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EVALUATION OF LAKE CHARACTERISTICS AND
FISH POPULATION SIZE AND STATUS
FOR THREE LAKES IN THE VICINITY
OF KETCHIKAN, ALASKA, DURING 1989¹

By

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ABSTRACT

Three lakes in the Ketchikan area were sampled to estimate the population size of sport fish species, to document lake characteristics, and to determine the current condition of fish populations present.

Connell Lake is a dammed lake that is inaccessible to anadromous fish species, with a surface area of 149.3 hectares (368.9 acres), a mean depth of 12.0 meters (39.5 feet) and a morphoedaphic index of 1.16. Connell Lake contained populations of cutthroat trout *Oncorhynchus clarki* and Dolly Varden *Salvelinus malma*. Population estimates were not obtained because too few marked fish were recaptured. A total of 88 cutthroat trout and 35 Dolly Varden were captured and released alive. The cutthroat trout in the population were in average condition (mean condition factor = 1.04, standard error = 0.01), and the Dolly Varden were in good condition (mean condition factor = 1.17, standard error = 0.02).

Talbot Lake is a small lake that is inaccessible to anadromous fish species, with a surface area of 27.6 hectares (68.2 acres), a mean depth of 13.3 meters (43.7 feet) and a morphoedaphic index of 1.05. Talbot Lake contained populations of cutthroat trout and Dolly Varden. No population estimate was obtained for cutthroat trout because of too few recaptures, although 66 cutthroat trout were captured and released alive. The population estimate for Dolly Varden was 820 fish with 95 percent confidence interval limits ranging from 633 to 1,007 Dolly Varden. The Talbot Lake cutthroat trout were in average condition (mean condition factor = 1.00, standard error = 0.01). The Dolly Varden were also in average condition (mean condition factor = 1.09, standard error = 0.05).

Perseverance Lake is a lake that is inaccessible to anadromous fish species, with a surface area of 73.0 hectares (180.3 acres). The lake's mean depth was estimated to be 26.2 meters (85.9 feet), and it had a morphoedaphic index of only 0.27. Perseverance Lake contained populations of brook trout *Salvelinus fontinalis* and rainbow trout *Oncorhynchus mykiss*. Population estimates were not obtained because too few marked fish were recaptured. A total of 32 brook trout and 15 rainbow trout were captured, marked, and released alive. The brook trout were in good condition with a mean condition factor of 1.37 (standard error = 0.13).

KEY WORDS: Southeast Alaska, rainbow trout, *Oncorhynchus mykiss*, cutthroat trout, *Oncorhynchus clarki*, Dolly Varden, *Salvelinus malma*, brook trout, *Salvelinus fontinalis*, Ketchikan, Revillagigado Island, Connell Lake, Talbot Lake, Perseverance Lake, enhancement, bathymetry, total dissolved solids, conductivity, yield, Morphoedaphic Index, condition factor, capture-recapture population estimation, catch per unit effort.

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. A task force consisting of local recreational anglers and Alaska Department of Fish and Game (ADF&G) staff met during the winter of 1987 to develop strategic plans regarding sport fishing in the Ketchikan area. During the planning process, several lakes were identified as 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.

This report describes the third 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); during 1988, Carlanna Lake, Lower Leask Lake, and Lower Silvis Lake were investigated and reported by Hubartt and Bingham (1989). The lakes examined during 1989 were Connell Lake, Talbot Lake, and Perseverance Lake (Figure 1).

Connell Lake is a dammed lake on the Ward Creek drainage which enters Ward Cove about 6.4 km (4 miles) north of Ketchikan. The lake supplies water for the Ketchikan Pulp Mill located at Ward Cove, and is one of four lakes in the system (Figure 1). The lake and an access road are on land that belongs to the United States Department of Agriculture (USDA), Forest Service, and the area is open to the public for recreational use. The dam at the outlet of the lake is a barrier to upstream migration of anadromous fishes.

Talbot Lake is another of the four lakes on the Ward Creek drainage. The lake is located on private property owned by the Cape Fox Corporation, and access is by permission only. There is a small inlet stream on the east end of the lake, and the outlet stream on the west end drains into Connell Lake.

Perseverance Lake is the highest in elevation of the four lakes that are part of the Ward Creek drainage. The lake is also located on land that belongs to the USDA Forest Service. There is a small inlet stream on the south end of the lake, and the outlet stream on the north end drains into Connell Lake.

Development of new freshwater fishing opportunities for the general public in the Ketchikan area is the overall goal of this research project. The objective of this report is to describe the three lakes by examining the abundance 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 abundance of species of sport fish in Connell, Talbot, and Perseverance lakes;
2. estimate the potential productivity in Connell, Talbot, and Perseverance lakes; and,
3. assess the status of current populations of sport fish species in Connell, Talbot, and Perseverance lakes.

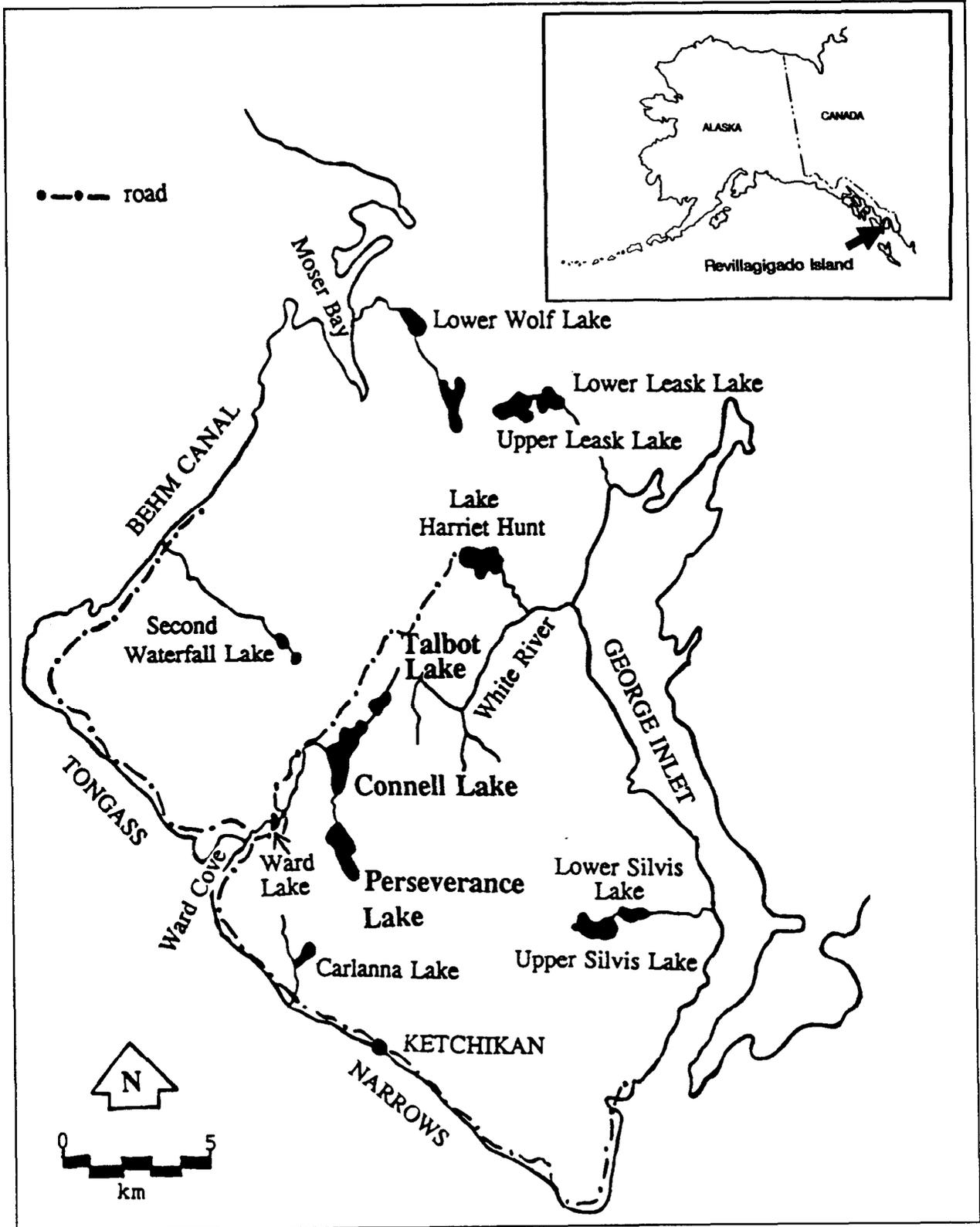


Figure 1. Lakes examined on Revillagigado Island.

METHODS

Lake Characteristics

Bathymetric maps were constructed 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 to map Connell Lake, seven transects were used to map Talbot Lake, and nine transects were used to map Perseverance Lake. Water and chemistry measurements (temperature profile, dissolved oxygen, pH, alkalinity, and conductivity) were collected from single stations located at the area of maximum depth on Connell, Talbot, and Perseverance 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

CF₁ = conversion factor to convert the vernier reading to the map scale

CF₂ = conversion factor to convert the map scale to acres or hectares

$$V = \sum_{i=1}^n \left\{ \left(\frac{h}{3} \right) (A_i + A_{i+1} + \sqrt{A_i A_{i+1}}) \right\} \quad (2)$$

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 ith horizontal stratum

$$Z = \frac{V}{A} \quad (3)$$

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

$$TDS = .07 C \quad (4)$$

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):

$$MEI = \frac{TDS}{Z} \quad (5)$$

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

$$y = 0.966 \sqrt{MEI} \quad (6)$$

MEI and y were 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. I chose to continue to use the "incorrect" equation (equation (6) above) in order to maintain comparability with previous studies (e.g., Schmidt 1983; Hubartt and Bingham 1988; and Hubartt and Bingham 1989).

Status of Fish Populations

Paired length and weight samples were obtained from all newly captured fish (see Fish Population Estimates section below). The relative condition of populations at the time of sampling was estimated by the condition factor (K) using the formula:

$$K = 10^5 \frac{\text{Weight (g)}}{(\text{Fork Length (mm)})^3} \quad (7)$$

The mean and standard deviation of condition factors were calculated using standard normal procedures. Parameters in the length-weight relationship were estimated using MS CHART.

