Fishery Data Series No. 91-51

Evaluation of the Recreational Fishery for Cutthroat Trout in Chilkat Lake, Alaska, 1990

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ABSTRACT

Creel surveys conducted at Chilkat Lake northwest of Haines in 1990 were used to estimate angler effort, catch, and harvest of cutthroat trout *Oncorhynchus clarki* and the size composition of the cutthroat trout in the angler harvest. An estimated 1,358 rod hours of effort (SE = 137) were expended to catch 1,180 (SE = 163) and harvest 674 cutthroat trout (SE = 109) between May 21 and October 7, 1990. Chartered anglers accounted for 30% of the effort and 41% of the cutthroat trout harvest at the lake. A total of 137 cutthroat trout were sampled to estimate mean length and weight at age. Cutthroat trout sampled from the chartered angler harvest had greater mean length and were older than those sampled in the nonchartered angler harvest. A weir was operated on the outlet of Chilkat Lake between March 21 and May 20, 1990. A total of 987 emigrant cutthroat trout were counted, of which 702 were tagged. Limited recoveries of cutthroat trout tagged in Chilkat Lake and outlet between October 1988 and May 1990 are used to document sport fishing harvest and fish migration patterns.

KEY WORDS: Southeast Alaska, Haines, Chilkat Lake, cutthroat trout, *Oncorhynchus clarki*, creel survey, angler effort, catch, harvest, chartered anglers, nonchartered anglers, weir, migrations.

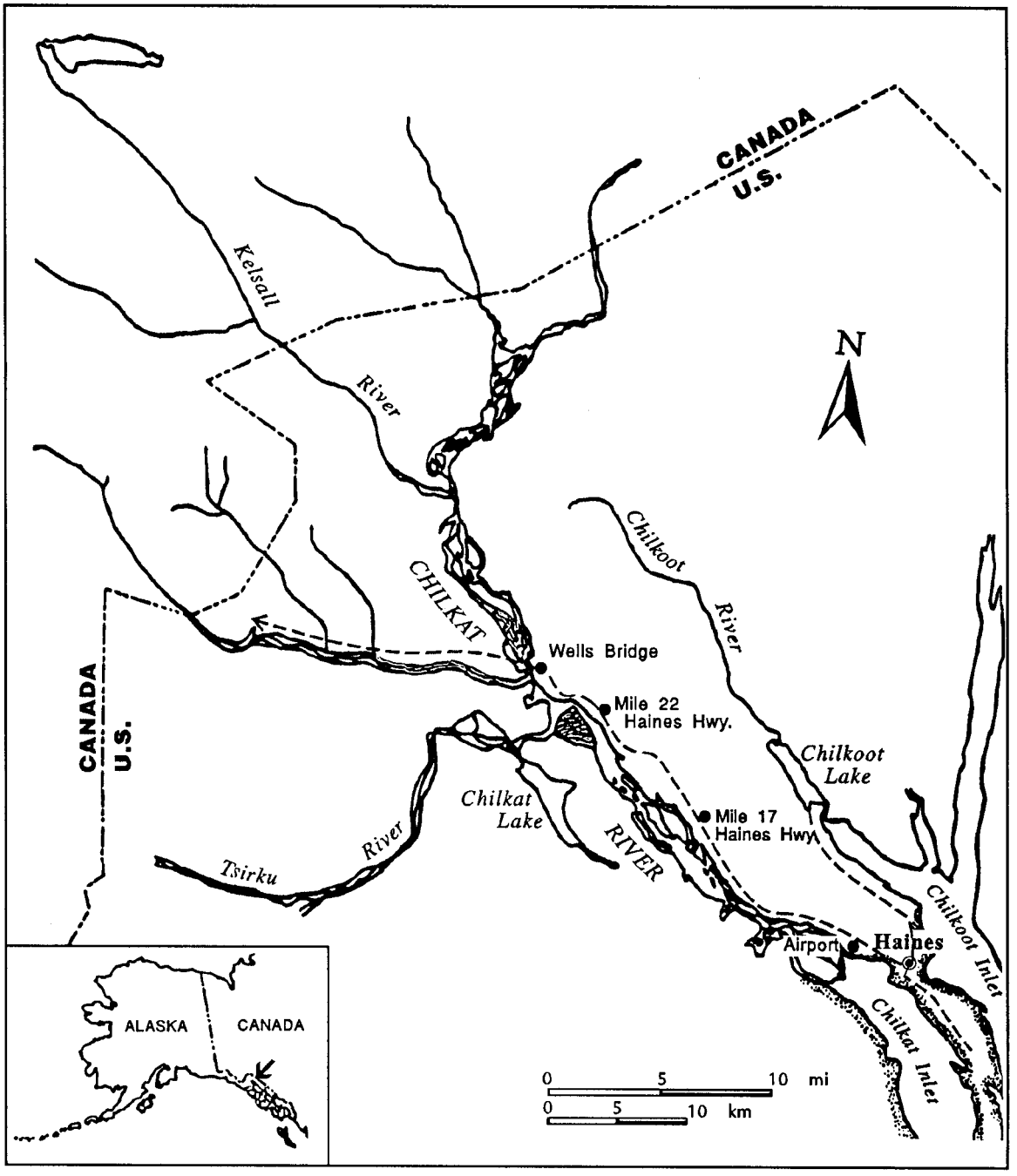

Figure 1. Chilkat Lake and Haines area, northern Southeast Alaska.

INTRODUCTION

Harvests of trophy class cutthroat trout *Oncorhynchus clarki* 1.36 kg (3 lb) and larger are rare in Southeast Alaska. Chilkat Lake near Haines, Alaska produces trophy class cutthroat trout and supports a developing fishery by chartered anglers.

Chilkat Lake is located approximately 29 km northwest of Haines (Figure 1) and is reached by float plane or river-boat. The lake is 10 km long, has a surface area of 984 hectares, a surface elevation of approximately 53 m, and a maximum depth of 57 m. The lake supports significant runs of coho *O. kisutch* and sockeye salmon *O.nerka*, and a large population of Dolly Varden *Salvelinus malma*.

Chilkat Lake is a popular recreation area and the cutthroat trout fishery is prized by residents of Haines and visitors to the area. In 1986 a sport fishing charter business which targets on cutthroat trout began to operate on Chilkat Lake. Since 1985, sport fishing regulations on the lake have permitted anglers to harvest 5 cutthroat trout per day, of which only one can be over 16 inches. Prior to 1985, anglers were permitted to harvest 4 cutthroat trout under, and one over, 16 inches per day. The possession limit has been two daily limits since 1983.

Between May 20 and October 8, 1989 we estimated 2,538 rod hours of effort (SE = 233) were expended on Chilkat Lake to catch 1,296 (SE = 171) and harvest 1,052 (SE = 153) cutthroat trout (Ericksen and Bingham 1990). Chartered anglers accounted for 43% of the effort expended on the lake and 63% of the cutthroat trout harvest. Harvest information for Chilkat Lake available before this study (Mills 1987, 1988, 1989, 1990) indicates angler effort increased from fewer than 100 angler days in 1984 to more than 2,700 angler days in 1989. Harvest estimates for the same period range from 17 (1985) to 953 (1989) cutthroat trout.

The objectives of the current study are to estimate recreational fishing effort for and harvest of cutthroat trout on Chilkat Lake from May 21 to October 7, 1990 by charter and noncharter fisherman, and to estimate the age and size composition of the harvest. Field work on this study was suspended in 1991. We are planning to return to Chilkat Lake in 1992, with an experiment to estimate the exploitation rate of cutthroat trout by the recreational fisheries.

