Fishery Data Series No. 93-14

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by

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[1] This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-8 Job Number S-2-3.

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ABSTRACT

During April 13 - June 19, 1992 a weir was operated at the outlet of Buskin Lake to estimate abundance, growth, length distribution, survival, age composition, and run timing of Dolly Varden *Salvelinus malma*. Of a total of 74,451 Dolly Varden that emigrated through the weir, 7,202 were tagged and 284 were recaptured from previous tagging efforts. A total of 3,422 Dolly Varden were counted emigrating through a weir on the stream running from Lake Louise to the Buskin River. The dominant age class in the 1992 emigration was age 5. Survival estimates from recaptures at the weir ranged from a low of 6.3% from 1990 to 1991 to a high of 18.5% from 1989 to 1990. The Jolly-Seber estimate of survival from 1990 to 1991 was 29.3%. The Jolly-Seber abundance estimate for 1991 was 60,585 compared to the weir count of 30,725. American River estimates of abundance for both Jolly-Seber and Petersen methods for 1989 and 1990 were not significantly different.

KEY WORDS: Buskin Lake, American River, Dolly Varden, *Salvelinus malma*, abundance, growth, length, age composition, survival, Jolly-Seber, Petersen, overwintering.

INTRODUCTION

The Buskin River (Figure 1), near the city of Kodiak, is the most intensively fished river on Kodiak Island. In 1990, approximately 42% of the freshwater sport fishing effort on Kodiak Island occurred on the Buskin River (Mills 1991). Angler effort on the Buskin River is directed toward Dolly Varden *Salvelinus malma*, coho salmon *Onchorhynchus kisutch*, sockeye salmon *O. nerka*, and pink salmon *O. gorbuscha*. The Dolly Varden sport harvest ranged from 3,948 to 15,680 fish during the period 1977 through 1990 (Mills 1979-1991).

Buskin Lake (Figure 2) was assumed to be the major overwintering area for Dolly Varden that spawn in tributaries throughout Chiniak Bay. This "super-population" of Dolly Varden was thought to overwinter in Buskin Lake and emigrate from Buskin River in the spring to feed in marine waters during the summer. Some individuals spawn in other streams before returning to the lake in the fall to overwinter (Sonnichsen 1990). This is consistent with the complex migratory patterns described by Armstrong (1965).

Dolly Varden found in the Buskin Lake "super-population" contribute to sport fisheries throughout the Chiniak Bay area. Depletion of the Dolly Varden population in the Buskin River could result in a reduction in the number available for sport harvest in all of the Chiniak Bay streams.

This is the seventh year of a long-term study of the Dolly Varden fishery in the Buskin River. This project has concentrated on developing a model of stock structure for this resource that includes abundance, survival, and growth.

Specific objectives for the 1992 study were to:

1. census the emigration of Dolly Varden 210 mm or longer (fork length) through the weir on the Buskin River from mid-April through mid-June.

2. estimate size at which the weir pickets without Vexar stop Dolly Varden to compare 1990 to 1992 data with 1989 data.

3. estimate abundance and survival of emigrating Dolly Varden 210 mm and over for 1990 and 1991 with the Jolly-Seber model using data from 1990 - 1992.

4. estimate length compositions of Dolly Varden during the entire spring emigration.

5. census the emigration of Dolly Varden 210 mm or longer (fork length) through the weir on the stream leaving Lake Louise and entering the Buskin River from mid-April through mid-June.

6. estimate length compositions of Dolly Varden during the emigration from Lake Louise.

7. estimate age composition of Dolly Varden emigrating from Buskin Lake.

8. develop a growth model from mark-recapture data.

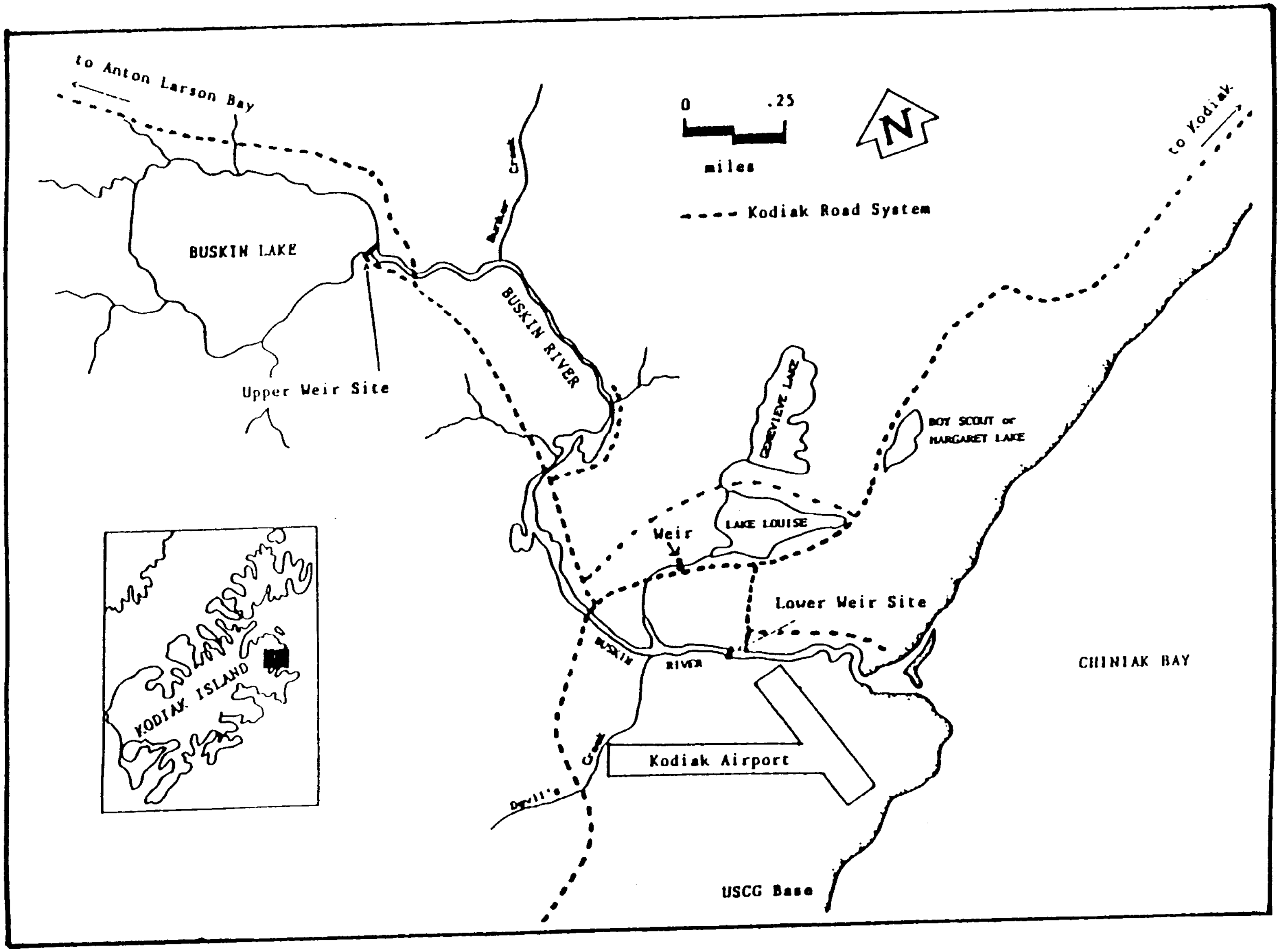

Figure 1. Buskin River, Kodiak Island, Alaska.

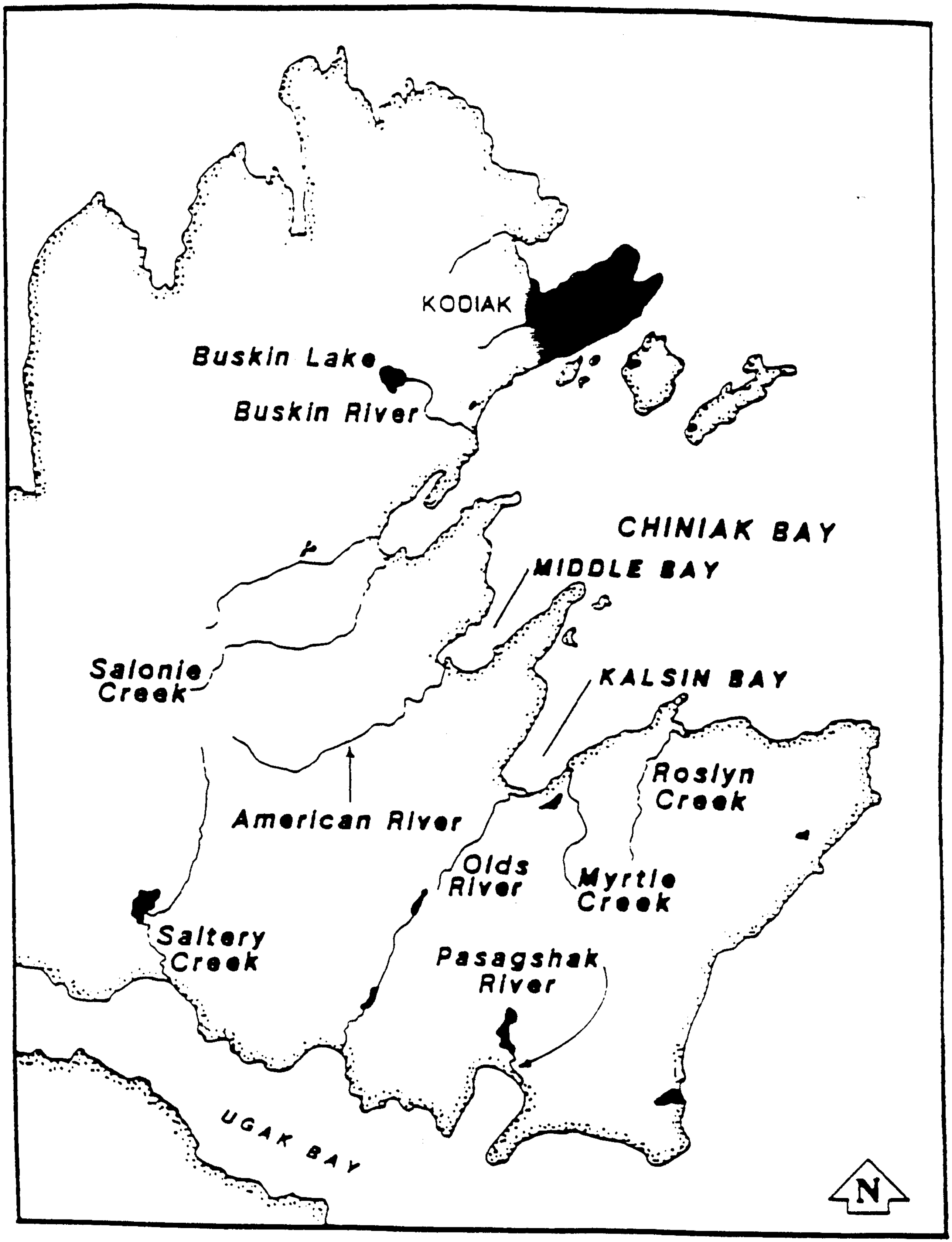

Figure 2. The Chiniak Bay area, Kodiak Island, Alaska.

9. estimate survival from recaptures at the Buskin River weir.

10. estimate abundance, survival, and recruitment for the American River spawning population from 1988 to 1990 with the Jolly-Seber model using data from 1988 to 1991.

METHODS

Dolly Varden Census

Weirs were constructed at the outlet of Buskin Lake and on the stream leaving Lake Louise.

Buskin River Weir:

Dolly Varden emigration was assessed with an aluminum picket weir overlaid with 2.54 cm (1 inch) Vexar plastic mesh. A trap was incorporated into the weir to capture Dolly Varden. The weir was installed at the outlet of Buskin Lake on 13 April and continued until 19 June. We believe the initial portion of the emigration was not missed because the weir was installed prior to ice breakup on Buskin Lake. The trap did not retain Dolly Varden from 25 to 30 May due to high water level.

Dolly Varden were counted and measured for fork length. Approximately 10% of the Dolly Varden passing through the weir were tagged with numbered green Floy FD 68D anchor tags as were done from 1989 to 1991. Another 12% of the Dolly Varden were examined for the presence of a tag. A sample of at least 150 fish was sacrificed during each two week time period to collect otoliths for age composition analysis.

Water temperatures and relative water levels were measured daily at the weir.

Lake Louise Weir:

A weir was installed on the stream that flows between Lake Louise and the Buskin River on 25 April. The weir consisted of a wood frame structure overlaid with 2.54 cm (1 inch) Vexar plastic mesh. A trap was incorporated into the center of the weir to capture and retain Dolly Varden. At least 125 fish were measured for fork length each week. No tagging was performed at this site. All Dolly Varden measured were examined for the presence of a tag and fin clips. On a few occasions, this weir was vandalized. It was believed that no fish emigrated without being enumerated due to the vandalism. The Lake Louise weir was dismantled on 19 June.

Biological Data

Length Composition:

Kolmogorov-Smirnov two-sample tests were used to test the null hypothesis that length distributions did not differ among weeks.

Prior to 1990, the Vexar mesh was not used on the weir, allowing smaller fish to pass through the pickets without being counted. A test was performed to estimate the size at which Dolly Varden could pass through the pickets without Vexar, so that weir data prior to 1990 could be evaluated. Approximately 100 tagged Dolly Varden between 250-350 mm in length were placed in a sampling box below the weir for four weeks. The sampling box had Vexar on the upstream end and two sides. The downstream end of the box was constructed with an aluminum weir picket panel placed at the same angle as the weir. Fish remaining in the box after 48 hours were removed and tag numbers were recorded.

