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FISHERIES RESEARCH BOARD OF CANADA

ANNUAL REPORT

of the

CENTRAL FISHERIES RESEARCH STATION

for

1951

With Investigators' Summaries as Appendices

by

K. H. Doan, Acting Director . .

WINNIPEG, MAN.

DECEMBER, 1951

Fisheries Research Board of Canada
Report for 1951 of the
Central Fisheries Research Station
Winnipeg, Man.

by K. H. Doan, Acting Director

The Central Fisheries Research Station is devoted to biological studies of the fishes and fisheries of the interior of Canada, embracing Alberta, Saskatchewan, Manitoba, Northwest Territories and, co-operatively with the provincial department, northwestern Ontario. It is the smallest of the Board's Stations and so perforce has had to restrict its work to a very few important projects within its huge region of operation. The fisheries are scattered and seasonal, so that detailed attention has been directed only towards the largest, Great Slave Lake in the Northwest Territories and Lake Winnipeg in Manitoba. The most important biological problem, both in extent and economic value, is the alleviation of poor quality in whitefish, Coregonus clupeaformis, caused by the presence in the flesh of a stage of the tapeworm Triaenophorus crassus; fish from some lakes may be so heavily infected as to create marketing difficulties not only interprovincially but, more importantly, in the export trade to the United States.

Whitefish Tapeworm Research

Life history and management studies. The general nature, and many of the details, of the life history of the whitefish tapeworm have been known for several years. The adult worm lives in the intestine of pike and passes eggs into the water in the spring, these then hatch and the larvae are eaten by a small water flea called Cyclops bicuspidatus. The infected water flea is consumed by whitefish or tullibee, Leucichthys spp., and the worm encysts in the flesh where it is objectionable on aesthetic grounds, although it is actually harmless to humans. When the whitefish is eaten by pike, Esox lucius, the tapeworm grows to maturity in its intestine and so completes the life cycle. The various hosts are quite specific, but large numbers of tapeworm eggs and larvae are produced so that in nature some of them are almost sure to survive into a new generation.

Heming Lake is a small lake north of The Pas, Manitoba, and for the past several years has been used in the tapeworm studies. During the year under review definitive and second intermediate hosts were further confirmed at Heming and neighbouring lakes, and the first North American record was obtained of the sculpin Cottus cognatus serving as second intermediate host for the related tapeworm T. nodulosus. There are three species of Triaenophorus commonly associated, and the whole group comes under review in any detailed work on T. crassus. There appeared to be a correlation between the size of whitefish and the length of worms

contained in them, the smaller whitefish having larger tapeworms. Limnological observations should bear some relationship to Trieno-phorus abundance, and these data are being accumulated. Pike were netted for the seventh successive year at Heming Lake, the catch of 2.7 pounds per acre from the 588-acre lake being of the same order as yields in previous years. Whitefish infection remained about the same, the conclusion being that a moderate pike netting programme has been ineffective in making more than a 50 per cent initial reduction in infection--an improvement in quality which has been maintained but not increased.

Wapun Lake, 3 miles south of Heming Lake and in the same drainage, was found to contain no whitefish or tullibee, although apparently suitable for them. Through the kindness of the Manitoba government, 850,000 eyed whitefish eggs were planted in January. The parent fish were preserved, and morphometrical measurements were made. The next few years should demonstrate, if the whitefish survive, the ability of T. crassus to infect them, and as the whitefish grow to maturity the effect of a new environment should be evident in their morphometry.

Co-operation with provinces on whitefish research. The Board was unable to expand the co-operative research programme with the provinces that was begun two years earlier. In northwestern Ontario some details of the 1950 investigations were completed in 1951, and it was concluded that the lake herring (cisco or tullibee) that was found in Lake Muskeg was a dwarf Leucichthys artedi. The plankton samples from lakes Onaman and Muskeg were analysed and the species listed.

Investigations in the Thunder Bay district, Ontario, during the present year were confined to Lake Nipigon and Shakespeare Island Lake. The Department of Lands and Forests encouraged the commercial fishermen to attempt a fish harvest aimed at upsetting the balance between ciscoes, pike, whitefish and T. crassus, with a view towards improving the quality of Lake Nipigon whitefish. Biological observations were made in conjunction with this fishery, and experimental nets were also fished. Whitefish in Shakespeare Island Lake were infected in the absence of ciscoes, and, with their pronounced planktonic diet and small size, they probably bridged the gap from plankton to pike as effectively as could have been done by plankton-eating ciscoes.

In 1949 and 1950, in co-operation with the Fisheries Branch of the Saskatchewan Department of Natural Resources and Industrial Development, ecological studies were made of the relationships between the whitefish tapeworm and its hosts in Nesslin Lake, northwest of Prince Albert. During the present year detailed plankton analyses were completed, and it was found that Nesslin Lake had its richest supply of plankton during the month of June, with a second smaller pulse later in July. T. crassus eggs were observed to hatch as late as June 13, and the coracidia would be available to Cyclops bicuspidatus which were numerically increasing towards their peak on June 24, when the lake contained an average of 7.1 Cyclops per liter of water. The moderately rich plankton crop of Nesslin Lake was compared with that of several other lakes,

and Nesslin had a production intermediate between alpine lakes and the richer eutrophic types.

Co-operative research with the Fisheries Branch of Alberta and the University of Alberta led to promising laboratory tests of a chemical, Dow K-604, which was effective against tapeworm eggs and larvae, but unfortunately a shipment of one ton of the chemical arrived too late in the spring to be given a field trial in a lake near Edmonton. The material is now in storage, ready for use early next spring. Experiments with pituitary suspensions and extracts, to promote sexual ripeness in live pike and maturation of their tapeworms, so that a supply of eggs from the latter could be obtained unseasonally in the laboratory, led to valuable experience in making injections to effect the desired results. Injections caused the tapeworms to become more mature than those in untreated pike, and the nearer the dates of injection to the natural spawning period the easier it was to advance development of the sex organs of both the fish and the tapeworm. Some worms were advanced to the stage where they released their undeveloped eggs upon contact with water. Although these eggs did not live, they contained well formed onchospheres. This difficulty in hatching might be overcome in future experiments by giving smaller dosages of pituitary extract and increasing the time intervals between injections.

Cisco research. The ciscoes (tullibee or lake herring) Leucichthys spp. play an important role in the life cycle of Triaenophorus crassus, and after this cycle was outlined for Western Canada detailed work on the relationship between ciscoes and the parasite became desirable. The systematics of ciscoes in the Prairie Provinces became known about 20 years ago, but subsequent work made the validity of these species questionable. Differences in morphometry apparently had been formulated from comparisons of relatively few specimens, so that when large series were analysed the intraspecific variations overlapped interspecific differences. Studies of growth rates and infection with Triaenophorus also showed differences between ciscoes, based on present taxonomy. If groups of ciscoes maintain their identity, then they must breed apart from other groups. Attention has been directed towards breeding activities of ciscoes in Lake Winnipeg.

The actual spawning of ciscoes has not been observed in Lake Winnipeg, because the fish spawn at freeze-up time, in mid-water without making nests, and the water is usually quite turbid. In 1950 it seemed, from specimens taken by gill-net, that different species of Leucichthys were spawning at the same time and place, but mixing of the species was not complete because there were differences in the proportions of zenithicus and nipigon taken from different depths at one locality. Freeze-up was unseasonally early in 1951, then the ice broke and later reformed, so that extensive fishing at spawning time was impractical.

Commercial Fisheries Research

Great Slave Lake. Biological surveys conducted by the Board in 1944 and 1945 on Great Slave Lake, N.W.T.--the fifth largest lake in North America--led to the establishment of

commercial fishing. Since 1945 the commercial catch has been carefully sampled in order to detect the effect of fishing on the stocks of fish. Quotas have been increased, until now the permitted annual catch is 9 million pounds round weight of lake trout, Cristivomer namaycush, and whitefish combined, the two principal commercial species. The total annual fishing effort is not believed to be excessive, being less than one per cent of that exerted in Lake Erie. However, it may be possible to have local over-fishing there, since tagging returns have indicated only limited fish movements, an average of 23 miles annually for trout and 8 miles for whitefish. Catch per unit of effort, i.e. the poundage taken in one gill-net in one night, or its equivalent, has fluctuated so erratically over the years that it cannot be considered the best index of the effect of fishing. Size, growth rate and mortality rate are better indices, and these have shown no significant changes since the fishery began. Over-fishing might be expected to produce smaller fish that grow faster and die sooner than in a virgin population, and since none of these things have happened it has been concluded that the present annual catch is having no effect on the fish population.

The Department has made adjustments in open areas and quotas to guard against local temporary depletion. These adjustments arose from heavier fishing out of Hay River where fewer lake trout and more rough fish (suckers, Catostomus spp., etc.) were taken in the summer of 1950.

The catch data collected at Great Slave Lake during the past few years have provided material for the calculation of the relative size of lifts taken from gill-nets that were fished for one day, two days, etc. It was found that the average catch taken after two days was less than twice the catch made in one day, because apparently the fish which are caught the first day decrease the efficiency of the net during the second day. The relationship depended only on the initial level of catch and was independent of the proportion of the various species and of the average size of individual fish. A high initial one-day catch resulted in proportionately lighter catches after two days, three days, etc. The saturation point was about 250 pounds per 100 yards of 5½-inch gill-net, and after saturation the net will not catch any more fish. Rapid supersaturation is possible under special conditions, such as a net set amongst a large number of active fish that are spawning, and in such exceptional circumstances the amount of fish that are retained by the net will probably decrease as the net is fished more than one day. These relationships are useful in converting catches to a one-day basis.

Examination of scales of whitefish from Great Slave Lake indicates that the fish commence growing about the middle of July in any year, that 90 per cent of the year's growth has been completed by the end of August, and that growth ceases from September until the next July. Smaller fish, less than 5 years of age, have a slightly longer growing season. It would appear that whitefish in Lake Winnipeg begin to grow at least one month earlier than in Great Slave Lake.

Lake Winnipeg. Commencing in 1948, the commercial fisheries of Lake Winnipeg have been studied with the object of establishing trends in populations so as to be able to predict the catch. Population studies consume many years, and results are at first not readily apparent. The relationships of the whitefish tapeworm to the abundance of fish, their movements, feeding and other habits, are also being determined. The study is more complex than that at Great Slave, because more species of fish are involved, and there are more extensive fishing seasons and scattered centres of operation.

During the winter of 1950-51 semi-monthly visits were made to fishing centres throughout the southern 120 miles of the lake, interviews were made with fishermen on the ice, and up to 500 individual sauger, Stizostedion canadense, and pikeperch, S. vitreum, were sampled in each area on each visit. During the summer of 1951, individual daily catch record cards were made for each fisherman operating in the whitefish fishery out of Big Black River. Catches were sampled randomly for weights of individual fish of various species. A census of the summer fishery was taken at Loon Straits, and sample weights and scales from individual fish were taken. A random sample of fish was taken from the summer fishery at Warren's Landing at the north end of the lake. Factors were determined for the conversion into round weight of 5 kinds of fish that were "dressed" and "dressed headless".

A comparison was made of the efficiency of nylon and cotton 3-inch gill-nets in the Lake Winnipeg winter fishery. The nylon nets caught about three times as many fish per unit of fishing effort as did the cotton nets. Both nets caught about the same size of fish, and there was no tendency in this fishery for nylon nets to catch predominantly small fish, as some fishermen have suggested.

The Lake Winnipeg whitefish of average commercial size are about one-half the age of those taken in Great Slave Lake and almost twice as old as those taken in Lake Erie. No great variations in Lake Winnipeg whitefish year class strength are evident, at least the frequency distributions approximate a normal curve.

Water temperatures were taken throughout June off Big Black River, and were almost identical at surface and bottom. Each day the temperature at a given spot increased slightly, so that a given temperature was to be found farther and farther offshore as the month progressed. Whitefish were taken farther offshore as the water became warmer, the fishery moving concurrently with water temperatures. It seemed that these whitefish avoided water over 60°F., but this hypothesis does not offer a complete explanation of all the apparent concentrations of whitefish.

