Fishery Data Series No. 95-44

Lower Kenai Peninsula Dolly Varden Studies During 1994

by

Larry L. Larson

December 1995

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. 95-44

LOWER KENAI PENINSULA DOLLY VARDEN STUDIES DURING 1994

by

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ABSTRACT

During the period 3 July to 15 August 1994, abundance, composition, and selected fishery statistics were estimated for Dolly Varden *Salvelinus malma* (Walbaum) on the Anchor River. A total of 17,259 Dolly Varden were counted through a weir located 1.5 km upstream from salt water on the Anchor River. This Dolly Varden immigration is the third highest total adult return documented since this study was begun in 1987. The number of deaths due to angling appears much lower than from "natural" causes. Although anglers appear to be practicing more hook and release fishing when pursuing Dolly Varden, they continue to select fish of spawning size for harvest.

Key words: Anchor River, Kenai Peninsula, anadromous, Dolly Varden, weir, age composition, sex composition, maturity index, *Salvelinus malma*, population dynamics, mortality, survival.

INTRODUCTION

This is the eighth year of a long-term study of lower Kenai Peninsula Dolly Varden *Salvelinus malma* (Walbaum) populations. This study provides information necessary to manage the Dolly Varden spawning stocks. The acquisition of basic Anchor River and non-Anchor River population data such as a total census, length and age composition, relative maturity, and exploitation and contribution rates to the fishery provides the means to estimate key population parameters necessary for estimating maximum sustained yield (MSY). Since this fishery is complicated by concurrent fisheries for other species, it is also necessary to acquire specific fisheries information on all species so that additional regulatory measures (if necessary) can be effectively implemented.

The Anchor River on the lower Kenai Peninsula (Figure 1) supports recreational fishing for chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch,* pink salmon *O. gorbuscha*, Dolly Varden, and anadromous (steelhead) and resident rainbow trout *O. mykiss*. The downstream section of this stream is crossed by the Sterling Highway making it easily accessible to the fishing public. Much of the river frontage along the lower 3 km of this stream is publicly owned, providing ample camping and parking areas. Due to the relatively small size of this stream, all fishing is conducted from the bank. The Anchor River has provided an average of 30,440 recreational fishing days (angler-days) annually from 1977 through 1994 (Mills 1979-1994, Howe et al. 1995). The fisheries targeting chinook salmon, coho salmon, steelhead, and Dolly Varden are of major importance to recreational anglers on the Anchor River, whereas the fisheries targeting resident rainbow trout and pink salmon are of lesser importance.

The recreational fishery for Dolly Varden in the Anchor River is one of the largest in Alaska and is of particular concern to resource managers. The recreational harvest has decreased in recent years, in part through more restrictive regulations and as the result of a declining Dolly Varden population. During the period 1977 to 1983, the harvest from this fishery averaged nearly 15,000 fish annually (Mills 1979-1984). In 1984, regulations for this fishery became more restrictive, bag and possession limits were reduced from ten to five fish, and the use of bait was prohibited after 16 September. While these regulations were in effect, the harvest of Dolly Varden averaged approximately 3,700 fish (Table 1). Although a marked decline in the harvest of Dolly Varden was observed after initiation of the new regulations, concerns were expressed that the decline may reflect a depressed population (Larson 1990). During 1990, the use of bait was prohibited from 15 August through 31 December (ADF&G 1990). In 1991, regulations further restricted the daily bag limit from five to two fish and the use of bait

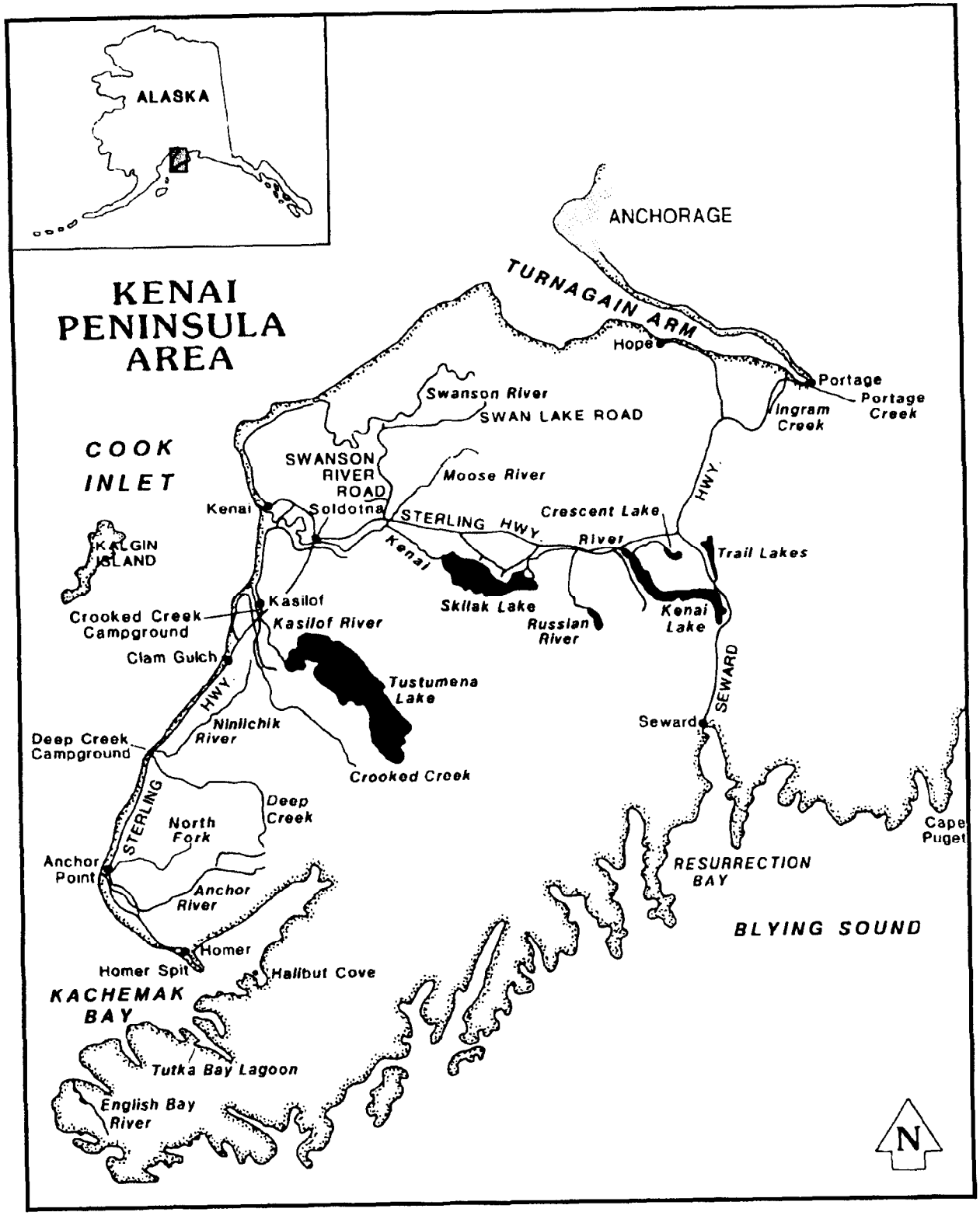

Figure 1.-Map of Kenai Peninsula.

Table 1.-Historical catch and harvest data from the Anchor River Dolly Varden sport fishery, 1977-1994.

	Creel Survey[a]		Statewide Harvest Survey[b]	
Year	Catch	Harvest	Catch	Harvest
1977				9,222
1978				17,357
1979				21,364
1980				10,948
1981				15,271
1982				10,375
1983				17,277
1984				5,560
1985				7,720
1986				3,910
1987	9,414	2,653		2,735
1988	11,992	2,915		2,746
1989	5,605	1,615		1,476
1990	5,391	2,124[c]	11,441	2,821
1991	5,995	1,520[d]	14,433	1,409
1992			18,303	2,532
1993			9,719	1,031
1994			13,305	1,574

[a] Larson et al. 1988; Larson and Balland 1989; Larson 1990-1992.

[b] Mills 1979-1994, Howe et al. 1995.

[c] Fishing for Dolly Varden was closed by emergency order after 7 August 1990.

[d] The daily Dolly Varden bag limit was reduced from five to two beginning in 1991.

was prohibited from 1 September through 31 December (ADF&G 1991). The reduction in bag limit from five to two Dolly Varden was implemented on the Anchor River, Deep Creek, Stariski Creek, and the Ninilchik River to protect the Dolly Varden spawning stocks of the lower Kenai Peninsula. These same regulations remained in effect during 1994.

The Anchor River Dolly Varden population seems to follow a life history model similar to those described for Kodiak and Southeast Alaskan Dolly Varden (Sonnichsen 1990; Armstrong 1965, 1984). In this hypothetical model, the Anchor River is a spawning stream inhabited by juveniles (presmolt) and adults. The adults that spawn in the Anchor River remain there over winter and those that survive return to salt water the following spring (Larson 1990). Subadults forage in Cook Inlet and migrate to an overwintering area possibly other than the Anchor River for 1 or 2 years after smolting. Major coastal overwintering areas that have been described for Dolly Varden are lakes (Armstrong 1965 and 1984); thus, likely areas for the Anchor

River population might be English Bay Lakes or Packers Lake, among others. Upon maturing, these fish return to the Anchor River as spawners. Results from 1989 (Larson 1990) indicate that (1) the immigration of mature females peaks early in the season and (2) the size range at which 100% of Dolly Varden are mature is narrow, but changes over time. Postspawners have been documented entering the Anchor River during September (Larson 1993) and may overwinter in the Anchor River as well. Although the postspawner origins are unknown, nearby Stariski Creek is one likely stream for this behavior.

This study provides information to test this model by censusing immigrating and emigrating Dolly Varden through the Anchor River weir.

The specific research objectives for 1994 were to:

1. census the immigration of Dolly Varden through a weir on the Anchor River during the period 1 July to 15 August;
2. estimate the length frequency of immigrating Dolly Varden at the weir by weekly intervals during the period 1 July to 15 August;
3. estimate the sex ratio, relative maturity, percent spawners, and age composition of immigrant Dolly Varden at the weir by biweekly periods during 1 July through 15 August; and
4. estimate the sex ratio, relative maturity, percent spawners, and age composition of Dolly Varden harvested downstream of the weir in the Anchor River sport fishery by biweekly periods during 1 July through 15 August.

This report includes historical data pertaining to Dolly Varden of the Anchor River that have been compiled and analyzed from the following sources: Allin (1954, 1957), Balland (1985, 1986), Nelson et al. (1987), Larson et al. (1988), Larson and Balland (1989), Larson (1990-1994), Wallis and Balland (1981-1984) and Wallis and Hammarstrom (1979-1982). Harvest and effort estimates have been reported by Mills (1979-1994) and Howe et al. (1995).

METHODS

STUDY DESIGN

A floating weir was installed in the Anchor River at the upstream limit of tidal influence to assess the immigration and emigration of all Dolly Varden over 200 mm in fork length between 3 July and 15 August. A random sample of immigrant Dolly Varden was collected at the weir and assessed for length during weekly periods and sex, age, and maturity during biweekly periods. Gonad development as described by Blackett (1968) was used to determine the relative maturity of female Dolly Varden collected at the weir, whereas subjective observations of gonad size and coloration were used to determine male relative maturity. There is currently no standard for determining the sexual maturity of male Dolly Varden and these subjective observations are a first attempt to develop a relative maturity standard for males. A random sample of harvested Dolly Varden was examined from the sport fishery and sampled for length, age, sex, and relative maturity during biweekly periods from 1 July through 15 August.