Fish Population Estimates

Multiple mark-recapture experiments were conducted on each study lake in order to estimate the abundance of each sport fish species. Fish were captured, marked, and recaptured in Connell, Talbot, and Perseverance lakes in the Ketchikan area (Figure 1) during June through September 1989. Three 5-day sampling periods were spent on each lake.

Fish were captured using Gee minnow traps (small traps), a larger version of the Gee minnow trap constructed of Vexar and aluminum (large traps), and hook and line. Both large and small traps were baited with salmon eggs that 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 salmonids 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 salmonids that were captured were marked, only fish that 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; and Dolly Varden *Salvelinus malma*, 165 mm. 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 2-phenoxyethanol; identified to species; counted 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 millimeter); 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). The program automatically selected the appropriate estimator (e.g., jackknife, Zippin, generalized removal) for the best fit model (i.e., M_0 : constant capture probabilities across time and animals; M_p : 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_{tbb}). The program was also used to test for closure to determine 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, I tested the hypothesis that the mixture of gear 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 $\alpha = 0.05$.

If the closure test was rejected, indicating that the population was open, 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 normal procedures (Ricker 1975).

RESULTS

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. All of the lake characteristic measurements were taken only once, and do not reflect any seasonal variation.

Connell Lake:

The surface area of Connell Lake (Figure 2) is 149.3 hectares (368.9 acres) and the elevation is approximately 77.4 meters (254 feet). The volume of the lake

is 1,798.9 hectare-meters (14,583.1 acre-feet) and the mean depth is 12.0 meters (39.5 feet).

Specific conductance was 20 micromhos (Table 1). This produced an estimate of TDS of 14.0 mg/l, a MEI of 1.16, and a potential annual yield of 1.04 kg/ha of fish flesh.

Talbot Lake:

The surface area of Talbot Lake (Figure 3) is 27.6 hectares (68.2 acres) and the elevation is approximately 78.3 meters (257 feet). The volume of the lake is 367.1 hectare-meters (2,975.8 acre-feet) and the mean depth is 13.3 meters (43.7 feet).

Specific conductance was 20 micromhos near the surface (Table 2). TDS was 14.0 mg/l, the MEI was 1.05, and the potential annual yield was 0.99 kg/ha.

Perseverance Lake:

The surface area of Perseverance Lake (Figure 4) 73.0 hectares (180.4 acres) and the elevation is approximately 157.9 meters (518 feet). The lake volume is 1,910.0 hectare-meters (15,483.7 acre-feet), and the mean depth is 26.2 meters (85.9 feet).

Specific conductance was 10 micromhos near the surface (Table 3). TDS was calculated to be 7.0 mg/l, the MEI was 0.27, and potential annual yield was 0.50 kg/ha.

Status of Fish Populations

Connell Lake:

Cutthroat trout and Dolly Varden were captured in Connell Lake on 5-9 June 1989, 29 August - 2 September 1989, and 18-22 September 1989.

Cutthroat trout. A total of 88 paired lengths and weights were collected from cutthroat trout captured in Connell Lake (Figure 5). Lengths ranged from 133 mm (5.2 in) to 359 mm (14.1 in), and averaged 219 mm (8.6 in) with a standard error of 43 mm (1.7 in). Cutthroat trout weights ranged from 27.4 g (0.06 lb) to 448.4 g (0.99 lb), and averaged 121.4 g (0.27 lb) with a standard error of 77.7 g (0.17 lb). Condition factors ranged from 0.60 to 1.65 and averaged 1.04 with a standard error of 0.01.

Dolly Varden. A total of 35 paired lengths and weights were collected from Dolly Varden captured in Connell Lake (Figure 6). Lengths ranged from 129 mm (5.1 in) to 230 mm (9.1 in), and averaged 195 mm (7.7 in) with a standard error of 26 mm (1.0 in). Dolly Varden weights ranged from 22.5 g (0.05 lb) to 164.5 g (0.34 lb), and averaged 90.8 g (0.20 lb) with a standard error of 31.8 g (0.07 lb). Condition factors ranged from 0.68 to 1.55 and averaged 1.17 with a standard error of 0.02.

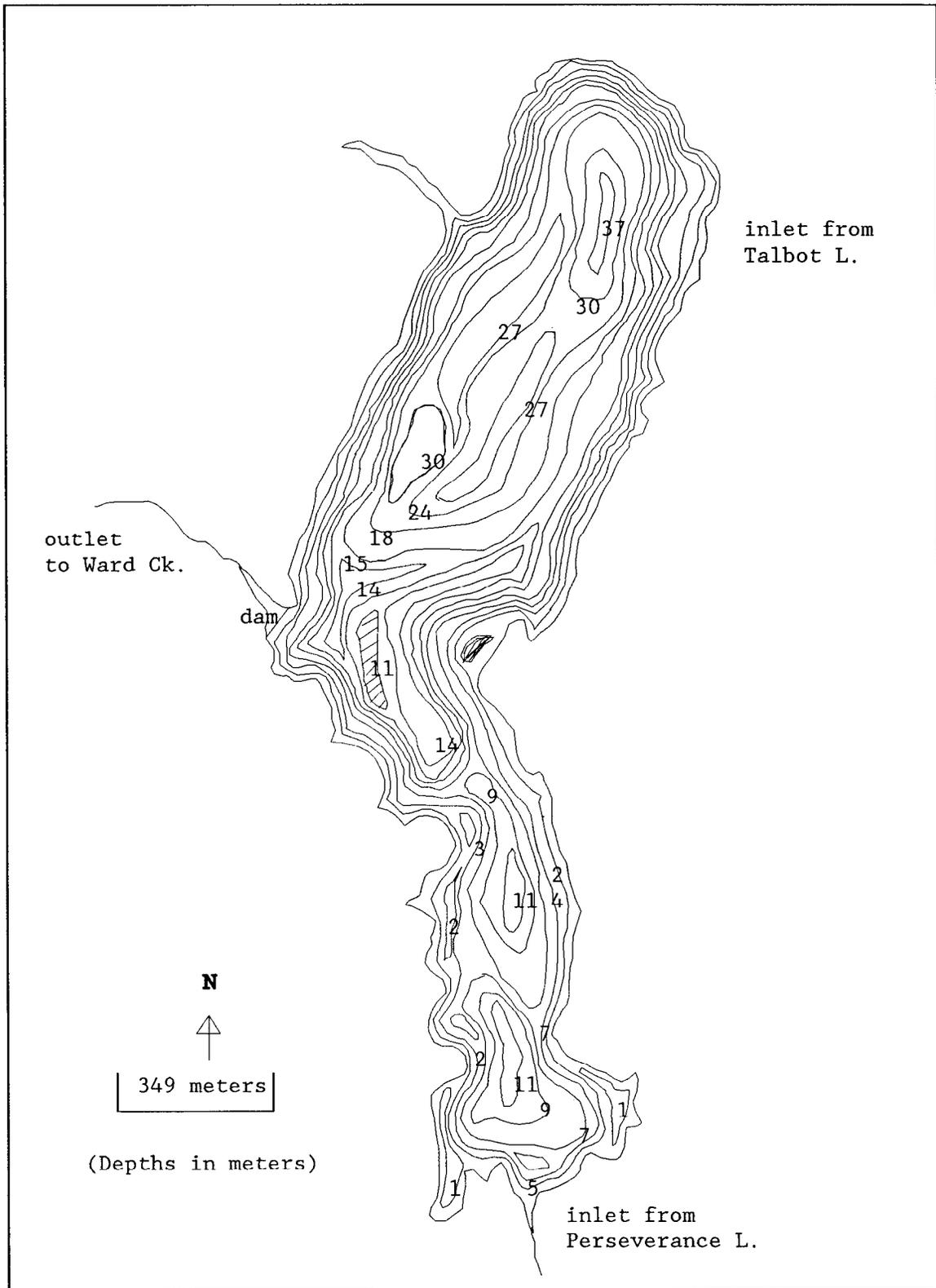


Figure 2. Contour map of Connell Lake near Ketchikan, Alaska.

Table 1. Temperature profile, pH, alkalinity, conductivity, and dissolved oxygen measurements from Connell Lake (20 September 1989).

Lake Characteristics

Temperature Profile

Water Chemistry

Depth (m) Temperature (°C)

surface:

surface 14.0
 2 14.0
 4 14.0
 6 13.5
 8 13.5
 10 13.5
 12 12.0
 14 12.0
 16 11.5
 18 11.0
 20 11.0
 22 11.0
 24 10.0
 26 9.0
 28 8.5
 30 8.0
 32 7.5
 34 7.0
 36 7.0
 38 6.5
 40 6.0
 42 6.0
 44 6.0
 46 5.5
 48 5.5
 50 5.5

pH = 6.5
 alkalinity = 23 mg/l
 conductivity = 20 μ mhos
 dissolved oxygen = 8.47 mg/l

mid depth:

pH = 6.5
 conductivity = 20 μ mhos

near bottom:

pH = 6.5
 alkalinity = 23 mg/l
 dissolved oxygen = 10.02 mg/l

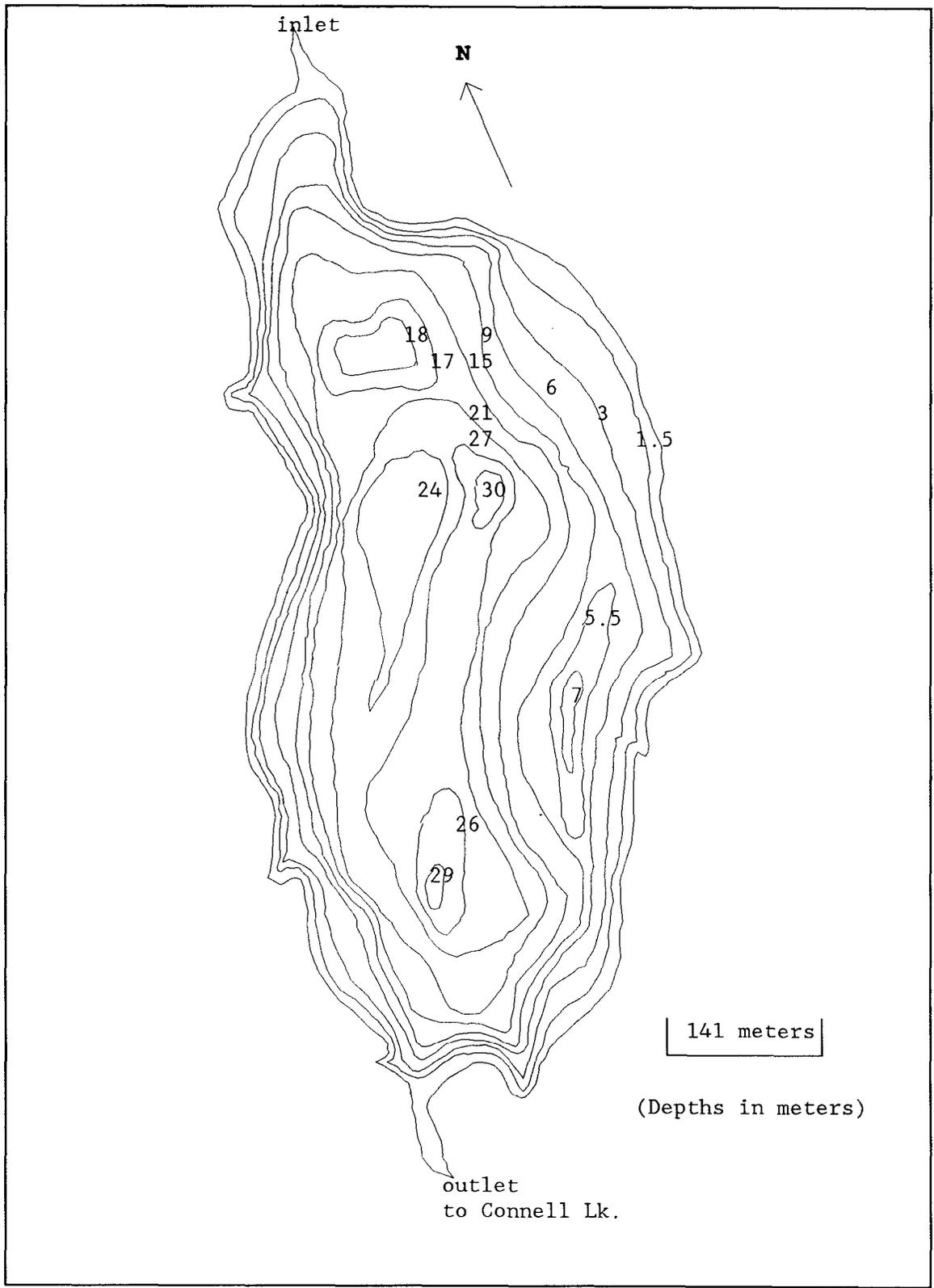


Figure 3. Contour map of Talbot Lake near Ketchikan, Alaska.

Table 2. Temperature profile, pH, alkalinity, conductivity, and dissolved oxygen measurements from Talbot Lake (12 July 1989).

Lake Characteristics

Temperature Profile

Water Chemistry

Depth (m) Temperature (°C)

surface:

surface 22.0
 2 22.0
 4 21.0
 6 20.0
 8 17.0
 10 15.0
 12 14.0
 14 12.0
 16 10.0
 18 9.0
 20 8.0
 22 7.5
 24 7.0
 26 6.5
 28 6.0
 30 6.0
 32 5.5
 34 5.0
 36 5.0
 38 5.0
 40 5.0
 42 4.5
 44 4.5
 46 4.0
 48 4.0
 50 4.0

pH = 6.0
 alkalinity = 22 mg/l
 conductivity = 20 μ mhos
 dissolved oxygen = 1.6 mg/l

mid depth:

pH = 6.0
 conductivity = 20 μ mhos

near bottom:

pH = 6.5
 alkalinity = 26 mg/l
 dissolved oxygen = 5.0 mg/l

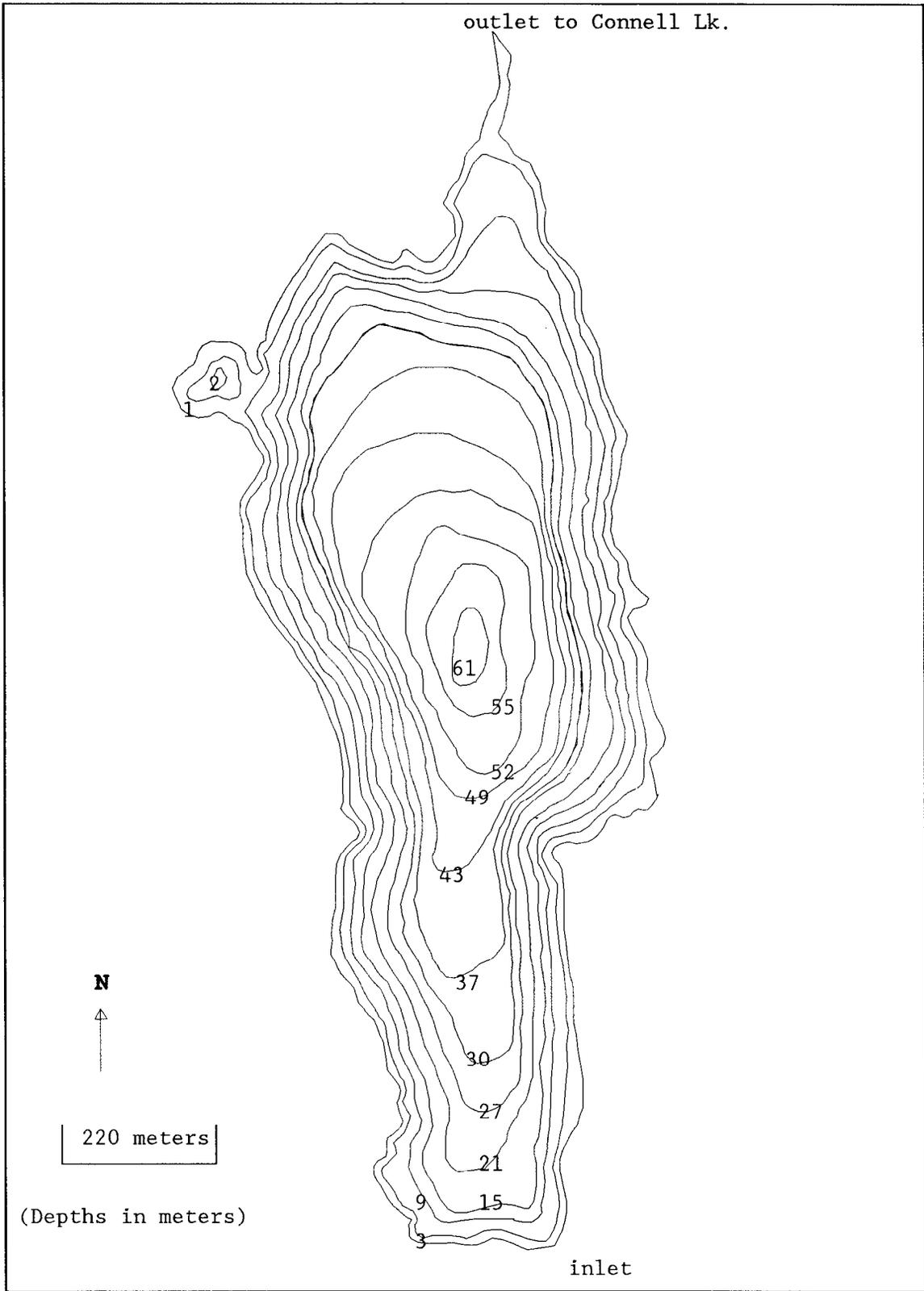


Figure 4. Contour map of Perseverance Lake near Ketchikan, Alaska.

Table 3. Temperature profile, pH, alkalinity, conductivity, and dissolved oxygen measurements from Perseverance Lake (20 July 1989).

Lake Characteristics

<u>Temperature Profile</u>		<u>Water Chemistry</u>
Depth (m)	Temperature (°C)	surface:
surface	17.5	pH = 6.0
2	17.0	alkalinity = 5.1 mg/l
4	17.0	conductivity = 10 μ mhos
6	17.0	dissolved oxygen = 8.9 mg/l
8	17.0	
10	17.0	mid depth:
12	16.5	
14	16.5	pH = 6.0
16	16.5	conductivity = 15 μ mhos
18	15.0	
20	14.0	
22	12.0	near bottom:
24	11.5	
26	10.0	pH = 6.0
28	8.5	alkalinity = 6.1 mg/l
30	7.5	dissolved oxygen = 10.0 mg/l
32	7.0	
34	7.0	
36	6.5	
38	6.0	
40	6.0	
42	5.5	
44	5.0	
46	5.0	
48	5.0	
50	5.0	

