Fishery Data Series No. 04-17

Seasonal Movements and Length Composition of Northern Pike in Old Lost Creek, 2001-2003

Final Report for Study 01-140
USFWS Office of Subsistence Management
Fishery Information Service Division

by
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August 2004

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

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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 SERIES NO. 04-17

SEASONAL MOVEMENTS AND LENGTH COMPOSITION OF NORTHERN PIKE IN OLD LOST CREEK, 2001-2003

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August 2004

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ABSTRACT

Concern raised by Stevens Village over the increased use of the northern pike *Esox lucius* sport fishery at the Dall River since the construction of the Dalton Highway Bridge at the Yukon River led to a series of studies on the Dall River and nearby tributaries to better understand the size and age distribution and movement of northern pike in this portion of the Yukon Flats. In 2001, 365 northern pike ≥450 mm FL were captured and tagged in the Old Lost Creek drainage. In 2002, an additional 285 northern pike were captured, measured and tagged. Twenty-one percent of the fish captured in 2001 and 27% of the fish captured in 2002 were greater than 720 mm FL. The proportions were significantly different at the 95% confidence level. In 2001, 60 fish ≥600 mm FL were fitted with radio transmitters. During the open water seasons of 2001, 2002, and 2003 radio-tracking stations were placed at the mouths of the Old Lost Creek drainage and at the mouth of the Dall River to record the movement of radio-tagged pike in and out of these two drainages. Radio-tagged fish typically moved into the Old Lost Creek drainage after ice-out in May and remained within the drainage throughout the first two-thirds of June. More than 20% of the radio-tagged fish moved out of the drainage by the end of June in 2002 and 2003 but remained nearby in the Yukon River. Fish moved a maximum of 56.6 kilometers downriver and 38.1 kilometers upriver of the drainage. Average maximum distances moved from the Old Lost Creek drainage were much lower than the maximum; they were 5.6 kilometers (SE = 1.54) between the spawning season of 2001-2002, 6.3 kilometers (SE = 1.58) between spawning in 2002 and 2003, and 10.8 kilometers (SE = 3.26) after the 2003 spawning season. In 2001, 19% of still active Dall River tagged northern pike were detected at the Old Lost Creek drainage. However, no more than 5% of Old Lost Creek northern pike were detected at any one time near the Dall River or in the Yukon River within 5 km of the mouth of the Dall River. Logistic regression models demonstrated that the proportion of radio-tagged northern pike remaining in the Old Lost Creek drainage after the spawning period depended upon the flow rate in the Yukon River, the section of the river in which the northern pike was initially caught, the year of the observation, and on the day of the year. The proportion of northern pike in the drainage was positively correlated with the flow rate in the Yukon River. Additionally, the five fish captured and tagged at the mouth of Old Lost Creek spent significantly more time outside of the drainage. Comparisons are made with the Dall River northern pike stock and management implications are discussed.

Key Words: Dall River, *Esox lucius,* movements, northern pike, Old Lost Creek, radiotelemetry, radio tracking stations, size composition, sport fishery, subsistence fishery, Yukon Flats.

INTRODUCTION

Construction of the Dalton Highway in the mid 1970s provided improved access to the Dall River and western portion of the Yukon Flats for anglers. Since that time, a summer season sport fishery has developed, which targets mostly northern pike *Esox lucius*. There is a subsistence fishery for northern pike and whitefish in the area. Subsistence fishing for northern pike occurs in the lower Dall River and the nearby sloughs of the Yukon River during spring prior to the arrival of salmon in the Yukon (R. Mayo, First Chief of Stevens Village, personal communication) and during early fall just prior to freeze-up (October). The only published report of subsistence harvest of northern pike from the area is from 1984 when 730 northern pike were taken in the subsistence fishery (Sumida 1988).

Fishery resources of the Dall River and the neighboring area are important to residents of Stevens Village who have expressed concerns over the increased level of use by non-locals that has occurred since the construction of the Dalton Highway Yukon River Bridge. The northern pike sport fishery has been the source of user conflicts and the focus of stock assessment and use survey studies in the last decade and a half. While there is wider acceptance that the level of harvest occurring at the Dall River is sustainable, local people have asserted that the quality of the northern pike stock, particularly in the Dall River as reflected by age and size composition, has decreased from historic levels.

This project represents part of an ongoing effort to understand the population structure and the seasonal movements of northern pike within and between streams of the Yukon Flats National

Wildlife Refuge. This effort began in the late 1980s with a series of projects conducted by the Alaska Department of Fish and Game (ADF&G; Arvey and DeCicco 1989, Arvey and Burkholder 1990) and by ADF&G and Stevens Village Natural Resource Office (Burr and James 1996, Chythlook and Burr 2002).

Between 1999 and 2001 a study was conducted in the Dall River system that investigated the degree to which northern pike radio-tagged shortly after spawning remained within the drainage. The study found that these northern pike exhibited strong fidelity to the drainage throughout much of the open water season (intra-annual fidelity), but that some northern pike (up to 19%) spent a portion of the open water season in the nearby Old Lost Creek drainage (Chythlook and Burr 2002). The study also reported that most of these fish showed movement toward the Yukon River in late summer and fall and over-wintered in the Yukon River. Thus, while fish from this stock spent most of their time in and around the Dall River, a small portion was vulnerable to harvest in the Yukon River and in the Old Lost Creek fishery.

The most extensive tributary upstream of the Dall River is the Old Lost Creek drainage. Comparison of length distribution from northern pike sampled from Old Lost Creek with samples from other areas showed that the Old Lost Creek samples were similar to the Dall River samples (Arvey and DeCicco 1989). The average size of northern pike in both Old Lost Creek and Dall River samples was larger than from samples collected from downstream sites including Ray River and Hess Creek (Arvey and DeCicco 1989).

The projects conducted in 1999 and 2000 were to the degree possible designed to provide a comparison with information obtained in earlier studies. This project is a continuation of that effort.

OBJECTIVES

The research goals for the Yukon Flats northern pike project were to describe the northern pike stock inhabiting the Old Lost Creek drainage in terms of fidelity to the Old Lost Creek drainage during open water season (i.e., intra-annual fidelity) and in terms of the proportion of adult northern pike in large size categories. The objectives of this study were to:

1. test the hypothesis that the proportion (p) of northern pike sufficiently large (≥600 mm FL; 25 in TL) to carry a radio transmitter with a 2-year life that left the Old Lost Creek drainage during the open water period was less than or equal to 0.20 with α=0.10 such that β = 0.20 if the true proportion was 0.35;
2. estimate the proportion of adult northern pike vulnerable to sampling gear (≥450 mm FL; 19 in TL) inhabiting the Old Lost Creek drainage, Alfred Creek that were ≥720 mm FL (30 in TL) such that the estimate of the proportion was within 5 percentage points of the actual value 95% of the time; and,
3. document the location of northern pike radio-tagged in the Old Lost Creek drainage in May/June 2001-2003, during the summer rearing period in 2001-2003 (July-September), during the winter period in 2001-2003 (December– March), and during the spawning period in April/May 2002-2003.

In addition to the three objectives, there were three additional tasks in this project. These tasks were to document:

1. the proportion of northern pike radio-tagged in the Old Lost Creek drainage in 2001 that entered the Dall River area during the 2000 and 2001 open water seasons;
2. the proportion of northern pike radio-tagged in the Dall River in 2000 that left the Dall River area during the 2000 and 2001 open water seasons; and,
3. the proportion of northern pike radio-tagged in the Dall River area during 1999 and 2000 seasons that entered the Old Lost Creek area during the 2000 and 2001 open water seasons.

METHODS

STUDY AREA

The study area was located approximately 32 km upstream of the Dalton Highway (Haul Road) Bridge on the Yukon River approximately 145 km north of Fairbanks, Alaska (Figure 1). The study area lied within the boundaries of the Yukon Flats National Wildlife Refuge and within the boundaries of the Traditional Lands claimed by Stevens Village. This extensive wetland area is characterized by slow flowing, meandering streams with interconnected wetlands and small, shallow lakes. Northern pike, least cisco *Coregonus sardinella*, humpback whitefish *C. pidschian*, broad whitefish *C. nasus*, sheefish *Stenodus leucichthys*, Arctic grayling *Thymallus arcticus*, burbot *Lota lota*, longnose suckers *Catostomus catostomus*, blackfish *Dallia pectoralis*, and slimy sculpin *Cottus cognatus* are present in waters within the study area. King salmon *Oncorhynchus tshawytscha, chum salmon O. keta, and coho salmon O. kisutch* have been recorded in catches in the area but are not believed to spawn within the any of the drainages.

For the purpose of describing movements within the study area, specific geographic areas were defined and a distinction was made between a "drainage" and an "area". The "Dall River drainage", the largest drainage in the study area, included the Dall and Little Dall rivers. The most extensive tributary upstream of the Dall River, the "Old Lost Creek drainage", was defined as Old Lost Creek, Alfred Creek, Jokinaugh Slough and the mouths of Old Lost Creek and Alfred Creek. Stevens Village is located about 48 km downstream of Old Lost Creek. The "Old Lost Creek area" was defined as being in the Old Lost Creek drainage and the Yukon River between five km upstream of the Old Lost Creek mouth and five km downstream of Jokinaugh Slough. The "Dall River area" was defined as all waters of the Dall Creek drainage and waters of the Yukon River within five km of the mouth of the Dall River. The latter area was consistent with the definition used by Chythlook and Burr (2002) to describe movements of northern pike radio-tagged in the Dall River.

EXPERIMENTAL AND SAMPLING DESIGN

Radiotelemetry (Objectives 1 and 3, Tasks 1-3)

Radiotelemetry was used to determine if northern pike present in the Old Lost Creek drainage in June 2001 remained in the drainage throughout the open water season (intra-annual fidelity; Objective 1) and returned in the 2002 and 2003 open water seasons (inter-annual fidelity). In addition, the telemetry data were used to document the movement of northern pike in the study area (Objective 3) and document movement between Dall River and Old Lost Creek (Tasks 1-3). For the purposes of this study, northern pike in the Old Lost Creek drainage were considered to show fidelity to the drainage if ≤ 20% of live radio-tagged northern pike were found outside of the Old Lost Creek drainage. Movements out of the drainage were examined on different temporal scales, but for management purposes movements were thought to be significant if fish

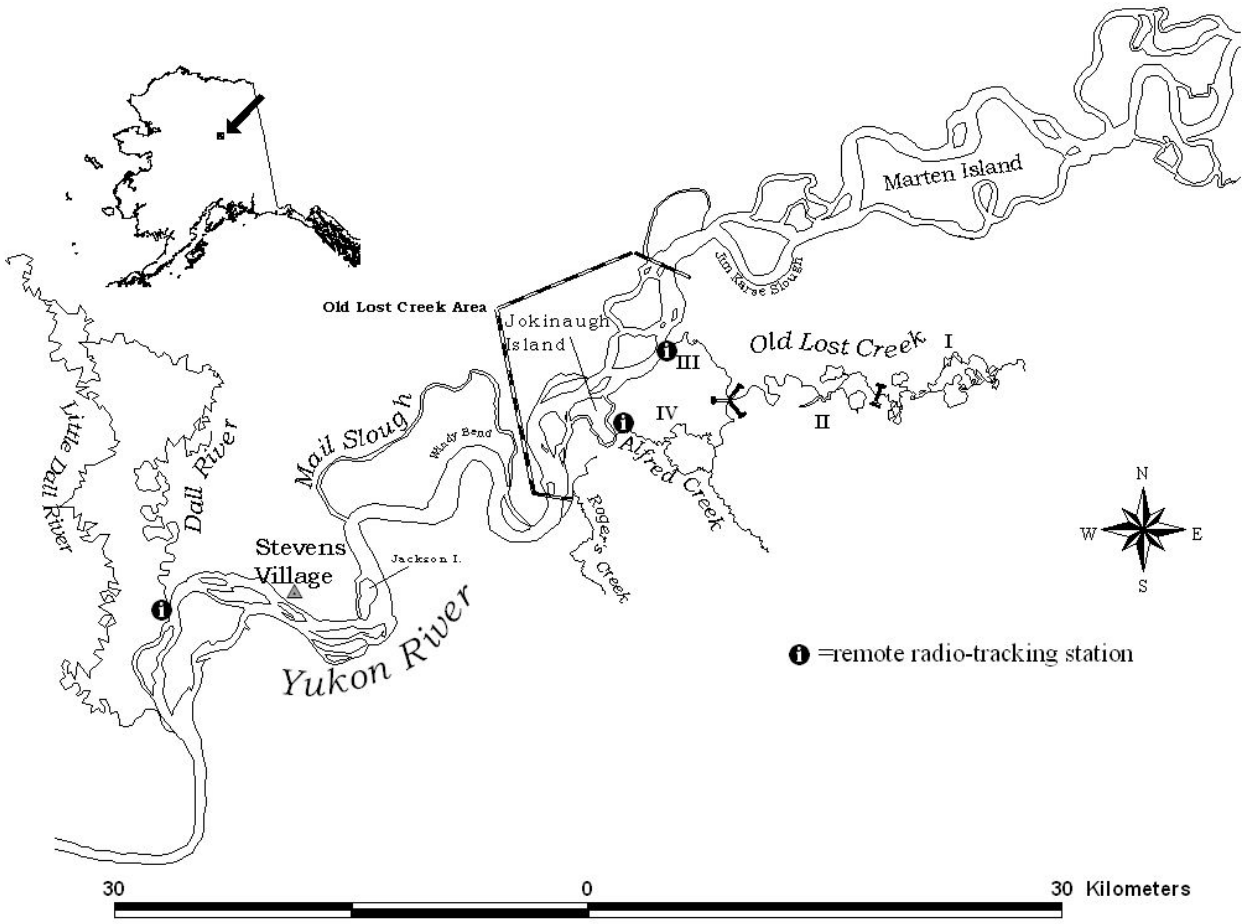

Figure 1.–The Yukon Flats study area with the location of the Old Lost Creek area, the Dall River area, the four (I-IV) sections of Old Lost Creek, and the radio-tracking stations used to record movement of radio-tagged pike into and out of their respective drainages.

remained outside of the drainage for all (or nearly all) of the open water period. Remote data loggers placed at the upper (Old Lost Creek) and lower (Alfred Creek) mouths of the Old Lost Creek drainage recorded the passage of radio-tagged northern pike when they moved into or out of the Old Lost Creek drainage. Ground tracking from boats and aerial tracking from fixed-wing aircraft were used to determine the location of northern pike and to determine if radio-tagged northern pike were alive.

Sampling Methods

In 2001, northern pike were captured in late May and early June while they were dispersed in the upper portion of the Old Lost Creek drainage following spawning. To distribute sampling throughout the drainage, the Old Lost Creek drainage was subdivided into four sections (Figure 1). For the purpose of the radiotelemetry portion of this project, sections I and II were combined to represent the upper portion of the drainage while section III and IV represented the lower portion. Equal fishing effort was expended in the upper and lower portions of the drainage during 2001 such that soak times of gill nets were approximately equal for the upper and lower sections of the study area. Sampling was conducted by two or three crews working simultaneously in different sections. It was anticipated that a larger portion of northern pike would be selected from the upper part of the drainage because previous sampling in other nearby tributaries found most fish in upstream locations during early summer and because most spawning was believed to occur in this part of the drainage. Fish to be radio-tagged were selected by length and location according to Table 1 in order to distribute radio tags according to the geographic and length distributions of northern pike in the Yukon Flats seen in prior studies (Chythlook and Burr 2002; Arvey and DeCicco 1989). A similar approach was used for the Dall River experiment (Chythlook and Burr 2002). Only northern pike larger than 575 mm FL were radio-tagged.

Table 1.-Number of northern pike to be radio-tagged and sampled for length composition in each of four sections within the Old Lost Creek drainage during May and June 2001.

Fork Length (mm)	River Drainage Section[a]				Total
	I	II	III	IV	
575-619	3		2		5
620-669	10		5		15
670-719	11		6		17
720-764	8		4		12
765-824	3		2		5
825-869	2		1		3
>869	2		1		3
Total Number of Radio-tagged Pike	39		21		60
Number of Samples for Length Composition	90	90	90	90	360

[a] Refer to Figure 1.

Northern pike were collected primarily with variable mesh gill nets (1-in, 1.5 in, and 2.0 in bar measure). Previous studies on northern pike in the Tanana River drainage have shown that the capture probability with the variable mesh gill nets for fish ≥ 450 mm FL did not vary by size (Roach 1999). Tests for length bias in samples used for mark-recapture experiments have shown that stratification was generally not necessary when only fish larger than 450 mm FL were considered (S. Roach, Alaska Department of Fish and Game, Fairbanks, personal communication). Trap nets were used when possible. Trap nets were checked daily or twice daily and gill nets were checked once every hour or more frequently as needed to minimize sampling induced mortality. All captured fish were tagged with sequentially numbered internal anchor tags (Floy[1] FD-94).

Northern pike selected for radio-tagging were anesthetized in water with clove oil (Anderson et al. 1997). LOTEK (MBFT-3L) digital radio transmitters with frequencies ranging from 149.320—149.800 MHz were surgically implanted within the coelomic cavity of each northern pike through a 2-3 cm incision along the linea alba, anterior to the pelvic girdle (Hart and Summerfelt 1975). Approximately five sutures were used to close the incision. The outlet incision for the trailing antenna was posterior to the pelvic girdle. The procedure used for the trailing antenna outlet incision was similar to that described by Ross (1982). During the surgical procedure, fresh water was periodically poured over the gills of each northern pike to prevent suffocation. Radio-tagged fish were retained until equilibrium was regained and then released once they were able to swim away.

Data Collection

Radio-tracking stations placed near the mouths of Old Lost Creek and the Dall River recorded the passage of radio-tagged northern pike into and out of these areas (Figure 1). The Radio-tracking stations were composed of integrated components: a power source, a Lotek SRX-400 data collection computer and receiver, and two five-element Yagi antenna. The length of time radio-tagged northern pike remained within Old Lost Creek drainage was determined by examining records downloaded from the remote data loggers and from information gathered during aerial and boat surveys. Northern pike were either considered within the Old Lost Creek drainage or outside of it. The data loggers were downloaded at regular intervals to prevent loss of data.

The distribution of radio-tagged fish throughout the area was examined by aerial and ground tracking events. Aerial tracking was scheduled at regular intervals through the open water season, once during the overwintering period and again during the spawning season. Locating fish consisted of flying the Old Lost Creek drainage, the Dall River area and the Yukon River between Marten Island and the Haul Road Bridge in a systematic manner while listening for signals from the transmitters with a five-element Yagi antenna with a 9 dBd gain mounted on a fixed-wing aircraft. Location of signal was determined with a map of the area. In 2003 telemetry flights were expanded and included the Yukon River up to the village of Beaver upriver of Marten Island. In 2001, radio tags deployed in the Dall River in 1999 and 2000 were still active and were monitored for movements within the study area.

