BULLETIN No. 107

The First Ten Years of Commercial Fishing on Great Slave Lake

BY

W. A. KENNEDY

Fisheries Research Board of Canada
Biological Station, Winnipeg, Manitoba

PUBLISHED BY THE FISHERIES RESEARCH BOARD OF CANADA UNDER THE CONTROL OF THE HONOURABLE THE MINISTER OF FISHERIES

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W. E. Ricker
N. M. Carter
Editors

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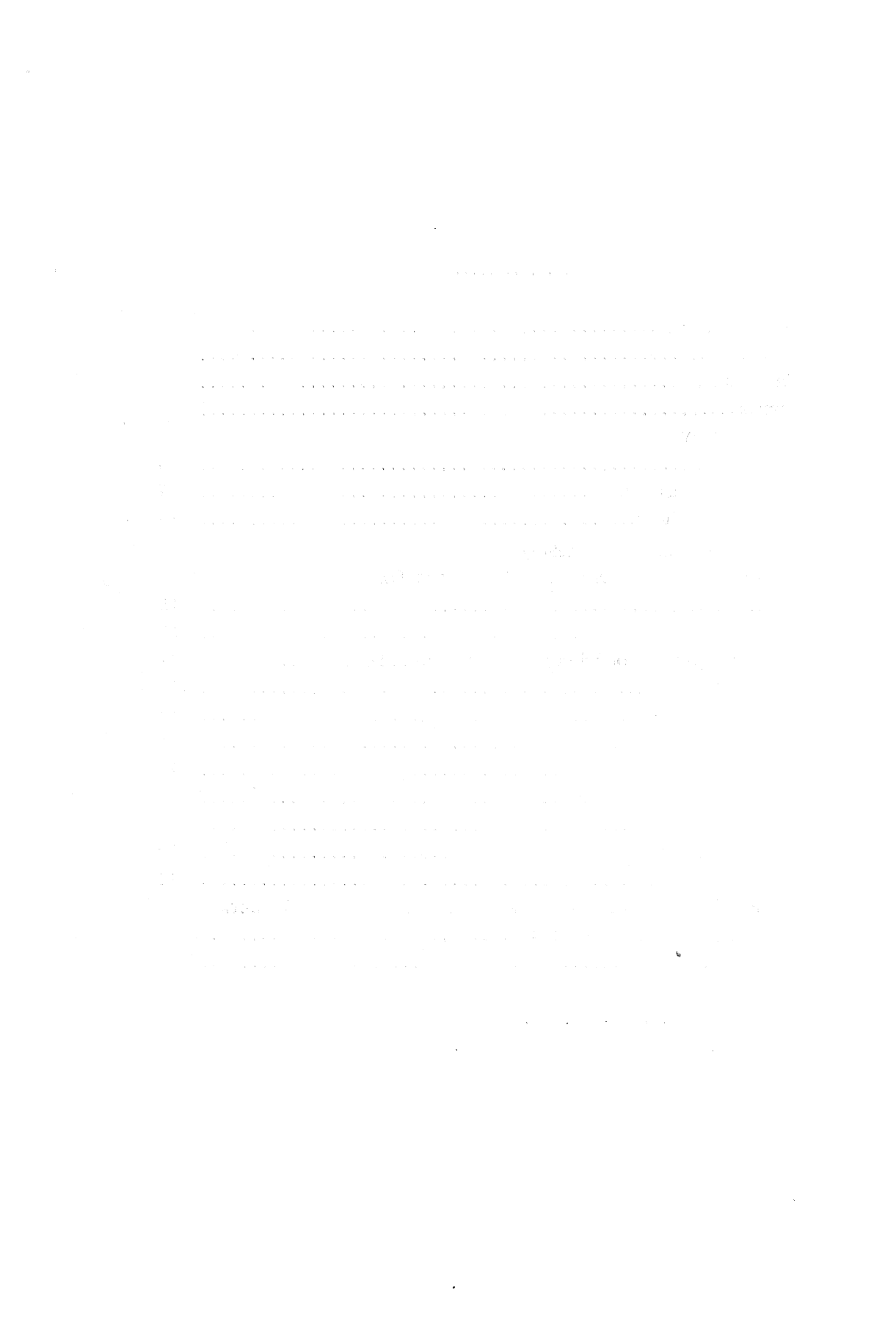

ABSTRACT

Great Slave Lake contains 10,430 square miles of water. It was opened to commercial fishing in 1945, and has been fished continuously since. Fishing is done exclusively with bottom-set gill-nets of 5 1/2-inch stretched mesh, set both during the summer, and during winter under the ice. The fish caught are predominantly lake trout, *Cristivomer namaycush*, and lake whitefish, *Coregonus clupeaformis*. These are taken in about equal quantities in summer, but relatively more whitefish are taken in winter. The 10-year catch was 24 million pounds of trout and nearly 36 million pounds of whitefish. Production has increased over the years, the 1954 catch being 2,389,000 pounds of trout and 4,490,000 pounds of whitefish. Other species amount to about 5 per cent of the combined trout and whitefish catch, and include burbot, ciscoes, suckers, inconnu, pike and walleye.

Data on catch per net for the summer season were collected by daily interviews with more than half the fishermen. Average sizes at various times and places were determined from representative samples that totalled 88,928 trout and 122,639 whitefish, or about 1,000,000 pounds out of a total commercial catch of 59,000,000 pounds over the ten years 1945-54. The following factors were used to convert dressed weights of individual fish to round weights: whitefish, gills and viscera removed, 1·1765; trout, gills and viscera removed, 1·2048; trout, head and viscera removed, 1·6667.

The average round weight of the trout taken was 7·9 pounds in 1945 and 6·3 pounds in 1954, having fluctuated irregularly in the interim. Whitefish varied from 3·1 pounds in 1945 to 2·6 pounds in 1954, again with irregular variations. Catch per net has decreased by about 45 per cent for trout and by about 30 per cent for whitefish, but it is still high for both species, by comparison with long-fished lakes. There seems to be a trend toward stabilization of both average size and catch per net, at values lower than the original.

Catch per net proved to be a rather poor index either for estimating changes in the stock of one species or for comparing the relative abundance of different species. It varies from place to place and from year to year, and it is a function (inverse) of the number of nets fished. The change in average size is probably a better indicator of change in abundance, but it too has fluctuated erratically, so that only trends over a period of years have significance. The decreases in catch per net and average size which have occurred are unavoidable results of having a fishery, and there are no indications that they have yet reached undesirably low levels. The amount of fishing done (about 1/200 as much as in Lake Erie) is far from excessive, and catch per net night is still large.

Several lines of evidence suggest that trout spawn more successfully in the eastern half of the lake and that whitefish spawn more successfully in the western half. It appears that each summer the larger trout and whitefish concentrate in deeper (colder) water than do smaller ones. Nylon gill-nets did not catch appreciably more fish than comparable cotton gill-nets.

PART 1. BACKGROUND INFORMATION

INTRODUCTION

When commercial fishing began at Great Slave Lake in 1945 it offered a unique opportunity to scientists. All other major freshwater fisheries were well developed before freshwater fisheries research was a recognized science. There are probably no lakes left in North America (perhaps in the world) where a major freshwater fishery is possible but not yet established. Great Slave Lake was probably the last chance to observe from the beginning the effect of a major fishery on unexploited freshwater fish populations. This paper reports the results of the first ten years of what is expected to be a much longer study on the Great Slave Lake fishery.

The material given in Part I will probably be of little interest to those readers who are concerned only with the conclusions that can be reached from results to date. Its main purpose is to put on record certain facts which may be required at some future time for re-assessing the data after further study. A good deal of space is devoted to describing fishing methods because there appears to be no detailed description in the literature of these widely used techniques.

THE LAKE

The physical and biological characteristics of Great Slave Lake have been dealt with in detail in a number of papers by Rawson (1950, 1951, 1953a, and 1953b). The facts which seem most pertinent to an understanding of the fishery are briefly summarized here.

Great Slave Lake lies in the Northwest Territories, and is centred at about latitude 62° N., longitude 114° W. It is the fifth largest lake in North America and the tenth largest in the world counting the Caspian and Aral Seas as lakes. It has an area of 11,070 square miles of which 10,430 square miles are water, the remainder islands. Soundings of over 2,000 feet have been taken which establishes it as the deepest lake in North America. The water from 380,000 square miles drains into Great Slave Lake, and it in turn is the source of the Mackenzie River.

The contact line between the Canadian Shield and more recent geological formations bisects the lake, running northwest and southeast between the mouth of the Slave River and Rae. The two halves are very different in several characteristics which affect the fishery.

To the southwest of the contact line the shore is low, the shoreline is regular and there are very few islands, so that the whole area is an unbroken expanse of open water. Inshore waters tend to be quite shallow and depths increase

very gradually to a maximum of 250 feet many miles offshore, except that near the contact line increase in depth is more abrupt and the maximum depth is 500 feet. The extensive open water, the shoal water inshore, and the dearth of harbours inherent in a regular shoreline, make this half of the lake more difficult for fishing operations.

To the northeast of the contact line the shoreline is very irregular, with long peninsulas, deep bays, and thousands of islands of all sizes. The islands are particularly numerous in a band across the lake starting about 30 miles from the contact line and extending about 60 miles farther northeast. Near the contact line the shore is relatively low, but farther northeast it becomes higher until at some places there are cliffs which rise abruptly for several hundred feet from the water's edge. Abrupt changes in water depths are characteristic of the northeast half of the lake. Particularly deep water is found throughout the Hearne Channel (maximum over 1,000 feet), in McLeod Bay (maximum over 900 feet) and in Christie Bay (maximum over 2,000 feet). The comparatively limited stretches of open water, many good harbours, and the deep water inshore make this the easier section of the lake for fishing operations.

The water in the 30-mile-wide strip between the contact line and the band of islands which, as mentioned above, stretch across the lake, is subject to continual mixing with water west of the contact line and necessarily has much the same characteristics. However the remainder of the northeast half differs noticeably from the southwest half in that the water is clearer and colder and plankton is only about half as abundant, particularly in McLeod Bay where it is only about one-third as abundant. Dissolved oxygen is adequate for all species of fish in both parts of the lake.

Great Slave Lake is greatly influenced by the Slave River from which the average inflow is about 118,000 cubic feet per second, about 90 per cent of the total inflow. During the summer it carries into the lake daily an average of about 60,000 tons of dissolved solids plus about 40,000 tons of silt. Most of the silt is deposited immediately at the mouth of the river, at such a rate that during the less than 10,000 years for which Great Slave Lake has existed, silt carried by the Slave River has completely filled what was a large bay extending to the south of the lake and in addition has formed a delta extending well into the lake. Some of the silt stays in suspension longer and causes the lake to be muddier off the mouth of the Slave River (from 10 to 40 miles offshore depending on rate of flow) than elsewhere. In summer the newly entered river water, which is recognizable by its excessive muddiness, is noticeably warmer than the rest of the lake. The dissolved solids become reasonably evenly distributed throughout the lake so that even in Christie Bay the concentration is about two-thirds as great as just off the river mouth. However in McLeod Bay, which is joined to the rest of the lake by a very narrow and shallow channel through which the current almost always flows southeast, the concentration is only about one-fifth as great as in neighboring Christie Bay. McLeod Bay, unlike

the rest of the lake, is also slightly acid. No doubt the abundance of dissolved solids (which promote plankton growth) brought in by the Slave River is an important reason for good fish production in Great Slave Lake.

THE FISH

Rawson (1951) lists 21 species of fish found in Great Slave Lake, exclusive of the genus *Leucichthys* which has not been identified to species. Only one additional species, yellow perch (*Perca flavescens*), has been collected since (Scott, 1956). There also has been an apparently authentic report of a chum salmon caught in the winter of 1946-47 in Great Slave Lake near the source of the Mackenzie. Two fishermen who are familiar with British Columbia salmon and who examined the fish, told a member of our field party on separate occasions that it was unquestionably a chum (dog) salmon. Dymond (1940) lists several records of both dog salmon (*Oncorhynchus keta*) and pink (humpback) salmon (*O. gorbuscha*) from the Mackenzie River, and cities one record of *O. keta* from the Slave River just below Fort Smith.

Two species make up over 95 per cent of the commercial catch, namely, lake trout (*Cristivomer namaycush*) and lake whitefish (*Coregonus clupeaformis*). Under some circumstances the species inconnu (*Stenodus leucichthys*), northern pike (*Esox lucius*), and yellow walleye (*Stizostedion vitreum vitreum*) are marketed, but comparatively few individuals of these species are caught. Other fish caught in quantities in commercial nets but never marketed are ciscoes (*Leucichthys* spp.) burbot (*Lota lota*), and two species of suckers, the rarely taken white suckers (*Catostomus commersoni*) and the frequently taken longnose suckers (*C. catostomus*. Round whitefish (*Prosopium cylindraceum*), American grayling (*Thymallus signifer*) and goldeye (*Amphiodon alosoides*) are occasionally caught in commercial nets. The northern lamprey (*Entosphenus japonicus septentrionalis*) makes its presence known by the characteristic sores found on a small proportion of the commercial whitefish. Whitefish with lamprey marks are found mostly in the southwest half of the lake particularly just to the west of the Slave River delta. The other nine species of fish listed by Rawson are an assortment of those which never become more than two or three inches long, hence never appear in the nets, although they are eaten by trout.

HISTORY

The first European to visit Great Slave Lake was Samuel Hearne, when in early 1772 on his return journey from the Coppermine River he reached the north shore of the lake just east of Gros Cap. Alexander Mackenzie traversed the lake in 1789 and he was soon followed by the fur traders.

The fur trade led to several permanent settlements, mainly of Indians, on or near the lake. The lake supplied the fish required by these settlements and by scattered families camped along its shores. The fishery for local use will be referred to as the domestic fishery. When first assessed in 1944 (Rawson

1947, 1949) the domestic fishery was taking an estimated 500,000 to 1,000,000 pounds annually, of which about one-third was species other than whitefish and trout, and about 80 per cent of the total was used to feed dogs. By that time, because aircraft had replaced dog teams to some extent as a means of transportation, the amount of dog food required annually had decreased appreciably, so that the annual catch of the domestic fishery must have been greater (probably not much greater) at an earlier date. Because of further replacement of dog teams as a means of transportation, and because unwanted fish suitable for dog food are a by-product of the commercial fishery, the annual production of the domestic fishery has decreased further since 1944. The protein requirements of the population of the recently established mining town of Yellowknife (the largest concentration of people in the Northwest Territories) are almost entirely supplied by food taken "down north" at great expense and only negligible quantities of local fish are used. When they can, local Indians buy canned fish from "outside" instead of using the excellent quality fish which abounds within sight of their homes.

In 1944, the Fisheries Research Board of Canada began exploring the fisheries resources of the Northwest Territories. As part of this program Dr. D. S. Rawson, of the University of Saskatchewan, made a biological investigation of Great Slave Lake during the summers of 1944, 1945, 1946, and 1947. By the end of the first summer it was obvious that the lake could support a substantial commercial fishery. Dr. Rawson estimated that at least 3 million pounds per annum could be taken in addition to the domestic catch, but pointed out that it was only a tentative estimate and that the question should be subject to review.

