

FISHERIES RESEARCH BOARD OF CANADA

UNDER THE CONTROL OF

THE HON. THE MINISTER OF FISHERIES

BULLETIN No. LXXII

NORTH WEST CANADIAN FISHERIES SURVEYS
IN 1944-1945

(VARIOUS AUTHORS)

OTTAWA
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CHAPTER I

INTRODUCTION

BY A. T. CAMERON

Arising from general plans for the post-war development of the Northwest Territories and the Yukon Territory the Fisheries Research Board of Canada was instructed by the Dominion Department of Fisheries early in 1944 to endeavour to make a general survey of the fisheries of these regions. The Board decided to send two parties into the Northwest Territories that summer. Full-time personnel of the Board's staff was not available, but it was fortunate in being able to engage Dr. D. S. Rawson of the University of Saskatchewan and Professor V. C. Wynne-Edwards of McGill University to lead these parties.

Professor Wynne-Edwards and a companion, Dr. Ronald Grant, journeyed by powered canoe a thousand miles down the Mackenzie River, from Waterways to north of Aklavik, and in addition made a side-trip by air to Great Bear Lake, and a brief examination of that lake.

Dr. Rawson, with a larger party, made a general survey of Great Slave Lake, and the results of this survey indicated that there was a definite possibility for a commercial fishery.

As a result of the reports received of the summer's work the Development Committee of the Board decided that there was no urgency for further exploration of the possibilities of the Mackenzie River at this time, but that more work should be done on Great Slave and Great Bear lakes, while work which Dr. Rawson had been carrying on in Lake Athabaska under other auspices should be continued by the Board. In addition, the waters of the Yukon called for at least a preliminary survey.

Accordingly, in the summer of 1945, Professor Wynne-Edwards and Dr. Grant made a reconnaissance survey of the chief rivers and lakes of the Yukon, Dr. R. B. Miller of the University of Alberta directed the work of a party making a general survey of Great Bear lake, and Dr. Rawson directed similar parties working in Great Slave and Athabaska lakes.

The results of all this work are set out in Chapters II to VI of this Bulletin. The Board asked one of its members, Professor J. R. Dymond of the University of Toronto, to discuss the general conclusions which can be drawn from these results, and he has done so in Chapter VII. The maps illustrating the Bulletin have been prepared by Dr. W. A. Kennedy of the Board's staff.

In carrying out their work the investigators received much help and many kindnesses from many people, both Government officials and others, and the Fisheries Research Board desires to acknowledge this assistance with gratitude.

The following call for special mention:

Mackenzie River survey, 1944:

General Foster, Northwest Command, Edmonton.
Mackay Meikle, Esq., Magistrate and District Agent, N.W.T. Administration,
Dept. of Mines and Resources.
Dr. Truesdale, Indian Agent, Fort Simpson.
Dr. Harvey, Indian Agent, Fort Norman.
Dr. Livingstone, Indian Agent, Aklavik.
Mr. Parsons, Mr. and Mrs. McGuinness, and Mr. Pat Hogan, Reindeer Station.
Dr. Stewart, Dominion Government Geologist at Norman Wells.
Col. L. W. Kehe, U.S. Army, Commanding Officer, Canol Project.
R. G. H. Bonnycastle, Esq., Winnipeg.
The Hudson's Bay Company and its officials at Winnipeg, and the offices and trading posts at Edmonton, Waterways, Fort Smith, Hay River, Simpson, Wrigley, Norman, Good Hope, Arctic Red River, and Aklavik.
Inspector Birch, the N.C.O.'s and Constables of the R.C.M.P. at every detachment visited, who all gave unfailing cooperation.

Yukon survey, 1945:

L. Higgins, Esq., Territorial Agent, Whitehorse.
F. H. R. Jackson, Esq., and G. Bidlake, Esq., Dept. of Mines and Resources,
Territorial Office, Whitehorse.
Hon. George Black, M.P., and Mrs. Black, Dawson City.
Inspector Cronkhite, R.C.M.P., Whitehorse.
Cpl. Cameron, R.C.M.P., Fort Selkirk.
Cpl. Kirk, R.C.M.P., and Mrs. Kirk, Old Crow.
Harvey Johnson, Esq., C.P.A. pilot, Whitehorse.
C. E. Fisher, Esq., Mayo.

Great Bear Lake survey, 1945:

Ed. Bolger, Esq., Manager, Eldorado Mining and Refining Co., Port Radium,
N.W.T.

Great Slave and Athabaska lakes' surveys, 1944-45.

The Administrative Officers of the North West Territories branch, Department of Mines and Resources, both in Ottawa and at the Regional Office at Fort Smith.
The R.C.M.P., and especially the detachments at Fort Chipewyan, Fort Smith, Resolution, Reliance and Yellowknife.
The Hudson's Bay Company, its transport division and post managers at Fort Chipewyan, Fort Smith, Resolution, Reliance and Yellowknife.
The Northern Transportation Company at Waterways and Fort Smith.
The Canadian Pacific Airlines.
The McInnes Products Corporation.

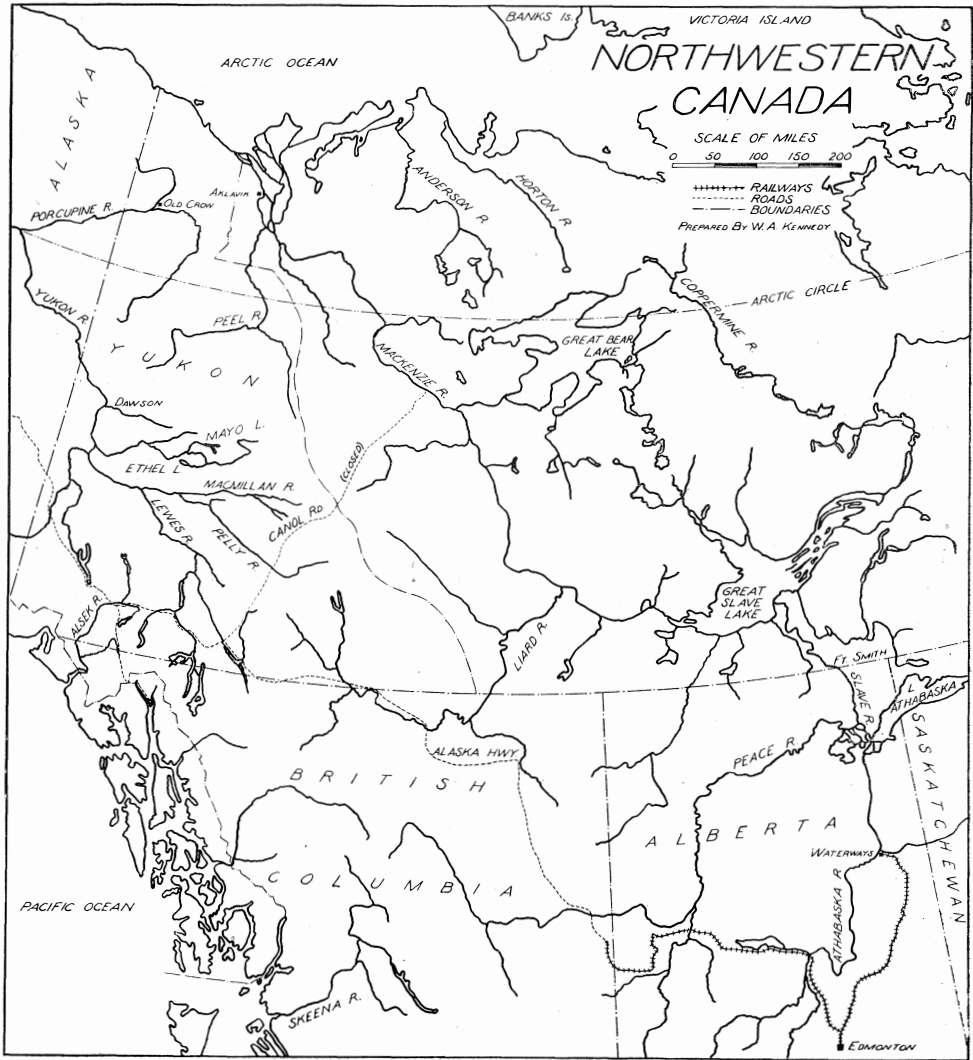


FIGURE 1. Northwestern Canada

CHAPTER II

THE YUKON TERRITORY

BY V. C. WYNNE-EDWARDS

THE TERRITORY

Following the Mackenzie river survey in 1944, Dr. Ronald Grant and the writer visited the Yukon Territory in July and August, 1945, to complete the preliminary reconnaissance of northwestern Canada. Though it was already known that the fishery resources of the Yukon Territory were comparatively poor, relative to those of the Mackenzie valley, a survey was required for the proper formulation of fishery regulations for the Territory, as well as for more purely scientific purposes.

The general topography of the Yukon Territory is similar to that of northern British Columbia. Across the southwestern corner the Coast range reaches its maximum elevation. Mount Logan (19,850 feet) lies in the centre of a glaciated region exceeded in size only by the ice-caps of Greenland and Antarctica. Like a wall these great mountains shut off the interior from the moist winds of the Pacific; and though the snowfall on the St. Elias plateau is reliably estimated at 120 feet per annum, the whole interior of the country is semi-arid.

The main northeast boundary is the watershed of the Mackenzie mountains, as yet little explored, but exceeding 10,000 feet in some places. The range is about 500 miles in length, forming the height of land between the Yukon system and the middle part of the Mackenzie valley. It is doubled at its two ends by two tributaries of the Mackenzie, the Peel in the northeast and the Liard in the southeast, which rise on the Yukon side of the range, and together drain about one-quarter of the Territory. The Liard valley also terminates the Rocky mountains, which enter the Territory only as rugged foothills along its southern border.

The southern part of the interior is high land, draining into the headwaters of the Yukon. The valley floors are about 2,000 feet above sea level; mountains between them often exceed 5,000 feet. Timber line is generally between 3,000 and 3,500 feet.

The character of the Yukon itself is very different from that of the Mackenzie. It discharges ultimately into Bering sea, and in its lower 1,200 miles traverses

Alaska. There it becomes a lowland river, broad and muddy, and comparable in size to the Mackenzie. Within the Territory we are concerned only with its headwaters, which rise in cold sub-arctic mountains. The Yukon is first recognized by name at Fort Selkirk, where the Pelley joins the Lewes, but in the minds of most residents it extends up the route of navigation to Whitehorse and beyond: in other words, the Lewes is considered to be the main tributary and is often popularly regarded as being the Yukon itself.

All of these headwaters are swift. From Whitehorse to Dawson the current averages 6 miles per hour, which is twice the speed of the Mackenzie. River steamers make the trip downstream in 36 hours, for a distance of 450 miles, including stops. The return journey takes upwards of five days. For fifty years authors have cited the remarkable journey of the king salmon, the most indomitable of which actually pass Whitehorse, to spawn about 1,800 miles from the sea in McClintock river. Such a journey has no known parallel among anadromous fish. Attention is not drawn to the fact that these salmon buck the current all the way, and, during their 12 weeks of travel, must swim a very minimum of 6,000 miles through the water.

With such a swift current it is surprising that navigation is never broken, all the way up from the sea to Whitehorse. There are two navigable rapids below Carmacks, known as the Five Fingers and the Rink, and certain other swift places where vessels are obliged to warp themselves up on a cable. Above Whitehorse are the long rapids from which the town takes its name, and immediately above them the even more formidable Miles canyon, where the Lewes has cut a trench in a sill of basalt. Above this in turn is an 80-mile chain of lakes from which the river takes its source. Here navigation is again possible, and is carried further by means of a slipway to Atlin lake in British Columbia, the south end of which is more than 100 miles distant from Whitehorse.

The rivers are also cold. The Lewes is clear and slightly greenish; the Teslin or Hootalinqua is slightly turbid; the Pelly and navigable Stewart are very muddy. The chief source of mud, however, is the White river, main outflow from the St. Elias range, which not only starts out as glacier water, but runs through an extensive deposit of white volcanic ash. This ash is of the nature of pumice, and remains long in suspension; it gives the Yukon at Dawson the appearance of café-au-lait.

One of the most curious features of the river is the low hissing sound made by the water, resembling that of water soaking into a fragment of porous earthenware. It is apparently associated in some way with the volcanic ash.

Entering the Territory from the southeast the Alaska highway follows a branch of the Liard, crosses the continental divide at 3,800 feet (the highest point on the road), and drops gradually to Teslin lake. From Teslin there is a low route leading past Squanga lake and through the mountains to the Lewes valley at Marsh lake, and so to Whitehorse. Westward from Whitehorse the road enters a remarkable broad trough, as much as five miles wide, which carries

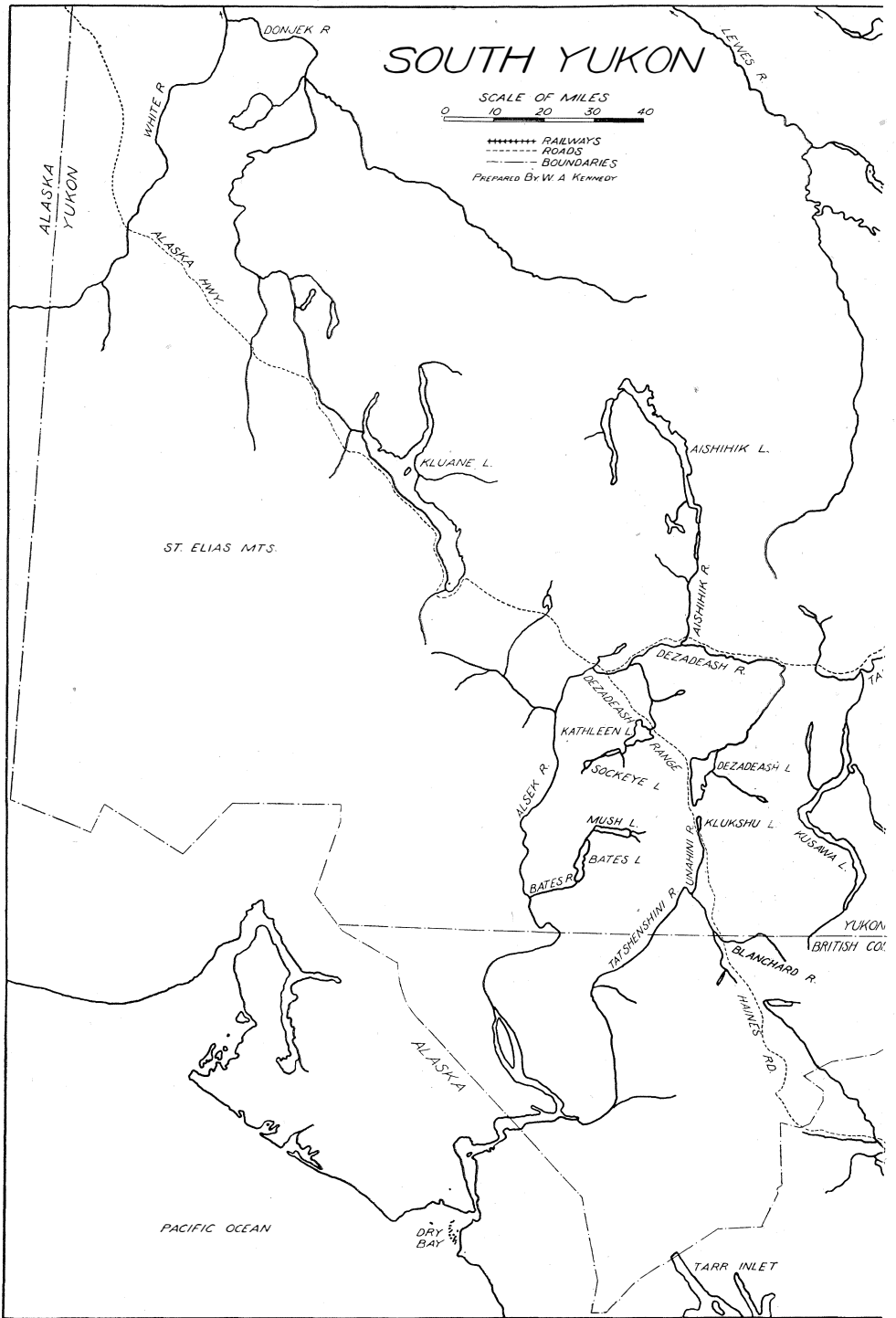


FIGURE 2. Southern Yukon.

it along the inner flank of the Coast range clear through to the Tanana valley in Alaska, 300 miles to the northwest. The trough transects all the valleys emerging from the mountains at right-angles; many of the rivers turn to follow it in one direction or the other for some distance, and one, the Kushawulsh, divides to flow both ways; so that, proceeding from Whitehorse, it is used successively by the Takhini (eastwards), Dezadeash (westwards), Bear creek (eastwards), Christmas creek (westwards), Kluane lake and river (westwards), and a variety of small streams as far as the Chisana and Tanana (westwards). Some evidence has been found that this trough, known in part as the Shawkak valley, may have served as a natural route of travel and migration since very early times.

The Dezadeash just mentioned is the main tributary of the Alsek, the only river in the Territory draining to the Pacific. In spite of the fact that it is a toss-up which way the Dezadeash should flow as it enters the trough from the south, it turns west; and, after running peacefully in the trough for 30 miles, cuts through the St. Elias range in a wild and spectacular valley, whose walls in many places rise thousands of feet above its narrow floor. Great glaciers sweep down to it from the mountains. One of these needs only to advance less than a mile to dam the valley at the present day; and it is evident that in quite recent times the Alsek gap was so blocked that a considerable part of the Shawkak valley formed a lake, draining either eastward to the Lewes or westward to White river. Old lake terraces are visible at Bear creek and elsewhere. This explains why the Alsek is the only river flowing into the Pacific ocean inhabited by grayling and round whitefish, which it has captured from the Yukon tributaries. Fortunately there seem to be no pike in it.

The Alsek-Dezadeash should be a good salmon stream. Indian tradition relates that not many generations ago salmon abounded in the Dezadeash; and even now there are landlocked rainbow trout and sockeyes in its headwaters. But for a reason still unexplained, which is discussed below, they no longer ascend the main river, but only its tributary the Tatsenshini, which barely enters the Territory.

The northern Yukon Territory is altogether different from the part already described. It is sharply cut off from all contact with the south by a westward branch of the Mackenzie mountains called the Ogilvie range. Some of the peaks are known to exceed 8,000 feet and others may be higher. The range stands right across the Territory not far north of Dawson. During the Pleistocene glaciation the peaks of St. Elias formed the regional centre, from which an ice-sheet extended north across the Yukon basin. The hills all over the southern part show ice-worn surfaces to a height of 5,000 feet; but neither the Ogilvie range, nor parts of the Mackenzie and Richardson mountains, were reached by the ice-sheets, and consequently their contours and general appearance are characteristic, and distinct from those of any other mountain systems in Canada.

A large part of this northern region is not mountainous, but runs out into relatively flat lowland plains, covered with muskeg ponds and traversed by winding

sluggish streams. These join either into the Peel, which drains the northern slopes of the Ogilvies and leads to the Mackenzie, or further north into the Porcupine, a large river exceeding 500 miles in length from its source to Fort Yukon, Alaska, where it joins the Yukon river. The Porcupine is navigable, and in spite of being north of the Arctic circle it is probably the warmest and most productive river in the Territory. Old Crow is the only inhabited place on the Canadian part of it.

From Old Crow the Indians sometimes travel to the shores of the Beaufort sea near Herschel island, encountering no mountains on the way. They reach the northern limit of trees about half way to the sea.

Excepting this northern fringe and the upper slopes and summits of all the mountains, the Territory is covered by northern spruce-poplar forest, broken here and there by small grassy prairies. So dry is the southern part of the country that at lower elevations all south-facing slopes are open and grassy, with only occasional clumps of tall spruce. The thickest forest is found in the bottom lands and on slopes facing away from the sun. (At higher elevations the reverse holds good: the trees grow better and higher up on the south than on the north faces of the mountains, on account of the moisture from melting snow and the difference in length of the growing season.) The forest is poor in species, lacking both the Pacific slope conifers and also such universal northern types as balsam fir, larch and birch. White and black spruce are universal; jack pine is predominant in some places near Whitehorse and in the Liard section, probably only where the ground is unfrozen.

THE SURVEY

Only eight weeks were available for the survey, which had therefore to be a cursory one. A variety of modes of transportation were employed to cover even superficially this Territory of 200,000 square miles, which is four-fifths the size of any one of the three prairie provinces.

From Whitehorse as a base, excursions were made by truck, boat and plane. The first was during the week-end of July 7 to 9, by aircraft to Old Crow on the Porcupine in the northern part of the Territory ($67^{\circ} 35' N.$, $139^{\circ} 49' W.$), about 500 air-miles north of Whitehorse. The following day we crossed to Arctic Red River on the Mackenzie, and from there flew southwest to land for an hour on the Peel about 50 miles above Fort McPherson, where three species of fish new to the Yukon Territory were collected. On the flight back to Whitehorse we recrossed the Ogilvie range by Braine pass, spending the night at Mayo lake.

The following day we embarked with an Indian named Frankie Jim in his 27-foot flat-bottomed boat on a trip down the Lewes and Yukon rivers to Dawson, which occupied exactly a week. Four days were spent around Dawson, and we then flew over to Mayo and made a brief investigation of Mayo lake.

After returning to Whitehorse the rest of our work, with one exception, was done by road. The exception was a flight to examine the inaccessible Alsek

valley from the air in an attempt to discover the falls said to prevent the ascent of salmon in this river. These falls are universally believed to exist, and we met in Whitehorse two prospectors who claimed to have visited them, and who were able not only to locate them precisely on a map, but also to estimate their height at 16 to 18 feet. They were vague about the nature of the valley immediately below the falls, where they said they saw many large bear tracks and quantities of salmon in the water. It is usually held that a narrow canyon exists there, and that consequently by blasting the walls into the stream it might conceivably be possible to convert the falls into a rapids that salmon could mount, thereby opening up a large part of the southwest corner of the Territory to profitable native salmon industry. The site is most inaccessible because of the rugged terrain, steep flanks of the valley, swift waters and large tributary streams entering from the adjacent glaciers; and careful questioning at Bear creek and Klukshu convinced us that no living Indian had actually seen the falls, even in winter.

We flew on August 4 by way of Kusawa, Dezadeash, Mush and Bates lakes, striking the Alsek within a mile or two of where the falls were supposed to be. Since we could see nothing of them, we headed south, following the valley between the mountains, across the British Columbia border. Still finding no falls, our plans had to be revised. The best course would have been to follow the river to the sea and make sure of locating the obstruction; but this would have carried us beyond our maximum cruising range, allowing for the return journey, and would have considerably exceeded our authorized estimate of expense. We therefore turned back, at a place where the valley widened out and the river ran in many channels over the flats for the next 15 miles. Whatever the obstruction is, it must be within a few miles of where the Tatsenshini comes in, close to the Alaska boundary.

We had invited Mr. Geoffery Bidlake of Whitehorse to come with us, so with the pilot there were four of us in the aircraft, each intent on watching the course of the river, which we followed at an altitude of only 1,000 feet. We are all certain that there are no falls within the 60 miles we examined, including all the unmapped section of the river lying in the Yukon Territory.

Turning north, we passed Bates river and over two of the largest glaciers emerging from the western mountains, one of which discharges bergs on the river flats. We then crossed a low divide and landed on the headwater lake of the Alsek river, which curves back on itself like the handle of a crook. This is Sockeye lake, so named by a prospector who told us he had taken small landlocked salmon in it. We searched for these for several hours, ultimately obtaining a good collection of young stages known as "parr", and incidentally finding specimens of a rare kind of whitefish of small size, known as Coulter's whitefish, and previously unrecorded in the Yukon Territory.

After August 10 we were able to use a 1½-ton truck, in which we traversed the Alaska highway southeast to the Liard valley and the British Columbia border before turning west to explore the Haines road and the western part of

the highway as far as the 141st meridian, which is the Alaska boundary. This occupied the last three weeks of the survey.

During our investigations we travelled about 2,500 miles by road, 500 miles by water and 2,200 miles by air.

FISHERIES

SALMON IN THE YUKON RIVER

Both king and dog salmon reach the Yukon Territory. The kings enter the mouth of the river in Norton sound early in June, and take about three weeks to make the first 1,250 miles to Dawson, where the run is expected to begin about June 28. The date varies from year to year: in 1945 the first was taken on July 9. The main run lasts only a week or ten days, after which the condition of the stragglers rapidly deteriorates.

Above Dawson progress is slower. July 10 is the established date for the beginning of the run at Fort Selkirk, though, being ten days late this year, they had not arrived when we were there on the 14th. (We actually saw the first on the 16th at Ogilvie, less than 50 miles above Dawson.)

By the time they pass Fort Selkirk they have already been a month in fresh water, and there is an increasing proportion of red and scabby fish no longer fit for human food. Beyond this post they have therefore a negligible economic value, and are netted and trapped only sporadically by the Indians. Considerable numbers actually reach lake Lebarge and Whitehorse in the first half of August; we found and collected salmon parr in many small creeks as far up as lake Lebarge. They are said to choose the same particular creeks year after year, and to avoid others. The two most remote from the sea regularly frequented by king salmon are said to be Richthofen creek, entering the west side of lake Lebarge, and McClintock river, entering the foot of Marsh lake. I examined two king salmon parr caught by rod and line above Whitehorse rapids.

A considerable king salmon fishery exists below Dawson, past Moosehide and Forty-mile to the border. Indians fishing for themselves require no licence. They use short gill-nets of 6- to 8-inch mesh, set in eddies. The majority of the fish are filleted, smoked and dried for winter use.

In the commercial fishery the commonest device is an ingenious trap known as a fish-wheel, for which eleven operating licences, costing \$30.00 each, were issued in 1944. From the mountain above Dawson City three fish-wheels were visible in 1945, one of which we visited and examined closely.

A hollow-square raft is moored in a strong current a few yards out from the bank. Each side of the raft forms a catwalk, in the middle of which is a 3-foot upright post bearing one end of the 12-foot axle. The axle and its bearings are wooden, made from spruce trunks. Bolted radially to the axle are wooden frames covered with chicken-wire, each shaped in the form of a hollow scoop, about 10 feet square. Some wheels have three or four scoops, forming the blades of the

wheel. The one we examined had a pair of paddle-boards alternating with two opposite fish-scoops.

