SURPRISE LAKE AND ANIAKCHAK RIVER FISHERY INVESTIGATION, ANIAKCHAK NATIONAL MONUMENT AND PRESERVE, ALASKA 1987 and 1988 FINAL REPORT

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ABSTRACT

An investigation of Surprise Lake and Aniakchak River fishery resources, Aniakchak National Monument and Preserve, Alaska, was initiated in 1987 and completed in 1988. A progress report was written for each year and both are presented under this cover as a final report.

During 24-27 July 1987, bathymetric and morphometric characteristics were determined for Surprise Lake, including mean depth (13.7 m, 44.9 ft), maximum depth (19.5 m, 64.0 ft), and shoreline development 1.3. Discharge measurements taken on four major tributaries in the Surprise Lake watershed ranged from 0.25-2.54 m^3/s (8.81-89.7 ft^3/s). Aniakchak River discharge was measured at 6.71 m^3/s (236.9 ft^3/s). Water quality data collected from the lake and tributaries included the following parameters and ranges: conductivity 43-901 uS/cm; dissolved oxygen concentration 2.5-13.4 mg/l; pH 5.25-7.90; and temperature 2.4°-19.4°C (36°-67°F). In addition, backpack electroshocker, gill nets, hook and line, and minnow traps were used to sample fish. Dolly Varden (Salvelinus malma) and sockeye salmon (Oncorhynchus nerka) were found in Surprise Lake and in two of the major tributaries. Dolly Varden ranged in age from 0-7 years and in fork length from 23-392 mm (0.9-15.4 in). Adult sockeye salmon were aged at 2.2 and 2.3 with a mid-eye to fork length range of 507-601 mm (20.0-23.7 in). Juvenile sockeye salmon ranged in age from 0-1 years and in fork length from 35-71 mm (1.4-2.8 in).

During 14-19 August 1988, fish were sampled from Surprise Lake and Tributary 5. Two Aniakchak River tributaries, Albert Johnson Creek and the North Fork of Aniakchak River, were sampled on 5 September 1988. Backpack electroshocker, dip net, gill net, hook and line, and minnow traps were used to sample fish. Dolly Varden and sockeye salmon were captured in Surprise Lake. Dolly Varden was the only species captured in Tributary 5. Dolly Varden ranged in age from 1-11 years with a maximum length of 477 mm (18.8 in) and were determined to be anadromous based on their bimodal length distribution. Sockeye salmon were aged at 2.1, 2.2 and 2.3 with a length range of 515-644 mm (20.3-25.4 in). Species diversity was greater in Aniakchak River tributaries than in Surprise Lake. Chum salmon (O. keta), coho salmon (O. kisutch), pink salmon (O. gorbuscha), sockeye salmon, Dolly Varden and threespine stickleback (Gasterosteus aculeatus) were collected from the two river tributaries.

DISCLAIMER

The mention of trade names or commercial products in this report does not constitute endorsement or recommendation for use by the federal government.

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INTRODUCTION

Under an interagency agreement between National Park Service and U. S. Fish and Wildlife Service, Alaska Regional Offices, the King Salmon Fishery Assistance Office was funded to conduct a two year fishery investigation of Surprise Lake and Aniakchak River, Aniakchak National Monument and Preserve. This progress report documents the 24-27 July 1987 investigation of Surprise Lake, two lake tributaries and two tributaries of the upper Aniakchak River.

One of the purposes for Aniakchak National Monument and Preserve as stated in Section 201 (1) of the Alaska National Interest Lands Conservation Act is to "maintain the caldera and it's associated volcanic features and landscape, including the Aniakchak River and other lakes and streams, in their natural state." Studying the effects of the 1931 Aniakchak volcanic eruption on biological communities in the caldera is a second mandate identified in Alaska National Interest Lands Conservation Act.

This study is the first survey of Surprise Lake fishery resources. Prior to this study information on fish species present in the system was based on limited recreational visitor reports and Alaska Department of Fish and Game (Department) aerial surveys of spawning salmon (Alaska Department of Fish and Game 1982). No data on physical characteristics or water chemistry of the aquatic habitats were available. Therefore, this investigation was designed to gather baseline information on: (1) bathymetric characteristics of Surprise Lake; (2) fish species composition and distribution; (3) stream discharge; and (4) water quality and limnological data.

Little was known about these aquatic resources except that Surprise Lake is partially fed by warm springs and the lake and Aniakchak River support sockeye salmon (Oncorhyncus nerka) and char (Salvelinus sp.) populations.

The National Park Service Cooperative Studies Unit at Oregon State University will begin an intensive limnological study of Surprise Lake during the summer of 1988. The limnological study will address the chemical, biological, and physical properties of the lake. The results of this progress report will provide baseline data which will assist in the development of sampling designs for the more intensive limnological study.