As there were no roads or railways to the lake at that time the type of commercial fishing operation usually carried on in Canadian lakes was impossible. However, there was one fish company, McInnes Products Corp. Ltd., that had the equipment needed to handle fish when only water transportation was available. This firm was then operating on Lake Athabasca and when they decided to fish in Great Slave Lake instead, it was a simple matter to move their equipment down the Slave River to Great Slave Lake, especially since most of their fish plant was permanently set up on barges. They established a camp on an excellent centrally located harbor, which camp has become known as "Gros Cap" after a prominent geographical feature of that name in the vicinity. At this camp the individual fishermen's catches were bought, then the fish, either dressed or filletted, were frozen and loaded on refrigerated barges. These barges were taken across Great Slave Lake and up the Slave River to the foot of an impassible rapid at Fort Smith. Here the fish were unloaded and taken in insulated trucks to the head of the rapids where they were loaded into other refrigerated barges, then taken up the rest of the Slave River, across Lake Athabasca and up the Athabasca River to the railhead at Waterways, Alberta. This firm also experimented with the transportation of fish by air, but abandoned the idea as unprofitable.

Commercial fishing began for the first time on Great Slave Lake on July 29, 1945. At first only the grounds close to Gros Cap were fished but gradually the fishermen went farther and farther afield until they were fishing most of the northeast half of the lake, although they never went far into the southwest half of the lake. Dr. Rawson's field party took some observations on this fishery in 1945, and other essential information has been supplied by Mr. M. B. Bell, who was the Fisheries Officer at Gros Cap in 1945. Commencing when fishing started in 1946, as directed by the Fisheries Research Board I established and gave general supervision to a detailed scientific study based on the Great Slave Lake commercial fishery. Starting in 1949, Messrs. L. J. Stephen, R. R. Wheaton and D. C. Scott were successively in charge of the project at Great Slave Lake and responsible for annual analysis of the data. All were ably assisted by Mr. R. M. Hanson.

In August 1948 an all-weather road was completed which linked the settlement of Hay River on Great Slave Lake with the road network of the Province of Alberta. This made it possible for fish companies which did not own costly freezing and water transportation facilities to operate. Even before the road was completed some Great Slave Lake fish had been taken to market over the roadbed during the winter when it was frozen enough to make it possible. Until 1948 the maximum annual catch allowed on Great Slave Lake was $3\frac{1}{2}$ million pounds in dressed weight of all species marketed, and this limit had never been quite reached. With the new road it was obvious that more than the limit could be taken. It seemed a good time to follow Dr. Rawson's recommendation and review the question of whether the $3\frac{1}{2}$ million pound annual limit was still indicated. The data collected during the study of the commercial fishery were examined and it was seen that even though enough fishing effort to take most of the existing limit had been concentrated in a relatively small part of the lake, that part showed no signs of overfishing. It therefore seemed safe to double the existing limit, if fishing pressure could be distributed reasonably evenly over the whole lake. A new limit of 9 million pounds[2], on the basis of round trout and whitefish only, was therefore set. To guard against local overfishing, boundary lines were defined which divided the lake into four areas, each of which was assigned a quota of the over-all annual limit. Although there have been some adjustments among areas, the over-all limit of 9 million pounds per year has remained unchanged (as of 1955).

With the new road and the higher limit, several fish companies established plants in the settlement of Hay River. This settlement is at the mouth of the river of the same name, and the river mouth is one of the few harbours in that part of the lake. The importance of Hay River as a base for fishing has increased

[2]The previous limit of $3\frac{1}{2}$ million pounds included all species of fish and specified dressed weights. Three and one-half million pounds dressed of all species represents about 4 million pounds of whitefish and trout before dressing. It was assumed that the domestic fishery would take another million pounds to give a maximum permitted production of 5 million pounds under the original limit. The new limit with 9 million pounds for the commercial fishery and one million pounds for the domestic fishery was therefore double the old limit.

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until now more than three-quarters of the fish caught (over half the summer catch and all of the winter catch) are shipped from there. At the same time the importance of Gros Cap as a fishing port has diminished because part of the equipment has been moved back to Lake Athabasca.

Annual production is shown in a later section (column 2, Table XVIII). The new limit has been reached only once—during the year immediately after it came into effect. In subsequent years, although the annual quota in the area nearest Hay River was inevitably taken, as well as most of the quota in the second nearest area, it has so far never been profitable to take more than part of the quota from the two more remote areas.

THE FISHERY

GILL-NETS

Gill-nets are the only gear used for catching commercial fish in Great Slave Lake. Although this type of gear is widely used, its use apparently has never been described in detail. The following description applies more or less to most gill-nets as used in the freshwater fisheries of this continent.

The "web" of a gill-net consists of tough, fine threads (twine) tied to one another in such a way as to form a network of equal sized squares each called a "mesh". The edges of the web are tied to "sidelines" which are stout cords that hold the web in the required shape and also take the various strains put on a gill-net. Along one edge of the net, moulded pieces of lead—called "leads"—are clinched to the sideline at regularly spaced intervals. Along the other edge buoyant objects known as "corks" are tied to the sideline, one opposite each lead. In the water a gill-net rests with a "lead line" on the lake bottom, and the rest of the net perpendicular to the bottom, because of the buoyancy at the "cork line".

Gill-nets vary in length, depth, thread size and other characteristics. Generally several gill-nets are tied end to end to make a "gang" of nets. A gang is always anchored at each end, and may also be anchored at one or more intermediate points. In Figure 1 one end of a gang is diagrammatically represented as anchored by an iron anchor of the kedge type, but rocks and other heavy objects are often used particularly in winter. A buoy, generally called a "flag", such as that represented in Figure 1 is attached to each end of the gang so that the gill-net can be located and brought to the surface. In winter the buoy is replaced by a stick frozen upright in the ice, otherwise the arrangement is exactly the same.

A gill-net catches a much wider size-range of fish than it would take if, as its name implies, it caught only those which put their heads in far enough that the mesh is behind the gill covers. In fact, in Great Slave Lake gill-nets capture most effectively only those commercial fish which are too big to put their heads through a mesh. (Kennedy, 1953 and 1954). They are caught when various mouth parts become entangled in the web.

Summer Fishery

The summer fishing season begins as soon as the lake is free of ice, generally just after the middle of June, and ends by regulation on September 15. A few local residents take part in the commercial fishery, but most of the fishermen live elsewhere, come to the lake for the fishing season only, and return home when it is over. Although fishermen from the Yukon, British Columbia, Alberta, Saskatchewan, Manitoba and Ontario have all taken part, most summer fishermen are either from the vicinity of Lesser Slave Lake or from the shores of the three large lakes in Manitoba. Each boat crew consists of at least two and not more than four fishermen, including the skipper. In some boats two men are partners but usually the skipper hires the rest of the crew. The majority of skippers own no equipment except their gill-nets. A fish company rents

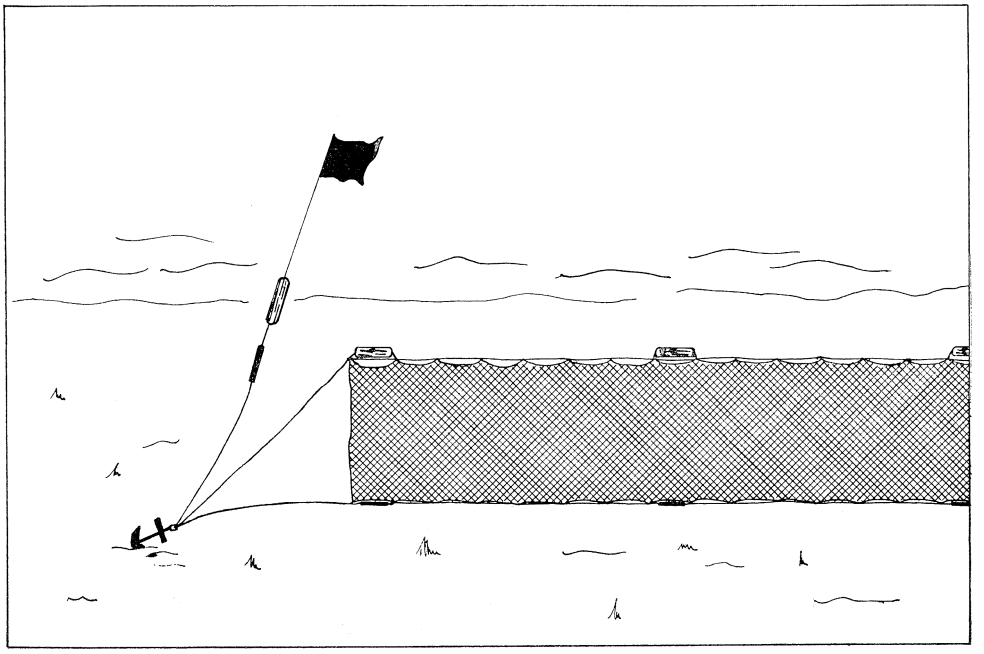

Figure 1.—Diagram of a gill-net in operation as it is most often set by Canadian freshwater commercial fishermen. See text for details.

them boats and the leads and corks for their nets (which are removed at the end of the season), sells them new nets and other gear on credit, and provides substantial cash advances as required. Such a skipper must sell his fish to the fish company which financed him. Even the skippers (about six in 1954) who own their boats and require no credit generally sell all their catch to one fish company.

Until recently the fishing boats were a motley assortment brought in from all over Western Canada from wherever second-hand boats to fill the needs of

the rapidly expanding fishery could be found. The only characteristics common to all were wooden hulls and gasoline motors. The nearest to a definite type was the boat in most common use at Gros Cap, built originally for use in Lake Athabasca, and actually too small for best results on Great Slave Lake. They are 28 feet long, powered with 10- to 15-h.p. gasoline motors and carry 3 to 4 tons of fish under ideal conditions. Experience has now shown what is needed and new boats of the required design are gradually replacing the others. The new boats have wooden hulls, are 35 to 45 feet long, of 10 to 12 foot beam, draw just over 3 feet of water, are powered with 30- to 70-h.p. gasoline motors, can carry over 5 tons of fish, and have a deckhouse amidships (nearer the stern) capable of giving reasonable shelter to a crew of four.

Gill-nets are "lifted" as follows. The flag at one end (generally the down-wind end) is taken aboard and the attached rope is pulled in until the anchor and the end of the net comes up. The net is then hauled in. In this process the two sidelines are kept together, and the web tends to collapse and to adhere to the sidelines, so the net can be handled as if it were a piece of rope. Any fish caught are removed from the mesh (picked) and the net is coiled away in a wooden box with flaring sides and ends (for compact stacking when empty) called a "net tray". Pulling in the net, moves the boat along and if there is much wind the boat's motor is used to move the boat as required thereby making it easier to lift the nets. On some boats one fisherman stands in the bow and pulls in the net hand over hand while the others, behind him, remove the fish and coil away the net. On other boats (as in Figure 2) nets are "walked in": a man grasps the net where it is coming in over the bow, walks aft for about 15 feet, releases it, and walks forward again. Meanwhile another man has walked forward, and as the first releases the net he takes over and follows exactly the same procedure. At the same time one or more men are picking fish and coiling the net away.

Nets are set again as follows. A tray of nets is placed near the stern, an anchor and flag are attached and thrown overboard. With the boat running ahead at reduced speed the net is paid out over the stern. One man "spins" by sitting near the tray and letting the net—still in the form of a "rope"—run through his hands, keeping the proper tension on it. Another man "spreads" by letting the cork line run through his hands and holding it up which separates it from the lead line and spreads out the web. Considerable skill is required, particularly on the part of the spinner, to avoid having leads and corks become entangled in the web.

The methods of Gros Cap fishermen differ in detail from those used by Hay River fishermen although the differences are disappearing. The differences can mostly be attributed to the fact that Gros Cap fishermen prefer to catch trout rather than whitefish to a greater extent than do Hay River fishermen. These differences in primary objective in turn are the result of the following factors: (1) trout are more "abundant" than whitefish on the grounds nearer Gros Cap while whitefish are more "abundant" than trout on the grounds nearer

Hay River; (2) the prices offered at the two places encourage the respective objectives; (3) most Gros Cap fishermen were fishing for trout before they came to Great Slave Lake while most Hay River fishermen were fishing for whitefish, and the men of each group still tend to use the techniques they know best. Gros Cap fishermen in general have always used gill-nets with coarser twine in the web than do Hay River fishermen. Although fish probably sense finer twine to a lesser extent than they sense coarser twine, hence are more likely to be caught in the former, finer twine is also weaker, and although able to hold whitefish is less likely to hold trout which get to be much bigger therefore more powerful. Other differences in methods arise because: (1) the Hay River fishermen fish mostly in the southwest half of the lake, which as shown in an earlier section differs considerably from the northeast half where the Gros Cap fishermen

FIGURE 2.—Lifting a gill-net with one of the newer Hay River boats. The man to the right is holding the net and is just beginning to walk backwards. The next man has just released the gill-net and is walking forward again. The other two are picking fish. Note the upper part of two flags that have been taken aboard and secured alongside the deckhouse.

generally fish; (2) because of lower prices offered them, Gros Cap fishermen must catch more per day to "break even"; (3) available equipment is different. In addition, the technique of each fisherman differs to some extent from that of every other fisherman.

The two fishing centres differ in the way that the catch is handled. Except when fishing is in the immediate vicinity, Hay River fish companies establish temporary bases at various places. A temporary base consists of one or two barges on which are facilities for handling fish and living accommodations for

fish company employees. The barges are anchored in a reasonably well protected place (there are seldom good harbors near the grounds fished by Hay River fishermen), the harbor being changed several times during a summer. Living quarters are not usually provided for the fishermen who sleep on their boats or put up tents ashore (if they can get ashore) and prepare their own food. Some fish companies have built ice houses at favorite temporary bases and there is a tendency for other shore facilities to be built near such ice houses and for such bases to become permanent fish camps. Since the temporary bases are near the grounds being fished at the time, the fishermen land their catch shortly after capture. The fish are unloaded onto the barge where the fishermen dress them. The catch is then weighed and the total brought in by each fisherman is recorded as a basis for later payment. Fish company employees then take over the handling of the fish. They weigh out standard quantities (generally 60-pound lots), and then pack each in wooden fish boxes with ice above and below the fish. The boxes of fish are held in "coolers" (temperature just above freezing) aboard the barge until enough are accumulated (generally not more than two days). Then the boxes are taken by boat to the fish company's headquarters in Hay River. The boats used to freight fish to Hay River were originally not much bigger than the fishing boats and in fact fishing boats have often been used, but the tendency is to build larger boats specifically for freighting fish. At Hay River, ice is added to the top of each box of fish, and they are then loaded into refrigerated trucks and hauled by road to the railway at Peace River or Edmonton, Alberta. When fishing is close to Hay River the fish are landed and packed there.

Gros Cap fishermen always land their catch at Gros Cap (Fig. 3) which necessitates long trips in most cases—a trip of 6 hours (each way) is commonplace and trips of as much as 12 hours have been made. During the long run home the fish are dressed and special precautions are required to keep them in good condition during the trip. At Gros Cap the fish are weighed and the fishermen credited accordingly. Some are then frozen in large freezing rooms without further preparation except that they are washed. Others are filleted and the fillets are cut into small pieces which are wrapped, put in standard frozen food packages, and plate frozen. In either form, when the fish are thoroughly frozen they are packed in cardboard cartons and loaded aboard refrigerated barges for water transportation to the railhead. In some years part of the catch at Gros Cap has been packed in ice, taken to Hay River by boat, and sent over the road to the railway.

Winter Fishery

The winter fishery by regulation lasts from December 1 to March 31. It is based entirely at Hay River. Although some summer fishermen also take part in the winter fishery, the winter fishermen in general are an entirely different group, mostly farmers from the northern settled areas of Alberta and Saskatchewan. As a rule two men work together, and although they may be partners,

more often one has the entire financial responsibility and hires the other. Usually a fish company finances the venture, and all fish are sold to that fish company.

