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EVALUATION OF POPULATION SIZE, STATUS OF FISH POPULATIONS, AND THE LAKE CHARACTERISTICS FOR THREE LAKES IN THE VICINITY OF KETCHIKAN, ALASKA, DURING 1988[1]

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ABSTRACT

Three lakes in the Ketchikan area were examined to estimate the population size of sport fish species, general lake characteristics, and the current condition of fish populations present. Carlanna Lake contained a stocked population of rainbow trout *Oncorhynchus mykiss*. The population estimate was 217 trout with 95% confidence interval limits from 62 to 920 trout. The fish in the population were in good condition (mean condition factor = 1.25, standard error = 0.019). Carlanna Lake is a small non-anadromous lake (13.7 hectares) with a mean depth of 20.6 meters (67.5 feet) and a comparatively high morphoedaphic index of 6.00. Lower Leask Lake contained a natural population of cutthroat trout *Oncorhynchus clarki*, as well as Dolly Varden *Salvelinus malma*, coho salmon *Oncorhynchus kisutch*, and sockeye salmon *Oncorhynchus nerka*. The population estimate for cutthroat trout was 327 fish with 95% confidence interval limits from 54 to 991 trout. The Lower Leask Lake cutthroat trout were in average condition (mean condition factor = 0.99, standard error = 0.013). The capture history data for Dolly Varden and juvenile coho salmon in Lower Leask Lake did not meet the requirements for mark-recapture estimation. Accordingly, population estimates were not obtained for these species. The Dolly Varden were in average condition (mean condition factor = 1.03, standard error = 0.023). The mean condition factor of juvenile coho salmon was 1.44 (standard error = 0.064). Lower Leask Lake is also a small lake (14.4 hectares) in a two lake anadromous system, with a mean depth of 19.0 meters (62.3 feet) and a morphoedaphic index of 1.03. Lower Silvis Lake contained the survivors of a stocked population of rainbow trout. The population estimate was 144 trout with 95% confidence intervals from 66 to 222 trout. These trout were in good condition with an mean condition factor of 1.12 (standard error = 0.032). Lower Silvis Lake is a small non-anadromous lake (14.1 hectares) in a two lake system, and is part of a hydroelectric project, which includes a power generating plant between the upper and low lake and a dam at the outlet of Lower Silvis Lake. The lake's mean depth was measured at 11.1 m (36.6 feet), and had a morphoedaphic index of only 0.47.

KEY WORDS: Southeast Alaska, rainbow trout, *Oncorhynchus mykiss*, cutthroat trout, *Oncorhynchus clarki*, Dolly Varden, *Salvelinus malma*, coho salmon, *Oncorhynchus kisutch*, Ketchikan, Revillagigado Island, Carlanna Lake, Lower Leask Lake, Lower Silvis Lake, enhancement opportunities, lake surface area, lake volume, mean depth, total dissolved solids, conductivity, Maximum Sustainable Yield, Morphoedaphic Index, condition factor, capture-recapture population estimation, catch per unit effort, Jolly-Seber population estimator, Anderson-Darling *K*-sample goodness-of-fit test, closure test, probability of capture, CAPTURE computer program, RECAP computer program, bootstrap confidence intervals.

INTRODUCTION

Several Ketchikan area lakes have become, or will soon become, more accessible to the public due to expansion of road systems associated with logging and other private enterprises. This report covers the second year of a project to evaluate the existing opportunities for recreational freshwater fishing in lakes in the Ketchikan area on Revillagigado Island. During 1987, Second Waterfall Lake, Lower Wolf Lake, and Harriett Hunt Lake were investigated and reported by Hubartt and Bingham (1988). The lakes examined during this period were Carlanna Lake, Lower Leask Lake, and Lower Silvis Lake (Figure 1).

The impetus for the project came from meetings of a task force comprised of local recreational anglers and Alaska Department of Fish and Game (ADF&G) staff during the winter of 1987. The task force was appointed by the Commissioner of the ADF&G to assist in the development of strategic plans regarding sport fishing in the Ketchikan area. During the planning process several lakes were identified as being the most likely to provide freshwater fishing opportunities if public access could be improved. Local sport fishing groups have expressed their willingness to donate time, labor, and materials to establish good trails to some of the lakes, and, hopefully, this report will help to ensure that such efforts are not wasted.

Development of new freshwater fishing opportunities for the general public in the Ketchikan area is the overall goal of this research project, and the objective of this report is to describe the three lakes by examining the size and status of fish populations, and by examining several physical aspects of the lakes and comparing them to other lakes in southeast Alaska.

The specific objectives of the project were to:

1. estimate the population size of species of sport fish in Lower Silvis, Carlanna, and Lower Leask lakes;

2. estimate the potential productivity in Lower Silvis, Carlanna, and Lower Leask lakes; and

3. assess the status of current populations of sport fish species in Lower Silvis, Carlanna, and Lower Leask lakes.

METHODS

Population Estimates

Trout and char were captured, marked, and recaptured in Carlanna, Lower Leask, and Lower Silvis Lakes in the Ketchikan area (Figure 1) during July through November 1988. Three 5-day sampling periods were spent on Carlanna Lake and Lower Leask Lake, and two 5-day sampling periods were spent on Lower Silvis Lake (the third trip to Lower Silvis Lake was cut short because of snow).

Fish were captured by using Gee minnow traps (small traps), a larger version of the Gee minnow trap constructed of Vexar and aluminum (large traps), and hook

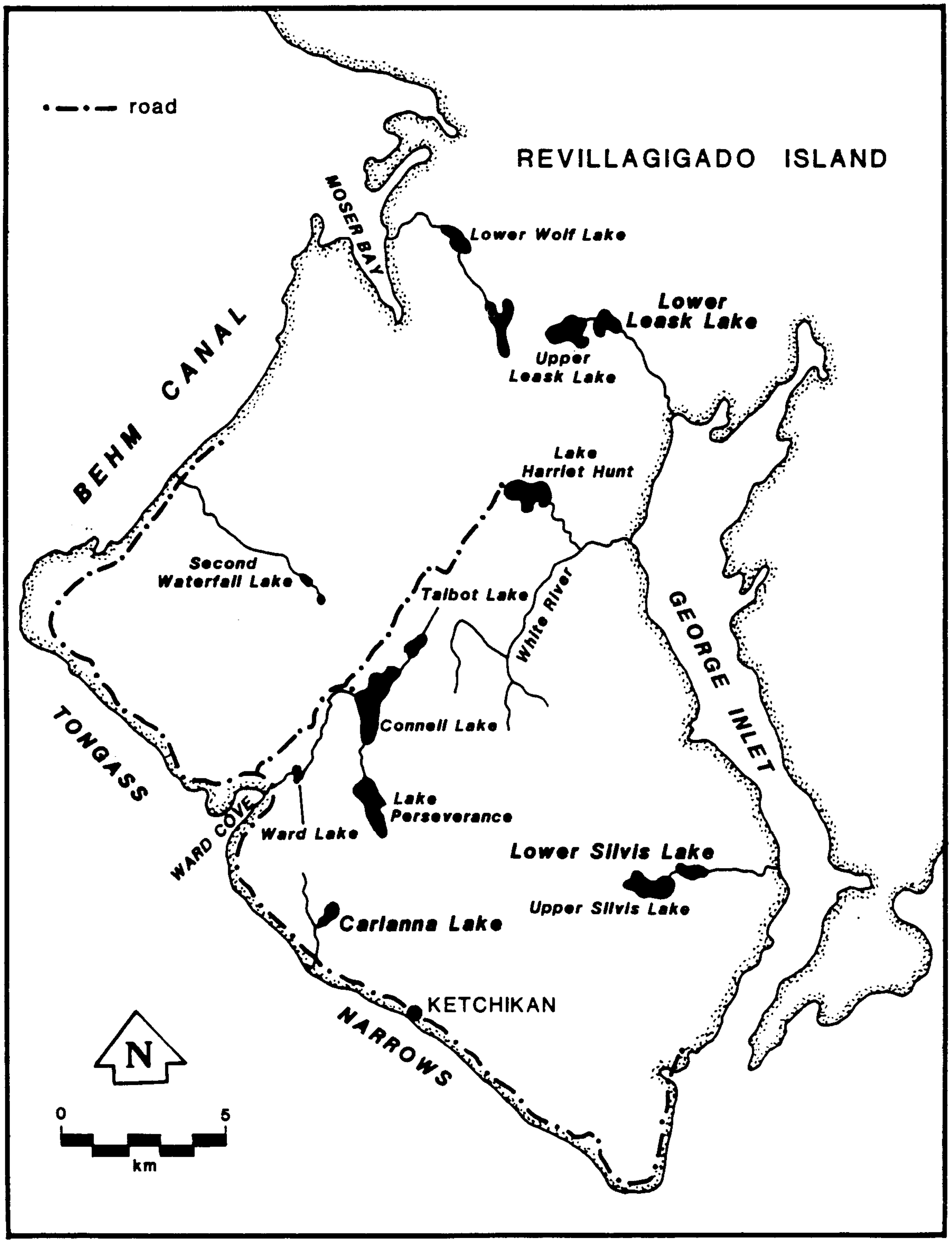

Figure 1. Lakes examined on Revillagigado Island in 1988.

and line. Both large and small traps were baited with salmon eggs, which had been disinfected with Betadyne and preserved with borax. Unique marks and numbered Floy tags were used for each sampling period. A lower caudal punch was used during period one, an upper caudal punch was used during period two, and an anal fin punch was used during period three. All fish captured were examined for marks and tags. The total number captured and initially marked, the total number recaptured with marks, and the total number recaptured without marks were recorded by species, mark, and tag number during each sample period. Although all fish captured were marked, only fish which exceeded minimum size limits were tagged with numbered Floy tags. The minimum sizes for tagging the various species were as follows: rainbow trout *Oncorhynchus mykiss* - 135 mm, cutthroat trout *O. clarki* - 135 mm, Dolly Varden *Salvelinus malma* - 165 mm, and juvenile coho salmon *O. kisutch* were not tagged. In several instances fish longer than these minimums were not Floy-tagged because of a small body girth.

During each sampling period, all captured fish were anesthetized with tricaine methanesulfonate (MS-222), identified as to species, counted (marked and unmarked fish were recorded separately by species by mark and by gear type), measured from the tip of the snout to the fork of the tail (fork length to the nearest mm), weighed to the nearest 0.1 gram on a triple-beam balance, allowed to recover, and released. All mortalities were recorded. The total fishing time (to the nearest hour) for each gear unit, and the number of gear units for each gear type (small minnow traps, large traps, and hook and line) were also recorded for each sampling period.

