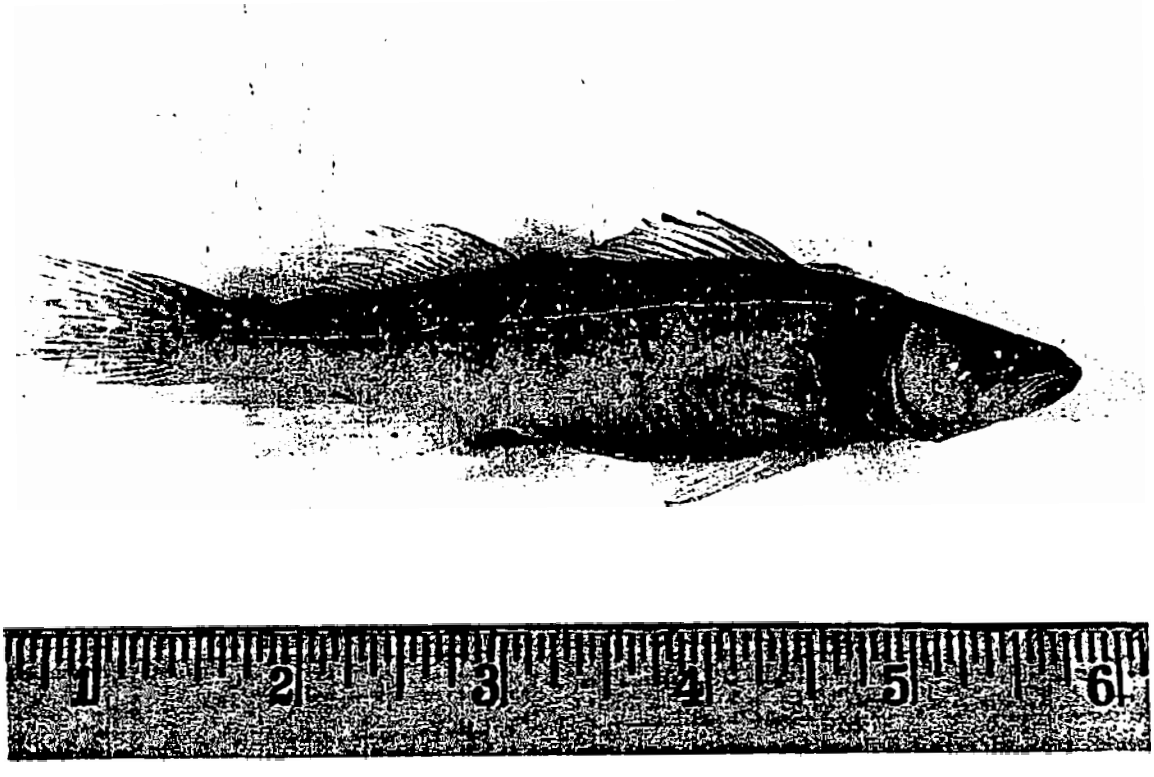
1958

Evaluation of Walleye Fingerling Plants in Lake Darling, North Dakota

George L. Van Wyhe

EVALUATION OF WALLEYE FINGERLING PLANTS IN LAKE DARLING, NORTH DAKOTA



WALLEYE FINGERLING, AGE-CLASS 0

EVALUATION OF WALLEYE FINGERLING PLANTS IN LAKE DARLING, NORTH DAKOTA

By

George L. Van Wyhe

A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science at South Dakota
State College of Agriculture
and Mechanic Arts

June, 1958

EVALUATION OF WALLEYE FINGERLING PLANTS

IN LAKE DARLING, NORTH DAKOTA

This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the thesis requirements for this degree; but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser

Head of the Major Department

ACKNOWLEDGEMENTS

This writer wishes to express his sincere appreciation to Mr. Marvin C. Allum, Assistant Professor of Zoology, for his valuable suggestions, personal interest, and constructive criticisms offered during the course of this investigation. He also wishes to thank Mr. Dale Henegar, Chief of Fisheries, North Dakota Game and Fish Department, for the use of equipment and personal field guidance during the course of the investigation.

Appreciation is also conveyed to Leo Whittenburg, refuge clerk at the Upper Souris Wildlife Refuge for data so willingly contributed, and to all personnel of the refuge for help and use of equipment. The writer also wishes to thank Mr. Ken Mckeauge, district game warden, for help contributed in the field. Special thanks is expressed to fellow graduate student, Mr. James W. Sprague, for assistance in collection of material.

GVW

TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

INTRODUCTION

The walleye, Stizostedion vitreum vitreum (Mitchill) is the largest American member of the perch family (Percidae); it represents the subfamily Lucioperchinae in our waters. The walleye has a wide range of distribution which, according to Hubbs and Lagler (1949), extends "From Great Slave Lake, The Saskatchewan River system and the Hudson Bay region to Labrador; southward on the Atlantic slope to North Carolina, and west of the mountains, to the Alabama River system of Georgia to the Tennessee River drainage of Alabama and to northern Arkansas and Nebraska. Common through the Great Lakes and many of the inland lakes and rivers of the basin; in Lake Erie chiefly to the westward". Lake Darling is well within this range of distribution. Early collections by Hankinson (1929), however do not list the taking of walleyes in the Souris River which in 1938 was impounded to form Lake Darling. It is, therefore, questionable whether this species is native to this watershed.

The effect of artificial propagation on the abundance of walleyes has received much critical attention in the past. For many years there was a great expansion of fish stocking of native fishes such as walleyes. It was thought then that annual plantings of fry were necessary to sustain a walleye fishery. However, the ineffectiveness of fry planting in lakes to maintain the fish populations has been demonstrated in Lake Of The Woods, Minnesota (Carlander, 1945); Red Lake, Minnesota (Van Oosten and Deason, 1957; Smith and Krefting, 1954); Lake Michigan and Lake Huron (Hile, 1937); Great Lakes (Van Oosten, 1937); and Spirit Lake, Iowa (Rose, 1949). Lack of correlation between the numbers of fry planted and

abundance of walleyes was evident in all the above lakes.