STUDY AREA

Aniakchak National Monument and Preserve is located on the Alaska Peninsula, 640 km (398 miles) southwest of Anchorage and 16 km (10 miles) east of Port Heiden. Aniakchak National Monument and Preserve together encompass approximately 235,000 hectares (580,685 acres), including the Aniakchak caldera (Figure 1). Aniakchak caldera is a 9.5 km (6 mile) wide and 762 m (2,500 ft) deep, ash filled bowl with a rim ranging from 609-1,220 m (2,000-4,000 ft) above mean sea level. The caldera was created about 3,500 years ago during an eruption that caused the collapse of a 2,100 m (7,000 ft) mountain. Aniakchak caldera is still volcanically active as indicated by warm water springs and ground temperatures reaching 80°C (175°F). The most recent eruption, in 1931, created a small explosion pit in the caldera floor, scattering many thousands of tons of ash. Some explosion features seem to have been created underwater, indicating that at one time the caldera was

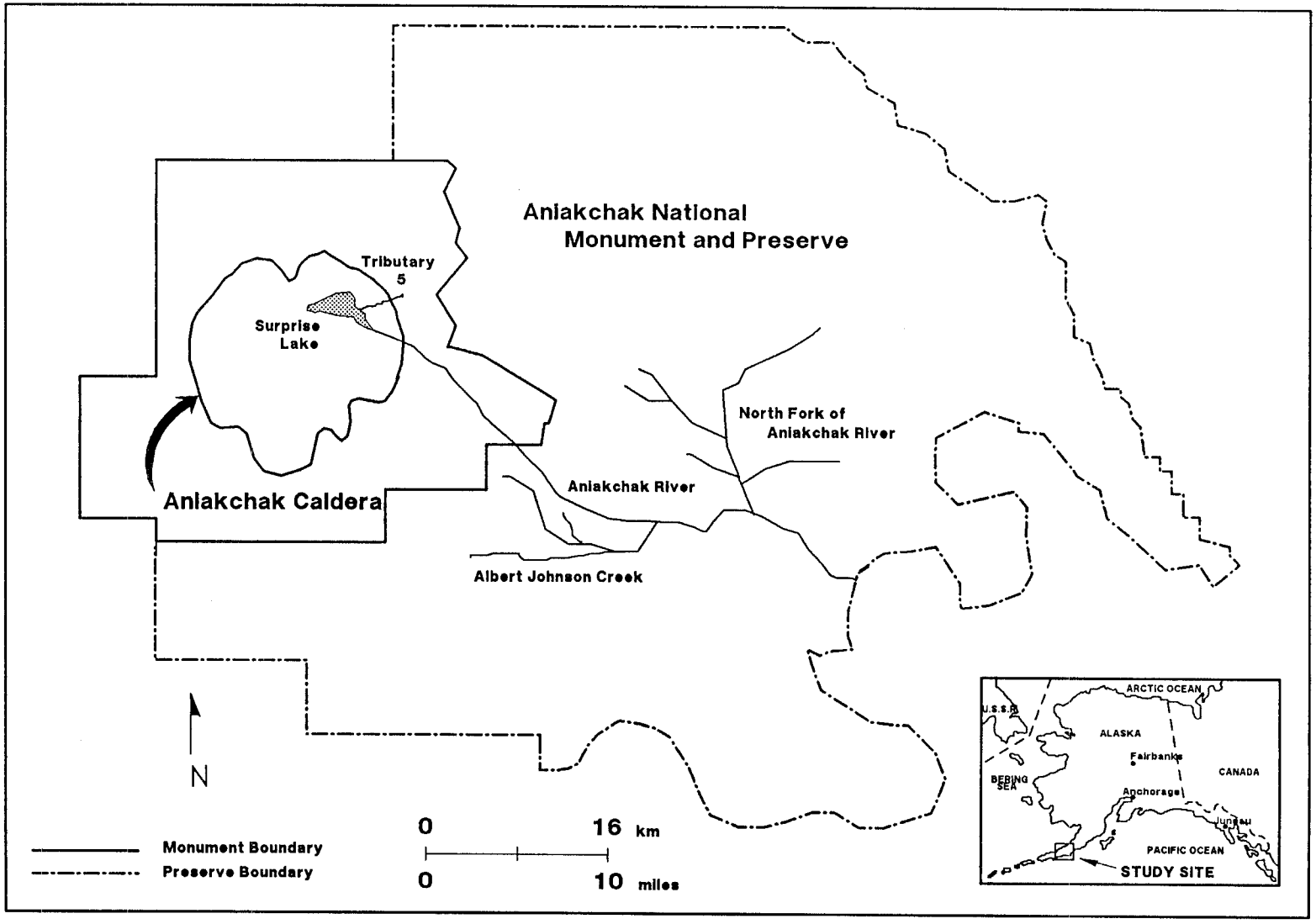

Figure 1.-Surprise Lake and Aniakchak River, Aniakchak National Monument and Preserve, Alaska, 1987.

probably a deep lake similar to Crater Lake, Oregon. Eventually a portion of the rim was breached by rising lake waters, that cut through about 457 m (1,500 ft) of both fossil-bearing sedimentary and volcanic rock layers to create the "Gates", through which the Aniakchak River now exits the caldera (National Park Service 1986).

Summers on the lower Alaska Peninsula are characterized by fog, drizzle, and protracted cloud cover on both coasts. Clouds obscure the caldera rim for most of the summer. Because of topography and location, the caldera creates its own microclimate. The caldera interior is subject to violent wind storms, even when the weather is relatively calm outside (National Park Service 1986).

