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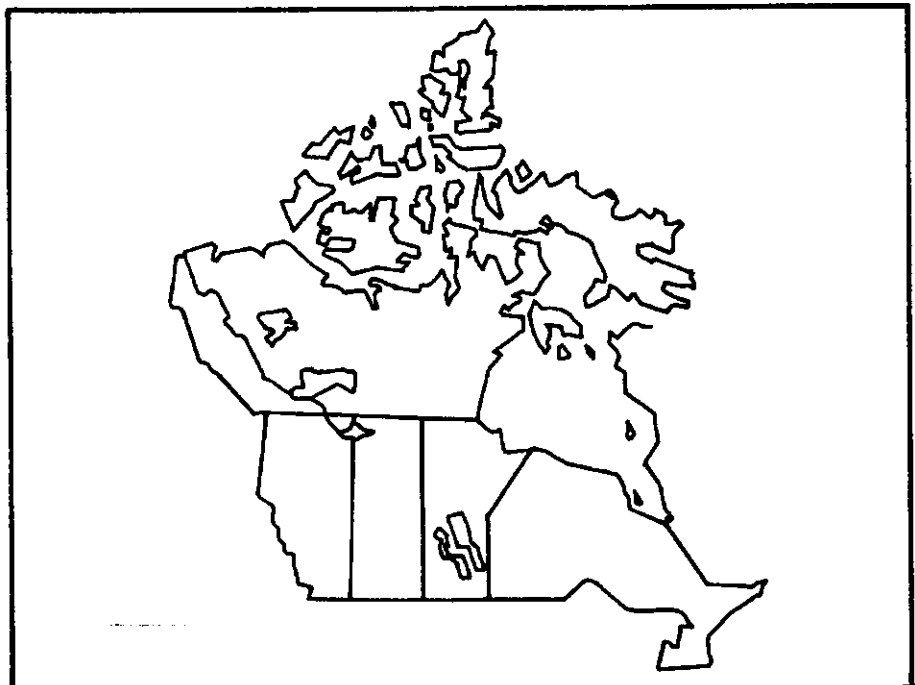
Limnological and Biological Survey of Hottah Lake, Northwest Territories.

by B. Wong and T. Whillans

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Resource Management Branch

Central Region



LIMNOLOGICAL AND BIOLOGICAL SURVEY OF
HOTTAH LAKE, NORTHWEST TERRITORIES

by

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A Joint Study

by

Fisheries Management Division
Resource Management Branch
Central Region
Fisheries and Marine Service

Fisheries Development
Department of Industry and Development
Government of the Northwest Territories

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ABSTRACT

A biological and limnological survey was conducted in Hottah Lake during the summer of 1972. The lake lies on the boundary of the Canadian Shield and is divided into two physiographic regions. The water area of the lake is 984.4 Km² with a mean depth of 18.9 m. No stable thermocline was observed in 1972. The lake water is noticeably uniform, being low in dissolved minerals. The bottom dissolved oxygen content remains near saturation throughout the summer. The lake is unproductive with low standing crops of plankton, benthos and fish. Lake whitefish and lake trout are the main fish species making up 94% of the catch by weight. It appears that past commercial fisheries have altered the population of fish in the lake. A revision of the present quota may be essential in the management of Hottah Lake.

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INTRODUCTION

A controlled expansion of the commercial fishery in the Northwest Territories beyond that on Great Slave Lake, commenced in December 1961. One of the main objectives of this expansion was to permit commercial harvesting of unexploited fish stocks under adequate safeguards for effective management. To fulfill this objective, increased knowledge of unexploited fish stocks through scientific surveys is necessary. Environment Canada, Fisheries and Marine Service are conducting numerous lake surveys in the N.W.T. to increase knowledge and establish fundamental guidelines for this myriad of virgin lakes. The Fisheries Development Branch of the Northwest Territories Government in conjunction with Fisheries Service sponsored an additional extensive survey of Hottah Lake to enlarge the basic understanding of these lakes.

The crew arrived on site on July 4, 1972 and continued its activities until September 14, 1972, The crew was composed of four persons and worked from a south camp at Bell Island and a north camp in one of the small northern islands.

DESCRIPTION OF THE STUDY AREA

Description of Lake

Hottah Lake lies about 30 miles southwest of the McTavish Arm of Great Bear Lake and 200 miles northwest of Yellowknife (Fig. 1). It has the shape of an inverted triangle and an area of 338 square miles centered at latitude 65° 00' and longitude 118° 30'. It is part of a chain of lakes forming the Camsell River system, which stretches from the northern arm of Great Slave Lake to Gunbarrel Inlet in Great Bear Lake. The system arises in Lake Sarah and flows through lakes Faber, Rae, Ste. Croix, Takatu, Segin, Hardisty, Isabella, Hottah, Grouard, Clut and Rainy en route to Great Bear Lake. Hottah is the largest of these lakes covering over 45% of the 700 or more square miles of water area. The drainage area of the system covers an elongated strip 300 miles long and up to 40 miles wide.

The main affluents to the lake are the Camsell River from the south and the Zebulon River from the east (Fig. 2). There are also several small streams which enter the lake on both the east and west shores. The Camsell River regains its course at the northeast corner of the lake and drains towards Great Bear Lake.

Geographic Situation

A good geographical account of the region is given by Kidd (1936) and Balkwill (1971). The area lies along the west edge of the Canadian Shield and is on the boundary between two contrasting types of topography. To the west, the underlying rocks are little disturbed sediments, in part at least of Palaeozoic age.

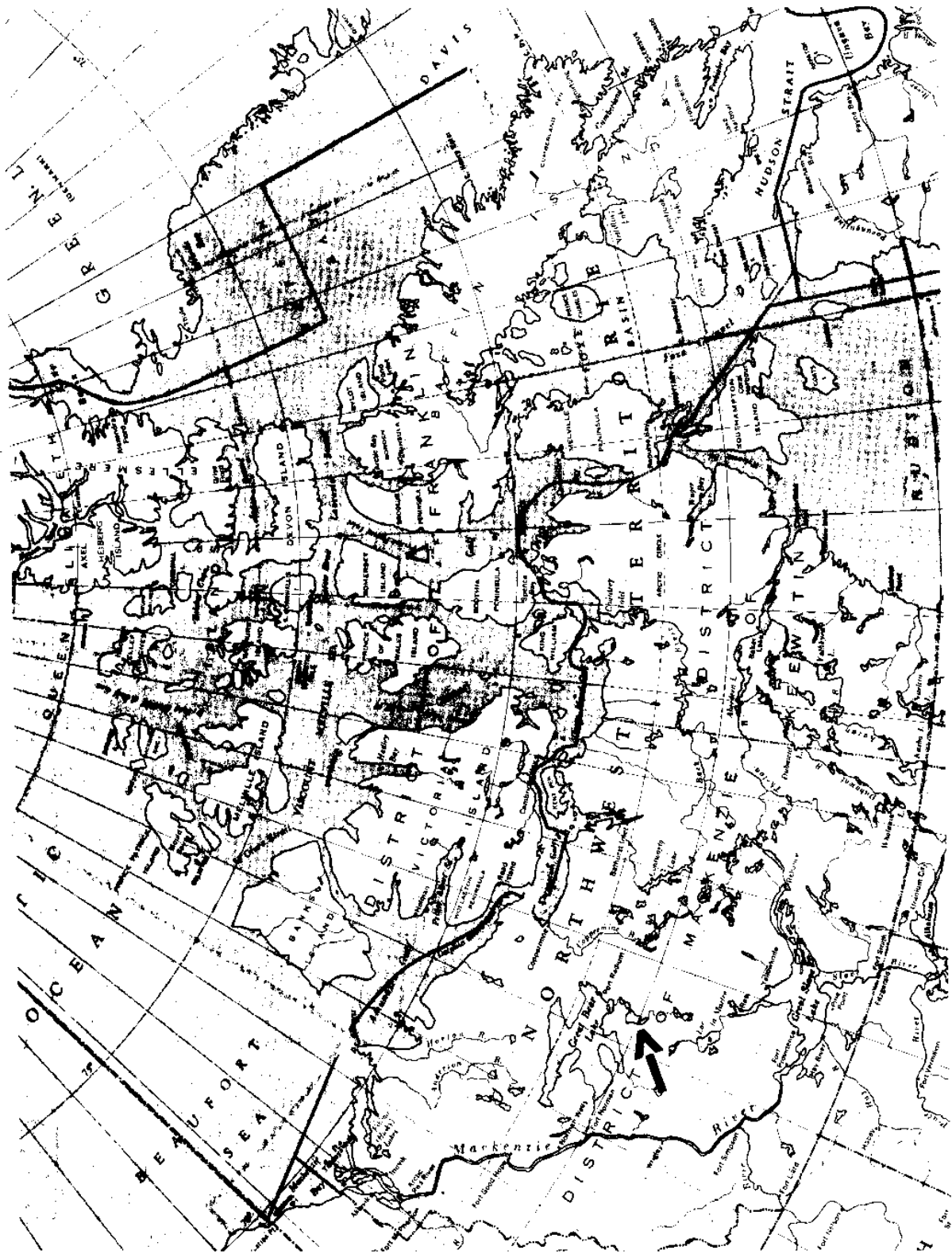


Figure 1. Map of the Northwest Territories showing the location of Hottah Lake.

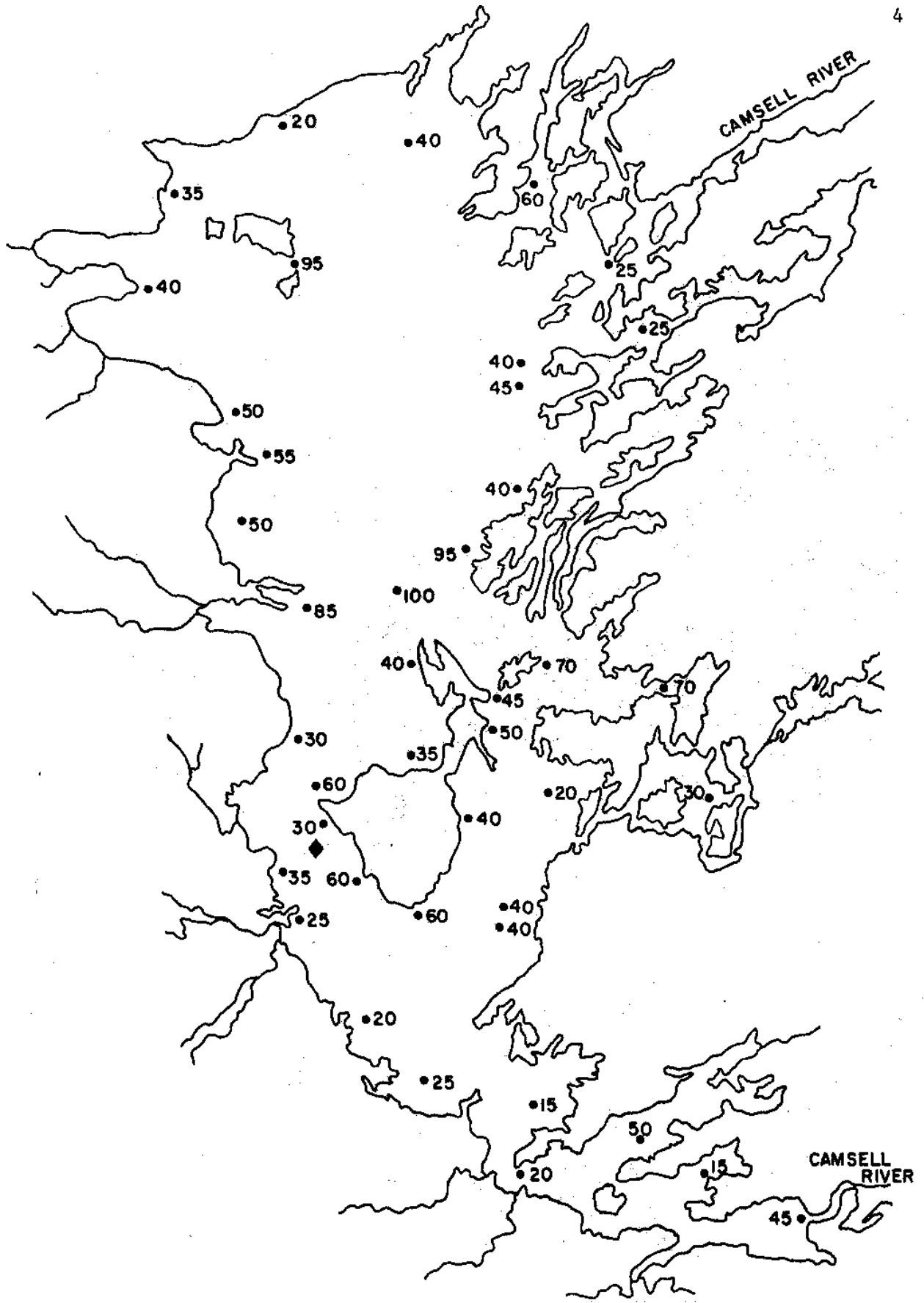


Figure 2. Map of Hottah Lake indicating sampling stations and their mean depth (in feet). A permanent station where water and plankton were sampled regularly is indicated by ◆ .

The topography is subdued and rolling; hills have even slopes and very few outcrops of bedrock occur. The eastern shore of flat-lying sediments rests unconformably on the Precambrian Shield. This physiographic unit is underlain by granites in which are elongated belts of older rocks. A large proportion of bedrock is exposed. Glaciation has scoured the bedrock and left many shallow depressions which are now occupied by irregular channels and lakes with numerous rocky islands. The physiographic boundary is not very sharp along the whole length of the lake; there may be a belt of low country several miles wide, largely drift covered, between the last outcrops of Precambrian (Kidd 1936).

Vegetation

The area is in the Northwestern Transition Section of the Boreal Forest Region of Canada (Rowe 1959). The annual length of growing season (mean daily temperature above 42F) ranges from 100 to 120 days. Annual number of days with snow cover is between 200-240 days with an annual maximum depth of snow of 20 to 30 inches.

