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A STUDY OF SOCKEYE SALMON IN WINDFALL LAKE, 1989[1]

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ABSTRACT

A total of 3,864 adult sockeye salmon *Oncorhynchus nerka* passed through the Windfall Lake weir from 12 June 1989 through 6 August 1989. Anglers expended an estimated 2,694 (standard error = 159) rod hours of effort in the Windfall Lake sockeye salmon fishery in 1989. Approximately 803 (standard error = 102) sockeye salmon were harvested, and approximately 499 (standard error = 139) were released. The total return including harvest was estimated to be 4,667 fish, and the sport harvest rate was approximately 17 percent. The peak escapement survey count was 1,766 sockeye salmon, made on 10 August 1989.

KEY WORDS: Southeast Alaska, Juneau, Windfall Lake, Herbert River, Slate Creek, sockeye salmon, *Oncorhynchus nerka*, weir, creel census, age-length-sex composition, sport harvest, escapement.

INTRODUCTION

Windfall Lake is approximately 32 km (29.8 mi) north of Juneau, and approximately 0.8 km (0.5 mi) south of the Herbert River (Figure 1). The lake is accessible by a single 4 km (2.5 mi) trail from the Juneau road system. Windfall Lake has a surface area of approximately 121.4 ha (300 ac), a maximum depth of 10.7 m (35 ft), and an elevation of 27.1 m (89 ft). The lake water is clear with a brownish tint. Windfall Lake has two inlets; the Windfall Creek-Slate Creek system enters at the southwest corner of the lake and a small, unnamed stream enters at the southeast corner of the lake. The lake shore is lined with lily pads, arrowhead, and other aquatic vegetation. A large muskeg area containing many grass mats, small waterways, and several beaver dams is located at the south end of the lake.

Windfall Lake supports populations of sockeye *Oncorhynchus nerka* and coho salmon *O. kisutch*, cutthroat trout *O. clarki*, and Dolly Varden *Salvelinus malma*. The sockeye salmon population contributes to mixed-stock commercial seine and gill net fisheries, and to an increasingly popular sport fishery. Windfall Lake supports one of only three sockeye salmon stocks that occur along the Juneau road system, and it is the only one of those systems in which sport angling for sockeye salmon is permitted. The sport fishery for sockeye salmon occurs at the confluence of the Herbert River and the outlet of Windfall Lake. The bag limit for sockeye salmon at Windfall Lake is two fish daily or in possession.

Estimates of sport harvest and sockeye salmon escapements to Windfall Lake have been sporadic. The estimates have been based on observations of the number of anglers and sockeye salmon at the outlet of Windfall Lake, followed by foot surveys on Slate Creek, the main spawning tributary to Windfall Lake. In order to relate the numbers of fish observed in spawning surveys to the total escapement and to assess the impact of the growing sport fishery, we needed determine the true size of the sockeye salmon run to Windfall Lake and to obtain a more accurate estimate of sport angling harvest and effort. The objectives of this study were:

1. Count the escapement of sockeye salmon to Windfall Lake between 1 June and 31 August 1989.

2. Estimate the total angler effort and harvest of sockeye salmon at the outlet of Windfall Lake from 1 June to 31 August 1989.

3. Estimate the age and sex composition of the sockeye salmon escapement to Windfall Lake.

4. Estimate the mean length at age of the sockeye salmon in the escapement to Windfall Lake.

METHODS

Sockeye Salmon Escapement

An aluminum picket and tripod weir was constructed near the outlet of Windfall Lake, approximately 61 m (200 yds) downstream from the lake. Sockeye salmon returning to Windfall Lake were counted as they were released from an immigrant trap in the weir. Water depth (nearest cm), water temperature (nearest °C), and

