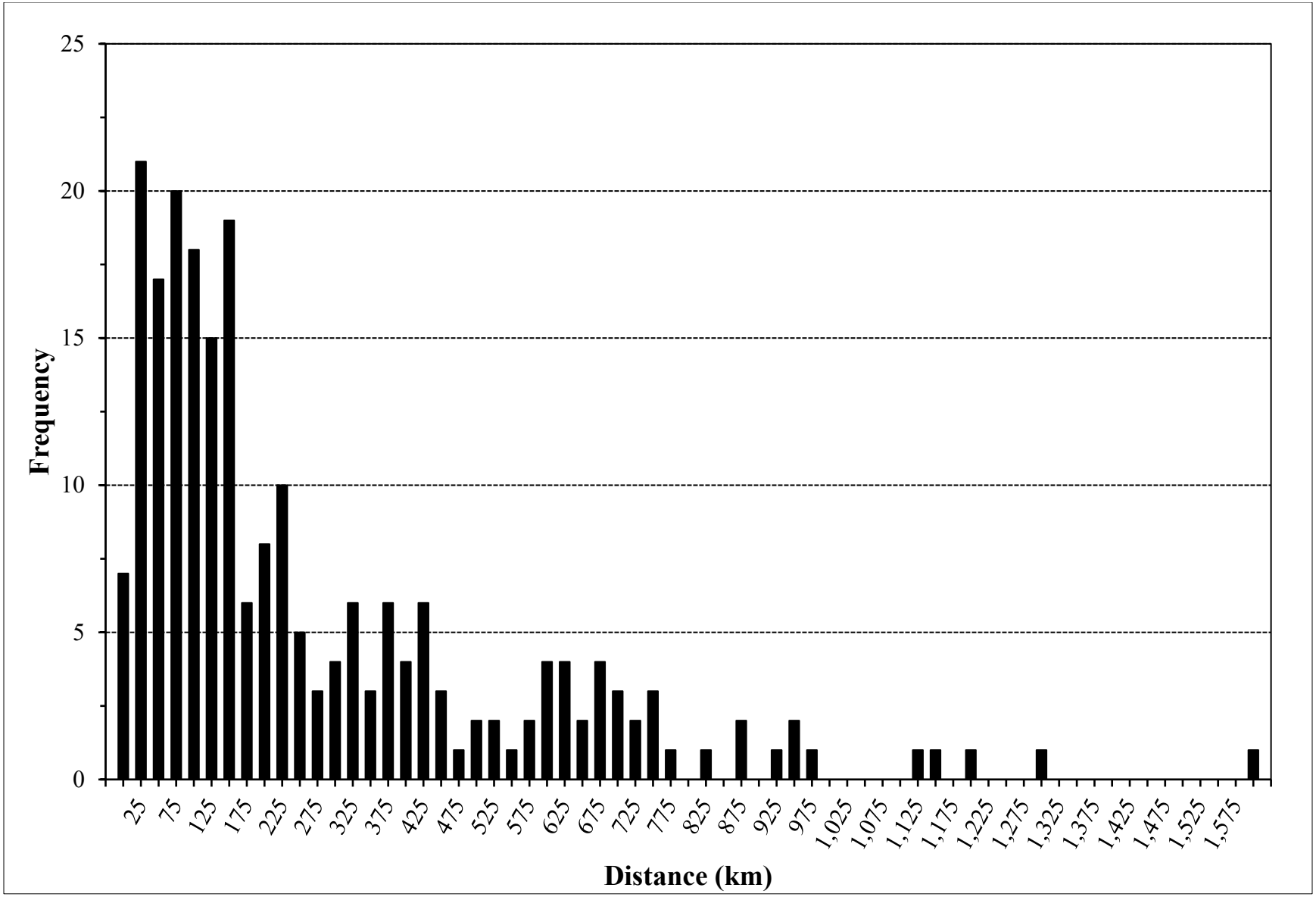


Figure 3.–Net travel distances over the 9 aerial tracking flights for burbot that were radiotagged during 2017 and 2018.

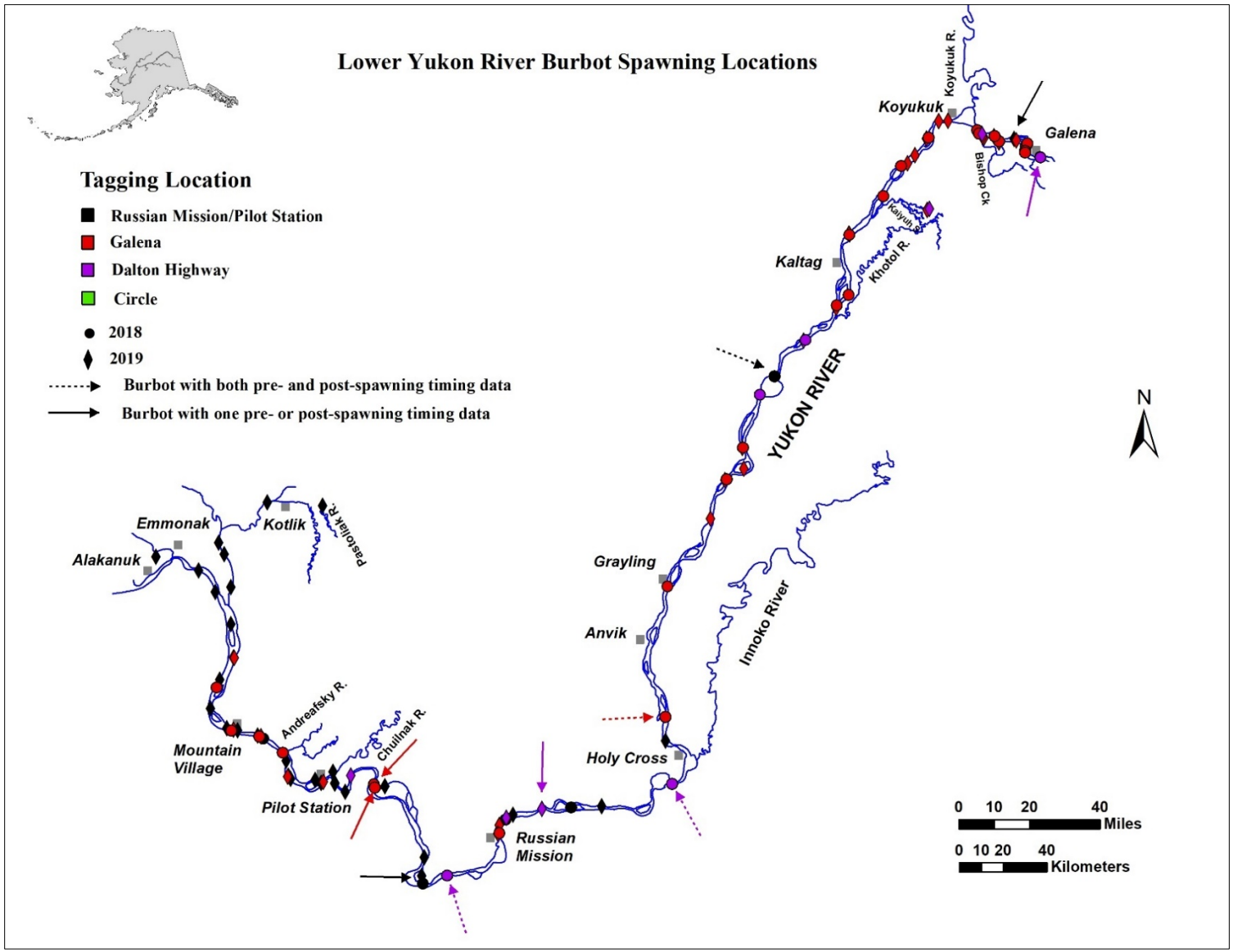


Figure 4.–Map of radiotagged burbot located during the late January/early February 2018 and 2019 aerial tracking flights in the Lower Yukon River with arrows pointing to the radiotagged fish with associated pre- and/or post-timing data.

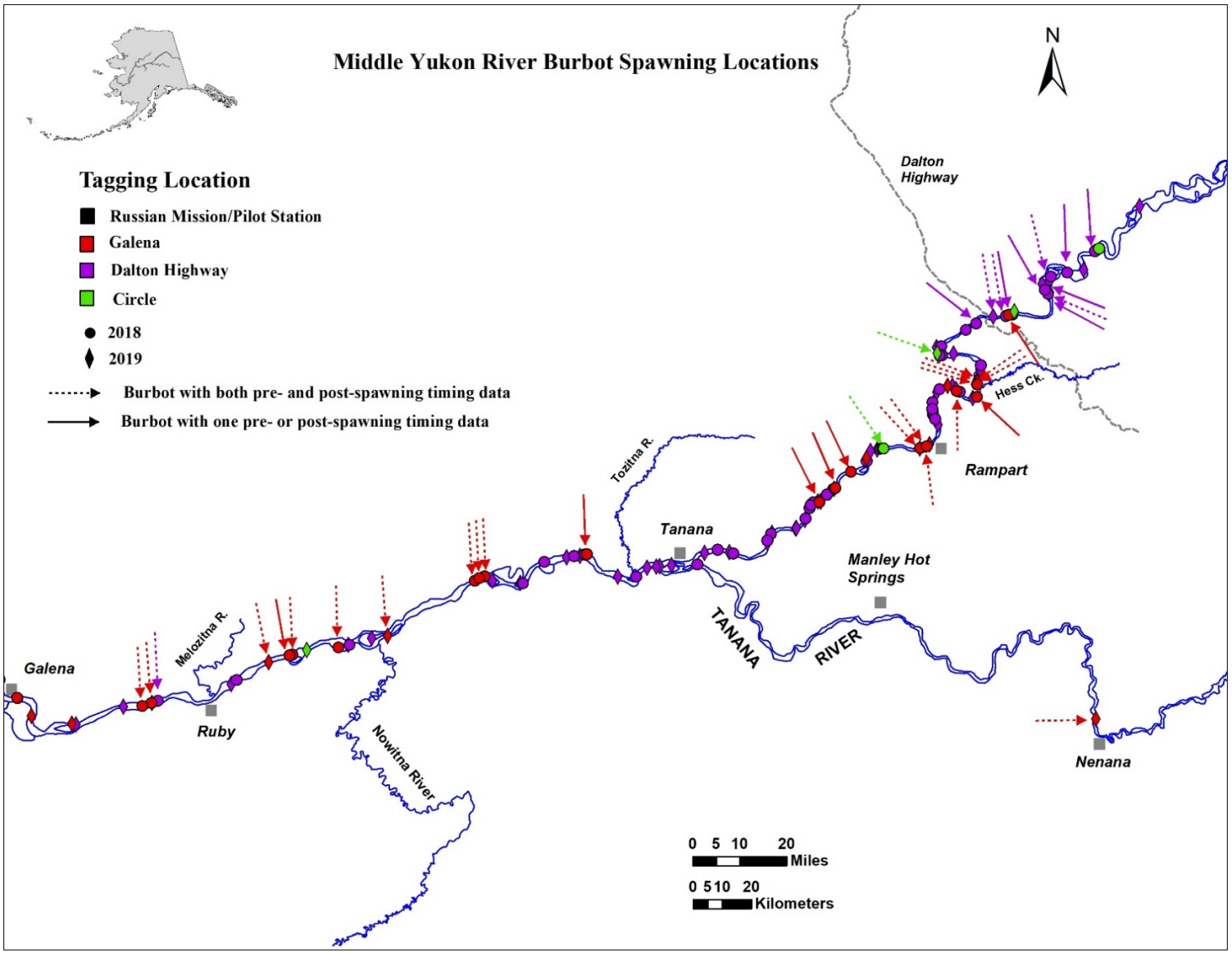


Figure 5.–Map of radiotagged burbot located during the late January/early February 2018 and 2019 aerial tracking flights in the Middle Yukon River with arrows pointing to the radiotagged fish with associated pre- and/or post-timing data.

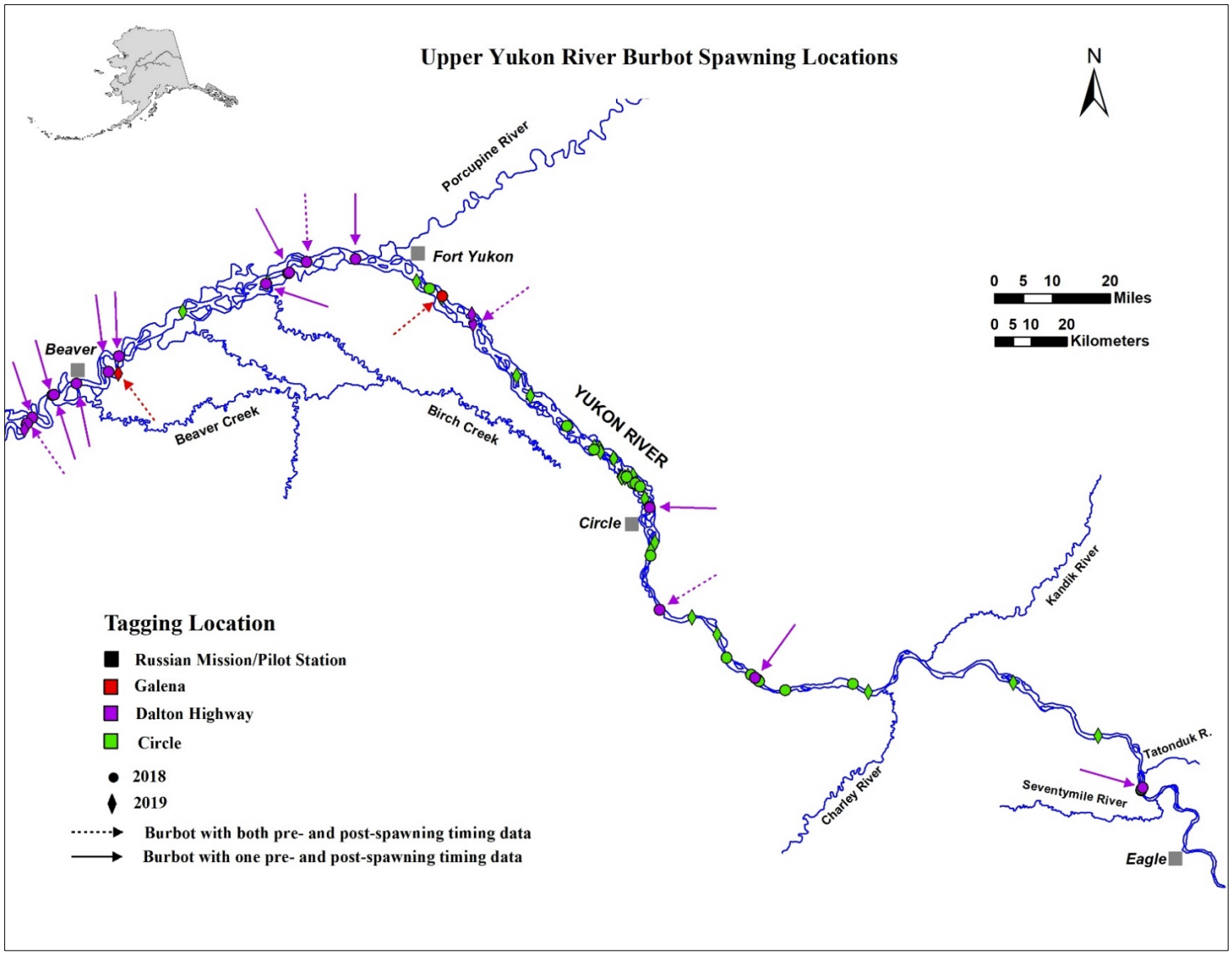


Figure 6.–Map of radiotagged burbot located during the late January/early February 2018 and 2019 aerial tracking flights in the Upper Yukon River with arrows pointing to the radiotagged fish with associated pre- and/or post-timing data.

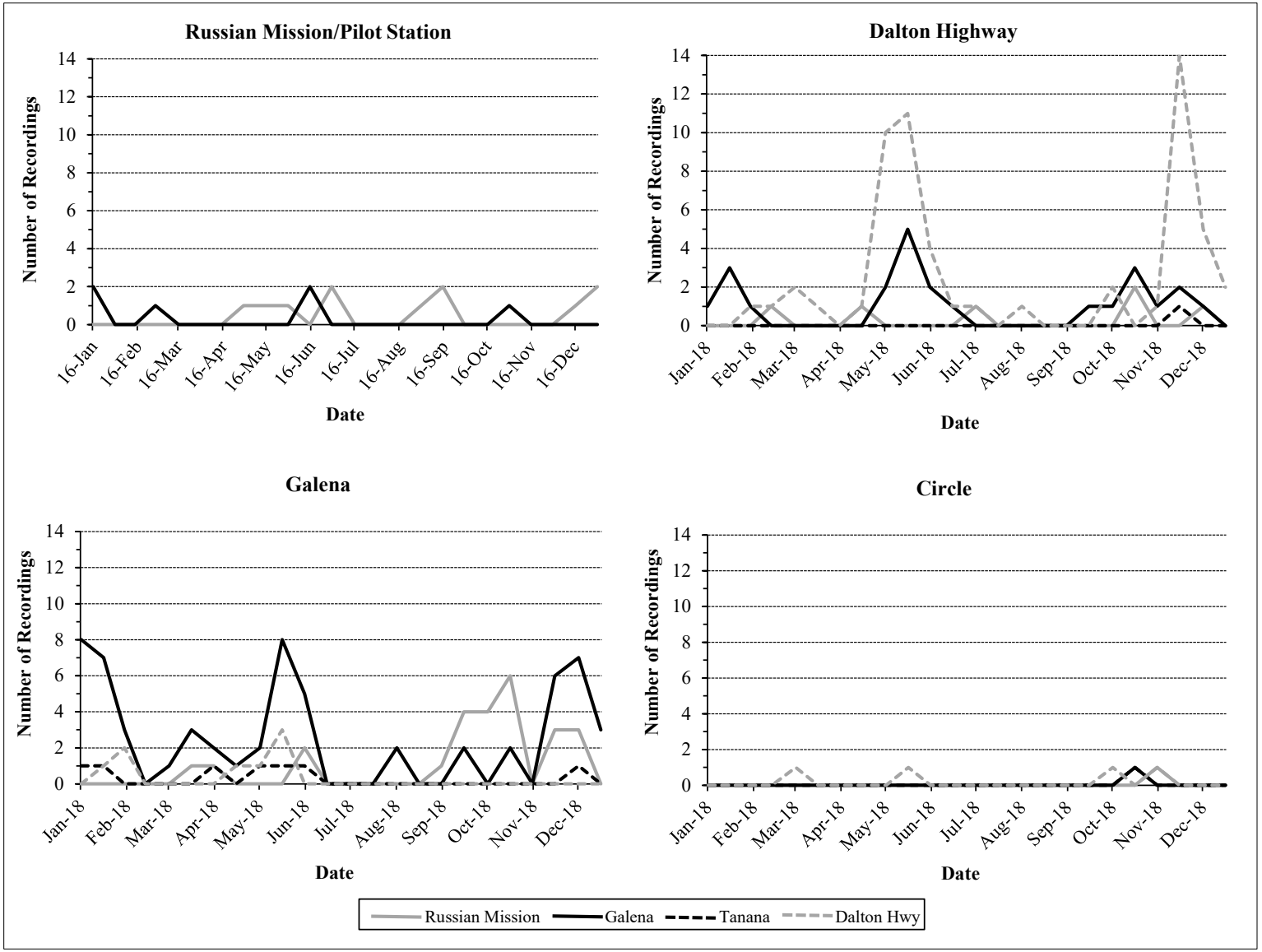


Figure 7.–Run-timing profiles for burbot that were radiotagged near Russian Mission/Pilot Station, Dalton Highway, Galena, and Circle and recorded by tracking stations during 2017–2019.