METHODS

Creel Surveys

Two creel surveys were used to estimate angler effort and harvest of cutthroat trout on Chilkat Lake in 1990. One survey was used to estimate parameters for nonchartered anglers, who could be identified on the lake by knowing the chartered boats. A second survey was conducted to estimate harvest of anglers who charter through (the business) Don's Camp for boats and guiding services. This survey was facilitated by cooperation of the owners of Don's Camp. Sampling with 2 surveys was intended to minimize disrupting anglers and increase precision of the harvest estimates.

Survey of Noncharter Anglers:

A stratified, three-stage roving creel survey based on expansion of sample ratios was used to estimate both fishing effort and harvest of cutthroat trout by non-

chartered anglers. Ten biweekly (14-day) seasonal strata and weekday versus weekend-holiday stratification were maintained. There were thus 20 discrete strata. Days were primary sampling units, periods within days were secondary sampling units, and anglers within periods were tertiary sampling units.

Four weekend-holiday and 4 weekdays per 14-day period were randomly selected for sampling. In each day selected for sampling, 2 of 3 possible periods were randomly selected to sample. The available sampling periods were equal in length and fixed at between 212 and 286 minutes, depending on the strata, and together equaled the length of time from 0800 hours to sunset on the average day in the strata. Few angler-interviews or harvested cutthroat trout were observed outside of these times in 1989.

During each sampling period, a technician both counted and interviewed anglers. Angler counts were conducted once in each sample period, at a randomly selected (beginning, middle, or end) period. When not counting anglers, the technician moved through the fishery to interview anglers completing their trip, or to interview anglers still fishing as the sampling period approached its end. When anglers could not be interviewed at the completion of their trip they were given a stamped and self-addressed post card asking about their completed trip (hours fished, cutthroat trout released and kept). Each postal interview card was numbered so that it could later be re-associated with a specific interview. Catch and effort information from postal interviews replaced information obtained from incomplete interviews, if received. These procedures were designed to reduce the bias which results when catch-per-unit-effort (CPUE) from completed-trip and incomplete trip interviews is significantly different (see Robson 1960).

The harvest (or catch) in each stratum is estimated by

$$\hat{C}_h = D_h \overline{C}_h \tag{1}$$

$$\overline{C}_h = \frac{\sum_{i=1}^{d_h} \hat{C}_{hi}}{d_h} \tag{2}$$

$$\hat{C}_{hi} = Q_h \overline{C}_{hi} \tag{3}$$

$$\overline{C}_{hi} = \frac{\sum_{j=1}^{q_h} \hat{C}_{hij}}{q_h} \tag{4}$$

where $\hat{C}_{hij}$ is the estimated harvest in period j day i stratum h, q_h is the number of periods sampled in a day, Q_h 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 by

$$V[\hat{C}_h] = (1-f_{1h}) D_h^2 \frac{\sum_{i=1}^{d_h} (\hat{C}_{hi} - \overline{C}_h)^2}{d_h (d_h - 1)} + D_h Q_h^2 \sum_{i=1}^{d_h} (1-f_{2h}) \frac{\sum_{j=1}^{q_h} (\hat{C}_{hij} - \overline{C}_{hi})^2}{d_h q_h (q_h - 1)} + D_h Q_h \frac{\sum_{i=1}^{d_h} \sum_{j=1}^{q_h} \hat{V}[\hat{C}_{hij}]}{d_h q_h} \quad (5)$$

where $f_{1h} = d_h/D_h$ and $f_{2h} = q_h/Q_h$.

The harvest for each sampling period is estimated by

$$\hat{C}_{hij} = \hat{E}_{hij} \overline{CPUE}^*_{hij} \quad (6)$$

where $\overline{CPUE}^*_{hij}$ is the "jackknife" estimate of mean CPUE during stratum h, day i, sampling period j, and E_{hij} is the fishing effort in angler hours during the same time.

Since anglers were counted only once in each period the variance of $\hat{C}_{hij}$ was estimated by

$$V[\hat{C}_{hij}] = \hat{E}^2_{hij} V[\overline{CPUE}^*_{hij}] \quad (7)$$

The $\overline{CPUE}^*_{hij}$ and its variance are calculated according to procedures in Efron (1982). The inherent correctable bias of m_{hij}^{-2} (the number of interviews in a sampling period) of our jackknife estimates are removed according to the procedure in Efron (1982, p.6).

Effort in each period is estimated by

$$\hat{E}_{hij} = H_h x_{hij} \quad (8)$$

where x_{hij} is the number of anglers counted during stratum h, day i, sampling period j. If $x_{hij} = 0$ and anglers are interviewed, then $\hat{C}_{hij}$ in (6) was set equal to the observed catch. In contrast, if $x_{hij} > 0$ *and* anglers are not interviewed, then $\overline{CPUE}^*_{hij}$ (or HPUE) in (6) was set equal to the mean $\overline{CPUE}^*_{hij}$ for the stratum.

Total angler effort in each stratum is estimated using equations 1-4 (only E is substituted for C). The variance of the effort in each stratum is estimated by

$$V[\hat{E}_h] = (1-f_{1h}) D_h^2 \frac{\sum_{i=1}^{d_h} (\hat{E}_{hi} - \overline{E}_h)^2}{d_h (d_h - 1)} + D_h Q_h^2 \sum_{i=1}^{d_h} (1-f_{2h}) \frac{\sum_{j=1}^{q_h} (\hat{E}_{hij} - \overline{E}_{hi})^2}{d_h q_h (q_h - 1)} \quad (9)$$

since variance of $\hat{E}_{hij}$ could not be estimated with only 1 count in each sample.

Harvest, catch, and effort for the entire season (and their variances) are the sums of the estimates for each strata.

A student's t-test was used to compare differences between CPUE obtained from complete-trip and incomplete-trip interviews. CPUE data from all strata were

lumped together to conduct the test. The t-test was

$$t = \frac{\overline{CPUE}^*_I - \overline{CPUE}^*_C}{\left(V[\overline{CPUE}^*_I] + V[\overline{CPUE}^*_C]\right)^{1/2}} \quad \text{vs.} \quad t_{\alpha, df} \tag{10}$$

where the subscript "I" denotes incomplete-trip interviews and "C" complete-trip interviews. The degrees of freedom (Steele and Torrie 1980, p.106) are

$$df = \frac{\left(V[\overline{CPUE}^*_I] + V[\overline{CPUE}^*_C]\right)^2}{\frac{(V[\overline{CPUE}^*_I])^2}{(n_I - 1)} + \frac{(V[\overline{CPUE}^*_C])^2}{(n_C - 1)}} \tag{11}$$

Survey of Charter Anglers:

A stratified, two stage "direct expansion" type survey of anglers completing their trips at Don's Camp on randomly selected days was used to estimate angler effort and harvest by "chartered" anglers. The fishery was stratified as above, yielding 20 distinct strata. The sampling design had days as primary units and anglers within days as secondary units.

In cooperation with our study, operators of Don's Camp distributed survey forms to every client. The operator recorded the number of clients fishing each day and the number of forms turned in each day; the number of anglers not completing interview forms was thus known by subtraction. The forms asked the length of time fished that day, the number of fish kept and released, and the gear type used. Letters explaining the study and sampling program were also posted at Don's Camp. We sampled this "fishery" on days selected, to sample noncharter anglers, and tabulated "interviews" from the collected forms. During each sampling day, the technician visited Don's Camp (possibly several times) to sample cutthroat trout for biological data. Thus, some daily interactions occurred that enabled the technician to monitor data collection.

