Fishery Data Series No. 09-45

Movements and Fidelity of Northern Pike in the Lower Innoko River Drainage, 2002–2004

by

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August 2009

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)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

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 REPORT NO. 09-45

MOVEMENTS AND FIDELITY OF NORTHERN PIKE IN THE LOWER INNOKO RIVER DRAINAGE, 2002–2004

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ABSTRACT

In June 2002, 60 northern pike in the Lower Innoko River drainage were implanted with radio tags to evaluate the movements from early June 2002 to May 2004. The goal of this study was to describe the fidelity of northern pike to a study area near Holy Cross. This is a study area where sportfishing is concentrated and where most of the subsistence fishing by the residents of Grayling, Anvik, Shageluk, and Holy Cross occurs during the open water season. The null hypothesis that the proportion of northern pike not located in the study area during at least one tracking event during the summer of 2002 was ≤ 0.30 was rejected. Thirty-five of 42 radio-tagged fish were located outside the study area during at least one tracking event. The proportion of radio-tagged northern pike located outside the study area during the 15 aerial surveys ranged from 0.28 (SE = 0.09) to 0.68 (SE = 0.08), with higher proportions of fish found outside the study area coinciding with winter surveys and lower proportions coinciding with the summer surveys. The proportion of radio-tagged northern pike not found in the study area during at least one aerial survey of the 2002 open-water season was 0.83 (95% C.I. = 0.67, 0.93). The lengths of all captured fish (n = 512) ranged from 211 mm to 1,180 mm FL.

Key Words: Northern pike, *Esox lucius*, radiotelemetry, subsistence fishery, sport fishery, Innoko River, GASH communities, fidelity.

INTRODUCTION

The Innoko River supports important sport and subsistence fisheries for northern pike *Esox lucius.* Increases in sport angling for northern pike by non-locals have become a source of conflict with local subsistence fishers. As a result, proposals have been submitted to the Alaska Board of Fisheries to restrict sportfishing activities for northern pike in the Innoko River. Because of the remoteness, size, and complexity of the Innoko River drainage, little biological or harvest information has been collected on Innoko River northern pike, so the goal of this study was to gain information on the movement and stock characteristics to better address conservation concerns, user conflicts, and future regulatory proposals.

HOLY CROSS STUDY AREA

The Innoko River is the fourth largest Yukon River tributary (744 km long) and drains approximately 16,500 km^2 of land from the Kaiyuh Mountains and the Innoko National Wildlife Refuge. The Innoko River has four major tributaries, the Iditarod, Dishna, Yetna, and Reindeer rivers, and connections to over 26,000 lakes and sloughs. While most of these lakes and sloughs are shallow and contain large areas of dense aquatic vegetation, the mainstem of the Innoko River is as deep as 75 feet (J. Burr, Fisheries Biologist, ADF&G, Fairbanks, personal communication). In addition to northern pike, least cisco *Coregonus sardinella*, humpback whitefish *C. pidschian*, broad whitefish *C. nasus*, sheefish *Stenodus leucichthys*, burbot *Lota lota*, longnose suckers *Catostomus catostomus*, blackfish *Dallia pectoralis*, slimy sculpin *Cottus cognatus*, and lake chub *Couesius plumbeus* are found in the Innoko River. Chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, pink salmon *O. gorbuscha*, and chum salmon *O. keta* pass through parts of the Innoko River during migrations to spawning areas in the Iditarod, Dishna, and Yetna river systems.

INNOKO RIVER NORTHERN PIKE FISHERY

In recent years, the Innoko River has become a popular destination for guided sport anglers seeking to catch northern pike. Catches of northern pike in the Innoko River averaged 3,907 and harvests have averaged 73 fish/year annually from 1990 to 2003 (Table 1; Mills 1991-1994; Howe et al. 1995, 1996, 2001a–d; Walker 2003; Jennings et al. 2004, Jennings et al. 2006a–b).

Table 1.–Catch, harvest, and sport angler effort for Innoko River northern pike, 1990–2003.

Year	Effort[a]	Catch	Harvest
1990	415	964	118
1991	520	1,544	118
1992	53	171	43
1993	637	1,661	151
1994	93	18	9
1995	430	1,039	90
1996	654	4,090	110
1997	445	3,024	56
1998	847	4,433	93
1999	551	3,770	145
2000	327	1,912	10
2001	1,458	12,866	28
2002	2,533	17,551	40
2003	174	1,655	12
Average 1990–2003	1,243	4,467	796

[a] Estimated number of angler-days fished.

However, these estimates of catch, harvest, and effort are based upon an expansion of angler survey results, and historically the responses from anglers who have fished the Innoko River are few and consequently, these estimates are not considered to be precise. The Innoko River is unique in that it offers one of the best opportunities for sport anglers to catch large northern pike in Alaska. The Alaska state record northern pike, 38 lb 8 oz, was caught in the Innoko River in 1991 and it is common to catch fish weighing 20 lbs or more. Most of the sport fishery occurs in an area by the mouth of the Innoko River, and south of Reindeer Lake down through Paimiut Slough (Figure 1). Most guides using the area encourage clients to practice catch-and-release but a small harvest does occur. Current sport fishing regulations for northern pike in the Innoko River are 3 per day, 3 in possession, only one of which may be over 30 inches, and no closed seasons.

Subsistence fishers for northern pike in the Innoko River drainage are typically residents of the local communities such as Grayling, Anvik, Shageluk, and Holy Cross (hereafter referred to as the GASH communities). Traditionally, subsistence and sport fishing areas near Holy Cross have not occurred in the same areas but there is some overlap (Figure 1). The subsistence fishery for northern pike is currently unregulated and there are no subsistence harvest reporting requirements. However, Wheeler (1998) reported that northern pike is a large component of the harvest of non-salmon species in the GASH communities, with a reported harvest of over 19,000 pounds (or ~2,700 fish at 7/lb ea.) in 1990–1991. In 1998, ADF&G initiated a program in conjunction with the Midnight Sun Trophy Northern Pike Adventures (MSTPA) guiding operation to sample northern pike for length, collect scales, and attach ADF&G tags on fish caught and released by their clients. This program has resulted in the sampling of more than

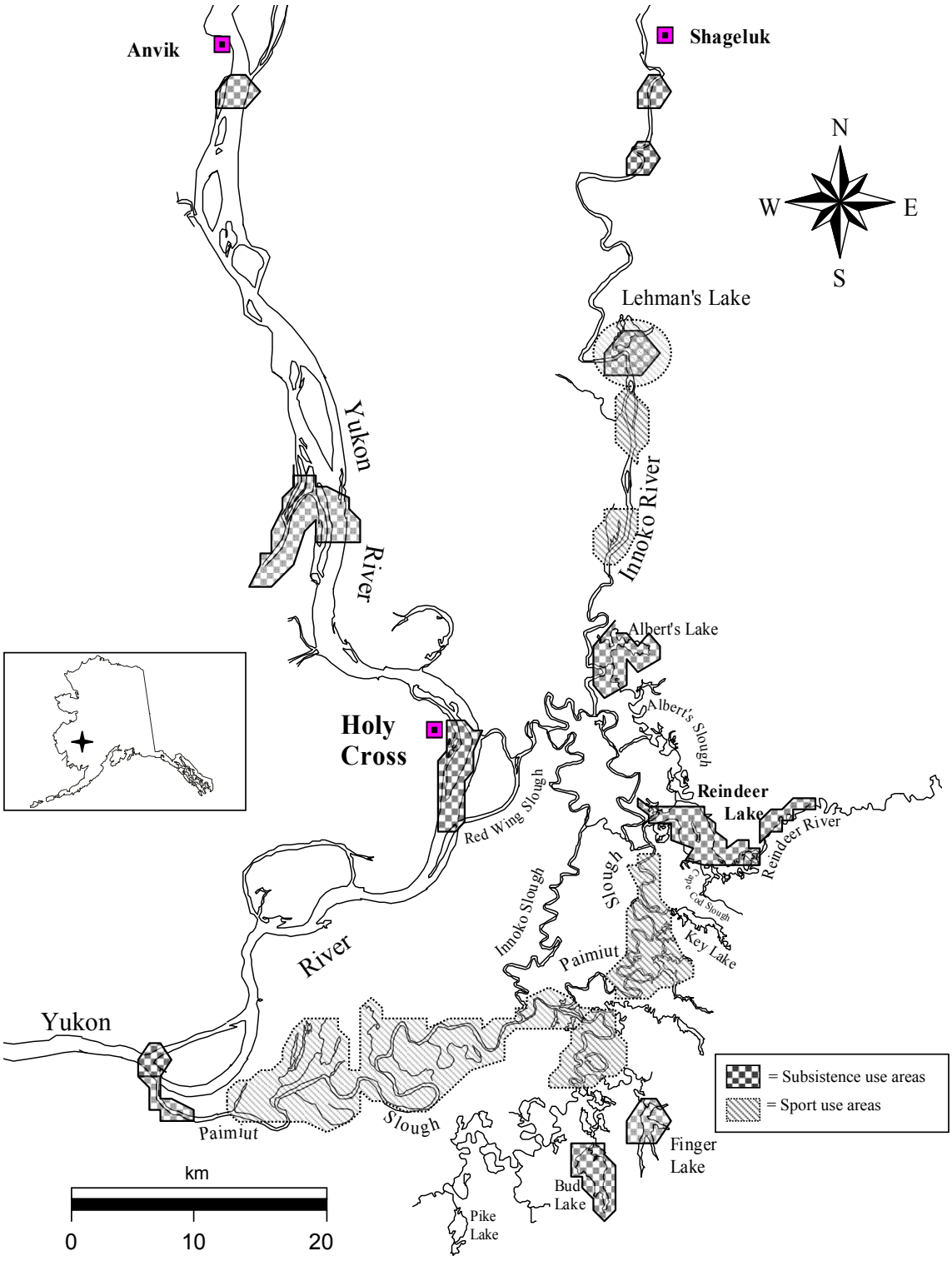

Figure 1.–Yukon and Lower Innoko rivers with both subsistence and sport fishing areas denoted.

2,000 fish over five summers, and provided age, length, and limited movement information on sport-caught northern pike in the Innoko River. The results of this cooperative study represent the only biological information collected on northern pike in the Lower Innoko River prior to this experiment.

OBJECTIVES

The goal of this study was to describe the northern pike stock inhabiting the Innoko River in terms of fidelity to the Holy Cross study area (Figure 2), where most of the subsistence fishing by the residents of Holy Cross occurs during the open water season, and where sport fishing effort is concentrated. A radiotelemetry study was used to determine the movements of this stock of fish over a period starting in early June of 2002 and continuing until spring 2004. The results can ultimately be used to help assess the effectiveness of current sport fishing regulations as well as preserve future opportunity for both sport and subsistence fishers. The objectives of this investigation were to:

1. estimate the proportion of northern pike (≥ 500 mm FL) tagged in the Holy Cross study area not found in the Holy Cross study area during each aerial survey to within 15 percentage points of the true proportions 95% of the time;
2. estimate the proportion of northern pike (≥ 500 mm FL) tagged in the Holy Cross study area not found in the Holy Cross study area during at least one aerial survey up to and including the mid-September survey to within 15 percentage points of the true proportions 95% of the time; and,
3. test the hypothesis that the proportion of northern pike (≥ 500 mm FL) that moved out of the Holy Cross study area during at least one aerial survey up to an including the mid-September survey is less than or equal to 0.30 with $\alpha = 0.05$ such that $\beta = 0.10$ if the true proportion is 0.50.

In this experiment, the null hypothesis of objective 3 (that ≤ 30% of the northern pike leave Holy Cross study area during at least one aerial survey up to and including the mid-September survey) corresponds to a decision criteria identified by the area manager. If the true proportion of northern pike that leave Holy Cross study area is ≤ 30%, then there may be a concern because the exploitation rate is not known. Given the statistical criteria, the experiment is designed such that there may be a conservation concern if the observed proportion located outside the area at least once was less than 0.40 (i.e. the null hypothesis will be rejected for observed proportions > 0.40). The probability of a type I error, α, was set such that there is at most a 5% chance of deciding that more than 30% of the pike leave Holy Cross study area (rejecting the null) when, in fact, less than 30% leave Holy Cross study area. The probability of a type II error, β, was set such that the power $(1 - \beta)$, to reject the null when the true proportion leaving is > 50% is > 90%.

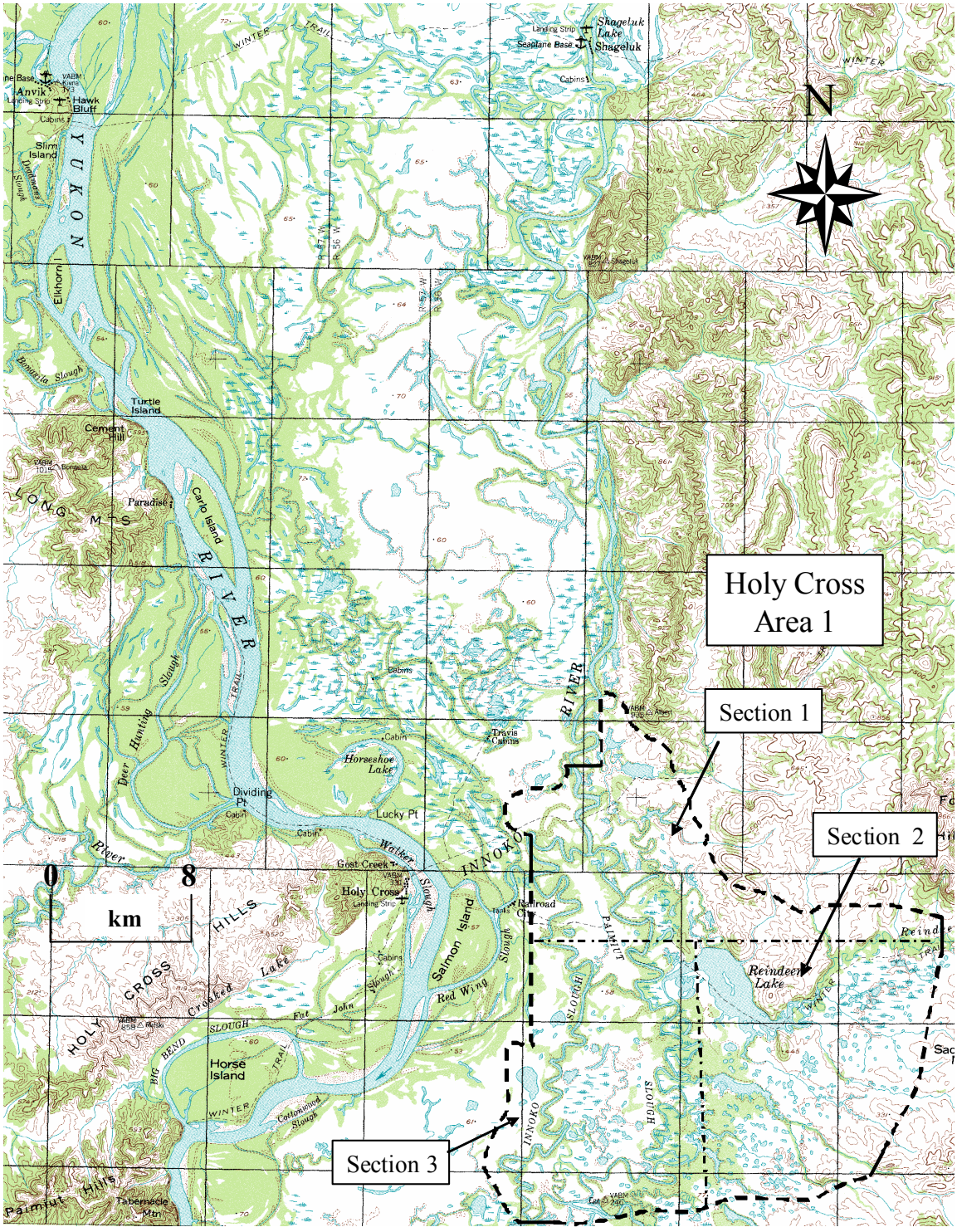

Figure 2.–Lower Innoko River with study area denoted.

