FEDERAL AID IN FISH RESTORATION
STUDY G-I-[illegible]

INVENTORY AND CATALOGING OF HIGH QUALITY FISHING WATERS IN SOUTHEAST ALASKA

ARTWIN SCHMIDT

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ALASKA DEPARTMENT OF FISH AND GAME
James W. Brooks, Commissioner

Sport Fish Division
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Volume 17 Study G-I-R

STATE OF ALASKA

Jay S. Hammond, Governor

Annual Performance Report for

INVENTORY AND CATALOGING RECREATIONAL WATERS IN SOUTHEAST ALASKA

by

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TABLE OF CONTENTS

RESEARCH PROJECT SEGMENT

State: ALASKA

Name: Sport Fish Investigations of Alaska

Project No.: F-9-8

Study No.: G-I

Study Title: INVENTORY & CATALOGING

Job No.: G-I-R

Job Title: Inventory of High Quality Recreational Fishing Waters in Southeast Alaska

Period Covered: July 1, 1975 to June 30, 1976.

ABSTRACT

Limnological investigations and recreational analyses were conducted on the Naha Lakes and Roosevelt Lagoon in an attempt to: (1) determine the relationship of physical, chemical, and biological characteristics to fish production and (2) protect this high-quality fishing and recreational area from undesirable development.

Intensive limnological investigations were conducted on two of seven lakes throughout the summer. Other lakes were each studied for a one-week period. Recreational analyses were conducted on all lakes.

Chemical and biological analyses indicate that lakes of the Naha drainage fall in the mid-range of productivity when compared to other Southeast Alaska lakes. Plankton indices point out the high usage of the anadromous lakes by rearing salmon.

Recreational analyses of the Naha drainage show that it is unique. The drainage contains some of the finest sport fishing available in Southeast Alaska. Included are: (1) high mountain lakes with reproducing Arctic grayling, Thymallus arcticus (Pallas), populations; (2) nonanadromous lakes with large cutthroat trout, *Salmo clarki* (Richardson); (3) anadromous lakes with sockeye, *Oncorhynchus nerka* (Walbaum), coho, *O. kisutch* (Walbaum), chum, *O. keta* (Walbaum), and pink salmon, *O. gorbuscha* (Walbaum); and (4) a large river with excellent steelhead, *S. gairdneri* Richardson, sea-run cutthroat trout *Salmo clarki* Richardson, and Dolly Varden, *Salvelinus malma* (Walbaum).

BACKGROUND

Limnological investigations have been conducted in several lakes in Southeast Alaska (Schmidt, 1974; Schmidt and Robards, 1975). One continuing objective of this project is to determine the relationship of physical, chemical, and biological characteristics to fish production.

The Alaska Department of Fish and Game, Sport Fish Division, has long attempted to obtain additional protection for high-quality fishing waters. In 1972 the Alaska Department of Fish and Game made an official request to the forest supervisor of the Tongass National Forest to give special consideration to 18 identified high-quality watersheds. This investigation was conducted in an attempt to further quantify the recreational value and limnological relationships of one of the previously mentioned 18 watersheds.

RECOMMENDATIONS

Management

The Naha drainage should be classified according to the U.S. Forest Service classification plan so that the recreational values will not be destroyed or deteriorated. An informational pamphlet describing the recreational value of the Naha should be prepared for the public.

Research

Similar investigations should be conducted on other high-quality recreation areas. An attempt should be made to protect all high-quality fishing waters from undesirable development.

OBJECTIVES

1. Determine the relationship of physical, chemical, and biological characteristics of selected lakes to fish production.

2. Identify and protect from undesirable development high-quality recreational fishing waters in Southeast Alaska.

3. Determine recreational fishing potential of the Naha system on Revillagigedo Island.

4. Determine recreational fishing potential and feasibility of using Turner Lake as a sockeye rearing area.

Objective No. 4 was not accomplished due to lack of finances and manpower.

TECHNIQUES USED

Relationship of Limnological Characteristics to Fish Production

Limnological relationships existing in eight lakes were investigated. These included Salmon Lake and Klawak Lake on Prince of Wales Island and the six main lakes of the Naha River system on Revillagigedo Island (Figure 1). The Naha River lakes included Snow, Orton, Chamberlain, Patching, Heckman, and Jordan.

Bathymetric maps were prepared from each of the Naha lakes. A recording fathometer was used to record record depth contours on transects crossing each lake. The depth contours were transferred to bathymetric maps, and morphometric data were calculated from these maps. Bathymetric maps and morphometric data for Salmon and Klawak lakes were prepared by Schmidt (1974).

Personnel from the Department of Fish and Game and the U.S. Geological Survey made two data collection trips to Salmon, Klawak, Patching, and Heckman lakes. These collections were timed to coincide as nearly as possible with summer stagnation and fall turnover periods. Sampling stations were established at each lake at approximately the deepest portion of the lake. Vertical profiles of pH, temperature, specific conductance, and dissolved oxygen concentrations were recorded at each station using a Martex Mark II water quality monitoring system Water samples for comprehensive chemical analyses were collected and preserved at each station. All chemical samples were analyzed in accordance with standard methods of the U.S. Geological Survey (Brown, Skougstad, and Fishman, 1970).

Intensive limnological and fishery investigations were conducted on the Naha lakes. Heckman Lake, an anadromous system, and Patching Lake, a nonanadromous system, were sampled every third week. A one-week investigation was conducted on each of the other lakes and Roosevelt Lagoon.

Zooplankton were collected biweekly by making duplicate vertical tows from the lake bottom with each of two nets. Nets used were 0.5 m diameter and 3 m long. Straining cloth of the No. 10 Nitex net had aperture of 153 microns and 45% open area, while the No. 20 Nitex net had aperture of 80 microns and 35% open area. Plankton were identified and counted. Dry and ash weight of plankton were determined gravimetrically. Efficiency of nets was not accounted for in calculations. Thermal profiles and Secchi disc readings were taken in conjunction with plankton tows.

Stream drift organisms were collected biweekly by placing two nets in the main inlet. Nets used were 12 inches square, 3 feet long, made of Nitex with pore size of 280 microns, and 45% open area. Benthos were preserved and later identified and enumerated in the laboratory.

Bottom fauna were collected by dredging with an Ekman 6-inch dredge. Bottom samples were washed through three screens, the finest having

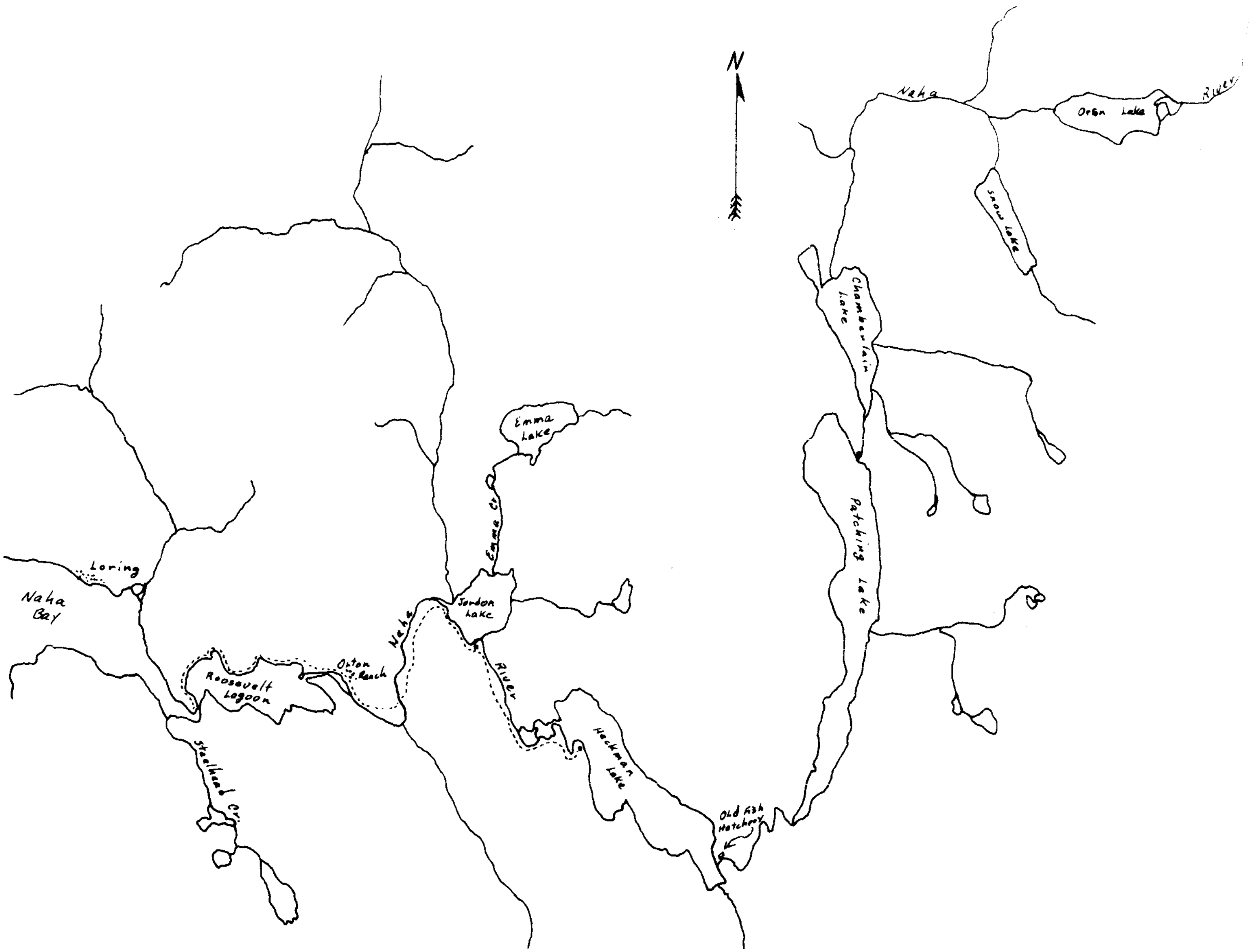

Figure 1. Naha River Drainage Showing Relative Location of Major Lakes.

28 meshes per inch. Organisms were preserved in 70% ethyl alcohol or frozen until laboratory analysis.

Age, growth, and food habits of fish in the lakes were determined from fish collected throughout the study period.

Protection of High-Quality Recreational Fishing Waters

A review of high-quality recreational waters was conducted to determine which were in danger of undesirable development. The Naha drainage of Revillagigedo Island was chosen for study.

The recreational potential of the Naha system as an entity and the recreational potential of each of the lakes was evaluated. Information evaluated included: present and future recreational opportunity and importance, proximity to other recreational areas, uniqueness of the area, ability of the system to support a viable fishery, accessibility, and aethetics.

FINDINGS

Relationship of Limnological Characteristics to Fish Production

Morphometry:

The depth, size, and shape of lakes strongly influence physical and chemical conditions which prevail in them. Since physical and chemical parameters limit species composition and abundance of organisms, it is essential to study the morphometric features of lakes. Bathymetric maps of Snow and Orton lakes (Figure 2), Chamberlain Lake (Figure 3), Patching Lake (Figure 4), Heckman Lake (Figure 5), and Jordan Lake (Figure 6) were prepared from sounding data. Morphometric data for these lakes are presented in Tables 1 through 6, respectively. Bathymetric features of Roosevelt Lagoon are shown in Figure 7.

Physical and Chemical Considerations:

Observations of temperature, pH, Secchi disc visibility, conductivity, and alkalinity were made on each lake during the study period.

Thermal profiles of Patching and Heckman lakes are presented in Figure 8. All lakes were holomictic, having two circulating periods per year. Pronounced thermal stratification during the summer season varied in depth from 3 to 12 m, depending upon wind conditions.

Alkalinity, conductivity, pH, and Secchi disc visibility of the Naha lakes and Roosevelt Lagoon are summarized in Table 7. All lakes studied had low alkalinity and conductivity readings indicating a lack of dissolved nutrients.

