THE INCONNU (STENodus LEUCIPTHYS MACKENZII) IN GREAT SLAVE LAKE AND ADJOINING WATERS.

A Thesis
Submitted to the Faculty of Graduate Studies
in partial fulfillment of the Requirements
for the Degree of
Master of Arts

in the
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University of Saskatchewan

by

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THE INCONNU (STENODUS LEUCICHTHYS MACKENZII)

IN GREAT SLAVE LAKE AND ADJOINING WATERS.

INTRODUCTION.

The inconnu, Stenodus leucichthys mackenzii, is a fish found in the Arctic Ocean off the coast of North America, and in some of the rivers which flow into it. It has been known to science since 1823 when Richardson first published a description of specimens caught in the Mackenzie basin. Even before this time, however, it was well known to the French-Canadian fur traders who spoke of it as a "poisson inconnu". Mention has also been made of this fish in the narratives of Mackenzie (1801) and Hearne (1795), the latter being the first to record its presence in Great Slave Lake.

Although the fish has been known and used as food for more than 150 years, very little has been learned concerning the details of its life history. Published accounts have dealt mainly with the distribution. Some details of taxonomy and life history were given by Dymond (1943). The inconnu made up about 5 per cent of the commercial catch in Great Slave Lake in 1945 and 1946 and is of considerable importance to the native population, therefore when the Fisheries Research Board of Canada undertook an investigation of the fresh water biology and fisheries of Great Slave Lake, one of the problems set aside for special investigation was a study of the inconnu. The survey occupied three seasons of approximately four
months duration. Each season routine examinations of inconnu were made. This included the recording of fork and standard lengths, weight and sex, examination of stomach contents, collection of parasites and taking of scale samples. In October of 1945 individuals returning from the spawning grounds on Big Buffalo River were examined by Mr. P. A. Larkin whose notes have proved to be very valuable. In 1946, measurements and counts of body parts of a number of inconnu were made, and the writer, accompanied by R. E. McFadden, made a trip by canoe to Big Buffalo Lake which was thought to be a spawning ground of this fish.

These data were supplemented by a daily census of the catch of individual fishermen carrying on commercial fishing operations, and by questioning the native population. The latter source provided information concerning the domestic consumption as well as information and misinformation concerning certain phases of the life history.

ACKNOWLEDGMENTS.

I wish to express my sincere appreciation for the help received from several sources. I am indebted first to Dr. D. S. Rawson, Department of Biology, University of Saskatchewan, for suggesting the topic, making provision for the field work and making laboratory facilities available. His continued interest in the problem and his guidance and criticism of all phases of the work have been of great value.
I am indebted also to the National Research Council of Canada for providing assistance in the form of a bursary. Special thanks are due Dr. W. A. Kennedy, Fisheries Research Board of Canada, Winnipeg, for suggestions and criticisms, particularly during the course of the field work, and for permitting the use of certain statistical data. I would like to express my heartfelt thanks, also, to the other members of the Northwest Fisheries Investigation party for their willingness to co-operate in the collection of data, even at considerable personal inconvenience.

TAXONOMY.

Description.

*Stenodus* is a genus in the family *Coregonidae*, bearing a strong superficial resemblance to the cisco, *Leucichthys* spp. in its immature stages. There is no danger, however, of confusing mature *inconnu*, which grow to a large size, with any northern Canadian fish. The distinguishing structural features are as follows.

A description follows. Head long (one-quarter of standard length), and pointed; lower jaw longer than upper and slightly hooked; maxillary slightly more than one-third of head length, reaching to posterior margin of pupil; greatest antero-posterior diameter of eye about three-quarters of the length of the snout; snout approximately equal to interorbital; nostrils with 2 flaps; branchiostegals 10.
Fig. 1. Photograph of an inconnu 32 inches, 12 1/2 pounds, from Yellowknife, N.W.T. September 1, 1944.
occasionally 11, rarely 9 or 12; gill rakers of moderate length, stiff and bony, number on first arch 7 + 16; very small teeth on palatine, vomer, tongue, premaxillary, head of maxillary and anteriorly on lower jaw. Body long and slender (depth about one-fifth of standard length), uniform silvery color, somewhat darker above (more noticeable in young specimens); dorsal fin with 12 fully developed rays preceded by 2 or 3 shorter ones, slightly higher than long, posterior margin dusky; anal fin immaculate with 14 or 15 developed rays preceded by 2 or 3 shorter ones; its base nearly equal to its height; pectorals and pelvicps well-developed, immaculate; caudal edged with black; scales in lateral line to end of caudal peduncle 98 (90-107). (Fig. 1).

Measurements and counts of body parts.

During the summer of 1946, measurements and counts of body parts of 26 individuals were made following the method outlined by Koelz (1929). Fourteen of these were caught by commercial fishermen using 5 1/2" mesh nets in the neighborhood of Inconnu Channel, 3 from Fort Resolution and 2 from Big Buffalo Lake were taken in a standard gang of test nets (1 1/2 - 5 1/2" mesh) and 2 from the mouth of the Big Buffalo River were caught by Mr. W. Greer in 4 1/2" mesh nets. These data are reproduced in Appendix 1. Dymond (1943) measured 11 specimens from the Slave River at Fort Smith, and Clemens (unpublished data) measured a sample of 14 *Stenodus* from Teslin Lake, northern
British Columbia, in 1944. On the basis of these data, Table 1 and Table 2 have been drawn up.

In Table 1, the measurements of all mature fish (standard length 60 cms. or more) are shown. Eighteen of the 26 specimens measured by the writer, 6 of those measured by Clemens, and all of Dymond's material is considered mature by this criterion. It is necessary to exclude all immature fish because proportions change markedly with the growth of the fish. For purposes of comparison the measurements are expressed as percentages of the standard length, and the mean and observed extremes are shown in Table 1.

The counts of body parts do not vary with the size of the fish, therefore, it has been possible to utilize all the data in calculating the mean values. The mode has also been included for two reasons, first because a count must always yield a discrete value, and the mean is often fractional, and second because in a small sample, one or two extreme individuals might distort the mean considerably.

In making counts of the number of rays in a fin, even the smallest rays are counted. The first fully developed ray however, is always preceded by \( \kappa \) to \( \jmath \) others which are less than \( 2/3 \) of its height. Dymond and Clemens have stated the total only, while the writer has indicated that the total is made up of a number of fully developed rays plus two or three shorter ones.
<table>
<thead>
<tr>
<th></th>
<th>Great Slave Lake 1946</th>
<th>Dymond, 1943</th>
<th>Teslin Lake 1944</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>extremes</td>
<td>mean</td>
</tr>
<tr>
<td>Head length</td>
<td>25.6</td>
<td>23.6-28.1</td>
<td>26.7</td>
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<tr>
<td>Head depth</td>
<td>13.2</td>
<td>12.2-15.5</td>
<td>15.3</td>
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<tr>
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<td>3.4</td>
<td>3.2-4.1</td>
<td>3.5</td>
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<td>4.9</td>
<td>4.2-5.9</td>
<td>6.0</td>
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<td>4.7</td>
<td>4.2-5.5</td>
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<td>Maxillary</td>
<td>9.1</td>
<td>7.5-10.5</td>
<td>9.4</td>
</tr>
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<td>21.5</td>
<td>19.5-22.6</td>
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<tr>
<td>Body width</td>
<td>13.1</td>
<td>9.9-15.5</td>
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<td>9.1-11.3</td>
<td>11.0</td>
</tr>
<tr>
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<td>6.1-7.5</td>
<td>7.1</td>
</tr>
<tr>
<td>Dors. fin height</td>
<td>15.2</td>
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<td>Dors. fin base</td>
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<td>12.5</td>
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<tr>
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<td>Pectoral length</td>
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<td>14.5-17.0</td>
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<tr>
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<td>13.1-15.6</td>
<td>15.2</td>
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</table>

Table 1. Proportionate measurements of *Stenodus* from Great Slave Lake, 1946 (18 specimens); Slave River, Dymond 1943 (11 specimens); Teslin Lake, Clemens 1944 (6 specimens)
<table>
<thead>
<tr>
<th></th>
<th>Great Slave Lake, 1946</th>
<th>Slave River, Dymond 1943</th>
<th>Teslin Lake, Clemens 1944</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>Mean</td>
<td>Mode</td>
<td>Extremes</td>
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<tr>
<td>Scales</td>
<td>97.9</td>
<td>97</td>
<td>92-107</td>
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<td>Gill Rakers</td>
<td>7.4+15.7</td>
<td>7+16</td>
<td>6+14-9+18</td>
</tr>
<tr>
<td>Branchiostegals</td>
<td>10.2</td>
<td>10</td>
<td>9-11</td>
</tr>
<tr>
<td>Dorsal fin rays</td>
<td>12+</td>
<td>2+12</td>
<td>1+11-3+16</td>
</tr>
<tr>
<td>Anal fin rays</td>
<td>14.5+</td>
<td>2+14</td>
<td>3+13-2+17</td>
</tr>
<tr>
<td>Vertebrae</td>
<td>64.3+</td>
<td>65+3</td>
<td>62+2-67+2</td>
</tr>
</tbody>
</table>

Table 2. Counts of body parts of *Stenodus* from Great Slave Lake, 1946; Slave River, Dymond 1943; Teslin Lake, Clemens 1944.

* Based on 25 specimens. One badly rubbed individual not included.

# Three specimens had fusion of vertebrae which rendered counting impossible. This average is therefore based on 23 specimens.
Vertebral counts were made by the writer only. The result has been expressed as the number of vertebrae to the end of the caudal peduncle plus the two or three rudimentary caudal vertebrae.

**Relationship to Asiatic Stenodus leucichthys.**

Richardson described the inconnu in 1823 as a separate species, *Stenodus mackenzii*. It is still commonly referred to by that name. Scofield, Halkett, Melville and Berg (in Dymond, 1943) have suggested the identity of *S. mackenzii* and *S. leucichthys*. Dymond concluded that the gill-raker count is the most stable morphological character of the coregonine fishes of northwestern Canada. It should, therefore, be the most dependable one to use for taxonomic purposes. Berg (in Dymond) stated that the number of gill-rakers of *S. leucichthys leucichthys* varies from 19 to 25 with a mean of 22 to 23. In the 51 American specimens referred to above, the range is 19 to 27 with a mean of 22.0. Only two specimens had more than 25. The number of scales on the lateral line is another character which has been widely used in studying the relationships of fishes. According to Berg, the range in Asiatic *Stenodus* is from 99 to 120 with a mean of 109.3. In American *Stenodus* the range is from 90 to 107 with a mean of 99.2. It is not stated whether Berg counted to the end of the caudal peduncle or to the end of the lateral line. If the latter is the case, the differences are considerably reduced. Dymond, on the basis of the
evidence available to him, was inclined to agree with Berg that American and Asiatic Stenodus are conspecific. The writer feels that the additional evidence which has now accumulated, strengthens rather than detracts from this conclusion. The inconnu should, therefore, be regarded as Stenodus leucichthys mackenzii Richardson.

Possibility of racial differences in American Stenodus.

Dymond's data contained a suggestion of morphological differentiation between Great Slave Lake and Mackenzie River populations, in that the former showed a tendency to a higher scale count. The writer is of the opinion that this is due to the inadequacy of the sample since Dymond's average is also considerably higher than that found in 1946 (Table 1). The scale counts of the Mackenzie River specimens, (98, 103, 97) are not then to be considered lower than the general average for Great Slave Lake specimens and since there has been no suggestion of other morphological differences, there seem to be no grounds for recognizing two races of Stenodus leucichthys in America.

Possibility of Stenodus x Leucichthys hybrids.

Dymond has discussed apparently well authenticated cases of hybrids between these two genera found in the lower Mackenzie River. No evidence of such a hybrid was encountered in Great Slave Lake.
DISTRIBUTION OF THE GENUS STENODUS.

Stenodus is native to the Arctic Ocean, off the coasts of Asia and North America. It is found also in most of the rivers emptying into the Arctic ocean. Spawning is reported to take place in the fresh water of these rivers. The genus is more widespread in Asia where it extends as far west as the White Sea. There is also a landlocked population in the Caspian Sea. In America, it is found as far east as the Anderson river, while in Great Slave Lake there is a population which, in effect, landlocked.

American Stenodus has been recorded from the rivers of Alaska "from the Kuskoquim to the Kuwuk". (Bean 1894), from headwaters of the Yukon (Evermann and Goldsborough 1907) and from the Mackenzie River system by numerous authors.

Inconnu are common in the lower 400 miles of the Mackenzie River and are found in some of its tributaries such as the Peel and Rat Rivers in considerable numbers. From here to Great Slave Lake, inconnu are occasionally caught, but are not common. It appears, however, that they can live in all parts of the river and pass freely up and down it. The species is able to ascend the Slave River, above Great Slave Lake, for a distance of nearly 200 miles to the foot of the rapids at Fort Smith. Large numbers of individuals are reported to spawn here each fall.