Although gill-nets are used exclusively, and although when set they are exactly the same as those set in the summer, fishing methods are quite different. To lift a net, the little sticks frozen upright in the ice which mark each end of the net are located. Then a round hole about 2 feet in diameter is made in the ice at each end by using a "needle bar" which is a bar of iron about 8 feet long with a hand grip on one end and a sharp point on the other. The needle

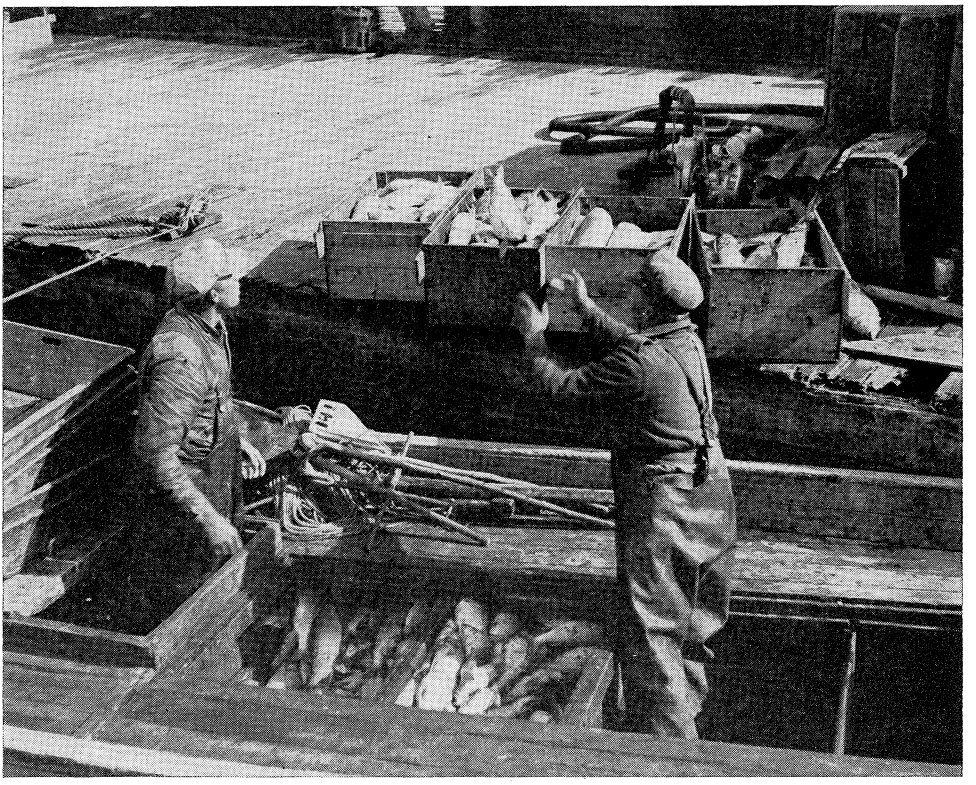

FIGURE 3.—Unloading the catch at Gros Cap. The man at the right has just thrown a whitefish from the hold of the fishing boat into one of the boxes in which fish are kept until processed. From left to right are two boxes of whitefish, a box of "headless" trout, a box of dressed trout and a lone inconnu. Behind the man to the left is a stack of net trays and beside him is an assortment of net flags (lower part only visible), net anchors and appertaining rope.

bar is used like a gigantic ice pick, and periodically a scoop shovel is used to remove the ice chips from the hole. The edges of the hole must be free of rough projections which would catch in the net, and many fishermen use an "ice chisel"—which is much like the needle bar except that the sharpened end is chisel-like—to finish the hole, but others use only the needle bar. When

the holes (they are known as "basin holes") are completed, each end of the net is pulled up and untied from the anchor stones. A length of rope, the "running line", is attached to one end of the net, then both fishermen haul in the net through the basin hole at the other end. They stand several feet behind the basin hole, one man pulling on the head line, the other on the cork line (Fig. 4). This causes the net to form a pile on the ice with the leads all at one side, the corks all at the other side, and the web stretched between. Since the water

FIGURE 4.—Lifting a gill-net through the ice. The two men farthest back, each pulling a sideline, are the fishermen. There are two visitors from the snowmobile at the left—one helping to pick fish, the other examining the catch which is strewn on the ice. In the foreground is the basin hole, to its right the stick which marks the position of the net, to its left a needle bar.

which impregnates the net freezes before the net reaches the pile, the pile does not freeze together. The fishermen stop frequently to pick the fish since they must be removed before they and the net become completely frozen. If there is trouble in this regard, part of the net is put back in the basin hole to thaw out. As can well be imagined, handling wet nets and fish at sub-zero temperatures is cold work. Winter fishermen carry a generous supply of dry mittens and change frequently. Fishing operations are usually suspended when it is colder than about −40° F.

The net is reset as follows. One fisherman goes to the basin hole opposite that where the net is stacked on the ice. He picks up the running line, which was pulled under the ice as the net was lifted and now is under the ice from one hole to the other, and with the running line over his shoulder he walks in the direction away from the pile of net, leaning well forward because of the heavy pull. This drags the net back through the basin hole and under the ice into its original position. The other fisherman watches the net and sees that it pays out properly. When the net is in its former position, the ends are re-tied to the anchor stones and allowed to settle to the bottom. Since nets are set end to end, the number of holes required each day is only one more than the number of nets lifted.

Catch per net decreases considerably from lift to lift at a given place so that nets have to be moved frequently. At a new locality a "jigger" (Sprules, 1949) is used to get the running line under the ice, otherwise the setting procedure is the same. At the beginning of the season basin holes are relatively easy to open but later, when the ice becomes as much as 6 feet thick, each hole becomes a major chore. To re-open a hole in thick ice calls for less work since a basin hole takes several days to freeze to the original thickness.

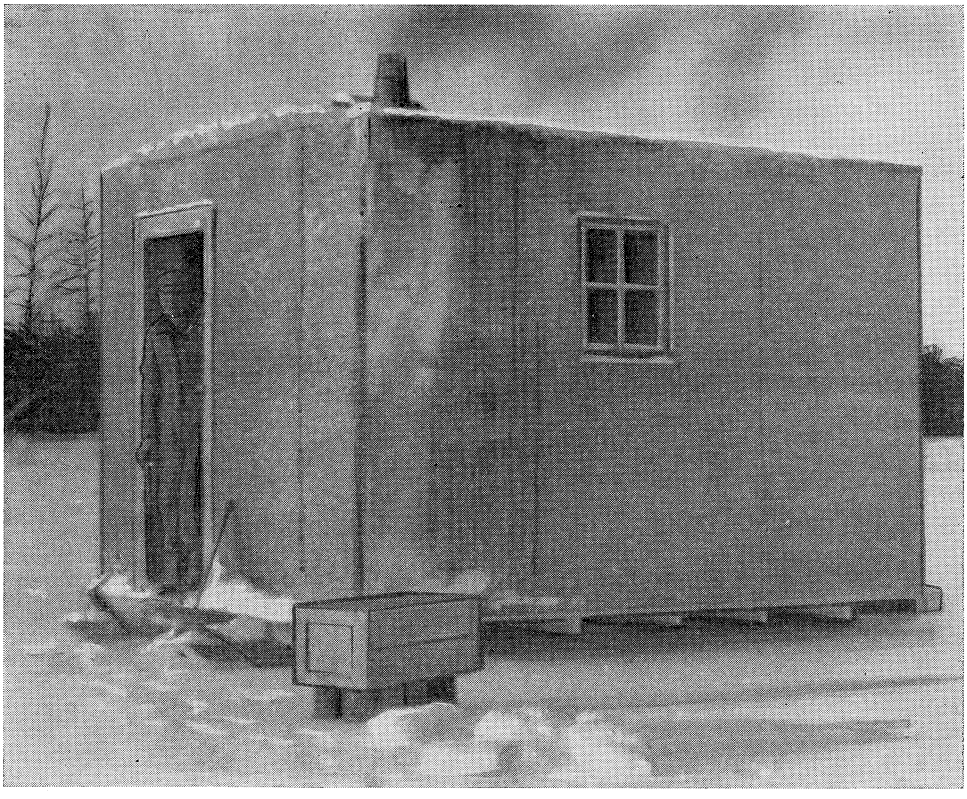

FIGURE 5.—A caboose—typical winter living quarters for two men. Note the skids under it so that it is easily moved.

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Treatment of the catch depends on whether it is to be sold as "fresh" or as "frozen". Since frozen fish sell for less, the catch is kept unfrozen by a variety of improvised devices unless there is no immediate prospect of transportation. Frozen fish are dressed immediately after capture, are spread out to expose them to the sub-zero air temperatures which generally prevail, then when completely frozen are piled at convenient places. Fresh (i.e. unfrozen) fish are generally not dressed on the ice; they are dressed later in Hay River under more comfortable conditions.

Most winter-caught fish are moved to Hay River in a snowmobile, which is a tracked mechanical vehicle. Some fishermen own such snowmobiles but in most cases they are owned by the fish companies or by private individuals who carry fish at rates which depend on the distance from Hay River. Almost every known type of mechanical vehicle, as well as dog sleds and aircraft, have been used to transport fish but the snowmobile has been found the most satisfactory. At Hay River the various fish companies prepare the fish for shipment as described in connection with the summer fishery, and send them by truck to the railway.

Each team of fishermen lives in a "caboose", a light well-insulated shack about 12 feet long and 10 feet wide mounted on skids (Fig. 5). Each caboose is on the ice near the nets and may be many miles from land, even many miles from another fisherman. When the general locality of the nets is changed, the caboose and fishing gear are towed to a new location by a snowmobile or other vehicle. The snowmobile brings various supplies and is the fishermen's main contact with the rest of the world. Most fishermen use a handsled for local transportation of fishing gear and fish.

PART II. SCIENTIFIC STUDY OF THE FISHERY

The study which the Fisheries Research Board has been conducting on Great Slave Lake has produced some interesting and useful results which are reported in Part II. Part II is also used to put on record certain data and ideas and discussions which contribute nothing to the conclusions that can be reached now but which may be needed when more data are available and when those who collected and analysed the early data are no longer available.

METHODS OF COLLECTING AND ANALYSING DATA

The following descriptions of techniques apply to the summer fishery only except for the section which specifically deals with the winter fishery.

AREAS

Limited tagging of trout and whitefish has shown that although some individuals, particularly trout, travel considerable distances, the average individual moves relatively little in the course of a year. Therefore, for statistical purposes, the lake was subdivided into thirteen "Areas". Each area is designated by a letter, and the letters are more or less in alphabetical order from southwest to northeast. The lake has also been subdivided into four parts for administrative purposes, but these subdivisions, which are designated by numbers, have nothing to do with our statistical areas which are designated by letters.

The boundaries of the areas and their designations are shown in Figure 6. Some of their characteristics are shown in Table I.

The areas are by no means of equal size. Instead they are defined in such a way as to group together parts with similar characteristics. Areas A to E inclusive are in the southwest half of the lake while the remainder are in the northeast half. The bottom in Area A is very regular, depths increase gradually from shore to the outer boundary and the area is noted for its production of non-commercial species of fish. Area B embraces the Slave River delta and, in spite of the good catches possible, is an unattractive fishing ground because of the debris from the river which fouls nets and tears them and because an unusually high proportion of the commercial fish are of unmarketable quality. Area C embraces the whole centre of the main body of the lake, it is deep at the eastern end, shallower in the middle and slightly deeper again toward the west, and although probably quite productive it has remained almost unexploited because the fishermen prefer to fish within sight of land. Area D is much like Area A, but it deepens a little faster offshore and there are several submarine ridges. Area E is shallow inshore, drops rather abruptly into a trough about three miles offshore beyond which is shallower water and it is noted for producing large trout. Area F is a mixture of the conditions in Areas E and G. In Area G the

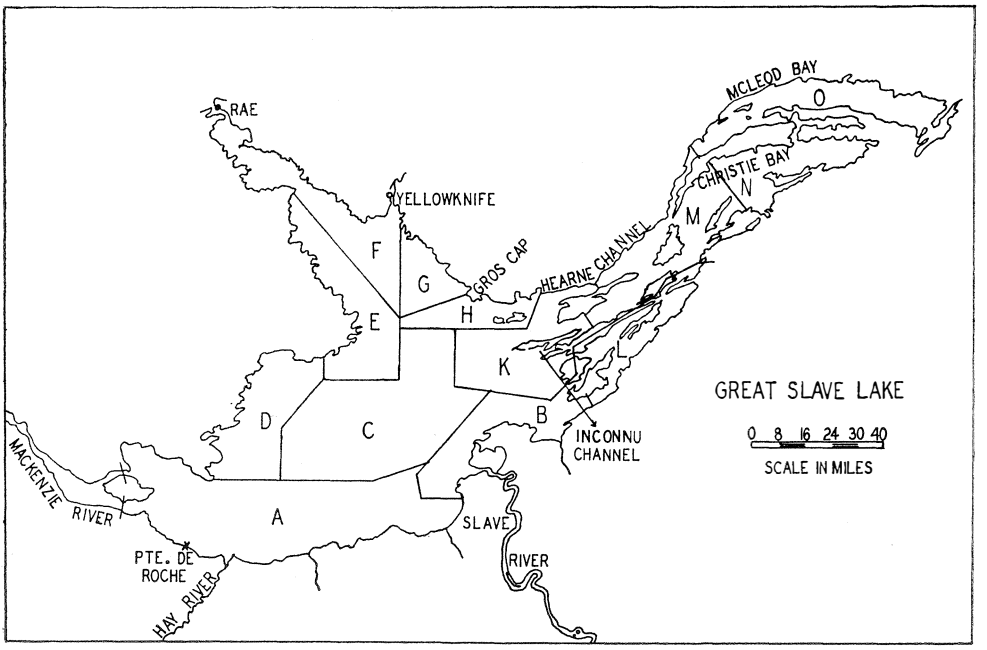

FIGURE 6.—A map of Great Slave Lake showing the boundaries of the statistical areas and the letters by which they are designated. Place names mentioned in the text are shown.

TABLE I.—Some characteristics of the subdivisions, designated as Areas (see Fig. 2), into which Great Slave Lake has been divided for scientific study of the fishery.

Area	Maximum depth	Average depth	Fishing grounds[a]	Percentage of lake surface	Percentage of lake volume
	feet	*feet*	%	%	%
A	150	57	74	19.3	6.0
B	220	67	44	4.6	1.7
C	530	215	36	17.6	20.6
D	230	93	55	7.3	3.7
E	410	134	56	7.7	5.6
F	200	55	54	7.4	2.2
G	160	87	70	3.0	1.4
H	980	140	44	2.8	2.1
K	1,050	158	54	7.7	6.6
L	630	175	44	3.5	3.3
M	1,820	497	15	6.7	18.3
N	2,010[b]	590	12	5.4	17.3
O	980	293	21	7.0	11.2

[a]The percentage of the Area which is potential fishing grounds, that is more than 25 and less than 150 deep—the range within which most commercial fishing on Great Slave Lake is done.

[b]The echo-sounder on the Fisheries patrol vessel *Daphnia* has registered a depth of 2,050 feet (personal communication from Mr. H. V. Dempsey).

water deepens offshore fairly regularly although there are some submarine ridges and holes. Area H consists of a large submarine east-to-west ridge, which becomes islands and shoals at some places, with a trench on either side, of which the one to the north is particularly deep. Area K has a very irregular bottom and contains thousands of small islands as well as a few larger ones. Area L is almost completely separated from the rest of the lake by islands. Most of Area M is too deep for fishing and the same applies to Area N. Area O is deeper, clearer and colder than the rest of Great Slave Lake to which it is connected by a very shallow and narrow strait.

