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Age and Growth Determination of the Black Bullhead From Soft Fin Rays

James W. Sprague

AGE AND GROWTH DETERMINATION OF THE BLACK BULLHEAD FROM SOFT FIN RAYS

By

James W. Sprague

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BLACK BULLHEAD FROM SOFT FIN RAYS

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

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J.W.S.

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INTRODUCTION

Knowledge of the age of individuals comprising populations of fish is essential to the fishery biologist. From such information he is able to calculate the rate of growth, determine the age at which sexual maturity is attained and the longevity of the species. These calculations and determinations can then be applied in the management of populations and in setting fishery regulations.

There are numerous methods being used to determine the age of an individual fish. Of these, the scale method is the most important means of age determination being utilized with species of fish possessing scales (Cooper, 1951). This method assumes that the ratio of body length to scale length is constant for all sizes of fish. As the fish grows, the scale increases in size proportionately and lays down concentric ridges called circuli. If growth of the fish is uninterrupted, no change will occur in the growth pattern of the scale. However, in areas that experience seasonal changes in temperature, the rate of metabolism will decrease with temperature, with a corresponding decrease in the rate of growth during periods of cold weather. The decrease in the rate of growth results in a corresponding period of interrupted growth of the scale and is recognized by the spacing of the circuli. The circuli tend to be more widely spaced during the summer's growth and more closely spaced during the winter's growth.

Another growth characteristic of the scale is that with a decrease in the growth rate the circuli will be interrupted and will end at different places along the lateral margin. Then, with the resumption of growth, the new ridges parallel the entire scale margin and hence cut across the unfinished circuli previously formed. This phenomenon is called "cutting over" and is very useful in determining the yearmark or "annulus". In the analysis of a scale for age determination the characteristics of cutting over and the spacing of the circuli are utilized to locate the annulus. The age of the fish is then determined by counting the number of annuli.

The first annulus is measured from the center (focus) of the scale to the outer margin of the first closely spaced circuli encountered and/or to where the cutting-over effects are observed. The other annuli present are measured from the outer margin of the previous year's growth to the next outer margin where the annular characteristics are located. Then, by measuring the distance between annuli, the rate of growth can be calculated for each year group with the assumption that the distance between the annuli is in direct proportion to the growth in length of the fish for that period (Lagler, 1956).

With those fish not possessing scales, other methods have necessarily been adopted. These methods have primarily utilized the hard bony structures such as the otoliths, vertebrae, and opercular bones, or other hardened portions of fish anatomy such as the pectoral fin rays. These structures, either sectioned or not, show zones of differential deposition of bony material which are considered to be year marks. The year marks appear as alternate light and dark bands. Annual growth is interpreted as the distance from the outer margin of one dark band to the outer margin of the next dark band. The calculations of growth for these methods are determined in the same manner and with the same assumptions as with the scales.

There has been considerable work carried out on the hardened structures. Sneed (1951) used the left pectoral spine to determine the age of the channel catfish (*Ictalurus lacustris*). Appelget and Smith (1951) successfully aged channel catfish by using the fifth vertebra; they also calculated the rate of growth of the fish from the same vertebra. Marzolf (1955) employed pectoral spines and vertebrae in determining the age and rate of growth of the channel catfish. McConnell (1952) studied opercular bones as indicators of age and growth of the carp (*Cyprinis carpio*). Forney (1955) employed the vertebra in a life history study of the black bullhead (*Ictalurus melas*).

The disadvantages connected with the use of the hardened structures in age and growth studies are found in the collection and examination of material. The collection of the structures usually necessitates the destruction of the fish, and the examination is tedious and time consuming. These disadvantages have therefore largely discouraged age and growth studies of scaleless fish.

An ideal technique for age and growth determination for scaleless fish should employ a structure that would eliminate the need of the study of the bony structures. The structure utilized should provide an expression of seasonal differential growth so that ages can be easily determined; it should be easily obtained in the field without causing undue mutilation of the fish or necessarily causing mortality; and it should be easy to prepare in the laboratory for age and growth determinations. The utilization of the soft rays of the fins appears to fill nearly all of these requirements.