Within Great Slave Lake, inconnu are found most commonly in two areas (Fig. 2). The first area is a large one, extending
Fig. 2. Map showing distribution of the inconnu in Great Slave Lake.
along the south shore from at least the Slave River delta in the east to the source of the Mackenzie at the west end of the lake. Throughout this area, the bottom slopes off gradually, the water is shallow and laden with silt from the Slave River. The second area is a restricted one at the western entrance to Inconnu Channel, in the angle formed by the south shore of Wilson Island and the west shore of Simpson Island. The depth in this area is in the neighborhood of 25 metres.

In the remainder of the lake, inconnu occur in smaller numbers or are absent altogether. They are sparingly distributed along the west shore, in the north arm, along the north shore from Yellowknife Bay to Gros Cap, in the vicinity of Outpost Islands, and along the south shore from the delta of the Slave to the Taltson River. The species was not found in the open water of the body of the lake or in the east arm.

Depth seems to be the main factor controlling their distribution. In 145 settings of test nets (300 yard gangs of 1 1/2 to 5 1/2" mesh) in all localities and at all depths, only two inconnu were caught in a depth exceeding 30 metres. The maximum depth at which inconnu were caught by commercial fishermen was 125 feet. The native population uses inconnu extensively as feed for their dogs. It was observed at Ft. Resolution, that all of their nets were set within about a mile of shore in depths which did not exceed 8 metres.
Stenodus is found at certain seasons of the year in some of the rivers which flow into Great Slave Lake. The Big Buffalo, Slave, Taltson and Hay Rivers, all of which empty into the south shore of the lake, are the most important in this respect. The Little Buffalo River which also enters on the south shore appears to be unsuitable, possibly because of its small size. Occasionally, some of the rivers of the north shore such as the Yellowknife River, are visited. Slave Lake inconnu, like those in the Arctic Ocean, appear to be river spawners.

ORIGIN OF GREAT SLAVE LAKE INCONNU.

It is perhaps dangerous to attempt to discover the original home of the genus Stenodus before even its present day distribution has been studied in detail. It may be of some value, however, to attempt to connect up what little is known and thus to arrive at a tentative, working hypothesis. The pertinent facts, in the opinion of the writer, are these.

1. Asiatic Stenodus better adapted than American.

Very often we find a genus or species is better adapted, in the sense that it is more abundant and has a wider range, near the area of its origin. If this is valid in the case of Stenodus, it indicates that the genus originated in Asia and spread out later to reach North America. This hypothesis must be used with caution, however, as there are well known instances of species becoming less abundant or even extinct throughout the area which was their original home.
2. **Subspecies recognized in Asia, not in America.**

Two races of Asiatic *Stenodus* are recognized, *Stenodus leucichthys nelma* in the ocean and rivers, and *S. l. leucichthys* in the Caspian Sea. On this continent, no morphological divergence of subspecific rank has as yet been observed between the anadromous and fresh water populations. While it is realized that time alone cannot bring about morphological differentiation, it seems logical that if the factors responsible are in any way comparable, the differentiation will be most marked in the place where the factors have been at work for the longest time. This adds to the plausibility of the theory that *Stenodus* was present in Asia before it appeared in North America.

3. **Relation to certain so-called "Marine relicts."**

In the present state of our knowledge, the argument to be presented here is not a clear-cut one. It is subject to many criticisms and other interpretations of the facts are possible. Final and complete understanding must wait for more detailed studies of the biology and distribution of the species in question and of the geological history of Siberia and the North West Territories.

*Stenodus* leucichthys, *Mysis caspia* and *Pontonoria caspia*, all of which are considered to be marine or closely related to marine forms, occur together in the Caspian Sea. Since the Caspian has no connection with the ocean whatever, these species must have been
carried there by the action of some external agency. The exact nature of this force is less important than its magnitude. We require a force large enough to transport a fish of moderate size such as Stenodus, over a distance of several hundred miles, at the same time as it carried the comparatively minute crustaceans. If, as seems entirely probable, Stenodus and the two relicts, Mysis and Pontoporeia reached the Caspian in the same way and at the same time, there is established a relationship between them in time and space.

In Great Slave Lake, we have what appears to be, at first sight, a similar situation, namely, Stenodus leucichthys in company with Mysis relicta and Pontoporeia affinis. However, there is an important difference between the two bodies of water in that Great Slave Lake is still connected with the Arctic Ocean by means of the Mackenzie River, which presents no impassable physical barriers to a migrating fish. When other large lakes, such as Great Bear and Athabaska, are considered, additional light is shed on the question. Mysis and Pontoporeia occur in both of these lakes, but Stenodus does not (with the exception of a single record for Great Bear by Simpson in 1843). Since rapids of formidable size and power guard the entrance to these lakes from the Mackenzie River, we would not expect any aquatic animal to be able to reach them by active migration. It is necessary once more, to call upon an external agency to explain the distribution of
Mysis and Pontoporeia. The fact that the inconnu was not carried into Great Bear and Athabaska along with Mysis and Pontoporeia, probably indicates that it had not yet colonized North America. On the basis of this assumption, there is established a negative relationship in time and space between the two groups on this continent.

The completed picture, then, may very well be that Stenodus originated as an anadromous, or at least euryhaline fish, in the coastal waters of northern Siberia. At some time of violent geological upheaval, probably associated with the last ice-age, it was introduced into the Caspian Sea. Later it spread in the Arctic Ocean and reached the coast of North America, and so migrated up the Mackenzie River to Great Slave Lake. An examination of some of the more important factors involved in the migration of inconnu will be found in a later section (page 38).
SOME IMPORTANT FEATURES OF GREAT SLAVE LAKE
AND ITS TRIBUTARY RIVERS.

The following brief description of Great Slave Lake and its tributaries is included to provide a background for the later discussion, in a later section, of the life history of the inconnu.

(1). Great Slave Lake.

Great Slave Lake lies in the North West Territories, extending from 61° to 63° north latitude and 109° to 117° east longitude. It is so situated that the north east shore of the north arm, and the entire east arm, lie within the Precambrian Shield. As a result, the shore line in these parts is very rocky and extremely irregular. In the east arm, escarpments rising vertically to a height of 200 feet or more are common. The south and west shores are bounded by the Mackenzie Lowlands and are, therefore, much lower and more regular.

The area of the lake is 10,500 square miles. It is composed of a main body, approximately 60 by 100 miles, a north arm extending 90 miles to the north west, and an east arm extending 150 miles to the north east.

There is great variation in depth and the contours of the bottom, also largely conditioned by the nature of the surrounding
country. In many parts of the east arm the bottom slopes off at an angle of more than 45°. Along the Precambrian shore generally, depths of 20 to 50 metres are encountered very close to shore, while along the south and west boundaries, the near shore areas are shallow and the bottom slopes off very slowly. The north arm, from Redrock Point to Fort Rae is less than 100 feet deep. Much of the east arm, on the other hand, exceeds 1000 feet and a small area is more than 2000 feet deep. Large portions of the main body of the lake exceed 300 feet. The maximum depth recorded for the open water area is 535 feet.

Temperature observations have been made in all parts of the lake. In 1944 seasonal observations were made in Yellowknife Bay and in 1946 in parts of Christie Bay and at Gros Cap (Station A). Of these Station A, located approximately 1 1/2 miles from Gros Cap (r00 feet) in a depth of 150 metres, was most representative of open water conditions. The surface and bottom temperatures recorded at Station A in the summer of 1946 have been plotted. (Fig. 3). On June 23, during the spring turnover, the temperature was nearly uniform (2.5°C) from surface to bottom. As the summer progressed, the water temperature rose at a fairly uniform rate till it reached its maximum in mid-August. The maximum observed on the surface was 14.6°C while the bottom only reached 4.8°C.
Figure 3. Temperature curve at station A (150 ± metres) Great Slave Lake, 1946. Surface temperature represented by solid line; bottom temperature by broken line.

Comparative seasonal observations are not available for any inshore area. However, from a great many observations in shallow water, the trend can be estimated quite accurately. Although the shallow water curve has essentially the same form as the deep water one, it rises more steeply in June, has a slightly higher maximum and falls more quickly in September. In depths of not more than 30 metres, the surface temperature may rise to 17°C and the bottom temperature to 10°C in mid-August.
The amount of dissolved oxygen was found to be quite adequate for fish at all times as would be expected in such an extremely oligotrophic lake. The actual amount present, varied from 6.3 to 8.7 ccs. per litre. Correcting for temperature and altitude, this represents a saturation value of at least 80 per cent. No seasonal abundance or depletion has been detected.

No biologically significant variations in hydrogen ion concentration were observed in the body of the lake. Values were always slightly on the alkaline side, and ranged from 7.4 to 8.2 with the majority being 7.6 to 7.8. The uniformity might be stressed by pointing out that the observations were made at many different points, in a variety of depths, at different seasons and over a period of three summers. There appeared to be no regular seasonal fluctuations.

The nature of the drainage area exerts a profound influence on the transparency of the water. The rivers which run in from the Precambrian Shield, and which drain an area composed largely of rock, bring down very little silt and organic material which would decrease the transparency. The rivers of the south shore, on the other hand, particularly the Slave and Big Buffalo, are laden with silt which spreads out over a considerable area. The muddy water of the Slave can be detected for a distance of 25 miles toward the centre of the lake, and then followed along the south shore to the outlet of the Mackenzie. In this area, the light penetration is very much reduced. The transparency of the water was measured by means of Secchi's disc. Secchi's disc readings in
the muddy water are 0.15 to 2.0 metres compared with 2.5 to 5.5 metres for most of the open water area and as much as 15.0 metres in restricted areas of the east arm.

(2) The Big Buffalo River System.

The Big Buffalo system arises in the Caribou Hills as three streams which empty into Big Buffalo Lake, a body of water with an area of over 300 square miles and a maximum reported depth of 4 1/2 feet (1.5 metres). The shores of this lake are soft mud, boulder strewn and weedy. From Big Buffalo Lake, the Big Buffalo River flows down 60 to 65 miles to Great Slave Lake. The upper part of the river is deep and smooth flowing, only occasionally interrupted by rocky bars. At a distance of 12 or 15 miles from its mouth it flows through a narrow gorge and over a small rapid with a velocity estimated to be at least 10 miles per hour. For several miles above and below this rapid, the bed is wide and strewn with boulders. Consequently the water is shallow and flows over an almost continuous series of "riffles" each with a drop of 6 to 12 inches. Occasionally the river narrows as it passes over one of these bars and flows with a velocity of 5 to 7 miles per hour. These obstructions make canoe travel on the river very difficult, but do not prevent the migration of inconnu and other fish.

As would be expected, the temperature of the Buffalo River system is higher than that of Great Slave Lake and responds more markedly to changes in the air temperature. The surface temperature
at the mouth of the river had already risen to 20°C on July 3, 1946. On August 12, 1946 it was 16.8°C, while on September 5, it had fallen to 10.3°C. This drop was probably only temporary and associated with a fall in air temperature from 16.9°C on August 31 to 4.3°C on the morning of September 5. A series of temperatures taken during the period August 31 to September 5 from Big Buffalo Lake, down the river to Great Slave Lake, showed a steady decrease from 15.3°C in the lake to a minimum of 9.8°C a few miles above the mouth. The slightly higher temperature at the mouth (10.3°C) was probably due to the influence of Great Slave Lake.

The water from the Big Buffalo River has a warming effect on Great Slave Lake which can be detected for some distance. On July 4, 1946 a series of surface temperatures was taken at intervals from the mouth of the river to Fort Resolution (50 ± miles). These data are presented in Table 3.

<table>
<thead>
<tr>
<th>Distance from Big Buffalo River, miles.</th>
<th>1/2</th>
<th>1</th>
<th>2 1/2</th>
<th>3 1/2</th>
<th>7</th>
<th>14</th>
<th>21</th>
<th>28</th>
<th>49</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Temperature °C.</td>
<td>17.0</td>
<td>17.0</td>
<td>15.5</td>
<td>15.5</td>
<td>15.5</td>
<td>14.8</td>
<td>14.5</td>
<td>15.2</td>
<td>14.0</td>
</tr>
</tbody>
</table>

Table 3. Warming effect of Big Buffalo River on Great Slave Lake.

It can be seen from this table that the effect is undiminished at a distance of one mile, and it is possible but by no means certain, that it is still noticeable at a distance of 7 miles. The continued
drop recorded at 14 and 21 miles is probably due to normal fluctuations in the surface temperature from one region to another. The direction and velocity of the wind, initial temperature of the Buffalo River and the rate of flow of both the Buffalo and Slave Rivers would modify both the direction and extent of this effect.

The water in the river and most of Big Buffalo Lake is extremely muddy and Secchi's disc is visible for only 0.15 metres (6 inches) or less. Along the south shore of the lake, it was noticed that the bottom was visible at a depth of approximately one foot. In all probability this indicates that the water flowing in from the Caribou Hills to the south, is much less turbid.

It is interesting to note that the silting from the Buffalo River can also be detected well out into Great Slave Lake. Secchi's disc readings were made at the same points as the temperature observations shown in Table 3. The Secchi's disc readings are shown in Table 4.