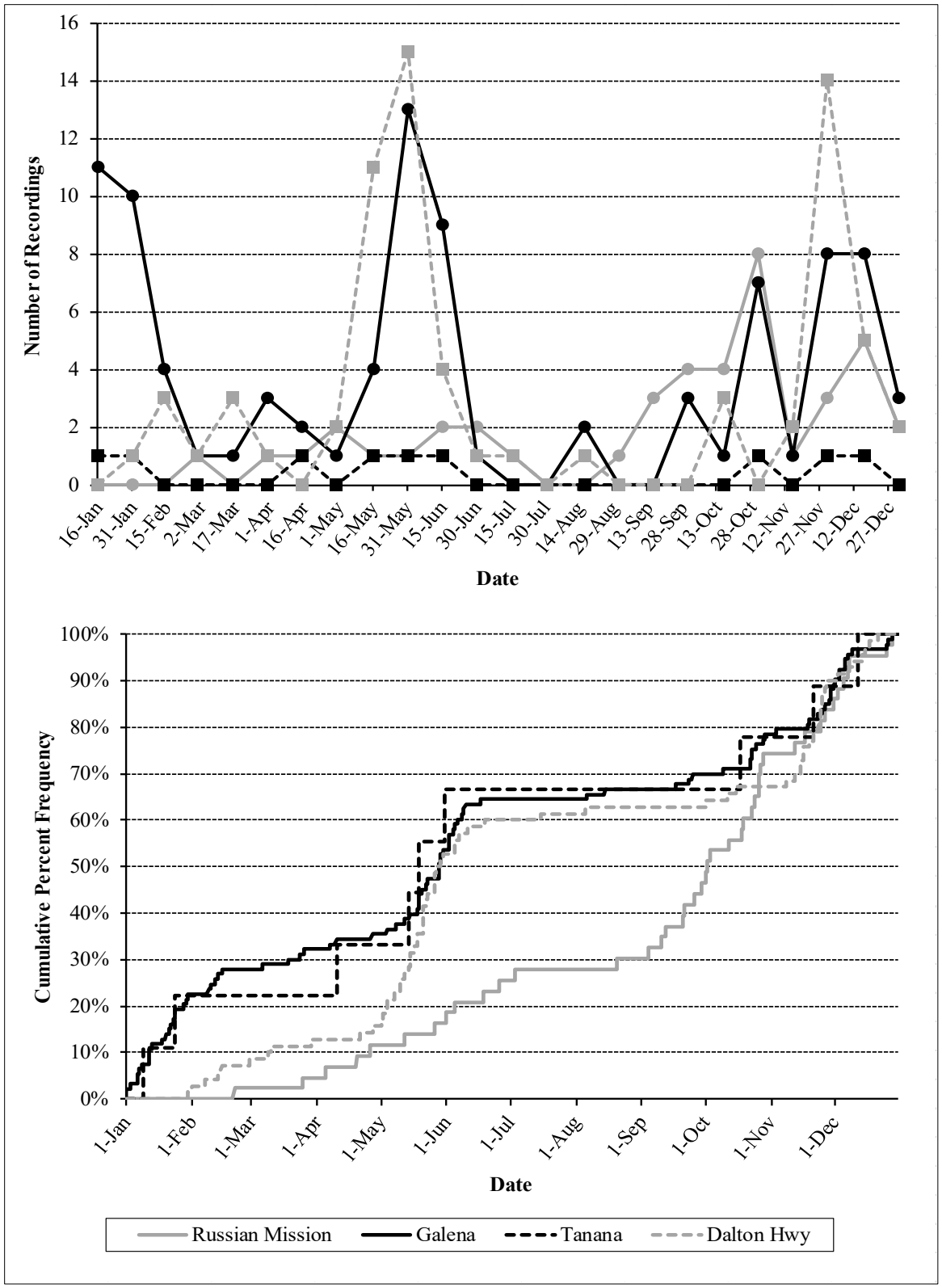


Figure 8.–Run timing profiles for the burbot that were radiotagged throughout the Yukon River during 2017 and 2018 and recorded past tracking stations located near Russian Mission, Galena, Tanana, and the Dalton Highway.

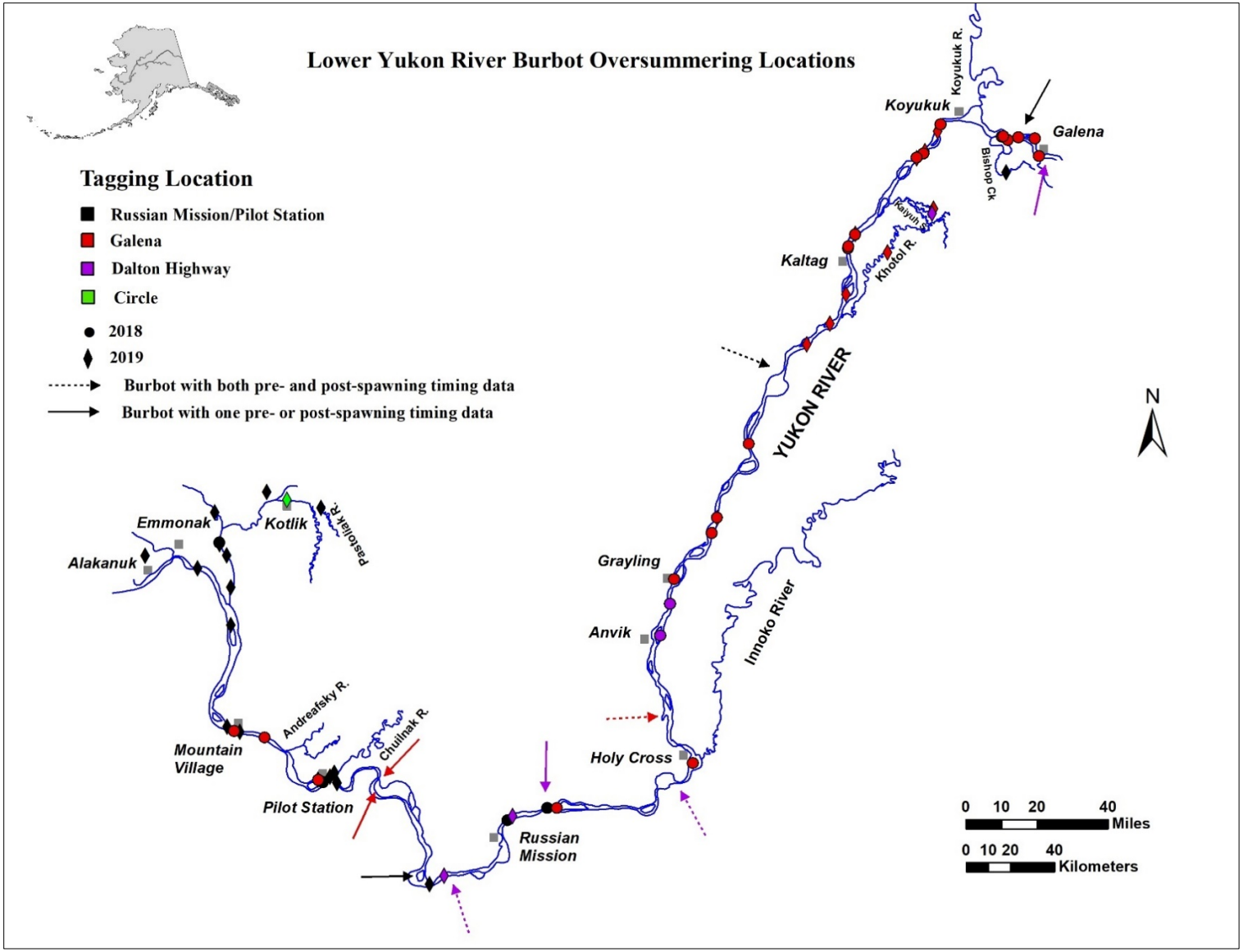


Figure 9.–Map of radiotagged burbot located during the June–July 2018 and 2019 aerial tracking flights in the Lower Yukon River. The arrows point to locations from the late January/early February flights for burbot with pre- and/or post-timing data as shown in Figure 3.

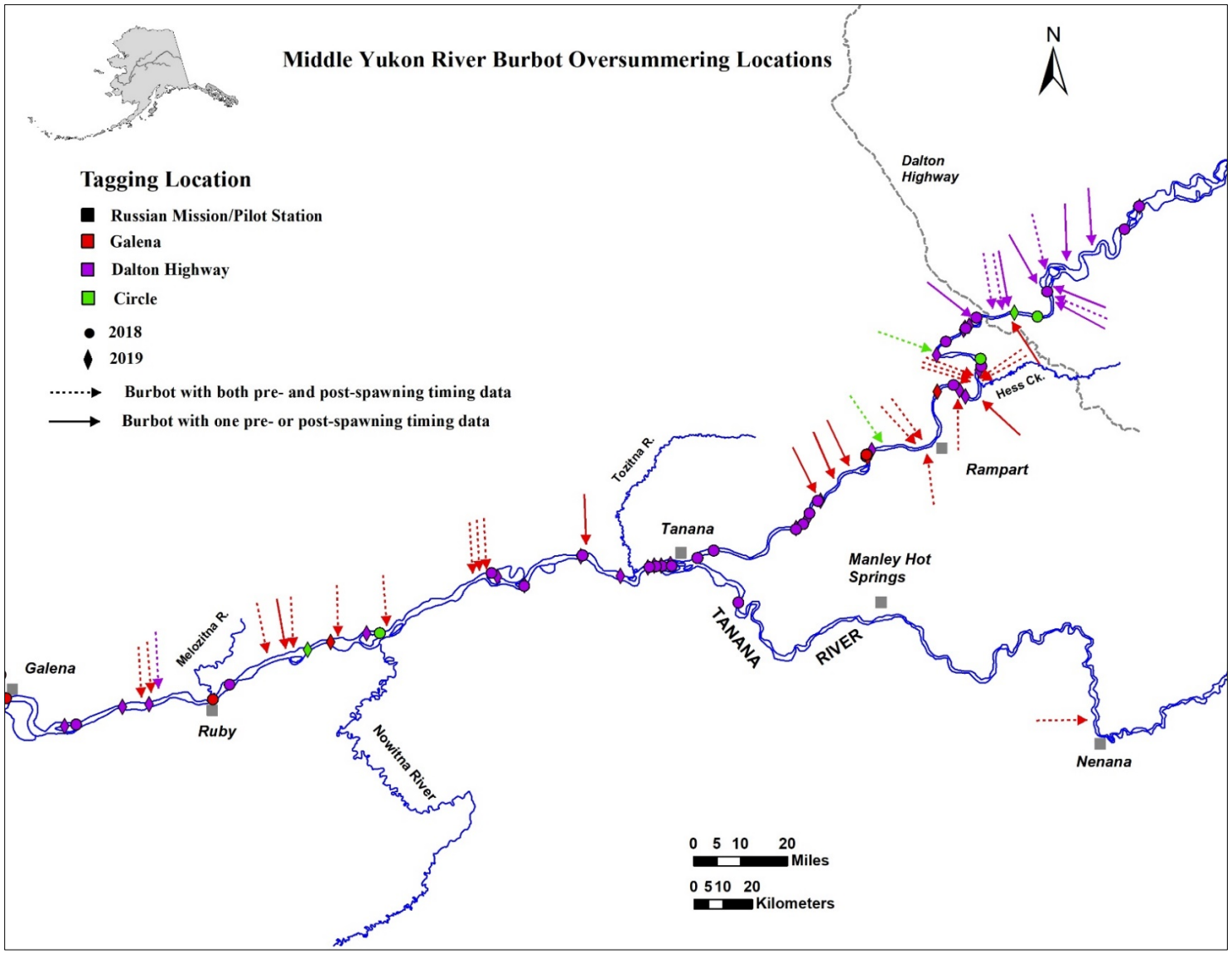


Figure 10.–Map of radiotagged burbot located during the June–July 2018 and 2019 aerial tracking flights in the Middle Yukon River. The arrows point to locations from the late January/early February flights for burbot with pre- and/or post-timing data as shown in Figure 4.

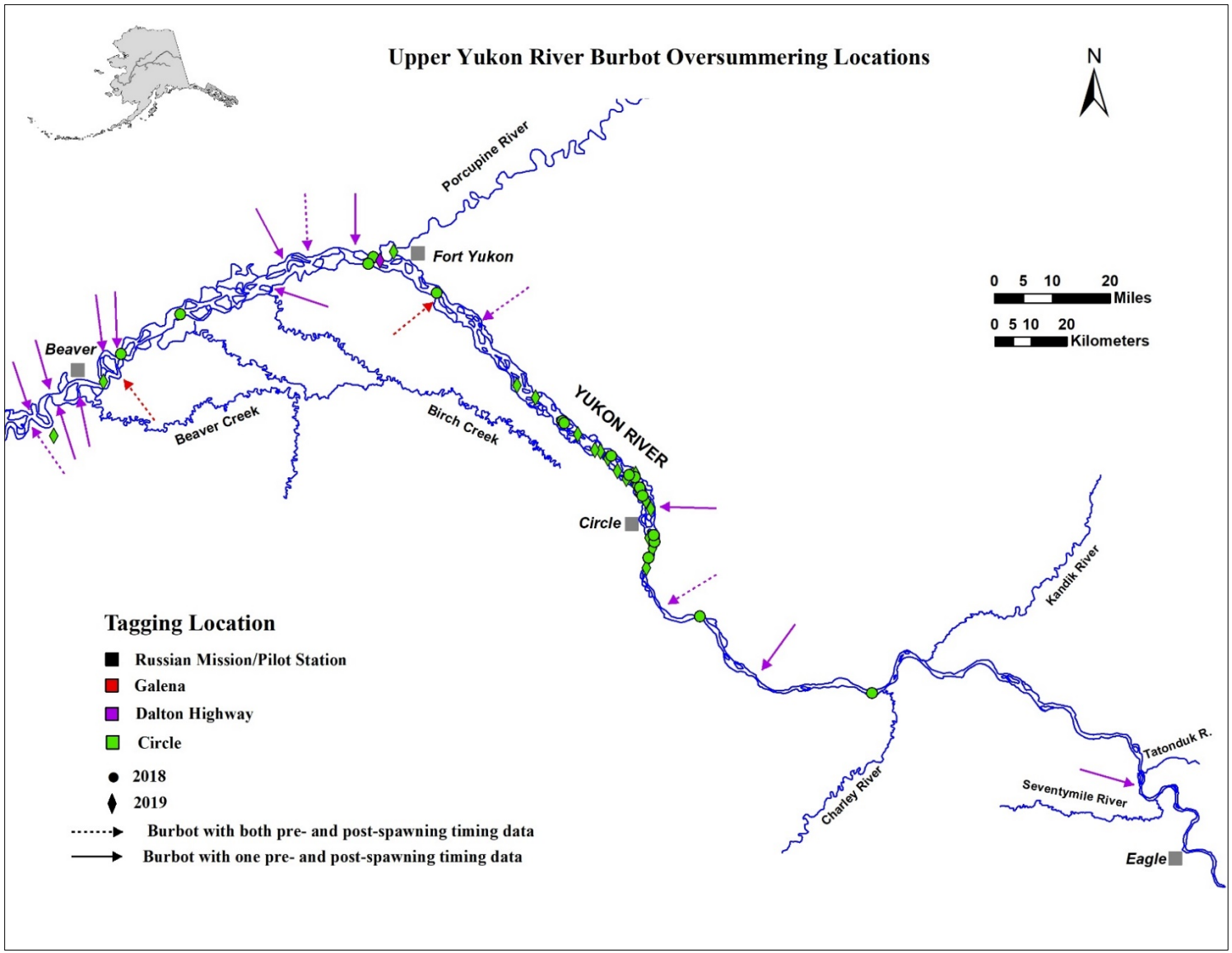


Figure 11.–Map of radiotagged burbot located during the June–July 2018 and 2019 aerial tracking flights in the Upper Yukon River. The arrows point to locations from the late January/early February flights for burbot with pre- and/or post-timing data as shown in Figure 5.

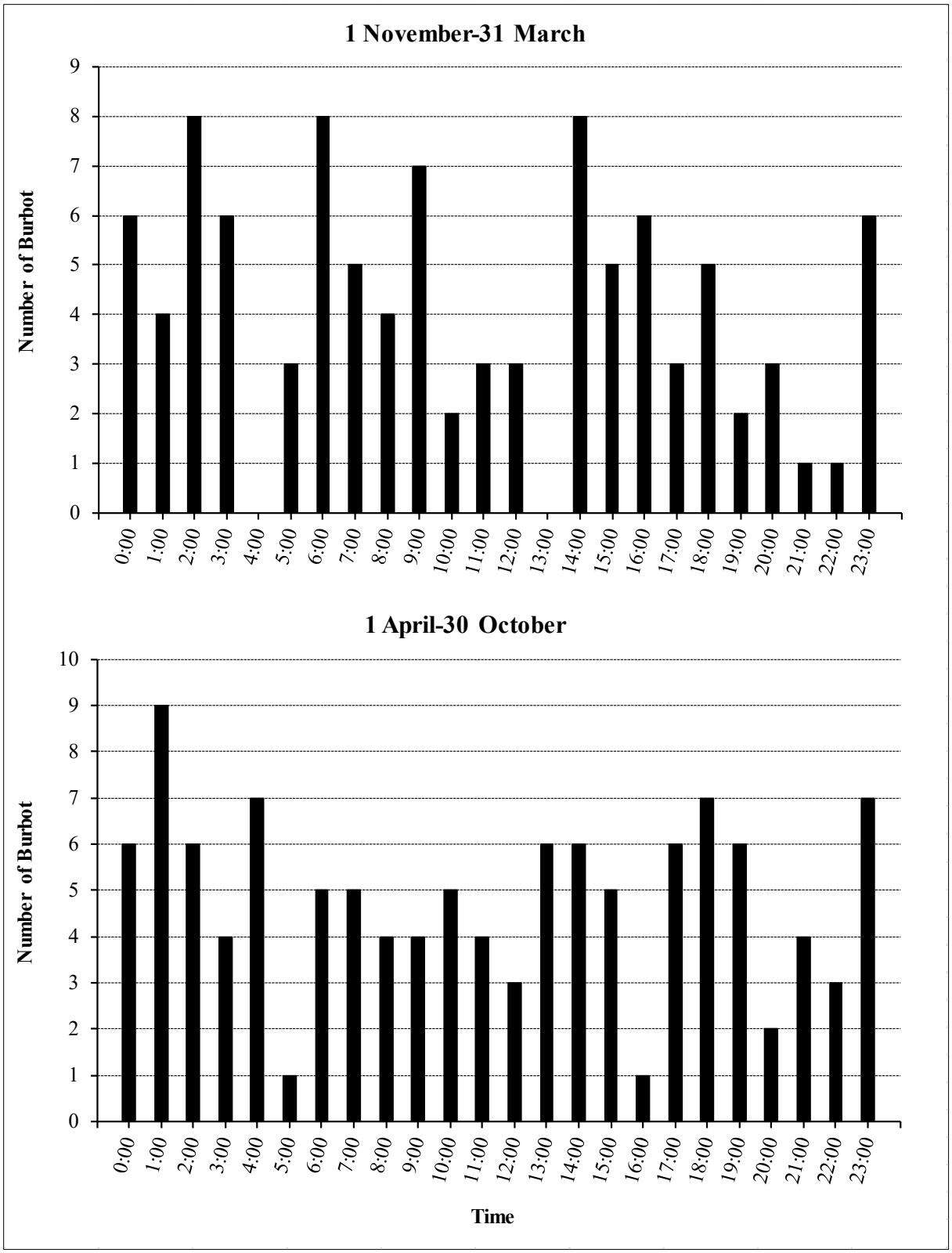


Figure 12.–Hourly migration timing for Yukon River burbot that were radiotagged during 2017 and 2018 and recorded past the stationary tracking stations during 2018–2020 during late fall, winter, and spring to early fall.