The harvest in each stratum was estimated by

$$\hat{C}_h = D_h \overline{C}_h \tag{12}$$

$$\overline{C}_h = \frac{\sum_{i=1}^{d_h} \hat{C}_{hi}}{d_h} \tag{13}$$

$$\hat{C}_{hi} = M_{hi} \overline{c}_{hi} \tag{14}$$

$$\overline{c}_{hi} = \frac{\sum_{j=1}^{m_{hi}} c_{hij}}{m_{hi}} \tag{15}$$

where c_{hij} is the harvest by angler j in sampling day i, stratum h; m_{hi} is the number of anglers interviewed in day i; M_{hi} is the number of anglers completing trips in day i; d_h is the number of days sampled in stratum h; and D_h is the number of days in stratum h.

The variance of the harvest in each stratum is estimated by

$$V[\hat{C}_h] = (1-f_{1h})\, D_h^2 \frac{\sum_{i=1}^{d_h} (\hat{C}_{hi} - \overline{C}_h)^2}{d_h\,(d_h-1)} + D_h \sum_{i=1}^{d_h} M_{hi}^2\,(1-f_{2hi}) \frac{\sum_{j=1}^{m_{hi}} (c_{hij} - \overline{c}_{hi})^2}{d_h\, m_{hi}\,(m_{hi}-1)} \qquad (16)$$

where f_{ih} = sampling fraction for days and f_{2hi} = sampling fraction for anglers.

Harvest, catch, and effort for the entire season (and their variances) are the sums of the estimates for each strata.

Age, Weight, and Length of Cutthroat Trout

Length, weight, scales, sex, and sagittal otoliths were collected from trout harvested by charter and noncharter anglers during sampling periods. Cutthroat trout harvested by charter anglers were sampled at Don's Camp after chartered anglers completed fishing trips, when possible. Operators of Don's Camp often assisted by holding clients' catches until a technician could collect samples. Cutthroat trout in the creel of interviewed noncharter anglers were sampled on the lake when possible. Fish were measured for fork length (FL) to the nearest millimeter, and round weight was recorded to the nearest gram. Sex was easily determined by examination of the sexual organs. Scales were collected from an area on the left side of the fish above the lateral line and between the posterior insertion of the dorsal fin and the anterior insertion of the anal fin.

Age of sampled trout was estimated by interpreting growth patterns on scales and sagittal otoliths. Scales were taken to increase the number of successfully aged fish (in instances where otoliths were not collected or were illegible) and to compare with ages estimated using otoliths. Scales were stored on an acetate sheet, and age was determined by counting the number of annuli, using a Micron 780 microfiche reader. Otoliths were stored dry, then soaked in a 50% glycerine and 50% water solution for approximately 48 hours before grinding by hand with number 220 wet/dry sandpaper. Age was determined by counting the number of hyaline zones on otoliths placed on a watch glass, viewed against a dark background with reflected light. A stereoscopic microscope with a ten-power ocular and a one-power objective was used for examinations. If fish age estimated by the two techniques did not agree, the estimate from the otolith was adopted.

A hypothesis that age composition of cutthroat trout harvested by charter and noncharter anglers was similar ($\alpha = 0.05$) was tested using contingency table analysis (Steele and Torrie 1980). When the hypothesis of similar age composition is rejected, age composition of the harvest (p_a) was estimated:

$$\hat{p}_a = \frac{\hat{N}_a}{\hat{N}} \qquad (17)$$

$$\hat{N}_a = \sum_{i=1}^{2} \hat{p}_{a,i}\, \hat{N}_i \qquad (18)$$

where N_a is harvest at age, $N=\Sigma N_i$ and N_i is the creel survey harvest estimate for anger group i (chartered or nonchartered anglers), and $p_{a,i}$ is the fraction

of sampled harvest from angler group i with estimated age a. The variance of the age composition is approximated using the Delta Method (Seber 1982):

$$V[\hat{p}_a] \approx \sum_{i=1}^{2} V[\hat{p}_{a,i}] \left(\frac{\hat{N}_a}{\hat{N}}\right)^2 + \frac{\sum_{i=1}^{2} V[\hat{N}_i] (\hat{p}_{a,i} - \hat{p}_a)^2}{\hat{N}^2} \quad (19)$$

where

$$V[\hat{p}_{a,i}] = \hat{p}_{a,i}(1-\hat{p}_{a,i})/(n_i-1) \quad (20)$$

and $V[\hat{N}_i]$ is the estimate from the creel survey for each angler group.

Mean length and weight at age (and associated standard errors) were estimated using standard statistical procedures.

Migrations of Cutthroat Trout

A weir was installed on the outlet of Chilkat Lake on March 21, 1990 to capture and tag emigrant Dolly Varden (Ericksen and Marshall *In press*). Before the weir was removed on May 20 we tagged 702 emigrant cutthroat trout ≥250 mm FL with individually numbered tags. Other cutthroat trout have also been incidentally captured and tagged at Chilkat Lake since 1988. Seven cutthroat trout were tagged in Chilkat Lake during October 1988, and 30 emigrants were tagged leaving the lake during the spring of 1989 (Ericksen, Schmidt, and Marshall 1990). Also, 4 cutthroat trout were tagged in Chilkat Lake during October 1989.

Forty of these incidentally tagged cutthroat trout were recaptured and reported to us between August 20, 1989 and June 30, 1991, mostly by sport fisherman. Most of the reported recaptures were tagged during the spring of 1990. The recovery data is tabulated to document sport fishing harvest and fish migration patterns.

RESULTS

Creel Survey

We observed 220 harvested cutthroat trout during 214 interviews (Table 1). Angling pressure was very light during the first and last biweekly periods, so our coverage of the fishery was, we believe, essentially complete.

Nonchartered anglers expended an estimated 946 angler hours (SE = 120) to catch 591 (SE = 131) and harvest 401 (SE = 99) cutthroat trout during the survey period (Table 2). Nonchartered anglers released 32% of the cutthroat trout they caught. Most of this catch (62%) and effort (82%) occurred between July 2 and August 26, 1990.

Chartered anglers expended an estimated 412 angler hours (SE = 66) to catch 589 (SE = 98) and harvest 273 (SE = 46) cutthroat trout during the survey period (Table 2). Chartered anglers released 54% of the cutthroat trout they caught. Most of this catch (76%) and effort (72%) occurred between July 18 and August 12, 1990. No chartered angler effort was observed after August 26.

In total, an estimated 1,358 angler hours of effort (SE = 137) were expended (Table 3) to catch 1,180 (SE = 163) and harvest 674 cutthroat trout (SE = 109)

Table 1. Number of interviews, observed angler effort, and observed catch and harvest of cutthroat trout in Chilkat Lake by chartered and nonchartered anglers by sampling period, May 21 through October 7, 1990.

