FISHERIES ASSESSMENT OF AISHIHIK, CANYON AND SEKULMUN LAKES 1991-92

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Technical Report

April, 1993

Government of Yukon TR-93-1

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1991

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ACKNOWLEDGMENTS

Funding for this project was by the Yukon Energy Corporation. I am deeply grateful for the field project coordination and data collection by Lorne LaRocque, Kevin Johnstone and Darryl Bouvier. Susan Thompson analyzed all the ageing structures. Don Toews, Len Mychasiw, Clive Osborne, John Maissan, Stuart Davies and Dr. R. A. Bodaly (Freshwater Institute) provided editorial comments in the preparation of this report. Caroline Lajoie and Lori Simpson helped typed this manuscript. The author gratefully acknowledges the assistance of these individuals.

1.0 INTRODUCTION

The Aishihik Lake watershed represents a major aquatic ecosystem within the Yukon Territory. Aishihik, Canyon and Sekulmun Lakes are the dominating features in the watershed. The habitat within each waterbody and associated streams are important to fish, waterfowl and aquatic furbearers.

The area is particularly important to the Champagne and Aishihik First Nation who traditionally utilized the region for subsistence and continue to practice a wide range of resource-use activities that rely upon a stable aquatic ecosystem. A historic settlement of archeological significance is located on the north shore of Aishihik Lake. The region also provides economic benefits to recreational boaters, hunters and fishers. In 1991 both Aishihik and Sekulmun Lakes were designated as High Quality Management Lakes (HQM) under the Yukon Territory Fishery Regulations, primarily to promote game fish species that inhabit the watershed. A territorial campground and boat launch is located near the outlet of Aishihik Lake. A small number of residents also live in the immediate area.

Aishihik Lake is utilized as a reservoir for hydroelectric power generation. The 30 MW hydro facility supplies 25-30% of the territory's present electrical demands (Yukon Council on Economy and Environment, 1992). Water levels and flows have been manipulated for hydroelectric power generation since construction was completed in 1975. Fisheries studies were included in the pre-development environmental studies to examine possible harmful effects on fish stocks, as a result of changes to the hydrological regime. These studies were primarily designed to provide baseline information which would allow for mitigation features to be incorporated into the construction and operational design of the facility. The data that were compiled also serve as a baseline for the present and future resource assessments.

Since construction of the hydro facility, concerns have been raised about a number of potential impacts associated with varying water levels, erosion and siltation upon fish and wildlife, and to the adjacent physical environment. As a result of increasing concerns the present study was initiated to reassess the fishery resources within Aishihik, Canyon and Sekulmun Lakes, particularly to examine fisheries impacts with respect to water fluctuations within Aishihik Lake.

2.0 OBJECTIVES

2.1 1991 Studies

The purpose of the 1991 field investigations was to determine the status of dominant fish stocks within the Aishihik Lake system

(Aishihik, Canyon and Sekulmun Lakes) and to document any fisheries impacts associated with past water management practises at this hydro-electric development. Data that were collected from the study would serve to formulate a comprehensive fisheries management strategy within these basins. The specific objectives of this study were:

(1) Collect information on lake morphometry, limnology and the littoral benthic community and evaluate it in light of potential for fish production.

(2) Determine the population dynamics of the dominant species within Aishihik, Canyon and Sekulmun Lakes.

(3) Based on findings of objectives 1 and 2, compare results with pre-impoundment data and the post-development hydrological regime.

2.2 1992 Studies

The purpose of the 1992 field investigations were to identify the specific causes of poor recruitment of lake whitefish within Aishihik and Sekulmun Lakes, as identified from the 1991 studies. Specific objectives were:

(1) Determine the population dynamics of the early life history stages of lake whitefish within Aishihik, Canyon and Sekulmun Lakes.

(2) Define the habitat requirements of the early life history stages of lake whitefish within Aishihik, Canyon and Sekulmun Lakes.

(3) Define the habitat requirements of spawning lake whitefish within Aishihik Lake.

(4) Document spawning aggregations of lake whitefish and monitor associated movements within Aishihik and Sekulmun Lakes.

3.0 STUDY AREA

Regional characterizations of geology, climate, soils and vegetation of the Aishihik area are described in Robertson and Eliasen (1974), Oswald and Senyk (1977) and Sauchyn (1986). The Aishihik Lake watershed comprises three major waterbodies that include Aishihik, Canyon and Sekulmun Lakes.

Sekulmun Lake is the headwater lake of the system and is connected with the northern basin of Aishihik Lake via the Sekulmun (Tagah) River. Flows out of Sekulmun Lake are not regulated and lake levels within the lake are largely unaffected under the present water management regime.

Aishihik Lake serves as a reservoir for water storage during the summer season. Water levels are controlled by a dam at the outlet, at the southern end of the lake. The Canyon River connects Aishihik and Canyon Lakes. Canyon Lake serves as a forebay, supplying water to a diversion channel that feeds the electrical generating station. Water levels within Canyon Lake are further controlled by a dam located at the natural outlet to the lake, allowing surplus water to be released at this site into the East Aishihik River through Otter Falls.

Together, these lakes comprise an important chain of headwater lakes within the Alsek River system, located in the south western portion of the Yukon Territory at 61°26′ N lat. and 137°15′ W long.

4.0 MATERIALS AND METHODS

4.1 1991 Studies

4.1.1 Lake Morphometry

Each lake was depth sounded with a Lowrance X-50 sonar. All sounding transects were completed during the month of June (Appendix 1). Lake elevations during this project averaged at 913.704 metres (2997.72 feet) for Aishihik Lake, 907.074 metres (2975.96 feet) for Canyon Lake and a gauge reading of 2.477 metres for Sekulmun Lake.

A transducer was mounted on the transom of the survey boat. Sounding transects were drawn in the field on a 1:50,000 scale topographic map and later transferred to a 1:50,000 drafting film base map for each lake. The bathygraphic maps were used to determine lake area, volume and mean depth according to procedures described by Wetzel (1975).

4.1.2 Physical and Chemical Limnology

Field measurements of water quality were collected between August 1 and September 6 for Aishihik, Canyon and Sekulmun Lakes. Variables included water temperature, dissolved oxygen, pH, alkalinity, total hardness, carbon dioxide, total dissolved solids (TDS), conductivity and transparency. Temperature, TDS and conductivity profiles were determined with a HACH model 44600 instrument. Transparency was estimated using a 20-cm diameter Secchi disc. All other chemical profiles were determined using a HACH water ecology test kit, model AI-36B. Limnology stations on each lake are shown in Appendix 2.

All hydrological data was obtained from Yukon Energy Corporation and Water Survey of Canada, collected from gauge stations located on each lake.

4.1.3 Morphoedaphic Index and Yield

Morphoedaphic indices were determined as the ratio between mean depth and observed TDS values within each lake. MEI's were then used to calculate an all-species maximum sustainable yield (MSY) using the following equation:

$$\log_{10} MSY = .050\ TEMP + .280 \log_{10} MEI + .236$$ (Schlesinger and Regier, 1982)

The temperature variable used for all calculations was from data collected by Environment Canada (1982) from an atmospheric weather station located at the north basin of Aishihik Lake. It is expressed as a mean annual air temperature, is from a weather station data base collected from 1931 to 1980. The calculated all-species MSY was then partitioned using index gillnet catch data (percent lake trout biomass) to determine a lake trout MSY and yield for each waterbody.

4.1.4 Lake Trout CPUE Gillnetting

A low-impact method of gillnet sampling to provide an index of lake trout abundance (Lester et al, 1991) was employed between June 4 and July 7, 1991. The method involved using three panels of small-mesh multifilament gillnet (3.8, 6.4 and 8.9 cm), set perpendicular to the shoreline at random locations within each lake. Each panel was 22.9 metres long and 2.4 metres deep. Duration of sets were between 1 to 18 hours. Set locations for each lake are presented in Appendix 3a. Surface temperatures at all set locations never exceeded 17° C. Upon capture, lake trout were measured for fork length and a round weight, then released at the sampling site. The few lake trout mortalities were sampled for sex, maturity, stomach contents and a otolith was obtained for aging. For age determination, otoliths were embedded in epoxy resin and cross sectioned on a Isomet low-speed saw. A microfiche reader was used to read the annuli of mounted otolith cross sections.

4.1.5 Index Gillnetting

Index gillnetting was performed to obtain species specific population statistics (age composition, length frequencies etc.) between July 18 and August 17 within all three lakes. The intensity of the gillnetting effort was dependent upon obtaining a minimum of 250 lake whitefish from each lake. Gillnet gangs were largely set off points of land, perpendicular to the shoreline. Each gang of nets consisted of seven sinking panels with mesh sizes arranged in the following order: 3.8 cm, 12.7 cm, 6.4 cm, 11.4 cm, 7.6 cm, 10.2 cm and 8.9 cm. Each panel was 22.9 metres long and 2.4 metres deep. Gangs were set overnight for approximately 24 hours. Efforts were made to sample a variety of locations within each lake. Set locations within each lake are presented in Appendix 3b.

Lake trout, lake whitefish and northern pike were sampled for fork length, weight, sex and maturity. All lake trout stomach contents were examined for food items. All other fish species were sampled for fork length and weight. For age determination, otoliths were embedded in epoxy resin and cross sectioned on a Isomet low-speed saw. A microfiche reader was used to read the annuli of mounted otolith cross sections.

4.1.6 Benthic Invertebrate Investigations

A preliminary sampling survey of the benthic invertebrate community was conducted within the north basin of Aishihik Lake on July 31 (Appendix 4a). Three areas were sampled within the basin. Lake elevation at time of sampling was 914.50 metres or 3000.3 feet. Samples were taken at one, three and five meter depths within each area. Sampling sites were chosen using substrate characteristics (silt-sand ≤ 2mm) as a criteria for selection.

Benthic sampling was again conducted on September 9 within the north basin of Aishihik Lake to provide information on relative abundance of organisms with depth. Lake elevation at time of sampling was 915.10 metres or 3002.3 feet. Three transects were established, perpendicular to the shoreline, with sampling at .5 meter increments to a depth of five metres.

In both sampling periods, an Ekman bottom dredge (model #3965) with a chamber volume of 3,540 cm^3 was used. Samples were washed in the field using a number 30 screen. The material remaining on the screen was preserved in 10% formalin. Organisms were later sorted, counted and identified to taxonomic order in the laboratory. A subsample of each transect during the September collection was submitted to a benthic invertebrate taxonomist for identification to species.

4.2 1992 Studies

4.2.1 Juvenile Lake Whitefish Gillnetting

Small mesh gillnetting was conducted on Aishihik, Canyon and Sekulmun Lakes to obtain information on relative abundance, distribution and year class strength of juvenile lake whitefish. Gangs of monofilament gillnets consisting of 2.5, 3.8 and 5.1 cm mesh were set overnight for approximately 24 hours. Each gang consisted of three panels, 22.9 metres long and 2.4 metres deep. Near shore littoral areas throughout each lake were targeted and all sets were made perpendicular to shore. Set locations within each lake are presented in Appendix 5.

All fish captured were sampled for fork length and weight. All live captured lake trout were sampled and released. Lake whitefish and lake trout mortalities were sampled additionally for sex, maturity with otoliths removed for ageing. In instances where catches of juvenile lake whitefish were large, a subsample of the catch was taken. For age determination, otoliths were embedded in epoxy resin and cross sectioned on a Isomet low-speed saw. A microfiche reader was used to read the annuli of mounted otolith sections.

4.2.2 Beach Seining

Beach seining for young-of-the-year lake whitefish was conducted on Aishihik, Canyon and Sekulmun Lake between July 8 and 10 in an attempt to evaluate spawning success of the 1991 year class. Seining sites were chosen subjectively, but primarily as a function of a shoreline that was conducive to beach seining. The seine consisted of .6 cm mesh and was 15.2 metres long and 2.4 metres deep. At each site, a surface temperature was recorded and the composition of the substrate was subjectively evaluated by visual inspection using the following criteria:

Fines	clay, silt, sand (<2mm)
Gravels	small (2-16mm)
	large (16-64mm)
Larges	small cobble (64-128mm)
	large cobble (128-256mm)
	boulder (>256mm)
Bedrock	

Seine contents were preserved in 10% formalin and later sorted to species. Fish were enumerated and a standard length measurement was made using calipers. Larval fish were identified using keys developed by the Alaska Cooperative Fish and Wildlife Research Unit (Sturm, 1992).

4.2.3 Trawling

Trawling for the early life history stages of lake whitefish was performed on Aishihik, Canyon and Sekulmun Lakes between August 21 and September 11. Trawling was limited to littoral areas in all three lakes (Appendix 6a). A 11.5 meter semi-balloon otter trawl, manufactured by Redden Net Company of Vancouver, British Columbia, Canada, was used for the project (Appendix 6b). Using a 6 meter aluminum boat with a 135 H.P. outboard motor, the net was retrieved or released using two electric winches mounted to a steel mast. All trawls were parallel to shore at a depth of 2 to 3 metres, a towing speed of 2 to 3 km\hr and a duration of 20 minutes. The towing pattern was constant with respect to cable length, cable angle and spread of net. Surface temperatures were recorded and catch was preserved in 10% formalin. All fish captured were sampled for fork length and weight. For age determination a scale smear was mounted on a slide and a microfiche reader was used to read the annuli.

4.2.4 Sonar and Radio Telemetry

A radio telemetry project was initiated on October 28, 1992 to monitor prespawning movements of mature lake whitefish with the goal to locate spawning grounds within the north basin of Aishihik Lake. Ten fish were captured using small mesh monofilament gillnets. Sex, maturity and a fork length were determined for each tagged fish. Two types of tracking tags were applied to sexually mature fish as follows:

a) Internal sonar tags, supplied by Sonotronics of Tucson, Arizona, USA, were implanted within five adult lake whitefish. Each fish was placed in a shallow holding basin with gills completely submerged during the implant. A small incision (3 cm) was made anterior to the pelvic fin. All instruments were rinsed with 99% isopropanol. The tag (9 mm diameter, 50 mm Length, 60 day life expectancy) was inserted into the peritoneal cavity. The incision was then sutured and each fish was returned to the lake through an opening in the ice. A receiver (model USR-4D) and directional hydrophone (model DH-2) was used to track tagged fish.

b) External radio tags, supplied by Advanced Telemetry Systems of Isanti, Minnisota, USA, were attached to five lake whitefish. Each fish was placed in a holding basin and fitted with radio transmitter tags at a location lateral to the dorsal fin. Hollow syringe needles were used to pierce through cartilage at the base of the dorsal fin to facilitate passage of tag anchoring wires. Once secured, radio tags were then activated and the fish returned to the lake through an opening in the ice. Tags were relocated by using a receiver (49-50 MHz, model 2000).

Attempts were made to relocate all tagged fish between October 30 and December 30, 1993. Locations were determined using the directional finding of the hydrophone and loop antenna.

4.2.5 Egg Trapping

Investigations to locate spawning sites of lake whitefish were conducted in two areas within the north basin of Aishihik Lake. Sites selected for sampling were based on information from:

a) reported spawning sites by local residents (Allen,1991);

b) experimental gillnetting catch statistics for juvenile lake whitefish from the area;

c) beach seining catch statistics for larval lake whitefish from the area.

Transect lines were established over each sampling site. On each transect, holes were drilled through the ice at regular intervals dependant on the site. Substrate was bottom sampled using an Ekman bottom dredge (catalog #196) with a chamber volume of 3,540 cm^3. A depth was recorded and bags of material were labelled, then frozen. Samples were later thawed and washed in the lab using a number 30 screen with 600 micron openings. The remaining material was inspected for lake whitefish eggs of a diameter of approximately 2.5 mm.

4.3 Other Calculations

Index gillnetting data for lake trout and lake whitefish were used to develop length-weight scatter plots. Curves were fitted by least squares regression of logarithmically transformed length and weight data. Von Bertalanffy growth parameter estimates were derived using an empirical method as described by Payne et al (1990). To reduce bias associated with small length at age sample sizes, age groups with less than five fish were excluded from parameter estimates.

The mean weighted age at onset of sexual maturity (Z) was calculated by the equation:

$$Z = \frac{A_1K_1 + A_2(K_2 - K_1) + A_3(K_3 - K_2) +. . . A_n(K_n - K_{n-1})}{K_1 + (K_2 - K_1) + (K_3 - K_2) + ... (K_n - K_{n-1})}$$

where A = age (years)

K_n= % of mature fish in the n^{th} age class

This is the corrected version of Abrasov's (1967) original equation

(Lysack, 1980). Criterion used for the calculation were a) a minimum of five age classes that contained both immature and mature fish and b) assumption of 100 percent maturity by age 20.

Total mortality rates were calculated according to Robson and Chapman (1961). Only age classes with five or more fish within the descending limb of the catch curve were used in the analysis.

5.0 RESULTS

5.1 1991 Studies

5.1.1 Lake Morphometry

The net water areas, volumes and depth variables for Aishihik, Canyon and Sekulmun Lakes are presented in Table I. Aishihik Lake is the largest waterbody, having approximately three times the surface area and four times the volume of Sekulmun Lake, the second largest lake in the system. Canyon Lake, which acts as the forebay to the hydroelectric facility, is the smallest lake in the system. Its low mean depth translates to a low water volume that is two orders of magnitude less than the calculated value for Aishihik Lake. Aishihik Lake had both the largest mean and maximum depths. Bathymetric maps for each lake are presented in Figures 1 to 3.

5.1.2 Physical and Chemical Limnology

A weak thermal stratification was apparent at each of the limnological stations. Although temperatures did decrease with depth in Aishihik and Sekulmun Lakes, the decline was very gradual with constant mixing of at least the top 30 metres of the water column (Kussat, 1973). Canyon Lake was generally isothermic. Secchi depths varied between and within each lake, with the greatest range of values observed within Aishihik and Sekulmun

Table I Morphometric data for Aishihik, Canyon and Sekulmun Lakes.

Variable	Lake		
	Aishihik	Canyon	Sekulmun
Surface Area (km^2)	145.0	8.7	49.3
Volume (km^3)	5.45	.04	1.36
Mean Depth (m)	37.6	4.9	27.7
Maximum Depth (m)	114	14	53

Table II Water chemistry data from Aishihik, Canyon and Sekulmun Lakes, collected between August 1 and September 6, 1991.

Variable	Lake		
	Aishihik	Canyon	Sekulmun
Secchi Depth Range[1] (m)	2.0 - 15.0	2.5 - 3.0	6.0 - 12.0
Total Alkalinity (mg/l)	1	1	1
Total Hardness (mg/l)	5	6	4
Carbon Dioxide (mg/l)	5	5	5
TDS (mg/l)	61	64	43
Conductivity (μmho)	122	128	86
pH	7.5	8.0	7.5
Stations	3	1	1

