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The Limnology and Fish Populations of Jacopie Lake, West Forebay, Smallwood Reservoir, Labrador

by W.J. Bruce

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DEPARTMENT OF THE ENVIRONMENT
FISHERIES AND MARINE SERVICE

Fisheries Operations Directorate
Newfoundland Region

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THE LIMNOLOGY AND FISH POPULATIONS OF JACOPIE LAKE, WEST FOREBAY, SMALLWOOD RESERVOIR, LABRADOR.

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St. John's, Newfoundland

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ABSTRACT

A limnological and fish inventory investigation was conducted on Jacopie Lake, Smallwood Reservoir, Labrador, during the summer of 1973. Chemical and physical parameters were measured for the lake. The water area of the lake is 12,070 acres (4,828 ha.) with a mean depth of 26.4 feet (8.1 m.). Results from gill netting showed eight species to be present in the lake. These include lake whitefish, brook trout, longnose sucker, northern pike, lake trout, round whitefish, burbot, and ouananiche. Lake whitefish was the most abundant species but comprised only 13.4 percent of the total sample by weight. Northern pike and brook trout made up 67.5 percent of the catch by total weight.

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INTRODUCTION

The investigation and management of the fish resources of the province's larger lakes and reservoirs is the responsibility of the Lake and Reservoir Fish Stocks Management Unit, Recreational Fisheries Group, Resource Development Branch.

Prior to 1973 this Unit's activities were confined to the island portion of the province. Also, up to this time, very little work had been done by anyone on the waters of inland Labrador. For years there have been angling reports of large fish, particularly trout, in the Labrador area but little was known concerning their general biology. Labrador also has a greater diversity of fish species than the island, including lake trout, whitefishes, suckers and pike. For this reason, and because of the increasing accessibility to inland areas, the Department felt it important that a crew be established in Labrador.

The larger lakes including the largest, Michikamau Lake, are found in western Labrador. The flooding of this and other surrounding lakes in 1971 helped form the vast 2,500 square mile hydroelectric storage reservoir. Undoubtedly the flooding of such a vast area is having dramatic effects on the fish life there. Some of these effects include the removal of spawning beds and habitats, new sources of food, upsetting of the long established balances of temperature and the possibility of a change in species composition. The fish present now find themselves in a changing environment different from the one in which they evolved.

The ideal situation would have been to conduct a baseline study on the lakes before inundation and a later monitoring of the results of flooding. However, this was not the case and we can only register the findings for post-flooding conditions.

The investigation of Jacopie Lake, a portion of the Smallwood Reservoir, last summer, marked the beginning of a long term study of Labrador's inland waters. Besides being an inventory of the fish resources of Jacopie Lake, this study formed the basis of a survey to assess the capacity of the reservoir to sustain a recreational and commercial fishery.

DESCRIPTION OF THE STUDY AREA

The Smallwood Reservoir

The Smallwood Reservoir complex (Fig. 1) lies between 53° and 55° North Latitude and 63° and 66° West Longitude. It is the largest single-site hydroelectric development in the western world. This 2,200 square mile hydroelectric storage reservoir is the third largest man-made lake in the world, with an estimated drainage area of 27,000 square miles. The other two larger bodies of water are the Volta in Ghana with an area of 3,372 square miles and the V.I Lenin in the U.S.S.R. with an area of 2,511 square miles. When it is filled, the Smallwood Reservoir will contain 1,000 billion cubic feet of water and the water level will fluctuate about 28 feet between winter low and spring high. The Smallwood Reservoir will drain an additional 100 billion cubic feet of water from the adjacent Ossokmanuan reservoir through the Gabbro control structure. This 320 square mile reservoir was initially built to supply the Twin Falls power plant.

Filling of the Smallwood Reservoir started on July 1, 1971, with the closure of the gates of Lobstick Structure (Fig. 2). During the initial diversion of the Michikamau complex approximately 1,000 square miles of taiga, low bogland and spruce forest were flooded. Forty miles of low, earth and rock dykes, along with seven major concrete spillways and control structures were constructed to contain and control the water flow in the reservoir.

The Smallwood Reservoir is contained by dykes in two general areas. One series flanks the Lobstick control structure for some miles in either

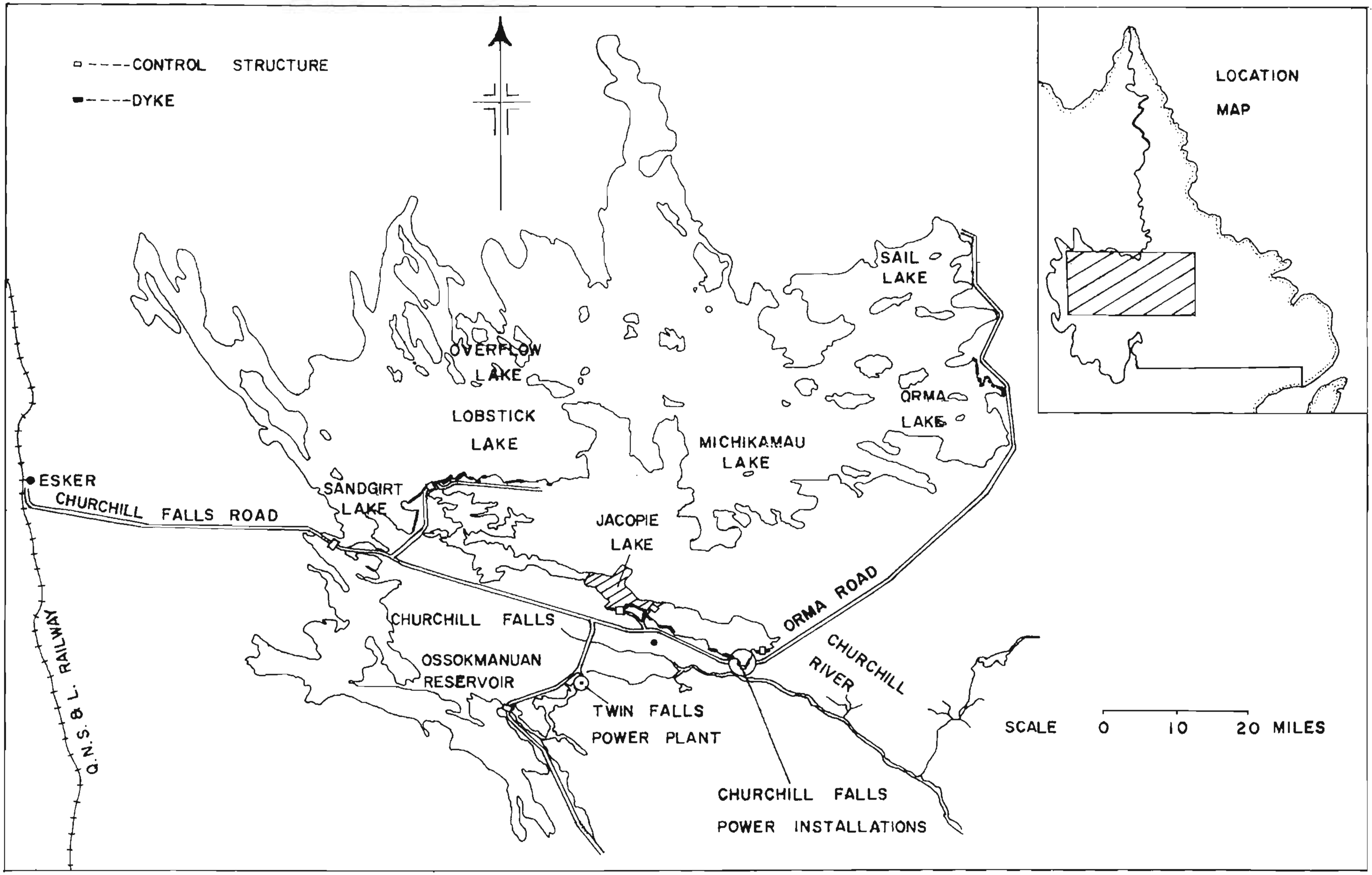


Fig. 1. Smallwood Reservoir, Labrador

direction, while the eastern end of the reservoir is formed by dykes at Orma and Sail Lakes. Further down, the Churchill River water is diverted towards the forebay of the reservoir by the Jacopie Structure (Fig. 3). Whitefish Structure (Fig. 4) controls the flow of water from the west forebay to the east forebay. Towards the end of the forebay is the intake structure where the water flows down into the underground powerhouse. Finally, the spent water from the turbines enters the lower Churchill River through two tailrace tunnels (Fig. 5).

Fig. 2. Lobstick Control Structure (controls the release of water from the main reservoir).

Fig. 3. Jacopie Control Structure (diverts water towards the forebay of the reservoir).

Fig. 4. Whitefish Control Structure separating the East Forebay (right) and the West Forebay (left).

Fig. 5. Two tailrace tunnels empty spent water into the lower Churchill River.

Description of the Lake

Jacopie Lake is situated at 53°37' North Latitude and 64°26' West Longitude. It lies approximately 15 miles west from the town of Churchill Falls (Fig. 1). Jacopie Lake has an elevation of approximately 1,500 feet. It is part of a chain of lakes forming the Smallwood Reservoir system, which extends from the northern rim of the Churchill River Valley, to Michikamats Lake and from Fremont to Birch Lake. The total drainage area of the Upper and Lower Churchill Rivers combined is 35,662 square miles (92,325 sq.km.), or 32% of Labrador.

The main effluent to Jacopie Lake is the Upper Churchill River. Prior to the Jacopie diversion, Jacopie Lake drained directly into the Churchill River above the Churchill Falls (Grand Falls). It now flows, via the East Forebay, to the powerhouse and then the Churchill

River below the falls via the tailrace. As a result of this diversion very little water now flows over the falls. The falls, before and after the diversion, are shown in Figs. 6 and 7.

Geographic Situation

The Labrador Plateau forms the eastern section of the Canadian Shield which extends across much of the northern part of the continent. The bedrock of this area is of archaean granites and gniesses dating back to the Cambrian era (Sheppard T. Powell Assc. Ltd., 1971). Glacier movements during the past ten million years has scoured the granite bedrock of Labrador leaving many dents and gouges. These dents eventually filled with water to form the many scattered lakes and the gouges became rivers like the Churchill. These glacial lakes are very irregular and rich in islands. The soil of the islands is highly leached and contains very few minerals.

Fig. 6. Churchill Falls, before the Jacopie diversion.

Fig. 7. Churchill Falls, after the Jacopie diversion.

Climate

The average annual precipitation of the Churchill Falls area is 30" (760 mm.), made up of 16" (400 mm.) of rain and 154" (4,000 mm.) of snow. The mean daily temperature for the month of January is -9°F (-23°C) and for the month of July is 56.5°F (13.6°C). The extreme temperature in the winter is -55°F (-48°C) and in the summer is 87°F (30°C). (CFLCO. News Service Fact Sheet).

Vegetative Cover

Most of the surrounding area is forested with scrub black spruce (Picea mariana). Scattered throughout the black spruce are patches of white spruce (Picea glauca), balsam fir (Abies balsama), and white

birch (*Betula papyrifera*).

Lichens and mosses, including the widespread caribou moss of the northland provide the ground cover. The colourful flora is mostly comprised of goldenrods and fireweeds.

Wildlife

There is no great amount or variety of animal life in the area. There are a few herds of caribou, some black beer, wolves, foxes, the common red squirrel and the porcupine. A small number of moose inhabit the lower river areas. The chief game birds are willow ptarmigan, ruffed grouse, and several varieties of migrating water fowl including greenwinged teals and Canada geese. The Canada jay, or more commonly, the Whiskey jack, is present in the forests year round. Yellowlegs and blackbirds are also present and osprey and owls are frequently seen.

METHODS AND MATERIALS

Morphometry

Outline maps of Jacopie Lake were prepared from aerial photographs published by the Department of Energy, Mines and Resources. Soundings of the lake were made using a Benmar DR-25 Model depth recorder with the transducer arm built into an 18' Grew-Cruiser boat. A bathymetric map was constructed and other morphometric parameters were calculated following the methods outlined by Welch (1948).

Physical and Chemical Studies

Physical and chemical data were collected at three different stations in the reservoir. Surface water temperature data of Jacopie Lake was obtained from a continuous recording Ryan thermograph during the months of June and July. Dissolved oxygen concentration readings were made by the modified Winkler system. Water analysis was carried out by both the Inland Waters Directorate, Environmental Management Services, Department of the Environment, Moncton, New Brunswick, and by the Laboratory Services Unit of the Water Resources Group, Resource Development, St. John's, Newfoundland.

Biological Studies

Stations for biological sampling were randomly selected ensuring that the lake was well represented. A total of 11 stations varying in depth from 10 to 50 feet were sampled for fish. Benthos samples were collected at 16 different stations around the lake. Plankton samples were taken at the centre of the lake.

Most of the fish samples were taken with gill nets. A lake trap-net was fished for two nights but caught very few fish. The gangs of gill nets each composed of five nets with mesh size 1-1/2" (3.8 cm.), 2" (5.1 cm.), 3" (7.7. cm.), 4" (10.2 cm.) and 5" (12.8 cm.), were allowed to fish overnight (except for one 48 hour setting). Each net measured 50 yards in length and was 6 feet deep. A total of 27 sets were made, either floating or sunken. At the completion of each set, records were made of the total catch of individual species by mesh size.

All collected fish (when the sample size was large enough) were used to calculate age and growth information plus other population parameters. Individual fish were weighed to the nearest gram and measured (fork length) to the nearest centimeter. Sexual condition of individual fish was recorded when macroscopically visible. Stomach contents removed from lower esophagus to pyloric sphincter were placed in mason jars containing 10% formalin. Qualitative studies of these contents were later performed in the laboratory. Scales were used in the aging of all species except for the burbot.

Bottom organisms were sampled with a Peterson dredge. Dredgings were washed through a series of wire screens of varying mesh size and the organisms were removed and preserved. They were shipped to headquarters where they were later identified.

Plankton samples were collected with a standard plankton townet of number 20 bolting silk, having a mouth diameter of 10 inches. They were immediately preserved in 4% formalin and later identified in the laboratory.

RESULTS AND DISCUSSION

Physical and Chemical Environment

Morphometry

A bathymetric map of Jacopie Lake is presented in Fig. 8, the morphometric parameters are given in Table 1. Jacopie Lake has a total area of 13,578 acres; of this there are 12,070 acres of water while the remaining 1,508 acres constitute islands. There are a total of 27 islands on the lake and the majority of them are in the north-western

Fig. 8. Bathymetric map of Jacopie Lake.

section. Jacopie Lake is very irregular in shape with a shoreline development index of 5.5.

Physical and Chemical Conditions

The ice-free period for most lakes in the Labrador region is from early or mid-June to early November.

The low surface water temperature for the working period was 54°F (12.2°C) on June 27 with the high being 64°F (17.8°C) on July 21.

Table 1. Summary of the morphometry of Jacopie Lake.

