Fishery Data Series No. 96-3

Abundance of Dolly Varden Overwintering in the Wulik River, Northwestern Alaska, During 1994/1995

by

Alfred L. DeCicco

March 1996

Alaska Department of Fish and Game

Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s
Spell out year, month, and week.	

Physics and chemistry

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

General

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

Mathematics, statistics, fisheries

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

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ABUNDANCE OF DOLLY VARDEN OVERWINTERING IN THE WULIK RIVER, NORTHWESTERN ALASKA, DURING 1994/1995

by

Alfred L. DeCicco
Division of Sport Fish, Fairbanks

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1599

March 1996

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Alfred L. DeCicco
Alaska Department of Fish and Game, Division of Sport Fish, Region III,
1300 College Road, Fairbanks, AK 99701-1599, USA

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ABSTRACT

The status of the Dolly Varden *Salvelinus malma* population overwintering in the Wulik River drainage of northwestern Alaska was investigated during 1994-1995. Population abundance, and length composition were estimated.

The number of Dolly Varden over 399 mm in FL overwintering in the Wulik River during the winter of 1994 - 1995 was estimated at 361,599 fish (SE = 62,306). Two aerial surveys conducted during the last week of September 1994 counted 66,937 fish and 65,100 fish respectively. It was assumed that the late migration of Dolly Varden into the Wulik River in 1994 accounted for much of this difference.

Dolly Varden ranged in fork length from 250 to 826 mm with the majority (79%) between 400 mm and 500 mm FL.

Scars from attempted predation by marine mammals were noted on 887 (20.7%) of fish inspected.

Key words: Dolly Varden, *Salvelinus malma*, population abundance, length composition, northwestern Alaska, Wulik River.

INTRODUCTION

The Kotzebue Sound and Chukchi Sea drainages of northwestern Alaska are known for their large populations of anadromous Dolly Varden, *Salvelinus malma*, and the quality sport fishing which they offer. Estimated annual sport fish harvests of Dolly Varden have averaged 1,300 fish since 1977 (Mills 1978-1994, Howe et al.). This area produces some the largest Dolly Varden in North America. Both the current International Game Fish Association world record for Dolly Varden and the State of Alaska angling record for Dolly Varden/Arctic char are from these waters. Although the sport fishery is of high quality, the remoteness of the region effectively limits participation.

Dolly Varden spawn and overwinter in fresh water. They return to natal streams to spawn, but overwintering populations are comprised of a mix of stocks. Tagging studies have shown that Dolly Varden overwintering in the Wulik River spawn in a wide variety of river systems including the Noatak, Kivalina, Wulik, Kobuk, and Pilgrim rivers. Tag recoveries have been obtained from distant locations including Pt. Hope, Norton Sound, St. Lawrence Island and the Anadyr River, Russia (DeCicco 1992, *in press*). The Wulik, Noatak, and Kivalina rivers are the most important Dolly Varden systems in this area of Alaska, supporting both overwintering and spawning populations. The Wulik River (Figure 1) supports some Dolly Varden spawning, but is most important because of the winter habitat it provides for fish. The Wulik River overwintering population is a major fisheries resource and aerial surveys of this population have been conducted on a fairly regular basis since 1968 (Table 1). Counts have ranged from a high of 297,257 in 1969 to a low of 5,590 in 1986. During the winter of 1988/1989, the population was estimated by mark-recapture methods for the first time at 76,892 fish >399 mm in FL. During that same year, an aerial survey count of 80,144 was obtained for fish of all sizes (DeCicco, 1990).

Because of the high proportion of Native Alaskans in this region and their relatively traditional lifestyle, the major harvests of Dolly Varden are for subsistence. The migratory patterns of the fish cause them to be locally abundant where they are opportunistically harvested during the fall after they have entered rivers to overwinter, and during the spring as they return to sea. Residents of Kivalina harvest Dolly Varden from the Wulik and Kivalina rivers using beach seines during the

