Fishery Data Series No. 00-3

Abundance and Composition of the Northern Pike Population in Harding Lake, 1999

by

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and

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May 2000

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

Symbols and Abbreviations

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Weights and measures (metric)

Centimeter	cm
Deciliter	dL
Gram	g
Hectare	ha
Kilogram	kg
Kilometer	km
Liter	L
Meter	m
metric ton	mt
Milliliter	ml
Millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
Foot	ft
Gallon	gal
Inch	in
Mile	mi
Ounce	oz
Pound	lb
Quart	qt
Yard	yd

Spell out acre and ton.

Time and temperature

Day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
Minute	min
Second	s

Spell out year, month, and week.

Physics and chemistry

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

General

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

Mathematics, statistics, fisheries

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

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ABSTRACT

In 1999, estimated abundance of northern pike *Esox lucius* within Harding Lake was 583 fish (SE = 76) for northern pike ≥ 300 mm FL, 357 fish (SE =48) for northern pike 450 to 624 mm FL, and 174 fish (SE = 25) for northern pike ≥ 625 mm FL. Estimated density of northern pike ≥ 300 mm FL was 0.52 (SE = 0.08) fish per hectare. The estimated proportion was 0.09 (SE = 0.01) for northern pike from 300 to 449 mm FL; 0.61 (SE = 0.02) for northern pike from 450 to 624 mm FL; and, 0.30 (SE = 0.02) for northern pike ≥ 625 mm FL. In 1999, estimated recruitment (abundance of age-5 fish) was 284 northern pike (SE = 58). Estimated abundance was 51 fish (SE = 19) for northern pike < age-5 and 532 fish (SE = 57) for northern pike > age-5. The mean error in assigning the proper incremental age from the scales of 56 northern pike recaptured in 1999 from 1998 was 0.21 years ($Z = 1.03$; $P < 0.30$). The estimated average percent error of the scale reader in reproducing the same age twice from a Harding Lake northern pike scale in 1999 was 2.8%.

Key Words: Northern pike, *Esox lucius*, population abundance, age composition, length composition, Harding Lake, mark-recapture.

Introduction

The Alaska Department of Fish and Game initiated northern pike *Esox lucius* studies in the Arctic-Yukon-Kuskokwim Region of Alaska (AYK) to insure that annual harvests do not exceed surplus production of northern pike. Objectives designed to obtain estimates of maximum sustainable yield (MSY) have included estimates of abundance, length composition, age composition, mortality, recruitment, and movements of northern pike within selected lakes and wetland complexes in AYK.

Studies to estimate abundance and length and age composition of Harding Lake northern pike began in 1990. In addition, an indirect estimate of sustainable yield for northern pike in Harding Lake based on methods in Ricker (1975) and Gulland (1983) was determined by Pearse and Hansen (1993) from four years of northern pike studies (Burkholder 1991; Skaugstad and Burkholder 1992; Pearse 1994). Pearse and Hansen (1993) used the indirect method of relating natural mortality and carrying capacity to MSY instead of regression techniques because of the few years of data. This estimate of sustainable yield was updated in 1998 (Roach and McIntyre 1999 using both the indirect method and regression techniques similar to those described by Pearse and Hansen (1993).

RESEARCH OBJECTIVES

To evaluate the current status of the northern pike stock, a mark-recapture experiment was conducted in Harding Lake in 1999. The research objectives were to:

1) estimate population abundance of northern pike ≥ 300 mm fork length (FL)[1] in Harding Lake such that this estimate is within 25% of the actual value 95% of the time; and,

2) estimate the age and length composition of the northern pike population ≥ 300 mm FL in Harding Lake such that these estimates of proportions are within 5 percentage points of the actual value 95% of the time.

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[1] Five critical fork lengths are referred to in this report: 300 mm is the length that northern pike begin to recruit to the sampling gear, 450 mm is considered the smallest length of fully recruited spawners, 625 mm is the minimum size limit that can be legally harvested, and 725 mm and greater is a length category reported in the statewide harvest survey, which managers use to monitor the catch of large northern pike.

DESCRIPTION OF FISHERY

In 1991, northern pike fishing in Harding Lake was restricted by regulation to June 1 through March 31; northern pike fishing with spears or bows and arrows was prohibited; and a minimum size limit for northern pike harvested was set at 26 inches (~625 mm FL). These restrictions were designed to eliminate the harvest of northern pike during the time of spawning and reduce the harvest of smaller northern pike. The management objectives of these regulations were to prevent a harvest level that is not sustainable and to help in rebuilding the population while allowing a limited recreational fishery. The minimum size limit allows northern pike two years of spawning before reaching the legal size for harvest. In addition, it was believed that these regulations would help achieve the strategy of limiting harvest to less than 15% of northern pike ≥ 300 mm FL, which was considered a sustainable and acceptable level of harvest.

Estimated sport fishing effort at Harding Lake increased from 1,707 angler-days in 1984 to about 5,000 from 1991 through 1994 to a high of 6,743 in 1995 and since has dropped below the average of 4,499 (Table 1; Mills 1985 - 1994; Howe et al. 1995 - 1999). Limited opportunities for fishing along the road system of the Tanana Valley and an increased angler demand for northern pike probably contributed to the increasing angler effort at Harding Lake through the mid 1990's. Even through the rise in angler effort for all species in Harding Lake, harvest of northern pike has remained relatively low since 1992 compared to 1984 through 1991 (Table 1). Harvest estimates have varied from 94 in 1997 to 2,092 northern pike in 1988. Prior to this study, estimated abundances for northern pike (≥ 300 mm FL) have ranged from 1,376 (SE = 279) in 1997 to 3,768 (SE = 432) in 1993 (Burkholder 1991; Skaugstad and Burkholder 1992; Pearse 1994; Roach 1996-1998; Roach and McIntyre 1999).

DESCRIPTION OF STUDY AREA

Harding Lake is the largest road-accessible lake in the Tanana River drainage (Figure 1) with a surface area of 1,000 ha, a maximum depth of 43 m, a surface elevation of 217 m, and a shoreline circumference of 12.4 km. Harding Lake is located 54 km (69 km by road) southeast of Fairbanks, Alaska near the confluence of the Salcha and Tanana rivers. It is a circular lake with a prominent point along the southern shore and a small point along the northern shore. There are two inlets; the east inlet, which drains a 2,580 ha basin to the east of Harding Lake and enters the northeast corner of the lake, and the Little Harding Lake inlet that enters the southwest corner. There are no outlets from Harding Lake (Figure 2).

LaPerriere (1975) and Nakao (1980) described Harding Lake as oligotrophic. Most of the lake is in an open-water zone with almost all marginal vegetation (emergent grasses) found along the north and northeast shores in water < 1 m deep. However, more than half of shallow water (< 3-m depth) in the north and northeast areas of the lake is free of vegetation. There are some deep beds of *Potamageton* sp. and *Chara* sp. located sporadically at about the 5-m contour. The littoral zone (the area from shoreline to the outer margin of the deep vegetation) comprises less than 33% of the surface area of the lake. Furthermore, there are large areas within this zone that are free of vegetation. Doxey (1991) hypothesized that macrophytes are not able to colonize

Table 1.-Estimated angler days expended, numbers (SE in parenthesis when available) of northern pike harvested and caught, and catches per angler day and harvests per catch in Harding Lake, 1984-1997 summarized by all northern pike and northern pike > 725 mm FL.