Black spruce is the predominant tree but white spruce and white birch are also very common. Some tamarack, stunted aspen and balsam poplar are also present. Good stands of deciduous trees occur in sheltered and low-lying areas, leaving the high, exposed areas to the more hardy evergreen conifers. To the east, where a large proportion of bedrock is exposed, the woods are thinner and resemble an open boreal forest; to the west, they are thicker and resemble a closed boreal forest.

Underbrush also grows thicker in the west than that in the east. On mineral soil, lichen, feathermosses, Labrador tea (*Ledum* sp.) and some *Sphagnum* moss form the undergrowth while on organic deposits, *Sphagnum* and lichen make up the ground layer and various berries, *Ledum* and wild roses comprise the upper growth. Along the water edges, willow, alder, swamp birch, horsetail, pondweed, sedges and various grasses congregate.

Economic Situation

Hottah Lake is inaccessible by land except for a winter road which passes through the length of the lake every year, connecting Yellowknife with Port Radium. Through a series of portages, Hottah Lake can be approached from Rae Lake by canoe during open water. Commercial fisheries in the area were limited by this isolation. Some commercial fishing was recorded between 1963 and 1966 and in 1971 (Table 1). From 1950 to 1956, uranium oxide was mined commercially in one of the peninsulas in Hottah Lake.

Table 1. Commercial Fisheries production in Hottah Lake recorded in pounds

Fish Harvested	Year fished				
	1963	1964	1965	1966	1971
Lake Whitefish	11,192	536,264	207,398	8,423	46,597
Lake Trout	8,913	227,348	157,623	5,921	7,005
Total	20,105	763,612	365,021	14,344	53,602

METHODS AND MATERIALS

Morphometry

Aerial photographs and national topographic maps published by the Department of Energy, Mines and Resources served as the basis for morphometric measurements. Outlines were prepared from topographic maps with a scale of 1:250,000. Identification of land marks for echo soundings was obtained from aerial photographs as were locations of islands and shoals. Bottom features of the lake were explored by echo sounding (Furuno, FG-11/200 Mark III with a side-mounted, 50 KHz transducer). A Bathymetric map was constructed from the 107 transects sounded in the lake following the method outlined by Welch (1948).

Physical and Chemical Studies

Atmospheric conditions of the general area were recorded at Port Radium and detailed weather statistics were obtained from Atmospheric Environment Service of Environment Canada.

Physical and chemical data were collected throughout the lake to determine variations within the lake. Locations for these samplings were chosen to coincide with the biological stations. A permanent station was established to obtain seasonal variations (Fig. 2). The position for this station was dictated by the speed of the boats.

Water transparency was determined with a Secchi disc. A hydrographic thermometer (Applied Research Austin Inc. FT3 Marine) was used to record the temperature profile of the lake. Daily water surface temperatures were also measured at camp every morning.

Water samples were collected at various depths with a Kemmerer sampler. Dissolved oxygen, carbon dioxide, pH, alkalinity (methyl-orange), hardness (Calcium) and specific conductivity were determined from these water samples using a Hach kit (model DR-EL).

Biological Studies

Stations for biological sampling were chosen randomly; precautions were taken to ensure that most areas of the lake were represented (Fig. 2). Stations varied in depths from 10 to over 110 feet. A total of 42 stations were sampled for fish through the summer and of these over half were sampled for plankton and benthos.

Plankton was collected with a Wisconsin net of number 20 bolting silk, having a mouth diameter of 12 cm. Three total vertical hauls were taken at a rate of 1 meter per second on each occasion. Preserved samples (5% formalin) were split for gravimetric analysis and for identification and enumeration.

Relative abundance of plankton was determined by counting individual organisms in subsamples as outlined by Welch (1948), using a Sedgwick-Rafter cell and a microscope fitted with an ocular micrometer. For computing standing crop, plankton were dried at 52°C, weighed and ashed (Koshinsky 1968). Two net calibrations (Welch 1948) were performed in the summer indicating the average net efficiency to be 27.9%.

Bottom organisms were sampled with a six-inch Eckman Dredge. Dredgings were washed through a thirty mesh per inch screen. Materials retained were washed off into six-inch petri dishes where organisms were sorted and preserved in 10% formalin.

Eighty-one dredgings were taken from depths between 10 and 100 feet. Preserved samples were identified, enumerated and weighed in the laboratory. Both wet and dried weights (52°C) were obtained for the various taxa of animals in each sample. The shells of molluscs were removed by dissection to obtain shell free dried weight. In computing standing crops, samples were analysed according to depth zones.

Larger fish in the lake were sampled with nylon gill nets. The two test gangs used were comprised of 1½, 2½, 3½, 4½ and 5½ inch stretched mesh gill nets each of 50 or 100 yards. A total of 42 sets were made, all on the lake bottom and all of approximately 24 hours duration (except for one 72 hour setting). All fish captured were used to estimate some of the basic population parameters. Individual fish were weighed to the nearest gram and measured to the nearest millimeter. Sexual condition of individual fish was noted. Qualitative studies of fish stomach contents were performed in the field while limited samples were used for quantitative studies in the laboratory. Growth in all cases was deduced through an examination of scales. Scales from each fish were read at least three times by a single individual to ensure greater accuracy and consistency.

RESULTS

Morphometry

Hottah is a large lake covering a total area of 984,4 Km²; of this 874.9 Km² is the area of water while the remaining 109.5 Km² the area of islands (Table 2). More than 680 islands are found in the lake and over 80% of them are scattered along the eastern shore of the lake. All the islands, with the exception of Bell, tend to be very small and many are but mere protrusions of rocks above the water.

The depth of Hottah is comparable to its size, with a maximum depth of 69.5 m and a mean depth of 18.9 m. Overall, the western portion of the lake is deeper than the east. The deep holes, however, are found in the mid-section of the eastern half (Fig. 3).

To the west, the shoreline is relatively smooth, but to the east, numerous narrow bays and channels disrupt the shoreline. The predominant shoreline is bedrock, typically granite. Off-shore, the bottom is usually composed of large broken rocks graduating into mud. Few abrupt drop-offs occur because of ice formed tallus slopes. The other major shoreline type is frequently found on the sedimentary based western shore and along the north border. This is a peat covered shore with irregular rocks of assorted sizes, sloping into the rock-mud bottom. Marshes develop along gentle slopes in the south and in some protected bays in the east. Similar shorelines are found at the outlets of streams, but the bottom is generally heavily silted in.

Table 2. Summary of the morphometry of Hottah Lake

	Metric system	British system
Length	74.95 Km	46.58 mi
Maximum breadth	26.47 Km	16.45 mi
Mean breadth	11.67 Km	7.26 mi
Maximum depth	69.5 m	211.8 ft
Mean depth	18.9 m	57.6 ft
Shoreline (without islands)	278.12 Km	172.85 mi
Shoreline (with islands)	541.51 Km	336.55 mi
Area of water	874.85 Km ²	337.79 mi ²
Area of islands	109.50 Km ²	42.28 mi ²
Total area	984.35 Km ²	380.08 mi ²
Insulosity	11.12%	
Volume	6383.43 x 10 ⁶ m ³	22.54 x 10 ¹⁰ ft ³
Mean slope	0.0111	
Shoreline development (without islands)	5.53	
Shoreline development (with islands)	10.76	
Volume development	0.82	

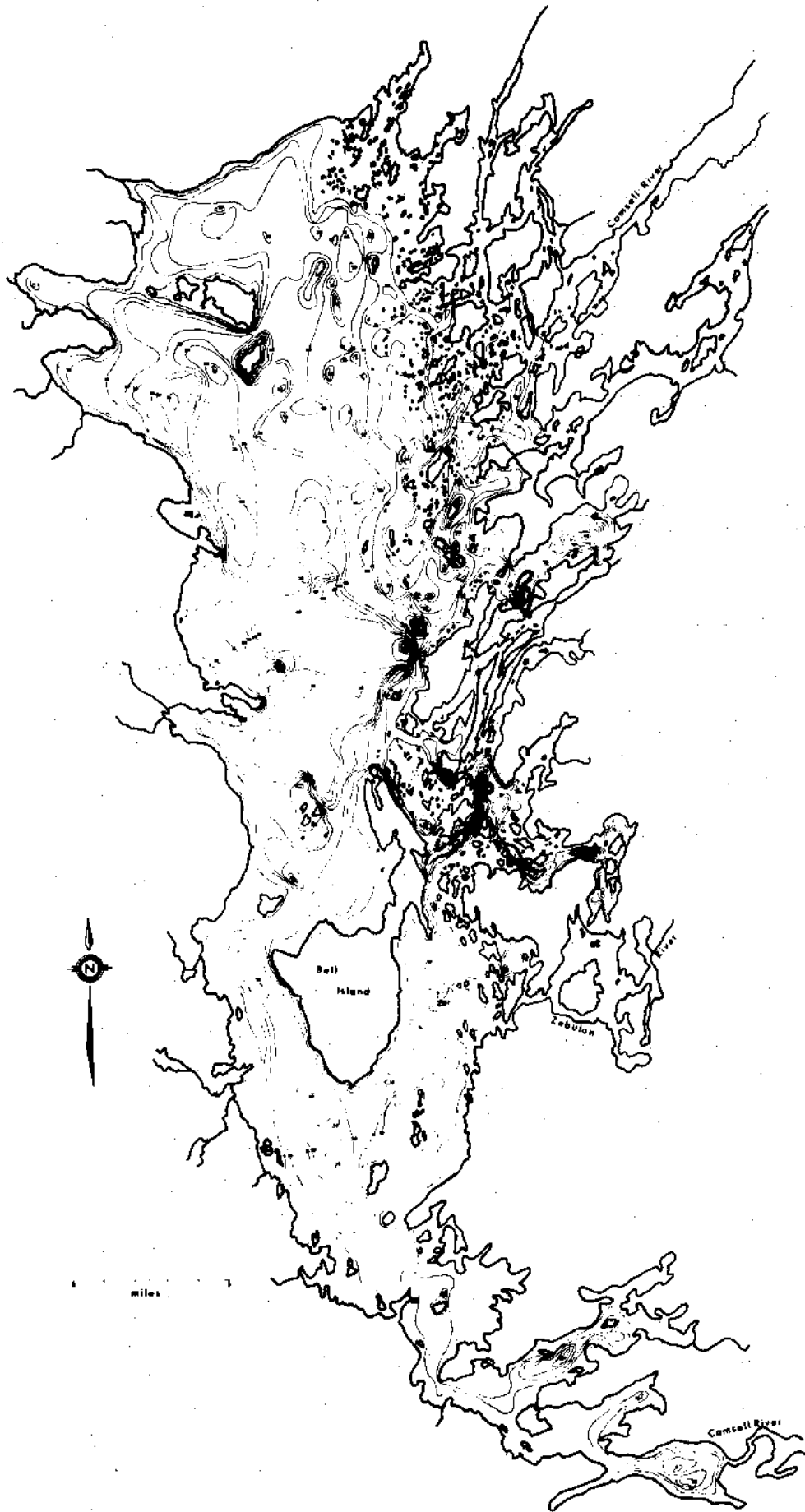


Figure 3. Bathymetric map of Hottah Lake (contour in meters)

Other areas in the south, such as Stairs Bay, are characterized by boulders of all sizes strewn along the shore and the shallows. Some clean sand beaches and a few gravel shores are scattered around the lake.

The mean slope of the lake is 0.011 and in general the slope is steeper in the west than in the east. The jagged shoreline of the east and the numerous islands contribute to a high development ratio of 10.76. An index of 0.83 in volume development is also noted for the lake. The detailed morphometry of the contours in the lake is summarized in Table 3.

Physical and Chemical Conditions

The exact date of break-up of ice cover was not known. During the reconnaissance flight on June 24th, ice was observed to cover most of the lake except for the portion south of Bell Island. Upon arrival by boats at Bell island on June 30th, no ice was within sight. A large piece of floating ice was observed in the north of the lake as late as July 6th.

Surface water temperature rose from 7°C on July 4th and reached a maximum of 18°C during the middle of the summer (Fig. 4). Daily surface temperatures correlate well with the atmospheric conditions recorded in Port Radium (Appendix 1). Temperature profile observations were taken in time to demonstrate spring and fall turnovers in the lake (Fig. 5). The average summer water temperature (0-10m) was 12.4°C. Detailed data on temperature profiles for various parts of the lake is listed in Appendix 2, No pronounced thermocline was observed in the lake during the summer of 1972 (Fig. 5).

Water chemistry performed at over twenty stations through the season reveals little variation in its chemical constituents (Appendix 3). Even a smaller variation was observed at different depths in each station.

