LAKE WHITEFISH (COREGONUS CLUPEAFORMIS (MITCHILL)) IN SOUTHERN INDIAN LAKE, MANITOBA

by
H.A. AYLES

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H. A. AYLES

This is the eighty-ninth Technical Report from the Research and Development Directorate Freshwater Institute Winnipeg, Manitoba

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ABSTRACT

Ayles, H. A. 1976. Lake Whitefish (Coregonus clupeaformis (Mitchill)) in Southern Indian Lake, Manitoba. Fish. Mar. Serv. Res. Dev. Tech. Rep. 640: 28pp.

The spawning and population characteristics of lake whitefish, (Coregonus clupeaformis), from Southern Indian Lake, are discussed. Whitefish spawn in shallow areas of rock and boulders. Temperature appears to trigger the spawning act. Whitefish(males and females) mature at an average age of 8.8 years. Growth and condition are good for lake whitefish in most regions of this large and complex lake. Different year class strengths appear to exist. Mortality rates vary from 0.43-0.70. The flow of the Churchill River through this lake has a strong influence on the productivity of the lake and therefore on the available commercial yield of whitefish. Commercial fishing of whitefish yields, on the average, 400,000 kilograms per year.

RÉSUMÉ

Ayles, H. A. 1976. Lake Whitefish (Coregonus clupeaformis (Mitchill)) in Southern Indian Lake, Manitoba. Fish. Mar. Serv. Res. Dev. Tech. Rep. 640: 28pp.

On étudie les caractéristiques du frai et de la population du grand corégone (Coregonus clupeaformis) qui vit dans le lac Southern Indian. Le grand corégone fraye dans des eaux peu profondes garnies de roches et de galets. La température semble activer le frai. Les grands corégones (mâles et femelles) atteignent l'âge adulte à 8.8 ans en moyenne. La croissance et l'état des grands corégones sont bons dans la plupart des régions de ce lac complexe et étendu. Il semble y avoir des différences de résistance à l'intérieur d'une même classe d'âge. Les taux de mortalité varient entre 0.43 et 0.70. Le courant de la rivière Churchill qui traverse ce lac exerce une forte influence sur la productivité du lac et, par conséquent, sur le rendement de l'industrie du grand corégone. La pêche industrielle du grand corégone rapporte une moyenne de 400,000 kg par an.

INTRODUCTION

Southern Indian Lake is a large body of water on the Churchill River drainage in northern Manitoba (98° 30'W, 57° 20'N). The lake is 2300 square kilometers in area with a tributary drainage area greater than 250,000 square kilometers. It lies in a shallow bedrock-dominated trough (mean depth 9.1 metres) mid-way in the subarctic zone of the Pre-Cambrian Shield.

The study of the fish species in Southern Indian Lake was undertaken as part of a multi-disciplinary investigation of aquatic conditions existing in this lake prior to the completion of a major hydroelectric development which will involve the lake and surrounding river systems.

As the lake whitefish (*Coregonus clupeaformis*)is the prime commercial fish species in this lake, considerable effort has been addressed to the various parameters of the population to determine condition, growth, spawning, food and fecundity prior to impoundment. This species (along with walleye (*Stizostedion vitreum*) has been commercially fished from 1941 to the winter of 1973. Because of the temporary availability of other work for the fishermen, the commercial fishery has ceased. This report summarizes data gathered by the author on the Southern Indian Lake whitefish and draws considerable information on spawning and fecundity of these whitefish from a report prepared by Weagle and Baxter (1974). It is hoped that these investigations will produce an insight into the conditions of a whitefish population in a relatively productive northern lake as well as provide the required baseline data to observe changes which may occur when the hydroelectric development is completed. As *Coregonus clupeaformis* is the only whitefish taken from Southern Indian Lake, it is referred to as "whitefish" rather than "lake whitefish" throughout this publication.

METHODS

The lake was divided, for experimental purposes, into eight different regions, because of its size and the physical complexity. Boundaries between regions were placed, where possible, at channel restrictions that divide the lake into natural basins and each of these regions was designated numerically (Fig. 1).

Gill netting was carried on from July to September in 1972 and 1974. In 1972 all regions of the lake were extensively fished; in 1974 two specific regions were chosen and intensively sampled. During this year emphasis was placed on gathering more information from one area which is presently in the flow of the Churchill River (region 2) and a second area which is adjacent to the first but which does not, at present, receive Churchill River water (region 6). Region 2 is 29,000 hectares in surface area and has a calculated flushing time of 24 days; Region 6 is 12,500 hectares in surface area and has a calculated flushing time of approximately 1000 days (Cleugh et al., 1974).

Fishing gear was composed of a standard gang of 6 multifilament nylon gill nets each fifty yards long of the following size and order (stretch mesh); 5¼ inch, 1½ inch, 4¼ inch, 2 inch, 3½ inch and 2 3/4 inch. All sets were overnight, on the bottom. Depths were recorded at fifty yard intervals and during 1972 vertical temperature profiles were recorded at each fishing location.

Fork lengths, weights, and scale samples were obtained for all whitefish. During 1972, sex was recorded also and a subsample of stomach contents from the total catch was analysed. All undigested organisms taken from stomach samples were identified and wet weights recorded (2/3 of the weight of molluscs was removed to compensate for shell weight).

Fish were considered to be the same age as the number of true annuli or rings appearing on the fish scale, as suggested by Carlander (1956). Scales sampled were not key scales, but were removed from the same area of each fish. Scale radius measurements and back calculation of ages were made on whitefish caught in 1972.