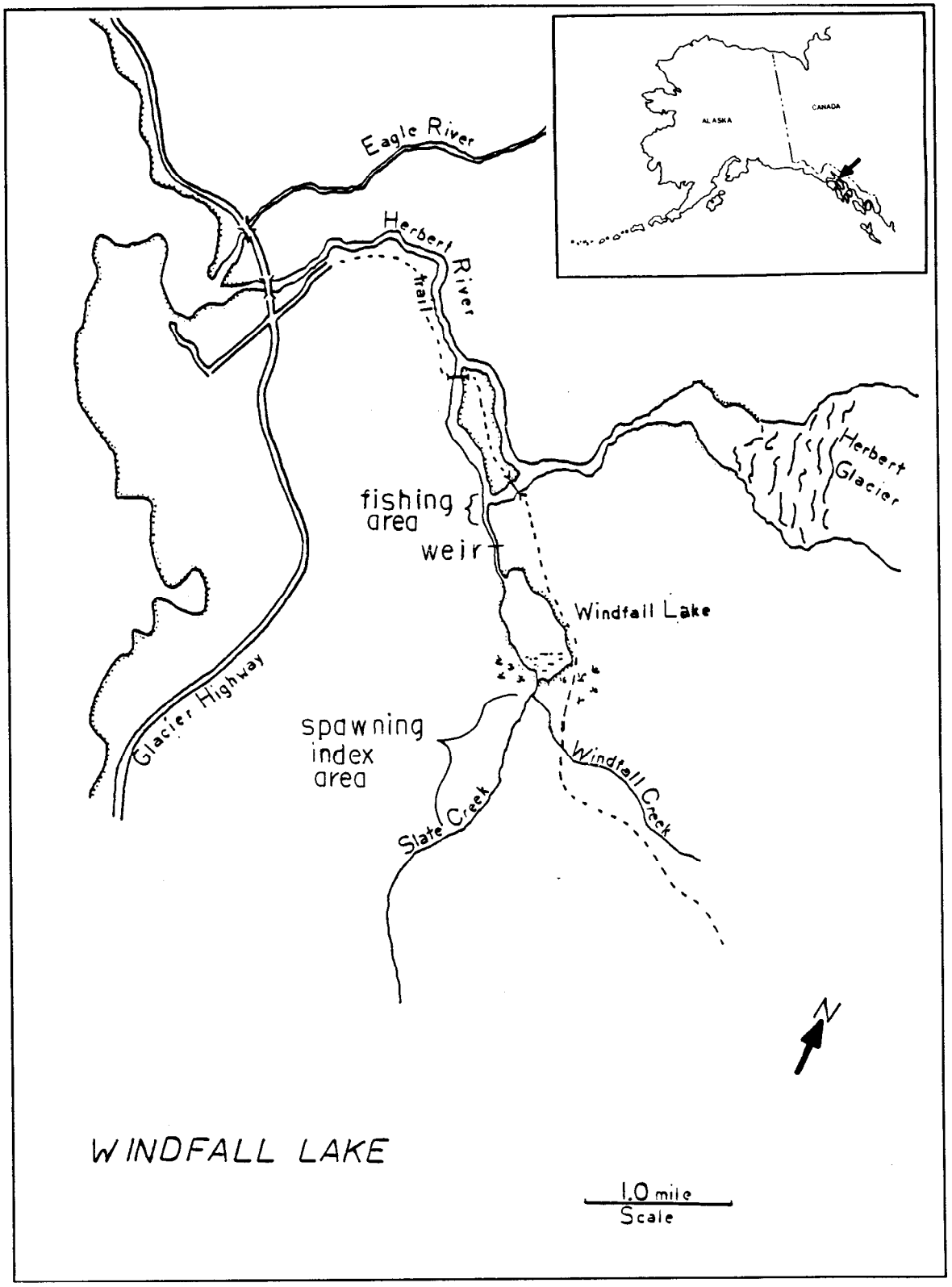

Figure 1. Map of the Windfall Lake system.

maximum and minimum air temperatures during the previous 24 hr period (nearest °C) were recorded daily at 0900-1000 hours. A meter stick attached to the downstream side of a weir tripod was used to monitor water level in the stream.

A subsample of fish was selected from those captured in the weir for estimates of age composition and estimates of mean length at age. Sockeye salmon found in the weir live box were periodically dipnetted from the weir live box for sampling; we attempted to keep the cumulative number sampled at approximately 30% of the total run. Salmon that were not sampled were counted as they were removed from the weir box. The sampled fish were tranquilized with a 12-volt electro-shocking basket (Gunstrom and Bethers 1985). Length (mid-eye to fork of tail) was measured to the nearest millimeter, and four scales were taken from the left side of each fish approximately two rows above the lateral line and on a diagonal row from the posterior insertion of the dorsal fin (Clutter and Whitesel 1956). Scales were affixed to gummed scale cards, pressed onto acetate sheets, and aged according to the procedures of Mosher (1968) and Jearld (1983). The mean and standard error for the length estimates at each age were calculated using standard statistical procedures.

Spawning escapement surveys for the Windfall Lake system are conducted on Slate Creek, a small tributary at the south end of Windfall Lake (Figure 1). Escapement surveys on Slate Creek have been conducted irregularly since 1968, and have been conducted annually since 1986. Surveys conducted since 1979 have been conducted on the same "index" section of Slate Creek. The upper and lower ends of the index area are marked with blaze marks on large spruce trees growing alongside the stream. Adult sockeye salmon were counted by a technician walking along the bank in an upstream direction. The peak counts are numbers of fish that were actually observed on that date.