Table 3. Summary of lake basin configuration of Hottah

Depth m	Length Km	Depth Zones m	Area Km ²	Area %	Volume x 10 ⁶ m ³	Volume %
0	545.51					
		0 - 5	309.41	35.36	2841.0	44.50
5	483.34					
		5 - 10	155.08	17.73	1139.2	17.85
10	342.40					
		10 - 15	79.06	9.04	574.7	9.00
15	245.21					
		15 - 20	89.94	10.28	422.2	6.61
20	194.37					
		20 - 25	85.46	9.77	438.4	6.87
25	136.44					
		25 - 30	32.86	3.76	285.5	4.47
30	101.69					
		30 - 35	52.23	5.97	210.8	3.30
35	92.03					
		35 - 40	49.51	5.66	254.3	3.98
40	41.83					
		40 - 45	16.64	1.90	158.1	2.48
45	18.02					
		45 - 50	3.36	0.38	45.8	0.72
50	10.30					
		50 - 55	0.53	0.06	8.7	0.14
55	9.01					
		55 - 60	0.10	0.01	1.5	0.02
60	7.08					
		60 - 65	0.48	0.05	1.3	0.02
65	4.51					
		65 - 70	0.21	0.02	1.7	0.03

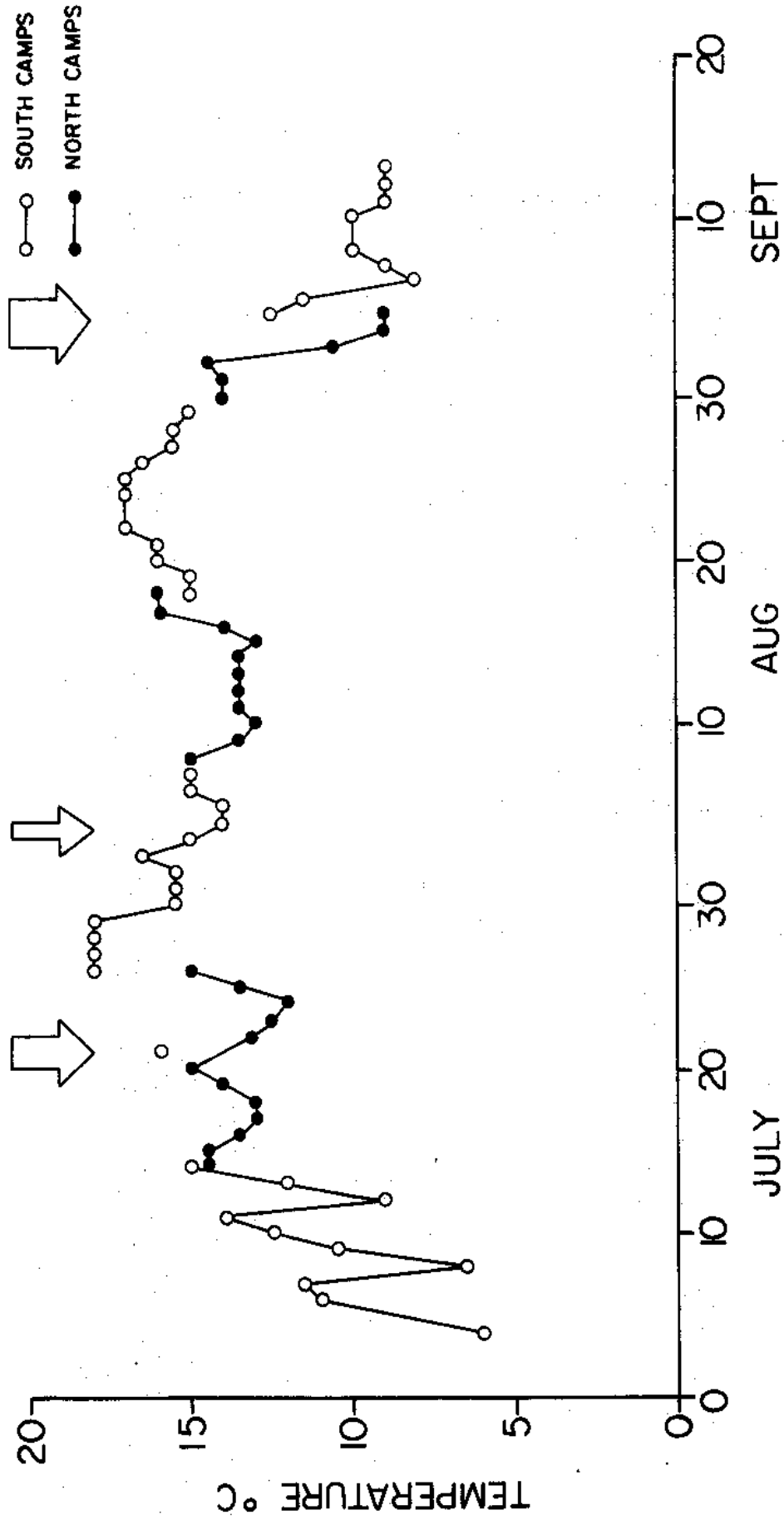


Figure 4. Surface temperature of Hottah Lake in summer 1972.

TEMPERATURE °C

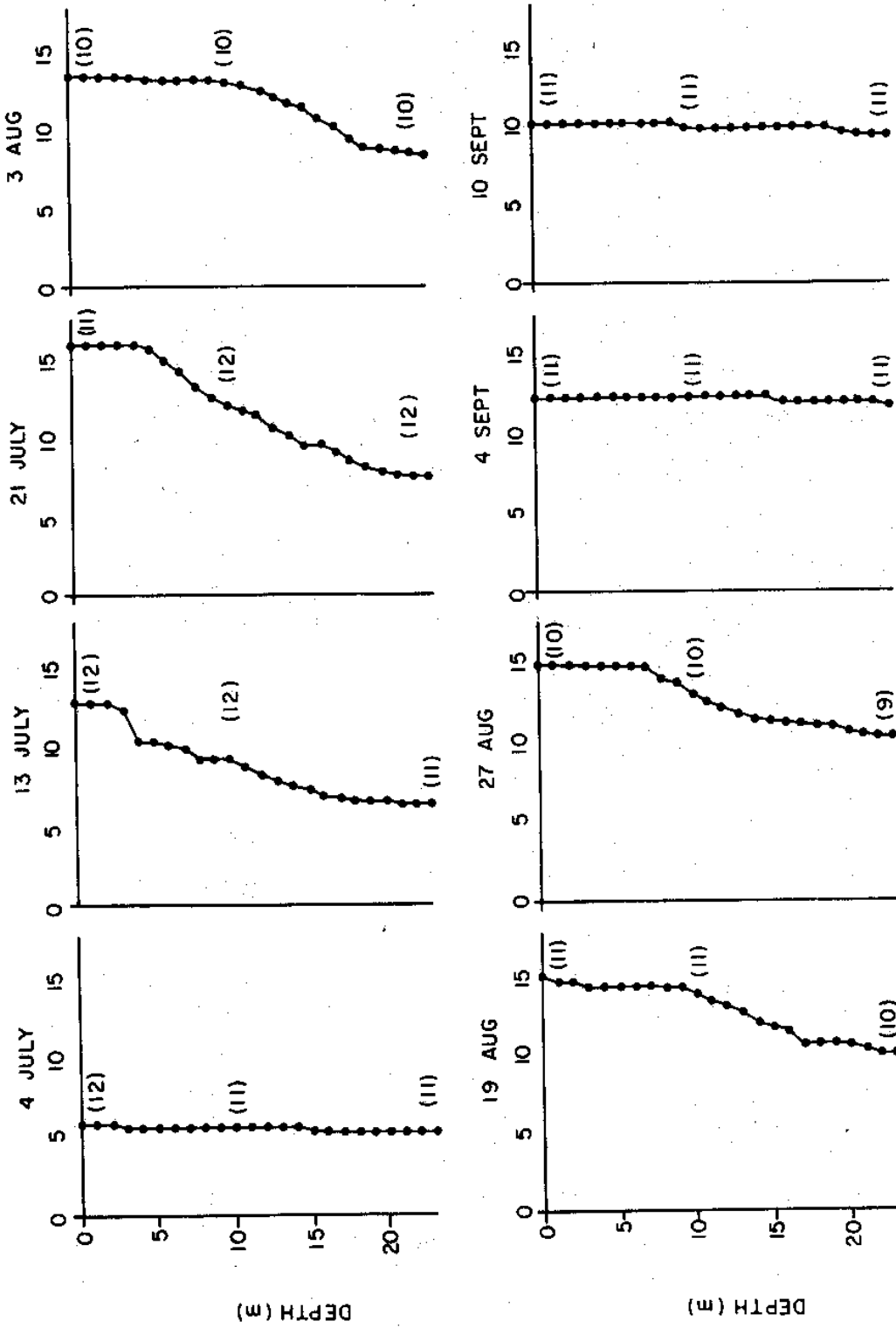


Figure 5. Temperature and dissolved oxygen profile of Hottah Lake, Summer 1972. Numbers in parentheses represent the dissolved oxygen contents in mg/l.

Oxygen concentrations remained virtually unchanged with depth (Fig. 5) and remained close to saturation throughout the summer. The lake is relatively alkaline with a mean pH of 7.9 and alkalinity (calcium) of 45 mg/l. Both the specific conductivity and the hardness (calcium) were moderately low being 100 M mhos and 36.2 mg/l respectively. The transparency of 5.5 m with a Secchi disc was exceptionally low for a large cold northern lake. A summary of the chemical parameters regularly examined appears in Table 4. The accuracy of the chemical analysis conducted in the field with a Hach kit is assessed by comparison with a detailed analysis conducted in a laboratory (Appendix 4).

Plankton

The summer standing crop of net plankton, based on 84 vertical hauls, was 17 kilograms per hectare dry weight (Appendix 5). Such low plankton values are more characteristic of lakes with very deep basins such as McLeod and Christie Bays in Great Slave Lake (Rawson, 1952). Although the standing crop is low, a large variety of species was represented (Appendix 6). The relative abundance of plankton organisms fluctuated to some degree through the summer, but no bloom of any species was in evidence.

The predominant phytoplankters were diatoms which formed 77.8% by number of the total collections. Asterionella, in particular, appeared consistently in quantities in all samples. Other species of diatoms that occurred in quantities but less frequently were Tabellaria and Melosira (Table 5). Yellow-green algae, contributing 12.4% by number, were represented almost entirely by Dinobryon.

Table 4. Summary of the water chemistry of the lake

		Summer average	Accuracy of measurement	Standard error	Maximum	Minimum
pH		7.89	0.1	± 0.130	8.2	7.6
Carbon dioxide	mg /l	0.48	0.4	± 0.166	0.8	0.4
Alkalinity (calcium)	mg/l	45.00	5.0	± 6.36	50.0	25.0
Hardness (calcium)	mg/l	36.20	5.0	± 4.44	45.0	25.0
Specific conductivity	M umhos	100.00	5.0	± 14.95	120.0	90.0
Secchi Disc	m	5.5	0.5	± 0.37	7.5	5.0

Table 5. Relative abundance* of the main phytoplankton in the lake

	July											August													
	6	8	9	12	13	17	20	23	25	27	28	2	3	4	6	9	10	12	13	14	16	19	21	25	30
Bacillariophceae																									
Asterionella	3	3	4	3	3	3	3	4	4	4+	4	3	4	4	4	3	3	3	4+	4	3	3	4	4+	4
Tabellaria	2	2	2	2	2	-	1	2	1	3	3	-	2	2	3	2	1	2	3	2	-	1	3	3	3
Melosira	2	2	3	2	1	1	1	1	-	3	3	-	2	1	3	2	1	-	2	1	2	-	2	2	1
Synedia	1	2	3	2	2	1	-	2	1	3	2	1	2	2	3	2	2	2	3	1	1	2	1	3	2
Chrysophyceae																									
Dinobryon.	3	2	4	3	3	2	2	4	2	2	1	1	2	1	3	2	1	2	4	2	1	4	2	2	3
Chlorophyceae																									
Dictyospharium	2	-	1	1	-	1	1	2	-	2	-	2	-	2	2	-	-	2	-	1	-	-	-	1	1
Myxophceae																									
<u>Anabaen</u>	-	-	-	-	-	-	-	1	-	2	4	-	1	3	1	-	-	-	-	1	-	-	1	-	2
<u>Aphanizomenon</u>	-	-	-	1	-	-	-	-	1	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
<u>Aphanothece</u>	-	-	-	-	-	-	-	-	-	-	4	-	-	2	3	-	-	-	-	1	-	-	1	2	1
Others	1	-	1	-	-	-	-	2	2	-	-	-	1	-	-	-	-	2	-	-	1	2	-	-	-
1	occasional	1 - 25 organisms per litre																							
2	common	26 - 100 organisms per litre																							
3	abundant	101 - 300 organisms per litre																							
4	very abundant	301- 1000 organisms per litre																							
4+		over 1000 organisms per litre																							

A good variety of green and blue-green algal species was also found but they generally appeared sporadically and in small numbers (Table 5), They formed 1.6% and 8.2%, by number respectively of the plankton sampled.

Ceratium was by far the most abundant single genus of zooplankton in the lake, making up 20.5% of the net plankton and a number of species were present (Table 6). Copepods, which formed 27.8% of the catch, contributed the most in trophic terms because of their larger size. The remaining zooplankton were cladocerans (3.7%) and other protozoa (16.5%).

Benthos

The dry weight of benthos ranges from 0.27 Kg/ha to 14.34 Kg/ha depending on the depth of the sample (Appendix 7). The standing crop of benthos calculated by area of depth zones was 6.4 Kg/ha or 1459 organisms per square meter for the summer. As in the case of plankton, the standing crop of benthos was low indicating the oligotrophic condition of the lake.

The bottom fauna found in the lake was typical of a cold northern lake (Appendix 8). The three main groups were amphipods, sphaeriids and chironomids (Table 6). Pontoporeia affinis was predominant in all samples, while some Hyaella azteca were found in many samples. Gammarus lacustris was infrequent and generally occurred in small numbers. Two genera of sphaeriids, Pisidium and Sphaerium, were identified. They occurred in large numbers in samples and despite their small size, could constitute up to 57% dry weight (excluding shells) of dredgings. The annelid insects and gastropods were the less prominent groups (Table 7); although they occurred in smaller numbers, they contributed over 10% of the total dry weight. The remaining groups were *Mysis relicta*, nematodes and ostracods which were of little importance both in terms of number and dry weight.