A probit analysis was conducted to model the probability of fish of a length class that could not pass through the weir picket panels. Fish were tagged, measured, categorized into 10 mm length classes, and placed in the sample box. Nearly an equal number of fish of each class was used during the test. The following probit model (Agresti 1990) was used:

$$\pi(x) = \Phi(\alpha + \beta x) \tag{1}$$

where:

π = probability that a fish of length class x will not pass through the weir picket panels,

Φ = standard normal cumulative distribution function,

α, β = parameters of the model, and

x = length class.

A goodness of fit test was conducted to test the null hypothesis that the expected probability of fish of length X retained by the weir panels satisfies the model. Rejecting the null hypothesis indicates the model does not adequately fit the data.

Anderson-Darling k-sample tests were used to determine significant differences between weekly length distributions at the Lake Louise weir.

Age Composition:

Sagittal otoliths were collected from random samples of emigrating Dolly Varden. Otoliths were stored dry, then soaked in a 50% glycerine and 50% water solution for about 24 hours. The otolith was placed on a black background and viewed with reflected light through a binocular microscope (10X). Age was determined by counting the number of hyaline zones on the otolith (Nordeng 1961). The age composition of Dolly Varden was estimated by:

$$\hat{P}_h = \frac{n_h}{n_t}, \tag{2}$$

and it's variance was estimated as:

$$V[\hat{p}_h] = \frac{\hat{p}_h(1 - \hat{p}_h)}{(n_t - 1)}, \qquad (3)$$

where:

n_h = number of otoliths of age h, and

n_t = total number of otoliths read.

Kolmogorov-Smirnov two-sample tests were used to determine significant differences between the lengths of the age sample and the length sample from the weir by three 2-week time periods. If the length distributions were the same between samples, the age composition was directly applied to weir length samples. Since the distributions differed in the second and third 2-week periods, the total age composition was weighted using the weir length compositions. The weighting procedure involved multiplying the value estimated in equation (2) (by each length category (10 mm groups) by age) with the actual number in each length category measured from the weir length sample. These values were summed across length categories. Age composition frequencies were calculated as in equation (2) and then pooled by 2-week periods for the total weighted age composition.

Anderson-Darling k-sample tests were used to test the null hypothesis that the length distributions did not differ between the two sexes of Dolly Varden.

Growth Model:

Non-linear least squares estimation procedures were done for all four cases of the Schnute size-age growth model (Schnute 1981, Baker et al. 1991) using mark-recapture data collected each spring from 1989 to 1992. I also added a case five representing the von Bertalanffy model:

$$Y_r = [Y_m^b \exp[-a(t_r - t_m)] + \frac{y_1^b - y_2^b \exp[-a(T_2 - T_1)]}{1 - \exp[-a(T_2 - T_1)]} (1 - \exp[-a(t_r - t_m)])]^{1/a}, \qquad (4)$$

where:

Y_r = size at recapture (input from data),

Y_m = size at marking (input from data),

$t_r - t_m$ = time (in years) between recapture and marking (input, from data),

y_1 = length of smallest fish found in mark-recapture sample (set at 198 mm),

y_2 = length of largest fish in population (parameter to be estimated),

T_1 = age at marking (determined from random age-length sample from 1989 to 1992 emigration, set at four),

T_2 = age at recapture (same as T_1, set at 12),

a = Brody growth parameter, determining the shape of the growth curve (parameter to be estimated),

b = relative location of the inflection point (in this case, set at one).

The most parsimonious model for each year was chosen using a general linear model F-test (Baker et al. 1991):

$$F = \frac{RSS_y - RSS_x}{df_y - df_x} / \hat{\sigma}_x^2 \qquad (5)$$

where:

RSS_y = residual sum of square of case y.

RSS_x = residual sum of square of case x.

df = degrees of freedom of the respective cases, and

$\hat{\sigma}_x^2$ = residual mean square error of case x

= (RSS_x/df_x).

The null hypothesis that both cases adequately fit the data was rejected at $\alpha = 0.05$ if the F value was greater than the $F\alpha(df_y-df_x, df_x)$. If more than one case was accepted and had the same number of parameters, the case with the lowest RSS was chosen.

Stock Structure

Jolly-Seber Estimation:

In addition to the weir counts, abundance and survival were estimated with a Jolly-Seber model (Jolly 1965, Seber 1965) using mark-recapture data collected at the weir. The Jolly-Seber model provided estimates of abundance for 1991 and survival for 1990. Jolly-Seber methods were also used on the American River spawning population data collected from 1988 to 1991. Estimates for the American River were for: 1988 and 1989 (survival), 1989 and 1990 (abundance), and 1989 (recruitment).

The following assumptions must be met to achieve unbiased estimates from this open population model (Seber 1982):

1. marked fish have the same probability of being caught in the *i*th sample as unmarked fish.

2. marked fish have the same probability of survival as unmarked fish.

3. marked fish do not lose their marks.

4. all samples are instantaneous.

5. all marks are recognized and reported on recovery.

The computer program JOLLY (Pollock et al. 1990) estimated abundance, recruitment and survival (Seber, 1982: 196-205). The capture histories for both data sets used in this program are given in Table 1.

To test the assumption that marked fish do not lose their marks, the fish that were tagged were also examined for adipose and left ventral fin clips. Dolly Varden were tagged and adipose fin clipped during the spring and fall sampling events in 1989 (Sonnichsen 1990). No fin clips were used in 1990. A left ventral fin clip was used on fish tagged during the 1991 spring emigration (Whalen 1992). Tag loss was estimated by:

$$\hat{p}_{li} = \frac{n_{li}}{n_l}, \tag{6}$$

where:

n_{li} = number of fish recaptured in 1992 that were missing a tag and fin clipped in year i, and

n_l = total number of fish recaptured in 1992 that were marked in year i.

Variance of the tag loss point estimate is approximated using the following equation:

$$\hat{V}[\hat{p}_{li}] = \frac{\hat{p}_{li}(1-\hat{p}_{li})}{n_l-1} \tag{7}$$

To distinguish naturally missing or disfigured adipose fins in fish with no tag and no adipose fin from fin clipped (hence tag loss) fish, I used the growth model described above to calculate what size the smallest fish tagged in 1989 would be during the 1992 season. I then removed all fish smaller than that size and used the remaining fish to estimate tag loss.

Survival Estimation:

In addition to the Jolly-Seber survival estimates, I estimated survival rates for the Buskin River and American River using recapture data one year after marking. The procedure involved using the proportion examined for marks from the weir operation the following year:

Table 1. Capture history for emigrating Buskin River Dolly Varden for 1990 to 1992 for the JOLLY computer program. Captured in the event = 1, not captured in the event = 0.

1990	1991	1992		Frequency
0	0	1		7,307
0	1	0		4,640
0	1	1		102
1	0	0		8,172
1	0	1		49
1	1	0		196
1	1	1		4
			Total	20,470

$$\hat{S}_i = \frac{m_{i+1}}{M_i \, \phi_{i+1}} \quad (8)$$

$$\phi_{i+1} = \frac{n_{i+1}}{N_{i+1}} \quad (9)$$

where:

$\hat{S}_i$ = survival from the ith year to the (ith + 1) year,

M_i = number of fish marked and released in the ith year,

m_{i+1} = recaptures found in (ith + 1) year marked in the ith year,

ϕ_{i+1} = proportion examined for marks in the (ith + 1) year,

n_{i+1} = number of fish examined for marks in the (ith + 1) year,

N_{i+1} = weir count in the (ith + 1) year.

Variance of survival was estimated as:

$$V[\hat{S}_i] = (\phi_{i+1})^{-2} \frac{p_m(1-p_m)}{M_i - 1} \quad (10)$$

where:

p_m = proportion marked in examined sample = m_{i+1}/M_i

RESULTS

Dolly Varden Census:

A total of 74,451 Dolly Varden emigrated through the Buskin River weir (Appendix A1) in 1992. Appendix A2 lists weir counts at the Buskin River weir for 1985-92. Peak weir counts coincided with increasing water level and a water temperature of 6° C. Water level remained low for an extended period of time due to a lack of rainstorm events followed by a storm on 25 May. The storm increased water levels and Dolly Varden holding in front of the weir moved downstream (Figure 3). A total of 33,128 (44.5% of the emigration) fish passed through the weir in the six days following the storm. These fish could not be measured, tagged or examined for tags, so a length distribution or a recapture percentage were not available for this portion of the population.

Data collected from the weir picket test did not allow for modeling the probability of fish of a given length class passing through the weir pickets. Because a number of fish of the larger length classes swam through the weir pickets in the sample box, there were no data to fit the upper end of the distribution. Dividing the data into different 10 mm length classes affected

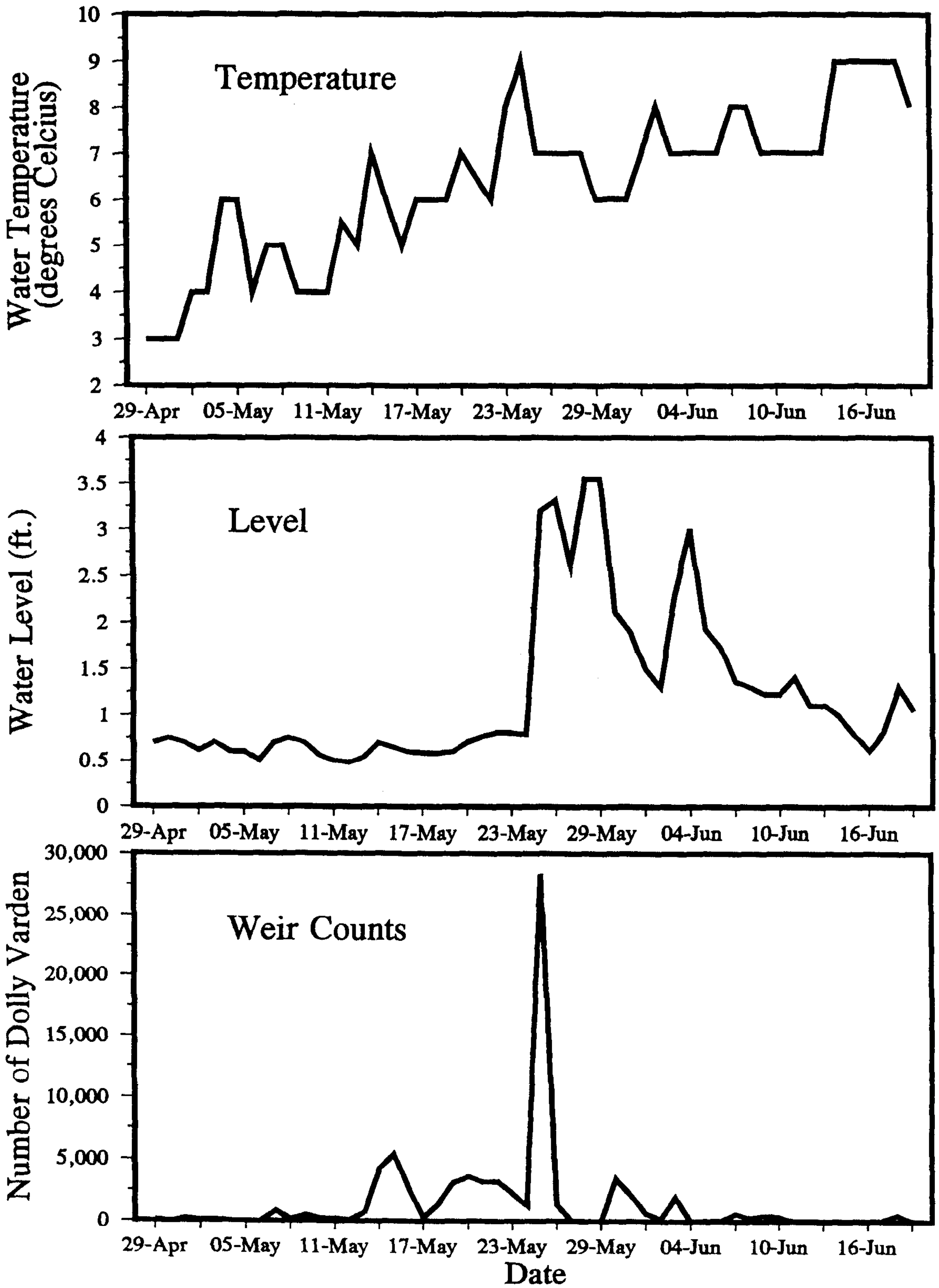

Figure 3. Water temperatures, levels, and daily weir counts for the Buskin River Dolly Varden emigration, spring 1992.

whether the model did not fit (Figure 4A; goodness of fit G^2 = 19.74, 8 df, P = 0.01) or did fit (Figure 4B; G^2 = 8.11, 7 df, P = 0.32) the data. The mean length at which Dolly Varden were too large to pass through the weir pickets was 329 mm. The variability in these data does not allow for a clean method by which to make data collected with Vexar mesh (1990 to 1992) comparable to data collected without Vexar mesh (1984 to 1989).

The Lake Louise weir count totalled 3,422 Dolly Varden and 161 rainbow trout (Appendix A3).