ANCHOR RIVER WEIR

A weir was installed approximately 1.5 km upstream from the saltwater terminus of the Anchor River (Figure 2). The weir structure was constructed nearly entirely of floating weir panels, with rigid panels connecting the floating panels to the embankments. The rigid panel pickets were 1.25 cm diameter solid aluminum rods placed in an aluminum

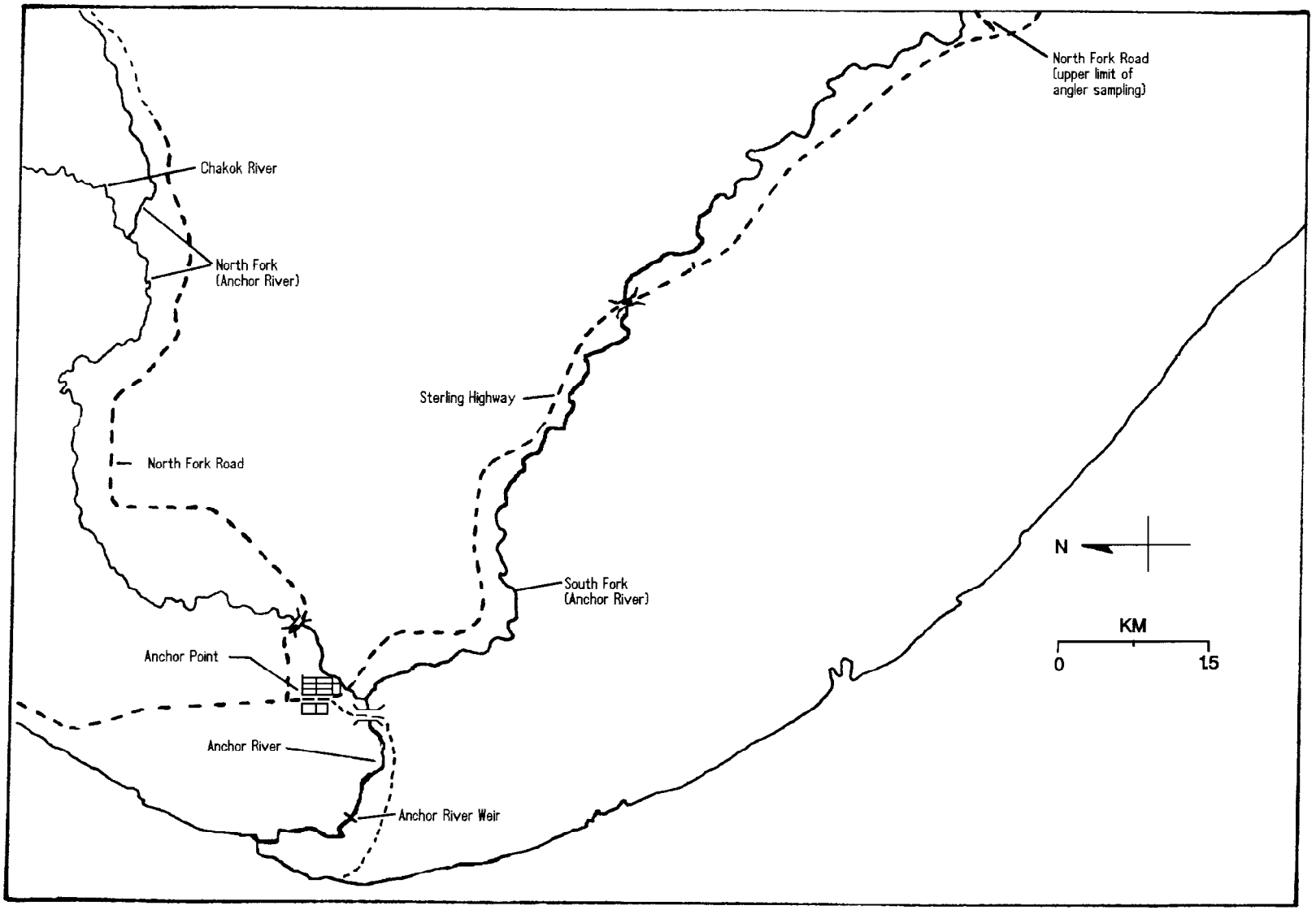

Figure 2.-Map of the Anchor River.

channel framework having a 1.25 cm gap between pickets. Channel frames were 3.6 m long by 1.05 m high. The aluminum frames rested against 1.05 m high vertical weir panels at the outer extremities of the floating weir panels and sandbag abutments along the shoreline. The floating panel pickets were 2.5 cm diameter hollow PVC tubing, capped at each end to provide buoyancy, having a 1.5 cm gap between pickets. Each panel, 4.5 m long, was anchored at one end to a cable and railroad track hinge system laid perpendicular to the stream flow and along the stream bottom. A resistance board fastened to the downstream end of each panel provided the necessary lift to the panels as river water depth varied. Traps were installed to capture both upstream and downstream migrating fish. The weir prevented passage of fish approximately 200 mm and larger.

Stream depth and temperature measurements were obtained on a daily basis at the weir site. Depth and temperature readings were recorded daily at 2200 hours from 3 July through 15 August and additional temperature readings were recorded continually with a thermograph from 3 July through 15 August.

All fish passing through the upstream and downstream traps were counted by species and examined for evidence of angler hook wounds. Fish sampled from the upstream trap were chosen by randomly selecting a trap load and sampling all fish from that trap load, whereas as many fish as possible were sampled in the downstream trap. Dolly Varden that were difficult to handle were anesthetized in a CO_2 water bath prior to being measured, otherwise a tagging cradle was used (Hammarstrom and Larson 1985).

To achieve the desired precision for estimates, approximately 5% of the immigrating Dolly Varden were sampled for length (nearest millimeter fork length). Approximately 2.5% of the Dolly Varden immigration were sampled for age, sex, relative maturity and weight. These fish were sacrificed, weighed, and measured to the nearest millimeter fork length, and otoliths were removed for age determination (Williams and Bedford 1973). Each female Dolly Varden sampled for relative maturity was given a maturity index code of 1 to 5 according to the following criteria (Blackett 1968): (1) immature female with egg diameter less than 0.90 mm; (2) mature female with egg diameter greater than 1.75 mm; (3) completely mature female, eggs easily stripped; (4) completely spawned female; and (5) immature female but showing development, egg diameter greater than 0.90 mm and less than 1.75 mm. Dolly Varden given maturity index codes of 2, 3, or 4 were categorized as spawners, those with index code 1 were categorized as nonspawners, and those with index code 5 were potential spawners. Males were classified as either spawners or nonspawners. Male spawners displayed gonads that were enlarged and of a milky-white appearance while nonspawners lacked any noticeable development. Male gonads were extracted and weighed to the nearest tenth of a gram; gonad weight was compared to total body weight.

Mortalities deposited on the upstream side of the weir face and in the downstream trap were sampled for age (by removal and examination of otoliths), sex, relative maturity, and length (nearest millimeter fork length). Mortalities were also examined for injuries. The purpose of sampling mortalities was to assess the different types of injuries which may be affecting Dolly Varden of various age, length and sexual maturity, in particular hook wounds. These observations are subjective in nature and do not necessarily constitute the cause of death but could have management implications depending on frequency.

SPORT FISHERY

Estimates of recreational harvest of Anchor River Dolly Varden and effort were provided through the postseason statewide harvest survey (Howe et al. 1995); inseason creel survey interviews of the Anchor River recreational fishery have not been conducted since 1991. Prior to 1992, these two independent estimates of harvest did not vary substantially (Table 1) and an inseason estimate was not considered necessary to manage the sport fishery. Estimates of catch from the creel survey were always substantially lower than those from the statewide harvest survey.

To obtain a maturity index of the harvest, biological samples were collected from the sport fishery from 1 July through 15 August by a part-time creel clerk and weir personnel. The creel clerk worked a random schedule and weir personnel assisted on a time available basis.

During 1994, biological sampling of Dolly Varden was attempted throughout the lower 10 miles of the Anchor River in response to the shift in angler harvest upstream of the weir observed during 1993. Fork length to the nearest millimeter was recorded, otoliths were removed for age determination, and sex and relative maturity were recorded for ungutted fish. Dolly Varden were also examined for injuries.

STOCK STRUCTURE AND DYNAMIC RATES

The proportions of fish in each age and sexual maturity component from 1989-1994, and their respective variances, were estimated as simple proportions (Cochran 1977, pp. 50-52). Sexual maturity of females was categorized three ways by maturity index codes 1-5: by spawners (codes 2-4 combined), nonspawners (code 1), and potential spawners (code 5); sexual maturity of males was categorized as either spawners or nonspawners. The inclusion of 1987 and 1988 data was based on 1989 maturity index and length frequency data (Larson 1990). Based on 1989 length frequency and maturity data, all Dolly Varden less than 300 mm fork length were considered nonspawners; fish 300-349 mm, potential spawners; and fish greater than 349 mm, spawners. Males and females were assumed to have the same proportions in the different maturity categories from 1987 through 1993.

The number of Dolly Varden (sexes combined) by sexual maturity or age component was estimated for biweekly time periods by:

$$\hat{N}_{il} = \hat{P}_{il} N_i , \quad (1)$$

where:

$\hat{N}_{il}$ = estimated number of fish in length range or age class l during period i;

$\hat{P}_{il}$ = proportion of fish in length range or age l during period i; and

N_i = weir count during period i.

The variance was estimated as:

$$V(\hat{N}_{il}) = N_i^2 V(\hat{P}_{il}) , \quad (2)$$

where:

$$V(\hat{P}_{il}) = \frac{\hat{P}_{il}(1-\hat{P}_{il})}{n_i - 1} . \quad (3)$$

The length frequency of immigrating Dolly Varden changes over time (Larson et al. 1988), therefore the estimated population of each sexual maturity component was stratified temporally in three, 2-week periods from July through mid-August. The time frame, July through mid-August, encompasses most of the Dolly Varden immigration and was common to all 8 years of weir operation. One-way analysis of variance (Snedecor and Cochran 1967) was used to test the null hypothesis that there was no change in mean length of fish by

age class across three biweekly periods at the weir.

Annual survival to the weir and instantaneous mortality rates were computed from estimates of abundance by age of the immigration through the weir in 1991 (Larson 1992), 1992 (Larson 1993), 1993 (Larson 1994) and 1994. These data were used to compute estimates of annual survival ($\hat{S}$) by age (Ricker 1975):

$$\hat{S}_{[l,l+1]} = \frac{\hat{N}_{[t+1,l+1]}}{\hat{N}_{[t,l]}}, \quad (4)$$

where:

$\hat{N}$ = immigration through the weir,

t = year, and

l = age.

Annual mortality ($\hat{A}$) was computed for each age class by subtraction:

$$\hat{A}_{[l,l+1]} = 1 - \hat{S}_{[l,l+1]}. \quad (5)$$

Annual fishing mortality or exploitation ($\hat{E}$) was defined as mortality due to fishing which occurs in the Anchor River. Nearly all of the harvest from 1988 through 1992, and 1994, occurred downstream of the weir. However, during 1993 the harvest occurred primarily upstream of the weir. Exploitation was computed from estimates of harvest ($\hat{H}$) and immigration ($\hat{N}$) by age:

$$\hat{E}_{[t,l]} = \frac{\hat{H}_{[t,l]}}{(\hat{H}_{[t,l]} + \hat{N}_{[t,l]})}. \quad (6)$$

The instantaneous rate of total mortality ($\hat{Z}$) was computed by age as (Ricker 1975):

$$\hat{Z}_{[t,l]} = -\ln(\hat{S}_{l,l+1}). \quad (7)$$

Instantaneous annual fishing mortality was computed from the Baranof catch equations:

$$\hat{H} = \hat{N}\left(\frac{\hat{F}}{\hat{Z}}\right)(1 - e^{-\hat{Z}}), \quad (8)$$

where:

$$\hat{F} = \left(\frac{\hat{H}}{1 - e^{-\hat{Z}}}\right)\left(\frac{\hat{Z}}{\hat{N}}\right).$$

Instantaneous natural mortality was computed by subtraction:

$$\hat{M} = \hat{Z} - \hat{F}. \quad (9)$$

RESULTS

ANCHOR RIVER WEIR

The Anchor River weir was in continuous operation from 3 July through 15 August 1994. The weir was removed from the river on 16 August. River water levels moderated slightly (Appendix A1) throughout the duration of the weir operation. One stream bed cavity approximately 6 inches in diameter was discovered during a daily inspection of the weir. The cavity was located underneath the winch stand of the floating weir on 16 July, which prevented the weir from being "fish tight" during its entire operation. However, the "S" shaped configuration of the cavity was such that egress through the opening would have been difficult and I believe few, if any, fish were likely to have passed through the weir in either an upstream or downstream direction during its existence.

Water depth and temperature recorded at the upstream trap location varied from 21.0 cm to 34.3 cm and 7.8°C to 18.0°C, respectively (Appendix A1). Daily water temperature readings varied from 0.7°C to 7.3°C within a 24-hour period. In comparison, the water depth was more variable and water temperature lower than during the previous year (Larson 1994) but fairly typical of most years. (Nelson et al. 1987; Larson et al. 1988; Larson and Balland 1989; Larson 1990-1993).

A total of 17,259 Dolly Varden 200 mm or greater in length were counted passing upstream of the Anchor River weir from 3 July through 15 August (Appendix A2). The

peak of the immigration occurred on 19 July (Figure 3), with 50% of the run having passed the weir by 20 July (Figure 4).

Samples collected from fish harvested in the sport fishery were insufficient to satisfy the biweekly sampling goal of 130 fish (Appendix A3). A total of 122 samples were collected from the sport fishery throughout the 6-week sampling period; these 122 samples were pooled for specific data analysis.

Dolly Varden immigrating through the weir and sampled in the sport fishery ranged in age from 2 to 8 years (Tables 2, 3 and Appendix A5). The age composition between weir and sport fishery samples was significantly different ($\chi^2 = 8.00$, df = 3, P = 0.046) (Table 2 and Figure 5). This is similar to the 1990-1992 findings but contrary to findings in 1989 and 1993.