		Number Harvested				Number Caught		Catch/Angler Day		Harvest/Catch	
Year	Angler Days	All		> 725 mm		All	> 725 mm	All	> 725 mm	All	> 725 mm
1984	1,707	766		-		-	-	-	-	-	-
1985	-	-		-		-	-	-	-	-	-
1986	2,064	673		-		-	-	-	-	-	-
1987	5,125	1,886		-		-	-	-	-	-	-
1988	3,256	2,092		-		-	-	-	-	-	-
1989	4,935	1,764		-		-	-	-	-	-	-
1990	3,895	591		-		3,629	-	0.93	-	0.16	-
1991	5,155	1,888[a]	(1,007)	401	(220)	5,071	476	0.98	0.09	0.37	0.84
1992	5,068	341	(128)	100	(34)	3,400	424	0.67	0.08	0.10	0.24
1993	4,885	391	(145)	238	(100)	6,041	619	1.24	0.13	0.06	0.38
1994	4,913	539	(197)	179	(72)	5,559	995	1.13	0.20	0.10	0.18
1995	6,743	502	(124)	87	(34)	3,852	753	0.57	0.11	0.13	0.11
1996	6,734	363	(123)	115	(46)	4,070	593	0.60	0.09	0.09	0.19
1997	4,100	94	(56)	94	(56)	2,234	344	0.54	0.08	0.04	0.27
1998	4,400	271	(151)	68	(41)						
Average	4,499	869		160		4,232	601	0.83	0.11	0.13	0.32

[a] The imprecision of this estimate of harvest was attributed to an extraordinarily large harvest reported by three respondents to the statewide harvest survey (Alaska Department of Fish and Game memorandum from Mike Mills to Cal Skaugstad dated November 2, 1992). The actual harvest was most likely much smaller.

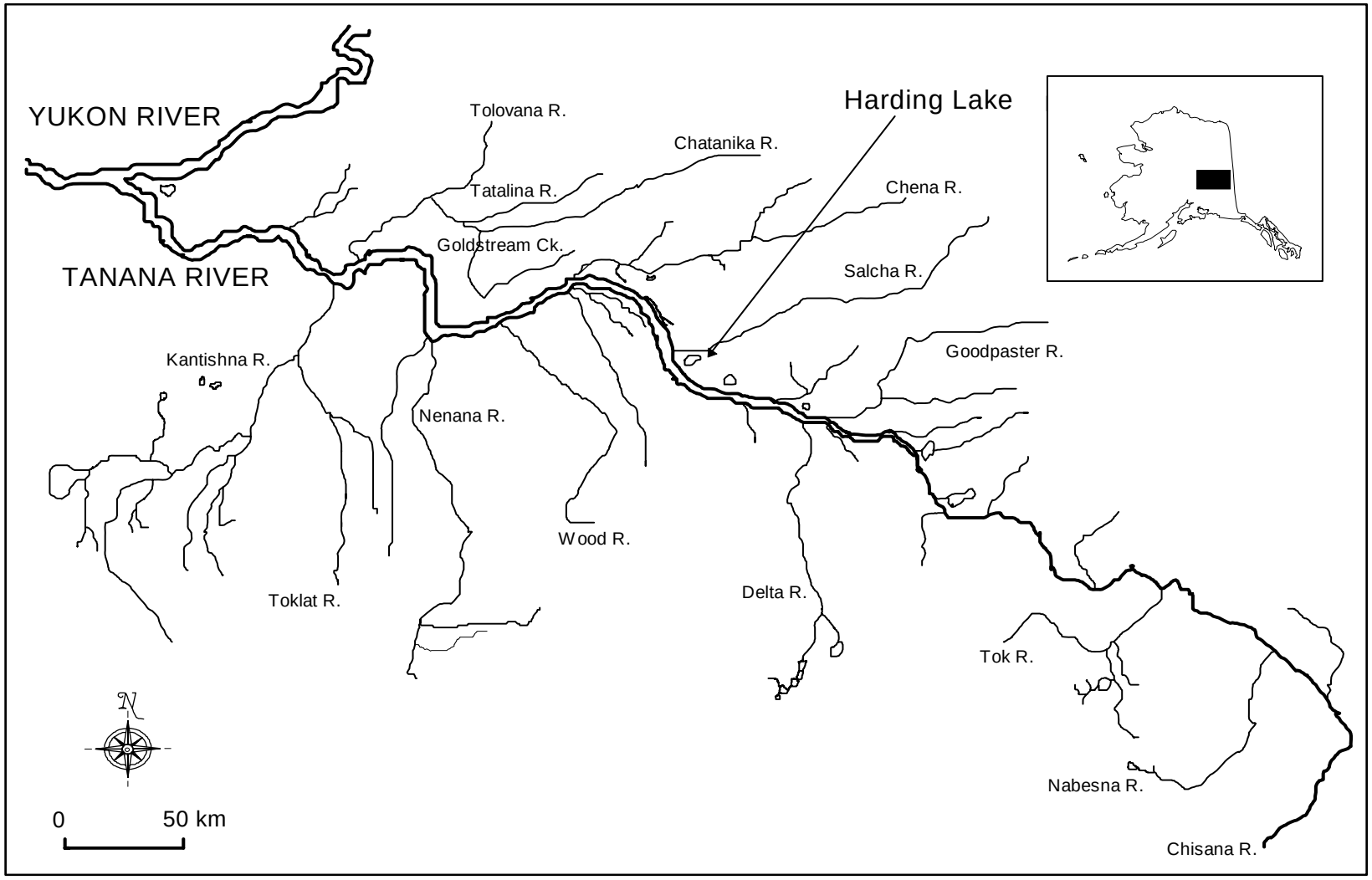

Figure 1.-Tanana River drainage.

large areas of the littoral zone within the lake because of wave action, freeze-down, and ice-scouring. Emergent vegetation comprises less than 10% of the surface area. Shallow areas are composed of sand, sand and gravel, or silt and the deeper areas of loose organic and clay sediments (Nakao 1980). In addition to northern pike, indigenous fish species that are found in Harding Lake are burbot *Lota lota*, least cisco *Coregonus sardinella*, and slimy sculpin *Cottus cognatus*. Introduced species include lake trout *Salvelinus namaycush* and Arctic char *S. alpinus*.

Historically, Harding Lake has been susceptible to frequent changes in water level. The water level has been dropping steadily since 1992, and is currently at its lowest level in 22 years (M. Doxey, Alaska Department of Fish and Game, Fairbanks, personal communication). Causes of water level fluctuation include lack of winter precipitation providing overland flow, and man-made alteration of the flow from the inlet.

Access to Harding Lake is by three roads from the Richardson Highway; one that leads to a State of Alaska boat launch, and two that lead to a North Star Borough boat launch. Salchacket Drive, a perimeter road, encircles approximately three fourths of the lake (Figure 2). Approximately 75% of the shoreline is ringed by private cabins, homes, and other human development. Docks, rafts, and boatlifts dot the inhabited areas of the shoreline in the summertime. There is a State of Alaska campground on the northwestern shore near the State boat launch with a channel, swimming beach, campsites, parking, athletic fields, and some undeveloped areas for hiking and unstructured outdoor recreation.