	May 21 June 3	June 4 June 17	June 18 July 1	July 2 July 15	July 16 July 29	July 30 Aug 12	Aug 13 Aug 26	Aug 27 Sept 09	Sept 10 Sept 23	Sept 24 Oct 7	Total
NONCHARTERED ANGLERS											
Weekends											
Number of interviews	6	7	9	13	20	11	11	8	12	0	97
Angler hours effort	3.5	2.0	4.2	14.8	23.3	12.8	20.5	8.5	13.3	0	103
Cutthroat caught	0	0	8	6	21	9	5	8	0	0	57
Cutthroat harvested	0	0	7	4	11	5	4	2	0	0	33
Weekdays											
Number of interviews	0	12	6	9	1	5	4	1	3	0	41
Angler hours effort	0	13.3	1.5	20.0	0.2	7.0	5.2	0.2	6.0	0	53
Cutthroat caught	0	1	0	13	0	12	6	1	4	0	37
Cutthroat harvested	0	1	0	8	0	9	5	1	4	0	28
CHARTERED ANGLERS											
Weekends											
Number of interviews	6	8	6	5	2	10	2	0	0	0	39
Angler hours effort	11.0	32.5	18.0	23.0	4.0	55.0	2.0	0	0	0	146
Cutthroat caught	24	23	29	27	7	73	3	0	0	0	186
Cutthroat harvested	17	12	6	16	1	30	3	0	0	0	85
Weekdays											
Number of interviews	0	5	8	13	4	5	2	0	0	0	37
Angler hours effort	0	11.5	22.0	23.0	14.0	22.5	12.0	0	0	0	105
Cutthroat caught	0	16	23	44	28	30	19	0	0	0	160
Cutthroat harvested	0	8	13	27	11	14	1	0	0	0	74
TOTAL											
Number of interviews	12	32	29	40	27	31	19	9	15	0	214
Angler hours effort	14.5	59.3	45.7	80.8	41.5	97.3	39.7	8.7	19.3	0	407
Cutthroat caught	24	40	60	90	56	124	33	9	4	0	440
Cutthroat harvested	17	21	26	55	23	58	13	3	4	0	220

Table 2. Estimated angler effort, catch, and harvest of cutthroat trout in Chilkat Lake by chartered and nonchartered anglers by sampling period, May 21 through October 7, 1990.

	May 21 June 3	June 4 June 17	June 18 July 1	July 2 July 15	July 16 July 29	July 30 Aug 12	Aug 13 Aug 26	Aug 27 Sept 09	Sept 10 Sept 23	Sept 24 Oct 7	Total
NONCHARTERED ANGLERS											
Angler hours effort	17	93	72	129	156	169	132	57	121	0	946
Standard error	12	44	47	13	48	50	42	21	44	0	120
Cutthroat caught	0	17	28	74	150	146	116	32	28	0	591
Standard error	0	17	12	36	50	96	53	15	25	0	131
Cutthroat harvested	0	17	19	48	79	97	92	21	28	0	401
Standard error	0	17	11	23	45	67	38	14	25	0	99
CHARTERED ANGLERS											
Angler hours effort	14	62	73	81	39	111	32	0	0	0	412
Standard error	4	16	38	29	27	25	23	0	0	0	66
Cutthroat caught	30	63	87	133	77	148	51	0	0	0	589
Standard error	8	22	27	49	54	40	37	0	0	0	98
Cutthroat harvested	21	32	39	81	29	65	6	0	0	0	273
Standard error	6	9	17	32	21	17	2	0	0	0	46

Table 3. Estimated total angler effort, catch, and harvest of cutthroat trout in Chilkat Lake, by sampling period, May 21 through October 7, 1990.

	May 21 June 3	June 4 June 17	June 18 July 1	July 2 July 15	July 16 July 29	July 30 Aug 12	Aug 13 Aug 26	Aug 27 Sept 09	Sept 10 Sept 23	Sept 24 Oct 7	Total
Angler hours effort	31	155	145	210	95	280	164	57	121	0	1,358
Variance	154	2,199	3,601	2,163	3,016	3,140	2,268	425	1,927	0	18,893
SE[a]	12	47	60	47	55	56	48	21	44	0	137
Relative precision[b]	0.78	0.59	0.81	0.43	0.55	0.39	0.57	0.71	0.71		0.20
Cutthroat catch	30	80	115	207	227	294	167	32	28	0	1,180
Variance	63	754	872	3,704	5,475	10,743	4,182	219	636	0	26,648
SE	8	27	30	61	74	104	65	15	25	0	163
Relative precision	0.52	0.67	0.50	0.58	0.64	0.69	0.76	0.91	1.77		0.27
Cutthroat harvest	21	49	58	129	108	162	98	21	28	0	674
Variance	32	354	392	1,564	2,443	4,791	1,470	187	636	0	11,869
SE	6	19	20	40	49	69	38	14	25	0	109
Relative precision	0.53	0.75	0.67	0.60	0.90	0.84	0.77	1.28	1.77		0.32

[a] Standard error.
[b] Relative precision = 1.96 * SE/estimate.

in Chilkat Lake between May 21 and October 7, 1990. Chartered anglers accounted for 30% of the effort, 50% of the cutthroat trout catch, and 41% of the cutthroat trout harvest at the lake. Variances for each sampling stage of the survey are compiled to aid in planning future surveys (Appendix A).

Proprietors of Don's Camp responded favorably to the cooperative survey techniques; in fact, survey cards were distributed every day that clients fished, regardless of our sampling schedule. When all survey cards were summed, chartered anglers fished an estimated 424 hours to catch 612 and harvest 303 cutthroat trout, which is close to our estimates. On days we did sample, some differences were found between the number of fish sampled by the technician and the number of harvested fish reported on survey cards. These differences invariably resulted when anglers were not careful in their reporting or were uncertain about the numbers they caught and released; the discrepancies were resolved after talking to the anglers.

In analysis of survey data for nonchartered anglers, we could not reject the hypotheses that mean CPUE estimated from complete and incomplete angler interview data were equal with any reasonable probability; we therefore used both types of data to estimate mean CPUE. Of interest is the fact that >50% (45 of 83) of the completed noncharter interviews indicated fishing trips ≤1 hour in length. In contrast, <10% (12 of 132) completed angler "interviews" from Don's Camp were ≤1 hour. We assume that "nonchartered" anglers tended to be more like "residents" of the lake, were often involved in activities other than fishing, and typically spent less time actually fishing (per trip) than anglers who paid to fish. We also had only four post cards returned to us, of approximately 15 distributed, asking noncharter anglers about their completed-trip fishing statistics; this did little to improve our collection of completed-trip interview data. Also of interest is that, in 9 of 42 sample periods, no noncharter anglers were counted at the arranged time but one (or more) was eventually interviewed during the period. This is not very surprising since we counted only once per period, and noncharter fishing trips tended to be short.

Age, Weight, and Length of Cutthroat Trout

We sampled 138 cutthroat trout in Chilkat Lake in 1990; the age of 134 of these fish was estimated by reading otoliths, the age of 117 fish was estimated from scales, and the age of 114 fish was estimated using both techniques (Figure 2). In total, 105 fish from chartered anglers and 32 fish from nonchartered anglers were assigned an age (Table 4), and length and weight were recorded for all but one of these fish. Ages sampled in the nonchartered harvest ranged from 3 to 9 years, while ages sampled in the chartered harvest ranged from 5 to 10 years.

Forty-eight percent (SE = 0.06) of the cutthroat trout sampled were female, and 52% (SE = 0.06) were male. No significant difference in the length or weight at age by sex was observed using t-tests to compare means (Steele and Torrie 1980, $P < 0.05$), so sex was not considered further in the analysis.

Trout sampled in the noncharter angler harvest were smaller (KS test, $D_{max} = 0.30$; $n = 138$, $P = 0.02$) and younger in age ($\chi^2 = 21$, 4 df, $p < 0.001$) than trout sampled in the charter angler harvest.[1] The estimated age composition

[1] Fish aged 3 and 4 and fish aged 9 and 10 were pooled to increase sample sizes before calculating the chi-square statistic.

