Fishery Data Series No. 11-46

Seasonal Distribution of Rainbow Trout Relative to Sport and Subsistence Fisheries in the Aniak River, 2008–2010

Final Report for Study 08-300

USFWS Office of Subsistence Management

Fisheries Resource Monitoring Program

by

Corey J. Schwanke

and

J. Michael Thalhauser

October 2011

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

Symbols and Abbreviations

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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

FISHERY DATA SERIES NO. 11-46

SEASONAL DISTRIBUTION OF RAINBOW TROUT RELATIVE TO SPORT AND SUBSISTENCE FISHERIES IN THE ANIAK RIVER, 2008-2010

by

Corey J. Schwanke
Division of Sport Fish, Glennallen

and

J. Michael Thalhauser
Kuskokwim Native Association

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

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Corey J. Schwanke
Alaska Department of Fish and Game, Division of Sport Fish,
1300 College Road, Fairbanks, AK 99701-1599, USA

and

J. Michael Thalhauser
Kuskokwim Native Association
PO Box 127, Aniak, AK 99557

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ABSTRACT

A two-year radiotelemetry study of Aniak River rainbow trout *Oncoryhncus mykiss* was initiated in 2008 to determine whether discrete geographic stocks exist within the drainage by examining their seasonal movements and distributions. From 6 to 12 August 2008, radio tags were surgically implanted into 125 rainbow trout ≥ 410 mm FL in four different river segments (Salmon River, Kipchuk River, Upper Aniak River and the mainstem Aniak River) spanning 134 river kilometers (rkm) of the Aniak River drainage. A total of 20 aerial tracking surveys were flown from 25 September 2008 through 25 June 2010. Results of the surveys indicated that: 1) none of the tagged rainbow trout overwintered near or downstream of Doestock Creek (the closest fish was 14.5 rkm upstream of Doestock Creek), which is the primary location of the winter subsistence fishery; 2) overwintering and spawning habitat were limited in the Salmon River; 3) overwintering and spawning areas were intermittent in the Kipchuk River and in the Upper Aniak River; 4) within the confines of our tagging study area, overwintering and spawning areas were widespread in the Aniak River mainstem; 5) few tagged rainbow trout made extensive spawning migrations from overwintering areas; 6) spawning appeared to take place from late May–early June; and, 7) a year after tagging, most rainbow trout returned to the same river segment in which they were initially tagged.

Key words: rainbow trout, *Oncoryhncus mykiss,* telemetry, Aniak River, movement, migration, overwintering, spawning

INTRODUCTION

The Aniak River is located approximately 300 river kilometers (rkm) upstream from the mouth of the Kuskokwim River and approximately 200 rkm upstream from the village of Bethel. The mainstem Aniak River originates at Aniak Lake within the Kilbuck Mountains and flows north approximately 185 rkm to the Kuskokwim River near the village of Aniak (Figure 1). Two major tributaries flow into the Aniak River: the Kipchuk and the Salmon rivers. The Kipchuk River joins the Aniak River about 87 rkm below Aniak Lake and the Salmon River joins the Aniak River about 2 rkm below the Kipchuk River confluence. The lower 70 rkm of the Aniak River flows through the Yukon Delta National Wildlife Refuge.

The Aniak River is the natal stream for five species of anadromous Pacific salmon: Chinook *Oncorhynchus tshawytscha*, chum *O. keta*, sockeye *O. nerka*, pink *O. gorbuscha*, and coho *O. kisutch*. In addition to rainbow trout *Oncoryhncus mykiss*, resident fish species inhabiting the Aniak River include: Dolly Varden *Salvelinus malma*, northern pike *Esox lucius*, Arctic grayling *Thymallus arcticus*, burbot *Lota lota*, sheefish *Stenodus leucichthys*, lake trout *Salvelinus namaycush*, humpback whitefish *Coregonus pidschian*, round whitefish *Prosopium cylindraceum*, longnose sucker *Catostomus catostomus*, blackfish *Dallia pectoralis*, and slimy sculpin *Cottus cognatus.*

The Aniak River is the most upstream tributary of the Kuskokwim River having a rainbow trout population that supports a rainbow trout fishery. Total sport fishing effort on the Aniak River peaked in the late-1990s, declined in the early 2000s, and has risen the last 4 years (Figure 1). The proportion of sport fishing effort directed at rainbow trout is unknown, but has likely trended with total sport fishing effort. Annual sport fishing harvests of rainbow trout have remained low, averaging 74 fish from 1989 to 2000, and zero fish since 2001. Total catch peaked in 1997 and again in 2008, and has averaged about 5,600 rainbow trout annually from 2004 to 2008 (Figure 1). Since 1985, sport fishing regulations for rainbow trout have become increasingly restrictive, prompted largely by local concerns about the health of the population. Prior to 1985, up to 15 rainbow trout could be harvested as part of a combined resident species bag limit. The combined bag limit was reduced to 2 fish in 1985. In 1990, the drainage upstream of Doestock Creek was restricted to catch-and-release for rainbow trout (single hook and no bait), and in 2001

the entire Aniak River was similarly restricted to catch-and-release sport fishing for rainbow trout.

The rainbow trout population in the Aniak River also contributes significantly to the local subsistence harvest of freshwater fish. There has been a strong local concern about an apparent large decline in the population and size of rainbow trout in the Aniak River since the mid-1980s. These declines were noted in interviews with subsistence users who reported being able to easily jig 30 or more rainbow trout through the ice per day (one report of 100 fish) from overwintering locations downstream of the Buckstock River during the 1960s and 1970s (Krauthoefer et al. 2006). Because of these declines and low catch rates (e.g., 5 fish per day) many subsistence users from Aniak and Chuathbaluk are no longer targeting rainbow trout as they did previously. The cause for these apparent declines are unclear, but they have been linked by subsistence users to the rise in the popularity of sport fishing in the region, and the overfishing and habitat problems associated with a large increase of people using the Aniak River and its tributaries (Krauthoefer et al. 2006).

The majority of the subsistence harvest of rainbow trout in the Aniak River is caught using rod-and-reel during winter and spring through the ice downstream of the Buckstock River, with limited fishing occurring as far up as the mouth of the Salmon River. The retention of rainbow trout by rod-and-reel subsistence users is prohibited only from June 1 to August 31 upstream of the Doestock Creek, and rainbow trout caught incidentally in other gears (e.g., gill nets) may be retained throughout the drainage and throughout the year. A complete history of federal and state subsistence regulations are described by Krauthoefer et al. (2006).

Two prior household census surveys were conducted to estimate subsistence harvest of rainbow trout. In 2001, a total of 342 rainbow trout were taken and in 2002, a reported 168 trout were taken from the Aniak River. These harvests were categorized by season, gear and area, and the majority of harvest taking place when the river is frozen, with hook and line, and in the vicinity of Doestock Creek (Krauthoefer et al. 2006). It should be noted that since the time of this survey (2001 and 2002), it appears that effort might be shifting farther upriver as catches have been decreasing in the lower river.

To evaluate these purported sport and subsistence fishing concerns and the long-term sustainability of rainbow trout in the Aniak River, information on both population size and life history is needed. The life history information is required to determine if unique sub-populations or stocks exist within the drainage that are affected differently based on harvest patterns or environmental factors. Telemetric studies have demonstrated that rainbow trout within a drainage can be composed of multiple spawning stocks, can exhibit wide variation in levels of fidelity to spawning, feeding, and overwintering areas, and can exhibit either very small (e.g., < 3 km) or large (> 75 km) intra-annual movements to these areas (Adams 1996 and 1999; Fleming 2004; Lisac 1996; Meka et al. 2000; Schwanke and Hubert 2000).

The goal of this study was to collect information on the seasonal movements and distribution of rainbow trout in the Aniak River to determine if discrete stocks exist within the drainage. In the absence of abundance-based information, quantifying rainbow trout movements will help to identify the distribution(s) of those fish affected by inriver fisheries.

Specific objectives for 2008 through 2010 were to:

1) Describe the seasonal (summer 2008 to winter 2009/2010) distributions of mature sized rainbow trout ≥ 420 mm fork length (FL) in the Aniak River implanted with radio transmitters during the summer feeding period when rainbow trout distributions are most widespread; and,

2) For each of the four hydrologic units (Salmon River, Kipchuk River, Upper Aniak River, and mainstem Aniak River from the Kipchuk River downstream to a point approximately 6 rkm below the Buckstock River), estimate the proportion of radio-tagged rainbow trout that remained in the hydrologic unit where they were tagged. These estimates will be made for each aerial tracking survey and each estimated proportion will be within 25 percentage points of the true value 95% of the time.

Relative to Objective 1, quantitative descriptions of rainbow trout locations during biologically meaningful periods were used to describe significant habitats (i.e., spawning and overwintering) by identifying aggregates of rainbow trout (e.g., 3 or more fish within a 1-km reach of the river). Mature-sized fish were selected because these fish will help to identify spawning habitats and because larger-sized fish are better able to bear a radio tag. Because very limited annual movements of rainbow trout have been observed in neighboring systems, Objective 2 was constructed as a means to identify potential discrete stocks and to grossly assess the contribution of these stocks to both the sport and subsistence fisheries.

METHODS

STUDY AREA

In 2007, prior to the initiation of this project, research was conducted to determine the distribution of rainbow trout during summer in the Aniak River drainage (Figure 2). One crew of two people floated down from Aniak Lake (the section from Aniak Lake to the confluence with the Kipchuk River is hereafter referred to as the Upper Aniak River) and another crew of two people floated down the Kipchuk River. Both crews sampled with hook and line to determine the detectable upper limits of distributions of rainbow trout in these two river segments. Rainbow trout distribution in the Upper Aniak River was determined to be the lower 30 rkm and distribution in the Lower Kipchuk River was determined to be the lower 35 rkm. Sport fishing guides and locals from Aniak village suggested rainbow trout distribution was similar in the more popular Salmon River tributary. Therefore, the tagging effort was initiated at these approximate locations within the three tributary segments. Within the mainstem, tagging efforts took place in an approximate 56-rkm segment from the Kipchuk River confluence down to a point about 11 rkm below the Buckstock River confluence. The river morphology changes at the lower boundary where it becomes slower moving with deeper water. Although rainbow trout were known to occur below this boundary, it was believed they were in very low densities and contributions to fisheries were considered negligible. The total study area, as it related to radio-tagging effort, was approximately 160 rkm in length, was assumed to contain most (>90%) of the adult rainbow trout population, and encompassed almost all of the sport fishing effort on rainbow trout (Figure 1). Actual radio tag distribution is discussed in the Results section.

In regards to aerial tracking, the search area extended well above the upper tagging locations in the tributary streams and included the lower half of the Buckstock River, Doestock Creek,

Timber Creek and occasionally the Lower East Fork Aniak River (although no tags were deployed in these tributaries, rainbow trout are known to reside in them at times), the mainstem Aniak River all the way down to the village of Aniak, as well as parts of the Kuskokwim River during some of the surveys.

STUDY DESIGN

During early August of 2008, 125 rainbow trout were radiotagged when they were presumably most widely distributed in their summer feeding areas. To help guard against potential behavioral differences in movements related to tagging location (i.e., habitat or hydrology), the radio tags were partitioned among four distinct hydrological units: the lower 35 rkm of the Salmon, Kipchuk and Upper Aniak rivers (25 radio tags each), and a 56-rkm section of the mainstem Aniak River between the northern boundary of the study area and the Kipchuk River (50 radio tags). A greater number of radio tags were placed into the mainstem to account for its greater density of rainbow trout, which was based on anecdotal information, interviews, and from the feasibility work conducted in 2007.

Within each hydrologic unit, efforts were made to uniformly distribute radio tags. In the Upper Aniak, Kipchuk, and Salmon rivers, radio tags were planned to be dispersed at a density of 5 radio tags per 7-km reach of water. This application density would ensure a fairly uniform distribution while allowing crews large enough reaches to locate fish where densities were relatively low and "clustered" (i.e., near upper boundaries of study area). The mainstem had higher densities of rainbow trout and radio tags were more uniformly dispersed at a density of 5 tags per 5-km stretch of river.

All fish implanted with transmitters were sufficiently large to accommodate the radio transmitter (Winter 1983). Nearly all rainbow trout ≥ 420 mm FL were expected to be mature (Wuttig et al. 2004) and the behavior of rainbow trout ≥ 420 mm FL was expected to be representative of all mature-sized fish. Therefore, the first healthy fish from each river section (e.g., 5-km stretch in the mainstem) sampled was radiotagged and each subsequent healthy fish was sampled until the sample goal was met for that river stretch.

FISH CAPTURE AND TELEMETRIC PROCEDURES

Rainbow trout were captured using hook and line from 6–12 August 2008 using four crews (two or three persons each). Pegged beads and small jigs tipped with shrimp or salmon eggs were the primary lures. All three tributary segments were sampled with two-person crews in rafts, all of which required fixed-wing aircraft for initial access. The Upper Aniak River was accessed from a gravel bar about 16 rkm below Aniak Lake, the Kipchuk River was accessed from an unnamed landing strip adjacent to the river, and the Salmon River was accessed by a landing strip near Bell Creek. The mainstem Aniak River was sampled using two jetboats.

The transmitters selected for this project were Lotek™ model SR-M11-25 (coded tags). This coded transmitter with a motion sensor had an estimated life of 735 (warranted for 588 days) days when operated 12 h on/off per day using 3- and 3.5-s pulse intervals. Transmitters weighed 9.5 g in air and were well below the criteria of 2% of the live weight of the fish recommended by Winter (1983). Tags transmitted from 8:00 am to 8:00 pm on frequencies of 149.700 and 149.800 MHz. The transmitters had individual codes (3–100 for 149.700 MHz and 3–30 for 149.800 MHz) so each fish was discernable. When a fish was inactive or died, the code

displayed a "1" in front of it (e.g., 149.800 MHz with code 130). The motion sensors activated when there was no movement for 24 hours or more.

Radio tags were surgically implanted following well established procedures. Fish selected for radiotagging were anesthetized with a clove oil solution (100 ml clove oil oil/1,000 ml ethanol) at a concentration of 100 mg l^{-1} based on the procedures outlined by Anderson et al. (1997). When rainbow trout succumbed to the anesthesia (rolling over and lack of response to handling), they were measured to the nearest mm FL. Each fish was then placed in a padded cradle upside down and their gills were bathed in water with clove oil solution to maintain their anesthetized state. At this time, surgery began by cutting a 15-mm incision anterior to the pelvic girdle, along the left ventral side, about 10 mm from the center line. A grooved director was then placed into the coelomic cavity and directed towards the rear where it would direct a needle (16G horse catheter) inserted from posterior of the pelvic girdle towards the incision in the anterior (Brown et al. 2002). The transmitter antenna wire was routed from the incision past the pelvic girdle by threading the wire through the needle. Upon exit, the needle and grooved director were removed and the radio tag fully inserted into the coelomic cavity. The incision was sutured with 3 to 4 simple, interrupted stitches of monofilament suture material (Wagner et al. 2000), and treated with an adhesive (vet bond™) before releasing the fish to a portion of the river without current, where it was monitored until it had recovered. All radiotagged fish were tagged with an individually numbered internal anchor Floy™ tag inserted below the base of the dorsal fin.

Data collected from each fish that was radiotagged included date, time of capture, length (FL), capture gear, general location, latitude, longitude, Floy Tag number and frequency/code of the transmitter. All fish were released within 100 yards of the capture location.

Tracking flights were conducted using a fixed wing aircraft and a Lotek SRX 600 receiver with an internal GPS that recorded time and location data. Dual H type antennas mounted on the wing struts were used to more accurately assess locations and to maximize fish detection. Flights occurred during a 22-month period. Timing of individual flights was primarily based on finding significant habitats (e.g., spawning, overwintering) and describing their migration timing (e.g., when fish moved between overwintering and spawning habitats). Weather and pilot availability also dictated flight times.

DATA ANALYSIS

After all the surveys were flown, the location of each fish was plotted on a map using ArcGIS® and fish locations were labeled by survey. When and if an individual fish died was determined by examining their movements and data provided by the motion sensors.

The motion sensors alone did not always accurately assess the fate of any single fish at any given time (i.e., an 'A' meaning alive and an 'I' meaning dead). Preliminary results from each survey were recorded for each fish for each flight based solely on its tags signal (A or I). The history of sensor recordings for each fish was then examined to decipher when it had died. Examples were when a fish emitted an inactive signal (I) during one or two surveys, only to move upstream later in time and emit multiple 'A' signals. In this situation, the I's were changed to A's. Conversely, when a fish had multiple consecutive 'I' signals, then an intermittent 'A', then a string of 'I' signals, all the while exhibiting no detectable movement, the intermittent 'A' signals were changed to 'I' and the fish was declared dead at the time when the first time consecutive 'I' signals occurred. At the conclusion of this exercise, an 'A' represented a fish considered to be alive and an 'I' represented a fish considered to be dead. The radio tag motion sensor codes were

very accurate in assessing fate during this study and were only changed approximately 1% (19 out of 1,930 available times) of the time.

A fish not detected during a specific survey was assigned an 'AL' meaning 'at large', or missing. Whether these fish died and floated out of the study area, had tag failure, or were just missed during a survey, they were excluded from the data analyses.

All biological and telemetry data were entered into an Excel® spreadsheet and the final file with all the edited data, complete with GPS coordinates and fate for each fish for each survey, was archived (Appendix A1).

OBJECTIVE 1

Detected transmitters were assigned to a hydrologic unit (e.g., Salmon River) for each survey. Because the GPS locations obtained in the field were taken from a moving aircraft, with the antennas aimed ahead, actual GPS coordinates were often not within the stream course or directly over the fish. The point with the highest signal strength for each fish during each survey was chosen and the closest point of the river to that specific location was defined as the fish's location in that stream. These locations were calculated with ArcGIS® software using the snapping function. The precision of aerial radio tracking is variable, but experienced researchers believe that 0.5-1 km is realistic (D. Palmer, Fish Biologist, USFWS, Kenai and B. King, Sport Fish Biologist, ADF&G, Soldotna, personal communication). Descriptions of seasonal distributions of fish were presented and summarized by plotting coordinates of all located fish deemed to be alive at the time of the survey onto a digitized map of the drainage using the program ArcGIS® and the Animal Movement Analyst extension written by P. Hooge and B. Eichenlaub (1997). Variables measured include:

1. Net distance traveled between tracking events;
2. Direction traveled between tracking events; and,
3. Number of radiotagged fish within 0.5, 1.0, and 2.0 kilometers.

Because there are uncertainties with precision of the actual location of radiotagged fish, we conducted two separate analyses for variable #1 (net distance traveled between tracking events), one with a minimum movement detection criterion of 0.1 km, and one using 0.5 km as the minimum criterion. Under these scenarios, a fish must have been detected at a distance of 0.1 or 0.5 km away from the previous survey. If the distance was equal to or less than the criteria, then the fish was deemed stationary. Conversely, if the distance between the two locations was greater, then the fish was deemed to have moved. For variable #2 (direction traveled between tracking events), the analyses was only done with the 0.1 km movement detection criterion to calculate maximum, minimum and mean distances moved between surveys.

Patterns in transmitter locations (i.e., movements and densities) were used to infer fish behavior and habitat use. Aggregations of fish were used to characterize significant spawning and overwintering habitats.

OBJECTIVE 2

When estimating the proportion of fish which remained within a hydrological unit during each period between flights, all fish tagged in that unit were accounted for and only those fish deemed

to be alive at the time of the survey were included in the analysis. Each respective proportion and variance was calculated (Cochran 1977):

$$\hat{p}_{ij} = \frac{x_{ij}}{n_{ij}} \quad (1)$$

$$\hat{V}(\hat{p}_{ij}) = \frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_{ij}-1} \quad (2)$$

where:

$\hat{p}_{ij}$ = the proportion of rainbow trout tagged in hydrological unit *i* that were located alive in hydrological unit *i* during aerial survey *j*;

x_{ij} = the number of rainbow trout tagged in hydrological unit *i* that were located alive in hydrological unit *i* during aerial survey *j*; and,

n_{ij} = the number of rainbow trout tagged in hydrological unit *i* still considered alive at the time of aerial survey *j*.

Confidence intervals around $\hat{p}_{ij}$ were calculated using exact binomial confidence limits (Cochran 1977).

RESULTS

SUMMARY OF FISH CAPTURED

From 6 to 12 August 2008, 125 rainbow trout ≥ 410 mm FL were surgically implanted with radio tags (Figure 3; Appendix A1). Fork lengths of radiotagged rainbow trout ranged from 410 mm to 640 mm FL and the mean length was 466 mm FL (SD = 39.3). Three fish were between 410 and 415 mm FL, but were tagged in areas where densities were low and it was difficult to capture fish ≥ 420 mm FL. The majority (61) of radiotagged fish were between 410 and 459 mm FL (Appendix A1). Twenty-five tags each were deployed both in the lower 22 rkm of the Upper Aniak River and in the lower 35 rkm of the Kipchuk River, 21 tags were deployed in the lower 17 rkm of the Salmon River, and 54 tags were deployed in the mainstem Aniak River in a 56 rkm segment down to a point about 11 rkm below the Buckstock River confluence (Figure 4). In total, radio tags were distributed over 130 rkm.

Tag deployment was not as uniform as planned in the three tributary segments because rainbow trout were not detected as far upstream as anticipated and/or capture rates were not sufficient in these upper reaches to tag 5 fish in each 7 rkm section (Figure 4). Twenty-five radio tags were scheduled to be deployed in the Salmon River, but only 20 were placed there because the upper distribution of rainbow trout in the Salmon River was much lower than expected. It was decided to place the remaining four tags in the lower Aniak River mainstem below the Buckstock River confluence (versus placing them all in the lower Salmon River). This worked out well because the study area was extended 5 rkm farther down the mainstem than originally planned, now extending 11 rkm below the Buckstock River confluence, and the tagging ratio remained approximately 5 fish per 5 rkm.

RADIO TRACKING

Overview

A total of 20 aerial tracking flights were conducted from 2008–2010 (Table 1; Figures 5–23). The surveys on 8 October 2008 and 4 June 2009 were incomplete due to high winds and the receiver failed to record GPS locations during the 13 May 2010. An attempt was made to appoint locations of fish based on the pilots tracking log for 13 May, but the accuracy of this was not precise enough for movement analyses.