Surprise Lake occupies four percent of the caldera floor, is 275 hectares (680 acres) in area and is located at the north side of the caldera. Surprise Lake is fed by several iron-soda springs and by snow melt from surrounding highlands. The lake is the headwaters for the 43 km (27 mile) long Aniakchak River, one of the larger rivers on the Alaska Peninsula that flows into the Gulf of Alaska (National Park Service 1986).

METHODS

Lake Sampling

Surprise Lake morphological characteristics were defined and calculated using the methods and descriptions in Hutchinson (1957). Water depths were determined using an Eagle Mach 1 chart recorder. A lake map was made by enlarging the U.S. Geological Survey 1:63,360 scale map Chignik, D-1, Alaska. Depth changes were plotted along 24 predetermined transects and depth contours were then drawn at 2.4, 8.5, 14.6, 18.3, and 19.5 m (8.0, 28.0, 48.0, 60.0, and 64.0 ft) intervals. A planimeter was used to compute surface area and shoreline length.

Fish in the lake were captured using the following gear types: minnow traps baited with preserved salmon eggs; hook and line; a 45.7 m (150.0 ft) by 1.8 m (6 ft) experimental gill net, consisting of six 7.6 m (25 ft) panels with 3.8-10.2 cm (1.5-4.0 in) stretched mesh in 1.3 mm (0.5 in) increments.

Sampling locations for each gear type are presented in Figure 2. Minnow traps were set along the shoreline at depths ranging from 0.5-1.1 m (1.5-3.5 ft) and time intervals ranging from 3-24 hours. Beach seining was conducted at two sites with one seine haul at 1130 hours and one at 2300 hours. Approximately four hours of hook and line fishing was conducted along the south and southeast shorelines of the lake. A bottom set gill net was fished overnight at four sites ranging in water depths from 1.8-18.3 m (6.0-60.0 ft).

Captured fish were anesthetized with tricaine methanesulfonate (MS-222) to facilitate length and weight measurement. Length measurements (nearest mm) were taken from adult fish and from a subsample of juvenile fish. Fork length (FL) measurements were taken from juvenile sockeye salmon and char; adult salmon were measured from mid-eye to fork (MEF). Scale samples were collected according to Department guidelines (Alaska Department of Fish and Game 1981). Weight measurements (nearest g), scales and otoliths were taken from a