Tasks:

In addition to the objectives, project tasks included:

1. documenting the locations of radio-tagged northern pike during the summer post-spawning and feeding period (June–September), during the winter (December–March), and during the spawning period (May) for the two years following implantation; and,
2. affixing a plastic Floy FD-68 internal anchor tag, recording fork lengths, and taking scale samples for ageing.

A concurrent study, funded by the ADF&G Subsistence Division, consisted of sampling the winter subsistence harvest of northern pike near Holy Cross for age, length, and sex composition in spring 2003 and 2004. The results of this research are summarized in the Discussion section of this report for comparative purposes.

As part of this study, length and age measurements were taken to characterize the size and age distributions of pike captured with various gear types. This was used as a basis for gear-specific age and length information that can be compared with: 1) gear-specific age and length information on Holy Cross study area northern pike collected in the future; and, 2) similarly collected data from other areas such as Minto Flats.

METHODS

STUDY DESIGN

The radiotelemetry component of the Innoko River northern pike study was designed to address concerns Holy Cross residents have about the degree to which the sport fishery for northern pike affects the subsistence fishery. Radiotelemetry was used to determine what proportion of the spawning stock of northern pike in Holy Cross study area leaves the area at different times of the year. The length of time that radio-tagged northern pike are absent from Holy Cross study area was determined from tracking surveys. Movements within Holy Cross study area were also documented by comparing locations of tagged fish from one tracking event to another. Determining fidelity of the northern pike population to Holy Cross study area during the open water season is important because virtually all of the sport fishing effort occurs during this time.

All northern pike ≥ 300 mm FL collected in June while sampling in Holy Cross study area were tagged with a uniquely numbered Floy™ tag. The purpose of affixing northern pike with Floy ™ tags was to provide information on fish movement, growth, and harvests (via tag returns from the subsistence and sport fisheries). Lengths and scales taken for age information.

SAMPLING METHODS

Sampling began in early June during safe boating conditions following break-up of the Yukon River. Northern pike were captured within a month after completion of spawning. Holy Cross study area was divided into three sections to facilitate an even distribution of tags throughout the main sportfishing areas (Figures 1 and 2). Only northern pike ≥500 mm FL were radio-tagged.

NORTHERN PIKE CAPTURE AND RADIO-TAG IMPLANTATION

From June 4 to 17, 2002, three two-person crews used hoop traps and gillnets to capture northern pike. Hoop traps had a 4-ft diameter opening and were 8-ft long. Each hoop trap had a 25-ft wing on one side and a 50 ft-wing on the other to funnel northern pike into the trap. They were placed parallel to the shoreline or blocking a slough in an effort to catch moving fish. Between the times when hoop traps were checked or moved, crews fished 80-ft by 6-ft sinking variable-mesh multifilament gillnets (1-, 1.5-, 2-, and 2.5-in bar mesh) within the designated section. Hoop traps were fished systematically by rotating the gear through each of the three sections of Holy Cross study area twice. Each crew sampled a particular section for three days before moving to a new section.

Northern pike selected to receive a radio tag were anesthetized with a clove oil and ethanol solution at a concentration of 25 mg L^{-1} based on the procedures outlined by Anderson et al. (1997). When a northern pike had succumbed to the anesthesia (by exhibiting rolling over behavior and lack of response to handling), it was then placed in a padded cradle upside down and its gills bathed in water with clove oil solution to maintain an anesthetized state. Radio transmitters were surgically implanted within the coelomic cavity of selected northern pike through a 2-3 cm incision along the linea alba, anterior to the pelvic girdle (Hart and Summerfelt 1975). The trailing antenna exited the fish through a needle-sized hole posterior to the pelvic girdle. Three to five sutures were used to close the main incision, and the incision was treated with an adhesive (Vet Bond™) before the fish was placed in a recovery tank. Typically, these fish had recovered from the surgery and were released within 15 minutes.

Implanted transmitters had a 24-month operational life and all tag frequencies were separated by at least 20 kHz within the 148 MHz bandwidth. The transmitters selected for this project were Lotek™ model *MBFT-3L*. Sixty transmitters were spread out over five frequencies with unique codes (1-12), and scan time through all frequencies was a total of 30 s. All frequencies were programmed into a Lotek™ SRX-400 receiver-scanner. Transmitters of this model and configuration had been used to successfully track movements of northern pike in the Dall River (Chythlook and Burr 2004).

The distribution of radio-tagged fish was determined by aerial tracking surveys flown in a systematic manner while listening for transmitter signals using a five-element Yagi antenna with 9 dBd gain mounted on a fixed-wing aircraft. During each survey, the Holy Cross study area was thoroughly flown first to ensure all tags within the study area were located. Thereafter, the surrounding waters of the Innoko River (including all lakes and sloughs upriver to Holikachuck, and all lakes and sloughs downriver to Lower Innoko and Paimiut sloughs) and portion of the Yukon River were flown to locate the remaining radio-tagged fish. Because of the large geographic area outside of the study area, all tags could not be located with certainty during each flight.

Location of a radio-tagged northern pike was determined using a map and a Global Positioning (GPS) unit. A radio-tagged fish was designated dead if locations over three consecutive tracking events were within a 0.3 km radius. All radio tags had tag return information printed on them. All radio-tagged fish were fitted with a Floy FD-68™ internal anchor tag as a secondary mark to help identify the fish if caught later by subsistence fishers or sport anglers.

DATA COLLECTION

For northern pike selected to receive a radio tag, the date, length, sex (if possible), radio frequency, gear type, water temperature, and GPS location were recorded in a field notebook. Capture locations and date caught were also recorded on a 1:63,360 USGS topographic map and on a GPS unit.

All northern pike ≥300 mm FL collected in June in Holy Cross study area were tagged with a uniquely numbered Floy FD-68™ internal anchor tag. Fork lengths were measured to the nearest mm and scales were removed for age determination. All data from captured northern pike was recorded on an ADF&G Tagging Length Mark-Sense Form, Version 1.0. Scales were mounted on gummed cards. A new gum card was used for each area with the corresponding mark-sense form number, date, and location recorded on the back.

DATA ANALYSIS

ASSIGNMENT OF FATE

To facilitate data analysis, locations of radio-tagged were plotted onto maps using ARCView™ and all radio-tagged northern pike were assigned a "fate" during each tracking survey. Fates were assigned based on observations from aerial tracking surveys and harvested northern pike for which tags were returned. Fates were defined as follows:

1) Tagging Mortality (TM) - A northern pike that died in response to tag implantation (either within the study area or outside the study area) between tagging and the first aerial survey. This was inferred from aerial surveys. Northern pike with this fate were not used for calculating proportions;
2) Post Tagging Mortality In (PTMI) – A northern pike located within the study area that was known to be alive during at least one prior survey, but was judged to be dead at the time of the survey being conducted. Northern pike with this fate were not used for calculating proportions for tracking surveys subsequent to the survey it was known to be dead;
3) Post-Tagging Mortality Out (PTMO) – A northern pike located outside the study area that was known to be alive during at least one prior survey, but was judged to be dead at the time of the survey being conducted. Northern pike with this fate were not used for calculating proportions for tracking surveys subsequent to the survey it was known to be dead;
4) Fishery Mortality Inside (FMI) – A northern pike that was reported harvested within the study area. Northern pike with this fate were not used for calculating proportions for tracking surveys subsequent to the survey it was known to be dead;
5) Fishery Mortality Outside (FMO) – A northern pike that was reported harvested outside the study area. Northern pike with this fate were not used for calculating proportions for tracking surveys subsequent to the survey it was known to be dead;
6) Unreported Harvest (UH) – A northern pike that was not reported as harvested but was assumed so because the radio tag was judged to be out of the water, away from any water body, and was located in or near a human abode. Radio tags out of the water have a pronounced increase in signal strength. The location where the northern pike was harvested was unknown. Northern pike with this fate were not used to calculate proportions in, and subsequent to, the survey it was known to be dead;

7) In the study area (IN) – A northern pike known to be alive at the time of a survey that was located within the study area;

8) Outside the study area (OUT) – A northern pike known to be alive at the time of a survey that was located outside the study area;

9) Unknown (U) – A northern pike that was never located after tagging because of tag failure or because it migrated outside the search area of the survey. In addition, those northern pike with fates not determinable with a reasonable degree of reliability will be designated "unknown" and accompanied by a rationale for the determination in the fate table. Northern pike with this fate were not used to calculate proportions; and,

10) At large (AL) – A northern pike that was not located during an aerial survey but was located again during one or more subsequent surveys. Northern pike with this fate were assigned a fate OUT for all previous surveys that they were not located. The AL fate was a temporary assignment until completion of all surveys, at which time the fate was assigned as OUT or U.

ESTIMATES OF PROPORTIONS

To facilitate calculating proportions, a fate history was prepared for each radio-tagged northern pike. Fate assignments were then tallied by survey.

The estimated proportion of northern pike not in the Holy Cross study area during each aerial survey (i) was calculated as:

$$\hat{p}_{out,i} = \frac{x_i}{n_i} \tag{1}$$

$$\hat{V}\left[\hat{p}_{out,i}\right] = \left[\frac{\hat{p}_{out,i}(1 - \hat{p}_{out,i})}{n_i - 1}\right] \tag{2}$$

where:

$\hat{p}_{out,i}$ = the proportion of northern pike that were not located in the Holy Cross study area during each aerial survey;

x_i = all TMO, PTMO, FMO, and OUT

n_i = Includes x_i, and all TMI, PTMI, FMI, and IN

The proportion of northern pike that was not located in the Holy Cross study area between the end of the tagging event and the mid-September survey was estimated by:

$$\hat{p}_{out} = \frac{x_{out}}{n} \tag{3}$$

$$\hat{V}\left[\hat{p}_{out}\right] = \left[\frac{\hat{p}_{out}\,(1 - \hat{p}_{out})}{n - 1}\right] \quad (4)$$

where:

$\hat{p}_{out}$ = the proportion of northern pike that was not located in the Holy Cross study area between the end of the tagging event and the mid-September survey;

x_{out} = all fish assigned an OUT fate at least once between the end of the tagging event and mid–September, and fish not designated OUT but designated as either TMO or FMO during period; and

n = includes x, all fish assigned an IN, and all fish not designated IN or OUT but designated as either TMI or FMI.

HYPOTHESIS TEST

The null hypothesis was tested:

H_o: $P_{OUT} \leq 0.30$

vs. the alternative hypothesis:

H_a: $P_{OUT} > 0.30$

where P_{OUT} is the proportion of northern pike ≥500mm FL that remained in the study area during at least one tracking event conducted between mid-June (after the capture period) and mid-September. Exact binomial procedures were used (Fleiss 1981).

RESULTS

From June 4 to June 17, 2002, a total of 512 northern pike were captured and sampled inside the study area (157 fish in Section 1, 164 in Section 2, and 191 in Section 3). Of these, 60 fish ≥ 500 mm FL were implanted with a radio tag (Table 2). All fish sampled ranged in size from 211 mm to 1,180 mm FL, with 407 fish (79%) ≥ 400 mm FL (Figure 3). Twenty-three fish (4%) of captured fish were killed, and one captured fish had a previous tag that was deployed by the guided sport fishery in 2001.

Fifteen aerial tracking surveys were conducted between July 1, 2002 and May 19, 2004 (Tables 3 and 4, and Figure 4). Initially, 17 (28%) of the radio-tagged northern pike failed to move from their release location, suggesting that these fish did not survive the surgery or expelled the radio tag before the first aerial survey. These fish were labeled as tagging mortalities (TM), leaving 43 radio-tagged fish believed to be alive and available for analysis of Objectives 1-3 at the time of the first tracking event. Contingency-table analysis of the length distribution of TM fish indicated that the percentage of tagging mortalities for northern pike ≤725 mm FL was not significantly different than that for northern pike >725 mm FL ($\chi^2 = 0.13$, df = 1, p-value = 0.71). In addition, the results of a Kolmogorov-Smirnov test indicated that the length distribution of

TM fish was not significantly different than that of the radio-tagged fish that survived at least until the first tracking survey (D = 0.21, p-value = 0.59). After the initial spike in mortality of radio-tagged fish immediately after deployment, 10 fish died throughout the remainder of the study (one was harvested by a sport angler, one by a subsistence fisher, and eight died from unknown causes; Appendix B).

Relative to Objective 1, the proportion of radio-tagged northern pike located outside the study area during any of the 15 aerial surveys ranged from 0.28 (SE = 0.09) on May 19, 2004 to 0.68 (SE = 0.08) on November 7, 2002 (Table 4 and Figure 4). The higher proportions fish found outside the study area tended to coincide with the winter surveys, while the lower proportions coincided with the summer surveys. Relative to Objective 2, the proportion of radio-tagged northern pike in the study area not found in the study area during at least one aerial survey up to and including the final 2002 open-water survey (August 27) was 0.83 (95% C.I. = 0.67, 0.93). Nineteen of the 43 radio-tagged northern pike (44%) left the study area between the time of tag deployment (June 4–17) and the first tracking event (July 1). Seven of these fish returned before the start of the second survey (July 31), and three of these fish left again before the last survey of the summer (August 27). Of the 41 fish that were still alive at the end of the last tracking survey (August 27), seven were never found outside the study area during the any of the tracking surveys. Relative to Objective 3, the null hypothesis that the proportion of northern pike not located in the study area during at least one tracking event conducted between July 1 and August 27, 2002 was ≤ 0.30 was rejected, with 35 of 42 radio-tagged fish (0.83; 95% C.I. = 0.67, 0.93) having left the study area at least once (Table 4 and Figure 4).