Biological Data

Length Composition:

The proportion of Dolly Varden < 300 mm increased over the first four weeks of the emigration (Figure 5). Trends during the last four weeks of the emigration were not as distinct, but appeared to go back to larger fish (Figure 6). Kolmogorov-Smirnov tests found significant differences in length distribution among all paired combinations of weeks (Table 2). Cumulative length distribution frequencies agreed with the above conclusions, though a number of the weeks did not show differences between 240 and 330 mm (Figure 7). A weighted overall length frequency was calculated using the weir counts and number of fish measured in each length category (Figure 8). Length at full recruitment to the weir appeared to be the same as in 1990 and 1991: 210 mm. A visual comparison of weighted length frequencies among 1990, 1991 and 1992 showed a higher portion of recruit size fish in 1992 (Figure 9).

The weighted length composition of Dolly Varden sampled at Lake Louise indicated these fish were smaller than those at the Buskin River (Figure 10). The cumulative length distributions of fish > 200 mm (Figure 11) were significantly different (D_{MAX} = 0.1434, P = 0.0001) between the two systems. Average size of Dolly Varden from Lake Louise (270 mm) was closer to the average size of fish from the Buskin River weir (284 mm) than in 1991. Average size of fish from Lake Louise and Buskin River in 1991 was 284 and 322 mm, respectively. Weighted length distributions of fish leaving Lake Louise were similar during 1991 and 1992 except that in 1992 there were fewer larger (> 330 mm) fish (Figure 12). As with the Buskin River, larger fish tended to emigrate from Lake Louise earlier than smaller fish. The length distribution shifted toward smaller fish over time, but a pulse of larger fish left the lake during the fourth week (Figure 13). Length compositions were not significantly different between weeks one and four and among weeks two, three and five (Table 3).

Tag Returns:

During 1984-92, a total of 60,367 Dolly Varden were tagged from the Chiniak Bay, Ugak Bay and Afognak Island areas combined (Table 4). Between 29 April and 19 June 1992, 7,202 Dolly Varden were tagged. A total of 15,928 Dolly Varden were examined for tags. Generally, fish were tagged in proportion to abundance (Figure 14) and in relation to length distribution. Recaptures totalled 284 fish. Thirty-seven percent (106 fish) of the recaptures were from 1991 spring Buskin Lake tagging (Table 5). Survival rates estimated from recapture rates varied considerably among years (Table 6).

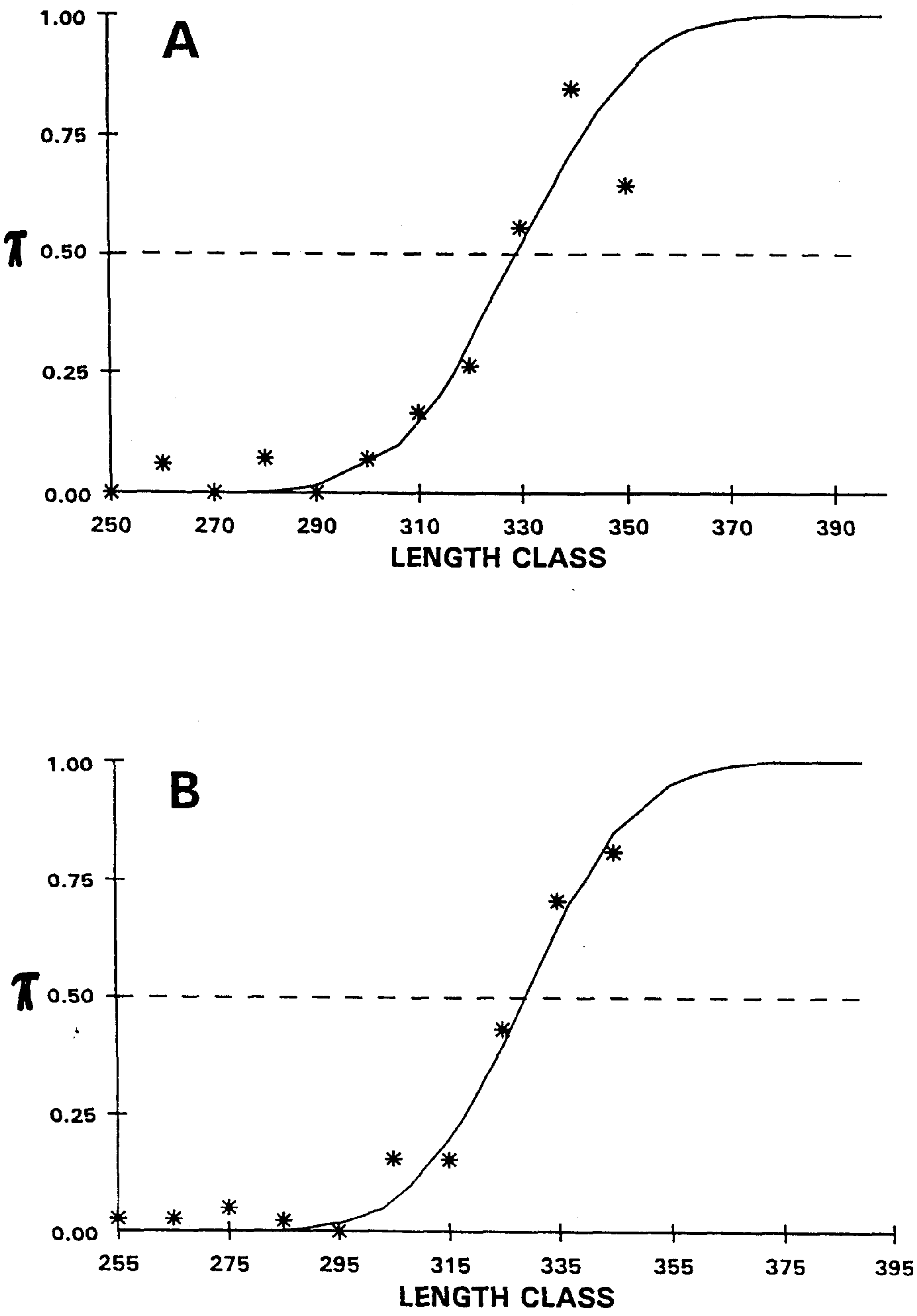

Figure 4. Probit models of the probability of Dolly Varden of a given length class not passing through the weir panel pickets. Model in A did not fit the data but model in B did fit the data.

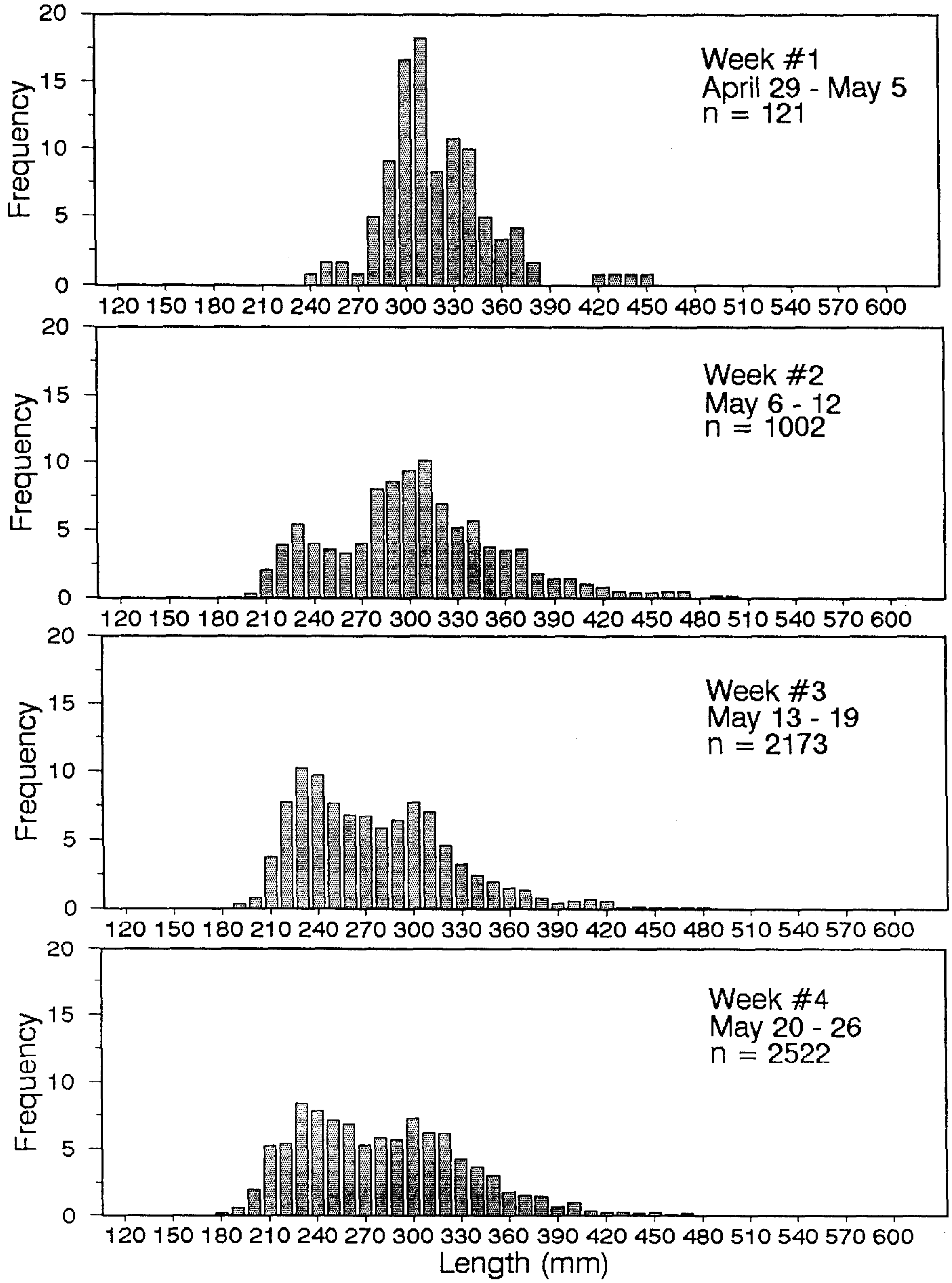

Figure 5. Length frequencies for emigrating Buskin River Dolly Varden for weeks 1 through 4, 1992.

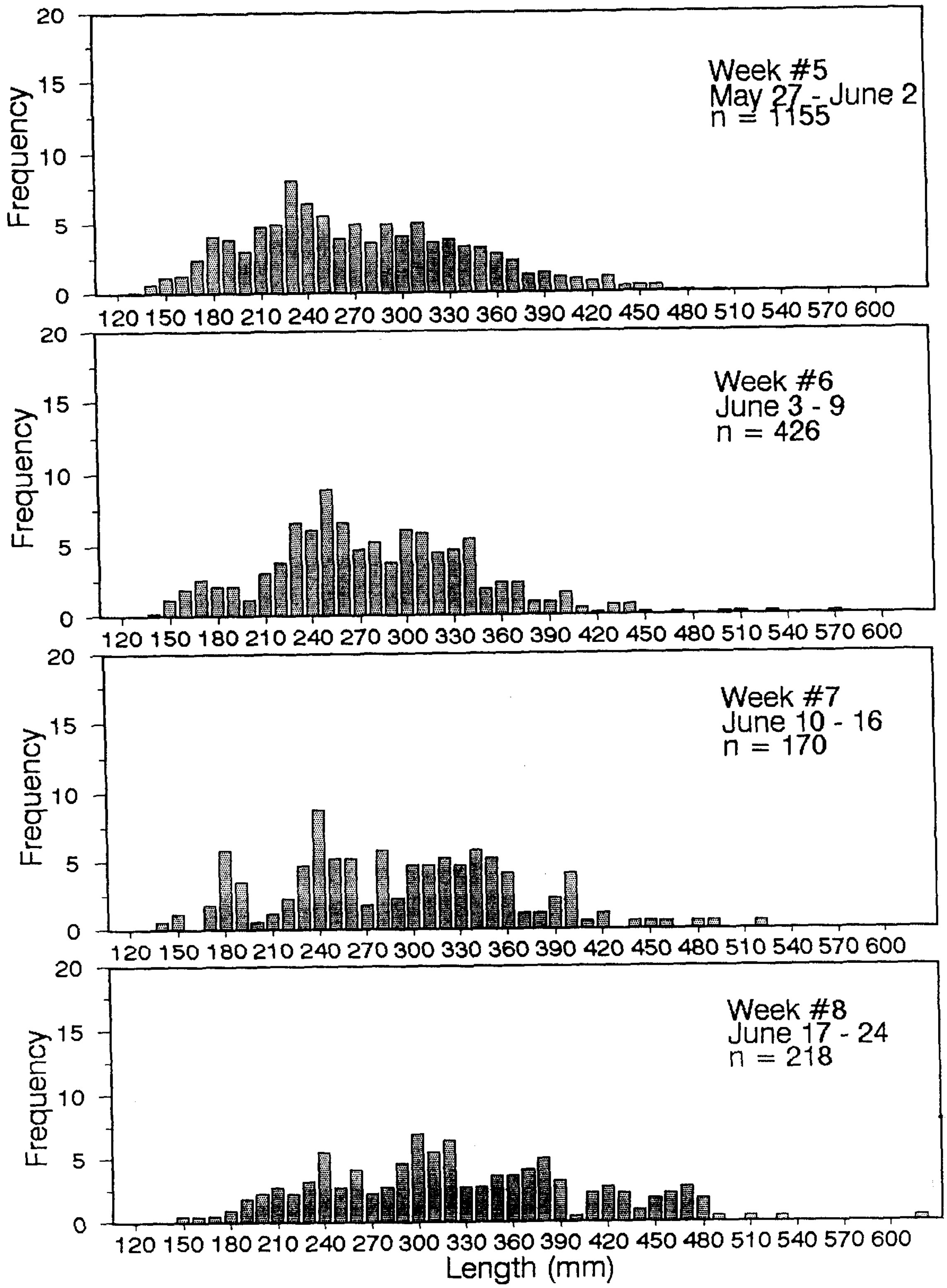

Figure 6. Length frequencies for emigrating Buskin River Dolly Varden for weeks 5 through 8, 1992.