Time Intervals

In the preliminary analyses the data were grouped by time intervals within each area. The time intervals used were from the first to the fifteenth of each month, and from the sixteenth to the last day of each month. Only a few analyses by half months are shown in this paper, but all are tabulated in a series of 15 Manuscript Reports that are on file at each Station of the Fisheries Research Board of Canada.

In the analyses given later in this paper the year shown is always the "fishing year" rather than the calendar year. A fishing year is defined as the interval from May 1 of one calendar year (which calendar year is used to designate the fishing year) to April 30 of the following calendar year. Thus the summer season, June to September, and the following winter season, December to March, are considered as a unit (the two seasons named are the only times at which commercial fishing is legal).

Catch per Unit of Fishing Effort—The FS-Index

Data for calculating catch per unit of fishing effort were collected by having investigators interview as many fishermen as possible each time they landed fish. The fishermen were asked for information on how many nets were lifted, the time elapsed between setting and lifting, where nets were set, and approximately what quantity of fish both of commercial and of non-commercial species was caught and discarded. The interviewer recorded all this information as well as the weight of fish which the fish company credited to the fisherman for the day.

Ideal interviewers are men who can "talk the fishermen's language". Every effort was made to gain the fishermen's confidence, particularly by assuring them that all information would be confidential. Newly contacted fishermen were inclined to be reticent and evasive but within a short time (generally not more than a year) most of them were supplying good information. Familiarity with the fishermen made it possible for interviewers to assess the reliability of the information and to make various independent checks for verification. In particular, every effort was made to verify the amount of gear used, since any fishermen who were using more than the legal amount might be expected to try to hide this fact. The value recorded for amount of gear fished was always the

most probable value, whether or not that value coincided with the fishermen's statements. It has been possible to interview every fisherman at Gros Cap almost every time that they lifted, but it was not possible to get as complete coverage of the Hay River fishermen. The percentage of fishermen interviewed is shown in column 6 of Table XVIII.

The first step in analysing these data was to compare the records of each boat from day to day, to reconcile if possible any inconsistencies and to discard all data considered unreliable. Then the weights of fish as bought (i.e., dressed fish) were multiplied by a factor to find their weight when captured. These factors had been previously determined by weighing individual fish, then having them dressed by various fishermen, then weighing each again. The factors also take account of the fish companies' practice of entering in their books an amount less than the actual weight, the difference being called a "shrinkage allowance". Whitefish and smaller trout were almost always sold dressed, that is they had the viscera and gills removed, but larger trout had the head cut off also. The factors required to convert recorded weights to weight when captured varied because of variations in shrinkage allowance. To the calculated weight when captured of all the fish sold was added an estimate of the fish which were caught, but, because of poor quality or for other reasons were not sold, to give the total weight of fish actually caught. Catches were summed to give the total catch of all interviewed fishermen for each half month in each area.

Total fishing effort was also determined for each half month in each area. Since most gill-nets on Great Slave Lake are a standard length (namely 100 yards long) then the obvious unit of fishing effort is a net-night, defined as the fishing effort exerted when 100 yards of typical gill-net are set, then lifted 24 hours later. In Great Slave Lake most commercial fish apparently are caught during the darker hours (because of the latitude it never becomes really dark during June and July), also nets are generally lifted and set during the lighter hours, hence a "net-night" rather than a "net-day". Unfortunately, gill-nets are sometimes not lifted every 24 hours, and since catch is not directly proportional to the interval between setting and lifting (the greater the catch per net, the less will a two-night catch differ from a one-night catch) some adjustment is required in such cases. Kennedy (1951) gives factors suitable for expressing fishing effort on Great Slave Lake in comparable terms regardless of the interval involved. By the use of these factors all fishing effort is converted to "equivalent net-nights" where the amount of gear that must be fished for a given number of nights to give the same average catch as 100 yards fished for 24 hours under identical conditions is defined as one equivalent net. By dividing each catch total by the corresponding equivalent net-night total, values for catch per unit of effort during each half month in each area were calculated.

Values for catch per unit of fishing effort are often referred to by some term such as "availability" which could be regarded as implying that catch per unit of effort is closely related to the amount of commercial size fish on the fishing

grounds. In this paper catch per unit of effort is referred to as the index of fishing success, which is shortened to FS-index. FS-index is intended only to record a characteristic of the fishery without necessarily implying anything about the abundance of fish. Preliminary analyses have shown that comparisons using an FS-index based only on those cases where nets were lifted every 24 hours would lead to essentially the same conclusions as those reached on the basis of the FS-index actually used. For the summer fishery, FS-index refers always to the number of pounds of the species in question (weight caught whether landed or not) caught per equivalent net-night.

Total Catch

The total catch taken by all fishermen whether interviewed or not was calculated as follows. The amount landed by non-interviewed fishermen was determined from fish company records, and sufficient enquiries were made to determine roughly what percentage of the fishing effort was exerted in each area at any given time. These data, together with the FS-index, made it possible to calculate with reasonable accuracy the amount of fish landed by non-interviewed fishermen in each area during each half month. An estimate was also made of the fish caught and discarded on the assumption that discarded fish formed the same proportion of the non-interviewed fishermen's catches as they did of the interviewed fishermen's catches, except that an adjustment was made if the habits of the two groups were known to differ in some way that would effect the proportion discarded. The known and calculated weights were then added to give total calculated catch in each area for each half month.

Obviously the usefulness of values for both total weight and FS-index depends on the reliability of the weights recorded by the fish companies. The various investigators have satisfied themselves that these figures are reliable. In particular, a careful check on one fish company for two summers showed that the quantity of the final product which left the plant (which quantity the field party could determine without question) was consistent with the amount of fish which the company recorded as caught.

As noted above, the interviewed fishermen were asked to estimate the quantity of non-commercial fish caught, and independent checks have shown that in most cases their estimates are reasonable. On the assumption that the catches of non-interviewed fishermen (this category included fishermen who seemed to make consistently unreasonable estimates) had the same proportion of non-commercial fish as did the others, the total quantity in pounds of each species of non-commercial fish caught in each area during each half month was calculated.

Average Size

Average size was determined from fish which were "borrowed" from their owners and which were generally available for only a few minutes. Hence all techniques used were designed to reduce to a minimum the time taken to deal

with a lot of fish. Among other things, it was considered too time consuming to record both length and weight. It was decided to record weight rather than length because (1) the weight of an individual not its length is the essential datum—the total weight of a group of fish is used frequently but their total length if laid end to end is of little interest; (2) weight could be taken more quickly than length; (3) length would be meaningless in the case of "headless" trout (see below). Lengths can be derived from the weights by published formulae (Kennedy, 1953 and 1954) if they are required. All weights were determined on a spring scale held in the hand except that the few which weighed more than the scales used would register (generally 30 pounds) were weighed on the fish company's scales.

Individual fish were weighed shortly after they were landed, while it was still evident whose catch was being examined. The original plan was to take, where possible, a sample of about 500 (more in recent years) of each species from the catches made in each area during each half month. Typically every sample was composed of several subsamples, where all the fish used from one catch constituted a subsample. Ideally subsamples were taken in such a way that when put together they would be fully representative of the fishery for the area during the half month. In the earlier years we did not fully realize the importance of getting large samples and of choosing for sampling catches that were in detail representative for time and place. Even after we fully realized the importance of large representative samples it was found impossible to make the subsamples strictly representative because the detailed pattern of distribution of fishing pressure was never fully apparent until sampling for the half month was finished. In any case, the various investigators did their best to eliminate bias, and the catches sampled can be regarded as reasonably representative of the whole fishery.

Subsamples of whitefish were taken as follows. Fish were observed as they were being unloaded from the holds of the fishing boats to boxes on the dock or barge (see Figure 3), to make sure that there had been no sorting for size before reaching the dock—with few exceptions they were piled indiscriminately in the fish holds as they were caught and re-piled in approximately the same order if they were dressed aboard. A box of fish was then chosen at random. If there were few fish in the box all were weighed, but if there were too many to allow all to be weighed, care was always taken to weigh the uppermost fish. Unless such precautions are taken people inevitably tend to take the larger fish out of a box first. When whitefish had been dressed before the boat docked, each individual weight was subsequently multiplied by the factor 1·1765 to convert it to round weight. This factor is different from the one used in dealing with recorded catch since the latter must take account of the shrinkage allowance. When whitefish were dressed after the boat docked the fish were weighed before they were dressed so a conversion factor was, of course, unnecessary.

When trout were not dressed until after they were unloaded the same procedure was followed. However, when they were dressed before the boat docked, the procedure was complicated by the fact that the larger trout had had their heads cut off, and the smaller ones did not, and that the two categories were separated because different prices were paid. Great care was taken to make sure that the proportion of headless trout to dressed trout in the subsample corresponded to the proportion in the boatload which provided the subsample. One or more boxes of dressed trout and the corresponding amount of headless trout were together regarded as the subsample. Later the individual weights for headless trout were multiplied by 1·6667 and those for dressed trout by 1·2048 to convert them to round weights.

Winter Fishery

The above descriptions apply to the summer fishery only. An attempt was also made to study the winter fishery during the five winters 1948-49 to 1952-53 inclusive. However, winter fishermen are scattered over the fishing grounds to such an extent that a party of two investigators even with the best transportation can only contact about 2 per cent of them per day. The winter data are therefore very meagre. Eventually the winter study was terminated because the information obtainable did not seem to justify its continuation.

In winter, nets are never lifted oftener than every two or three days, and since it seemed inadvisable to use the summer factors for converting to equivalent net-nights without confirming that the relationships are the same in the winter as in the summer, the net-night was obviously useless as a unit of winter fishing effort. A different unit of fishing effort was therefore chosen to apply to the winter fishery—the "net-lift". A net-lift is defined as the fishing effort exerted by 100 yards of gill-net between the time it is set and the time it is lifted, however long that interval may be. Since the interval can vary, the net-lift is obviously a poor measure of fishing effort, yet it probably has some value for purposes of comparison because the average time interval has remained relatively unchanged from year to year, although it has increased slightly. Generally the weight of the catch was estimated when the number of net-lifts was recorded because the fish were not weighed by the fish company until they reached Hay River, by which time they could not be related to specific nets. Some of the information on fishing effort and estimated catch was recorded by the field party, but more often it was recorded by interested fishermen who were visited at intervals. By dividing the estimated catches by the number of net-lifts involved, a winter FS-index (in pounds per net-lift) was determined. The winter FS-index cannot, of course, be compared with the summer FS-index.

By knowing the total weight bought by the fish companies, the approximate distribution of the fishermen, and the comparative FS-indices in various areas, it was possible to calculate about how much of each commercial species was taken in each area. Fortunately all commercial fish caught were sold, so no correction for discarded fish was necessary. On the basis of the ratio of

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non-commercial fish to commercial fish among the few fishermen visited, a rough estimate of total catch of the former by species was made.

Average weights of winter-caught fish were determined in the same way as in the summer, except that generally the investigators went to where the nets were being lifted and weighed the fish as they were being picked or shortly afterwards. These averages are therefore probably less subject to inadvertent selection for size than are the summer samples. However, because of travel difficulties, a winter sample may be less representative of a whole area than is a summer sample.

AVERAGE WEIGHT

The average size of fish taken by the commercial fishermen was tabulated by half month periods for each year in each area. These data are too extensive to include here: they are on file in manuscript reports at all Stations of the Fisheries Research Board and typical examples are shown in the Appendix. Highlights of the data on file are as follows.

In all areas average size fluctuated greatly from half month to half month. Typically the average size of trout has tended to decrease through the summer so that it is generally noticeably less at the end of each fishing season than at the beginning of the next fishing season by more than could be attributed to growth in the interval (Kennedy, 1954). There might have been a slight tendency for the average size of whitefish to be greater in the middle of the season than at either the beginning or the end but it was by no means as obvious as was the trend in trout sizes.

Trout

Average sizes of trout when half monthly samples are grouped by areas for the whole summer are shown in Table II—the lower part of the table shows the number of fish in each sample. Statistical analyses that are on file indicate that to be significantly different these average weights must differ by about 0·5 pound where each sample consists of 500 fish, by about 0·25 pound where each sample consists of 1,000 fish and by about 0·1 pound where each sample consists of 10,000 fish. It appears that average size has decreased in most, if not all, of the areas, which is the expected result of fishing. In the areas which have been fished longest there seems to be a tendency for average size to become stabilized within the most recent years although there is no area for which it could be positively stated that the average size is no longer declining. The outstanding decline in Area E is the expected result of encouraging heavier-than-average fishing there. There is a slight tendency for average size to be bigger in the southwest part of the lake than in the northeast part—presumably because trout grow more quickly in the southwest part of the lake than in the northeast part (fig. 3 of Kennedy, 1954).

Whitefish

Table III shows similar data for whitefish. Almost all differences between averages in Table III can be regarded as statistically significant differences. As

TABLE II.—The average size of TROUT in pounds (round weight) in representative samples of the fish landed by commercial fishermen during summer fishing seasons (all half-monthly samples combined) from each area of Great Slave Lake, and the number of fish in the respective samples.

Fishing year	Areas												Whole lake
	A	B	C	D	E	F	G	H	K	L	M	N	
AVERAGE SIZE													
1945..	....	....	....	....	....	....	7.8	....	8.1	....	....	....	7.9
1946..	....	....	....	....	12.3	....	6.5	8.5	8.7	....	....	....	8.6
1947..	....	....	....	....	10.7	10.6	8.1	8.1	10.5	....	7.9	....	8.7
1948..	....	....	....	....	11.8	7.9	7.9	9.0	8.7	7.0	8.5	....	8.8
1949..	10.0	....	....	10.9	10.7	10.2	6.1	....	6.0	7.1	8.3	....	9.1
1950..	5.7	14.5	....	11.1	9.9	6.2	6.5	7.0	10.2	6.8	8.1	....	8.9
1951..	8.3	13.9	....	8.8	8.3	6.3	6.2	7.0	10.5	6.6	7.9	....	7.5
1952..	7.1	14.3	7.9	8.2	7.0	6.5	6.1	6.2	11.1	6.2	7.8	7.9	7.0
1953..	7.1	13.9	....	9.1	10.7	6.2	5.3	6.5	7.5	6.5	8.1	8.3	7.0
1954..	6.7	9.5	....	6.5	6.9	6.2	5.8	7.4	6.9	6.1	7.2	7.4	6.5
NUMBER IN SAMPLE													
1945..	0	0	0	0	0	0	48	0	24	0	0	0	72
1946..	0	0	0	0	179	0	314	366	145	0	0	0	1,004
1947..	0	0	0	0	324	323	1,405	1,003	420	0	818	0	4,293
1948..	0	0	0	0	531	591	447	838	985	280	1,049	0	4,721
1949..	635	0	0	696	1,468	327	498	0	67	940	718	0	5,349
1950..	520	449	0	1,019	1,042	251	202	692	657	960	907	0	6,699
1951..	639	197	0	597	1,475	735	1,553	1,507	481	1,183	1,305	0	9,672
1952..	1,079	49	1,084	1,460	2,616	2,166	1,667	1,801	210	1,781	2,371	139	16,423
1953..	1,389	18	0	868	79	3,839	2,012	2,550	203	1,254	2,702	1,361	16,275
1954..	1,141	40	0	816	822	2,829	4,000	1,800	1,030	1,852	2,044	1,144	17,518

TABLE III.—The average size of WHITEFISH in pounds (round weight) in representative samples of the fish landed by commercial fishermen during summer fishing seasons (all half-monthly samples combined) from each area of Great Slave Lake, and the number of fish in the respective samples.