The closed population capture—recapture computer program called CAPTURE was used to evaluate the capture history data from each lake for each species of fish (White et al. 1982).[2] The program automatically selected the appropriate estimator (e.g., jackknife, Zippin, generalized removal) for the best fit model (i.e., M_o: constant capture probabilities across time and animals; M_b: behavioral response affect after first capture; M_t: capture probabilities vary by occasion; M_h: capture probabilities vary by animal; and their combinations: M_{tb}, M_{bh}, M_{th}, M_{tbh}). Additionally the program was used to test for closure, that is whether the population is subject to death, immigration, emigration, birth, or recruitment. Refer to White et al. (1982) and Otis et al. (1978) for details on testing procedures and estimation formulae. In addition to evaluating the closure hypothesis and selecting the appropriate model via the CAPTURE program, we tested the hypothesis that our mixture of the gear deployed was size selective. This test was performed by comparing the empirical density distribution of the length of fish captured on the first sampling occasion with the density distribution of fish lengths recaptured on the second occasion. A *K*-sample Anderson-Darling test was used to test the null hypothesis of no difference between the distributions (Scholz and Stephens 1987). All tests (both for closure and for size-selective capture probabilities) were conducted at an $\alpha = 0.05$.

2 A simple Petersen type mark-recapture estimator was used to estimate the population abundance of rainbow trout in Lower Silvis Lake due to the shortened third sampling period. The Chapman-modified version of this estimator was used and the procedures outlined by Seber (1982) were used to obtain confidence interval limits about this estimate.

If the closure test was rejected, indicating that the population was open, then we used the Jolly-Seber type estimator as provided in the program RECAP. This program implements a modified Jolly-Seber estimator and uses the bootstrap approach to obtain non-parametric confidence intervals (Buckland 1980, 1982).

Catch per unit-effort (CPUE) by sampling period by species by gear type was calculated using standard methods (Ricker 1975).

Lake Characteristics

Bathymetric maps were constructed by using an outline map constructed from aerial photographs and a Simrad EYM fathometer to record continuous depths along selected transects crossing each lake (see Dodge et al. 1981). Ten transects were used in mapping Carlanna Lake, seven transects were used in mapping Lower Leask Lake, and ten transects were used in mapping Lower Silvis Lake.

General water chemistry measurements (water temperature profile, dissolved oxygen, pH, alkalinity, and conductivity) were collected from single stations on Carlanna, Lower Leask, and Lower Silvis Lakes.

Data obtained from bathymetric mapping, a polar planimeter, and the following formulae were used to estimate the surface area (A), volume (V), and mean depth (Z) for each lake:

$$A = (VR)\ (CF_1)\ (CF_2) \quad [1]$$

VR = vernier reading of the lake perimeter from a polar planimeter

CF_1 = conversion factor to convert the vernier reading to the map scale

CF_2 = conversion factor to convert the map scale to acres or hectares

$$V = \sum_{i=1}^{n} \{ [h_i \div 3]\ [A_i + A_{i+1} + (A_i A_{i+1})^{\frac{1}{2}}] \} \quad [2]$$

i = subscript denoting horizontal stratum

n = number of horizontal strata

h_i = vertical distance between A_i and A_{i+1}

A_i = area of the *i*th horizontal stratum

$$Z = V \div A \quad [3]$$

Total dissolved solids (TDS) was estimated using conductivity measurements and the following formula (Schlesinger and Regier 1982):

$$TDS = 0.65\ C \quad [4]$$

C = conductivity (μmhos/cm)

The TDS was then divided by the mean depth to obtain the morphoedaphic index (MEI) for each lake (Ryder 1964, 1965):

$$MEI = TDS \div Z \qquad [5]$$

An approximation of potential fish production (y) in kg/ha was calculated using the following equation (modified for metric units) from Ryder (1965):

$$y = 0.966\ (MEI)^{1/2} \qquad [6]$$

MEI and y were then compared with similar information from other lakes in southeast Alaska (Schmidt 1983). Schneider and Haedrich (1989) reported that the original equation as modified for metric units, given by Ryder et al. (1974) was incorrect. We chose to continue to use the "incorrect" equation (equation [6] above) in order to maintain comparability with previous studies (e.g., Schmidt 1983 and Hubartt and Bingham 1988).

<u>Population Status</u>

Paired length and weight samples were obtained from all newly captured fish (see Population Estimates section above) to estimate the relative condition of populations at the time of sampling as measured by the condition factor (K) using the following formula: $K = 10^5 \times \text{Weight (g)} / (\text{Fork Length (mm)})^3$. The mean and standard deviation of condition factors were calculated using standard statistical procedures.

RESULTS

<u>Population Estimates</u>

Multiple mark-recapture experiments were conducted on each study lake in order to estimate the population abundance of each sport fish species.

Carlanna Lake:

A total of 219 rainbow trout were captured, marked, and released during three sampling periods at Carlanna Lake (Table 1). No other species were captured. During the first sample period (18 July through 22 July 1988), 58 rainbow trout were captured. This number included three mortalities and two recaptures, so the total number of newly marked and released fish in the lake at the end of sample period one was 53 (Table 2).

A total of 63 rainbow trout were captured during sampling period two (8 August through 12 August 1988). There were two mortalities, one recapture had been marked during period two, and three were recaptures of fish marked during the first sampling period. The total number of marked fish in the lake at the end of sampling period two was at most 110 trout (Table 2).

Table 1. Summary of effort, catch, and catch per unit effort (CPUE) by lake, sample period, gear type, and species, 1988.

				Species[1]							
Lake	Period	Gear	Effort[2]	RT Catch	RT CPUE[3]	CT Catch	CT CPUE[3]	DV Catch	DV CPUE[3]	SS Catch	SS CPUE[3]
Carlanna	1	Large Traps	414.0	41	0.10	-	-	-	-	-	-
Carlanna	1	Small Traps	616.0	9	0.01	-	-	-	-	-	-
Carlanna	1	Hook and Line	18.0	8	0.44	-	-	-	-	-	-
Carlanna	1	ALL GEAR	1048.0	58	0.06	-	-	-	-	-	-
Carlanna	2	Large Traps	616.0	47	0.08	-	-	-	-	-	-
Carlanna	2	Small Traps	546.0	8	0.01	-	-	-	-	-	-
Carlanna	2	Hook and Line	18.0	8	0.44	-	-	-	-	-	-
Carlanna	2	ALL GEAR	1180.0	63	0.05	-	-	-	-	-	-
Carlanna	3	Large Traps	616.0	85	0.14	-	-	-	-	-	-
Carlanna	3	Small Traps	455.5	10	0.02	-	-	-	-	-	-
Carlanna	3	Hook and Line	28.0	31	1.11	-	-	-	-	-	-
Carlanna	3	ALL GEAR	1099.5	126	0.11	-	-	-	-	-	-
Lower Leask	1	Large Traps	437.5	-	-	77	0.18	125	0.29	43	0.10
Lower Leask	1	Small Traps	571.5	-	-	18	0.03	65	0.11	48	0.08
Lower Leask	1	Hook and Line	5.0	-	-	2	0.40	0	0	0	0
Lower Leask	1	ALL GEAR	1014.0	-	-	97	0.10	190	0.19	91	0.09
Lower Leask	2	Large Traps	480.0	-	-	31	0.06	10	0.02	47	0.10
Lower Leask	2	Small Traps	567.0	-	-	1	0.00	0	0	2	0.00
Lower Leask	2	Hook and Line	23.5	-	-	27	1.15	0	0	1	0.04
Lower Leask	2	ALL GEAR	1070.5	-	-	59	0.06	10	0.01	50	0.05
Lower Leask	3	Large Traps	430.0	-	-	28	0.07	96	0.22	41	0.10
Lower Leask	3	Small Traps	540.0	-	-	3	0.01	21	0.04	6	0.01
Lower Leask	3	Hook and Line	13.0	-	-	14	1.08	0	0	0	0
Lower Leask	3	ALL GEAR	983.0	-	-	45	0.05	117	0.12	47	0.05
Lower Silvis	1	Large Traps	460.0	32	0.07	-	-	-	-	-	-
Lower Silvis	1	Small Traps	543.0	1	0.00	-	-	-	-	-	-
Lower Silvis	1	Hook and Line	19.0	11	0.58	-	-	-	-	-	-
Lower Silvis	1	ALL GEAR	1022.0	44	0.04	-	-	-	-	-	-
Lower Silvis	2	Large Traps	630.0	21	0.03	-	-	-	-	-	-
Lower Silvis	2	Small Traps	543.0	0	0	-	-	-	-	-	-
Lower Silvis	2	Hook and Line	26.0	5	0.19	-	-	-	-	-	-
Lower Silvis	2	ALL GEAR	1199.0	26	0.02	-	-	-	-	-	-
Lower Silvis	3	Large Traps	120.0	4	0.03	-	-	-	-	-	-
Lower Silvis	3	Small Traps	120.0	1	0.01	-	-	-	-	-	-
Lower Silvis	3	Hook and Line	8.0	0	0	-	-	-	-	-	-
Lower Silvis	3	ALL GEAR	248.0	5	0.02	-	-	-	-	-	-

1 RT = rainbow trout; CT = cutthroat trout; DV = Dolly Varden; and SS = juvenile coho salmon.

2 Effort = number of gear units X hours fished.

3 CPUE = catch per unit effort.

Table 2. Summary of marks, recaptures, mortalities, and the population estimate with 95% confidence interval by sample period for rainbow trout in Carlanna Lake, 1988.

	Sample Period 1 (7/18-7/22)	Sample Period 2 (8/8-8/12)	Sample Period 3 (9/12-9/16)
Captured, marked, and released alive			
Newly marked fish	53 (19)[1]	57 (39)	109 (97)
Recaptures			
from period 1	2 (1)	3 (2)	1 (1)
from period 2	- -	1 (0)	8 (7)
from periods 1 & 2	- -	- -	1 (1)
from period 3	- -	- -	2 (2)
from periods 2 & 3	- -	- -	3 (3)
Captured and died			
Newly captured fish	3 (0)	2 (1)	2 (1)
Recaptures			
from period 1	- -	- -	- -
from period 2	- -	- -	- -
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -
Total Catch	58 (20)	63 (42)	126(112)
Population Estimate (Jolly-Seber from RECAP)		217	
95% confidence interval		62 - 920	

[1] Note: the numbers of Floy tagged fish are indicated in parentheses.

During the third sampling period (12 September through 16 September 1988) 126 rainbow trout were captured. There was one mortality, six recaptures had been marked during period three, eight recaptures had marks from the second sampling period, and one had a mark from the first sampling period (Table 2). The total number of marked fish in the lake at the end of sampling period three was at most 219 trout (assuming no mortality of marked fish that were released alive), and 155 of these were marked with numbered Floy tags.