METHODS

Methods for the Harding Lake northern pike mark-recapture experiment in 1999 were similar to those used from 1993 to 1998 (Pearse 1994; Roach 1996-1998; Roach and McIntyre 1999) in that the two-event mark-recapture experiment was scheduled in late May and early June. The Harding Lake northern pike radio telemetry study (Roach 1993) indicated that Harding Lake northern pike are more uniformly distributed by sex and length in June compared to May. Therefore, to help ensure a uniform sample by sex and length during at least one of the sampling events, the recapture event took place in early June. Unlike northern pike in other Interior lakes, Harding Lake northern pike remain in shallow water (< 3 m) during late May and early June (Roach 1993) and are susceptible to in-shore sampling techniques during this time. Methods in 1998 and 1999 were different from those used from 1993 to 1997 because low water and the lack of water precluded sampling in the emergent vegetation along the north and east shores. In previous years these two areas were sampled on foot with gill nets and back-pack electrofishing gear. After a preliminary check indicated that water was too low for fish in these areas, all sampling in 1998 and 1999 took place in deeper water from boats. The marking event (June 1 – June 4) and recapture event (June 8 - June 11) took four days each to complete with a three-day hiatus between events (June 5 – June 7). Data files for both events were archived (Appendix A1).

SAMPLING TECHNIQUES

In previous years (1993-1997) Harding Lake was divided into 15 sampling sections to examine movement, test for differences in catchability, and help ensure uniform sampling effort

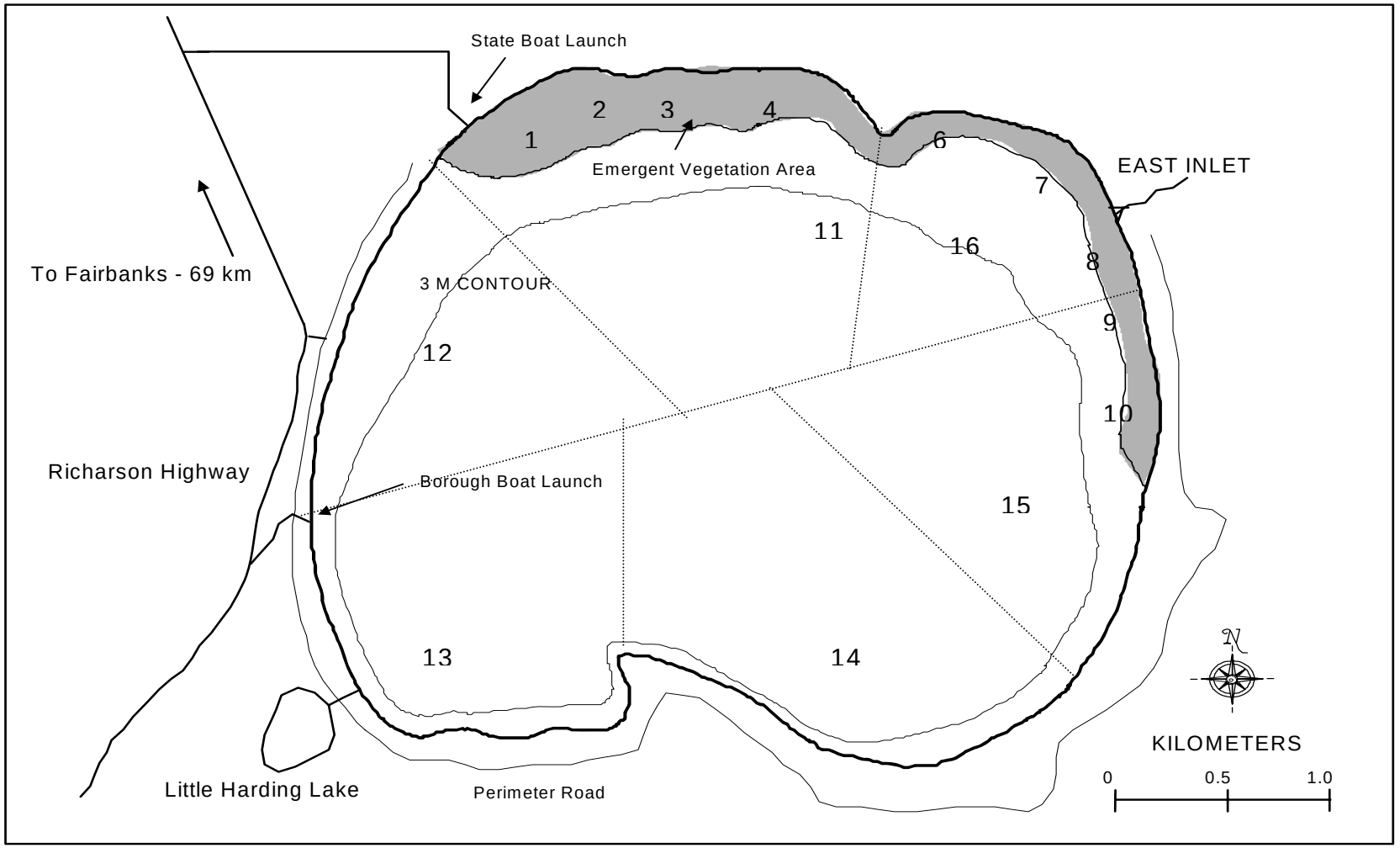

Figure 2.-Harding Lake with sampling sections (1 - 16) indicated, which were used for capture probability and movement analysis.

(Figure 2). This was reduced to six (sections 11 – 16) in 1998 and 1999 since the emergent vegetation (sections 1- 10) was void of fish during both years due to low water.

Two crews of two individuals each set gill nets from boats in open water. Each day one crew sampled in two sections of the lake; one with historically high catches and one with historically low catches, with most effort concentrated on the high catch area so as to distribute effort by density of fish. Effort and strategy were mirrored as closely as possible for both the marking event and recapture event. Gill nets were deployed at the beginning of the day perpendicular to shore, checked a minimum of once every hour, and moved uniformly throughout the section. All healthy northern pike were released immediately after data collection 50 to 100 m from the capture site.

All data from northern pike captured during the mark-recapture experiment were recorded on ADF&G Tagging Length Mark-Sense Form, Version 1.0. A new form was used for each section with the date and area on the description line. Scales for age determination were mounted directly to gummed cards at the time of sampling and mounted on gummed scale cards. A new gummed card was used for each section with the corresponding mark-sense litho-code, date, and waterbody recorded on the back. All crewmembers were aware of the importance of thoroughly examining all northern pike for Floy tags, recent tagging wounds, recent fin clips, and the importance of accurately recording data. All crewmembers performed these tasks appropriately.

During the marking event, all northern pike ≥ 300 mm FL that were captured were measured for length, examined for tags, two or more scales removed from each for age determination, and left pectoral fin slightly clipped. Length was measured and recorded to the nearest millimeter FL. Scales were taken from the preferred zone adjacent to but not on the lateral line and above the pelvic fins as described by Williams (1955). Both the left and right side of the dorsal fin were examined for the presence of a Floy tag. If a Floy tag was present, the color and number of the tag were recorded; or if not present, a new uniquely numbered Floy FD-68 internal anchor tag inserted at the left base of the dorsal fin. All northern pike were released alive and in apparent good condition. During the recapture event, the same data collection procedures were used as during the marking event except northern pike without Floy tags were not given a new Floy tag. Both the left and right side of the dorsal fin were examined closely for recent tag wounds and the left and right pectoral fins examined closely for recent clips, and then the right pectoral fin, instead of the left, was slightly clipped. Tag loss (TL) was clearly noted in the blank space after the tag number on the mark-sense forms for northern pike without a Floy tag but with a recent tag wound or recent left pelvic fin clip. Recapture (RC) was clearly noted on the mark-sense form for known recaptures from the marking event. Northern pike were not sampled more than once during the recapture event. Northern pike already sampled during the recapture event were identified by the presence of a recent right pectoral fin clip.