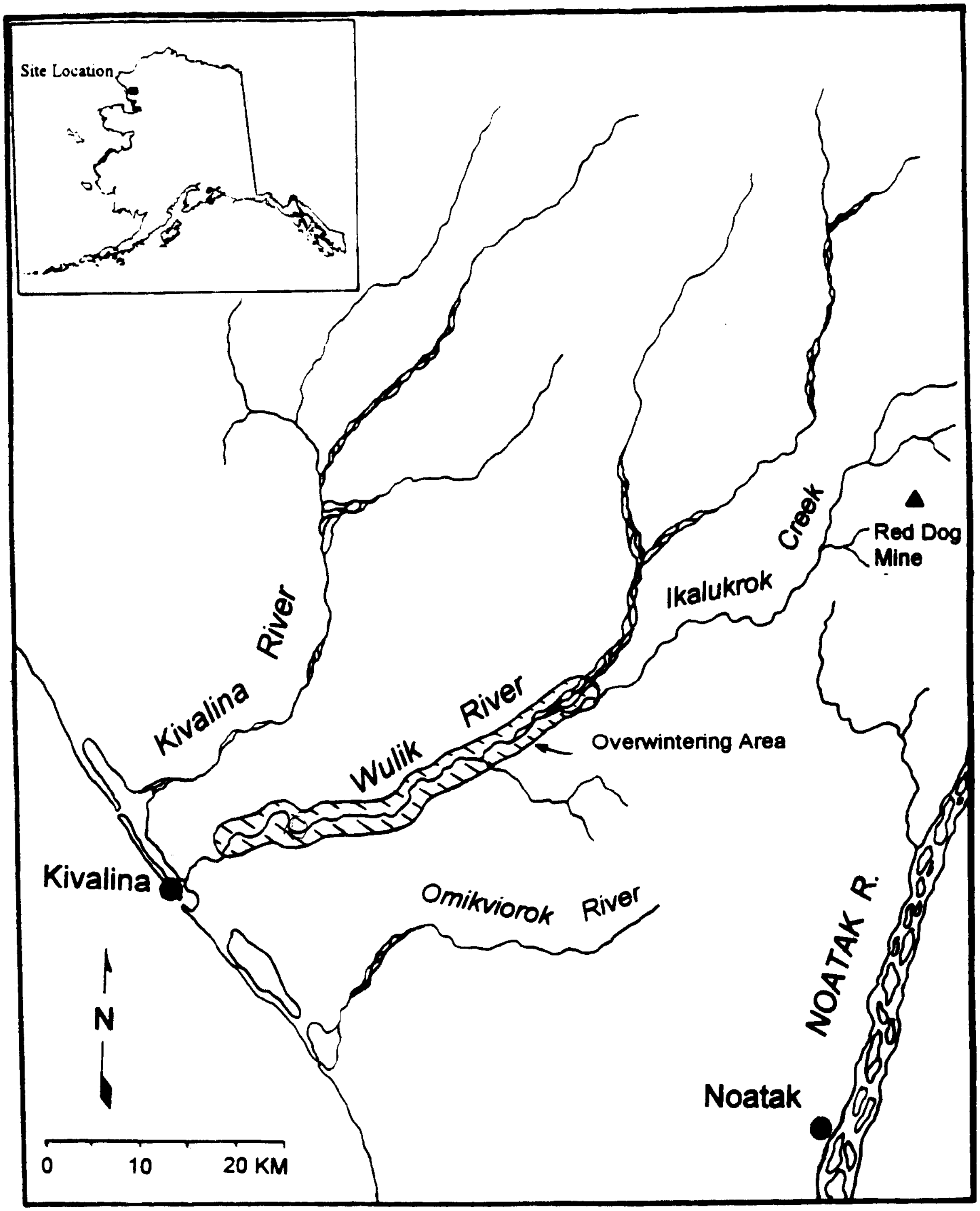


Figure 1.-The Wulik River showing the location of the Dolly Varden overwintering area.

Table 1.-Number of overwintering Dolly Varden counted during aerial surveys[a] on the Wulik River (1968 -1995), and mark - recapture estimates 1988 and 1994.

Year	Number of Dolly Varden counted	Mark - Recapture Abundance >399 mm FL	Surveyor or Source
1968	90,236		Winslow (1969)
1969	297,257		ADF&G Div. of Com. Fish[b]
1976	68,300		Alt (1981)
1979	55,030		Alt (1981)
1980	113,553		Alt (1981)
1981	101,826		DeCicco (1982)
1982	65,581		DeCicco (1983)
1984	30,923		DeCicco (1985)
1986	5,590		DeCicco[c]
1987	61,290		DeCicco (1990)
1988	80,144	76,892	DeCicco (1990)
1989	56,384		DeCicco (1990)
1991	126,985		DeCicco[d]
1992	135,135		DeCicco[e]
1993	144,138		DeCicco[f]
1994	66,937	381,737	DeCicco[g]
1995	128,705		DeCicco[h]

[a] All surveys were flown with fixed winged aircraft just before freeze-up in the year noted.

[b] ADF&G memorandum, 7 October 1969, from Carl Yanagawa, Commercial Fisheries Division Area Management Biologist to George Van Wyhe, Sport Fish Division Regional Supervisor.

[c] Unpublished field notes, survey conducted 2 October, 1986.

[d] Unpublished field notes, survey conducted 2 October, 1991.

[e] Unpublished field notes, survey conducted 8 September, 1992

[f] Unpublished field notes, survey conducted 29 September, 1993

[g] This study, survey conducted 24 September 1994.

[h] This study, survey conducted 2 October, 1995.

fall, and a combination gill nets and hook and line during the spring. Estimated subsistence harvests from the Wulik River have ranged from nearly 50,000 fish in 1960 and 1969, to 6,700 fish in 1989 (Sarrio and Kessel 1966, Winslow 1969, DeCicco 1990). In 1992, the estimated harvest in Kivalina was 21,149 Dolly Varden (Magdanz et al. 1995).

The Red Dog zinc and lead mine is located on Red Dog Creek which flows into Ikalukrok Creek, a major tributary of the Wulik River. The mouth of Ikalukrok Creek is the functional upper limit of overwintering habitat in the Wulik River. Contaminated water originating near the mine in 1989 degraded the water quality in Ikalukrok Creek and posed a threat to the quality of overwintering habitat in the Wulik River (DeCicco 1990). The contamination was successfully controlled by the construction of a clean water diversion near the mine site in 1991 (Ott and Webber-Scannell 1993). A similar condition at another location, or some other catastrophic event near the mine could threaten the quality of water used by 95 % of the Dolly Varden that overwinter in the Wulik River. Aerial counts of overwintering Dolly Varden are funded annually through the Division of Habitat from their Red Dog monitoring program.

This project, to estimate abundance of Dolly Varden overwintering in the Wulik River using mark-recapture methodology, is aimed at obtaining another data point with which to compare an aerial count. In addition, this project increased the number of marked fish at large from which data on movements and stock interchange may be obtained.

Project objectives in 1994 were to estimate:

1. the abundance of Dolly Varden overwintering in the Wulik River; and,
2. the length composition of Dolly Varden overwintering in the Wulik River.

METHODS

POPULATION ABUNDANCE

A mark-recapture experiment was used to estimate the abundance of Dolly Varden overwintering in the Wulik River during the winter of 1994-1995. Dolly Varden were captured for marking in the overwintering area using a 91 m beach seine deployed from a 4.25 m riverboat powered by a 20 hp outboard motor during late September 1994.

Each Dolly Varden was measured to the nearest mm in fork length and tagged with an individually numbered Floy FD-94 internal anchor tag inserted such that the "T" anchor locked between the base of adjacent dorsal fin rays. Each fish was also marked with a an adipose fin clip (Appendix A1). Dolly Varden captured during the first day of sampling were suspended in a net and weighed to the nearest 25 g using a Chatillion spring scale. Each fish which was in spawning or post spawning condition was noted, as was the presence of scars presumably caused by marine mammals. The subsistence fishery in Kivalina served as the recapture event. Each fish sampled from the fishery was measured and inspected for tags. Some fish had already been cut for drying when the fishery was sampled. In these cases, hanging fish were counted, and tags were obtained from the fishers.

Data were recorded on standard ADF&G Tagging-Length forms (version 1). Data files were archived with ADF&G Research and Technical Services (RTS) in Anchorage (Appendix B1).

A Petersen mark-recapture experiment (Seber 1982 and Chapman 1951) was used to estimate the abundance of Dolly Varden. Sampling for the marking event was performed in the upper part of the overwintering area during late September 1994. The spring 1995 subsistence fishery at Kivalina was inspected to obtain a sample for the recapture event.

The assumptions necessary for the accurate estimation of abundance in a closed population are (from Seber 1982):

1. there is neither mortality nor recruitment between sampling events (closed population);
2. fish have an equal capture probability in the first event or the second event, or marked fish mix completely with unmarked fish during the second sampling event;
3. marking does not affect capture probability in the second event;
4. marks are not lost between events; and,
5. marked fish can be recognized from unmarked fish.