Rates of growth in both years were determined by establishing lengths at age for whitefish. Where it appeared evident that the rate of growth followed a linear curve, an analysis of co-variance was used to determine differences between fish in specific areas and between years sampled. Mean ages were compared using an analysis of variance. All statistical tests completed were set prior to testing at a level of significance of 0.05.

The relationship between length and weight of a fish is a measure of the plumpness or condition of the fish. Length-weight relationships for whitefish were determined by fitting a log-log (base 10) linear regression to the data. Slopes and elevations of the condition regressions were compared using an analysis of co-variance. A condition factor

$$\left(K = \frac{\text{Weight} \times 10^5}{\text{length } 3}\right)$$

was calculated using the formula described by Carlander (1969). Mortality rates were determined using the method described by Robson and Chapman (1961).

Whitefish population size can be estimated on a relative basis by comparing quantities caught with a standard amount of effort. Effort, for this purpose, was one gang of gill nets set overnight for 16 hours and actual times for gill net sets arithmetically corrected to equal 16 hours. The basic assumption that number of fish caught is proportional to length of time of net set was made. Catch per unit effort is described in both numbers and pounds of whitefish.

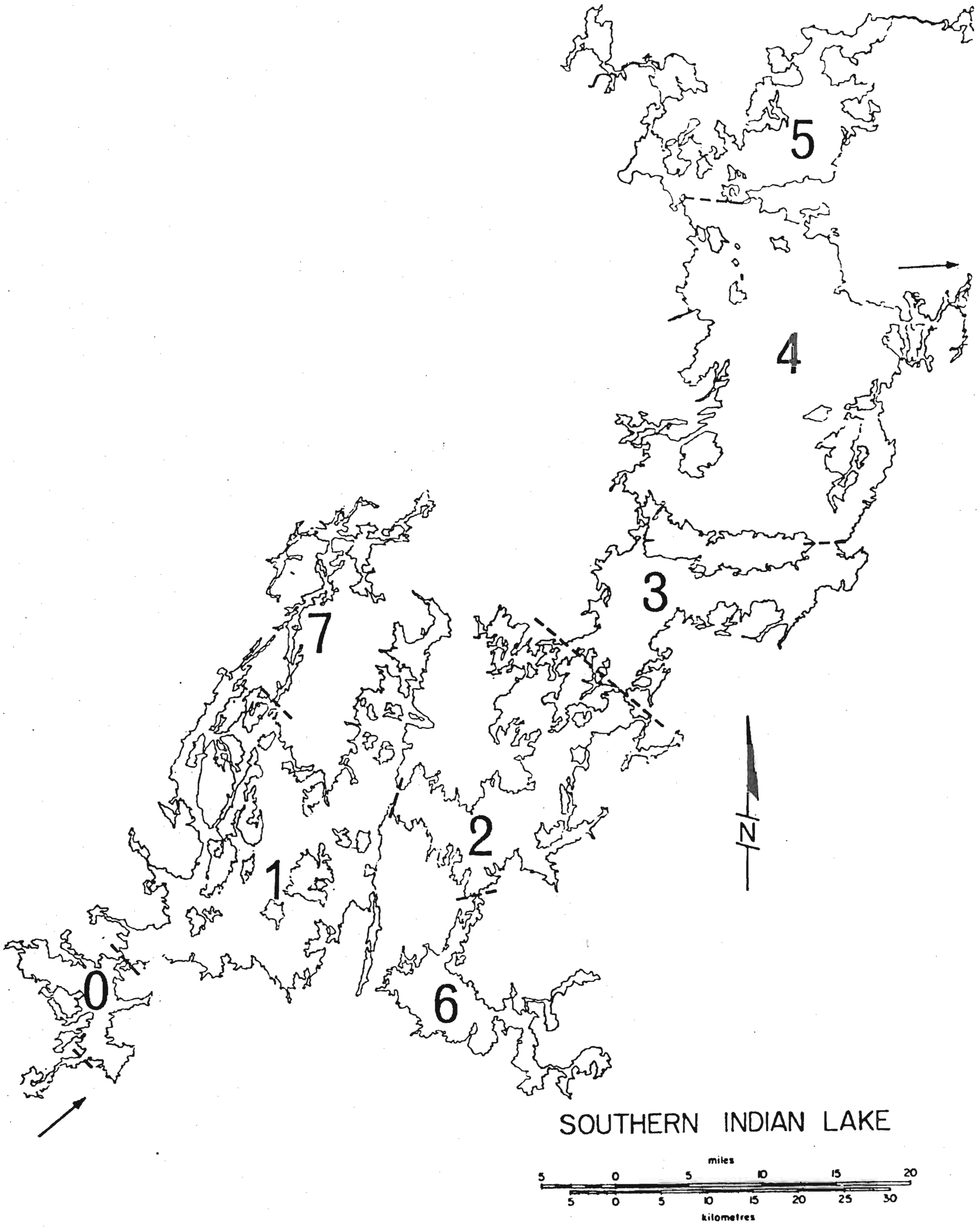

Figure 1.

Eights experimental regions of Southern Indian Lake. Inlet of the Churchill River is in the south-west and present outlet is in the north-east from region 4, as indicated by arrows.

GROWTH, CONDITION, AND MORTALITY

Growth in length is presented as an average for each year class in Table 1. No information on young-of-the-year whitefish was collected and growth data for these fish may only be inferred by back calculation (Tesch, 1971). Since the samples were taken from June to September, essentially the whole growing season in this lake, the averages shown are assumed to indicate the approximate mid-point in growth for any year class. Back calculations of length at annulus formation were determined assuming direct proportionality between scale radius and fork length.