Upon completion of fieldwork, collected northern pike scales were processed for age determination. Scale impressions were made on 20 mil acetate sheets using a Carver press at 241,315 kPa (35,000 psi) heated to 150°C for 150 s from scales collected in the field on gummed cards. Ages were determined from scale impressions using a Micron 770 microfiche reader (32X) according to criteria established by Williams (1955), and Casselman (1967). Because scale collection was after or near the time of annulus formation, growth beyond the last annulus was only considered an additional year when the distance from the last annulus to the edge was fairly parallel in the lateral to posterior direction for fish older than age-4. In cases of age-4 and

younger fish, growth beyond the last annulus was generally always considered plus growth instead of an additional year.

ABUNDANCE

The mark-recapture experiment was designed to satisfy the assumptions of a Petersen mark-recapture experiment (Seber 1982). These assumptions were that:

1) the population was closed (no change in the number or composition of northern pike during the experiment);
2) all northern pike had the same probability of capture during the marking event or the same probability of capture during the recapture event or marked and unmarked northern pike mixed completely between the marking and recapture events;
3) marking of northern pike did not affect their probability of capture in the recapture event;
4) northern pike did not lose their mark between events; and,
5) all marked northern pike were reported when recovered in the recapture event.

The validity of assumption 1 was inferred because northern pike movement into or from Harding Lake was unlikely. Mortality and growth, which may contribute to the violation of assumption 1, were assumed negligible because of the short duration of the experiment. The validity of assumptions 2 and 3 was tested by comparing recapture rates and movements of fish between events with tests of consistency designed to detect unequal catchability by area and by size of fish (Seber 1982). The validity of assumption 4 was ensured by double marking (Floy tag and fin-clip) each northern pike during the marking event. Tag loss was noted when a fish was recovered during the recapture event with the specific fin clip but without a Floy tag. In addition, Floy tag placement was standardized, which enabled the fish handler to verify tag loss by locating recent tag wounds. The validity of assumption 5 was ensured by a thorough examination of fins for fin-clips and recording Floy tag numbers for all northern pike. Floy tag numbers used for this mark-recapture experiment were archived (Appendix B1).

To reduce bias from unequal catchability by length, samples were divided into two length strata. Abundance of northern pike was estimated for both of the two groups from the number of northern pike marked, examined for marks, and recaptured in each length strata and then these were summed to estimate the total abundance. The Chapman estimator (Seber 1982) was used for each stratum:

$$\hat{N} = \frac{(M+1)(C+1)}{R+1} - 1 \qquad (1)$$

where:
- M = the number of northern pike marked and released alive during the marking event;
- C = the number of northern pike examined for marks during the recapture event;
- R = the number of northern pike recaptured during the recapture event; and,
- $\hat{N}$ = estimated abundance of northern pike at the time of marking.

Variance of the abundance estimate (Seber 1982) was estimated as:

$$\hat{V}\left[\hat{N}\right] = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}. \quad (2)$$

LENGTH AND AGE COMPOSITIONS

Length and age compositions of northern pike ≥ 300 mm were estimated without adjustment (Appendix C2 and B3).

The proportion and the variance estimator approximated by the delta method were:

$$\hat{p}_k = \frac{x_k}{n}, \text{ and} \quad (3)$$

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

where: $\hat{p}_k$ = the proportion of northern pike that were length *k*

x_k = the number of northern pike sampled that were length *k*; and,

n = the number of northern pike sampled that were measured.

AGE VALIDATION

Accuracy of age determinations from scales collected during the 1999 mark-recapture experiment was tested indirectly. Scales from northern pike tagged in previous years that were recaptured during the experiment were used to determine the relative accuracy of age determination. The mean error in assigning the correct incremental age from scales of these northern pike was used as a measure of bias. The mean error was determined for ages of all northern pike, northern pike ≤ age-5, and northern pike > age-5 because this age is the age of full recruitment into the spawning stock (Pearse and Hansen 1993). The Wilcoxon Signed-Rank Test was used to determine significance of the bias (Conover 1980). Probabilities of a Type I error (α) of 0.05 or lower were considered significant.

Error in assigning the correct incremental age for each fish was calculated as:

$$\text{ERROR} = AGE_{t+\Delta} - AGE_t - \Delta t \quad (5)$$

where: $AGE_{t+\Delta}$ = age assigned when fish was recaptured;

AGE_t = age assigned at earlier capture; and,

Δt = number of years elapsed from capture to recapture.

Mean error was calculated as the sum of all the errors divided by the number of fish recaptured.

Furthermore, to evaluate the precision in age determination, ages were determined twice for a random sample of 99 scales taken during the experiment. The average percent error (APE; Beamish and Fournier 1981) of the scale reader to reproduce the same age twice from a Harding Lake northern pike scale in 1999 was calculated as:

$$\text{APE} = \sum_{i=1}^{S} \left[\frac{\sum_{j=1}^{R} \frac{\left| x_{ij} - \bar{x}_i \right|}{\bar{x}_i}}{R} \right] \cdot \frac{100}{S} \qquad (6)$$

where: x_{ij} = age determined from the j^{th} reading of the i^{th} scale;

$\bar{x}_i$ = average age determined from the i^{th} scale;

R = total number of readings; and,

S = total number of scales in the sample.

APE provides a means to evaluate the reproducibility of ages within a year, but should not be considered independent of age (Laine et al. 1991).

RESULTS

Of the 249 unique northern pike handled during the mark-recapture experiment, 113 were tagged and released alive during the marking event and 168 were examined for marks during the recapture event of which 32 were recaptures from the marking event (Appendix B4). There was no observed tag loss or handling mortality during the experiment, and 138 northern pike with Floy tags from prior mark-recapture experiments (55% of unique northern pike handled) were identified.

ABUNDANCE

Estimated abundance of northern pike within Harding Lake was germane to fish ≥ 300 mm FL during June 1999. To examine tag-recovery rates by area, Harding Lake was divided into two areas in such a way to minimize the difference in recovery rates within each area but maximize the difference between the areas. A comparison of the recovery history of fish marked in these two areas indicated mixing rates were not significantly different between the areas (χ^2 = 1.01; 2 df; P < 0.60; Table 2). In addition, proportions of marked fish recovered in each area were not significantly different (χ^2 = 0.84; 1 df; P = 0.36; Table 3). This suggests that all fish had a similar probability of capture during the recapture event, and that mixing rates were similar for both areas. Marking rates were also not significantly different by area (χ^2 = 1.21; 1 df; P = 0.27; Table 4), which suggested that all fish had a similar probability of capture by area during the marking event as well. These tests indicated that all three of the "or" conditions of Assumption 2 were met, thereby satisfying the requirements of this assumption by geographic strata for a Peterson mark-recapture experiment.