Creel Survey

A roving type creel survey (Neuhold and Lu 1957) was conducted to estimate angler effort and harvest of sockeye salmon at Windfall Lake. The period from 5 June through 30 July was divided into four biweekly periods. Data collected from 31 July through 5 August was added to that for the last biweekly period. A fishing day was defined as the number of daylight hours between sunrise and sunset. Weekly sunrise and sunset times were estimated for Windfall Creek, rounded to the nearest 0.25 hour, and each day in that week was divided into one-hour sample periods. Sampling was stratified by type of day (weekday or weekend-holiday).

Samples were allocated according to the following scheme:

1. During each week (Monday-Friday) two contiguous weekdays were randomly sampled for "non-sampling." All other weekdays, and weekend-holidays were selected for sample allocation.

2. Three combination samples (i.e., both counts and interviews) were allocated to each sampling day. Sample times were selected in a random fashion (without replacement) from the possible sampling times available for that day. Counts were conducted either before or after interviews on a random basis.

3. Two count-only samples were allocated to each sampling day. Sample times were selected in a random fashion (without replacement) from the possible remaining sampling times.

If time was inadequate to conduct a scheduled sample (e.g., due to weir installation, repair, illness of crew, etc.) the following procedure was followed to drop or reschedule a sample.

1. In any particular sampled day, one count-only type sample was randomly selected (i.e., by the flip of a coin) for dropping. If it was necessary to drop an additional sample, both count-only type samples were dropped.

2. If it was necessary to drop more samples (after dropping both count-only type samples), a random number from 1 to 3 was selected. The selected number corresponded to the combination (count and interview) sample to be dropped. If an additional sample was dropped, then a coin was tossed to select which of the remaining two combination samples was to be dropped. If no time was available to sample, all samples were dropped.

3. Attempts were made to reschedule dropped samples during the scheduled "days off" within any particular biweekly period. Accordingly, if weekday samples within a biweekly period were dropped, the dropped sample(s) were rescheduled to any remaining "days off" within the same biweekly period. Missed weekend-only type samples were not rescheduled, and if no "days off" remained within the biweekly period, the missed sampled were not rescheduled.

4. At least two samples within a biweekly period and type of fishing day (i.e., weekdays versus weekend-holidays) were conducted to ensure ability to obtain estimates and their variances.

Each sport angler interviewed at Windfall Lake was asked: the number of hours fished, to the nearest 0.25 hour; whether the trip was complete or incomplete; and the number of fish kept and/or released by species. Length measurements and scales were obtained from all harvested sockeye salmon observed in the creel survey. If an angler had been interviewed previously the same day, subsequent samples included only effort and catch since the previous interview.

Angler counts were considered instantaneous, and reflected fishing effort at the time of the count. A stratified random estimator was used to estimate effort in angler-hours. The average angler count for each stratum was multiplied by the total number of available fishing hours within each stratum. The effort estimates and the associated variance estimates were obtained according to the following equations (essentially following the approach of Von Geldern and Tomlinson 1973).

$\hat{E}_h$ = estimated angler-hours expended on the hth stratum (as defined by the combination of biweekly period, and type of fishing day, i.e., weekday versus weekend-holiday);

$$= U_h \bar{x}_h \quad (1)$$

h = subscript denoting stratum;

U_h = total number of hours (available for fishing) in the hth stratum;

$\bar{x}_h$ = mean number of anglers fishing for the hth stratum;

$$= \frac{\sum_{i=1}^{d_h} (x_{hi})}{d_h} \quad (2)$$

i = subscript denoting sample within the hth stratum;

d_h = number of samples (i.e., counts) completed in the hth stratum;

x_{hi} = number of recreational anglers fishing counted in the ith sample in the hth stratum;

$\hat{V}_h(\hat{E}_h)$ = the variance estimate for the estimate of E_h, obtained by the standard formula for the estimation of the variance of a product of a constant and a variance estimate, and utilizing a finite population correction factor (Lehmann 1975, equation A.19, page 330);

$$= [\frac{(D_h - d_h)}{D_h}] [U_h^2 (\frac{s_h^2}{d_h})] \quad (3)$$

D_h = number of possible counts which can be conducted in the hth stratum;

$$s_h^2 = \frac{\sum_{i=1}^{d_h} (x_{hi} - \bar{x}_h)^2}{(d_h - 1)} \quad (4)$$

Angler harvest rates were estimated from interview data using a stratified random estimator, according to the following equations:

$\hat{T}_h$ = estimated total harvest per unit of effort (HPUE) for the hth stratum;

$$= \frac{\sum_{i=1}^{n_h} (\sum_{j=1}^{o_i} c_{hij})}{\sum_{i=1}^{n_h} (\sum_{j=1}^{o_i} e_{hij})} \quad (5)$$

h = subscript denoting the stratum;

i = subscript denoting an individual interview sample within the hth stratum;

j = subscript denoting the angler interviewed in the ith sample;

n_h = number of interview samples collected within the hth stratum;

o_i = number of anglers interviewed within the ith sample;

c_{hij} = harvest of the jth angler interviewed on the ith sample in the hth stratum;

e_{hij} = effort of the jth angler interviewed;

$\hat{V}_h(\hat{T}_h)$ = estimated variance of the HPUE estimate in the hth stratum, which is estimated approximately by the standard formula for the variance of the ratio of random variables (Jessen 1978, equation 5.8, page 128, omitting the finite population correction factor);

$$\approx \left\{\frac{\bar{c}_{h..}}{\bar{e}_{h..}}\right\}^2 \left\{\left[\frac{s_c^2}{(\bar{c}_{h..})^2}\right] + \left[\frac{s_e^2}{(\bar{e}_{h..})^2}\right] - \left[\frac{2\mathrm{cov}(c,e)}{\bar{c}_{h..}\bar{e}_{h..}}\right]\right\} \quad (6)$$

$\bar{c}_{h..}$ = overall mean of means harvest per angler in the hth stratum;

$$= \frac{\sum_{i=1}^{n_h} \bar{c}_{hi.}}{n_h} \quad (7)$$

$\bar{c}_{hi.}$ = mean harvest per angler within the ith sample in the hth stratum;

$$= \frac{\sum_{j=1}^{o_i} c_{hij}}{o_i} \quad (8)$$

$\bar{e}_{h..}$ = overall mean of means effort per angler in the hth stratum, calculated by replacing the appropriate effort statistics into equation 7, above;

$\bar{e}_{hi.}$ = mean effort per angler within the ith sample with the hth stratum, calculated by replacing the appropriate effort statistics into equation 8, above;

s_c^2 = variance estimate associated with estimating the harvest component of the HPUE estimate, obtained by using a modified two-stage sampling approach estimator (Cochran 1977);

$$= \left[\frac{N_h - n_h}{N_h}\right]\left[\frac{s_{B_c}^2}{n_h}\right] + \left[\frac{1}{N_h}\right]\left[\frac{s_{W_c}^2}{n_h}\right] \quad (9)$$

N_h = total number of possible interview samples in the hth stratum;

$s_{B_c}^2$ = the between samples variance component of the variance estimate for harvest;

$$= \frac{\sum_{i=1}^{n_h} (\bar{c}_{hi.} - \bar{c}_{h..})^2}{n_h - 1} \quad (10)$$

$s^2_{w_c}$ = the within sample variance component of the variance estimate for harvest;

$$= \sum_{i=1}^{n_h} \left\{ \left[\frac{(O_i - o_i)}{O_i} \right] \left[\frac{1}{o_i} \right] \left[\frac{\sum_{j=1}^{o_i} (c_{hij} - \bar{c}_{hi.})^2}{(o_i - 1)} \right] \right\} \quad (11)$$

O_i = Total number of anglers fishing during the interview sample (including anglers interviewed, o_i, and anglers not interviewed);

s^2_θ = variance estimate associated with estimating the effort component of the HPUE estimate which is calculated by substituting the corresponding effort statistics into equations 9 through 11, above;

$cov(c,e)$ = covariance estimate between the harvest and effort components of the HPUE estimate;

$$= \left[\frac{N_h - n_h}{N_h} \right] \left[\frac{cov_B(c,e)}{n_h} \right] + \left[\frac{1}{N_h} \right] \left[\frac{cov_W(c,e)}{n_h} \right] \quad (12)$$

$cov_B(c,e)$ = the between samples covariance component of the covariance estimate between harvest and effort;

$$= \frac{\sum_{i=1}^{n_h} (\bar{c}_{hi.} - \bar{c}_{h..})(\bar{e}_{hi.} - \bar{e}_{h..})}{(n_h - 1)} \quad (13)$$

$cov_W(c,e)$ = the within samples covariance component of the covariance estimate between harvest and effort;

$$= \sum_{i=1}^{n_h} \left\{ \left[\frac{(O_i - o_i)}{O_i} \right] \left[\frac{1}{o_i} \right] \left[\frac{\sum_{j=1}^{o_i} (c_{hij} - \bar{c}_{hi.})(e_{hij} - \bar{e}_{hi.})}{o_i - 1} \right] \right\} \quad (14)$$

As indicated in equation 9, a modified two-stage estimator was used. However, the sampling design was more accurately a stratified random design. In the modified two-stage design we have defined period sampled as the primary level of sampling and anglers interviewed as the secondary level. Since the anglers interviewed represent a random component in the model rather than a fixed component, the secondary term in the corresponding variance equation does not include a finite population correction factor (fpc).