Fin rays have been employed in age and growth work for a number of years, but the work was concerned mainly with fish having much larger fins than the bullhead. Apparently the procedure has not been applied to the bullhead. Boyko (1950) found that the annual rings are formed not only on hard, spiny rays, but also are well marked on the soft branched rays. His work was concerned mainly with the sturgeon (*Acipenser sp.*). Cuerrier (1951) made age determinations from cross-sections of the marginal ray of the pectoral fin of the lake sturgeon (*Acipenser fulvescens*). Scidmore and Glass (1953) employed similar techniques for aging the white sucker (*Catostomus commersoni*).

This problem was directed toward determining the possibility of employing the soft rays of the fin in age and growth work on the black bullhead and thereby eliminating most of the disadvantages of hardened structures previously employed. In order to establish this possibility, it was necessary to first establish a feasible technique of sectioning the fin. Once the method of sectioning was decided upon it was then necessary to determine whether this method had merit and could be relied upon.

As the use of vertebra is a commonly accepted method of determining age and growth in the bullhead, a comparison of the results obtained from the fin-ray sections with the results obtained from readings of corresponding vertebrae would be an indication of the relative accuracy of the fin-ray method in age and growth determinations.

FIELD COLLECTIONS

Location of Collection

The fish for this study were captured during July and August of 1957 from three North Dakota lakes: Lake Darling, in the northwest section of the state (Renville and Ward Counties); Lake Ashtubula, in the southeast section of the state (Barnes County); and Heart Butte Reservoir, in the southwest section of the state (Grant County). The specimens collected from the three lakes were handled as separate units throughout the problem. This was done because the methods of collection and the type of gear used varied in each of the lakes.

Methods of Collection

Fish Samples

The specimens collected from Lake Ashtubula were obtained from commercial fishermen. Their method of holding the fish, after capture, in cribs constructed of lath accounts for the single size represented from this lake. The laths are so spaced as to allow the smaller fish to escape. The kinds of gear employed on the other lakes were fyke-nets and pocket-nets. Although both of these nets operate on the same principle, the pocket-nets took more bullheads and were more desirable due to their smaller size and easier handling. The pocket-set consists of a lead or fence that directs the fish either way into the throat or funnel of the net. As the fish pass through the funnel they become trapped and are unable to escape. Figure 1 illustrates the construction of one-half of a pocket-net. Several pocket-nets were combined

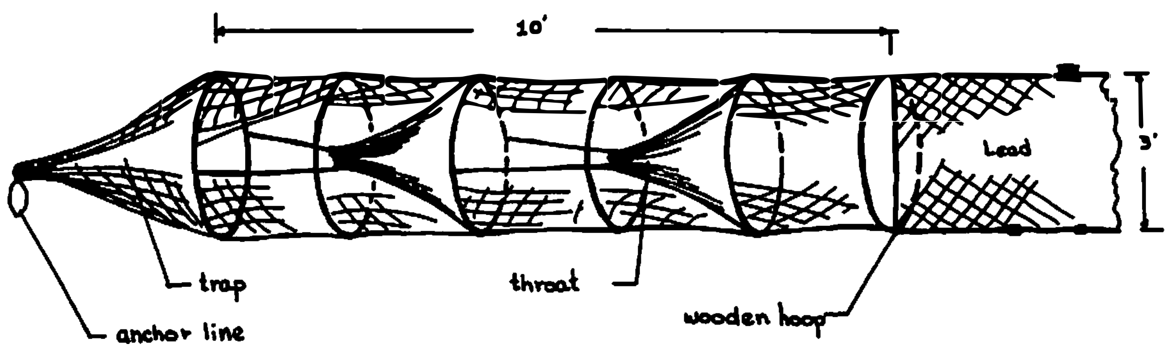

Figure 1. -- Schematic drawing of one-half of a pocket-net.

to form an extended net. This added length of net was found to bring about a greater capture of bullheads per net hour than did the single nets. These strings of nets were checked at 24-hour intervals and the catch removed.

Upon capture, the weight (in tenths of pounds) and the total[1] and standard[2] lengths (in tenths of inches), together with the locality and date of capture, were recorded on the sample envelope. The following portions of the fish were then removed and placed in the sample envelope: the left pectoral spine, the fifth vertebra, a section of the caudal fin, and the entire pelvic fin.

<u>Vertebrae Samples</u>

The fifth vertebra is easily located since the first four vertebrae are fused together. Passing a knife transversely down through the body on a 45 degree angle, just ahead of the dorsal fin, bisects the vertebral column anterior to the fifth vertebrae. The actual dissection of the vertebral column is not difficult but time consuming. Upon removal, the vertebrae were placed in the sample envelope and allowed to dry.

