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Stock Assessment and Biological Characteristics of Burbot in Hudson and Moose Lakes, 1998, and Tolsona Lake, 1995-1998

by

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and

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December 1999

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

Abundance and indices of abundance were estimated for populations of burbot *Lota lota* in Hudson, Moose, and Tolsona lakes in Southcentral Alaska. Sampling occurred in May and July of 1998. Bootstrapped mean catch per unit of effort of fully recruited burbot (450 mm total length and larger) per 48-h set ranged from 2.19 (SE =) in Tolsona Lake to 3.49 (SE =) in Moose Lake. Estimate of catch per unit effort in Hudson Lake was biased due to sampling mortality at depths greater than 8 m from low dissolved oxygen. Abundance during 1998 of fully recruited burbot estimated with mark-recapture experiments was 893 (SE = 447) in Tolsona Lake. During 1996-1997, estimated annual survival rate for fully recruited burbot in Tolsona Lake was 72.5%. Catch per unit effort of fully recruited burbot in Moose Lake was similar to estimates from 1990-1992.

Key words: Burbot, *Lota lota,* abundance estimate, length composition, catch per unit effort, hoop traps, mean length, survival rates, recruitment.

INTRODUCTION

Historically, the lakes of the Upper Copper/Upper Susitna management area (UCUSMA) supported the largest burbot fishery in the state (Figure 1). Harvests from the UCUSMA averaged over 9,000 burbot or 60% of the statewide burbot harvest from 1977 – 1986. The fishery peaked in 1985 when over 19,000 burbot were harvested from the UCUSMA, accounting for 71% of the statewide burbot harvest (Mills 1986; Figure 2). The Tyone River drainage (consisting of Lake Louise, Susitna and Tyone lakes) supported over half of the burbot harvest in the Glennallen area prior to 1987. Concerns over overexploitation resulted in the Alaska Department of Fish and Game (ADF&G) initiating a research study in 1986 to collect basic life history information necessary to assess stock status and to estimate the sustained yield of burbot in interior Alaskan lakes. In 1988, the Board of Fisheries adopted as regulation (5 AAC 52.045) a lake burbot management plan so that the burbot fishery in the UCUSMA could be managed for maximum sustained yield and opportunity to participate. This plan gives the ADF&G the authority to manage burbot stocks in the UCUSMA to permit maximum sustainable harvests on healthy stocks and rebuild depressed stocks.

The ADF&G has managed the UCUSMA burbot fisheries through bag limit reduction, gear restriction, and lake closures. Since 1988, bag and possession limits have been reduced to five burbot per day on most lakes, two burbot per day on some heavily fished road accessible lakes. The use of setlines has been prohibited by emergency order in the Tyone River drainage and Tolsona and Moose lakes from 1989 - 1991, and by regulation since 1991 in the entire UCUSMA. The Lake Louise and Hudson Lake burbot sport fisheries were closed in 1988 due to continued declines in burbot abundance. Lake Louise remains closed to burbot fishing; stock assessment indicates that the population has stabilized but has not returned to historical levels. Since 1996, stock assessment on Lake Louise has been reduced to a once every 3-year cycle. Hudson Lake was reopened following stock assessment in 1993, which indicated the burbot population had recovered to previous abundance levels. Prior to this study, Hudson Lake had not been assessed since it was reopened.

Tolsona Lake is the only lake in the UCUSMA that has been assessed every year since 1986. This is due to accessibility, ease of sampling, and the opportunity for a long-term study on an exploited population. It has also provided information on a burbot stock that resides in a shallow, productive lake, atypical for burbot. In 1998, Tolsona Lake was closed to burbot

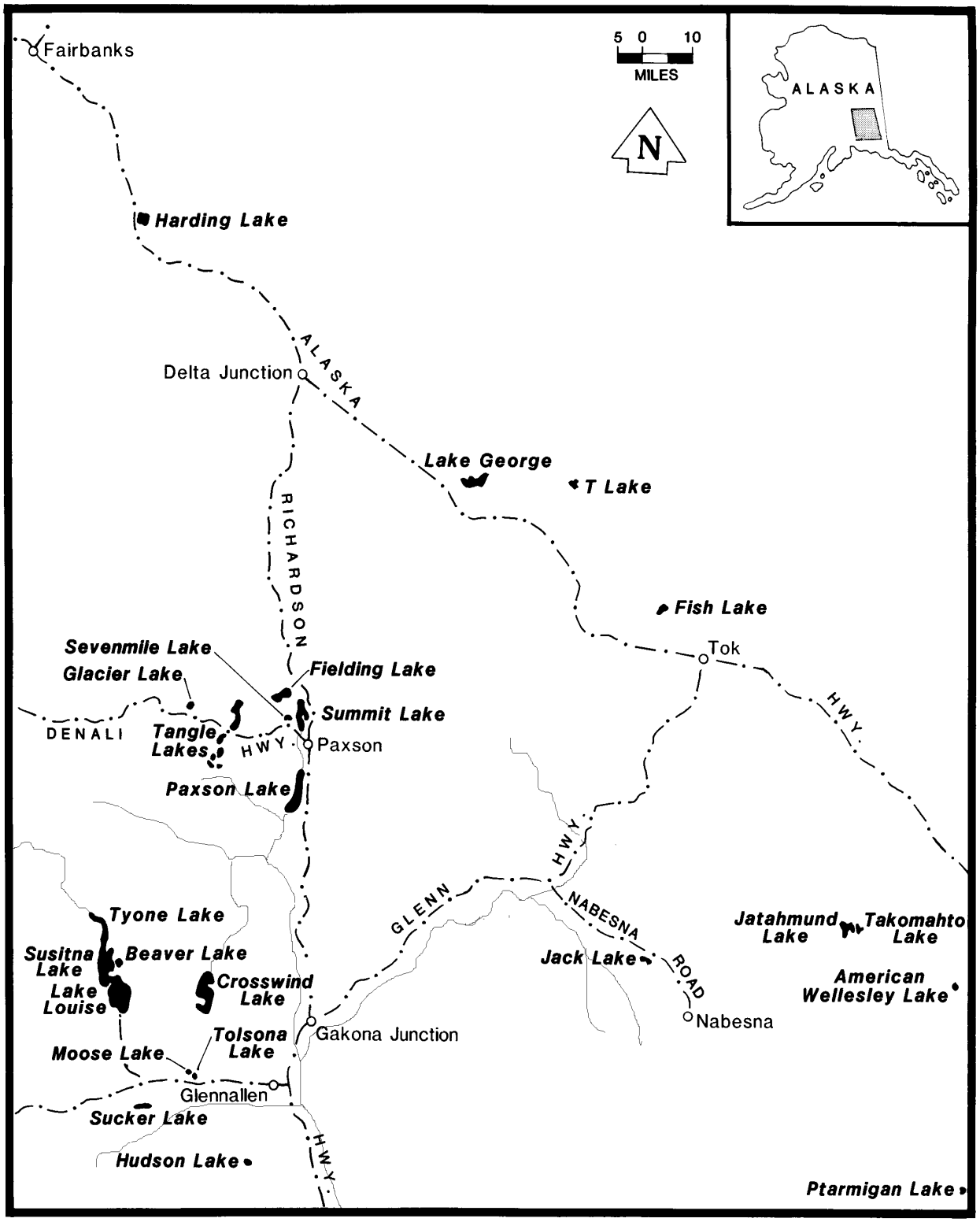

Figure 1.-Locations of lakes sampled in 1998. (Tom: the map should be shrunk down to cover just the Glennallen area.

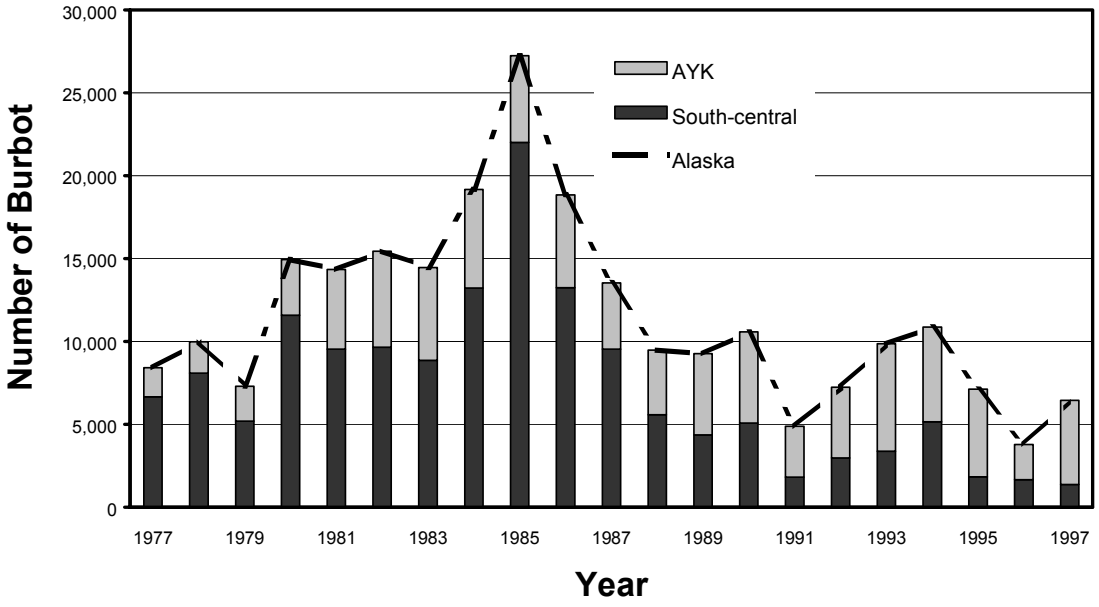

Figure 2.-Estimated harvests of burbot in Alaskan sport fisheries, 1977-1997 by region.

