Fishery Data Series No. 90-24

# CUTTHROAT TROUT STUDIES: TURNER/FLORENCE LAKES, ALASKA, DURING 1989[1]

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August 1990

[1] This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-5, Job Number T-1-1.

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ABSTRACT

Turner Lake southeast of Juneau, and Florence Lake on the west side of Admiralty Island were examined in 1988 and 1989 to estimate the size of the cutthroat trout *Oncorhynchus clarki* population, the condition of the population, the angler effort and harvest, and the condition of the cutthroat trout in the angler harvest. During 19 June to 24 July at Turner Lake and 5 August to 29 August at Florence Lake, two sampling trips were conducted at each lake. The abundance estimate for cutthroat trout between approximately 100 millimeters and 400 millimeters in Turner Lake in 1988 was 1,526 trout (standard error = 154). Harvest studies showed catch per unit effort to be comparable with our studies in Turner Lake in 1988 and with other studies conducted in 1985. We estimated 623 angler-hours of fishing (standard error = 208) during our presence at Turner Lake and a harvest of 128 cutthroat trout (standard error = 65), 14 Dolly Varden *Salvelinus malma* (standard error = 8), and 34 kokanee *Oncorhynchus nerka* (standard error = 22). At Florence Lake an estimated 246 angler-hours (standard error = 369) were expended to harvest an estimated 125 cutthroat trout (standard error = 118).

KEY WORDS: Southeast Alaska, cutthroat trout, *Oncorhynchus clarki*, Dolly Varden char, *Salvelinus malma*, kokanee, *Oncorhynchus nerka*, Turner Lake, Florence Lake, capture-recapture abundance estimation, catch per unit effort, CPUE.

## INTRODUCTION

Turner Lake is located in upper Taku Inlet 26 km east of Juneau (Figure 1). The lake is 14 km long and has a surface elevation of just over 22 m. Turner Lake is very steep sided except near inlet streams, and is about 1,270 ha in surface area. Maximum depth is 215 m (Figure 2) with a mean depth of 30 m (Schmidt 1979). The lake outlet flows about 1,700 m from the lake to Taku Inlet and is blocked to upstream fish passage by a barrier falls just below the lake. Turner Lake has produced over 10% of the cutthroat trout *Oncorhynchus clarki* in the Alaska Department of Fish and Game's (ADF&G) Trophy Fish Program. The largest cutthroat trout registered with the Trophy Fish Program from Turner Lake weighed 6 pounds 7 ounces (Robert Bentz, ADF&G, Sport Fish Division, Juneau, Alaska, personal communication) and was caught in 1980.

Turner Lake was selected as the site of a sockeye salmon *Oncorhynchus nerka* enhancement project to supplement the commercial gillnet harvest in the Taku Inlet area (McNair 1987). The ADF&G Fisheries Rehabilitation Enhancement and Development (F.R.E.D.) Division proposed to stock between 5 and 25 million juvenile sockeye salmon annually into Turner Lake. Sockeye salmon eggs were scheduled to be taken from Speel Lake in Port Snettisham in the fall of 1990. The eggs would have been incubated in a special facility at the Snettisham Hatchery and the resulting fry released as soon as Turner Lake was ice free the following spring (McNair 1987).

The Turner Lake stocking project was canceled in May of 1990 as a result of concerns relating to the potential for introduction of Infectious Hematopoietic Necrosis Virus (IHNV). There was concern for both the kokanee *Oncorhynchus nerka* and cutthroat trout in Turner Lake, as both species are IHNV susceptible. Sixty-four Turner Lake kokanee were sampled for IHNV in 1985 by the Northern Southeastern Aquaculture Association (NSRAA) (Joyce 1986). Kokanee were sampled again in 1988 (80 fish tested) and in 1989 (167 fish tested) by the ADF&G. No virus was detected in any of the 311 fish sampled. All of the potential brood sources for sockeye eggs are known to have the IHNV. Fish populations that have had no contact with a disease can be more susceptible than those that have had long term contact with it (Rohovec, et al. 1988). The ADF&G has a disease policy that prohibits the transplant of a stock of fish having a history of a particular disease agent into another system containing significant population of salmonid fish that does not have that disease.

Another concern was the potential for competition between age-0 cutthroat trout, planted sockeye salmon fry (age-0), and fry from existing kokanee stocks. Sockeye salmon fry and kokanee are very efficient open water planktivores (Leathe and Graham 1981). Sockeye salmon fry (and kokanee) can compete with young cutthroat trout for plankton (Marnell 1988), which can be an important food for juvenile cutthroat trout (Gresswell and Varley 1988; Gerstung 1988). Since cutthroat trout fry emerge in late summer, age-0 cutthroat trout would enter the lake up to two months after the sockeye fry were stocked. After feeding for the summer, sockeye salmon fry would be larger and more competitive for existing plankton resources, particularly during the subsequent winter months, when other food sources (like terrestrial insects) are limited.

According to Schmidt (1979), cutthroat trout rely heavily on kokanee as a food source once the cutthroat trout reach a size (fork length) of about 240 mm. Other studies indicate that cutthroat trout switch to a piscivorous diet between 300 mm (Gerstung 1988) and 386 mm (Nielson and Lentsch 1988). Those larger

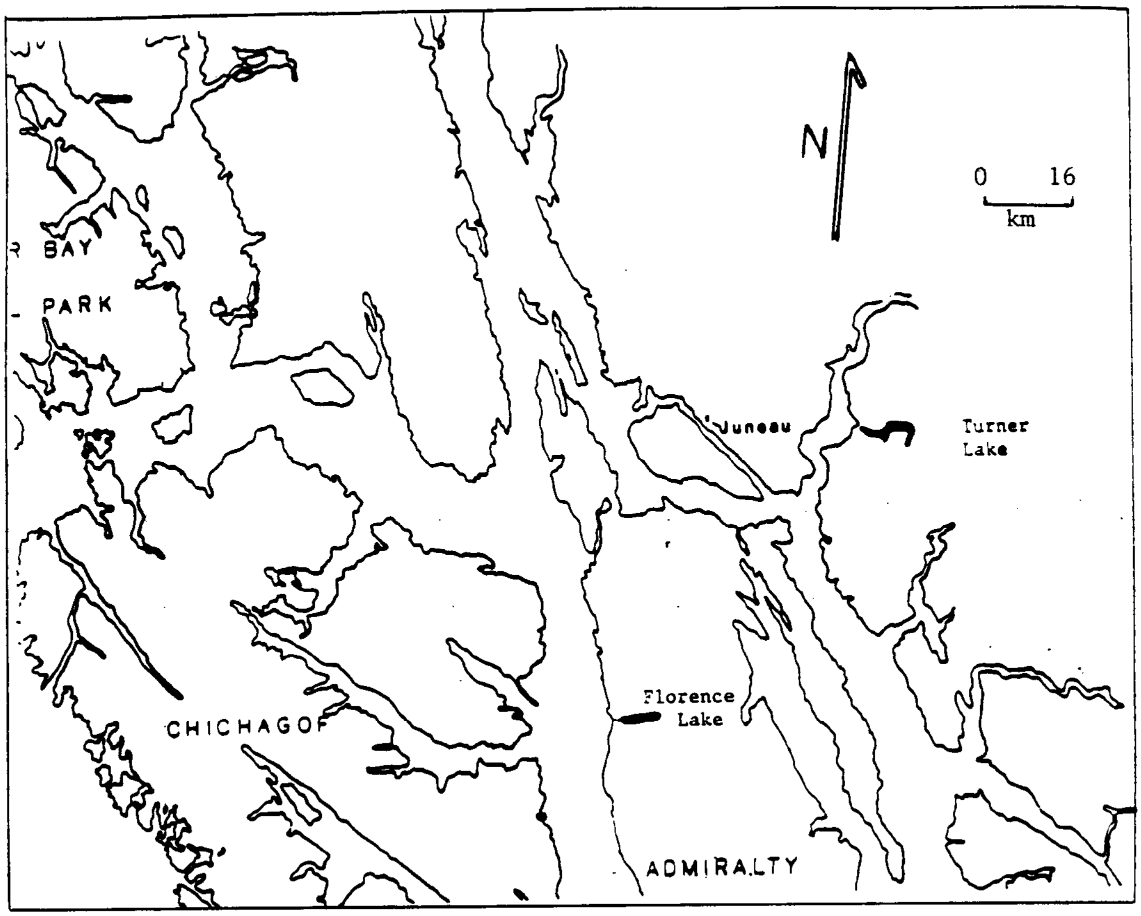


Figure 1. Map of the Juneau area showing the location of Turner and Florence Lakes.

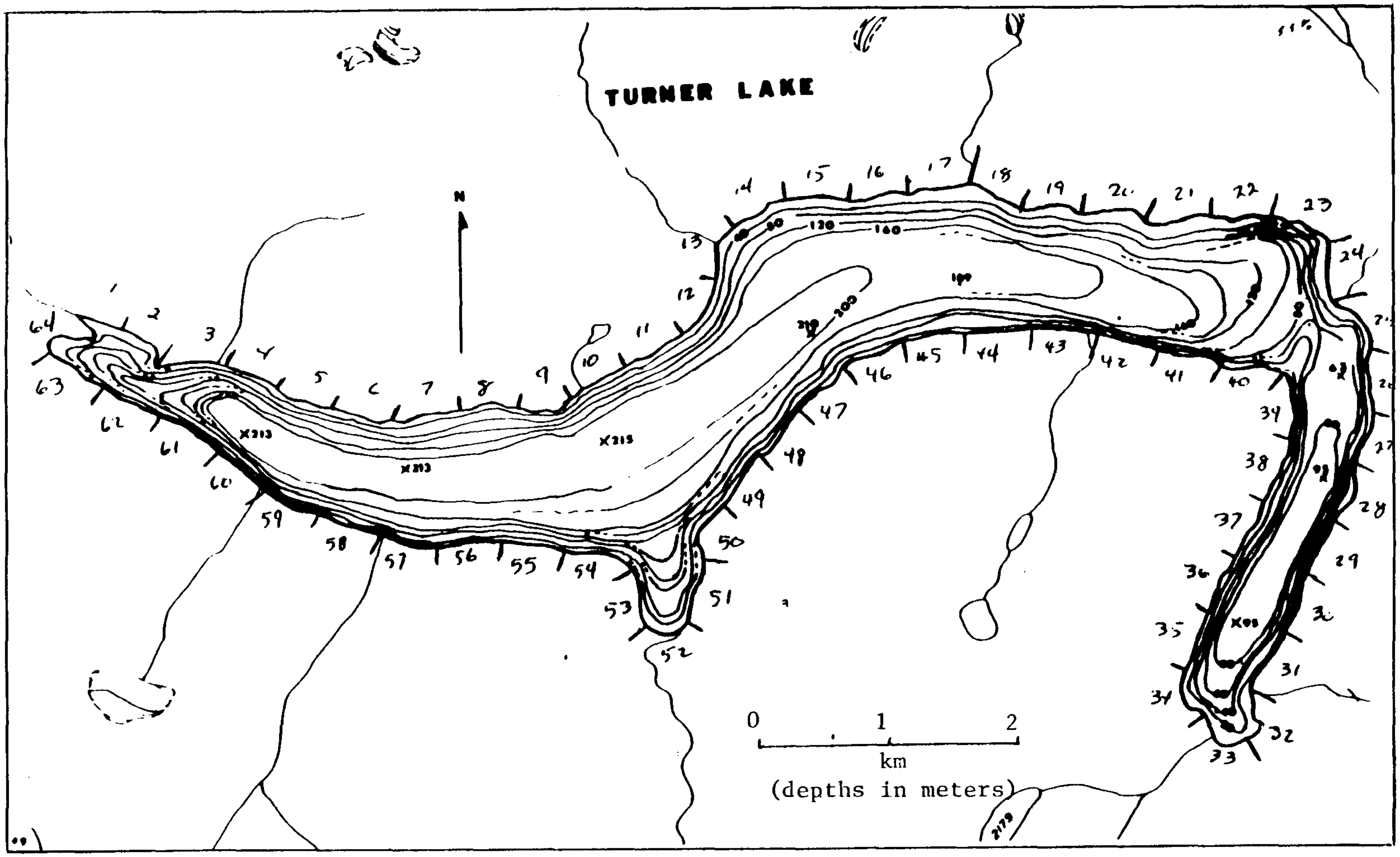


Figure 2. Turner Lake Bathymetric Map with the 1988 study area locations.

cutthroat trout that have shifted to a piscivorous diet in Turner Lake might have benefitted from increased food availability as a result of the introduction of large numbers of sockeye salmon fry.

Preliminary research in Turner Lake by Schmidt (1979) and Joyce (1986) provided no insights on the abundance, recruitment rates, or harvest rates of cutthroat trout. Anecdotal information for Turner Lake from anglers is that the catch rates have dropped since the mid-1970's. Hydroacoustic population assessment of the existing kokanee population in Turner Lake was done by ADF&G F.R.E.D. Division in September, 1986. Two sets of the nine transects were run, and the resulting population estimate was 29,650 kokanee (Dave Barto, ADF&G F.R.E.D. Division, P.O. Box 20, Douglas, AK. 99824, personal communication).

Florence Lake is located on the west side of Admiralty Island about 50 km southwest of Juneau (Figure 1). Florence Lake is a narrow lake approximately 7.2 km long with a maximum depth of just over 27 m (Figure 3). The lake outlet flows about 1 km into Chatham Straits directly across from Tenakee Inlet. There is a barrier falls about 400 m upstream of Chatham Straits.