Relative to project tasks, locations of radio-tagged northern pike presumed to be alive were determined from fifteen aerial surveys conducted between July 1, 2002 and May 19, 2004 (Table 3 and Appendix B). In addition to accomplishing project objectives, the goal of these surveys was to document locations of northern pike during the summer post-spawning and feeding period (June through September, when they are most vulnerable to the sport fishery), during the winter (November through March, the peak of the subsistence fishery) and during spawning (late April through mid-May). Of the 41 radio-tagged northern pike found to have survived and retained their tags through summer 2002, seven (17%) never left the study area throughout the duration of the experiment (Tables 3 and 4). The proportion of radio-tagged fish located outside the study area in summer 2002 ranged from 0.44 to 0.57 (Table 4). Most movements were relatively small and consisted of short trips in and out of the study area; although one fish, originally tagged and released at 11-km Albert Slough, immediately moved up into the mainstem Innoko River, traveling a distance of at least 30 km outside the study area in 33 d. This fish was apparently destined for Lehman's Lake, where it was found throughout the winter. One radio-tagged fish was harvested by a sport angler in Reindeer Lake on August 18, 2002.

Table 2.–Capture and tagging information and final fate for each radio-tagged northern pike.

Date	Fish	Length (mm FL)	Location Tagged	Frequency (148.xxxKHz)	Code	Fate
6/6/2002	1	808	Reindeer Lake	400	1	IN
6/6/2002	2	652	Reindeer Lake	400	2	TMI, June 2002
6/8/2002	3	666	1 mile Reindeer River[a]	400	3	IN
6/8/2002	4	579	1 mile Reindeer River	400	4	TMI, June 2002
6/9/2002	5	810	Reindeer River Outlet	400	5	IN
6/10/2002	6	800	Albert Slough	400	6	TMO, March 2003
6/10/2002	7	988	Albert Slough	400	7	OUT
6/10/2002	8	675	Albert Slough	400	8	IN
6/11/2002	9	851	Albert Slough	400	9	TMO, July 2003
6/12/2002	10	927	Reindeer Lake	400	10	IN
6/12/2002	11	536	Reindeer Lake	400	11	IN
6/15/2002	12	890	Reindeer Lake	400	12	TMI, June 2002
6/6/2002	13	735	Reindeer Lake	440	1	IN
6/8/2002	14	630	1 mile Reindeer River	440	2	TMI, June 2002
6/8/2002	15	767	1 mile Reindeer River	440	3	TMI, June 2002
6/8/2002	16	575	1 mile Reindeer River	440	4	TMI, June 2002
6/9/2002	17	624	Reindeer Lake Outlet	440	5	U, May 2004
6/10/2002	18	530	Albert Slough	440	6	TMI ,June 2002
6/10/2002	19	724	Albert Slough	440	7	OUT
6/11/2002	20	748	Albert Slough	440	8	IN
6/11/2002	21	970	Albert Slough	440	9	TMI, June 2002
6/12/2002	22	640	Albert Slough	440	10	TMI ,June 2002
6/12/2002	23	935	Reindeer Lake Outlet	440	11	TMI, June 2002
6/16/2002	24	978	Leon Lake	440	12	OUT
6/6/2002	25	630	Reindeer Lake	520	1	IN
6/6/2002	26	598	Albert Slough	520	2	TMI
6/8/2002	27	725	1 mile Reindeer River	520	3	TMI
6/8/2002	28	620	1 mile Reindeer River	520	4	IN
6/9/2002	29	807	1 mile Paimiut Slough	520	5	OUT
6/9/2002	30	608	Albert Slough	520	6	IN
6/10/2002	31	558	Albert Slough	520	7	IN
6/11/2002	32	928	Albert Slough	520	8	U, March 2004
6/11/2002	33	800	Albert Slough	520	9	U, May 2003

-continued-

Table 2.–Page 2 of 2

Date	Fish	Length (mm FL)	Location Tagged	Frequency (148.xxxKHz)	Code	Fate
6/12/2002	34	915	Reindeer Lake	520	10	IN
6/12/2002	35	555	Reindeer Lake	520	11	IN
6/15/2002	36	890	Reindeer Lake	520	12	U, May 2004
6/6/2002	37	748	Reindeer Lake	540	1	TMI, June 2002
6/7/2002	38	815	Albert Slough	540	2	IN
6/8/2002	39	800	Near Moose Lake	540	3	TMI, 2002
6/10/2002	40	660	1 mile Reindeer River	540	4	TMI, 2002
6/10/2002	41	970	Reindeer Lake Outlet	540	5	TMO, April 2004
6/10/2002	42	585	Albert Slough	540	6	TMO, April 2004
6/11/2002	43	626	Albert Slough	540	7	IN
6/11/2002	44	882	Albert Slough	540	8	FMO, March 2003
6/12/2002	45	830	Albert Slough	540	9	U, May 2004
6/12/2002	46	763	Reindeer Lake Outlet	540	10	OUT
6/12/2002	47	891	Reindeer Lake Outlet	540	11	FMI, July 2002
6/14/2002	48	502	Reindeer Lake Outlet	540	12	IN
6/6/2002	49	715	Reindeer Lake	540	1	U
6/6/2002	50	690	Reindeer Lake	560	2	OUT
6/8/2002	51	793	1 Mile Reindeer River	560	3	TMI, June 2002
6/8/2002	52	790	1 Mile Reindeer River	560	4	TMI, June 2002
6/9/2002	53	561	Albert Slough	560	5	TMI, July 2003
6/9/2002	54	534	Albert Slough	560	6	IN
6/9/2002	55	681	Albert Slough	560	7	U
6/11/2002	56	830	Albert Slough	560	8	U
6/12/2002	57	834	Reindeer Lake Outlet	560	9	TMI, March 2004
6/12/2002	58	1,180	Reindeer Lake Outlet	560	10	OUT
6/12/2002	59	868	Reindeer Lake Outlet	560	11	TMO, March 2004
6/16/2002	60	1,080	Leon Lake	560	12	TMI, June 2002

[a] The definition of "1 Mile Reindeer River" means that a fish was caught in the Reindeer River one mile up from its confluence with Reindeer Lake.

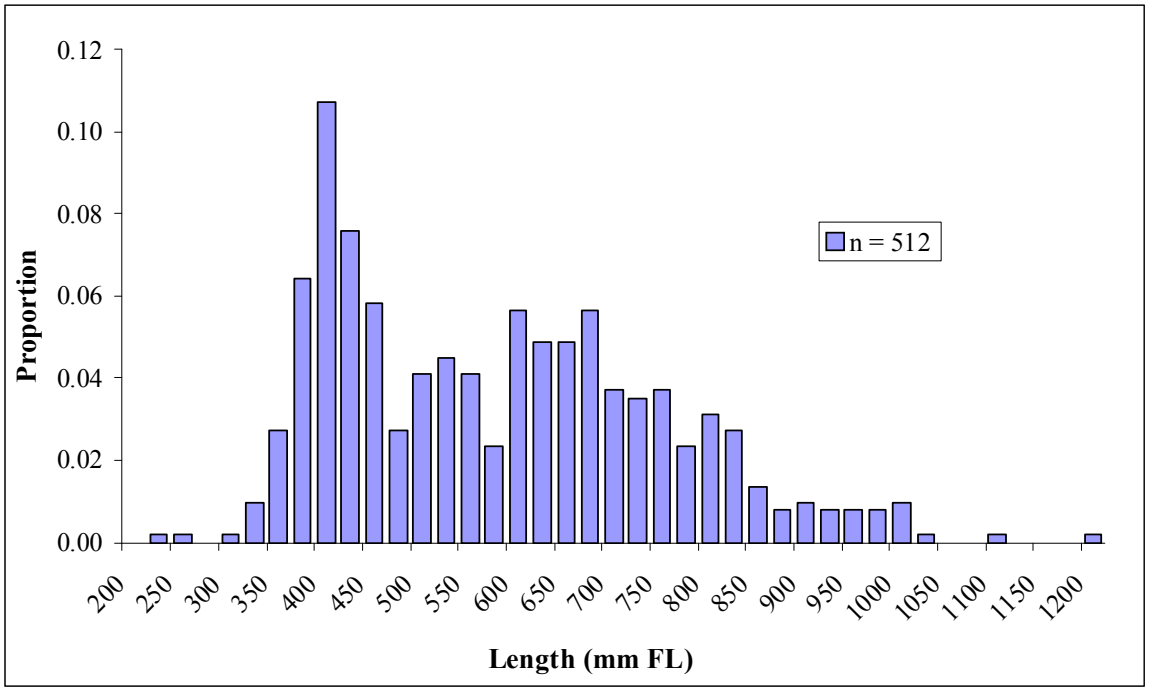

Figure 3.–Proportions of northern pike ≥ 200 mm FL by 50-mm length classes captured within the Lower Innoko River drainage during late May through early June 2002.

Table 3.–Number of assigned fates for each tracking event, July 1, 2002–May 19, 2004.

		Alive			Dead
Flight	**Date**	**In**	**Out**	**U**	
Tagged	June 10 – 16, 2002	60			
1	July 1, 2002	24	19		17
2	July 31, 2002	18	24		18
3	August 27, 2002	21	20		19
4	October 15, 2002	14	26		20
5	November 7, 2002	13	27		20
6	January 30, 2003	18	21		21
7	March 29, 2003	16	22		22
8	May 13, 2003	22	15	1	22
9	May 29, 2003	18	19	1	22
10	July 31, 2003	22	12	2	24
11	March 10, 2004	11	21	3	25
12	March 22, 2004	13	19	3	25
13	April 29, 2004	17	12	4	27
14	May 10, 2004	18	10	5	27
15	May 19, 2004	18	7	8	27

Table 4.–For each tracking event, number of radio-tagged northern pike assigned to each fate and proportions of northern pike remaining in the study area.

Radio Tag	Flight Date							
Frequency	July 1, 2002	July 31, 2002	August 27, 2002	October 15, 2002	November 7, 2002	January 30, 2003	March 29, 2003	May 13, 2003
IN	24	18	21	14	13	18	16	22
OUT	19	24	20	26	27	21	22	15
TM	17	1						
PTMI								
PTMO				1		1		
FMI			1					
FMO							1	
U								1
Total	60	43	42	41	40	40	39	37
$\mathbf{n}_i$	43	42	42	41	40	40	39	37
$\mathbf{x}_i$	19	24	20	27	27	22	23	15
$\mathbf{P}_{out,i}$	0.44	0.57	0.48	0.66	0.68	0.55	0.59	0.41
$\mathbf{V}[\mathbf{P}_{out,i}]$	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
UCL[a]	0.59	0.72	0.63	0.81	0.82	0.71	0.75	0.57
LCL[b]	0.29	0.42	0.32	0.51	0.53	0.39	0.43	0.25

-continued-

Table 4.–Page 2 of 2

Radio Tag Frequency	Flight Date: May 29, 2003	July 31 2003	March 10, 2004	March 22, 2004	April 29, 2004	May 10, 2004	May 19, 2004
IN	18	22	11	13	17	18	18
OUT	19	12	21	19	12	10	7
TM							
PTMI		1	1				
PTMO		1			2		
FMI							
FMO							
U	1	2	3	3	4	5	8
Total	37	36	33	32	31	28	25
$\mathbf{n_i}$	37	36	33	32	31	28	25
$\mathbf{x_i}$	19	13	21	19	14	10	7
$\mathbf{P_{out,i}}$	0.51	0.36	0.64	0.59	0.45	0.36	0.28
$\mathbf{V[P_{out,i}]}$	0.01	0.01	0.01	0.01	0.01	0.01	0.01
UCL[a]	0.68	0.52	0.80	0.77	0.63	0.54	0.46
LCL[b]	0.35	0.20	0.47	0.42	0.27	0.18	0.10

[a]Upper 90% confidence limit determined using exact methods

[b]Lower 90% confidence limit determined using exact methods

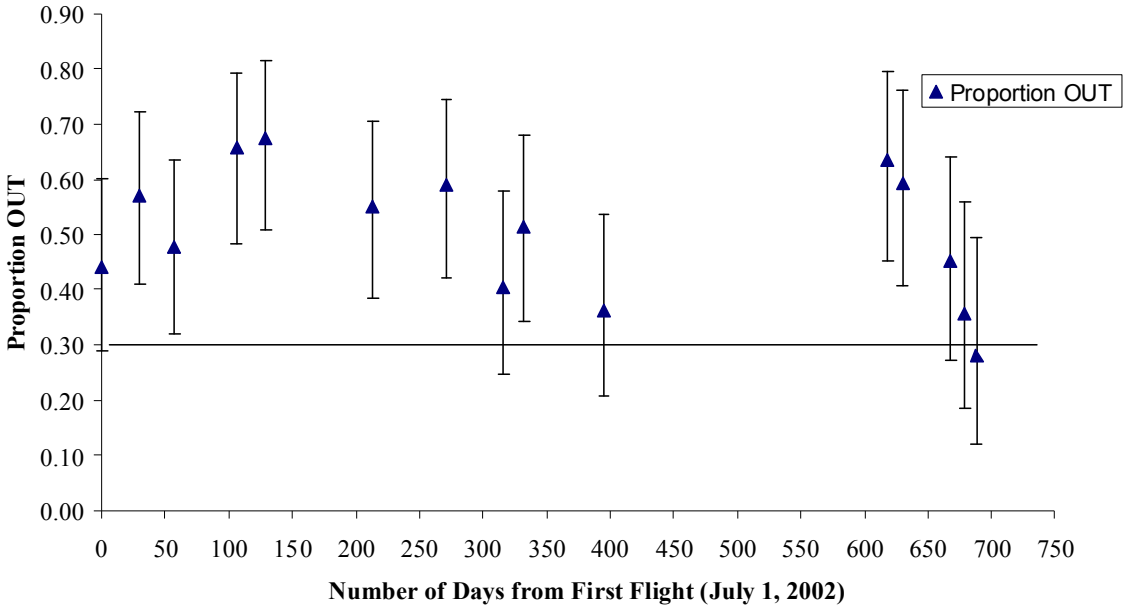

Figure 4.–Proportion of live radio-tagged fish not found inside the study area (with 95% C.I.) during each tracking event, July 1, 2002–Mar 19, 2004

Four tracking surveys were conducted during the winter of 2002–2003 (Tables 3 and 4). During these surveys, the proportion of radio-tagged fish located outside the study area ranged from 0.55 to 0.68 (Table 4 and Figure 4). Of the 39 fish still alive at the end of the last winter survey, six (15%) never left the study area. Major overwintering congregations of northern pike were found in three areas: 1) the Reindeer River, from the outlet to 25 km upriver; 2) inside or near the outlet of Lehman's Lake; and, 3) the mainstem Yukon River between the outlet of Paimiut Slough to 10 km upstream of the village of Holy Cross (Figure 5). Of the 39 live fish located on January 30, 2003, 15 (38%) were in the Reindeer River, eight (21%) were inside or just outside Lehman's Lake and 5 (13%) were in the Yukon River. The remaining 11 fish (28%) were spread out through Albert and Paimiut Sloughs, with no fish found inside Reindeer Lake. One fish originally captured and tagged on June 10, 2002 in 24 km Albert Slough, overwintered at the mouth of Otter Slough, a distance of at least 100 km. The Reindeer River overwintering area was characterized as being a relatively shallow, spring-fed river with open leads throughout the winter scattered between 25 km upriver and just above the outlet, where there is likely sufficient food and oxygen to survive the winter. The remaining overwintering areas were in or near deep water.