Beluga. The beluga, Delphinapterus leucas, that passed through the reduction plant at Churchill, Man., during the summer would have formed a line more than one mile in length--584 animals that averaged 9.9 feet. Although the Station did not have an observer present at the fishery, certain reports were made available. Animals taken by harpoon and net were stripped of blubber which was cooked to remove the oil, which was later clarified by settling and

centrifuge. Most of the remainder of the carcass was ground up, packed in cartons, and frozen for disposal as animal food. The season's production amounted to approximately 18,674 gallons of oil which weighed about 172,735 lbs., 4,750 lbs. of liver, 133,000 lbs. of ground meat, and 3,200 lbs. of steaks, a total of 313,785 lbs. The total yield of all products per beluga was 646 lbs. in 1949, 619 lbs. in 1950, and 538 lbs. in 1951. The increased use of nets in 1951, as compared with former years, probably contributed to the smaller average size of beluga this year. Twenty-eight per cent of the beluga that were harpooned were less than 10 feet in length, as contrasted with 55 per cent of those that were netted. The sex ratio was almost exactly two males to one female, with an overall length range of 5 to 14 feet. The kill was considerably greater than in the first two years that the plant was operated, 215 beluga having been taken in 1949 and 326 in 1950, but still within the district quota of 600.

STAFF

Scientific

Mr. R. R. Wheaton is attending the University of Saskatchewan for the fall term and is enrolled for the Master's degree. His thesis will be on the "black whitefish" of Great Slave Lake.

Technical

Miss Dawn L. Brown was appointed Assistant Technician Grade 1 to read fish scales, replacing Miss E. J. Johanson who resigned.

Seasonal and part-time

I. G. Arnason who has been associated seasonally and part-time with the Station was granted the Ph.D. degree from the University of Manitoba, based in part upon a thesis entitled "A survey of the entomostraca of Manitoba, and a study of the feeding of Lake Winnipeg ciscoes".

M. L. Libin, employed seasonally and part-time from April, 1949, was given the degree of M.Sc. from the University of Alberta, and prepared a thesis entitled "Laboratory experiments on the control of the tapeworm, Triaenophorus crassus".

BUILDINGS

Winnipeg

The Station moved into new quarters at 165 Garry Street on Feb. 20, upon the completion of a new two-storey brick and concrete building. The second floor of 5,000 square feet was leased on the Board's behalf by the Department of Public Works. The interior arrangement provides adequate office-laboratory space for each research project and for clerical and administrative functions, thus relieving the serious overcrowding which prevailed

in the former location in the Childs Building. There is a large general laboratory, storeroom, library, dark rooms, and wash rooms. The interior finish is of plywood and opaque glass, with composition tile floors and fluorescent lighting throughout. Deliveries and car parking are in the rear. Janitor and electric service are supplied, and there are several extensions on a two-line rotary switch telephone.

Lake Winnipeg

The small warehouse at Selkirk continued to be of great use for the storage of nets and boat equipment, and is in good condition. A garage for sheltering the bombardier snowmobile was built on Public Works property at Selkirk, and given two coats of paint. The cabin at Big Black River is in fair condition, and was of great service to field parties working in that region.

Heming Lake

The log cabin at Heming Lake, which was in a used condition when acquired by the Board in 1949, deteriorated somewhat, and a new floor was laid in part of the interior. A warehouse 15'x 22' was built of logs and rough poles, for the shelter of nets and equipment near the dock. The land reservation of 28 acres has been maintained.

Great Slave Lake

The former R.C.M.P. house on high land near the old townsite of Hay River, which was transferred to the Board, is in fair condition, and was used as living quarters in the winter and summer. It has now been considered advisable to continue temporary living quarters in this building, until such time as the severity and frequency of floods on Island "E" and in the new townsite are more fully known and/or controlled. A garage for the bombardier was built beside this house. Two cabooses, formerly on the barge, were placed on our lot in Hay River, situated near the largest fish packing plant, and were used for storage and sleeping quarters. Both were given coats of paint.

Lake Athabasca

The Board's cabin at Fort Chipewyan, formerly used in goldeye work, is on loan to the Department of Resources and Development.

EQUIPMENT

The 28-foot gas boat "Limnos" was completely destroyed by fire at Gros Cap on Great Slave Lake in August, and Mr. Hanson was hospitalized with severe burns. It is proposed to transfer the 35-foot gas boat "Coregonus" from Lake Winnipeg to Great Slave Lake next year. The construction of a 45-foot diesel-powered steel boat is in the advanced planning stage, and it is expected to be available for Lake Winnipeg next year.

Four small boats were acquired during the year; a yawl for Lake Winnipeg and one for Great Slave, and two flat-bottom rowboats for use in the vicinity of Heming Lake.

A new Ford half-ton panel truck was purchased for Great Slave Lake, to replace the 1941 station wagon. The other vehicles, two bombardiers and a panel truck, are in good condition and gave satisfactory service during the year.

Nearly one ton of the chemical Dow K-604 is in storage in Edmonton, for trial use against the larvae of the whitefish tapeworm.

Miscellaneous tools were bought for the laboratory, vehicles, boat engines and field camps, as well as nets, parkas, camping equipment etc., and churns for storing fish specimens.

PUBLIC RELATIONS AND MEETINGS

The Station provided information requested by individuals on a variety of subjects, including fisheries biology and operating conditions on Lake Winnipeg and Great Slave Lake. A number of visitors were shown through the Station, and had discussions with the staff.

Meetings of the Administrative Advisory Committee of this Station were held in April in Winnipeg and in September in Saskatoon.

The Board's annual meeting in Ottawa in January was attended by Drs. Doan and Kennedy, and the former attended meetings of the Executive Committee in Ottawa in January, Montreal in June, and Ottawa in October. Dr. Doan became secretary of the Director's committee.

At the meeting of the Board's Committee on Biological Investigations in Ottawa in January Drs. Doan and Kennedy and Mr. Lawler were present, the latter serving as secretary.

Dr. Kennedy was chairman of the section on fish migrations, of the Canadian Committee for Freshwater Fisheries Research, at its January meeting in Ottawa which was also attended by Dr. Doan and Mr. Lawler.

The April meeting, held in Winnipeg, of the Administrative Advisory Committee on the Control of Whitefish Infestation was attended by some of the Station's scientific staff, as was the meeting of the scientific sub-committee. The Board's committee on Trianaophorus research also met at this time.

Dr. Kennedy met with Resources and Development officials at Fort Smith, N.W.T. in July to discuss the Great Slave fishery, and attended a meeting on the same subject with Indian Affairs Branch in Ottawa in October. Mr. Wheaton attended and Dr. Kennedy addressed a meeting called by the fishermen at Hay River, N.W.T. in July.

A meeting of Lake Nipigon commercial fishermen was arranged by the Ontario Department of Lands and Forests in Port Arthur in April and was attended by Dr. Doan and Mr. Lawler. Mr. O. E. Devitt of Lands and Forests spent about two weeks at the Station in November and December, studying the theory and practice of reading fish scales.

Contributions to the training course given in Winnipeg in November to the new inspectors of the inland division of the Department of Fisheries were made by Drs. Doan and Kennedy and Mr. Lawler.

Professor J. Stuart Hay of the University of Manitoba, in connection with survey work which he conducted for the Manitoba Department of Mines and Natural Resources, used the Station's facilities for reading fish scales. University staff were consulted on statistical procedures. Because of the Station's great interest in the results, the Lake Winnipeg whitefish scales taken by the Manitoba Game and Fisheries Branch were read by Station personnel.

Dr. Doan addressed the second annual banquet of the Prairie Fisheries Federation in Winnipeg in March. Mr. Wheaton gave a seminar on Great Slave Lake at the University of Saskatchewan.

Mrs. Dixon assisted with clerical work at the June annual meeting of the Chemical Institute of Canada, in Winnipeg.

ACKNOWLEDGEMENTS

The basis for a successful study of the commercial fisheries has been the good relations and co-operation shown by the fishermen of Great Slave Lake and Lake Winnipeg. We wish to take this opportunity to express our thanks and appreciation to the many individual fishermen on these lakes and others. We are further indebted to several organizations and individuals for many courtesies: Department of Fisheries, Department of Public Works, Royal Canadian Mounted Police, Army Signals, Canadian National Railways, Manitoba Department of Mines and Natural Resources, Manitoba Government Air Service, Alberta Fisheries Branch, Ontario Department of Lands and Forests, University of Alberta, University of Manitoba, Royal Ontario Museum of Zoology, University of Toronto, McInnes Products Corp. Ltd., W. R. Menzies Co., Clarke Fisheries, Alaska Fisheries, Western Fisheries, Carter's Fisheries, Kucher and Trefiak Fisheries, Inland Fisheries, Gateway Fisheries, Big Four Fish Packers, Hallgrimson Fisheries, New Fish Co., Booth Fisheries, Stephanson Bros., Adanac Whale and Fish Products, W. Monkman, W. E. Cudmore, A. Boag, J. E. Maloney, and E. Valquette.

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- Doan, K. H. 1951. Report for 1950 of the Central Fisheries Research Station, Winnipeg, Man. Fish. Res. Bd. Can., Ann. Rpt. 1950: 52-61.
- Hewson, L. C. 1951. A comparison of nylon and cotton gill-nets used in the Lake Winnipeg winter fishery. Can. Fish. Cult., 11:7-9.
- W. B. Scott, D. N. Omand and G. H. Lawler. 1951. Experimental rearing of yellow pikeperch fry in natural waters. Can. Fish. Cult., 10: 38-43.

STAFF OF CENTRAL FISHERIES RESEARCH STATION, 1951

Scientific, full-time

K. H. Doan, M.A., Ph.D.	Acting Director and Senior Scientist
W. A. Kennedy, Ph.D.	Associate Scientist
G. H. Lawler, M.Sc.	Assistant Scientist
J. J. Keleher, M.A.	Assistant Scientist
L. C. Hewson, B.A.	Junior Scientist
R. R. Wheaton, B.Sc.	Junior Scientist (half-time Oct.1-)

Technical

Ellen J. Johanson, B.Sc.	Assistant Technician Grade 2 (to Nov. 16)
R. M. Hanson	Assistant Technician Grade 2
K. G. Roberts	Assistant Technician Grade 2
Dawn L. Brown	Assistant Technician Grade 1 (from Nov. 5)

Administration and Clerical

Phyllis M. Dixon	Clerk Grade 4
Alice B. Whitney	Stenographer Grade 2A

Seasonal

J. A. Dick, B.A.	Junior Research Assistant (June 8-Sept.8)
R. H. D. Harris B.Sc.	Junior Research Assistant (May 18-Sept. 26)
H. E. Welch, B.A.	Junior Research Assistant (May 21-Sept. 22)
D. L. Hurst	Junior Research Assistant (June 1-Sept. 1)
J. E. Matheson	Junior Research Assistant (May 8-Sept. 1)
R. S. Williams	Assistant Technician Grade 1 (June 1-Sept. 1)
F. Watt	Assistant Technician Grade 1 (Nov. 24-)

Part-time

I. G. Arnason, Ph.D.	Assistant Technician Grade 2 (to March 31)
C. W. Douglas, B.Sc.	Assistant Technician Grade 2 (to March 31)
G. E. M. Hazen, B.A.	Assistant Technician Grade 2 (to March 31)
M. L. Libin, M.Sc.	Junior Research Assistant (to March 31)

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WHITEFISH TAPEWORM RESEARCH

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G. H. Lawler

Appendix No. 1

OBSERVATIONS ON TRIAENOPHORUS AT HEMING LAKE AND VICINITY, 1951

During the summer nets were set at regular intervals in Heming, Home and Wapun Lakes to collect fish for examination for the various Triaenophorus parasites, and the degree of infection was recorded. Lengths, weights, scales, otoliths and stomachs, when required, were also recorded. The catch of fish is presented in Table I.