Assumption 1 could not be tested directly, however the overwintering movement into the Wulik River occurred later than normal in 1994. Consequently, the entire overwintering population was not in the river when marking occurred, and there was some functional recruitment to the population after the first sampling event. Any overwinter should have affected tagged and untagged fish equally, however, it was assumed that overwinter mortality was negligible. Assumption 2 was tested with two Kolmogorov-Smirnov two-sample tests (Conover 1980). The first test compared the cumulative length distribution of fish marked in the first sampling event (mark event) with the cumulative length distribution of marked fish recaptured during the second sampling event (recapture event). In the second test, the cumulative length distribution of fish captured during the marking event was compared to the cumulative length distribution of all fish captured during the recapture event (Seber 1982). If the results of the first test showed that the samples were different ($P < 0.05$), size selectivity between samples was indicated. If the results of the second test showed that the samples were different ($P < 0.05$), recruitment, migration, capture gear selectivity, or some other factor affecting the size distribution of the two samples was indicated. A more complete tracking of test results and consequences is contained in Bernard and Hansen (1992). All fish were released within the reach of the river in which they were captured, and marked fish had the entire winter to mix with unmarked fish prior to migrating toward the sea in the spring of 1995. All fish did not have equal probability of being marked because the entire population was not present in the river during the marking event. However, the entire population moved through the subsistence fishery in the spring and all fish had an equal probability of capture during the second sampling event. To meet conditions of assumption 4, all tagged fish were also marked with an adipose fin clip.

The Chapman estimator of population abundance and the approximate variance of the estimate were calculated with the following formulas (Seber 1982):

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

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

where:

M = the number marked during the first event;

C = the number captured during the second event;

R = the number captured during the second event with marks from the first event;

$\hat{N}$ = the estimated abundance of Dolly Varden during the first event; and,

V = the approximate variance of the abundance estimate.

LENGTH COMPOSITION

The proportions of fish in each 25 mm size category were estimated as multinomial proportions (Cochran 1977).

The proportion in each category was estimated as:

$$\hat{p}_j = \frac{n_j}{n} \qquad (3)$$

where:

n_j = the number in the sample from group j;

n = the sample size; and,

p_j = the estimated fraction of the population that is made up of group j.

The unbiased variance of this proportion was estimated as:

$$V\left[\hat{p}_j\right] = \frac{p_j\left(1-\hat{p}_j\right)}{(n-1)} \qquad (4)$$

Abundance of Dolly Varden by length category was estimated as follows:

$$\hat{N}_j = \hat{p}_j(\hat{N}); \qquad (5)$$

where:

$\hat{N}_j$ = estimated number of fish in age category j;

$\hat{p}_j$ = estimated proportion of fish in age category j; and,

$\hat{N}$ = estimated abundance of Dolly Varden.

Variances for Equation 4 were estimated using Goodman's (1960) formula:

$$V[\hat{N}_j] = \left(\hat{p}_j^2 V\left[\hat{N}\right]\right) + \left(\hat{N}^2 V\left[\hat{p}_j\right]\right) - \left(V\left[\hat{p}_j\right] V\left[\hat{N}\right]\right); \qquad (6)$$

where:

$V[\hat{N}]$ was obtained from the mark recapture analyses.

Fulton - type condition factors were calculated using the following formula (Anderson and Gutreuter 1983).

$$K = \frac{W}{L^3}(X) \qquad (7)$$

where:

W = weight in grams;

L = fork length in millimeters;

X = a scaling constant, for these data, X = 10^4.

RESULTS

POPULATION ABUNDANCE

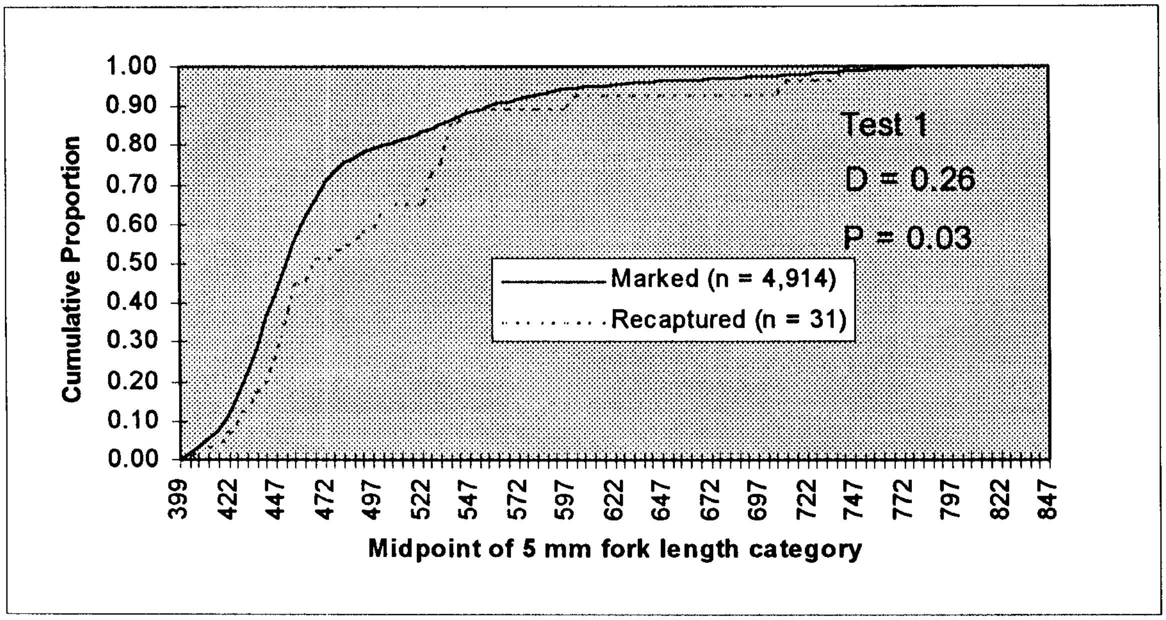
The estimated abundance of Dolly Varden greater than 399 mm FL in the Wulik River during the winter of 1994-1995 was 381,737 fish (SE = 74,400 fish, CV = 19.5%).