<table>
<thead>
<tr>
<th>Distance from Big Buffalo River, miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2  1  2  1/2  3  1/2  7  14  21  28  49</td>
</tr>
<tr>
<td>Secchi's disc, metres</td>
</tr>
<tr>
<td>0.20  0.20  0.66  0.66  0.66  0.66  0.66  0.66  0.40</td>
</tr>
</tbody>
</table>

Table 4. Effect of silt from Big Buffalo River on transparency of Great Slave Lake.
The effect of the heavy silting was apparently lost somewhere between 2 1/2 and 3 1/2 miles from the mouth of the river. Its direction and extent would be influenced by the same factors as were mentioned with respect to temperature.

No estimations of the amount of dissolved oxygen were made, it being assumed that the value would be close to saturation at all times. This assumption should be valid for a fast flowing stream, constantly bubbling over rocks, and for a shallow lake with a large surface area exposed to winds from every direction. Assuming 100 per cent saturation at a maximum temperature of 20°C, the minimum amount of dissolved oxygen present would be 6.3 ccs. per litre.

The hydrogen ion concentration of the Big Buffalo system lies within the range observed in Great Slave Lake, but tends toward the upper extreme. Most readings were 7.8 to 8.0.

A peculiarity of the Buffalo system is the presence of tiny streams with a high sulfur content, many of which flow into the lower portion of the river between the rapids and Slave Lake. It is almost certain, however, that any excess of sulfur would be lost immediately by dilution and buffer action. Its effect could certainly not be noticeable for any distance in Great Slave Lake.

(3) Taltson (Rocher) River.

The Taltson River differs in many respects from Big Buffalo. The lower portion of the Taltson is comparatively deep. Lake
tugs are able to navigate it for a distance of 5 miles to the settlement of Rocher River, and small power launches can go considerably farther. It was found to be 5 metres deep at a point half a mile above the settlement, that is, 5 to 6 miles from the mouth.

Another striking difference is in the transparency of the water. Secchi's disc was visible at a depth of 2.25 metres in the Taltson.

An important feature of the Taltson is the presence of large rapids about 25 miles above the mouth. Besides halting all river traffic, these rapids set a limit to the distance which fish are able to migrate.

Surface temperatures recorded in the Taltson River were 16.8°C on July 12, 1946 and 17.5°C on August 5. These are nearly the same as those observed in the Buffalo. Any differences are probably due to minor fluctuations in air temperature.

Oxygen content was not measured, it being again assumed that the water was always saturated.

The water of the Taltson tends to be somewhat less basic than that in Great Slave Lake or the Big Buffalo River. Readings of 7.3 and 7.2 were observed.

(4) Slave River.

The Slave is a large river formed by the confluence of the Peace and Athabaska Rivers. It flows gently through the Mackenzie
Lowlands, uninterrupted by rapids for approximately 200 miles from Fort Smith to Great Slave Lake. This part of the river presents no impediments to migrating fish.

In its physical and chemical features the Slave is similar to the Big Buffalo. Temperatures, transparency and p.H. values are almost identical. Due to its large volume, however, the Slave River exerts a far greater influence on the temperature and transparency of the lake.

(5) Hay River.

No quantitative observations were made in the Hay River. When the settlement at its mouth was visited, it was noticed that the turbidity of the water was somewhat intermediate between that of the Slave and Buffalo Rivers on one hand, and the Taltson on the other. The summer temperatures are probably very similar to those of the other rivers under discussion. They are undoubtedly higher than those in Great Slave Lake. The oxygen content is probably high.

The Hay River is blocked by the Alexandra Falls, about 48 miles from its mouth, in which respect it resembles the Taltson and the Slave.

(6) Other Tributaries.

Many other rivers of small to moderate size flow into Great Slave Lake. Of these, the Little Buffalo from the south is extremely shallow, while most of those flowing in from the north are impassable due to rapids and falls. None of these is used by immature as a migration route to any extent.
FOOD OF THE INCONNU

The stomachs of 196 inconnu from Great Slave Lake were examined in the field and the contents noted. The specimens in this sample varied in length from 17 cm. to 108 cm. The results of the survey indicate that the inconnu is almost exclusively piscivorous in Great Slave Lake. Only 4 specimens (2 per cent) had fed on invertebrates. Of the remainder, 111 or 57 per cent were empty at the time of capture and 81 or 41 per cent contained fish, or unidentified fish remains. Although the four specimens containing invertebrates were small (22 to 27 cm.), other specimens in the same size range and even smaller, had fed on fish. It is believed, therefore, that feeding on invertebrates is the exception, rather than the rule, even for small specimens.

On September 1 and 2, 1946, 38 large inconnu were examined at Big Buffalo Lake. Of these, 27 had empty stomachs as would be expected since all were nearly ripe and on route to their spawning grounds. Nine others contained fish remains, while two specimens, both 64 cm. in length, contained aquatic insects (corixids and notonectids).

Some interesting information was collected at the mouth of the Big Buffalo River by P. A. Larkin who observed the fall fishery there in early October, 1945. Inconnu caught in the nets
immediately prior to the commencement of the run of fish from the spawning grounds, were found to be gorged with small inconnu. This cannibalism has not been observed under any other conditions in Great Slave Lake, but one of the fish caught in Big Buffalo Lake contained the remains of a small fish which was undoubtedly an inconnu. 

There can be no doubt that the small fish had come from Big Buffalo Lake since their stomachs contained about 70 per cent ephippia of Daphnia sp., 25 per cent chironomid larvae and 5 per cent other aquatic insects, but no amphipods or fish remains. Qualitative samples of the plankton and bottom organisms of Buffalo Lake taken in September of 1946 showed a large number of the cladoceran (Daphnia pulex) and the copepod (Epischura sp.), ephippia of Daphnia, a few aquatic insects (corixids and notonectids) and no amphipods. Small specimens in the rivers, then, probably feed exclusively on invertebrates. There is a sudden and complete change of diet when they reach Great Slave Lake.

In the lake, it might appear that inconnu compete with the commercially more desirable lake trout (Cristivomer namaycush).

Any competition is probably not serious for the following reasons. The two species do not reach their maximum abundance in the same parts of the lake. The range of the two species does not overlap to any extent. Trout are relatively scarce along the shallow south shore while there are few inconnu in the parts of the Lake inhabited by trout. The trout is several times as abundant as the inconnu, therefore, competition amongst the trout themselves is more severe than that between trout.
and inconnu. Furthermore, there are differences in the food taken. The trout subsist mainly on ciscoes (*Leucichthys* sp.). Perhaps 80 per cent of their food consists of ciscoes with the remainder being made up of other coregonines, northern sucker (*Catostomus catostomus*) and loche (*Lota maculosa*). The food of the inconnu is largely very small fish, less than 4" long. It is difficult to estimate what proportion of these are very young ciscoes since most of the remains are partially digested and therefore unidentifiable, but a careful estimate would place it at less than 50 per cent.
MIGRATION AND SPAWNING.

INTRODUCTION.

The migration of living organisms is a problem which has interested naturalists from the time of Aristotle. The best known examples are the movements of birds and fishes. Scientific interest and the great economic importance of fish have led to detailed studies of the migration of such commercial species as the salmon (Salmo spp.), sturgeon (Acipenser sp.), cod (Gadus sp.), herring (Clupea sp.) and others. Roule (1933) has given an excellent account of the journeys undertaken by many of the important food fishes of Europe. He has also attempted to show that migration is a response to the interaction of an internal factor and one or more external factors. The internal factor may be nutritional, but is more often associated with spawning. With the onset of maturity the gonads increase greatly in size and activity, which alters the metabolism of the whole fish and makes it more sensitive to changes in environmental factors such as light penetration, temperature, amount of dissolved oxygen and so forth. When the migration is of this sort, it serves the useful function of bringing together large numbers of individuals and thus helps to insure a high percentage of fertilization.
Roule has distinguished four types of movements which might be summarized by these four examples. (a) Local aggregations at one spot on the surface of the sea (Clupea and Sardinella).
(b) Movement from deep to shallow water in lakes (Coregonus).
(c) Movement of a river species up or down the river (Salmo trutta).
(d) True migration from salt to fresh water (Salmo and Oncorhynchus).

The inconnu in Great Slave Lake does not fit into any of these groups. We might define a fifth group to contain lake dwelling fish such as the inconnu and the grayling (Thymallus) which journey into the rivers. Stenodus of the Arctic Ocean and lower Mackenzie River, however, is anadromous and belongs therefore, with the truly migratory fishes of group (d). It is perhaps better that we should consider the migration of Great Slave Lake inconnu as a small scale counterpart of this behavior.

MIGRATION OF ADULTS.

Introduction.

The regular movement of inconnu from Great Slave Lake to the rivers and back is well known throughout this region. The inhabitants take advantage of this knowledge to catch large quantities of inconnu, mainly for winter use as dog feed, during the run from the spawning grounds. The time of this run does not vary by more than a few days from year to year. The movement up river, however, has never been critically analyzed.
Mr. William Greer Sr., a trapper who lives on the Big Buffalo River, fishes inconnu through the summer at the mouth of the river. He is able to catch from 2 to 12 inconnu per day in about 50 feet of 4 1/2" mesh net, and is of the opinion that these fish are beginning their journey up river. Some indians and halfbreeds who were questioned shared this view and claimed that the heaviest run occurred immediately after the ice went out. Such an irregular movement, proceeding in a haphazard way throughout the summer is not in accordance with what is known of the migrations of other fishes, nor is it substantiated by other observations made on Great Slave Lake. In all probability, the fish caught by Mr. Greer are merely transients in the mouth of the river which have wandered in for the purpose of feeding.

If the inconnu moved up river all through the summer, the commercial catch would be expected to show a more or less steady decline as the number of available fish was continually being reduced. Table 5 is a summary of the weekly catch of inconnu and the weekly total catch of commercial species (trout, whitefish and inconnu) at Gros Cap.

It will be noticed that the catch of inconnu fell suddenly from 13,812 pounds for the week ending August 10 to 2,484 pounds for the week ending August 17. Over the same period, the total catch actually increased from 190,426 pounds to 235,342 pounds, which indicates that there was no decrease in fishing effort. The drop can be accounted for in one of two ways. Either there was a decrease in
Table 5. Weekly catch, in pounds, of inconnu and all commercial species, Gros Cap area, Great Slave Lake, 1946.

availability of inconnu, or the fishermen stopped fishing the areas in which inconnu are most abundant. The catch per unit of effort is, subject to certain limitations, a fairly accurate indicator of the availability. The writer is indebted to W. A. Kennedy, Central Fisheries Research Station, Winnipeg for permission to use the
information contained in Tables 6 and 7, which was secured by keeping a daily census of the catch of individual fishermen. In Table 6 is shown the catch per unit effort for two week periods in each of the five areas into which the commercial fishing area was subdivided (Fig. 4).

Fig. 4. Divisions of the commercial fishing area of Great Slave Lake.
Two things are clearly shown, first that the catch of inconnu per net is insignificant in all areas except the "Islands" and second, that in this area there is a sudden drop in availability after August 15.

<table>
<thead>
<tr>
<th></th>
<th>Gros Cap</th>
<th>Northwest</th>
<th>Islands</th>
<th>West</th>
<th>East</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 28-July 15</td>
<td>4</td>
<td>3</td>
<td>24</td>
<td>8</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>July 16-31</td>
<td>2</td>
<td>3</td>
<td>10</td>
<td>6</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Aug. 1-15</td>
<td>1</td>
<td>2</td>
<td>26</td>
<td>2</td>
<td>0.1</td>
<td>6</td>
</tr>
<tr>
<td>Aug. 16-31</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>12</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Sept. 1-15</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0.3</td>
<td>0.2</td>
<td>2</td>
</tr>
<tr>
<td>Season</td>
<td>2</td>
<td>2</td>
<td>16</td>
<td>7</td>
<td>0.1</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 6. Catch of inconnu per unit effort in 5 divisions of the commercial fishing area. Great Slave Lake, 1946. The unit was 100 yards of 1/4" mesh net fished for one night. 

The "Islands" area extends from the Outpost Islands to Wilson and Simpson Islands, that is, to the entrance to Inconnu Channel. This region was further subdivided into areas which were (1) the immediate vicinity of Outpost Islands, (2) the entrance to Inconnu Channel, (3) all other parts of the region. Table 7 was prepared to show the catch per unit effort in each of these
subdivisions. The interesting point brought out by these data is the steady decline in availability in the Inconnu Channel subdivision which began about July 15, and the corresponding increase in availability in the Outpost Islands subdivision until August 15 when there was a sudden drop.

<table>
<thead>
<tr>
<th></th>
<th>Outpost Islands</th>
<th>Inconnu Channel</th>
<th>Remainder of Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 28–July 15</td>
<td>3</td>
<td>37</td>
<td>20</td>
</tr>
<tr>
<td>July 16–31</td>
<td>21</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Aug. 1–15</td>
<td>34</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Aug. 16–31</td>
<td>0.1</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Sept. 1–15</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 7. Catch per unit effort in the subdivisions of the "Islands" fishing area, Great Slave Lake, 1946.

The information contained in Tables 5 to 7 provides ample evidence that the movement of inconnu begins in the Inconnu Channel and region shortly after July 15, proceeds in a southwesterly direction to Outpost Islands. About August 15, there is a mass exodus from the entire commercial fishing area, which is interpreted as indicating the beginning of the migration.
Information received at Rocher River settlement also supports the view that the run of inconnu begins about August 15 or September 1. A net was set in the river on August 12, 1946 which failed to catch inconnu. Local fishermen were still fishing in the large bay at the mouth of the Taltson River, but were expecting the inconnu to move into the river very soon.