Table I. Catch of fish in Heming, Home and Wapun Lakes.

Species	Number of Fish		
	Heming	Home	Wapun
<u>Coregonus clupeaformis</u>	611	6	-
<u>Leucichthys tullibee</u> ?	162	-	-
<u>Esox lucius</u>	1075	19	8
<u>Perca flavescens</u>	197	22	40
<u>Stizostedion v. vitreum</u>	276	72	42
<u>Lota lota</u>	7	2	35
<u>Catostomus commersonii</u>	328	38	13
<u>Percopsis omiscomaycus</u>	234	-	-
<u>Cottus cognatus</u>	55	19	3
<u>Boleosoma nigrum</u>	? (Preserved)	4	4
<u>Notropis hudsonius</u>	? (")	?	?

No new hosts of Triaenophorus crassus were found. The hosts of the three Triaenophorus species found in Heming, Home and Wapun Lakes are listed in Table II. The lake names are abbreviated as follows; Heming (Hm.), Home (Ho.) and Wapun (Wa.).

Table II. Identified hosts of Triaenophorus.

	First intermediate.	Second intermediate	Definitive
<u>T. crassus</u>	?	<u>C. clupeaformis</u> (Hm.) <u>Leucichthys</u> (Ho.)	<u>E. lucius</u> (Hm.)
<u>T. nodulosus</u>	?	<u>Lota lota</u> (Hm., Wa.) <u>P. flavescens</u> (Hm., Ho., Wa.) <u>Cottus cognatus</u> (Hm.) *	<u>E. lucius</u> (Hm., Ho., Wa.)
<u>T. stizostedionis</u>	?	<u>P. omiscomaycus</u> (Hm.)	<u>S. vitreum</u> (Hm., Wa.)

* Believed not reported previously in North America.

The percentage infection of perch with T. nodulosus for the three lakes was as follows: Heming 44%, Home 48% and Wapun 51%.

The percentage infection of burbot with T. nodulosus for Heming has been reported as 60% (C.F.R.S. Ann. Rpt. 1950 Appendix No. 8). The burbot of Wapun lake were 48 per cent infected in 1951.

Only one Cottus cognatus was found to contain T. nodulosus, however, this observation is in agreement with various European investigators who record T. nodulosus only sparsely from cottids.

Size of plerocercoids

The plerocercoids were removed from 50 whitefish throughout the summer. The worms were allowed to relax and then the total length was measured in millimetres. The results, although a complete analysis has not been made, indicate the younger whitefish have the largest worms. There appears to be a definite correlation between length and weight of whitefish and length of worm.

Measurements were also made of immature and adult T. nodulosus from perch, burbot and pike.

G. H. Lawler

Appendix No. 2

LIMNOLOGICAL OBSERVATIONS ON HEMING, HOME AND WAPUN LAKES, MANITOBA.

Wapun, Heming and Home Lakes are connected in the order listed, and are located about 80 miles north of The Pas, Manitoba. Although of comparable size and depth, these fish populations and degrees of infection with Triaenophorus were strikingly dissimilar. Scattered limnological information was collected during 1951, which may contribute towards further ecological knowledge of the tapeworm Triaenophorus crassus.

Temperature

The water temperature of Heming Lake was measured throughout the observational period by a continuous recording thermometer placed about two feet deep in four feet of water off the camp dock. The air temperature was taken between the hours 7.00 a.m. to 9.00 a.m. with a maximum-minimum thermometer. The semimonthly average water and air temperatures for Heming Lake are shown in the table. It is intended to analyze the catch statistics and correlate the results with the temperatures to determine what effect temperature has on the movements of fish.

Table. Semimonthly average water temperature (deg. F.) at Heming Lake between May 13 and September 19, 1951.

Period	Average water temperature
May 13 - May 26	52°
May 27 - June 9	54°
June 10 - June 23	62°
June 24 - July 7	65°
July 8 - July 21	66°
July 22 - Aug. 4	69°
Aug. 5 - Aug. 18	68°
Aug. 19 - Sept. 1	63°
Sept. 2 - Sept. 15	60°

Dissolved Oxygen

Miller's method was used to determine the dissolved oxygen in the water. The surface oxygen in Heming Lake ranged from 7.7 to 8.4 c.c./litre and the oxygen near the bottom at a depth of 15 feet varied from 8.0 to 8.6 c.c./litre. The dissolved surface oxygen in Home Lake ranged from 7.5 to 8.6 and in Wapun Lake from 8.0 to 9.2 c.c./litre.

pH

The water in Heming Lake is very nearly neutral ranging in pH throughout the observational period from 7.0 to 7.2. The pH of Home Lake was erroneously reported in the 1950 report as being approximately 5.2. Such a high acidity reading was the result of using old reagents. The pH recorded during 1951 varied from 7.0 to 7.2. The pH of Wapun Lake ranged from 7.0 to 7.2.

Soundings

Accurate sounding maps of Heming and Home Lakes, useful for future netting programs were made during 1951. The greatest depth found in Heming Lake was 19½ feet and in Home Lake 12 feet.

G. H. Lawler

Appendix No. 3

PIKE CONTROL AND WHITEFISH INFESTATION, HEMING LAKE

For the seventh successive year netting of pike, Esox lucius, was conducted at Heming Lake with the purpose of reducing their numbers to a point low enough to bring about some significant reduction in the incidence of cysts of the tapeworm Triaenophorus crassus in the flesh of whitefish, Coregonus clupeaformis. A summary of the results is presented in Table I.

Table I. Catch of pike, and whitefish infection in Heming Lake, Manitoba, between 1945 and 1951.

	1945	1946	1947	1948	1949	1950	1951
<u>Pike caught, nets, angling and poisoning</u>							
Number	563	571	931	705	490	1071	1075
Per cent 18" in length and over	82	58	48	53	59	39	47
<u>Pike killed, pounds per acre</u>							
Nets and angling	2.25	1.8	2.31	1.95	0.44	2.08	2.7
Poisoning					0.76	.23	
					<u>1.20</u>	<u>2.31</u>	
<u>Whitefish</u>							
Number examined, all lengths	273	125	161	278	183	228	611
Cysts, No. per 100 whitefish over 13"	528	327	322	353	350	333	314
Cysts, No. per 100 lbs. whitefish over 13"	290	156	168	196	194	155	164
Cysts, greatest No. in one fish	99	33	17	32	32	19	34

The number of pike taken each year since 1945 has increased owing to the use of nets over a longer period each year, but the average size of individual fish caught, although generally decreasing, appears to fluctuate somewhat. The reduction of the larger pike, capable of consuming whitefish has been valuable.

The overall infection of whitefish by tapeworm cysts has remained relatively constant since 1946 the year of the initial decrease. The number of cysts per 100 fish is lowest in 1951 and this may be the result of greater availability of fish of younger age groups with low infection rates. It seems reasonable to conclude that the reduction of pike in the lake has resulted in a decreased infection in the whitefish but that increased exploitation of the pike population is necessary to effect a substantial decrease.

The 1951 infection rates were analyzed weekly to determine at what time during the summer the greatest increase in cysts occurred. From these data it did not appear evident at what time the worms actually appeared in the flesh. The data reduced to monthly intervals are shown in Table II. The infection per 100 pounds increased considerably during August, however, the large number of fish under 13 inches in length may have masked the picture. The results may be clarified when the infection rates are analyzed on an age group basis.

Table II. Infection rate of Heming Lake whitefish during the summer 1951.

Sampling period	Whitefish of all lengths					Whitefish over 13 inches in length				
	Total No.fish	No.of Cysts	Weight of fish /100 lbs.	Infection /100 fish	Infection	No.of fish	No.of cysts	Weight of fish /100 lbs.	Infection /100 fish	Infection
May 13-June 9	225	542	309.5	175	240	158	494	260.5	189	312
June 10-July 7	57	90	72	125	157	28	67	51	131	239
July 8-Aug. 4	96	105	86.5	121	109	39	81	63.5	127	207
Aug. 5-Sept. 1	141	158	43.5	363	112	12	25	18	138	208
Sept. 2-Sept.22	84	116	74	156	138	38	72	56	128	189

In 1950, 81 yearling whitefish were captured; 43 per cent of the fish were infected with T. crassus. Sixty-seven 2-year-old fish in 1951 showed a very high rate of infection both on a pound-age and a numerical basis, 55 per cent of the fish being infected. As many as 9 cysts were found in 2-year-old whitefish. As the yearling fish in 1951 were not as heavily infected as the yearlings in 1950 it might indicate that the year 1950 was an exceptionally good year for a successful hatching and/or survival of Triaenophorus crassus.

The percentage infection with T. crassus for various sizes of whitefish is shown in Table III.

Table III. Percentage of whitefish infected with Triaenophorus crassus, 1951.

	Size range				
	Under 6"	6"-8"	8"-10"	10"-13"	13" and over
No. of fish	89	67	20	122	193
Percentage infection	24.7	55.2	20	37.7	81.8

G. H. Lawler

Appendix No. 4

RESULTS OF ANGLING AT HEMING LAKE, MAN.

A census on summer angling begun at Heming Lake during the summer of 1950 was continued in 1951. Angling was undertaken to catch pike for the Triaenophorus studies, in addition to nets, and for recreational purposes. Heming Lake cannot be considered a good trolling lake because of its shallowness and heavy vegetation, and most fish were caught by casting artificial baits.

A total of 424 fish were taken by angling, a yield of 0.72 fish per acre. During May to September 1951 the total number of hours fished were 173½ or 0.29 hours per acre. The catch of fish was 2.4 fish per rod hour, (somewhat higher than the catch in 1950) or 6.2 fish per angling effort. The catch of pike was 2.1 fish per rod hour. The average fork lengths of the fish were: pike 18.9 inches, yellow pikeperch 16.1 inches, and whitefish 16.25 inches. Pike constituted 88 per cent of all fish caught by angling and pikeperch and whitefish made up 10.5 and 0.5 per cent respectively.

Table. Catch of pike per unit of effort during May and June at Heming Lake.

Year	Number of Fish	Number of rod hours	Number of fish /rod hour	Pounds of fish per rod hour
1945	67	45	1.48	2.35
1946	136	42.5	3.2	6.8
1950	178	75	2.3	4.0
1951	257	82.75	3.1	5.98

G. H. Lawler

Appendix No. 5

THE IDENTIFICATION OF HEMING LAKE CISCOES,
AND PARASITISM WITH T. CRASSUS

In 1950 the Heming Lake ciscoes were tentatively identified as Leucichthys nigripinnis. Subsequent analysis revealed that although the totality of characters investigated supported this identification, some characters approached L. artedi. Heming Lake is a shallow, small lake and therefore from an ecological viewpoint these ciscoes differ from the Great Lakes nigripinnis which are considered to be deep water fish.

When both the morphometry and ecology of the Heming Lake ciscoes are considered it appears advisable to refer them to L. tullibee. The type locality of L. tullibee is Pine Island Lake, Saskatchewan, a shallow water lake, and Dymond (1943) has shown that the Pine Island Lake cisco more closely approximates nigripinnis than artedi.

Incidence of Triaenophorus infection

The number of parasites for each fish was recorded and ages were determined for the 1950 specimens. Of the 150 ciscoes taken in 1950, 60 per cent were one year old and lightly infected. The incidence of infection and the age of the 1950 ciscoes are shown in Table I. Complete age determinations for the 1951 specimens are not yet available. A positive correlation between the age of the fish and the number of cysts is evident from Table II, the mean number ranging from 0.12 for the one-year-old fish to 6.8 for the five-year-old fish. The mean number of cysts in the seven-year-old fish was 15, but only three fish were examined.

Table I. Triaenophorus infection and age of Heming Lake ciscoes, 1950. Figures in parentheses are number of specimens.

