A STUDY OF THE AGE, GROWTH, AND YEAR CLASS ABUNDANCE OF THE WHITEFISH, COREGONUS CLUPEAFORMIS (MITCHILL,) FROM BIG BAY DE NOC, DELTA COUNTY, MICHIGAN

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

Allan Mosley Barker

1953

This is to certify that the

thesis entitled

A Study of the Age, Growth, and Year Class Abundance of the Whitefish, Coregonus Clupeaformis (Mitchell), from Big Bay de Noc, Delta County, Michigan

presented by

Allan M. Barker

has been accepted towards fulfillment of the requirements for

M.S. degree in F & W

Peter T. Tack
Major professor

Date July 24, 1953

O-169

V-255

P-316

A STUDY OF THE AGE, GROWTH, AND YEAR CLASS ABUNDANCE OF THE WHITEFISH, *COREGONUS CLUPEAFORMIS* (MITCHILL), FROM BIG BAY DE NOC, DELTA COUNTY, MICHIGAN.

By

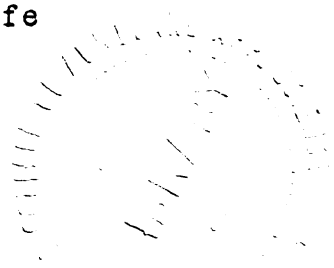
Allan Mosley Barker

A THESIS

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE

Department of Fisheries and Wildlife

1953



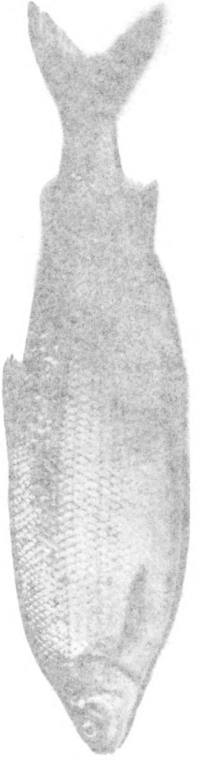
THESIS

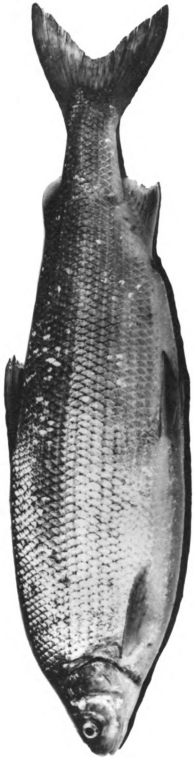
ACKNOWLEDGMENTS

The author wishes to express his sincere gratitude to Dr. P. I. Tack, Professor and Head of the Department of Fisheries and Wildlife, Michigan State College, who directed this study and whose suggestions and guidance were always available. Special thanks are also due Drs. Robert C. Ball and Don W. Hayne, Department of Zoology, for additional assistance.

The cooperation of the commercial fishermen of Big Bay de Noc, Lake Michigan, was greatly appreciated.

This investigation was supported in part by aid from the Michigan Agricultural Experiment Station.





CONTENTS

LIST OF FIGURES

INTRODUCTION

The whitefish, Coregonus clupeaformis (Mitchell), is the largest and most widely known species of the coregonid fishes in North America. It may attain a weight of twenty-six pounds and reach the age of sixteen years in the Great Lakes. This fish is usually confined to lakes having cold, deep water, and is distributed throughout much of Canada and the states bordering the Great Lakes. Jordan and Evermann (1911) review the distribution of the whitefish in the Great Lakes and other regions, and Koelz (1929, 1931) gives an account of the distribution and natural history of the coregonid fishes in the Great Lakes and in northeastern America. Records indicate that the whitefish was formerly abundant all along the shores of Lake Michigan and around the islands at the northern end of the lake. At the present time this species is the object of a special fishery only in the northern part of the lake.

The value of the whitefish as food has been fully recognized since it was first captured. This species brings a higher market price than that of any other lake fish except the sturgeon. Less than one million pounds of whitefish were taken from the state of Michigan waters of Lake Michigan in 1951 but the value of this catch was nearly one-half million dollars. Lake Michigan produces the bulk of the present catch from Michigan waters of the Great Lakes and most of

these fish are caught in the vicinity of Big Bay de Noc. Production of whitefish has fluctuated drastically in Lake Huron and Lake Michigan in recent years. A phenomenally high peak of production was reached in both these lakes in 1948, but the populations have apparently returned to more normal levels. The catch in Lake Huron was nearly three million pounds in 1948, but it declined to 114,203 pounds in 1950 (Michigan Biennial Reports, Fish Division). The Lake Michigan catches increased from 1,326,235 pounds in 1945 to a peak of 4,262,678 pounds in 1948 and then declined to 2,101,561 pounds in 1950 and 971,098 pounds in 1951 (Michigan Biennial Reports, Fish Division).

More study is needed as to the influence of the strongly represented year classes which may dominate the catch for a short period. Additional information on the strength of year classes making up the commercial catches is also needed. Most age and growth studies have been based on whitefish caught by the commercial fishery. Very little is known about the early life history of this valuable species. As most of the fish are netted on the spawning grounds in fairly shallow water, information as to migration and the possible existence of isolated populations of this species is almost completely lacking. In bodies of water as vast as the Great Lakes these problems may never be fully solved. Many more investigations on the early life history of the whitefish are needed before the age and growth data can be completely interpreted.

MATERIALS AND METHODS

This study of the age and growth of the whitefish is based on data obtained from 839 specimens taken by the commercial fishery from the Big Bay de Noc waters of northern Lake Michigan (Figure 1). Field collections were made during October and November, 1951 and May and September, 1952. Data relating to dates of collection, locality of catch, type of gear used, and total number of fish in each sample are given in Table 1.

All the fish were weighed and measured immediately upon delivery to the fish house. Weights were determined by using a spring balance and are recorded in pounds and ounces. Length measurements were recorded in millimeters. The total length was obtained by using the conventional fish measuring board having a vertical end-piece, to place the snout against, and an inset millimeter rule. In this study the total length is defined as the distance from the junction of the premaxillaries to the tip of the caudal fin, with the lobes compressed in order to give the maximum possible measurement.

Sex and stage of sexual maturity were recorded for the 1951 samples as the bulk of the catches were sub-legal fish, which made it possible to retain these whitefish for further study. The sex of the fish taken in 1952 could not be determined, as most of these specimens exceeded the legal limit of

Figure 1. Big Bay de Noc in northern Lake Michigan, showing the collecting localities of this study.

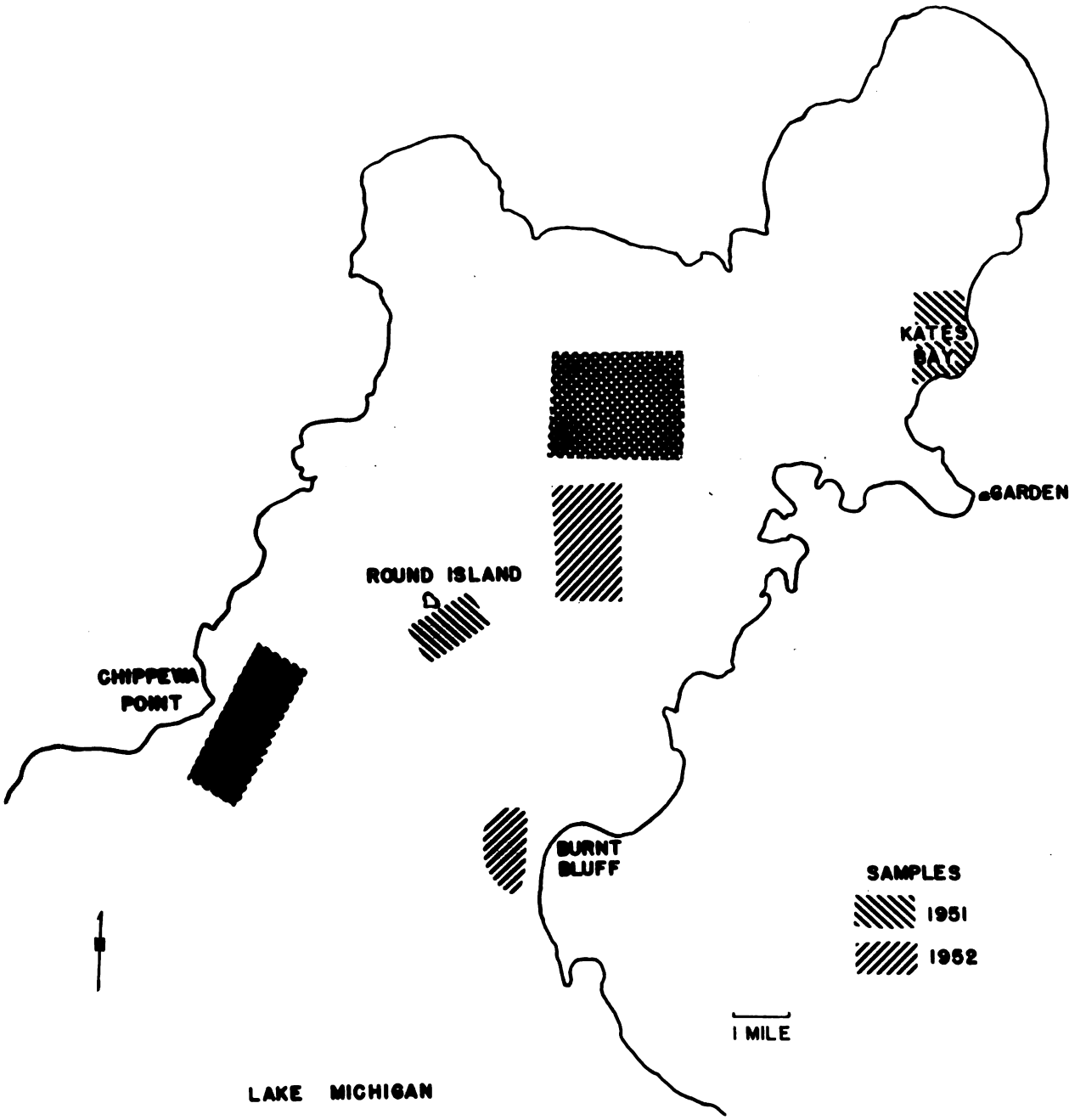

KATES BAY
GARDEN
ROUND ISLAND
CHIPPEWA POINT
BURNT BLUFF
SAMPLES
1951
1952
1 MILE
LAKE MICHIGAN

TABLE 1. Samples of Big Bay de Noc Whitefish Used in Age and Growth Studies

Date	Locality	Gear	Fish
1951			
Oct. 30	Kates Bay	trap nets	60
Nov. 1	Chippewa Point	trap nets	33
Nov. 1	Round Island	trap nets	19
Nov. 1	Big Hump	trap nets	43
Nov. 3	Kates Bay	trap nets	12
1952			
May 4	Middle Grounds	gill nets	83
May 5	Burnt Bluff	pound nets	93
May 7	Burnt Bluff	pound nets	92
May 7	Chippewa Point	pound nets	63
May 9	Big Hump	pound nets	80
May 9	Chippewa Point	pound nets	51
May 10	Burnt Bluff	pound nets	83
Sept. 9	Burnt Bluff	pound nets	13
Sept. 12	Burnt Bluff	pound nets	114

two pounds and were sold intact or "in the round" by the commercial fishermen.

Scale samples were taken from the left side of the fish, from an area just above the lateral line and immediately anterior to the dorsal fin. The scales were preserved in envelopes on which the catalog number assigned to the fish and information as to date, locality of catch, sex, length, weight, and other data were recorded. In the laboratory the scales were cleaned and mounted on glass slides in a solution of gelatin and glycerin. Scale reading was accomplished by projecting the image through a scale projection apparatus resembling the one used by Van Oosten, et al (1934). The positions of the essential scale features were recorded on Mc Bee Keysort cards having a millimeter rule printed along one edge. In measuring the radii of the annuli, the card was placed along the anterior radius of the scale image (x 29 approximately) with the zero mark on the calibrated edge at the focus of the scale. Without moving the card, the location of the annuli and the anterior margin of the scale were marked on the card. The card was coded with the catalog number of the fish, as designated on the scale slide, and was later used in determining the growth rates. Growth computations were made on the assumption that the body-scale ratio remained constant after the completion of the first annulus. A direct proportion nomograph, calibrated in millimeters, as described by Carlander and Smith (1944) was used to calculate

the annual growth from the scale measurements. For the back-calculation procedure, the value of "c", length of the fish when scales first appear, is set at 35-40 millimeters for the whitefish (Van Oosten, 1929).

In these calculations the value of "c" was set at 40 millimeters, to be consistent with the value used by Caraway (1951) in his study of the whitefish of Big Bay de Noc. Van Oosten (1923) established the validity of age determinations from whitefish scales and he also demonstrated that direct-proportion calculations of growth based on diameter measurements of the scale are satisfactorily accurate. Ages are expressed by Roman numerals and indicate the number of annuli on the scale. The year of life of the fish is one greater than the number of annuli present. A fish having two annuli visible on its scales is in the third year of life.

AGE COMPOSITION AND LENGTH-FREQUENCY DISTRIBUTIONS

In Tables 2-4, the whitefish have been placed in appropriate age groups and year classes, with the individuals of each age arranged according to their total length. The midpoints of the intervals of total length in millimeters are converted to total lengths in inches for each sample. The number of fish in each age group, the percentage of that number in the combined samples, and the average total length of the individuals in each group, as well as of the entire collection, are shown at the bottom of each table. The column at the extreme right of each table gives the total number of fish in each size group. In these tables the data of the 1951 collections have the sexes combined, and the 1952 data are composed of both sexed and non-sexed fish. In the work of Caraway (1951) the sexes were combined, and an analysis by Van Oosten (1939) showed that the length frequencies of the sexes were virtually the same within an age group. In this study the individual samples were combined to give a collection of more adequate size. The age composition and length-frequency distributions for each sample have also been determined and are included in the Appendix.