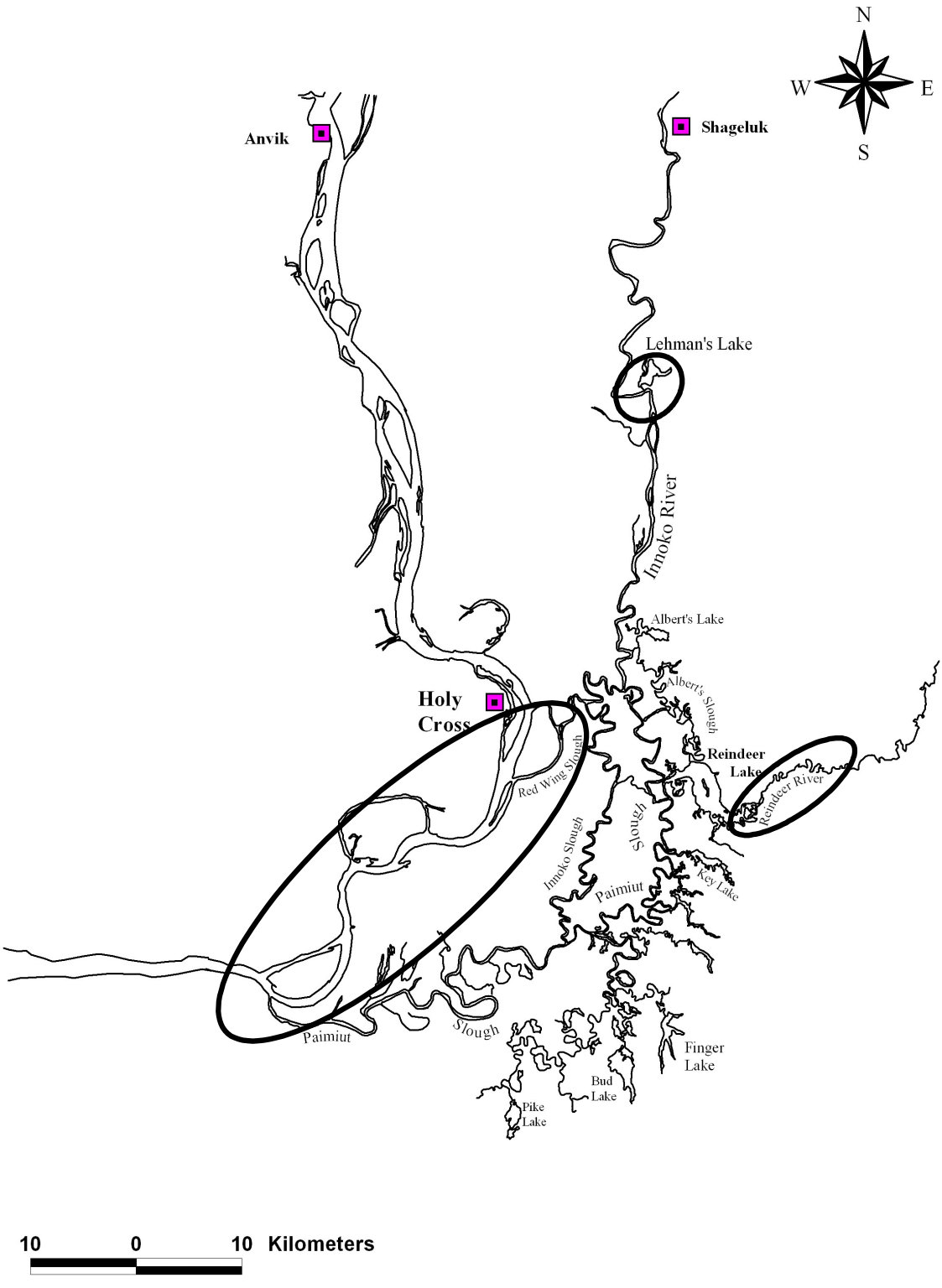

Figure 5.–Map of the three major overwintering locations for radio-tagged northern pike in the Lower Innoko River drainage.

On May 13, 2003, a tracking survey was conducted in attempt to locate radio-tagged fish during the spawning period. Nine of the 22 fish (41%) that were outside the study area in March returned to study area in May, including four of the five fish that had overwintered in the Yukon River and seven of the eight fish that had overwintered in Lehman's Lake. Of the 15 fish that had overwintered in the Reindeer River, all but three moved out into the lake and nearby channels after ice-out.

Because of the timing of radio tag deployment (early to mid-June), it is unlikely that fidelity to spawning areas could be determined using the May 13 tracking survey. Ice-out, and consequent spawning activity in the Lower Innoko drainage likely begins in late-April and early-May, and therefore spawning activity of northern pike in the study area was completed when the radio tags were deployed.

Determining fidelity to spawning areas was more difficult due to: 1) spawning habitat being widely-dispersed throughout the study area; 2) the short duration of the active spawning period; 3) uncertainty of when exactly spawning is occurring. Given this uncertainty, fidelity of northern pike to spawning areas for this purpose is defined as having been located within 5 km of the same location during flights conducted at suspected spawning times over two different years (May 10, 2003 and May 19, 2004). Locations of radio-tagged fish in May 2003 and 2004 showed that of the 27 fish located both years, 15 fish (56%) found in 2004 were located ≤ 5 km of the same location where found in 2003. Of these, nine fish (60%) were found in Reindeer Lake both years while others were found both years in the Reindeer River (three fish), and in river mile 15–18 in Albert Slough (Figure 1). Of the remaining 14 fish (44%) found in both years but in different locations, all but two were found in the Holy Cross study area both years.

Results from Kolmogorov-Smirnov tests revealed significant differences in length distribution of sampled northern pike by gear type (hoop traps versus gill nets; $D = 0.21$, $P < 0.01$). In addition, significant differences in length composition were found between fish sampled from sections 1 and 2 ($D = 0.20$, $P < 0.01$) and sections 2 and 3 ($D = 0.11$, $P = 0.03$), but no difference between sections 1 and 3 ($D = 0.08$, $P = 0.61$), suggesting that a representative sample of the population was not captured. These results indicate that this sample is unsuitable to compare the length distribution of northern pike captured in this study to those from other populations from which length composition information was collected (e.g., the Dall River or Minto Flats).

The results from scale ages indicated large error in assigning ages. For example, 66 fish were age-2 but their lengths all exceed 400 mm FL. Lengths from a 400 mm fish should be generally age-4 or greater. Therefore age data is not presented.

DISCUSSION

The results from this experiment suggest that northern pike move freely in and out of the study area (where much of the sportfishing occurs) during the open water months. Northern pike that were radio-tagged inside the study area in June traveled up to 50 km between monthly tracking surveys, and 83% (35 of 42) of live radio-tagged northern pike left the study area at least once during the summer of 2002. This amount of movement coupled with low reported harvests from the sport fishery suggests concern about overexploitation by the sport fishery is unwarranted at this time.

The telemetry data showed that northern pike targeted by the sport fishery within the study area during summer are also subject to harvest pressure from the subsistence fishery that occurs primarily during the winter. The major overwintering locations of northern pike located in this experiment (Reindeer River, mainstem Yukon River between Holy Cross and Paimiut Slough, and Lehman's Lake) coincided with locations of directed effort by subsistence fishers in the winter (Figure 1). In addition, evidence of fidelity to overwintering areas (59% of fish overwintered at or near the same locations in both years) as well as traditional use of these locations for winter subsistence fishing suggest that these overwintering locations are historical overwintering sites for northern pike. Fidelity to overwintering locations has been found in other northern pike populations in Interior Alaska (Taube and Lubinski 1996; Hallberg 1984). Therefore, while the results of this experiment suggest that the sport fishery is not likely to be a source of overexploitation for northern pike in the Lower Innoko River drainage, vulnerability to the winter subsistence fishery may be noteworthy, but cannot be quantified at this time because the current lack of harvest reporting requirements for subsistence fishers in this area.

Evidence for fidelity to spawning areas could not be determined accurately in this experiment for the reasons stated in the Results section. However, based on research conducted on other northern pike populations in large river systems it is unlikely that northern pike in the Innoko River drainage are loyal to a particular spawning site. Craig (1996) reported that there is little evidence for homing of spawning northern pike to their native spawning grounds, and that the selection of spawning areas may be related to the chemical and thermal cues provided by littoral areas with emergent vegetation. Similarly, Taube and Lubinski (1996) found that radio-tagged northern pike in the Kaiyuh Flats (in the Upper Innoko River drainage) did not congregate during spawning, and that similar to the Lower Innoko River drainage, suitable habitat is widespread.

One disappointing result from this experiment was the high tagging mortality rate (TM). In this study, 17 of the 60 of radio-tagged fish died or lost their tags before the first tracking event (28%) compared to two out of 50 (4%) for Taube and Lubinski (1996) in the Kaiyuh Flats; zero out of 68 for Roach (1998) in the Minto Lakes; and, 11 out of 60 (18%) for Joy and Burr (2004) in the Yukon Flats. In two of these studies, larger fish were chosen for implantation ($\geq$ 620 for Joy and Burr and $\geq$ 750 for Taube and Lubinski compared to $\geq$ 500 mm FL for this study). In the Minto Lakes experiment, fish as small as 413 mm FL were implanted with radio tags (Roach 1998). However, length of fish did not appear to affect survival in this experiment. One difference in the tag deployment strategy that may affect survival is the timing of the tag deployment. In this study and in the Yukon Flats study (where TM was $\geq$ 18%), radio tags were deployed in early June, whereas in the Kaiyuh Flats experiment tags were deployed later (July 9–29; Taube and Lubinski 1996) and in the Minto Lakes experiment, tags were deployed just before spawning (April 27–May 4; Roach 1998). By deploying tags soon after spawning, it is possible that the physiological stressors of spawning coupled with that from the surgery and handling may have contributed to the high TM rate, and that future radiotelemetry experiments conducted on northern pike should be designed to schedule tag implantation either prior to spawning in early spring or at least eight weeks after spawning to ensure low tagging mortality rates.

The Lower Innoko River drainage is known for producing exceptionally large northern pike. In this experiment, a high proportion of large fish were captured and sampled (33% of fish $\geq$ 400 mm FL were also $\geq$ 720 mm FL, with one fish 1,180 mm FL). Similarly, information provided

by MSTPA showed that in 2002 over 400 northern pike captured by clients in this area were 1,000 mm FL or larger. While length composition of the population could not be estimated in this experiment, the presence of a large proportion of large fish in our sample is inconsistent with what would be found in a highly-exploited population.

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APPENDIX A
DATA FILE LISTING

Appendix A1.–Data files for all captured northern pike from the Lower Innoko River, 2002–2004.

Data file[a]	Description
2004InnokoNPdata.xls	Population and telemetry data for Innoko River northern pike from June 3, 2002 to May 19, 2004

[a] Data files were archived at and are available from the Alaska Department of Fish and Game, Sport Fish Division, 1300 College Road, Fairbanks, Alaska 99701.

APPENDIX B
FATES TABLE SUMMARIES

Appendix B1.–Fates of individual northern pike radio-tagged in the Lower Innoko River study area, 2002–2004 by tracking event.

Tracking Event 148.400															
Code	1 July 2002	31 July 2002	27 Aug 2002	15 Oct 2002	7 Nov 2002	30 Jan 2003	29 Mar 2003	13 May 2003	29 May 2003	31 July 2003	10 Mar 2004	22 Mar 2004	29 Apr 2004	10 May 2004	19 May 2004
1	IN	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	IN	OUT	OUT	OUT	OUT	IN
2	**TMI**														
3	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN
4	**TMI**														
5	IN	IN	IN	OUT	OUT	OUT	OUT	IN	OUT	IN	OUT	OUT	OUT	OUT	IN
6	OUT	IN	OUT	OUT	OUT	**PTMO**									
7	IN	OUT	OUT	OUT	IN	IN	IN	IN	OUT	OUT	IN	IN	IN	IN	OUT
8	IN	OUT	IN	OUT	OUT	OUT	OUT	OUT	IN	IN	OUT	OUT	IN	IN	IN
9	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	**PTMO**					
10	OUT	OUT	OUT	OUT	OUT	OUT	IN	IN	IN	IN	IN	IN	IN	IN	IN
11	OUT	IN	IN	OUT	OUT	OUT	OUT	IN	OUT	IN	IN	IN	IN	IN	IN
12	**TMI**														

Tracking Event 148.440															
Code	1 July 2002	31 July 2002	27 Aug 2002	15 Oct 2002	7 Nov 2002	30 Jan 2003	29 Mar 2003	13 May 2003	29 May 2003	31 July 2003	10 Mar 2004	22 Mar 2004	29 Apr 2004	10 May 2004	19 May 2004
1	OUT	IN	IN	IN	OUT	IN	IN	OUT	OUT	OUT	OUT	IN	IN	OUT	IN
2	**TMI**														
3	**TMI**														
4	**TMI**														
5	IN	IN	IN	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	IN	**U**	**U**
6	**TMI**														
7	IN	OUT	OUT	OUT	IN	IN	IN	IN	OUT	OUT	IN	IN	IN	IN	OUT
8	IN	OUT	IN	OUT	OUT	OUT	OUT	OUT	IN	IN	OUT	OUT	IN	IN	IN
9	**TMI**														
10	**TMI**														
11	**TMI**														
12	OUT	OUT	OUT	OUT	IN	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT

-continued-

Tracking Event 148.520

Code	1 July 2002	31 July 2002	27 Aug 2002	15 Oct 2002	7 Nov 2002	30 Jan 2003	29 Mar 2003	13 May 2003	29 May 2003	31 July 2003	10 Mar 2004	22 Mar 2004	29 Apr 2004	10 May 2004	19 May 2004
1	OUT	OUT	IN	IN	IN	IN	IN	IN	IN	OUT	IN	IN	OUT	OUT	IN
2	**TMI**														
3	**TMI**														
4	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN
5	IN	IN	OUT	OUT	OUT	OUT	OUT	IN	IN	IN	OUT	OUT	OUT	IN	OUT
6	IN	IN	OUT	IN	IN	IN	OUT	IN	IN	IN	IN	IN	IN	IN	IN
7	IN	IN	IN	IN	OUT	IN	IN	IN	IN	OUT	OUT	OUT	IN	IN	IN
8	IN	OUT	IN	OUT	OUT	OUT	OUT	OUT	OUT	IN	**U**	**U**	**U**	**U**	**U**
9	OUT	OUT	IN	IN	IN	IN	IN	**U**	**U**	**U**	**U**	**U**	**U**	**U**	**U**
10	IN	OUT	OUT	OUT	IN	IN	IN	IN	IN	IN	OUT	OUT	IN	IN	IN
11	OUT	OUT	IN	IN	OUT	IN	IN	IN	IN	IN	IN	IN	OUT	IN	IN
12	OUT	OUT	OUT	OUT	IN	IN	IN	OUT	OUT	IN	OUT	IN	IN	IN	**U**