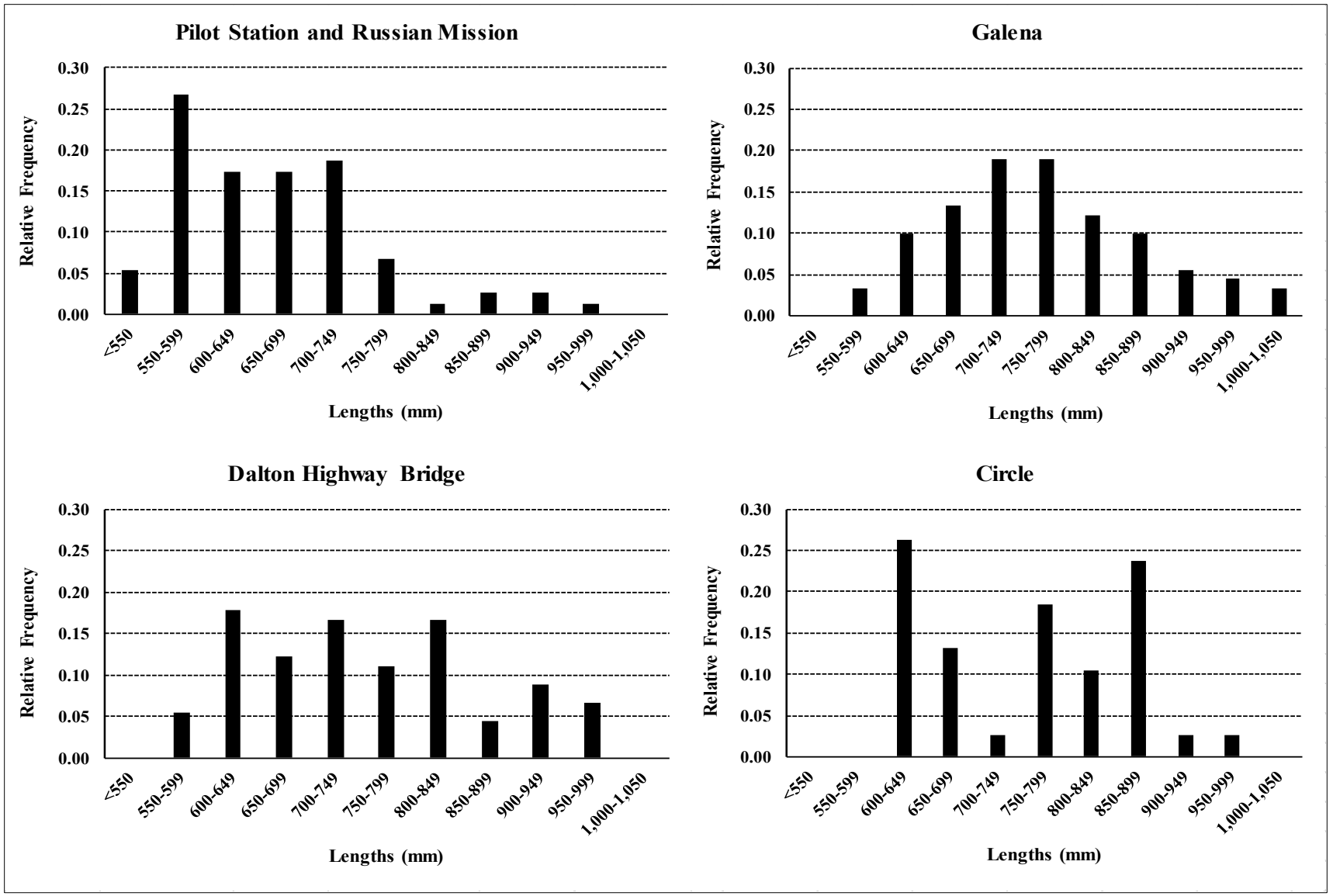


Figure 13.–Lengths of burbot that were captured and radiotagged at 4 locations in the lower, middle, and upper portions of the Yukon River during 2017 and 2018.

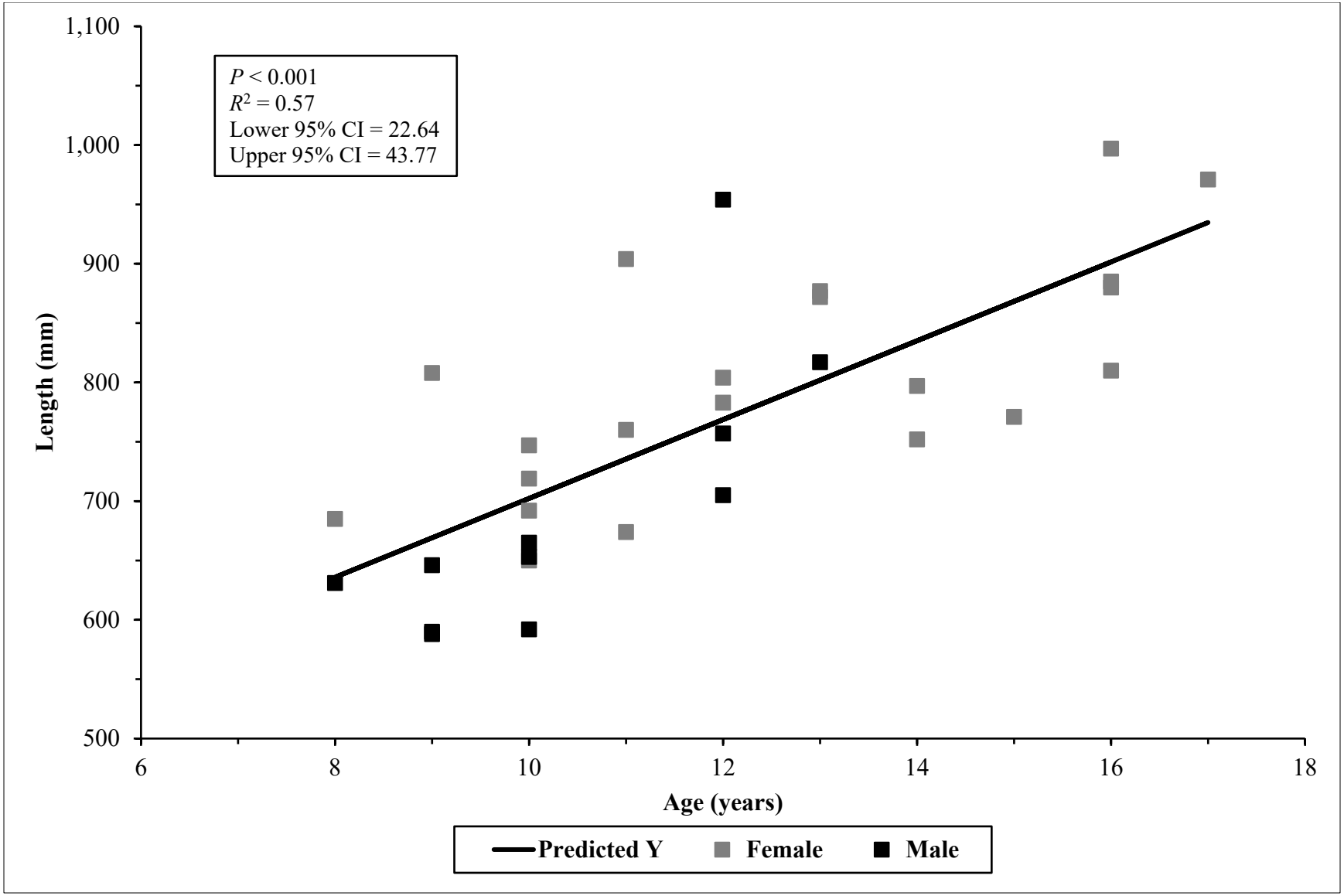


Figure 14.–Length at age for male and female burbot that were captured during radiotagging efforts during 2017 and 2018 and were sacrificed during analysis for spawning readiness during 4–7 February 2020, with the regression line showing the positive relationship between length and age.

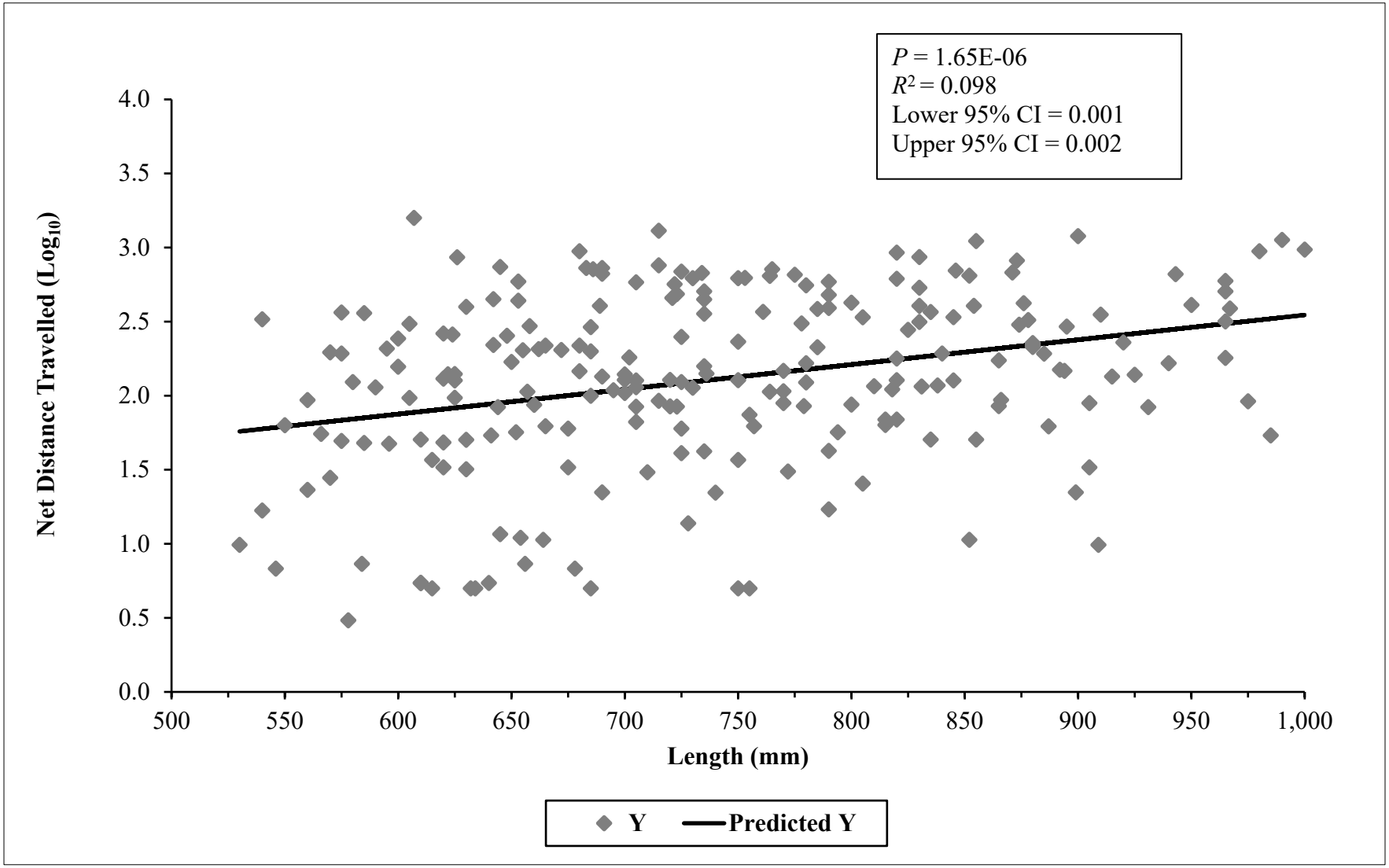


Figure 15.–Analysis of regression showing the relationship between length of radiotagged burbot and propensity to travel longer distances as noted during the 2017 and 2019 aerial tracking flights.

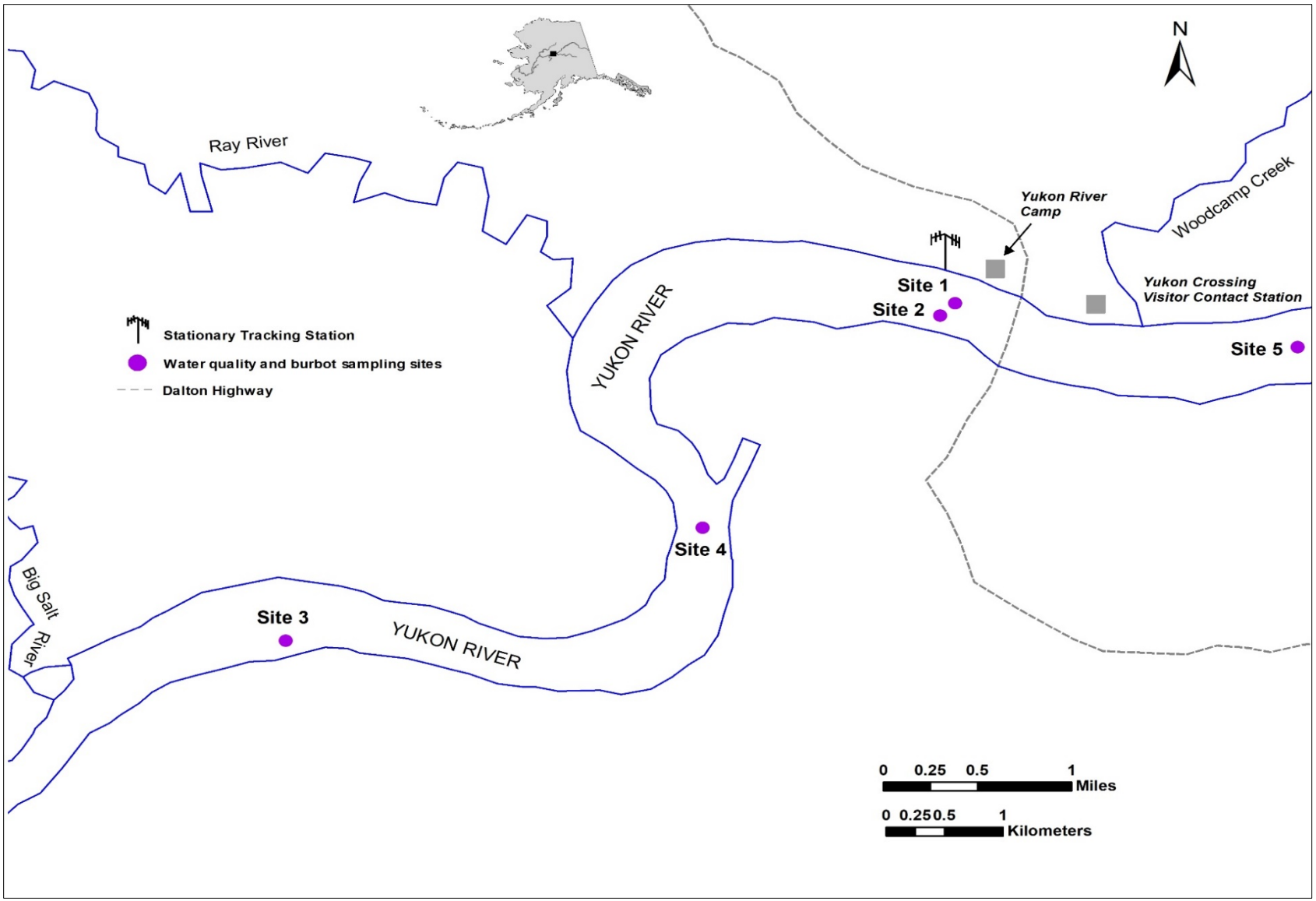


Figure 16.–Water quality characteristics for areas near the Dalton Highway where burbot were captured and examined for spawning readiness or post-spawning characteristics during 4–7 February 2020. Water quality data for the sites are found in Appendix E2.