Collections of October-November, 1951

In the 1951 samples all the whitefish were taken in trap nets set by the commercial fishermen in Big Bay de Noc from October 30 to November 3. Fish from four localities (Kates

Bay, Chippewa Point, Big Hump, and Round Island) comprised the entire collection. Samples from the first three localities are so similar in age composition and length-frequency distributions that the data suggest the possibility of the fish all coming from the same or very similar populations. Age group II (1949 year class) fish constituted over 80 per cent of the total catch in these three samples and the remaining individuals were of age group III (1948 year class), except for one group I (1950 year class), the only whitefish of this age taken during the investigation. The Round Island sample was obtained on the same date as the Big Hump and Chippewa Point samples, but the age composition and length-frequency distribution of this sample are very different from the others in the 1951 collection. Although only nineteen fish came from the waters near Round Island, three of the specimens were older than age group III. No whitefish older than age group III were found among the remaining 148 individuals in the total collection of 1951. The bulk (57.8 per cent) of the Round Island sample consisted of age group III fish, and age group II represented only 26.3 per cent of the total number caught. A possible explanation for the greater age and size of the Round Island fish may be that the waters of this area are shallower than those of the other localities from which samples were obtained in 1951. Hart (1930, 1931) suggests that at certain times the larger forms of whitefish may frequent waters of less depth than those inhabited by the smaller forms. Since all of the fish in the 1951 collection were

taken during the spawning period, the greater proportion of mature individuals in the Round Island sample may also have been a factor tending to cause this apparently unequal distribution of the Big Bay de Noc whitefish.

The length-frequency distributions arranged according to age groups and intervals of total length for the whitefish in the combined collection of 1951 are given in Table 2. The bulk (98.2 per cent) of the samples ranged from 360 millimeters (14.2 inches) to 499 millimeters (19.7 inches) in total length, with an average length of 415 millimeters (16.3 inches). The smallest fish had a total length of 318 millimeters (12.5 inches) and belonged to age group I. This specimen represented the only whitefish of age group I taken in either 1951 or 1952. The largest fish had a total length of 597 millimeters (23.5 inches) and belonged to age group VII. The overlapping of the lengths of the age II and III individuals may be due to the selective action of the trap nets. Most of the age II whitefish weighed less than the legal limit of two pounds and were not retained by the nets but the larger fish would have had a greater chance of being captured.

Age group II dominates the sample (80.8 per cent) and age group III (16.8 per cent) represents the remainder of the 167 fish in the collection, except for four specimens representing age groups I, IV, VI, and VII. The 1946 year class (age group V) is not represented. This age group was quite abundant in the samples of Big Bay de Noc whitefish taken by

Caraway (1951) in September of 1949 and 1950. The complete absence of this age group in all of the 1951 and 1952 collections tends to indicate the efficiency of the intensive fishery for this species. Another possible explanation may be that these fish had moved out of the Big Bay de Noc area.

Collections of May, 1952

The 545 whitefish obtained during May, 1952 were taken in pound nets, except for the Middle Grounds sample of May 4 which was taken with gill nets, operated by the commercial fishermen in Big Bay de Noc. The sample from the gill nets was so nearly identical to the others taken during May that it was combined with them. The seven samples were obtained during the period May 4-10 and represent four localities (Middle Grounds, Burnt Bluff, Chippewa Point, and the Big Hump). The age composition of all the samples was very nearly identical except for the Burnt Bluff sample of May 5. All of the 93 fish collected on this date belonged to age group II (1949 year class). The length-frequency distributions arranged according to age groups and intervals of total length for the whitefish captured in Big Bay de Noc during May, 1952 are given in Table 3. The apparent discrepancy between age group and year class in the table headings is due to the fact that the annulus for 1952 had not yet formed on the scales. The year class was determined by assuming that this annulus was present, thus making the fish one year older than it appeared.

Table 2. Length-frequency Distribution of Big Bay de Noc Whitefish

(Samples of October 30-November 3, 1951. The sexes are combined.)

Total length interval[1]	Total length* (inches)	Age Group II	III	IV	VI	VII	Total
		Year Class 1949	1948	1947	1945	1944	
360-369	14.4	2					2
370-379	14.8	5					5
380-389	15.2	16					16
390-399	15.6	35					35
400-409	15.9	29					29
410-419	16.3	24	1				25
420-429	16.7	15					15
430-439	17.1	8	1				9
440-449	17.5		6				6
450-459	17.9	1	2				3
450-469	18.3		6				6
470-479	18.7		8				8
480-489	19.1		3		1		4
490-499	19.5		1				1
500-509	19.9						
510-519	20.3			1			1
...							
...							
590-599	23.4					1	1
Average total length (millimeters)		405	462	519	488	597	415
Average total length (inches)		15.9	18.2	20.4	19.2	23.5	16.3
Total number of fish		135	28	1	1	1	167
Percentage of total		80.8	16.8	0.8	0.8	0.8	100.0

[1] Millimeters
* Equivalent to midpoints of intervals of total length

In the combined collection the bulk (97.0 per cent) of the samples ranged from 380 millimeters (15.0 inches) to 529 millimeters (20.9 inches) in total length with an average length of 441 millimeters (17.3 inches). The smallest fish taken had a total length of 380 millimeters (15.0 inches) and belonged to age group II. The largest specimen had a total length of 647 millimeters (25.2 inches) and belonged to age group XI. This was the oldest whitefish taken during the investigation. Overlapping of the lengths of most of the age groups is probably due to the selectivity of the gear and the inadequate numbers of older fish.

Age group II (1949 year class) dominated the sample (80.2 per cent) and age group III (1948 year class) represented most (16.2 per cent) of the remaining fish in the collection. The youngest specimens belonged to age group II and the oldest to age group XI (1940 year class). Age group IV is represented by 1.1 per cent, VI group by 0.2 per cent, VII group by 0.2 per cent, VIII group, the third most abundant, by 1.7 per cent, IX group by 0.2 per cent, and XI group by 0.2 per cent. Age group V (1946 year class) and age group X (1941 year class) are not represented.

A comparison of the age composition of the 1951 collection with that of May, 1952 proved very interesting. The percentage of age II and III fish was almost identical in both collections. Age group II represented 80.8 per cent of the total catch in 1951 and 80.2 per cent in May, 1952. Age group

Table 3.—Length-frequency distribution of Big Bay de Noc whitefish.

(Samples of May 4 - 10, 1952. The sexes are combined.)

Total length 1/ interval	Total length* (inches)	Age group II	III	IV	VI	VII	VIII	IX	XI	Total
		Year class 1949	1948	1947	1945	1944	1943	1942	1940	
380-389	15.2	2	1							3
390-399	15.6	5	1							6
400-409	15.9	21								21
410-419	16.3	51								51
420-429	16.7	91								91
430-439	17.1	134	1							135
440-449	17.5	81	4							85
450-459	17.9	31	9							40
460-469	18.3	9	8							17
470-479	18.7		18	1						19
480-489	19.1	1	18							19
490-499	19.5		13							13
500-509	19.9		3	2						5
510-519	20.3		8							8
520-529	20.7		2							2
530-539	21.1			2						2
540-549	21.5									
550-559	21.9									
560-569	22.2									
570-579	22.6				1					1
580-589	23.0			1						1
590-599	23.4									
600-609	23.8									
610-619	24.2					1	3			4
620-629	24.6						3			3
630-639	25.0						1			1
640-649	25.4						2	1	1	4
Average total length (millimeters)		432	476	532	578	614	628	640	647	444
Average total length (inches)		16.6	18.9	21.1	22.8	24.2	24.7	25.2	25.5	17.5
Total number of fish		426	86	6	1	1	9	1	1	531
Percentage of total		80.2	16.2	1.1	0.2	0.2	1.7	0.2	0.2	100.0

* Equivalent to midpoints of intervals of total length

1/ Millimeters

III comprised 16.8 per cent of the total in 1951 as compared with 16.2 per cent in May, 1952. Age groups V and X were not represented in either sample. Age group VIII was the third most abundant group in the 1952 collection but it was not represented in the 1951 samples. This age group was one of the most dominant in the samples of Big Bay de Noc whitefish taken by Caraway during 1949 and 1950. Excluding age group VIII, no age group above IV was represented by more than one fish in either collection.

Collection of September, 1952.

This sample consisted of 127 whitefish taken from pound nets set in the waters off Burnt Bluff on September 9 and 12, 1952. Thirteen fish were obtained on September 9 and the others were captured on September 12. Length-frequency distributions and age composition for this collection are presented in Table 4. The fish ranged from 366 millimeters (14.4 inches) to 507 millimeters (20.2 inches) in total length with an average length of 459 millimeters (18.1 inches).

The catch was composed almost entirely of age group III (1949 year class) fish and only three individuals did not belong to this age group. The only age II specimen had a total length of 366 millimeters (14.4 inches). Two fish of age group IV had an average total length of 507 millimeters (20.2 inches). The age III whitefish had an average total length of 459 millimeters (18.1 inches).

Table 4. Length-frequency Distribution of Big Bay de Noc Whitefish

Total length interval (millimeters)	Total length* (inches)	Age group II	Age group III	Age group IV	Total
		Year class 1950	Year class 1949	Year class 1948	
360-369	14.4	1			1
...					
...					
420-429	16.7		2		2
430-439	17.1		7		7
440-449	17.5		32		32
450-459	17.9		33		33
460-469	18.3		22		22
470-479	18.7		16		16
480-489	19.1		8		8
490-499	19.5		2		2
500-509	19.9		2	2	4
Average total length (millimeters)		366	459	507	459
Average total length (inches)		14.4	18.1	20.1	18.1
Total number of fish		1	124	2	127
Percentage of total		0.8	97.6	1.6	100.0

* Equivalent to midpoints of total length intervals.

A comparison of the collections taken during May and September of 1952 shows a great increase in dominance by the fish of the 1949 year class in the September sample. This group represented 80.2 per cent of the May samples and comprised 97.6 per cent of the September catch. The 1948 year class composed 16.2 per cent of the May collection but was represented by only 1.6 per cent in the September samples.

STRENGTH OF AGE GROUPS AND YEAR CLASSES

Many problems are encountered in the determination of the relative abundance of the different age groups and year classes. Gear selectivity and the season of sampling are perhaps the main problems involved in this phase of the investigation. All the whitefish captured were used for these comparisons as the majority of the collections came from pound nets, and the 1951 samples taken in trap nets were included, since Van Oosten and Hile (1947) stated that the selective action of trap nets is similar to that of pound nets.

Although the data are inadequate to permit any definite conclusions, enough information is available so that certain year classes may be safely described as being of greater or less than average strength. An analysis of the age composition of the whitefish collected in 1951 and 1952 suggests the presence of certain year classes that may be termed relatively poor or relatively good. In Big Bay de Noc the year class of 1949 as the age group II of 1951 represented over 80 per cent of the samples and as the III group in 1952 it was even more dominant, comprising 97.6 per cent of the total collection (Figure 2, Tables 5-7). In contrast, the year class of 1946 was not represented in either 1951 or 1952.

Collections of October-November, 1951

The age compositions and percentage representations for the individual samples and the combined collection are given in Table 5. All the fish were taken in trap nets during the period October 30-November 3. The samples came from four localities (Kates Bay, Chippewa Point, Round Island, and Big Hump) in Big Bay de Noc. The percentage compositions of all the samples were very similar, except for the Round Island collection which contained most of the older fish. This was the only sample having any individuals older than age group III and, although this collection was made on the same date as those of Chippewa Point and Big Hump, the age composition was very different. The 1949 year class (age group II) was strongly dominant in all the other samples taken in 1951 but this group composed only 26.3 per cent of the Round Island fish. The 1948 year class (age group III) dominated this sample (57.8 per cent of the total) and age groups IV, VI, and VII each represented 5.3 per cent of the total. The Kates Bay collections appeared to contain a slightly higher percentage of age group II fish. The small sample of 12 specimens taken on November 3 was comprised entirely of age II individuals and the October 30 collection consisted of 93.3 per cent age II and 6.7 per cent age group III. In the combined collection it is evident that the 1949 year class (age II) is strongly dominant (80.8 per cent). The 1948 year class (III group) represents 16.8 per cent of the total and age groups I, IV, VI, and VII each comprise 0.6 per cent of

Table 5. Age Composition of the Samples of Big Bay de Noc Whitefish Taken During October-November, 1951

Date	Locality	I	II	III	IV	V	VI	VII	Fish
October 30	Kates Bay	0 (0)	93.3[1] (56)*	6.7 (4)	0 (0)	0 (0)	0 (0)	0 (0)	60
November 1	Chippewa Point	0 (0)	81.8 (27)	18.2 (6)	0 (0)	0 (0)	0 (0)	0 (0)	33
November 1	Round Island	0 (0)	26.3 (5)	57.8 (11)	5.3 (1)	0 (0)	5.3 (1)	5.3 (1)	19
November 1	Big Hump	2.3 (1)	81.4 (35)	16.3 (7)	0 (0)	0 (0)	0 (0)	0 (0)	43
November 3	Kates Bay	0 (0)	100.0 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	12
Total fish (combined)		(1)	(135)	(28)	(1)	(0)	(1)	(1)	167
Percentage (combined)		0.6	80.8	16.8	0.6	0	0.6	0.6	100.0

[1] Percentage

* Number of fish

the total catch. The 1946 year class (V group) is not represented in 1951 or 1952 and may be considered poor.