fishing due to a dramatic decline in burbot abundance and poor summer survival (Figure 3). This decline was likely due to a combination of factors; high summer water temperatures may have contributed to a decrease in survival. Moose Lake is adjacent to Tolsona Lake and has similar limnological characteristics. Moose Lake had not been sampled since 1992, and there was concern that the factors that resulted in the burbot decline in Tolsona Lake may have occurred in Moose Lake. In 1998, Hudson, Moose, and Tolsona lakes were assessed for burbot abundance, length composition and CPUE. Results from sampling burbot in 1995, 1996 and 1997 at Tolsona Lake have not been previously presented. Thus, data for those years will be included in this report.

Objectives for 1995 (Project F-10-11, R-2-4) and 1996 (Project F-10-12, R-2-4) were to:

1. estimate the length composition of burbot captured;

2. estimate the abundance of burbot $\geq$ 450 mm TL; and,

3. index the abundance of burbot $\geq$ 450 mm TL with mean CPUE.

There was no operational plan for sampling conducted in 1997; funds were expended from the management budget to capture and sample burbot in Tolsona Lake in 1997.

The objectives for the project during 1998 Federal Aid project F-10-14, R-3-4(c) were to:

1. estimate the length composition of burbot (≥ 450 mm TL) for each sampling event in Hudson, Moose, and Tolsona lakes such that the estimated proportions are within ± 10 percentage points of the actual values 95% of the time;

2. estimate the abundance of burbot (≥ 450 mm TL) in Hudson, Moose, and Tolsona lakes such that the estimated abundance is within ± 25% of the true abundance 90% of the time; and,

3. estimate mean catch per unit of effort (CPUE) of burbot (≥ 450 mm TL) in Hudson, Moose, and Tolsona lakes such that mean CPUE is within ± 50% of its asymptotic value 90% of the time.

Project tasks for 1998 were to:

1. provide a temperature profile of Tolsona and Moose lakes during the open water period; and,

2. collect water quality data at one month intervals in Tolsona and Moose lakes from May – September.

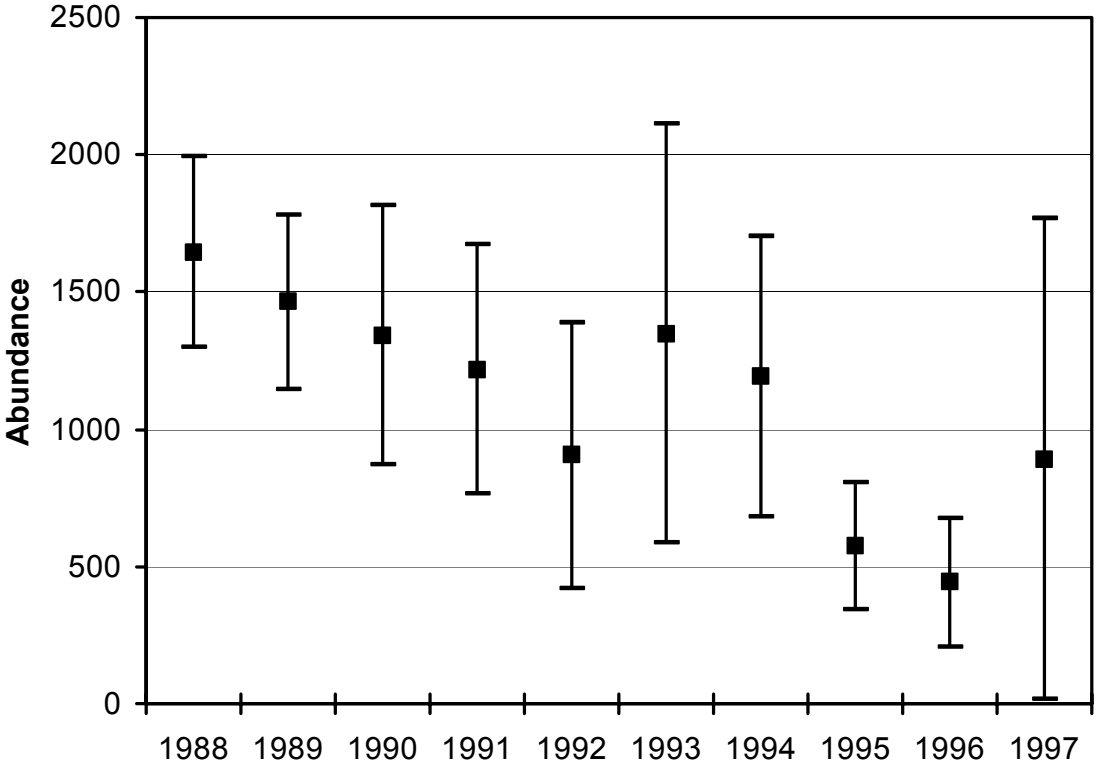

Figure 3.-Estimated abundance and 95% confidence intervals of burbot (>450 mm) in Tolsona Lake, 1988 – 1997.

Past research on these and other lakes in interior and southcentral Alaska can be found in previous technical reports (Lafferty et al. 1990-1992; Lafferty and Bernard 1993; Potterville and Bernard 1987; Parker et al. 1988, 1989; Taube et al. 1994; and Taube and Bernard 1995). Presentation of tables and figures are in similar format to past reports to provide easy summarization of time series information. Each of the populations studied in 1998 has (or had) a popular sport fishery for burbot. Descriptions of each study lake are presented in Appendix A.

METHODS

Study Design

Burbot were captured in 3-m long, baited hoop traps with 25-mm mesh net set on the bottom as described in Bernard et al. 1991. Burbot ≥ 450 mm TL are fully recruited to this gear. Traps were positioned according to a systematic sampling design as described in Bernard et al. (1993) to minimize competition among the gear while still covering the bottom of each lake. Sampling at Tolsona and Moose lakes commenced immediately after the lakes became ice-free to maximize the catch per set (Bernard et al. 1993). A set is defined as a single hoop trap soaked for 48 h. Sixty sets were used at both Moose Lake and Tolsona Lake. Sampling occurred at Moose Lake, May 20-22 and Tolsona Lake, May 19-21 (Table 1). Sampling at Hudson Lake occurred July 7-9 and 80 sets were used. Sampling at Hudson Lake in 1993 occurred in May, but all previous sampling (1987-1990) occurred in late June or early July. The estimate of mean CPUE in 1998 can be directly compared to past summer estimates and adjusted for comparison to the 1993 estimate.

Table 1.-Number of sets and dates of sampling events for the stock assessment of burbot populations in Hudson, Moose, and Tolsona lakes, 1995 – 1998.

Lake	Area (ha)	Dates of Sampling Events	Number of Sets
Hudson	259	7/7 – 9/98	80
Moose	130	5/20 – 22/98	60
Tolsona	130	5/19 – 21/98	60
		5/27 – 29/97	60
		6/5 – 7/96	60
		5/23 – 25/95	58

After lifting a hoop trap, the catch was emptied into a holding tank and burbot were inspected for previous marks, tagged (if necessary) and measured for total length. Each unmarked burbot was tagged with an individually numbered Floy tag inserted in the musculature beneath the dorsal fin.

All tags were checked to see if the tag is locked between the pterygiophores of the dorsal fin. Each burbot also received a second mark in the form of a left pectoral finclip. This second mark is used to evaluate loss of Floy tags. The left opercular punch (1992), left ventral fin clip (1993), or right ventral fin clips (1994) have been used as secondary marks in a three year rotation. A burbot that is identified as a tag loss is attributed to the most recent year the secondary mark was used. The data are adjusted prior to calculating the population estimate. During 1995 – 1997, a half-dorsal clip was used during each sampling event. Burbot captured missing Floy tags and with a half-dorsal clip can be marked as a recapture, but not attributed to a specific year. All burbot were measured for total length to the nearest 5 mm and returned to the lake promptly. Individual trap and associated catch information were recorded on the standard hoop net mark-sense form (Heineman *Unpublished* 1998). The trap information include the following: hoop trap number, location of set, depth of set, hour trap set and hour pulled, and number of fish caught by species. Tag number and color, secondary mark, and total length were recorded on the mark-sense form for each burbot caught in each set. In the event of sampling induced mortalities, otoliths were extracted, and age determined at a later date. Processing and reading of otoliths followed the procedures described by Chilton and Beamish (1982). Ages were recorded into the appropriate databases.

