A COMPARISON OF TWO POPULATIONS OF WHITEFISH, *Coregonus clupeaformis* (MITCHILL), IN THE MUNISING BAY AREA OF LAKE SUPERIOR

Thesis for the Degree of M. S.

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James Robert Clary

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ABSTRACT

A COMPARISON OF TWO POPULATIONS OF
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All of the fish used in this study were taken by pound nets and by gill nets. Collections were made during the months of June, July, and October of 1961, and May of 1962. Additional data were obtained from collections made in the same area in July 1957 and May 1958.

The calculated growth of the fish under study indicated that two populations of whitefish exist in the Munising Bay area, in so far as the rate of growth is concerned (slow and fast growing). The length-weight relations of the two populations were compared and found to be significantly different. The slow growing whitefish weigh less than fast growing whitefish of the same length. The total length-standard length relations of the fast and slow growing whitefish less than 350 millimeters standard length were compared and found to be significantly different, the tail lengths of the slow growing whitefish being more variable than those of the fast

growing whitefish. Morphometric measurements were taken from both populations. Statistical analysis indicated that the slow growing whitefish have longer heads than fast growing whitefish of the same length, while the fast growing whitefish are deeper in the body.

The distributions of the two populations have not been determined. But, the fast growing whitefish appear to inhabit the waters surrounding Munising Bay, while the slow growing whitefish seem to be concentrated in the bay.

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By

James Robert Clary

A THESIS

Submitted to
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Approved E. W. Roelofs

DEDICATED TO MY PARENTS

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TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

A population of relatively slow growing whitefish, *Coregonus clupeaformis* (Mitchill), in Munising Bay, Lake Superior was discovered in 1957 by investigators at Michigan State University. Since only a few specimens were available, no further study was made of these fish at that time. Edsall (1960) analyzed data collected by the United States Bureau of Commercial Fisheries in 1953. The results of Edsall's work indicated that the Munising Bay whitefish had a slower growth rate than any whitefish previously found in the Great Lakes (Table 1). He determined that they rarely reached the legal minimum commercial length of 17 inches.

Evidence for the existence of a fast growing population of whitefish is provided by a commercial fishery in the Munising area, which must depend upon fishes other than those of the slow growing population.

The purpose of this study was to establish the existence of more than one population of whitefish in the Munising Bay area and to compare their growth rates and certain morphometric features.

Munising Bay, the site of this study, is located 100

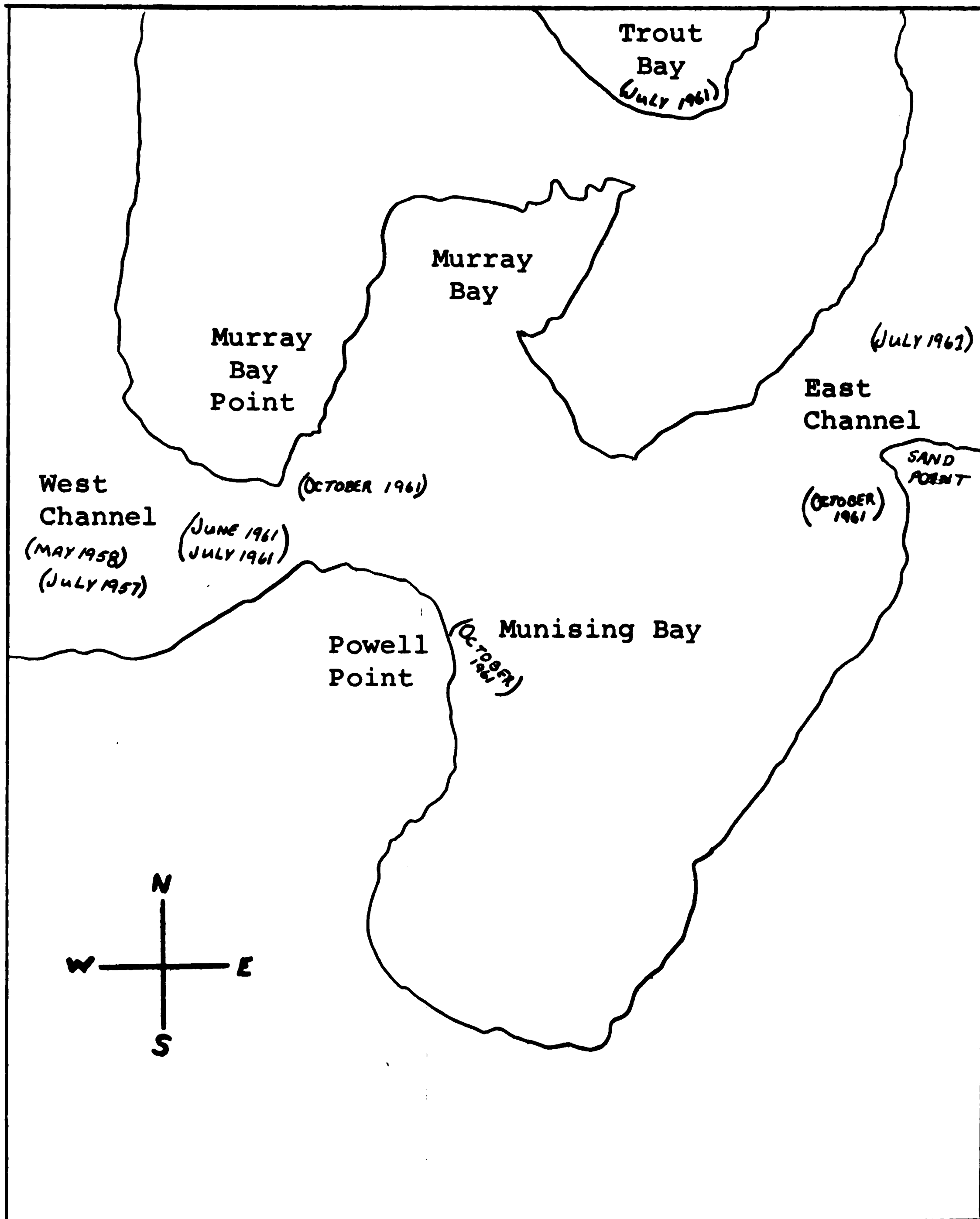
Table 1. Growth in length of whitefish in Munising Bay, Lake Superior and other Great Lakes waters.

Area	Average Calculated Total Lengths (inches) at end of year of life													
Great Lakes	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Lake Superior	5.5	7.2	8.4	9.4	10.1	10.8	11.5	12.1	12.9	13.6	14.4	15.4	15.7	16.0
Lake Erie	6.9	12.7	16.1	18.1	19.6	20.7	21.4	22.1	22.8	23.2	23.7	24.2	24.6	
Lake Huron	5.0	8.9	12.3	16.1	19.2	21.4	22.9	23.9	24.8	25.3	25.9	26.6		
Lake Michigan														
Big Bay deNoc	5.6	9.4	13.8	17.9										
South Fox Is.	4.3	7.0	9.9	13.2										
Lake Ontario	--	--	9.4	12.0	15.4	17.9	19.1	20.4	21.0	23.3	--	25.8		

Sources of Data: Lake Superior, Edsall (1960); Lake Erie, Van Oosten and Hile (1949); Lake Huron, from Van Oosten (1939); Lake Ontario, adapted from Hart (1931); Lake Michigan, Roelofs (1957).

miles west of Sault Ste. Marie, Michigan on Lake Superior (Figure 1).

Figure 1. Munising Bay, Lake Superior, showing sample areas.



FIELD METHODS

All of the fish used in this study were taken by pound nets with 5 1/2" stretched mesh and by gill nets with 2 1/2" stretched mesh. Collections were made during the months of June, July, and October of 1961, and May of 1962. Some data were also obtained from collections made in the same area in July 1957 and May 1958. All weights and measurements were taken by the writer, except those in the July 1957 and May 1958 collections. The locations of the nets used for each collection are indicated in Figure 1. The type of net employed and number of fish caught in each collection are listed in Table 2.

At the beginning of the study an attempt was made to weigh and measure the fish on board the boat used to lift the nets; this proved to be unsatisfactory due to the constant motion of the boat. Therefore, all subsequent measurements were made on shore after the boat had docked. The measurements which were made are as follows:

Total Length. Measured from the tip of the snout to the tip of the caudal fin with the lobes compressed to give the maximum possible measurement

Table 2. Dates, collections, gear used, and numbers of whitefish collected for age-growth and morphometric studies from Munising Bay area.

Date	Locality	Gear	Number of fish
1957			
July 11	West Channel *(1-300)	Pound nets	300
1958			
May 23	West Channel *(1-76)	Pound nets	76
1961			
June 21	West Channel *(1-59) (104-109)	Pound nets	64
	Mid Channel *(60-82)	Pound nets	22
	East Channel *(83-103) (110-111)	Pound nets	22
July 19	West Channel *(1-43, 86-122)	Pound nets	80
	Middle Channel *(44-58)	Pound nets	14
	East Channel *(44-58)	Pound nets	10
	Trout Bay *(70-85)	Pound nets	15
Oct. 26	Murray Bay Point *(1-129)	Gill nets	129
	Powell Point *(130-159)	Gill nets	29
	Sand Point *(160-201)	Gill nets	41

*Catalogue numbers.

Standard Length. Measured from the tip of the snout to the end of the last vertebra

Head Length. Measured from the junction of the premaxillaries (tip of the snout) to the extreme bony margin of the operculum, excluding the opercular membrane

Dorsal-Pectoral Distance. The distance between the origins of the dorsal and pectoral fins.