Florence Lake is one of the most popular fly-in lakes in Southeast Alaska with over 4,000 visitor days (United States Forest Service (USFS), Juneau, Alaska, personal communication) of use annually. The Florence Lake watershed is scheduled for extensive clear cut logging in the next two to four years (James Senna Shee Atika Corporation, P.O. Box 1949, Sitka, Alaska 99835, personal communication). The proposed logging is expected to strip the watershed around the lake of all marketable timber. The potential impacts of the logging and associated road building on the lake and its fishery resources are unknown. Studies by Jones (1982) in Florence Lake included habitat mapping, but work on the cutthroat trout population was limited to lengths and ages for 30 fish. No estimate was obtained for the abundance of cutthroat trout.

The only consistent harvest information available for Turner and Florence lakes is the Statewide Harvest Survey (Mike Mills, ADF&G, 333 Raspberry Road, Anchorage, AK 99518, personal communication). Harvests for Turner Lake range from 42 cutthroat trout in 1983 (Mills 1984), to 882 in 1979 (Mills 1981). Harvests for Florence Lake range from 112 cutthroat in 1986 (Mike Mills, ADF&G, Anchorage, personal communication) to 1,727 in 1979 (Mills 1981). The five year average harvest for 1977-1981 in Turner Lake was 488 fish; the recent five year average (1984-1988) is 246 cutthroat trout, a 49.5% decrease. In Florence Lake, the decline between the same two periods was 60.6% (985 to 388). The number of reported visitor days at both Turner and Florence lakes have nearly doubled in the past 15 years (Laura Calhoon, USFS, Sitka, Alaska, personal communication).

Trophy size cutthroat trout *Oncorhynchus clarki* are rare in southeast Alaska. Turner and Florence lakes are designated as "High Quality or Important Watersheds" by both the Department of Fish and Game and the U.S. Forest Service (TLMP 1979). This project was designed to provide the base-line information needed to conserve and manage the high-value cutthroat trout fisheries in these important fly-in lakes and it is a continuation of studies reported in Jones, et. al (1989). The objectives of this project were:

1. Develop methods to estimate the abundance of cutthroat trout in Turner and Florence lakes, and estimate abundance of the cutthroat trout in Turner Lake during 1988.

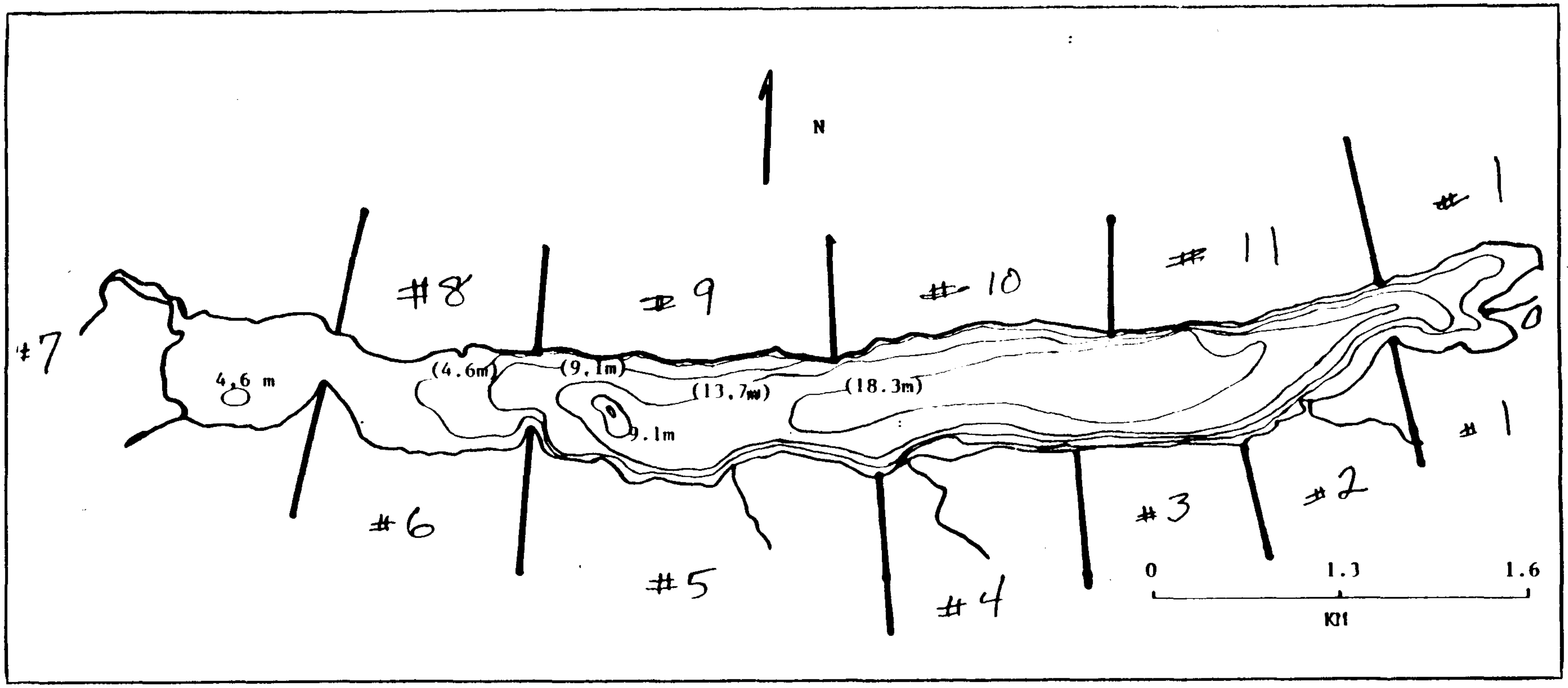


Figure 3. Florence Lake bathymetric map with study area locations.

2. Estimate the age and size composition of cutthroat trout in Turner and Florence lakes during 1989.

3. Estimate the size composition of cutthroat trout observed in the angler catch at Turner and Florence lakes during 1989.

4. Estimate angler effort and harvest at Turner and Florence lakes during select periods in 1989.

## METHODS

### Abundance Estimates and Population Status

Fish were captured using baited fyke nets, baited funnel traps, gill nets (both baited and unbaited), and sport gear. The fyke net had 13 cm mesh with a 0.9 m by 1.8 m opening, two 6.1 m by 1 m wings off each side, a 15.2 m by 1 m center lead, and two funnel entrances leading to the codend. The baited traps were of two sizes. The large traps were 1.5 m in length, 0.6 m in diameter, with a 9 cm opening the funnels at each end of the trap and a mesh size of 1 cm. The small funnel traps were 44 cm long and 23 cm wide, with 4 cm openings and a mesh size of 0.6 cm. The gill nets were 38.1 m long, 1.8 m deep and consisted of five 7.6 m panels of stretched mesh sizes 12.7 mm, 19.1 mm, 25.4 mm, 38.1 mm, and 50.8 mm. Sport gear was rod and reel with a small lure or spinner attached as bait.

Each captured cutthroat trout over 200 mm was tagged with a uniquely numbered T-bar (Floy type) anchor tag and a visual implant tag, and its adipose fin was removed. Each fish was measured from the tip of snout to fork of tail (fork length) to the nearest millimeter, weighed (nearest gram), and a smear of scales was removed from the area just forward of a line from the posterior portion of the dorsal fin to the anterior portion of the anal fin just over the lateral line. Cutthroat trout under 200 mm were too small to tag conveniently, so each was fin clipped with a clip pattern unique to each sampling trip. Dolly Varden *Salvelinus malma* and kokanee were weighed (nearest gram) and measured to the nearest millimeter fork length. Scale smears from the same area as in the cutthroat trout were taken from the kokanee.

All captured fish under about 180 mm were anesthetized with tricaine methanesulfonate (MS222). All fish over that size range were anesthetized using an electroshock basket (Gunstrom and Bethers 1985). This avoided the possibility of residual amounts of MS222 in any fish caught for consumption in the recreational fishery.

The salmon eggs used for bait in the lake fyke net, funnel traps and on the baited gillnets were disinfected with a 5% Betadine solution. The eggs were soaked in Betadine for 15 minutes before preservation with about 1 kg of Borax per 5 kg of eggs. Bait was secured inside nets and traps in perforated plastic sample jars. Salmon eggs were hung loose through the mesh of baited gillnets at several places along the net. We found that by baiting the gillnets and keeping sets to 20 minutes or less, the variable mesh gillnets were more effective and mortality was reduced.

The shorelines of Turner Lake were divided into 64 sections (Figure 2) and Florence Lake into 11 sections (Figure 3) to allow us to track the movements of tagged fish. As each fish was caught, the area of capture was recorded. Distance traveled was estimated by measuring the shortest distance (from point to point) from the tagging location to the recovery location. A fish that was recaptured in the study area where it was originally tagged, or in an adjacent study area, was reported as not moving.

Two sampling trips were conducted into the Turner Lake system. The first trip started on 18 June and ran through 5 July. The second trip ran from 10 July to 24 July. Two trips were also conducted into Florence Lake. Work started there on 5 August and the first trip ended on 16 August. The final trip ran from 24 August through 29 August.

The abundance of cutthroat trout in Turner Lake was estimated using a Peterson-type mark and recapture experiment. The initial marking period was 1988, and 1989 was the recapture period. During the two sampling occasions we assumed that both recruitment and mortality occurred. Accordingly, a simple Peterson type estimator would give biased estimates of the population abundance. We, therefore, used the procedure developed by Robson and Flick (1965) and outlined by Seber (1982; section 3.2.1, pages 72-78) to correct for the effect of recruitment on our abundance estimate. We assumed that mortality affected both marked and unmarked portions of the 1988 population similarly, and as such our recruitment-corrected estimate would be unaffected by mortality.

The first step we used to correct for recruitment involved conducting the Robson-Flick nonparametric test. This test involved ordering the lengths of the $m_2$ recaptures (from the 1988 marked fish caught during 1989) as follows: $L_1 < L_2 < \ldots < L_{m_2}$. Then we defined $u_i$ $(i = 1, 2, \ldots, m_2+1)$ to be the number of unmarked fish caught during 1989 with lengths $L$ in the interval $L_{i-1} \le L < L_i$ $(L_0 = 0,\ L_{m+1} = \infty)$. We then incrementally compared each $u_i$ to its expected value by computing the following tail probability:

$$Pr[U_i \ge u_i \mid u_1,\ u_2,\ \ldots, u_{i-1}] = \frac{\binom{n_2 - a_i - i + 1}{m_2 - i + 1}}{\binom{n_2 - a_{i-1} - i + 1}{m_2 - i + 1}}; \quad (1)$$

$$= \frac{\left\{\frac{(n_2 - a_i - i + 1)!}{(n_2 - a_i - m_2)!}\right\}}{\left\{\frac{(n_2 - a_{i-1} - i + 1)!}{(n_2 - a_{i-1} - m_2)!}\right\}}; \quad (2)$$

where:

$U_i$ = is a random variable taking the values of $u_i$;

$n_2$ = the number of fish captured (both marked and unmarked) during 1989;

$m_2$ = the number of fish captured during 1989 that had been marked during 1988 (i.e., recaptures); and

$R_h$ = total number of hours (available for sampling) in stratum *h*;

$\overline{x}_h$ = mean number of anglers fishing over all samples, each sample represented one count taken each day within stratum *h*;

$$= \frac{\sum_{i=1}^{d_h} x_{hi}}{d_h}; \qquad (11)$$

$i$ = subscript denoting count sample within stratum *h*;

$d_h$ = number of samples (i.e., counts) completed in stratum *h*;

$x_{hi}$ = number of anglers counted in sample *i* for stratum *h*;

$\hat{V}_h[\hat{E}_h]$ = the variance estimate for the estimate of $\hat{E}_h$;

$$= R_h^2\left(\frac{s_h^2}{d_h}\right); \qquad (12)$$

$$s_h^2 = \frac{\sum_{i=1}^{d_h}(x_{hi} - \overline{x}_h)^2}{d_h - 1}. \qquad (13)$$

The results from equation (12) are assumed to be biased, since we conducted only one angler count per day sampled. As such, equation (12) does not incorporate any within day variance component and is therefore negatively biased by an unknown amount.