<u>Pectoral Spine Samples</u>

The left pectoral spine was collected following the procedure

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[1]Total length was measured from the tip of the snout to the tip of the dorsoventrally compressed caudal fin.

[2]Standard length was measured from the tip of the snout to the structural base of the caudal fin as determined by flexing the caudal fin to locate the base.

outlined by Sneed (1951). The spine was grasped with a pair of pliers, pulled outward to loosen the joint, and then rotated in a clockwise direction. The spines were removed free of practically all tissue except a thin layer of skin.

Fin-ray Samples

With scissors the complete pelvic fin and the dorsal one-third of the caudal fin were removed from the fish. The caudal fin was cut deep enough to include the base of the fin. Since this deep cut caused severe mutilation, it is doubtful if the caudal fin can be utilized in age and growth studies without destruction of the fish. The pelvic fin was cut flush against the body and apparently caused little injury.

LABORATORY PROCEDURES

Vertebrae

Direct observation upon the faces of the centra of the vertebrae was attempted but proved to be difficult due to the dried material adhering to them. More satisfactory results were obtained by removing this adherent material in a digestive solution prior to aging. The vertebrae were cleaned by a period of incubation in a digestive solution composed of 0.4 percent hydrochloric acid and 0.7 percent pepsin, as suggested by Appelget and Smith (1951). Each of the specimens was placed in a vial containing 10 milliliters of solution and incubated at 37 degrees centigrade for 24 hours. This procedure removed all traces of the adherent material and, without further treatment, the annuli could be read directly. It was noted that vertebrae from freshly killed fish required a longer period of time in the incubator to remove the adherent material.

After cleaning, the vertebrae were studied under a low power dissecting microscope at a magnification of 13 diameters. The vertebrae were placed in a wire clamp and arranged so as to bring the ventral field of the centrum into view from its center to its edge. A drop of xylol added to the vertebra helped to reveal the yearmarks. Figure 2 shows a vertebra as it appears under the binocular microscope after the cleaning process. Measurements between yearmarks were made with the aid of an ocular micrometer along the line A - B projected from the center along the ventral surface to the edge of the centrum (Figure 2).