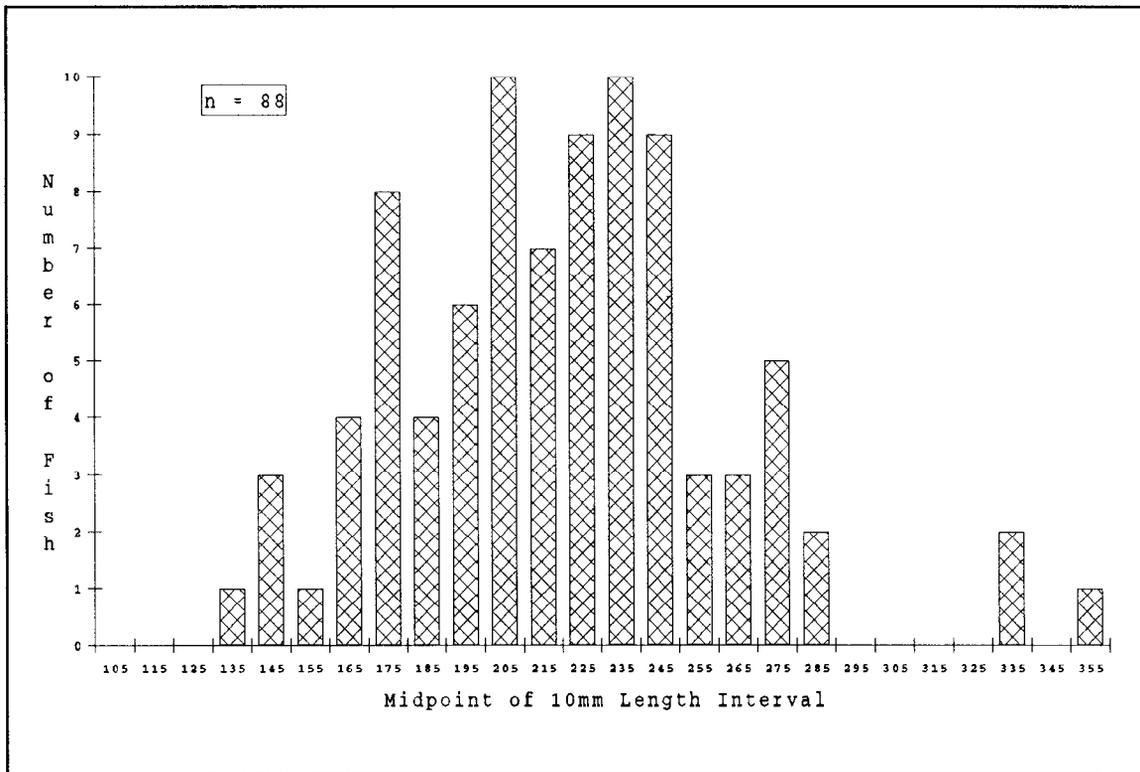
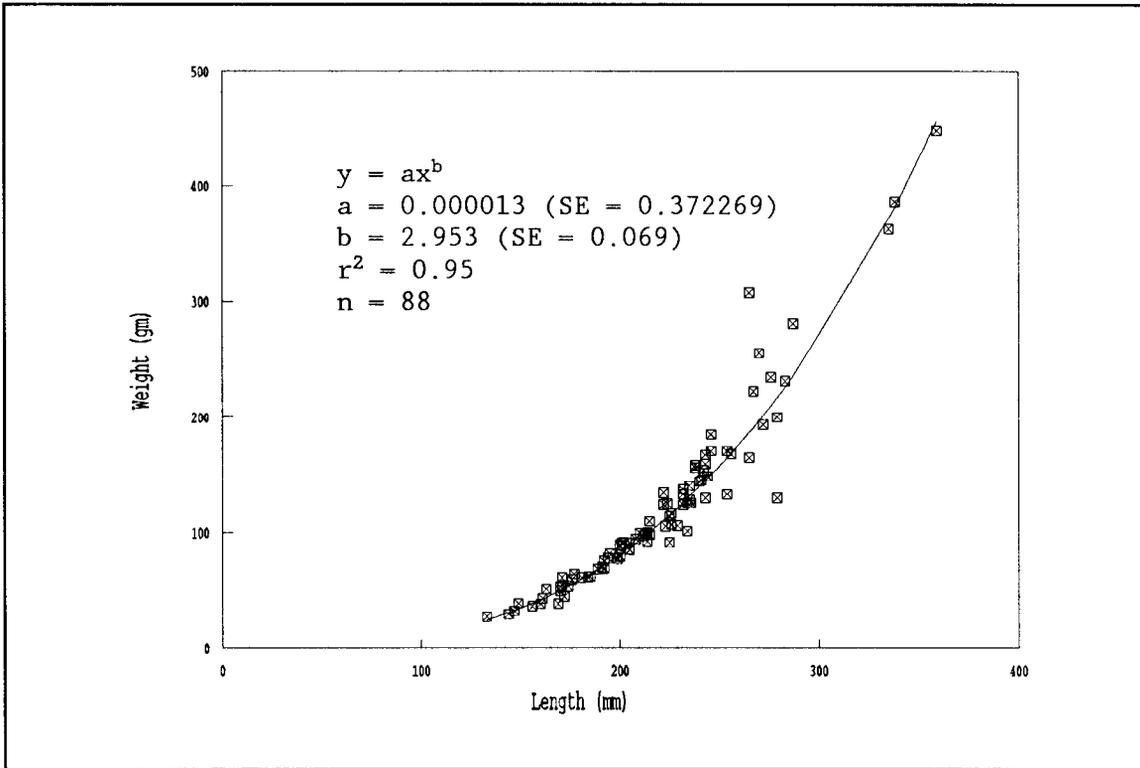


Figure 5. Length-weight relationship and length frequency distribution for cutthroat trout, Connell Lake, Alaska, 1989.

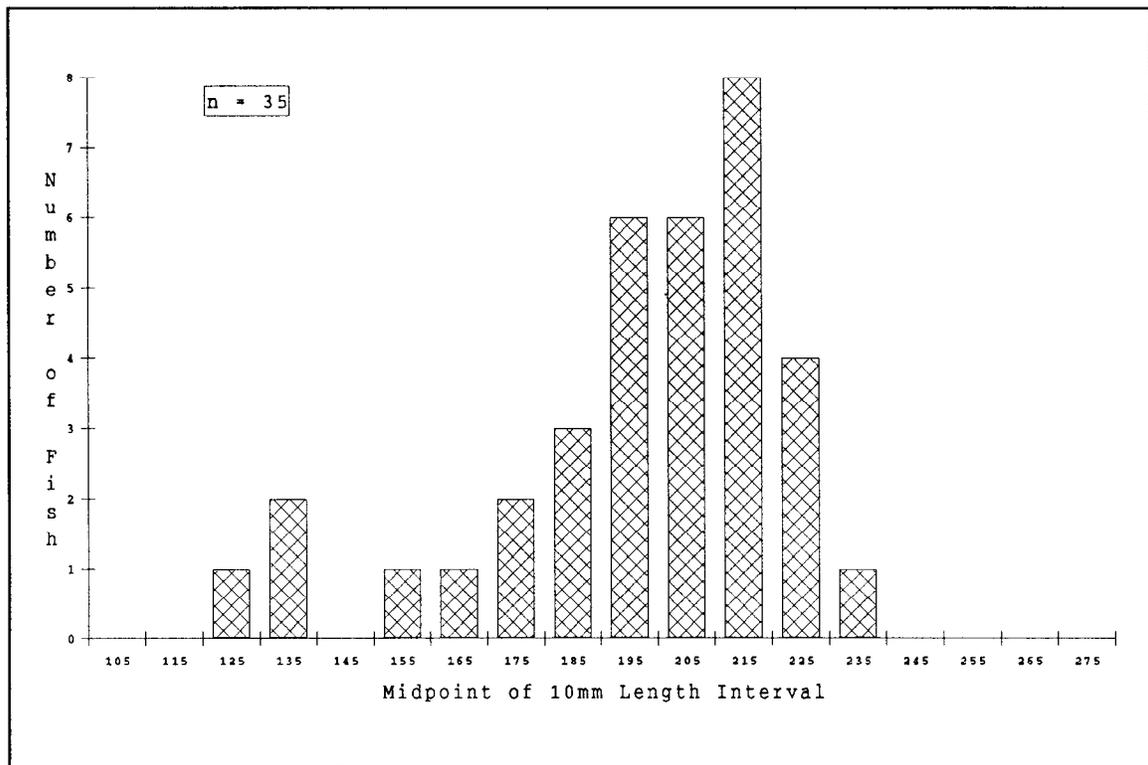
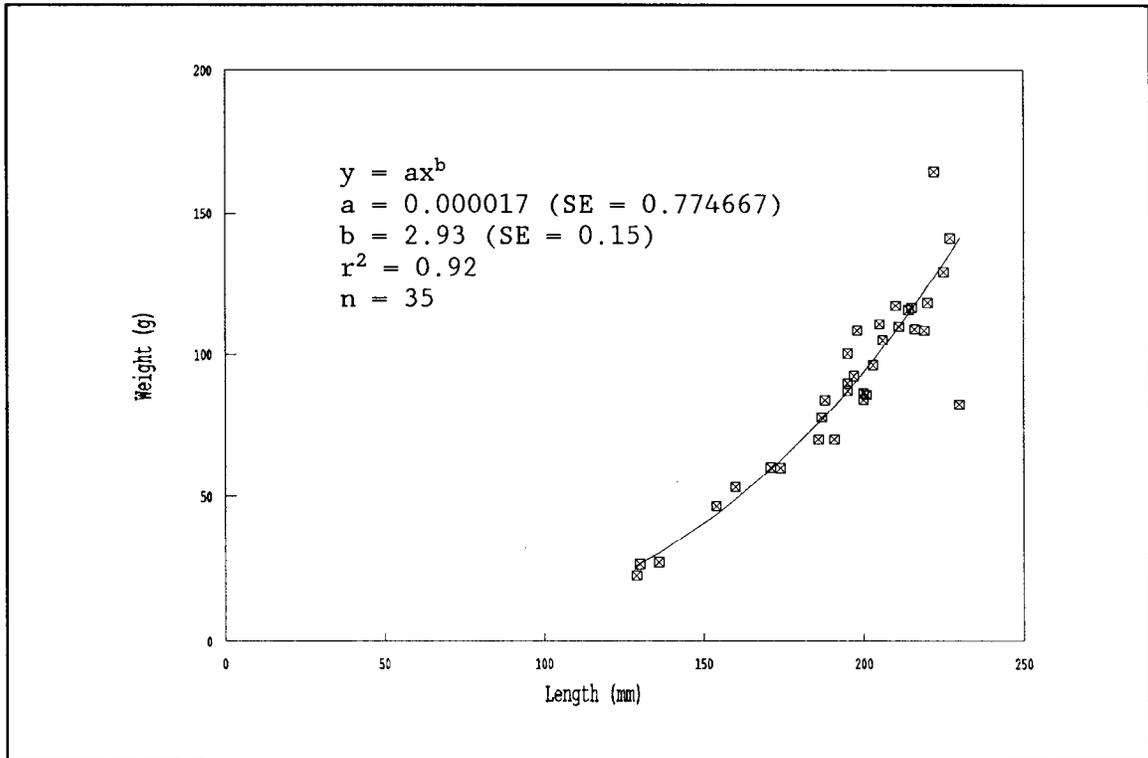


Figure 6. Length-weight relationship and length frequency distribution for Dolly Varden, Connell Lake, Alaska, 1989.

Talbot Lake:

Cutthroat trout and Dolly Varden were captured in Talbot Lake on 12-16 June 1989, 10-14 July 1989, and 14-18 August 1989.

Cutthroat trout. A total of 70 paired lengths and weights were collected from cutthroat trout captured in Talbot Lake (Figure 7). Lengths ranged from 115 mm (4.5 in) to 290 mm (11.4 in), and averaged 196 mm (7.7 in) with a standard error of 32 mm (1.3 in). Cutthroat trout weights ranged from 17.8 g (0.04 lb) to 240.8 g (0.53 lb), and averaged 79.9 g (0.18 lb) with a standard error of 37.8 g (0.08 lb). Condition factors ranged from 0.84 to 1.61 and averaged 1.00 with a standard error of 0.01.

