Fishery Data Series No. 96-29

Seasonal Movements, Age and Size Statistics, and Food Habits of Northern Pike in Upper Cook Inlet during 1994 and 1995

by

David S. Rutz

September 1996

Alaska Department of Fish and Game

Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

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

Spell out acre and ton.

Time and temperature

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

Spell out year, month, and week.

Physics and chemistry

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

General

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

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

FISHERY DATA SERIES NO. 96-29

SEASONAL MOVEMENTS, AGE AND SIZE STATISTICS, AND FOOD HABITS OF UPPER COOK INLET NORTHERN PIKE DURING 1994 AND 1995

by

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September 1996

This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-10 and F-10-11, Job No. R-2-8.

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This document should be cited as:
Rutz, David S. 1996. Seasonal movements, age and size statistics, and food habits of upper Cook Inlet northern pike during 1994 and 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-29, Anchorage.

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ABSTRACT

Fourteen lakes and two tributaries of the Susitna River drainage, supporting northern pike *Esox lucius*, were sampled during 1994 and 1995 to assess seasonal migrations and distributions, age and size compositions, and food habits. Seasonal migrations and distributions of northern pike were investigated using radiotelemetry. Based on radiotelemetry information spawning migrations appeared to begin during the last week of April for Trapper, Ding Dong and Alexander lakes, and during the first week of May for Whiskey Lake, and continued through late May or early June. The greatest distance a radio-tagged fish traveled from capture location was 13 km; the least distance traveled was less than 1 km. Some northern pike remained within the lakes they were captured in while others moved into outlet streams or adjacent connecting lakes.

Selected Susitna River drainage lakes were sampled using modified hoop nets, gillnets, and hook and line during the spring and summer of 1994 and 1995. Northern pike captured with hook and line were generally larger and older than northern pike caught in hoop nets or gillnets. Northern pike captured with hoop nets in the spring of 1994 from Alexander Lake were divided among the relative stock density categories of "stock," "quality," and "preferred" (40%, 35% and 22%, respectively), while northern pike captured from Trapper Lake in the spring of 1994 were primarily in the "stock" and "quality" categories (77% and 20%, respectively).

During 1995, stomach contents were analyzed from northern pike captured in selected Susitna River drainage lake systems and three area stocked lakes to assess dietary trends of northern pike by two major habitat types. Of the 237 stomachs examined, 24% were empty. Of nonempty stomachs of northern pike caught in systems with fast clearwater streams and deep lakes with little aquatic vegetation, 73% contained salmonids and 11% contained invertebrates. In contrast, of the nonempty stomachs of northern pike caught in systems with well established northern pike populations and having slow-moving streams and shallow lakes with abundant vegetative mats, 96% contained invertebrates and 3% contained salmonids. Of nonempty stomachs examined from northern pike caught in three area stocked lakes, 59% contained rainbow trout O. *mykiss*, 26% contained other fish species, and 26% contained invertebrates.

Several lake systems within the Susitna River drainage that were historically productive coho *O. kisutch* and sockeye *O. nerka* salmon streams are now believed to contain only northern pike. To document the presence or absence of juvenile coho salmon in these systems, we sampled five systems: Fish Creek (Kroto Slough), Witsoe Creek (Kroto Slough), Trapper Creek (Deshka River), Fish Creek (Nancy Lake System) and Fish Lake Creek (Yentna River). Two-hundred fifty wire mesh minnow traps baited with salmon roe were set for a period of 24 hours in these systems, supposedly barren of coho salmon. Catch per unit of effort (CPUE) was 0.25 juvenile coho salmon per trap set. Coho salmon juveniles were completely absent in two of the five systems sampled. In the remaining three systems, juvenile coho salmon were found in low numbers and only in the immediate vicinity of the stream's confluence area. Juvenile salmon captured near these confluence areas most likely originated from other parent streams, because juvenile salmon seek out confluence areas for short-term rearing during outmigration.

Key words: Northern pike, *Esox lucius*, coho salmon *Oncorhynchus kisutch*, sockeye salmon *Oncorhynchus nerka*, rainbow trout *Oncorhynchus mykiss*, radio telemetry, seasonal movements, seasonal distributions, sex ratio, age composition, length composition, growth, abundance, survival, length-at-age, Relative Stock Density, Susitna River drainage, predation, diet.

INTRODUCTION

HISTORY OF NORTHERN PIKE IN THE SUSITNA RIVER DRAINAGE

Northern pike *Esox lucius* are not indigenous to the Susitna River drainage and were probably established through a series of illegal introductions in the early 1950s. The Susitna River drainage is a large river basin encompassing tens of thousands of square miles and is roughly the area of the state of Indiana (Figure 1). This system comprises hundreds of shallow lakes, clear water tributaries, and sloughs. This area supports large beds of aquatic vegetation, which are ideal spawning and rearing habitat for northern pike. Northern pike have expanded throughout most of this drainage (Whitmore et al. 1994).

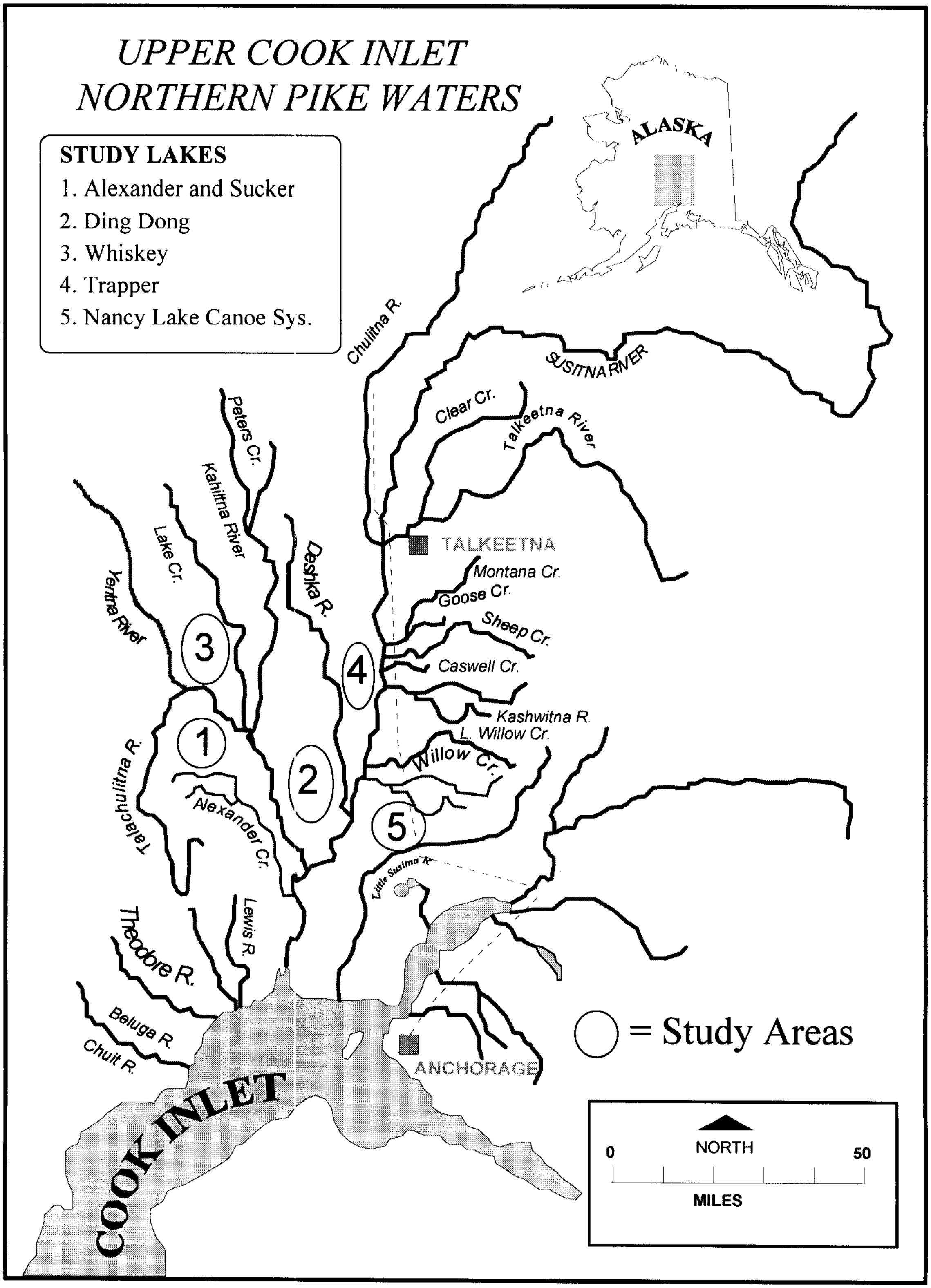

Figure 1.-Sampling locations for northern pike in the Susitna River drainage during 1994.

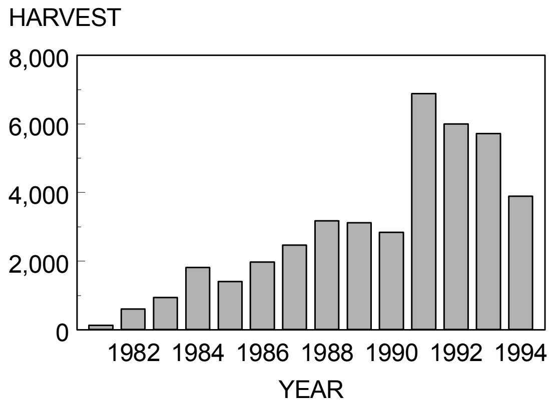

Figure 2.-Number of northern pike harvested in the Susitna River drainage, 1981-1994 (Mills 1982-1994, Howe et al. 1995).

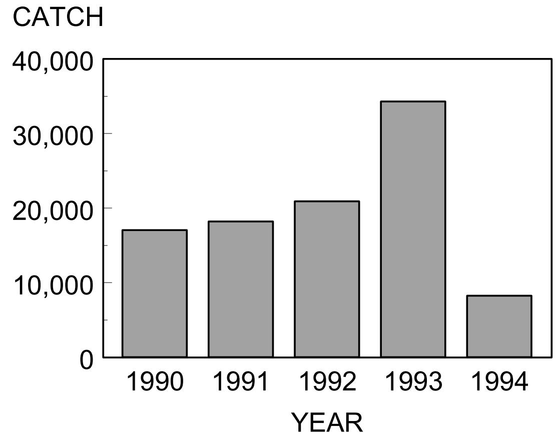

Figure 3.-Number of northern pike caught in the Susitna River drainage, 1990-1994 (Mills 1991-1994; Howe et al. 1995).

Sport harvest in the Susitna River drainage increased from 125 northern pike in 1981 (Mills 1982) to a peak of nearly 7,000 northern pike in 1991 (Mills 1992; Figure 2). Catch (fish retained or released) peaked in 1993 at about 34,000 northern pike (Figure 3), representing nearly 30% of the total statewide catch (Mills 1994). However, in 1994, catch dropped to a 5-year low (Figure 3; Howe et al. 1995) and harvest has decreased every year since 1991. We suspect that decreasing catch and harvest reflect a lack of large northern pike and waning angler interest in sport fishing for northern pike, rather than a decrease in the overall abundance of northern pike.

Alexander, Trapper, and Whiskey lakes and the Fish Lake Creek and Fish Creek drainage are among the most popular waters fished for northern pike in the Susitna River drainage, accounting for 60% (2,416 fish) of the area's northern pike harvest during 1994 (Howe et al. 1995). Despite recent decreases in harvest and catch, this fishery still ranks as Alaska's third largest northern pike fishery.

Several lakes in the Susitna River drainage have produced northern pike in the trophy length class (>1,080 mm, >42.5 in). Anglers commonly report weights of northern pike in excess of 9 kg (20 lb) and occasionally in excess of 13.6 kg (30 lb). Although catch and harvest of northern pike grew during the past decade, management of northern pike harvests continues to be liberal at 10 fish per day, no size limit, and no closed season.

FOOD HABITS OF NORTHERN PIKE

Northern pike prefer soft-rayed fish such as suckers *Catostomus*, salmonids *Oncorhynchus*, black fish *Dallia pectoralis*, and burbot *Lota lota* (Eklov and Ganrin 1989). Mann (1985) suggested that northern pike make rapid changes to their prey selection in response to changes in abundance and vulnerability of potential prey. Once the preferred food items are no longer available, northern pike quickly adapt to alternate food sources (Eddy and Surber 1947) such as insects, leeches, snails, clams, and smaller northern pike. Northern pike were introduced to a reservoir in Colorado to control abundant populations of white suckers *Catostomus commersoni*. Once the suckers declined to a fraction of their previous numbers, northern pike shifted to preying on stocked rainbow trout populations (Chapman et al. 1989). Because northern pike are efficient predators, they have also been successfully introduced as a means to reduce stunted fish populations (Powell 1973).

Northern pike are known to consume large proportions of stocked and migrating salmonid juveniles. Pervozvanskiy et al. (1988) showed that northern pike account for up to 35% of the stocked Atlantic salmon smolt mortality in the Keret River in Russia. Larsson (1985) indicated that at least 50% of migrating Baltic salmon are lost to predation during downstream migration. Information obtained from the Por'ya River (Karelian Autonomous Republic, Old USSR) shows that in some years northern pike consume 30%-33% of migrating wild juvenile salmon (Smirnov et al. 1977). According to Movchan and Chechenkov (1979), more than 70% of juvenile hatchery salmon released in the Shuya River (White Sea Basin) from the Kem' Hatchery are eaten by northern pike. Mann (1985) suggested that the removal of large older northern pike reduces predation on catchable-size rainbow trout (200-250 mm).

In the Susitna River drainage, coho salmon *O. kisutch* and rainbow trout *O. mykiss* are the most likely species of salmon to be impacted by northern pike because these species and northern pike occupy similar habitat niches (Carbine and Applegate 1994; Diana et al. 1977; Narver 1978).

MANAGEMENT OPTIONS FOR NORTHERN PIKE

Sport anglers advocate two opposing management schemes for northern pike. Anglers who want to fish for northern pike support management that would increase the number of large northern pike available for catch and harvest. Anglers who are primarily interested in catching and harvesting coho salmon and other salmonids prefer management aimed at reducing or eliminating northern pike in Southcentral Alaska.

Anglers wanting management aimed at improving sport fishing for northern pike advocate restrictive regulations for northern pike. These anglers point to research showing that many northern pike stocks in the midwestern United States (Jacobson 1992) and the Arctic-Yukon-Kuskokwim (AYK) area of Alaska (Pearse 1991) have been subject to overexploitation by sport fisheries. Introduction of minimum size limits may successfully increase the number of large, older fish (Kempinger and Carline 1978). Given the potential of some lakes in Southcentral Alaska for producing trophy-sized northern pike, some of the lakes in the Susitna River drainage may be targeted for special trophy management of northern pike, such as size limits, spawning closures, gear restrictions, and reduced bag limits, during the upcoming Alaska Board of Fishery cycle.

In direct contrast to trophy management, other anglers would prefer a management scheme directed at eliminating northern pike populations from streams and lakes of the Susitna River drainage. Some anglers believe that decreases in coho salmon abundance in specific drainages are a result of predation by northern pike. These decreases, however, cannot be quantified through the Statewide Harvest Survey (SWHS) or commercial fish catch index because no site specific information is available. In addition sport fishing effort (both guided and nonguided) has increased dramatically in the past decade along with more effective sport fishing harvest techniques which does not allow for valid comparison between years.

Sixty-five of the 70 Susitna River drainage lakes and streams identified as containing northern pike populations (Appendix C1) once contained healthy populations of rainbow trout *Oncorhynchus mykiss*. Most of these same lakes also had previous histories of coho *O. kisutch* and sockeye *O. nerka* salmon production along with various resident fish populations which were documented by stream and lake surveys conducted from the mid-1960s through the early 1980s.

Much of the Susitna River drainage salmon production is driven by the many shallow lakes and ponds that provide the necessary rearing habitat for juvenile salmon (Roth and Stratton 1984). Some anglers believe that northern pike have reduced or eliminated coho salmon, rainbow trout, and other sport fish species from these lakes.

The lack of stock assessment information, growth of the sport fishery, possible predation on salmonids by northern pike, and opposing opinions about management of northern pike make it imperative that we collect basic information about northern pike in Southcentral Alaska. Prior to 1994, only anecdotal information was available concerning northern pike stocks of the Susitna River drainage. Management decisions regarding northern pike relied on catch and harvest trends generated from the SWHS, with additional input from sport anglers. Alaska State law mandates that Alaska's wild fisheries resources be managed under a sustainable yield concept. Given the potential heavy predation of northern pike on other fish species targeted by sport anglers, managing northern pike stocks for trophy type fisheries and limiting predation of northern pike on coho salmon and rainbow trout stocks may be mutually exclusive.

Before the existing or any new regulatory strategies can be evaluated properly, the effects of northern pike predation on salmonid populations must be documented. Therefore, in 1994, the Alaska Department of Fish and Game initiated a stock assessment program for northern pike of the Susitna River drainage.

STUDY OBJECTIVES

This project had four components. The first component was to collect abundance and life history information on northern pike in a heavily fished lake. The second component was to investigate northern pike predation on rainbow trout in three small stocked lakes. The third component was to a search for an anadromous lake system to study the impact of northern pike predation on coho salmon fry. The last component was to track the movements of northern pike in several open lake systems.

Specific objectives for this study were to:

1. Describe the average monthly movements of radio-tagged northern pike in four open lake systems (Alexander, Trapper, Ding Dong, and Whiskey lakes);
2. Estimate the age, length, and sex compositions of northern pike ≥ 300 mm FL in Alexander Lake;
3. Estimate the mean length-at-age for northern pike in Alexander Lake;
4. Estimate the relative stock densities of northern pike in Alexander Lake;
5. Estimate the abundance of spawning northern pike ≥ 300 mm FL in Alexander Lake;
6. Estimate the proportion of nonempty northern pike stomachs containing rainbow trout from Crystal and South Rolly lakes prior to and immediately after rainbow trout stocking in June and just prior to freeze up;
7. Estimate the abundance of northern pike ≥ 300 mm FL in Crystal and South Rolly Lake;
8. Estimate the abundance of age-1+ and older rainbow trout stocked in Crystal and South Rolly lakes, such that the

estimate is within 25 percentage points of the true value 90% of the time; and

9. Determine if juvenile coho salmon are present in the following drainages: Fish Lake Creek (Yentna River Drainage), Fish Creek (Nancy Lake Canoe System), Fish Creek (Kroto Slough), Witsoe Creek (Kroto Slough), and Trapper Creek drainage.

It was determined that the northern pike population in Alexander Lake is an open population with little mixing occurring during the spring spawning season. For this reason it was necessary to use a Jolly Seber estimate, which requires at least 3 years of data collection. Therefore, objective 5 will be addressed during the 1997 reporting period.

In addition to the objectives listed above, stomach contents of northern pike were analyzed, and cannibalism in northern pike caught in hoop nets was compared to those caught with hook and line.

METHODS

STUDY AREA

The Susitna River drainage originates from two major mountain ranges (Talkeetna and Alaska), generally flowing in a southerly direction before emptying into upper Cook Inlet. The drainage comprises hundreds of shallow lakes, high and low velocity clearwater tributaries, and sloughs supporting large beds of aquatic vegetation that are ideal spawning and rearing habitats for northern pike. Six lake systems of this drainage were sampled for northern pike during this study: Alexander, Sucker, Ding Dong, Whiskey, and Trapper lakes, and several lakes in the Nancy Lake Canoe System.

BIOLOGICAL SAMPLING

The following biological sampling procedures were common to assessment of all objectives. All northern pike greater than 150 mm (including fish recaptured within a season) were measured to the nearest millimeter of fork length. A smear of scales was removed from each live fish. Each fish over 299 mm in FL was marked with a Floy FD-68 internal anchor tag inserted posteriorly at the left base of the dorsal fin. Because Pearse (1991) showed that sex determination by external characteristics as described in Casselman (1974) was unreliable, sex was recorded only for northern pike extruding sexual products. Northern pike for which sex could not be determined were recorded as unknown. All mortalities were dissected to verify sex and maturity through examination of the gonads.

Age was determined using scales (Peckham and Bernard 1987). A smear of scales (consisting of at least three) was taken from the preferred zone adjacent to, but not on, the lateral line above the pelvic fins as described by Williams (1955). Scales were stored in coin envelopes and were later removed for cleaning and mounting on gum cards. The cards were used to make scale impressions on 20 ml acetate sheets using a Carver press at 137,895 kPa (20,000 psi) heated to 93°C for 45 s. Scales were read on a Micron 770 microfiche reader (32X). Ages were recorded in accordance with age identification criteria established by Williams (1955) and Casselman (1967). Scales were taken from each dead fish for subsequent age determination, and stomach contents were noted on scale envelopes.

Care was taken to minimize trauma to fish through proper handling. Processed fish were released near location of capture. The capture location of each fish was recorded.