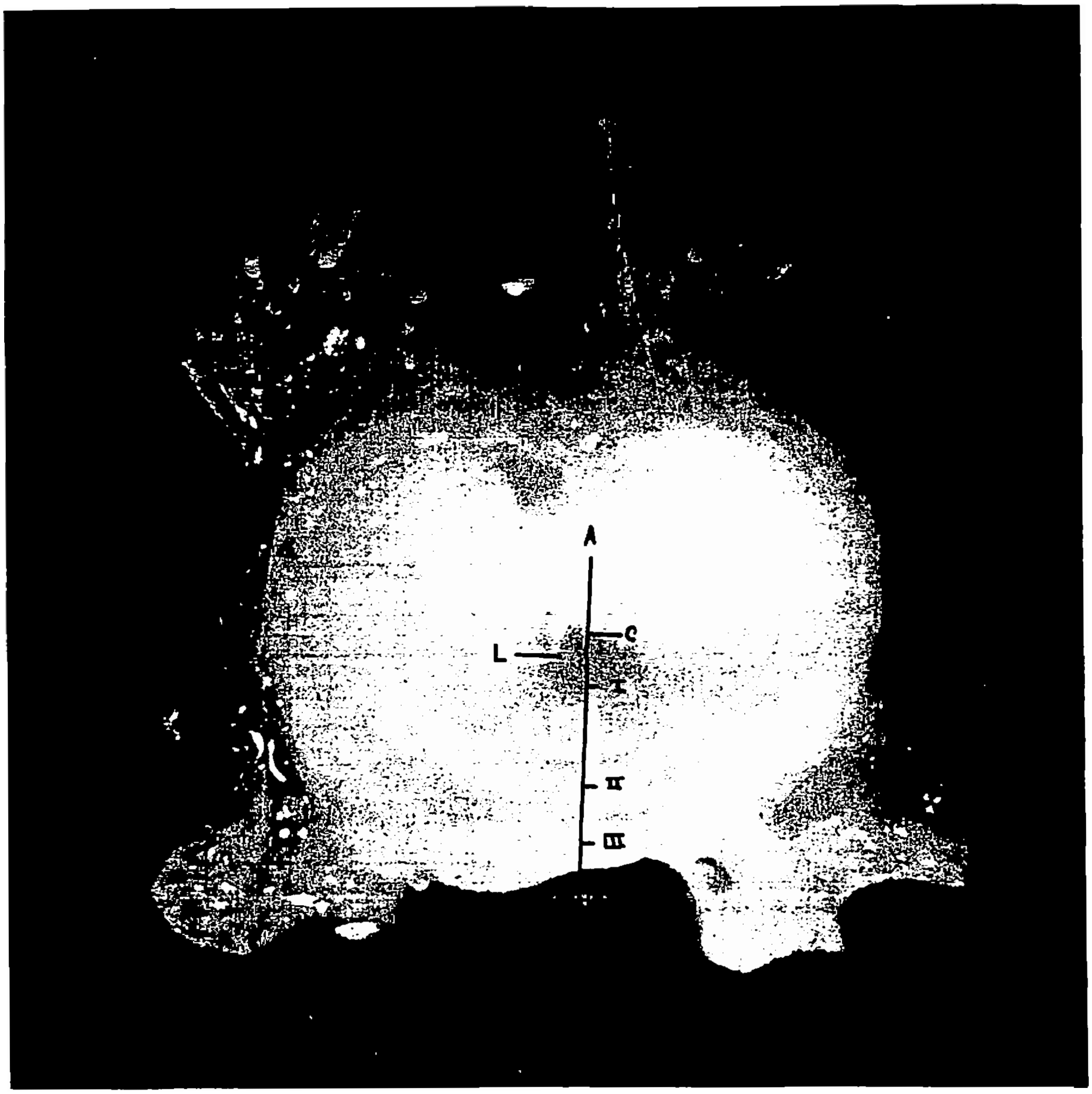

Figure 2. -- Photograph of the fifth vertebra of the black bullhead. A - B, line along which vertebra was measured; C, position where measurement was begun; E, edge of spine; L, lumen of vertebra; I, II, III, yearmarks.

Pectoral Spines

The pectoral spines were imbedded in celloidin and sectioned, with a fine-toothed jeweler's saw, just above the deep groove on the base of the spine. The sections were then placed in a drop of xylol and aged by counting the growth rings seen with the aid of the dissecting microscope. The spine was not included in the study except as a check in the establishment of the locations of yearmarks.

Fin Ray

In an attempt to discover a feasible method of preparing soft fin rays for age and growth determination, several methods were tested. Some of the methods adapted for use on the bony structures that were attempted include imbedding the fins in paraffin then sectioning them to various thicknesses (5, 10, and 15 microns) with a microtome, softening the fins with one and four percent potassium hydroxide solution prior to imbedding in paraffin, and imbedding the fins in celloidin then sectioning with a fine-toothed jeweler's fret saw.

The results obtained, except for those of fin rays imbedded in celloidin, were negative. The fins upon sectioning with a microtome tore loose from the imbedding material regardless of the width of section used or the prior softening with potassium hydroxide. The sections imbedded in celloidin were completely mutilated by the jeweler's fret saw, but sectioning by hand with a small unmounted microtome blade provided usable sections. There are two disadvantages apparent in this method: the amount of time consumed in preparation prior to sectioning and the necessity of removing the celloidin before aging since it obscures the outer edge of the section.

The technique finally adopted was to section untreated fins by hand with a small microtome blade or razor-blade. The results obtained by this method proved just as accurate as those obtained from imbedding in celloidin. In the process of sectioning, the fins were held down with the thumb while the index finger was used to guide the blade in cutting. No preparation of the fin was necessary, since the rays of the fin are held together by the dried fin membranes and slime. The sections were made as close to the base of the fin as possible, and care was taken to insure that the section was made at right angles to the fin rays. It was found that the sections must be made thin enough to show good differential transparency. A section between 0.5 and 1.0 millimeters thick was easily read and was not difficult to obtain by hand sectioning. Several sections were cut from the fin and placed on a glass slide. A drop of xylol was added to help distinguish yearmarks and a drop of balsam was used as a mounting medium to preserve the specimen.

Determination of the yearmarks was made with a compound microscope using 140 X magnification. Measurements between yearmarks were made with the aid of an ocular micrometer along the line A - B projected from the inner margin of the section through the widest portion of the section (Figure 3).