The *K*-sample Anderson-Darling test comparing lengths of rainbow trout captured on the second sampling occasion with the recaptured trout from the third occasion indicated no size selectivity (with $A^2_{akN} = 1.25$, $\sigma^2_N = 0.5562$, and $T_{akN} = 0.335$, with the critical value of 1.96 for T_{akN}). The CAPTURE program indicated that the closure hypothesis was rejected, indicating an open population ($z = -1.84$). The CAPTURE program also indicated that the best model for the data was M_{tbh}, in which case the closure test does not work properly. However, considering the comparatively large mortality rate caused directly by our sampling (7 mortalities), we assumed that the closure assumption was inappropriate and would lead to a biased estimate. Accordingly, we used the RECAP program to calculate a Jolly-Seber population estimate at the start of sampling period two. The estimate was 217 rainbow trout with 95% confidence interval (C.I.) limits of 62 to 920 (Table 2). The assumptions necessary for an unbiased Jolly-Seber estimate are not as restrictive as a closed population estimator (e.g., CAPTURE or Petersen), however if the M_{tbh} model still applies[3] then our Jolly-Seber estimate is also biased. The degree of the bias is unknown.

Lower Leask Lake:

A total of 201 cutthroat trout, 317 Dolly Varden, one adult and 188 juvenile coho salmon, 17 adult sockeye salmon *Oncorhynchus nerka*, and 842 stickleback *Gasterosteus* species, were captured during three sampling periods at Lower Leask Lake.

Cutthroat trout. During the first sample period (16 August through 19 August 1988), 97 cutthroat trout were captured (Table 1). There were 17 mortalities and one of these trout was a recapture, so the total number of newly marked and released cutthroat trout in the lake at the end of sample period one was 79 (Table 3). Almost all of the mortalities occurred while the fish were being handled. Warm water temperatures (17.8 to 18.3° C) probably contributed to rapid oxygen depletion while the fish were being transported and held in buckets. Additional stresses associated with the anesthetic and handling led to the mortalities.

A total of 59 cutthroat trout were captured during sampling period two (20 September through 24 September 1988). There was one mortality of a fish that had been marked during both period 1 and period 2, one live recapture had been marked during both period 1 and period 2, three recaptures had been marked during

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[3] Note that heterogenous capture probabilities are difficult to estimate in the Jolly-Seber model due to the confounding effects of recruitment and death on these probabilities.

Table 3. Summary of marks, recaptures, mortalities, and the population estimate with 95% confidence interval by sample period for cutthroat trout in Lower Leask Lake, 1988.

	Sample Period 1 (8/16-8/19)	Sample Period 2 (9/20-9/24)	Sample Period 3 (10/31-11/4)
Captured, marked, and released alive			
Newly marked fish	69 (59)[1]	48 (47)	33 (32)
Recaptures			
from period 1	1 (1)	6 (6)	4 (4)
from period 2	- -	3 (2)	7 (7)
from periods 1 & 2	- -	1 (1)	- -
from period 3	- -	- -	1 (1)
Captured and died			
Newly captured fish	17 (10)	- -	- -
Recaptures			
from period 1	- -	- -	- -
from period 2	- -	- -	- -
from periods 1 & 2	- -	1 (1)	- -
from period 3	- -	- -	- -
Total Catch	87 (70)	59 (57)	45 (44)
Population Estimate (Jolly-Seber from RECAP)		327	
95% confidence interval		54 - 991	

[1] Note: the numbers of Floy tagged fish are indicated in parentheses.

period two, and six were recaptures of fish marked during the first sampling period. The total number of marked cutthroat trout in the lake at the end of sampling period two was at most 127 (Table 3).

During the third sampling period (31 October through 4 November 1988), 45 cutthroat trout were captured (Table 3). There were no mortalities, one recapture had been marked during period three, seven recaptures had marks from the second sampling period, and four had marks from the first sampling period (Table 3). The total number of marked cutthroat trout in the lake at the end of sampling period three was at most 160 (assuming no mortality of marked fish that were released alive), and 149 of them had been tagged with numbered Floy tags.

The *K*-sample Anderson-Darling test comparing lengths of cutthroat trout captured on the first sampling occasion with the recaptured trout from the second occasion indicated no size selectivity (with $A^2_{akN} = 0.62$, $\sigma^2_N = 0.5706$, and $T_{akN} = -0.500$, with the critical value of 1.96 for T_{akN}). The CAPTURE program indicated that the closure hypothesis was not rejected, indicating a closed population ($z = -0.9$). However, the CAPTURE program also indicated that the best model for the data was M_b, in which case the closure test does not work properly. However, considering the comparatively large mortality rate caused directly by our sampling (18 mortalities), we assumed that closure was not obtained. Accordingly, we used the RECAP program to calculate a Jolly-Seber population estimate at the start of sampling period two. The estimate was 327 cutthroat trout with 95% C.I. limits from 54 to 991. If capture probabilities were heterogenous (as indicated by the CAPTURE program), then our Jolly-Seber estimate is likely to be biased.

Dolly Varden. During the first sample period (16 August through 19 August 1988), 190 Dolly Varden were captured (Table 1). There were six mortalities and one Dolly Varden was recaptured, so the total number of newly marked and released Dolly Varden in the lake at the end of sample period one was at most 183 fish (Table 4).

A total of 10 Dolly Varden were captured during sampling period two (20 September through 24 September 1988). There were no mortalities, one recapture had been marked during both period 1 and period 2, and one recapture had been marked during the first sampling period. The total number of marked Dolly Varden in the lake at the end of sampling period two was at most 191 fish (Table 4). The poor catches of Dolly Varden during the second sampling period may have been related to the appearance of adult sockeye salmon which were present throughout the lake, and were actively spawning in the inlet streams.

During the third sampling period (31 October through 4 November 1988), 117 Dolly Varden were captured (Table 4). There were no mortalities, nine recaptures had been marked during period three, two recaptures had marks from the second sampling period, and three had marks from the first sampling period (Table 4). The total number of marked Dolly Varden in the lake at the end of sampling period three was at most 294 fish (assuming no mortality of marked fish that were released alive), and 177 of them had been tagged with numbered Floy tags.

Table 4. Summary of marks, recaptures, and mortalities by sample period for Dolly Varden in Lower Leask Lake, 1988.

	Sample Period 1 (8/16-8/19)	Sample Period 2 (9/20-9/24)	Sample Period 3 (10/31-11/4)
Captured, marked, and released alive			
Newly marked fish	183(104)[1]	8 (7)	103 (66)
Recaptures			
from period 1	1 (0)	1 (1)	3 (3)
from period 2	- -	- -	2 (2)
from periods 1 & 2	- -	1 (1)	- -
from period 3	- -	- -	9 (5)
Captured and died			
Newly captured fish	6 (3)	- -	- -
Recaptures			
from period 1	- -	- -	- -
from period 2	- -	- -	- -
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -
Total Catch	190(107)	10 (9)	117 (76)

[1] Note: the numbers of Floy tagged fish are indicated in parentheses.

The *K*-sample Anderson-Darling test comparing lengths of Dolly Varden captured on the first sampling occasion with the recaptured from the third occasion indicated size selectivity (with A^2_{akN} = 3.56, σ^2_N = 0.6002, and T_{akN} = 3.305, with the critical value of 1.96 for T_{akN}). The CAPTURE program indicated that the closure hypothesis was not rejected, indicating a closed population (z = 0.9). The CAPTURE program also indicated that the best model for the data was M_{tb}, in which case the closure test does not work properly. However, considering low total number of recaptures and the apparent low probability of capture during the second sampling period (Table 4), we decided that estimating the population abundance was inappropriate with the mark-recapture data for Dolly Varden.

Juvenile coho salmon. During the first sample period (16 August through 19 August 1988), 91 juvenile coho salmon were captured (Table 1). There were 11 mortalities and no recaptures, so the total number of newly marked and released juvenile coho salmon in the lake at the end of sample period one was at most 80 salmon (Table 5).

A total of 50 coho salmon were captured during sample period two (20 September through 24 September 1988). There were two mortalities, and one recaptured coho salmon had been marked during the first sampling period. The total number of newly marked and released coho salmon in the lake at the end of sampling period two was at most 127 (Table 5).

During the third sampling period (31 October through 4 November 1988), 47 juvenile coho salmon were captured (Table 5). There were no mortalities, one recapture had been marked during period three, and seven recaptures had marks from the second sampling period (Table 5). The total number of newly marked and released coho salmon in the lake at the end of sampling period three was at most 166 juvenile coho salmon (assuming no mortality of marked fish that were released alive).

The *K*-sample Anderson-Darling test comparing lengths of juvenile coho salmon captured on the second sampling occasion with the recaptured coho salmon from the third occasion indicated no size selectivity (with A^2_{akN} = 1.67, σ^2_N = 0.5485, and T_{akN} = 0.905, with the critical value of 1.96 for T_{akN}). The CAPTURE program indicated that the closure hypothesis was rejected, indicating a open population (z = -2.0). The CAPTURE program also indicated that the best model for the data was M_b, in which case the closure test does not work properly. However, considering low total number of recaptures and the apparently decreasing probability of capture during our experiment (Table 5), we decided that estimating the population abundance was inappropriate for juvenile coho salmon.

Lower Silvis Lake:

A total of 74 rainbow trout were captured during three sampling periods at Lower Silvis Lake. No other species were seen. During the first sample period (18 July through 22 July 1988), 44 rainbow trout were captured (Table 6). There were three mortalities and three recaptures, so the total number of newly marked and released fish in the lake at the end of sample period one was 38.

Table 5. Summary of marks, recaptures, and mortalities by sample period for juvenile coho salmon in Lower Leask Lake, 1988.

	Sample Period 1 (8/16-8/19)		Sample Period 2 (9/20-9/24)		Sample Period 3 (10/31-11/4)	
Captured, marked, and released alive						
Newly marked fish	80	(0)[1]	47	(0)	39	(0)
Recaptures						
from period 1	-	-	1	(0)	-	-
from period 2	-	-	-	-	7	(0)
from periods 1 & 2	-	-	-	-	-	-
from period 3	-	-	-	-	1	(0)
Captured and died						
Newly captured fish	11	(0)	2	(0)	-	-
Recaptures						
from period 1	-	-	-	-	-	-
from period 2	-	-	-	-	-	-
from periods 1 & 2	-	-	-	-	-	-
from period 3	-	-	-	-	-	-
Total Catch	91	(0)	50	(0)	47	(0)

[1] Note: the numbers of Floy tagged fish are indicated in parentheses.

Table 6. Summary of marks, recaptures, mortalities, and the population estimate with 95% confidence interval by sample period for rainbow trout in Lower Silvis Lake, 1988.