Routine plantings of fry in general management practice have been discontinued in many states, including North Dakota (Henegar, 1957); Michigan (Cooper, 1948); and Minnesota (Kimball, 1956). As a result, an entirely different stocking program has been initiated. The general trend now is to stock walleye fry only in lakes where the fish population has been depleted or reduced because of winter kill, or in newly created or rehabilitated waters. The problem of establishing a fishable population of walleyes in a lake containing diversified species composition is a vexing one to fishery men of this area. Consequently, information pertaining to stocking procedures which influence the establishment of year-classes is of considerable importance to sport fishery management.

Negative returns from the stocking of over three million walleyes in Lake Darling, North Dakota, over a period of eight years instigated experimental stockings of walleye fingerlings in the years 1952, 1953, and 1954 with special emphasis on distribution methods, planting procedures, and condition of the fish. This study is an attempt to evaluate these experimental stockings. Information on age and growth along with species composition are presented to provide a more complete species evaluation in the lake.

Gill net and fyke net catches provided only walleyes of year-classes which are attributed to the stocking of walleye fingerlings. Data on size and method of planting are also included.

DESCRIPTION OF LAKE DARLING

This study was conducted on Lake Darling, near Minot, in north-central North Dakota. Lake Darling is a long, relatively narrow body of water (Figure 1), of about 14,000 acres. That portion of the Souris River Drainage upstream from Lake Darling extends from North Dakota into Canada. The watershed usage is 85 percent cropland and 15 percent pasture. Water released from the lake returns to the Souris River as regulated by the requirements of the International Water Commission (not less than 20 cubic feet per second). There are additional seasonal demands as the lake is the reservoir water supply for the city of Minot and must also supply water to meet the requirements of waterfowl on the Lower Souris Wildlife Refuge.

The lake has a slightly irregular shoreline of sand and clay approximately 50 miles in length. The maximum reported depth is approximately 25 feet (at spillway level) with considerable areas of 18 feet in depth; thus there is sufficient water volume to prevent severe winterkills. The waters are moderately hard and have a total alkalinity of about 200 parts-per-million. The lake annually supports an algae bloom which indicates reasonably good fertility. There is an absence of aquatic vegetation due primarily to fluctuating water levels and wind action. The water temperature ranged from 69°F to 78°F from July 7th to August 10, 1957, the period in which the survey was conducted.

The lake is located within the boundary of the Upper Souris Wildlife Refuge; therefore, angling is restricted to certain portions of the lake. These areas total approximately 4,000 acres. In recent years the

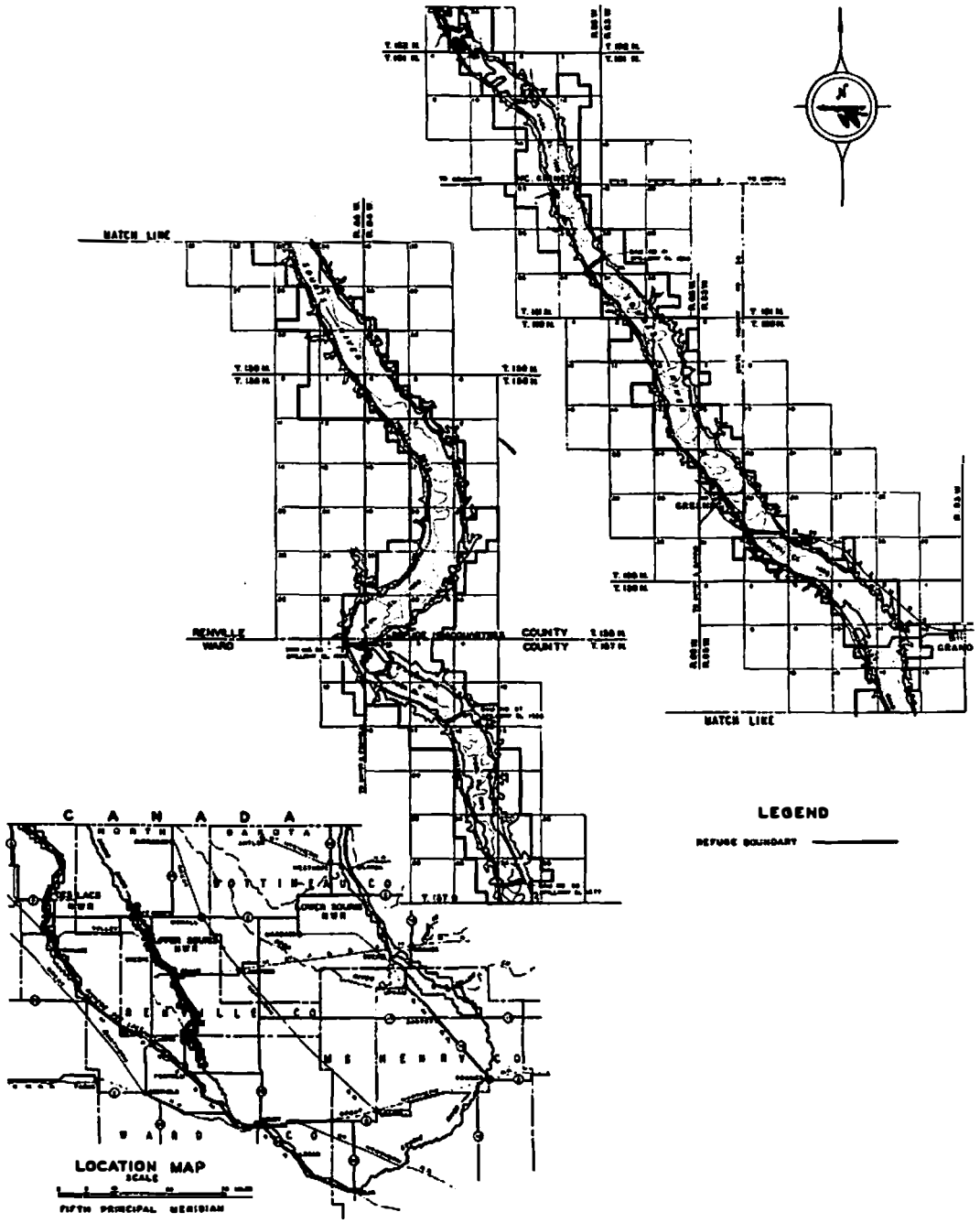


Figure 1. Map of Lake Darling.

lake has supported good fishing for northern pike, Esox lucius Linnaeus, with an estimated harvest of five tons in a single season. In addition to the northern pike fishery, heavy fishing for yellow perch, Perca flavescens (Mitchill), is experienced during the winter months. In a recent survey by the North Dakota Game and Fish Department as many as 600 fishermen were observed utilizing the lake at a given time. The importance of this fishery is, in great part, due to the lack of other fishing water in this section of the state (Figure 1). This is evidenced by the fishing pressure exerted.