As the wheel is slowly rotated by the current, making two to three revolutions per minute, each frame in turn dips about 6 feet under water. The concave or hollow side is downstream; and in rising again to the surface it traps any fish which happens at that moment to swim against it. As it now swings up into the air, the fish slides inwards towards the axle, and is diverted to one side or the other by sloping gutters meeting at the centre, to fall into collecting boxes placed under the ends of the axle on the catwalks.

Considerable quantities of fish are taken during the run. The boxes are emptied daily. Sixty-four salmon, weighing between 4 and 20 pounds, and totaling some 500 pounds, were removed from the trap we visited; and on the previous day there had been 81. Each trap probably takes upwards of 2,500 pounds of king salmon during a good season like 1945, so that the total catch of eleven wheels is in the neighbourhood of 25,000 to 30,000 pounds. Added to this is the gill-net catch, almost impossible to estimate, since we did not travel down the most productive part of the river below Dawson. The Indian population, however, is naturally concentrated in this region, and may account for an additional 5,000 to 10,000 pounds caught in nets.

Both fish-wheels and nets also catch small quantities of other fish, especially humpbacked or Nelson's whitefish, inconnu, dog salmon and grayling. The total value of these miscellaneous species alone would not be sufficient to pay for the costs of operating the wheel on the Yukon, but it would be interesting to see one set up for trial at the Ramparts or Arctic Red River on the Mackenzie.

Relatively little of the salmon catch is sold. Fresh and dressed it fetches 13 to 15 cents per pound in Dawson City, up to the capacity of the Northern Commercial Company's freezer, which is about 3,500 pounds. Relatively little, not more than 250 pounds, is retailed fresh. The hotels, transportation company and a few private buyers rent cold storage space until the cold weather comes in November; the trading company also retails fish right through the winter, until the following May or June.

It is apparently cheaper to supply the needs of Whitehorse from British Columbia or Alaska via Skagway than to bring salmon up from Dawson, on account of the lack of cold storage space on the river boats. There is therefore no export of salmon from Dawson.

There seems to be little doubt that the Yukon salmon fishery has declined within living memory, almost certainly on account of operations lower down in Alaska. On the Porcupine at Old Crow we were told that before 1914 their salmon run was sufficiently large to justify a fishery during the second week of July. Now, although the Old Crow Indians are active fishermen, they take no more than 20 king salmon a year in the whitefish nets, and have long abandoned the use of salmon nets.

The same informants stated that the dog salmon arrive at Old Crow, likewise in very small numbers, soon after July 1, and ahead of the kings. This is difficult to credit, since at Dawson the dog salmon are six weeks behind the kings, running during the last two weeks of August. Dog salmon have little economic value, since their condition deteriorates immediately upon entry into fresh water.

In summary of the Dawson salmon fishery, it may be said to have great local importance, providing one of the main protein foods of white men, Indians and their dog-teams throughout the year. It might bear somewhat heavier exploitation, if local demands were to increase; but there can never be any reason to export salmon from the Territory, since the potential production is negligible compared with that of many less remote rivers in British Columbia and Alaska.

SALMON IN THE ALSEK TRIBUTARIES

As already explained, the main Alsek-Dezadeash river is closed to salmon by some unknown obstacle near the Alaska border. There might be an impassable fall, or perhaps ice-tunnels under a glacier tongue. Judging by the Yukon, the muddiness of the water is no deterrent to salmon.

This deficiency seriously affects the Indian population in the southwest Yukon. Formerly, according to tradition, there was a salmon industry throughout the main river and its spreading tributaries in the Shakwak valley, covering almost 2,000 square miles of territory. These waters now contain rainbow trout, which is a landlocked steelhead; and, as previously mentioned, landlocked sockeye salmon, similar to the well-known kokanee of British Columbia, occur in the uppermost lake of the Alsek. The presence of these fish provides evidence of former access from the sea; but it is by no means impossible, as Dr. C. H. D. Clarke has pointed out to me, that they entered the system, not by the Alsek itself, but by its tributary the Tatsenshini. Salmon and steelheads are still able to run up the latter river, which enters the Alsek not far from the sea and below the obstruction; and one of its sources, the Unahini, rises close to Dezadeash lake, from which it is separated by a lowland divide not many feet in elevation. In the recent past the Dezadeash river may have captured Dezadeash lake from the Unahini, and the sockeyes and rainbow trout with it. There are thus two alternative explanations for the presence of sockeyes and rainbows in the upper Alsek, though if the Indian tradition is well founded, the simpler explanation is probably correct.

These Indians have their present headquarters at Champagne, where the Dezadeash emerges into the Shawak valley, 56 miles west of Whitehorse on the highway. They are a coastal tribe, speaking a different language from the natives of Kluane and the Yukon valley; and each summer they migrate to a fishing camp at Klukshu, near the head of the Unahini, to catch salmon. Not all can engage in this limited fishery, and they have come to rely largely, therefore, on moose hunting to feed themselves and their dogs. In consequence, the stock of moose has been seriously reduced, and any hunting by tourists and other white people is really taking the food out of the Indians' mouths.

This large corner of the Territory is now set aside as the projected St. Elias National Park, containing the most majestic mountain country in Canada, and still richly supplied with game, including mountain goats and bears of three species. It would be in the interests of the park as well as of the Indians to spare the moose along its fringe in the Shakwak valley by re-establishing the Alek salmon run, if this were at all possible. At the same time the entire watershed would be opened to steelhead trout, an unrivalled attraction to sportsmen.

At present all five species of salmon, as well as steelhead trout, are taken in the vicinity of Klukshu. The steelheads arrive first in June, followed by the king salmon, weighing mostly between 9 and 15 pounds, which run throughout July. With the kings are a few humpbacks, weighing 5 to 9 pounds, amounting to about 1% of the catch by weight in mid-July. There were still a few humpbacks at the time of our second visit on August 20, several weeks after the kings had ceased to run.

At the latter date the main run of sockeyes was on; and we understood that the Indians were still looking forward to the arrival of cohoes in September. It was difficult to obtain accurate information from people uncertain of the proper designations of the numerous and confusing English names. We saw no dog salmon on either visit; but since we caught their parr at Klukshu, it is presumed that they also arrive in September. Dr. C. H. D. Clarke informs me that he saw cohoes at Klukshu in July and August, 1943, and that their run was over by mid-August, so it is very possible that we missed them between our two visits.

The time-honoured methods of fishing at Klukshu are by gaffs and traps. Though illegal under the existing regulations, a gaff is actually the most reasonable implement to use. The Unahini is a small creek, and with a gaff on a 16-foot pole it is easy to reach the middle and in many places right across to the further bank. The water is clear and shallow, enabling a man to pick only the best fish. Traps and nets, on the contrary, are non-selective, and kill many salmon in a condition so poor that they have to be thrown away. There is little danger of wounding fish with the gaff, because they have no chance of escape. Moreover the Indians depend on the conservation of salmon for their livelihood; their customary practices have been tested by time, and are not any more likely to deplete the stock now than they were in the past.

After fighting their way up 2,000 feet above sea-level in a distance scarcely exceeding 100 miles, some of the salmon are badly battered when they reach Klukshu. The river bed is thick with spawn, on which numbers of Dolly Varden trout are continually feeding. Some salmon ascend past the Indian village into Klukshu lake, in the mouth of which short nets are set. There are also weir-type traps made of small staves, but these contained nothing on either of our visits, though we examined in all over 100 salmon in the round, freshly taken from them. Naturally we did not see the gaffs in use, because they are known to the Indians to be illegal; but we examined them, and observed too that at least half the fish drying on the stages had wounds in the flesh.

After they are caught, the salmon are strung on a line and made fast to a stake in cold running water. In due course they are taken up, split, and hung on stages made of poles, the process being exactly the same as that for whitefish described on p. 27. Here, however, smoking and drying are simultaneous. The stage is roofed over with canvas or brush, and surrounded by a 4-foot wall of logs. This makes a square house with a 2-foot space all around between the walls and roof. On the floor a poplar fire smoulders. The constant smoke serves to discourage blow-flies, whose eggs have time to develop if drying is too slow.

Owing to language difficulties and the lack of a trading-post or any experienced white resident, it was impossible to determine the total catch. Looking around on August 20, I estimated there were about 2,000 pounds (wet weight) of fish on the stages. Bales of dried fish had no doubt already been cached, out of the way of dogs and bears, and were no longer in sight. From the standpoint of the natives this is a substantial and important industry.

We did not visit Dalton Post, where the Unahini flows into the Tatsenshini. It lies some miles off the Haines road, and is approached only by a pack-horse trail. There is a similar fishery there, between the Post and the Tatsenshini falls at the British Columbia border, also conducted entirely by natives for local use.

The Blanchard river is another tributary of the Tatsenshini, entering from the east along the provincial boundary. A young prospector described to us the run of salmon he had seen at the end of July, at the point where the Haines road crosses the stream; but on August 20 we found neither adults nor young at that place.

WHITEFISH, LAKE TROUT, LEAST HERRING AND OTHER SPECIES

The Indian population of the Yukon Territory is very much smaller than that of the Mackenzie valley, reflecting in part the general scarcity of fish. The white population, on the contrary, is much greater, on account of the wealth of mining resources. There are thus relatively few sled-dogs to be fed, particularly in the southwest Yukon where both Indians and prospectors make extensive use of pack-horses.

On the other hand, a number of white residents have in the recent past engaged very profitably in the fur-farming industry, which demands a constant supply of fish to feed the foxes and mink.

Fishing permits to use gill-nets for domestic or commercial purposes numbered 23 in 1944. Most of the fishing is done in the larger lakes, including Teslin, Tagish, Marsh, Lebarge, Ethel (but not Mayo lake), Tatlain, Kathleen, Deza-deash and Kluane. Indians require no licences, and fish wherever they may live.

In the lower end of Kluane lake, near Burwash Landing, lake trout and Nelson's whitefish are the most important species. Here the water is relatively shallow; but at the south end a depth of 270 feet has been found, and the fish taken are chiefly round whitefish and lake trout, with an occasional inconnu. It may be added that both king and dog salmon reach Kluane lake in small numbers, but their condition is very poor.

In lake Lebarge an Indian chief named Jim Boss was engaged all summer in commercial fishing, almost exclusively for Nelson's whitefish, with an occasional trout and Mackenzie whitefish. He supplied the river boats, but had great difficulty in disposing of the rest of his catch in Whitehorse, where the market is spoilt by imported salmon and halibut.

Marsh, Tagish and Bennett lakes form a very extensive chain with many long arms. The principal fox and mink ranches were at Carcross and Tagish; and for these enormous quantities of fish were taken from the lakes, amounting at the peak between 1925 and 1935 to some thousands of pounds a week. There is no doubt in my mind that this is the direct cause of the present depletion of these lakes. The principal species taken were Nelson's whitefish, lake trout and least "herring" or cisco. Fishing is now so poor that most of the fur ranches have closed down.

Least herring easily pass through the 4-inch gill-nets used to take Nelson's and round whitefish, lake trout, suckers, pike and burbot. They are particularly abundant in the narrows at Tagish and Carcross.

A word of explanation may be given here on the subject of the "tezra" or "tizareh," a fish renowned in the Yukon for its palatability and delicate flavour. In the days of the winter mail-stages, which ended about twenty years ago, whitefish caught by Indians in Minto lakes were carried frozen to Dawson and Whitehorse, and known by this Indian name. Actually the tezra is the Mackenzie whitefish; it enjoys an equal reputation along the Mackenzie, and is quite possibly the finest freshwater table-fish in Canada. It is rarer in the Yukon than in the Mackenzie, though by no means confined to Minto lakes.

NOTES ON THE FISHES

The Yukon Territory is a region interesting from the biological standpoint because of the varied connections and relationships of the fishes found in its waters. When studying the distribution of animal and plant life in Canada one must always bear in mind that this part of the North American continent has but recently emerged from the Pleistocene Ice Age; and not so very long ago, geologically speaking, most of the Dominion was covered by continental ice-sheets of great thickness, producing conditions under which neither animals nor plants could survive. A process of recolonization has therefore been going on in recent times from regions which escaped glaciation; and in the case of fishes it has been greatly aided by the fact that the glaciers temporarily disturbed the normal drainage systems, and often, during their retreat, dammed up immense lakes which permitted fish to pass from one watershed to another.

The Yukon Territory has been recolonized from three sources, namely (i) the "Middle West", a comprehensive area which for general purposes means the Mississippi valley and Great Lakes; (ii) the Pacific slope, and (iii) the Bering sea region, in which, on both Alaskan and Siberian shores, extensive areas entirely escaped glaciation. In the majority of cases it is possible to assign any particular

species of fish to one of these three categories. Naturally the Bering sea group have had the best opportunity to repopulate the Yukon system: some of them may have survived the entire glacial epoch in the lower part of the river itself. They are the group discussed in the Mackenzie chapter (p. 28), namely the inconnu, Nelson's and the Mackenzie whitefish, Laretta and least cisco or herring and the western burbot; to these the pond smelt may now be added. None of them has yet been able to extend its range in North America east of the Mackenzie and Anderson.

The Pacific slope species include the king salmon, dog salmon, and Dolly Varden trout. The rare Coulter's whitefish (see p. 12) is also included here; it has not actually been found in the Yukon watershed, but only in the Alsek up to the present time. Elsewhere it has been discovered in two localities in British Columbia and two in southwest Alaska.

The third, typically American, group has spread very widely over the northern part of the continent from its refuge area of survival in the "Middle West." The Rockies have effectively prevented its members from crossing to the Pacific watershed almost everywhere; but a few pioneers have reached the Yukon system, perhaps by the Liard or Peel rivers, which, though tributary to the Mackenzie, nevertheless rise in the interior of Yukon Territory; they may have exchanged parts of their drainage, or otherwise given opportunity for the fish to reach the Yukon. Into this group fall the lake trout, arctic grayling, round whitefish, northern chub, trout-perch and common sculpin. The lake trout has crossed the continental divide elsewhere, for example into the Fraser river system of British Columbia. Both this species and also the round whitefish and grayling have gone a step further than the Yukon in colonizing the Alsek-Dezadeash, which, as already mentioned, has the distinction of being the only river draining into the Pacific proper known to contain round whitefish and grayling. It is not difficult to see how their migration took place, since the Takhini, flowing to the Yukon, and the Dezadeash come within about 6 miles of one another in the broad Shakwak trough previously described; and the presence of a former lake, filling the trough and connecting the two systems when the Alsek gap was ice-blocked, is clearly indicated.

There remain two species probably but not certainly belonging to the continental or "Middle West" group, namely the northern sucker and northern pike. Both occur widely in Canada from the Atlantic coast northwestward, like many members of the continental group; both are absent from the Pacific watershed: but they occur also in eastern Siberia (the pike extending as far west as Europe), and in this they resemble the Bering sea group. In fact, the species must have survived in both regions, without becoming differentiated into recognizable local races during their isolation. Consequently we cannot now be sure from which source the Yukon has been repopulated. The pike is an outstanding example of invariability: in spite of its immense circumpolar range, and the fact that the glacial period must have split it into several isolated stocks for very long periods,

specimens from Ireland are identical with those from Quebec, twelve thousand miles "overland" in a direct line. Other species with a wide distribution in New and Old Worlds, for example the round whitefish, grayling and burbot, have under similar circumstances differentiated into two or more subsidiary regional forms.

CONCLUSIONS

The Yukon fishery resources will probably never be exploited for export to outside markets, because they are insignificant compared with those of neighbouring British Columbia; in fact fresh salmon, halibut, etc., are actually imported to Whitehorse from the Pacific coast at the present time. The fisheries are nevertheless of substantial local importance, both to Indians and white residents, the majority of whom live in regions too remote to receive regular shipments of perishable foods.

There is, however, a great opportunity for developing sport fishing for tourists, to whom the Yukon is now more accessible than ever before. In a setting of mountains of exceptional grandeur and beauty, in a summer climate which is genial and dry, there are many good rivers and lakes accessible without great trouble or expense. "Bluefish" or grayling are often so plentiful that they may be taken on a fly at the rate of thirty an hour. Dolly Varden trout, though the least sporting of the native char, can likewise be caught on a fly in the eastern section and in the Tatsenshini. In the Dezadeash and Alsek there is first-class rainbow trout fishing; and all the lakes contain lake trout, and often large "jack-fish" or pike.

The fact that rainbow trout are confined to the Alsek watershed is merely a natural accident; there can be no doubt that they would thrive almost anywhere in the southern Yukon if they could be established. There seems to be no objection to making the experiment, so successful in many much less favourable parts of the continent; but for this purpose a trout-farm or hatchery would be required. An attempt to introduce rainbow trout, by importing 25,000 eggs from British Columbia and planting them in the Klondike at Dawson, was made by the Hon. George Black, M. P., some years ago, but it was not successful. In a hatchery it is possible to rear the fish to yearling size, when they are strong enough to look after themselves and can be distributed readily by truck or plane. If such a hatchery were contemplated, the Whitehorse district would be the most favourable location, adjacent to the railway by which the necessary supplies of food and equipment could be delivered.

It is intended very shortly to revise the Fishery Regulations for the Territory, making proper provision for the development of sport fishing, and for the enlistment of expert local advice in its control and administration. A great expansion of the tourist industry in this hospitable and supremely beautiful country may be confidently expected.

CHAPTER III

THE MACKENZIE RIVER

BY V. C. WYNNE-EDWARDS

THE RIVER

A preliminary survey of the fishery resources of the Mackenzie river was made by the writer, accompanied by Dr. Ronald Grant, in the summer of 1944.

The Mackenzie, properly speaking, is the river connecting Great Slave lake with the Arctic ocean. It is about one thousand miles in length; but its largest tributaries, the Athabaska and Peace, which join in northern Alberta to form the Slave river, have already run almost 1,500 miles from their sources to Great Slave lake. The Mackenzie is consequently a river comparable in size to the St. Lawrence, draining a quarter of the mainland of Canada.

Our party of two travelled in a 20-foot freighter canoe equipped with a 10 H.P. outboard engine. With a load of about 1,000 pounds of equipment and supplies we made $8\frac{1}{2}$ m.p.h. in still water; but since for most of the distance the steady current is 3 m.p.h. or over, it was usually possible to make about 12 m.p.h., or a maximum of 80 to 100 miles a day in good weather. In summer the prevailing wind is from the northwest, blowing against the current; and in so large a river small boats are often held up for one or two days at a time by choppy water. For the same reason it was almost always necessary to unload the canoe and draw it up on shore at night. At times we resorted to night travel to avoid the strong day-time winds: there was no true darkness during the period of our investigations.

River navigation is broken at Fort Smith by 16 miles of rapids on the Slave, where it crosses the 60th parallel from Alberta into the Northwest Territories. We set off from that point down the Slave on the evening of June 10. Like most parts of the Mackenzie system, the Slave is muddy and often loaded with driftwood, some of which floats at or even below the water surface. Its course winds through a northward extension of the western plains, covered by immense deposits of alluvium. The river banks are soft and continually falling. Coarser materials carried away from the banks are soon deposited as low bars and islands, especially in time of flood. During most of the year these bars are therefore partly exposed, and soon afford anchorage for dense stands of willow stems. These stems in turn hold the mud, and their presence greatly increases the

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quantity deposited by the next spring flood. Naturally the willows grow more quickly than the mud is deposited; and when mature, in perhaps 50 years, the islands are built up to flood level, often 20 feet above the mean level of the river. Willows are succeeded by aspen and balsam poplars, which in 50 more years become tall trees.

Long before this the river has begun to demolish the obstacle it has created, tearing it down at the upstream end and depositing a lengthened mud-spit below. Construction and destruction are rapid, mutual and unceasing. Channels shift and change, and experience is needed to pilot large river-boats, often with two or three barges lashed ahead, safely through the muddy water.

In the northern hemisphere all moving bodies have a slight tendency to sheer off to the right, and the effect grows stronger towards the north. There is a general opinion among experienced pilots that in these soft alluvial beds the river courses of the Mackenzie valley (in particular the lower Athabaska and Slave) are migrating perceptibly to the eastward. Eastern banks are more often steep-cut, western banks more often flat and shallow.

The river shores are forested to the outer fringe of the Mackenzie delta within a few miles of the Beaufort sea. The traveller can seldom see beyond the river banks and the ends of the reach ahead and astern, through many hundreds of miles of identical tall spruce spires, cut banks, willow islands, and bars littered with bleached driftwood.

The shores of the southwest part and outlet of Great Slave lake are remarkably flat. Even in a canoe it is often necessary to travel one or two miles off shore, and sound continuously with a pole to keep from running aground. Here the water is well warmed; and as it runs on to the sea beyond the Arctic circle it retains much of this temperate warmth, profoundly affecting not only the aquatic fauna, but also the vegetation on its banks.

From Great Slave lake the Mackenzie first flows 250 miles to the west-northwest, past Providence and Simpson, where it receives its third great tributary, the Liard, from distant sources in the Yukon Territory and British Columbia. The mud of the Slave river settles in Great Slave lake, and from there to Simpson the Mackenzie is clean and clear. The Liard once more charges it with mud, though for 100 miles below Simpson the two streams run side by side, the clear water of the right bank gradually dwindling until it can be seen no more.

About 70 miles below Simpson the gently undulating plain abruptly ends. At dawn on July 6 we saw ahead an imposing wall of limestone cliffs and spurs, three to five thousand feet high. These are the outliers of the Mackenzie mountains, which take up the line of the Rockies again north of the Liard gap, and for five hundred miles form the watershed between the Mackenzie and Yukon. The North Nahanni river flows in on the left bank at this point, and the Mackenzie is deflected sharply to the north, forming Camsell bend, one of its special landmarks. From here to the sea the mountains are not far away on either side, though seldom visible.

The next small settlement is Wrigley, and 150 miles below it lies Fort Norman, at the confluence of the cold clear Bear river, discharging from Great Bear lake. Fifty miles further down, also on the right bank, is Norman Wells, which at the time of our visit (July 21 to August 5) was much the largest and most active inhabited place on the river. The Canol road was already completed, carrying a 4-inch pipe-line from the Norman Wells oilfield 550 miles across the Mackenzie mountains to the southwest, to join the Alaska highway at Teslin lake. We were able to travel up the road 111 miles to Pump Station no. 4, situated in the wild treeless glen of Bolstead creek, 4,400 feet above sea-level, and surrounded by snow-lined peaks rising to 7,500 feet or over.

From Norman Wells also a two-day flight took us around Great Bear lake; landings were made at Fort Franklin, McVicar arm near Johnny Hoe river, Eldorado Mines at Port Radium, and at Whitefish river on Smith arm (August 2 and 3).

The Mackenzie is continuously navigable, but there are four rapids to be negotiated, namely the rapids just above Providence, the Green Island rapids above Simpson, and the Sans Sault and Ramparts rapids between Norman Wells and Good Hope. The Ramparts themselves form another special landmark of the river. For nine miles above Good Hope it has cut its way back through a level limestone terrace, forming a defile with vertical or undercut walls, over 100 feet deep and half a mile wide.

From Good Hope to the head of the delta is a distance of 250 miles. The river is upwards of a mile wide, deeply entrenched, with banks often over 200 feet high. Just above Arctic Red River it narrows into the so-called Lower Ramparts, which, though the cliffs are higher, are far less remarkable than the real Ramparts at Good Hope.

At point Separation it widens and divides into the network of channels of the delta. The middle channel is the largest, but there is a well-defined east channel, and also the western Peel channel. The latter is used for navigation and carries past Aklavik to the sea the waters of the Peel river, which enters the head of the delta from the south. The delta is over 100 miles long, with a maximum width of 50 miles; it contains thousands of lakes and ponds and an intricate maze of twisting channels. Their banks are muddy and seldom twenty feet high; along the water-courses grow tall spruces, giving the impression of valuable stands of timber when seen from the water; but from the air they are revealed as narrow groves fringing the channels, and behind them is everywhere a wilderness of ponds, willows and swamps.

The delta is extremely flat and devoid of eminences, excepting the curious earth-mounds or "pingoes" on the outer islands. Along its seaward edge the Mackenzie finally deposits its mud, continually extending the shoals and backing up the water. At numerous points in the delta stumps of ancient trees, uncovered by the moving channels, stand with their feet now submerged, presumably because of the gradual rise of delta levels through sedimentation.

To the west the barren Richardson mountains rise in sight of the town of Aklavik, beautiful by the time we saw them with bright autumn colours, or powdered with early snow. On the east side of the delta lie the Caribou hills, a rolling plateau of tundra and ponds lying 500 feet above the delta. They are remarkable for being formed entirely of alluvial clay. At their foot on the right bank of the east channel is the Government Reindeer Station, in lat. 68° 42' N, from which furthest point we turned back to Aklavik on August 19th.

FISHERIES

The Indians of the Mackenzie valley number about 2,000, chiefly centred upon the trading posts of Providence, Simpson, Wrigley, Norman, Franklin (on Great Bear lake), Good Hope, Arctic Red River, McPherson and Aklavik. In winter many of them disperse to engage in trapping, travelling by dog-team and toboggan. Consequently they have numerous dogs, roughly estimated at 5,000 including those of the police and other white residents. When supplies are available the dogs are fed on fish, each receiving 9 pounds of green fish per day when working (or an equivalent ration of other food), and perhaps 2 pounds when idle from June to November. If they were fed entirely on fish, which in practice is seldom if ever the case, each dog would therefore consume about a ton a year. Between Providence and Good Hope there is a stretch of 600 miles where the fisheries are poor and fish may constitute less than 10% of the dogs' food; nevertheless, it is clear that the total consumption of fish by dogs alone, apart from what is used for human food, amounts to several million pounds annually.

Much of this is caught in the river; and though winter fishing under the ice is practicable in lakes, the currents and eddies along the banks make it impossible in the river, except in some quiet channels of the delta. Fishing must therefore be undertaken chiefly in summer and fall, at the time when the Indians are concentrated around the trading posts, three of which (Good Hope, Arctic Red River and Aklavik) are situated within reach of well-known summer fisheries.

Economically the most important fish in the river are (i) the Mackenzie whitefish, (ii) the humpbacked or Nelson's whitefish, (iii) the "herring" or Lauretta cisco, and (iv) the "coney" or inconnu. They all belong to the whitefish family, and are to a greater or less extent migratory within the river or, in the lower section, between the river and the sea.

They are caught in gill-nets. During the summer the surplus catch is dried and smoked, rendering it light, compact and easy to carry on the trail in winter. The early fall is the spawning season, when large numbers of fish can be caught in a short time on their spawning beds, and when the weather is just becoming cold enough to preserve the catch without processing. A special effort is usually made therefore just before freeze-up in late September to obtain a very large supply of fish to last through the winter. Such a fishery is known as a "fall fishery", and may conveniently be distinguished from summer fisheries for descriptive purposes.