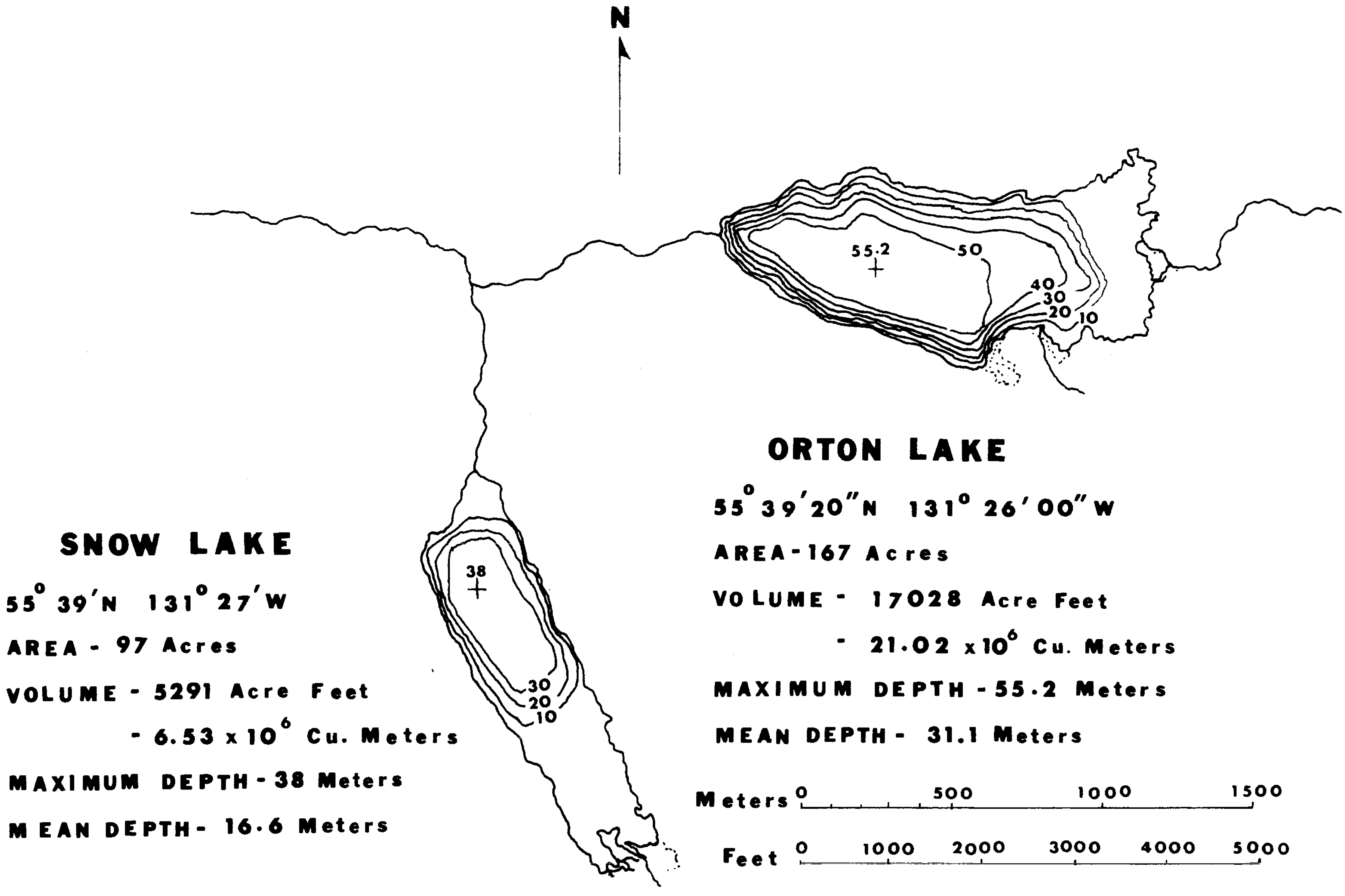

Figure 2. Bathymetric Maps of Snow and Orton Lakes.

CHAMBERLAIN LAKE

55° 38′ N 131° 29′ W

AREA - 201 Acres

VOLUME - 14921 Acre Feet

- 18.42 x 10^6 Cu. Meters

MAXIMUM DEPTH - 43 Meters

MEAN DEPTH - 22.6 Meters

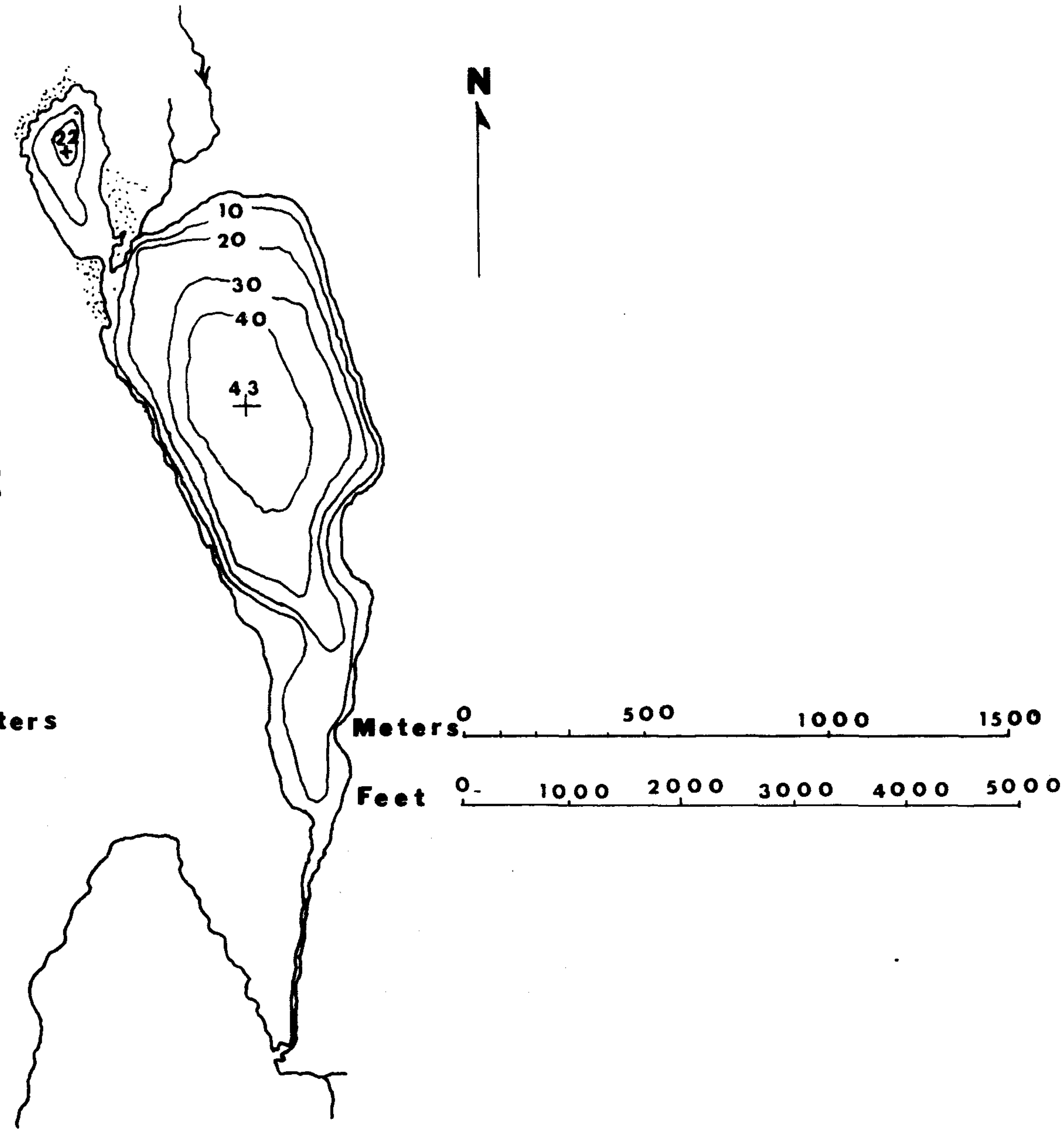

Figure 3. Bathymetric Map of Chamberlain Lake.

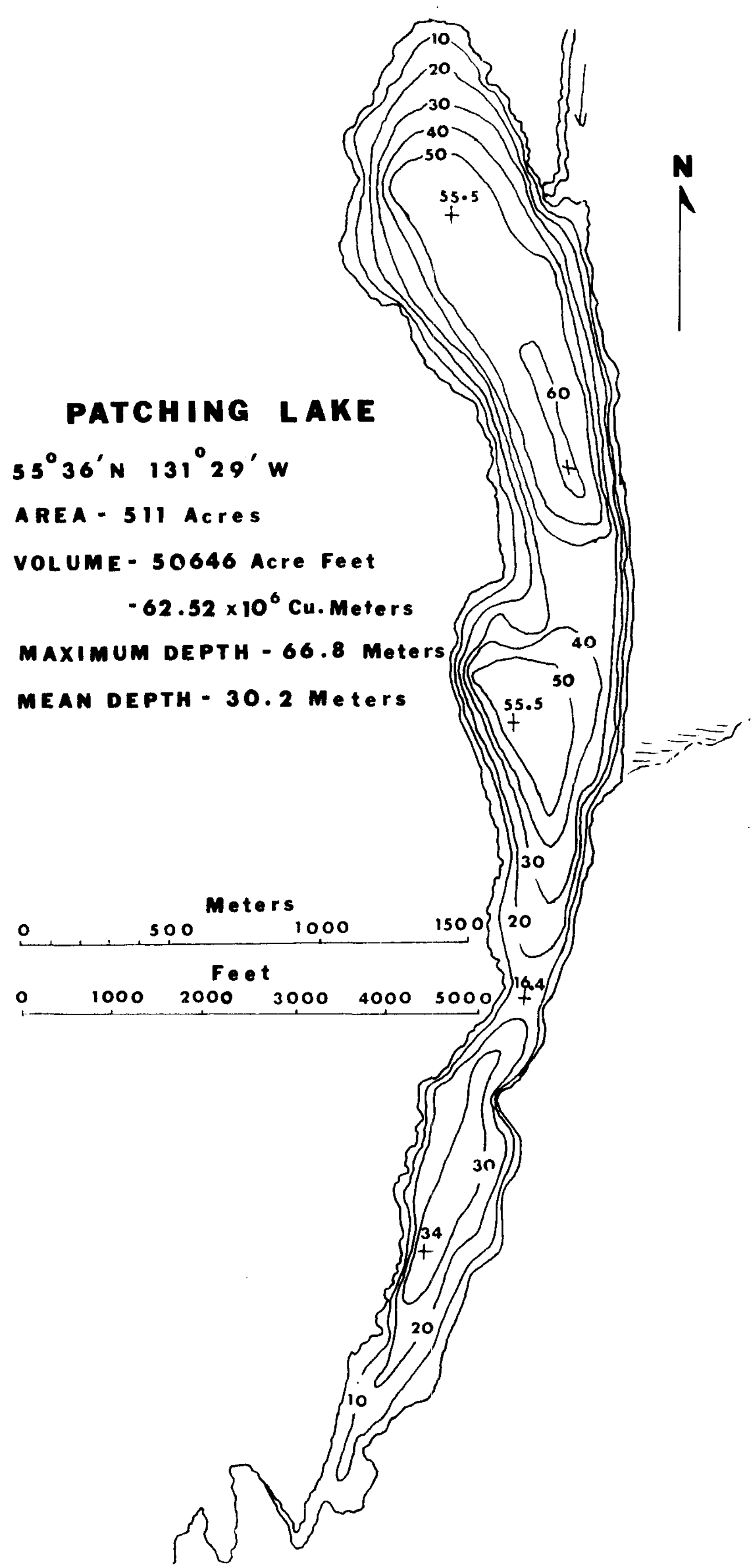

Figure 4. Bathymetric Map of Patching Lake.

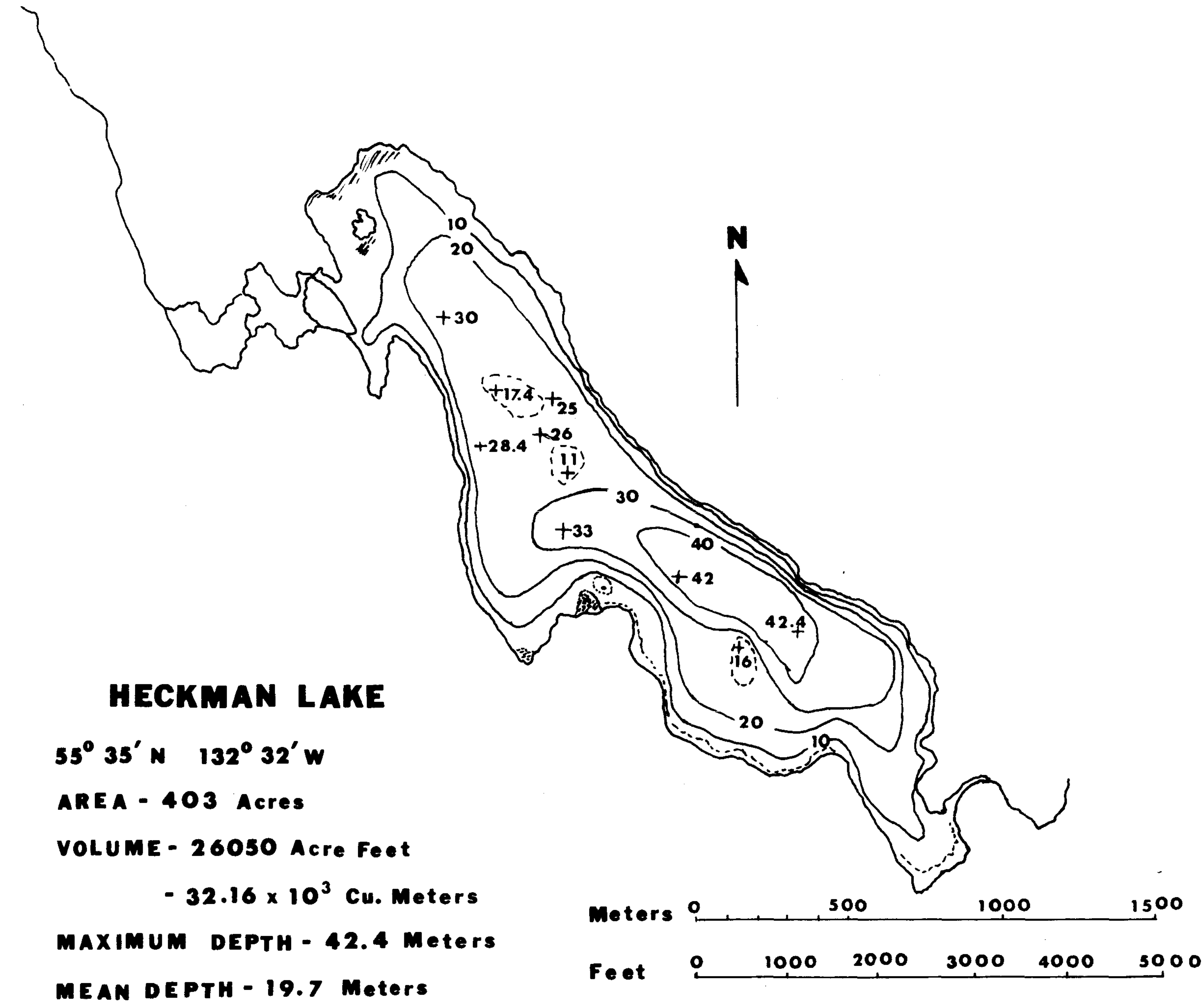

Figure 5. Bathymetric Map of Heckman Lake.