Length measurements were made on a conventional fisheries measuring board. Unless otherwise specified, all measurements are given to the nearest millimeter. Head lengths and dorsal-pectoral distances were taken with needle-point dividers. This distance was then transferred to the meter stick on the measuring board and read to the nearest millimeter.

Weights were taken on a spring balance and read to the nearest ounce, with the exception of the May 25, 1962 collection which was weighed on a Hobart spring scale.

Scale samples were taken from the left side of the fish, just below and anterior to the dorsal fin but above the lateral line. Some difficulty was encountered in obtaining scales from this key area when the fish were captured in gill nets, as the netting tended to scrape the scales from the fishes' body. In these instances, scale samples were taken as close to the key area as possible. The scale samples from each fish were preserved in small envelopes and all data pertinent to that fish were recorded on the envelope.

AGE DETERMINATION

Scale impressions were made on cellulose acetate 0.020" thick, utilizing a roller press constructed like the one described by Smith (1954). These impressions were examined with a Bausch and Lomb Tri-Simplex microprojector under a magnification of 43 times. The age of each fish is given in terms of completed years of life, a determination reached by counting the number of annuli on the scale. The distance from the focus to each annulus was measured along the greatest radius of the scale and recorded on a calibrated IBM scale card.

Each fish is considered to have passed into the next highest age-class after January 1st. Therefore, all fish captured after that time were assigned a virtual annulus at the edge of the scale until the actual annulus was formed. This procedure affected only the two groups of fish collected in May 1958 and 1962, as the writer determined that annulus formation occurs in late May or early June.

GROWTH DETERMINATION

Growth computations were based on the assumption that after the completion of the first annulus, scale growth is directly proportional to fish growth. A direct proportion nomograph, as described by Carlander and Smith (1944), was utilized for growth determination. Van Oosten (1923) determined that the total length of whitefish at the time of scale formation is between 35 and 40 millimeters. By a scale diameter-total length relation, Edsall (1960) determined that the intercept value was 37.74 millimeters for Munising Bay whitefish. In this study, however, the intercept value, "c" was arbitrarily set at 40 millimeters. This value was used because the exact intercept value of the body-scale regression might be distorted by obtaining scale samples from different areas on some fish. It is thought by the writer that the use of 40 millimeters as the intercept value will not greatly distort the calculated growth values.

CALCULATED GROWTH

The calculated growth of the fish under study indicated that two populations of whitefish exist in the Munising Bay area, in so far as the rate of growth is concerned. Although the July 1957, June 1961, and July 1961 collections contained a few individuals from the slow growing population of fish, they consisted primarily of fast growing individuals. For the purpose of this study, having first eliminated the few slow growing individuals from all computations of those collections, the writer will refer to them as collections of fast growing fish. In the same manner, the October 1961 collection was pruned of the few fast growing individuals which it contained. Thus, the collections can now be designated as fast and slow growing throughout the paper. The number of fast and slow growing individuals excluded from the collections' computations are indicated in Tables 1 to 5 in the appendix, the length-frequency distributions for each of the collections.

The calculated length at the end of each year of life for the fast and slow growing populations is listed in Tables 3 and 4, respectively.

The growth rates of the two populations were compared

Table 3. Average calculated lengths attained by the age group at the end of each year's life for fast growing whitefish derived from May 1958, July 1957, June 1961, July 1961 collections in Munising Bay, Lake Superior.

Age Group	Number of Fish	AGE GROUPS Calculated total length (millimeters) at end of year							
		1	2	3	4	5	6	7	8
II	18	193	273						
III	82	173	244	313					
IV	304	171	246	318	395				
V	145	171	235	303	371	447			
VI	31	169	224	287	355	415	472		
VII	3	167	216	277	335	382	431	482	
Average		172	243	312	385	440	468	482	

Table 4. Average calculated lengths attained by the age groups at the end of each year's life for Munising Bay whitefish (slow growing) Oct. 1961.

Age Group	Number of Fish	AGE GROUPS													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
III	5	136	214	268											
IV	12	137	206	252	285										
V	27	132	181	224	260	289									
VI	44	130	173	211	247	278	306								
VII	37	138	175	207	237	266	292	313							
VIII	36	128	167	201	229	255	280	303	323						
IX	14	123	155	188	216	243	269	290	314	330					
X	12	130	164	189	214	234	257	279	299	318	335				
XI	6	132	168	198	225	250	274	297	320	340	362	383			
XII	4	130	167	195	222	250	283	303	327	348	375	399	417		
XIII	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
XIV	1	138	182	209	232	265	290	311	331	357	383	413	436	459	480
Aver.		132	174	210	240	265	287	302	317	330	351	392	420	459	480

by a "t" test (Snedecor, 1946) to determine if they were significantly different. For this test, the July 1961 collection of fast growing fish was compared to the October 1961 collection of slow growing fish. Five-year-old fish were chosen for the test as they were the oldest group of fast growing fish in which could be found enough individuals to permit comparison by the "t" test.

Twenty-seven 5-year-old fish from each collection were chosen without reference to length. The growth rate of each individual fish was plotted as follows: The age was plotted on a logarithmic scale on the X-axis against the back-calculated length at each age on the Y-axis (Figure 2). A regression line was calculated for the five plotted points (back-calculated lengths at ages I, II, III, IV, V). The slopes (regression coefficients) of the 27 lines representing each population were totaled, and the averages were obtained (Table 5). The two averages were then compared and a "t" value of 9.37 was obtained. This value indicates that the growth rates are significantly different at the 0.1% level.

The general growth curves for the slow and fast growing populations of whitefish are shown in Figure 3.

Figure 2. Typical regression line used for growth comparisons of Munising Bay whitefish.