	Sample Period 1 (7/18-7/22)	Sample Period 2 (8/08-8/12)	Sample Period 3 (9/12-9/13)
Captured, marked, and released alive			
Newly marked fish	38 (34)[1]	19 (19)	4 (4)
Recaptures			
from period 1	3 (3)	6 (5)	1 (1)
from period 2	- -	- -	- -
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -
Captured and died			
Newly captured fish	3 (1)	- -	- -
Recaptures			
from period 1	- -	- -	- -
from period 2	- -	- -	- -
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -
Total Catch	44 (38)	25 (24)	5 (5)
Population Estimate (Petersen Type using only first two sampling periods)	144		
95% confidence interval	66 - 222		

[1] Note: the numbers of Floy tagged fish are indicated in parentheses.

A total of 25 rainbow trout were captured during sampling period two (8 August through 12 August 1988). There were no mortalities and six were recaptured fish marked during the first sampling period. The total number of marked fish in the lake at the end of sampling period two was at most 57.

The third sampling period at Lower Silvis Lake was scheduled for 12 September through 16 September 1988, but heavy snow in the area caused us to withdraw on 13 September after only one night of sampling. A total of five rainbow trout were captured during this period. There were no mortalities and one rainbow trout that had been marked during period one was recaptured. Hence, assuming no mortality of marked fish released alive, there were a total of 61 marked rainbow trout in the lake at the end of the third sampling period. Fifty-seven of these marked fish had also been tagged with numbered Floy tags (Table 6). A sport fisherman returned a tag from one of these fish on 17 September 1988.

The *K*-sample Anderson-Darling test comparing lengths of rainbow trout captured on the first sampling occasion with the recaptured trout from the second occasion indicated no size selectivity (with A^2_{akN} = 0.3996, σ^2_N = 0.5420, and T_{akN} = -0.816, with the critical value of 1.96 for T_{akN}). Due to the shortened third sampling period we used a simple Chapman-modified Petersen type mark-recapture estimator using the data from the first two sampling occasions only. The estimate at the start of sampling period one was 144 rainbow trout, with a 95% C.I. limit from 66 to 222 (Table 6). Due to the short interval between the two sampling occasions we could safely assume a closed population (necessary for the use of the Petersen type estimator). Conversely, the short interval may not have allowed for complete mixing of the marked trout with the unmarked portions of the population. However, the distribution of our sampling effort in this small lake would ease the restriction of complete mixing, in that all members of the population (marked and unmarked) would have had approximately equivalent probabilities of capture during the second occasion. Unfortunately, we did not collect the necessary data to evaluate these assumptions. Accordingly, our estimate may be biased.

Lake Characteristics

Morphometric and water quality measurements were obtained without replication as time and weather permitted. Calm weather with little or no wind was necessary when taking morphometric measurements, and water quality measurements could not be obtained during storms or periods of heavy rains. Work related to capturing and handling fish consumed much of the time available during each five-day sampling period. Hence, all of the lake characteristic measurements were taken only once, and do not reflect any seasonal variation.

Carlanna Lake:

Carlanna Lake is a small lake located above the Alaska Marine Ferry terminal near the north edge of the Ketchikan city limits. There is a dam at the lower outlet, and at one time the lake was part of the city water supply. The lake and an access road are on city property, and proposals have been made to open the area to the public for recreational use.

Construction of the contour map (Figure 2) and the use of a polar planimeter allowed calculation of surface area, volume, and mean depth. The surface area of the lake is 33.9 acres (13.7 ha) and the elevation is approximately 450 feet (137 m) (Table 3). The volume of the lake is 242.3 acre-feet (29.9 ha-m) and the mean depth is 67.5 feet (20.6 m).

Specific conductance was measured as 190 micromhos (Table 7). Total dissolved solids (TDS) is 123.5 mg/l, the morphoedaphic index is 6.00, and the potential yield is 2.37 kg/ha.

Lower Leask Lake:

Lower Leask Lake is the lowest of two lakes located approximately 14 miles (22.5 km) north and slightly east of Ketchikan. Currently, it is accessible by hiking about 2 miles (3.2 km) from saltwater near the head of George Inlet, or by float plane. U.S.D.A. Forest Service plans indicate that a logging road will probably cross the outlet stream near saltwater by George Inlet.

Construction of the contour map (Figure 3) and the use of a polar planimeter allowed calculation of surface area, volume, and mean depth. The surface area of the lake is 35.6 acres (14.4 ha) and the elevation is approximately 200 feet (61 m) (Table 3). The volume of the lake is 2,217.9 acre-feet (150.8 ha-m) and the mean depth is 62.3 feet (19.0 m).

Specific conductance was measured as 30 micromhos near the surface (Table 8). Total dissolved solids (TDS) is 19.5 mg/l, the morphoedaphic index is 1.03, and the potential yield is 0.98 kg/ha.

A temperature profile and pH, alkalinity, and dissolved oxygen measurements are presented in Table 8.

Lower Silvis Lake:

Lower Silvis Lake is about 6 miles (9.7 km) northeast of Ketchikan. It is accessible by driving to the Beaver Falls hatchery and Ketchikan Public Utilities (KPU) power station at the end of the South Tongass Highway. The lake is part of a hydro-electric power system and is located on property owned by the KPU. The maintenance road from the hatchery and power station is closed to public vehicular traffic, but foot access up the three mile road to the lake is usually allowed after obtaining permission from KPU.

Construction of a contour map (Figure 4) and the use of a polar planimeter allowed calculation of surface area, volume, and mean depth. The surface area is 34.9 acres (14.1 ha) and the elevation is approximately 800 feet (243.8 m). The lake volume is 1,240.7 acre-feet (178.2 ha-m), and the mean depth is 36.6 feet (11.1 m).

Specific conductance was measured as 8 micromhos near the surface. TDS was calculated to be 5.2 mg/l, the MEI was 0.47, and potential yield was 0.66 kg/ha. A temperature profile and pH, alkalinity, and dissolved oxygen measurements are presented in Table 9.

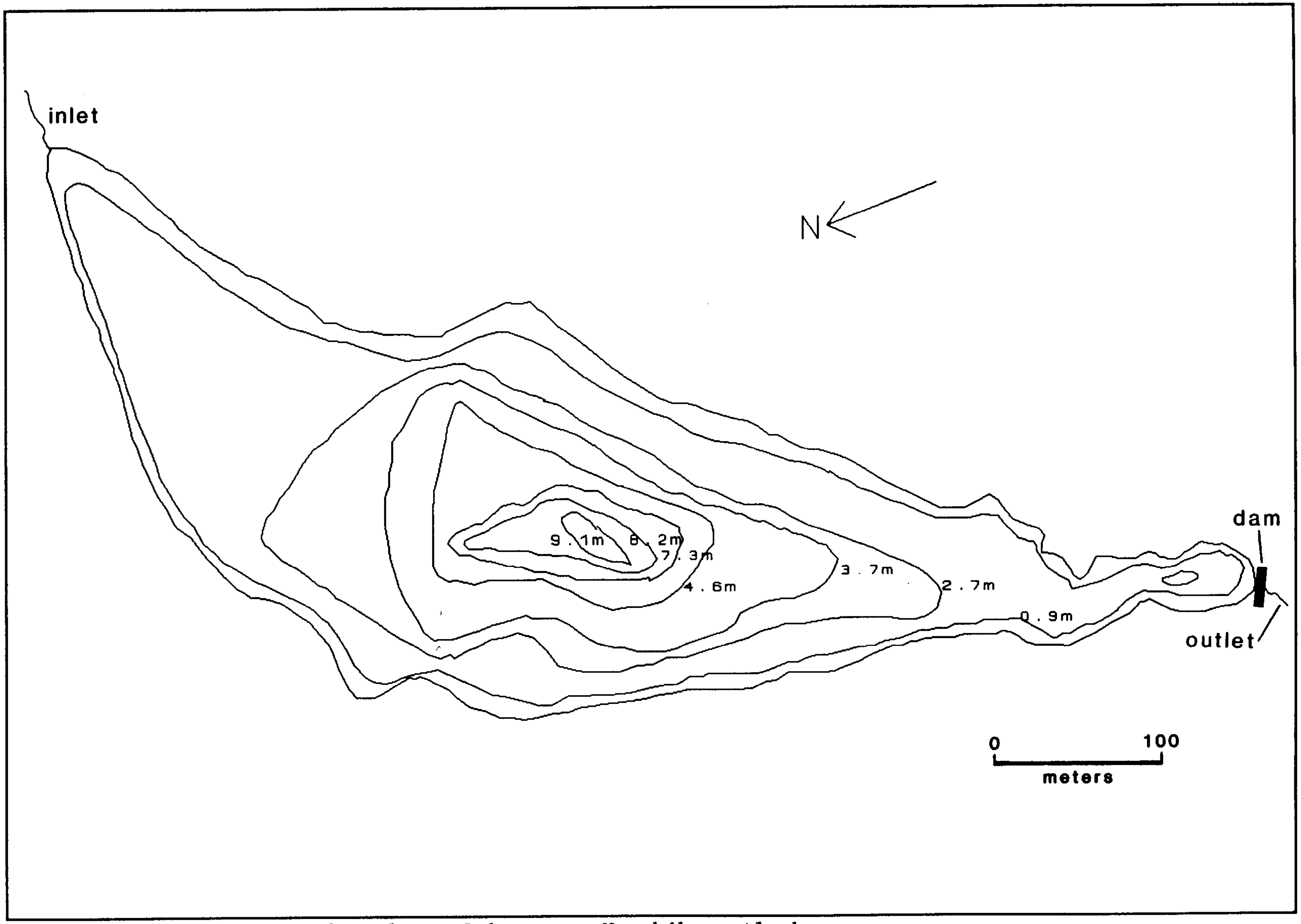


Figure 2. Contour map of Carlanna Lake, near Ketchikan, Alaska.

Table 7. Temperature profile, pH, alkalinity, conductivity, and dissolved oxygen measurements from Carlanna Lake (10 August 1988).