The age distribution of immigrating Dolly Varden sampled at the weir changed significantly ($\chi^2 = 90.83$, df = 6, $P < 0.001$) (Table 3) over biweekly periods. The proportion of younger fish increased from 3 July through 15 August (Appendix A5). Samples collected from fish harvested in the sport fishery were insufficient to determine age composition by biweekly periods.

Immigrating male Dolly Varden were predominantly age 4 and female Dolly Varden were predominantly age 5 (Figure 5). Few fish were older than age 6 and the combined year-classes from 7 through 9 accounted for less than 10% of the run. These results are consistent with those observed from 1990-1993 (Larson 1991-1994) and suggest a low frequency of repeat spawning due to high natural or fishing mortality.

Of the 410 fish sampled at the weir, 65% were females; of the 117 fish sampled in the sport harvest, 50% were females (Table 2). These ratios did not change significantly ($\chi^2 = 0.422$, df = 2, P = 0.802) over time when compared in biweekly periods. These results are contradictory to 1990 (Larson 1991) but similar to 1991-1993 (Larson 1992-1994) findings.

The mean length by age class changed significantly across the three biweekly periods at the weir for age-4 ($F = 36.8$, df = 2, 83, $P < 0.001$) and age-5 ($F = 7.1$, df = 2, 18, P = 0.001) fish. Age-4 fish decreased in size over biweekly periods, with a significant difference in mean length occurring between all three periods. Age-5 fish decreased in size over biweekly periods, with a significant difference in mean length between the first and third and second and third periods, but not between the first and second periods. These results differ from 1993 when significant differences in mean length were found within age-4, age-6, and age-7 fish (Larson 1994).

The overall change in mean length generally decreased over a 6-week period from 3 July through 15 August (Figure 6) with a noticeable increase from the previous week occurring in the second and sixth week. These specific results are variable with previous years but the general trend of decreasing mean length over this 6-week period is consistent with those observed from 1989 through 1993 (Larson 1990-1994).

Dolly Varden harvested in the sport fishery had a tendency to be slightly larger than those sampled at the weir (Tables 4 and 5), thus indicating a tendency by anglers to harvest larger fish (Figure 7). The difference in mean length between the sport fishery and fish sampled at the weir was significant for age-3 nonspawners ($F = 6.32$, df = 1, 101, P = 0.014) and for age-5 spawners ($F = 4.83$, df = 1, 76, P = 0.031).

Maturity estimates of the Dolly Varden immigration through the weir from 3 July through 15 August (Table 6, Figure 8, Appendix A4) indicate that about 39% were

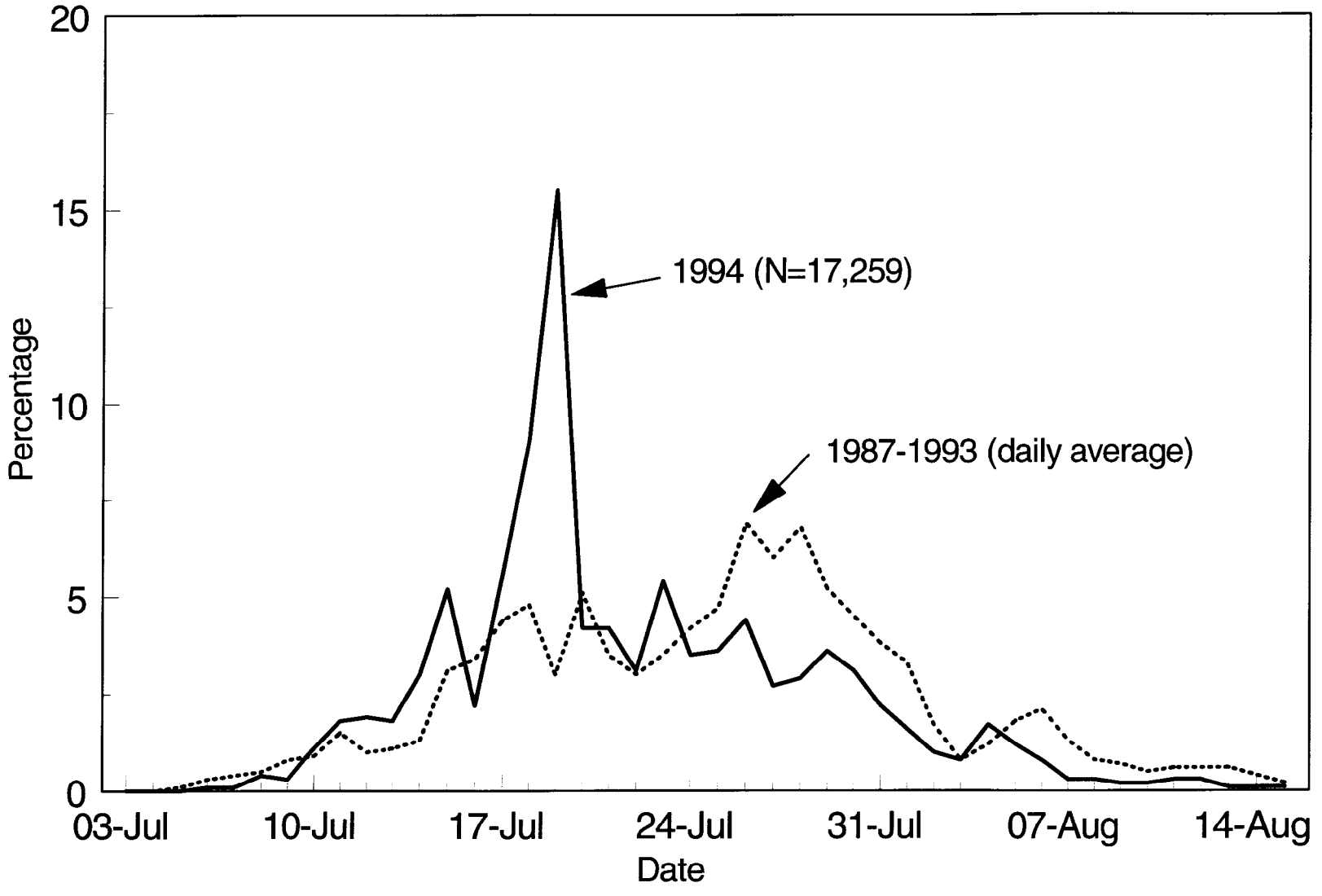

Figure 3.-Daily run timing of Dolly Varden entering the Anchor River, 3 July-15 August. Fish were counted while passing upstream through the Anchor River weir, 1987-1994.

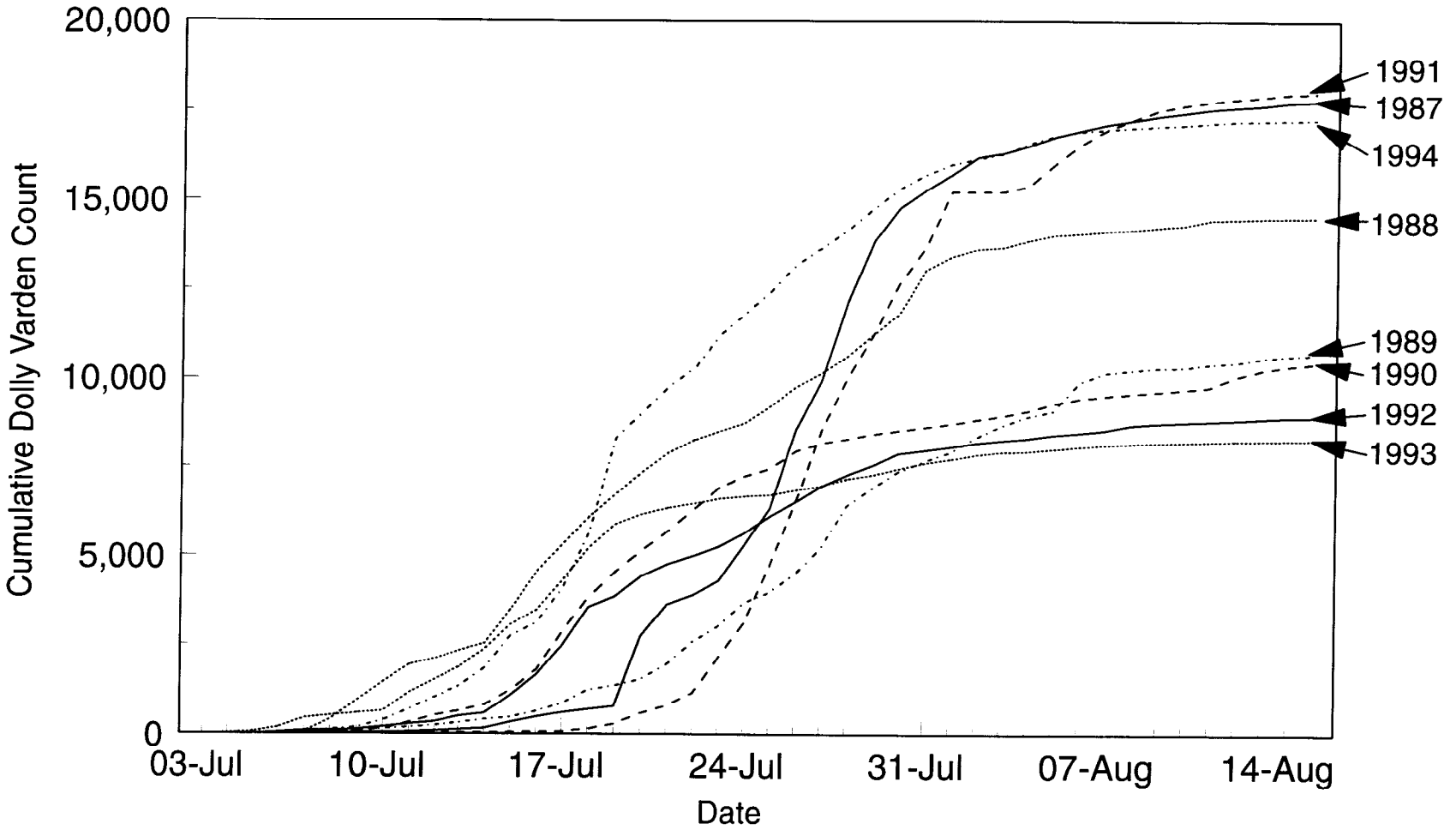

Figure 4.-Cumulative run timing of Dolly Varden entering the Anchor River weir, 3 July-15 August. Fish were counted while passing upstream through the Anchor River weir, 1987-1994.

Table 2.-Age and sex compositions of Dolly Varden collected at the weir site and in the sport harvest on the Anchor River during 1994.

	Age Group[a]							
Component	2	3	4	5	6	7	8	Total
Weir Samples (Upstream Trap)								
Male								
Percent	0.7	28.5	36.8	22.9	9.0	1.4	0.7	100.0
SE		5.0	7.3	11.7	22.3	27.5		
Sample Size	1	41	53	33	13	2	1	144
Female								
Percent	0.4	19.6	29.8	29.4	14.3	6.0	0.4	100.0
SE		3.6	6.0	7.1	9.8	13.5		
Sample Size	1	52	79	78	38	16	1	265
Sexes Combined[b]								
Percent	0.5	22.9	32.2	27.1	12.4	4.4	0.5	100.0
SE	11.0	3.1	4.6	6.0	9.2	12.2	43.5	
Sample Size	2	94	132	111	51	18	2	410
Sport Harvest								
Male								
Percent	2.0	16.3	44.9	26.5	6.1	2.0	2.0	100.0
SE		4.3	14.8	18.2	28.7			
Sample Size	1	8	22	13	3	1	1	49
Female								
Percent	0.0	10.3	34.5	43.1	10.3	1.7	0.0	100.0
SE		4.3	13.6	9.8	8.3			
Sample Size	0	6	20	25	6	1	0	58
Sexes Combined[b]								
Percent	0.9	15.4	39.3	34.2	7.7	1.7	0.9	100.0
SE		2.8	9.6	8.4	10.8	62.0		
Sample Size	1	18	46	40	9	2	1	117

[a] Age groups 2 and 3, and 6 through 8, were combined for Chi-square analysis.

[b] The combined sex category contains additional samples than the sum of the individual male and female categories. This is due to age but not sex being determined on some biological samples.

Table 3.-Estimated age and sex composition of Anchor River Dolly Varden sampled biweekly from the weir site, 1994.