Dolly Varden. A total of 395 paired lengths and weights were collected from Dolly Varden captured in Talbot Lake (Figure 8). Lengths ranged from 104 mm (4.1 in) to 221 mm (8.7 in), and averaged 171 mm (6.7 in) with a standard error of 15 mm (0.6 in). Dolly Varden weights ranged from 11.5 g (0.03 lb) to 110.2 g (0.24 lb), and averaged 55.8 g (0.12 lb) with a standard error of 14.0 g (0.03 lb). Condition factors ranged from 0.47 to 1.66 and averaged 1.09 with a standard error of 0.05.

Perseverance Lake:

Brook trout were captured in Perseverance Lake on 12-16 June 1989, 21-25 August 1989, and 5-9 September 1989.

Brook trout. A total of 32 paired lengths and weights were collected from brook trout captured in Perseverance Lake (Figure 9). Lengths ranged from 95 mm (3.7 in) to 337 mm (13.3 in), and averaged 243 mm (9.6 in) with a standard error of 57 mm (2.2 in). Brook trout weights ranged from 12.8 g (0.03 lb) to 468.2 g (1.03 lb), and averaged 206.6 g (0.46 lb) with a standard error of 117.0 g (0.26 lb). Condition factors ranged from 0.94 to 5.25 and averaged 1.37 with a standard error of 0.13.

Fish Population Estimates

Connell Lake:

A total of 89 cutthroat trout, 36 Dolly Varden, one rainbow trout, 726 sculpins *Cottus sp.*, and 47 stickleback *Gasterosteus sp.* were captured and released during three sampling periods at Connell Lake (Table 4).

Cutthroat trout. During the first sample period (5 June through 9 June 1989), 3 cutthroat trout were captured. There were no mortalities, so the total number of newly marked and released fish in the lake at the end of sample period one was 3 (Table 5).

A total of 18 cutthroat trout were captured during sampling period two (29 August through 2 September 1989). There were no mortalities, so the total number of marked fish in the lake at the end of sampling period two was 21 cutthroat trout (Table 5).

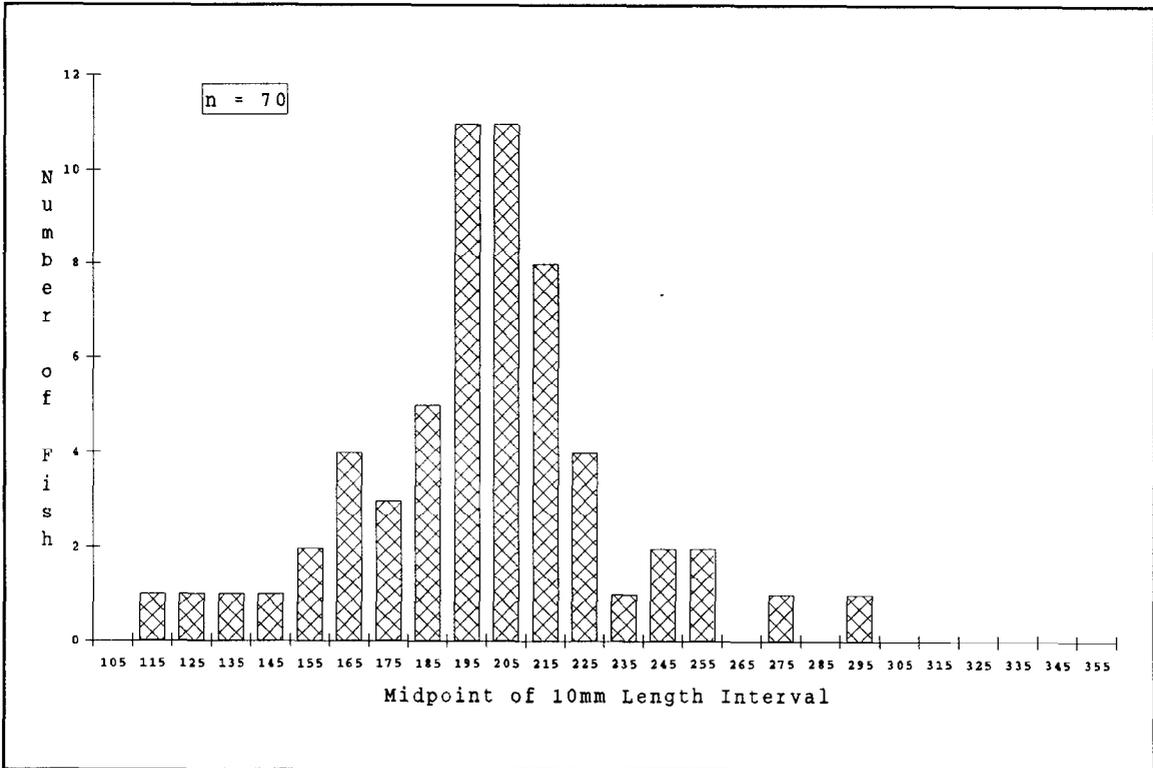
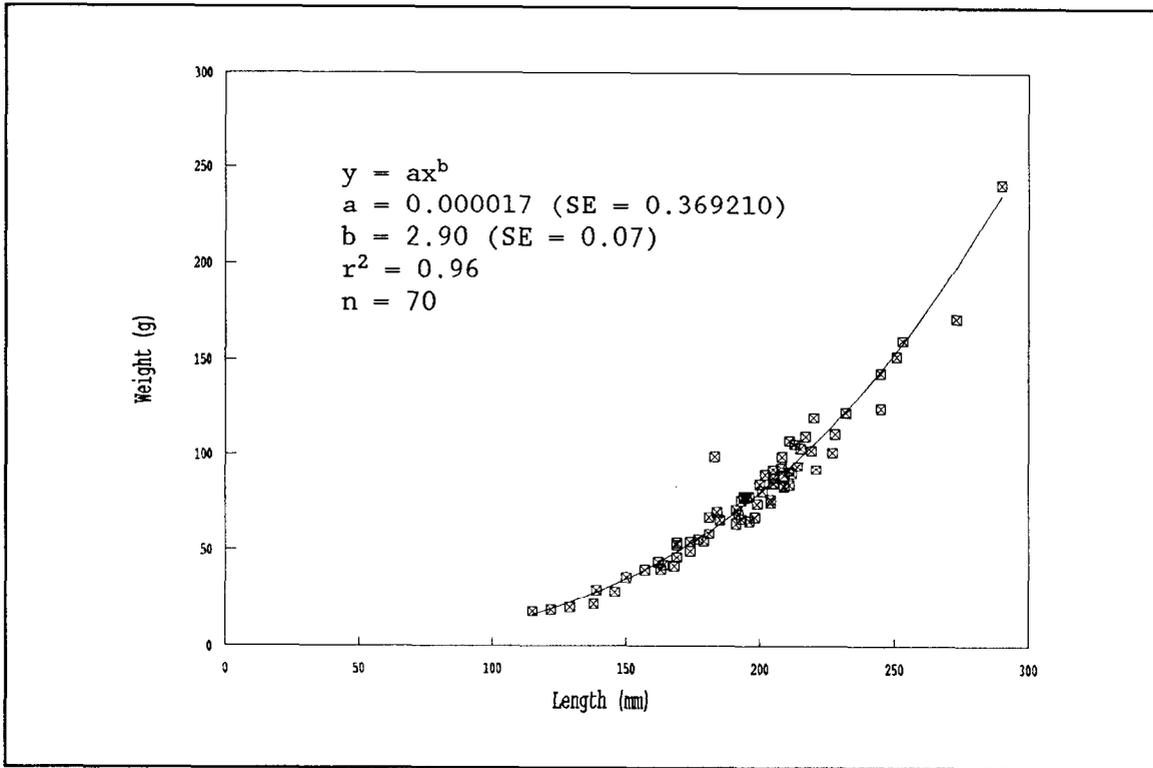


Figure 7. Length-weight relationship and length frequency distribution for cutthroat trout, Talbot Lake, Alaska, 1989.