	Age in completed years							
	1	2	3	4	5	6	7	8
Mean No. of cysts	.13 (85)	2 (3)	2.5 (2)	4.05 (17)	6.9 (27)	5.5 (4)	15 (3)	4 (1)
Percentage ciscoes infected	12.9	66.6	100	94.1	96.3	100	100	100
No. of cysts per 100 pounds	120 (78)	377 (2)	-	545 (7)	862 (17)	478 (4)	1306 (2)	-
No. of cysts per 100 fish	12.9 (85)	200 (3)	250 (2)	405 (17)	692 (27)	550 (4)	1533 (3)	400 (1)

The 1951 sample of ciscoes showed a higher percentage of infection and almost twice the number of cysts as were recorded for 1950. A comparison of the infection in the years 1950, 1951 is presented in Table II.

Table II. Triaenophorus infection of Heming Lake ciscoes collected during 1950, 1951.

	1950	1951
No. of specimens	150	149
Percentage infected	44	75
No. of cysts	386	731
No. of cysts/fish	2.57	4.9
No. of cysts/infected fish	5.8	6.5
Greatest No. of cysts in one fish	37	20

The increased infection in 1951 may be the result of the following factors. From an analysis of the whitefish infestation the inference was made that there was a successful hatching and/or survival of T. crassus in 1950. Because infection increases with age and as there were not many older fish in 1950, the two years may not be comparable. Thirdly, the worms in the one-year-old fish do not appear to encyst till late in the summer consequently it is difficult to obtain an accurate cyst count when the worms are interlaced through several myomeres. The writer found during the summer of 1951 that only by dissecting out the worms and counting the scolices in a watch glass could any degree of accuracy be obtained. Most likely then the counts made on one-year-old fish in 1950 were too low.

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Appendix No. 6

THE WAPUN LAKE EXPERIMENT

Introduction

Eyed whitefish eggs were planted in Wapun Lake, Manitoba, to (1) study the effectiveness of such introduction in a lake formerly devoid of coregonines, (2) follow the rise and growth of a Triaenophorus population, (3) determine the effect transplantation to a new environment would have on the morphometrical characters of whitefish.

Description of Lake

Wapun Lake is situated in the Province of Manitoba at approximately 54° 51' N. latitude and 101° 11' W. longitude at an elevation of 1104 feet. The lake is three miles south of Heming

Lake and lies in the headwaters of the Grass River, a tributary of the Nelson River, which flows into Hudson Bay. Wapun Lake drains through a small creek, a small lake and another small creek into Heming Lake and is comparable to Heming both in depth and pH. The lake is C shaped having a length of approximately three miles and an area of 1.05 sq. miles.

Fish population

Gill-netting and shore poisoning showed the following species present: yellow pikeperch Stizostedion vitreum vitreum, pike Esox lucius, common sucker Catostomus commersonii, yellow perch Perca flavescens, burbot Lota lota, Miller's thumb Cottus cognatus, johnny darter Bolevsoma nigrum, spottail shiner Notropis hudsonius. No whitefish or ciscoes were captured during 1950 and 1951 and residents who had fished the lake previously found no evidence of a coregonine population.

Collection and Dispersion of eggs

The Manitoba Department of Mines and Resources, Game and Fisheries Branch, made possible the planting of eyed whitefish eggs in Wapun Lake. Eggs and milt were stripped from whitefish taken at Clearwater Lake, 14 miles northeast of The Pas, on October 26, 1950, and were flown to the Whiteshell hatchery at West Hawk Lake. The eggs were kept in jars in the hatchery until well advanced in the eyed stage. Approximately 950,000 eggs were collected and the loss during incubation was 100,000 eggs. On January 16, 1951, 850,000 eggs were flown by the Manitoba Government Air Service to The Pas and from there to Wapun Lake on January 17. Dr. K. H. Doan and the writer assisted Mr. C. H. Watson, hatchery supervisor, in the dispersal of the eggs. The holes in the ice had been previously prepared through the agency of the Game and Fisheries Branch.

Treatment of parent fish

The 97 parent fish, stripped of eggs and milt, were shipped to the Central Fisheries Research Station and placed in cold storage. As morphometrical measurements are used almost exclusively in the taxonomy of coregonine fish, 26 measurements and counts were made on the 97 parent fish so that when the eggs hatch and the fish grow to maturity we will be able to determine what effect the transplantation to a new environment will have on the morphometry.

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Appendix No. 7

AGE STUDIES OF HEMING LAKE WHITEFISH

During the years 1948, 1949 and 1950 scale samples were taken from 828 whitefish caught for infestation studies. Ages were determined for all fish. The average weight in ounces of these fish is shown in the following table.

Table. Average weight in ounces of Heming Lake whitefish. The figures in parentheses are the number of fish of each age in the samples.

Age	Year		
	1950	1949	1948
0+	- (1)	-	-
1+	1.45 (81)	-	-
2+	3.97 (9)	-	-
3+	9.5 (2)	-	-
4+	14.7 (51)	20 (2)	20 (18)
5+	22.7 (82)	23.8 (37)	25.3 (95)
6+	29.7 (116)	28.0 (88)	29.0 (77)
7+	34.1 (28)	31.3 (33)	32.7 (41)
8+	36.7 (7)	34.3 (10)	34.3 (20)
9+	- (1)	38.5 (8)	37.2 (14)
10+	-	-	46.0 (3)
11+	-	40 (1)	43.5 (2)
12+	-	-	50 (1)

The younger age groups do not appear for the years 1948, 1949 as the study was concerned only with infestation of whitefish of commercial size.

The growth rate appears relatively constant for the three year's data. The data indicate a fairly rapid though constant increase in weight during the first three years. In the fifth and sixth year the weight increased sharply, especially in the 1950 sample. Before estimating natural and fishing mortality it will be necessary to complete the age determinations back to 1945.

H. E. Welch

Appendix No. 8

TRIAENOPHORUS INVESTIGATIONS

IN THE THUNDER BAY DISTRICT, ONTARIO, IN 1951

Investigations in the summer of 1951 were restricted to Lake Nipigon and to Shakespeare Island Lake. Both of these lakes have received considerable biological attention in the past, but no investigations have been carried out in the last decade. A similar plan of investigation was followed this year as was outlined in the preceding report. (C.F.R.S. Ann. Rpt. 1950, Appendix No. 6). As before, the object was to study factors which affect the degree of infection of Triaienophorus in whitefish.

Shakespeare Island Lake, or Teapot Lake, as it is known locally, was found to have a very heavy infection. Likewise, the whitefish of Lake Nipigon were found to be heavily infected. A relatively small pike population was found in Shakespeare Island Lake. Pike studies on Lake Nipigon were confined to minor observations only. The whitefish of Shakespeare Island Lake, and especially the smaller fish, had a higher percentage of plankton

in their diet than had those caught in Lake Nipigon. No lake herring, Leucichthys sp., were caught in Shakespeare Island Lake, while five species of this fish were cut and examined from Lake Nipigon, in which waters they appear to be abundant.

Investigations were carried out by the author assisted by Mr. C. W. Douglas, Biologist with the Ontario Department of Lands and Forests. Salary, equipment, travel between Toronto and Lake Nipigon, and field expenses for myself were provided by the Fisheries Research Board of Canada. Transportation in the Nipigon area, movement of supplies and equipment, and boats and motors for operation on the lakes were provided by the Ontario Department of Lands and Forests.

Lake Nipigon, having an elevation of 852 feet, and an area of 1770 square miles, is 50 miles north of Lake Superior. The Nipigon River, dropping 250 feet in its 60 mile length, drains the lake via Lake Helen to Nipigon Bay on Lake Superior. Lake Nipigon is a deep lake, the greatest officially recorded depth being 402 feet. Shakespeare Island Lake is located on the south-east corner of Shakespeare Island proper, which is the largest island in the southern half of Lake Nipigon. The 81-acre lake has a level approximately 5 feet above that of Lake Nipigon and drains during the summer through a marshy slough into Lake Nipigon. However, there is evidence that the drainage does assume larger proportions during the spring freshet. The deepest sounding recorded for this lake is 45 feet, while a large area of the lake has an average depth of 30 feet. No irregularities were observed in either the temperature stratification or the pH of the lake. Identification of the plankton of this lake has not been completed.

Four hundred and forty-three whitefish from Shakespeare Island were examined. All of these fish were taken in experimental nets. Four hundred and seventy-nine whitefish from the sample area in Lake Nipigon were examined also. This sample area, south of Kelvin Island and north of Shakespeare Island was studied by sampling the commercial catch once a month. Table I shows the cyst distribution in these samples. Two sets of experimental nets were made in the sample area; the data for these catches are included with the Shakespeare Island Lake data in Table II.

The food habits of whitefish were investigated. Nine hundred and eighty-three stomachs were examined, 353 of these were from Shakespeare Island Lake, and the remaining 630 were from Lake Nipigon fish. A greater planktonic incidence was found in Shakespeare Island fish than in Nipigon fish; but, this could be attributed to the size preference in the sampling methods. The smaller Shakespeare Island whitefish were observed to have a greater planktonic incidence in their diet than is usually the case.

Infection in Shakespeare Island Lake is difficult to explain on the basis of the hypothesis that lake herring are necessary for the maintenance of infection in a lake. The occurrence of cysts in Shakespeare Island whitefish would seem to be explained by the pronounced planktonic diet of the smaller whitefish caught there, which fill the same ecological niche as the lake herring; and, by the close co-existence of the second intermediate host,

the whitefish, and the definitive host, the pike, and the resultant predation within a restricted volume of water. That lake herring are absent from this lake seems to be a logical assumption; in 121 net nights during the past summer no lake herring were caught. Hart (1932) does not list lake herring as a member of the lake fauna, and his investigations covered a period of several summers prior to the publication of his report. I consider it highly improbable that any lake herring could gain entrance to the lake even at the time of the spring floods. All Triaenophorus hosts are present in Lake Nipigon, and the infection here can be understood in terms of the hypothesis that lake herring must be present for Triaenophorus infection.

Table I. Cyst distribution in 4 samples of whitefish from the sample area in Lake Nipigon.

No. of cysts	No. of individuals			
	June 12	July 21	Aug. 11	Sept. 5
0	30	35	24	20
1	14	16	20	18
2	20	12	13	13
3	9	19	6	11
4	9	8	9	10
5	6	4	4	7
6	3	2	2	2
7	2	1	4	4
8	-	-	4	3
9	-	1	3	5
10	-	-	-	2
11-15	3	-	5	2
16-20	2	-	2	1
21-25	1	-	-	2
26-30	1	-	1	-
50	-	-	1	-
63	-	1	-	-
70	-	-	1	-
105	-	-	1	-
Depth (fathoms)	18-23	25-30	25-27	24-26
Cysts per 100 lbs.	184	148	358	221

Table II. Fish caught by experimental nets, 1951.

Date	Net nights	Whitefish	Lake herring	Burbot	Northern sucker	Pike	Perch
<u>Shakespeare Island Lake</u>							
June 21-28	88	361	-	-	-	4	1
Aug. 28-30	33	133	-	-	-	4	-
	121	494	-	-	-	8	1
<u>Lake Nipigon</u>							
Aug. 4-8	28	33	701	30	1	-	-
Sept. 11-13	30	37	1051	41	5	-	-
	58	70	1751	71	6	-	-

Literature cited

Hart, J. L. Statistics of the whitefish Coregonus clupeaformis population of Shakespeare Island Lake, Ontario. Univ. Tor. Stud., Biol. Ser. 42; Publ. Ont. Fish. Res. Lab. 42. 1932.

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Appendix No. 9

THE IDENTIFICATION OF A LAKE HERRING FROM LAKE MUSKEG, ONTARIO

A dwarf species of herring, hitherto unreported, was found in Lake Muskeg during the Triaenophorus investigations in 1950 (C.F.R.S. Ann. Rpt. 1950, App. 6). In identifying this fish the author has grouped the specimens and treated the 43 fish as one sample. In the author's opinion this is justified as all of the fish were taken within an area of one-half square mile and at a depth of 7 fathoms. This was the only location where lake herring were caught in this lake. The taxonomic procedure was then to identify the sample on the basis of the average and range of the measurements.