Area, including islands (acres)	13,578	Area, excluding islands (acres)	12,070
(ha.)	5,431	(ha.)	4,828
Maximum length (mi.)	11.3	Maximum effective length (mi.)	7.1
(km.)	18.1	(km.)	11.4
Maximum width (mi.)	3.3	Maximum effective width (mi.)	3.0
(km.)	5.3	(km.)	4.8
Mean width (mi.)	1.9	Volume (cu.ft.)	1.39×10^{10}
(km.)	3.0	(cu.m.)	3.94×10^{8}
Maximum depth (ft.)	85.0	Mean Depth (ft.)	26.4
(m.)	25.9	(m.)	8.1
Mean depth-Maximum depth ratio	0.31	Volume development	0.93
Perimeter, including islands (mi.)	85.0	Perimeter, excluding islands (mi.)	52.2
(km.)	136.7	(km.)	83.9
Shore development, including islands	5.5	shore development, excluding islands	3.4
Direction of major axes	WNW-ESE		

Temperature profile observations were taken on three different occasions in the middle of Jacopie Lake (Fig. 9). No pronounced thermocline was observed in the lake during the summer of 1973. This is characteristic of lakes in the Churchill area, and is attributable to the shallowness of the stations

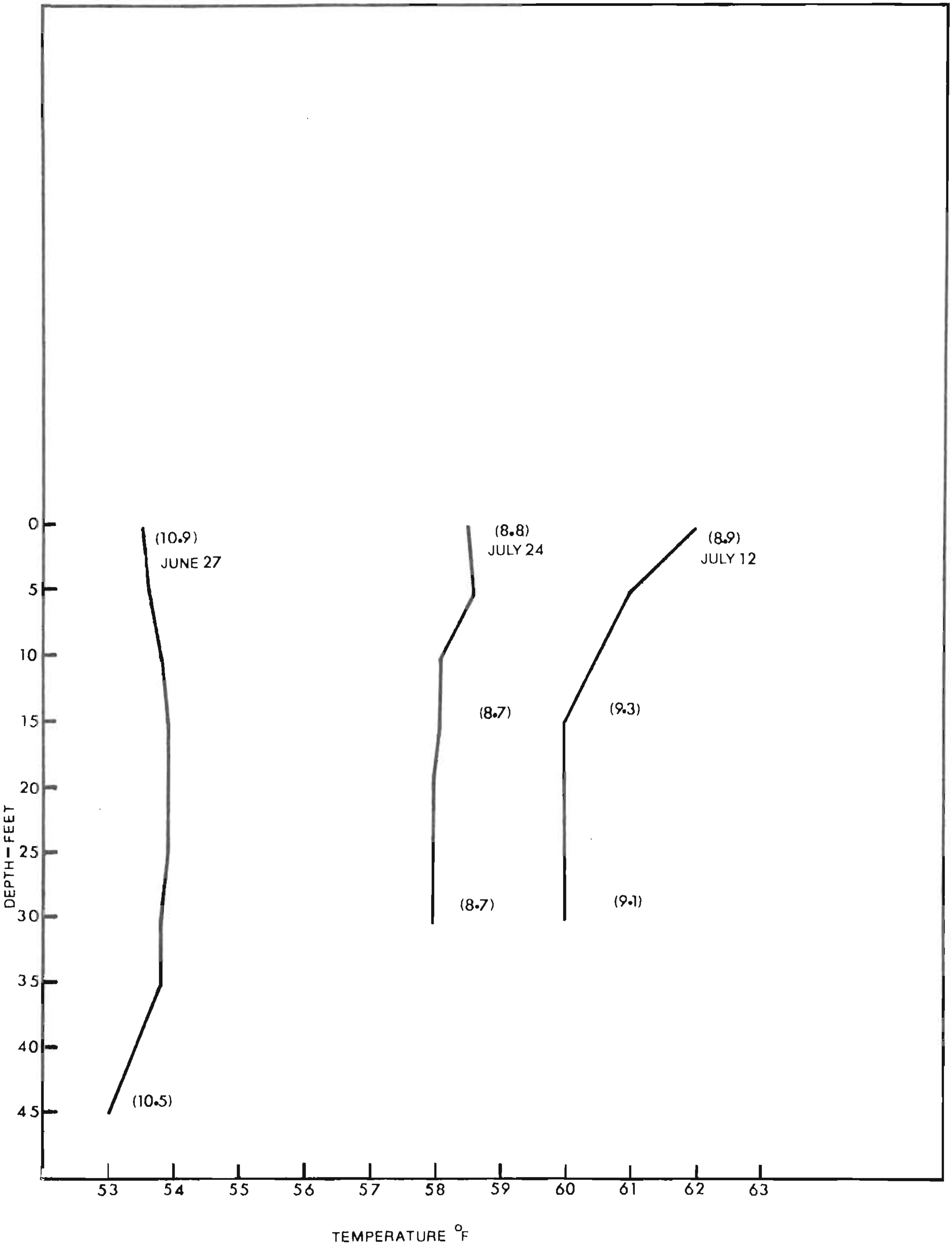


FIG. 9 . TEMP. AND D.O. PROFILE OF JACOPIE LAKE, SUMMER 1973.

NUMBERS IN PARENTHESES REPRESENT D.O. CONTENTS IN Mg./L.

and wind action. Oxygen concentration remained virtually unchanged with depth (Fig. 9), and remained close to saturation throughout the summer.

Analysis of water samples (Table 11) taken from three different stations on the reservoir showed very little variation in the chemical properties. Even a smaller variation was observed at different depths in each station.

Table 11. Water quality analysis of surface water from three selected stations on the Smallwood Reservoir (samples collected during open-water period, 1973).

Station	pH	Total Hardness	Sp. Cond. at 25°C	T.D.S.	Total Alk.	Color	Turb.	Ca^+	Cl^-	HCO_3^-
Lobstick	6.8	11.0	22.3	24.3	10.8	10	1.2	2.5	1.1	15.3
Whitefish	6.8	11.6	23.3	25.5	10.5	15	2.0	2.6	1.1	14.0
Mid-Jacopie	6.8	11.8	22.0	26.5	10.6	10	1.4	3.0	1.2	13.0

The lake is slightly acidic with a mean pH of 6.8. The mean specific conductance value (22.5) from these three stations is considerable lower than the mean value (38.0) for 354 Newfoundland lakes and rivers. This would indicate that, nutrient wise, these waters are less productive than Newfoundland waters. Earlier consultants' studies conducted on the reservoir have shown that the lakes comprising the reservoir were very oligotrophic and that the waters were very dilute in terms of nutrient concentration and biologically unproductive.

Specific conductance values were converted to total dissolved solids (T.D.S.) by the formula given in Appendix 1. T.D.S. values are used in calculating the morphoedaphic index (T.D.S./mean depth) of a lake in a formula recommended by Ryder (1965). This morphoedaphic index is used for estimating the fish production of north temperate lakes. A rapid approximation of the morphoedaphic index can be obtained by solving the equation $Y = 2\sqrt{X}$; where X represents the morphoedaphic index.

Combining chemical and morphometric data on Jacopic Lake indicates an estimated fish yield of 1.96 pounds per acre per year. This compares quite favourably with estimates made for reservoirs and large lakes on the island. Long Pond Reservoir and Victoria Lake Reservoir, in the Bay d'Espoir power development, have an estimated annual fish yield of 0.88 and 0.97 pounds per acre, respectively. Data collected on seven large natural lakes on the island give an average yield of 1.54 pounds per acre annually. Therefore, although Jacopie Lake has low levels of dissolved nutrients, its rather shallow nature tends to compensate, resulting in a moderately good level of fish production, at least for large bodies of water. Small, shallow lakes on the island only yield an average of 3.55 pounds of fish per acre annually.

Benthos

Although sampling was limited, the bottom fauna sampled in the lake are shown in Table 111. There would not appear to be a great diversity of invertebrates in the lake. This is typical of most temperate oligotrophic lakes which generally are not highly productive. The two main groups sampled were chironomids and dipteran pupae.

Table 111. The bottom fauna of Jacopie Lake expressed as percentages of frequency of occurrence (based on samples taken at 16 stations during July, 1973).

Group	Frequency	Percent occurrence
Chironomidae	8	50.0
Diptera (pupae)	4	25.0
Trichoptera (larvae)	1	6.3
Sphaeriidae	1	6.3
Oligochaeta	1	6.3
Copepoda	1	6.3
Cladocera	1	6.3

Plankton

Plankton tows made at the centre of the lake indicated that cladocerans were far more abundant than copepods during this time of the year. The plankton species present and their frequency of occurrence are listed in Table IV.

Table IV. List of zooplankton species identified in Jacopie Lake, 1973 (samples taken July 24).

Zooplankton	Frequency
Copepoda	
Epischura lacustris	few
Eucyclops agilis	rare
Diaptomus sanguineus	rare
Diaptomus spatulocrenatus	rare

Table IV. (cont'd.)

Zooplankton	Frequency
Cladocesa	
Daphnia middendorffiana	few
Daphnia galeata mendotae	very common
Daphnia longiremis	few
Polyphemus pediculus	common
Chydorus sphaesicus	very common
Sida crystallina	common
Acroperus harpae	few
Alona sp.	few
Bosmina sp.	common
Holopedium gibberum	rare

Fish Species Summary

Whitefishes - Family Coregonidae

Lake Whitefish - Coregonus chupeaformis (Mitchill)

The lake or humpback whitefish is widely distributed in North American freshwaters from the Atlantic coastal watersheds westward across Canada and the northern United States, to British Columbia, the Yukon Territory and Alaska. The lake whitefish is indigenous to Labrador and constitutes one of the major freshwater species of that area. The greatest concentration of whitefish populations is in the north-western portion of Labrador, with populations being relatively sparse, or even non-existent, in south-eastern Labrador.

The lake whitefish is a cool-water species which inhabits lakes and large rivers. Spawning occurs from late summer to December and occurs earlier in the northern regions. Spawning takes place over rocky shoals of lakes or in shallows of rivers (McPhail and Lindsey, 1970).

Adult lake whitefish are chiefly bottom feeders, feeding on aquatic insect larvae, molluscs and amphipods. They also eat fish and fish eggs. The young are mainly planktonic feeders (Reckahn, 1970).

Back-calculation of Growth

Van Oosten (1923) and Hogman (1968) have previously shown that scales may be used to age lake whitefish. The Lee method of back-calculation, which assumes a constant ratio in body and scale increments was used successfully in this study.

A plot of the average fish lengths against the average scale diameters indicated the data were best described by a straight line (Fig. 10). The equation for the line fitted by least squares is:

$$L_f = 1.38\ L_s + 7.19$$

The average scale lengths for each year of life and the corresponding calculated fish lengths are given in Table V and presented in Fig. 11.

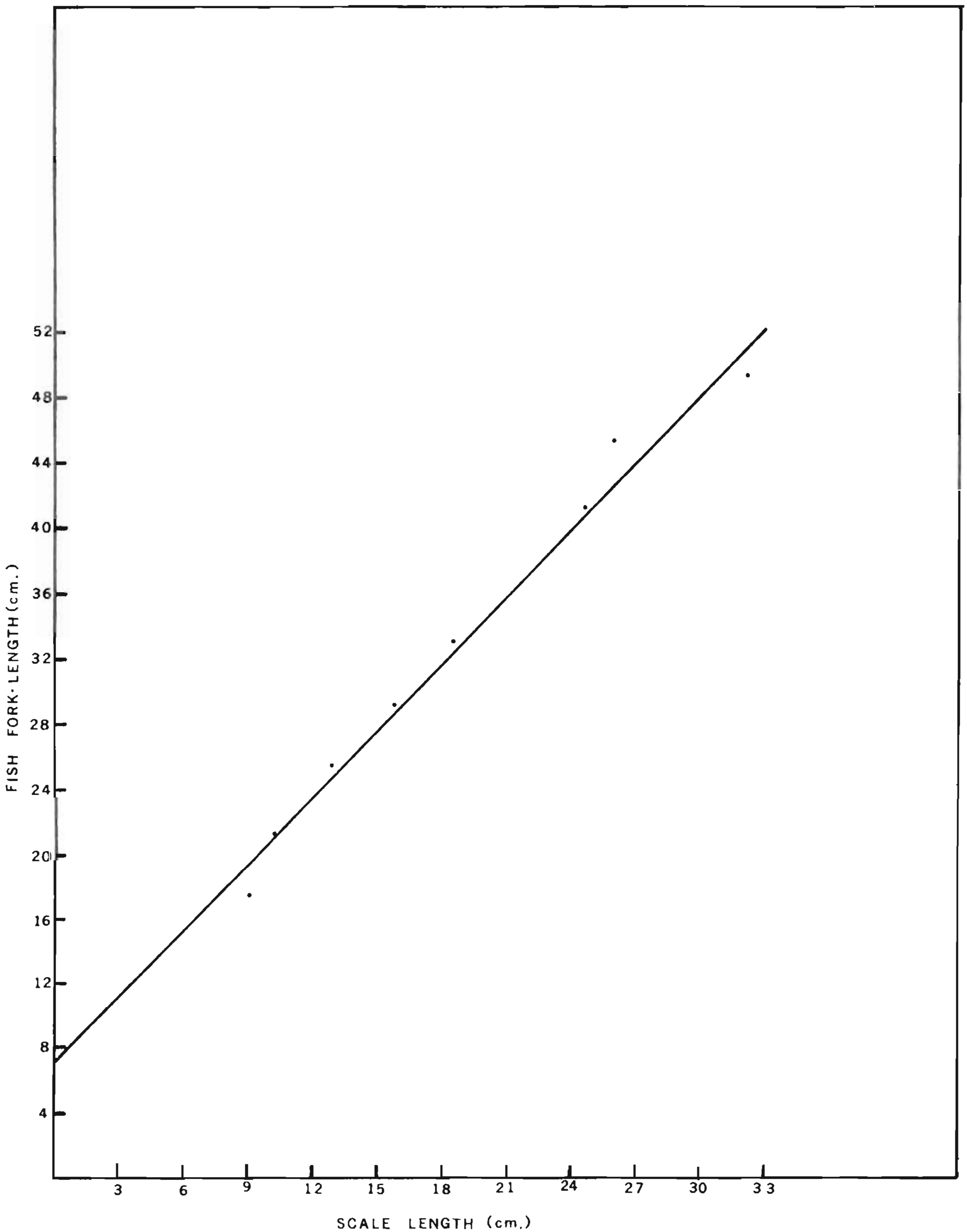


FIG. 10. FISH-LENGTH-SCALE-LENGTH RELATIONSHIP FOR JACOPIE LAKE LAKE WHITEFISH

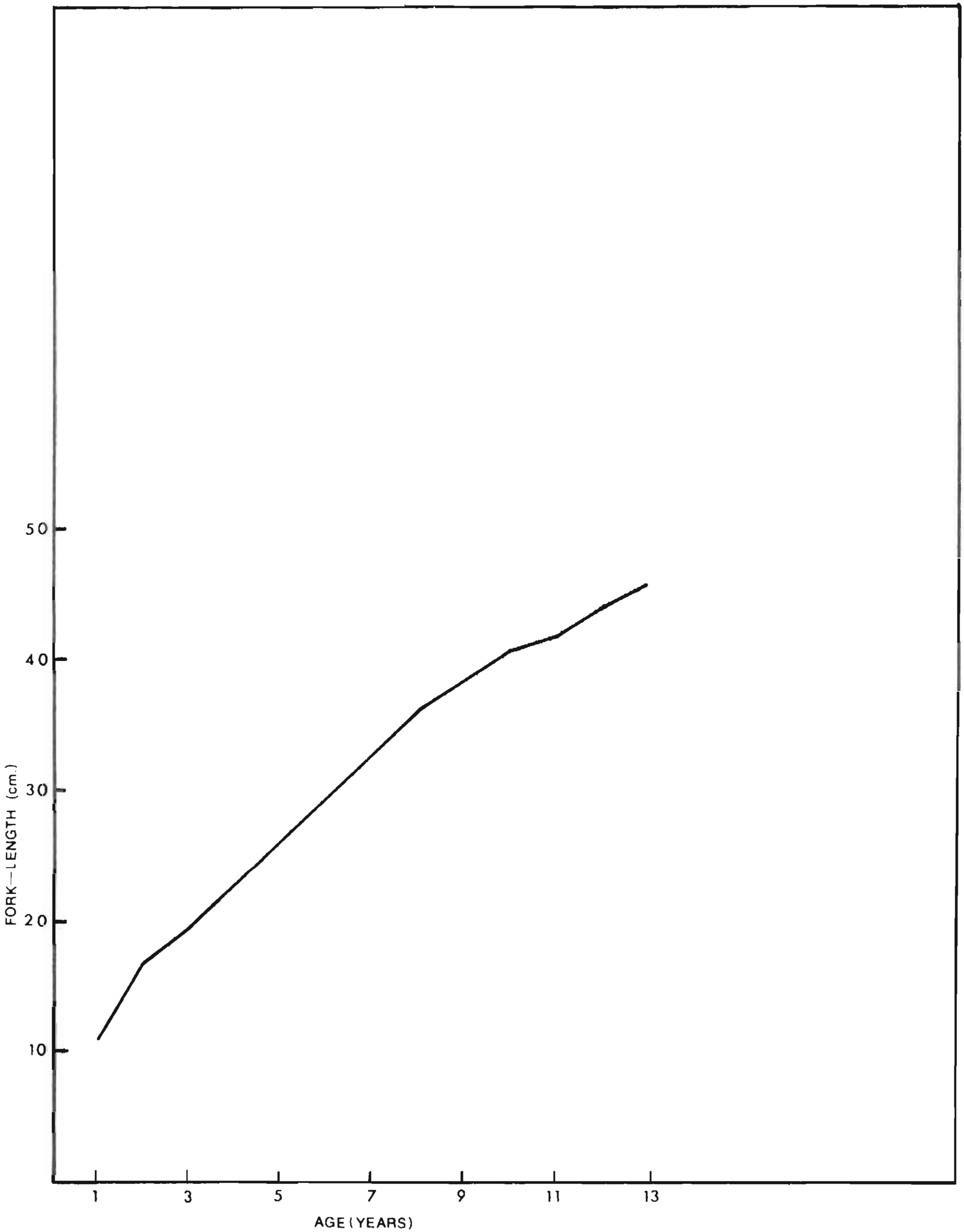


FIG. 11. AGE—LENGTH RELATIONSHIP FOR LAKE WHITEFISH.

Table V. Actual scale length and calculated fork length at annulus formation of Jacopie Lake whitefish.

Annulus	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Scale length (cm.)	2.8	7.1	9.0	11.5	13.9	16.3	18.7	21.0	22.7	24.2	25.1	26.8	28.4
Fork length (cm.)	11.1	17.0	19.6	23.1	26.4	29.7	33.0	36.2	38.5	40.6	41.8	44.2	46.4

The growth rate is similar to that reported by Hatfield et al. (1972) for the Mackenzie River Valley and Byran et al. (1973) for the Northern Yukon Territory. However, it is comparatively slower than rates given for southern regions (Scott and Crossman, 1973).

The oldest and largest fish taken was $XIII^+$ years with a fork length of 48.5 cm.

Length Distribution and Age Composition

Figure 12 presents the size distribution of lake whitefish from Jacopie Lake. The total mean fork length was 26.9 cm. with a range of 16.4 cm. - 48.5 cm. The mean female fork length (40.9 cm.) was significantly higher than the mean male fork length (25.5 cm.).

The age composition for lake whitefish is presented in Figure 13. It is seen that over 67% of the catch is less than VI^+ years old.

