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ABSTRACT

A two-year study of the large recreational fishery for Dolly Varden *Salvelinus malma* occurring along the Sitka roadside was conducted in 1989-1990. Fisheries along the Sitka roadside were surveyed during the spring of 1989. During the fall of 1989, 1,125 Dolly Varden presumed to be overwintering in Salmon Lake, about 6 miles southeast of Sitka, were captured using a variety of gear types, measured for length, marked with an adipose clip, and released into the lake. During the spring emigration of 1990, 8,909 Dolly Varden were captured as they left the lake, marked with a dorsal fin clip, and subsampled for length. Two hundred and ninety-nine of these fish were missing their adipose fin. We estimate 33,400 (standard error = 1,600) Dolly Varden ≥190 mm fork length overwintered in Salmon Lake during the winter of 1989-1990.

Between 26 March and 27 May 1990 a creel survey of Dolly Varden anglers was conducted along the Sitka roadside near the Sheldon Jackson Hatchery and at Starrigavan Bay. About 869 angler hours (standard error = 102) were expended to catch 1,135 Dolly Varden (standard error = 399) of which 214 (standard error = 75) were harvested. These catch and harvest estimates are well below those found during 1989 and are presumed to be the result of a concurrent reduction in angler effort, not lower abundance.

During the creel survey 46 harvested Dolly Varden were examined, and no adipose clips were found. However, 16 fish marked with a dorsal clip were found during the survey near the Sheldon Jackson Hatchery, during the period 16 April to 6 May. An estimate of the contribution of these (8,909) marked fish to the sport fishery is 62 fish ≥260 mm fork length (standard error = 29). This is a minimum estimate for fish that overwintered at Salmon Lake; the actual contribution to the fishery near Sheldon Jackson Hatchery between 16 April to 6 May might have approached the majority of the 176 fish harvested during that period.

KEY WORDS: Dolly Varden, *Salvelinus malma*, Sitka, Southeast Alaska, Salmon Lake, overwintering population, population estimate, length distribution, creel survey, angler effort, harvest, contribution.

INTRODUCTION

Resident and anadromous Dolly Varden *Salvelinus malma* are the focus of large recreational fisheries in Southeast Alaska. Anadromous Dolly Varden reside in lakes and large rivers during winter, migrate to sea in the spring or early summer, and return to their natal streams or lakes to spawn in the fall. In Southeast Alaska, immature Dolly Varden migrate to sea at ages II-IV, may migrate between several freshwater systems during a given year, and may overwinter in a non-natal system (Armstrong 1974). Dolly Varden marked in Southeast Alaska have been recaptured at sea 152 km (95 mi) from their natal systems, and in freshwater systems 116 km (72 mi) from their natal systems (Armstrong 1965).

Based on the Statewide Harvest Survey (Mills 1990), harvests of Dolly Varden in the Sitka area have varied from about 3,000 in 1978 to about 10,000 fish in 1980 and 1988 (Table 1). These estimates include the Baranof and Chichagof Island areas, so they are not necessarily representative of the immediate City of Sitka area. While a predictable trend in harvest is not evident, total angler effort has increased from about 33,000 angler-days in 1978 to about 59,000 angler-days in 1989 (Table 1).

The Dolly Varden fishery in the immediate Sitka area is composed of several different fisheries. The first and most intense fishery occurs along the road system (Figure 1) early in the spring when Dolly Varden first appear after overwintering in lakes and larger rivers. This fishery usually starts in late March and continues through May. We monitored this fishery in 1989 and estimated about 1,481 angler-hours of effort were expended to harvest 731 Dolly Varden between 27 March and 30 April (Ericksen et al. 1990). All of the harvest occurred at the Sheldon Jackson Hatchery area (99%) or at the Starrigavan Recreation Area (1%)(Figure 1). Another Dolly Varden fishery begins along the roadside in July when Dolly Varden begin entering the streams concurrent with salmon runs. This fishery is popular with nonresidents who are visiting the area. The third fishery occurs in the late summer when local fishermen concentrate at mouths of larger rivers to catch anadromous Dolly Varden which are returning to spawn. In addition, anglers trolling for salmon catch Dolly Varden. We do not know what proportion of the total Dolly Varden harvest occurs in each fishery.

Based on results from our survey in 1989 (Ericksen et al. 1990), we focused study in 1990 on the spring roadside fishery near the Sheldon Jackson Hatchery and the population of Dolly Varden that overwinters in the large (41 hectare) Salmon Lake near Sitka.

During 1990 our objectives were to estimate:

1. abundance of Dolly Varden >190 mm in fork length residing in Salmon Lake during the winter of 1989-1990;

2. angler effort and harvest of Dolly Varden along the Sitka roadside from 26 March to 27 May 1989; and,

3. contribution of Dolly Varden overwintering in Salmon Lake to the Sitka sport fishery.

Table 1. Estimated harvest of Dolly Varden and effort in angler days, Sitka Area, 1978-1989.

	Sitka Area Dolly Varden Harvests													
	Starrigavan				Sitka Sound									
	Boat		Shore		Boat		Shore		Saltwater		Freshwater		Total	
Year	Harvest	effort[a]	Harvest	effort[a]	Harvest	effort[a]	Harvest	effort[a]	Harvest	effort[a]	Harvest	effort[a]	Harvest	effort[a]
1978[b]									1,600	27,638	1,736	5,303	3,336	32,941
1979[c]									3,081	36,564	2,627	3,946	5,708	40,510
1980[d]									4,736	33,172	5,407	5,510	10,143	38,682
1981[e]									4,017	34,650	1,739	3,884	5,756	38,534
1982[f]									5,565	37,686	3,605	5,663	9,170	43,349
1983[g]									5,570	39,160	1,582	4,998	7,152	44,158
1984[h]	466	5,238	2,603	4,938	50	9,139			4,636	35,791	931	4,258	5,567	40,049
1985[i]	1,144	6,017	867	2,774	243	9,589			3,884	31,935	2,826	4,680	6,710	36,615
1986[j]	382	1,940	961	2,042	198	17,384	641	1,416	3,214	35,173	2,214	4,587	5,428	39,760
1987[k]	937	4,067	937	3,438	487	19,537	937	3,257	4,606	39,972	2,066	5,611	6,672	45,583
1988[l]	964	4,734	1,619	2,769	545	20,213	2,128	2,369	6,675	43,603	3,275	5,077	9,950	48,680
1989[m]	117	2,147	214	1,185	118	31,044	1,185	1,380	3,738	54,076	1,975	5,154	5,713	59,230

[a] Effort = Total effort for all species in angler days
[b] Mills 1980
[c] Mills 1981a
[d] Mills 1981b
[e] Mills 1982
[f] Mills 1983
[g] Mills 1984
[h] Mills 1985
[i] Mills 1986
[j] Mills 1987
[k] Mills 1988
[l] Mills 1989
[m] Mills 1990