		Age Group[a]							
		2	3	4	5	6	7	8	Total
3-18 July									
Male	Est. Dolly Varden	0	278	517	676	239	80	0	1,790
	SE	0	103	137	154	96	56	0	256
	Percent	0.0	4.9	9.2	12.0	4.2	1.4	0.0	31.7
	Sample Size	0	7	13	17	6	2	0	45
Female	Est. Dolly Varden	0	80	994	1,392	1,034	318	40	3,858
	SE	0	56	181	205	184	110	40	354
	Percent	0.0	1.4	17.6	24.6	18.3	5.6	0.7	68.3
	Sample Size	0	2	25	35	26	8	1	97
Total	Est. Dolly Varden	0	358	1,511	2,068	1,273	398	40	5,648
	SE	0	116	211	229	199	121	40	
	Percent	0	6.3	26.8	36.6	22.5	7.0	0.7	99.9
	Sample Size	0	9	38	52	32	10	1	142
19-31 July									
Male	Est. Dolly Varden	0	888	1,628	814	370	0	74	3,775
	SE	0	246	319	236	163	0	74	500
	Percent	0.0	8.8	16.2	8.1	3.7	0.0	0.7	37.5
	Sample Size	0	12	22	11	5	0	1	51
Female	Est. Dolly Varden	0	962	2,072	2,072	740	444	0	6,291
	SE	0	255	350	350	226	178	0	627
	Percent	0.0	9.6	20.6	20.6	7.4	4.4	0.0	62.5
	Sample Size	0	13	28	28	10	6	0	85
Total	Est. Dolly Varden	0	1,850	3,701	2,887	1,110	444	74	10,066
	SE	0	336	418	392	271	178	74	
	Percent	0.0	18.4	36.8	28.7	11.0	4.4	0.7	100.0
	Sample Size	0	25	50	39	15	6	1	136

-continued-

Table 3.-Page 2 of 2.

		Age Group[a]							
		2	3	4	5	6	7	8	Total
1-15 August									
Male	Est. Dolly Varden	12	258	211	59	23	0	0	562
	SE	12	50	46	26	16	0	0	76
	Percent	0.8	16.7	13.6	3.8	1.5	0.0	0.0	36.4
	Sample Size	1	22	18	5	2	0	0	48
Female	Est. Dolly Varden	12	433	304	176	23	23	0	971
	SE	12	61	54	43	16	16	0	95
	Percent	0.8	28.0	19.7	11.4	1.5	1.5	0.0	62.9
	Sample Size	1	37	26	15	2	2	0	83
Total	Est. Dolly Varden	23	702	515	234	47	23	0	1,545
	SE	16	67	64	48	23	16	0	
	Percent	1.5	45.5	33.3	15.2	3.0	1.5	0.0	100.0
	Sample Size	2	60	44	20	4	2	0	132
Grand Total									
	Est. Dolly Varden	23	2,911	5,727	5,189	2,430	865	114	17,259
	SE	16	361	472	456	337	216	84	
	Percent	0.1	16.9	33.2	30.1	14.1	5.0	0.7	100.1
	Sample Size	2	94	132	111	51	18	2	410

[a] Age groups 2 and 3, and 6 through 8, were combined for Chi-square analysis.

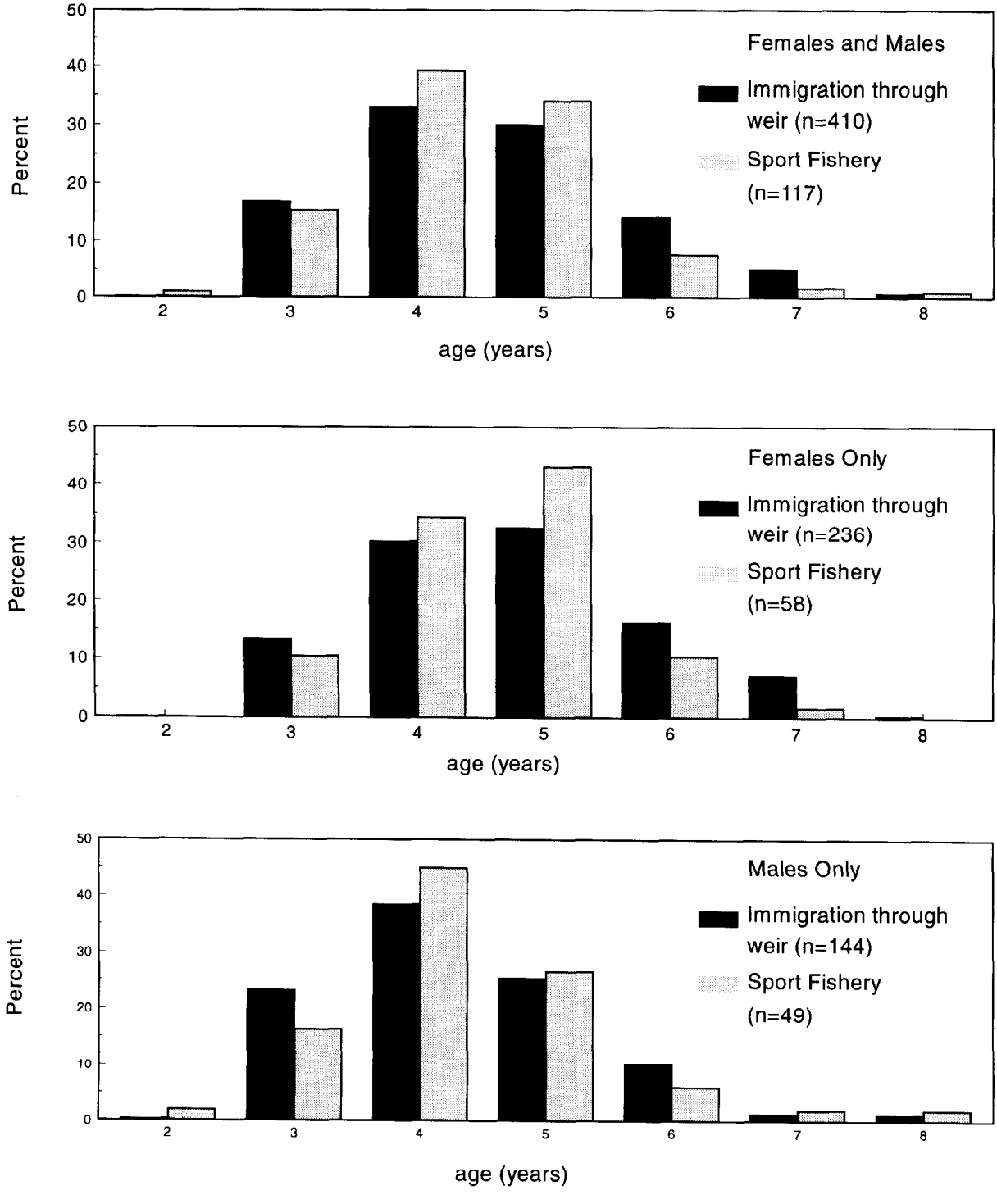

Figure 5.-Age and sex composition of Dolly Varden sampled at the Anchor River weir and in the sport fishery, 1994.

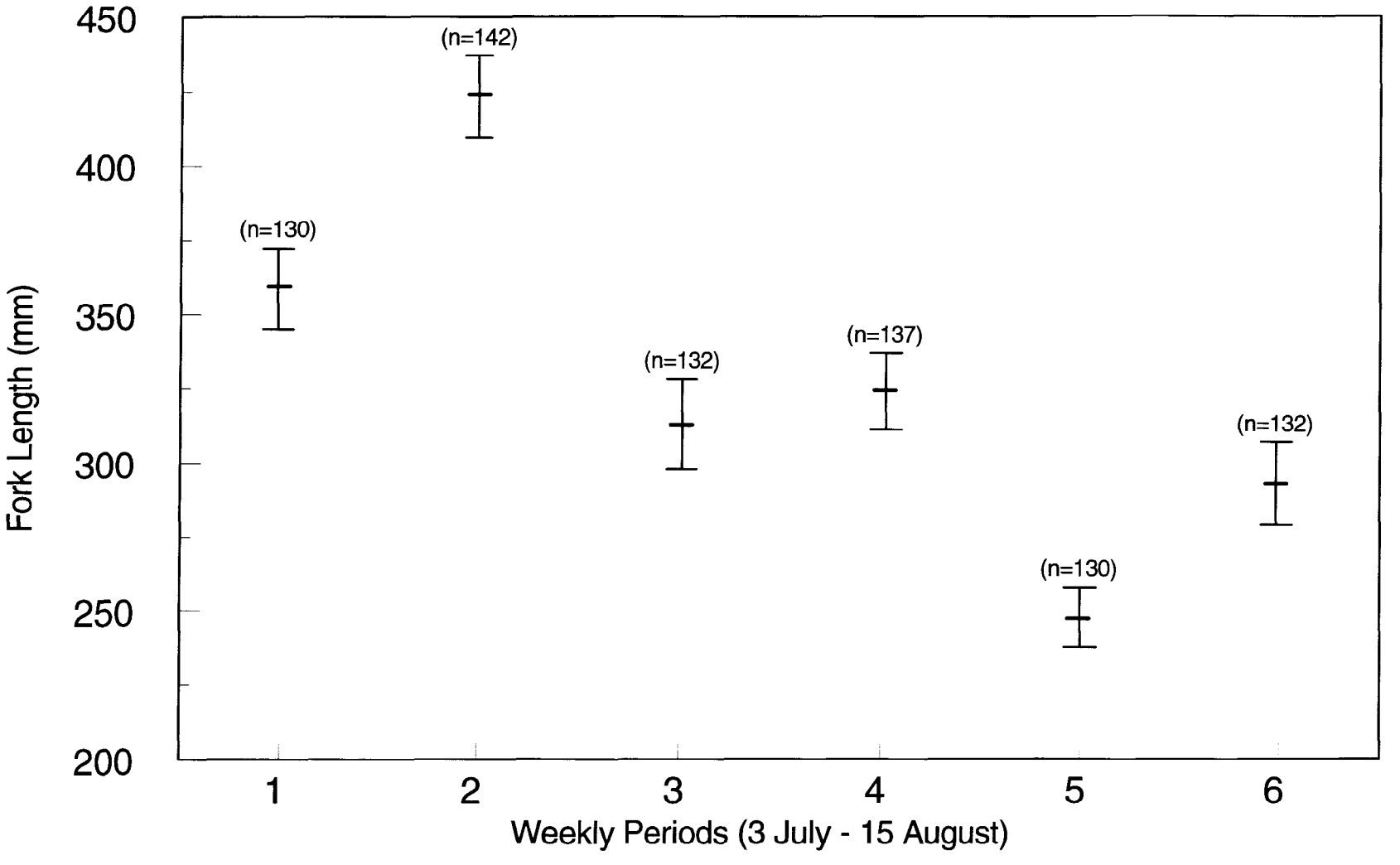

Figure 6.-Mean length by weekly period with 95% confidence intervals from Dolly Varden sampled moving upstream through the Anchor River weir, 1994.

Table 4.-Mean length (millimeters) by age group and sexual maturity of Dolly Varden collected at the Anchor River weir, 1994.

Component		Age Group 2	3	4	5	6	7	8
Weir Samples (Upstream Trap)								
Nonspawners[a]								
Males								
	Mean Length	232	212	251	298	263		
	Standard Error		5.4	7.6	23.1	55.5		
	Sample Size	1	37	39	8	2		
Females								
	Mean Length	254	223	251	270			
	Standard Error		3.2	5.6	10.2			
	Sample Size	1	49	49	15			
Total								
	Mean Length	243	218	251	280	263		
	Standard Error	11.0	3.0	4.6	10.5	55.5		
	Sample Size	2	86	88	23	2		
Potential Spawners[b]								
Females								
	Mean Length	276	319	357	390	421		
	Standard Error	21.4	5.8	7.8	14.9	18.1		
	Sample Size	3	25	32	13	6		
Spawners[c]								
Males								
	Mean Length		224	312	375	445	455	535
	Standard Error		15.0	11.6	11.4	11.7	27.5	
	Sample Size		4	14	25	11	2	1
Females								
	Mean Length			345	396	449	469	380
	Standard Error			35.1	7.9	19.3	16.8	
	Sample Size			5	31	25	10	1
Total								
	Mean Length		224	321	387	448	467	492
	Standard Error		15.0	12.4	6.8	8.3	14.4	43.5
	Sample Size		4	19	56	36	12	2

[a] Immature males with no evidence of gonad development (maturity index code 1).

Immature females with egg diameter less than 0.90 mm (maturity index code 1).

[b] Immature females showing development, egg diameter greater than 0.90 mm and less than 1.75 mm (maturity index code 5).

[c] Mature males with gonads showing signs of development, e.g., milky white coloration (maturity index code 2).

Mature females with egg diameter greater than 1.75 mm, or completely mature females (eggs easily stripped), or completely spawned females (maturity index codes 2-4).

Table 5.-Mean length (millimeters) by age group and sexual maturity of Dolly Varden collected in the sport fishery, 1994.