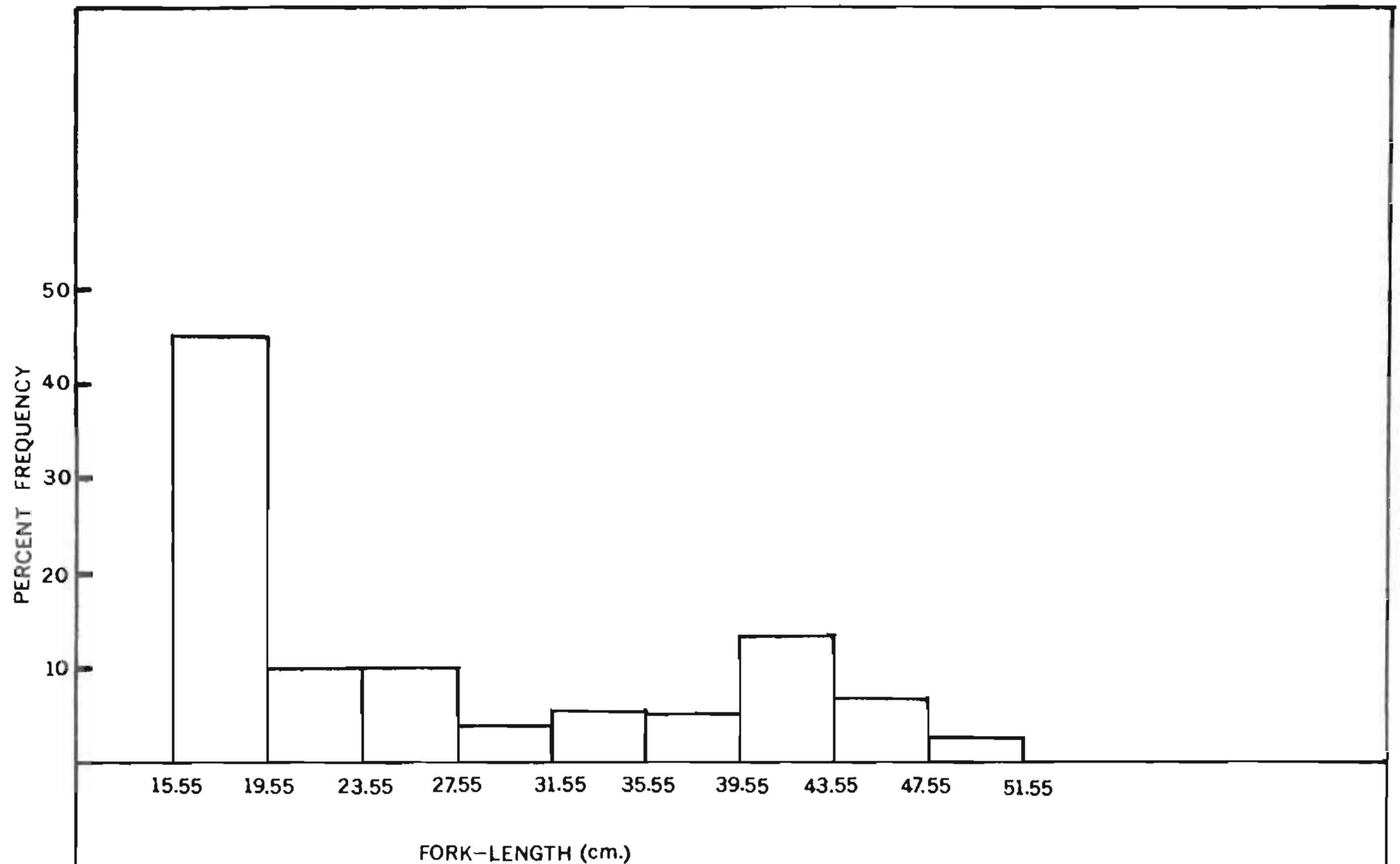


FIG. 12. FORK-LENGTH DISTRIBUTION OF JACOPIE LAKE WHITEFISH.

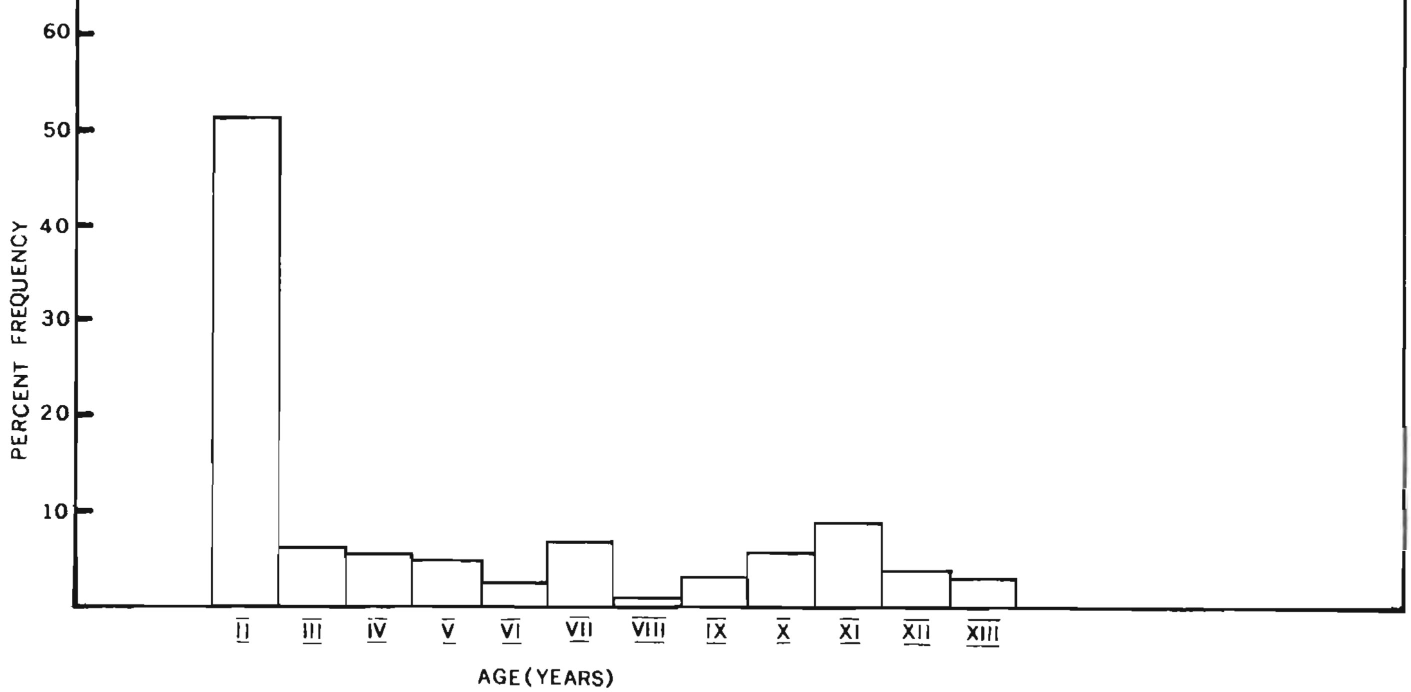


FIG. 13. AGE COMPOSITION OF LAKE WHITEFISH FROM JACOPIE LAKE.

Length-Weight Relationship

The length-weight relationship for lake whitefish (Fig. 14) is expressed by the equation:

$$\text{Log } W = 3.1395 \text{ Log } L - 2.0526$$

where W = weight in grams and L = fork length in millimeters. The value of the exponent "b" (3.1395) corresponds well with that of 3.247 and 3.243 reported by Hatfield et al. (1972) for Norman Wells and Fort Simpson in the Mackenzie River Valley.

Females were heavier than males for a given length, and the mean female weight (1,128.4 g.) was significantly higher than the mean male weight (345.2 g.).

Sex Ratio

Sex ratio of lake whitefish (male to female) was 3 to 1.

Food Habits

Analysis of 164 stomachs indicated that adult lake whitefish were chiefly benthic feeders while the young fish fed almost entirely on plankton (Table VI). Eight percent of the stomachs were empty and fish remains were present in only two stomachs.

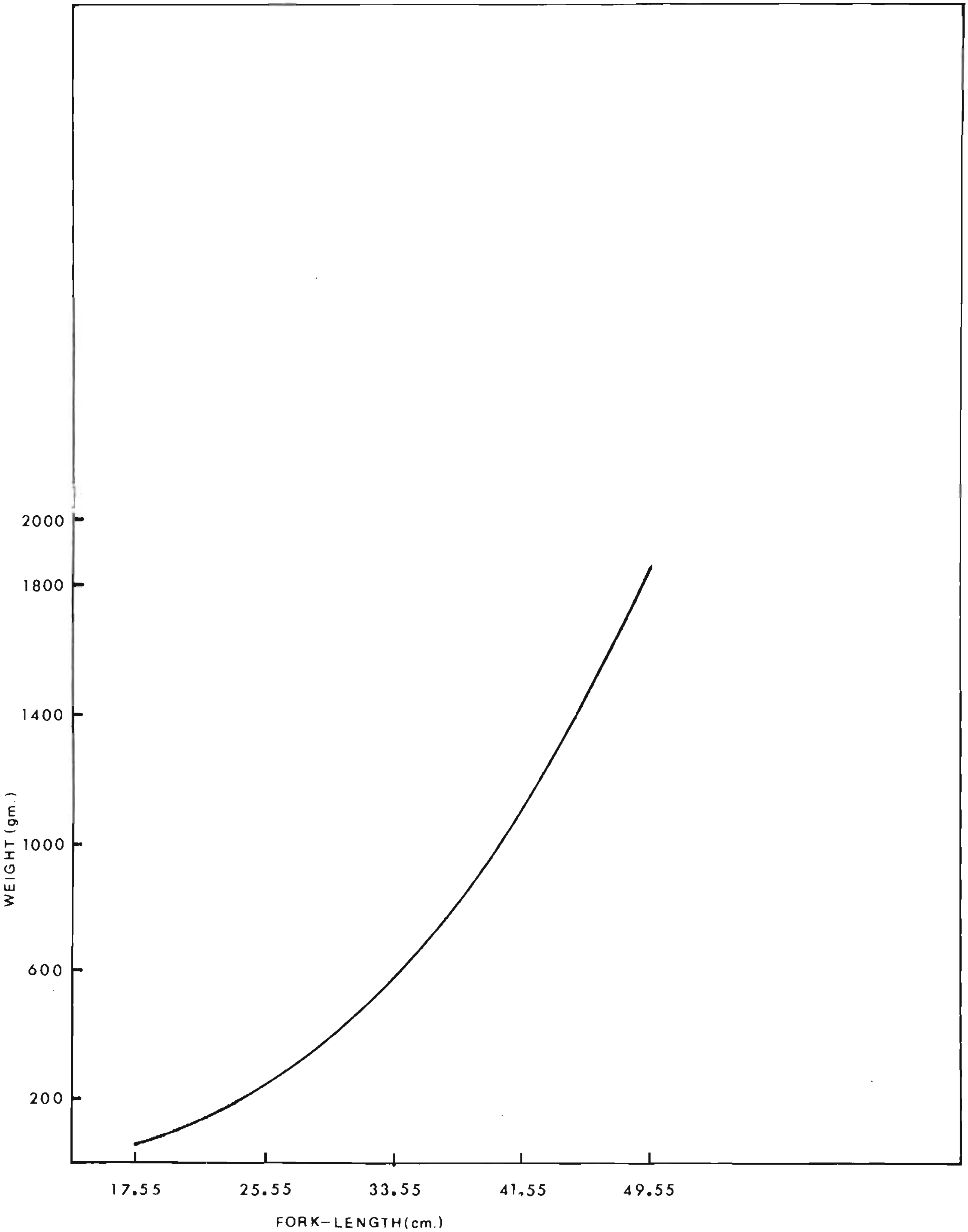


FIG. 14. LENGTH-WEIGHT RELATIONSHIP FOR LAKE WHITEFISH

Table VI. The food of Jacopie Lake lake whitefish expressed as percentages of frequency of occurrence (based on examination of fish 16.4 - 48.5 cm. caught during the summer, 1973).

Food item	Frequency	Percentage occurrence
Trichoptera	4	2.7
Ephemeroptera	30	20.0
Diptera (pupae)	128	85.3
Ceratapogonidae	57	38.0
Amphipoda	2	1.3
Hemiptera	3	2.0
Coleoptera	8	5.3
Hydracarina	30	20.0
Gastropoda	21	14.0
Pelecypoda	10	6.7
Copepoda	13	8.7
Cladocera	114	76.0
Arachnida	1	0.7
Algae	2	1.3
Unidentifiable insect remains	2	1.3
Unidentifiable fish remains	2	1.3
Detritus	36	24.0

Round Whitefish - Prosopium cylindraceum (Pallas)

The round whitefish ranges widely through northern North America and into north-western Asia (Scott and Crossman, 1973). It occurs

throughout eastern Canada, Quebec, Labrador and from the Great Lakes region of Ontario to north-western Canada. Very little is known about its distribution in Labrador.

The round whitefish is found in various depths of water, from very shallow to deep. It also may be found in rivers and streams. Spawning usually takes place during November and December in the shallow parts of the lakes and river mouths. They are bottom feeders which utilize a wide variety of aquatic invertebrates. For further information on the general biology of the round whitefish see Bailey (1963), Mray (1964), Mackay and Power (1968), Normandeau (1969), and Jessop and Power (1973).

Age and Growth

The four round whitefish taken from Jacopie Lake ranged in length from 22.0 to 31.3 centimeters. Two of the fish were V^+ years of age and one VI^+ and one IX^+ fish were also taken. Age and growth data for a number of populations, taken from Scott and Crossman (1973), are presented in Table VII. Due to our small sample size very little can be said concerning the growth rate in comparison with other populations. Generally the populations in the southern part of the range display a much faster growth rate than those in the north.

Table VII. Growth rate for a number of round whitefish populations.

		Age (Years)											
		I+	II+	III+	IV+	V+	VI+	VII+	VIII+	IX+	X+	XI+	XII+
Ungava (Koksvak R.) (Mackay and Power, 1968)	FL.IN.	-	6.0	6.9	7.9	8.7	9.5	10.5	11.6	12.0	12.6	13.9	14.6
	FL.MM.	-	152	175	201	221	241	266	294	305	320	352	370
L. Michigan (Mray 1964)	TL.IN.	-	12.2	14.2	15.5	17.4	18.3	19.6	-	-	-	-	-
	TL.MM.	-	310	361	394	442	465	495	-	-	-	-	-
Apostel Is., Lake Superior (Bailey 1963)	TL.IN.	4.3	7.1	9.0	10.7	12.0	13.0	14.0	15.0	15.5	-	-	-
	TL.MM.	109	180	229	272	305	330	356	381	394	-	-	-

Pikes - Family Esocidae

Northern Pike - Esox lucius (Linnaeus)

The northern pike occurs throughout the northern hemisphere in North America, northern Europe and northern Asia. In Canada, it is found in Labrador (absent in the Maritime provinces and Newfoundland) from Quebec westward to British Columbia and the Northwest Territories. It is generally distributed throughout the inland waters of Labrador.

The northern pike prefers clear, warm, heavily vegetated rivers or warm, weedy bays of lakes. They are spring spawners and usually spawn shortly after the ice goes out. They spawn during daylight hours on the heavily vegetated floodplains of rivers, marshes, and bays of larger lakes (Scott and Crossman, 1973).

Pike are voracious predators feeding mainly on fishes of all available species. They also eat insects, small birds and small mammals. They aren't selective feeders and will eat whatever is available.

Back-calculation of Growth

Frost and Kipling (1959) describe the method for aging pike by both the scale and opercular methods. The opercular method was found the most accurate for back-calculation of growth but the scales gave an accurate estimate when a correction was made for the time the scale was laid down.

The method of back-calculation for pike was the same as the one described for lake whitefish.

The equation for the line describing the body/scale relationship fitted by least squares is:

$$L_f = 1.94 (L_s) + 4.10$$

The average scale lengths for each year of life and the corresponding calculated fish lengths are given in Table VIII and presented in Figure 15.