Table 6. Relative abundance* of the main zooplankton in the lake

	July											August													
	6	8	9	12	13	17	20	23	25	27	28	2	3	4	6	9	10	12	13	14	16	19	21	25	30
Protoza																									
<u>Ceratium</u>	-	-	3	2	-	-	2	4	-	4	3	-	4	4	3	-	2	4	4	2	3	2	4	4	-
Others	1	-	2	2	-	-	1	2	-	4	2	3	2	4	-	-	2	-	4	-	1	-	1	3	3
Rotifera																									
<u>Kellicottia</u>	-	-	3	-	-	-	2	-	-	3	3	3	2	2	3	-	-	3	4	3	4	-	1	2	1
<u>Keratella</u>	-	-	-	-	-	-	-	-	-	3	2	-	-	-	2	-	-	-	2	1	1	-	-	2	2
<u>Polyarthra</u>	-	-	-	-	-	-	-	2	-	2	2	-	-	-	-	-	-	-	2	1	-	-	-	-	3
Others	2	-	-	-	-	-	1	4	3	4	3	4	3	4	2	-	3	2	3	2	3	2	3	2	2
Copepoda																									
<u>Cyclopoida</u>	-	-	3	-	-	1	2	-	-	-	3	2	2	-	4	-	2	-	-	2	1	3	2	2	1
<u>Calanoida</u>	2	-	2	2	-	-	3	3	2	-	2	2	2	-	2	-	-	-	-	2	3	2	-	2	
<u>Nauplii</u>	2	-	-	3	-	-	3	3	2	4	3	2	3	4	4	-	2	2	3	3	3	3	2	2	
Cladocera																									
<u>Bosmina</u>	-	-	-	-	-	-	-	-	-	2	2	2	2	2	-	-	-	-	2	-	-	2	-	3	2
<u>Daphnia</u>	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	-	-	-	2

* 1 occasional 1 - 10 individuals per litre
 2 common 11 - 30 individuals per litre
 3 abundant 31 - 80 individuals per litre
 4 very abundant 81 - over individuals per litre

Table 7 . Relative abundance of the main benthic organisms in Hottah Lake

	Percentages by number	Percentage by dry weight
Amphipods	61.57	49.17
Sphaereids	22.77	26.88
Chironomids	11.36	13.12
Annalids	2.24	5.19
Insects	0.68	2.49
Gastropods	0.73	2.47
Mysids	0.37	0.63
Others	0.28	0.05

Fish

A total of nine fish species was collected from the lake (Appendix 9). Whitefish and lake trout were the most abundant large fish (Table 8). Northern pike were caught infrequently and in restricted areas. The total number of small fish caught was low but if consideration is given to the size of nets in which they could be caught, their importance becomes apparent. In the case of ciscoes, only adults were caught in the 12 inch mesh gill net and younger fish escaped detection completely. The abundance of ciscoes in the lake could be comparable to that of whitefish on examination of the catch per 50 yard gill net (Table 7). Burbot, sculpins, grayling and sticklebacks were never caught in gill nets. Specimens were obtained from stomach samples, dip net collections and angling.

The standing crop of fish, parallel to that of plankton and benthos, was low. Average gill net catch per 50 yards/24 hr was 7.5 fish weighing 9.7 Kg (19.6 lbs). Whitefish and lake trout made up 94% of the total fish weight (Table 8). The small percentage by weight of ciscoes and suckers in the catch does not diminish their importance as forage for the larger predator fish in the lake.

Table 8. Summary of gill net catches in Hottah Lake

	Total number caught	Total weight Kg	Mean weight per fish Kg	Catch per 50 yards of gill net			
				Number	Weight	% Number	% Weight
Lake whitefish	1065	1629.7	1.53	3.13	4.79	41.62	49.47
Lake trout	549	1476.9	2.69	1.61	4.33	21.42	44.74
Ciscoes	161	9.7	0.06	2.25	0.14	29.92	1.46
Northern	51	113.4	2.18	0.15	0.33	1.99	3.38
Longnose sucker	50	12.3	0.25	0.38	0.09	5.05	0.95
Total	1876	3239.9		7.52	9.68	100.00	100.00

Lake Whitefish

Growth of whitefish is moderate for a large cold lake such as Hottah. Fish attain a weight of 4 lbs (1.8 kg) or 50 cm (19.7 in) at the age of 11 or 12 (Fig. 6). Over 93% of the seven year old fish examined were sexually mature (Table 8). The length-weight relationship of whitefish is $\log Wt = -5.8506 + 3.37 \log L$ (Appendix 10). Condition coefficients by age group are listed in Table 9.

Little sexual dimorphism was observed. More females became sexually mature before age seven than males, indicating an earlier sexual maturity for females. Growth in length and weight are similar for both sexes (Table 9). Length-weight relationships are also comparable between male and female. The sex ratio varied with age (Table 9). Half as many females were caught as males at the onset of maturity but the ratio increased with age until equal numbers of each sex were caught at the ages of 14 and 15.

Whitefish were caught in all but one of the 42 net settings showing that they were well distributed throughout the lake. Larger fish tended to be caught in deep and open areas while smaller ones in the shallow and protected areas. Triaenophorus sp. cysts were found in fish caught in 18 of the 42 settings. The infected fish were represented in most parts of the lake and showed no sign of localization (Fig. 7). Infection rate of the lake as a whole was very low being 2.5 cysts per 100 lbs of fish.

The catch of whitefish (Fig. 8) shows a deviation from normal. A poor representation of fish between 5 to 8 years old is seen on the ascending limb of the catch curve. The indicated weakness of these age groups does not seem to be the result of net selectivity. Both younger and older fish were susceptible to 1½ and 2½ inch mesh size gill nets (Table 10) and there is little cause to assume these nets were ineffective towards the 5 - 8 year old fish.

Table 9. Summary of the biology of whitefish

Age	Number of fish		Sex ratio Female/Male	Mean length (mm)		Percentage immature	Mean weight (gm)		Condition Coefficient
	Total	Immature		Male	Female		Male	Female	
I	1	1	-	-	-	100.0	-	-	1.17
II	7	7	-	-	-	100.0	-	-	0.98
III	22	18	-	-	-	81.8	-	-	1.10
IV	28	25	-	4	312.3	92.6	498.0	149.0	1.52
V	12	10	-	2	309.5	83.3	386.0	165.0	1.45
VI	14	3	-	6	308.4	21.4	375.0	690.8	1.26
VII	32	2	-	5	398.0	6.3	436.4	1024.0	1.21
VIII	92	4	-	10	420.6	4.2	436.4	1151.3	1.40
IX	160	-	-	57	435.8	0.0	436.4	1398.4	1.45
X	204	-	-	92	456.7	0.0	477.3	1623.9	1.42
XI	167	-	-	111	477.3	0.0	485.6	1904.8	1.47
XII	133	-	-	87	483.0	0.0	496.3	1809.5	1.53
XIII	73	-	-	69	506.9	0.0	501.7	2138.5	1.50
XIV	41	-	-	36	487.1	0.0	495.5	1927.1	1.42
XV	12	-	-	21	519.6	0.0	519.6	2241.7	1.63
XVI	15	-	-	6	545.2	0.0	537.2	2505.0	1.61
XVII	4	-	-	6	536.0	0.0	539.2	2541.7	1.50
XVIII	6	-	-	4	554.3	0.0	554.3	2793.75	1.58
XIX	-	-	-	1	597.0	0.0	597.0	3130.0	1.53
XX	-	-	-	-	-	0.0	-	2545.0	-
XXI	-	-	-	-	-	0.0	-	-	-
XXII	1	-	-	-	562.0	0.0	562.0	2720.0	1.53
XXIII	-	-	-	-	-	0.0	-	-	-
XXIV	-	-	-	-	-	0.0	-	-	-
XXV	1	-	-	1	632.0	0.0	632.0	3990.0	1.58

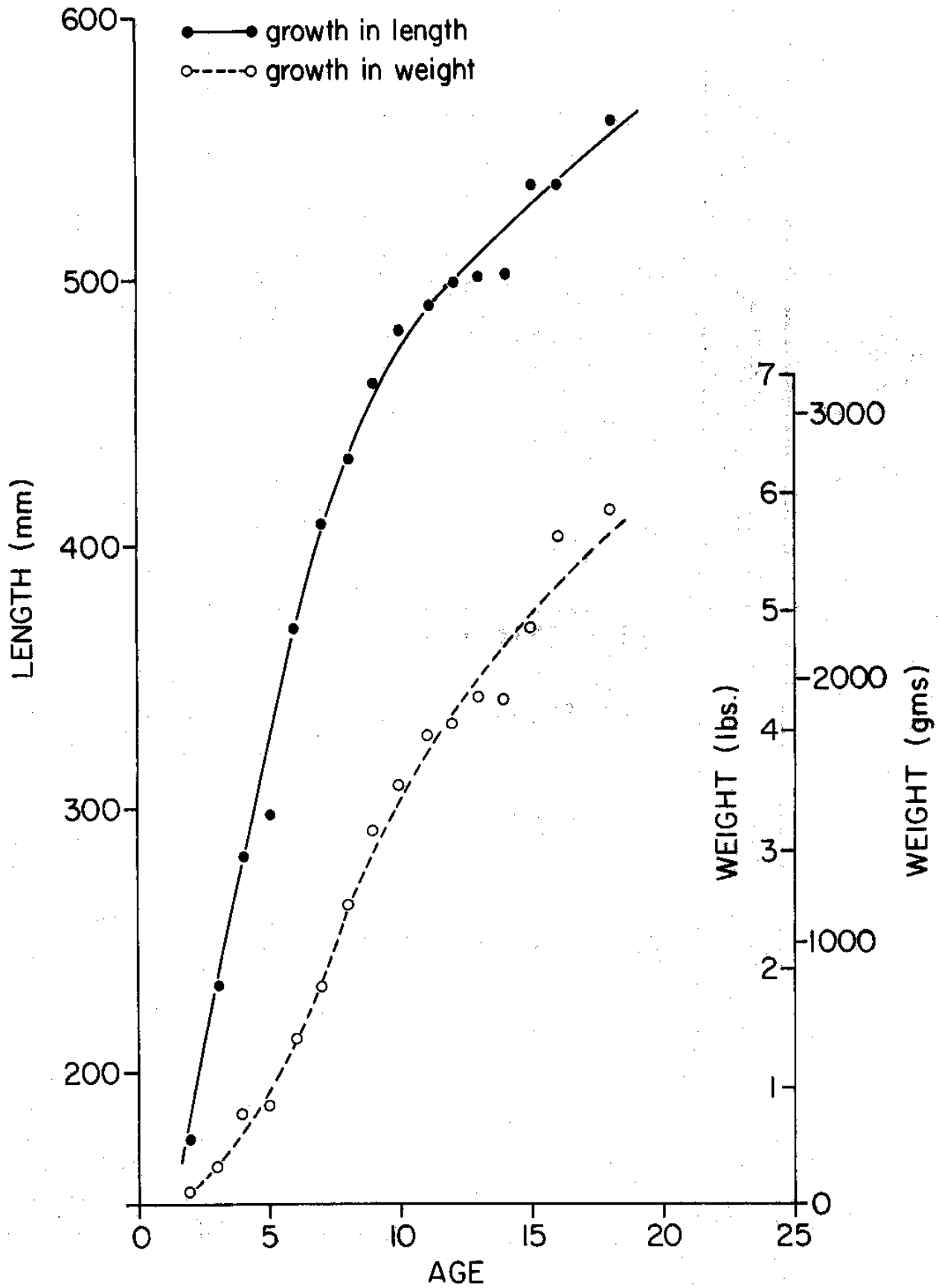
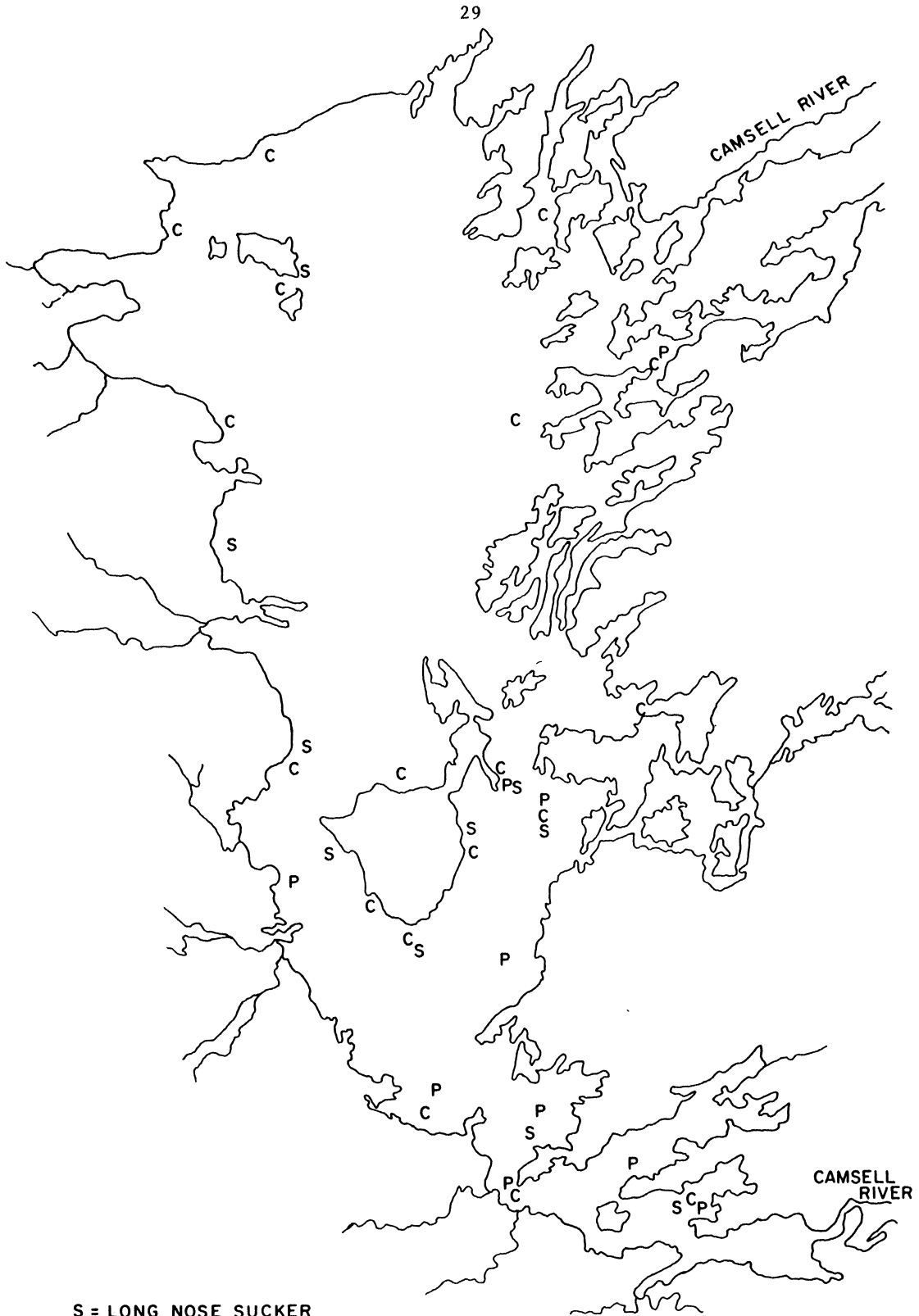


Figure 6. Growth in length and weight of whitefish.



S = LONG NOSE SUCKER
 P = NORTHERN PIKE
 C = CYSTS IN WHITEFISH

Figure 7. Distribution of northern pike, longnose suckers and Triaenophorus sp. infested whitefish.