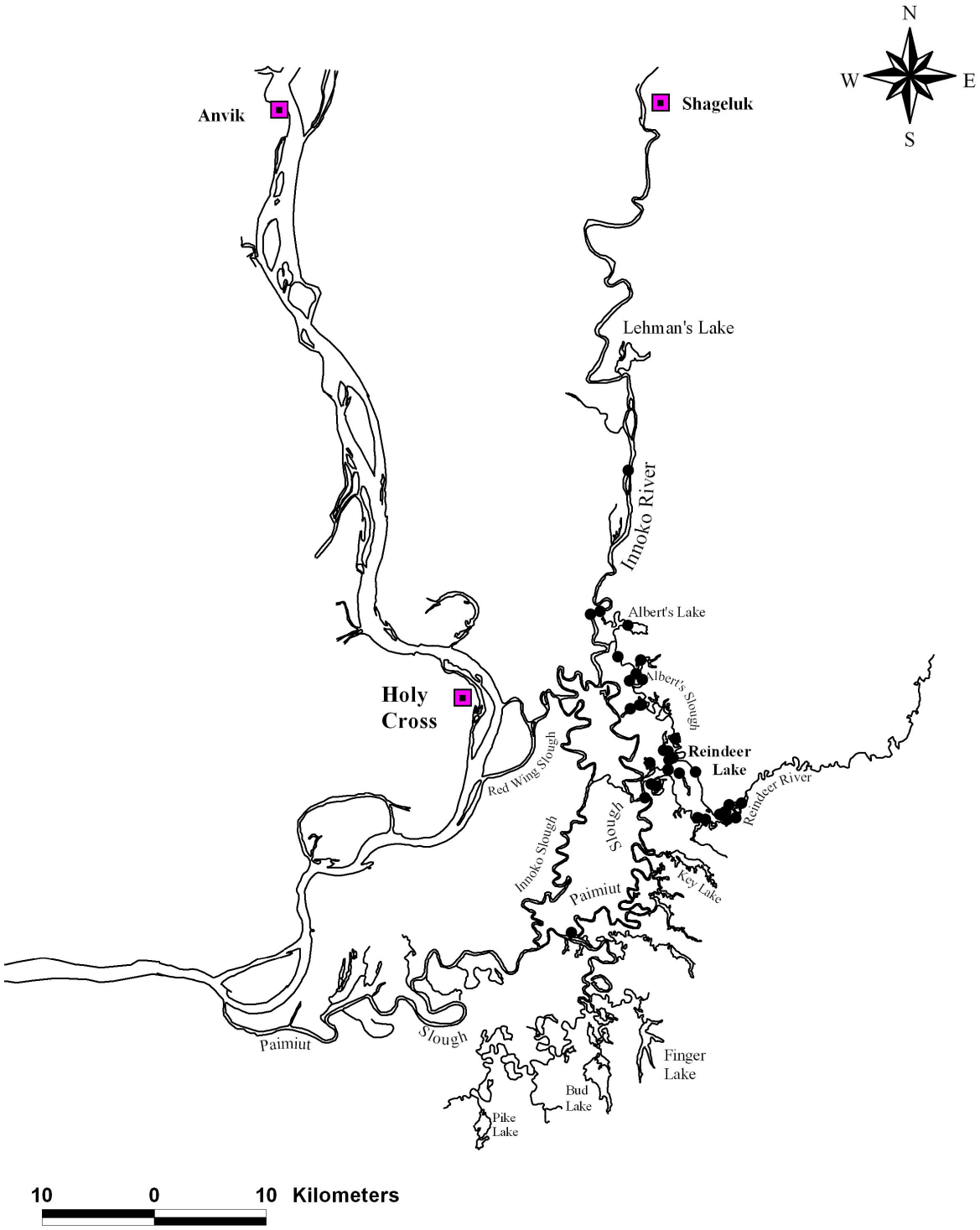
Tracking Event 148.540

Code	1 July 2002	31 July 2002	27 Aug 2002	15 Oct 2002	7 Nov 2002	30 Jan 2003	29 Mar 2003	13 May 2003	29 May 2003	31 July 2003	10 Mar 2004	22 Mar 2004	29 Apr 2004	10 May 2004	19 May 2004
1	IN	**TMI**													
2	OUT	IN	IN	OUT	OUT	OUT	OUT	IN	OUT	OUT	OUT	OUT	OUT	OUT	IN
3	**TMI**														
4	**TMI**														
5	OUT	OUT	OUT	OUT	OUT	OUT	OUT	IN	IN	IN	OUT	OUT	**PTMO**		
6	IN	OUT	IN	IN	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	**PTMO**		
7	IN	IN	OUT	OUT	OUT	IN	OUT	IN	IN	IN	OUT	OUT	IN	IN	IN
8	IN	IN	IN	OUT	OUT	OUT	**FMO**								
9	OUT	OUT	IN	OUT	OUT	IN	OUT	IN	IN	OUT	OUT	OUT	OUT	IN	**U**
10	IN	OUT	IN	OUT	OUT	OUT	OUT	IN	OUT	OUT	OUT	OUT	OUT	OUT	OUT
11	OUT	IN	**FMI**												
12	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN

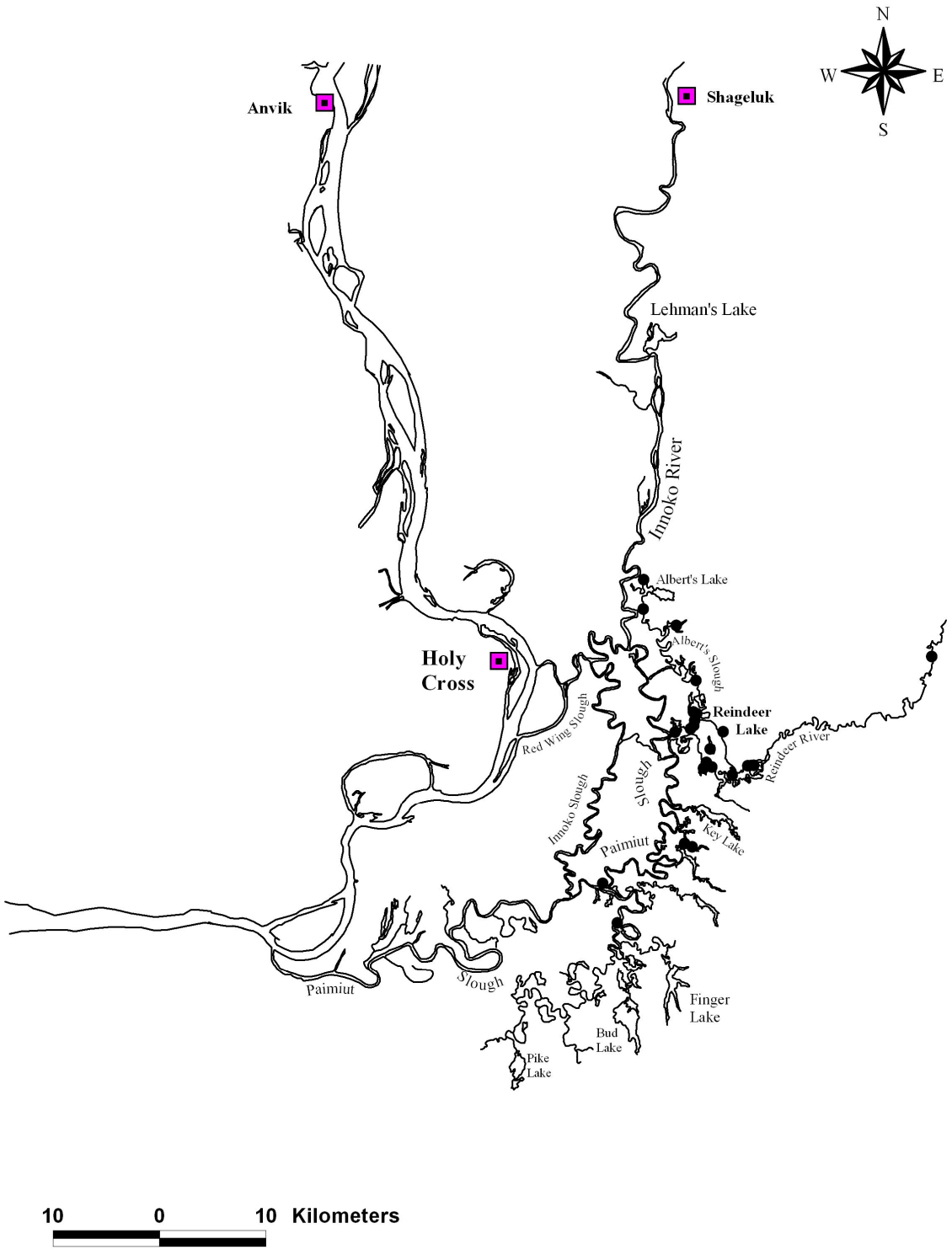
-continued-

Tracking Event 148.560															
Code	**1 July 2002**	**31 July 2002**	**27 Aug 2002**	**15 Oct 2002**	**7 Nov 2002**	**30 Jan 2003**	**29 Mar 2003**	**13 May 2003**	**29 May 2003**	**31 July 2003**	**10 Mar 2004**	**22 Mar 2004**	**29 Apr 2004**	**10 May 2004**	**19 May 2004**
1	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	U	U	U
2	IN	OUT	IN	IN	OUT	IN	IN	IN	IN	IN	OUT	OUT	OUT	OUT	OUT
3	TMI														
4	TMI														
5	IN	OUT	IN	IN	IN	IN	IN	IN	IN	PTMI					
6	OUT	IN	OUT	OUT	OUT	IN	IN	IN	IN	IN	IN	IN	IN	IN	IN
7	OUT	IN	OUT	IN	OUT	OUT	OUT	OUT	OUT	IN	OUT	OUT	OUT	OUT	U
8	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	OUT	U	U	U	U	U	U
9	IN	OUT	OUT	IN	IN	OUT	OUT	OUT	OUT	IN	PTMI				
10	IN	IN	OUT	OUT	OUT	OUT	OUT	OUT	OUT	IN	OUT	OUT	OUT	OUT	OUT
11	OUT	OUT	OUT	PTMO											
12	TMI														

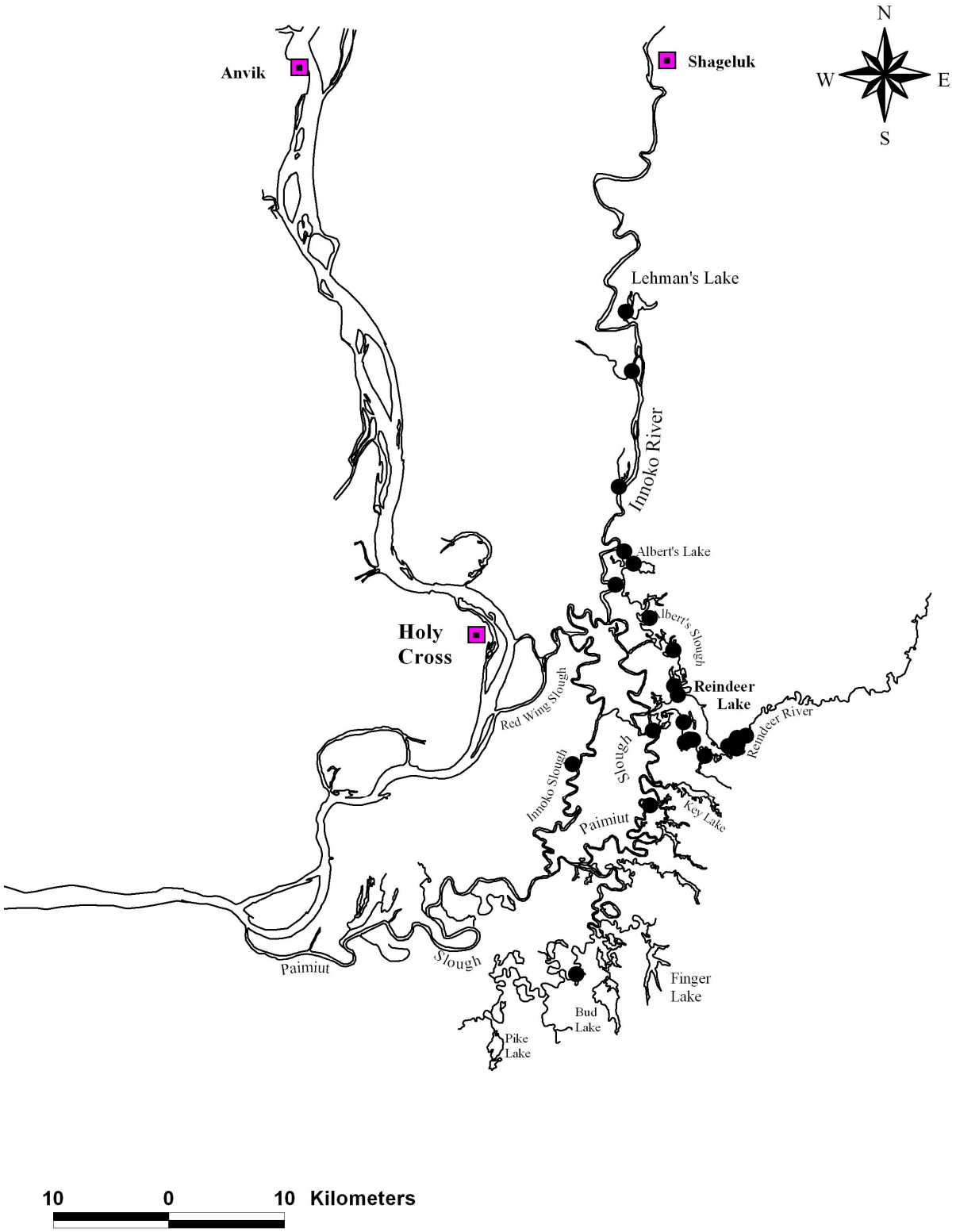
APPENDIX C
LOCATIONS OF RADIO-TAGGED NORTHERN PIKE IN THE LOWER INNOKO RIVER DRAINAGE