[1] seechi data collected from gillnet sample sites

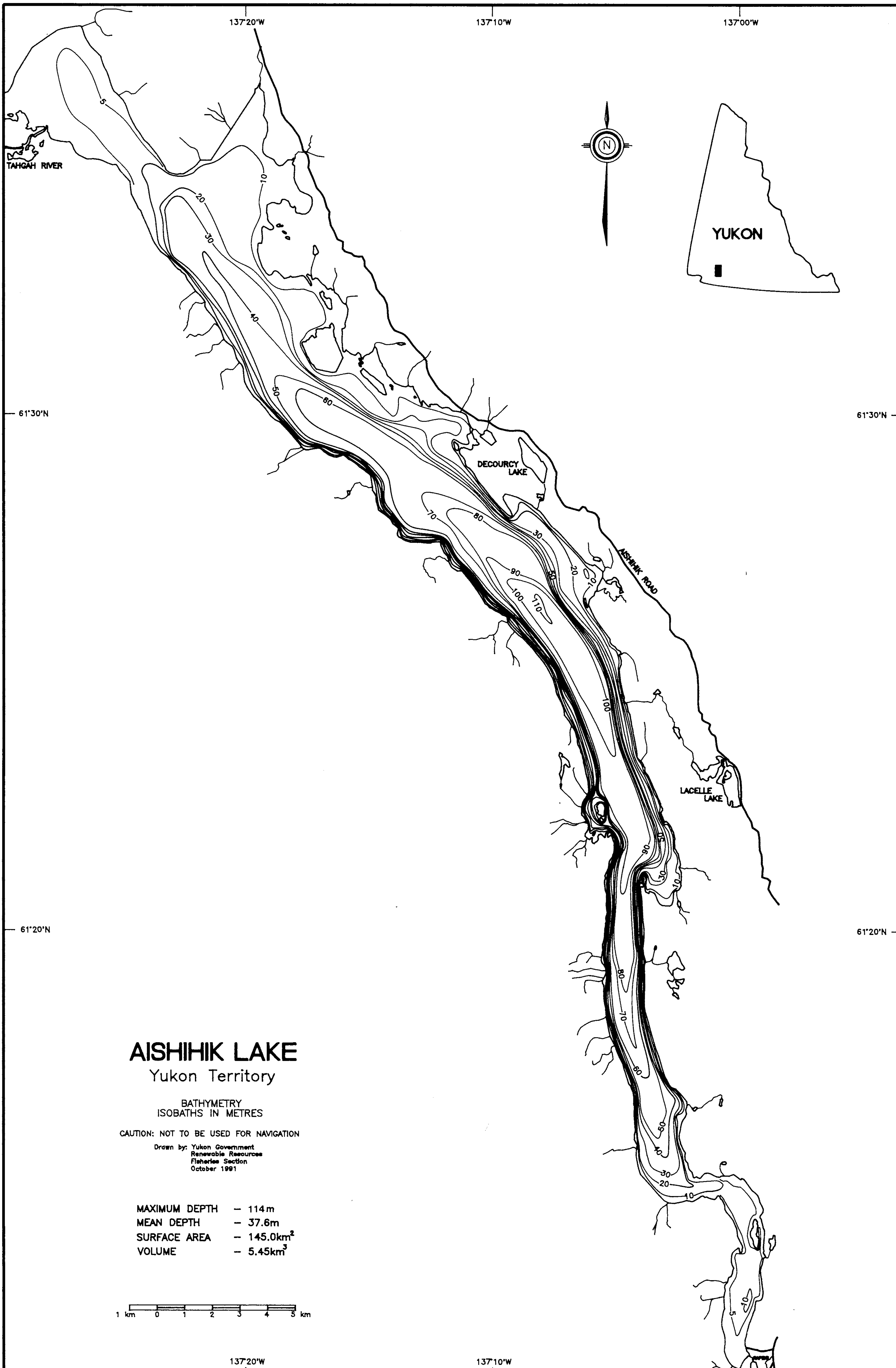


Figure 1 Bathymetric map of Aishihik Lake, Yukon Territory

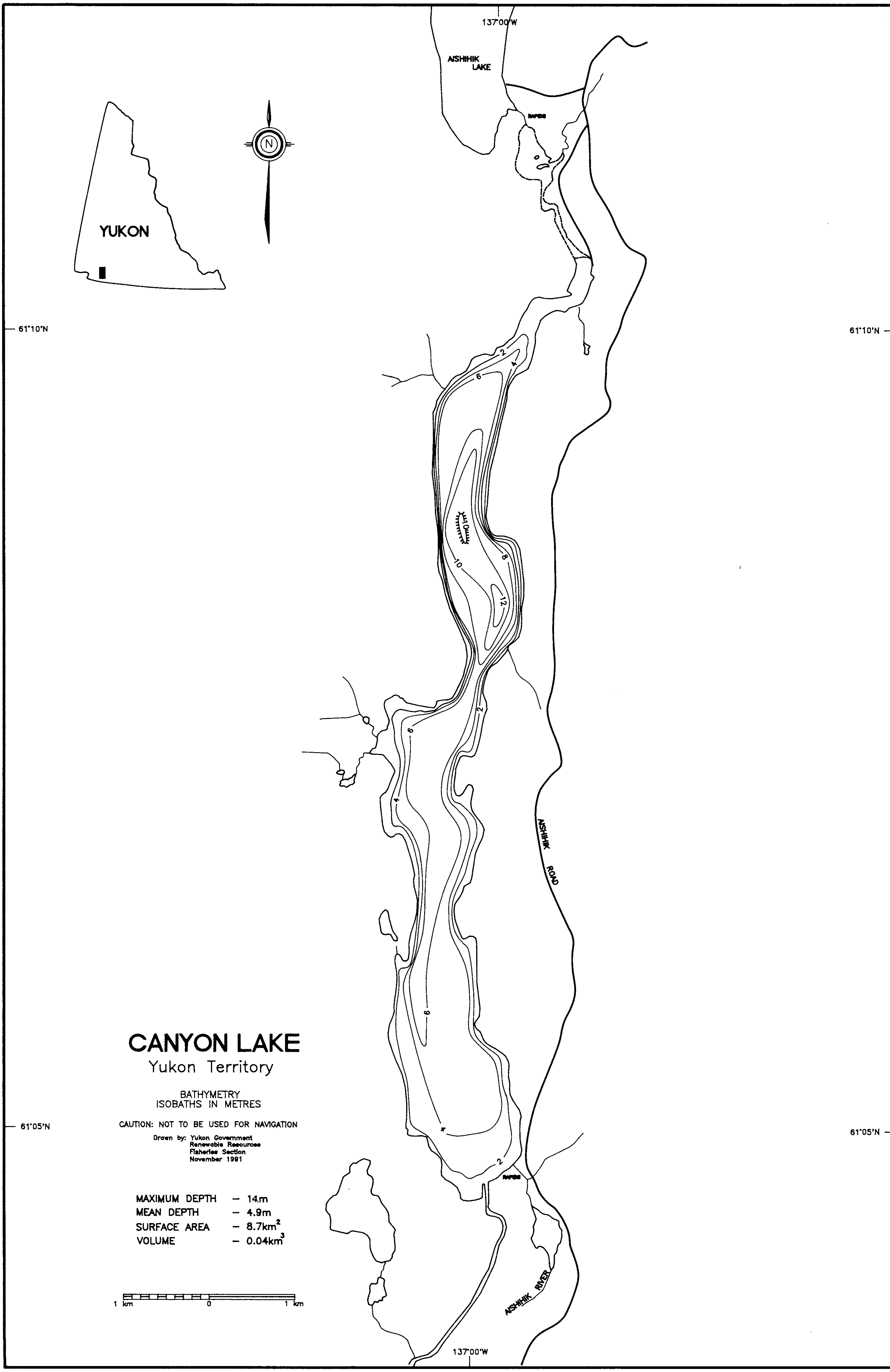


Figure 2 Bathymetric map of Canyon Lake, Yukon Territory

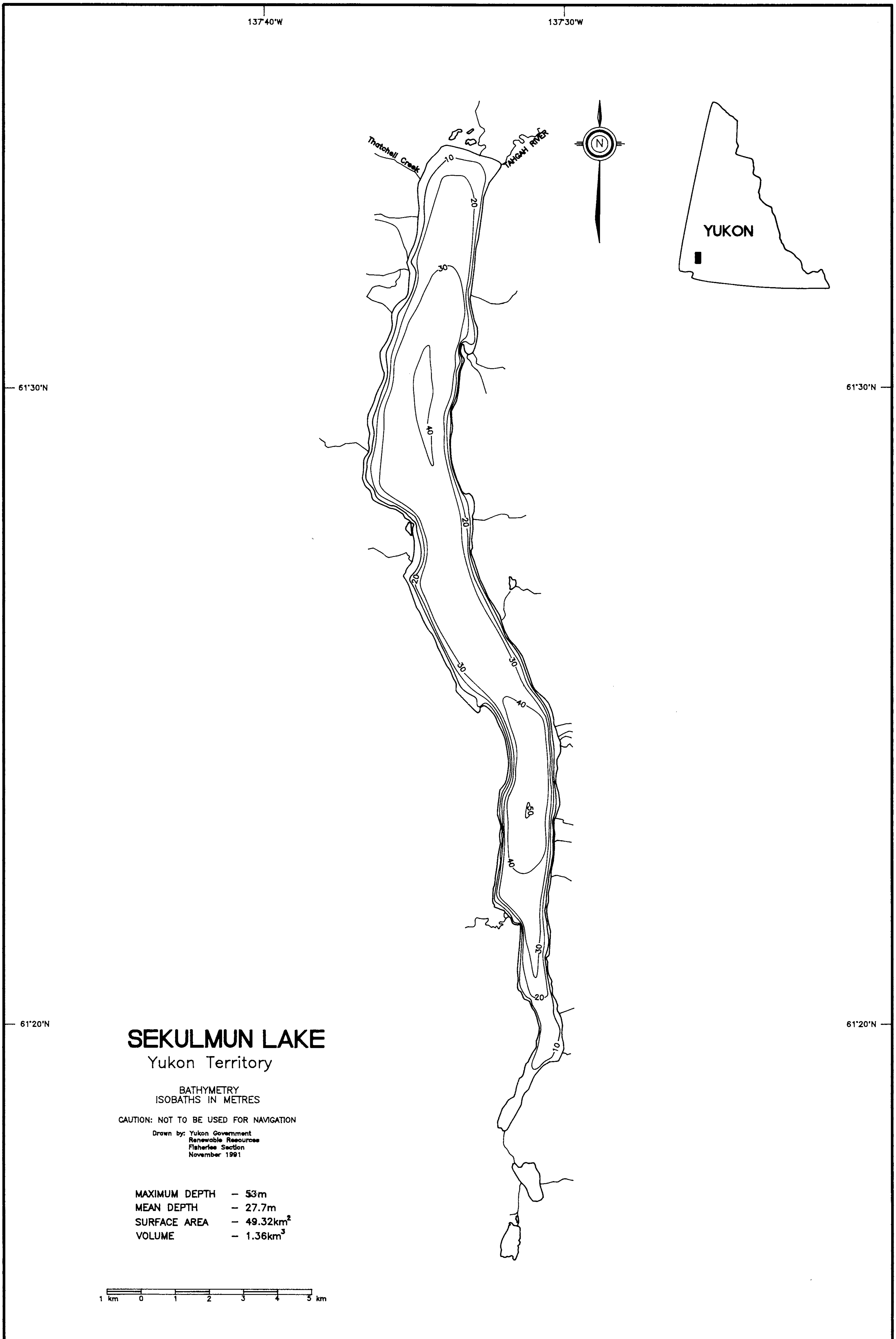


Figure 3 Bathymetric map of Sekulmun Lake, Yukon Territory

Lakes (Table II). Lower values were generally associated with Canyon Lake and the north basin of Aishihik Lake.

Each lake was comprised of relatively soft water with a total hardness ranging from 4-6 mg/L. Averaged values of total dissolved solids (TDS) and conductivity from the limnological stations within Aishihik Lake were comparable to those determined for Canyon Lake. Values recorded for Sekulmun Lake were the lowest. Surface waters in all three lakes were slightly alkaline.

Graphic comparisons of the temporal changes in surface elevations for Aishihik, Canyon and Bennett Lakes, are presented in Figure 4. The magnitude of fluctuation was greatest on Aishihik Lake, at approximately three metres. The highest recorded elevation within Aishihik Lake occurred in 1975 (915.64 m, 3004.22 ft), coincident with the construction phase of the facility. Following this high, the lake steadily declined in stages reaching a low in 1982 (912.54 m, 2994.04 ft). Depressed surface elevations on Aishihik Lake did not influence water elevations on Sekulmun Lake. Canyon Lake surface elevations are erratic and dissimilar to the cyclical patterns displayed for Aishihik or Sekulmun Lakes.

5.1.3 Morphoedaphic Indices and Yield

Calculated morphoeadaphic indices (MEI) and maximum sustainable yields (MSY) for each lake are shown in Table III. MEI's were

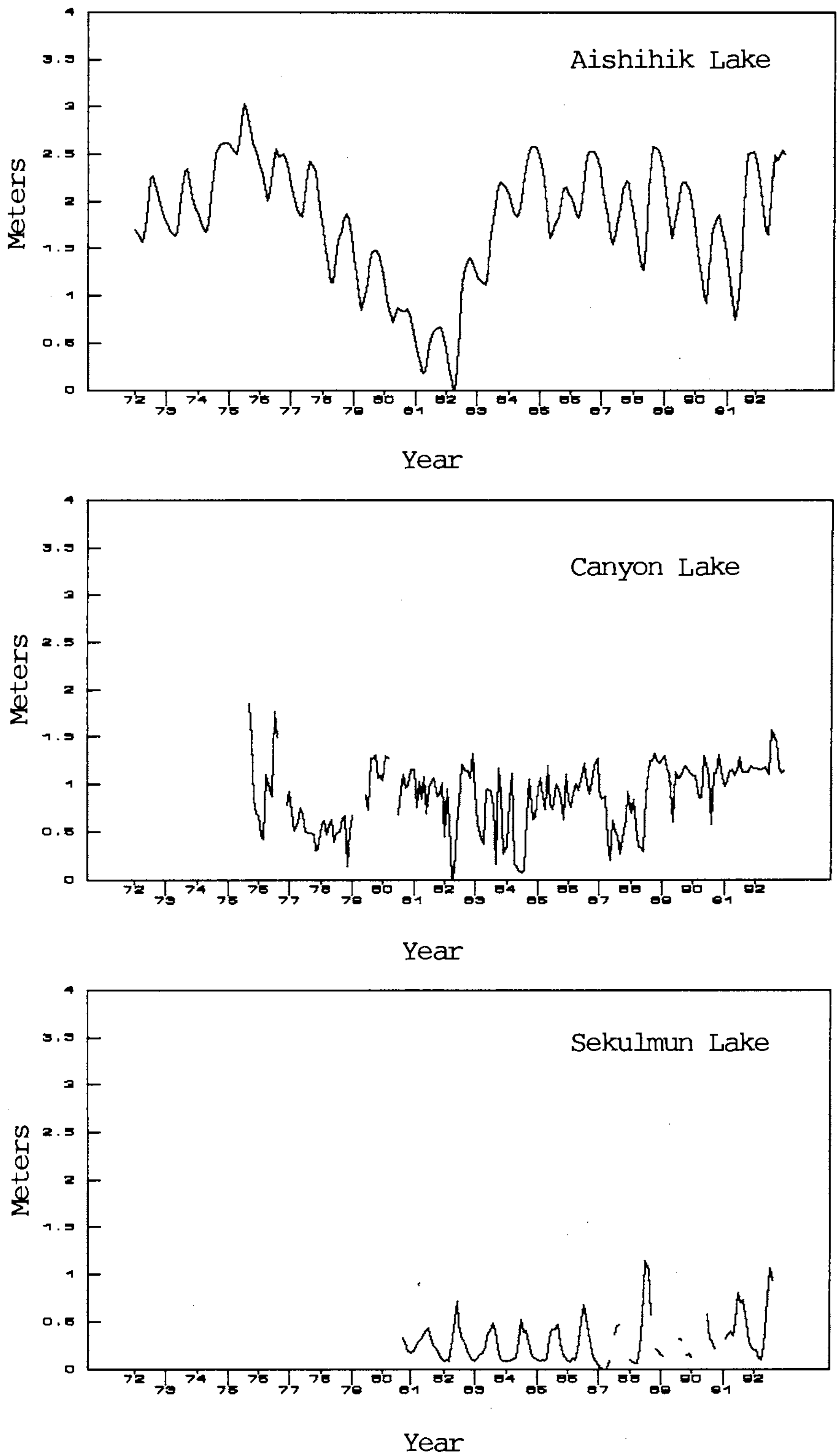


Figure 4 Temporal changes of surface elevations within Aishihik, Canyon and Sekulmun Lakes.

Table III Calculated morphoedaphic indices (MEI) and all-species maximum sustainable yields (MSY) for Aishihik, Canyon and Sekulmun Lakes.

Variable	Lake		
	Aishihik	Canyon	Sekulmun
TDS (mg/l)	61	64	43
Mean Depth (m)	37.6	4.9	27.7
MEI	1.62	13.06	1.55
Mean Annual Temperature (C°)	-4.4	-4.4	-4.4
MSY (kg/hct)	1.19	2.13	1.17

Table IV Catch compositions, presented as percentages of catch biomass, from the 1991 index gillnetting program within Aishihik, Canyon and Sekulmun Lakes.

Species	Scientific Name	Lake		
		Aishihik	Canyon	Sekulmun
Lake Trout	*Salvelinus namaycush*	30.6	4.4	27.4
Lake Whitefish	*Coregonus clupeaformis*	60.1	26.0	66.0
Round Whitefish	*Prosopium cylindricum*	1.9	2.1	.8
Longnose Sucker	*Catostomus catostomus*		62.2	
Northern Pike	*Esox lucius*	7.0	5.3	5.6
Burbot	*Lota lota*	.2		.2
Arctic Grayling	*Thymallus arcticus*	.2		

comparable between Sekulmun (1.55) and Aishihik Lakes (1.62). Canyon Lake had the highest value of 13.06. Resulting all species MSY's were 1.19 kg/hct for Aishihik Lake, 2.13 kg\hct for Canyon Lake and 1.17 kg/hct for Sekulmun Lake.

5.1.4 Lake Trout CPUE Gillnetting

Lake trout CPUE was highest on Aishihik Lake at 9.58 ± 4.23 fish/100 m /24 hr, followed by Sekulmun Lake at 7.73 ± 7.73 fish/100 m /24 hr and Canyon Lake at 4.02 ± 3.47 fish/100 m/24 hr. The same trend is apparent when CPUE values are presented as biomass, with Aishihik Lake having the highest (23.20 ± 10.24 kg/100 m/24 hr) followed by Sekulmun Lake (16.96 ± 8.71 kg/100 m/24 hr) and Canyon Lake (5.47 ± 4.72 kg/100 m/24 hr).

5.1.5 Index Gillnetting

5.1.5.1 Catch Composition and CPUE

Catch compositions from the index gillnetting program were similar between Aishihik and Sekulmun Lakes (Table IV). Within these lakes, lake trout and lake whitefish dominated catches. Lake whitefish represented the largest percentage of the catch biomass at 60 percent for Aishihik Lake and 66 percent for Sekulmun Lake. Longnose sucker were absent in catches in both lakes. Conversely, longnose sucker dominated the catch in Canyon Lake and represented 62 percent of the catch biomass. Lake whitefish were the second most commonly caught species by weight at 26 percent. Catches of lake trout in Canyon Lake were significantly less than those established for Aishihik or Sekulmun Lakes. Catch compositions for northern pike and round whitefish were relatively consistent between all three lakes. Burbot and arctic grayling were infrequently caught throughout the survey.

Relative CPUE statistics from the index gillnetting programs are presented in Table V. The highest values were recorded for lake whitefish on Aishihik Lake and longnose sucker on Canyon Lake. Although the catch compositions for lake trout and lake whitefish were similar between Aishihik and Sekulmun Lakes, CPUE for both these species were lower for the latter. The lowest CPUE values for lake trout and lake whitefish were calculated for Canyon Lake.

5.1.5.2 Age and Growth

Lake Trout

Age frequencies from each lake are presented in Figure 5. Sampled lake trout ranged in age from 2 to 34 years. Low sample numbers from Canyon and Sekulmun Lakes produced irregular age frequencies, with many year classes not represented. Mean ages of catch were 13.22 years for Aishihik Lake, 11.59 years for Canyon Lake and

Table V Comparisons of CPUE statistics from the 1991 index gillnetting program conducted on Aishihik, Canyon and Sekulmun Lakes.

UNIT	SPECIES	LAKE		
		Aishihik	Canyon	Sekulmun
#/100 m/24 hr	Lake trout	8.78 ± 3.56	2.08 ± .75	4.97 ± 3.02
	Lake Whitefish	38.75 ± 12.21	20.75 ± 8.46	30.72 ± 9.79
	Round Whitefish	3.68 ± 1.88	8.05 ± 3.86	1.47 ± 1.23
	Northern Pike	2.50 ± 3.18	1.82 ± 1.84	1.48 ± 1.12
	Longnose Sucker	no catch	40.00[1]	no catch
	Burbot	.15 ± .19	no catch	.16 ± .28
kg/100 m/24 hr	Lake trout	20.95 ± 8.49	2.28 ± .83	13.57 ± 8.23
	Lake Whitefish	45.74 ± 14.41	13.46 ± 5.49	31.87 ± 10.16
	Round Whitefish	1.34 ± .69	1.13 ± .54	.46 ± .38
	Northern Pike	5.46 ± 6.94	3.26 ± 3.29	3.23 ± 2.44
	Longnose Sucker	no catch	32.00[1]	no catch
	Burbot	.13 ± .16	no catch	.11 ± .20

[1] no confidence limits available

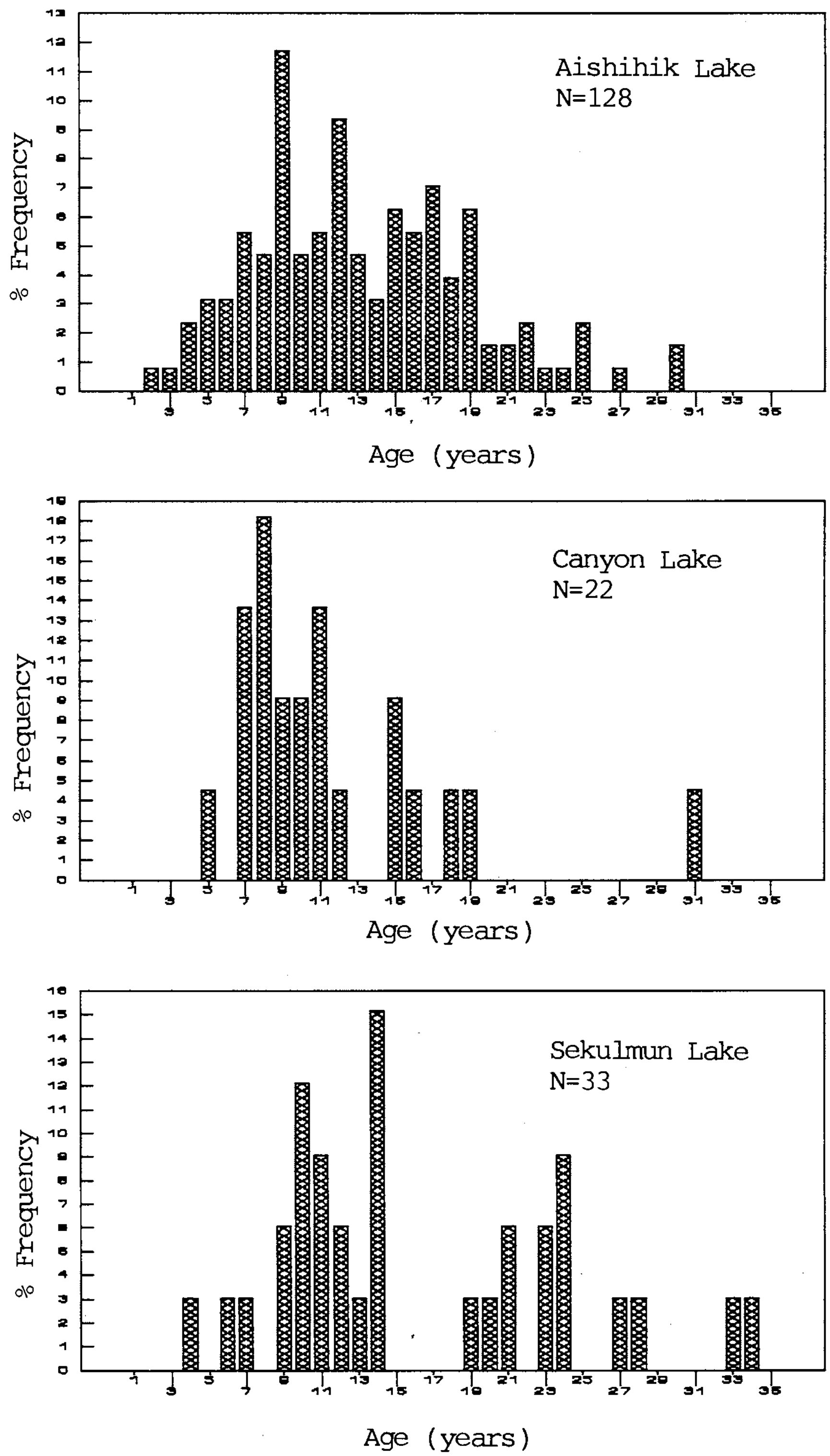


Figure 5 Age frequencies of lake trout captured during the 1991 index gillnetting program within Aishihik, Canyon and Sekulmun Lakes.

16.24 years for Sekulmun Lake. Age specific mean fork lengths and mean weights of lake trout from each lake are presented in Appendix 7a.

Length-weight scatter plots for each lake are presented in Figure6. Fitted regressions of log transformed data are presented in Table VI. No trends were established between sexes or lakes. Sampled lake trout ranged in fork length from 170 mm to 920 mm. Average lengths were 552 mm for Aishihik Lake, 440 mm for Canyon Lake and 594 mm for Sekulmun Lake.

Lake trout growth analysis was only conducted on data from Aishihik Lake, as this data base had sufficient sample sizes within several age classes to do the analysis. The results show that male lake trout, while having a larger asymptotic size (3 cm), had a slightly lower growth coefficient than those observed for females. Von Bertalanffy growth variables and age-length scatter plot are presented in Table VII and Figure 7.