STOCKING PRACTICES IN LAKE DARLING

In the years from 1942 to 1950 a total of 3,732,000 walleyes was stocked in Lake Darling. The records of the North Dakota Game and Fish Department show that these fish were delivered to Lake Darling but the condition of the fish on arrival was not noted. The stocking program did not follow any biologically sound plan as is evidenced by the random stocking of different species totaling 4,083,220 fish during this period.

The surveys of 1952 showed the walleye population of Lake Darling to be almost non-existant, with a single walleye taken in 500 hours of fishing with gill and fyke nets by the North Dakota Game and Fish Department. In a survey conducted by the United States Fish and Wildlife Service the same year (Sharp, unpub. ms.), only four walleyes were taken in 174 hours of intensive gill netting. Creel census reports showed that not a single walleye was taken by anglers from the time the lake was opened in 1946 through the 1952 season.

It was decided then to suspend all routine plantings of walleye fry and to conduct experimental plantings of walleye fingerlings of various sizes and numbers in order to investigate the possibility of their establishment in this fishery.

In the fall of 1952, 7,600 four-inch walleye fingerlings were stocked in the lake. During the summer of 1953, 16,300 fingerlings of the two-inch size were released in Lake Darling waters; and, in 1954, 8,900 fingerlings of four-inch length were stocked. All of the above fish were obtained from the Federal Fish Hatchery at Valley City. It is believed, for this reason, that only one strain of parent fish was

involved.

The fish were transported from the hatchery to Lake Darling in fish tanks loaded on trucks. The distance from the hatchery to point of release is approximately 350 miles. About 14 hours elapsed from the time the fish were loaded until they were released. Special emphasis was placed on water temperature during transportation. Ice was used to keep temperatures at approximately the same level as in the rearing ponds. Aeration of the water was accomplished by a pump system which circulated the water throughout the tank and sprayed a portion of it back through the air. Further aeration was provided by bubbling small quantities of pure oxygen through the water. When the distribution truck arrived at the lake, the fish were transferred to pails and were adjusted to the temperature of the lake water by intermittently introducing lake water into the fish pail so as to effect a slow and gradual temperature change.

The condition of all fish transported and planted in Lake Darling in this manner for the 1952-53-54 plantings was excellent with no mortality during the entire stocking operation. Plantings of these fingerlings in the lake were made in several locations but always in shallow water along the shore line from which the wind was blowing.

COLLECTION OF FISH

It would be difficult, if not impossible, to accurately measure a walleye population scattered unevenly over a lake of this size. To secure a representative sample of different age-classes of this species, experimental gill nets, fyke nets, and a minnow seine were employed.

Gill Nets

Standardized experimental gill nets, made up of 50 foot sections of 3/4-, 1-, 1¼-, 1½-, and 2 inch nylon mesh, were used (Figure 2). Nylon nets were employed because nylon is reported to fish more efficiently than linen or cotton (Peterson, 1952). These nets, set throughout the period of the study in all parts of the lake, are felt to provide a crude measure of the catchable population of walleyes.

It has been shown by Moyle (1950) that the catch bears some relationship to the abundance of fish but that other factors also affect the catch. Gill nets depend on the movement of fish and, therefore, the catch per hour is a function of activity of the fish in the vicinity of the nets as well as of their abundance. Fish move more at certain times of day than at others and each species appears to have characteristic activity cycles (Carlander, 1953). Because of this, interpretation of the catch data to derive abundance indices is subject to considerable error.

In the Lake Darling study gill nets were usually lifted at 12 hour intervals. It was necessary to fish the nets for less than 24 hours because the heavy take of perch after 10 to 15 hours impaired the fishability of the nets. The nets were fished both during the daylight and night hours to secure as adequate a sampling of fish as possible during all

Figure 2. Experimental nylon gill net used in the Lake Darling study.

movement periods.

A total of 240 hours of gill-netting was carried out during this study. During this time, 4,334 fish were captured with a combined weight of 2,035 pounds. Of this number, 170 were walleyes, for a percentage composition of 3.9. The walleyes ranged in length from 16.5 to 22.6 inches and averaged 18.7 inches. These fish ranged in weight from 1.18 to 4.25 pounds and averaged 2.58 pounds. The lengths, weights, and percentage composition of the other species captured in the gill nets are shown in Table 1.

Fyke Nets

Fyke nets were employed for the capture of walleyes to compare these size and age groups against those captured in the gill nets. The general appearance of the nets is shown in Figure 3. These fyke nets were of the double pot type, with each pot four feet in circumference and seven feet in depth, making the entire trap 23 feet in length. The mesh was 3/4 inch square throughout including the lead which was 100 feet long. Nets of this type were used in Michigan lakes to capture large numbers of fish (Crowe, 1953).

All fyke nets were fished for 24 hours throughout the lake. The nets were set with the lead line anchored to shore to intercept all movement of fish in water too shallow for efficient gill netting. These nets were weighted so as to fish on the bottom and all fish were impounded in nets. It is felt that this system of netting gave as complete a picture of the walleye age-class composition of the lake as possible.

The locations of all sets were recorded, by number, on a map of the area and exact sites were marked with steel posts. The posts were

Table 1. Gill netting summary for Lake Darling.

TEST-NETTING SUMMARIES

1957

Waters: Lake Darling

County: Renville & Ward

Dates: 6-VII-57 : 8-VIII-57

Type of Gear: Exp. Gill Net

Total Hours Fished: 240 hrs.