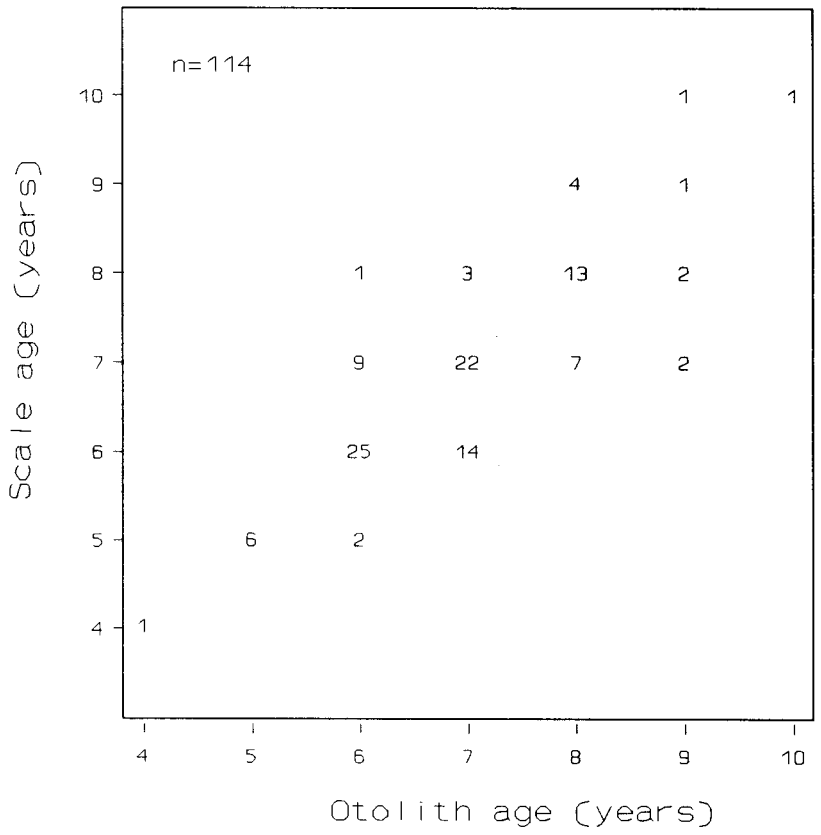

Figure 2. Matrix of frequencies of cutthroat trout ages determined by otoliths and scales.

Table 4. Estimated mean length and weight of harvested cutthroat trout sampled at Chilkat Lake, by age and angler type, 1990.

Age	Mean length[a]			Mean weight		
	N	mm	SE	N	g	SE
			Nonchartered anglers			
3	1	225		0		
4	2	256	6	2	178	12
5	5	301	7	5	286	18
6	9	337	7	9	402	25
7	10	367	10	10	563	40
8	3	430	6	3	877	23
9	2	470	0[b]	2	1,100	0[b]
All	32	349	11	31	512	45
			Chartered anglers			
5	2	291	14	2	250	40
6	35	337	3	35	409	14
7	37	375	4	37	593	27
8	25	413	4	25	769	27
9	5	460	13	5	1,144	86
10	1	495		1	1,425	
All	105	375	4	105	604	24
			All anglers			
3	1	225		0		
4	2	256	6	2	178	12
5	7	298	6	7	276	16
6	44	337	3	44	408	12
7	47	374	4	47	587	23
8	28	414	4	28	781	25
9	7	463	9	7	1,131	60
10	1	495		1	1,425	
All	137			136		

[a] Snout to fork of tail.
[b] Length and weight measured the same on both fish.

of the overall harvest (Table 5) was thus compiled by adding estimated numbers at age in each angler group (Equations 17-20). The resulting age composition is not statistically different than that observed by Ericksen and Bingham (1990) in 1989 (Figure 3; Table 5). However, a downward shift in the age composition of the harvest is apparent (Figure 3), and is likely due to the smaller proportion of the harvest taken by chartered anglers in 1990 (41%) compared to 1989 (63%), and not a change in the age composition of the fished population. This statement is easily justified using equations (17) and (18) to re-estimate age composition for 1990, *assuming* the harvest rates by angler group were the same as in 1989.

Cutthroat trout we sampled show a steady increase in length with increasing age (Figure 4; Table 4). In Chilkat Lake it takes about 7 years for a cutthroat trout to reach a fork length of 374 mm.

The mean length of fish sampled in the nonchartered angler harvest was 349 mm (SE = 11) (13.7 in.), ranging from 225 to 470 mm (8.9 to 18.5 in.). The mean length of fish sampled in the chartered harvest was 375 mm (SE = 4)(14.7 in.), ranging from 277 to 500 mm (10.9 to 19.7 in.).

The mean weight of fish sampled in the nonchartered angler harvest was 512 g (SE = 45) (1.1 lb), ranging from 165 g to 1,100 g (0.4 lb to 2.4 lb). The mean weight of fish sampled in the chartered harvest was 604 g (SE = 24) (1.3 lb), ranging from 210 g to 1,425 g (0.5 lb to 3.1 lb).

Migrations of Cutthroat Trout

A total of 987 cutthroat trout were counted through our weir between March 21 and May 20, 1990 (Figure 5). Water temperature during this time ranged between 2°C and 12°C (Figure 5). The first cutthroat trout was counted through the weir on April 12 when the water temperature reached 4°C. The ice went off the lake on April 20. The weir was opened on this day to allow ice to pass downstream. Therefore, the count on this day was incomplete. The peak of the emigration occurred on April 25, soon after the ice left the lake. Based on qualitative observation, most of the trout captured during this time appeared to be close to spawning. Size of emigrant trout was relatively constant over time (Figure 6). The mean length for all cutthroat trout sampled was 345 mm (SE = 2) and ranged from 98 to 523 mm (3.7 to 20.6 in.). The mean length for the 702 cutthroat trout tagged at the weir was somewhat larger, at 371 mm (SE = 2), and ranged from 248 to 523 mm (9.8 to 20.6 in.).

Fifteen cutthroat trout were recovered during operations by the Alaska Department of Fish and Game, four were harvested by sport anglers fishing in the Chilkat River drainage (excluding Chilkat Lake), and 21 were caught (nine of which were released) by sport anglers fishing at Chilkat Lake (Table 6). Tagged fish were recaptured up to 35.2 km (22 mi) by water from the lake outlet.

DISCUSSION

The harvest of cutthroat trout in Chilkat Lake in 1990 was down substantially (36%) from 1989. This was due mostly to a decline in harvests in the charter fishery. In contrast, total catch of cutthroat trout was down only 9% from 1989, indicating that anglers were actually more successful in 1990 at catching fish.

Table 5. Estimated age composition of the harvest of cutthroat trout in Chilkat Lake, May 21 through October 7, 1990.

Age	p_a	SE(p_a)
3	0.019	na
4	0.037	0.144
5	0.101	0.122
6	0.302	0.100
7	0.329	0.097
8	0.152	0.128
9	0.056	0.150
10	0.004	na

na = not applicable (see Table 4).