Collections of May, 1952

Age compositions and percentage representations for the individual samples and the combined collection are shown in Table 6. Most of the samples were very similar in age composition and the percentage composition of the combined collection is almost identical to that of the 1951 collection. The values agree very closely except for the 1943 class (VIII group), which is not represented in the 1951 data but was the third most abundant group (1.6 per cent) in the May, 1952 collection. The 1949 year class continued its strong dominance (80.8 per cent) with the 1948 year class representing the second most dominant group. Age group IV was the fourth most abundant (1.3 per cent), VII group (0.4 per cent) was fifth, and age groups VI, IX, and XI each represented 0.2 per cent of the total. The 1943 year class may be considered very successful on the basis of the nine specimens of age VIII taken in the May, 1952 collection. No other age group above IV was represented by more than two individuals. Caraway (1951) found that this year class was dominant in the samples of the Big Bay de Noc whitefish taken in 1949 and 1950.

Considering the individual samples, the Big Hump collection of May 9 is very similar in percentage composition to the Round Island sample of 1951, except that the 1948 year class is not as strongly represented in the Big Hump catch. Both samples contained the highest percentages of age III fish and

Table 6. Age Composition of the Samples of Big Bay de Noc Whitefish Taken During May, 1952

Date	Locality	II	III	IV	V	VI	VII	VIII	IX	X	XI	Fish
May 4	Middle Grounds	86.7[1] (72)*	12.0 (10)	0 (0)	0 (0)	0 (0)	1.3 (1)	0 (0)	0 (0)	0 (0)	0 (0)	83
May 5	Burnt Bluff	100.0 (93)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	93
May 7	Burnt Bluff	80.4 (74)	18.5 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1.1 (1)	0 (0)	0 (0)	92
May 7	Chippewa Point	73.0 (46)	22.2 (14)	1.6 (1)	0 (0)	0 (0)	0 (0)	1.6 (1)	0 (0)	0 (0)	1.6 (1)	63
May 9	Big Hump	62.5 (50)	28.7 (23)	3.7 (3)	0 (0)	1.3 (1)	1.3 (1)	2.5 (2)	0 (0)	0 (0)	0 (0)	80
May 9	Chippewa Point	78.4 (40)	19.6 (10)	2.0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	51
May 10	Burnt Bluff	73.5 (61)	16.9 (14)	2.4 (2)	0 (0)	0 (0)	0 (0)	7.2 (6)	0 (0)	0 (0)	0 (0)	83
Total fish (combined)		(436)	(88)	(7)	(0)	(1)	(2)	(9)	(1)	(0)	(1)	545
Percentage (combined)		80.0	16.1	1.3	0	0.2	0.4	1.6	0.2	0	0.2	100.0

[1] Percentage

* Number of fish

each had at least five different year classes represented. The Burnt Bluff sample taken on May 5 was composed of 93 fish of age II. A collection made at Burnt Bluff on May 7 had 80.4 per cent age II and 18.5 per cent age III. Caraway found a sharp fluctuation in the percentage composition of samples of whitefish taken on successive days from the waters near Burnt Bluff in September, 1950.

Collections of September, 1952

This sample was obtained on September 9 and 12 from the Burnt Bluff locality. Age composition and percentage representation of the catch are presented in Table 7. The importance of the age group III fish is very evident and the dominating influence of this very strong year class of 1948 is graphically illustrated in Figure 2, which shows the percentage representation of the different year classes. Age group IV (1948 year class) was still the second most abundant group but it decreased greatly in dominance (16.1 to 1.6 per cent) while age group III increased from 80.0 to 97.6 per cent. Much of this decline in representation by the IV group is probably due to the fact that most of the whitefish of this age are of legal size. The 1950 year class was represented by one specimen which comprised 0.8 per cent of the total catch.

Fluctuations in the strength of year classes of fishes have perplexed fishery biologists for many years. Investigators agree that the strength of the year class is determined very early in the life history of the fish but the problems

Table 7. Age Composition of the Samples of Big Bay de Noc Whitefish Taken During September, 1952

Date	Locality	II	III	IV	Fish
September 9	Burnt Bluff	0 (0)	100.0[1] (13)*	0 (0)	13
September 12	Burnt Bluff	0.9 (1)	97.3 (111)	1.8 (2)	114
Total fish (combined)		(1)	(124)	(2)	127
Percentage (combined)		0.8	97.6	1.6	100.0

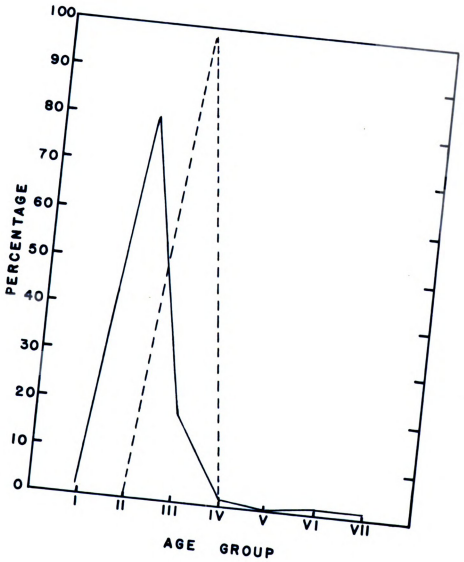
[1] Percentage

* Number of fish

Figure 2. Percentage Representation of the Different Age Groups of Big Bay de Noc Whitefish Taken During the Years Indicated.

1951, ——— ;

1952, - - - - ;


100
90
80
70
60
50
40
30
20
10
0
PERCENTAGE
I
II
III
IV
V
VI
VII
AGE GROUP

involved in determining the controlling factors are very complex. Meteorological factors which affect water conditions are considered to be very important in the determination of the strength of year classes but Van Oosten and Hile (1947) failed to find any indication of a correlation between meteorological-limnological conditions and fluctuations in the strength of year classes of Lake Erie whitefish. Much more information and work is needed before the numerous complex factors which determine the strength of year classes are fully understood.

CALCULATED GROWTH

The samples of Big Bay de Noc whitefish used for the comparisons of the calculated growth rates were taken in pound and trap nets during October and November of 1951 and May and September of 1952. For best comparisons, all the fish should have come from the same type of gear set at the same locations, but the data from these samples permit some general conclusions to be made. The numbers of older fish utilized for these comparisons were so small that the presence of only a few very fast or slow-growing individuals probably had a pronounced effect on the determination of calculated lengths in the later years of life. The lengths at capture and the calculated lengths at the end of each year of life are presented in Tables 8 to 10. The grand averages of lengths and the increments in length are included at the bottom of each table.

Collections of October-November, 1951

The samples were all taken during the period October 30-November 3, 1951 from four localities (Kates Bay, Round Island, Big Hump, and Chippewa Point) in Big Bay de Noc. All the data are from specimens captured in trap nets set by the commercial fishermen. The 1951 sample is heavily dominated by the age II fish, which represented over 80 per cent of the catch. Calculated lengths of age groups I and II have values higher than those of the first two years of life calculated from the

older fish captured in 1951 (Table 8). The greater lengths for these ages may be due to the inadequate numbers of age I fish and possibly gear selectivity could also have been a factor, especially with the age II individuals. The large value for age group II appears to indicate the presence of Lee's phenomenon, in which the younger fish tend to have higher calculated lengths for the earlier years of life than do older fish. This effect was also evident in the 1952 collections. Van Oosten and Hile (1947) found an indication of Lee's phenomenon in their study of Lake Erie whitefish but Kennedy (1943) stated that no evidence of the presence of this phenomenon existed in the whitefish of Lake Opeongo. The calculated lengths for ages III, IV, and VI are very similar for the first year but the growth in length of the age VI fish apparently was much less than that of ages III and IV after the first year. The low value for the first year of life of age group VII is probably a result of the small sample, although the fish did not appear to have a slow growth rate after the first year. This individual had the greatest increment in length after the second year of life. The collections of 1951 and 1952 exhibit a drastic fluctuation in the growth rates of different age groups from year to year. This may indicate an application of the "law of compensation of growth", which states that the smaller fish of an age group tend to grow faster than the larger members after the first year of life, but it is more likely caused by the small samples

Table 8. Average Length at Capture of the Whitefish Collected in Lake Michigan and the Average Calculated Lengths and Increments Attained by the Age Groups at the End of Each Year of Life

(Big Bay de Noc samples of October 30-November 3, 1951)
(The sexes are combined.)

Age group	Number of fish	Total length (millimeters	Total length (inches)	Calculated total length (millimeters) at end of year						
				1	2	3	4	5	6	7
I	1	318	12.5	180						
II	135	405	15.9	180	318					
III	28	462	18.2	155	285	400				
IV	1	519	20.4	160	278	400	465			
VI	1	488	19.2	150	241	350	368	443	470	
VII	1	597	23.5	113	230	345	468	505	543	580
I-VII	167	-	-	175	311	397	434	474	507	580
Annual increment in length				175	136	86	37	40	33	73
Average total length (inches)				6.9	12.2	15.6	17.1	18.7	20.0	22.8
Annual increment (inches)				6.9	5.3	3.4	1.5	1.6	1.3	2.8

which were obtained for most age groups. Van Oosten (1939) found that a growth compensation occurred in the Lake Huron whitefish but Kennedy failed to find this tendency in the whitefish of Lake Opeongo. With most of the better represented age groups, the advantage of size reached in the first year was usually maintained throughout life, although much of this difference in length may have been caused by the varying growth rates of the different year classes. Caraway (1951) found that the Big Bay de Noc whitefish taken in 1949 and 1950 appeared to maintain the first year size advantage throughout life.

Collections of May, 1952

These samples came from four localities (Middle Grounds, Burnt Bluff, Chippewa Point and Big Hump) in Big Bay de Noc. All of the fish were taken in pound nets operated by the commercial fishermen during the period May 4-10. Data pertaining to the calculated lengths of these fish are presented in Table 9. The catch was dominated by age group II, which formed over 80 per cent of the total number of fish. Age II (16.4 per cent) was the only other group adequately represented. The calculated lengths for most of the age groups are very similar, except for the low value of VI and the high value of age VII during the first year of life. The age groups above IV, with the exception of age VIII, cannot be accurately compared because of the small number of individuals representing these ages. The calculated lengths at the end of each

Table 9. Average Length at Capture of the Whitefish Collected in Big Bay de Noc and the Average Calculated Lengths and Increments Attained by the Age Groups at the End of Each Year of Life.

(Samples of May 4-10, 1952. The sexes are combined.)

Age group	Number of fish	Total length*	Total length (inches)	Calculated total length (millimeters) at end of year										
				1	2	3	4	5	6	7	8	9	10	11
II	436	432	17.0	184	318									
III	88	476	18.7	163	289	395								
IV	7	532	20.9	164	302	415	479							
VI	1	578	22.8	135	250	360	442	502	550					
VII	2	614	24.2	222	332	380	430	527	594	614				
VIII	9	628	24.7	153	276	377	455	503	540	578	608			
IX	1	640	25.2	185	332	457	560	580	591	600	612	625		
XI	1	647	25.5	160	310	420	485	515	540	565	583	607	625	640
II-XI	545			180	312	395	472	513	548	581	606	616	625	640
Annual increment in length				180	132	83	77	41	35	33	25	10	9	15
Average total length (inches)				7.1	12.3	15.6	18.6	20.2	21.6	229.	23.9	24.3	24.6	25.2
Annual increment (inches)				7.1	5.2	3.3	3.0	1.6	1.4	1.3	1.0	0.4	0.3	0.6

* Millimeters

year of life and the annual increments are very similar to those of the 1951 collection.

Collections of September, 1952

The whitefish comprising these samples came from the waters of Burnt Bluff during the period September 9-12. The entire catch was taken in pound nets set by the commercial fishermen. The calculated lengths and increments for this collection are given in Table 10. Age group III represented 97.6 per cent of the total catch. The low values for ages II and IV are probably a result of the inadequate representation by these age groups due to recruitment. The calculated lengths and annual increments compare favorably with those of the May, 1952 collection, and are even more similar to the values for the 1951 samples. Inspection of the annual increments shows that the whitefish grows rapidly during the first year of life and the length increment added during the second year is more than two-thirds that of the first year. The increment during the third year is almost one-half that of the first year of life and in the fourth and fifth years the increment decreases at a much slower rate. The grand average calculated total lengths at the end of each year of life are plotted in Figure 3.

The growth rate of Big Bay de Noc whitefish (Figures 4-5, Tables 11-13) compares very favorably with that of populations of this species in the other Great Lakes and Canada. Van Oosten (1939) found that in the Lake Huron whitefish the males

Table 10. Average Length at Capture of the Whitefish Collected in Lake Michigan and the Average Calculated Lengths and Increments Attained by the Age Groups at the End of Each Year of Life

(Big Bay de Noc samples of September 9-12, 1952. The sexes are combined)

Age group	Number of fish	Total length (millimeters)	Total length (inches)	Calculated total length (millimeters) at end of year 1	2	3	4
II	1	366	14.4	158	282		
III	124	459	18.1	172	299	406	
IV	2	507	20.0	151	284	410	475
II-IV	127	-	-	172	299	406	475
Annual increment in length				172	127	107	69
Average total length (inches)				6.8	11.8	16.0	18.7
Annual increment (inches)				6.8	5.0	4.2	2.7

Figure 3. Calculated Growth in Length of the Whitefish in Big Bay de Noc Based on Total Samples for the Dates Indicated. The sexes are combined.