Growth rings on a section of the fin ray appear as wide light-

Figure 3. -- Photograph of a section of the pelvic fin of the black bullhead. A - B, line along which the fin was measured; C, position where measurement was begun; E, edge of fin; I, II, III, yearmarks.

colored bands interrupted by narrower dark-colored bands. The dark-colored bands are winter-marks and the distance from the outer margin of one to the outer margin of the next represent annual growth. The inner margin of the fin was difficult to determine on sections not made close to the base. The area between the second and third year's growth must also be examined carefully as the difference in color is very slight and easily overlooked.

RESULTS

The method of determining age from the vertebrae had been accepted as reliable (Forney, 1955); therefore, a comparison of the age and growth determinations obtained from the fin-ray sections with those obtained from the vertebrae should be an indication of the validity of the fin-ray method.

In an attempt to establish a correlation between the two methods, the results from each method were treated in various ways: (1) by calculating the length at each predetermined yearmark, (2) by totaling the growth during the successive years, (3) by determining the absolute[3] growth for each age group, and (4) by calculating the annual increment of growth (Tables 1, 2, and 3).

These same tables illustrate the results determined from the specimens obtained from each of the three lakes for both the vertebrae and the fin-ray methods. With the measurements placed side by side the correlation, or the variance in some cases, between the two methods can be readily observed.

The absolute growth and the annual increment of growth from each of the lakes are presented graphically in Figures 4, 5, 6, and 7. The results of the fin-ray method and the vertebra method for each lake were placed on the same graph to better illustrate the degree of correlation or variation attained.

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[3]Absolute growth is the average total size at each age (Lagler, 1956).

Table 1. Growth calculations by fin-ray and vertebra method for black bullheads; Lake Darling, North Dakota 1957.

Age Group	Length at Capture	Calculated length at each yearmark (inches)							
		I		II		III		IV	
		Fin	Vert.	Fin	Vert.	Fin	Vert.	Fin	Vert.
I	(none)								
II	4.5	1.7	1.9	3.8	3.2				
III	7.4	1.8	2.5	3.7	4.9	6.2	6.2		
	7.6	2.7	1.9	5.4	3.8	6.7	5.7		
	8.1	2.5	2.4	5.1	5.7	7.1	7.2		
	8.3	2.6	2.8	4.8	5.2	6.6	6.9		
	8.3	2.2	1.8	5.5	5.2	7.2	7.0		
	8.4	2.6	2.5	4.9	5.5	7.1	7.1		
	8.5	2.4	1.8	6.5	4.9	7.7	7.2		
	8.6	1.9	2.0	4.9	4.3	7.5	7.0		
	8.6	2.9	2.2	4.8	4.3	7.6	6.9		
	8.6	1.9	2.0	5.7	4.3	7.6	7.0		
	8.7	1.9	2.2	4.8	6.1	7.2	7.8		
	8.7	2.9	2.1	4.8	4.1	7.2	6.2		
	9.0	2.2	2.6	5.1	4.7	7.9	6.9		
	9.0	2.4	2.2	4.9	4.5	7.4	6.8		
	9.0	2.4	2.6	5.3	5.1	7.8	6.9		
	9.1	2.3	2.3	5.3	4.9	7.6	7.2		
	9.1	3.0	2.6	6.1	4.3	7.6	6.9		
	9.2	2.6	1.9	4.6	4.6	7.7	6.9		
	9.2	3.1	2.3	6.1	4.6	7.7	6.9		
	9.2	2.8	1.9	5.1	4.6	7.8	7.7		
	9.2	2.6	2.0	6.6	4.6	7.9	6.9		
	9.3	2.1	2.3	5.2	4.6	7.8	7.4		
	9.3	2.4	2.4	6.2	4.5	8.4	6.5		
	9.4	2.7	2.0	6.0	5.3	8.7	7.8		
	9.4	2.4	2.0	5.2	4.7	8.0	7.4		
	9.4	2.5	2.6	5.1	5.6	7.9	7.7		
	9.4	2.2	2.0	6.4	5.1	8.3	7.4		
	9.5	2.8	1.9	5.6	5.3	7.8	8.0		
	9.5	2.6	1.8	5.3	4.9	7.9	7.0		
	9.6	2.6	2.4	5.2	5.6	7.8	8.0		
	9.6	2.4	2.2	6.6	6.1	8.4	7.8		
	9.6	3.2	2.5	6.4	5.7	8.0	7.8		
	9.8	2.3	2.6	5.3	5.1	7.5	7.7		
IV	10.1	2.8	2.0	6.4	3.4	7.8	6.1	9.2	8.1
	11.0	3.3	3.1	5.7	5.1	8.1	7.4	10.0	9.4

Table 1. (cont.)