PROVIDENCE FALL FISHERY

The largest of the fall fisheries is conducted around Big island and Slave point, where the Mackenzie leaves Great Slave lake; to it expeditions are made from Providence and, now somewhat irregularly, from Simpson. The limits of the season are dictated by (i) sufficiently cold weather to prevent the fish spoiling, and (ii) open water for the journey home.

The location is at the extreme western end of Great Slave lake, some thirty to fifty miles above Providence. The river leaves the lake by two main broad channels separated by Big island, where there are great areas of shallow water in which the whitefish spawn. At present the favourite fishing sites are along the North channel, in Deep bay, and off Slave point.

The fishery is pursued by residents of Providence, and to a varying extent by parties from Hay river and other points on the lake, and by those from Simpson. It is nowadays considered a debatable question whether the 400-mile round-trip journey from Simpson is worth while; and in fact no fall fishery expeditions from there were contemplated in 1944.

The Roman Catholic mission at Providence at the present time takes 20,000 fish (about 75,000 pounds), which is less than formerly, since they have no longer any dogs at the mission; the R.C.M.P. detachment at Providence took 13,600 pounds in 1941, 13,000 pounds in 1942 and 9000 pounds in 1943. Numerous Indian families also participate. Fishing crews are scattered along miles of shallow spawning beds, leaving Providence about September 22, and remaining at the camps if necessary until the last possible moment before the ice takes, about October 15. The production of particular grounds varies; sometimes the crews have their scows filled ready to return home in as little as two weeks.

This fishery, which so greatly impressed Sir John Richardson a century ago, appears to have yielded at the maximum something of the order of 250,000 pounds annually, though the demands on it have apparently decreased in recent years. The principal catch is whitefish, of which only one species is recognized, but quantities of pike and lake trout are also taken. Long nets of 4½- and 5-inch mesh are used, in shallow water. They are fished more or less continuously when weather permits.

Very small quantities of fish are taken in the Providence district at other seasons. At Brabant island (Wrigley Harbour, not to be confused with Wrigley 350 miles lower down) crews of vessels habitually tie up when entering or leaving the lake, and are able to obtain unlimited quantities of pike and grayling on lines trolled in the current. At Axe point and Mills lake, some distance below Providence, there are summer camps, where perhaps 30 Indian families manage to keep their dogs alive on what they catch in their nets.

SIMPSON, WRIGLEY AND NORMAN

These three posts are in the most unproductive section of the river, but fishing is done all summer with short nets set slanting out from shore in back-

eddies, a method characteristic of all parts of the Mackenzie. In spring two kinds of suckers are caught, and later pike, burbot, pike-perch and inconnu. At Simpson, pike and burbot are the most numerous; but at Wrigley and below, inconnu become much commoner, and the upper limit of river whitefish and herrings is reached. Burbot and grayling are also caught on lines in certain places, and sometimes through the ice.

In Blackwater and other lakes adjacent to Wrigley there is a small yet productive fishery for lake trout and whitefish. Twenty-five years ago river-herrings were abundant at Wrigley, and many Indians took part in the fishery. At the present time practically no dried fish is prepared at any of these three posts. The residents say it would take on the average one 35-yard net to keep one dog supplied, so that actually fish is no more than a minor part of the dogs' diet.

It is not surprising to note that where whitefish and herring are unobtainable, burbot and inconnu are more highly esteemed as food.

THE RAMPARTS SUMMER FISHERY, AND FISH-CURING

The Ramparts are the scene of an important summer "herring" fishery, conducted from June to late September. In the stretch of ten miles between the rapids and Good Hope some fifteen families of Indians had their tents, perched on ledges and in gullies. Nets of $3\frac{1}{2}$ " mesh are set in the eddies and even in the current; each 35-yard net catches about 40 fish per day for more than two months. The herring have all spawned by about August 15. This fishery may yield 100,000 pounds of fish. Though there are two species of ciscoes in the Mackenzie we saw only the large Laretta herring at the time of our visit (August 6), and failed to find or hear of the smaller "big-eye" or least cisco which occurs at Arctic Red River and in the delta.

Inconnu are also caught in fair numbers; on account of their narrow heads 30-pound inconnu may be taken in the same net as one-pound herring. So caught they die almost at once, perhaps because their mouths are closed by the mesh of the net and respiratory movements are impeded. Throughout the lower river "coney" are esteemed as food, either fresh or dried, in contrast to the opinion prevailing on the shores of Great Slave lake, where they are said to be too oily and to have a cathartic effect on dogs.

Whitefish and pike are also taken in small numbers, though it is not the practice to set nets for them. Late in the fall, so we were informed, a few Pacific salmon are regularly obtained.

Herrings and inconnu are dried in considerable numbers. The procedure is the same for all species, including the whitefish which predominate in Arctic Red River catches. The fish is split down the back, the two fillets remaining joined along the belly. The viscera are carefully removed, the roes being separated. The backbone is then detached from both sides, except at the tail. The clean fillets are scored crossways with the knife at intervals of 1 to 2 inches;

similar incisions are cut longways in the belly, and in the larger fish the knife is also thrust between the neural spines of the vertebrae in half a dozen places. The fish is then thrown over a stage of 4-inch poles, high enough to be out of reach of dogs and small children; the fillets hang down on one side, the backbone on the other. They are left here about three days, after which they are removed to similar racks in a smoke-tent or house, where a poplar-wood fire smoulders on the floor. Smoking takes 48 hours, improves the flavour, and prevents the development of blow-fly eggs. The cured fish are afterwards tied in bunches by the tail, and left on the outdoor stages until baled. About three-quarters of the weight is lost in the process. The roes and guts are frequently dried separately. Dogs enjoy meat, skin, scales, guts, bones and all.

ARCTIC RED RIVER, MCPHERSON, AKLAVIK AND THE DELTA

The summer fishery becomes even better towards the delta, owing to the increasing number of whitefish. At Arctic Red River, separate nets of different sizes are used for whitefish and for herring, coneys being caught in both. Nets are set as usual in the eddies.

Of the whitefish, the Mackenzie whitefish is the more numerous, being about twice as plentiful as the hump-back. It attains a weight of 4 pounds and over, exceeding the average run of hump-backs by about 1 pound. Mackenzie whitefish also run earlier than hump-backs, according to the late Mr. William Clark of Arctic Red River, who caught them for fifty years. In both species the females taken outnumber the males by 12 or 15 to one.

Of the river herrings, the Laretta outnumbers the "big-eye" by at least 20 to one in the catches, due in part, no doubt, to the smaller size of the latter, which permits the majority to squeeze through the nets.

In the fall more time and attention is given to the fishery, to provide a supply of green fish for the winter. The R.C.M.P. detachment at Arctic Red River make a special expedition some distance upstream at this time. Indian and white trappers are distributed rather uniformly along the river banks from Good Hope to the delta, and, though it is impossible to guess the annual output, it greatly exceeds the estimate given for the Ramparts fishery. The delta provides excellent whitefish, which are not now exploited to the extent they have been in the past.

The delta of the Mackenzie is but little smaller than that of the Mississippi. More than half of the area between the channels is occupied by lagoons, muskegs and ponds, which communicate with the channels during spring floods, many only during particularly high floods. At such times the fish locked in them are able to get out and spawn so that the height of spring floods is likely to have some bearing on the delta fisheries, and likewise on the production of muskrats, through its effect on stagnant water levels.

As already mentioned little net-fishing can be done in the river in winter because the current renders operations through the ice impossible. In the delta

at Aklavik for example, the flow is weak enough to permit of a herring fishery from the time the ice is strong enough to cross until Christmas, while the herrings are presumably migrating down again to the sea.

NOTES ON THE FISHES

In addition to collecting information from white residents and Indians, we made collections of our own at thirteen localities, using a small (12-foot) seine net in backwaters and shallows, and gill-nets of various sizes. No systematic collection had previously been made in the district, and several records we obtained of the smaller species were new for the Northwest Territories, extending their known range in a few cases for more than 1,000 miles.

One of the most interesting features of the Mackenzie, which it shares with the Yukon and smaller Arctic rivers east to the Anderson, is the presence of certain fish not known elsewhere in America, but closely related to Siberian species. The most celebrated of these is the inconnu, a large fish reaching 40 or even 60 pounds, named by Alexander Mackenzie's French-Canadian voyageurs, to whom it was a totally "unknown" fish. In their long western journeys from Montreal and the Great Lakes they found a substantially uniform representation of fish right across the continent to the Rockies. The familiar types were whitefish and ciscoes, lake trout, suckers, pike, pike-perch (doré), and burbot (methye or loche), which have an immense distribution from the Maritimes to the Mackenzie. The Mackenzie, however, has these additional species of fish, which have invaded the river from its mouth in the not very distant past, and which have not yet penetrated to its headwaters, much less the other river-systems of the interior of Canada.

Besides the inconnu these are: the two river whitefish known as the Mackenzie whitefish and the hump-backed or Nelson's whitefish, usually weighing 3 to 5 pounds; the Lauretta and least ciscoes; and also the burbot, which differs quite distinctly from the usual American form; the species has an extensive distribution in the northern hemisphere and at least three regional varieties are distinguishable.

Of the salmon family, the lake trout is very generally distributed in lakes, where it often attains a great size, but is seldom caught in the river. In the clear streams of the Mackenzie and Richardson mountains the Dolly Varden trout occurs: we saw one weighing 4 pounds taken in the Carcajou river beside the Canol road. It is a "char," related to the eastern brook or speckled trout, though not quite so game a fish. Arctic char, the so-called "salmon" of the Arctic regions, ascend the Mackenzie in small numbers as far as Good Hope; and single individuals of three of the five species of Pacific salmon are fairly regularly caught in the lower part of the river in the fall: specimens have been examined by Prof. J. R. Dymond from the delta.

The arctic grayling is a handsome fish which offers excellent sport to the angler and is a delicious table fish if eaten immediately; preferring clear water,

it is universally distributed except in the muddy parts of the Mackenzie itself. The small tributaries often contain enormous numbers of grayling, locally known as "bluefish".

Of interest to the scientist, and of value as forage for the larger fish, are the small species, commonly called minnows, shiners, chub and dace. Owing to the warmth of the Mackenzie water in summer, several of them are able to live much farther north in this district than elsewhere in Canada. Knowledge of their distribution is still very incomplete, as indicated by our finding the fine-scaled dace (*Pfrille neogaea*) at Good Hope, 1,500 miles from its nearest previously known station at Fort Severn, Ontario (on Hudson bay) and somewhat farther from other stations in South Dakota and Nebraska.

The northern pike or "jackfish" is another circumpolar species, of considerable economic value in the poorer middle section of the Mackenzie, where the more highly esteemed whitefish are uncommon. It occurs throughout the Mackenzie lowlands north to the delta. Much the same applies to the pike-perch, also known as pickerel or doré, which we collected as far as Arctic Red River although not actually in the delta; and to the burbot, found everywhere and formerly known by the Cree-Indian name of "methye."

CONCLUSION

Fisheries are a staple summer industry of the Indians and of all those white residents who require to travel by dog-team during the winter. Besides being the principal item of dog-feed, fish constitute in most places the chief and most readily procurable source of protein in the diet of the human population. Many of the white residents have cellars dug into the frozen ground, in which fish and other perishable food can be kept almost indefinitely.

There is no evidence of depletion through over-fishing; the presumption is that production could be raised should this at any time be required to meet increased local demands. At present little trading is done in fish, though in an emergency additional supplies for dog-feed can usually be bought during the winter; some trading posts buy up a small stock of fish in the fall to meet such demands. Fish are frequently sold by the "stick", which holds about 25 pounds or 10 fish strung through a cut in the tail, just the way they are placed on racks or stages for freezing. Each family or group ordinarily makes provision for its own summer and winter requirements; and since much more money can be made by trapping furs, Indians do not concern themselves with selling fish as a regular occupation, with the result that officials and employees at such points as Norman Wells, Port Radium and Aklavik often have difficulty in buying what they would like to procure for domestic use.

Commercial development of fisheries for export from the Territories is at least a possibility in the lower river and delta, but at present it would not be practicable on account of transportation difficulties. The Mackenzie is open for navigation for a little over three months at most. Refrigerator barges are

already in use; but fish for export from the delta would have to be taken 1,300 miles upstream to Fort Smith, then carried across the 16-mile portage to Fitzgerald above the Slave river rapids; from there a second set of tugs and barges would be required to make the remaining 300 miles up to the rail-head at Waterways, Alberta. Two round trips are as much as can be expected in one summer, and the freighting costs would be prohibitive.

The building of an all-year road or railway to the head of the Mackenzie at the western end of Great Slave lake would lengthen the season of navigation by some weeks, shorten the long slow haul by water, and reduce the handling of shipments. It would render the resources of the Mackenzie District available for export at lower cost and at once raise the local economic level, by dropping the prices of imported goods and equipment and making production pay on materials less valuable than furs, high-grade pitchblende or gold. With such an improvement in transportation, the fisheries of the lower Mackenzie may become a reasonable commercial venture.

CHAPTER IV

GREAT BEAR LAKE

By R. B. MILLER

Great Bear lake lies 60 miles east of the Mackenzie river and about 400 miles north of the Alberta boundary. The Arctic circle cuts across its northern tip. It has an area of 11,800 square miles and is the fourth largest North American lake. Five sprawling arms make up Great Bear lake; of these McTavish and Dease arms, to the east, lie largely in the Precambrian Shield. Their shores are high, rocky and irregular with many bays and islands. In some places the cliffs reach 700 feet above the lake level. For the most part these rocks are barren of trees but here and there a straggly black spruce and, in the valleys, a

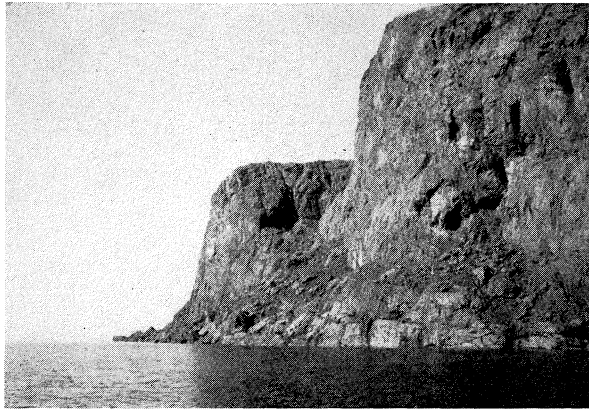


FIGURE 3. Great Bear lake. Typical shore line near Port Radium. The cliff rises to about 700 feet above the lake level.

few birch survive. During June and July brightly coloured herbs occupy the crevices and ledges of the rock and relieve the oppressive drabness of the landscape.

The western two thirds of the lake, Smith, Keith and McVicar arms, lie in the lowlands bordering the Mackenzie river. Their shores are low, sandy and in numerous places, heavily timbered. In other places extensive muskegs form the lake margin, especially bordering the bays that receive rivers. The shore

line is very regular with a gentle slope and sandy beaches. Harbours for craft larger than canoes are few and far between. There are only a handful of small, low, scattered islands which, like the larger points projecting into the lake, lack trees and shrubs and give a floral picture resembling the tundra.

Great Bear lake has a surprisingly small drainage basin—only 54,600 square miles. The majority of the rivers entering the lake are short and small; many of them are hardly more than creeks. The only outlet is the Bear river which rises in Keith arm and flows about 60 miles east to the Mackenzie. It is a broad, swift, shallow river; vessels which draw more than 20 inches cannot navigate it and there is a nine-mile stretch of rapids navigable only by canoe. It is strange that this great lake should have such a young and shallow river draining it; swift though it is, the Bear river has cut only a very shallow valley. It seems likely that not long ago the lake drained by another route, possibly to the north where the height of land separating the Arctic drainage lies within a few miles of the shore. We saw several old beaches at levels of 500 feet above the present lake level; when the lake lay at these heights it could have flowed over the present divide to the north.

Extensive soundings have not been made in Great Bear lake. The few that have been taken show it to be of great depth. A considerable area in McTavish arm is over 1,300 feet deep; the eastern part of the basin, though shallower, is still of considerable depth—around 400 feet—and there is no extensive area of shallow water in any part.

THE SURVEY

ITINERARY

The party sent to survey the fisheries of Great Bear lake consisted of three people, including myself. We arrived at Port Radium, the site of the Eldorado mine, early in the morning of June 23, 1945. We established our headquarters on Cobalt island, a small rock near Port Radium, and from there conducted our survey of McTavish arm by canoe.

Our scientific equipment consisted of 500 yards of gill nets, several thermometers, a dredge for sampling the lake bottom, a water bottle for obtaining water samples from beneath the surface, a silk net for straining out minute organisms, a chemical kit for making water analyses, calibrated lines for soundings, instruments and numerous odds and ends of glassware, preservatives dissecting tools and hardware.

For camping we carried two 10' × 12' tents, sleeping bags, air mattresses and cooking utensils for use on an open fire. Dr. Kennedy and Mr. Smith each carried a rifle and these, with our clothing, completed our equipment.

During most of the first three weeks an 18-foot prospector canoe was the only craft available; this we paddled approximately 200 miles to investigate Echo bay and other areas near Port Radium. Later we borrowed a 22-foot,

Chestnut freight canoe from the Eldorado Mine which, equipped with an outboard motor, enabled us to make extended trips and remain away from headquarters several days at a time. This canoe was a very stable craft and proved ideal for setting and lifting several hundred yards of net, a task which was rather awkward in the light 18-foot canoe. We covered about 300 miles with this outfit and investigated Lindsley bay, Conjuror bay, Camsell river and Gunbarrel inlet.

On August 2 we crossed the lake on a load of uranium ore and established a camp at the source of the Bear river on Keith arm (Bear River Landing). This is the place where the ore from Port Radium is transferred to a river barge to begin the trip to the Mackenzie river. The Indian village of Fort Franklin, the only settlement on the lake aside from the mine, is close to Bear River Landing.

From August 4 to 12 we studied the fishery in Keith arm. On August 13 we chartered a 40-foot gasoline launch from the Blondins, father and son, and with them as crew and guides made trips to Smith and McVicar arms to study the main whitefish fisheries of the lake. These trips aggregated about 750 miles and lasted until September 1 when the survey was brought to a close. The next two weeks were consumed in packing equipment and specimens and moving to Norman Wells on the Mackenzie river, whence we flew to Edmonton on September 14.

WORK

The main objective of the survey was to determine the possibilities for a commercial fishery on Great Bear lake. To thoroughly achieve such an objective attention must be given to many things besides the fish themselves. The plankton and bottom fauna should be investigated; the physics, chemistry and morphometry of the lake need to be studied; and conditions affecting the quality of the fish, such as parasites, should be looked into. To do all these adequately on a vast lake in one short season was manifestly impossible. Accordingly we concentrated our efforts on the fish and made observations on other factors only when the main business of fishing gave us opportunity.

The principal work of the survey, then, consisted of setting and lifting strings of gill nets of various mesh sizes in as many different places as we could reach. The catch was recorded, the fish weighed, measured, sexed, examined for parasites and stomach contents noted; scale samples for age determination were also taken. Considerable numbers of fishes were preserved and brought out for museum study. When this routine permitted, soundings, bottom samples, plankton hauls and temperatures were obtained and analyses for pH, oxygen and carbon dioxide were performed.

WEATHER

Such a programme is greatly facilitated by fine weather. During June and July we enjoyed exceptionally fine weather. Rain fell on only three days, all

day for only one of them. The average daily maximum temperature was 75°F. and the average daily minimum 44°F. There was almost no wind; for days at a time the lake remained motionless. This remarkable dead flat calm was one of the most amazing phenomena we observed; it probably was caused by the large expanse of water at a much lower temperature than the surrounding land.

In August the weather was very bad. The sun shone on only nine days; rain fell on 15 days, continuously for eight of them. The average daily maximum temperature was 67°F. and the nights often became freezing. Winds blew almost constantly, often in gale proportions. This forced the survey party and its two Indians to remain for cooking, eating and sleeping in the cargo hold of the launch, a space about 7 by 15 feet and too low to sit erect.

PHYSICAL AND CHEMICAL CONDITIONS

TEMPERATURE

This past summer the ice began to break up on Great Bear lake around the 15th of June (1945). Large ice floes continued to drift around for more than a month after this; we saw the last large one on July 24. Ice begins to form again in October but often no complete ice cover is formed until December. The small inland lakes freeze long before this and aircraft supplying Port Radium make use of these frozen lakes for early winter landing fields.

Surface water temperatures in the open lake remain not far from freezing all summer. Near Port Radium the surface temperature was 35.2°F. early in June. By the end of July the water had warmed to 43.2°F. On the west shore the surface temperature reached 55.2°F. in August. Protected areas like deep bays became much warmer, as much as 22°F. higher than exposed areas. The surface water of Conjuror bay, for example, reached 63.1°F. toward the end of July and tempted the party to indulge in its only bath (in the lake) for the summer.

Below the surface the water remains uniformly cold. At depths of 100 feet or more the temperature is never far from 39°F. the temperature of maximum density.

DISSOLVED GASES AND PH

Carbon dioxide was present only in insignificant amounts at all depths sampled. No quantity greater than 4 p.p.m. was found.

Oxygen was present to the extent of 85 to 91 per cent of saturation at all places sampled, not excepting the great depth of 1,134 feet.

The pH is very uniform and never exceeded the limits of 7.2 to 7.4, only slightly on the alkaline side of neutrality. No variation in acidity or alkalinity was observed with depth.

TRANSPARENCY

The water is remarkably clear. A small, white-enamelled dinner plate suspended by a rope could be seen clearly to depths as great as 60 to 70 feet all along the east shore. In more open water, three miles from shore, the plate could be seen 96 feet below the surface. On calm days, while paddling our canoe, we could see the bottom some 40 to 60 feet below us so clearly that it gave us the sensation of floating in air. We could see every little detail of the bottom and also, of course, any fish which happened to be below us. At one place we were able to count over a hundred trout merely by standing in the canoe. At other places we saw and easily identified large, uncountable schools of ciscoes, although they were many feet below us.

In protected bays the water was less clear, the visibility falling to 25 feet in the most enclosed areas. Along the west shore we were unable to make accurate transparency measurements because of constant winds; but the transparency is considerably less, around 40 to 45 feet in the open water near Fort Franklin.

PLANKTON AND BOTTOM FAUNA

The plankton is made up of a vast assemblage of microscopic plants and animals which are distributed in the waters of lakes between the surface and the bottom. The plant plankton is dependent on sunlight for photosynthesis and so is restricted to the upper layers of the lake. The animal plankton, which feeds on the plants, must, of course, take up the same distribution. The animal plankton provides food for the young of all species of fishes and is the sole food of fish like ciscoes throughout their lives. Some idea of the quantity of this plankton present in a lake is, therefore, useful for estimating productivity of fish. The plankton strained from the waters of Great Bear lake with a fine silk net proved to be exceedingly meagre both in quantity and number of kinds of plants and animals. These findings indicated a probable low productivity of fishes.

The bottom fauna is made up of snails, small clams, larvae of aquatic insects and certain small crustaceans which live in or on the lake bottom. The kinds and numbers of animals change with type of bottom and depth. This fauna is sampled with a small dredge which is lowered to the bottom with its jaws open and is closed by dropping a weight down its rope. The mud thus obtained is washed through fine screens and the animals picked out. In Great Bear lake the small crustaceans known as scuds or fresh water shrimps were the most numerous bottom animals. In general, the bottom fauna was poor; in the open lake there were no animals deeper than 60 feet. In protected areas the fauna was more abundant but still far less than in warmer, southern lakes. These findings indicate rather meagre provender for such bottom feeding fishes as whitefish.

THE FISHES

We did most of our fishing with gill nets but we collected a few by angling, seining and dip-netting. Our gill nets were in two gangs, each 250 yards long; each gang was made up of 50 yards each of 2½, 3, 4, 5 and 5½ inch (stretched mesh) nets from four to six feet deep. Nets were set at various depths ranging to 400 feet. We made 65 sets, each of about 24 hours' duration. Including those taken by angling and seining our catch was of the following kinds and numbers:

- 438 lake trout, *Cristivomer namaycush* (Walbaum)
- 313 ciscoes, *Leucichthys artedi* (Le Sueur)
- 271 whitefish, *Coregonus clupeaformis* (Mitchill)
- 164 pike, *Esox lucius* Linnaeus
- 107 Arctic grayling, *Thymallus signifer*, Richardson
- 79 round whitefish, *Prosopium cylindraceum* (Pallas)
- 32 northern suckers, *Catostomus catostomus* (Forster)
- 17 pikeperch, *Stizostedion vitreum* (Mitchill)
- 2 burbot, *Lota lota maculosa* (Le Sueur)

and numerous sculpins, *Cottus cognatus* Richardson, and sticklebacks, *Pungitius pungitius* (Linnaeus).

We found one troutperch, *Percopsis omiscomaycus* (Walbaum), in a trout stomach. The species is evidently rare in the lake. It is an interesting fact that we found no fishes of the minnow family although we were constantly on the lookout for them and seined in all favourable places.

Considering the amount of fishing done our catch was a poor one. It represents an average of only 8.5 fish per 100 yards of net, a very low figure.

LAKE TROUT

The lake trout are the dominant fish of Great Bear lake. They occur everywhere around the shore and out as deep as 400 feet. They are splendid fish of excellent colour and flavour. We are well qualified to judge their gastronomic excellence as they formed our chief article of diet for the summer.

The trout spend their first four summers hiding among boulders in very shallow water along the shores. By July of their third summer, i.e., as two-year-olds, they are only four inches long. After the fourth summer the trout move to deeper water. They grow very slowly; as four-year-olds they average just over seven inches from snout to fork of tail; by ten years they have grown to 14.5 inches and weigh between one and two pounds; in the next ten years they increase to about two feet in length and weigh between six and seven pounds. Most of the fish we caught were from 9 to 21 years old and weighed between one and eight pounds.

We found lake trout moving in to spawn on the west shore as early as August 14. Spawning fish were all over three pounds weight and mostly over seventeen years old. As well as maturing so slowly these fish apparently do not

spawn every year after sexual maturity is reached. We found that of 129 mature female fish only 47 were in condition to spawn. These figures indicate that only one third to one half of the mature fish spawn in any one year, or that each fish spawns only every second or third year after attaining sexual maturity.