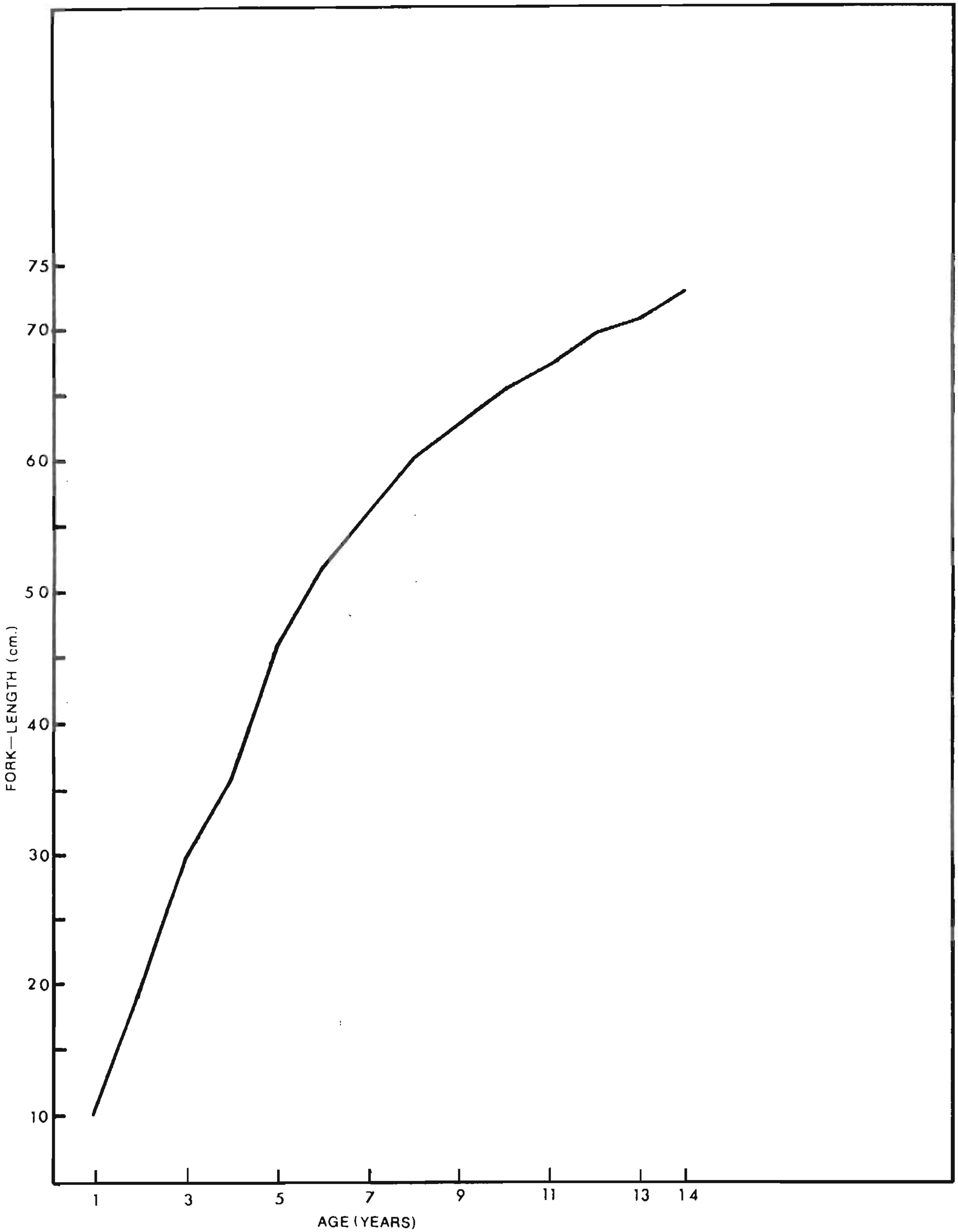
Table VIII. Actual scale length and calculated fork length at annulus formation of Jacopie Lake northern pike.

Annulus	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Scale length (cm.)	3.13	8.02	13.07	16.47	21.67	24.53	26.86	28.87	30.30	31.67	32.68	34.47	34.54	35.52
Fork length (cm.)	10.2	19.7	29.5	36.1	46.1	51.7	56.2	60.1	62.9	65.5	67.5	70.0	71.1	73.0

Growth rate is similar to those reported by Hatfield et al. (1972) for the Mackenzie River Valley and Miller and Kennedy (1948) for Great Bear Lake, Northwest Territories. Northern pike display a much faster growth rate in the more southern regions (Rawson, 1932; Wainio, 1966).

Northern pike displayed the fastest growth rate of the fish species present in Jacopie Lake. They made their greatest annual growth in length (10 cm.) during their fourth year of life. They grew fastest during their first four years but the length increments decreased thereafter.

The oldest fish taken was XIV^{+} years of age and had a fork length of 78.3 cm. The largest pike captured, however, was 84.0 cm. in fork length. This fish could not be aged because all the scales were regenerated.



F'C. 15. AGE—LENGTH RELATIONSHIP FOR NORTHERN PIKE.

Length Distribution and Age Composition

The length distribution and age composition of northern pike is presented in Figures 16 and 17.

The mean total length was 57.7 cm. with a range of 20.6 - 84.0 cm. The mean female length (63.5 cm.) was somewhat higher than the mean male length (55.9 cm.).

Length-Weight Relationship

The general length-weight equation, determined by fitting a straight line to the logarithms of length and weight was:

$$\text{Log } W = 3.0477 \text{ Log } L - 2.1877$$

The "b" value of 3.0477 shows that the weight of the pike increases at a rate a little greater than the cube of the length. The weights computed for the mean lengths of fish in each length class are the bases of the curve in Figure 18.

Hatfield et al. (1972) report a similar "b" value for northern pike from the Mackenzie River Valley.

Sex Ratio

Sex ratio of northern pike (male to female) was found to be 1.9 to 1.

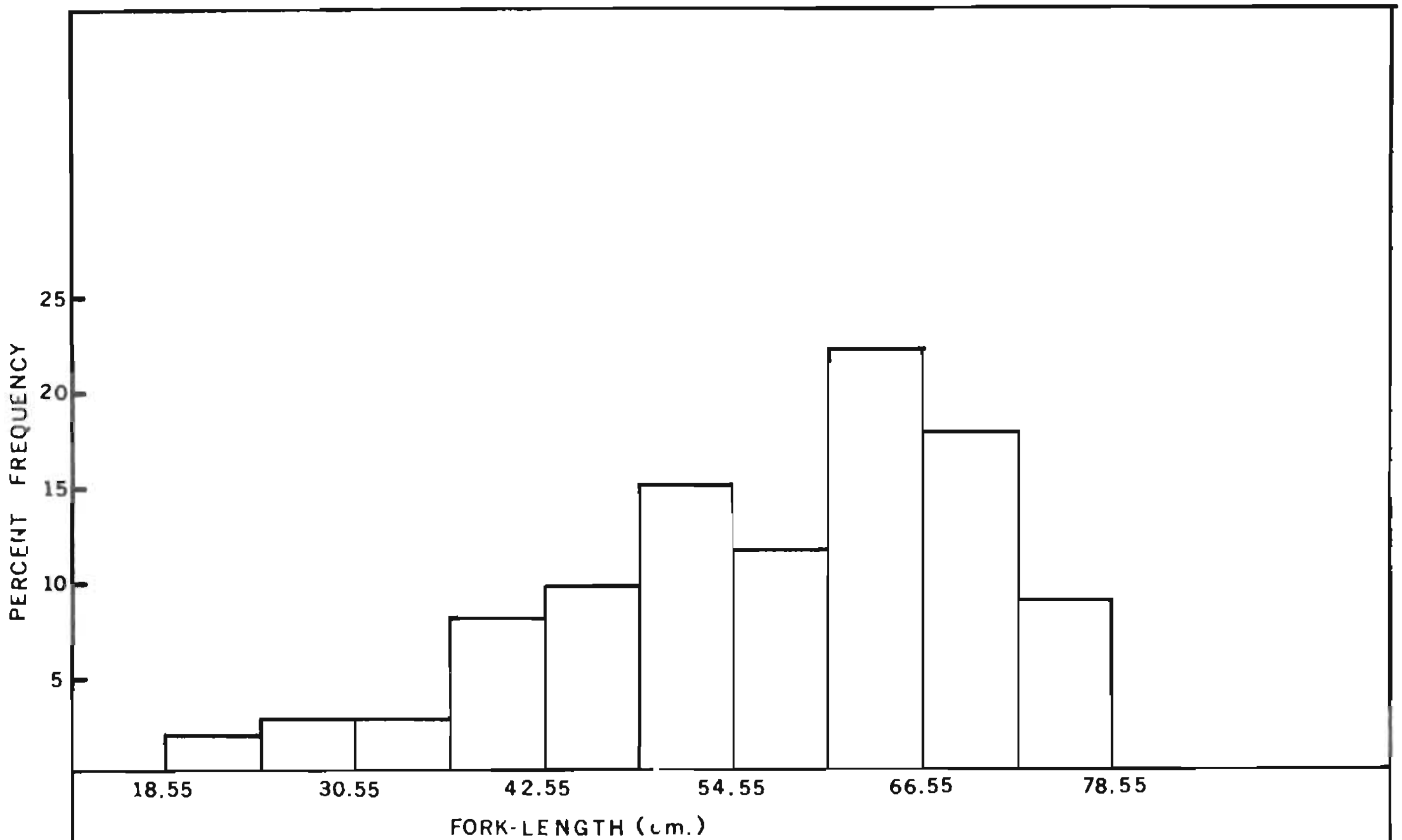


FIG. 16. FORK-LENGTH DISTRIBUTION OF JACOPIE LAKE NORTHERN PIKE

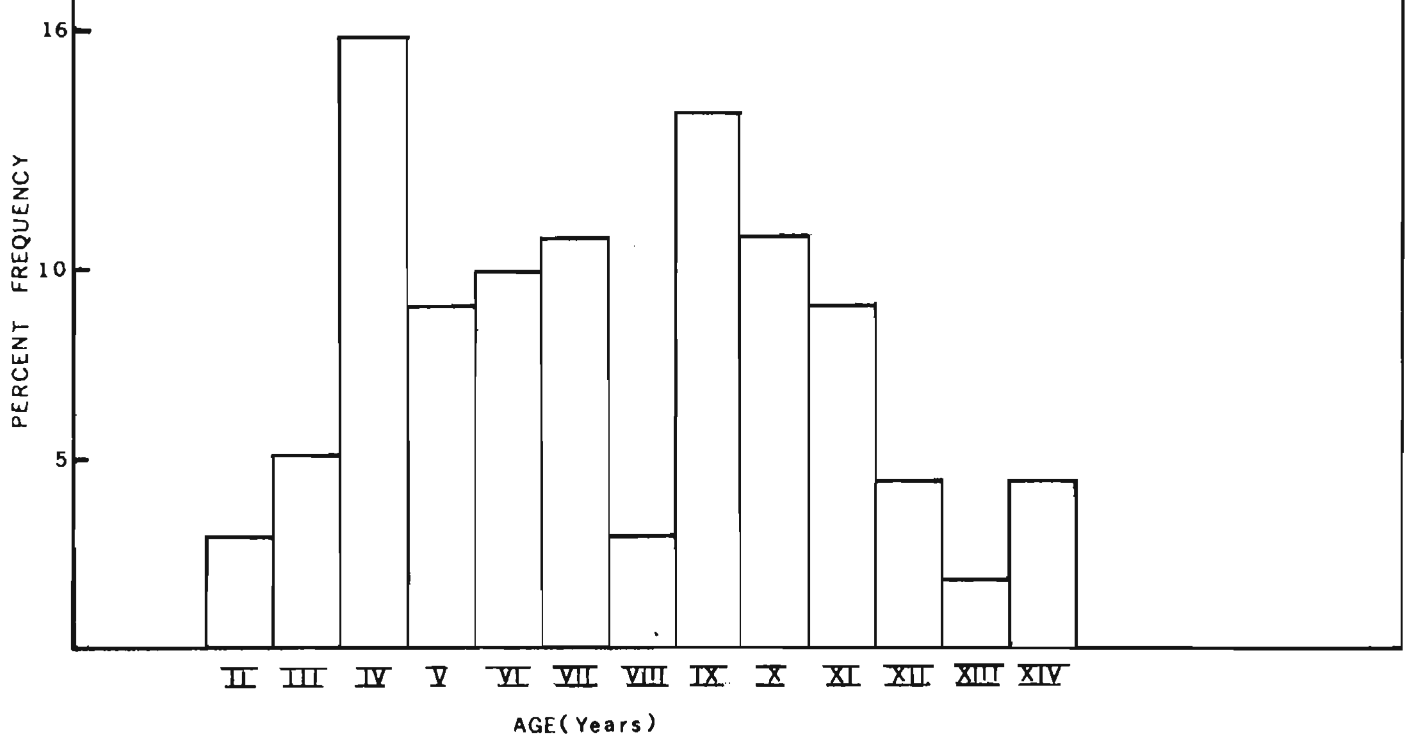


FIG.17. AGE COMPOSITION OF JACOPIE LAKE NORTHERN PIKE

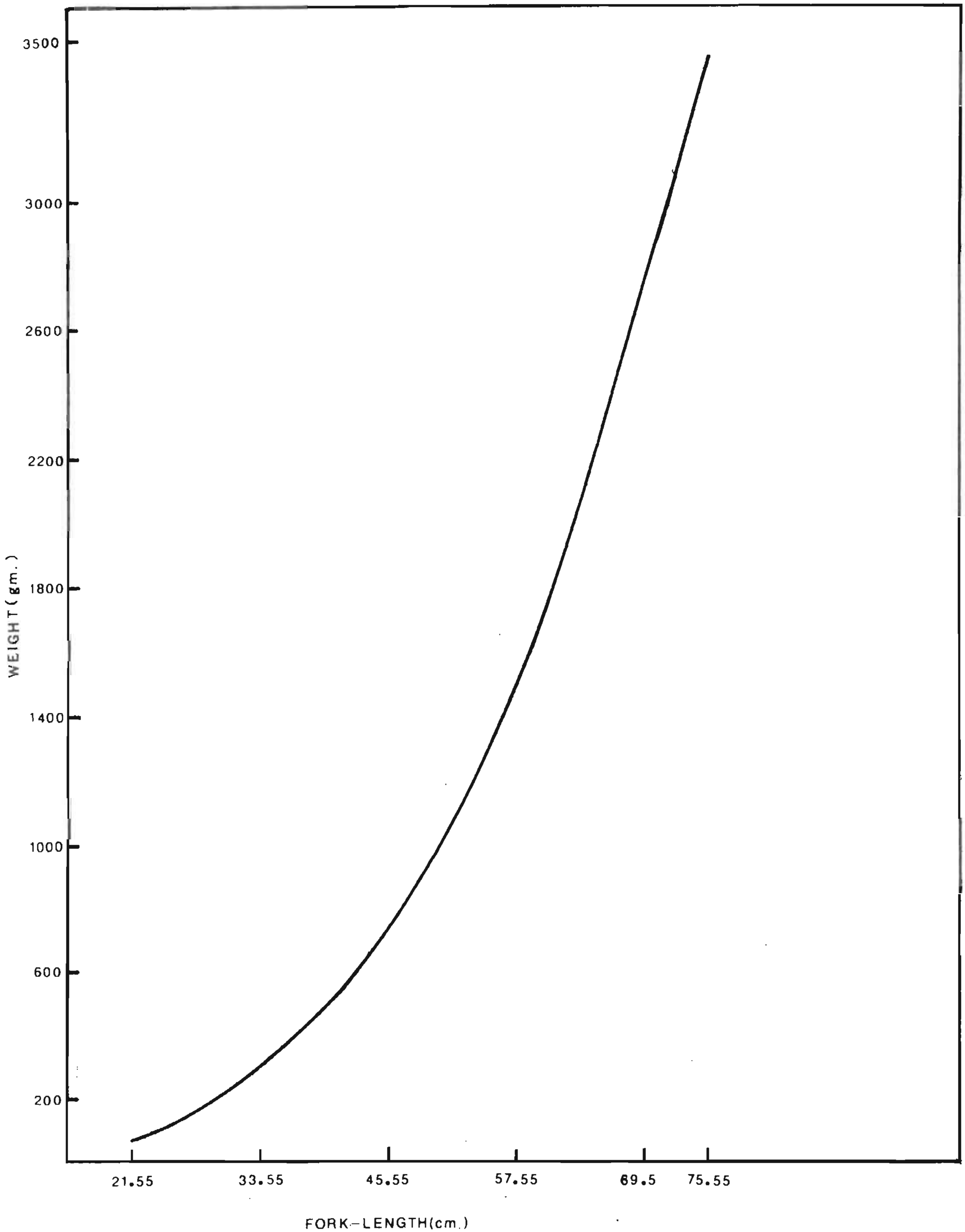


FIG. 18. LENGTH-WEIGHT RELATIONSHIP FOR NORTHERN PIKE

Food Habits

Stomachs from 98 northern pike caught in gill nets were examined to determine food habits of this species in Jacopie Lake. 32 (33%) of these were empty. Out of the remaining 66 feeding pike, 58 (88%) contained fish or fish remains (Table IX). This agrees well with the results of other workers who have studied the food habits of this species (Frost, 1954; Lawler, 1965). Insects and insect remains occurred in 9.1% of the stomachs. Other invertebrates occurred in trace amounts.

Table IX. The food of Jacopie Lake northern pike expressed as percentages of frequency of occurrence (based on examination of fish 20.6 - 84.0 cm. caught during the summer, 1973).

Food item	Frequency	Percentage occurrence
Odonata	1	1.5
Diptera (pupae)	2	3.0
Hirudinea	1	1.5
Mollusca	1	1.5
Unidentifiable insect remains	3	4.6
Detritus	3	4.6
Unidentifiable fish remains	17	25.8
Round whitefish	8	12.1
Brook trout	6	9.1
Burbot	16	24.2
Longnose sucker	4	6.1
Minnows	7	10.6
Northern pike	1	1.5
Cottids	8	12.1
Indistinguishable	5	7.6

Suckers - Family Catostomidae

Longnose Sucker - Catostomus catostomus (Forster)

The longnose sucker is the only North American sucker which is present in Asia as well. It is generally present throughout Canada except the Arctic islands and Newfoundland. It is generally distributed throughout Labrador, and is one of the most frequently occurring fish in the area.