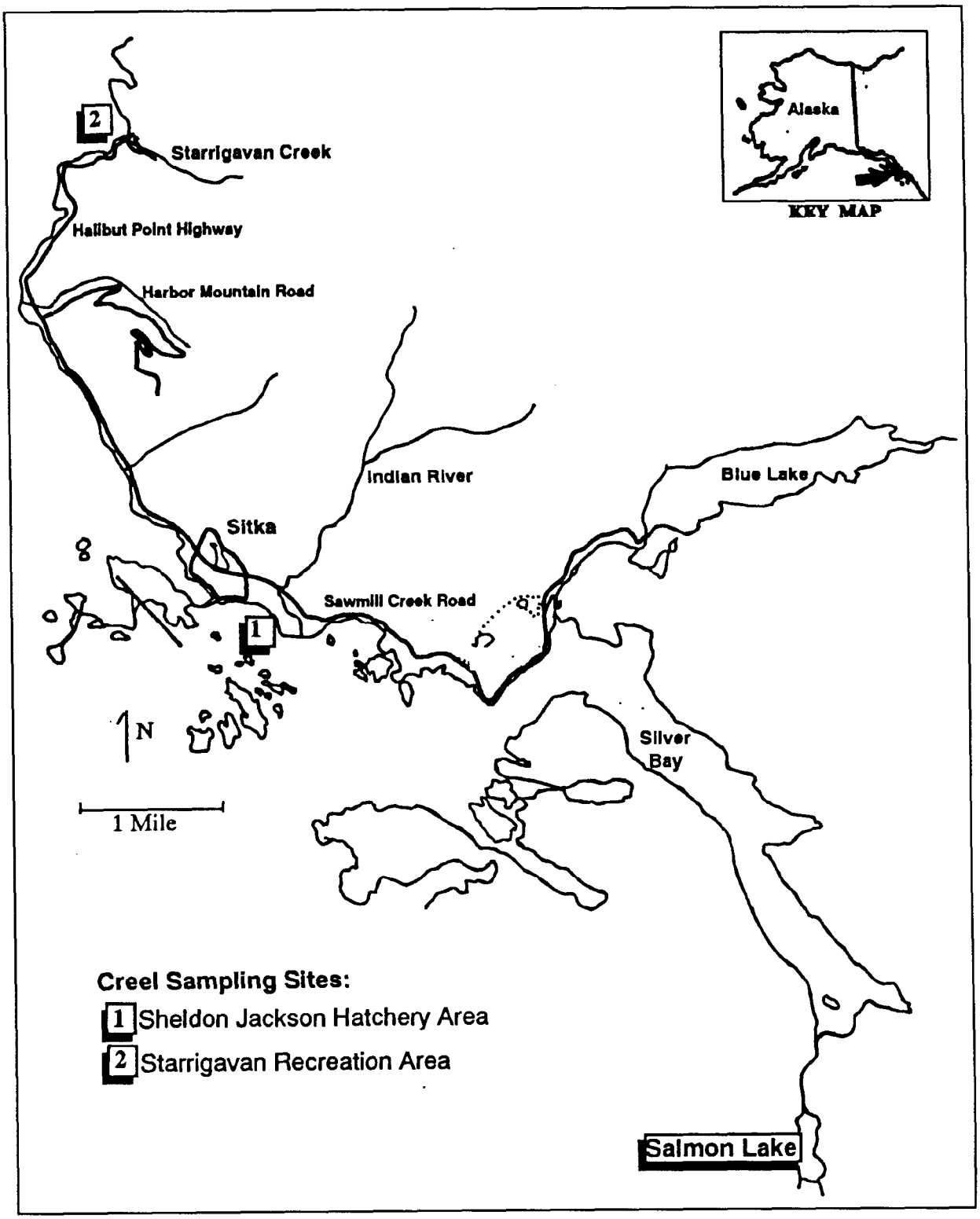

Figure 1. Location of Dolly Varden creel survey sites at Sitka and the Salmon Lake study site, 1989-1990.

METHODS

Abundance Study

The number of large Dolly Varden overwintering in Salmon Lake was estimated using the Chapman-modified Petersen estimator (Seber 1982):

$$\hat{N} = \frac{(n_1+1)(n_2+1)}{(m_2+1)} - 1 \qquad (1)$$

$$V[\hat{N}] = \frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)} \qquad (2)$$

where:

$\hat{N}$ = abundance of large Dolly Varden;
n_1 = number of Dolly Varden marked in the fall of 1989;
n_2 = number of Dolly Varden examined in the spring of 1990;
m_2 = number of marked Dolly Varden recaptured in the spring of 1990.

Beach seines, baited fyke traps, sport fishing gear, and a weir were used to capture fish of all sizes ≥190 mm fork length (FL) for marking. Each fish over 190 mm FL was marked with an adipose fin clip and measured (FL) to the nearest millimeter. The fyke traps were baited with salmon roe and fished periodically during September of 1989 near the inlet stream to Salmon Lake where Dolly Varden congregate. A beach seine was fished periodically near the inlet stream during late September and early October. Hook and line fishing was conducted throughout the lake, but effort was concentrated near the inlet where a concentration of Dolly Varden was found. The weir operated for coho salmon on the outlet stream caught only the larger Dolly Varden from late August to the time of weir removal on 6 October.

The recapture event was accomplished by trapping emigrating Dolly Varden in a two-unit fyke net array positioned in the outlet of Salmon Lake from March through May 1990. Every captured Dolly Varden was counted, examined for an adipose clip, and measured for length if the adipose fin was missing. All captured fish were also marked with a dorsal caudal punch to increase the number of marks released into the sport fishery and to avoid repeat enumeration of fish moving back into Salmon Lake. The date, number of fish captured, number of adipose-clipped fish recaptured, and the number of new marks released were recorded.

In estimating abundance (N) we assume:

(a) marked and unmarked fish suffer the same, negligible, mortality rate between sampling events;
(b) the population of fish ≥190 mm FL is closed to recruitment during the experiment;

(c) marked and unmarked fish mix completely between the two samples or all fish ≥190 mm FL have the same probability of capture in the second sample; and,
(d) fish do not lose marks between sampling events.

We did not test assumption (a) but guess overwinter survival is high (≥94%), as measured by Armstrong (1965) in Lake Eva (about 30 air miles from Sitka). Although marked and unmarked fish probably mixed completely over the winter, assumption (c) - equal probability of capture - was tested with a Kolmogorov-Smirnov (K-S) two-sample goodness-of-fit test comparing the size distributions of fish marked in the fall and recaptured in the spring. If the K-S test indicates the second sampling event is size selective, the experiment is stratified by length, and separate abundance estimates computed.

Assumption (b) relates to both growth and immigration. We did not test this assumption. In Lake Eva, Armstrong (1965) found that immigration of Dolly Varden occurred over a 6- to 7-month period with the last fish entering in December. However, the proportion entering during November was small (2.7%), while the proportion entering in October was 10.7% (of the total annual immigration). Thus, tagging late in the fall reduced the possibility of significant immigration after tagging. Little or no growth recruitment was expected to occur during our winter hiatus between sampling events. Heiser (1966) sampled different age groups of Dolly Varden overwintering in Lake Eva and reports a net change of +2%, -3%, +8%, +10%, and +2% in fork length for fish aged III to VII (mean fall lengths for these ages ranged from 202 mm to 386 mm FL). In Chilkat Lake (≈110 air miles north of Sitka) we found that overwinter growth for Dolly Varden ≈280 mm FL is typically <10 mm FL (≈3%), and decreases to near 0 for fish longer than about 420 mm FL (Ericksen and Marshall *In press*).

The possibility of a significant incidence of naturally missing adipose fins in the population in Salmon Lake was examined during the first marking event. Armstrong (1965) found that only about 1 in 1,000 Dolly Varden examined in Eva Creek were naturally missing the adipose fin. Armstrong (1965) also found the rate of adipose fin regeneration to be very low.

Fish Size

Measurements of fork length were recorded for all fish sampled during the fall sampling event. During the spring sampling event, a systematic sampling schedule was used to sample unmarked fish at the fyke net array. At first, every second fish captured was measured. After about 1,000 length measurements were obtained, sampling frequency was halved (to 1 in 4 fish) until another 1,000 fish were measured. This method of decreasing the sampling frequency at intervals of 1,000 fish continued until a frequency of every eighth fish was attained. A representative sample was later obtained by subsampling each group of length measurements at rates that produced a sample in proportion to actual capture rate at the fyke trap.

Following field collections and subsampling of length measurements, we used a second K-S goodness-of-fit test, to compare the size distributions of fish captured during both sampling events. We used this test to determine a method to alleviate bias in estimates of lengths of fish overwintering in Salmon Lake that would result if sampling was size selective (Clark and Ridder 1990, and Appendix A1).