The 16 measurements and 4 counts were taken in accordance with the procedure outlined in Dymond, 1947. All measurements were recorded in millimetres. Generally the counts and ratios are based on 43 specimens, the exceptions being those instances where broken, damaged, or missing parts prevented accurate count and measurement.

Identification:

Key	Determination
Dymond 1926	<u>Leucichthys artedi</u> (Le Sueur)
Dymond 1947	<u>Leucichthys hoyi</u> (Gill)
Koelz 1931	<u>Leucichthys hoyi</u> (Gill) and <u>Leucichthys artedi</u> (Le Sueur)
Hubbs and Lagler 1947	<u>Leucichthys reighardi</u> <u>dymondi</u> Koelz

There is little agreement on the identification of the fish with these keys. Both L. hoyi and L. reighardi dymondi seem to be incorrect identifications since these fish are deep water forms, being taken in 30- and 60- fathom water respectively.

A reasonable identification would be a dwarf Leucichthys artedi (Le Sueur). L. artedi is the only lake herring which is commonly taken at shallow depths and in such Ontario lakes as Lake Muskeg. After examining the data Dr. W. B. Scott of the Royal Ontario Museum of Zoology agreed with the identification and has shown me other records of dwarf lake herring occurring in Ontario waters.

Table. Ratios and counts for the identification of Lake Muskeg herring.

	n	Statistical character		
		\bar{x}	$\pm 2S$	Range
Standard length-mm.	43	120.3	± 23.6	89-136
Gillraker count	26	41.4	± 4.2	35-45
Lateral line count	11	68.9	± 4.6	66-72
<u>Standard length</u> Head	43	4.09	$\pm .30$	3.70-4.50
<u>Standard length</u> Eye	43	14.2	± 2.16	12.0-16.0
<u>Head length</u> Eye	43	3.46	$\pm .62$	2.88-4.40
<u>Head length</u> Maxillary	42	3.03	$\pm .48$	2.70-3.78
<u>Head length</u> Interorbital	43	4.18	$\pm .68$	3.58-5.17
<u>Caudal peduncle length</u> Caudal peduncle depth	43	1.39	$\pm .34$	1.09-1.78
<u>Dorsal fin height</u> Dorsal fin base	43	1.48	$\pm .56$	1.17-1.93

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H. E. Welch

Appendix No. 10

IDENTIFICATION OF PLANKTON FROM LAKE ONAMAN AND LAKE MUSKEG, ONT.

The following lists are the identification of plankton collected during the summer of 1950 from Lake Onaman and Lake Muskeg. These identifications had not been made at the time of last year's annual report (1950, Appendix No. 6).

In the identification of the plankton, the author is greatly indebted to Mr. Alan McCombie of the University of Toronto for his kind assistance in the identification of forms.

Lake Onaman

Early and mid-July

Phytoplankton

Cyanophyceae - Blue-green algae

Coelosphaerium Nageli

Microcystis Kutzing

Gloeotrichia J. G. Agardh

Eucapsis Clements and Shantz

Anabaena flos-aquae (Lyngb.) Brebisson

Nodularia Mertens

Bacillarieae - Diatoms

Asterionella formosa Hassall

Tabellaria fenestrata Kutzing

Diatoma elongatum Agardh

Chlorophyceae - Green algae

Spondylosium Archer

Staurostrum sp. Lundell

Arthrodesmus Ehrenberg

Pediastrum Meyen

Dinophyceae

Ceratium hirundinella Muller

Chrysophyceae

Dinobryon Ehrenberg

Synura Ehrenberg

Zooplankton

Protozoa

Epistylis Ehrenberg 1830

Rotifera

Nothalca longispina Kellicott

Keratella (Anurea) cochlearis Gosse

(Rattulus) Trichocerca

Polyarthra trigla Ehrenberg

Copepoda

Diaptomus sp.

Cyclops bicuspidatus Claus 1857

Nauplius

Cladocera

- Holopedium gibberum Zaddach 1855
Daphnia longispina (O. F. Muller) 1785
Bosmina sp. Baird 1845

Lake Muskeg

Sampling late July and early August

Phytoplankton

Cyanophyceae - Blue-green algae

- Coelosphaerium Nageli
Nodularia Mertens 1822
Anabaena spiroides Klebahn
Chroococcus Nageli 1849

Bacillarieae - Diatoms

- Asterionella formosa Hassall
Tabellaria fenestrata Kutzing
Tabellaria flocculosa (Roth) Kutzing
Diatoma elongatum Agardh
Melosira granulata (Ehr.) Ralfs.
Stephanodiscus Ehrenberg
Fragillaria crotonensis Kitton
Fragillaria capucina Desmaz.

Chlorophyceae - Green algae

- Pediastrum Meyen
Staurostrum Lundell

Dinophyceae

- Ceratium hirundinella Muller 1786

Chrysophyceae

- Mallomonas caudata Conrad

Zooplankton

Protozoa

Rotifera

- Notholca longispina Kellicott
Conochilus unicornis Rousselet
Polyarthra trigla Ehrenberg
Keratella cochlearis Gosse

Copepoda

- Diaptomus sp.
Cyclops sp.
 Nauplius

Cladocera

- Daphnia longispina (O. F. Muller) 1785
Bosmina sp. Baird 1845

THE NET PLANKTON OF NESSLIN LAKE, SASK.

Nesslin Lake is situated 13 miles northeast of the town of Big River, Sask., just outside the west boundary of Prince Albert National Park. An investigation was conducted jointly by the Saskatchewan Department of Natural Resources and Industrial Development, and the Central Fisheries Research Station into the feasibility of reducing the infection of whitefish by the tapeworm T. crassus by conducting heavy fishing for cisco or tullibee. It was soon discovered in 1949 that, while the whitefish were heavily infected, tullibee were absent (C.F.R.S. Ann. Rpt. 1949, Appendix 2). The following year ecological studies were continued to determine the relationship between whitefish, pike, plankton and Triaenophorus in the absence of tullibee (C.F.R.S. Ann. Rpt. 1950, Appendix No. 4). Weekly or bi-weekly plankton samples were taken with a Wisconsin type plankton net, from May 22 to August 26, 1950. A detailed report on the plankton analyses was completed during the present year by Mr. Hazen, and the manuscript is on file at the Station.

Organisms were counted, but in order to make the results comparable with those from other lakes the dry weights and organic weights were calculated on a basis of area and volume. The average dry weight was 53.9 kg./ha. or 175.6 mg./m³., while the weight of organic matter was 101.6 mg./m³. Nesslin Lake had its richest supply of plankton during the month of June, with a second slighter pulse in the latter half of July. Adult T. crassus were found to be ripe as late as June 13 when eggs were observed hatching into coracidia. These latter would be available to Cyclops bicuspidatus, which genus was numerically increasing at that time just prior to its peak on June 24 when the lake contained an average of 7.1 Cyclops per liter of water.

Comparisons were made between the plankton crop of Nesslin Lake and those of six alpine lakes and Lake Wasquesieu, Lake Athabasca and Great Slave Lake. The plankton of Nesslin Lake closely resembles Paul Lake, B. C. Although Wasquesieu is separated by only 15 miles from Nesslin, it is much richer than the latter, indicating, perhaps, some greater tendencies to eutrophy. The other lakes are much leaner in plankton, and might be considered oligotrophic in this regard. The moderately rich plankton in Nesslin Lake is ample for sport, and even small commercial populations of fish. Nesslin Lake is too small (2.3 sq. miles) to withstand a great amount of fishing, but it is important to the mink rancher who uses fish as a main item of diet for his animals.

(Note. Mr. Hazen worked under the direction of Dr. D. S. Rawson. This appendix was prepared by K. H. Doan from a report submitted by Mr. Hazen).

M. L. Libin.Appendix No. 12OBSERVATIONS ON THE EFFECT OF PITUITARY SUSPENSIONS
AND EXTRACTS ON T. CRASSUS AND ITS HOST, E. LUCIUS

Pituitary suspensions and extracts were injected into live pike with the objective of causing maturation of the pike's sexual products in the hope that tapeworms of the species Triaenophorus crassus, harboured in the pike's intestinal tracts, would also mature and produce ripe eggs. The latter were needed as experimental material in a search for a chemical poison effective against the tapeworm eggs and coracidia. The research has been conducted co-operatively between the Alberta Fisheries Branch and this Station. Progress reports on the work appeared in the Central Station's annual report for 1949 (Appendix No. 3) and in the report for 1950 (Appendix No. 2, 3). A complete detailed report was placed on file at the Station in the form of a M.Sc. thesis (University of Alberta).

Although viable cestode eggs were not obtained, considerable data were recorded regarding the effects of pituitary (from pike and frogs) upon pike and upon the tapeworm. A high rate of mortality among the pike was experienced with the early experiments but was overcome by using fish taken from the nets at frequent intervals, and by using lake and river water rather than that supplied by Edmonton city. Suspensions of pituitary were less suitable for injection than extracts, and small doses of the latter at two- or three-day intervals were more effective than large single doses.

Loss of colour was the first noticeable change following injection, but as soon as 4 days, viable spermatozoa were produced in male pike, although no advancement could be detected in injected female pike. Histological examination was made of the testes. The injections caused the tapeworms to become more mature than those in untreated pike, and the nearer the dates of injection to the natural spawning period the easier it was to advance the sex organs of both the fish and the tapeworm. Some worms were advanced to the stage where they released their undeveloped eggs upon contact with water. Although these eggs did not live, they contained well formed onchospheres. This difficulty in hatching might be overcome in future experiments by giving smaller dosages of pituitary extract and increasing the time intervals between injections.

J. J. KeleherAppendix No. 13

SPAWNING STUDIES AND THEIR RELATION TO CISCO SYSTEMATICS

Investigation of the breeding activities of Lake Winnipeg ciscoes is a new development in the program of the Central Station. This study's connection to cisco systematics in Western Canada and to Triaenophorus crassus research is indicated in this appendix.

During the early Forties research was renewed on the tapeworm T. crassus. After the life history in Western Canada became known, detailed work on the relationship of the various hosts to the parasite became desirable. Observations, mainly by Professor R. A. Wardle in the Thirties, and later by Dr. R. B. Miller, suggested that differential infection of the various species of ciscoes might exist. The systematics of the ciscoes occurring in Prairie Provinces was established in the Thirties but subsequent work, in eastern North America particularly, made the validity of these species questionable. This uncertainty should be resolved before further studies of T. crassus infection of ciscoes are continued.

Because Lake Winnipeg contained almost all species found in Western Canada, it was naturally first chosen for investigation. Since the summer of 1947, morphometrical and meristic measurements have been collected from 1600 Lake Winnipeg ciscoes. Specific identifications were made with the aid of taxonomic keys but it was impossible to distinguish and separate the various species on their general facies. The Great Lakes species of Leucichthys are recognizable on sight (Dr. R. Hile, personal communication). Preliminary analysis of the Lake Winnipeg data showed the species to be morphometrically very similar. Differences in morphometry of the species apparently were formulated from comparisons of a few specimens; when a large series is analyzed intraspecific variation overlaps interspecific differences. Although the above method is useful, it cannot force either a repudiation of the present systematics or its revision. When present taxonomic keys are applied to identify species, then comparison of the morphometry of these groups can never lead to an acceptance or rejection of the validity of species. This procedure is the logic of the vicious circle.

Another approach to the problem was attempted. Accepting present species, a study was made of their biological characteristics. The various species exhibited differences in the curve of growth and T. crassus infection. The design of the experiment was imperfect because any findings could only support, not refute the present taxonomy.

What criterion is available to judge the validity of Lake Winnipeg Leucichthys species? Most present day systematists use a biological species definition.

"Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups."
Mayr. 1940.