They are generally restricted to clear, cold freshwater lakes or their tributaries. They spawn in the spring, usually after ice-out, in tributaries or shallower parts of the lakes. Rawson and Elsey (1950), Harris (1962) and Green et al. (1966) found that temperature was the deciding factor in longnose suckers starting their spawning run.

Adult longnose suckers are mainly benthic feeders. They feed on aquatic insects, amphipods, and molluscs. The smaller suckers are chiefly plankton feeders.

Back-calculation of Growth

Scales were used in the aging of longnose suckers. No mention is made anywhere in the literature of the method of back-calculation of growth for longnose suckers. The method used in this study was the same used for lake whitefish and northern pike.

The equation for the line describing the body/scale relationship fitted by least squares is:

$$L_f = 2.06 (L_s) + 5.64$$

The average scale lengths for each year of life and the corresponding calculated lengths are given in Table X and presented in Figure 19.

Table X. Actual scale length and calculated fork length at annulus formation of Jacopie Lake longnose sucker.

Annulus	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Scale length (cm.)	0.97	1.98	4.95	5.52	6.69	7.19	10.73	11.13	11.84	15.10	18.90	20.60
Fork length (cm.)	7.6	9.7	15.8	17.0	19.4	20.5	26.7	28.6	30.0	36.8	44.6	48.1

The growth rate is slower than those reported by Hatfield et al. (1927) for the Mackenzie River Valley and Harris (1962) for the northern part of Great Slave Lake, Northwest Territories.

The oldest fish taken was XII^{+} years and had a fork length of 48.7 cm. The largest longnose sucker taken was 52.9 cm. Longnose suckers are reported to reach a length of 63.5 cm. and a weight of 3,200 grams (McPhail and Lindsey, 1970).

Length Distribution and Age Composition

The length distribution and age composition of the longnose sucker are presented in Figures 20 and 21.

The mean total length was 24.5 cm. with a range of 14.0 - 52.9 cm. The mean female length (42.9 cm.) was significantly higher than the mean male length (33.2 cm.). This was the case in all the previous studies on the longnose sucker.

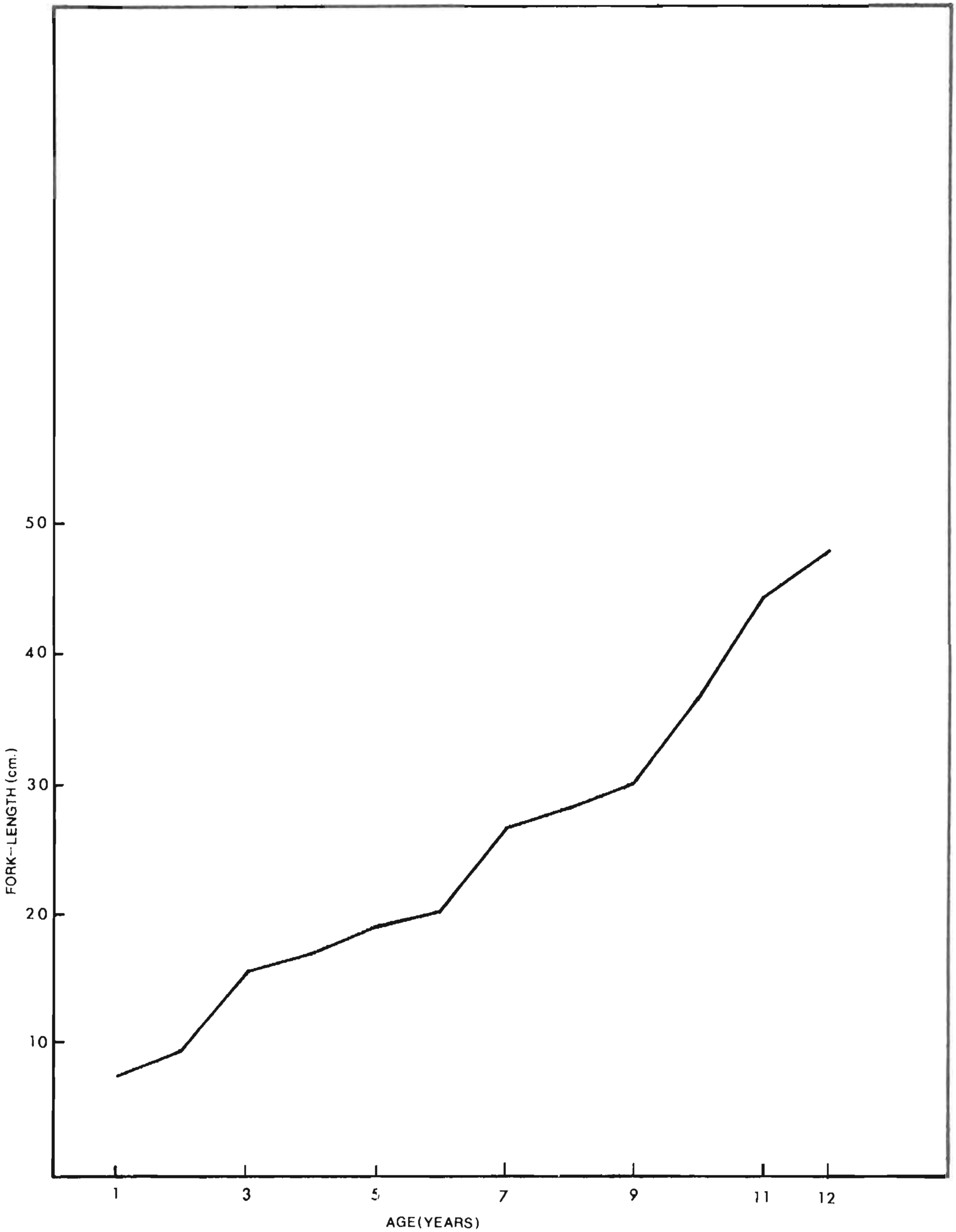


FIG. 19. AGE—LENGTH RELATIONSHIP FOR LONGNOSE SUCKER.

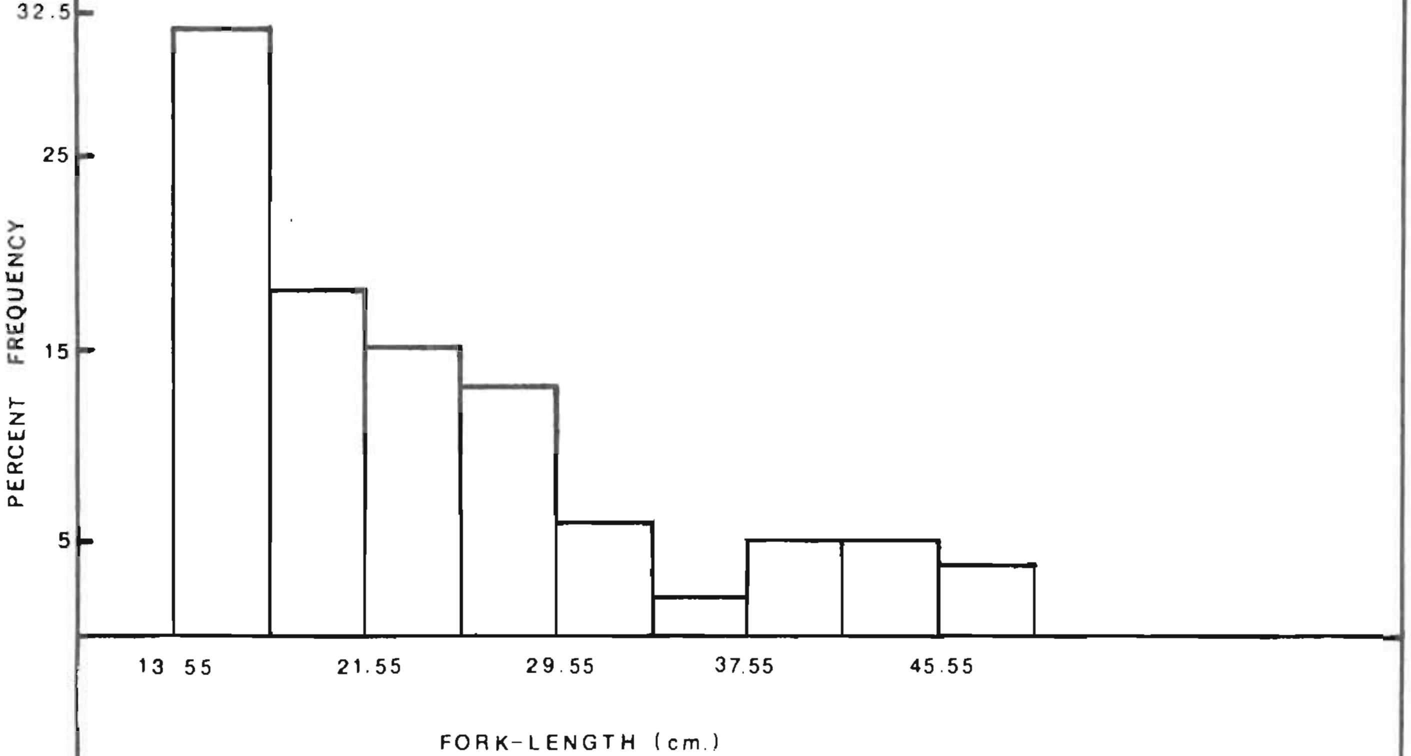


FIG.20. FORK-LENGTH DISTRIBUTION OF JACOPIE LAKE LONGNOSE SUCKER

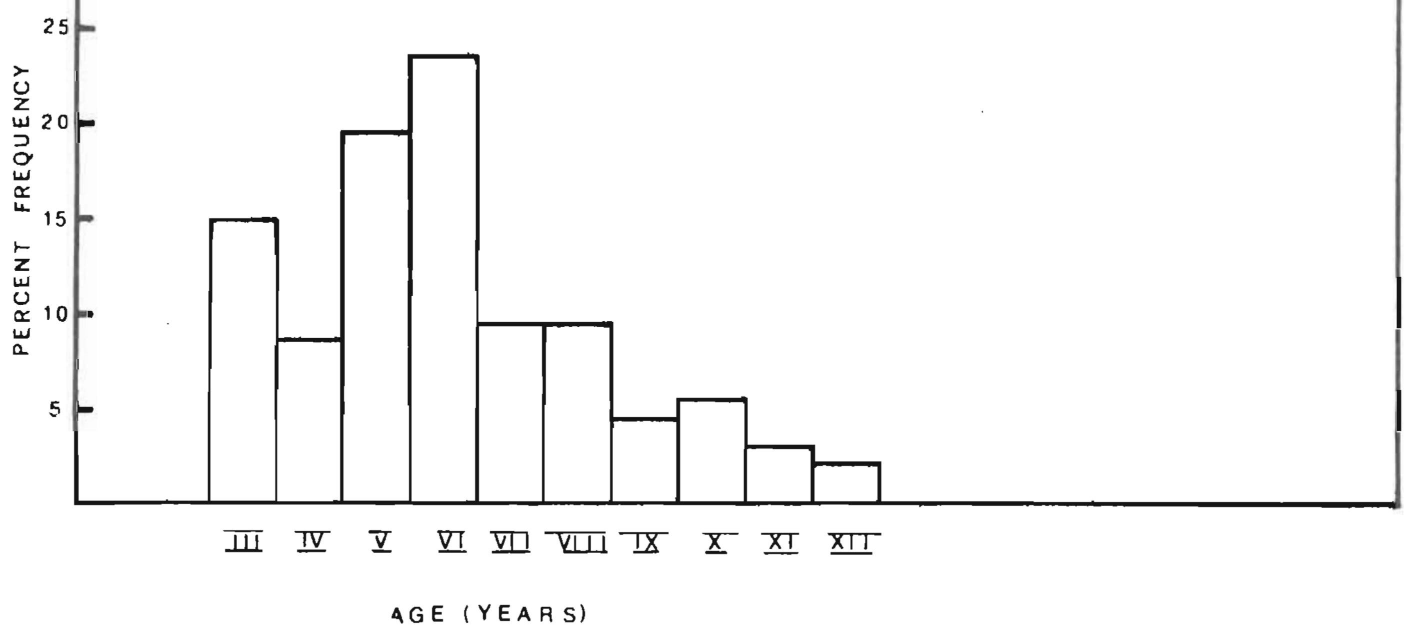


FIG.21. AGE COMPOSITION OF LONGNOSE SUCKER FROM JACOPIE LAKE

Length-Weight Relationship

The general length-weight relationship (Fig. 22), determined by fitting a straight line to the logarithms of length and weight was:

$$\text{Log } W = 3.1937 \text{ Log } L - 2.1143$$

The value of the exponent (3.1937), is a little higher than those calculated for longnose suckers in other lakes. Hatfield et al. (1972) report a mean value of 2.838 for the Mackenzie River Valley and Harris (1962) a value of 2.880 for the longnose suckers of Great Slave Lake.

Sex Ratio

Sex ratio of longnose suckers (male to female) was 3.3 to 1.

Food Habits

Of the 53 longnose sucker stomachs examined to determine food habits only 1 (1.9%) was empty. The main food items of the adults were dipteran pupae (59.6%) and chironomids (69.2%) while cladocerans (59.6%) constituted the bulk of the diet of the young fish. Table XI shows that algae occurred in only 3.9% of the stomachs. Brown and Graham (1954) found that suckers from Yellowstone Lake, Wyoming, fed predominantely on algae and higher aquatic plants.

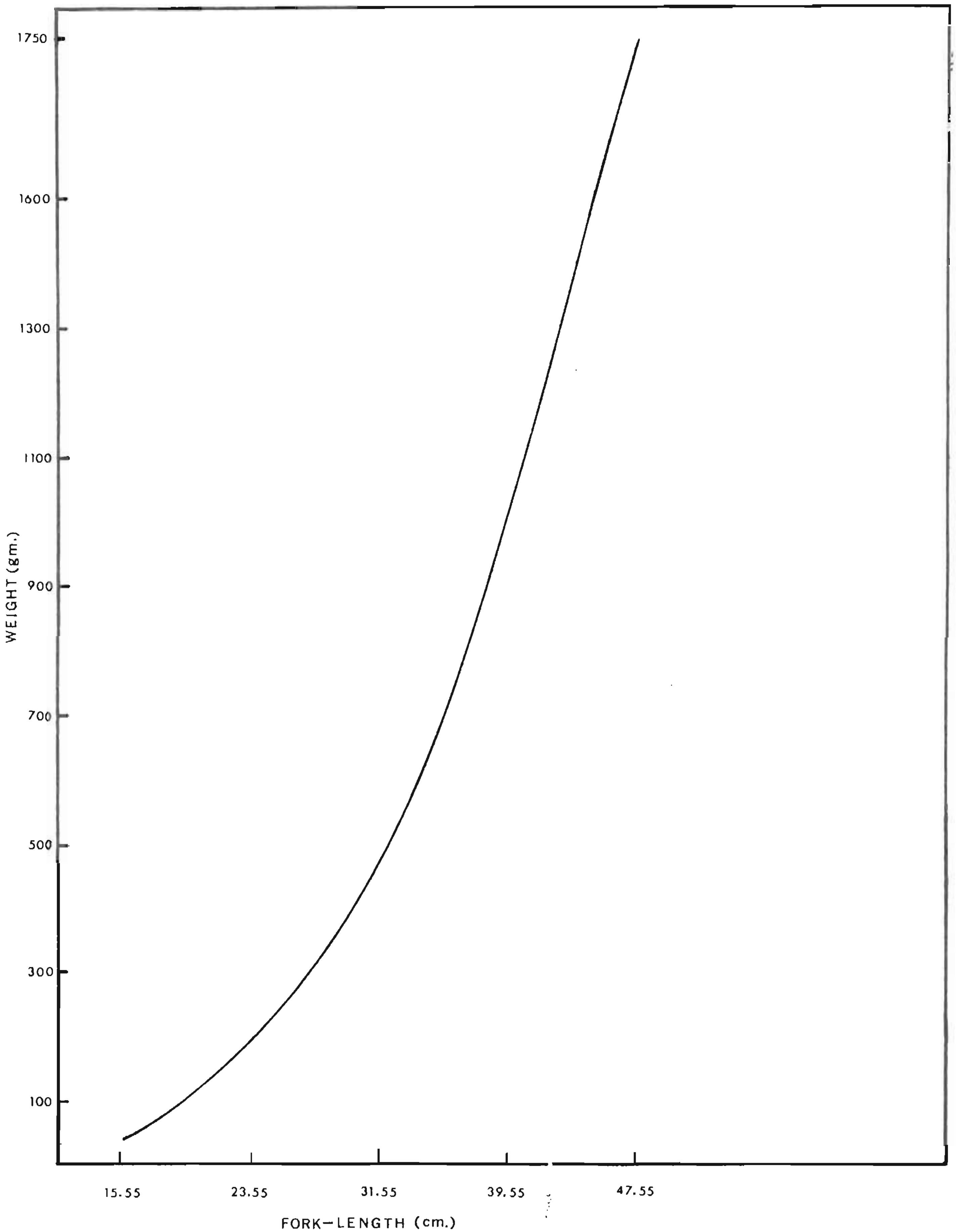


FIG.22 LENGTH-WEIGHT RELATIONSHIP FOR LONGNOSE SUCKER

Table XI. The food of Jacopie Lake longnose suckers expressed as percentages of frequency of occurrence (Based on examination of fish 14.0 - 48.7 cm. fork length caught during the summer, 1973).