Role of physical and chemical features in inconnu migration.

The discussion to follow, of the way in which certain features of the environment influence the migration of inconnu, will deal principally with the Big Buffalo River system since we have a more extensive knowledge of conditions there.

In order to show a causal relationship between any factor and migration, either all the rivers must differ from the lake in the same way with respect to that factor, or, it must show a regular seasonal variation in either the rivers or the lakes or both. Two factors may therefore be ruled out almost without comment. These are the amount of dissolved oxygen and the hydrogen ion concentration. It has been pointed out on page 17 that the oxygen does not vary seasonally to a point of supersaturation or to a point which would adversely affect the well-being of fish. There are, however, slight changes since warm water can hold less dissolved oxygen than cold water. However, when the inconnu begin their migration, the temperature is
at its maximum and the amount of oxygen therefore is a minimum. Since the rivers are even warmer than the lake at this time, they probably do not contain more dissolved oxygen. A maturing fish, with an increasing metabolic rate would not be expected to seek waters of low oxygen content.

The pH in the Big Buffalo tends to be higher than the average for Great Slave Lake, while that in the Taltson is somewhat lower, yet inconnu run up both of them. This, together with the fact that there is no seasonal fluctuation in pH, eliminates it as a factor.

The amount of light penetration in the water may have a slight effect. It is possible that inconnu seek to avoid strong light. Although they are shallow water forms, they prefer shallow water which is also very turbid. In the Inconnu Channel region, where the water is more transparent, they go down to greater depths. This might help to explain the preference shown for the Big Buffalo and Slave Rivers. It is possible however, that the fish are sensitive to some unknown feature which is present along with the turbidity, and thus the apparent correlation between light penetration and migration is accidental and meaningless. The effect, if any, is of minor importance since the species also runs up the Hay and Taltson Rivers.
Photoperiodism, or the changing length of night and day, is a factor which has not been adequately investigated in fish migration studies. No attempt was made to evaluate it in the present study.

Water temperature appears to play an important role. There is a regular seasonal temperature cycle which has a maximum occurring at the time the inconnu are leaving the commercial fishing area. This could indicate an avoidance reaction to higher temperatures, or, since the rivers are at this time a few degrees warmer than Great Slave Lake, it could also indicate a positive thermo-tropism. The writer is inclined to believe that the former is the case, in view of the fact that the inconnu is typically an Arctic fish. Furthermore, spawning does not take place till approximately October 1, at which time below freezing temperatures have been experienced, and the temperature in the smaller waterways has fallen below that in Great Slave Lake. More information concerning temperatures in the near shore areas and rivers, and the time the fish spend in their journey across the lake and up the rivers, is necessary before a definite opinion can be expressed.

Rheotropism, or the response to a current, has been shown to play an important role in the migration of the salmon and other fishes by Roule, and it is undoubtedly also a factor in inconnu migration. It has been pointed out in an earlier section that the
waters from the Big Buffalo and Slave Rivers can be followed for a long distance into Great Slave Lake by their effect on temperature and transparency. These are very crude methods of detection and should not be interpreted as indicating the limit at which fish are able to detect a current. Fish which react to a current always do so by keeping their heads pointing upstream. Houle calls this "polarization". No one is sure of the reason for this behavior, but, whatever its cause, it accounts very nicely for the way in which inconnu are able to locate the river mouths and why they proceed up the rivers. In part, also, it explains why the inconnu enter the rivers even though they are a degree or two warmer than the lake. The positive rheotropism may be apparently stronger than any negative thermo-tropism. Internal changes in metabolism due to the rapid changes taking place in the gonads, coupled with rising temperatures in the lake, probably initiate the response of the fish to almost imperceptible currents. A strong, positive rheotropism could account for the remainder of the migration.

There must always be a slight current flowing along the south shore from the mouth of the Slave to the source of the Mackenzie; therefore, it is probable that all inconnu in this region begin moving in an easterly direction, that is, toward the Slave River. Some would swim into the stronger current of the Hay River and still more, apparently, into that of the Big Buffalo, and their courses
would be altered accordingly. The silt from the Slave River spreads out almost to Outpost Islands, and currents perceptible to fish probably travel farther than this. The current from the Big Buffalo almost certainly could not be felt at a distance of 80 miles which makes it appear likely that all fish from the Outpost Islands region migrate up the Slave. There is always the possibility of seiches and other currents entering in. It will be noticed that the islands in the east arm have their long axis in a north east to south west direction. They represent the tops of former mountains, and there are many submerged ridges and depressions on the lake floor which run in the same direction. The direction of currents along the bottom is undoubtedly influenced by the presence of these ridges, and it is possible also that the fish follow the depressions. It is almost necessary to assume that some of the fish from the body of the lake find their way to the Buffalo River in order to account for the size of the run there. At the height of the run, about a dozen men can catch as many inconnu in two or three nights as are caught by some forty crews of fishermen in the course of a whole season's fishing in Great Slave Lake.

At this point we might digress and discuss briefly the original migration of *Stenodus* up the Mackenzie River to Great Slave Lake. The normal condition for the sea run fish is for them to spawn in the tributaries of the Mackenzie. They enter the Mackenzie, governed
probably by a rheotropism and proceed up it until they arrive at the mouth of a tributary. There they are presented with two alternatives — to continue in the main stream or to turn into the tributary. Since the tributaries flow down directly from the mountains, they normally have a slight advantage in that they are a little bit colder and may have a stronger current. The temperature difference could hardly be very great at a latitude of 70° north, and the strength of current might vary widely with flood conditions in the respective drainage areas. It is not unreasonable to suppose, then, that at some time the difference was either not apparent or at least very small, with the result that some fish "missed the turn" as it were, and, still driven by a positive rheotropism, followed the Mackenzie to its source in Great Slave Lake. It is possible that even at the present time, this occasionally takes places.

Return of Adults from Spawning Grounds.

The following information concerning the run of inconnu down the Buffalo River was also collected by P. A. Larkin in 1945. From September 29, when Mr. Larkin began his observations until the evening of October 8, the catch of inconnu was light and consisted of ripe individuals of both sexes and others which were apparently not spawning. Larkin was of the opinion that these fish "presumably do not comprise a part of the run, but are mostly individuals which
summer in the river in addition to a few large specimens which are late in their upward migration. The run commenced on the evening of October 8, when "the fish came very quickly. Within two hours the water level in the river rose 6-12 inches, the current became at least one-and-one-half times as rapid, the water became muddy and foam flecked. . . . . All during the night (the fishermen) could not remove the fish as fast as they got in the nets". The run fell off during the day and increased again on the evening of October 9, but did not reach the same intensity as on the previous night. There was a continued decrease on October 10, and by the morning of October 11 the run was over. The lengths of fish in the run varied from 65 to 85 cm. Most of the individuals above 75 cm. come down in the early part of the run so that in the later parts, most of the fish were between 65 and 75 cm. in length. All the fish in the run were spawned out; nevertheless, they were in good condition and active in the nets.

The factor responsible for the return to the lake is probably a nutritional one since in the spawning run the fish take little or no interest in food. Immediately following completion of the spawning act, the desire for food returns. Certain physical and chemical features of the water probably play a part also. Light is certainly important as is shown by the fact that the run is heaviest at night. Apparently the fish swim actively at night and allow
themselves to be carried passively by the current during the day. There is a belief among the natives that the run coincides with a change of the moon. No contrary or substantiating evidence was obtained.

**SPAWNING**

**Time of Spawning.**

The time of spawning was accurately determined by observations made at Big Buffalo River and Lake. Individuals caught in the lake on September 1 and 2, 1946, were nearly ready to spawn as milt and eggs could be expressed with very little pressure. Actual spawning, however, takes place immediately prior to the downstream run. This is shown by the fact that ripe individuals were caught at the river mouth right up until the commencement of the run. Several parties who have fished for inconnu at the river mouth for many years were questioned concerning the time of its occurrence. The earliest date remembered was September 27, and the latest, October 12. Reports indicate that on the Taltson River the run usually occurs between September 23 and 30. Spawning occurs in the Slave and Hay Rivers at approximately the same period.

**Place of Spawning.**

It is apparent that *Stenodus* normally spawns in rivers. The fresh-water and sea-run forms are alike in this respect. River spawning does not appear to be obligatory, however, and a small
number spawn in Great Slave Lake each year. This group would include the ripe individuals, noted above, which were caught just before the run on the Big Buffalo. Some spawning undoubtedly occurs in Resolution Bay seine small inconnu in their first season have been caught there in seine nets and it is unreasonable to suppose that they could have accomplished a journey of 150 miles in so short a time.

There has been some question as to whether or not Big Buffalo Lake serves as a spawning ground. The presence of the lake is sometimes given as the reason for the large run in the Big Buffalo River although proponents of this theory are unable to explain how the fish know it is there. By analogy with other coregonines and the sea-run Stenodus we would expect the inconnu to spawn in the river, and if it were a lake spawner, there would be no need for it to leave Great Slave which has many miles of shore line suitable for spawning grounds. Big Buffalo Lake, on the other hand, has a very soft, muddy bottom in places with aquatic vegetation, but with large areas entirely unprotected, and its water is extremely polluted with silt. Since it is extremely shallow, (4 to 4 1/2 feet) it must freeze to the bottom in most winters which would make it impossible for fish to overwinter there. Yet, evidence will be presented later to show that inconnu normally spend their first three seasons on or near the
spawning grounds. Perhaps the most convincing evidence is the failure to catch young inconnu in Buffalo Lake. Immature specimens of whitefish, pike and pickerel were caught in the standard gang, but only large, mature inconnu. Seining proved difficult because of the softness of the bottom and the boulder-strewn littoral zone, however, it was attempted at several places, and very small individuals of five species were taken. These were trout perch (Percopsis), burbot (Lota), pike (Esox), pickerel (Stizostedion) and northern sucker (Catostomus). There is probably some significance in the fact that no very small whitefish were found, since the whitefish and the inconnu are the two coregonines which inhabit the lake.

It must be admitted that operations on Big Buffalo Lake were carried on over a limited period of 2 1/2 days, and at the extreme east end of the lake. Since the lake is all of 30 miles long, the possibility that inconnu spawn in other parts of the lake is still not excluded.

Size and Age of Spawning Individuals.

In Table 8 is summarized the condition of the gonads in a random sample of 127 fish of various lengths caught at Big Buffalo River between September 29 and October 8, 1945. The size at maturity is very clearly indicated.
<table>
<thead>
<tr>
<th>Size</th>
<th>Males</th>
<th></th>
<th>Females</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ripe</td>
<td>Not Spawning</td>
<td>Ripe</td>
<td>Not, Spawning</td>
</tr>
<tr>
<td>under 50 cm.</td>
<td>2</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>50-54.5</td>
<td>3</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>55-59.5</td>
<td>4</td>
<td>17</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>60-64.5</td>
<td>13</td>
<td>5</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>65-69.5</td>
<td>9</td>
<td>1</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>70-74.5</td>
<td>1</td>
<td></td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>75-79.5</td>
<td>1</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>over 80</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>28</td>
<td>32</td>
<td>39</td>
</tr>
</tbody>
</table>

Table 8. State of maturity of 127 inconnu of various lengths, Big Buffalo River, October, 1945.

Males first mature at a length of 55 cm. In the 55 to 59.5 cm. group only about 20 per cent mature, in the 60 to 64.5 cm. group, 70 per cent, and in the 65 to 69.5 cm. group, 90%. It should be noticed also that only 2 individuals, or less than 4 per cent of the males in this sample had attained a length of 70 cm. Both were mature. The majority of fish 55 to 59.5 cm. long are in their eighth year. A few however, are still in their seventh, and it is likely that these faster growing fish also mature more quickly. If so,
about 20 per cent of the males mature at the end of their seventh season, less than \(\frac{1}{3}\) are not mature at the end of the eighth, and practically all are mature by the end of the ninth. Only a very few males longer than 70 cm. were caught throughout the course of the whole survey, and the oldest of these was in its twelfth season. No male could spawn more than five times, therefore, and the number that live long enough to spawn more than two or three times is very small.

No females were found to be mature which were smaller than 65 cm. In the 65 to 69.5 cm. group considerably more than \(\frac{1}{3}\) were mature, while above 70 cm. no immature specimens were taken. On the basis of this sample, the transition is much more sudden in females than in males, and occurs for the fastest growing individuals at the end of the ninth year of life, and for probably all the rest at the end of the tenth season.

Females continue to grow to lengths of more than a metre and ages of 20 years and more. Females may spawn several times, but it is certain that all do not spawn every year. Each season a few very large females (up to 106 cm.) were captured, which, from the small size of their gonads and eggs, were obviously not in condition to spawn. Unfortunately, these fish were described in different terms by various members of the field party before their significance was known, so that the writer does not feel justified
in making any estimate of the ratio of spawners to non-spawners which might afford a clue to the frequency of spawning.

EARLY GROWTH AND RETURN OF YOUNG TO GREAT SLAVE LAKE.