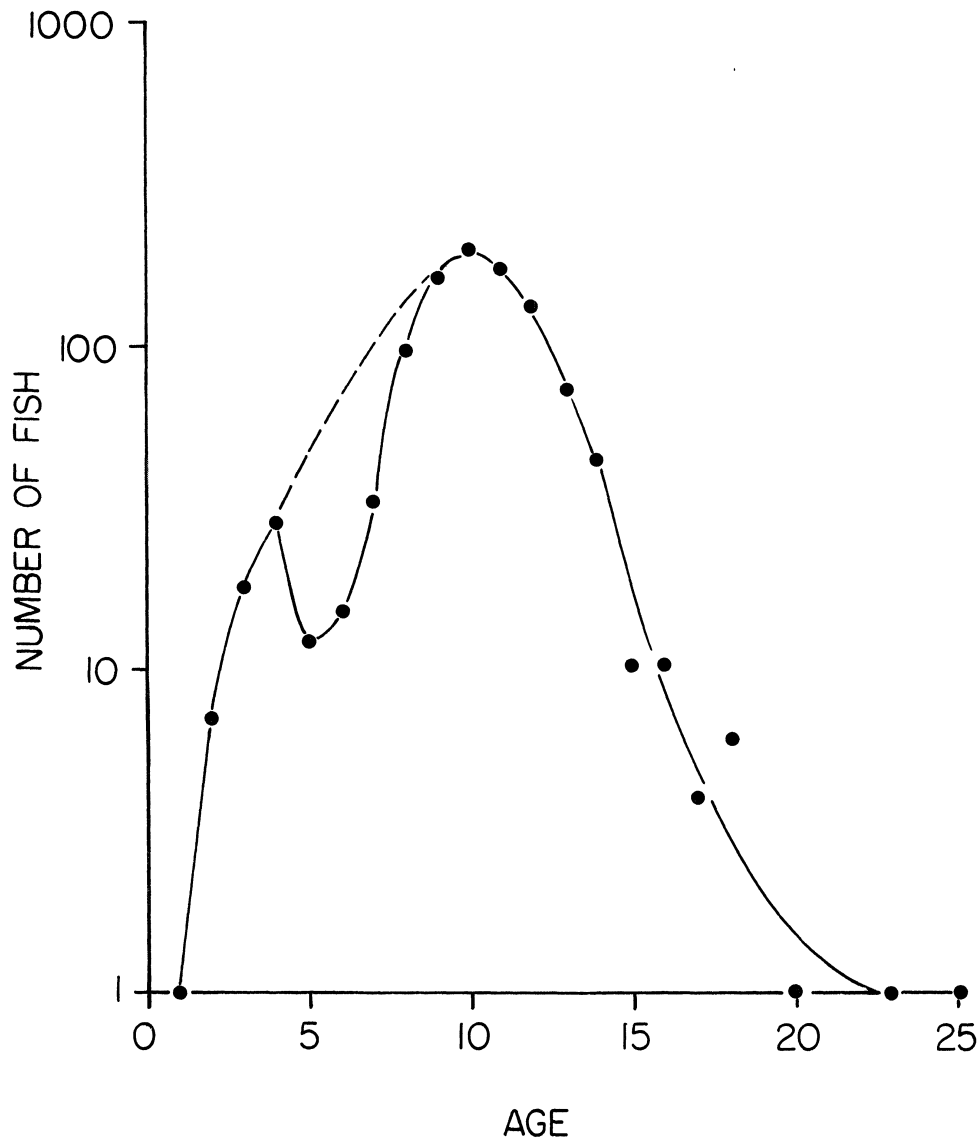


Figure 8. Catch curve of whitefish.

The food consumed by whitefish (Table 11) was mainly benthic and tends to parallel the composition of the benthic communities. Sphaeriids and amphipods are the main food items of the fish. Oligochaets, which were relatively abundant in the bottom fauna, were not apparently utilized by the whitefish.

Lake Trout

The growth of lake trout, characteristic of a subarctic lake, is slow (Fig. 13). A weight of 5 lbs (2.2 kg) is achieved by trout in the range of 10 or 11 years. Hottah's trout have a length-weight relationship of $\text{Log Wt} = -5.1960 + 3.09 \text{ Log L}$ (Appendix 10). The condition coefficient of each age group is listed in Table 12. Development with respect to length and weight is comparable between sexes (Table 12). There is also a similarity in the length weight relationships of males and females. Sexual maturity was noted in over 98% of the eight year old fish (Table 12), and sex ratios for all ages are approximately equal. Accordingly, the incidence of sexual dimorphism is low in lake trout.

The catch curve of lake trout (Fig. 10) is erratic and difficult to interpret. The catches according to mesh sizes of gill nets are presented in Table 13.

The food of lake trout is primarily fish (58.5%, and secondarily insects (17.7%). Although sticklebacks were present in great numbers in the stomachs, ciscoes, because of their size, made up the main diet of trout (Table 14) . Close to 24% of the trout sampled had empty stomachs.

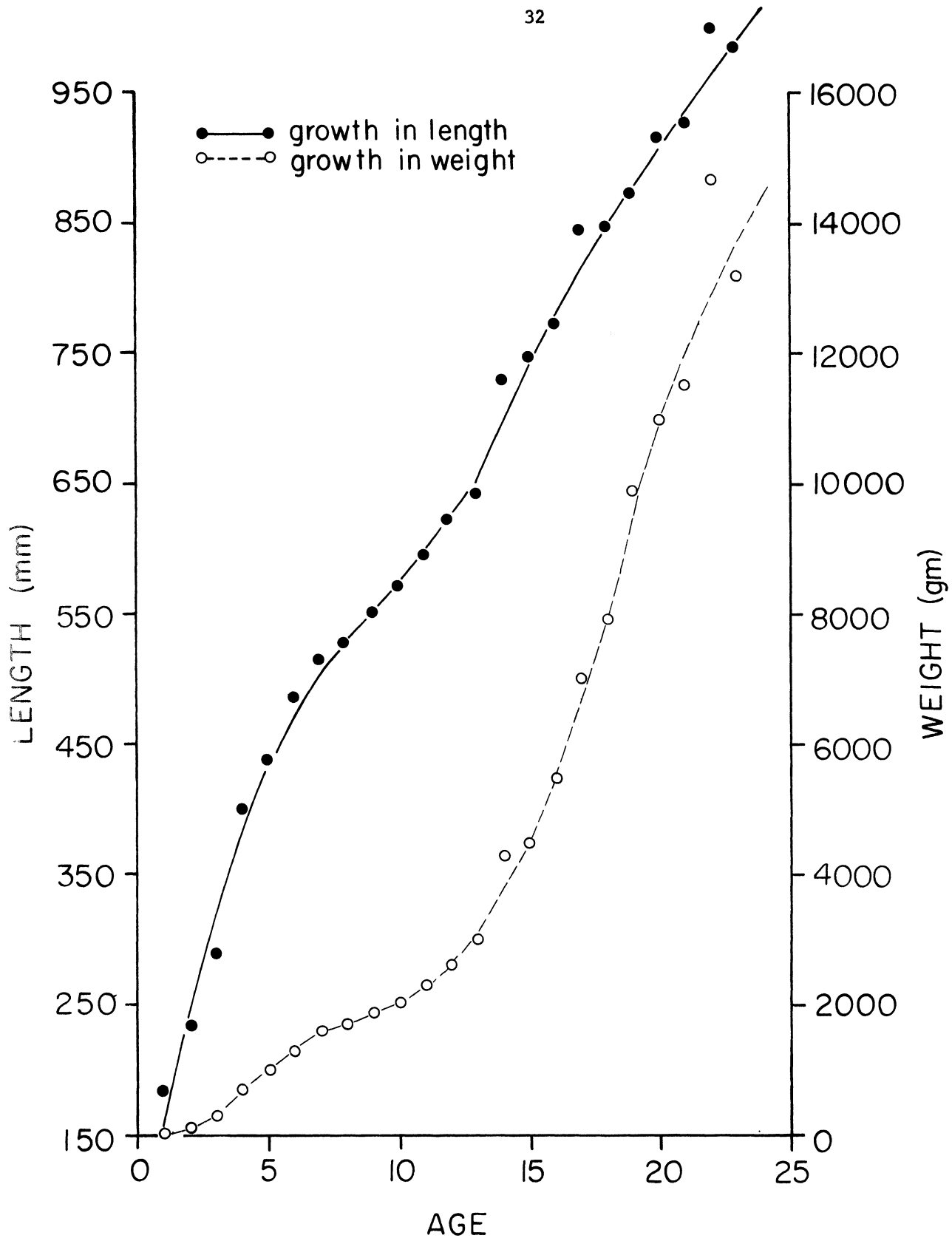


Figure 9. Growth in length and weight of lake trout.

Table 10. Gill net catches of whitefish according to mesh sizes

Mesh size	A G E																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1½	1	7	13	10	5	2	5	13	21	15	11	19	6	4		2		1				
2½			6	18	3	6	11	22	40	43	45	20	15	15	3	2						
3½					3	7	11	38	63	67	45	35	21	8	1	4	1					
4½					1		4	11	26	44	45	37	14	7	6	2	2	5		1		1
5½							1	12	16	38	24	24	18	10	2	5	1					

Table 11. Stomach contents of whitefish

Food	% weight
Sphaeriids (with shells)	38.59
Amphipods	28.56
Gastropods (with shells)	13.22
Tricoptera	6.91
Chironomids	6.28
Diptera	3.71
Hymenoptera	2.44
Coleoptera	0.29

Table 12. Summary of the biology of lake trout

Age	Number of fish				Percentage immature	Sex ratio Female/Male	Mean length (mm)			Mean weight (gm)			Condition Coefficient
	Total	Immature	Male	Female			Male	Female	Both sexes	Male	Female	Both sexes	
1	4	4	-	-	100.0	-	-	-	187.25	-	-	58.87	0.89
II	14	14	-	-	100.0	-	-	-	234.78	-	-	143.07	1.10
111	5	5	-	-	100.0	-	-	-	289.60	-	-	304.40	1.25
IV	12	12	-	-	100.0	-	-	-	400.25	-	-	742.92	1.15
v	12	6	2	4	50.0	2.00	487.50	464.50	438.58	1655.00	1302.50	1104.91	1.30
V1	22	4	7	8	18.2	1.10	498.80	479.12	486.30	1438.57	1250.00	1312.04	1.14
VII	26	2	16	7	7.7	0.40	510.19	525.86	515.08	1595.62	1702.14	1628.65	1.19
VIII	78	1	47	28	1.3	0.60	530.45	530.71	530.58	1727.45	1720.36	1724.81	1.15
IX	88	-	46	39	0.0	0.80	549.37	557.59	552.08	1848.80	2001.28	1916.73	1.14
X	90	-	46	43	0.0	0.90	571.26	567.51	569.56	2055.87	2053.26	2054.22	1.11
X1	60	-	24	32	0.0	1.30	587.12	603.90	597.16	2239.00	2386.56	2338.76	1.10
XII	33	-	19	13	0.0	0.70	629.00	612.69	623.54	2723.68	2558.46	2655.45	1.09
XIII	10	-	4	6	0.0	1.50	648.50	641.83	644.50	3042.50	3090.00	3071.00	1.15
XIV	10	-	8	2	0.0	0.25	735.38	712.50	730.80	4506.25	3740.00	4353.00	1.11
\V	12	-	8	3	0.0	0.40	755.50	739.33	747.08	4545.00	4696.67	4525.00	i.08
XVI	13	-	4	9	0.0	2.25	829.75	759.78	781.30	6485.00	-5086.67	5516.92	1.16
XVII	17	-	7	10	0.0	1.40	866.57	829.10	844.53	7279.71	6953.00	7087.53	1.18
XVIII	13	-	8	4	0.0	0.50	854.50	817.75	847.61	7932.50	7215.00	7913.08	1.30
XIX	6	-	4	1	0.0	0.25	874.50	560.00	873.50	9362.50	8700.00	9158.33	1.37
XX	5	-	2	3	0.0	1.50	930.00	908.67	917.20	11350.00	10880.00	11068.00	1.43
XXI	2	-	1	1	0.0	1.00	853.00	1005.00	929.00	8730.00	14400.00	11565.00	1.44
XXII	4	-	3	1	0.0	0.30	991.67	1033.00	1002.00	14066.67	16700.00	14725.00	1.46
XXIII	2	-	1	1	0.0	1.00	1009.00	956.00	982.50	12700.00	13400.00	13050.00	1.37