[1] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

Length and Age Composition (Objective 2)

Fish were captured and handled in the same manner as described in the radiotelemetry section above. All captured fish were measured to the nearest mm and had several scales removed for aging. In 2001, the proportion of adult northern pike (≥ 450 mm FL) in Old Lost Creek that were ≥ 720 mm FL was estimated from samples collected during capture efforts to radio-tag northern pike in the same area. All healthy northern pike that were not fitted with radio tags were released immediately after tagging and data collection. In 2002, capture efforts were for the purpose of collecting samples for estimating length and age composition only.

The timing of sampling was designed to minimize differences in distribution of fish by sex and size. Radiotelemetry studies of northern pike at Harding Lake and Minto Flats indicated that northern pike were distributed more uniformly by sex and length in early summer compared with spatial distribution during spawning (Roach 1993; Burkholder and Bernard 1994; Roach 1998). Results from the Dall River telemetry study suggest that June sampling provided the best opportunity for representative sampling (Chythlook and Burr 2002). In addition, changes in the length composition of northern pike were minimized by the short duration of the sampling efforts.

DATA ANALYSIS

Radiotelemetry (Objective 1 and Tasks 1-3)

Assignment of Fates

For data analysis, each month was divided into thirds (for months with 31 days, the last third of the month consisted of 11 days). To facilitate data analysis, all radio-tagged northern pike were assigned a "fate" for each ten day period during the study. Fates were assigned based on information collected from aerial tracking surveys, boat tracking surveys and from stationary data logging stations. Additional knowledge came from radio-tagged fish being captured in subsequent sampling events and from reported harvests of northern pike. Fates are defined as follows:

1. In the Old Lost Creek drainage (OLC) – a fish that was determined to be in the Old Lost Creek drainage, including Alfred Creek. In addition, fish considered to be in the mouth of Old Lost Creek or Alfred Creek as well as in Jokinaugh Slough were considered to be in the Old Lost Creek drainage;
2. In the Yukon River (YUK) – a fish known to be alive during the time period that was determined to be in the Yukon River. During time periods associated with an aerial survey a designation of Old Lost Creek area (LC-area) was added to a fish that was determined to be in the Yukon River within five km of Old Lost Creek or Jokinaugh Slough (i.e., LC-area);
3. In the Dall River (DAL) – a fish that was determined to be in the Dall River drainage or the Little Dall River drainage or the mouth of either of these rivers;
4. Dead – a fish that was determined to be dead based on a lack of movement over a extended period of time when movements would be expected, a fish located in unsuitable habitat (e.g., in Old Lost Creek in the winter, when it is dry and/or frozen through or in a village), or a reported harvest;

5. At Large (AL) – a fish that was not located during an aerial tracking event, but was subsequently located. The At Large fate was a temporary assignment until completion of the survey when it was assigned as having been in the Yukon River or as missing;
6. Missing – a fish whose location during the time period in question was neither known nor could it be deduced with reasonable certainty. During periods associated with aerial tracking no fish was initially assigned a fate of Missing as they received a fate of At Large if they where not located. Fish assigned a Missing fate were located at least once prior to the period in question; and,
7. Failed Tag (FT)– a tagged fish that was not located at any time during the study.

For each ten day period, each fish was assigned a location or considered missing if its location could not be determined (Appendix A). Fish were determined to be either in the Old Lost Creek drainage or in the Yukon River. If a fish was not located during an aerial telemetry flight it was considered at large and, if later located, was assigned the fate of having been in the Yukon River (i.e., YUK) for purposes of the analysis. This approach was chosen because Old Lost Creek was always flown methodically during aerial surveys and the chances of missing a fish that was present were minimal as the creek is narrow and shallow and tags could be heard from a considerable distance while flying over it. Conversely, there was a much greater chance of not detecting a fish in the Yukon River as fish may have resided either in a deep water hole that obscured its signal or outside of the study area. If a fish was never located again after an "at large" designation then it was assigned the fate "missing" for the remainder of the study.

Telemetry flight data not only let us determine which fish remained in the Old Lost Creek drainage but also afforded us the opportunity to determine if fish outside of the drainage were still residing in the Old Lost Creek area. Therefore, these data were analyzed by area instead of by drainage. Fish determined to be at large during a particular flight were assigned to be either in the Old Lost Creek area of the Yukon or outside of that area in the Yukon River using the geometric mean of the proportions of northern pike located in the Yukon River that were located in the Old Lost Creek area during the telemetry flights.

$$p_{OLC-Area} = 1 - \sqrt[n]{(1-p_1)(1-p_2)...(1-p_n)} \quad (1)$$

where

$p_{OLC-Area}$ = The proportion of "at large" fish assigned to being in the Old Lost Creek area of the Yukon River for each telemetry flight; and

p_n = the proportion of northern pike located in the Yukon River on telemetry flight n that were located in the Old Lost Creek area of the Yukon River.

Estimates of Proportions

The proportion of northern pike ≥ 600 mm FL that were estimated to be in the Old Lost Creek drainage and variance estimators were:

$$\hat{p} = \frac{x}{n} \quad \text{and} \quad (2)$$

$$\hat{V}[\hat{p}] = \frac{\hat{p}(1-\hat{p})}{n-1} \quad (3)$$

where,

$\hat{p}$ = the estimated proportion of northern pike that were in the Old Lost Creek drainage;

x = the number of northern pike located in the Old Lost Creek drainage (i.e., with fate OLC); and,

n = the total number of northern pike located (i.e., those with fates OLC and YUK).

The proportion of northern pike ≥ 600 mm FL that were estimated to be in the Old Lost Creek area (i.e., with analyses restricted to aerial telemetry data) using equations 2 and 3 with the terms defined as follows:

$\hat{p}^*$ = the estimated proportion of northern pike that were in the Old Lost Creek area;

x = the number of northern pike located in the Old Lost Creek area; and,

n = the total number of northern pike located (i.e., those with fates OLC and YUK).

Confidence intervals were calculated for both proportion estimates using the following equations presented in Fleiss, 1981 to obtain more appropriate intervals for $0.7 < \hat{p} < 0.3$ than provided using the standard normal approximation:

$$\hat{P}_L = \frac{(2n\hat{p} + c^2_{\alpha/2} - 1) - c_{\alpha/2}\sqrt{c^2_{\alpha/2} - (2 + 1/n) + 4\hat{p}(n\hat{q}+1)}}{2(n + c^2_{\alpha/2})} \text{ and} \quad (4)$$

$$\hat{P}_U = \frac{(2n\hat{p} + c^2_{\alpha/2} + 1) + c_{\alpha/2}\sqrt{c^2_{\alpha/2} + (2 + 1/n) - 4\hat{p}(n\hat{q}+1)}}{2(n + c^2_{\alpha/2})} \quad (5)$$

where:

$\hat{p}$ = the estimated proportion of northern pike that were in the Old Lost Creek drainage or area (i.e., $\hat{p}$ or $\hat{p}^*$);

$\hat{q}$ = $1 - \hat{p}$;

n = the total number of northern pike located; and,

$c_{\alpha/2}$ = the value cutting off the area α/2 in the upper tail of the standard normal distribution.

The proportion of radio-tagged northern pike found within either the Dall River area or Old Lost Creek area during each tracking event was considered an estimate of the proportion of northern pike that remained in the area up to the time of tracking.

Hypothesis Tests

Using the telemetry data to define fates, we tested the following hypothesis for each 10-day period:

H_0: $\hat{p}_{OUT} \leq 0.20$

versus the alternative hypothesis

H_a: $\hat{p}_{OUT} > 0.20$

where $\hat{p}_{OUT}$ is the proportion of northern pike ≥ 600 mm FL that left the Old Lost Creek drainage during open water. For aerial tracking surveys the same hypothesis was tested, however $\hat{P}_{out}$ was the proportion of northern pike ≥ 600 mm FL that left the Old Lost Creek area during open water.

In the event that n>5 for both $\hat{p}_{OUT}$ and $(1-\hat{p}_{OUT})$, methods based on the normal distribution are appropriate to approximate the exact binomial procedures for performing this test. In this case, a z-test was performed using the following test statistic:

$$z = \frac{\left|p_{OUT} - p_{OUT,0}\right| - 1/(2n)}{\sqrt{\frac{p_{OUT,0}(1-p_{OUT,0})}{n}}} \tag{6}$$

where $p_{OUT,0}$ is the proportion specified by the null hypothesis and p_{OUT} is the true underlying proportion estimated by $\hat{p}_{OUT}$. The quantity $1/(2n)$ is a continuity correction, which should be applied only when it is numerically smaller than $\left|p_{OUT} - p_{OUT,0}\right|$ (Fleiss 1981). In the event that the criteria for using the normal approximation were not met, exact binomial procedures were used to perform the test (Mendenhall et al. 1990).

Logistic regression methods were used to model the relationship between the proportion of radio-tagged northern pike remaining in the OLC drainage after the spawning period and the following explanatory variables: 1) the flow rate in the Yukon River (as measured at the USGS gauging station downriver of Stevens Village), 2) the section of Old Lost Creek in which the fish was tagged, 3) the year of observation, and 4) day of the year. Autocorrelation in the model residuals was accounted for using a method based on partial likelihoods (Kedem and Fokianos 2002). Models were fit and diagnostic tests were performed using Splus6 (Insightful Corporation, Seattle, WA).

Length and Age Composition (Objective 2)

We estimated the proportion of northern pike (≥ 450 mm FL) in the Old Lost Creek drainage that were ≥ 720 mm FL. The proportion and variance estimators were:

$$\hat{p}_{>720} = \frac{x}{n} \qquad \text{and} \tag{7}$$

$$\hat{V}[\hat{p}_{>720}] = \frac{\hat{p}_{>720}(1-\hat{p}_{>720})}{n-1} \tag{8}$$

where:

$\hat{p}_{>720}$ = the estimated proportion of northern pike (≥ 450 mm FL) that were ≥ 720 mm FL;

x = the number of northern pike sampled ≥ 720 mm FL; and,

n = the total number of northern pike sampled ≥ 450 mm FL.

The proportion of adult northern pike in the two size groups (450-720 mm and > 720 mm FL) captured within Old Lost Creek drainage during sampling was considered an estimate of the proportion of northern pike at the time of sampling.

Chi-square tests were used to determine if there were significant differences in the proportion of fish ≥ 720 mm FL between areas and years and between fish ≥ 720 mm FL in this study and the fish from the Dall River (Chythlook and Burr 2002). Kolmogorov-Smirnov (K-S) tests were used to determine if there were significant differences in the size distribution of northern pike sampled between 2001 and 2002 (Hollander and Wolfe 1973; Kim and Jennrich 1970).

Ages were estimated from scales in accordance with age identification criteria established by Williams (1955) and Casselman (1967). Because experience has shown that the formation of scale annuli in Alaskan stocks of northern pike generally coincides with the sampling period in late May, ages assigned corresponded to counts of annuli detected on the scales (i.e., assigned age = total age).

Documentation of Locations and Movements (Objective 3)

During aerial tracking events, the location of radio-tagged northern pike were noted on maps and later transposed into latitude and longitude coordinates. During boat surveys the latitude and longitude of a located fish was recorded using a handheld GPS unit. All location data were entered into a geographic information system (GIS) data base using ArcView version 3.2.

To measure movement distances of northern pike, the maximum observed distance from the lower (for fish located downstream) or upper (for fish located upstream) mouths of Old Lost Creek drainage was measured for each fish between spawning events in spring 2001 and spring 2002, between spring 2002 and spring 2003, and after spring 2003. Thus, each fish was assigned one value based on its maximum observed distance from the Old Lost Creek drainage. If a fish was located outside of the drainage in several locations only the distance for the location farthest from the drainage was used.

RESULTS

All data collected during this study were archived in electronic files (Appendix B).

SAMPLING AND TRACKING SUMMARY

Between June 5 and 15, 2001, 60 northern pike were fitted with radio transmitters. The fish ranged in length from 620 to 920 mm FL (Table 2). Five radio tags were deployed in the lower sections and the other 55 radio tags were deployed in the upper portion of the drainage consistent with the proportion of fish sampled in each section for length composition (χ^2 = 2.88, P–value=0.09, df = 1). The length distribution of radio-tagged fish was consistent with the proposed deployment of radio tags in Table 1 (χ^2 = 11.04, P–value=0.09, df = 6). During 2001 and 2002, aerial tracking events were sporadic and the primary means of monitoring movements of fish came from the tracking stations. During the 2003 field season, the tracking station at Old Lost Creek was not functional for the bulk of the field season. However, there were monthly aerial tracking events conducted during the 2003 open water season as well as several tracking events from a boat over the course of the summer.

Table 2.–Number of northern pike radio-tagged and sampled for length composition within the Old Lost Creek drainage during June 2001**.**

Radio Tag Samples		River Drainage Section				
Fork Length (mm)	Total Length (inches)	I	II	III	IV	Total
575-619	24-26	0	0	0	0	0
620-669	26-28	11	1	1	0	13
670-719	28-30	15	3	3	0	21
720-764	30-32	4	1	1	0	6
765-824	32-34	3	4	0	0	7
825-869	34-36	2	2	0	0	4
>870	>36	8	1	0	0	9
	Total Number of Radio-tagged Pike	55		5		60

MORTALITY OF RADIO-TAGGED FISH

By the start of the open water season in 2002, 11 radio-tagged fish (19% of active tags) were judged to have died because they had not moved. Nine of these fish were located during the winter of 2001-2002 in the Old Lost Creek drainage, most of which is dry and/or frozen solid. The two other fish died near the mouth of Old Lost Creek (Figure 2).

By the start of the 2003 open water season 17 additional radio-tagged fish (41% of tags active as of the start of the 2002 open water season) had died. Eight died in Old Lost Creek, three died at the mouth of Old Lost Creek and three died in the Yukon River. Additionally, two fish were taken in the subsistence fishery (one each at Stevens Village and Beaver) and one was taken by a sport fisherman and the tag turned into ADF&G (Figure 2).

During the 2003 open water season two fish (7% of tags active as of the start of the 2003 open water season) were judged to have expired based on their lack of movement and their continued presence in Old Lost Creek in early November when the creek was dry and icing up. An additional tag was last seen in the Old Lost Creek drainage in late summer and may have expired in the drainage. However, this tag expired in late summer of 2003 and we were unable to determine conclusively if it remained in the drainage or if it returned to the Yukon before the creek iced over (Figure 2).

Overall 30 of 59 (51%) of the fish tagged in 2001 suffered mortality during the study period. Of the fish that died over the course of the study three (5% of all tagged northern pike) were known to be harvested by humans. One (1.7% of all tagged fish) was taken by a sport angler. The other two (3.4% of all tagged fish) were presumed to have been taken in subsistence fisheries as one was located in Stevens Village and the other was located in Beaver. Of those not harvested by humans, 19 (32% of all tagged fish) died in Old Lost Creek, five (8% of all tagged fish) died at the mouth and three (5% of all tagged fish) died in the Yukon River (Figure 2).

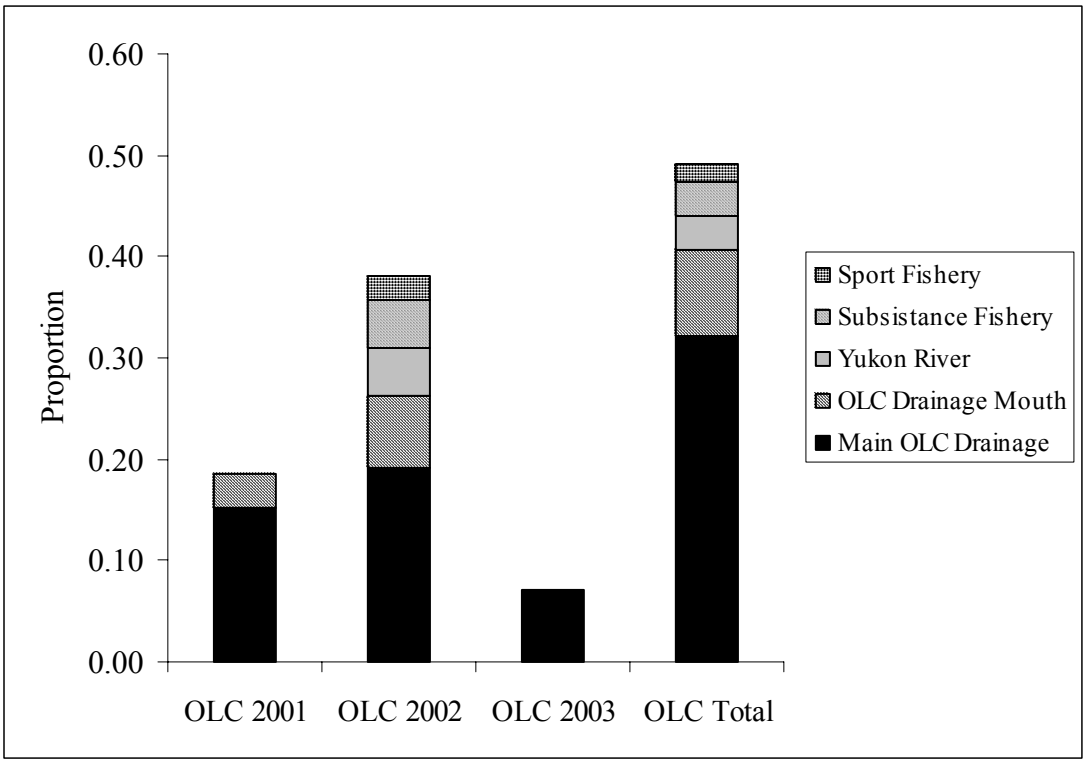

Figure 2.–Proportion of active radio-tagged fish released in Old Lost Creek (OLC) that died during each year in various locations.

INTRA-ANNUAL FIDELITY (OBJECTIVE 1) AND INTER-ANNUAL FIDELITY TO THE OLD LOST CREEK SPAWNING AREA

During the three open water seasons that radio tags were active, similar patterns of movement into and out of the Old Lost Creek drainage were observed. Northern pike generally moved into the drainage after ice out in the spring, remained there through the spawning season and early summer, rapidly left the drainage between early July and river freeze-up, and were essentially out of the drainage during the winter months (Figure 3). During the 2001 open water season the percentage of radio-tagged northern pike that left the Old Lost Creek drainage did not rise significantly above 20% until the last third of July 2001. After this time the proportion of fish outside of the drainage remained above 20% for the duration of the 2001 open water season (Figure 3). During 2002, the proportion of northern pike outside of the Old Lost Creek drainage remained significantly above 20% from February through the first two-thirds of May (Figure 3; Appendix A). From the last third of May through the middle third of June the proportion of fish outside of the Old Lost Creek drainage remained near 20%. From the last third of June through the rest of the open water season the proportion of northern pike located outside the Old Lost Creek drainage rose and remained significantly above 20% (Figure 3). In 2003, the proportion of northern pike outside the Old Lost Creek drainage had a similar pattern to that seen in 2002 (Figure 3).