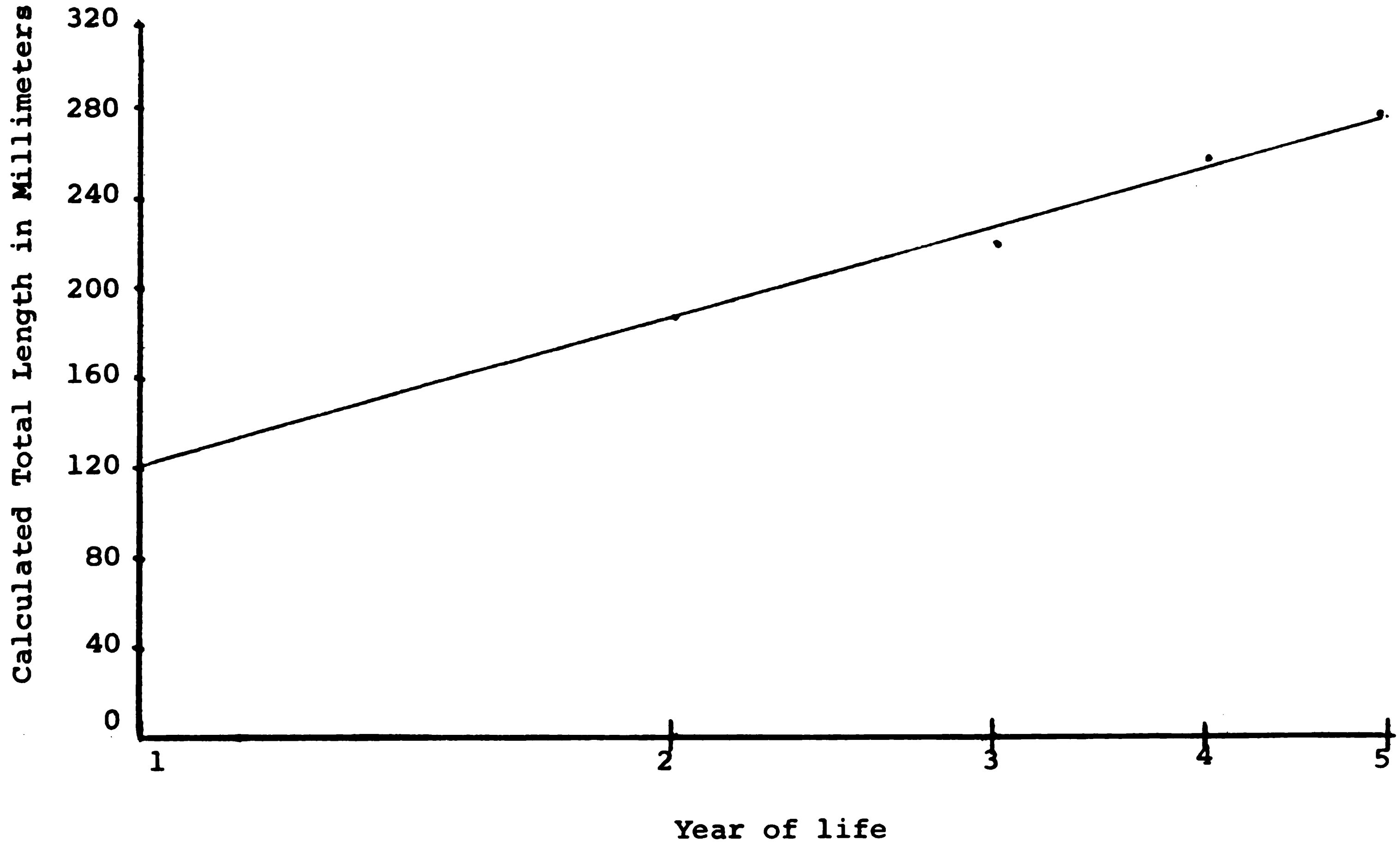


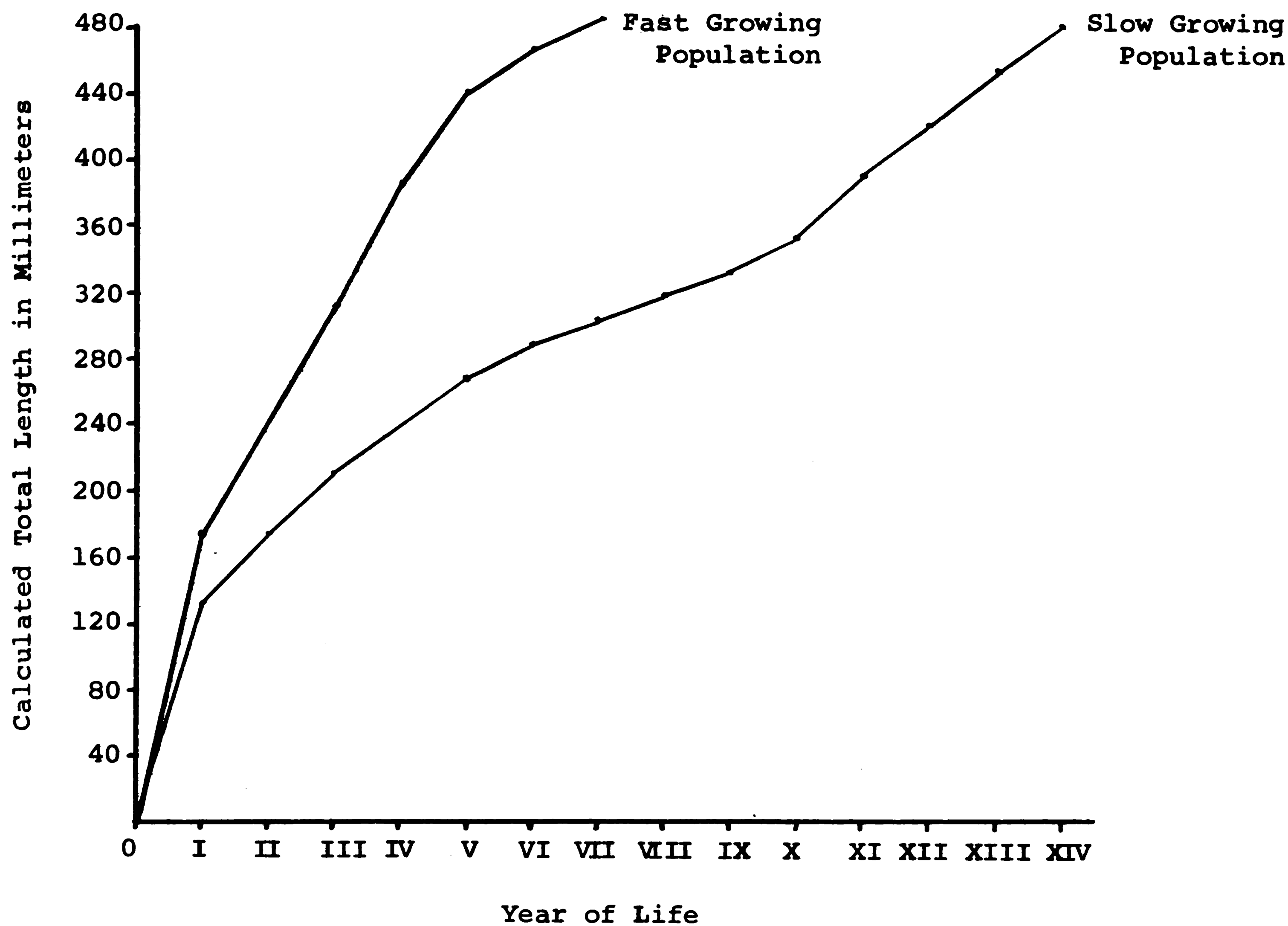
Table 5. Regression coefficients of Munising Bay whitefish (used in growth rate comparison of fash and slow growing populations).

Fast Growing Population	Slow Growing Population
29.837	22.527
30.515	20.670
49.071	23.855
30.755	26.606
34.841	20.574
30.242	27.347
31.580	22.191
48.602	29.253
42.386	23.355
35.086	28.042
33.446	27.561
37.237	20.826
35.073	23.156
33.678	19.017
29.094	20.421
31.065	21.509
42.937	18.641
32.717	20.393
26.609	17.915
29.104	19.392
31.306	16.044
35.076	25.963
31.387	24.184
43.587	25.434
34.121	24.294
35.903	20.265
33.888	14.373

Average Fast Growing Population = 34.783

Average Slow Growing Population = 22.363

Figure 3. General growth in length of Munising Bay whitefish.



LENGTH-WEIGHT RELATION

The length-weight relation of fish having a constant form and specific gravity is $W = CL^3$, where W = weight, C = a constant, and L = length. However, this relation is rarely encountered in nature due to the variability in form and weight of different species of fish. A more accurate method of computation, as described by Hile and Jobes (1942), involves the use of the equation $W = cL^n$. The length-weight regression was determined for each collection by the method of least squares using the logarithms of the lengths and weights.

The length-weight relations for each collection of fast growing fish were compared by analysis of covariance (Snedecor, 1946) to determine if a common line could be used to describe all of the collections. The results (Table 6) indicate that the length-weight regressions are not significantly different; therefore, they can be described by the following equation, where W = weight in ounces and L = length in centimeters:

$$\text{Log } W = -3.86768 + 3.23033 \text{ Log } L$$

The length-weight relation for the October 1961 collection of slow growing fish was significantly different from the relation derived from the combined collections of fast

Table 6. Analysis of covariance of length-weight relations (fast growing collections) Munising Bay whitefish.

Notation	May 1958	July 1957	June 1961	July 1961	Totals
Σx^2	.0527	.7857	.4578	.5258	2.0232
Σy^2	.6329	8.4535	5.3824	5.7512	22.2515
Σxy	.1720	2.5129	1.5366	1.6769	6.5356
Slope	3.2634	3.1981	3.3567	3.1891	3.2303
n	76	258	102	173	609
Σd^2	.0717	.4170	.2245	.4035	1.1394

To test for significant differences in the slopes:

$s_1^2 = .003003$ $\qquad$ $s_2^2 = .001858$

$$F = \frac{s_1^2}{s_2^2} = 1.6163 \ \binom{3}{601} \text{ defrees of freedom.}$$

1.6163 is less than 2.62, therefore the slopes are not significantly different.

To test for significant differences in the elevations:

$s_3^2 = .00461$ $\qquad$ $s_4^2 = .00186$

$$F = \frac{s_3^2}{s_4^2} = 2.473 \ \binom{3}{604} \text{ degrees of freedom.}$$

2.473 is less than 2.62, therefore the elevations are not significantly different.

growing fish (Table 7). Therefore, the following equation must be used when predicting weight for the slow growing whitefish:

$$\text{Log } W = -3.7816 + 3.12152 \text{ Log } L$$

The predicted weights obtained from the length-weight relations for the fast and slow growing populations are listed in Table 8. These indicate that slow growing whitefish always weigh less than fast growing whitefish of the same length. At first it may be presumed that the difference is a result of seasonal variation of the length-weight regressions, but Edsall (1960) based his length-weight relation on fish captured in June of 1953, and the predicted weights obtained from his relation and this writer's are not appreciably different (Table 9). Since the writer's length-weight relation for the fast growing fish is based on collections made at the same time of year as Edsall's, it seems apparent that the slow growing whitefish do in fact weigh less per given length than the fast growing whitefish.

The calculated weights at the end of each year of life for both populations of fish are shown in Table 10.

Table 7. Analysis of covariance of length-weight relations of Munising Bay whitefish (fast and slow growing).

Notation	Fast growing	Slow growing	Totals
Σx^2	2.0232	.3040	3.7566
Σy^2	22.2515	3.4185	47.4130
Σxy	6.5356	.9489	13.0594
Slope	3.2303	3.1216	3.4764
n	609	198	807
Σd^2	1.1394	.4564	2.0133

To test for significant differences in the slopes:

s_1^2 = .00316 s_2^2 = .00199

$$F = \frac{s_1^2}{s_2^2} = 1.587 \quad \binom{1}{803} \text{ degrees of freedom.}$$

1.587 is less than 3.86, therefore the slopes are not significantly different.

To test for significant differences in the elevations:

s_3^2 = .41435 s_4^2 = .00199

$$F = \frac{s_3^2}{s_4^2} = 208.3208 \quad \binom{1}{804} \text{ degrees of freedom}$$

208.3208 is greater than 6.70, therefore the elevations are significantly different at the 0.1% level.

Table 8. Calclulated weights of fast and slow growing whitefish from the Munising Bay area.

Total length in millimeters	Calculated weight in ounces	
	Fast growing[1]	Slow growing[2]
250	4.45	3.94
260	5.05	4.45
270	5.70	5.01
280	6.41	5.61
290	7.18	6.26
300	8.02	6.96
310	8.91	7.71
320	9.87	8.52
330	10.91	9.37
340	12.01	10.29
350	13.22	11.26
360	14.45	12.30
370	15.78	13.40
380	17.20	14.56
390	18.72	15.79
400	20.30	17.09
410	21.99	18.46
420	23.77	19.90
430	25.64	21.42
440	27.62	23.01
450	29.70	24.68

[1]Fast growing length-weight relation based on combined July 1957, May 1958, June 1961, and July 1961 collections.

[2]Slow growing length-weight relation based on October 1961 collection.