No direct observations of rearing conditions at the spawning grounds or the return of the young to the lake were made with the exception of the recovery of one-year-olds from the stomachs of older fish at the mouth of the Big Buffalo River (see page 25). Since these older fish were not considered to be part of the run, we must assume that the small ones came down by a process of active migration, which indicates that the fish may return as early as the end of their first year. The majority probably come down at the end of their third year, with some lagging until the fifth.

This conclusion is based upon the following evidence:

(1) There is an increase in the rate of growth in the fourth year, presumably due to the richer food supply in Great Slave Lake and the change from a diet of invertebrates to a piscivorous one. This theory will be elaborated in a later section (page 57).

(2) The size distribution of all inconnu caught in test nets shows a disproportionately small number of immature inconnu.

The length frequency distribution of 152 inconnu has been worked out and the results appear in Table 9 (see also Fig. 23 page 38). The frequency of each group has been expressed both as
a number and as a percentage of the total. It will be noticed that only 12.5 per cent of the sample is smaller than 30 cm. in length. This is the approximate length at the end of the third year. Only 33 per cent are under 50 cm. in length which is only slightly more than the length at the end of the fifth year. 49.2 per cent fall between 55 and 69.5 cm. which includes a large part of the spawning population.

<table>
<thead>
<tr>
<th>Length</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 cm.</td>
<td>5</td>
<td>3.3</td>
</tr>
<tr>
<td>20-24.5</td>
<td>6</td>
<td>3.9</td>
</tr>
<tr>
<td>25-29.5</td>
<td>5</td>
<td>3.3</td>
</tr>
<tr>
<td>30-34.5</td>
<td>3</td>
<td>2.0</td>
</tr>
<tr>
<td>35-39.5</td>
<td>8</td>
<td>5.3</td>
</tr>
<tr>
<td>40-44.5</td>
<td>8</td>
<td>5.3</td>
</tr>
<tr>
<td>45-49.5</td>
<td>15</td>
<td>9.9</td>
</tr>
<tr>
<td>50-54.5</td>
<td>13</td>
<td>8.6</td>
</tr>
<tr>
<td>55-59.5</td>
<td>25</td>
<td>16.4</td>
</tr>
<tr>
<td>60-64.5</td>
<td>25</td>
<td>16.4</td>
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<tr>
<td>65-69.5</td>
<td>25</td>
<td>16.4</td>
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<td>70-74.5</td>
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<td>3.9</td>
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<td>75-79.5</td>
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<td>3.3</td>
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<td>80-84.5</td>
<td>3</td>
<td>2.0</td>
</tr>
<tr>
<td>Total</td>
<td>152</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 9. Length frequency distribution of inconnu caught in test nets, Great Slave Lake, 1944-46.
The scarcity of small specimens represents either a real scarcity in the lake or inadequate sampling. This sample is the total number of inconnu caught in 145 settings of the standard gang of nets, in literally all parts of the lake and at all depths down to a maximum of 700 feet. There can, therefore, be no doubt of the adequacy of the coverage. To show that the nets were efficient in catching the smaller sizes of fish, the distribution of all whitefish caught in the first 9 settings made in 1946 was calculated. Their distribution is indicated in Table 10. On a percentage basis, nearly three times as many whitefish under 30 cm. were caught (35.8%).

The distribution of the cisco would provide a more striking illustration of the ability of the nets to take small specimens. It seems valid to conclude, therefore, that the data in Table 9 indicate a real scarcity of immature inconnu in Great Slave Lake, which is best explained on the assumption that they spend from one to five years in the rivers.

<table>
<thead>
<tr>
<th>Length</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 cm.</td>
<td>17</td>
<td>4.0</td>
</tr>
<tr>
<td>20-24.5</td>
<td>50</td>
<td>11.6</td>
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<tr>
<td>25-29.5</td>
<td>87</td>
<td>20.2</td>
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<tr>
<td>30-34.5</td>
<td>82</td>
<td>19.1</td>
</tr>
<tr>
<td>35-39.5</td>
<td>38</td>
<td>8.8</td>
</tr>
<tr>
<td>40-44.5</td>
<td>118</td>
<td>27.4</td>
</tr>
<tr>
<td>45-49.5</td>
<td>38</td>
<td>8.8</td>
</tr>
<tr>
<td>Total</td>
<td>430</td>
<td>99.9</td>
</tr>
</tbody>
</table>

Table 10. Length frequency distribution of a random sample of common whitefish (Coregonus) from Great Slave Lake, 1946.
The return of the young to the lake has not been observed with the exception of the one-year-olds, noted above, which were taken early in October. The reason for the journey may be a nutritional one, since this appears to be an abrupt change from a diet consisting largely of invertebrates in the river to a piscivorous one in Great Slave Lake. It is not known what other factors, if any, may be involved.
The reason for their return is probably a nutritional one. As the fish grow a diet consisting mainly or entirely of invertebrates becomes inadequate. This is further evidenced by the abrupt change to an entirely piscivorous diet in Great Slave. What other factors are involved is not known, nor is the season of the year at which they travel, although the one-year-olds mentioned above were taken early in October.

**RATE OF GROWTH**

*Materials and Methods.*

Age determinations were made by examination of the scales of a sample of fish, some of which were caught in test nets, some by commercial fishermen and the remainder by natives, especially in the vicinity of Fort Resolution and Big Buffalo River. In the first two seasons, only representative series of scales were collected. In 1946, a scale sample was saved from all inconnu caught in test nets and a large number of fish caught by commercial fishermen. The scales were taken from the region between the dorsal fin and the lateral line. In all, the scales of 326 individuals were mounted, of which it was possible to determine the age of 298. The remainder were illegible, mostly through damage.

The scales were mounted according to a technique devised by the writer. To remove traces of epidermis and mucus, they
were soaked for five to ten minutes in dilute potassium hydroxide (1 to 2 per cent). They were then removed, dipped in a water bath made very faintly acid with a few drops of acetic acid, rubbed clean between the thumb and fingers, dried thoroughly between filter papers and mounted in glycerine jelly. This method does away with the necessity for long soaking and is particularly adapted for use in a small lab where no full-time technician is employed and scales must be mounted in small lots as opportunity affords.

Reading was facilitated by using a projection apparatus designed by Dr. Rawson and the writer (Fig. 5) which projects the image of the scales horizontally. The optical equipment consists of a good quality microscope set into the table in such a way that its stage is flush with the table top, a projecting prism and an 8 x 10 inch, front-silvered mirror in an adjustable mounting. Using a 16 mm. objective, 5x and 10x oculars, and adjusting the image distance by moving the mirror, a considerable range of magnification is possible. Light from a powerful source is concentrated on the mirror of the microscope by means of a concave mirror and a pair of condensing lenses. The condensing lenses are moveable in one plane only. Movement of the lenses changes the angle at which the light passes through the optical system and thereby alters the pattern of the image. This often throws obscure characteristics of the scale into sharp relief which greatly simplifies the reading. All controls
Fig. 6. Scale number 48, from an inconnu 5 cm. long showing 4 completed years of growth, continuity of annuli around the scale, clear region in the posterior field, and "breaks" in the anterior field x 21.
Fig. 7. Magnification of part of a field of #18 showing characteristic appearance of "break". Note the position of the hair in Figs. 6 and 7.
are operated with the left hand, leaving the right free for marking
the position of the annuli and recording the age.

The causes of annulus formation are not well understood,
but temperature seems to play an important role. In Great Slave
Lake, where the fish live at an almost constant year-round temperature,
the annuli are often not distinct; therefore, it was necessary to
define carefully certain morphological characters of an annulus and
accept as true year marks, only those which showed a majority of
these characters. Because there is likely to be more work done on
the growth rates of northern fishes, the writer believes that a brief
description of these criteria should be included. They are as follows.

(1) It must be possible to follow the annulus completely around
the scale (Fig. 6).

(2) There must be a definite "break" in the anterior field.
The break is formed by irregularities in one or more circuli (Figs. 6 and
7).

(3) There must be a clear, unsculptured region in the posterior
field (Fig. 6).

(4) There must be "cutting-across" along the postero-lateral
radii (Fig. 8). The last circuli laid down in the fall are formed in
the anterior field, grow along the sides, but are not complete in
the posterior field. The first circulus laid down the following spring,
being complete, "cuts across" the ends of these incomplete circuli.
If true cutting across, not merely accidental fusion of two or three
circular, can be demonstrated, there is no doubt as to the validity of the annulus.

(5) The circulars laid down in the fall are often closer together than those laid down in the spring, which helps to accentuate the annuli (Figs. 6 and 7). Occasionally, for unknown reasons, the opposite is found. False annuli which probably represent a temporary slowing down of growth in midseason, are also formed in this way so that this character must be used with caution.

(6) When a definite decision cannot be reached on the basis of the foregoing characters, it is sometimes safe to make use of the position of the suspected annulus in relation to other annuli. This is a subjective test however, and should be avoided except in the most obvious cases.

The writer also sometimes double annuli on many occasions. They had the appearance of two closely placed breaks in the anterior field, but careful examination showed only one set of circulars cut across, and only one mark in the posterior field, which usually coincided with the outermost break. The inner break apparently formed at the time when growth began to slow down, and it was usually possible to show that all the circulars laid down between the two breaks were cut across along the side of the scale.

The data were recorded on 3 x 5 inch index cards. On the top line was placed the serial number assigned the scale, the locality, date and magnification (which was always 2lx); on the bottom line, the standard length, fork length, weight, sex and age;
Fig. 8. Magnification of a portion of the lateral field of a scale from a small whorl

(to show "cutting across")
along the top margin was marked the position of the focus and all
the annuli in the anterior field of the scale. If the scale was
small enough to allow it, the annuli in the posterior field were
marked also. On the second line was recorded the diameter of the
scale (D), the anterior radius (R), and the distance from the focus
to the first annulus in the anterior field (r₁). The body of the
card scale was reserved for the calculated length of the fish at previous
ages. Here was recorded the age (roman numerals), the last 2 digits
of the calendar year (arabic), the calculated length (L), and the
first and second differences (d₁ and d₂) which represent the velocity
and acceleration of growth respectively. The method of recording
is illustrated in Figure 12. No use was made of the second difference in the
final analysis.

After all the scales had been read once, they were checked
without reference to the original cards. If the second reading did
not agree with the original, a more careful re-examination was made,
which often necessitated the remounting of the scale, and either a
final decision was made, or the scale was rejected. The ages were
then plotted against the length and any which seemed to be too high
or too low were examined for the third time.

Relationship of age to length at time of capture.

As a first analysis, the age of the fish was plotted
against its length at the time of capture. In the graph (Fig. 9)
each ordinate represents a completed years growth, and, since there is
Fig. 9. Age-length relationship of a sample of 298 inconnu from Great Slave Lake. Solid circles represent males; open circles, females; triangles, sex undetermined.
theoretically at least, no growth during the winter, it also represents a winter period. The space between two ordinates represents the summer growing season. By this method, it is possible to make some distinction between fish of the same age, caught at a different time. If a fish was caught in June, even though its scales showed no new growth, it was listed as A+ years of age. If it was caught at any other time throughout the season, right up until the time of annulus formation, it was also listed as A+. If however, there was definite proof that an annulus was forming, indicating that it had completed growth for the year, it was listed as A+1 years.

From this analysis it was possible to determine several things. First, there appears to be no essential difference in growth rate between males and females. The age of the fish at the time of spawning has already been referred to. The age of the fish making up most of the commercial catch may also be determined. Finally, close observation of the scales of spring and fall caught fish has given a fairly accurate determination of the length of the growing season. For the majority, growth begins during the last week of June and ends during the first week of September. A small proportion begin their growth before June 15, and some may continue to grow well into September. Older specimens, in general, begin to grow later and cease earlier in each season. It is remarkable that any fish with such a limited growing period could have as rapid a rate of growth as the inconnu.
The average length of the fish at the end of each of the first 11 years was then calculated. Too few specimens older than 11 years were available to yield an accurate average. In calculating this average, no allowance was made for the time of year at which the fish was captured. For example, no distinction was made between an 8-year-old fish caught in September, 1945, and an 8-year-old caught in August 1946, although the former was truly 8 years old while the latter was 8+ and much closer to nine. For this reason, the calculated average is too high. Furthermore, the fish of any age group belonged to different year classes, depending on the year of their capture. For example, an 8-year-old fish, caught in 1944 was hatched in 1936, while an 8-year-old caught in 1946 was hatched in 1938. If, now, 1938 had been a bad year, it would likely have affected the very young fish more than the older ones, therefore, the 1938 year class would have a slower growth rate and would thus tend to lower the average size of all 8-year-olds. Similarly a very favorable year could cause the reverse affect. It will be shown later that this effect was very small in the present sample of inconnu.

The value of the average growth curve lies mainly in the fact that it can be used for comparison with similar curves which have been prepared for other fish in Great Slave and other lakes. The averages for inconnu, common whitefish, and lake trout in Great Slave Lake have been plotted in Figure 10. The inconnu grows about twice as fast as the common whitefish, while the trout grows still
more slowly. A suggested explanation for this rather striking difference is the fact that the inconnu is an arctic fish, approaching, or quite at, the southern limit of its range, while the other species are temperate ones, approaching their northern limit.