The mortality rate of radiotagged fish was higher than expected. Approximately 50 days after tagging, 88 unique fish were found alive. Only 15 fish were still alive after the last survey on 25 June 2010 (Table 1). It is assumed that most of the 77 fish that died or went missing after the initial survey (50 days after tagging) had fates not associated with tagging (Appendix A1). This mortality was probably an artifact of tagging older, mature fish.

Based on fish movement, observations on water conditions, and known spawning times of rainbow trout throughout southcentral and southwestern Alaska (Lisac 1996; Nelle 2002; Fleming 2004), it appeared spawning took place from late May through mid-June. In 2009, the survey conducted on 28 May (Figure 11) probably best represents spawning distribution, and in 2010 the survey on 2 June (Figure 22) probably best represents spawning distribution. Rainbow trout started dispersing to summering areas from mid-June to late July, remained relatively stationary until late October/early November, then made migrations of varying distances to overwintering areas. Fish remained at overwintering areas until the following spawning period. Most fish made little to no migrations from overwintering to spawning locations.

Distance Traveled

Net distance traveled between each survey varied by individual fish and time between surveys. Based on mean absolute distance traveled, rainbow trout exhibited the greatest movement when traveling from summer to winter locations. Mean absolute distance traveled was highest (5.0 rkm) between the surveys conducted on 8 October 2008 and 14 March 2009 (Table 2). The following year there was substantial absolute movement (4.0 rkm) between 30 October 2009 and 26 November 2009 (Table 2). A vice versa trend of fish returning to summering areas surely existed but was masked due to a higher frequency of surveys during the spring and summer when this movement occurred. Little movement occurred from wintering to spawning areas suggesting that these trout typically do not make extensive migrations to spawning areas.

Annual mean range (defined by the greatest distance between any two surveys throughout the year) of the 50 fish that lived for at least the first 12 months ranged from 1.8 km to 51.9 km, and averaged 11.9 rkm (Appendix A1; Table 3). Expectantly, initial tagging location was related to annual movements. The fish tagged in the Upper Aniak River displayed the least amount of movement where 90% ranged ≤ 10 rkm over the course of a year, and their mean range was 6.0 rkm. In contrast, just one of six (17%) fish surviving one year that were originally tagged in the Salmon River ranged ≤ 10 rkm over the course of the first year, and they exhibited a mean range of 16.2 rkm. Fish originally tagged in the Kipchuk River displayed similar mean range over the course of a year (16.5 km), but in contrast to the Salmon River, a higher percentage (25%) moved ≤ 10 rkm (Table 3). Fish originally tagged in the mainstem Aniak River moved the least, where nearly half (45%) ranged ≤ 5 rkm and the majority (72%) ranged a distance ≤ 10 rkm during the first 12 months of the study. However, two individual fish made extensive upstream

movements during the spawning period (44.7 and 51.1 rkm), contributing to the mean annual range of 11.0 rkm (Table 3).

Directionality

Although direction of movements were calculated using detection criteria of 0.1 km and 0.5 km (Tables 4 and 5), the remainder of the results and discussion relate only to the 0.5 km criterion (Table 5) because of our uncertainty with the 0.1-km criterion. For 12 of the 19 consecutive surveys, > 50% of the fish exhibited no detectable movement between surveys. The maximum proportion of fish exhibiting downstream movement occurred during the overwintering migration and was 0.56 for the winter of 2008/2009 and was 0.55 for the winter of 2009/2010 (Table 5). Maximum proportions of upstream movement ranged from 0.34-0.40 and occurred during spring and early summer indicating fish were moving back up river from overwintering or spawning areas.

Proportions Remaining In Respective River Segments Where Tagged

Rainbow trout tagged in the Salmon River demonstrated virtually no fidelity to this river segment during winter; only 8% remained the first winter (1 of 13) and 0% (0 of 5) remained the second winter (Table 6). The one fish that remained during the first winter was within 0.2 rkm of the mouth, and considering our precision on locating fish, it could have easily been in the mainstem. Most of the fish overwintered in two general areas: near the forks (i.e., the general area where the Upper Aniak, Kipchuk and Salmon rivers converge) and above Timber Creek (Figure 24). Despite very little annual wintertime fidelity to the Salmon River, these fish did show strong summertime fidelity with 100% of tagged fish returning to the Salmon River the next two summers (Table 6). Assuming 28 May 2009 to be peak spawning, there is evidence that some of the fish tagged in the Salmon River returned there to spawn (3 of 9), but all of these fish were located in the lower 2.2 rkm of the Salmon River (Table 6; Figure 24).

Rainbow trout tagged in the Kipchuk River displayed 100% annual summertime fidelity both summers (i.e., all fish tagged in the Kipchuk summer of 2008 returned the following two summers). For wintertime, 56% (10 out of 18) remained the first winter, and 50% (1 of 2) remained the second winter (Table 6). The fish that left all overwintered in the mainstem segment, predominately near the forks. In regards to spawning, 71% (10 of 14) of these fish were found in the Kipchuk River on 28 May 2009 and 75% (3 of 4) were found in the Kipchuk River on 2 June 2010 (Table 6). Of the 5 fish that were not in the Kipchuk River during these periods, 4 fish were detected in the mainstem within 4.0 rkm of the Kipchuk River confluence, and 1 fish was found in the lower 2.0 rkm of the Upper Aniak River segment (Figure 25).

Rainbow trout in the Upper Aniak River segment demonstrated partial fidelity to this river segment throughout the study. For wintertime, proportions of fish remaining in this tributary varied, but 80% (12 of 15) remained the first winter, and 50% (3 of 6) overwintered there the second year (Table 6). In regards to spawning, 83% (10 of 12) of these fish were found in the Upper Aniak River segment on 28 May 2009 and 100% (3 of 3) were there on 2 June 2010. The 2 fish that were not located in the Upper Aniak River segment during these periods were found in the mainstem within 5.5 km of the Upper Aniak River confluence (Figure 26).

Rainbow trout tagged in the mainstem Aniak River exhibited strong seasonal fidelity to this river section. For 16 of the 19 surveys, 100% of the fish tagged in this river section remained there, and the lowest percentage of fish found elsewhere was 8% when 2 of 23 fish were found in a

different river section on 10 June 2009 (Table 6). One of these two was found in the lower 2 km of the Salmon River and the other was determined to be in the lower 1.5 km of the Kipchuk River, both of which were presumably spawning (Figure 27).

For the purpose of objective 2 (proportions remaining in their respective tagging river segments), it should be noted that three fish were possibly residing in the lower 1.0 rkm of the Buckstock River (i.e., had the highest signal strength when the plane was directly over the Lower Buckstock River), but with the uncertainties of our location precision, and that this only occurred for one or two survey's for each fish, these fish were grouped with the Aniak River mainstem fish.

Densities

Clusters of radiotagged fish indicated several important areas of seasonal use. Since these radio tags were spread out during the summertime when rainbow trout were widely distributed, density analyses does little for this time period; however, this analyses does document areas important for overwintering and spawning, and provides insight as to when migrations occur. Many fish concentrated in two distinct, but relatively close, locations during the winter and throughout spring: in the immediate vicinity of the Salmon River confluence and at a location 6.5 rkm below there (just above the confluence of Timber Creek; Figures 28–30).

Fish generally aggregated for overwintering and started to disperse for spawning during mid-May (Figure 31). On 14 March 2008 (first overwintering), the highest percentage of the study area had clustering at the scale of 3 or more fish per 0.5 km (9%) 1.0 km (24%) and 2.0 km (54%). The scale of 3 fish per 2 rkm revealed that fish remained clustered until 20 May when they started to disperse, presumably for spawning (Figure 31). It is important to realize that sample sizes decreased over time, and that increases or sudden decreases in percentages of clustered fish is what is most signifying, such as an increase of clustering during the second winter (26 November, 15 February and 4 March 2010 surveys).

DISCUSSION AND RECOMMENDATIONS

Prior to this study, it was assumed that rainbow trout in the Aniak River would make extensive annual migrations for summering, overwintering and/or spawning, due in part to the known congregations of rainbow trout found in the lower river during late winter. Although a handful of fish in this study did make large-scale interannual movements, the majority did not, and none of these fish overwintered in the lower river (i.e., in the vicinity of Doestock Creek). The high proportion of fish that moved little during the course of 12 months in the Upper Aniak River and Aniak River mainstem segments (Table 3) is sensible because these two river segments had the largest volume of water and hence, more potential seasonal habitat, particularly for overwintering (i.e., deeper pools or runs). Rainbow trout had greater annual ranges in the smaller tributaries of the Salmon and Kipchuk rivers where overwintering and spawning habitat appeared more limited.

Of interest in this study was determining the degree of overlap between the distributions of fish targeted in the sport fishery during summer and in the subsistence fishery during winter. Local residents have reported a decrease in the size and numbers of rainbow trout caught while subsistence fishing (Krauthoefer et al. 2006). It was suggested that increasing sport fishing effort might be contributing to these declines. The radio tags in this study were deployed where the majority of sport fishing occurs during the summer time. In contrast, the majority of the subsistence fishing for rainbow trout takes place with hook and line gear through the ice in late

winter/early spring, and the majority of this harvest occurs below our study area in the vicinity of Doestock Creek (Krauthoefer et al. 2006). The second largest amount of harvest occurs between Doestock Creek and the Buckstock River. Limited subsistence harvest of rainbow trout takes place above the Buckstock River (Krauthoefer et al. 2006). None of the radiotagged rainbow trout which were deemed to be alive during this study were ever tracked more than 0.75 rkm below the tagging study area, approximately 14.5 rkm above Doestock Creek.

The results of this study alone cannot fully address concerns that the sport fishery might be contributing to the perception of decreasing size and abundance of rainbow trout available in the lower river during winter/spring subsistence fishing. However, it does provide strong evidence that these two user groups are utilizing two groups of fish with geographically discrete distributions, and that a decreasing trend in size may be unrelated to the sport fishery. Conversely, the results of this study cannot rule out the chance that fish found in the lower river during winter do spend time upriver where the sport fishery is primarily occurring, and consequently, could be impacted by sport fishers. For instance, it is possible that fish which overwinter in the lower river (i.e., the vicinity of Doestock Creek) do mix with those targeted by sport fishers in the summer time where feeding and spawning habitat are more suitable, but make up a small component of the overall population in the sport fishery, and therefore, were not detected in this study.

Factors influencing a putative decrease in abundance and size of rainbow trout in 2001 and 2002 are difficult to address in the absence of estimates of population parameters. For example, subsistence fishers may have simply witnessed natural variation, a shift in preferred overwintering habitats to upriver areas, or a localized depletion of rainbow trout by subsistence and sport fishers, which is plausible given the lack of movement of mainstem rainbow trout.

Before any future studies are implemented, it would be useful to determine if there is still a belief that the size and abundance of rainbow trout available to subsistence users in the lower river is still decreasing. The last documented concern of decreasing size and abundance of rainbow trout was in 2001 and 2002 (Krauthoefer et al. 2006). Coincidently, in 2001, the sport fish regulations restricted the harvest of rainbow trout in the entire Aniak River drainage (from 1990 to 2000, sport fishers were only allowed to harvest rainbow trout in the Aniak River below Doestock Creek). It is unknown how much sport fishing effort took place in this river segment, but it is believed that only a small portion of overall effort for rainbow trout occurred below Doestock Creek. During the time period when harvest was restricted to below Doestock Creek (1990–2000), estimated annual sport fish harvest ranged from 0 to 349 and averaged 86 trout (Chythlook 2009). Because many subsistence fishers purchase sport fishing licenses, it has always been assumed that some of these fish were mistakenly reported by subsistence fishers. Reported subsistence harvest of rainbow trout in Doestock Creek and the mainstem Aniak River below Doestock Creek averaged 129 annually during 2001 and 2002 (Krauthoefer et al. 2006). Regardless, if the sport fishery harvest contributed to a decline in size and abundance of fish targeted by local subsistence fisherman, the decreasing trend may have ceased when the sport fishery regulation was changed to catch and release below Doestock Creek.

If there is still a concern with decreasing size and abundance of rainbow trout caught by subsistence fishers, a telemetry study specific to the lower river in the winter time would identify seasonal use and summertime distribution of these fish. A second plausible study would be to determine if genetically discrete stocks exist within the Aniak River.

This study spanned two consecutive spawning seasons (spring 2009 and spring 2010) and provided some additional insight with spawning behavior. Rainbow trout generally moved little for spawning, and although sample sizes were small (19) for fish that survived both years, several of these fish made relatively long migrations to spawn (i.e., > 20 rkm) in spring 2009, but did not in spring 2010. This suggests either of two things: these fish displayed no annual fidelity to spawning areas or skip spawning occurred. Skip spawning is difficult to conclusively document, especially with river resident populations, but it has been documented for a lacustrine population of rainbow trout in the Naknek River drainage (Schwanke 2009).

One final pertinent observation is that these rainbow trout typically remained in their summertime distribution throughout the month of October. This is useful information if a mark-recapture study is ever conducted because it allows the option of having the second sample to be taken later in the fall when rainbow trout are more vulnerable to capture while still maintaining the assumption of population closure. Also, if a similar telemetry study were ever conducted upriver, it is suggested that the tags be deployed late in the fall when rainbow trout are still widely distributed and the water is cooler, hence promoting better initial survival.

ACKNOWLEDGEMENTS

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FIGURES

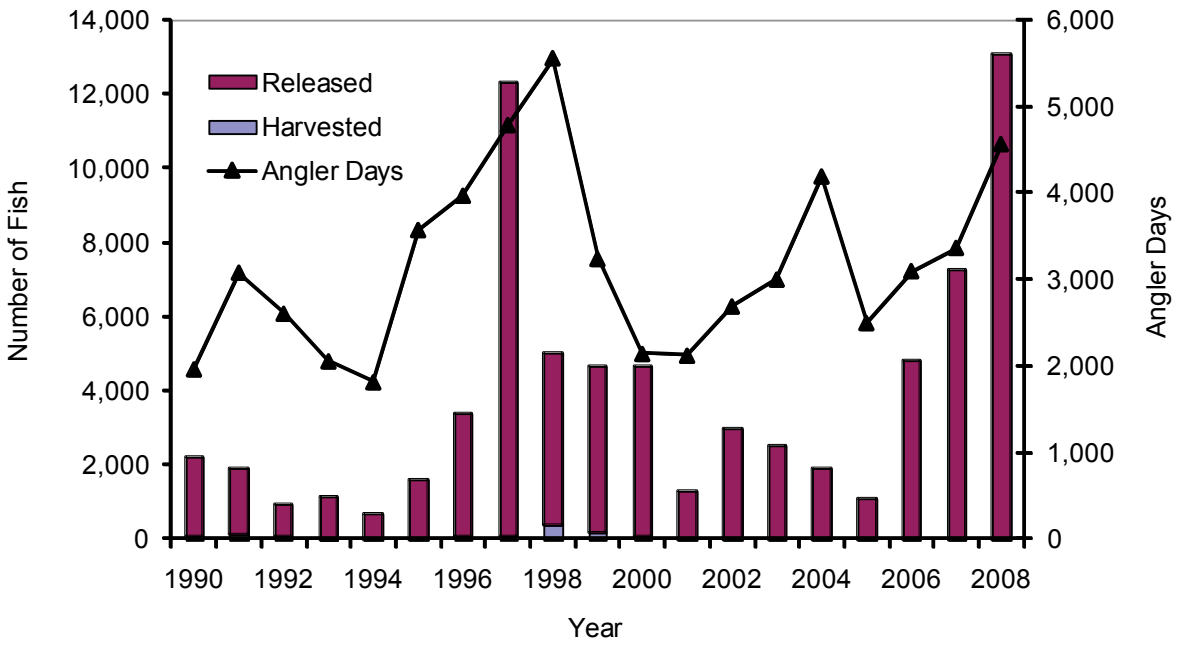

Figure 1.–Total sport fishing effort (number of angler days) along with catch and harvest of rainbow trout in the Aniak River, 1990–2006

Source: Mills 1991-1994; Howe et al. 1995, 1996, 2001a-d; Jennings et al. 2004, 2006a-b, 2007, 2009a-b, 2010a-b; Walker et al. 2003.

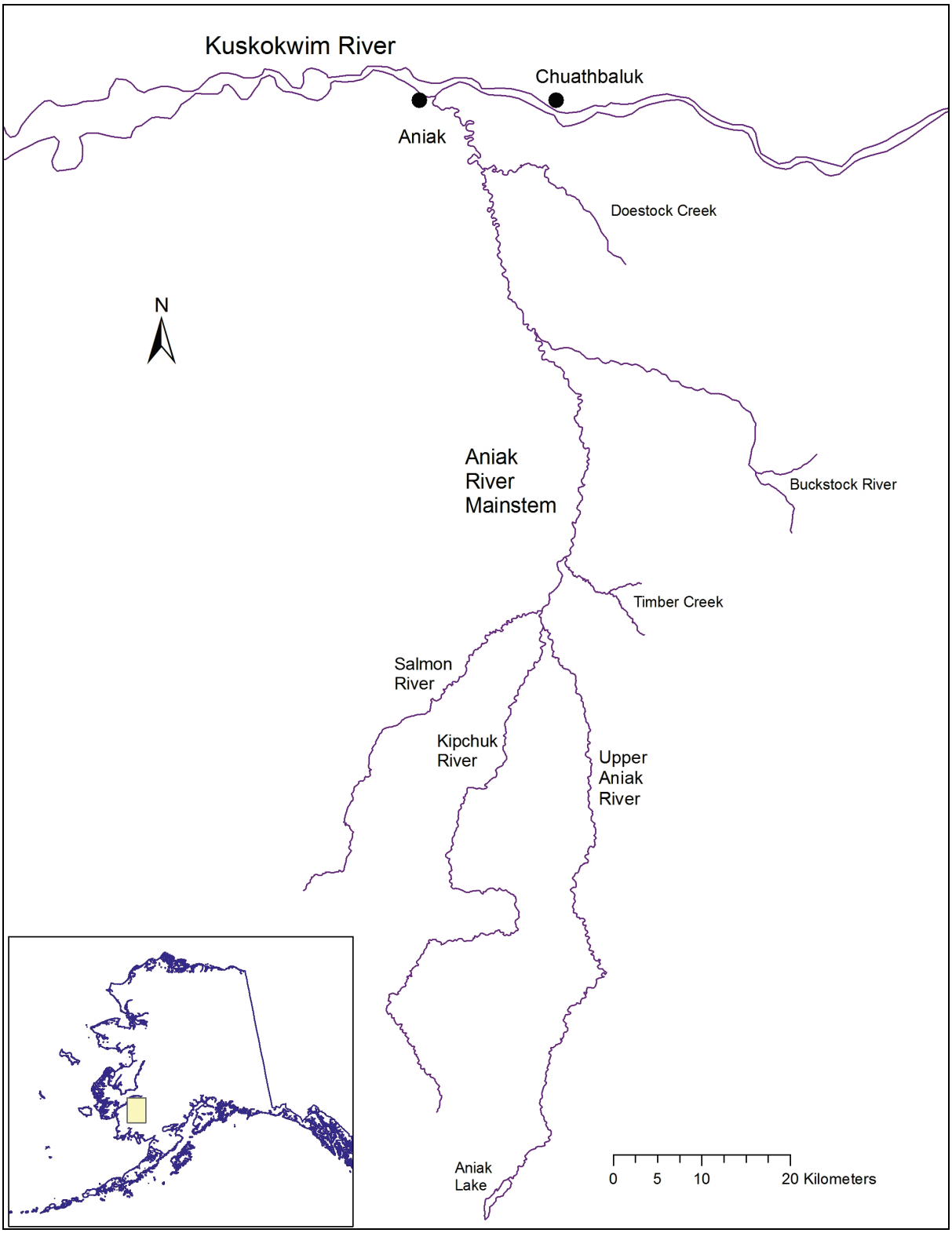

Figure 2.–Map of the Aniak River.

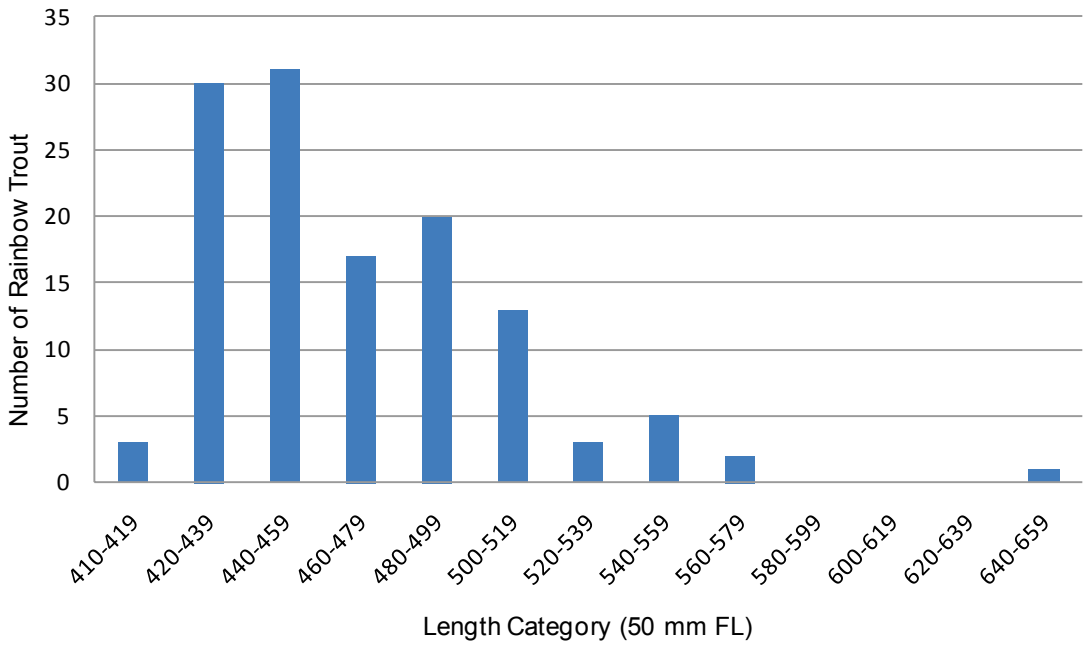

Figure 3.–Length histogram of rainbow trout radiotagged in the Aniak River, 5–12 August 2008.