Table 9. Calculated weights of slow growing whitefish from the Munising Bay ares in June 1953 (Edsall) and October 1961.

June 1953 (Edsall)			October 1961
Average total length (inches)	Average weight (ounces)	Calculated weight (ounces)	Calculated weight (ounces)
7.3	1.4	1.5	1.55
7.5	1.6	1.6	1.67
8.2	2.1	2.2	2.23
8.8	2.8	2.7	2.77
9.2	3.1	3.1	3.19
9.7	3.6	3.7	3.77
10.2	4.2	4.4	4.41
10.7	5.1	5.1	5.12
11.2	6.1	5.9	5.90
11.7	6.9	6.7	6.76
12.3	7.8	7.9	7.90
12.7	8.9	8.9	8.73
13.2	10.2	9.9	9.85
13.7	11.4	11.1	11.10
14.3	12.4	12.7	12.64
14.7	14.1	13.9	13.79
15.2	16.3	15.4	15.31
15.7	16.7	17.1	16.93
16.4	16.1	19.6	19.38
16.8	20.8	21.2	20.91
17.4	26.8	23.7	23.34

Table 10. Calculated weights at the end of each year of life of Munising Bay whitefish, slow and fast growing populations.

Year of life	Slow growing		Fast growing	
	Calculated weight (ounces)	Increment in weight (ounces)	Calculated weight (ounces)	Increment in weight (ounces)
I	.54	.54	1.33	1.33
II	1.27	.73	4.06	2.73
III	2.29	1.02	9.10	5.04
IV	3.47	1.18	17.94	8.84
V	4.73	1.26	27.62	9.68
VI	6.06	1.33	33.71	6.09
VII	7.11	1.05	37.08	3.37
VIII	8.27	1.16		
IX	9.37	1.10		
X	11.37	2.00		
XI	16.05	4.68		
XII	19.90	3.85		
XIII	26.25	6.35		
XIV	30.59	4.34		

(Weights are from the length-weight relation derived from the combined May 1958, July 1957, June 1961, and July 1961 collections for the fast growing population; and October 1961 for the slow growing population.)

TOTAL LENGTH-STANDARD LENGTH RELATIONSHIP

The total length-standard length relationship makes it possible to calculate the average expected total lengths from actual standard length measurements. It also provides an indirect measurement of tail length, but since tail growth is not constant throughout the life of whitefish (Van Oosten and Hile, 1949), those under study were divided into two groups according to size. A separate relationship was then derived for each group. One group included all fish with standard lengths of less than 350 millimeters. The other group contained all fish with standard lengths of between 350 and 449 millimeters.

The total length-standard length relationship was derived for each size group by taking the average total length of the fish in that group and dividing it by the average standard length of the same fish. The resulting factor was then used to calculate total length from standard length. The reciprocal of that factor can be used to calculate standard length from total length.

The relationship for the slow growing whitefish was obtained from the October 1961 collection. This collection consisted almost entirely of fish with standard lengths of less than 350 millimeters. Only 4 of the 198 fish in that collection had standard lengths greater than 350 millimeters. Therefore, it was not possible to derive a total length-standard length relationship for the 350 to 449 millimeter size group. The total length-standard length relationship for the slow growing whitefish with standard lengths of less than 350 millimeters is:

Total length = 1.206 Standard length

The total length-standard length relationships for the fast growing whitefish were based upon the June 1961 and July 1961 collections (standard length measurements were not taken in 1957 or 1958). Two relationships, one for each size group, were calculated for each collection. The total length-standard length relations of the fast growing fish with standard lengths of less than 350 millimeters were compared by analysis of covariance. The results of the test indicate that the two relationships are not significantly different (Table 11). Thus, all of the fast growing fish with standard lengths of less than 350 millimeters can be described by the following relationship:

Total length = 1.1985 Standard length

Similarly, the total length-standard length relationship

Table 11. Analysis of covariance of total length-standard length relationships of fast growing whitefish less than 350 millimeters standard length, June 1961 and July 1961.

Notation	July 1961	June 1961	Totals
Σx^2	1477.46	379.26	2093.31
Σy^2	1975.02	481.03	2794.75
Σxy	1699.90	423.86	2406.84
Slope	1.15055	1.11760	1.14978
n	115	45	160
Σd^2	19.19	7.32	27.41

To test the slopes for significant differences:

$s_1^2 = .37$ $\qquad$ $s_2^2 = .17$

$$F = \frac{s_1^2}{s_2^2} = 2.176 \ (\overset{1}{1}56) \text{ degrees of freedom.}$$

2.176 is less than 3.91, therefore the slopes are not significantly different.

To test the elevations for significant differences:

$s_3^2 = .52$ $\qquad$ $s_4^2 = .18$

$$F = \frac{s_3^2}{s_4^2} = 2.9714 \ (\overset{1}{1}57) \text{ degrees of freedom.}$$

2.9714 is less than 3.91, therefore the elevations are not significantly different.

of the 350 to 449 millimeter size group were compared by analysis of covariance (Table 12). The results of this test indicate that the fast growing fish in that size group can be described by the following relationship:

Total length = 1.1919 Standard length

The total length-standard length relationships of the fast and slow growing whitefish less than 350 millimeters standard length were compared by analysis of covariance to determine if they were significantly different. The results show that the slopes of the total length-standard length regression of this size group are significantly different at the 1% level (Table 13). The actual calculated values of the two relationships are not appreciably different, however. The important difference lies in the variability of the tail length. The lengths of the tails of slow growing whitefish are more variable than are the tail lengths of fast growing whitefish of the same total length.

The total length-standard length relationships derived thus far rest on the assumption that the intercept value is zero, that is, when the total length is zero, the standard length is also zero. An intercept value does exist for the data used in this study, however, due to the absence of small fish in the collections. These fish normally would

Table 12. Analysis of covariance of total length-standard length relationships of fast growing whitefish between 350 and 449 millimeters standard length, June 1961 and July 1961.

Notation	July 1961	June 1961	Totals
Σx^2	1560.18	247.62	1922.28
Σy^2	2248.14	327.94	2772.44
Σxy	1861.16	279.56	2290.65
Slope	1.193	1.129	1.192
n	58	57	115
Σd^2	27.78	12.32	41.99

To test the slopes for significant differences:

$s_1^2 = 1.03$ $\qquad$ $s_2^2 = .36$

$$F = \frac{s_1^2}{s_2^2} = 2.861 \quad \overset{1}{(111)} \text{ degrees of freedom}$$

2.861 is less than 3.94, therefore the slopes are not significantly different.

To test the elevations for significant differences:

$s_3^2 = .86$ $\qquad$ $s_4^2 = .37$

$$F = \frac{s_3^2}{s_4^2} = 2.324 \quad \overset{1}{(112)} \text{ degrees of freedom}$$

2.324 is less than 3.94, therefore the elevations are not significantly different.

Table 13. Analysis of covariance of total length-standard length relationships of fast and slow growing Munising Bay whitefish.

(All fish included with standard lengths less than 350 mm.)

Notation	Fast growing (June & July 1961)	Slow growing (October 1961)
Σx^2	2093.31	795.68
Σy^2	2794.75	1119.40
Σxy	2406.84	850.69
Slope	1.1478	1.0691
n	160	192
Σd^2	27.41	209.93

To test the slopes for significant differences:

$s_1^2 = 3.62$ $s_2^2 = .68$

$$F = \frac{s_1^2}{s_2^2} = 5.323 \quad \binom{1}{348} \text{ degrees of freedom}$$

5.323 is greater than 3.89, therefore the slopes are significantly different at the 5% level.

reduce the intercept value to zero. Therefore, to determine a more accurate total length-standard length relationship, the formula for a straight line was used. This formula is: $Y = a + bX$, where Y = total length, a = intercept, b = slope, and X = standard length. The total length-standard length regressions derived for the fast and slow growing fish using this formula (Table 14) were based upon the same data used in the previous relationships and analysis of covariance tests, and the initial differences were maintained. The predicted values obtained from the total length-standard length relations derived by both methods are listed in Table 15. It is apparent that the slight increase in accuracy obtained by using the intercept value does not warrant the extra work necessary to derive it.

Table 14. Total length-standard length regressions of Munising Bay whitefish.

	Fast growing population
Size group	Total length-standard length regression
< 350 mm.	Total length = 15.1 + 1.150 standard length
350 to 449 mm.	Total length = 0.00 + 1.192 standard length

	Slow growing population
Size group	Total length-standard length regression
< 350 mm.	Total length = 37.2 + 1.069 standard length

Table 15. Total length-standard length relationships of fast growing Munising Bay whitefish.

Number of fish	Average total length	Average standard length	Predicted total length[1]	Predicted total length[2]
3	286	236	283	285
4	294	242	290	293
4	307	255	306	308
5	313	259	311	313
4	325	272	326	328
3	334	278	333	335
8	346	286	343	344
4	356	295	354	354
4	363	302	362	362
8	375	314	376	376
4	383	323	387	387
8	394	331	397	396
23	405	341	408	408
48	414	350	417	417
28	423	357	426	426
8	434	362	431	431
5	447	374	446	446
13	454	378	451	451
9	465	390	465	465
5	475	399	476	476
5	485	407	485	485
1	496	416	496	496
1	500	422	503	503
1	511	433	516	516
1	525	440	524	524

[1]Based on total length-standard length relationships derived by dividing total length by standard length.

[2]Based on total length-standard length regression derived by utilizing the formula for a straight line.