Fig. 10. Comparison of the rate of growth of the inconnu, common whitefish and lake trout in Great Slave Lake.
Fig. 11. Average annual increments of growth of a sample of 298 inconnu, showing acceleration of growth in the fourth year.
If the inconnu is fished commercially for some time, some changes in the length composition of the population, or the rate of growth, or both, may be expected. Since the present graph represents the growth rate of an almost unexploited population, it may be a valuable standard with which to compare the population existing in a few years time.

Careful examination of Figures 9 and 10 reveals what appears to be a slight increase in the rate of growth in the fourth year. To be sure that this represents a true acceleration of growth rate, the annual increments of growth (d₁) were calculated and plotted (Fig. 11). The annual increment is obtained by subtracting the length at each age from the length at the end of the previous year. Theoretically, growth should gradually slow down, that is, its velocity becomes less, and therefore, the annual increments should decrease at a regular rate. Figure 11 shows, however, that there is a real increase in growth rate in the fourth year as compared with the third.

The most likely cause of a sudden acceleration of growth rate is a change in food supply. Thus, we might assume that at the end of the third year or early in the fourth, the majority of young inconnu undergo a marked change in diet, which, in all probability means that they have left the rivers, with their rather scanty supply of invertebrates and taken up residence in the lake where a plentiful supply of small fish awaits them. The average curve is useful only in showing the majority condition. It is conceivable however, that
conditions would vary from year to year, and influence the age at which the inconnu leave the spawning grounds. In order to further analyze the population, the rate of growth of each individual fish was calculated by employing the body-scale relationship.

**Use of the body-scale relationship.**

Some aspects of the body-scale relationship will be discussed in more detail in the next section. Essentially it implies that, since the number of scales remains constant throughout the life of the fish, the scales must grow at a rate proportional to that of the body if the fish is to remain covered. Therefore, the length of the fish at any age may be determined simply by measuring the length of the scale to each annulus and applying the formula,

\[
\frac{l_x}{l_n} = \frac{L_x}{L_n}
\]

where \(L_n\) = length of fish at capture.

\(L_x\) = length of fish at age \(x\).

\(l_n\) = length of scale at time of capture of fish.

\(l_x\) = length of scale at age \(x\).

For greater accuracy, a correction is made which takes into account the length of the fish \((a)\) at the time of scale formation. The formula then becomes

\[
\frac{l_x}{l_n} = \frac{L_x}{L_n - a}
\]
The calculation is quickly performed by means of the nomograph described by Carlander and Smith (1944) and illustrated in Figure 12. The nomograph is a series of parallel lines which cut off proportionate segments on any line drawn at an angle to them, in this case, the margin of the card. It was not possible to
determine empirically the length of inconnu at the time of scale formation. It has been determined for other species of fish both related and unrelated to the inconnu and is usually approximately 2 cm. This value was therefore used. It is certain that this figure is not more than 5 mm. in error. Error was introduced in measuring the fish, choosing the scales, marking the annuli and focus, and in using the nomograph, therefore it is felt that this assumption does not introduce any significant source of error. In making the calculation the centre of the mark representing the focus was placed on the 2 cm. line of the nomograph, the card was rotated until the mark representing the edge of the scale coincided with the line of the nomograph representing the length of the fish at capture. The length of the fish at previous ages was read directly from the position of each annulus on the nomograph.

The average rate of growth of all fish in each year-class was then calculated (Table 11). By this method the sample was divided into groups. The members of each group began their lives in the same year and therefore lived under the same conditions throughout.

It should be pointed out that there are fish older than the 16-year-olds appearing in Table 11, but there are not enough of them to provide a reliable average. The years 1930 to 1935 (with the exception of 1934) and 1943 and 1944 are also represented by a
<table>
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<tr>
<th>Year Class</th>
<th>No. of Specimens</th>
<th>Average length at end of each year of life</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16</td>
</tr>
<tr>
<td>1930</td>
<td>4</td>
<td>12.6 19.6 26.3 30.8 37.5 42.3 47.6 52.6 57.5 63.1 67.8 71.8 75.0 77.0 78.8 80.1</td>
</tr>
<tr>
<td>1931</td>
<td>8</td>
<td>13.9 22.5 28.5 34.8 40.8 47.1 53.6 58.6 63.7 68.8 72.3 74.7 76.9 78.6 79.9</td>
</tr>
<tr>
<td>1932</td>
<td>8</td>
<td>12.5 19.8 27.3 34.2 40.0 46.9 52.9 58.3 62.9 69.0 71.9 74.4 76.7 75.8</td>
</tr>
<tr>
<td>1933</td>
<td>7</td>
<td>12.3 18.5 24.2 29.5 34.5 41.4 49.8 55.4 61.2 66.0 70.1 72.0 76.0</td>
</tr>
<tr>
<td>1934</td>
<td>21</td>
<td>11.5 19.2 26.1 33.0 38.8 44.5 51.3 57.3 62.5 67.0 69.8 72.8</td>
</tr>
<tr>
<td>1935</td>
<td>7</td>
<td>12.1 20.3 28.8 36.0 44.9 52.5 59.3 64.5 68.2 70.1 72.8</td>
</tr>
<tr>
<td>1936</td>
<td>23</td>
<td>11.5 19.5 27.8 35.2 41.6 47.9 54.5 59.8 65.6 68.9</td>
</tr>
<tr>
<td>1937</td>
<td>42</td>
<td>11.7 18.8 27.0 34.4 41.5 48.4 54.1 59.1 62.7</td>
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<td>1938</td>
<td>64</td>
<td>12.5 21.4 30.0 37.0 43.8 50.2 56.2 61.1</td>
</tr>
<tr>
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<td>25</td>
<td>12.5 21.6 30.5 37.7 44.8 51.1 57.3</td>
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<tr>
<td>1945</td>
<td>17</td>
<td>13.5</td>
</tr>
</tbody>
</table>

Table 11. Average length at end of each year of life for the year classes of *innmu* from 1930 to 1945.
small number of specimens. When the growth rates are plotted (Fig. 13) three irregularities appear, involving the year classes, 1929 and 30, 1934 and 1935, and 1943. These are probably due to the inadequacy of the samples. The year classes 1936 to 1941 inclusive show remarkably uniform growth rates which means that conditions for growth in these years were uniform and thus one of the objections to using a mixed sample for calculating the average rate of growth is removed.

Fig. 13. Average rate of growth for each year-class of inconnu from 1930 to 1945.
Fig. 14. Annual increments of growth in length of 4 representative year-classes.
In Figure 13, the smoothed growth curves show little or no evidence of an accelerated growth rate in any of the early years. The average annual increments of growth for each year class were therefore determined and plotted. Representative increment curves are shown in Figure 14. The year-classes 1937 and 1941 show only one irregularity which occurs in the third and fourth years respectively. The year-class 1935 shows two quite distinct irregularities, the major one in the fifth year and the minor in the third, while 1939 shows two less pronounced breaks, the larger in the third and the smaller in the fifth year.

The age at which each year-class displays its greatest growth is shown in Table 12. The acceleration may occur at any time between the second and seventh years, but is most often found in the third. If this acceleration is connected with the arrival of immature inconnu in Great Slave Lake, it indicates that the fish may leave the spawning grounds at any time between the end of their first year and the beginning of their seventh, but that in most years, the major run occurs at the end of the second or early in the third. The average from Table 12 however, is 3.92, which is too low when secondary runs such as occurred in 1935 and 1939 are taken into consideration. The results therefore are in complete agreement with the curves in Figures 10 and 11 where the acceleration occurred in the fourth year.
Year-class

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Age of greatest growth</td>
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<td>4</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3.92</td>
<td></td>
</tr>
</tbody>
</table>

Table 12. Age of greatest growth for each year-class of inconnu.

Compensation in growth rate.

In fish growth studies in general, the following two principles have been established, (a) that the individuals which are largest at the end of their first year are always the largest members of their age group, and (b) that the difference between the largest and smallest individuals decreases with advancing age. In other words, the slower growing individuals are continually gaining on the faster, but never succeed in overtaking them. This principle has been named compensation. As a corollary of the law of compensation, the individuals in the higher age groups should be more closely grouped about the mean than those in the lower age groups. The amount of dispersion about the mean should therefore be a measure of the compensation effect. A glance at Figure 9 is sufficient to show that the absolute amount of dispersion is greater for the older age groups. In order to find out which age groups had the greatest relative amount of dispersion, the standard deviation of the mean, $\sigma$, was calculated for each age-group in the sample (Table 13).
Fig. 15. Standard deviation of the mean length for each age-group of the 1938 year-class.
Table 13. Mean length and standard deviation for each age-group of a sample of inconnu from Great Slave Lake.

Table 13 reveals that there is no uniformity and little or no general trend to the values of $\sigma$. Values for the third, sixth and seventh years are high, while after seven years, there is apparently a tendency toward a steady decrease.

Assuming that the irregularity was due to the mixed nature of the sample, it was decided to use a more homogeneous group. The group chosen contained all the members of the 1938 year class captured in 1946. There were 50 specimens in this group. The standard deviation was calculated for each age and plotted (Fig. 15).

Obvious evidence of compensation in growth in the sixth, seventh and eighth years is contained in Figure 15. Apparently the compensating effect, if any, is outweighed in the earlier years by another factor which produces an ever increasing dispersion. In the 1938 year-class this factor ceased to operate after the fifth year. One such factor is the ratio between the time spent in the rivers, with a slow growth rate, and in Great Slave Lake with a comparatively faster growth rate. The high standard deviation

<table>
<thead>
<tr>
<th>Age-groups</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean length</td>
<td>14.6</td>
<td>24.7</td>
<td>31.2</td>
<td>40.3</td>
<td>47.3</td>
<td>52.9</td>
<td>57.2</td>
<td>61.0</td>
<td>65.7</td>
<td>68.8</td>
<td>72.7</td>
</tr>
<tr>
<td>Stand. dev.</td>
<td>3.08</td>
<td>3.02</td>
<td>6.06</td>
<td>3.60</td>
<td>3.60</td>
<td>5.24</td>
<td>5.35</td>
<td>4.42</td>
<td>4.26</td>
<td>4.45</td>
<td>3.87</td>
</tr>
</tbody>
</table>
for the fifth year is then due to the fact that the 1938 year-class contains individuals, which at age five, had spent one year in the rivers and four years in the lake, or, two years in the rivers and three in the lake and so forth. After the fifth year, when all had apparently arrived at the lake, the law of compensation was gradually able to exert itself, the slower growing individuals began to overtake the faster and therefore, the amount of dispersion about the mean gradually decreased.

One other factor would account for the decreased dispersion after the fifth year, that is, the death of either the slowest or the fastest growing individuals or both. There is no way of deciding whether this actually happened with the evidence at hand, but no factors were observed which might have caused the necessary mortality.

**Relationship between age and weight.**

The average weight attained at each age was calculated for the first 11 years (Table 14). This average is subject to the same criticisms as were mentioned in the discussion of average lengths, plus an additional one due to variability in the state of sexual maturity. Thus for the seventh, eighth and ninth years particularly, there is variation in the ratio of mature individuals, with greatly increased gonads, to immatures. Also, after maturity is reached the individuals caught late in the season will be proportionately heavier than those caught in the spring.
When the average values are plotted, a curve (Fig. 16) is obtained which rises slowly until the end of the fourth year of life, then more sharply. There is no indication of a slowing of growth in weight even at the end of the eleventh year.

Fig. 16. Rate of growth in weight of a sample of 278 inconnu from Great Slave Lake.
It is rather surprising that the point of inflection of this curve should come in the fifth year whereas the greatest increase in growth in length occurs in the fourth year (Fig. 11). The annual increments of growth in weight, when plotted, form a curve of much the same pattern with the greatest increase coming in the fifth year (Fig. 17).

The relationship between length and weight is considered in the following section.

Fig. 17. Average annual increments of growth in weight of a sample of 278 inconnu from Great Slave Lake.
Fig. 18. Length-weight relationship of Great Slave Lake inconnu.

- = ♀  o  ♀  ▲  sex undetermined
The standard deviation of the mean weight for each age is presented in Table 14. It is seen that weight is a much more variable character than length. For example the mean weight at age 7 is 5.62 pounds while the standard deviation is 1.51 pounds. Approximately two-thirds of the variates lie within one of the mean, in this case, therefore, between 4.11 and 7.13 pounds. The curve in Fig. 14 is seen to be of little practical importance since its accuracy is little better than that of a guess.

<table>
<thead>
<tr>
<th>Age</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean wt. lbs.</td>
<td>.12</td>
<td>.44</td>
<td>.87</td>
<td>1.62</td>
<td>3.00</td>
<td>4.36</td>
<td>5.62</td>
<td>7.13</td>
<td>8.31</td>
<td>9.75</td>
<td>11.05</td>
</tr>
<tr>
<td>Stand. dev.</td>
<td>.22</td>
<td>.49</td>
<td>.61</td>
<td>1.22</td>
<td>1.27</td>
<td>1.51</td>
<td>1.70</td>
<td>1.75</td>
<td>1.94</td>
<td>2.06</td>
<td></td>
</tr>
</tbody>
</table>

Table 14. Mean weight and standard deviation for each age-group in a sample of inconnu from Great Slave Lake.