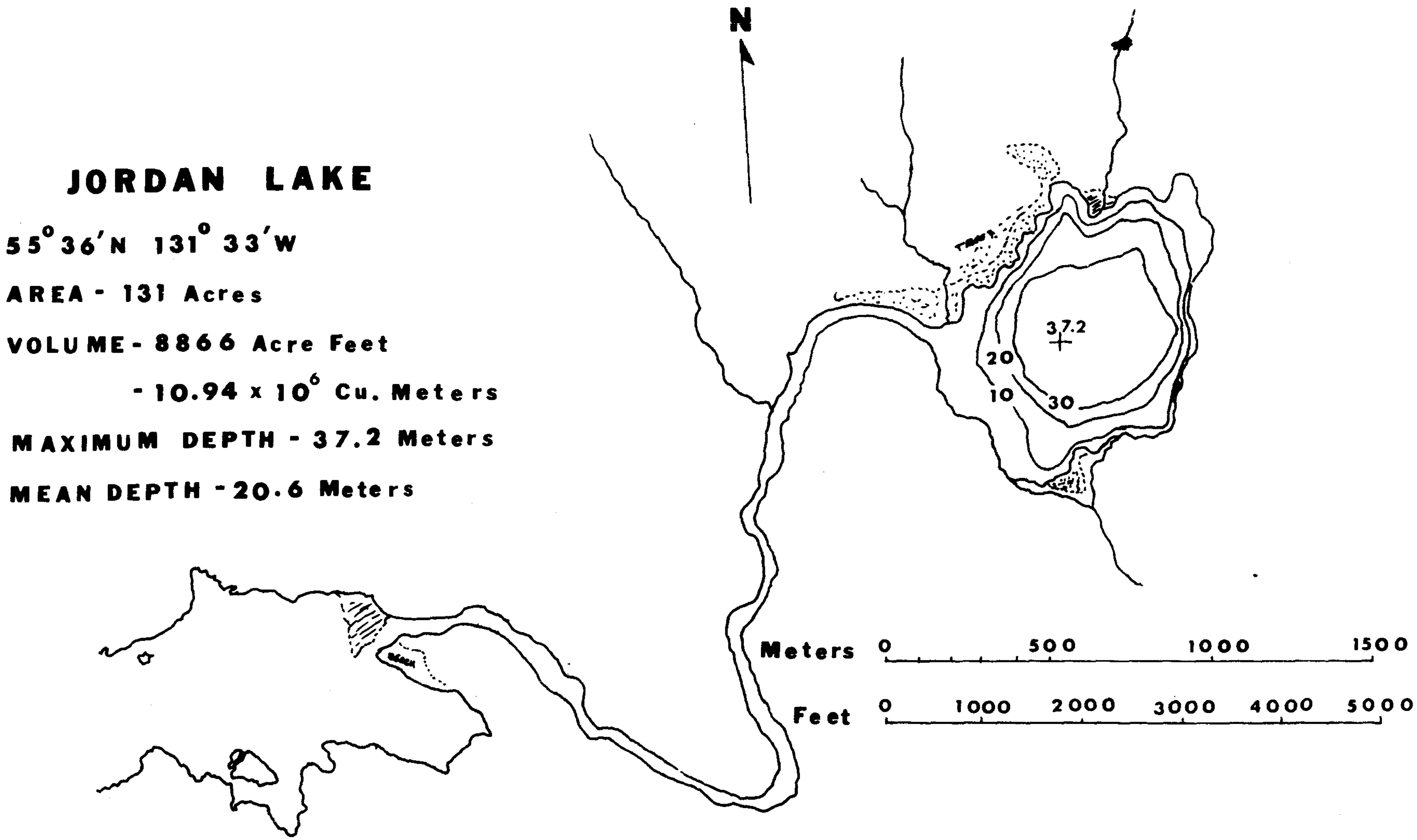

Figure 6. Bathymetric Map of Jordan Lake.

Table 1. Morphometry of Snow Lake.

Water Area

Hectares 39.4

Acres 97.4

Area by Depth Zones

Depth Zone (m)	Area (m^2)	Percent of Total Area
0-10	194,581	49.3
10-20	47,005	11.9
20-30	47,610	12.1
30+	105,324	26.7

Water Volume

Cubic Meters 6,531,594

Acre Feet 5,291

Volume by Depth Zones

Depth Zone (m)	Volume (m^3)	Percent of Total Volume
0-10	2,917,716	44.7
10-20	1,759,124	26.9
20-30	1,283,913	19.7
30+	570,841	8.7

Maximum Depth = 38.0 m

Mean Depth = 16.6 m

Shoreline Length = 3,535.0 m

Shoreline Development = 1.59

Table 2. Morphometry of Orton Lake.

Water Area

Hectares 67.6

Acres 167.0

Area by Depth Zones

Depth Zone (m)	Area (m^2)	Percent of Total Area
0-10	170,197	25.2
10-20	69,621	10.3
20-30	67,229	9.9
30-40	76,172	11.3
40-50	105,914	15.7
50+	186,852	27.6

Water Volume

Cubic Meters 21,020,360

Acre Feet 17,028

Volume by Depth Zones

Depth Zone (m)	Volume (m^3)	Percent of Total Volume
0-10	5,888,332	28.0
10-20	4,705,481	22.4
20-30	4,020,838	19.1
30-40	3,301,510	15.7
40-50	2,378,356	11.3
50+	725,843	3.5

Maximum Depth = 55.2 m Mean Depth = 31.1 m

Shoreline Length = 4,156.0 m Shoreline Development = 1.43

Table 3. Morphometry of Chamberlain Lake.

<u>Water Area</u>

Hectares 81.3

Acres 200.8

Area by Depth Zones

Depth Zone (m)	Area (m^2)	Percent of Total Area
0-10	192,797	23.7
10-20	172,571	21.2
20-30	159,468	19.6
30-40	148,775	18.3
40+	139,831	17.2

<u>Water Volume</u>

Cubic Meters 18,418,462

Acre Feet 14,921

Volume by Depth Zones

Depth Zone (m)	Volume (m^3)	Percent of Total Volume
0-10	7,148,737	38.8
10-20	5,320,220	28.9
20-30	3,654,288	19.8
30-40	2,097,751	11.4
40+	197,466	1.1

<u>Maximum Depth</u> = 43.0 m

<u>Mean Depth</u> = 22.6 m

<u>Shoreline Length</u> = 6,020.0 m

<u>Shoreline Development</u> = 1.88

Table 4. Morphometry of Patching Lake.

Water Area

Hectares 206.8

Acres 511.0

Area by Depth Zones

Depth Zone (m)	Area (m^2)	Percent of Total Area
0-10	352,165	17.0
10-20	332,729	16.1
20-30	352,872	17.1
30-40	354,050	17.1
40-50	227,911	11.0
50-60	416,530	20.1
60+	31,544	1.5

Water Volume

Cubic Meters 62,518,988

Acre Feet 50,646

Volume by Depth Zones

Depth Zone (m)	Volume (m^3)	Percent of Total Volume
0-10	18,889,292	30.2
10-20	15,462,371	24.7
20-30	12,021,473	19.2
30-40	8,468,196	13.5
40-50	5,581,382	8.9
50-60	1,995,016	3.2
60+	101,258	0.2

Maximum Depth = 66.8 m

Mean Depth = 30.2 m

Shoreline Length = 12,326.0 m

Shoreline Development = 2.42

Table 5. Morphometry of Heckman Lake.

Water Area

Hectares 163.3

Acres 403.0

Area by Depth Zones

Depth Zone (m)	Area (m^2)	Percent of Total Area
0-10	430,222	26.3
10-20	343,357	21.0
20-30	553,399	33.9
30-40	191,601	11.7
40+	114,250	7.0

Water Volume

Cubic Meters 32,157,800

Acre Feet 26,050

Volume by Depth Zones

Depth Zone (m)	Volume (m^3)	Percent of Total Volume
0-10	14,122,465	43.9
10-20	10,261,301	31.9
20-30	5,592,479	17.4
30-40	2,023,442	6.3
40+	158,113	0.5

Maximum Depth = 42.4

Mean Depth = 19.7 m

Shoreline Length = 9,746.0 m

Shoreline Development = 2.15

Table 6. Morphometry of Jordan Lake.

Water Area

Hectares 53.0

Acres 131.0

Area by Depth Zones

Depth Zone (m)	Area (m^2)	Percent of Total Area
0-10	145,186	27.4
10-20	105,325	19.9
20-30	102,360	19.3
30+	177,320	33.4

Water Volume

Cubic Meters 10,944,866

Acre Feet 8,866

Volume by Depth Zones

Depth Zone (m)	Volume (m^3)	Percent of Total Volume
0-10	4,556,664	41.6
10-20	3,309,428	30.2
20-30	2,265,648	20.7
30+	813,126	7.4

Maximum Depth = 37.2 m

Mean Depth = 20.6 m

Shoreline Length = 3,108.0 m

Shoreline Development = 1.20

Table 7. Alkalinity, Conductivity, pH, and Secchi Disc Visibility of Naha Lakes and Roosevelt Lagoon, 1975.

Lake	Alkalinity (mg/L)	Conductivity (μ mhos)	pH	Secchi Disc Visibility (m)
Snow	3.0-4.0	7.5-16.5	6.3-7.5 (?)*	9.5
Orton	4.0-9.2	10 -19	6.3-7.5 (?)*	7.5
Chamberlain	2.0-3.0	11 -26	6.2-7.2 (?)*	6.3
Patching	4.0-7.0	14 -16	5.5-6.3	6.0-7.9
Heckman	3.0-6.0	15	5.8-6.7	5.4-7.0
Jordan	5.0-6.0		6.6	6.5
Roosevelt Lagoon		610-23,000		

*Readings may be high due to instrument malfunction.

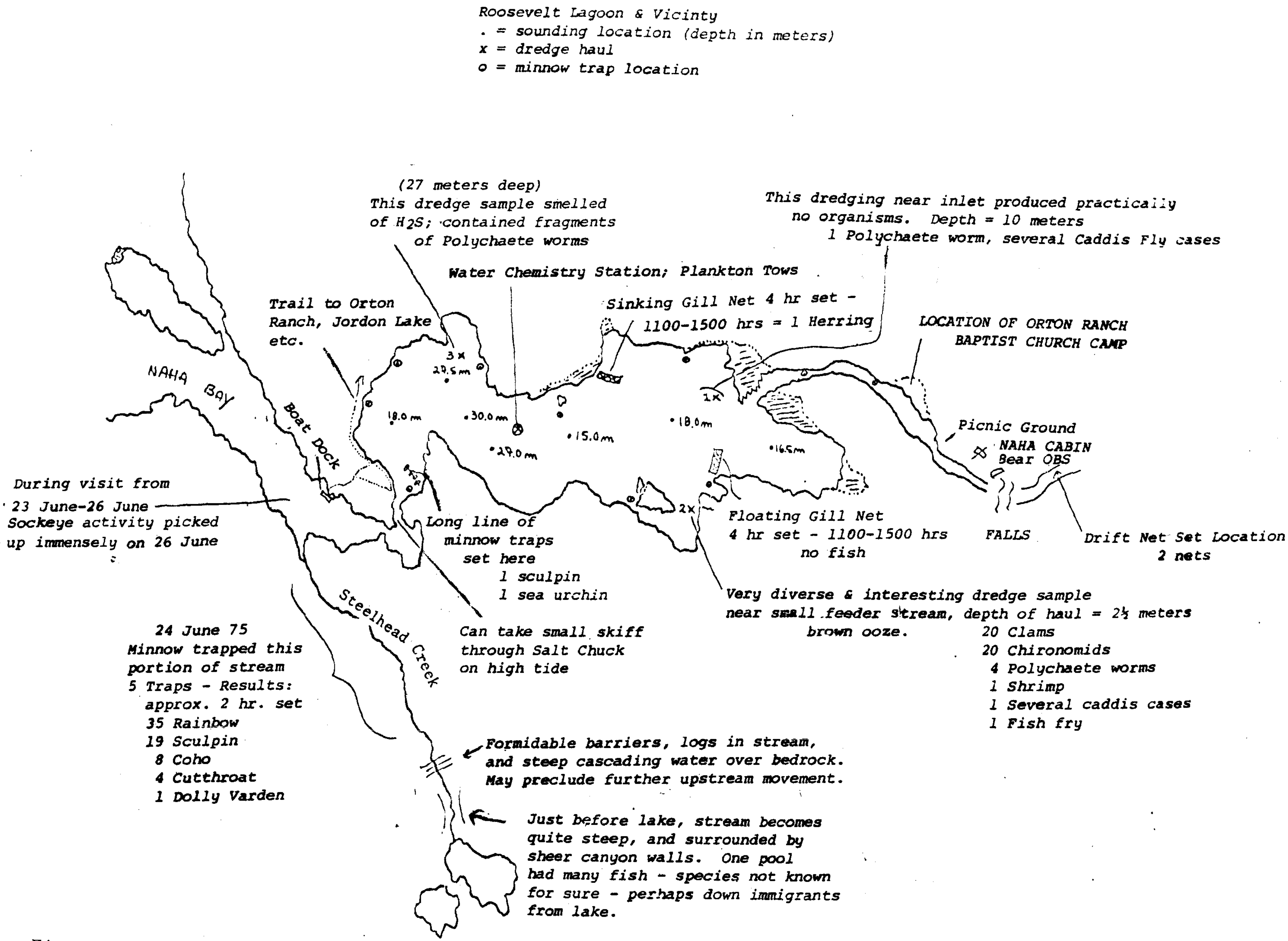

Figure 7. Map of Roosevelt Lagoon and Vicinity.