Fish were a large component in the diet of lake trout within all three lakes, ranging from 48 percent (Sekulmun Lake) to 55 percent (Aishihik Lake) of the stomachs containing food. Prey species were mainly coregonids (round and lake whitefish) and less frequently sculpins, burbot and lake trout. The balance of the remaining food items consisted of invertebrates (mollusks, gastropods, crustaceans) representing 37 percent (Aishihik Lake) to 52 percent (Sekulmun Lake) of examined stomach contents.

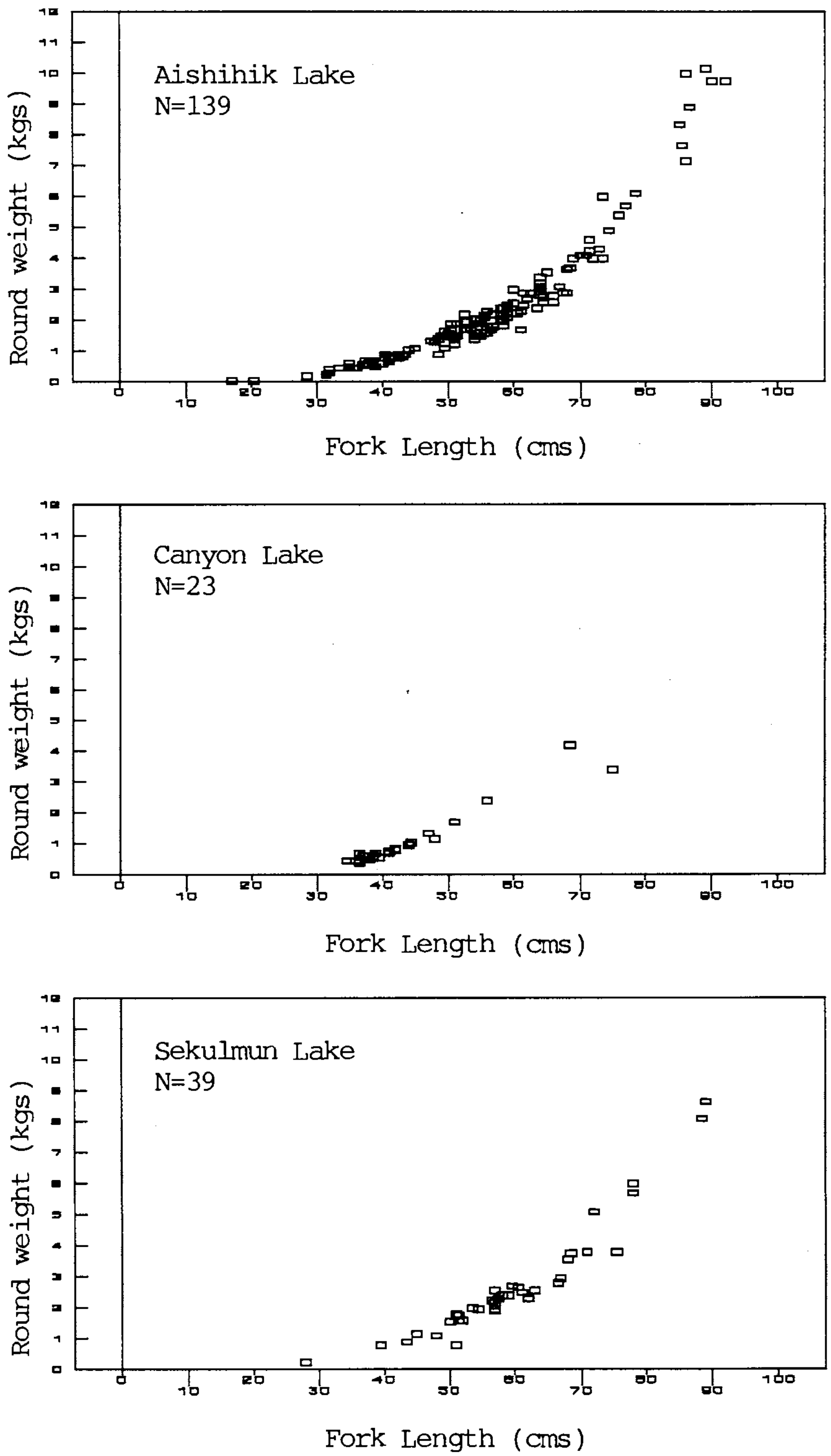


Figure 6 Length-weight scatter plots of lake trout captured during the 1991 index gillnetting program within Aishihik, Canyon and Sekulmun Lakes, 1991.

Table VI Age specific length-weight relationships of lake trout from the 1991 index gillnetting program within Aishihik, Canyon and Sekulmun Lakes, 1991.

Lake	Sex	Length-Weight Equation	N	r^2
Aishihik	M	Log weight = -5.08 + Log length (3.05)	62	.9640
	F	Log weight = -5.50 + Log length (3.20)	72	.9707
	Combined	Log weight = -5.50 + Log length (3.20)	139	.9746
Canyon	M	Log weight = -6.22 + Log length (3.48)	11	.9291
	F	Log weight = -5.09 + Log length (3.04)	10	.9614
	Combined	Log weight = -5.28 + Log length (3.12)	23	.9405
Sekulmun	M	Log weight = -5.01 + Log length (3.03)	20	.9865
	F	Log weight = -4.55 + Log length (2.85)	19	.8347
	Combined	Log weight = -4.87 + Log length (2.98)	39	.9492

Table VII Von Bertalanffy growth variables of lake trout captured during the 1991 index gillnetting program within Aishihik Lake, 1991.

Sex	L∞′	K′	Age Range	N
Male	893	.078	9,13,16	20
Female	868	.087	9,11,12,15,17	32
Combined	879	.086	7-13,15-19	96

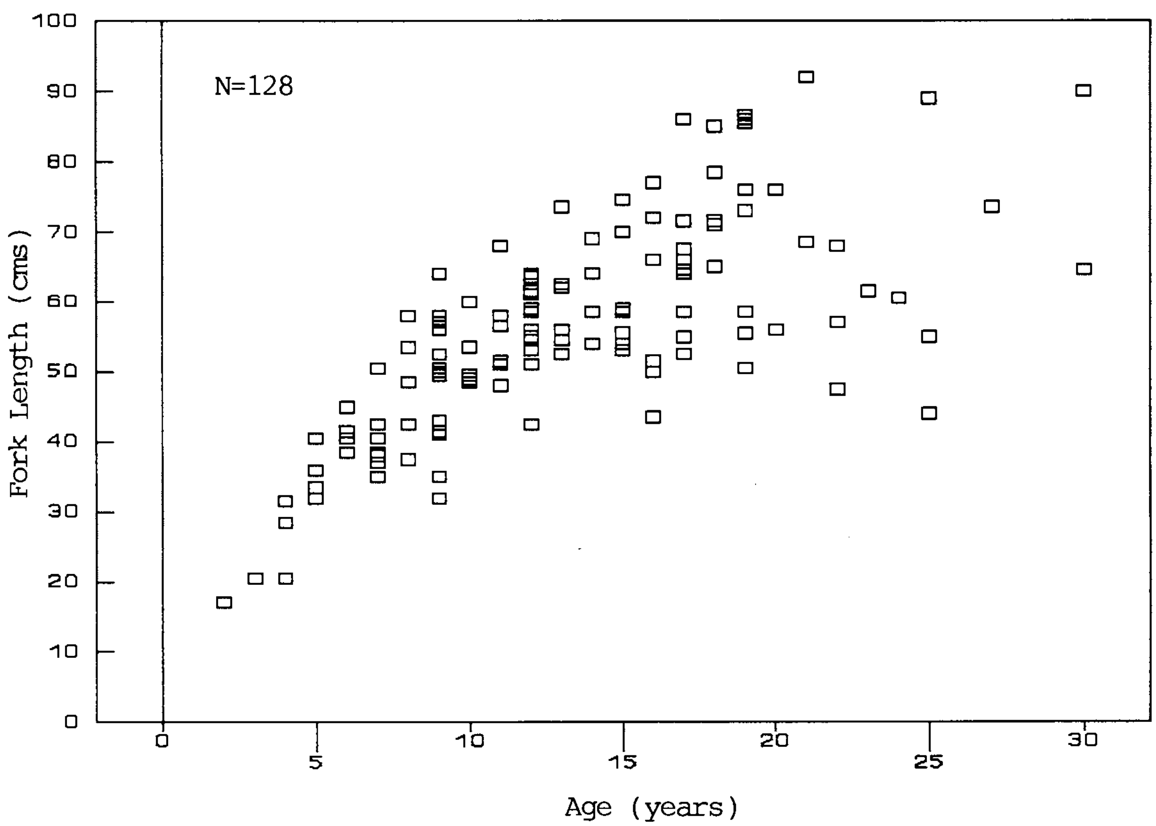


Figure 7 Age-length scatter plot of lake trout captured during the 1991 index gillnetting program within Aishihik Lake.

Lake Whitefish

Age specific mean fork lengths and mean weights of lake whitefish from index gillnet catches for each lake are presented in Appendix 7b. Overall catches of lake whitefish ranged in age from 4 to 37 years, with modal ages ranging from 11 years (Canyon Lake) to 17 years (Aishihik Lake). Age frequencies are presented in Figure 8. Mean age of catch were 18.5 years for Aishihik Lake, 12.9 years for Canyon Lake and 22.3 years for Sekulmun Lake.

Length-weight scatter plots for each lake are presented in Figure 9. Fitted regressions of log transformed data are presented in Table VIII. Lake whitefish within Canyon Lake averaged the lowest weights for any given length. Length-weight relationships were comparable between Aishihik and Sekulmun Lakes. Sampled lake whitefish ranged in fork length from 240 mm to 555 mm. Average lengths were 440 mm for Aishihik Lake, 386 mm for Canyon Lake and 430 mm for Sekulmun Lake.

Age-length scatter plots and Von Bertalanffy growth variables are presented in Figure 10 and Table IX. Asymptotic sizes of lake whitefish were similar between Aishihik and Sekulmun Lakes, and greater than those estimated for Canyon Lake. Lake whitefish growth coefficients (K') were the greatest for Canyon Lake, almost doubling those estimated for Aishihik and Sekulmun Lakes. No dramatic differences were observed in growth variables between sexes within any of the surveyed lakes.

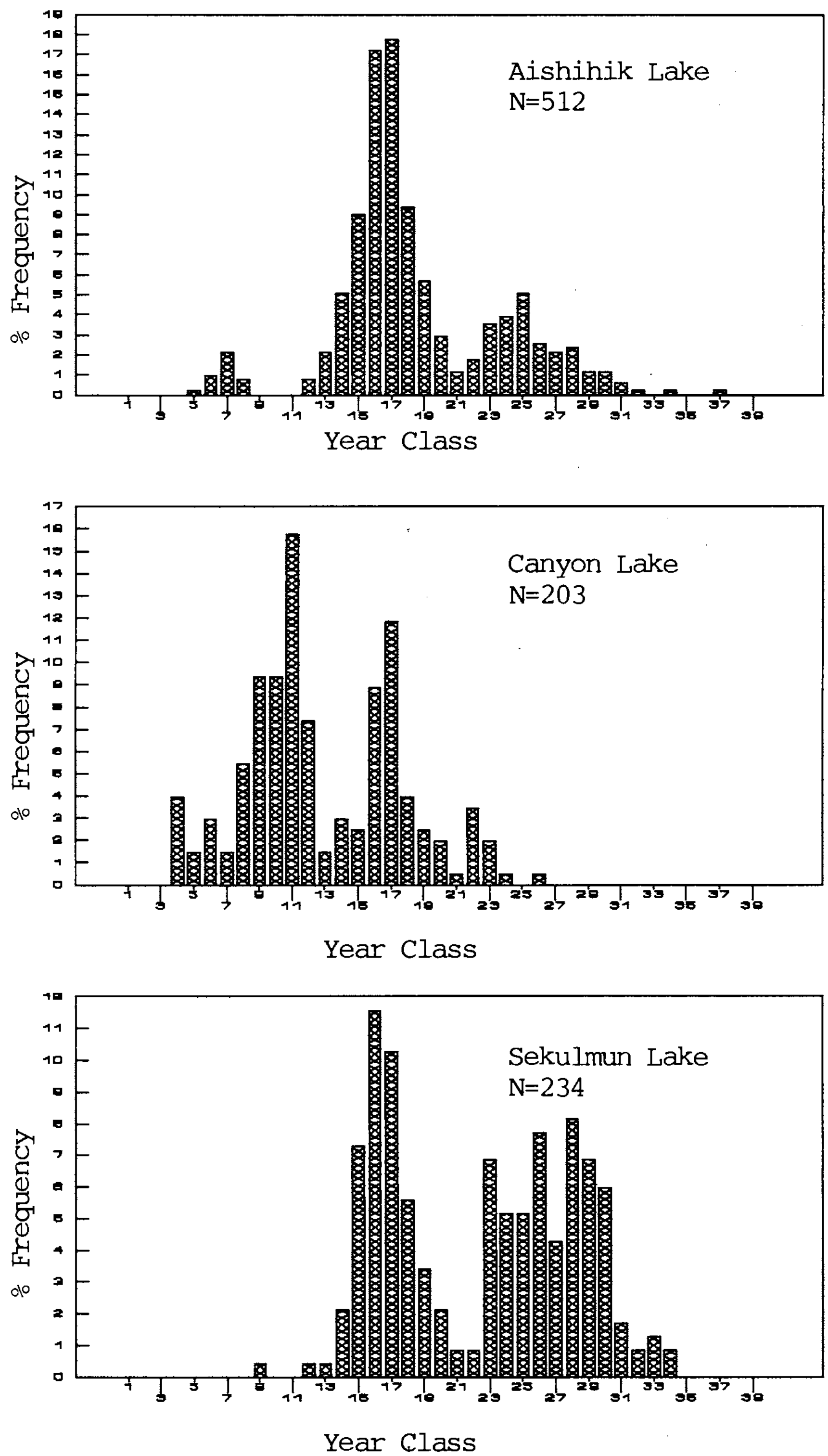


Figure 8 Age frequencies of lake whitefish captured during the 1991 index gillnetting program within Aishihik, Canyon and Sekulmun Lakes, 1991.

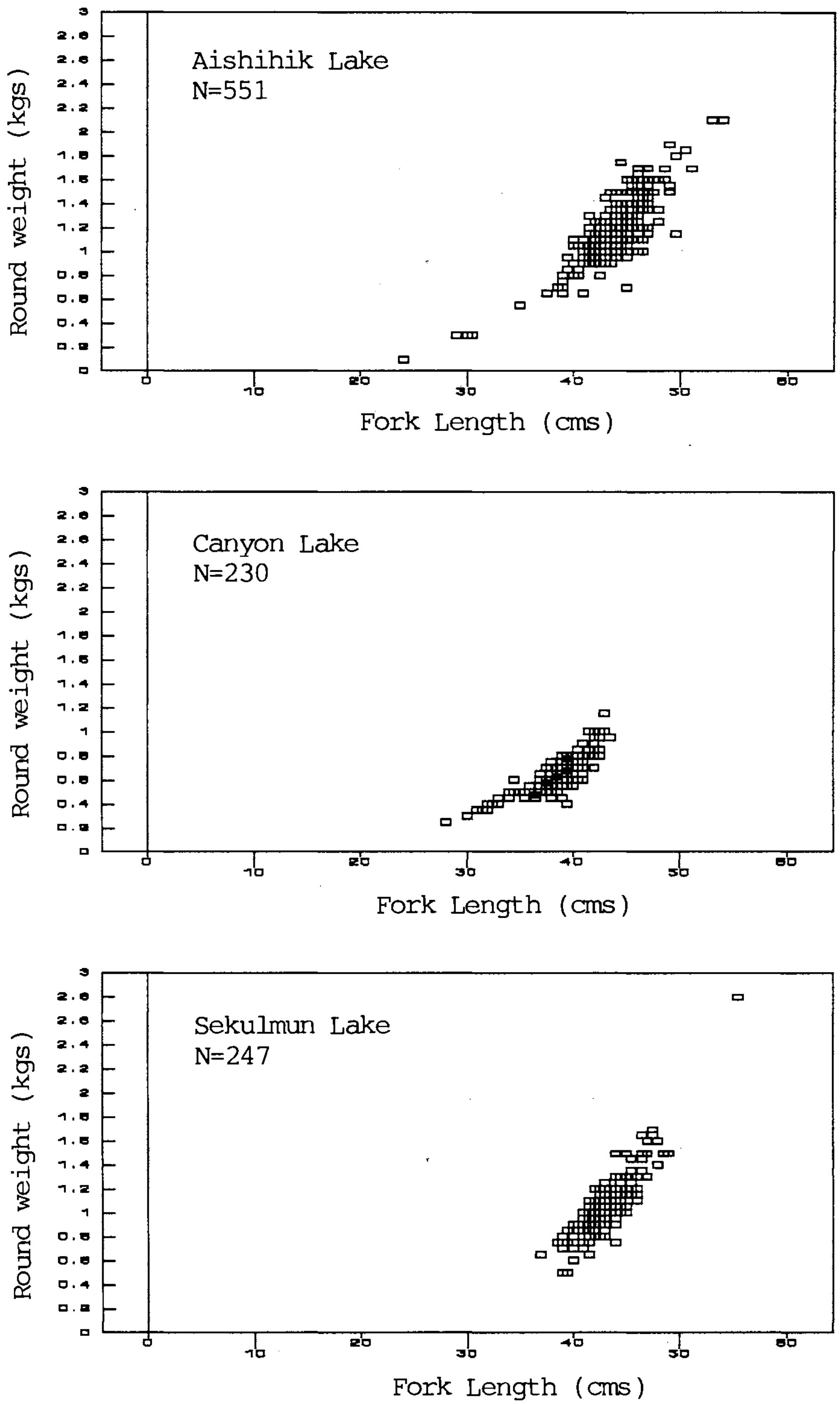


Figure 9 Length-weight scatter plots of lake whitefish captured during the 1991 index gillnetting program within Aishihik, Canyon and Sekulmun Lakes.

Table VIII Sex specific length-weight relationships of lake whitefish captured during the 1991 index gillnetting program within Aishihik, Canyon and Sekulmun Lakes.

Lake	Sex	Length-Weight Equation	N	r^2
Aishihik	M	Log weight = -5.32 + Log length (3.17)	263	.7180
	F	Log weight = -5.48 + Log length (3.23)	284	.6864
	Combined	Log weight = -5.79 + Log length (3.35)	551	.7607
Canyon	M	Log weight = -4.33 + Log length (2.75)	110	.7362
	F	Log weight = -5.45 + Log length (3.20)	116	.6879
	Combined	Log weight = -4.89 + Log length (2.97)	230	.7228
Sekulmun	M	Log weight = -6.88 + Log length (3.76)	89	.7264
	F	Log weight = -7.02 + Log length (3.81)	157	.7333
	Combined	Log weight = -6.99 + Log length (3.80)	247	.7307

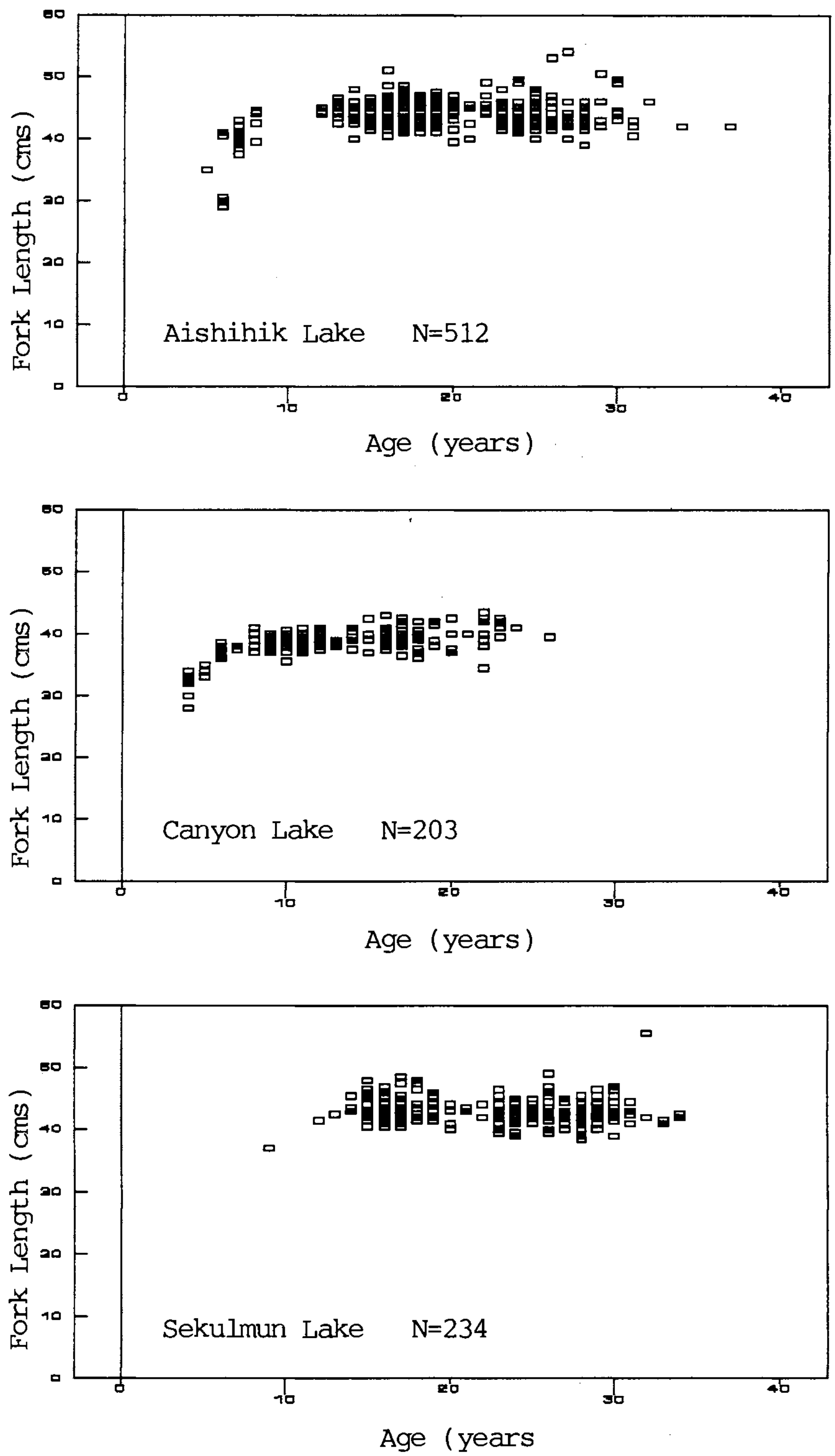


Figure 10 Age-length scatter plots of lake whitefish captured during the 1991 index gillnetting program within Aishihik, Canyon and Sekulmun Lakes.

Table IX Von Bertalanffy growth variables of lake whitefish captured during the 1991 index gillnetting program within Aishihik, Canyon and Sekulmun Lakes, 1991.