MORPHOMETRIC MEASUREMENTS

Various workers have used morphometric measurements for distinguishing populations of fish. Marr (1957) defines the term "population" as:

> A population of fish includes all individuals of a given species when there are no subspecies, or if there are subspecies, when their distributions are not discrete. It includes only all individuals of a subspecies when the distributions of the subspecies are discrete.

The results of current studies point out that morphologically different populations of whitefish do exist in various geographic localities of the same body of water as well as in separate bodies of water. Svardson (1949) maintains that the Genus Coregonus is subject to considerable morphological variation due to environmental changes. One of the purposes of this paper is to point out differences between the two populations of whitefish inhabiting Munising Bay. These fish occupy the same area, yet they have significantly different growth rates and body proportions.

Caraway (1951) compared whitefish of the same age class in his morphometric studies. Due to the extreme difference in growth rates, such comparisons are questionable for the Munising Bay whitefish because proportional body measurements may vary with size. Therefore, through use of analysis of covariance, the comparison of the slow and fast growing populations of Munising Bay whitefish are based upon fish of the same size.

Morphometric measurements were taken from 135 fish in the July 1961 collection (fast growing) and from 198 fish in the October 1961 collection (slow growing).

Head Length

The head length measurements of the fast and slow growing populations of whitefish were compared by analysis of covariance. The results indicate that the two populations are significantly different at the 5% level (Table 16). The slow growing whitefish have longer heads than do fast growing whitefish of the same length. This difference is apparent in Figure 4 which contains the regression lines of each population.

Dorsal-Pectoral Distance

The dorsal-pectoral distance was the measurement used to depict the body depth of the fish under study. This measurement was used in preference to the depth measurement normally employed by biologists because of the variability of the abdomen in whitefish.

Table 16. Analysis of covariance of head lengths of fast and slow growing Munising Bay whitefish.

Notation	July 1961	October 1961	Totals
Σx^2	2430.14	2078.39	8133.61
Σy^2	6712.03	7503.17	196.14
Σxy	360.84	344.14	1171.88
Slope	.14848	.16558	.14408
n	136	198	334
Σd^2	12.64	13.81	27.30

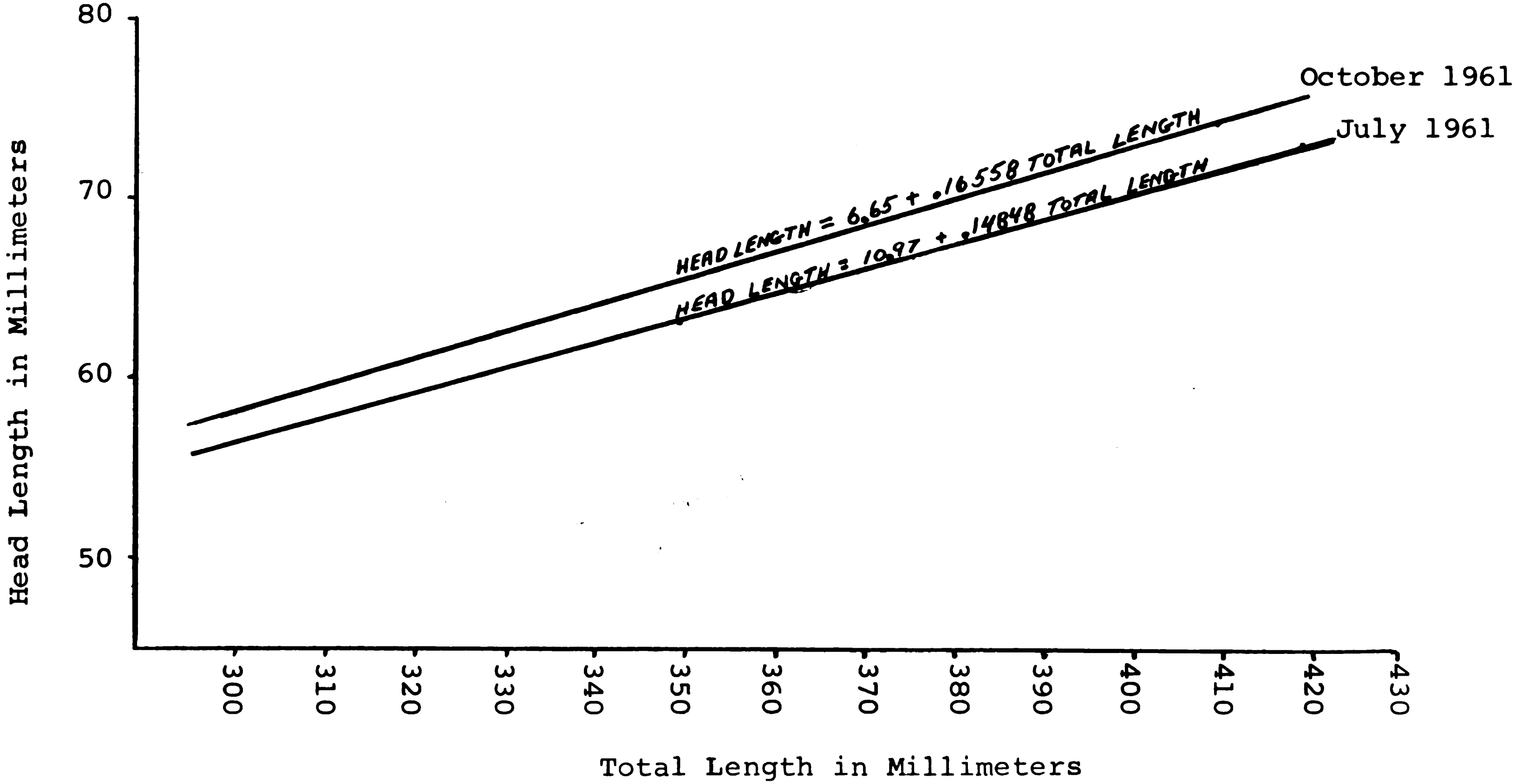
To test for significant differences in the slopes:

$s_1^2 = .33$ $s_2^2 = .080$

$$F = \frac{s_1^2}{s_2^2} = 4.125 \ (\overset{1}{330}) \text{ degrees of freedom.}$$

4.125 is greater than 3.89, therefore the slopes of the two populations are different at the 5% level.

Figure 4. Head length-total length relationships of Munising Bay whitefish.



The dorsal-pectoral distances for each population and their relation to total length were compared by analysis of covariance. The results of the test indicate that the two populations are significantly different at the 1% level (Table 17). This difference is apparent in Figure 5.

Table 17. Analysis of covariance of dorsal-pectoral distance of fast and slow growing Munising Bay whitefish.

Notation	July 1961	October 1961	Totals
Σx^2	2424.77	2078.39	8094.06
Σy^2	15099.46	13116.80	28216.26
Σxy	647.30	528.17	2471.94
Slope	.26695	.2541	.3054
n	135	198	333
Σd^2	32.42	27.43	80.00

To test for significant differences in the slopes:

$s_1^2 = .21$ $s_2^2 = .182$

$$F = \frac{s_1^2}{s_2^2} - 1.1445 \; \frac{1}{(329)} \text{ degrees of freedom}$$

1.1445 is less than 3.89, therefore the slopes are not significantly different.

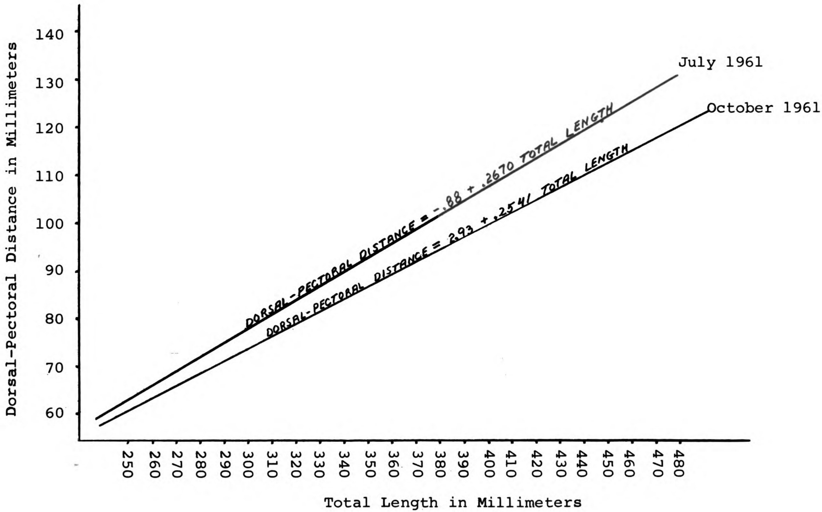
To test for significant differences in the elevations:

$s_3^2 = 19.94$ $s_4^2 = .182$

$$F = \frac{s_3^2}{s_4^2} = 109.56 \; \frac{1}{(330)} \text{ degrees of freedom}$$

109.56 is greater than 6.76, therefore the elevations are significantly different beyond the 1% level.

Figure 5. Dorsal-pectoral--total length relationships of Munising Bay whitefish.



DISCUSSION

Further research must be carried on before the distributions of the two populations can accurately be determined. The fast growing whitefish appear to inhabit the waters surrounding Munising Bay. However, a collection made in May 1962 indicates that they do move into the bay. The extent and frequency of these movements have yet to be determined. Very little information is available regarding the movements of the slow growing whitefish. They seem to be concentrated in Munising Bay; but, commercial catches indicate that they occasionally move into the west channel. Nets which were set on the east and west side of Grand Island in May 1962 failed to take any slow growing whitefish. This may be an indication that their distribution is confined primarily to Munising Bay. However, there are no apparent physical barriers which would prevent them from leaving the bay. This concentration of slow growing whitefish in Munising Bay may have resulted in it being closed to commercial fishing as a nursery area; a function which it apparently does not serve. Extensive tagging experiments are needed before the movements and distributions of the two populations can be accurately ascertained.