Angler catch and harvest rates along with their variances were estimated from interview data from both completed and incompleted-trip anglers using a stratified random estimator, according to the following equations:

$\hat{T}_h$ = estimated total catch or harvest per unit effort for stratum *h* of each fishery;

$$= \frac{\sum_{j=1}^{n_h}\left(\sum_{k=1}^{o_j} c_{hjk}\right)}{\sum_{j=1}^{n_h}\left(\sum_{k=1}^{o_j} e_{hjk}\right)}; \qquad (14)$$

$j, k$ = subscripts denoting the individual interview sample and the angler interviewed, respectively, within stratum *h*;

$n_h$ = number of interview samples collected within stratum *h*;

$o_j$ = number of anglers interviewed within sample *j*;

$c_{hjk}$ = catch or harvest of angler $j$ interviewed within sample $j$ in stratum $h$;

$e_{hjk}$ = effort expended by angler $j$ interviewed within sample $j$ in stratum $h$;

$\hat{V}_h[\hat{T}_h]$ = estimated variance of the catch per unit effort (CPUE) or harvest per unit effort (HPUE) for stratum $h$, obtained by the approximation formula for the variance of the ratio of random variables (Jessen 1978, equation 5.8, page 128, omitting the finite population correction factor);

$$\approx \left\{\frac{\bar{\bar{c}}_h}{\bar{\bar{e}}_h}\right\}^2 \left\{\frac{s^2_{(c)h}}{\bar{\bar{c}}^2_h} + \frac{s^2_{(e)h}}{\bar{\bar{e}}^2_h} - \frac{2\,\mathrm{cov}_{(c,e)h}}{\bar{\bar{c}}_h\,\bar{\bar{e}}_h}\right\}; \tag{15}$$

$\bar{\bar{c}}_h$ = mean of mean catch or harvest per angler for stratum $h$;

$$= \frac{\sum_{j=1}^{n_h} \bar{c}_{hj}}{n_h}; \tag{16}$$

$\bar{\bar{e}}_h$ = mean of mean effort per angler for stratum $h$;

$$= \frac{\sum_{j=1}^{n_h} \bar{e}_{hj}}{n_h}; \tag{17}$$

$\bar{c}_{hj}$ = mean catch or harvest per angler for sample $j$ in stratum $h$;

$$= \frac{\sum_{k=1}^{o_j} c_{hjk}}{o_j}; \tag{18}$$

$\bar{e}_{hj}$ = mean effort per angler for sample $j$ in stratum $h$;

$$= \frac{\sum_{k=1}^{o_j} e_{hjk}}{o_j}; \tag{19}$$

$s^2_{(c)h}$ = variance estimate associated with estimating the catch or harvest component of CPUE or HPUE in stratum $h$;

$$= \left\{\left[1 - \frac{n_h}{N_h}\right]\left[\frac{s^2_{(c)_b h}}{n_h}\right]\right\}; \tag{20}$$

$N_h$ = total possible number of interview samples within stratum *h*;

$s^2_{(c)_b h}$ = the between sample variance component for the variance estimate of catch or harvest in stratum *h*;

$$= \frac{\sum_{j=1}^{n_h}\left(\bar{c}_{hj} - \bar{\bar{c}}_h\right)^2}{n_h - 1}; \tag{21}$$

$s^2_{(e)h}$ = variance estimate associated with estimating the effort component of CPUE or HPUE in stratum *h*, calculated by substituting the corresponding effort statistics into equation (20);

$\mathrm{cov}_{(c,e)h}$ = covariance estimate between the catch (or harvest) and effort components of the CPUE or HPUE in stratum *h*;

$$= \left\{\left[1 - \frac{n_h}{N_h}\right]\left[\frac{\mathrm{cov}_{(c,e)_b h}}{n_h}\right]\right\}; \tag{22}$$

$\mathrm{cov}_{(c,e)_b h}$ = the between sample covariance component between catch (or harvest) and effort in stratum *h*;

$$= \frac{\sum_{j=1}^{n_h}\left[\left(\bar{c}_{hj} - \bar{\bar{c}}_h\right)\left(\bar{e}_{hj} - \bar{\bar{e}}_h\right)\right]}{n_h - 1}; \tag{23}$$

Note, that in both equations (20) and (22) we only use the first-stage terms of what appears to be a two-stage estimator. This is because on each day sampled we interviewed all anglers, and hence the second-stage variance and covariance term was by definition equal to zero.

Estimates of angler catch or harvest and their variances were obtained by combining the estimated stratum estimates of effort and catch (or harvest) rates, as follows:

$$\hat{C}_h = \hat{E}_h \hat{T}_h; \tag{24}$$

$\hat{V}_h[\hat{C}_h]$ = estimated variance of $\hat{C}_h$ in stratum *h*, assuming independence of the estimates of effort and CPUE or HPUE, obtained by using the formula proposed by Goodman (1960);

$$= \hat{E}_h^2 \hat{V}_h[\hat{T}_h] + \hat{T}_h^2 \hat{V}_h[\hat{E}_h] - \hat{V}_h[\hat{E}_h] \hat{V}_h[\hat{T}_h]. \tag{25}$$

Total angler effort, catch, or harvest across all strata (or select combinations of strata) were obtained by the following equations:

$\hat{Y}$ = total estimated effort, catch, or harvest, were Y equals the parameter of interest (e.g., E, C, or H for effort, catch, or harvest);

$$= \sum_{h=1}^{q} \hat{Y}_h ; \tag{26}$$

q = number of strata to be combined;

$\hat{Y}_h$ = estimate for the parameter of interest in stratum *h*;

$\hat{V}[\hat{Y}]$ = estimated variance of $\hat{Y}$, assuming independence of the stratum estimates;

$$= \sum_{h=1}^{q} \hat{V}_h[\hat{Y}_h] ; \tag{27}$$

$\hat{V}_h[\hat{Y}_h]$ = variance estimate for the parameter of interest in stratum *h*.

Standard errors for stratum estimates and across stratum estimates were obtained by taking the square root of each appropriate variance estimate.

The estimates for angler effort, catch, harvest, HPUE, and CPUE are assumed to be biased by an unknown, although small amount. This bias is due to the non-random sampling of days within each stratum. We assume the bias is quite small in that we sampled nearly all of the days within each stratum.

The assumptions necessary for our effort, catch, and harvest estimates to be unbiased by any other factors (excepting the non-random sampling of days and the conducting of only one count per day) include the following:

1. anglers accurately report their hours of fishing effort and the number by species of fish released;

2. incomplete trip angler interviews provide an unbiased estimate of completed-trip HPUE and CPUE; and

3. sampled days are representative of the days within each stratum.

## RESULTS

### Turner Lake

A total of 684 cutthroat trout, 159 Dolly Varden, and 180 kokanee were captured in our sampling in Turner Lake (Table 1). We did catch additional cutthroat in short trips for other purposes after our main sampling trip, so numbers in subsequent tables vary when they are included. We marked and released a total of 575 cutthroat trout into Turner Lake during our sampling in 1988 and an additional 412 fish in 1989 (Table 2).

Forty-four cutthroat trout with unique floy tags that had been applied during 1988 were recovered during 1989. Twenty-five (56.8%) had moved 0.6 km or more from tagging to recapture. Another 19 fish (43.2%) were recaptured in the same area (or an adjacent area) in which they had been originally tagged and released. The average distance traveled by these 44 fish from their tagging in 1988 to recapture in 1989 was 1.6 km (0.99 miles). The farthest a fish moved was 8.1 km (5.0 miles). The mean growth of the tagged fish from 1988 to 1989 was 30 mm (1.2 inches) with a range from 6 mm to 54 mm (Table 3).

No size-selectivity in our sampling gear or size-specific difference in mortality was detected in 1989. A contingency table analysis was used to compare the number of fish recaptured in 1989 from the 1988 tagging, by length category (<221 mm, ≥221 mm & < 255 mm, ≥255 mm & <293 mm, and >293 mm), with the number of fish in each category that were newly captured in 1989 (Table 4). Only fish that had been marked with unique tags were used for this analysis; none of the fin-clipped fish were included. Similar rates of new captures in each category to recaptures were observed for all size categories, suggesting that there was little size selective overwinter mortality (i.e. we failed to reject the null hypothesis of equal probability of capture, ($G = 5.821$, $p = 0.121$).

We also found no differences between the rates of tagged fish recaptured to the rate of newly captured fish in different areas of Turner Lake. A contingency table analysis was used to compare the ratio of recaptures by lake section in 1989 (from fish tagged in 1988) with the total number of new fish captured during 1989 (Table 5). All six areas of the lake displayed similar rates of recapture (i.e., we failed to reject the null hypothesis of equal probability of capture, $G = 4.891$, $p = 0.429$).

The graphical analysis of "running average unmarked-to-marked ratio" (i.e., $\overline{u}_i$ versus $L_i$) indicated that growth recruitment from the 1988 to 1989 capture occasions leveled off at approximately 265 mm (Figure 4). The tail probabilities associated with the Robson-Flick nonparametric test (Appendix A) confirmed this determination, in that a total of 11 of the 31 tests for length stanzas (i.e., $L_{i-1} \le L < L_i$ ($L_0 = 0$, $L_{m+1} = \infty$)) for lengths less than 266 mm were rejected at $\alpha = 0.10$. Whereas, only one of the 33 tests for larger lengths were rejected. As such, we chose 266 mm as $L_{r+1}$ which had an associated value of 1.6471 for $\overline{u}_{r+1}$ (Figure 4), and 0.07109 for $\hat{V}[\overline{u}_{r+1}]$ (Appendix A).

While several large fish were marked in 1988, none of them were recaptured in 1989 so we used only the only smaller fish (less than 400 mm) in calculating the abundance estimate. Additionally, note that only fish greater than approximately 100 mm were captured either year. A total of 576 trout smaller than 400 mm were captured (equal to the term $n_1$), marked, and released during 1988. As such our

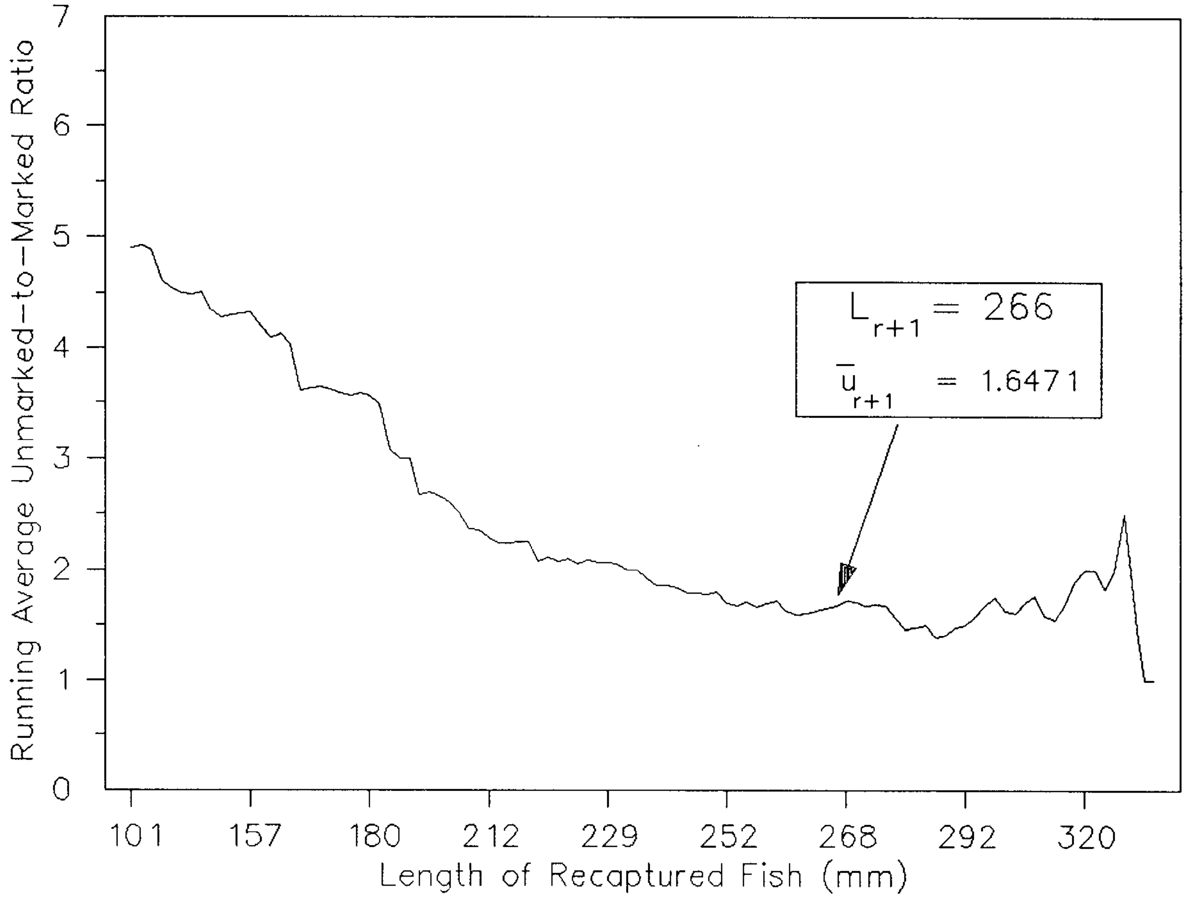


Figure 4. Plot of running average unmarked-to-marked ratio versus length of recaptured fish in Turner Lake. Marked fish from 1988 marking only and all capture occasions during 1989 treated as the recapture occasion. Plot was used to determine the approximate length at which growth recruitment no longer appreciably impacts the unmarked-to marked ratio. The length at which the plot's slope is approximately zero was chosen as the length at which recruitment is insignificant. The next greater length was then defined as $L_{r+1}$, which along with the associated running average unmarked-to-marked ratio was used to estimate the population size according to the Robson-Flick recruitment culling procedure (Robson and Flick 1965; Seber 1982).