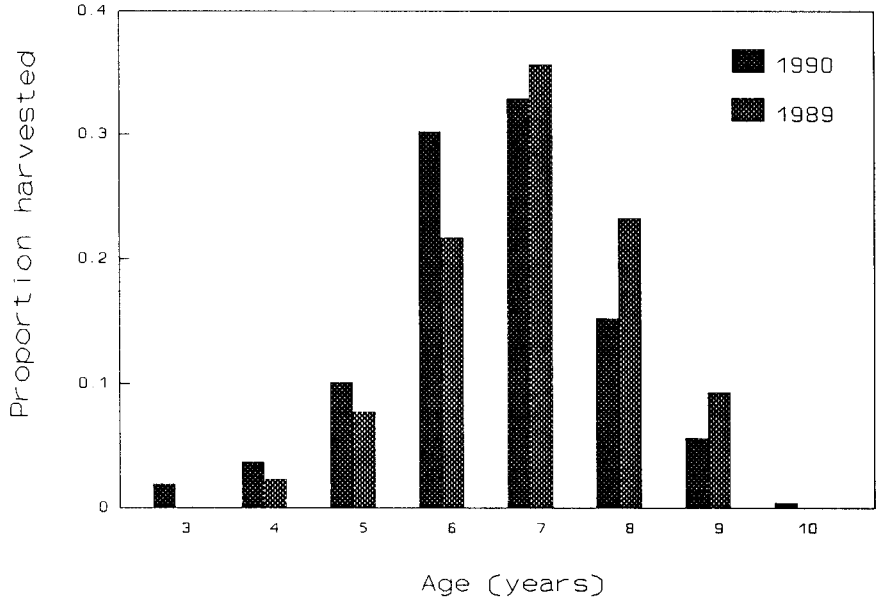

Figure 3. Estimated proportions of cutthroat trout harvested at age in Chilkat lake, 1989 and 1990.

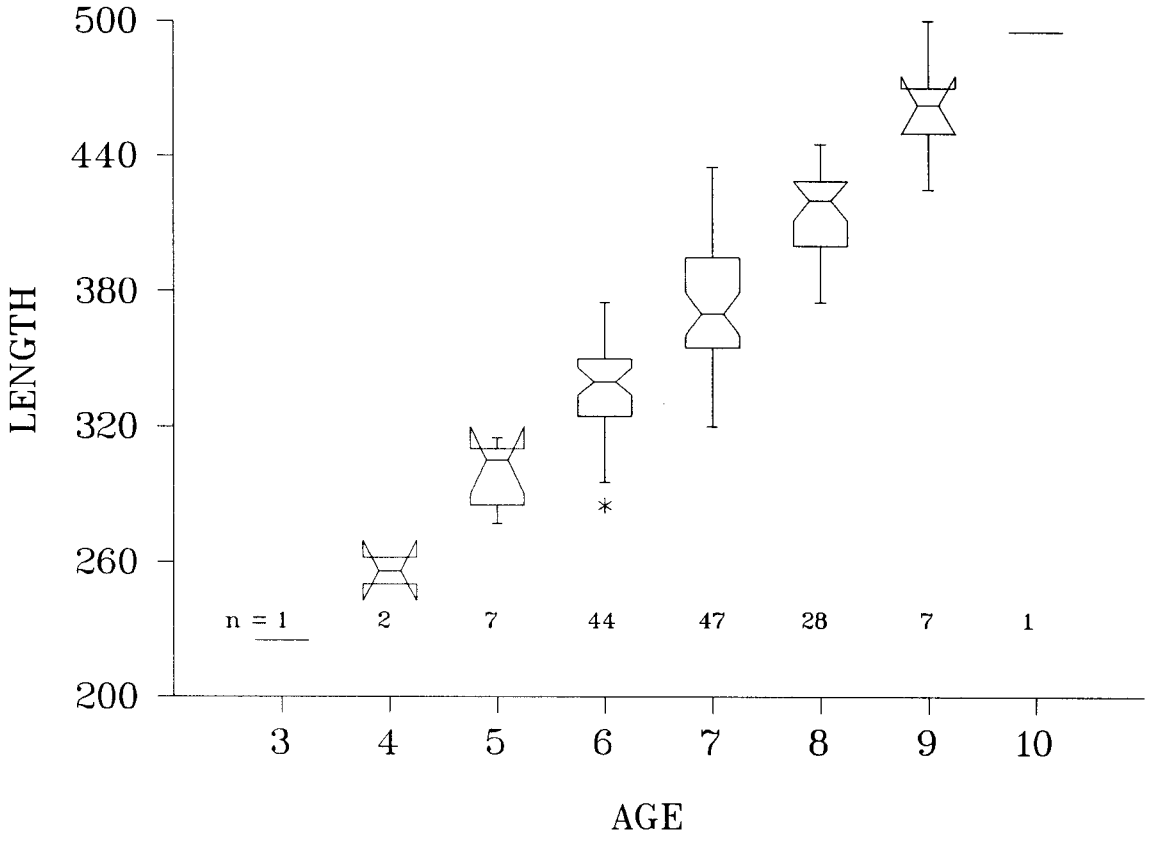

Figure 4. Notched box plot of mean length at age for cutthroat trout sampled at Chilkat Lake, 1990. Age was determined from otoliths. The median length at age is represented by a horizontal line within the box. The top and bottom of each box are, respectively, upper and lower quartiles of length at age. Vertical lines extend to the upper and lower adjacent values (upper and lower quartiles ± 1.5·IQR, where IQR is the interquartile range); lengths outside the adjacent values are plotted as asterisks. The tops and bottoms of the notches are located at $M \pm 1.57 \cdot IRQ/\sqrt{n}$, where M is the median and n is the number of observations, and estimate 95% confidence intervals assuming a normal distribution of values about the median.

