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Seasonal Migrations of Northern Pike in the Kaiyuh Flats, Innoko National Wildlife Refuge, Alaska

by

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and

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November 1996

Alaska Department of Fish and Game **Division of Sport Fish**

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
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
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
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

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	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
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.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
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
standard length	SL
total length	TL
variance	Var

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SEASONAL MIGRATIONS OF NORTHERN PIKE IN THE KAIYUH FLATS, INNOKO NATIONAL WILDLIFE REFUGE

by

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ABSTRACT

From July 1994 through July 1996, the Department of Fish and Game, Division of Sport Fish and the US Fish and Wildlife Service (USFWS), conducted a joint study to identify overwintering areas and estimate length and age compositions of the Kaiyuh Flats northern pike population. During July 9 - 29, 1994, 50 large (>750 mm FL) northern pike were implanted with radiotelemetry transmitters and 962 northern pike were sampled for length and age. From June 12 - 22, 1995, the USFWS sampled an additional 840 northern pike for length and age. Northern pike were captured using trap nets, hook and line, and gill nets. Ages of northern pike sampled in 1994 ranged from 2 to 14 years. Mean length of all northern pike sampled in 1994 was 666 mm. Ages of northern pike sampled in 1995 ranged from 1 to 17 years. Mean length of all northern pike sampled in 1995 was 618 mm. During winter 1994-95, 45 (90%) of the 50 radio-tagged fish were found to have survived and retained their transmitters and were located within three distinct overwintering areas (2 lake/channel habitats and 1 channel habitat). Sixteen (52%) of 31 fish tracked through winter 1995-96 were found to have survived and retained their transmitters into summer 1996, with an additional 6 fish perishing or expelling their tags within their overwintering area. Of the 22 fish confirmed to have survived and retained their transmitters during winter 1995-96, 16 (73%) returned to their 1994-95 overwintering area, suggesting a strong fidelity to winter areas for those fish. Northern pike left the overwintering areas for spawning areas beginning in early May and did not concentrate in any specific spawning areas.

Key words: Northern pike, *Esox lucius*, radiotelemetry, overwintering area, Kaiyuh Flats, length composition, age composition

INTRODUCTION

The northern unit of the Innoko National Wildlife Refuge lies southwest of Galena. It is bounded on the north and west by the Yukon River and along the southeast by the Kaiyuh Mountains. The external boundary of the unit encompasses approximately 304,000 ha (Anonymous 1993). The unit is an extensive floodplain consisting of water and wetlands known as the Kaiyuh Flats. The study area is located in the southwestern part of the unit and consists of approximately 75,000 ha. The myriad of lakes and sloughs in the Kaiyuh Flats study area are accessible to watercraft via Kaiyuh Slough and the Khotol River (Figure 1). After freeze up, overland trails provide access from the nearby villages. Kaltag, Nulato, Koyukuk, and Galena are located opposite of the refuge on the north bank of the Yukon River.

Current sport fishing regulations for northern pike *Esox lucius* in Kaiyuh Flats are 10 northern pike per day, 10 in possession, no size limit, and no closed seasons. No direct estimates of sport catch or harvest are available for this specific fishery. At least one commercial sport fish guiding operation has been targeting northern pike in Kaiyuh Flats in recent years and interest by another guiding operation to participate in this fishery has been expressed.

In addition, a subsistence fishery for northern pike in Kaiyuh Flats by residents of the nearby communities (Kaltag, Nulato, Koyukuk, and Galena) occurs. This fishery is currently unregulated and there are no subsistence harvest reporting requirements. No estimates of harvest for this subsistence fishery are available. Previous to this study, the Department of Fish and Game had not conducted any studies concerning northern pike in Kaiyuh Flats. However, two separate studies have been conducted within the Kaiyuh Flats on heavy metal concentrations in adult northern pike (< 200 fish) (Mueller et al. 1995; Headlee 1996).

Concern by the USFWS over potential increased sport fishing effort on previously unstudied northern pike populations of the Innoko National Wildlife Refuge and lack of base population data prompted the development of a cooperative study between the Department of Fish and

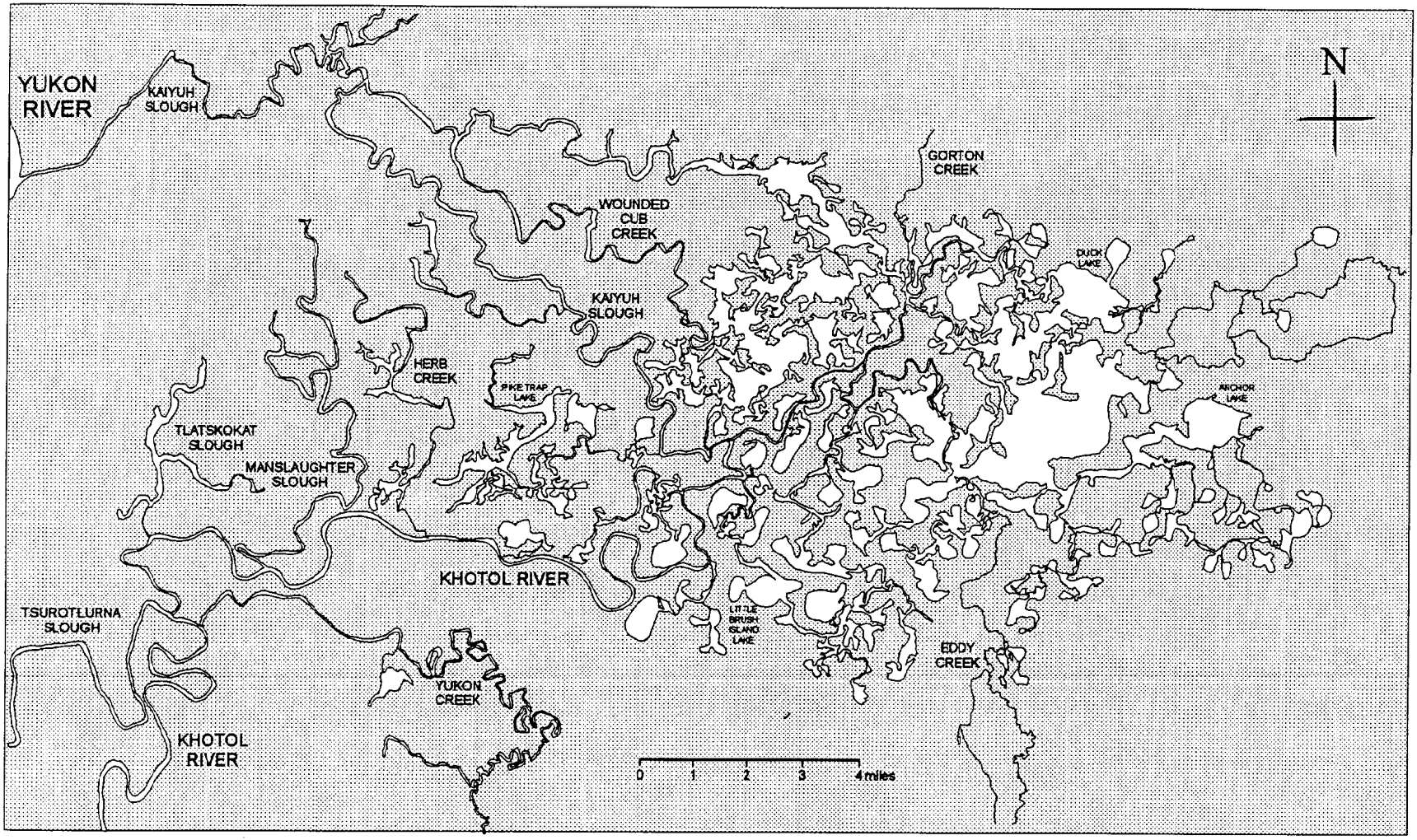

Figure 1.-Map of the Kaiyuh Flats northern pike study area.

Game, Division of Sport Fish, and the USFWS. The goal of this project was to provide information on the seasonal distributions and movements of northern pike in the Kaiyuh Flats, especially to identify up to nine overwintering areas for northern pike radio-tagged in Kaiyuh Flats.

METHODS

RADIOTELEMETRY

Overwintering locations of northern pike captured in Kaiyuh Flats were determined by radiotelemetry. Fifty northern pike were surgically implanted with radio tags (LOTEK FRT-2) during hook and line composition sampling in July 1994. Each transmitter frequency was unique, permitting recognition of individual fish. Northern pike that were selected for implantation of radio tags were anesthetized in a solution of tricane methanosulfate (MS-222) and water, approximately 100 mg/L. A fish was considered ready for surgery when a slight loss of equilibrium was reached (stage 3 anesthesia; Summerfelt and Smith 1990). The fish was then placed ventral side up in a foam-lined trough and a 12-18 mm incision was made posterior to the pelvic girdle, just large enough for the radio tag to be inserted into the peritoneal cavity. The outlet incision for the trailing antennae was approximately 3 cm posterior to the radio tag incision. Three to five absorbable sutures (3-0 PDS II) and Vetbond adhesive were used to close the radio tag incision. After the surgery, fish were placed into a holding tank (114 L) of fresh water and allowed to recover. Fish were released once they regained equilibrium. This procedure is similar to that described by Hart and Summerfelt (1975), with the exception that the incision for insertion of the radio tag was posterior of the pelvic girdle, due to the large size of northern pike selected for implantation. Large (> 750 mm), healthy northern pike were selected for implantation of radio tags to insure a high level of survival. A healthy northern pike was one that was free of lesions, abrasions, fungus, and external parasites, and had no fin and mouth damage. It was believed that fish > 750 mm would minimize the behavioral changes associated with radio tag implantation, due to the lower radio tag to body size ratio. Mean length and weight of radio-tagged northern pike was 901 mm and 5,849 g (range: 750-1,160 mm; 3,100-12,200 g). Only one northern pike died after implantation of a radio tag; the carcass was recovered, the tag was removed, and implanted into another northern pike.

Surveys were conducted in a fixed wing aircraft equipped with dual H-antennae, one mounted on each wing strut. The survey began at a altitude of 300 m until a signal was received and located; the altitude was then reduced to approximately 100 m to better pinpoint the signal origin. Physical locations of each transmitter were plotted onto USGS topographic maps (1:63,360). Latitude and longitude using a Global Positioning System (GPS) were recorded and used later to truth visual locations.

Movements of radio-tagged northern pike were monitored by 16 aerial surveys during 1994-96 (Table 1). Summer (June - August), overwintering (December - March), and spawning (May) areas were documented by locating fish within each of these periods. Summer locations were used to determine radio-tagged fish survival and tag retention during each winter by documenting significant movements into and out of the overwintering areas. Based on the relocation error observed during this study and others (Lubinski 1995), significant movements were determined to be those greater than 1.6 km (straight line distance between locations). Movements of this length were considered to be due to fish movement and not relocation error. A radio-tagged northern pike was considered dead or to have expelled the tag when: 1) it did not move greater than 1.6 km from a specific location for at least three

Table 1.-Summary of aerial surveys for radio-tagged northern pike conducted over Kaiyuh Flats, 1994-96.

Flight number	Date	Number of fish alive at time of flight	Number of fish located[a]	Percent located	Days since last flight
1	7/27-7/28/94	49	36 (36)	73	-
2	8/9-8/10/94	49	47 (48)	96	14
3	9/1-9/2/94	48	48 (50)	100	24
4	10/12-10/13/94	47	47 (50)	100	42
5	12/20/94	45	45 (50)	100	69
6	1/31/95	45	43 (48)	96	42
7	3/28/95	45	45 (50)	100	56
8	5/1-5/2/95	45	44 (49)	98	35
9	5/8/95	44	32 (38)	73	6
10	5/15/95	43	38 (44)	91	7
11	5/22/95	40	30 (40)	75	7
12	6/13/95	38	24 (32)	63	22
13	12/13/95	31	20 (34)	65	183
14	3/27-3/29/96	25	23 (45)	92	106
15	6/25-7/2/96	18	17 (38)	94	93
16	7/25/96	17	8 (21)	47	28

[a] The number in parentheses includes tags associated with fish, later determined to have died or expelled their tags, located during the flight.

flights or two seasons (summer - winter, winter - summer); or 2) the expelled tag or carcass was located during ground sampling. The time of death was then associated to the flight (and date) following the last movement greater than 1.6 km in length. Only those overwintering fish determined to have survived and retained their transmitters into the winter or following summer were used to document locations of winter areas and fidelity to winter area. Locations of radio-tagged northern pike at the time of each survey are shown in Appendix A.

LENGTH AND AGE COMPOSITIONS

Sampling was conducted from July 9-29, 1994 and June 12-22, 1995. During sampling in July 1995, as many of the radio-tagged and Floy tagged fish as possible were located and captured to determine condition of northern pike implanted with radio tags. Trap nets and hook and line sampling were the primary sampling methods during both events. Only three sets were made with variable mesh (25, 38, 51 mm) gillnets in 1994; poor fish condition due to warm water temperatures prevented further use. Two to six trap nets per day were set (40 sets total) from July 11-20, 1994. Only two sets were made with gillnets in 1995. One to five trap nets per day were set (29 sets total) from June 13-21, 1995.