If present species can be shown to usually interbreed in nature, then the specific status of these species must be rejected.

Practical difficulties arise when the breeding activities are examined. Actual observations of breeding have been made in other species of fish--pikeperch, black bass and speckled trout--but are unlikely in the Lake Winnipeg ciscoes. Spawning takes

place in the deeper parts of the lake and the ice cover further hinders scrutiny. Information regarding spawning groups must come from specimens collected by fishing gear and therefore is more liable to be incorrect because of man's intervention. Is it possible to discover when a cisco is breeding? The author would consider a fish to be spawning if it liberates its sexual products on being removed alive from gill-nets. One difficulty is apparent. Individuals in spawning condition may be moving to an area where they will spawn. An example of fish moving amongst spawning areas is reported by Miller (1948). Capture by a gill-net may cause a stimulation which forces them to release their eggs or milt. The investigator may decide that they were spawning in the location of the gill-nets when they became enmeshed, whereas in fact they may have been only moving towards other areas.

Several conclusions have been reached regarding the writer's investigation into the systematics of the Lake Winnipeg ciscoes. Present species are not recognizable by spot characters. The morphometry of these species is not as distinct as previously believed. Investigation of spawning is the best approach to testing the validity of the present systematics.

Literature cited

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- Miller, R. B. A note on the movement of the pike, Esox lucius. Copeia No. 1: 62. 1948.

J. J. Keleher

Appendix No. 14

SPAWNING STUDY OF LAKE WINNIPEG CISCOES

To date (October 31, 1951) three different localities have been sampled in a study of the spawning activities of the Lake Winnipeg ciscoes. Interim findings are given under the appropriate locality headings.

Matheson Island, 1948

The Central Station received its first sample of ciscoes collected during the breeding season from a local resident of Matheson Island. The proportion of various species present in the sample more closely resembled the Doghead than the Mukatawa River collection. Since no information regarding the taking of these ciscoes was available, the extent to which the fish are representative of spawning groups in this area is not known. This sample was of value in that additional data on the morphometry of the ciscoes were obtained and it was realized that more precise collecting of ciscoes during the spawning season should be attempted.

Mukatawa River, 1949

Seventy-eight ciscoes were collected after the formation of the ice cover from November 22-28. Mr. E. Valiquette, the local resident who obtained the specimens, believed spawning had been completed. Examination of the gonads supported this view as only one of the 38 females had mature eggs in the abdominal cavity. Although this sample does not represent fish captured during the act of breeding, the writer believes it is representative of the fish which had spawned in the Mukatawa River area during 1949.

The sample consisted of 4 L. zenithicus, 38 L. nigripinnis, 29 L. tullibee and 7 specimens referable to either nigripinnis or tullibee. No specimens of L. nipigon were present. Percentage composition by species is: zenithicus 5, nigripinnis 49, tullibee 37, nipigon 0. On a percentage basis, tullibee is more abundant and zenithicus and nipigon are fewer than in the samples made at Doghead and Matheson Island. Spawning groups of ciscoes, therefore, appear different for the north and central portions of Lake Winnipeg.

Doghead, 1950

This locality in the Lake Winnipeg "Narrows" was the first place visited by the author in the breeding investigation of the ciscoes. Ciscoes collected from November 4-16 were not considered to be spawning but two spent females were taken on November 14. "Freeze-up" occurred on the 19th and specimens were collected from November 22-28 by nets set under the ice. Approximately 40 per cent of the cisco catch was spawning during this interval. The date of completion of spawning was not determined.

A most interesting fact relating to the validity of the specific status of the Lake Winnipeg ciscoes was discovered. Identification of spawning specimens revealed that different species of Leucichthys were spawning at the same time and place. Examination of the table shows that, in the author's opinion, different species were spawning together. Mixing of the species was not complete for there appears to be a difference in the proportion of zenithicus and nipigon in the two depths sampled.

Table. Numbers and percentages (in parentheses) of spawning Leucichthys collected at Doghead, November 22-28, 1950.

Depth of set, feet	Species			Totals
	<u>zenithicus</u>	<u>nigripinnis</u>	<u>nipigon</u>	
15-17	45 (62)	10 (14)	17 (24)	72 (100)
39-42	31 (13)	56 (23)	157 (64)	244 (100)

CISCO RESEARCH DURING SUMMER OF 1951

The operational area for the cisco project was considerably increased by the acquisition of a 20-foot yawl and outboard engine which enabled field work to be carried out in the northern, central and southern portions of Lake Winnipeg.

Ciscoes under 100 mm. in standard length have not been taken by gill-nets. Other methods of collecting were attempted. A small mesh net was attached to the bottom of the heart of the trapnet (see Appendix No. 28) but no small ciscoes were obtained. Seining was more successful. Two 2-inch gill-nets were used as wings on a 20-foot minnow seine. It was usually set about 35 yards out and parallel to the shore in 6 feet of water. One-half hour later it was hauled in by ropes attached to the outside ends of the wings. Small ciscoes are obtainable by seining but this should be done as early as possible after the ice break-up in the spring.

From July 6-29 field work was undertaken from Black Bear Island. Three sizes of gill-nets, 1½-, 2-, and 3-inch stretched mesh, were set on the bottom at depths ranging from 12 to 78 feet and lifted every day. With a fishing effort equivalent to 1250 yards, 21 ciscoes were collected. This is poor availability. Ciscoes spawning around Matheson Island and the Narrows at the time of freeze-up are presumed to have migrated from the north. Since few ciscoes were collected in these areas in July this hypothesis appears strengthened.

The southern portion of Lake Winnipeg was investigated during August. Data on the morphometry and T. crassus infection of ciscoes in the area near Victoria Beach were obtained. Specific identification of 594 ciscoes revealed 228 L. zenithicus, 365 L. nigripinnis and 1 L. tullibee.

The cisco population at this locality appears to differ from the population in northern Lake Winnipeg which was sampled in the vicinity of Mukatawa River during 1947-49. In the northern areas zenithicus is the dominant species, whereas nigripinnis is the most numerous in the south end. L. nipigon was entirely absent in the samples collected at Victoria Beach but was the second most prevalent species in the north.

T. crassus infection may differ in the north and south portions of the lake. The mean number of cysts per fish for Mukatawa River zenithicus was 1.5 while the Victoria Beach average was 3.1 for 141 specimens. The average for 118 nigripinnis from Mukatawa River was 2.6 cysts per fish while 273 specimens from Victoria Beach had an average infection of 3.2 cysts per fish. These differences may be not significant statistically, and it is also realized that the samples are composed of different year classes.

SOME MERISTIC CHARACTERS OF LAKE WINNIPEG CISCOES

Five meristic characters of Lake Winnipeg ciscoes, Leucichthys zenithicus, L. nigripinnis and L. nipigon were compared. Another species, L. tullibee was omitted because of scarcity of data. Analysis of intraspecific factors such as age groups, year classes and location was not attempted. Comparison of interspecific differences of the mean and variance of each character was made by the "t" test.

With respect to the means, the three species did not differ in the total number of vertebrae or dorsal rays. All species differed in average number of branchiostegal rays and abdominal vertebrae. L. zenithicus had a different average number of anal rays from nigripinnis and nipigon.

Homogeneous variance for each species in the total number of vertebrae, branchiostegal and anal rays was observed. In both dorsal rays and abdominal vertebrae the three species lacked a common variance.

Differences of certain meristic characters among Lake Winnipeg ciscoes are so slight that these characters cannot be used in identification. They appear to be taxonomic characters but are of no diagnostic value.

Table. Statistics of meristic characters of Lake Winnipeg ciscoes, Leucichthys.

	No. of specimens	Range	Mean	Variance
Dorsal Fin Rays				
<u>zenithicus</u>	504	8-13	10.40	.621
<u>nigripinnis</u>	164	9-15	10.96	.624
<u>nipigon</u>	181	9-12	10.75	.432
Anal Fin Rays				
<u>zenithicus</u>	504	9-14	11.81	.538
<u>nigripinnis</u>	164	9-14	11.99	.669
<u>nipigon</u>	181	11-14	12.05	.470
Branchiostegal Rays				
<u>zenithicus</u>	503	6-10	8.33	.461
<u>nigripinnis</u>	163	6-11	8.64	.490
<u>nipigon</u>	181	6-10	8.94	.368
Total Vertebrae				
<u>zenithicus</u>	500	51-61	57.63	1.882
<u>nigripinnis</u>	162	51-62	57.64	3.321
<u>nipigon</u>	180	53-61	57.69	2.504
Abdominal Vertebrae				
<u>zenithicus</u>	499	25-35	31.00	1.466
<u>nigripinnis</u>	162	26-34	30.59	2.107
<u>nipigon</u>	180	25-33	30.83	1.830

EXPERIMENTAL FISHING FOR TULLIBEE AT ROCKY LAKE, MAN.

Sir John Richardson described a fish in 1836 which he called Salmo tullibee, and which he collected at Pine Island Lake during the winter of 1819-20. The description was inadequate and the specimens are not now extant. The lake, now called Cumberland Lake, has changed greatly owing to extensive silting having been caused by a break-through of the Saskatchewan River, and tullibee are now exceedingly scarce there (see C.F.R.S. Ann. Rpt. 1946, Appendix No. 2). Awareness of the taxonomic need to relocate a population of Richardson's tullibee, which he said was prevalent throughout the fur country, led to an interest in Rocky Lake.

The presence of a cisco in Rocky Lake identified as Leucichthys nigripinnis was noted by Mr. W. McTavish (1950). Interest was heightened by local reports that tullibee of large size lived in Rocky Lake. An adequate sample of these fish would be a valuable contribution towards the solution of the western Leucichthys problem.

Rocky Lake is 29 miles north of The Pas and lies in limestone rock a few miles south of the Precambrian Shield. McTavish reported that depths did not exceed 25 feet. Fishing was conducted by G. H. Lawler, J. J. Keleher and K. H. Doan from October 13 to 21, 1951. Stormy weather and the imminent approach of freeze-up prevented netting except in the east end of the lake, and areas of reportedly greater cisco abundance could not be reached.

Ten gill-nets, each approximately 50 yards in length and ranging in size from $1\frac{1}{2}$ - to $5\frac{1}{2}$ -inch stretched mesh were used in obtaining fish. Ciscoes were tagged with an aluminum identification marker and delivered to The Pas to be quick frozen. The frozen fish were placed in a locker in Winnipeg and complete taxonomic measurements will be made during the winter. The daily catch of the various species is shown in Table I.

Table I. Unit of effort and total catch of fish at Rocky Lake, Manitoba.

Date	Number of net nights	Number of each species captured						
		Pike	Pike-perch	Suckers	Burbot	Cisco	White-fish	Perch
Oct. 14	10	72	56	19	5	13	-	-
" 15	10	82	29	26	4	3	3	2
" 16	10	152	53	7	1	7	-	-
" 17	5	29	20	12	4	6	-	-
" 20	4	68	3	1	-	2	-	-
" 21	16	122	8	17	6	29	3	-
Totals	55	525	169	82	20	60	6	2

The total number of fish of all species was 867. This represents an average of 15.6 fish per net per night, indicating fair availability. Pike were most easily caught, averaging 9.5 fish per net night, 20.2 inches in fork length and 2.15 pounds in weight. The pikeperch averaged 16.41 inches in length and 2.0 pounds in weight. An estimated 1782 pounds of fish were removed from Rocky Lake during the 8 day period.

Table II. Estimated poundage of all species taken at Rocky Lake, and percentage of each species.

Species	Estimated weight	Percentage of total catch
Pike	1128 pounds	60.5
Pikeperch	338 "	19.5
Suckers	205 "	9.4
Burbot	45 "	2.3
Cisco	48 "	6.9
Whitefish	18 "	.7
Perch	-	.2

Pike were dominant in the catch. The local residents claimed that the fish were running at this time of the year. This is quite feasible as Table I shows how the catch of pikeperch was highest the first few days of netting and then there was a sharp decrease, yet the nets remained in relatively the same localities. Many of the pike stomachs examined contained ciscoes ranging up to 12 inches in length. The pikeperch stomachs contained large numbers of nine-spined sticklebacks and small perch.