Data Analysis

Abundance, survival rates, and recruitment statistics were generated for the burbot population in Tolsona Lake with the Jolly-Seber model (Seber 1982) using the computer program JOLLY (Model A) developed by Brownie et al. (1986) at the Patuxent Wildlife Research Center (see Pollack et al. 1990 for a description of JOLLY). Abundance was estimated for the populations in Moose and Hudson lakes by expansion of mean CPUE. The Jolly-Seber model is described below, followed by an explanation of the expansion method.

Individual burbot that were captured more than once in 1998 were considered to have been caught only once in this analysis to estimate abundance. Conditions for producing accurate statistics with the Jolly-Seber model are:

1. all burbot have the same probability of capture during each sampling event (probability of capture can vary among events) or marked burbot must completely mix with unmarked burbot between sampling events;
2. no marks are lost between sampling events;
3. marked burbot must behave (enter traps) as do unmarked burbot;
4. marked burbot must have the same mortality rate as unmarked burbot; and
5. immigration and emigration is permanent.

Because Bernard et al. (1991) showed that burbot < 450 mm TL are not fully recruited to the sampling gear used in this project, statistics will only be generated for burbot ≥ 450 mm TL. Although the probability of capturing extremely large burbot (> 900 mm TL) is less than the probability of capturing other burbot ≥ 450 mm TL in the hoop traps used in this project (Bernard et al. 1991), populations studied here have been heavily exploited and have few extremely large fish. Sets were distributed uniformly to promote mixing and to homogenize the probability of capture of burbot across each lake. Over the span of a year, burbot should completely mix across all depths (Bernard et al. 1993). Double marking of burbot (tag and fin clip) permitted correction

of any bias in estimates due to loss of tags. Previous studies indicate little trap happiness or trap shyness of captured burbot (Bernard et al. 1991). Although an intermittent stream connects Moose and Tolsona lakes, only one of several thousand burbot recaptured since 1986 had moved to the other lake.

Mean CPUE was estimated for fully and partially recruited burbot following a two-stage sampling design with transects as first-stage units and sets along transects as second-stage units (Sukhatme et al. 1984). Although all transects had an equal probability of being included in a survey, they were of different lengths depending upon the shape of the lake. Under these conditions, an unbiased estimate of mean CPUE is:

$$\overline{\mathrm{CPUE}} = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{m_i}\sum_{j=1}^{m_i}\omega_i c_{ij} \qquad (1)$$

Where:

c_{ij} = catch of burbot from the jth set on the ith transect;

n = number of transects;

m_i = number of sets sampled on the ith transect;

$\omega_i = M_i / \overline{M}$

M_i = maximum possible sets on the ith transect; and,

$\overline{M}$ = mean of possible sets across all transects.

Although the M_i and $\overline{M}$ are unknown, the m_i and m were used as a substitute because both M and m are directly related to the length of transects. Thus $\varpi_i = m_i/m$ was used to estimate ω_i. Because few burbot enter traps during daylight (Bernard et al. 1991), catches were not adjusted for the few hours deviation in soak times from the standard 48 h for most sets. Estimates of mean CPUE were also not adjusted for recaptured burbot. A two-stage, resampling procedure (Efron 1982,: Roa and Wu 1988) was used to generate an empirical distribution of mean CPUE for each survey from which variance of mean CPUE and bias from using ω were estimated. In resampling procedures, sets were chosen randomly even though the original selection of sets was systematic. Systematically drawn data can be treated as randomly drawn with little concern for bias in the resultant statistics only so long as these data are not auto correlated or follow a trend (Wolter 1984). Analysis of data from surveys has revealed no meaningful trends or autocorrelations among catches along transects (Bernard et al. 1993). Estimates of mean CPUE for two groups of burbot (≥ 450 mm and < 450 mm TL) will be calculated for each sampling event using procedures described in Bernard et al. (1993). A computer program RAOWU.EXE, written originally in FORTRAN was used to estimate mean CPUE, approximate its variance, and estimate inherent bias in the estimate according to a two-stage bootstrap procedure based on a model in Rao and Wu (1988). Individual burbot that were captured more than once in 1998 were considered to be different fish each time captured in calculation of mean CPUE. Conditions for the accurate calculation of mean CPUE as an index of abundance are:

1. gear do not compete for burbot;
2. burbot do not saturate the gear; and,
3. gear is not size-selective.

Bernard et al. (1993) showed that the spacing of sets used in this project is sufficient to avoid competition among gear for burbot and that saturation of gear by burbot is negligible. Because hoop traps as fished in this project are size-selective for burbot (Bernard et al. 1991, 1993), mean CPUE for only fully-recruited burbot were considered as a valid index of abundance.

Mean CPUE was used to estimate abundance of fully recruited burbot in Hudson and Moose lakes in 1998 using the relationship:

$$\hat{N} = A(\overline{CPUE})\hat{q}^{-1} \quad (2)$$

where *A* is the surface area of the lake (ha) and *q* is the catchability coefficient (the fraction of the population removed instantaneously with one unit of sampling effort). Estimates of *q* were obtained from previous sampling in both lakes (Taube et al. 1994). Because of some problems in estimating abundance for this population in other years (Parker et al. 1989), the catchability coefficient was estimated from the mark-recapture experiment in 1987 in Hudson Lake. Only the later survey in that experiment was used because its scheduling is similar to the scheduling for this year's survey. Because only one survey was used, variance of the abundance estimate reflects sampling error in that survey only and not interannual variation in catchability.

RESULTS

TOLSONA LAKE

Estimated abundance of burbot in 1995 was 576 (SE = 118). The estimate of abundance in 1996 (443 fish, SE = 119) at Tolsona Lake was the lowest since the study was initiated (Table 2). Survival rates and recruitment were low for 1994 and 1995 and likely contributed to the decline in abundance. Survival and recruitment increased in 1996 and are reflected in the increased abundance in 1997. Although numbers of large burbot in Tolsona Lake are currently low, a large number of recruits ($\geq$ 450 mm TL) entered the population in 1998. Density of fully recruited burbot in 1998 was 6.87 in Tolsona Lake, the highest density since 1995 (Table 3). Of the fully recruited burbot released in Tolsona Lake in previous years and recaptured in 1998, 29% had lost their tags. This tag loss was unusually high, given prior years' reported tag losses: 3%, 0%, and 0% in 1995, 1996 and 1997. The 29% tag loss observed in 1998 arose from either (or a combination): 1) a single year's loss between tags applied in 1997 and lost by 1998; 2) cumulative tag loss over a series of years; or, 3) random chance (due to low numbers). In Jolly-Seber models unique secondary marks between annual events are critical to adjust for tag loss. In addition, close examination of fish for lost tags is essential. Unfortunately, sampling at Tolsona Lake in years prior to 1998 was not conducted carefully, and the same secondary mark (half dorsal clip) was applied in 1995, 1996 and 1997. Thus, without unique secondary marks, it cannot be determined with certainty whether the 29% tag loss resulted from just 1997 or was

Table 2.-Estimates of abundance, survival rates, and recruitment for fully recruited (≥ 450 mm TL) burbot residing in Tolsona Lake.

Date	Days between events	Abundance			Survival Rate %		Recruitment	
		Estimate	SE	CV %	Estimate	SE	Estimate	SE
9/26/86		1,901[a]	120	21.6				
	235				60.0	4.6	138	209
6/25/87		1,291	120	9.3				
	335				77.9	7.1	645	144
5/26/88		1,647	178	10.8				
	95				66.6	7.4	45	111
9/01/88		1,142	132	11.5				
	263				77.8	9.1	576	124
5/24/89		1,464	162	11.0				
	110				100.0[b]	17.6	277	174
9/13/89		1,846	311	16.8				
	251				47.9	9.8	460	153
5/24/90		1,344	240	17.9				
	104				36.0	6.6	88	69
9/07/90		572	89	15.6				
	255				63.5	12.0	856	186
5/22/91		1,220	231	18.9				
	109				33.4	6.1	96	80
9/12/91		503	96	19.0				
	273				85.3	23.1	478	163
6/11/92		906	247	27.3				
	341				24.6	6.2	1,127	368
5/20/93		1,350	389	28.8				
	375				90.9	17.7	-30	435
6/01/94		1,193	261	21.9				
	354				33.3	7.5	180	84
5/23/95		576	118	20.5				
	377				40.2	10.8	213	78
6/05/96		443	119	26.8				
	354				72.5	35.1	588	326
5/27/97		893	447	50.1				

[a] Estimate obtained from Potterville and Bernard (1987).