Harvest Study

A stratified three-stage "direct expansion" type creel survey was conducted at the Sheldon Jackson and Starrigavan sampling sites between 26 March and 27 May 1990. The design had days as primary units, periods within days as secondary units, and anglers within periods as tertiary units. Stratification was by seasonal 21-day (3-week) periods (3 levels), sites (Sheldon Jackson area, Starrigavan area), and type of day (weekday vs. weekend-holiday). Type of day stratification was only maintained at Sheldon Jackson area, so there were nine strata. Stratification by site and types of day were determined from results of the a survey along the Sitka roadside in 1989 (Ericksen et al. 1990).

In each day selected for sampling, two of four periods (or two of five in the last seasonal strata) available were sampled according to a predetermined random schedule. The available sampling periods were equal in length and fixed at between 193 and 223 minutes, depending on the strata. The available periods in a day together equaled the length of time from one-half hour past sunrise to sunset, on the average day in the strata.

Since the vast majority of harvest was expected to occur in the Sheldon Jackson area, sampling at Starrigavan was limited to 3 days in each strata. An approximate optimal allocation was then used to partition available sampling effort between weekday and weekend strata at the Sheldon Jackson site. During each sampling period the survey technician recorded the number of anglers who completed their fishing trips during the period. Data recorded during each interview included: 1) the number of Dolly Varden caught and kept, 2) the number of Dolly Varden caught and released, and 3) angler effort in hours.

The harvest in each stratum was estimated:

$$\hat{C}_h = D_h \overline{C}_h \tag{3}$$

$$\overline{C}_h = \frac{\sum_{i=1}^{d_h} \hat{C}_{hi}}{d_h} \tag{4}$$

$$\hat{C}_{hi} = P_h \overline{C}_{hi} \tag{5}$$

$$\overline{C}_{hi} = \frac{\sum_{j=1}^{p_h} \hat{C}_{hij}}{p_h} \tag{6}$$

$$\hat{C}_{hij} = M_{hij} \overline{C}_{hij} \tag{7}$$

$$\overline{C}_{hij} = \frac{\sum_{k=1}^{m_{hij}} C_{hijk}}{m_{hij}} \tag{8}$$

where c_{hijk} is the harvest by angler k in period j day i stratum h, m_{hij} is the number of anglers interviewed in period j, M_{hij} is the number of anglers completing trips in period j, p_{hi} is the number of periods sampled in a day, P_{hi} is the number of periods in a day, d_h is the number of days sampled in stratum h, and D_h is the total number of days in stratum h. The variance of the harvest in each stratum is estimated:

$$V[\hat{C}_h] = (1-f_{1h})D_h^2 \frac{\sum_{i=1}^{d_h}(\hat{C}_{hi}-\bar{C}_h)^2}{d_h(d_h-1)} + D_h P_h^2 \sum_{i=1}^{d_h}(1-f_{2h}) \frac{\sum_{j=1}^{p_h}(\hat{C}_{hij}-\bar{C}_{hi})^2}{d_h p_h (p_h-1)} +$$

$$D_h P_h \sum_{i=1}^{d_h}\sum_{j=1}^{p_h} M_{hij}^2 (1-f_{3hij}) \frac{\sum_{k=1}^{m_{hij}}(c_{hijk}-\bar{c}_{hij})^2}{d_h p_h m_{hij}(m_{hij}-1)} \qquad (9)$$

where f_{1h} = the sampling fraction for days, f_{2h} = sampling fraction for periods, and f_{3h} = sampling fraction for anglers.

Estimation of catch H (or effort E) will used the same formula with H or E substituted for C. Harvest (or effort) for the season (and their variances) are the sums across strata ΣC_h and $\Sigma V[C_h]$, and ΣE_h and $\Sigma V[E_h]$.

Contribution to Sport Fisheries

All Dolly Varden present in interviewed anglers' creels were inspected for adipose clips and dorsal punch holes placed during sampling experiments, then measured for length if possible. The occurrence of every marked fish found was recorded along with the type of mark(s) found. Contribution(s) to the sport fishery in stratum h were estimated:

$$\hat{C}_{t_h} = \frac{m_{c_h}}{\hat{\phi}_h \theta_h} \qquad (10)$$

where m_{c_h} is the number of marked Dolly Varden found in the inspected harvest, $\hat{\phi}_h$ is the fraction of the harvest in the sport fishery that was inspected, θ_h is the fraction of the stock of interest marked, and $\hat{C}_{t_h}$ is the estimated harvest of the stock of interest in stratum h.

The variance of $\hat{C}_{t_h}$ was estimated:

$$\hat{V}[\hat{C}_{t_h}] = \hat{C}_{t_h}^2 \left[\frac{V[\hat{H}_h]}{\hat{H}_h^2} \frac{(m_{c_h}-1)}{m_{c_h}} + \frac{1}{m_{c_h}}\right] \qquad (11)$$

where $\hat{H}_h$ is estimated harvest of Dolly Varden (all stocks) in the sport fishery in stratum h. This variance is an approximation to corresponding formula in Clark and Bernard (1987, p.24) which we employ since harvest in stratum h is estimated, not a known quantity. The approximation is $(\hat{C}_{t_h}-1)\approx\hat{C}_{t_h}$, $(H_h-1)\approx H_h$, and $(n_2-1)\approx n_2$ (where n_2 is the number of fish inspected for marks) in equation 12 of Clark and Bernard (1987). Equation 11 (above) results when the contribution (equation 10, above) is recast as the product of a constant $1/(\theta_h \cdot n_2)$ times two

random variables (m_{c_h} and H_h) and Goodman's formula (1960) for the variance of a product of random variables is employed.

Contributions and variances for the season are the sums across strata $\sum_{h=1}^{L} \hat{C}_{t_h}$ and $\sum_{h=1}^{L} \hat{V}[\hat{C}_{t_h}]$.

If a significant fraction of out-migrating Dolly Varden ≥190 mm FL escaped the fyke traps and the marking fraction for adipose clips was relatively uniform over time, a marking fraction (and contribution based on adipose clips) would be estimated from the sampled weir data. If a significant fraction of out-migrating Dolly Varden ≥190 mm FL escaped the weir and the marking fraction was not relatively uniform over time (but related to fish size), the experiment would be stratified by fish length.

Finally, if the fyke traps captured all emigrant Dolly Varden ≥190 mm FL, then the entire population had dorsal marks, and the marking fraction for this mark would be 1. If the fyke trap did not stop all fish, the contributions of fish with a caudal-mark to sport fisheries could still be estimated, assuming marking occurred prior to fishing.

RESULTS

Abundance Study

One thousand one hundred and twenty-five (1,125) Dolly Varden were captured in Salmon Lake between 26 August and 13 October 1989. None of these fish had naturally missing adipose fins, and all were marked by removing the adipose fin. Different capture gear caught different sizes of fish as shown by fork length. Those fish caught by the weir were largest ($\bar{x}$ = 368 mm FL, n = 38), but very similar to the size of fish caught in beach seines ($\bar{x}$ = 358 mm FL, n = 632). Hook and line caught fish were smaller ($\bar{x}$ = 308 mm FL, n = 59), while those caught in fyke nets were smallest ($\bar{x}$ = 257 mm FL, n = 396). Most marked fish were thus either relatively small (caught with fyke nets) or relatively large being caught with seines (Figure 2).

The fyke traps were installed in the lake outlet stream on 22 March and were removed on 19 May (Table 2, Figure 3). Fyke traps were removed from the river during two periods of high water (27-29 March and 19-22 April). Peak catches occurred in the second and third weeks of April concurrent with high stream flows (Appendix A2). The traps fished the outlet stream and accumulated about 80% of their catch between midnight and 0300 hours. A total of 8,909 Dolly Varden were captured, and 299 of these fish had missing adipose fins. Following the field season every eighth fish (1,067 total) was systematically subsampled for length (Figure 4).