ASSESSMENT OF SEASONAL MOVEMENTS

Seasonal migrations and distributions of northern pike were investigated using radiotelemetry. Radiolocations from low and high frequency radios implanted in northern pike were used to describe spawning migrations and identify spawning areas. However, because of the extended battery life, high frequency radio tags were also used to describe major seasonal movements and to note habitat and location selections on a seasonal basis for up to 18 months and to further facilitate field sampling.

Thirty-eight northern pike were captured through the ice using hook and line (polar tip-ups baited with herring) and were surgically implanted with radio transmitters from March 15 through April 6, 1994 at four selected study sites in the Susitna River drainage. These sites were Alexander (n = 9), Trapper (n = 12), Whiskey (n = 8), and Ding Dong (n = 9) lakes. This time frame was chosen to ensure that low frequency radio tags would last through the duration of the spawning season and high frequency radios would last for two consecutive spawning seasons.

Radio tags were internally implanted in each fish using standard surgical procedures. Only northern pike >490 mm FL were used, given a recommendation by Winter et al. (1978) that the weight of the radio transmitter should not exceed more than 2% of the fish's body weight. Tricaine methanesulfonate (MS-222) was not used to anesthetize fish because recovery times for northern pike in cold water were slow and fish seemed to undergo added stress. All fish were tagged prior to release with a sequentially numbered Floy anchor tag. Sex was not determined for radio tagged northern pike. Locations of captured fish were verified with a Magellan Global Positioning System Unit and noted on a map.

Radio transmitters (hereafter referred to as radios) were 2.5 cm long by 1.1 cm wide by 0.6 cm thick and weighed 4.5 g with an external 26 cm antenna (model CHP-1P transmitter with a TA-5LT antenna, manufactured by Telonics, Inc., Mesa, Arizona). The operational life of transmitters for low frequency radios was slightly less than 3 months at a pulse rate of approximately 60 signals per min and transmitted in the frequency band between 48.170 and 49.980 MHz. The operational life of transmitters for high frequency radios was 18 months, at a pulse rate of approximately 60 signals per min, and transmitted in the frequency band between 148.110 and 149.790 MHz. The receiving equipment (also from Telonics, Inc.) consisted of a TR-2 receiver mated to a TS-1 scanner-programmer, which were fed by an RA-4B directional eight-element "Yagi" antenna with 11.8 dB of forward gain. All radios were ground-truthed prior to deployment to detect and compensate for any frequency drift that might have occurred. The antenna and receiving equipment were mounted on the strut of a Piper Supercub aircraft. Reception distances ranged from 2.1 km to 3.2 km.

Locations of radio-tagged fish were monitored twice weekly during the spawning season and monthly thereafter. Weekly tracking commenced in late April and continued through late May. This time frame was chosen because it was thought to encompass the time of spawning. Tracking consisted of programming frequencies of all deployed transmitters into the receiver/scanner (occasional frequency drift did occur, but did not interfere with adjacent transmitters), and flying to the last location of the respective fish. Each time a radiolocation was made, date and time were recorded. Locations of individual northern pike determined during a given sampling period were plotted on maps. Locations on Alexander and Trapper lakes, determined through the use of aerial telemetry as potential spawning areas, were ground-truthed for confirmation. Monthly tracking periods continued through the remainder of the radio's battery life.

A site was suspected to be a spawning location if a radio-tagged northern pike was found within 50 m of an inlet stream or from the shore lakeward to 1.3 m water depth. Suspected spawning areas were sampled to confirm the presence of gravid northern pike.

Analysis and presentation of radiolocation data collected in the Susitna River drainages relative to radio-tagged northern pike generally followed the methodology described by Pearse and Clark (1992) and Roach (1993). Data on fish locations, direction of movements, and distances between radiolocations were entered on a digitized replica of field sampling maps. Range of movements and migration patterns of northern pike were determined by locating northern pike with radio transmitters, determining latitude and longitude with a Global Positioning Unit, and marking locations on a corresponding map. On final summary maps, locations of individual fish were shown only once for a given time period.

ASSESSMENT OF AGE, SEX, AND SIZE COMPOSITIONS

Northern pike were sampled during two distinct time periods: winter (the ice covered period from December 15, 1993 through April 15, 1994) and spring (the open water period from May 15 through June 1, 1994). Northern pike were collected using modified hoop nets, gillnets, and hook and line. Modified hoop nets were only fished during spring. The modified hoop nets measured 1 m by 4 m long with 25 mm square mesh nylon netting on seven fiberglass hoops with finger-style throats on second and fourth hoops and with attached 15 m leads. Variable mesh gillnets were used during spring sampling to collect fish for dietary analysis. Variable mesh gillnets were 46 m long with 7.6 m panels of 15, 25, 38, and 51 mm square bar mesh. Hook and line were used during both the spring and winter sampling. During the winter, tip-ups were used exclusively with herring for bait. During the spring, conventional spin casting equipment with terminal gear consisting of artificial lures and herring with bobber set ups was used.

Mean lengths were calculated as the arithmetic mean of all fish lengths. Variances were calculated with the squared deviations from the mean (standard variance formula). Standard errors of the mean (SE) were calculated as the square root of the variance divided by the sample size.

The proportion in each age, sex, and length class was estimated as:

$$\hat{p}_j = \frac{n_j}{n}, \qquad (1)$$

where:

n = the number of fish sampled;

n_j = the number of sampled fish in age, sex or length group j; and

$\hat{p}_j$ = the estimated fraction of the fish in age, sex or length group j.

The variance of the proportion was calculated as:

$$V\left[p_j\right] = \frac{\hat{p}_j(1-\hat{p})}{n-1}. \qquad (2)$$

Kolmogorov-Smirnov tests were used to evaluate whether cumulative length distributions varied between gear within lakes and between lakes within gear. Chi-square tests were used to evaluate whether age or sex compositions varied by gear or lake. In all tests, data were grouped by sampling event. For purposes of this study a sampling event was considered to be the actual amount of time spent collecting data on a given lake during the spring spawning season within lakes and between years.

Length distribution data were evaluated using relative stock density (RSD) as described by

Gabelhouse (1984). RSD length categories were defined as follows: "stock," 300 to 524 mm; "quality," 525 to 654 mm; "preferred," 655 to 859 mm; "memorable," 860 to 1,079 mm; and "trophy," 1,080 mm and longer.

Mean length-at-age for northern pike sampled was estimated for each of the study areas as:

$$\bar{l}_a = \frac{\sum_{i=1}^{n_a} l_{ai}}{n_a}, \quad (3)$$

where:

$\bar{l}_a$ = mean length-at-age a,

l_{ai} = length of ith fish at age a, and

n_a = number of sampled fish at age a.

The variance of l_a was estimated as:

$$V[\bar{l}_a] = \frac{\sum_{i=1}^{n_a} (l_{ai} - \bar{l}_a)^2}{n_a - 1}. \quad (4)$$

Standard analyses of variance (ANOVA) methods were used to evaluate differences in mean length-at-age between lakes.

NORTHERN PIKE PREDATION ON RAINBOW TROUT

Hoop nets were used to collect northern pike in South Rolly and Crystal lakes for assessment of food habits. Sampling commenced in late July immediately after the lakes were stocked with 10,000 rainbow trout fingerlings. All captured northern pike were dissected, and stomach contents were examined for the presence of rainbow trout onsite.

SAMPLING OF JUVENILE COHO SALMON

Several tributaries of the Susitna River drainage were sampled to detect the presence of juvenile coho salmon from mid-June through August. Streams were categorized into two habitat types: fast clearwater streams and deep lakes with little aquatic vegetation (type 1 habitat); or shallow lakes and slow-moving streams with abundant vegetative mats (type 2 habitat). Type 1 habitat is marginal habitat for northern pike and coho salmon; type 2 habitat is the preferred habitat of northern pike in all life stages and of coho salmon for rearing (Carbine and Applegate 1946; Diana et al. 1977; Narver 1978).

The two habitat types were sampled in each system with 11 to 200 minnow traps. The number of minnow-trap sets per system was primarily dependent upon the accessibility of the stream and size of the system: fewer traps were set in smaller systems with limited access. The cylindrical traps measured 42 cm in diameter with a mesh size of 0.6 cm square. Minnow traps were soaked at least 24 hr. One set was equal to one trap being fished for a 24-hour period.

To ensure that gear was effectively capturing coho salmon, we sampled four streams with type 2 habitat but with no previous documentation of northern pike. Because these streams were sampled to test the catchability of the gear and observed catches of coho salmon were almost immediate, it was necessary to soak the sampling gear for only 2-3 hr. In addition, because these streams were within or adjacent to urban areas, there was a good chance of traps being molested, stolen or vandalized. CPUE was expressed as the average number of juvenile coho salmon per trap set for each location sampled.

ANALYSES OF FOOD HABITS

Sampling of northern pike stomachs was conducted on several Susitna River drainage systems, including Hewitt and Trapper lakes, Fish Creek (Kroto Slough), Alexander Lake, Fish Creek (Nancy Lake Canoe System), Deshka River and Onestone Lake. In addition, three Susitna area stocked lakes, South Rolly, Sand and Fire lakes, were also sampled. Habitat of these systems was categorized as either type 1 or type 2.

The three stocked lakes contain nonindigenous populations of northern pike. These lakes have been annually stocked with catchable rainbow trout (mean length of 215 mm) and fingerlings (mean length of 125 mm) for several years. Sampling gear consisted of hoop nets and variable mesh gillnets, each soaked for 24 hr, and hook and line. Gillnets were only set in waters deeper than 1 m.

All captured northern pike were sacrificed, dissected, and stomach contents analyzed onsite to identify incidence of major food items (vertebrates and/or invertebrates) present. Occurrences of major food items ingested were determined along with occurrences of empty versus nonempty stomachs. Because both invertebrates and vertebrates were found within the same stomachs, percentages of major food items ingested were individually estimated as a portion of the total number of nonempty stomachs. This method did not consider the amount or bulk of food types per stomach. However, it is a method of providing a crude assessment of what is being eaten at the time of sampling (Hyslop 1980).

PIKE CANNIBALISM BETWEEN GEAR TYPES

Incidences of cannibalism by northern pike captured in hoop nets in the AYK region have been observed (Gary Pearse, Alaska Department of Fish and Game, Fairbanks, personal communication). This suggests that small northern pike are susceptible to predation by large northern pike while confined in hoop nets. Therefore, younger age classes may be underestimated in analyses. All northern pike sampled during the spring on Alexander Lake were physically examined for evidence of cannibalism (i.e., prominent bulging of the northern pike stomach). For purposes of our study a northern pike was only considered to be cannibalistic when it was positively determined through physical observation (i.e., tail or portion of partially ingested northern pike present in buccal cavity). Capture gear was recorded for all northern pike captured. Chi-square tests were used to determine if observed cannibalism in northern pike varied between gear types.

RESULTS

MIGRATION AND MOVEMENT

Thirty-eight northern pike were captured and implanted with radio tags between March 15 and April 6, 1994 (Table 1). Of these, 16 received high frequency (up to 18 month life) radio tags and 22 received low frequency (up to 3 month life) radio tags. Northern pike with low frequency radio tags were located five times to detect prespawning and spawning movements. Northern pike with high frequency tags were located between 10 and 13 times to detect both spawning and seasonal movement information.

Based on movement patterns, such as fish concentrating in nearshore vicinities or within close proximity to lake outlets, northern pike began their migration to potential spawning sites during the last week of April (Appendices A1 through A4). Except for Whiskey Lake (Appendix A3), use of potential spawning sites began during the first week of May, with peak activity occurring

Table 1.-Northern pike radio tagged during winter 1994 in the Susitna River drainage.

Lake	Radio Frequency Number	Tag Frequency	Length (mm)	Weight (lb)	Date Tagged
Alexander Lake	148.580	High	534	2.7	04/06/94
	148.590	High	725	6.7	04/06/94
	149.640	High	598	3.5	04/06/94
	148.930	High	590	3.5	04/06/94
	48.210	Low	570	3.8	04/06/94
	48.410	Low	575	3.3	04/06/94
	48.810	Low	565	3.3	04/06/94
	49.490	Low	602	4.0	04/06/94
	49.230	Low	565	3.3	04/06/94
Trapper Lake	149.750	High	588	3.5	03/31/94
	149.670	High	652	3.7	03/31/94
	148.710	High	595	4.2	03/31/94
	148.870	High	654	4.5	03/31/94
	48.480	Low	550	3.0	03/31/94
	48.500	Low	541	2.7	03/31/94
	48.750	Low	578	3.3	04/01/94
	49.180	Low	558	2.7	04/01/94
	49.345	Low	512	2.5	04/01/94
	49.590	Low	543	2.5	04/01/94
	49.760	Low	554	3.0	04/01/94
	49.860	Low	524	2.7	04/01/94
Ding Dong Lake	148.110	High	655	4.0	03/21/94
	148.290	High	738	6.7	03/21/94
	148.510	High	910	14.7	03/21/94
	148.670	High	681	5.5	03/21/94
	148.820	High	751	8.2	03/21/94
	48.170	Low	631	4.0	03/21/94
	48.610	Low	678	5.0	03/21/94
	48.890	Low	609	3.8	03/21/94
	49.440	Low	715	5.5	03/23/94
Whiskey Lake	148.320	High	611	3.5	03/23/94
	148.600	High	678	3.7	03/23/94
	149.790	High	837	11.2	03/23/94
	48.340	Low	493	2.0	03/25/94
	48.450	Low		2.8	03/25/94
	48.510	Low	675	4.8	03/23/94
	48.980	Low	590	3.0	03/23/94
	49.315	Low	534	2.5	03/24/94

during mid-May, and continuing through late May or early June. We began sampling immediately after ice-out and many of the fish examined were either completely or partially spent at that time, indicating that spawning began prior to ice-out.

High Frequency Tags

Fish that were tagged with high frequency tags ranged in length from 534 mm for a fish tagged in Alexander Lake to 910 mm for a fish tagged in Ding Dong Lake (Table 1). There was no indication that migration activity differed for northern pike of different sizes (Appendices B1-B16). The farthest a northern pike was observed to have traveled from its capture location was 13 km by fish 148.110 on Ding Dong Lake (Appendix B12). The minimum distance traveled by a single fish was less than 1 km for fish 148.870 on Trapper Lake (Appendix B4). Seven of the 16 radio-tagged fish were only located within the lake where they were originally tagged (Appendices B1, B2, B4, B7, B8, B10, and B11), while the remainder of the fish were located in adjoining outlet streams or adjacent connecting lakes (Appendices B3, B5, B6, B9, B12-B16). In Trapper Lake, three of the four tagged northern pike resided almost entirely in the north end of the lake (Appendices B1, B2, and B4) while only one fish (148.710) moved into Trapper Creek (Appendix B3). In Alexander Lake all radio-tagged fish seemed to move throughout the lake (Appendices B5-B8) and two of the fish spent time in Alexander Creek (Appendices B5 and B6), one of which remained in the creek for most of the study (Appendix B6). In Whiskey Lake, two of the three tagged northern pike resided entirely in the lake (Appendices B10 and B11) while the remaining northern pike moved between Whiskey Lake and its outlet stream (Appendix B9). All of the fish tagged in Ding Dong Lake moved between lakes and/or resided entirely in Fish Creek (Appendices B12-B16). Visual inspection of location of confirmed radiolocations indicated that all tracked fish resided in areas of dense aquatic vegetation.

Age, Sex, and Length Compositions

From January 1994 through October 1995, 2,593 northern pike were collected from Alexander, Trapper, Ding Dong, and Sucker lakes (Table 2). Of these captures, 1,403 were by hook and line and 1,190 by modified hoop nets, which were only fished during the ice-free season. During winter sampling, 213 northern pike were captured and 2,380 northern pike were captured during spring sampling.

Mean Length and Length Distributions

Northern pike sampled from all study lakes ranged in length from 161 mm to 1,070 mm FL. Gear was selective in terms of the length of northern pike captured. Northern pike captured during the spring with hook and line were significantly larger than northern pike caught in the spring with hoop nets in Alexander Lake during 1994 (KS test, $D = 0.223$, $P < 0.001$) and 1995 (KS test, $D = 0.087$, $P < 0.009$). However, they were not significantly different in Trapper Lake ($P > 0.5629$) (Figures 4 and 5).

There were also differences in the lengths of northern pike present in the sampled lakes. Northern pike captured during the spring using either hoop nets ($P < 0.001$) or hook and line ($P < 0.001$) in Alexander Lake were significantly larger than those captured in Trapper Lake using these gear types (Figure 6). Northern pike captured during spring 1995 using either hoop nets ($P < 0.001$) or hook and line ($P < 0.001$) were significantly larger than those caught during 1994 (Figure 7).

Table 2.-Number of northern pike captured throughout the Susitna River drainage during the winter and spring, 1994 and 1995.

Lake/Seasons	Hook and Line	Hoop Nets	Total
Alexander Lake			
Winter 1994-1995	70	0	70
Spring 1994	440	218	658
Spring 1995	648	839	1,487
Combined	1,158	1,057	2,215
Trapper Lake			
Winter 1994	61	0	61
Spring 1994	60	133	193
Combined	121	133	254
Ding Dong Lake			
Winter 1993-1994	50	0	50
Spring 1995	27	0	27
Combined	77	0	77
Sucker Lake			
Winter 1994	32	0	32
Spring 1994	15	0	15
Combined	47	0	47
All Lakes			
Winter 1993-1995	213	0	213
Spring 1994, 1995	1,190	1,190	2,380
Combined	1,403	1,190	2,593

Relative Stock Densities

Given that gear influenced length of captured northern pike, I examined mean RSD of northern pike in studied lakes by gear. During spring sampling in 1994 and 1995, most northern pike captured with hook and line and hoop nets in Alexander and Trapper lakes were in the stock and quality categories, with Alexander Lake having more captured northern pike in the quality and preferred categories than Trapper Lake (Tables 3 and 4). On Alexander Lake, there were more fish caught in the preferred category during 1994 than in 1995. During the winter sampling, most of the northern pike captured using hook and line in the studied lakes were in the quality and preferred categories (Table 5).

Age Compositions

Northern pike sampled from all study lakes ranged in age from 1 to 15 years. As was the case with lengths, gear was selective in terms of the ages of northern pike captured (Figures 8 and 9). Ages of northern pike captured during the spring with hook and line were significantly different from ages of northern pike caught with hoop nets in both Alexander, (χ^2 = 78.7, df = 9, P < 0.001) and Trapper (χ^2 = 12.8, df = 5, P = 0.026) lakes.

Ages of northern pike present in the samples between lakes also differed. Northern pike captured during the spring using either hoop nets (χ^2 = 63.6, df = 4, P < 0.001) or hook and line (χ^2 = 72.4, df = 4, P < 0.001) in Alexander Lake were significantly different from those captured in Trapper Lake using these gear types (Figure 10). Fish caught in Alexander Lake during 1995 were significantly different from those caught in 1994 for both gear types (χ^2 test, both P-values < 0.001). Interestingly, northern pike captured in Alexander Lake during 1995 were not only larger-at-age, but there were proportionally more large fish (Figure 11) than in 1994 (χ^2 = 45.6, df = 10, P < 0.001).

Sex Compositions

In Alexander Lake, more male northern pike were captured during the spring with hook and line than were expected while the opposite was true in Trapper Lake (χ^2 = 28.0, df = 1, P<0.001). There was no significant difference between sex ratios of northern pike captured in either Alexander or Trapper lakes using hoop nets (χ^2 = 0.3, df = 1, P = 0.604).

Overall male to female ratios of northern pike captured in Trapper Lake during 1994 and Alexander Lake during 1995 were similar (2:3); while only a 1:3 male to female ratio was observed on Alexander Lake during 1994 (Figure 12).

MEAN LENGTH-AT-AGE

Given that gear influenced length of captured northern pike, I examined mean length-at-age by gear type. Because of small sample sizes for winter samples, I limited the analyses to spring samples. For hook and line, there were significant differences between mean length-at-age of northern pike captured between lakes (ANOVA, $P < 0.001$). Northern pike captured in Sucker and Ding Dong lakes exhibited greater mean length-at-age than did northern pike in Alexander and Trapper lakes; northern pike in Whiskey Lake exhibited mean length-at-age between these lakes (Figure 13).

For hoop nets, significant differences occurred between the mean length-at-age of northern pike captured between lakes (ANOVA, $P = 0.005$). Northern pike captured in Trapper Lake exhibited greater mean length-at-age than did northern pike in Alexander Lake during 1994 and 1995 (Figure 14). There were no significant differences in mean length-at-age (ANOVA, $P = 0.224$) of northern pike captured by hook and line from Alexander Lake between 1994 and 1995. There were, however, significant differences for northern pike captured in hoop nets (ANOVA, $P < 0.001$). Northern pike captured in 1994 exhibited a smaller mean length-at-age than those caught in 1995. Overall, northern pike captured in hoop nets during the spring of 1995 in Alexander Lake exhibited a greater mean length-at-age ($P < 0.001$) then those captured in Alexander Lake during the previous spring (Figure 14).