Component		Age Group 2	3	4	5	6	7	8
Sport Harvest								
Nonspawners[a]								
Males								
	Mean Length	192	233	278	341			
	Standard Error		5.6	15.7	31.7			
	Sample Size	1	5	8	4			
Females								
	Mean Length		227	279	293			
	Standard Error		4.5	22.8	12.0			
	Sample Size		5	4	2			
Total								
	Mean Length	192	230	279	325			
	Standard Error		3.5	10.6	22.7			
	Sample Size	1	10	17	6			
Potential Spawners[b]								
Females								
	Mean Length			355	379	405		
	Standard Error			20.1	13.1	0.0		
	Sample Size			6	9	2		
Spawners[c]								
Males								
	Mean Length		231	326	418	441	445	
	Standard Error		8.2	20.4	14.2	48.5		
	Sample Size		3	12	8	2	1	
Females								
	Mean Length			387	410	432	439	
	Standard Error			11.7	10.2	14.2		
	Sample Size			4	14	3	1	
Total								
	Mean Length		231	342	413	435	501	445
	Standard Error		8.2	16.8	8.1	17.3	62.0	
	Sample Size		3	16	22	5	2	1

[a] Immature males with no evidence of gonad development (maturity index code 1).

Immature females with egg diameter less than 0.90 mm (maturity index code 1).

[b] Immature females showing development, egg diameter greater than 0.90 mm and less than 1.75 mm (maturity index code 5).

[c] Mature males with gonads showing signs of development, e.g., milky white coloration (maturity index code 2).

Mature females with egg diameter greater than 1.75 mm, or completely mature females (eggs easily stripped), or completely spawned females (maturity index codes 2-4).

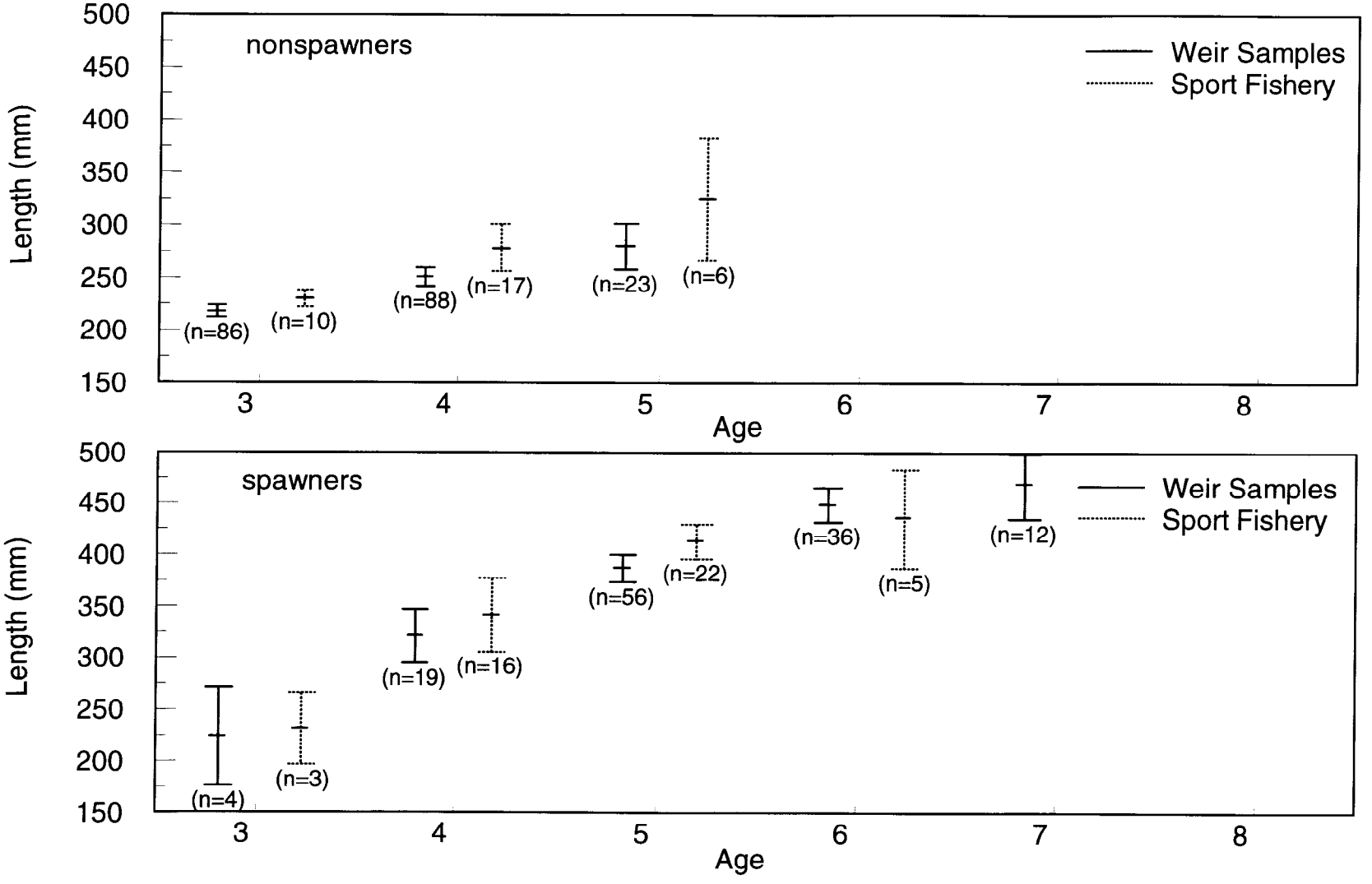

Figure 7.-Mean length by age with 95% confidence intervals from nonspawner and spawner Anchor River Dolly Varden sampled at the weir and in the sport fishery, 1994.

Table 6.-Relative maturity and sex ratios of Dolly Varden sampled at the Anchor River weir and in the sport fishery by period, 1994.

				Maturity Index[a]																
				1					2					3	4	5				
Period	N	Sex	n_i	n	%	Mean Length	$\hat{N}$	SE	n	%	Mean Length	$\hat{N}$	SE	n	n	n	%	Mean Length	$\hat{N}$	SE
Weir																				
7/3-18	5,648	F	97	6	4.2	254.8	239	115	29	20.4	442.5	1,153	231	0	0	62	43.7	363.7	2,466	284
		M	45	22	15.5	259.2	875	305	23	16.2	380.0	915	310							
7/19-31	10,066	F	86	47	34.3	254.8	3,453	515	33	24.1	421.3	2,425	464	0	0	6	4.4	325.7	441	222
		M	51	24	17.5	253.5	1,763	536	27	19.7	364.9	1,984	561							
8/1-15	1,545	F	84	62	47.3	228.2	731	84	11	8.4	364.7	130	47	0	0	11	8.4	303.9	130	47
		M	47	40	30.5	219.3	472	104	7	5.3	342.4	83	51							
Total	17,259		410		43.6	240.2	7,533	823		38.8	398.0	6,689	827	0	0		17.6	352.5	3,037	364
Sport																				
7/1-18		F	20	1	3.1	232.0			9	28.1	399.9			0	0	10	31.3	383.8		
		M	12	5	15.6	305.4			7	21.9	427.4									
7/19-31		F	31	13	21.3	267.3			10	16.4	415.2			0	0	8	13.1	369.3		
		M	30	13	21.3	278.2			17	27.9	323.2									
8/1-15		F	8	2	16.7	264.0			5	41.7	390.4			0	0	1	8.3	320.0		
		M	4	2	16.7	210.5			2	16.7	456.5									
Total	1,574		105	36		272.2			50		382.0			0	0	19		374.3		

[a] Female maturity index: 1 = immature female with egg diameter less than 0.90 mm; 2 = mature female with egg diameter greater than 1.75 mm; 3 = completely mature female (eggs easily stripped); 4 = completely spawned female; and 5 = immature female but shows development, egg diameter greater than 0.90 mm and less than 1.75 mm.

Male maturity index: 1 = no gonad development; 2 = gonads showing signs of development (milky-white coloration).

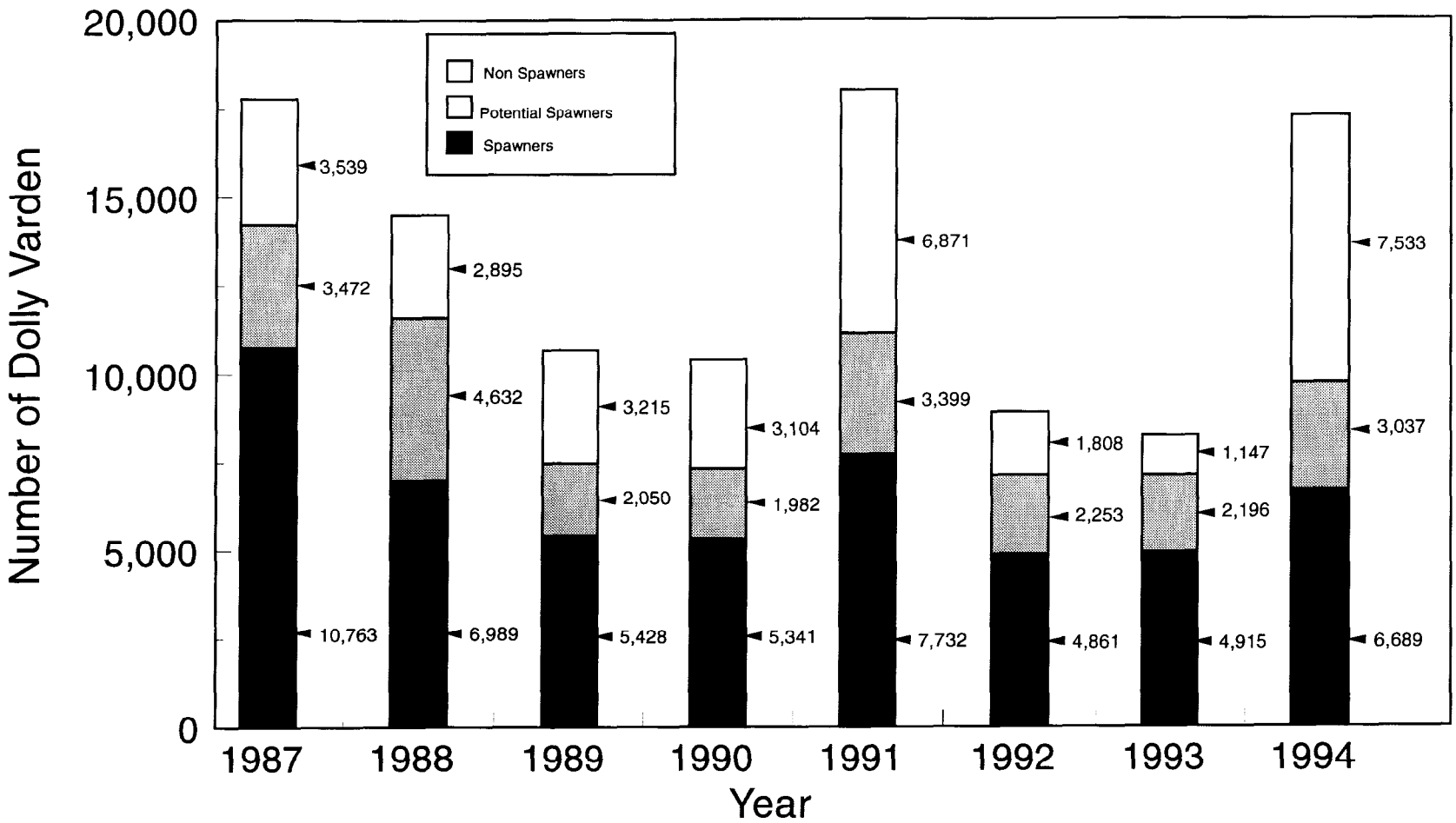

Figure 8.-Estimated sexual maturity of immigrating Dolly Varden sampled at the Anchor River weir from 3 July through 15 August, 1987-1994.

spawners, 18% potential spawners, and 44% nonspawners. The proportion of immigrating Dolly Varden nonspawners (maturity index code 1) and spawners (maturity index code 2) changed significantly at the weir ($\chi^2 = 108$, df = 2, $P < 0.001$) over time, but not in the sport fishery harvest ($\chi^2 = 3.19$, df = 2, $P = 0.203$). At the weir, nonspawners increased in abundance while spawners decreased biweekly through 15 August. These results are consistent with those observed in 1989, 1990, 1992 and 1993 (Larson 1990, 1991, 1993, and 1994).

The cumulative length distribution between immigrating spawners and nonspawners differed significantly at age group 4 ($D_{max} = 0.55$; n = 19, 88; $P < 0.001$) and age group 5 ($D_{max} = 0.74$; n = 56, 23; $P < 0.001$), spawners being larger than nonspawners (Table 4). These results are consistent with those observed from 1989 through 1993 (Larson 1990-1994).

A total of 147 Dolly Varden were found dead in the downstream trap or along the upstream side of the weir face (Table 7). A subjective examination for possible causes of death (Table 8) revealed 75 fish (51.0%) with apparent hook wounds, 29 (19.7%) fish with no apparent injuries, 20 (13.3%) fish with predator injuries, 18 (12.2%) fish with unknown injuries, and 5 (3.4%) fish with net injuries. Injuries which resulted in lesions to the skin generally had topical evidence of a bacterial infection resembling furunculosis (a necrotic lesion which ulcerates to release lightly infectious reddish fluid).