Table 1. Effort (hours), catch, and catch per unit effort (CPUE, fish per hour) by period, gear, and species for 1989 Turner Lake sampling.

| | | | Cutthroat Trout | | Dolly Varden | | Kokanee | |
|---|---|---|---|---|---|---|---|---|
| Period | Gear | Effort | Catch | CPUE | Catch | CPUE | Catch | CPUE |
| 1[a] | Fyke Net | 344.8 | | 0.08 | 48 | 0.14 | 35 | 0.10 |
| | Gillnet | 37.6 | 32 | 0.85 | 2 | 0.05 | 23 | 0.61 |
| | Hook & Line | 8.3 | 7,027 | 8.53 | 1 | 0.12 | 6 | 0.72 |
| | Large Trap | 1,824.7 | 190 | 0.10 | 77 | 0.04 | 17 | 0.01 |
| | Small Trap | 48.4 | | | 1 | 0.05 | | |
| | Total | 2,263.8 | 319 | 0.14 | 129 | 0.06 | 81 | 0.04 |
| 2[b] | Fyke Net | 210.3 | 18 | 0.09 | | | 46 | 0.22 |
| | Gillnet | 8.6 | 21 | 2.44 | | | 42 | 4.88 |
| | Hook & Line | 12.5 | 72 | 5.76 | 10 | 0.80 | 1 | 0.08 |
| | Large Trap | 1,658.0 | 253 | 0.15 | 15 | 0.01 | 10 | 0.01 |
| | Small Trap | 393.9 | 1 | 0.00 | 5 | 0.01 | | |
| | Total | 2,283.3 | 365 | 0.16 | 30 | 0.01 | 99 | 0.04 |
| Total | Fyke Net | 555.1 | 45 | 0.08 | 48 | 0.09 | 81 | 0.15 |
| | Gillnet | 46.2 | 53 | 1.15 | 2 | 0.04 | 65 | 1.41 |
| | Hook & Line | 20.8 | 142 | 6.83 | 11 | 0.53 | 7 | 0.34 |
| | Large Trap | 1,623.1 | 443 | 0.27 | 92 | 0.06 | 27 | 0.02 |
| | Small Trap | 14.6 | 1 | 0.07 | 6 | 0.41 | | |
| | Total | 4,547.1 | 684 | 0.15 | 159 | 0.03 | 180 | 0.04 |

[a] 19 June to 5 July
[b] 10 July to 24 July

Table 2. Summary of marks, recaptures, and population estimate for cutthroat trout in Turner Lake, 1988-89.

| | Capture Occasion[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Captured, marked, & released Newly Marked Fish | 40 | 103 | 112 | 141 | 95 | 150 | 278 | 134 |
| Recaptures from | | | | | | | | |
| Period 1 | 0 | 1 | 5 | 3 | 3 | 0 | 0 | 0 |
| Period 2 | - | 3 | 2 | 3 | 4 | 3 | 4 | 3 |
| Period 3 | - | - | 0 | 9 | 6 | 8 | 5 | 6 |
| Period 4 | - | - | - | 5 | 5 | 23 | 8 | 7 |
| Period 5 | - | - | - | - | 1 | 11 | 12 | 1 |
| Period 6 | - | - | - | - | - | 6 | 12 | 3 |
| Period 7 | - | - | - | - | - | - | 0 | 29 |
| Period 8 | - | - | - | - | - | - | - | 1 |
| Captured and died newly marked fish | 1 | 3 | 1 | 11 | 6 | 6 | 5 | 6 |
| Total Catch | 41 | 110 | 120 | 172 | 120 | 190 | 324 | 190 |
| Removed by anglers from | - | 3 | 3 | 3 | 4 | 3 | 12 | 2 |

[a] Occasion
#1 8 June - 17 June, 1988
#2 28 June - 7 July, 1988
#3 13 July - 21 July, 1988
#4 26 July - 3 Aug, 1988
#5 9 Aug - 15 Aug, 1988
#6 23 Aug - 31 Aug, 1988
#7 19 June - 5 July, 1989
#8 10 July - 24 July, 1989

Table 3. Turner Lake cutthroat trout growth and movement information for fish tagged in 1988 and recaptured in 1989.

| Tag # | Capture Date | Recapture Date | Capture Length | Recap Length | Growth (mm) | Daily Growth | Distance Traveled (km) |
|---|---|---|---|---|---|---|---|
| 1034 | 01-Jul-88 | 21-Jun-89 | 256 | 310 | 54 | 0.152 | 0.6 |
| 1083 | 14-Jul-88 | 16-Jun-89 | 260 | 298 | 38 | 0.113 | 0.0 |
| 1087 | 14-Jul-88 | 21-Jun-89 | 234 | 263 | 29 | 0.085 | 1.5 |
| 1095 | 15-Jul-88 | 23-Jul-89 | 213 | 267 | 54 | 0.145 | 0.6 |
| 1099 | 16-Jul-88 | 21-Jul-89 | 220 | 226 | 6 | 0.016 | 0.0 |
| 1119 | 18-Jul-88 | 22-Jun-89 | 227 | 263 | 36 | 0.106 | 3.3 |
| 1128 | 19-Jul-88 | 22-Jul-89 | 268 | 300 | 32 | 0.087 | 2.2 |
| 1134 | 20-Jul-88 | 19-Jul-89 | 190 | 222 | 32 | 0.088 | 0.0 |
| 1143 | 21-Jul-88 | 25-Jun-89 | 242 | 275 | 33 | 0.097 | 8.1 |
| 1157 | 27-Jul-88 | 19-Jul-89 | 230 | 264 | 34 | 0.095 | 0.0 |
| 1170 | 28-Jul-88 | 13-Jul-89 | 200 | 238 | 38 | 0.109 | 0.0 |
| 1171 | 28-Jul-88 | 04-Jul-89 | 203 | 227 | 24 | 0.070 | 1.4 |
| 1174 | 28-Jul-88 | 17-Jul-89 | 257 | 299 | 42 | 0.119 | 1.0 |
| 1176 | 28-Jul-88 | 02-Jul-89 | 200 | 222 | 22 | 0.065 | 6.4 |
| 1198 | 30-Jul-88 | 15-Jul-89 | 240 | 288 | 48 | 0.137 | 1.1 |
| 1213 | 31-Jul-88 | 23-Jul-89 | 223 | 254 | 31 | 0.087 | 5.9 |
| 1247 | 03-Aug-88 | 24-Jul-89 | 267 | 285 | 18 | 0.051 | 7.0 |
| 1248 | 03-Aug-88 | 26-Jun-89 | 200 | 237 | 37 | 0.113 | 1.4 |
| 1253 | 03-Aug-88 | 23-Jul-89 | 186 | 214 | 28 | 0.079 | 4.7 |
| 1255 | 09-Aug-88 | 28-Jun-89 | 241 | 275 | 34 | 0.105 | 0.0 |
| 1263 | 10-Aug-88 | 27-Jun-89 | 300 | 315 | 15 | 0.047 | 0.6 |
| 1271 | 11-Aug-88 | 15-Jul-89 | 264 | 279 | 15 | 0.044 | 0.0 |
| 1272 | 11-Aug-88 | 28-Jun-89 | 250 | 265 | 15 | 0.047 | 0.0 |
| 1277 | 12-Aug-88 | 22-Jun-89 | 277 | 310 | 33 | 0.105 | 1.6 |
| 1278 | 12-Aug-88 | 30-Jun-89 | 188 | 229 | 41 | 0.127 | 2.4 |
| 1280 | 12-Aug-88 | 04-Jul-89 | 212 | 250 | 38 | 0.117 | 0.6 |
| 1281 | 12-Aug-88 | 12-Jul-89 | 251 | 270 | 19 | 0.057 | 0.0 |
| 1291 | 13-Aug-88 | 26-Jun-89 | 240 | 280 | 40 | 0.126 | 0.0 |
| 1299 | 14-Aug-88 | 24-Jul-89 | 211 | 240 | 29 | 0.084 | 0.6 |
| 1304 | 14-Aug-88 | 22-Jun-89 | 206 | 238 | 32 | 0.103 | 0.0 |
| 1310 | 23-Aug-88 | 20-Jun-89 | 245 | 271 | 26 | 0.086 | 0.0 |
| 1317 | 24-Aug-88 | 04-Jul-89 | 237 | 256 | 19 | 0.061 | 0.0 |
| 1324 | 25-Aug-88 | 23-Jun-89 | 266 | 292 | 26 | 0.086 | 0.0 |
| 1325 | 25-Aug-88 | 04-Jul-89 | 219 | 228 | 9 | 0.029 | 0.0 |
| 1338 | 26-Aug-88 | 23-Jun-89 | 209 | 234 | 25 | 0.083 | 7.3 |
| 1346 | 27-Aug-88 | 13-Jul-89 | 223 | 262 | 39 | 0.122 | 6.0 |
| 1351 | 28-Aug-88 | 19-Jun-89 | 244 | 268 | 24 | 0.081 | 0.0 |
| 1366 | 29-Aug-88 | 19-Jun-89 | 215 | 240 | 25 | 0.085 | 0.0 |
| 1367 | 30-Aug-88 | 15-Jul-89 | 295 | 313 | 18 | 0.056 | 1.1 |
| 1386 | 31-Aug-88 | 02-Jul-89 | 260 | 284 | 24 | 0.079 | 0.0 |
| 1388 | 31-Aug-88 | 02-Jul-89 | 213 | 240 | 27 | 0.089 | 0.0 |
| 1390 | 31-Aug-88 | 24-Jun-89 | 275 | 317 | 42 | 0.141 | 1.1 |
| 1395 | 31-Aug-88 | 24-Jul-89 | 385 | 436 | 51 | 0.156 | 2.1 |
| 1397 | 31-Aug-88 | 21-Jul-89 | 197 | 225 | 28 | 0.086 | 0.9 |
| Average | | | | | 30 mm | 0.091 mm | 1.6 km |

Table 4. Turner Lake cutthroat trout recaptures in 1989 from the 1988 tagging and the numbers of newly marked fish in 1989 by length category.

| Size Category | Newly Marked Fish Released | Recaptures from 1988 |
|---|---|---|
| Less than 221 mm | 296 | 17 |
| ≥221 mm and <255 mm | 121 | 14 |
| ≥255 mm and <293 mm | 72 | 10 |
| Greater than 293 mm | 63 | 6 |

Table 5. Turner Lake cutthroat trout recaptures in 1989 from the 1988 tagging and the numbers of new fish marked in 1989.

| Lake Area | Unmarked Fish Captured in 1989 | Recaptures from 1988 |
|---|---|---|
| Northwest Shore Main Lake | 73 | 22 |
| Northeast Shore Main Lake | 109 | 27 |
| East Shore Cold Bay | 51 | 20 |
| West Shore Cold Bay | 57 | 25 |
| Southeast Shore Main Lake | 184 | 50 |
| Southwest Shore Main Lake | 55 | 14 |

population estimate of fish greater than 100 mm and less than 400 mm is 1,526 cutthroat trout (SE = 154) in Turner Lake during 1988.

Most of the fish we caught in our sampling in Turner Lake in 1988 were ages three and four (Table 6) comprising 52.7% of the sampled fish. In 1989, the largest categories were ages-2 and -3 which comprised 61.8% of the sample. This is a shift toward younger (and smaller) fish. Based on our sampling for the past two seasons, and on trophy fish that have been voluntarily given to us, it takes a cutthroat trout about nine years to reach trophy size (1,360 gm, 3 pounds) in Turner Lake. The largest (and oldest) fish we have examined to date was a 5 pound cutthroat trout that was 15 years of age caught in Turner Lake by an angler in 1989.

The estimated length-weight parameters for 1,428 cutthroat trout sampled in Turner Lake in 1988 and 1989 combined were: $a$ = -11.7637 (SE = 0.07198); $b$ = 3.0338 (SE = 0.00682); correlation ($a,b$) = 0.9964 (Figure 5).

The estimated parameters for the length-weight relationship for 664 Dolly Varden sampled in Turner Lake were: $a$ = -11.3873 (SE = 0.08143); $b$ = 2.9646 (SE = 0.01401); correlation ($a,b$) = 0.9927 (Figure 6).

The estimated parameters for the length-weight relationship for 390 kokanee sampled in Turner Lake in 1988 and 1989 were: $a$ = -11.9465 (SE = 0.07838); $b$ = 3.0926 (SE = 0.05212); correlation ($a,b$) = 0.9491 (Figure 7).

The length frequency distribution of cutthroat trout in Turner Lake in 1989 shows a high percentage of small fish when compared with the length frequency distribution from our studies in 1988 (Figure 8). In 1989, 56.8% of the cutthroat trout we captured were 200 mm or less in length. In 1988, only 38.8% of the fish we caught were in that same category. The mean length decreased from 225 mm in 1988 to 198 mm in 1989, this was a significant difference (Student's $t$-test, $t$ = 8.65, df = 1,410, $p$ = 0.001).

The 118 anglers interviewed at Turner Lake between 19 June and 30 July, 1989 expended 422 angler-hours to catch 193 cutthroat trout, of which 118 (61%) were released (Table 7). Also, 74 kokanee were caught with 53 (72%) released, and 21 Dolly Varden caught and 13 (62%) released.

Expanding the observed Turner Lake catch data for each biweekly period results in an estimated catch of 340 cutthroat trout (SE = 147), 37 Dolly Varden (SE = 25), and 124 kokanee (SE = 74) from 19 June to 30 July 1989 (Table 8). The estimated effort during this time was 623 angler-hours (SE = 208). The 1989 Turner Lake estimated catch per unit effort (CPUE) for cutthroat trout ranged from 0.3086 (SE = 0.1614) for the period 19 June to 2 July, and 0.6463 (SE = 0.2082) for 3 July to 30 July (Table 8).

Data from three voluntarily returned forms indicated that 10 anglers spent 302 angler-hours to catch 163 cutthroat trout, of which 119 (73%) were released (Table 7). These anglers also reported 66 kokanee caught with 22 (33%) released, and 53 Dolly Varden caught with 49 (92%) released.