Trap nets were set across the mouth of sloughs and consisted of two hoop traps connected by a 30.5 m x 1.2 m lead and a 15.2 m x 1.2 m lead on both traps extending from the trap to shore. Hoop

traps were set in opposing directions to capture fish moving in and out of the sloughs. Each trap was stretched and anchored with a weight or staked at the cod end of the trap. Hoop traps were 3.66 m in length tapering from 0.91 m at the entrance to 0.69 m at the cod end. Each trap was double throated (tied to the second and fourth hoop) with throats narrowing to an opening 36 cm in diameter. All netting material was knotted nylon with 25 mm bar mesh. Traps were checked for fish at least once per day. Location of the hoop traps and sites of capture by hook and line were recorded on USGS 1: 63,360 maps. Latitude and longitude of the capture/release sites were taken by GPS and recorded into a field notebook. Trap, gillnet, and angling location, length, sex, weight, and tag data were recorded on Tagging Length Version 1.0 mark-sense forms. All northern pike captured were examined for Floy tags and measured to the nearest millimeter of fork length. Untagged northern pike judged to be in healthy condition were released after being marked with an individually numbered Floy FD-67 internal anchor tag inserted at the left base of the dorsal fin so that the tag locked between the posterior interneural rays. The sex of live fish was not determined, however sex of fish that died during capture or handling was determined by internal examination.

Scales were taken from all northern pike captured and mounted directly onto gum cards. A minimum of two scales were taken from the preferred zone adjacent to, but not on the lateral line, above the pelvic fins as described by Williams (1955). Scale impressions were made on 20 mil acetate sheets using a Carver press at 241,315 kPa (35,000 psi) heated to 135° C for 135 s. Scales were read on a Micron 770 microfiche reader (40X) and ages were recorded in accordance with annulus determination criteria established by Williams (1955) and Casselman (1967). In addition to these guidelines the following methods were also used: 1) the scale for each fish was colored with a dry erase marker, to assist in annulus identification; 2) all scales were examined at the high magnification of a Micron 770 microfiche reader (17 mm objective); and 3) growth beyond the last annulus was considered "plus" growth and not considered an additional year.

Scales were aged by a different reader in 1995 than in 1994. Scales aged in 1994 were aged three times and the modal age was reported. Scales aged in 1995 were aged once.

RESULTS

RADIOTELEMETRY

Fish Survival and Transmitter Retention

Only two of the 50 radio-tagged northern pike died or expelled its transmitter during the summer 1994 (Table 2). Of the remaining 48 fish, 45 (94%) were found to have survived and retained their transmitters through winter 1994-95 (their first winter with transmitters). During spring and summer 1995, 14 fish (spring n=8; summer n=6) had either perished or expelled their transmitters. Of the 30 fish determined to have survived and retained their transmitters into winter 1995-96 and the one fish of undetermined status, 16 (52%) were confirmed to have successfully overwintered and retained their transmitters. Mortality of radio tagged northern pike from July 1994 to July 1995 was 10%, from October 1994 to December 1995 was 35%, and from June 1995 to June 1996 was 55%.

Winter Habitat

The 45 radio-tagged northern pike found to have survived and retained their transmitters through winter 1994-95 were located within three core areas (North Lakes, South Lakes, Khotol River)

Table 2.-Status of northern pike radio-tagged July 1994 within the Kaiyuh Flats, Innoko National Wildlife Refuge, Alaska.

	Habitat Transition			
	Summer 1994 to Winter 1994-95	Winter 1994-95 to Summer 1995	Summer 1995 to Winter 1995-96	Winter 1995-96 to Summer 1996
Alive and with Transmitter[a]	48	45	30	16
Stationary[b]	2	3	14	13
Undetermined[c]	0	0	1	2
Total	50	48	45	31

[a] Fish in this category are those fish which have made a significant movement ($\geq$ 1.6 km); 1) into or out of their overwintering area, or 2) during or between subsequent seasons.

[b] Stationary fish moved < 1.6 km during and between the seasons, as well as subsequent seasons, and are considered to have died or expelled their transmitter.

[c] These fish had not been located within at least one of the two seasons.

(Table 3, Figure 2). Radio-tagged northern pike were located at the overwintering areas by mid-October and there was no movement into or out of the areas after mid-December. Two of the three overwintering areas are lakes with a major channel running through them and the third is the Khotol River itself. Fish in North and South Lakes were closely associated with the lacustrine habitat, but showed a distinct shift towards the channel within the lakes by late March 1995. Following are descriptions of the three overwintering areas during the winter of 1994-95. North Lakes is located in the northeastern portion of the study area, east of Gorton Creek and northeast of Eddy Creek. The majority of northern pike overwintered in Duck Lake. South Lakes is located in the southcentral portion of the study area, west of Eddy Creek and southeast of the Khotol River The majority of northern pike overwintered in Little Brush Island Lake. Khotol River covers the southwestern quarter of the study area and includes the Khotol River downstream of the confluence of Kaiyuh Slough to approximately 16 km below the confluence of Yukon Creek. Khotol River fish were scattered throughout a 16 km reach. However, 11 (69%) of 16 Khotol River fish were located within 3 km of Manslaughter Slough by late March 1995.

Table 3.-Number (percent) and overwintering location of northern pike surviving through winter 1994-95.

Overwintering Area	Number of Radio-Tagged Northern Pike
North Lakes	9 (20%)
South Lakes	20 (44%)
Khotol River	16 (36%)
Total	45 (100%)

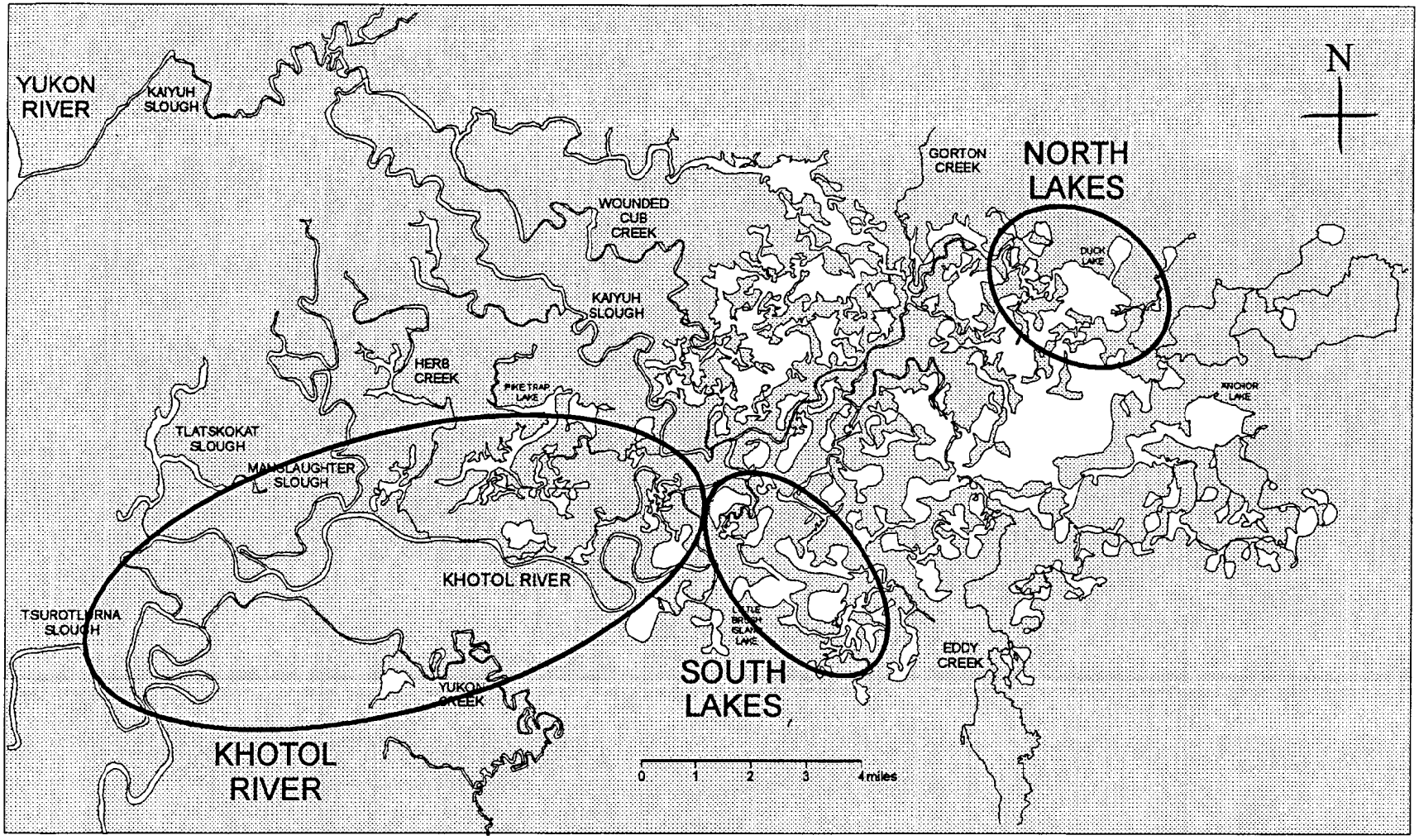

Figure 2.-Map of the three overwintering locations for radio-tagged northern pike at Kaiyuh Flats.

On March 29, 1995, USFWS personnel located 11 radio-tagged northern pike in the South Lake overwintering area by ground tracking. An attempt was made to observe these fish under the ice using a periscope and underwater video camera. No fish were observed, but hookless lures were fished for approximately 1 h resulting in numerous strikes. Habitat measurements were taken in areas directly over radio-tagged fish locations. Approximately 1 m of ice covered these areas with water depths of 0.3 to 0.75 m (n = 12) in the outlet and 0.3 m (n = 1) in the lake itself. The outlet area had a flat, mud bottom with no vegetation or structure visible. Water velocity within the channel was estimated at 0.5 m/s, water clarity was excellent, and numerous invertebrate larva and adults were observed.

Movement out of the overwintering areas began in late March or April, particularly out of the North Lakes and Khotol River areas. By mid-May nearly all radio-tagged northern pike had left the overwintering areas and dispersed throughout the Kaiyuh Flats. Northern pike did not concentrate in any specific area during spawning. Suitable spawning habitat in the Kaiyuh Flats is widespread and is likely the reason for no centralized spawning areas. During the spawning period radio-tagged northern pike were found in areas previously unused in prior flights. These included the area surrounding Pike Trap Lake between Herb Creek and Kaiyuh Slough, and the area of lakes north of the Khotol River and east of Kaiyuh Slough.

Sampling in June 1995 determined that at least three of the radio-tagged northern pike had died or expelled the radio-tags. A log jam blocked access to the South Lakes overwintering area and most sampling effort was directed at fish located in an area bounded to the north by Gorton Creek, the east by Anchor Lake, the south by a line from the confluence of Kaiyuh Slough and the Khotol River to Anchor Lake and the west the upper Khotol River. Three additional radio-tagged fish that were not located during the June 13 flight, were located by ground surveys conducted during sampling. Fourteen radio-tagged northern pike were located by ground surveys, five of these were recaptured by hook and line and one that had died was recovered along the windward side of a small lake. Radio-tagged northern pike were frequently found along shallow shorelines in a lethargic state and were reluctant to take a lure. Eleven northern pike tagged with Floy tags and five fish radio-tagged in July 1994 were recaptured by trap net or hook and line during June 1995 sampling. Comparisons of data collected on fish captured in both sampling years are shown in Appendix B.

Twenty-two fish were determined to be alive during the first survey of winter 1995-96 (December 13, 1995), six of these died or expelled their transmitters by the survey of March 27-29, 1996. Based upon the results of the 1994-95 surveys it was assumed that northern pike alive in December would be at the overwintering areas. Of the 22 fish that had survived to migrate to the overwintering areas, four (18%) were located within the North Lakes overwintering area, six (27%) within the South Lakes, and 12 (55%) within the Khotol River. Sixteen of the 22 (73%) northern pike returned to the same area as in winter 1994-95. The six fish which did not demonstrate winter area fidelity during winter 1995-96 had overwintered in the South Lakes area during winter 1994-95. Of these, five overwintered in the Khotol River area and one in the North Lakes area during winter 1995-96.

Fidelity to summer areas was not as strong as fidelity to winter areas. Of those fish which were alive into winter 1995-96, 48% were found to occupy the same area in both summer 1994 and 1995. Of those fish which survived into summer 1996, 24% occupied the same area in summer 1994, 1995, and 1996, while 47% of those fish surviving into summer 1996 were found near their 1994 capture sites.

Of 962 northern pike captured in July 1994 using trap nets, hook and line, and gill nets, lengths were obtained from 961 and age determined from 926. Trap nets and hook and line captured 49% each, and the remaining 2% were captured in gill nets. There was a significant difference in the length distribution of fish captured by hook and line versus trap net ($D = 0.255$; $P < 0.001$). Northern pike captured by hook and line (704 mm) were larger on average than northern pike captured in trap nets (624 mm)($t = -8.196$; $P < 0.001$). Estimated ages of northern pike captured ranged from age 2 to age 14. The sex of only 32 northern pike (19 female, 13 male) in 1994 was determined through internal examination.