Fishing year	Areas												Whole lake
	A	B	C	D	E	F	G	H	K	L	M	N	
AVERAGE SIZE													
1945..	....	....	....	....	....	....	2.9	3.3	....	....	....	....	3.1
1946..	....	....	....	....	2.8	....	2.8	3.1	....	....	....	....	2.9
1947..	....	....	....	....	2.9	2.9	2.7	3.0	3.3	....	3.3	....	2.9
1948..	....	....	....	....	2.9	2.8	2.8	3.1	3.7	3.3	3.9	....	3.3
1949..	3.0	....	....	3.2	2.8	3.0	2.9	....	3.8	3.4	4.1	....	3.2
1950..	3.1	3.6	2.8	2.8	2.9	2.7	2.6	3.0	3.4	3.5	4.1	....	3.2
1951..	2.8	3.5	....	2.6	2.9	2.5	2.8	2.9	3.3	3.3	4.3	....	3.0
1952..	3.0	3.0	2.3	2.3	2.3	2.4	2.6	2.7	2.9	3.1	3.4	4.2	2.7
1953..	2.7	3.0	....	2.3	2.3	2.5	2.4	3.0	3.1	3.0	3.4	4.5	2.9
1954..	2.5	3.0	....	2.4	2.7	2.4	2.4	2.8	3.0	3.0	3.0	4.1	2.6
NUMBER IN SAMPLE													
1945..	0	0	0	0	0	0	74	61	0	0	0	0	135
1946..	0	0	0	0	95	0	802	414	0	0	0	0	1,311
1947..	0	0	0	0	518	419	2,098	1,031	887	0	245	0	5,198
1948..	0	0	0	0	458	422	1,047	570	1,056	234	748	0	4,535
1949..	758	0	0	1,116	2,391	938	517	0	646	1,109	446	0	7,921
1950..	1,520	1,628	105	1,601	2,045	1,182	186	895	1,082	1,473	1,501	0	13,218
1951..	800	992	0	1,627	2,198	940	1,490	1,906	934	1,600	1,019	0	13,506
1952..	709	873	1,246	1,940	2,114	2,233	1,769	1,869	1,126	1,676	2,451	250	18,256
1953..	2,188	642	0	1,402	117	4,635	1,613	2,441	244	1,449	2,488	1,389	18,608
1954..	3,002	402	0	900	1,796	4,208	4,308	1,760	990	1,952	2,132	1,096	22,546

in the case of the lake trout, average size decreased from year to year within each area, and there seems to be a tendency for it to become stabilized in the areas where fishing has been carried on for the longest time. Average size is least in the southwest part of the lake and increases progressively toward the northeast—presumably because whitefish in the southwest part of the lake grow more slowly than those in the northeast part (page 431 of Kennedy, 1953). The average size of whitefish in the catch has decreased partly because the size of whitefish in each area has actually decreased, and partly because an increasing proportion of the fishing has been done in those areas where whitefish are smaller.

Size Distribution

A study of the extensive data on size distribution that is on file indicates that for both species it is generally true that the more big fish there are in a sample the fewer small fish there are—not only relatively fewer but absolutely fewer. An increase in average size from one half month to another is generally the result not only of more big fish but also of fewer small fish, in the catch. There apparently is some inverse relationship between abundance of small fish and abundance of large fish depending on time and place. A probable explanation is that trout and whitefish in Great Slave Lake behave in a way comparable to the cisco of Lake Nipissing (Fry, 1937). That is, as the upper waters warm in early summer (see Rawson, 1950, for temperatures), the trout and whitefish there move to deeper (colder) waters and, further, that the older (bigger) fish of each species tend to go to deeper water than do younger fish. Then for much of the summer the size of fish available for capture would vary with depth, hence the size range in any sample would depend on where the fishermen decide to put their nets—a decision based on complex and varying set of circumstances. Limited analyses that are on file indicate that samples taken on a specific day within a small part of a statistical area tend to differ less in size distribution than do samples taken on different days at that place, or samples taken in other parts of the statistical area on the same day. Unfortunately there is no information on the depth at which each fish was caught so absolute confirmation of this explanation is not possible from the data at hand.

The tendency for average size to depend on depth shows that caution must be used in interpreting changes in average size. Changes from one year to the next can result from a change in fishermen's habits or from a change in the water temperature pattern from year to year. Of course a trend in one direction for several years must be regarded as good evidence of some real change.

Winter Fishing

Samples were also taken from some areas during the winter fishing season (Tables IV and V). The average size of both trout and whitefish has decreased in much the same way as it has in the summer samples, although the values are more erratic because the samples are smaller. The fluctuations in size in winter samples are not synchronized with the fluctuations in the summer samples.

TABLE IV.—The average size of TROUT in pounds (round weight) in representative samples of the fish landed by commercial fishermen during winter fishing seasons from each area of Great Slave Lake, and the number of fish in the respective samples.

Fishing[a] year	Areas								Whole lake
	A	C	D	E	F	G	L	K	
AVERAGE SIZE									
1948	10.9[b]	...	...	...	...	...	...	...	10.9
1949	6.6	12.6	10.6	7.7	...	...	...	...	7.6
1950	10.5	...	5.0	...	...	...	5.9	...	6.6
1951	5.8	...	7.0	5.9	...	7.8	7.0	...	6.4
1952	8.5	...	7.9	...	7.4	7.1	6.8	11.8	8.0
NUMBER IN SAMPLE									
1948	772[b]	0	0	0	0	0	0	0	772
1949	864	118	116	58	0	0	0	0	1,156
1950	125	0	94	0	0	0	472	0	691
1951	1,021	0	621	119	0	107	117	0	1,985
1952	1,398	0	415	0	107	51	296	31	2,298

[a]The fishing year lasts from December of one calendar year until March of the next calendar year and the fishing year is designated by the calendar year in which the winter starts.

[b]Part of this sample is from the southern end of Area D. It is not possible to distinguish which part of the sample.

The average size of fish of both species taken in the winter is slightly smaller than the average size taken in the summer. Presumably in summer temperature gradients are such that the larger trout and whitefish go deeper (see next section) than the smaller ones, whereas in winter, since temperature is more or less the same everywhere, there is not the same tendency for fish of different sizes to be segregated.

OTHER SPECIES

Some data were recorded on the average size of fish other than trout and whitefish. Part of these data (particularly for inconnu) was obtained when fish of these species were landed for sale. In other cases fishermen brought them in at our request. Fish of these species which research personnel caught in $5\frac{1}{2}$-inch-mesh gill-nets fished are also treated as part of the samples.

Table VI shows that cisco and pike tend to be biggest toward the southwest, that walleye tend to be smallest toward the southwest and that the others show no consistent gradient. The figures in the last line are not necessarily good approximations to the average size caught in the lake as a whole because the numbers sampled were by no means proportional to catch. The fishermen took

TABLE V.—The average size of WHITEFISH in pounds (round weight) in representative samples of the fish landed by commercial fishermen during winter fishing seasons from each area of Great Slave Lake, and the number of fish in the respective samples.

Fishing[a] year	Areas								Whole lake
	A	C	D	E	F	G	K	L	
AVERAGE SIZE									
1948	2.7[b]	...	...	...	...	...	...	...	2.7
1949	2.6	2.9	2.7	2.5	...	...	...	...	2.7
1950	2.6	...	2.2	...	...	...	...	2.8	2.5
1951	2.2	2.4	2.2	2.4	...	2.6	...	2.8	2.3
1952	2.4	...	2.0	...	2.5	2.6	2.9	2.9	2.4
NUMBER IN SAMPLE									
1948	180[b]	0	0	0	0	0	0	0	180
1949	3,368	1,096	1,543	444	0	0	0	0	6,451
1950	301	0	801	0	0	0	0	400	1,502
1951	1,735	320	1,517	214	0	468	0	101	4,355
1952	1,592	0	1,366	0	388	247	1,040	284	4,917

[a]The fishing year lasts from December of one calendar year until March of the next calendar year and the fishing year is designated by the calendar year in which the winter starts.

[b]Part of this sample is from the southern end of Area D. It is not possible to distinguish which part of the sample.

TABLE VI.—The average size of various species of non-commercial fish in pounds (round weight) in representative samples of fish caught by 5½-inch-mesh gill-nets in Great Slave Lake during the summer fishing seasons. Each average shown is based on at least 20 fish.

Area	Inconnu	Cisco	Burbot	Pike	Longnose sucker	Walleye
A	8.2	1.2	5.8	9.0	3.7	3.1
D	6.3	...	...	6.5	...	...
E	9.3	...	...	...	...	3.7
F	6.9	0.8	5.3	5.7	4.2	3.4
G	9.9	1.2	5.1	6.6	3.6	4.3
H	9.0	1.4	6.0	...	...	4.5
K	9.7	0.3	...	...	...	...
M	8.5	0.6	...	...	...	...
Whole Lake[a]	9.1	1.0	5.6	7.1	3.9	3.7

[a]This is an unweighted average of all the fish sampled, including samples of less than 20 for an area.

additional species occasionally, but so infrequently that few data are available. The comparable over-all average size for these species is as follows: white suckers 3·5 pounds, round whitefish 0·8 pound, grayling 2·2 pounds and goldeye 0·5 pound.

ANNUAL CATCH

The annual commercial catch of the two principal species are shown in Tables VII and VIII. The values are total production of summer and winter seasons added together. The summer catches from each area were known with reasonable accuracy, but the corresponding winter catches were only rough estimates. However, the totals for the ten years in each area are reasonable approximations to the catches of round fish as they come out of the water before they have been dressed and have lost weight through shrinkage.

Production per Square Mile

Removals from the various statistical areas are compared in Table IX.

Comparisons are somewhat artificial since some of the areas have been fished for ten years while others have been fished for various shorter times. Some parts of the lake have been exploited considerably more than other parts. The heavy exploitation in Area D has been the result of its proximity to Hay River. The part of Area A nearest Hay River has been even more heavily exploited but light fishing in the remainder has produced a moderate value for the area as a whole. Area G was such a popular fishing ground for Gros Cap fishermen during the first four years that it has been almost the most heavily exploited area in spite of only moderate fishing in subsequent years.

Relative Catches of Trout and Whitefish

The proportion of trout increases from southwest to northeast—this will be discussed more fully in connection with FS-index in the following section. The high summer value in Area C presumably shows a preference by trout for the deeper offshore waters, while the low summer value in Area B probably indicates that whitefish can better tolerate the warm, muddy waters of the Slave Lake delta. The proportion of trout in the catch is much higher in the summer than in the winter probably because in summer the two species tend to be at separate depths to some extent (Rawson, 1951, p. 214). Presumably the tendency for both species to seek deeper water as the surface warms is more pronounced in trout than in whitefish which makes it possible for the fishermen to set their nets where they will get a disproportionate amount of the more valuable trout. On the other hand, the two species are probably not separated to the same extent in winter so the winter percentage presumably is closer to the true relationship between trout and whitefish. Rawson's data (1951, p. 212) indicate 5 to 10 times as much whitefish as trout in summer catches in the southwest part of the lake when nets are set more or less at random. The last three lines in Table IX indicate that the proportion of trout to whitefish has changed very little if at all in ten years.

TABLE VII.—The annual commercial catch of Great Slave Lake TROUT in thousands of pounds (round weight) by areas. Because values are rounded off to the nearest thousand pounds, marginal values are not necessarily exactly the sums of rows and columns.

Year	Areas													Whole lake
	A	B	C	D	E	F	G	H	K	L	M	N	O	
1945....	0	0	0	0	0	106	426	213	319	0	0	0	0	1,065
1946....	21	0	0	0	320	98	502	347	256	0	73	0	0	1,617
1947.....	161	0	0	54	96	108	332	157	193	0	564	0	0	1,665
1948....	553	0	0	253	116	160	202	215	258	74	358	0	0	2,187
1949....	889	0	11	1,129	920	188	47	43	103	323	360	0	0	4,015
1950....	381	152	3	553	627	103	15	56	66	219	372	0	0	2,546
1951....	412	34	71	463	701	193	187	180	120	179	230	0	0	2,769
1952....	524	1	22	507	551	607	199	59	81	316	382	25	0	3,274
1953....	355	12	71	287	66	383	282	154	58	168	353	244	0	2,434
1954....	257	1	20	237	274	185	505	166	102	211	307	120	3	2,389
Ten years....	3,554	199	198	3,482	3,671	2,132	2,696	1,590	1,556	1,490	2,999	389	3	23,960

TABLE VIII.—The annual commercial catch of Great Slave Lake WHITEFISH in thousands of pounds (round weight) by areas. Because values are rounded off to the nearest thousand pounds, marginal values are not necessarily exactly the sums of rows and columns.

Year	Area													Whole lake
	A	B	C	D	E	F	G	H	K	L	M	N	O	
1945....	0	0	0	0	0	50	201	100	151	0	0	0	0	502
1946....	128	0	0	0	185	144	392	168	207	0	32	0	0	1,255
1947....	841	0	0	280	137	52	347	71	124	0	132	0	0	1,984
1948....	2,609	0	0	1,201	160	319	148	75	191	38	90	0	0	4,831
1949....	1,749	0	30	1,630	889	711	23	13	138	173	72	0	0	5,430
1950....	947	616	12	1,845	824	1,015	6	24	156	224	68	0	0	5,737
1951....	914	141	272	1,162	766	171	167	85	363	109	57	0	0	4,208
1952....	1,220	27	9	850	488	582	103	29	296	191	186	11	9	3,993
1953....	1,130	49	287	472	285	365	140	191	55	215	94	70	0	3,352
1954....	910	17	242	764	950	527	374	117	190	218	117	63	0	4,490
Ten years....	10,449	850	852	8,205	4,686	3,937	1,901	874	1,870	1,168	846	145	0	35,782

TABLE IX.—Miscellaneous information on the total catches of trout and whitefish made during the first ten years of commercial fishing on Great Slave Lake.

	Area													Whole lake
	A	B	C	D	E	F	G	H	K	L	M	N	O	
POUNDS PER SQUARE MILE PER YEAR														
Trout	176	42	11	458	456	276	862	545	194	408	429	69	+	229
Whitefish	510	176	464	1,079	583	510	608	299	233	320	121	26	+	343
PERCENTAGE TROUT[a]														
All winters	21	38	17	17	5	7	13[b]	23[b]	19	37	52[b]	46	..	19
All summers	40	16	69	46	54	49	59	65	53	61	78	81	87[b]	55
Summers 1945-48	34[b]	...	..	34[b]	56	53	58	69	60	66	80	..	..	62
Summers 1949-51	42	18	..	47	54	48	57	69	38	60	83	..	..	51
Summers 1952-54	39	4	69	46	52	48	63	53	45	62	73	81	87[b]	54

[a]Percentage trout is the ratio: pounds of trout ÷ (pounds of trout + whitefish).
[b]These values based on very little data.

Other Species

Table X gives information on the catch of species other than trout and whitefish—called "non-commercial" fish for convenience. These species are caught only incidentally to the fishery for the two main species. Since this actual production seems of little interest in itself, the data are presented in Table X as the ratio of the non-commercial species to the combined trout and whitefish landings (multiplied by 1,000). In most cases the proportions remained relatively unchanged from year to year but the proportion of ciscoes increased about tenfold starting about 1951. The increase paralleled very closely the introduction of nylon gill-nets in various parts of the lake, and presumably resulted from that innovation. To a lesser extent, the proportion of burbot caught also increased in recent years, presumably because of the burbot's well-know habit of attacking ciscoes which are already in the mesh, so the more cisco the more burbot.

Most of the minor species were taken in greatest abundance in the warmer, muddier, shallower waters of the southwest part of the lake rather than in the colder, clearer, deeper waters of the northeast part (Table X).