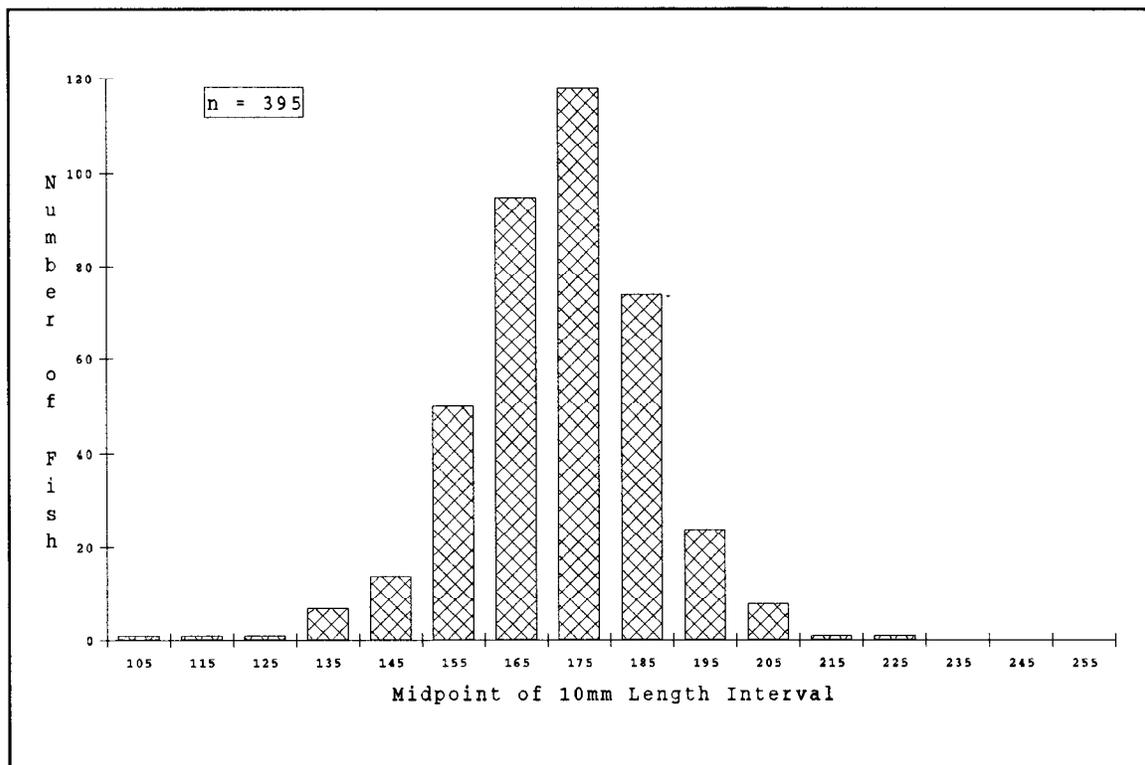
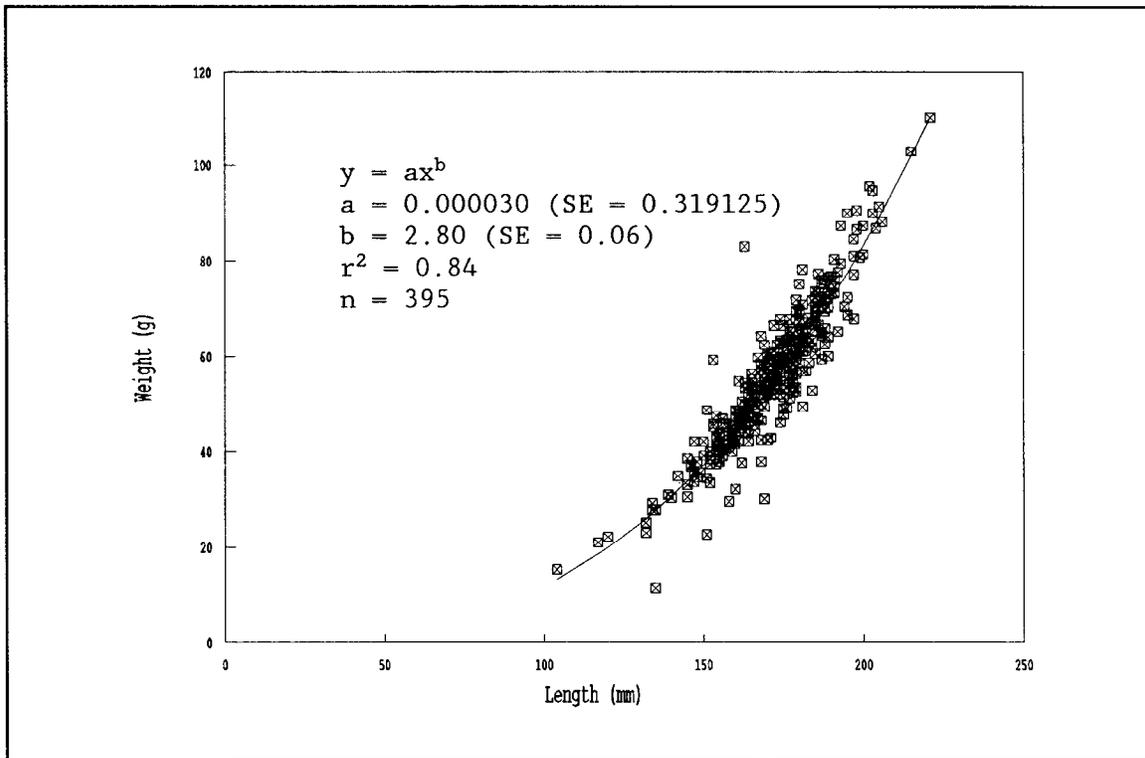


Figure 8. Length-weight relationship and length frequency distribution for Dolly Varden, Talbot Lake, Alaska, 1989.

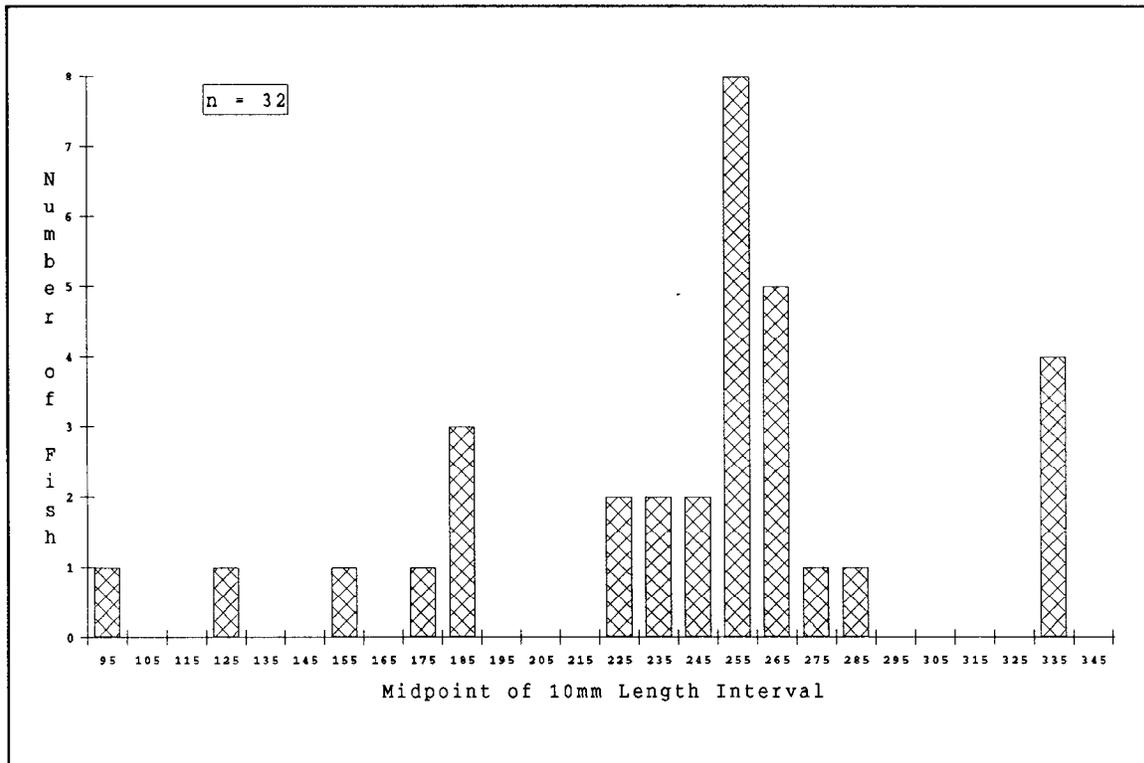
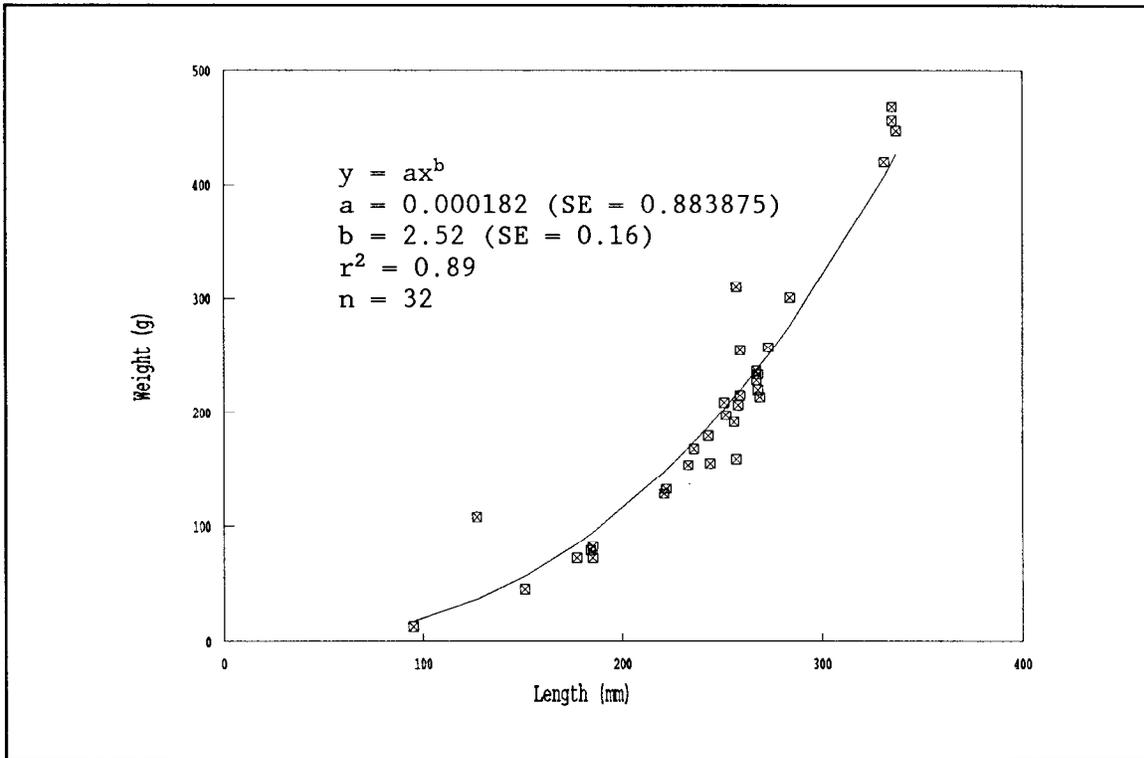


Figure 9. Length-weight relationship and length frequency distribution for brook trout, Perseverance Lake, Alaska, 1989.

Table 4. Summary of effort, catch, and catch per unit effort (CPUE) by lake, sample period, gear type, and species, 1989.