Of 840 northern pike captured in June 1995 using trap nets, hook and line, and gill nets, lengths were obtained from 838 and age determined from 718. Trap nets captured 78%, while hook and line, and gillnets captured 20% and 3%, respectively. Length distribution of captured northern pike by gear type and year is presented in Figure 3. As in 1994, there was a significant difference in length distribution of fish captured by hook and line versus trap net ($D = 0.322$; $P < 0.001$). Northern pike captured on hook and line (710 mm) were again larger on average than northern pike captured in trap nets (590 mm)($t = -8.806$; $P < 0.001$). Estimated ages of northern pike captured ranged from age 1 to age 17. The sex of only 36 northern pike (23 female, 13 male) in 1995 was determined through internal examination.

DISCUSSION

Movement out of the study area may be partially responsible for some of the radio-tagged northern pike not being located during a survey. The Khotol River and Kaiyuh Slough provide access to the Yukon River and passage to other northern pike habitat. It could be possible for mixing to occur between Yukon River northern pike populations, but without a large scale tagging study and/or genetic sampling this cannot be determined. Other factors that would prevent radio-tagged pike from being located during flights would include weak transmitter signals, due to fish location and/or a weak battery. Towards the end of the study, transmitter failure due to the end of battery life (two year battery), would result in the fish not being located. Aircraft problems and conflicting aircraft schedules were primarily responsible for less than 50% of the radio-tagged northern pike being located during the last flight.

Burkholder and Bernard (1994) reported radio-tagged northern pike in Minto Flats during 1987-88 overwintered in the same areas reported by Hallberg (1984) for radio-tagged northern pike in 1982-83. Since 73% of radio-tagged northern pike returned to the same overwintering areas, it would appear that northern pike in the Kaiyuh Flats are loyal to overwintering areas. Unless ground-truthing is conducted and a tagged fish is captured, the only method to determine if a fish is alive from one time to another is by movement. Thus, a radio-tagged fish may have moved into an area between June 13 and December 13, died, and would appear to be overwintering in that area. One factor encouraging fidelity to overwintering areas in Kaiyuh Flats may be dissolved oxygen levels. Casselman (1978) determined that northern pike can detect and avoid low oxygen concentrations in lakes. The South and North lakes overwintering areas likely have higher dissolved oxygen levels than other lake areas in the Kaiyuh Flats. In addition to high dissolved oxygen levels other factors such as water level and food concentration may dictate which sites are utilized in a given year.

During field sampling in March 1995, habitat measurements were taken in areas directly over radio-tagged fish locations in the South Lake area. Approximately 1 m of ice covered these areas

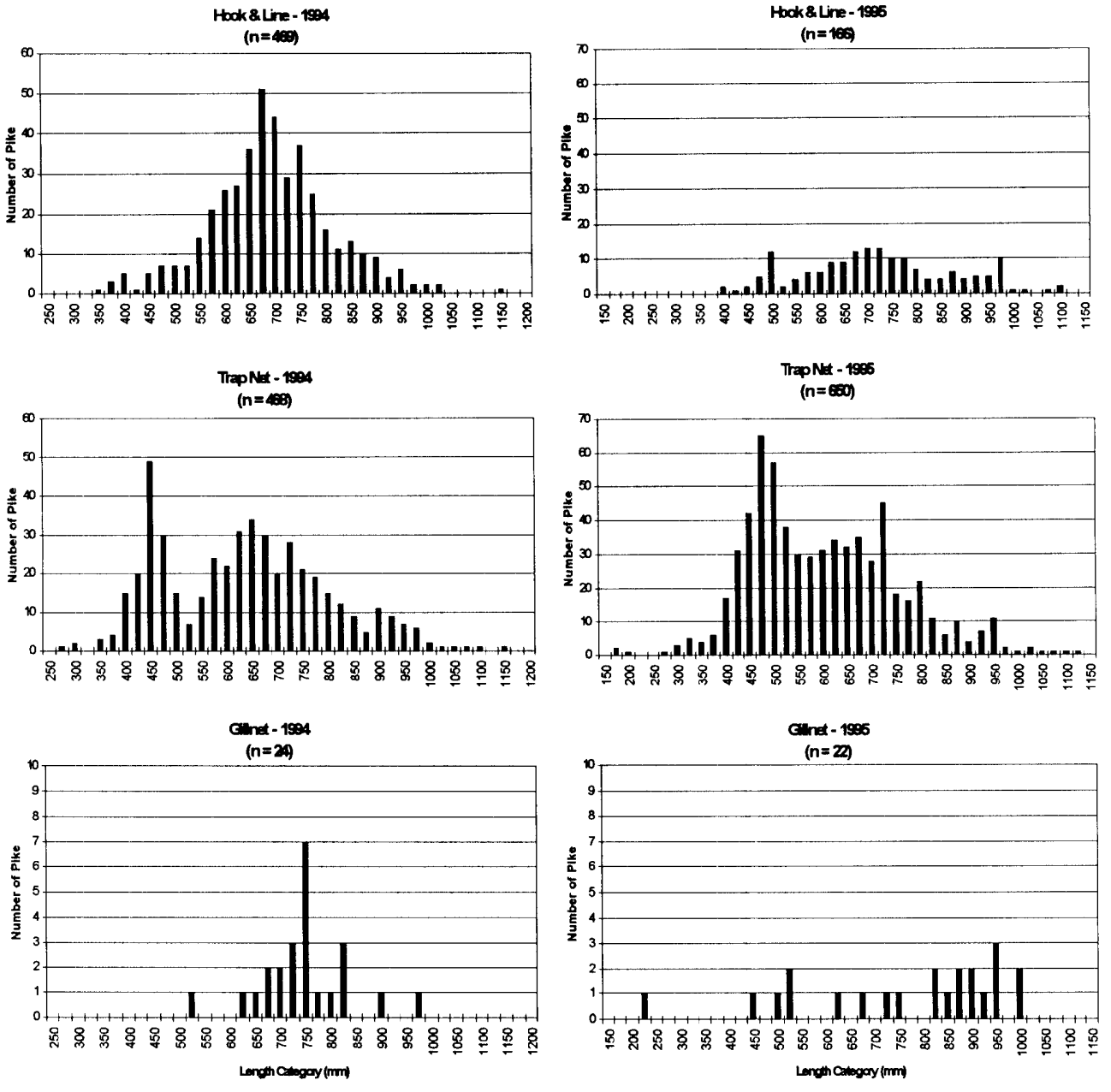

Figure 3.-Length distribution of northern pike captured by gear type at Kaiyuh Flats during sampling in July 1994 and June 1995.

with water depths of 0.3 to 0.75 m in the outlet and 0.3 m in the lake itself. During winter 1994-95, 44% of radio tagged northern pike overwintered in this area, and 27% overwintered in this area during winter 1995-96. Cook and Bergersen (1988) found only 11% of their radio-tagged northern pike in 0-1.9 m winter water depths in Eleven Mile Reservoir, Colorado and Diana et al. (1977) found only 21% of northern pike at 0-1.9 m winter water depths in Lac Ste Anne near Edmonton, Alberta. These studies both documented the majority of northern pike within 2-3.9 m water depths in winter. Since winter habitat measurements were taken only at the South Lakes overwintering area, it is not known whether North Lakes or the Khotol River areas are similar to South Lakes habitat or contain winter water depths of 2-3.9 m or greater. Examination of the other overwintering sites would show whether South Lakes habitat is unique for overwintering habitat or similar to the other two sites.

There was difficulty in determining where the first annulus developed on the scales. The distance from the focus to the first annulus was variable between fish. If the first annulus was missed, the length-at-age would be greater than it actually is. Four northern pike captured in 1995 were age 1, but no age 0 were captured. To clarify the development and location of the first annulus, a larger sample of age 1 and age 0 fish need to be examined. Scales of 53 northern pike from Minto Flats, Alaska were more difficult to read than northern pike scales from Squeers Lake, Ontario (L. Stuby, Alaska Department of Fish and Game, Fairbanks, 1995 memorandum). Although the Kaiyuh Flats sample of age data on northern pike captured in both years was small (11), the results were similar to the Minto Flats sample. The proper incremental age in Minto Flats northern pike was assigned 15 - 32% of the time, whereas in Kaiyuh Flats northern pike it was assigned correctly 36% of the time. The proper age within one year was assigned 60 - 80% for Minto Flats and 91% for Kaiyuh Flats northern pike. With less than 50% of northern pike ages correct, length data in addition to scale age data from northern pike populations in Alaska should be used for population assessment.

Mortality of radio-tagged northern pike increased over the study period (10 - 55%). Mean age of fish that had died and those that were alive at the end of the study was identical (age 10, range 6 - 14 years). Mosindy et al. (1987) reported annual mortality for northern pike (age 4 - 12) in an Ontario lake at 18.7%. Mortality rates of 24 - 57% for three Michigan lakes were reported by Diana (1983). The higher of these rates was associated with a lake that had high exploitation by sport fishing, in contrast Kaiyuh Flats exploitation by fishing is low. Based upon the identical mean age of fish that died and those that were alive, it is unlikely that age was a factor in the increase in mortality over time. Whether the higher mortality of radio-tagged northern pike in Kaiyuh Flats was due in part to the transmitters themselves could not be determined from this study. It may be that mortality for the first year (10%) is not representative of true mortality. Northern pike that were selected for radio transmitter implantation were healthy, robust fish. Since all fish implanted with transmitters were in good condition, these fish were more likely to survive through the winter and spawning, than if fish in good and poor condition had been implanted. Thus, the estimate for the first year would be biased toward low mortality, while the mortality for the second year would be more representative of the true mortality, since there would be radio-tagged northern pike in good and poor condition going into the second year.

When interpreting the results of radiotelemetry studies, it is assumed that behavior of radio-tagged northern pike is similar to that of untagged northern pike. In this study, the smallest radio-tagged northern pike was 750 mm, therefore the results cannot be applied to the portion of northern pike < 750 mm. Only fish that were known to be alive during the second winter were considered when

determining fidelity to overwintering areas. It is not known if the fish that died prior to the second winter would have exhibited the same fidelity to overwintering areas. Once a radio-tagged fish was determined to have died or expelled its transmitter, it ceased to provide information and was removed from the sample for further movement or overwintering area estimates.

The northern pike population in the Kaiyuh Flats is relatively unexploited. A relatively large number of northern pike captured were ≥ 1,000 mm in 1994 (17) and 1995 (10) during the sampling period. Pearse and Burkholder (1993) reported only seven fish ≥ 1,000 mm during 9 years of sampling in Volkmar Lake, and Pearse (1994) reported no northern pike ≥ 1,000 mm in 6 years at George Lake. Volkmar Lake sport fish harvest averaged 415 northern pike with a average effort of 484 angler-days from 1981-92, while George Lake averaged 1,722 northern pike harvested with an average effort of 1,163 angler-days during this same period (Mills 1982-93). The presence of large northern pike in the Kaiyuh Flats is possible in part due to the lack of sport fish harvest. If aging error is not a factor, the large size of northern pike could also be related to high growth rate due to environmental or genetic conditions in the Kaiyuh Flats population.