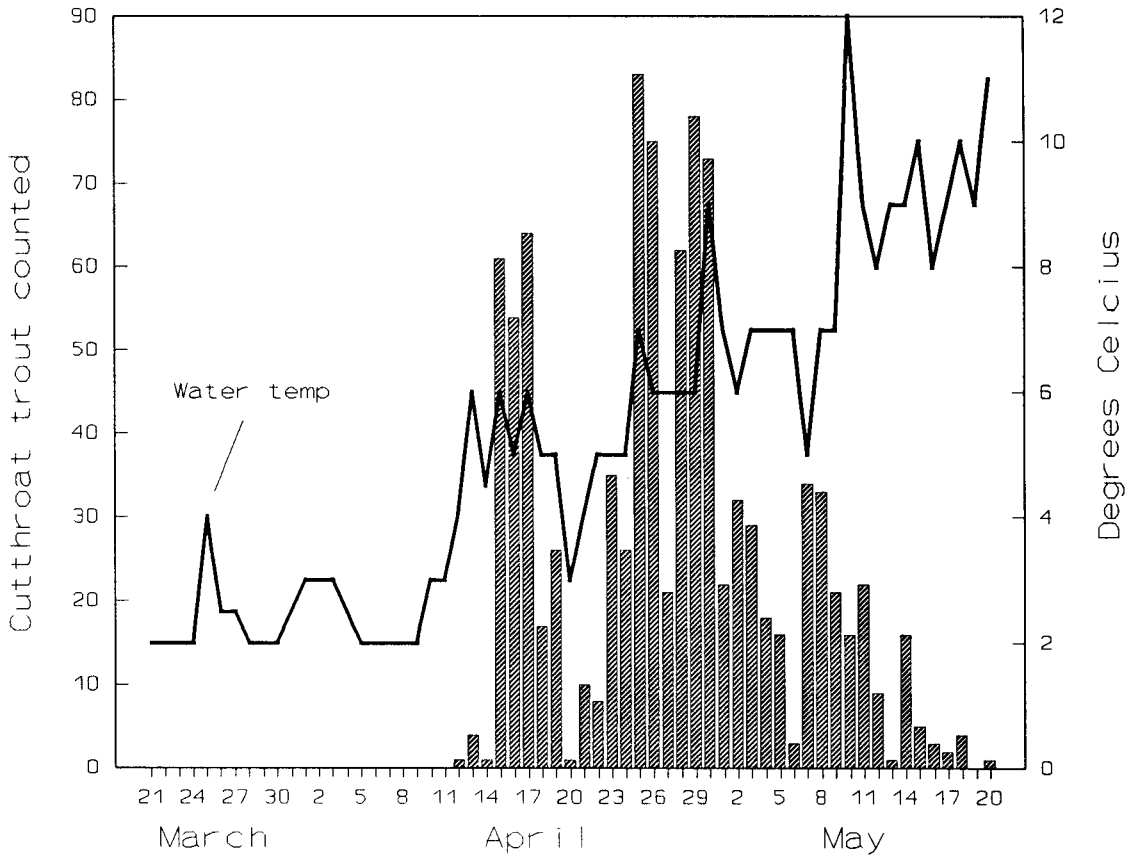

Figure 5. Emigration of cutthroat trout from Chilkat Lake and water temperature by day, March 21 through May 20, 1990. The weir was opened to allow ice to move downstream on April 20, so the daily count of cutthroat trout is incomplete on this day.

Table 6. Detailed release and recovery information from cutthroat trout tagged and released at Chilkat Lake and outlet between fall 1988 and spring 1990.

Tag number	Date tagged	Length at tagging	Date recovered	Days out	Length at recovery	Growth[a]	Recovery location	Recovery source[b]
001[c]	10/04/88	325	08/20/89	320			Chilkat Lake	sport C&R
004[c]	10/11/88	294	04/16/90	552	373	79	Chilkat Outlet	ADFG-O
025	05/11/89	239	04/25/90	349	316	77	Chilkat Outlet	ADFG-O
038	05/28/89	249	05/07/90	344	317	68	Chilkat Outlet	ADFG-O
104[c]	10/30/89	331	04/23/90	175	338	7	Chilkat Outlet	ADFG-O
104[c]	10/30/89	331	07/22/90	265			Chilkat Lake	sport C&R
137	04/15/90	400	06/26/90	72			Chilkat Lake	sport C&R
213	04/17/90	393	09/26/90	162	415	22	Chilkat River-08[d]	ADFG-FW
242	04/18/90	312	05/17/90	29			115-32-10260[e]	ADFG-SS
245	04/18/90	341	05/17/91	394	380	39	10300-2002-3019[f]	ADFG-SS
251	04/19/90	380	04/21/90	2			Chilkat River-24[d]	sport
263	04/19/90	380	06/06/90	48			Chilkat Lake	sport
283	04/23/90	384	07/30/90	98			Chilkat Lake	sport
352	04/25/90	389	07/14/90	80			Chilkat Lake	sport
375	04/25/90	332	05/16/91	386	345	13	115-32-10260	ADFG-SS
377	04/25/90	376	08/06/90	103			Chilkat River-10[d]	sport
384	04/25/90	340	12/31/90	250			Mosquito Lake	sport
393	04/26/90	429	06/25/90	60			Chilkat Lake	sport
397	04/26/90	452	05/09/90	13			115-32-10260	ADFG-SS
406	04/26/90	356	05/17/90	21			115-32-10260	ADFG-SS
443	04/26/90	399	06/20/90	55	420	21	Chilkat Lake	sport
447	04/26/90	420	06/24/90	59	430	10	Chilkat Lake	sport
451	04/27/90	430	08/05/90	100			Chilkat Lake	sport C&R
473	04/28/90	386	06/20/91	418	438	52	Chilkat Lake	sport
496	04/28/90	357	07/02/90	65			Chilkat Lake	sport C&R
543	04/29/90	362	09/02/90	126	385	23	Chilkat River-08[d]	ADFG-FW
628	04/30/90	331	05/17/90	17			115-32-10260	ADFG-SS
646	05/01/90	394	07/29/90	89			Chilkat Lake	sport C&R
651	05/02/90	503	09/04/90	125			Chilkat Lake	sport
658	05/02/90	371	06/25/90	54			Chilkat Lake	sport C&R
688	05/03/90	313	01/19/91	261	330	17	Mosquito Lake	sport
710	05/07/90	361	05/21/90	14			10250-2067-3002[g]	ADFG-SS
727	05/07/90	391	05/21/90	14			10250-2067-3002	ADFG-SS
729	05/08/90	372	07/17/90	70	406	34	Chilkat Lake	sport
743	05/08/90	329	06/05/91	393	333	4	Chilkat River-08[d]	ADFG-FW
744	05/08/90	362	07/29/90	82			Chilkat Lake	sport C&R
754	05/09/90	381	07/11/90	63			Chilkat Lake	sport C&R
769	05/09/90	465	06/26/90	48			Chilkat Lake	sport
802	05/10/90	335	06/20/90	41	350	15	Chilkat Lake	sport
889	05/16/90	359	06/08/90	23	368	9	Chilkat Lake	sport

[a] Difference between lengths at recovery and release in mm.

[b] sport = sport catch; sport C&R = sport catch-and-release.
ADFG-O = ADFG crew monitoring emigration of trout and char.
ADFG-FW = ADFG crew monitoring Chilkat River fish wheel.
ADFG-SS = ADFG cutthroat trout spawning survey.

[c] Tagged in Chilkat Lake; all others tagged at Chilkat Lake outlet.

[d] Indicates nearest mile marker of Haines Hwy adjacent to recovery location.

[e] Stream located at one mile Mud Bay Rd in Haines.

[f] Tributary of Sawmill Creek located at 6th & Dalton, Haines.

[g] Headwaters of the Little Salmon River in the Chilkat River drainage.

The percentage of cutthroat trout caught and released by all anglers increased between 1989 (19%) and 1990 (43%). This increase in catch-and-release fishing was most dramatic in the charter fishery, where anglers released 56% of the cutthroat trout they caught in 1990, compared to 18% in 1989. We commend the proprietors of Don's Camp for promoting catch-and-release fishing.

Cutthroat trout we sampled show a steady increase in length with increasing age (Figure 4; Table 4), suggesting the oldest age classes in the lake were not sampled, or age estimated from otoliths tends to underestimate age in the older fish sampled. Since anglers tend to harvest the larger, older fish, it is unlikely that we did not sample the oldest age classes in the lake. Furthermore, we have no evidence to suggest that a substantial population of older cutthroat trout exits the lake and resides elsewhere. Barber (1987) found that external annulus on otoliths taken from Arctic char often overlapped and were not visible unless the otolith was ground prior to aging. Although we did grind the otoliths, and soaked them in glycerine prior to aging, it is possible that the outer annuli were not detected on the larger fish.

Most of the cutthroat trout we observed emigrating from Chilkat Lake in 1990 were in pre-spawning condition. However, we did observe a small component of the emigration that may have been anadromous smolts. These fish were generally smaller (<250 mm FL) and were silvery in appearance. This corresponds roughly with descriptions of cutthroat trout smolt in Oregon (Giger 1972). However, since we tagged fish which were 250 mm FL and larger, we have no tag recovery information on this component of the emigration.