It is likely that some growth recruitment and/or immigration occurred between completion of marking on 13 October 1989 and the spring sampling. However, at Lake Eva (Armstrong 1965) less than 10% of the immigration occurred after 13 October. Also, no Dolly Varden were observed during dive surveys of the outlet of Salmon Lake in mid-October. If significant recruitment occurred after 13 October, our estimate is germane to the spring recapture event.

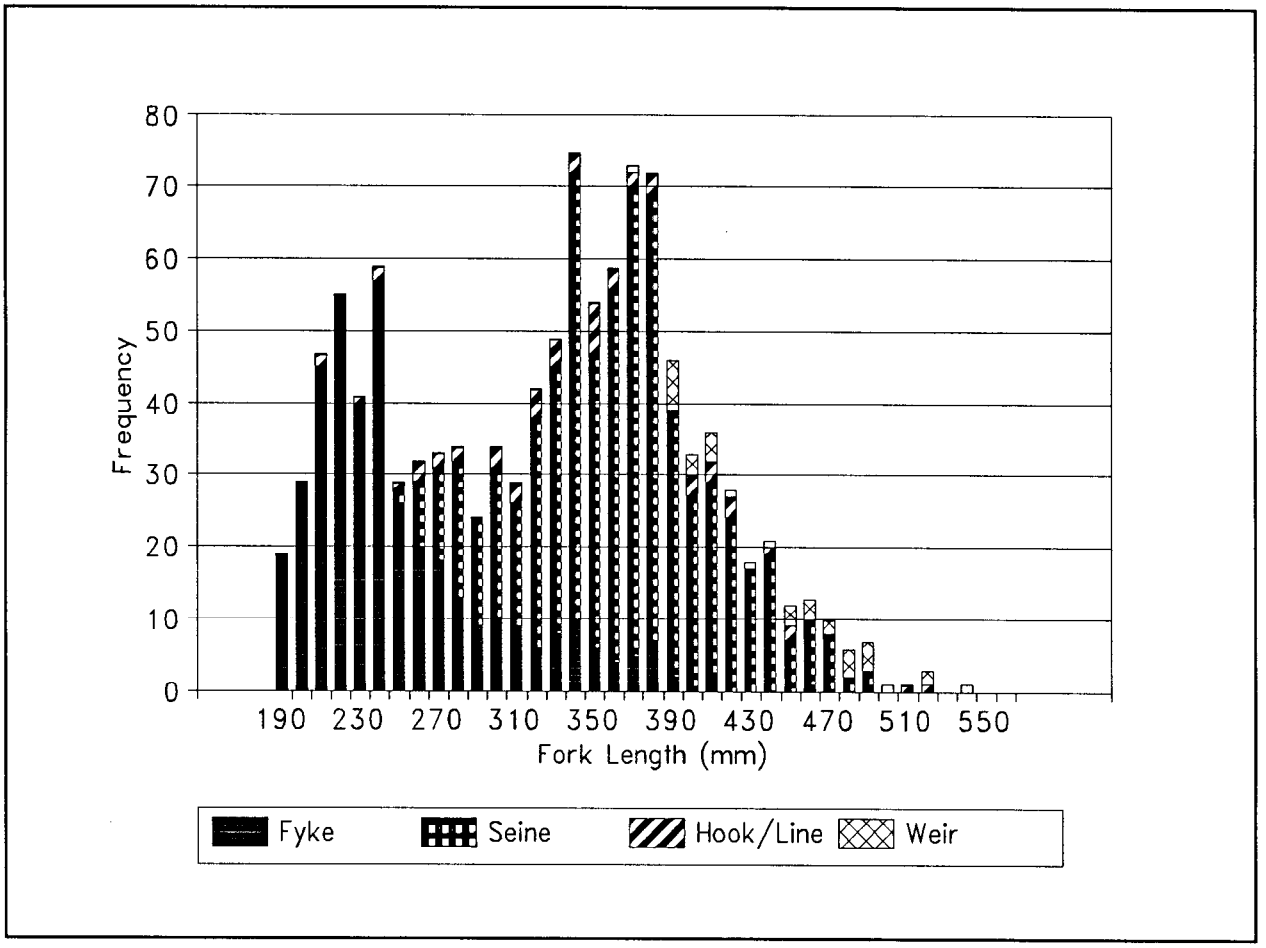

Figure 2. Length frequency distributions of Dolly Varden caught by different gear types at Salmon Lake, fall 1989.

Table 2. Number of Dolly Varden captured in fyke nets and number of marked Dolly Varden released by day at Salmon Lake, 22 March to 19 May 1990.

Date	Dolly Varden caught		Dolly Varden released	
	Total	Adipose clipped	Dorsal caudal clipped	Adipose and dorsal caudal clipped
22 Mar	12	0	12	0
23 Mar	22	3	19	3
24 Mar	10	1	9	1
25 Mar	22	0	22	0
26 Mar	37	2	35	2
30 Mar	94	2	92	2
31 Mar	61	1	59	1
01 Apr	89	3	86	3
02 Apr	51	2	49	2
03 Apr	52	3	49	3
04 Apr	125	5	119	5
05 Apr	93	3	90	3
06 Apr	8	0	5	0
07 Apr	52	4	48	4
08 Apr	376	18	356	18
09 Apr	210	13	191	13
10 Apr	291	7	284	7
11 Apr	262	12	250	12
12 Apr	706	26	668	26
13 Apr	763	33	697	33
14 Apr	981	44	931	43
15 Apr	996	50	944	50
16 Apr	404	13	391	13
17 Apr	1,022	30	986	29
18 Apr	556	9	546	9
19 Apr	0	0	0	0
20 Apr	0	0	0	0
21 Apr	0	0	0	0
22 Apr	0	0	0	0
23 Apr	131	3	128	3
24 Apr	347	4	343	4
25 Apr	245	2	243	2
26 Apr	129	2	127	2
27 Apr	258	2	255	2
28 Apr	0	0	0	0
29 Apr	132	0	132	0
30 Apr	72	0	72	0

-continued-

Table 2. (Page 2 of 2).

Date	Dolly Varden caught		Dolly Varden released	
	Total	Adipose clipped	Dorsal caudal clipped	Adipose and dorsal caudal clipped
01 May	90	0	90	0
02 May	41	0	41	0
03 May	120	0	120	0
04 May	15	0	15	0
05 May	0	0	0	0
06 May	2	0	2	0
07 May	3	0	3	0
08 May	6	0	6	0
09 May	8	1	7	1
10 May	0	0	0	0
11 May	3	1	2	1
12 May	5	0	5	0
13 May	4	0	4	0
14 May	0	0	0	0
15 May	2	0	2	0
16 May	0	0	0	0
17 May	1	0	1	0
18 May	0	0	0	0
19 May	0	0	0	0