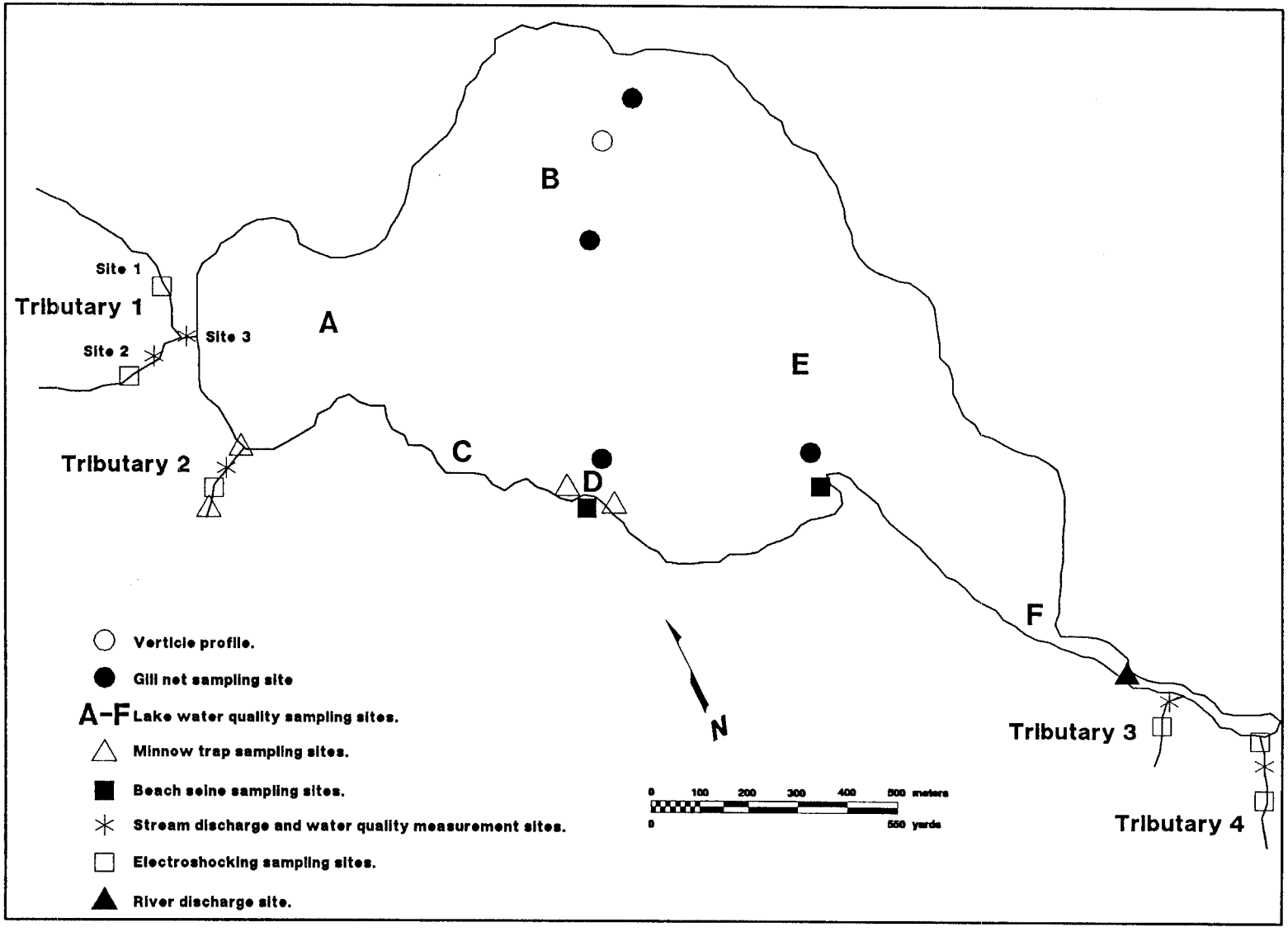

Figure 2.-Surprise Lake sampling sites, Aniakchak National Monument and Preserve, Alaska, 1987.

subsample of char. Thirty-three percent of the char were randomly sampled for gill raker counts. Gill raker counts were used to identify char species, with Arctic char (Salvelinus alpinus) having 23-32 gill rakers and Dolly Varden (S. malma) having 11-26 gill rakers (Scott and Crossman 1973, Morrow 1980). Sex of adult fish was determined by secondary sex characteristics.

Scales were aged according to techniques described by Koo (1962). Scales were placed between microscope slides and magnified on a microprojector 20-60 times. Regenerated scales were discarded. Scales were aged twice and a third reading was used to resolve disagreements. Otoliths were cleared with xylene, ground on a coarse whetstone when necessary to enhance readability, magnified 10-70 times using a dissecting microscope, and aged by counting annuli. Freshwater and saltwater residency periods were recorded according to the European method (Koo 1962), a two-digit age designation which counts annuli as winter marks. The first digit represents the number of freshwater annuli, while the second digit represents the number of saltwater annuli. Therefore, a 2.3 fish spent two winters in fresh water, three winters in salt water, and is in it's sixth year.

Conductivity (uS/cm), dissolved oxygen concentration (DO) (mg/l), pH, and temperature (°C) measurements were taken at six Surprise Lake locations at depths ranging from 0.9-18.3 m (3.0-60.0 ft) using a HYDROLAB 4000 series instrument. Secchi disk readings were taken in conjunction with the water quality measurements. At one additional site, a vertical profile of conductivity, DO, pH, and temperature was taken from the surface to a depth of 19.0 m (62.0 ft) at 2 m (6.6 ft) intervals.

Stream Sampling

Fish were sampled from four tributaries (Figure 2) using minnow traps baited with preserved salmon eggs, and a Smith-Root model 15-A backpack electroshocker. Minnow traps were set at various water temperatures and depths in Tributary 2. Electrofishing was used to sample juvenile fish from stream sections varying in length from 3-30 m (10-100 ft). A subsample of juvenile fish was measured to the nearest mm (FL) and released. A small sample was preserved for further identification.

Stream discharge was measured at selected sites (Figure 2) using a Marsh-McBirney flow meter, top setting wading rod and meter tape. The following criteria were used in selecting discharge measurement sites: (1) flows parallel to the banks; (2) few obstructions (boulders or large debris); and (3) moderate depth and flow. Velocity measurements were taken at 0.6 of the water column depth. The procedure of Rantz et al. (1982) was used to calculate stream discharges. Conductivity, DO, pH, and temperature were measured just below the stream surface at all stream discharge measurement sites.

RESULTS AND DISCUSSION

The water quality value ranges measured in Surprise Lake were as follows: conductivity 369-489 uS/cm; dissolved oxygen 8.5-10.4 mg/l; and pH 6.2-6.8 (Table 1). The following morphometric parameters were calculated for the lake: mean depth 13.7 m (44.9 ft); maximum depth 19.5 m (64.0 ft); and

Table 1.-Water depth, depth of measurement and water quality parameters for six sampling locations in Surprise Lake, Aniakchak National Monument and Preserve, Alaska, 26 July 1987.

Parameter	Sampling Location					
	A	B	C	D	E	F
Total depth (m)	13.7	18.6	1.8	1.4	15.9	2.0
Depth of measurement (m)	10.0	16.0	1.4	0.9	10.0	1.8
Secchi disk (m)	2.6	2.9	1.7	1.4	2.3	2.0
Conductivity (uS/cm)	394	390	489	369	390	386
Dissolved oxygen (mg/l)	10.4	10.1	8.5	9.7	10.2	10.4
pH	6.8	6.8	6.2	6.7	6.8	6.7
Temperature (°C)	10.0	9.4	12.6	10.1	9.6	11.4

shoreline development 1.3 (Table 2). A bathymetric map of Surprise Lake is presented in Figure 3.