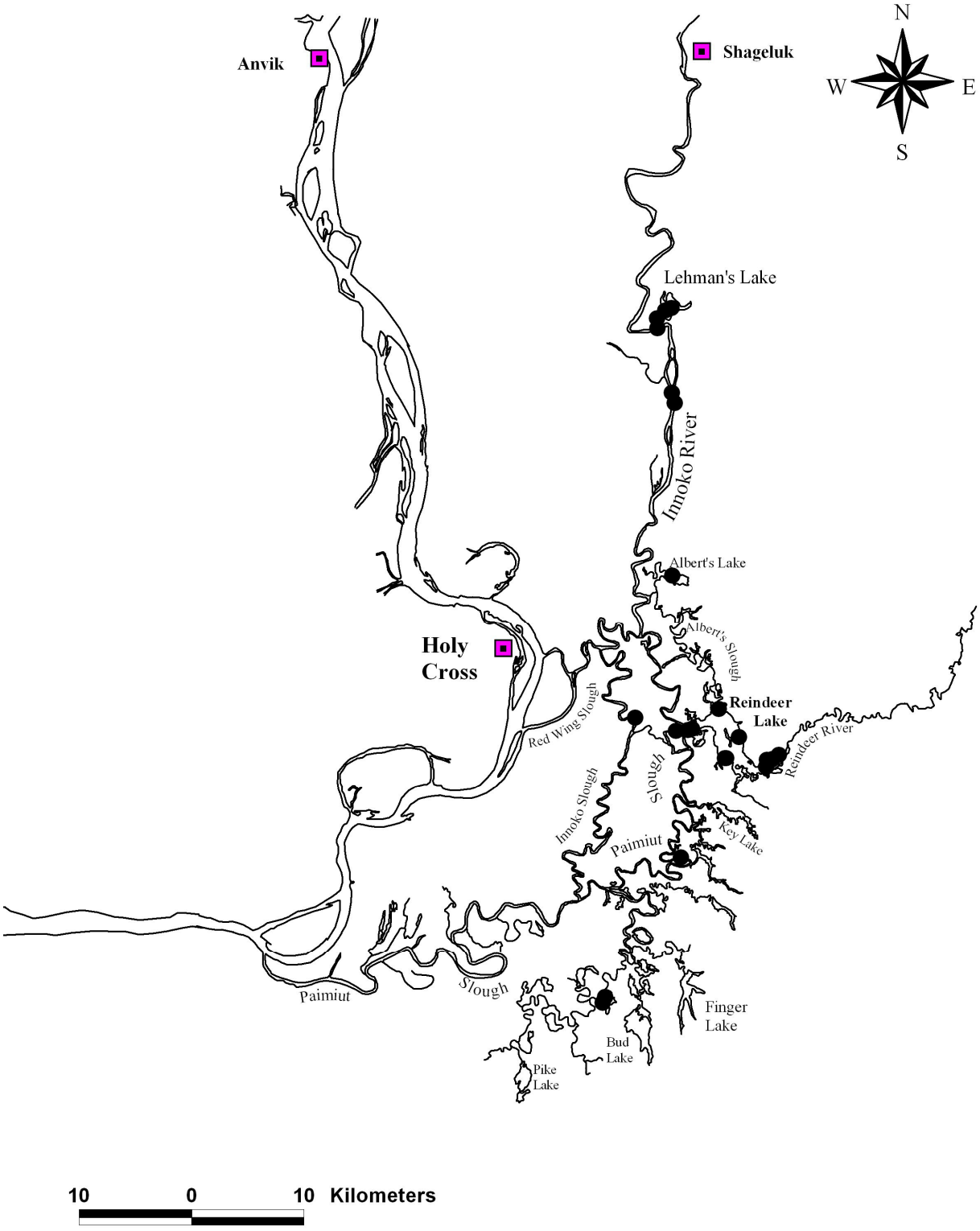
Appendix C1.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, July 1, 2002 (n = 43).



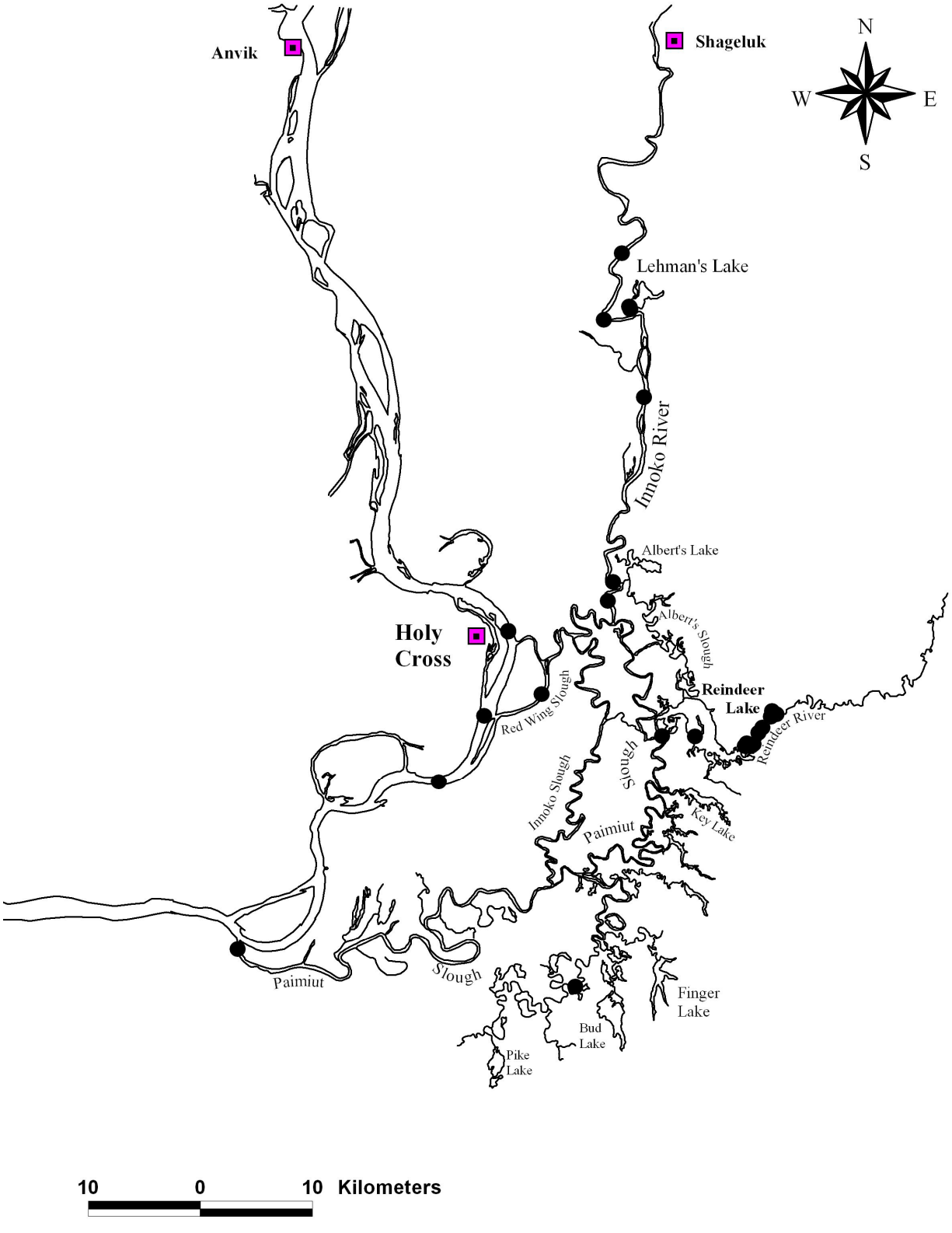
Appendix C2.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, July 31, 2002 (n = 43).



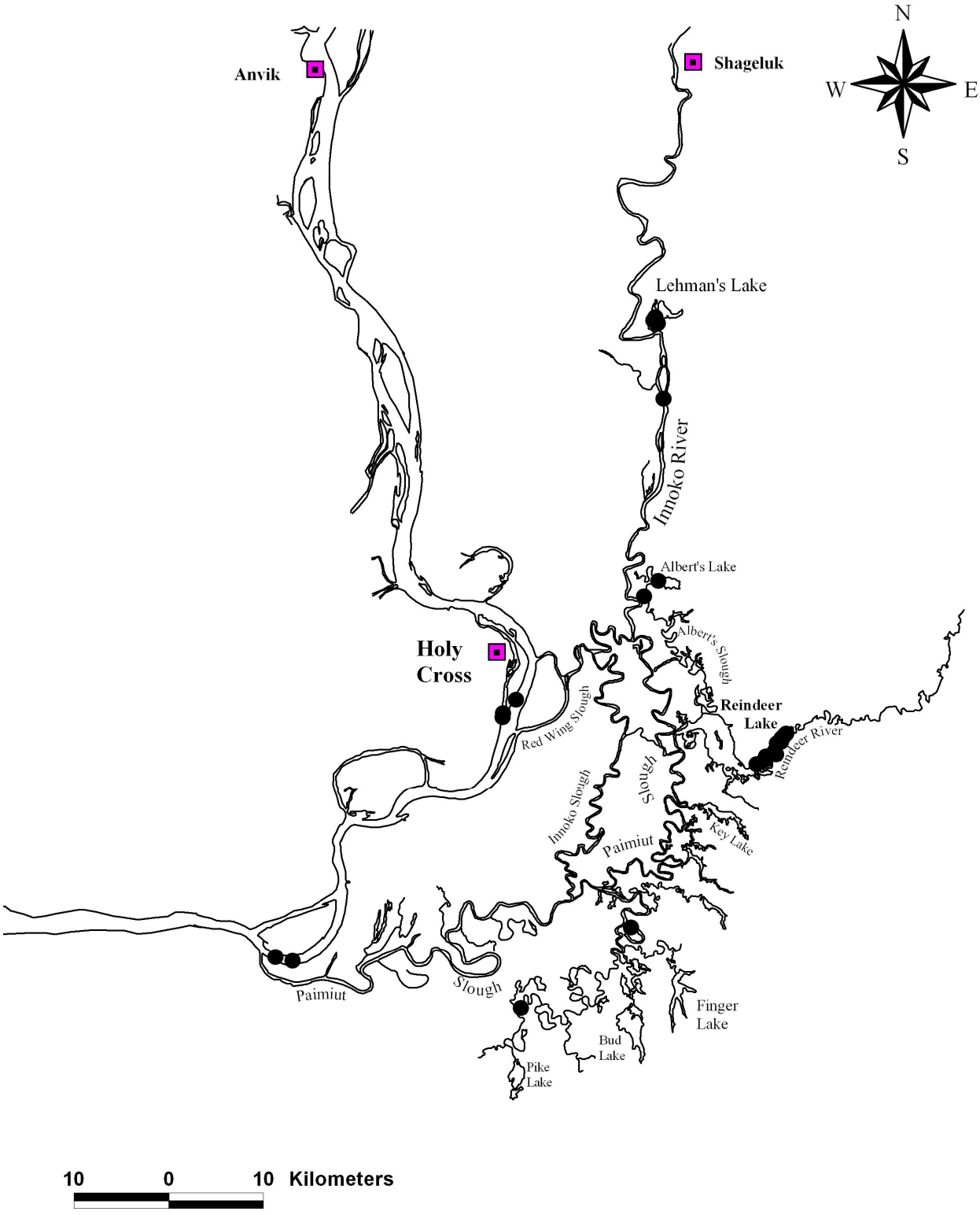
Appendix C3.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, August 27, 2002 (n = 42).



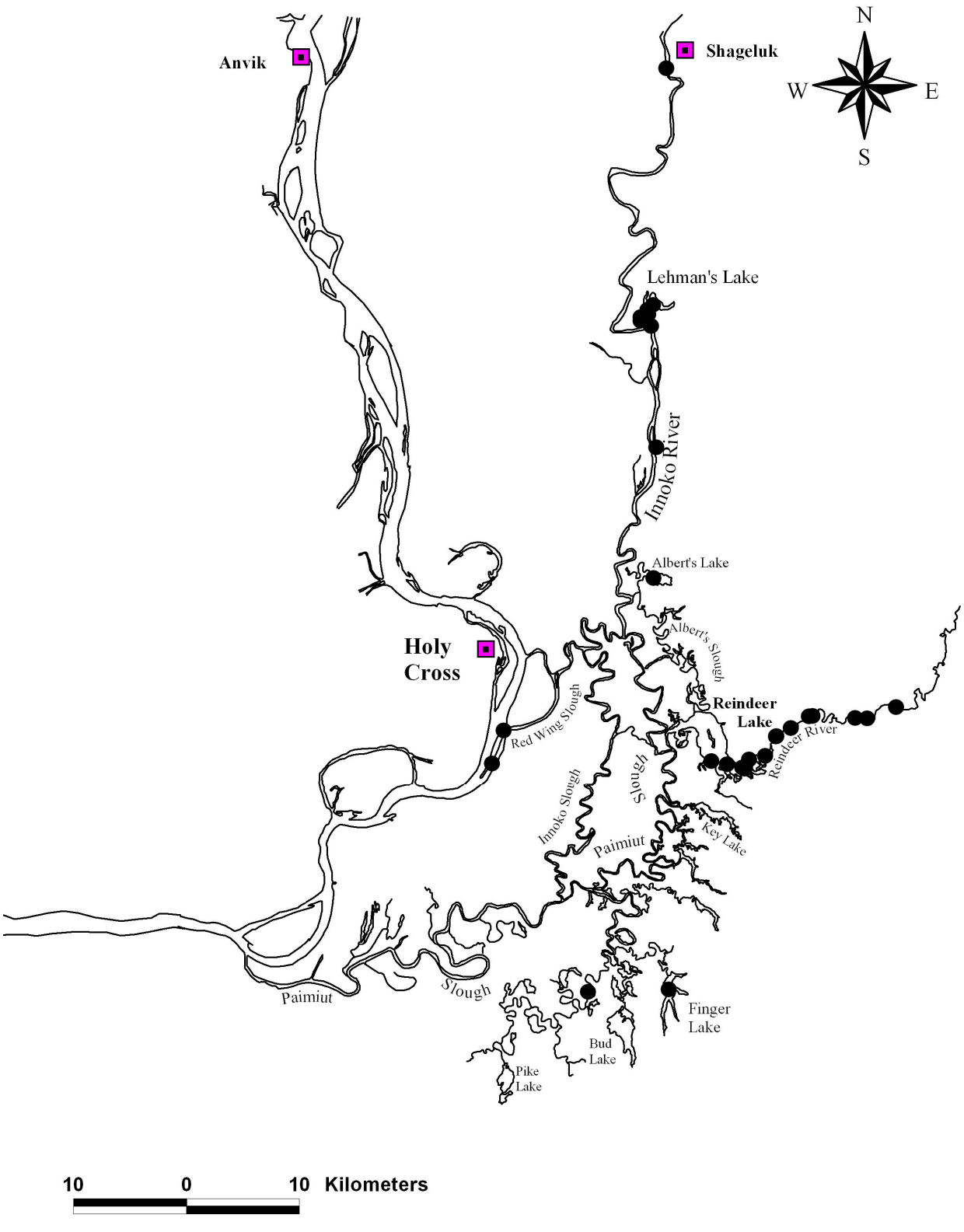
Appendix C4.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, October 15, 2002 (n = 41).