Literature cited

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A REVIEW OF THE GREAT SLAVE LAKE STUDIES

In April 1951 the Department of Fisheries requested an opinion on whether Great Slave Lake is being over-fished, based on the latest evidence. A careful review was, therefore, made of the data collected since 1944, which forms the basis for the following conclusions:

1. The amount of commercial fishing done on Great Slave Lake is insignificant when compared with some lakes. For instance the total annual fishing effort exerted in Great Slave Lake is less than one per cent of that exerted in Lake Erie.

2. Analysis of the results of tagging and recovery show that commercial fish tend to remain in one place. Lake trout moved an average of 23 miles in approximately one year and whitefish moved an average of 8 miles. It is, therefore, possible to have local over-fishing without general over-fishing.

3. There has been no clear-cut decrease in catch per unit of effort either locally or generally since commercial fishing began in 1945. In Great Slave Lake catch per unit of effort fluctuates erratically to such an extent that it cannot be considered as a delicate index of the effect of fishing on the commercial fish populations.

4. There has been no clear-cut decrease either locally or generally in the average size of fish caught since commercial fishing began. It is obvious that when a virgin fish population is reduced in numbers, by a fishery with gill-nets of a fixed mesh size, then that fishery will have to depend more and more on fish which have just become big enough to be caught. The rate of change in average size of fish in an exploited population, therefore, seems to be a good index of the rate at which the number of fish in the population is changing, and in the case of Great Slave Lake it is considered to be the best index now available.

5. There has been no obvious increase either locally or generally in growth rate since commercial fishing began. On the basis of experience elsewhere a likely result of reducing the number of commercial fish present would be an increase in rate of growth.

6. There has been no obvious increase either locally or generally in mortality rate since commercial fishing began. Natural mortality rate plus fishing mortality rate now is not appreciably different from the natural mortality rate alone, which prevailed previous to exploitation.

7. Because, as far as can be ascertained, there has been no decrease in catch per unit of effort, no decrease in average size of fish caught, no increase in growth rate and no increase in mortality rate, it is obvious that, far from being over-fished, the Great Slave Lake fish populations fail to show any detectable effects from the commercial fishery.

R. R. WheatonAppendix No. 19

GREAT SLAVE LAKE COMMERCIAL FISHERIES STUDY, SUMMER 1950

No significant difference in the average size of lake trout and whitefish was observed. This was reported in more detail in the Annual Report of 1950.

Double the number of rough fish were reported caught in the summer of 1950 than in the previous high year of 1949. This great increase was in the Hay River area where fishing was done in shallower water than usual and where large numbers of rough fish are to be encountered.

During the summer of 1950 fewer lake trout than whitefish were taken. This is due in part to the gradually growing Hay River summer fishery, where the availability of lake trout is much lower, than on the grounds fished by the Gros Cap fishery. In addition the availability of lake trout in Areas A and D showed a drop. These areas have borne a large proportion of the Hay River fishery in the past. This suggests the possibility that too large a proportion of the fishing has been done in the vicinity of Hay River, although other indices of the effects on the fish population fail to confirm this. To guard against any possibility of local depletion the Department of Fisheries has changed the boundary lines between fishing areas and has established new quotas.

R. R. WheatonAppendix No. 20

GREAT SLAVE LAKE COMMERCIAL FISHERIES STUDY, WINTER 1950-51

During December and the first part of January fishing was concentrated in Areas E and F. Unfortunately, we arrived too late to observe operations in these two areas. However, weight samples were taken from Areas A, D and L, where the fishing was done for the remainder of the season. The average size of whitefish in each area was very near the average size for the winter of 1949-50. Area L had never been winter fished before and the whitefish showed a slightly smaller average size than those caught during the summer of 1950. Lake trout samples were small and difficult to obtain. Area L samples of lake trout, sufficiently large enough, show no difference in average size from the summer of 1950.

Availability of lake trout in Areas A and D was lower than the winter of 1949-50. The catch per net of whitefish was higher. In Area D the availability was the highest recorded for the previous winter and two previous summers. Excellent fishing was found in this area especially during March at which time ninety per cent of the fishermen were found here.

W. A. KennedyAppendix No. 21

GREAT SLAVE LAKE COMMERCIAL FISHERIES STUDY, SUMMER 1951

The study of the commercial fisheries of Great Slave Lake, which was initiated in 1946 was continued during the summer fishing season 1951. The study was not as thorough as it was planned to be, because, the research boat "Limnos" was lost by fire, R. M. Hanson was hospitalized for burns, and R. R. Wheaton was hospitalized for typhoid.

Since the data are only partially analysed, no conclusions are as yet available.

W. A. KennedyAppendix No. 22THE RELATIONSHIP OF FISHING EFFORT BY GILL-NETS
TO THE INTERVAL BETWEEN LIFTS

On the average a gill-net which is lifted after two days catches noticeably less than twice as much fish as one net which is lifted after one day. Apparently the fish which are caught the first day decrease the efficiency of the net during the second day.

During the course of the studies on Great Slave Lake in 1946, 1947, and 1948, 151 clear-cut cases were noted where average availability (catch per net) in a group of nets (an average of 2,250 yards per group) that were lifted after two days could be compared with average availability in the same nets when lifted by the same fisherman on the same grounds after one day, and where the one-day lift was either immediately before or immediately after the two-day lift.

For each of the six more or less distinct fishing grounds represented, the average availability for one-day and two-day lifts was found. These averages when plotted on a graph indicated a definite relationship between the two availabilities. The relationship seemed to depend only on total weight of fish and to be independent of the proportion of the various species and of the average size of individual fish.

The graph indicated that the greater the catch that can be made in nets that are lifted daily, the more will the catch that can be made in nets that are lifted every two days depart from the "expected" value of twice the daily catch. In the fishery in question, when approximately 250 pounds of fish are caught per 100 yards of gill-net the net becomes "saturated" and will not catch any more fish. It is possible to "supersaturate" a net under some conditions in which case the amount of fish will probably decrease as time goes on.

By considering the relationship between one-day and two-day availabilities, and other factors, an approximate relationship between availabilities for nets lifted daily and nets lifted every three days, every four days, every five days etc. were determined.

From these relationships factors have been calculated which are used to make all Great Slave Lake availabilities comparable, regardless of the interval between lifts.

W. A. Kennedy

Appendix No. 23

AGE STUDIES ON LAKE TROUT AND WHITEFISH FROM GREAT SLAVE LAKE

All of the lake trout and whitefish scales collected from Great Slave Lake during the years 1944-1949 inclusive for age studies have now been read. Analyses of these data are only partially completed, and most of such as are completed have been shown in previous Annual Reports.

We have been designating fish on which there are, say, 10 annuli as "10+" years old since there is generally a space between the tenth annulus and the outside of the scale which represents growth during the current growing season. It is apparent from Appendix No. 24 that in a fish taken in early July with 10 annuli plus marginal growth--which would be designated as a 10+ fish in the nomenclature used to date--the marginal growth represents a full year's growth and that such a fish is essentially exactly 11 years old. We intend to designate such a fish as "11" in the future and to group it with the 11+ fish when analysing the data. An age 11 fish in early July will of course become an age 11+ fish within a few days, just as soon as it begins to grow and shows another annulus at the edge.

This change in nomenclature will call for a re-examination of those scales taken at the critical time when some fish have begun to grow while others have not as yet. Until it is completed further analyses of these data would be futile. The necessary adjustments are not expected to appreciably change either results as shown in previous Annual Reports or any of the conclusions previously reached on the basis of age studies.

W. A. Kennedy

Appendix No. 24

THE GROWING SEASONS OF WHITEFISH IN GREAT SLAVE LAKE AND LAKE WINNIPEG

Great Slave Lake and Lake Winnipeg produce approximately one-half of all the whitefish produced in Canada. As an essential part of the age studies now being made on these whitefish, the question of what proportion of the total annual growth is made during each part of the year is being investigated.

The problem is being approached as follows:

Groups of whitefish scales are selected from all those at hand (which represent randomly chosen samples). Each group selected represents whitefish caught on a single day at one place, and the groups selected are such that they represent fish taken at approximately ten-day intervals throughout the season. There is no

selection otherwise so that they can be considered to be a random sample of all the fish at the place sampled.

A magnified image of the scale is projected as for scale reading, and a straight-edge is laid along the dorsoventral diameter of the magnified image. Along this straight edge the distance from the outer edge of the scale to the outermost annulus is measured, also the distance from the outermost annulus to the one next inside it, and also the distance from the latter to the one next inside it. If the usual assumption that the distance between annuli is proportional to the amount of growth made (in this case it is the growth in girth, but for the size of fish considered this is approximately proportional to either growth in length or growth in weight) during the corresponding year is correct, then these measurements are respectively proportional to the amount of growth made during the current year, the amount made last year, and the amount made the year before.

The percentage that the "current year's growth" is of "last year's growth" is next calculated as is the proportion that "last year's growth" is of "the year before last's growth". The average of all the former percentages for fish caught on a single day represents approximately the average percentage of a year's growth that the group of fish have made by that time. The average of all the latter percentages is a "control", and if it departs by much from a value of 100 per cent, then the average of the former percentages must be adjusted accordingly.

To date a few groups of whitefish scales from the vicinity of Gros Cap on Great Slave Lake have been treated in this way, and it appears that there is no appreciable growth until about mid-July when the average fish begins to grow rapidly so that by early August it has done about one-half of all its growing for the year, and by the end of August it has done about 90 per cent. By extrapolation it would appear that growth stops some time in September and that the fish then remain the same size until the following July. These remarks apply particularly to fish of commercial size. There is some indication that fish less than five years old have a slightly longer growing season. The question of differences between growing seasons in different parts of the lake has not yet been examined.

A few observations on whitefish scales from Lake Winnipeg indicate that whitefish begin growing at least a month sooner than those from Great Slave Lake.

L. C. Hewson

Appendix No. 25

THE LAKE WINNIPEG FISHERY INVESTIGATION, WINTER 1950-51

Early in January 1951 an investigation of the Lake Winnipeg winter fishery was started, and continued through February. For the first time, a Bombardier snowmobile was made available for use in the investigation on the frozen lake. Whereas the 1950 winter study was confined to a few shore stations on the southern part of the lake, during the 1951 investigation it was possible to cover

the entire sauger fishery area throughout its length of approximately 120 miles.

For study purposes, the fishery area was divided into 4 adjoining sections, each of which was visited at least once at two-week intervals through the two-month study period. Within each section, randomly selected fishermen were visited upon the ice while they were actually engaged in lifting their gill-nets. The fishermen were interviewed regarding the length, depth, material and mesh size of their nets, as well as the interval between lifts. The total number of nets lifted for the day, together with the weight of the various species of fish taken, was recorded. Nets were selected at random and the weights of the individuals of the various species of fish appearing in the catch were recorded. The dominant species in all sections were sauger and pikeperch. An attempt was made to record the weight of at least 500 individuals of these two species in each section during each two-week interval. In two sections this was frequently possible. Other pertinent data were recorded some of which were of an incidental nature.

A complete description of the general aspects of the winter fishery forms part of a manuscript report which deals with the other Lake Winnipeg fisheries in the same connection. The scientific data are being treated along the same lines as the summer commercial fishery studies of Great Slave Lake and Lake Winnipeg. Although considerable progress has been made conclusions have yet to be drawn.

L. C. Hewson

Appendix No. 26

THE LAKE WINNIPEG FISHERY INVESTIGATION, SUMMER 1951

The 1951 summer fishery investigation, June 7 to July 30, was a continuation of the 1950 program. At the regular check station at Big Black River, individual catch record cards were kept for each fisherman in the whitefish fishery. On these cards, the number of nets lifted each day and the weight of fish caught were recorded together with the locality of the lift, depth of water, type of bottom, and other details. The catches were sampled at random for weights of individual fish of various species.