Four species were completely absent from catches in Area C, a deep, comparatively clear area in the southwest end of the lake, that resembles somewhat the waters to the northeast where those species are rarely taken. The catches do not truly reflect the distribution of ciscoes because in the most easterly areas they are smaller than elsewhere (Table VI) so they are less likely to be caught there. Rawson's (1951) data and other evidence indicates that ciscoes are considerably more plentiful in the northeast part of the lake than these figures would indicate. Burbot were mostly taken in the shallower, muddier water—the catches in Area C were presumably the result of heavy cisco catches there.

The comparatively large proportion of inconnu taken in Area K is mainly the result of catches made in Inconnu Channel, which, as the name implies, has long been known as a place in which inconnu can be caught in quantity. Some local people contend that most inconnu spend the summer in Inconnu Channel and migrate to Buffalo River (in Area A) to spawn in September or October. However, our figures contradict this idea because the comparatively high value for inconnu in Area K results mostly from catches made fairly late in the year, and in the same half month that high values also occur in Area A. In other words, the inconnu found in Inconnu Channel must be a different group from those generally caught off Buffalo River. Fuller (1955) discusses this question.

The second half of Table X deals with the catch of non-commercial fish for the whole year, that is, for both the summer and winter combined. These values must be used with considerable caution because few data were available for estimating winter catches. Except for ciscoes, more non-commercial fish were caught in winter than summer.

TABLE X.—Comparative quantities of non-commercial fish caught during the first ten years of commercial fishing on Great Slave Lake, on the basis of estimated round weights.

	Area													Whole lake
	A	B	C	D	E	F	G	H	K	L	M	N	O	
SUMMER ONLY (Proportion [a])														
Burbot	251	151	166	52	38	62	80	49	65	7	9	+	0	69
Cisco	43	4	760	44	48	43	65	15	15	1	2	1	1	35
Sucker	241	36	0	23	11	22	7	2	4	1	3	+	0	34
Inconnu	53	53	0	11	17	28	29	46	93	8	8	0	0	29
Pike	8	14	0	6	5	9	8	9	17	6	2	+	0	7
Walleye	5	+	0	1	+	+	+	1	+	+	+	0	0	1
WHOLE YEAR (Pounds per square mile per year)														
Burbot	80	31	3	103	34	46	116	42	27	5	5	+	0	38
Cisco	10	1	1	38	39	23	94	13	5	2	1	+	+	13
Sucker	147	87	1	33	12	12	10	2	2	1	2	+	0	34
Inconnu	63	12	2	57	23	17	41	39	43	11	4	+	0	28
Pike	32	3	+	12	7	12	13	8	8	5	1	+	0	10
Walleye	1	+	+	1	1	+	+	1	+	+	+	+	0	0.4

[a]Proportion of non-commercial fish is the ratio: $\frac{\text{Pounds of non-commercial fish} \times 1000}{\text{Pounds of whitefish+trout}}$

In addition to the species tabulated grayling, round whitefish, and goldeye are taken in negligible numbers (average less than 300 pounds per year for all three). Grayling and round whitefish were taken mainly in the northeastern part of the lake, and goldeye are taken almost exclusively in the southwestern part of the lake, near the Slave River delta.

FS-INDEX

The FS-index represents fishing success and shows how much is caught for a given fishing effort. The units used are defined in an earlier section.

The values used below are based on a major part of the fishing that has been done. Except for the year 1945, practically every time that Gros Cap fishermen landed fish they were interviewed, so that for the areas which they fished (Areas H, K, L, M, N and O, and until recently Areas E, F, and G) the values for FS-index are based on almost the entire catch. It has not been possible to record the fishing efforts of the Hay River fishermen so completely. Nevertheless the FS-indices for areas fished usually by Hay River fishermen (Areas A and D, and more recently E, F and G) are generally based on substantial catches. The proportions of the total fishing effort which were used in calculating the FS-indices are shown in a latter section (Table XVIII).

The FS-index has been calculated for trout and for whitefish for each area during each half month for each of the ten years. As in the case of average size, these data are too extensive to include here; they are on file in Manuscript Reports at all Fisheries Research Board Stations and typical examples are shown in the Appendix. Highlights of the data on file are as follows. The FS-index tends to fluctuate considerably and erratically. Some of the variation can be attributed to the fact that little fishing was done in certain cases so that the values are based on very little data. But, in many cases two consecutive values which differ considerably are based on over 100,000 pounds of fish so the difference can not be attributed to sampling error. This indicates that, although abundance of fish in the lake must necessarily be one factor that determines FS-index, there must also be other very important factors. Therefore, a variation in FS-index over a short period of time should not be interpreted as indicating a change in abundance of fish, although a trend in one direction over several years could logically be so interpreted. Presumably variations in hydrographic conditions and variations in fishermen's attitudes and activities are among the factors involved.

The FS-index of trout tends to increase throughout the season probably because trout concentrate at certain places prior to and during spawning (which occurs after September 10), hence become increasingly easier to catch. The high value for FS-index in Area A in 1952 (see Table XI) is explained by the fact that 1952 was the only year in which regulations permitted fishing near Hay River in September. There is no comparable increase during the season in FS-index amongst the whitefish, probably because their spawning time is later than

that of the trout. Although the whitefish probably begin to concentrate in September, fishing for trout is presumably so good by that time that fishermen tend to disregard this opportunity to catch whitefish.

The FS-indices for the whole summer are shown by areas in Tables XI and XII. In addition to these values, some data were gathered in 1954 in Area O, which shows an FS-index of 70 for trout and 10 for whitefish. The FS-indices have fluctuated considerably but not enough to obscure a decrease in almost every area. The decrease has been more noticeable for trout than for whitefish. Part of the explanation for this lies in the fact that a larger proportion of the fishing is being done by Hay River fishermen who tend to catch a higher proportion of whitefish than do Gros Cap fishermen under the same circumstances. However the changes in FS-indices probably also indicate an actual decrease in abundance of fish in most areas (but not necessarily in the same proportion as the FS-index). The rate of decrease has become slower and the FS-index has tended to become stabilized in recent years in those areas which have been fished longest. The FS-index for trout is roughly half what it was when fishing began, and the FS-index for whitefish is roughly two thirds. The decreases for trout from 1953 to 1954 can not be interpreted as representing a sudden decrease in abundance; they must represent unfavourable conditions for catching trout that year. The fact that warm, muddy water from the Slave River spread further in 1954 than in any previous recent year was no doubt a factor.

Table XI indicates that within any one year the FS-index for trout is higher towards the northeast than it is towards the southwest. Rawson (1951) postulates that young trout are produced mostly in the northeast end of the lake and that those in the southwest end of the lake are mostly immigrants from the northeast. Rawson's theory has been supported by evidence derived from age studies (Kennedy, 1954). The indication from Table XI that trout are probably more plentiful toward the northeast than they are toward the southwest, is a further confirmation of Rawson's theory. The theory does not preclude the possibility that some trout spawn in the southwest part of the lake—in fact it is well known that considerable numbers of them spawn near Point de Roche—but it does infer that such spawning as takes place may not produce many young trout.

Some evidence gathered from age studies on whitefish (Kennedy, 1953) indicates a comparable but opposite situation among the whitefish, namely that more young whitefish are produced in the southwest part of the lake and that many of the whitefish found in the northeast are immigrants. Table XII does not show nearly as strong a gradient in FS-index from one end of the lake to the other as does Table XI but it does indicate that the FS-index for whitefish tends to be larger in the southwest and middle parts of the lake than it is in the northeast part.

TABLE XI.—All summer FS-indices for TROUT in the various statistical areas of Great Slave Lake.

Fishing year	Area												Whole lake
	A	B	C	D	E	F	G	H	K	L	M	N	
1945....	...	...	...	...	...	...	67	65[a]	48	..	...	...	62
1946....	...	...	...	...	188	78	51	48	48	..	98	...	61
1947....	...	...	...	...	75	118	42	46	54	..	145	...	68
1948....	...	...	...	...	112	60	50	57	59	90	103	...	68
1949....	43	...	...	50	84	44	39	45	39	70	78	...	58
1950....	16	9	...	27	80	43	49	45	39	68	112	...	41
1951....	28	14	...	21	40	54	37	43	16	63	57	...	37
1952....	118	3	30	31	29	37	42	30	18	70	63	76	43
1953....	16	5	7[a]	15	14	42	49	42	41	42	66	141	45
1954....	8	2	...	10	22	11	27	31	31	40	55	51	22

[a]Value based on a comparatively small sample—less than 200 equivalent net-nights.

TABLE XII.—All summer FS-indices for WHITEFISH in the various statistical areas of Great Slave Lake.

Fishing year	Area												Whole lake
	A	B	C	D	E	F	G	H	K	L	M	N	
1945....	..	..	..	..	..	..	40	20[a]	31	..	..	..	34
1946....	..	..	..	..	112	59	40	23	39	..	39	..	40
1947....	..	..	..	..	102	59	45	21	35	..	30	..	41
1948....	..	..	..	..	92	96	36	19	44	41	24	..	43
1949....	47	..	..	40	87	67	19	14	51	38	16	..	48
1950....	28	84	..	51	60	54	19	19	56	65	20	..	47
1951....	26	60	..	28	44	43	32	21	38	36	14	..	33
1952....	23	99	21	23	18	38	19	15	34	37	30	34	27
1953....	35	60	13[a]	17	18	36	18	21	37	29	18	26	27
1954....	25	30	..	29	43	34	20	21	34	32	18	18	27

[a]Value based on a comparatively small sample—less than 200 equivalent net-nights.

As explained in an earlier section, the FS-index for the winter is in no way comparable to summer FS-indices. Winter FS-indices are shown in Tables XIII and XIV. Neither table has a column showing FS-index for the whole lake since it would be meaningless because the samples are by no means in proportion to the amount of fishing done in each area. The FS-index for whitefish in Area F during 1949 was particularly high because big catches were made where whitefish had concentrated on certain grounds to spawn. Those spawning grounds have since been closed to commercial fishing at that season. The values in Tables XIII and XIV suggest a decrease in abundance of fish over several years, just as do the summer FS-indices.

TABLE XIII.—All winter FS-indices for TROUT in the various statistical areas of Great Slave Lake—note that the winter FS-index is not comparable with the summer FS-index.

Fishing year	Area				
	A	C	D	E	F
1948	23	...	15	...	...
1949	16	26[a]	13	7	+[a]
1950	8	...	5	...	...

[a]Value based on a comparatively small sample—less than 200 equivalent net-lifts.

TABLE XIV.—All winter FS-indices for WHITEFISH in the various statistical areas of Great Slave Lake—note that the winter FS-index is not comparable with the summer FS-index.

Fishing year	Area				
	A	C	D	E	F
1948	109	...	86	...	...
1949	38	20[a]	40	41	160[a]
1950	31	...	55	...	...

[a]Value based on a comparatively small sample—less than 200 equivalent net-lifts.

When the nets were left out for two or three nights they produced approximately the same FS-index as nets left one night during the summer so even though the winter FS-index is not comparable to the summer FS-index, it is obvious that fishing is not nearly as good in the winter as it is in the summer. Presumably, this is the result of low water temperatures. Obviously fish will not be caught in a gill-net unless they move around and in the winter when water temperatures are near freezing it seems likely that fish move less than in summer. When winter fishermen first set their nets in a specific place they get

reasonably good catches the first lift, poorer catches the second lift, and poorer still the third lift. Generally, after the third lift they move their nets and, although they may move only a few hundred yards, the first catch is again reasonably good. Presumably in the winter a fisherman's catch is mostly from the fish within a very limited area near his nets. Probably fish are so inactive in winter that fish caught within that limited area are not replaced by immigration for a considerable time.

COTTON VS. NYLON GILL-NETS

There is considerable controversy amongst the fishermen regarding the relative efficiency of the nylon gill-nets which have been recently introduced, and the cotton and linen gill-nets formerly used exclusively. Fishermen generally believe that nylon gill-nets are much more effective in catching fish and that the fish they catch tend to be *smaller*. Tests by Lawler (1950), Hewson (1952) and Atton (1955) indicate that nylon gill-nets catch more fish than cotton or linen gill-nets; there is some disagreement about whether the fish caught are of the same average size or whether nylon gill-nets take *larger* fish. It is obviously important to try to assess the probable effect of introducing them on the FS-index and on average size. Unfortunately, no data are at present available for Great Slave Lake on actual comparisons between catches made in nylon nets and those made in cotton nets when both are fished simultaneously at exactly the same place. However, some of the data available do bear on this subject.

Up until the end of 1949 practically no nylon gill-nets were used in Great Slave Lake. In 1950 a few were introduced toward the end of the season but their use can still be considered as inconsequential during that year. In 1951, the fishermen from Hay River did about three-quarters of their fishing with nylon gill-nets. By 1952, practically all the fishing done by Hay River fishermen was with nylon gill-nets and it is estimated that less than 5 per cent was done by cotton or linen gill-nets. On the other hand, the Gros Cap fishermen fished cotton gill-nets almost exclusively until at least the end of 1952, and it is estimated that until that time less than 5 per cent of their fishing was done with nylon gill-nets. In 1953 and 1954, it is estimated that about one-third of the fishing done by Gros Cap fishermen was with nylon gill-nets. As it happened, the Gros Cap fishermen who used nylon gill-nets were mostly men who fished in the northeastern part of the lake and were consequently farthest from the Hay River fishermen's fishing grounds. It is therefore possible to make gross comparisons between fishermen who used mainly nylon gill-nets in 1951 and subsequent years (the Hay River fishermen) and fishermen who used the other gear during the same time (the Gros Cap fishermen).

Had the nylon gill-nets been an important factor in determining the catch of lake trout or whitefish in Great Slave Lake, then the FS-indices for the southwest areas should have increased suddenly in 1951 when the Hay River fishermen changed from cotton to nylon nets. As can be seen in Tables XI and XII there was no spectacular increase which indicates that any effect from the introduction

of nylon gill-nets probably was of a minor nature. The data in Tables II and III show that the introduction of nylon did not have a pronounced effect on average size.

Gros Cap and Hay River fishermen have mostly fished separate grounds but they have frequently both fished in Areas E, F and G. Pertinent data for comparing FS-indices and average sizes in catches made by the two groups are shown in Tables XV, XVI and XVII. Obviously, in spite of using nylon gill-nets, Hay River fishermen did not catch more than Gros Cap fishermen. Differences in techniques may be a factor. Gros Cap fishermen set their nets in

TABLE XV.—A comparison between fishermen based at Hay River (HR) and fishermen based at Gros Cap (GC) with respect to FS-index and to average size of individual fish caught in Area E. Catches taken mainly by nylon nets are marked by an asterisk; other catches were mainly by cotton nets.