Sixty-one cutthroat trout, seven Dolly Varden, and two kokanee were measured in the angler harvest. Cutthroat trout averaged 270 mm (10.6 inches) (SE = 14 mm), which is 63 mm (2.5 inches) larger than the sizes we observed in our hook and

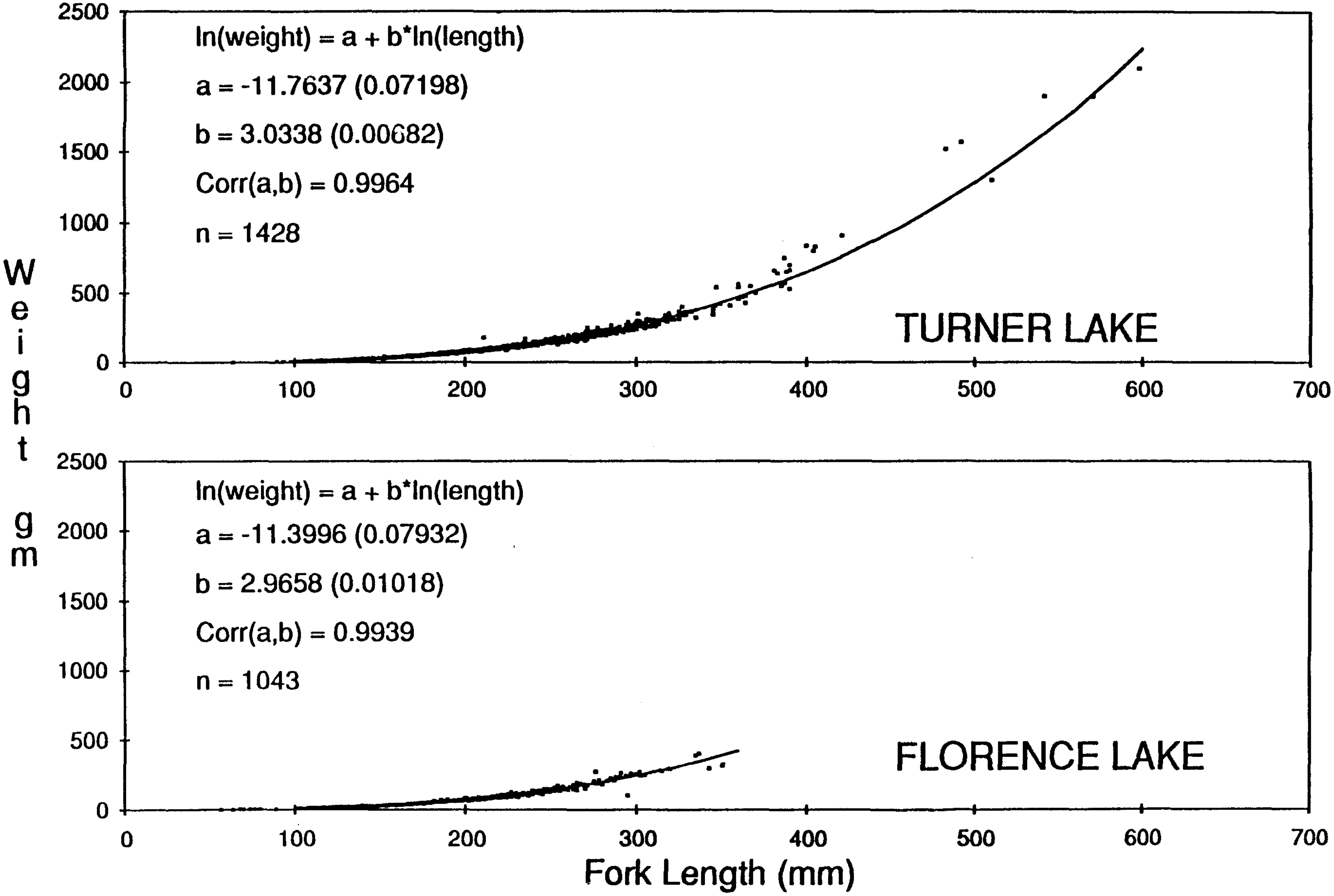


Figure 5. Estimates of parameters in the length-weight relationships for cutthroat trout in Turner and Florence Lakes for the years 1988 and 1989 combined. Values in parentheses are standard errors of estimates.

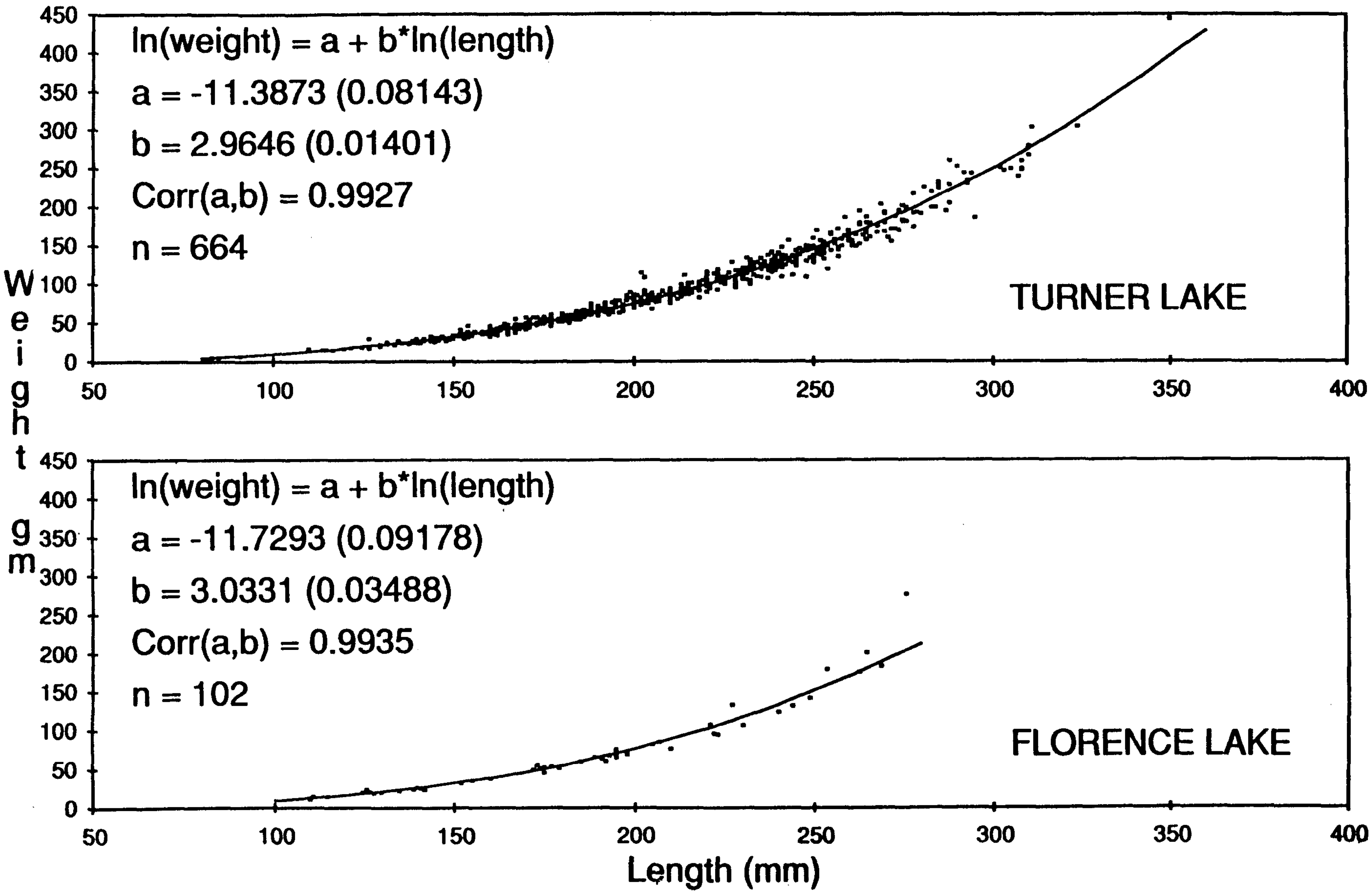


Figure 6. Estimates of parameters in the length-weight relationships for Dolly Varden in Turner and Florence Lakes for the years 1988 and 1989 combined. Values in parentheses are standard errors of estimates.

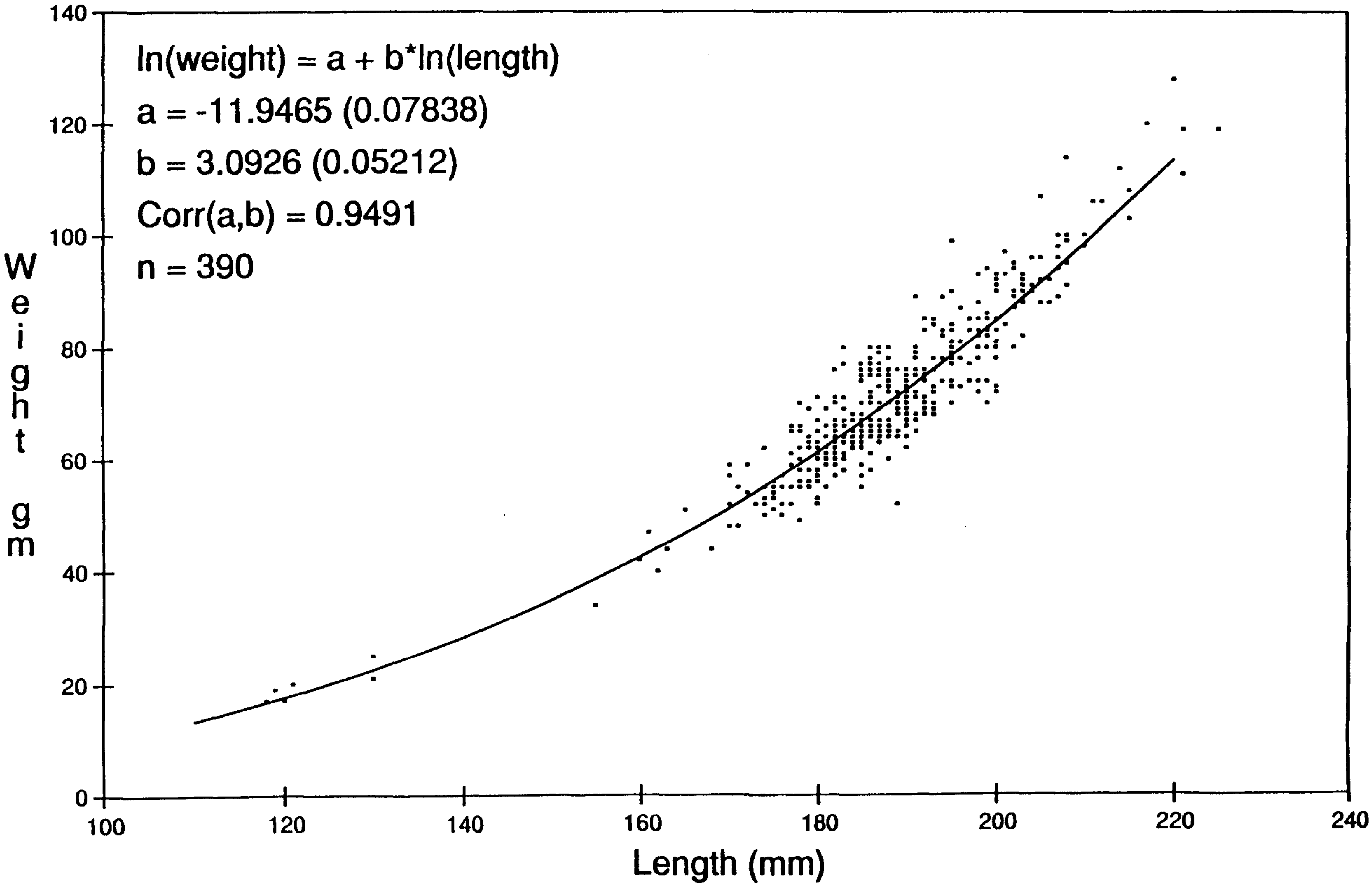


Figure 7. Estimates of parameters in the length-weight relationships for kokanee in Turner and Florence Lakes for the years 1988 and 1989 combined. Values in parentheses are standard errors of estimates.

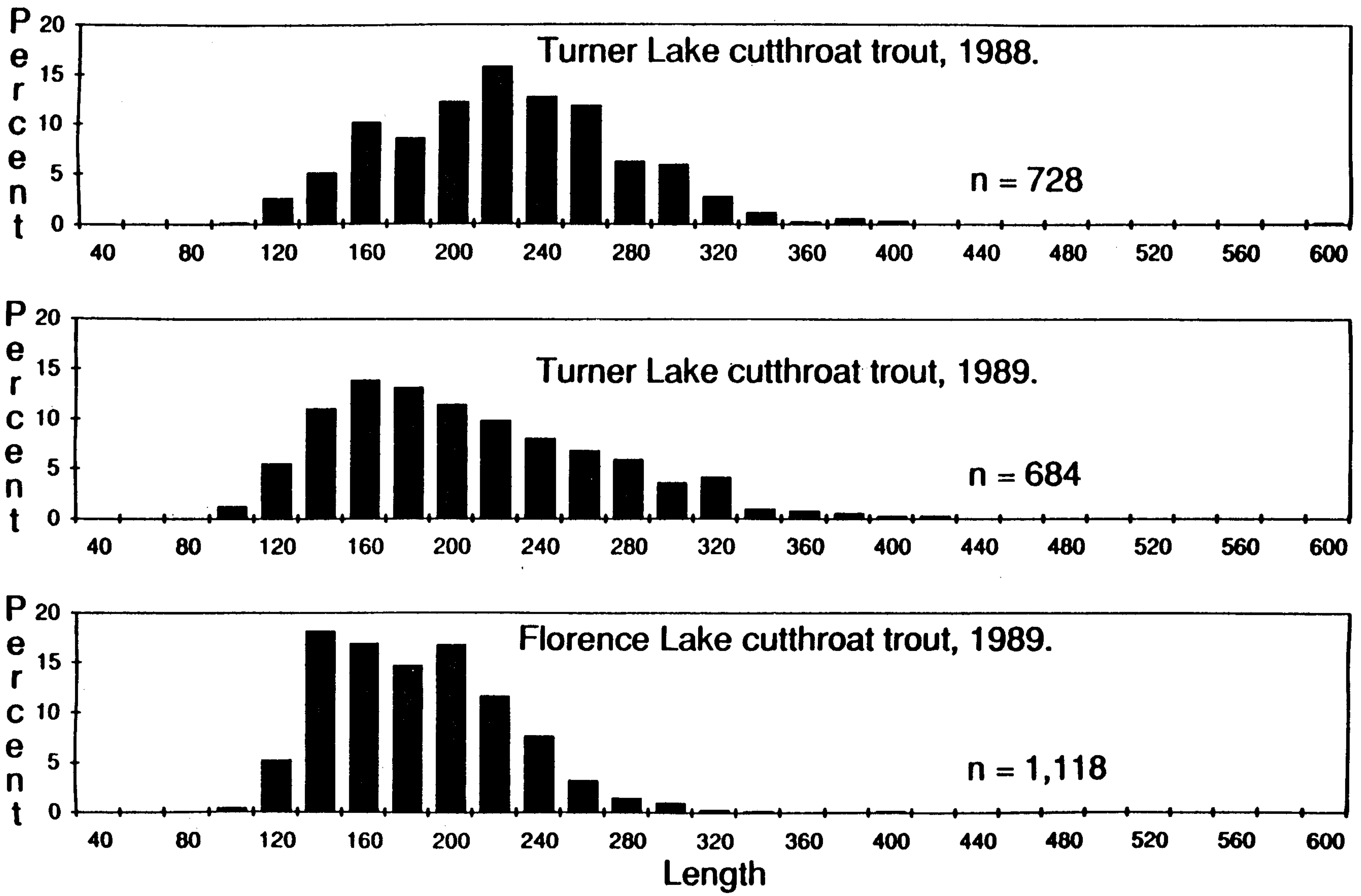


Figure 8. Length frequency distribution of cutthroat trout in our sampling in Turner Lake in 1988 and 1989 and Florence Lake in 1989.