The timing of the emigration of cutthroat trout observed at Chilkat Lake outlet was generally earlier, and shorter in duration, than that observed at Petersburg Creek, near Petersburg in Southeast Alaska (Jones 1977). Jones observed that migration of cutthroat trout leaving Petersburg Lake reached a peak in late May to early June, and continued through July. In contrast, the peak of the migration at Chilkat Lake occurred in late April in 1990, and relatively few cutthroat trout were counted after mid-May. Jones (1977) also noted that larger cutthroat left Petersburg Lake earlier than smaller ones. We observed that the size of emigrant trout at Chilkat Lake was relatively constant over time (Figure 6). No cutthroat trout were captured at the weir between March 21 and April 11, and few were captured between May 15 and May 20 (when sampling stopped)(Figure 5). Thus, we believe that our sampling of the emigration of cutthroat trout from Chilkat Lake was essentially complete.

All tagged cutthroat trout that were recaptured and reported to us were caught within the Chilkat River drainage, or were observed spawning in a small stream which drains into the intertidal mouth of the river. Most of the reported recaptures were caught in Chilkat Lake, indicating that a number of cutthroat trout that leave the lake to spawn return to the lake to spend the summer. The one recovery of a tagged cutthroat trout caught while ice-fishing in Mosquito Lake in January indicates that trout sometimes change their overwintering location within the freshwater drainage from year to year.

ACKNOWLEDGMENTS

We acknowledge David R. Bernard for statistical methodology of the roving creel survey and generally insightful discussions. Special thanks are extended to Don's Camp, Haines, Alaska, for generous assistance in improving the quality of

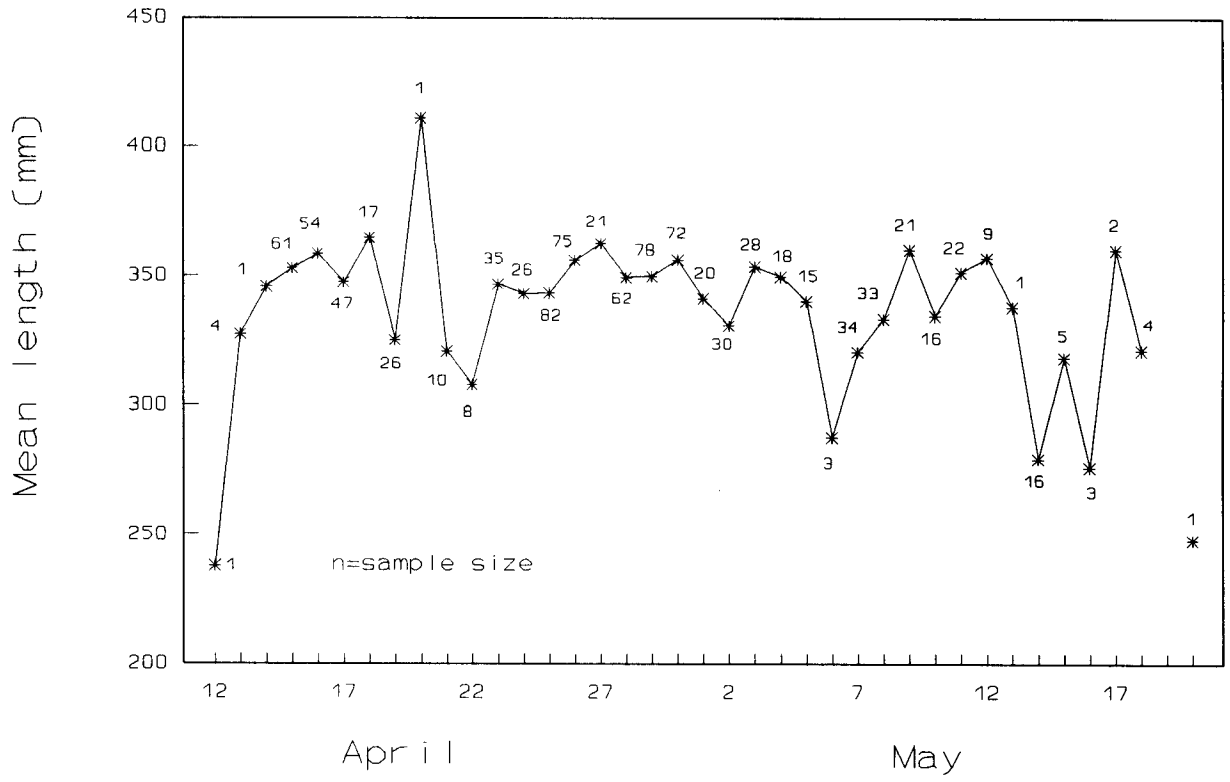

Figure 6. Mean length of emigrant cutthroat trout, Chilkat Lake, April 12 through May 20, 1990 (no count or sample on May 19).

the study. We also thank Gordon Whitermore and David Pahl for collection of creel survey data. Donna Buchholz and Gail Heineman (ADFG, Anchorage) provided the mark-sense forms and all processing required to give us electronic data files.

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APPENDIX A

Appendix A. Estimated variances for effort, catch, and harvest of cutthroat trout for charter and nonchartered anglers, by stratum and sampling period, May 21 through October 7, 1990.

		May 21 June 3	June 4 June 17	June 18 July 1	July 2 July 15	July 16 July 29	July 30 Aug 12	Aug 13 Aug 26	Aug 27 Sept 09	Sept 10 Sept 23	Sept 24 Oct 7
Nonchartered anglers											
Weekends											
Effort	stage 1	60	0	0	206	0	0	0	257	0	0
	stage 2	80	3	74	546	326	835	465	168	615	0
	stage 3	0	0	0	0	0	0	0	0	0	0
Catch	stage 1	0	0	0	251	0	0	0	58	0	0
	stage 2	0	0	148	334	29	236	58	55	0	0
	stage 3	0	0	0	74	2,506	40	17	97	0	0
Harvest	stage 1	0	0	0	111	0	0	0	30	0	0
	stage 2	0	0	57	149	666	69	43	52	0	0
	stage 3	0	0	61	0	1,323	5	13	97	0	0
Weekdays											
Effort	stage 1	0	1,750	1,728	395	1,600	1,484	1,196	0	1,074	0
	stage 2	0	205	384	203	356	183	67	0	239	0
	stage 3	0	0	0	0	0	0	0	0	0	0
Catch	stage 1	0	164	0	510	0	8,466	2,219	6	477	0
	stage 2	0	37	0	157	0	367	532	2	106	0
	stage 3	0	73	0	3	0	18	2	0	53	0
Harvest	stage 1	0	164	0	209	0	4,121	1,172	6	477	0
	stage 2	0	37	0	63	0	147	237	2	106	0
	stage 3	0	73	0	3	0	165	2	0	53	0
Chartered anglers											
Weekends											
Effort	stage 1	15	0	0	90	0	0	0	0	0	0
	stage 2	0	0	0	0	0	0	0	u	u	u
Catch	stage 1	63	0	0	81	0	0	0	0	0	0
	stage 2	0	0	0	0	0	0	0	u	u	u
Harvest	stage 1	32	0	0	30	0	0	0	0	0	0
	stage 2	0	0	0	0	0	0	0	u	u	u
Weekends											
Effort	stage 1	0	241	1,415	723	735	638	540	0	0	0
	stage 2	u	0	0	0	0	0	0	u	u	u
Catch	stage 1	480	724	2,295	2,940	1,615	1,354	0	0	0	0
	stage 2	u	0	0	0	0	0	0	u	u	u
Harvest	stage 1	0	80	274	1,000	454	285	4	0	0	0
	stage 2	u	0	0	0	0	0	0	u	u	u

u = undefined: no anglers interviewed.