Lake Characteristics

<u>Temperature Profile</u>

Depth (m)	Temperature (°C)
surface	12.0
1	12.0
2	11.0
3	11.0
4	10.0
5	10.0
6	10.0
7	10.0
8	10.0
9	10.0

<u>Water Chemistry</u>

surface:

pH = 6.0
alkalinity = 21 mg/l
conductivity = 190 µmhos
dissolved oxygen = 62.1 mg/l

near bottom:

pH = 6.0
alkalinity = 25 mg/l
dissolved oxygen = 45.9 mg/l

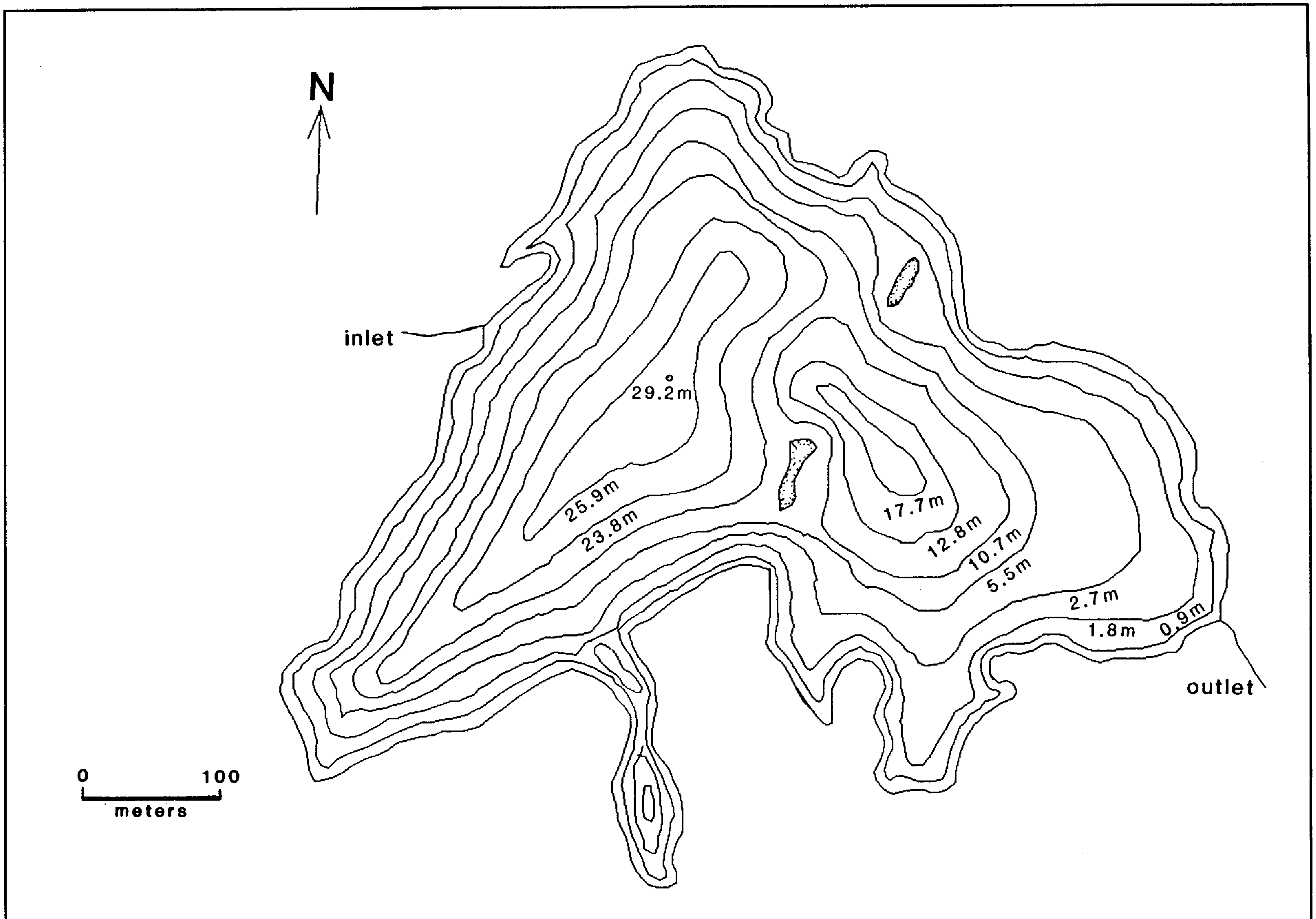


Figure 3. Contour map of Lower Leask Lake, near Ketchikan, Alaska.

Table 8. Temperature profile, pH, alkalinity, conductivity, and dissolved oxygen measurements from Lower Leask Lake (18 August 1988).

Lake Characteristics

Temperature Profile

Depth (m)	Temperature (°C)
surface	17.5
2	17.5
4	17.5
6	17.0
8	16.0
10	15.0
12	14.0
14	13.5
16	12.0
18	10.5
20	9.0
22	8.0
24	7.0
26	6.5
28	6.0
30	5.8
32	5.0
34	5.0
36	4.8
38	4.7
40	4.5
42	4.2
44	4.1
46	4.0
48	3.9
50	3.9

Water Chemistry

surface:

pH = 6.0
alkalinity = 19 mg/l
conductivity = 30 μmhos
dissolved oxygen = 8.8 mg/l

mid depth (40 m):

pH = 6.0
conductivity = 60 μmhos

near bottom (70 m):

pH = 6.0
alkalinity = 26 mg/l
dissolved oxygen = 7.7 mg/l

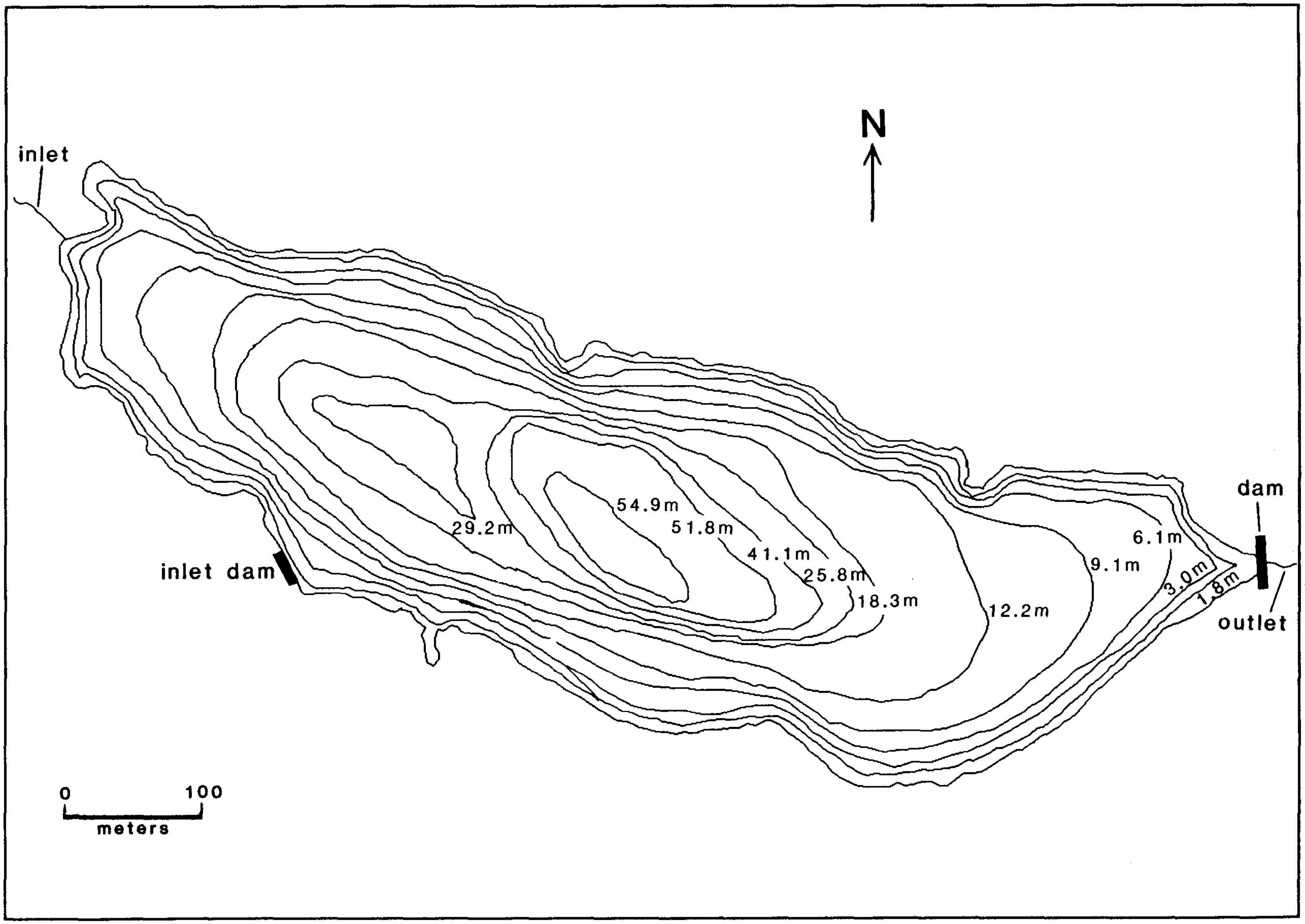


Figure 4. Contour map of Lower Silvis Lake, near Ketchikan, Alaska.

Table 9. Temperature profile, pH, alkalinity, conductivity, and dissolved oxygen measurements from Lower Silvis Lake (23 August 1988).

Lake Characteristics

Temperature Profile

Depth (m)	Temperature (°C)
surface	11.0
2	10.0
4	10.0
6	9.0
8	8.5
10	8.2
12	8.1
14	8.0
16	8.0
18	8.0
20	8.0
22	8.0
24	8.0
26	8.0
28	8.0
30	8.0
32	8.0
34	8.0
36	8.0
38	8.0
40	8.0
42	8.0
44	8.0
46	7.8
48	7.6
50	7.5

Water Chemistry

surface:

pH = 5.5
alkalinity = 15 mg/l
conductivity = 8 μmhos
dissolved oxygen = mg/l

mid depth (40 m):

pH = 6.0
conductivity = 10 μmhos

Population Status

Lengths and weights were measured from sampled fish from all three lakes. The relationship between weight and length for each species of fish in each lake is summarized in the following sections.

Carlanna Lake:

A total of 228 paired lengths and weights were collected from rainbow trout captured in Carlanna Lake (Figure 5). Lengths ranged from 60 mm (2.4 in) to 398 mm (15.7 in), and averaged 177 mm (6.98 in) with a standard error of 4.48 mm (0.176 in). Trout weights ranged from 2.9 g (0.0064 lb) to 610.0 g (1.34 lb), and averaged 95.2 g (0.021 lb) with a standard error of 6.91 g (0.015 lb). Condition factors ranged from 0.68 to 3.50 and averaged 1.25 with a standard error of 0.019.