Food item	Frequency	Percentage occurrence
Diptera pupae	31	59.6
Ceratapogonidae	36	69.2
Amphipoda	1	1.9
Hydracarina	2	3.9
Mollusca	1	1.9
Copepoda	1	1.9
Cladocera	31	59.6
Algae	2	3.9
Unidentifiable insect remains	4	7.7
Detritus	4	7.7

Trout and Salmon - Family Salmonidae

Brook Trout - Salvelinus fontinalis (Mitchill)

The brook trout is an endemic species to north-eastern North America but has been successfully introduced into other parts of the world. It is generally distributed throughout eastern Canada. They are generally distributed throughout Labrador with heavy concentrations of the larger trophy fish in the south-eastern section.

Brook trout occur in clear, cool freshwater lakes and streams. There are also sea-running forms of brook trout but they will not be discussed in this report. They spawn in the fall of the year and the

exact time varies with temperature and latitude. They usually spawn in gravely streams where they dig redds, but if these are not available they spawn around the shores of the lake wherever they find suitable conditions.

Brook trout aren't selective feeders and will eat almost anything available. Among the wide variety of organisms eaten are aquatic and terrestrial insects, molluscs, amphipods, leeches, frogs and small mammals such as voles and shrews. Ricker (1932) lists a large number of organisms eaten by brook trout.

Back-calculation of Growth

The method of aging brook trout by scales has been validated by a number of authors including Cooper (1951), Alvord (1953), and Allen (1956).

Plotting body length against scale length gave a curvilinear relationship. The Monastyrsky logarithmic method was used to fit the data and straighten out the regression.

Back calculation of lengths was then made from the equation:

$$\text{Log } L_f = 0.9294 \text{ Log } L_s + 0.9576$$

The average scale lengths for each year of life and the corresponding calculated lengths are given in Table XII and presented in Figure 23.

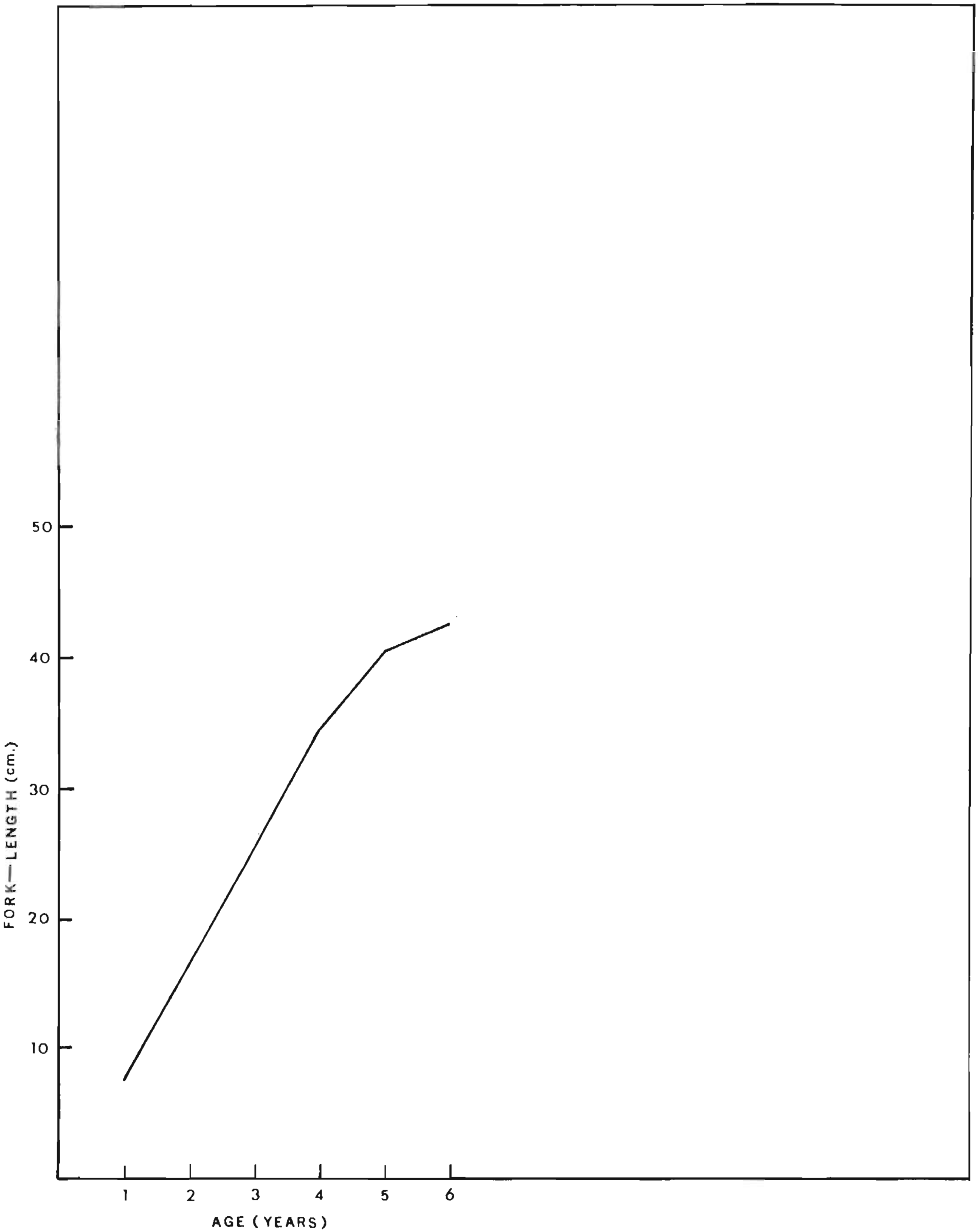


FIG.23. AGE—LENGTH RELATIONSHIP FOR BROOK TROUT

Table XII. Actual scale length and calculated fork length at annulus formation of Jacopie Lake brook trout.

Annulus	I	II	III	IV	V	VI
Scale length (cm.)	0.82	1.91	3.12	4.22	5.01	5.26
Fork length (cm.)	7.5	16.6	26.1	34.6	40.5	42.4

The growth rate shown in Table XI is far better than that exhibited by brook trout on the island. Wiseman (1972) gives the mean growth rate for 37 different populations of brook trout on the Avalon Peninsula (Table XIII).

Table XIII. Back-calculated growth in fork length (cm.) for brook trout in selected Avalon Peninsula lakes.

Annulus	I	II	III	IV	V	VI	VII	VIII
Fork length (cm.)	5.5	10.9	16.2	21.4	26.6	30.8	35.0	36.8

The growth rate of Jacopie Lake trout is similar to that of the brook trout of Pyramid Lake, Alberta, (Rawson and Elsey, 1950) and is somewhat faster than the growth rate of brook trout from Matamek Lake, Quebec (Saunders and Power, 1970).

The oldest and largest fish was VI^+ years of age and measured 52.2 cm. Brook trout are a short-lived species and rarely live longer than VII years.

Length-Distribution and Age Composition

The length distribution and age composition are presented in Figures 24 and 25.

The mean total length was 41.5 cm. with a range of 25.0 - 52.2 cm. The mean male length (43.0 cm.) was higher than the mean female length (40.7 cm.).

Length-Weight Relationship

The general length-weight relationship (Fig. 26), determined by fitting a straight line to the logarithms of length and weight was:

$$\text{Log } W = 3.1669 \text{ Log } L - 2.1323$$

The value of the exponent (3.1669) is higher than those calculated for two brook trout populations on the Avalon Peninsula of Newfoundland. Wiseman (1971, 1972) gives a calculated value of 3.0824 for Thomas Pond brook trout and a value of 2.7651 for Paddys Pond brook trout. Besides attaining a greater length than Newfoundland brook trout they appear to be better conditioned.

Sex Ratio

Sex ratio of brook trout (male to female) was 1.2 to 1. There were eight immature fish.

Food Habits

Results of food studies conducted on a sample of 72 brook trout are presented in Table XIV. Approximately 8.3% of the stomachs were

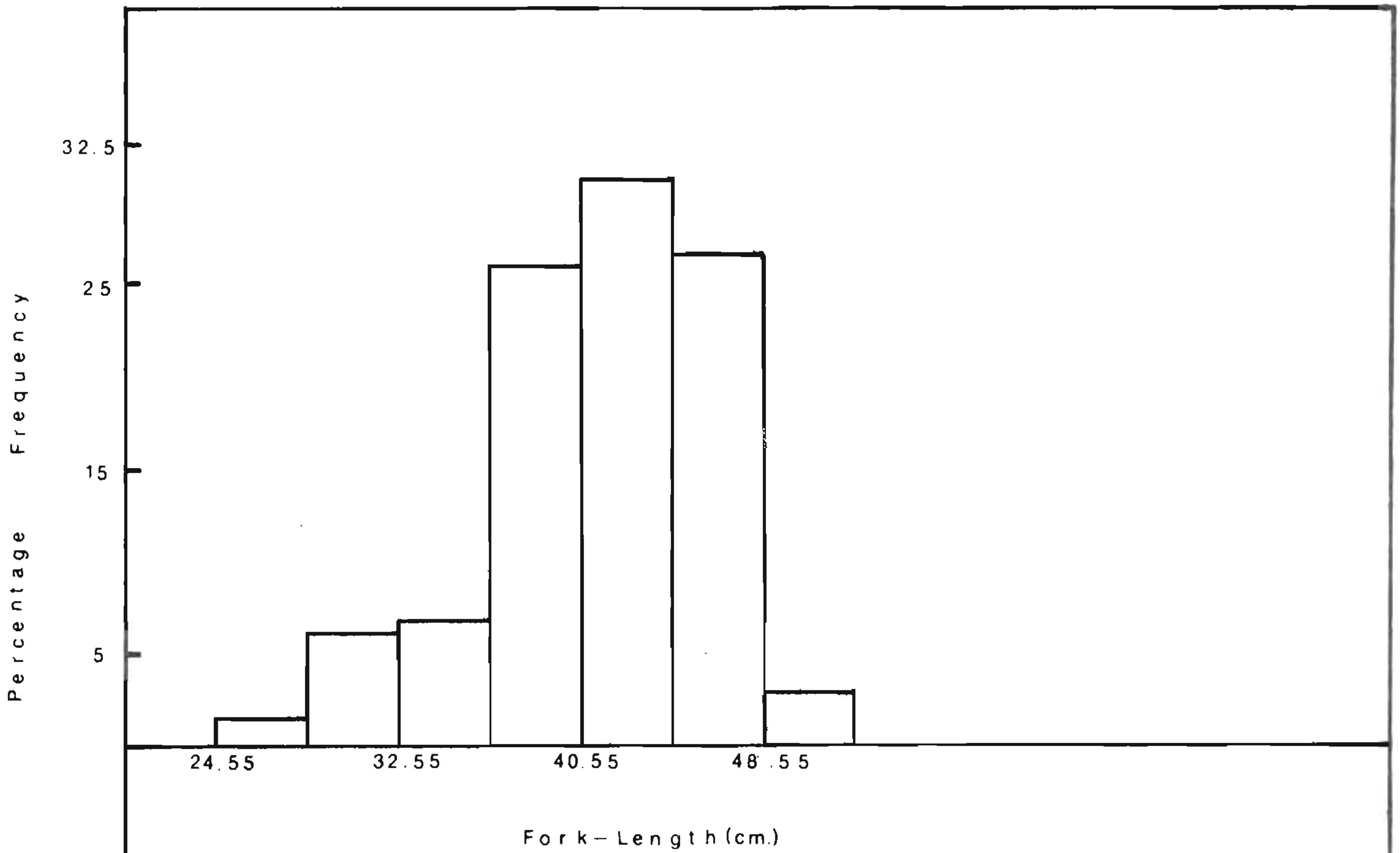


FIG.24. FORK-LENGTH DISTRIBUTION OF JACOPIE LAKE BROOK TROUT

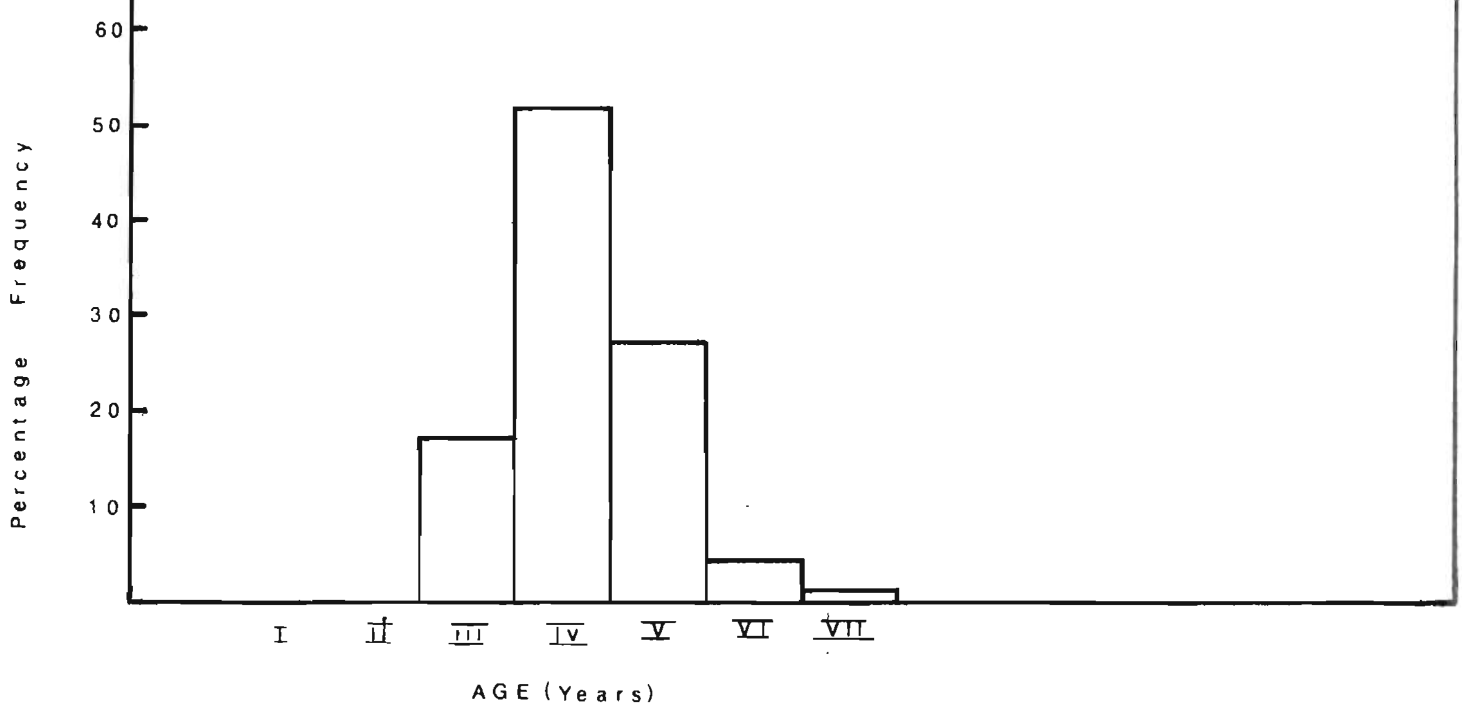


FIG.25. AGE COMPOSITION OF BROOK TROUT TAKEN AT JACOPIE LAKE

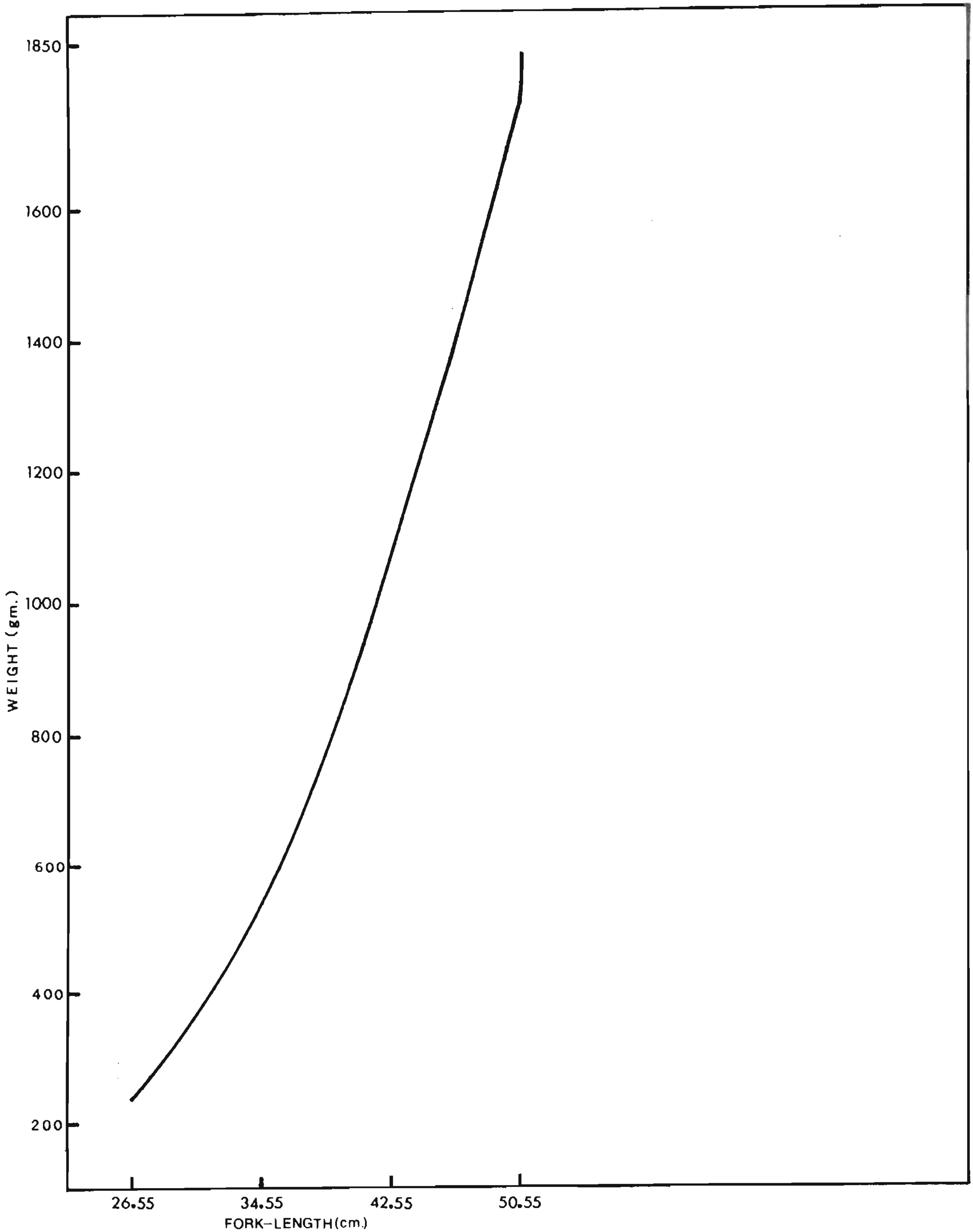


FIG. 26. LENGTH-WEIGHT RELATIONSHIP FOR BROOK TROUT.

empty while 12.1% contained some type of fish remains. Aquatic insects and larvae constituted the main components of the diet. These were made up mostly of ephemeroptera, dipteran pupae and coleoptera.