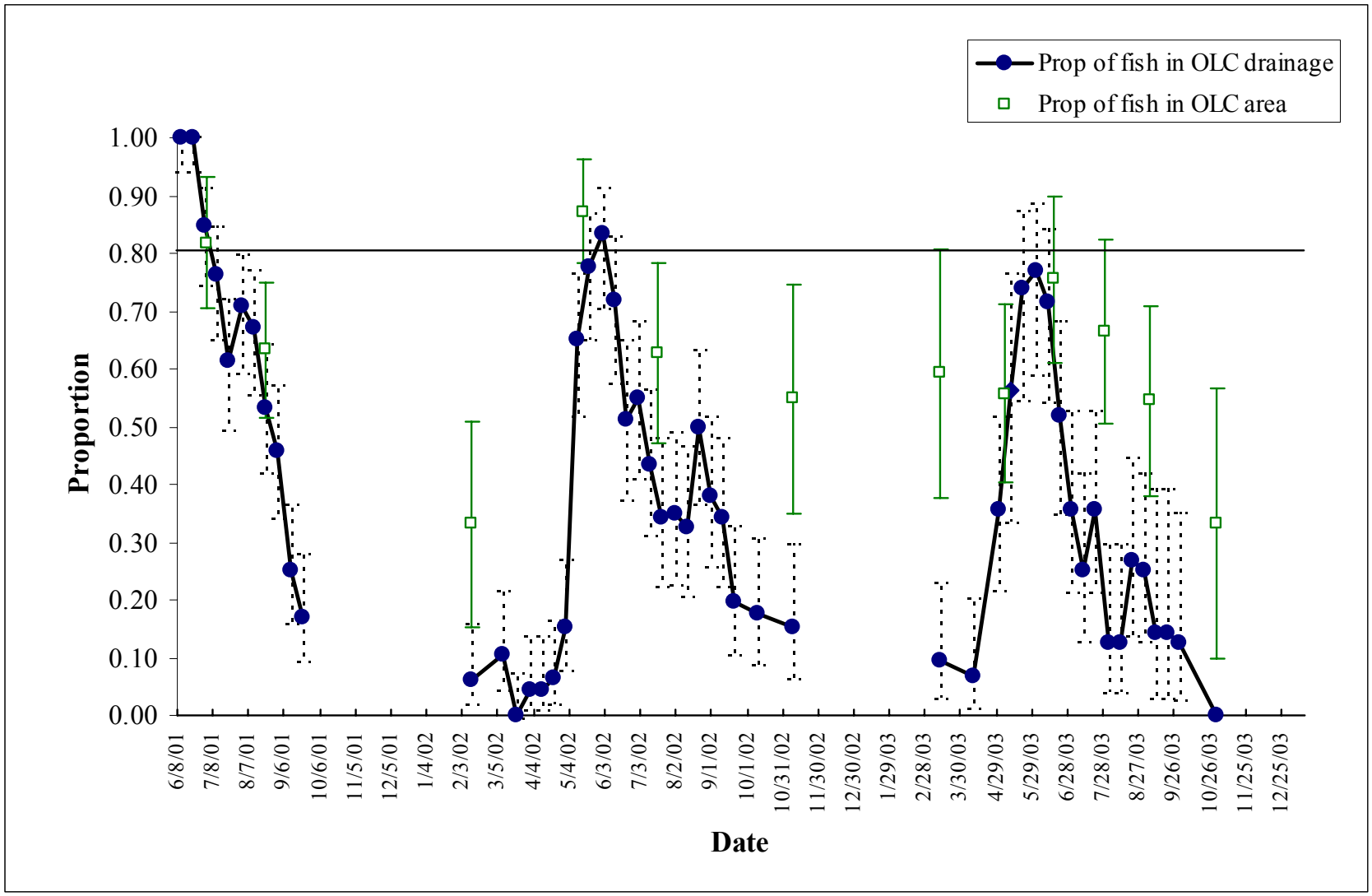

Figure 3.–Proportion of northern pike ≥ 600 mm FL determined to be in the Old Lost Creek drainage and Old Lost Creek area between June 2001 and November 2003. Vertical bars represent 95% confidence intervals.

Aerial survey data, when analyzed separately, revealed a similar pattern of fidelity in radio-tagged northern pike in the larger Old Lost Creek area (Figure 3). For telemetry flights northern pike located in the Yukon River between five km downriver of Jokinaugh Slough and five km upriver of Old Lost Creek were combined with those located in Old Lost Creek and treated as being in the Old Lost Creek area. On the July 3, 2001 telemetry flight less than 20% of the radio-tagged northern pike were located outside the Old Lost Creek area. On August 21, 2001 and February 2002 significantly more than 20% of the fish were located outside the Old Lost Creek area (P-values < 0.01). During the 2002 open water season, there were less than 20% of the northern pike outside the area during the May 16 flight. However, there were significantly more than 20% of the fish outside of the Old Lost Creek area on the July 17 flight (P-value=0.02). Over the 2002/2003 winter there were significantly more than 20% of the northern pike outside the Old Lost Creek area on November 9, 2002 (P-value=0.01) and on March 13, 2003 (P-value =0.045). During the 2003 spawning season there were not significantly more than 20% of the active radio-tagged northern pike outside the Old Lost Creek area during the June 16, 2003 telemetry flight (P-value=0.38). There were significantly more than 20% of the northern pike outside the Old Lost Creek area during telemetry flights on July 29, 2003, (P-value=0.07), May 7 (P-value = 0.01), September 5 (P-value = 0.01), and November 1, 2003 (P-value = 0.01; Figure 3; Appendix A).

Despite the relatively small degree of intra-annual fidelity of northern pike to the Old Lost creek drainage, aerial telemetry data revealed that the proportion of northern pike ≥ 600 mm FL that left the Old Lost Creek area tended to be lower (Figure 3). While there is fair deal of uncertainty with these estimates, the range seen in the estimates suggests that, on average, roughly half of the Old Lost Creek northern pike ≥ 600 mm FL remain in the Old Lost Creek area for the duration of the open water season.

Northern pike ≥ 600 mm FL exhibited a high degree of inter-annual fidelity to Old Lost Creek during the spawning season. The proportion of northern pike in the Old Lost Creek drainage peaked at 0.83 (SE = 0.06) in 2002 in the first third of June and peaked at 0.77 (SE = 0.08) in 2003 in the first third of June. The peak proportion of northern pike ≥ 600 mm FL returning to Old Lost Creek to spawn in 2002 and 2003 was never significantly less than 80% (Figure 3). It is likely that these proportions represent the true values (i.e., not minimum values) for fidelity to the area because we examined: 1) locations for all radio-tagged fish located outside the drainage during the period before the peak period to determine if they had entered the area and then left; and, 2) during the period after the peak to determine if "new" fish had moved in. No such occurrences were documented.

Logistic Regression

Logistic regression models demonstrated that the proportion of radio-tagged northern pike remaining in the Old Lost Creek drainage after the spawning period depended upon the flow rate in the Yukon River, the section of the river in which the northern pike was caught when tagged (i.e., the upper or lower part of the drainage), the year of observation, and the day of the year. Autocorrelation in the residuals was modeled using a method based on partial likelihoods (Kedem and Fokianos 2002). The preferred model was selected using model selection criteria AIC (Akaiki Information Criterion; Akaike, 1973); AICc, small sample size AIC (Hurvich and Tsai 1989; Burnham and Anderson 1998); and QAICc, dispersion adjusted, small sample size AIC (Lebreton et al. 1992; Burnham and Anderson 1998). Residuals were centered about zero and showed no clear patterns. An autocorrelation function of the residuals showed no significant

temporal dependencies. The family of logistic regression equations for the preferred model is of the form:

$$\pi_t(\hat{\boldsymbol{\beta}}) = \frac{1}{1+\exp-\left\{\left(\hat{\beta}_0 + \hat{\beta}_1 flow + \hat{\beta}_2 location + \hat{\beta}_3 year + \hat{\beta}_4 day + \hat{\beta}_5 propIN_{t-1}\right)\right\}} \quad (9)$$

where

$\pi_t(\hat{\boldsymbol{\beta}})$ = Proportion of northern pike in the OLC drainage at time t

$$= \frac{e^{\hat{\beta}_0+\hat{\beta}_1 flow+\hat{\beta}_2 location+\hat{\beta}_3 year+\hat{\beta}_4 day+\hat{\beta}_5 propIN_{t-1}}}{1+e^{\hat{\beta}_0+\hat{\beta}_1 flow+\hat{\beta}_2 location+\hat{\beta}_3 year+\hat{\beta}_4 day+\hat{\beta}_5 propIN_{t-1}}};$$

$\hat{\boldsymbol{\beta}} = (\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_3, \hat{\beta}_4, \hat{\beta}_5)$ = vector of estimated coefficients;

flow = Yukon River daily discharge (ft^3/sec);

location = Section of the Old Lost Creek drainage (i.e., upper and lower river);

year = Year of observation (i.e., 2001, 2002, and 2003);

day = Day of year (Julian day beginning 1/1 of each year); and,

$propIN_{t-1}$ = Proportion of northern pike in the Old Lost Creek drainage at time t-1.

The parameter estimates for the fitted model are provided in Table 3.

Table 3.-Estimated coefficients, corresponding standard errors, and t-values for the logistic regression model run to determine if flow rate in the Yukon River, tagging location, year of observation and day of the year (Julian date) were related to the proportion of fish located in Old Lost Creek.

Coefficients	Value	Standard Error	t-value
Intercept	-1.21	4.05e-001	-2.99
Flow	8.93e-006	1.17e-006	7.62
Location (Upper)	Set to zero		
Location (Lower)	-9.73e-001	2.52e-001	-3.85
Year 2001	Set to zero		
Year 2002	2.31	5.01e-001	4.62
Year 2003	4.54	1.06	4.27
Day	-7.04e-003	1.50e-003	-4.70
$PropIN_{t-1}$	1.78	3.79e-001	4.71

The proportion of radio-tagged northern pike that remained in Old Lost Creek drainage after spawning each year was significantly lower for northern pike tagged in the lower river than for those tagged in the upper river. While the sample size for the lower river was small (n_{lower}=5; n_{upper}=55), the proportion of these fish that remained in Old Lost Creek after spawning was consistently less than that for the upper river during each of the three years resulting in the statistically significant result. Additionally, only one of the five fish tagged at the mouth of Old

Lost Creek was ever detected in the upper sections of Old Lost Creek and this only occurred on one occasion over the course of the study.

Comparing the observed proportions and the 95% confidence intervals for the model mean response estimates shows good agreement with the general pattern; however, many of the observations lie outside the confidence intervals (Figure 4). The lack of fit is most extreme for the lower stratum primarily due to the small sample sizes ($n \leq 5$), which results in punctuated estimates. The observed proportions can only take on a limited number of values (e.g., 0 = 0 of 5 fish, 0.2 = 1 of 5 fish, 0.25 = 1 of 4 fish, or 0.33 = 1 of 3 fish and no values intermediate to these). Lack of fit was also evident, though to a lesser degree, in the upper stratum. Of those values lying outside of the confidence intervals for the upper stratum, 67% were within 0.05 of the confidence limit and 93% were within 0.10 of the confidence limit. "Extra" variability (i.e., that not addressed by the binomial model) can be quantified by the variance inflation factor, $\hat{c} = \frac{Deviance}{df}$, where $Deviance$ and the degrees of freedom, df, are taken from the most highly parameterized model in the candidate set. For this model $\hat{c} = 1.36$, indicating that the model was over dispersed (values close to 1 indicate no dispersion).

The flow rate or daily discharge (ft^3/sec) for the Yukon River measured at the USGS gauging station downriver of Stevens Village was near maximum at the time of spawning and decreased to a minimum by the end of winter. Within the seasonal decline in daily discharge were episodes of increased flow and corresponding increases in the proportion of radio-tagged northern pike in the Old Lost Creek drainage (Figure 5). There were a similar number of peaks in both time series and while the peaks were sometimes in phase they were often partially or completely out of phase. The correlation of these fluctuations was strong enough, however, that flow rate was an important covariate even with a covariate for day of year (which effectively removed the seasonal trend).

MOVEMENT INTO AND OUT OF THE DALL RIVER (TASKS 1-3)

Only a very minor portion of the Old Lost Creek radio-tagged northern pike was detected at or near the Dall River tracking station. In 2001 one fish (2% of active tags) was recorded at the Dall River station in mid and late August (Appendix C3). No fish were detected at or near the Dall River tracking station in 2002. In 2003 one fish (5% of active tags) was located at the Dall River tracking station in early August and was not subsequently relocated. A different fish was located at the tracking station in mid August and subsequently recorded at or near the Dall River tracking station in late September and early October and at the mouth of the Yukon River canyon on November 1 (Appendix C8).

Northern pike fitted with radio transmitters in the Dall River drainage in 1999 and 2000 were detected by the Old Lost Creek tracking stations during 2001 (Table 4). In June, 2001 eight (19%) of the located and still viable transmitters were located in Old Lost Creek. In July and August 2001 only four (9%) Dall River northern pike were observed in Old Lost Creek.

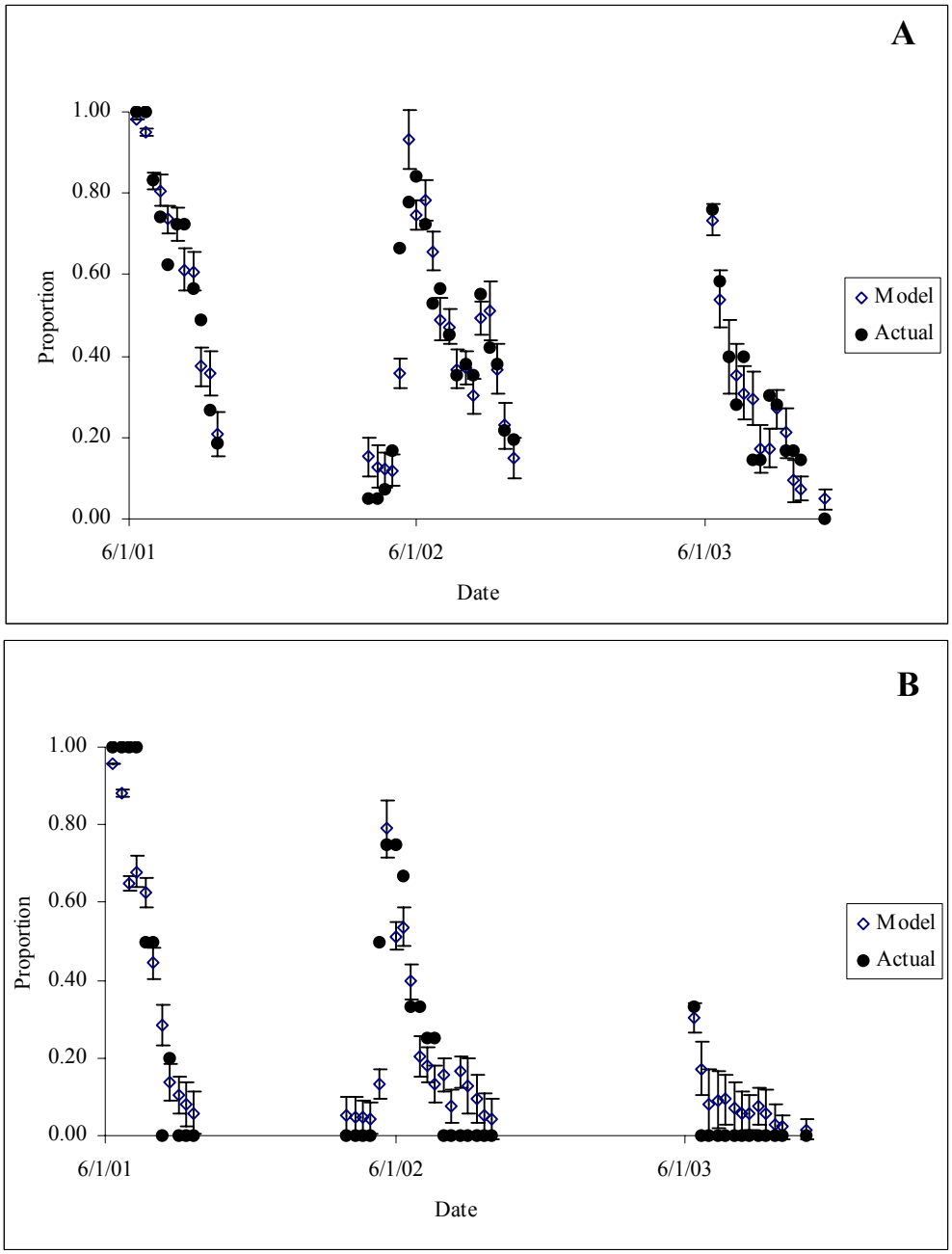

Figure 4.–The actual and predicted proportions of northern pike in Old Lost Creek drainage for those fish tagged in the upper Old Lost Creek drainage (A) and for those fish tagged in the mouth of Old Lost Creek (B). Error bars represent 95% confidence intervals.