Lower Leask Lake:

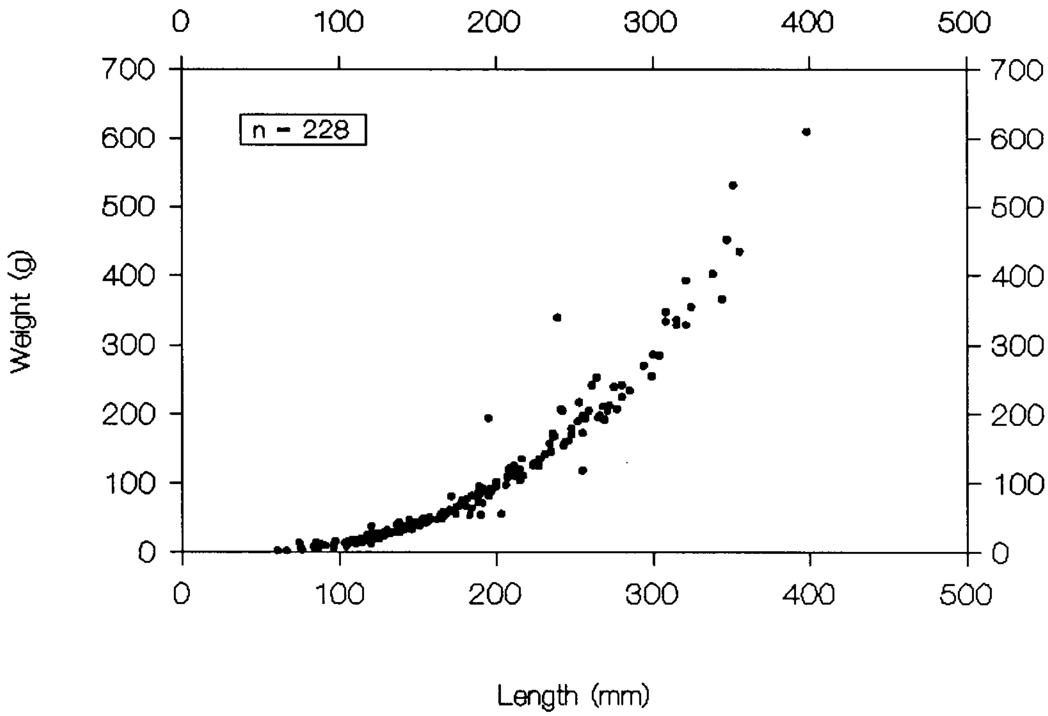
A total of 177 paired lengths and weights were collected from cutthroat trout captured in Lower Leask Lake (Figure 6). Lengths ranged from 106 mm (4.17 in) to 341 mm (13.4 in) and averaged 210 mm (8.28 in). Weights ranged from 11.7 g (0.0258 lb) to 456.9 g (1.01 lb), and averaged 109.8 g (0.242 lb) with a standard error of 6.12 g (0.0135 lb). The mean condition factor was 0.99 with a standard error of 0.013.

A total of 301 paired lengths and weights were collected from Dolly Varden captured in Lower Leask Lake (Figure 7). Lengths ranged from 81 mm (3.19 in) to 305 mm (12.0 in), and averaged 165 mm (6.51 in) with a standard error of 2.15 mm (0.0847 in). Weights ranged from 4.8 g (0.0106 lb) to 311.5 g (0.687 lb), and averaged 52.8 g (0.116 lb) with a standard error of 2.27 g (0.005 lb). The mean condition factor was 1.03 with a standard error of 0.022.

A total of 179 paired lengths and weights were collected from juvenile coho salmon captured in Lower Leask Lake (Figure 8). Lengths ranged from 45 mm (1.77 in) to 125 mm (4.92 in), and averaged 99 mm (3.9 in) with a standard error of 1.32 mm (0.0519 in). Weights ranged from 0.8 g (0.00176 lb) to 22.9 g (0.0505 lb), and averaged 13.4 g (0.0295 lb) with a standard error of 0.346 mm (0.000763 in). The mean condition factor was 1.44 with a standard error of 0.064.

Lower Silvis Lake:

A total of 64 paired lengths and weights were collected from rainbow trout captured in Lower Silvis Lake (Figure 9). Lengths ranged from 87 mm (3.43 in) to 425 mm (16.7 in), and averaged 217 mm (8.53 in) with a standard error of 9.29 mm (0.366 in). Weights ranged from 9.2 g (0.0203 lb) to 688.4 g (1.52 lb), and averaged 144.4 g (0.318 lb) with a standard error of 17.8 g (0.0393 lb). The mean condition factor was 1.12 with a standard error of 0.032.



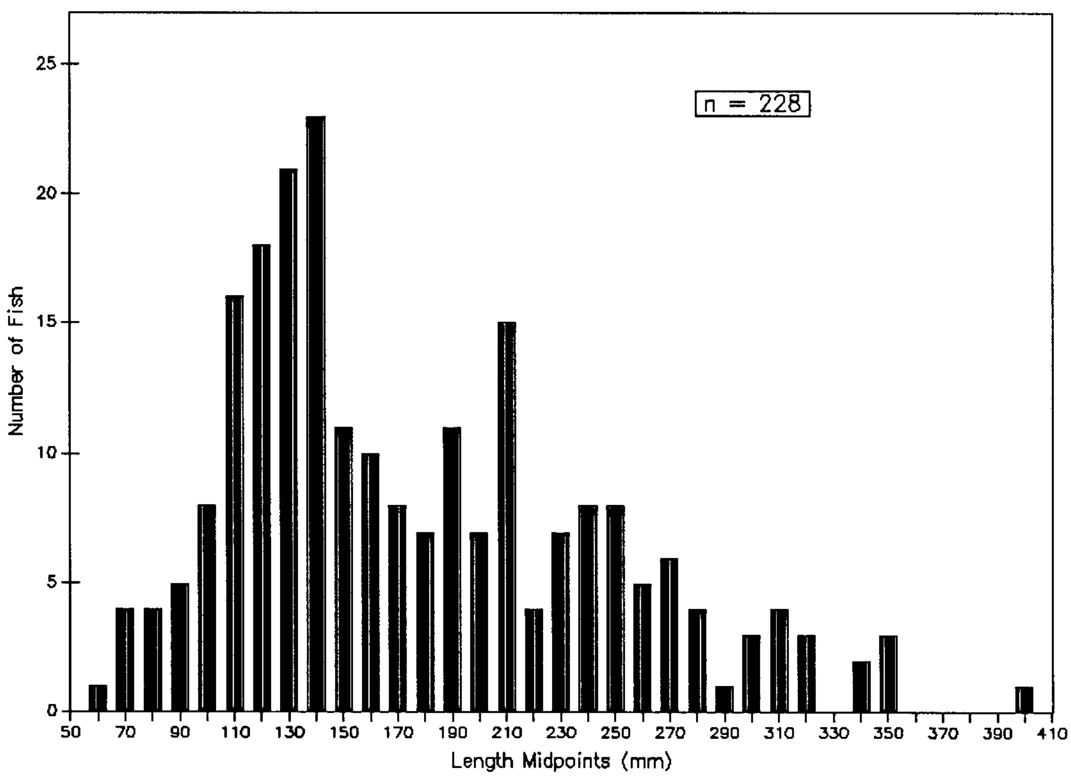


Figure 5. Weight versus length scatterplot and length frequency histogram of rainbow trout sampled from Carlanna Lake near Ketchikan, Alaska, 1988.

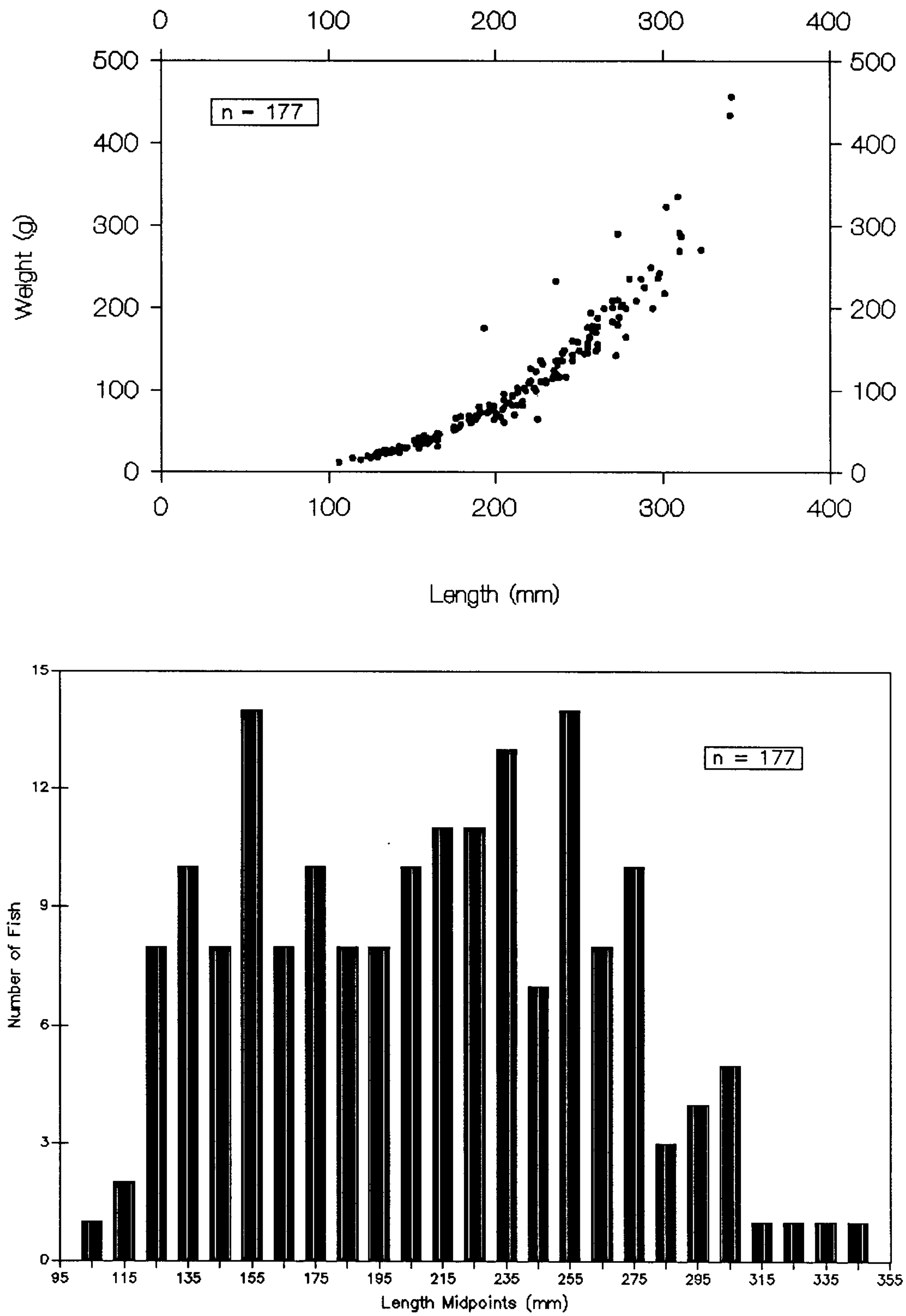
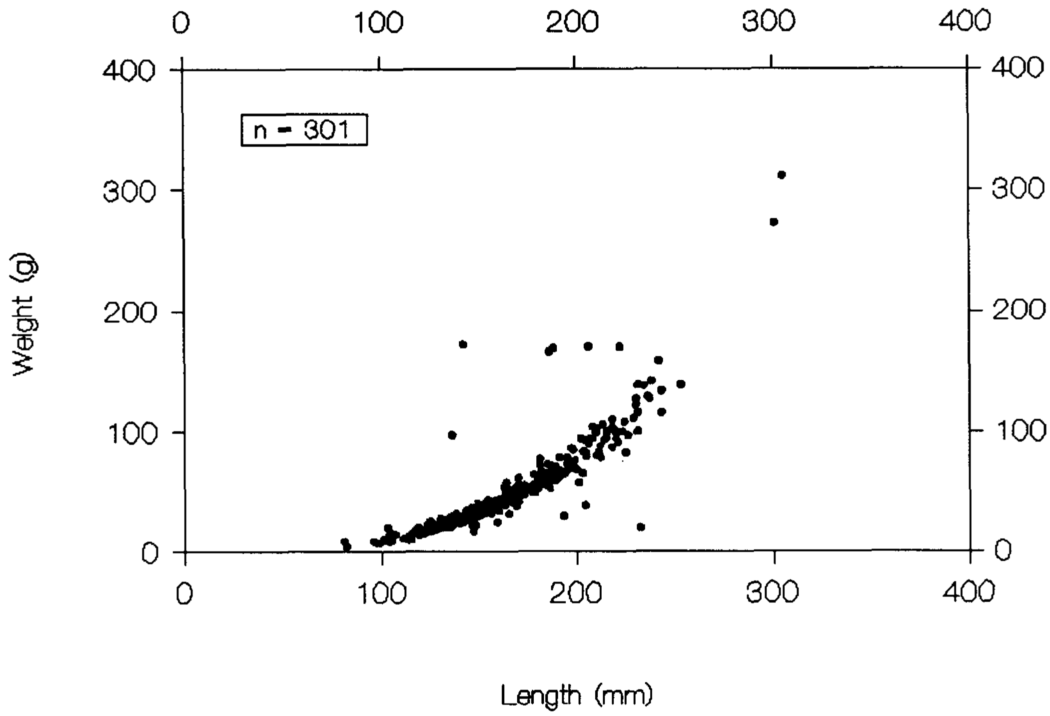