To test assumptions of equal capture probability by length, length distributions of fish marked, examined for marks, and recaptured were compared. There was no significant difference

Table 2.-Numbers of northern pike marked in areas A (section 14) and B (sections 11, 12, 13, 15, and 16) and recovered in area A, area B, or not recovered.

Marking	Recovery History			
Area	A	B	Not Recovered	Total
A	2	3	19	24
B	8	19	62	89
Total	10	22	81	113

Table 3.-Numbers of marked northern pike recovered and not recovered during the recapture event by areas A (sections 14) and B (sections 11, 12, 13, 15, and 16).

	Marking Area		
History	A	B	Total
Recovered	5	27	32
Not Recovered	19	62	81
Total	24	89	113

Table 4.-Numbers of marked and unmarked northern pike captured during the recapture event by areas A (section 14) and B (sections 11, 12, 13, 15, and 16).

	Capture Area		
Northern Pike	A	B	Total
Marked	10	22	32
Unmarked	30	106	136
Total	40	128	168

between the length distributions of fish marked and fish recaptured ($D = 0.15$; $P < 0.62$; Figure 3) and there was no significant difference between the length distributions of fish marked and fish examined for marks ($D = 0.09$; $P = 0.68$; Figure 3). This suggests that capture probability by length was not significantly different during the two events.

Estimated abundance of northern pike ≥ 300 mm FL within Harding Lake was 583 fish (SE = 76; CV = 13%). The lower and upper bounds of the 95% C.I. were 422 and 1,116 northern pike ≥ 300 mm FL. Estimated density of northern pike ≥ 300 mm FL was 0.58 (SE = 0.08) fish per hectare.

LENGTH COMPOSITION

Since capture probability was similar between both events ($D = 0.09$; $P = 0.68$; Figure 3), fork lengths from both events were pooled for estimating length composition. However, since capture probability by length was not significantly different ($D = 0.15$; $P = 0.62$; Figure 3), length proportions were not adjusted for unequal capture probability.

Fork lengths measured from 279 northern pike ≥ 300 mm FL in Harding Lake ranged from 302 mm to 750 mm (mean = 581 mm; SE = 5). The estimated abundance was 52 fish (SE = 10) for northern pike from 300 to 449 mm FL; 357 fish (SE = 48) for northern pike from 450 to 624 mm FL; and, 174 fish (SE = 25) for northern pike ≥ 625 mm FL (Figure 4). The estimated proportion was 0.09 (SE = 0.012) for northern pike from 300 to 449 mm FL; 0.61 (SE = 0.021) for northern pike from 450 to 624 mm FL; and, 0.30 (SE = 0.020) for northern pike ≥ 625 mm FL (Figure 4).

AGE COMPOSITION

Using scales, investigators determined ages for 238 of 249 unique northern pike (≥ 300 mm FL) sampled during the mark-recapture experiment. Scales were not taken or lost from 3 fish, were not readable because of regeneration from 7 fish, and were not readable because of poor acetate impression from one fish. Of scales collected during the marking event, ages were determined for 109 unique northern pike. Of scales collected during the recapture event, ages were determined for 129 unique northern pike. Investigators determined ages for 56 northern pike within the sample that were also aged in 1998.

The estimated average percent error of the scale reader in reproducing the same age twice from a Harding Lake northern pike scale in 1999 was 2.8% (Figure 5). The mean error in assigning the proper incremental ages from the scales of the 56 northern pike that were recaptured in 1999 from 1998 was 0.21 years ($Z = 1.03$; $P < 0.31$; Figure 6).

DISCUSSION

In 1999, a Peterson mark-recapture model was used to estimate abundance of Harding Lake northern pike. Unlike 1998, no size selectivity was detected in 1999. All conditions of Assumption 2 were met, and therefore there was no need to stratify by size.

The estimate of abundance for 1999 was the lowest since assessment studies of northern pike in Harding Lake began in 1991 (Figure 7). In addition, there was a decrease in estimated proportion and estimated abundance of fish between 300 and 450 mm FL from recent years (0.09 in 1999 compared to 0.32 in 1998). Even though it is possible that small fish were present in the lake but missing from the sample, it is more likely these fish were missing from the lake entirely.

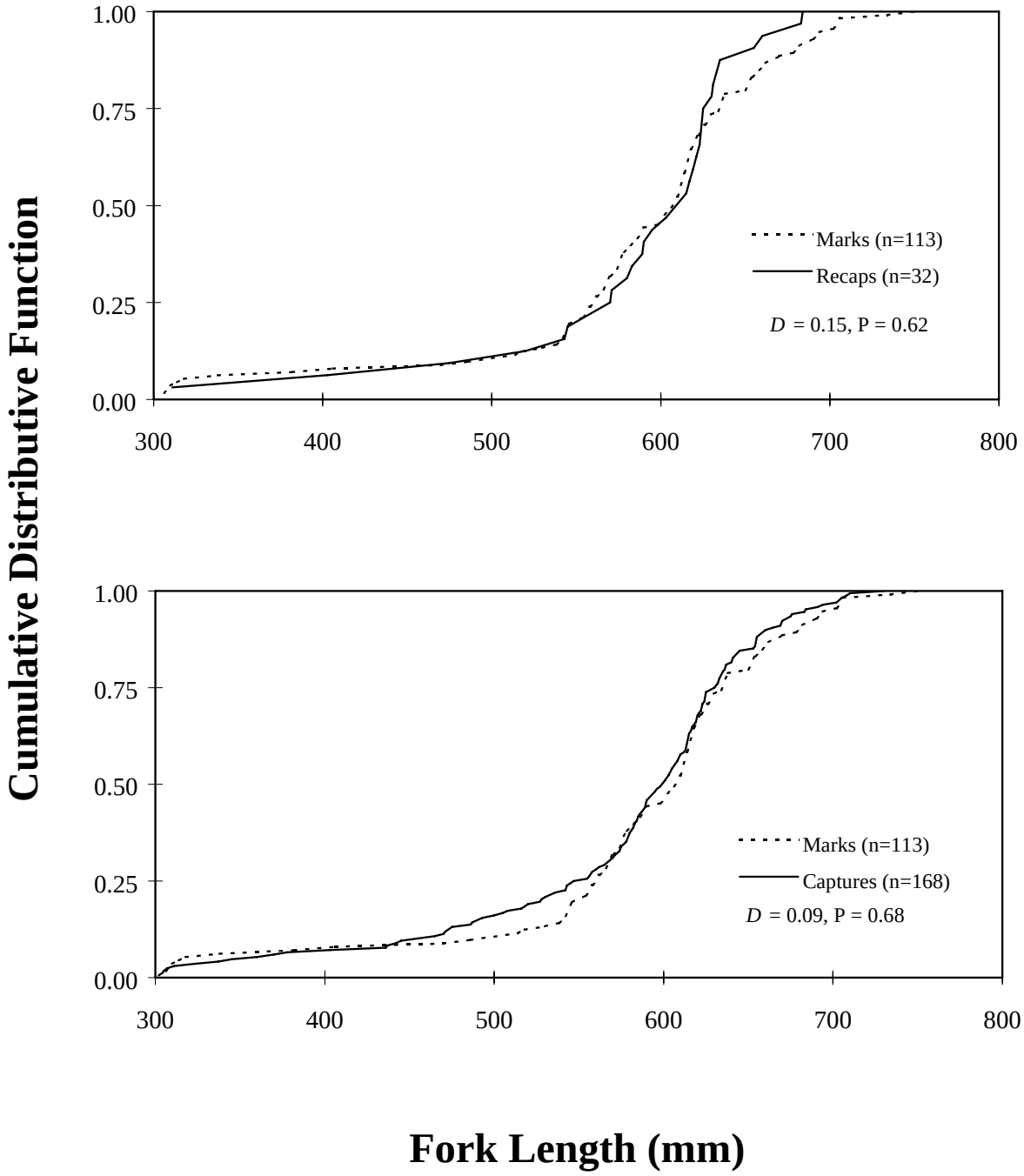

Figure 3.–Cumulative distributive functions of fork lengths of northern pike marked versus recaptured and marked versus captured in Harding Lake, 1999.