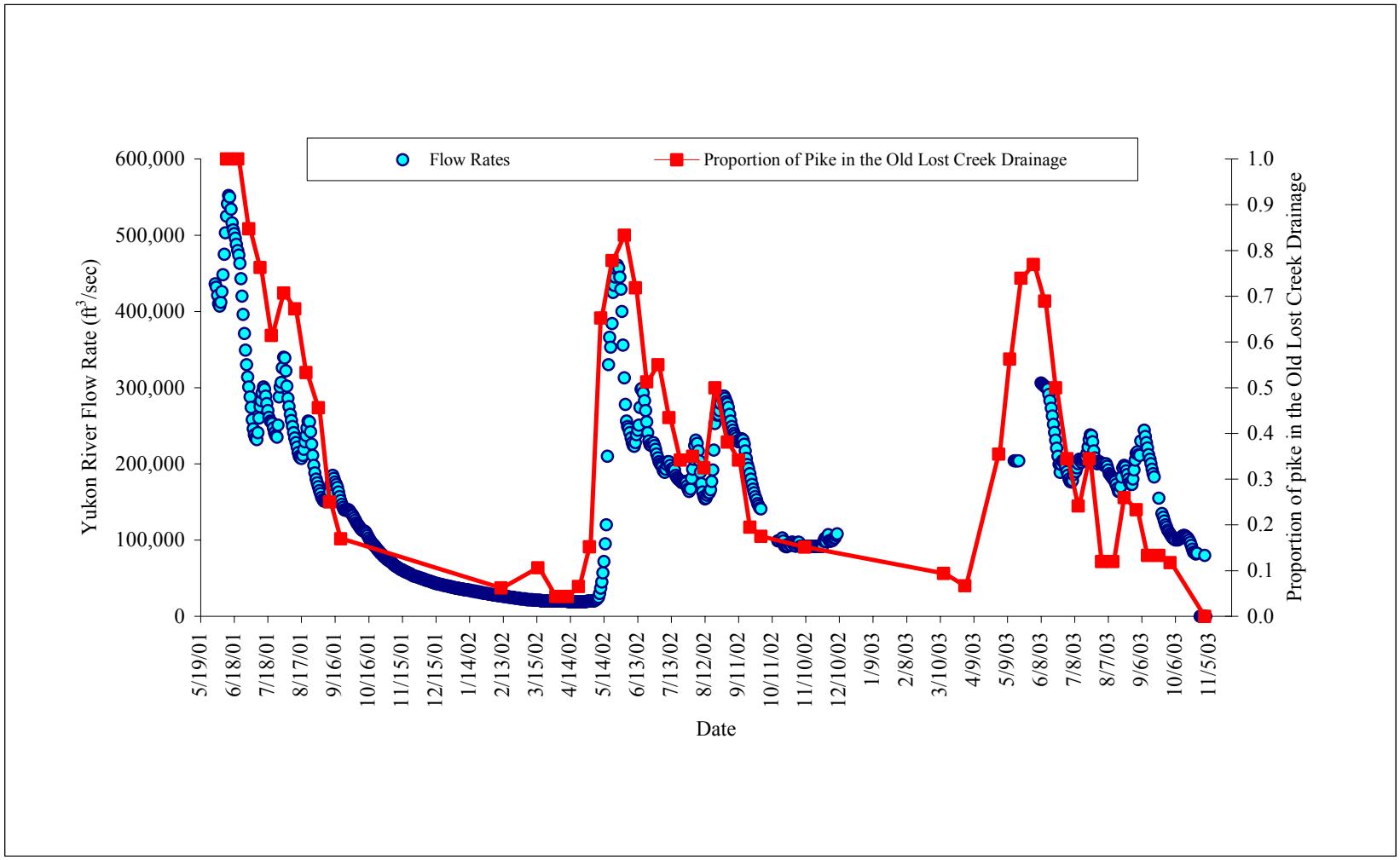

Figure 5.–Estimated proportion of northern pike ≥ 600 mm FL in the Old Lost Creek drainage (squares connected by line) and the flow rate of the Yukon River as measured by the gauging station downriver of Stevens Village (circles).

Table 4.–Locations during 2001 of northern pike radio-tagged in the Dall River in 1999 and 2000 and the corresponding proportion (p) of all known active tags in live fish.

	Dall River		Yukon River		Old Lost Creek		Unknown
Month	Number	P	Number	p	Number	p	Number
June	28	0.65	7	0.16	8	0.19	9
July	34	0.74	8	0.17	4	0.09	6
August	29	0.74	6	0.15	4	0.10	13
September	21	0.62	13	0.38	1	0.03	17

The proportion of northern pike radio-tagged in the Dall River in 1999 that left the Dall River in 2000 and 2001 is documented in detail in Chythlook and Burr (2002). In 2000 the proportion outside of the Dall River area stayed below 20% throughout the open water season until September when it rose to 51%. In 2001, the proportion of fish outside of the Dall River area stayed above 20% throughout the open water season; it was 35% in June, 26% in July, 26% in August and 40% in September (Chythlook and Burr 2002).

LENGTH COMPOSITION (OBJECTIVE 2)

During the June, 2001 sampling period, 365 northern pike larger than 450 mm FL were sampled in Old Lost Creek. The 60 northern pike fitted with radio transmitters were included in this sample. Nearly all of the samples were collected in the upstream sections; 289 (83%) were sampled from sections I and II (Table 5).

The proportion of northern pike (≥ 450 mm FL) that were ≥ 720 mm FL in Old Lost Creek in June 2001 was estimated to be 0.21 (SE = 0.02; Table 5). The proportions of large fish caught in each of the four sections of the Old Lost Creek study areas were similar (Table 5). Chi-square tests failed to reject the hypothesis of equal proportions of large fish when comparing all four sections (χ^2 = 2.25, P-value = 0.52, df = 3), when comparing the upper two sections with the lower two (χ^2 = 1.53, P-value = 0.22, df = 1), and when comparing section one with all others combined (χ^2=0.16, P-value = 0.69, df = 1).

During the June 2002 sampling period, 285 northern pike larger than 450 mm FL were sampled in Old Lost Creek, all of them in the upper sections. As a result of the geographic distribution of northern pike in Old Lost Creek observed in 2001 and the noticeable difference in habitat (Sections I and II were most characteristic of northern pike spawning habitat (Bry 1996), sampling in 2002 focused on upstream locations (sections I and II; Appendix C). The proportion of northern pike ≥ 450 mm FL that were ≥ 720 mm FL in Old Lost Creek in June 2002 was estimated to be 0.27 (SE = 0.03; Table 5).

There was a significant difference in the proportion of fish greater than 720 mm FL in Old Lost Creek between 2001 and 2002 (χ^2 = 3.74, P-value = 0.05, df = 1). However, when comparing 2001 results from the upper river (sections I and II) with 2002 results, the difference in the proportion of fish greater than 720 mm FL was not significant (χ^2 = P–value = 0.21, df =1).

Table 5.–Number of northern pike sampled for length composition within the Old Lost Creek drainage during June 2001 and June 2002.

	River Drainage Section				Total
	I	II	III	IV	
		2001			
Total number of samples for length composition	257	32	41	18	348
Number <720 mm (30 in)	201	23	35	15	274
Number ≥720 mm (30 in)	56	9	6	3	74
Proportion (p) ≥ 720 mm	0.22	0.28	0.15	0.17	0.21
SE (p)	0.03	0.08	0.06	0.09	0.02
		2002			
Total number of samples for length composition		285			285
Number <720 mm (30 in)		208			208
Number ≥720 mm (30 in)		77			77
Proportion (p) ≥ 720 mm		0.27			0.27
SE (p)		0.03			0.03

A K-S test demonstrated that there was a significant difference in the size distribution of fish sampled in Old Lost Creek in 2001 and 2002 (D-statistic = 0.12; P-value = 0.02). Results from this test showed that there were more, large fish in the second year of the study than in the first year (Figure 6). Similarly, the age distributions of the two samples indicated the fish sampled in 2002 were generally older than those sampled in 2001 (Figure 7).

LOCATIONS AND MOVEMENT (OBJECTIVE 3)

Northern pike tagged in Old Lost Creek were detected in the Yukon River as far as 38.1 km upriver from the mouth of Old Lost Creek toward the upper end of Marten Island, and as far downstream as 56.6 km downriver of Jokinaugh Slough near the entrance to the canyon (Figures 8 and 9). There was no apparent preference by radio-tagged northern pike to move either upriver or downriver from the Old Lost Creek drainage once in the Yukon River (Figure 10). Between tagging and the 2002 open water season, fish moved between 0 and 56.6 km from the Old Lost Creek drainage. Of fish that were alive and left the drainage, the average maximum observed movement was 5.6 km (SE = 1.54). Between spawning in 2002 and spawning in 2003 fish moved between 0 and 35.4 km with an average maximum observed movement of 6.3 km (SE = 1.58) from the Old Lost Creek drainage. After the 2003 spawning season fish moved between 0 and 51.5 km from the Old Lost Creek drainage. Of fish that were alive and left the drainage, the average maximum observed movement was 10.8 km (SE = 3.26). The movements of some of the more mobile northern pike are shown in Appendix C.

Of the fish that left the Old Lost Creek area during the study, two were detected both above and below the area between the spawning seasons of 2001 and 2002 and one was located both above and below the area between the 2002 and 2003 spawning seasons. The rest of the fish that were detected outside of the Old Lost Creek area were located either below or above the study area only.

DISCUSSION

SAMPLE REPRESENTATIVENESS

The 2001 sample was considered representative of northern pike in the Old Lost Creek drainage because sampling occurred just after spawning, a time when these fish congregate in Yukon River tributaries in locations having favorable habitat, and because fishing effort was distributed evenly across all sections. In 2001, the upper portion of the drainage proved to be the only area where substantial numbers of northern pike were caught; 83% of the sample in 2001 was from sections I and II. The upper sections pass through broad areas and small lakes that are lined with abundant emergent vegetation. The lower two sections consist mainly of a narrow channel with minimal emergent vegetation. Given that the vast majority of fish were caught in the upper sections, that northern pike caught in the lower sections were likely to have been either moving toward or leaving the upper portions of the drainage that contained favorable spawning habitat, and the similarity in the proportion of northern pike $\geq$ 720 in the upper and lower river in 2001, sampling in the 2002 field season was focused in the upper two sections. It was concluded that the upper portions of the drainage were preferred by the Old Lost Creek northern pike stock and that sampling in these areas would give a representative sample of the northern pike in the population.

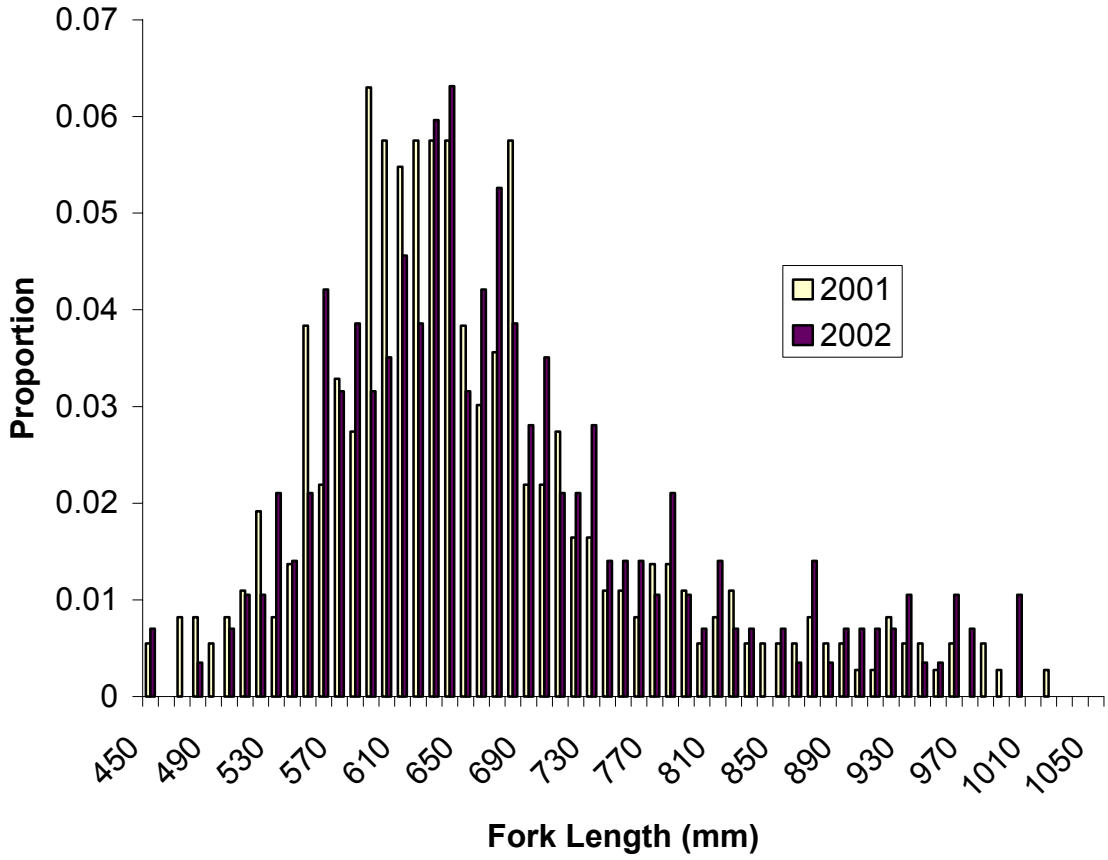

Figure 6.–Size distribution of northern pike sampled in Old Lost Creek in 2001 and 2002.

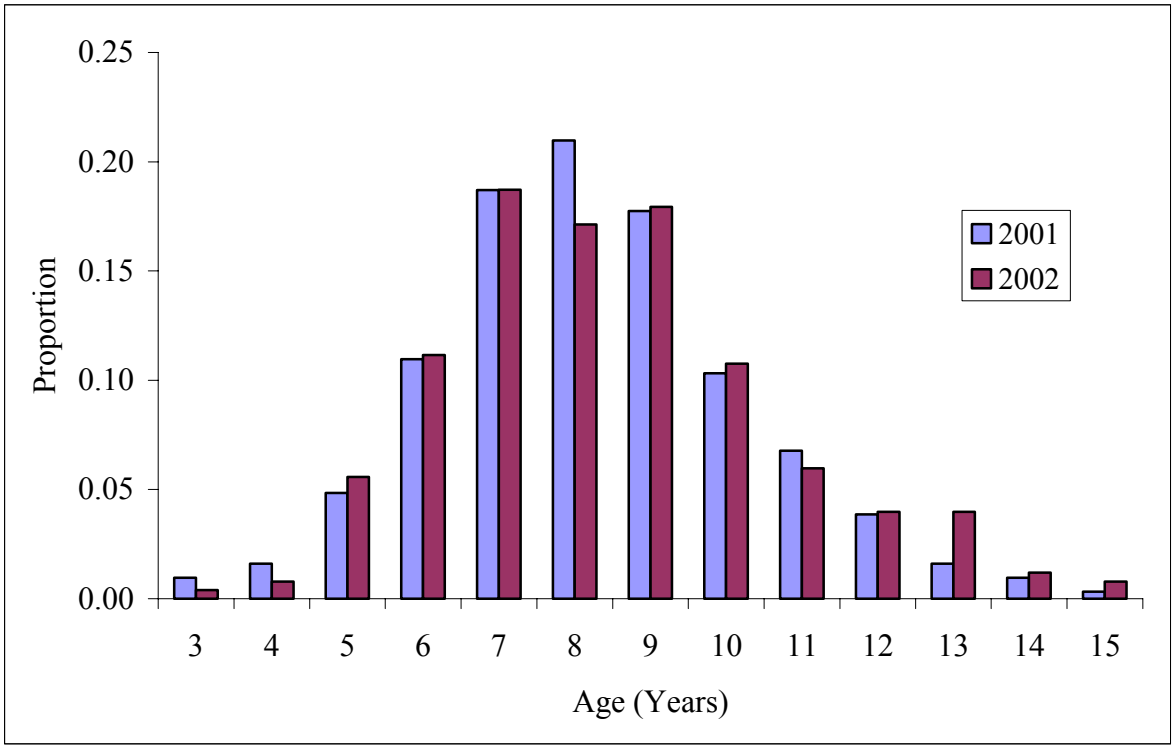

Figure 7.–Age distribution of northern pike sampled in Old Lost Creek in 2001 and 2002.

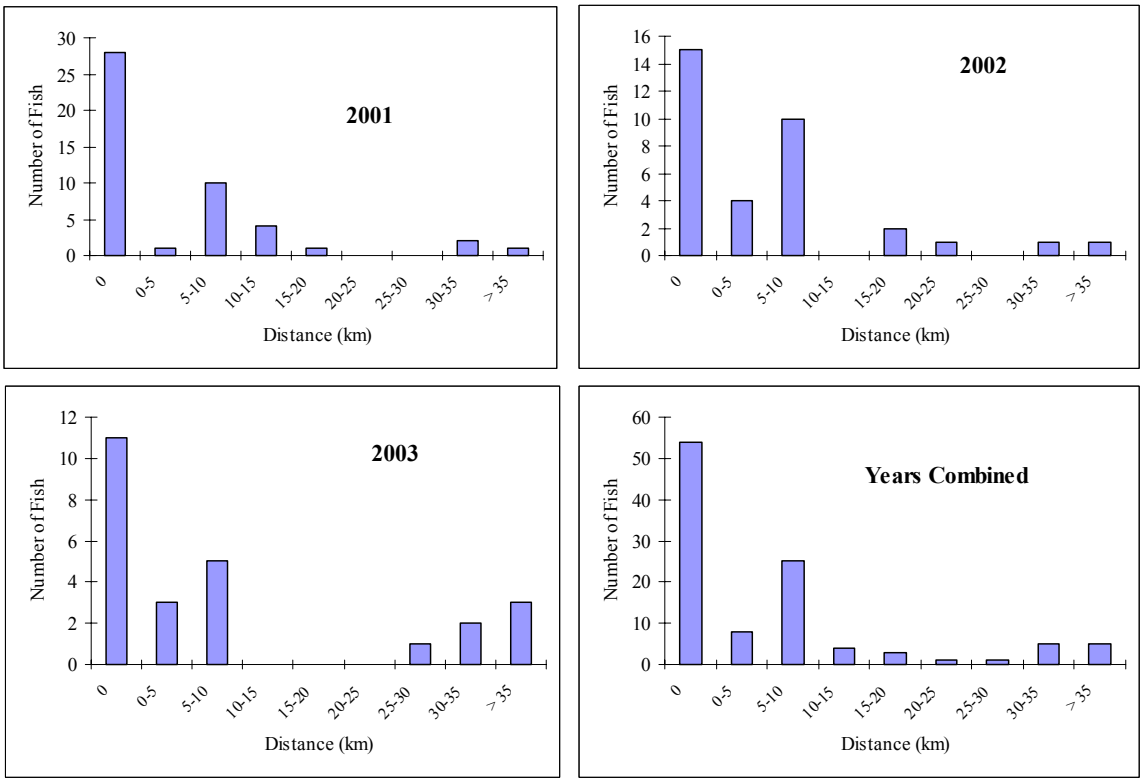

Figure 8.–Maximum observed distances moved by radio-tagged northern pike from the Old Lost Creek drainage during three years of study and for all years combined.