Table 6. Turner Lake cutthroat trout age composition and mean length by age for 1988, 1989 and both years combined.

| | 1988 | | | 1989 | | | Combined Data | | |
|---|---|---|---|---|---|---|---|---|---|
| Age | Number Sampled | Mean Length | SE | Number Sampled | Mean Length | SE | Number Sampled | Mean Length | SE |
| 1 | 16 | 121.8 | 3.34 | 11 | 105.7 | 4.67 | 27 | 115.2 | 3.10 |
| 2 | 117 | 157.5 | 1.88 | 155 | 147.6 | 1.61 | 272 | 151.9 | 1.25 |
| 3 | 160 | 200.3 | 1.68 | 170 | 184.9 | 1.50 | 330 | 192.4 | 1.20 |
| 4 | 150 | 242.7 | 1.80 | 100 | 231.1 | 2.10 | 250 | 238.1 | 1.41 |
| 5 | 97 | 275.1 | 2.84 | 57 | 277.1 | 2.85 | 154 | 275.8 | 2.07 |
| 6 | 34 | 308.3 | 4.98 | 23 | 311.4 | 4.25 | 57 | 309.5 | 3.41 |
| 7 | 12 | 375.4 | 17.58 | 9 | 366.7 | 7.77 | 21 | 371.7 | 10.41 |
| 8 | | | | 1 | 404.0 | | 1 | 404.0 | |
| 9 | 1 | 541.0 | | | | | 1 | 541 | |
| 12 | 1 | 598.0 | | | | | 1 | 541 | |

Table 7. Summary of the Turner Lake observed creel data from 19 June to 30 July and the voluntary creel census returns for 1990.

Observed Creel Data

| Biweekly Sample Period | Total # of Interviews | Total # of Angler Hours | Cutthroat Trout | | Kokanee | | Dolly Varden | |
|---|---|---|---|---|---|---|---|---|
| | | | Caught | Released | Caught | Released | Caught | Released |
| 12 | 2 | 48 | 4 | 0 | 3 | 0 | 0 | 0 |
| 13 | 40 | 156 | 17 | 31 | 2 | 20 | 2 | 4 |
| 14 | 40 | 96 | 19 | 29 | 7 | 11 | 6 | 8 |
| 15 | 36 | 122 | 35 | 58 | 9 | 22 | 0 | 1 |
| Total | 118 | 422 | 75 | 118 | 21 | 53 | 8 | 13 |

Voluntary Creel Census

| Date | Total # of Anglers | Total # of Angler Hours | Cutthroat Trout | | Kokanee | | Dolly Varden | |
|---|---|---|---|---|---|---|---|---|
| | | | Caught | Released | Caught | Released | Caught | Released |
| 8/21-27 | 4 | 240 | 40 | 90 | 40 | 20 | 0 | 2 |
| 9/04- 6 | 2 | 22 | 4 | 26 | 0 | 1 | 4 | 39 |
| 9/12-17 | 4 | 40 | 0 | 3 | 0 | 1 | 0 | 8 |
| Total | 10 | 302 | 44 | 119 | 40 | 22 | 4 | 49 |

Table 8. Estimated angler effort (angler-hours), catch (kept and released), and harvest by species for the Turner Lake fishery from 19 June to 30 July, 1989.

| Period | Dates | Number of Counts | Angler Per Count | SE | Estimated Effort Hours | SE | 95% CI | Relative Precision |
|---|---|---|---|---|---|---|---|---|
| 13 | 6/19-7/2 | 14 | 0.8 | 0.31 | 187 | 132.44 | 0 - 447 | 139.0 |
| 14 | 7/3-7/16 | 10 | 1.7 | 0.27 | 405 | 123.16 | 0 - 646 | 59.6 |
| 14 & 15 | 7/3-7/30 | 18 | 0.9 | 0.12 | 436 | 160.53 | 122 - 751 | 72.1 |
| Total Season | | 32 | | | 623 | 208.11 | 210 - 1030 | 65.3 |

Estimated catch and harvest for Turner Lake Cutthroat Trout

| Period | Dates | Effort Angler Hours | Catch | | | | Harvest | | | | Percent Harvest |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CPUE[a] | SE | Number | SE | HPUE[b] | SE | Number | SE | |
| 13 | 6/19-7/2 | 187 | 0.3086 | 0.1614 | 58 | 50.8 | 0.1093 | 0.0476 | 20 | 15.8 | 34.4 |
| 14&15 | 7/3-7/30 | 436 | 0.6463 | 0.2082 | 282 | 137.8 | 0.2475 | 0.1218 | 108 | 63.4 | 38.3 |
| Total | | 623 | | | 340 | 146.9 | | | 128 | 65.3 | 37.6 |

-(Continued)-

Table 8. (page 2 of 2).

Estimated catch and harvest for Turner Lake Dolly Varden

| Period | Dates | Effort (Angler Hours) | Catch | | | | Harvest | | | | Percent Harvest |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CPUE[a] | SE | Number | SE | HPUE[b] | SE | Number | SE | |
| 13 | 6/19-7/2 | 187 | 0.0386 | 0.0148 | 7 | 5.8 | 0.0129 | 0.0061 | 2 | 1.88 | 33.3 |
| 14&15 | 7/3-7/30 | 436 | 0.0688 | 0.0544 | 30 | 24.7 | 0.0275 | 0.0163 | 12 | 7.94 | 40.0 |
| Total | | 623 | | | 37 | 25.4 | | | 14 | 8.20 | 37.8 |

Estimated catch and harvest for Turner Lake Kokanee

| Period | Dates | Effort (Angler Hours) | Catch | | | | Harvest | | | | Percent Harvest |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CPUE[a] | SE | Number | SE | HPUE[b] | SE | Number | SE | |
| 13 | 6/19-7/2 | 187 | 0.1415 | 0.2649 | 26 | 52.8 | 0.0129 | 0.0712 | 2 | 9.6 | 9.1 |
| 14&15 | 7/3-7/30 | 436 | 0.2246 | 0.0860 | 98 | 52.0 | 0.0733 | 0.0395 | 32 | 19.9 | 32.7 |
| Total | | 623 | | | 124 | 74.1 | | | 34 | 22.1 | 27.4 |

[a] CPUE = Catch per Unit Effort
[b] HPUE = Harvest per Unit Effort

line sampling in Turner Lake. This is a significant size difference (Students *t*-test, $t = 6.57$, df = 88.8, p = 0.0001) and it was expected because the anglers tend to target on larger fish and not to keep most of the smaller fish they catch. The size range of the cutthroat trout in the angler harvest was 229 mm (9.0 inches) to 577 mm (22.7 inches).

The 7 Dolly Varden observed in the Turner Lake angler harvest averaged 268.9 mm (10.6 inches) (standard error = 3.94 mm) with a range of 260 mm (10.2 inches) to 279 mm (11.0 inches). This compares with an average size of 227.2 mm (8.9 inches) observed in our sampling program with all gear types combined.

We only saw 2 kokanee in our standard sampling of the angler harvest at Turner Lake. Both fish were 198 mm (7.8 inches) in length and 78 g (0.17 lbs) in weight.

<u>Florence Lake</u>

A total of 1,118 cutthroat trout, 54 Dolly Varden, and 19 kokanee were caught during the two trips (Table 9). Since we recaptured so few fish (Table 10), we could not estimate of the abundance of cutthroat trout in Florence Lake.

In Florence Lake the estimated length-weight parameters from the 1,043 cutthroat trout sampled in 1988 and 1989 were: $a = -11.3996$ (SE = 0.07932); $b = 2.9658$ (SE = 0.01018); correlation $(a,b) = 0.9939$ (Figure 5).

We were unable to determine the age of cutthroat trout from their scales. The annuli were not obvious like those on scales from Turner Lake.

Dolly Varden were much less numerous in our sampling at Florence Lake versus Turner Lake. We caught only 54 Dolly Varden in Florence Lake in our sampling in 1989 and none in 1988. The estimated parameters in the relationship between length-weight were: $a = -11.7293$ (SE = 0.09178); $b = 3.0331$ (SE = 0.03488); correlation $(a,b) = 0.9935$ (Figure 6).

Kokanee were also much less abundant in Florence Lake; we caught only 19 kokanee in 1989 and none in 1988. Since so few kokanee were collected in Florence Lake we were unable to do any meaningful length-weight analysis.

In Florence Lake, the catch rates for cutthroat trout (Table 9) in our sampling were considerably higher in Turner Lake (Table 1). The CPUE in large traps was 2.6 times higher in Florence Lake, and the lake fyke net CPUE was 31 times higher.

The 51 anglers interviewed spent a total of 125 angler-hours to catch 477 cutthroat trout, of which 64 (87%) were released (Table 11); no Dolly Varden or kokanee were caught. Expanded estimates were 246 angler-hours (SE = 370) expended to catch 1,050 cutthroat trout (SE = 1,117), of which an estimated 925 (88%) were released. Estimated catch rates were 3.430 (SE = 1.1405) for 5 August to 13 August and 4.526 (SE = 1.8945) between 14 August and 29 August (Table 12).

An additional 82 angler hours were spent to catch 226 cutthroat trout, of which 167 (74%) were released (Table 11) according to the information on the three voluntary forms returned from 8 anglers. These anglers fished Florence Lake in September or October 1989, when we were not present. These fishermen also caught

Table 9. Effort (hours), catch, and catch per unit effort (CPUE, fish per hour) by period, gear, and species for 1989 Florence Lake sampling.

| | | | Cutthroat Trout | | Dolly Varden | | Kokanee | |
|---|---|---|---|---|---|---|---|---|
| Period | Gear | Effort | Catch | CPUE | Catch | CPUE | Catch | CPUE |
| 1[a] | Fyke Net | 180.2 | 503 | 2.79 | 19 | 0.11 | 1 | 0.01 |
| | Hook & Line | 6.3 | 5 | 0.79 | | | | |
| | Large Trap | 448.3 | 318 | 0.71 | 19 | 0.04 | | |
| | Total | 634.8 | 826 | 1.30 | 38 | 0.06 | 1 | 0.00 |
| 2[b] | Fyke Net | 102.9 | 202 | 1.96 | 5 | 0.05 | 17 | 0.17 |
| | Hook & Line | 1.5 | | | | | | |
| | Large Trap | 227.8 | 160 | 0.70 | 11 | 0.05 | 1 | 0.00 |
| | Total | 332.2 | 362 | 1.09 | 26 | 0.05 | 18 | 0.05 |
| Total | Fyke Net | 283.1 | 705 | 2.49 | 24 | 0.08 | 18 | 0.06 |
| | Hook & Line | 7.8 | 5 | 0.64 | | | | |
| | Large Trap | 676.1 | 478 | 0.71 | 30 | 0.04 | 1 | 0.00 |
| | Total | 967.0 | 1,118 | 1.23 | 54 | 0.06 | 19 | 0.02 |

[a] 5 August to 16 August
[b] 24 August to 29 August

Table 10. Summary of marks, recaptures, by sample period for cutthroat trout in Florence Lake, 1988-89.

| | Capture Occasion[a] | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Captured, marked and released Newly Marked Fish | 82 | 562 | 569 |
| Recaptures from | | | |
| Period 1 | 0 | 3 | 1 |
| Period 2 | - | 1 | 15 |
| Period 3 | - | - | 3 |
| Captured and Died | 11 | 11 | 0 |
| Total Catch | 93 | 577 | 588 |
| Removed by anglers (Recaptures from) | 1 | 26 | 1 |

[a] Occasion #1 8 Aug - 11 Aug, 1988
5 Aug - 16 Aug, 1989
24 Aug - 29 Aug, 1989

Table 11. Summary of the Florence Lake observed creel data from 5 August to 29 August and the voluntary creel census returns for 1990.