Table 2. Results of Kolmogorov-Smirnov tests on length distributions for Buskin River Dolly Varden emigration, spring 1992.

			Comparison Week[a]						
			2	3	4	5	6	7	8
Week #	n		n = 1002	n = 2173	n = 2522	n = 1155	n = 426	n = 170	n = 218
1	121	D_{MAX}	0.0542	0.0046	0.0117	0.0449	0.0303	0.0964	0.2449
		P	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001
2	1002	D_{MAX}		0.0005	0.0008	0.0022	0.0094	0.0458	0.2087
		P		<0.0000	<0.0001	<0.0001	<0.0001	0.0001	<0.0001
3	2173	D_{MAX}			0.0666	0.0961	0.0921	0.2036	0.3247
		P			0.0001	<0.0001	0.0004	<0.0001	<0.0001
4	2522	D_{MAX}				0.0555	0.0432	0.1568	0.2822
		P				<0.0001	0.0033	0.0007	<0.0001
5	1155	D_{MAX}					0.1033	0.1329	0.2751
		P					0.0024	0.0097	<0.0001
6	426	D_{MAX}						0.1229	0.2586
		P						0.0447	<0.0001
7	170	D_{MAX}							0.1924
		P							0.0013

[a] Weeks significantly different if $P < 0.05$.

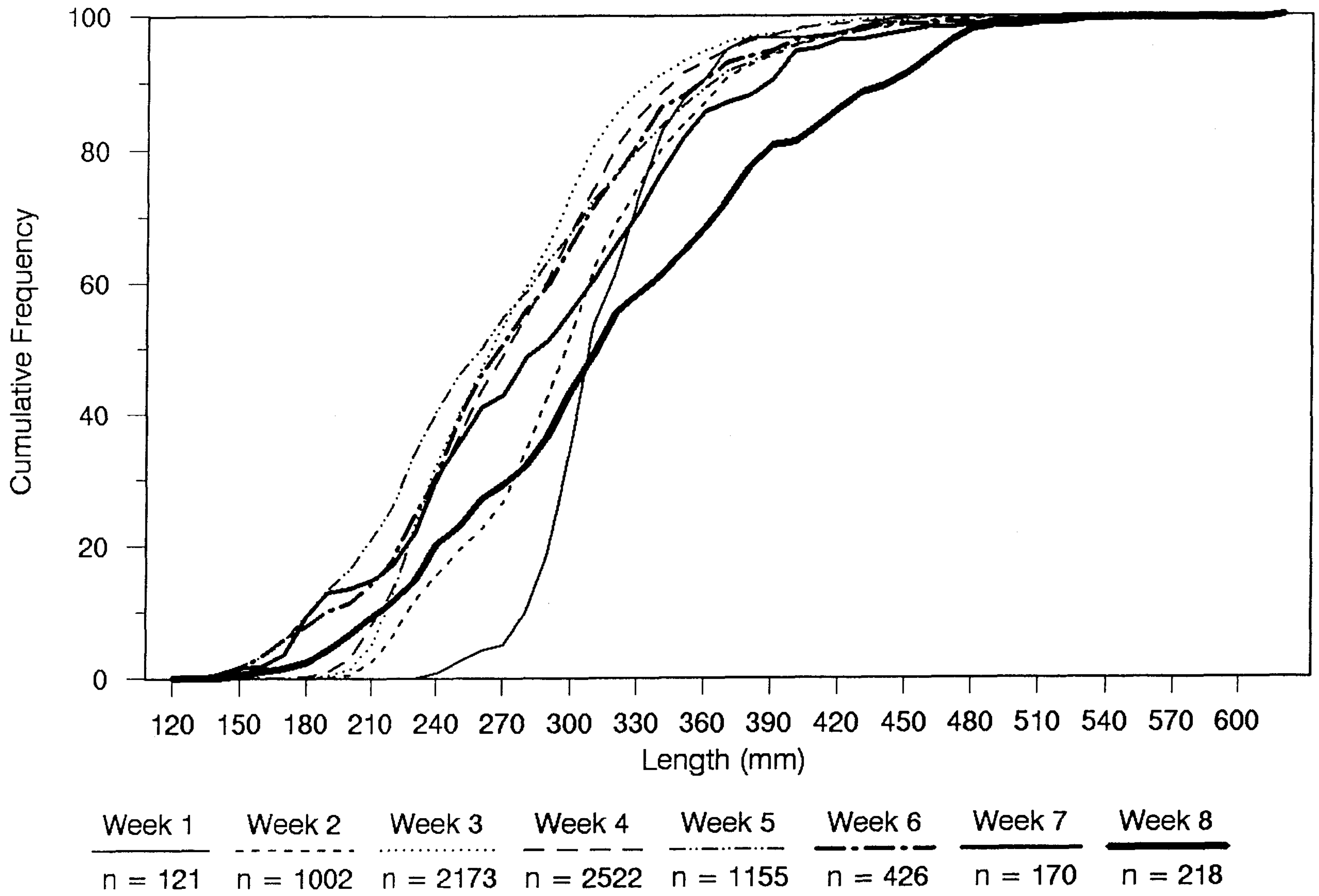

Figure 7. Cumulative length frequencies for emigrating Buskin River Dolly Varden, spring 1992.

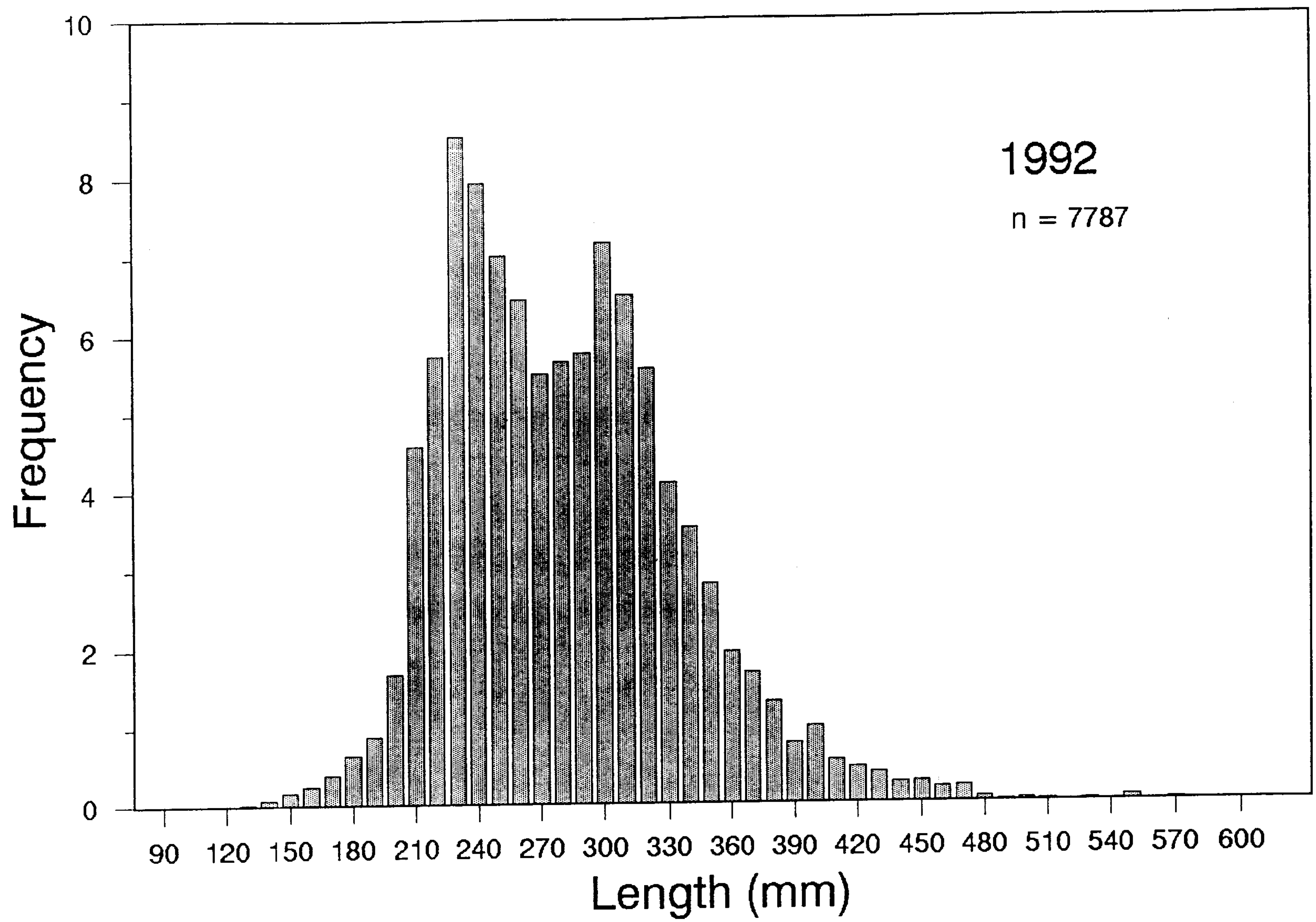

Figure 8. Weighted length frequency for emigrating Buskin River Dolly Varden for spring 1992.

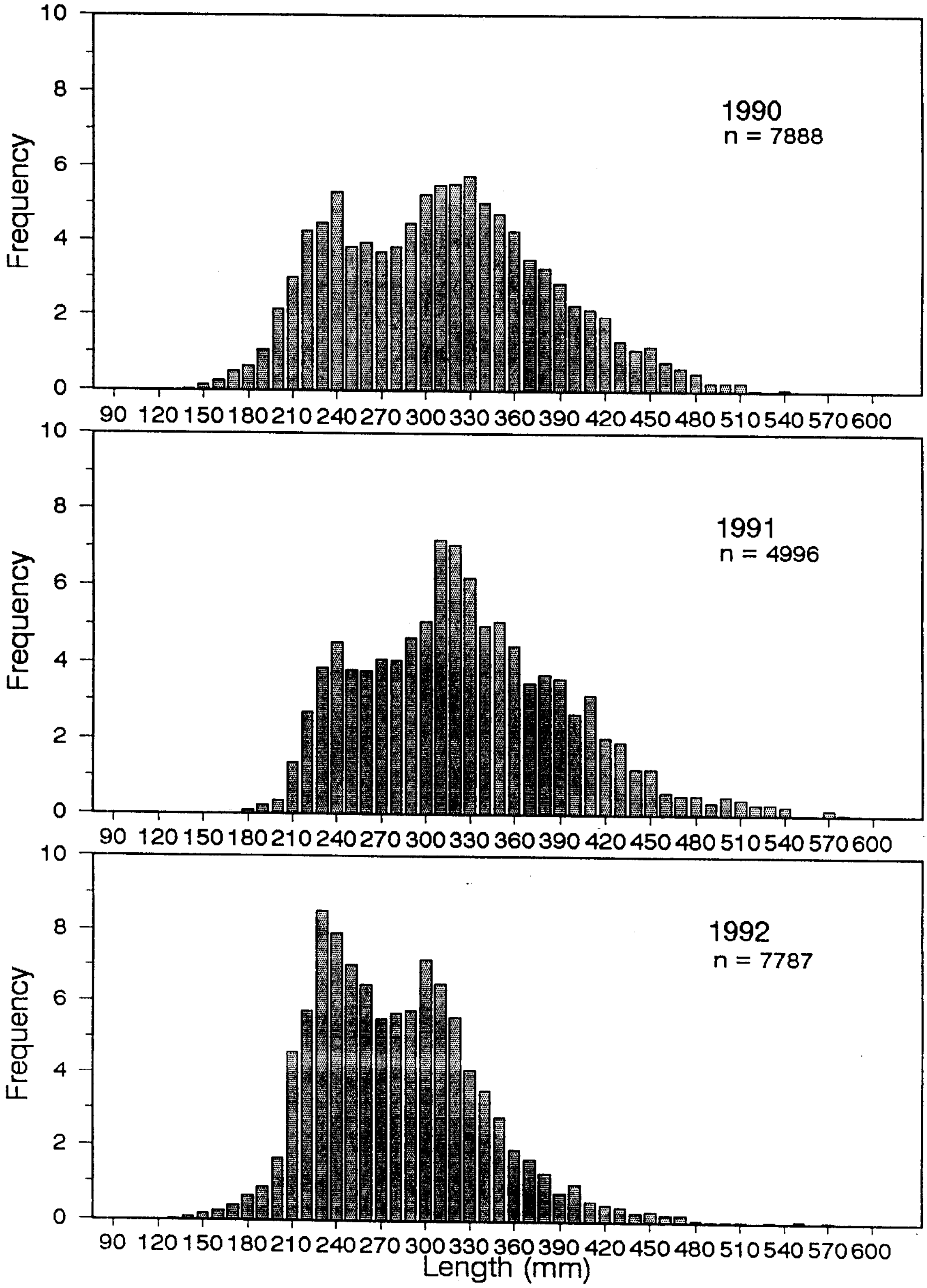

Figure 9. Weighted length frequency comparisons for emigrating Buskin River Dolly Varden for 1990 to 1992.