During the first sampling event, 14-23 September 1994, a total of 5,784 Dolly Varden were captured, and tagged in a 2 km section of the Wulik River. Of these fish, all but 10 were measured and they ranged from 250 mm to 826 mm FL. During the second sampling event, 7-12 June 1995, 1,058 Dolly Varden were measured from the subsistence fishery in Kivalina, of which 13 were carrying tags from the mark event. These fish ranged from 288 mm FL to 804 mm FL. In addition, 1,485 fish were inspected that were not measured because they had already been cut and hung on racks for drying. Of these unmeasured fish, 21 had been tagged. Eighteen of these tags were recovered, and three had been lost by the persons harvesting the fish. The tag recovery rate for measured fish was 1.21%, not different from the incidence of tags in the unmeasured sample, 1.41% (χ^2 = 0.157, p = 0.69). In order to use the unmeasured sample as well as the measured sample in calculating the abundance estimate, it must be assumed that the length distribution of the unmeasured sample is similar to that of the measured sample. This assumption was accepted because a Kolmogorov-Smirnov two sample test of the cumulative length distribution at the time of marking of the recaptures in the measured sample was similar to the length distribution at the time of marking of the recaptures in the unmeasured sample (D = 0.176, P = 0.976, n_1 = 13, n_2 = 17). The smallest of 5,774, Dolly Varden measured in the first sampling event was 250 mm FL and the smallest of 1,058 Dolly Varden measured in the second sampling event was 288 mm FL. Ten fish were tagged but not measured. The smallest marked fish recaptured in the second event was 430 mm FL when recaptured and 409 mm when marked. It was noted that all 13 recaptured fish that were measured had increased in length from the time of marking. This increase ranged from 9 mm to 37 mm with a mean of 22 mm. There was no correlation between length increase and initial size of the fish. Length increase may have been due to growth over the winter or because all recaptured fish were dead when measured (dead fish would likely be longer than live fish because of muscle relaxation), or due to the combination of these factors. Therefore, all lengths in the measured sample from the second sampling event were reduced by 22 mm in order to adjust for this phenomenon. The abundance estimate was calculated for Dolly Varden >399 mm FL because it is close to the length of the smallest recaptured fish at the time of marking, and it is the same lower bound used in the 1989 abundance estimate for the Wulik River.

Of the 5,784 Dolly Varden marked in the first sampling event, a total of 4,914 Dolly Varden were >399 mm FL. During the recapture event, 2,353 Dolly Varden >399 mm FL at the time of marking were examined (a combination of measured and unmeasured fish) of which 31 had tags from the marking event. No tag losses were detected.

Kolmogorov-Smirnov two sample tests of the cumulative length distributions of Dolly Varden > 399 mm FL marked during the first sampling event versus those recaptured during the second sampling event (length at marking) (test 1) detected significant differences (D = 0.26, P = 0.03, n_1 = 4914, n_2 = 31, Figure 2). A similar test of those marked during the first sampling event versus those examined in the second sampling event (lengths adjusted by -22 mm to account for the measurement of live fish in the fall of 1994 and dead fish in the spring of 1995) (test 2) also detected significant differences (D = 0.15, P < 0.01, n_1 = 4914, n_2 = 979; Figure 2). These tests indicate that size differences existed between the two samples. The size differences were likely due to gear bias during the second sampling event where gillnets and hook and line were used to capture fish in the subsistence fishery. Therefore, an abundance estimate stratified into two length groups was calculated. The first length group consisted of fish > 399 mm FL and < 481 mm FL and the second length group consisted of fish > 480 mm FL. The bound between length groups was established at the location of the greatest D value on test 2. Only fish from the first sample were used to estimate length composition since that sample was collected with a small mesh beach seine and was the sample with the least likelihood of size bias.

For the first length group in the stratified estimate, 3,650 Dolly Varden >399 mm FL and < 481 mm FL were marked in the first sampling event and 1,440 were examined during the second sampling event. Of these, 16 carried marks from the first sampling event. The estimated



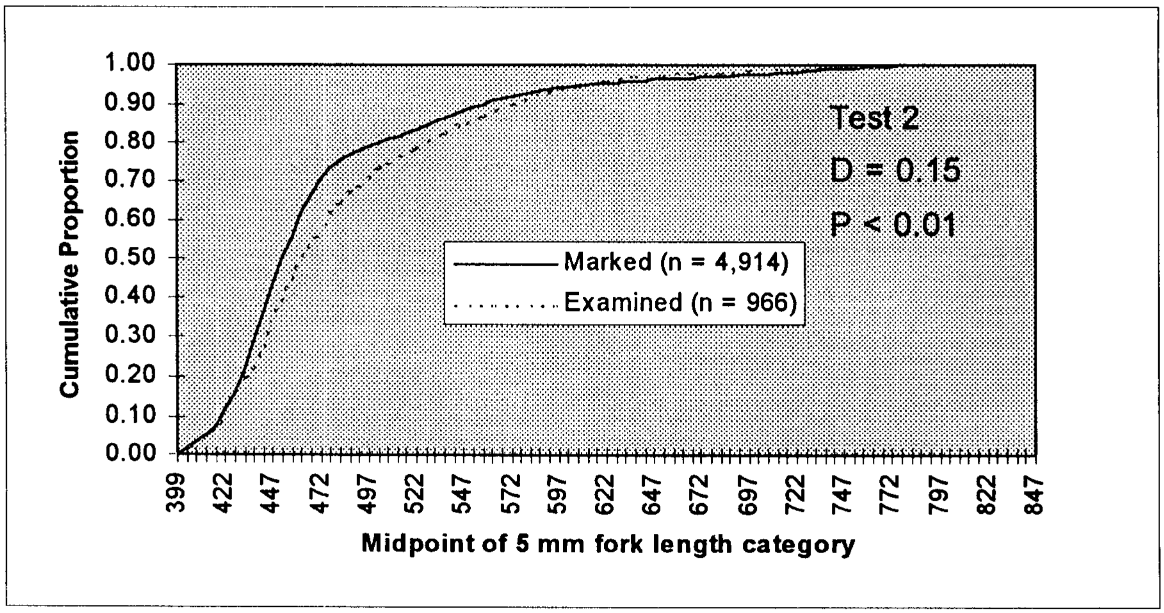


Figure 2.-Cumulative length distribution plots (tests 1 and 2) of Dolly Varden >399 mm FL sampled from the Wulik River during the fall of 1994 and the spring of 1995.

abundance of Dolly Varden >399 mm FL < 481 mm FL was 309,475 (SE = 72,344 fish, CV = 23.4%). For the second length group (fish >480 mm FL), 1,264 were marked in the first sampling event and 913 were examined during the second sampling event of which 15 carried tags. The estimated abundance of Dolly Varden >480 mm FL was 72,262 (SE = 17,262 fish, CV = 23.9%). This gives a total abundance estimate of 381,737 (SE = 74,375, CV = 19.5%). For comparative purposes a single unstratified estimate of abundance was also calculated providing an estimate of 361,559 (SE = 62,306, CV = 17.2%) Dolly Varden >399 mm FL.