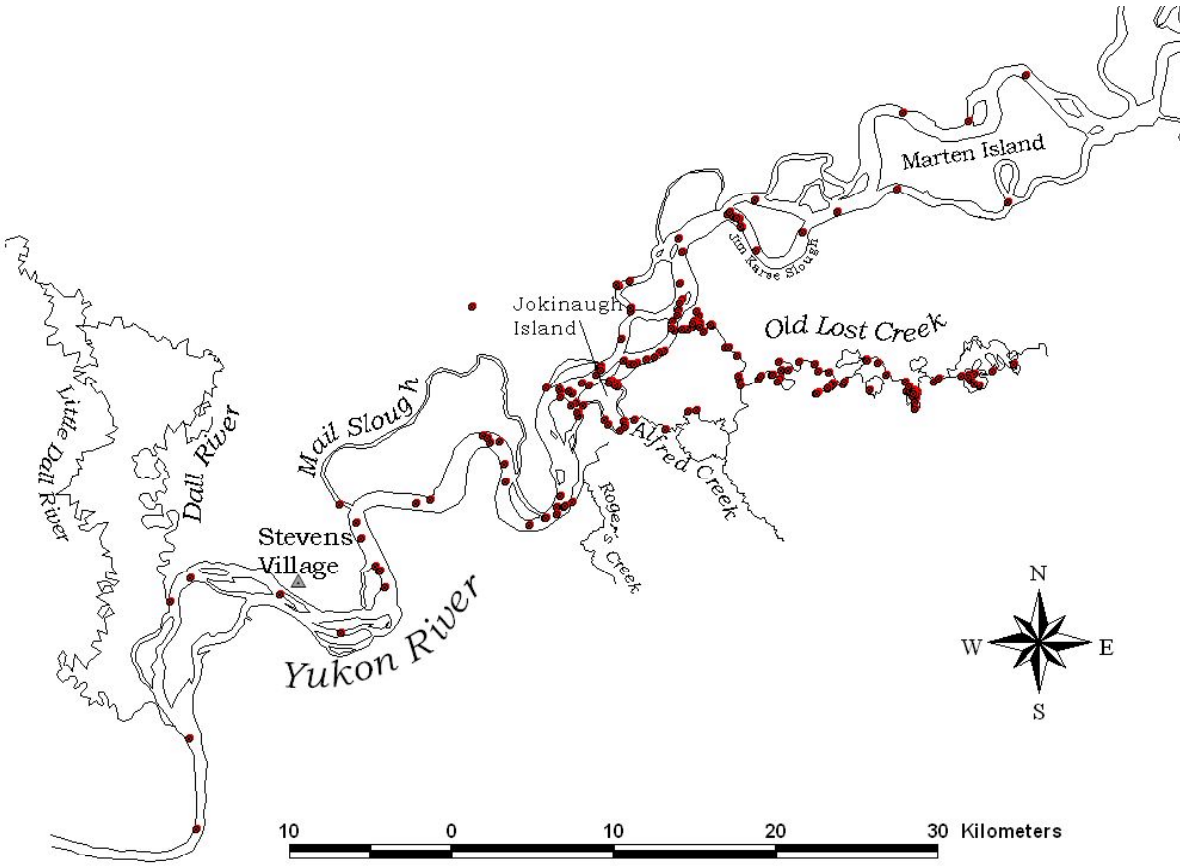

Figure 9.–Locations of all live northern pike detected between June 2001 and November 2003.

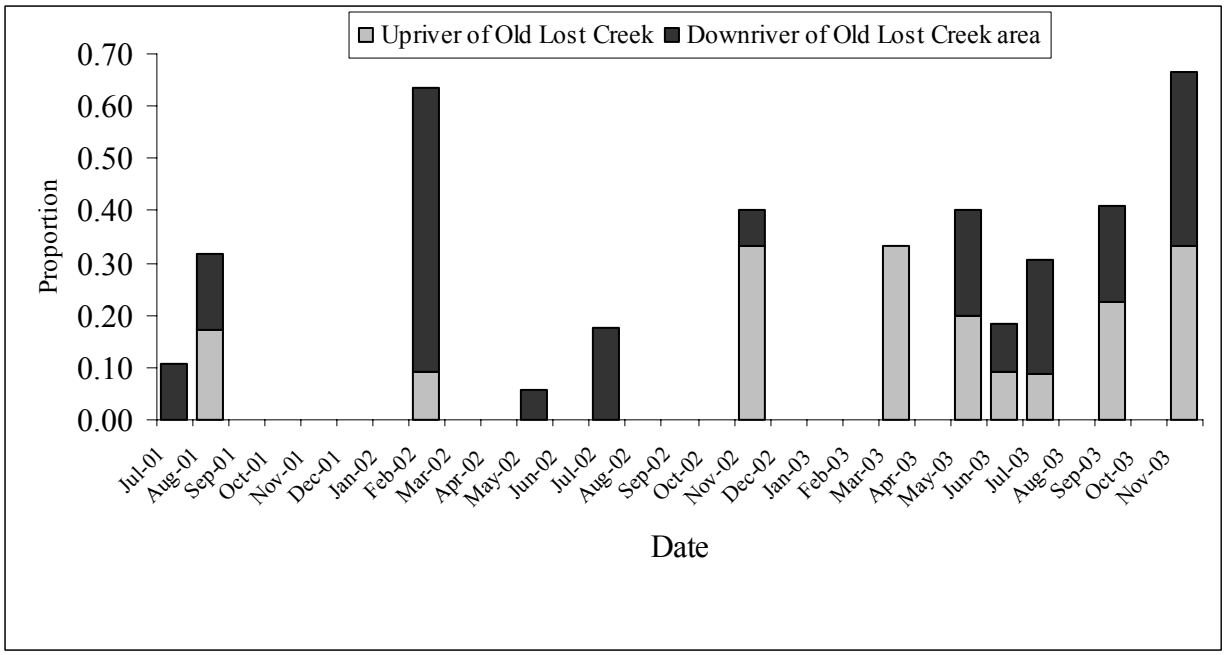

Figure 10.–Proportion of all northern pike located during telemetry flights that were upriver and downriver of the Old Lost Creek area in the Yukon River.

Although the sampling in both years was thought to be representative, comparison of the 2001 and 2002 samples revealed differences in length composition between the 2001 and 2002 samples. A K-S test comparing the length distribution of fish caught in the two years found a significant difference with the largest differences occurring in the size range 626-629 mm FL. In addition, chi-square tests indicated that the proportion of fish ≥720 mm FL was also different, and that this difference was likely due to the exclusion of the lower part of the drainage from the sample in 2002. A chi-square test indicated that the fish caught in the upper portion of the drainage in both years had a similar proportion of fish ≥720 mm FL. However, it is also possible that differences in composition between years do not necessarily indicate size selective sampling. Natural factors such as mortality and recruitment could explain differences in composition.

The sample of northern pike that were radio-tagged in 2001 was considered representative of the Old Lost Creek pike stock because they were deployed in proportion to the catch in the upper and lower sections of the drainage. Although a K-S test demonstrated that the length distribution of radio-tagged fish was different from that of all sampled fish ≥ 600 mm FL, the sample of radio-tagged fish was comparable for size ranges ≥ 625 mm FL indicating that too few radio tags were deployed for fish ranging in size from 600 to 625 mm FL. It is not believed that fish in this size category would exhibit any biologically significant difference in behavior or distribution.

The results of the logistic regression model indicated that the location in which a fish was tagged (i.e., upper or lower drainage) was related to their movement and that fish tagged at the mouth of Old Lost Creek spent more time out of the drainage than did those tagged in the upper portion of the drainage. These results would indicate that the estimates of the proportion of northern pike that were in Old Lost Creek should be stratified according to the tagging location of the fish. However, given the small number of fish tagged in sections III and IV (n = 5) stratified

estimates, weighted by the proportion of tags released in each stratum, are virtually identical to the pooled estimates. The results from the pooled estimates were presented.

The reason for the dependence of proportion of time spent in the Old Lost Creek drainage on tagging location is unknown. Whether it reflects a difference in the behavior of the stock or simply a matter of proximity to the Yukon River is not known. Fish radio-tagged at the mouth of Old Lost Creek (average length of 685 mm FL, SE = 15.81) were significantly smaller than those radio-tagged in the main portion of the drainage (average length of 743 mm FL, SE = 13.18; P-value <0.01) which may or may not be related to the observations.

One hypothesis, stemming from the differences seen in length distribution (see below), is that the there are more males at the mouth of the creek in June (only female northern pike are known to achieve lengths ≥750 mm (Casselman 1996), and differences seen in movement are a reflection of differences seen in the movement patterns of male and female northern pike. Alternatively, the differences in movement behavior may be the result of differences in movement of big and small northern pike resulting from competitive interactions that may result in the exclusion of smaller fish from the more preferred habitat of the upper drainage. There are certainly other explanations for the results that were observed in this study. However, there is not enough data to support more than speculation as to the reasons why northern pike radio-tagged at the mouth of Old Lost Creek behaved differently from those tagged in the upper drainage.

It is possible that there are important biological differences in the northern pike that reside in the upper and lower portions of the drainage during spawning and that tagging more northern pike in the lower sections of the drainage may provide additional insight regarding the population structure and seasonal movements of the Old Lost Creek stock.

RADIOTELEMETRY (OBJECTIVE 1 AND TASKS 1-3)

Mortality of Radio-tagged Fish

Our mortality rates were similar to those reported from the Dall River (Chythlook and Burr 2002). In 1999 15 (17%) of Dall River tagged fish were reported to have died with two (3%) being taken in the sport fishery and two (3%) being taken in the subsistence fishery.

The estimates of radio-tagged fish harvested in the sport and subsistence fishery are minimum estimates, because it is possible that tags from harvested fish were discarded at the location of harvest and not reported. Additionally, radio tags could have been taken by sport or subsistence fishermen outside of the study area where their signals were not detectable by telemetry flights. At least one expired tag at the mouth of Old Lost Creek was out of the water (judging by its very strong signal) and may be an example of harvested fish that was not reported.

Intra-annual Fidelity (Objective 1) and Inter-annual Fidelity to Spawning Area

Northern pike tagged in Old Lost Creek spent considerably more time in the Yukon River than did northern pike tagged in the Dall River in 1999. Whereas over 80% of fish remained in the Dall River through August in 1999 and 2000 (Chythlook and Burr 2002), over 80% of fish remained in Old Lost Creek through only mid July in 2001 and through mid June in 2002 and 2003. The strong correlation between water flow in the Yukon and the proportion of fish in Old Lost Creek (Figure 5; Table 3) may explain the lower proportion of fish remaining in Old Lost Creek. We were unable to travel by boat up Old Lost Creek on July 8, 2003 as the creek was dry roughly a mile above the mouth. The Dall River has a considerably deeper channel above its mouth and thus may provide suitable, and even preferable, habitat for northern pike throughout

most of the open water season. While the Yukon River may not be preferable habitat for northern pike as compared to the Old Lost Creek drainage, the simple lack of water and habitat may force Old Lost Creek northern pike into the Yukon River. Evidence from this study and the Dall River study (Chythlook and Burr 2002) suggests that northern pike greater than 600 mm FL in the Yukon Flats study area exhibit a great deal of inter-annual fidelity to their spawning streams.

Radiotelemetry Tasks 1-3

It appears that movement of northern pike between the Dall River and Old Lost Creek is predominantly in one direction: from the Dall River to Old Lost Creek. While up to 19% of radio-tagged northern pike from the Dall River were detected at the Old Lost Creek drainage, only sporadic and occasional fish (5% at most) radio-tagged in Old Lost Creek were detected at the Dall River. These results may be indicative of a source-sink relationship between the two populations of fish as the Dall River may produce an over abundance of fish that are forced to emigrate to other drainages to find suitable habitat while the Old Lost Creek drainage does not provide such a surplus. There may be other explanations for why northern pike from the Dall River spent some time in the Old Lost Creek drainage and not vice-versa. Current information is inadequate for more than speculation.

LENGTH COMPOSITION (OBJECTIVE 2)

Old Lost Creek and the Dall River appear to support relatively similar proportions of large (>720 mm FL) northern pike (Figure 11). Two years of sampling northern pike in the Old Lost Creek drainage indicates that the proportion of northern pike greater than 720 mm FL was greater than 20% and similar to the results from the Dall River study in 1999 and 2000 (Chythlook and Burr 2002; Figure 11). The proportion of fish greater than 720 mm FL in the Dall River was 0.24 (SE = 0.02) in 1999 and 0.31 (SE = 0.03) in 2000. In a comparison of the ratio of fish larger than 720 mm FL from Old Lost Creek in 2001 and 2002 and the Dall River in 1999, no difference was detected ($\chi^2 = 3.76$, P-value = 0.15, df = 2). However, there were significantly more fish greater than 720 mm FL in the Dall River in 2000 than in either year in Old Lost Creek ($\chi^2 = 10.70$, P-value < 0.01, df = 2; Figure 11). Although there were significantly more big fish in the 2000 Dall River sample than in the other three samples, the difference (0.31 compared 0.21, 0.27 and 0.24) is not pronounced. Also, there does not appear to be a major difference in the proportion of large northern pike in Old Lost Creek compared to the samples taken by ADF&G in 1988 (Arvey and DeCicco 1989). In July 1988, 430 northern pike larger than 450 mm FL were captured, tagged and released in Old Lost Creek. The proportion of northern pike larger than 720 mm FL in the 1988 sample was 0.18 (SE = 0.02). There was no significant difference in proportion of large fish between the 1988 and 2001 samples ($\chi^2 = 0.89$, P-value = 0.34, df = 1). However, there was a significant difference between the 1988 and 2002 samples ($\chi^2 = 8.42$, P-value < 0.01, df = 1; Figure 11) with a greater proportion of large fish being captured in 2002.

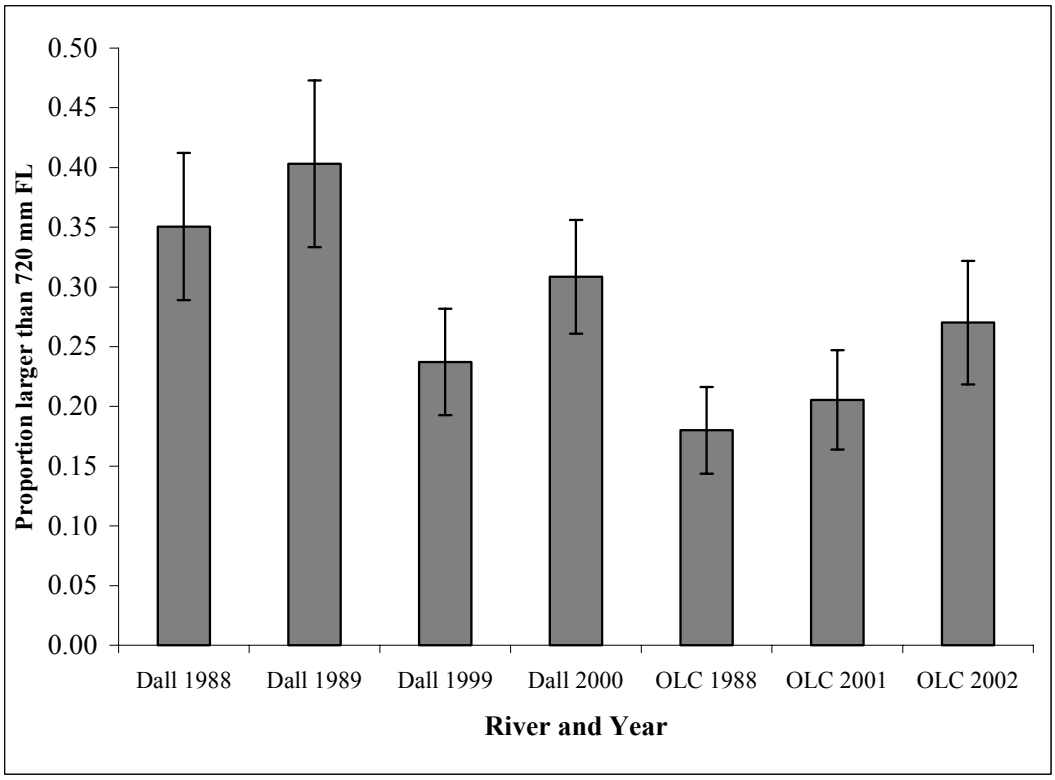

Figure 11.–Proportion of sampled northern pike larger than 720 mm FL at the Dall River in 1988 - 1989 and in Old Lost Creek (OLC) in 1988, 2001, 2002. Data from Arvey and DeCicco (1989; Dall River 1988 and OLC 1988), Arvey and Burkholder (1990; Dall River 1989), and Chythlook and Burr (2002; Dall River 1999 and 2000 and OLC 2001).

Differences in the population of large fish seen in the upper and lower sections of Old Lost Creek may be related to the distribution of female pike. Because only female northern pike are known to achieve lengths ≥750 mm (Casselman 1996), we examined differences in the proportions of fish ≥750 mm FL (as opposed to 720 mm FL used in the analysis). Differences in the proportion of pike ≥ 750 mm FL seen in the upper sections (0.17) versus the lower sections (0.07) were significant at the 92% confidence level ($\chi^2 = 3.15$, P-value = 0.07, df = 1). It may be that the lack of significance in the sectional differences in 2001 was a result of low power and there was, in fact, a smaller proportion of large fish in the mouth than in the upper drainage. This would also lend a partial explanation to the lower proportion of large fish (0.18) seen in the 1988 study (Arvey and DeCicco 1989) when fish were sampled primarily at the mouth.

LOCATIONS AND MOVEMENT (OBJECTIVE 3)

Northern pike tagged in the Old Lost Creek drainage exhibited a fair degree of movement in the Yukon River after spawning, but the number of tracking events was insufficient to make more definitive statements about the movement of northern pike in the Yukon River after spawning and over winter.

Northern pike were located regularly at certain locations in the Yukon River. The lower mouth of Jim Karse Slough, the mouth of Roger's Creek, the area around Jackson Island, and Windy Bend were all locations in the Yukon River that provided habitat that was frequented by Old Lost Creek northern pike (Figure 9; Appendix C). It was not possible to determine with the current data why northern pike preferred these areas or what the habitat characteristics of the areas were compared to other locations in the Yukon River. Future studies meant to address these questions would have to consider such habitat variables as water flow and turbidity, upwellings, and the availability of cover material such as sunken trees and debris, as well as prey availability.

Additionally, northern pike were not detected in any other streams upriver of Old Lost Creek. However, only in 2003 did telemetry surveys extend all the way to the village of Beaver, 91 km upriver of Old Lost Creek. Nevertheless, the farthest that northern pike were detected was around Marten Island and all were waters of the mainstem Yukon River.

CONCLUSIONS

Current fishing pressure does not appear to have depleted or altered the Old Lost Creek stock based on comparisons to 1988 samples. The Old Lost Creek northern pike stock appears to contain a similar proportion of large fish to that of the Dall River and age and length distributions are comparable to historical levels.

Telemetry data from this study indicated that only a small portion of the Old Lost Creek stock (~ 5%) traveled as far as the Dall River and therefore were not vulnerable to harvest outside of the immediate area. The area around Jackson Slough, just upriver from Steven's Village, was also a location where fish from Old Lost Creek were regularly located. Thus, it may be likely that Old Lost Creek northern pike are harvested in the Dall River fishery and in the Jackson Slough fishery; however it is probably only a small percentage of the Old Lost Creek stock. Conversely, up to 19% of radio-tagged pike from the Dall River were located at the Old Lost Creek tracking station and therefore vulnerable to exploitation outside of the Dall River area.

Although few northern pike from the Old Lost Creek fishery were detected near the Dall River, most northern pike from the stock spent the bulk of the open water season in the mainstem of the Yukon River and roughly half of the radio-tagged northern pike were detected outside of the Old Lost Creek area of the Yukon River. Thus, this stock of fish appears to be vulnerable to harvesting in the Yukon River for the majority of the year. It is likely that northern pike caught in subsistence gill nets in the Old Lost Creek area are from the Old Lost Creek stock. During low water periods even more of the stock would be vulnerable to fishing gear in the Yukon River both within the Old Lost Creek area and outside of this area.