Observed Creel Data

| Biweekly Sample Period | Total # of Interviews | Total # of Angler Hours | Cutthroat Trout | | Kokanee | | Dolly Varden | |
|---|---|---|---|---|---|---|---|---|
| | | | Caught | Released | Caught | Released | Caught | Released |
| 16 | 33 | 78 | 38 | 228 | | | | |
| 17 | 15 | 37 | 15 | 160 | | | | |
| 18 | 3 | 10 | 11 | 25 | | | | |
| Total | 51 | 125 | 64 | 413 | | | | |

Voluntary Creel Census

| Date | Total # of Anglers | Total # of Angler Hours | Cutthroat Trout | | Kokanee | | Dolly Varden | |
|---|---|---|---|---|---|---|---|---|
| | | | Caught | Released | Caught | Released | Caught | Released |
| 9/14-17 | 2 | 17 | 9 | 5 | 0 | 0 | 1 | 0 |
| 9/16-17 | 2 | 1 | 6 | 6 | 0 | 0 | 0 | 0 |
| 10/6-11 | 4 | 64 | 44 | 156 | 0 | 0 | 3 | 6 |
| Total | 8 | 82 | 59 | 167 | 0 | 0 | 4 | 6 |

Table 12. Estimated angler effort (angler-hours), catch (kept and released), and harvest by species for the Florence Lake fishery from 5 August to 29 August 1989.

| Period | Dates | Number of Counts | Angler Per Count | SE | Estimated Effort Hours | SE | 95% CI | Relative Precision |
|---|---|---|---|---|---|---|---|---|
| 16 | 8/5-13 | 9 | 0.8 | 1.69 | 174 | 291.57 | 0 - 745 | 139.0 |
| 17 | 8/14-29 | 10 | 0.3 | 0.90 | 72 | 227.68 | 0 - 300 | 59.6 |
| Total | | 19 | | | 246 | 369.93 | 0 - 971 | 72.1 |

| Period | Dates | Effort (Angler Hours) | Catch CPUE[a] | SE | Number | SE | Harvest HPUE[b] | SE | Number | SE | Percent Harvest |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 8/5-13 | 174 | 3.430 | 1.1405 | 597 | 387.9 | 0.4903 | 0.1830 | 85 | 54.5 | 14.2 |
| 17 | 8/14-29 | 72 | 4.526 | 1.8945 | 328 | 1047.5 | 0.5621 | 0.3373 | 40 | 105.2 | 12.2 |
| Total | | 246 | | | 925 | 1116.7 | | | 125 | 118.5 | 13.5 |

[a] CPUE = Catch per Unit Effort
[b] HPUE = Harvest per Unit Effort

10 Dolly Varden of which 6 (60%) were released. Only 4 kokanee were observed in our creel surveys and none were reported harvested by anglers in the voluntary creel forms at Florence Lake during 1989.

In Florence Lake, we measured 41 cutthroat trout and 4 kokanee in the angler harvest. The cutthroat trout averaged 238.1 mm (9.4 inches) in length which, like Turner Lake, is larger than the mean length observed in our sampling. The kokanee averaged 180.0 mm (7.1 inches) in length. We did not get any weights from the angler harvest as all the fish had been cleaned.

## DISCUSSION

The cutthroat trout population in Turner Lake was smaller than we had anticipated considering the size of the lake and its popularity as a trophy class cutthroat system. Other studies on cutthroat trout populations in lakes around Southeast Alaska (Table 13) also show that resident cutthroat trout populations are relatively small. One factor that may be influencing the size of the Turner Lake cutthroat trout population is the small amount of good rearing area for the fry. The lake is very steep and deep, and a large part of the shoreline is sheer rock that provides little cover for the smaller fish.

Since our sampling in 1989 did not include many fish under 100 mm or over 400 mm and only one fish that was a recapture from the 1988 sampling, our abundance estimate for cutthroat trout (1,526) only includes the fish in that size range. The abundance of fish over large cutthroat trout (400 mm and over) is probably not equal to the population of fish under that size because both natural and fishing mortality remove fish from the population each year. As a result, we feel that the total abundance of large cutthroat trout in Turner Lake is less than 1,500.

As previously mentioned, the Turner Lake abundance estimate was done after culling recruits out of the population using a non-parametric method for detecting and eliminating recruits outlined by Robson and Flick (1965). The large number of recruits in the smaller length categories and comparison of the length frequency distributions for 1988 and 1989 indicate that there was strong recruitment of new fish into the smaller length categories and growth recruitment.

This year we tried fyke nets in both lakes with excellent results. Turner Lake is very steep-sided, so it was not easy to find areas to fish the net. In Florence Lake it was easily the gear of choice. We caught so many cutthroat trout in the fyke net and large traps in Florence Lake that we had little time to use any other gear types. Next season the use of other gear types will be emphasized to insure that we catch a representative cross-section of all size categories.

## ACKNOWLEDGEMENTS

We wish again to thank the Northern Southeastern Aquaculture Association and in particular Steve Reifenstuhl for loaning us the original data collected in John Joyce's Turner Lake study in 1985. We also would like to thank Kurt Kondzela, Brian Glynn, and Brad Gruening, our seasonals, for their help with the field work

Table 13. Estimated population size of resident cutthroat trout in five lakes in Southeast Alaska.

| Lake | Area (ha) | Year | Population Estimate | 95% Confidence Limits | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| Turner Lake | 1,270 | 1988 | 1,526 | 1,224 | 1,828 |
| Jims Lake[a] | 112 | 1980 | 2,816 | 1,908 | 5,373 |
| Mirror Lake[c] | 474 | 1986 | 5,633 | 5,118 | 6,263 |
| Harvey Lake[b] | 160 | 1979 | 669 | NA | NA |
| Virginia Lake[b] | 258 | 1979 | 5,631 | 4,710 | 6,998 |

[a] Jones 1982.
[b] Jones 1981.
[c] Jones 1986.

and insights into the information we collected. We would like to thank the Shee Atika Corporation for allowing us to maintain a field camp on their property while we conducted our field studies on Florence Lake. We would also like to thank Dave Bernard for his editorial comments and suggestions. His suggestions were very helpful in improving this report.

## LITERATURE CITED

Gerstung, E. R. 1988. Status, life history, and management of the Lahontan cutthroat trout. American Fisheries Society Symposium 4:93-106.

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association 55:708-713.

Gresswell, R. E., and J. D. Varley. 1988. Effects of a century of human influence on the cutthroat trout of Yellowstone Lake. American Fisheries Society Symposium 4:45-52.

Gunstrom, G., and M. Bethers. 1985. Electrical anesthesia for handling large salmonids. The Progressive Fish-Culturist 47:67-69.

Jessen, R. J. 1978. Statistical survey techniques. John Wiley and Sons, New York, New York, USA. 520 pp.

Jones, D. E. 1981. Development of techniques for enhancement and management of cutthroat trout in Southeast Alaska. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Report of Progress, 1980 - 1981, Project AFS-42, Volume 22 (AFS-42-9-B), Juneau, Alaska, USA. pp 27-50.

__________. 1982. Studies of cutthroat and steelhead in southeast Alaska. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Report of Progress, 1981 - 1982, Volume 23 (AFS-42-10-A&B), Juneau, Alaska, USA. 46 pp.

__________. 1986. Recreational surveys of selected lakes in southern Southeast Alaska - Mirror Lake. Alaska Department of Fish and Game, Division of Sport Fish, Federal Aid in Fish Restoration, Annual Report of Progress, 1981 - 1982 (unpublished), Juneau, Alaska, USA. 18 pp.

Jones, J. D., A. E. Bingham, and R. H. Harding. 1989. Cutthroat trout studies: Turner/Florence Lakes, Alaska, During 1988. Alaska Department of Fish and Game, Fishery Data Series No. 111, Juneau, Alaska, USA. 39 pp.

Joyce, J. 1986. Turner Lake Investigations. Northern Southeast Regional Aquaculture Association Fisheries Sampling Report, 12 March 1986, Sitka, Alaska, USA. 31 pp.

Leathe, S. A., and P. J. Graham. 1981. Flathead Lake fish food habits study. Montana Department of Fish, Wildlife, and Parks, Sponsored by Environmental Protection Agency, Region VIII, Water Division, Denver, Colorado, USA. 93 pp.

Marnell, L. F. 1988. Status of the Westslope cutthroat trout in Glacier National Park, Montana. American Fisheries Society Symposium 4:61-70.

McNair, J. A., editor. 1987. Sockeye salmon development proposals for Turner Lake. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development, Juneau, Alaska, USA. 42 pp.

Mills, M. J. 1981. Statewide harvest study - 1979 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1980-1981, Project F-9-13, Volume 22 (SW-I-A), Juneau, Alaska, USA. 78 pp.

__________. 1984. Statewide harvest study - 1983 data. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 1983-1984, Project F-9-16, Volume 25 (SW-I-A), Juneau, Alaska, USA. 122 pp.

Nielson, B. R., and L. Lentsch. 1988. Bonneville cutthroat trout in Bear Lake: status and management. American Fisheries Society Symposium 4:128-133.

Robson, D. S. and W. A. Flick. 1965. A non-parametric statistical method for culling recruits from a mark-recapture experiment. Biometrics 21:936-947.

Rohovec, J. S., J. R. Winton, and J. L. Fryer. 1988. Potential hazard for spread of infectious disease by transplantation of fish. *In* Salmon production, management, and allocation biological, economic, and policy issues. William J. McNeil, editor. Oregon State University Press, Corvallis, Oregon, USA. 194 pp.

Schmidt, A. E. 1979. Inventory of high quality recreational fishing waters in Southeast Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Performance, 1977-1978, Project F-9-10, Volume 19 (G-I-R), Juneau, Alaska, USA. 64 pp.

Seber, G. A. F. 1982. The estimation of animal abundance. MacMillan Publishing Company, New York, New York, USA. xvii + 654 pp.

TLMP. 1979. Tongass Land Management Plan - Final Environmental Impact Statement (Two Parts). Alaska Region, Forest Service, U.S. Department of Agriculture (P.O. Box 1628, Juneau, Alaska 99802). March 1979, Series No. R10-57.

Von Geldern, C. E., Jr., and P. K. Tomlinson. 1973. On the analysis of angler catch rate data from warmwater reservoirs. California Fish and Game 59:281-292.

# APPENDIX A

Appendix A. Application of the nonparametric test described by Robson and Flick (1965) for growth recruitment, for Turner Lake 1988-1989 mark-recapture experiment on cutthroat trout. Fish greater than 400 mm were not used in the following statistics, since recaptures were not made above this length.

| | | "Robson-Flick" Statistics[a] | | | | | | | | | Running Average Marked-to-Unmarked Ratio Statistics[b] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $i$ | $L_i$ | $u_i$ | $a_i$ | $n_2-a_i-i+1$ | $m_2-i+1$ | $n_2-a_{i-1}-i+1$ | $n_2-a_i-m_2$ | $n_2-a_{i-1}-m_2$ | $Pr[U_i \geq u_i]$[c] | Significant at $\alpha$ = 0.10 | $\bar{u}_i$ | $\hat{V}[\bar{u}_i]$ |
| 1 | 101 | 3 | 3 | 611 | 104 | 614 | 507 | 510 | 0.57 | | 4.90 | 0.46 |
| 2 | 119 | 10 | 13 | 600 | 103 | 610 | 497 | 507 | 0.15 | | 4.92 | 0.47 |
| 3 | 136 | 31 | 44 | 568 | 102 | 599 | 466 | 497 | 0.00 | * | 4.87 | 0.48 |
| 4 | 139 | 12 | 56 | 555 | 101 | 567 | 454 | 466 | 0.09 | * | 4.61 | 0.42 |
| 5 | 141 | 9 | 65 | 545 | 100 | 554 | 445 | 454 | 0.16 | | 4.54 | 0.42 |
| 6 | 143 | 6 | 71 | 538 | 99 | 544 | 439 | 445 | 0.30 | | 4.49 | 0.43 |
| 7 | 144 | 2 | 73 | 535 | 98 | 537 | 437 | 439 | 0.67 | | 4.48 | 0.44 |
| 8 | 148 | 20 | 93 | 514 | 97 | 534 | 417 | 437 | 0.02 | * | 4.51 | 0.45 |
| 9 | 150 | 10 | 103 | 503 | 96 | 513 | 407 | 417 | 0.12 | | 4.34 | 0.43 |
| 10 | 151 | 3 | 106 | 499 | 95 | 502 | 404 | 407 | 0.53 | | 4.28 | 0.43 |
| 11 | 152 | 3 | 109 | 495 | 94 | 498 | 401 | 404 | 0.53 | | 4.30 | 0.44 |
| 12 | 154 | 4 | 113 | 490 | 93 | 494 | 397 | 401 | 0.43 | | 4.31 | 0.45 |
| 13 | 157 | 15 | 128 | 474 | 92 | 489 | 382 | 397 | 0.04 | * | 4.32 | 0.46 |
| 14 | 160 | 14 | 142 | 459 | 91 | 473 | 368 | 382 | 0.05 | * | 4.20 | 0.46 |
| 15 | 161 | 1 | 143 | 457 | 90 | 458 | 367 | 368 | 0.80 | | 4.09 | 0.46 |
| 16 | 164 | 12 | 155 | 444 | 89 | 456 | 355 | 367 | 0.07 | * | 4.12 | 0.47 |
| 17 | 170 | 41 | 196 | 402 | 88 | 443 | 314 | 355 | 0.00 | * | 4.03 | 0.47 |
| 18 | 171 | 2 | 198 | 399 | 87 | 401 | 312 | 314 | 0.61 | | 3.61 | 0.29 |
| 19 | 173 | 3 | 201 | 395 | 86 | 398 | 309 | 312 | 0.48 | | 3.63 | 0.30 |
| 20 | 174 | 5 | 206 | 389 | 85 | 394 | 304 | 309 | 0.29 | | 3.64 | 0.31 |
| 21 | 175 | 7 | 213 | 381 | 84 | 388 | 297 | 304 | 0.18 | | 3.62 | 0.32 |
| 22 | 176 | 5 | 218 | 375 | 83 | 380 | 292 | 297 | 0.29 | | 3.58 | 0.32 |
| 23 | 177 | 2 | 220 | 372 | 82 | 374 | 290 | 292 | 0.61 | | 3.56 | 0.33 |
| 24 | 178 | 5 | 225 | 366 | 81 | 371 | 285 | 290 | 0.29 | | 3.58 | 0.34 |
| 25 | 180 | 10 | 235 | 355 | 80 | 365 | 275 | 285 | 0.08 | * | 3.56 | 0.34 |
| 26 | 188 | 35 | 270 | 319 | 79 | 354 | 240 | 275 | 0.00 | * | 3.48 | 0.35 |
| 27 | 190 | 9 | 279 | 309 | 78 | 318 | 231 | 240 | 0.08 | * | 3.08 | 0.19 |
| 28 | 191 | 3 | 282 | 305 | 77 | 308 | 228 | 231 | 0.42 | | 3.00 | 0.19 |
| 29 | 196 | 27 | 309 | 277 | 76 | 304 | 201 | 228 | 0.00 | * | 3.00 | 0.19 |
| 30 | 197 | 1 | 310 | 275 | 75 | 276 | 200 | 201 | 0.73 | | 2.68 | 0.09 |
| 31 | 198 | 5 | 315 | 269 | 74 | 274 | 195 | 200 | 0.20 | | 2.70 | 0.09 |
| 32 | 200 | 7 | 322 | 261 | 73 | 268 | 188 | 195 | 0.10 | | 2.67 | 0.10 |
| 33 | 204 | 10 | 332 | 250 | 72 | 260 | 178 | 188 | 0.04 | * | 2.61 | 0.09 |