Two aerial surveys were conducted by different observers in the last week of September 1994. The first survey count (24 September) was 66,937, and the second count (29 September) was 65,100.

LENGTH COMPOSITION

Captured Dolly Varden ranged in fork length from 250 to 826 mm. Length composition was estimated in 25 mm increments for Dolly Varden > 399 mm FL overwintering in the Wulik River during the winter of 1994 - 1995 (Table 2, Figure 3A). The vast majority of the population over 399 mm FL were between 399 and 500 mm FL (79%). Examination of size distribution of all Dolly Varden sampled during the fall of 1994 (Figure 3B) shows that several length modes (280 mm, 380 mm, 450 mm and 530 mm) were present in the sample. Although the first of these is poorly represented, the first three length modes likely correspond to size at the end of the first three years of anadromy.

WEIGHT - LENGTH RELATIONSHIPS AND CONDITION

Weight - length relationships were calculated for male and female nonspawning and spent Dolly Varden sampled from the Wulik River after entering from the sea during the fall of 1994, and after overwintering in the river during the spring of 1995. Spent Dolly Varden were lighter for their length than nonspawning Dolly Varden (Figures 4 and 5). Dolly Varden were lighter for their length after spending the winter in the Wulik River (Figure 6). Dolly Varden had a higher condition factor during the fall of 1995 than during the fall of 1994. The mean condition factor (Table 3) for Dolly Varden was 1.092 during the fall of 1994 and 1.178 during the fall of 1995, suggesting that better feeding conditions were available to them during the summer of 1995 than during the summer of 1994. It was also noted that Dolly Varden began entering the Wulik River from the sea much later in 1994 (early September) than in 1995 (early August). Fish that spawned during 1994 were in poor condition at onset of the overwintering period. The mean condition factor of Dolly Varden migrating to the sea in the spring of 1995 was 0.867 indicating that considerable energy reserves are utilized throughout the overwintering period.

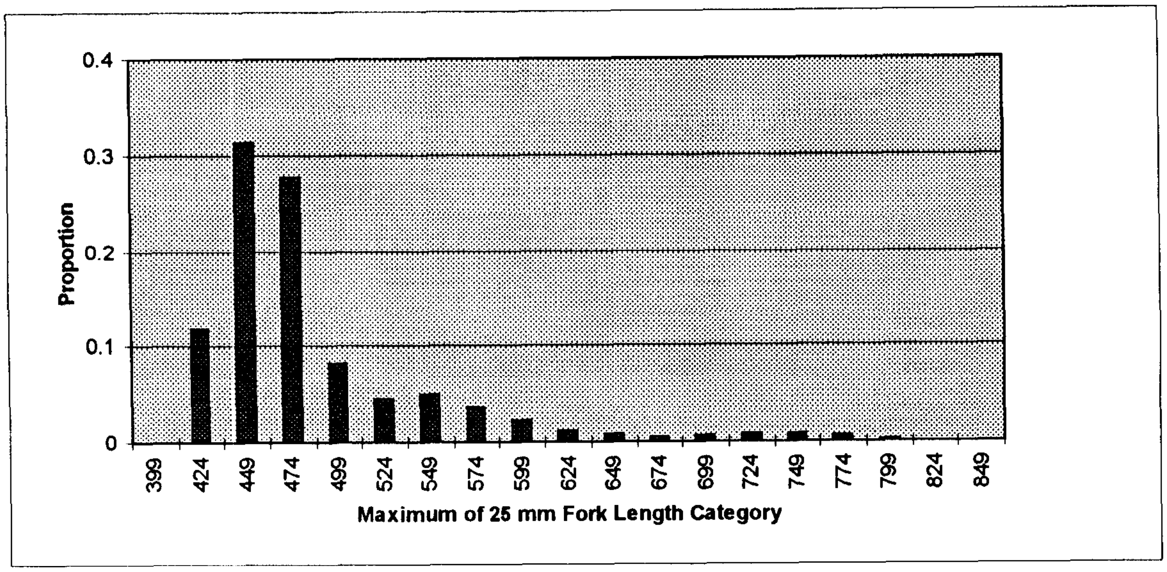
PRESENCE OF SCARS

The presence of scars was noted on Dolly Varden sampled during the fall 1994 marking event. Scars on the body of fish appeared as abrasions of the skin or disruptions of the scale pattern in a series of parallel, sometimes wavy lines consistent with injury caused by attempted predation by marine mammals. A total of 887 fish had scars (20.7%) of those inspected for this phenomenon.

Table 2.-Estimated length composition of Dolly Varden >399 mm FL in the Wulik River during the winter of 1994 - 1995 by 25 mm length increments.

Size Group (mm)	Sample Size	Estimated Proportion	Standard Error of Proportion	Estimated Abundance	Standard Error of Abundance
400 - 424	581	0.118	0.005	49,262	11,659
425 - 449	1,536	0.313	0.007	130,234	30,543
450 - 474	1,368	0.278	0.006	115,990	27,221
475 - 499	400	0.081	0.004	27,425	4,760
500 - 524	214	0.044	0.003	12,234	3,015
525 - 549	244	0.050	0.003	13,949	3,422
550 - 574	179	0.036	0.003	10,233	2,540
575 - 599	114	0.023	0.003	6,517	1,656
600 - 624	59	0.012	0.003	3,373	908
625 - 649	38	0.008	0.002	2,172	619
650 - 674	25	0.005	0.002	1,429	438
675 - 699	31	0.006	0.001	1,772	522
700 - 724	39	0.008	0.001	2,230	633
725 - 749	38	0.008	0.001	2,172	619
750 - 774	34	0.007	0.001	1,944	564
775 - 799	9	0.002	0.001	515	206
800 - 824	4	0.001	<0.001	229	124
825 - 850	1	<0.001	<0.001	57	57
Totals	4,914	1.00		381,737	89,506

A.



B.