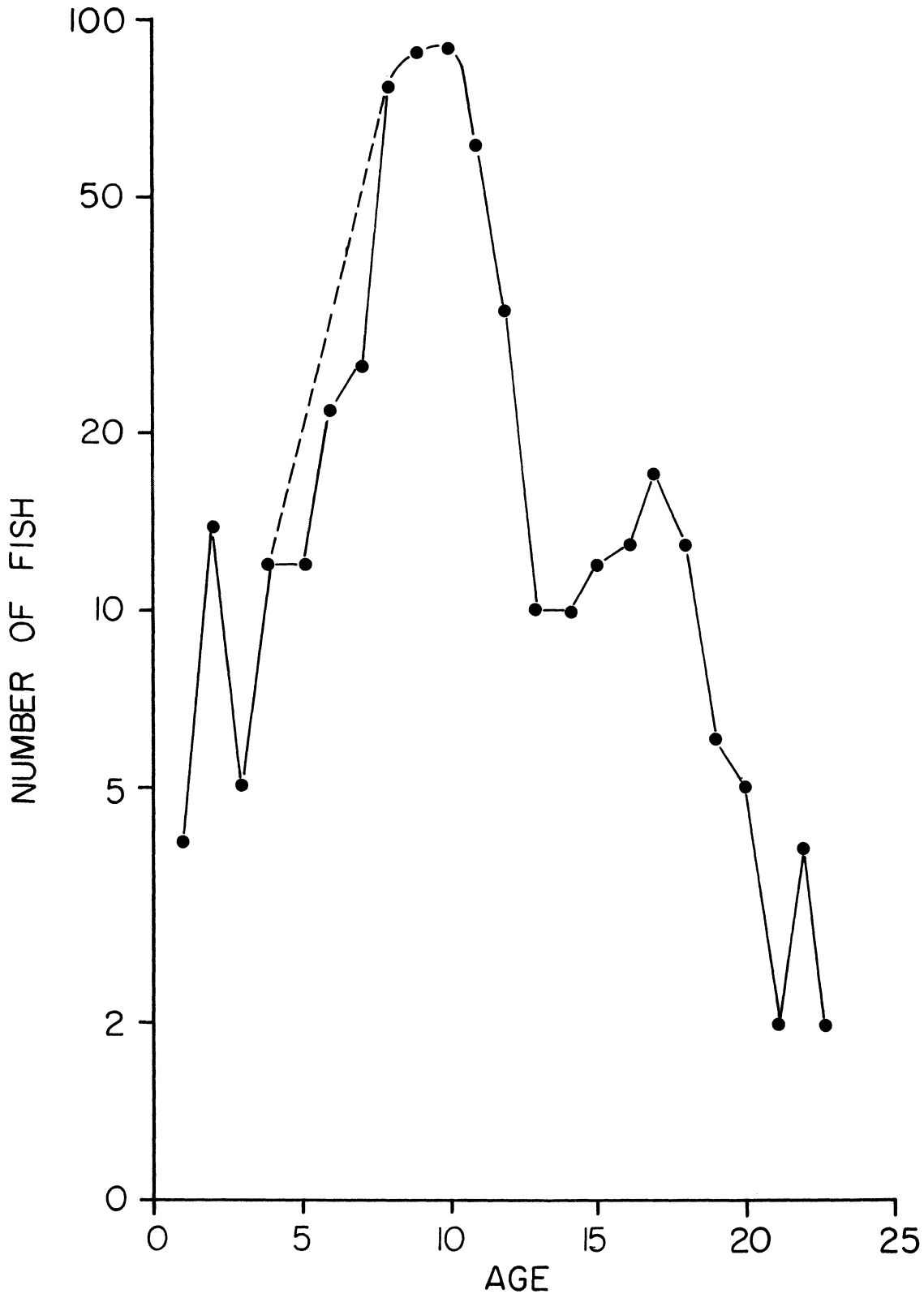


Figure 10. Catch curve of lake trout.

Table 13. Gill net catches of lake trout according to mesh sizes

Mesh size	AGE																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
12	4	11	3	2	2	4	2	6	7	12	4	3	3	2		2	2	1			1		
22		3		1	3	6	6	7	14	11	9	6			1	3	2	4					
32			1	4	3	6	11	18	15	28	21	7	1	3	4	3	5	3	3			2	2
42		1		3	3	7	6	23	34	27	16	9	5	2	3	3	2	2					
52				1	2		2	25	18	13	11	6	1	3	3	1	6	3	2	4	1	2	

Table 14. Stomach contents of lake trout

Stomach contents	% Occurrence	% Number	% Weight
Fish	58.5		
Stickleback		42.1	
Cisco		20.3	
Sculpin		5.1	
Whitefish		4.1	
Burbot		2.5	
Lake Trout		0.5	
Unidentified		26.4	
Insects	17.7		
Coleoptera			33.4
Hymenoptera			19.9
Hemiptera			19.9
Tricoptera			18.4
Arachnids			5.5
Plecoptera			2.3
Empty	23.8		

Northern Pike

Pike were caught in 10 of the 42 net settings. Their distribution seemed to be limited to the shallows along the southern and eastern shores (Fig. 11). On the contrary, whitefish and Triaenophorus sp. infested whitefish were well distributed around the lake (Fig. 11). The difference in distribution of pike and infested whitefish demonstrates that there are migrations of fish in the lake.

Growth of pike is presented in Table 15. The length-weight relationship is $\text{Log Wt} = -4.4684 + 2.77 \text{ Log L}$ (Appendix 10). Food of the pike caught is exclusively fish (Table 16). Large numbers of pike were caught with empty stomachs (30%). The high incidence of empty stomachs in pike and lake trout compliments the evidence that fish production in the lake is low.

Other Fish

Ciscoes and suckers were caught in small numbers. Their growths are presented in Table 15, and their length-weight relationship in Appendix 10. Food items of ciscoes (Table 17) differ greatly from that of whitefish, showing that there is little competition for food between the two species.

Productivity of the Lake

In an attempt to evaluate lake productivity, many authors have considered morphometric, chemical, physical and biological measurements as key indicators of lake productivity. The utilization of one of the different environmental features as a trophic indicator is generally inconclusive and subject to error. To evaluate the trophic condition of Hottah Lake, various factors are examined in Table 18.

Table 15. Summary of weight and fork length of Northern Pike, Ciscoes and Longnose Suckers

Age	Northern Pike		Cisco		Longnose Sucker	
	Length (mm)	Weight (gm)	Length (mm)	Weight (gm)	Length (mm)	Weight (gm)
I	-	-	-	-	-	-
II	-	-	163.4	45.6	-	-
III	-	-	174.2	51.4	159.5	51.0
IV	-	-	181.3	57.4	170.6	63.2
V	-	-	202.5	67.4	175.1	65.3
VI	563.0	1475.0	207.8	75.4	236.7	190.7
VII	634.0	1950.0	274.5	151.0	299.0	449.0
VIII	644.0	1887.5	-	-	328.0	520.0
IX	630.5	1748.3	-	-	359.8	681.8
X	649.5	2008.8	-	-	397.5	1015.0
XI	681.1	2337.5	-	-	334.0	570.0
XII	723.5	2897.7	-	-	-	-
XIII	699.0	2360.0	-	-	-	-
XIV	724.2	2872.0	-	-	-	-
XV	730.7	2916.2	-	-	-	-
XVI	-	-	-	-	-	-
XVII	980.0	7100.0	-	-	-	-
XVIII	877.0	5350.0	-	-	-	-
XIX	-	-	-	-	-	-
XX	817.0	4220.0	-	-	-	-
XXI	-	-	-	-	-	-

Table 16. Stomach contents of Northern Pike

Stomach contents	% Number
Ciscoes	28 .6
Sticklebacks	16.3
Burbot	8.2
Lake Whitefish	2.0
Suckers	2.0
Unidentified fish	42 .9

Table 17. Stomach contents of Ciscoes

Food	% Weight
Mysids	68 . 4
Chironomids (larvae and pupae)	23.5
Oligochaets	6.2
Amphipods	1.8
Nematodes	0.1

Table 18. Productivity of Hottah Lake

Tropic Indicators	Measurements	Productivity	Reference for Standard
Morphometric			
mean depth	18.9 m	medium	Rawson (1955)
transparency (secchi disc)	5.5 m	medium	Rawson (1955)
area	27,060 acres	low-medium	Rounsefell (1946)
Chemical			
total dissolved solid	55 mg/1	very low	Northcote and Larkin (1956)
or specific conductivity	100 M mho		
bottom oxygen	10 mg/1	very low	Hutchinson (1957)
total alkalinity	45 mg/1	medium	Moyle (1946)
phosphorous	0.005 mg/1	low	Moyle (1946)
Morpho-edaphic index	2.91	low	Ryder (1972)
Thermal			
water temperature (0-10m)	12.4°C	low	Northcote and Larkin (1956)
temperature stratification	unstable	low	Hutchinson (1957)
Biological			
plankton crop	17 Kg/ha	very low	Rawson (1953)
benthos crop	6.4 Kg/ha	low	Rawson (1953)
fish wt /50 yds net	9.7 Kg	very low	Rawson(1951)

The presence and absence of certain plant or animal species in a lake has also been considered as a criterion for evaluating lake trophic condition. Since the success of organisms in a lake depends on the primary lake characteristics, such as its morphometry, chemical and physical properties, their function as an indicator of productivity is generally secondary. Nevertheless, plankton species observed in Hottah Lake (Appendix 7) correspond to those submitted by Rawson (1956) as characteristic of an oligotrophic lake.

Sport Fishing

The principal sport fish is the lake trout while pike and grayling are also readily attainable. Lake trout are widespread in early summer and easily caught from rocky shores or in boats by casting and trolling. In August they become elusive near shore and appear to have moved to deeper waters. They also seem more particular than about the bait they will take. Lake trout were taken successfully on four lures: red and white; Len Thompson yellow with black diamonds; a Thompson green with black spots; and a Thompson yellow with red diamonds. The southern part of the lake was shallow and poor trout water but the middle and north were excellent, especially in certain channels where a few minutes trolling always resulted in a catch. Trophy fish up to 35 lbs have been landed by net although angling resulted in catches up to 20 lbs. Flesh colour varied from white to orange-red, the latter being the better tasting.

Pike are caught mainly in weedy bays and channels in early summer but move out along the shores as the season progresses. They were angled successfully at all times of the summer by casting or trolling with almost any bait. In the shallow southern part of Hottah Lake, pike are the

predominant sports fish while their abundance is reduced in the north. Maximum size angled was 20 lbs.

Grayling are abundant in the rivers of the lake at all times of the summer. However in August their activity increases and they are also found in small schools moving along the shore. Grayling were effectively lured by #0 and #1 Mepps, dry and wet flies.

DISCUSSION AND CONCLUSIONS

Hottah Lake is divided into two morphological regions which are a direct result of its position across the boundary of the Precambrian Shield. Similar physiographic divisions are seen in Great Slave Lake (Rawson 1950) and in Nettilling Lake on Baffin Island (Oliver 1964). Besides the differences in their geomorphological features, the thermal properties and the water qualities also differ considerably in these two lake regions.

In Hottah Lake, the two regions, western and eastern, differ substantially in basin configuration and in the number of islands, but little in other ways. Little physical, chemical and biological variations were found in the lake proper. Uniform water qualities appear to be the result of water circulation in the lake. Undoubtedly, variations may be found in some isolated channels and bays along the eastern shore, but insufficient data were collected in these areas to demonstrate differences. Hottah Lake, in this study, is considered as a whole to be without any physical or biological divisions.

The length axis of Hottah Lake is north-south (Fig. 2). Analysis of 1972 summer wind data and past data (Rawson 1947) for this general area (Port Radium) shows that the predominant wind directions are also along this axis. Consequently, winds play a large role in determining the thermal conditions in the lake. Stratification was observed in the lake when warm calm days occurred consecutively, but with the first gust of strong wind the formation of a stable thermocline was disrupted. The gentle temperature gradient in the lake (Fig. 5) suggests that partial mixing of lake water persisted throughout the summer.

Complete turnover of the lake occurred during spring and fall when the lake water was homothermal. The high temperature of 12.5°C when homothermy was achieved in the fall suggests that a prolonged period of mixing occurred in the lake. Thus Hottah Lake, according to Hutchinson's lake classification (1957), is a dimictic lake of the second class.

The various parameters measured demonstrated that Hottah Lake ranges from moderate to very low in production. The size and configuration of the basin indicates that the lake can be moderately productive or mesotrophic. Water chemistry, on the other hand, shows that the edaphic conditions in the lake basin is unfavourable for a productive community. In addition, the thermal properties of the lake are representative of an unproductive lacustrine system. Consequently, the biological standing crops in the lake can be expected to be low as were observed in the study.

Great Slave Lake, the Camsell River System and Great Bear Lake straddle the boundary of the Precambrian Shield. However, the main water sources of the Camsell River System, like those of Great Bear Lake (Rawson 1951) and the eastern half of Great Slave Lake, are within the Shield. Rawson (1951) demonstrated that lakes with water originating from the hard rocks of the Canadian Shield generally contain less minerals and are usually less productive than those from the softer rocks of the Interior Plain. Great Bear Lake and the Eastern Arm of Great Slave Lake (McLeod Bay) have been shown to be very unproductive. The Camsell River System would accordingly be low in productivity as was observed in Hottah Lake.

Hottah Lake, though unproductive, does not approach the extreme oligotrophic condition of Great Bear or the Eastern Arm of Great Slave Lake. The main basic differences are morphometric. Hottah is small and shallow compared to Great Bear Lake and McLeod Bay. According to Rounsefell (1946) and Rawson (1952) these morphometric differences would indicate Hottah is a more productive lake. Along the Camsell System, Hottah is by far the largest lake covering over 45% of the water area. Other lakes in the chain are smaller, and judging from their early ice breakup, they are most likely much shallower. It would seem that most lakes along this system would be more productive than Hottah Lake.

Hottah Lake is in the District of Mackenzie, Control Area II, which was designated for fishing on a six-year cycle, with 2 years open and 4 years closed. The quota on the lake was ½ lb whitefish and trout annually per acre (or 651,483 lbs per six year cycle). The past fishing activities in Hottah Lake are poorly documented. Available data show that intensive commercial fishing between 1963 and 1966 harvested 1,163,082 lbs of whitefish and trout (Table 1). It is difficult to assess the impact of commercial fisheries at the present quota since the quota was exceeded in 1963 and 1966.

The direct effect of commercial fishing between 1963 and 1966 on adult whitefish cannot be ascertained from the catch curve. The mean age of whitefish caught with 5½" stretched mesh gill net is 11 years old. The bulk of the fish removed commercially from 1963 to 1966 would be in their late teens and early twenties during the sampling of this study. These age groups represent a very small proportion of the population and fall beyond the range of the catch curve (Fig. 8). Survival rates of fish 10 years or older, estimated for 1972 according to Robson (1961), is 62%.

The low mortality rate of these fish implies that an adequate recruitment of matured fish is present to propagate and maintain the population. In other words, a 6 year closed season for commercial fisheries leaves sufficient time for the rebuilding of population and ensures an adequate number of commercial size fish for fisheries.

At the present cycle with a 4 year closed season, some ages of whitefish (29% by weight) which were exploited during the two years cycle would be under fishing pressure again after 4 years of sanction, whereas with 6 years of closed season, only the very old fish (8% by weight) would be harvested again. On the other hand, a prolonged closed season to commercial fisheries for 8 or 10 years would be undesirable. Offspring from the previously commercially exploited fish would attain the commercial size after 8 years. If year-class strength of the newly recruited commercial size fish was reduced due to the removal of spawning fish previously, a decrease in harvest would undoubtedly result. Furthermore, a group of potentially harvestable fish would be forfeited to natural mortality through prolonged sanction. It would seem that a 6 year closed season is a useful period for the management of the populations in Hottah Lake.