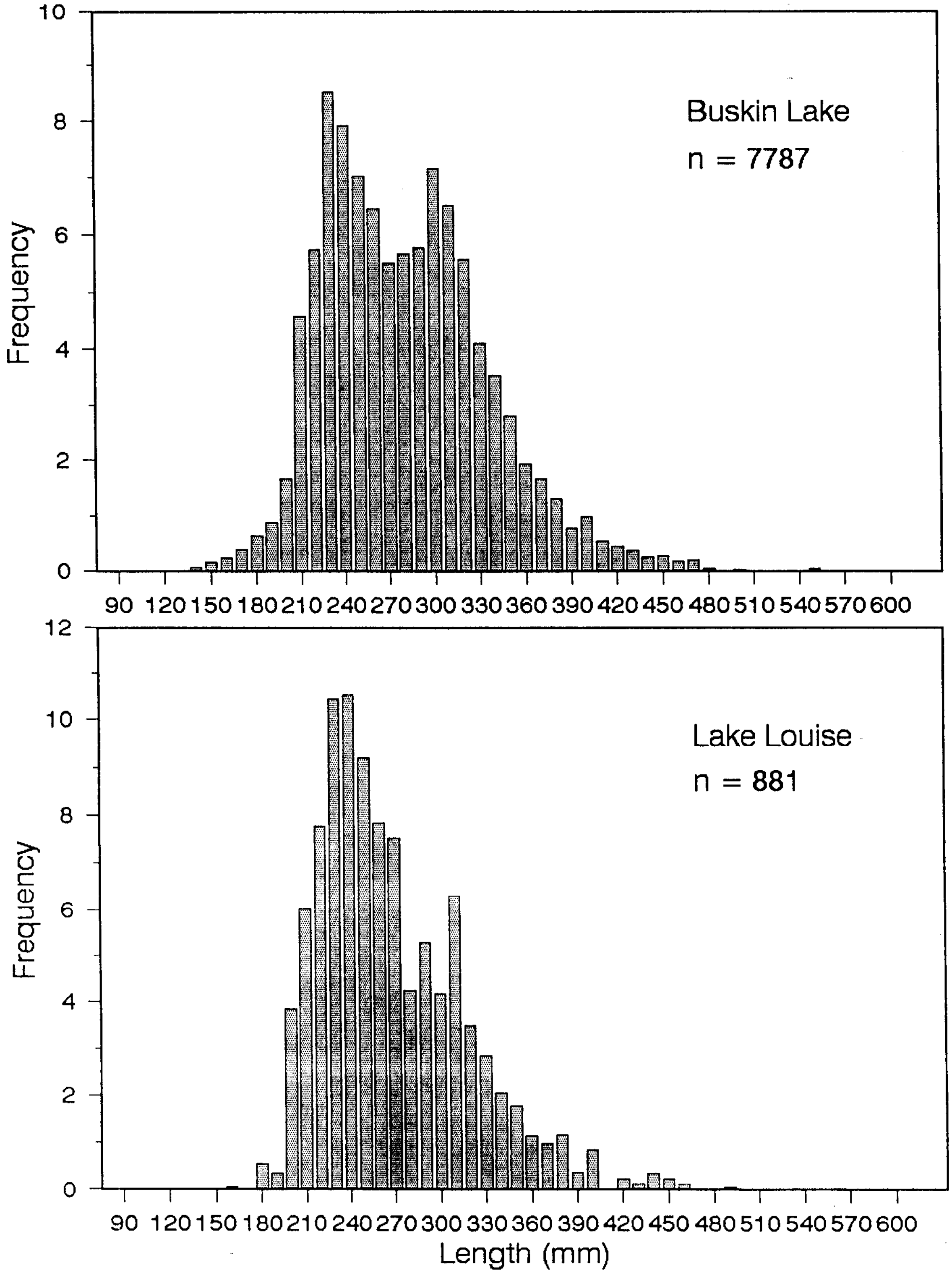

Figure 10. Weighted length frequencies for emigrating Dolly Varden from Buskin Lake and Lake Louise weirs, spring 1992.

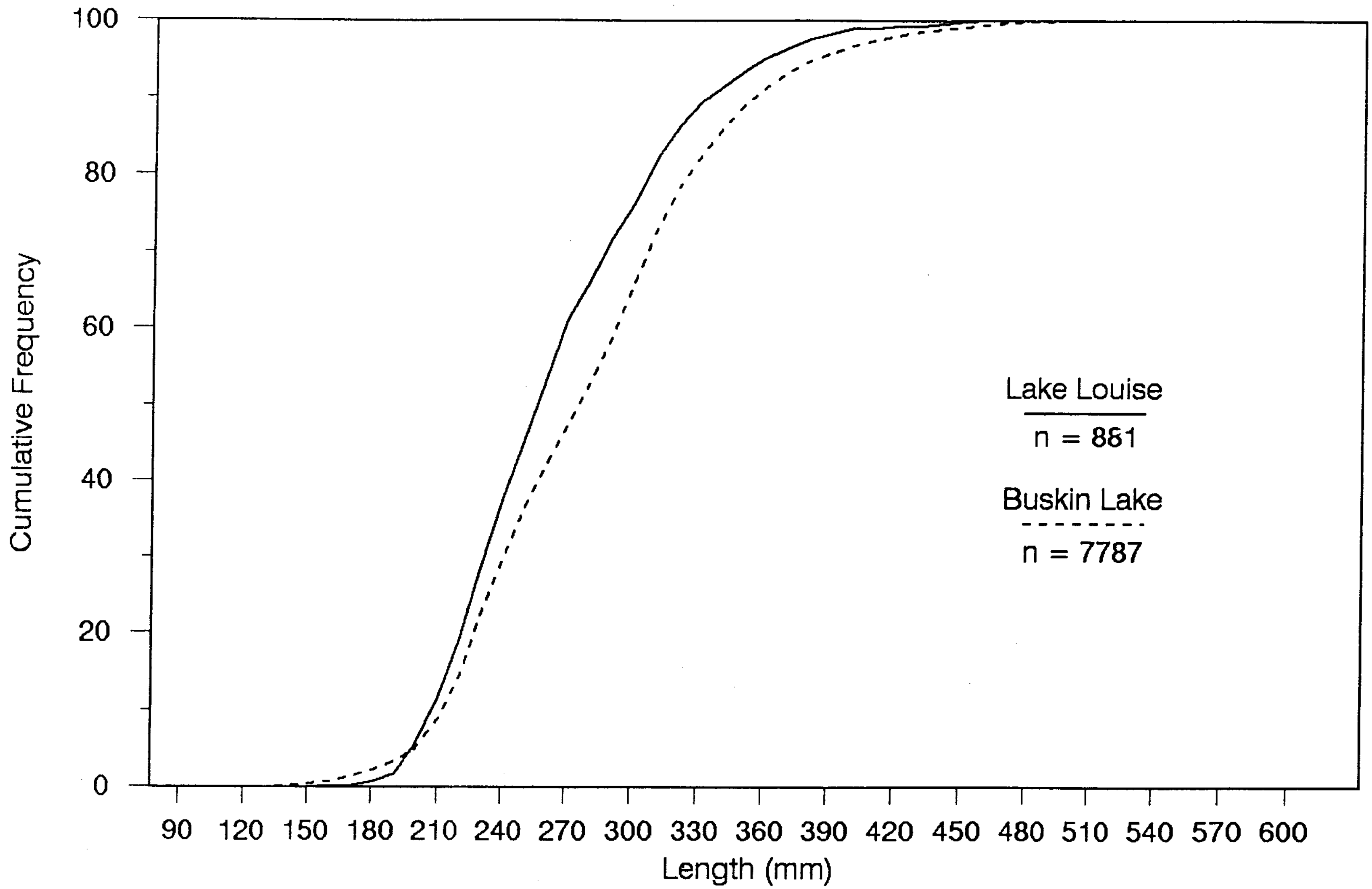

Figure 11. Cumulative length frequencies of emigrating Dolly Varden from Lake Louise and Buskin Lake weirs, spring 1992.

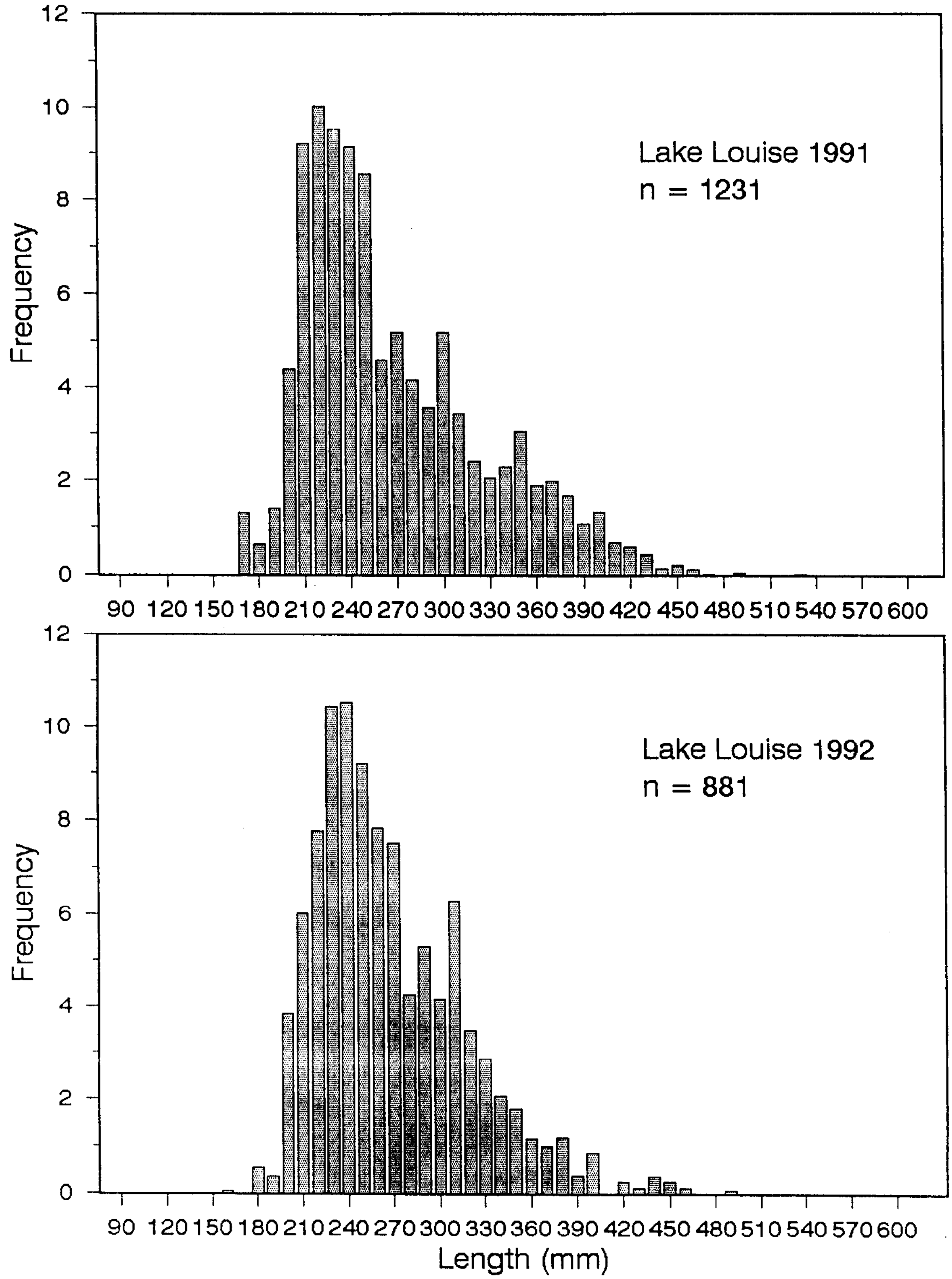

Figure 12. Weighted length frequencies for emigrating Dolly Varden from Lake Louise, spring 1991 and 1992.