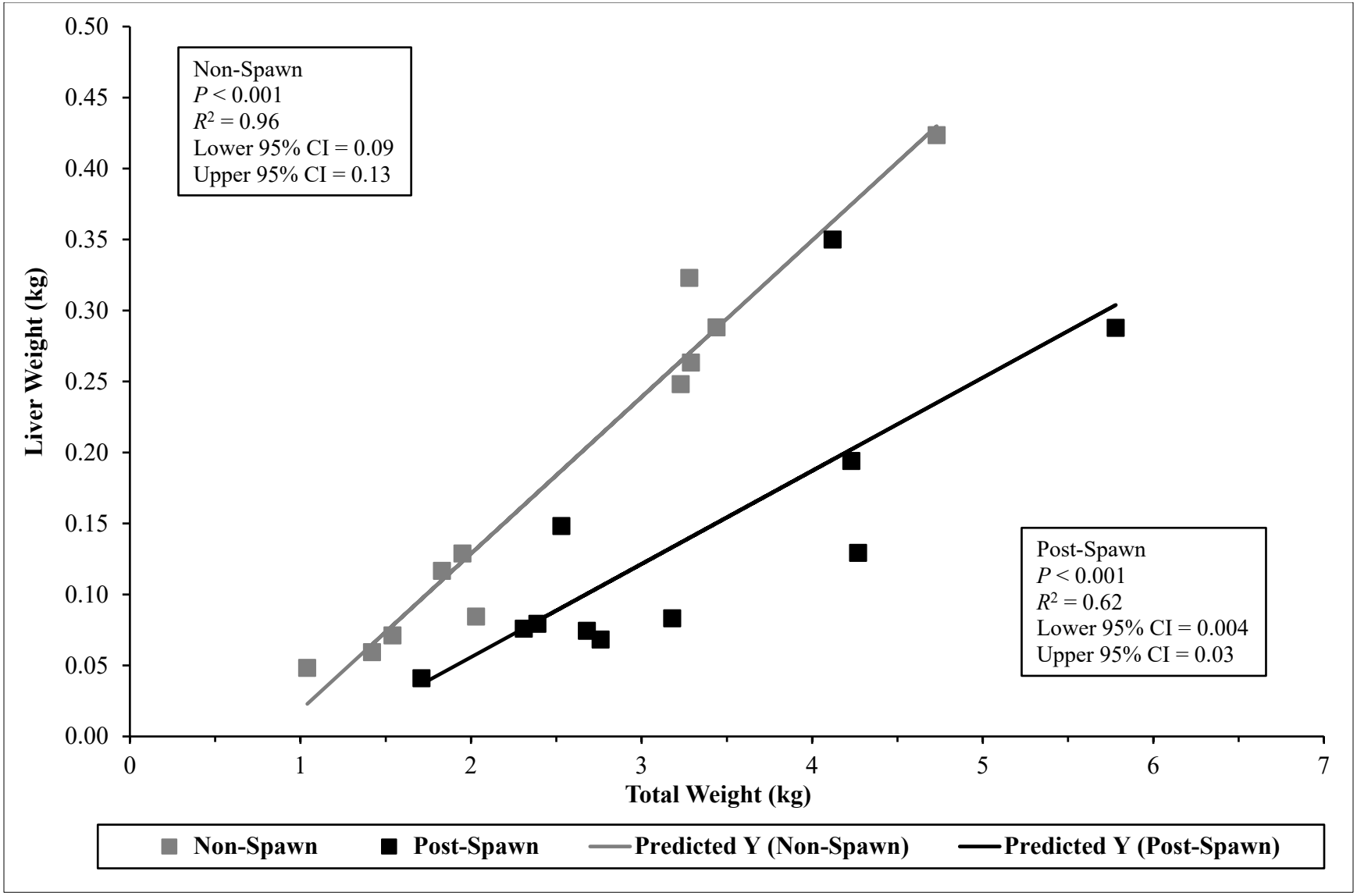


Figure 17.–Post- and non-spawning liver weights with associated lines of regression for burbot that were captured and examined for spawning readiness or post-spawning characteristics during 4–7 February 2020.

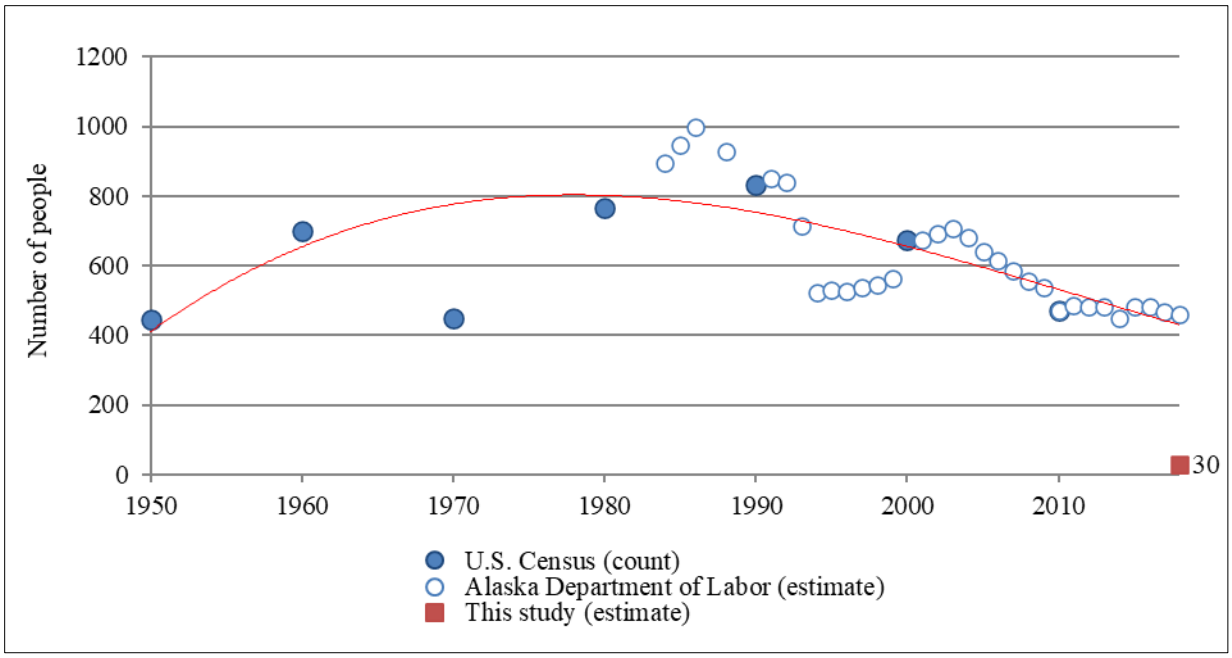


Figure 18.–Population history, Galena, 1950–2017.

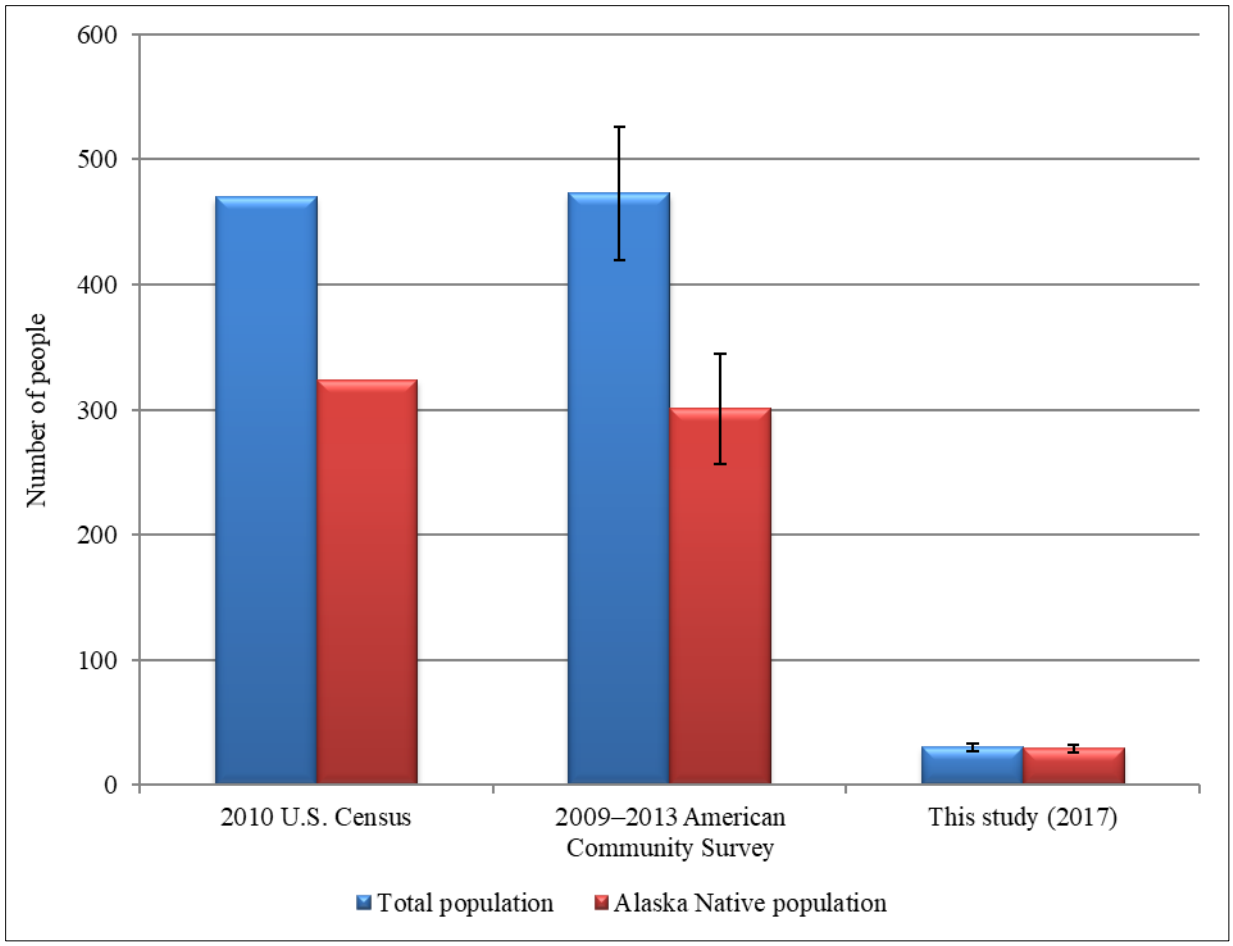


Figure 19.–Population estimates, Galena, 2010, 2009–2013, and 2017.

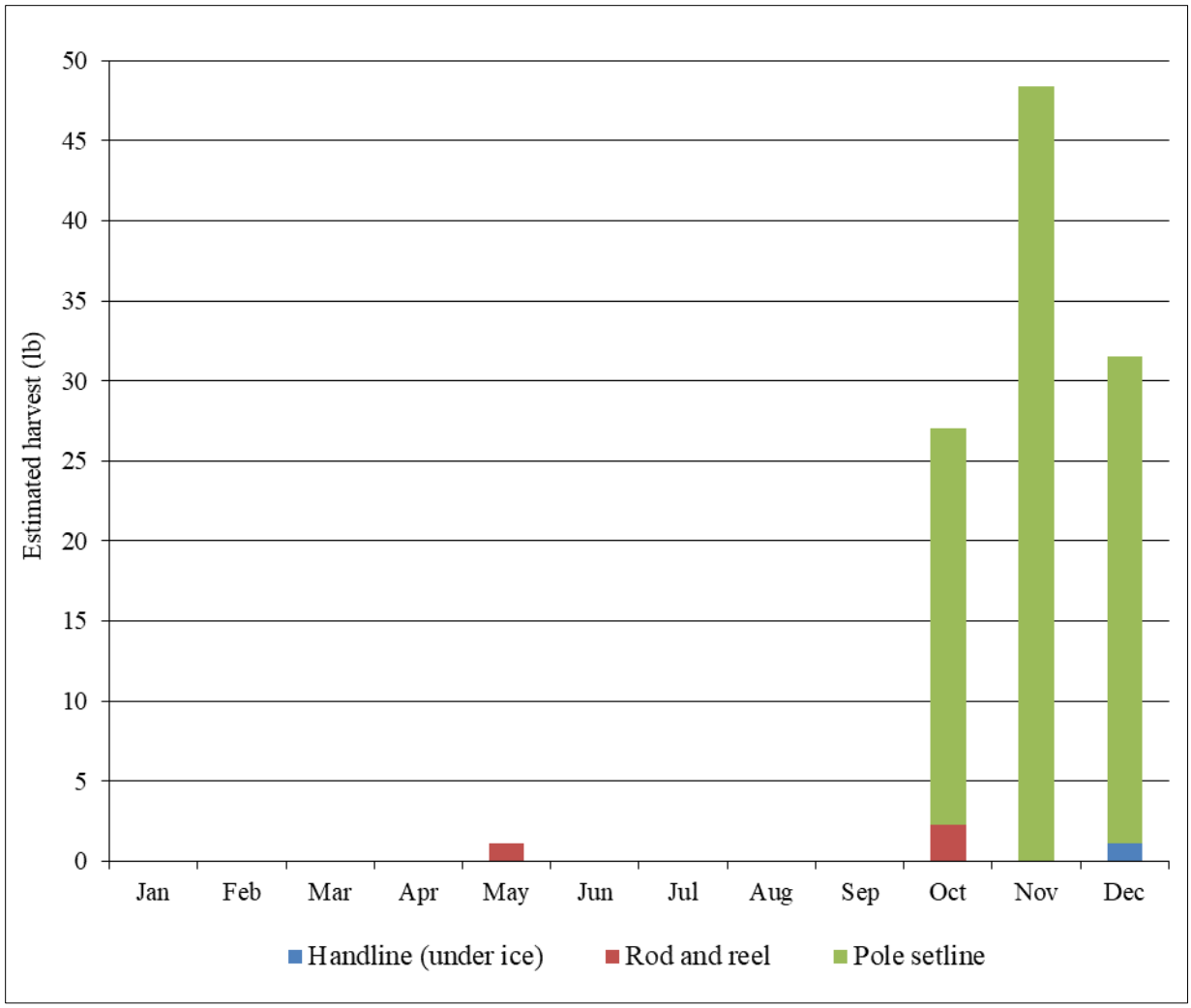


Figure 20.–Estimated burbot harvests by gear type and month, Galena, 2017.

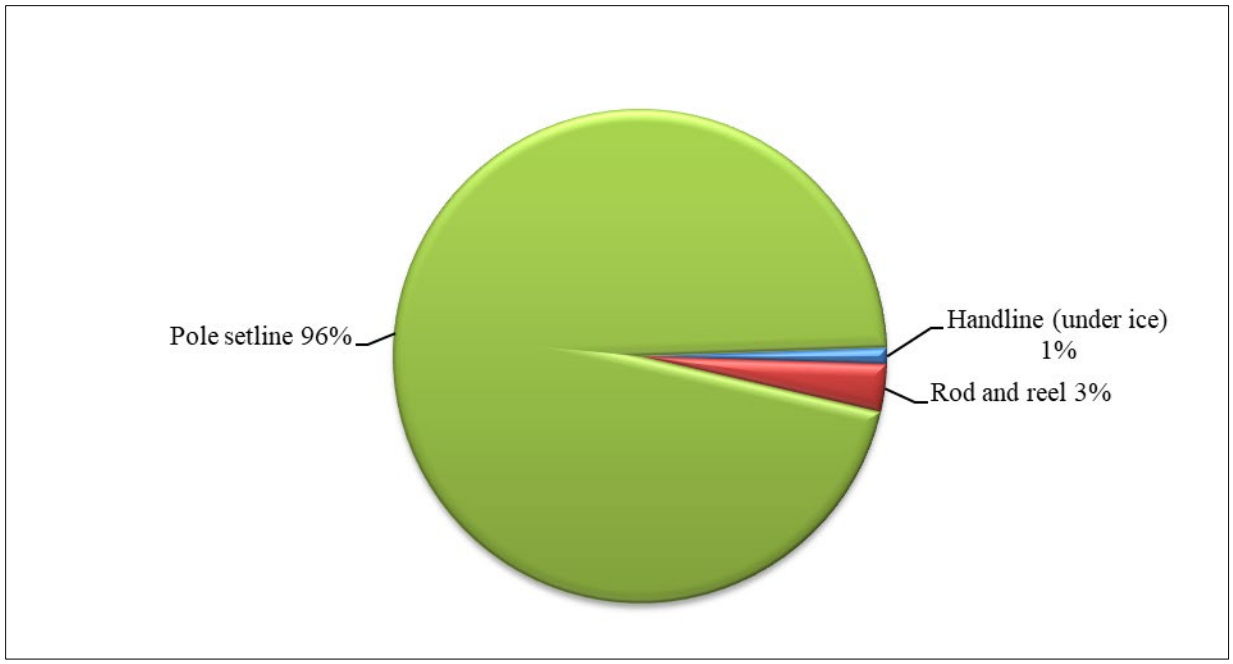


Figure 21.–Composition of burbot harvests by gear type, Galena, 2017.

Figure 22.–Burbot search and harvest areas, Galena, 2017.

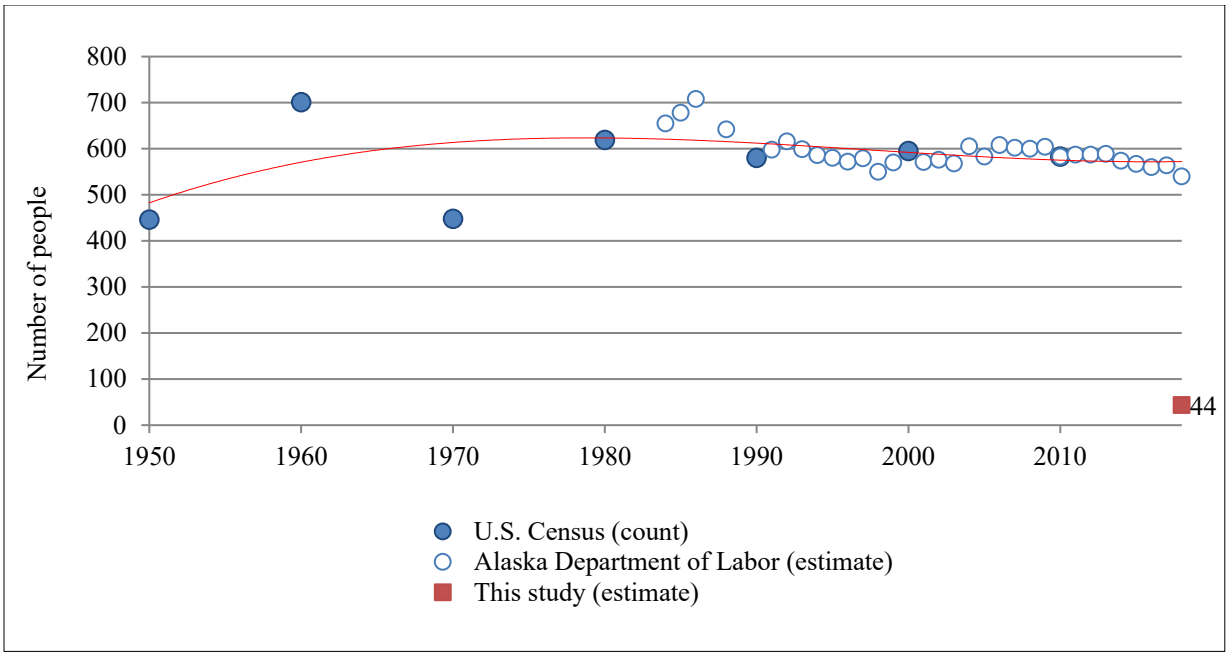


Figure 23.–Population history, Fort Yukon, 1950–2017.