The stomach contents of 383 trout were examined. Of those with food 25.1% contained bottom organisms, 21.8% plankton, 33.5% terrestrial insects (mainly grasshoppers) and 44.3% fish. The remarkable thing about this record is the small percentage of stomachs which contained fish remains. In most places lake trout, particularly the large ones, are fish eaters. In Great Bear lake trout of all sizes consumed less fish than bottom organisms, plankton and insects.



FIGURE 5. A 24-lb. lake trout. In the background is the abandoned town-site of Cameron bay

The flesh colour of trout is highly variable. It varies from lake to lake and also, often, fish in the same lake show differences in flesh colour. Great Bear Lake trout are no exception; we found all varieties of flesh colour from white to an intense red. Our observations showed that flesh colour is not correlated with sex or with size, but is definitely correlated with ripeness. Thus of the fish which were going to spawn the coming fall more than half had white flesh and most of the remainder had a pale yellow flesh; only a few were orange and none of them was red. Of the fish which were not going to spawn the coming fall over sixty per cent had orange or red flesh and less than ten percent had white flesh. Probably the developing eggs or sperm use the stored fats which give the flesh its colour so that ripening fish are pale of flesh and non-ripening fish are red.

The tapeworm, *Triaenophorus crassus*, the encysted stage of which is such an economic nuisance in whitefish, was found in the flesh of the lake trout of Great Bear lake. The cyst, while harmless to man, is ugly and repugnant, and spoils a fish for market purposes. We carefully cut up the flesh of 313 trout in a search for these cysts; 26.8% of these were infested, with an average of 1.1 cysts per fish and 21.5 cysts per hundred pounds of trout. In certain areas of the lake we found no cysts in the trout, while in other areas, often just a few miles away, as many as 91.2% of the population were parasitized with an average of 6.1 cysts per fish.

Our study of this infestation revealed an interesting fact in the life history of the trout. The tapeworm cysts are known to persist in the flesh for at least three years after they are established. Yet populations of trout only eight miles apart showed variations in infestation of from 0 to 64 %. Obviously these trout populations do not mix. Evidently the trout spend their lives close to the region where they were born.

WHITEFISH

Strictly speaking, the whitefish can hardly be said to be one of the fishes of Great Bear lake. While it is true that we encountered a few in the lake, these were near some river mouth and we believe they are pretty much confined to the rivers and their headwater lakes. Whitefish are abundant in the Johnny Hoe river, in McVicar arm, where they are caught in large quantities in late August and early September. Similar fall whitefish catches are made in the Whitefish river of Smith arm. The Indians informed us that whitefish could be taken in several rivers along the north and northeast shores. It is clear from our survey and from what we learned from the Indians that whitefish can only be taken in quantity in the fall and then only in or near the mouths of certain rivers.

The growth rate of the whitefish we took in the Johnny Hoe river is surprisingly fast. A length of about one foot and a weight of approximately one pound is attained during the fifth year of life; in the tenth year lengths over 20 inches and weights over four pounds are achieved. While the growth is slower than in many whitefish-producing lakes it is faster than in some lakes, such as lake Nipigon, which lie much further south.

TRIAENOPHORUS IN WHITEFISH

This infestation, a source of much grief in whitefish of the prairies, is of small consequence in Great Bear lake. Of 129 whitefish examined, only 19, or 15%, were infested, and these very lightly. The average for the 129 fish was 0.19 cysts per fish or 5.2 cysts per 100 pounds. No local severe infestations were found.

CISCOES

These fish, known as "Bear Lake herring," are widespread in the lake. Each bay appears to have its local cisco population. The principal cisco fishery is near

Ft. Franklin in Keith arm. They are plump, attractive fishes which closely resemble the tullibee of the prairie lakes.

A study of the ages of a hundred of these fish showed that they grow at very nearly the same rates as ciscoes on the prairies and in the Great lakes.

TRIAENOPHORUS IN CISCOES

An examination of 223 ciscoes revealed a very high degree of infestation with *Trienophorus crassus*. In most localities over 80 % of the population was infested. A severe infestation of 1,675 cysts per 100 pounds was encountered in one locality. The Ft. Franklin ciscoes were the only ones not heavily parasitized. Of 147 of these fish which we examined, only 12 were infested and these had a total of only 33 cysts. As was the case with the lake trout, populations of ciscoes exist fairly near one another with widely different degrees of infestation; this indicates that the ciscoes, like the lake trout, are more or less confined to one locality for life.

ARCTIC GRAYLING

Bays all around the lake contained these fish, which probably came from nearby streams. We saw the greatest numbers in and near the Bear river. Here we watched thousands of grayling jumping at all hours of the day. They can be readily taken on a fly. The majority are about a pound, or slightly over, in weight and from 11 to 15 inches long. Such fish are four or five years old. Quite a few exceed two pounds but three-pounders are rare. One fish, 18.15 inches long and weighing almost three pounds, was in its twelfth year of life.

Of the 101 grayling stomachs in which food was found 75 contained terrestrial insects, mostly grasshoppers, 25 contained plankton, 18 contained bottom animals, 7 contained fish and 1 held two young lemmings.

The Arctic grayling spawn in the early spring in small streams. About the middle of June, when the ice cover on the lake is breaking up, they descend to the larger rivers and to the bays of the lake. Here they spend the summer and, according to our Indian informants, return to small headwater lakes in the fall. We found grayling fry in the mouths of two east-shore streams and in bays near river mouths.

Grayling contribute a small amount to the food supply of the Franklin Indians. In years when the "herring" are abundant, only the few grayling caught incidental to "herring" fishing are used. But in years when the "herring" fishing is poor a special effort is made to secure grayling. The usual method is to construct traps across streams tributary to the Bear river. This operation is performed in June when the grayling are moving to their summer feeding grounds in the larger rivers and the lake. Edward Blondin told us that one year he caught in this manner and dried 150 bales of "bluefish" (grayling); one bale contains from 100 to 150 fish. This was used principally for dog food.

Of 98 grayling examined for parasites 8.2% contained cysts of *Trienophorus*

crassus in their flesh. *T. crassus* has not been previously recorded from the grayling.

ROUND WHITEFISH

This fish is widespread and common in Great Bear lake. Quite large catches may be made in Keith arm near the Bear river. The Indians recognize them as a distinct fish but have no particular use for them. They are not sufficiently abundant to be important in a fishery; furthermore, these in Keith arm are rather heavily infested with a sporozoan which produces large milky cysts in their flesh.

NORTHERN PIKE

This fish has a wide but spotty distribution in Great Bear lake. They are scarce in most places on the east shore but in a few bays, such as Conjuror bay, they are abundant. On the west shore they are very numerous in Smith and McVicar arms and less abundant in Keith arm. We were informed that small headwater lakes are commonly full of these "jackfish."

They grow rapidly—at about the same rate as in the northern prairie lakes. Pike are important chiefly because of the parasite *Triaenophorus crassus* for which they are the sole final host. They are held in low regard by the Indians and only those taken occasionally in "herring" nets are used (as dog food).

PIKEPERCH

These fish (widely but inaccurately called pickerel) do not really belong in the list for this lake. We found them only at one place, the mouth of the Johnny Hoe river in McVicar arm. The Franklin Indians know of them only from this place. This population is slow-growing and long-lived; fish of sixteen years which weighed only four pounds were not uncommon.

NORTHERN SUCKER

While this fish is seldom encountered in the lake it is quite common in streams running into the lake on both east and west shores.

BURBOT

This species is exceedingly rare in Great Bear lake. We took only two specimens and one of these by the unorthodox method of stabbing it with a hunting knife. Burbot are said to be plentiful in some of the small lakes around Great Bear.

SCULPIN

These small fishes were particularly abundant on the Precambrian shores where we found them under stones in shallow water. They are an important food item for lake trout.

STICKLEBACK

We found these little fish near the shores at all points around the lake.

PRESENT FISHERIES

There are at present four fisheries on Great Bear lake; these are, one, the sport fishing at and around Port Radium; two, summer fishery in Keith arm centred at Fort Franklin; three, fall fishery at the Johnny Hoe river in McVicar arm; four, fall fishery at Whitefish river in Good Hope bay of Smith arm. In the past there were summer, fall and winter fisheries on the east shore at Cameron bay and in Conjuror bay around the mouth of the Camsell river. With the closing of the Hudson's Bay Post at Cameron bay, the town was abandoned, the fisheries ceased and the Indians moved across the lake to their present home at Fort Franklin. Here the Hudson's Bay Company operates a winter post. We were unable to get figures on the extent of the abandoned fisheries. The localities are now visited only sporadically by a few Dog Rib Indians who come down the Camsell river from Hottah lake. The amount of fish they take is negligible.

1. The sport fishery at Port Radium: Estimates on the extent of this fishery given us by the mine staff were very variable. A reasonable figure is perhaps 3,000 pounds of trout per year. It is interesting to note that we found our poorest fishing around the mine. It is possible this may be due to angling pressure, slight though this appears to be.

The mine is very anxious to have a constant supply of fish. Since April, 1942, fish have been bought from the Indians at 15 cents per pound, filleted. The Indians have supplied 6,000 pounds of fillets to date—a very inadequate quantity. Most of this has been trout.

2. The fishery in Keith arm. This fishery is pursued by the Franklin Indians mainly in summer. The species taken are ciscoes (Bear Lake herring) and trout. A few pike, whitefish, round whitefish and grayling are also caught. A rough idea of the extent of this fishery may be obtained as follows: The fish are used mainly for dog food; the 100 families at Franklin keep about 600 dogs; for about 150 days in the summer each dog eats 4 or 5 herring or a total of 400,000 pounds of fish.

A variable amount of fishing takes place here in the fall and winter; probably not more than 100,000 pounds of fish are taken in Keith arm in the winter.

This fishery is very unreliable. This year and last (1944 and 1945) the herring were abundant, but for several years previous to this they were very scarce. Old Indians told us such fluctuations have always been.

The gear used is mainly shallow 3 and 3½ inch (stretched mesh) gill nets. These cost the Indians \$12 to \$15 per 3 pounds of web and are not hung. Regulation leads and floats are quite unknown to them and ours were regarded with great interest. Most of the Indians dye their nets but they seem to view the process as an end in itself and not as a means to an end; frequently bright pinks and purples are employed which can have no value for camouflage. For trout,

set-lines of 12 hooks baited with herring strips are often used. The trout are dried and smoked for both men and dogs.

3. Fall fishery at Johnny Hoe river in McVicar arm. This fishery is also operated by the Franklin Indians who migrate to the Johnny Hoe river in late August and September. The operation is exclusively for whitefish which are moving in the river from around August 15 to September 15. The fish are caught in weirs in the river and also in 4 and 4½ inch nets. The winter supply is taken in this period and frozen.

For 215 winter days the dogs are fed over twice as much per day as in the summer, so that approximately 900,000 pounds are needed. In addition there is a quantity used for human food which we are able to estimate from figures given us by Edward Blondin. The Blondins and ten other families have fished together for years; he has kept a record of their catches and told us that 59,000 fish were their annual requirements. This amounts to 5,364 fish per family; the 100 Franklin Indian families would use, then, 536,400 whitefish or about 1,609,200 pounds per winter. Of this amount about 900,000 pounds are used for the dogs and the remainder, approximately 7,000 pounds per family, is used as human food.

We have every confidence in the accuracy of Edward Blondin's figures. However, the quantity used for dogs does not agree with the findings of the Great Slave lake party who reported a considerably lower consumption of fish per dog. Possibly the Franklin Indians are more generous to their dogs as several different Indians gave us similar figures on amounts fed to their dogs.

4. The fall fishery at the Whitefish river in Smith arm. This fishery is exactly the same as that in the Johnny Hoe river. We have no information on the number of Indians who come here or how much fish they use.

We may now arrive at a rough estimate of the total take of fish in Great Bear lake:

1. Port Radium - 3,000 pounds
2. Keith arm - 500,000 pounds.
3. Johnny Hoe river - 1,600,000 pounds.
4. Whitefish river - 100,000 pounds (guess only).

Total approximately over two million pounds of whitefish, cisco and trout.

DISCUSSION AND CONCLUSIONS

The principal conclusion is that Great Bear lake is not suitable for a commercial fishery. Leaving out all consideration of distance from markets and transportation problems there is still abundant evidence to support this conclusion:

1. Lake trout. These are the dominant species in the lake. Thus a summer fishery on Great Bear would take mainly lake trout. These are not as valuable a product as whitefish. In most cases where lake trout are produced commercially they are treated as a side issue, caught during operations directed mainly at

another species, usually whitefish. It is doubtful if there are many lakes where the lake trout would stand up under a fishery in which they were the principal fish. They grow slowly everywhere; in Great Bear lake our findings suggest a long period of immaturity and spawning seasons only every second or third year after sexual maturity is attained.

If a lake trout fishery were established, we believe that operation would be unusually expensive; evidence from the study of *Triacnophorus* in lake trout shows that the trout consist of local populations, each more or less confined to a certain small area of shore line. The fact that during the last few years angling at Port Radium has grown less productive lends weight to this view. A commercial outfit would be forced to make a change of headquarters each time the trout in their immediate vicinity became exhausted.

Finally, the company catching lake trout commercially would soon run into the problem of *Triacnophorus* as heavy infestations were found in some of the best trout areas.

2. Whitefish. It can be said that, for practical purposes, whitefish do not occur in Great Bear lake. It is true that whitefish may be caught in the lake, but it is very probable that these are largely scattered members of the populations of rivers and their headwater lakes. The only large fishery is that on the Johnny Hoe river; it can be used only in late August and early September, too late in the year to ship the catch by water. This fishery is exploited fully now as the Indians fish there each year until they no longer catch fish.

3. Cisco. The Great Bear "herring" is a fine fish and looks to be of excellent smoking quality. Those from the Fort Franklin fishery are practically free of infestation; elsewhere, however, they are heavily infested with *Triacnophorus*. The Fort Franklin fishery has a history of violent ups and downs and could not be relied on to support commercial fishing.

4. The nature of the lake. Great Bear lake with its great depth, constant cold, remarkable transparency, scant plankton and bottom fauna, and small drainage basin exhibits a condition of extremely low biological productivity. It is naturally unproductive; in fact its open waters constitute almost a biological desert. Its fish population is merely a fringe of life inhabiting the near-shore zone and the protected bays where warmer water and the inwash of nutritive materials in small streams create local areas of higher productivity. No large-scale fishery could be expected to survive under these conditions.

APPRECIATION

I would like to take this opportunity to pay tribute to Dr. Kennedy, my associate in the field during this survey. His great knowledge of fishing gear, his ingenuity and his energy were invaluable; these coupled with a remarkably even disposition made him the ideal field companion.

CHAPTER V

GREAT SLAVE LAKE

BY D. S. RAWSON

INTRODUCTION

Great Slave lake has long been known as a main link in the water route to the Arctic and as the headwaters of the great Mackenzie river. Down-river traffic reaching the lake may proceed northwest to Aklavik, north to Yellowknife or east to Reliance and the barren lands. The earlier interest in this area was chiefly connected with fur trade, travel and exploration. In recent years the mineral wealth has attracted wide attention.

The District of Mackenzie is mountain on the west, barren to the north-east and forested in the centre. Great Slave lake is located in the southern part of this forested area. Most of the lake lies within the Mackenzie Lowlands, a narrow northern continuation of the Great Central Plains, but the long east arm extends far into the Precambrian Shield. The contact of the Precambrian with the later sedimentary rocks cuts across the lake from a point near the mouth of the Slave river to Fort Rae on the north arm. Thus the north and east shores are of rugged Precambrian rocks while to the south and west are found sedimentary rocks mostly overlain with glacial drift. It is of interest that Great Bear and Athabaska, the other two large lakes in the Mackenzie drainage, have similar shores since they too lie across the edge of the Precambrian Shield.

The area around Great Slave lake is drained by half-a-dozen rivers which are of considerable size and important for power development, for transportation and for the spawning of certain species of fish. The greatest inflow, however, comes from the Athabaska and Peace rivers which join near lake Athabaska to become the Slave river. The total area draining into the lake is 370,000 sq. miles, more than one-tenth of the total land area of Canada. It is thus understandable that the lake receives a tremendous inflow and that the Mackenzie river leaves Great Slave with an average discharge one-and-one-half times that of the Fraser river and two-thirds that of the St. Lawrence at the outlet of lake Ontario.

The climate in the Great Slave area is not as cold as its northern location might suggest. Winter temperatures are low and the lake is covered with ice for more than seven months, but the summer temperatures are high. The mean

BULL. FISH. RES. BD. CAN. LXXII (1947).

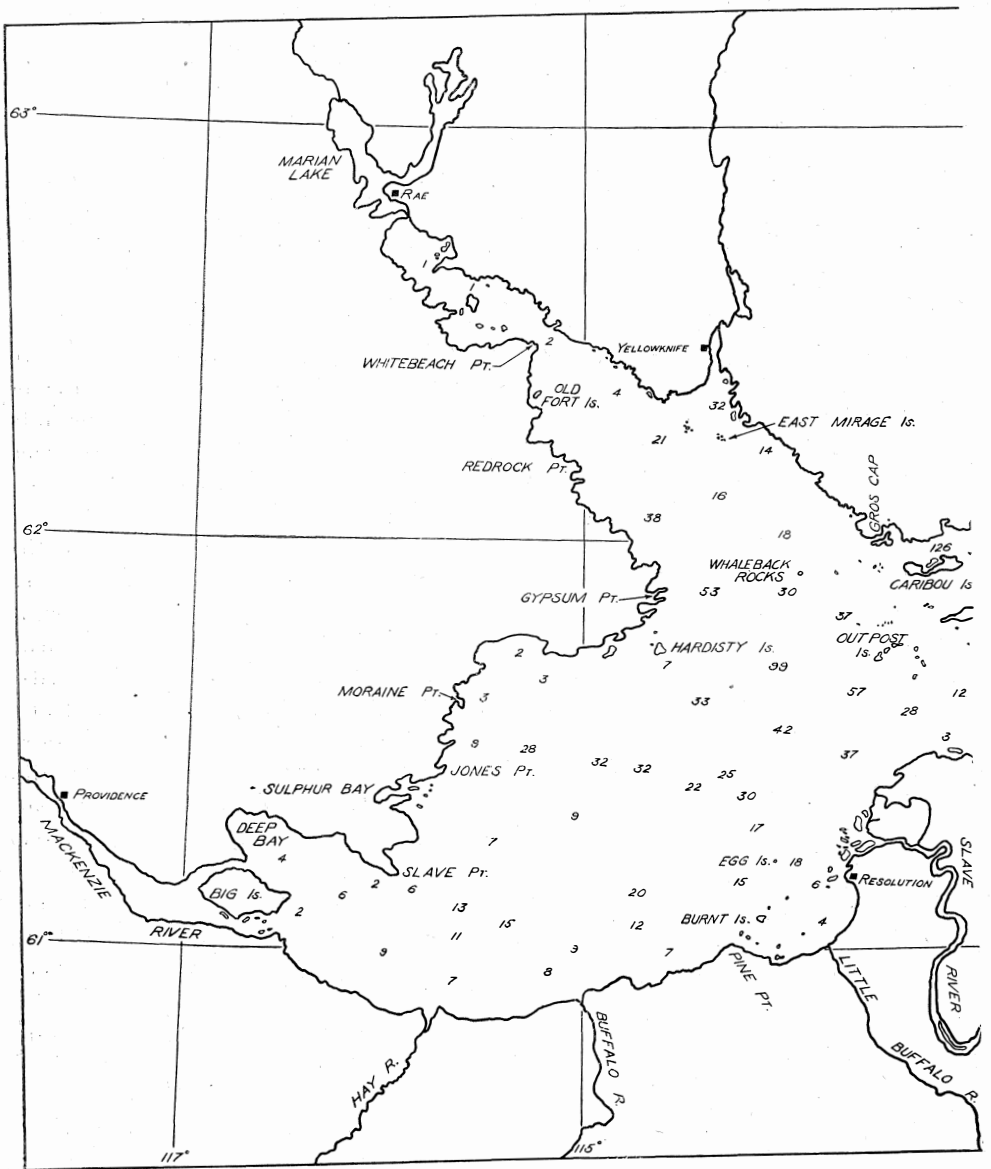


FIGURE 6. Great Slave lake.

temperature for July at Resolution is 60°F. as compared with 61° at Edmonton. The low altitude (495 feet) and the moderating influence of the large body of water must have a considerable effect on the temperatures around the lake. The mean summer temperature (June, July and August) is 56°F. and there is an average of 19 hours of daylight in June and July. The result is a short but vigorous growing season. Since the lake extends over 265 miles from east to west there is a wide range in climatic conditions. The west end is not far from prospective wheat-growing lands, while the east is only thirty miles from the barrens. Reliance, at the east end, is usually ice-bound at least a month later than Hay River in the western part of the lake.

The forest of the Mackenzie lowlands is at its best along the Slave river and especially in the delta where the alluvial soils support some fine stands of white spruce. Several sawmills are located in this area and their product finds a ready market at Yellowknife and "down river". The remainders of the south and west shores show a varied forest cover of spruce, poplar, birch and jackpine, alternating with large areas of muskeg and "scrub". The East arm and the northeast shore lie in the Northern Transition Forest. The rocky ridges support a few stunted trees but even in this section the lower and protected areas have a good forest cover, capable of supplying useful timber for local needs. The sudden change from forest to the stunted vegetation of the barren lands or tundra is encountered half way down Artillery lake, only 40 miles east of Reliance.

The present inhabitants of the Slave lake area include some 1700 Indians and mixed-bloods, a handful of whites at the half-dozen settlements and a large but fluctuating group at Yellowknife. The rapid movements of the mining population defy a census, but late in 1945 the population of Yellowknife was estimated at 3,000. The outlying settlements of Rae, Snowdrift and Rocher River are still only small trading posts. Resolution and Hay River, having closer association with the river traffic, are more active. Landing fields are now in use at Yellowknife and Resolution and the general situation with regard to transport and communication is improving.

In the past the fur trade has been the mainstay of the scattered population around the lake. Now mining, lumbering and commercial fishing are in progress. Further expansion of the mining and development of water power are such an immediate prospect that a continued increase in population may be expected. It is hoped that the development of these varied resources will be planned with due regard for their conservation and for the welfare of the people. The present investigation of the fisheries of Great Slave lake, is mainly directed toward the protection and most effective use of this resource.

PERSONNEL AND ITINERARY

In 1944 the survey party included Dr. J. G. Oughton of the Royal Ontario Museum, Toronto, Messrs. P. A. Larkin and E. N. Reich, special students in limnology at the University of Saskatchewan, and the writer. Leaving Edmonton

on May 29 we went by rail and water to Fort Smith where a 60-foot barge and two cabooses were purchased to provide a floating laboratory. Arrangements were made to charter the diesel-powered tug "Guy" at intervals to move the barge and for extended trips to various parts of the lake. Much of the work was carried on from skiffs with outboard motors.

Reaching the lake on June 12 the party began the survey in the vicinity of Resolution. On June 25 the laboratory was taken across the lake to Hardisty island and then north to reach Yellowknife on June 28. During July observations were made first in the north arm, then south to the Slave delta and west to Buffalo and Hay rivers, Wrigley harbour and Slave point. On August 7 the main body of the lake was traversed from Jones point to the Slave delta. In the latter part of August the east arm of the lake was examined with special observations at Reliance and Snowdrift. The party then returned to Yellowknife and completed the field work on September 13.

In 1945 a larger field party included Dr. W. H. Johnson of the University of Western Ontario and Mr. J. R. Vockeroth of the University of Saskatchewan as well as Dr. Oughton, Mr. Reich and the writer. During the winter a 35-foot power boat, the "Investigator," had been built at Edmonton to our specifications. This, with our floating laboratory, a new "Chipewyan" skiff and an outboard motor provided excellent transportation for our survey.

Field work in 1945 was begun at Resolution on June 17. On June 30 the barge was moved to the harbour at Outpost island where it served as a base for work in the centre of the lake. Since most parts of the lake had been covered in the summer of 1944, it was possible in 1945 to make intensive studies in this middle region and to investigate the Gros Cap area where commercial fishing was in progress. In August the party began a study of the very deep water in McLeod and Christie bays of the east arm. Storms in late August hampered the survey and the general field work was concluded on September 8. Mr. Larkin, after completing his work on lake Athabaska, came to Slave lake and made valuable observations on the fall fisheries, especially the inconnu fishery at Big Buffalo river.

THE WATER AREA

Great Slave lake, with an area of 10,500 square miles, is the fifth largest on the continent. It lies 550 miles north of Edmonton and extends from latitudes 61 to 63° north and longitudes 109 to 117° east (see fig. 6). The body of the lake is a large open area, about 50 by 100 miles, from which the long north arm stretches 90 miles toward Rae. The still larger but much divided east arm extends 150 miles to Reliance. Islands, mostly in the east arm, make up about 600 square miles, leaving a water area of about 9,900 square miles. The first detailed mapping of the lake was carried out by G. H. Blanchet in his exploration and survey of the area in the years 1921-25. This has been extended by aerial surveys of the east and north arms.

The shore length is nearly 2,000 miles, much of it in the highly irregular Precambrian shores of the north and east arms. The islands contribute an additional 700 miles of shoreline. The irregular shoreline provides many harbours and sheltered bays. Some of these are weedy and rich in animal life but others, because of the declivity of their rocky margins, are relatively barren. The view of Yellowknife bay (fig. 7) is typical of the rocky north shore of the north arm. In the east arm the topography is more rugged with escarpments several hundred feet high and impressive cliffs along shore (fig. 8). Travelling from Gros Cap to Reliance through the Hearne channel, past the cliffs of Utsingi and through Talthelii narrows, the magnificent scenery at once suggests possibilities for recreational development, supported of course by good angling and abundant



FIGURE 7. Rocky Precambrian shore of Yellowknife bay.

wildlife. The west and south shores, lying in the Mackenzie Lowlands, are marked by low contours and exposed rocky or sandy margins (fig. 9). The shallow water and the long stretches lacking harbours provide hazards to navigation in this area.

Soundings were taken in all parts of the lake, since depth affects both the productivity of the lake and the success with which it can be fished. Detailed hydrographic surveys were available for an area along the southwest shore (1928-1931) and for Yellowknife bay (1944). The main area of the lake had not been sounded and our investigations revealed some rather surprising depths. Travellers frequently get the impression that the lake is shallow since the steamer route down-river follows the low south shore. It is true that the shores decline gradually in this area, but even in the west arm depths down to 200 feet are

found. The central part of the lake is much deeper, with a maximum of about 535 feet, west of Outpost island. The deep water continues some distance into the north arm but from Yellowknife bay northwest it is quite shallow. Representative soundings are shown on the map (fig. 6).