	Sex	L∞′	K′	Age Range	N
Aishihik	Male	485	.116	7,13-20,23-25,27,28	222
	Female	483	.113	13-20,29,22-26,30	241
	Combined	503	.095	6,7,13-30	497
Canyon	Male	419	.194	4,8-12,16-18	71
	Female	428	.190	9-12,16,17	75
	Combined	426	.170	4,6,8-12,14-19,22	183
Sekulmun	Male	494	.086	15-17,19,24,28-30	60
	Female	476	.098	15-18,23,25-30	120
	Combined	485	.094	14-20,23-30	216

The diet of sampled lake whitefish juveniles and adults primarily consisted of gastropods within all three lakes. Other components in decreasing frequency, included mollusks, crustaceans and the aquatic larvae of insects (dipteran).

5.1.5.3 Maturity

The calculated mean age of maturity (MAM) for lake trout (combined sexes) within Aishihik Lake was 12.04 years (Table X). First onset of sexual maturation was at 7 years with the bulk of maturation complete by age 15. The male lake trout MAM was approximately a year greater than that calculated using combined sex data. Lake trout maturity at age tables for each lake are presented in Appendix 8a.

Lake whitefish MAM within Canyon Lake were generally greater than those calculated for Aishihik Lake. Data suggests the first onset of sexual maturation begins at age 6 with maturation occurring over a broad range of age groups. Lake whitefish maturity at age tables for each lake are presented in Appendix 8b.

5.1.5.4 Mortality

Mortality and survival rates for lake trout and lake whitefish by lake are presented in Table XI. Annual survival rates were similar

Table X Mean ages of maturity of lake trout and lake whitefish captured during the 1991 index gillnetting program within Aishihik, Canyon and Sekulmun Lakes.

Species	Lake	Male	Female	Combined
Lake Trout	Aishihik	13.05	*	12.04
	Canyon	*	*	*
	Sekulmun	*	*	*
Lake Whitefish	Aishihik	10.07	*	10.51
	Canyon	12.57	8.61	11.98
	Sekulmun	*	*	*

* insufficient data

Table XI Robson-Chapman mortality and survival rates of lake trout and lake whitefish captured during the 1991 index gillnetting program within Aishihik, Canyon and Sekulmun Lakes.

Species	Lake	Instantaneous mortality (Z)	Annual mortality (A)	Annual survival (S±1.96 S.E.)	Age Classes used
Lake trout	Aishihik	.159	.147	.853 ± .029	10-25,27,30
	Canyon	-	-	-	*
	Sekulmun	-	-	-	*
Lake whitefish	Aishihik	.192	.175	.825 ± .021	19-32,34,37
	Canyon	.189	.172	.828 ± .031	12-24,26
	Sekulmun	.126	.118	.882 ± .016	17-34

* insufficient age classes for calculation

between lakes and species. The greatest range in survival rates for lake whitefish was between Aishihik (.825) and Sekulmun Lakes (.882). The overall highest instantaneous mortality rate was associated with lake whitefish on Aishihik Lake (.192).

5.1.6 Benthic Invertebrate Investigations

Organisms collected from the September sampling program and identified to family, genus or species are presented in Appendix 4b. Benthic organisms that dominated the north basin sampling sites, throughout both sampling periods, were chironomids (66 percent) and oligochaetes (14 percent). Other less abundant groups included gastropods (5 percent), nematodes (4 percent), pelecypods (3.5 percent), amphipods (3 percent) and cladocerans (2.5 percent). Incidental taxa that were collected but in low abundance in the samples were hirudinea, trichoptera, hydracarina, copepoda and emphemeroptera.

The relative abundance of organisms generally increased with depth within both sample periods (Figure 11). The bulk of the benthic organisms enumerated were below an elevation of 913.10 metres or 2995.7 feet.

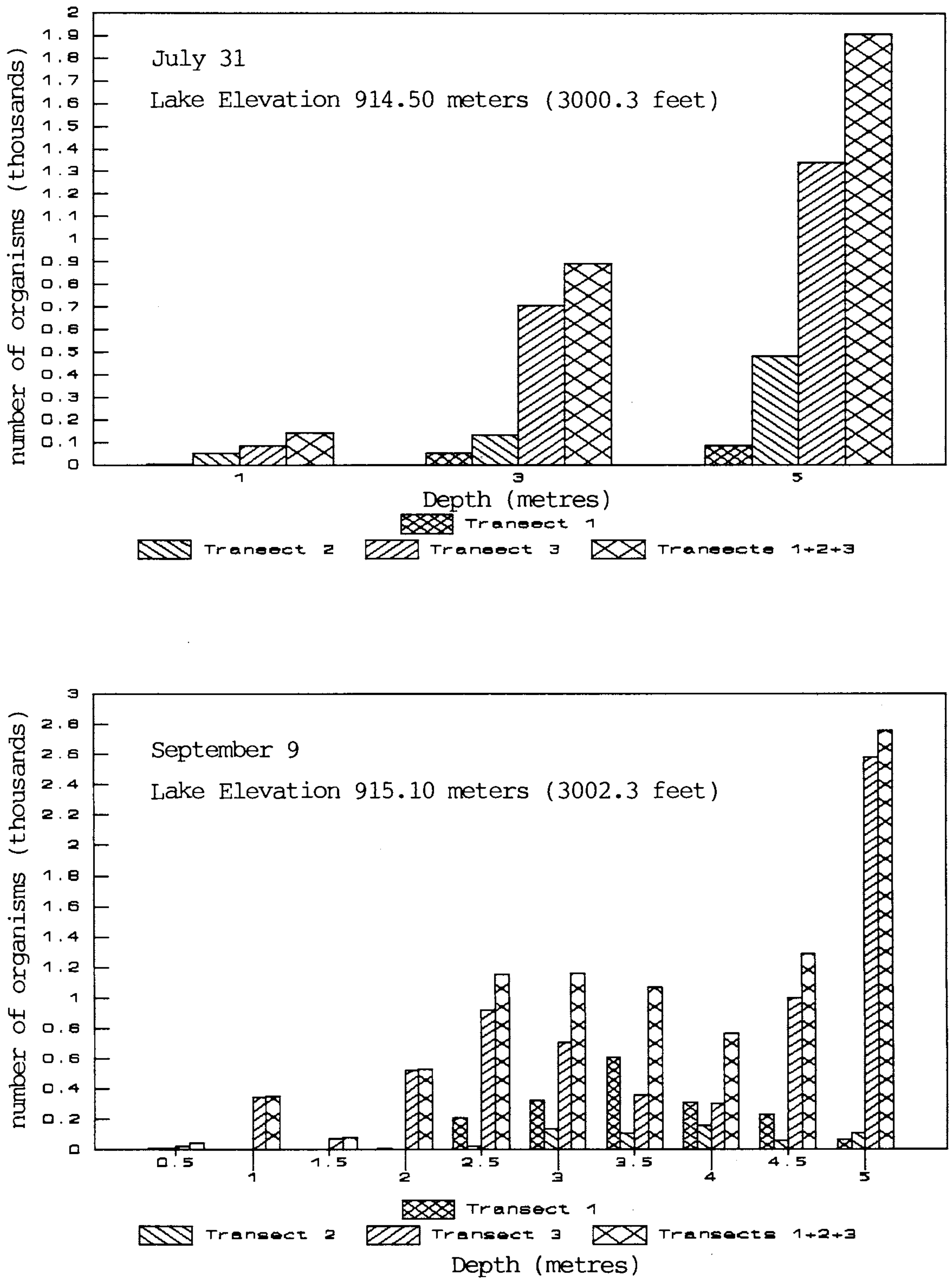


Figure 11 Relative abundances of benthic organisms as a function of depth within the north basin of Aishihik Lake, July and September, 1991.

5.2 1992 Studies

5.2.1 Juvenile Lake Whitefish Gillnetting

The spatial distribution of captured juvenile lake whitefish (fork length $\leq$ 250 mm) from the small mesh gillnet survey sites within Aishihik, Canyon and Sekulmun Lakes are presented in Figure 12. Locations of relatively good catches were clustered within the north basin of Aishihik Lake (including Soldiers Bay) and throughout Canyon Lake. Age compositions of captured lake whitefish from each surveyed lake are presented in Figure 13. Captured lake whitefish ranged in age from 2 to 38 years using the survey gear. The 3 year age class was very strong in both Aishihik and Canyon Lakes, dominating their respective age frequencies. Age classes 3 to 11 years that were represented in Aishihik Lake, were noticeably absent in the age frequency for Sekulmun Lake. Sekulmun Lake had very poor representation of cohorts less than 15 years. Older cohorts (greater than 25 years) were generally confined to Aishihik and Sekulmun Lakes.

5.2.2 Beach Seining

Catch locations of young-of-the-year (YOY) and yearling lake whitefish are shown in Figure 14. The most successful seining site for lake whitefish was a gravel beach located in the northern portion of Canyon Lake where 2296 YOY's were enumerated in a single

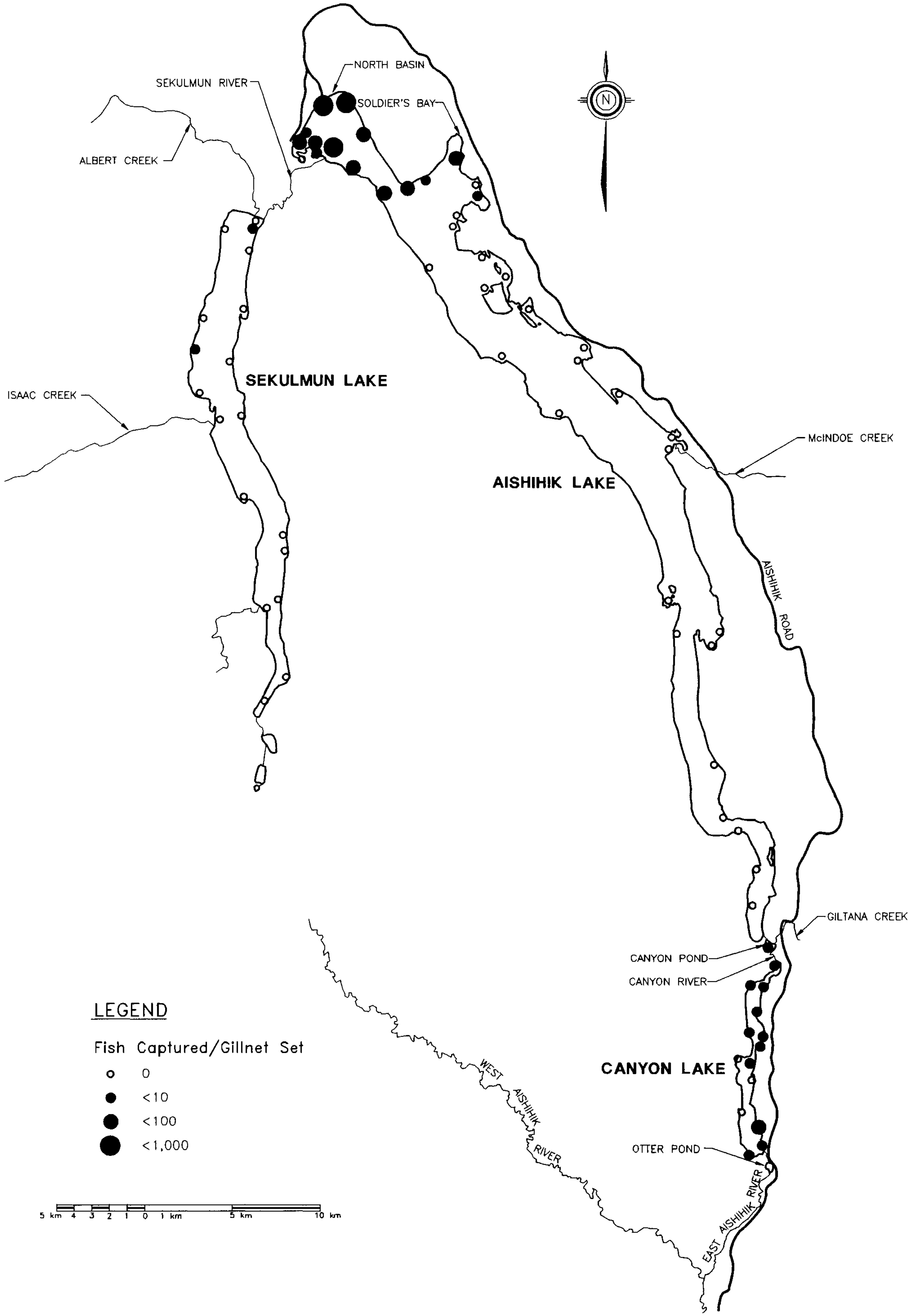


Figure 12 Catch distribution of juvenile lake whitefish (fork length $\leq$ 250 mm) captured during the 1992 juvenile gillnetting program within Aishihik, Canyon and Sekulmun Lakes, Summer, 1992.

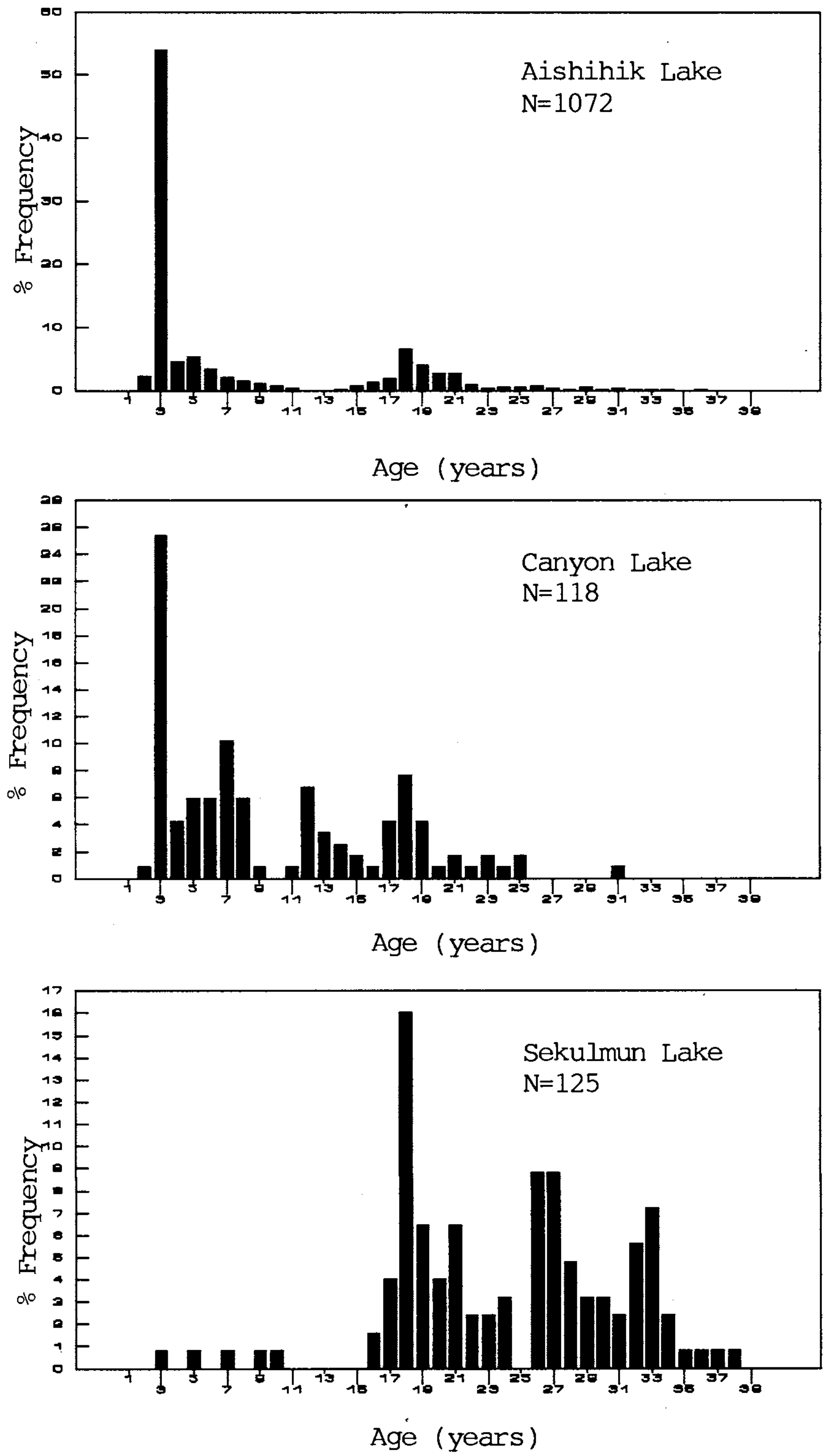


Figure 13 Age frequencies of lake whitefish captured during the 1992 juvenile gillnetting program within Aishihik, Canyon and Sekulmun Lakes.

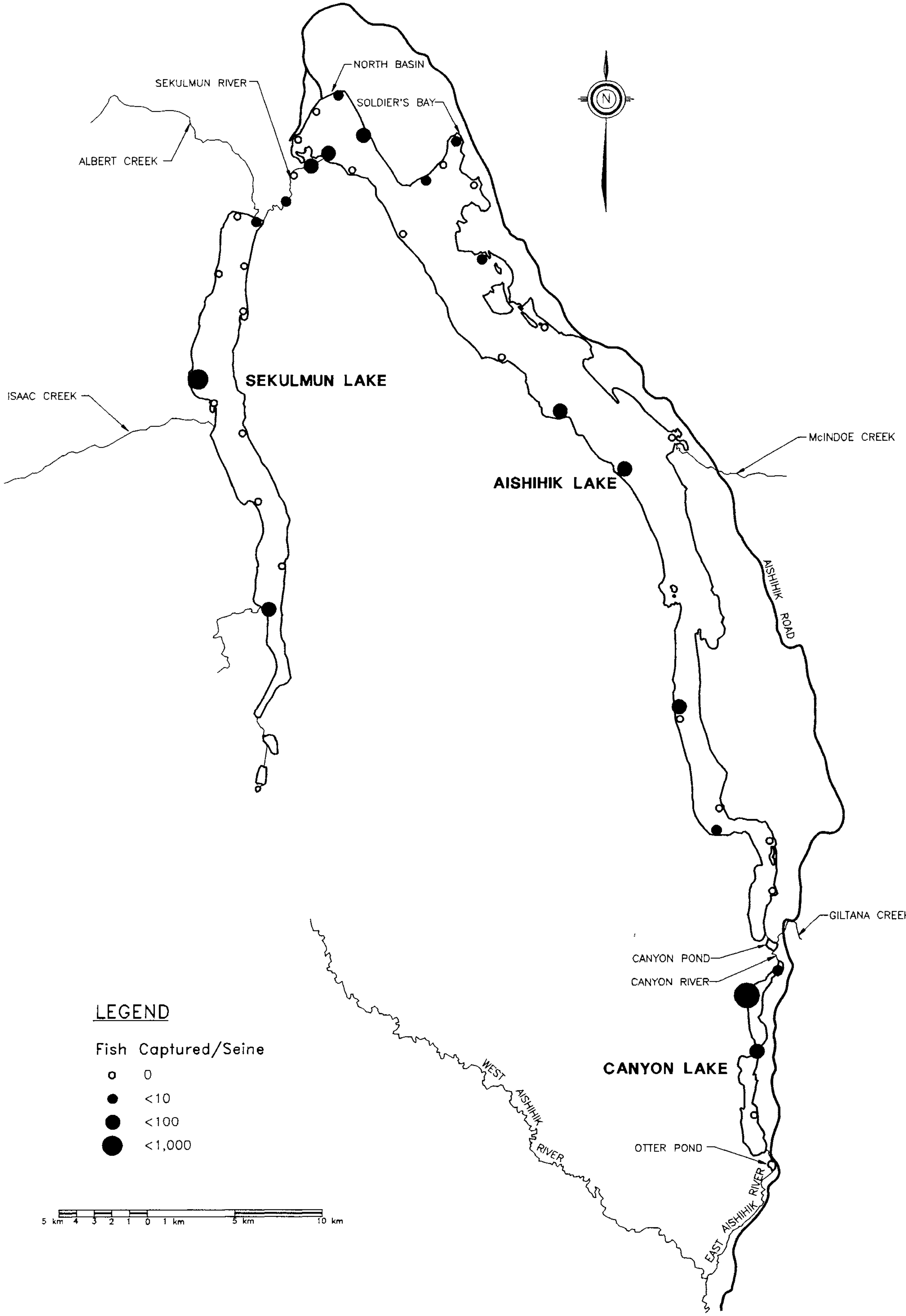


Figure 14 Beach seine catch distribution of young-of-the-year and yearling lake whitefish during the 1992 beach seining program within Aishihik, Canyon and Sekulmun Lakes.

seine. Results from the survey indicate that the type of habitat, utilized by each species early life history stages, was a function of substrate. Capture frequencies of lake trout, lake whitefish, round whitefish and slimy sculpin over various categories of bed material are presented in Figure 15. Catches of juvenile lake whitefish were associated with a bed material consisting of small gravels (2-16 mm).

Length frequencies of beach seined lake and round whitefish from Aishihik Lake are presented in Figure 16. The histograms show round whitefish to have two prominent age groups (0+, 1+). In comparison very few yearling lake whitefish were captured. YOY's for both species were similarly sized, averaging 20 mm in length. The variability in the standard lengths of yearling round whitefish is approximately double those determined for YOY's.