Age Group	Length at Capture	Calculated length at each yearmark (inches)							
		I		II		III		IV	
		Fin	Vert.	Fin	Vert.	Fin	Vert.	Fin	Vert.
IV (cont.)	11.4	3.1	3.0	5.7	6.8	8.3	9.1	9.8	10.6
	11.4	3.4	3.3	6.7	5.9	8.7	9.2	10.1	10.3
	11.4	2.7	2.8	6.0	5.9	8.1	8.3	10.3	10.4
	12.0	3.1	2.8	6.8	4.9	8.9	7.4	10.4	10.2
	12.2	2.1	2.0	5.9	4.9	9.3	7.3	11.4	10.2
	12.2	2.4	2.6	6.1	5.9	8.0	7.8	9.8	10.7
	12.4	3.6	2.8	5.6	6.9	7.9	9.6	10.2	11.4
Grand Totals	404.2	110.1	99.6	237.2	215.6	326.7	308.0	91.2	91.3
Average length	9.4	2.6	2.3	5.5	5.0	7.9	7.3	10.1	10.1
Increments of growth		2.6	2.3	3.0	2.7	2.3	2.3	2.4	2.8

Table 2. Growth calculations by fin-ray and vertebra method for black bullheads, Lake Ashtubula, North Dakota, 1957.

Age Group	Length at Capture	Calculated length at each yearmark (inches)							
		I		II		III		IV	
		Fin	Vert.	Fin	Vert.	Fin	Vert.	Fin	Vert.
I	(none)								
II	(none)								
III	7.5	1.8	1.9	5.3	4.7	6.6	6.6		
	7.5	2.7	3.0	5.4	5.2	6.5	6.4		
	7.5	1.9	2.6	5.0	5.4	6.2	6.2		
	7.6	2.0	2.5	4.2	4.8	6.8	6.8		
	7.7	1.6	2.7	5.0	4.5	6.6	6.3		
	7.7	2.0	2.4	4.6	4.0	6.2	5.6		
	7.7	1.6	1.8	5.5	4.5	6.6	6.3		
	7.7	2.0	2.0	5.1	4.8	6.7	6.5		
	7.7	2.2	1.7	5.5	4.3	6.6	6.0		
	8.0	1.6	1.8	5.3	3.6	6.9	5.0		
	8.0	1.9	2.0	5.2	4.8	7.0	6.8		
	8.0	3.4	1.9	5.1	4.6	6.9	6.9		
	8.0	1.9	2.8	4.2	5.6	6.6	7.0		
	8.1	2.4	2.3	3.7	5.4	6.0	6.9		
	8.1	1.8	2.8	3.3	4.9	6.6	7.0		
	8.1	1.9	2.2	5.6	5.0	6.8	6.8		
	8.1	2.0	2.0	5.0	4.8	7.0	7.0		
	8.2	1.9	2.5	5.3	4.9	7.2	6.6		
	8.2	1.2	3.0	5.3	6.0	7.0	7.0		
	8.2	2.2	2.4	5.5	3.7	7.7	5.2		
	8.2	2.2	2.6	6.0	5.4	7.1	6.7		
	8.2	2.3	2.8	4.1	4.5	7.3	6.3		
	8.2	2.9	2.0	4.3	5.0	7.0	6.6		
	8.2	2.5	2.2	5.7	5.2	6.9	7.4		
	8.2	2.3	1.8	5.3	4.1	7.0	6.4		
	8.2	2.7	2.6	4.6	5.6	6.4	6.9		
	8.2	3.0	2.2	4.8	5.2	6.5	6.9		
	8.2	2.5	2.3	5.7	4.1	6.9	6.8		
	8.3	2.2	2.0	5.5	4.4	6.6	5.9		
	8.3	2.2	3.0	5.5	4.7	7.2	6.1		
	8.3	2.4	2.5	5.9	4.2	7.1	6.2		
	8.3	2.9	2.5	4.9	4.6	7.3	6.6		
	8.3	2.8	2.6	4.6	5.7	6.9	7.0		
	8.5	3.0	3.5	4.4	5.8	7.8	7.3		
	8.6	2.0	3.0	5.3	5.5	7.3	7.0		
	8.6	2.2	1.8	5.9	4.5	7.8	6.8		
	8.7	3.2	3.2	5.0	5.0	6.9	6.9		

Table 2. (cont.)