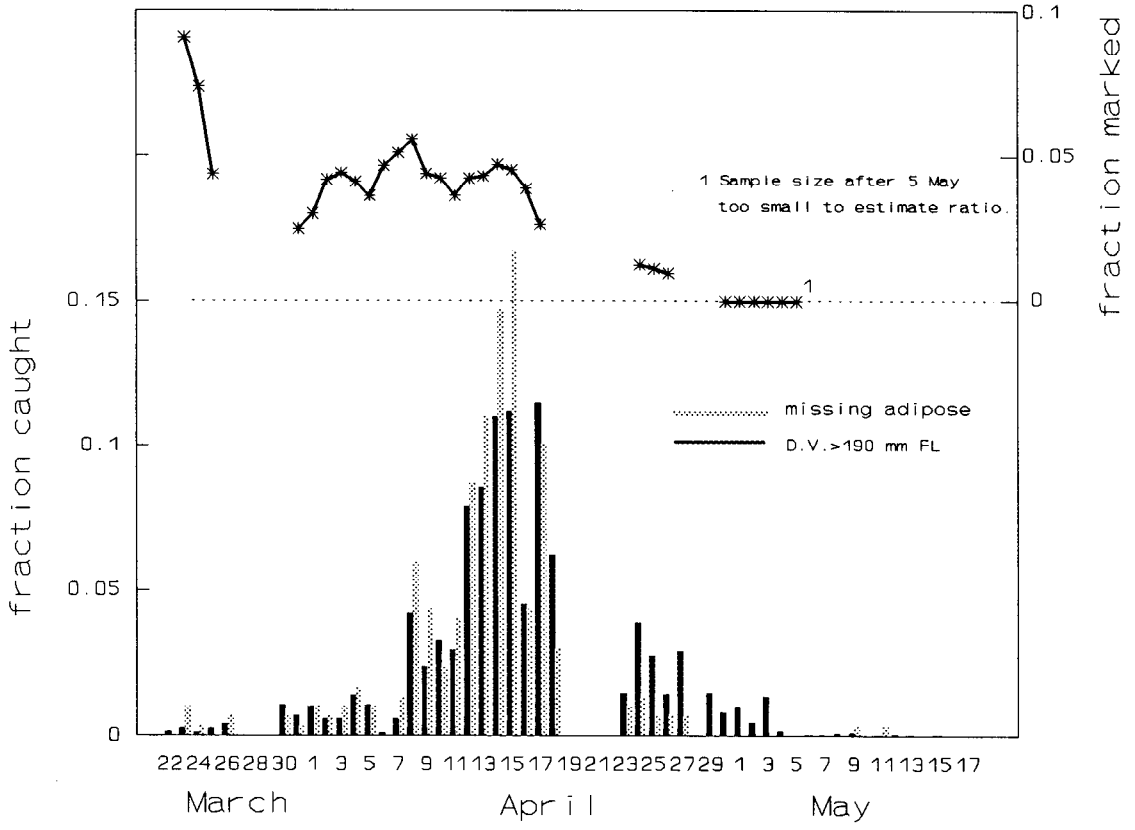

Figure 3. The proportion of all Dolly Varden captured during March–May 1991 at Salmon Lake that were ≥190 mm FL, the proportion of all Dolly Varden captured that were without adipose fins, and the 3-day running average mark–unmarked ratio, by day.

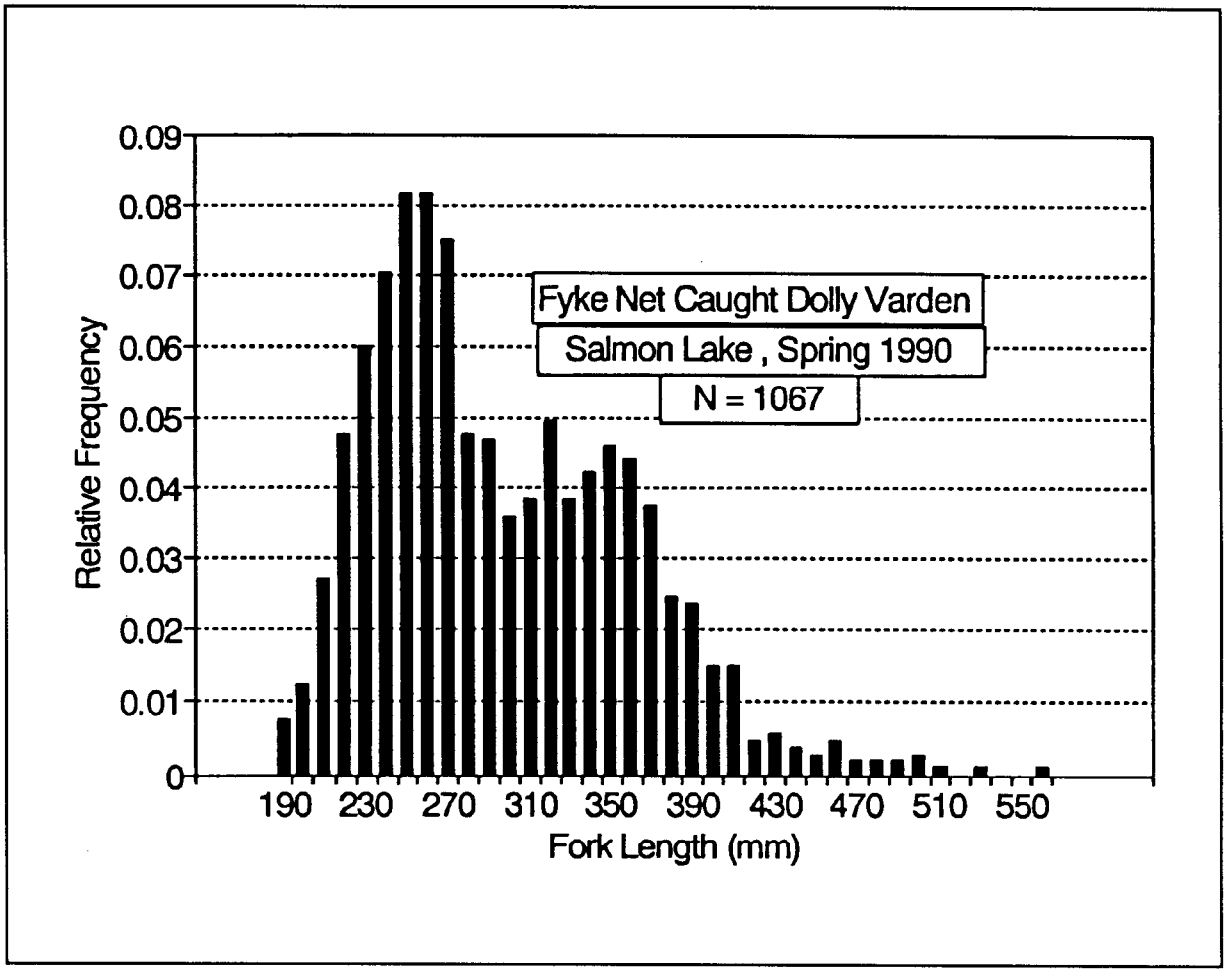

Figure 4. Length frequency distribution of Dolly Varden from fyke catch at outlet of Salmon Lake, spring 1990.

The cumulative distribution function (CDF) of lengths of Dolly Varden marked in the fall of 1989 differed significantly from the CDF of marked Dolly Varden recaptured during spring of 1990 (K-S test, D = 0.125, p = 0.002). Thus, equal probability of capture during the second sampling event is unlikely. However, the difference is at least partly a result of the large sample sizes, enabling detection of small differences, rather than a functional difference between the distributions (Figure 5, top panel). Because of this ambiguous result, abundance for both stratified (at 300 mm FL) and unstratified populations were estimated for comparison.

After stratification, we estimated 18,689 Dolly Varden ≤299 mm FL (SE = 1,426) and 14,202 Dolly Varden ≥300 mm FL (SE = 884) overwintered in Salmon Lake. The combined estimate for all sizes ≥190 mm FL was 32,891 (SE = 1,677). There were 119 adipose clipped Dolly Varden ≤299 mm FL and 180 adipose clipped Dolly Varden ≥300 mm FL recaptured during spring fyke net trapping. There were an estimated 5,227 Dolly Varden ≤299 mm FL and 3,682 Dolly Varden ≥300 mm FL captured during the fyke net trapping. Also, there were 428 adipose-clipped Dolly Varden ≤299 mm FL and 697 adipose-clipped Dolly Varden ≥300 mm FL marked in the fall.