A total of 190 live Dolly Varden passed through the downstream trap from 3 July through 15 August (Table 7). The majority (69%) of these fish were less than 300 mm in fork length. When examined for injuries, 60.5% had apparent hook wounds while 26.8% had no apparent injuries (Table 8).

STOCK STRUCTURE AND DYNAMIC RATES

The historical spawner component of immigrating Dolly Varden sampled at the Anchor River weir from 3 July through 15 August has varied between an estimated 4,861 and 10,763 fish (Table 9 and Figure 8). The estimated 1994 spawner return of 6,689 fish is the fourth highest return in the 8 consecutive years of this study.

Estimates of annual survival through age 5 were generally greater than one because fish younger than age 5 were incompletely recruited to the spawning population. Seventeen of the 18 estimates of annual survival (Table 10) for ages 6-8 were all less than one and show a strong decreasing trend as fish age from age 6 to age 8. Based on maturity sampling, these age classes are comprised virtually entirely of spawners and should annually return to spawn. These estimates seem a realistic expression of that phenomenon. While age 9 and older fish should fit the same pattern as that described for age 6-8 fish, annual survival for these age classes varies widely from 0 to 1.5 and is likely attributable to rare event sampling; these age classes are found in only trace levels (less than 1%) (Table 10).

Sport anglers harvest fish of spawning age, primarily age 4 and older (Table 11).

Values of annual survival by age ($\hat{S}$) (Table 10) were realistic for ages 5-9. Fish less than age 5 were incompletely recruited to the sampled population. The instantaneous rates of total mortality (Z) (Table 12) were generally positive and increasing after age 5 from 1988-1994. This indicates a decrease in Dolly Varden recruitment after age 4 in most years, although in 1989 and 1992 Dolly Varden recruitment decreased after age 3.

No trends were evident in instantaneous annual fishing mortality ($\hat{F}$) (Table 12) and

Table 7.-Number of Dolly Varden sampled from the upstream trap, sport harvest, mortalities recovered at the weir site, and downstream trap, by length range, Anchor River, 3 July-15 August 1994.

Length Range (mm)	Upstream Trap		Sport Harvest		Mortalities		Downstream Trap	
	Count	%	Count	%	Count	%	Count	%
<200	41	5	2	2	5	3	22	12
200-249	180	22	25	20	48	33	74	39
250-299	117	15	11	9	25	17	34	18
300-349	154	19	22	18	46	31	35	18
350-399	110	14	29	24	16	11	12	6
400-449	89	11	22	18	4	3	8	4
450-499	73	9	10	8	1	1	4	2
500>	39	5	1	1	2	1	1	1
Total	803	100	122	100	147	100	190	100

Table 8.-Injuries observed by length range from Dolly Varden sampled in the emigration and immigration through the Anchor River weir and from mortalities collected at the weir site, 1994.

Length Range	No Injuries	%	Angler Wound	%	Net Wound	%	Unknown Injuries	%	Predator Injuries	%	Total
Live Emigration											
<200	7	3.7	12	6.3	0	0.0	0	0.0	3	1.6	22
200-249	24	12.6	47	24.7	0	0.0	2	1.1	1	0.5	74
250-299	8	4.2	20	10.5	2	1.1	2	1.1	2	1.1	34
300-349	8	4.2	19	10.0	1	0.5	1	0.5	6	3.2	35
350-399	2	1.1	8	4.2	0	0.0	1	0.5	1	0.5	12
400-449	0	0.0	7	3.7	0	0.0	0	0.0	1	0.5	8
450-499	2	1.1	2	1.1	0	0.0	0	0.0	0	0.0	4
500>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.5	1
Total	51	26.8	115	60.5	3	1.6	6	3.2	15	7.9	190
Downstream Mortalities											
<200	2	1.4	2	1.4	0	0.0	0	0.0	1	0.7	5
200-249	8	5.4	22	15.0	2	1.4	9	6.1	7	4.8	48
250-299	0	0.0	20	13.6	0	0.0	5	3.4	0	0.0	25
300-349	9	6.1	26	17.7	1	0.7	3	2.0	7	4.8	46
350-399	7	4.8	3	2.0	1	0.7	1	0.7	4	2.7	16
400-449	2	1.4	1	0.7	0	0.0	0	0.0	1	0.7	4
450-499	1	0.7	0	0.0	0	0.0	0	0.0	0	0.0	1
500>	0	0.0	1	0.7	1	0.7	0	0.0	0	0.0	2
Total	29	19.7	75	51.0	5	3.4	18	12.2	20	13.6	147
Live Immigration											
<200	37	4.6	2	0.2	0	0.0	0	0.0	2	0.2	41
200-249	174	21.7	3	0.4	0	0.0	0	0.0	3	0.4	180
250-299	115	14.3	1	0.1	0	0.0	0	0.0	1	0.1	117
300-349	149	18.6	3	0.4	0	0.0	0	0.0	2	0.2	154
350-399	104	13.0	3	0.4	0	0.0	0	0.0	3	0.4	110
400-449	85	10.6	1	0.1	0	0.0	0	0.0	3	0.4	89
450-499	71	8.8	0	0.0	0	0.0	0	0.0	2	0.2	73
500>	36	4.5	0	0.0	2	0.2	0	0.0	1	0.1	39
Total	771	96.0	13	1.6	2	0.2	0	0.0	17	2.1	803

Table 9.-Estimated sexual maturity of Dolly Varden sampled at the Anchor River weir from July through 15 August, 1987-1994.

			Nonspawners				Potential Spawners				Spawners			
Year	Period	Weir Cnt	n	%	$\hat{N}$	SE	n	%	$\hat{N}$	SE	n	%	$\hat{N}$	SE
1987[a]	July 4-17	596	17	3.8	23	5	57	12.9	77	8	369	83.3	496	9
	July 18-31	14,688	215	17.3	2,534	46	237	19.0	2,794	48	794	63.7	9,360	58
	Aug 1-15	2,490	431	39.4	982	24	264	24.2	601	21	398	36.4	907	24
	Total	17,774	663	23.8	3,539	57	558	20.1	3,472	53	1,561	56.1	10,763	66
1988[a]	July 4-17	5,323	105	7.8	417	20	431	32.2	1,712	34	804	60.0	3,194	36
	July 18-31	7,713	337	29.3	2,258	40	403	35.0	2,701	42	411	35.7	2,754	42
	Aug 1-15	1,480	8	14.8	219	14	8	14.8	219	14	38	70.4	1,041	18
	Total	14,516	450	17.7	2,895	46	842	33.1	4,632	57	1,253	49.2	6,989	60
1989[b]	July 5-18	1,229	3	4.5	56	7	21	31.8	391	16	42	63.6	782	17
	July 19-31	6,429	50	32.9	2,115	38	22	14.5	931	28	80	52.6	3,384	40
	Aug 1-15	3,034	43	34.4	1,044	26	30	24.0	728	24	52	41.6	1,262	27
	Total	10,692	96	28.0	3,215	46	73	21.3	2,050	42	174	50.7	5,428	52
1990[b]	July 2-15	1,201	12	15.8	190	13	15	19.7	237	14	49	64.5	774	17
	July 16-31	7,418	16	23.9	1,771	37	12	17.9	1,329	33	39	58.2	4,318	42
	Aug 1-15	1,808	55	63.2	1,143	21	20	23.0	416	18	12	13.8	249	15
	Total	10,427	83	36.1	3,104	49	47	20.4	1,982	41	100	43.5	5,341	51
1991[b]	July 2-18	141	3	37.5	53	6	1	12.5	18	4	4	50.0	71	6
	July 19-31	13,531	24	40.0	5,412	57	12	20.0	2,706	47	24	40.0	5,412	57
	Aug 1-15	4,330	25	32.5	1,406	31	12	15.6	675	24	40	51.9	2,249	33
	Total	18,002	52	35.9	6,871	64	25	17.2	3,399	51	68	46.9	7,732	67

-continued-

Table 9.-Page 2 of 2.

Year	Period	Weir Cnt	Nonspawners				Potential Spawners				Spawners			
			n	%	$\hat{N}$	SE	n	%	$\hat{N}$	SE	n	%	$\hat{N}$	SE
1992[b]	July 4-18	3,547	5	6.9	246	15	22	30.6	1,084	27	45	62.5	2,217	29
	July 19-31	4,423	14	21.2	938	27	15	22.7	1,005	28	37	56.1	2,480	33
	Aug 1-15	953	38	65.5	624	15	10	17.2	164	12	10	17.2	164	12
	Total	8,923	57	29.1	1,808	43	47	24.0	2,253	40	92	46.9	4,861	47
1993[b]	July 3-18	5,217	7	7.9	410	19	28	31.5	1,641	34	54	60.7	3,166	35
	July 19-31	2,390	17	20.0	478	20	15	17.6	422	19	53	62.4	1,490	24
	Aug 1-15	651	35	39.8	259	12	18	20.5	133	10	35	39.8	259	12
	Total	8,258	59	22.5	1,147	38	61	23.3	2,196	38	142	54.2	4,915	45
1994[c]	July 3-18	5,648	28	19.7	1,114	326	62	43.7	2,466	284	52	36.6	2,068	387
	July 19-31	10,066	71	51.8	5,217	743	6	4.4	441	222	60	43.8	4,408	728
	Aug 1-15	1,545	102	77.9	1.203	134	11	8.4	130	47	18	13.7	212	69
	Total	17,259	201	43.6	7,533	823	79	17.6	3,037	364	130	38.8	6,689	827

[a] Sexual maturity based on female length frequency and maturity index data collected during 1989 (nonspawners: <300 mm; potential spawners: 300-349 mm; spawners: >349 mm).

[b] Sexual maturity based on female gonad development; male sexual maturity was assumed to be equal in proportion to female maturity findings. Nonspawners were females with egg diameter less than 0.90 mm, potential spawners were females with egg diameter greater than 0.90 mm and less than 1.75 mm, and spawners were females with egg diameter greater than 1.75 mm.

[c] Sexual maturity of females based on criteria described in footnote "b," above. Sexual maturity of males based on gonad development: nonspawners displayed gonads with little or no development; spawners displayed gonads showing signs of development (milky-white coloration).

Table 10.-Anchor River Dolly Varden estimates by age of percent composition, weir counts, annual survival and annual mortality from 1 July through 15 August, 1988-1994.

		Age[a]									
Year	n	2	3	4	5	6	7	8	9	10+	Total
Weir Count											
1988	622	58	842	3,353	7,040	2,366	682	73	102	0	14,516
1989	557	71	750	2,492	2,681	3,520	933	231	14	0	10,692
1990	366	38	1,961	2,580	3,409	1,595	769	25	25	21	10,427
1991	240	164	1,663	6,262	6,229	2,185	1,040	423	36	0	18,002
1992	380	8	1,387	2,474	2,751	1,882	552	182	57	0	9,293
1993	400	5	858	1,585	3,097	2,065	439	194	19	0	8,262
1994	410	23	2,911	5,727	5,189	2,430	865	114	0	0	17,259
Percent											
1988	622	0.4	5.8	23.1	48.5	16.3	4.7	0.5	0.7	0.0	100.0
1989	557	0.7	7.0	23.3	25.1	32.9	8.7	2.2	0.1	0.0	100.0
1990	366	0.4	18.8	24.7	32.7	15.3	7.4	0.2	0.2	0.2	100.0
1991	240	0.9	9.2	34.8	34.6	12.1	5.8	2.3	0.2	0.0	100.0
1992	380	0.1	14.9	26.6	29.6	20.3	5.9	2.0	0.6	0.0	100.0
1993	400	0.1	10.4	19.2	37.5	25.0	5.3	2.3	0.2	0.0	100.0
1994	410	0.1	16.9	33.2	30.1	14.1	5.0	0.7	0.0	0.0	100.1

	Age[a]				
	5-6	6-7	7-8	8-9	9-10
Annual Survival					
1988-1989	0.500	0.394	0.339	0.192	0.000
1989-1990	0.595	0.218	0.027	0.108	1.500
1990-1991	0.641	0.652	0.550	1.440	0.000
1991-1992	0.302	0.253	0.175	0.135	0.000
1992-1993	0.751	0.233	0.351	0.104	0.000
1993-1994	0.785	0.419	0.260	0.000	0.000
Annual Mortality					
1988-1989	0.500	0.606	0.661	0.808	1.000
1989-1990	0.405	0.782	0.973	0.892	-0.500
1990-1991	0.359	0.348	0.450	-0.440	1.000
1991-1992	0.698	0.747	0.825	0.865	1.000
1992-1993	0.249	0.767	0.649	0.896	1.000
1993-1994	0.215	0.581	0.740	1.000	1.000

[a] Age composition based on fish mortalities collected on the weir face (1988) and random sampling schedules (1989-1994).

Table 11.-Anchor River sport harvest estimates of percent composition, harvest and annual fishing mortality by age downstream of the fish weir, 1988-1994.