Age Group	Length at Capture	Calculated length at each yearmark (inches)							
		I		II		III		IV	
		Fin	Vert.	Fin	Vert.	Fin	Vert.	Fin	Vert.
III (cont.)	8.7	2.5	2.6	6.2	4.8	7.5	7.0		
	9.0	2.8	3.3	6.6	5.9	8.5	7.2		
	9.0	1.9	2.7	5.8	5.0	7.7	7.2		
	9.0	2.6	2.6	4.7	5.3	7.3	7.1		
	9.0	3.9	3.2	6.3	5.4	7.8	7.2		
	9.1	2.4	2.4	6.0	5.9	7.9	7.5		
	9.1	2.8	2.7	6.3	5.0	7.7	6.8		
	9.1	2.0	2.5	5.0	5.3	7.9	7.4		
	9.2	2.0	3.3	5.1	5.9	7.7	7.4		
	9.2	3.2	3.3	5.5	5.9	7.4	7.7		
	9.2	3.5	2.2	5.4	4.4	8.0	7.5		
	9.2	2.2	3.2	4.5	5.6	7.4	7.6		
	9.3	3.1	2.1	6.2	4.2	8.0	7.2		
	9.3	2.5	2.1	6.2	4.2	8.0	6.3		
	9.3	2.7	2.5	4.8	5.5	7.8	7.6		
	9.4	2.5	3.0	6.9	5.3	8.4	7.1		
	9.5	1.9	2.6	4.8	6.6	8.0	8.0		
	9.6	2.7	1.9	6.9	3.5	8.5	6.7		
	9.6	3.6	2.5	5.7	5.0	8.5	8.6		
	9.7	2.2	3.1	6.7	6.2	8.2	8.2		
	10.0	2.6	3.0	5.8	5.7	9.0	8.3		
Grand Totals	493.6	139.9	145.8	308.0	288.6	421.7	398.3		
Average length	8.5	2.4	2.5	5.3	5.0	7.3	6.9		
Increments of growth		2.4	2.5	2.9	2.5	2.0	1.9		

Table 3. Growth calculations by fin-ray and vertebra method for black bullheads, Heart Butte Reservoir, North Dakota, 1957.

Age Group	Length at Capture	Calculated length at each yearmark (inches)							
		I		II		III		IV	
		Fin	Vert.	Fin	Vert.	Fin	Vert.	Fin	Vert.
I	4.3	1.7	1.8						
	4.5	2.2	2.4						
	4.6	2.0	2.4						
II	5.0	1.4	1.5	3.4	3.5				
	5.3	2.0	1.3	4.0	3.5				
	5.3	1.8	2.4	3.5	3.5				
	5.4	1.7	1.5	4.0	3.4				
	5.5	2.4	1.6	4.7	4.4				
	5.6	1.3	1.3	4.3	3.0				
	5.6	2.0	2.3	4.1	4.2				
	6.1	2.4	1.7	4.3	3.9				
	6.1	2.0	1.7	4.6	3.9				
	6.1	2.5	1.7	4.6	3.5				
	6.2	2.5	2.2	5.0	4.5				
	6.3	2.1	2.1	4.9	4.7				
	6.7	2.1	1.9	4.6	4.3				
III	7.6	2.1	2.0	4.8	3.6	6.2	5.6		
	8.4	1.8	2.1	4.8	5.5	6.6	7.1		
	8.7	1.7	2.4	5.2	5.2	7.0	7.3		
	9.5	2.4	2.4	6.3	5.1	7.9	6.7		
	9.6	1.8	2.6	4.6	5.4	6.8	7.7		
	10.1	2.8	3.0	6.9	5.7	8.5	7.9		
	10.2	2.3	2.3	5.6	4.6	7.9	7.9		
IV	10.3	2.6	2.3	5.7	4.2	7.7	6.5	9.3	9.2
	10.4	2.0	2.0	4.4	3.9	6.9	6.8	8.4	8.8
	10.4	2.1	3.2	5.5	5.7	7.6	8.2	9.0	9.7
Grand Totals	183.8	53.7	54.1	109.8	99.2	73.1	71.7	26.7	27.7
Average length	7.6	2.1	2.1	4.8	4.3	7.3	7.2	8.9	9.2
Increments of growth		2.1	2.1	2.7	2.2	2.5	2.9	1.6	2.0