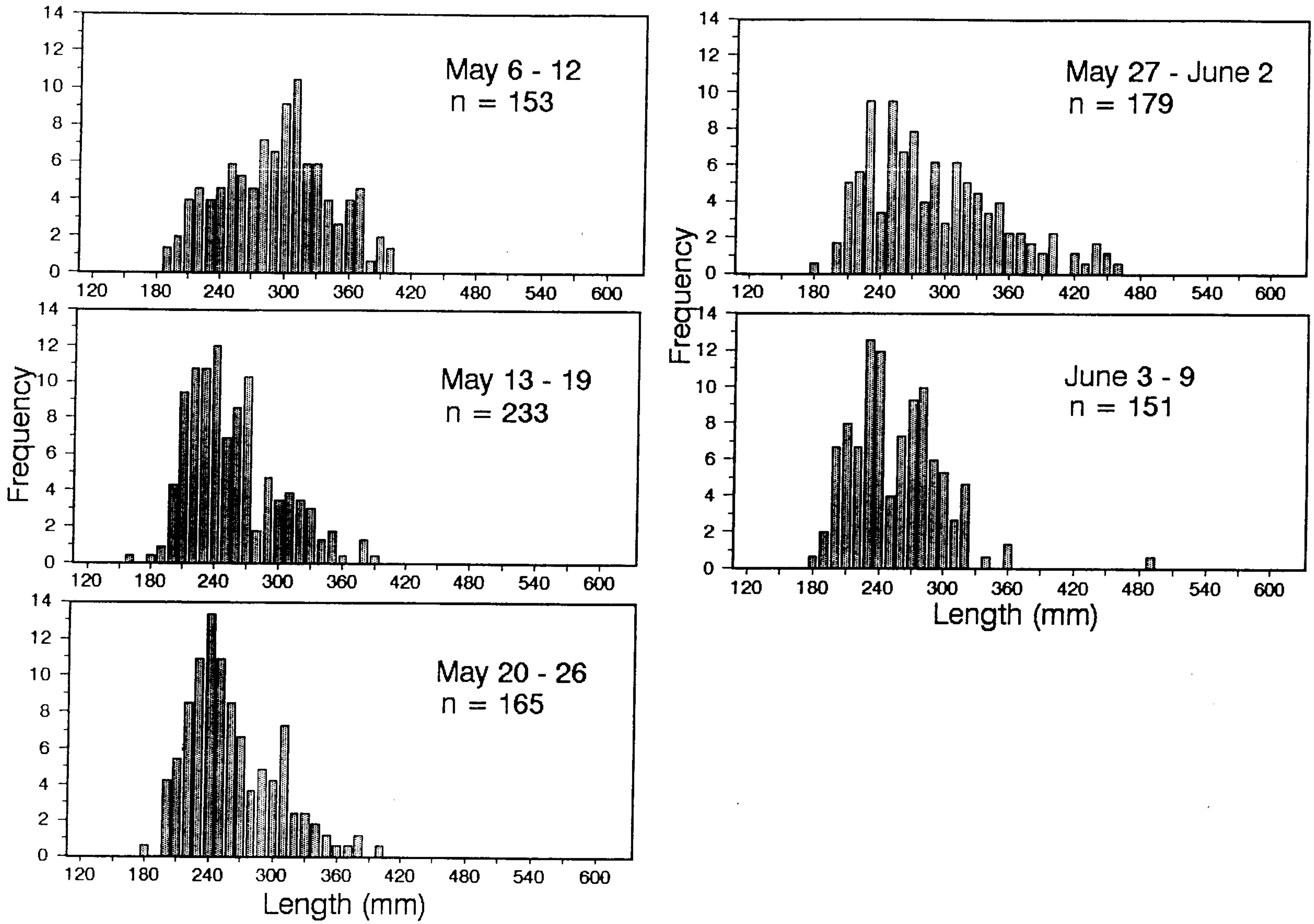

Figure 13. Length frequencies for emigrating Dolly Varden from Lake Louise for spring 1992.

Table 3. Results of the K-sample Anderson-Darling tests showing differences in the length distributions for Lake Louise Dolly Varden emigration, spring 1992.

			Comparison Week #			
Week #	n		2 n = 233	3 n = 165	4 n = 179	5 n = 151
1	153	A^2_{akN}	23.779	16.147	1.959	22.687
		σ^2	0.574	0.573	0.573	0.573
		T_{akN}	30.174[a]	20.042[a]	1.261	28.822[a]
2	233	A^2_{akN}		0.944	16.890	0.762
		σ^2		0.574	0.574	0.574
		T_{akN}		-0.064	21.024[a]	-0.330
3	165	A^2_{akN}			10.494	1.500
		σ^2			0.573	0.573
		T_{akN}			12.534[a]	0.710
4	179	A^2_{akN}				15.220
		σ^2				0.573
		T_{akN}				18.880[a]

[a] significant difference at a = 0.05.

Table 4. Tagging summary, Kodiak Dolly Varden 1984 - June 1992.

Year	Site	Dates	Tag Color	Tag Numbers	Number Tagged
1984	Buskin River	17 May-17 Jun	Yellow	1 - 474	472
1985	Buskin River	27 Apr-17 Jun	Yellow	475 - 1800	1318
			Green	651 - 743	
1986	Buskin River	24 Apr-16 May	Pink	2001 - 6000	3986
	Buskin River	29-30 Oct	Red	1 - 575	461
	Salonie Creek	14 Aug	Orange	2501 - 2550	97
		14 Sept	Orange	2851 - 2897	
	American River	7-12 Aug	Orange	1403 - 1962	560
	Olds River	5-6 Aug	Orange	1 - 1402	1402
	Roslyn River	13 Aug	Orange	2001 - 2030	30
	Pasagshak River	15 & 19 Aug	White	1 - 1000	1596
		11-12 Sept	White	18235 - 19993[a]	
	Afognak River	4-5 Sept	Blue	1 - 1000	1476
			Blue	20325 - 20803	
1987	Buskin River	20-30 May	Yellow	1801 - 4000	4051
			Orange	1963 - 3000[a]	
			Pink	4001 - 5000	
	Buskin River	26-27 Aug	Pink	6001 - 7000	1000
	American River	20 & 22 Aug	Orange	4501 - 6000	1500
	Olds River	11-12 Aug	Orange	3001 - 4500	1498
	Pasagshak River	24-25 Aug	White	1001 - 2000	1000
	Saltery Creek	14-15 May	Green	3001 - 5000	2000
	Afognak River	4-5 Sept	Blue	1001 - 2000	1000
1988	Buskin River	20-25 Oct	Red	1001 - 2000	2998
			Pink	7001 - 8000	
			Green	124001 - 125000	
	American River	18-22 Oct	Pink w/ Black	5001 - 6000[a]	650
	Olds River	26-31 Oct	Green	125001 - 125267	267
1989	Buskin River	3 May-1 Jun	Green	125268 - 129308[a]	4012
	Buskin River	Oct	Green	155737 - 156500	4433
			Green	156550 - 157000	
			Green	157347 - 157999	
			Green	162457 - 164280[a]	
			Green	164801 - 165375	
			Green	165501 - 165725[a]	
	American River	Oct	Green	157001 - 157346	801
			Green	162001 - 162456	
	Olds River	Oct	Green	155001 - 155736	784
			Green	156501 - 156550	

- continued -

Table 4. (Page 2 of 2).

Year	Site	Dates	Tag Color	Tag Numbers	Number Tagged
1990	Buskin Lake	30 Apr-14 Jun	Green	190001 - 195000	7492
			Green	211001 - 213499	
	American River	6 Oct-8 Oct	Green	213500 - 214045	546
			Green	214610 - 214821	212
	Olds River	7 Oct	Green	214046	1
			Green	214601 - 214609	9
	Buskin Lake-NW	9 Oct-11 Oct	Green	215085 - 215731	646
	Buskin Lake-Out	9 Oct	Green	214826 - 215084	259
	Buskin River	9 Oct	Green	214047 - 214125	79
	Pillar Creek	10 Oct	Green	214126 - 214268	143
1991	Buskin Lake	26 Apr-16 Jun	Green	216000 - 217000	4500
			Green	218001 - 220000	
			Green	250001 - 251501	
	Olds River	7 Oct-12 Oct	Green	255001 - 255589	589
			Green	255601 - 255767	167
			Green	256001 - 256186	187
			Green	256965 - 257000	36
	American River	9 Oct-11 Oct	Green	255590 - 255599	10
			Green	256201 - 256467	267
			Green	256630 - 256964	334
	Buskin Lake	10 Oct-13 Oct	Green	255768 - 255891	124
			Green	256468 - 256629	162
1992	Buskin Lake	29 Apr-19 Jun	Green	252001 - 255000	
			Green	368001 - 371000	
			Green	372001 - 373216	7212
				Total Tagged	60,367

a Missing blocks of tags in this sequence.

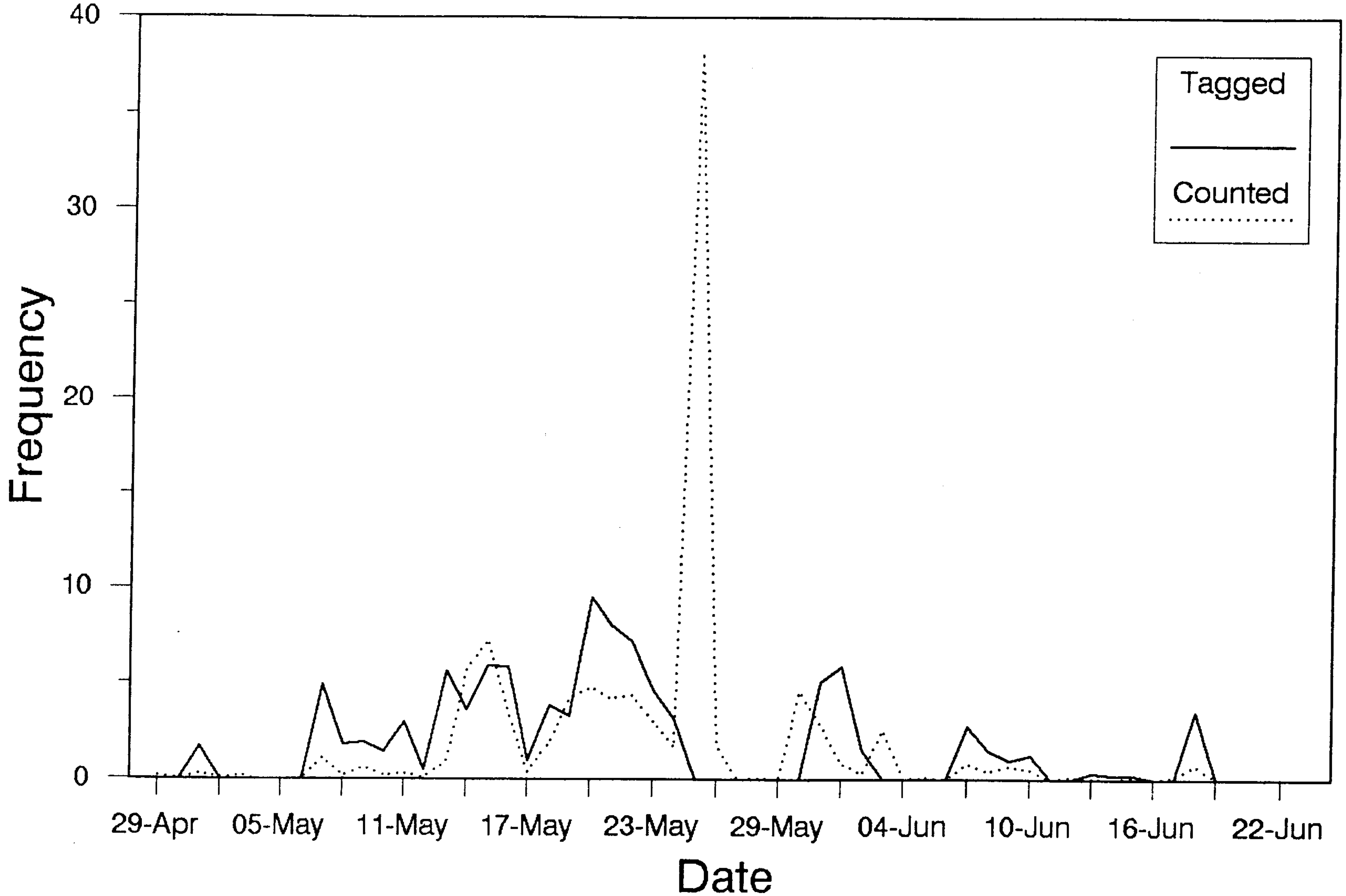

Figure 14. Percent of total emigrating Buskin River Dolly Varden weir count and daily tag count, spring 1992.

Table 5. Dolly Varden tag recoveries by release location for all tagging sites for 1988 - 1992.

Recaptures (# unique examined)	Releases (# unique releases with tags): 1988 Fall American (709)	1988 Fall Olds (283)	1988 Fall Buskin R (3,006)	1989 Spring Buskin R (4,476)	1989 Fall American (893)	1989 Fall Olds (833)	1989 Fall Buskin R (4,484)	1990 Spring Buskin L (8,450)	1990 Summer Buskin (21)	1990 Fall American (897)	1990 Fall NW Busk L (725)	1990 Fall Busk Main (87)	1990 Fall Busk R Out (4)	1990 Fall Busk L Out (295)	1990 Fall Olds (11)	1990 Fall Pillar Cr (143)	1991 Spring Buskin L (4,956)	1991 Spring L Louise (32)	1991 Fall American (715)	1991 Fall Olds (1,163)	1991 Fall NW Busk L (340)	1992 Spring Buskin L (7,479)
1989 Spring Buskin R (10,126)	50	21	105																			
1989 Fall American (896)	38	0	3	50		0	0															
1989 Fall Olds (836)	1	5	9	21	0		0															
1989 Fall Buskin R (4,503)	0	0	30	12	0	0																
1990 Spring Buskin L (22,815)	16	10	161	221	57	69	378															
1990 Spring Busk Creel (372)	0	0	4	4	0	0	4	19														
1990 Summer Buskin R (403)	0	0	2	3	0	0	4	11														
1990 Fall American (897)	2	0	6	8	34	0	7	33	0			0	0	0								
1990 Fall Olds (12)	0	0	0	0	0	1	0	0	0			0	0	0								
1990 Fall NW Busk L (725)	0	0	4	14	2	0	4	52	2	0		0	0	1	0	0						
1990 Fall Busk R Main (87)	0	0	2	0	0	1	1	5	0	0	0		0	0	0	0						
1990 Fall Busk R Out (276)	0	0	0	0	0	0	3	1	0	0	0	0		0	0	0						
1990 Fall Busk L Out (391)	0	0	0	0	1	0	20	16	0	0	0	0	0		0	0						
1991 Spring Buskin L (11,549)	1	0	22	27	5	15	95	201	1	23	58	3	0	14	0	0						
1991 Spring L Louise (1232)	0	0	0	0	0	3	3	13	0	11	0	0	0	0	0	0						
1991 Summer Busk Matur (288)	0	0	0	0	0	0	2	2	0	0	1	0	0	0	0	0	5	0				
1991 Fall American (715)	2	0	0	4	13	0	17	17	0	19	1	0	0	0	0	0	18	0		0	0	
1991 Fall Olds (1,164)	3	0	0	3	0	18	12	19	0	0	3	0	0	1	0	0	18	0	0		0	
1991 Fall NW Busk L (340)	0	0	3	2	0	2	3	17	0	0	11	1	0	1	0	0	16	0	0	0		
1992 Spring Buskin L (15,938)	2	0	8	5	2	5	28	53	0	4	0	0	0	9	0	0	106	1	14	34	9	
1992 Spring L Louise (959)	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	8	0	3	8	0	0

Table 6. Dolly Varden survival rates calculated from recaptures found at the Buskin River weir, 1989 to 1992.