ACKNOWLEDGMENTS

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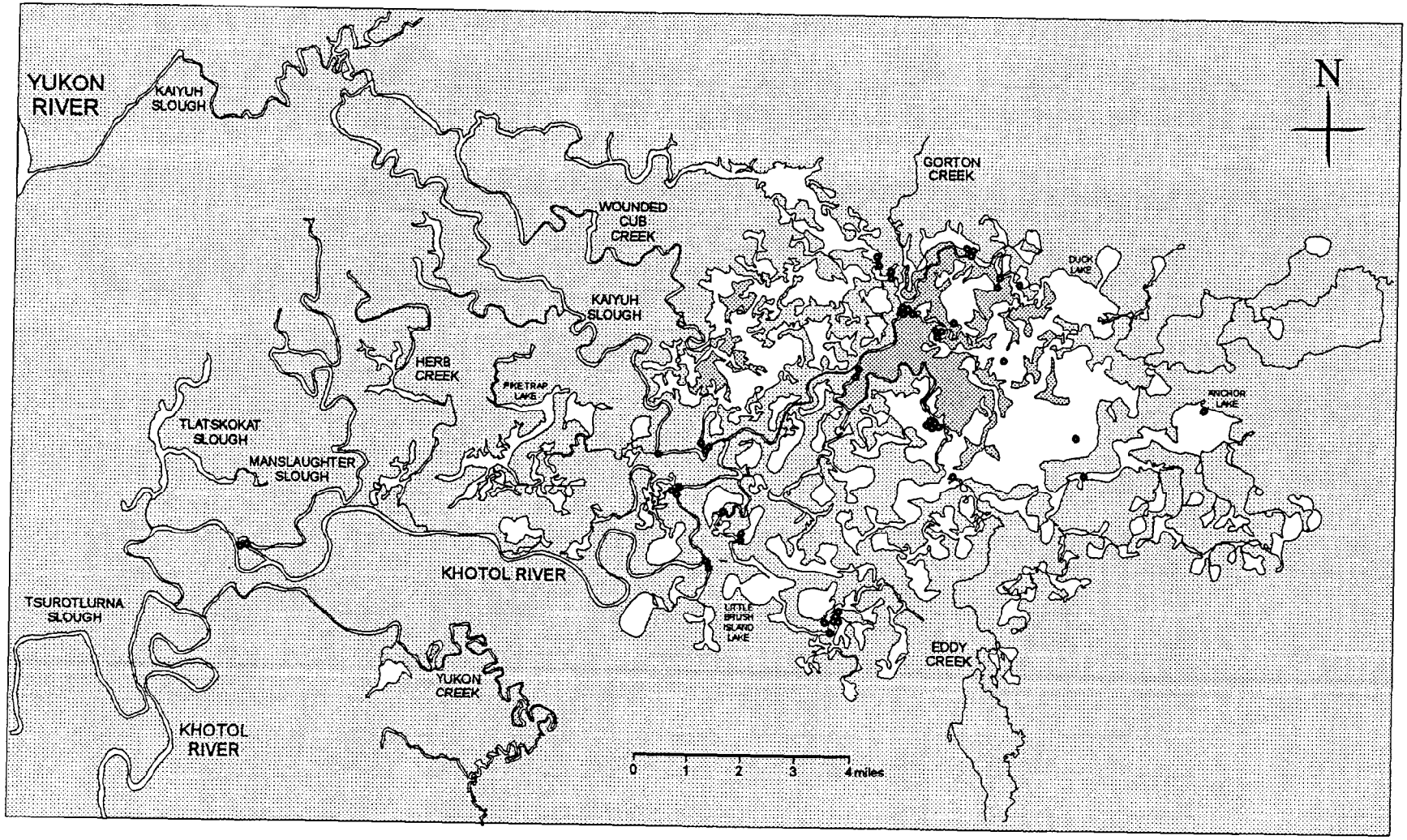
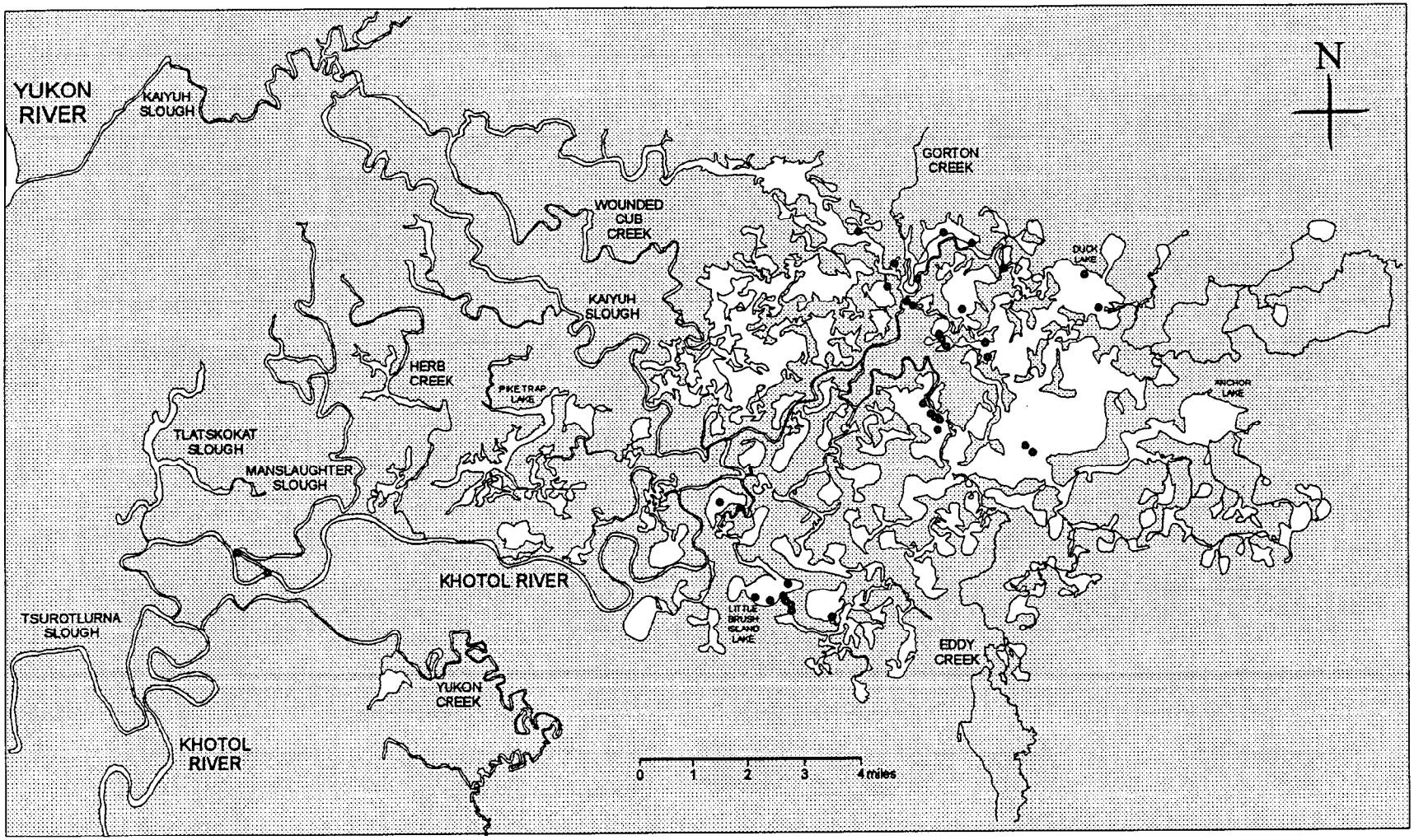
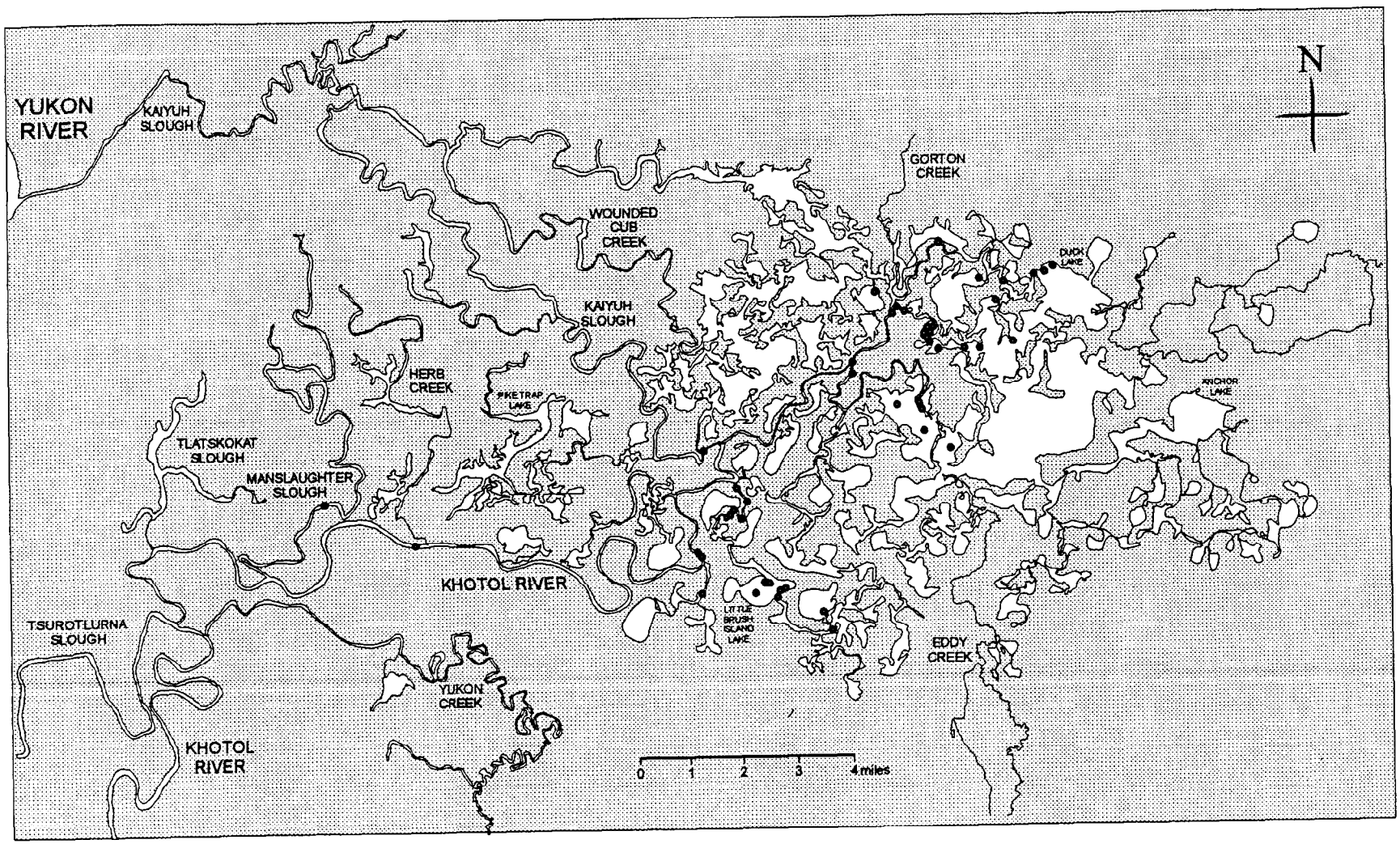
APPENDIX A.
LOCATIONS OF RADIO-TAGGED NORTHERN PIKE



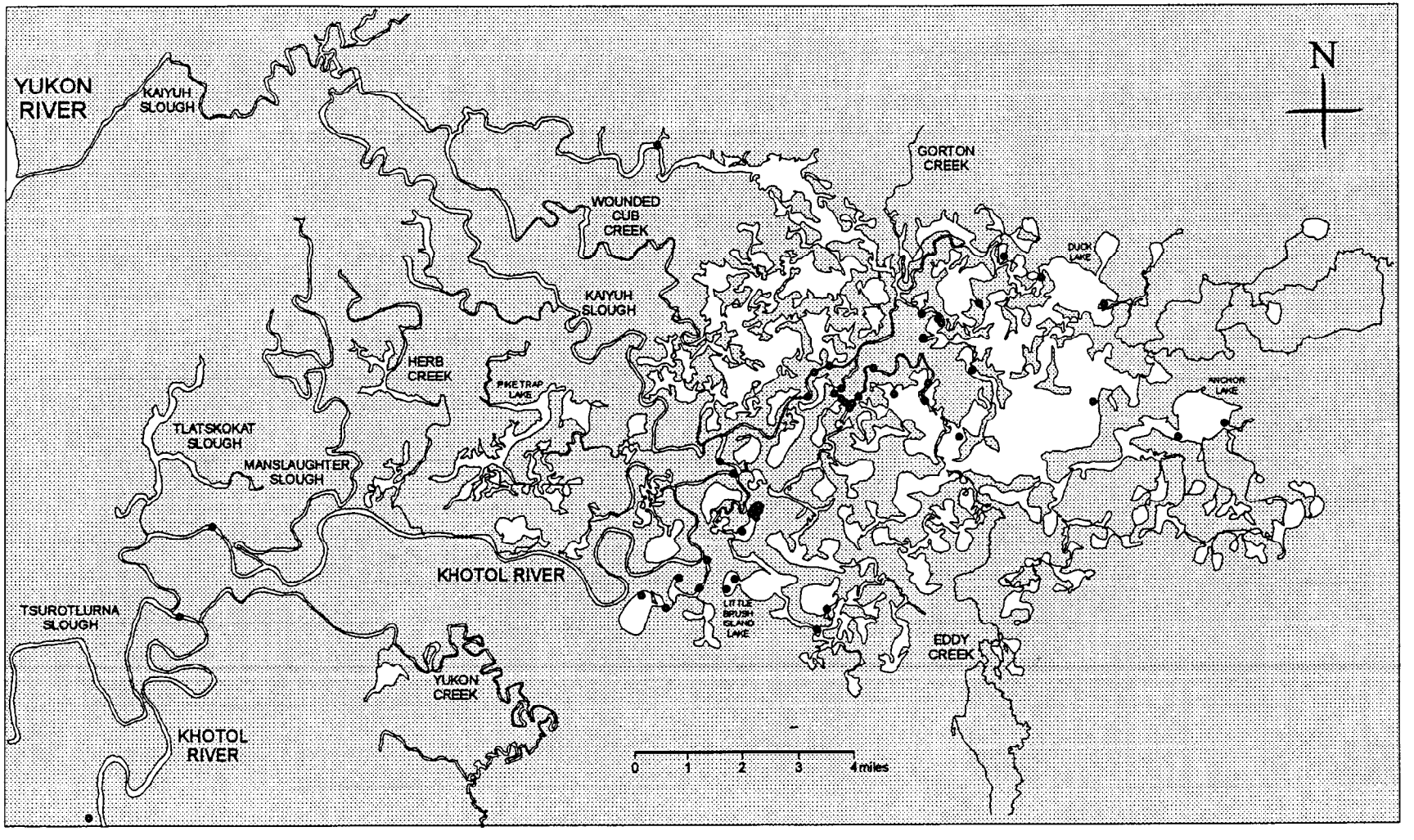
Appendix A1.-Release locations of radio-tagged northern pike in the Kaiyuh Flats (7/9-29/94).