It is also interesting to notice that the standard deviation continually increases. The law of compensation therefore, does not operate for rate of growth in weight.

Relationship between length and weight.

In Figure 18, the length of 278 specimens was plotted against their weight. There is a slight tendency for females to be heavier than males of the same length. This is to be expected, in
mature individuals due to the greater size of the female gonad.

There is a theoretical relationship connecting length and weight. The volume of solid objects varies as the cube of any linear dimension, provided that form and specific gravity remain constant. This may be expressed mathematically as,

\[ V = kL^3 \]

where \( V \) = the volume,
\( L \) = any linear dimension,
\( k \) = a constant,

Since weight (\( W \)) varies directly as the volume, we may substitute for \( V \) in the above equation which now becomes, \( W = kL^3 \).

In applying this relationship to living organisms, however, we must take into account the possibility of a change in form and differential growth of certain tissues or organs of a higher or lower specific gravity than the organism as a whole. Any such change will alter the value of \( k \). If \( k \) is not constant, therefore, it indicates a change in form or condition, especially the condition of the gonads. Thompson (1914) stated that by observing the year round fluctuation in the value of \( k \) he could determine the beginning and the end of the spawning season "without ever seeing a fish spawn, and without ever dissecting one to see the state of its reproductive system".

Accordingly, the value of \( k \) was determined empirically for
each age-group of inconnu by substituting the mean weight and mean length in the equation \( W = kL^3 \). The mean value for \( k \) was found to be \( 2.987 \times 10^{-5} \). The values for each age were plotted (Fig. 19). The curve shows some interesting characteristics. The value for age one is probably too high since the minimum weight recorded in the field was 2 ounces and many of the age one fish weighed less than 2 ounces. The curve declines slowly in the second and third years and sharply in the fourth year. It then rises sharply in the fifth year and continues to rise till the eighth, after which it is more or less steady.

Fig. 19. Changes in the condition coefficient, \( k \), with advancing age.
The sudden drop in the value of \( k \) in the fourth year obviously reflects a change in form coincident with the great growth in length which takes place at this time. Since the weight did not increase in proportion to the length the change in form must have been in the direction of slimmer bodies. The increase in the value of \( k \) in the fifth year, indicates that there was a proportionately more rapid growth in weight than in length, therefore, we would expect to find proportionately deeper and broader bodies in fish in their fifth year. Some corroboration of this hypothesis will be found in Table 15, in which the body measurements of a fish which had completed its third year, and a fish in its fifth year (B.L. 4 and G.C. 14, appendix 1) are compared with the average for 18 mature specimens.

<table>
<thead>
<tr>
<th></th>
<th>B.L. 4</th>
<th>G.C. 14</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body depth</td>
<td>19.9</td>
<td>22.1</td>
<td>21.5</td>
</tr>
<tr>
<td>Body width</td>
<td>12.1</td>
<td>12.7</td>
<td>13.1</td>
</tr>
</tbody>
</table>

Table 15. Comparison of certain proportionate measurements of a three-year-old fish (B.L. 4) a fifth year fish (G.C. 14) and the average for 18 mature specimens (more than 60 cm.).

It is dangerous to generalize on the basis of one or two proportionately specimens, however, the three-year-old fish is smaller than average
in both body dimensions, while the fifth year fish exceeds the average in one dimension and is nearly equal to it in the other.

The continual increase in the value of \( k \) to the eighth year probably indicates other minor changes in form up to the time of maturity. Beyond this time, the fluctuations are probably due to a condition factor. Since the values are based on relatively few individuals, they would be expected to vary with such things as the ratio of males to females or the proportion of spring and fall caught individuals. It should be pointed out that the fluctuations in later life are of an extremely small order, the difference between the eighth and eleventh year being only \( 0.27 \times 10^{-5} \).

THEORETICAL ASPECTS OF THE BODY-SCALE RELATIONSHIP

Relationship between antero-posterior diameter and anterior radius.

As mentioned above, the use of the body-scale relationship implies that the scale grows in length at the same rate as the body. Geometrically it is immaterial whether radius or diameter is used. If, however, the anterior and posterior fields of the scale grow at different rates, we are no longer dealing with radius and diameter in the geometric sense. By definition, length of scale should be interpreted as greatest diameter in an antero-posterior direction.
Van Oosten (1929) has shown that this measurement is better than any other for calculating the length at previous ages of the cisco (*Leucichthys artedi*) in Lake Huron.

Early in the present investigation it became apparent that use of the diameter would be very inconvenient because of the size of the scales, which, in large individuals are too big to project in their entirety at a magnification which would allow accurate reading. Accordingly, a series of scales was picked at random, both the radius and diameter were marked, the lengths of the fish at previous ages were calculated, assuming a length of two centimeters at scale formation, and plotted. The resulting rough graph indicated that use of the anterior radius would be justified for fish of all ages.

To give a more reliable picture, a more homogenous group was chosen and treated in the same way. It was desirable that this group should have enough members to yield dependable averages, and that it be as old as possible. It was found that scales from seven-year-old fish were the largest which could be projected in toto in one field. The seven-year-old members of the 1939 year-class were therefore selected. There were 19 specimens in this class. The growth rate of this group, calculated from both the diameter and the radius of the scales, and the growth rate of the entire sample based on age and length at time of capture was plotted (Fig. 20).
Fig. 20. Comparison of the rate of growth of the 1939 year-class calculated from both the radius and the diameters of the scales, with that of a mixed sample based on the age and length of the fish at the time of capture (broken line).

It will be seen from Figure 20 that the growth curve based on measurements of the diameter exceeds the average, while that based on the radius is slower than the average in the early years. It has been pointed out, however, (page 55) that the average based on length
of the fish at capture is too high, therefore, it is apparent that the anterior radius of inconnu scales is more nearly proportional to the length of the body than the antero-posterior diameter when a correction of two centimeters for length of fish at time of scale-formation is introduced. If this correction is not used the two curves very nearly coincide. Used in this way, the diameter may yield slightly more accurate results. In view of the other experimental errors present and the inconvenience of using the diameter, the writer feels that use of the anterior radius is entirely justified.

Difficulties of the scale theory as applied to the present study.

The use of the scale theory is open to several quite obvious criticisms, some of which have already been suggested. Some of the potentially more serious ones are discussed below.

(a) Changes in the form of the fish.

Some parts of the fish, particularly the head, are not covered by scales, therefore, the body-scale relationship really implies that the length of the scale varies directly as the length of the scale-covered part of the body. The length of the scale will only be proportional to the length of the whole fish if there are no changes in the form of the fish involving the ratio of scaled parts to uncovered parts. In Table 16 there is some evidence that the proportionate length of the head changes as the fish increase in size.
Table 16. Changes in proportionate length of the head of inconnu with increase in size of fish.

(b) Unequal growth of different parts of the scale.

It has already been demonstrated (Fig. 20) that calculation of the length of the fish based on the diameter and the radius of the scale do not agree for the early years, but it should be noticed that the agreement is quite close in the later years of life. It is obvious therefore that the anterior and posterior fields of the scale grow at different rates. In actual fact, the posterior field shows precocious initial development, then slows down at a much more rapid rate than the anterior field.

It was also noticed that the general outline of the scale varied with the size of the fish. A series of scales was therefore chosen at random, on which the antero-posterior (A.P.) and dorso-ventral (D.V.) diameters were measured. The ratio of A.P./D.V. was then plotted against the length of the fish. The points were widely
scattered, doubtless reflecting the variability of individual scales, however, the trend was as illustrated in Figure 21.

Fig. 21. Ratio of the antero-posterior diameter to the dorso-ventral diameter of the scales for fish of different lengths.
In young fish the scales are wider than long. As the fish grows, the scale grows proportionately more in length than in width. At a length of approximately 50 cm. the process is reversed and in the largest fish the width is again considerably greater than the length. This suggests the possibility of a more than proportionate increase in the width, and a less than proportionate increase in the length of the scale. Microscopically the annuli are crowded at the margin of the anterior field, which suggests that there is an almost complete cessation of growth about the twelfth or fourteenth year. Whether this apparent cessation of growth of the scale is correlated with an abrupt slowing of the growth of fish has not been determined due to an insufficient number of specimens in the larger size groups.

(c) Structural changes in the scale.

The distinction between structural changes and differential growth in parts of the scale is a fine one. Structural change implies a remodelling in a part of the scale after growth has ceased in that region, while differential growth implies that more or less scale material is deposited during the actual growth process. Both have essentially the same effect on the ratio of scale length to length of the fish.

There are many possible structural changes which could occur. Two of these are particularly well known and have been described by many investigators. The first is a reabsorption of the scale margin
which is best illustrated by the salmon. After about four years, the entire new marginal growth is reabsorbed thus rendering the scales useless as indicators of the age of the fish. The crowding of annuli on the anterior margin of the scales of inconnu may be at least partially due to a reabsorption. The second is Lee's phenomenon of apparent change in rate of growth. Lee (1912) found that when she calculated the length of fish at age one from the scales of old and young fish she obtained different results. The older fish apparently had not grown as much in their first year. The older the fish, the smaller the apparent first year growth. Many species of fish have since been studied and evidence of Lee's phenomenon has been found for some, not for others, and in a few cases conflicting reports have been given by different investigators.

Evidence of the occurrence of Lee's phenomenon in inconnu is not convincing. The average length at age one has been plotted against the age of the fish from which the calculation was made. (Fig. 22). There is a downward trend, indicative of Lee's phenomenon, until the tenth year, and then an upward trend until the sixteenth year. Assuming for the moment that the downward trend is due to a progressive shrinking in the centre of the scale, the upward trend can be explained in two ways.
(a) a sudden reversal of conditions at the centre of the scale leading to expansion rather than shrinkage or, (b) a more than proportionate shrinkage of the entire anterior field of the scale. In an effort to determine which was the case, the average length of the anterior radius from the focus to the first annulus was determined for each age group. This has also been plotted in Figure 22. Since this curve, which is entirely independent of the length of the scale as a whole, follows the other almost exactly, it appears as though the fluctuations in the curve are dependent on the centre of the scale only.

Another test for Lee's phenomenon would be to sample fish of a given age, A, in one year and fish of the same year-class in some later year, for example two years later, when the age of the fish would be A + 2. If there is any evidence of Lee's phenomenon, the calculated length at age one of the A + 2 fish will always be less than that of the A fish. It is possible to apply this test to Great Slave Lake inconnu since there were some members of each of the year classes 1933 to 1938 caught in 1944 and others caught in 1946. The calculated length at age one for each of these groups is shown in Table 17.
<table>
<thead>
<tr>
<th>Year-class</th>
<th>1933</th>
<th>1934</th>
<th>1935</th>
<th>1936</th>
<th>1937</th>
<th>1938</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at capture</td>
<td>13 11 12 10 11 9 10 8 9 7 8 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculated length at age one</td>
<td>12.0 14.8 12.0 11.3 12.0 11.0 12.2 11.4 11.9 10.9 12.2 14.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 17. **Calculated length at age one of fish of the same year-class but different ages.**

It is seen from Table 17 that the younger fish showed the largest first year growth in 1933 and 1938 but that in the other four years the opposite was true. Such irregularity is not consistent with the theory that there is a progressive shrinkage of the centre of the scale.

With reference to both Figure 22 and Table 17, it should be noted that the fluctuations in calculated length are small and irregular which is much more suggestive of chance variation due to sampling, than of structural change in the scale. The number of specimens available for study in the larger size groups was very small. Because of this only the first eleven years were considered in the growth rate study. It seems unreasonable to suppose, without more confirmatory evidence, that there is an expansion in the center of the scale in the later years of life. While there may be a small tendency toward contraction, errors arising from structural changes in the scales used in the present study are probably of a very small order.
(d) Differences in growth of scales from different regions of the body.

It has been shown by numerous workers that scales do not grow at the same rate on all parts of the body. Most constant in form and growth are the scales from the region between the dorsal fin and the lateral line. In 1946, if scales were taken from any other region of the body they were designated as not standard. No notation to this effect was made in 1944 or 1945, therefore, it had to be assumed that all were standard. Since the number of scales taken in these two seasons was not large, and since standard scales were easily obtained on all but the smallest inconnu, it was felt that error introduced by the use of non-standard scales in the present study, would be insignificant.

Advantages of the body-scale relationship.

The advantages of the body-scale relationship in the present study were the following:

(a) It made available many more data for the study of the growth rate. In particular, it provided information concerning the smaller size groups which were poorly represented in the sample.

(b) It made it possible to break down the mixed sample into its components, the separate year classes. This in turn provided information which enabled us to predict the time of arrival of the young fish at Great Slave Lake. It also gave added meaning and reliability to
the average growth curve based on age and length at capture.

Since the curves based on calculated lengths agree so well with each other and with the curve based on observed lengths it is evident that the difficulties discussed above are either not serious in the case of *Stenodus*, or that they tend to cancel each other rather than to have a cumulative effect.

**PARASITES.**

Parasites *collected* from Great Slave Lake fishes were identified by Dr. R. B. Miller, University of Alberta. Dr. Miller's report for 1946 had not been received at the time of writing, therefore, the following list is not complete.

**Copepoda**

An unidentified copepod was found *attached* to the gills of inconnu on several occasions and from widely separated points in the lake.