Residents from the village of Beaver, located upriver of Old Lost Creek, may also be harvesting this stock. This was evidenced by the fact that one radio-tagged fish from Old Lost Creek was located in the village of Beaver. We had not initially considered residents of Beaver as users of this stock. However, it is unclear as to where and when this fish was harvested. It may have been caught during the summer near Old Lost Creek or it may have been harvested in a winter fishery. Northern pike from Old Lost Creek were detected as far upstream as Marten Island, therefore, management decisions for this stock should also consider use by Beaver residents in addition to Stevens Village residents and non local recreational anglers.

RECOMMENDATIONS

To further our understanding of northern pike in this area, it is recommended that radiotelemetry studies be conducted to investigate seasonal movements of northern pike to and from the Dall River and other nearby tributaries to the Yukon River, specifically between the Dall River and the Ray River (25 mi. downstream) and Hess Creek (52 mi. downstream). Previous tagging studies (Arvey and DeCicco 1989, Arvey and Burkholder 1990) have documented that movements between these systems do occur, but the magnitude and the timing of the movements are not understood.

Given the degree of movement of northern pike between Old Lost Creek and the Dall River described in this report and the current level of use by anglers, it is not recommended that sport fishery regulation for Old Lost Creek be changed to be in alignment with the more restrictive regulation for the Dall River special management area.

The logistic regression model used in this study was very useful in describing movements of northern pike as they relate to water level. Future studies of northern pike in wetland complexes associated with large river systems should continue to collect water flow and water level data, and temperature data should be collected as well to investigate any effects it might have on northern pike movements.

ACKNOWLEDGEMENTS

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REFERENCES CITED

Akaike, H. 1973. Information theory and an extension of the maximum likelihood principle. Pages 267-281 *in* B.N. Petranand F. Csaki, editors. International Symposium on Information theory. Second Edition. Akademiai Kiadi, Budapest, Hungary.

Anderson, W., R. McKinley, and M. Colavecchia. 1997. The use of clove oil as an anesthetic from rainbow trout and its effects on swimming performance. North American Journal of Fisheries Management. 17:301-307.

Arvey, W. and A. DeCicco. 1989. Northern pike in the vicinity of the Yukon River haul road crossing, 1988. Alaska Department of Fish and Game, Fishery Manuscript Number 105, Anchorage.

Arvey, W. and A. Burkholder. 1990. Stock assessment of northern pike in the vicinity of the Yukon River haul road crossing, 1988 and 1989. Alaska Department of Fish and Game, Fishery Manuscript Number 90-1, Anchorage.

Bry, C. 1996. Role of vegetation in the life cycle of pike *in* Pike: Biology and Exploitation. J. F. Craig, eds. Chapman & Hall, London.

Burkholder, A. and D. Bernard. 1994. Movements and distributions of radio-tagged northern pike in Minto Flats. Alaska Department of Fish and Game, Fishery Manuscript Number 94-1, Anchorage.

Burnham, K. P. and D. R. Anderson. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, New York.

Burr, J. and D. James. 1996. Dall River cooperative research project, 1995. Alaska Department of Fish and Game, Fisheries Data Series Number 96-34, Anchorage.

Casselman, J. M. 1996. Age, growth and environmental requirements of pike *in* Pike: Biology and Exploitation. J. F. Craig, eds. Chapman & Hall, London.

Casselman, J. M. 1967. Age and growth of northern pike, *Esox lucius* Linnaeus, of the upper St. Lawrence River. MS thesis, University of Guelph, Ontario.

Chythlook, J. and J. M. Burr 2002. Seasonal movements and length composition of northern pike in the Dall River, 1999-2001. Alaska Department of Fish and Game, Fishery Data Series No. 02-07, Anchorage.

Fleiss, J. L. 1981. Statistical methods for rates and proportions. Second Edition. John Wiley & Sons, New York.

Hart, L. and R. Summerfelt. 1975. Surgical procedures for implanting ultrasonic transmitters into flathead catfish (*Pylodictic olivaris*). Transactions of the American Fisheries Society 104:56-59.

Hollander M. and D. A. Wolfe (1973). Nonparametric Statistical Methods. John Wiley and Sons, New York.

Hurvich, C. M., and C.-L. Tsai. 1989. Regression and time series model selection in small samples. Biometrika 76:297-307.

Kedam, B. and K. Fokianos. 2002. Regression Models for Time Series Analysis. John Wiley & Sons, New Jersey.

Kim, P. J. and R. I. Jennrich. (1970). Tables of the exact sampling distribution of the two sample Kolmogorov-Smirnov criterion, $D_{mn}m \leq n$. In "Selected Tables in Mathematical Statistics", Vol. 1, H. L. Harter and D. B. Owen (Eds.), p. 85. Markham, Chicago.

Lebreton, J.-D., K. P. Burnham, J. Clobert, and D. R. Anderson. 1992. Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. Ecological Monographs, 62(1), pp.67-118.

Mendenhall, W., D. D. Wackerly, and R. L. Scheaffer. 1990. Mathematical Statistics with Applications, 4th Edition. Duxbury Press, California.

Roach, S. 1993. Movements and distributions of radio-tagged northern pike in Harding Lake. Alaska Department of Fish and Game, Fishery Data Series Number 93-12, Anchorage.

Roach, S. 1999. Site fidelity, dispersal, and movements of radio-tagged northern pike in Harding Lake. Alaska Department of Fish and Game, Fishery Data Series No. 99-31, Anchorage.

REFERENCES CITED (Continued)

Roach, S. 1998. Site fidelity, dispersal, and movements of radio-implanted northern pike in Minto Lakes, 1995-1997. Alaska Department of Fish and Game, Fishery Manuscript No. 98-1, Anchorage.

Ross, M. 1982. Shielded-needle technique for surgically implanting radio-frequency transmitters in fish. Progressive Fish Culturist 44:41-43.

Sumida, V. A. 1988. Land and resource use patterns in Stevens Village, Alaska. Alaska Department of Fish and Game, Technical Paper No. 129. Juneau, Alaska. 205 pp.

Williams, J. E. 1955. Determination of age from the scales of northern pike (*Esox lucius* L.). Ph.D. Thesis, University of Michigan, Ann Arbor.

APPENDIX A

FATES OF RADIO-TAGGED NORTHERN PIKE IN THE OLD LOST CREEK DRAINAGE AND ACCOMPANYING HYPOTHESIS TESTS, 2001-2003

Appendix A1.–Fates of radio-tagged northern pike in Old Lost Creek in 2001. Fates are defined in the Methods section.

Channel	June		July			August			September		
Code	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30
10-11	OLC	OLC	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
10-12	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK
10-13	OLC	OLC	OLC	OLC	Missing	Missing	Missing	AL	Missing	Missing	Missing
10-14	OLC	OLC	OLC	YUK	YUK	YUK	YUK	AL	YUK	YUK	YUK
10-15	OLC	OLC	OLC	OLC	YUK	OLC	OLC	YUK	YUK	YUK	YUK
10-16	OLC	OLC	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
10-17	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK
10-18	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC
10-19	OLC	OLC	OLC	OLC	OLC	OLC	OLC	LC-Area	OLC	Dead	Dead
12-11	OLC	OLC	OLC	YUK	YUK	YUK	OLC	OLC	OLC	YUK	YUK
12-12	OLC	OLC	OLC	YUK	YUK	YUK	YUK	AL	YUK	YUK	YUK
12-13	OLC	OLC	AL	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
12-14	OLC	OLC	AL	YUK	YUK	YUK	YUK	AL	YUK	YUK	YUK
12-15	OLC	OLC	YUK	YUK	YUK	YUK	OLC	YUK	YUK	OLC	OLC
12-16	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK	YUK	YUK
12-17	OLC	OLC	OLC	OLC	Missing	OLC	OLC	YUK	FT	YUK	YUK
12-18	OLC	OLC	Missing	Missing	Missing	Missing	Missing	OLC	FT	FT	FT
13-11	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC
13-12	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK
13-13	OLC	OLC	OLC	OLC	LC-Area	OLC	OLC	OLC	YUK	YUK	YUK
13-14	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC
13-15	OLC	OLC	OLC	OLC	LC-Area	OLC	OLC	OLC	OLC	YUK	YUK
13-16	OLC	OLC	OLC	OLC	LC-Area	OLC	OLC	OLC	OLC	YUK	YUK
13-17	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK
13-18	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	OLC	YUK	YUK
13-19	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Missing
14-11	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC

-continued-

Appendix A1.-Page 2 of 3.

Channel	June		July			August			September		
Code	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30
14-12	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Missing
14-13	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC
14-14	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK
14-15	OLC	OLC	OLC	OLC	OLC	OLC	DAL	DAL	YUK	YUK	YUK
14-16	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK	YUK
14-17	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK	YUK
14-18	OLC	OLC	AL	YUK	YUK	YUK	OLC	OLC	YUK	YUK	YUK
14-19	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK	YUK
16-11	OLC	OLC	OLC	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
16-12	OLC	OLC	AL	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
16-13	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Dead
16-14	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC
16-15	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC
16-16	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC
16-17	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK
16-18	OLC	OLC	YUK	LC-Area	YUK	YUK	YUK	YUK	YUK	YUK	YUK
16-19	OLC	OLC	OLC	OLC	OLC	OLC	OLC	LC-Area	OLC	YUK	YUK
19-11	OLC	OLC	OLC	OLC	OLC	OLC	OLC	AL	YUK	YUK	YUK
19-12	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Missing	Missing	Missing
19-13	OLC	OLC	OLC	OLC	LC-Area	OLC	YUK	OLC	YUK	YUK	YUK
19-14	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK	YUK	YUK	YUK
19-15	OLC	OLC	OLC	OLC	YUK	YUK	YUK	AL	YUK	YUK	YUK
19-16	OLC	OLC	OLC	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
19-17	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK
19-18	OLC	OLC	OLC	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
20-11	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK
20-12	OLC	OLC	OLC	OLC	OLC	OLC	OLC	LC-Area	OLC	YUK	YUK

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Channel	June		July			August			September		
Code	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30
20-13	OLC	OLC	LC-Area	OLC	LC-Area	OLC	LC-Area	OLC	YUK	YUK	YUK
20-14	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK	YUK
20-15	OLC	OLC	OLC	OLC	OLC	YUK	YUK	YUK	YUK	YUK	YUK
20-16	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK	YUK	YUK
20-17	OLC	OLC	OLC	OLC	OLC	OLC	LC-Area	LC-Area	LC-Area	LC-Area	LC-Area
20-18	OLC	OLC	OLC	OLC	YUK	YUK	YUK	YUK	YUK	YUK	YUK
Hypothesis Test											
Proportion in OLC	1.00	1.00	0.85	0.76	0.61	0.71	0.67	0.53	0.46	0.25	0.17
Proportion out of OLC	0.00	0.00	0.15	0.24	0.39	0.29	0.33	0.47	0.54	0.75	0.83
P-value	1.00	1.00	0.77	0.29	0.00	0.05	0.01	0.00	0.00	0.00	0.00
Significantly more than 20% outside	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Telemetry Flight Date			July 3					Aug 21			
Proportion in OLC and LC-Area			0.82					0.63			
Proportion out of OLC and LC-Area			0.18					0.37			
P-value			0.49					0.00			
Significantly more than 20% outside			No					Yes			

Appendix A2.–Fates of radio-tagged northern pike in Old Lost Creek in 2002. Fates are described in Methods section.

Channel		March		April			May			June		
Code	February	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30
10-11	YUK	YUK	YUK	YUK	YUK	YUK	YUK	LC-Area	OLC	OLC	YUK	YUK
10-12	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
10-13	AL	Missing	Missing	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
10-14	AL	YUK	YUK	YUK	YUK	YUK	YUK	AL	YUK	YUK	YUK	YUK
10-15	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC	YUK
10-16	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	LC-Area
10-17	LC-Area	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC	YUK
10-18	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
10-19	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
12-11	YUK	OLC	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
12-12	AL	OLC	YUK	OLC	OLC	OLC	OLC	OLC	Missing	Missing	Missing	Missing
12-13	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	YUK	YUK
12-14	AL	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
12-15	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
12-16	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC	OLC
12-17	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	Missing	Missing
12-18	FT	FT	FT	FT	FT	FT	FT	FT	FT	FT	FT	FT
13-11	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-12	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	YUK
13-13	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
13-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-15	OLC	OLC	YUK	YUK	YUK	OLC	LC-Area	OLC	OLC	OLC	OLC	OLC
13-16	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC
13-17	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
13-18	YUK	OLC	YUK	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC
13-19	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
14-11	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-12	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
14-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-14	YUK	OLC	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-15	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	YUK

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Channel	July			August			September			October	November
Code	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	9th
10-11	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
10-12	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK	YUK	YUK
10-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
10-14	YUK	AL	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	AL
10-15	YUK	YUK	YUK	YUK	YUK	OLC	YUK	YUK	YUK	YUK	YUK
10-16	OLC	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
10-17	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	YUK	YUK	YUK
10-18	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
10-19	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
12-11	OLC	OLC	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC
12-12	Missing	AL	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	AL
12-13	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
12-14	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Dead
12-15	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Dead
12-16	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK	YUK
12-17	OLC	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC
12-18	FT	FT	FT	FT	FT	FT	FT	FT	FT	FT	FT
13-11	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-12	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
13-13	OLC	OLC	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-15	OLC	OLC	YUK	YUK	YUK	OLC	OLC	YUK	YUK	YUK	YUK
13-16	OLC	OLC	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Dead
13-17	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Dead
13-18	OLC	OLC	YUK	YUK	YUK	OLC	OLC	Dead	Dead	Dead	Dead
13-19	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Dead
14-11	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-12	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Dead
14-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-15	YUK	YUK	YUK	YUK	YUK	OLC	YUK	OLC	YUK	YUK	OLC

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Channel		March		April			May			June		
Code	February	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30
14-16	AL	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
14-17	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
14-18	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
14-19	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
16-11	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	Missing	Missing
16-12	AL	YUK	YUK	YUK	YUK	YUK	YUK	AL	YUK	YUK	YUK	YUK
16-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-15	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-16	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-17	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	YUK	YUK
16-18	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	YUK
16-19	YUK	YUK	YUK	YUK	YUK	YUK	YUK	LC-Area	YUK	YUK	YUK	YUK
19-11	AL	YUK	YUK	YUK	YUK	YUK	YUK	AL	YUK	YUK	YUK	YUK
19-12	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing
19-13	YUK	YUK	YUK	YUK	YUK	YUK	YUK	LC-Area	OLC	OLC	OLC	OLC
19-14	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC
19-15	AL	YUK	YUK	YUK	YUK	YUK	YUK	AL	YUK	YUK	YUK	YUK
19-16	OLC	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	Missing	Missing	Missing
19-17	AL	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC	OLC
19-18	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	YUK	YUK
20-11	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
20-12	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	OLC
20-13	OLC	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	YUK
20-14	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	Missing	Missing	Missing
20-15	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	YUK	YUK
20-16	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	Missing	Missing	Missing
20-17	LC-Area	YUK	YUK	YUK	YUK	YUK	YUK	OLC	YUK	YUK	OLC	YUK
20-18	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	Missing	Missing

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Channel	July			August			September			October	November
Code	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	9th
14-16	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Dead	Dead
14-17	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK	OLC
14-18	OLC	OLC	YUK	YUK	YUK	OLC	OLC	YUK	YUK	YUK	YUK
14-19	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Dead
16-11	Missing	AL	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	LC-Area
16-12	YUK	AL	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	LC-Area
16-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-15	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-16	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-17	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
16-18	YUK	YUK	YUK	YUK	YUK	OLC	OLC	OLC	YUK	YUK	YUK
16-19	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
19-11	YUK	AL	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	LC-Area
19-12	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing
19-13	OLC	OLC	OLC	Missing	Missing	YUK	YUK	YUK	YUK	YUK	YUK
19-14	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK	YUK	YUK	YUK
19-15	YUK	AL	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	AL
19-16	Missing	AL	Missing	Missing	Missing	YUK	YUK	YUK	YUK	YUK	LC-Area
19-17	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Dead
19-18	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
20-11	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	Dead
20-12	OLC	OLC	OLC	OLC	OLC	OLC	LC-Area	OLC	YUK	YUK	YUK
20-13	YUK	YUK	YUK	OLC	LC-Area	OLC	YUK	YUK	YUK	YUK	YUK
20-14	Missing	AL	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing
20-15	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
20-16	Missing	AL	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
20-17	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC
20-18	Missing	AL	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK

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Channel		March		April			May			June		
Code	February	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30
Hypothesis Tests												
Proportion in OLC	0.06	0.11	0.00	0.04	0.04	0.07	0.15	0.65	0.78	0.83	0.72	0.51
Proportion out of OLC	0.94	0.89	1.00	0.96	0.96	0.93	0.85	0.35	0.22	0.17	0.28	0.49
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.42	0.65	0.08	0.00
Significantly more than 20% outside	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes
Telemetry Flight Date	Feb 11							May 16				
Proportion in OLC and LC-Area	0.33							0.87				
Proportion out of OLC and LC-Area	0.67							0.13				
P-value	0.00							0.18				
Significantly more than 20% outside	Yes							No				

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Channel	July			August			September			October	November
Code	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	9th
Hypothesis Tests											
Proportion in OLC	0.55	0.43	0.34	0.35	0.33	0.50	0.38	0.34	0.20	0.18	0.15
Proportion out of OLC	0.45	0.57	0.66	0.65	0.67	0.50	0.62	0.66	0.80	0.82	0.85
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Significantly more than 20% outside	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Telemetry Flight Date			July 17								Nov 9
Proportion in OLC and LC-Area			0.63								0.55
Proportion out of OLC and LC-Area			0.37								0.45
P-value			0.02								0.01
Significantly more than 20% outside			Yes								Yes

Appendix A3.–Fates of radio-tagged northern pike in Old Lost Creek in 2003. Fates are defined in Methods section.