Scale sampling for age determination of the whitefish catches was an important feature of the investigation. Scale samples were taken from 1000 of the whitefish from the catches at Loon Straits where a short fishing season for pikeperch is permitted. This fishery opens the same day as the whitefish fishery further north. In addition to the scale sampling a census of the fishery was kept in the same manner as at the whitefish fishery check station at Big Black River, which lies 120 miles north of Loon Straits.

At Big Black River, two series of scale samples of 1000 each, were taken from whitefish at a sampling point there. One series was taken early in the season and the other just before the

close. At Warren's Landing about 50 miles north of Big Black River, one series of 1000 scale samples was taken from the whitefish catches there, about mid-season. No catch census was attempted at this point.

Census data collected during the 1951 investigation are not yet analysed, nor are the scales read.

L. C. Hewson

Appendix No. 27

LAKE WINNIPEG EXPERIMENTAL FISHING

The experimental fishing program was designed to supplement the regular commercial fishery study at a time when the fishery is closed. The program began August 6 and continued until August 31. An attempt was made to work as closely as possible in co-operation with the party engaged in cisco research which has a direct bearing on the Triaenophorus problem.

The fishing was done with 2 gangs of gill-nets which were fished on alternate days. One gang contained 50 yards each of 1½-, 2-, 3-, 4- and 5-inch mesh. The other gang was similar, but contained 50 yards of 5½-inch mesh in addition to the other mesh sizes. The 3-inch net in this gang was approximately 100 yards long. A total of 15 sets were made in various depths at various places in the southern part of the lake through a distance of about 60 miles. Because of the presence of suitable harbours most of the sets were made near the east shore.

The catches were recorded by meshes. Individual fish were weighed, their sex recorded and an examination made of the stomach contents. The whitefish were examined for Triaenophorus and some other fish preserved for later study. The species of fish which appear also in commercial catches were dressed and weighed again in order to determine a conversion factor between round weight and dressed weight for use in the commercial fishery study. Conversion factors for 6 species have been determined, but no further study of these data has yet been made. Conversion figures are given below:

Species	Round weight = dressed weight X	Round weight = dressed headless weight X
Pikeperch	1.196	1.552
Drum	-	1.634
Sauger	-	1.516
Pike	-	1.534
Whitefish	1.186	-
Cisco	1.107	-

W. A. KennedyAppendix No. 28

THE TRAP-NET EXPERIMENT, 1951

The Lake Erie Ohio type trap-net was fished again in June and early July of 1951 in the vicinity of Big Black River, Lake Winnipeg. It caught reasonable quantities of fish, particularly burbot, but failed to catch many tullibee, although a few were taken each day. Further tests are planned, although it now seems unlikely that this gear will be outstandingly useful for controlling T. crassus by reducing the number of tullibeas in a lake.

Because the fish were at hand, 103 yellow pikeperch, 84 saugers and 14 yellow perch were tagged and released alive. Twenty-seven of the tags have been recovered to date, mostly from the vicinity of the tagging site.

L. C. HewsonAppendix No. 29A COMPARISON OF NYLON AND COTTON GILL-NETS
USED IN THE LAKE WINNIPEG WINTER FISHERY

Some of the data collected during the usual study of the 1950-51 winter fishery on Lake Winnipeg was suitable for comparing the efficiency of cotton and nylon gill-nets. The comparison was based on catches made by commercial fishermen in about 9800 yards of cotton gill-nets and about 2500 yards of nylon gill-nets when fished under apparently identical conditions.

The nylon nets caught about three times as many fish per unit of fishing effort as did the cotton nets. Both nets caught approximately the same size of fish--that is there was no tendency in this fishery for nylon nets to catch predominantly small fish as some fishermen suggest.

W. A. KennedyAppendix No. 30

AGE STUDIES ON LAKE WINNIPEG WHITEFISH

A series of whitefish scales from Lake Winnipeg, collected each summer from 1938 to 1951 inclusive, was made available to the Central Station by the Department of Mines and Natural Resources of the Province of Manitoba. The scales for the years 1945 to 1951 have been read and partly analysed. No difficulty such as that mentioned in Appendix No. 23 is anticipated since all the samples were taken after marginal growth for the current year was readily apparent.

Most of the commercial catch seems to be composed of fish from 5+ to 8+ years old inclusive. That is, they are about one-half as old as the commercial whitefish taken in Great Slave Lake and almost twice as old as those taken in Lake Erie.

There is no evidence that year classes differ from one another in "strength". The average age of fish in the samples differed from year to year, but in each case the frequency distribution of ages approximated a normal curve, with no unusually high or low values such as would be expected if year class "strength" were an important factor.

Evidence has been reported previously to show that the whitefish population of Lake Winnipeg is probably made up of a number of distinct sub-populations, of which, at any given time, only a few are contributing to the fishery. Presumably chance, and possibly some unknown condition depending probably on the weather, determines whether the sub-populations being exploited at the time scale samples are taken are predominantly older or younger fish.

W. A. Kennedy

Appendix No. 31

WATER TEMPERATURES IN LAKE WINNIPEG, 1951

The studies of water temperature and its effect on fish movements and on concentrations of fish were continued in 1951. Water temperatures taken regularly in June off Big Black River, Lake Winnipeg, showed that although at any given place surface and bottom temperatures were almost identical, there was a gradation from warmer water inshore to colder water offshore. Each day the temperature at a given distance offshore increased by a small amount, with the result that each day water of a given temperature would be found further offshore.

At the beginning of the season (which was earlier than usual) the best whitefish catches were made in the shallowest water in which the gear could be fished. As time went on the best catches were made progressively further offshore. The rate at which the locus of the best catches moved offshore was roughly the same as the rate at which the position of water of a given temperature moved offshore.

The limited data available fit the hypothesis that these whitefish tend to avoid water warmer than about 60°F, which tends to cause a concentration in slightly cooler water. This hypothesis is, of course, far from being an established fact, and it is not a complete explanation of all the apparent concentrations of whitefish.

L. C. Hewson

Appendix No. 32

DECOMPOSITION RATE OF DISCARDED FISH

Some controversy exists regarding the practice of discarding fish at the fishing grounds and prompted an experiment to determine the decomposition rate in the water of various fishes. The experiment was conducted at Big Black River, Lake Winnipeg during July 1 to 21, 1951.

The species selected were burbot and sucker which are frequently thrown overboard while commercial fishermen are lifting their gill-nets. The fish were put into small wooden crates made with slats to allow free access of water. Two stations at different distances from shore were selected, and the crates anchored at the bottom at each station. At intervals of about one week the crates were hauled up for inspection. Water temperature and the apparent state of decay of the fishes were noted at these times at each station. The average bottom temperature for the 3 weeks was 63°F.

The results were somewhat inconclusive because of the short time that the experiment ran, and because some fish were lost from the crates before they were entirely rotted. However, at one station one burbot weighing originally about 8 pounds was almost totally decomposed at the end of the 3 weeks. Only the skeleton and miscellaneous bits of tissue remained. It is planned to repeat this experiment next year in greater detail.

K. H. Doan

Appendix No. 33

BELUGA FISHERY AT CHURCHILL, MAN., 1951

A line of beluga more than one mile in length--584 animals that averaged 9.9 feet--passed through the reduction plant of Adanac Whale and Fish Products at Churchill, Man., between June 9 and September 8, 1951. Although the Central Station did not have an observer at Churchill, some data became available through the licensees, the plant management, and the Royal Canadian Mounted Police. Fishery Officer O. B. Rutherford also reported on a trip he made to Churchill at the end of August and early September.

Beluga were taken by harpoon and net in the mouth of the Churchill River and vicinity, and at the reduction plant the blubber layer was removed from each animal and the oil was obtained by cooking in a steam retort, draining into a settling tank, and centrifuging. The remainder of the carcass was ground up, packaged in cartons, and frozen for sale as animal food. Livers were saved separately, also for animal food. About 3,200 lbs. of individually wrapped whale steaks were shipped to the Winnipeg market. Total production in 1951 exceeded that of the two previous years, but the average yield of all products per animal was lower in 1951. Total production was 18,674 gallons of oil which weighed about 172,735 lbs. 4,750 lbs. liver, 133,100 lbs. of meat for animal food, and 3,200 lbs. of steaks, making a total of 313,785 lbs. from 584 beluga. From the figures, Table I, it would appear that greater emphasis had been placed on oil production in 1951 than on meat, compared with former years.

Table I. Average yields of commercial products from beluga at Churchill, Man. The weight of oil is taken as 9.25 pounds per gallon.

	1949	1950	1951
Number of beluga on which averages were calculated	203	273	584
Average yield: oil, gallons	24.6	35.1	32.0
oil, pounds	227.6	324.7	296.0
animal food, meat, pounds	418.7	294.3	227.9
animal food, liver, pounds			8.1
steak, pounds			5.5
Total yield, all products, per beluga, lbs.	646	619	538

Netting was undertaken more extensively in capturing beluga in 1951 than in previous years, and resulted in the catching of a greater proportion of small animals than did harpooning, see Table II. Twenty-eight per cent of the beluga that were harpooned were less than 10 feet in length, while 55 per cent of those netted were smaller than 10 feet. The summer's kill consisted of 385 male and 199 female beluga, a sex ratio of about 2:1. The length range was from 5.0 to 14.0 feet.

Aerial observations have been accumulating in recent years, Table III, and it is to be expected that eventually some relationship will become evident between the aerial counts and the commercial catch and availability at Churchill.

Table II. Length distribution of beluga taken at Churchill in 1951.

	Length in feet										Totals
	5	6	7	8	9	10	11	12	13	14	
Net:											
No. taken	2	3	23	21	45	43	17	15	2	-	171
% of total	1.2	1.8	13.5	12.3	26.3	25.1	9.9	8.8	1.2	-	
Harpoon:											
No. taken	3	7	23	35	48	126	75	83	12	1	413
% of total	0.7	1.7	5.6	8.5	11.6	30.5	18.2	20.1	2.9	0.2	
All methods:											
No. taken	5	10	46	56	93	169	92	98	14	1	584
% of total	0.9	1.7	7.9	9.6	15.9	28.9	15.8	16.8	2.4	0.2	

Table III. Aerial counts of beluga made along the west shore of Hudson Bay. 1948, Doan and Sprules; 1950, Douglas and Arnason; 1951, Rutherford.

Date	Flight course	Approx. miles	No. beluga counted
1948 Aug. 12	Churchill to Term Point, return	500	589
Sept. 13	Churchill to Term Point, return	500	32
1950 July 19	Churchill to Seal River, return	100	1250
July 29	Churchill to Seal River, return	100	1400
Aug. 1	Churchill to Seal River, return	100	1638
Aug. 31	Churchill vicinity	20	33
1951 Aug. 31	Churchill to Eskimo Point, return	300	631
Aug. 31	Churchill to Nelson River, return	300	76

W. A. Kennedy

Appendix No. 34

THE MORPHOMETRY OF THE COREGONINE FISHES OF GREAT BEAR LAKE, N.W.T.
INCLUDING SOME STATISTICAL ANALYSIS TECHNIQUES

In 1945 morphometric measurements and counts were made on 78 whitefish, 77 ciscoes and 8 round whitefish from Great Bear Lake. These data indicate that in Great Bear Lake the whitefish species is Coregonus clupeaformis, the cisco species is Leucichthys artedi and the round whitefish species is Prosopium cylindraceum. No other species of coregonine fish were collected.

The amount of variability found within the homogeneous whitefish population of Great Bear Lake casts doubt on the validity of several of the species that have been described from this general region. Doubt is also cast on the validity of some cisco species for the same reason.

A paper with the same title as this appendix has been prepared for publication and it illustrates certain statistical analysis techniques which may encourage more people to use these valuable tools in taxonomic problems.