Temperature Range: 69°F - 78°F

NUMBER	SPECIES	LENGTH RANGE-Average		WEIGHT RANGE-Average		TOTAL WEIGHT	FREQ-UENCY	% COMPO-SITION
20	Northern Pike	30.3-15.5	19.2	7.0-0.9	1.95	39.1	0.14	0.46
396	White Sucker	19.5-9.2	14.0	2.87-0.4	1.77	699.6	2.5	9.10
3	Black Bullhead	9.3-8.7	9.0	0.7-0.43	0.56	1.7	0.02	0.06
170	Walleye	22.6-16.5	18.7	4.25-1.18	2.58	439.5	1.10	3.90
3,745	Perch	13.0-4.0	7.2	1.5-0.1	0.23	855.0	24.8	86.40
4,334						2,035		

REMARKS: Frequency is the gill net frequency which indicates the number of fish per hour for 250' of experimental gill net (Standard North Dakota).

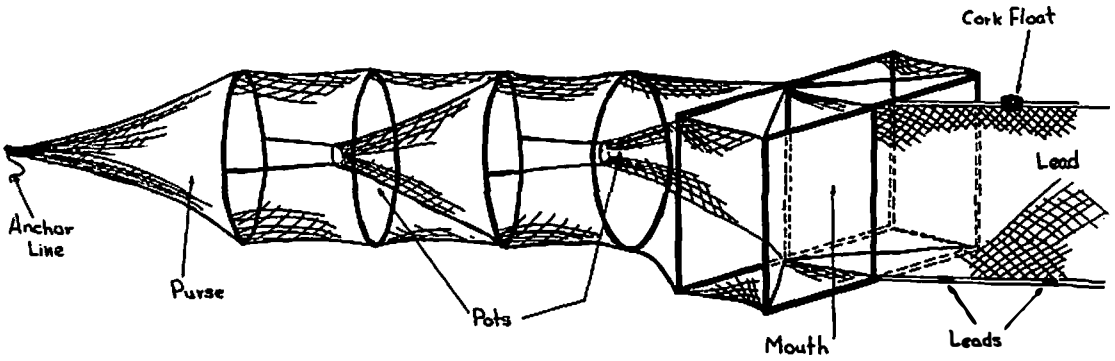


Figure 3. Diagrammatic fyke net.

set above the high water mark, and the set numbers were stamped on them with a steel marking tool for set comparisons in future surveys.

The procedure was to fish a net at each station for approximately the same period of time. When possible, gill and fyke nets were alternated. When the nets were lifted, all fish were removed, weighed, measured, sexed, and scale samples were taken. All walleyes captured were measured while still fresh and the total lengths[1] were recorded for each fish. The above information was recorded on standard catch record forms (Figure 4) and the scale samples were placed in scale envelopes (Figure 5) for future analysis.

Fyke nets were used for a total of 369 hours during which 2,210 fish were captured with a total weight of 3,974 pounds. Thirty-three walleyes were taken in these nets for a percentage composition of 1.4. The walleyes captured in the fyke nets ranged in length from 16.2 to 22.9 inches with an average length of 18.6 inches. The average weight of these fish was 2.60 pounds with a range from 1.70 to 4.50 pounds. The returns from the gill and fyke nets show good correlation in size and length (Table 2).

Table 2. Comparison of gill and fyke net catches

Type Net	Hours Fished	Number of Fish Cap.	Percentage Composition	Length		Weight		Age Class	
				Range	Ave.	Range	Ave.	III	IV
Gill	240	170	3.9%	22.6-16.5	18.7	4.25-1.18	2.58	79%	21%
Fyke	369	33	1.4%	20.9-16.2	18.6	4.50-1.70	2.61	68%	32%

[1] Total length is the distance from the tip of the snout to the posterior edge of the dorsoventrally compressed caudal fin.

Fisheries Research Division
North Dakota Game & Fish Department

CATCH RECORD

Set No._____ Date_____
Name of Water_____
County_____
Type of Gear Used_____
Location_____ Depth_____
Distance off Shore_____
Set_____ Temp._____
Removed_____ Temp._____

SPECIES	NO.	SEX	LENGTH	WEIGHT	REMARKS

Figure 4. Standard catch record form.

Coll. No._____

FISHERIES RESEARCH DIVISION
North Dakota Dept. of Game, Fish & Parks

Species_____ Date_____
Locality_____ Length_____
T.____R.____Sec._____ Weight_____
County_____ Sex_____
Gear_____ Maturity_____
Collector_____ Age_____
Notes:

Figure 5. Scale envelope.

Shoreline Seining

Shoreline seinings were made with a 100' X 6' X ¼" square mesh seine (Figure 6). The procedure was to make a 50 foot pull with the seine at regular intervals around the entire lake. An estimated total of 43,500 square feet (surface area) was seined. This effort produced 24 young-of-year walleyes, with an average length of 5.3 inches, constituting approximately 0.2 percent of the total catch.

Figure 6. Shoreline seining procedure.

AGE AND GROWTH

No critical analysis of the scale method as applied to the walleye has been published, but the annulus was found to be a satisfactory mark for determination of age of Lake Of The Woods walleyes (Carlander, 1945). Eschmeyer (1950) found that the generally accepted scale method for fish older than one growing season was valid for walleyes from Lake Gogebic, Michigan.

The year-classes of the Lake Darling walleyes were determined from examination of 203 scale samples obtained from fish ranging in length from 16.2 to 22.9 inches. These year-classes were based on readings from scales taken at approximately the same location on each fish. Scales taken from each specimen were removed from the scale rows immediately below the lateral line and even with the insertion of the dorsal fin (Figure 7).

Examination of the scales for annuli to be used for the determination of year-classes was done in the following manner. The scales were soaked in water and cleaned of epidermis and slime by means of a clipped soft bristle art brush. The cleaned scales were then placed convex-side up on a standard microscope slide. A second slide was then placed over the scales and distilled water was introduced between the slides to flood the space between and around the scales, thus making a temporary water mount similar to that described by Lewis and Carlander (1949). The mounted scales were then placed on the stage of the micro-projection unit of the type described by Lagler (1949) which projects a much enlarged image of the scale on a ground-glass viewing screen.