November, 1951, ——;

May, 1952, — —;

September, 1952 ----;

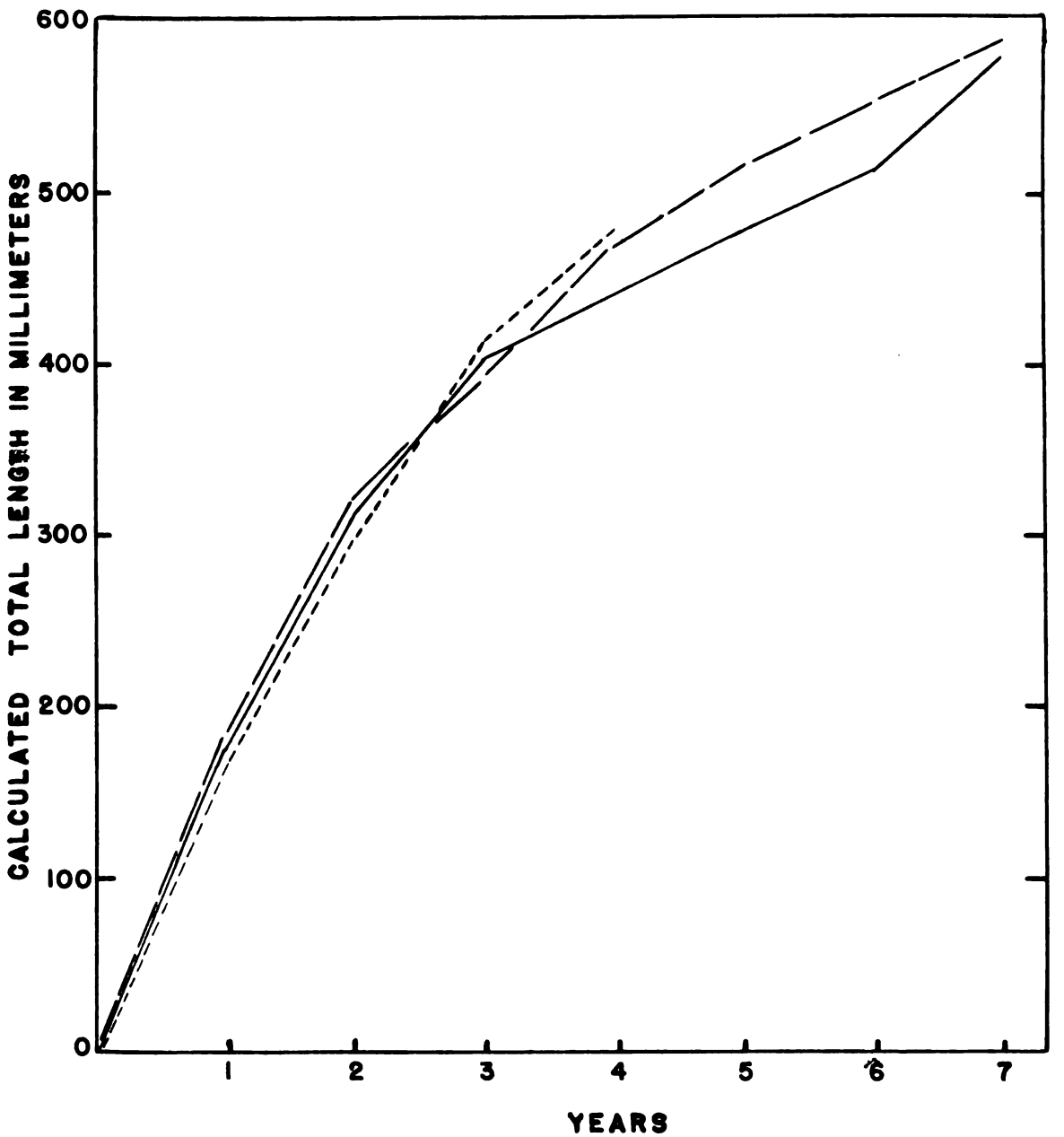

600
500
400
300
200
100
0
CALCULATED TOTAL LENGTH IN MILLIMETERS
1
2
3
4
5
6
7
YEARS

Figure 4. Observed Growth in Length of the Whitefish of Big Bay de Noc Based on Total Samples for the Dates Indicated. The sexes are combined.

November, 1951, ———;

May, 1952, - - - - -;

September, 1952, — —;

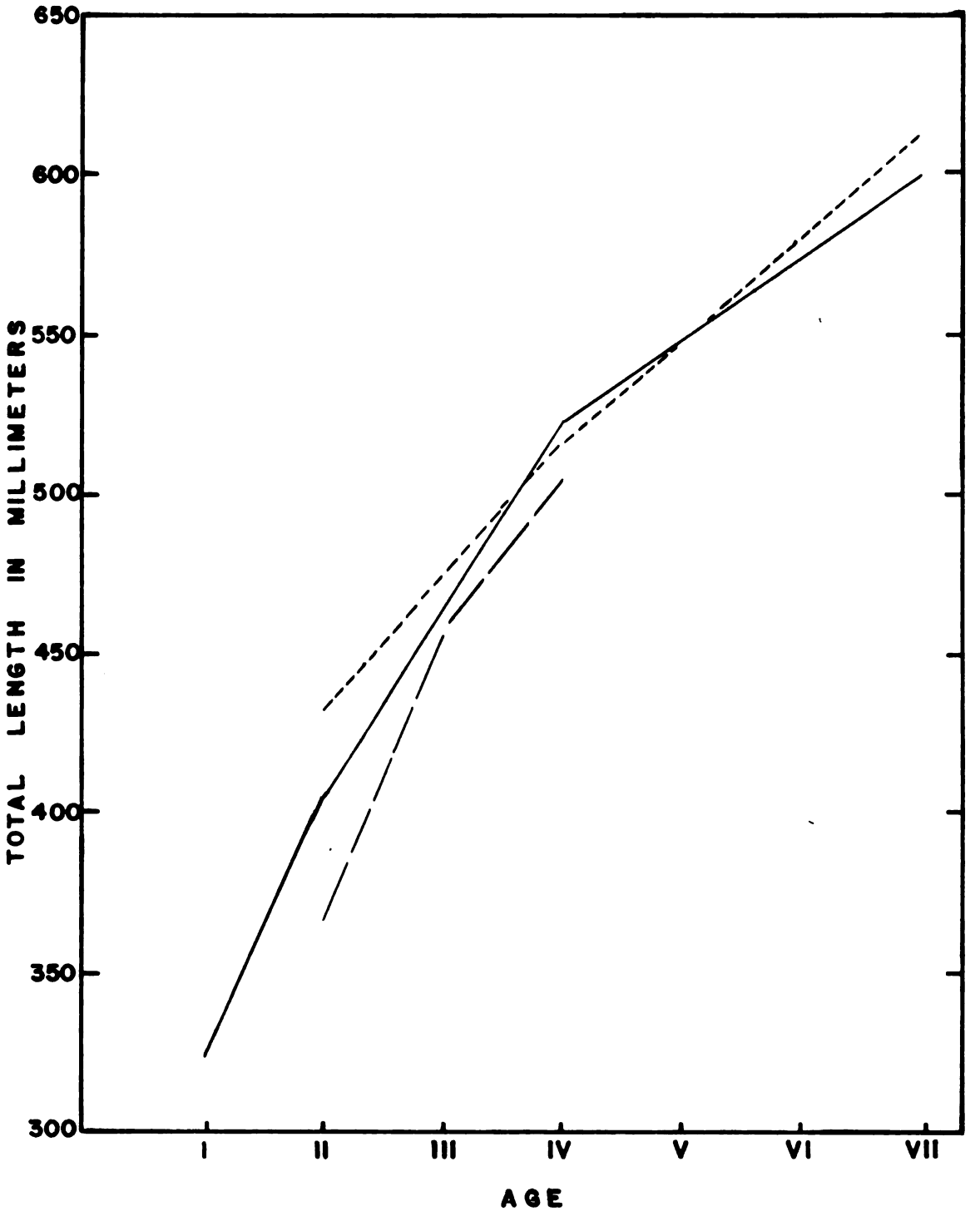

650
600
550
500
450
400
350
300
TOTAL LENGTH IN MILLIMETERS
I
II
III
IV
V
VI
VII
AGE

Figure 5. Average Weights of the Whitefish from Big Bay de Noc Based on Total Samples for the Dates Indicated. The sexes are combined.

November, 1951, - - - -;

May, 1952, — —;

September, 1952, ——;

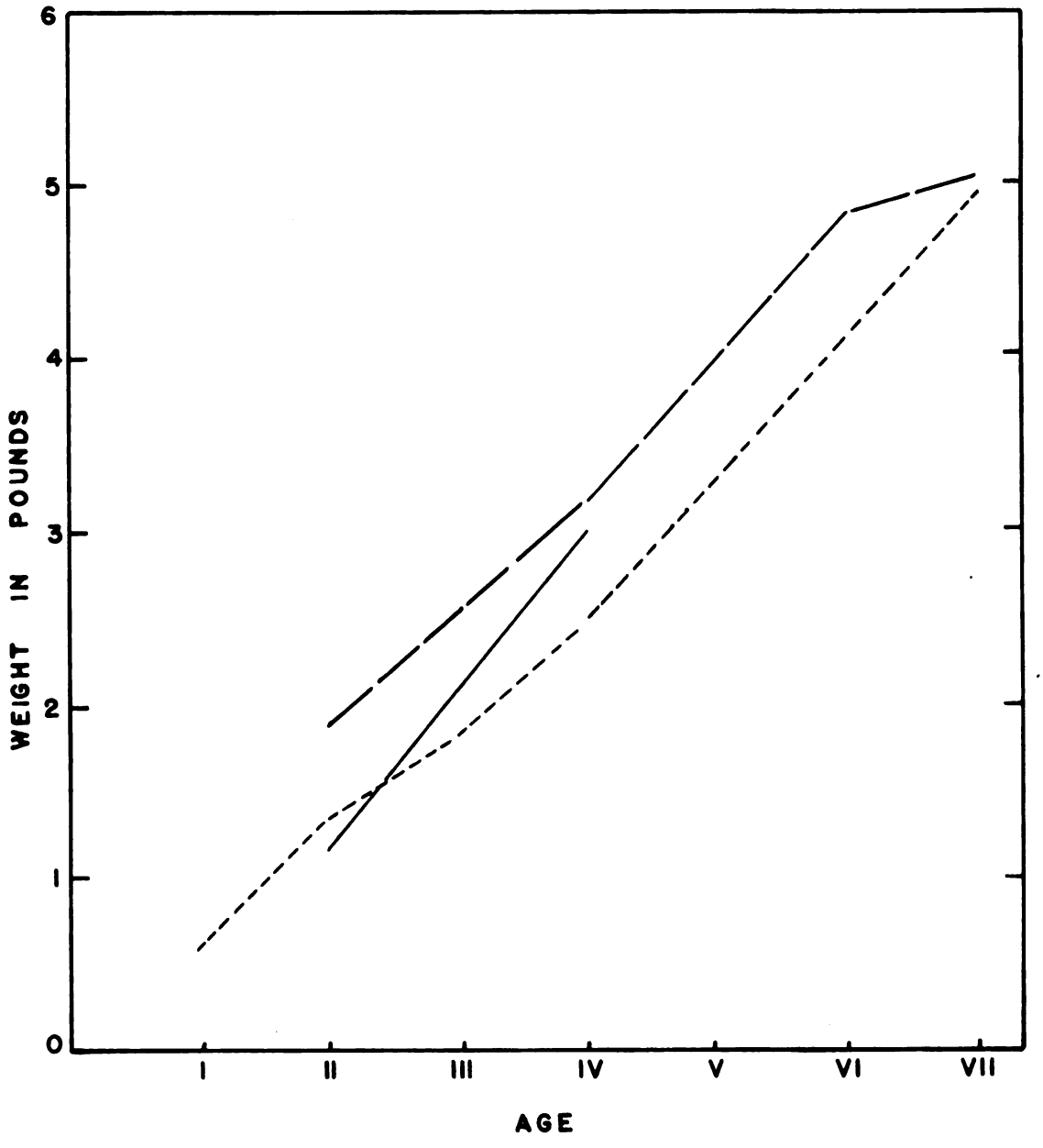

6
5
4
3
2
1
0
WEIGHT IN POUNDS
I
II
III
IV
V
VI
VII
AGE

Table 11. Average Weight in Pounds of the Big Bay de Noc Whitefish Taken During 1951.

Date	Locality	I	II	III	IV	V	VI	VII	Fish
October 30	Kates Bay	0 (0)	1.20[1] (56)*	1.72 (4)	0 (0)	0 (0)	0 (0)	0 (0)	60
November 1	Chippewa Point	0 (0)	1.28 (27)	1.70 (6)	0 (0)	0 (0)	0 (0)	0 (0)	33
November 1	Round Island	0 (0)	1.36 (5)	2.01 (11)	2.50 (1)	0 (0)	2.06 (1)	4.88 (1)	19
November 1	Big Hump	0.56 (1)	1.37 (35)	1.67 (7)	0 (0)	0 (0)	0 (0)	0 (0)	43
November 3	Kates Bay	0 (0)	1.16 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	12
Average weight (combined)		0.56	1.26	1.81	2.50	0	2.06	4.88	
Total fish (combined)		(1)	(135)	(28)	(1)	(0)	(1)	(1)	167

[1] Weight
* Number of fish

Table 12. Average Weight in Pounds of the Big Bay de Noc Whitefish Taken During May, 1952.

Date	Locality	II	III	IV	V	VI	VII	VIII	IX	X	XI	Fish
May 4	Middle Grounds	1.83[1] (72)*	2.22 (10)	- (0)	- (0)	- (0)	5.13 (1)	- (0)	- (0)	- (0)	- (0)	83
May 5	Burnt Bluff	1.64 (93)	- (0)	- (0)	- (0)	- (0)	- (0)	- (0)	- (0)	- (0)	- (0)	93
May 7	Burnt Bluff	1.90 (74)	2.50 (17)	- (0)	- (0)	- (0)	- (0)	- (0)	5.63 (1)	- (0)	- (0)	92
May 7	Chippewa Point	1.91 (46)	2.49 (14)	3.06 (1)	- (0)	- (0)	- (0)	5.69 (1)	- (0)	- (0)	6.63 (1)	63
May 9	Big Hump	1.96 (40)	2.53 (10)	3.54 (3)	- (0)	4.75 (1)	4.19 (1)	5.31 (2)	- (0)	- (0)	- (0)	80
May 9	Chippewa Point	1.95 (40)	2.44 (10)	2.88 (1)	- (0)	- (0)	- (0)	- (0)	- (0)	- (0)	- (0)	51
May 10	Burnt Bluff	1.98 (61)	2.51 (14)	2.66 (2)	- (0)	- (0)	- (0)	5.21 (6)	- (0)	- (0)	- (0)	83
Average weight (combined)		1.86	2.46	2.97	-	4.75	4.66	5.29	5.63	-	6.63	
Total fish (combined)		(436)	(88)	(7)	(0)	(1)	(2)	(9)	(1)	(0)	(1)	545

[1] Weight
* Number of fish

Table 13. Average Weight in Pounds of the Big Bay de Noc Whitefish Taken During September, 1952.