	Survival Estimate	Standard Error
1989 to 1990	0.1846	0.0125
1990 to 1991	0.0629	0.0044
1991 to 1992	0.0996	0.0096

Age Composition:

Age classes 3 through 9 were present in the 1992 Dolly Varden emigration sample (Table 7). The weighted age sample was dominated by age 5 (34.3%, SE = 0.55) and age 6 (31.4%, SE = 0.54). The mean length for age 5 Dolly Varden was 245 mm (SE = 2.46) and for age 6 was 283 mm (SE = 3.30) (Table 8). The Kolmogorov-Smirnov test showed a significant difference between the length distributions from the age sample and the length sample at the weir for the second and third 2-week time periods, but not the first period (Time period 1: $D_{MAX} = 0.0636$, $P = 0.5891$; Time period 2: $D_{MAX} = 0.2254$, $P = 0.0001$; Time period 3: $D_{MAX} = .2930$, $P = 0.0001$). Anderson-Darling tests found no significant difference between the length distributions of the two sexes ($T_{aKN} = -0.888$, $A^2_{aKN} = 0.3275$, $\sigma^2 = 0.5738$).

Growth Model:

For 1989 to 1990 and 1990 to 1991, the case five (von Bertalanffy) model was the most parsimonious model fitting the data, while case three was selected for 1991 to 1992 (Table 9). I wanted to use the same procedure to model growth for all three years, and because results of the von Bertalanffy model were similar to the case three model (i.e. similar F-value and RSS) for 1991 to 1992, I used the von Bertalanffy model for all three years. The Schnute mark-recapture version of the von Bertalanffy model estimated parameters y_2 and a (Table 10). These estimates were then used in equation (4) to model growth during each year (Figure 15).

Stock Structure

During the 1992 spring emigration, 21% of the Dolly Varden passing through the weir were examined for missing fins. Seven fish were discovered with no tag and no adipose fin. Of these seven fish, four were deleted because they were < 304 mm, the length the growth models predicted that a 151 mm fish (smallest tagged fish in the fall of 1989) would be in 1992. A total of 15 recaptures from the 1989 season were found in the 1992 sample. Therefore maximum tag loss for the 1989 adipose clipped fish was estimated at 20% (SE = 0.01). This estimate was larger than the 1991 tag loss estimate for adipose clipped fish at 9.9% (SE = 0.05) (Whalen 1992). Of fish marked in 1991 and recaptured in 1992, only one of 55 fish examined with a left ventral fin clip was missing the tag, resulting in a 1.82% (SE = 0.15) tag loss estimate.

The Jolly-Seber estimate of Dolly Varden emigrating from the Buskin River in 1991 was considerably higher than the weir count. The weir count in 1991 was 30,725 and the Jolly-Seber estimate was 60,585 (SE = 10,354). The weir count did not fall within the 95% confidence intervals of 40,291 to 80,879. The Jolly-Seber estimate of survival 29.26% (SE = 4.63%) was significantly higher than the estimated survival from recaptures of 6.29% (SE = 0.44). The 95% confidence intervals for the two estimates of survival did not overlap.

The Jolly-Seber estimate of abundance was 3,790 (SE = 1,267) for the American River in 1989 (Table 11). A Petersen estimate for 1989 of 4,125 (SE = 805.22) (Sonnichsen 1990) was within the 95% confidence intervals (1,308 to 6,273) of the Jolly-Seber estimate. The 1990 Jolly-Seber estimate was 12,423 (SE = 4,574). The Petersen estimate for 1990 of 3,947 (SE = 540) (Whalen 1991) was

Table 7. Age distribution of Dolly Varden sampled at the Buskin Lake weir during emigration, spring 1992.

	Age								
	Age Not Available	3	4	5	6	7	8	9	Total
Females									
Sample Size	3	4	37	105	42	16	5		212
% of sexed sample	0.8	1.1	9.9	28.1	11.2	4.3	1.3		56.7
SE	0.46	0.53	1.55	2.33	1.63	1.05	0.59		2.57
Males									
Sample Size		1	37	61	47	12	2	2	162
% of sexed sample		0.3	9.9	16.3	12.6	3.2	0.5	0.5	43.3
SE		0.27	1.55	1.91	1.72	0.91	0.38	0.38	2.57
Sex Not Recorded									
Sample Size	1		5	25	37	30	7	1	106
All									
Sample Size	4	5	79	191	126	58	14	3	480
% of sample	0.8	1.0	16.5	39.8	26.3	12.1	2.9	0.6	100.0
SE	0.42	0.46	1.69	2.24	2.01	1.49	0.77	0.36	
Weighted All[a]									
Sample Size		34	697	2608	2588	1183	234	52	7396
% of sample		0.6	11.4	34.3	31.4	17.8	3.9	0.7	100.0
SE		0.09	0.37	0.55	0.54	0.44	0.23	0.10	

a Weighted by total weir length distribution.

Table 8. Mean fork length (mm) at age of Dolly Varden sampled at the Buskin Lake weir during the emigration, spring 1992.

	Age								
	Age Not Available	3	4	5	6	7	8	9	Total
Females									
Average Length	219	184	196	240	279	322	361		248
SE	8.67	17.13	4.93	2.83	5.90	5.65	11.87		3.38
Sample Size	3	4	37	105	42	16	5		212
Minimum	204	145	142	191	218	285	330		142
Maximum	234	228	261	326	362	372	397		397
Males									
Average Length		163	199	234	272	349	400	386	249
SE			4.46	2.88	4.97	10.39	19.50	33.50	4.24
Sample Size		1	37	61	47	12	2	2	162
Minimum		163	155	196	207	295	381	353	155
Maximum		163	249	290	344	426	420	420	426
Sex Not Recorded									
Average Length	285		240	295	301	340	360	383	313
SE			12.14	7.73	5.42	6.24	7.76		4.23
Sample Size	1		5	23	36	30	7	1	103
Minimum	285		216	196	217	257	320	383	196
Maximum	285		285	373	350	406	381	383	406
All									
Average Length	236	179	200	245	283	337	366	385	262
SE	17.52	13.89	3.38	2.46	3.30	4.30	6.96	19.38	2.57
Sample Size	4	5	79	189	125	58	14	3	477
Minimum	204	145	142	191	207	257	320	353	142
Maximum	285	228	285	373	362	426	420	420	426

Table 9. F-test results for comparison of growth models on Buskin River Dolly Varden for mark-recapture data from 1989 to 1992.

	Data Sets		
	1989 to 1990	1990 to 1991	1991 to 1992
Comparisons[a]:			
Case 1[b] = Case 2	4.51	1.86	3.58
Case 1 = Case 3	1.30	3.26	0.45
Case 1 = Case 5	0.49	0.00	0.69
$F_{critical}$	3.88	3.89	3.94
RSS (3 parameter models):			
Case 2	104,838.9	72,144.9	33,288.0
Case 3	103,352.6	72,655.6	32,298.7
Case 5	102,981.4	71,469.4	32,377.2

a Case 4 would not run since one parameter had to be set, leaving only one parameter left for this model.

b Schnute's growth submodels (Baker et al. 1991):
Case 1 is the general 4 parameter growth model.
Case 2 is a 3 parameter Gompertz growth model.
Case 3 is a general 3 parameter growth model in which linear and quadratic models are special cases.
Case 4 is a 2 parameter t^{th} power growth model
Case 5 is a 3 parameter von Bertalanffy model.

Table 10. Parameter estimates for selected growth models for Buskin River Dolly Varden, 1989 to 1992.

		Selected Model and Year			
		1989 to 1990	1990 to 1991	1991 to 1992	
Parameter[a]		Case 5	Case 5	Case 3[b]	Case 5[c]
y_2	Estimate	530.50	522.51	522.94	491.58
	SE	9.99	12.00	13.20	13.00
a	Estimate	0.1999	0.2276		0.2107
	SE	0.0259	0.0271		0.0352
b	Estimate			2.4951	
	SE			0.2660	

a y_2 = the largest fish in the population.
a = the Brody growth parameter.
b = the location of inflection point.

b Case 3 was the most parsimonious model.
c Case 5 was chosen as explained in text.

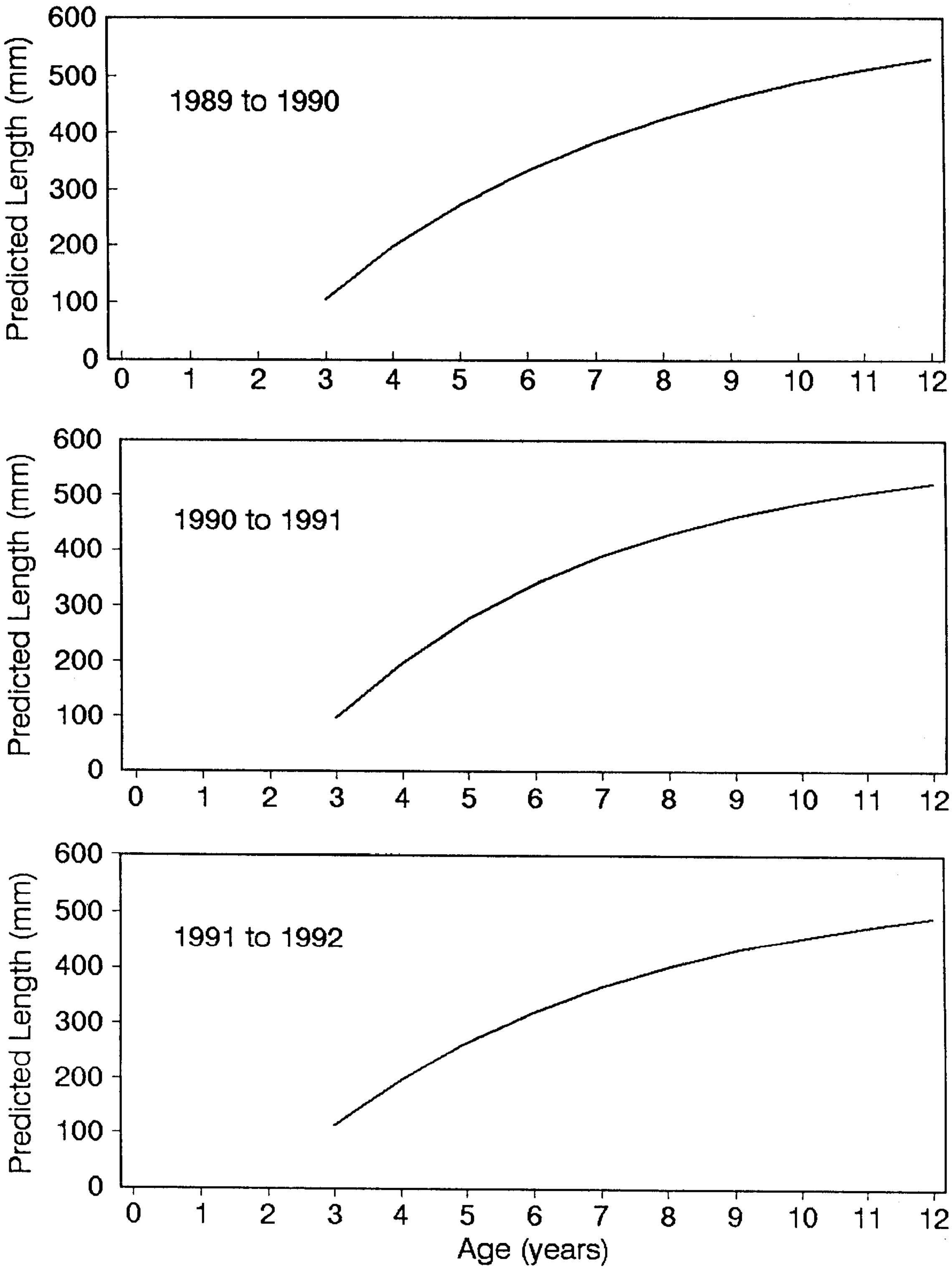

Figure 15. Von Bertalanffy growth curves for Buskin River Dolly Varden, 1989 to 1992.

Table 11. Results of the Jolly-Seber run made on Dolly Varden mark-recapture data from the American River, 1988 to 1992.

Parameter		Year 1988	1989	1990
Abundance	Estimate		3,790	12,424
	SE		1,267	4,574
Survival	Estimate	0.2481	0.5777	
	SE	0.0778	0.1976	
Recruitment	Estimate		10,234	
	SE		3,963	

also within the 95% confidence intervals (3,458 to 21,389) of the Jolly-Seber estimate.

DISCUSSION

The 1992 spring Buskin River emigration increased by over 40% from the 1991 season. This increase is mainly due to a larger recruit class. This was evidenced by weighted length distribution comparisons. These comparisons of length distribution are questionable because of the high percentage (94.5%) of Dolly Varden that were not measured on 25 May 1992 due to high water.

Temporal length composition changes were similar to 1990 and 1991 in that the large fish emigrated first and then smaller fish became progressively more abundant. This year, however, the large fish were present throughout the run causing the length distributions later in the run to flatten out.