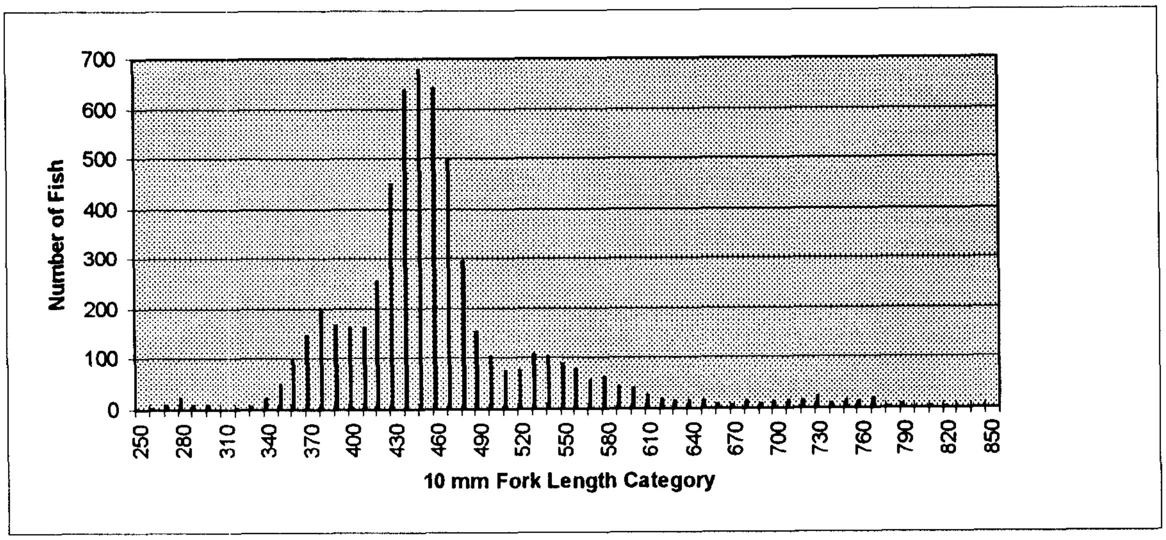
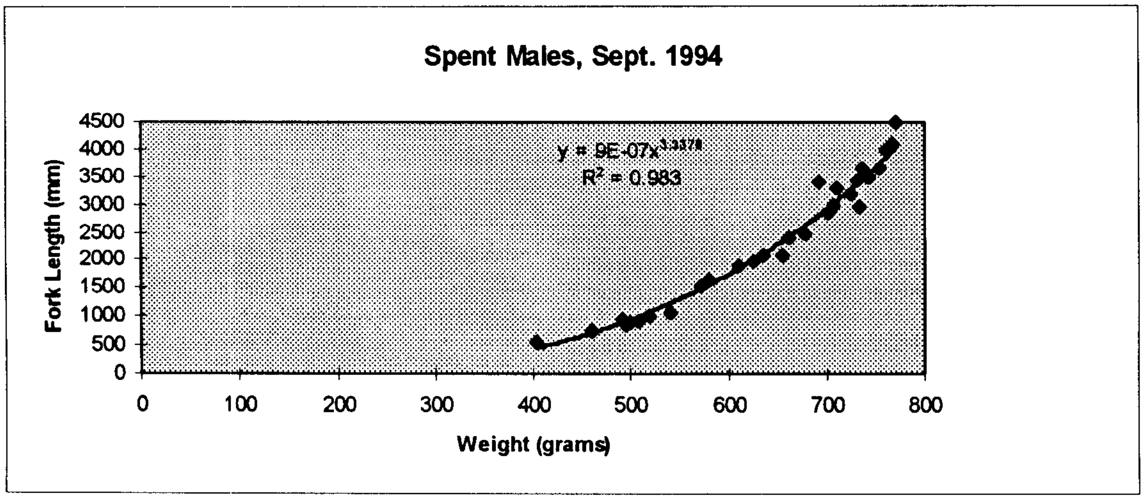


Figure 3.-Estimated length composition in 25 mm increments of Dolly Varden >399 mm FL in the Wulik River during the winter of 1994 - 1995 (A), and length distribution in 10 mm increments of Dolly Varden >200 mm FL sampled during the fall of 1994 (B).



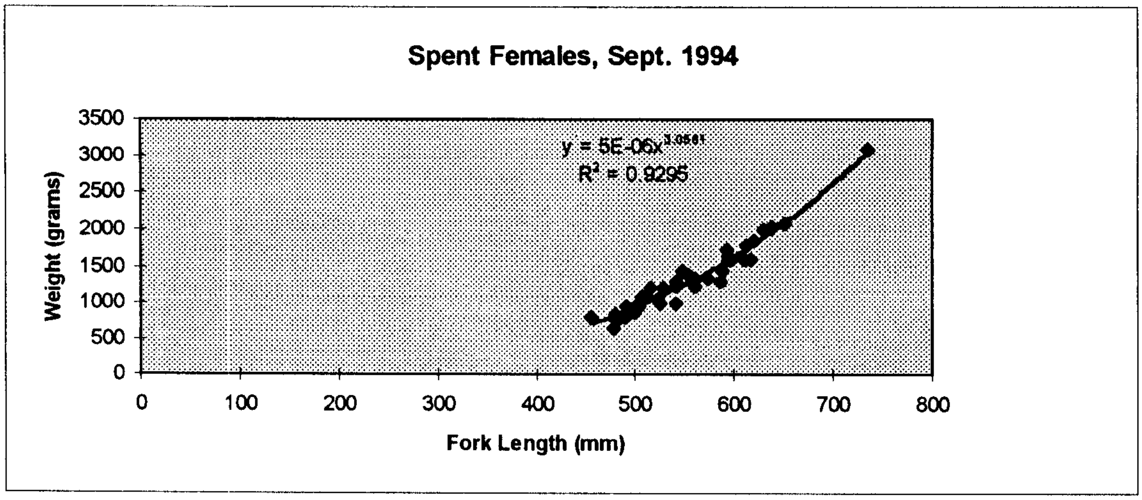
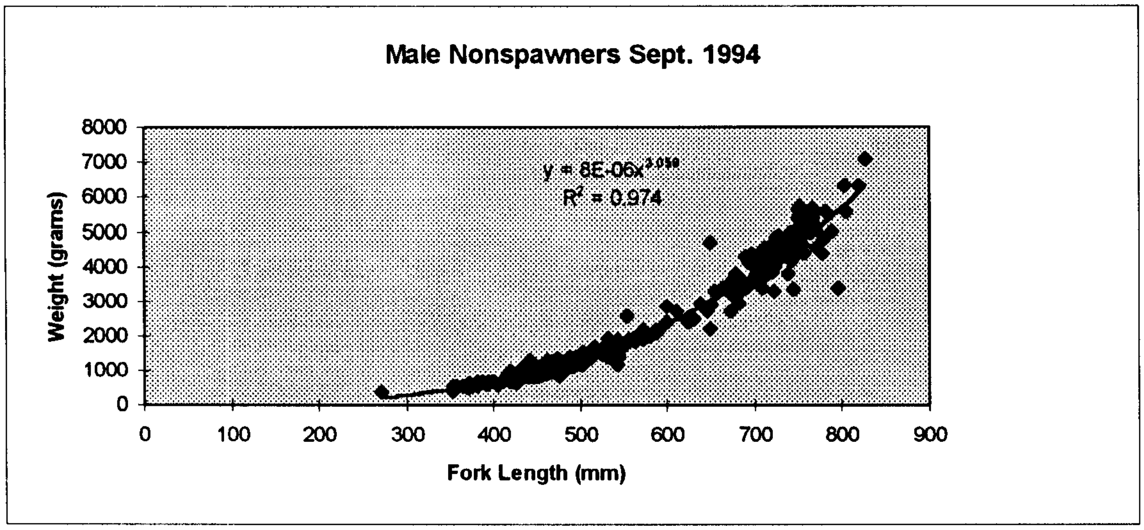


Figure 4.-Weight - length relationships of male and female spent Dolly Varden sampled from the Wulik River during the fall of 1994.