Date	Locality	II	III	IV	Fish
September 9	Burnt Bluff	- (0)*	33.2[1] (13)	- (0)	13
September 12	Burnt Bluff	17.0 (1)	33.3 (111)	47.5 (2)	114
Average weight (combined)		17.0	33.3	47.5	
Total fish (combined)		(1)	(124)	(2)	127

[1] Weight
* Number of fish

were sexually mature in the fifth year of life at a total length of 19.3 inches and a weight of 2.4 pounds. He also stated that the Lake Huron whitefish had a better growth rate than did those of Lake Erie and Lake Ontario. In the Big Bay de Noc whitefish, age group IV males had an average total length of 21.0 inches and an average weight of 2.95 pounds. Couch (1922) compares the growth rates of whitefish from Lake Erie, Lake Ontario and Hudson Bay, and Hile and Deason (1934) give a good comparison of the growth of whitefish populations in various localities in the United States and Canada.

LENGTH-WEIGHT RELATIONSHIP

The data for this relationship are based on the combined collections of whitefish from Big Bay de Noc. All fish were taken in trap and pound nets during October and November of 1951 and May and September of 1952. Length-weight relationships were obtained from 167 fish taken during the period October 30-November 3, 1951, 545 fish captured in May, 1952, and 127 fish taken in September, 1952. The sexes are combined. The individuals were placed in 10 millimeter length groups and the average standard lengths and weights were obtained for each group. Standard lengths in millimeters were converted from total lengths in inches using factors derived by Caraway (1951) for the whitefish of Big Bay de Noc.

The length-weight data of the Big Bay de Noc whitefish are fitted to the following formulae:

$$W = c(L)^n$$

$$\log W = \log c + n \log L$$

The values of n and log c are determined empirically using the method outlined by Lagler (1950). Regression lines are calculated for the two combined collections by methods presented by Snedecor (Sec. 6.10, 1946).

Collections of October-November, 1951
and September, 1952

The small numbers of fish in both these collections made it appear advisable to combine them, giving a fairly adequate sample of whitefish taken during the Fall. The formula expressing the length-weight relationship was calculated from the means of 16 size groups between 315 and 500 millimeters in standard length. The means are based on measurements from 294 fish. The values for these and the regression line calculated from them are plotted in Figure 6. Open circles indicate those groups represented by less than 5 individuals. The better represented size groups correspond very closely to a straight line. The length-weight relationship for the Big Bay de Noc whitefish of the 1951 and September, 1952 collections may be expressed by the formula:

$$\log W = -8.9333 + 3.4371 (\log L)$$

where W = weight in kilograms

and L = standard length in millimeters

Figure 8. Length-weight Relationship of Big Bay de Noc Whitefish Taken in November, 1951 and September, 1952.

The regression line was calculated from the size groups containing 5 or more fish (represented by black dots). Size groups containing less than 5 fish are represented by circles.

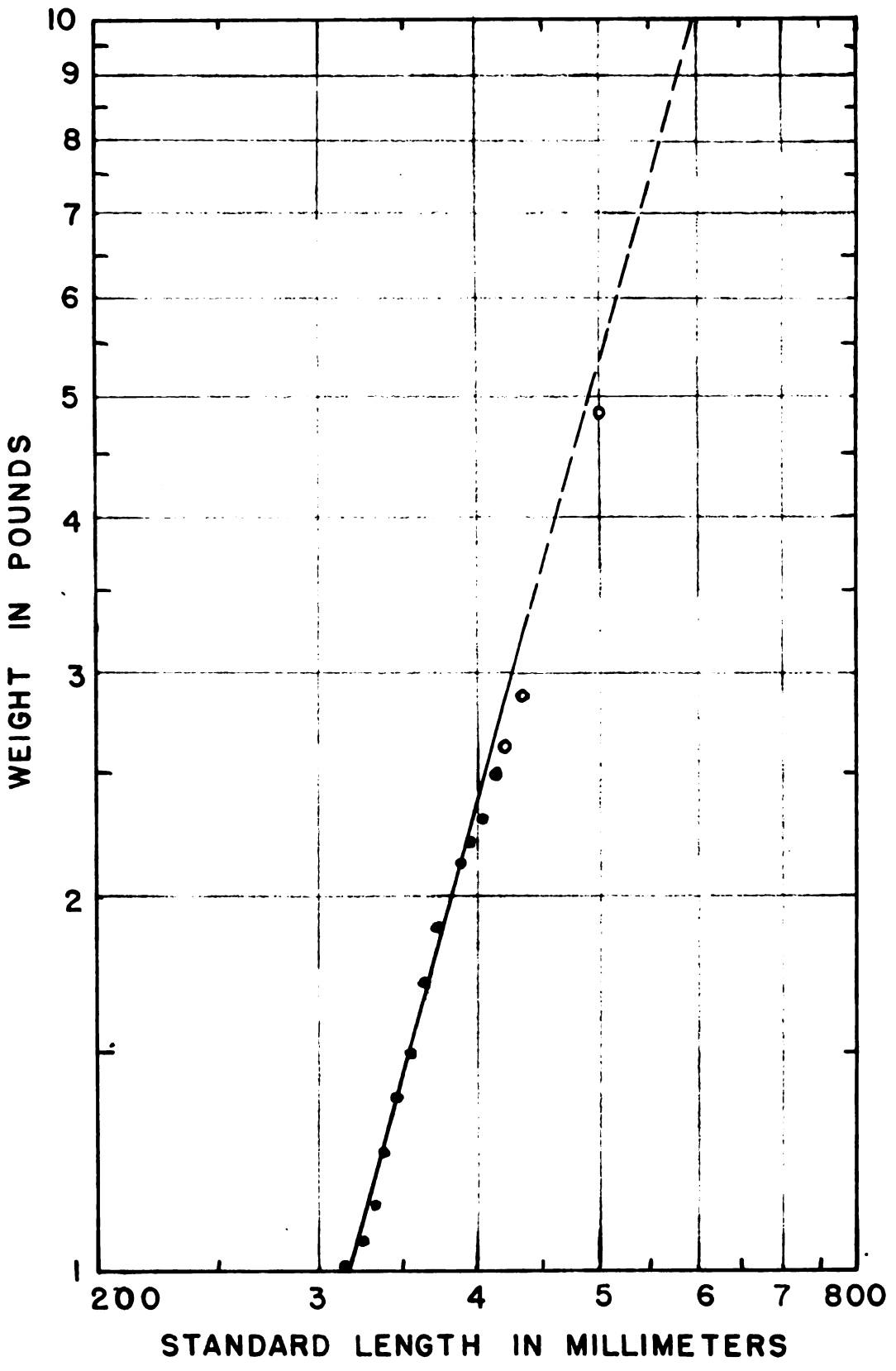
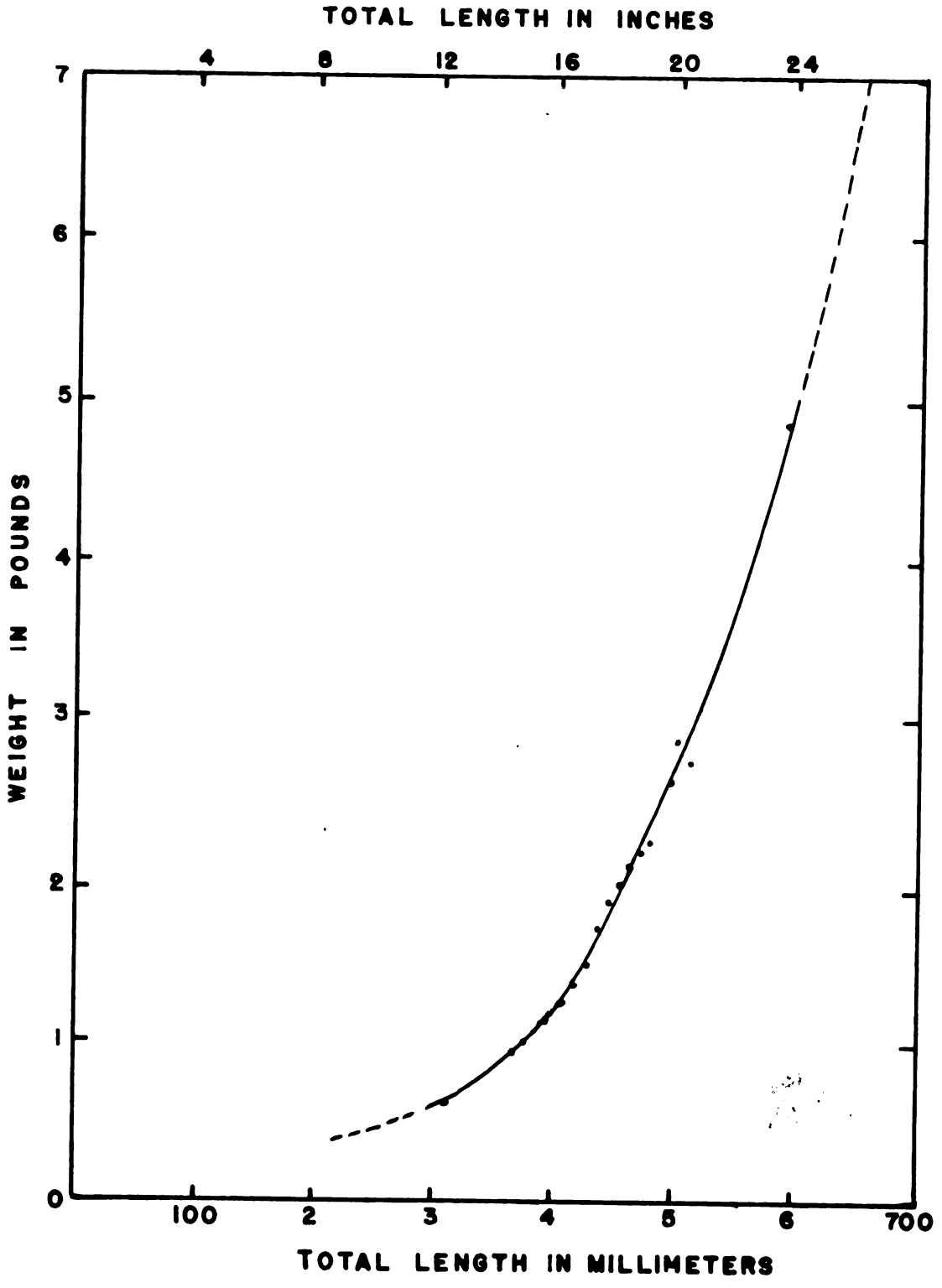

10
9
8
7
6
5
4
3
2
1
WEIGHT IN POUNDS
200
3
4
5
6
7
800
STANDARD LENGTH IN MILLIMETERS

Figure 7. Length-weight Relationship of Big Bay de Noc Whitefish Taken in November, 1951 and September, 1952.


TOTAL LENGTH IN INCHES
4
8
12
16
20
24
7
6
5
4
3
2
1
0
WEIGHT IN POUNDS
100
2
3
4
5
6
700
TOTAL LENGTH IN MILLIMETERS

Collections of May, 1952

The formula expressing the length-weight relationship was calculated from the means of 22 size groups between 323 and 540 millimeters in standard length. The means are based on measurements from 545 fish. The values for these and the regression line calculated from them are plotted in Figure 8.

The length-weight relationship for the Big Bay de Noc whitefish of the May, 1952 collections may be expressed by the formula:

$$\log W = -7.1858 + 2.7783 (\log L)$$

where W = weight in kilograms

and L = standard length in millimeters

Figure 8. Length-weight Relationship of Big Bay de Noc Whitefish Taken in May, 1952

The regression line was calculated from the size groups containing 5 or more fish (represented by black dots). Size groups containing less than 5 fish are represented by circles.