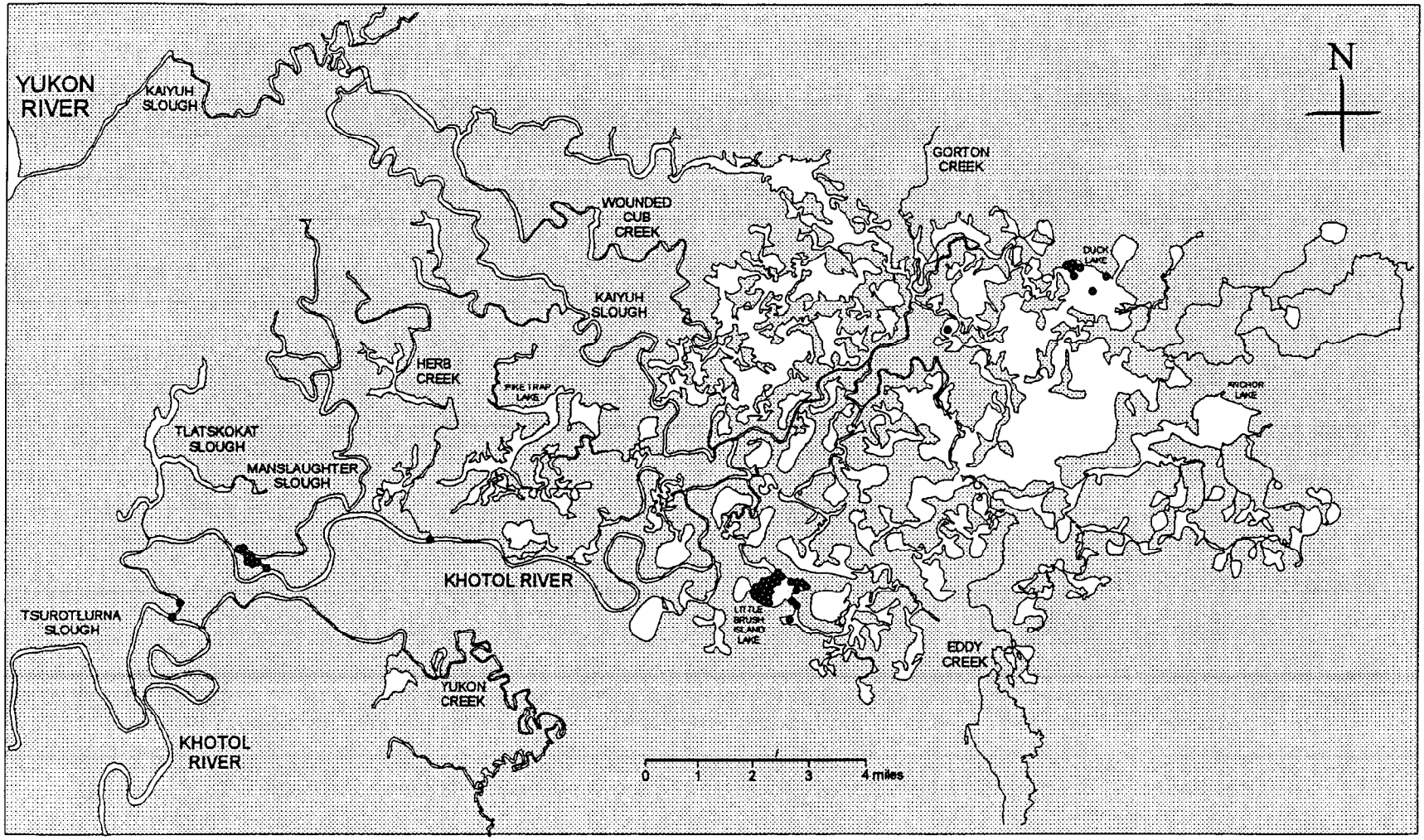
Appendix A2.-Locations of radio-tagged northern pike in the Kaiyuh Flats (7/27-28/94).



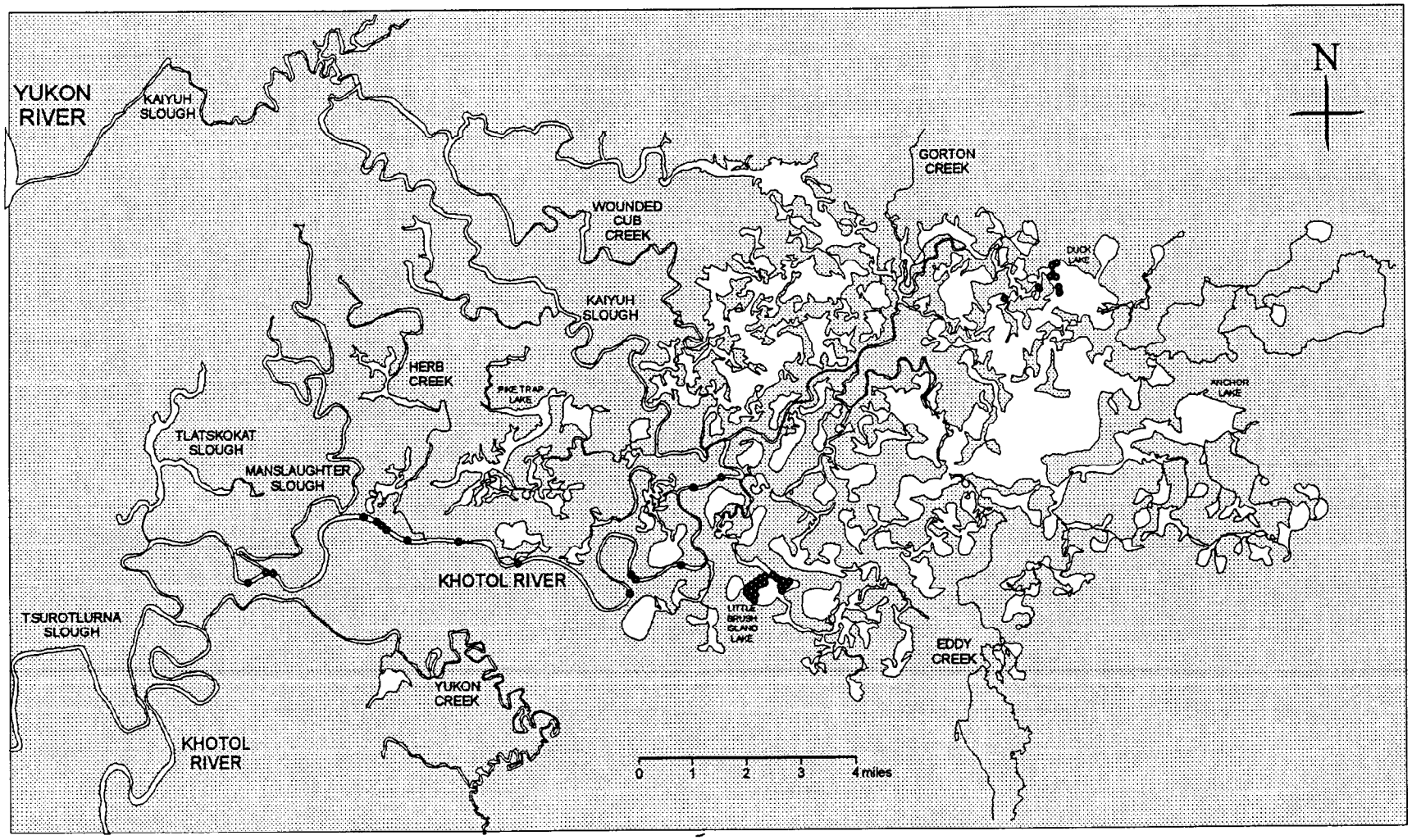
Appendix A3.-Locations of radio-tagged northern pike in the Kaiyuh Flats (8/9-10/94).



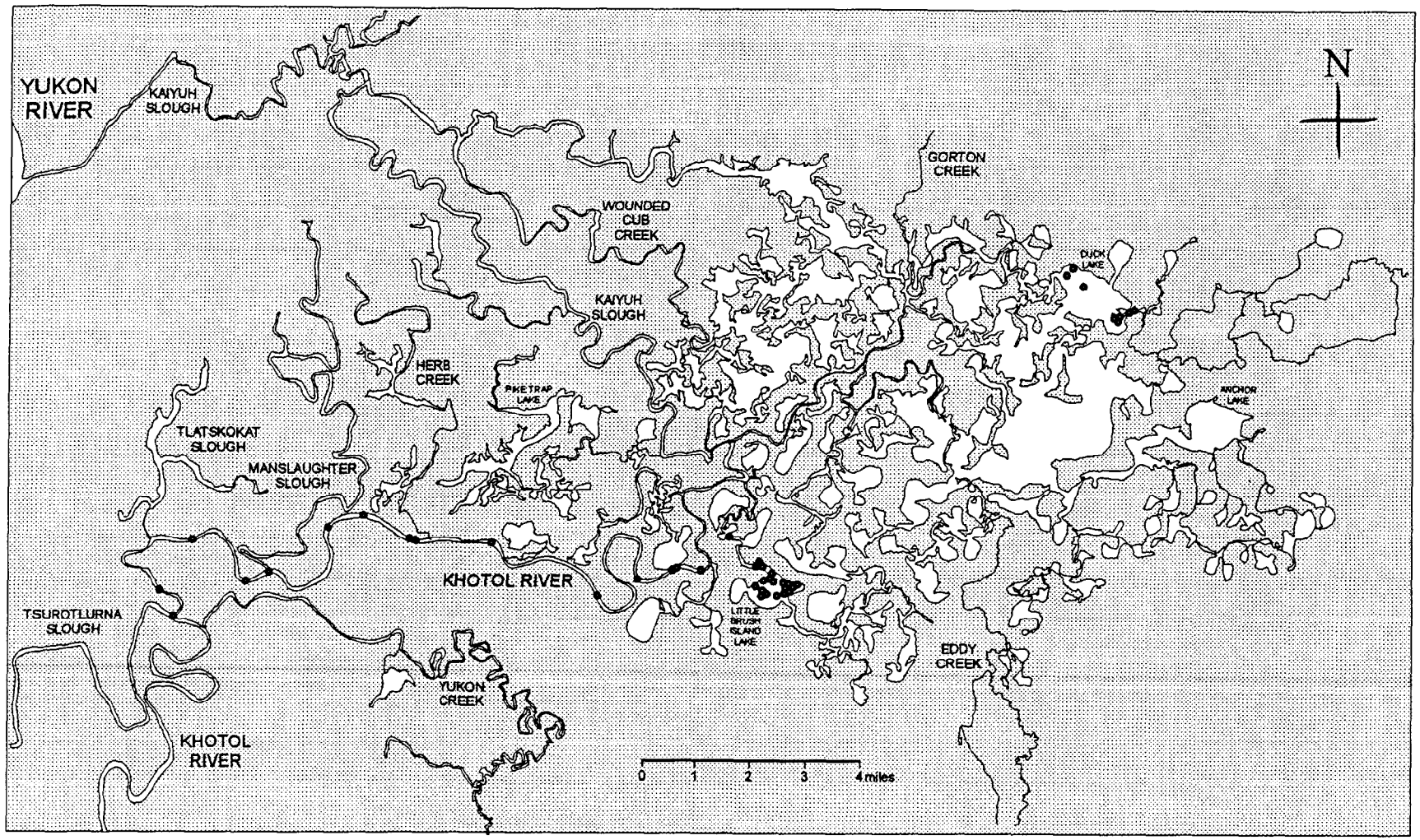
Appendix A4.-Locations of radio-tagged northern pike in the Kaiyuh Flats (9/1-2/94).



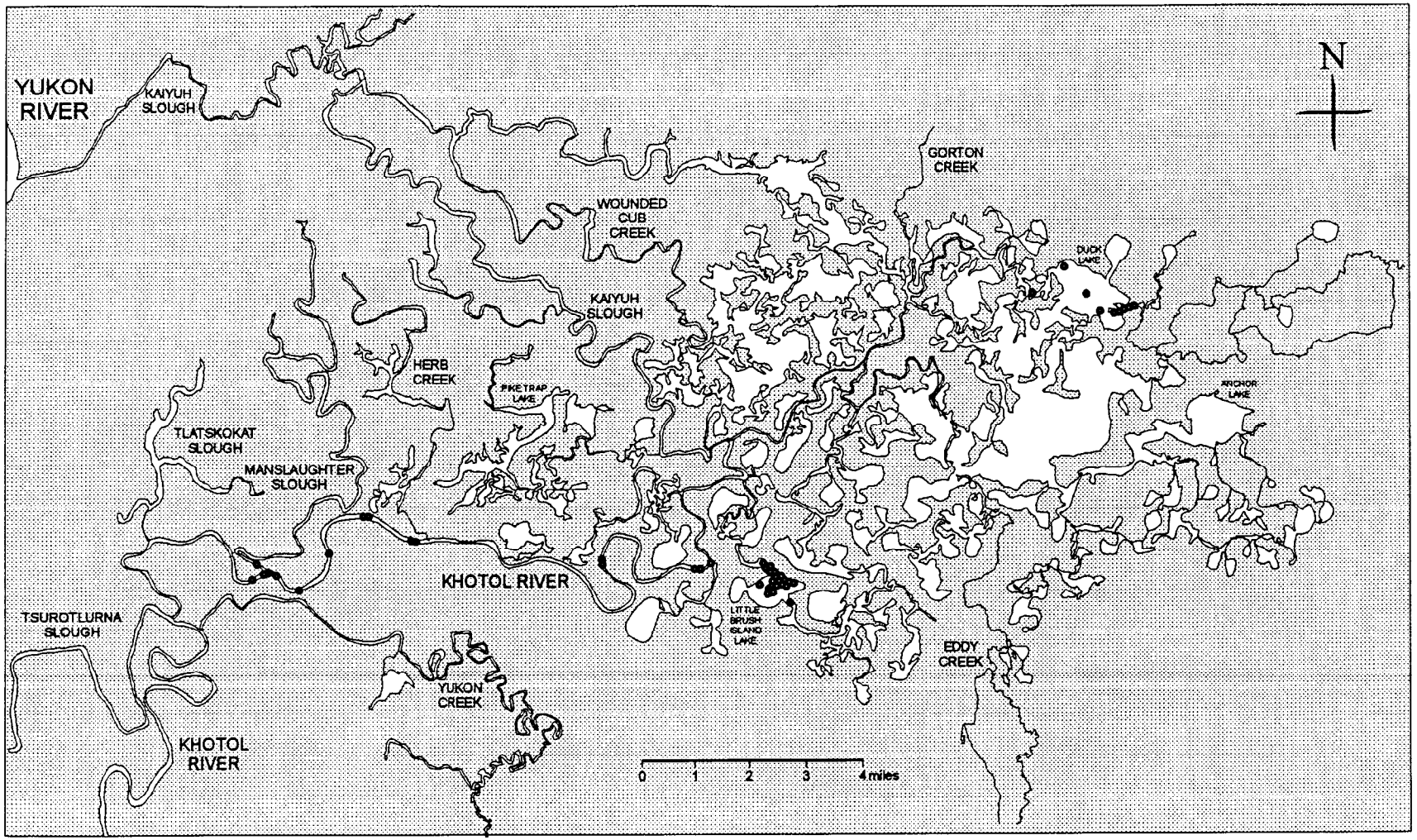
Appendix A5.-Locations of radio-tagged northern pike in the Kaiyuh Flats (10/12-13/94).