5.2.3 Trawling

It was noted through field observations that the success in capturing juvenile lake whitefish using the trawl increased with increasing turbidity. Sizable captures were only associated with the more turbid waters within Soldiers Bay and the north basin of Aishihik Lake. Although visual observations of large rearing schools of YOY lake whitefish were documented in Sekulmun Lake, they avoided capture in the trawl. Canyon Lake could not be successfully surveyed due to the abundance of aquatic macrophytes

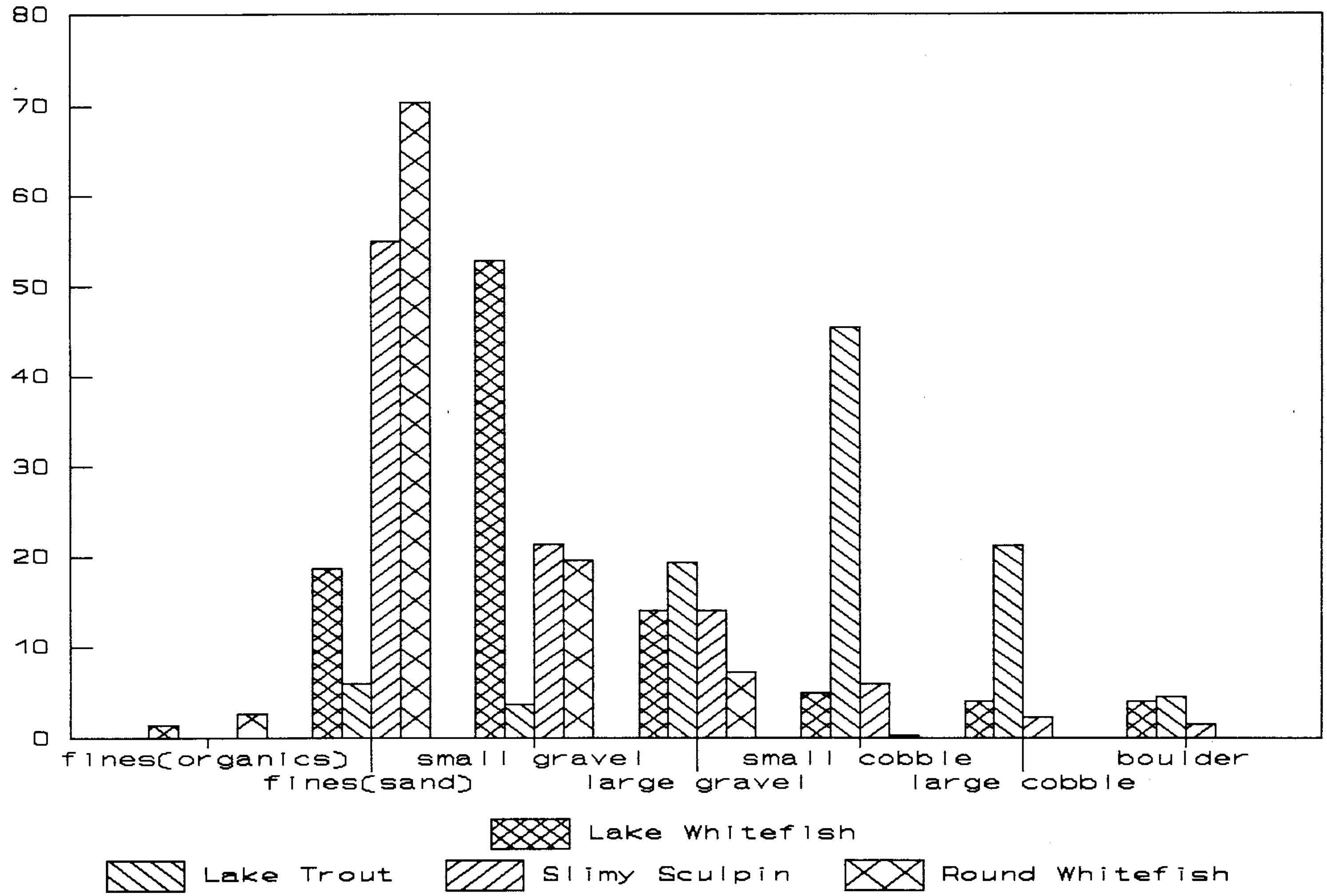
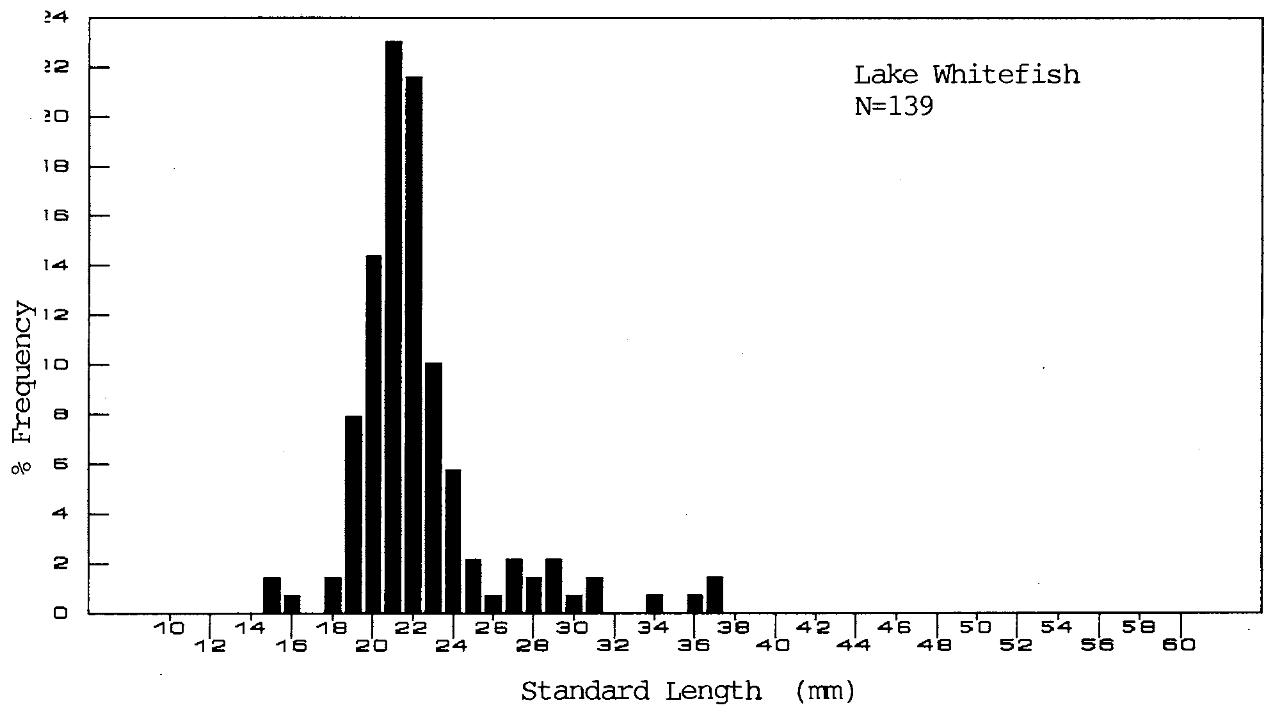


Figure 15 Frequencies of fish captured by beach seining over various substrate types within Aishihik, Canyon, and Sekulmun lakes.



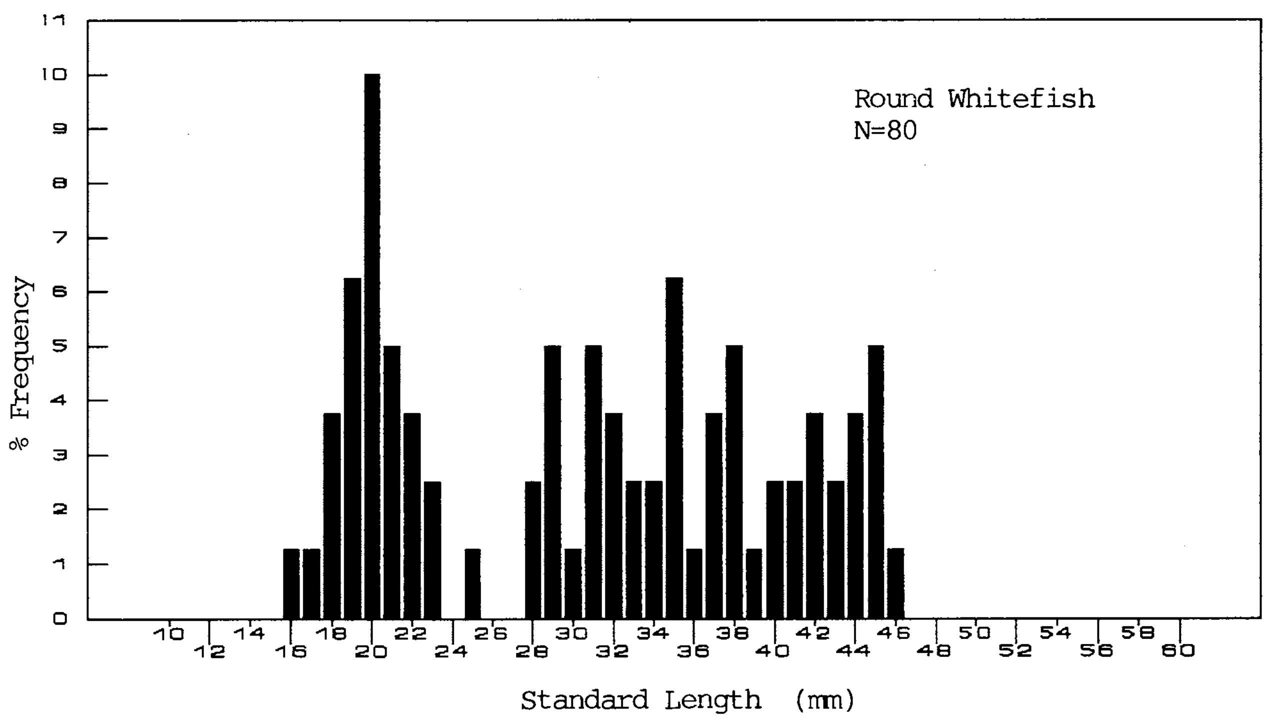


Figure 16 Length frequencies of lake whitefish and round whitefish captured during the 1992 beach seining program within Aishihik Lake.

that impeded the efficiency of the trawl.

Catches ranged in age from YOY to age 4. The most abundant age group of lake whitefish in the trawl catch were the two year old cohort. Average length of this age group was 76 mm.

5.2.4 Sonar and Radio Telemetry

At the commencement of the tagging project, the condition of the fish indicated spawning had occurred sometime prior to October 27. Indications included the almost complete absence of tubercles in all the mature fish, watery milt in the males and absence of gravid females. One female did egress eggs when pressure was applied ventrally, however eggs appeared opaque and their viability questionable. Tagging dates, tag type, number and specifics for each tagged fish are presented in Appendix 9. Tagging sites and subsequent relocation sites are presented in Figure 17.

All tagged fish remained in the northern basin of Aishihik Lake in the general vicinity where they were originally tagged, through to mid-November. Signals from the sonar tags were too weak to pinpoint locations during the last week of December. Only two radio tagged fish were relocated within the north basin on December 30, 1992, when the project concluded.

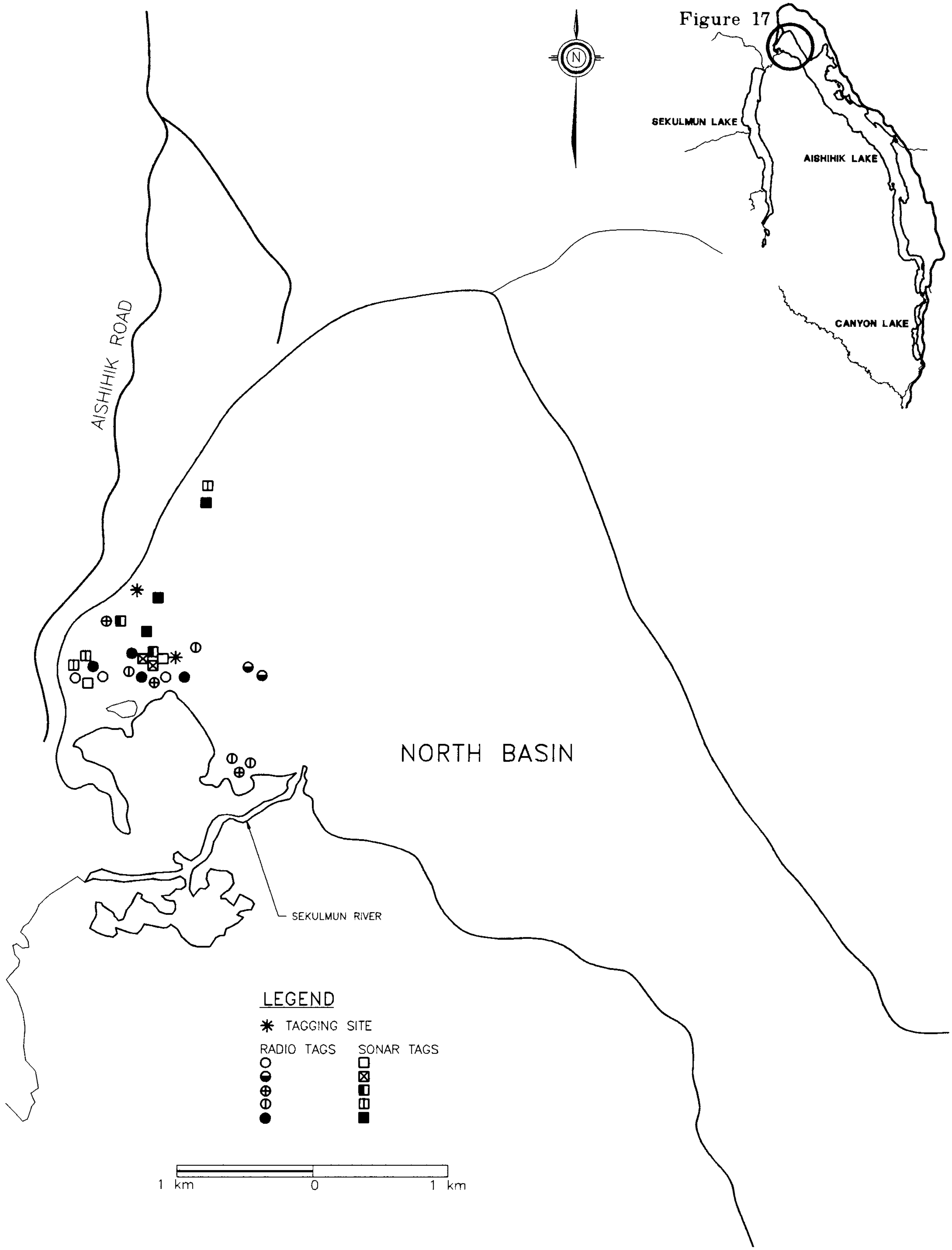


Figure 17 Locations of tagged lake whitefish within the north basin of Aishihik Lake between October 28th and December 30th, 1992.

5.2.5 Egg Trapping

All sample collections of bottom substrate at both sites occurred between elevations of 910.04 metres (2985.71 feet) and 914.24 metres (2999.48 feet) above sea level, averaging 912.33 metres (2993.21 feet). Substrate, that was taken within 100 metres of shorelines, generally consisted of sand with some clay. No lake whitefish eggs were observed in any of the samples at either site.

6.0 DISCUSSION

6.1 Background

Literature on the effects of water-level changes on lake and reservoir ecosystems is extensive, with most research being conducted in the United States where a profusion of hydro-electric development has occurred over the past 100 years. Research has centred upon evaluating the effects on species of plants, invertebrates, or fish (Ploskey, 1986). Generally, hydroelectric facilities affect fisheries by creating impoundments, imposing migration barriers, and by altering physio-chemical characteristics and biota of impounded water (Prosser, 1986). Literature associated with water-level management within reservoirs is summarized in annotated bibliographies by Tripplett et al. (1980) and Ploskey (1982). Other post-impact fisheries investigations within natural lakes affected by hydro-electric developments in Canada have been reported by Bodaly et al (1984) and Gaboury and Patalas (1982). While these studies have provided some cause and effect relationships associated with hydro developments on relatively shallow mesotrophic lakes, the impacts within deep, cold, oligotrophic lakes are less well known.

6.2 Aishihik Lake

Aishihik Lake is an oligotrophic lake, similar in both morphology and limnology to other lakes of comparable size within the Territory. Its long deep U-shaped basin, steep shoreline, low MEI, modest littoral expanses and the cold climate all contribute to its limited overall productivity.

Water-levels within Aishihik Lake have been controlled for the purposes of hydro-electric power production since the completion of the facility in 1975. At the onset of the project the natural fluctuations in lake elevation were determined by Pearse-Bowden (1975) to be between 914.10 metres (2999 feet) and 915.16 metres (3002.5 feet). While the control dam at the outlet of Aishihik Lake was designed to permit water storage between elevations 911.35 metres (2990 feet) and 916.69 metres (3007.5 feet), the current operating licence allows for a range of 2.74 metres (9 feet) between elevations 912.42 metres (2993.5 feet) and 915.16 metres (3002.5 feet). The utility has generally operated the facility within a seasonal fluctuation range of approximately .6 to 1.2 metres (2 to 4 feet). With the exception of the 1975 high, lake elevations have been maintained within the licensed range.

Draw down below the natural low elevation results in the exposure of near shore littoral habitat throughout the lake. Littoral exposure is especially pronounced within Soldiers Bay and the north basin of the lake, where the largest expanses of littoral habitat are located (G.McRobb and E. Workman, pers. commun.). Benthic sampling revealed the littoral maximum for macroinvertebrates to be below an elevation of approximately 913.18 metres (2996 feet). This maximum in benthic productivity is immediately below the region that has been subject to recent (1991) direct water level fluctuation (913.26 to 915.14 metres, 2996.26 to 3002.43 feet). This phenomena of a littoral maximum below the region of direct water fluctuation has been observed by Fillion (1963) and Seghers (1988) in hydroelectric reservoirs in Alberta. Similar research has shown the abundance of benthos in nonfluctuating reservoirs is usually greater in shallow than in deep areas, but in fluctuating reservoirs inverted distributions result from the lack of a littoral community or concentration of mobile species at or just below the drawdown limit (Davis and Hughes 1966; Cowell and Hudson 1967).

The components of the macroscopic benthic community within the littoral zone of the north basin of the lake were dominated by chironomids and oligochaetes. Hunt and Jones (1972a, 1972b) determined that changes from nonfluctuating to fluctuating regimes may be followed by shifts in species composition from diverse littoral communities (mayflies, stoneflies, odonates, beetles and snails) to communities dominated by chironomids and oligochaetes. Pre-impoundment data indicate that chironomids, gastropods and mollusks were abundant at depths of 1.5 to 4.5 metres within twelve sampling stations randomly chosen throughout Aishihik lake and that gastropods represented a large percentage of the diet of lake whitefish (Kussat, 1973). It has been speculated that littoral invertebrates have distinct preferences for habitat such as soft mud (Benson 1973), macrophytes (Wegener et al. 1975), or inundated terrestrial vegetation (Aggus 1971; Jones and Selgeby 1974). The loss or addition of such habitat caused by changes in water levels may greatly alter species composition (Ploskey, 1986).

The past hydrological regime appears to have had a direct impact on lake whitefish within Aishihik Lake. Figure 18 shows the relationship between weak year classes between 1978 to 1983 with lower lake elevations. This anomaly in the age composition was verified through an independent analysis of the ageing structures by laboratories operated through the Ontario and Manitoba Departments of Natural Resources. Additional studies in 1992 show an impact of the 1990 brood year, coincident with depressed lake elevations within this particular year. Stronger year classes are associated with years when annual lake levels are maintained above the lakes natural low elevation of 914.10 metres (2999 feet). While the impacts are largely confined at present to 5 or 6 year classes, the overall effect on the stock is unknown. Age compositions similarly determined for other lake whitefish populations within the Territory do not have successive year class recruitment failures. However, calculated length-weight relationships, asymptotic sizes, mean ages of maturity, mortality rates and growth coefficients are consistent with values found for other stocks within similarly sized lakes in the Territory (de Graff, 1992).

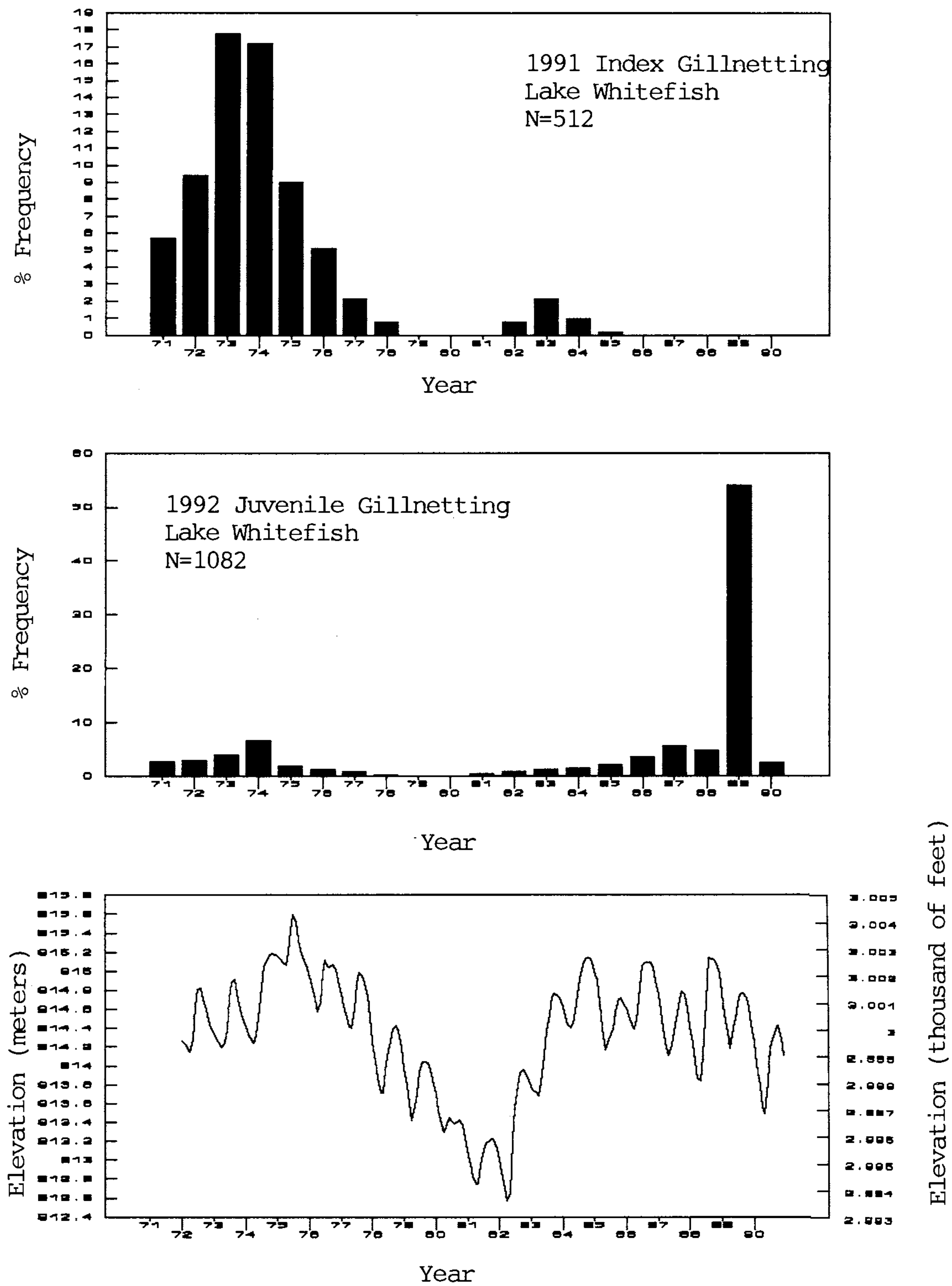


Figure 18 Relationship between lake elevation and age compositions of lake whitefish captured from gillnetting programs within Aishihik Lake, during the summers of 1991 and 1992.