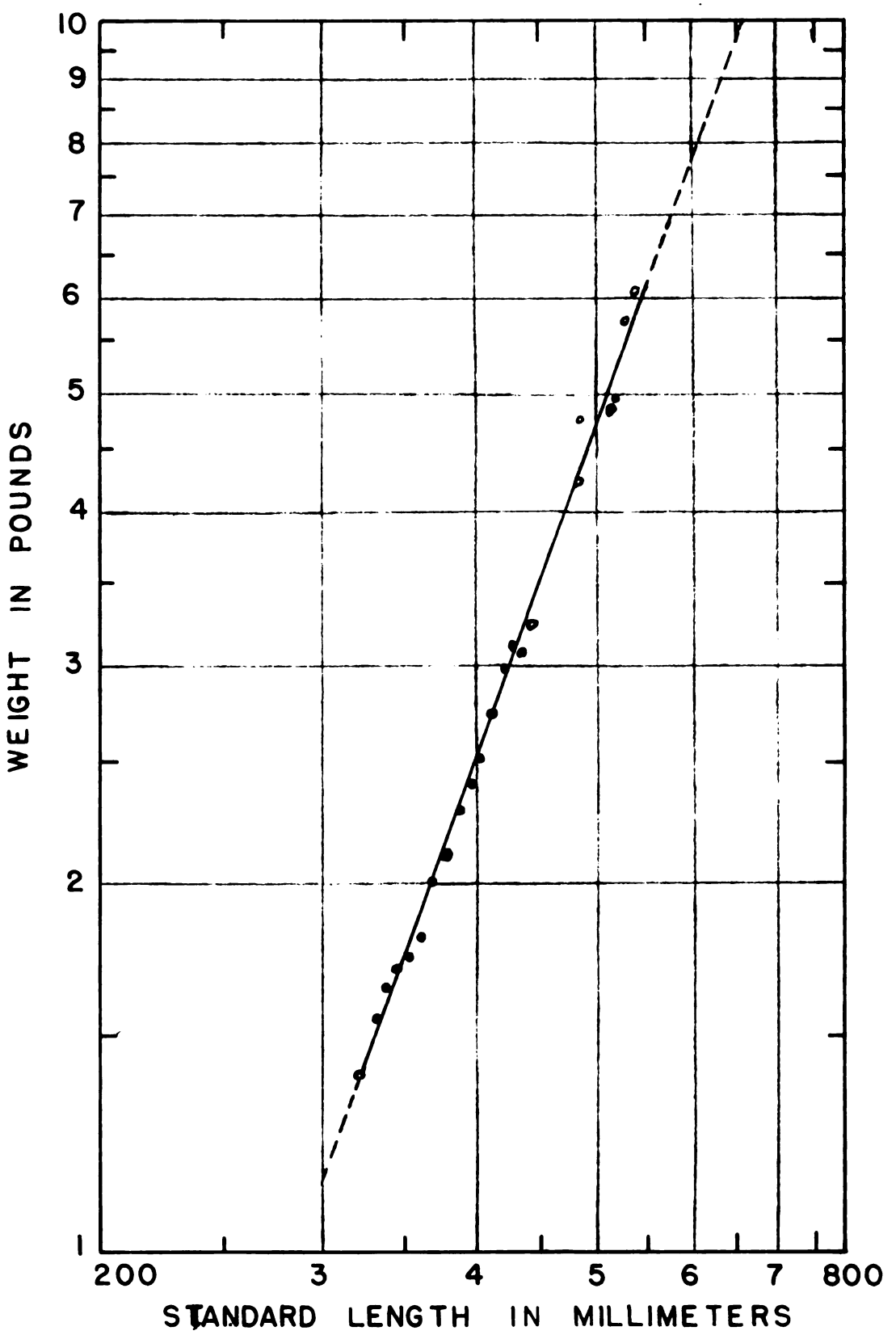
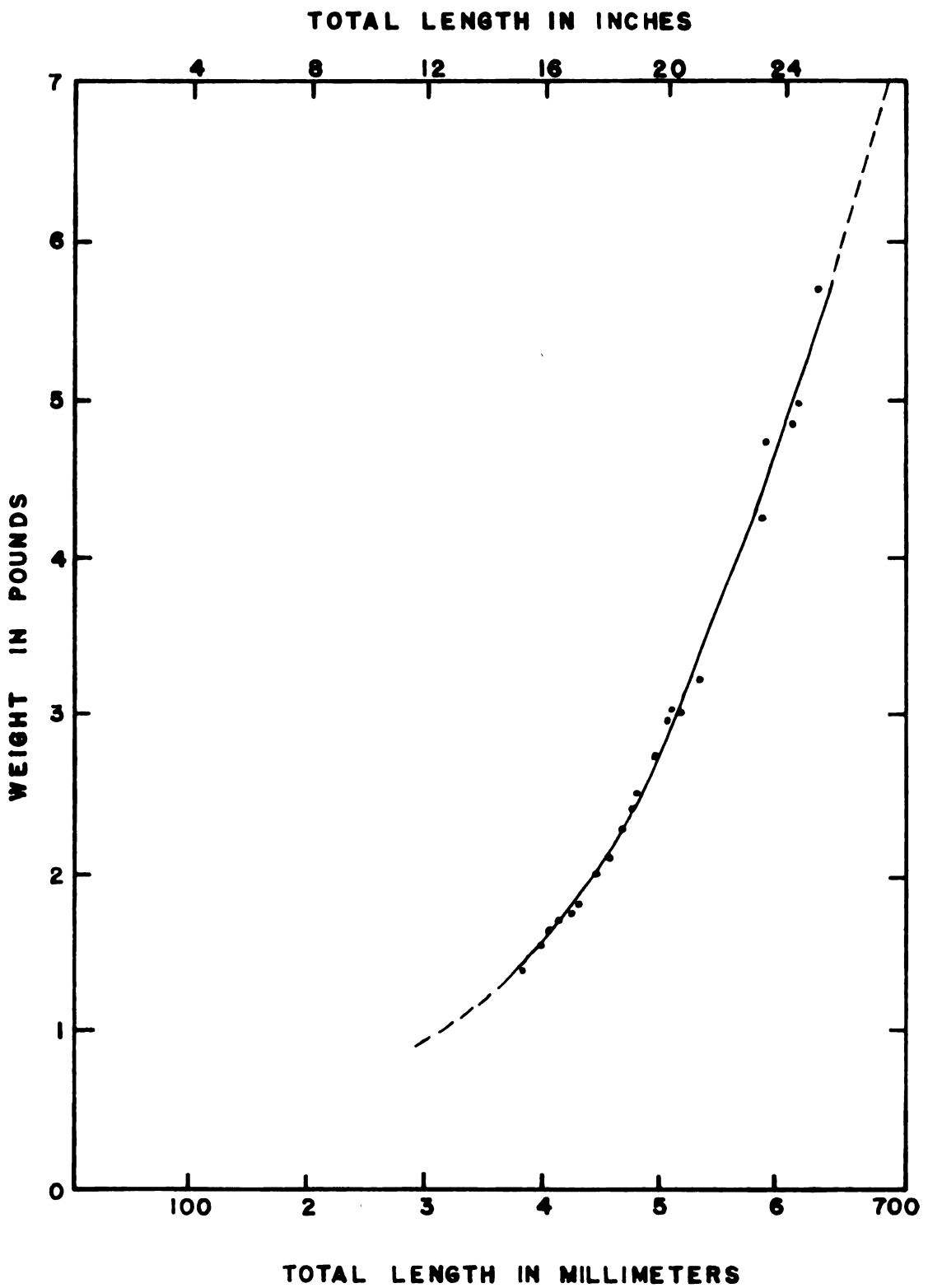

10
9
8
7
6
5
4
3
2
1
WEIGHT IN POUNDS
200
3
4
5
6
7
800
STANDARD LENGTH IN MILLIMETERS

Figure 9. Length-weight Relationship of Big Bay de Noc Whitefish taken in May, 1952


TOTAL LENGTH IN INCHES
4
8
12
16
20
24
7
6
5
4
3
2
1
0
WEIGHT IN POUNDS
100
2
3
4
5
6
700
TOTAL LENGTH IN MILLIMETERS

The formulae expressing the regression lines for length-weight relationships of fish for the two collection periods indicate a distinct advantage of the whitefish caught in 1951 and September of 1952 over the fish taken during May, 1952.

The weights of the Big Bay de Noc whitefish increased to the following powers of their lengths: collections of 1951 and May, 1952, 3.4371; collections of May, 1952, 2.7783. The departures from the theoretically ideal value of 3.0000 may indicate the poorer condition of the fish in the Spring than that attained in the Fall previous to spawning. Van Oosten and Hile (1947), using combined data taken throughout the year, give a value of 3.1523 for the Lake Erie whitefish. Hart (1932) found an average value of 3.4 for the whitefish of two lakes in Canada. He stated that the departure from the cube relationship was probably associated with the increase in proportionate depth and width with growth.

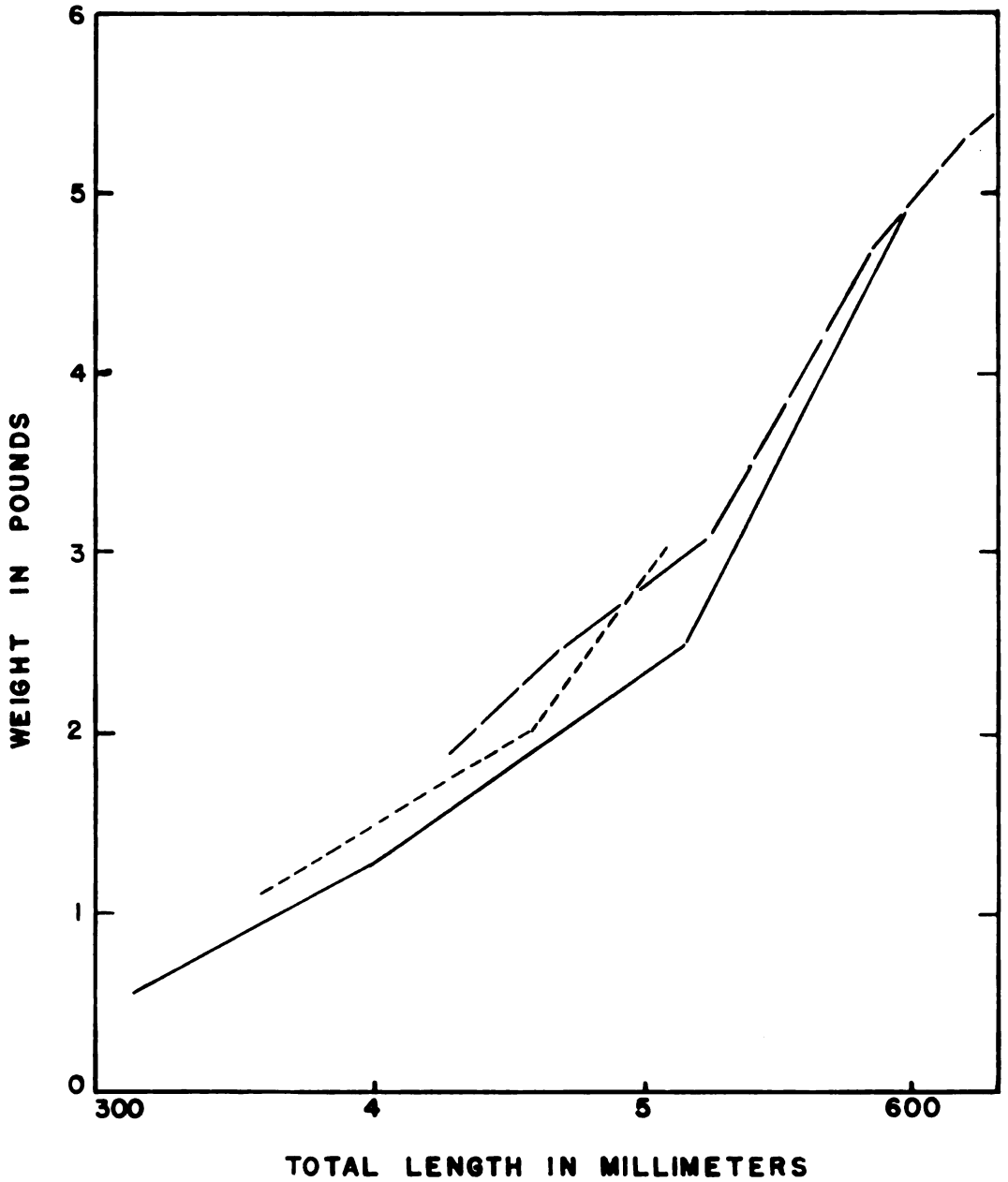
Comparative growth curves of the Big Bay de Noc whitefish taken during the two collection periods, based on average calculated lengths at the end of each year of life (Figure 3), exhibit a very similar relationship.

Figure 10. Observed Length-weight Relationships of the Big Bay de Noc Whitefish Taken During the Dates Indicated. The sexes are combined.

November, 1951 ——;

May, 1952 — —;

September, 1952 ----;


6
5
4
3
2
1
0
WEIGHT IN POUNDS
300
4
5
600
TOTAL LENGTH IN MILLIMETERS

COMPARISON OF SEXES

The collections of 1951 and the sample taken on May 7, 1952 have data on the sexes available, and permit analysis of several age groups on the basis of observed lengths and weights of the sexes.

Collections of 1951

This sample of 167 was almost completely dominated (96 per cent) by male whitefish. Age group II was composed of 134 males and one female. The females had a much better representation in age group III (24 males to 4 females) but they were still greatly outnumbered by the males. This distinct dominance by the male whitefish indicates that this sex probably precedes the females on the breeding grounds. The nearly equal distribution of the sexes in the May, 1952 collection also indicates that this unbalanced sex ratio may be due to different behavior by the sexes prior to spawning. Van Oosten (1939) found that the Fall collections of Lake Huron whitefish were strongly dominated by males, although a 50:50 sex ratio existed in the general population. Van Oosten and Deason (1938) found only a slight dominance by males in the spawning schools of Lake Champlain whitefish. The best represented age group (III) indicates that the females are slightly longer than the males of the same age group (0.4 inch). The observed weights of the females are

distinctly higher than those of the males. Females of age group III averaged 0.32 pound above weights of the males. The one female of age II was 1.0 inch longer than the average length of the males of the same age group and was 0.50 pound heavier. Four of the six females taken in the 1951 collection were captured near Round Island, which is the locality that produced most of the larger and older fish.

Collection of May, 1952

This sample consisted of 42 fish, of which 24 (57 per cent) were males. Age group II was composed of 20 males and 17 females and age III consisted of 4 males and 1 female. In age group II, the females had an advantage of 0.2 inch in length and they were 0.07 pound heavier than the males. The one female of age III was 1.8 inches longer than the average length of the males of the same age and the female had a weight advantage of 0.81 pound.

Bajkov (1930) found the same growth rate for both sexes in Lake Winnipeg whitefish, and Hart (1931) stated that the growth rates for both sexes of Lake Nipigon whitefish were similar. Most studies reveal that the rate of growth in length for both sexes is nearly equal, but the females tend to be slightly heavier than the males at corresponding lengths and ages.

SUMMARY

1. This study was based on whitefish, Coregonus clupeaformis (Mitchill), taken from the Big Bay de Noc waters of Lake Michigan. Data were obtained from 839 specimens caught in pound and trap nets set by the commercial fishermen during portions of 1951 and 1952.