Char and sockeye salmon were the only fish species found in Surprise Lake and the four tributaries. Gill raker counts on 29 char were examined and ranged from 11-19, indicating that the fish were Dolly Varden. Juvenile Dolly Varden were collected from Site 1 (FL range 24-82 mm (0.9-3.2 in)) and Site 2 (FL range 34-70 mm (1.3-2.7 in)) of Tributary 1 and in Tributary 3 (FL range 29-79 mm (1.1-3.1 in)). The presence of Dolly Varden young-of-the-year in Tributaries 1 and 3 may indicate that these streams are important for spawning.

Dolly Varden ranged in age from 0-7 years and from 23-392 mm (0.9-15.3 in) FL (Figure 4). A 31 fish sample of corresponding otoliths and scales was compared for age agreement (Table 3). Only 32 percent (10 fish) of the otolith and scale ages agreed; in all cases where otolith and scale ages disagreed the otolith age was 1-3 years greater than the scale age. Because salmonids may miss forming a scale annulus during their first year (Lentsch and Griffith 1987), otolith age is a more accurate measurement of true age (Heidinger and Clodfelter 1987).

Eleven adult sockeye salmon were aged at either 2.2 or 2.3 and ranged from 507-601 mm (19.8-23.4 in) MEF (Table 4). All adult sockeye salmon were captured in bottom set gill nets in water depths of 1.8-9.1 m (6.0-30.0 ft). Two beach seine hauls captured a total of 175 juvenile sockeye salmon; a haul at 1130 hours caught 18 juvenile sockeye salmon which ranged from 35-71 mm (1.4-2.8 in) FL and a 2330 hours haul caught 157 juvenile sockeye salmon, of which 24 (15 percent) were measured and ranged from 51-71 mm (2.0-2.7 in) FL. Young-of-the-year sockeye salmon were captured (FL range 35-45 mm (1.4-1.8 in)) in Tributary 1 and indicate that this stream is used for salmon spawning. Department aerial surveys have documented adult sockeye salmon in Tributary 1 (Alaska Department of Fish and Game 1982).

The length frequency histogram (Figure 5) and scale ages of 42 fish indicated the presence of 0.0 and 1.0 year old sockeye salmon in Surprise Lake, which is consistent with the two winter freshwater residency period observed in the adult scales. The sampling period was probably too late in the season to capture age 2.0 sockeye salmon in the lake. Peak outmigration of sockeye smolt generally occurs in June, beginning when water temperatures approach 4°-7°C (39°-45°F) (Hart 1973, Scott and Crossman 1973, and Morrow 1980).

No fish were collected in Tributaries 2 and 4. The apparent lack of fish in Tributary 2 can be explained by the low DO (2.5 mg/l) and high temperature (19.4°C (67°F)), which exceed the tolerance range for salmonid egg incubation and juvenile rearing (Reiser and Bjornn 1979).

Estimated tributary discharge ranged from 0.25-2.54 m^3/s (8.8-89.7 ft^3/s) and Aniakchak River discharge was estimated at 6.71 m^3/s (236.9 ft^3/s) (Table 5). Tributary 1 has two forks that merge together and flow into Surprise Lake as one stream where discharge was measured at Site 3 (Figure 2). The 2.54 m^3/s (89.7 ft^3/s) discharge at Site 2 was larger than the 1.95 m^3/s (68.9 ft^3/s) measured at Site 3. This discrepancy may have been caused by a portion of the stream flow becoming intergravel above Site 3. The north fork

Table 2.-Surprise Lake morphological characteristics, Aniakchak National Monument and Preserve, Alaska, 24 July 1987.

Characteristic	Value
Surface area (hectare)	275.2
Maximum length (m)	2,595.1
Maximum breadth (m)	1,363.9
Maximum depth (m)	19.5
Mean depth (m)	13.7
Volume (m^3)	37,585,665.0
Shoreline length (m)	7,728.6
Shoreline development[a]	1.3
Littoral area (%)[b]	17.0

[a] Reflects the degree of irregularity: shoreline length/(2 $\sqrt{\pi A}$), where A = surface area in m^2.

[b] Area that extends from the shore to a depth where light penetrates to the bottom.