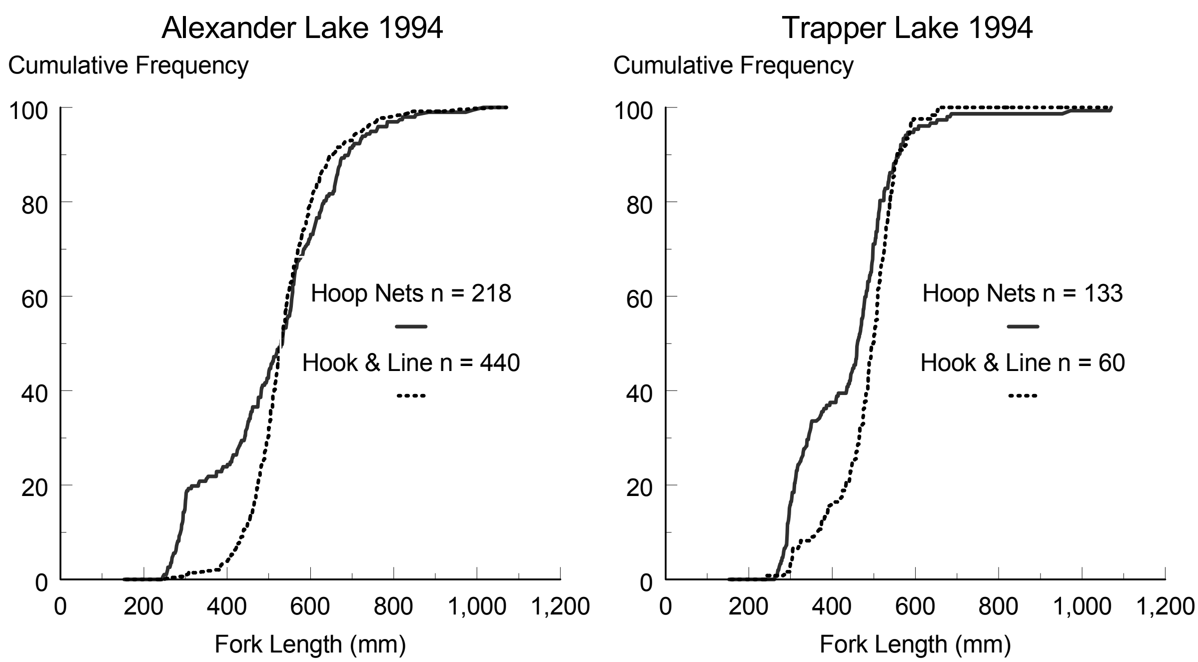

Figure 4.-Cumulative length frequencies of northern pike caught with hook and line and hoop nets in Alexander and Trapper lakes during the spring, 1994.

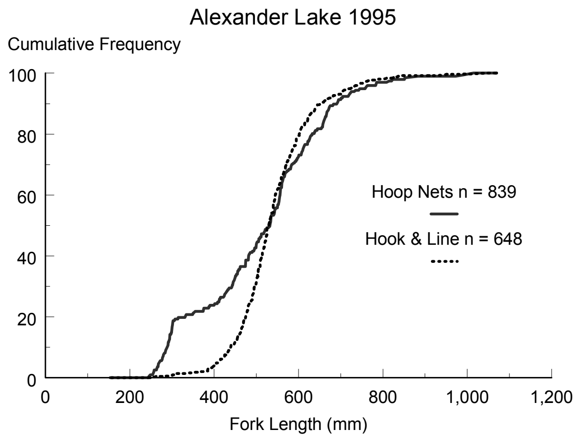

Figure 5.-Cumulative length frequencies of northern pike caught with hoop nets and hook and line in Alexander Lake during the spring, 1995.

NORTHERN PIKE PREDATION ON RAINBOW TROUT

Objectives 7 and 8 of this study were to estimate abundance of northern pike ≥ 30 mm in the spring of 1996, and the abundance of rainbow trout age 1+ in the fall of 1995 in Crystal and South Rolly lakes. These objectives were established to compare stocked rainbow trout survival in lakes containing northern pike populations.

Intensive sampling with fyke nets during August in South Rolly Lake revealed that none of the 10,000 rainbow trout stocked in the spring of 1995 were present in the lake and only eight northern pike were captured. In addition, there were no northern pike captured from Crystal Lake during fall sampling efforts. Therefore, objectives 7 and 8 of this study were not met.

FOOD HABITS

Stomach contents of 237 northern pike captured in two habitat types and in stocked lakes were examined. Overall, 24% were empty.

Type 1 Habitat

Of the 59 stomachs examined from northern pike captured in type 1 habitat, 24% were empty (Table 6). Of the nonempty stomachs, 73% contained salmonids (mostly sockeye,

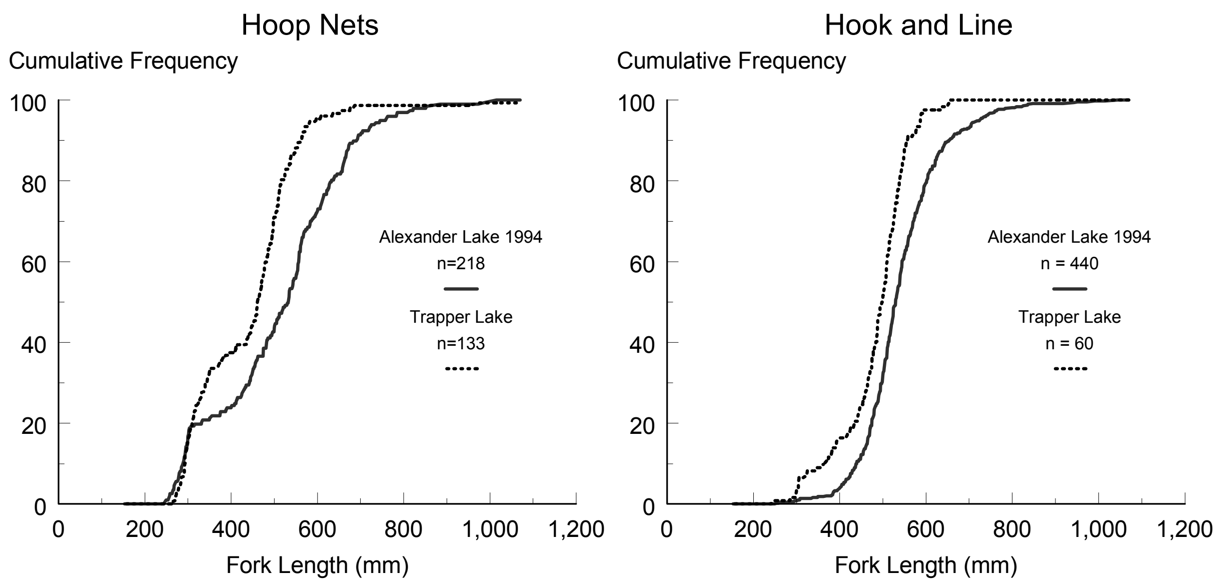

Figure 6.-Cumulative length frequencies of northern pike caught with hoop nets and hook and line in Alexander and Trapper lakes during the spring, 1994.

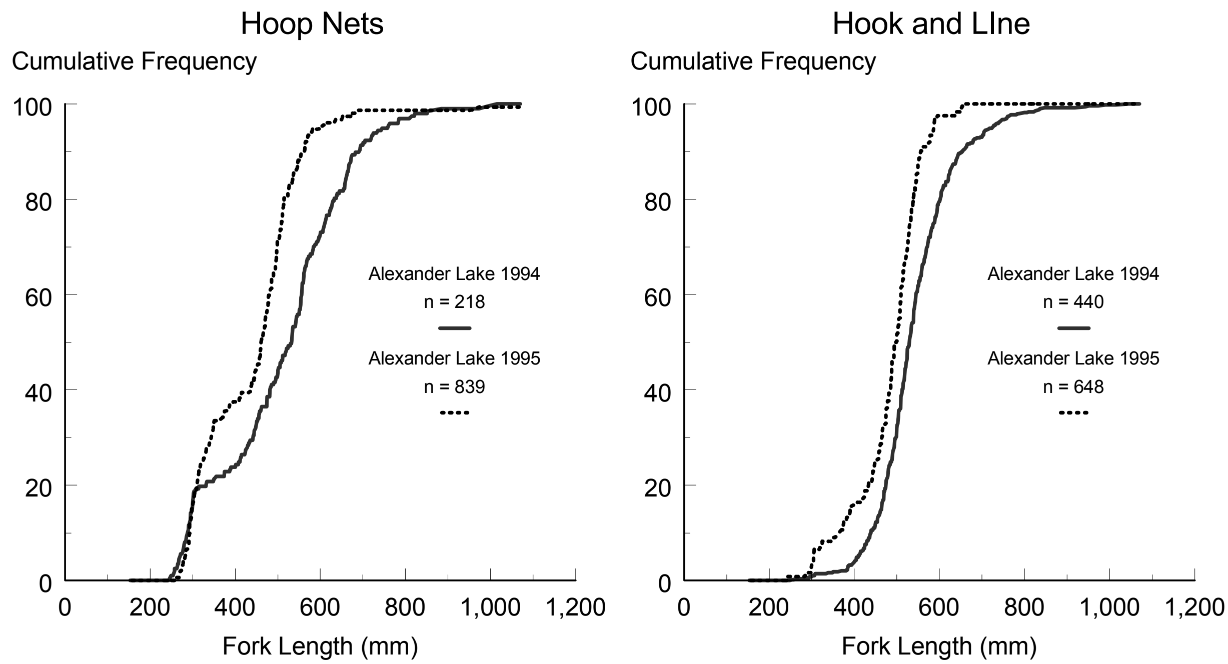

Figure 7.-Cumulative length frequencies of northern pike caught in Alexander Lake during the spring, 1994 and 1995.

Table 3.-Relative stock density (RSD) estimates with number of stock, quality, preferred, memorable, and trophy size northern pike sampled during the spring, 1994.

	Gabelhouse	Hoop Nets				Hook and Line			
	Minimum	Alexander Lake		Trapper Lake		Alexander Lake		Trapper Lake	
Category	Length	RSD[a]	Number	RSD[a]	Number	RSD[a]	Number	RSD[a]	Number
Stock	300 mm	40	87	77	103	50	220	75	45
Quality	525 mm	35	77	20	27	40	178	25	15
Preferred	655 mm	22	49	2	2	9	40	0	0
Memorable	860 mm	2	5	1	1	0	2	0	0
Trophy	1,080 mm	0	0	0	0	0	0	0	0
Total		100	218	100	133	100	440	100	60

[a] Relative stock density expressed as a percentage. Categories taken from Gabelhouse (1984).

Table 4.-Estimates of relative stock density (RSD) with number of stock, quality, preferred, memorable, and trophy size northern pike sampled from Alexander Lake, May 1-May 28, 1995.

Category	Gabelhouse Minimum Length	Hoop Nets		Hook and Line	
		RSD[a]	Number	RSD[a]	Number
Stock	300 mm	48	399	51	333
Quality	525 mm	41	342	40	262
Preferred	655 mm	10	88	8	51
Memorable	860 mm	1	10	<1	2
Trophy	1,080 mm				
Total		100	839	100	648

[a] Relative stock density expressed as a percentage. Categories taken from Gabelhouse (1984).

Table 5.-Relative stock density (RSD) estimates with number of stock, quality, preferred, memorable, and trophy size northern pike captured with hook and line through the ice, December 1993 through April 1994.

Category	Gabelhouse Minimum Length	Alexander Lake		Trapper Lake		Ding Dong Lake		Sucker Lake	
		RSD[a]	Number	RSD[a]	Number	RSD[a]	Number	RSD[a]	Number
Stock	300 mm	3	2	62	38	2	1	3	1
Quality	525 mm	50	35	38	23	38	19	38	12
Preferred	655 mm	41	29			52	26	56	18
Memorable	860 mm	6	4			8	4	3	1
Trophy	1,080 mm								
Total		100	70	100	61	100	50	100	32

[a] Relative stock density expressed as a percentage. Categories taken from Gabelhouse (1984).

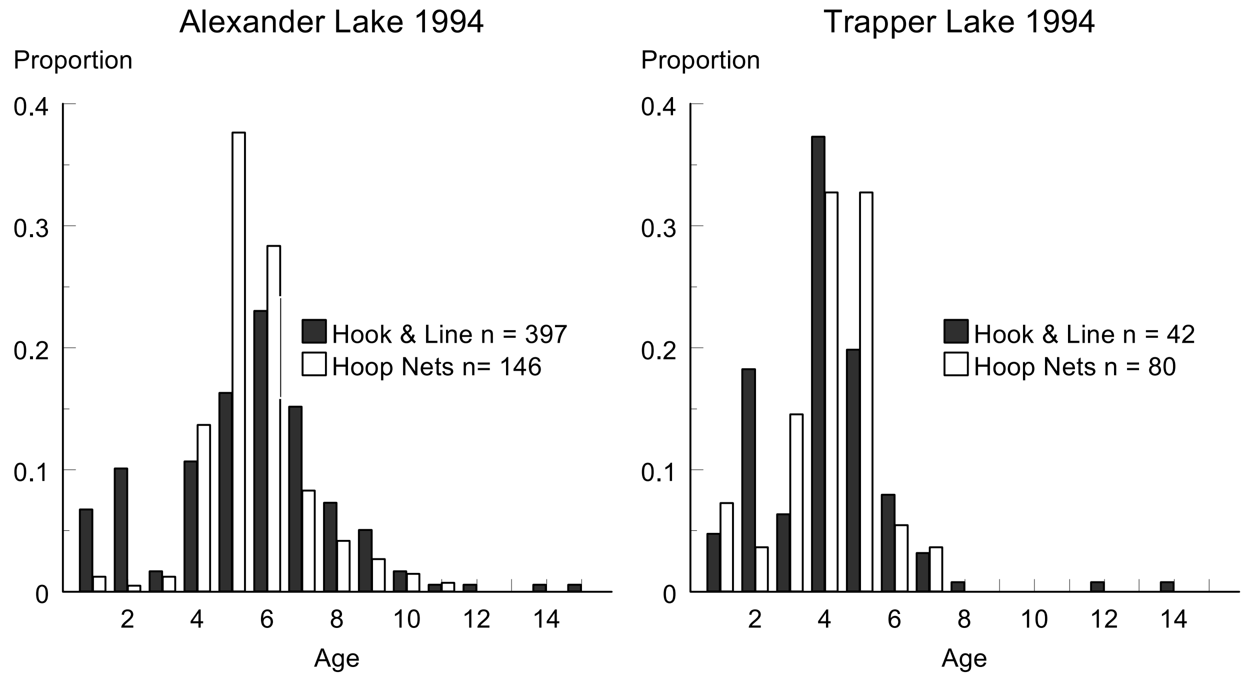

Figure 8.-Age composition of northern pike caught in Alexander and Trapper lakes with hook and line and hoop nets during the spring, 1994.

and coho salmon), 49% contained nonsalmonid fish species, and only 11% contained invertebrates. Only one stomach contained any evidence of mammal, however due to the advanced state of decomposition we made no attempt to identify this animal to species.

Of the stomachs containing nonsalmonid fish species, the three-spined stickleback *Gasterosteus aculeatus* was the most common, while other species found in order of magnitude included northern pike, long nosed sucker *Catostomus catostomus*, and round white fish *Prosopium cylindraceum*. All of the stomachs examined from northern pike collected near the outlet of Hewitt Lake or in the outlet stream (Hewitt Creek) contained salmonids while those collected in the shallow bays of the lake, where only stickleback were observed, contained mostly sticklebacks.

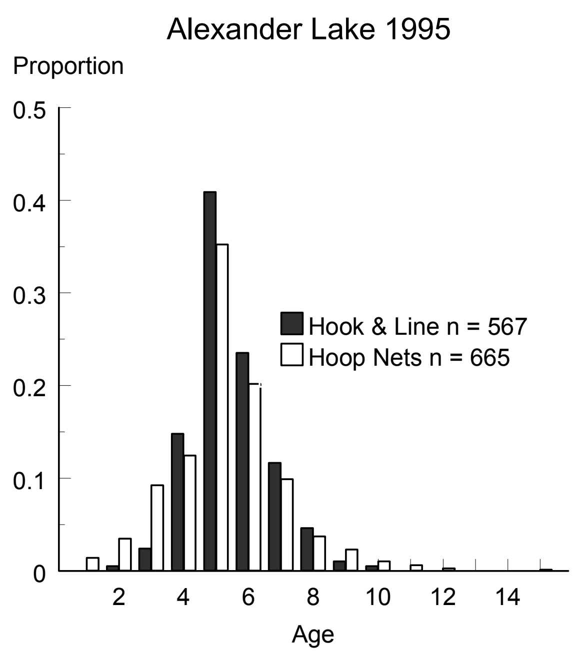

Figure 9.-Age compositions of northern pike caught with hook and line and hoop nets in Alexander Lake, spring 1995.

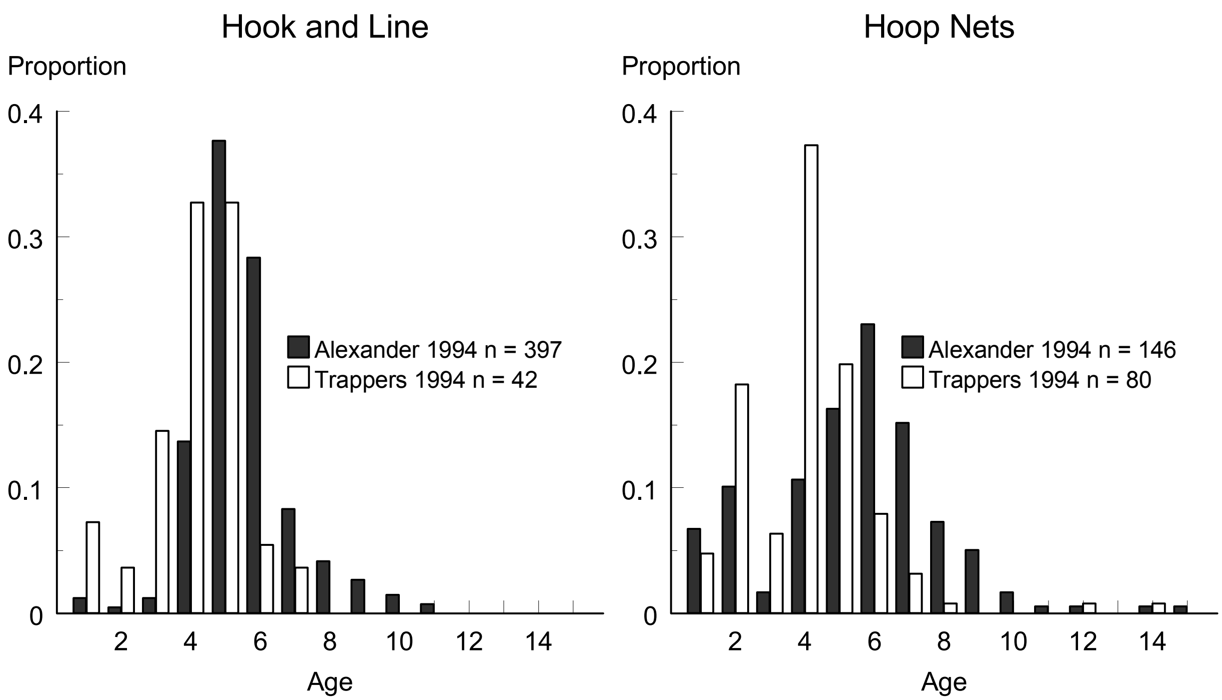

Figure 10.-Age composition of northern pike caught in Alexander and Trapper lakes with hook and line and hoop nets during the spring, 1994.