2. Age composition, growth in length and weight, and strength of year classes for collections taken during the periods October 30-November 3, 1951, May 4-10, 1952, and September 9-13, 1952 are presented.

3. Length-frequency distributions arranged according to age of fish are given for each sample. The lengths of fish belonging to the older age groups exhibit considerable overlapping.

4. In the 1951 collections year class 1949 (age group II) dominated the catch, comprising over 80 per cent of the total number of fish. The 1948 year class (age group III) represented 17 per cent of the catch. The 1946 year class was not recorded in any of the samples.

5. The collections of May, 1952 were very similar to those of 1951, except that the greater number of fish gave better representation by the older age groups. Age II made up 80 per cent and age III formed 16 per cent of the total catch. The 1943 year class (age VIII) was represented by 9 individuals (1.7 per cent). Year classes 1946 and 1941 (ages

V and X respectively) were not recorded in any of the catches sampled.

6. The collections of September, 1952 were almost completely dominated by the very strong 1949 year class. As age group III, this year class comprised 97.6 per cent of the total catch. Age II (0.8 per cent) and age IV (1.6 per cent) were the only other age groups represented.

7. Calculated total lengths for each year of life are presented. Lengths and increments for the same ages in the different collections are very similar. Growth in length is most rapid during the first year. Increments in length during the second and third years decrease but are approximately one-half that of the first year.

8. The length-weight relationship of the 1951 and September, 1952 collections of Big Bay de Noc whitefish with standard lengths of 315 to 500 millimeters may be expressed by the equation:

$$\log W = -8.9333 + 3.4371 (\log L)$$

9. The length-weight relationship of the May, 1952 collections of Big Bay de Noc whitefish with standard lengths of 323 to 540 millimeters may be expressed by the equation:

$$\log W = -7.1858 + 2.7783 (\log L)$$

10. The 1951 collections were heavily dominated by male whitefish (96 per cent) although a sample taken in May, 1952 had almost equal representation of the sexes. The data indicate that male whitefish probably precede the females on the spawning grounds.

11. Both sexes had similar growth rates in length but the females tended to be slightly heavier than the males at corresponding lengths and ages in the Fall.

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APPENDIX

Original Data of the 1951 and

1952 Collections

Total lengths are expressed in millimeters.

Weights are expressed in pounds.

Length-frequency Distribution of Big Bay de Noc Whitefish.

(Kates Bay samples of October 30-November 3, 1951.
(The sexes are combined.)

Total length interval (millimeters)	Total length* (inches)	Age group II	Age group III	Total
		Year class 1949	Year class 1948	
360-369	14.4	1		1
370-379	14.8	1		1
380-389	15.2	15		15
390-399	15.6	24		24
400-409	15.9	11		11
410-419	16.3	7		7
420-429	16.7	4		4
430-439	17.1	5		5
440-449	17.5			
450-459	17.9		1	1
460-469	18.3		1	1
470-479	18.7		2	2
Average total length (millimeters)		400	466	404
Average total length (inches)		15.7	18.3	15.9
Total number of fish		68	4	72
Percentage of total		94.4	5.6	100.0

* Equivalent to midpoints of intervals of total length.

Table - Length-frequency distribution of Big Bay de Noc whitefish.

(Big Hump sample of May 9, 1952. The sexes are combined.)

Total length interval 1/	Total length* (inches)	Age group II	III	IV	VI	VII	VIII	Total
		Year class 1949	1948	1947	1945	1944	1943	
410-419	16.3	3						3
420-429	16.7	9						9
430-439	17.1	12						12
440-449	17.5	17						17
450-459	17.9	7	3					10
460-469	18.3	1	3					4
470-479	18.7		6					6
480-489	19.1	1	6					7
490-499	19.5		3					3
500-509	19.9			1				1
510-519	20.3		1					1
520-529	20.7		1					1
530-539	21.1			1				1
540-549	21.5							
550-559	21.9							
560-569	22.2							
570-579	22.6				1			1
580-589	23.0			1				1
590-599	23.4							
600-609	23.8							
610-619	24.2					1	1	2
620-629	24.6							
630-639	25.0							
640-649	25.4						1	1
Average total length (millimeters)		439	480	539	578	612	632	460
Average total length (inches)		17.3	18.9	21.2	22.8	24.1	24.9	18.1
Total number of fish		50	23	3	1	1	2	80
Percentage of total		62.5	28.7	3.7	1.3	1.3	2.5	100.0

* Equivalent to midpoints of intervals of total length

1/ Millimeters

Length-frequency Distribution of Big Bay de Noc Whitefish.

(Burnt Bluff sample of May 10, 1952.)
(The sexes are combined.)

Total length interval (millimeters)	Total length* (inches)	Age group II	III	IV	VIII	Total
		Year class 1949	1948	1947	1943	
420-429	16.7	6				6
430-439	17.1	22				2
440-449	17.5	23	1			24
450-459	17.9	8				8
460-469	18.3	2	1			3
470-479	18.7		4	1		5
480-489	19.1		2			2
490-499	19.5		2			2
500-509	19.9		2	1		3
510-519	20.3		2			2
...						
...						
610-619	24.2				1	1
620-629	24.6				3	3
630-639	25.0				1	1
640-649	25.4				1	1
Average total length (millimeters)		440	485	490	629	462
Average total length (inches)		17.3	19.1	19.3	24.8	18.2
Total number of fish		61	14	2	6	83
Percentage of total		73.5	16.9	2.4	7.2	100.0

* Equivalent to midpoints of intervals of total length.

Weight-length Relationship of Big Bay de Noc Whitefish

Taken During September, 1952 and October-November, 1951

Total length interval (millimeters	Number of fish	Average total length (millimeters)	(inches)	Average weight (ounces)	(pounds)
310-319	1	318	12.5	9.0	0.56
...					
...					
360-369	3	367	14.4	15.0	0.94
370-379	5	375	14.8	16.0	1.00
380-389	16	385	15.2	17.0	1.06
390-399	35	395	15.6	18.1	1.13
400-409	29	405	15.9	20.0	1.25
410-419	25	415	16.3	22.1	1.38
420-429	17	423	16.7	24.0	1.50
430-439	16	435	17.1	27.0	1.69
440-449	38	445	17.5	30.1	1.88
450-459	36	455	17.9	32.0	2.00
460-469	28	465	18.3	34.1	2.13
470-479	24	473	19.6	35.0	2.19
480-489	12	484	19.1	37.0	2.31
490-499	3	493	19.4	42.1	2.63
500-509	4	504	19.8	46.1	2.88
510-519	1	519	20.4	40.0	2.50
...					
...					
590-599	1	597	23.5	78.0	4.88

Weight-length Relationship of Big Bay de Noc Whitefish Taken During May, 1952.

Total length interval (millimeters	Number of fish	Average total length (millimeters)	(inches)	Average weight (ounces)	(pounds)
380-389	3	387	15.2	22.0	1.38
390-399	6	396	15.6	25.0	1.56
400-409	21	404	15.9	26.0	1.63
410-419	51	414	16.3	27.0	1.69
420-429	91	423	16.7	27.2	1.72
430-439	135	434	17.1	29.0	1.81
440-449	85	443	17.4	31.8	2.00
450-459	40	455	17.9	33.6	2.10
460-469	17	465	18.3	36.4	2.28
470-479	19	475	18.7	38.4	2.40
480-489	19	483	19.0	40.3	2.52
490-499	13	494	19.4	43.8	2.74
500-509	5	506	19.9	47.6	2.98
510-519	8	514	20.2	49.1	3.07
520-529	2	521	20.5	49.0	3.06
530-539	2	530	20.9	51.5	3.22
...					
...					
570-579	1	578	22.8	76.0	4.75
580-589	1	581	22.9	68.0	4.25
...					
...					
610-619	4	616	24.3	77.8	4.86
620-629	3	621	24.5	79.0	4.94
630-639	1	635	25.0	91.0	5.69
640-649	4	644	25.4	97.0	6.06

Kates Bay October 30, 1951

Catalog Number	Weight	Total Length	Catalog Number	Weight	Total Length
3406	1.56	421	3436	1.13	395
4507	1.56	407	3437	1.06	382
3408	1.75	467	3438	1.13	395
3409	1.75	471	3439	1.06	384
3410	1.56	434	3440	1.19	412
3411	1.50	425	3441	1.13	396
3412	1.63	452	3442	1.13	396
3413	1.38	411	3443	1.56	433
3414	1.56	438	3444	1.19	395
3415	1.75	472	3445	1.13	393
3416	1.38	419	3446	1.19	399
3417	1.75	436	3447	1.19	402
3418	1.63	438	3448	1.25	412
3419	1.00	385	3449	1.38	389
3420	1.06	392	3450	1.06	390
3421	1.06	390	3451	1.19	407
3422	1.00	379	3452	1.06	381
3423	1.00	385	3453	1.13	388
3424	1.19	405	3454	1.19	402
3425	1.19	402	3455	1.31	413
3426	1.13	389	3456	1.25	394
3427	1.00	385	3457	1.13	384
3428	1.00	392	3458	1.13	399
3429	1.06	387	3459	1.44	426
3430	1.00	391	3460	1.38	416
3431	1.06	382	3461	1.25	403
3432	1.00	380	3462	1.00	387
3433	1.19	399	3463	1.00	391
3434	0.88	369	3464	1.00	401
3435	1.13	399	3465	1.13	399

Chippewa Point November 1, 1951

Catalog Number	Weight	Total Length
3466	1.25	405
3467	1.88	463
3468	1.19	407
3469	1.56	441
3470	1.81	443
3471	1.56	436
3472	1.44	393
3473	1.44	401
3474	1.31	409
3475	1.38	420
3476	1.50	418
3477	1.38	417
3478	1.13	403
3479	0.94	373
3480	0.94	367
3481	1.50	428
3482	1.25	408
3483	1.81	460
3484	1.38	416
3485	1.38	412
3486	1.38	417
3487	0.94	387
3488	1.00	375
3489	1.31	409
3490	1.81	470
3491	1.06	406
3492	1.38	416
3493	1.38	413
3494	1.44	420
3495	1.19	400
3496	1.31	432
3497	1.31	420
3498	1.69	428

Round Island November 1, 1951

Catalog Number	Weight	Total Length
3499	1.19	394
3500	1.38	413
3501	1.19	396
3502	1.38	413
3503	1.50	425
3504	1.81	447
3505	1.63	458
3506	1.94	474
3507	2.06	481
3508	1.94	475
3509	1.94	481
3510	4.88	597
3511	2.00	488
3512	2.13	487
3513	2.31	493
3514	2.25	470
3515	2.06	468
3516	2.50	519
3517	2.06	488

Big Hump November 1, 1951

Catalog Number	Weight	Total Length
3518	1.88	472
3519	1.81	460
3520	1.75	430
3521	1.88	472
3522	0.56	318
3523	0.88	373
3524	1.13	396
3525	1.19	410
3526	1.31	407
3527	1.38	418
3528	1.69	441
3529	1.31	408
3530	1.13	397
3531	1.38	412
3532	1.81	427
3533	1.56	418
3534	1.63	447
3535	1.38	405
3536	1.06	377
3537	1.25	402
3538	1.56	449
3539	1.38	421
3540	1.25	410
3541	1.19	395
3542	1.44	408
3543	1.19	398
3544	1.75	456
3545	1.81	422
3546	1.25	417
3547	1.31	420
3548	1.31	398
3549	1.38	417
3550	1.44	404
3551	1.31	400
3552	1.38	401
3553	1.13	391
3554	1.63	423
3555	1.25	396
3556	1.44	415
3557	1.31	399
3558	1.38	408
3559	1.44	418
3560	1.69	433

Kates Bay November 3, 1951

Catalog Number	Weight	Total Length
3562	1.13	400
3563	1.13	390
3564	0.94	385
3565	1.13	393
3566	1.13	395
3567	1.38	415
3568	1.06	393
3569	1.13	396
3570	1.25	398
3571	1.38	421
3572	1.13	402
3573	-	-
3574	1.19	408

Middle Grounds May 4, 1952

Catalog Number	Weight	Total Length
3575	5.13	615
3576	1.81	420
3577	1.19	385
3578	1.69	405
3579	2.06	435
3580	1.88	415
3581	2.00	423
3582	1.69	404
3583	2.19	440
3584	2.25	440
3585	2.13	437
3586	2.38	480
3587	2.06	437
3588	2.31	455
3589	1.75	398
3590	2.69	490
3591	1.94	428
3592	2.19	438
3593	1.75	415
3594	2.13	440
3595	1.63	415
3596	2.00	436
3597	2.00	430
3598	1.88	432
3599	1.56	398
3600	1.56	395
3601	1.75	415
3602	1.69	422
3603	1.81	423
3604	2.06	445
3605	2.50	393
3606	1.50	407
3607	1.56	400
3608	1.81	410
3609	2.00	435
3610	1.81	397
3611	1.63	410
3612	1.56	422
3613	1.75	424
3614	1.50	395
3615	2.50	475
3616	1.81	430
3617	2.19	445
3618	2.13	427
3619	1.75	410
3620	1.81	425
3621	1.75	417
3622	1.75	420
3623	2.00	435
3624	1.88	423
3625	1.75	425
3626	2.44	476
3627	1.63	403
3628	1.75	425
3629	1.63	413
3630	1.88	418
3631	1.63	415
3632	1.88	420
3633	1.50	405
3634	1.63	410
3635	1.69	407
3636	2.00	435
3637	1.69	404
3638	1.69	405
3639	1.75	420
3640	1.75	428
3641	1.63	405
3642	2.00	440
3643	3.19	512
3644	3.44	448
3645	2.00	432
3646	1.81	425
3647	1.88	430
3648	1.50	388
3649	2.00	440
3640	1.63	400
3651	1.75	415
3652	1.69	416
3653	2.19	447
3654	1.63	405
3655	1.63	404
3656	1.75	423
3657	2.13	438