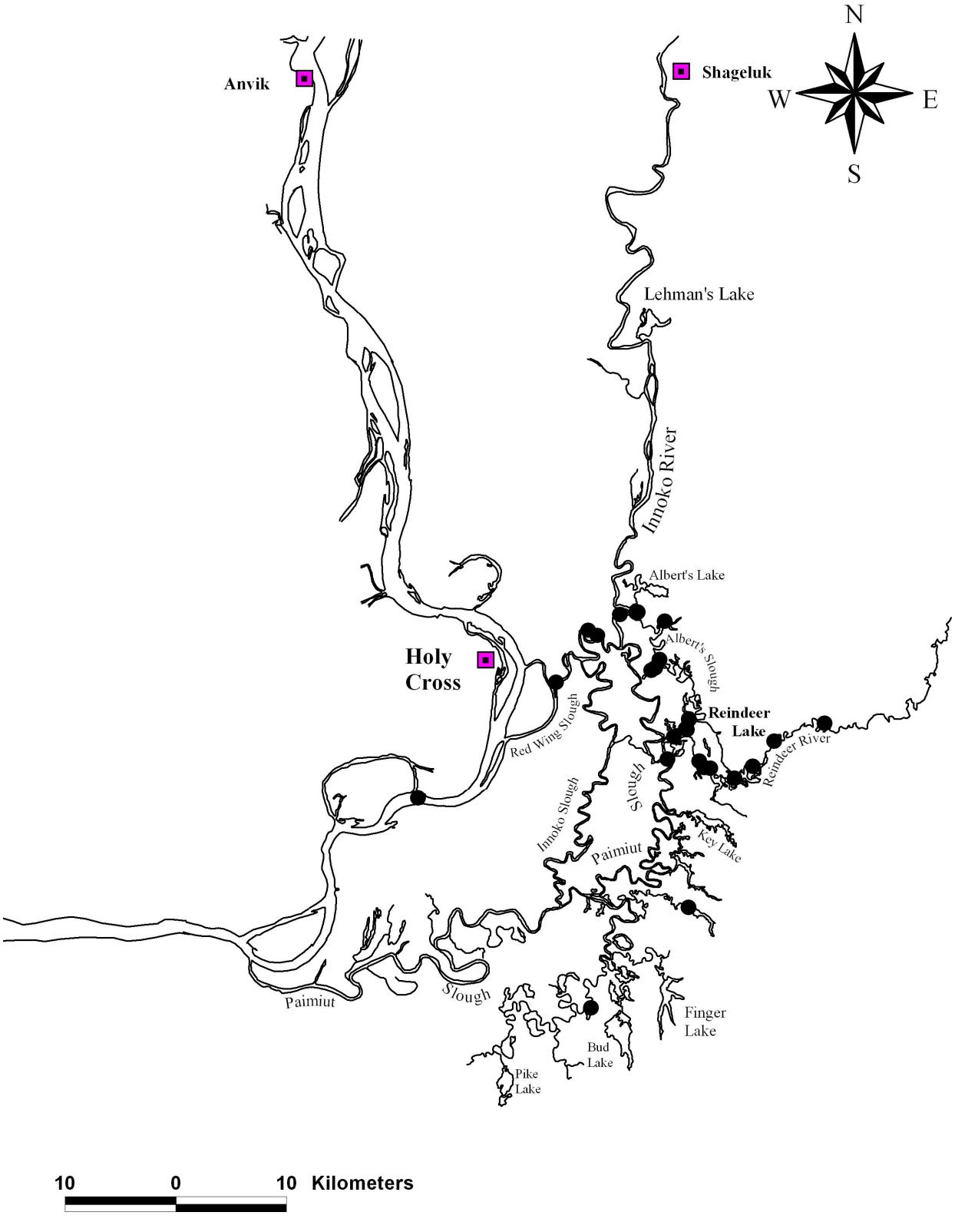
Appendix C5.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, November 7, 2002 (n = 40).



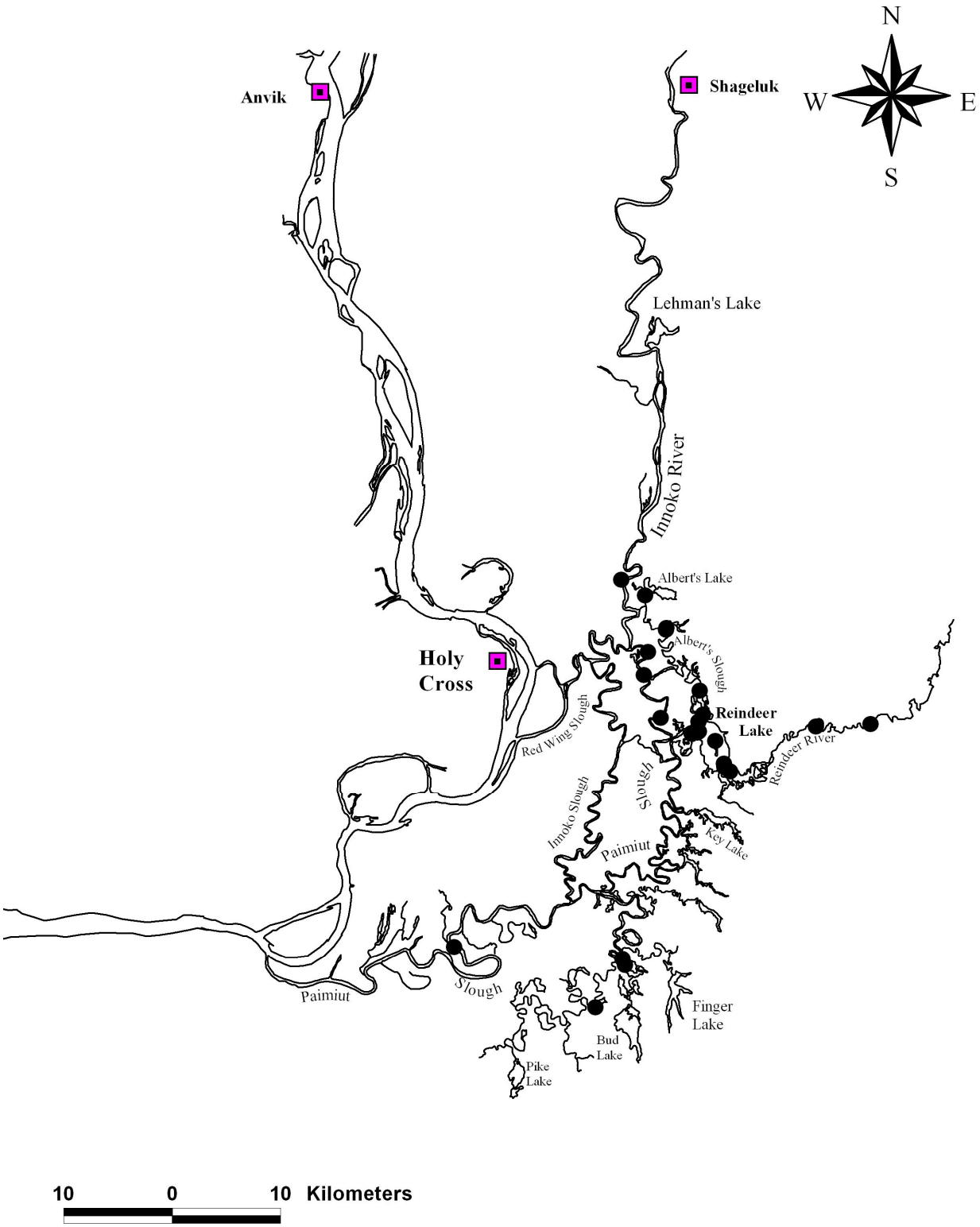
Appendix C6.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, January 30, 2003 (n = 40).



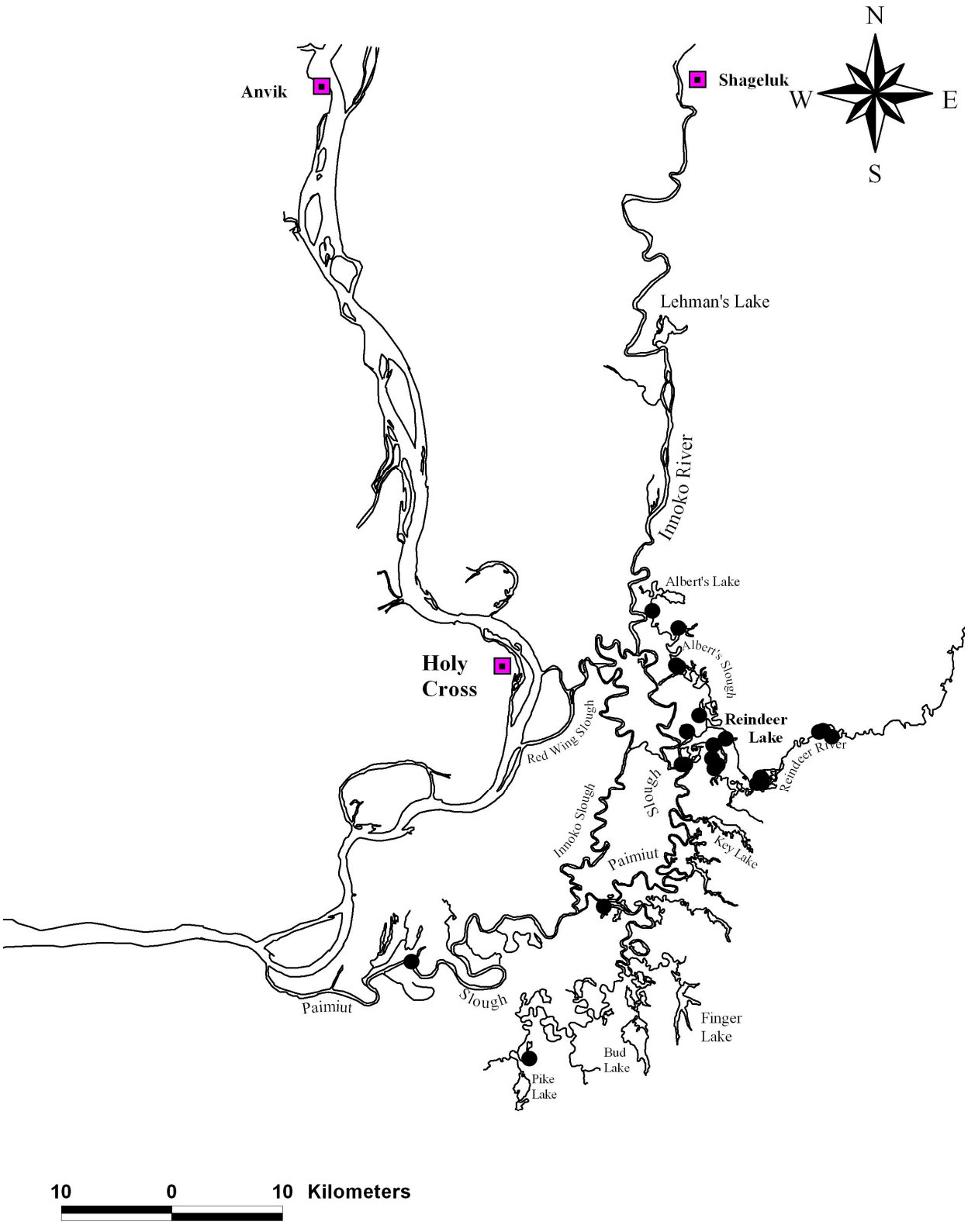
Appendix C7.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, March 29, 2003 (n = 39).



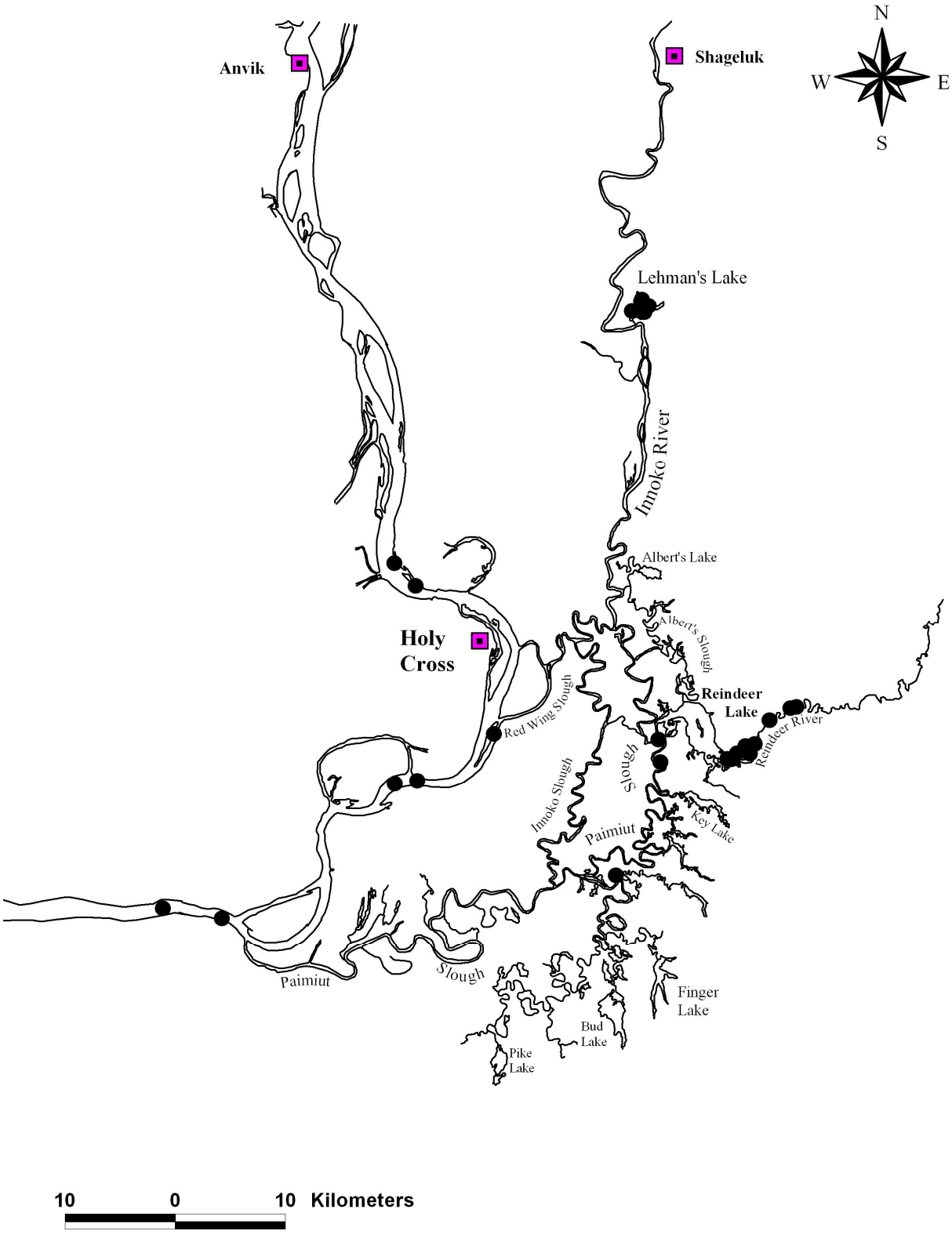
Appendix C8.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, May 13, 2003 (n = 37).