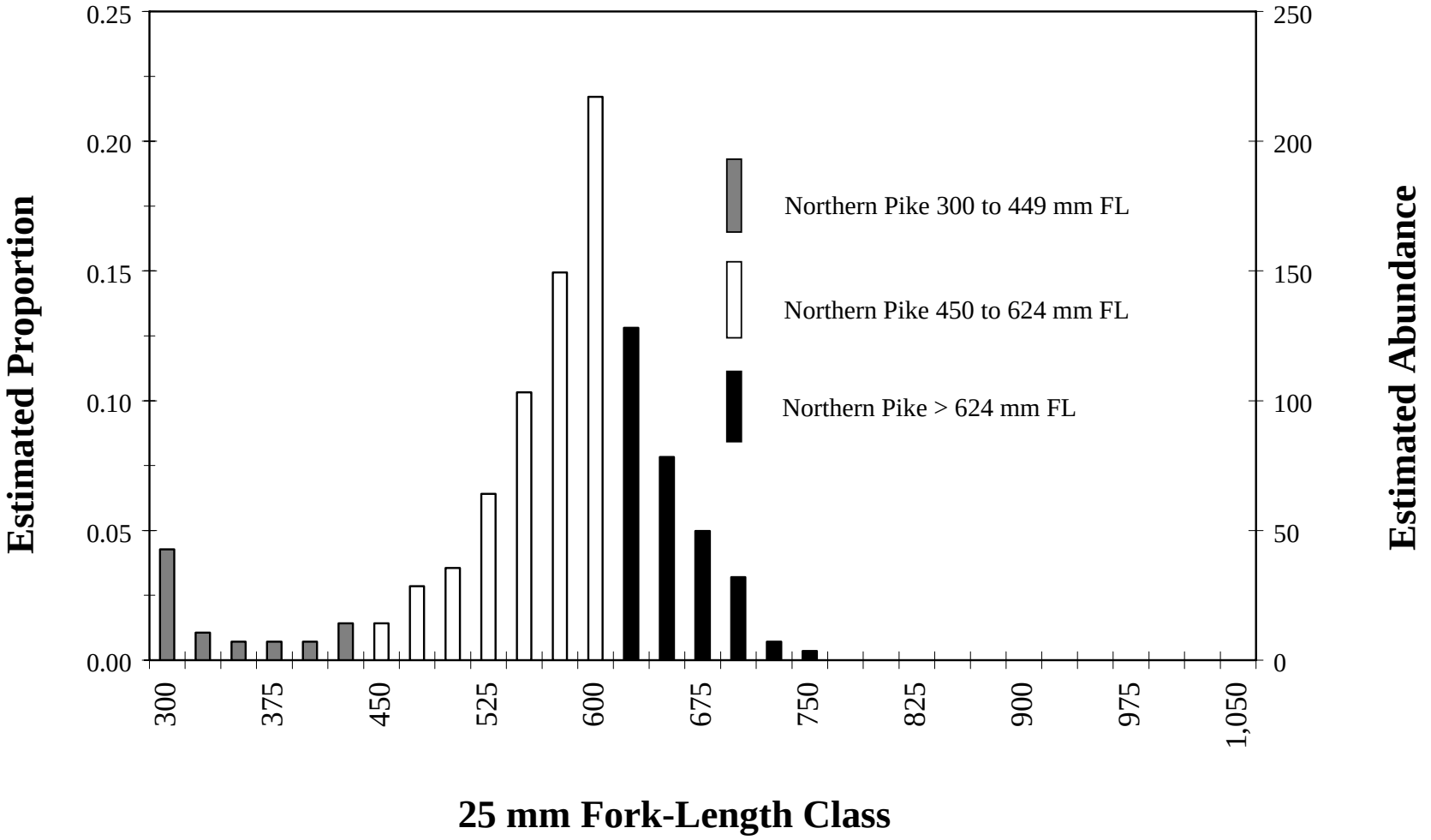

Figure 4.-Estimated proportions and abundances of northern pike ≥ 300 mm FL by 25-mm length classes within Harding Lake during June 1999.

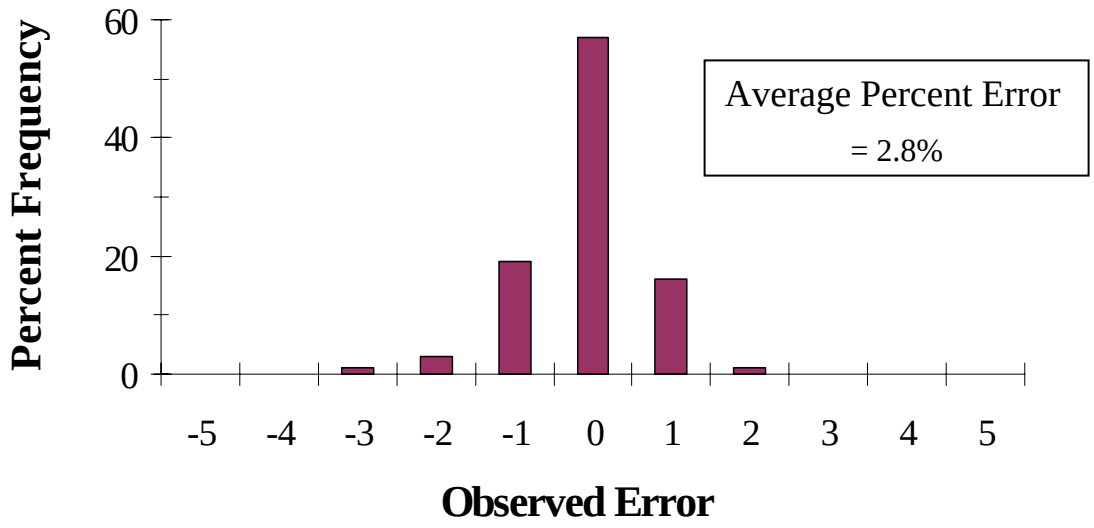

Figure 5.-Percent frequencies for observed errors in reproducing the same age twice from a Harding Lake northern pike scale in 1999.