**Nematoda**

A common location of nematodes in the body of the host is the swim bladder. The swim bladders of 30 inconnu caught at Big Buffalo Lake were opened and only 2 were found to contain nematodes. Nematodes may also occur in the coelom and in the gut. Both of these
cavities were routinely examined and although nematodes were occasionally found, the impression gained was that *Stenodus* is relatively free from internal parasites.

**Cestoda**

Adult cestodes were rarely encountered in *inconnu* in 1946. The 30 specimens mentioned above as having been examined for round worms, were also examined for cestodes by opening the stomach, removing and stripping the gut. Only one fish was found to be *harboring* suffering from intestinal tapes, which have not as yet been identified.

*Proteocephalus* n. sp. Specimens of a species of *Proteocephalus* differing markedly from all other Canadian species were found in the stomachs of *inconnu* caught at Fort Resolution in 1944. No further information regarding this parasite has been obtained.

*Triaenophorus crassus*. *Triaenophorus* is a common parasite encountered in the flesh of whitefish and tullibee and was therefore to be expected in *inconnu* although the actual discovery made in 1944 constituted a new host record for the species. The primary host is the pike (*Esox lucius*), and the first larval stages are passed in the copepod *Cyclops*. Since pike are abundant in the Buffalo River system, and since immature *inconnu* feed to a large extent on copepods, a rather high rate of
<table>
<thead>
<tr>
<th>Date and place</th>
<th>Fish Examined</th>
<th>Fish Infested</th>
<th>Degree of Infestation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Weight</td>
<td>Number</td>
</tr>
<tr>
<td>Resolution</td>
<td>1</td>
<td>10.5lb</td>
<td>1</td>
</tr>
<tr>
<td>June 23/45</td>
<td>3</td>
<td>21.8</td>
<td>2</td>
</tr>
<tr>
<td>Outpost Is.</td>
<td>2</td>
<td>12.0</td>
<td>2</td>
</tr>
<tr>
<td>June 25/45</td>
<td>5</td>
<td>45.0</td>
<td>3</td>
</tr>
<tr>
<td>Gros Cap</td>
<td>5</td>
<td>48.5</td>
<td>4</td>
</tr>
<tr>
<td>Aug. 2/45</td>
<td>5</td>
<td>37.5</td>
<td>4</td>
</tr>
<tr>
<td>Big Buffalo R.</td>
<td>14</td>
<td>67.0</td>
<td>14</td>
</tr>
<tr>
<td>June 24/46</td>
<td>8</td>
<td>87.0</td>
<td>7</td>
</tr>
<tr>
<td>Big Buffalo Lake</td>
<td>6</td>
<td>46.5</td>
<td>6</td>
</tr>
<tr>
<td>Sept. 2/46</td>
<td>49</td>
<td>375.8</td>
<td>43</td>
</tr>
</tbody>
</table>

Table 18. *Triaenophorus* infestation of Great Slave Lake inconnu.
infestation is also to be expected. Examinations for the larval cysts were made by filleting the fish and making transverse sections of the fillets at intervals of about one-eighth of an inch. The results of the examinations appear in Table 18.

Since the cysts in the flesh are unsightly, they render the fish unfit for market. It should be pointed out, however, that the worms are harmless in mammals, so that their presence does not materially reduce the value of inconnu for domestic consumption where its chief use is as dog feed.

ECONOMIC IMPORTANCE.

The commercial fishery.

When McInnes Products Corporation began commercial fishing operations on Great Slave Lake in 1945, the inconnu formed a significant part of the catch of the fisherman. The company therefore bought them and sought to establish a market. The flavor of the inconnu is quite distinctive. Many people are of the opinion that it should only be used for dog feed, while others prefer it to all other fish in the lake, and there seem to be relatively few who merely tolerate it. As with other foods, a great deal depends upon the manner in which it is prepared. The writer found fresh inconnu quite palatable, and other members of the field party and a group of fisheries experts at Edmonton were also favorably impressed.
Because of the tremendous distances involved and its high fat content, the inconnu is not well suited for sale on eastern markets as fresh frozen fillets. The high fat content should, however, make it an excellent fish for smoking. Mr. Greer, at the Big Buffalo River, smokes inconnu regularly for his own use. His smoked product has a fine taste which the writer found suggestive of smoked gold-eye. Inconnu might also be cheaply processed for use as dog feed or as feed for fur-bearers on ranches. Extraction of the oils or reduction of the whole fish for use as fertilizer may also prove to be economically feasible. All the commercial prospects have not been exhausted by any means.

The amount of the catch in 1946 has been indicated in Table 5. Although the inconnu makes up only about 5 per cent of the total commercial catch, its weight of 130,000 pounds is quite significant.

The domestic fishery.

The inconnu is probably without a peer for use as dog feed. It has a very rich flesh and a large average size which means a significant saving in bulk to the trapper who must carry his dog feed in his sleigh. Furthermore, it is a shallow-water fish, easily caught by the natives who are inclined to be lazy and haphazard about securing an adequate supply of food for their dogs. The runs on the
rivers in the late fall provide a particularly convenient way for
the trappers, police detachments and others to secure their dog
feed for the winter. The fish are very abundant and the run is
usually late enough that preservation is no problem. It is only
necessary to throw the fish on the bank where they freeze and
will then keep for the winter.

The amount of the catch at Big Buffalo River has been
estimated at 100,000 pounds, annually. Smaller amounts are taken
from the Taltson and Hay Rivers and the Slave at Fort Smith. In
addition, there is a moderate summer fishery at some of the posts
on the lake, notably Fort Resolution and Rocher River. The total
annual domestic consumption is therefore in the neighborhood of
150,000 pounds.

Recommendations for conservation.

Because of the potential commercial value of the inconnu
and still more because of the important part it plays in the lives
of the inhabitants of the Great Slave Lake region, it seems desirable
to take steps to insure its preservation. An examination of present
day fishing practices is therefore in order.

A random sample of 342 inconnu from the commercial catch
was measured on July 4 and 5, 1946. The length frequency distribution
of this sample is compared with that of 152 fish caught in test nets
Fig. 23. Length frequency distribution of a sample of 152 inconnu caught in test nets (solid line) and 342 inconnu from the commercial catch (broken line).
in Figure 23. (The distribution of fish caught in test nets should be compared with Table 9, page 47). As would be expected, the mode class in the commercial catch (5 1/2" mesh nets) is much higher than that of the test nets, only one-sixth of which are 5 1/2" mesh.

An analysis of the sample of fish in the commercial size range disclosed the following facts.

(1) Approximately 8 per cent are immature.

(2) Approximately 51.5 per cent are in the size range 55 - 69.5 cm., most of which is made up of fish maturing in the present season or fish which had only spawned once. (A very small fraction of this group might be males which had spawned more than once).

(3) Approximately 54.0 per cent are in the size range 65 - 74.5 cm. which constituted the major portion of the spawning run on the Big Buffalo River in 1945. Presumably these fish had spawned for their first or second time.

(4) Approximately 41 per cent of the sample is composed of fish larger than 70 cm. It has been observed that very few males attain a length of 70 cm. or more. Assuming then, that 90 per cent of the fish over 70 cm. are females, and that the sex ratio in the smaller sizes is equal, about 66 per cent of the catch is females, of which almost half have not spawned more than once.

It has been pointed out that the majority of inconnu do not spawn more than two or three times, which probably indicates that there is a high degree of fertility and good conditions for
survival on the spawning grounds. Whether or not the natural fertility of the population can stand the strain occasioned by the removal of such large numbers of newly matured individuals, particularly the females, is a question which can only be answered by continued careful observation. Conditions on the spawning grounds should be studied and more detailed analyses of the commercial catch should be made with a view to determining more accurately the sex ratio and the proportion of non-spawning individuals in the population. The situation may be described as at least potentially dangerous.

The domestic fall fishery is also open to criticism. The present custom of attempting to block the rivers completely is not in the interests of conservation. Fishing has been carried on in this manner on the Big Buffalo River since 1929 at least, and apparently enough fish have always escaped to maintain the population at a more or less constant level. Up until the summer of 1945 the fish which escaped were almost entirely unmolested throughout the rest of the year. With the introduction of commercial fishing in 1945, the rate of exploitation has been approximately doubled.

There is as yet no evidence that the fishery practices now in use have done serious damage to the inconnu population. There is every reason to believe, however, that the present rate of exploitation, especially in combination with the methods and gear in
use, will result in a reduction in the population. Thus, while there is no need to apply restrictions at the present time, it is essential, in the opinion of the writer, that a careful watch be kept on the commercial catch and the fall fishery so that fluctuations in the population may be detected; also that an attempt be made to verify, by direct observation, the details of the life history, many of which could only be inferred from indirect evidence in the foregoing discussions, in order that intelligent and comprehensive conservation methods may be devised and introduced when and if necessary.
SUMMARY AND CONCLUSIONS.

(1) An investigation of the fresh water biology and fisheries of Great Slave Lake was commenced by the Fisheries Research Board of Canada in 1944 and continued through the summers of 1945 and 1946. The inconnu was considered to be of sufficient scientific interest and economic importance to warrant a special study of its life history.

(2) A description of the fish is given, based on measurements made in the field. The inconnu S. mackenzii resembles the asiatic species S. leucichthys in many respects, notably in gill-raker count. It should probably be known as Stenodus leucichthys mackenzii Richardson. No evidence for racial differentiation in America has been found.

(3) The genus Stenodus is widely distributed in the rivers of the northern coasts of Asia and America and in the Arctic Ocean. It is found in the Mackenzie River, the shallower parts of Great Slave Lake and in some of the rivers draining into it. It probably originated in Asia, spread to North America and reached Great Slave Lake by migrating up the Mackenzie River.

(4) Examination of some physical and chemical conditions in Great Slave Lake and its tributaries reveals a seasonal variation in water temperatures. The fluctuations in oxygen content and p.H. are probably biologically insignificant. The silt content of the
water, and hence the degree of light penetration, varies widely in different parts of the lake. Some rivers are more heavily silted than others.

(5) The immature inconnu in the rivers appear to feed mainly on invertebrates. In Great Slave Lake the inconnu is almost entirely piscivorous. Competition with commercially more desirable fish is not considered to be serious.

(6) The migration probably does not take place in a haphazard way throughout the summer as was previously thought. There appears to be a mass movement of inconnu from the commercial fishing areas about August 15. The most important external stimuli are probably rising water temperatures and currents. Light may also play a part. The fish return to the lake during the first week in October, immediately after spawning. This movement is probably initiated by the return of the desire for food.

(7) Spawning occurs about the first week in October. It normally takes place in the rivers, occasionally in Great Slave Lake. Males spawn when they have attained a length of 55 to 60 cm. (7 or 8 years old), and females at a length of 65 to 70 cm. (9 years old). The majority probably do not spawn more than three times.

(8) The young inconnu live for two or three years on the spawning grounds. Their journey to the lake is probably initiated
by the insufficiency of the food supply in the rivers.

(9) The rate of growth in length is the same for males as for females. The average rate is twice as fast as that of the common whitefish (Coregonus). The growing season extends from the last week in June until the first week in September. There is an increase in the average rate of growth in the fourth year which probably coincides with the arrival of the young at Great Slave Lake. The increase in the different year-classes was found to occur in any year between the second and the seventh. The growth of the different year-classes was very similar. There is some evidence of the law of compensation of growth in length. Growth in weight is also rapid. Females tend to be slightly heavier than males of the same length. There is a decided acceleration in the fifth year. There are changes in the form of the fish correlated with the rapid growth in length in the fourth year, and in weight in the fifth year.

(10) Some aspects of the scale theory are enumerated and evaluated as possible sources of error. Evidence for the presence of Lee's phenomenon is inconclusive.

(11) An incomplete list of the parasites of the inconnu is presented. Only one parasite, Triaenophorus crassus is of economic importance. The degree of parasitization by Triaenophorus is high (64 cysts per 100 pounds).
(12) The inconnu makes up 5 per cent of the commercial catch in Great Slave Lake which amounted to 130,000 pounds in 1946. About an equal amount is removed annually for domestic use. Domestic fishing preys heavily on the run of adults returning from the spawning grounds.

(13) Commercial fishing operations have been carried on for less than two full seasons, therefore, it is probably too soon for any deleterious effects to have become visible. It is to be expected that the present rate of exploitation combined with the methods and gear in use will affect the inconnu population. It has been shown that there is a need to verify the deductions which were made concerning certain phases of the life history, if intelligent, practical conservation measures are to be instituted.
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Mackenzie, Alexander, 1801 - Voyages from Montreal, on the River St. Lawrence, through the continent of North America to the frozen and Pacific Oceans; in the years 1789 and 1893. London. (Not seen, information from Dymond, 1943).

Roule, Louis, 1933 - Fishes, their journeys and migrations, George Routledge and Son's, London.


Appendix I - Measurements and counts of byely parts of inconnu from Great Slave Lake & Big Buffalo Lake, 1946
### FISHERIES RESEARCH BOARD OF CANADA

**Species:** *Stenodus leucichthys mackenzii*

**Measurements by:** W. A. Fuller

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**N.B.** 1 = immature  
* = Small eggs