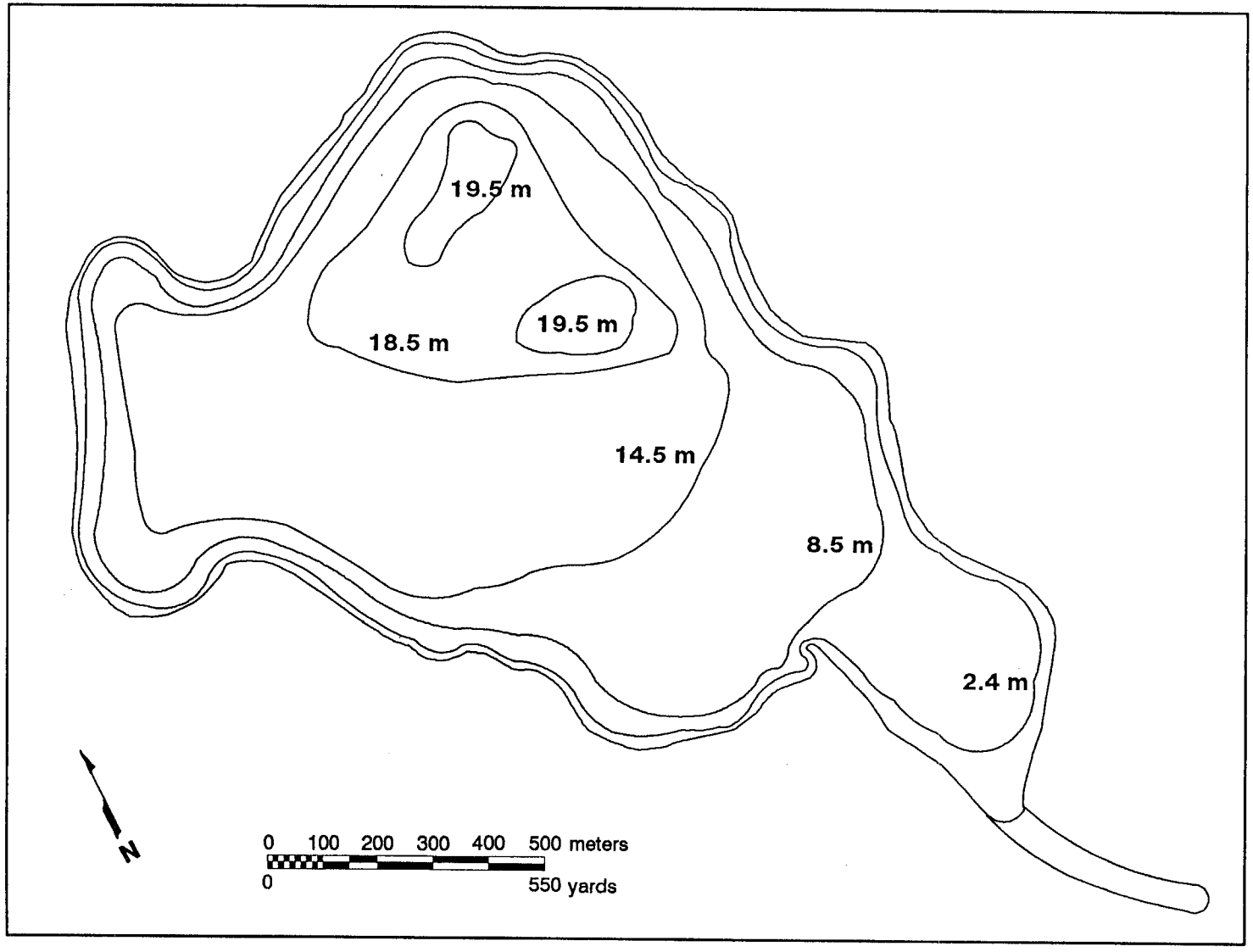

Figure 3.-Bathymetric map of Surprise Lake, Aniakchak National Monument and Preserve, Alaska, 1987.