The next step involved estimating the harvest for each stratum:

$\hat{H}_h$ = estimated harvest or the hth stratum;

$$= \hat{E}_h \hat{T}_h \quad (15)$$

$\hat{V}_h(\hat{H}_h)$ = estimated variance of the estimate of H_h, assuming independence of the estimates of effort and HPUE, obtained by using the formula proposed by Goodman (1960) for the

estimation of the variance of a product of two random independent variables;

$$= \hat{E}_h^2 \hat{V}_h(\hat{T}_h) + \hat{T}_h^2 \hat{V}_h(\hat{E}_h) - \hat{V}_h(\hat{E}_h)\hat{V}_h(\hat{T}_h) \quad (16)$$

HPUE estimates across strata (e.g., for one seasonal period disregarding day type) were obtained as follows:

$\hat{P}_c$ = combined HPUE estimate over selected strata;

$$= \frac{\sum_{h=1}^{q} \hat{H}_h}{\sum_{h=1}^{q} \hat{E}_h} \quad (17)$$

q = the number of stratum to be combined;

$\hat{V}_c(\hat{P}_c)$ = the variance of the across-strata estimate of HPUE;

$$\approx \left\{\frac{\hat{H}_c}{\hat{E}_c}\right\}^2 \left\{\left[\frac{\hat{V}_{H_c}}{\hat{H}_c^2}\right] + \left[\frac{\hat{V}_{E_c}}{\hat{E}_c^2}\right] - \left[\frac{2\mathrm{cov}_c(H,E)}{\hat{H}_c\hat{E}_c}\right]\right\} \quad (18)$$

$$\hat{H}_c = \sum_{h=1}^{q} \hat{H}_h \quad (19)$$

$$\hat{E}_c = \sum_{h=1}^{q} \hat{E}_h \quad (20)$$

$$\hat{V}_{H_c} = \sum_{h=1}^{q} \hat{V}_h(\hat{H}_h) \quad (21)$$

$$\hat{V}_{E_c} = \sum_{h=1}^{q} \hat{V}_h(\hat{E}_h) \quad (22)$$

$$\mathrm{cov}_c(H,E) = \sum_{h=1}^{q} (\mathrm{cov}_h(h,e)) \quad (23)$$

Variance equations 21 and 22, used above, indicate an assumed independence of the various harvest and effort estimates among strata. This assumption was not entirely valid in that positively correlated levels of effort and harvest would be expected during similar time periods. However, this assumption was conservative in nature such that the variance estimates obtained would be positively biased.

The final step in estimating the effort or harvest for the entire season or for unique combinations of individual sampling strata involved combining the stratum estimates:

$\hat{H}$ = overall estimated harvest or effort;

$$= \sum_{h=1}^{q} (H_h) \quad (24)$$

q = number of strata to be combined;

$\hat{V}(\hat{H})$ – estimated variance of H, assuming independence of the stratum estimates;

$$= \sum_{h=1}^{s} (\hat{V}_h(\hat{H}_h)) \quad (25)$$

RESULTS

Sockeye Salmon Escapement

A total of 3,864 sockeye salmon were passed through the Windfall Lake weir from 12 June through 6 August 1989. The return was 50% complete on 27 June and 95% complete on 23 July. The record of daily and cumulative weir counts and numbers of sockeye salmon sampled is presented in Appendix A1, and the daily record of water temperature, water level, and air temperature is presented in Appendix A2. Age, length, and sex data were collected from 851 (22%) of the adult sockeye passed through the weir, and from 147 fish taken in the sport fishery (Table 1). Age-1.3 sockeye salmon were most prevalent in both the samples from the sport fishery (93.8%) and the escapement through the weir (92.5%). Age-1.2 sockeye salmon comprised approximately 5% of both the sampled sport fishery harvest and weir escapement. Male sockeye salmon comprised slightly more than half of the sampled sport fishery harvest (55%) and the escapement through the weir (52%).

A total of four escapement surveys (27 July, 1 August, 10 August, and 17 August) were conducted on Slate Creek. A peak count of 1,766 sockeye salmon was made on August 10, 1989.