Without stratification we estimated 33,441 (SE = 1,623) Dolly Varden overwintered in Salmon Lake. The Chapman equation parameters for this estimate are n_1 = 1,125, n_2 = 8,909, m_2 = 299. The stratified and unstratified estimates are not statistically different.

Fish Size

The CDF of lengths of Dolly Varden sampled during fall marking was significantly different than the CDF of lengths of all Dolly Varden measured during the spring emigration (K-S test, D = 0.233, p = 0.0001, Figure 5 bottom panel). Although the second sampling event may not be functionally size-selective, the first sampling event was (Appendix A1). This is not surprising since fish were captured for marking using various size-selective gear types. We thus used only data from the second sampling event (Figure 4) to estimate the size composition of the over-wintering population.

Although the fyke traps are relatively nonselective for size, large Dolly Varden tended to out-migrate first (Figure 6). This emigration pattern has been observed by other researchers who have operated weirs on outlet rivers from lake systems (Ericksen et al. 1990; Sonnichsen 1990).

Harvest Study

The creel survey occurred from 26 March through 27 May 1990. During this period, we conducted 272 interviews and observed 238 angler-hours of effort to catch 294 Dolly Varden (Table 3). An estimated total of 1,135 (SE = 399) Dolly Varden were caught, and 214 (SE = 75) were retained during the sampled spring fishery (Table 4). All of the catch occurred at the Sheldon Jackson site, with no catch and very little effort at Starrigavan. Population variances for each stage of sampling were compiled for planning future surveys (Appendix A3).

The smallest sampled Dolly Varden kept by anglers was 260 mm FL. Length frequency of the fish kept and length frequency of the marked fish encountered during the creel survey were very similar (Figure 7).

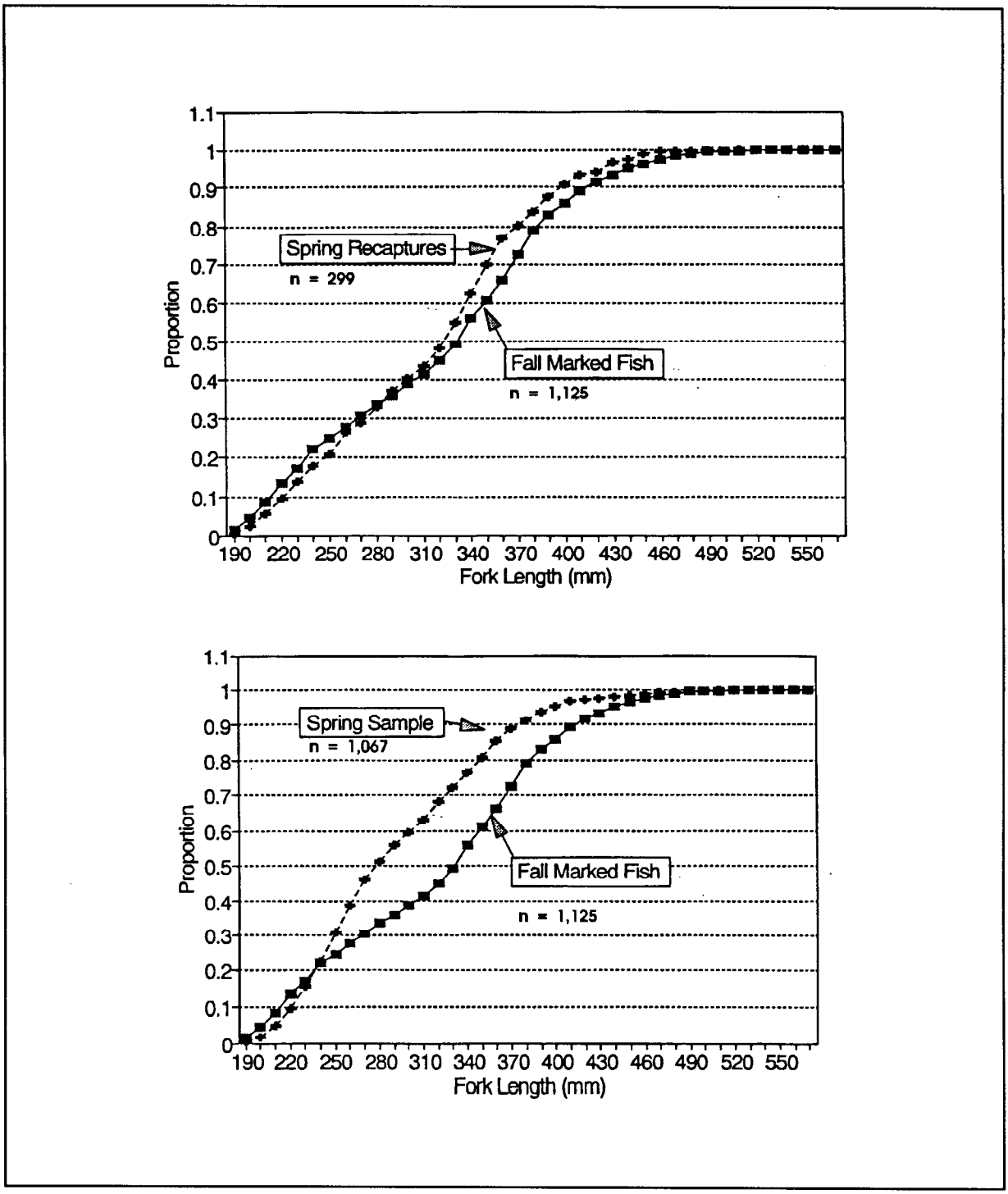

Figure 5. Cumulative distribution functions of lengths of Dolly Varden marked during fall versus lengths of Dolly Varden recaptured the following spring (top) and versus lengths of all Dolly Varden examined for marks during the following spring (bottom), Salmon Lake, 1989–1990.