Year	FS-Index				Average weight in Pounds			
	Trout		Whitefish		Trout		Whitefish	
	GC	HR	GC	HR	GC	HR	GC	HR
1946	188	...	112	...	12.3	...	2.8	...
1947	75	...	102	...	10.7	...	2.9	...
1948	112	...	92	...	11.8	...	2.9	...
1949	79	116	80	109	10.7	...	2.9	2.5
1949	86	63	66	54	9.9	...	2.9	2.6
1951	94	25*	65	38*	7.5	9.7*	3.0	2.8*
1952	27	29*	22	17*	9.7	6.9*	2.4	2.3*
1953	...	14*	...	18*	...	10.7*	...	2.3*
1954[a]	...	22*	...	43*	...	6.9*	...	2.7*

[a]One lift made by Gros Cap fishermen represents too little data for presentation.

short gangs which they space out over a considerable distance. They spend much time sounding the water before they set and try to set in such a way that the water is considerably deeper at one end of the gang than at the other. Hay River fishermen, on the other hand, are more inclined to set their nets in longer gangs and are not so particular about choosing a suitable place. Also the Hay River fishermen tend to set their nets very close to one another. Another consideration is the fact that Gros Cap fishermen are paid considerably less per pound of fish than are the Hay River fishermen. Gros Cap fishermen must therefore make better catches, and if they do not get them at one place they quickly try somewhere else. Hay River fishermen have not the same desperate need for good catches and tend to stay close to the fish company barge which

means that they are competing with other fishermen for whatever fish are in the vicinity. Gros Cap fishermen immediately vacate a fishing ground when a barge from Hay River comes into the vicinity because they need bigger catches than can be made when nets are set close together. As a result, the expansion in the range of Hay River fishermen is forcing a contraction in the range of Gros Cap fishermen. It would appear that the extra care used by the

TABLE XVI.—Comparison between fishermen based at Hay River (HR) and fishermen based at Gros Cap (GC) with respect to FS-index and to average size of individual fish caught in Area F. For earlier years (when only Gros Cap fishermen fished the area) see Tables VIII, IX, XXIII and XXIV. Catches taken mainly by nylon nets are marked by an asterisk; other catches were mainly by cotton nets.

Year	FS-Index				Average weight in pounds			
	Trout		Whitefish		Trout		Whitefish	
	GC	HR	GC	HR	GC	HR	GC	HR
1950	43	...	54	...	6.2	...	2.7	...
1951	54	...	43	...	6.3	...	2.5	...
1952[a]	37	...	38	...	6.6	5.6*	2.3	2.4*
1953	15	44*	44	36*	7.7	5.6*	2.3	2.5*
1954	...	11*	...	34*	...	6.2*	...	2.4*

[a]Fishing done almost entirely by Gros Cap fishermen but some fishing done by Hay River fishermen during the first month. The FS-index for trout was much higher for Gros Cap then for Hay River fishermen.

TABLE XVII.—A comparison between fishermen based at Hay River (HR) and fishermen based at Gros Cap (GC) with respect to FS-index and to average size of individual fish caught in Area G. For earlier years (when only Gros Cap fishermen fished the area) see Tables VIII, IX, XXIII and XXIV. Catches taken mainly by nylon nets are marked by an asterisk; other catches were mainly by cotton nets.

Year	FS-Index				Average weight in pounds			
	Trout		Whitefish		Trout		Whitefish	
	GC	HR	GC	HR	GC	HR	GC	HR
1950	49	...	19	...	6.5	...	2.6	...
1951	37	...	32	...	6.2	...	2.8	...
1952	31	104*[a]	18	22*[a]	6.1	...	2.6	...
1953	17[a]	50*	18[a]	19*	...	5.3*	...	2.4*
1954	21	26*	22	35*	6.0	5.7*	2.5	2.3*

[a]Based on few samples.

Gros Cap fishermen, plus the advantage of spacing their nets out more, plus the economic spur, offset any advantage the Hay River fishermen may have had through their use of nylon gill-nets.

Gros Cap fishermen tend to catch bigger fish than the Hay River fishermen, and this is particularly true of the whitefish. This helps to explain a paradox which arises from the values in Tables II and III. Table III shows for any given year a *pronounced* gradation in average size from southwest to northeast amongst the whitefish, whereas the growth rate of whitefish varies only *slightly* from southwest to northeast (Kennedy, 1953). On the other hand, Table II shows only a *moderate* gradation in average size of trout from northeast to southwest whereas the growth rate of trout increased *greatly* from northeast to southwest (Kennedy, 1954). This paradox is readily explained by the tendency for the Hay River fishermen (who fished to the southwest) to catch smaller fish of each species than do Gros Cap fishermen (who fished to the northeast). It is not obvious why Gros Cap fishermen should catch larger fish than Hay River fishermen, but presumably it is somehow related to differences in their fishing technique. It cannot be attributed to the introduction of nylon gill-nets since there was no sudden decrease in size when they were introduced.

Part of the decrease from year to year in the average size of fish captured, as shown in the last columns of Tables II and III respectively, must be attributed to the fact that the percentage of fishing done by Hay River fishermen has been continually increasing while the percentage of fishing done by Gros Cap fishermen has been decreasing. Part of the decrease in FS-index from year to year, as shown in the last columns of Tables XI and XII respectively, may be attributable to the same cause.

FISHING EFFORT

Table XVIII reviews data that have already been given in a different form and also presents data on fishing effort. The unit of fishing effort used is thousands of yard-nights which is considered more appropriate and convenient here than the net-night used above as a unit of fishing effort. In Table XVIII column 5 shows the total fishing effort which was recorded as a result of interviewing fishermen. Column 6 shows the estimated percentage of fishing effort exerted by those interviewed. It is estimated on the basis of the catch made by fishermen who were interviewed as compared with the known total catch (actually the total catch was prorated among the areas and the fishing effort in each area derived). The last column shows the total fishing effort as calculated from the data in columns 5 and 6. The total catch divided by the total fishing effort does not give the total FS-index exactly because of the variation in FS-index from area to area, and because fishing pressure varied from area to area.

In general, fishing effort has tended to increase from year to year. FS-index increased for a few years, presumably as the fishermen found better and better grounds and as they improved their techniques; then it declined. There is

TABLE XVIII.—Catch and summer FS-index of Great Slave Lake commercial fish (trout and whitefish combined) and the fishing effort required.

Year	Catch of commercial fish in thousands of pounds		Commercial fish FS-Index	Summer fishing effort in thousands of yard-nights		
	Whole year	Summer only		Amount recorded	Percentage recorded	Estimated total amount
1945.....	1,567	1,567	96	...	2	...
1946.....	2,872	2,623	101	2,536	97	2,614
1947.....	3,649	2,313	109	1,985	94	2,119
1948.....	7,018	2,418	111	1,984	100	1,984
1949.....	9,446	5,337	106	3,841	81	4,760
1950.....	8,283	4,307	88	3,478	70	4,934
1951.....	6,977	4,436	70	3,929	61	6,398
1952.....	7,267	4,515	70	3,405	55	6,190
1953.....	5,786	3,627	72	3,581	80	4,500
1954.....	6,879	4,192	49	7,264	90	8,099

some indication that, superimposed on the general tendency for FS-index to decline, there is a tendency for it to be inversely related to amount of fishing effort. This is not a surprising observation, since more fishing effort means more competition amongst nets, hence automatically a smaller catch per net for a given amount of fish available.

During the last seven years, summer fishing effort averaged about 6,000,000 yard-nights. Although winter fishing effort is by no means comparable with summer fishing effort, still, on the basis of proportion of catches in the two seasons, the winter fishing effort can be regarded as not more than 4,000,000 yard-nights in terms of summer effort. Therefore, the total fishing effort in Great Slave Lake in recent years has been not more than 10,000,000 summer yard-nights per year. This fishing effort has produced roughly 7,000,000 pounds of fish per year. On the basis of the number of gill-net tugs known to operate in Lake Erie, the average amount of gear fished by each, and average number of days fished per year by each, I estimate that the total gill-net fishing effort on Lake Erie is roughly 1,000,000,000 yard-nights per year. Other types of gear are also used on Lake Erie, and on the basis of relative catch I estimate that they are roughly equivalent to another 1,000,000,000 yard-nights of fishing effort by gill-nets. Therefore about 200 times as much fishing effort is exerted each year in Lake Erie as is exerted in Great Slave Lake. With this extra effort, Lake Erie produces only about six times as much as does Great

Slave Lake, although the two are approximately the same size (Lake Erie is about 5 per cent smaller). It is true that part of the discrepancy between catch per unit of effort in Lake Erie and in Great Slave Lake can be attributed to the fact that in Lake Erie the fish populations are undoubtedly at a relatively low level of abundance. But a factor in the discrepancy must also be the intense competition between nets for the fish available in Lake Erie. This is another indication that FS-index is inversely related to amount of gear used, which confirms both a seeming trend in Table XVIII and the fishermen's opinion that catches decline as more nets are set within a limited area. A similar tendency for FS-index and amount of gear used to be inversely related is well illustrated in the Pacific halibut fishery (Thompson, 1950).

ARE THE COMMERCIAL FISH OF GREAT SLAVE LAKE BEING DEPLETED?

According to the Concise Oxford Dictionary, deplete means "empty out, exhaust", so a lake depleted of a species of fish would, strictly speaking, be completely devoid of that species. Most people use the term to represent a less drastic reduction in a fish population, but unfortunately the exact meaning varies. Many seem to consider a lake depleted when fish are harder to catch than they were formerly. Since the removal of even one fish makes the capture of the next one a little harder, then by this definition the utilization of fish (no matter how slight) is synonymous with depletion. Biologists generally use the term for some condition intermediate between these extremes, for instance, that a lake is depleted if it has been fished so hard that more intensive fishing would produce a smaller rather than a larger sustained yield. A common element of all views is obviously a feeling that a depleted fish population is one that has been subjected to a heavier exploitation than the person in question considers desirable.

Exploitation is generally presumed to cause certain changes in fish populations, the readily apparent results of which are (1) a decrease in catch per unit of fishing effort (when fish are removed, provided recruitment is not correspondingly increased, the number of fish left is decreased, hence the chances of catching any given one are presumably lessened); (2) a decrease in average size of individual fish (if fewer fish remain, and if the average number of small fish which grow big enough for capture each year remains unchanged, then the *proportion* of the latter present must increase); (3) an increase in growth rate (because intraspecific competition presumably decreases); and (4) an increase in mortality rate (obviously the number of fish can decrease only if they die faster—this includes being caught—than formerly).

Changes in the growth rates and mortality rates of Great Slave Lake trout and whitefish are discussed in earlier papers (Kennedy, 1953, 1954). For both species, no very obvious change could be detected in either mortality rate or growth rate. Data presented in this paper indicate that both FS-index and

average size have decreased perceptibly during the ten years the fishery has been in operation. The question is whether the amount by which they have decreased represents depletion—many people have said that it does. It is instructive to compare the situation in Great Slave Lake with that of a fishery which was generally regarded as depleted, namely the halibut fishery off the west coast of Canada in Statistical Area 2 just before 1932 (Thompson and Bell, 1934) when regulations to correct the situation were introduced. Because a relatively small reduction in total annual catch was sufficient to restore the halibut fishery to a condition generally considered satisfactory it must have been only moderately depleted, and it is therefore a good standard of comparison. The following comparisons can be made:

The Area 2 halibut fishery	*The Great Slave Lake fishery*
Total annual catch decreased in spite of increased fishing effort.	Total annual catch increased when fishing effort increased.
The original catch per unit of effort was at least eight times (probably more) as great as it was after exploitation.	The original catch per unit of effort was roughly one-and-one-half times as great as it was after exploitation.
Over 40 per cent of the stock of commercial fish was caught each year.	A negligible fraction of the stock of commercial fish is caught each year (no change in mortality rate as a result of the fishery).
The average size of fish caught was much smaller than in the original condition, and large fish were notably absent from the catch.	The average size has decreased only slightly and there has been no outstanding decrease in proportion of quite large fish caught.

It seems obvious that Great Slave Lake is far from being depleted in the same sense that the halibut were depleted just before the regulations were enacted. The tendency for both FS-index and average size to become stabilized indicates that the Great Slave Lake populations will probably reach a state of equilibrium with the fishery at a much more satisfactory level than that exhibited by the depleted halibut population. The only way to avoid all decrease in FS-index and in average size is to prohibit all fishing. The observed moderate decline in both factors is the inevitable result of catching fish. A fishery intensive enough to cause FS-index and average size to decline to approximately the same extent as they declined in the halibut fishery would probably also reduce the fish populations to such an extent that sustained yield would decrease. However the present rate of exploitation seems far less than the rate required to produce that undesirable result.

Therefore I conclude that the present commercial fishery on Great Slave Lake has not depleted, and is not likely to deplete, the trout and whitefish there.

In fact a rate of exploitation appreciably higher than that now being applied could probably be maintained indefinitely.

The question of depletion in Great Slave Lake involves the relationship between whitefish and trout. To some extent, trout prey on whitefish, so that deliberately overfishing the trout might produce more whitefish. Whether overfishing the trout would be to our overall advantage calls for a good deal of detailed study relevant to this predator-prey relationship. One of the factors that must be taken into account is the theory that trout spawn in the northeast end of the lake and that those found in the southwest end have mostly migrated there. If this view proves to be correct then protection for the trout in the southwest end of the lake cannot be justified on the grounds of ensuring sufficient spawning. In that case it might be advantageous to deliberately overfish the trout in the southwest end (which would reduce their average size) on the grounds that it is mostly the larger trout which prey on whitefish. Such a policy implies extra protection for trout in the northeast part of the lake which presumably supplies most of the young trout for the lake. Fortunately much of the northeast part of the lake is so deep that fishermen fish only a very limited peripheral area. Presumably trout in that end prey mostly on ciscoes, which makes them relatively independent of the bottom hence generally invulnerable to capture. It seems likely that under existing conditions this situation is in itself sufficient protection for the trout stocks.

APPLICATIONS TO MANAGEMENT

The primary purpose of the Great Slave Lake study has been to accumulate information which will make possible improved techniques in fisheries management. To fully achieve this purpose will require careful work for many years. It is however gratifying to be able to report considerable progress already.

Data from the study have formed the basis of a management policy on Great Slave Lake that has made possible a minimum of restraints on the fishing industry on one hand, while on the other hand adequately protecting the fish populations. An outstanding instance was when the data were used in early 1948 as a basis for the decision to increase the limit on annual production. Had this information not been available there is no question but that the legal limitation on annual production of whitefish and trout as caught would have continued as 4,200,000 pounds, so that in the seven years since the change was made the maxium total that could have been produced would have been $7 \times 4{,}200{,}000 = 29{,}400{,}000$ pounds. Our information was the basis for amended regulations under which just over 50,000,000 pounds of these species have been marketed from the time the limit was changed to March, 1955. Thus the knowledge gained from this study has resulted up to March, 1955 in a crop of about 21,000,000 pounds of fish more than would otherwise have been harvested, and there is every prospect that the fishery will continue to produce this extra 3,000,000 pounds or more per year. To March, 1955 this represents a benefit

to the Canadian fishing industry of about $5,000,000, with prospects of nearly $1,000,000 each year in perpetuity. The following conclusions from the data at hand represent progress towards the development of better general management. They are not necessarily original ideas but the Great Slave Lake study has materially strengthened the case for applying them to the management of Canadian freshwater fisheries.

1. Verbal reports of better fishing in former years, when unsupported by recorded numerical evidence, are probably not reliable. Shortly after fishing started we began getting reports that fishing was much poorer than when fishing started. These reports proved to be greatly exaggerated, as the data given in this paper show. An important lesson learned from Great Slave Lake is that people's memories cannot be trusted with respect to how good fishing has been at some earlier date.

2. There is a good chance that most Canadian lakes are being underfished. Many people concerned with Great Slave Lake fish were by 1947 convinced that the lake was being overfished. The 1948 recommendation that the limit be increased was regarded as a mistake and strongly opposed. However, as the data show, the lake was definitely not overfished in the first instance, with the new higher limit it is not being overfished, and in fact it probably could be fished more heavily without overfishing it. Since the bases for the erroneous conclusion that Great Slave Lake was being overfished in 1947 are essentially the same as the bases for many of the regulations which at present limit lake production elsewhere, there seems to be good reason to suspect that most Canadian lakes may be underfished. There is evidence from other sources which supports this idea: (a) In Lake Winnipeg a similar study of the commercial fishery for whitefish has led to the conclusion that they are not being overfished, in spite of strong feeling to the contrary on the part of fishermen and others. (b) At Heming Lake, Manitoba, we have had no success in an attempt to eliminate one species of fish—the pike—and in fact have not even appreciably reduced its numbers. This is in spite of using a variety of gears, including some types more efficient than those used commercially anywhere in western Canada, and in spite of using a greater fishing effort than it would be profitable to use to take any species commercially. (c) In Alberta the deliberate overfishing of one lake required about three times as great a catch as had previously been considered the safe limit, and another lake has continued to yield twice as much as was previously regarded as the safe limit (Miller, 1947). There is a strong enough possibility that most Canadian lakes are underfished to justify a re-examination of all restrictions on the various freshwater fisheries.