Lake	Period	Gear	Effort ^b	Species ^a							
				RT	RT	CT	CT	DV	DV	BT	BT
				Catch	CPUE ^c	Catch	CPUE ^c	Catch	CPUE ^c	Catch	CPUE ^c
Connell	1	Large Traps	552.0	0	0	3	0.005	3	0.005	-	-
Connell	1	Small Traps	513.0	0	0	0	0	0	0	-	-
Connell	1	Hook and Line	6.0	0	0	0	0	0	0	-	-
Connell	1	ALL GEAR	1071.0	0	0	3	0.002	3	0.002	-	-
Connell	2	Large Traps	564.0	0	0	17	0.032	29	0.051	-	-
Connell	2	Small Traps	417.0	1	0.002	1	0.002	0	0	-	-
Connell	2	Hook and Line	7.0	0	0	0	0	0	0	-	-
Connell	2	ALL GEAR	988.0	1	0.001	18	0.019	29	0.029	-	-
Connell	3	Large Traps	612.0	0	0	13	0.021	5	0.008	-	-
Connell	3	Small Traps	373.5	0	0	8	0.021	0	0	-	-
Connell	3	Hook and Line	13.2	0	0	47	3.561	0	0	-	-
Connell	3	ALL GEAR	998.2	0	0	68	0.068	5	0.005	-	-
TOTAL	ALL		3057.2	1	0.000	89	0.029	37	0.012	-	-
Talbot	1	Large Traps	570.0	2	0.004	1	0.002	61	0.107	-	-
Talbot	1	Small Traps	475.0	0	0	0	0	0	0	-	-
Talbot	1	Hook and Line	8.2	0	0	14	1.707	0	0	-	-
Talbot	1	ALL GEAR	1053.2	2	0.004	15	0.014	61	0.058	-	-
Talbot	2	Large Traps	564.0	0	0	10	0.018	117	0.207	-	-
Talbot	2	Small Traps	376.0	0	0	2	0.005	2	0.005	-	-
Talbot	2	Hook and Line	14.7	1	0.068	29	1.973	0	0	-	-
Talbot	2	Test Traps	188.0	0	0	2	0.011	1	0.005	-	-
Talbot	2	ALL GEAR	1142.7	1	0.001	43	0.038	120	0.105	-	-
Talbot	3	Large Traps	570.0	1	0.002	11	0.019	296	0.519	-	-
Talbot	3	Small Traps	475.0	0	0	0	0	9	0.019	-	-
Talbot	3	Hook and Line	9.0	0	0	2	0.222	0	0	-	-
Talbot	3	ALL GEAR	1054.0	1	0.001	13	0.012	305	0.289	-	-
TOTAL	ALL		3249.7	4	0.001	71	0.022	486	0.150	-	-
Perseverance	1	Large Traps	748.0	3	0.004	-	-	-	-	9	0.012
Perseverance	1	Small Traps	435.0	0	0	-	-	-	-	1	0.002
Perseverance	1	Hook and Line	12.2	0	0	-	-	-	-	4	0.328
Perseverance	1	ALL GEAR	1195.2	3	0.003	-	-	-	-	14	0.012
Perseverance	2	Large Traps	709.0	7	0.010	-	-	-	-	13	0.018
Perseverance	2	Small Traps	425.0	0	0	-	-	-	-	0	0
Perseverance	2	Hook and Line	8.2	0	0	-	-	-	-	3	0.366
Perseverance	2	ALL GEAR	1142.2	7	0.006	-	-	-	-	16	0.014
Perseverance	3	Large Traps	630.0	4	0.006	-	-	-	-	4	0.006
Perseverance	3	Small Traps	445.0	1	0.002	-	-	-	-	2	0.004
Perseverance	3	Hook and Line	11.0	0	0	-	-	-	-	1	0.091
Perseverance	3	ALL GEAR	1086.0	5	0.005	-	-	-	-	7	0.006
TOTAL	ALL		3423.4	15	0.004	-	-	-	-	37	0.011

^a RT = rainbow trout; CT = cutthroat trout; DV = Dolly Varden; and BT = brook trout.

^b Effort = number of gear units X hours fished.

^c CPUE = catch per unit effort.

Table 5. Summary of marks, recaptures, and mortalities by sample period; and the total number of marked fish remaining after sampling for cutthroat trout in Connell Lake, 1989.

	Sample Period 1 (6/5-6/9)	Sample Period 2 (8/29-9/2)	Sample Period 3 (9/18-9/22)
Captured, marked, and released alive			
Newly marked fish	3 (3) ^a	18 (17)	67 (67)
Recaptures			
from period 1	- -	- -	- -
from period 2	- -	- -	1 (1)
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -
from periods 2 & 3	- -	- -	- -
Captured and died			
Newly captured fish	- -	- -	- -
Recaptures			
from period 1	- -	- -	- -
from period 2	- -	- -	- -
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -
Total Catch	3 (3)	18 (17)	68 (67)
Total number of marked fish remaining after sampling		88 (87)	

^a Note: the numbers of Floy tagged fish are indicated in parentheses.

During the third sampling period (18 September through 22 September 1989) 68 cutthroat trout were captured. There were no mortalities, and one recapture had marks from the second sampling period (Table 2). The total number of marked fish in the lake at the end of sampling period three was 88 cutthroat trout (assuming no mortality of marked fish that were released alive), and 87 of these were marked with numbered Floy tags. Population estimates were not calculated because of the paucity of recaptures.

Dolly Varden. During the first sample period, 3 Dolly Varden were captured. There were no mortalities, so the total number of newly marked and released Dolly Varden in the lake at the end of sample period one was 3 (Table 6).

A total of 29 Dolly Varden were captured during sampling period two. There was one mortality but no recaptures, so the total number of marked fish in the lake at the end of sampling period two was 31 Dolly Varden (Table 6).

During the third sampling period 5 Dolly Varden were captured. There was one mortality of a recaptured fish that had been marked during period two but no other recaptures (Table 6). The total number of marked Dolly Varden in the lake at the end of sampling period three was 35 fish (assuming no mortality of marked fish that were released alive), and 32 of these were marked with numbered Floy tags. Population estimates were not calculated because of the paucity of recaptures.

Talbot Lake:

A total of 71 cutthroat trout, 486 Dolly Varden, four steelhead smolt, 393 sculpins, and 2 stickleback were captured during three sampling periods at Talbot Lake.

Cutthroat trout. During the first sample period (12 June through 16 June 1989), 15 cutthroat trout were captured (Table 7). There was one mortality of a newly captured fish; the total number of newly marked and released cutthroat trout in the lake at the end of sample period one was 14 (Table 4).

A total of 43 cutthroat trout were captured during sampling period two (10 July through 14 July 1989). There were three mortalities of fish that had been marked during period 2, but no other mortalities or recaptures. The total number of marked cutthroat trout in the lake at the end of sampling period two was at most 54 (Table 7).

During the third sampling period (14 August through 18 August 1989), 13 cutthroat trout were captured (Table 7). There were no mortalities and one recapture, which had been marked during period two (Table 7). The total number of marked cutthroat trout in the lake at the end of sampling period three was at most 66 (assuming no mortality of marked fish that were released alive), and 63 of them had been tagged with numbered Floy tags. No population estimates were calculated because of the low number of recaptures.

Dolly Varden. During the first sample period, 61 Dolly Varden were captured. There were no mortalities and six Dolly Varden were recaptured, so the total number of newly marked and released Dolly Varden in the lake at the end of sample period one was 55 fish (Table 8).

Table 6. Summary of marks, recaptures, and mortalities by sample period; and the total number of marked fish remaining after sampling for Dolly Varden in Connell Lake, 1989.

	Sample Period 1 (6/5-6/9)	Sample Period 2 (8/29-9/2)	Sample Period 3 (9/18-9/22)
Captured, marked, and released alive			
Newly marked fish	3 (3) ^a	28 (25)	4 (4)
Recaptures			
from period 1	- -	- -	- -
from period 2	- -	- -	- -
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -
Captured and died			
Newly captured fish	- -	1 (1)	- -
Recaptures			
from period 1	- -	- -	- -
from period 2	- -	- -	1 (1)
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -

Total Catch	3 (3)	29 (26)	5 (5)
Total number of marked fish remaining after sampling		35 (32)	

^a Note: the numbers of Floy tagged fish are indicated in parentheses.

Table 7. Summary of marks, recaptures, and mortalities by sample period; and the total number of marked fish remaining after sampling for cutthroat trout in Talbot Lake, 1989.

	Sample Period 1 (6/12-6/16)	Sample Period 2 (7/10-7/14)	Sample Period 3 (8/14-8/18)
Captured, marked, and released alive			
Newly marked fish	14 (13) ^a	40 (38)	12 (12)
Recaptures			
from period 1	- -	- -	- -
from period 2	- -	- -	1 (1)
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -
Captured and died			
Newly captured fish	1 (0)	- -	- -
Recaptures			
from period 1	- -	- -	- -
from period 2	- -	3 (1)	- -
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -

Total Catch	15 (13)	43 (39)	13 (13)
Total number of marked fish remaining after sampling		66 (63)	

^a Note: the numbers of Floy tagged fish are indicated in parentheses.

Table 8. Summary of marks, recaptures, mortalities by sample period; and the population estimate with 95% confidence intervals for Dolly Varden in Talbot Lake, 1989.

	Sample Period 1 (6/12-7/10)	Sample Period 2 (7/10-7/14)	Sample Period 3 (8/14-8/18)
Captured, marked, and released alive			
Newly marked fish	55 (55) ^a	89 (89)	248(240)
Recaptures			
from period 1	6 (6)	21 (21)	8 (8)
from period 2	- -	6 (6)	34 (34)
from periods 1 & 2	- -	1 (1)	5 (5)
from period 3	- -	- -	4 (4)
from periods 2 & 3	- -	- -	4 (4)
from periods 1, 2, & 3	- -	- -	2 (2)
Captured and died			
Newly captured fish	- -	3 (2)	- -
Recaptures			
from period 1	- -	- -	- -
from period 2	- -	- -	- -
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -
Total Catch	67 (67)	120(119)	305(297)
Chapman-modified Petersen Estimate		820	
95% confidence interval		633 - 1,007	

^a Note: the numbers of Floy tagged fish are indicated in parentheses.

Table 9. Summary of marks, recaptures, and mortalities by sample period; and the total number of marked fish remaining after sampling for eastern brook trout in Lower Perseverance Lake, 1989.

	Sample Period 1 (7/17-7/21)	Sample Period 2 (8/21-8/25)	Sample Period 3 (9/5-9/13)
Captured, marked, and released alive			
Newly marked fish	14 (14) ^a	13 (13)	5 (4)
Recaptures			
from period 1	- -	2 (2)	1 (1)
from period 2	- -	1 (1)	1 (1)
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -
Captured and died			
Newly captured fish	- -	- -	- -
Recaptures			
from period 1	- -	- -	- -
from period 2	- -	- -	- -
from periods 1 & 2	- -	- -	- -
from period 3	- -	- -	- -

Total Catch	14 (14)	16 (16)	7 (6)
Total number of marked fish remaining after sampling		32 (31)	

^a Note: the numbers of Floy tagged fish are indicated in parentheses.

A total of 120 Dolly Varden were captured during sampling period two. There were three mortalities of newly captured fish, 21 recaptures had been marked during period one, six recaptures had been marked during period two, and one recapture had been marked during both period one and period two. The total number of marked Dolly Varden in the lake at the end of sampling period two was 89 fish (Table 8).