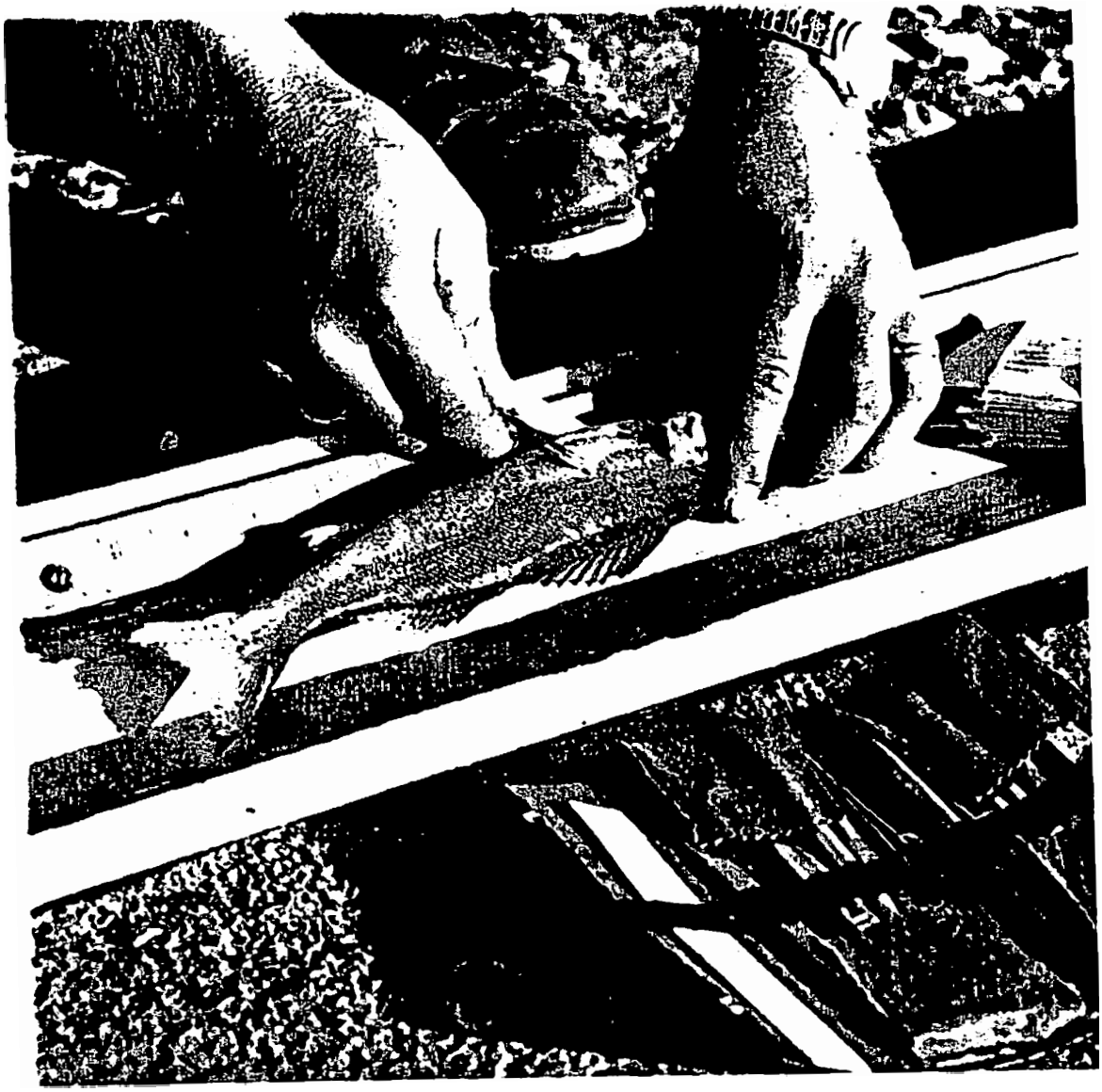


Figure 7. Method of removing scales.