The writer has referred to the fast and slow growing whitefish as populations throughout the paper. This implies that heritable differences do exist between the two groups. The highly significant difference in growth rates lends credence to this implication. The continuous exchange of water which occurs between Munising Bay and its surrounding waters supports the idea that the environments are similar thus weakening any argument in favor of environmentally induced differences. However, a complete limnological study of the area is needed before the environment as a causal factor of population differences can be completely discounted.

If we consider the two populations to be genetically compatible, we must assume that they are not interbreeding. Any long term interbreeding would tend to eliminate the significant differences between the populations. Therefore, either they spawn in different areas, or at different times in the same area.

Whether one accepts environment or genetics as the cause for the population differences, the fact remains that these differences are present. The need for further study is obvious.

SUMMARY

1. The calculated growth of the fish under study indicated that two populations of whitefish exist in the Munising Bay area, in so far as the rate of growth is concerned. The growth rates of the two populations were compared by a "t" test and found to be significantly different at the 0.1% level.

2. The length-weight relationships were derived for each population of whitefish. The relations were compared by analysis of covariance and found to be significantly different at the 1% level. The length-weight relations indicate that the slow growing whitefish always weigh less than fast growing whitefish of the same length.

3. The total length-standard length relationships of the fast and slow growing whitefish less than 350 millimeters standard length were compared by analysis of covariance. The results indicated that the relations were significantly different. The significant difference lies in the variability of the tail length. The lengths of the tails of slow growing whitefish are more variable than are the tail lengths of fast growing whitefish of the same length.

4. Morphometric measurements were taken from 135 fast

growing fish and from 198 slow growing fish. Two such measurements were taken, head length and the dorsal-pectoral distance. The head length measurements of the fast and slow growing populations were compared by analysis of covariance. The results indicate that the two populations are significantly different at the 5% level. The slow growing whitefish have longer heads than do fast growing whitefish of the same length.

The dorsal-pectoral distance was used to depict body depth. The distances for each population and their relation to total length were compared by analysis of covariance. The results of the test showed that the two populations were significantly different at the 1% level.

5. Further research is necessary before the distributions of the two populations can accurately be determined. The fast growing whitefish appear to inhabit the waters surrounding Munising Bay, while the slow growing whitefish seem to inhabit the Bay. This concentration of slow growing whitefish in Munising Bay may have resulted in it being closed as a "nursery area," which function the Bay apparently does not serve.

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APPENDIX A

Table 1. Length frequency distribution of Munising Bay whitefish, July, 1957.

Total length in millimeters	AGE GROUPS							
	II	III	IV	V	VI	VII	VIII	IX
260-269								
270-279								
280-289	2							
290-299		5						
300-309	1	6			1*			
310-319	1	6						
320-329		4				1*		
330-339		3						
340-349		2					1*	
350-359		2						
360-369		2	1					
370-379		1	2					
380-389			5					1*
390-399		1	22			1*		
400-409			31					
410-419			27	2				1*
420-429			25					
430-439			28	11				
440-449		1	17	11	1			
450-459			3	8				
460-469			1	9		1		
470-479				4	6			
480-489				2	2			
490-499				1		1		
500-509								
510-519								
520-529					1			
530-539				1				
540-549					1			
550-559								
560-569							1	
Average Total Length	297	329	417	454	483	481	560	
Total Number of Fish	4	33	162	49	12	4	2	2

*Designates slow growing whitefish.

Table 2. Length frequency distribution of Munising Bay whitefish, May 1958.

Total length in millimeters	AGE GROUP					
	III	IV	V	VI	VII	VIII
270-279						
280-289						
290-299						
300-309						
310-319						
320-329						
330-339						
340-349						
350-359						
360-369						
370-379						
380-389						
390-399						
400-409						
410-419						
420-429		2	3			
430-439		4	12	1		
440-449		3	9			
450-459		4	12	1		
460-469		2	6	1		
470-479			1	3		
480-489			2	1		
490-499			1			
500-509						
510-519			2	1		
520-529		1		1		
530-539			1	1		
540-549						
550-559			1			
Average Total Length	0	449	456	483		
Total Number of Fish	0	16	50	10	0	0

Table 3. Length frequency distribution of Munising Bay whitefish, June 1961.

Total length in millimeter	AGE GROUPS											
	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
260-269		1*										
270-279	1											
280-289												
290-299	2	2										
300-309	1	4										
310-319		3	2			1*						
320-329		1	1									
330-339		2										
340-349		4	1									
350-359		3	2					1*	1*			
360-369		1	3									
370-379		1	7								1*	
380-389			4									
390-399												
400-409			3									
410-419			1	1								
420-429			3	4								
430-439			5	3								
440-449				4								
450-459			4	9								
460-469			2	5	2							
470-479				2	3							
480-489				3	2							
490-499				1								
500-509					1							
510-519				1								
520-529				1								
530-539												
540-549												
550-559				1								
Average Total Length	293	331	401	459	479							
Total Number of Fish	4	22	38	35	8	1	0	1	1	0	1	

*Designates slow growing whitefish.

Table 4. Length frequency distribution of Munising Bay whitefish, July 1961.

Total length in millimeters	AGE GROUPS								
	II	III	IV	V	VI	VII	VIII	IX	X
260-269									
270-279									
280-289	2	1							
290-299	3	1							
300-309	1	3							
310-319	2	3							
320-329	2	2	1			1*			
330-339		1	2						
340-349		7	1		1*				
350-359		2	2						
360-369		2	2				1*		
370-379			1						
380-389			1					1*	
390-399		2	6						
400-409		2	18	3				1*	
410-419			44	4	1				
420-429		1	21	6					
430-439			1	1					
440-449			1	3	1				
450-459				4					
460-469			2	3					
470-479			2						
480-489									
490-499				1					
500-509				1					
510-519				1					
520-529				1					
530-539									
540-549									
550-559				1					
560-569									
570-579						1			
Average Total Length	304	344	410	447	449	571			
Total Number of Fish	10	27	105	29	3	2	1	2	

*Designates slow growing whitefish.

Table 5. Length frequency distribution of Munising Bay whitefish, October 1961.

Total length in millimeter	AGE GROUP											
	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
250-259				1								
260-269												
270-279			1									
280-289	2		4	1								
290-299	1		3	3	3							
300-309	2	4	4	2	5	2		2				
310-319		3	7	14	6	7	1					
320-329		3	5	12	11	7	3	1				
330-339		1	1	4	6	7	5	1				
340-349		1	1	2	4	6	1	2				
350-359				2	1	5	2	3	2			
360-369			1		1	1	1	2		1		
370-379				1		1	1					
380-389				1		1				1		
390-399				1				1	1			
400-409									1			
410-419												
420-429									1			
430-439												
440-449				1**						1		
450-459												
460-469									1			
470-479				1**								
480-489				1**								
490-499										1		1
Average Total Length	296	317	311	323	322	333	339	346	398	424	0	490
Total Number of Fish	5	12	27	47	37	36	14	12	6	4	0	1

**Designates fast growing whitefish.

APPENDIX B

July 11, 1957
(Slow growing fish designated by *)

Catalogue Number	Total Length	Weight
1	372	19
2	351	14
3	394	18
4	369	16
5	383	17
6	352	14
7	370	15
8	360	15
9	377	18
10	422	23
11	395	19
12	407	21
13	400	20
14	305	14
15	365	13
16*	342	12
17	336	12
18	341	12
19*	326	11
20	344	11
21	315	10
22	310	8
23	310	8
24	306	8
25	322	10
26	322	8
27	301	8
28	315	8
29	329	9
30	290	7
31	319	9
32	333	11
33	298	8
34	330	11
35	316	9
36	301	8
37	303	9
38	309	8
39*	308	8
40	299	8
41	297	8
42	296	8
43	308	8

July 11, 1957

Catalogue Number	Total Length	Weight	Catalogue Number	Total Length	Weight
44	289	7	88	450	35
45	311	9	89	450	32
46	284	7	90	434	25
47	320	9	91	417	21
48	449	28	92	537	55
49	397	20	93	504	40
50	428	25	94	482	35
51	397	21	95	450	32
52	450	26	96	465	32
53	470	35	97	400	22
54	448	28	98	433	29
55	440	24	99	407	22
56	471	29	100	522	47
57	405	23	101	475	36
58	412	23	102	449	32
59	408	21	103	458	29
60	420	23	104	390	22
61	414	21	105	449	25
62	433	24	106	441	28
63	426	25	107	435	26
64	422	25	108	425	34
65	414	23	109	433	26
66	430	24	110	433	27
67	400	22	111	434	25
68	415	23	112	461	38
69*	394	19	113	480	37
70	560	52	114	397	21
71	445	26	115	414	24
72	447	23	116	408	21
73	425	25	117	433	24
74	430	25	118	406	22
75	405	21	119	404	21
76	390	21	120	388	20
77	434	23	121	415	22
78	387	19	122	435	29
79	408	20	123	417	25
80	437	28	124	413	24
81	468	30	125	399	24
82	463	35	126	475	38
83	396	19	127	440	31
84	423	26	128	435	28
85	497	42	129	416	23
86	460	38	130	443	32
87	520	46	131	412	24