The catch curve of whitefish also shows an interesting situation. A large group of fish between the ages of 5 to 8 seems to be partially missing. Ricker (1968) in his interpretation of catch curves suggests a missing group on the ascending limb of the curve to be the result of net selectivity. In many cases, because of the choice of mesh sizes in a test gang, a small group of fish may fall in the inefficient ranges of nets of adjacent mesh sizes. In our case, four consecutive age groups ranging from sizes of 300 to 425 mm were lacking; the poor representation

of such a large group cannot be attributed to net selectivity alone. Both younger and older fish were susceptible to 1½" and 2½" mesh size gill nets (Table 9) and there is little cause to assume these nets were ineffective towards the 5 - 8 year old fish. The fact that these age classes also correspond to the offspring which were heavily fished in the years 1963 - 1966 cannot be dismissed as coincidence. Commercial fisheries, in view of the above, appear to have had a prominent effect on the success of year classes.

A variety of compensating reactions may occur when a fish population is under exploitation stress. Larger members tend to have increased growth rates and fecundity, and reduced ages of sexual maturation, while smaller members have reduced mortality (Regier and Loftus 1972). If the level of exploitation does not exceed the compensating reaction, the population can maintain itself. From this study, it seems that the quota (in terms of poundage) of the lake should not be exceeded in order to maintain the population and a reduced quota in terms of poundage may be in order.

If an 8 year fishing cycle (2 years open and 6 years closed) is adopted, a revision of the quota in terms of poundage is also required. The present quota permits the harvesting of ½ lb/acre annually over 6 year period (651,483 lb) taken with the 2 years open fishing. An extension of the cycle to 8 years would increase the poundage that can be removed during the 2 years open season to 868,644 lbs. Fishing in this magnitude, as seen earlier, may affect the year-class strength of the offspring. An adjustment to ½ lb/acre annually (434,322 lbs) would reduce the fishing pressure and relinquish an adequate spawning population to maintain year-class strength.

The commercial fishing between 1963 and 1966 appears also to have had an influence on the trout population in Hottah Lake. A poor representation of ages 5 - 7 in trout as in the case of whitefish can be seen on the ascending limb of the catch curve (Fig. 9). A clear interpretation cannot be obtained because of the effect of possible selectivity by smaller nets. It cannot be certain whether the year-class strength was lowered as a result of the commercial fisheries.

The descending limb of the catch curve is markedly concave upward. Ricker (1968) attributes the concave character of a catch curve to a decrease in natural mortality with age, or the outcome of a recent exploitation of the stock as a whole. The mode of fish caught by a 5½" stretches mesh gill net is 8 years old (Table 13). The group of fish under the maximum fishing pressure during the fishing activities of 1963 to 1966 would be about 14 - 17 years old at the time of sampling in this study. The coincidence of these age groups to those of greater mortality rates does not dispute the possibility that there is a decrease in natural mortality with age.

Age of maturity for lake trout in Hottah is eight years old. The mode of fish caught with 5½ stretched mesh gill net is also eight. To harvest fish at the onset of their maturity would reduce the spawning population and possibly the year-class strength. In addition, trout in Hottah do not attain commercial size until 12 years of age. The slow growth rate and the susceptibility of small fish to 5½" gill nets demonstrate that trout in Hottah cannot sustain any serious fishery pressure.

Hottah Lake lies on the main corridor connecting Yellowknife and the towns and settlements in Great Bear Lake. The annual winter road and the proposed highway (dated back to the nineteen fifties)

demonstrate the inevitability of the area being opened up in the near future. With increased accessibility, the recreation appeal of the lake will be greatly enhanced.

The climate of the area is pleasant with mild summer temperatures in the high sixties. Clean, sandy beaches, scattered around the lake, offer favorable sites for camp grounds and fishing lodges. Good sport fishing and shore lunches are ensured by the trout and grayling in the lake. The large lake area and the surrounding small lakes present numerous fishing grounds with different settings for anglers. With improved transportation Hottah Lake can prove to be a favorable sport fishing ground. However, sport and commercial exploitation cannot likely co-exist in a lake with as delicate a lake trout population as Hottah's.

RECOMMENDATIONS

1. The quota set for Hottah Lake should be adhered to strictly and excess exploitation must not be tolerated.
2. A revision of quota for Hottah Lake should be made. An extension of the fishing cycle from 6 to 8 years (2 years open and 6 years closed) would allow the rebuilding of commercial size fish in the lake.

To compensate for the increase in the fishing cycle, which would intensify the harvest over the two years open fishing, it would be advisable to reduce the quote to $\frac{1}{4}$ lb/acre annually, thus permitting a larger surviving spawning population and its resultant strengthened year-classes.

3. Other lakes along the Camsell River System are perhaps more productive and may sustain the present quota. (Future study)
4. In a limited area such as the Camsell River System, two levels of quota are required; it is obvious that a multi-level quota system should be considered for the whole of the territories rather than blanketing a variegated region with a uniform quota as is the present practice.
5. A minimum size of 6 $\frac{1}{4}$ " stretched mesh gill net has proved itself in deterring over-exploitation of spawning fish in Lac La Martre (Bond 1973) and could prove itself again in Hottah Lake.

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Appendix 1. Summary of the atmospheric conditions in Port Radium

Date	Temperature			Precipitation (inches)	Station Pressure (mb)	Relative Humidity %
	Water Surface °C	Air Max. °C	Air Min. °C			
July						
1	-	13.89	5.56		1000.2	64
2	-	6.67	2.78	.01	1002.3	87
3	-	7.22	2.22		1005.9	93
4	6.	16.67	1.67		1006.5	92
5	-	17.78	9.44		1006.3	68
6	11.	22.22	11.64		1001.5	58
7	11.5	12.22	3.33	.02	990.8	67
8	6.5	11.11	1.67	.27	996.3	88
9	10.5	17.22	3.89		993.8	79
10	12.5	16.67	6.11		990.5	79
11	14.	12.78	5.00		988.8	81
12	9.	10.00	5.56		990.3	59
13	12.	11.11	3.33		989.1	58
14	15.	16.67	6.11		984.2	49
15	14.5	16.11	7.78		986.7	59
16	13.5	12.78	6.11		997.1	65
17	13.	15.56	4.44		1001.4	71
18	13.	15.56	6.11		1001.2	70
19	14.	20.00	7.22	.08	998.4	63
20	15.	17.78	6.67		995.1	77
21	16.	14.44	5.00	.21	993.1	90
22	13.	14.44	5.00	.11	997.6	89
23	12.5	12.22	5.56		1000.7	80
24	12.	14.44	5.56	.26	1001.6	79
25	13.5	21.11	8.33	.01	1001.0	78
26	18.	25.56	14.44		995.9	60
27	18.	24.44	15.56		988.3	54
28	18.	19.44	13.33	.02	986.5	68
29	18.	15.00	7.78		990.8	64
30	15.5	8.89	2.78		995.9	80
31	15.5	11.67	2.78		999.0	81

Appendix 1. Summary of the atmospheric conditions in Port Radium

Date	Temperature			Precipitation (inches)	Station Pressure (mb)	Relative Humidity %
	Water Surface °C	Air max. °C	Air Min. °C			
August						
1	15.5	16.64	6.67		998.8	69
2	16.5	11.67	4.44	.03 R	992.2	63
3	15.2	7.78	3.89	.02 R	994.8	78
4	14.	13.89	2.78		996.0	85
5	14.	12.78	10.00	TR R	988.4	64
6	15.	21.67	9.44		983.9	77
7	15.	18.33	9.44	.19 R	986.2	82
8	15.	11.67	6.11	TR R	985.0	94
9	13.5	12.22	5.56		985.2	85
10	13.	11.11	4.44	TR R	993.0	84
11	13.5	16.67	6.11	.06 R	993.9	96
12	13.5	12.22	6.11	.04 R	987.7	75
13	13.5	15.56	8.89		988.6	90
14	13.5	16.67	9.44	.06 R	988.0	80
15	13.	18.89	10.56		983.9	85
16	14.	15.00	5.56	TR R	983.9	96
17	16.	20.00	8.89	TR R	988.4	92
18	15.	17.78	7.22		991.1	96
19	15.	17.78	8.33		991.8	80
20	16.	20.00	11.67		990.0	54
21	16.	18.89	7.78	TR R	987.4	87
22	17.	22.78	10.56	.13 R	987.1	59
23	-	22.78	15.56		985.8	77
24	17.	23.89	12.78		979.1	79
25	17.	12.78	6.11		976.9	90
26	16.5	12.78	8.33		982.0	70
27	15.5	7.78	3.33		986.6	81
28	15.5	10.56	3.89		992.3	71
29	15.	12.78	7.22		986.5	73
30	14.	9.44	4.44		988.4	90
31	14.	12.78	6.11	TR R	992.4	72

Appendix 1. Summary of the atmospheric conditions in Port Radium

Date	Temperature		Air Min. °C	Precipitation (inches)	Station Pressure (mb)	Relative Humidity %
	Water Surface °C	Air Max. °C				
Sept.						
1	14.5	10.56	7.78		986.8	75
2	10.5	3.89	-0.56	.04 R, .3 S	987.7	74
3	9.	5.00	0.00		1000.0	73
4	9.	3.33	-1.67		1003.5	70
5	11.5	6.11	-2.78		1000.6	75
6	8.	7.78	1.67		996.2	79
7	9.	7.22	3.33	.01 R	991.5	83
8	10.	5.56	2.22		990.7	82
9	-	3.89	0.56	.01 S	988.4	78
10	10.	2.78	-1.11	.02 S	989.0	78
11	9.	3.89	-0.56	.01 S	991.6	70
12	9.	3.33	0.56	TR S	993.5	76
13	9.	2.22	-2.22		989.1	72

Appendix 2. Temperature profiles at the different stations in the lake

Depth (m)	J U L Y														
	4	6	8	9	12	13	17	19	20	21	22	24	28	29	31
0	6.0	11.5	8.5	11.75	12.5	13.0	12.75	16.0	16.0	16.25	12.5	12.25	17.5	16.5	15.5
1	6.0	11.25	8.5	11.5	12.5	13.0	9.75	14.75	16.0	16.25	12.5	12.0	17.5	16.5	15.5
2	6.0	11.0	8.25	11.25	12.5	13.0	9.5	14.25	15.25	16.25	12.5	12.0	17.25	16.5	15.5
3	5.75	11.0	8.25	11.0	12.5	12.5	9.5	13.5	14.25	16.75	12.5	12.0	17.0	16.25	15.25
4	5.75	10.75	8.25	10.0	12.0	10.5	9.25	12.75	13.25	16.25	12.5	11.5	17.0	16.0	15.25
5	5.75	10.75	7.75	9.25	11.0	10.5	8.75	12.5	12.5	16.0	12.5	11.75	16.75	16.0	15.25
6	5.75	10.5	7.5	9.0	10.5	10.25	8.0	12.0	12.0	15.0	12.5	10.25	16.25	15.75	15.0
7	5.75	9.25	7.5	8.25	9.75	10.0	5.75	11.5	11.75	14.5	12.5	9.75	15.75	15.75	14.75
8	5.75	8.5	7.5	8.25	8.5	9.5	5.5	10.0	11.5	13.25	12.5	8.75	14.75	15.5	14.5
9	5.75	8.25	7.5	8.25	8.0	9.5	5.25	9.0	11.25	12.75	12.5	8.25	13.5	15.25	14.25
10	5.75	8.0	7.25	7.5	8.0	9.5	5.0	8.75	10.75	12.25	12.5	8.25	10.75	13.75	14.0
11	5.75	7.5	7.25	7.25	7.75	9.0	5.0	8.25	10.5	12.0	12.5	8.25	9.25	11.5	12.75
12	5.75	7.0	7.0	7.0	7.75	8.5	5.0	8.0	10.25	11.75	12.0	8.25	8.0	7.5	11.75
13	5.75	6.75	7.0	6.75	7.75	8.0	4.75	7.5	10.25	10.75	8.0	8.0	8.0	7.25	11.5
14	5.75	6.75	6.75	6.5		7.75	4.75	7.25	10.0	10.25	8.0	8.0	7.5	7.0	11.5
15	5.5	6.5	6.75	6.5		7.5	4.5	7.0	9.5	9.75	7.5	8.0	7.25	7.0	11.0
16	5.5	6.5	6.75	6.5		7.0	4.5	6.75		9.75	7.2	7.25	6.75	6.75	11.0
17	5.5	6.0	6.75	6.5		7.0	4.5	6.75		9.25	6.9	6.75	6.5	6.5	10.75
18	5.5	5.5	6.75	6.5		6.75	6.5	6.5		8.75	6.7	6.0	6.0	6.25	10.0
19	5.5	5.5	6.75	6.5		6.75	6.5	6.5		8.25	6.6	5.5	5.5	8.0	8.25
20	5.5	5.0	6.75	6.5		6.75	6.5	6.5		8.0	6.5	5.5	5.5	8.0	8.0
21	5.5	4.5	6.75	6.5		6.5	6.5	6.5		7.75	6.2	5.5	5.5	8.0	8.0
22	5.5	4.5	6.5	6.5		6.5	6.5	6.5		7.75	6.0	5.5	5.5	8.0	7.75
23	5.5	4.5	6.5	6.5		6.5	6.5	6.5		7.75	5.8	5.5	5.5	8.0	7.75
24	5.5					6.5	6.5	6.5			5.8	5.5	5.5	8.0	7.75
25						6.5	6.5	6.5			5.8	5.5	5.5	8.0	7.75
26						6.5	6.5	6.5			5.8	5.5	5.5	8.0	7.75
27						6.5	6.5	6.5			5.8	5.5	5.5	8.0	7.75
28						6.5	6.5	6.5			5.8	5.5	5.5	8.0	7.75
29						6.5	6.5	6.5			5.9	5.5	5.5	8.0	7.75
30						6.5	6.5	6.5			5.9	5.5	5.5	8.0	7.75
31						6.5	6.5	6.5			5.9	5.5	5.5	8.0	7.75
32						6.5	6.5	6.5			5.9	5.5	5.5	8.0	7.75
33						6.5	6.5	6.5			5.9	5.5	5.5	8.0	7.75
34						6.5	6.5	6.5			5.9	5.5	5.5	8.0	7.75
35						6.5	6.5	6.5			5.9	5.5	5.5	8.0	7.75