Creel Survey

Approximately 46 meters of the stream upstream and downstream from the weir was closed to sport fishing. The location of the weir was approximately 1,100 meters upstream from the customary fishing area, in a area that had not been used for sport fishing before weir construction. The location of the weir is not believed to have had any impact on the sport fishing activity.

A total of 201 anglers were interviewed from 10 June through 5 August 1989 (Table 2). An estimated 2,691 (SE = 159) rod hours of effort were expended in the sockeye salmon sport fishery during that period (Table 3). An estimated 803 (SE = 102) sockeye salmon were harvested, and 499 (SE = 139) were released. Harvest rates peaked during the first period (10 June – 18 June) at 0.435 (SE = 0.185) sockeye salmon per angler hour, and declined in each subsequent survey period (Table 4). The estimated in-river return (escapement plus harvest) of sockeye salmon to Windfall Lake in 1989 was 4,667 fish.

Sockeye salmon was the principal species taken during the fishery, with small numbers of Dolly Varden and cutthroat trout appearing only later during the season. An estimated 21 (SE = 9.6) Dolly Varden were kept during the period 3 July – 16 July, and an estimated 3 (SE = 2.8) fish were kept during the period 17 July – 5 August. An estimated 10 (SE = 8.5) cutthroat trout were released during the period 17 July – 5 August.

Table 1. Age, sex, and length (mid-eye to fork of tail) of adult sockeye salmon taken in the sport fishery and passed through the weir at Windfall Lake, 1989.

SPORT FISHERY

	Male			Female			Combined			
Age	N[a]	Mean Length (cm)	SE[b]	N	Mean Length (cm)	SE	N	Mean Length (cm)	SE	Percent at Age
1.2	5	52.7	1.6	3	53.4	0.7	8	53.0	1.0	5.4
1.3	75	61.8	0.3	63	58.2	0.3	138	60.2	0.3	93.8
2.3	1	60.0	–	–	–	–	1	60.0	–	0.7

WEIR

	Male			Female			Combined			
Age	N[a]	Mean Length (cm)	SE[b]	N	Mean Length (cm)	SE	N	Mean Length (cm)	SE	Percent at Age
1.2	40	48.1	0.7	6	49.5	2.4	46	48.3	0.7	5.4
1.3	398	60.8	0.2	388	57.5	0.1	787[c]	59.2	0.1	92.5
1.4	2	63.7	0.2	4	59.0	1.2	6	60.6	1.3	0.7
2.2	–	–	–	1	49.1	–	1	49.1	–	0.1
2.3	6	60.8	0.8	5	57.7	0.6	11	59.4	0.7	1.3

[a] N is the total number of fish aged in 1989.
[b] SE is the estimated standard error of the estimate.
[c] Includes one fish (Age 1.3) of unknown sex.

Table 2. Number of samples (one-hour periods), number of interviews, total effort, and total harvest observed by seasonal period at Windfall Lake between 10 June and 5 August, 1989.

Period	Sampling		Interviews		Observed	
	n[a]	N[b]	o[c]	C[d]	e[e]	c[f]
10 June – 18 June	34	162	52	10	80.7	32
19 June – 2 July	50	252	147	17	264.8	88
3 July – 16 July	50	248	104	25	222.7	58
17 July – 5 August	67	337	14	6	33.7	2
Total	201	999	317	58	601.9	180

[a] n is the number of count samples.
[b] N is the number of possible count samples.
[c] o is the number of interviews.
[d] C is the number of complete-trip anglers interviewed.
[e] e is the number of hours of angler effort observed during the interviews.
[f] c is the number of sockeye salmon observed harvested during the interviews.

Table 3. Estimated number of sockeye salmon harvested and released during seasonal period of the fishery at Windfall Lake, 1989.

Period	Effort			Harvest			Released		
	E[a]	SE[b]	CV[c]	H[d]	SE	CV	R[e]	SE	CV
10 June – 18 June	312	47	15	136	54	40	147	85	58
19 June – 2 July	1,349	106	8	423	71	17	262	75	29
03 July – 16 July	919	89	10	238	50	21	80	81	101
17 July – 5 August	115	64	56	7	4	59	10	6	62
Total	2,694	159	6	803	102	13	499	139	28

[a] E is the estimated effort in angler hours.
[b] SE is the standard error of the estimate.
[c] CV is the coefficient of variation of the estimate in percent (%).
[d] H is the estimated number of sockeye salmon harvested.
[e] R is the estimated number of sockeye salmon released.