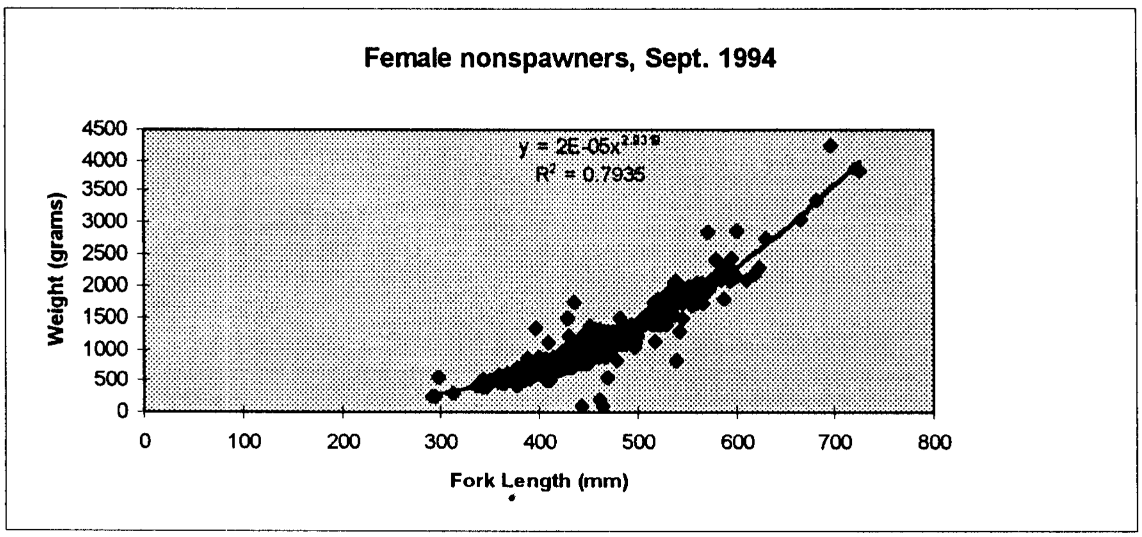
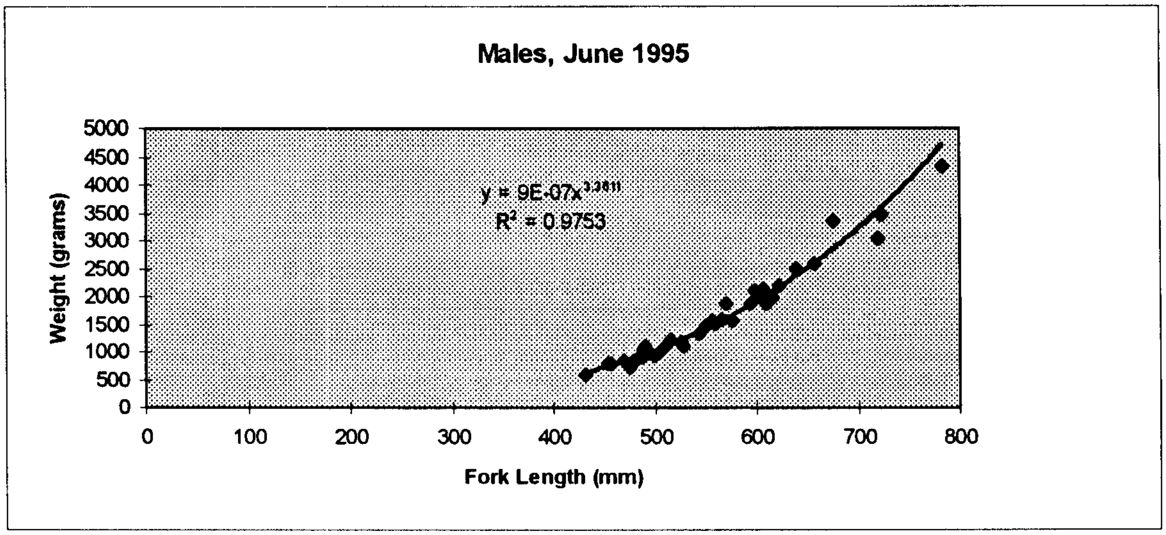


Figure 5.-Weight - length relationships of male and female nonspawning Dolly Varden sampled from the Wulik River during the fall of 1994.



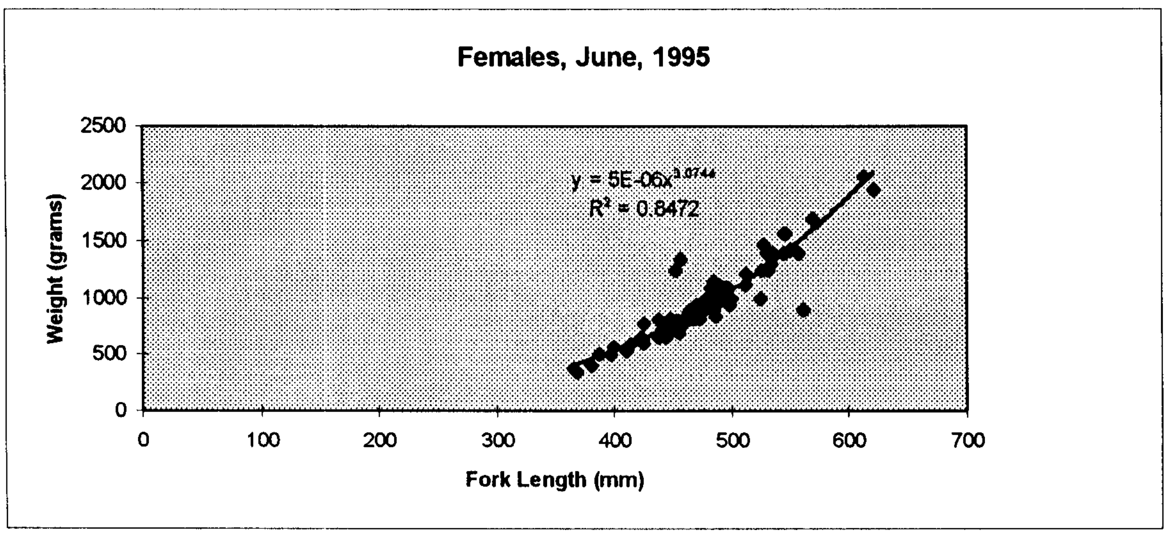


Figure 6.-Weight - length relationships of male and female nonspawning Dolly Varden sampled from the Wulik River during the spring of 1995.