Channel	March		May			June			July		
Code	13th	April	1-10	11.20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
10-11	YUK	YUK	YUK	Missing	OLC	OLC	OLC	YUK	YUK	YUK	YUK
10-12	YUK	YUK	OLC	Missing	OLC	OLC	OLC	OLC	OLC	OLC	OLC
10-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
10-14	AL	YUK	AL	YUK	YUK	YUK	AL	YUK	YUK	YUK	AL
10-15	YUK	YUK	YUK	Missing	OLC	OLC	OLC	LC-Area	OLC	LC-Area	LC-Area
10-16	YUK	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
10-17	YUK	YUK	YUK	Missing	Missing	OLC	OLC	OLC	OLC	OLC	OLC
10-18	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
10-19	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
12-11	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
12-12	AL	Missing	AL	Missing	Missing	Missing	Dead	Dead	Dead	Dead	Dead
12-13	YUK	OLC	YUK	Missing	OLC	YUK	YUK	YUK	YUK	YUK	YUK
12-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
12-15	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
12-16	YUK	YUK	YUK	Missing	Missing	OLC	OLC	OLC	OLC	OLC	OLC
12-17	OLC	YUK	LC-Area	LC-Area	OLC	OLC	OLC	OLC	OLC	OLC	OLC
12-18	FT	FT	FT	FT	FT	FT	FT	FT	FT	FT	FT
13-11	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-12	YUK	YUK	YUK	YUK	YUK	YUK	YUK	OLC	YUK	YUK	YUK
13-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-15	YUK	YUK	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC
13-16	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-17	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-18	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-19	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-11	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-12	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-15	OLC	YUK	OLC	OLC	OLC	OLC	OLC	Missing	LC-Area	YUK	OLC

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Channel	August			September			October	November
Code	1-10	11-20	21-31	1-10	11-20	21-30	1-10	1st
10-11	YUK	YUK	YUK	YUK	Missing	Missing	Missing	Missing
10-12	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Dead
10-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
10-14	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
10-15	YUK	YUK	OLC	LC-Area	Missing	Missing	Missing	Missing
10-16	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
10-17	Missing	Missing	Missing	OLC	Missing	Missing	Missing	Missing
10-18	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
10-19	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
12-11	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
12-12	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
12-13	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
12-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
12-15	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
12-16	Missing	Missing	OLC	OLC	Missing	Missing	LC-Area	LC-Area
12-17	YUK	YUK	YUK	LC-Area	LC-Area	LC-Area	LC-Area	LC-Area
12-18	FT	FT	FT	FT	FT	FT	FT	
13-11	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-12	DAL	YUK	YUK	AL	Missing	Missing	Missing	Missing
13-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-15	OLC	OLC	OLC	OLC	OLC	OLC	OLC	Dead
13-16	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-17	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-18	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13-19	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-11	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-12	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-15	YUK	YUK	OLC	OLC	YUK	YUK	LC-Area	LC-Area

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Channel	March		May			June			July		
Code	13th	April	1-10	11.20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
14-16	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-17	OLC	YUK	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC
14-18	YUK	YUK	OLC	OLC	OLC	OLC	OLC	OLC	YUK	YUK	LC-Area
14-19	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-11	YUK	YUK	OLC	Missing	Missing	Missing	AL	YUK	YUK	YUK	OLC
16-12	YUK	YUK	YUK	Missing	Missing	OLC	OLC	OLC	YUK	YUK	YUK
16-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-15	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-16	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-17	YUK	OLC	OLC	OLC	OLC	OLC	OLC	OLC	OLC	YUK	OLC
16-18	YUK	YUK	OLC	OLC	OLC	OLC	OLC	OLC	LC-Area	YUK	LC-Area
16-19	LC-Area	YUK	LC-Area	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing
19-11	YUK	YUK	OLC	YUK	LC-Area	Missing	AL	YUK	YUK	YUK	AL
19-12	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing
19-13	YUK	YUK	OLC	Missing	LC-Area	YUK	YUK	YUK	LC-Area	LC-Area	LC-Area
19-14	YUK	YUK	YUK	Missing	OLC	OLC	OLC	YUK	YUK	YUK	YUK
19-15	AL	YUK	AL	YUK	YUK	YUK	OLC	OLC	OLC	YUK	YUK
19-16	LC-Area	YUK	YUK	YUK	LC-Area	OLC	LC-Area	LC-Area	LC-Area	LC-Area	LC-Area
19-17	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
19-18	YUK	YUK	YUK	Missing	OLC	OLC	OLC	LC-Area	LC-Area	OLC	YUK
20-11	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
20-12	YUK	YUK	OLC	OLC	OLC	OLC	OLC	OLC	OLC	LC-Area	OLC
20-13	YUK	YUK	YUK	OLC	OLC	OLC	OLC	YUK	YUK	YUK	YUK
20-14	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing
20-15	YUK	YUK	YUK	OLC	OLC	YUK	YUK	DAL	YUK	YUK	YUK
20-16	YUK	YUK	YUK	YUK	OLC	OLC	OLC	OLC	YUK	YUK	YUK
20-17	LC-Area	LC-Area	LC-Area	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
20-18	YUK	YUK	AL	Missing	Missing	OLC	OLC	YUK	YUK	YUK	YUK

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Channel	August			September			October	November
Code	1-10	11-20	21-31	1-10	11-20	21-30	1-10	1st
14-16	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14-17	OLC	OLC	OLC	OLC	Missing	Missing	Missing	Missing
14-18	YUK	YUK	LC-Area	LC-Area	LC-Area	LC-Area	LC-Area	YUK
14-19	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-11	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing
16-12	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
16-13	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-14	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-15	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-16	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16-17	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
16-18	YUK	YUK	LC-Area	LC-Area	Missing	Missing	Missing	Missing
16-19	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing
19-11	YUK	YUK	YUK	AL	YUK	YUK	LC-Area	LC-Area
19-12	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing
19-13	YUK	YUK	YUK	YUK	Missing	Missing	Missing	Missing
19-14	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
19-15	YUK	YUK	YUK	AL	Missing	Missing	Missing	Missing
19-16	YUK	YUK	YUK	LC-Area	Missing	Missing	Missing	Missing
19-17	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
19-18	YUK	YUK	YUK	YUK	Missing	Missing	Missing	Missing
20-11	Dead	Dead	Dead	LC-Area	Dead	Dead	Dead	Dead
20-12	Missing	Missing	OLC	OLC	Missing	Missing	LC-Area	LC-Area
20-13	YUK	DAL	YUK	YUK	YUK	DAL	DAL	YUK
20-14	Missing	Missing	Missing	Missing	Missing	Missing	Missing	Missing
20-15	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK
20-16	YUK	YUK	YUK	AL	Missing	Missing	Missing	Missing
20-17	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
20-18	YUK	YUK	YUK	YUK	YUK	YUK	YUK	YUK

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Channel	March		May			June			July		
Code	13th	April	1-10	11.20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
Hypothesis Tests											
Proportion in OLC	0.09	0.07	0.35	0.56	0.74	0.77	0.71	0.52	0.36	0.25	0.36
Proportion out of OLC	0.91	0.93	0.65	0.44	0.26	0.23	0.29	0.48	0.64	0.75	0.64
P-value	0.00	0.00	0.00	0.02	0.32	0.44	0.18	0.00	0.00	0.00	0.00
Significantly more than 20% outside	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes
Telemetry Flight Date	Mar 13		May 7				June 16				July 29
Proportion in OLC and LC-Area	0.59		0.56				0.76				0.66
Proportion out of OLC and LC-Area	0.41		0.44				0.24				0.34
P-value	0.05		0.00				0.38				0.07
Significantly more than 20% outside	Yes		Yes				No				Yes

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Channel	August			September			October	November
Code	1-10	11-20	21-31	1-10	11-20	21-30	1-10	1st
Hypothesis Tests								
Proportion in OLC	0.13	0.13	0.27	0.25	0.14	0.14	0.13	0.00
Proportion out of OLC	0.87	0.87	0.73	0.75	0.86	0.86	0.87	1.00
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Significantly more than 20% outside	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Telemetry Flight Date				Sept 5				Nov 1
Proportion in OLC and LC-Area				0.55				0.33
Proportion out of OLC and LC-Area				0.45				0.67
P-value				0.00				0.00
Significantly more than 20% outside				Yes				Yes

APPENDIX B
DATA SUMMARY

Appendix B.–Data files used in the analysis of the Old Lost Creek northern pike movement and age and length distribution analysis for 2001 through 2003.

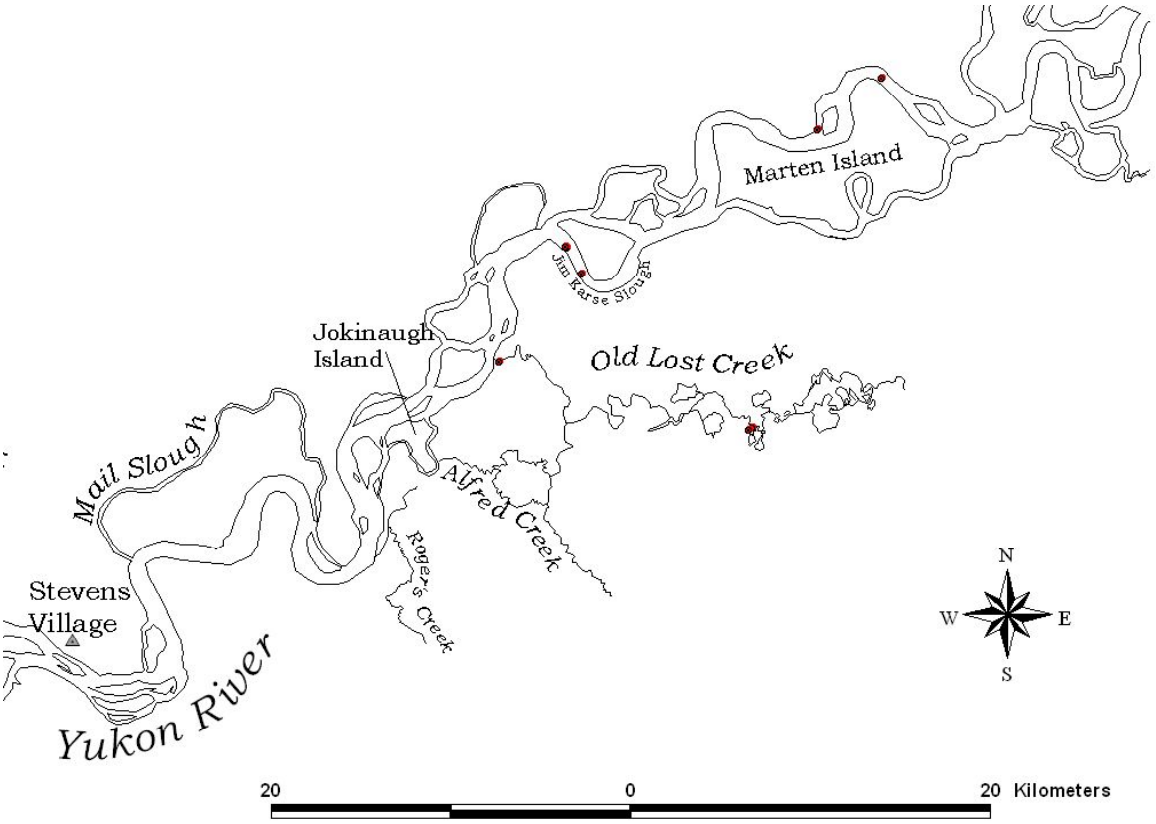
Data File[a]	Description
Yuk Flats Pike Flow Rate Data - '04.xls	Data used to determine the effects of Yukon River flow rate on the movement of northern pike in Old Lost Creek between June 2001 and November 2003.
Yuk Flats Pike Length Age-'04.xls	Data used to analyze the age and length distribution of northern pike sampled in the Old Lost Creek drainage in 2001 and 2002 and compared to data from the Dall River in 1999 and 2000 and Old Lost Creek in 1988.
Yuk Flats Pike Telemetry - '04.xls	Data used to analyze the movement of northern pike in and around Old Lost Creek between June 2001 and November 2003.

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

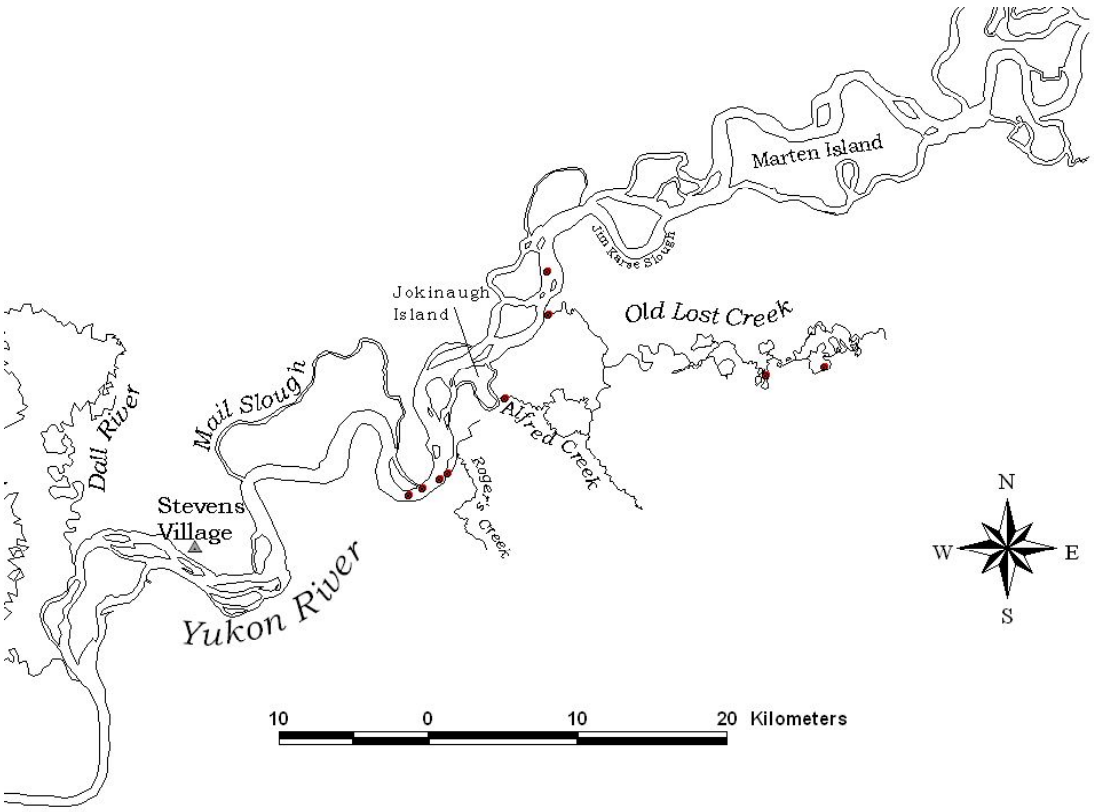
APPENDIX C

LOCATIONS OF INDIVIDUAL RADIO-TAGGED NORTHERN PIKE BETWEEN JUNE 2001 AND NOVEMBER 2003

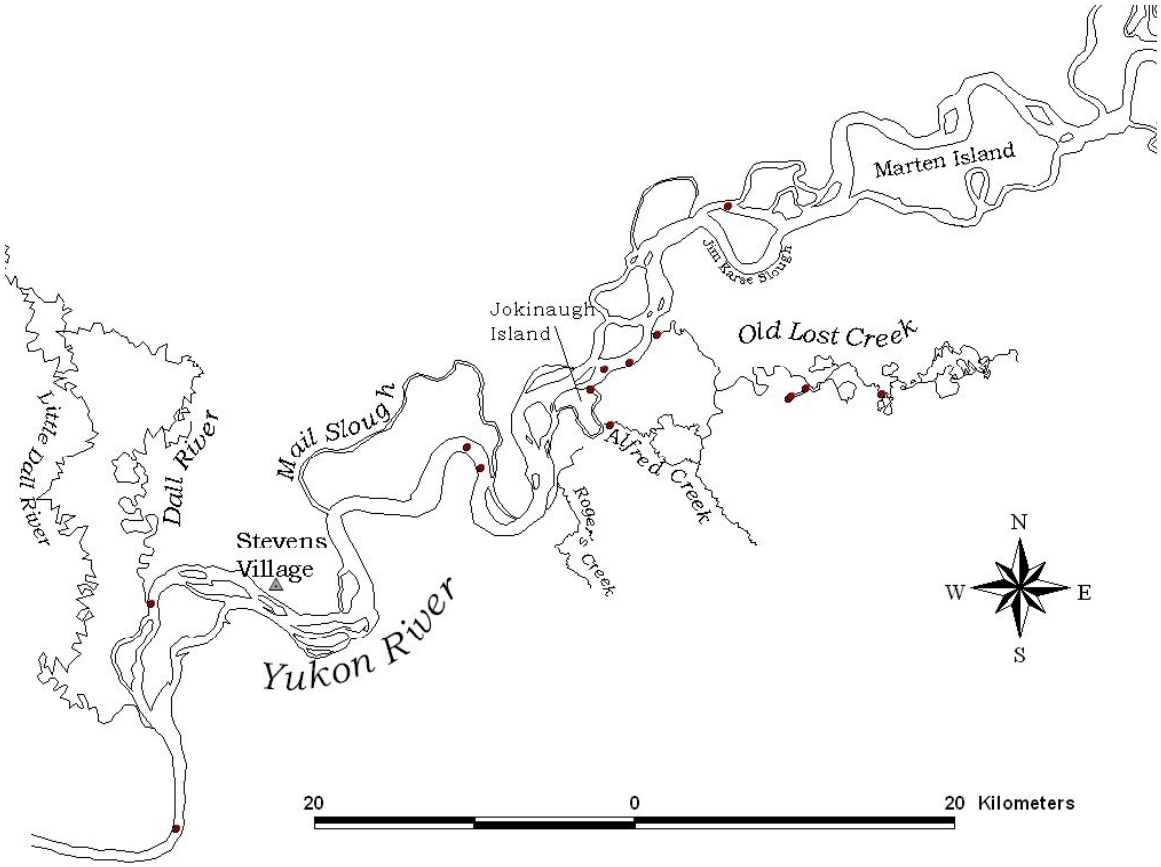
Appendix C1.-Known locations of northern pike #19-14, 945 mm FL, between June 2001 and November 2003.