Figure 6. Weight versus length scatterplot and length frequency histogram of cutthroat trout sampled from Lower Leask Lake near Ketchikan, Alaska, 1988.



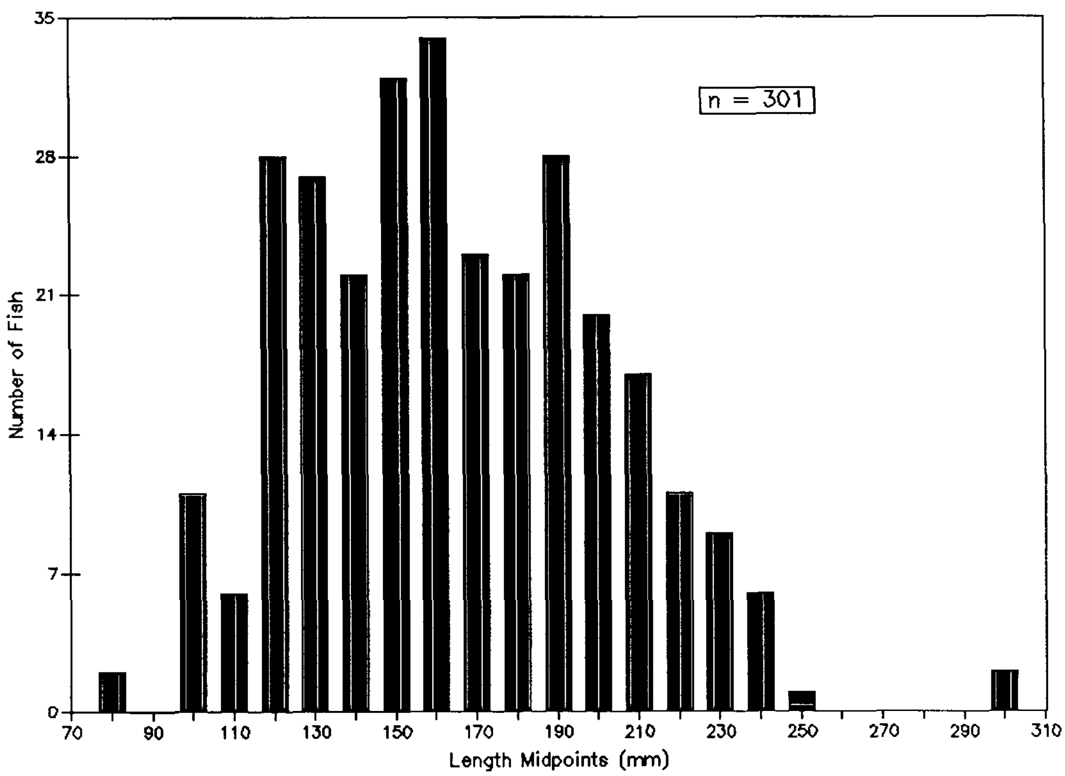
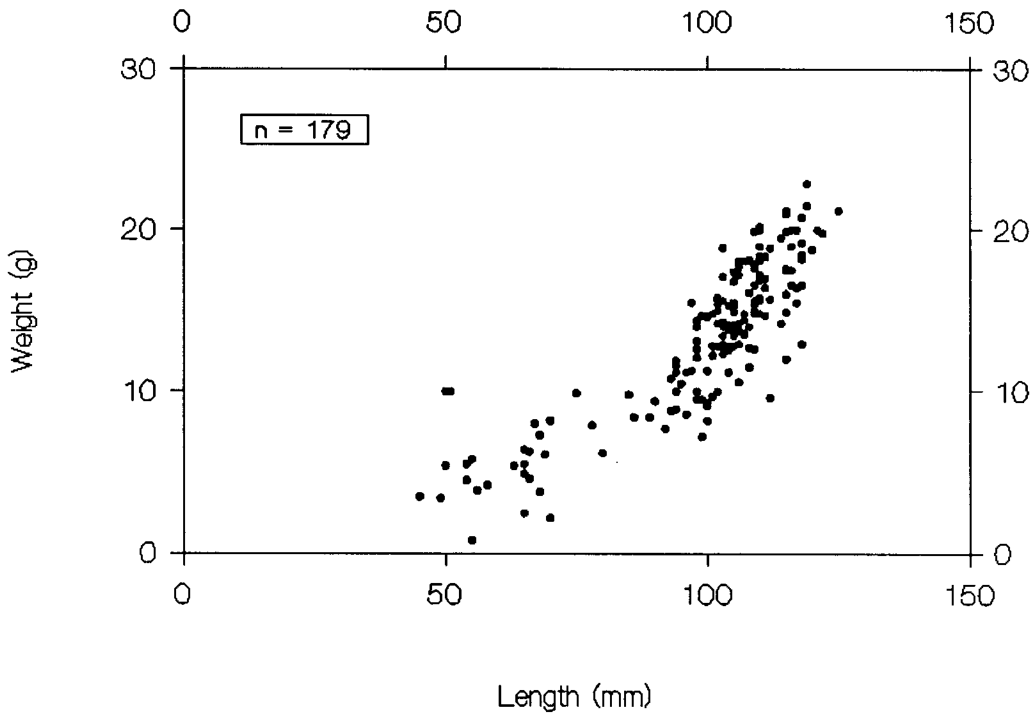


Figure 7. Weight versus length scatterplot and length frequency histogram of Dolly Varden sampled from Lower Leask Lake near Ketchikan, Alaska, 1988.



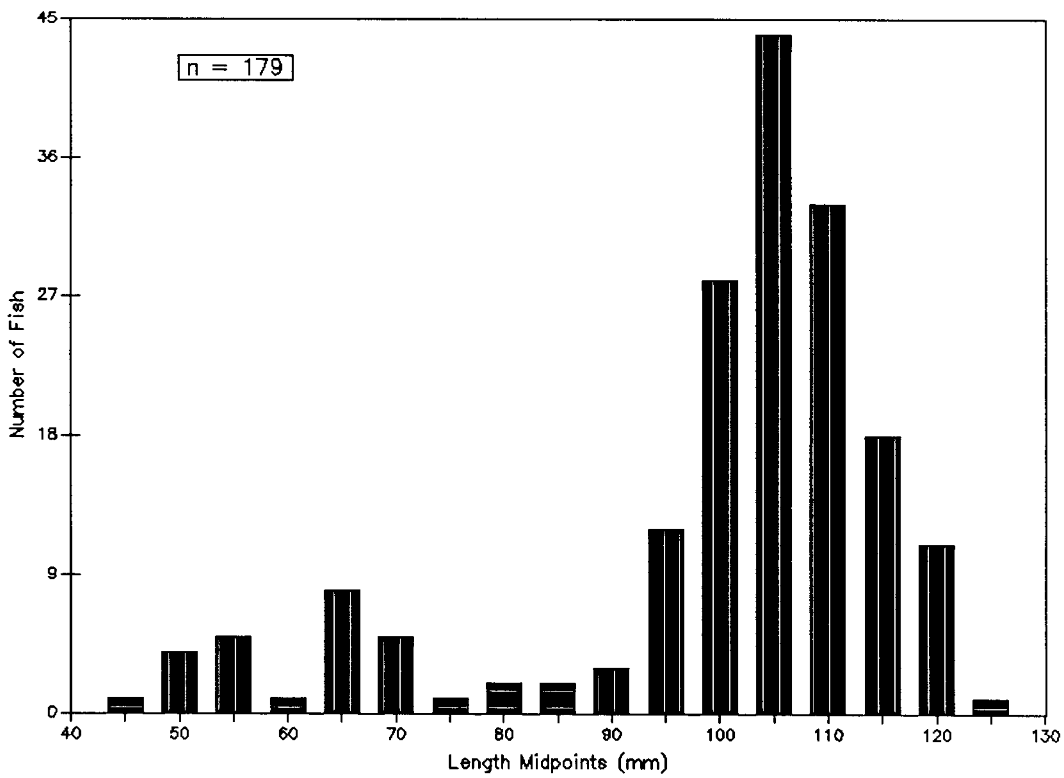


Figure 8. Weight versus length scatterplot and length frequency histogram of coho salmon sampled from Lower Leask Lake near Ketchikan, Alaska, 1988.