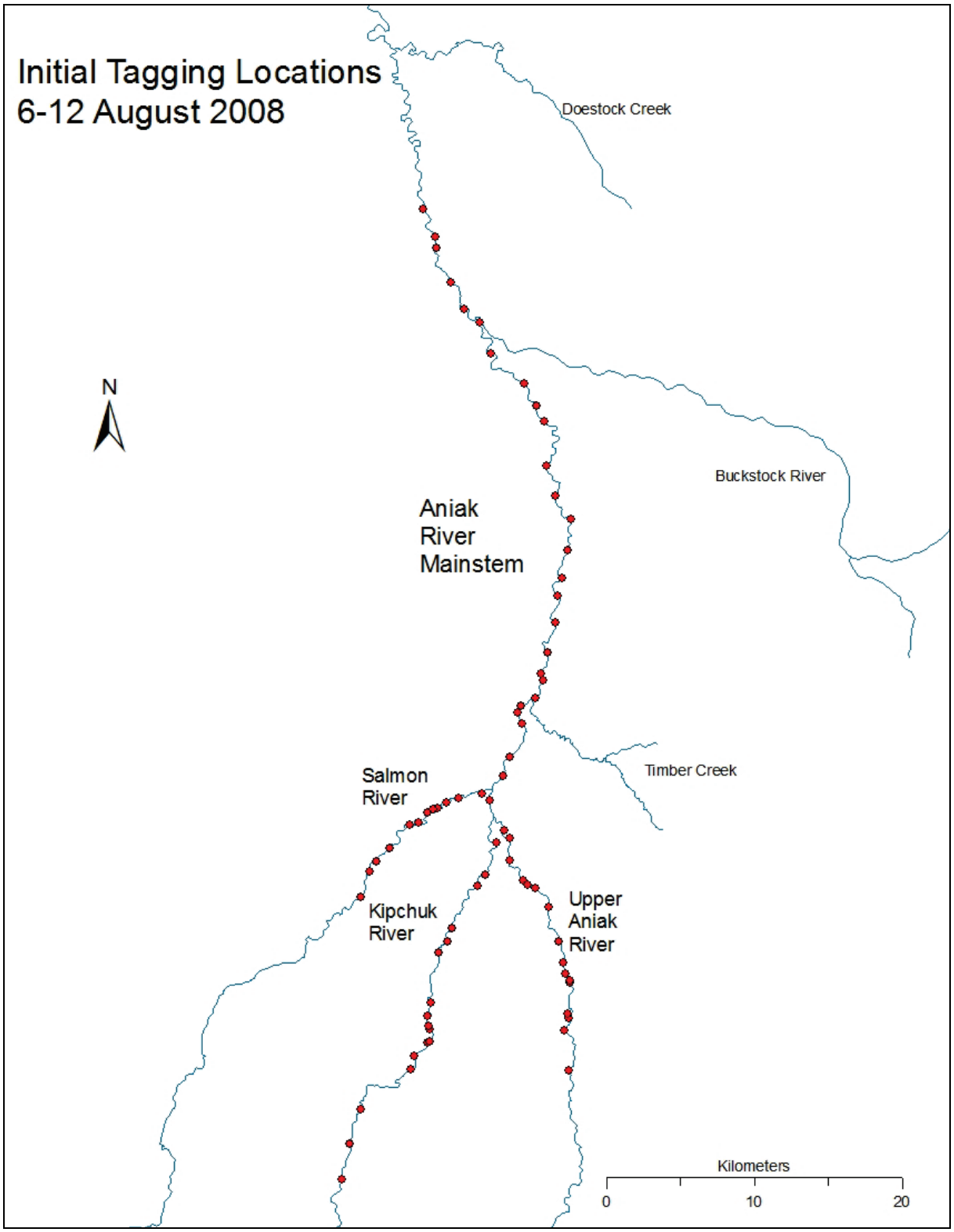

Figure 4.–Map of the Aniak River drainage and the tagging locations of 125 rainbow trout ≥ 410 mm FL from 5–12 August 2008. Each dot may represent more than one fish.

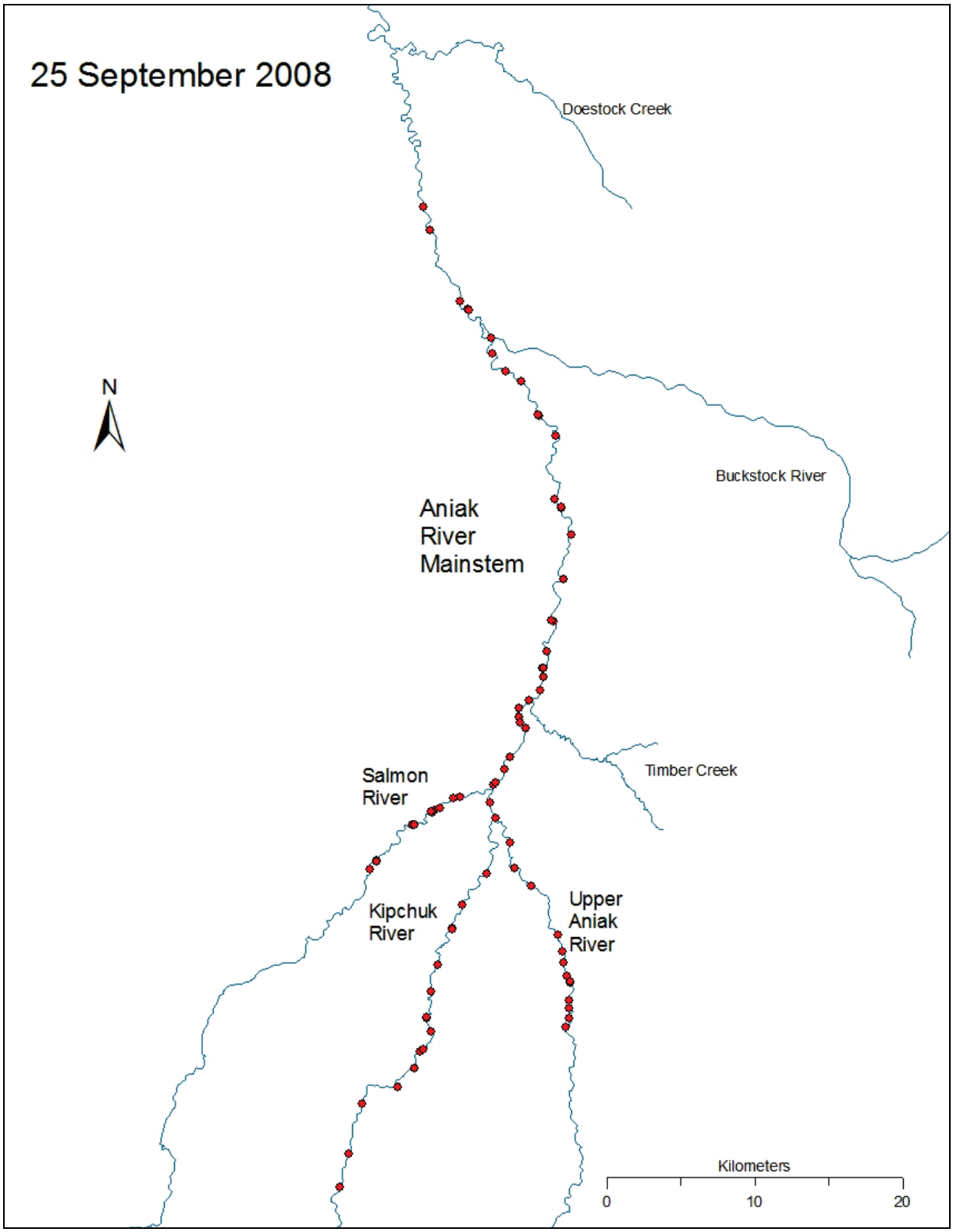

Figure 5.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 25 September 2008. Each dot represents one fish.

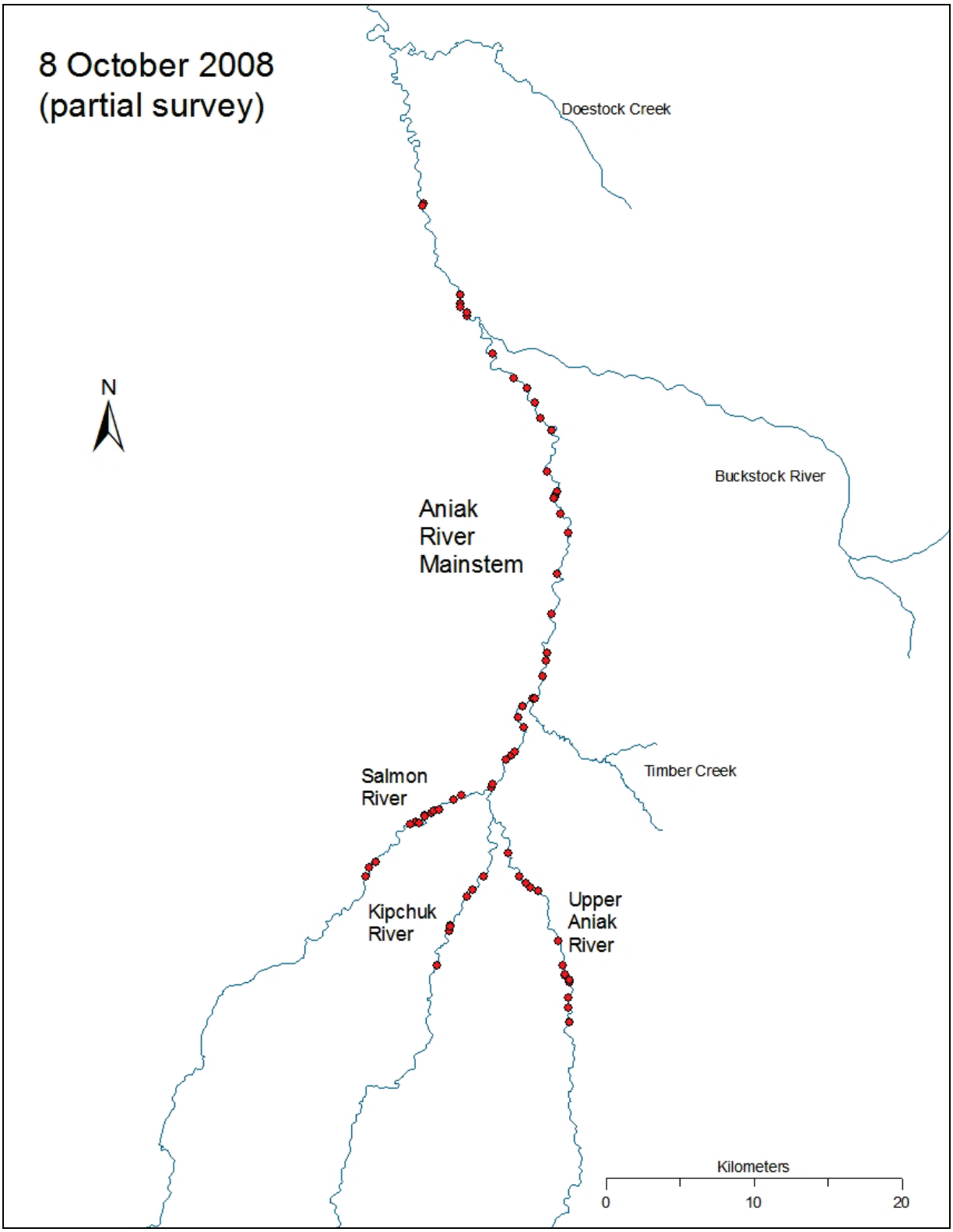

Figure 6.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 8 October 2008. Each dot represents one fish.

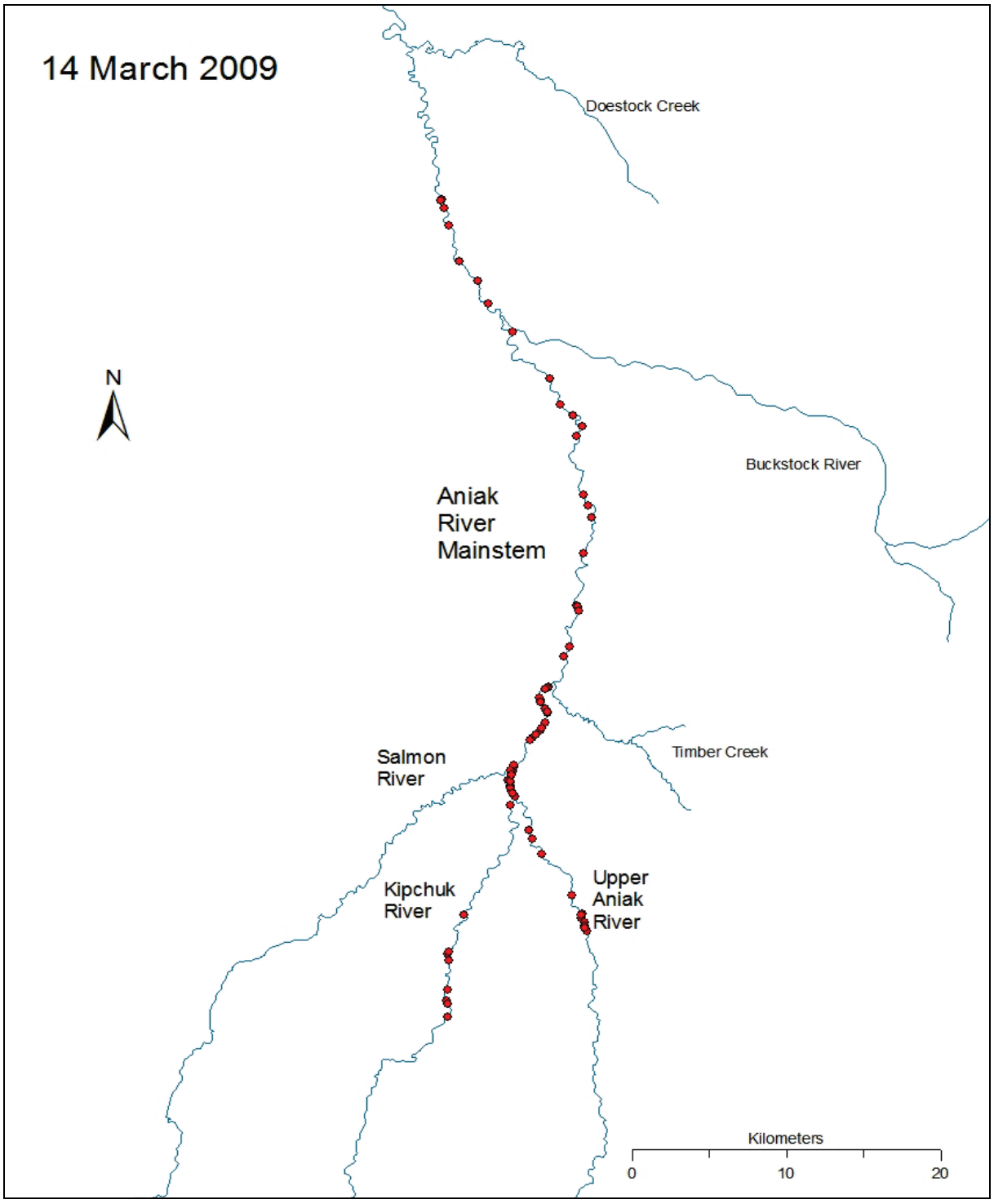

Figure 7.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 14 March 2009. Each dot represents one fish.

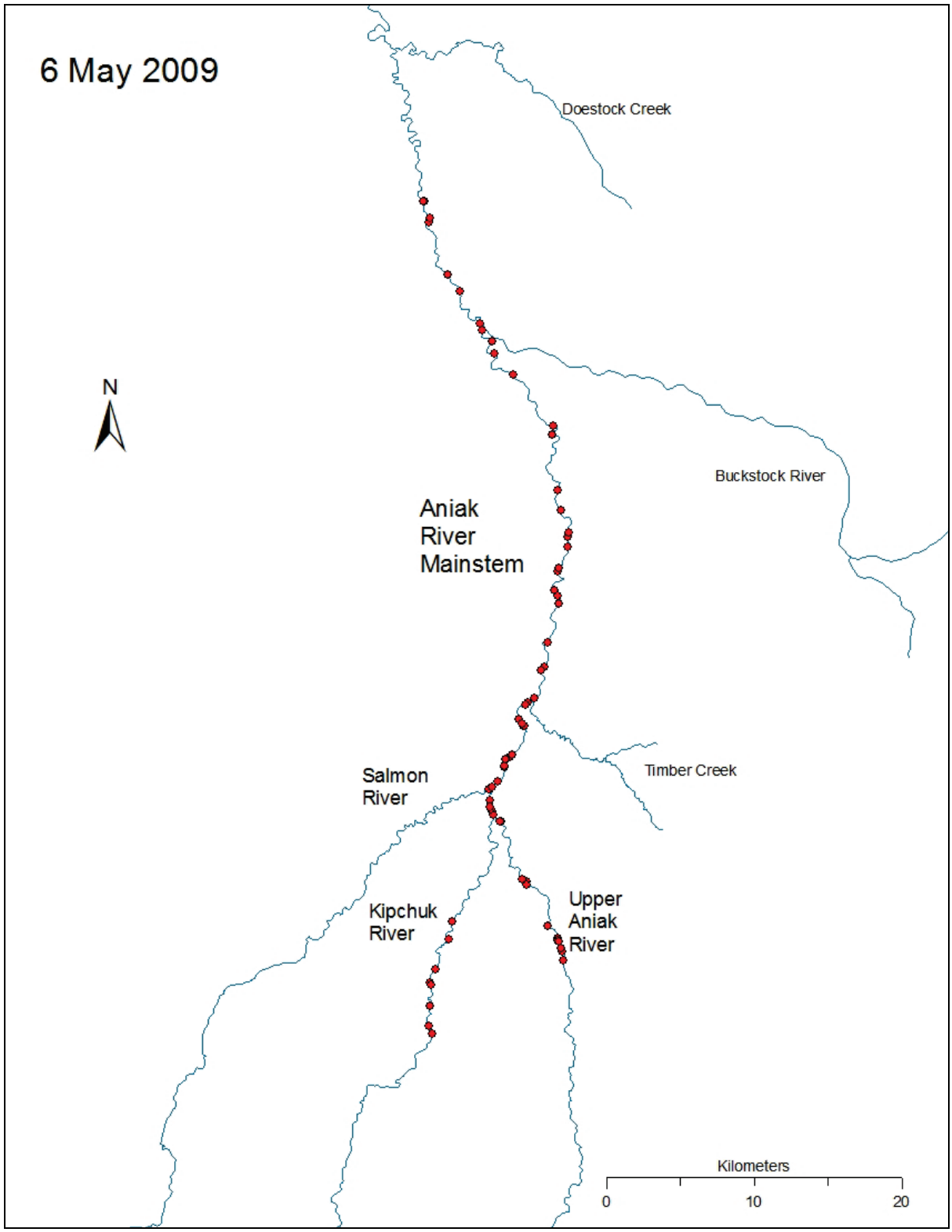

Figure 8.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 6 May 2009. Each dot represents one fish.

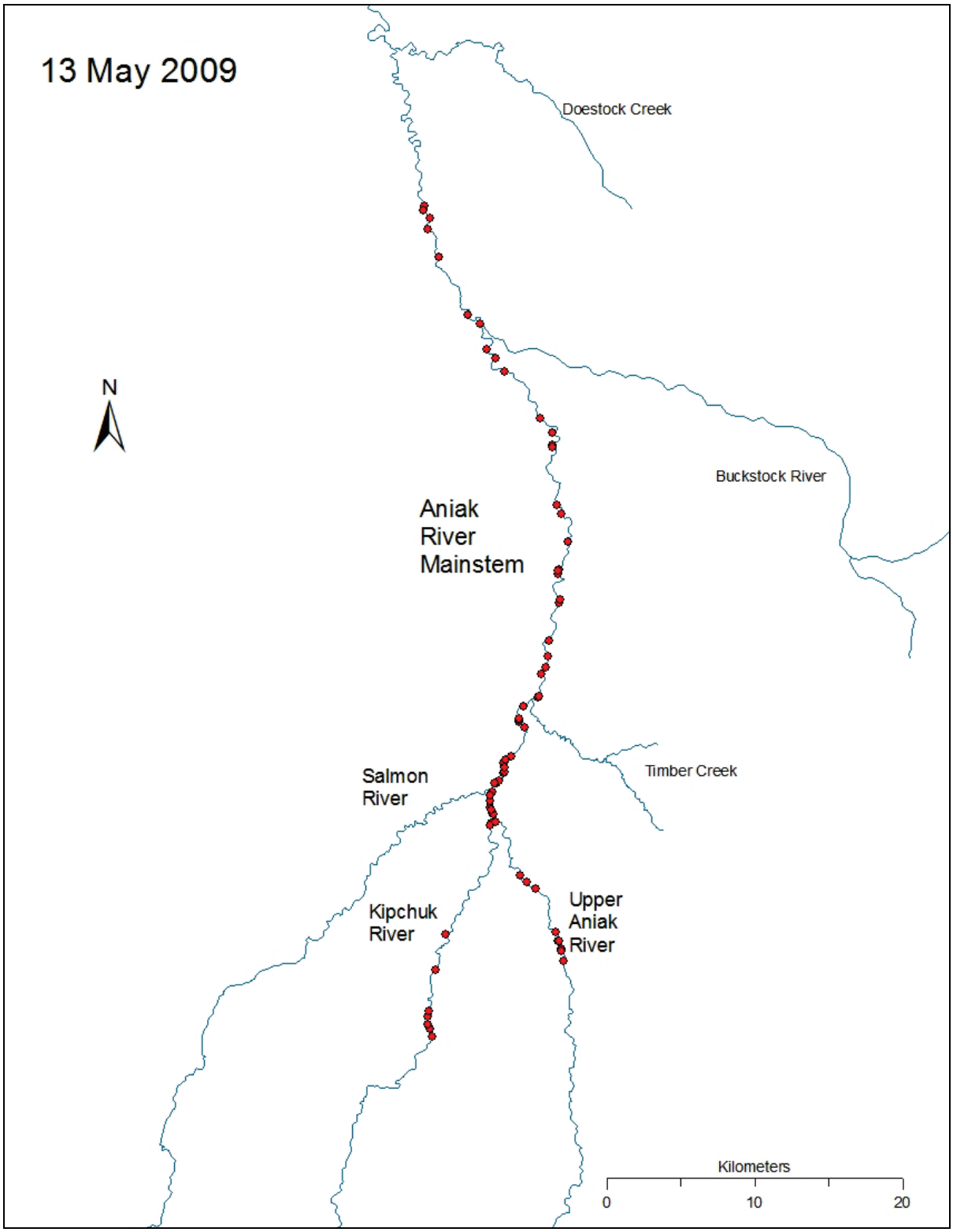

Figure 9.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 13 May 2009. Each dot represents one fish.