		Age									
Year	n	2	3	4	5	6	7	8	9	10+	Total
Percent by Age											
1988	224	0	2.7	26.3	47.7	17.8	3.6	1.4	0.5		100.0
1989	60	0	6.7	30.0	25.0	31.6	5.0	1.7			100.0
1990	87	0	9.2	27.6	41.3	9.2	9.2	2.3	1.2		100.0
1991	188	0	3.7	23.4	36.2	24.5	9.6	1.6	0.5	0.5	100.0
1992	143	0	4.9	34.3	35.0	21.0	1.4	1.4	2.1		100.1
1993	47	0	4.3	21.3	40.4	23.4	10.6				100.0
1994	109	0	10.1	42.2	36.7	8.3	1.8	0.9			100.0
Estimated Harvest by Age											
1988	224	0	58	567	1,028	384	78	30	11	0	2,156
1989	60	0	71	316	263	333	53	18	0	0	1,053
1990	87	0	195	586	877	195	195	49	25	0	2,124
1991	188	0	56	356	550	372	146	24	8	0	1,520
1992	143	0	124	868	885	532	35	35	53	0	2,532
1993	47	0	44	220	417	241	109	0	0	0	1,031
1994	109	0	159	664	578	131	28	14	0	0	1,574
Exploitation by Sport Fishery (E)											
1988			0.065	0.145	0.127	0.140	0.102	0.293	0.096		
1989			0.086	0.113	0.089	0.086	0.053	0.072	0.000		
1990			0.091	0.185	0.205	0.109	0.203	0.661	0.505	0.000	
1991			0.033	0.054	0.081	0.146	0.123	0.054	0.174	1.000	
1992			0.082	0.260	0.244	0.220	0.060	0.163	0.483		
1993			0.049	0.122	0.119	0.105	0.199	0.000	0.000		
1994			0.052	0.104	0.100	0.051	0.032	0.111			

Table 12.-Anchor River Dolly Varden instantaneous estimates of total, fishing and natural mortality, 1988-1994.

	Age				
Year	5-6	6-7	7-8	8-9	9-10
Instantaneous Total Mortality (Z)					
1988-1989	0.693	0.931	1.083	1.651	
1989-1990	0.519	1.521	3.620	2.224	-0.405
1990-1991	0.445	0.428	0.598	-0.365	
1991-1992	1.197	1.376	1.743	2.004	
1992-1993	0.287	1.456	1.046	2.260	
1993-1994	0.243	0.870	1.348		
Instantaneous Fishing Mortality (F)					
1988-1989	0.066	0.034	0.043	0.000	
1989-1990	0.093	0.108	0.195	0.275	0.000
1990-1991	0.135	0.112	0.042	0.252	
1991-1992	0.146	0.030	0.072	0.291	
1992-1993	0.101	0.110	0.000	0.000	
1993-1994	0.048	0.021	0.059		
Instantaneous Natural Mortality (M)					
1988-1989	0.628	0.896	1.040	1.651	
1989-1990	0.426	1.413	3.425	1.948	-0.405
1990-1991	0.309	0.315	0.556	-0.617	
1991-1992	1.050	1.346	1.671	1.713	
1992-1993	0.186	1.345	1.046	2.260	
1993-1994	0.195	0.850	1.290		

the values are variable across years and ages. The year 1994 stands out as a year with some of the lowest values of annual fishing mortality in fish older than age 5 (Tables 11 and 12). Although anglers tend to select older and larger fish to harvest, only 11% of the harvest was from fish older than age 5, which represented 19.8% of the run (Table 10).

Instantaneous natural mortality ($\hat{M}$) (Table 12) was much higher than the values of F for ages 5 through 9, demonstrating that the number of deaths due to harvest in the sport fishery was much lower than from natural causes. These results are consistent with previous years and support the literature which indicates mortality due to spawning is high.

DISCUSSION

This study has provided information necessary to manage the Dolly Varden spawning stock. The Anchor River spawning population has varied from an estimated high of 10,763 fish during 1987 to a low of 4,861 fish during 1992 (Figure 8). Dolly Varden recruitment to the spawning population has been shown to be dependent on multiple cohorts in any one year (Table 4), and depending on the success or failure of each cohort, a high degree of fluctuation in the population should be expected. With multiple age classes comprising a particular spawning population, the causes for the rise or fall of the spawning population is complex and comprise both natural and human influences.

The scope of this study has focused on recreational angling impacts to the Dolly Varden spawning population. The decline of the spawning population observed from 1987 through 1990 (Figure 8) was believed to reflect an angler depressed stock (Larson 1990) and a regulatory reduction in the daily bag limit from five to two fish was imposed. In addition to the two fish bag limit restriction, recent observations of the sport fishery indicate anglers are self-imposing more hook-and-release practices than before. It seems that a growing number of Dolly Varden anglers are fishing more for recreation than for food. This may be a product of public awareness of the conservation issue relating to recent Dolly Varden stocks or the two-fish bag limit restriction may be deterring harvest oriented anglers from participating in the fishery. If an angler creel survey is conducted in the future, soliciting why anglers fish for Dolly Varden would help characterize anglers and aide managers in further developing effective management strategies.

Mortality associated with hook-and-release practices on Dolly Varden stocks remains a concern. Hook injuries (Table 8) are the most prevalent type of injury evident from mortalities deposited by the river current on the upstream side of the weir face (51%) and in the emigration through the downstream trap (60.5%). Hook injuries disrupt the osmoregulatory system of fish and become sites for bacterial and fungal infections (Larson 1994), any of which can be lethal. Empirical evidence from this study indicates that as water temperature increases the mortality associated with hook injuries also increases. Because there is some level of mortality associated with hook-and-release practices, excessive catch rates can have severe impacts to a fish population. Catch rates as high as 80% of the total Dolly Varden immigration were estimated on the Anchor River during 1988 (Larson and Balland 1989). Encouraging too many people to participate in this Dolly Varden fishery, even if the harvest is low, may result in excessive hook and release mortality. Fishery managers and the public must have realistic expectations of how much fishing opportunity our wild Dolly Varden stocks can provide and regulate accordingly.

The maximum potential for Dolly Varden production (MSY), and therefore fishing opportunity, from Anchor River stocks remains unknown. The spawner component, although important for potential fish production, is only one component of what provides for annual fishing opportunity. The nonspawner component of this fishery, believed to represent mixed stocks (Armstrong 1984, Larson 1993), can contribute significantly to the recreational angler's fishing opportunity. The nonspawner component of the 1991 and 1994 Anchor River Dolly Varden return (Figure 8) was substantial; it was similar to or exceeded the estimated spawner components. An exceptionally large nonspawner component may give the illusion to anglers that a given stream's Dolly Varden stock is healthier than it really is. It is possible that a large nonspawner component may have been responsible for the exceptionally large harvests observed from 1978-1983 (Table 1). Therefore, we can not assume the large harvests from 1978-1983 necessarily represented large spawner returns as well. Important questions that remain to be answered are the spawning and rearing limitations of the Anchor River Dolly Varden stock.

The importance that water temperature plays in fish behavior, incidence of diseases, and survival of Dolly Varden has become more evident throughout this and other studies. Anadromous Dolly Varden on the Kenai Peninsula enter fresh water during the warmest time of the year and spawn during the coldest periods. Excessively warm or cold water has been shown to have lethal effects on Dolly Varden. McCauley (1991) determined 23.5°C to be the ultimate upper lethal temperature for Arctic char. Likewise, Bjornn (1991) found that temperatures below 4°C during the early stages of egg incubation can be fatal to trout and char. Water temperatures in the Anchor River have approached the upper threshold of what char can tolerate and are often below 4°C during spawning. Temperatures of 21.2°C were recorded during 1993 at the weir site (Larson 1994) and fell below 3°C as early as 11 September during 1992 (Larson 1993).

The protection of the watershed habitat from logging and development may be critical to the survival of Dolly Varden and salmonids, especially along clearwater streams like the Anchor River. Armstrong (1991) states that it is especially important to protect the small tributary streams where juvenile char rear before they leave streams as smolt. Overhanging vegetation minimizes the solar warming affect on stream water and plant transpiration buffers the severity of run-off from rain falls. The forest along the Chakok River, an important nursery tributary within the Anchor River watershed, is currently being logged, as are sections of every watershed south of the Kasilof River. The short term economic gain of logging these areas will likely have long-term impacts on our fisheries resources. The boreal forest habitat of our local watersheds are complex ecosystems that are not completely understood, but their value to our fisheries resources are becoming clearer. Without the forest habitat, especially in the riparian zone, water temperature and run-off is expected to fluctuate more dramatically and this will likely have an adverse effect on our fisheries.

Our attempt to establish a standard for determining the sexual maturity of male Dolly Varden was not conclusive. The laboratory resources were not available to conduct detailed chemical analysis of the male gonad samples. With a lack of qualitative analysis, our criteria for determining male sexual maturity remains subjective. I believe our criteria, though subjective, more accurately portrayed the true sexual maturity of the male

component than past practices of assuming the male component to be equal in proportion to the female component. Intuitively, this was likely a false assumption. Males have been known to mature earlier than females and are less likely to survive multiple spawning events than females (Armstrong 1974).

Of interest in our comparison of individual male Dolly Varden gonad weights to body weights (Appendix A6), was a doubling of the mean ratio from 0.015 to 0.035 from the first to the second biweekly period and then stabilizing at 0.034 during the third biweekly period. This may indicate that male gonad development is rapid prior to 28 July when the second samples were obtained. Establishing a standard based on this ratio may need to be weighted temporally. Because fish need to be sacrificed in order to weigh their gonads, resampling of the same fish at a later date to further assess maturation development is not possible.

Stock Structure and Abundance

An examination of dynamic rates pertaining to Dolly Varden, presented each year since 1991 (Larson 1992-1994), indicates that the Anchor River Dolly Varden stock has a high rate of turnover. To some extent, a high degree of fluctuation should be expected. These fish are fairly productive and the number of deaths due to fishing is much lower than from "natural" causes. The annual rates of fishing mortality reflect changes in availability of Dolly Varden to the fishery and changes in regulations. The number of fish available for harvest varies from year to year, depending on run timing, as well as abundance.

The effects from varying spawning escapements, documented since 1987, on recruitment will become evident with each additional year this project is funded. The 1987 and 1988 escapements provided age-6 and age-5 Dolly Varden, respectively, to the fishery during 1994. These age groups consist largely of spawners and are reflective of Anchor River recruitment from the 1987 and 1988 spawning escapements (Table 4). Although premature, there is no apparent evidence which links relatively high Dolly Varden escapements with high recruitment. With a decrease of approximately 4,000 estimated Dolly Varden spawners from 1987 to 1988 (Figure 8), the 1988 escapement appears to be more productive (Table 10). Until we can create a more complete brood table, we are premature in modeling relationships between spawning escapement and recruitment. Through the continuation of this project, the importance of varying escapement levels will become more evident.

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APPENDIX A: SUPPORTING STATISTICS

Appendix A1.-Daily river water depth and temperature readings recorded at the Anchor River weir upstream trap, 1994.

Date	Water Depth[a] (cm)	Water Temp[b] (2200 hrs)	Thermograph Readings[b] Lows (Celsius)	Highs (Celsius)	Difference (Celsius)
03-Jul	31.1	11.5	8.0	10.9	2.9
04-Jul	29.8	12.0	9.0	11.0	2.0
05-Jul	34.3	12.0	9.1	11.6	2.5
06-Jul	30.5	14.0	7.8	14.3	6.5
07-Jul	28.6	15.0	9.0	15.8	6.8
08-Jul	27.3	15.5	10.0	16.0	6.0
09-Jul	25.4	14.0	11.0	14.6	3.6
10-Jul	27.3	14.0	11.0	13.3	2.3
11-Jul	27.3	14.5	10.9	13.8	2.9
12-Jul	26.7	15.0	11.1	14.2	3.1
13-Jul	26.0	14.2	11.0	14.5	3.5
14-Jul	25.4	15.0	11.1	15.0	3.9
15-Jul	24.8	12.5	11.0	12.2	1.2
16-Jul	24.8	13.5	10.0	12.7	2.7
17-Jul	24.8	14.5	11.1	13.5	2.4
18-Jul	26.0	13.0	11.0	12.7	1.7
19-Jul	26.0	16.0	10.5	16.7	6.2
20-Jul	26.0	13.0	10.3	14.7	4.4
21-Jul	31.8	11.5	10.2	11.7	1.5
22-Jul	29.2	12.0	9.7	10.4	0.7
23-Jul	26.7	12.5	10.0	12.9	2.9
24-Jul	26.0	12.0	10.2	11.9	1.7
25-Jul	26.7	13.5	10.2	12.0	1.8
26-Jul	27.9	13.5	11.0	12.0	1.0
27-Jul	31.8	15.0	10.0	15.1	5.1
28-Jul	27.9	16.0	9.8	16.4	6.6
29-Jul	25.4	16.5	10.5	17.3	6.8
30-Jul	24.1	16.5	11.2	17.0	5.8
31-Jul	23.5	17.5	12.2	17.9	5.7
01-Aug	24.1	14.0	13.6	15.7	2.1
02-Aug	24.8	17.0	12.5	16.8	4.3
03-Aug	24.1	17.0	13.0	17.8	4.8
04-Aug	22.9	17.0	13.2	17.3	4.1
05-Aug	22.2	17.0	10.7	18.0	7.3

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Date	Water Depth[a] (cm)	Water Temp[b] (2200 hrs)	Thermograph Readings[b] Lows (Celsius)	Highs (Celsius)	Difference (Celsius)
06-Aug	22.2	15.0	12.2	15.0	2.8
07-Aug	24.1	14.5	12.2	14.2	2.0
08-Aug	25.4	14.5	12.2	14.6	2.4
09-Aug	24.8	15.0	11.3	14.0	2.7
10-Aug	24.1	15.5	12.7	15.0	2.3
11-Aug	23.5	15.5	13.0	16.0	3.0
12-Aug	22.9	16.5	11.4	17.4	6.0
13-Aug	21.6	16.5	10.2	17.0	6.8
14-Aug	21.6	17.0	10.8	17.7	6.9
15-Aug	21.0	16.0	10.3	17.2	6.9

[a] Depth was recorded at 2200 hours daily. Water depth was relative to a selected location on the upstream trap.