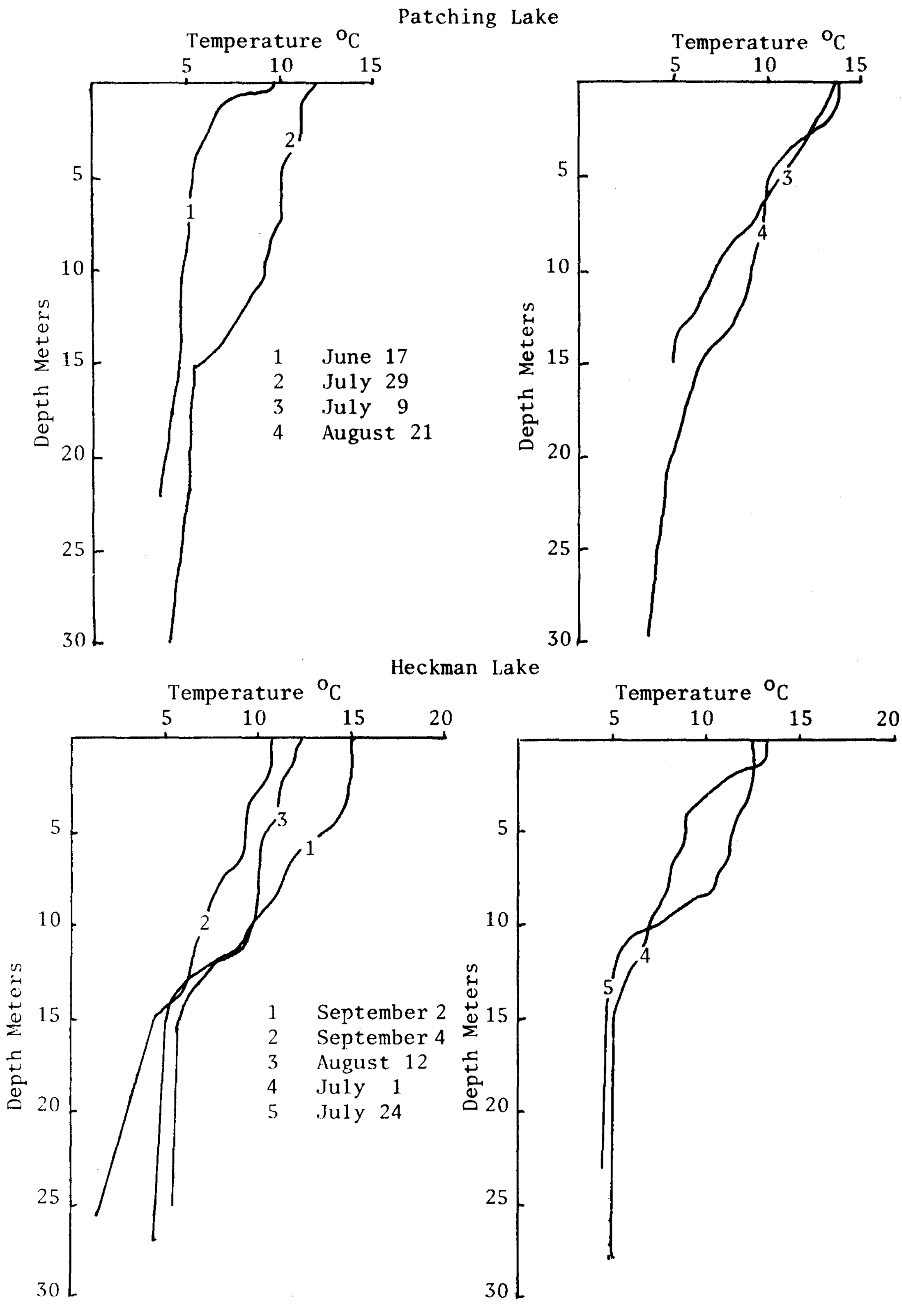

Figure 8. Thermal Profiles of Patching and Heckman Lakes, 1975.

The wide range of pH fluctuations also indicates a low buffering capability of the water. Roosevelt Lagoon has pure strength salt water at the bottom and fresh water at the surface.

Quantitative analyses of ions in Heckman, Patching, Klawak, and Salmon lakes are presented in Table 8.

Rawson (1951) described the usefulness of mineral content (total dissolved solids) as "a rough indicator of edaphic conditions which must in some measure affect the productivity of lakes." He suggested that a preoccupation with ionic components and limiting elements had led to neglect of the measurement of total dissolved solids as a simple and useful index to the conditions which lie behind productivity. Rawson qualified this observation by noting that differences in productivity in the Laurentian Great Lakes could not be ascribed to differences in mineral content alone. For example, lakes Erie and Ontario have approximately the same mineral content; Erie has a fish yield about ten times that of Ontario. This difference could be explained better on a morphometric basis rather than an edaphic one, as Lake Ontario has a mean depth about five times that of Lake Erie. Rawson (1951) suggested that the relative shallowness of Lake Erie (morphometry) far outweighed the effect of the mineral content or edaphic influence.

Rawson (1952) considered the depth of a lake to be important mainly for its effects on temperature, thermal stratification, and the circulation and dilution of nutrient materials. He suggested that mean depth might be correlated with standing crops of both plankton and bottom fauna as well as with sustained fish yield. He provided data to support this hypothesis (Rawson, 1955).

The morphoedaphic index (Ryder, 1964; 1965) is an empirically-derived formula that was described initially as a convenient method of rapidly calculating potential fish yields from unexploited north-temperate lakes. Since its inception, the constraints on the use of the morphoedaphic index (MEI) have been relaxed as it has been applied to sets of lakes other than those for which it was originally devised. Various investigators have clarified our understanding of the MEI (e.g., Jenkins, 1967; Regier et al., 1971; and Henderson et al., 1973) and have extended the application of this index to other climatic systems.

A MEI for 12 lakes in Southeast Alaska is presented in Table 9. This shows a relative ranking in productivity from the most productive (Klag) to the least productive (Swan). This productivity ranking may not be exact within the range encompassed but appears to have some usefulness as a productivity index for Southeast Alaska lakes. Correlation of MEI with zooplankton productivity may yield a more meaningful index.

Plankton:

Zooplankton populations were monitored throughout the summer at Patching Lake (Table 10) and Heckman Lake (Table 11). Zooplankton was collected only once for each of the other lakes (Table 12) and Roosevelt Lagoon (Table 13).

Table 8. Water Quality and Nutrient Analysis of Selected Southeast Alaska Lakes, 1975.

Lake and Date	Depth (m)	Alkalinity ($CaCO_3$) (mg/l)	Aluminum Total (ug/l)	Bicarbonate HCO_3 (mg/l)	Boron Total (ug/l)	Calcium Dissolved (mg/l)	Carbon Total Organic (mg/l)	Chloride Dissolved (mg/l)	Cyanide Total (mg/l)	Color	Conductivity (micromhos)	Flouride (mg/l)	Hardness (mg/l) Total (mg/l)	Hardness (mg/l) Noncarbonate	Iron Dissolved (ug/l)	Magnesium Dissolved (mg/l)	Manganese Dissolved (mg/l)	Molybdenum Total (ug/l)
Heckman,																		
August 5	0.3	5.0	80.0	6.0	6.0	2.2	3.6	0.7	11.0	18	15	0.0	7.0	2.0	50.0	0.4	0.0	
	7.3	3.0	90.0	4.0	30.0	2.3	13.0	0.5		18	15	0.1	7.0	4.0	50.0	0.4	0.0	
	14.0	3.0	90.0	4.0	20.0	2.3	3.2	0.9		15	15	0.0	8.0	5.0	50.0	0.5	0.0	
November 17	0.9	6.0		7.0		2.1	3.8	1.3		20	15	0.0	6.0	0.0	110.0	0.1	0.0	
Salmon,																		
August 8	0.3	7.0	90.0	9.0	30.0	3.4	2.6	1.9		15	26	0.0	11.0	4.0	40.0	0.7	0.0	
	5.9	7.0	110.0	9.0	20.0	3.4	5.0	2.6		15	26	0.1	11.0	4.0	70.0	0.7	0.0	
	11.9	5.0	150.0	6.0	30.0	3.2	5.4	2.5		20	26	0.0	10.0	6.0	10.0	0.6	0.0	
November 17	0.9	10.0		12.0		3.1	4.3	1.7		20	23	0.0	8.0	0.0	70.0	0.1	0.0	
Patching,																		
August 7	6.5	4.0	90.0	5.0	20.0	1.8	3.8	1.4		15	14	0.0	7.0	2.0	30.0	0.5	0.0	
	18.9	7.0	100.0	8.0	40.0	2.2	4.0	1.5		10	16	0.0	8.0	1.0	60.0	0.5	0.0	
November 17	0.7	6.0		7.0		2.2	7.8	1.3		15	16	0.0	6.0	1.0	100.0	0.2	0.0	
Klawock,																		
August 8	0.3	13.0	130.0	16.0	30.0	4.6	4.0	3.0		20	37	0.0	14.0	0.0	20.0	0.5	0.0	
	4.9	16.0	150.0	19.0	20.0	4.4	4.6	3.1		20	37	0.0	13.0	0.0	20.0	0.5	0.0	
	14.9	13.0	100.0	16.0	30.0	4.3	3.1	3.3		20	37	0.0	13.0	0.0	10.0	0.5	0.0	
November 17	0.9	15.0		18.0		4.5	4.6	3.3		25	37	0.1	17.0	2.0	500.0	1.3	20.0	

Table 8. (Cont.) Water Quality and Nutrient Analysis of Selected Southeast Alaska Lakes, 1975.

	Nitrogen (mg/l)									Phosphate (mg/l)				Residue								
Lake and Date	NH_4 AS N Total	Total AS N	Total AS NO_3	Total ORG N	Total KJD AS N	$NO_2 + NO_3$ AS N Total	$NO_2 + NO_3$ AS N Dissolved	Oxygen Dissolved (mg/l)	pH (units)	Ortho Dissolved AS P	Ortho Dissolved	Total AS P	Potassium Dissolved (mg/l)	Dissolved Calculated Sum (mg/l)	Dissolved Ton/ Acre Foot	Dissolved 180°C (mg/l)	SAR	Silica Dissolved (mg/l)	Sodium Dissolved (mg/l)	Sodium Percent	Sulfate Dissolved (mg/l)	Temperature (°C)
Heckman,																						
August 5	0.00	0.12	0.53	0.12	0.12	0.00	0.00	10.8	6.7	0.00	0.00	0.00	0.2	22.0	0.02	12.0	0.2	1.0	1.4	29.0	1.9	13.0
	0.00	0.26	1.20	0.25	0.25	0.01	0.01	10.8	6.7	0.00	0.00	0.00	0.2	11.0	0.02	12.0	0.1	1.2	0.8	19.0	3.1	11.0
	0.00	0.16	0.71	0.16	0.16	0.00	0.00	11.3	5.8	0.00	0.00	0.00	0.2	10.0	0.01	5.0	0.1	1.1	0.7	16.0	1.8	5.9
November 17	0.00	0.05	0.22	0.04	0.04	0.01	0.01	12.0	6.5	0.00	0.00	0.00	0.2	11.0	0.02	11.0	0.1	1.0	0.7	21.0	2.0	5.4
Salmon,																						
August 8	0.00	0.10	0.44	0.09	0.09	0.01	0.01	10.4	7.2	0.01	0.03	0.02	0.1	16.0	0.03	19.0	0.2	1.7	1.5	22.0	2.3	14.0
	0.00	0.11	0.49	0.08	0.08	0.03	0.03	10.4	6.9	0.00	0.00	0.02	0.2	17.0	0.03	19.0	0.2	1.8	1.4	21.0	2.1	12.8
	0.00	0.24	1.10	0.16	0.16	0.08	0.02	11.7	6.5	0.00	0.00	0.01	0.1	15.0	0.02	15.0	0.3	1.7	2.0	29.0	2.3	7.0
November 17	0.00	0.11	0.49	0.04	0.04	0.07	0.03		6.6	0.00	0.00	0.00	0.1	16.0	0.03	19.0	0.3	1.3	1.8	32.0	1.6	5.8
Patching,																						
August 7	0.00	0.06	0.27	0.01	0.01	0.05	0.05	11.1	5.5	0.00	0.00	0.02	0.2	13.0	0.01	10.0	0.1	1.3	0.6	16.0	4.6	10.0
	0.00	0.03	0.13	0.01	0.01	0.02	0.02	11.9	5.6	0.24	0.74	0.30	0.3	15.0	0.02	16.0	0.2	1.3	1.1	23.0	3.1	4.1
November 17	0.00	0.15	0.66	0.14	0.14	0.01	0.01	12.4	6.3	0.00	0.00	0.00	0.2	11.0	0.02	12.0	0.1	1.0	0.7	19.0	2.2	5.2
Klawock,																						
August 8	0.00	0.02	0.09	0.01	0.01	0.01	0.00	10.4	7.0	0.00	0.00	0.01	0.2	23.0	0.03	21.0	0.3	1.7	2.5	28.0	3.0	14.0
	0.00	0.06	0.27	0.05	0.05	0.01	0.00	10.8	7.4	0.00	0.00	0.01	0.2	25.0	0.03	22.0	0.3	1.7	2.4	28.0	3.2	14.0
	0.00	0.07	0.31	0.05	0.05	0.02	0.01	12.4	6.9	0.00	0.00	0.01	0.2	24.0	0.03	20.0	0.3	1.8	2.4	29.0	3.2	8.0
November 17	0.00	0.13	0.58	0.12	0.12	0.01	0.01			0.01	0.03	0.00	2.5	27.0	0.02	18.0	0.2	1.7	2.0	18.0	2.6	5.7

Table 9. Morphoedaphic Index of Twelve Lakes in Southeast Alaska.