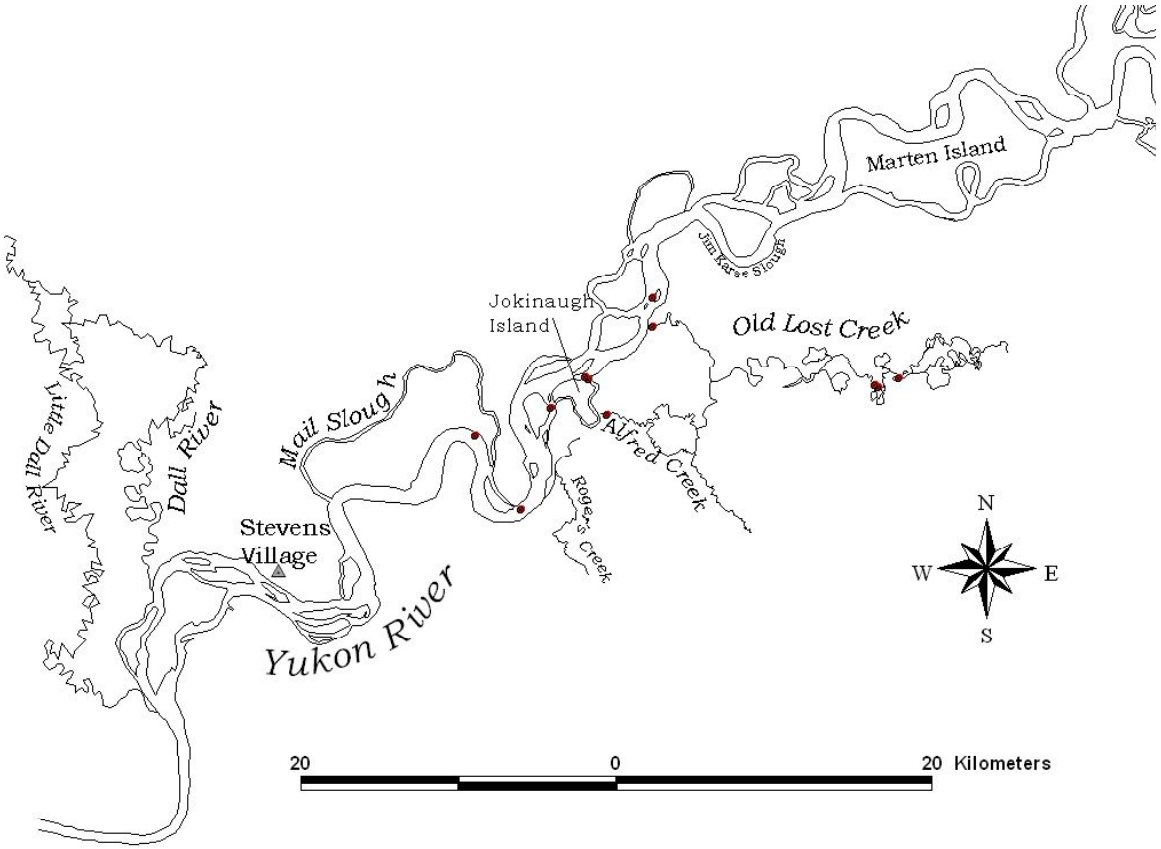
Appendix C2.–Known locations of northern pike #10-11, 870 mm FL, between June 2001 and November 2003.



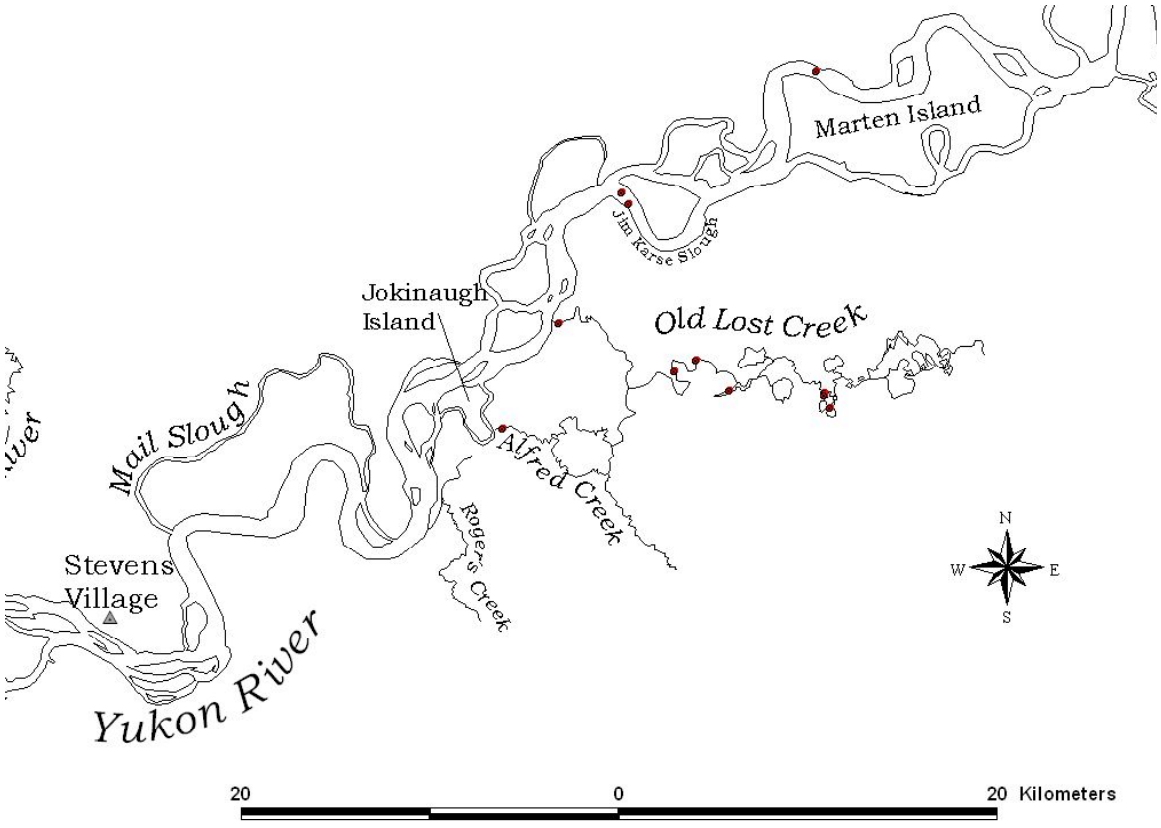
Appendix C3.–Known locations of northern pike #10-15, 840 mm FL, between June 2001 and November 2003.



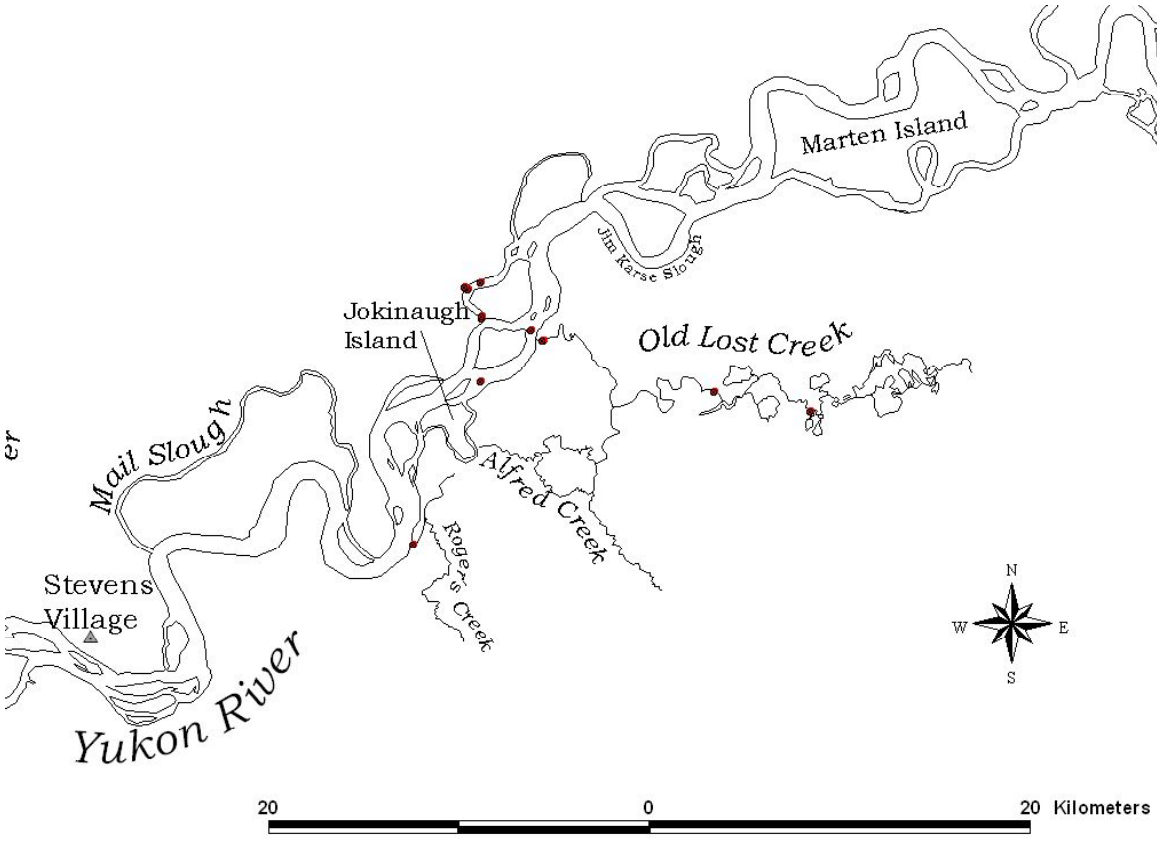
Appendix C4.–Known locations of northern pike #14-18, 740 mm FL, between June 2001 and July 2003.



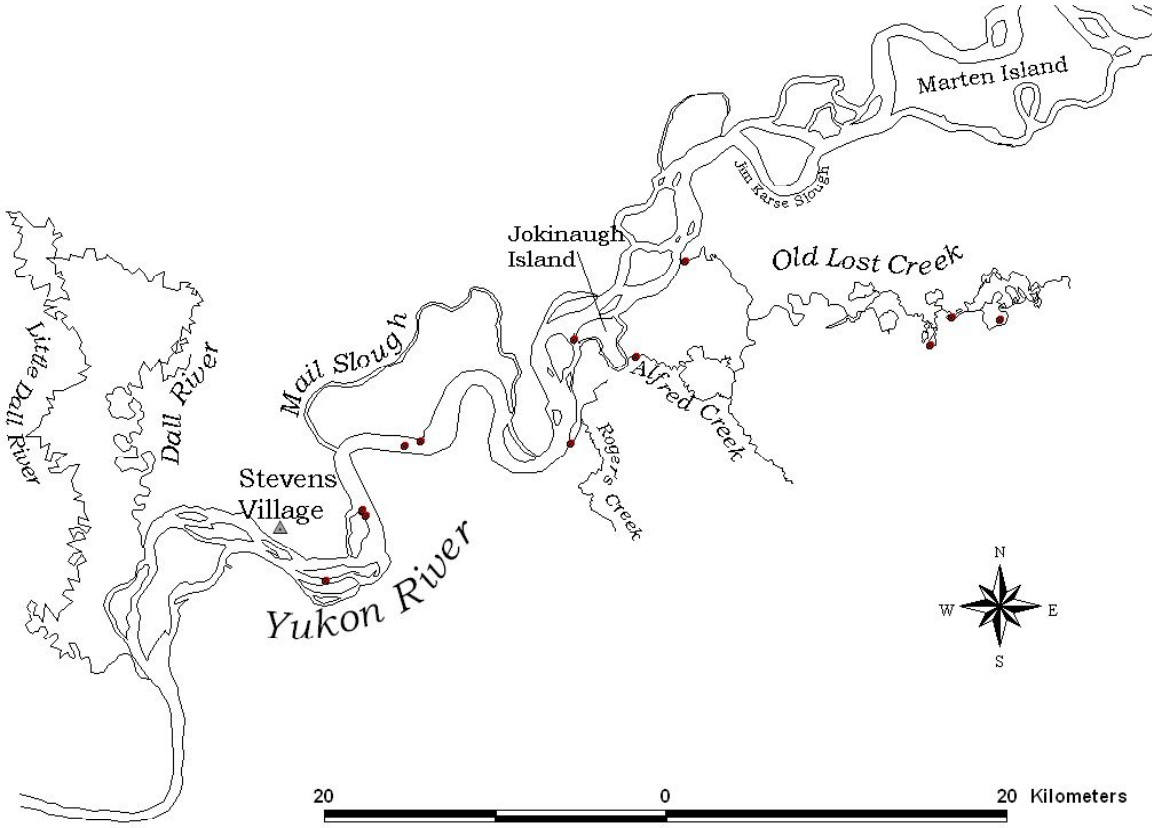
Appendix C5.–Known locations of northern pike #16-17, 890 mm FL, between June 2001 and November 2003.



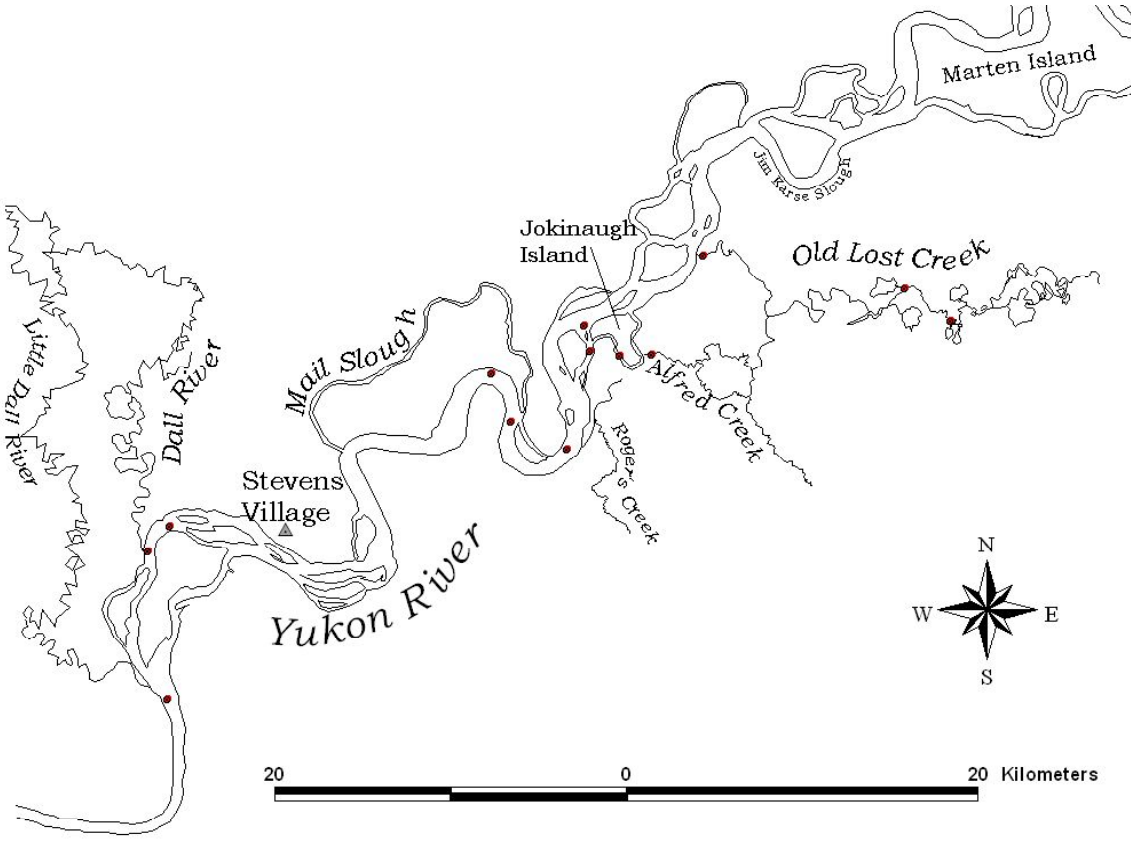
Appendix C6.–Known locations of northern pike #19-16, 705 mm FL, between June 2001 and November 2003.



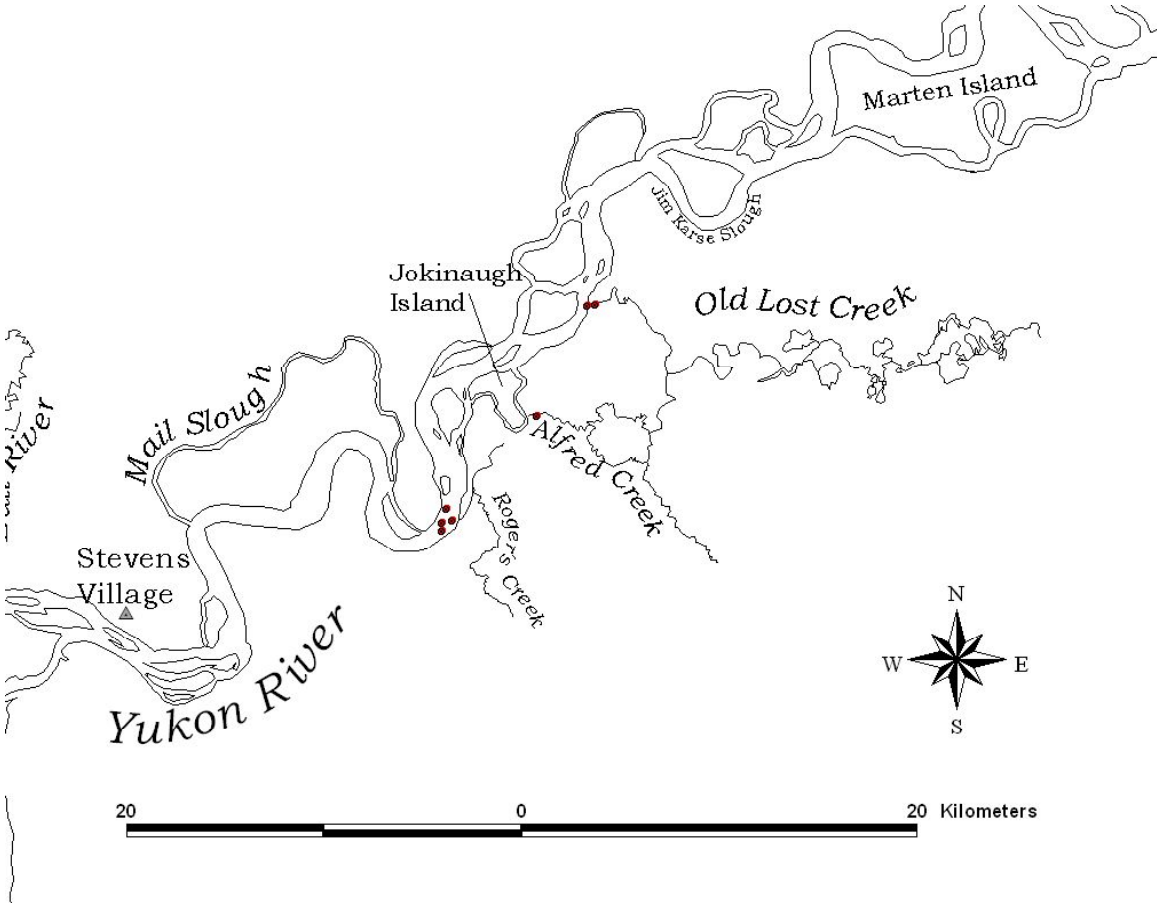
Appendix C7.–Known locations of northern pike #19-18, 970 mm FL, between June 2001 and November 2003.



Appendix C8.–Known locations of northern pike #20-13, 730 mm FL, between June 2001 and November 2003.



Appendix C9.–Known locations of northern pike #20-15, 710 mm FL, between June 2001 and November 2003.



Appendix C10.–Known locations of northern pike #20-18, 730 mm FL, between June 2001 and November 2003.