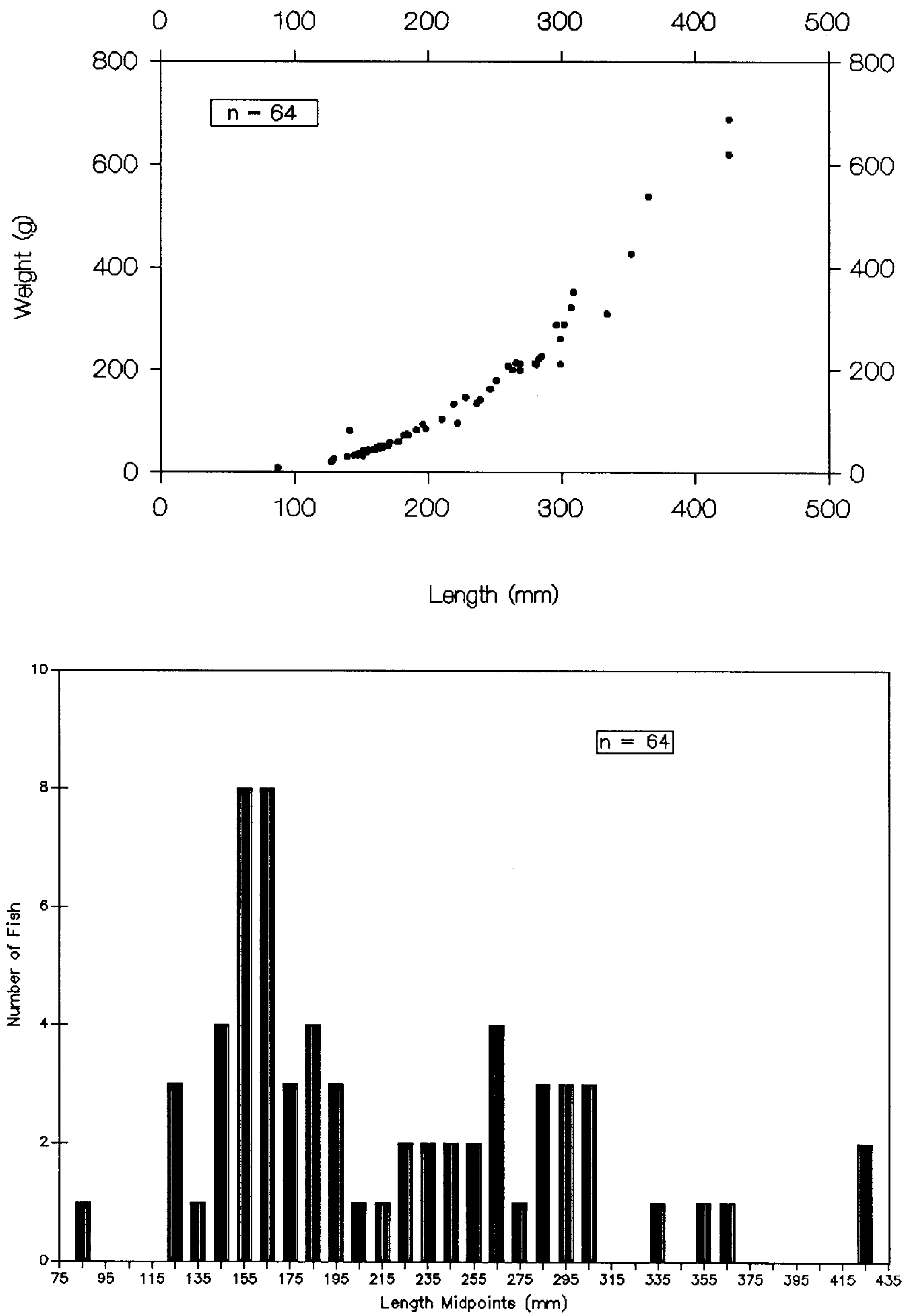


Figure 9. Weight versus length scatterplot and length frequency histogram of rainbow trout sampled from Lower Silvis Lake near Ketchikan, Alaska, 1988.

DISCUSSION

Carlanna Lake was stocked with an unknown number of rainbow trout in 1954 or 1955. The present population appears to be in good condition with all size classes represented in the catch (Figure 5). The good condition factor and the high MEI and potential yield indicate that the lake's physical attributes are conducive to production of fish biomass (Table 10). The CPUE for hook and line sampling (Table 1) indicates that the lake can provide a good fishing experience when conditions are good. We seemed to have better luck with hook and line during cloudy or rainy weather, and trolling small spinners or spoons seemed most effective. Although we have no quantitative information about the sport fishing pressure on Carlanna Lake, our observations while we were sampling indicate that sport fishing occurred only occasionally. Hence, current fishing levels probably do not warrant any enhancement activities, but if proposals to make the lake available to the general public are acted upon, future enhancement activities will probably be needed. Stocking additional rainbow trout in the lake would probably be the most feasible enhancement activity, but a modest lake fertilization program could be considered.

Lower Leask Lake contains natural populations of cutthroat trout, Dolly Varden, coho salmon and sockeye salmon. The population of cutthroat trout appears to be small, as does the Dolly Varden population. As has been mentioned, the low catch rates in the baited traps during the second sampling period were probably related to the increased activity of adult salmon in the system at the time. Our inability to catch Dolly Varden on hook and line indicates that fishing techniques that are successful with respect to cutthroat trout (i.e., trolling small spinners and spoons, and fly fishing) are not effective with respect to Dolly Varden. However, the presence of coho and sockeye salmon, and the close proximity of Upper Leask Lake (which is about twice as large as Lower Leask Lake) adds greatly to the recreational fishing opportunities. The aesthetic beauty of the area and associated wildlife also add to the recreational values of this system. Current sport fishing pressure probably does not warrant enhancement activities at this time, but if proposed logging roads do increase accessibility to the lake for the general public and sport fishing pressure increases substantially, the need for enhancement activities could arise. If so, we feel that additional research would needed so that the interactions between the various species throughout the drainage system could be more thoroughly documented, and the effects of enhancement activities could be predicted with more accuracy.

Lower Silvis Lake contains a small population of rainbow trout resulting from a plant of 5,000 eyed eggs in Lower Silvis Lake, and 10,000 eyed eggs in Upper Silvis Lake in 1954. The absence of small trout (<80 mm) and the limited spawning area in the lake may indicate that the population of the lower lake is sustained by trout coming down from the upper lake. The low MEI and potential productivity of the lower lake tend to support this idea (Table 10). We observed a few anglers fishing the Lower Silvis Lake while we were there. However, most of these anglers appeared to fish in the lower lake only for a short period before hiking to the upper lake. One angler turned in a Floy tag from a ripe female rainbow trout that was caught on 18 September 1988. Probably the most feasible enhancement activity for this lake would be periodic stocking of rainbow trout.

Table 10. Comparison of parameters associated with three Ketchikan lakes studied in 1988 (in CAPS) and with other lakes in Southeast Alaska.

Lake	Conductance (μmhos)	TDS[1] (mg/l)	A (ha)	Z (m)	MEI[2]	YIELD[3] (kg/ha)
CARLANNA	190	125[4]	13.7	20.6	6.00	2.37
LOWER LEASK	30	20[4]	14.4	19.0	1.03	0.98
LOWER SILVIS	8	5[4]	14.1	11.1	0.47	0.66
Waterfall[5]	15	22[4]	5.4	1.9	11.50	3.27
Wolf[5]	...	...	24.8	13.2	...	...
Harriett Hunt[5]	20	13[4]	78.3	24.7	0.53	0.70
Helen[6]	50	35[7]	14.5	3.7	9.46	2.97
Red[6]	93	65[7]	166.0	10.4	6.25	2.41
Mountain[6]	100	59	83.0	20.5	2.88	1.64
Situk[6]	105	60	408.0	27.3	2.20	1.43
Streets[6]	30	21	60.7	11.0	1.91	1.34
Finger[6]	28	20[7]	347.0	10.7	1.87	1.32
Tammy[6]	25	18[7]	134.0	10.0	1.80	1.30
Green[6]	39	22	70.0	12.3	1.79	1.29
Salmon[6]	26	18	41.1	10.4	1.75	1.28
Bear[6]	29	21[7]	30.7	12.2	1.66	1.24
Klawak[6]	39	24	1177.0	17.7	1.36	1.13
Hofstad[6]	17	12[7]	60.3	9.8	1.22	1.07
Auke[6]	28	20	46.0	19.0	1.05	0.99
Virginia[6]	18	13[7]	258.0	13.0	1.00	0.97
Manzanita[6]	60	42[7]	625.0	49.0	0.86	0.89
Salmon Bay[6]	30	21[7]	388.0	26.7	0.79	0.86
Sitkoh[6]	39	27[7]	209.5	35.2	0.77	0.85
Heckman[6]	17	14	163.0	19.7	0.71	0.81
Spurt[6]	16	14	107.0	22.2	0.63	0.77
Karta[6]	26	16	508.0	27.6	0.58	0.74
Bugge[6]	20	14[7]	66.8	24.0	0.58	0.74
Akwe[6]	48	28	216.0	50.1	0.56	0.72
De Boer[6]	13	13	51.0	23.0	0.56	0.72
Wilson[6]	51	36[7]	468.0	54.0	0.67	0.69
Ella[6]	47	33[7]	710.0	70.0	0.47	0.66
Patching[6]	17	14	207.0	30.2	0.46	0.66
Blue[6]	33	22	538.0	52.0	0.42	0.63
Turner[6]	15	10[7]	1270.0	30.0	0.33	0.55
Plotnikof[6]	14	10	320.4	37.4	0.27	0.50
Osprey[6]	20	14	109.0	60.0	0.23	0.46
Baranof[6]	22	8[7]	323.6	39.0	0.20	0.43
Swan[6]	20	16	208.0	91.4	0.18	0.41
Avoss[6]	21	8[7]	123.7	45.8	0.18	0.41
Davidof[6]	12	8	140.8	52.5	0.15	0.38
Lonieof[6]	5	4[7]	179.0	55.1	0.07	0.25
Rezanof[6]	3	2[7]	354.0	71.2	0.03	0.17

1 TDS = Total Dissolved Solids

2 MEI = Morphoedaphic Index

3 Ryder (1965) described the equation $y \approx 2\sqrt{x}$ where y = yield in pounds per acre and mean depth (Z) was in feet. The metric expression is therefore $y \approx 0.966\sqrt{x}$ where yield is fish yield as kg/ha and x = MEI.

4 Calculated as 0.65 x specific conductance.

5 Data source is Hubartt and Bingham (1988).

6 Data source is Schmidt (1983).

7 Calculated as 0.70 x specific conductance.

Due to the possible biases in our population estimates, as noted above, any future enhancement activities planned for these lakes should be preceded by a more directed individual study of the lake involved.

ACKNOWLEDGEMENTS

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