Table 3.-Fulton's condition factors calculated for Dolly Varden sampled from the Wulik River during 1994 and 1995.

Sample Group	Sex	Sample Size	Mean Fulton's Condition Factor	Standard Error of Condition Factor
Fall 1994 Non - Spawners	Male	486	1.091	0.113
	Female	817	1.094	0.140
	Combined	1373	1.092	0.132
Fall 1994 Post - Spawners	Male	29	0.827	0.081
	Female	40	0.754	0.064
	Combined	69	0.786	0.080
Spring 1995 Non - Spawners	Male	39	0.871	0.080
	Female	96	0.866	0.117
	Combined	135	0.867	0.108
Fall 1995 Non - Spawners	Male	45	1.190	0.116
	Female	18	1.150	0.122
	Combined	63	1.178	0.119

DISCUSSION

The estimated abundance of Dolly Varden >399 mm FL overwintering in the Wulik River during the winter of 1994-1995 (381,737) was higher than any previous estimate or survey for this river. It is generally accepted that aerial surveys underestimate the true abundance of fish. The 24 September, 1994 aerial survey count of 66,937 grossly underestimated the overwintering population. However, this was more likely due to the run timing of the overwintering migration than to inability of observers to detect fish. A second observer conducted an aerial survey on 29 September, 1994 and counted 65,100 Dolly Varden. Dolly Varden normally begin entering the Wulik River during the second or third week of August, and by September 1st are well distributed within the entire length of the river used for overwintering. In 1994 fish did not begin entering from the sea until the first week of September, and were not distributed throughout the overwintering area until after 15 September. Residents of Kivalina reported that Dolly Varden were still entering the river as ice was forming on the last days of September. It was therefore assumed that the entire run of fish was not present in the river when the aerial surveys were conducted. An alternate explanation could involve an early summer movement of Dolly Varden from the Noatak River to the Kivalina Lagoon. Large numbers of Dolly Varden overwinter in the Noatak River which enters Kotzebue Sound about 145 km south along the coast from the mouth of the Wulik River. Armstrong (1965) indicated that nonspawning southern form Dolly Varden entered the lower reaches of nearby streams after leaving a system used for overwintering. If large numbers or Dolly Varden from the Noatak River entered Kivalina Lagoon in June, the effect would be to have inflated the abundance estimate. However, the distances involved in Armstrong's study were shorter, and although it is possible for some fish to move from the Noatak to Kivalina Lagoon, I consider it unlikely that large numbers of fish would undertake this movement after just having overwintered in the Noatak River.

Anadromous Dolly Varden and Arctic char make annual seaward migrations after smoltification at age 2 -7 (Johnson 1980, DeCicco 1985, Dempson and Kristofferson 1987). Reasons for the return to freshwater for overwintering have included osmoregulatory stress, and intolerance of winter sea temperatures, or some combination of these factors. Finstad et al. (1989) found seasonal differences in the ability of Arctic char to tolerate full strength seawater and concluded that increased day length induced hypo-osmoregulatory capacity in Arctic char during the summer. They also suggested that shorter photo periods in the fall corresponded to a decrease in seawater tolerance. The extreme differences in the timing of the fall migration into the Wulik River during 1994 and 1995, coupled with the differences in observed condition of fish sampled during these years offers another hypothesis that may be based on energetics. During years when ocean conditions are favorable for growth, fish are able to reach some threshold of condition in a short time and may enter fresh water earlier than in years when conditions are less favorable. During years with less favorable summer feeding conditions, fish may remain at sea as long as they are physiologically able to tolerate seawater, in order to accumulate as much energy reserves as possible. In the latter case, the movement into fresh water would be later and fish would tend to be in poorer condition than in the former case. The summer of 1994 is an example of the latter case, and the summer of 1995 is an example of the former.

That the summer of 1995 was an exceptional year for ocean growth of Dolly Varden in northwestern Alaska is best illustrated with the following example. Based on mean condition factors, a 700 mm FL male Dolly Varden in the Wulik River would have weighed about 3.75 kg in the fall of 1994. The same fish would have weighed about 3 kg as it migrated to sea in the spring of 1995. A similar 700 mm FL fish would have weighed 4 kg when it returned to the Wulik River in the fall of 1995. However, based on tag recovery data, a 700 mm FL fish in the spring of 1994 would have grown to about 755 mm FL by the fall of 1995 and weighed about 5.1 kg, a 70% increase in weight in just a few months.

The 21% rate of scaring observed on the 1994 fall sample was remarkable and suggests that predation by marine mammals may be a significant cause of mortality for Dolly Varden in northwestern Alaska during some years. I have observed such scars in other years, but never have they been prevalent enough to note their frequency of occurrence. Examination of photographs of Dolly Varden with scars suggests that they are consistent with those caused by spotted seal *Phoca largha* Pallas, the most common marine mammal in the region. The timing of the fall migration in 1994 may have caused Dolly Varden to come in contact with higher concentrations of spotted seals. Spotted seals from the northern Chukchi Sea (Kasigiuk Lagoon group) tend to move southward during late September and October (Lloyd Lowery, ADF&G Division of Wildlife Conservation, personal communication). Dolly Varden moving from the north along the coast toward the Wulik River would more likely encounter concentrations of these mammals during a late fall migration than during a normal or early fall migration. If this is indeed true, it would suggest that additional time spent at sea is not without additional risk.

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APPENDIX A

Appendix A1.-List of numbered tags and finclips used to mark Dolly Varden sampled from the Wulik River in 1994.

Location	Month	No. Fish	Tag Numbers	Color	Fin Clip
Wulik River	September	5,781	0001 - 5,781	White	Adipose

APPENDIX B

Appendix B1.-List of data files[a] used to estimate parameters of Dolly Varden in the Wulik River, 1994-1995.

Data File	Description
X0050LA5.DTA	Mark data for Dolly Varden captured from the Wulik River during the fall of 1994.

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