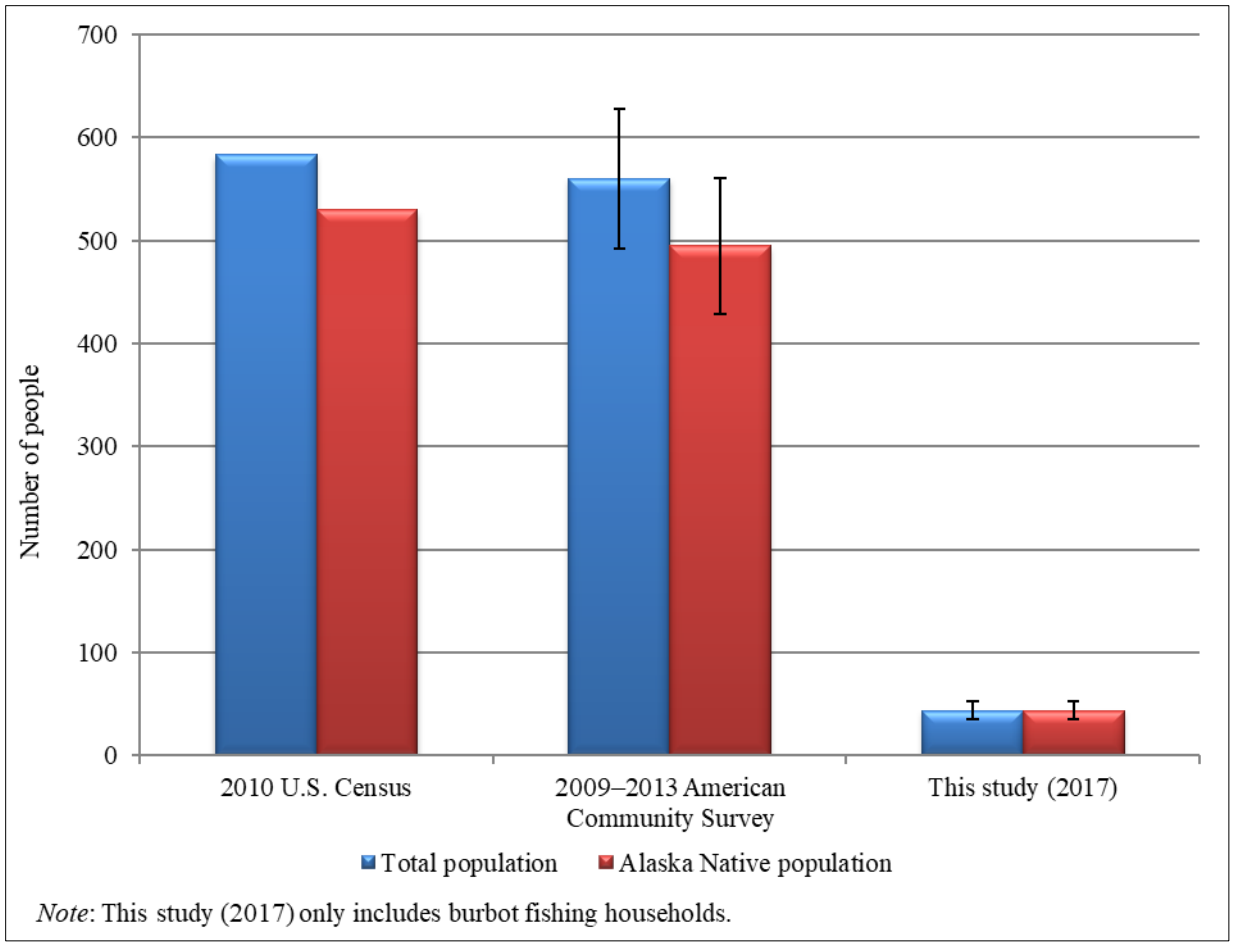


Figure 24.–Population estimates, Fort Yukon, 2010, 2009–2013, and 2017.

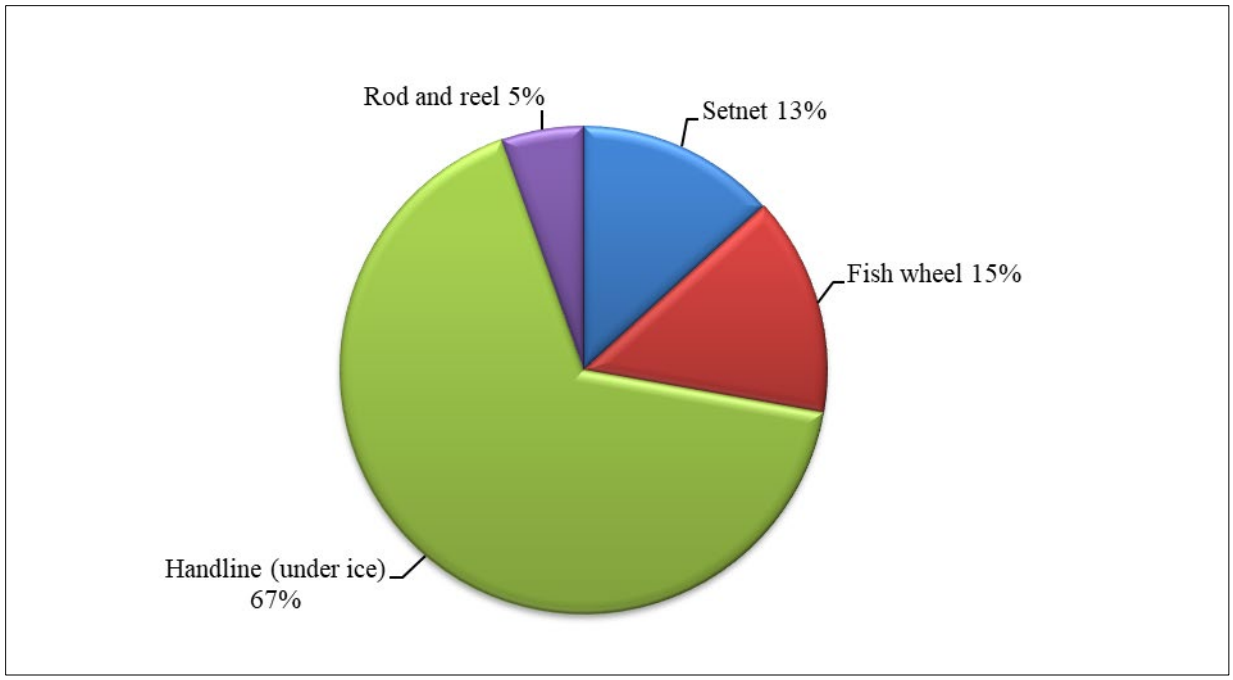


Figure 25.–Composition of burbot harvests by gear type, Fort Yukon, 2017.

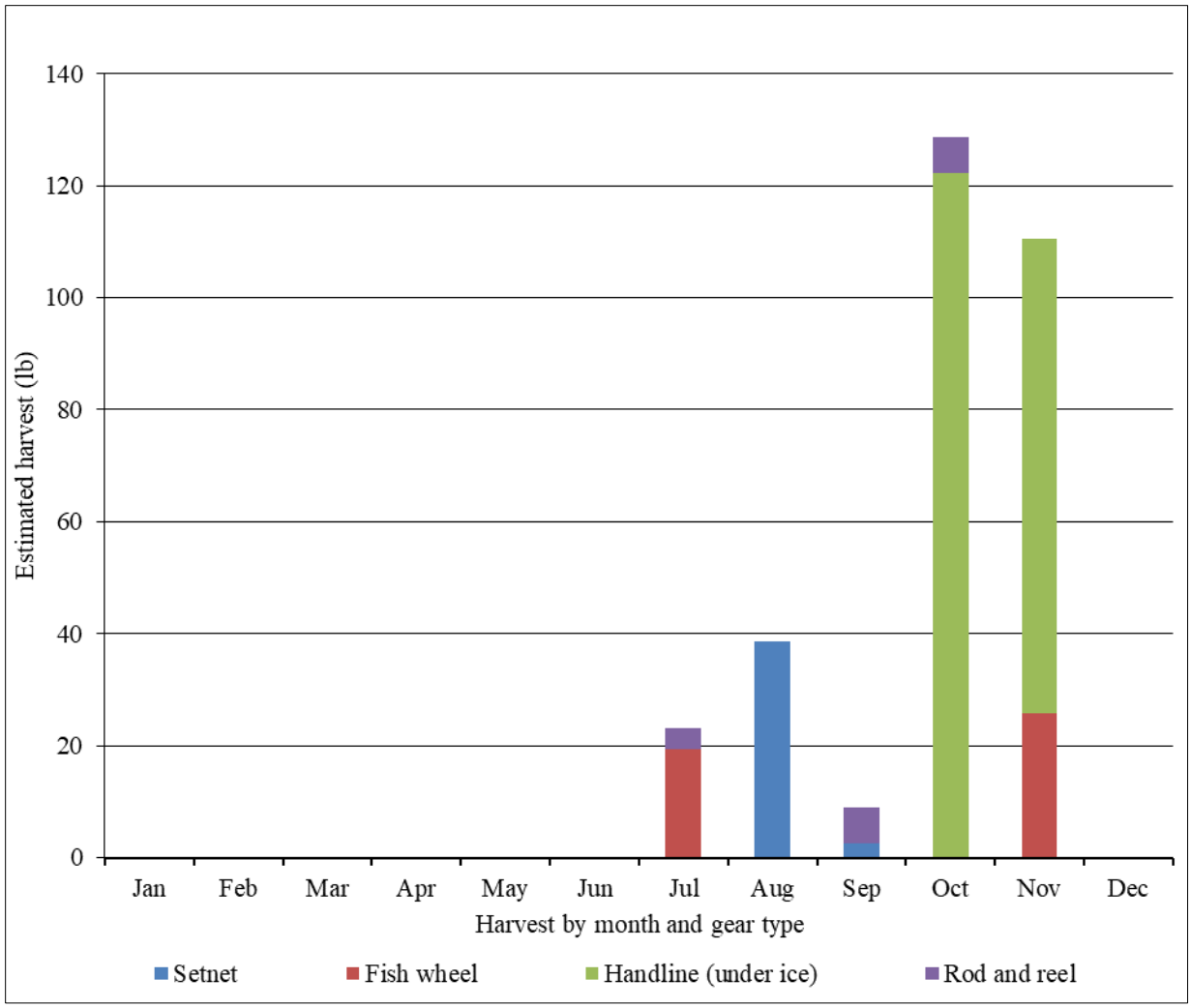


Figure 26.–Estimated burbot harvests by gear type and month, Fort Yukon, 2017.

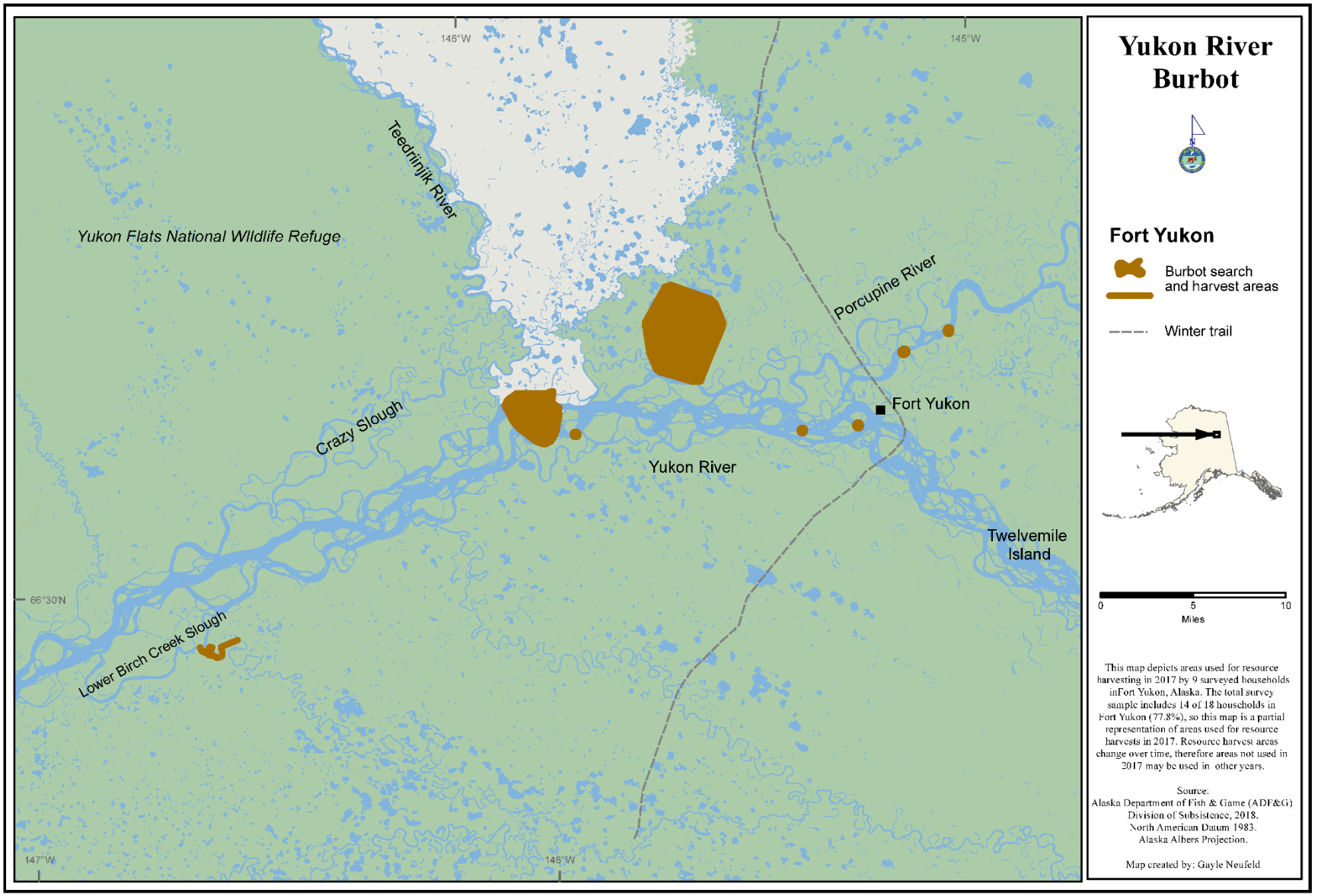


Figure 27.–Burbot search and harvest areas, Fort Yukon, 2017.

APPENDIX A:
SUBSISTENCE SURVEY INSTRUMENT

Appendix A1.–Subsistence survey instrument.

FISH SURVEY

PILOT STATION, ALASKA

From January 1, 2017 to December 31, 2017

OSM YUKON RIVER
BURBOT

printed: 2018-01-02

This survey is used to estimate subsistence harvests and to describe the role of subsistence in the local economy of your community. We will publish a short summary report, that will be available to community members. We share this information with the U.S. Fish and Wildlife Service and other divisions of the Alaska Department of Fish and Game. We work with the Federal Regional Advisory Councils and with local Fish and Game Advisory Committees to better manage subsistence, and to implement federal and state subsistence priorities.

We will NOT identify your household. We will NOT use this information for enforcement. Participation in this survey is voluntary. Even if you agree to be surveyed, you may stop at any time.

HOUSEHOLD ID:		
COMMUNITY ID:	PILOT STATION	273
INTERVIEWER #1:		
INTERVIEWER #2:		
INTERVIEW DATE:		
START TIME:		
STOP TIME:		
DATA CODED BY:		
DATA ENTERED BY:		
SUPERVISOR:		

Photo by Alida Trainor

PILOT STATION NATIVE CORPORATION
PO BOX 5059
PILOT STATION, AK 99650
907-549-3512

ALASKA DEPARTMENT OF FISH AND GAME
1300 COLLEGE RD
FAIRBANKS, AK 99701
907-459-7320

-continued-

OSM Yukon River Burbot - Fish Survey, 2018

HOUSEHOLD MEMBERS **HOUSEHOLD ID**

First, I would like to know a few things about the people in your household. I want to know about permanent members of your household, including college or high school students who return home every summer, or anyone else who stayed in your household at least 6 months during 2017.

Between January 1, 2017 and December 31, 2017…
…who lived in your household?

Person ID#	How is this person related to head 1? *(relation)*	Is this person MALE or FEMALE? *(circle)*	How old is this person? *(age)*	Is this person Alaska Native? *(circle)*	Is this person answering questions *on this survey?* *(circle)*	Comments *(enter text)*
HEAD 1	SELF	M F		Y N	Y N	
01	1					
NEXT, enter spouse or partner. If household has a SINGLE HEAD, leave HEAD 2 blank.						
HEAD 2		M F		Y N	Y N	
02	2					
BELOW, enter children (oldest to youngest), grandchildren, grandparents, brothers, sisters, and other household members.						
03		M F		Y N	Y N	
04		M F		Y N	Y N	
05		M F		Y N	Y N	
06		M F		Y N	Y N	
07		M F		Y N	Y N	
08		M F		Y N	Y N	
09		M F		Y N	Y N	
10		M F		Y N	Y N	
11		M F		Y N	Y N	
12		M F		Y N	Y N	
13		M F		Y N	Y N	
14		M F		Y N	Y N	
15		M F		Y N	Y N	

PERMANENT HH MEMBERS: 01 **PILOT STATION: 70**

Page 2

-continued-

OSM Yukon River Burbot - Fish Survey, 2018

HARVESTS: BURBOT

HOUSEHOLD ID

1. Do members of your household USUSALLY FISH FOR BURBOT?..... Y N

2. Between January 1, 2017 and December 31, 2017 did members of your household use or try to fish for BURBOT?..... Y N

If this household did NOT USE or HARVEST last year, go to the ASSESSMENT section on page 11.

Otherwise, continue with HARVEST section below.

During the last year,[1] did you or members of your household...

A ... use[2] burbot?
B ...receive burbot from another HH or community?
C ...give burbot to another HH or community?
D ...try[2] to harvest burbot?
E ...actually harvest any burbot?

if harvest is "yes"

Please estimate how many burbot ALL MEMBERS OF YOUR HOUSEHOLD got for subsistence uses during the last year. Include those taken to share with other outside of your fishing group. How many were harvested with ....

INCLUDE burbot that members of this household gave away, are fresh, fed to dogs, lost to spoilage, or got by helping others. If fishing with or helping others, report ONLY THIS HOUSEHOLD'S share of the harvest. DO NOT INCLUDE burbot that you caught and released or retained from commercial harvests.

Read names below in blanks above	A USE	B REC	C GIVE	D TRY	GEAR TYPE USED	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	UNKNOWN	TOTAL	UNITS[6]	# of those used just for dog food?
						(specify amount harvested per month)														(specify)	amt.
BURBOT *tiktaaliq*	Y N	Y N	Y N	Y N	ROD & REEL[3]																
124800000					15																
					DRIFT NET																
					6																
					SET NET																
					5																
					HOOK & LINE[4] *(under ice)*																
					10																
					HANDLINE[5] *(under ice)*																
					11																
					DIP NET																
					8																
					OTHER (specify)																

1. Did you fish with OTHER HOUSEHOLDS, or did someone other than a members of your household HELP YOU fish for BURBOT?..... Y N

If yes, please list them below.

2. Do you know of anyone else who fishes for BURBOT?..... Y N

If yes, please list them below.

1 *"LAST YEAR" means between January 1, 2017 and December 31, 2017.*
2 *"USE" includes harvesting, processing, eating, trading, feeding to dogs, etc. "TRY" includes looking, hunting, fishing, or any attempt to get.*
3 *"ROD AND REEL" includes jigging with a stick or fishing with a rod and reel ONLY in open water.*
4 *"HOOK AND LINE" includes jigging with a stick or fishing with a rod and reel ONLY through the ice.*
5 *"HANDLINE" is a hand held line, with one or more hooks, which may also include jigging through the ice.*
6 *UNITS will differ by species and situation. Units may be pounds (lbs), individuals (ind), portions of individuals (1/4), buckets, sacks, tubs, etc.*

BURBOT: 06 **PILOT STATION: 273**

Page 3

-continued-

OSM Yukon River Burbot - Fish Survey, 2018

ASSESSMENTS: HOUSEHOLD ID

To conclude our burbot section, I am going to ask a few general questions about burbot.

During the last year,[1]

… did your household use LESS, the SAME, or MORE burbot than in recent years? ..... X L S M

IF LESS or MORE … *(X = do not use)*

WHY was your use different? _____ 1

_____ 2

If household does not use burbot, continue on the next page.