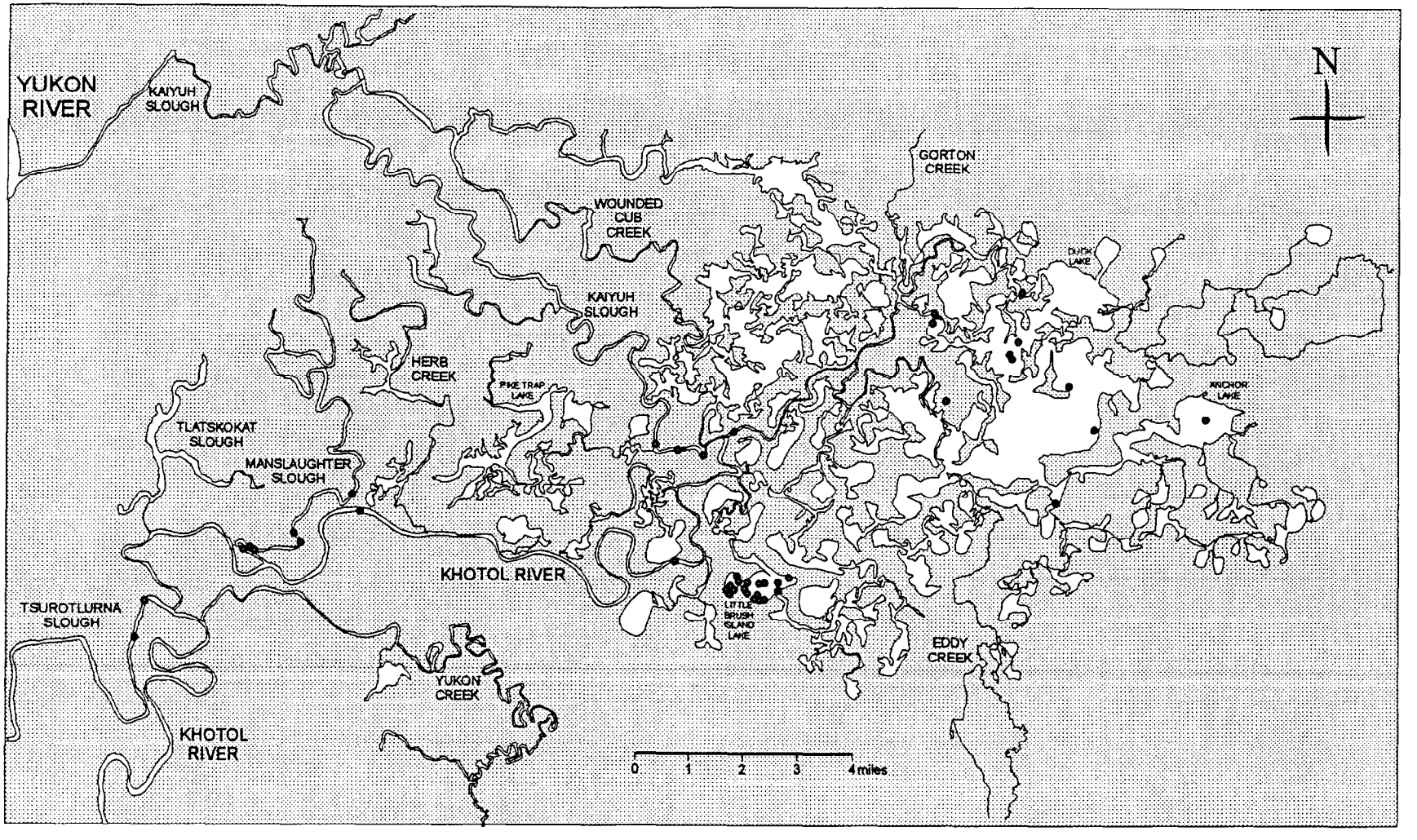
Appendix A6.-Locations of radio-tagged northern pike in the Kaiyuh Flats (12/20/94).



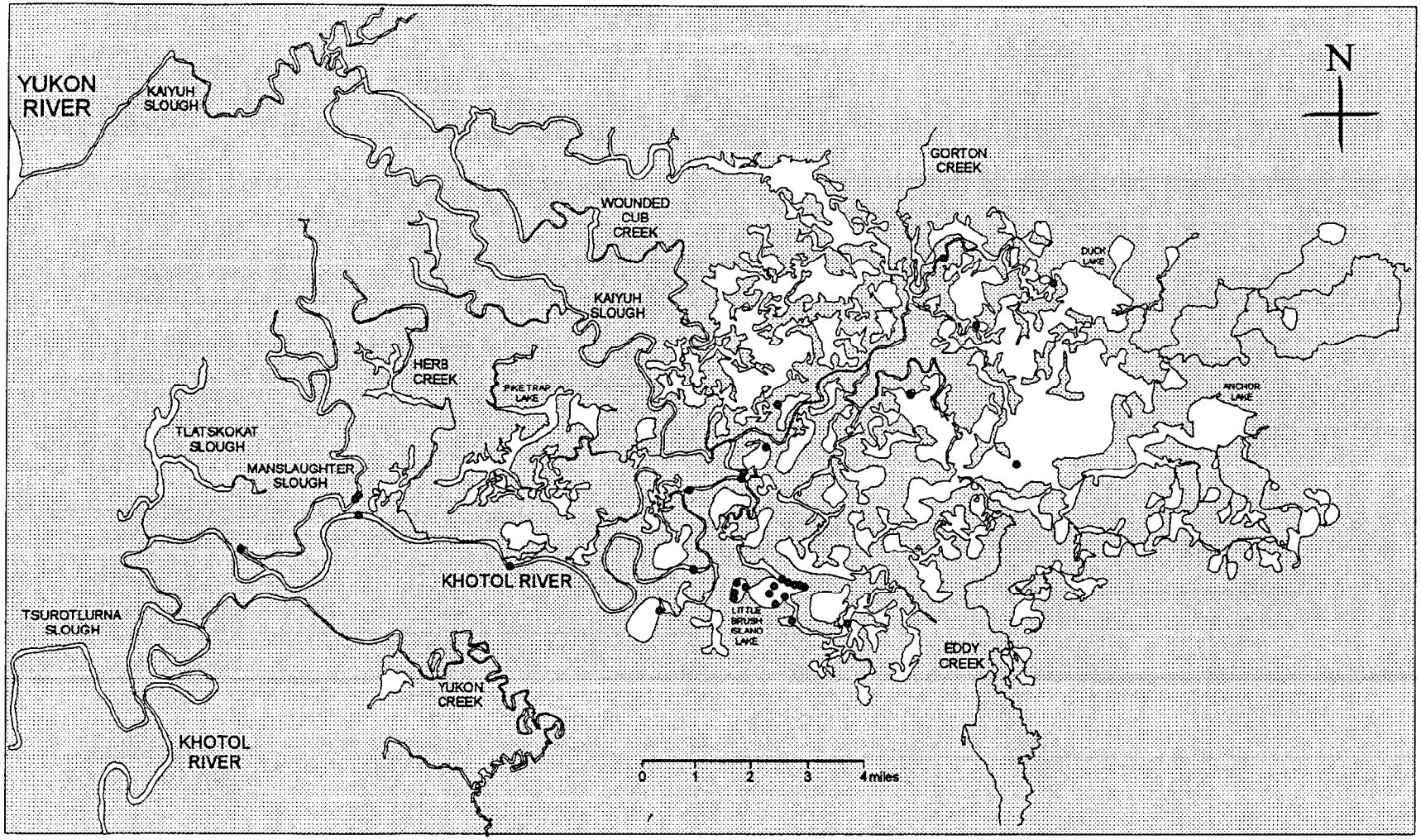
Appendix A7. -Locations of radio-tagged northern pike in the Kaiyuh Flats (1/31/95).



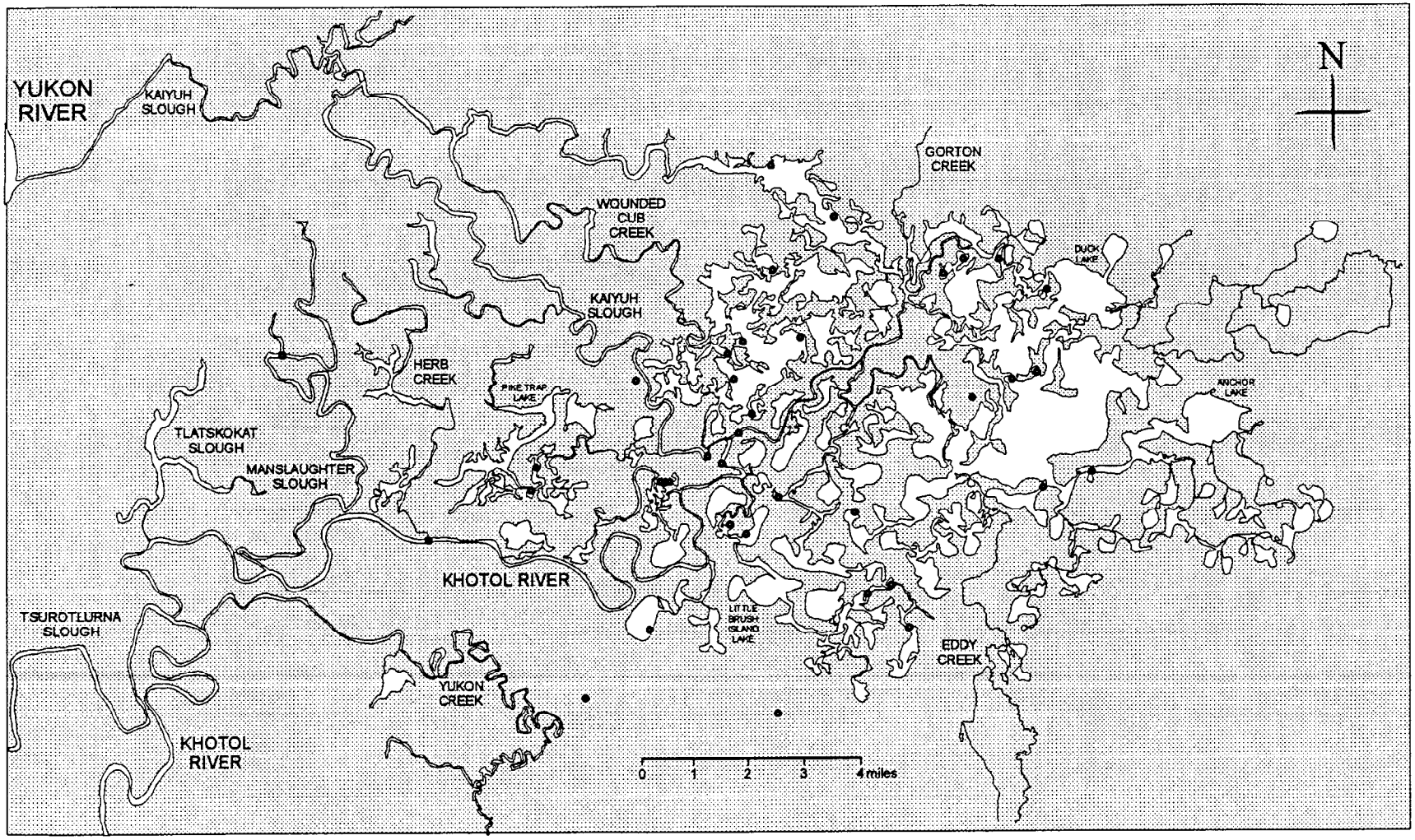
Appendix A8.-Locations of radio-tagged northern pike in the Kaiyuh Flats (3/28/95).