During the third sampling period, 305 Dolly Varden were captured. There were no mortalities, eight recaptures had been marked during period one, 34 recaptures had marks from the second sampling period, five had marks from both period one and period two, four recaptures had marks from period three, four recaptures had mark from both period two and period three, and 2 recaptures had marks from all three periods (Table 8). The total number of marked Dolly Varden in the lake at the end of sampling period three was 392 fish (assuming no mortality of marked fish that were released alive), and 384 of them had been tagged with numbered Floy tags.

The K -sample Anderson-Darling test comparing lengths of 55 Dolly Varden captured on the first sampling occasion with the lengths of 21 Dolly Varden marked during the first occasion and recaptured during the second occasion indicated severe size selectivity ($A_{akN}^2 = 3.41$, $\sigma_N^2 = 0.553$, and $T_{akN} = 3.243$, with the critical value of 1.96 for T_{akN}). Comparitively, the statistics associated with comparing lengths of Dolly Varden captured during occasion three (from occasion two) with lengths of fish captured and released during occasion two indicated no size selectivity ($A_{akN}^2 = 0.66$, $\sigma_N^2 = 0.566$, and $T_{akN} = -0.566$, with the critical value of 1.96 for T_{akN}). As such, I chose to use only the second and third occasion capture-recapture data to estimate the size of the population. I could not evaluate the closure assumption, nor could a Jolly-Seber model be applied with only two capture occasions.

Assuming that minimal growth recruitment or mortality occurred between the last two occasions, I applied the Chapman-modified Petersen type estimator (see equations in Seber 1982, page 60). A total of 110 Dolly Varden were captured, marked, and released alive during occasion two. During occasion three a total of 295 Dolly Varden were captured and examined for tags, of these 39 had been previously marked during occasion two. The resultant population estimate was 820 Dolly Varden (SE = 95), with approximate 95% confidence intervals from 633 to 1,007 fish (Table 8).

Perseverance Lake:

A total of 35 brook trout, 15 rainbow trout, and 1,203 stickleback were captured during three sampling periods at Perseverance Lake. No other fish species were captured.

During the first sample period (17 July through 21 July 1989), 14 brook trout were captured (Table 9). There were no mortalities or recaptures, so the total number of newly marked and released brook trout in the lake at the end of sample period one was 14.

A total of 19 brook trout were captured during sampling period two (21 August through 25 August 1989). There were no mortalities, and there were two recaptures from sampling period one and one recapture from sampling period two. The total number of marked brook trout in the lake at the end of sampling period

two was 30.

During the third sampling period at Perseverance Lake (5 September through 9 September 1989), nine brook trout were captured. There were no mortalities, and one brook trout that had been marked during period one and one brook trout from period two were recaptured. Hence, assuming no mortality of marked fish released alive, there were a total of 35 marked brook trout in the lake at the end of the third sampling period. All of these marked fish had also been tagged with numbered Floy tags (Table 9). A population estimates was not calculated because of the paucity of recaptures.

DISCUSSION

The failure to obtain population estimates for cutthroat trout and Dolly Varden in Connell Lake was disappointing. I was hampered by the inability to capture and tag sufficient fish during the first two sampling trips to the lake. This failure may be related to several unusual factors that occurred. Because of a hot, dry summer and a light snow pack in the mountains, the Ketchikan Pulp Mill utilized all the available water reserves impounded by Connell Lake. Connell Lake was drawn down to a level nine meters below its normal depth. The water supply problem for the pulp mill became so serious by the end of the summer, that the mill had to be shut down, and a pipeline was constructed to siphon water from Perseverance Lake into Connell Lake.

In addition to low water levels in Connell Lake, surface water temperatures ranged from 17 to 18 °C (62 to 64 °F) in early June during sampling period one, from 15.5 to 17 °C (60 to 62 °F) during sample period two in early September, and from 13 to 16 °C (56 to 61 °F) during sample period three in late September. During a normal year in this area, surface water temperatures ranging from 13 to 14 °C would have been expected.

I do not know how or if these factors affected the normal distribution of fish in the lake, or their response to baited traps. Fish were, however, available to other types of gear during this period. Personnel from the Southern Southeast Regional Aquaculture Association (SSRAA) captured 91 cutthroat trout and two Dolly Varden at the outlet of Connell Lake with gillnets on 5 September 1990, between our sampling period two and sampling period three. These fish were examined for pathogens to determine if Connell Lake cutthroat trout could be used as a brood source for future stocking programs. No tags were observed on any of these fish.

In spite of our inability to generate population estimates, the average condition factors, a relatively high morphoedaphic index (MEI) and potential yield, and the good CPUE with hook and line during the third sampling period all indicate that Connell Lake has the potential to provide a good sport fishery for cutthroat trout.

Although water levels on Talbot Lake were not severely affected by the hot, dry summer and the Connell Lake draw-down, surface water temperatures were high and may have affected my ability to capture fish. Surface temperatures ranged from 14 to 17 °C (58 to 63 °F) during the first sampling period in mid June; from 19 to 21 °C (67 to 70 °F) during the second sampling period in mid July; and stayed at 15.5 °C (60 °F) during the third sampling period in mid August.

A population estimate for cutthroat trout in Talbot Lake was not obtained because of too few recaptures. Condition factors indicated that the cutthroat trout were in average condition, but average lengths and weights were less than those obtained from Connell Lake. The population estimate for Dolly Varden was 820 with 95% confidence intervals from 633 to 1,007. The condition factors were also average, and mean lengths and weights were also less than those obtained from Connell Lake. The smaller average lengths and weights are probably related to the lower MEI and potential yield calculated for Talbot Lake. Talbot Lake is occasionally fished by local anglers, and anglers returned floy tags from two cutthroat trout that were sport caught during July.

Perseverance Lake contained small populations of brook trout and rainbow trout. Although population estimates were not obtained because of too few recaptures, the hypothesis of small populations is supported both by low catch rates, by a low MEI, and by low potential yield calculations. Good condition factors also support a hypothesis of a small, but healthy population of brook trout. Neither the draw-down of water from Connell Lake, nor the installation of the pipeline to siphon water from Perseverance Lake into Connell Lake appeared to severely affect the water levels in Perseverance Lake. This was due primarily to the fact that fall rains began shortly after the pipeline had been installed. Since the pulp mill has applied for permits to keep the pipeline in place to supply future water needs, and because of the limited spawning area in Perseverance Lake (primarily at the outlet stream), there is a potential for future adverse impacts to the fish populations if the lake water level were to be significantly reduced.

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Table 10. Comparison of parameters associated with three Ketchikan lakes studied in 1989 (in CAPS) and with other lakes in Southeast Alaska.

Lake	Conductance (μ mhos)	TDS ^a (mg/l)	A (ha)	Z (m)	MEI ^b	YIELD ^c (kg/ha)
CONNELL	20	14	149.3	12.0	1.16	1.04
TALBOT	20	14	27.6	13.3	1.05	0.99
PERSEVERANCE	10	7	73.0	26.2	0.27	0.50
Carlanna ^e	190	125 ^d	13.7	20.6	6.00	2.37
Lower Leask ^e	30	20 ^d	14.4	19.0	1.03	0.98
Lower Silvis ^e	8	5 ^d	14.1	11.1	0.47	0.66
Waterfall ^e	15	22 ^d	5.4	1.9	11.50	3.27
Lower Wolf ^e	24.8	13.2
Harriett Hunt ^e	20	13 ^d	78.3	24.7	0.53	0.70
Helen ^f	50	35 ^g	14.5	3.7	9.46	2.97
Red ^f	93	65 ^g	166.0	10.4	6.25	2.41
Mountain ^f	100	59	83.0	20.5	2.88	1.64
Situk ^f	105	60	408.0	27.3	2.20	1.43
Streets ^f	30	21	60.7	11.0	1.91	1.34
Finger ^f	28	20 ^g	347.0	10.7	1.87	1.32
Tammy ^f	25	18 ^g	134.0	10.0	1.80	1.30
Green ^f	39	22	70.0	12.3	1.79	1.29
Salmon ^f	26	18	41.1	10.4	1.75	1.28
Bear ^f	29	21 ^g	30.7	12.2	1.66	1.24
Klawak ^f	39	24	1177.0	17.7	1.36	1.13
Hofstad ^f	17	12 ^g	60.3	9.8	1.22	1.07
Auke ^f	28	20	46.0	19.0	1.05	0.99
Virginia ^f	18	13 ^g	258.0	13.0	1.00	0.97
Manzanita ^f	60	42 ^g	625.0	49.0	0.86	0.89
Salmon Bay ^f	30	21 ^g	388.0	26.7	0.79	0.86
Sitkoh ^f	39	27 ^g	209.5	35.2	0.77	0.85
Heckman ^f	17	14	163.0	19.7	0.71	0.81
Spurt ^f	16	14	107.0	22.2	0.63	0.77
Karta ^f	26	16	508.0	27.6	0.58	0.74
Bugge ^f	20	14 ^g	66.8	24.0	0.58	0.74
Akwe ^f	48	28	216.0	50.1	0.56	0.72
De Boer ^f	13	13	51.0	23.0	0.56	0.72
Wilson ^f	51	36 ^g	468.0	54.0	0.67	0.69
Ella ^f	47	33 ^g	710.0	70.0	0.47	0.66
Patching ^f	17	14	207.0	30.2	0.46	0.66
Blue ^f	33	22	538.0	52.0	0.42	0.63
Turner ^f	15	10 ^g	1270.0	30.0	0.33	0.55
Plotnikof ^f	14	10	320.4	37.4	0.27	0.50
Osprey ^f	20	14	109.0	60.0	0.23	0.46
Baranof ^f	22	8 ^g	323.6	39.0	0.20	0.43
Swan ^f	20	16	208.0	91.4	0.18	0.41
Avoss ^f	21	8 ^g	123.7	45.8	0.18	0.41
Davidof ^f	12	8	140.8	52.5	0.15	0.38
Lonieof ^f	5	4 ^g	179.0	55.1	0.07	0.25
Rezanof ^f	3	2 ^g	354.0	71.2	0.03	0.17

^a TDS = Total Dissolved Solids

^b MEI = Morphoedaphic Index

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

^d Calculated as 0.65 x specific conductance.

^e Hubartt and Bingham (1988, 1989).

^f Schmidt (1983).

^g Calculated as 0.70 x specific conductance.

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