Table 4. Mean estimated HPUE (fish harvested per angler-hour) for sockeye salmon by sampling period at Windfall Lake during 1989.

Period	HPUE	SE
10 June - 18 June	0.435	0.185
19 June - 02 July	0.314	0.058
03 July - 16 July	0.259	0.060
17 July - 05 August	0.059	0.049
All Periods	0.298	0.042

DISCUSSION

No earlier comparable estimates of sport harvest, escapement, and size at age exist for sockeye salmon at Windfall Lake. The age composition is similar, however, to that obtained from a sample of 75 sockeye salmon scales collected in 1987 from Windfall Lake in which 95% of the fish were aged 1.3, i.e., one year in freshwater and three years in saltwater (McPherson, et al. 1987). Our study in 1989 also showed that the predominant age class for Windfall Lake sockeye salmon was age 1.3.

The predominance of the 1.3 age class at Windfall Lake is somewhat unique. Only about 70% of the sockeye salmon returning to the Berners River, just north of Windfall Lake, are aged 1.3. Farther to the north in Lynn Canal, only about 75% of the Chilkoot River sockeye salmon and 33% of the Chilkat River sockeye salmon return at age 1.3. Stock separation specialists report that the Windfall Lake sockeye salmon display a very specific scale pattern that can be easily distinguished from those of other Lynn Canal sockeye salmon stocks (Scott McPherson, ADF&G, Division of Commercial Fisheries, Douglas, Alaska, personal communication).

The sport fishery for sockeye salmon at Windfall Lake proved to be very popular in 1989, with 2,694 hours of effort expended. There are no comparable data from previous seasons, but angling effort observed at Windfall Lake in 1989 appeared to be substantially higher than the casual observations of effort in any previous year. The amount of precipitation during the summer of 1989 was less than normal, and water levels in the outlet of Windfall Lake were also low. Sockeye salmon tended to hold longer in the fishing area, where they were vulnerable to harvest. Under these conditions, anglers harvested 17 percent of the sockeye salmon return to Windfall Lake.

Escapement surveys have been conducted irregularly at Slate Creek, and comparable surveys have been conducted only since 1986 (Table 5). The 1989 surveyed sockeye salmon escapement of 1,766 fish was approximately 41 percent greater than the previous three year average of 1,254 fish. The 1989 sockeye salmon return to the Chilkoot and Chilkat rivers was also approximately 45 percent above the previous three year average. (McPherson and Olson 1989). The reason for the above average sockeye salmon returns in 1989 has not been determined.

The spawning capacity of Slate Creek has never been determined, but the department considers a peak count of 1,000 adult sockeye salmon in the spawning index area to be a working escapement goal. The 1989 peak count of 1,766 adult sockeye salmon should adequately fill the spawning area.

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Table 5. Peak counts of sockeye salmon escapement surveys at Slate Creek, Windfall Lake, 1968 to 1989.

Year	Day	Peak Count	Number of Surveys
1968	07/14	2,000	1
1973	08/02	1,285	1
1979	07/26	1,650	2
1980	07/25	1,515	1
1986	08/07	1,114	3
1987	08/10	1,724	5
1988	08/12	925	6
1986 - 1988	Average	1,254	
	SE	241	
1989	08/10	1,766	4

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APPENDIX A

Appendix A1. Daily and accumulative weir counts of adult sockeye salmon, and numbers fish sampled at Windfall Lake, 1989.