[b] Actually computed at 107.2. Since this value is impossible, estimate was truncated to 100.

Table 3.-Estimated density of fully recruited (≥ 450 mm TL) burbot in Tolsona Lake during 1995 – 1998.

Lake	Date	Estimated Abundance	SE	Area of Lake (ha)	Estimated Density (burbot/ha)	SE
Tolsona						
1995	6/01-03	1,193	261	130	9.18	2.01
1996	5/23-25	576	118	130	4.43	0.91
1997	6/05-07	443	119	130	3.41	0.92
1998	5/27-29	893	447	130	6.87	3.44

cumulative loss from several prior years. Also, it cannot be determined with certainty that technician crews in 1995-1997 closely observed fish for tag loss, so that the 3% and 0% reported tag losses might be underestimates. Finally, these are small numbers we are dealing with – random chance could have produced the recaptured fish with missing tags. In 1998, six of 26 fish recaptured from previous years were identified only by half-dorsal secondary marks. If tag loss is from a single year, bias in parameter estimates for 1997 will be high; if tag loss is cumulative, then bias across years will be unknown, but of a lesser extent than from a single year. Fish missing tags were not included in the model, resulting in biased estimates of all parameters for 1997. The survival estimate will be low because recaptured fish were not included in the model.

Mean CPUE of fully recruited burbot in Tolsona Lake in 1998 was greater than the 1997 estimate, but still less than the 1995 estimate (Table 4). The estimate of CPUE in 1997 was the lowest reported since the initiation of the study. The 1995 estimate was similar to previous estimates for Tolsona Lake from 1991- 1994 (Lafferty et al. 1992, Lafferty and Bernard 1993, Taube et al. 1994, and Taube and Bernard 1995).

HUDSON LAKE

Sampling at Hudson Lake occurred over a three-day period; 80 traps were set in one day and pulled 48-h later. When the traps were pulled all burbot captured in traps set in water greater than 8 m in depth were dead. Of 108 burbot captured, 58 (54%) were sampling mortalities. It is assumed that low dissolved oxygen level in depths greater than 8 m caused the mortalities. A dissolved oxygen meter was not available to corroborate this theory, but Bernard et al. (1993) reported that at Hudson Lake traps set in deeper sections of the lake resulted in mortality of all burbot captured in these sets. This generally occurred after a series of windy days. Sixty-one traps were set in waters greater than 8 m deep and 17 traps were set in waters less than 8 m deep. CPUE in the shallow sets was more than twice that of the deep sets, indicating that burbot were attracted to the lethal sets by the bait. This condition at the lake resulted in biased estimates of mean CPUE that could not be directly comparable to past estimates.

MOOSE LAKE

Mean CPUE of fully recruited burbot at Moose Lake was similar to estimates from 1990 – 1992 (3.15, 3.27, and 2.93, respectively), but significantly less than estimates from 1988 (6.95) and 1989 (7.11) (Parker et al. 1989, Lafferty et al. 1990, Lafferty et al. 1991, Lafferty and Bernard 1992, Lafferty et al. 1993). Length composition of the burbot sampled in Moose Lake in 1998 were similar to those in 1992. Overall, there were larger fish captured in 1998, mean length was 518 mm in 1998 (Table 5) and 490 mm in 1992. From Equation 2, estimated abundance of burbot $\geq$ 450 mm TL in 1998 is 833 (catchability coefficient – 0.54).

Estimates of CPUE for Tolsona and Moose lakes in previous years when sampling occurred were similar. Since sampling did not occur at Moose Lake in 1997, it is not specifically known if a similar population decline occurred there as did in Tolsona Lake, but based upon the CPUE estimate in 1998 it would appear that it did not. Statistics concerning the mean CPUE for partially recruited burbot are listed in Table 6. Due to lack of equipment and staffing shortage, water quality and temperature data for Moose and Tolsona lakes were not collected in 1998.

Table 4.-Estimated mean CPUE of fully recruited (≥ 450 mm TL) burbot from systematic sampling of populations studied in Hudson and Moose lakes, 1998, and Tolsona Lake, 1995 – 1998.

Lakes And Dates	Strata	Sets	Transects	Mean CPUE			Bootstrapped	
				Boot-strapped	Arithmetic	%Δ	SE	CV
Hudson	< 8 m	17	4	2.19	2.18	0.5%	0.457	20.9%
7/7-9/98	> 8 m	61	8	0.96	0.95	0.4%	0.191	20.0%
Moose								
5/20-22/98	All depths	60	12	3.49	3.53	-1.2%	0.597	17.1%
Tolsona								
5/19-21/98	All depths	60	9	2.19	2.20	-0.5%	0.392	17.9%
5/27-29/97	All depths	60	11	0.80	0.80	-0.3%	0.144	18.1%
6/5-7/96	All depths	59	11	2.19	2.17	0.7%	0.241	11.0%
5/23-25/95	All depths	56	7	3.44	3.43	0.3%	0.363	10.5%

Table 5.-Estimated mean CPUE of partially recruited (<450 mm TL) burbot from systematic sampling of populations studied in Hudson and Moose lakes, 1998 and Tolsona Lake, 1995 – 1998.

Lakes And Dates	Strata	Sets	Transects	Mean CPUE			Bootstrapped	
				Boot-strapped	Arithmetic	%Δ	SE	CV
Hudson	< 8 m	17	4	0.17	0.18	-1.8%	0.119	68.6%
7/7-9/98	> 8 m	61	8	0.04	0.03	5.5%	0.032	92.9%
Moose								
5/20-22/98	All depths	60	12	0.95	0.93	1.3%	0.201	21.3%
Tolsona								
5/19-21/98	All depths	60	9	2.41	2.42	-0.3%	0.562	23.3%
5/27-29/97	All depths	60	11	1.12	1.12	0.1%	0.361	32.3%
6/5-7/96	All depths	59	11	0.34	0.34	0.4%	0.121	35.4%
5/23-25/95	All depths	56	7	0.10	0.11	-3.0%	0.057	54.4%

Table 6.-Mean lengths (mm TL) of burbot measured during sampling events in Hudson and Moose lakes, 1998 and Tolsona Lake, 1995 – 1998.

Lake/Year	Statistic	Partially Recruited[a]	Fully Recruited	All
Hudson	Mean	381	621	610
1998	SE	25	10	11
	Sample size	5	103	108
Moose	Mean	394	551	518
1998	SE	7	6	6
	Sample size	56	213	269
Tolsona				
1998	Mean	412	523	465
	SE	3	9	6
	Sample size	146	132	278
1997	Mean	382	618	481
	SE	4	14	13
	Sample size	67	48	115
1996	Mean	360	613	576
	SE	11	8	10
	Sample size	22	129	151
1995	Mean	402	612	605
	SE	16	5	6
	Sample size	7	195	202

[a] Burbot partially recruited to the gear are < 450 mm TL and fully recruited burbot are ≥ 450 mm TL.

COMPARISONS AMONG LAKES

Hudson Lake had the largest mean size of fully recruited burbot in all of the lakes sampled in 1998. Ten percent of burbot caught in Hudson Lake, 6% of burbot captured in Tolsona Lake in 1998, and 4% of burbot captured in Moose Lake were > 750 mm TL (Figures 4, 5, and 6). In 1998, only 15% of burbot sampled were greater than >550 mm TL in Tolsona Lake, compared to 1995, 1996, and 1997 when 72%, 64%, and 29% respectively, of all burbot sampled were greater than 550 mm TL. In 1998, 29% of burbot sampled in Moose Lake and 69% in Hudson Lake were greater than 550 mm TL.

Several additional appendices (B1, B2, and C) provide continuity among previous annual reports or summarize information that could be useful to the reader. Appendix B1 contains mark-recapture histories of Tolsona Lake. Appendix B2 is a listing of the data for each specific study lake and the custodian. A graphic presentation of the catch by depth for partially and fully recruited burbot in 1998 (1995 1998 for Tolsona Lake) is presented in Appendix C.

DISCUSSION

Estimates of abundance, survival rate, and recruitment of Tolsona Lake burbot are potentially biased due to lack of different secondary marks in 1995 – 1997. Of the 21 burbot released in previous years and recaptured in 1998, six could not be assigned to the appropriate marking event. These recaptured burbot were removed from the model and could result in inflated estimates of abundance, and reduced estimates of survival and recruitment. The use of a half-dorsal secondary mark should be discontinued, it is cosmetically unappealing to sport anglers and may result in a higher rate of tag loss. Many of the fish with half-dorsal clips observed in 1998 were disfigured from excessive fin removal and this may have resulted in a less secure insertion of the Floy tag. The secondary mark rotation described in the Methods was reinstated in 1998 and should remain as scheduled in future sampling.