July 11, 1957

Catalogue Number	Total Length	Weight	Catalogue Number	Total Length	Weight
132	399	21	178	403	21
133	440	27	179	405	20
134	416	23	180	407	18
135	398	21	181	416	20
136	417	24	182	420	20
137	404	23	183	381	18
138	415	23	184	413	21
139	420	24	185	403	22
140	440	26	186	416	21
141	463	28	187	400	21
142	431	25	188	391	18
143	406	21	189	423	24
144	407	21	190	414	21
145	409	22	191	434	25
146	416	22	192	442	33
147	414	23	193	543	61
148	493	38	194	449	29
149	439	25	195	431	29
150	407	20	196	415	21
151	399	19	197	406	22
152	407	20	198	406	22
153	391	19	199	402	20
154	423	28	200	415	24
155	393	20	201	461	31
156	429	28	202	417	25
157	412	25	203	430	25
158	435	27	204	411	23
159	439	28	205	498	44
160	460	36	206	408	22
161	415	24	207	394	22
162	402	19	208	414	22
163	401	17	209	432	24
164	430	27	210	463	36
165	456	30	211	402	24
166	442	25	212	460	33
167	396	21	213	438	25
168	450	28	214	439	29
169	439	28	215	402	22
170	408	24	216	403	20
171	402	21	217	471	35
172	406	20	218	388	19
173	406	20	219*	437	29
174	399	20	220	440	29
175	473	35	221	404	19
176	401	21	222	404	20
177	420	22	223	422	25

July 11, 1957

Catalogue Number	Total Length	Weight	Catalogue Number	Total Length	Weight
224	397	19	263	456	32
225	391	18	264	443	27
226	482	36	265	413	22
227	439	26	266	445	29
228	440	28	267	413	22
229	438	27	268	418	23
230	384	21	269	453	31
231	428	26	270	447	30
432	409	22	471	447	28
233	425	27	272	442	24
234	440	25	273	417	23
235	421	23	274	417	23
236	394	19	275	433	22
237	416	24	276	465	23
238	422	24	277	440	32
239	413	24	278	415	25
240	425	24	279	474	37
241	400	19	280	436	24
242	398	21	281	428	24
243	431	25	282	431	24
244	393	19	283	435	27
245*	412	21	284	440	28
246	399	20	285	444	29
247	422	26	286	434	27
248	422	25	287	437	26
249	422	27	288	662	98
250	446	31	289	471	36
251	457	31	290	479	35
252	452	30	291	477	36
253	460	30	292	436	27
254	456	30	293	425	25
255	430	27	294	467	30
256	460	38	295	446	28
257	431	27	296	437	26
258	442	20	297	435	27
259	419	19	298	445	28
260	429	21	299	448	26
261	424	22	300	485	35
262	434	23			

May 23, 1958

Catalogue Number	Total Length	Weight	Catalogue Number	Total Length	Weight
1	423	28	39	428	26
2	458	30	40	442	29
3	425	23	41	455	27
4	520	50	42	452	30
5	448	28	43	523	44
6	452	28	44	466	34
7	440	28	45	430	27
8	458	34	46	489	43
9	439	29	47	482	36
10	450	32	48	455	32
11	465	34	49	440	29
12	435	23	50	457	32
13	450	31	51	438	29
14	439	26	52	492	41
15	463	33	53	435	27
16	447	29	54	453	33
17	483	38	55	462	31
18	465	31	56	458	31
19	454	26	57	472	37
20	456	31	58	474	36
21	447	27	59	434	27
22	455	32	60	458	33
23	440	26	61	474	34
24	463	34	62	440	32
25	434	25	63	550	58
26	428	25	64	465	37
27	470	30	65	460	36
28	532	45	66	438	30
29	432	27	67	532	53
30	515	50	68	428	25
31	516	44	69	435	28
32	442	26	70	437	26
33	430	25	71	456	33
34	440	24	72	440	25
35	435	25	73	445	28
36	438	27	74	429	26
37	437	31	75	551	60
38	460	34	76	455	27

June 21, 1961

(Slow growing fish designated by *)

Catalogue Number	Total Length	Standard Length	Weight
1	387	327	18
2	415	357	22
3	405	339	20
4	378	313	15
5	365	305	14
6	355	288	11
7	351	291	12
8	407	340	22
9	361	297	15
10	405	344	23
11	374	316	15
12	341	286	13
13	342	287	13
14	383	321	18
15	351	297	7
16	340	284	11
17	349	288	14
18	376	311	15
19	375	319	16
20	373	314	15
21	370	308	19
22	377	312	18
23	381	323	18
24	382	321	18
25	357	291	14
26	278	322	16
27*	310	---	9
28	365	313	16
29	297	245	8
30	335	283	11
31	308	253	8
32	317	267	10
33	299	248	--
34	308	251	8
35	299	243	7
36	350	291	12
37	466	400	32
38	428	356	27
39	455	369	29

June 21, 1961

Catalogue Number	Total Length	Standard Length	Weight
40	456	378	31
41	456	370	35
42	434	358	27
43	455	382	35
44	437	366	25
45	474	398	37
46	475	400	35
47	450	377	31
48	428	360	26
49	470	401	34
50	440	370	27
51	425	354	24
52	457	385	29
53	491	407	36
54	449	375	31
55	464	389	33
56	467	390	32
57	434	362	25
58	420	354	28
59	453	378	28
60	462	385	32
61	464	394	36
62	506	430	46
63	462	388	33
64	489	410	33
65	433	358	29
66	435	364	27
67	455	380	36
68	550	464	47
69	430	362	26
70	469	392	36
71	428	356	28
72	433	364	25
73	457	378	29
74	440	367	34
75	438	360	24
76	456	383	35
77	450	376	28
78	367	311	19
79	479	400	40

June 21, 1961

Catalogue Number	Total Length	Standard Length	Weight
80	456	381	34
81	465	383	32
82	445	367	28
83	451	377	30
84	525	440	53
85	464	388	37
86	476	398	38
87	485	406	39
88	486	406	39
89	482	407	39
90	511	433	45
91	426	358	24
92	426	360	26
93	485	404	33
94	299	250	7
95	275	228	5
96	309	257	8
97	319	268	10
98*	352	288	14
99	315	265	9
100	300	251	8
101*	264	221	5
102	310	258	9
103	300	249	8
104	321	262	10
105	311	258	8
106*	354	291	13
107	326	271	11
108	415	350	20
109	331	276	14
110*	370	306	16
111	341	282	13

July 19, 1961

(Slow growing fish desiganted by *)

Catalogue Number	Total Length	Standard Length	Weight	Head Length	Dorsal-Pectoral
1	342	290	12	63	90
2	350	290	12	63	93
3	289	237	7	52	77
4	283	233	7	52	76
5	295	240	8	54	74
6	308	251	8	57	79
7	307	259	8	55	83
8	403	337	23	78	106
9	399	336	23	72	105
10	416	348	24	74	110
11	422	352	25	74	110
12	460	388	33	--	---
13	422	355	29	--	---
14	310	255	8	53	74
15	452	373	29	--	---
16	510	421	41	83	115
17	460	377	29	77	99
18	457	384	38	--	---
19	430	360	23	--	---
20	430	364	24	--	---
21	406	342	23	70	109
22	345	284	11	60	90
23	316	262	9	64	81
24	340	276	12	56	88
25	361	299	17	65	103
26A	331	275	10	58	80
26B	268	307	15	71	95
27*	340	284	12	61	91
29A	361	304	12	77	99
29B	403	331	22	79	104
30	410	347	25	68	112
31	383	324	16	68	102
32	416	355	22	70	107
33	407	334	22	70	109
34	418	347	22	74	105
35	415	348	24	74	111
36	425	357	24	73	112
37	405	340	22	66	110

July 19, 1961

Catalogue Number	Total Length	Standard Length	Weight	Head Length	Dorsal-Pectoral
38	427	362	23	70	115
39	420	353	21	75	108
40	406	344	22	69	109
41	415	350	22	76	110
42	465	384	32	--	---
43	425	360	23	74	111
44	422	356	27	72	115
45	345	291	13	61	92
46	556	476	59	--	---
47	522	440	51	--	---
48	496	416	46	--	---
49	463	386	33	--	---
50	460	386	28	--	---
51	410	338	22	70	109
52	420	354	24	75	113
53	418	350	22	75	110
54	336	283	12	60	86
55	425	360	24	75	120
56	444	370	27	--	---
57	449	380	30	--	---
58	408	478	22	74	112
59	312	258	9	58	80
60	425	356	25	76	117
61	470	392	32	--	---
62	448	374	28	--	---
63	419	347	22	78	108
64	457	381	33	--	---
65	500	422	45	--	---
66	404	332	23	69	115
67*	362	304	12	78	91
68	456	383	31	--	---
69	420	346	23	75	116
70*	381	311	16	72	97
71	417	341	23	77	95
72*	403	338	20	76	108
73	392	325	18	70	103
74	421	357	24	78	108
75	422	354	27	73	117
76	425	357	24	71	116
77	410	338	23	73	102

July 19, 1961

Catalogue Number	Total Length	Standard Length	Weight	Head Length	Dorsal-Pectoral
78	417	366	27	73	118
79	419	354	25	75	116
80	413	347	24	71	117
81	410	349	26	77	116
82	413	346	26	72	108
83	359	290	15	62	92
84	414	346	24	74	115
85	403	337	21	70	110
86	402	335	21	77	105
87	410	346	22	72	109
88	410	345	22	72	111
89	417	348	22	69	112
90	405	337	27	69	107
91	405	347	23	70	112
92	413	347	21	74	109
93	416	348	26	74	114
94	422	353	24	75	112
95	421	348	25	72	115
96	412	344	23	72	113
97	379	321	17	66	99
98	412	342	21	73	108
99	390	327	21	71	109
100	408	342	21	69	109
101	428	364	24	75	105
102	419	347	21	75	110
103	410	342	23	72	110
104	392	333	22	70	109
105	410	344	20	71	107
106	391	327	18	65	105
107	395	336	18	69	107
108	423	357	24	73	115
109	420	354	24	73	116
110	418	349	25	73	116
111	405	336	22	70	108
112	405	337	22	69	113
113	423	357	26	75	114
114	410	346	21	68	114
115	411	348	22	72	111
116	418	350	22	73	107
117	---	390	31	74	129