Lake	Specific Conductance (µ mho)	Residue Dissolved Calculated Sum (mg/1)	Surface Area (ha)	$\bar{x}$ Depth (m)	MEI*	Potential Yield** (kg/ha)
Klawak	39	24	1,177	17.7	1.36	1.13
Green	39	22	70	12.3	1.79	1.29
Blue	33	22	538	52.0	0.42	0.63
Auke	28	20	46	19.0	1.05	0.99
Karta	26	16	508	27.6	0.58	0.74
Swan	20	16	208	91.4	0.18	0.41
Osprey	20	14	109	60.0	0.23	0.46
Patching	17	14	207	30.2	0.46	0.66
Heckman	17	14	163	19.7	0.71	0.81
Spurt	16	14	107	22.2	0.63	0.77
De Boer	13	13	51	23.0	0.56	0.72
Klag	24	51	190	12.0	4.25	1.99

*MEI - Morphoedaphic Index = $\frac{\text{Total Dissolved Solids (TDS)}}{\text{Mean Depth } (\bar{z})}$ (Ryder, 1965)

**Ryder (1965) described the equation $y \sim 2\sqrt{x}$ where y = yield in pounds per acre and mean depth ($\bar{z}$) was in feet. The metric expression (Ryder et. al., 1974) is therefore $y \sim 0.966\sqrt{x}$ where yield is expressed as kg/ha, $\bar{z}$ as meters, and TDS as mg/1.

Table 10. Plankton Composition, Density (organisms per square meter), and Weight (milligrams per square meter) as Collected With No. 10 and No. 20 Nitex Plankton Nets, Patching Lake, 1975.

Date	June 18		July 9		July 29		August 19		September 9	
Depth of Tow (m)	30	25	49	43	43	54	44	50	53	51
Mesh Size	10	20	10	20	10	20	10	20	10	20
Copepoda										
Calanoida	1,732	814	4,634	4,380	17,658	11,882	21,390	20,372	1,325	22,068
Cyclopoida	3,259	3,106	2,394	3,208	763	1,614	2,444	3,734	4,074	6,452
Nauplii	611	4,788	1,732	4,125	509	1,782	814	4,074	4,416	19,353
Cladocera										
Daphnia sp.	1,782	1,782	1,476	1,476	4,498	3,646	5,092	2,378	5,434	8,490
Bosmina sp.	51	102	1,274	662	8,572	8,572	31,168	46,856	40,066	73,680
Holopedium sp.	51		306	408	678	254			342	1,018
Polyphemus sp.			102	204	1,360	850	408	3,055	1,018	2,038
Rotatoria										
Kellicottia sp.		204	850	916	168	4,751	408	47,532	2,038	1,400
Keratella sp.				102						
Miscellaneous	204		53,818	714	313,216	193,532	1,970,976	1,115,350	945,592	926,916
Dry Weight	49.9	49.9	61.6	141.6	180.8	221.5		502.1	314.2	312.2
Organic Weight	40.7	39.2	54.0	121.2	157.4	195.6		458.9	304.6	275.5
Ash Weight	9.2	10.7	7.6	20.4	23.4	26.0		43.3	9.6	36.7

Table 11. Plankton Composition, Density (organisms per square meter), and Weight (milligrams per square meter) as Collected With No. 10 and No. 20 Nitex Plankton Nets, Heckman Lake, 1975.

Date	June 10	July 1		July 24		August 13		September 3	
Depth of Tow (mm)	27	37	37	38	32	38	39	22	32
Mesh Size	20	10	20	10	20	10	20	10	20
Copepoda									
Calanoida			342		342				
Cyclopoida	98,462	66,040	46,178	129,020	147,018	378,547	378,547	288,620	249,554
Nauplii	168	2,206	31,406	2,038	303,198	1,696	199,476	7,640	111,408
Cladocera									
Daphnia sp.	2,378	2,378	5,435	9,508	6,112	9,336	9,336	44,140	16,042
Bosmina sp.	4,242	6,112	5,435	47,196	24,788	61,966	58,568	122,230	98,930
Holopedium sp.	510		678	678		850		110,348	
Rotifera									
Kellicottia sp.	168		342		1,018	850	168		1,782
Keratella sp.	168		342				850		
Miscellaneous					3,396		2,546		891
Dry Weight	205.2	126.3	133.4	183.8	285.2	633.6	505.2	484.8	411.0
Organic Weight	177.7	118.7	118.2	159.9	249.0	607.1	454.3	458.9	383.5
Ash Weight	27.5	7.6	15.2	23.9	38.2	26.5	50.9	25.9	27.5

Table 12. Plankton Composition. Density (organisms per square meter), and Weight (milligrams per square meter) as Collected With No. 10 and No. 20 Nitex Plankton Nets; Snow, Orton, Chamberlain, and Jordan Lakes, 1975.

Lake	Snow		Orton		Chamberlain		Jordan	
Date	August 27		September 11		August 7		July 16	
Depth of Tow (m)	32	33	47	50	27	28	33	31
Mesh Size	10	20	10	20	10	20	10	20
Copepoda								
Calanoida	30,898	25,720	7,130	8,404	12,900	5,770	7,808	4,924
Cyclopoida	3,734	2,292	2,038	3,819	15,278	8,148	2,546	2,714
Nauplii	168				1,018		1,546	16,638
Cladocera								
Daphnia sp.	12,055	12,224	6,112	7,384	6,788	1,442	1,696	1,186
Bosmina sp.	850	254	1,359	2,546	27,502	3,734	5,602	3,906
Holopedium sp.	6,112	5,856	6,788	4,838				
Polyphemus sp.	510	510	342					
Rotatoria								
Kellicottia sp.	1,696	41,594	1,186	10,696	2,378	342	342	678
Keratella sp.		3,396		5,349		86	168	
Miscellaneous	117,648	79,833	4,752	16,043			168	17,994
Dry Weight	588.7	472.1	358.5	400.3	265.8	399.8	35.7	78.9
Organic Weight	511.8	406.4	269.9	254.6	241.4	280.1	26.0	50.9
Ash Weight	76.9	65.7	88.6	145.7	24.4	119.7	9.7	28.0

Table 13. Plankton Composition, Density (organisms per square meter), and Weight (milligrams per square meter) as Collected With No. 10 and No. 20 Nitex Plankton Nets, Roosevelt Lagoon, June 25, 1975.

Depth	17 Meters	
Meters	10	20
Dinoflagellida		
Noctiluca sp. (marine)	185,724	164,502
Miscellaneous		52,966
Holotrichia		
Tintinnida		3,056
Scyphazoa	76	117
Gastropoda (larvae)	11,546	21,390
Pelycepoda (larvae)	117,816	122,740
Cladocera		
Daphnia sp.	341	
Evadne sp. (marine)	342	510
Cirripedia (nauplii)	3,056	2,038
Copepoda		
Calanoida	30,898	29,539
Cyclapoida	42,440	4,889
Harpacticoida	341	
Nauplii	12,564	41,762
Dry Weight	628.0	526.1
Organic Weight	257.2	246.0
Ash Weight	370.8	280.1

Plankton composition of Patching and Heckman lakes is quite similar with one exception. Heckman, an anadromous lake, has only a trace population of the larger copepod Diaptomus sp. Heckman serves as a rearing area for juvenile sockeye, Oncorhynchus nerka (Walbaum), and coho salmon, O. kisutch (Walbaum). Although Patching, a nonanadromous lake, has a population of kokanee, the Diaptomus sp. population develops dense concentrations.

Although standing crop of plankton does not measure production, net plankton samples may show some distinction between oligotrophic and eutrophic lakes. Rawson (1953) stated that the standing crop of No. 20 net plankton measured by total vertical hauls exhibits this distinction in western Canada. He gives this range as 10-40 kg/ha dry weight for alpine and large oligotrophic lakes, while mesotrophic and moderately eutrophic lakes have up to 100 kg/ha.

The standing crop of No. 20 net plankton was calculated using an assumed net efficiency of 25%. The organic weight of the four heaviest plankton samples collected throughout the summer was averaged for each lake with available data. Average standing crop (organic weight in kg/ha) of No. 20 net plankton for 11 lakes in Southeast Alaska are: Klawak, 41.9; Swan, 23.9; Osprey, 15.9; Blue, 15.8; Auke, 12.0; Heckman, 12.0; De Boer, 10.7; Patching, 10.5; Spurt, 7.0; Redoubt, 4.1; and Green, 1.6.

Bottom Fauna:

Bottom fauna collected by dredging and screening benthic material are identified and enumerated in Table 14. Analysis of stream drift net samples collected from the Naha River inlets to Patching Lake (Table 15), Heckman Lake (Table 16) and other lakes sampled (Table 17) show a wide diversity of species. Identification of insects collected with the surber sampler (Table 18) and insects collected by hand collecting (Table 19) yielded a number of species not previously encountered. These include species of the genus Ephemerella.

Fish:

Species distribution of fish in lakes is described in the following section, "Recreational Survey." Length-age of Arctic grayling, Thymallus arcticus (Pallas), from Snow and Orton lakes is presented in Figure 9. Length-age relationship of cutthroat trout, Salmo clarki Richardson, in Chamberlain and Patching lakes is shown in Figure 10. Stomach content analysis from cutthroat is presented for Patching Lake (Table 20) and for Chamberlain Lake, Jordan Lake, and Roosevelt Lagoon (Table 21). Stomach content analysis from rainbow trout, S. gairdneri Richardson, is presented in Table 22.

Recreational Surveys of Naha Drainage

The Naha River is located on Revillagigedo Island, just north of Ketchikan. The Naha system is accessible only by boat or floatplane. From Ketchikan, Naha Bay can be reached via boat by traveling northwest up Tongass Narrows, through Clover Passage and Behm Canal, to Naha Bay. The trip

Table 14. Identification and Enumeration (organisms/m^2) of Benthic Organism From Lakes Studied, 1975.

Lake	Heckman	Patching	Orton	Snow	Chamberlain	Jordan	Roosevelt Lagoon
Depth Range (m)	0.5-24.0	0.7-21.0	1.5-39.5	1.0-32.0	3.0-30.0	1.5-32.0	10.0
Number Samples	12	8	3	3	3	3	3
Nematoda	3.6						
Oligochaeta	165.1	145.3	301.4	287.0	57.4	100.4	
Polychaeta							129.2
Hirudinea	14.4	5.4			14.4		
Ostracoda					143.5		
Amphipoda	82.6	48.4		100.4	14.4		14.3
Araneae				28.7			
Ephemeroptera				14.4			
Tricoptera	18.0	5.4		14.4	28.7	28.7	
Lepidoptera						14.4	
Coleoptera		5.4					
Diptera							
Chironomidae	398.5	242.1	660.1	459.2	617.0	502.2	301.4
Empididae	18.0	10.8					
Ceratopogonidae	3.6	32.3					
Chilopoda						14.4	
Gastropoda	46.7	5.4			57.4		172.2
Pelecypoda	201.0	156.0	186.5	244.0	1,119.3	301.4	186.6

Table 15. Identification and Enumeration of Stream Drift Organisms, Naha River Above Patching Lake, 1975.

Date	June 18		July 10		July 29		July 30		August 20		September 4	
Net	1	2	1	2	1	2	1	2	1	2	1	2
Oligochaeta						2						2
Hydracarina		2	2	3	1				4	10	2	3
Araneae		1							1			
Collembola			3	3		2						1
Plecoptera												
Nemouridae												
Nemoura sp.										1		
Capnidae												
Capnia sp.		1										
Leuctridae												
Leuctra sp.		14		1		1		1	1	1	1	
Perlidae												
Acroneuria pacifica										1		
Chloroperlidae												
Alloperla oregonensis	2	2										
Alloperla sp.						1	1					
Hemiptera				1								
Homoptera				1	1							
Coleoptera				1								
Dytiscidae			1									1
Staphylinidae		6										
Trichoptera												
Psychomyiidae			1									
Limnephilidae		1						1	1	1		1
Lepidostomatidae												
Lepidostoma sp.						1						
Hydropsychidae												
Arctopsyche sp.												1
Hydroptilidae												
Agraylea sp.				1	1							
Lepidoptera				1	1							
Diptera												
Sciaridae					1							
Ceratopogonidae				1	1	1						
Calliphoridae					2							
Chironomidae												
Adults and Pupae	6	9	10	14	7	3		2		3		2
Larval Forms	4	1	4	2	4	1		6	1	2	3	1
Tanpodinae		1	2		1							
Pentaneurini				1	2			2	1		1	
Orthocladiinae			1					1		2	1	1
Psectrocladius sp.	1											
Chironominae												
Tanytarsini			1									
Micropsectra sp.	1			1								
Chironomini		9			2			3				
Simuliidae				17								
Prosimulium sp.		14										
Simulium sp.			4		142	35		39	52	18	3	
Tipulidae				1								9
Dicranota sp.			1					1				
Unidentified								3				
Empididae	1		2	4	2					2		
Psychodidae						1						
Dolichopodidae		1										
Miscellaneous Terrestrial	1	3	2	20		2		1	2			
Hymenoptera				7				3				
Ephemeroptera												
Baetidae						3		19				
Baetis bicaudatus					2		8		3	4		
B. tricaudatus				4	1		8		2	2	4	
Siphlonuridae												
Siphlonurus sp.			1									
Leptophlebiidae								1				
Paraleptophlebia memorialis			2	14		2	4	7				
Paraleptophlebia debilis		2			2		1		1	5	3	
Ameletus		1										
Ephemerellidae												
Ephemerella (Drunella) doddsi						1						
E. (Serratella) tibialis				1	1	7	37			1		
E. S. S. inermis	1						2					
Ephemerella sp.						1						
Heptageniidae												
Cinygmula sp.			1							1		
Epeorus longimanus	1			1	3		1					
E. albertae							3		1			
Rhithrogena sp.				1				2				
Exuviae	10	12	10	23	8	23						
Zooplankton	2	4					20	20				

Table 16. Identification and Enumeration of Stream Drift Organisms, Naha River Above Heckman Lake, 1975.