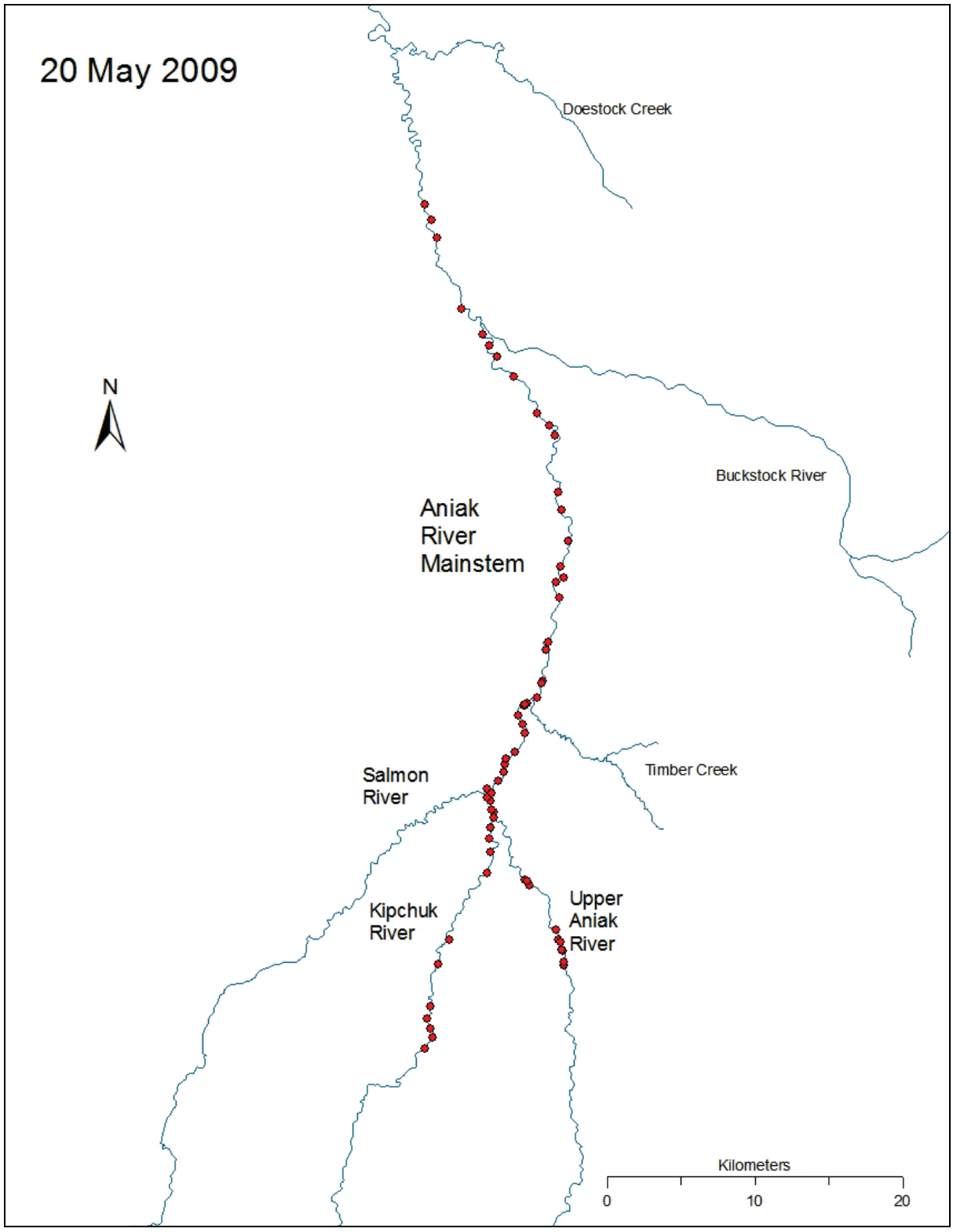

Figure 10.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 20 May 2009. Each dot represents one fish.

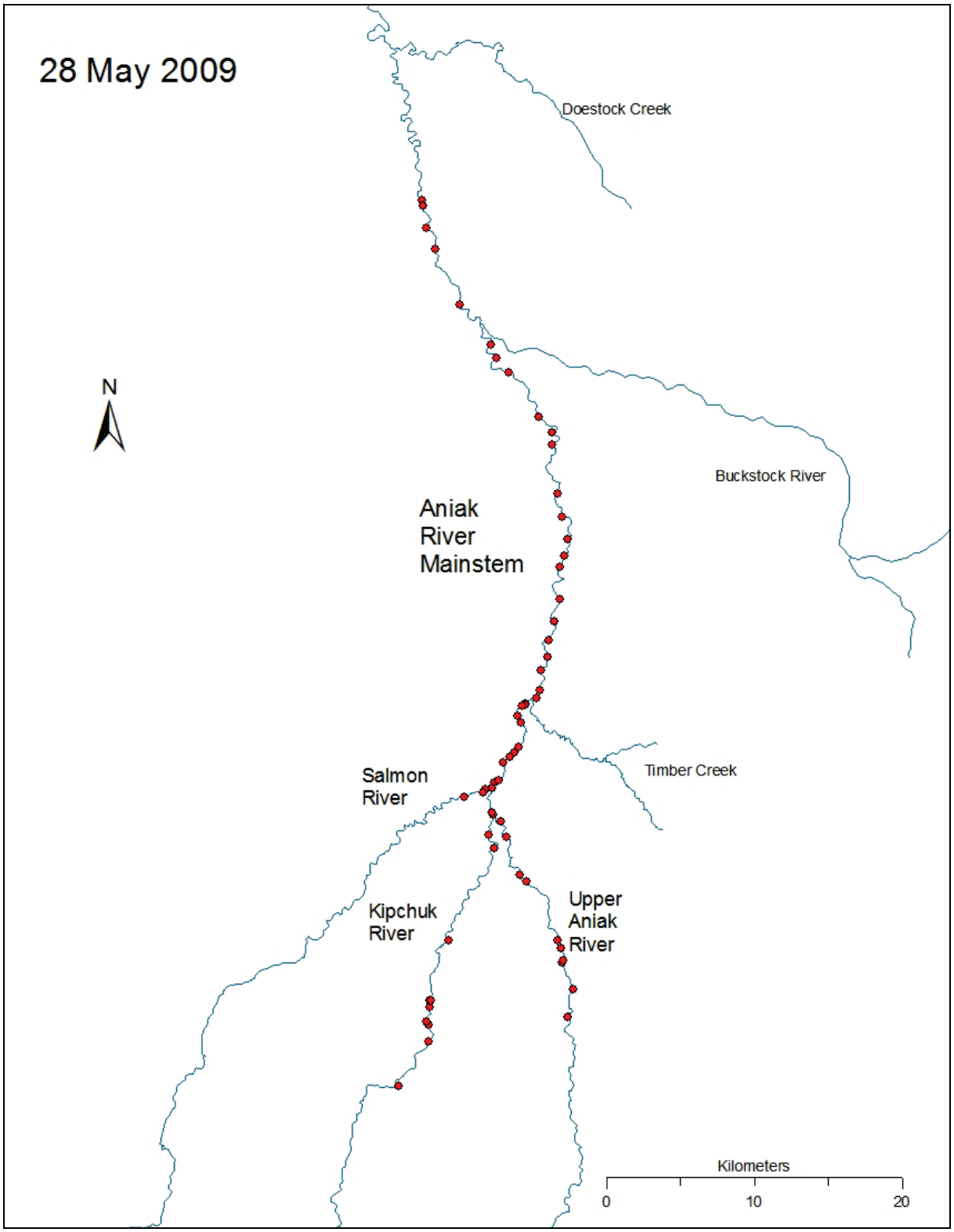

Figure 11.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 28 May 2009. Each dot represents one fish.

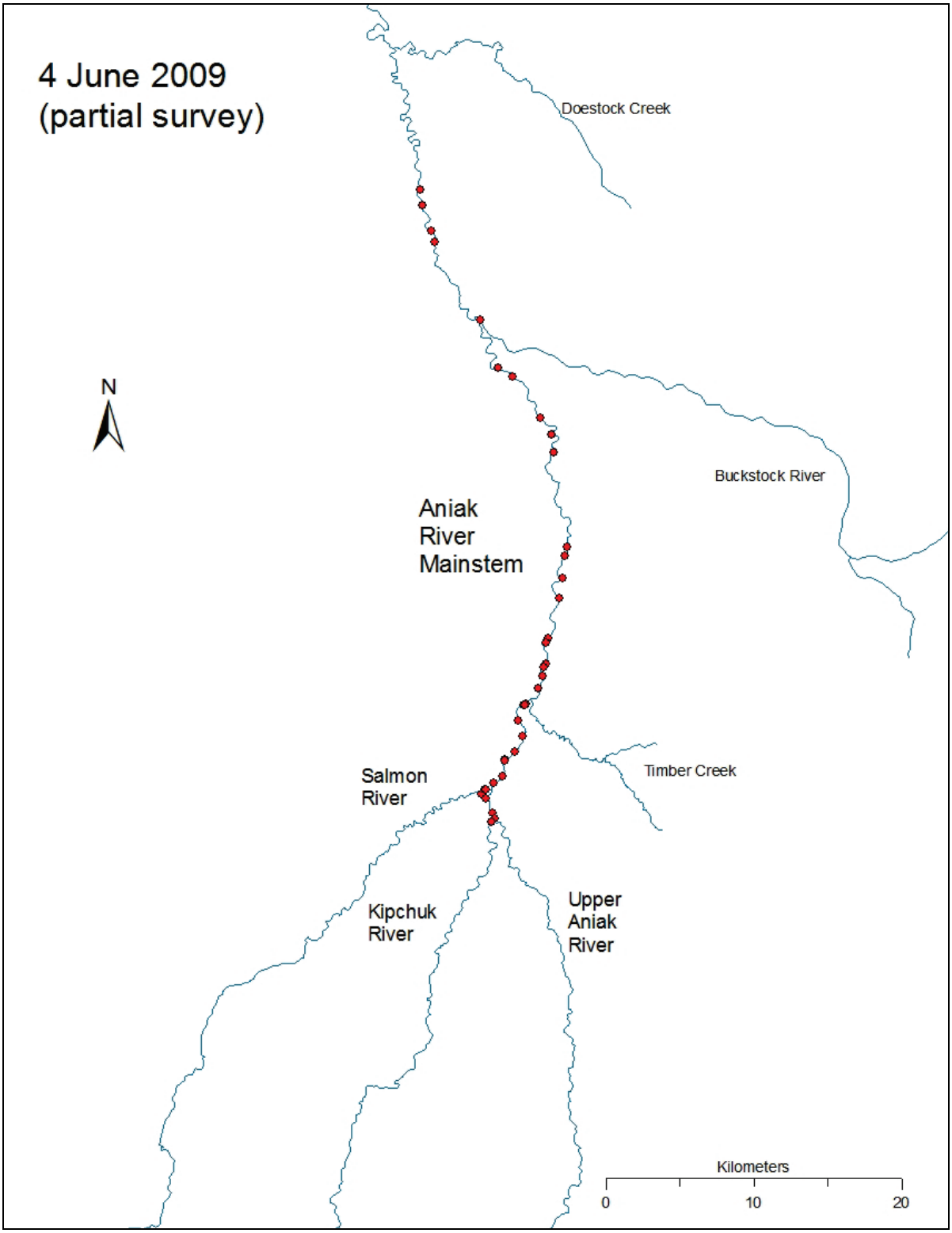

Figure 12.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 4 June 2009. Each dot represents one fish.

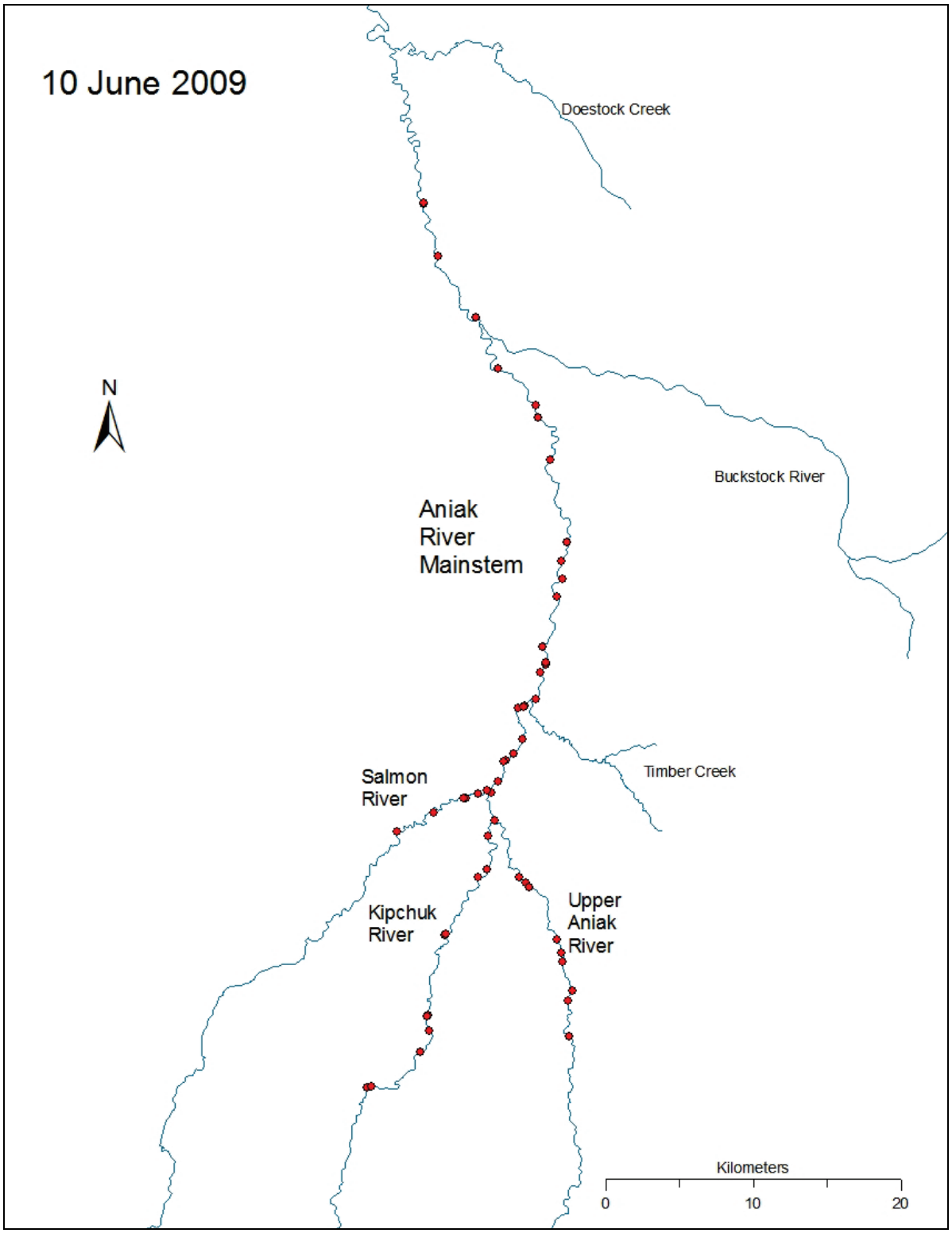

Figure 13.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 10 June 2009. Each dot represents one fish.

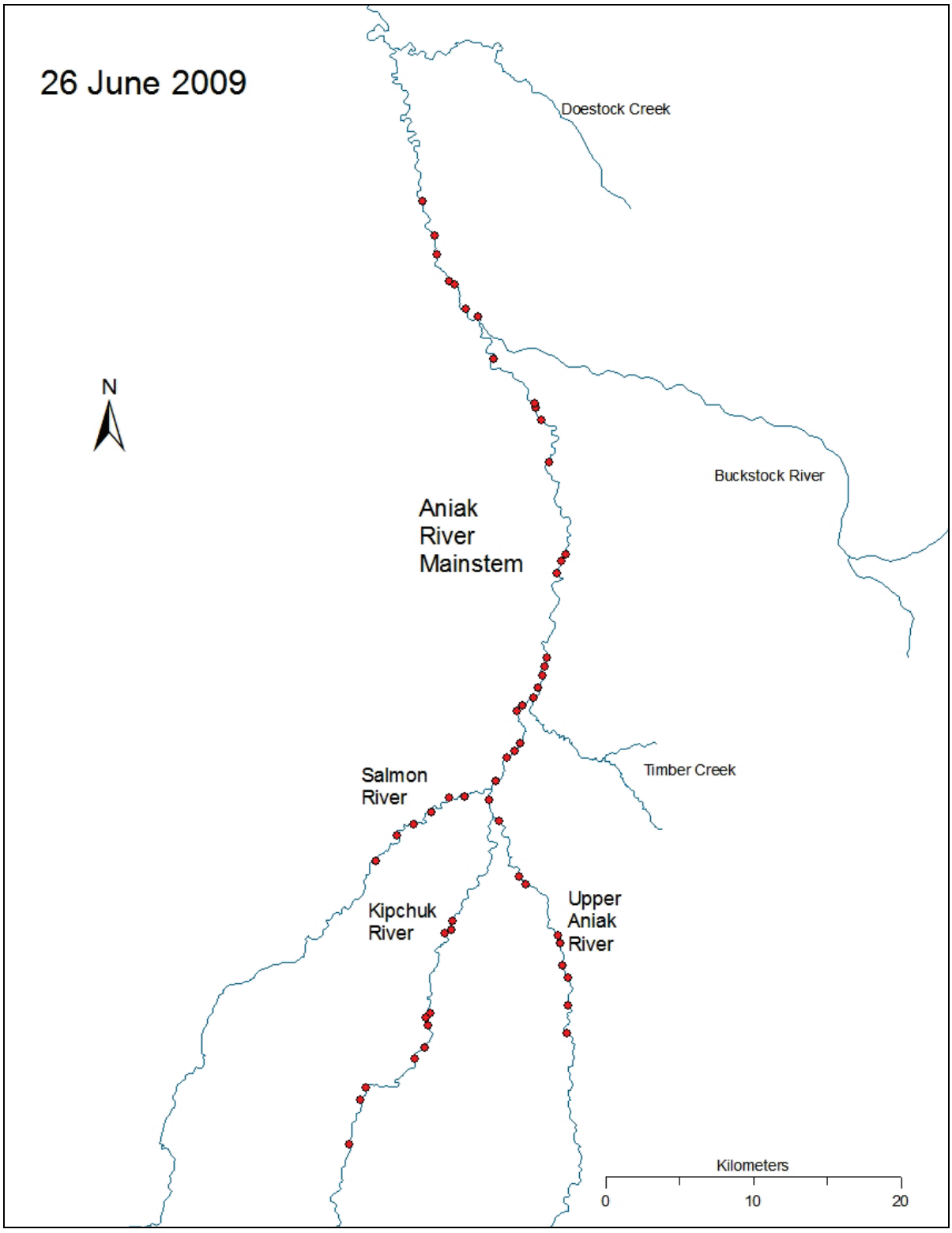

Figure 14.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 26 June 2009. Each dot represents one fish.

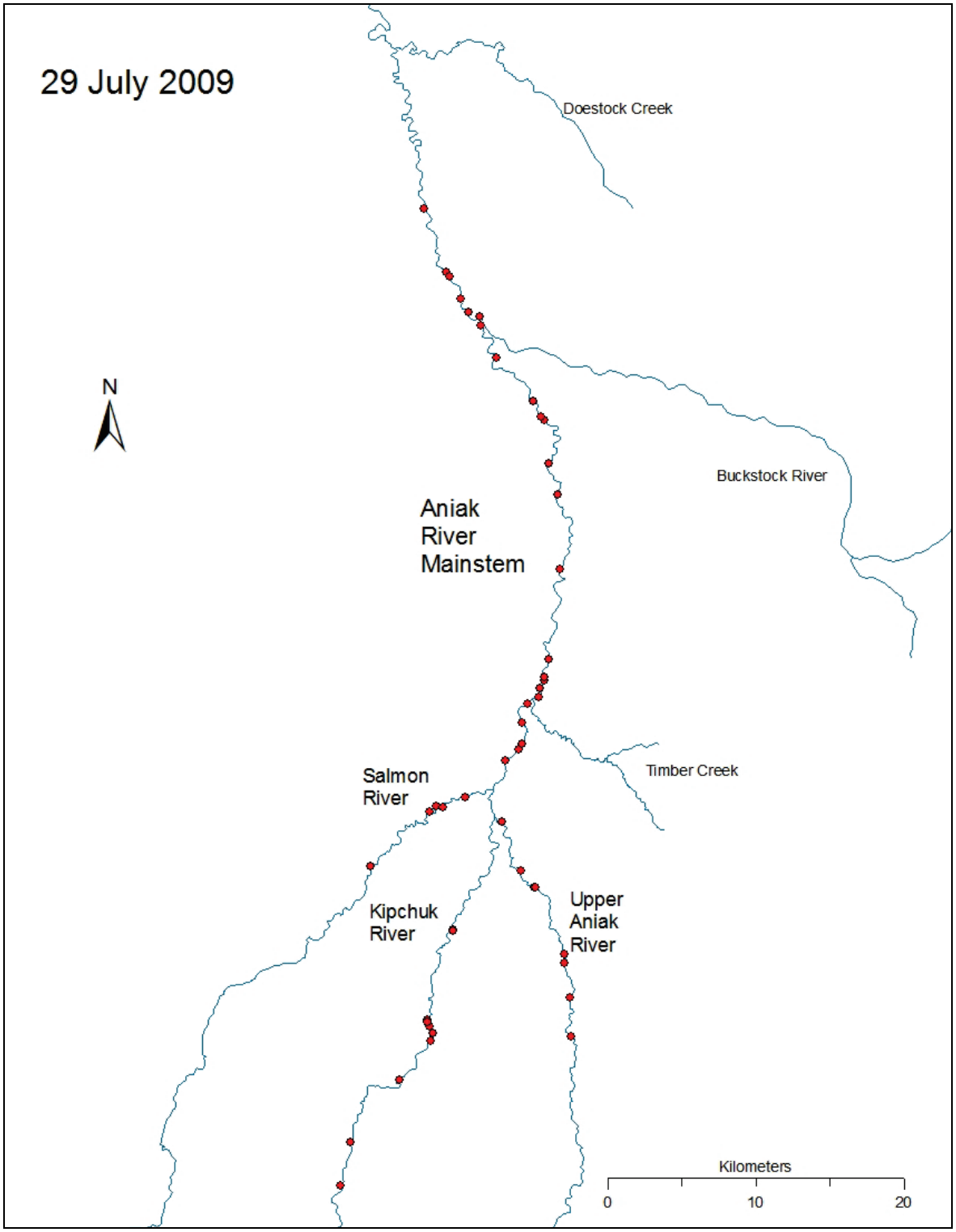

Figure 15.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 29 July 2009. Each dot represents one fish.