About three-quarters of the open portion of the lake lies west of latitude 113°. The mean depth of this area has been calculated as 120 feet. Much of it is suitable for commercial fishing with gill nets, but the deepest area, west of Outpost island, extends toward Gros Cap and into the Hearne channel restricting to some extent the fishing grounds available from the base at Gros Cap.

The depths in the east arm are quite a different story. Many places in the Hearne channel are deeper than 1,000 feet. McLeod bay, which was sounded extensively, has a mean depth of 395 feet. The greatest depths yet encountered

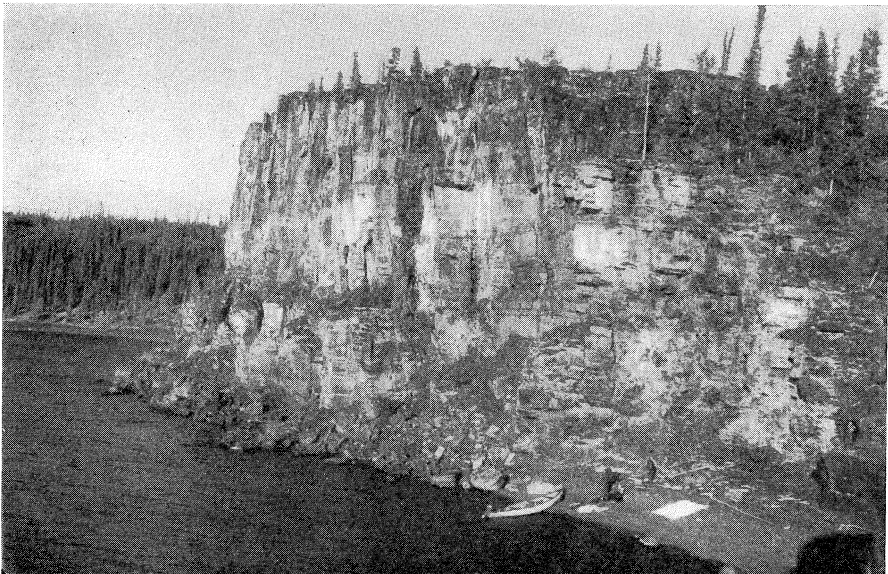


FIGURE 8. Cliffs at Gibraltar point, McLeod bay.

are in Christie bay north of Snowdrift, where a maximum of 2,000 feet was observed. This exceeds the maximum for lake Superior, the deepest of the Great lakes.

The biological and physical conditions in these great depths are little known and provide a challenging field for investigation. Very deep water is obviously less productive than water of moderate depth, but the exact value of the deep water areas in the total productivity of the lake remains to be determined.

TEMPERATURE

Ice begins to form in the small bays of Great Slave lake about October 15 and in the larger bays by December 1. The main lake is usually frozen over

before January 1 and the ice is soon strong enough to support the many tractor trains which carry freight each winter. Ice thickness of four to five feet is reported and this along with scarcity of shelter and the great distances would explain why fishing through the ice has not been extensive. The ice in the small bays and inland lakes melts in the latter part of May. Harbours at Resolution and Hay River on the south shore are open in the first week of June and the main lake is usually clear by June 10. The opening of navigation is eagerly awaited and the first boats usually reach Yellowknife and Hay River between June 12 and 22. Snowdrift is free of ice about June 20 but the ice of McLeod bay often keeps Reliance isolated until July 1. In different years the dates of freezing and break-up may vary by a week or ten days but the sequence is fairly



FIGURE 9. Low shore at Big Buffalo river, typical of the Mackenzie lowlands.

constant. Navigation lasts about 4 months, ending around October 7. The freezing and breaking periods occupy about $2\frac{1}{2}$ months and the period of complete ice cover the remaining $5\frac{1}{2}$ months.

The surface temperature of the open lake is rarely higher than 55°F. In June it is about 40°, in July and August from 45 to 55° and in September back to 40°. Extremes of cold water are observed in McLeod bay where on August 12, 1945, the surface was 39.5° in the centre and 45°F. near shore. The inflow from the Slave river has a warming effect over a broad area near the delta. In the river mouth and in shallow areas such as the harbour at Resolution the surface temperature rises above 62° and allows a short period of bathing. On July 27, 1945, the temperature of surface water at Resolution was 62°F. and

decreased gradually away from shore until at a point 35 miles north it was only 39°.

The deep water is of course still colder than the surface. The summer's heat barely penetrates to a depth of 100 feet where temperatures of 39 to 43° are found. From 100 feet down to the maximum depth of 2,000 feet temperatures range between 38 and 39°. The mean temperature of the western part of the lake was 44.6° at midsummer 1945. That of McLeod bay was 41.4°F. Such water temperatures are very low and compare fairly closely with those of lake Superior.

OTHER PHYSICAL AND CHEMICAL CONDITIONS

The penetration of light into the water of the lake is necessary for the production of its primary foodstuffs. A rough measure of light penetration can be obtained by observing the depth to which a white disc can be seen when lowered into the water. In Great Slave lake the disc may disappear at six inches in the muddy water of the delta or at 56 feet in the clear water of McLeod bay. The heavy silting from the Slave river marks the extent to which this warmer water spreads over the surface of the lake. The margin of this area is quite sharply defined and is especially impressive when viewed from the air. At midsummer this boundary extends northeast to Outpost island and west in a great arc as far as 25 miles from the delta. Turbid water continues along the south shore toward the outlet and is found also in the shallow end of the north arm at Rae. Most of the lake area is relatively clear, with disc readings of 10 or 15 feet in the middle of the lake and from 20 to 56 feet in the east arm.

The dissolved oxygen in the lake water is used by the fish and other aquatic animals in their breathing. In cold, well-circulated water such as that of Great Slave lake, there is never any doubt as to the adequacy of the oxygen supply, but the amount of dissolved oxygen is a useful indicator of the inner economy or metabolism of the lake. The quantity of oxygen even in the greatest depths of Great Slave lake is usually more than 80 per cent of the amount required for saturation. This indicates a condition described as extreme oligotrophy in which the small water animals and plants are not abundant but are used with considerable efficiency by the larger animals and fish.

Great Slave lake contains a much smaller amount of dissolved salts than commonly found in fresh waters. In McLeod bay where the drainage is from hard Precambrian rock surface, the total solids are only 22 parts per million. (At Snowdrift the total solids were 107 and in Yellowknife bay 60 p.p.m.) At Outpost island, where the influence of the Slave river is felt, the amount is 140 p.p.m. The salts are mostly bicarbonates of calcium with a little magnesium and only traces of chlorides and sulphates. The water is very slightly acid in McLeod bay and in the rest of the lake somewhat alkaline in reaction.

PLANKTON

The microscopic plants scattered through the lake water are the basic producers of food in the lake. They are eaten by the minute animals which in turn provide food for fish. The minute plants live mostly in the upper 50 feet of water but some of the animals live also at great depths. Both can be sampled by hauling a net of extremely small-meshed silk from bottom to surface. The concentrated sample obtained in this way is first examined microscopically and then dried, weighed and finally ignited to determine the relative amounts of organic (nutritive) matter and ash.

Samples taken at 28 widely separated stations and at different seasons show that plankton was scanty in June and early July. It was reduced again in late August and early September. Even in the midsummer period the average quantity was small as would be expected in a cold, deep lake with a small supply of dissolved mineral matter. The plankton of the open western part of the lake was nearly twice that found in McLeod and Christie bays. These large, cold bays support a quantity of plankton almost identical with that collected in Great Bear lake. The plankton of four large alpine lakes in the Canadian Rockies (Rawson, D. S. *A comparison of some large alpine lakes in Western Canada. Ecology*, 23, Apr., 1942) was intermediate in quantity between that of Great Slave and Great Bear lakes.

The adequacy of the supply of plankton for fish production is demonstrated by the fact that plankton forms almost the entire food of the ciscoes which were the most numerous of the species taken in the test gill nets set in all parts of the lake.

BOTTOM FAUNA

Another group of animals, which includes the small shrimps, molluscs and insect larvae, inhabits the ooze of the lake bottom. These animals are the food of bottom-feeding fish and especially the whitefish. It is therefore important to sample this population and to estimate the grazing capacity of these bottom areas. A grab dredge which brings up about a square foot of bottom is used to take hundreds of samples representing different areas and depths of the lake. These samples are screened to collect the animals which are then enumerated and weighed.

The bottom fauna of Great Slave lake averages 1,275 animals per square yard and 3.4 pounds dry weight per acre. It is higher than this in some shallow areas and much lower in the extreme depths of McLeod bay. About 66% of the weight of the bottom population is contributed by a small shrimp, *Pontoporeia*, which also provides a large proportion of the food of the whitefish. *Pontoporeia* is a common inhabitant of deep cold lakes and is found in large numbers in Athabaska, Michigan and Nipigon. A somewhat larger shrimp, *Mysis*, is not a true bottom dweller, since it makes daily excursions toward the surface. It is of great importance because it eats the smaller plankton organisms and thus makes them available for the larger fish.

The quantity and quality of bottom food in the main part of Great Slave lake is not unlike that of other large lakes. In McLeod bay there are few bottom animals and very few whitefish but moderate numbers of trout are produced since the latter feed mostly on the smaller plankton-feeding fish.

Studies of the quantity of plankton and bottom fauna reveal a thin population such as we expect to find in a large cold and deep lake. The food supply is not rich but clearly capable of supporting fish in commercial quantity in most parts of the lake.

FISH

At least 22 species of fish are found in Great Slave lake. The most abundant are the common whitefish, the ciscoes and lake trout. Six others are fairly widespread but abundant only in restricted localities. These include the inconnu, pike, northern sucker, grayling, burbot and round whitefish. Another four species which are neither abundant nor widespread are the pike-perch, goldeye, common sucker and flathead chub. The remaining species include the minnows and other small fish of little economic significance except that some of them, such as the cottids, provide a small proportion of the food of larger fish.

Most of these species are common in more southern waters but the inconnu is found no further south than Fort Smith. The grayling is common both in the arctic areas and in northern Alberta and Saskatchewan. The abundance of grayling and the scarcity of pike perch and goldeye are the main differences between the fish faunas of Great Slave and Athabaska. In the west end of the latter, pike-perch and goldeye reach commercial concentrations, while in Great Slave they are rare and extremely limited in their distribution.

WHITEFISH

The common whitefish, *Coregonus clupeaformis*, is the dominant bottom-feeding fish in Great Slave lake. Forty-seven test nets set in all parts of the lake took 1,400 of this species representing about 40% of the total catch. It was taken in fairly uniform numbers at all depths down to 200 feet. McLeod bay is the only part of the lake in which whitefish are scarce, and this, though a large bay, represents only a small fraction of the total water area.

The growth of whitefish in Great Slave lake is comparatively slow. It reaches the size taken in commercial nets of 5½-inch mesh in eight or nine years and the average of the commercial catch in 1945 was in the twelfth year. The approximate lengths and weights of whitefish from the centre of the lake are as follows:

8 years, 14 inches, 1 pound	14 years, 20 inches, 3¾ pounds
10 years, 16½ inches, 2¼ pounds	16 years, 21 inches, 4¼ pounds
12 years, 18 inches, 3 pounds	

Whitefish up to 24 inches and 5½ pounds are common and rare individuals were observed which weighed 8 and 12 pounds.

In the warmer waters off Resolution on the south shore, the whitefish grow more rapidly, especially in the first 7 years. A seven-year fish from this area is two inches longer than one of the same age from the Yellowknife area, having gained the equivalent of a year's growth as compared with those from the colder deeper water. Fish from the Gros Cap area show intermediate growth between those from Resolution and Yellowknife. Whitefish from Christie bay and Taelthilei appear to grow still more slowly than those from Yellowknife.

Among the whitefish taken at Gros Cap are certain individuals of somewhat darker colour, longer and more compressed bodies and softer flesh. They appear to be mostly confined to the shallow near-shore areas. A similar, inferior group of whitefish was observed in lake Athabaska where their difference from the typical form was more marked. Fortunately, in Great Slave lake these fish

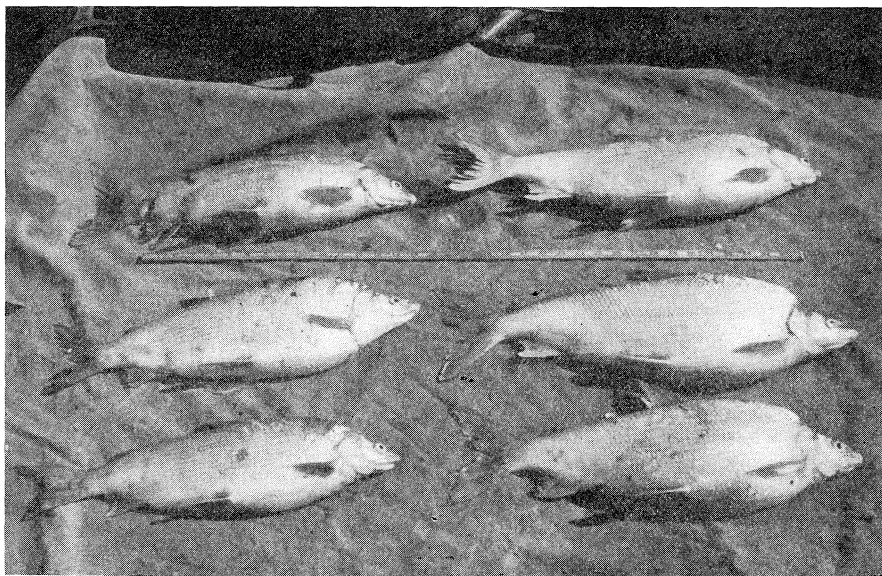


FIGURE 10. Large common whitefish taken near the Slave river delta. Note the transition from regular form to "humpback".

make up only a small percentage of the commercial catch. Their relation to the main population with respect to such matters as comparative growth and interbreeding should be investigated.

The growth of Great Slave lake whitefish is slower than in other large lakes such as Erie, Huron and Winnipeg but considerably faster than in lake Nipigon. In lake Athabaska, growth is similar to that in the Resolution area of Great Slave, but the maximum size attained is considerably smaller. The result of variation in growth rate is seen in the age composition of commercial catches of whitefish from large lakes. In Great Slave lake the majority of the fish caught

in commercial nets of 5½-inch mesh were 10 to 12 years old. The majority of whitefish from similar nets in Cold lake were 7 to 9 years old, from lake Winnipeg 5 to 7 years old and from Lesser Slave lake 4 to 6 years old. Data of this kind are needed in order to adjust the rate of exploitation to the growth of the fish.

Whitefish spawning was just beginning at Gros Cap on September 16, 1945. Along the south shore it began about the first of October and was nearly complete by the tenth.

The food of the whitefish in Great Slave lake includes the shrimp, *Pontoporeia*, and other bottom animals such as midge larvae, snails and minute clams. *Pontoporeia* is found in about 80% of the stomachs and contributes about 60% of the food. The whitefish occurs in large numbers at all depths down to 200 feet and, since it eats most of the animals found in the bottom fauna, we may assume that a large proportion of the bottom area is efficiently grazed.

Of three parasites found in the whitefish at Slave lake, only one is of economic importance. This is the common tapeworm, *Triaenophorus crassus*, the plerocercoid larvae of which are found encysted in the flesh of the whitefish. The presence of this parasite in any considerable numbers renders the fish so unfit for human consumption that the rate of infestation needs careful checking. The average over all parts of the lake was about 35 cysts per hundred pounds of fish. Fish taken in the deep water had half as many cysts as those from shallow water and those from offshore locations had only one-third as many as those taken near shore. Thus the commercial catch, mostly from offshore areas, was considerably better than the average for the whole lake. Since the processing of these fish involves filleting and wrapping, the inspection and control of the product is readily accomplished.

The commercial catch of whitefish in 1945 was 388,000 pounds dressed, equivalent to 465,000 pounds round weight. This was taken in a short season and without going any great distance from the base camp at Gros Cap. The average size of these fish was 18½ inches, 3 pounds and the age 11 years. The area fished is estimated at not more than one-tenth of the fishable area of the lake, so that a much larger production may be anticipated.

Domestic fishing in the past has taken its small toll in a few places around the margin of the lake. Now that the resources of the main body of the lake are being exploited, it will be important to watch for evidences of change in the population. With extensive cropping of the whitefish some decrease in the average size and downward shift in the age composition of the catch may be expected. Such observations, along with the catch per unit of effort, will provide the main guides in the proper exploitation of the fish population.

LAKE TROUT

The lake trout, *Cristivomer namaycush*, is common in all parts of the lake at depths of 15 feet or more. It is found in considerable numbers even in the area affected by the muddy water of the Slave delta and in the extremely deep

water of McLeod bay where few whitefish are to be found. Trout were caught at all depths down to 275 feet but were most abundant between 50 and 100 feet, probably because the ciscoes, their chief food, have a similar depth distribution. At certain seasons, the lake trout go into shallow water, as they did in late July 1945 to feed on grasshoppers and again early in September in preparation for spawning.

The growth of the lake trout is slow, most of those in the commercial catch of 1945 being from 15 to 22 years in age. Their average rate of growth can be indicated as follows:

14 years, 19½ inches, 2¾ pounds	20 years, 25½ inches, 7 pounds
16 years, 21½ inches, 4 pounds	22 years, 27½ inches, 8½ pounds
18 years, 23¾ inches, 5½ pounds	24 years, 28¾ inches, 10 pounds

This growth is slightly slower than that of the same species in lake Athabaska. Some scattered records suggest that trout in lakes Michigan and Superior grow considerably faster. Spawning occurred at Gros Cap during the second week of September, 1945, and appeared to be somewhat later at Taltheilei narrows. All spawning fish appear to be at least ten years old and many of the older fish do not spawn every year. Some of the scales show what appears to be a distinct spawning mark every third year, suggesting a situation similar to that observed by Dr. Miller in Great Bear lake.

The food of the lake trout is almost entirely composed of fish, the ciscoes being the most important species. Northern suckers, ling, whitefish, cottids and young lake trout appeared in significant numbers. Shrimps, aquatic insects and occasionally terrestrial insects, such as grasshoppers, are also taken, but the main food chain is from plankton through ciscoes to trout.

The quality of the lake trout is uniformly good. They are firm, reasonably fat and often yellow, orange or pinkish in flesh colour. Cysts of the tapeworm, *Trianaenophorus crassus*, are found in the flesh of the trout in highly variable numbers. Samples from some areas were free from the parasite, but one lot averaged 9 cysts per fish or 150 per 100 pounds. In the commercial catch the number of cysts was not excessive and the size of the cyst much smaller than that in whitefish. Most of the trout is filleted, which facilitates the removal of cysts or rejection of heavily infested specimens.

The commercial catch of trout in 1945 was 1,022,000 pounds round weight, a very satisfactory catch for the first and a rather short season. As indicated above, the quality of the fish was excellent. The proportion of large trout—weighing more than eight pounds and sold with the heads removed—was not high, probably less than 10%. This differed from the catch in our test nets which included nearly 40% of fish over eight pounds. Many of these large fish were caught in small-mesh test nets when they attempted to eat a cisco or other small fish which had been caught in the net.

Extensive commercial fishing may well be expected to have a considerable effect on this virgin population of slowly growing fish. A reduction in the number

of large, old trout would undoubtedly increase the efficiency of production. Whether this would be accompanied by an increase in growth rate remains to be seen, but it is noted that trout in Athabaska after many years of heavy fishing now grow only slightly faster than those in Great Slave lake.

CISCOES

The ciscoes of the lake appear to be at least of three species, a small form of *Leucichthys artedi*, a slender species with black fins and large eyes resembling *L. nigripinnis* in some respects and a large form up to 24 inches in length which is called tullibee by the fishermen. This larger species is present in small numbers, usually less than 5% of the cisco catch. Experimental gill nets took ciscoes in almost every set and in numbers greater than those of any other species. In Yellowknife bay a net 200 yards in length took 289 ciscoes. The average number caught at different depths increased steadily down to about 100 feet and decreased beyond that depth.

The cisco feeds almost entirely on the water fleas which are the larger animals in the plankton. At times it takes quantities of the free-swimming shrimp, *Mysis*, which in turn feeds on the plankton. Insect larvae are sometimes eaten and on rare occasions terrestrial insects from the water surface.

The ciscoes are very heavily infested with *Triaenophorus*, the number of cysts per fish in those examined varying from 3 to 41 and averaging 14. This is equivalent to about 4,200 per 100 pounds. This condition, together with the relatively small size of the ciscoes, makes it unlikely that they will provide any commercial fishery. Their great importance is in their role as the chief eaters of plankton, thus making the primary food supply available to the lake trout.

INCONNU

The inconnu, *Stenodus leucichthys*, is widespread in Great Slave lake. It is best known for its great spawning runs in tributary streams such as the Big Buffalo and Talston rivers. Moderate numbers are taken throughout the summer in gill nets off Resolution, Yellowknife and Rae. It inhabits the inshore waters and is generally considered to be thinly scattered around the lake but it was sufficiently numerous in the area south and east of Gros Gap to provide 5% of the commercial catch in 1945.

Adult inconnu enter Big Buffalo river steadily and in considerable numbers during May and June. Smaller numbers keep entering during the remainder of the summer. After spawning they come back to the lake in a tremendous rush. In 1945, nearly 10,000 inconnu were caught in the four days beginning October 8. The spawning runs in other tributaries of the lake are less well known but differ somewhat in the length of time spent in the river. It is probable that the young remain for two years in Big Buffalo river before entering the lake.

The growth of the inconnu is more rapid than that of other large fish in the lake. Ten-year fish are about 24 inches in length and weigh 5 pounds, fifteen-

year-olds are 36 inches and 16 pounds. The average weight of the fish in the spawning run is from 10 to 12 pounds. The largest fish taken at Big Buffalo river weighed 55 pounds.

The inconnu is the only fish-eating member of the whitefish family. Stomachs were found with young whitefish and ciscoes, cottids, sticklebacks, minnows and young of its own species. Immature individuals had eaten mayfly nymphs and other insect materials. In its early stages it feeds on water-fleas and thus becomes infested by the tapeworm, *Triaenophorus crassus*, which was also found in whitefish and trout.

The edibility of the inconnu has been the subject of varied and often contradictory reports. At one extreme it is described as excessively oily and fit only for dog food. Inconnu dried in the summer months and baled for dog food have a strong odour and drip with oil. Those caught in the fall are hung on sticks

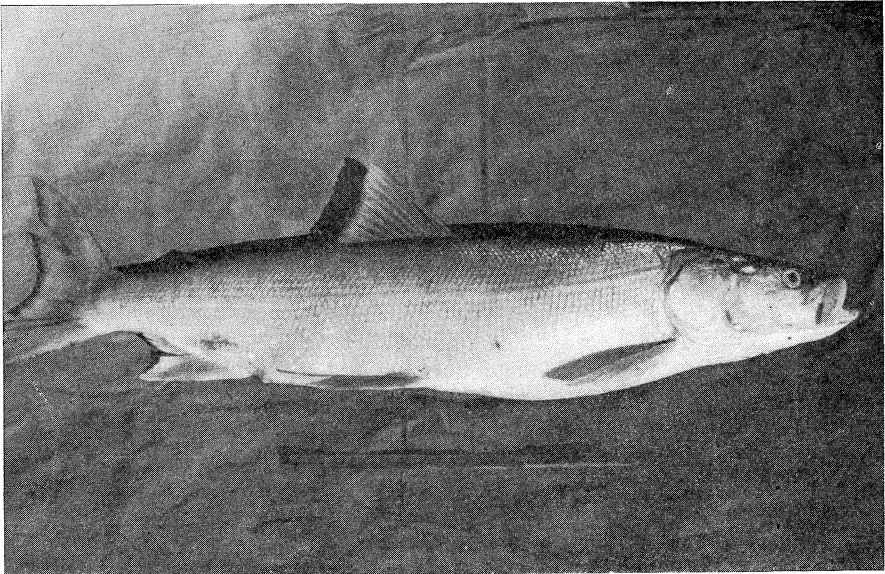


FIGURE 11. 12-lb. inconnu from Yellowknife bay.

without dressing and if the weather happens to be warm they undergo considerable disintegration before they are frozen. Such a product is good dog food but obviously nothing else. Whitefish or trout handled in the same way are no more appetizing. On the other hand the inconnu taken from the lake rather than from the spawning run, and properly preserved, is highly palatable. It was preferred to whitefish and trout by many of the commercial fishermen and highly praised by a group of fisheries experts who sampled a specimen which was taken by air from Fort Smith to Edmonton on September 3, 1944. The rich flavour and high oil content suggest that the inconnu may prove suitable for smoking, mild curing or canning.

The extent of the inconnu population in the lake has not yet been thoroughly assessed. A moderate lake fishery would seem to be quite justified and probably also some fishing for adults returning from the spawning grounds. The present practice of attempting to catch the whole downstream run can hardly be condoned. It would seem still more important to protect the individuals entering the stream in May and June and remaining to spawn in late September.

GRAYLING

The grayling, *Thymallus signifer*, is the best game fish in the region and the only one which can be taken consistently by fly-fishing. It is most abundant in the east arm and common along the rocky shores of the north arm. Very few are taken in the muddy water from the Slave delta westward along the

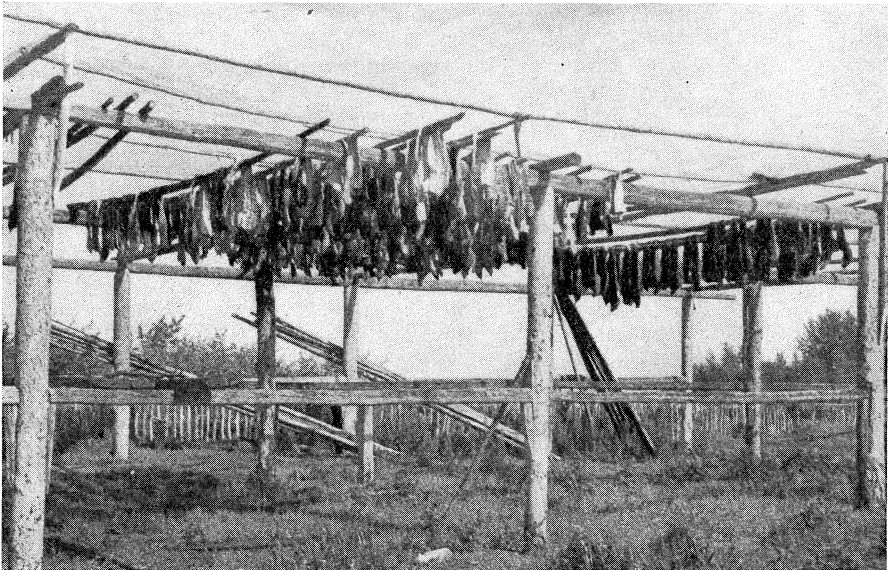


FIGURE 12. Inconnu drying for dog feed at Big Buffalo river June 1944.

south shore but it abounds again at Wrigley Harbour where the Mackenzie river leaves the lake. Adults are frequently found at the mouths of rocky streams entering the lake. They spawn in these streams in early spring and the young are found later along the rocky shores. The usual size of mature fish is from 11 to 17 inches, the latter weighing about $2\frac{1}{4}$ pounds.