Mean length of fully recruited burbot in Hudson Lake in 1998 was similar to that during sampling in 1993 (Taube et al. 1994). In 1993 and 1998, the greatest number of burbot captured were found in the 575 mm length category (Figure 6). Burbot harvests in Hudson Lake since 1993 have remained relatively low, 103 burbot harvested in 1995 was the greatest harvest between 1993 – 1997 (Mills 1994, Howe et al. 1995 – 1998). Winter fishery surveys conducted by ADF&G staff and Fish and Wildlife Protection officers, in addition to anecdotal information from local fishermen indicate that the harvest estimates may be lower than actual harvest. The number of respondents to the Statewide Harvest Survey (SWHS) questionnaire have ranged from one to three, and estimates from this number of respondents should only be used to document that fishing occurred (Mills and Howe 1992). In addition, past regulatory closures on UCUS burbot fisheries due to overharvest and tag returns may have resulted in underreporting or no response by local fishermen to SWHS questionnaires. Since the 1998 estimate of mean CPUE was biased, no direct comparison between the 1993 and 1998 estimates can be made to determine if the current regulations (two burbot per day) are sustainable. It is recommended that sampling of Hudson Lake for CPUE estimates occur in the near future for comparison to the 1993 estimates. Sampling should occur during May, shortly after ice-out, to reduce the potential for sampling mortality due to low dissolved oxygen. A transect to sample for dissolved oxygen levels should be conducted before sampling. Sampling in 1993 resulted in some mortality due to

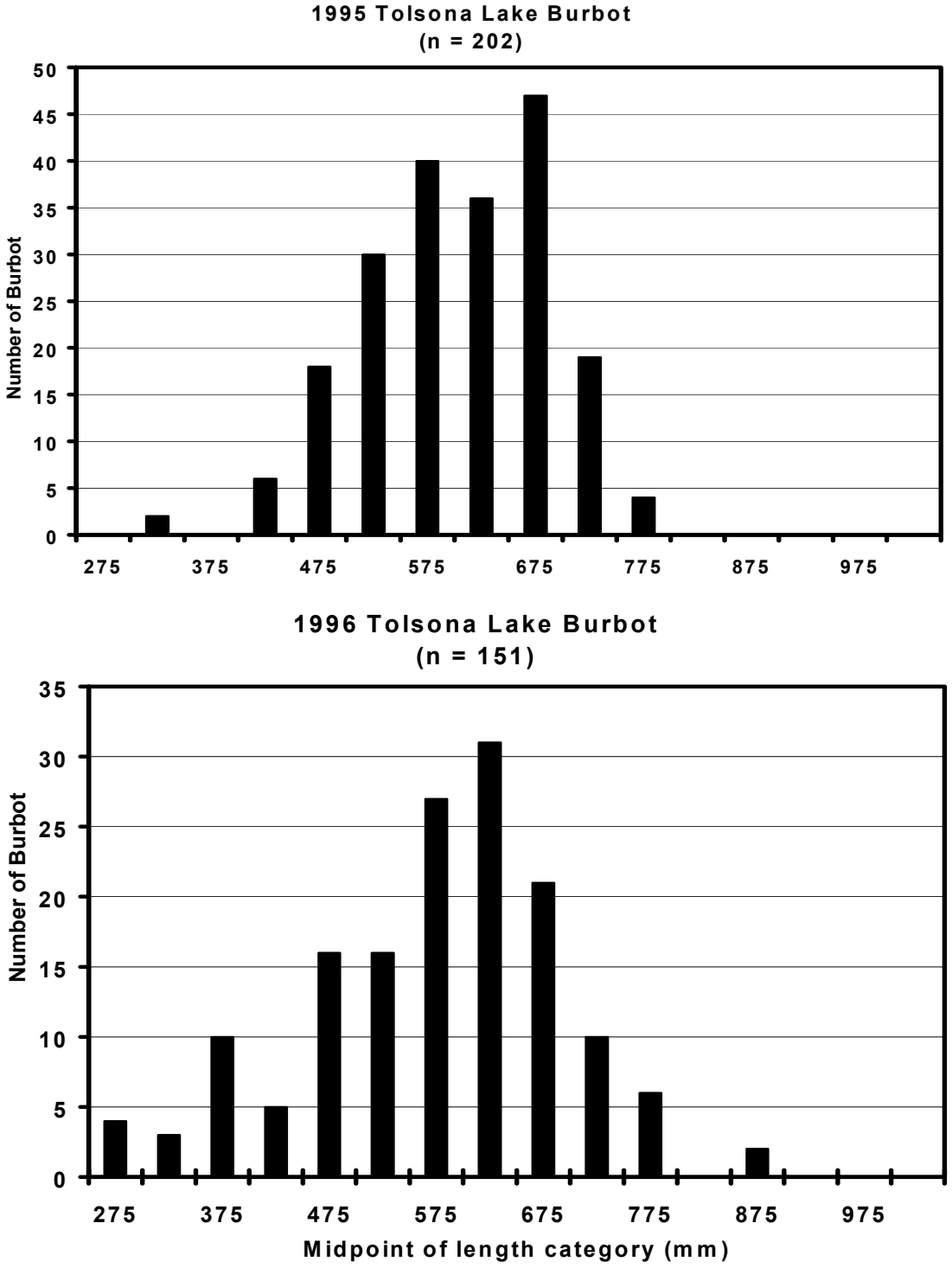

Figure 4.-Length-frequency histograms of burbot captured in Tolsona Lake in 1995 and 1996.

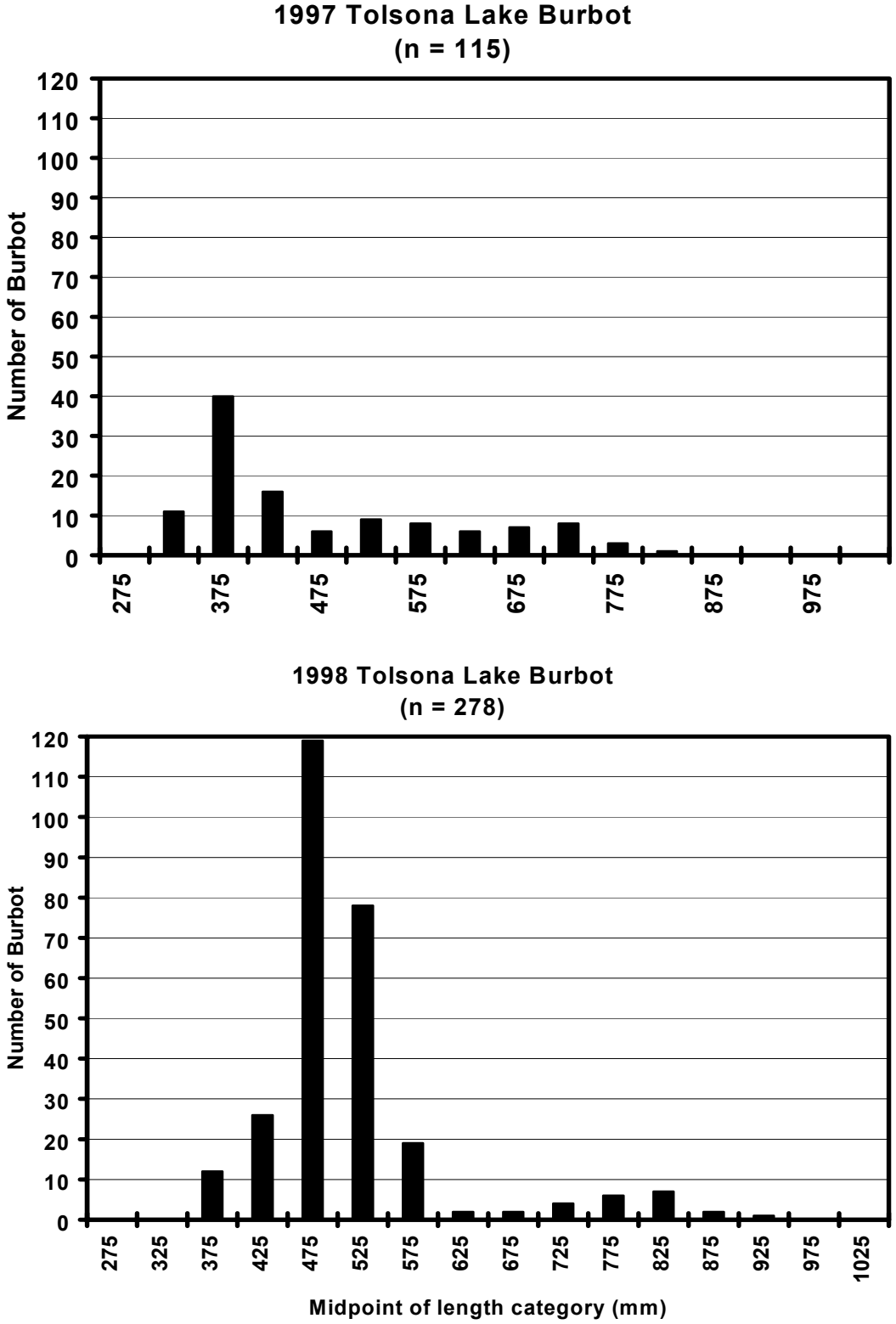

Figure 5.-Length-frequency histograms of burbot captured in Tolsona Lake in 1997 and 1998.