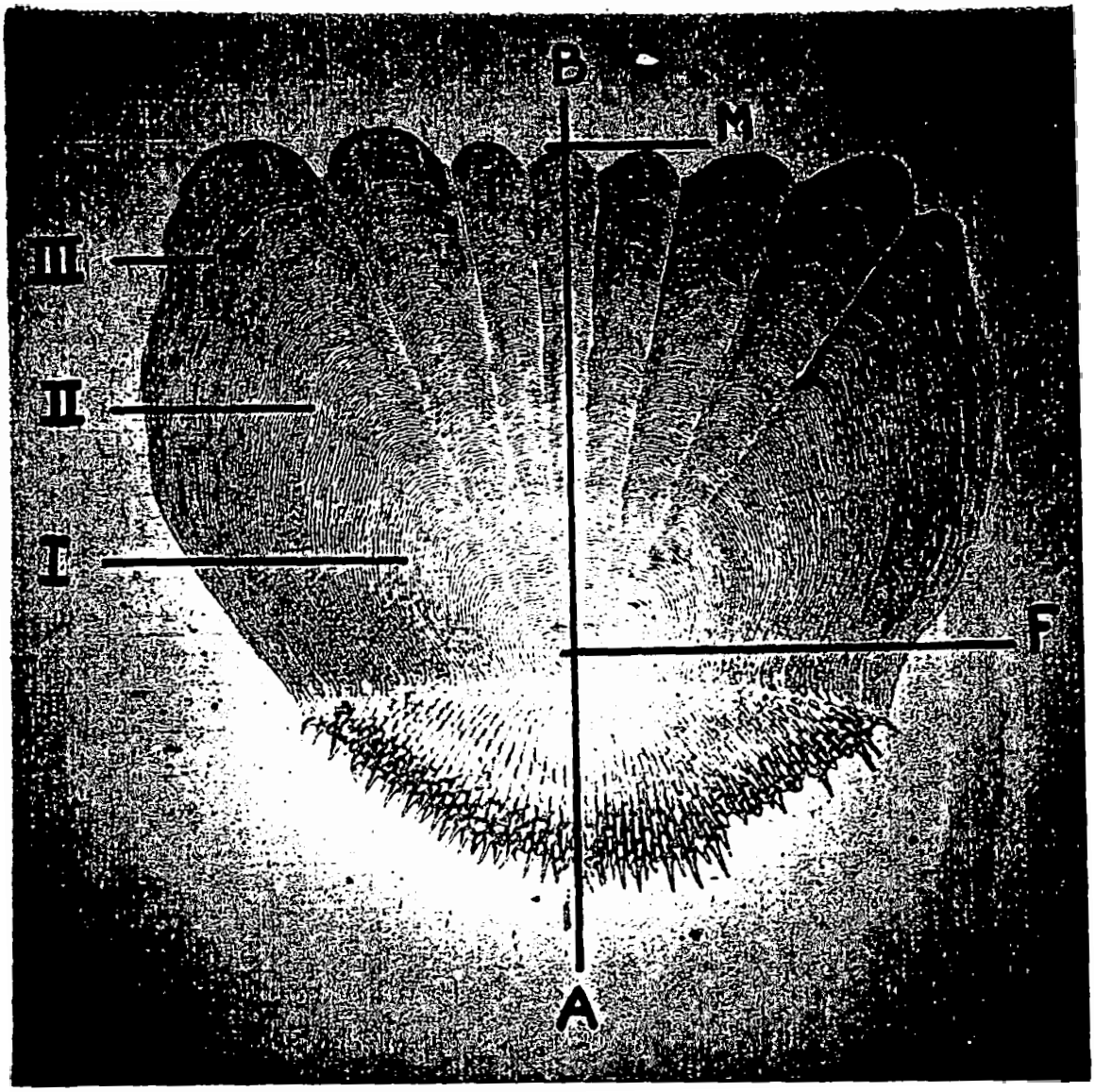


Figure 8. Photograph of walleye scale, age-class III. A-B, line along which the scale was measured; F, focus, position where measurement was begun; M, margin of fin; I, II, III, annuli.

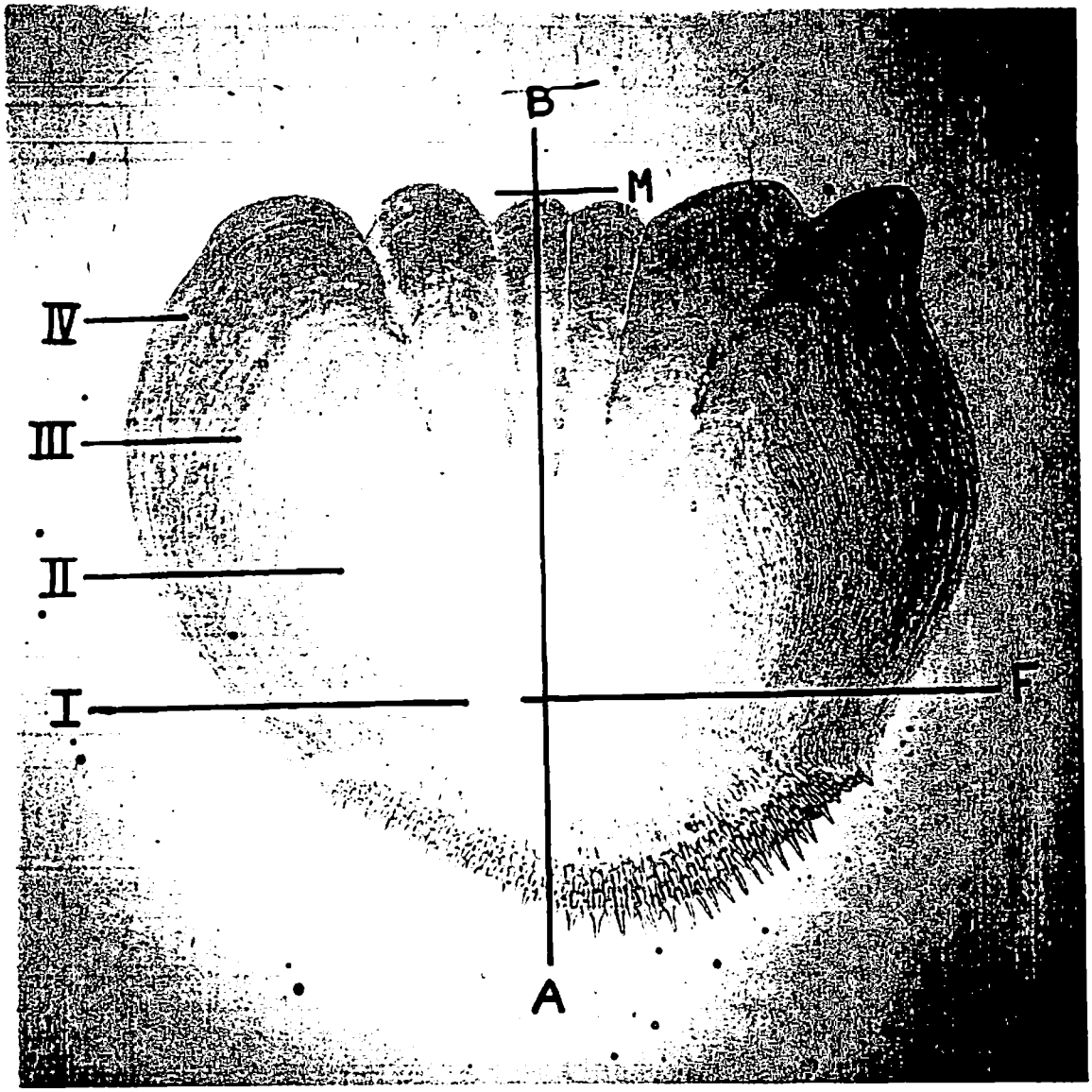


Figure 9. Photograph of walleye scale, age-class IV. A-B, line along which the scale was measured; F, focus, position where measurement was begun; M, margin of scale; I, II, III, IV, annuli.