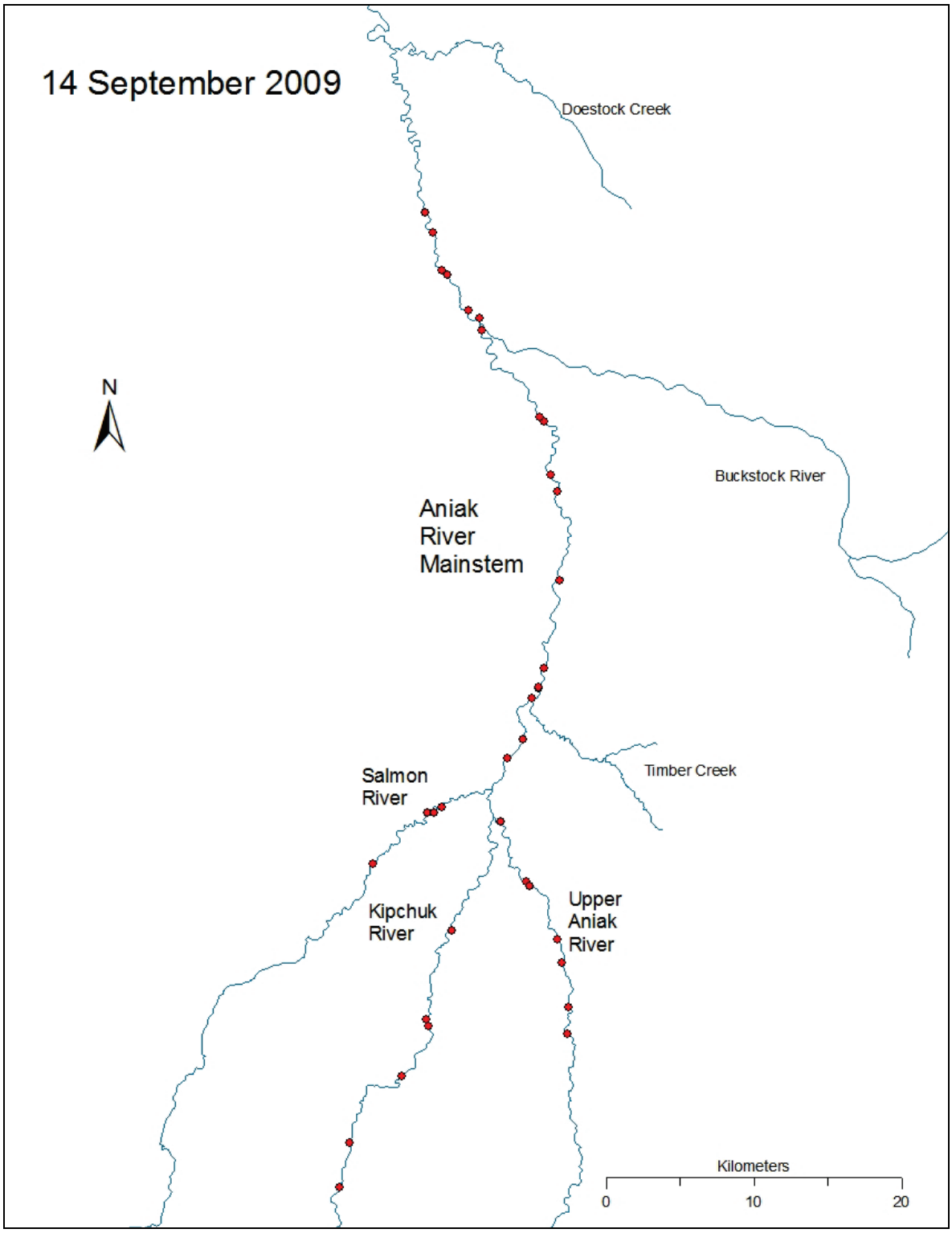

Figure 16.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 14 September 2009. Each dot represents one fish.

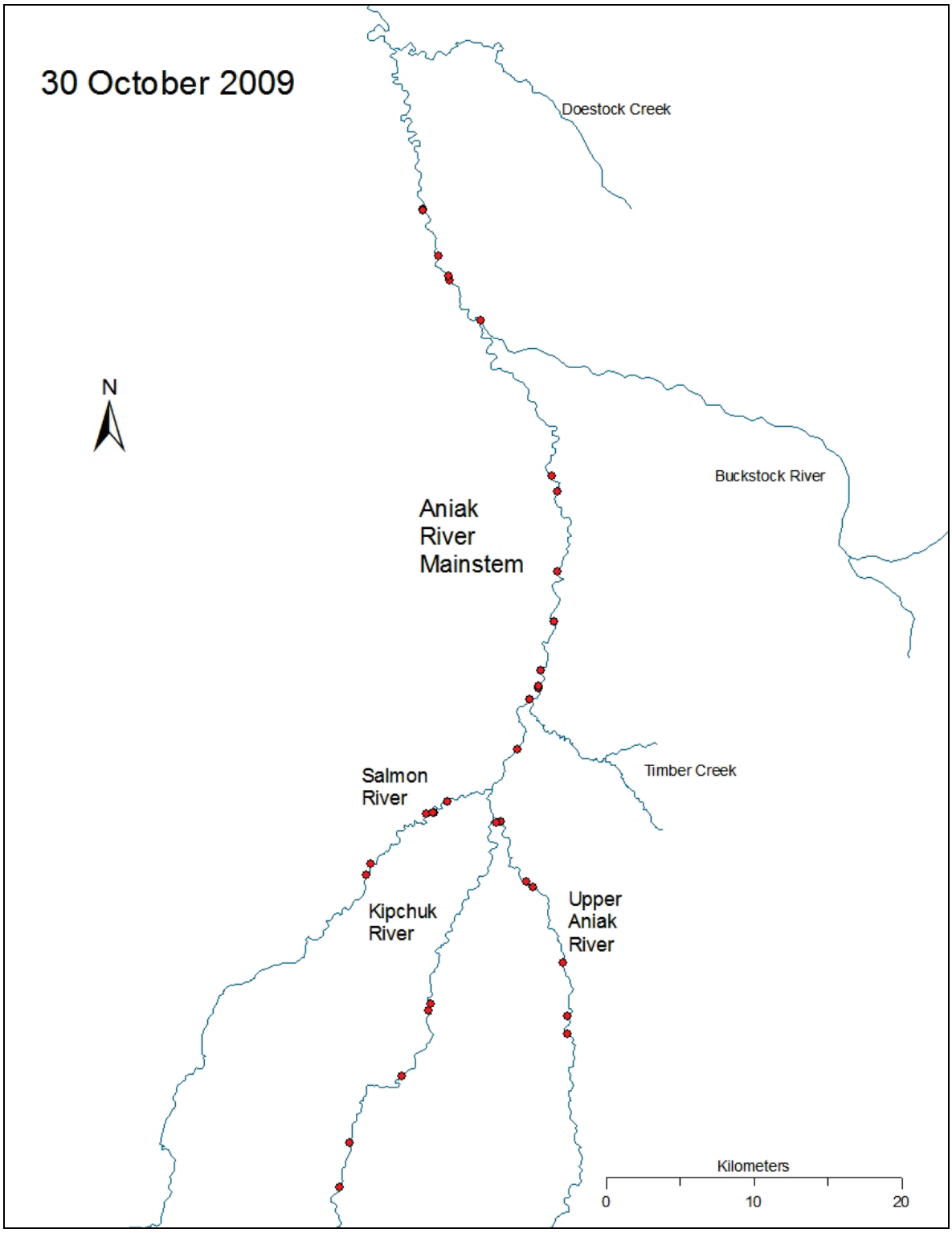

Figure 17.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 30 October 2009. Each dot represents one fish.

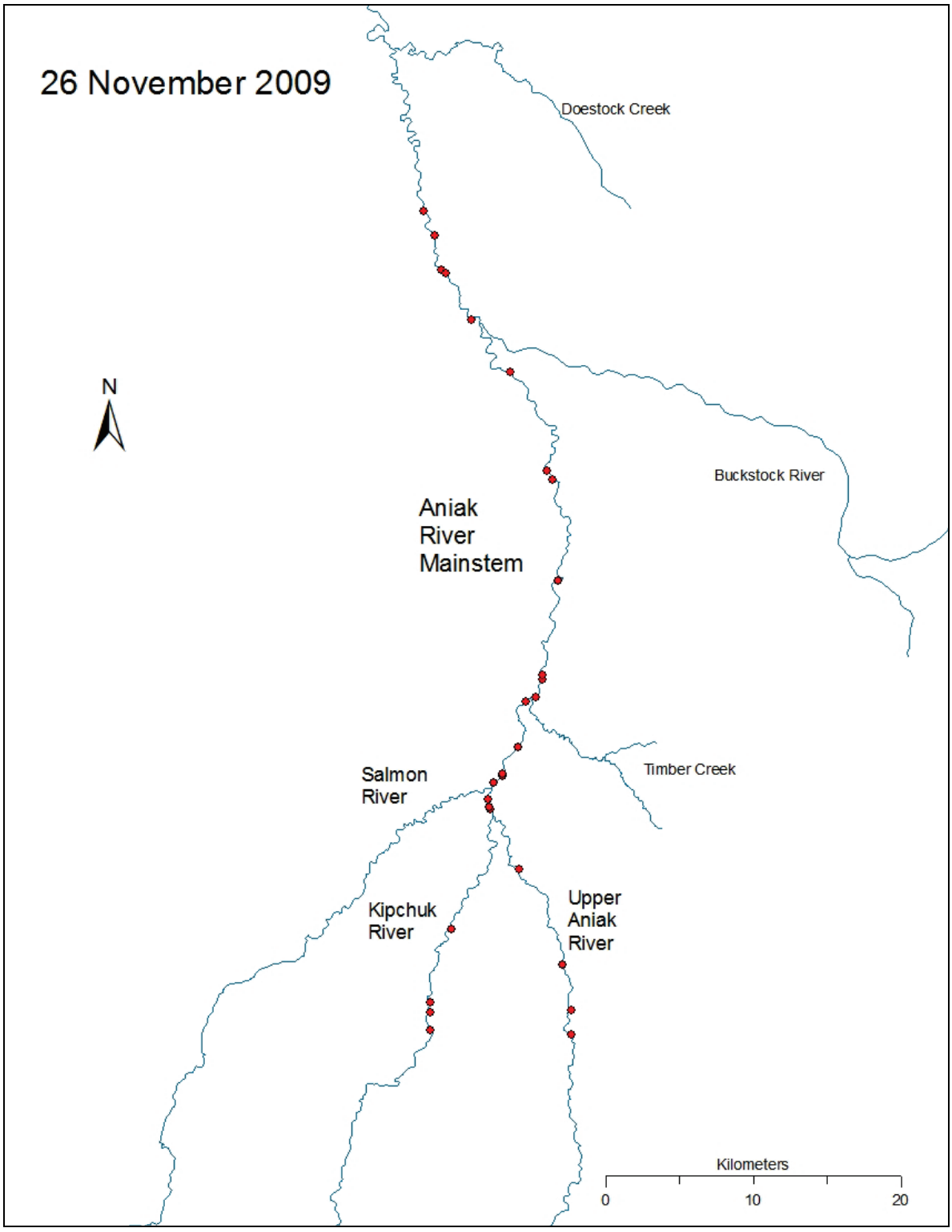

Figure 18.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 26 November 2009. Each dot represents one fish.

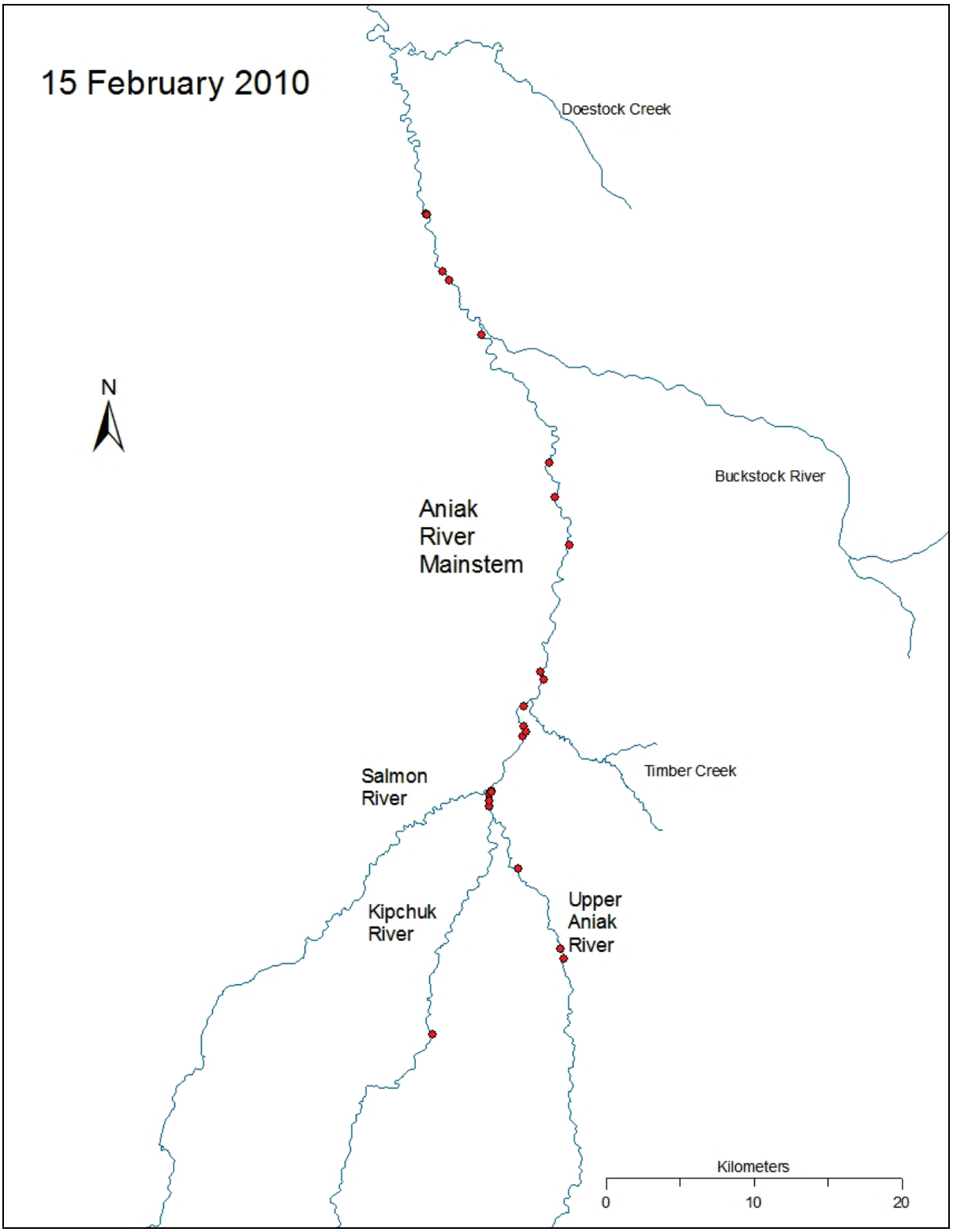

Figure 19.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 15 February 2010. Each dot represents one fish.

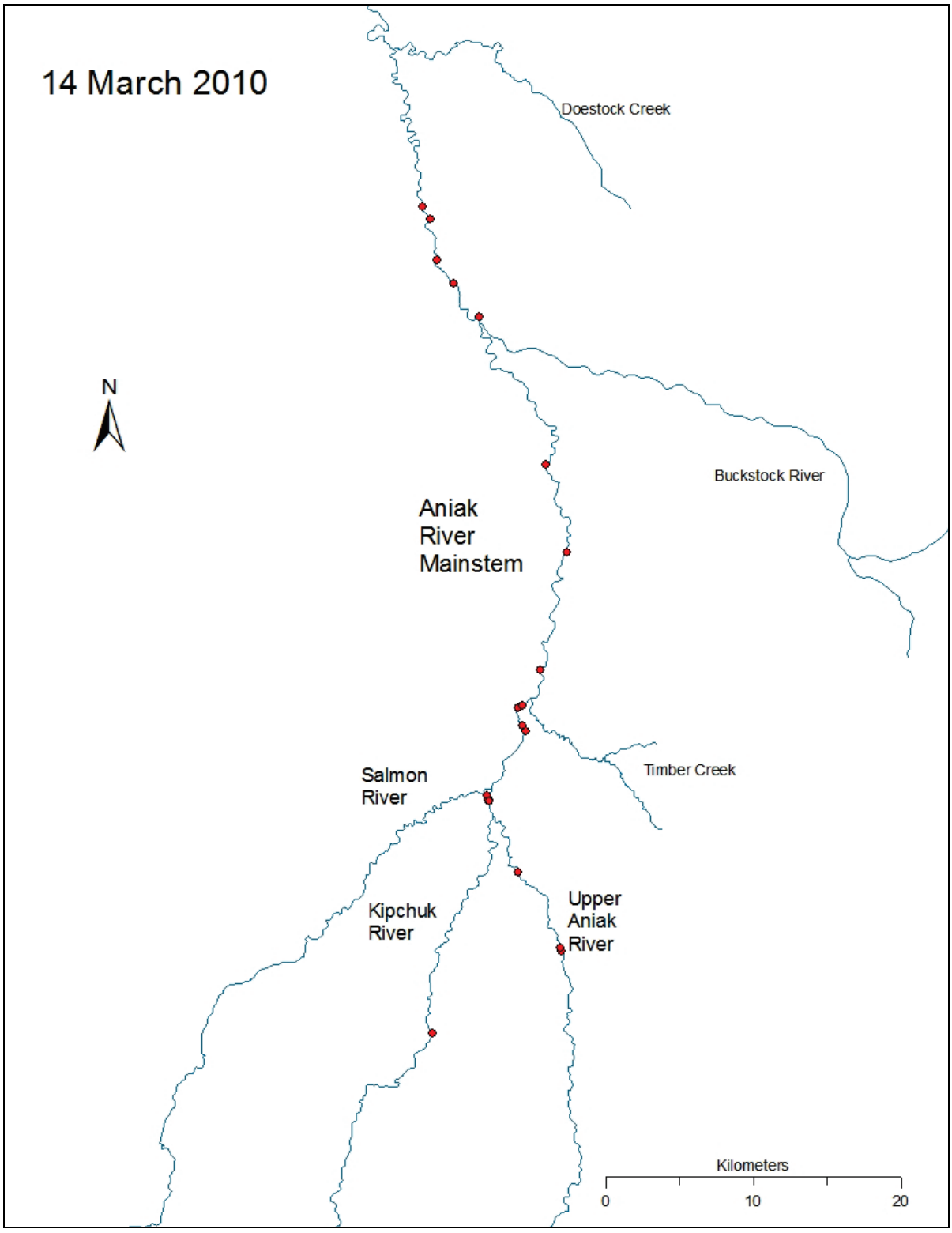

Figure 20.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 14 March 2010. Each dot represents one fish.