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| | | | | "Robson-Flick" Statistics[a] | | | | | | | Running Average Marked-to-Unmarked Ratio Statistics[b] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $i$ | $L_i$ | $u_i$ | $a_i$ | $n_2-a_i-i+1$ | $m_2-i+1$ | $n_2-a_{i-1}-i+1$ | $n_2-a_i-m_2$ | $n_2-a_{i-1}-m_2$ | $Pr[U_i \geq u_i]$[c] | Significant at $\alpha = 0.10$ | $\bar{u}_i$ | $\hat{V}[\bar{u}_i]$ |
| 34 | 207 | 12 | 344 | 237 | 71 | 249 | 166 | 178 | 0.02 | * | 2.51 | 0.09 |
| 35 | 209 | 4 | 348 | 232 | 70 | 236 | 162 | 166 | 0.24 | | 2.37 | 0.07 |
| 36 | 210 | 6 | 354 | 225 | 69 | 231 | 156 | 162 | 0.12 | | 2.35 | 0.07 |
| 37 | 212 | 6 | 360 | 218 | 68 | 224 | 150 | 156 | 0.11 | | 2.29 | 0.07 |
| 38 | 214 | 2 | 362 | 215 | 67 | 217 | 148 | 150 | 0.48 | | 2.24 | 0.07 |
| 39 | 215 | 2 | 364 | 212 | 66 | 214 | 146 | 148 | 0.48 | | 2.24 | 0.07 |
| 40 | 216 | 2 | 366 | 209 | 65 | 211 | 144 | 146 | 0.48 | | 2.25 | 0.07 |
| 41 | 220 | 13 | 379 | 195 | 64 | 208 | 131 | 144 | 0.01 | * | 2.25 | 0.08 |
| 42 | 221 | 0 | 379 | 194 | 63 | 194 | 131 | 131 | 1.00 | | 2.08 | 0.05 |
| 43 | 222 | 4 | 383 | 189 | 62 | 193 | 127 | 131 | 0.21 | | 2.11 | 0.05 |
| 44 | 223 | 1 | 384 | 187 | 61 | 188 | 126 | 127 | 0.68 | | 2.08 | 0.05 |
| 45 | 225 | 5 | 389 | 181 | 60 | 186 | 121 | 126 | 0.14 | | 2.10 | 0.05 |
| 46 | 226 | 0 | 389 | 180 | 59 | 180 | 121 | 121 | 1.00 | | 2.05 | 0.05 |
| 47 | 227 | 3 | 392 | 176 | 58 | 179 | 118 | 121 | 0.31 | | 2.09 | 0.05 |
| 48 | 228 | 2 | 394 | 173 | 57 | 175 | 116 | 118 | 0.45 | | 2.07 | 0.05 |
| 49 | 229 | 3 | 397 | 169 | 56 | 172 | 113 | 116 | 0.30 | | 2.07 | 0.05 |
| 50 | 230 | 5 | 402 | 163 | 55 | 168 | 108 | 113 | 0.13 | | 2.05 | 0.06 |
| 51 | 231 | 2 | 404 | 160 | 54 | 162 | 106 | 108 | 0.44 | | 2.00 | 0.06 |
| 52 | 234 | 6 | 410 | 153 | 53 | 159 | 100 | 106 | 0.08 | * | 2.00 | 0.06 |
| 53 | 237 | 5 | 415 | 147 | 52 | 152 | 95 | 100 | 0.12 | | 1.92 | 0.05 |
| 54 | 238 | 2 | 417 | 144 | 51 | 146 | 93 | 95 | 0.42 | | 1.86 | 0.05 |
| 55 | 240 | 3 | 420 | 140 | 50 | 143 | 90 | 93 | 0.27 | | 1.86 | 0.05 |
| 56 | 241 | 4 | 424 | 135 | 49 | 139 | 86 | 90 | 0.17 | | 1.84 | 0.06 |
| 57 | 242 | 2 | 426 | 132 | 48 | 134 | 84 | 86 | 0.41 | | 1.79 | 0.06 |
| 58 | 245 | 2 | 428 | 129 | 47 | 131 | 82 | 84 | 0.41 | | 1.79 | 0.06 |
| 59 | 247 | 1 | 429 | 127 | 46 | 128 | 81 | 82 | 0.64 | | 1.78 | 0.06 |
| 60 | 250 | 6 | 435 | 120 | 45 | 126 | 75 | 81 | 0.07 | * | 1.80 | 0.06 |
| 61 | 252 | 3 | 438 | 116 | 44 | 119 | 72 | 75 | 0.25 | | 1.70 | 0.06 |
| 62 | 254 | 0 | 438 | 115 | 43 | 115 | 72 | 72 | 1.00 | | 1.67 | 0.06 |
| 63 | 255 | 4 | 442 | 110 | 42 | 114 | 68 | 72 | 0.15 | | 1.71 | 0.06 |
| 64 | 256 | 0 | 442 | 109 | 41 | 109 | 68 | 68 | 1.00 | | 1.66 | 0.06 |
| 65 | 257 | 1 | 443 | 107 | 40 | 108 | 67 | 68 | 0.63 | | 1.70 | 0.06 |
| 66 | 260 | 5 | 448 | 101 | 39 | 106 | 62 | 67 | 0.10 | | 1.72 | 0.06 |
| 67 | 262 | 3 | 451 | 97 | 38 | 100 | 59 | 62 | 0.23 | | 1.63 | 0.06 |
| 68 | 263 | 1 | 452 | 95 | 37 | 96 | 58 | 59 | 0.61 | | 1.59 | 0.06 |

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| | | | | "Robson-Flick" Statistics[a] | | | | | | | Running Average Marked-to-Unmarked Ratio Statistics[b] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $i$ | $L_i$ | $u_i$ | $a_i$ | $n_2-a_i-i+1$ | $m_2-i+1$ | $n_2-a_{i-1}-i+1$ | $n_2-a_i-m_2$ | $n_2-a_{i-1}-m_2$ | $Pr[U_i \geq u_i]$[c] | Significant at $\alpha$ = 0.10 | $\bar{u}_i$ | $\hat{V}[\bar{u}_i]$ |
| 69 | 264 | 1 | 453 | 93 | 36 | 94 | 57 | 58 | 0.62 | | 1.61 | 0.06 |
| 70 | 265 | 1 | 454 | 91 | 35 | 92 | 56 | 57 | 0.62 | | 1.63 | 0.07 |
| 71 | 266 | 1 | 455 | 89 | 34 | 90 | 55 | 56 | 0.62 | $r+1=71$ $L_{r+1}=266$ | 1.6471 | 0.07109 |
| 72 | 267 | 0 | 455 | 88 | 33 | 88 | 55 | 55 | 1.00 | | 1.67 | 0.08 |
| 73 | 268 | 2 | 457 | 85 | 32 | 87 | 53 | 55 | 0.40 | | 1.72 | 0.08 |
| 74 | 270 | 3 | 460 | 81 | 31 | 84 | 50 | 53 | 0.25 | | 1.71 | 0.08 |
| 75 | 271 | 1 | 461 | 79 | 30 | 80 | 49 | 50 | 0.63 | | 1.67 | 0.09 |
| 76 | 272 | 2 | 463 | 76 | 29 | 78 | 47 | 49 | 0.39 | | 1.69 | 0.09 |
| 77 | 275 | 5 | 468 | 70 | 28 | 75 | 42 | 47 | 0.09 | * | 1.68 | 0.10 |
| 78 | 278 | 4 | 472 | 65 | 27 | 69 | 38 | 42 | 0.13 | | 1.56 | 0.09 |
| 79 | 279 | 1 | 473 | 63 | 26 | 64 | 37 | 38 | 0.59 | | 1.46 | 0.09 |
| 80 | 280 | 1 | 474 | 61 | 25 | 62 | 36 | 37 | 0.60 | | 1.48 | 0.09 |
| 81 | 284 | 4 | 478 | 56 | 24 | 60 | 32 | 36 | 0.12 | | 1.50 | 0.10 |
| 82 | 285 | 1 | 479 | 54 | 23 | 55 | 31 | 32 | 0.58 | | 1.39 | 0.10 |
| 83 | 286 | 0 | 479 | 53 | 22 | 53 | 31 | 31 | 1.00 | | 1.41 | 0.11 |
| 84 | 288 | 1 | 480 | 51 | 21 | 52 | 30 | 31 | 0.60 | | 1.48 | 0.11 |
| 85 | 292 | 0 | 480 | 50 | 20 | 50 | 30 | 30 | 1.00 | | 1.50 | 0.12 |
| 86 | 293 | 0 | 480 | 49 | 19 | 49 | 30 | 30 | 1.00 | | 1.58 | 0.13 |
| 87 | 294 | 0 | 480 | 48 | 18 | 48 | 30 | 30 | 1.00 | | 1.67 | 0.14 |
| 88 | 298 | 4 | 484 | 43 | 17 | 47 | 26 | 30 | 0.15 | | 1.76 | 0.14 |
| 89 | 299 | 2 | 486 | 40 | 16 | 42 | 24 | 26 | 0.38 | | 1.63 | 0.14 |
| 90 | 300 | 0 | 486 | 39 | 15 | 39 | 24 | 24 | 1.00 | | 1.60 | 0.16 |
| 91 | 302 | 1 | 487 | 37 | 14 | 38 | 23 | 24 | 0.63 | | 1.71 | 0.17 |
| 92 | 310 | 4 | 491 | 32 | 13 | 36 | 19 | 23 | 0.15 | | 1.77 | 0.19 |
| 93 | 313 | 2 | 493 | 29 | 12 | 31 | 17 | 19 | 0.37 | | 1.58 | 0.19 |
| 94 | 315 | 0 | 493 | 28 | 11 | 28 | 17 | 17 | 1.00 | | 1.55 | 0.22 |
| 95 | 316 | 0 | 493 | 27 | 10 | 27 | 17 | 17 | 1.00 | | 1.70 | 0.25 |
| 96 | 317 | 1 | 494 | 25 | 9 | 26 | 16 | 17 | 0.65 | | 1.89 | 0.26 |
| 97 | 320 | 2 | 496 | 22 | 8 | 24 | 14 | 16 | 0.43 | | 2.00 | 0.32 |
| 98 | 328 | 3 | 499 | 18 | 7 | 21 | 11 | 14 | 0.27 | | 2.00 | 0.43 |

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| | | | | "Robson-Flick" Statistics[a] | | | | | | | Running Average Marked-to-Unmarked Ratio Statistics[b] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $i$ | $L_i$ | $u_i$ | $a_i$ | $n_2-a_i-i+1$ | $m_2-i+1$ | $n_2-a_{i-1}-i+1$ | $n_2-a_i-m_2$ | $n_2-a_{i-1}-m_2$ | $Pr[U_i \geq u_i]$[c] | Significant at $\alpha$ = 0.10 | $\bar{u}_i$ | $\hat{V}[\bar{u}_i]$ |
| 99 | 329 | 1 | 500 | 16 | 6 | 17 | 10 | 11 | 0.65 | | 1.83 | 0.56 |
| 100 | 331 | 0 | 500 | 15 | 5 | 15 | 10 | 10 | 1.00 | | 2.00 | 0.80 |
| 101 | 364 | 5 | 505 | 9 | 4 | 14 | 5 | 10 | 0.13 | | 2.50 | 0.92 |
| 102 | 387 | 3 | 508 | 5 | 3 | 8 | 2 | 5 | 0.18 | | 1.67 | 0.44 |
| 103 | 390 | 1 | 509 | 3 | 2 | 4 | 1 | 2 | 0.52 | | 1.00 | 0.00 |
| 104 | --- | 1 | 510 | 1 | 1 | 2 | 0 | 1 | --- | | 1.00 | --- |

a $L_i$ = ordered lengths of the $m_2$ recaptured fish (from the 1988 marked fish caught during 1989);

$u_i$ = the number of unmarked fish caught during 1989 with lengths in the interval $L_{i-1} \leq L < L_i$ ($L_0 = 0$, $L_{m+1} = \infty$) ;

$a_i$ = $\sum_{j=1}^{i} u_j$ ;

$n_2$ = number of fish captured (both marked and unmarked) during 1989); and

$m_2$ = number of recaptures from the 1988 marked fish caught during 1989.

b $Pr[U_i \geq u_i]$ = tail probability of observing random variable $U_i$ greater than or equal to observed $u_i$, given the preceding values of $u_i$, calculated according to procedure outlined by Seber (1982).

c $\bar{u}_i$ = $\dfrac{\sum_{k=1}^{m_2+1} u_k}{m_2 - 1}$ ; and

$\hat{V}[\bar{u}_i]$ = $\dfrac{\sum_{o=i}^{m_2+1} (u_o - \bar{u}_i)^2}{(m_2 - i - 1)(m_2 - i)}$ .