Date	June 12		July 2		July 24		August 13		September 3	
Net	1	2	1	2	1	2	1	2	1	2
Hydracarina	1			5		1	2		4	
Araneae	2	1					1		1	
Collembola				1					1	
Smynthuridae	3		1							
Plecoptera										
Leuctridae										
Leuctra sp.			1	1		2				
Chloroperlidae										
Alloperla sp.		2		1		2	6			
A. oregonensis	9	12								
A. (Suwallia) sp.								2	1	
Hemiptera										
Miridae							1			
Homoptera	2		1			1	1			
Cicadellidae			1							
Coleoptera			1							
Carabidae						3				
Dytiscidae									1	
Staphylinidae							1			
Trichoptera										
Limnephilidae	2	1	2	1	1					
Brachycentridae										
Micrasema sp.	1	2		1						
Rhyacophilidae										
Rhyacophila sp.			1	1	1					
Glossosoma sp.						1				
Lepidostomatidae										
Lepidostoma sp.					2	3	1			
Hydropsychidae										
Hydropsyche sp.						1				
Lepidoptera	1		1							
Diptera										
Ceratopogonidae								1		
Dixidae								1		
Chironomidae						3				
Adults and Pupae	58	59	12	3	1	2	8		1	1
Larval Forms	1	2	7	7	8	7		1	4	1
Tanypodinae		1	2	3	3					
Pentaneurini						1				
Orthocladiinae					1	1			4	1
Chironominae					1	1				
Tanytarsini			2							
Micropsectra sp.						1				
Tanytarsus sp.										
Chironomini	1	1	1	4	4	1		1		
Simulidae			2	2	1					
Prosimulium sp.	2									
Simulium sp.		2	9				1	3	3	
S. eusimulium				3						
Tipulidae										
Dicranota sp.						2	1			
Empidadae		2	2	1	2		2	1		
Dolichopodidae							1			
Miscellaneous Terrestrial							2		1	3
Ephemeroptera										
Baetidae	14	18	13		4					1
Baetis bicaudatus										
B. tricaudatus				19	6	16	7	20	8	
Leptophlebidae									1	
Paraleptophlebia memorialis	1	1	2		4	17	1	1		
Ephemerellidae										
E. S. S. inermis		1		1						
Heptageniidae										
Cinygmula sp.				4		1				
Epeorus longimanus	1	1					1	1		
Rhithrogena sp.										
Fish			1	1						
Exuviae	19	56	23	7					15	2
Zooplankton		2	1							

Table 17. Identification and Enumeration of Stream Drift Organisms, Naha River Inlet Above Orton, Snow, Chamberlain, and Jordan Lakes, and Roosevelt Lagoon, 1975.

Lake	Orton		Snow		Chamberlain		Jordan		Roosevelt Lagoon	
Date	September 10		August 27		August 6		July 16		June 25	
Net	1	2	1	2	1	2	1	2	1	2
Oligochaeta		1		2		1				1
Turbellaria			1							
Hydracarina					1				3	
Araneae		2								
Collembola		2				1				
Plecoptera										
Nemouridae										
Nemoura sp.	51	35	1	1						
Leuctridae										
Leuctra sp.	1	4				5				
Chloroperlidae										
Alloperla (Suwallia) pallidula	25	51								2
Allperla sp.							1			
Perlodidae	3									
Coleoptera										
Carabidae					2					
Dytiscidae	3	3		1						
Staphylinidae	2	4		1						
Scolytidae		1								
Tricoptera										
Philopotamidae										
Dolophilus moetrus										
Lepidostomatidae							1	1		
Lepidostoma sp.						1				
Hydropsychidae										
Hydropsyche sp.							1			
Leptoceridae										
Mystacidides sp.				1						
Lepidoptera			1							
Diptera										
Chironomidae										
Adults and Pupae	1		2	1		1	3	2		
Larval Form	13	8			3	11		1	4	
Tanypodinae						3			4	
Pentaneurini					3	3				
Diamesinae		2								
Orthocladinae		2				5				
Nanocladius sp.								1		
Chironominae						3				
Tanytarsini						1				
Micropsectra sp.						1				
Chironomini						2				
Simulidae			1	3						
Prosimulium sp.									1	
Simulium sp.	4	5					2	4		11
Tipulidae		2								
Empididae										
Miscellaneous Terrestrial		2					3			1
Ephemeroptera										
Siphlonuridae					2					
Ameletus sp.	10		42	2				1		
Baetidae										
Baetis bicaudatus	145	19	7	10	1		9	2	2	4
B. tricaudatus					1			8		
Heptageniidae										
Cinygmula sp.	22	5	14	2		1			1	
Epeorus (Iron) albertae	11	53	2							
E. I. longimanus						2		1	1	1
Rithrogena sp.	8									
Leptophlebiidae										
Paraleptophlebia memoralis					2	1	2	1		4
P. debilis			1							
Ephemerellidae										
Ephemerella (Drunella) coloradensis			3							
E. (Serratella) tibialis						1		1		
E. S. S. inermis						2				1

Table 18. Identification and Enumeration of Invertebrates Collected With Surber Sampler, Naha River Above Jordan, Patching, and Heckman Lakes, 1975.

Lake	Jordon		Patching					Heckman	
Date	July 18		July 9	July 29	August 20	August 21		July 2	July 23
Net	1	2	1	2	3	4	5	1	2
Oligochaeta						1		4	
Hydracarina	1								
Ephemeroptera									
Baetidae									
Baetis tricaudatus	1	3				1		8	4
Baetis sp.				4					
Heptageniidae									
Cinygmula sp.	1				1	1	8		
Epeorus (Iron) albertae							1		
E. (Iron) longimanus		3	1				3		
Rhithrogena sp.					1		16		
Leptophlebiidae									
Paraleptophlebia memorialis		3	1			1		3	1
Paraleptophlebia sp.	1								
Ephemerellidae									
Ephemerella (Drunella) doddsi					2				
E. (Seratella) tibialis				4					
E. S. S. inermis		1						1	
Siphlonuridae									
Ameletus sp.				1					
Plecoptera									
Nemouridae									
Nemoura sp.							1		
Capnidae									
Capnia sp.						1			
Perlodidae							1		
Chloroperlidae									
Alloperla sp.		2	1				1		
Tricoptera									
Hydropsychidae									
Arctopsyche sp.						1			
Limnephilidae	1								
Philopotamidae									
Dolophilus sp.		2							
Diptera									
Tipulidae									
Eriocera sp.								1	
Chironomidae									
Tanypodinae									
Pentaneurini				1				1	1
Chironominae									
Tanytarsini									
Micropsectra sp.				1					
Rheotanytarsus sp.		2							
Chironomini				2				1	4
Dolichopodidae	1								
Simulidae									
Simulium sp.			10	1	3	1			

Table 19. List of Insects Found in Grab Samples Collected From Naha River Inlets to Snow, Patching, Heckman, and Jordan Lakes, 1975.

Lake	Snow	Patching	Heckman	Jordan
Ephemeroptera				
Baetidae				
Baetis bicaudatus		X	X	
B. tricaudatus			X	X
Heptageniidae				
Cinygmula sp.	X	X	X	X
Epeorus (Iron) albertae	X		X	
E. I. longimanus		X	X	X
E. (Ironopsis) grandis		X		
E. deceptivus		X		
E. (Ironodes) nitidus				X
Rhithrogena sp.		X		
Leptophlebiidae				
Paraleptophlebia memorialis			X	X
Ephemerellidae				
Ephemerella (Drunella) coloradensis	X			X
E. (Drunella) doddsi	X			
E. (Drunella) spirifera	X			
E. (Drunella) grandis flavitica			X	
E. (Seratella) tibialis			X	X
E. S. S. inermis			X	
Siphlonuridae				
Ameletus sp.	X			
Plecoptera				
Nemouridae				
Nemoura sp.	X			
Perlodidae				
Isogenus sp.				X
Chloroperlidae				
Alloperla sp.				X
Perlidae				
Acroneuria pacifica		X	X	
Coleoptera				
Staphylinidae		X		
Tricoptera				
Rhyacophilidae				
Rhyacophila sp.	X		X	X
Hydropsychidae				
Hydropsyche sp.			X	X
Limnephilidae		X	X	
Philopotamidae				
Dolophilus moestrus				X
Diptera				
Tipulidae				
Dicranota sp.			X	
Chironomidae				
Orthocladinae	X			
Chironominae				
Tanytarsini				X
Rheotanytarsus sp.			X	
Simulidae				
Simulium sp.		X	X	X

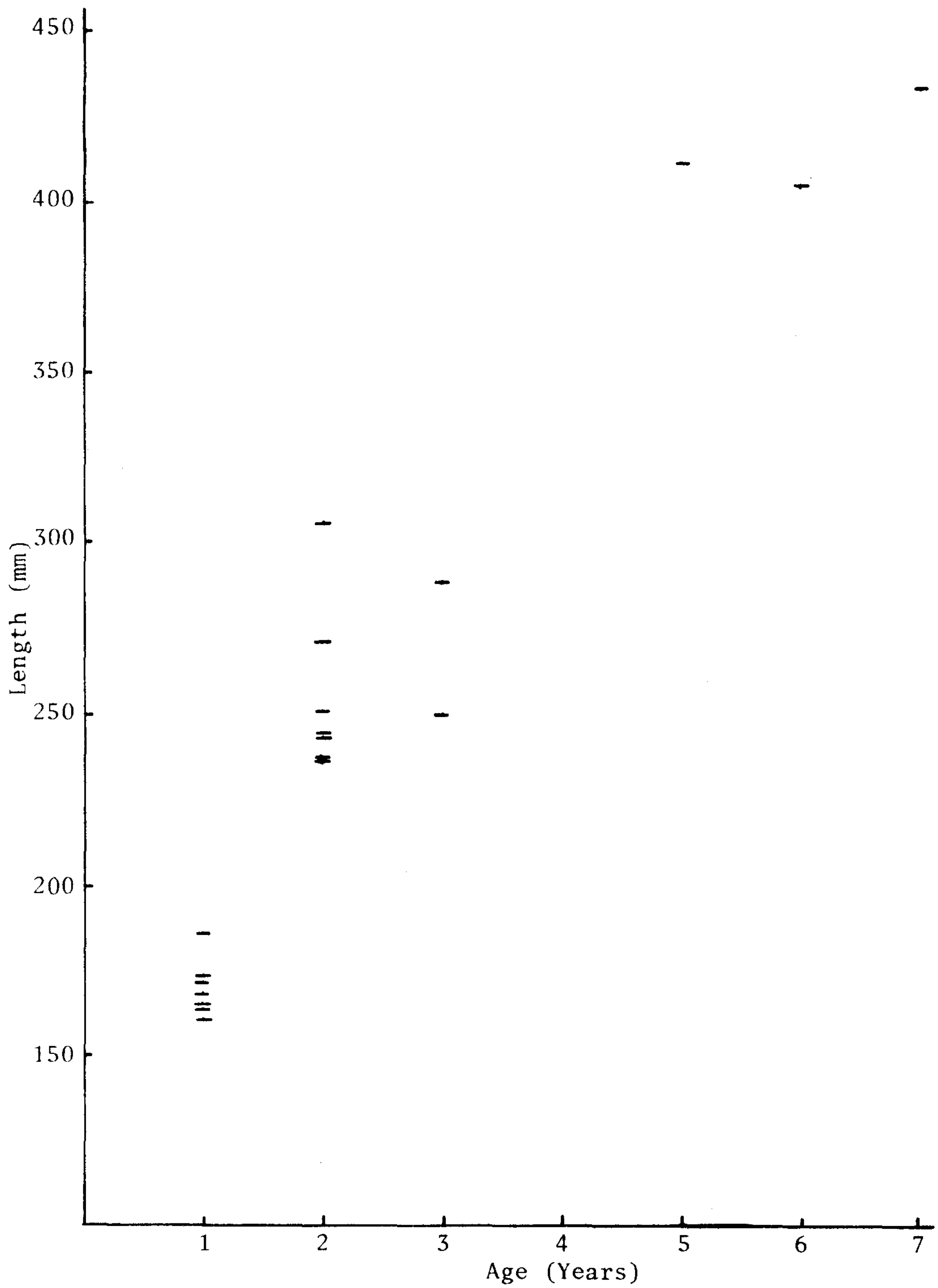

Figure 9. Length-Age of Arctic Grayling, Snow and Orton Lakes, 1975.