In a lake such as Southern Indian where there is significant commercial fishing pressure the selective fishing mortality might be expected to result in a situation in which "back calculations of length .... exhibit a tendency for computed lengths at a given age to be smaller, the older the fish from which they are computed" (Lee's phenomenon, Tesch, 1971). If the commercial fishery were applying an excessive amount of pressure the faster growing fish would have been selected first as they reached the commercial size. Back calculations on the scales of the remaining, slower growing fish would show the discrepancy between rates of growth of the present young and rates of growth of these old fish when they were young. There was no evidence for "Lee's phenomenon" even though experimental gill nets with the smaller net sizes should have sampled the younger, faster growing whitefish. Thus there was no evidence for selective fishing mortality i.e. over-exploitation by the commercial fishery.

Growth between years of sampling (1972 and 1974) as indicated by size at age did not differ appreciably in the areas fished and similarly there was little difference in growth when different regions of the lake were compared within a year (Table 2).

Mean age, length and weight for whitefish sampled in 1974 were less than mean age, length and weight of whitefish sampled in 1972 in the same two regions (Table 3). From the age-frequency data (Fig. 3) it would appear there was a significantly different age class structure of whitefish in 1972 than there was in 1974 in these regions. This is not an unusual phenomenon. Van Oosten and Hile (1949) reported that "the annual difference in the age composition of the samples of the Lake Erie whitefish were sufficiently great to indicate considerable variation from year to year in the success of reproduction" and Dryer (1963) found that year class strengths of whitefish varied throughout Lake Superior. Although no records of climatological, or water conditions have been available for Southern Indian Lake, factors such as sampling techniques and fishing pressure have remained relatively stable until the summer of 1974 and it would appear that year class fluctuation for whitefish in Southern Indian Lake may be due, in part, to variable reproductive success.

Comparative data on the growth of whitefish from elsewhere in North America is presented in Table 4. Whitefish growth from the main lake (region 2) was considerably better than whitefish growth from some northern lakes (Lac la Ronge) but not as good as from other northern lakes (Lac la Martre, Hottah) or from more southerly, highly exploited lakes (Huron, Erie).

Statistics from length-weight regressions (condition regressions) for whitefish sampled in 1972 and 1974 are compared in Table 5. It appears that there are differences in condition of whitefish sampled in regions 2 and 6 during these two years. Differences between years are more apparent than differences between areas although all comparisons suggest a great deal of variability. The same trends between years are apparent when the condition factor or K values are compared (Table 5). These differences are due, in large part, to the differences in mean age of the two samples from each region. Younger fish (1974 samples) generally are not in as good condition (Carlander, 1969) and hence the slopes of the regression lines and the K values are less.

Values of K for whitefish from Southern Indian Lake are as good as, or better than K values for whitefish from other lakes in North America (Table 5).

Mortality rates varied during 1972 and 1974 (Table 6). During 1972 the rates for regions 2, 4 and 5 were relatively high and for region 6, much lower. Two years later, the two regions sampled (2 and 6), were similar to region 6 during 1972. During 1972 commercial fishing was in progress and variability between regions may be partially explained by fishing pressure in some regions and not in others. However, it seems unreasonable to assume that the demise of the commercial fishing industry in 1973 could account for as rapid a decrease in mortality rates as appeared in 1974. It is quite probable that the fluctuation could be a result of varying year class strengths. Lawler (1965) found definite year class strengths in Lake Erie whitefish and mortality rates calculated by Healey (1975) based on this information varied from 0.4 - 0.94.

Healey (1975) proposed that the general condition of a whitefish population may be surmised by the study of the growth, mortality, age structure and age of maturation of the population. Briefly, he stated that whitefish being heavily exploited will respond by increased growth rate, increased mortality, decreased age of maturation and a young age structure. Whitefish from Southern Indian Lake have a growth rate which can be described as about average when compared with other exploited lakes in northern Canada.

The mortality varies, but again falls in the mid range when compared with those listed by Healey (1975). Age structure of the population (particularly in 1972 when the commercial fishery was intact) suggests that there are year classes available for increased exploitation. Fish are maturing at ages VII and VIII, ages which are typical for whitefish from many lakes in the north.

Taking all these points into consideration, as directed by Healey (1975), it would appear that Southern Indian Lake whitefish are receiving moderate fishing pressure with some scope for increased exploitation. Perhaps this is an underestimation. Southern Indian Lake is a productive northern lake and scope for improvement in growth may be higher in this lake than in many other northern water bodies.

Table 1. Length-at-age for whitefish from all regions sampled Southern Indian Lake in 1972 and 1974.

Age Class	Mean Length (Fork) (cm)	No. Fish
1	14	7
2	16	123
3	20	128
4	24	125
5	29	153
6	33	163
7	36	169
8	39	134
9	41	113
10	43	71
11	44	44
12	43	13
13	47	6

Table 2. Length-at-age for whitefish from various regions of Southern Indian Lake in 1972 and 1974.