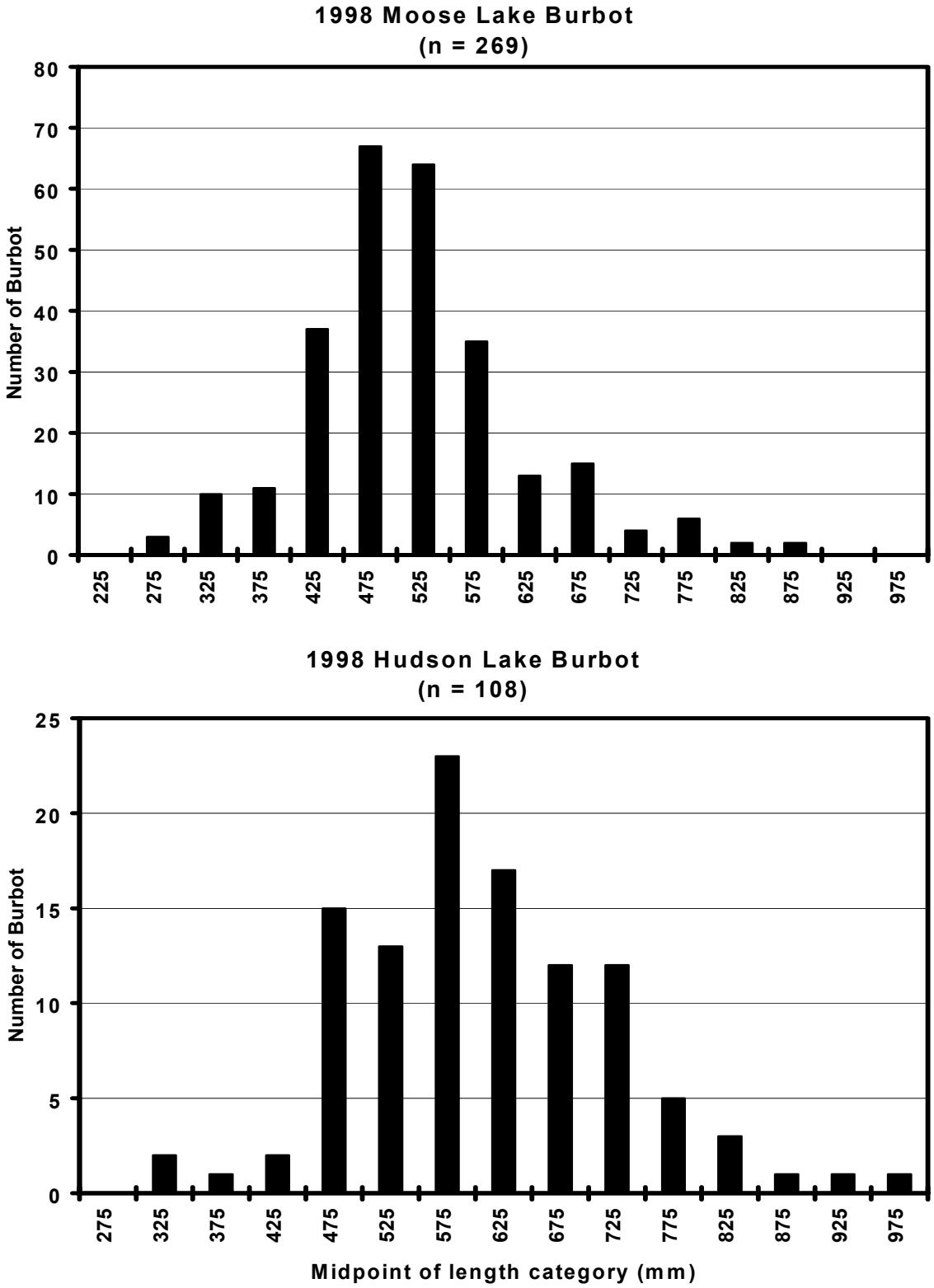

Figure 6.-Length-frequency histograms of burbot captured in Moose and Hudson lakes in 1998.

decompression when burbot sets were deeper than 9.5 m, if this should occur in future sampling, sampling should be adjusted to set in depths less than 9.5 m.

Based on estimates of mean CPUE in 1998, it appears that Moose Lake did not experience the population decline that Tolsona Lake did from 1996 to 1997. Moose Lake is identical in size to Tolsona Lake (130 ha), but the maximum depth is 6 m, whereas Tolsona Lake has a maximum depth of 4 m. The greater depth of Moose Lake may provide a temperature refuge (area of cooler water temperatures), whereas Tolsona Lake does not provide this refuge resulting in summer kill of adult burbot due to stress. In Tolsona Lake data, estimates of survival indicate summer mortality of fully recruited burbot in 1990 and 1991 (summer survival estimates of 36.0% and 33.4%) and possible summer mortality in 1992, 1994, and 1995 (annual survival estimates of 24.6%, 33.3%, and 40.2%) (Table 2). In addition, estimates of recruitment indicate recruitment failures in 1994, 1995, and 1996 (0, 180, 213). The high number of burbot captured in 1997 at the 375 length category and the 475 length category in 1998 supports these estimates. These burbot represent the 1993 age class, the year when summer mortality did not occur, entering the population. Water temperature data are not available for the years indicating summer mortality, but installation of temperature data loggers and water quality monitoring are planned for Tolsona Lake in 1999 to collect thermal data. If similar conditions occur in Tolsona Lake in the future, Moose Lake should again be sampled to see if the population was similarly affected.

ACKNOWLEDGMENTS

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APPENDIX A

Appendix A.-Description of lakes with burbot populations sampled in 1998.

HUDSON LAKE (61°53' N, 145°40' W) is a remote lake 19km southwest of Copper Center. Hudson Lake is 259 hectare with a maximum depth of 16 m and an elevation of 655 m. Although there are no cabins or public recreational facilities at the lake, there was a large winter ice fishery for burbot. Hudson Lake contains Arctic grayling *Thymallus arcticus*, longnose suckers *Catostomus catostomus*, rainbow trout *Oncorhynchus mykiss* and round whitefish *Prosopium cylindraceum*.

MOOSE LAKE (62°07' N, 146°05' W) is accessible from Tolsona Lake by a 1 km trail from the north end of Tolsona Lake. Moose Lake is 130 hectare with a maximum depth of 6 m and an elevation of 625 m. There are four cabins located along the lakeshore and no public recreational facilities. Moose Lake receives fishing pressure largely during the winter months for burbot. Moose Lake contains burbot, Arctic grayling, longnose suckers, and rainbow trout.

TOLSONA LAKE (62°06' N, 146°04' W) is accessible from the Glenn Highway. Tolsona Lake is 130 hectare with a maximum depth of 4 m and an elevation of 625 m. Tolsona Lake has numerous cabins and one lodge. No public recreational facilities are available. This lake has had a popular burbot fishery in the winter in recent years. Tolsona Lake has Arctic grayling, longnose suckers, and stocked rainbow trout.