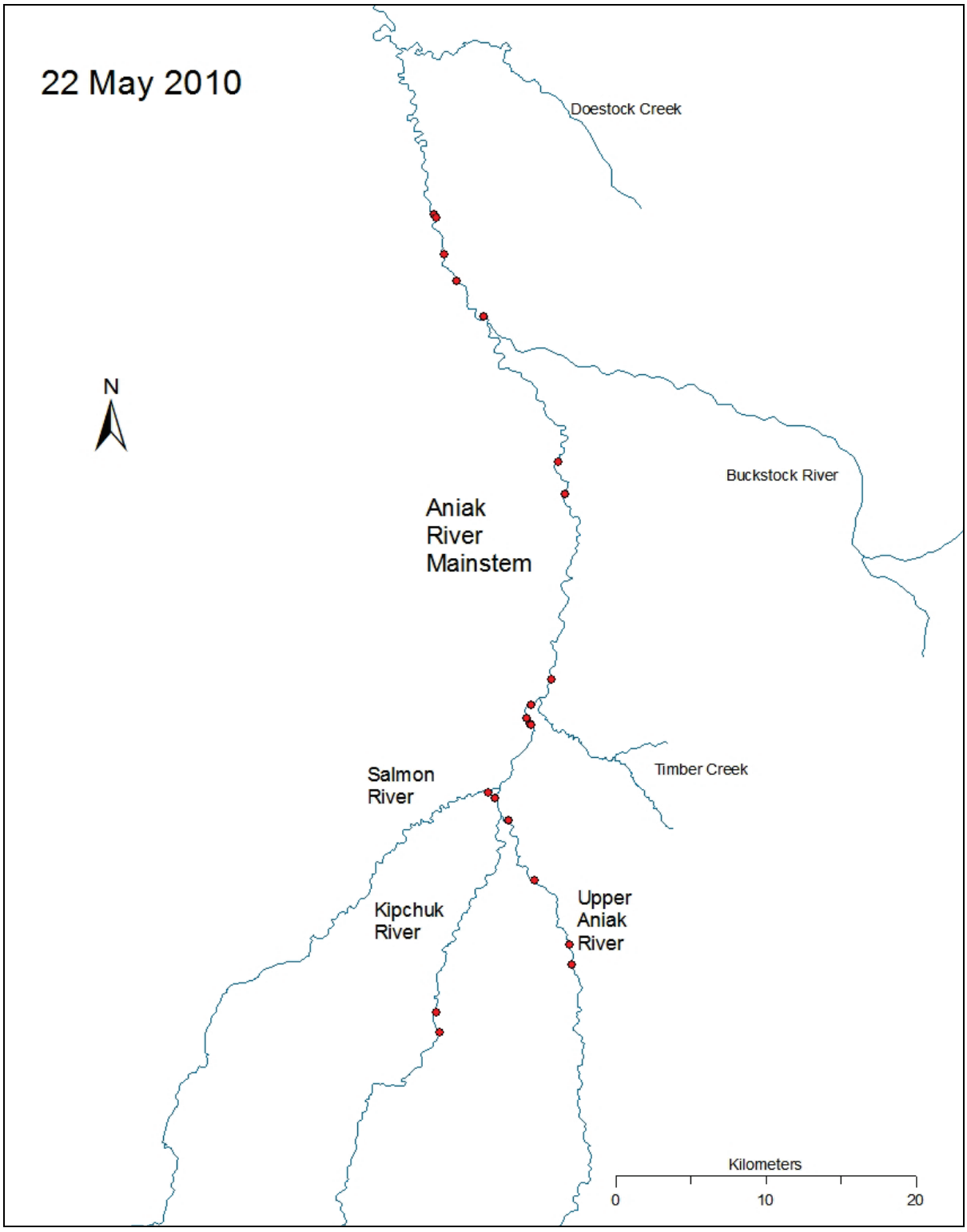

Figure 21.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 22 May 2010. Each dot represents one fish.

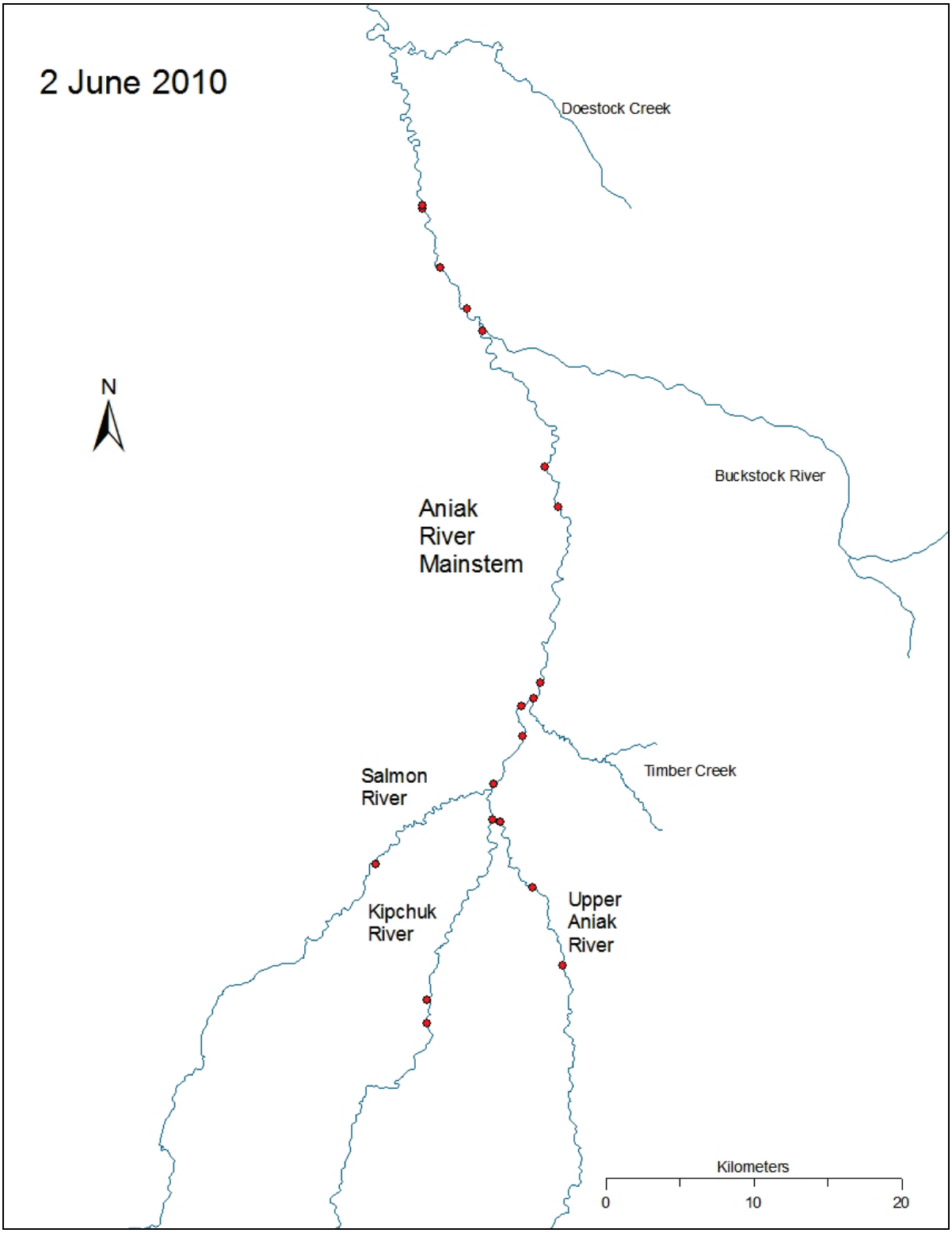

Figure 22.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 2 June 2010. Each dot represents one fish.

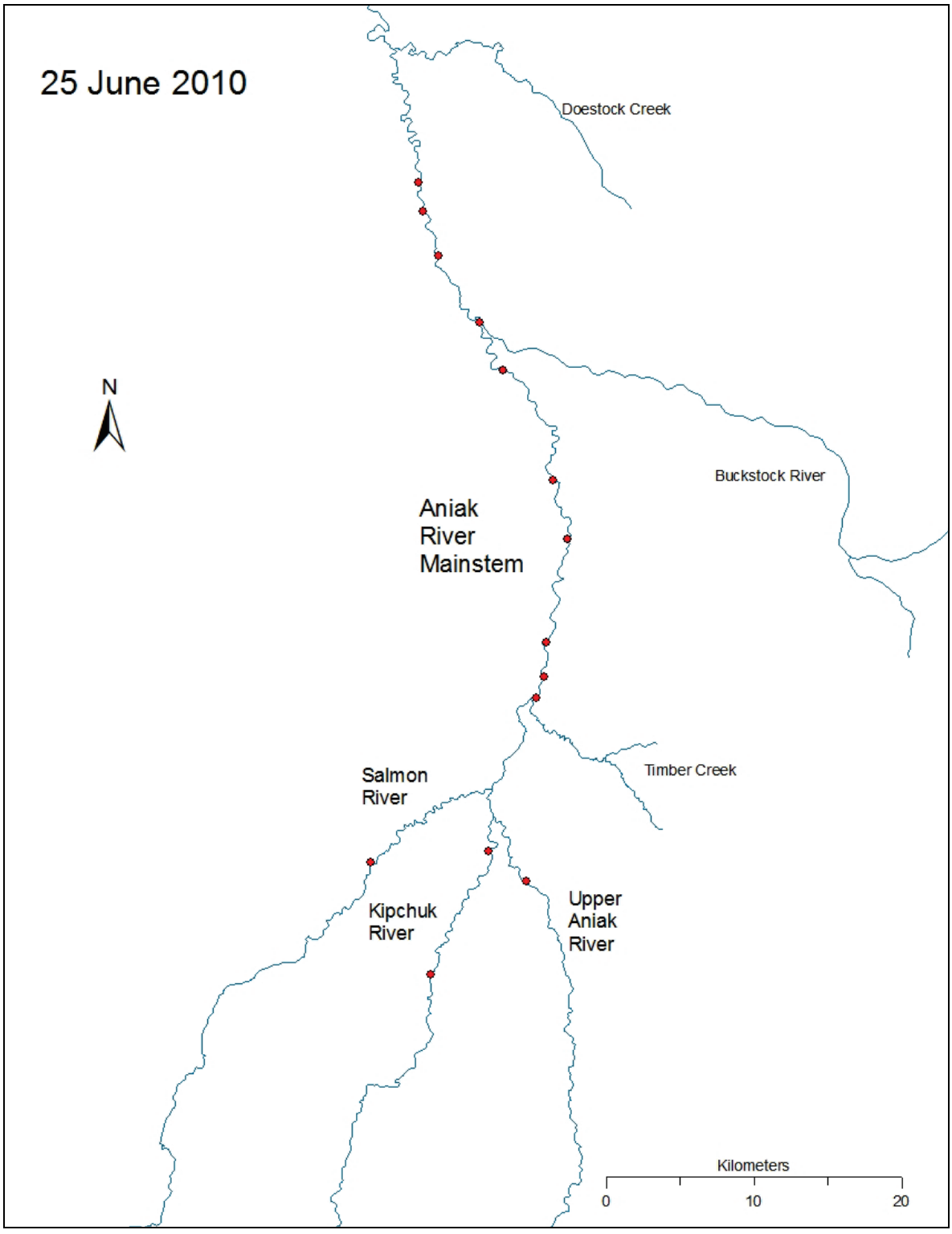

Figure 23.–Map of the Aniak River drainage and the locations of radiotagged rainbow trout ≥ 410 mm FL deemed alive on 25 June 2010. Each dot represents one fish.

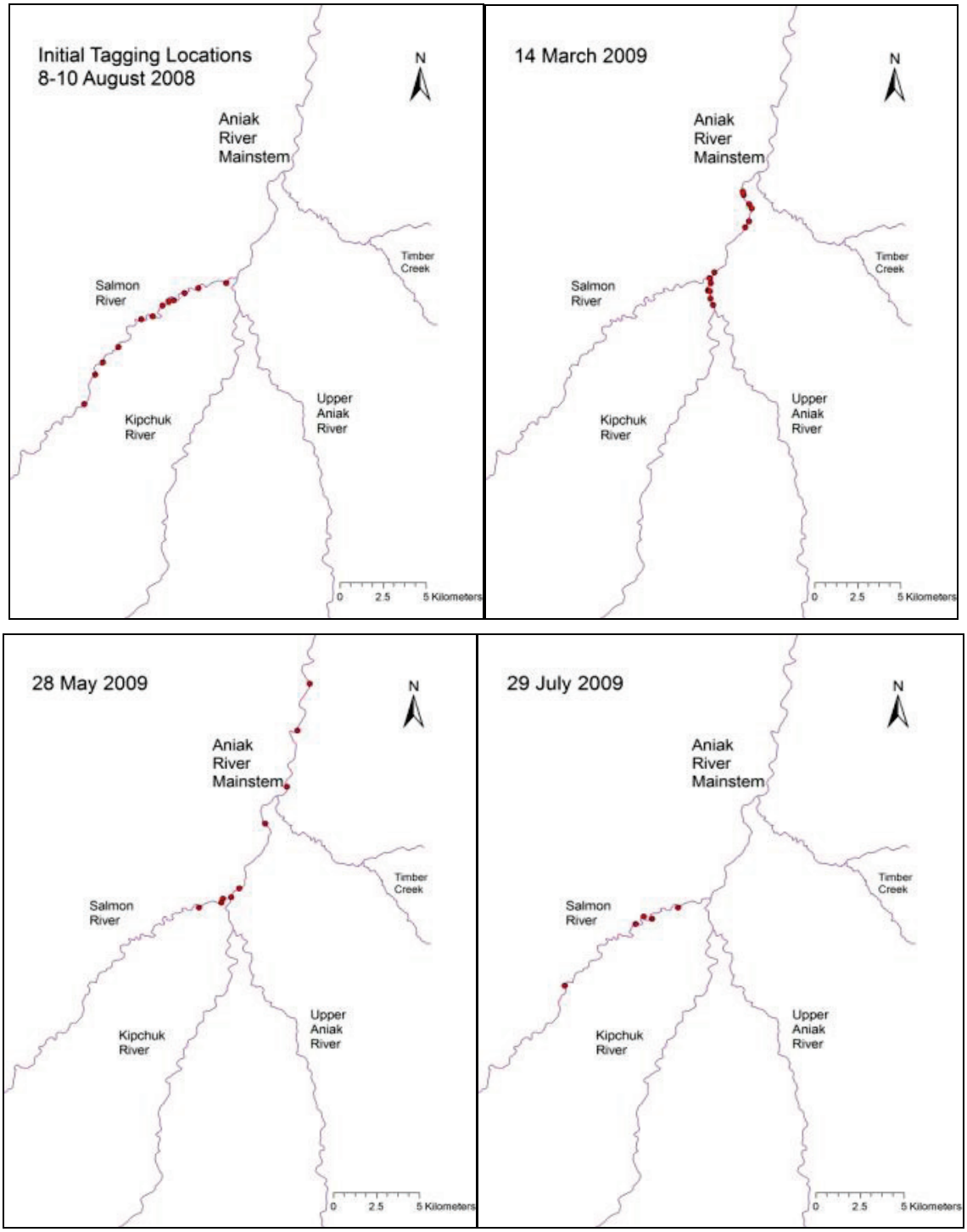

Figure 24.–Locations of rainbow trout originally radiotagged in the Salmon River. Dates represent important seasonal use periods (summering, overwintering, spawning, and second summering) for a 12 month period after tagging.

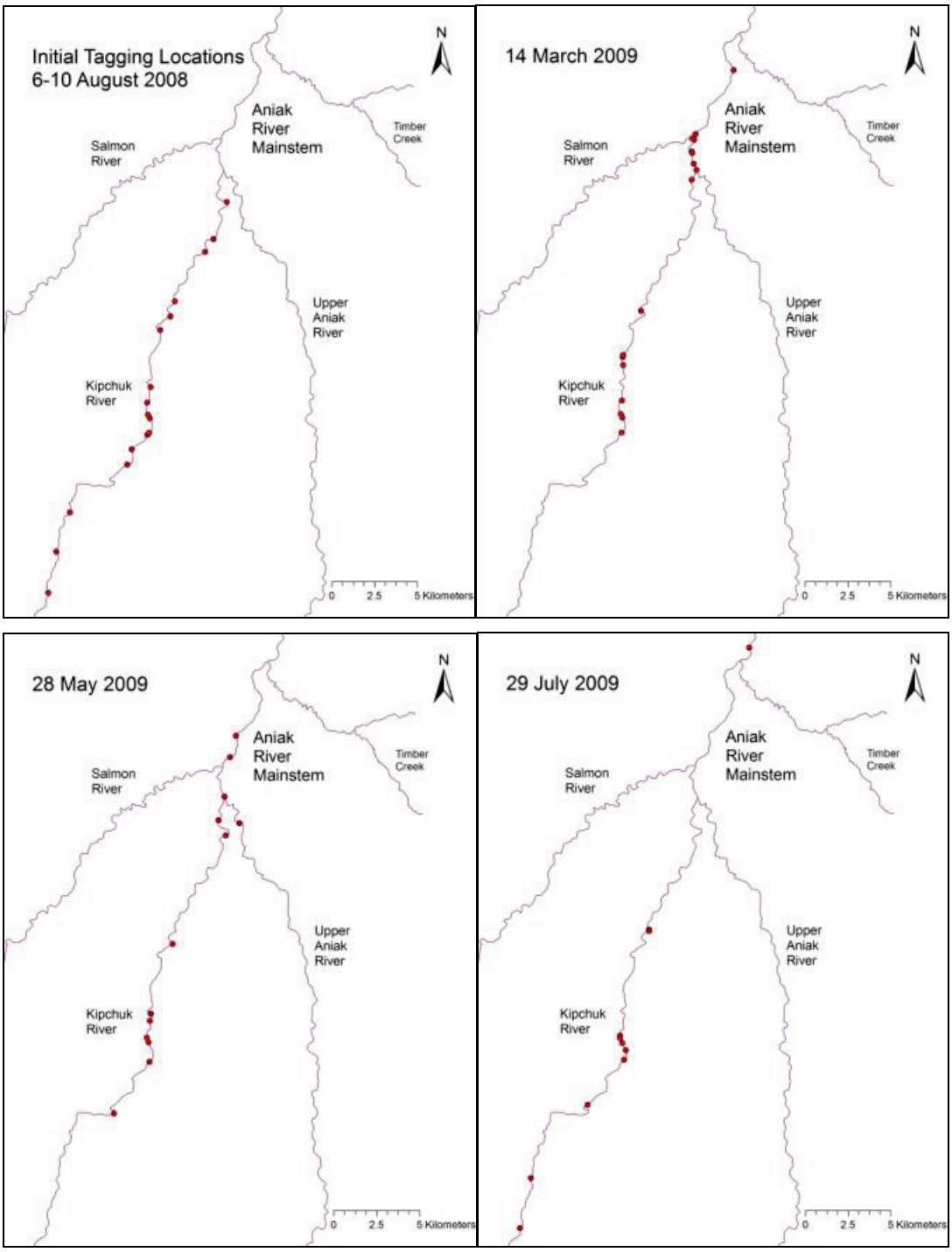

Figure 25.–Locations of rainbow trout originally radiotagged in the Kipchuk River. Dates represent important seasonal use periods (summering, overwintering, spawning and second summering) for a 12 month period after tagging.

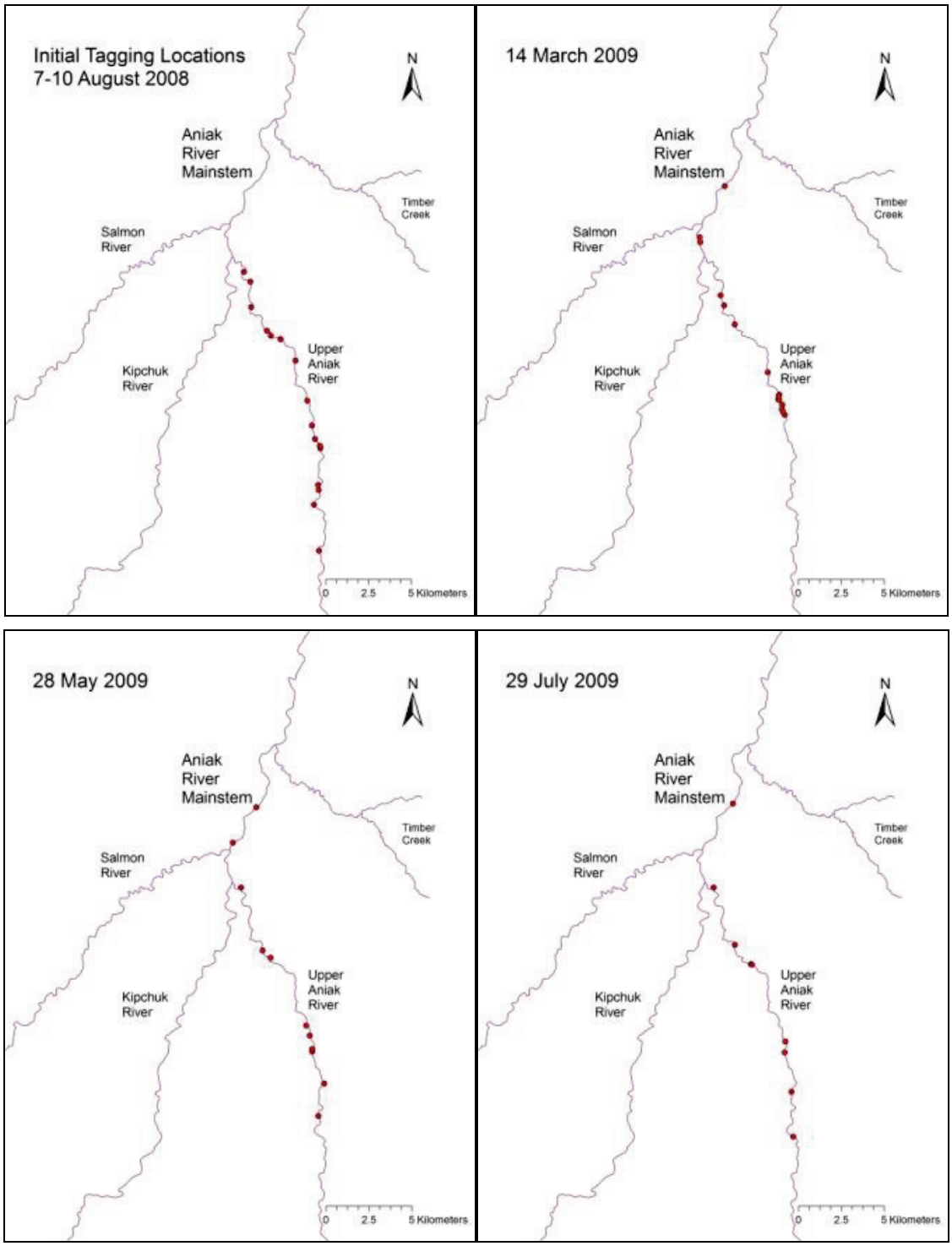

Figure 26.–Locations of rainbow trout originally radiotagged in the Upper Aniak River. Dates represent important seasonal use periods (summering, overwintering, spawning and second summering) for a 12 month period after tagging.