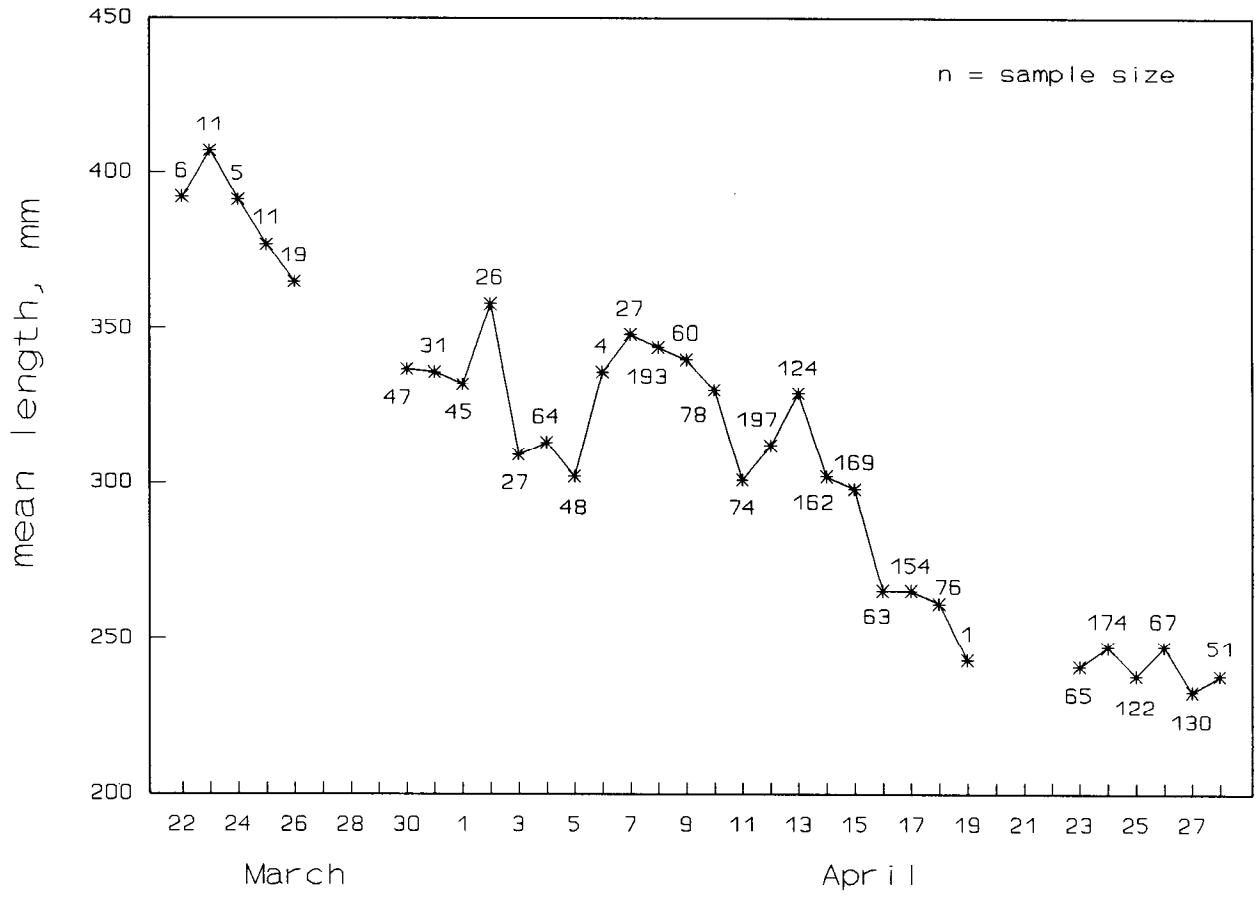

Figure 6. Mean Length of Dolly Varden ≥190 mm fork length or larger captured in the outmigrant fyke traps, by day, Salmon Lake 1991.

Table 3. Observed angler effort (hours), number of interviews, number of periods sampled, number of possible sampling periods, and observed harvest and catch of Dolly Varden by site and sampling period, 1990.

Sampling period	Angler effort	Number of interview	Periods sampled	Periods possible	DV caught	DV kept
Sheldon Jackson						
Weekend						
3/26-4/15	49.50	49	6	24	11	0
4/16-5/06	50.25	47	6	24	119	26
5/07-5/27	2.75	4	6	30	0	0
Weekday						
3/26-4/15	50.42	73	16	60	46	9
4/16-5/06	74.00	74	16	60	118	20
5/07-5/27	1.25	3	16	75	0	0
Starrigavan						
3/26-4/15	2.25	6	6	84	0	0
4/16-5/06	2.50	7	6	84	0	0
5/07-5/27	5.25	9	6	105	0	0

Table 4. Estimated total effort, catch, and harvest of Dolly Varden, with estimates of precision, for Sheldon Jackson and Starrigavan sites by sampling period, 26 March through 27 May 1990.

	26 Mar 90 15 Apr 90	16 Apr 90 06 May 90	07 May 90 27 May 90	Total
Sheldon Jackson				
Angler hours				
Estimate	387	462	20	869
Variance	6,594	3,733	116	10,443
SE[a]	81	61	11	102
Rel.Prec.[b]	0.42	0.26	1.08	0.23
Dolly Varden caught				
Estimate	217	918	0	1,135
Variance	12,372	147,277		159,649
SE	111	384		399
Rel.Prec.	1.02	0.84		0.70
Dolly Varden kept				
Estimate	35	179	0	214
Variance	222	5,467		5,689
SE	15	74		75
Rel.Prec.	0.85	0.83		0.70
Starrigavan				
Angler hours				
Estimate	32	35	92	159
Variance	603	60	556	1,218
SE	24	8	24	35
Rel.Prec.	1.53	0.44	0.51	0.44
Dolly Varden caught				
Estimate	0	0	0	0
Dolly Varden kept				
Estimate	0	0	0	0

[a] SE = standard error.
[b] Relative precision = 2 SE/estimate.

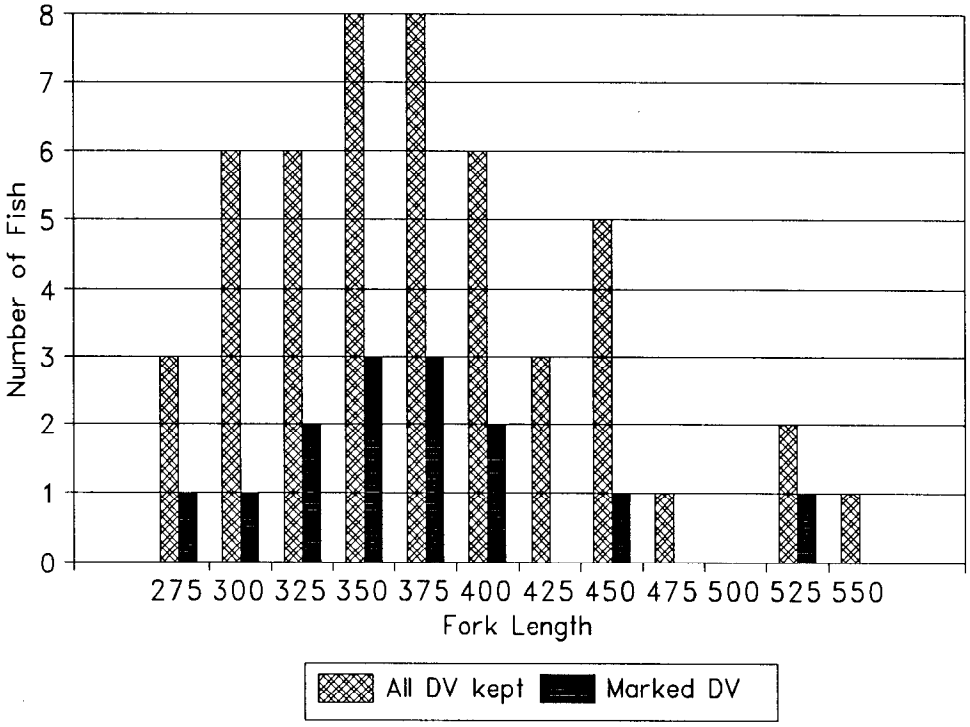

Figure 7. Length frequencies of Dolly Varden which were kept, and marked Dolly Varden sampled during roadside creel survey at Sitka, March-May 1990.

Contribution to Sport Fisheries

Sixteen Dolly Varden marked with a dorsal clip were encountered during the second (16 April-6 May) period of the creel survey. No Dolly Varden marked by a missing adipose clip were sampled in any period. Thus, an unbiased estimate of the contribution to the roadside sport fishery was only possible for the emigrant population which was marked with a dorsal clip in time for that mark to reach the sport fishery. Most dorsal clipped fish were marked prior to 16 April, and nearly all were marked by 6 May (Table 2). No fish smaller than 260 mm FL was harvested (and sampled) during the survey, so we estimated the contribution of the marked emigrants with $m_{c_h} = 16$, $\hat{\Phi}_h = 0.257$, and $\theta_h = 1.0$.

During the period from 16 April to 6 May 1990, an estimated 62 (SE = 29) dorsal marked Dolly Varden ≥260 mm FL which emigrated from Salmon Lake were harvested in the roadside sport fishery. This represents over one-third of the estimated harvest (179) during this period.