APPENDIX B

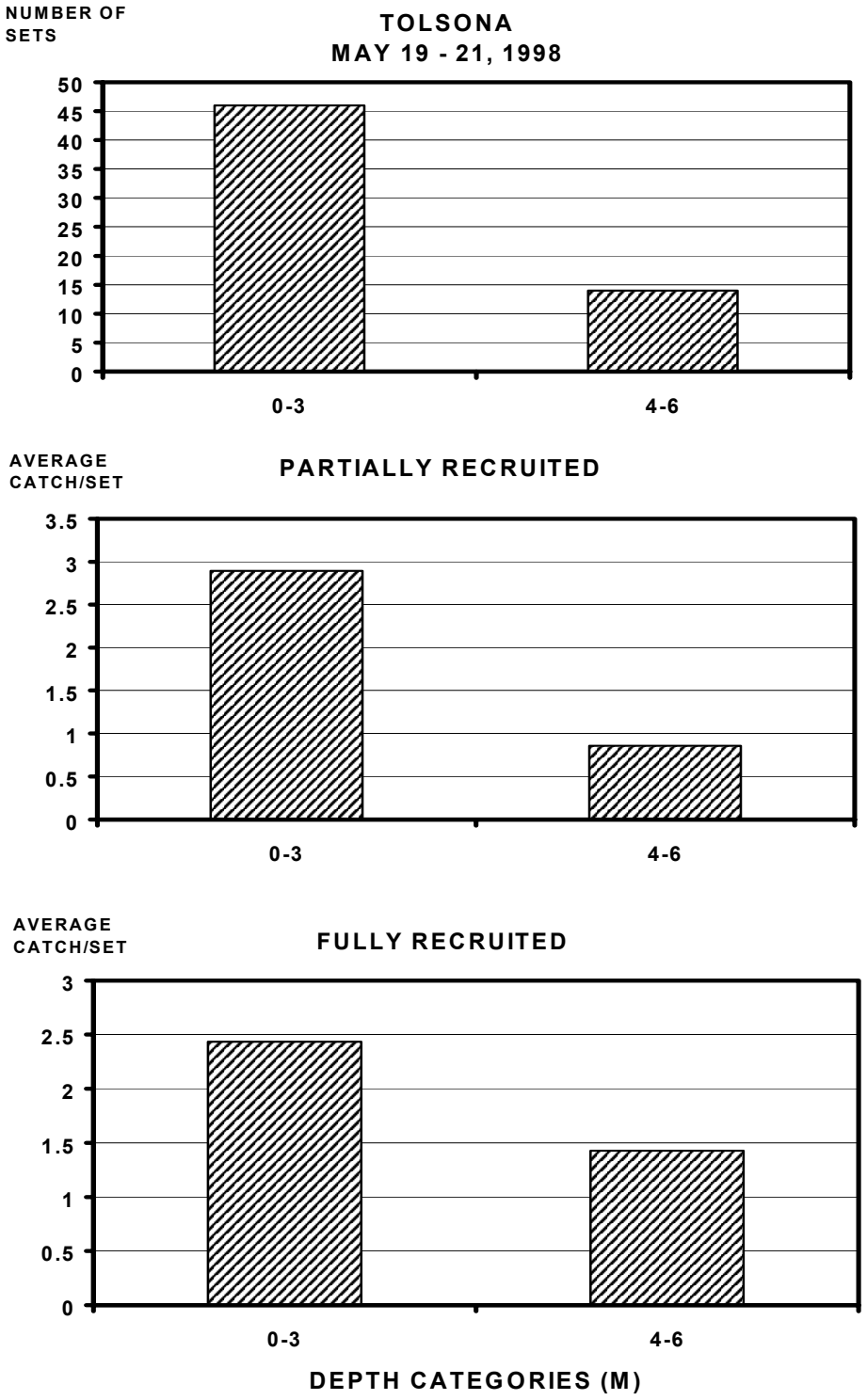
Appendix B.-Mark-recapture histories of fully recruited[a] burbot by year for the populations in Tolsona Lake.

Tolsona Lake																	
Date : Year	1986	1987	1988	1988	1989	1989	1990	1990	1991	1991	1992	1993	1994	1995	1996	1997	1998
Beginning	9/23	6/02	5/25	8/30	5/22	9/11	5/22	9/05	5/20	9/09	6/11	5/20	6/01	5/23	6/05	5/27	5/19
Ending	10/10	6/04	5/27	9/01	5/24	9/13	5/24	9/07	5/23	9/12	6/13	5/22	6/03	5/25	6/07	5/29	5/21
Number of Fully Recruited Burbot:																	
Recaptured from Event 1	0	123	35	14	5	3	5	9	0	0	0	0	0	0	0	0	0
Recaptured from Event 2		0	79	32	33	18	11	5	1	1	0	0	0	0	0	0	0
Recaptured from Event 3			0	51	36	11	8	6	0	0	0	0	0	0	0	0	0
Recaptured from Event 4				0	47	12	10	5	3	0	0	0	0	0	0	0	0
Recaptured from Event 5					0	62	16	11	10	2	0	0	0	1	0	0	0
Recaptured from Event 6						0	22	11	3	1	0	0	0	0	0	0	0
Recaptured from Event 7							0	21	12	2	2	0	0	1	0	0	0
Recaptured from Event 8								0	33	5	7	0	1	0	0	0	0
Recaptured from Event 9									0	35	12	6	1	0	1	0	0
Recaptured from Event 10										0	27	3	3	1	0	0	0
Recaptured from Event 11											0	6	6	5	0	1	1
Recaptured from Event 12												0	37	16	7	2	0
Recaptured from Event 13													0	27	3	2	0
Recaptured from Event 14														0	29	3	2
Recaptured from Event 15															0	11	6
Recaptured from Event 16																0	6
Recaptured from Event 17																	0
Captured with tags	0	123	114	97	121	106	72	68	62	46	48	15	48	51	40	19	15
Captured without tags	531	379	236	118	237	143	143	112	301	91	148	214	162	151	111	96	264
Captured	531	502	350	215	358	249	215	180	363	137	196	229	210	202	151	115	279
Released with tags	531	497	350	215	358	249	215	180	362	136	196	225	209	198	129	104	279

[a] Burbot ≤ 450 mm are considered fully recruited.

APPENDIX C

Appendix C.-Frequency of sets by depth and average catch of burbot by depth in Moose Lake in 1998 and Tolsona Lake, 1995-1998.



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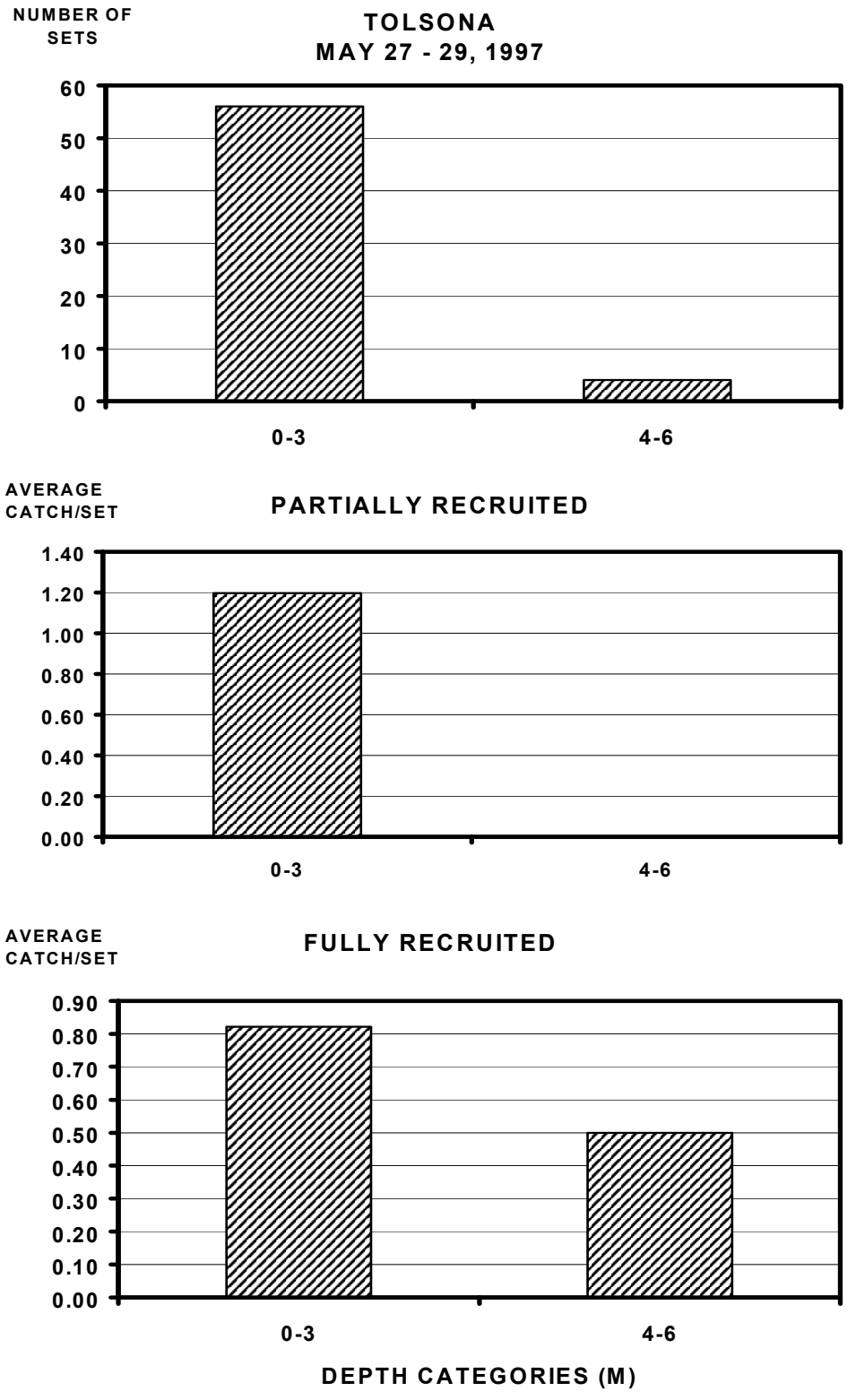
NUMBER OF SETS
TOLSONA
MAY 27 - 29, 1997
60
50
40
30
20
10
0
0-3
4-6
AVERAGE CATCH/SET
PARTIALLY RECRUITED
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0-3
4-6
AVERAGE CATCH/SET
FULLY RECRUITED
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0-3
4-6
DEPTH CATEGORIES (M)