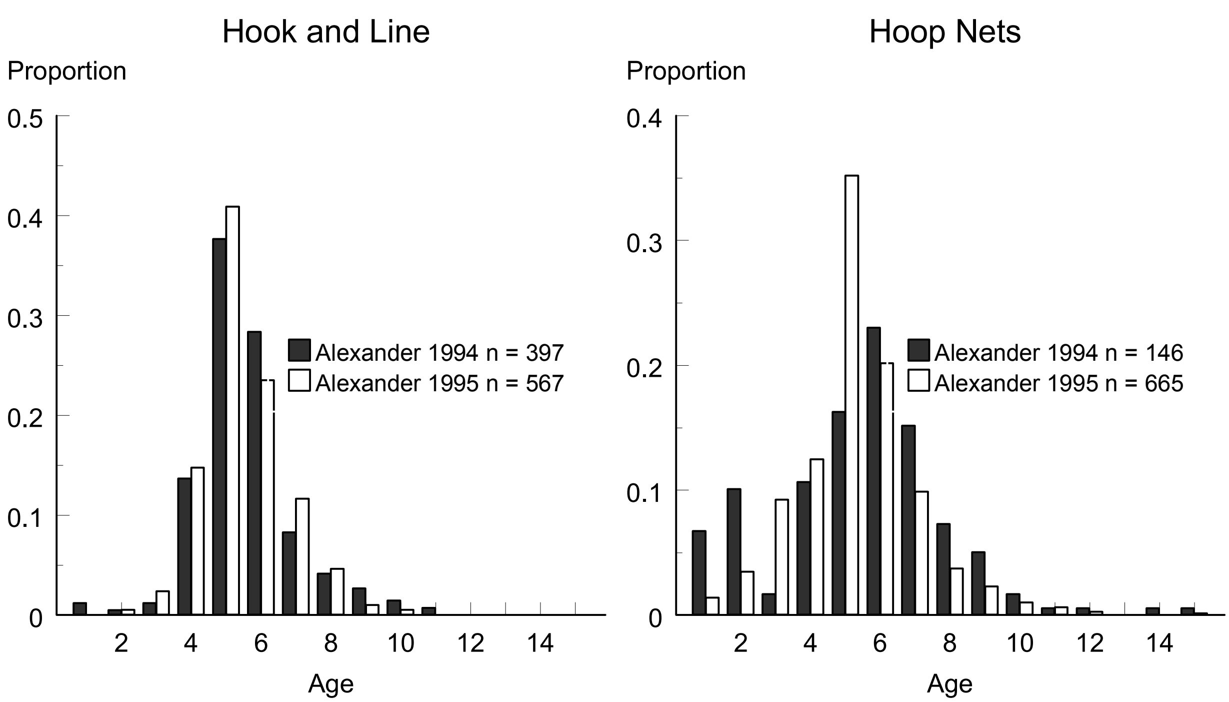

Figure 11.-Age compositions of northern pike caught with hook and line and hoop nets in Alexander Lake during the spring, 1994 and 1995.

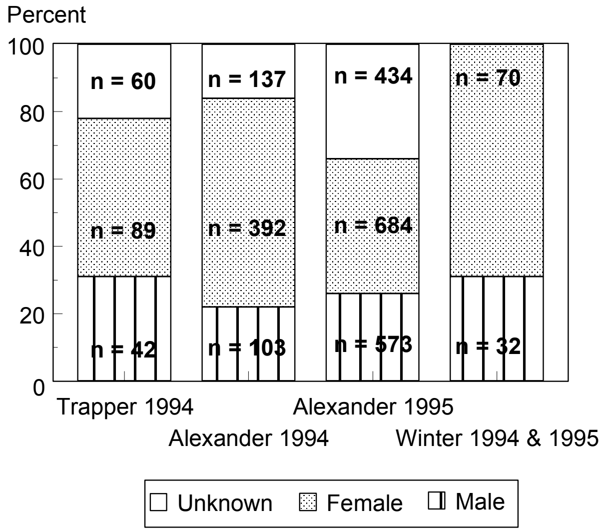

Figure 12.-Sex ratios of northern pike caught with hoop nets and hook and line in Alexander Lake during 1994 and 1995 and Trapper Lake during 1994.

Type 2 Habitat

Of the 143 stomachs examined from northern pike captured in type 2 habitat, 35 (24%) were empty (Table 6). Of the nonempty stomachs, 96% contained a variety of invertebrates, 3% contained salmonids (coho salmon), 16% contained nonsalmonid fish species and 3% contained a species of mammal. Of the stomachs containing other fish species, northern pike, long nosed sucker, and three-spined stickleback were the predominant fish species ingested. The red backed vole *Clethrionomys gapperi* was the only species of mammal observed.

Area Stocked Lakes

Of the 35 northern pike stomachs examined from the three stocked lakes, 23% were empty (Table 6). Of the nonempty stomachs

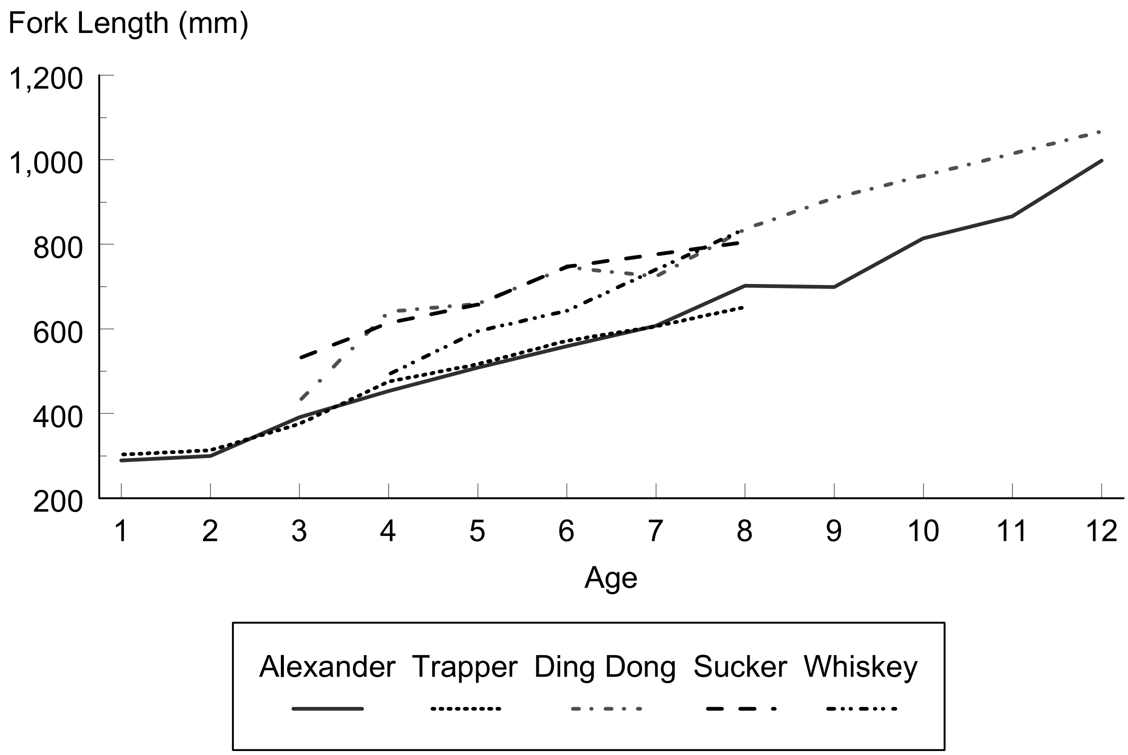

Figure 13.-Mean length-at-age of northern pike caught with hook and line during February and March 1994, in Alexander, Trapper, Whiskey, Sucker, and Ding Dong lakes.

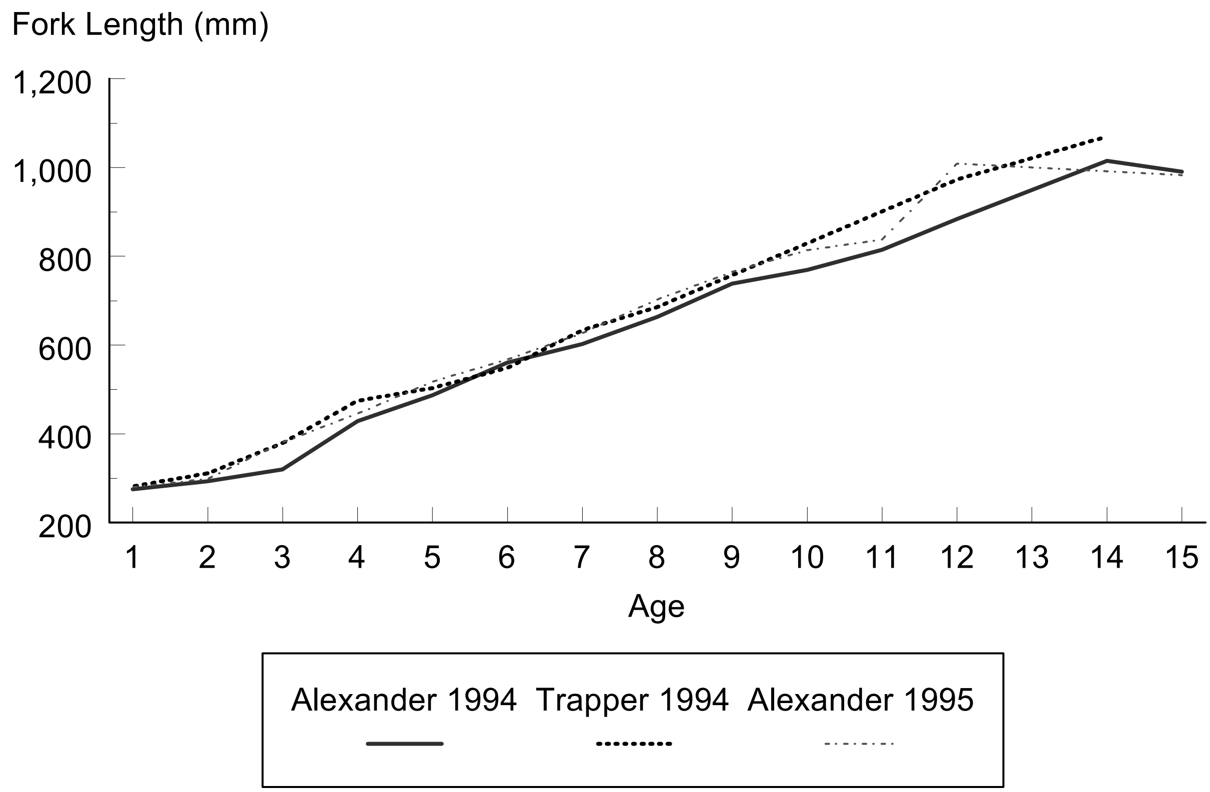

Figure 14.-Mean length-at-age of northern pike caught with hoop nets during the spring of 1994 and 1995 in Alexander Lake and 1994 in Trapper Lake.

Table 6.-Analyses of stomach contents of northern pike sampled from selected Susitna River drainage systems and three area stocked lakes.

Lakes	Total Number Collected	Mean Length (mm)	Frequency of Salmonids (percent) [a]	Frequency of Other Fish (percent) [a]	Frequency of invertebrates (percent) [a]	Number of Nonempty Stomachs (percent)	Number of Empty Stomachs (percent)
Stocked Lakes	35	469	16 (59)	7 (26)	7 (26)	27 (77)	8 (23)
Type 2 Habitat [b]	143	497	3 (3)	17 (16)	104 (96)	108 (76)	35 (24)
Type 1 Habitat [c]	59	521	33 (73)	22 (49)	5 (11)	45 (76)	14 (24)
Total	237					180 (76)	57 (24)

[a] Out of nonempty stomachs.

[b] Type 2 habitat is slow-moving streams and shallow lakes with abundant vegetative mats.

[c] Type 1 habitat is fast clearwater streams and deep lakes with little aquatic vegetation.

examined, 59% contained salmonids (fingerling and catchable rainbow trout), 26% contained other fish species (mostly black fish), and 26% contained invertebrates.

Pike Cannibalism Between Gear Types

Of the 1,361 northern pike examined during 1995, 626 were captured by hook and line and 735 were captured in hoop nets. Of the hook-and-line caught fish, 14 were determined to be cannibalistic while 24 of the hoop net captured fish were determined to be cannibalistic. There was no significant difference (χ^2 = 1.39, df = 1, P < 0.251) in observed occurrences of cannibalism between northern pike captured with hook and line and those captured with hoop nets.

Juvenile Coho Salmon Sampling

A total of 467 minnow traps were fished for at least 24 hr, 229 sets in type 1 habitat and 205 traps in type 2 habitat (Table 7). For a control, 33 minnow traps were fished in five systems with type 2 habitat but these systems contained no northern pike.

Type 1 Habitat

Of the 229 minnow traps set in the Deshka River, Lake Creek and Hewitt Creek, 2,783 juvenile coho salmon were caught. Although other species were captured they were not enumerated. Coho salmon were present in all traps with overall CPUE of 12.1 juvenile coho salmon per trap set (Table 7).

Type 2 Habitat

Of the 205 traps set in Fish Creek (Kroto Slough), Fish Creek (Nancy Lake System), Fish Lake Creek (Yentna River), Trapper Creek (Deshka River), and Witsoe Creek (Kroto Slough) a total of 91 coho salmon were captured. No juvenile coho salmon were captured or observed in Fish Creek of the Nancy Lake Canoe System and Fish Creek (Kroto Slough). Though coho salmon were captured in the other three systems, only a small number were taken, and then only within close proximity to the stream's confluence. Overall CPUE for coho salmon was less than 0.4 fish per trap set (Table 7).

Control

Of the 33 minnow traps set in Cottonwood, Spring, Fish (Big Lake), Lake (of the Nancy Lake System but not part of the Nancy lake Canoe System), and Wasilla creeks, 553 juvenile coho salmon were captured. Coho salmon were present in all sets. Overall CPUE for coho salmon was 16.3 fish per trap set.

DISCUSSION AND RECOMMENDATIONS

We successfully documented seasonal movements of northern pike and locations of spawning areas using radiotelemetry. The majority of northern pike moved throughout the lake system where they were originally tagged. Many of the fish remained or moved to the outlet areas or streams of the lakes shortly after spawning. These movements may be in response to salmonid smolt emigration from lake systems. The radiotelemetry portion is complete and no more radios remain active.

Gear influenced the length, age, and sex compositions of northern pike captured during this study. Given this, I recommend that future sampling be conducted with gear that is consistent across lakes and years. Because fish are concentrated during the spring, and hoop nets seem to be the most effective gear during that time of year, I recommend this gear for spring sampling events. However, hook and line are more successful during the summer, fall, and winter. We should continue to sample with this gear during these times.

Table 7.-Catch of juvenile coho salmon in select Susitna River drainage and control systems in the Matanuska-Susitna area.

System	Date	Total Number of Minnow Traps	Number of Juvenile Coho Salmon Sampled	CPUE (Fish per Trap)
Type 1 Habitat [a]				
1. Deshka River	6/15/95 - 7/01/95	200	2,413	12.0
2. Lake Creek	7/03/95	13	260	20.0
3. Hewitt Creek	6/16/95	16	110	6.7
Total		229	2,783	12.1
Type 2 Habitat [a]				
1. Fish Creek (Nancy Lake Rec Area)	6/18/95 - 7/13/95	111	0	0
2. Trapper Creek Including a Lake[b]	6/01/95 - 6/22/95	31	3	1.7
3. Fish Creek (Kroto Slough)	6/16/95	52	0	0
4. Fish Lake Creek Sys. (Yentna River)[b]	6/16/95	29	7	0.2
5. Witsoe Creek (Kroto Slough)[b]	6/16/95	11	31	2.8
Total		205	91	0.4
Control Group [c d]				
1. Cottonwood Creek	8/17/95	10	61	6.1
2. Spring Creek	8/17/95	4	23	5.7
3. Fish Creek (Big Lake)	8/17/95	11	188	17.1
4. Wasilla Creek	8/17/95	2	89	44.5
5. Lake Creek (Nancy Lake System)	8/17/95	6	177	29.5
Total		33	538	16.3

[a] All traps were only fished for a period of 24 hours. Type 1 habitat is fast clearwater streams and deep lakes with little aquatic vegetation. Type 2 habitat is slow-moving streams and shallow lakes with abundant vegetative mats.

[b] Juvenile coho salmon were only captured near confluence areas.

[c] No northern pike present in any of these systems.

[d] Traps were only fished for a period of 2 hours.

In general, most of the northern pike sampled throughout the Susitna River drainage were in the stock, quality, and preferred categories. There were, however, significant differences in the lengths of northern pike sampled from studied lakes. For example, during winter sampling, fish captured in Ding Dong and Sucker lakes were larger, while fish captured in Trapper Lake were smaller. In general, more large fish were available to the gear during the winter than during the spring. Probable reason for this is that the larger females may be more actively feeding than the males since nearly 70% of the fish captured during the winter were females (Figure 12). The ratio of females to males in samples was about 10% greater during the winter than during the spring.

There were significant differences in mean length-at-age of northern pike sampled in the study lakes, indicating that samples varied by lake. During spring sampling in 1994 and 1995, Alexander Lake samples had significantly more large fish than did Trapper Lake. However, northern pike samples from Trapper Lake were larger-at-age than Alexander Lake northern pike for both years. Moreover, Trapper Lake is much more accessible to sport anglers than Alexander Lake; thus, large older fish in Trapper Lake are probably being harvested by the sport fishery. Interestingly, in Alexander Lake where the northern pike diet consists mainly of invertebrates, northern pike were actually larger-at-age in 1995 than in 1994.

Analysis of stomach contents collected from northern pike in type 2 habitat revealed that northern pike primarily feed upon invertebrates, however, they also fed upon fish. The relative low contribution of fish in the diet may not be reflective of invertebrates as preferred food for northern pike, rather it may be indicative of available food in these lakes. Prior to encroachment of northern pike, these systems were very productive coho and sockeye salmon and rainbow trout systems.

Eklov and Ganrin (1989) showed that northern pike prefer soft-rayed fish. Observations from this study suggest that when given the option, northern pike prefer salmonids over some other fish species and invertebrates. Data show that in type 1 habits, northern pike primarily feed on salmonids. Based on these results, northern pike may have completely eliminated salmonids as a food source in systems with type 2 habitat. Moreover, hundreds of minnow trap sets were made in an attempt to capture coho salmon within this habitat type and very few salmon were captured. Northern pike have likely played a key roll in eliminating juvenile salmonids from these systems.

In areas of type 1 habitat, stomach contents of northern pike revealed that northern pike primarily feed upon salmonids. Other fish, primarily sticklebacks, were also present in northern pike stomachs. However, in areas where sticklebacks and salmonids were both present, the overwhelming majority of food items found in northern pike stomachs was salmonids. This suggests that salmonids may be preferred over other fish species. However, because overall northern pike numbers are currently low in this type of system, it is unlikely that salmonid populations will be reduced as much as in type 2 habitat. Observations of radio-tagged northern pike indicate that some northern pike migrate to lake outlets and streams coinciding with the timing of salmon smolt outmigration. For example, northern pike were observed to migrate to the outlet areas and associated outlet stream of Hewitt Lake. Sampling of the outlet stream and outlet of Hewitt Lake revealed an unusually high concentration of northern pike. Stomach analysis of all northern pike captured indicated that they were feeding predominantly on juvenile sockeye and coho salmon, ranging between 5 and 20 juvenile salmon per stomach.

This movement may be a response to temporal movements of outmigrating salmon smolt. For example, South Rolly Lake of the Nancy Lake Canoe system was stocked in early 1994 and 1995 with 20,000 rainbow trout fingerlings, yet fall and mid-summer gillnet and fyke net surveys of this lake produced no rainbow trout, only northern pike. Also, few fish species other than northern pike were captured in the variable mesh nets used to sample northern pike for stomach content analyses. Past research has indicated that northern pike can be responsible for up to 35% of the mortality of emigrating salmon (Pervozvanskiy et al. 1988). This, coupled with observations that northern pike have now expanded throughout the Susitna River drainage and are now found in areas utilized by juvenile chinook salmon stocks, warrants further study of northern pike distribution.

The depletion of coho salmon stocks in several historically productive Susitna River drainage systems has been attributed to predation by northern pike. Five of these systems were sampled to determine if coho salmon juveniles were still present. Sampling yielded only 0.4 juvenile coho salmon per trap set, and coho salmon were not detected in two of the five systems. In the remaining three systems, coho salmon were found in low numbers and only near the confluence areas. Juvenile coho salmon are generally very susceptible to capture using minnow traps baited with salmon roe (Havens et al. 1995). This was evident in sampling various other stream locations using identical sampling techniques that yielded catches of 12 and 16 juvenile coho salmon per trap set. The fact that confluence areas attract juvenile salmon from other parent streams, coupled with the results from the dietary study, make it likely that coho salmon stocks from these systems of type 2 habitat were eliminated by northern pike predation.

Realistically, management of northern pike will probably be complex. Hill (1974) reports that up to 85% of a population of northern pike were removed from a small Iowa lake through intensive angling. Though this method may be effective for removing northern pike from a small rural lake system, it would have little utility for a system as large as the Susitna River drainage.

A simplistic approach to resolving predation of northern pike on juvenile salmonids would be to eliminate them (e.g. chemically) from the Susitna River drainage. Realistically, this solution is impractical because of the shear size of the drainage and the widespread distribution of northern pike.

Another solution would be to simply remove all bag and possession limits, along with increasing the amount of allowable sport fishing gear, thereby letting the sport anglers reduce northern pike abundance. Because northern pike are such voracious feeders, anglers would be very successful at removing large older fish from the population. As the size of fish decreased though, anglers would quickly lose interest in fishing for smaller fish (< 450 mm). Unfortunately, small northern pike tend to consume more small fish, such as juvenile salmonids, than large northern pike (Diana 1979). Sampling at Hewitt Lake in 1995 confirmed this. Larger northern pike seek out larger prey to conserve energy, as much more energy is required to capture several small prey items then to capture one large item. There are few large forage species available to northern pike in the Susitna River drainage, so larger northern pike (> 480 mm) tend to become cannibalistic. Water temperatures influence the digestion rate of northern pike: digestion may take between 8 and 14 days during the winter and between 30 and 48 hours during the summer (Diana 1979). Given this, it is conceivable that a large northern pike may consume as many as 100 small northern pike a year.