Age Class	Region 2				Region 6				Region 4		Region 5	
(years)	1972		1974		1972		1974		1972		1972	
	(cm)	(#fish)	(cm)	(#fish)	(cm)	(#fish)	(cm)	(#fish)	(cm)	(#fish)	(cm)	(#fish)
1	14	(4)	15	(1)	14	(1)						
2	17	(11)	16	(8)	17	(6)	16	(24)	16	(7)	17	(3)
3	22	(22)	20	(23)	19	(7)	18	(8)	20	(14)	21	(11)
4	26	(20)	25	(21)	24	(3)	23	(11)	24	(6)	26	(8)
5	30	(16)	27	(30)	28	(2)	25	(13)	27	(15)	30	(17)
6	35	(36)	32	(16)	30	(6)	32	(7)	28	(17)	34	(29)
7	37	(44)	37	(5)	35	(4)	35	(7)	34	(11)	37	(30)
8	41	(9)	37	(10)	39	(4)	37	(7)	38	(29)	41	(31)
9	42	(7)	40	(5)	40	(2)	40	(2)	40	(29)	43	(40)
10	39	(4)			40	(1)	38	(1)	42	(24)	45	(25)
11	46	(1)			39	(1)	42	(1)	43	(11)	47	(12)

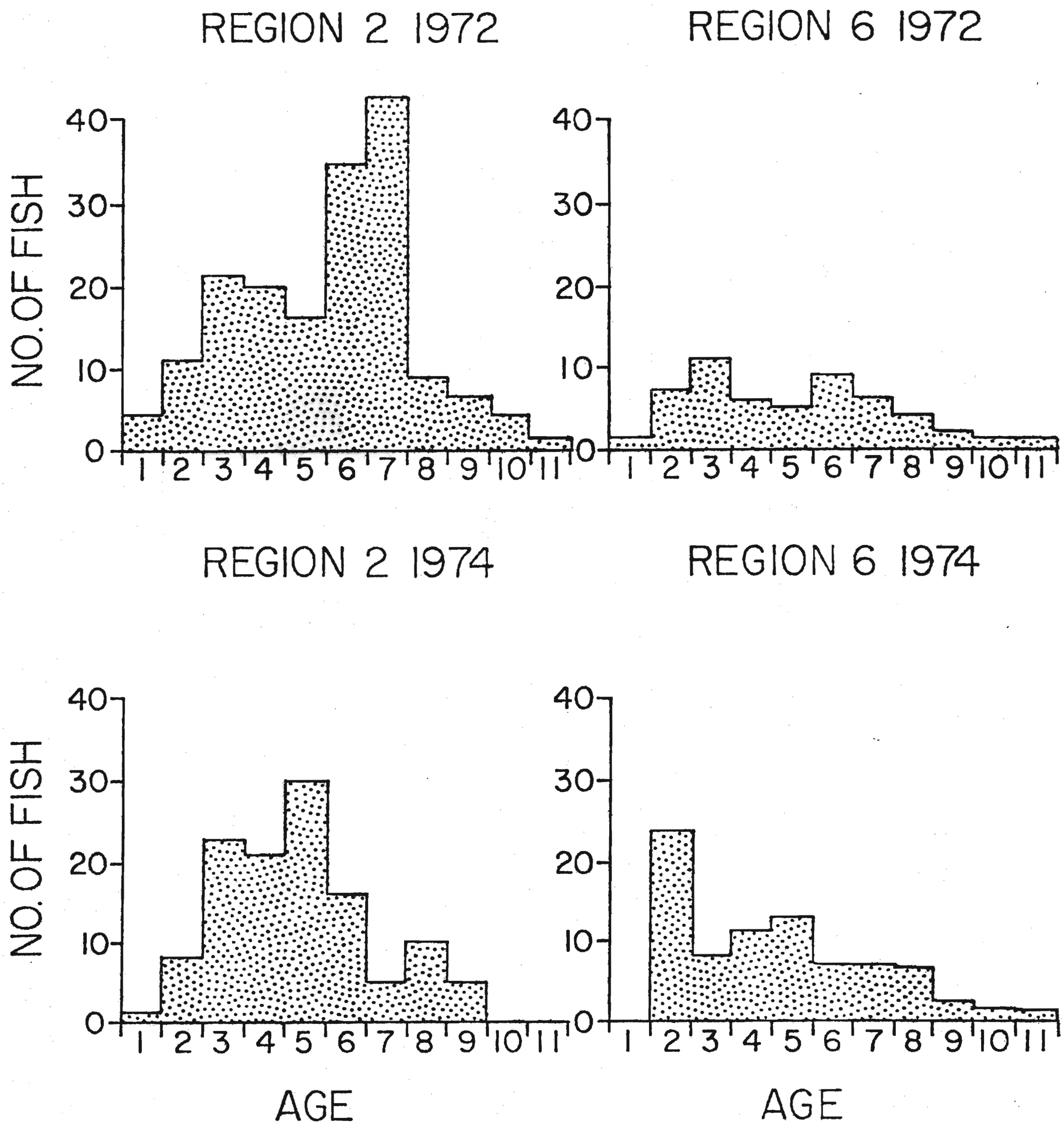

Figure 2. Age frequency of whitefish from Region Two and Region Six during 1972 and 1974.

Table 3. Mean age, weight and length for whitefish from two areas of Southern Indian Lake during 1972 and 1974.

	Region 2		Region 6	
	1972	1974	1972	1974
Mean age (yr)	5.5	4.9	5.3	4.6
Mean weight (gr)	520	272	454	181
Mean length (cm)	31.7	27.0	27.9	24.6

Table 4. Fork length-at-age for whitefish from a variety of lakes in North America.