Table XIV. The food of Jacopie Lake brook trout expressed as percentages of frequency of occurrence (based on examination of fish 25.0 - 52.2 cm. fork length caught during the summer, 1973).

Food item	Frequency	Percentage occurrence
Odonata	3	4.6
Trichoptera	3	4.6
Ephemeroptera	59	89.4
Plecoptera	4	6.1
Diptera (adult)	5	7.9
Diptera (pupae)	44	66.7
Ceratapogonidae	3	4.6
Amphipoda	2	3.0
Hiruidinea	1	1.5
Coleoptera	18	27.3
Mollusca	6	9.1
Copepoda	1	1.5
Algae	2	3.0
Unidentifiable insect remains	4	6.1
Detritus	27	40.9
Burbot	1	1.5
Pike	1	1.5
Unidentifiable fish remains	6	9.1

Ouananiche - Salmo salar (Linnaeus)

Ouananiche, or landlocked salmon, populations are generally spread throughout Newfoundland. They also occur in Labrador, Quebec and the Maritime provinces. This species is relatively less abundant in Labrador than Newfoundland. However, the fish there exhibit a far faster growth rate. R.G. Ferguson, Conservationist with CFLCO (personal communications) reports only 5 ouananiche taken from 7 different stations on the reservoir complex during the summer, 1973.

For an account of the biology of the landlocked salmon see Havey and Warner (1970).

The two fish taken from Jacopie Lake in 1973 were 41.8 cm. (VII^+) and 55.8 cm. ($VIII^+$).

Age and Growth

Age and growth data calculated from scales sent to the Department from western Labrador during 1972 are presented in Table XV and Figure 27.

Table XV. Actual scale lengths and calculated fork lengths at annulus formation of western Labrador ouananiche.

Annulus	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Scale length (cm.)	0.9	2.7	4.9	7.3	10.2	12.4	14.1	15.3	17.3	19.4	19.8	19.9
Fork length (cm.)	7.9	13.7	20.8	28.5	33.4	45.0	50.4	54.3	60.8	67.6	68.9	69.2

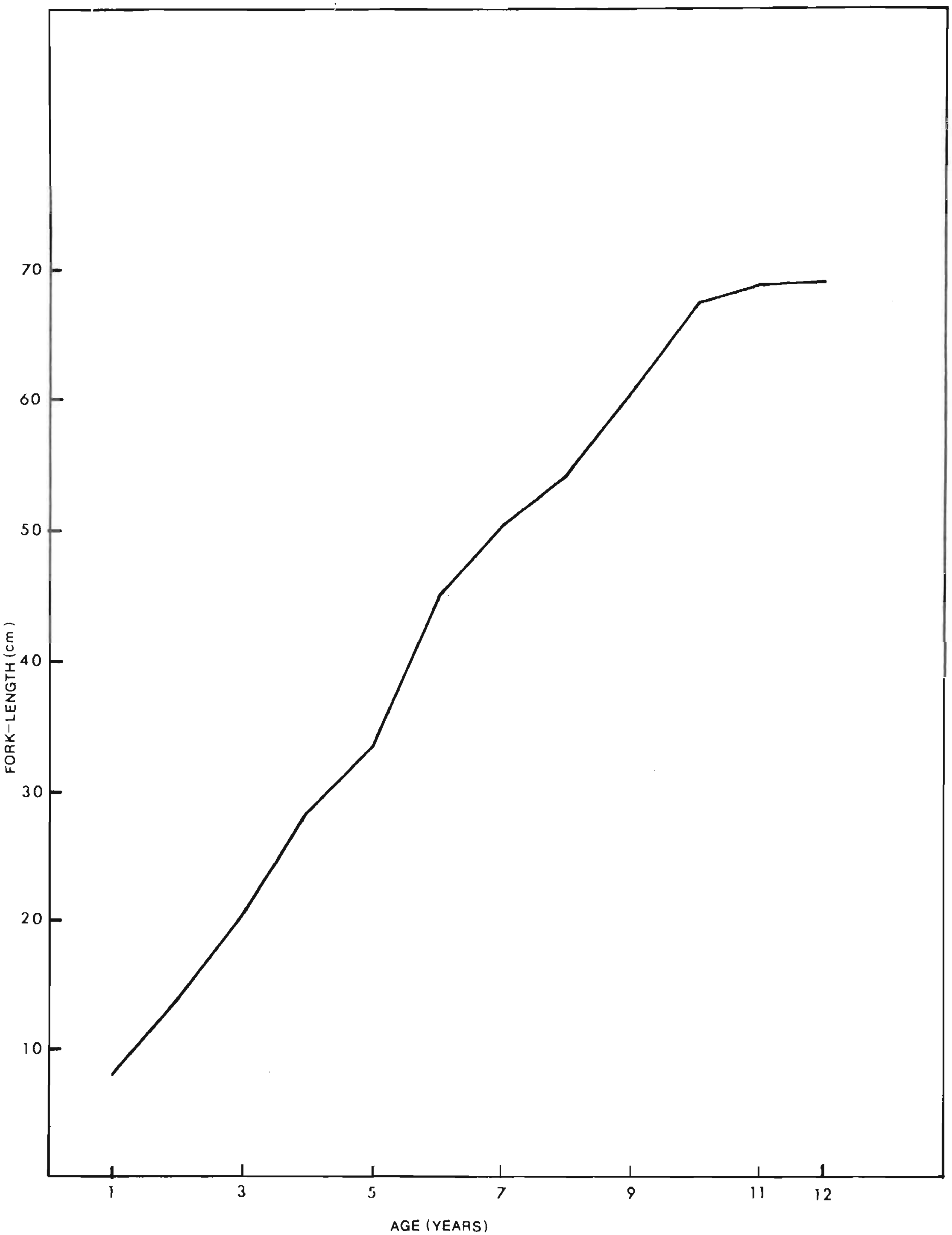


FIG. 27. AGE-LENGTH RELATIONSHIP FOR OUANANICHE FROM WESTERN LABRADOR, 1973.

Lake Trout - Salvelinus namaycush (Walbaum)

The lake trout is widely distributed across northern North America from the Maritime provinces and Labrador on the east, to northern British Columbia, Northwest Territories, and the Yukon on the west (Scott, 1967). It is generally distributed throughout most large lakes in Labrador but is more prevalent in the north-western section.

Its presence seems to be limited by lakes large enough to provide a large volume of cool water during the summer months. Spawning takes place during the fall of the year, usually on any shoals present in the lake. However, they have been recorded to spawn in water depths up to 200 feet (Martin, 1957).

They are mainly piscivorous whenever forage fish are available. When fish are not present in suitably large quantities they usually eat plankton and aquatic insects.

Back-calculation of Growth

The sample (24) of lake trout taken from Jacopie Lake was too small for back-calculation of growth. However, scale samples from trout in the western Labrador region sent to the Department in 1972 were used in this study. These are presented in Table XVI and Figure 28.

Table XVI. Actual scale lengths and calculated fork lengths at annulus formation of western Labrador lake trout.

Annulus	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
Scale length (cm.)	0.86	1.6	2.47	3.38	4.36	5.32	6.26	7.11	7.84	8.70	9.33	9.98	10.65	10.00	11.50
Fork length (cm.)	8.0	13.0	18.8	24.8	31.4	37.8	44.0	49.7	54.6	60.3	64.5	68.9	73.3	75.0	79.0

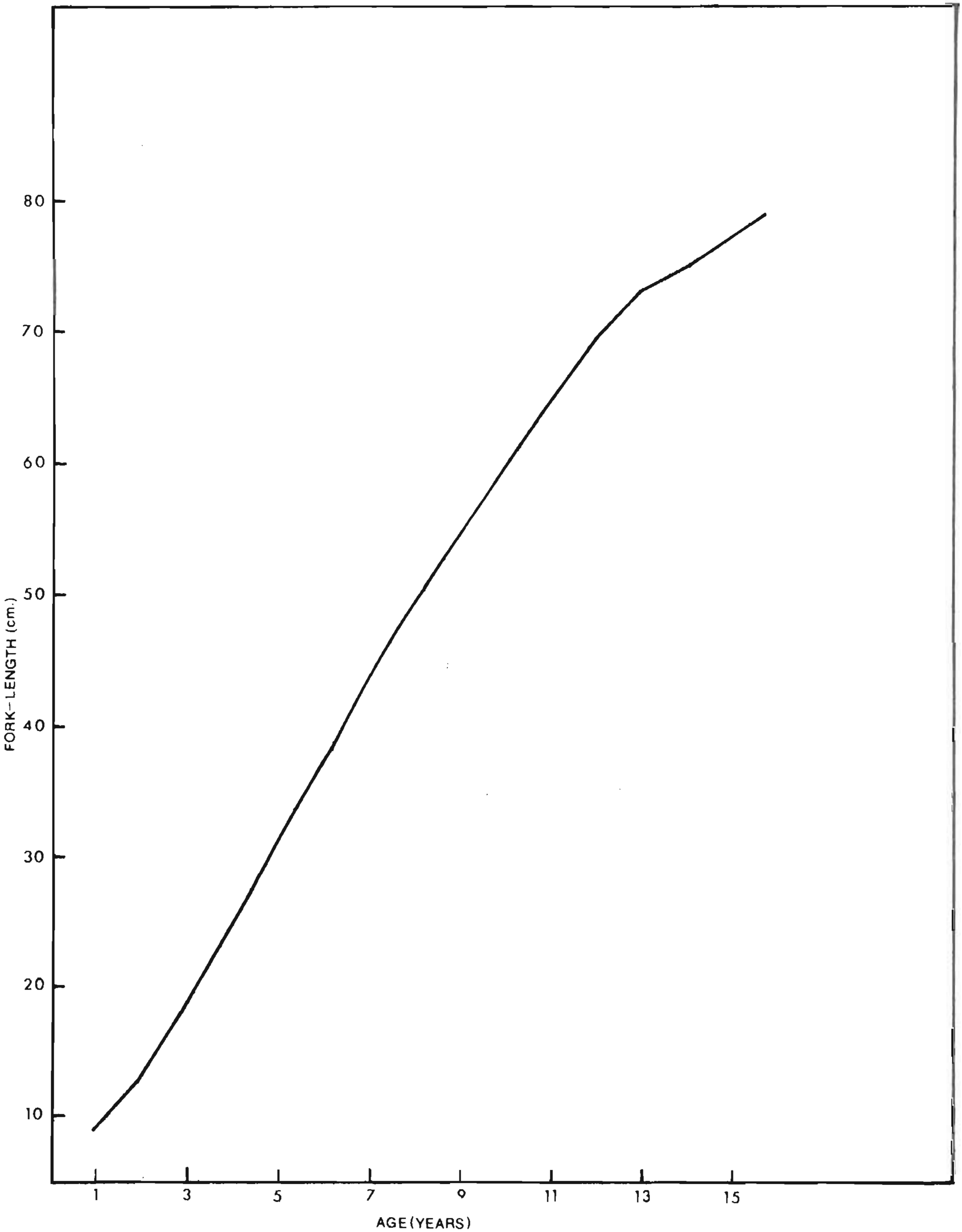


FIG. 28 AGE-LENGTH RELATIONSHIP FOR LAKE TROUT.

Growth of lake trout, like other species, varies in lakes throughout its range and also in lakes within the same general area. Generally speaking, populations in the southern part of its range have a faster growth rate than those in the northern part. However, lake trout attain the greatest size of all the Labrador fish and for this reason they are of great interest to the angler.

Length Distribution and Age Composition

The length and age distribution of the lake trout are given in Tables XVII and XVIII.

The mean total length was 56.3 cm. with a range of 48.1 - 67.2 cm. The mean male and female lengths were exactly the same (57.2 cm.). There were 12 females and 8 males and 4 fish were immature.

Table XVII. Length distribution of lake trout taken from Jacopie Lake, summer 1973.

Class internal (cm.)	Frequency	Percent frequency
47.55-51.55	7	29.2
51.55-55.55	5	20.8
55.55-59.55	5	20.8
59.55-63.55	4	16.7
63.55-67.55	3	12.5

Table XVIII. Age composition of lake trout taken from Jacopie Lake, summer 1973.

Age class	Frequency	Percent frequency
VII^{+}	1	4.4
$VIII^{+}$	4	17.4
IX^{+}	7	30.4
X^{+}	5	21.7
XI^{+}	2	8.7
XII^{+}	2	8.7
$XIII^{+}$	2	8.7

Length-Weight Relationship

The general length-weight relationship (Fig. 29), determined by fitting a straight line to the logarithms of length and weight was:

$$\text{Log } W = 2.9157 \text{ Log } L - 1.7857$$

Martin (1970) reports a "b" value of 3.09839 for lake trout of Lake Opeongo, Ontario. The mean whole weight for lake trout was 2112.9 g. with the mean male weight (2345.0 g.) being greater than the mean female weight (2087.0 g.). Since they had the same mean length, it appears that the males are in better condition. However, this may only be a result of the small sample size.

Food Habits

Out of the 14 feeding fish, 13 (92.9%) contained some type of fish remains. This is in agreement with most other food studies of the lake trout (Rawson, 1961; Dryer et al. 1965; Martin, 1970).

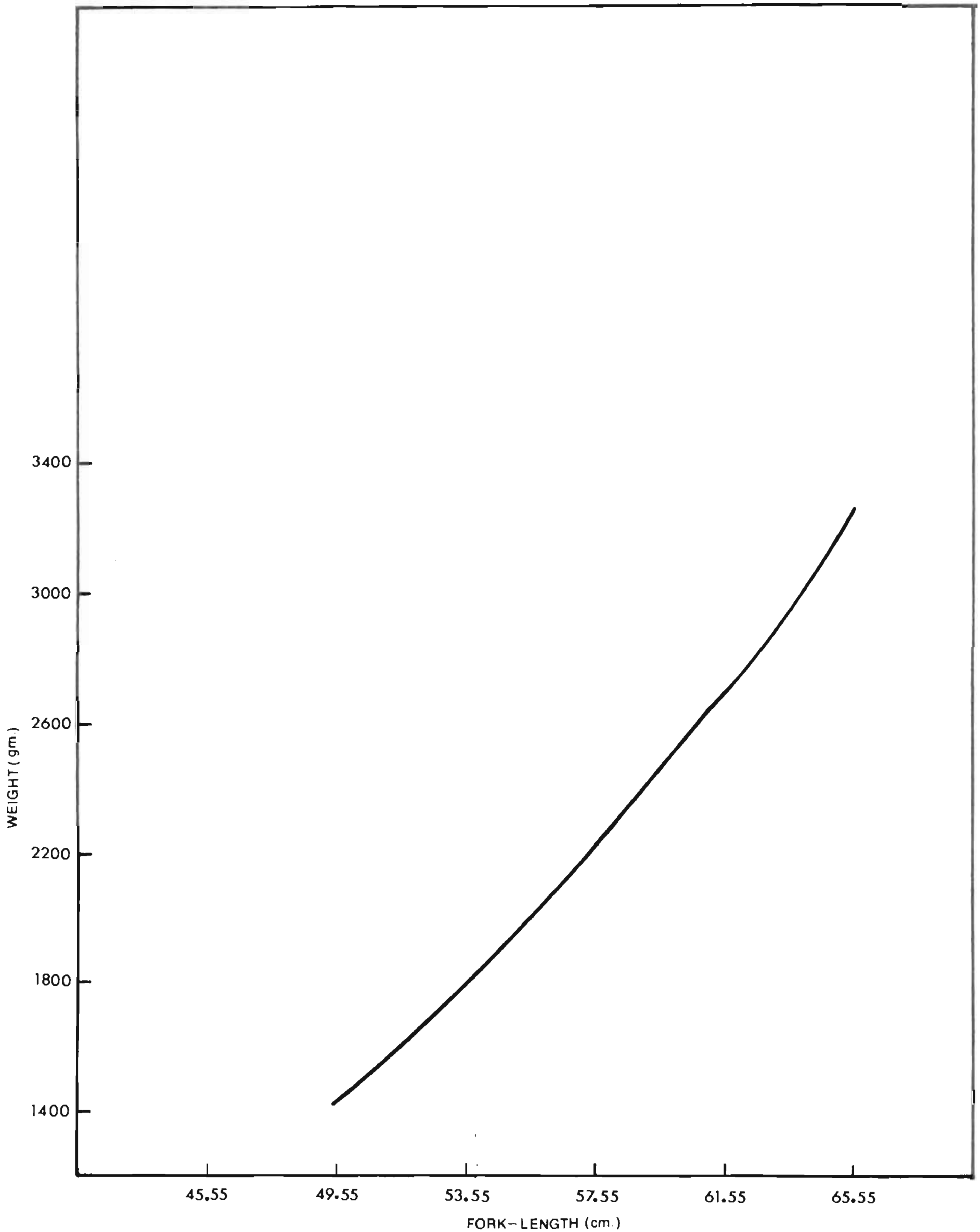


FIG. 29. LENGTH—WEIGHT RELATIONSHIP FOR LAKE TROUT.