The Alaska Board of Fisheries (BOF) is meeting to deliberate Upper Cook Inlet fisheries issues during February of 1996. The department is submitting, and supports public proposals, to further liberalize sport fishing regulations for northern pike in Upper Cook Inlet (UCI) waters. Should these regulatory proposals be adopted by the BOF it is important that we monitor the impacts of these new regulations and determine whether or not they are successful, and if so, for which Susitna River drainage systems.

The overall intent for instituting a liberal management scheme for UCI northern pike is to: (1) further curtail the spread of northern pike, (2) decrease the amount of salmonid predation, and (3) decrease the number of northern pike to a low enough level that salmon stocks would be able to recolonize areas where they have been depleted by northern pike predation. The effects of these new regulations would probably not be realized for many years. However, monitoring these effects is not expected to be labor intensive or costly. Areas that are found to respond positively should continue to be managed under the existing liberal management strategies, while alternative approaches need to be investigated for those that do not.

We would like to recommend that the stock assessment work on Alexander Lake continue through the spring of 1997. We also recommend that a new component be added to the existing study that would determine the effects of predation on coho, sockeye and chinook salmon juveniles by slough-dwelling northern pike in the Susitna River drainage. These side sloughs and channels provide important rearing habitat for salmon smolt on their seaward migration and for juvenile salmon from adjacent systems that do not contain adequate rearing habitat. These sloughs and side channels are areas where juvenile salmon from all Susitna River drainage systems will, for a time, become vulnerable to northern pike predation.

ACKNOWLEDGMENTS

I would like to thank Doug Vincent-Lang and Pat Hansen for their significant contributions to the study and editorial comments. I would also like to thank Lawrence Erie for conducting the data analysis and assisting with the field collection and radiotelemetry portion of this study.

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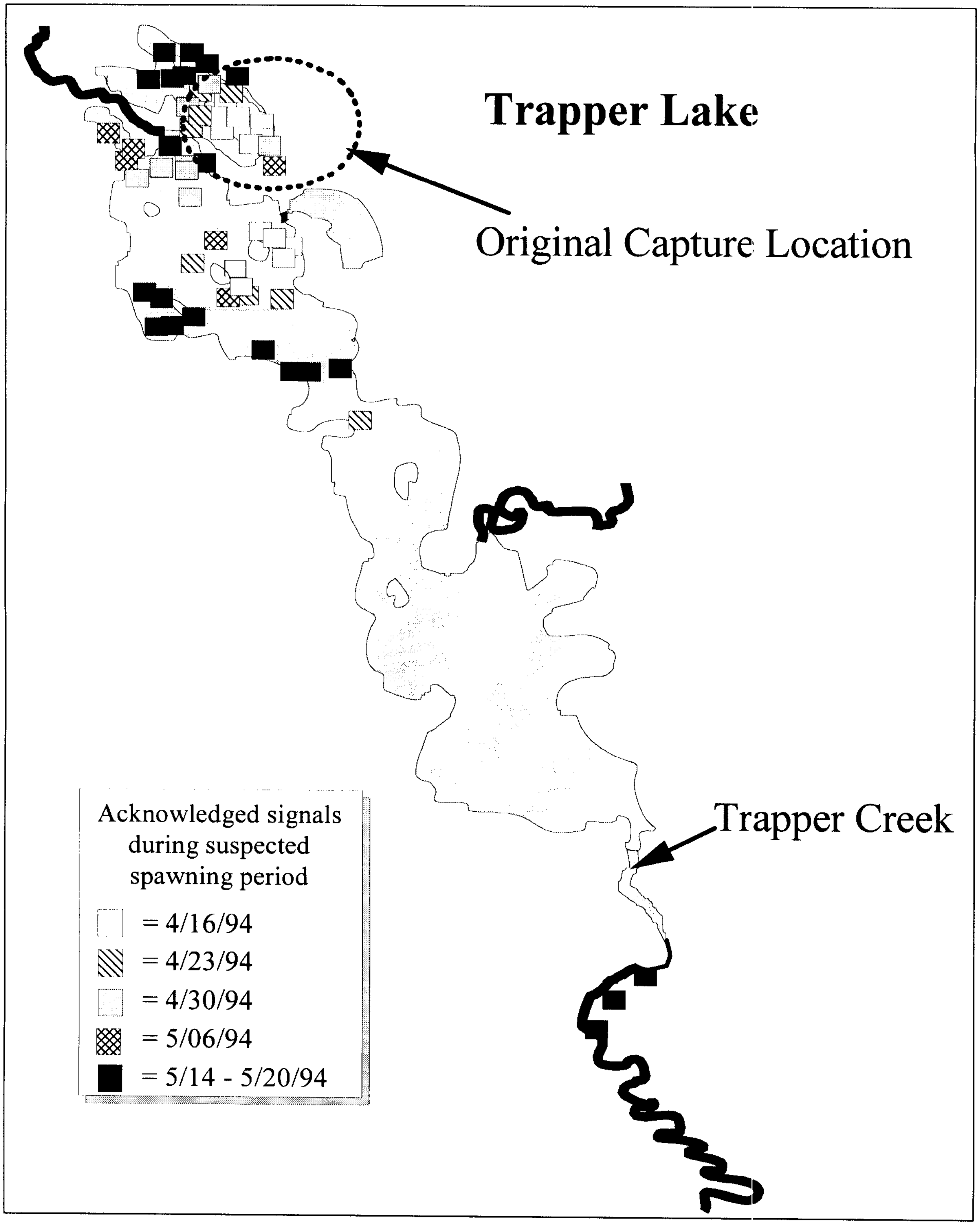
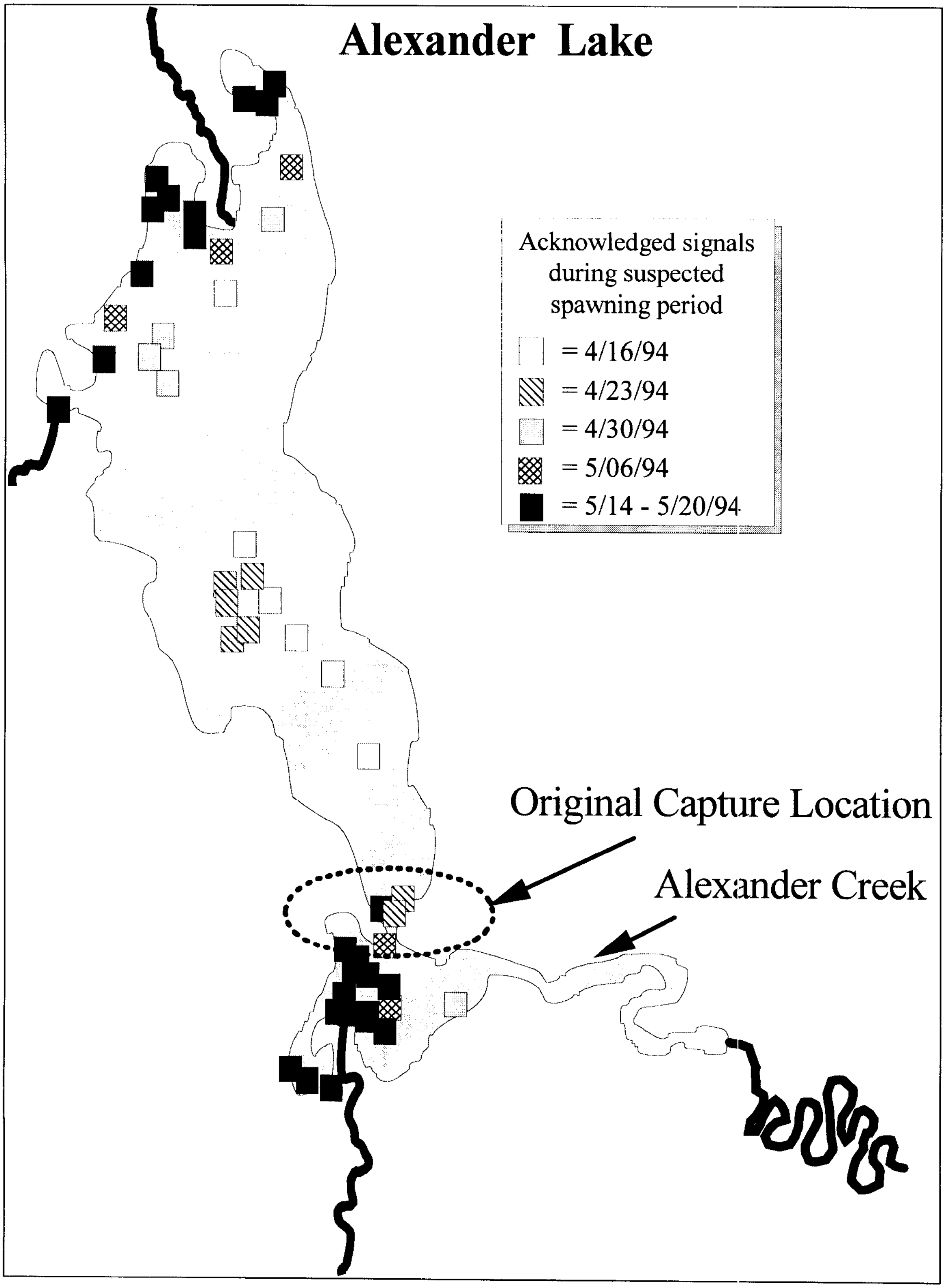
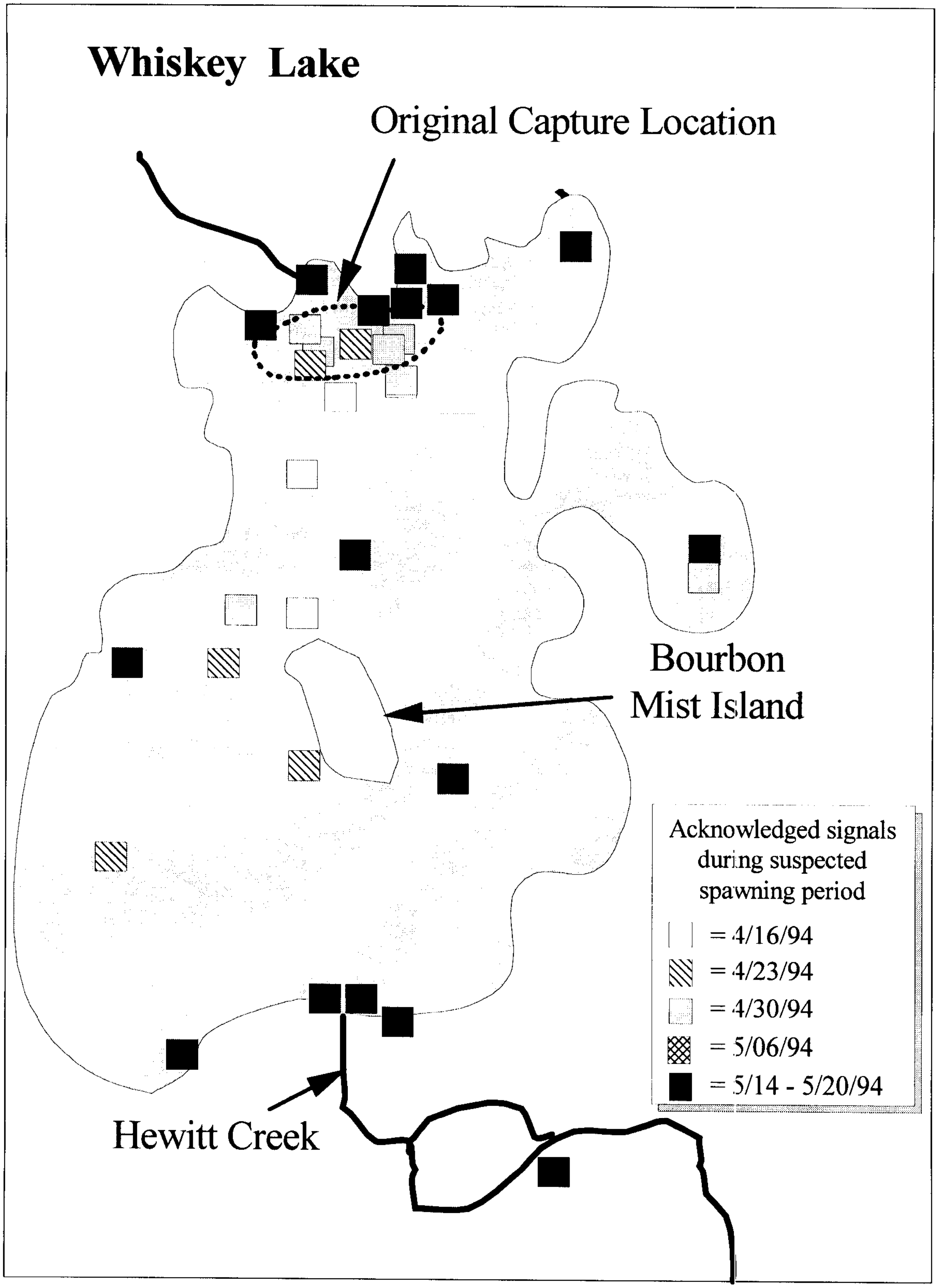
APPENDIX A. MOVEMENTS AND DISTRIBUTION OF SPAWNING NORTHERN PIKE IN TRAPPER, ALEXANDER, WHISKEY, AND DING DONG LAKES



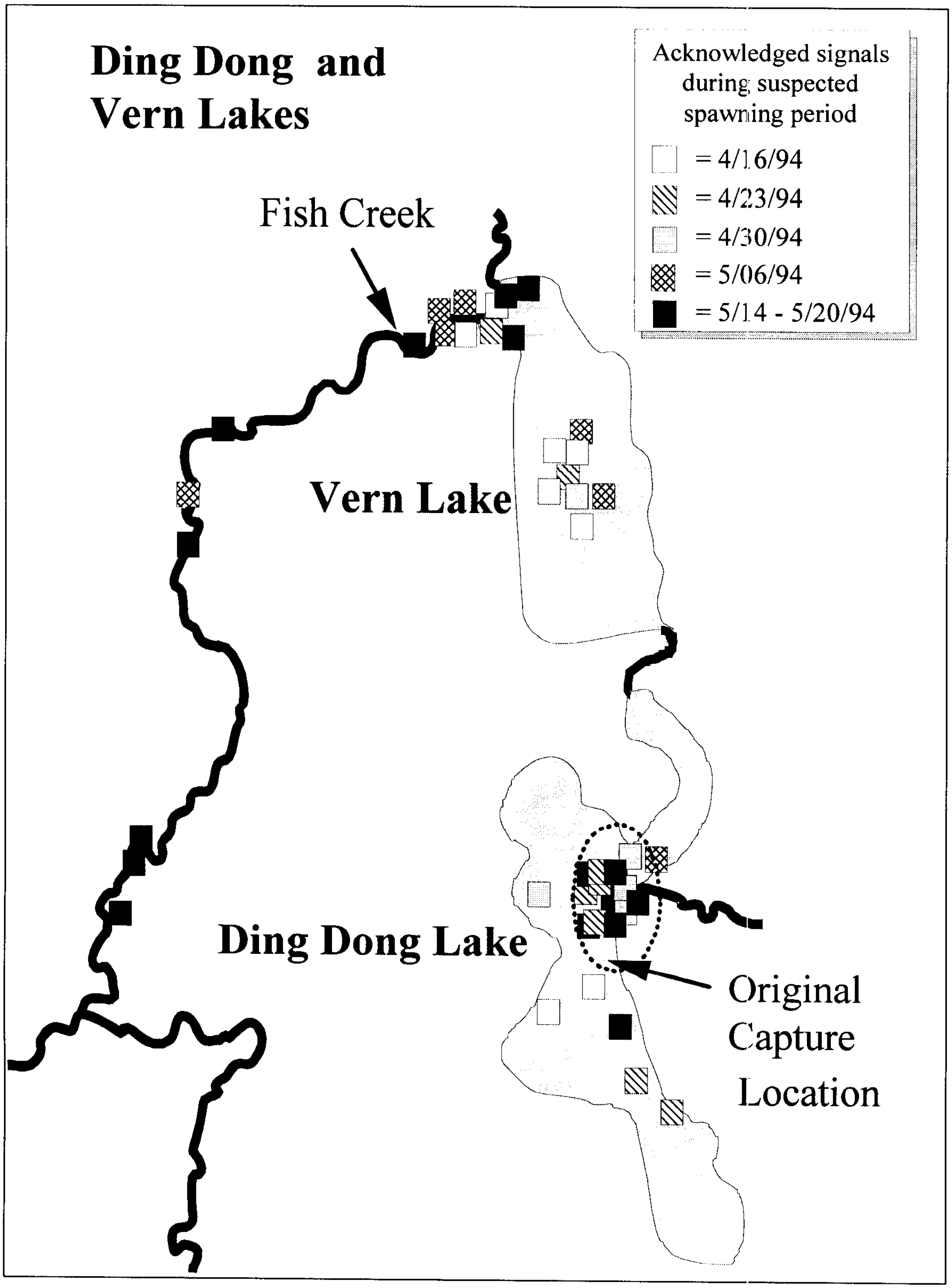
Appendix A1.-Movements and distribution of spawning northern pike in Trapper Lake, April 16-May 20, 1994.



Appendix A2.-Movements and distribution of spawning northern pike in Alexander Lake, April 16-May 20, 1994.

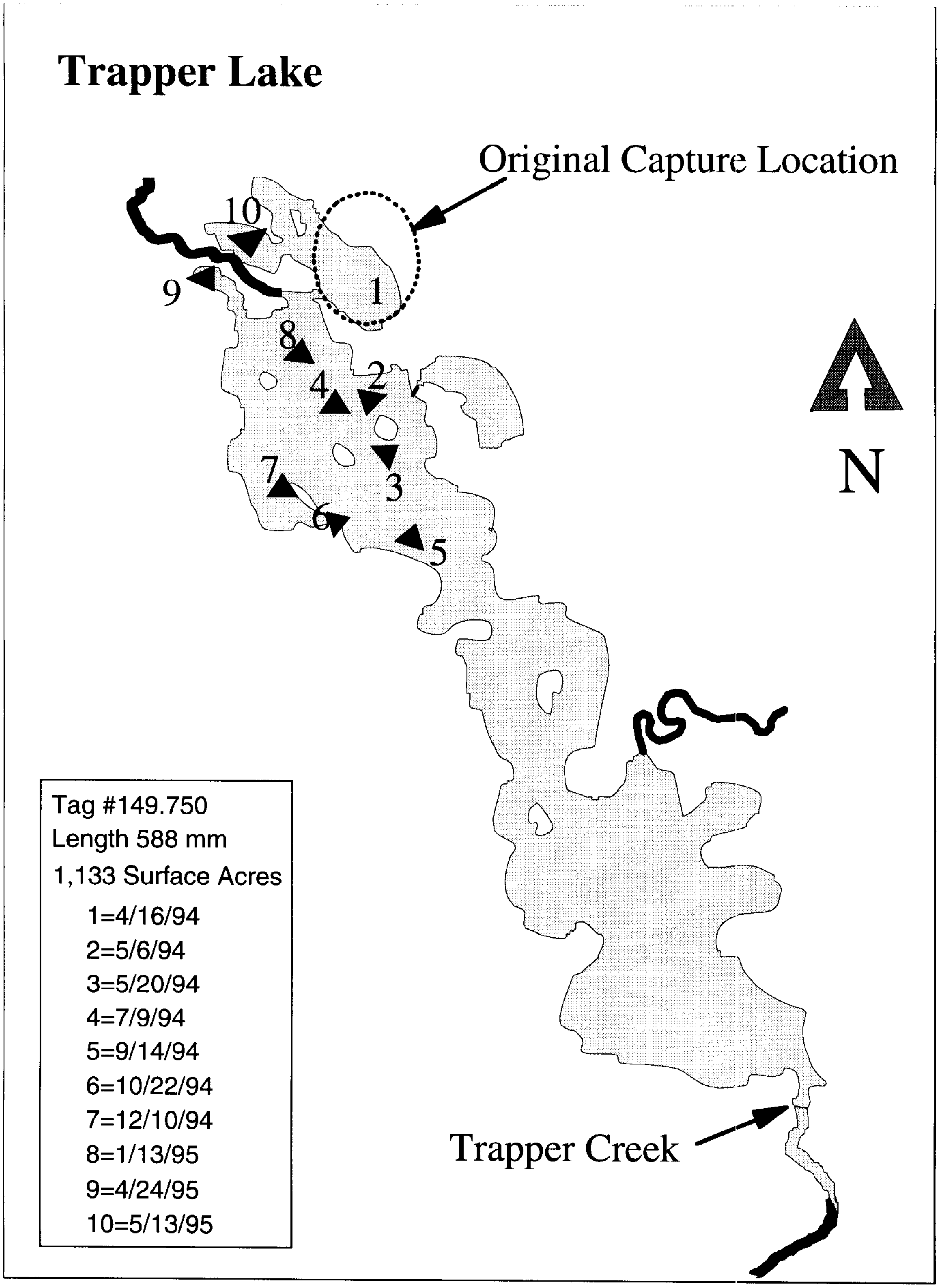


Appendix A3.-Movements and distribution of spawning northern pike in Whiskey Lake, April 16-May 20, 1994.