Age	Southern Indian		Lac la Ronge[a]	Wollaston[b]	Lac la Martre[c]	Hottah[d]	Big Peter Pond[e]	Huron[f]	Erie[g]
	Fork length (mm)								
	Region 2	Region 6							
1	145	140		140	155	129	142	113	279
2	165	165	160	191	197	175	183	201	349
3	210	185	203	231	264	234	224	279	418
4	255	235	241	259	303	283	262	365	446
5	285	265	284	292	375	296	302	436	478
6	335	310	315	330	420	369	340	486	506
7	370	350	345	358	441	409	373	520	530
8	390	380	368	389	505	434	391	542	568
9	410	400	394	424	511	462	411	563	568
10	390	390	417	452	532	481	432	574	578
11	460	400	437	480	554	491	450	588	602
12			457	505	573	499	475	604	610
13			477	531	590	501	485		
14			503	554		504			
15			526	579		537			
16									

from

a Rawson and Atton(1953)
b Rawson (1959)
c Bond (1973)
d Wong and Whillans(1973)
e Rawson (1957)
f Carlander(1969)
g Van Ooosten and Hile(1947)

Table 5. Condition regression formulae and 'K' values for whitefish from two regions of Southern Indian Lake and from other North American lakes.

CONDITION REGRESSIONS			
Southern Indian	Region 2	1972	log W = -5.93 + 3.22 log F.L.
		1974	log W = -4.40 + 2.81 log F.L.
	Region 6	1972	log W = -5.28 + 3.22 log F.L.
		1974	log W = -4.56 + 3.04 log F.L.
Great Slave[a]			log W = -5.71 + 3.33 log F.L.
Lake Winnipeg[a]			log W = -4.65 + 2.96 log F.L.
Lac la Ronge[a]			log W = -6.16 + 3.48 log F.L.
K VALUES			
Southern Indian	Region 2	1972	1.63
		1974	1.38
	Region 6	1972	2.09
		1974	1.22
	all years, main lake		1.89
Lac la Ronge[b]			0.53-0.86
Hunter Bay (Lac la Ronge)[b]			0.69-1.03
Minnesota Standards[b]	Excellent		>1.85
	Average		1.34-1.70
	Poor		<1.19

a from Carlander,(1969)
b adapted from Carlander(1969)

Table 6. Mortality and survival rates for whitefish from Southern Indian Lake, 1972 and 1974.

	1972				1974	
	Region				Region	
	2	4	5	6	2	6
Mortality rate (m)	0.63	0.70	0.63	0.47	0.43	0.46
Survival rate(s)	0.39	0.30	0.37	0.53	0.57	0.54
Variance (of s)	0.0023	0.0029	0.0035	0.0053	0.0008	0.003
Standard Error (of s)	0.048	0.054	0.059	0.073	0.028	0.059

SPAWNING

The whitefish of Southern Indian Lake spawn throughout the lake on shoals or rocky ledges. Qadri (1955) found that whitefish in Lac la Ronge spawned in depths of less than 3 meters while Eddy and Surber (1947) described whitefish spawning in 1.8-2.4 meters in Red Lake, Minnesota and as deep as 22 meters in Lake Superior. This latter depth is unusual, however, and for smaller, inland lakes the depth is generally less than 7.6 meters (Scott and Crossman, 1973). Reported spawning substrates may be rock and sand bottom (McCrimmon, 1956), gravel (Eddy and Surber, 1947) or hard, stoney bottoms (Scott and Crossman, 1973). In Southern Indian Lake, Weagle and Baxter (1974) netted mature, ripe whitefish most often over areas of broken rock and boulders but occasionally over areas of sand and gravel. They were taken to depths of 6.75 m but were found more commonly at 1.5-2.5 meters. Several attempts at dredge samples produced no whitefish eggs.

Whitefish have been reported to spawn at temperatures as low as 0.5 C (Eddy and Surber, 1947) and as high as 10 C (Hart, 1930). According to Weagle and Baxter (1974), in Southern Indian Lake in 1972, temperature appeared to be a trigger for spawning activity. No ripe or spent fish were encountered in the nets until water temperature dropped from 4 to 3 C. When water temperature reached 2 C there appeared to be a rush of spawning activity and within four days at this temperature 80% of the mature fish netted were spent.

Migration of whitefish to specific areas in a lake at the time of spawning have been noted by Qadri (1968) in Lac la Ronge and Budd (1956) in Lake Huron. In Southern Indian Lake changes in whitefish distribution in early September suggest that movements of whitefish just prior to spawning may be migration to a specific location. It appears that the area north of Long Point (region 4) is a prime spawning area for whitefish and although this species undoubtedly spawns throughout the whole lake, concentrations of whitefish in region 4 are much greater during the spawning period than at other times of the year. The established pattern of commercial fishing substantiates the hypothesis that many whitefish are migrating to one area in the lake to spawn. Local commercial fishermen concentrate their fishing efforts in the more southern part of the lake during spring and summer and it is not until the late summer and winter that they move to region 4.

The age and sex composition of the spawning whitefish in region 4 was examined in some detail by Weagle and Baxter (1974). The average age for both mature males and females was 8.8 years (Fig 2). Whitefish have been known to spawn as young as age II (Mraz, 1964); the age of the youngest whitefish spawners in Southern Indian was male VII, female VI. the smallest mature whitefish were 340-349 mm which were longer than those recorded from Lac la Ronge (Qadri, 1955), and Great Slave Lake (Kennedy, 1953) but shorter than those from the Great Lakes (Mraz, 1964; Hart, 1930; Cucin and Regier, 1965).

The egg counts from the ovaries examined by Weagle and Baxter (1974) (a total of 42) averaged 28,652 eggs/female (range; 14, 175 to 58,000 eggs/female). There was an average of 26,883 eggs/kg of body weight. (Arithmetic means were taken to allow for comparison with other research). This was considerably lower than was found in Lake Erie (Lawler, 1961) with 35,495 eggs/kg of body weight but higher than Lake Ontario, 21,795 eggs/kg (Christie, 1963), Lac la Ronge, 15,775-19,880 eggs/kg (Qadri, 1955) and Lake Huron, 18042 eggs/kg (Cucin and Region, 1965). No egg size measurements were made; hence comparison of productivities of total egg biomass was not possible.