DISCUSSION

Based on our results, the density of Dolly Varden overwintering in Salmon Lake in 1990 was about 815 Dolly Varden ≥190 mm FL per hectare. This is similar to estimates for Buskin Lake in 1990 (893 Dolly Varden ≥210 mm FL per hectare, Sandy Sonnichsen, ADF&G, Anchorage, Alaska, pers. comm.), and Lake Eva in 1963 (853 Dolly Varden of age classes IV-XI[1] per hectare, Armstrong 1965). Salmon Lake has an area of about 40 hectares while Buskin and Eve Lakes are about 100 hectares. In comparison, Ericksen and Marshall (*in press*) infer that in Chilkat Lake, which is nearly 1000 hectares, only about 156 Dolly Varden ≥231 mm FL per hectare overwintered during 1990. Thus, numbers-per-hectare may not be a good measure of overwintering "capacity" for all lakes.

The estimated catch of Dolly Varden during the spring roadside fishery this year (1,135) was considerably lower than the estimated catch in the same fishery last year (1,632) (Ericksen et al. 1990). The estimated number of fish kept this year (214) was also much lower than the estimated number kept last year (731). This decline is not related to a lower abundance of Dolly Varden in the fishery since overall CPUE ($\Sigma C/\Sigma E$) in 1990 is not less than in 1989. It thus appears to us that the decline in catch, effort, and harvest between the two years is related to fluctuating interest in the fishery. Again in 1990 we saw the entire harvest come from the Sheldon Jackson Hatchery area. This was a surprise since in some years many Dolly Varden are caught at Starrigavan.

The contribution estimate from this study is a minimum estimate for fish that emigrated from Salmon Lake since only about 8,900 of an estimated 33,400 Dolly Varden were marked with a dorsal clip. Indeed, if these numbers were used to estimate a dorsal-marked to total population ratio (≈0.27), then one might suggest that about 230 Dolly Varden which overwintered in Salmon Lake were harvested in the sport fishery between 16 April to 6 May. Although this estimate is highly unlikely (the point estimate for harvest is 179 and the implicit assumptions are easily criticized) it is clear that the population emigrating from Salmon Lake contributed heavily to the described sport fishery.

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[1] 93,300 emigrants, of which 92.3%, or 86,119 are age IV-XI. The mean length of age IV Dolly Varden emigrants was ≈207 mm FL; see Heiser, 1966.

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APPENDIX A

Appendix A1. Methodologies for alleviating bias due to gear selectivity by means of statistical inference (Clark and Ridder 1990).

Result of first K-S test[a]	Result of second K-S test[b]
Case I[c]	
Fail to reject H_0	**Fail to reject H_0**
Inferred cause: There is no size-selectivity during either sampling event.	
Case II[d]	
Fail to reject H_0	**Reject H_0**
Inferred cause: There is no size-selectivity during the second sampling event, but there is during the first sampling event.	
Case III[e]	
Reject H_0	**Fail to reject H_0**
Inferred cause: There is size-selectivity during both sampling events.	
Case IV[f]	
Reject H_0	**Reject H_0**
Inferred cause: There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	

[a] The first K-S (Kolmogorov-Smirnov) test is on the lengths of fish marked during the first event versus the lengths of fish recaptured during the second event. H_0 for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish recaptured during the second event.

[b] The second K-S test is on the lengths of fish marked during the first event versus the lengths of fish captured during the second event. H_0 for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish sampled during the second event.

[c] Case I: Calculate one unstratified abundance estimate, and pool lengths and ages from both sampling events for size and age composition estimates.

[d] Case II: Calculate one unstratified abundance estimate, and only use lengths and ages from the second sampling event to estimate size and age composition.

[e] Case III: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Pool lengths and ages from both sampling events and adjust composition estimates for differential capture probabilities.

[f] Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Also calculate a single abundance estimate without stratification. If stratified and unstratified estimates are dissimilar, discard unstratified estimate and use lengths and ages from second event and adjust these estimates for differential capture probabilities. If stratified and unstratified estimates are similar, discard estimate with largest variance. Use lengths and ages from first sampling event to directly estimate size and age compositions.

Appendix A2. Daily catches of fish and measurements of rainfall, water temperature, and maximum stream depth at the site of the fyke net on the outlet stream from Salmon Lake, 1990.

Date	Previous 24-hour rainfall (inches)	Mean water temp. (°C)	Maximum stream depth (cm)	Dolly Varden
22 Mar				12
23 Mar	0.00		41	22
24 Mar	0.00		40	10
25 Mar	0.20	1.5	41	22
26 Mar	0.10	1.5	46	37
27 Mar	0.20	1.5	98	0[a]
28 Mar	1.10	1.5	94	0[a]
29 Mar	1.70	2.0	97	0[a]
30 Mar	0.20	1.5	67	94
31 Mar	0.45	1.5	53	61
01 Apr	0.20	1.5	48	89
02 Apr	0.10	1.5	47	51
03 Apr	0.25	1.5	47	52
04 Apr	0.50	1.0	46	125
05 Apr	0.70	2.0	51	93
06 Apr	0.00	2.0	47	8
07 Apr	0.00	2.0	46	52
08 Apr	0.00	2.0	44	376
09 Apr	0.00	2.0	44	210
10 Apr	0.00	2.5	43	291
11 Apr	0.00	2.0	44	262
12 Apr	0.50	2.0	51	706
13 Apr	0.00	2.0	64	763
14 Apr	0.00	2.0	68	981
15 Apr	0.00	2.0	62	996
16 Apr	0.00	2.5	65	40
17 Apr	trace	2.5	67	1,022
18 Apr	0.10	3.0	62	556
19 Apr	0.70	3.0	76	0[b]
20 Apr	0.50	3.0	74	0[b]
21 Apr				0[b]
22 Apr				0[b]
23 Apr	0.00	3.5	53	131
24 Apr	0.30	4.0	53	347
25 Apr	0.25	4.0	53	245

-continued-

Appendix A2. (Page 2 of 2).

Date	Previous 24-hour rainfall (inches)	Mean water temp. (°C)	Maximum stream depth (cm)	Dolly Varden
26 Apr	0.00	5.0	52	129
27 Apr	0.00	5.0	52	258
28 Apr	0.00	5.0	52	0
29 Apr	0.00	6.0	52	132
30 Apr	0.00	5.5	52	72
01 May	0.35	6.0	50	90
02 May	0.15	5.5	51	41
03 May	0.50	5.0	68	120
04 May	0.80	5.5	78	15
05 May	0.00	5.0	62	0
06 May	0.10	5.5	52	2
07 May	trace	5.5	51	3
08 May	0.48	5.0	54	6
09 May	0.10	5.0	54	8
10 May	0.10	5.5	56	0
11 May	0.10	5.5	54	3
12 May	0.10	6.0	55	5
13 May	trace	6.0	52	4
14 May				4
15 May	0.00	7.0	49	2
16 May	0.00	7.0	48	0
17 May	0.00	7.0	48	1
18 May	trace	7.0	50	0
19 May	0.00	7.0	53	0

[a] fyke nets washed-out.
[b] high water, fyke nets deactivated.

Appendix A3. Estimated population variances for effort, harvest, and catch of Dolly Varden, by stratum, sampling stage[a], and site, 1990.

Sampling period	Effort			Harvest			Catch		
	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
SHELDON JACKSON									
weekends									
3/26-4/15	5,850	68	0	0	0.0	0.0	728	404	0
4/16-5/06	1,650	340	0	4,810	104	0.0	94,200	2,770	0
5/07-5/27	95	4.2	0	0	0.0	0.0	0	0	0
weekdays									
3/26-4/15	344	329	3.7	118	101	2.8	6,690	4,300	251
4/16-5/06	1,490	252	0	285	270	0	33,900	16,400	0
5/07-5/27	10	7.5	0	0	0	0	0	0	0
STARRIGAVAN									
3/26-4/15	599	4.4	0	0	0	0	0	0	0
4/16-5/06	42	18	0	0	0	0	0	0	0
5/07-5/27	345	212	0	0	0	0	0	0	0

[a] Stage 1: days within 14-day seasons; Stage 2: periods within days; Stage 3: anglers within periods.