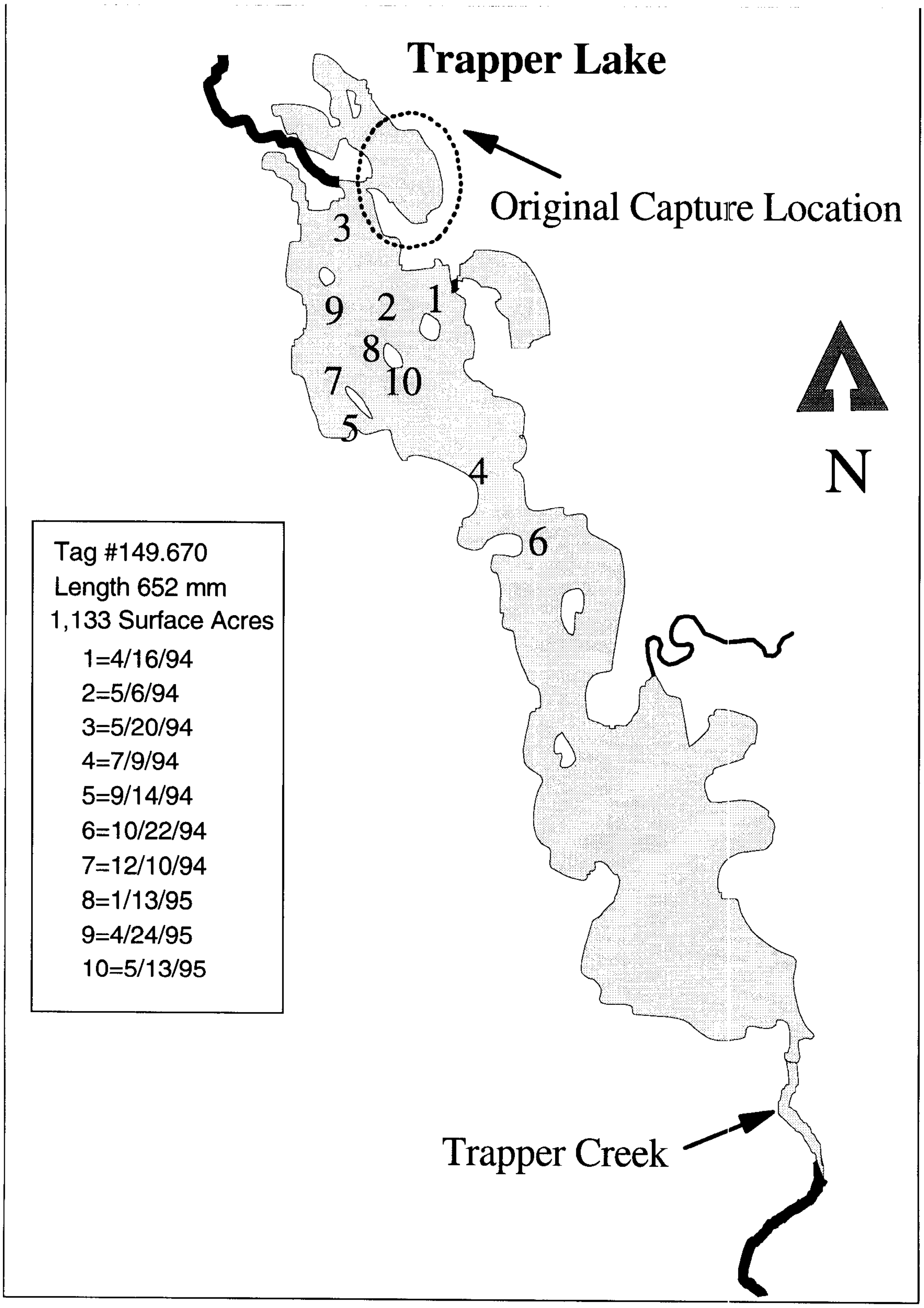


Appendix A4.-Movements and distribution of spawning northern pike in Ding Dong Lake, April 16-May 20, 1994.

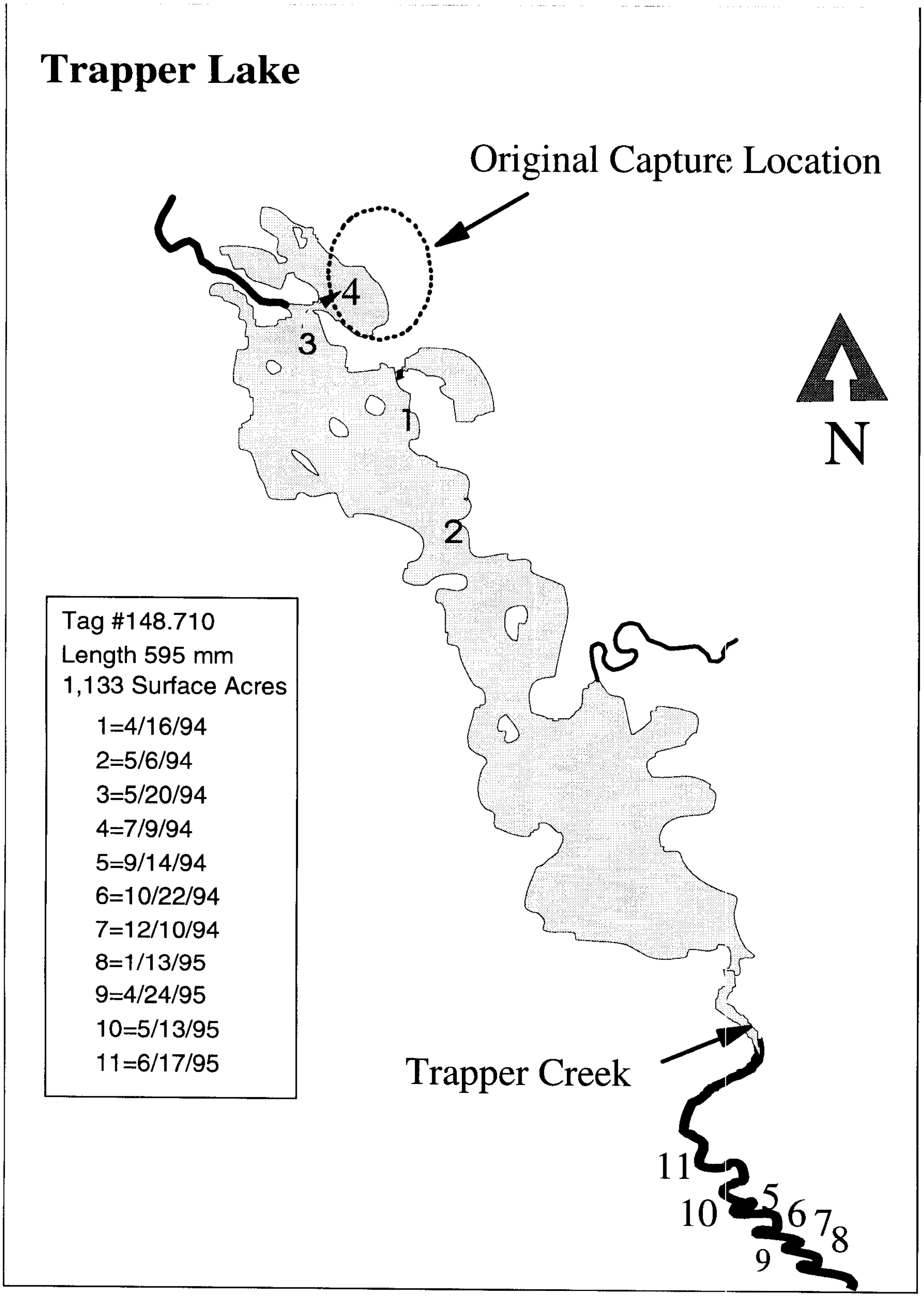
APPENDIX B. MOVEMENTS OF NORTHERN PIKE TAGGED WITH HIGH FREQUENCY RADIO TAGS IN TRAPPER, ALEXANDER, WHISKEY AND DING DONG LAKES, 1994 AND 1995



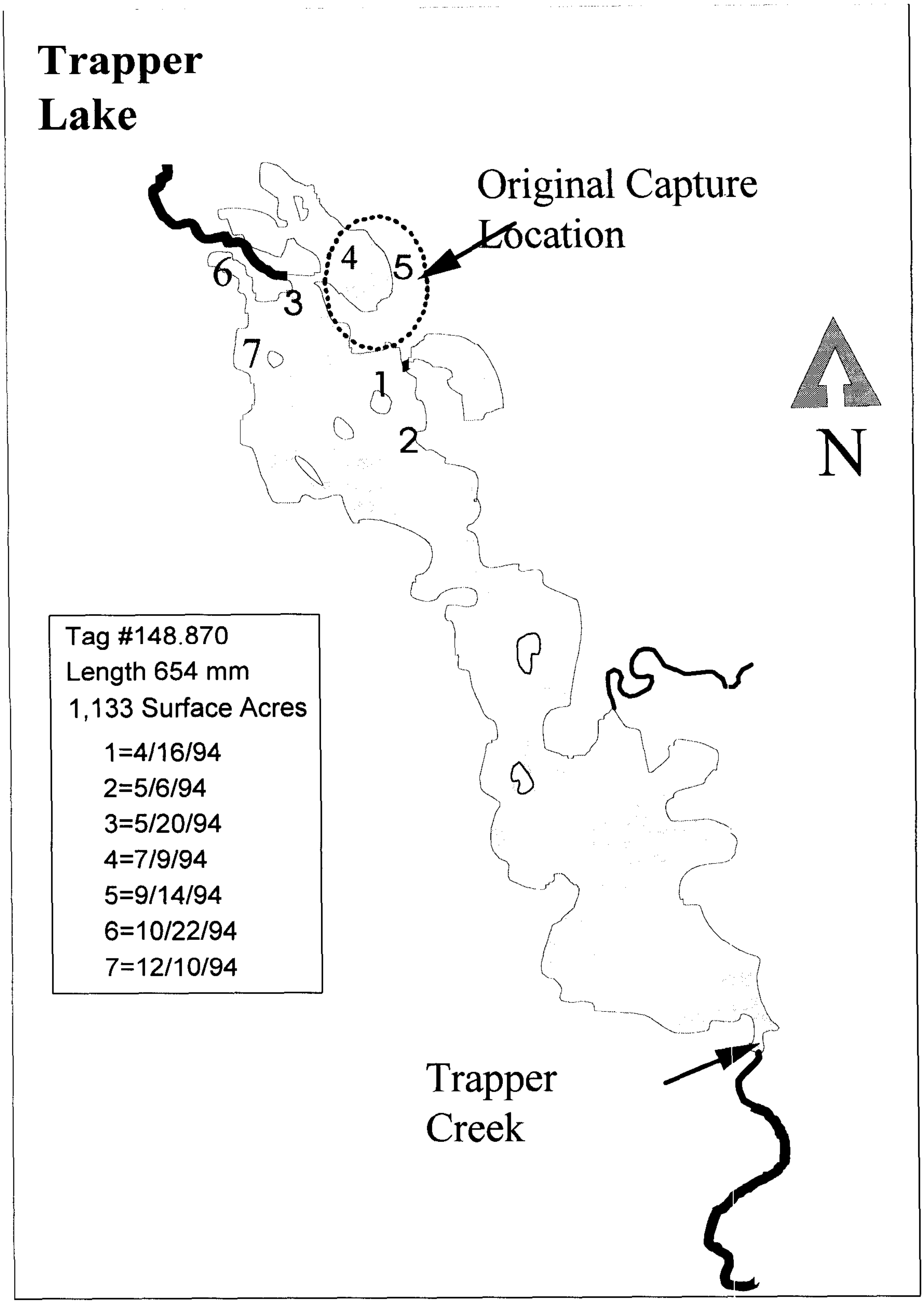
Appendix B1.-Movements of northern pike number 149.750 in Trapper Lake, April through May 1995.



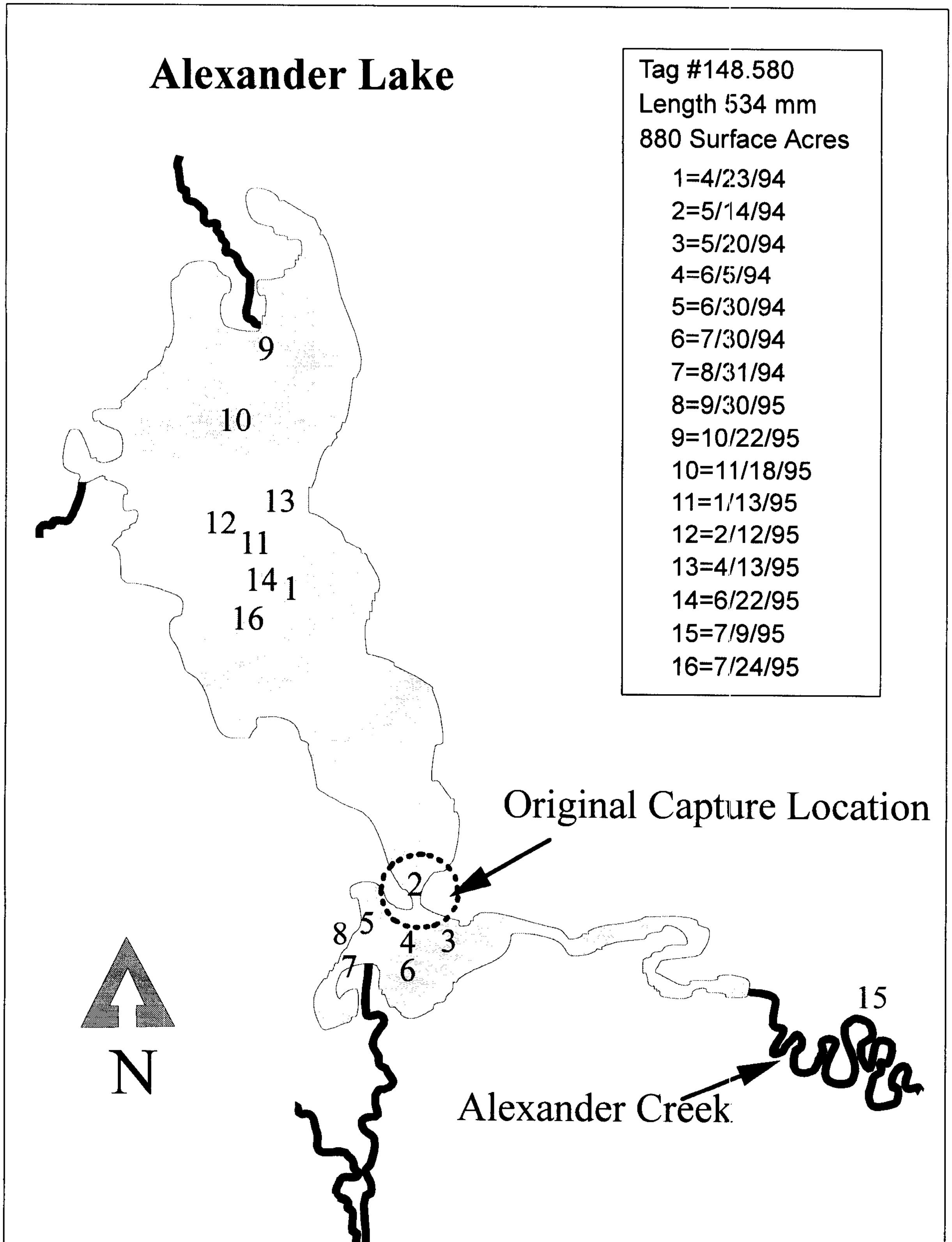
Appendix B2.-Movements of northern pike number 149.670 in Trapper Lake, April through May 1995.



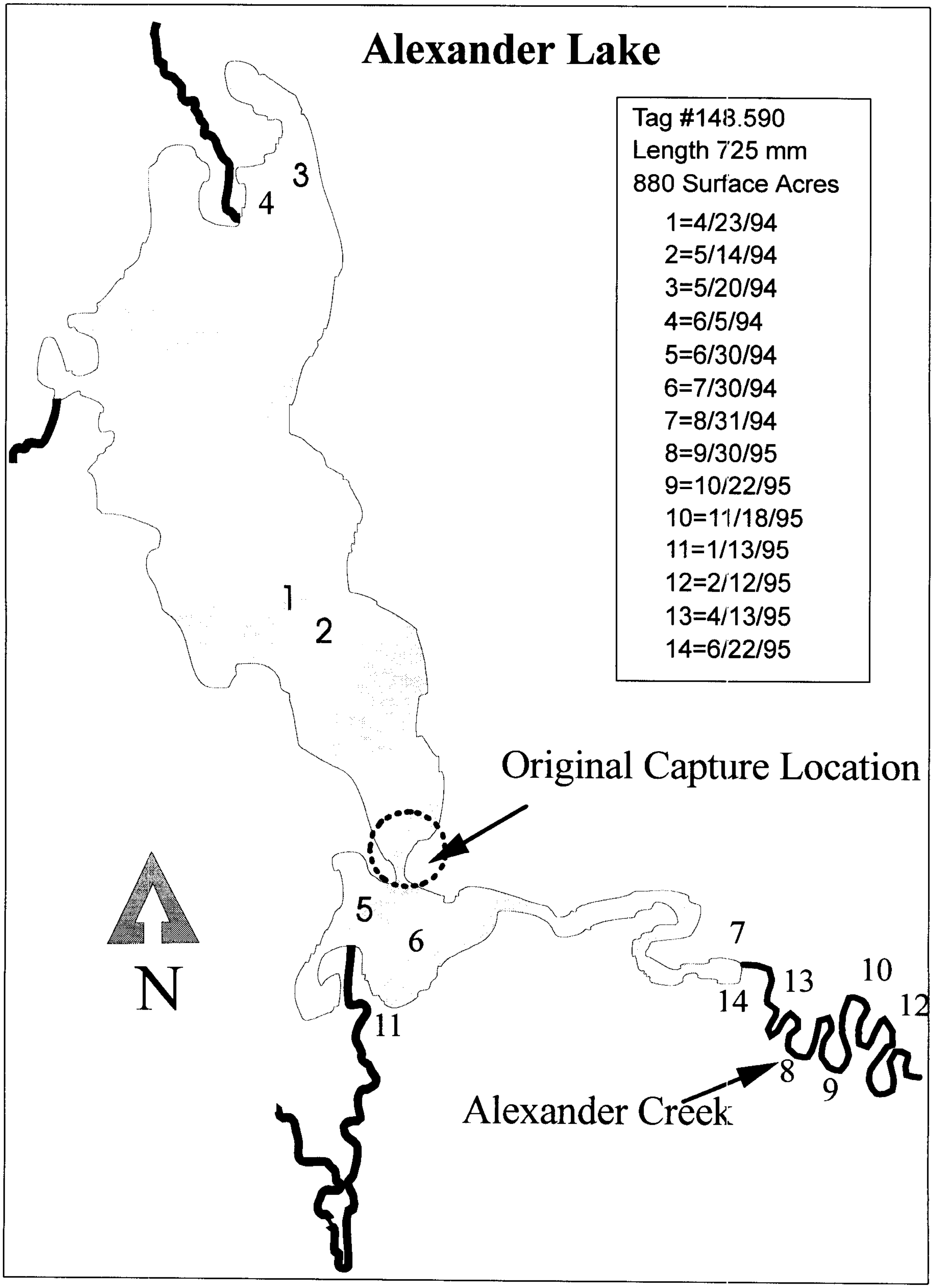
Appendix B3.-Movements of northern pike number 148.710 in Trapper Lake, April through June 1995.