During the last year,[1]

…did your household GET ENOUGH burbot? ..... Y N

If NO…

What KIND of burbot did you need? _____ 1

2

How would you describe the impact to your household of not getting enough burbot last year? *… not noticable? (0)* *… minor ? (1)* *… major? (2)* *… Severe? (3)*

…did your household do anything DIFFERENTLY because you did not get enough burbot? ..... Y N

If YES…

What did your household do differently? _____ 1

_____ 2

ASSESSMENT COMMENTS:

1 *"LAST YEAR" means between January 1, 2017 and December 31, 2017.*

BURBOT: 66 **PILOT STATION: 273**

Page 4

-continued-

OSM Yukon River Burbot - Fish Survey, 2018

COMMENTS HOUSEHOLD ID

DO YOU HAVE ANY QUESTIONS, COMMENTS OR CONCERNS?

DON'T FORGET TO FILL IN THE STOP TIME._____

INTERVIEW SUMMARY:

COMMENTS: 300 **PILOT STATION: 273**

Page 5

APPENDIX B:
KEY RESPONDENT INTERVIEW PROTOCOL

Appendix B1.–Key respondent interview protocol.

Semi-structured interview protocol for Yukon Burbot project

Burbot, often referred to as lush fish. In Yupik they are called: *manignaq* (*mah-NIGHH-n-ak*)

Demographic Information

1. Name and age
2. Year/location born
3. Parents names and where from?
4. How long has respondent been fishing for burbot?

Early experiences fishing for burbot

5. When did you first start fishing for burbot?
6. Who taught you?
7. What gear did you use then?

Current fishing practices

1. What months do you fish for burbot?
2. Do you fish with other people? How is this determined?
3. How do you catch them? What gear do you use? Does the gear you use change depending on the season?
4. Who owns the gear you use?
5. If the fisher uses some unique gear type, ask how it's made and how it's deployed. Ask about construction materials and tools. Take pictures if they have a trap or some other gear type readily available. Consider possible participant observation opportunities.
6. Which parts of the fish do you use? How do you preserve/process these parts?
7. What do you do with the burbot you harvest – how do you distribute/share it?
8. Are younger people learning to fish for them? If so, how do they do that?
9. How would you characterize burbot fishing in your community? Ex: Is it more of an individual activity or a communal one?
10. Are there any rules about burbot fishing or the treatment of fish/nets during fishing?

Changes observed over time

1. Have your fishing areas changed at all? (Map current fishing locations and past locations, differentiate between present and past locations)
2. If there are changes to your fishing areas, explain those changes? (Environmental conditions, personal circumstances, traditional areas, changes in the fish population, regulations, etc.)
3. Are there environmental factors that contribute to changes in burbot fishing? (Weather, river conditions, etc.)

-continued-

Natural Indicators and health

1. How do you know when burbot are present?
2. Are there natural indicators such as ice, presence of other species, or water condition that is a signal burbot are available?
3. How do you feel the burbot population is doing right now? Why do you think the population is declining/increasing? Are they healthy?
4. Are people catching more or less burbot now than they did in the past? Why?

Knowledge of spawning and migration patterns and other features of the life cycle

1. Do you know of any burbot spawning location near your community? If so, please describe timing and location (map)
2. Do burbot spend time off of the mainstem in sloughs or smaller tributaries? If so, when? For how long?
3. Are there patterns you've observed about burbot behavior and migration? How does this affect your fishing?
4. What type of environment are burbot most commonly found in? (ex: deep water, calm water, brackish, silty, etc.)
5. What do burbot feed on?
6. Do the burbot you harvest ever look like they are about to spawn? (describe)

APPENDIX C:
INDIVIDUAL SPAWNING MIGRATION LOCATIONS AND TIMING

Appendix C1.–Spawning migration locations with timing for individual burbot radiotagged during 2017 and 2018 and located during late January/early February 2018.

			Pre-spawning				Post-spawning			
Frequency-code	Tagging location	Spawning location	Tracking station	Date/time	Tracking station	Date/time	Tracking station	Date/time	Tracking station	Date/time
149.630-12	Russian Mission	Grayling to Galena	Russian Mission	12/28/2017 16:38			Russian Mission	5/12/2018 3:15		
149.820-15	Galena	Galena to Nowitna R.	Galena	1/24/2018 14:17			Galena	6/5/2018 13:10		
149.820-11	Galena	Below Grayling	Russian Mission	10/28/2017 2:33			Russian Mission	6/1/2018 22:06		
149.820-23	Galena	Galena to Nowitna R.	Russian Mission	10/12/2017 19:57	Galena	1/19/2018 23:42	Galena	2/8/2018 23:13		
149.820-24	Galena	Tanana to Rampart	Galena	12/7/2017 15:09			Galena	5/18/2018 3:23		
149.820-38	Galena	Galena to Nowitna R.	Galena	1/30/2018 14:54			Galena	4/7/2018 13:21		
149.820-41	Galena	Grayling to Galena	Russian Mission	12/8/2017 8:14						
149.820-42	Galena	Galena to Nowitna R.	Galena	1/22/2018 10:50						
149.820-43	Galena	Tanana to Rampart	Galena	1/6/2018 14:28						
149.820-45	Galena	Nowitna R. to Tanana	Galena	1/1/2018 16:17			Galena	5/12/2018 19:59		
149.820-46	Galena	Rampart to Dalton Hwy	Galena	12/9/2017 2:34			Galena	4/26/2018 23:36		
149.820-48	Galena	Tanana to Rampart	Galena	11/26/2017 11:13						
149.820-50	Galena	Galena to Nowitna R.	Galena	1/29/2018 18:14			Galena	2/10/2018 1:28		
149.820-53	Galena	Fort Yukon to Circle	Galena	11/30/2017 6:09			Dalton Hwy	5/26/2018 12:53	Galena	6/2/2018 7:50
149.820-55	Galena	Rampart to Dalton Hwy	Galena	11/28/2017 12:10			Galena	5/19/2018 1:06		
149.820-57	Galena	Tanana to Rampart	Galena	1/1/2018 20:24			Galena	5/23/2018 22:40		

-continued-

Appendix C1.–Page 2 of 4.

Frequency-code	Tagging location	Spawning location	Pre-spawning				Post-spawning			
			Tracking station	Date/time	Tracking station	Date/time	Tracking station	Date/time	Tracking station	Date/time
149.820-61	Galena	Nowitna R. to Tanana	Galena	11/23/2017 19:40			Galena	6/9/2018 18:10		
149.820-69	Galena	Rampart to Dalton Hwy	Galena	12/6/2017 12:46						
149.820-71	Galena	Above Dalton Hwy Infer	Galena	11/29/2017 8:23	Dalton Hwy	1/30/2018 20:53	Dalton Hwy	5/27/2018 7:35	Galena	6/4/2018 0:15
149.820-72	Galena	Tanana to Rampart	Galena	1/7/2018 15:46						
149.820-76	Galena	Nowitna R. to Tanana	Galena	12/6/2017 3:25			Galena	5/19/2018 9:53		
149.820-78	Galena	Tanana to Rampart	Galena	1/6/2018 22:38			Galena	3/6/2018 5:48		
149.820-84	Galena	Below Grayling	Russian Mission	10/3/2017 15:41						
149.820-93	Galena	Nowitna R. to Tanana	Russian Mission	12/7/2017 17:03	Galena	1/18/2018 16:56				
149.820-94	Galena	Rampart to Dalton Hwy	Galena	1/3/2018 18:51			Dalton Hwy	2/7/2018 6:17	Galena	5/22/2018 18:29
149.820-97	Galena	Below Grayling	Russian Mission	10/24/2017 13:05						
149.820-99	Galena	Dalton Hwy to Beaver	Galena	11/29/2017 7:55			Dalton Hwy	2/13/2018 20:04		
149.780-16	Dalton Hwy	Dalton Hwy to Beaver					Dalton Hwy	5/14/2018 4:58		
149.780-18	Dalton Hwy	Below Grayling	Russian Mission	10/23/2017 8:44			Russian Mission	7/3/2018 8:49		
149.780-19	Dalton Hwy	Below Grayling	Russian Mission	10/18/2017 21:34			Russian Mission	4/19/2018 23:04		
149.780-20	Dalton Hwy	Dalton Hwy to Beaver					Dalton Hwy	5/21/2018 14:32		
149.780-21	Dalton Hwy	Grayling to Galena	Galena	1/23/2018 5:41						
149.780-22	Dalton Hwy	Beaver to Fort Yukon					Galena	5/29/2018 9:12		

-continued-

Frequency-code	Tagging location	Spawning location	Pre-spawning Tracking station	Pre-spawning Date/time	Pre-spawning Tracking station	Pre-spawning Date/time	Post-spawning Tracking station	Post-spawning Date/time	Post-spawning Tracking station	Post-spawning Date/time
149.780-23	Dalton Hwy	Circle to Charley R.	Dalton Hwy	12/17/2017 11:30			Dalton Hwy	6/11/2018 21:38		
149.780-35	Dalton Hwy	Dalton Hwy to Beaver					Dalton Hwy	6/5/2018 14:49		
149.780-38	Dalton Hwy	Galena to Nowitna R.	Galena	1/8/2018 6:40			Galena	5/14/2018 23:03		
149.780-40	Dalton Hwy	Above Dalton Hwy Infer	Dalton Hwy	11/25/2017 18:15			Dalton Hwy	5/4/2018 1:34		
149.780-42	Dalton Hwy	Dalton Hwy to Beaver	Dalton Hwy	11/24/2017 3:49						
149.780-43	Dalton Hwy	Beaver to Fort Yukon					Dalton Hwy	5/22/2018 6:35	Galena	6/6/2018 21:27
149.780-45	Dalton Hwy	Circle to Charley R.					Dalton Hwy	6/7/2018 17:11		
149.780-48	Dalton Hwy	Dalton Hwy to Beaver	Dalton Hwy	11/23/2017 23:45			Dalton Hwy	2/14/2018 23:56		
149.780-49	Dalton Hwy	Dalton Hwy to Beaver	Dalton Hwy	11/24/2017 5:31						
149.780-50	Dalton Hwy	Fort Yukon to Circle					Dalton Hwy	5/23/2018 10:15	Galena	5/30/2018 14:50
149.780-51	Dalton Hwy	Dalton Hwy to Beaver					Dalton Hwy	4/21/2018 4:28		
149.780-52	Dalton Hwy	Dalton Hwy to Beaver	Dalton Hwy	11/23/2017 2:16			Dalton Hwy	5/10/2018 13:40		
149.780-53	Dalton Hwy	Charley R. to Eagle					Dalton Hwy	6/5/2018 15:52		
149.780-54	Dalton Hwy	Dalton Hwy to Beaver	Dalton Hwy	12/21/2017 14:18						
149.780-70	Dalton Hwy	Above Dalton Hwy Infer	Dalton Hwy	12/2/2017 12:40			Dalton Hwy	5/21/2018 10:31	Galena	5/28/2018 17:00
149.780-71	Dalton Hwy	Above Dalton Hwy Infer	Dalton Hwy	12/14/2017 3:45			Dalton Hwy	5/26/2018 6:12		
149.780-73	Dalton Hwy	Dalton Hwy to Beaver					Dalton Hwy	5/30/2018 2:04		

-continued-

Frequency-code	Tagging location	Spawning location	Pre-spawning				Post-spawning			
			Tracking station	Date/time	Tracking station	Date/time	Tracking station	Date/time	Tracking station	Date/time
149.780-76	Dalton Hwy	Beaver to Fort Yukon	Dalton Hwy	11/15/2017 14:04						
149.780-79	Dalton Hwy	Above Dalton Hwy Infer	Dalton Hwy	11/26/2017 2:44			Dalton Hwy	5/4/2018 1:38		
149.780-80	Dalton Hwy	Rampart to Dalton Hwy	Dalton Hwy	1/31/2018 23:38			Dalton Hwy	5/18/2018 7:23		
149.780-81	Dalton Hwy	Dalton Hwy to Beaver	Dalton Hwy	11/27/2017 2:34						
149.780-83	Dalton Hwy	Dalton Hwy to Beaver	Dalton Hwy	11/25/2017 9:52			Dalton Hwy	5/12/2018 19:21		
149.780-85	Dalton Hwy	Beaver to Fort Yukon					Dalton Hwy	2/28/2018 7:02		
149.780-86	Dalton Hwy	Galena to Nowitna R.	Galena	1/24/2018 18:25			Galena	2/12/2018 18:23		
149.780-88	Dalton Hwy	Beaver to Fort Yukon					Dalton Hwy	5/26/2018 19:58		
149.780-92	Dalton Hwy	Dalton Hwy to Beaver					Dalton Hwy	5/15/2018 11:10		
149.780-94	Dalton Hwy	Beaver to Fort Yukon	Dalton Hwy	12/15/2017 14:04						
149.900-24	Circle	Above Dalton Hwy Infer					Dalton Hwy	5/29/2018 8:47		
149.900-35	Circle	Tanana to Rampart	Dalton Hwy	11/12/2017 14:14						

Appendix C2.–Spawning migration locations with timing for burbot radiotagged during 2017 and 2018 and located during late January/early February 2019 and 2020.

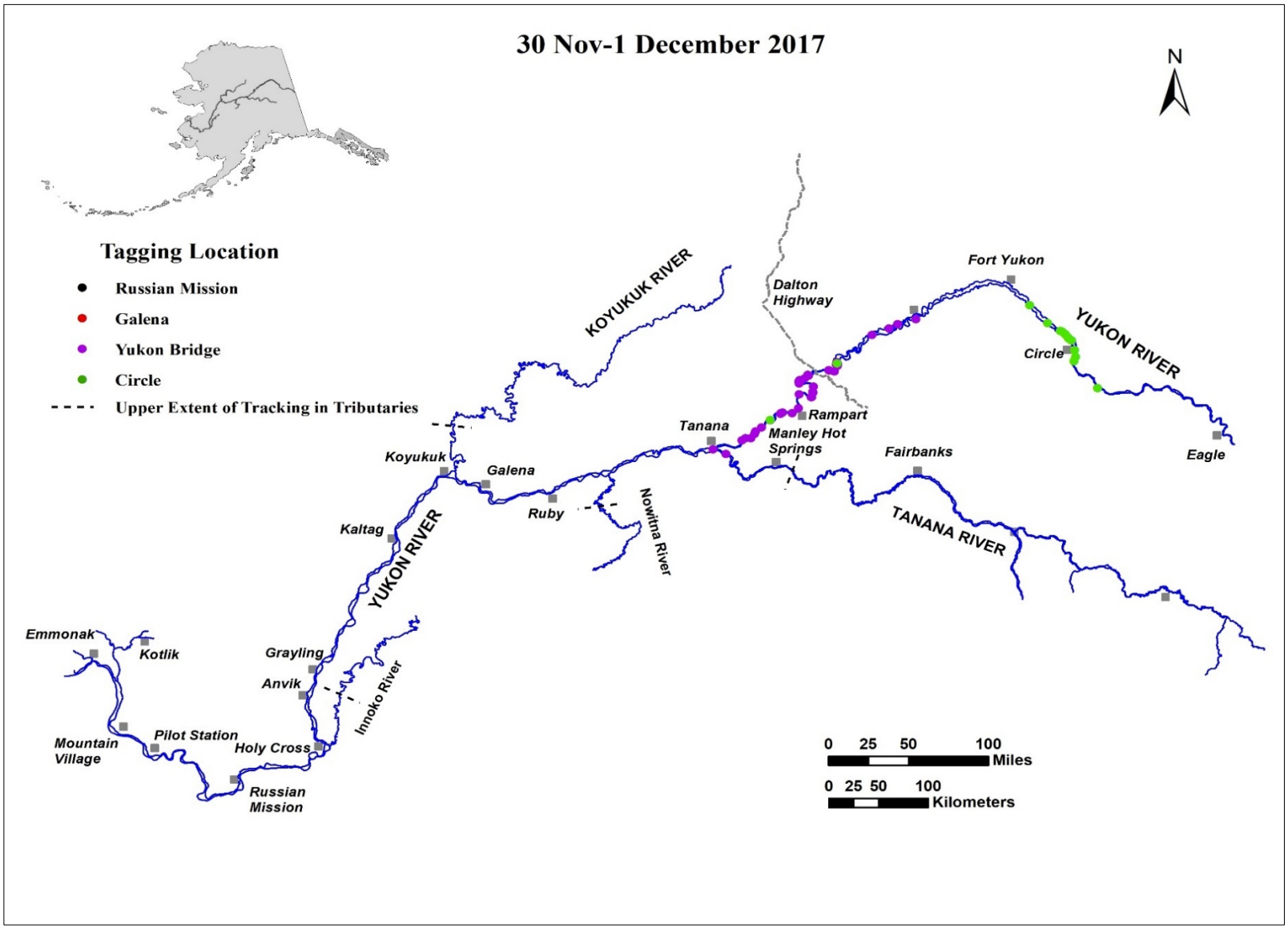
		Pre-spawning							Post-spawning					
Frequency-code	Tagging location	Spawning location	Tracking station	Date/ time	Tracking station	Date/ time	Tracking station	Date/ time	Tracking station	Date/ time	Tracking station	Date/ time	Tracking station	Date/ time
149.630-42	Pilot Station	Grayling to Galena	Russian Mission	12/2/ 2018 7:52										
149.630-58	Pilot Station	Galena to Nowitna R	Galena	1/12/ 2020 0:52					Galena	6/9/ 2020 23:29				
149.630-64	Pilot Station	Below Grayling	Russian Mission	12/25 /2018 0:18										
149.630-74	Pilot Station	Galena to Nowitna R	Galena	1/12/ 2020 0:22					Galena	2/15/ 2020 2:25				
149.780-19	Dalton Hwy	Galena to Nowitna R.	Russian Mission	11/30 /2018 9:02	Galena	1/28/ 2019 19:22			Galena	5/4/ 2019 0:00				
149.780-43	Dalton Hwy	Fort Yukon to Circle	Galena	11/3/ 2018 2:08	Tanana	11/21 /2018 17:10	Dalton Hwy	12/10 /2018 9:22	Dalton Hwy	5/7/ 2019 1:17	Galena	5/28/2019 2:27		
149.780-45	Dalton Hwy	Below Grayling	Russian Mission	10/22 /2018 3:03										
149.780-48	Dalton Hwy	Dalton Hwy to Beaver	Dalton Hwy	11/21 /2018 3:39					Dalton Hwy	3/10/ 2019 1:09				
149.780-49	Dalton Hwy	Above Dalton Hwy Infer	Dalton Hwy	11/16 /2018 6:07										
149.780-52	Dalton Hwy	Dalton Hwy to Beaver	Dalton Hwy	12/8/ 2018 0:28					Dalton Hwy	2/28/ 2019 15:46				
149.780-53	Dalton Hwy	Fort Yukon to Circle	Dalton Hwy	11/16 /2018 9:37										
149.780-80	Dalton Hwy	Dalton Hwy to Beaver	Dalton Hwy	11/19 /2018 16:09										