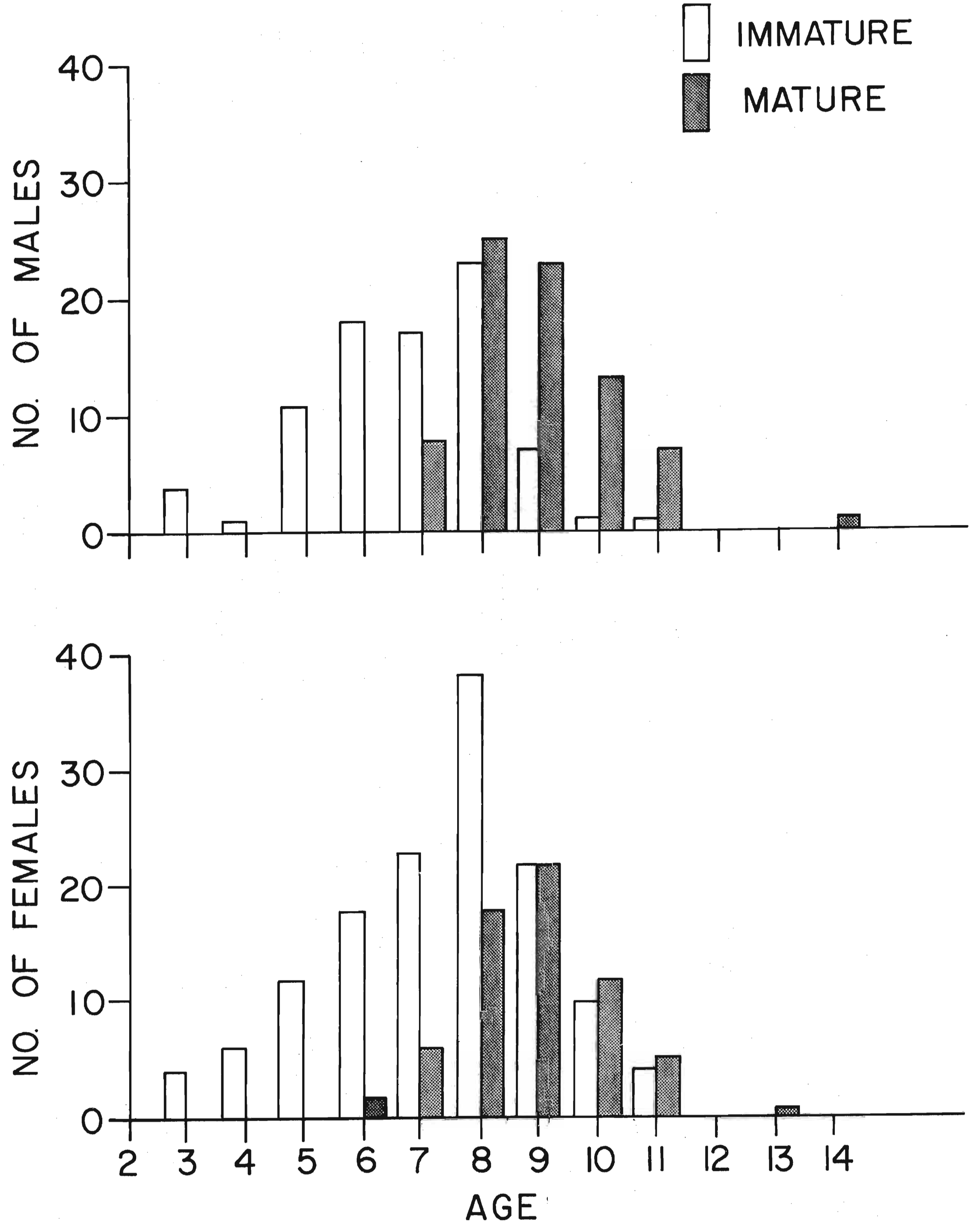

Figure 3. Age distribution of male and female whitefish netted during the 1972 whitefish spawning survey (from Weagle and Baxter, 1974).

FOOD

Principal food items of whitefish were amphipods (45% by weight) sphaeriids (22%), gastropods (13%) and chironomid larvae (8%) (Table 7).

An apparent preference for specific food was suggested in some regions of the lake although selectivity must be considered in conjunction with availability of food organisms. According to Hamilton (1974) Pontoporeia sp. (amphipods) were, quantitatively, in largest supply in all regions except South Bay (region 6) where the gastropods were dominant. In the main lake regions (2 and 4) amphipods were the main dietary organisms although only in region 2 did whitefish appear to be selectively taking this item (amphipods were 68% of the diet, but only 54% of the available benthic population as represented in the samples). Chironomids were important food items in the region near the inflow of the Churchill (region 1) and also in the north basin at the present location of the outflow (region 4). Although chironomids in the stomachs were not identified to the genus level, in region 4 it was likely that the large Chironomini, (subfamily Chironomidae), which are present in region 4 in greater numbers than other chironomids, were taken. Chironomini were not predominant in benthic samples in region 1,but because of their size they probably comprised a large percentage of the total weight of chironomids taken by whitefish in this region.