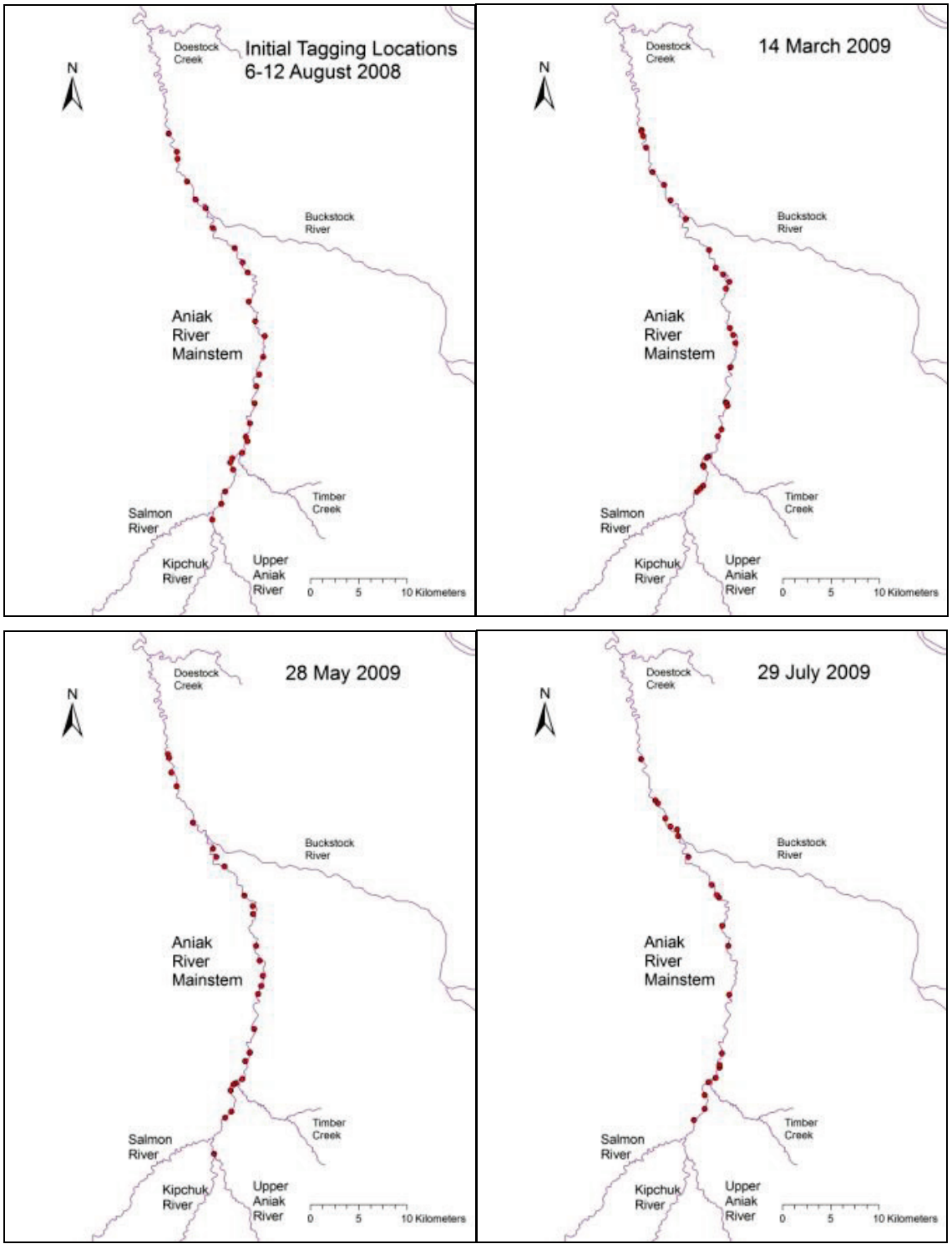

Figure 27.–Locations of rainbow trout originally radiotagged in the Upper Aniak River. Dates represent important seasonal use periods (summering, overwintering, spawning and second summering) for a 12 month period after tagging.

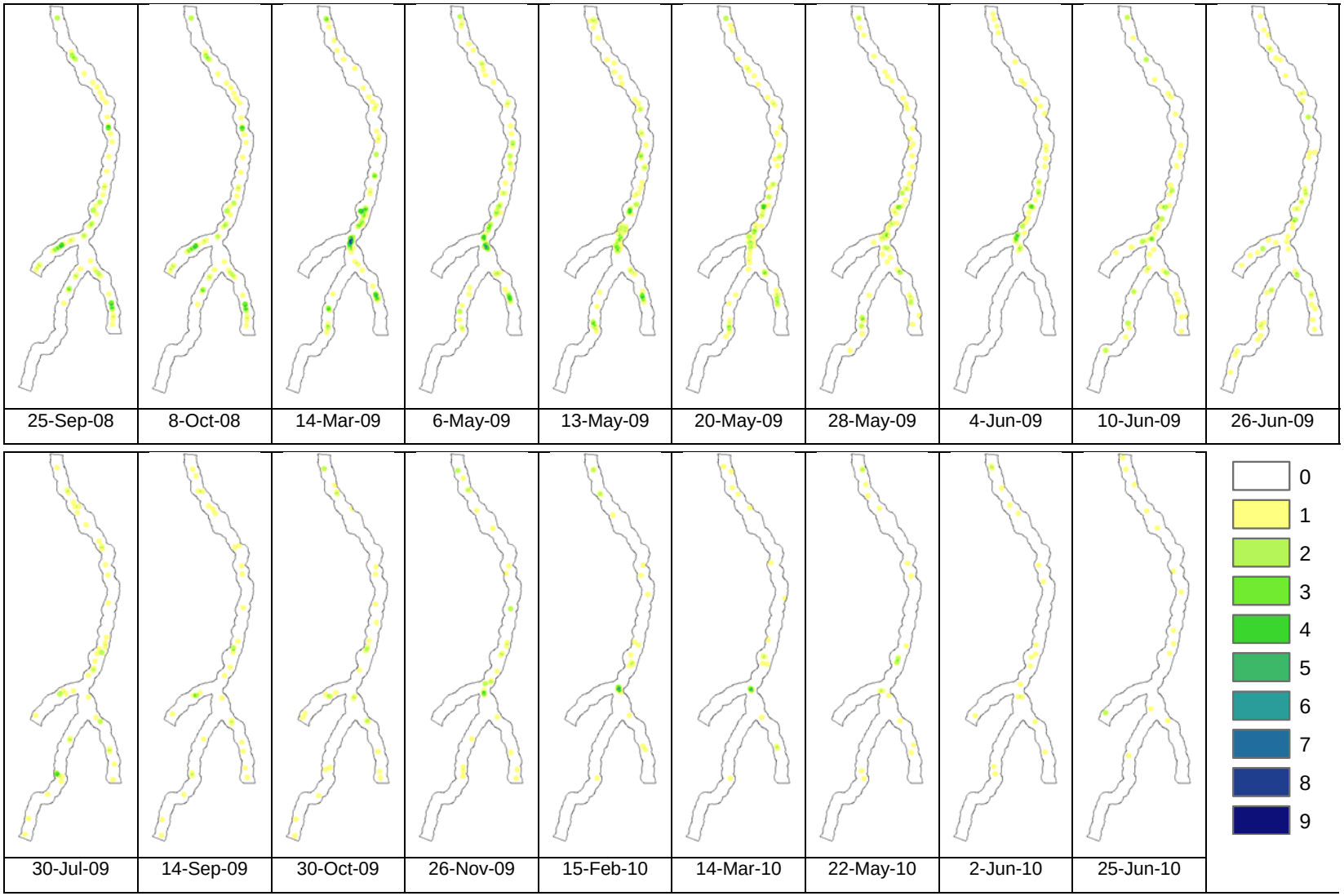

Figure 28.–Number of rainbow trout within 0.5 rkm, Aniak River.

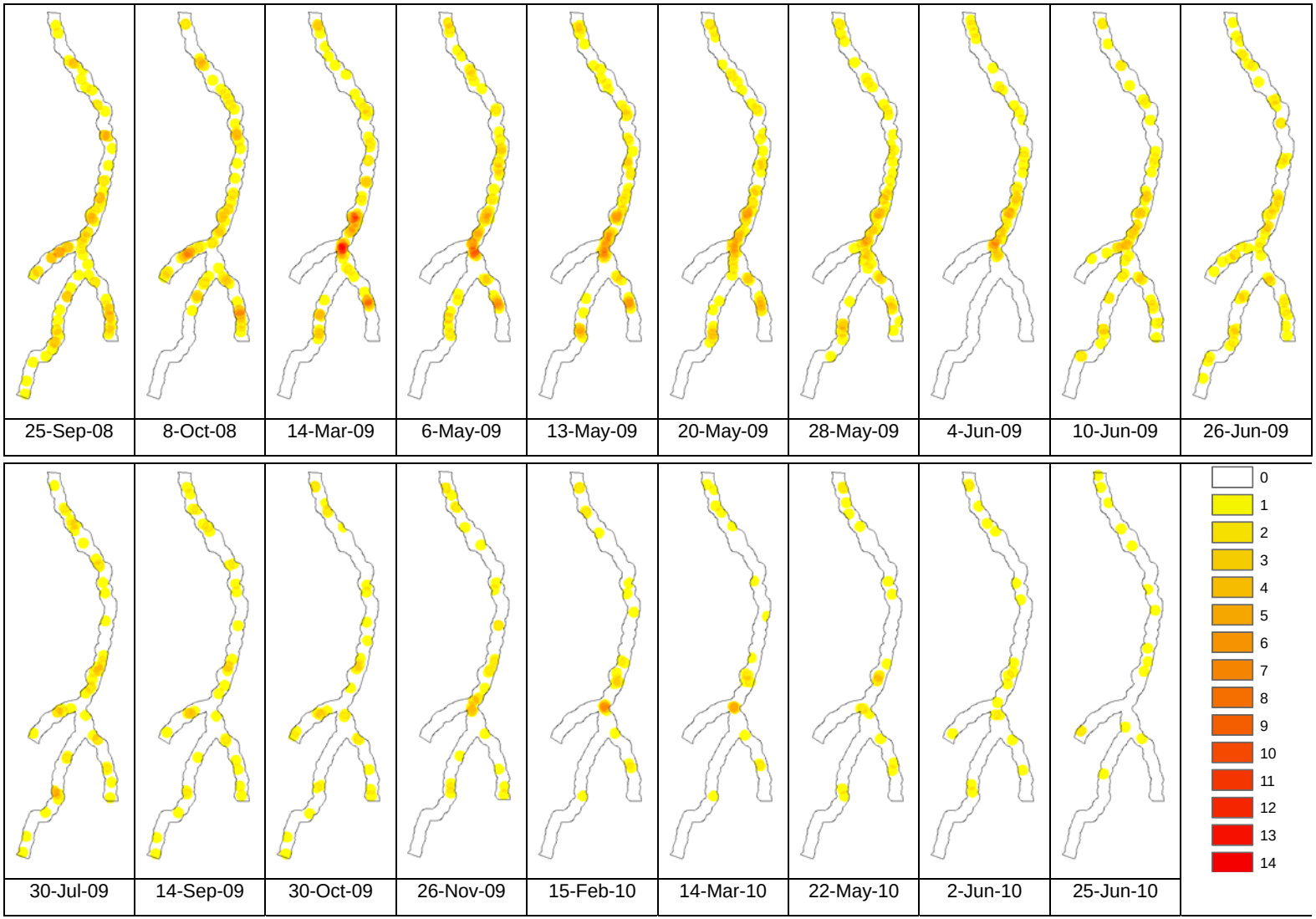

Figure 29.–Number of rainbow trout within 1.0 rkm, Aniak River.

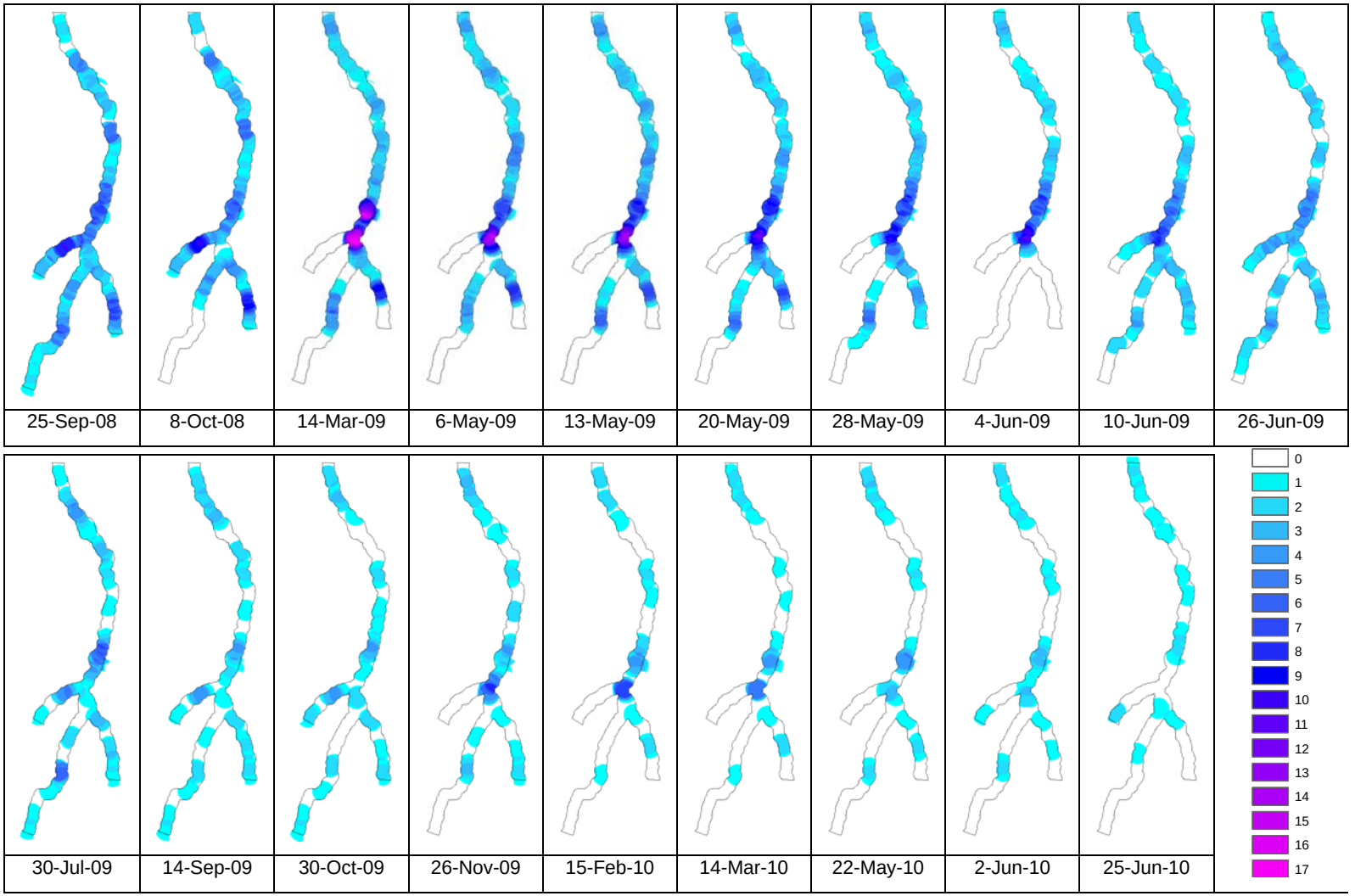

Figure 30.–Number of rainbow trout within 2.0 rkm, Aniak River.

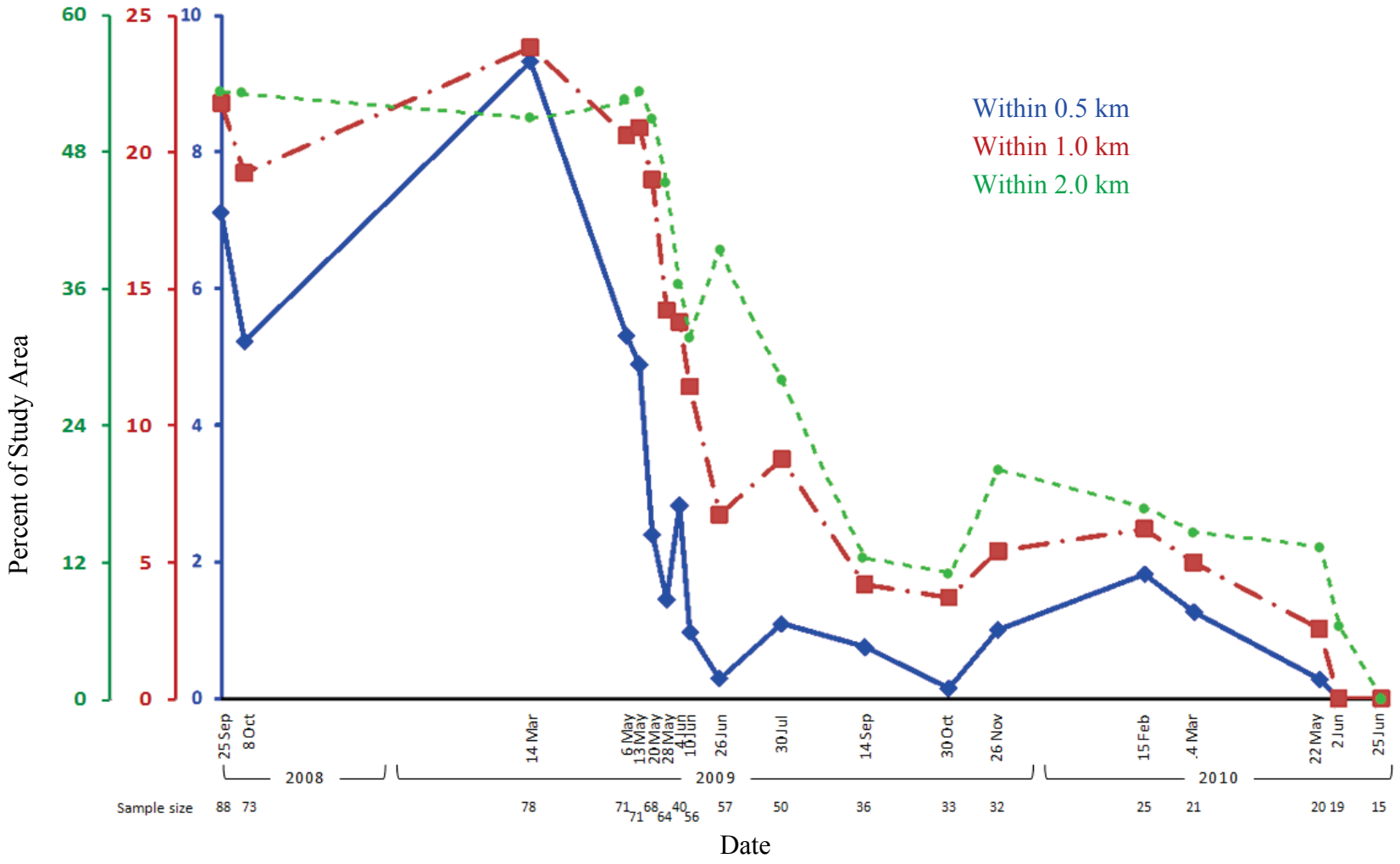

Figure 31.–Percent of study area where there were more than three rainbow trout within 0.5, 1.0 and 2.0 rkm.

TABLES

Table 1.–Aerial tracking dates and fates of rainbow trout, Aniak River, 2008–2010.

Aerial Survey Date	No. of Active Signals	No. of Inactive Signals	No. of Fish Undetected
25 September 2008	88	21	16
8 October 2008[a]	73[a]	20[a]	32[a]
14 March 2009	78	41	6
6 May 2009	71	31	23
13 May 2009	71	37	17
20 May 2009	68	42	15
28 May 2009	64	42	19
4 June 2009[a]	40[a]	39[a]	46[a]
10 June 2009	59	46	20
26 June 2009	57	50	18
30 July 2009	50	56	19
14 September 2009	36	69	20
30 October 2009	33	68	24
26 November 2009	32	70	23
15 February 2010	25	74	26
14 March 2010	21	79	25
13 May 2010 [b]	NA [b]	NA [b]	NA [b]
22 May 2010	20	81	24
2 June 2010	19	69	37
25 June 2010	15	70	40

[a] Incomplete survey due to inclement weather.
[b] GPS unit in receiver failed to record fish locations.

Table 2.–Movement distance summary of radiotagged rainbow trout in the Aniak River, as ascertained with 0.1 km detection criterion, 2008–2010.

Dates of Surveys	Days Between Surveys	Sample Size	Maximum Upstream Movement (km)	Maximum Downstream Movement (km)	Mean Absolute Distance (km)[a]
Tagging 9/25/08	44-50	88	22.8	17.4	2.2
9/25/08 10/8/08	13	68	1.7	4.5	0.5
10/8/08 3/14/09	157	59	10.7	20.5	5.0
3/14/09 5/6/09	53	70	2.4	13.3	1.9
5/6/09 5/13/09	7	67	24.1	13.3	1.5
5/13/09 5/20/09	7	67	22.9	5.6	1.2
5/20/09 5/28/09	8	64	30.9	6.2	2.2
5/28/09 6/4/09	7	40	10.9	3.4	1.0
6/4/09 6/10/09	6	37	18.7	1.1	1.9
6/10/09 6/26/09	16	53	14.4	51.1	3.8
6/26/09 7/29/09	33	48	26.5	11.2	2.8
7/29/09 9/14/09	46	35	11.5	9.5	1.2
9/14/09 10/30/09	46	31	1.0	11.2	1.2
10/30/09 11/26/09	27	29	4.2	34.3	4.0
11/26/09 2/15/10	81	24	1.6	12.3	1.8
2/15/10 3/14/10	64	19	1.1	2.6	0.5
3/14/10 5/22/10	9	18	2.0	5.1	1.0
5/22/10 6/2/10	11	18	12.6	2.5	1.7
6/2/10 6/25/10	23	15	20.9	15.6	4.9

[a] Absolute values of net movement were used to calculate mean distances traveled.

Table 3.–Proportion of radiotagged rainbow trout tagged from each river segment, and their maximum range over an approximate year (early August 2008 through 30 July 2009), Aniak River.

River Segment	Active Fish (n)	Maximum Movement (rkm)							
		0.0-5.0	5.1-10.0	10.1-15.0	15.1-20.0	20.1-25.0	25.1-30.0	> 30	Mean Distance
Salmon	6	0.00	0.17	0.17	0.33	0.33	0.00	0.00	16.2
Kipchuk	12	0.17	0.08	0.33	0.00	0.17	0.17	0.08	16.5
Upper Aniak	10	0.30	0.60	0.10	0.00	0.00	0.00	0.00	6.0
Mainstem	22	0.45	0.27	0.05	0.05	0.05	0.05	0.09	11.0
All	50	0.30	0.28	0.14	0.06	0.10	0.06	0.06	11.9

Table 4.–Movement direction summary of radiotagged rainbow trout in the Aniak River, as ascertained with 0.1 km detection criterion, 2008–2010.