Comparisons of catch effort data for this species to other surveyed lakes (de Graff, 1992) within the Territory suggests a relatively robust lake whitefish stock. While these statistics are based on index gillnetting programs, it is believed that the higher CPUE values are the result of the preponderance of older age groups. It can be speculated that as these older age groups become weak through natural mortality, they will be replaced by a series of weak cohorts and may influence future CPUE. This trend may be already apparent in subsistence harvests where one native fisher noted their catches were mostly big whitefish, with "no smaller ones" and the contention by the Champagne Aishihik Band that the whitefish population is in a state of decline from historical levels (Allen, 1992).

Results from this study have confirmed that the north basin of Aishihik Lake is an important rearing ground for early-age classes of lake whitefish. This was suspected in the pre-impoundment studies conducted in 1974 (Schouwenburg, 1974) and has also been reported by the Champagne and Aishihik First Nation (Allen, 1992). While no evidence of spawning or egg deposition were found within two suspected spawning locations within the basin, other early life history stages were captured. It is believed that the higher productivity through the shallow morphology and summer turbidity, which provides cover, contribute in making the north basin ideal for rearing. While captures of beach seined YOY's over sand-gravel substrate in various locations suggest spawning activity throughout the lake, the quality and quantity of rearing habitat, as exemplified in the north basin, is limited. Utilization of sand for the deposition of eggs by lake whitefish has been documented by other researchers (Scott and Crossman, 1973). The tagging project suggested an affinity of post-spawning fish to the north basin into the early winter, however, the effects of tagging stress on their movements is unknown.

Lake trout data suggests that this species is not directly impacted by the past hydrological regime. Relatively high catch-effort statistics from both the index gillnetting program and the angler harvest survey (Osborne, in prep.), combined with an age composition that is typical of other unexploited stock suggests little impact. Other lake trout parameters, including length-weight relationships, mean ages of maturity, mortality rates and growth coefficients are consistent with values found for other unexploited stocks within similarly sized waterbodies in the Territory (de Graff, 1992). However, it is cautioned that since lake whitefish form a large proportion of the lake trout diet, the relative abundance of this forage base will ultimately have some effect on the lake trout population.

6.3 Canyon Lake

The morphology of Canyon Lake is substantially different from either Aishihik or Sekulmun Lakes. Its very low mean depth and relatively high MEI are features that increase its productive potential. As a forebay for the generating plant, the lake has endured a very erratic pattern in lake elevations unlike those apparent in Aishihik and Sekulmun Lakes. Manipulations of flows at the water control structures at either the outlet or inlet, quickly influence surface elevations on this small-volume lake. Although lake levels do fluctuate more frequently, the zone of fluctuation over the longer term is less severe than those occurring on Aishihik Lake.

The catch composition within Canyon Lake differed substantially from Aishihik and Sekulmun Lakes. Longnose sucker dominated the catch. This species has been documented to spawn in a tributary of the lake (Kendal, 1975) and, as stream spawner, it is less likely to be adversely affected be changes in water levels (Benson, 1973). The effects of the past hydrological regime on the lake whitefish stock within Canyon Lake could not be defined. While the present study demonstrates active recruitment of younger year classes, the fact that several weak year classes are present with fewer older age groups (25 years and older) suggest some impact. Population statistics for lake whitefish were dissimilar with those determined for the same species in Aishihik and Sekulmun Lakes. While mortality rates were similar, higher growth coefficients, a smaller asymptotic size, depressed length-weight coefficients and the distinct difference in age compositions, strongly indicate stock isolation between Canyon and Aishihik Lakes. This attribute and absence of longnose sucker catches in Aishihik Lake during this study unlike the 1973 investigations (Kussat, 1973), may reflect the inadequacy of the fish ladder within the Aishihik Lake water control structure to allow fish passage.

The low lake trout catch effort statistics and modest representation within the catch composition indicate a sparse population. The morphology and habitat characteristics of Canyon Lake are atypical of waters usually associated with this species. It is speculated that lack of deep water habitat may be the key factor in limiting lake trout productivity within this lake.

6.4 Sekulmun Lake

Sekulmun Lake is connected to the north basin of Aishihik Lake by the Sekulmun (Tagah) River. The river is low in gradient (<1%) and poses no barrier to fish passage. Water levels within the lake are not affected by water elevations within Aishihik Lake under the present operating license. Basin morphometry, catch composition and computed MEI value for Sekulmun Lake approximates very closely with those established for Aishihik Lake. The greatest morphological contrast between lakes is the lack of relatively large littoral expanses that are more prevalent within Aishihik Lake (e.g. North Basin, Soldier's Bay). The littoral zone within Sekulmun Lake is more or less restricted to a thin band around the lake and alluvial fans associated with inflowing streams.

Results from the current study suggest lake whitefish stocks are not distinct between lakes. Age frequencies, length-weight relationships, growth coefficients and asymptotic sizes were analogous between Aishihik and Sekulmun Lakes. Year classes that were weak in Aishihik Lake corresponded to weak year classes in Sekulmun Lake. However, one notable difference was the overall lack of juvenile representation in experimental catches throughout Sekulmun Lake. This feature may be reflected in the lake's lower catch effort statistics relative to Aishihik Lake.

Lake trout catch effort statistics were comparable to other lightly exploited lakes in the Territory (de Graff,1992) and depressed to those for Aishihik Lake. The extent of stock mixing between lakes is unknown. The low sample sizes on Sekulmun Lake make reliable comparisons of population statistics to Aishihik Lake sheer conjecture.

6.5 Conclusions

Drawdown of Aishihik Lake below historical natural low elevations impacts the benthic community especially in the shallow, low gradient, littoral regions of the lake. These regions are sparsely distributed within the lake and are typically characterized by the abundance of emergent and submergent aquatic vegetation during late summer. The most extensive littoral region is located within the north basin of the lake and associated wetlands adjacent to the Sekulmun River. These areas are prone to dewatering at lake elevations below 914.10 metres (2999 feet).

The age composition of lake whitefish from Aishihik Lake shows weak or missing cohorts coincident with lake elevations below 914.10 metres (2999 feet). The weakest cohorts are apparent when lake elevations fall below 913.18 metres (2996 feet). A similar pattern was apparent within lake whitefish stocks from Sekulmun Lake. Similarities in age compositions of lake whitefish between Aishihik and Sekulmun Lakes infers a mixing of stocks. Beach seine catches of YOY lake whitefish suggests that spawning occurs over substrates consisting of sand or gravel. A quantitative delineation of important spawning sites of lake whitefish was not achieved. Small mesh netting data indicates that the north basin of Aishihik Lake is an important rearing area for juvenile lake whitefish. Adults were captured throughout each lake. A cause and effect relationship between lake elevation and recruitment success is indicated but specific mechanisms that limit lake whitefish recruitment during periods of low water levels were not established.

Data suggests lake trout populations within Aishihik and Sekulmun Lakes are not directly affected by water level fluctuations. While the indirect effects through the food chain were not evaluated, the principal components in the diet of lake trout are affected.

The extent of stock mixing between Canyon and Aishihik Lakes prior to the construction of the facility is unknown, however no barriers prevented fish movements between lakes. To facilitate fish passage within the water control structure at the outlet of Aishihik Lake, a vertical slot fish ladder was incorporated in the design. Results from this study show dissimilarities in the species composition and population statistics for lake whitefish, suggesting stock isolation between lakes. Bathometry data shows Canyon Lake to be relatively shallow and productive for lake whitefish and longnose sucker, but generally poor habitat for lake trout.

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PERSONAL COMMUNICATIONS

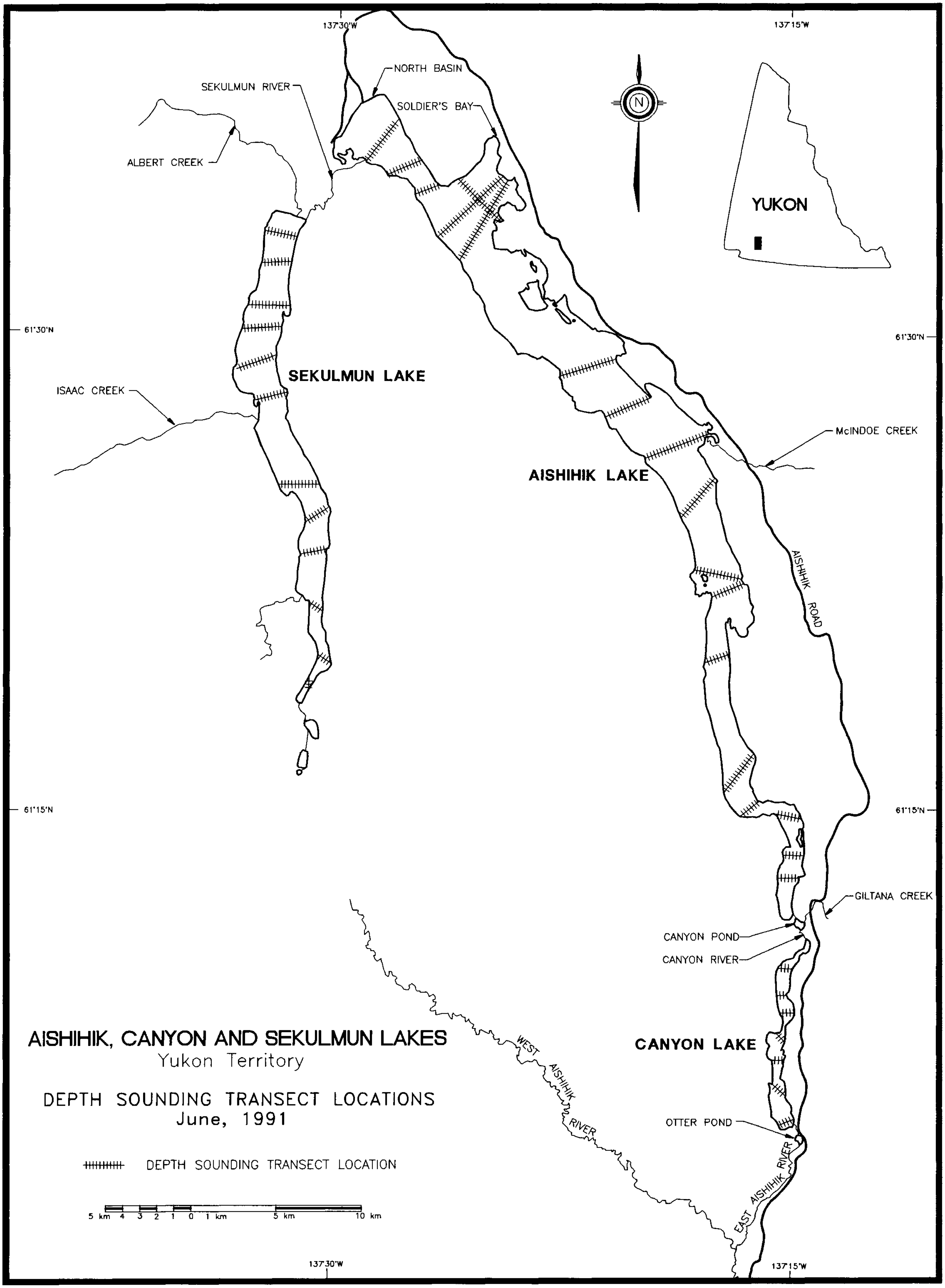
G. McRobb, Aishihik Lake resident, Y.T.
E. Workman, Whitehorse, Y.T.

Appendices

APPENDIX 1

Sounding Transects

APPENDIX 1

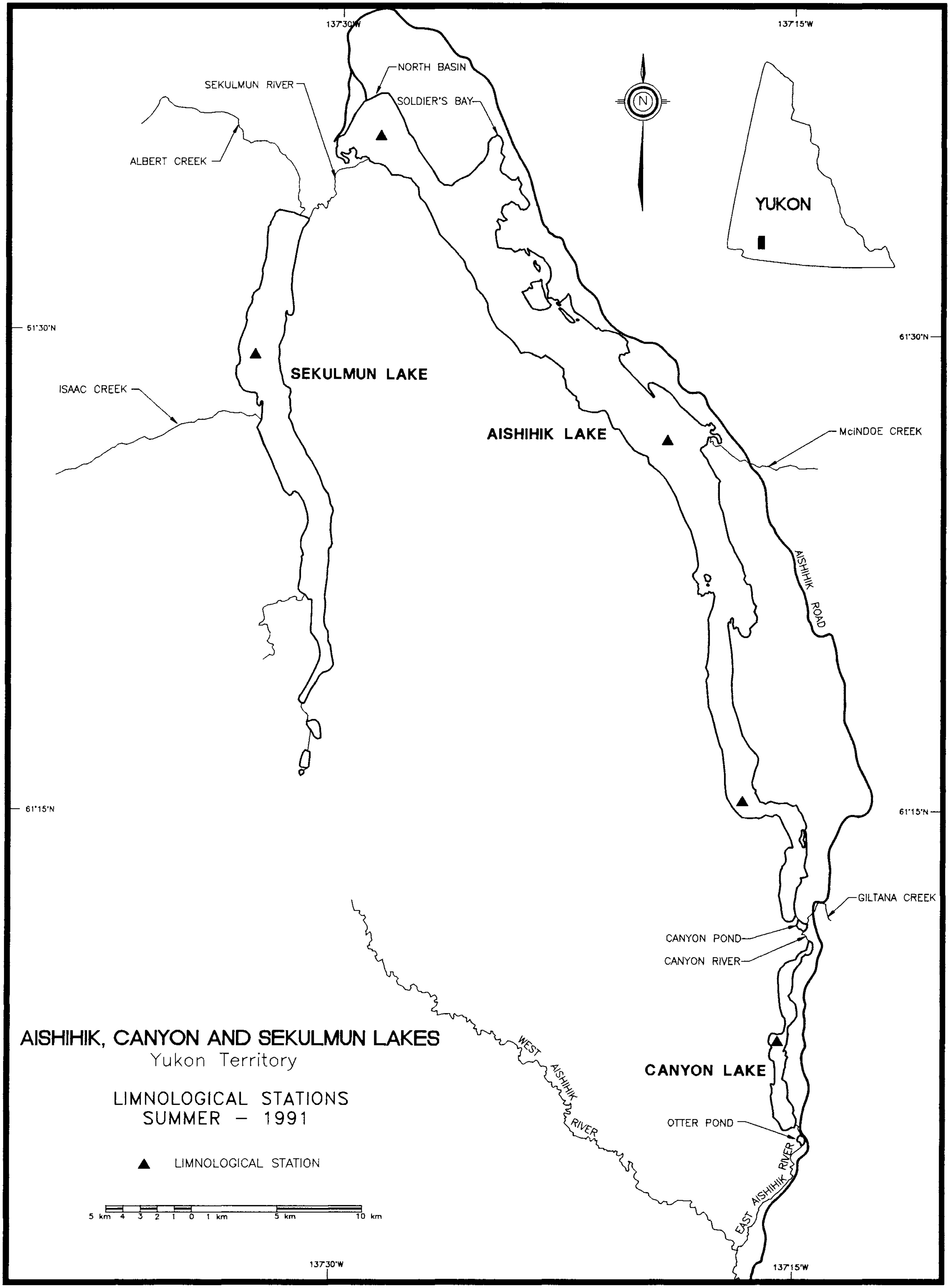


137°30'W
137°15'W
NORTH BASIN
SEKULMUN RIVER
SOLDIER'S BAY
ALBERT CREEK
YUKON
61°30'N
SEKULMUN LAKE
ISAAC CREEK
McINDOE CREEK
AISHIHIK LAKE
AISHIHIK ROAD
61°15'N
GILTANA CREEK
CANYON POND
CANYON RIVER
CANYON LAKE
WEST AISHIHIK RIVER
OTTER POND
EAST AISHIHIK RIVER
AISHIHIK, CANYON AND SEKULMUN LAKES
Yukon Territory
DEPTH SOUNDING TRANSECT LOCATIONS
June, 1991
DEPTH SOUNDING TRANSECT LOCATION
5 km 4 3 2 1 0 1 km 5 km 10 km

APPENDIX 2

Limnology Stations
1991

APPENDIX 2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137°15'W
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SEKULMUN RIVER
SOLDIER'S BAY
ALBERT CREEK
N
YUKON
51°30'N
61°30'N
SEKULMUN LAKE
ISAAC CREEK
AISHIHIK LAKE
McINDOE CREEK
AISHIHIK ROAD
61°15'N
61°15'N
GILTANA CREEK
CANYON POND
CANYON RIVER
AISHIHIK, CANYON AND SEKULMUN LAKES
Yukon Territory
LIMNOLOGICAL STATIONS
SUMMER – 1991
WEST AISHIHIK RIVER
CANYON LAKE
OTTER POND
LIMNOLOGICAL STATION
AISHIHIK RIVER
EAST AISHIHIK
5 km 4 3 2 1 0 1 km 5 km 10 km
137°30'W
137°15'W

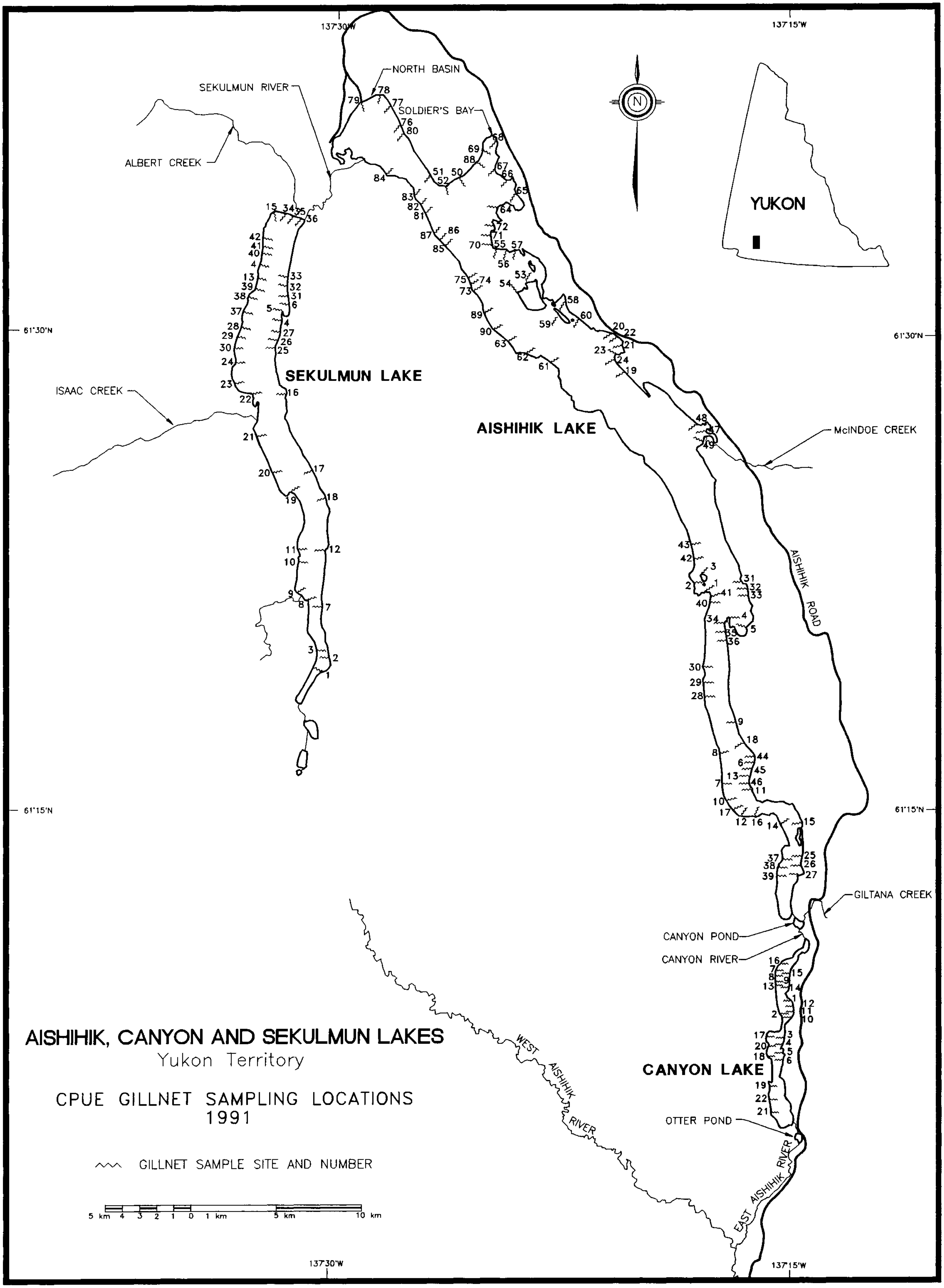
APPENDIX 3

Gillnet Set Locations
1991

a)Lake Trout Catch Effort Gillnetting

b)Index netting

APPENDIX 3a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137°15'W
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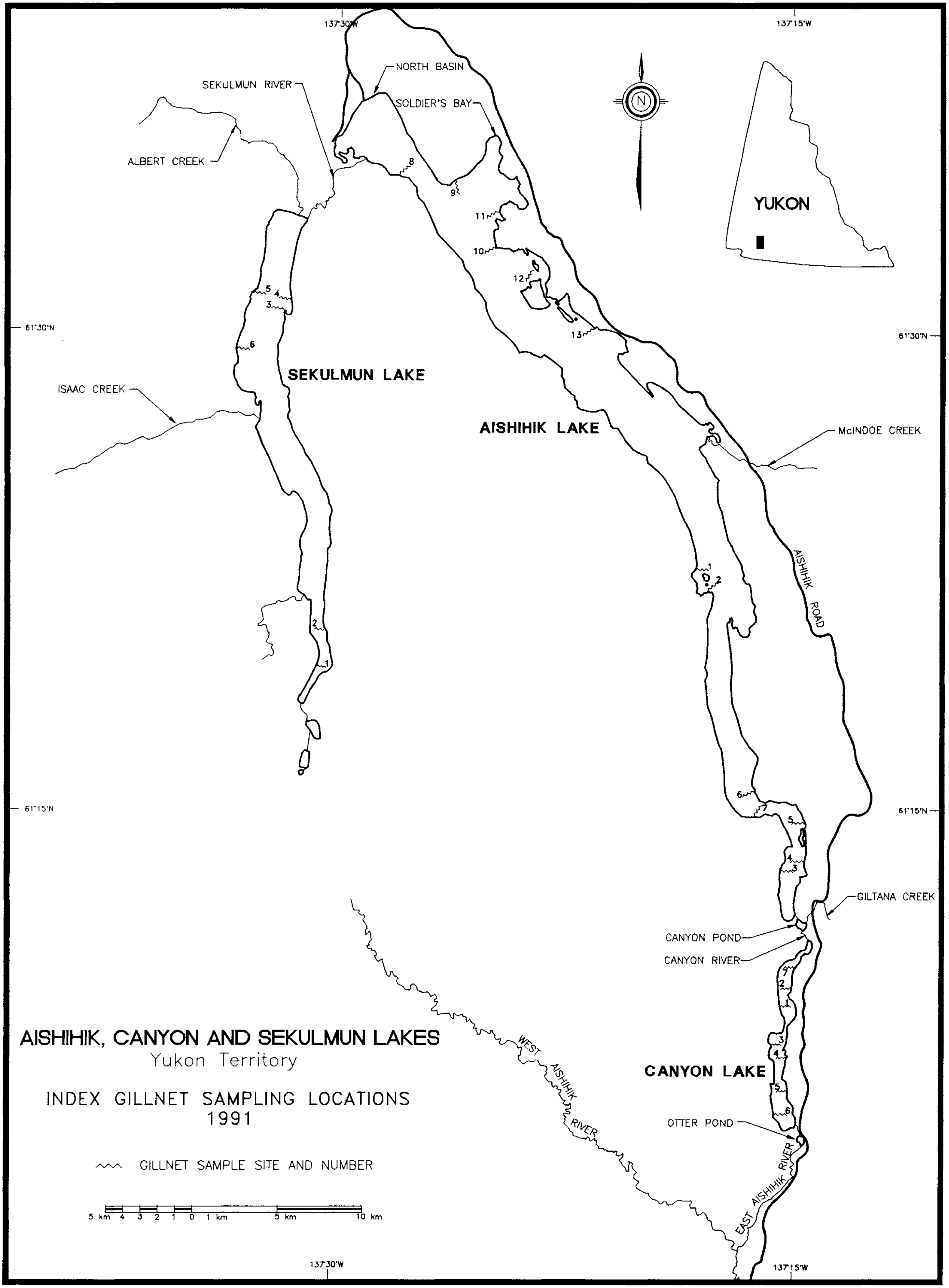
SOLDIER'S BAY
ALBERT CREEK
YUKON
61°30'N
SEKULMUN LAKE
ISAAC CREEK
AISHIHIK LAKE
McINDOE CREEK
AISHIHIK ROAD
61°15'N
GILTANA CREEK
CANYON POND
CANYON RIVER
CANYON LAKE
OTTER POND
WEST AISHIHIK RIVER
EAST AISHIHIK RIVER
AISHIHIK, CANYON AND SEKULMUN LAKES
Yukon Territory
CPUE GILLNET SAMPLING LOCATIONS
1991
GILLNET SAMPLE SITE AND NUMBER
5 km 4 3 2 1 0 1 km 5 km 10 km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NORTH BASIN
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SOLDIER'S BAY
ALBERT CREEK
YUKON
61°30'N
SEKULMUN LAKE
ISAAC CREEK
AISHIHIK LAKE
McINDOE CREEK
AISHIHIK ROAD
61°15'N
GILTANA CREEK
CANYON POND
CANYON RIVER
WEST AISHIHIK RIVER
CANYON LAKE
OTTER POND
EAST AISHIHIK RIVER
AISHIHIK, CANYON AND SEKULMUN LAKES
Yukon Territory
INDEX GILLNET SAMPLING LOCATIONS
1991
GILLNET SAMPLE SITE AND NUMBER
5 km 4 3 2 1 0 1 km 5 km 10 km