After careful study of the scale, the annuli (Figures 8 and 9) were traced on the ground-glass viewing screen. A clear plastic millimeter ruler was used to take the readings off the viewing screen. One corner of the ruler was placed in the center of the focus of the projected image of the scale with one of its margins extending along or near the center of the scale image. At the points where the previously made annuli tracings and the scale margin intersected the ruler, readings were taken and were recorded on the data sheet which included the collection number and date of the reading.

The growth of the fish was calculated from the measurements mentioned above, assuming a straight line relationship between the growth of the fish and the growth of the scale, according to the following formula as discussed by many authors, including Schuck (1949), Lagler (1949, 1952), Van Oosten (1929), and Rounsefell and Everhart (1953):

A : X :: a : b, where

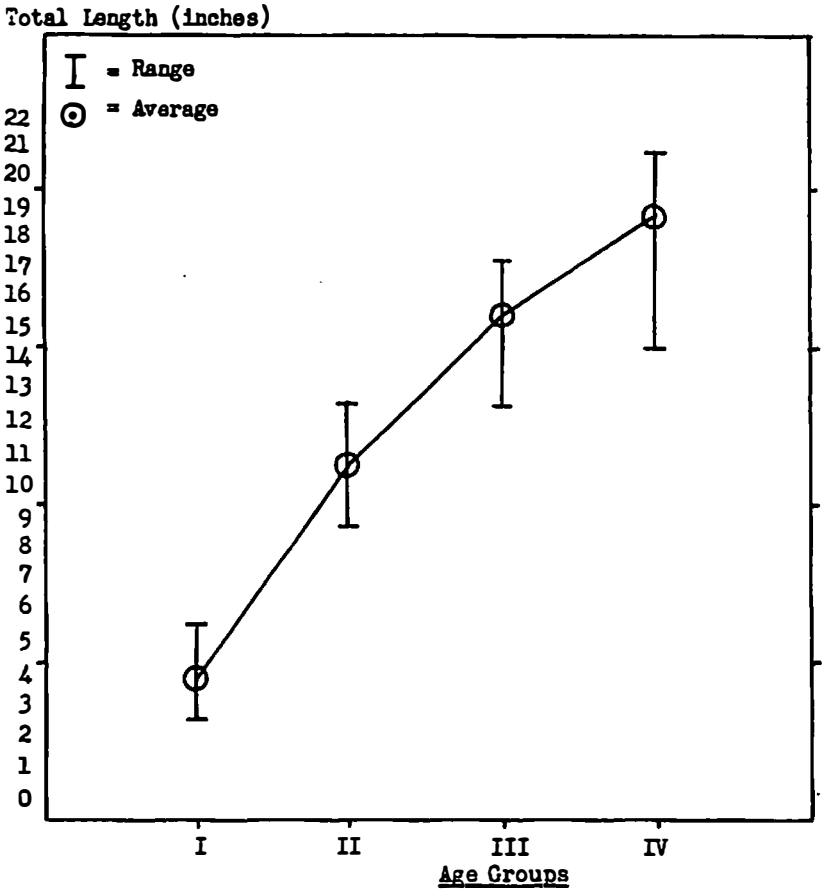
A = Length of fish at capture

X = Length of fish at formation of annulus,

a = Length of scale, and

b = Length of scale to annulus

After the entire series of scales was read and the growths calculated, the information was tabulated and graphs of age and growth and growth increments were prepared (Figure 10).



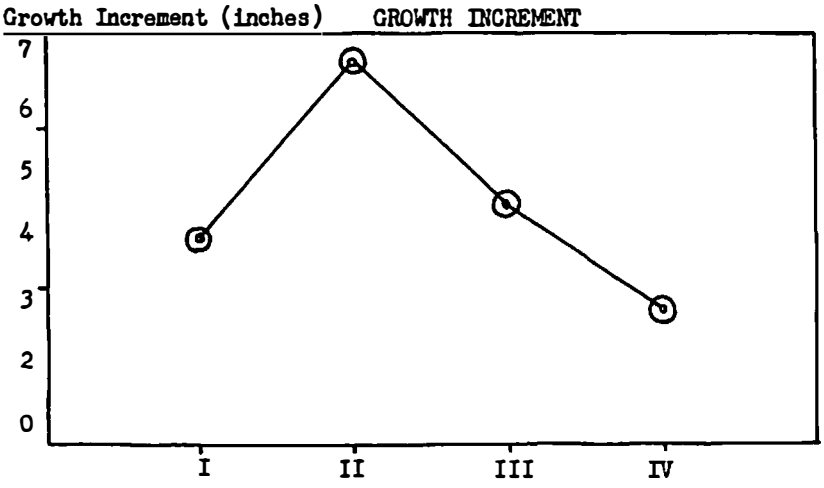


Figure 10. Age and Growth of walleye, Lake Darling.

DISCUSSION

The results of this study indicate a high return from hatchery reared walleye fingerlings stocked in Lake Darling in 1953 and 1954. Of the walleyes captured and aged by the use of the scale method, only age-classes III and IV were observed. The annuli were very distinct for both age-classes III and IV and the scales shown in Figures 9 and 10 are typical of the majority of the scales read from the Lake Darling walleyes. No great difficulty was experienced in the determination of the annuli. These age-classes correspond directly with the 1953 and 1954 plantings as is shown in Table 3.

Table 3. Relationship of plantings to existing age-classes.

Year Planted	1952	1953	1954
Size of Plant	7,600	26,400	9,000
Age-Class Represented	V	IV	III
Percent of 1957 capture	0%	23%	77%

As shown in Table 1, the percentages of age-classes varied little with type of collecting gear used, with no age-class difference shown by either the gill net or fyke net catches. The fact that age-class III was represented by 77 percent and age-class IV by 23 percent of scale samples read indicates that these two groups make up the bulk of the present walleye population.

The total absence of age-class V which would correspond to the

1952 planting is difficult to explain. The success of the planting appears to have been favorable up to age-class II as a survey conducted by the United States Fish and Wildlife Service (Sharp, unpub. ms.) in 1954 showed that 91 percent of the walleyes captured were of the same length as the fish of this study exhibited at age-class II. Had Sharp's age-class II survived, it would have been represented by age-class V in this study. The total absence of age-class V in this study would seem to indicate either a high mortality rate for this age-class or escapement from the lake over the spillway or through the gates.