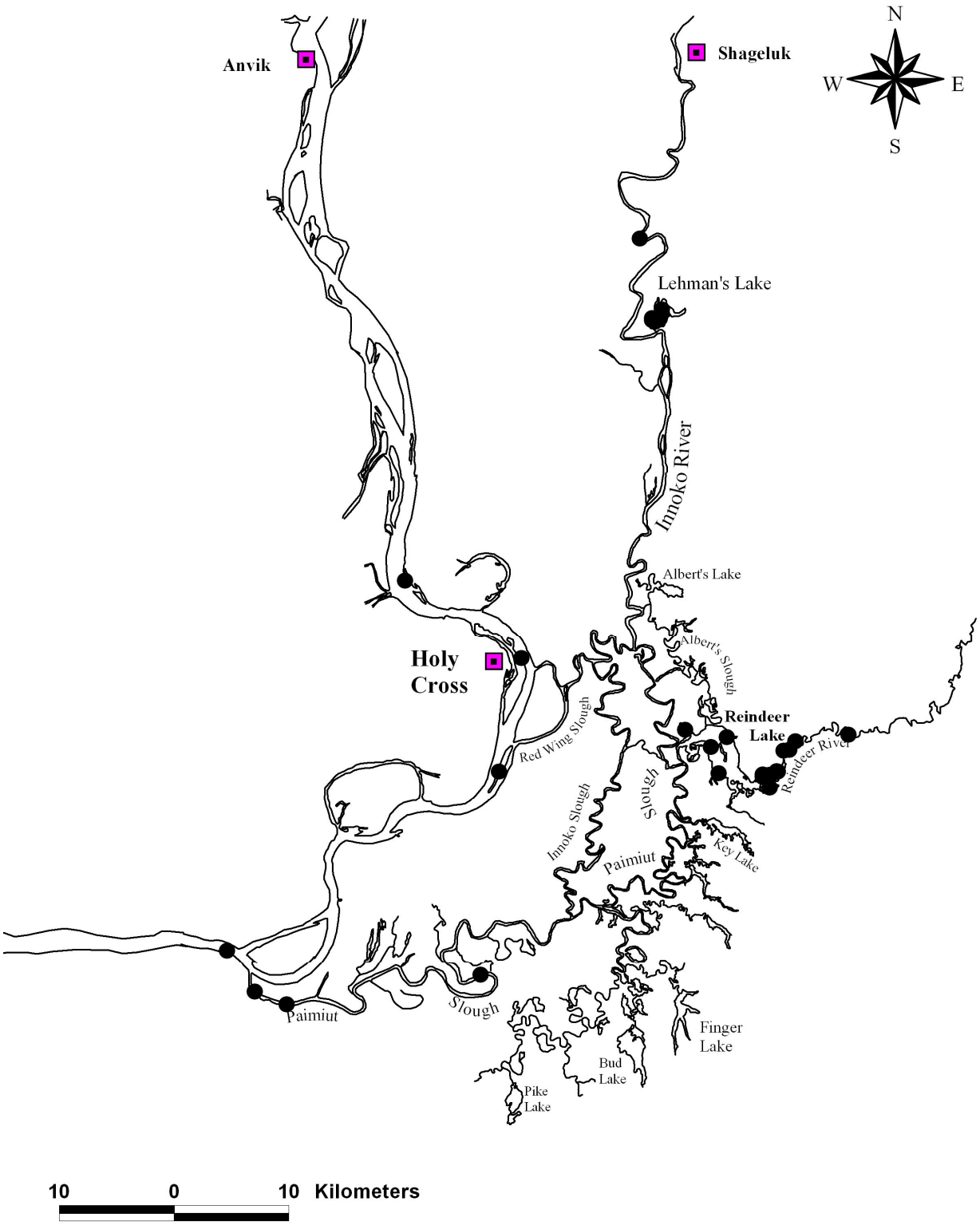
Appendix C9.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, May 29, 2003 (n = 37).



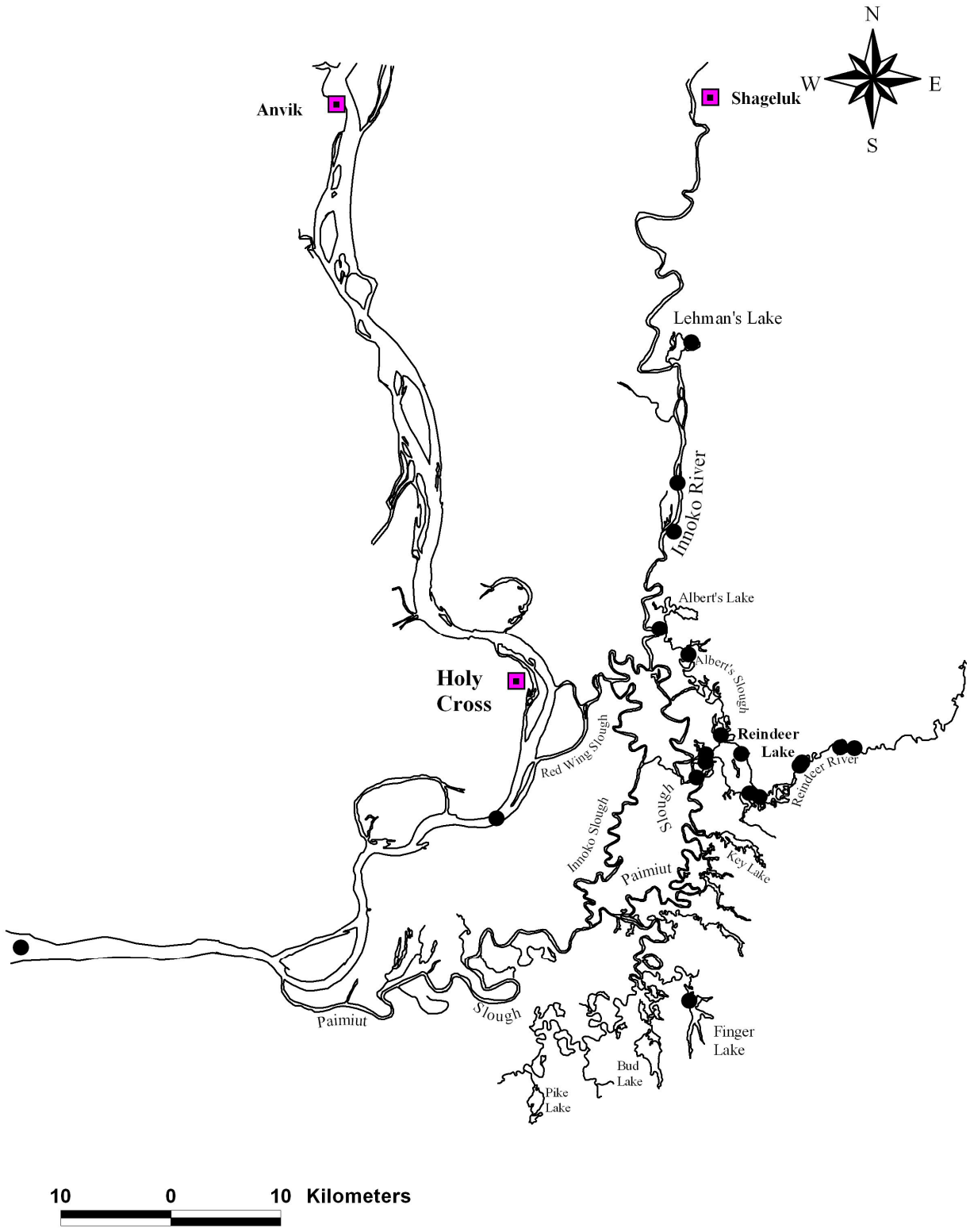
Appendix C10.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, July 31, 2003 (n = 36).



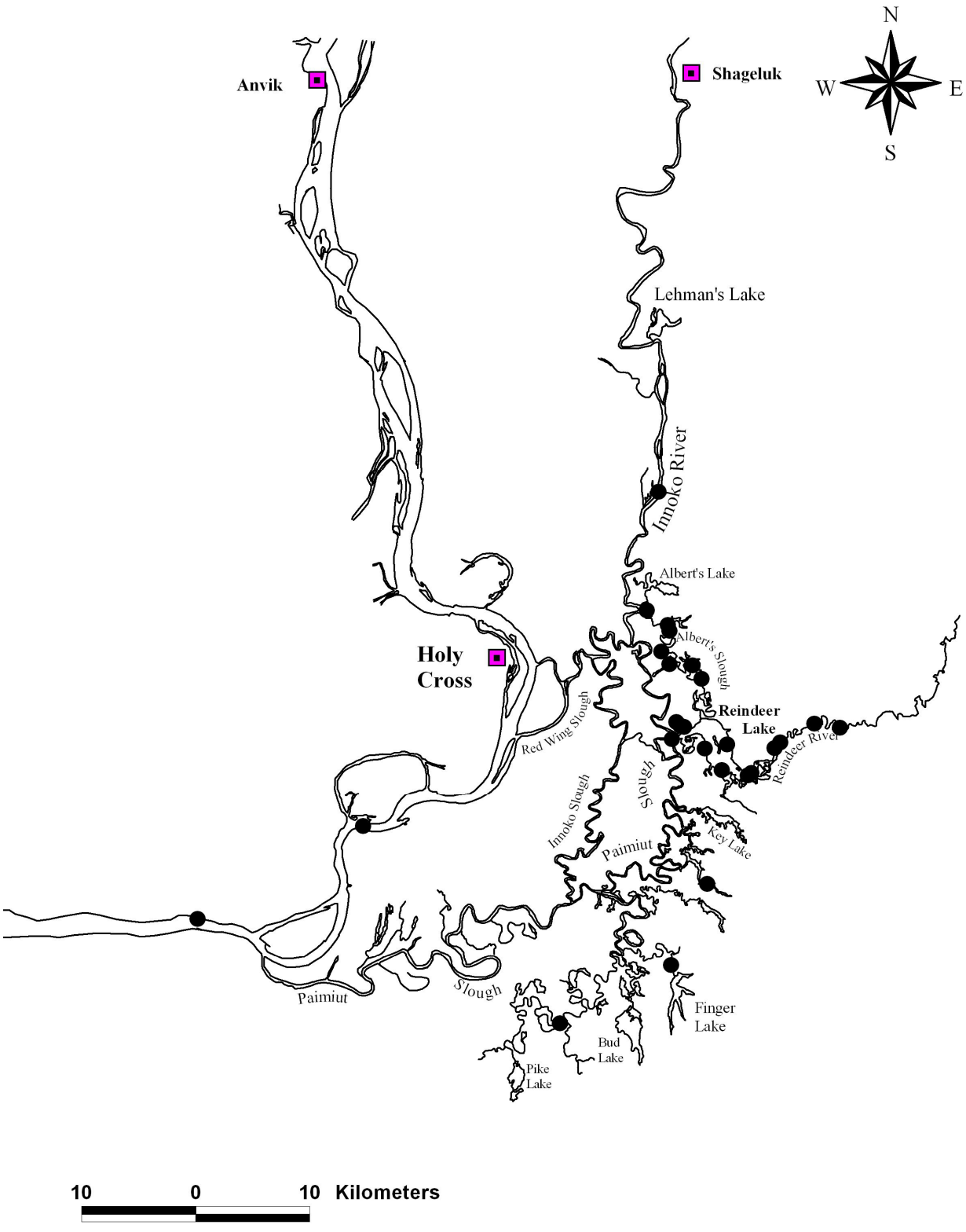
Appendix C11.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, March 10, 2004 (n = 33).



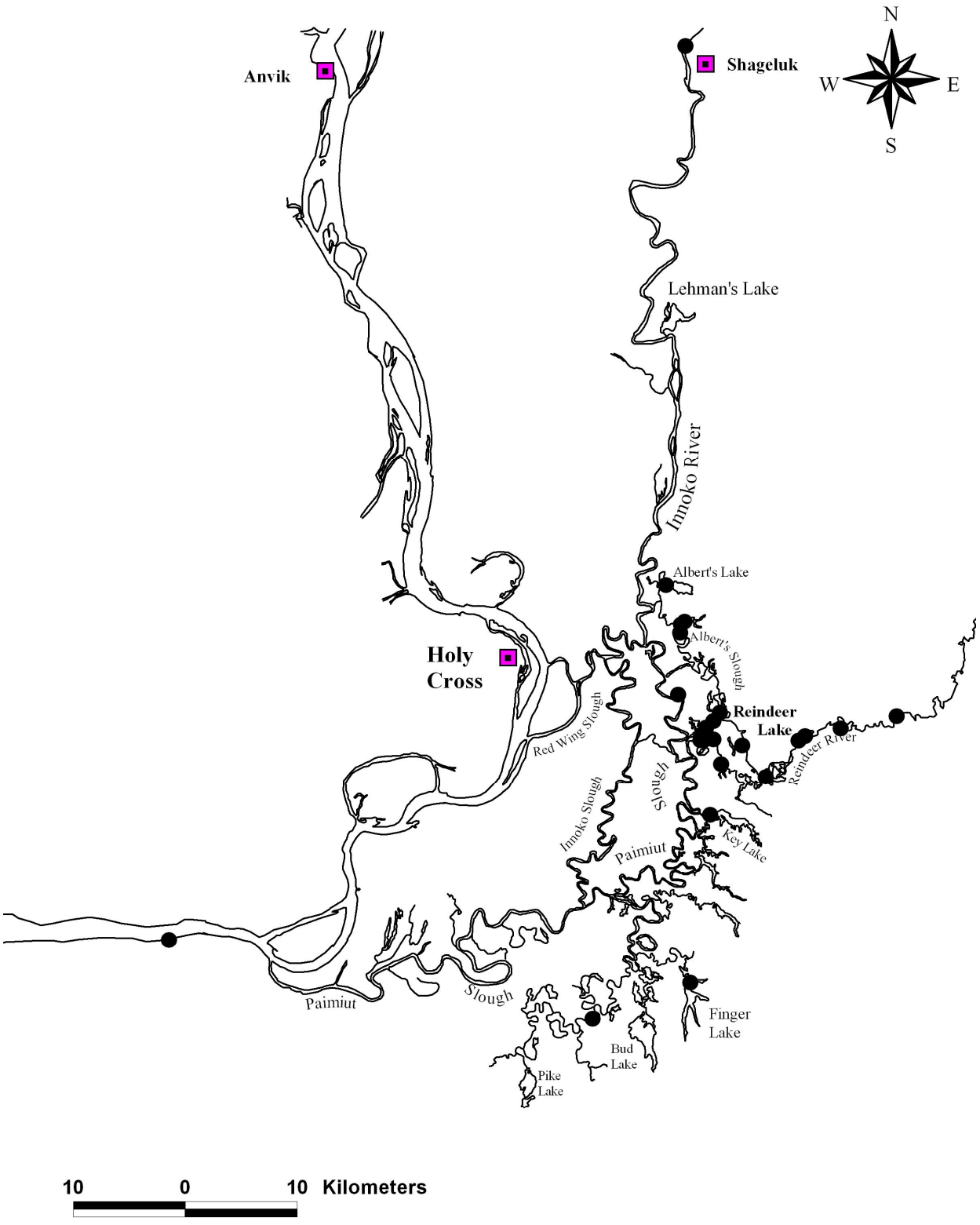
Appendix C12.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, March 22, 2004 (n = 32).



Appendix C13.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, April 29, 2004 (n = 31).



Appendix C14.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, May 10, 2004 (n = 28).



Appendix C15.–Locations of live radio-tagged northern pike in the Lower Innoko River drainage, May 29, 2004 (n = 25).