Burnt Bluff May 5, 1952

Catalog Number	Weight	Total Length
3658	1.69	424
3659	1.69	438
3660	1.56	415
3661	1.69	435
3662	1.63	425
3663	1.63	437
3664	1.63	430
3665	1.69	420
3666	1.63	415
3667	1.63	412
3668	1.56	418
3669	1.69	430
3670	1.69	431
3671	1.63	418
3672	1.69	421
3673	1.63	422
3674	1.75	417
3675	1.63	407
3676	1.56	427
3677	1.63	431
3678	1.63	423
3679	1.63	427
3680	1.63	400
3681	1.63	425
3682	1.69	430
3683	1.63	430
3684	1.50	406
3685	1.56	410
3686	1.69	427
3687	1.50	409
3688	1.63	420
3689	1.69	417
3690	1.69	427
3691	1.63	418
3692	1.63	425
3693	1.69	421
3694	1.63	410
3695	1.63	414
3696	1.56	428
3697	1.63	420
3698	1.69	413
3699	1.63	430
3700	1.69	415
3701	1.63	432
3702	1.69	417
3703	1.69	432
3704	1.56	404
3705	1.69	432
3706	1.75	430
3707	1.69	425
3708	1.69	420
3709	1.56	412
3710	1.75	420
3711	1.69	430
3712	1.69	430
3713	1.69	430
3714	1.56	415
3715	1.75	432
3716	1.69	434
3717	1.63	425
3718	1.56	405
3719	1.69	430
3720	1.69	425
3721	1.75	432
3722	1.69	438
3723	1.63	403
3724	1.69	421
3725	1.69	415
3726	1.50	421
3727	1.69	418
3728	1.69	414
3729	1.69	418
3730	1.69	435
3731	1.69	413
3732	1.69	420
3733	1.63	421
3734	1.63	417
3735	1.69	435
3736	1.50	414
3737	1.63	420
3738	1.63	435
3739	1.69	427
3740	1.63	426
3741	1.50	415
3742	1.56	412
3743	1.56	425
3744	1.56	422
3745	1.63	437
3746	1.63	445
3747	1.19	387
3748	1.63	427
3749	1.63	420
3750	1.75	430

Burnt Bluff May 7, 1952

Catalog Number	Weight	Total Length	Catalog Number	Weight	Total Length
3751	1.88	432	3777	2.00	438
3752	2.19	455	3778	1.88	447
3753	2.75	493	3779	2.25	465
3754	2.88	510	3780	2.19	457
3755	2.38	478	3781	1.88	425
3756	2.06	480	3782	1.88	431
3757	2.06	437	3783	1.94	458
3758	1.75	433	4784	1.81	432
3759	1.88	428	4785	1.69	420
3760	2.06	452	3786	2.69	460
3761	1.88	450	3787	1.88	440
3762	2.06	456	3788	1.75	427
3763	1.94	437	3789	1.94	437
3764	2.69	487	3790	1.88	438
3765	1.75	427	3791	2.00	428
3766	1.94	440	3792	1.88	442
3767	1.88	430	3793	2.56	489
3768	1.94	438	3794	2.69	490
3769	2.06	433	3795	1.88	427
3770	2.25	467	3796	1.88	430
3771	1.88	446	3797	2.00	440
3772	2.00	447	3798	2.00	460
3773	2.06	447	3799	5.63	640
3774	2.00	445	3800	1.88	434
3775	1.81	432	3801	2.25	460
3776	1.81	422			

Chippewa Point May 7, 1952

Catalog Number	Weight	Total Length	Catalog Number	Weight	Total Length
3802	2.56	477	3834	3.06	517
3803	1.88	445	3835	2.00	442
3804	2.25	456	3836	2.00	430
3805	1.75	437	3837	1.69	421
3806	2.63	477	3838	1.88	457
3807	2.06	452	3839	1.94	436
3808	1.81	434	3840	1.94	436
3809	2.00	456	3841	1.88	435
3810	1.69	436	3842	2.13	482
3811	1.81	431	3843	6.63	647
3812	2.13	457	3844	2.25	457
3813	2.19	458	3845	2.38	475
3814	1.88	430	3846	1.75	439
3815	1.94	432	3847	5.69	617
3816	2.50	490	3848	1.88	443
3817	1.88	440	3849	2.25	468
3818	1.88	438	3850	1.81	437
3819	1.88	442	3851	2.50	481
3820	1.88	442	3852	1.94	434
3821	2.38	466	3853	1.88	449
3822	1.81	431	3854	2.88	496
3823	1.63	422	3855	1.75	432
3824	1.94	449	3856	2.81	485
3825	2.63	487	3857	2.44	491
3826	1.81	427	3858	2.06	440
3827	-	444	3859	1.94	445
3828	1.63	442	3860	3.06	530
3829	1.81	430	3861	1.88	432
3830	1.88	437	3862	1.88	414
3831	1.88	442	3863	1.75	430
3832	2.63	482	3864	1.88	433
3833	2.00	437			

Burnt Bluff May 7, 1952

Catalog Number	Weight	Total Length
3865	1.88	431
3866	1.88	421
3867	-	434
3868	1.94	442
3869	1.88	413
3870	1.75	416
3871	1.94	446
3872	1.81	427
3873	1.75	416
3874	1.75	433
3875	2.13	476
3876	1.56	421
3877	1.75	416
3878	2.38	448
3879	2.00	439
3880	1.69	413
3881	1.94	424
3882	1.94	433
3883	2.13	457
3884	1.75	414
3885	1.75	424
3886	1.94	431
3887	2.25	457
3888	1.81	428
3889	1.69	421
3890	1.81	422
3891	1.81	422
3892	1.81	-
3893	1.75	414
3894	3.25	520
3895	3.38	518
3896	2.13	439
3897	1.75	438
3898	1.88	435
3899	1.88	434
3900	1.81	422
3901	1.94	440
3902	1.75	420
3903	1.75	409
3904	2.13	435
3905	1.75	410
3906	1.69	425

Big Hump May 9, 1952

Catalog Number	Weight	Total Length	Catalog Number	Weight	Total Length
3907	4.25	581	3947	2.44	475
3908	4.69	618	3948	2.13	455
3909	5.94	645	3949	2.13	456
3910	4.75	578	3950	2.50	485
3911	2.00	442	3951	2.19	433
3912	4.19	612	3952	2.75	478
3913	1.94	440	3953	3.00	498
3914	2.19	458	3954	2.94	492
3915	2.88	514	3955	2.00	443
3916	-	442	3956	2.25	470
3917	2.13	450	3957	3.38	530
3918	2.13	443	3958	2.06	457
3919	2.00	450	3959	2.88	522
3920	2.00	443	3960	2.19	455
3921	2.25	471	3961	2.06	445
3922	1.88	445	3962	1.94	437
3923	2.00	443	3963	1.94	471
3924	1.88	439	3964	1.88	447
3925	2.00	445	3965	2.75	480
3926	2.00	425	3966	3.00	507
3927	2.31	461	3967	2.00	422
3928	1.88	432	3968	1.94	423
3929	2.38	480	3969	1.94	437
3930	2.31	456	3970	2.13	447
3931	2.00	435	3971	2.81	497
3932	2.00	443	3972	2.63	484
3933	2.13	454	3973	1.69	420
3934	1.88	440	3974	2.00	457
3935	2.19	447	3975	1.75	420
3936	2.38	481	3976	1.75	426
3937	2.44	469	3977	1.75	432
3938	2.69	483	3978	1.81	438
3939	2.00	433	3979	1.63	416
3940	2.00	439	3980	1.81	445
3941	2.00	418	3981	1.75	425
3942	2.81	486	3982	1.69	420
3943	2.31	465	3893	1.69	434
3944	2.44	468	3984	1.69	415
3945	2.31	447	3985	1.69	426
3946	2.50	478	3986	1.75	435

Chippewa Point May 9, 1952

Catalog Number	Weight	Total Length	Catalog Number	Weight	Total Length
3987	1.94	443	4013	3.13	518
3988	1.88	452	4014	2.31	482
3989	1.69	425	4015	1.81	442
3990	1.88	440	4016	1.94	438
3991	1.94	436	4017	2.31	457
3992	1.88	445	4018	1.81	445
3993	1.94	432	4019	2.00	438
3994	1.88	428	4020	1.81	440
3995	2.19	448	4021	1.94	451
3996	1.88	442	4022	2.00	447
3997	2.13	466	4023	3.00	492
3998	2.88	594	4024	1.94	442
3999	2.50	477	4025	1.94	439
4000	2.38	490	4026	2.13	462
4001	2.19	447	4027	1.81	430
4002	1.94	442	4028	1.75	428
4003	2.06	440	4029	1.94	446
4004	2.19	447	4030	2.00	439
4005	3.19	507	4031	1.94	427
4006	1.94	450	4032	2.00	437
4007	1.81	436	4033	2.25	467
4008	1.88	430	4034	1.88	452
4009	1.81	435	4035	2.00	432
4010	2.31	455	4036	1.88	437
4011	1.88	443	4037	1.81	440
4012	1.88	443			

Burnt Bluff May 10, 1952

Catalog Number	Weight	Total Length
4038	2.00	440
4039	1.94	442
4040	1.88	445
4041	1.88	437
4042	2.00	442
4043	1.94	437
4044	5.69	635
4045	2.13	455
4046	2.06	438
4047	2.44	475
4048	2.00	437
4049	2.00	434
4050	1.94	432
4051	2.19	452
4052	1.94	438
4053	2.00	440
4054	2.00	447
4055	1.94	432
4056	2.06	445
4057	1.88	443
4058	2.06	446
4059	2.88	502
4060	4.88	615
4061	1.88	440
4062	1.94	438
4063	-	627
4064	2.13	464
4065	3.19	512
4066	2.63	472
4067	1.94	431
4068	2.00	473
4069	5.00	620
4070	3.00	508
4071	2.88	512
4072	1.88	440
4073	1.88	425
4074	2.00	435
4075	2.00	435
4076	2.00	443
4077	1.88	440
4078	1.94	437
4079	2.00	437
4080	1.94	451
4081	1.94	435
4082	5.63	655
4083	2.00	455
4084	2.63	492
4085	2.56	496
4086	1.94	438
4087	2.31	465
4088	1.88	421
4089	4.88	621
4090	2.31	462
4091	2.13	445
4092	1.94	435
4093	2.38	476
4094	2.50	475
4095	2.81	505
4096	2.13	450
4097	1.94	440
4098	2.00	437
4099	2.00	445
4100	1.94	425
4101	1.94	442
4102	1.81	423
4103	1.88	441
4104	2.06	450
4105	2.13	437
4106	1.88	436
4107	2.00	440
4108	1.81	447
4109	1.88	420
4110	1.94	450
4111	2.00	480
4112	1.88	435
4113	1.88	445
4114	1.94	430
4115	2.13	447
4116	2.00	445
4117	2.50	483
4118	1.94	448
4119	1.94	428
4120	2.00	455

Burnt Bluff September 9-10, 1952

Catalog Number	Weight	Total Length	Catalog Number	Weight	Total Length
4121	2.75	494	4166	1.75	474
4122	2.38	465	4167	2.00	474
4123	2.19	457	4168	1.75	427
4124	2.31	474	4169	2.00	448
4125	2.38	483	4170	2.38	469
4126	2.25	465	4171	1.94	459
4127	1.88	440	4172	2.06	461
4128	2.13	454	4173	1.81	448
4129	2.50	463	4174	2.13	462
4130	2.00	441	4175	2.19	470
4131	1.81	428	4176	2.13	471
4132	1.94	447	4177	1.81	447
4133	1.06	366	4178	2.19	464
4134	2.13	459	4179	2.56	479
4135	1.81	442	4180	1.94	434
4136	1.88	440	4181	2.00	454
4137	1.88	451	4182	1.88	437
4138	2.31	469	4183	2.06	451
4139	2.19	476	4184	2.50	483
4140	1.88	459	4185	2.44	487
4141	1.88	444	4186	1.81	446
4142	1.88	445	4187	1.81	448
4143	2.13	453	4188	2.13	464
4144	2.00	464	4189	1.88	442
4145	2.00	465	4190	2.00	451
4146	2.13	468	4191	1.88	450
4147	2.50	480	4192	1.94	440
4148	2.19	481	4193	2.06	455
4149	2.06	463	4194	4.81	472
4150	2.00	462	4195	1.81	448
4151	1.81	446	4196	2.25	468
4152	2.38	483	4197	2.00	461
4153	1.94	449	4198	2.00	448
4154	1.94	438	4199	1.94	446
4155	1.94	458	4200	2.06	452
4156	2.00	457	4201	1.88	435
4157	2.19	469	4202	2.00	440
4158	2.13	476	4203	2.13	454
4159	2.19	474	4204	2.13	467
4160	1.88	457	4205	1.88	442
4161	1.75	434	4206	1.81	453
4162	1.81	453	4207	2.31	449
4163	2.25	459	4208	2.81	500
4164	1.88	457	4209	2.69	507
4165	1.88	456	4210	2.25	473

Burnt Bluff September 12, 1952

Catalog Number	Weight	Total Length
4211	1.88	451
4212	2.00	452
4213	2.50	487
4214	2.13	473
4215	2.38	483
4216	2.19	466
4217	2.25	473
4218	2.81	502
4219	3.25	506
4220	2.44	474
4221	2.13	464
4222	2.06	455
4223	2.06	451
4224	1.75	439
4225	2.00	440
4226	2.00	443
4227	2.00	453
4228	1.81	449
4229	2.75	492
4230	2.25	471
4231	2.25	479
4232	1.81	459
4233	1.88	446
4234	2.13	472
4235	2.06	455
4236	2.19	465
4237	2.19	443
4238	2.06	455
4239	1.81	440
4240	2.06	461
4241	1.88	456
4242	1.75	445
4243	1.94	446
4244	1.81	435
4245	1.81	455
4246	1.75	442
4247	1.75	444