Appendix 3. Water chemistry at the different stations in the lake

Date	Surface	<u>Dissolved oxygen mg/1</u>			<u>Carbon dioxide mg/1</u>			pH	Conductivity Mmho	mg/1	Hardness mg/1	Alkalinity mg/1
		Middle	Bottom	Surface	Middle	Bottom						
July												
4	12	11	11	0.8	0.8	0.8		7.6	70	-		
6	15	15	12	0.4	0.4	0.4		7.9	95	-	-	
8	10	9	8	0.4	0.4	0.4		7.8	90	35	45	
9	11	11	13	0.4	0.4	0.4		7.9	100	35	50	
12	12	11	11	0.4	0.4	0.4		8.0	100	35	40	
13	12	12	11	0.8	0.8	0.8		7.9	110	35	40	
17	12	12	12	0.4	0.8	0.4		8.2	110	35	45	
19	13	12	12	0.4	0.4	0.4		7.9	100	35	45	
21	11	12	12	-	-	-	-	-	-	-	-	
24	12	-	12	0.4	-	0.4		8.0	-	40	50	
27	10	-	-	0.8	-	-	7.8	-	35	45		
29	9	10	11	0.8	-	0.8		7.9	120	45	45	
31	10	-	10	0.4	-	0.4		7.9	110	30	40	
August												
1	8	-	10	0.4	-	0.4		7.9	100	35	40	
3	10	10	10	0.4	-	0.4		7.7	95	40	50	
10	12	-	12	0.4	-	0.4		7.9	-	40	40	
16	13	13	11	0.8	-	0.8		7.8	95	35	40	
19	11	11	10	0.4	-	0.4		8.0	90	-	45	
25	11	-	11	0.4	-	0.4		8.0	-	45	50	
27	10	10	9	0.4	-	0.4		7.8	110	35	55	
31	10	9	11	0.4	-	0.4		7.7	110	40	55	
September												
10	11	11	11	0.4	-	0.4		8.0	110	35	45	

Appendix 4. Detailed water chemistry of lake water

Method of analysis

Characteristic	Unit	Field-Hachkit	Laboratory
Turbidity	J .T .U.	0.0	0.59
Colour		0.0	0.0
Specific conductance	Mmho /cm	100.0	143.0
pH		7.9	7.7
Chloride: dissolved	mg /1	7.5	2.0
Copper: dissolved	mg/1	0	0.002
Iron: dissolved	mg/1	0.05	0.16
Lead: dissolved	mg/1	-	0.005
Manganese: dissolved	mg/1	0.5	0.005
Nitrogen: total	mg/1	0.0	0.33
Nitrogen: Nitrate, Nitrite diss.	mg/1	0.0	1.7
Phosphorus: total	mg/1	-	0.005
Phosphorus: Ortho Phosphate diss.	mg/1	-	0.003
Phosphorus: diss.inorg.Phosphate	mg/1	0.0	0.003
Alkalinity: total	mg/1	45.0	51.8
Hardness	mg /1	35.0	-
Hardness: total	mg/1	65.0	64.4
Calcium: dissolved	mg/1	-	15.5
Fluoride: dissolved	mg/1	0.25	-
Bromine: dissolved	mg/1	0.0	-
Sulphate: dissolved	mg/1	-	12.2
Silica: reactive	mg/1	-	1.4
Sodium: dissolved	mg /1	-	1.7
Zinc: dissolved	mg/1	-	0.005
Arsenic: dissolved	mg /1	-	0.004
Carbon: total inorganic	mg/1	-	8.0
Carbon: total organic	mg/1	-	9.0
Potassium: dissolved	mg /1	-	0.9
Acidity	mg /1	0.0	0.0
Total acidity	mg/1	0.0	0.0
Calcium Carbonate: diss.	mg/1	10.555*	-
Sodium Chloride: diss.	mg/1	12.375*	-

* calculated from chloride

Appendix 5. Abundance of plankton at different times of the summer

Date	Dry weight per T.V.H.	Ash free dry weight per T.V.H.	Dry weight Kg/ha	Organic matter

July				
7	0.0186	0.0161	17.72	15.337
8	0.0039	0.0018	3.71	1.715
9	0.0316	0.0282	30.10	26.864
12	0.0183	0.0052	17.43	4.954
12	0.0135	0.0107	12.86	10.193
13	0.0179	0.0148	17.05	14.099
17	0.0108	0.0065	10.29	6.192
20	0.0248	0.0164	23.62	15.623
23	0.0108	0.0060	10.29	5.716
23	0.0075	-	7.14	-
25	0.0074	0.0051	7.05	4.858
27	0.0104	0.0071	9.91	6.764
28	0.0234	0.0191	22.29	18.195
August				
2	0.0156	0.0130	14.86	12.384
3	0.0303	0.0193	28.86	18.385
4	0.0210	0.0152	20.00	14.480
6	0.0345	0.0120	32.86	11.431
9	0.0161	0.0120	15.34	11.431
10	0.0157	0.0123	14.95	11.717
12	0.0137	0.0104	13.05	9.907
13	0.0174	0.0091	16.57	8.669
14	0.0225	0.0162	21.43	15.432
16	0.0214	0.0188	20.38	17.909
21	0.0713	0.0156	20.29	14.861
25	0.0191	0.0098	18.19	9.336
30	0.0159	0.0130	15.15	12.384

Appendix 6. List of plankton species identified in the lake

Phytoplankton	Zooplankton
Bacillariophyceae	Protozoa
<u>Asterionella Formosa</u>	<u>Ceratium hirundinella</u>
<u>Ceratium hirundinella</u>	<u>Pediastrum angulosum</u> <u>boryanum</u>
<u>Tabelliria fenestrata</u>	<u>Glenodinium</u> sp.
<u>Melosira italica subarctica</u>	<u>Peridinium</u> sp.
<u>Synedra actinastroïdes</u>	<u>Vorticella</u> sp.
<u>Ulva</u>	
<u>Rhizosolenia eriensis</u>	Rotifera
<u>Cymbella</u> sp.	<u>Kellicotia longispina</u>
<u>Surirella ovalis</u>	<u>Keratella cochlearis</u> <u>quadrata</u>
<u>Amphora ovalis</u>	<u>Polyarthra</u> sp.
<u>Campylodiscus hibernicus</u>	<u>Ascomorpha</u> sp.
<u>Nitzschia</u> sp.	<u>Ploesoma</u> sp.
Chrysophyta	Copepoda
<u>Dinobryon divergens</u>	<u>Cyclops bicuspidatus</u> <u>vernalis</u>
<u>Salpingoeca frequestissima</u>	<u>Disptomus ashlandi</u> <u>sicilis</u>
<u>Rhizochrysis</u> sp.	<u>Epischura lacustris</u>
Chlorophyta	<u>Limnocalanus macrurus</u>
<u>Dictyosphaerium pulchellum</u>	
<u>Ankistrodesmus falcatus</u>	Cladocera
<u>Chlamydomonas</u> sp.	<u>Bosmina longirostris</u>
<u>Zygnema</u> sp.	<u>Daphnia longiremis</u>
<u>Spondylosium</u> sp.	<u>Disphanosoma leuchtenbergianum</u>
<u>Cosmarium</u> sp.	<u>Polyphemus pediculus</u>
<u>Spinocosmarium</u> sp.	<u>Holopedium gibberum</u>
Cyanophyta	
<u>Anabaena flos-aquae</u> <u>circinalis</u>	
<u>Aphanizomenon flos-aquae</u>	
<u>Aphanothece</u> sp.	
<u>Aphanocapsa</u> sp.	
<u>Microcystis</u> sp.	
<u>Oscillatoria splenclida</u> <u>tenuis</u> <u>limosa</u>	
<u>Chroococcus limneticus</u>	

Appendix 7. Abundance of benthic organisms at different depths of the lake

Date	Depth (m)	Total # animals per dredge	Total dry weight per dredge	Dry weight Kg/ha	org/m ²	
July	7	30	0.0162	2.3364	640.7	
	8	56	0.0104	1.4999	807.7	
	9	83	0.0191	2.7547	1197.1	
	17	55	0.0242	3.4903	793.2	
	19	5	0.0048	0.6923	72.1	
	20	94	0.0577	8.3218	1355.7	
	23	97	0.0426	6.1440	1399.0	
	24	42	0.0366	5.2786	605.7	
	27	103	0.0542	7.8170	1485.5	
	28	28	0.0098	1.4134	403.8	
	29	138	0.0712	10.2688	1990.3	
	31	109	0.0252	3.6345	1572.1	
	August	3	52	0.0418	6.0286	750.0
		4	33	0.0085	1.2259	475.9
6		121	0.0503	7.2545	1745.1	
8		2	0.0019	0.2740	28.8	
9		53	0.0307	4.4277	764.4	
10		79	0.0363	5.2354	1139.4	
12		153	0.0580	8.3651	2206.6	
13		41	0.0542	7.8170	799.3	
14		266	0.0570	8.2208	3836.4	
16		43	0.0133	1.9182	620.2	
21		110	0.0243	3.5047	1586.5	
25		60	0.0184	2.6537	865.4	
30		13	0.0083	1.1971	187.5	
September		6	207	0.0994	14.3360	2985.5
	8	118	0.0693	9.9948	1701.9	

Appendix 8. List of bottom benthic organisms identified in the lake

Amphipoda

Pontoporeia affinis H

Hyaella azteca

Gammarus lacustris

Mollusca

Sphaerium sp.

Pisidium sp.

Ammicola sp.

Gyraulus sp.

Valvata sp.

Annalida

Lumbriculidae

Naidium sp.

Chaetogaster sp.

Helobdella sp.

Insecta

Chironomidae (larvae and pupae)

Hydroptilidae (larvae) Molanna (larvae)

Corixidae (nymph and adult) Dytiscus

(adult) Chrysops (larvae) Gomphidae

(nymph)

Nematoda

Appendix 9. List of fish species found in the lake

<i>Coregonus clupeaformis</i> (Mitchill)	Lake whitefish	gill nets
<i>Salvelinus namaycush</i> (Walbaum)	Lake trout	gill nets
<i>Coregonus artedii</i> LeSueur	Lake cisco	gill nets
<i>Esox lucius</i> Linnaeus	Northern pike	gill nets
<i>Catostomus catostomus</i> (Forster)	Longnose sucker	gill nets
<i>Thymallus arcticus</i> (Pallas)	Arctic grayling	angling
<i>Pungitius pungitius</i> (Linnaeus)	Ninespine stickleback	dip net
<i>Lota Iota</i> (Linnaeus)	Burbot	stomach samples
<i>Cottus cognatus</i> Richardson	Slimy sculpin	stomach samples

Appendix 10. Length-weight relationship of fish species in Hottah Lake
 $\text{Log Wt} = a + b \text{ Log L}^*$

Species	Sex	n	a	b	F	P <
Whitefish	both	1040	-5.8507	3.37	663,653.7	0.005
	male	540	-5.7168	3.33	39,890.9	0.005
	female	438	-5.6082	3.29	95,849.3	0.005
Lake trout	both	544	-5.1960	3.09	631.3	0.05
	male	259	-4.9727	3.01	813.7	0.05
	female	210	-5.0726	3.05	3,584.4	0.025
Tulibee**	both	147	-3.2459	2.21	1,789.1	0.025
Pike	both	52	-4.4684	2.77	2,541.3	0.025
	male	24	-4.8203	2.89	336.1	0.05
	Female	28	-4.2027	2.67	1,323.0	0.025
Sucker	both	48	-5.5596	3.29	10,048.9	0.01
	male	6	-4.842	3.01	42.6	0.25
	female	7	-4.9681	3.05	287.7	0.05

Wt = wet weight in gm L
 =fork length in mm a and b
 are constants

Tulibee appear to have several growth stanzas and insufficient numbers were taken to calculate length-weight relationship for the stanza of each sex.

Appendix 11. List of birds sighted in Hottah Lake

Common name	Scientific name
Common Loon	<u>Gavia immer</u>
Arctic Loon	<u>Gavia arctica</u>
Red-throated Loon	<u>Gavia stellata</u>
Red-necked Grebe	<u>Podiceps grisegena</u>
Whistling Swan	<u>Olor columbianus</u>
Bufflehead	<u>Bucephala albeola</u>
Oldsquaw	<u>Clangula hyemalis</u>
Surf Scoter	<u>Melanitta</u> <u>perspicillata</u>
White-winged Scoter	<u>Melanitta deglandi</u>
Common Merganser	<u>Mergus merganser</u>
Golden Eagle	<u>A eila chrysaetos</u>
Bald Eagle	<u>Haliaeetus leucocephalus</u>
Spruce Grouse	<u>Canachites canadensis</u>
American Coot	<u>Fulica americana</u>
Semipalmated Plover	<u>Charadrius semipalmatus</u>
Lesser Yellowlegs	<u>Totanus flavipes</u>
Bonapartes Gull	<u>Larus Philadelphia</u>
Herring Gull	<u>Larus argentatus</u>
Mew Gull	<u>Larus canus</u>
Common Tern	<u>Sterna hirundo</u>
Arctic Tern	<u>Sterna paradisaea</u>
Belted Kingfisher	<u>Megaceryle alcyon</u>
Gray Jay	<u>Perisoreus canadensis</u>
Common Raven	<u>Corvus corax</u>
Common Crow	<u>Corvus brachyrhynchos</u>
Boreal Chickadee	<u>Parus hudsonicus</u>
Robin	<u>Turdus mirgatorius</u>
Swainson's Thrush	<u>Hylocichla ustulata</u>
Bohemian Waxwing	<u>Bombycilla garrula</u>
Brownheaded Crowbird	<u>Molothrus ater</u>
Yellow Warbler	<u>Dendroica petechia</u>
Myrtle Warbler	<u>Dendroica coronata</u>
Sharp-tailed Sparrow	<u>Amospiza caudacerta</u>
Slate-coloured Junco	<u>Junco hyemalis</u>
Tree Sparrow	<u>Spizella arborea</u>
White-throated Sparrow	<u>Zonotrichia albicollus</u>