-continued-

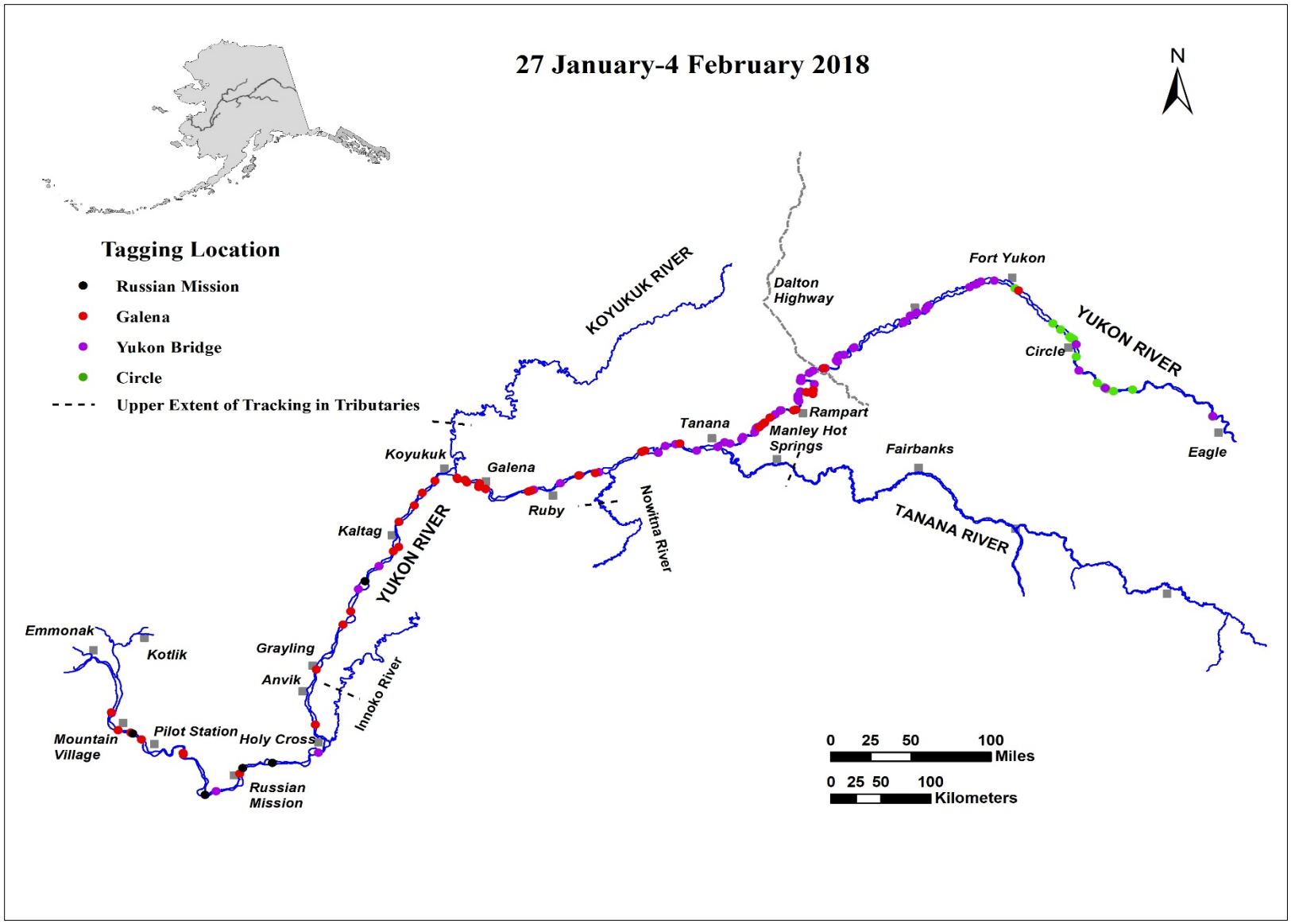
Appendix C2.–Page 2 of 2.

		Pre-spawning							Post-spawning					
Frequency-code	Tagging location	Spawning location	Tracking station	Date/ time	Tracking station	Date/ time	Tracking station	Date/ time	Tracking station	Date/ time	Tracking station	Date/ time	Tracking station	Date/ time
149.820-15	Galena	Beaver to Fort Yukon	Galena	11/19 /2018 9:13	Tanana	12/12 /2018 15:26			Dalton Hwy	5/15/ 2019 11:06	Tanana	5/19/2019 0:08	Galena	5/29/201 9 4:07
149.820-23	Galena	Grayling to Galena	Russian Mission	12/5/ 2018 9:06										
149.820-39	Galena	Rampart to Dalton Hwy	Galena	12/25 /2018 15:00	Tanana	1/9/2 019 14:28			Galena	5/8/ 2019 4:51				
149.820-41	Galena	Galena to Nowitna R.	Russian Mission	11/24 /2018 6:31	Galena	1/21/ 2019 6:50			Galena	3/18/ 2019 3:25				
149.820-50	Galena	Galena to Nowitna R.	Galena	1/13/ 2019 2:41					Galena	2/13/ 2019 8:06				
149.820-52	Galena	Above Nenana	Galena	9/24/ 2018 23:45					Manley HS	5/4/ 2019 19:42	Tanana	5/14/2019 7:00	Galena	5/28/201 9 18:16
149.820-55	Galena	Rampart to Dalton Hwy	Galena	12/28 /2018 10:17					Galena	5/19/ 2019 13:22				
149.820-91	Galena	Rampart to Dalton Hwy	Galena	1/12/ 2019 17:28	Tanana	1/24/ 2019 16:26			Dalton Hwy	5/21/ 2019 13:41	Tanana	5/31/2019 11:43		
149.900-35	Circle	Rampart to Dalton Hwy							Dalton Hwy	3/9/ 2019 0:56				

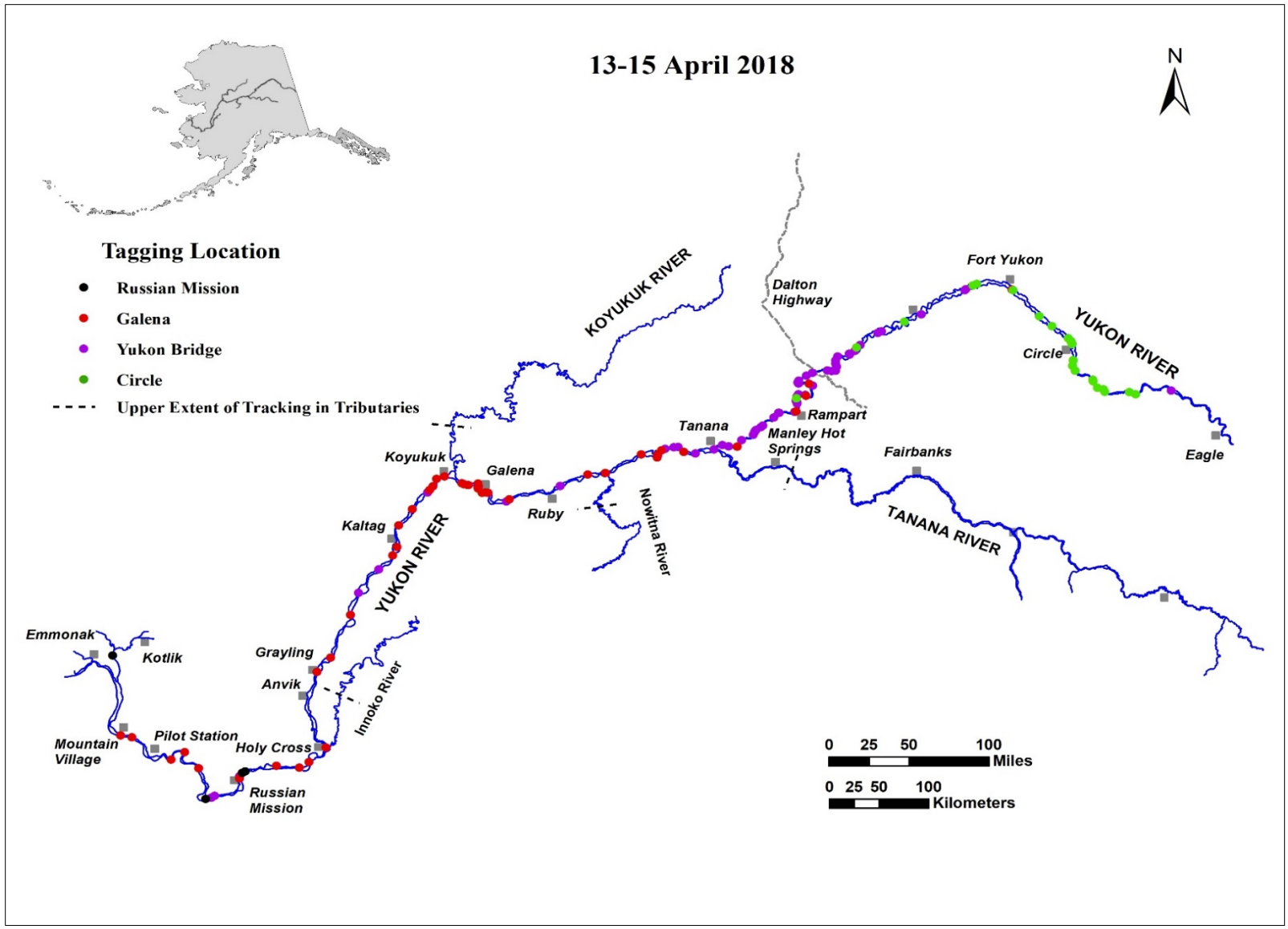
APPENDIX D:
DRAINAGEWIDE MAPS OF RADIOTAGGED BURBOT LOCATIONS



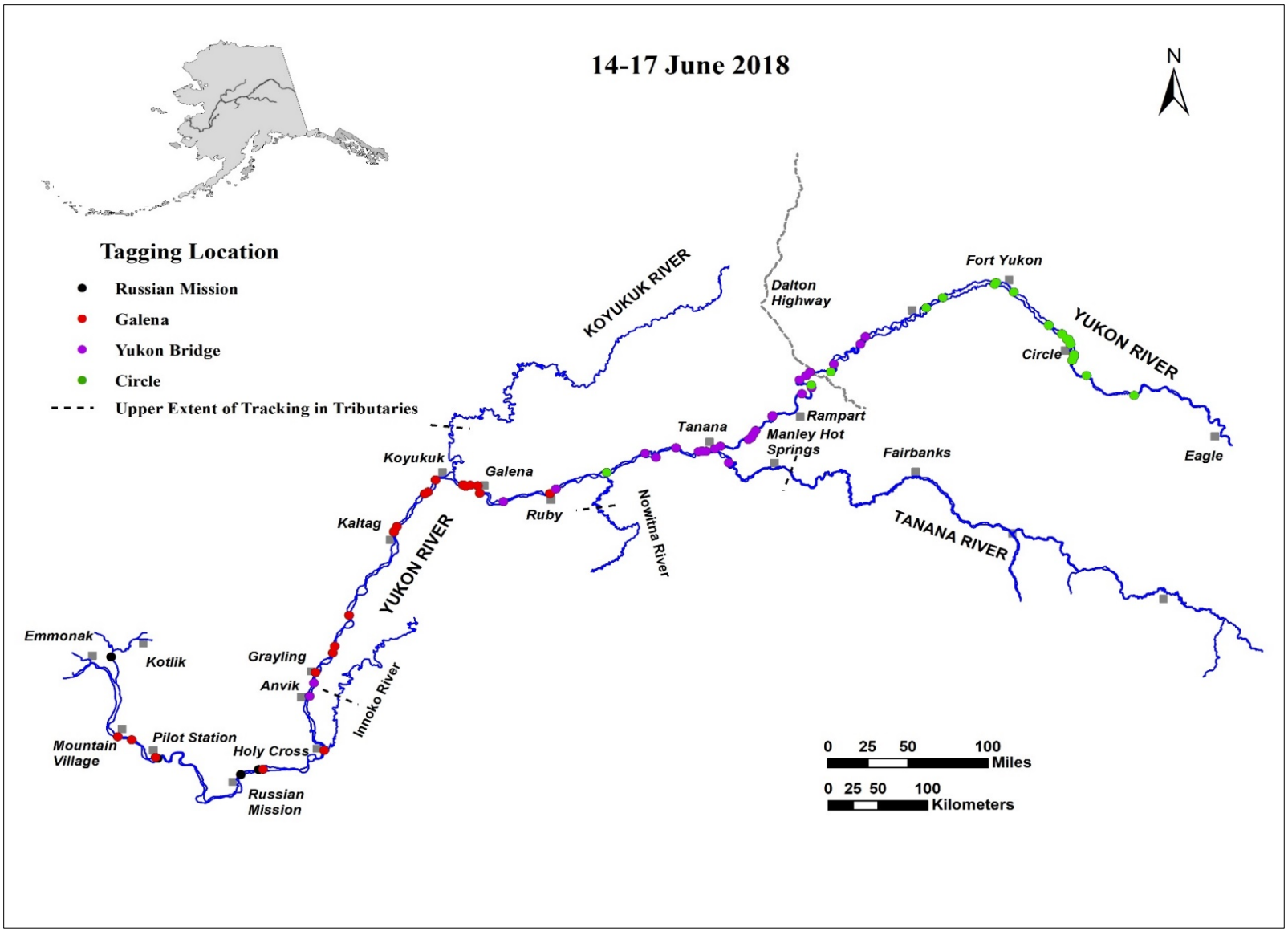
Appendix D1.–Map of the Yukon River showing the locations of radiotagged burbot that were detected during the 30 Nov–1 Dec 2017 aerial tracking flights.



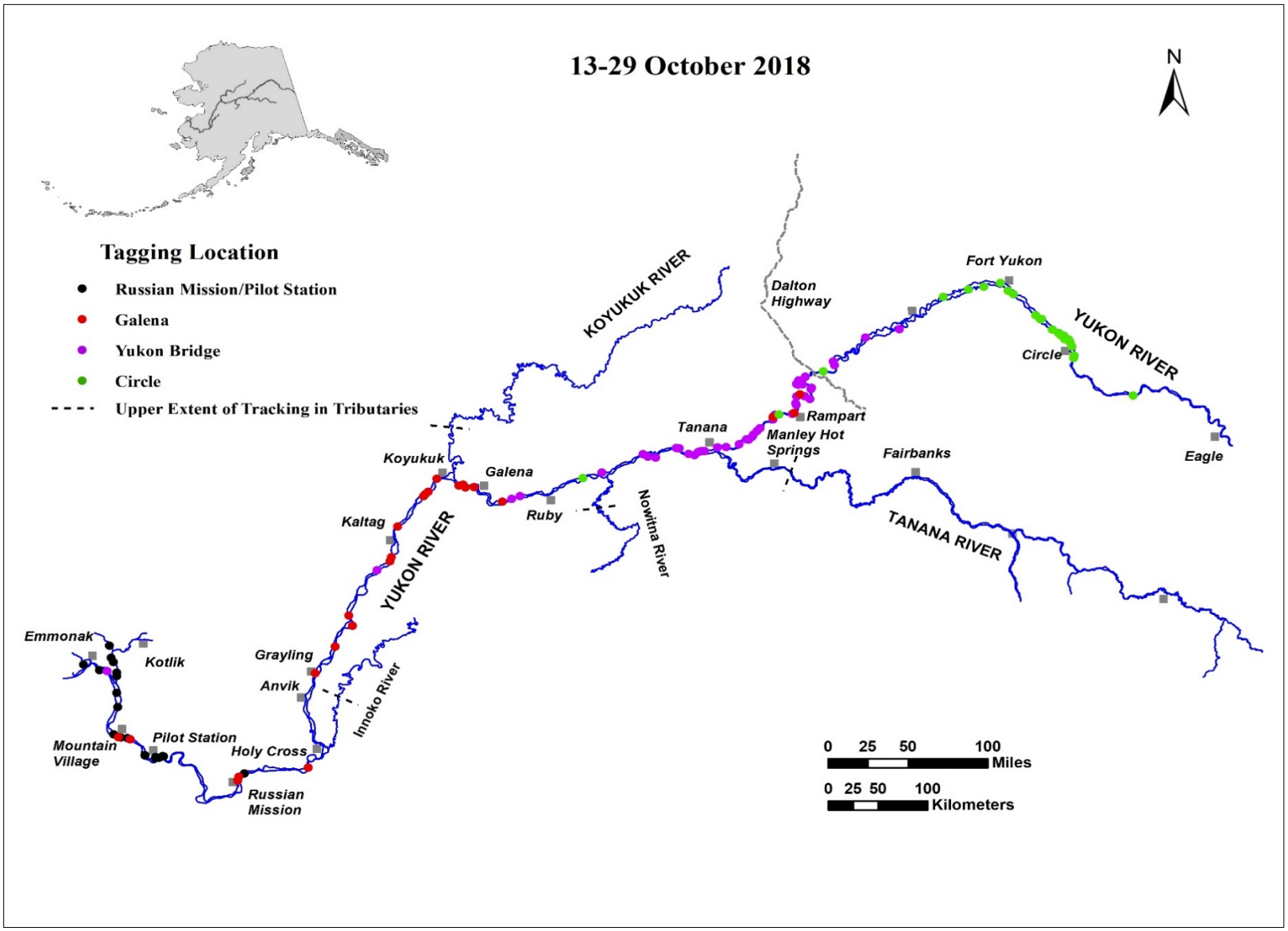
Appendix D2.–Map of the Yukon River showing the locations of radiotagged burbot that were detected during the 27 Jan–4 Feb 2018 aerial tracking flights.