It would appear from the literature, that items found in the gut vary according to the geographic location and the type of lake. Koshinsky (1971) found amphipods to be the principal food item of lake whitefish in Trout and McIntosh lakes as did McPhail and Lindsey (1970) for Great Slave Lake and Lake Athabaska. Bajkov (1930) found crustacea (amphipods dominant) to be the principal food item for whitefish in Lake Winnipeg with insect larvae (chironomids dominant) of much less importance. Lake Manitoba and Lake Winnipegosis lake whitefish selected insect larvae and mollusca much more often (as high as 95% in Lake Manitoba) than other items such as crustacea (Bajkov, 1930).

Table 7. Food of whitefish as percent weight by items from 7 regions on Southern Indian Lake, 1972.

	Region						
	1	2	3	4	5	6	7
Amphipods	19.48	67.84	10.47	47.02	53.88	0.70	10.82
Sphaeriids	37.40	6.96	9.67	15.56	28.76	35.44	13.45
Gastropods	1.42	0.56	31.38	13.05	4.67	67.77	32.97
Chironomid larvae	25.65	11.70	3.92	15.36	3.77	0.02	1.60
Caddis larvae	6.49	0.44	17.68	4.73	5.93	2.48	0.33
Corixidae	1.05	0.60	10.92	1.08	0.03	0.76	6.73
Conchostraca	1.10	4.00	8.74	2.82	2.26	0.70	19.75
Mayfly nymphs	7.41	7.90	7.22	0.38	0.70	2.13	14.35
Number examined	105	197	107	383	383	79	74
% with food present in stomach	66	44	52	65	63	77	47

POPULATION DENSITY

Whitefish are considered to be deep water fish occupying the cooler hypolimnetic waters of lakes (Scott and Crossman, 1973). Whitefish in Southern Indian Lake were taken more frequently (catch/effort) from depths greater than 10 meters during the early part of the summer season. During this period, although no specific thermocline appeared to be present, the lake (water) was warmer near the surface than it was in deeper areas (e.g. 0 m - 15^{o}C; 10 m - 9^{o}C). The water column became isothermal as the summer progressed and whitefish were taken with greater frequency from the more shallow depths.

Production, as measured by experimental fishing, is an indication of relative quantities of whitefish at different locations at the same time and at the same location at different times. Quantities of whitefish varied within a region at different periods throughout the summer season. During 1972 the number (catch/effort) of whitefish in region 2 decreased as the summer progressed but in region 4 they increased sharply towards the end of the field season (Table 8). This could be an indication of movement for the purpose of spawning (see Spawning, page 15).

Table 8. Total number of whitefish caught in one gang of gillnets during three different periods of time in a summer season, 1972.

	Region 2 1972	Region 4 1972
July 1 - July 17	142	56
August 9 - August 26	93	56
August 30 - September 9	42	122

Although mixing is well developed vertically in the lake basin, there are widespread lateral variations in water masses. The Churchill River flow enters the western end of the lake (region 1) and appears to move without widespread diffusion through regions 2, 3 and 4 to the northeastern outlet at Missi Falls.

When sampling results (in terms of weight of fish caught per net night) from the same depth (less than 10 meters) in regions 2 and 6 were compared there was a considerable difference between the region within the through-flow(2) and the region not subject to the through-flow(6) [region 2, 1972 and 1974; 21.8 and 16.1 kg/net night and region 6, 1972 and 1974; 6.2 and 5.7 kg/net night]. This difference, where through-flow catch is greater than region 6 catch, becomes even greater when sampling is conducted at all depths (regions 2 and 4; 42.6 and 29.4 kg/net night and regions 6 and 7; 5.9 and 9.9 kg/net night). One apparent exception is the productivity of region 5. This area of the lake is off the main flow and yet remains relatively quite productive (29.4 kg/net night). This may be explained by the number of longer tributaries entering this sub-basin.

The apparent density of whitefish (in Southern Indian Lake, particularly in region 2, the main basin) as determined by experimental netting is higher than densities shown for other lakes in northern Manitoba and Saskatchewan (Table 9). Although some of the lakes mentioned in Table 9 are also on the Churchill River in Saskatchewan, the river at these locations is considerably smaller than when it reaches Southern Indian Lake. Not even Playgreen Lake, receiving a large flow from another major river system(the Nelson River) displays a density of whitefish similar to the density of whitefish in region 2 of Southern Indian Lake. The very high density of whitefish in region 2 of Southern Indian Lake supports the concept of the importance of the Churchill River system on the productivity of this lake.

In the years 1941 to 1972 the annual commercial catch of whitefish from Southern Indian averaged 400,000 kg (886,000 pounds) or 91% of the total annual fish production (Weagle and Baxter, 1974). The domestic catch (fish caught for personal use) has not been estimated but use of gill nets is common and the size of the catch should not be discounted as irrelevant. There has been some evidence to indicate that the whitefish stock is not being depleted or that it is not being fished to its maximum capacity. The average annual harvest of whitefish is approximately 2.13 kg/ha and has been as high as 2.97 kg/ha (1961-62; 550,000 kg of whitefish) (Weagle and Baxter, 1974). Rawson (1952) suggested that there is a close correlation between total harvest and mean depth of a lake. The mathematical relationship that he describes suggests that Southern Indian Lake with a mean depth of 9.1 m could have a total harvest, including other than whitefish, of approximately 3.71 kg/ha which is well above actual harvest. Using Ryder's morphoedaphic index (Ryder et al, 1974) total harvest could equal 3.20 kg/ha. This discrepancy between suggested potential harvest and actual harvest may be due to two causes. First, effort is a key factor to be considered in discussion on yield, and Southern Indian Lake does not appear to have been fished with maximum effort. In the past 18 years the quota for the lake has been met or surpassed on 7 occasions only. Second, this lake is morphometrically very complex and only specific areas of the lake are fished. When these areas are considered only, the present harvest of whitefish averages 2.93 kg/ha and has been as high as 3.72 kg/hg per ha (1961-62); in fact, the total harvest for all commercial species for 1961-62 reached 3.95 kg/ha.