The food of the grayling is mostly insects but is it sometimes found gorged with freshwater shrimps. The variety and quantity of terrestrial insects found in its stomach explain the excellent fly-fishing which it provides.

OTHER FISH

Two species of suckers are found in the lake. The northern sucker is smaller, long-nosed and fine-scaled. It is much more abundant than the common sucker which is heavy-bodied and coarse-scaled. The latter is confined to shallow warmer areas and even the northern sucker is uncommon in depths greater than fifty feet. Neither species occurs in sufficient numbers to provide extensive competition for the common whitefish which is the dominant bottom-feeder in the lake.

The pike and burbot (ling) are the main fish eaters other than those already considered. The pike is numerous in shallow water close to shore. It feeds on ciscoes and small fish such as cottids and sticklebacks. Thus it competes with the lake trout but it is so strictly confined to the shore waters that the competition is unimportant. It is of more significance as the host for the adult of the tapeworm *Triaenophorus*, the larvae of which infest all three of the present commercial fish. In the flesh of the pike (and also in the pike-perch) are found the cysts of another tapeworm, *Diphyllobothrium*, an important parasite of dog and man in this region. The burbot occurs sparingly at all depths down to 200 feet. It sometimes provides a considerable quantity of dog food in the domestic catch but is only infrequently taken in the commercial nets.

The round whitefish is uncommon and of little significance except in the east arm where it feeds near shore and provides some food for the lake trout.

The pike-perch, also called pickerel and doré, is taken in small numbers along the south shore and especially in the mouths of the rivers. A few are found in the north arm at Rae. In general this species is scarce in Great Slave lake though often common in small lakes such as those in the vicinity of Yellowknife.

It is evident from the foregoing discussion that the fish which compete with the commercial species are in a very subordinate position. The competitors are greatly outnumbered and they are mostly confined to the inshore areas. In the open water, the whitefish feeds on bottom fauna with little interference from suckers and round whitefish. The trout feeds on ciscoes with a minimum of competition from the burbot. In addition a considerable amount of this coarse and competitor fish from the shallow water is used in domestic fishing for dog feed. All these factors seem to be favourable for efficient production and utilization of the commercial species.

THE FISHERIES

DOMESTIC FISH USE

Since the safeguarding of the supply of fish for domestic needs was one of the primary aims of the survey, it was necessary to investigate rather thoroughly the annual consumption of fish around the lake. Domestic fishing was observed in every community and enquiries made as to the fish used by Indians, trappers, fur-farmers, missions, trading posts, park wardens and the Royal Canadian Mounted Police.

The native population eats a good deal of fish, mostly in the summer months, but about four-fifths of the annual catch goes to feed the dog teams which provide winter transportation. The summer fishing is continuous and relatively inefficient but the fall fisheries take advantage of the spawning runs to capture great quantities of fish for dog feed. As yet relatively little fish is used by the white population. It is to be expected that some enterprising fisherman will discover the potential market among the 3,000 or more members of Yellowknife's rapidly increasing population.

Summer fishing is carried on at each of the eight or nine settlements around the lake. The largest continuous fishery is at Resolution, where approximately one-third of the lake's native population is found. In 1944 about 23 nets, from 50 to 100 yards in length, were in use throughout the summer. (Rae has a larger population but most of it is at the lake for only one month). At most of the settlements one or two nets are set by each family, depending on the number of dogs to be fed. It is estimated that the average number of domestic nets in the lake during the summer is seventy-five. These are all set close to the settlements, the fishermen rarely travelling as much as two miles from home. Allowing five miles as the length of shore fished by each settlement, the summer fishing is concentrated in less than fifty miles of the total 2,000 miles of shoreline.

Some of the more capable fishermen are employed by the Missions and the R.C.M.P., but in general the native methods are very inefficient. The nets are set too close together, usually with one end tied to shore and moved only infrequently to new locations. A few individuals dry and mend their nets, but they are often left in the water continuously until they rot. At Snowdrift our nets were set one-quarter of a mile from shore and took several times as much fish as the Indian nets. Our catch was mostly trout and large whitefish as contrasted with much coarse fish in the Indian catch. This caused great excitement and there was a rush to receive our fish after we had examined them. However, the Indians did not move their nets from the usual position along shore. In most places they continue to use the primitive paddle-shaped float and stones for weights. Standard floats and leads are often refused even when available without cost.

Any excess of summer-caught fish may be filleted and dried on racks for later use. This is done regularly with inconnu at Big Buffalo river and elsewhere. More frequently, however, as a result of lack of initiative and inefficient methods, the catch is inadequate to feed the dogs properly. Most of the teams observed were miserable and emaciated.

The main fall fisheries are for inconnu taken at Big Buffalo river and Rocher river, for whitefish at Rae, Yellowknife, Big island and Slave point and for trout with a few whitefish at Taltheilei narrows and Snowdrift. Great quantities of fish are taken from the spawning runs in the course of a few days. At Big Buffalo river 10,000 inconnu weighing more than 100,000 pounds were taken in about four days beginning October 7, 1945. At Slave point 100,000 pounds

of whitefish were taken between September 28 and October 9, 1945. Since the fall fishery must provide dog food for at least seven months and since the dogs are fed more in winter than in summer, the fall catch greatly exceeds that of the summer months.

Fall-caught fish are not dressed but "hung" on sharpened sticks which pierce the gill region and are supported on high racks out of reach of the dogs. If the autumn weather is cold it may be well preserved, but warm periods often result in partial decomposition. The residents report that this does not reduce its value as dog food. Some of the fish is bought and sold locally by post managers. Some goes as far as Simpson or Fort Smith, but none of it is exported. The "sticks" hold from five to ten fish and weigh from 30 to 50 pounds. The usual selling price is one dollar per stick.

In order to assess the domestic fish use at Great Slave lake it was necessary to search out all available catch records for the fall fisheries and to obtain estimates from residents of the area. Unfortunately these estimates are often conflicting. There is reason to believe that in the past exaggerated reports have been submitted in order to stress the importance of preserving the fish supply for the native population. The figures given in table I have been carefully prepared as an estimate approaching the maximum rather than the average use over the past ten years. The amounts listed agree in general with the known requirements of 1,800 persons and 4,000 dogs living near the lake. It is believed that the average native eats about one pound and the dogs two pounds per day. Adjustments have been made for the part-time residence of much of the population. The amount consumed varies greatly according to the caribou migration. In years of caribou abundance its meat provides food for both men and dogs.

Data presented in table I suggest that the maximum domestic consumption is in the order of 1,500,000 pounds per year. It is believed that the average use in recent years is more nearly 1,000,000 pounds. In 1926 G. H. Blanchet, after spending five years surveying the shores of Great Slave lake, suggests a fall fish catch of 500,000 pounds. Since the fall catch is larger than that taken in summer this would imply a total of less than 1,000,000 pounds.

It is expected that as the population of the Great Slave area increases, more fish will be used as human food, although as indicated above the rapidly growing white population at Yellowknife now uses very little fish. Any increase in the human consumption of fish may be partially balanced by decrease in the use of fish for dog feed and by the native population. In the past decade extensive use of aeroplane transport by trappers and the increasing amounts and variety of imported foods have had the effect of diminishing domestic use of fish. It seems probable therefore that the total domestic use of fish in this area will not exceed 1,000,000 pounds for a number of years.

The catch from the fall fishery is mostly whitefish with large quantities of inconnu and lake trout. The domestic summer fishery takes large quantities of non-commercial species. The weight of the catch off Resolution in early summer in 1944 and 1945 was made up of inconnu 47%, ling 21%, lake trout 17%,

TABLE I. Estimated domestic consumption of fish from Great Slave lake

	Persons using fish (no.)	Fish consumed by man (lb. per year)	Dogs (no.)	Fish eaten by dogs (lb. per year)	Total fish consumption (lb. per year)
Resolution	675	126,000	1,300	470,000	596,000
Big Buffalo R.....	1	10	100,000	100,000
Hay River	60	12,000	100	36,000	48,000
Big Island and Slave point*.	75,000	225,000	300,000
Rae.....	700†	25,000	2,000	150,000	175,000
Yellowknife.....	200	36,000	400	144,000	180,000
Reliance.....	4	†	15	10,000	10,000
Snowdrift.....	144	21,000	200	50,000	71,000
Taltson (Rocher) River....	75	14,000	225	80,000	94,000
TOTALS.....	1,859	309,000	4,250	1,265,000	1,574,000

*For use at Providence and Simpson.

†700 for one month, a few for whole year.

northern sucker 7%, common whitefish 5%. The remaining 3% was made up of pike, pike-perch, cisco and common sucker.

It is possible that the fall fishery, which makes use of the spawning runs of whitefish, trout and inconnu, may have some adverse effect on the fish production of the lake. This cannot be proven and it is likely that in so large a lake enough fish will escape to seed the spawning grounds. Also there are undoubtedly many spawning areas which the domestic fisheries do not touch. In any case the present fall fisheries are vital to the communities around the lake and must not be restricted unless other provision is made for the supply of dog food. The possibility of refrigerating all non-marketable fish taken in the course of commercial operations should be investigated with the view of using this for dog feed.

The domestic summer fishery is carried on in restricted areas and close to shore where it does not conflict with commercial operations. The utilization of coarse fish by this summer fishery is highly desirable and for this reason it is considered justifiable to allow natives to continue their use of 4½-inch-mesh gill nets.

GAME FISH POSSIBILITIES

Great Slave lake has considerable possibilities for sport fishing especially in the east arm and along the Precambrian shore. In these areas, grayling, lake trout and pike are readily caught by angling. The pike-perch (pickerel) is also easily taken in the restricted localities where it is found.

The grayling has been described above as the species which provides fly-fishing along the rocky shores and at the mouths of streams. It is a good fighter, handsome in appearance and tasty. Well known fishing grounds are in the Yellowknife river and at Wrigley Harbour where specimens up to 3½ pounds have been taken.

The lake trout is widespread in Great Slave and, since it comes into shallow water during most of the summer, the deep water trolling equipment often used for this species is unnecessary. Taltheilei narrows has become a famous fishing ground for lake trout. Outstanding sportsmen have for some years made use of aeroplanes to reach this area where trout seem always abundant. A record specimen of 44 pounds was taken here by Mr. Plummer of Flin Flon, one of the regular visitors.

Reference has been made to the wonderful cliffs and channels of the east arm. Fly-fishing for grayling and trolling for large lake trout in the area should provide angling in keeping with its magnificent scenery.

It is evident that angling, like domestic fishing, will be mostly near shore and in areas where it need not be hindered by commercial fishing. The best game fish, the grayling, is only rarely taken in nets and the pike is not sought commercially. It may be desirable at some future time to reserve areas for game fishing, but such action is not urgent. The suggestion of some sportsmen that the whole east arm should be reserved for sport fishing, is regarded as extreme in view of the vast area of the lake.

CAPACITY FOR COMMERCIAL PRODUCTION

The studies of the kinds and quantities of fish in the lake, of the kinds and quantities of potential fish food, and of the area, depths and physical conditions were all made with the purpose of estimating the fish-producing capacity of the lake. This estimate was facilitated by the general resemblance of Great Slave lake to lake Athabaska which has been fished commercially for many years. Although Great Slave is somewhat deeper and colder, the two lakes have comparable food supplies and fish fauna. Lake Athabaska with an area of 3,000 square miles has been producing about one million pounds of trout and whitefish per year. At the same rate, Great Slave lake with more than three times this area might be expected to produce a minimum of three million pounds per year.

It is also true that Great Slave lake resembles in a general way the upper Great lakes, Superior, Michigan and Huron. The bottom fauna of the deeper water in lake Michigan is very like that of Great Slave, Athabaska and Reindeer lakes. The sustained yield of fish from the upper Great lakes is about 1½ pounds per acre. Lake Nipigon has produced 1.07 pounds per acre over a twenty-five year period. We know that the whitefish in Great Slave grow more slowly than those in the Great lakes but faster than those in lake Nipigon. If Great Slave lake were to produce only one pound of fish per acre its annual yield would exceed six million pounds. Allowing a million pounds for domestic use it was estimated

in 1944 that the commercial production might run from three to five million pounds per year.

Commercial fishing was begun on Great Slave lake late in July, 1945. Forty-two fishermen used twenty boats and each fisherman was allowed to use up to 900 yards of 5½-inch-mesh gill net. Nets were lifted on 43 days between July 28 and September 15. The total catch was 809,000 pounds of trout, 388,000 pounds of whitefish and 55,000 pounds of inconnu, all dressed weights. This is equivalent to a total of 1,550,000 pounds of round fish and it was taken in approximately two-thirds of a normal fishing season. The area from which this catch was taken represents about five per cent of the lake area. Making generous allowance for some non-productive areas, the area fished in 1945 is probably less than one-tenth of the fishable area. It would seem therefore that the previous estimate of a minimum production of three million pounds per year, exclusive of the domestic catch, is quite reasonable.

COMMERCIAL FISHING OPERATIONS

The pioneering commercial fishing operations on Great Slave lake were carried out with thoroughly modern equipment and methods. The catch was taken in not more than three hours to the fish camp at Gros Cap. Here it was filleted, packaged and frozen, part of it in patented quick-freeze units. It was then placed in large refrigerator barges which were hauled across the lake and up the Slave river to Fort Smith (230 miles). Insulated trucks were used to take it across the 16-mile portage to Fitzgerald, where it was again loaded in refrigerator barges for a 290-mile trip up the Slave and Athabaska rivers to Waterways. Here at rail-head it was ready to begin a 2,000 mile train journey to Chicago and other eastern markets.

The filleting of the catch effects a great reduction in weight and a still greater reduction in the bulk of the fish to be transported. This is of special importance where long distances are to be covered. Filleting also facilitates the inspection and control of parasitic infestation especially in the whitefish where the fillets are passed over a glass plate for examination by transmitted light. The whitefish and trout fillets have a long established reputation on the market. Inconnu fillets are also of excellent quality and will no doubt attract a good market in due course.

CONSERVATION

Scientific studies of fish and fishing in many areas have provided much special knowledge of the relation of fish populations to environment and of the effects of fishing on a population. But there is no ready-made formula for applying this knowledge in the conservation and exploitation of the fish in any area. Our attack on this problem is quite simple. We measure, as well as we can, the present fish population, its food supply and rate of growth; then on a basis of all available information we set a tentative rate of exploitation. The

result is watched closely for any evidence of change in the catch which may indicate the effects of fishing on the population.

This procedure has been followed and the result is a suggested limit of three million pounds per year, exclusive of the domestic catch. We should now insist on a constant and careful analysis of the catch. Certain changes such as a decrease in the number of trout and an increase in the proportion of whitefish to trout in the catch may be expected. These changes may be accompanied by increased growth rate of the trout.

The safeguarding of the domestic fishery is of primary importance but not separable from the general problem of adjusting the rate of exploitation to get the maximum production from the lake as a whole. It is true however that the domestic fishery is to some extent dependent on inshore species which are little affected by the commercial fishery.

The investigation of Great Slave lake in a virgin condition provides an unique opportunity for a program of fisheries research and conservation. It is doubtful whether any other lake of comparable size has been adequately surveyed prior to the commencement of commercial fishing. The opportunity should be seized to initiate adequate conservation practices and to put to test the newer knowledge of populations and theories of exploitation.

CHAPTER VI

LAKE ATHABASKA

By D. S. RAWSON

INTRODUCTION

Athabaska is the first of the three great lakes of the Mackenzie drainage area which are linked by the water route to the Arctic. Although Athabaska is smaller and shallower than Great Slave and Great Bear, the lakes have much in common. Each has rugged Precambrian shores to the north and east, faced by shallow areas and low sandy shores to the south and west. The chief species of fish and the shrimps which are the main supply of fish food are common to all three. In one respect lake Athabaska differs from the others. It has been fished commercially for twenty years. This has provided information which makes it of special value for comparison with Great Slave and Great Bear, in which we need to estimate the possible fish production.

The area north of lake Athabaska is characteristic of the Canadian Shield. It is of low or moderate relief with exposed granite ridges and sparse vegetation. The northern shoreline is very irregular, especially in the eastern part of the lake. The country south of the lake is of an entirely different nature. Regular sandy beaches run almost the full length of the lake. These merge into sand banks or dunes alternating with patches of vegetation. Further south are sandstone cliffs which form a high escarpment towards the east end of the lake. The flat lying beds of Athabaska sandstone, which have eroded in this area, are considered to be of late Precambrian age.

The lake basin is presumed to have been deepened and widened by the southwest movement of the Keewatin ice sheet. As the ice retreated, it filled with water to become an arm of a large post-glacial lake, which also covered the Great Slave area and united the two by a broad union. This history is of special interest in our comparison of the present fauna of the two lakes.

The drainage into lake Athabaska comes from an area of about 106,000 square miles. Most of this, 61,000 square miles, is drained by the Athabaska river which enters the lake at the west end. The remaining 45,000 square miles is drained partly by numerous small rivers around the lake but mostly through the Fond-du-Lac river, which provides the outlet for Cree and Wollaston lakes. The outlet of lake Athabaska is through three channels which connect with the

BULL. FISH. RES. BD. CAN. LXXII (1947).

Peace river. At high water the flow in these channels is reversed and water from the Peace enters the lake. At low water the flow from the Athabaska river cuts across the west end to the outlet and barely enters the lake. Thus the drainage situation and the water level of the lake are subject to wide variation. Seasonal variations in level often amount to eight feet and the annual changes may be still larger. The last year of extremely high water was 1935.

The mean air temperature for June, July and August is about 60° F. and thus similar to that at Resolution on Great Slave lake. It is also like Great Slave in having considerably lower temperatures at the east end, within the Precambrian, than at the west end which verges on the lowlands. The annual precipitation is about 13 inches, of which 9 fall as rain. Frequently storms, which sweep the

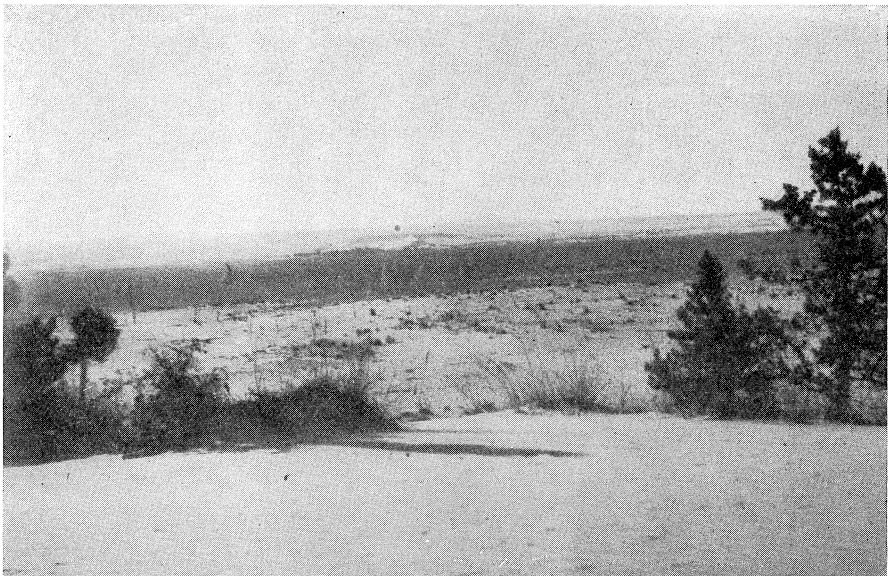


FIGURE 13. Sand dunes and escarpment on south shore of lake Athabaska.

lake from both east and west, are a menace to navigation, especially along the south shore where harbours are lacking.

The forest along the north shore is mostly of spruce and poplar with scattered jackpine on the sandy plains and rocky ridges. Much of this area has been burned over. The sandy country to the south has some stands of spruce and jackpine, alternating with bare dunes and cut banks. West of the lake is a great expanse of low-lying marsh land including the Athabaska delta, lake Claire and the area between the Athabaska and the Peace. This is the southern portion of the Mackenzie Lowlands. Its characteristic vegetation is of grasses and marsh plants with a little forest of spruce, poplar and alder. Furbearing mammals and waterfowl are abundant in this region.

The Athabaska lake region is lightly populated, probably not more than 600 persons living near the lake and a few others coming in for trading or to receive treaty. About half of this population is found at Fort Chipewyan and in the near-by delta area. The settlement at Camsell portage may total 100 persons, Goldfields is at present deserted, Fond-du-Lac has about 100 and Stony Rapids about 60. A few trappers have cabins widely scattered along the north shore. The Indians of the two settlements at the east end are mostly Chipewyans, those at the west, about equal numbers of Chipewyans and Crees. The majority of these people are treaty Indians, many are of mixed blood and a very few white.

Trapping is the sustaining occupation of most of these people and many of the men have trap lines at some distance from the lake. A few obtain summer

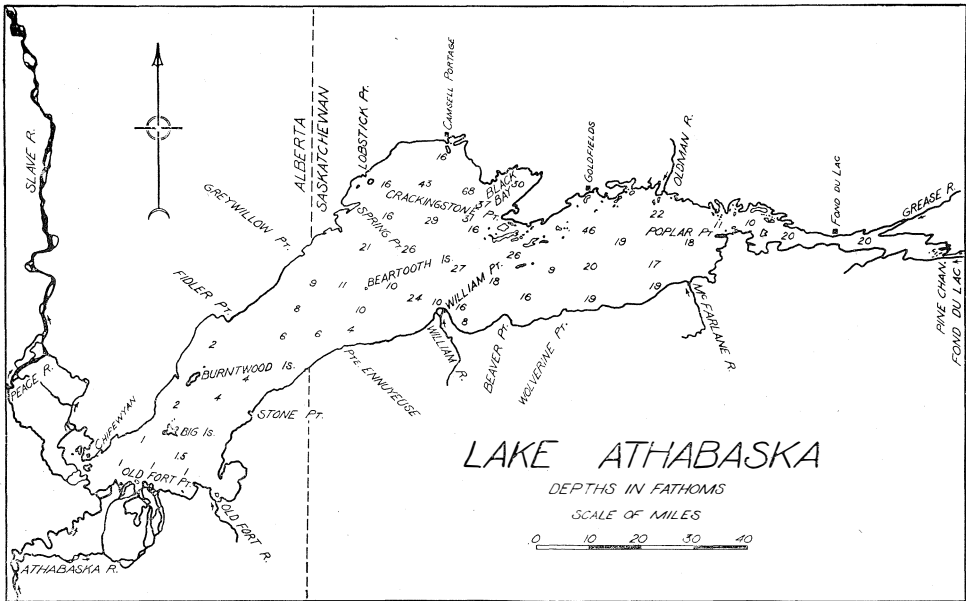


FIGURE 14. Lake Athabaska.

employment with the river transport system which crosses the west end of the lake and a still smaller group is employed in the commercial fishing operations which have been carried on usually at Crackingstone point and the Athabaska delta.

With the town of Goldfields deserted, the east-west traffic on the lake has been reduced to two or three boats per season. The settlements at the east end of the lake have difficulty in obtaining their requirements other than those carried by air. It is anticipated that mining may be resumed in the Goldfields area and that commercial fishing, dropped in 1945, will also be continued. These two industries make possible a much better transportation system and their resumption will bring about a considerable improvement in the local economy.

PERSONNEL AND ITINERARY

The fisheries survey of lake Athabaska was begun in 1943 when the writer spent the month of June investigating the west end and the Crackingstone area. Financial support for this work was received from the National Research Council. In 1945 the Fisheries Research Board authorized the completion of this survey.

The field party in 1945 included Messers. P. A. Larkin, W. A. Fuller and H. T. Fredeen, all graduates in biology from the University of Saskatchewan. Mr. Larkin was in charge of field operations and the writer divided his time between Athabaska and Slave lakes. Suitable transportation was provided by a 28-foot fishing boat, the "*Limnos*" built at Waterways for this purpose.

The field work began on June 10 at the Athabaska delta where the early season of commercial fishing was in progress. Toward the end of June the party moved to headquarters at Fort Chipewyan where a small laboratory was built. Four extended trips, covering the whole area of the lake, were made during July and August. In these trips it was the practice to cut across the lake from shore to shore in a zig-zag pattern thus sounding and sampling the whole area. Field work was concluded at Fort Chipewyan in the first week of September.

THE WATER AREA

The area of lake Athabaska is 3,050 square miles, of which 2,160 lie in Saskatchewan and the remainder in Alberta. The length from Chipewyan to Fond-du-Lac is about 150 miles and the width in most places is from 15 to 30 miles. The main axis of the lake is from east to west, but the west arm turns south in the line of the major ice movement over this area.

The north shore from Chipewyan to Black bay is rocky and moderately irregular. From Crackingstone point to Fond-du-Lac it is extremely irregular with long, narrow bays and numerous rocky islands. The south shore is sandy and the water so shallow that a boat of any considerable draught can rarely get near shore. Harbours are lacking for a stretch of nearly 100 miles. The shore length, not including islands, is about 750 miles, nearly two-thirds of which is contributed by the irregular north shore.