July 19, 1961

Catalogue Number	Total Length	Standard Length	Weight	Head Length	Dorsal-Pectoral
118	---	435	33	88	126
119	571	465	57	95	142
120	470	390	32	78	124
121	448	373	28	78	121
122	447	373	27	76	116
1A	415	348	22	--	---
2A	394	329	--	76	110
3A	418	349	29	73	116
4A	325	263	9	58	78
5A	311	260	9	53	77
6A	322	274	10	61	85
7A	359	301	14	62	91
8A	415	348	23	74	104
9A	416	342	22	74	103
10A	408	338	25	70	113
11A	415	349	25	72	111
12A	422	348	--	74	112
13A	406	343	24	71	110
14A	348	290	13	62	89
15A	402	336	26	67	109
16A	421	353	24	70	109
17A	416	350	26	70	108
18A	415	348	26	74	113
19A	402	338	20	67	108
20A	411	346	23	69	110
21A	400	338	23	69	109
22A	405	340	21	71	105
23A	420	350	23	73	114
24A	405	342	29	74	116
25A	412	348	29	74	110
26A	416	342	26	71	110
27A	420	350	21	69	---
28A	418	346	24	74	115
29A	355	298	15	63	91
30A	348	281	10	67	89
31A	349	287	12	59	84
32A	307	257	10	54	82
33A	417	349	24	71	104
34A	334	277	12	73	91
35A	425	361	23	76	109

July 19, 1961

Catalogue Number	Total Length	Standard Length	Weight	Head Length	Dorsal-Pectoral
36A	410	343	23	75	110
37A	292	240	8	52	66
38A	305	252	8	51	78
39A	410	347	23	73	114
40A	413	349	22	66	106
41A	398	332	23	--	---
42A	417	350	24	--	---
43A	286	236	7	--	---
44A	295	242	8	--	---
45A	411	342	21	--	---
46A	423	354	25	--	---
47A	417	352	22	--	---
49A	327	271	11	--	---
50A	420	352	22	--	---
51A	422	355	24	--	---
52A	294	244	7	--	---
53A	321	269	10	--	---
54A	416	347	21	--	---
55A*	322	257	25	--	---
56A	400	334	21	--	---
57A	363	297	13	--	---
58A	318	262	9	--	---
59A	348	287	13	--	---
60A	329	275	12	--	---
61A	407	349	27	73	114

October 26, 1961

(Fast growing fish desiganted by **)

Catalogue Number	Total Length	Standard Length	Weight	Head Length	Dorsal-Pectoral
1	342	287	12	66	85
2	324	268	8	63	78
3	356	292	9	67	82
4	313	256	9	57	75
5	357	300	14	64	93
6	344	282	11	62	87
7	321	266	10	61	80
8	357	295	11	65	84
9	339	279	10	67	78
10	343	288	11	61	88
11	348	287	11	66	86
12	330	273	10	62	75
13	333	277	10	62	84
14	320	265	8	60	75
15	351	288-	11	68	80
16	346	281	10	62	83
17	314	257	7	61	70
18	315	262	8	64	75
19	300	247	7	54	72
20	388	276	10	62	79
21	322	270	9	60	80
22	365	305	12	64	91
23	323	267	9	59	84
24	320	264	8	58	82
25	309	255	8	58	75
26	323	266	8	62	80
27	329	268	9	61	79
28	306	252	7	51	74
29	325	271	9	59	75
30	323	269	9	60	82
31	347	288	10	63	84
32	338	280	10	63	81
33	299	250	7	55	75
34	352	290	11	63	88
35	333	278	10	64	77
36	309	255	8	56	77
37	330	274	9	61	79
38	326	272	9	59	81

October 26, 1961

Catalogue Number	Total Length	Standard Length	Weight	Head Length	Dorsal-Pectoral
39	318	265	8	62	81
40	335	277	9	60	80
41	298	245	7	56	70
42	305	252	7	57	71
43	305	250	8	55	73
44**	475	400	35	80	129
45**	445	372	27	75	115
46	469	388	31	85	123
47**	481	405	34	80	121
48	498	417	41	91	132
49	400	328	20	74	106
50	449	375	29	80	116
51	490	407	34	88	120
52	317	252	8	54	74
53	395	327	17	70	99
54	377	312	15	69	95
55	362	298	12	66	97
56	358	292	12	64	85
57	328	272	10	62	80
58	341	281	10	66	85
59	320	264	9	60	81
60	342	284	11	64	86
61	329	270	9	70	80
62	295	240	7	55	75
63	340	282	11	62	88
64	368	307	13	68	91
65	375	307	13	68	91
66	319	265	9	60	79
67	306	255	8	57	73
68	367	303	14	69	87
69	350	285	12	67	82
70	374	311	14	66	88
71	314	263	8	55	72
72	326	268	9	64	79
73	393	327	17	74	98
74	423	349	23	83	106
75	345	287	11	63	91
76	316	258	9	60	76
77	318	263	9	67	77

October 26, 1961

Catalogue Number	Total Length	Standard Length	Weight	Head Length	Dorsal-Pectoral
78	353	293	12	63	92
79	281	231	7	54	70
80	366	300	13	66	90
81	323	269	9	58	77
82	331	278	11	61	80
83	331	273	9	61	82
84	320	264	9	56	81
85	318	252	8	62	76
86	322	265	9	59	82
87	308	252	8	59	77
88	335	280	9	61	83
89	330	271	10	65	75
90	326	268	9	58	78
91	365	303	14	66	91
92	337	278	11	64	85
93	331	277	11	63	85
94	328	279	9	62	80
95	318	265	8	58	76
96	355	294	12	63	93
97	325	270	10	59	82
98-	352	290	12	66	90
99	320	269	9	61	83
100	315	260	9	58	79
101	325	267	9	58	79
102	383	315	16	77	92
103	330	273	10	62	83
104	342	281	9	60	80
105	324	269	8	57	78
106	338	278	11	67	83
107	328	270	9	59	76
108	354	289	12	68	75
109	345	296	9	65	84
110	308	252	7	57	76
111	317	264	10	62	80
112	310	258	8	59	78
113	306	255	8	62	72
114	301	240	7	59	70
115	297	245	8	54	72
116	316	263	8	59	74
117	323	268	10	63	84

October 26, 1961

Catalogue Number	Total Length	Standard Length	Weight	Head Length	Dorsal-Pectoral
118	309	257	8	62	77
119	305	252	7	53	77
120	322	265	8	58	81
121	328	273	9	59	80
122	313	255	8	56	77
123	319	266	9	57	74
124	310	258	8	57	78
125	288	238	6	54	70
126	305	250	8	59	77
127	315	283	9	57	77
128	310	258	8	60	71
129	318	265	9	58	78
130	318	258	8	57	75
131	331	278	10	58	80
132	351	284	10	70	82
133	338	278	12	63	89
134	390	320	16	75	91
135	315	262	8	58	79
136	360	297	11	65	86
137	299	253	7	54	74
138	323	273	10	58	84
139	322	266	8	57	80
140	338	280	9	60	81
141	321	269	8	58	75
142	300	248	7	53	74
143	322	268	9	59	79
144	334	278	9	61	79
145	351	291	11	67	88
146	334	273	9	61	85
147	338	284	10	62	84
148	307	257	7	55	76
149	337	277	9	59	82
150	315	262	8	56	78
151	299	248	7	57	72
152	333	277	9	64	80
153	306	255	8	55	76
154	354	294	12	64	84
155	315	262	7	59	74
156	310	257	7	58	71
157	316	258	8	57	78

October 26, 1961

Catalogue Number	Total Length	Standard Length	Weight	Head Length	Dorsal-Pectoral
158	329	278	9	60	83
159	285	235	6	53	67
160	320	267	10	57	85
161	329	270	10	62	82
162	316	264	10	57	80
163	347	295	12	65	90
164	304	258	8	57	79
165	330	277	8	63	78
166	323	268	10	59	83
167	322	266	8	60	83
168	252	---	8	55	78
169	295	---	7	66	77
170	323	270	8	61	79
171	348	287	11	68	85
172	316	260	7	58	75
173	314	262	7	57	75
174	318	265	8	60	77
175	332	277	8	65	76
176	308	348	6	62	73
177	320	268	7	60	78
178	304	251	7	58	75
179	312	261	7	59	77
180	321	267	7	58	77
181	277	230	5	54	67
182	347	290	12	64	87
183	341	287	10	60	85
184	312	257	8	57	79
185	323	268	8	60	78
186	340	280	10	61	83
187	310	261	7	57	75
188	300	252	7	56	74
189	286	240	6	54	72
190	292	244	7	57	70
191	355	301	12	65	88
192	310	258	6	57	78
193	324	274	9	59	82
194	293	242	5	54	72
195	317	262	7	59	79
196	310	256	6	61	70
197	282	217	5	52	70
198	298	248	6	53	71
199	287	238	7	54	69
200	289	240	6	56	65
201	315	258	8	57	76