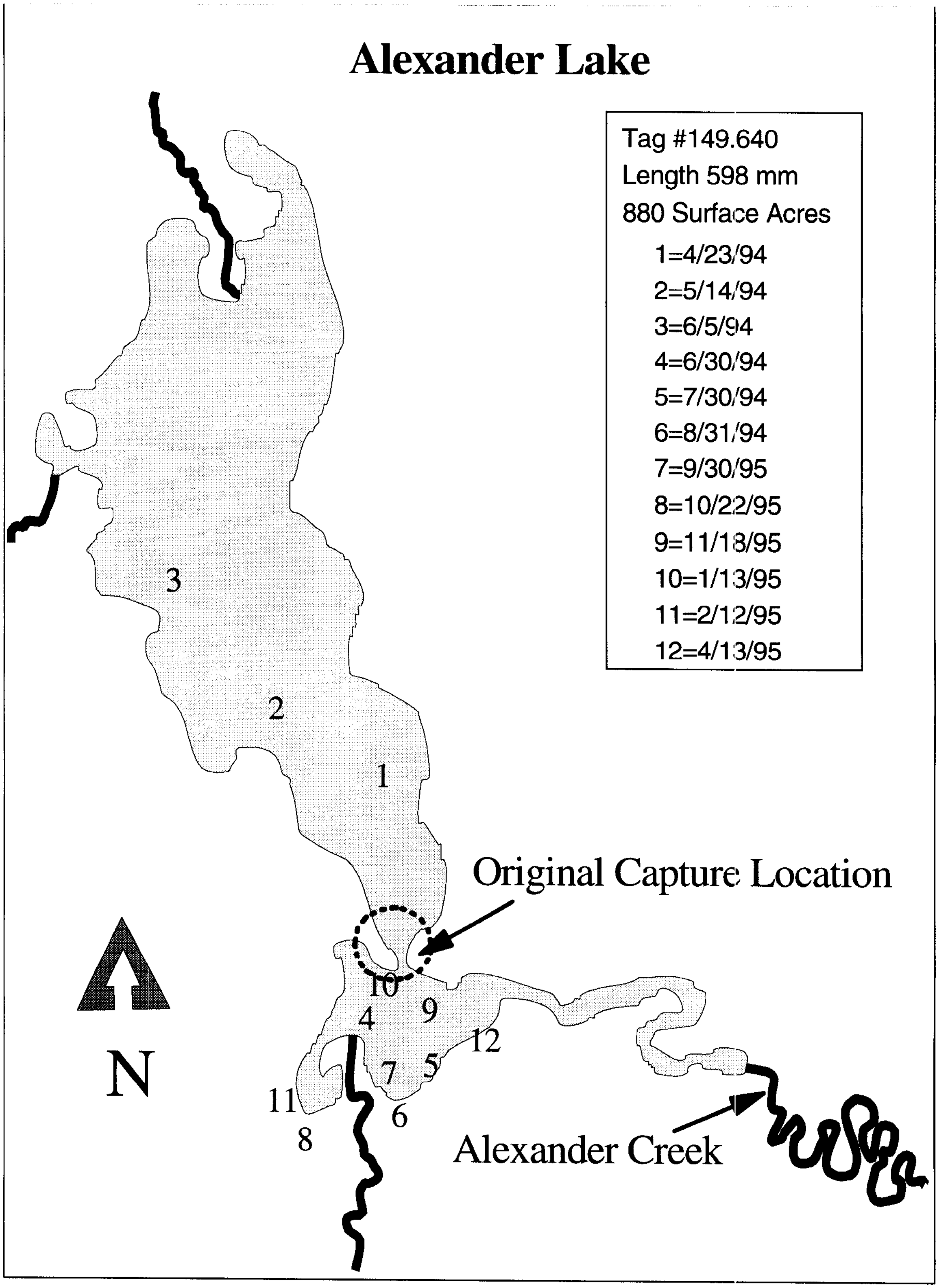
Appendix B4.-Movements of northern pike number 148.870 in Trapper Lake, April through December 1994.



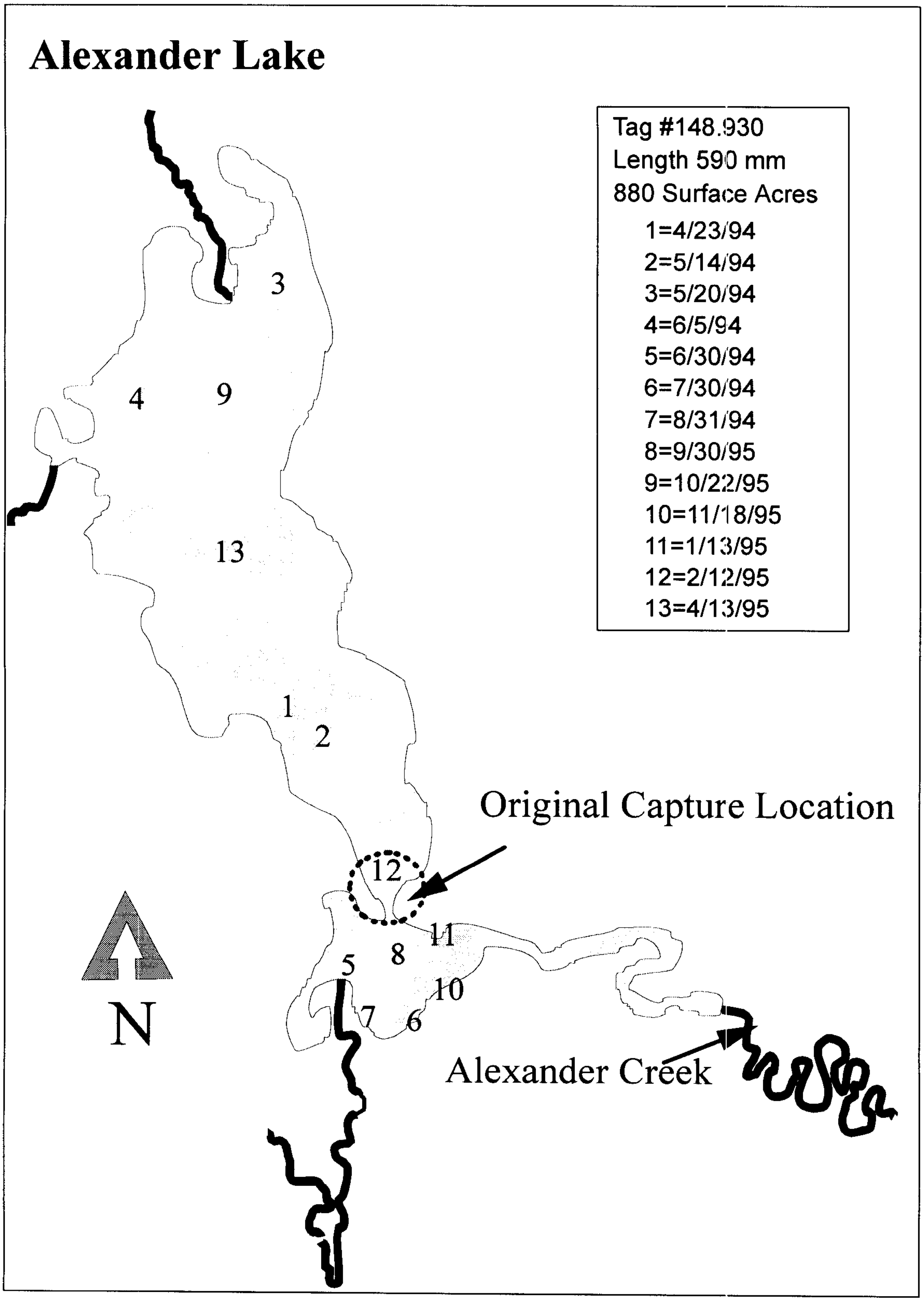
Appendix B5.-Movements of northern pike number 148.580 in Alexander Lake, April 1994 through July 1995.



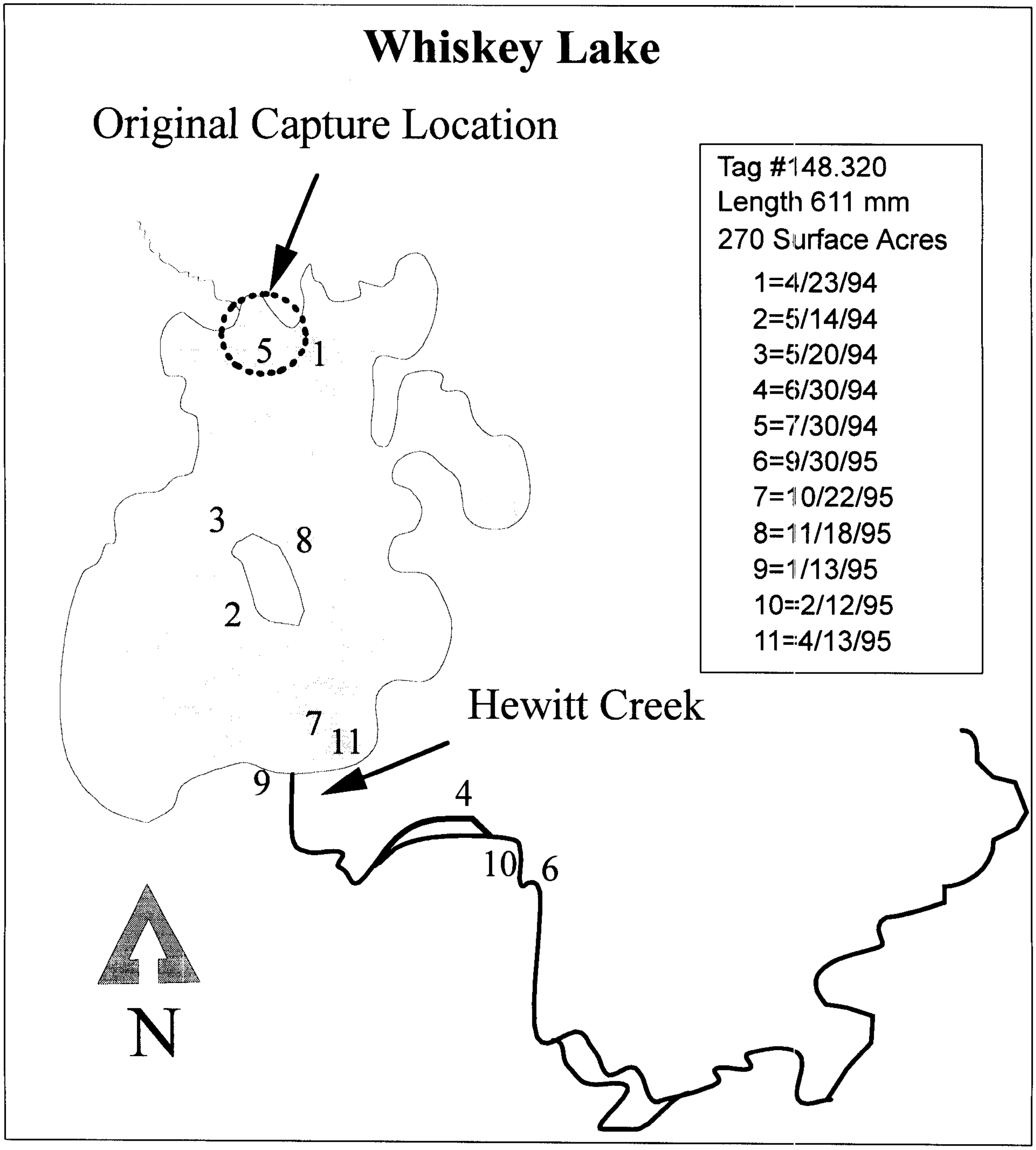
Appendix B6.-Movements of northern pike number 148.590 in Alexander Lake, April 1994 through June 1995.



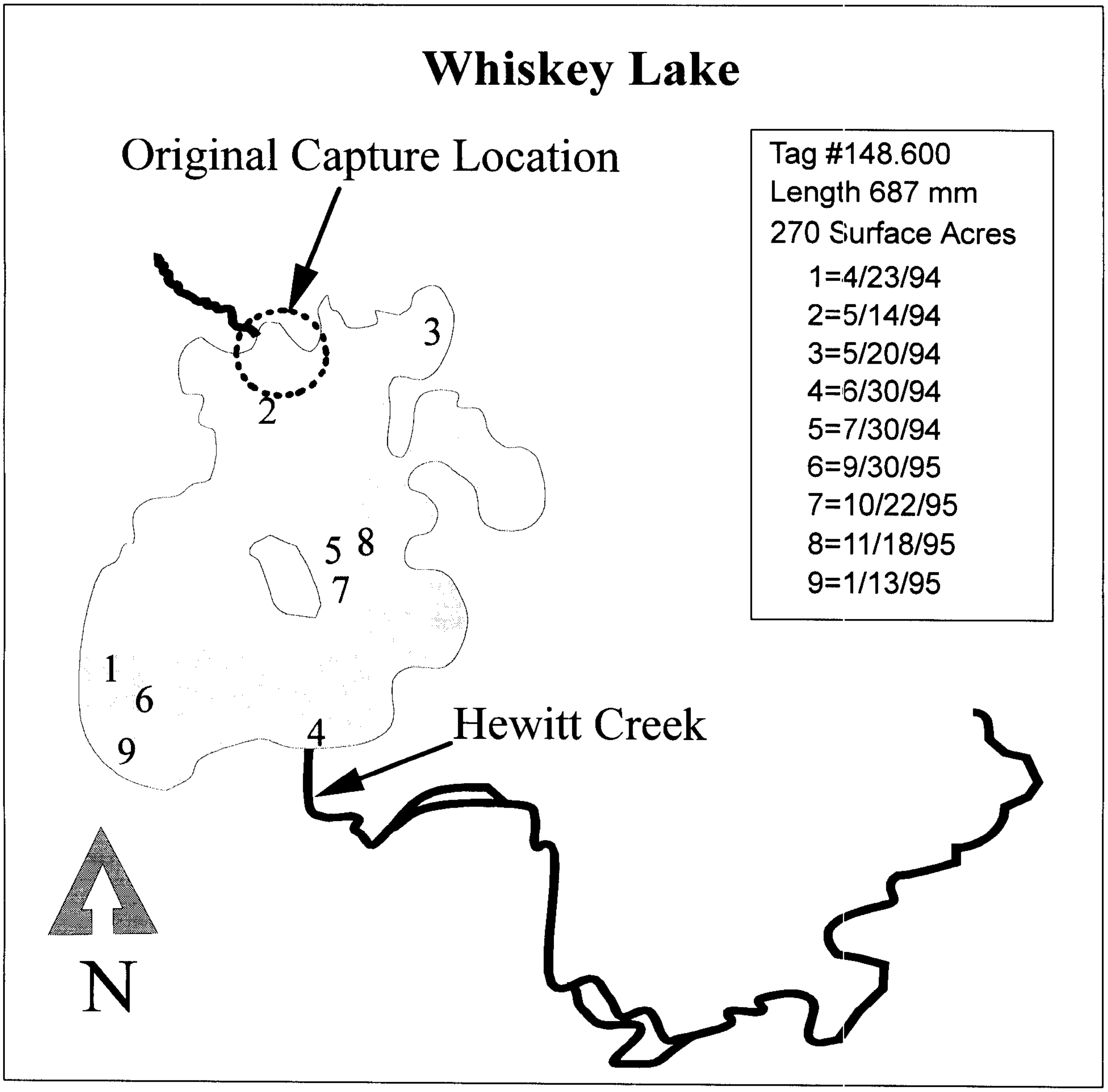
Appendix B7.-Movements of northern pike number 149.640 in Alexander Lake, April 1994 through April 1995.



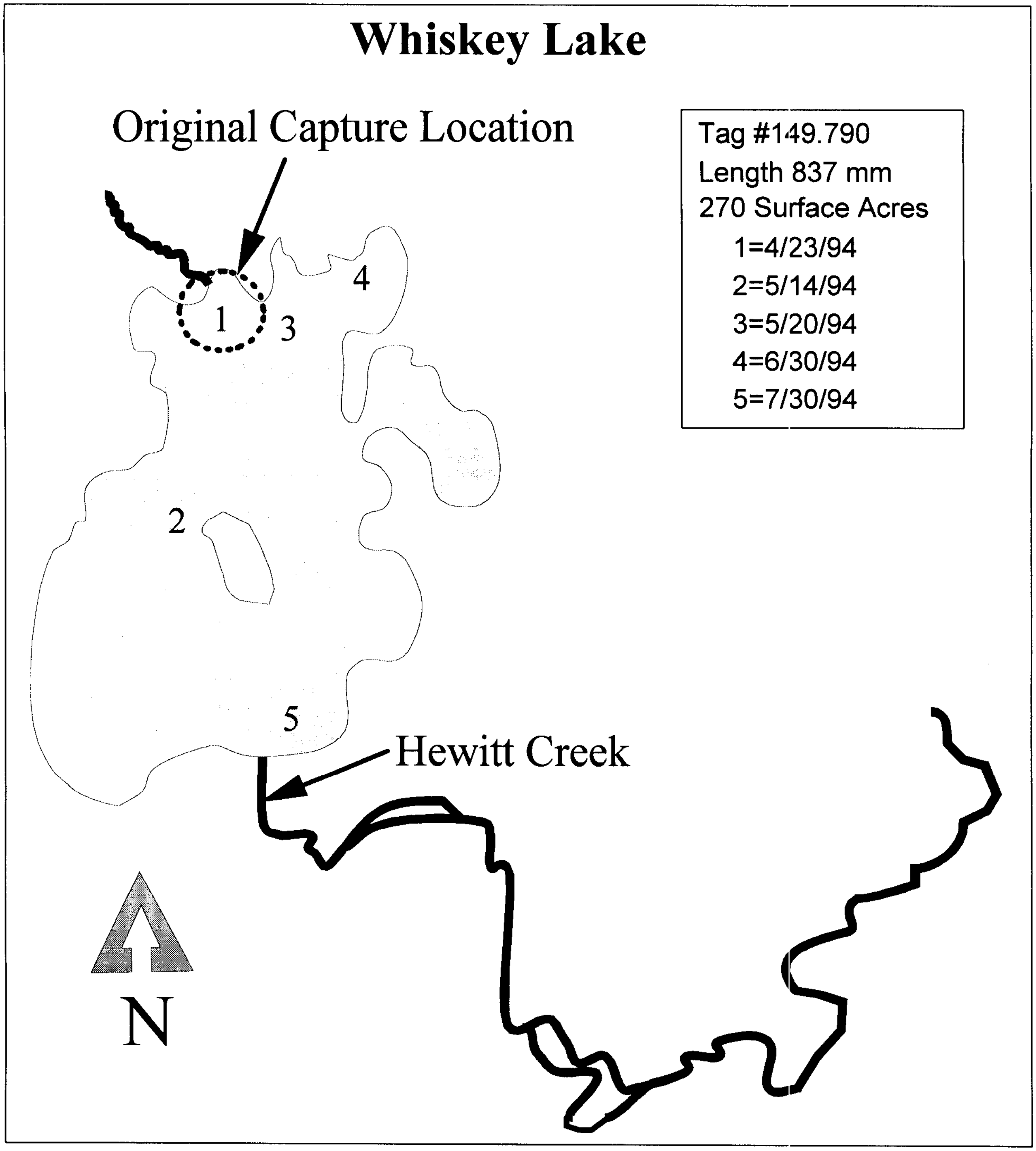
Appendix B8.-Movements of northern pike number 148.930 in Alexander Lake, April 1994 through April 1995.



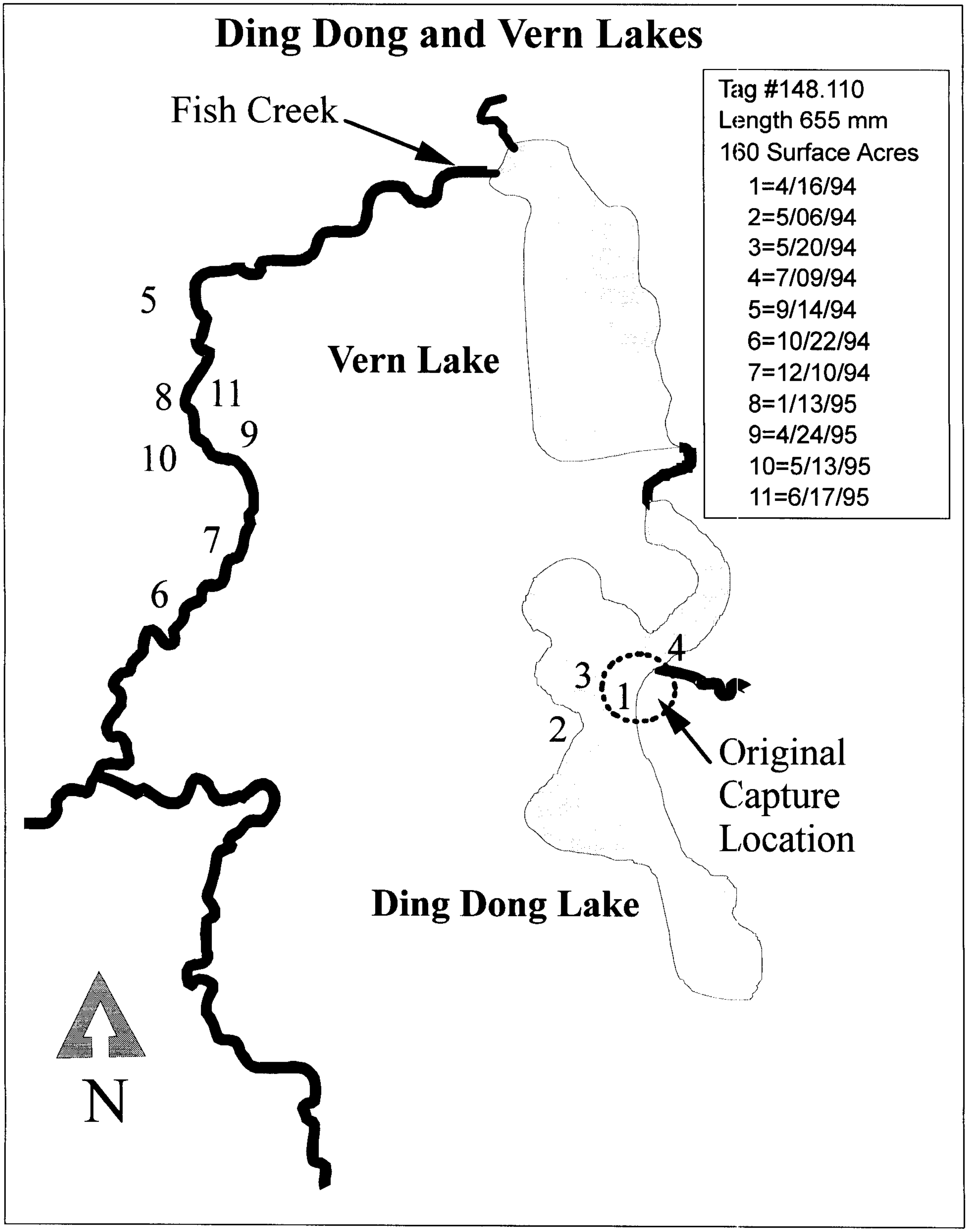
Appendix B9.-Movements of northern pike number 148.320 in Whiskey Lake, April 1994 through April 1995.