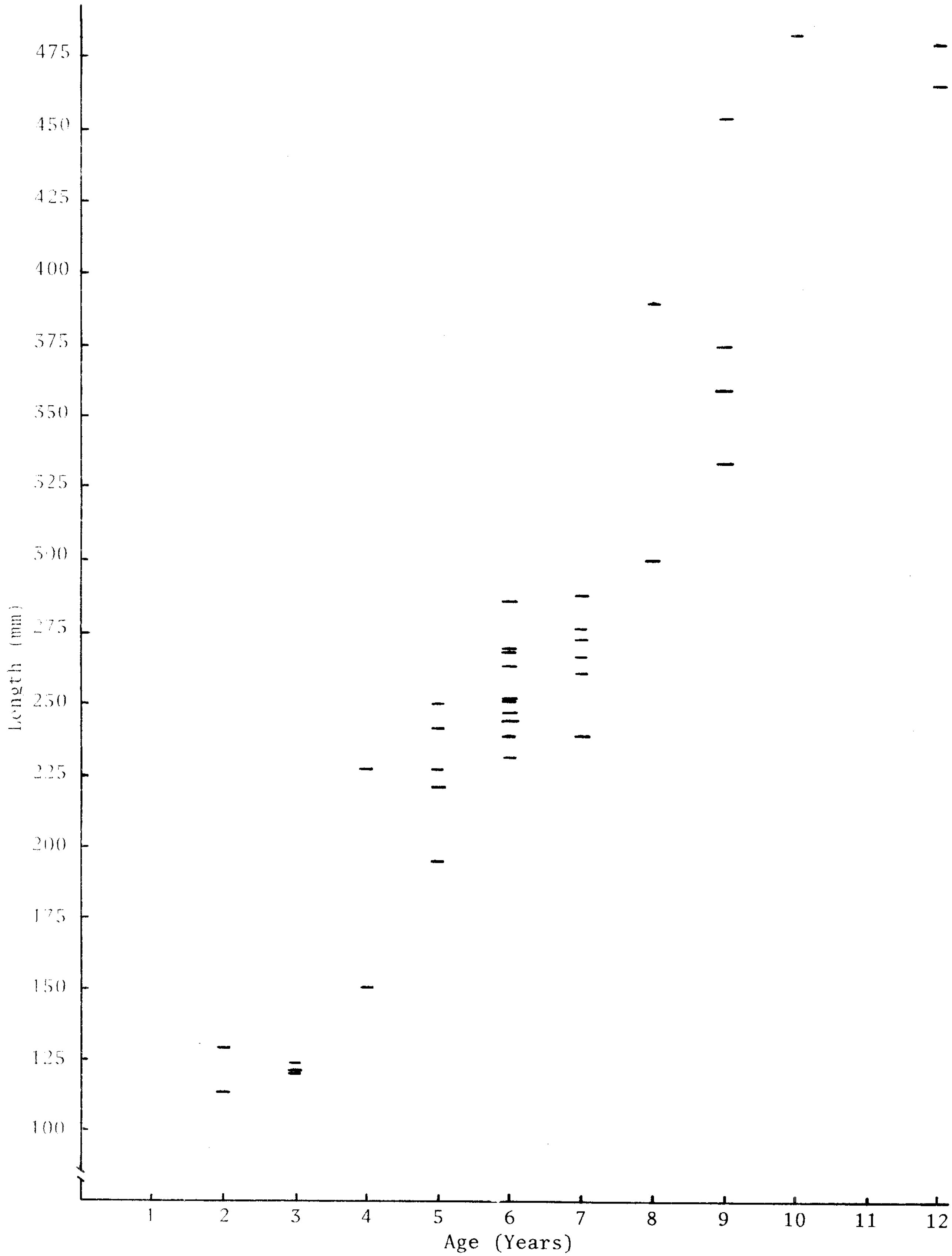

Figure 10. Length-Age of Cutthroat Trout, Chamberlain and Patching Lakes, 1975.

Table 20. Stomach Content Analysis From Cutthroat Trout, Patching Lake, 1975.

Fish Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Date	June 19-		July 8	July 9 →										August 7	August 20 →							September 7
Length (mm)	276	250	227	242	466	277	261	239	150	460	375	273	227	114	129	251	390	232	120	480	483	160
Amphipoda								5	3						1			1				
Araneae		3	1		1		9		1				1					1				
Gastropoda								2														
Sphaeridae								1														
Hirudinea			1																			
Nematoda															5		2					
Chilopoda												1										
Collembola															1							
Plecoptera																						
Nemouridae																						
Nemoura cinctipes	3																					
Nemoura sp.							1															
Capnidae																						
Capnia sp.							1															
Leuctridae																						
Leuctra sp.														1								
Perlidae																						
Acroneuria pacifica	2																					
Chloroperlidae																						
Alloperla oregonensis							4															
Alloperla sp.													2									
Perlodidae																	5					
Hemiptera																		2				
Homoptera							7		1				2									
Coleoptera																						
Cerambycidae		1	2																			
Cerabidae		9																				
Cantharidae		3			3	1	9	2	2	1	3	2						1				
Staphylinidae		1	1	1	2		6		1			2	1									
Curculionidae		1																				
Scolytidae							1															
Dendroctonus sp.		1																				
Elateridae			9	1	7	24	6	4		1	21	36	3									5
Chrysomelidae												1										
Miscellaneous Terrestrial	1					3																
Unidentified			1		1		2	1				1						1				
Trichoptera																						
Limnephilidae			1	3		1								3	1							
Leptoceridae															6							
Mystacides sp.								6						6		1						
Brachycentridae																						
Micrasema sp.															1							
Lepidostomatidae																						
Lepidostoma sp.									2													
Hydropsychidae																						
Cheumatopsyche sp.	2																					
Lepidoptera		1	2		1		3	3	2				18									
Diptera																						
Chironomidae	5	115	9	14	17		144	4	52	5	5	9	30	12	5	3		25	1			5
Adults	1	100	7	11	17		142	2	48	3	3	9	29	7	4	3						4
Pupae	4	15	2	1			2	2	4	2	2		1		1							1
Larval Forms				2										5					1			
Simulidae													5									
Simulium sp.														10					3			
Tipulidae			6	4	13	25	53	9	6		18	11	5					7				1
Dicranota sp.				1																		
Empididae								1	1				1									
Psychodidae							1	5														
Bibionidae					4		1		2													
Miscellaneous Terrestrial		1	5		20		36		10				12	2				20				
Hymenoptera	1		3	2	6		19		3				4	1	1	2		2				
Ephemeroptera							7		3													
Leptophlebiidae																						
Paraleptophlebia sp.																		1				
Ephemerellidae													8									
Ephemerella (Drunella) doddsi																	1					
E. (Drunella) spinifera																	2					
E. (Serratella) tibialis																	1					
Ephemerella sp.														2								
Exuviae													10									
Odonta																						
Libellulidae																						
Cordulia sp.	1																					
Neuroptera																						
Hemerobiidae									2				3									2
Fish			3		1			2											2			
Stickleback		1																				
Kokanee																				2		

Table 21. Stomach Content Analysis From Cutthroat Trout, Chamberlain Lake, Jordan Lake, and Roosevelt Lagoon, 1975.

Lake	Chamberlain		Jordan		Roosevelt Lagoon
Fish Number	1	2	1	2	1
Date	August 6		July 15	July 17	July 24
Length (mm)	221	269	210	255	192
Amphipoda					8
Isopoda					1
Aranea	8	3			
Gastropoda	19				
Pelecypoda	3				
Plecoptera					
Chloroperlidae					
Alloperla coloradonsis				1	
A. oregonensis			4		
Nemouridae					
Nemoura cinctipes			1		
Homoptera	4	5			
Coleoptera					
Staphylinidae	1	1			
Elateridae	2	1			
Cantheridae	1				
Tricoptera					
Leptoceridae		1			
Brachycentridae					
Micrasema sp.			2	1	
Ryacophilidae					
Ryacophila sp.			2		
Hydropsychidae					
Hydropsyche sp.			3		
Hydroptilidae	1				
Lepidoptera	2	1			
Diptera					
Chironomidae					
Adults and Pupae	40	18			
Larvae			1	4	
Ceratopogonidae		39			
Simulidae	3	3	120	161	
Tipulidae	1				
Empididae	11	6	1		
Other	25	10			
Hymenoptera	18	10			1
Ephemeroptera	1				
Baetidae					
Baetis sp.				5	

Table 22. Stomach Content Analysis From Rainbow Trout, Jordan and Heckman Lakes, 1975.

Lake	Jordan							Heckman
Fish Number	1	2	3	4	5	6	7	1
Date	July 14	July 16 →	→	→	→	→	July 17	July 2
Length (mm)	128	239	168	123	162	331	107	482
Hydracarina							1	
Aranea							2	2
Gastropoda							1	
Plecoptera								
Capnidae								1
Chloroperlidae	1							3
Tricoptera								
Limnephilidae						3		
Lepidostomatidae					1			
Brachycentridae							1	
Hydropsychidae			1					
Unidentified			1					
Coleoptera								
Elateridae								12
Cerambycidae								4
Cantheridae								3
Staphylinidae								2
Scolytidae								2
Lepidoptera								5
Diptera								
Chironomidae								
Adults and Pupae			2		2	1		7
Larvae					2			
Simulidae	7	926	247	117	409	1	57	
Tipulidae								1
Empididae		4						
Hymenoptera								1
Ephemeroptera						6		
Baetidae	18		2		2		2	
Leptophlebiidae							1	
Ephemerellidae			2		1			
Heptageniidae							2	

takes from 45 minutes to 2 hours, depending on the speed of the boat and point of departure from the Ketchikan vicinity. In good weather the trip to Naha Bay can be made in a small skiff. The North Tongass Highway now extends along Behm Canal, and there is a boat slip near the end of the highway. This provides a shorter and more protected boat ride to Naha Bay for people traveling with a small boat and trailer.

The Naha system may be reached in approximately 20 minutes by floatplane from Ketchikan, depending upon weather conditions. When low cloud cover prevails, air traffic routes follow salt water to Naha Bay and then continue up the river. If higher ceilings allow, pilots will fly up Ward Cove, over Harriet Hunt Lake, and intersect the Naha system near the inlet end of Heckman Lake. Of the seven major lakes in the Naha system, only Jordan and Emma lakes are not serviced by local air taxi operators because of their smaller size.

The Naha drains a watershed of approximately 52 square miles. It is isolated by ridges on the north and east from Traitors Cove and Carroll Inlet, respectively. The Naha River flows 17 miles to the head of Naha Bay, on the eastern side of Upper Behm Canal. The main river passes through five lakes and one estuarine lagoon. With the inclusion of Emma, Snow, and several small lakes that drain into the Naha River; the number of lakes in this system totals 14.

The Naha River was inhabited by aboriginal peoples in much earlier times, as indicated by the presence of tool artifacts. The word "Naha" is derived from the Tlinget Indian name Na-a, meaning "the country of distant lakes" (Scidmore, 1899). The Naha River became known to white settlers when a salmon saltery was established at Naha Bay in about 1883. At that time the saltery site was known as "Naha Bay." The name was later changed to Loring when the post office was established September 20, 1885 (Ricks, 1965). In 1930 the last salmon pack was produced, and in 1936 the Loring Post Office closed. Today several families still live in Loring, but the community is only a remnant of what it once was.

Near the head of Naha Bay the U.S. Forest Service boat dock facility serves as the trail head for the U.S. Forest Service Naha River Trail. The trail follows the northern shore of Roosevelt Lagoon, passes along the river to Jordan Lake, and terminates at Heckman Lake, 6 miles from its origin at Naha Bay. The trail is good but muddy and slippery in places, necessitating appropriate foot apparel and caution while walking.

There are xix cabins maintained by the U.S. Forest Service along the Naha system. These include the Naha River cabin 1/3 mile above Roosevelt Lagoon; one cabin at Jordan Lake, which is accessible by trail either from Naha Bay (4 miles) or Heckman Lake Trail terminus (1 3/4 miles); two cabins at Heckman Lake (Heckman Camp at the outlet and Fisheries Camp near the inlet); and two cabins at Patching Lake (Patching Camp at the inlet and Portage Camp at the outlet). These cabins may be rented through the U.S. Forest Service office in Ketchikan. All cabins have wood-burning stoves, outhouses, wood supplies, axes, and skiffs with oars.

The sport fishing opportunities along the Naha River are excellent. Possibly the biggest attraction for local fishermen is the steelhead fishing during April and May and again in September and October. Cutthroat trout weighing up to 5 pounds have been taken from the Naha system.

This system is an anadromous drainage upstream to a series of falls below the outlet of Patching Lake. These falls form a barrier to upstream movements of fish. The river up to Heckman Lake is quite fishable because of the maintained trail. There are several riffle areas and five deep pools. The forest along the river is primarily hemlock, spruce, and cedar. Anadromous species include sockeye, coho, chum, and pink salmon and spring and fall runs of steelhead, Dolly Varden, and sea-run cutthroat. Resident species include rainbow and cutthroat trout, Dolly Varden, Arctic grayling, kokanee (landlocked red salmon), and stickleback. Arctic grayling, introduced into Orton and Snow lakes in 1966, have now moved down through the entire system, as they have been captured in Chamberlain, Patching, and Jordan lakes. Arctic grayling are not abundant in any of the lakes except Snow and Orton. There are kokanee in Patching Lake, which were introduced while the Fortmann Hatchery was in operation at Heckman Lake. There is no indication that kokanee are taken by sport fishermen, but they do serve as a food source for cutthroat trout.

Roosevelt Lagoon:

Roosevelt Lagoon is an estuary, influenced by the ocean via a salt chuck at the head of Naha Bay and by the Naha River, which flows into the northeast corner of the lagoon. The lagoon is approximately 1 mile long and ranges between 15 and 30 m in depth. It can be reached by trail, approximately 1/4 mile from the U.S. Forest Service float in Naha Bay, or via small boat by traveling through the salt chuck on high tides of 14 feet or greater. An old tramway at the salt chuck is presently not operational because of rusty winches and broken winch lines.