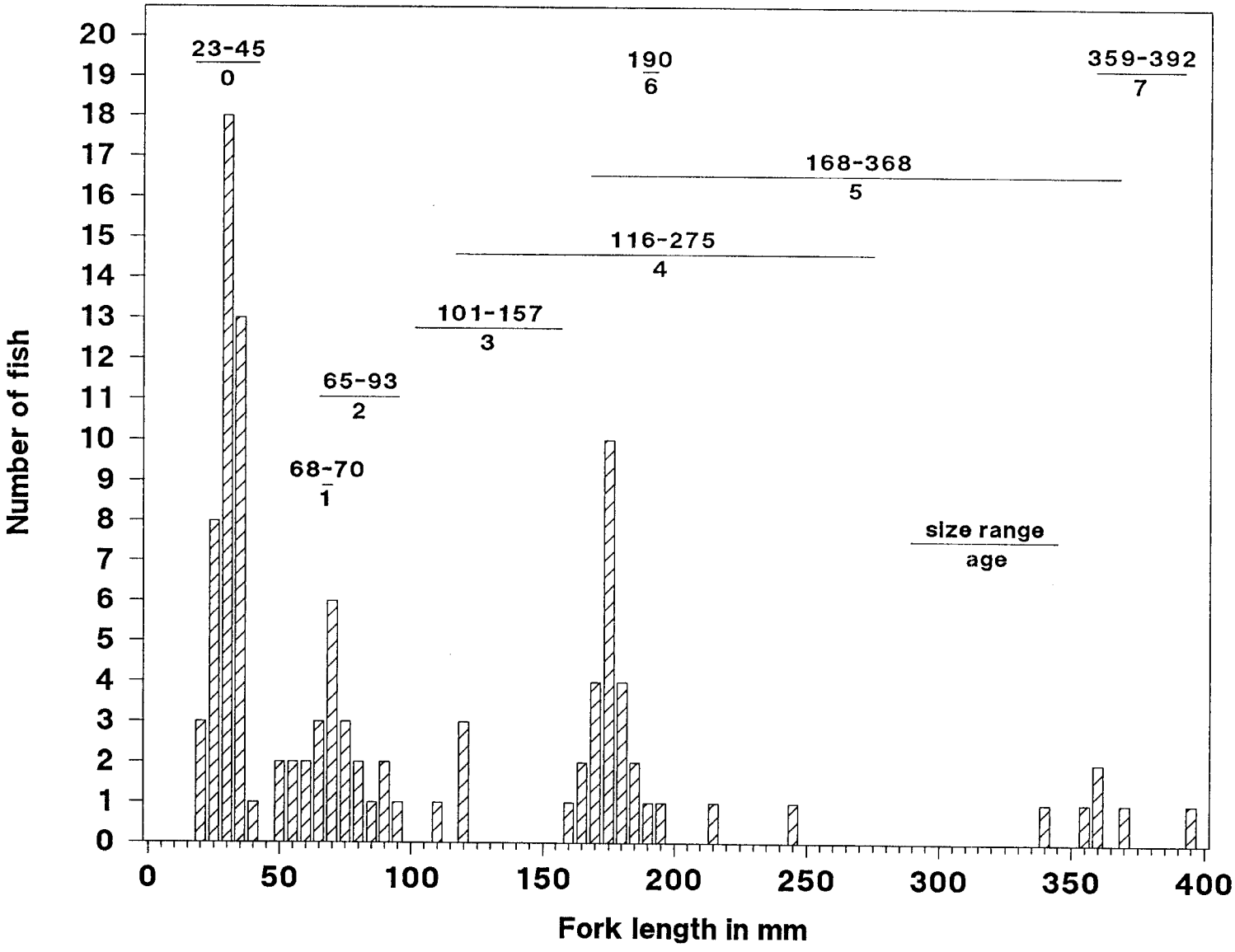

Figure 4.-Length frequency and ages of 92 Dolly Varden collected from Surprise Lake and tributaries, Aniakchak National Monument and Preserve, Alaska, 24-26 July 1987.

Table 3.-A comparison of otolith and scale ages of 31 Dolly Varden, Aniakchak National Monument and Preserve, Alaska, 1987.

Fork Length (mm)	Weight (g)	Sex	Otolith Age	Scale Age	Difference
78	4.0	-	2	1	+1
92	5.5	-	2	1	+1
120	15.5	F	3	2	+1
157	36.0	M	3	2	+1
160	49.0	M	4	2	+2
165	42.5	F	4	3	+1
168	45.0	M	5	2	+3
175	52.0	F	5	3	+2
175	54.0	M	5	3	+2
176	54.0	M	4	4	0
177	55.0	F	5	3	+2
178	53.0	M	4	3	+1
178	54.0	M	4	3	+1
179	56.0	M	4	4	0
179	57.0	M	4	4	0
185	53.0	M	5	3	+2
185	60.0	M	4	3	+1
188	64.0	M	4	2	2
188	75.0	M	4	4	0
190	70.0	M	6	3	+3
192	69.0	M	4	4	0
195	82.0	M	4	4	0
217	125.0	M	5	5	0
242	150.0	M	5	3	+2
250	90.0	M	5	3	+2
275	175.0	F	4	4	0
353	425.0	M	5	5	0
358	450.0	F	5	5	0
359	425.0	M	7	5	+2
368	525.0	M	5	4	+1
392	625.0	M	7	5	+2

Table 4.-Scale age and length of adult sockeye salmon collected in Surprise Lake, Aniakchak National Monument and Preserve, Alaska, 24-26 July 1987.

Parameter	Age	
	2.2	2.3
Length range (mm)	507-571	546-601
Mean length (mm)	529.3	575.1
SD	20.8	7.1
N	3	8

Table 5.-Calculated stream discharge measurements of tributaries to Surprise Lake and the Aniakchak River, Aniakchak National Monument and Preserve, Alaska, 24-26 July 1987.

Discharge Site	Discharge (m^3/s)	Stream width (m)	Mean Velocity (m/s)	Maximum Depth (m)	Minimum Depth (m)
Tributary 1					
Site 1	unable to measure because of channel braiding				
Site 2	2.54	8.5	1.01	0.9	0.03
Site 3	1.95	17.3	0.50	0.5	0.1
Tributary 2 Warm Water Springs	0.38	5.7	0.22	0.3	0.1
Tributary 3	0.25	4.5	0.16	0.2	0.1
Tributary 4 Waterfall Creek	2.48	7.3	1.41	0.5	0.2
Aniakchak River	6.71	19.9	1.85	1.2	0.1