Dates of Surveys	Days Between Surveys	Number Upstream	Proportion Upstream	Number Downstream	Proportion Downstream	Number Stationary	Proportion Stationary (<0.1 rkm)
Tagging 9/25/08	44-50	38	0.43	44	0.50	6	0.07
9/25/08 10/8/08	13	27	0.40	31	0.46	10	0.15
10/8/08 3/14/09	157	20	0.34	38	0.64	1	0.02
3/14/09 5/6/09	53	27	0.39	42	0.60	1	0.01
5/6/09 5/13/09	7	32	0.48	28	0.42	7	0.10
5/13/09 5/20/09	7	30	0.45	30	0.45	7	0.10
5/20/09 5/28/09	8	27	0.42	27	0.42	10	0.16
5/28/09 6/4/09	7	25	0.63	13	0.33	2	0.05
6/4/09 6/10/09	6	18	0.49	13	0.35	6	0.16
6/10/09 6/26/09	16	35	0.66	16	0.30	2	0.04
6/26/09 7/29/09	33	27	0.56	17	0.35	4	0.08
7/29/09 9/14/09	46	18	0.51	15	0.43	2	0.06
9/14/09 10/30/09	46	11	0.35	12	0.39	8	0.26
10/30/09 11/26/09	27	9	0.31	20	0.69	0	0.00
11/26/09 2/15/10	81	9	0.38	15	0.63	0	0.00
2/15/10 3/14/10	64	5	0.26	7	0.37	7	0.37
3/14/10 5/22/10	9	7	0.39	8	0.44	3	0.17
5/22/10 6/2/10	11	11	0.61	6	0.33	1	0.06
6/2/10 6/25/10	23	8	0.53	7	0.47	0	0.00

Table 5.–Movement direction summary of radiotagged rainbow trout in the Aniak River, as ascertained with 0.5 km detection criterion, 2008–2010.

Dates of Surveys	Days Between Surveys	Number Upstream	Proportion Upstream	Number Downstream	Proportion Downstream	Number Stationary	Proportion Stationary (<0.5 rkm)
Tagging 9/25/08	44-50	17	0.19	24	0.27	47	0.53
9/25/08 10/8/08	13	12	0.18	15	0.22	41	0.60
10/8/08 3/14/09	157	17	0.29	33	0.56	9	0.15
3/14/09 5/6/09	53	11	0.16	32	0.46	27	0.39
5/6/09 5/13/09	7	14	0.21	14	0.21	39	0.58
5/13/09 5/20/09	7	17	0.25	15	0.22	35	0.52
5/20/09 5/28/09	8	20	0.16	16	0.25	28	0.44
5/28/09 6/4/09	7	10	0.25	6	0.15	24	0.60
6/4/09 6/10/09	6	14	0.38	4	0.11	19	0.51
6/10/09 6/26/09	16	18	0.34	6	0.11	29	0.55
6/26/09 7/29/09	33	18	0.23	11	0.23	19	0.40
7/29/09 9/14/09	46	6	0.17	7	0.20	22	0.63
9/14/09 10/30/09	46	3	0.10	10	0.32	18	0.58
10/30/09 11/26/09	27	4	0.14	16	0.55	9	0.31
11/26/09 2/15/10	81	3	0.13	9	0.38	12	0.50
2/15/10 3/14/10	64	2	0.11	5	0.26	12	0.63
3/14/10 5/22/10	9	7	0.39	2	0.11	9	0.50
5/22/10 6/2/10	11	9	0.40	5	0.28	4	0.22
6/2/10 6/25/10	23	6	0.40	5	0.33	4	0.27

Table 6.–Proportion of fish found in the river segment they were originally radiotagged in, Aniak River 2008–2010.

Dates of Survey	Mainstem			Upper Aniak River			Kipchuk River			Salmon River		
	n^a	$\hat{p}$	SE($\hat{p}$)	n^a	$\hat{p}$	SE($\hat{p}$)	n^a	$\hat{p}$	SE($\hat{p}$)	n^a	$\hat{p}$	SE($\hat{p}$)
Tagging	54	NA	NA	25	NA	NA	25	NA	NA	21	NA	NA
9/25/08	36	1.00	0.000	16	0.94	0.059	18	1.00	0.000	14	0.82	0.095
10/8/08[b]	34	1.00	0.000	16	0.94	0.059	7	1.00	0.000	14	0.93	0.067
3/14/09	32	1.00	0.000	12	0.80	0.107	10	0.56	0.121	1	0.08	0.077
5/6/09	31	1.00	0.000	12	0.80	0.107	8	0.50	0.129	1	0.11	0.111
5/13/09	31	1.00	0.000	11	0.79	0.114	10	0.59	0.123	0	0.00	0.000
5/20/09	28	0.97	0.034	10	0.71	0.125	11	0.69	0.120	0	0.00	0.000
5/28/09	29	1.00	0.000	10	0.83	0.112	10	0.71	0.125	3	0.33	0.167
6/4/09[b]	25	0.96	0.038	1	0.33	0.333	0	0.00	0.000	3	0.38	0.183
6/10/09	23	0.92	0.055	10	0.83	0.112	10	0.83	0.112	5	0.71	0.184
6/26/09	25	1.00	0.000	10	0.91	0.091	11	0.85	0.104	7	0.88	0.125
7/29/09	23	1.00	0.000	8	0.89	0.111	11	0.92	0.083	6	1.00	0.000
9/14/09	17	1.00	0.000	7	0.88	0.125	6	1.00	0.000	5	1.00	0.000
10/30/09	14	1.00	0.000	6	0.75	0.164	5	1.00	0.000	6	1.00	0.000
11/26/09	15	1.00	0.000	4	0.57	0.202	4	0.80	0.200	0	0.00	0.000
2/15/10	11	1.00	0.000	3	0.50	0.224	1	0.25	0.250	0	0.00	0.000
3/14/10	9	1.00	0.000	3	0.50	0.224	1	0.50	0.500	0	0.00	0.000
5/22/10	9	1.00	0.000	4	0.80	0.200	2	0.67	0.333	1	0.33	0.333
6/2/10	9	1.00	0.000	3	1.00	0.000	3	0.75	0.250	1	0.33	0.333
6/25/10	9	1.00	0.000	1	0.50	0.500	2	1.00	0.000	2	1.00	0.000

[a] A *n* represents the total number of fish remaining in the same river segment they were radiotagged in.
[b] Partial survey due to high winds.

APPENDICES

Appendix A1.–Summary of data archives for the Aniak River rainbow trout telemetry study, 2008–2010.

Year	Data File[a]	Software
2010	AniakRiver_rainbowtrout_telemtrydata.xls	Microsoft Excel

[a] Data files are archived at and are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.

Appendix B1.–Date of capture, length, tag information, release location, final fate, date of final fate and range of each radiotagged rainbow trout, Aniak River, 6–12 August 2008.

Date	Floy Tag #	FL (mm)	Radio Tag Frequency 149.xxx MHz	Radio Tag	River Segment	Latitude Decimal Degrees	Longitude Decimal Degrees	Final Fate	Survey Date of Final Fate Assignment	Maximum Range (km)
8/6/08	none	450	700	03	Kipchuk	60.8228	-159.3214	Alive	NA	38.1
8/6/08	2500	470	700	04	Kipchuk	60.8443	-159.3168	Missing	6/25/10	15.2
8/6/08	2501	525	700	05	Kipchuk	60.8649	-159.3058	Mortality	6/10/09	9.7
8/7/08	2504	485	700	06	Kipchuk	60.9010	-159.2532	Missing	5/20/09	27.8
8/7/08	2505	450	700	07	Kipchuk	60.9010	-159.2532	Alive	NA	27.9
8/7/08	2506	460	700	08	Kipchuk	60.9010	-159.2532	Mortality	7/30/09	6.8
8/7/08	2507	490	700	09	Kipchuk	60.8925	-159.2504	Missing	6/25/10	5.5
8/7/08	2508	445	700	10	Kipchuk	60.9082	-159.2306	Mortality	9/25/08	NA
8/8/08	2514	450	700	11	Kipchuk	60.9249	-159.2334	Mortality	9/14/09	11.6
8/9/08	2517	455	700	12	Kipchuk	60.9712	-159.2171	Mortality	3/14/09	4.0
8/9/08	2519	520	700	13	Kipchuk	60.9801	-159.2098	Mortality	3/14/10	13.4
8/9/08	2518	515	700	14	Kipchuk	60.9801	-159.2098	Mortality	9/14/09	21.4
8/8/08	2512	480	700	15	Kipchuk	60.9249	-159.2334	Mortality	9/25/08	NA
8/10/08	2523	425	700	16	Kipchuk	61.0138	-159.1782	Mortality	5/13/09	8.3
8/8/08	2509	445	700	17	Kipchuk	60.9178	-159.2247	Mortality	10/30/09	27.8
8/10/08	2525	435	700	18	Kipchuk	61.0339	-159.1627	Mortality	9/25/08	NA
8/10/08	2522	425	700	19	Kipchuk	61.0055	-159.1840	Mortality	3/14/09	NA
8/10/08	2521	475	700	20	Kipchuk	61.0055	-159.1840	Mortality	5/20/09	0.4
8/9/08	2520	490	700	21	Kipchuk	60.9801	-159.2098	Mortality	9/14/09	12.0
8/10/08	2524	460	700	22	Kipchuk	61.0138	-159.1782	Mortality	5/28/09	21.5
8/9/08	2516	480	700	23	Kipchuk	60.9646	-159.2245	Mortality	3/14/09	0.8
8/8/08	2515	490	700	24	Kipchuk	60.9336	-159.2286	Mortality	9/14/09	21.5
8/8/08	2513	460	700	25	Kipchuk	60.9249	-159.2334	Mortality	2/15/10	1.8
8/8/08	2510	465	700	26	Kipchuk	60.9092	-159.2280	Mortality	9/14/09	5.8
8/8/08	2511	455	700	27	Kipchuk	60.9193	-159.2291	Mortality	7/30/09	7.9

-continued-

Appendix B1.–Page 2 of 5.

Date	Floy Tag #	FL (mm)	Radio Tag Frequency 149.xxx MHz	Radio Tag Code	River Segment	Latitude Decimal Degrees	Longitude Decimal Degrees	Final Fate	Survey Date of Final Fate Assignment	Maximum Range (km)
8/10/08	2610	420	700	28	Aniak	61.0351	-159.1507	Mortality	6/25/10	11.3
8/9/08	2639	565	700	29	Aniak	60.9564	-159.0672	Mortality	7/30/09	3.1
8/9/08	2641	455	700	30	Aniak	60.9636	-159.0698	Missing	7/25/10	2.0
8/10/08	2606	420	700	31	Aniak	61.0226	-159.1479	Alive	NA	19.6
8/9/08	2632	410	700	32	Aniak	60.9519	-159.0599	Mortality	3/14/09	1.9
8/8/08	2631	445	700	33	Aniak	60.9329	-159.0591	Mortality	3/14/09	4.8
8/8/08	2627	440	700	34	Aniak	60.9224	-159.0619	Mortality	9/25/08	NA
8/10/08	2601	430	700	35	Aniak	61.0073	-159.1115	Mortality	6/26/09	3.6
8/10/08	2737	475	700	36	Mainstem	61.1200	-159.1290	Mortality	3/14/10	2.3
8/6/08	2709	460	700	37	Mainstem	61.2120	-159.0990	Mortality	5/6/08	10.7
8/6/08	2704	415	700	38	Mainstem	61.2460	-159.1290	Alive	NA	7.0
8/10/08	2615	515	700	39	Aniak	61.0406	-159.1576	Mortality	9/25/08	NA
8/8/08	2628	435	700	40	Aniak	60.9301	-159.0586	Missing	5/13/09	6.1
8/7/08	2625	430	700	41	Aniak	60.8991	-159.0499	Missing	9/25/08	NA
8/10/08	2604	415	700	42	Aniak	61.0226	-159.1479	Mortality	9/14/09	7.7
8/10/08	2603	455	700	43	Aniak	61.0114	-159.1271	Alive	NA	7.9
8/10/08	2613	440	700	44	Aniak	61.0406	-159.1576	Mortality	3/14/09	1.3
8/9/08	2638	420	700	45	Aniak	60.9564	-159.0672	Mortality	5/28/09	4.5
8/10/08	2600	435	700	46	Aniak	61.0073	-159.1115	Mortality	9/25/08	NA
8/10/08	2649	440	700	47	Aniak	61.0073	-159.1115	Mortality	9/25/08	NA
8/9/08	2648	435	700	48	Aniak	60.9965	-159.0937	Mortality	9/25/08	NA
8/9/08	2633	420	700	49	Aniak	60.9519	-159.0599	Mortality	3/14/09	0.0
8/8/08	2626	420	700	50	Aniak	60.9224	-159.0619	Mortality	2/15/10	8.9
8/9/08	2634	430	700	52	Aniak	60.9519	-159.0599	Mortality	9/14/09	2.8
8/9/08	2636	465	700	53	Aniak	60.9532	-159.0611	Mortality	6/26/09	24.0
8/9/08	2642	545	700	54	Aniak	60.9763	-159.0776	Mortality	11/26/09	11.3

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Date	Floy Tag #	FL (mm)	Radio Tag Frequency 149.xxx MHz	Radio Tag Code	River Segment	Latitude Decimal Degrees	Longitude Decimal Degrees	Final Fate	Survey Date of Final Fate Assignment	Maximum Range (km)
8/8/08	2630	500	700	55	Aniak	60.9329	-159.0591	Missing	6/2/10	5.8
8/10/08	2602	500	700	56	Aniak	61.0090	-159.1226	Mortality	5/22/10	10.7
8/8/08	2723	505	700	57	Mainstem	61.2889	-159.1460	Mortality	10/30/09	2.8
8/8/08	2724	445	700	58	Mainstem	61.2889	-159.1460	Mortality	3/14/10	9.7
8/8/08	2726	545	700	59	Mainstem	61.1686	-159.1125	Mortality	7/30/09	4.8
8/8/08	2729	500	700	60	Mainstem	61.1851	-159.1105	Mortality	9/25/08	NA
8/8/08	2730	480	700	61	Mainstem	61.1964	-159.1084	Alive	NA	7.6
8/10/08	2736	450	700	62	Mainstem	61.1120	-159.1510	Mortality	2/15/10	15.2
8/8/08	2722	505	700	63	Mainstem	61.2975	-159.1589	Mortality	10/30/09	5.4
8/8/08	2728	435	700	64	Mainstem	61.1851	-159.1105	Mortality	9/25/08	NA
8/6/08	2701	450	700	65	Mainstem	61.2620	-159.1390	Mortality	2/15/10	27.0
8/8/08	2727	435	700	66	Mainstem	61.1686	-159.1125	Mortality	9/25/08	NA
8/6/08	2705	510	700	67	Mainstem	61.2310	-159.1050	Mortality	3/14/09	1.3
8/8/08	2720	575	700	68	Mainstem	61.3108	-159.1740	Mortality	3/14/09	0.8
8/6/08	2702	445	700	69	Mainstem	61.2620	-159.1390	Mortality	3/14/10	16.0
8/6/08	2707	435	700	70	Mainstem	61.2310	-159.1050	Mortality	3/14/09	23.0
8/6/08	2703	495	700	71	Mainstem	61.2460	-159.1290	Mortality	6/4/09	11.5
8/6/08	2708	460	700	72	Mainstem	61.2120	-159.0990	Alive	NA	23.7
8/7/08	2713	500	700	73	Mainstem	61.3690	-159.2770	Alive	NA	8.0
8/7/08	2711	465	700	74	Mainstem	61.3450	-159.2390	Mortality	3/14/09	1.7
8/10/08	2738	455	700	75	Mainstem	61.1200	-159.1290	Mortality	3/14/09	NA
8/9/08	2734	490	700	76	Mainstem	61.1370	-159.1248	Mortality	6/4/09	13.7
8/12/08	2746	425	700	77	Mainstem	61.3876	-159.2973	Mortality	3/14/09	NA
8/12/08	2747	485	700	78	Mainstem	61.3950	-159.3017	Mortality	3/14/09	NA
8/11/08	2745	450	700	79	Mainstem	61.0590	-159.1740	Mortality	9/25/08	NA
8/10/08	2740	420	700	80	Mainstem	61.1326	-159.1203	Mortality	9/25/08	NA

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Date	Floy Tag #	FL (mm)	Radio Tag Frequency 149.xxx MHz	Radio Tag	River Segment	Latitude Decimal Degrees	Longitude Decimal Degrees	Final Fate	Survey Date of Final Fate Assignment	Maximum Range (km)
8/12/08	2749	545	700	81	Mainstem	61.4111	-159.3206	Mortality	3/14/09	0.2
8/12/08	2748	505	700	82	Mainstem	61.4111	-159.3206	Alive	NA	3.0
8/11/08	2572	455	700	83	Mainstem	61.0856	-159.1590	Mortality	9/14/09	3.6
8/9/08	2733	505	700	84	Mainstem	61.1370	-159.1248	Mortality	2/15/10	2.9
8/11/08	2744	420	700	85	Mainstem	61.0590	-159.1740	Mortality	7/30/09	21.1
8/10/08	2741	450	700	86	Mainstem	61.1062	-159.1441	Mortality	5/20/09	24.1
8/9/08	2732	470	700	87	Mainstem	61.1497	-159.1196	Mortality	9/25/08	NA
8/10/08	2739	430	700	88	Mainstem	61.1326	-159.1203	Mortality	3/14/09	0.2
8/9/08	2735	440	700	89	Mainstem	61.1370	-159.1248	Alive	NA	2.0
8/9/08	2731	480	700	90	Mainstem	61.1497	-159.1196	Mortality	9/14/09	4.5
8/10/08	2742	440	700	91	Mainstem	61.1062	-159.1441	Mortality	9/14/09	8.8
8/11/08	2743	470	700	92	Salmon	61.0615	-159.1876	Mortality	3/14/09	15.5
8/6/08	2700	490	700	93	Mainstem	61.2620	-159.1390	Mortality	3/14/09	NA
8/7/08	2718	450	700	94	Mainstem	61.3251	-159.2200	Mortality	9/25/08	NA
8/7/08	2715	485	700	95	Mainstem	61.3510	-159.2580	Mortality	9/14/09	6.1
8/7/08	2719	480	700	96	Mainstem	61.3251	-159.2200	Alive	NA	51.0
8/7/08	2714	425	700	97	Mainstem	61.3690	-159.2770	Mortality	9/25/08	NA
8/8/08	2721	420	700	98	Mainstem	61.2975	-159.1589	Mortality	6/26/09	8.7
8/7/08	2712	475	700	99	Mainstem	61.3450	-159.2390	Missing	9/25/08	NA
8/7/08	2710	480	700	100	Mainstem	61.3450	-159.2390	Alive	NA	11.4
8/6/08	2706	440	800	03	Mainstem	61.2310	-159.1050	Mortality	5/13/09	0.8
8/7/08	2717	640	800	04	Mainstem	61.3510	-159.2580	Mortality	11/26/09	51.9
8/9/08	2554	495	800	05	Salmon	61.0239	-159.2990	Missing	3/14/09	NA
8/7/08	2716	465	800	06	Mainstem	61.3510	-159.2580	Mortality	7/30/09	2.3
8/10/08	2566	495	800	07	Salmon	61.0494	-159.2482	Mortality	5/22/10	7.7
8/10/08	2567	490	800	08	Salmon	61.0497	-159.2428	Mortality	9/25/08	NA

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Date	Floy Tag #	FL (mm)	Radio Tag Frequency 149.xxx MHz	Radio Tag	River Segment	Latitude Decimal Degrees	Longitude Decimal Degrees	Final Fate	Survey Date of Final Fate Assignment	Maximum Range (km)
8/11/08	2570	420	800	09	Mainstem	61.0732	-159.1594	Mortality	9/25/08	NA
8/8/08	2550	475	800	10	Salmon	60.9930	-159.3292	Mortality	10/8/08	17.0
8/10/08	2569	420	800	11	Salmon	61.0575	-159.2166	Mortality	6/10/09	4.9
8/10/08	2559	550	800	12	Salmon	61.0426	-159.2644	Mortality	7/30/09	21.3
8/11/08	2571	475	800	13	Mainstem	61.0856	-159.1590	Mortality	10/30/08	1.0
8/10/08	2560	450	800	14	Salmon	61.0463	-159.2536	Mortality	9/25/08	NA
8/9/08	2553	480	800	15	Salmon	61.0152	-159.3122	Alive	NA	21.3
8/10/08	2565	450	800	16	Salmon	61.0494	-159.2482	Mortality	5/20/09	6.2
8/10/08	2556	420	800	17	Salmon	61.0426	-159.2644	Mortality	5/6/09	14.3
8/9/08	2552	500	800	18	Salmon	61.0152	-159.3122	Missing	5/6/09	16.8
8/10/08	2557	455	800	19	Salmon	61.0426	-159.2644	Mortality	9/25/08	NA
8/11/08	2573	445	800	20	Mainstem	61.1165	-159.1485	Mortality	6/26/09	1.5
8/10/08	2561	425	800	21	Salmon	61.0494	-159.2482	Mortality	2/15/10	23.1
8/10/08	2563	550	800	22	Salmon	61.0494	-159.2482	Mortality	7/30/09	9.0
8/10/08	2564	425	800	23	Salmon	61.0494	-159.2482	Missing	7/25/10	19.4
8/10/08	2562	440	800	24	Salmon	61.0494	-159.2482	Mortality	3/14/09	1.0
8/9/08	2555	525	800	25	Salmon	61.0395	-159.2772	Mortality	3/14/09	0.2
8/11/08	2616	455	800	26	Mainstem	61.1165	-159.1485	Mortality	9/25/08	NA
8/11/08	2617	425	800	27	Mainstem	61.1165	-159.1485	Alive	NA	1.8
8/10/08	2568	510	800	28	Salmon	61.0530	-159.2319	Alive	NA	15.8
8/8/08	2551	430	800	29	Salmon	61.0089	-159.3207	Mortality	11/26/09	16.3
8/10/08	2558	480	800	30	Salmon	61.0426	-159.2644	Mortality	5/6/09	8.7