The emigration from Lake Louise dropped this year from 1991 by over 25%. It is possible that a portion of the Lake Louise overwintering population had moved to Buskin Lake, especially since the Buskin Lake emigration increased this year. Lake Louise Dolly Varden exhibited similar temporal length composition changes as Buskin Lake with a pulse of large fish near the end of the emigration. The narrower length interval of fish at that time could be due to the smaller sample size at Lake Louise versus Buskin Lake. In general, Dolly Varden from Lake Louise were smaller than Buskin Lake, but the difference between the two was smaller in 1992 than in 1991.

The dominant age groups from the emigration sample were age 5 and 6. From maturity samples taken in 1990 and 1991, age 5 and 6 fish were predominantly fish preparing to spawn the next year (Whalen 1992). This is further evidence for a higher number of recruit age fish this year compared to previous years.

The tag loss estimate for adipose clipped fish was higher than the 1991 estimate as expected because the tag loss estimate spanned three years instead of two as in 1991. Several recommendations concerning clipping adipose fins for a tag loss study have surfaced. First, a comprehensive baseline estimate of naturally missing adipose fins for the population in question must be acquired for all size groups. Second, great care must be given to the clipping procedure and in the observation of clips in subsequent years. Either poor quality control was exercised during tagging or examination; or Buskin River Dolly Varden exhibit adipose fin regeneration; or these fish can possess a naturally disfigured fin as evidenced by at least 3 fish found this year in length groups extremely unlikely to have been part of the 1989 adipose fin clip sample. Ventral clips, on the other hand, are easier to detect. The fin is clipped at the bone and does not regenerate. Therefore, the tag loss estimate of 1.82% from the left ventral clip was used in all analyses. This level of tag loss was considered insignificant and I would conclude that the Jolly-Seber assumption that fish did not lose their marks was sufficiently met.

At the present, weir data prior to the 1990 season cannot be used in conjunction with 1990 - 92 data for analysis because it was not possible to use the probit analysis model. The Jolly-Seber abundance estimate for 1991 was significantly higher than the weir count of 30,725 in 1991 (Whalen 1992).

Also, differences between survival rates calculated from recaptures at the weir and the Jolly-Seber estimates imply that there was a portion of the recaptures that actually may have been alive but were not seen at the weir. Six explanations are possible. First, Dolly Varden may remain in Buskin Lake during the time of weir operation, second and third, Dolly Varden may leave Buskin Lake before or after weir operation. Fourth, these fish may overwinter in another freshwater system other than Buskin Lake. Fifth, some Dolly Varden may overwinter in marine waters. Finally, it is possible that the Jolly-Seber estimate is biased and the conclusions made above in error.

Ericksen and Marshall (1991) discovered Dolly Varden of all sizes staging in Chilkat Lake, Haines after the emigration. No surveys in Buskin Lake during the summer months were performed. It is not believed that Dolly Varden leave Buskin Lake before or after weir operation because weir counts at the beginning and end of the weir operation were very low. Sonnichsen et al. (*In prep*) concluded that these fish were not overwintering in freshwater systems outside of Chiniak Bay. Over 31,000 Dolly Varden were tagged during this study within and outside the Chiniak Bay area and no Dolly Varden were recaptured in nearby Pasagshak, Saltery, or Afognak rivers during extensive tagging efforts. Bias of the Jolly-Seber estimates is possible, but the survival estimate of 29% is closer to the survival estimate of 23.5% reported by Armstrong and Morrow (1980) than the weir estimates of survival of 6% for 1991.

I conclude that Dolly Varden are either remaining in Buskin Lake through the summer, or staying in marine waters throughout the winter. Further investigation is needed to fully assess where these fish are located. I recommend a gill net survey on Buskin Lake during the summer.

The close agreement between estimates of abundance from the Jolly-Seber and Petersen models for the American River spawning population indicates that this stock of Dolly Varden annually returns to the American River to spawn.

Future goals of this project are to continue with the Jolly-Seber estimation procedure on the Buskin River so that precision in the estimates can be improved. Also, since only one abundance estimate was produced with the 1990 to 1992 data, further years of Jolly-Seber estimates would determine if Dolly Varden are consistently being missed at the weir.

ACKNOWLEDGEMENTS

I thank Len Schwarz and Doug McBride for their supervision and guidance. Technicians Robert Lynch, Gail Smith and Glen Eaton helped conduct weir operations. Doris Mensch provided secretarial support. Volunteers Dave Rutz, Robert Begich, Jeff Ruppart, and Marcella Hill helped considerably. The U.S. Coast Guard allowed us access to their land and facilities. Jim Hasbrouck and Sandy Sonnichsen provided biometrical support.

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APPENDIX A

Appendix A1. Weir counts for the Buskin River Dolly Varden emigration, 1992.

Date	Daily Weir Count	Cumulative Weir Count
29-Apr	104	104
30-Apr	0	104
01-May	226	330
02-May	83	413
03-May	108	521
04-May	0	521
05-May	0	521
06-May	0	521
07-May	814	1335
08-May	139	1474
09-May	461	1935
10-May	174	2109
11-May	221	2330
12-May	66	2396
13-May	714	3110
14-May	4219	7329
15-May	5355	12684
16-May	2638	15322
17-May	293	15615
18-May	1421	17036
19-May	3092	20128
20-May	3573	23701
21-May	3127	26828
22-May	3220	30048
23-May	2246	32294
24-May	1259	33553
25-May	28358	61911
26-May	1301	63212
27-May	21	63233
28-May	28	63261
29-May	0	63261
30-May	3420	66681
31-May	2108	68789
01-Jun	623	69412
02-Jun	198	69610
03-Jun	1930	71540

Date	Daily Weir Count	Cumulative Weir Count
04-Jun	0	71540
05-Jun	72	71612
06-Jun	24	71636
07-Jun	623	72259
08-Jun	283	72542
09-Jun	488	73030
10-Jun	382	73412
11-Jun	0	73412
12-Jun	89	73501
13-Jun	31	73532
14-Jun	18	73550
15-Jun	80	73630
16-Jun	12	73642
17-Jun	80	73722
18-Jun	519	74241
19-Jun	0	74241
20-Jun	21	74262
21-Jun	0	74262
22-Jun	0	74262
23-Jun	22	74284
24-Jun	0	74284
25-Jun	0	74284
26-Jun	0	74284
27-Jun	3	74287
28-Jun	158	74445
29-Jun	1	74446
30-Jun	1	74447
01-Jul	0	74447
02-Jul	1	74448
03-Jul	0	74448
04-Jul	2	74450
05-Jul	0	74450
06-Jul	0	74450
07-Jul	0	74450
08-Jul	1	74451

Appendix A2. Weir counts for the Buskin River Dolly Varden emigration, 1985 through 1992.

Date	1985	1986	1987	1988	1989	1990	1991	1992
21-Apr	2	0	0	0	0	0	0	0
22-Apr	0	0	69	0	0	0	0	0
23-Apr	0	0	49	0	0	0	0	0
24-Apr	0	0	113	0	0	0	0	0
25-Apr	0	0	81	0	0	1	0	0
26-Apr	0	0	33	0	0	0	4	0
27-Apr	0	0	40	0	123	10	0	0
28-Apr	241	0	20	0	0	0	0	0
29-Apr	0	6	62	0	0	7	8	104
30-Apr	0	17	221	0	738	2	249	0
01-May	0	1	14	0	1081	12	0	226
02-May	0	3	27	0	0	492	50	83
03-May	0	3	8	0	17	41	0	108
04-May	0	0	6	0	75	1099	9	0
05-May	158	0	2482	453	98	0	69	0
06-May	0	17	3660	0	2	1999	460	0
07-May	0	16	659	330	298	394	0	814
08-May	0	0	939	408	1215	2663	204	139
09-May	0	1	50	4059	3054	2663	918	461
10-May	0	0	1081	1012	780	10385	185	174
11-May	0	0	3721	6420	3	1152	245	221
12-May	1849	0	35	44	58	976	115	66
13-May	0	0	30	0	2065	1735	619	714
14-May	0	0	109	255	5825	2235	1075	4219
15-May	0	0	1014	340	2307	3656	2635	5355
16-May	0	684	4803	349	1485	2829	1003	2638
17-May	0	161	71	4167	541	1508	151	293
18-May	0	264	3050	29	0	19317	6198	1421
19-May	7584	15099	1318	1920	742	5490	691	3092
20-May	0	1995	2046	1327	10737	3330	2060	3573
21-May	0	3713	541	7041	1791	1043	2636	3127
22-May	0	76	292	421	540	329	365	3220
23-May	0	3215	391	179	720	334	830	2246
24-May	0	14507	130	106	0	315	2883	1259
25-May	0	3	409	1245	30	212	1169	28358
26-May	6456	523	658	40	50	8468	142	1301
27-May	0	1355	25	38	747	40	53	21
28-May	0	0	19	49	6	7140	675	28
29-May	0	0	641	3	66	4162	69	0
30-May	0	0	628	12	10	914	177	3420
31-May	0	0	69	0	289	269	31	2108
01-Jun	0	0	30	1	43	200	60	623
02-Jun	5505	0	15	0	0	20	375	198
03-Jun	0	0	12	85	0	271	2411	1930

-continued-

Appendix A2. (Page 2 of 2).

Date	1985	1986	1987	1988	1989	1990	1991	1992
04-Jun	0	0	5	2	0	687	411	0
05-Jun	0	0	10	1	5	248	0	72
06-Jun	0	0	213	0	13	2330	-2	24
07-Jun	0	0	3	0	3	1075	51	623
08-Jun	0	0	7	0	15	420	0	283
09-Jun	0	0	0	0	1	69	791	488
10-Jun	0	0	10	0	1	11	347	382
11-Jun	0	0	0	0	7	32	31	0
12-Jun	0	0	0	0	1	1	17	89
13-Jun	0	0	0	0	2	54	68	31
14-Jun	0	0	0	0	6	325	105	18
15-Jun	0	0	0	0	0	106	79	80
16-Jun	2	0	0	0	2	2	3	12
17-Jun	0	0	0	0	3	0	0	80
18-Jun	0	0	0	0	2	0	0	519
19-Jun	0	0	0	0	1	0	0	0
20-Jun	0	0	0	0	2	0	0	21
21-Jun	0	0	0	0	2	1	0	0
22-Jun	0	0	0	0	1	0	0	0
23-Jun	0	0	0	0	0	0	0	22
24-Jun	0	0	0	0	0	0	0	0
25-Jun	0	0	0	0	0	0	0	0
26-Jun	0	0	0	0	0	0	0	0
27-Jun	0	0	0	0	0	0	0	3
28-Jun	0	0	0	0	0	0	0	158
29-Jun	0	0	0	0	0	0	0	1
30-Jun	0	0	0	0	0	0	0	1
01-Jul	0	0	0	0	0	0	0	0
02-Jul	0	0	0	0	0	0	0	1
03-Jul	0	0	0	0	0	0	0	0
04-Jul	0	0	0	0	0	0	0	2
05-Jul	0	0	0	0	0	0	0	0
06-Jul	0	0	0	0	0	0	0	0
07-Jul	0	0	0	0	0	0	0	0
08-Jul	0	0	0	0	0	0	0	1
09-Jul	0	0	0	0	0	4	0	0
10-Jul	0	0	0	0	0	0	0	0
11-Jul	0	0	0	0	0	0	0	0
12-Jul	0	0	0	0	0	0	0	0
13-Jul	0	0	0	0	0	0	0	0
14-Jul	0	0	0	0	0	0	0	0
15-Jul	0	0	0	0	0	4	0	0
16-Jul	0	0	0	0	0	25	0	0
Total	21797	41659	29919	30336	35603	91107	30725	74451

Appendix A3. Weir counts for the Lake Louise Dolly Varden and rainbow trout emigration, 1992.

Date	Dolly Varden Daily Count	DV Cumm	Rainbow Trout Daily Count	RT Cumm
06-May	30	30	7	7
07-May	18	48	11	18
08-May	26	74	2	20
09-May	0	74	0	20
10-May	1	75	2	22
11-May	13	88	0	22
12-May	65	153	8	30
13-May	115	268	6	36
14-May	63	331	7	43
15-May	64	395	3	46
16-May	17	412	2	48
17-May	11	423	2	50
18-May	12	435	0	50
19-May	130	565	7	57
20-May	109	674	3	60
21-May	119	793	0	60
22-May	293	1086	6	66
23-May	210	1296	4	70
24-May	40	1336	2	72
25-May	197	1533	6	78
26-May	778	2311	7	85
27-May	173	2484	8	93
28-May	136	2620	6	99
29-May	169	2789	9	108
30-May	64	2853	5	113
31-May	67	2920	4	117
01-Jun	21	2941	1	118
02-Jun	80	3021	4	122
03-Jun	66	3087	3	125
04-Jun	179	3266	4	129
05-Jun	15	3281	3	132
06-Jun	6	3287	1	133
07-Jun	21	3308	3	136
08-Jun	8	3316	0	136
09-Jun	36	3352	9	145
10-Jun	12	3364	6	151
11-Jun	12	3376	5	156
12-Jun	3	3379	0	156
13-Jun	7	3386	1	157
14-Jun	8	3394	0	157
15-Jun	4	3398	1	158
16-Jun	6	3404	1	159
17-Jun	13	3417	2	161
18-Jun	5	3422	0	161
19-Jun	0	3422	0	161

Appendix A4. Average growth (in mm) of Buskin River Dolly Varden from mark-recapture data, spring 1989 to spring 1992, by one year intervals.

Year	n	< 270 mm	n	>= 270 mm
1989 to 1990	52	69.57	200	48.20
1990 to 1991	68	72.67	130	51.66
1991 to 1992	31	63.74	73	43.93