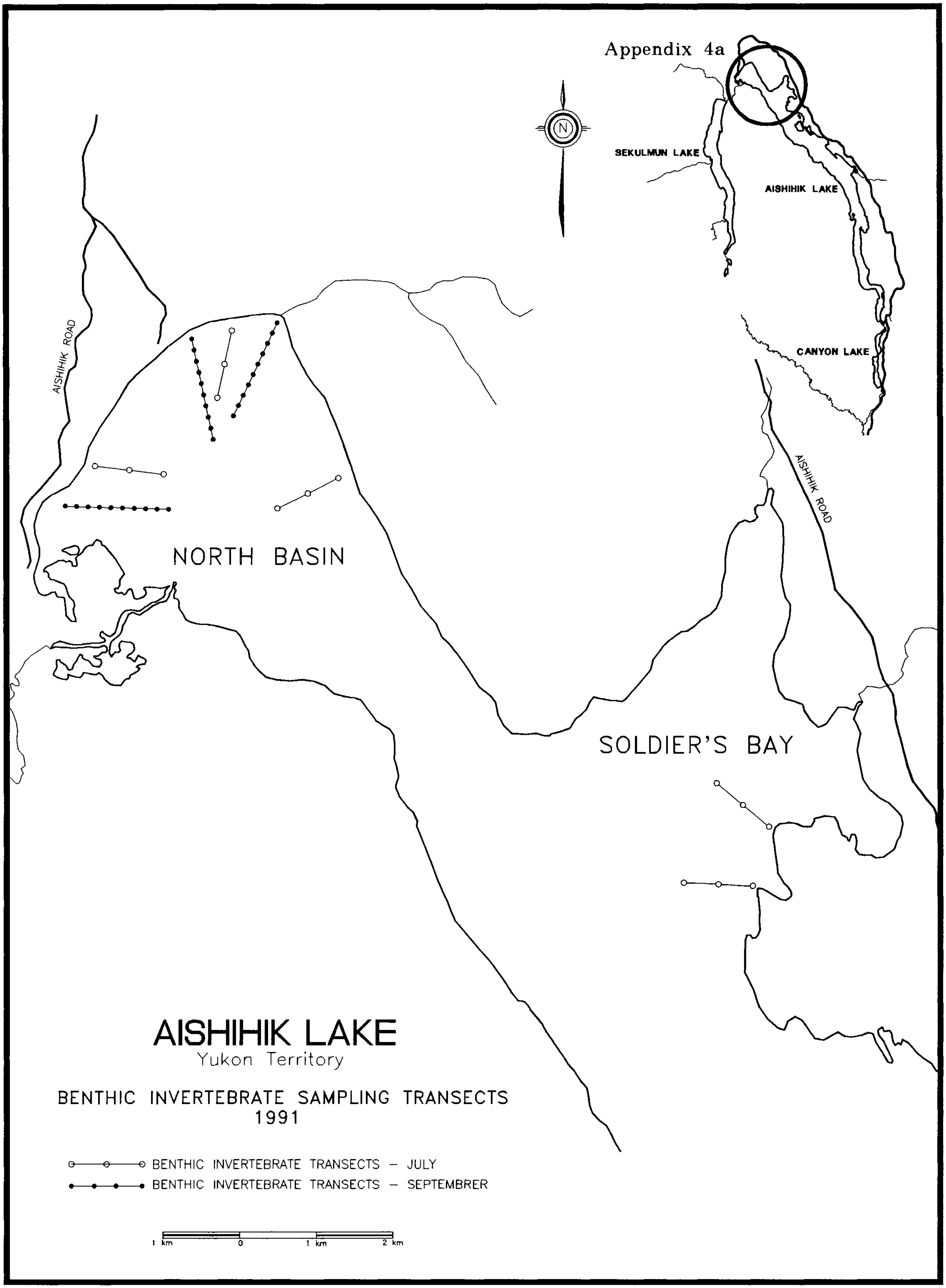
APPENDIX 4

Benthic Sampling
1991

a) locations

b) species list

APPENDIX 4a


Appendix 4a
SEKULMUN LAKE
AISHIHIK LAKE
CANYON LAKE
N
AISHIHIK ROAD
AISHIHIK ROAD
NORTH BASIN
SOLDIER'S BAY
AISHIHIK LAKE
Yukon Territory
BENTHIC INVERTEBRATE SAMPLING TRANSECTS
1991
BENTHIC INVERTEBRATE TRANSECTS – JULY
BENTHIC INVERTEBRATE TRANSECTS – SEPTEMBRER
1 km
0
1 km
2 km

Appendix 4b

Abundance of Aishihik Benthic Invertebrate Subsample
Identified to Genus and Species Levels

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total	Percent
Transect	1	2	2	3	1	2	2	2	1	2	2	3	1	1	1	2	2	2	3	3	3		
Depth (m)	5	1	3	1	1	1	3	5	1	1	5	3	0.5	3	4.5	0.5	3	5	1	3.5	4		
Organism																							
Tricoptera																							
Leptoceridae ? (Pupa)										1							1	1		2		5	0.16%
Arypnia sp																					1	1	0.03%
Limnephilus sp																				1		1	0.03%
Mysticides sp										1												1	0.03%
Oecetis sp																				1		1	0.03%
Diptera																							
Chironomidae																							
Chironomidae pupae			1	1			1	10			3											16	0.52%
Chironomidae larvae unid.			3	3		1		3													2	12	0.39%
Tanytarsini																							
Constempelina sp														2	1							3	0.10%
Micropsectra sp				1		1		4		2	2			1	3					1		15	0.49%
Tanytarsus sp	157	2	1	28		3	2	106	8	15	8			75	120	1				10		536	17.48%
Chironomini																							
Chironomus sp																				3	14	17	0.55%
Chryptochironomus sp					1					1	1										3	6	0.20%
Dicrotendipes sp					3		1					2		4			1			77	1	89	2.90%
Microtendipes sp																				1		1	0.03%
Paracladopelma sp		1																				1	0.03%
Phaenopsectra sp	1		9	1		20	14	82	1		6	10		17	4	1	6	1		1	6	180	5.87%
Polypedilum sp														2			1			22	1	26	0.85%
Xenochironomus sp							1															1	0.03%
Orthocladinae																						0	0.00%
Cardiocladius sp	1	1					1	22						1								26	0.85%
Crictopus sp					1	4																5	0.16%
Eukiefferiella sp		1		6		10	2	2														21	0.68%
Paracladius sp			32	4	5	35	11	41			4				3		2	3			2	142	4.63%
Psectrocladius sp	2									1												3	0.10%
Diamesinae																							
Monodiamesa sp	6		8					3	1	1	1	2	1		2	6	1	3	3			38	1.24%
Tanypodinae																							
Procladius sp	1	1		5			3	2		2				3	2					16	6	41	1.34%
Trissopelopia sp				1				4												12	4	21	0.68%
Dolichopodidae																							
(Dolichopus sp ?)																			2			2	0.07%
Ephydridae ? L dam																							
Empididae																							
Chelifera sp						1			1		1			4	1							8	0.26%
Hydracarina																							
Arrenurus sp			1																	1		2	0.07%
Forellia sp																				1		1	0.03%
Hydrachna sp								1												1		2	0.07%
Unid J/D (Sperchon sp ?)						2														1		3	0.10%

Appendix 4b

Abundance of Aishihik Benthic Invertebrate Subsample
Identified to Genus and Species Levels

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total	Percent
Transect	1	2	2	3	1	2	2	2	1	2	2	3	1	1	1	2	2	2	3	3	3		
Depth (m)	5	1	3	1	1	1	3	5	1	1	5	3	0.5	3	4.5	0.5	3	5	1	3.5	4		
Organism																							
Amphipoda																							
Gammarus lacustris									3			2	3							9	19	36	1.17%
Hyalella azteca		2		1	1									20			1	2	3	50	6	86	2.80%
Ostracoda																							
Cladocera, unid dam										1			1							1		3	0.10%
Eurycercus lamellatus	3			2																		5	0.16%
Latanopsis sp ? *				8										7								15	0.49%
Simocephalus vetulus																				1		1	0.03%
Copepoda, calanoida																							
Diaptomus sp J/D		1	1			1								1					2	3	1	10	0.33%
(Heterocope septentrionalis)								1														1	0.03%
Unid juv (Eurytemora sp ?)								1														1	0.03%
Cyclopoida																							
Cyclops (crassicaudis ?)								7														7	0.23%
Oligochaeta, tubificidae																							
Unid Juv (Aulodrilus sp ?)	1	7		2		32	1	10	4	4	1	1		5	3			1		1	1	74	2.41%
Unid Juv (Potamothrix sp ?)	30		46		31	22	20	49	1	1	3	6		8	24	2	53	13		6	51	366	11.93%
Unid Juv (Rhyacodrilus sp ?)	1		6			3	1	10				27		40	7		10	12			2	119	3.88%
Naididae																							
Nais sp									4	1			1						1			7	0.23%
Pristina forelli									1													1	0.03%
Stylaria lacustris				2																		2	0.07%
Uncinais uncinata	5			5	3	10		1	3	2				3					2		1	35	1.14%
Enchytraeidae					3	1			11	25			1	1						2		44	1.43%
Hirudinea																							
Helobdella stagnalis																				1		1	0.03%
Helobdella (triserialis sp ?)																				1		1	0.03%
Pisicola milneri														1			1					2	0.07%
Mollusca, bivalvia																							
Pisidium (caseratum ?)	5		2	7	9	12	1	12	4	4				6	6		6	10		15	16	115	3.75%
Pisidium idahoensis											1			1								2	0.07%
Sphaerium (nitidum ?)	4		5	2	23	22	9	19	3	3	4	6		25	14	3	7	9		10	12	180	5.87%
Sphaerium (striatum)															1							1	0.03%
Gastropoda																							
Fossaria modicella								6				2	1	4			1		277			291	9.49%
Lymnaea atkaensis												2										2	0.07%
Planorbula sp																			9			9	0.29%
Valvata sincera (sincera)	10	4	8	2			3	18	1	1		10		7	15		10	24	8	11	4	136	4.43%

Appendix 4b — Abundance of Aishihik Benthic Invertebrate Subsample Identified to Genus and Species Levels

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total	Percent
Transect	1	2	2	3	1	2	2	2	1	2	2	3	1	1	1	2	2	2	3	3	3		
Depth (m)	5	1	3	1	1	1	3	5	1	1	5	3	0.5	3	4.5	0.5	3	5	1	3.5	4		
Organism																							
Coelenterata																							
Hydra sp						2											1					3	0.10%
Nematoda	7	23	3	2	6	47	3		84	21				21	2			6		52	7	284	9.26%
																						Total 3067	

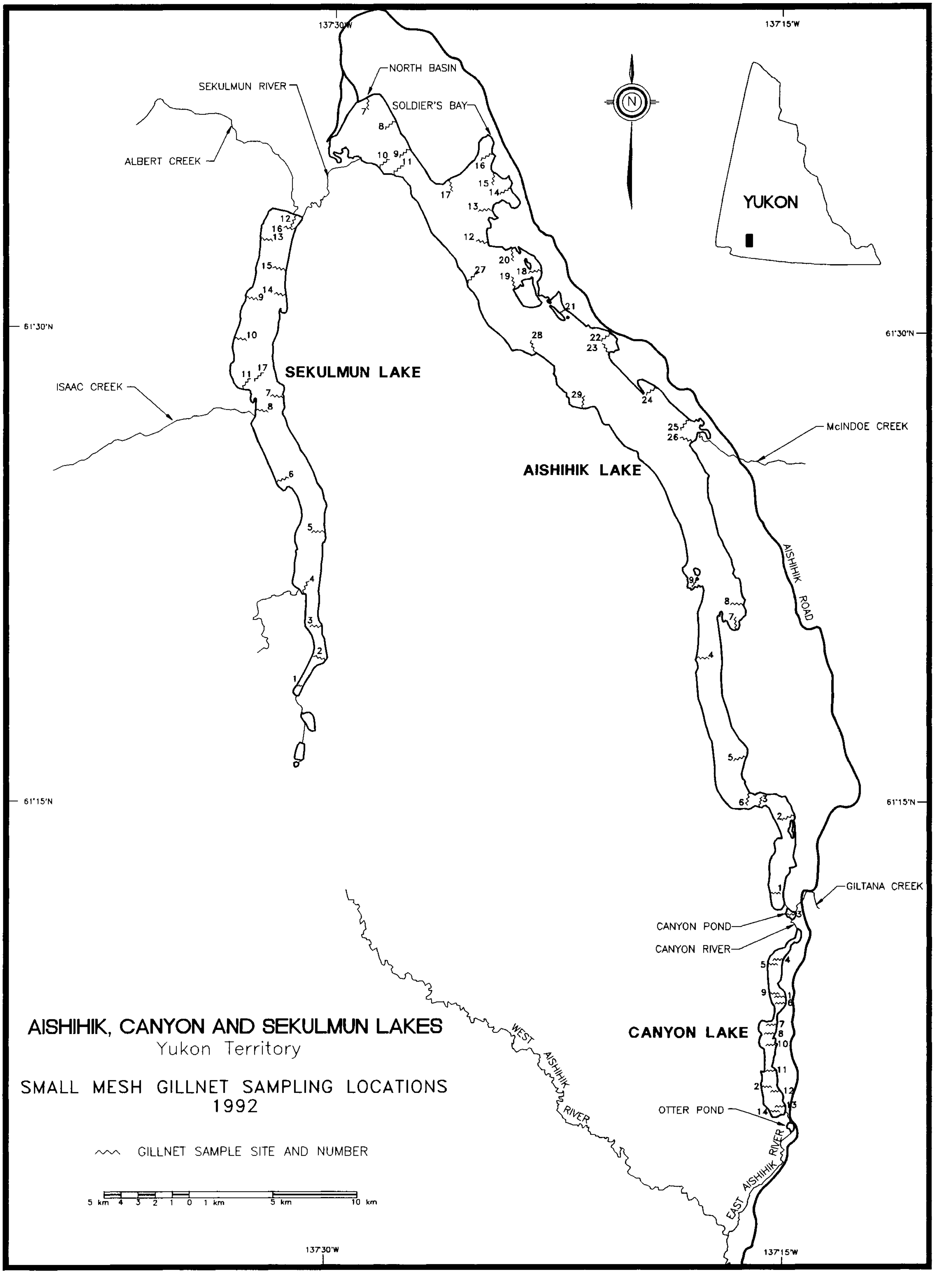
* - Undescibed

APPENDIX 5

Gillnet Set Locations
1992

Juvenile Lake Whitefish
(Small Mesh) Gillnetting

APPENDIX 5

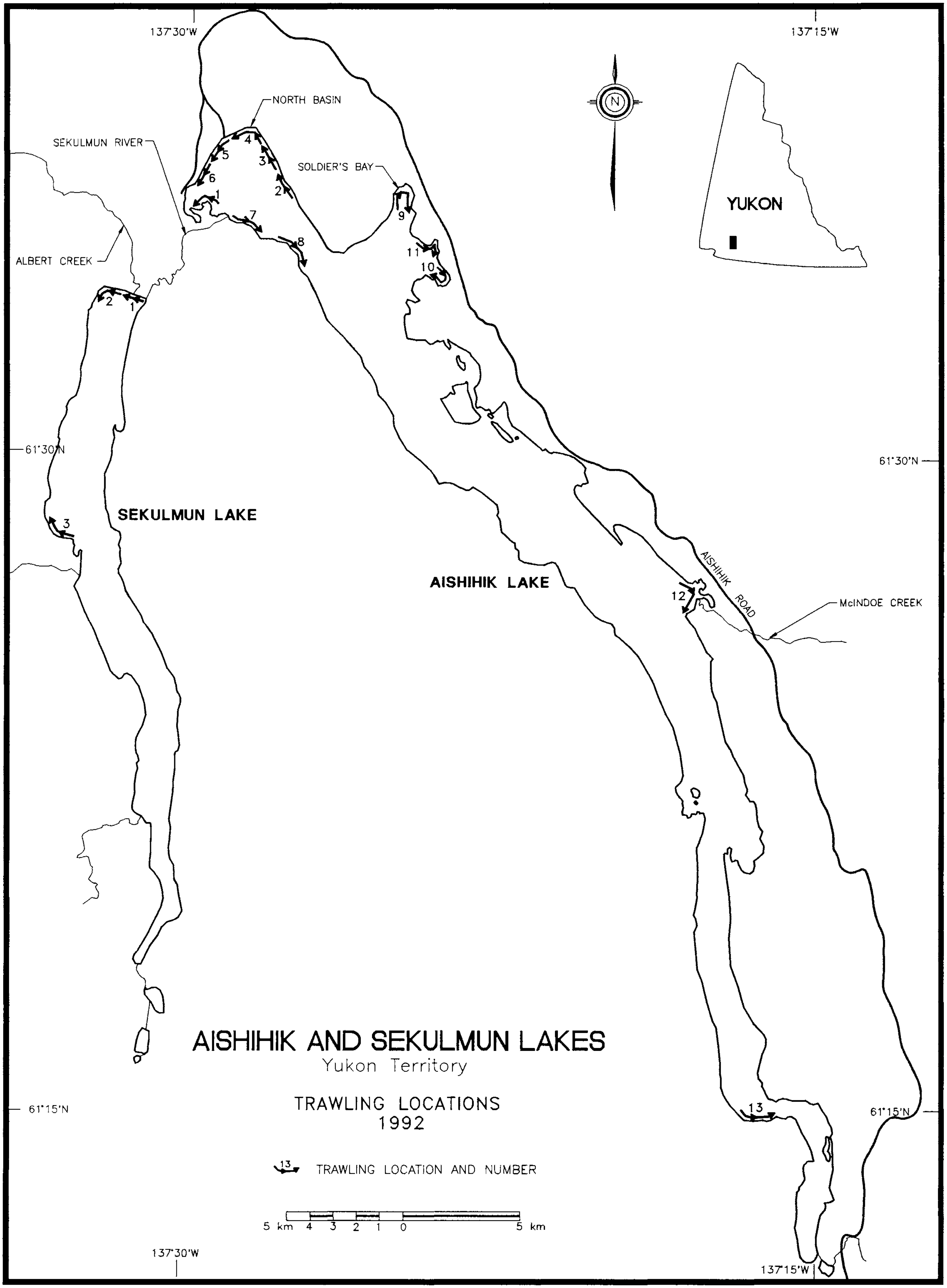

137°30'W
137°15'W
NORTH BASIN
SEKULMUN RIVER
SOLDIER'S BAY
ALBERT CREEK
YUKON
61°30'N
SEKULMUN LAKE
ISAAC CREEK
AISHIHIK LAKE
McINDOE CREEK
AISHIHIK ROAD
61°15'N
GILTANA CREEK
CANYON POND
CANYON RIVER
CANYON LAKE
OTTER POND
WEST AISHIHIK RIVER
EAST AISHIHIK RIVER
AISHIHIK, CANYON AND SEKULMUN LAKES
Yukon Territory
SMALL MESH GILLNET SAMPLING LOCATIONS
1992
GILLNET SAMPLE SITE AND NUMBER
5 km 4 3 2 1 0 1 km 5 km 10 km