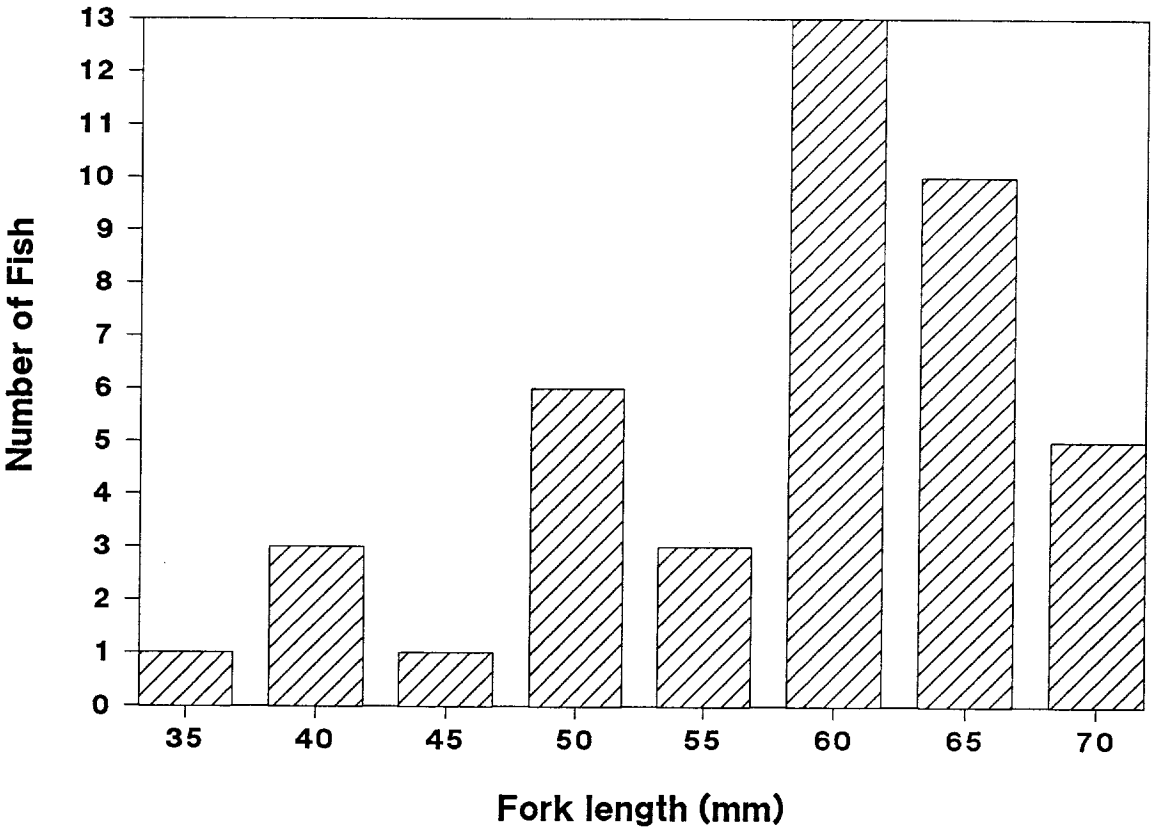

Figure 5.-Length frequency histogram and ages of 42 juvenile sockeye salmon collected from Surprise Lake and tributaries, Aniakchak National Monument and Preserve, Alaska, 24-27 July 1987.

of Tributary 1 was not measured because the stream was too shallow and braided to provide a suitable discharge measuring site. Tributary 2 originates as a warm water spring and flows about 150 m (492 ft) to the lake. Tributary 3 and 4 are primarily fed by snow melt and flooding was observed during the warm weather which occurred during the sampling period (D. Manski, National Park Service, personal communication).

Tributary water quality measurements are presented in Table 6. A warm temperature and low pH indicate that warm water springs have an influence on the water quality of Tributary 2. In contrast to the other tributaries, Tributary 2 originates from iron-soda springs, consequently this tributary had the highest water temperature and the lowest pH readings. Low pH readings predominantly occur in volcanic regions that receive strong mineral acids, particularly sulfuric acid (Wetzel 1975).

The vertical profile of Surprise Lake water quality measurements are presented in Table 7. These results suggest that the lake was homogeneous at the time of sampling with no thermocline present.

Table 6.-Water quality measurements of tributaries to Surprise Lake and Aniakchak River, Aniakchak National Monument and Preserve, Alaska, 24-26 July 1987.

Sampling Site	Conductivity (uS/cm)	Dissolved Oxygen (mg/l)	pH	Temperature °C
Tributary 1				
Site 1	101	10.8	6.8	11.4
Site 2	289	10.4	6.15	9.8
Site 3	288	10.5	6.2	8.9
Tributary 2 Warm Water Springs	901	2.5	5.25	19.4
Tributary 3	58	12.7	7.9	4.4
Tributary 4 Waterfall Creek	43	13.4	7.45	2.4

Table 7.-Vertical profile of water quality measurements taken at two meter intervals in Surprise Lake, Aniakchak National Monument and Preserve, Alaska, 26 July 1987.

Depth (m)	Conductivity (uS/cm)	Dissolved oxygen (mg/l)	pH	Temperature °C
0.2	387	10.4	6.9	11.1
3.0	388	10.0	7.0	10.9
5.0	389	10.1	7.0	10.5
7.0	390	8.7	7.1	10.3
9.0	393	10.0	7.1	9.9
11.0	393	9.1	7.2	9.8
13.0	392	9.3	7.2	9.5
15.0	392	9.2	7.2	9.3
17.0	392	9.6	7.1	9.2
19.0	394	8.7	7.1	9.1

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