[b] Water temperature was recorded continually by thermograph and also by thermometer at 2200 hours.

Appendix A2.-The daily and cumulative number of fish, by species, passed downstream through the Anchor River weir during 1994.

	Dolly Varden		Chinook S.		Pink Salmon		Coho Salmon		Steelhead		Sockeye S.		Chum Salmon	
Date	Daily Count	Cum.[a] Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count
03-Jul	5	5	1	1	7	7		0		0		0		0
04-Jul	5	10	2	3	2	9		0		0		0		0
05-Jul	8	18	16	19	9	18		0		0		0		0
06-Jul	13	31	3	22	7	25		0		0		0		0
07-Jul	20	51	2	24	4	29		0		0		0		0
08-Jul	62	113	1	25	16	45		0		0		0	1	1
09-Jul	60	173	2	27	8	53		0		0		0		1
10-Jul	196	369	10	37	2	55		0		0		0		1
11-Jul	316	685	2	39	31	86		0		0		0		1
12-Jul	331	1,016	1	40	41	127		0		0		0		1
13-Jul	310	1,326		40	16	143		0		0	1	1		1
14-Jul	513	1,839		40	16	159		0		0		1		1
15-Jul	900	2,739		40	10	169		0		0	1	2		1
16-Jul	378	3,117	2	42	13	182		0		0		2		1
17-Jul	964	4,081		42	9	191		0		0		2		1
18-Jul	1,567	5,648		42	20	211		0		0		2		1
19-Jul	2,672	8,320	2	44	22	233		0		0	3	5		1
20-Jul	722	9,042		44	12	245		0		0		5		1
21-Jul	732	9,774	4	48	24	269		0		0	1	6		1
22-Jul	532	10,306	4	52	12	281		0		0		6	1	2
23-Jul	929	11,235	9	61	28	309		0		0	1	7		2
24-Jul	603	11,838	1	62	13	322		0		0	2	9		2
25-Jul	620	12,458	3	65	24	346		0		0	4	13		2

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	Dolly Varden		Chinook S.		Pink Salmon		Coho Salmon		Steelhead		Sockeye S.		Chum Salmon	
Date	Daily Count	Cum.[a] Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count
26-Jul	754	13,212	4	69	17	363		0		0	3	16		2
27-Jul	466	13,678	7	76	36	399	2	2		0	4	20		2
28-Jul	501	14,179	2	78	36	435		2		0	3	23		2
29-Jul	618	14,797	4	82	50	485		2		0	3	26		2
30-Jul	532	15,329	2	84	48	533		2		0		26		2
31-Jul	385	15,714		84	29	562	1	3		0	4	30		2
01-Aug	283	15,997		84	27	589	1	4		0	2	32		2
02-Aug	164	16,161		84	12	601	5	9		0	8	40		2
03-Aug	130	16,291	3	87	16	617	6	15		0	3	43		2
04-Aug	291	16,582	1	88	15	632	15	30		0	2	45		2
05-Aug	211	16,793	1	89	19	651	24	54		0	2	47		2
06-Aug	133	16,926	3	92	15	666	24	78		0	1	48		2
07-Aug	55	16,981	1	93	8	674	23	101		0		48		2
08-Aug	51	17,032	5	98	15	689	177	278		0	3	51		2
09-Aug	42	17,074	6	104	9	698	48	326	1	1	1	52		2
10-Aug	39	17,113	3	107	8	706	11	337		1	2	54		2
11-Aug	48	17,161	3	110	2	708	3	340		1	5	59		2
12-Aug	45	17,206		110	2	710	17	357		1	1	60		2
13-Aug	19	17,225		110	2	712	2	359		1		60		2
14-Aug	13	17,238		110	4	716	22	381		1	1	61		2
15-Aug	21	17,259	1	111	7	723	39	420		1		61		2

[a] Cumulative count.

Appendix A3.-Dolly Varden samples collected at random from the Anchor River sport fishery showing daily summaries of male and female gonad maturity, sex ratios, and length samples, 1994.

Date	Nonspawners[a] Code 1			Spawners[a] Code 2			Potential Spawners[a] Code 5		Lengths
Sampled	F	M	Total	F	M	Total	F	Total	Sampled
7/14/94	0	2	2	0	1	1	2	2	7
7/15/94	0	0	0	0	2	2	2	2	4
7/16/94	1	2	3	2	2	4	2	2	9
7/18/94	0	1	1	7	2	9	4	4	17
7/19/94	0	0	0	2	2	4	4	4	11
7/21/94	0	0	0	0	0	0	1	1	1
7/22/94	3	3	6	0	3	3	0	0	9
7/24/94	0	2	2	1	1	2	1	1	5
7/25/94	5	2	7	2	4	6	0	0	13
7/26/94	1	0	1	2	3	5	2	2	12
7/27/94	3	1	4	2	4	6	0	0	10
7/29/94	0	0	0	0	0	0	0	0	2
7/30/94	1	3	4	1	0	1	0	0	5
7/31/94	0	2	2	0	0	0	0	0	4
8/01/94	0	0	0	2	0	2	0	0	2
8/02/94	0	0	0	1	0	1	0	0	1
8/03/94	0	1	1	0	1	1	0	0	2
8/04/94	0	0	0	1	1	2	1	1	3
8/05/94	2	0	2	0	0	0	0	0	2
8/08/94	0	1	1	0	0	0	0	0	1
8/11/94	0	0	0	1	0	1	0	0	2
Grand Total	16	20	36	24	26	50	19	19	122

[a] Female maturity index: code 1 = immature female with egg diameter less than 0.90 mm; code 2 = mature female with egg diameter greater than 1.75 mm; code 3 = completely mature female (eggs easily stripped); code 4 = completely spawned female; and, code 5 = immature female but shows development, egg diameter greater than 0.90 mm and less than 1.75 mm.

Male maturity index: code 1 = no gonad development; code 2 = gonads showing signs of development (milky-white coloration).

Appendix A4.-Dolly Varden samples collected at random from the upstream trap of the Anchor River fish weir showing daily summaries of male and female gonad maturity, sex ratios, and length samples, 1994.

Date	Nonspawners[a] Code 1			Spawners[a] Code 2			Potential Spawners[a] Code 5		Lengths
Sampled	F	M	Total	F	M	Total	F	Total	Sampled
7/5/94	0	0	0	0	0	0	0	0	9
7/6/94	0	0	0	0	0	0	0	0	12
7/7/94	0	0	0	0	0	0	0	0	20
7/8/94	0	0	0	0	0	0	0	0	62
7/9/94	0	0	0	0	0	0	0	0	27
7/13/94	3	5	8	2	4	6	13	13	27
7/14/94	3	17	20	27	19	46	49	49	115
7/20/94	0	0	0	0	0	0	0	0	132
7/28/94	47	24	71	33	27	60	6	6	137
8/2/94	0	0	0	0	0	0	0	0	68
8/3/94	0	0	0	0	0	0	0	0	62
8/10/94	11	8	19	1	0	1	2	2	22
8/11/94	20	19	39	3	2	5	2	2	47
8/12/94	26	10	36	6	3	9	2	2	47
8/13/94	4	4	8	1	2	3	5	5	16
Grand Total	114	87	201	73	57	130	79	79	803

[a] Female maturity index: code 1 = immature female with egg diameter less than 0.90 mm; code 2 = mature female with egg diameter greater than 1.75 mm; code 3 = completely mature female (eggs easily stripped); code 4 = completely spawned female; and, code 5 = immature female but shows development, egg diameter greater than 0.90 mm and less than 1.75 mm.

Male maturity index: code 1 = no gonad development; code 2 = gonads showing signs of development (milky-white coloration).

Appendix A5.-Daily summary of Dolly Varden age compositions from fish sampled at random from the upstream trap of the Anchor River weir, 1994.

	Age Group							Daily
Date	2	3	4	5	6	7	8	Total
13-Jul	0	3	6	11	7	0	0	27
14-Jul	0	6	32	41	25	10	1	115
28-Jul	0	25	50	39	15	6	1	137
10-Aug	0	14	7	1	0	0	0	22
11-Aug	2	20	18	5	2	0	0	47
12-Aug	0	21	14	11	1	0	0	47
13-Aug	0	5	5	3	1	2	0	16
Totals:	2	94	132	111	51	18	2	410

Appendix A6.-Comparison of individual male Dolly Varden gonad samples collected at random from males passing through the upstream trap of the Anchor River fish weir which showed signs of gonad development, 1994.

Sample	Body Length (millimeters)	Body Weight (grams)	Gonad Weight (grams)	Gonad / Body weight ratio	Age (years)
13-Jul	273	255	3.4	0.0133	5
13-Jul	321	370	5.7	0.0154	5
13-Jul	440	1,020	21.1	0.0207	5
13-Jul	355	580	14.5	0.0250	6
14-Jul	457	1,155	8.3	0.0072	5
14-Jul	293	295	2.7	0.0092	4
14-Jul	374	665	6.2	0.0093	5
14-Jul	319	400	3.8	0.0095	4
14-Jul	446	1,180	13.5	0.0114	6
14-Jul	413	930	11.2	0.0120	6
14-Jul	345	505	6.6	0.0131	5
14-Jul	451	1,150	15.1	0.0131	6
14-Jul	354	530	7.5	0.0142	4
14-Jul	387	650	9.5	0.0146	5
14-Jul	305	355	5.3	0.0149	4
14-Jul	410	790	12.8	0.0162	5
14-Jul	389	645	10.6	0.0164	5
14-Jul	360	605	10.4	0.0172	5
14-Jul	428	900	17.2	0.0191	7
14-Jul	387	785	15.2	0.0194	5
14-Jul	483	1,365	26.5	0.0194	7
14-Jul	392	810	18.1	0.0223	4
14-Jul	359	595	17.3	0.0291	5
28-Jul	364	600	11.9	0.0198	4
28-Jul	426	1,010	21.3	0.0211	5
28-Jul	480	1,245	26.4	0.0212	6
28-Jul	311	345	7.9	0.0229	4
28-Jul	354	560	13.1	0.0234	5
28-Jul	255	200	4.7	0.0235	4
28-Jul	310	320	8.3	0.0259	4
28-Jul	200	100	2.7	0.0270	3
28-Jul	496	1,545	42.7	0.0276	6
28-Jul	417	885	25.0	0.0282	5
28-Jul	229	155	4.7	0.0303	3
28-Jul	421	855	26.0	0.0304	5

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Sample	Body Length (millimeters)	Body Weight (grams)	Gonad Weight (grams)	Gonad / Body weight ratio	Age (years)
28-Jul	243	195	6.2	0.0318	4
28-Jul	296	315	10.6	0.0337	4
28-Jul	254	210	7.6	0.0362	4
28-Jul	364	585	21.4	0.0366	5
28-Jul	464	1,110	44.9	0.0405	6
28-Jul	492	1,530	62.3	0.0407	5
28-Jul	330	465	19.3	0.0415	4
28-Jul	448	970	40.3	0.0415	6
28-Jul	535	1,905	79.8	0.0419	8
28-Jul	415	810	34.9	0.0431	5
28-Jul	344	510	23.4	0.0459	4
28-Jul	202	105	5.3	0.0501	3
28-Jul	434	1,030	55.5	0.0539	6
28-Jul	417	800	44.5	0.0556	5
28-Jul	350	515	30.8	0.0598	5
11-Aug	279	235	1.5	0.0064	5
11-Aug	264	250	8.1	0.0324	3
12-Aug	252	215	4.2	0.0195	5
12-Aug	427	1,040	38.4	0.0369	6
12-Aug	351	530	23.4	0.0442	5
13-Aug	482	1,385	53.9	0.0389	6
13-Aug	342	450	27.1	0.0602	5