APPENDIX 6

Trawling
1992

a) Locations

b) Trawl Design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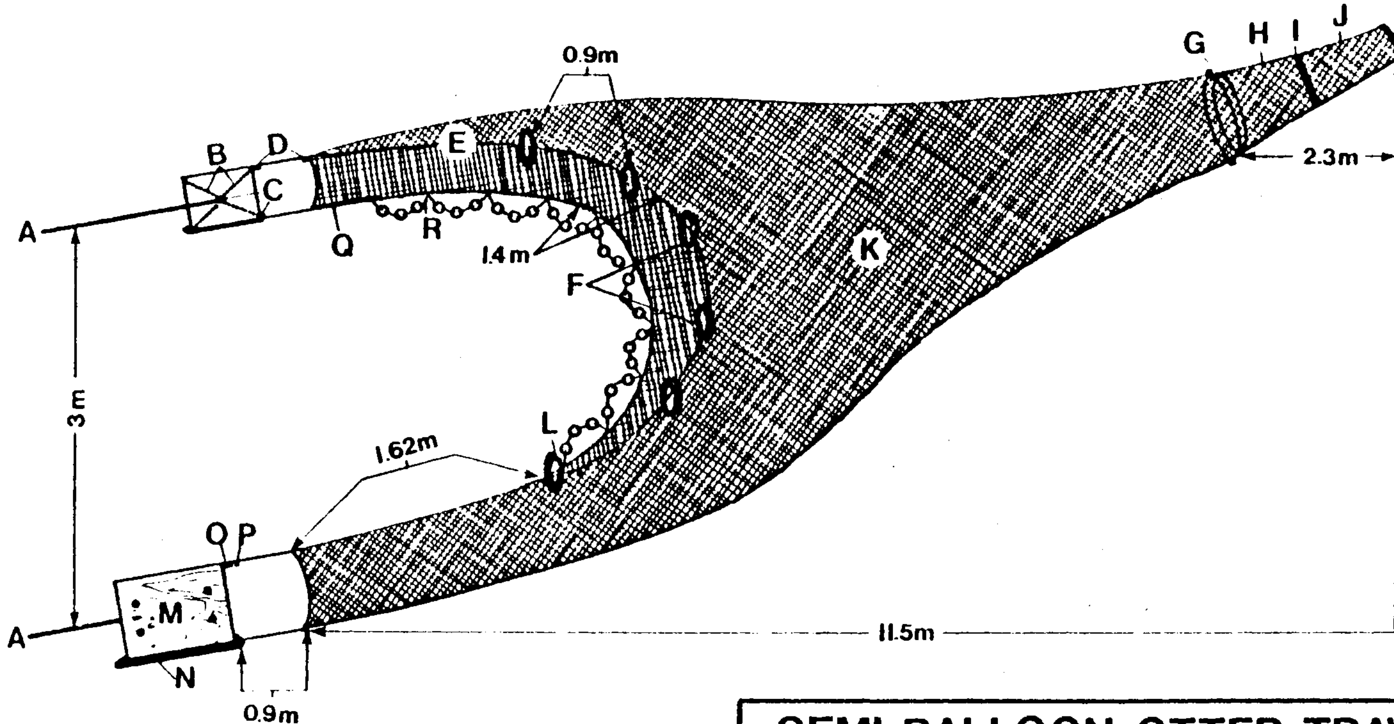
SEKULMUN RIVER
SOLDIER'S BAY
ALBERT CREEK
YUKON
61°30'N
61°30'N
SEKULMUN LAKE
AISHIHIK LAKE
AISHIHIK ROAD
McINDOE CREEK
AISHIHIK AND SEKULMUN LAKES
Yukon Territory
TRAWLING LOCATIONS
1992
TRAWLING LOCATION AND NUMBER
5 km 4 3 2 1 0 5 km
61°15'N
61°15'N
137°30'W
137°15'W



SEMI-BALLOON OTTER TRAWL

- **A** Warp Aircraft Cable (4.7 mm)
- **B** Galvanized Chain (2 mm)
- **C** Shackles
- **D** Polydac (9.5 mm)
- **E** Headrope (7.62 m)
- **F** Polydac (9.5 mm)
- **G** Two Detachable Stainless Steel Rings (6.6 mm) Fastened by Threaded Lugs
- **H** Codend Outerliner 3.2 cm Stretch Mesh (1.6 cm Bar - #15 Thread)
- **I** Detachable Codend
- **J** Codend Innerliner 1.27 cm Stretch Mesh (#63 Thread)
- **K** 3.8 cm Stretch Mesh (1.9 cm Bar - #9 Thread)
- **L** 6 - 381 cm x 6.34 cm ARC Floats
- **M** Treated Plywood Otter Board (122 mm)
- **N** Iron Runner
- **O** Shackle
- **P** Wire Thimble
- **Q** Polydac (9.5 mm); Footrope (9.45 mm)
- **R** Galvanized Chain Hung 20 cm from Footrope

APPENDIX 7

Age Specific Lengths and Weights

a) Lake Trout

b) Lake Whitefish

Appendix 7a Age specific mean fork lengths and weights for lake trout from Aishihik Lake, 1991.

AGE	MALE			FEMALE			COMBINED		
	N	Mean Length (mm)	Mean Weight (gm)	N	Mean Length (mm)	Mean Weight (gm)	N	Mean Length (mm)	Mean Weight (gm)
2	0			0			1	170.00	50.00
3	0			1	205.00	50.00	1	205.00	50.00
4	0			0			3	268.33	166.67
5	0			3	361.67	550.00	4	355.00	525.00
6	2	400.00	725.00	2	427.50	950.00	4	413.75	837.50
7	3	426.67	1050.00	4	385.00	662.50	7	402.86	828.57
8	3	496.67	1600.00	3	428.33	1000.00	6	462.50	1300.00
9	8	479.38	1356.25	7	470.00	1192.86	15	475.00	1280.00
10	4	501.25	1448.75	2	600.00	2775.00	6	534.17	1890.83
11	2	495.00	1275.00	5	584.00	2060.00	7	558.57	1835.71
12	4	573.75	1962.50	8	568.13	2112.50	12	570.00	2062.50
13	6	601.67	2533.33	0			6	601.67	2533.33
14	3	588.33	2416.67	1	690.00	4000.00	4	613.75	2812.50
15	2	565.00	1950.00	6	609.17	2808.33	8	598.13	2593.75
16	6	602.50	2800.00	1	500.00	1550.00	7	587.86	2621.43
17	3	616.67	2483.33	6	667.50	3575.00	9	650.56	3211.11
18	2	712.50	4175.00	3	761.67	6000.00	5	742.00	5270.00
19	4	713.75	5400.00	4	715.00	5275.00	8	714.38	5337.50
20	1	760.00	5400.00	1	560.00	2300.00	2	660.00	3850.00
21	2	802.50	6725.00	0			2	802.50	6725.00
22	1	475.00	1350.00	2	625.00	2925.00	3	575.00	2400.00
23	1	615.00	2900.00	0			1	615.00	2900.00
24	1	605.00	2250.00	0			1	605.00	2250.00
25	2	495.00	1325.00	1	890.00	10150.00	3	626.67	4266.67
27	0			1	735.00	6000.00	1	735.00	6000.00
30	1	900.00	9750.00	1	645.00	2600.00	2	772.50	6175.00

Appendix 7a Age specific mean fork lengths and weights for lake trout from Canyon Lake, 1991.

AGE	MALE			FEMALE			COMBINED		
	N	Mean Length (mm)	Mean Weight (gm)	N	Mean Length (mm)	Mean Weight (gm)	N	Mean Length (mm)	Mean Weight (gm)
5	0			0			1	390.00	700.00
7	2	392.50	750.00	1	365.00	400.00	3	383.33	633.33
8	3	378.33	566.67	1	440.00	950.00	4	393.75	662.50
9	0			1	380.00	500.00	2	400.00	675.00
10	1	375.00	500.00	1	360.00	450.00	2	367.50	475.00
11	2	477.50	1475.00	1	385.00	600.00	3	446.67	1183.33
12	1	480.00	1150.00	0			1	480.00	1150.00
15	1	470.00	1350.00	1	410.00	700.00	2	440.00	1025.00
16	0			1	685.00	4200.00	1	685.00	4200.00
18	1	510.00	1700.00	0			1	510.00	1700.00
19	0			1	445.00	1050.00	1	445.00	1050.00
31	0			1	750.00	3400.00	1	750.00	3400.00

Appendix 7a Age specific mean fork lengths and weights for lake trout from Sekulmun Lake, 1991.

AGE	MALE			FEMALE			COMBINED		
	N	Mean Length (mm)	Mean Weight (gm)	N	Mean Length (mm)	Mean Weight (gm)	N	Mean Length (mm)	Mean Weight (gm)
4	1	280.00	250.00	0			1	280.00	250.00
6	1	515.00	1600.00	0			1	515.00	1600.00
7	1	535.00	2000.00	0			1	535.00	2000.00
9	1	395.00	800.00	1	510.00	1800.00	2	452.50	1300.00
10	2	457.50	1000.00	2	550.00	1600.00	4	503.75	1300.00
11	1	570.00	1900.00	2	542.50	1850.00	3	551.67	1866.67
12	0			2	550.00	2000.00	2	550.00	2000.00
13	1	780.00	5700.00	0			1	780.00	5700.00
14	3	601.67	2450.00	2	642.50	3050.00	5	618.00	2690.00
19	1	545.00	1950.00	0			1	545.00	1950.00
20	0			1	680.00	3550.00	1	680.00	3550.00
21	1	890.00	8650.00	1	755.00	3800.00	2	822.50	6225.00
23	2	675.00	3825.00	0			2	675.00	3825.00
24	1	780.00	6000.00	2	587.50	2600.00	3	651.67	3733.33
27	0			1	665.00	2800.00	1	665.00	2800.00
28	1	610.00	2500.00	0			1	610.00	2500.00
33	0			1	885.00	8100.00	1	885.00	8100.00
34	0			1	580.00	2400.00	1	580.00	2400.00

Appendix 7b Age specific mean fork lengths and weights for lake whitefish from Aishihik Lake, 1991.

AGE	MALE			FEMALE			COMBINED		
	N	Mean Length (mm)	Mean Weight (gm)	N	Mean Length (mm)	Mean Weight (gm)	N	Mean Length (mm)	Mean Weight (gm)
5	1	350.00	550.00	0			1	350.00	550.00
6	3	371.67	683.33	2	297.50	300.00	5	342.00	530.00
7	8	399.38	787.50	3	408.33	883.33	11	401.82	813.64
8	2	432.50	1050.00	2	420.00	1100.00	4	426.25	1075.00
12	2	442.50	1200.00	2	450.00	1250.00	4	446.25	1225.00
13	6	447.50	1333.33	5	443.00	1130.00	11	445.45	1240.91
14	13	445.00	1157.69	13	440.38	1184.62	26	442.69	1171.15
15	22	439.55	1140.91	24	441.25	1197.92	46	440.43	1170.65
16	44	446.59	1223.86	44	445.57	1240.91	88	446.08	1232.39
17	43	446.28	1218.60	48	442.29	1222.92	91	444.18	1220.88
18	23	448.04	1215.22	25	441.76	1178.00	48	444.77	1195.83
19	10	450.00	1255.00	19	439.47	1223.68	29	443.10	1234.48
20	10	443.50	1185.00	5	438.00	1210.00	15	441.67	1193.33
21	2	425.00	1075.00	4	432.50	1100.00	6	430.00	1091.67
22	4	452.50	1350.00	5	453.00	1360.00	9	452.78	1355.56
23	8	439.38	1150.00	9	440.56	1161.11	18	439.72	1144.44
24	11	438.64	1154.55	9	439.44	1094.44	20	439.00	1127.50
25	10	443.00	1095.00	16	433.44	1143.75	26	437.12	1125.00
26	3	460.00	1233.33	9	431.67	1150.00	13	445.77	1242.31
27	6	428.33	1050.00	4	430.00	1075.00	11	439.09	1154.55
28	8	435.63	1093.75	4	435.00	1112.50	12	435.42	1100.00
29	1	460.00	1350.00	5	455.00	1370.00	6	455.33	1366.67
30	1	495.00	1800.00	5	450.00	1300.00	6	457.50	1383.33
31	2	412.50	975.00	1	430.00	1100.00	3	418.33	1016.67
32	1	460.00	1400.00	0			1	460.00	1400.00
34	1	420.00	950.00	0			1	420.00	950.00
37	0			1	420.00	900.00	1	420.00	900.00

Appendix 7b Age specific mean fork lengths and weights for lake whitefish from Canyon Lake, 1991.

AGE	MALE			FEMALE			COMBINED		
	N	Mean Length (mm)	Mean Weight (gm)	N	Mean Length (mm)	Mean Weight (gm)	N	Mean Length (mm)	Mean Weight (gm)
4	7	316.43	371.43	1	330.00	400.00	8	318.13	375.00
5	2	345.00	500.00	1	330.00	450.00	3	340.00	483.33
6	3	376.67	575.00	3	368.33	566.67	6	372.50	570.83
7	1	380.00	700.00	2	375.00	637.50	3	376.67	658.33
8	8	391.25	675.00	3	393.33	666.67	11	391.82	672.73
9	5	382.00	640.00	14	388.57	639.29	19	386.84	639.47
10	9	384.44	655.56	10	386.50	660.00	19	385.53	657.89
11	15	387.33	653.33	17	387.35	669.12	32	387.34	661.72
12	8	386.88	606.25	7	392.14	700.00	15	389.33	650.00
13	1	390.00	650.00	2	382.50	625.00	3	385.00	633.33
14	4	396.25	637.50	2	390.00	550.00	6	394.17	608.33
15	4	387.50	612.50	1	425.00	1000.00	5	395.00	690.00
16	7	392.86	632.14	11	398.18	786.36	18	396.11	726.39
17	7	393.57	692.86	16	397.19	728.13	24	395.83	718.75
18	5	384.00	650.00	3	398.33	650.00	8	389.38	650.00
19	2	390.00	600.00	3	405.00	733.33	5	399.00	680.00
20	3	381.67	600.00	1	425.00	800.00	4	392.50	650.00
21	1	400.00	700.00	0			1	400.00	700.00
22	4	403.75	700.00	3	393.33	666.67	7	399.29	685.71
23	2	407.50	675.00	2	417.50	875.00	4	412.50	775.00
24	1	410.00	600.00	0			1	410.00	600.00
26	1	395.00	400.00	0			1	395.00	400.00

Appendix 7b Age specific mean fork lengths and weights for lake whitefish from Sekulmun Lake, 1991.

AGE	MALE			FEMALE			COMBINED		
	N	Mean Length (mm)	Mean Weight (gm)	N	Mean Length (mm)	Mean Weight (gm)	N	Mean Length (mm)	Mean Weight (gm)
9	1	370.00	650.00	0			1	370.00	650.00
12	0			1	415.00	900.00	1	415.00	900.00
13	0			1	425.00	1050.00	1	425.00	1050.00
14	2	442.50	1150.00	3	431.67	1066.67	5	436.00	1100.00
15	6	428.33	1008.33	11	440.91	1118.18	17	436.47	1079.41
16	13	427.69	1007.69	14	432.86	1053.57	27	430.37	1031.48
17	12	435.42	1087.50	12	430.00	1075.00	24	432.71	1081.25
18	4	421.25	900.00	9	448.33	1244.44	13	440.00	1138.46
19	5	435.00	1140.00	3	443.33	1150.00	8	438.13	1143.75
20	1	430.00	950.00	4	420.00	1012.50	5	422.00	1000.00
21	0			2	432.50	1025.00	2	432.50	1025.00
22	1	440.00	1100.00	1	420.00	950.00	2	430.00	1025.00
23	3	405.00	766.67	13	427.31	1011.54	16	423.13	965.63
24	8	422.50	956.25	4	422.50	1025.00	12	422.50	979.17
25	3	420.00	966.67	9	430.56	1100.00	12	427.92	1066.67
26	4	437.50	1112.50	14	437.86	1085.71	18	437.78	1091.67
27	4	427.50	1012.50	6	430.00	1058.33	10	429.00	1040.00
28	5	412.00	810.00	14	422.86	928.57	19	420.00	897.37
29	5	439.00	1050.00	10	430.50	1025.00	16	434.06	1050.00
30	6	437.50	1141.67	8	425.63	1018.75	14	430.71	1071.43
31	0			4	427.50	912.50	4	427.50	912.50
32	2	487.50	1875.00	0			2	487.50	1875.00
33	0			3	411.67	816.67	3	411.67	816.67
34	1	425.00	950.00	1	420.00	950.00	2	422.50	950.00

APPENDIX 8

Maturity Schedules

a)Lake Trout

b)Lake Whitefish

Appendix 8a Maturity schedule of lake trout from Aishihik Lake, 1991.

Age	Immature			Mature			Percent Mature		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
3		1	1						
4			1						
5		1	1						
6	2	2	4						
7	2	3	5		1	1		25.00	16.67
8	3	2	5						
9	5	3	8	2		2	28.57		25.00
10	1		1	2		2	66.67		66.67
11	1	1	2	1	2	3	50.00	66.67	60.00
12	3	2	5		4	4		66.67	44.44
13	2		2	2		2	50.00		50.00
14	1		1	1	1	2	50.00	100.00	66.67
15	1		1		5	5		100.00	83.33
16	1		1	1	1	2	50.00	100.00	66.67
17				2	4	6	100.00	100.00	100.00
18				1	2	3	100.00	100.00	100.00
19				4	4	8	100.00	100.00	100.00
20				1	1	2	100.00	100.00	100.00
21	1		1	1		1	50.00		50.00
22				1	1	2	100.00	100.00	100.00
23				1		1	100.00		100.00
25				1	1	2	100.00	100.00	100.00
27					1	1		100.00	100.00
30				1	1	2	100.00	100.00	100.00

Appendix 8a Maturity schedule of lake trout from Canyon Lake, 1991.

Age	Immature			Mature			Percent Mature		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
7	2	1	3						
8	2	1	3						
9			1						
10	1	1	2						
11	1	1	2						
15	1		1		1	1		100.00	50.00
16					1	1		100.00	100.00
31					1	1		100.00	100.00

Appendix 8a Maturity schedule of lake trout from Sekulmun Lake, 1991.

Age	Immature			Mature			Percent Mature		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
4	1		1						
6	1		1						
7	1		1						
9	1		1		1	1		100.00	50.00
10	2		2						
11	1		1		1	1		100.00	50.00
12					1	1		100.00	100.00
13	1		1						
14		2	2		1	1		33.33	33.33
19				1		1	100.00		100.00
20					1	1		100.00	100.00
21				1		1	100.00		100.00
23				2		2	100.00		100.00
24					2	2		100.00	100.00
27					1	1		100.00	100.00
28	1		1						
33					1	1		100.00	100.00
34					1	1		100.00	100.00

Appendix 8b Maturity schedule of lake whitefish from Aishihik Lake, 1991.

Age	Immature			Mature			Percent Mature		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
5	1		1						
6	1	2	3						
7	4	2	6	2		2	33.33		25.00
8	1	1	2	1		1	50.00		33.33
12				2	2	4	100.00	100.00	100.00
13				6	5	11	100.00	100.00	100.00
14				13	13	26	100.00	100.00	100.00
15				16	24	44	100.00	100.00	100.00
16	4		4	38	44	82	90.48	100.00	95.35
17	2		2	34	42	76	94.44	100.00	97.44
18		1	1	22	24	46	100.00	96.00	97.87
19	2			6	18	24	75.00	100.00	100.00
20				8	5	13	100.00	100.00	100.00
21				2	3	5	100.00	100.00	100.00
22				4	5	9	100.00	100.00	100.00
23		1	1	5	8	13	100.00	88.89	92.86
24				7	9	16	100.00	100.00	100.00
25				7	14	21	100.00	100.00	100.00
26	1		2	2	8	10	66.66	100.00	83.33
27	1		2	4	3	7	80.00	100.00	77.78
28				7	4	11	100.00	100.00	100.00
29					5	5		100.00	100.00
30				1	4	5	100.00	100.00	100.00
31	1		1	1		1	50.00		50.00
32				1		1	100.00		100.00
37					1	1		100.00	100.00

Appendix 8b Maturity schedule of lake whitefish from Canyon Lake, 1991.

Age	Immature			Mature			Percent Mature		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
4	7	1	8						
5	2	1	3						
6	1	1	2	1	1	2	50.00	50.00	50.00
7		1	1		1	1		50.00	50.00
8	3		3	5	1	6	62.50	100.00	66.67
9		1	1	3	10	13	100.00	90.91	92.86
10	5	1	6		7	7		87.50	53.85
11	7	3	10	5	9	14	41.67	75.00	58.33
12	6	2	8	1	4	5	14.29	66.67	38.46
13	1		1		1	1		100.00	50.00
14	1	1	2	1		1	50.00		33.33
15	2		2		1	1		100.00	33.33
16	2	1	3	3	6	9	60.00	85.71	75.00
17	3	2	5	3	7	10	50.00	77.78	66.67
18	3	1	4						
19	1	1	2						
20	2		2		1	1		100.00	33.33
22	1		1	2	2	4	66.67	100.00	80.00
23	2		2		2	2		100.00	50.00
24	1		1						
26	1		1						

Appendix 8b Maturity schedule of lake whitefish from Sekulmun Lake, 1991.

Age	Immature			Mature			Percent Mature		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
9	1		1						
13					1	1		100.00	100.00
14		1	1	1	1	2	100.00	50.00	66.67
15		1	1	5	9	14	100.00	90.00	93.33
16	1		1	7	13	20	87.50	100.00	95.24
17				7	9	16	100.00	100.00	100.00
18					8	8		100.00	100.00
19				4	3	7	100.00	100.00	100.00
20					4	4		100.00	100.00
21					2	2		100.00	100.00
22					1	1		100.00	100.00
23	1		1		10	10		100.00	90.91
24				6	4	10	100.00	100.00	100.00
25		2	2		5	5		71.43	71.43
26	1	1	2	2	10	12	66.67	90.91	85.71
27				1	6	7	100.00	100.00	100.00
28	2	1	3		11	11		91.67	78.57
29	1		1	2	10	12	66.67	100.00	92.31
30	1	1	2	1	6	7	50.00	85.71	77.78
31					3	3		100.00	100.00
32	1	1	2						
33		1	1		2	2		66.67	66.67
34					1	1		100.00	100.00

APPENDIX 9

Telemetry Project Information

Appendix 9 Details on lake whitefish tagged within the north basin of Aishihik Lake with radio and sonar tags, October 1992.

Variable	Tag Referance Number									
	1	2	3	4	5	6	7	8	9	10
Date Tagged (day/month/year)	28/10 1992	28/10 1992	29/10 1992	29/10 1992	29/10 1992	28/10 1992	28/10 1992	29/10 1992	29/10 1992	29/10 1992
Tag Type	Radio	Radio	Radio	Radio	Radio	Sonar	Sonar	Sonar	Sonar	Sonar
Tag I.D. Number	49270	49350	49070	49230	49130	1066	1182	1316	1155	1177