DEPTH

The lake has been sounded rather thoroughly along lines across all parts of the lake. By plotting these depths and drawing contours it was found that about 30% of the lake is less than 50 feet deep, 24% from 50 to 100, 24% from 100 to 200 and 12% over 200 feet. The mean depth of the lake is 85 feet and the maximum 405 feet. The mean depth of the main part of Great Slave lake was 120 feet, and that of the east arm much deeper. The western third of lake Athabaska, which lies mostly in Alberta, is shallow. From 10 feet near Fort Chipewyan and at Old Fort Point, it slopes uniformly down to about 60 feet near Beartooth island—a distance of about 50 miles. The greatest depths are found near the geographic centre of the lake. Here, west of Black bay and south from Camsell

portage is the maximum of 405 feet and a considerable area more than 250 feet in depth. The east arm is also deep but rather irregular. Depths of 120 feet are common but some of the best fishing grounds are found near the off-shore shoals in this part of the lake. Lake Athabaska has only a small area more than 300 feet deep which is usually considered too deep for convenient gill-net fishing.

TEMPERATURE

The ice in the west end of the lake usually begins to move in the last week of May, but the down-river passage for boats is precarious until at least a week into June. The main body of the ice breaks up ten days or two weeks later and the west end of the lake is often not clear of ice until the end of June. Freezing of the lake begins in late October and is usually complete by mid-December.



FIGURE 15. Camsell portage, lake Athabaska (Courtesy of R.C.A.F.)

Surface temperatures in the shallow west end of the lake differ greatly from those in the central and eastern parts. At the west, where the Athabaska river enters the delta, the water warms rapidly and temperatures of 63° F. are common by the end of June. At this time the centre of the lake may have a surface temperature of only 43°. By mid-July the open lake is warmed to 50 or 55° and in mid-August temperatures of 60 to 66° are common in all parts of the lake. The maximum temperature, observed only in shallow near-shore areas, is about 77°F.

The deep water remains cold throughout the summer. At 100 feet the temperature is less than 50° and at 200 feet about 40°. The mean temperature of the lake at midsummer was approximately 51°. This is considerably warmer than the main part of Great Slave lake for which the mean temperature was calculated as 44.6°F.

OTHER PHYSICAL AND CHEMICAL CONDITIONS

Dissolved oxygen is plentiful in the lake water, usually more than 80% saturation at the bottom and close to saturation at the surface. The hydrogen ion concentration varies from slight acidity, pH 6.6, in the east end to a moderate alkalinity, pH 7.7, at the west. In both of these features Athabaska closely resembles Great Slave.

The water is clear in the central and eastern parts. In the centre of the lake Secchi's disc could be seen at depths of 20 to 25 feet. In the channel at Fond-du-Lac it was seen at 8 and 10 feet. The shallow western part of the lake is heavily silted. The maximum turbidity was near Fort Chipewyan where the disc reading was 0.5 feet. It is assumed that this muddiness is from the inflow of the Athabaska river. At midsummer the silting may extend as much as 50 miles up the centre of the lake and much further along the south shore. On August 23, 1945, the margin of the muddy water passed just south of Beartooth island and on north of William point.

The mineral content of water from lake Athabaska was 58 p.p.m. in the vicinity of Goldfields and 52 in a sample from Fond-du-Lac. It is apparently higher and more variable in the west end where it is affected by the inflow from the Athabaska river. Water from Reindeer lake in northern Saskatchewan had 61 p.p.m. and several samples from lake Superior averaged 60 p.p.m. This relatively small quantity of minerals appears to be characteristic of lakes with much of their drainage from the Precambrian Shield.

PLANKTON AND BOTTOM FAUNA

Samples of plankton have been collected from 18 stations in all parts of the lake. The net used was of number 20 silk and had a mouth 25 cm. in diameter. These samples are made up chiefly of the Entomostraca and diatoms which are usually found in the open water of large lakes. The quantity in total vertical hauls from ten stations in the deeper water averaged 40 mg. dry weight. In eight stations in the shallower and more silty water, the average quantity was 20.5 mg. Typical samples taken in Great Slave lake averaged 34 mg. in 1944 and 30 in 1945. These quantities indicate a thin plankton but greater than the average of 23 mg. in four large lakes of the Canadian Rockies.

The bottom fauna was also investigated using the standard procedures. In 214 dredgings from all parts of the lake the average population was 1,200 per square yard and the average dry weight of organisms 2.9 pounds per acre. This compares closely with the average of 1,275 organisms per square yard and

3.4 pounds dry weight per acre in the main part of Great Slave lake (excluding the very deep Christie and McLeod bays).

The bottom fauna of lake Athabaska is dominated by the shrimp *Pontoporeia*, which contributes 61% of the numbers and 70% of the weight of the population. Similar dominance was observed in Great Slave lake, where it forms 82% of the numbers and 76% of the weight. In lake Michigan the same shrimp contributes 66% of the deep water bottom population (Eggleton, F. E. *Productivity of the profundal benthic zone in lake Michigan. Mich. Acad. Sci., 22, 1937*). Minute snails and clams and the larvae of midges make up most of the remainder of the bottom population of lake Athabaska. They are important as food for bottom-feeding fish especially in the shallow west end of the lake.

The resemblance both in quantity and quality between the bottom fauna in Great Slave and Athabaska is helpful in our deductions as to the relative productivity of the two lakes. When we note also the similarity in the amount of plankton and in certain fundamental physical and chemical features, it seems probable that these two lakes have about equal capacity per unit area, for fish production.

FISH

The common whitefish, the lake trout and two species of cisco are dominant in the fish population of lake Athabaska. Five other species are common but somewhat restricted in their distribution. They are the pike-perch, goldeye, northern sucker, pike and round whitefish. Less common are the burbot, common sucker, arctic grayling and flat-head chub (*Platygobio*). The yellow perch is present but quite rare. Eight or nine species of small fish including minnows, cottids and sticklebacks have been collected.

The fish of lake Athabaska may be divided into three groups or associations each with fairly definite distribution. The open water area is dominated by the common whitefish, ciscoes and the lake trout. Occasional northern suckers and burbot are taken in this region. Along the rocky north shores are found round whitefish and grayling. The muddy shallow water of the west end has the greatest variety of fish. Here are found many pike-perch, pike and goldeyes with moderate numbers of common suckers, burbot and occasional whitefish and ciscoes.

The fish fauna of lake Athabaska differs only a little from that of Great Slave lake. This is not surprising since the geological evidence indicates a broad connection between the two lakes when the Keewatin ice sheet was retreating from this area. The main differences are in the distribution of the inconnu and the yellow perch. The inconnu is common in Great Slave lake but not found above the rapids at Fort Smith. It is presumed to have entered the system late in the post-glacial period. The yellow perch has not been found in Great Slave and only rarely in lake Athabaska which must be near to the northern limit of its distribution. There is also an important difference in the relative numbers of certain species in the two lakes. The pike-perch and the goldeye, which are present in Athabaska in commercial quantities, are small in size and of little value in Great Slave.

Some indication of the density of the fish population is provided by the catch from test nets set in lake Athabaska in 1945. Standard gangs of gill net, each 300 yards in length and including meshes from $1\frac{1}{2}$ to $5\frac{1}{2}$ inch, were set for 24 hours in 36 different localities. The average catch was 103 fish weighing 97 pounds. Forty-seven sets with similar nets in Great Slave lake averaged 86 fish weighing 103 pounds. The Slave lake catch includes more trout and the Athabaska catch more whitefish, but the total weight of fish caught is similar in the two lakes. It was noticed above that these lakes had similar supplies of potential fish food. The gill net catches indicate that the densities of the fish populations in the two lakes are also of the same order.

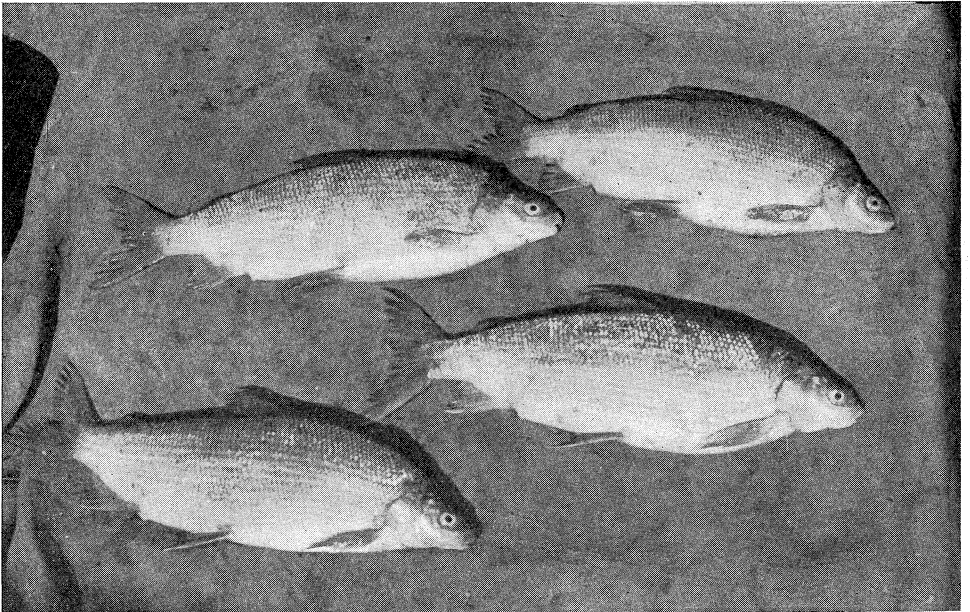


FIGURE 16. Typical form of whitefish, lake Athabaska.

WHITEFISH

The common whitefish, *Coregonus clupeaformis*, is found in all areas and at all depths in lake Athabaska. Thirty-six test nets took 2,089 whitefish representing 56% of the total catch. The great majority of these fish were of the typical form, similar to those taken in Great Slave lake but slightly smaller. A small proportion of the common whitefish catch was of a peculiar, dark, soft-fleshed variety with small eyes, long shallow bodies and elongate heads. Most of these specimens were taken in shallow water along the rocky north shore. Whether these dark terete forms intergrade with the typical whitefish has not been established. Their rate of growth is somewhat slower than that of the typical form. A dark variety has been observed at Gros Cap on Great Slave lake. These

fish are of inferior quality and more heavily parasitized than the typical whitefish. The relation of the dark variety to the main population should be investigated.

The rate of growth of whitefish from different parts of lake Athabaska does not differ significantly. It is almost identical with the growth of whitefish from the Fort Resolution area of Great Slave lake and thus slightly faster than the average growth for Slave lake whitefish indicated on page 55.

The average size attained by whitefish in lake Athabaska is about $16\frac{1}{4}$ inches and 2 pounds 2 ounces in weight. This is considerably smaller than the average of $18\frac{1}{2}$ inches and 3 pounds in the commercial catch from Great Slave. It might be assumed that the smaller size is the result of commercial fishing in the lake but this is apparently not the explanation. The whitefish of lake Athabaska were only lightly fished until 1942 and the average size of the fish caught has not

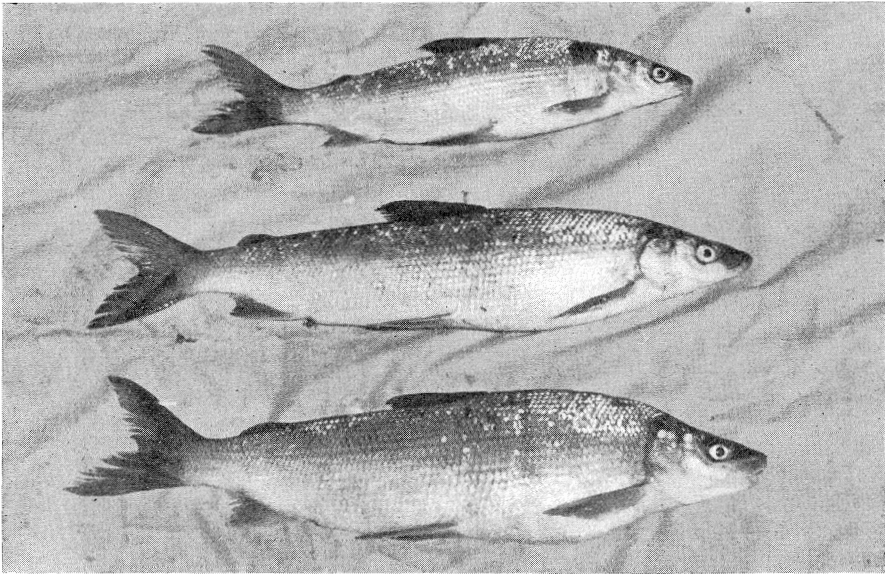


FIGURE 17. Peculiar dark, terete form of common whitefish.

changed in recent years. The usual commercial nets of $5\frac{1}{2}$ -inch mesh take only small numbers of whitefish and nets of $4\frac{3}{4}$ -inch mesh have been used in this lake for many years.

The food of the common whitefish is mostly the shrimp *Pontoporeia* and minute molluscs. In the deeper water, *Pontoporeia* makes up about 85% of the food. In the shallower half of the lake (less than 65 feet deep), *Pontoporeia* contributes about 50% and the remainder is equally divided between minute snails and clams. Insect larvae are sometimes eaten but are of little importance in the whole picture.

Infestation of whitefish by the larvae of the tapeworm *Triaenophorus*

is high in the shallow water near the delta. Whitefish from this area averaged 4.1 cysts per fish and 164 per 100 pounds. In a general sample from the central part of the lake the rate was 1 cyst per fish and 40 per 100 pounds, but in a sample from the commercial catch examined by the fishery officer in 1944 the average rate was 26 per 100 pounds. This conforms with the observations on Great Slave lake where it was shown that whitefish in the deeper and offshore waters, where most of the commercial fishing is done, have a lower rate of infestation. Filleting and inspection of the fillets by transmitted light has made possible the production of whitefish fillets satisfactory for marketing.

LAKE TROUT

The lake trout of Athabaska are of good quality and have always been the mainstay of commercial fishing. They are the dominant fish-eaters of the lake and are abundant in the central and eastern areas. In the shallow west arm they are rare and their place is taken by the pike-perch and pike. Local reports suggest that the trout were formerly numerous in the vicinity of Burntwood island, possibly in years of high water level.

The growth of trout in lake Athabaska has been determined as follows:

12 years, 19 $\frac{1}{4}$ inches, 3 pounds.	18 years, 25 $\frac{1}{2}$ inches, 8 $\frac{3}{4}$ pounds.
14 " , 21 $\frac{1}{2}$ " , 4 $\frac{1}{2}$ " .	20 " , 27 " , 10 $\frac{1}{4}$ " .
16 " , 23 $\frac{3}{4}$ " , 6 $\frac{1}{2}$ " .	22 " , 28 $\frac{1}{2}$ " , 12 " .

This represents a growth in length slightly faster and a growth in weight considerably faster than that of trout in Great Slave lake. The trout of Athabaska are distinctly fatter than those of Great Slave; for example, a 26-inch trout from Athabaska weighs 8 $\frac{3}{4}$ pounds and from Great Slave 6 $\frac{1}{2}$ pounds. This increased fatness is not necessarily an advantage, since fat trout deteriorate more rapidly in cold storage.

The food of adult trout, as shown by the examination of many stomachs, is mostly ciscoes with some common whitefish and occasional aquatic insects. Other species of fish such as the round whitefish and the northern sucker are of minor importance in the food of trout.

Cysts of the tapeworm *Triaenophorus* were found in the flesh of the lake trout but never in sufficient numbers to interfere with marketing.

CISCOES

The ciscoes of lake Athabaska represent two species and possibly a third. Most of those taken are *Leucichthys artedi tullibee*, a large, heavy-bodied species which is properly called "tullibee", the name applied locally to all ciscoes. Some of the ciscoes taken were *L. zenithicus*, a small form with a long jaw and slender head. They were commonly found in stomachs of pickerel at the west end. The third form may be the black-fin, *L. nigripinnis*, but there is some doubt as to whether these specimens are of this species or a variant of the tullibee.

The ciscoes of all species make up about 15% of the catch in test nets in all parts of the lake. This is a much smaller proportion than that taken in Great Slave lake. Nevertheless they are sufficiently numerous to provide a large part of the food of the lake trout. Most of the specimens examined were heavily infested with *Triaenophorus*. The number of cysts per fish varied from 2 to 28 and averaged 9. It is not anticipated that the cisco will prove of economic value except as food for trout.

PIKE-PERCH

The pike-perch, pickerel or doré, is abundant in the west end of the lake where in recent years 100,000 to 200,000 pounds have been taken in less than one month's fishing. Many were taken in the test nets around Big (Bustard) and Burntwood islands, three at Fidler point and none in the central or western parts of the lake.

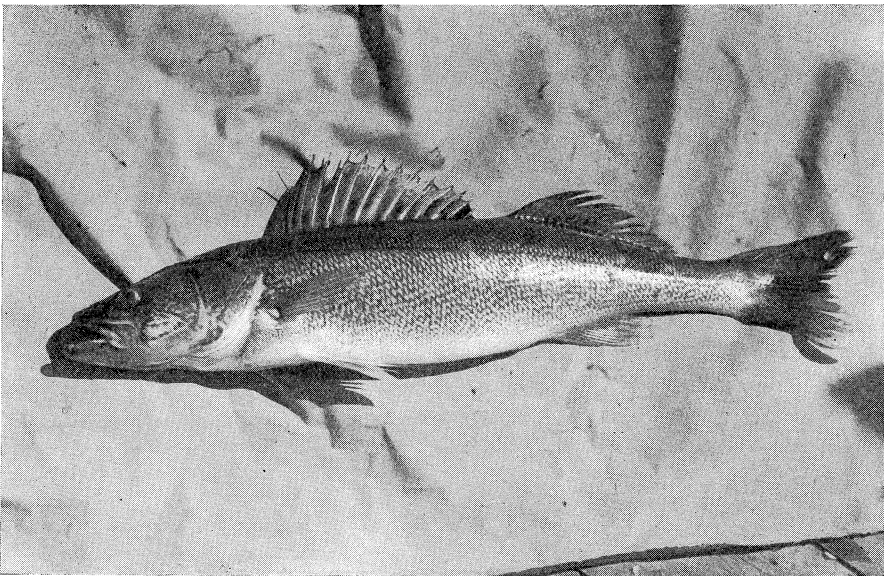


FIGURE 18. Pike-perch (pickerel).

The pike-perch are of fine quality and grow to a good size. The average of the commercial catch was about 21 inches, $3\frac{1}{4}$ pounds. They feed chiefly on two species of small fish, the trout perch and the nine-spined stickleback. Occasional minnows, whitefish, goldeyes and ciscoes are also eaten.

The infestation of the pike-perch with the larvae of the tapeworm *Diphyllobothrium latum* is general in this area. Forty-nine specimens taken in the delta region in early June, 1945, averaged 2.5 cysts per fish and 54 per 100 pounds. These cysts are less conspicuous than those of *Triaenophorus* but more important

since they infect man. Investigation by Dr. L. G. Saunders indicated a high incidence of this parasite in both dog and man in the Fort Chipewyan area. Fortunately infestation by this species appears to cause little harm to the host.

GOLDEYE

The goldeyes are numerous in the shallow water of the west end, especially in the river channels and the flat expanses near the delta. They are caught in large numbers in the domestic nets set to catch dog feed throughout the summer. Most of the specimens taken are from 6 to 11 years old, 12 to 16½ inches in length and 11 ounces to 2 pounds in weight. Their growth is slower than that of the same species in Manitoba lakes, but slightly faster than in Great Slave lake where it is not of much importance. The food consists largely of aquatic insects with some small fish such as trout-perch and sticklebacks, taken mostly by the larger goldeyes. They also eat terrestrial insects from the surface of the water and provide good sport when caught on a fly. Since the goldeyes are numerous and of good quality it is expected that they will eventually be used commercially.

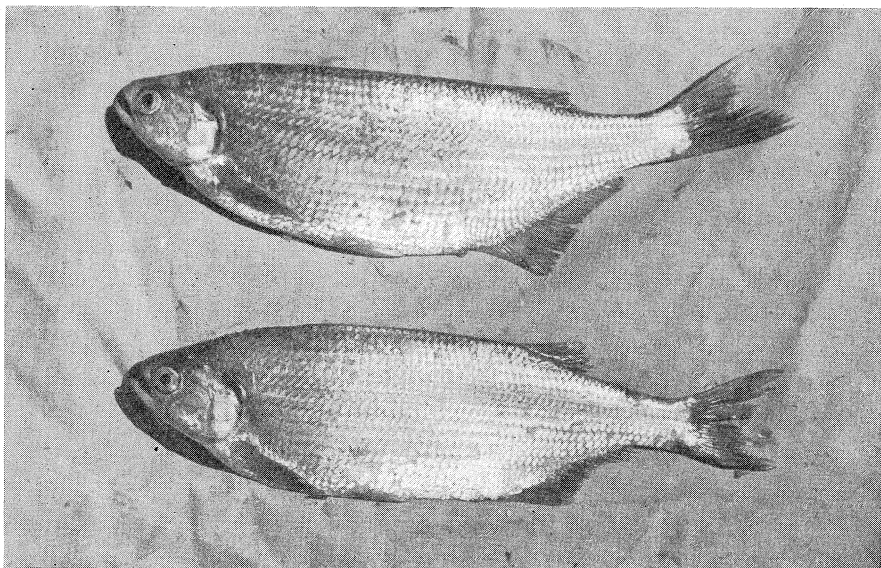


FIGURE 19. Goldeyes from Athabaska delta.

OTHER FISH

The pike is important only at the west end of the lake, where 97,000 pounds were taken in 1945 in the commercial catch. The average weight of the pike in the commercial catch was about 5 pounds. It is widely predaceous with ten species of fish identified from its stomach contents. Trout-perch were the main food near the delta in early June. Whitefish, ciscoes, common and northern

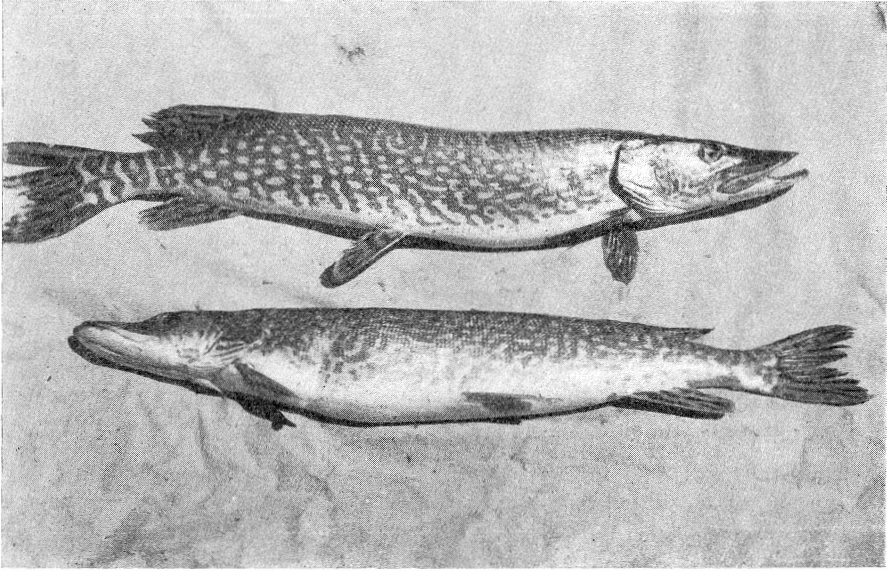


FIGURE 20. Northern pike.

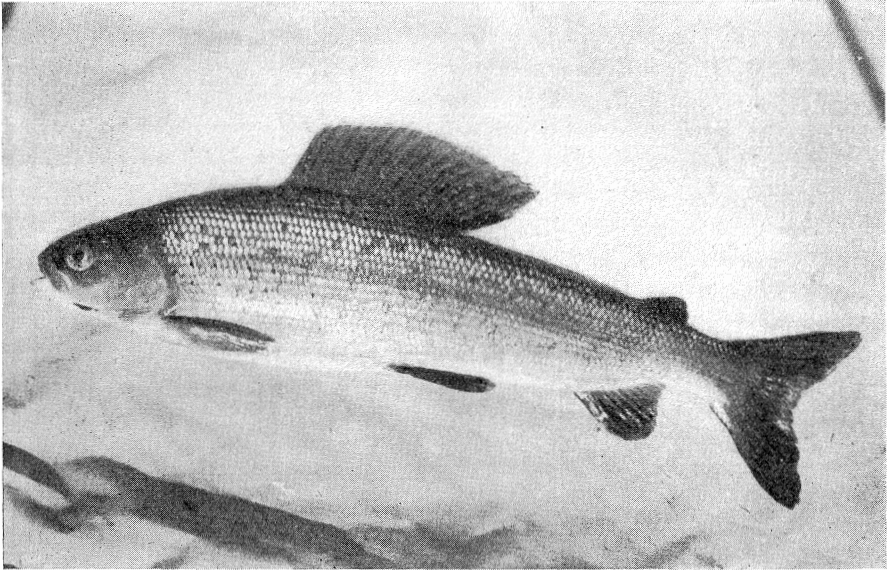


FIGURE 21. Arctic grayling, Crackingstone point.

suckers were commonly eaten. Like the pike-perch, it harbours in its flesh the cysts of the tapeworm *Diphyllbothrium*, which infects man and dog. The examination of forty pike revealed an average of 1.2 cysts per fish, equivalent to 36.5 per 100 pounds.

The grayling is common in the clear water along rocky shores to the north and east. Most of the specimens taken by angling and in the gill nets were from 12 to 16 inches and from 12 ounces to 1½ pounds. The food of fifteen specimens was insects, mostly terrestrial and including a great variety of beetles, flies, ants and other forms. The excellent game qualities of this species are widely recognized, but little angling is done at present in the Athabaska area.

The northern sucker is present in moderate numbers and provides a little competition for the main bottom-feeding fish, the common whitefish. The common sucker is much less numerous and restricted to a limited area of shallow water. It is thus of little importance in the economy of the lake.

The burbot, or ling though widespread is not numerous. Its only importance is in the catch of dog-feed made each summer chiefly in the river channels at the west end of the lake. It feeds on such fish as the trout, perch, minnows, sticklebacks and to a lesser extent on invertebrates such as leeches, shrimps and *Mysis*.

THE FISHERIES

DOMESTIC USE

Some records of domestic fish catch in lake Athabaska have been obtained for the years 1927 to 1945. These were kept by the Federal Department of Fisheries prior to 1930 and since that time by the Saskatchewan Department of Natural Resources. This fishing is done chiefly under free permits by Indians from whom it is almost impossible to obtain records of catch. The available figures suggest increasing catches from 1928 to 1939 and larger catches of 250,000 to 450,000 since that time.

In the course of the survey in 1945, visits were made to all settlements around the lake and detailed enquiries were made as to domestic fishing. On a basis of these records and from information as to the numbers of persons and dogs around the lake, it has been estimated that the annual domestic consumption from lake Athabaska is about 500,000 pounds. This represents about the same rate of consumption per man and dog as was found at Great Slave lake.