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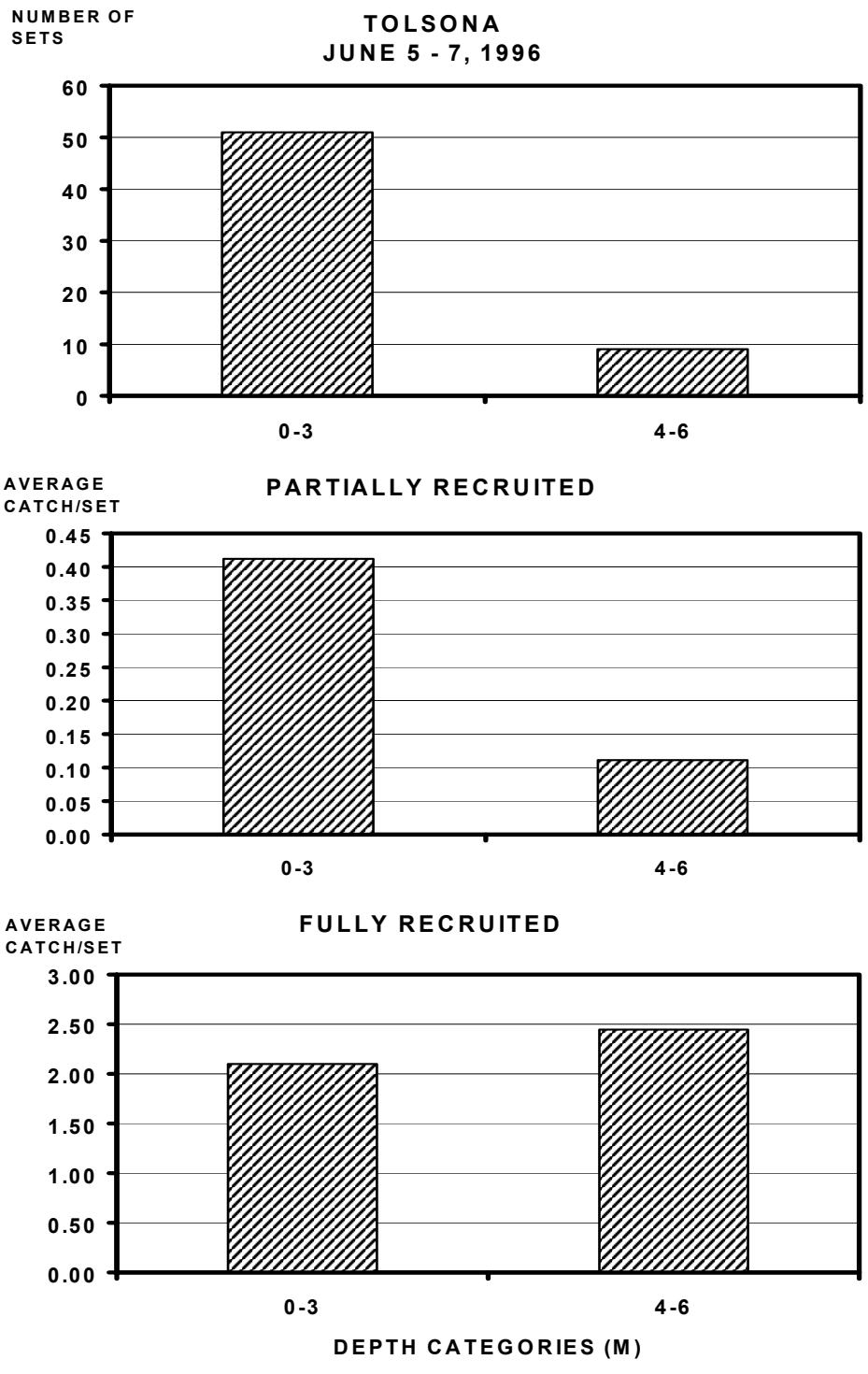
NUMBER OF SETS
TOLSONA
JUNE 5 - 7, 1996
60
50
40
30
20
10
0
0-3
4-6
AVERAGE CATCH/SET
PARTIALLY RECRUITED
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0-3
4-6
AVERAGE CATCH/SET
FULLY RECRUITED
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0-3
4-6
DEPTH CATEGORIES (M)

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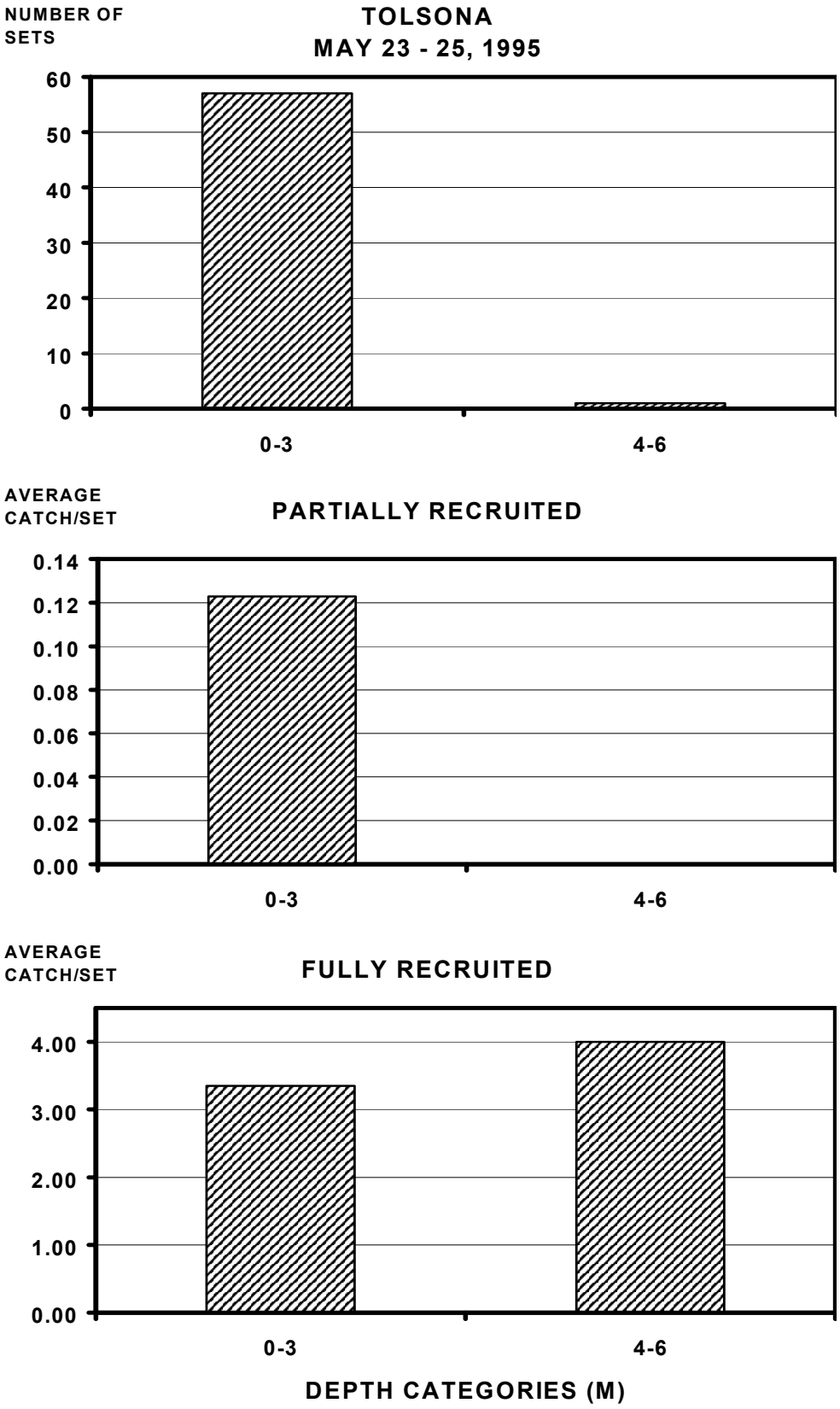
NUMBER OF SETS
TOLSONA
MAY 23 - 25, 1995
60
50
40
30
20
10
0
0-3
4-6
AVERAGE CATCH/SET
PARTIALLY RECRUITED
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0-3
4-6
AVERAGE CATCH/SET
FULLY RECRUITED
4.00
3.00
2.00
1.00
0.00
0-3
4-6
DEPTH CATEGORIES (M)

-continued-

Appendix C.-Page 5 of 5.