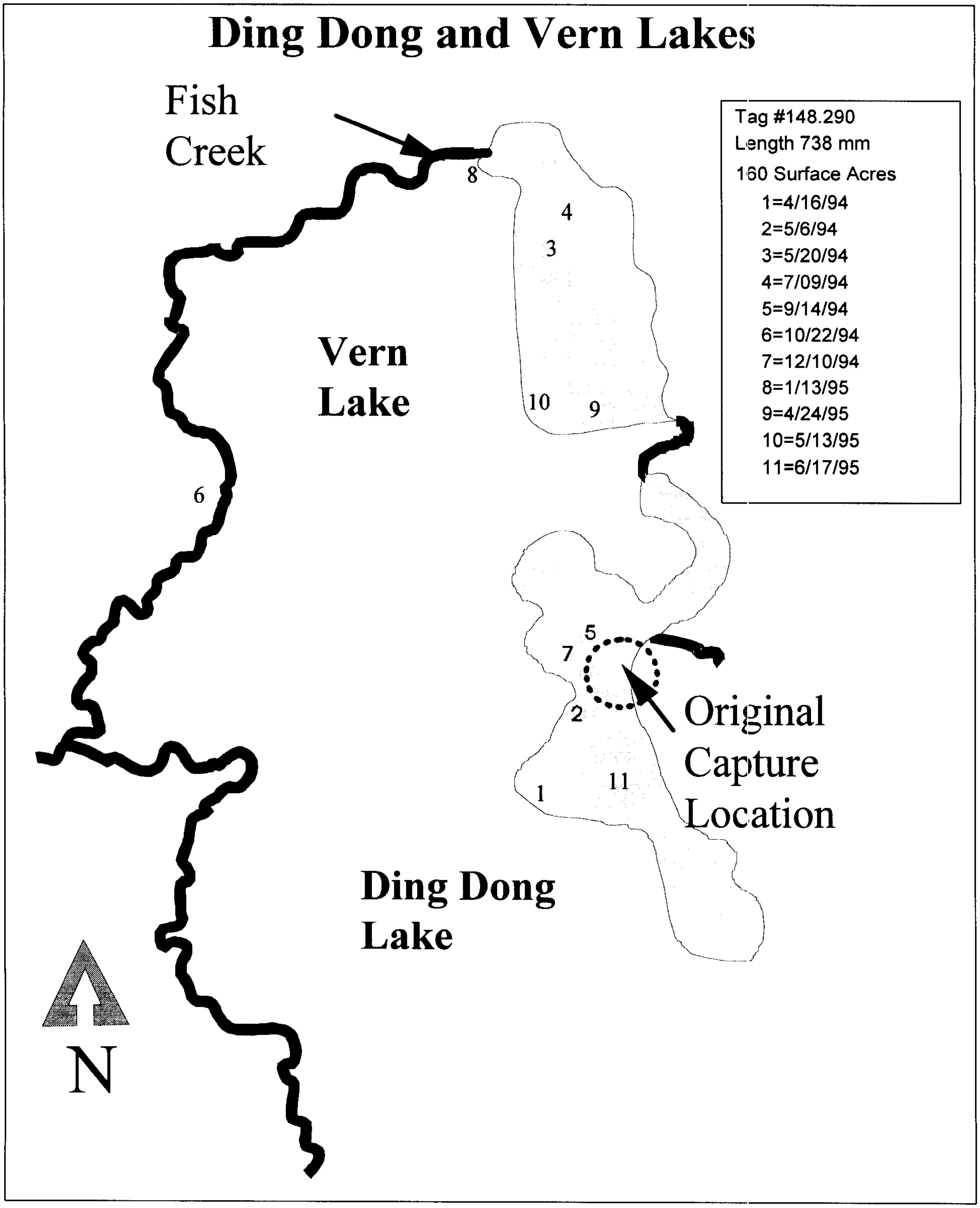
Appendix B10.-Movements of northern pike number 148.600 in Whiskey Lake, April 1994 through January 1995.



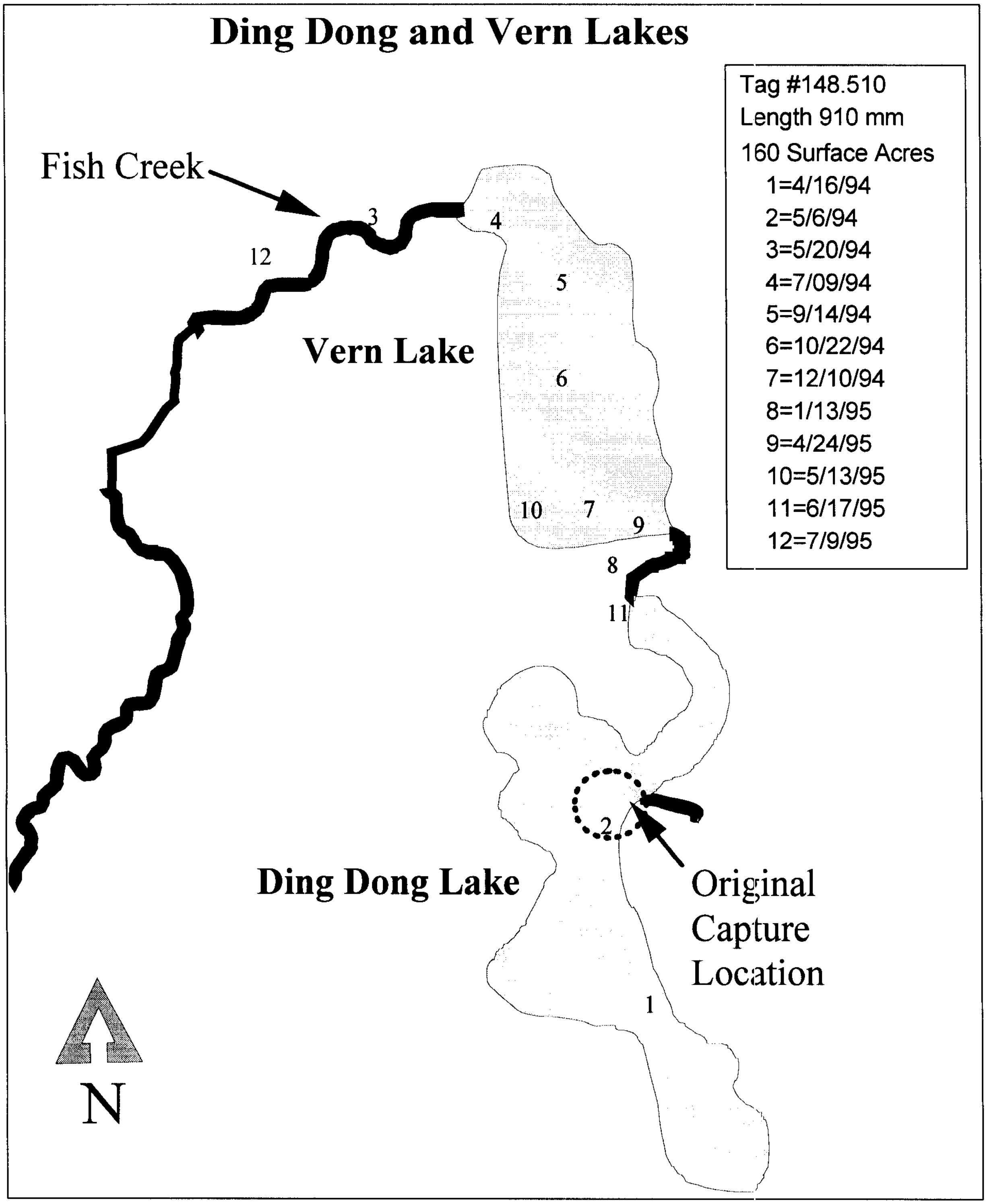
Appendix B11.-Movements of northern pike number 149.790 in Whiskey Lake, April 1994 through July 1994.



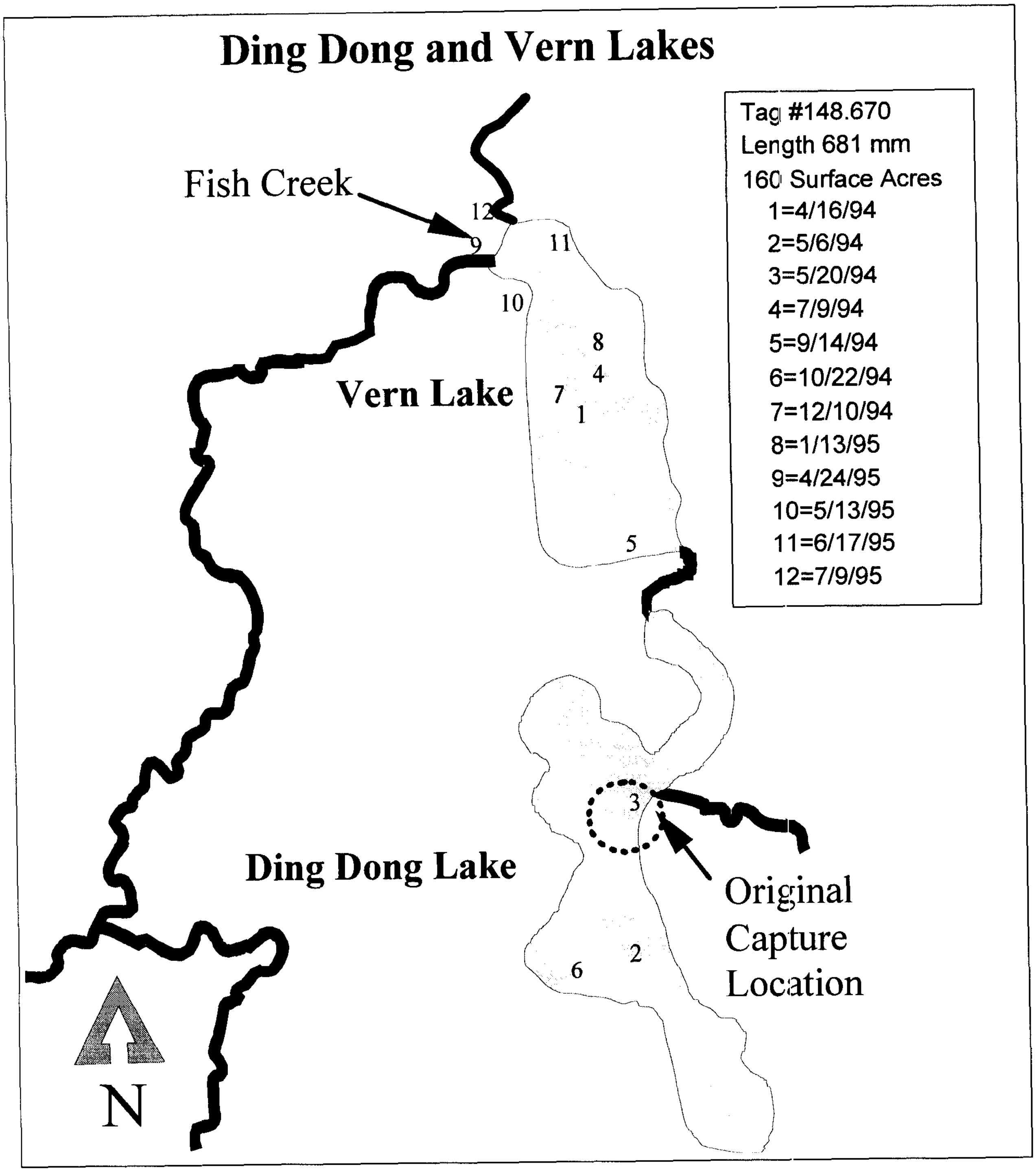
Appendix B12.-Movements of northern pike number 148.110 in Ding Dong Lake, April 1994 through June 1995.



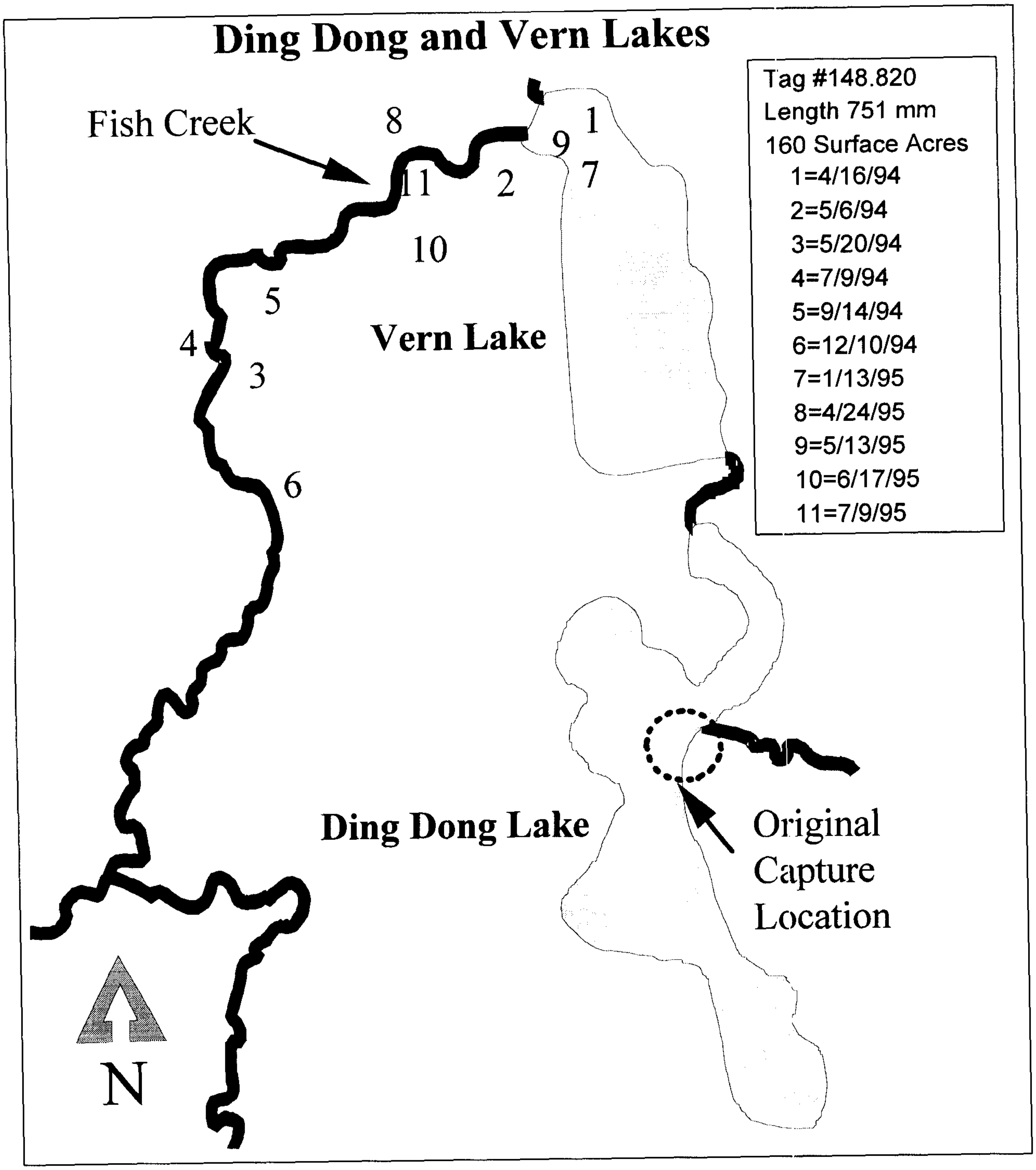
Appendix B13.-Movements of northern pike number 148.290 in Ding Dong Lake, April 1994 through June 1995.



Appendix B14.-Movements of northern pike number 148.510 in Ding Dong Lake, April 1994 through July 1995.



Appendix B15.-Movements of northern pike number 148.670 in Ding Dong Lake, April 1994 through July 1995.



Appendix B16.-Movements of northern pike number 148.820 in Ding Dong Lake, April 1994 through July 1995.

APPENDIX C. CONFIRMED AND REPORTED NORTHERN PIKE WATERS IN THE NORTHERN COOK INLET MANAGEMENT AREA

Appendix C1.-Confirmed and reported northern pike waters in the Northern Cook Inlet Management Area.

Susitna River Drainage Lakes

Alexander Creek
1. Alexander Lake
2. Sucker Lake
3. Trail Lake
4. Rabbit Lake

Lower Susitna
1. Flathorn Lake
2. Figure 8 Lake
3. No Name (NW of Fig 8 L.)

Mid Susitna
1. Witsoe Lake
2. Witsol Lake
3. Lockwood Lake
4. Lady Slipper
5. Unnamed
6. Unnamed
7. Unnamed
8. Vern Lake
9. Ding Dong

Yentna River
1. Whiskey Lake
2. Bulchitna Lake
3. Fish Creek Lake 1
4. Fish Creek Lake 2
5. Fish Creek Lake 3
6. Fish Creek Lake 4
7. Donkey Lake
8. Hewitt Lake
9. No Name (Big Bend)
10. Chelatna Lake
11. Cabin Lake (Big Bend)
13. Pear Lake (Up. Skwentna)
14. Stickleback Lake

Skwentna River
1. Eight Mile Lake
2. Seven Mile Lake
3. No Name (Herk Strip)
4. One Stone Lake

Deshka River
1. Parker Lake
2. Trapper Lake
3. No Name Lake
4. Ambler Lake
5. Rocky Lake
6. Neil Lake
7. Kroto Lake

Upper Susitna
1. Kashwitna Lake*
2. Caswell Lake*
3. Fish Lake*
4. Sawmill Lake*
5. Swan Lake

Nancy Lake Area
1. Redshirt Lake
2. Lynx Lake
3. Cow Lake
4. Little Chicken
5. South Rolly Lake
6. North Rolly Lake
7. Tanaina Lake
8. Milo Lake
9. Frazer Lake
10. Little Frazer Lake
11. James Lake
12. Owl Lake
13. Char Lake
14. Ardaw Lake
15. Phoebe Lake
16. Chicken Lake
17. Echo Pond #1
18. Echo Pond #2
19. Echo Pond #3
20. Candle Stick Lake
21. Bains Pond #1
22. Bains Pond #2
23. Bains Pond #3

Susitna Tributaries

Deshka River
1. Fish Creek (Flathorn)
2. Fish Creek (Kroto)
3. Lake Creek
4. Fish Lake Creek
5. Alexander Creek
6. Trapper Creek
7. Sucker Creek
8. Montana Creek
9. Rolly Creek
10. Moose Creek
11. Bottle Creek
12. Hewitt Creek
13. Donkey Creek
14. Indian Creek (Yentna)
15. Indian (Chulitna)*
16. Rabideux Creek
17. Fish Lake Creek
18. Kutna Creek (Yentna)
19. Shell Creek
20. Eightmile Creek
21. Caswell Creek
22. Witsoe Creek
23. Trapper (Talkeetna)*
24. Talachulitna Creek*
25. Johnson Creek
26. Otter Creek
27. Unnamed (Low Su)
28. Sunshine Creek*
29. Anderson Creek*
30. Wiggel Creek*
31. Birch Creek*
32. Yentna River
33. Skwentna River
34. Chulitna River*
35. Little Susitna River*
36. Tokositna

Knik Arm Drainages
1. Little Susitna*
2. Swan Lake*
2. Jim Lake*
4. Knik River
5. Big Lake*
6. Fish Creek*
7. Horseshoe Lake

West Cook Inlet
1. Chuit River
2. Chuit Lake
3. Threemile Creek
3. Chuit Lake
4. Threemile Lake

Anchorage Lakes
1. Sand Lake
2. Delong Lake
3. Lower Fire Lake
4. Upper Fire Lake*
5. Mink Creek
6. Fire Creek

Mat-Su Valley Lakes
1. Crystal Lake*
2. Blodgett Lake*

* Reported but not confirmed northern pike populations