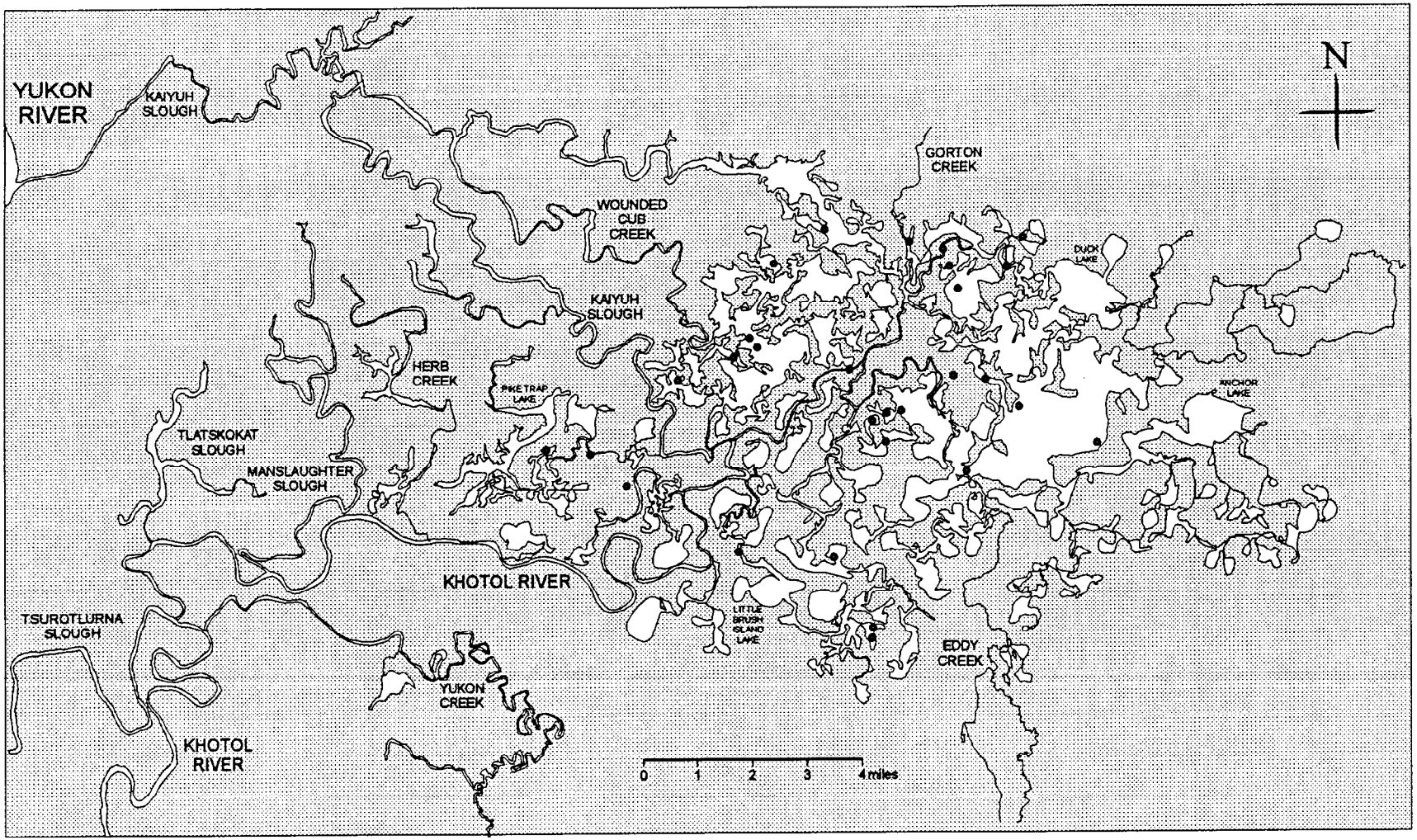
Appendix A9.-Locations of radio-tagged northern pike in the Kaiyuh Flats (5/1-2/95).



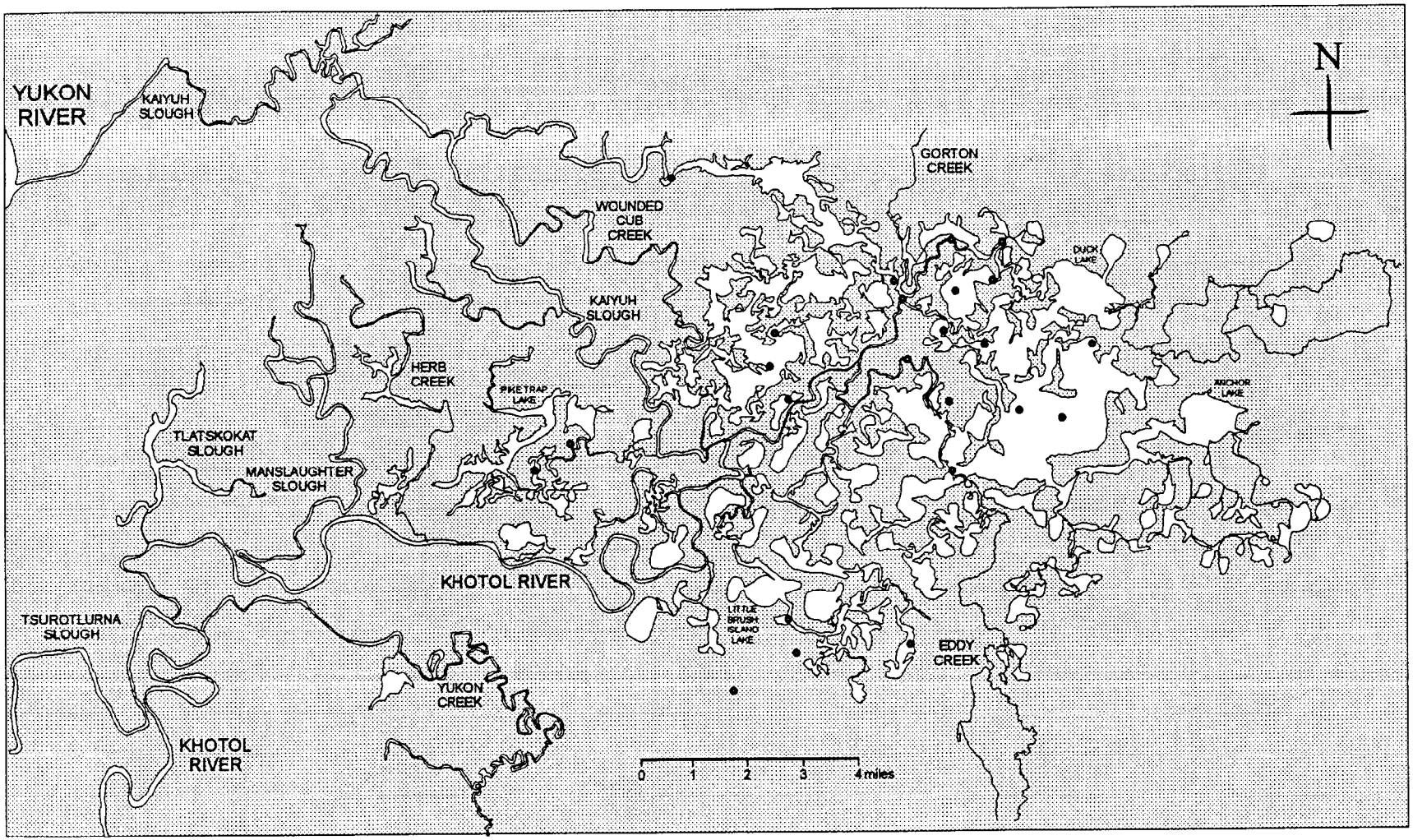
Appendix A10.-Locations of radio-tagged northern pike in the Kaiyuh Flats (5/8/95).



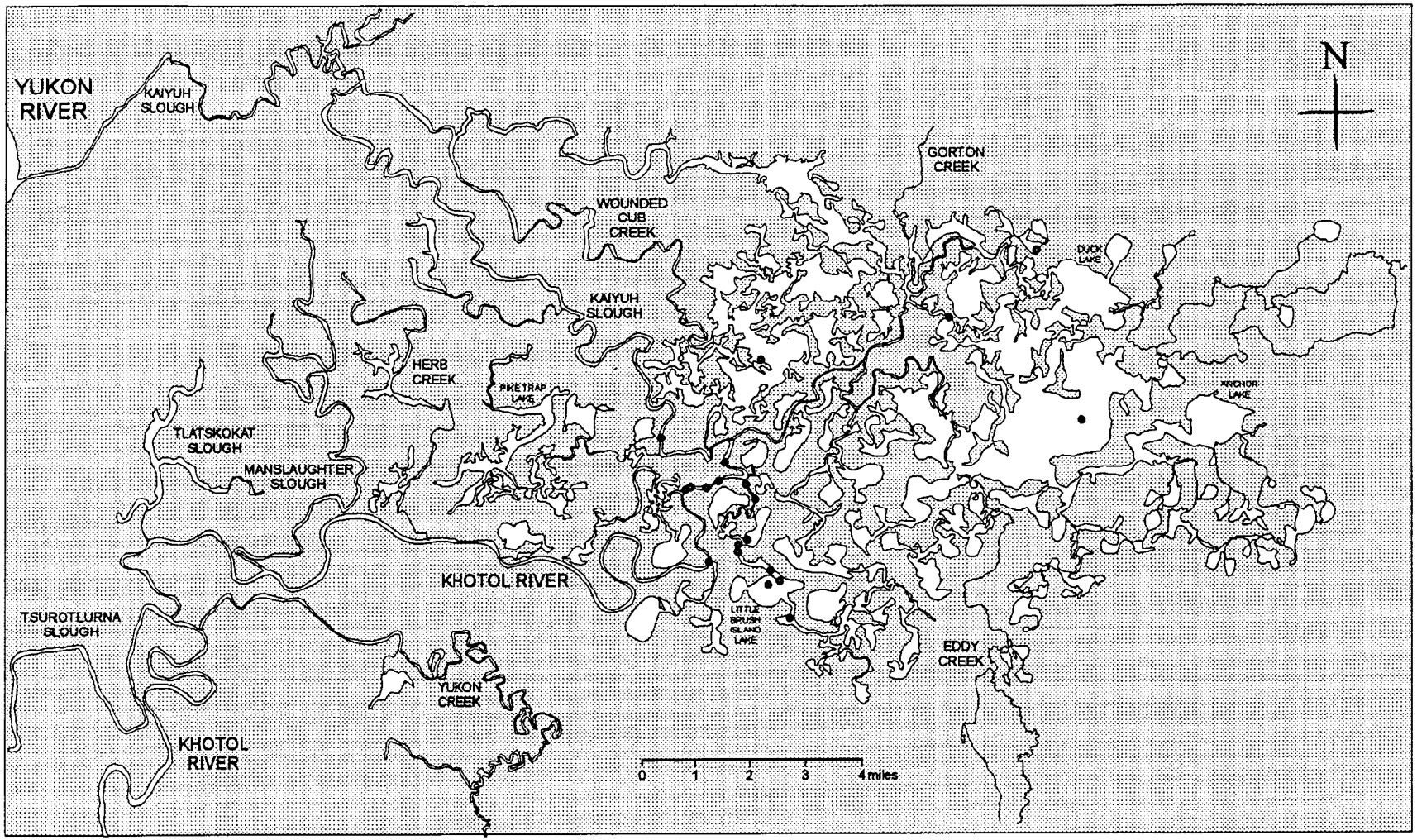
Appendix A11.-Locations of radio-tagged northern pike in the Kaiyuh Flats (5/15/95).