Date	Counted			Sampled		
	N	Cum.	Cum.%	N	Cum.	Cum.%
12-Jun-89	35	35	1%	3	3	8.6%
13-Jun-89	25	60	2%	10	13	21.7%
14-Jun-89	31	91	2%	6	19	20.9%
15-Jun-89	109	200	5%	0	19	9.5%
16-Jun-89	127	327	8%	0	19	5.8%
17-Jun-89	0	327	8%	0	19	5.8%
18-Jun-89	254	581	15%	36	55	9.5%
19-Jun-89	68	649	17%	54	109	16.8%
20-Jun-89	0	649	17%	0	109	16.8%
21-Jun-89	78	727	19%	72	181	24.9%
22-Jun-89	101	828	21%	90	271	32.7%
23-Jun-89	0	828	21%	0	271	32.7%
24-Jun-89	0	828	21%	0	271	32.7%
25-Jun-89	152	980	25%	54	325	33.2%
26-Jun-89	465	1,445	37%	44	369	25.5%
27-Jun-89	864	2,309	60%	30	399	17.3%
28-Jun-89	91	2,400	62%	72	471	19.6%
29-Jun-89	86	2,486	64%	72	543	21.8%
30-Jun-89	0	2,486	64%	0	543	21.8%
01-Jul-89	15	2,501	65%	0	543	21.7%
02-Jul-89	0	2,501	65%	0	543	21.7%
03-Jul-89	77	2,578	67%	0	543	21.1%
04-Jul-89	142	2,720	70%	99	642	23.6%
05-Jul-89	0	2,720	70%	0	642	23.6%
06-Jul-89	7	2,727	71%	2	644	23.6%
07-Jul-89	0	2,727	71%	0	644	23.6%
08-Jul-89	8	2,735	71%	8	652	23.8%
09-Jul-89	0	2,735	71%	0	652	23.8%
10-Jul-89	0	2,735	71%	0	652	23.8%
11-Jul-89	0	2,735	71%	0	652	23.8%
12-Jul-89	0	2,735	71%	0	652	23.8%
13-Jul-89	0	2,735	71%	0	652	23.8%
14-Jul-89	0	2,735	71%	0	652	23.8%
15-Jul-89	0	2,735	71%	0	652	23.8%
16-Jul-89	65	2,800	72%	0	652	23.3%
17-Jul-89	0	2,800	72%	0	652	23.3%
18-Jul-89	0	2,800	72%	0	652	23.3%
19-Jul-89	0	2,800	72%	0	652	23.3%
20-Jul-89	543	3,343	87%	42	694	20.8%
21-Jul-89	285	3,628	94%	144	838	23.1%
22-Jul-89	7	3,635	94%	7	845	23.3%
23-Jul-89	30	3,665	95%	11	856	23.4%
24-Jul-89	6	3,671	95%	0	862	23.5%
25-Jul-89	1	3,672	95%	0	862	23.5%
26-Jul-89	0	3,672	95%	0	862	23.5%
27-Jul-89	0	3,672	95%	0	862	23.5%

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Date	Counted			Sampled		
	N	Cum.	Cum.%	N	Cum.	Cum.%
28-Jul-89	0	3,672	95%	0	862	23.5%
29-Jul-89	0	3,672	95%	0	862	23.5%
30-Jul-89	0	3,672	95%	0	862	23.5%
31-Jul-89	0	3,672	95%	0	862	23.3%
01-Aug-89	2	3,674	95%	2	864	23.5%
02-Aug-89	0	3,674	95%	0	864	23.5%
03-Aug-89	0	3,674	95%	0	864	23.5%
04-Aug-89	180	3,854	100%	27	891	23.1%
05-Aug-89	8	3,862	100%	8	899	23.3%
06-Aug-89	2	3,864	100%	0	899	23.3%

Appendix A2. Daily water temperature, water levels, and air temperature at Windfall Lake weir, 1989.

Date	Water Temp. (°C)	Water Level (cm)	Air Temperature (°C) High	Air Temperature (°C) Low
06/15	14	65	16	6
06/16	12	76	15	4
06/17	14	69	22	0
06/18	14	65	12	5
06/19	13	63	14	6
06/20	14	61	13	5
06/21	15	59	17	6
06/22	13	58	18	7
06/23	14	60	15	7
06/24	14	59	19	8
06/25	14	59	14	3
06/26	14	58	19	3
06/27	16	56	24	7
06/28	17	56	24	11
06/29	18	56	26	6
06/30	18	54	23	5
07/01	19	54	27	6
07/02	18	55	19	5
07/03	18	-	25	-
07/04	17	56	17	9
07/05	16	56	17	8
07/06	15	55	-	8
07/07	17	54	25	8
07/08	17	54	25	6
07/09	17	55	25	5
07/10	19	55	28	5
07/11	19	55	29	9
07/12	18	58	29	9
07/13	20	56	29	12
07/14	18	57	28	9
07/15	17	58	-	9
07/16	18	57	-	-
07/17	18	56	22	6
07/18	16	53	22	6
07/19	15	54	17	9
07/20	16	57	17	9
07/21	-	72	17	9
07/22	15	68	-	-
07/23	15	65	15	-
07/24	15	65	14	5
07/25	15	62	13	6
07/26	14	61	25	6

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Appendix A2. (page 2 of 2)

Date	Water Temp. (°C)	Water Level (cm)	Air Temperature (°C) High	Air Temperature (°C) Low
07/27	16	58	27	5
07/28	14	58	25	6
07/29	16	58	23	7
07/30	15	52	-	-
07/31	15	54	19	8
08/01	15	57	16	8
08/02	-	-	-	-
08/03	15	63	-	8
08/04	14	111	14	7
08/05	14	82	18	5
08/06	14	73	-	7