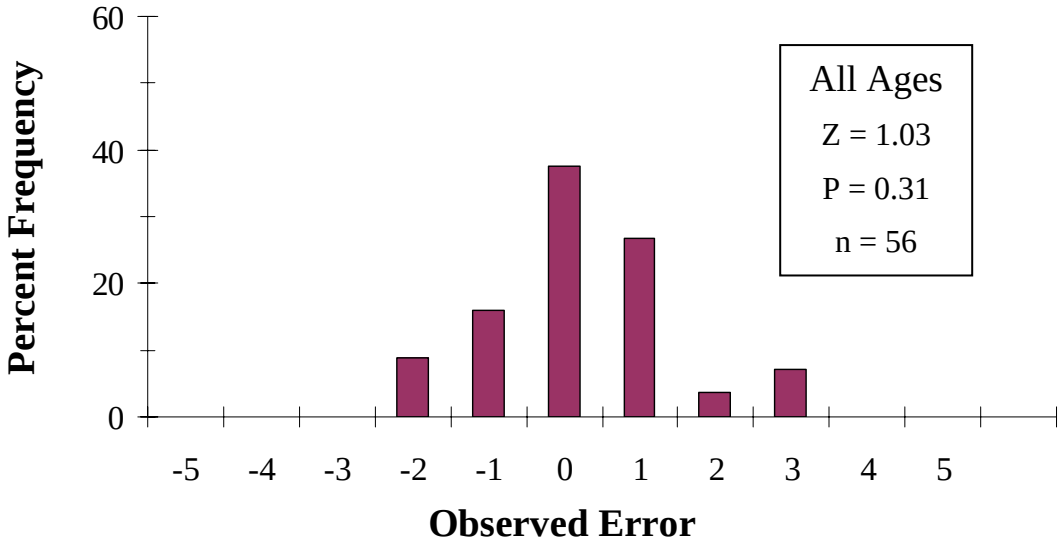

Figure 6.-Percent frequencies of observed errors in assigning the proper incremental ages to Harding Lake northern pike marked in 1998 and recaptured in 1999.

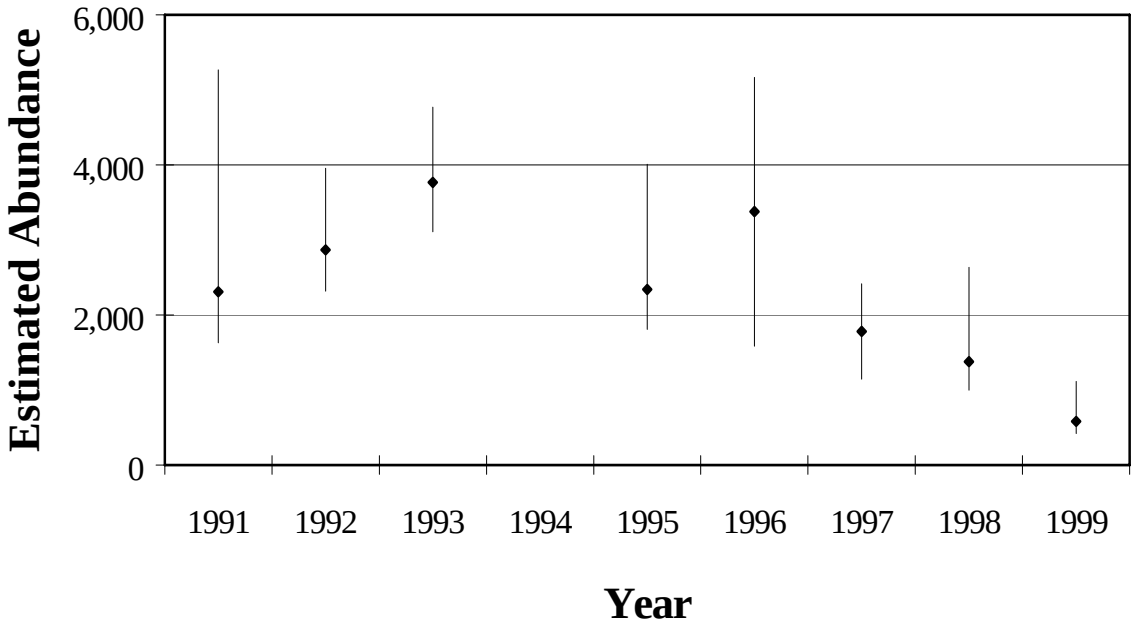

Figure 7.-Estimated abundance and 95% C.I. for Harding Lake northern pike, 1991 - 1999.

The 1999 sampling protocol was similar to the 1998 study, in which fish of this size class were easily caught (Roach and McIntyre 1999). It is likely that production and survival of recent cohorts (1994-1997) was lower than normal. The lack of small fish was probably related to the consistent drop in water level, which has occurred each year since 1992. The water level is currently at its lowest level since 1978 (M. Doxey, Alaska Department of Fish and Game, Fairbanks, personal communication).

Drops in water level affect the survival of northern pike in several ways. For example, the emergent vegetation (primarily grasses) on the east side of the lake, which normally is a prime spawning and rearing habitat for northern pike, was completely void of water. The water level was such that there were few if any vegetated areas where spawning could occur. Franklin and Smith (1963) report that prolarval density of northern pike was related to vegetation, and that highest prolarval densities occurred in dense tufts of emergent sedges (*Carex*). Fabricius and Gustafson (1958) also observed that northern pike in Europe deposited eggs only over suitable vegetation. Morrow (1980) reports that northern pike in Alaska normally spawn in marshy areas where there is shallow emergent vegetation and in water less than 26 cm. Lack of suitable spawning habitat could lead to reduction in hatching success and survival of alevins. This will probably continue to contribute to low spawning success for adults over several years.

Absence of emergent vegetation could also lead to reduction in survival of juvenile northern pike through increased cannibalism. Giles et al. (1986) found that cannibals were attracted by fry movements which often initiated attacks. Therefore, lack of sufficient cover normally provided

by vegetation probably increases incidence of cannibalism. Since there is a lag between spawning and recruitment to the gear, this lack of small fish will likely be reflected in the population over the next several years.

The issue of controlling the cyclic nature of the Harding Lake water level for the benefit of local residents and recreational users (which could also have the added benefit of increasing critical northern pike habitat) is being discussed by the Sport Fish Area Manager, the Harding Lake Association, the Alaska Department of Natural Resources, and the U.S. Army Corps of Engineers. Restoring and maintaining water level at a range that provides for ample critical habitat would likely be necessary to restore the abundance of northern pike to historic levels.

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APPENDIX A

Data File Listing

Appendix A1.–Data files used to estimate parameters of the Harding Lake northern pike populations, 1999.

Data file[a]	Description
U18900L011999.DTA	Population and marking data for Harding Lake northern pike captured during the marking event, June 1 through June 4, 1999.
U18900L021999.DTA	Population and recapture data for Harding Lake northern pike captured during the recapture event, June 8 through June 11, 1999.

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

APPENDIX B

Historical Data Summaries

Appendix B1.–Floy tag numbers used for Harding Lake northern pike mark-recapture experiments by year and color, 1990-1999.

Year	Tag Color			
	White	Blue	Gray	Red
1990		62,765-62,999 63,550-63,984		
1991		64,000-64,099 64,400-64,415 64,700-64,999		
1992	351-900 1,001-1,053			
1993			48,000-48,868	
1994				
1995			40,000-40,783	
1996		53,000-53,271 53,750-53,894		
1997			4,425-4,774	
1998				22,001-22,270
1999		52,400-52449 52,800-52830		

Appendix B2.–Sample sizes, estimated abundances, and standard errors by length category for Harding Lake northern pike, 1995 – 1999 (adjustments made in sample sizes and abundances for unequal capture probabilities in 1995, 1996, 1998).