When compared to the walleyes in other impoundments of this state, the walleyes of this study show better than average length and growth, as is shown in Table 4. This better-than-average growth indicates that environmental factors are favorable toward the establishment of a walleye fishery.

TABLE 4. Age and growth of walleyes in North Dakota impoundments

Lake	Age Classes (in inches)			
	I	II	III	IV
Darling				
Average	4.2	11.2	16.0	19.1
Range	3.1-6.1	9.4-14.4	13.1-17.7	15.0-21.3
Increment	4.2	7.0	4.8	3.1
Heart Butte				
Average	5.2	9.2	13.4	15.8
Range	3.0-9.0	6.9-12.9	9.4-15.7	14.4-18.8
Increment	5.2	4.0	4.2	2.3
Ashtabula				
Average	4.3	9.2	13.5	16.5
Range	3.0-7.0	6.1-12.5	9.8-17.3	11.9-19.6
Increment	4.3	4.9	4.3	3.0

It appears from evidence of this study that the establishment of

age-classes of walleyes can be made in water with similar conditions as those existing in Lake Darling at the time of the plantings.

SUMMARY

The purpose of this study was to evaluate experimental walleye fingerling plants in relationship to the establishment of year-classes.

The study was conducted from July 7th to August 10th, 1957, on Lake Darling in north-central North Dakota. This lake of 14,000 acres supports good northern pike and yellow perch fisheries.

Fish for this study were collected by the use of gill, and fyke nets and then aged by the use of the scale method. All walleyes examined were of either age-class III or IV. These age-classes correspond to the experimental stockings of 1953 and 1954. It appears that these two age-classes make up the bulk of the existing walleye population.

LITERATURE CITED

Carlander, Kenneth D.
1945. Age, growth, sexual maturity, and population fluctuations of yellow pike-perch, Stizostedion vitreum vitreum (Mitchill), with reference to the commercial fisheries, Lake Of The Woods, Minnesota. Trans. Am. Fish. Soc., Vol. 73 (1945), pp. 90-107.

1953. Use of gill nets in studying fish populations, Clear Lake, Iowa. Proc. Iowa Acad. Sci. Vol. 60, pp. 621-625.

Cooper, Gerald P.
1948. Fish stocking policies in Michigan. Trans. 13th N. Amer. Wildlife Conf., pp. 187-193.

Crowe, Walter R.
1953. An analysis of the fish population of Big Bear Lake, Otsego County, Michigan. Pap. Mich. Acad. Sci., Arts, and Letters, Vol. 38 (1952), pp. 187-206.

Eschmeyer, Paul H.
1950. The life history of the walleye, Stizostedion vitreum vitreum (Mitchill), in Michigan. Mich. Dept. Cons., Bull. Inst. Fish. Res. No. 3, 99 pp.

Hankinson, T.L.
1929. Fishes of North Dakota. Pap. Mich. Acad. Sci., Arts, and Lett., Vol. 10 (1928), pp. 439-460, 4 pl.

Henegar, Dale
1957. Report sixth annual meeting-Great Plains Fisheries workers. Feb. 20-21, 1957-Deadwood, South Dakota. pp. 1-2.

Hile, Ralph
1937. The increase in the abundance of the yellow pike-perch, Stizostedion vitreum (Mitchill), in lakes Huron and Michigan, in relation to the artificial propagation of the species. Trans. Am. Fish. Soc. Vol. 66 (1936), pp. 143-159, (paper not seen).

Hubbs, Carl L. and Karl F. Lagler
1949. Fishes of the Great Lakes Region. Cranbrook Inst. of Sci. Bull. No. 26, Bloomfield Hills, Mich. pg. 86.

Kimball, James W.
1956. The fish management policy. Minn. Cons. Volunter, Vol. 19, No. 111 (May-June), pp. 34-47.

Lagler, Karl F.
1949. Studies in freshwater fishery biology. J. W. Edwards, Ann Arbor, Mich., pp. 56-72.

1952. Freshwater fishery biology. Wm. C. Brown Co., Dubuque, Iowa. pp. 99-127.

Lewis, William M., and Kenneth D. Carlander
1949. A simple method of mounting scales. Prog. Fish Cult. Vol. XI, 4 (Oct.), pg. 263.

Moyle, John B.
1950. Gill nets for sampling fish populations in Minnesota waters. Trans. Amer. Fish. Soc., Vol. 79 (1949), pp. 195-204.

Rose, Earl T.
1949. The population of yellow pike-perch, Stizostedion V. vitreum in Spirit Lake, Iowa. Trans. Am. Fish. Soc., Vol. 77 (1949), pp. 32-41.

Rounsefell, George A., and W. Harry Everhart
1953. Fishery science, its methods and applications. John Wiley and Sons, New York, pp. 297-206.

Schuck, Howard A.
1949. Problems in calculating size of fish at various ages from proportional measurements of fish and scale sizes. Jn. Wildlife Mgt., Vol. XIII, 3 (July), pp. 298-303.

Sharp, Robert W.
ms. Preliminary fishery management report-Upper Souris National Wildlife Refuge, North Dakota. 3 pp., (unpublished).

---
ms. Progress report-fishery management program, Upper Souris Refuge-North Dakota. 6 pp., (unpublished).

Smith, Lloyd L., and Laurits W. Krefting
1954. Fluctuations in production and abundance of commercial species in the Red Lakes, Minnesota, with special reference to changes in the walleye population. Trans. Am. Fish. Soc., Vol. 83 (1953), pp. 131-160.

Van Oosten, John
1929. Life history of the lake herring, Leucichthys artedi Le Sueur, of Lake Huron as revealed by its scales, with a critique of the scale method. Bull. Bur. Fish., Vol. 44 (1928), pp. 265-428.

1937. Artificial propagation of commercial fish of the Great Lakes. Trans. Second N.A. Wildlife Conf., pp. 605-612.

Van Oosten, John, and Hilary J. Deason
1957. History of Red Lakes fishery, 1917-38, with observations on population status. U.S. Fish and Wildlife Serv., Spec. Sci. Rept. Fish. No. 229, 63 pp.