3. Changes in catch per net do not necessarily indicate corresponding changes in abundance of fish. As the data presented here and on file show, catch per net can fluctuate too rapidly, and over too short a time, to represent fluctuations in abundance of fish. It is not obvious what causes catch per net to fluctuate, but one important factor seems to be the weather, probably through its action on

water temperatures. Catch per unit effort is also greatly influenced by the skill of the individual fisherman—it has been my observation that a skillful fisherman will catch at least twice as much under the same conditions as an unskilled fisherman. A comparison of the catches of the two groups of fishermen, those from Hay River and those from Gros Cap, indicates that skill in catching one species of fish does not necessarily imply skill in catching another species. Closely related to skill is the attitude of the individual fisherman. Sometimes they have the skill but because they think the lake is "fished out", or for some other reason, they fail to put forth the extra effort required to handle nets in the most efficient way; instead they handle them lackadaisically and get smaller catches. Competition between nets for the fish available is probably a very important factor in catch per net because the more closely nets are to each other the smaller will be the catch per net expected from a given concentration of fish. Furthermore, relative catch per net is not necessarily a good indication of the relative abundance of two species. On the basis of catch per net by the summer commercial fishery it would be assumed that for fish of commercial size trout are more plentiful than whitefish in Great Slave Lake, whereas other evidence points to the fact that whitefish are several times as plentiful as trout. In the same way, any changes in catch per net of non-commercial fish must be interpreted with great caution since the amount of non-commercial fish caught presumably depends on the degree to which temperatures have induced them to be in the same area as commercial fish which are currently being fished.

4. Changes in average size in the catch must be interpreted with caution. It seems likely that the size range of the fish which occur at any given depth of water varies with water temperature, that bigger fish are found deeper, and smaller fish found shallower, and that therefore the average size of fish caught depends on just where the nets are set at a particular time, which in turn depends on a complex set of circumstances. Therefore, although a long-term trend in average size is probably of importance, any changes over a short time (2 or 3 years) may be purely accidental.

5. Nylon gill-nets are not necessarily more efficient than cotton gill-nets. In Great Slave Lake specifically, nylon nets were not notably more efficient than cotton. No doubt lakes differ among themselves by enough that the relative efficiency of the two types of twine varies from lake to lake. Atton (1955) found less difference between nylon and cotton with large mesh gill-nets such as those used at Great Slave Lake than with small mesh gill-nets such as those in which the difference has been more obvious.

SUMMARY

1. A major fishery has been studied from its inception. Data on catch per net based on daily interviews of the fishermen by trained personnel were recorded for a majority of the summer catches. A total of 88,928 lake trout and 122,639 whitefish (the two commercial species), taken mostly during the sum-

mer, was used as a representative sample of the catch to calculate average sizes at various times and places—this represents just over 1,000,000 pounds in the samples from a total catch of 59,000,000 pounds during the ten years.

2. The average individual weight of commercially-caught trout and whitefish decreased over the ten years: the decrease being about 15 per cent in both species (Tables II and III). For both species there seems to be a tendency for average size to become stabilized at a lower value than the original one. Trout tend to be bigger at the southwest end of the lake, whitefish tend to be bigger at the northeast end.

3. For both species average catch per net has decreased appreciably: by about 45% for trout and 30% for whitefish (Tables XI and XII). The greater decrease of trout results from their comparatively heavier exploitation. For both species there seems to be a tendency for catch per net to become stabilized at a lower value than original one. Catch per net is greatest for trout toward the northeast and for whitefish toward the southwest. Catch per net for trout increases as their spawning time approaches, but for whitefish it remains relatively unchanged through the summer fishing season. Fishing is poorer in winter than in summer, particularly for trout.

4. The decreases in catch per net and in average size are the natural result of moderate fishing (the fishing effort is less than 0·05 of that used on Lake Erie), and do not indicate depletion.

5. Both catch per net and average size fluctuate so much that it takes several years to be sure that a change in either or both represents a change in the fish populations.

6. Further evidence is presented in support of a theory that trout spawn more successfully in the northeast end of Great Slave Lake and that whitefish spawn more successfully in the southwest end.

7. Several lines of evidence indicate that something (presumably a reaction to a temperature gradient) causes the larger Great Slave Lake trout and whitefish to concentrate at different depths from the smaller individuals.

8. Catch per net seems to be inversely related to amount of gear fished, presumably because of competition among nets for the catchable fish.

9. In Great Slave Lake nylon gill-nets are not noticeably more efficient than are cotton gill-nets.

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APPENDIX

This appendix shows in detail certain data on those three Areas of Great Slave Lake which have been most consistently exploited, namely Areas G, H, and K. Similar but less complete data for all statistical areas are on file at each Station of the Fisheries Research Board, in the series of Manuscript Reports of the Biological Stations. The data tabulated here illustrate the extent to which both the average size and the FS-index fluctuate from half month to half month within a year and from year to year at comparable half months. They also illustrate the fact that, in spite of such fluctuations, both average size and FS-index have tended to decline when a long enough period is considered. In both respects the few Tables presented here are typical of the Tables that are on file in the Manuscript Reports.

Data on the actual distribution of sizes within the samples are also on file. Tests of the statistical significance of differences between various samples (where a sample represents size in one area during one half-month of one year) show that the following general rules apply. In Tables XIX, XX and XXI any two typical samples must differ by at least ½ pound to be significantly different; in an appreciable number of the possible comparisons they must differ by 2 pounds; and for a few extreme cases the samples are so small that they must differ by 5 pounds. In Tables XXII, XXIII and XXIV any two typical samples must differ by about 0·07 pound to be significantly different (hence a majority of the apparent differences in these tables are significant differences); in an appreciable number of the possible comparisons they must differ by as much as ½ pound; and for a few extreme cases they must differ by ¾ pound.

TABLE XIX.—The average size of TROUT in pounds (round weight) in representative samples of the fish landed by commercial fishermen from Area G, Great Slave Lake.

Fishing year	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	All summer
1945	...	...	...	7.8	...	...	7.8
1946	...	7.7	...	...	5.4	...	6.5
1947	...	9.5	9.9	8.1	6.4	5.0	8.1
1948	11.7	10.4	...	7.5	...	5.1	7.9
1949	...	...	...	...	8.6	5.4	6.1
1950	6.5	...	...	8.6	...	4.3	6.5
1951	...	8.2	6.5	6.6	5.7	4.8	6.2
1952	9.7	8.3	...	5.8	4.5	4.6	6.1
1953	...	...	5.4	5.0	4.9	5.7	5.3
1954	6.1	6.1	6.1	5.9	5.6	5.0	5.8

TABLE XX.—The average size of TROUT in pounds (round weight) in representative samples of the fish landed by commercial fishermen from Area H, Great Slave Lake.

Fishing year	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	All summer
1946	...	...	...	...	8.5	...	8.5
1947	...	8.7	8.5	7.4	8.3	7.9	8.1
1948	9.0	9.6	8.8	8.2	8.9	7.0	9.0
1949	...	...	...	...	...	...	...
1950	...	...	6.9	6.8	7.2	6.8	7.0
1951	...	7.9	6.9	7.3	7.2	6.1	7.0
1952	6.5	6.7	6.6	6.2	5.8	5.8	6.2
1953	...	9.0	7.1	5.4	5.6	5.1	6.5
1954	...	8.2	...	5.6	7.1	7.3	7.4

TABLE XXI.—The average size of TROUT in pounds (round weight) in representative samples of the fish landed by commercial fishermen from Area K, Great Slave Lake.

Fishing year	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	All summer
1945	...	...	...	8.1	...	...	8.1
1946	...	...	...	...	8.7	...	8.7
1947	...	10.6	10.2	10.9	...	...	10·5
1948	8.6	11.6	7.9	7.8	7.5	7.4	8.7
1949	...	6.0	...	...	...	...	6.0
1950	12.8	15.7	8.9	9.4	8.3	6.7	10·2
1951	19·4	10·1	9·6	10·7	...	7·2	10·5
1952	10·6	11·5	12·2	...	...	...	11·1
1953	...	9.4	...	...	7.1	...	7.5
1954	...	7.4	6.3	...	6.5	8.3	6.9

TABLE XXII.—The average size of WHITEFISH in pounds (round weight) in representative samples of the fish landed by commercial fishermen from Area G, Great Slave Lake.

Fishing year	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	All summer
1945	...	...	...	2.9	...	...	2.9
1946	...	2.6	...	...	3.0	...	2.8
1947	...	3.0	2.6	2.7	2.7	2.7	2.7
1948	...	2.7	...	2.7	2.7	3.0	2.8
1949	...	...	2.9	...	...	...	2.9
1950	...	...	...	2.6	...	...	2.6
1951	...	2.5	3.1	2.9	2.8	2.7	2.8
1952	2.8	2.9	...	2.4	2.4	2.3	2.6
1953	...	...	...	2.4	2.4	2.4	2.4
1954	2.1	2.2	2.4	2.4	2.3	2.6	2.4

TABLE XXIII.—The average size of WHITEFISH in pounds (round weight) in representative samples of the fish landed by commercial fishermen from Area H, Great Slave Lake.

Fishing year	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	All summer
1945	...	...	...	3.3	...	...	3.3
1946	...	...	...	...	3.1	...	3.1
1947	...	2.9	2.9	2.9	3.1	3.5	3.0
1948	...	2.8	3.1	3.1	3.2	...	3.1
1949	...	...	...	...	...	...	...
1950	...	...	3.0	3.1	3.0	3.1	3.0
1951	2.9	2.5	3.1	3.0	2.8	3.0	2.9
1952	2.5	2.8	2.5	2.9	2.6	2.9	2.7
1953	...	3.0	3.0	3.0	3.2	2.9	3.0
1954	...	2.8	3.0	2.8	2.6	2.8	2.8

TABLE XXIV.—The average size of WHITEFISH in pounds (round weight) in representative samples of the fish landed by commercial fishermen from Area K, Great Slave Lake.

Fishing year	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	All summer
1947	...	3.1	3.4	3.4	3.0	...	3.3
1948	3.4	3.5	4.2	3.6	5.0	3.1	3.7
1949	...	3.7	4.1	...	...	...	3.8
1950	3.2	3.7	3.3	3.6	...	2.9	3.4
1951	3.8	3.2	3.4	3.4	...	3.2	3.3
1952	2.6	3.0	2.9	...	...	...	2.9
1953	...	2.9	...	...	3.2	...	3.1
1954	...	3.0	2.8	...	2.9	3.2	3.0

TABLE XXV.—Half-monthly FS-indices recorded over a period of 10 years for TROUT catches in Area G, Great Slave Lake.

Fishing year	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	All summer
1945	...	...	...	67	...	...	67
1946	46	35	53	44	59	106	51
1947	...	38	25	40	60	68	42
1948	47	25	82	81	74	54	50
1949	37	35[a]	29[a]	32[a]	46[a]	47	39
1950	..	..	11[a]	55[a]	47[a]	77[a]	49
1951	..	37	25	41	38	41	37
1952	22	10	36[a]	36	71	65	42
1953	25[a]	10	21	35	93	57	49
1954	19[a]	15	11	38	28	13	27

[a]Value based on a comparatively small sample—less than 200 equivalent net-nights.

TABLE XXVI.—Half-monthly FS-indices recorded over a period of 10 years for TROUT catches in Area H, Great Slave Lake.

Fishing year	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	All summer
1945	..	..	..	65[a]	..	..	65[a]
1946	34	45	43	52	52	45	48
1947	..	45	31	43	56	52	46
1948	39	41	60	122	56	31	57
1949	28[a]	35[a]	136[a]	..	61	37	45
1950	35[a]	20[a]	26[a]	42[a]	79[a]	51	45
1951	71[a]	37	30	60	50	26	43
1952	19	11[a]	35	30	27[a]	39	30
1953	19[a]	10	50	42	44	40	42
1954	..	12	10	56	44	26	31

[a]Value based on a comparatively small sample—less than 200 equivalent net-nights.

TABLE XXVII.—Half-monthly FS-indices recorded over a period of 10 years for TROUT catches in Area K, Great Slave Lake.

Fishing year	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	All summer
1945	..	..	..	48	..	..	48
1946	33[a]	51	39	43	27	94	48
1947	..	60	47	38	64	81	54
1948	41	42	55	102	65	66	59
1949	32	33	40	76[a]	64	62[a]	39
1950	16[a]	18	29	22	78	58[a]	39
1951	37	17	11	10[a]	0[a]	18	16
1952	21	10	4	45	53[a]	5[a]	18
1953	32	28	39[a]	52	80[a]	..	41
1954	..	16	42	52	48	21[a]	31

[a]Value based on a comparatively small sample—less than 200 equivalent net-nights.

TABLE XXVIII.—Half-monthly FS-indices recorded over a period of 10 years for WHITEFISH catches in Area G, Great Slave Lake.

Fishing year	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	All summer
1945	..	..	..	40	..	..	40
1946	45	47	44	34	33	29	40
1947	..	50	54	47	31	26	45
1948	25	40	59	30	38	38	36
1949	32	23[a]	16[a]	10[a]	14[a]	6	19
1950	..	..	36[a]	28[a]	16[a]	9[a]	19
1951	..	18	45	42	28	23	32
1952	36	16	22[a]	19	19	13	19
1953	19[a]	17[a]	22	15	18	21	18
1954	19[a]	15	23	24	17	15	20

[a]Value based on a comparatively small sample—less than 200 equivalent net-nights.

TABLE XXIX.—Half-monthly FS-indices recorded over a period of 10 years for WHITEFISH catches in Area H, Great Slave Lake.

Fishing year	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	All summer
1945	..	..	..	20[a]	..	..	20[a]
1946	26	36	28	19	20	22	23
1947	..	29	21	15	16	16	21
1948	26	23	12	10	19	27	19
1949	12[a]	13[a]	132[a]	..	8	13	14
1950	36[a]	33[a]	7[a]	17[a]	16[a]	19	19
1951	37[a]	23	27	21	18	15	21
1952	13	23[a]	12	21	21[a]	11	15
1953	17[a]	34	20	12	28	39	21
1954	..	23	31	40	18	13	21

[a]Value based on a comparatively small sample—less than 200 equivalent net-nights.

TABLE XXX.—Half-monthly FS-indices recorded over a period of 10 years for WHITEFISH catches in Area K, Great Slave Lake.

Fishing year	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	All summer
1945	..	..	..	31	..	..	31
1946	18[a]	44	47	28	36	36	39
1947	..	52	20	53	22	17	35
1948	63	54	56	19	36	28	44
1949	44	65	42	24[a]	22	26[a]	51
1950	60[a]	11	48	78	32	23[a]	56
1951	60	30	44	28[a]	48[a]	18	38
1952	26	23	48	39	25[a]	19[a]	34
1953	22	41	55[a]	31	36[a]	..	37
1954	..	40	31	39	15	31[a]	34

[a]Value based on a comparatively small sample—less than 200 equivalent net-nights.