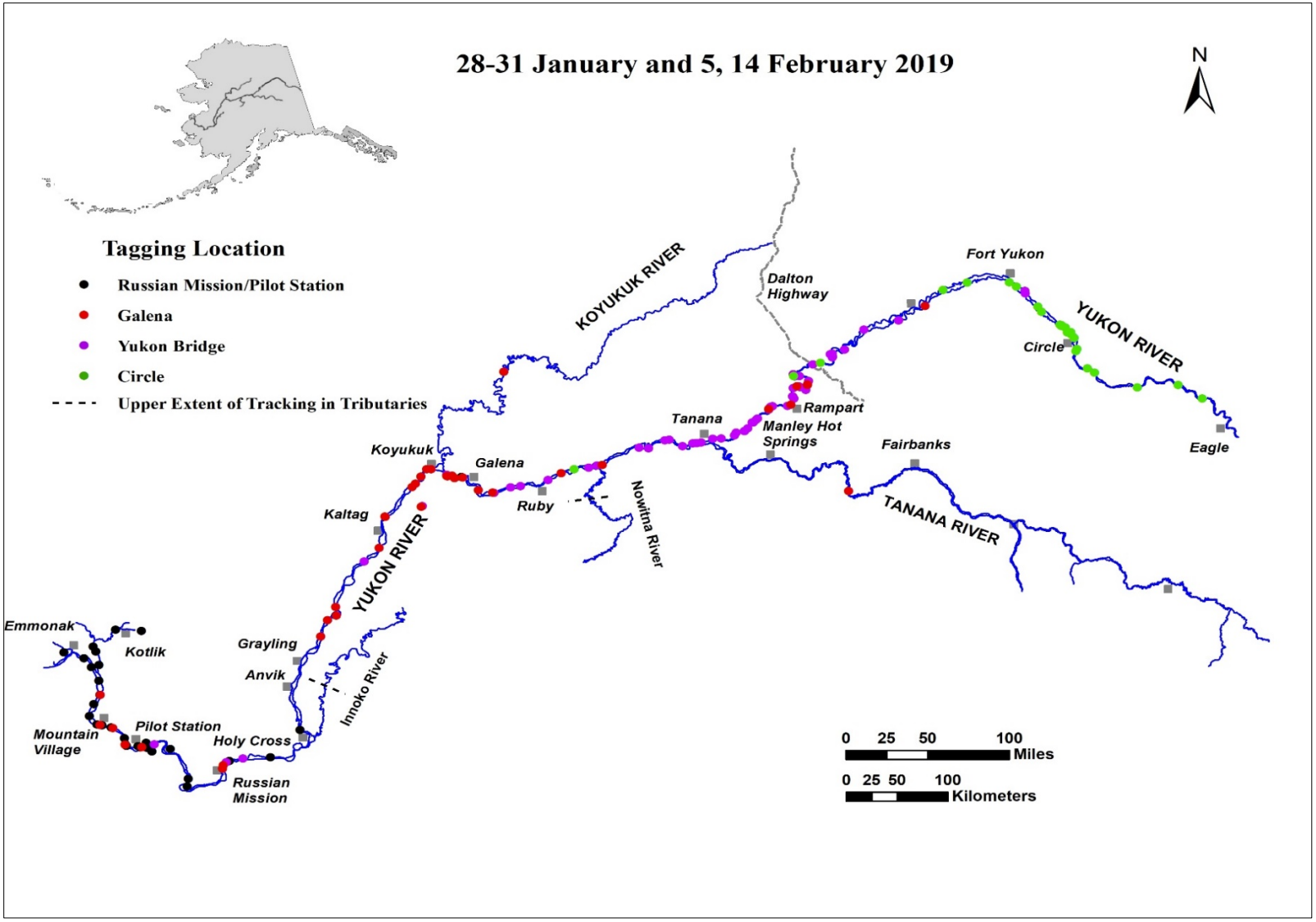
Appendix D3.–Map of the Yukon River showing the locations of radiotagged burbot that were detected during the 3–15 April 2018 aerial tracking flights.



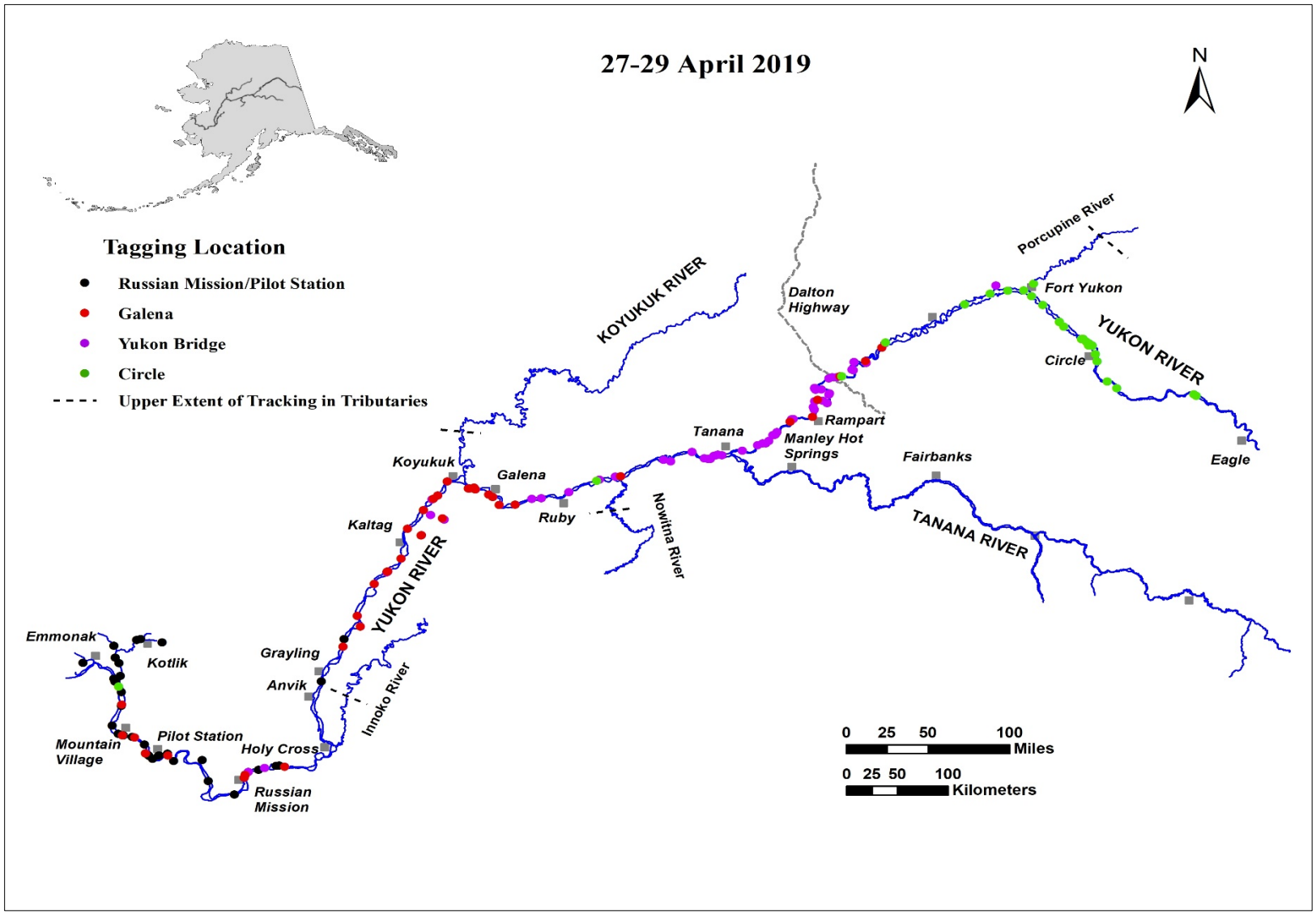
Appendix D4.–Map of the Yukon River showing the locations of radiotagged burbot that were detected during the 14–17 June 2018 aerial tracking flights.



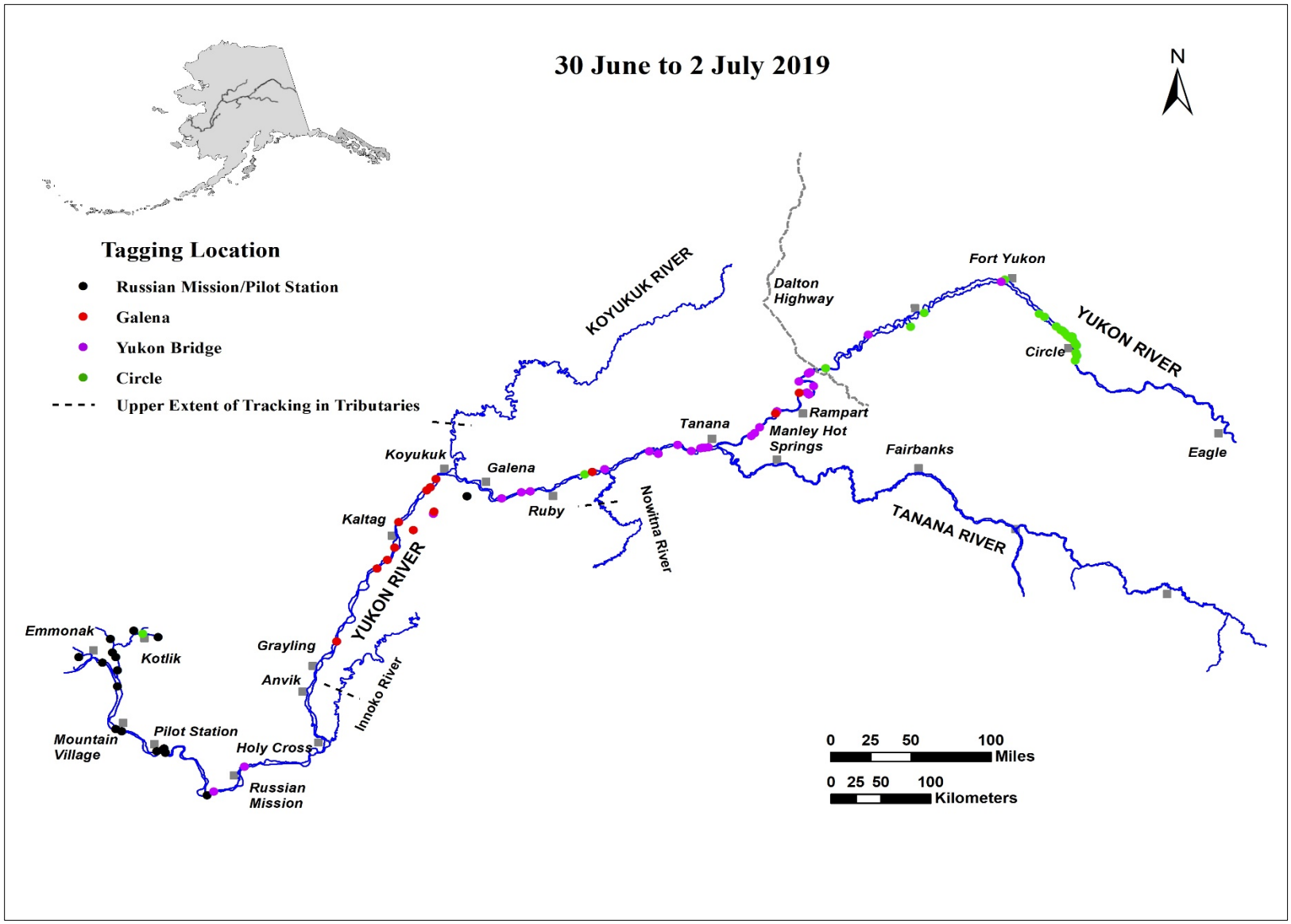
Appendix D5.–Map of the Yukon River showing the locations of radiotagged burbot that were detected during the 13–29 Oct 2018 aerial tracking flights.



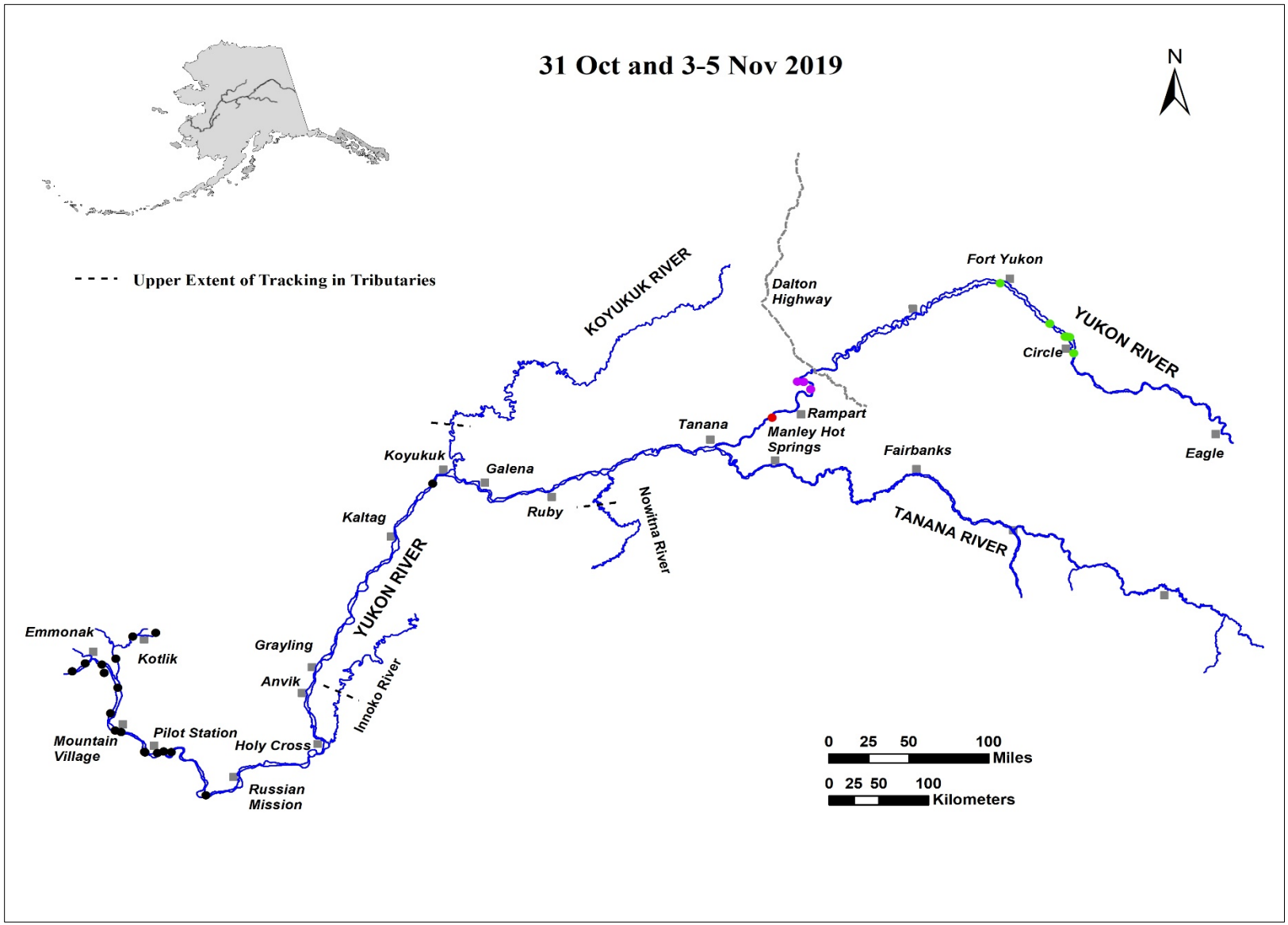
Appendix D6.–Map of the Yukon River showing the locations of radiotagged burbot that were detected during the 28–31 Jan and 5 and 14 Feb 2019 aerial tracking flights. The 14 Feb 2019 flight covered the Koyukuk River from the Dalton Highway to Koyukuk, and most of the Tanana River was covered by the Tanana River burbot radiotelemetry project.



Appendix D7.–Map of the Yukon River showing the locations of radiotagged burbot that were detected during the 27–29 Apr 2019 aerial tracking flights. The lower 130 km of the Porcupine River was flown and most of the Tanana River was covered by the Tanana River burbot radiotelemetry project.



Appendix D8.–Map of the Yukon River showing the locations of radiotagged burbot that were detected during the 30 June–2 July 2019 aerial tracking flights. Most of the Tanana River was covered by the Tanana River burbot radiotelemetry project.



Appendix D9.–Map of the Yukon River showing the locations of radiotagged burbot that were detected during the 31 Oct, 3–5 Nov 2019 aerial tracking flights. Most of the Tanana River was covered by the Tanana River burbot radiotelemetry project.

APPENDIX E:
SPAWNING CHARACTERISTICS AND SPAWNING HABITAT DATA COLLECTED NEAR THE DALTON HIGHWAY BRIDGE

Appendix E1.–Burbot sampled and analyzed for spawning readiness at the Yukon River near the Dalton Highway spawning location. Sites are illustrated in Figure 16.

Site #	Collection date	Fish #	Location		Length (mm)	Gender	Total weight (Kg)	Gonad weight (g)	Liver weight (g)	Spawning condition
			Latitude	Longitude						
Site 2	7-Feb-20	1	65.8781	-149.7315	719	F	2.03	54.8	84.4	non-spawning
Site 1	7-Feb-20	2	65.8793	-149.7285	692	F	1.71	30.6	40.9	post-spawn
Site 4	7-Feb-20	3	65.8612	-149.7785	650	F	1.42	22.5	59.3	non-spawning
Site 4	7-Feb-20	4	65.8612	-149.7785	880	F	3.18	54.8	83.1	post-spawn
Site 4	7-Feb-20	5	65.8612	-149.7785	904	F	4.23	76.5	194.0	post-spawn
Site 4	7-Feb-20	6	65.8612	-149.7785	771	F	3.44	16.5	288.1	non-spawning
Site 1	7-Feb-20	7	65.8793	-149.7285	971	F	4.27	118.8	129.2	post-spawn
Site 1	7-Feb-20	8	65.8793	-149.7285	797	F	2.31	49.1	75.8	post-spawn
Site 2	7-Feb-20	9	65.8784	-149.7315	997	F	5.78	116.3	287.7	post-spawn
Site 4	6-Feb-20	10	65.8613	-149.7784	592	M	1.41	1.3	–	non-spawning
Site 4	6-Feb-20	11	65.8613	-149.7784	747	F	1.92	13.9	–	post-spawn
Site 2	6-Feb-20	12	65.8788	-149.7304	653	M	1.83	1.6	116.6	non-spawning
Site 5	7-Feb-20	13	65.8739	-149.6653	810	F	2.76	34.5	68.2	post-spawn
Site 3	7-Feb-20	14	65.8584	-149.8581	757	M	3.23	2.6	248.1	non-spawning
Site 3	7-Feb-20	15	65.8584	-149.8581	760	F	2.39	29.2	79.3	post-spawn
Site 3	7-Feb-20	16	65.8584	-149.8581	685	F	1.54	5.3	71.1	non-spawning
Site 2	5-Feb-20	17	65.8781	-149.7315	674	F	1.95	6.6	128.8	non-spawning
Site 2	5-Feb-20	18	65.8781	-149.7315	783	F	2.53	26.6	148.1	post-spawn
Site 1	5-Feb-20	19	65.8792	-149.7286	817	M	3.29	2.8	263.3	non-spawning
Site 2	6-Feb-20	20	65.8788	-149.7304	877	F	4.73	23.2	423.4	non-spawning
Site 2	6-Feb-20	21	65.8788	-149.7304	872	F	4.12	76.9	349.9	post-spawn
Site 1	5-Feb-20	22	65.8792	-149.7286	804	F	3.28	16.6	322.9	non-spawning
Site 1	5-Feb-20	23	65.8792	-149.7286	808	F	2.68	57.0	74.3	post-spawn
Site 1	5-Feb-20	24	65.8792	-149.7286	588	M	1.04	0.8	48.2	non-spawning

Appendix E2.–Water quality data recorded from the ice holes where burbot were sampled for spawning readiness during 4–7 February 2020. The sites are shown in Figure 16.

			Dissolved oxygen (DO)		Conductivity	Temperature	Depth
Location	Date	pH	mg/L	%	$\mu S/cm$	°C	m
Site 1	5-Feb-20	7.2	8.3	58.3	321	0.1	1.4
Site 2	5-Feb-20	7.6	–	–	324	0.1	1.9
Site 3	6-Feb-20	6.9	8.2	57.3	339	0.1	4.7
Site 4	6–7-Feb-20	7.5	8.2	56.5	342	0.1	–
Site 5	7-Feb-20	7.7	8.2	57	341	0.1	1.9
Average		7.4	8.2	57.3	333	0.1	2.5