Commercial production of whitefish in Lac la Ronge has averaged approximately 53,000 kg/year or approximately 0.5 kg/ha per year for 27 years (peak of 1.24 kg/ha in 1931) (Rawson and Atton, 1953). This lake supports a total harvest (commercial, domestic and sports) of up to 270,000 kg/year (2.09 kg/ha). Production of whitefish from Lac la Martre, N.W.T. is approximately 95,000 kg/year or 0.5 kg/ha/year (Bond, 1973). Lake Winnipeg at one time supported an annual whitefish fishery of 1,800,000 kg or approximately 1.0 kg/ha (if only the"whitefish grounds"are considered when calculating surface ares (Kennedy, 1954)). In comparison, then, Southern Indian Lake even at its present harvest is a productive lake. This is probably due to the influence of the nutritively rich Churchill River and to the high flushing rate that exists in the main lake regions of this body of water. These conditions support higher levels of biological production, (plankton, and benthos and fish) than other shield lakes with longer residence times (Hecky *et al*., 1974).

Table 9. Catch per unit effort (numbers) for whitefish from twelve lakes in Northern Saskatchewan and Manitoba. All data except from Southern Indian Lake have been changed to the standards set for the Southern Indian Lake data to allow for comparison.

Lake	C.U.E.	Lake	C.U.E.
Southern Indian	45	Churchill[a]	20
Southern Indian*	56	Cree[d]	20
		Mountain[c]	13
Playgreen[b]	46	Nistowiak[c]	9
Lac la Ronge[a]	44	Drinking[c]	9
Big Peter Pond[a]	42	Otter[c]	2
Reindeer[a]	25		
Wollaston[d]	20		

* Catch/unit effort for whitefish from the main lake regions; 1, 2, 3 and 4.

a from Koshinsky (1965.)

b from Ayles (1973.)

c from Rawson (1960.)

d from Rawson (1959.)

DISCUSSION

The flow of the Churchill River through Southern Indian Lake has a noticeable effect on the general productivity of the lake. Hecky et al (1974) found that lower biomasses were observed in areas not influenced by the Churchill River. These areas also had very low nutrient loading rates in comparison to the main lake regions of Southern Indian which receive directly the Churchill River through-flow. Hamilton (1974) found the zoobenthos in Southern Indian Lake to be considerably more abundant than should be expected from a northern lake of this size. He attributes the richness of these fauna to the influence of the Churchill River on the lake and notes that this same phenomenon has been observed but to a lesser extent, for other lakes on the Churchill River in northern Saskatchewan.

This higher productivity is reflected in the relative numbers of whitefish taken in different areas of the lake. There were more than three times as many whitefish taken from through-flow areas of the main lake than there were from South Bay (region 6), a body of water not receiving Churchill flows. The catch/effort of whitefish caught was greater from Southern Indian Lake than from other shield lakes in northern Canada. Commercial production of whitefish from this lake was correspondingly high as well.

The one exception to high whitefish productivity relating to the nutrient supply of the Churchill River occurs in the most northerly area of the lake, north of Sand Point (region 5). Th waters in this area originate primarily in the surrounding Pre-Cambrian Shield area. Hecky et al 1974 found that nutrient loading in region 5 was lower than the main regions and was quite similar to loading in South Bay. The availability of light in region 5 was greater than in region 6, but not as great as that which occurred in the main lake regions. Numbers of zooplankton (Patalas and Salki, 1974) were high in region 5 although Hamilton (1974) found benthic invertebrates to be considerably lower in density in region 5 in comparison to the main lake. Whitefish in region 5 were similar in numbers and in better condition than fish from most other regions of the main lake (with the exception of region 2). This area (region 5) of the lake is not commercially fished. It is the furthest distance from the settlement of South Indian and in the past the *Triaenophorus crassus* (a parasite which encycts in the flesh of whitefish) levels in the whitefish have been high enough that these fish could not be exported (L. Sunde, pers. comm.). The low fishing pressure exerted on this population of fish could account for a higher mean age, weight and length but should not, in itself, create a population that is in as good condition (relatively) as is evident. It appears that the combination of no fishing pressure and good light conditions allowing for maximum use of available nutrients creates reasonable conditions for whitefish in region 5.

SUMMARY

1. Whitefish in Southern Indian Lake appear to be spawning in late October or early November over areas of large boulders or broken rocks in depths of 1 to 7 meters. Temperature appeared to be the significant trigger for spawning with activity becoming pronounced when water temperatures fall to 2°C.
The average age for spawning lake whitefish, both males and females. was 8.8 years and average egg count/female was 28,600.
2. Whitefish from the main lake regions of Southern Indian Lake had similar growth rates. Whitefish from South Bay did not appear to grow as quickly as whitefish from other areas of the lake.
3. Mean age, weight, and length for whitefish sampled in 1974 were less than for whitefish sampled in 1972, suggesting a fluctuation in year class strength.
4. Principal food items for Southern Indian Lake lake whitefish were amphipods, sphaeriids, gastropods and chironomid larvae. An average of 59% of the fish sampled had food in their stomach.
5. Catch/effort of whitefish varied according to the region of the lake.
6. Lake whitefish are the major commercial species taken in Southern Indian Lake. The average commercial production since 1942 has been 400,000 kg/year.

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