	1995			1996		
Length	n	$\hat{N}$	SE	n	$\hat{N}$	SE
300-324	23	101	18	16	126	34
325-349	23	77	13	3	28	8
350-374	23	77	14	19	155	42
375-399	33	94	16	14	112	30
400-424	32	75	13	16	126	34
425-449	53	119	21	31	253	69
450-474	32	115	20	26	211	57
475-499	52	138	24	31	253	69
500-524	72	203	36	31	253	69
525-549	60	154	27	55	450	122
550-574	88	283	50	52	421	114
575-599	101	250	44	62	506	137
600-624	74	190	33	20	164	44
625-649	64	143	25	14	116	31
650-674	37	83	15	9	76	21
675-699	24	62	11	4	30	8
700-724	20	42	8	2	18	5
725-749	13	28	5	1	9	3
750-774	8	20	4	1	12	3
775-799	4	10	2	2	14	4
800-824	8	20	3	1	9	3
825-849	3	5	1	1	12	3
850-874	2	3	1	0	2	1
875-899	2	6	1	1	7	2
900-924	7	27	5	1	7	2
925-949	-	-	-	1	7	2
950-974	2	7	1	-	-	-
975-999	1	3	0	-	-	-
1,000-1,024	1	3	0	-	-	-
1,025-1,049	-	-	-	-	-	-
> 1,050	-	-	-	-	-	-
Totals	862	2,338	-	600	3,377	-

- continued -

Appendix B2.–Page 2 of 3.

	1997			1998		
Length	n	$\hat{N}$	SE	n	$\hat{N}$	SE
300-324	10	37	12	35	112	23
325-349	10	37	12	22	71	14
350-374	22	82	21	26	81	17
375-399	9	34	11	22	71	14
400-424	20	74	19	19	61	12
425-449	27	101	24	14	46	9
450-474	37	138	31	24	76	15
475-499	50	186	40	21	66	13
500-524	38	142	32	29	92	19
525-549	36	134	30	48	153	31
550-574	49	182	39	49	158	32
575-599	60	223	47	31	99	20
600-624	44	164	36	32	101	20
625-649	31	115	27	28	90	18
650-674	9	34	11	11	36	7
675-699	2	7	5	9	29	6
700-724	6	22	9	9	28	6
725-749	4	15	7	-	-	-
750-774	0	0	0	-	-	-
775-799	4	15	7	<1	2	<1
800-824	3	11	6	-	-	-
825-849	5	19	8	-	-	-
850-874	0	0	0	1	5	1
875-899	1	4	3	-	-	-
900-924	-	-	-	-	-	-
925-949	-	-	-	-	-	-
950-974	-	-	-	-	-	-
975-999	-	-	-	-	-	-
1,000-1,024	1	4	3	-	-	-
1,025-1,049	-	-	-	-	-	-
> 1,050	-	-	-	<1	2	<1
Totals	478	1,780	-	432	1,376	279

- continued -

Appendix B2.–Page 3 of 3.

	1999		
Length	n	$\hat{N}$	SE
300-324	12	25	3
325-349	3	8	1
350-374	2	4	1
375-399	2	4	1
400-424	2	4	1
425-449	4	8	1
450-474	4	8	1
475-499	9	19	2
500-524	10	21	3
525-549	18	37	5
550-574	29	60	8
575-599	42	87	11
600-624	61	126	16
625-649	35	72	9
650-674	21	43	6
675-699	14	29	4
700-724	2	19	2
725-749	1	4	1
750-774	1	2	-
775-799	-	-	-
800-824	-	-	-
825-849	-	-	-
850-874	-	-	-
875-899	-	-	-
900-924	-	-	-
925-949	-	-	-
950-974	-	-	-
975-999	-	-	-
1,000-1,024	-	-	-
1,025-1,049	-	-	-
> 1,050	-	-	-
Totals	281	583	76

Appendix B3.–Sample sizes, estimated abundances, and standard errors by age for Harding Lake northern pike ≥ 300 mm FL, 1990-1999 (adjustments made in sample sizes and abundances for unequal capture probabilities in 1995, 1996, and 1998).

	1990[a]			1991[a]			1992[a]			1993[a]			1994[b]		
Age	n	$\hat{N}$	SE	n	$\hat{N}$	SE	n	$\hat{N}$	SE	n	$\hat{N}$	SE	n	$\hat{N}$	SE
2	1	11	11	---	---	---	---	---	---	16	71	19	---	---	---
3	15	160	48	11	126	56	51	538	111	128	571	80	---	---	---
4	47	484	106	15	171	72	87	892	164	254	1,134	143	---	---	---
5	88	657	125	30	343	131	75	609	97	220	982	126	---	---	---
≥ 6	324	973	140	192	1,668	482	133	829	174	226	1,007	185	---	---	---
Totals	475	2,285	---	248	2,308	---	519	2,868	---	581	3,765	---	---	---	---

-continued-

Appendix B3.–Continued.

	1995[c]			1996[d]			1997[e]			1998[f]			1999		
Age	n	$\hat{N}$	SE	n	$\hat{N}$	SE	n	$\hat{N}$	SE	n	$\hat{N}$	SE	n	$\hat{N}$	SE
2	5	15	3	-	-	-	8	35	13	8	31	6	8	18	5
3	46	185	32	29	244	66	34	151	35	47	172	35	8	18	5
4	128	431	76	34	289	78	53	235	50	43	159	32	8	15	5
5	225	704	124	92	781	212	85	377	75	77	284	58	8	13	4
≥ 6	357	1,003	177	242	2,063	560	222	982	183	200	730	148	236	519	57
Totals	761	2,338	---	397	3,377	---	402	1,780	---	375	1,376	---	268	583	---

a From Pearse (1994).

b Data were not collected in 1994.

c From Roach (1996), d: from Roach (1997), e: from Roach (1998), f: from Roach and McIntyre (1999).

Appendix B4.-Number of northern pike ≥ 300 mm FL marked (M), examined for marks (C), and recaptured with marks (R) by section during Harding Lake two-event mark-recapture experiments, 1995 - 1999.

Section	1995			1996			1997			1998			1999		
	M	C	R	M	C	R	M	C	R	M	C	R	M	C	R
1	45	56	7	48	46	6	23	26	3	--	--	--	--	--	--
2	22	15	1	10	9	0	0	2	0	--	--	--	--	--	--
3	5	3	0	1	10	1	0	0	0	--	--	--	--	--	--
4	116	46	18	55	50	7	62	54	8	--	--	--	--	--	--
6	3	5	2	0	5	2	5	0	0	--	--	--	--	--	--
7	28	15	3	8	19	4	4	8	1	--	--	--	--	--	--
8	32	53	15	24	19	3	45	19	3	--	--	--	--	--	--
9	60	71	25	45	33	9	21	27	11	--	--	--	--	--	--
10	15	32	10	33	15	5	17	24	7	--	--	--	--	--	--
11	1	9	3	11	0	0	0	0	0	4	--	--	5	5	0
12	3	4	1	1	0	0	0	1	0	24	9	3	1	0	0
13	31	37	3	23	26	1	11	18	1	57	50	13	29	37	6
14	34	25	4	14	25	3	3	31	4	39	63	10	24	40	10
15	25	15	5	5	13	2	30	25	2	37	67	12	37	67	13
16	26	26	8	26	43	8	7	15	5	17	19	8	17	19	3
Totals	446	412	105	304	313	51	228	250	45	210	222	46	113	168	32