Among the fish eaten were lake whitefish (14.3%), burbot (7.1%), and longnose suckers (7.1%). Aquatic insects comprised most of the remaining diet (Table XIX).

Table XIX. The food of Jacopie Lake lake trout expressed as percentages of frequency of occurrence (based on examination of fish 48.1 - 67.2 cm. fork length caught during the summer, 1973.

Food item	Frequency	Percent occurrence
Ephemeroptera	1	7.1
Diptera (pupae)	1	7.1
Algae	2	14.3
Unidentifiable insect remains	1	7.1
Detritus	1	7.1
Unidentifiable fish remains	10	71.4
Lake whitefish	2	14.3
Burbot	2	7.1
Longnose sucker	1	7.1

Cods - Family Gadidae

Burbot - Lota lota (Linnaeus)

The burbot is generally distributed in the fresh waters of continental Eurasia and North America, southward to about 40°N (Scott and Crossman, 1973). It is spread throughout Canada except for Nova Scotia and the Atlantic islands. At the present, very little is known of its distribution in Labrador.

The burbot has similar habits to the lake trout in that they inhabit the deeper, cooler water during the summer months. They are sometimes found in large rivers. They are one of the few freshwater fishes that spawn during the winter (January to March). They spawn on gravel shoals in the lakes and sometimes in the rivers. Adult burbot are mainly fish eaters while the yound feed upon aquatic insect larvae and other invertebrates. Clemens (1951), Martin (1941), McCrimmon and Devitt (1954), Hewson (1955), and Lawler (1963), give accounts of burbot biology for some Ontario and Manitoba lakes.

Only four burbot were taken from Jacopie Lake in 1973. They ranged in fork length from 22.3 to 41.0 cm. These fish couldn't be aged since no otoliths were taken. The maximum length of a burbot taken by LeDrew (1972) from the Naskaupi River, Labrador, was 27 cm.

Three of the fish taken were eating aquatic insects and one contained fish remains.

Composition of the Catch

The total catch for 27 sets was 609 fish weighing 526.1 kg. (Table XX). The average catch per set was 22.6 fish and 19.5 kg. Lake whitefish dominated the catch in numbers (27.4%) and ranked third in weight (13.5%) (Figure 30). Brook trout, longnose suckers and northern pike made up 24.6%, 23.2% and 19.2% of the catch respectively, by numbers. Northern pike and brook trout made up 67.5% of the catch by total weight (Figure 30). Burbot, ouananiche and round whitefish were caught in very few numbers and together made up 1% of the total catch by weight.

Catch in Different Mesh Sizes

The catch broken down by number and weight for each mesh size is presented in Table XXI and Figure 31. It can be clearly seen that there was very little difference between the 1-1/2", 2" 3" and 4" mesh size with respect to the number of fish taken. However, the greatest percentage (75.6%) by weight was taken in the 3" and 4" mesh.

Table XX. Percent number and weight of each species taken from Jacopie Lake, 1973.

Species	Number	Percent	Weight (gm.)	Percent
Longnose sucker	141	23.2	44541.9	8.5
Lake whitefish	167	27.4	71142.0	13.5
Brook trout	150	24.6	158520.0	30.1
Northern pike	117	19.2	196864.2	37.4
Lake trout	24	3.9	50709.6	9.6
Burbot	4	.7	695.2	.2
Ouananiche	2	.3	2979.0	.6
Round whitefish	4	.7	646.0	.1
Total	609		526097.3	

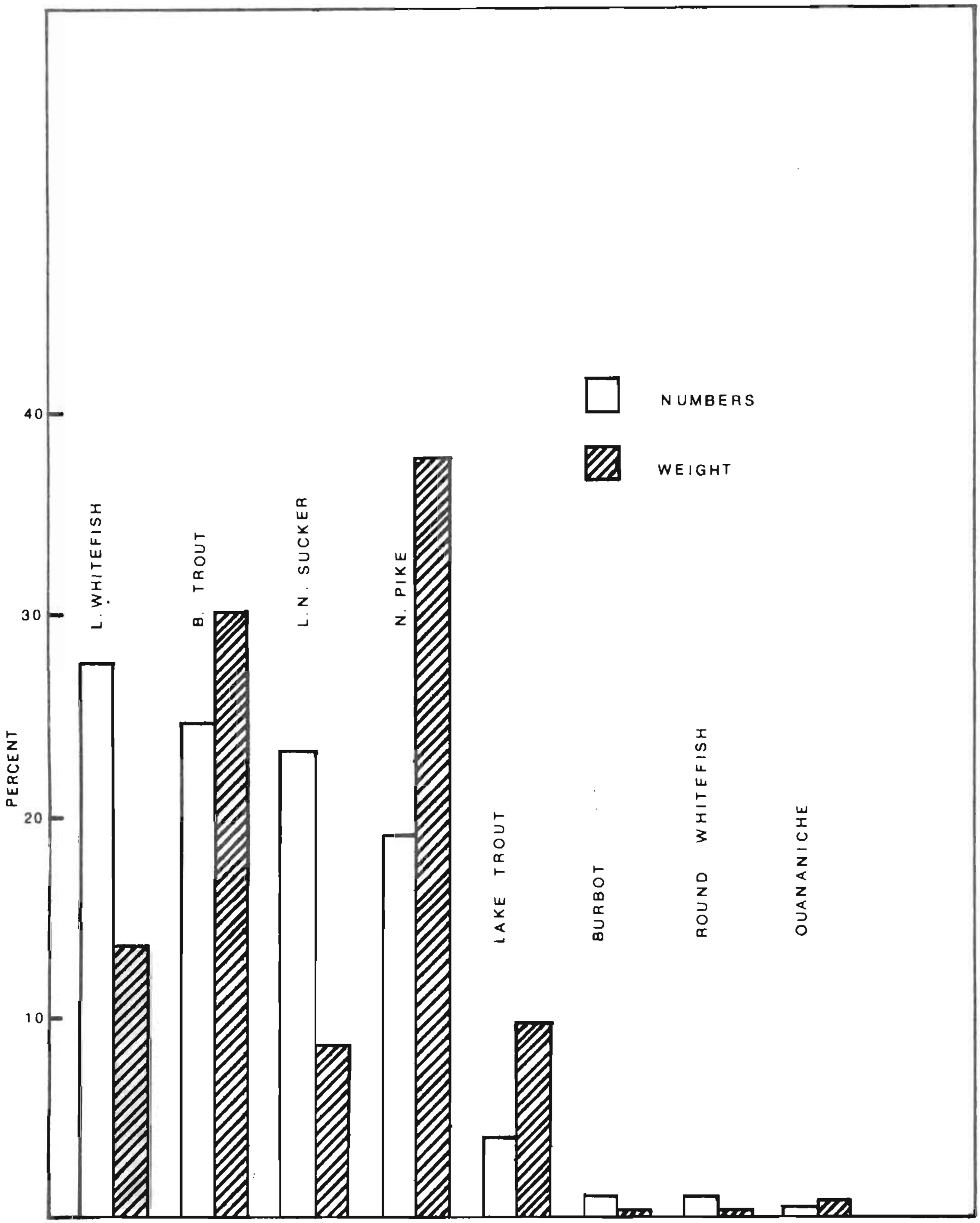


FIG.30 PERCENTAGE COMPOSITION OF GILL NET CATCH

EXPRESSED NUMERICALLY AND IN TERMS OF

WEIGHT

Table XXI. Number of fish caught in various mesh sizes at Jacopie Lake, 1973.*

Species	1-1/2"	2"	3"	4"	5"	Total
Longnose sucker	64	42	22	3	6	137
Lake whitefish	38	33	28	22	6	127
Northern pike	2	13	48	39	2	104
Lake trout	3	1	4	5	6	19
Burbot	2	1	1	-	-	4
Ouananiche	-	1	1	-	-	2
Round whitefish	-	-	1	-	-	1
Total number	109	91	105	69	20	394
Percent	27.7	23.1	26.7	17.5	5.1	
Total weight (kg.)	17.1	25.8	127.9	116.3	25.7	233.9
Percent	5.3	8.0	39.6	36.0	11.1	

*Brook trout data were not available for this analysis.

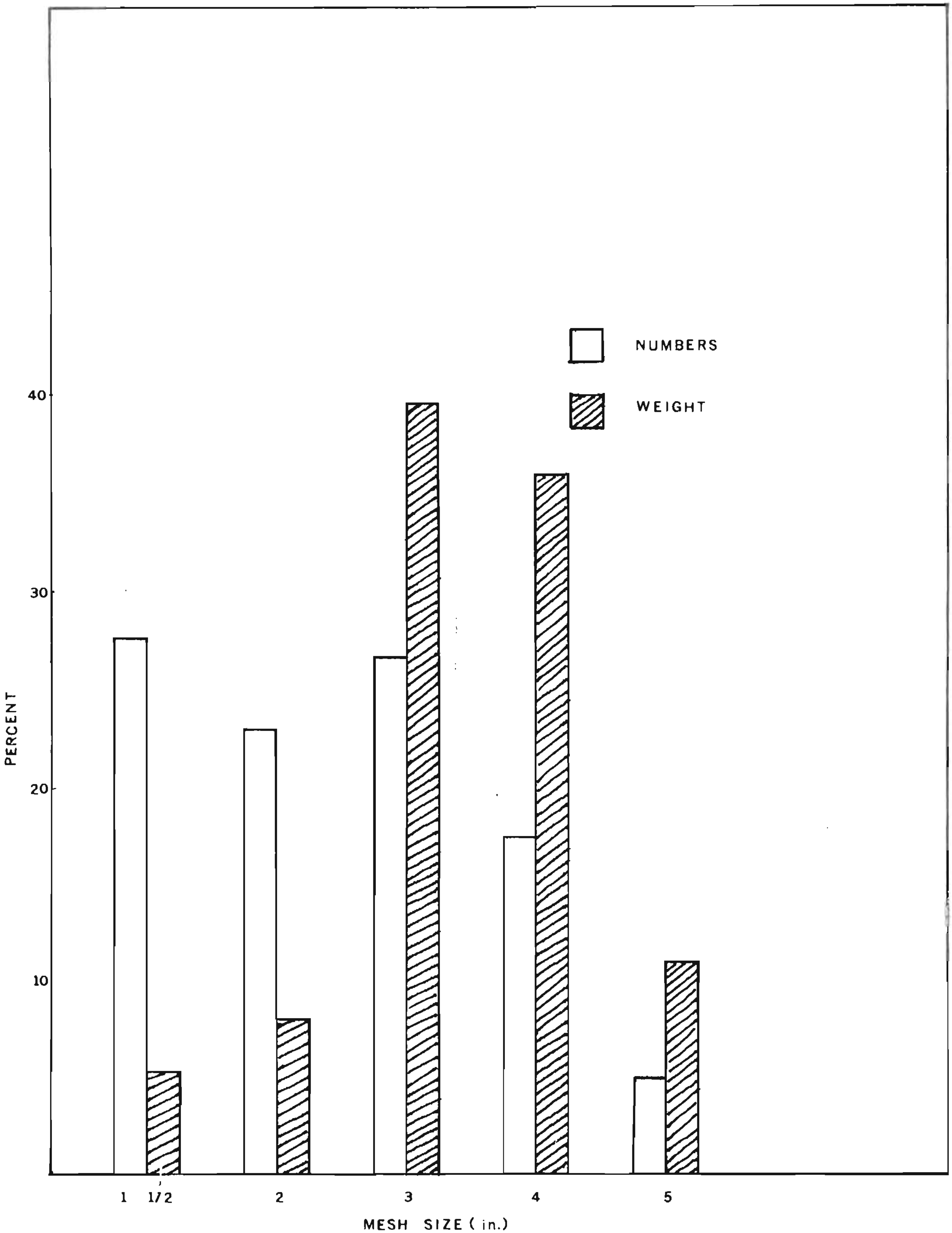


FIG. 31. PERCENTAGE OF GILL NET CATCH IN EACH MESH SIZE EXPRESSED NUMERICALLY AND IN TERMS OF WEIGHT

SUMMARY

Fish Species and Sampling Gear

Sampling with gill nets showed four fish species to be numerically dominant in Jacopie Lake, Smallwood Reservoir. These were lake whitefish, longnose suckers, brook trout, and northern pike. Other species present in the lake are round whitefish, lake trout, burbot, and ouananiche. Except for lake whitefish, most of the fish taken were the larger individuals of the populations. This, no doubt, is a result of the sampling gear used. Also, the sampling stations help determine the type of fish caught in any area, for all species or populations of the same species do not occupy the same habitat during the same time of the year.

Gill nets also affect the food contents of the captured fish. When fish first become tangled in the mesh, digestion continues to take place, and regurgitation occurs in some instances. In the case of piscivorous fish e.g. pike, they may often eat fish captured in the net before they themselves become meshed.

Food Analysis

Food analysis showed that most of the species in the lake were benthic feeders, utilizing mostly aquatic insect larvae. The young of these same species are mostly plankton feeders. Minnows and cottids are the main forage food for the two piscivorous species, lake trout and northern pike.

Age and Growth

Inherent in any age and growth study involving scales are sources of error. These stem mainly from the inability to locate the first annulus in some cases, the presence of false annuli, and the clumping together of the annuli in the older fishes. However, there was good agreement between different readers for the same scales. Also, back-calculated rates of growth compared favourably well with those of other workers for the same species in northern Canada and the Northwest Territories.

Commercial and Sport Fishery

On the basis of the biological information collected in this study a small commercial fishery could possibly be established on the Smallwood Reservoir. However, before any commercial fishery is started, certain precautions should be taken. There should be a yearly quota established for each species. Guaranteed markets should be found before the fish are harvested and proper storing and freezing facilities must be obtained to preserve the fish before they are sent out.

There is also a good potential for a recreational fishery on the reservoir. At the present time most of the sport fishing is carried out at the control structures. As these sites become too crowded as a result of more people joining the angling population, small boats will become more important. As a result of this we will have to increase our protection and conservation staff in this area. Additional creel censuses would also give us much needed information concerning the sport fishery.

The commercial and sport fisheries in this area could be of great economic and recreational value to the local people if they are managed wisely and correctly.

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APPENDICES

Appendix 1. Conversion of conductivity values to TDS

$$\frac{C_2}{C_1} = \frac{4 + T_2}{4 + T_1}$$

C_2 = actual reading microhoms

C_1 = reading at 77°F (25°C)

T_2 = temperature of water at actual reading

T_1 = 77°F

e.g. $\frac{190}{C_1} = \frac{4 + 78}{4 + 77}$ $\quad C_1 = 187.7$

$Y(T.D.S.) = 7.02 + (0.72)\ (C_1)$

e.g. $Y = 7.02 + 0.72\ (187.7)$

$Y = 7.02 + 135.14$

$Y = 142.16$

Appendix II. Temperature readings for Jacopie Lake (June-July, 1973).

Date	Surface Water Temperature	Date	Surface Water Temperature
June	°F		
22	57.0		
23	57.8		
24	57.0		
25	57.0		
26	57.0		
27	57.3		
28	57.3		
29	57.3		
30	57.8		
July	°F	July	°F
1	58.5	17	61.5
2	59.5	18	61.5
3	60.3	19	61.8
4	61.0	20	62.0
5	61.3	21	62.3
6	62.0	22	64.0
7	62.5	23	62.7
8	62.8	24	62.0
9	61.8	25	62.0
10	61.8	26	62.0
11	61.8	27	62.0
12	61.8	28	62.0
13	61.8	29	62.5
14	62.3	30	62.5
15	61.7	31	62.0
16	61.5		