The domestic catch is reported to be made up mostly of whitefish, with moderate quantities of trout, pike, suckers and burbot also a few pike-perch and tullibee (ciscoes). In Athabaska as in Great Slave lake, it is true that most of the domestic fishing is carried on in areas not touched by commercial fishing.

COMMERCIAL FISHING

Commercial fishing has been carried on by McInnes Products Corporation since 1926. In the first three years the company operated from Spring point

and in 1929 the camp was moved to Crackingstone point where it has remained since that time. Most of the fishing has been in the Saskatchewan portion of the lake where the catch was trout and whitefish. However, in 1943, 1944 and 1945 the area near the Athabaska delta was fished for a month at the beginning of the season. This fishing was for the pike-perch and pike which had not been used previously.

The methods of handling the fish have improved steadily during the twenty-year period. Powerful diesel tugs are used to haul barges 90 miles down the lake and 175 miles up the Athabaska river to Waterways. In the first five years ice was used for preservation, but in 1931 mechanical refrigeration was introduced. Barges with freezing equipment were operated close to the fishing grounds. In

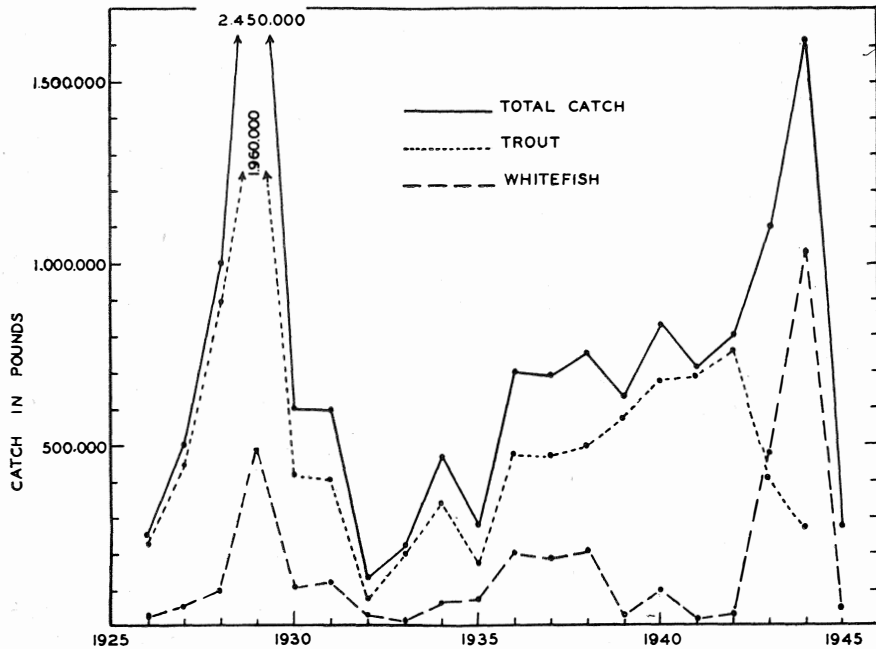


FIGURE 22. Commercial fish catch in lake Athabaska, 1926 to 1945.

1942 patented quick-freezing equipment was installed and further improvements were made in filleting, inspection and packaging. The quality of fish products from lake Athabaska has built up a well deserved reputation.

The record of the commercial fish catch in lake Athabaska is presented in graphic form in figure 22. From small beginnings in 1926 the catch increased rapidly to a maximum of 2,450,000 pounds in 1929. This large catch was the combined effort of McInnes Products Corporation which took 1,750,000 pounds and National Fish Foods which took about 700,000 pounds. The latter company operated for only one year. In 1930 and 1931 the catch dropped to 600,000

pounds and was still lower in the next four years of the "depression". From 1936 to 1942 the catch varied around 700,000 pounds and increased again in 1943 and 1944. The small catch in 1945 was the result of only one month's fishing in the Alberta waters off the Athabaska delta. Because of difficulties concerning the size of mesh to be used, the equipment was all moved to Great Slave lake in July 1945 and there was no commercial fishing in the main body of lake Athabaska.

In the twenty years of commercial fishing about 14,600,000 pounds of fish were taken, an average of 730,000 pounds per year. Of this catch 69% was trout, 24% whitefish and the remaining 7% pike-perch, pike, suckers and burbot. In the early years the catch of pike-perch and pike was very small, but in 1943 fishing was begun in the delta region at the west end of the lake. This extended the season by almost a month, operations being possible from June 1 to September 15. In this first month of fishing, in 1943, 1944 and 1945 the catch averaged about 157,000 pounds of pike-perch and 40,000 pounds of pike.

Referring to figure 22, it will be seen that prior to 1943 the proportion of trout in the catch was very high, usually 80 to 90% of the total catch. In 1943 and 1944 special efforts were made to produce whitefish fillets, and trout production dropped accordingly in these years. It is concluded that the fluctuations in the amount and composition of the catch from lake Athabaska are a reflection of marketing conditions and fishing effort rather than an indication of change in the availability of fish in the lake.

GAME FISHING

The grayling, pike, pike-perch and goldeye, all offer possibilities for sport fishing. Fly-fishing is effective for grayling along the rocky north shore and especially at the mouths of streams. Goldeyes can also be caught by fly-fishing in the river channels at the west end of the lake. Pike and pike-perch are taken mostly by trolling or with bait-casting tackle used from shore. Little use is made of these game fish potentialities at the present time but, if the expected rehabilitation of Goldfields takes place, game fishing may well increase in importance.

FISH PRODUCTION AND CONSERVATION

The survey of the fish population of lake Athabaska in 1945 and the examination of the records of commercial catches for the past twenty years, suggest that there has been no depletion of fish in this lake. The average trout catch of 500,000 pounds per year is apparently within the capacity for sustained yield of that area of the lake in which trout are found. It is possible that a larger annual crop might be taken. A limit of 700,000 pounds might be tried for several years as a test.

The whitefish of lake Athabaska have not been fished intensively. In 1929 and 1943 about 500,000 pounds were taken and in 1944 a catch of 1,000,000

pounds. In the remaining seventeen years catches were small and the average for the whole period of twenty years is 176,000 pounds. This is only a small fraction of the amount which the lake can produce.

Experience has shown that the lake can produce at least 500,000 pounds of trout per year. Whitefish and trout grow at about the same rate in lake Athabaska, but the whitefish feeds directly on small organisms while the trout is dependent on other fish, which in turn must feed on smaller animals. This extra link in the food chain decreases the efficiency of production. It is widely recognized that a lake will produce a greater quantity of a fish which feeds on plankton and bottom animals than of one which feeds on other fish. Lake Nipigon, for example, has produced in twenty-five years four times as much whitefish as trout. Thus lake Athabaska would be expected to produce several times as much whitefish as trout.

From the standpoint of total fish production lake Athabaska, with an area of 3,000 square miles, and a food supply comparable to that of other large lakes, might be expected to produce at least 1.5 pounds per acre or three million pounds per year. It is suggested that a reasonable annual limit would be 2,000,000 pounds of whitefish, 500,000 pounds of trout and possibly 150,000 pounds of pike-perch. These, with the present domestic catch, would bring the total production to something more than 3,000,000 pounds per year.

Information from the biological survey of lake Athabaska has been used in attempting to estimate the possible fish production, as was done for Great Slave lake. In Athabaska we have the advantage of records of commercial fishing over a twenty-year period. Thus the annual limits suggested above may be named with moderate confidence. Nevertheless the commercial catch on lake Athabaska should be carefully recorded and investigated periodically for possible changes in age composition, rate of growth and other indications of the condition of the population. Such investigations would be of particular importance if it should be decided to raise the present annual catch limits in order to see whether the lake is capable of greater production.

CHAPTER VII

GENERAL CONCLUSIONS

By J. R. DYMOND

Recent developments in the Northwest Territories have emphasized the importance of adequate knowledge of the nature and extent of their fishery resources. These resources may contribute to the development of the area through (1) the provision of food in a region in which there is otherwise comparatively little produced locally, (2) the export of any excess commercial fish production, and (3) the attraction of anglers through the appeal of new areas and unusual species. Although a good deal of general knowledge as to the kinds of fish and something of their abundance had resulted from the observations of various explorers and travellers into the region, this information had for more than a century been unsatisfactory as a basis for administration on sound conservation lines. Knowledge of the fisheries resources of the area is still far from being entirely adequate, but the investigations of the past two years have given us much soundly-based information as to the probable productive capacities of some of the more important waters, and have also provided a basis for formulating plans for future studies.

Although the mere presence of water does not guarantee fish, it should be borne in mind in considering the fisheries resources of the Northwest and Yukon Territories that the area contains two of the earth's largest lakes and two mighty rivers besides literally thousands of lesser waters, many of which if they occurred in other regions would be notable features.

Great Bear lake with an area of 11,800 square miles, and Great Slave lake 10,500 square miles, are respectively the fourth and fifth largest North American lakes. Lake Athabaska, which like the other two drains into the Mackenzie river, is much smaller with an area of 3,050 square miles.

These lakes, though having much in common, show many contrasts and their study throws light on the factors affecting productivity. Athabaska in addition to being the more southern and therefore having the longer growing season is also the shallowest. Its mean depth is 85 feet and its maximum 405, whereas the mean depth of the main part of Great Slave is 120 feet with greater average depths obtaining in the east arm where a depth of 1,440 feet has been determined. Great Bear lake has not yet been thoroughly explored, but it is known to con-

tain a great deal of very deep water, a considerable part of McTavish arm being over 1,300 feet deep. The low temperature and scant light in deep water greatly reduce the growth of the smaller organisms which serve as the ultimate food of all fish, and therefore reduce the productivity of lakes containing much very deep water. Surface water temperatures in the open lake in midsummer vary from 60 to 65°F. in Athabaska, to about 55° in Great Slave and somewhat lower in Great Bear.

ESTIMATING PRODUCTIVE CAPACITY OF LAKES

The quantity of fish a body of water will produce cannot exceed the number that can find food, and the quantity of fish food (smaller fish, bottom-living animals and the tiny, often microscopic plants and animals known as plankton which float in the water) is dependent on the supply of nutritive materials in the water, the amount of light available, and the temperature. Therefore, an understanding of the productive capacities of a lake can only be had from a study of all these factors as well as of the fish themselves.

Although there is no formula available by which the annual yield of fish which a lake will produce may be derived from a knowledge of the physical and chemical characteristics of the water and of the plankton and bottom fauna, there is gradually accumulating as a result of surveys similar to those here reported, a body of knowledge which makes estimates of productivity more and more reliable. It is on the basis of such comparisons that Rawson estimates that Great Slave lake will probably yield a commercial catch of at least 3,000,000 pounds a year, and that Miller concludes that Great Bear lake will not support a commercial fishery but should be exploited only for the support of the local population.

In the present state of our knowledge of the productivity of lakes, estimates such as that of Rawson are largely tentative. What needs to be done if we are ultimately to be able to make more satisfactory estimates is, after making thorough studies of a variety of lakes, to follow their actual yield of fish and to determine what effect such yields are having on the population, whether it is maintaining itself or gradually decreasing. The making of biological studies of lakes is, therefore, not the end of lake studies. Accurate catch statistics should be recorded as a measure of yields, and population studies made from time to time by setting such a variety of nets as will give information on the relative numbers not only of fish of commercial size but of younger ages which will be entering the catch in future years.

The value of these studies on three large northern lakes is based not only upon the light they throw on their probable productive capacities, but also upon the contribution they make to the steadily accumulating knowledge of lakes in general. It is the first time, at least in America, that large northern lakes have been studied and it is doubtful if any lake as large as Great Slave has been surveyed prior to the commencement of commercial fishing.

FISH FOR DOMESTIC USE

The safeguarding of a supply of fish for local consumption should be the first object of the administration of the fisheries of these regions. Fish have always been vital to the maintenance of the local population. Richardson, the naturalist who accompanied Franklin on his first and second expeditions into northern Canada, noted this in his account of the fish life there. In speaking of the whitefish he said: "Several Indian hordes mainly subsist upon it, and it forms the principal food at many of the fur posts, for eight or nine months of the year." (*Fauna Boreali-Americana, Part III, The Fish, by Sir John Richardson, London, 1836.*)

Modern developments in transportation have made the importation of food into the area more feasible, but a serious reduction in availability of a valuable local food through unwise exploitation would be an economic loss and one that might seriously interfere with the development of the area at a time when its importance is rapidly increasing. The first object of the surveys here reported was to provide information as a basis for opening the waters to commercial fishing, but only in so far as that might be done without endangering a supply of fish adequate to local needs. No accurate statistics of the local consumption of fish are available, but Rawson after careful inquiries has estimated a domestic consumption of Great Slave lake fish of between 1,000,000 and 1,500,000 pounds annually. For Great Bear lake Miller's figures are 2,500,000 pounds. The dogs of the Indians and whites in the Mackenzie region are estimated by Wynne-Edwards to consume "several million pounds annually". Most of this local consumption of fish in the Northwest Territories is by Indians and their dogs, the white population as yet depending very little on local fish as food. However, the mine at Port Radium on Great Bear lake is anxious to obtain a regular supply. With such excellent food as whitefish, trout and inconnu at their very door, the use of fish by the increasing white population is bound to increase.

The greater part of the fish taken by Indians is for winter feed for their dog teams. This consists largely of whitefish and in Great Slave lake and the lower Mackenzie of inconnu as well. Some picture of the extent and nature of the catch of fish for dog feed is afforded by Rawson's account of this fishery. When we read of the taking of 100,000 pounds of inconnu in one spot in four days and of 100,000 pounds of whitefish at another place, we naturally ask whether, as the demand for fish increases, some less valuable fish may not be substituted as dog food, in the future. Rawson's suggestion that the possibility of refrigerating for dog feed non-marketable fish taken in commercial operations should be investigated. Where whitefish and lake herring are unobtainable, burbot are at present used as dog feed. Since the dog is so vital to the native populations of our northern regions, studies of its nutrition, diseases, etc., should receive more support than has heretofore been given them.

While the Indian population of the Yukon is much smaller than that of the Mackenzie valley, the white population is greater. There are therefore relatively

fewer dogs. One of the important Yukon fisheries is that for salmon in the Yukon river. Wynne-Edwards estimates that the catch by whites is in excess of 25,000 pounds annually and that of the Indians between 5,000 and 10,000 pounds. Besides king salmon, the Yukon river catch includes whitefish, inconnu, dog salmon and grayling. Five species of salmon as well as steelhead trout are caught by Indians in tributaries of the Tatsenshini which flows into the Alsek not far from the sea.

Considerable quantities of lake trout and whitefish are taken in lakes. Much of this in the past has been consumed on fur farms, but the number of these has decreased in recent years owing to a decline in the supply of fish. Wynne-Edwards points out that the Yukon fisheries are of considerable importance to the people living in that area owing to the difficulty of importing many other kinds of food. He concludes that there will probably never be any fish to export from the Yukon.

COMMERCIAL FISHERIES

Lake Athabaska, which, however, is not in the Northwest Territories, has been fished commercially since 1926, during which an average of 730,000 pounds per year has been taken without any evidence of overfishing. Rawson estimated that the lake is probably capable of yielding a total of 3,000,000 pounds per year, including a domestic catch of 500,000 pounds.

For Great Slave lake, he also estimates a possible commercial production of 3,000,000 pounds a year in addition to the present domestic consumption.

Miller doubts if Great Bear lake should ever be fished commercially, since the fish it produces are all needed locally. For the Mackenzie, Wynne-Edwards regards the commercial export of fish from the lower section of the river a possibility, but not under present transport conditions. Investigation of the fisheries of the Beaufort sea may indicate the existence of commercial quantities of fish as suggested by some reports, but, until the area has been given scientific study, judgment on the commercial possibilities of this area must be reserved.

The Yukon fisheries in the opinion of Wynne-Edwards will probably never be exploited for export to outside markets, the whole production being capable of consumption by the local population to whom it is of great importance.

GAME FISH

The Northwest Territories and especially the Yukon possess considerable game fish possibilities. The principal game species are, rainbow trout, steelhead, Arctic char, Dolly Varden "trout", grayling, lake trout, pike, pike-perch and goldeyes.

Lake trout are widely distributed, reach a large size and are of excellent quality. In these northern lakes the lake trout are not forced into deep water by the warming of the water in the surface layers and as a consequence deep trolling is not necessary as it is in summer farther south. Rawson points out that

Taltheilei narrows, Great Slave lake, have already become a famous fishing ground for lake trout, aeroplanes having been used for years to reach this spot. Trout up to 44 pounds in weight have been taken. Other areas in Great Slave lake also provide excellent fishing. The wonderful cliffs and channels of the East arm add to the charm of fishing in this out-of-the-way area.

In Great Bear lake there is already a considerable sport fishery at and around Port Radium. Miller reports that other parts of Great Bear lake, notably Conjuror bay, South narrows of Richardson island and Gunbarrel inlet, are ideal sites for lake trout fishing. The trout are numerous and are readily taken by casting from shore. The scenery too is very fine.

Many of the smaller lakes of the Northwest Territories contain populations of lake trout often of large size, which will long provide excellent fishing for sportsmen keen to fish in unusual and out-of-the-way places.

The grayling, or bluefish as it is called locally, is the most attractive of the game fish of the Northwest and Yukon Territories. It rises readily to the fly, is handsome in appearance, and tasty to eat. It is found in most of the lakes and rivers of the area. In Great Slave lake it is especially abundant along the rocky north shore, at the mouths of rocky streams, and in the river channels at the west end of the lake. The source of the Bear river near Fort Franklin on Great Bear lake offers unique sport in grayling fishing. The fish leap here all summer and can readily be taken on the fly. Wynne-Edwards reports that grayling may be taken in the Mackenzie river at almost all localities from Providence to Arctic Red river, and are also abundant in the clear tributaries. In the Yukon too they are generally distributed and usually common in all rivers and creeks.

Rainbow trout, could, Wynne-Edwards believes, be brought into the Alsek-Dezadeash river system in southwest Yukon by the removal of a barrier presumed to prevent the ascent of salmon and trout from the Pacific. Some are at present found land-locked in the headwaters of the Dezadeash and steelheads run up the Tatsenshini river, a tributary which enters the Alsek not far from the sea and below the presumed obstruction. Rainbows are abundant in Kathleen lake and in the river and small lakes below it. There is good fishing below St. Mary's falls on the Aishink river. Steelhead is the name given to the migratory form when in the sea or shortly after its return to freshwater. When it has been long enough in freshwater to assume the pinkish or reddish band along its sides or is permanently land-locked, it is called a rainbow.

The Arctic char, usually called salmon, in this area is reported from Good Hope to the sea. It is known to run into the Coppermine and undoubtedly does so in other streams flowing into the Arctic. The Dolly Varden is in the eastern section and in Tatsenshini.

The goldeye is not usually regarded as a game fish, but in waters lacking trout it provides fair sport when fished with the fly. It is found in some numbers in lake Athabaska, but is not numerous northward, although it occurs sparingly in Great Slave lake and the upper Mackenzie.

Pike, locally called jackfish, is generally distributed in the waters of the Northwest and Yukon Territories. It often reaches a large size, specimens of over forty pounds in weight having been reported.

Pike-perch, locally called pickerel, is not uncommon in lake Athabaska and in some of the smaller lakes in the southern part of the Northwest Territories.

POSSIBILITY OF IMPROVING FISHING

As already explained, the quantity of fish which a body of water will produce is largely determined by the supply of nutritive materials in the water and by the amount of heat and light affecting plant and animal growth. The only means available for increasing or improving the fish life in a body of water is through increasing the supply of nutrients in the water (fertilization), modifying the light or heat conditions in the water, or by improving the utilization of the basic food materials for the support of fish life. Only the latter method seems feasible at the present time.

Some kinds of fish life are more desirable than others. Much of the food of the burbot is the same as that of the lake trout. An increase in the proportion of burbot to lake trout in a lake probably lowers the efficiency of a lake as a producer of desirable fish. An increase of suckers may similarly interfere with whitefish production. Selective fishing for certain species such as trout and whitefish may favour the increase of their less valuable competitors (burbot and suckers) and thus lower the efficiency of a lake as a producer of valuable fish. In the Northwest and Yukon Territories where there is a demand for fish for dog food and on fur farms it would be well worthwhile to carry out studies to determine whether it might not be possible to catch and use species such as burbot and suckers as food for dogs and fur-bearing animals.

Sometimes species of desirable fish which could thrive in a body of water do not occur in it for geological reasons and might be introduced advantageously. The possibility of restoring salmon runs to the Alsek-Dezadeash river system covering an area of 2,000 square miles in southwest Yukon should be investigated. According to Wynne-Edwards' account, salmon which formerly ran throughout the main river and its widespread tributaries have been denied access by some unknown obstacle near the Alaska border. Restoration of the salmon runs would, it is believed, lessen the drain on the moose to which the Indians have turned for food for themselves and their dogs. The preservation of the moose population would add to the attractiveness of the St. Elias National Park recently set aside in an area containing "the most majestic mountain scenery in Canada". There is, however, always a risk in introducing a species into waters to which it is not native. If it thrives, it often interferes with indigenous species. It is then a question as to which is the more valuable, the introduced or the native species. The possible effect of introductions should always be considered before they are made.

POLLUTION

While there have been few sources of pollution yet, the possibility of injury to the fishing from this source cannot be overlooked. Wynne-Edwards draws attention to the fact that a break in the oil pipeline at Norman Wells left its mark for 100 miles along the river.

With the development of gold and other mining, wastes from smelters and refineries if placed in the waters may be injurious to fish life.

Because fish is so important, especially to the native population of the area, the danger of injury through pollution must be carefully watched

THEORETICAL INTEREST OF RESEARCHES IN THE AREA

Besides the many practical values of fisheries research in the Yukon and Northwest Territories, information on the distribution of fishes and other forms of life in this area is of very considerable theoretical interest. The fauna of Canada and of northern Asia and to a lesser extent that of northern Europe are similar in many respects. Interchange of plants and animals between North America and Asia undoubtedly occurred, perhaps at several periods in the earth's history, across a land bridge connecting northwestern America and northeastern Asia. Indication of the period or periods at which these interchanges occurred, and of the areas from which northern lands were repopulated after the last glaciation, may be gained from studies of the details of the present distribution of life in northwestern America and northeastern Asia. The distribution of freshwater fishes is of special importance in this connection since they can move from one area to another only in freshwater and not from one land mass to another separated by salt water. They also spread slowly as compared with birds, mammals and many other forms of life.

The area under discussion is of special importance in zoogeographical studies, as Wynne-Edwards points out, on account of the fact that extensive areas on both the Alaskan and Siberian shores entirely escaped glaciation.

ARCTIC RESEARCH

The investigations reported in this bulletin concern only a small, though important part of Canada's vast northern areas.

Canada's Arctic is an immense area whose proper management presents many problems for whose solution very inadequate information at present exists. The studies here reported should be regarded as only the first step in a programme which should as soon as funds and personnel are available be extended first to the Beaufort sea and ultimately to other regions of our Arctic.

That considerable quantities of fish exist off the Mackenzie coast of Canada is indicated by the experience of Anderson (*"Fishes"* by R. M. Anderson in *"My life with the Eskimo"* by Vilhjalmur Stefansson, 1913) who took about thirteen barrels of sea herring (*Clupea*) off cape Bathurst sandspit on August 3, 1911, in one haul of a 200-foot sweep-net. According to the Baillie island Eskimos, the

herring were never caught before the white men came. This suggests that there may be still unexploited populations of fish in other areas.

RECOMMENDATIONS

The needs of the local population, both Indian and white, should receive first consideration in the management of the fishery resources of the Northwest and Yukon Territories.

Commercial exploitation of the fisheries of Great Slave lake may be permitted up to a maximum of 3,000,000 pounds per year in addition to local consumption.

Accurate and detailed statistics should be kept of the catch on lakes fished commercially and scientific studies made from time to time to determine whether the provisional limit may be increased or should be decreased in order to avoid over-fishing.

Thorough scientific studies of all aspects of the fish life and of limnological conditions should be continued on at least one of the northern lakes, preferably Great Slave lake, to provide an understanding of the factors affecting the character and abundance of fish under conditions obtaining in Canada's northern areas.

The game fish and other recreational resources of the Northwest and Yukon Territories should be brought to public attention. These include: The grayling, rare or lacking in other parts of Canada; several other species, some of which are abundant and reach large sizes; out of the way and unfrequented areas; many places of historical interest; interesting native peoples; and in the Yukon some of the most majestic mountain scenery to be found anywhere.

Since dogs are still of such importance in northern Canada and are fed such large quantities of whitefish, trout, inconnu, and other valuable food fishes, the feeding of dogs should be made the subject of a thorough scientific study to determine to what extent species of fish less valuable as human food may be caught and used to advantage as dog food.

The provision of fish as food for ranch-raised fur-bearers should be made the subject of a study similar to that suggested in the case of dog food.

Species caught in commercial nets but of no commercial value and the offal from the dressing of fish sold commercially should be studied for the purpose of discovering whether such material may be used as food for dogs or fur-bearers or in the making of oil and fish meal or in other ways.

Since the inconnu is known in Canada only in the Northwest and Yukon Territories and since it is of such importance locally, its life-history and habits should be made the subject of a thorough scientific investigation for the purpose of learning how its population may be maintained or increased.

Since the whitefish is also of such enormous importance in this area and since it has not yet been definitely determined whether the population of whitefish consists of more than one species, and, if so, what their relationships to the

whitefish of more southern areas are, special taxonomic and life-history studies should be made of the whitefish of the Northwest and Yukon Territories.

The grayling, practically confined so far as Canada is concerned to the far north, should also receive further study. It is not only important locally as a food fish, but is a game fish of considerable merit and one that may attract anglers to this area because of its abundance, its unusual qualities and its occurrence in the less frequented part of the continent.

The lower Mackenzie, the most productive portion of the river, should receive further study.

The Beaufort sea should also receive biological and oceanographic study as part of a broader programme of research in Arctic Canada.

The possibility of the pollution of fish-producing waters in the Northwest and Yukon Territories by wastes from industries connected with mining and oil should be carefully watched.

The possibility of restoring salmon runs to the Alsek-Dezadeash river system in southwest Yukon should be investigated.

The introduction of rainbow trout into Yukon waters to which they are not native should be attempted only after careful consideration of their possible effect on native fish populations.