All anadromous fish species which enter the Naha River do so via Roosevelt Lagoon. Roosevelt Lagoon has, at the outlet by the salt chuck, a picnic area overlooking the head of Naha Bay; there is one table covered by an open shelter. The picnic area is 1/4 mile from the U.S. Forest Service boat ramp and near the start of the tramway. This location was the original site of the first saltery in Naha Bay during 1883 before it moved to the Loring townsite. Orton Ranch, a private church camp, is located approximately 1/4 mile above the lagoon on the north bank of the river. Fishing from shore is restricted to trailside locations and the area near the tramway. Dense shoreline vegetation and lack of shoreline shallows make the lagoon's edge quite inaccessible for foot travel.

The lagoon certainly could be better utilized as a means of access to the Naha River and upstream lakes. It is approximately 2 miles from the trail to the head to the falls near Orton Ranch. This means an additional 4-miles round trip hike for persons taking the river trail from Naha Bay. More people would be able to enjoy the Naha River up to Jordan Lake and Heckman Lake in a day's outing if the tramway was made operational and a dock facility was constructed near the inlet of the lagoon.

Jordon Lake

Jordan Lake is a circular lake approximately 1/2 mile in diameter with a maximum depth of 122 feet and an elevation of 66 feet above sea level. This lake can be reached by trail from the Naha Bay float (4 miles) or from Heckman Lake (1 3/4 miles).

Jordan Lake contains resident populations of rainbow and cutthroat trout, Dolly Varden, sculpin, and stickleback. During appropriate seasons, steelhead, sea-run cutthroat, and four species of salmon are present. Besides the Naha River, Jordan Lake has several small feeder tributaries. One of these, Emma Creek which originates at Emma Lake, is a good spawning stream and rearing area for rainbow trout, steelhead, and coho salmon.

Fishermen enjoy excellent sport fishing at Jordan Lake and also consider the inlet a very good place to fish. The inlet and outlet vicinities can be easily fished from shore with hip boots, but the outlet channel and north shore of the lake are best fished from the boat available at the U.S. Forest Service cabin. The location of Jordan Lake, on the Naha River Trail, provides fine stream fishing in the vicinity of Jordan Lake. Excellent cutthroat trout and Dolly Varden fishing can be experienced during the fall, especially while salmon are spawning in these areas.

Many people do not get to Jordan Lake on a day's outing from Ketchikan because of the round-trip walking distance from the dock facility at Naha Bay. The cabin would experience much heavier use if people could fly directly into Jordan Lake rather than hiking from Heckman Lake. Use increases considerably, however, during fall salmon runs and the steelhead runs. Because of Jordan Lake's small size and very good fishing, it could become overcrowded with people were it not for the buffer created by long hiking distances.

Emma Lake:

Emma Lake is located at 55°37'15" N latitude, 131°32'48" W longitude. Surface elevation of the lake is about 360 feet, and surface area is approximately 102 acres. Access is difficult as the lake is too small for floatplane, and no trail has been constructed.

Native fish species include cutthroat trout, sculpin, and stickleback. The cutthroat trout population is at a climax, and 10- to 12-inch trout are easily caught near the outlet.

One major inlet enters the head of the lake and provides a spawning and rearing area. The outlet to Jordan Lake has several high, impassable falls. This lake receives little use at present because of poor access. An extension of the existing Naha trail system could connect Emma and Patching lakes. A branch trail past Emma to Patching and upstream to Orton or Snow would enhance the recreational opportunity of the Naha system.

Heckman Lake:

Heckman Lake has a maximum depth of 139 feet and an elevation of 139 feet. The Heckman Lake cabin is 1 3/4 miles from Jordan Lake at the terminus of the 6-mile Naha River Trail. There is another U.S. Forest Service cabin near the inlet, Fisheries Camp, which is accessible by plane or by skiff from Heckman Camp. At present the users of the Fisheries Camp cabin enter entirely via floatplane.

Heckman Lake is the last anadromous lake in the system and contains all fish species present in the drainage. The Naha inlet is a good spawning stream for sockeye, coho, and pink salmon. Deer Creek, a tributary which flows into the lake at the southeastern shore, is a major spawning and rearing area.

There is good rainbow and cutthroat trout fishing at the inlet, outlet, and downstream in the Naha River. The trail from the outlet, presence of U.S. Forest Service skiffs, and easy walking along the inlet provide good access for the sport fisherman. The lake shoreline, however, is rocky and relatively steep, making walking difficult.

The remains of the old Fortmann Hatchery, which operated from 1901 until 1927, are near the inlet. Nearly all the structures have since been destroyed, but rearing ponds and one or two buildings still remain.

Heckman Lake is a very popular place with the people of Ketchikan. Nonresidents are directed there for a fine Southeast Alaskan experience. Early in the summer the cabins are lightly used, but by late June weekend traffic has increased. When salmon fishing starts, the cabins are heavily occupied. The cabins are both in good condition and are isolated from one another to minimize people contact. Both are located near good fishing areas. If pressures increase, another cabin could be constructed near the outlet to allow heavier overnight use and still not overcrowd the available fishing areas.

Heckman Lake also has deer hunting usage from both cabins. Hunters commonly utilize the area between lower Heckman Lake and Jordan Lake for deer in the fall.

Patching Lake:

Patching Lake is a narrow, 3-mile long lake located approximately 8 1/2 river miles upstream from Naha Bay. This lake has a maximum depth of 219 feet in the north basin, is steep sided, and presently has no developed trail; floatplane is the only means of access. There are two U.S. Forest Service cabins, one near the outlet and one beside the Naha River inlet. The outlet cabin is in very fine condition; but the inlet cabin, Patching Camp, is in need of replacement.

The sport fishery in this lake centers around cutthroat trout. There is no access to anadromous species. Fish species in Patching Lake include cutthroat trout, Dolly Varden, stickleback, Arctic grayling (which have moved down from Orton or Snow lakes), and landlocked red salmon or kokanee. Kokanee were probably introduced when the Fortmann Hatchery was in operation at Heckman Lake.

Sport fishing success seems variable. The outlet just above the waterfall is an excellent place to catch pan-size cutthroat. Large cutthroat trout exceeding 3 pounds are present in the lake. Travel around the lake is restricted to boat, however, the inlet is easily walked from shore and can be waded using hip boots when water levels are not too high.

The Naha River, between Patching and Chamberlain lakes, flows about 1/3 mile along a straight course. It has a gravel bottom with a pool-riffle combination suitable for spawning. There is only one other feeder stream entering the lake on the east shore.

Suggested improvements include a short trail from the Portage cabin to the outlet. The river between Heckman and Patching lakes has some impressive waterfalls. A trail following the Naha River, connecting these two nearby lakes, would afford hikers some impressive scenery.

Chamberlain Lake:

Chamberlain Lake is a small, tear-drop shaped lake at an elevation of 309 feet. There are no facilities or trails at this lake. Fish species include cutthroat trout, Dolly Varden, and Arctic grayling. Little is known about the sport fishing history or recreational use of this lake.

The inlet end of the lake is wadable and fishable from shore. This area has good campsite locations. There are two feeder streams which enter the lake on the eastern shore, but they do not appear to have much spawning potential. The Naha River above Chamberlain Lake appears to be a fine spawning stream. The river in the first half mile above the lake varies from widths of 40 to 50 feet to much narrower runs with very fast water. The banks of the river along the lower stretches are hard to walk because of old beaver runs that are overgrown with grass.

Chamberlain Lake, because of its location and easy access by floatplane, would be a logical starting point for backpacking trips to the upper Naha River valley and Orton or Snow lake. The 3-mile stretch of river above Chamberlain Lake is situated in a very picturesque valley, so a trail beginning at Chamberlain Lake could expand the recreational potential of the Naha watershed.

Orton Lake:

Orton Lake is the farthest upstream lake, approximately 17 miles from Naha Bay. It lies at an elevation of 935 feet. Floatplanes can service Orton Lake as weather permits. Presently there is neither a trail nor facilities at Orton Lake, although there are ample places to establish a tent camp in the mature spruce forest. It is easiest to travel by boat or raff as shore travel is difficult. Present use of Orton Lake is very light, but it would undoubtedly be more extensively if a trail and shelter were provided.

Orton Lake is an excellent starting point for hikers interested in alpine terrain. A trail system around the lake and leading up the two inlets would allow relatively easy foot travel through timberline terrain. The alpine scenery here is probably unmatched anywhere in the Naha drainage.

Orton Lake was barren of fish before 1966, at which time the Alaska Department of Fish and Game planted 50,000 Arctic grayling. Arctic grayling are now reproducing and maintaining their population in the lake. The size of the population is not known, but anyone who knows how to cast an artificial fly should have success.

There are two inlets to Orton Lake which appear to be suitable for spawning, and invertebrate fauna in these streams is relatively rich compared to that seen in the other Naha lake inlets.

Snow Lake:

Snow Lake is one of the two headwater lakes of the Naha River, approximately 17 river miles from Naha Bay. This lake is situated in a scenic, glacially carved basin at an elevation of 1,054 feet. It is surrounded by stands of hemlock and spruce with alpine meadows up from the inlet. The lake is not large but is quite accessible by floatplane. At present there are no trails or facilities of any kind. When water levels are down, the shoreline beach is easily walked.

There were no fish in Snow Lake prior to 1966 when 50,000 Arctic grayling were introduced. Since then the population has reproduced and maintained itself. This potential recreational sport fishery is currently not utilized. This lake has been used primarily as a base camp for deer hunters. Air taxi operators, who know this lake from hunting, seem surprised to hear that a good Arctic grayling population exists. The best fishing is at the outlet logjam using artificial flies.

Approximately 20 to 25% of the lake at the inlet end is very shallow, only 1 m deep when the lake level is low. Much of this area has submergent aquatic vegetation and supports a rich invertebrate fauna.

If the upper Naha drainage were made accessible via a trail from Chamberlain Lake, Snow and Orton lakes would offer a fine recreational alternative to the sport fishery potential at the lower Naha lakes. If a shelter and skiff were available at Snow Lake, the Arctic grayling fishery and impressive scenery would surely enhance the overall value of the Naha system as a recreational area.

DISCUSSION

Relationship of Limnological Characteristics to Fish Production

Bathymetric maps and morphometric data for Naha lakes show that, the lakes are quite steep sided. Analysis of chemical and plankton data shows that the Naha lakes are midrange in productivity when compared to other Southeast Alaska lakes. A plankton index derived by comparing organic weight from comparable plankton samples places Heckman Lake on a productivity base equivalent to Auke Lake. Differences in zooplankton composition between Patching and Heckman lakes are attributed to the foraging of rearing salmon in Heckman Lake.

Analysis of stream benthos and drift shows that these organisms contribute significantly to the overall productivity of the system. Several species of Ephemerella, which are normally found only in large rivers, were collected from the Naha River. The fish fauna of the Naha drainage is described in the following "Recreation Survey."

Recreation Survey

The Naha drainage is unique in many ways, and it is easily accessible from a major population center. The system contains both river and lake fishing for a diversity of fish species. The U.S. Forest Service cabins and trail provide easy access and comfortable accommodation. Recreational opportunities encompass a wide range of activities such as hunting, fishing, backpacking, bird watching, photography, etc. The terrain varies from sea level spruce forests to alpine meadows.

Fishing opportunities are the best available in Southeast Alaska. The Arctic grayling introduced into Orton and Snow lakes have established viable populations. Growth is good with fish 2 years old weighing over 1/2 pound. Older fish (age 6-7) exceed 16 inches length and 1 1/2 pounds. Arctic grayling have spread downstream from Orton and Snow lakes and are now occasionally caught throughout the lake system to Jordan Lake.

Cutthroat trout are resident to all lakes except Orton and Snow. Emma Lake has a climax population of easily caught 10- to 12-inch cutthroat trout. Patching Lake has large cutthroat trout exceeding 3 pounds. The larger cutthroat trout include the introduced kokanee in their diet. The anadromous portion of the drainage, through Heckman Lake, has a good population of sea-run cutthroat.

Dolly Varden are found in all lakes except Orton, Snow, and Emma. Excellent Dolly Varden fishing for the larger anadromous specimens is available on the Naha River.

Rainbow trout and steelhead are found throughout the anadromous portion of the drainage. Excellent steelhead fishing is available in the spring and fall. Steelhead Creek, which enters Naha Bay, is an important rearing area.

Sockeye, coho, pink, and chum salmon are abundant in the Naha during summer and fall. The abundance of salmon draws a number of black bear to the "Black Bear Observatory" just above Roosevelt Lagoon.

Present facilities along the 6-mile Naha River Trail include several U.S. Forest Service cabins. These are the Naha River cabin 1/3 mile above Roosevelt Lagoon; one cabin at Jordan Lake, which is accessible by trail either from Naha Bay (4 miles) or Heckman Lake Trail terminus (1 3/4 miles); two cabins at Heckman Lake (Heckman Camp at the outlet and Fisheries Camp near the inlet); and two cabins at Patching Lake (Patching Camp at the inlet and Portage Camp at the outlet). These cabins may be rented through the U.S. Forest Service office in Ketchikan. All cabins have wood-burning stoves, outhouses, wood supplies, axes, and skiffs with oars.

The construction of a branch trail to Emma Lake, Patching Lake, and up to Orton or Snow lakes would provide the backpacker with a wide variety of experiences. It would be possible to catch Dolly Varden, cutthroat trout, and Arctic grayling; enjoy alpine hiking; and return to steelhead and salmon fishing on the lower lakes during one outing.

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