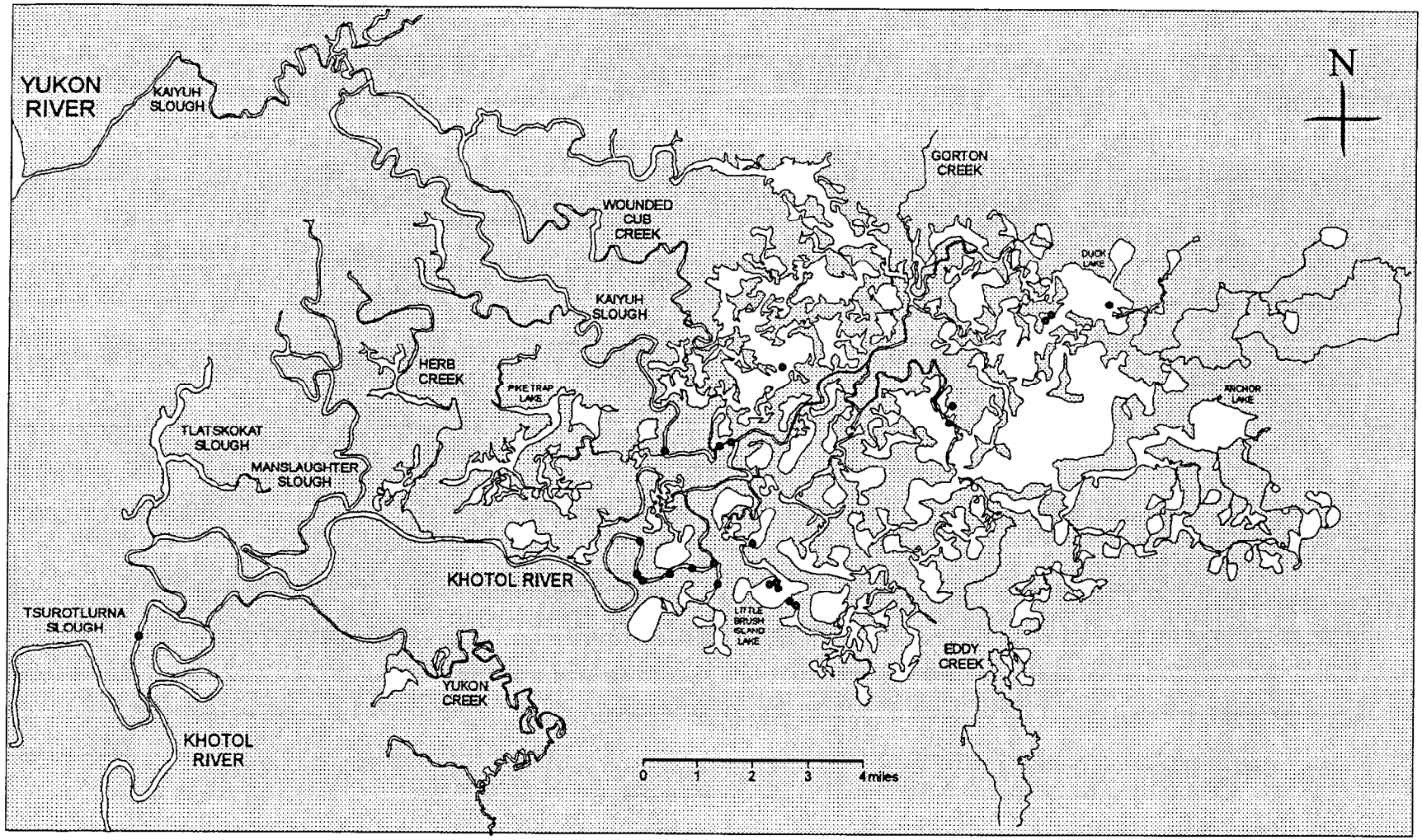
Appendix A12.-Locations of radio-tagged northern pike in the Kaiyūh Flats (5/22/95).



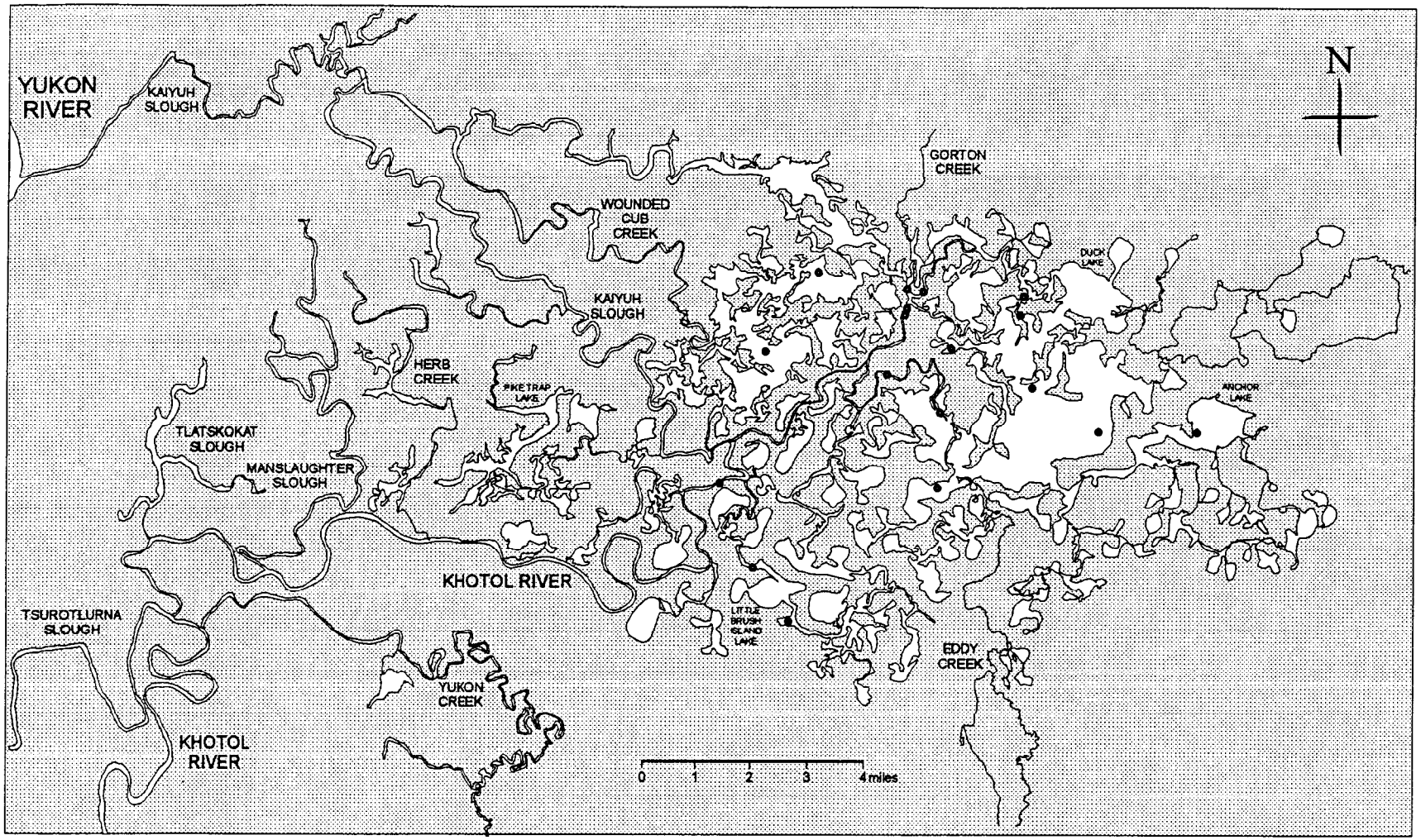
Appendix A13.-Locations of radio-tagged northern pike in the Kaiyuh Flats (6/13/95).



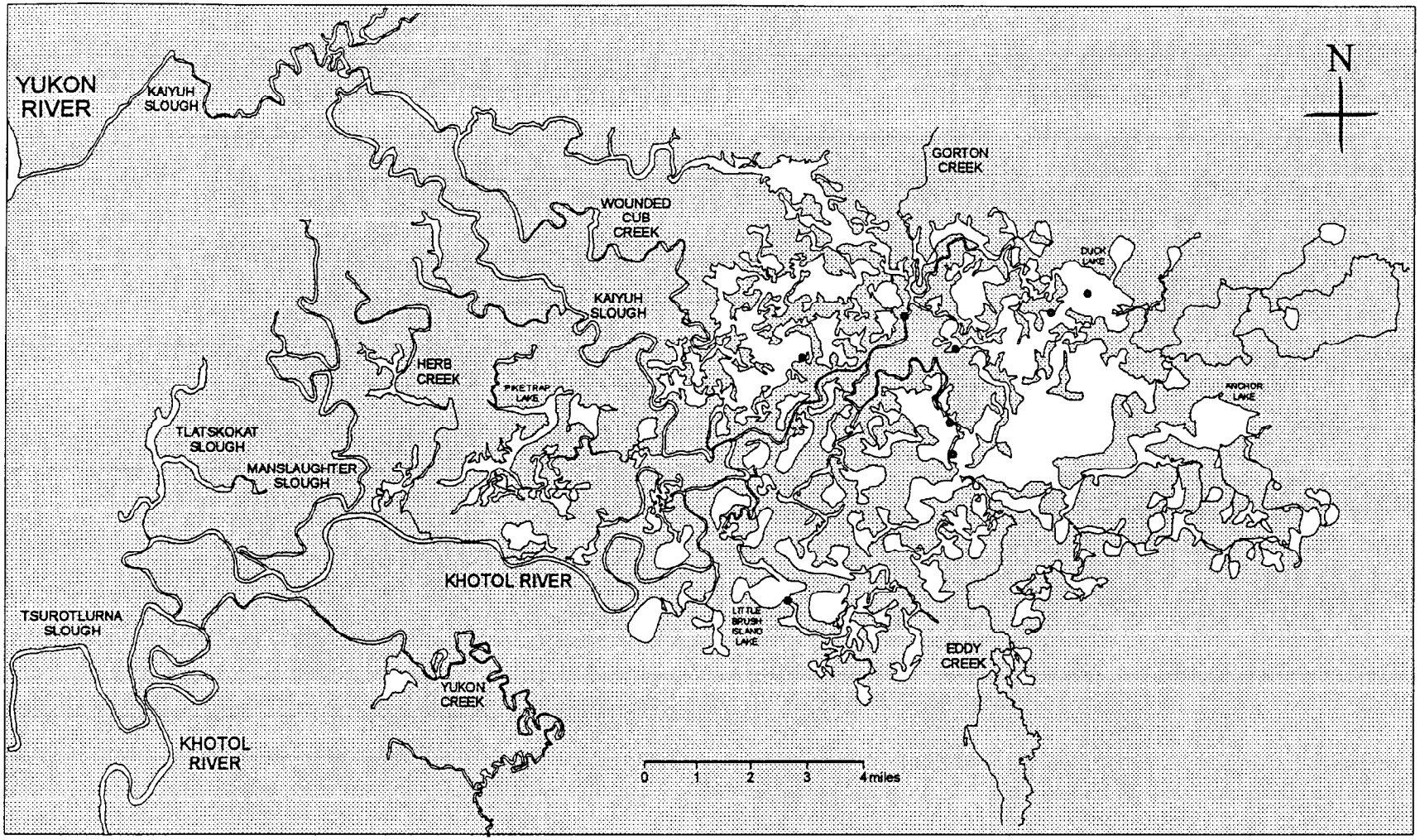
Appendix A14.-Locations of radio-tagged northern pike in the Kaiyuh Flats (12/13/95).



Appendix A15.-Locations of radio-tagged northern pike in the Kaiyuh Flats (3/27-3/29/96).



Appendix A16.-Locations of radio-tagged northern pike in the Kaiyuh Flats (6/25-7/2/96).



Appendix A17.-Locations of radio-tagged northern pike in the Kaiyuh Flats (7/25/96).

APPENDIX B.
1994 AND 1995 NORTHERN PIKE DATA COMPARISON

Appendix B.-Data comparison of northern pike captured in both July 1994 and June 1995 at Kaiyuh Flats.

Tag	Length (mm)			Weight (g)			Age		
Number	1994	1995	difference	1994	1995	difference	1994	1995	age error
31025	615	600	-15	1650	1500	-150	6	6	-1
31118	612	624	12	1700	1900	200	6	7	0
31135	458	483	25	690	750	60	4	4	-1
31153	989	975	-14	8450	7800	-650	13	12	-2
31194	669	685	16	2100	2800	700	7	8	0
31198	514	543	29	1050	1000	-50	4	5	0
32450	790	800	10	3500	3700	200	8	10	1
32480	657	675	18	1800	2200	400	7	8	0
39439	726	726	0	2500	2100	-400	10	10	-1
39518	647	661	14	1920	1900	-20	4	6	1
39558	555	572	17	1400	1300	-100	4	6	1
Average			10			17			

APPENDIX C.
LENGTH COMPOSITION OF NORTHERN PIKE SAMPLED AT KAIYUH FLATS

Appendix C1.-Length composition of northern pike examined by gear type during sampling July 9 - 29, 1994 and June 12 - 22, 1995 at Kaiyuh Flats.

Length (mm)	1994			1995		
	Gillnet	Trap Net	Hook & Line	Gillnet	Trap Net	Hook & Line
150	0	0	0	0	0	0
175	0	0	0	0	2	0
200	0	0	0	0	1	0
225	0	0	0	1	0	0
250	0	0	0	0	0	0
275	0	1	0	0	1	0
300	0	2	0	0	3	0
325	0	0	0	0	5	0
350	0	3	1	0	4	0
375	0	4	3	0	6	0
400	0	15	5	0	17	2
425	0	20	1	0	31	1
450	0	49	5	1	42	2
475	0	30	7	0	65	5
500	0	15	7	1	57	12
525	1	7	7	2	38	2
550	0	14	14	0	30	4
575	0	24	20	0	29	6
600	0	22	26	0	31	6
625	1	31	27	1	34	9
650	1	34	36	0	32	9
675	2	28	51	1	35	12
700	2	20	44	0	28	13
725	3	28	28	1	45	13
750	7	21	38	1	18	10
775	1	19	27	0	16	10
800	1	15	21	0	22	7
825	3	12	15	2	11	4
850	0	9	16	1	6	4
875	0	5	17	2	10	6
900	1	11	12	2	4	4
925	0	9	10	1	7	5
950	0	7	9	3	11	5

-continued-

Appendix C1.-Page 2 of 2.

Length (mm)	1994			1995		
	Gillnet	Trap Net	Hook & Line	Gillnet	Trap Net	Hook & Line
975	1	6	6	0	2	10
1000	0	2	5	2	1	1
1025	0	1	6	0	2	1
1050	0	1	2	0	1	0
1075	0	1	1	0	1	1
1100	0	1	0	0	1	2
1125	0	0	0	0	1	0
1150	0	1	1	0	0	0
1175	0	0	1	0	0	0
1200	0	0	0	0	0	0
Total	24	468	469	22	650	166