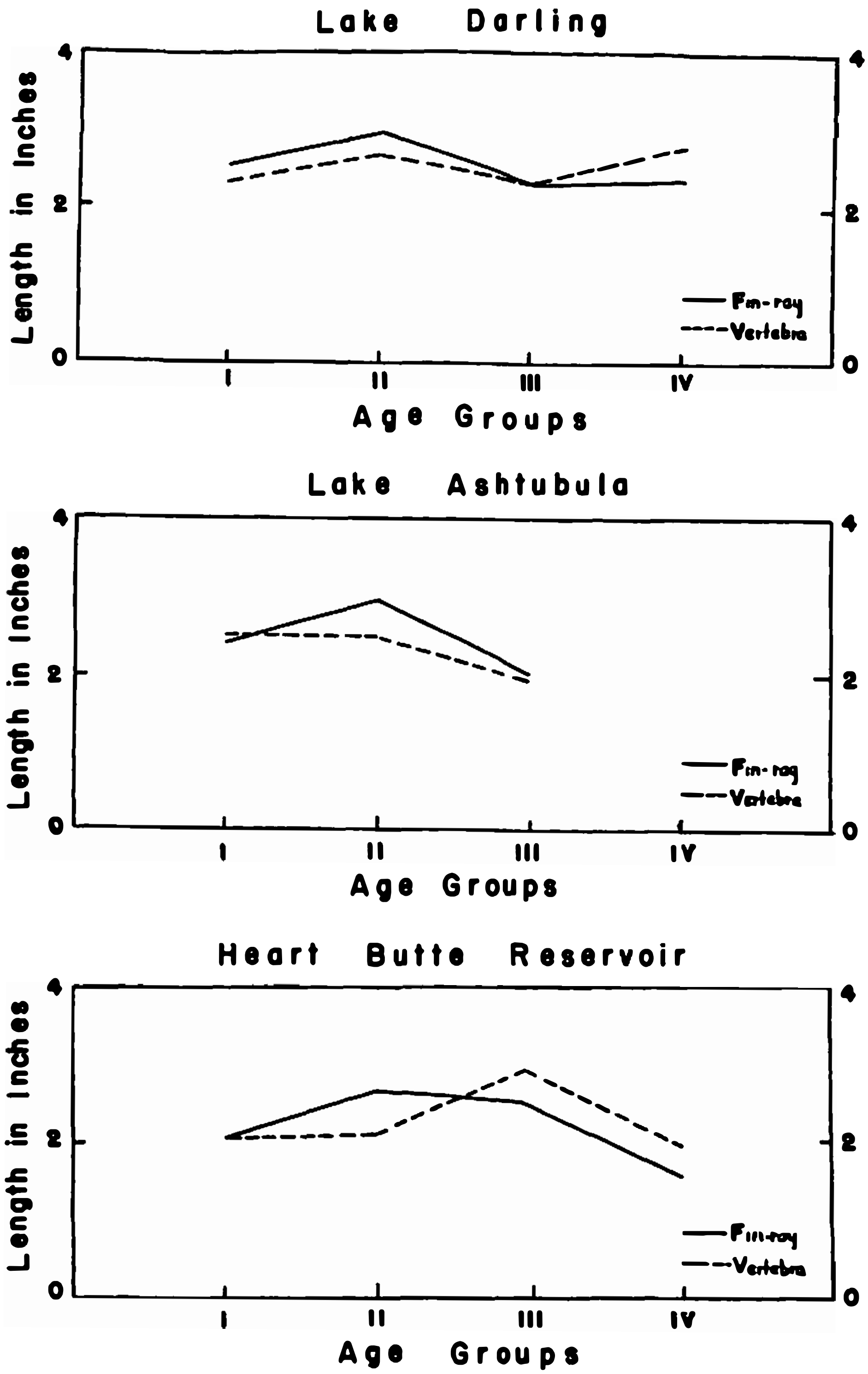

Figure 4. — Annual increments of growth, calculated from the fin ray method and the vertebrae method, North Dakota, 1957.

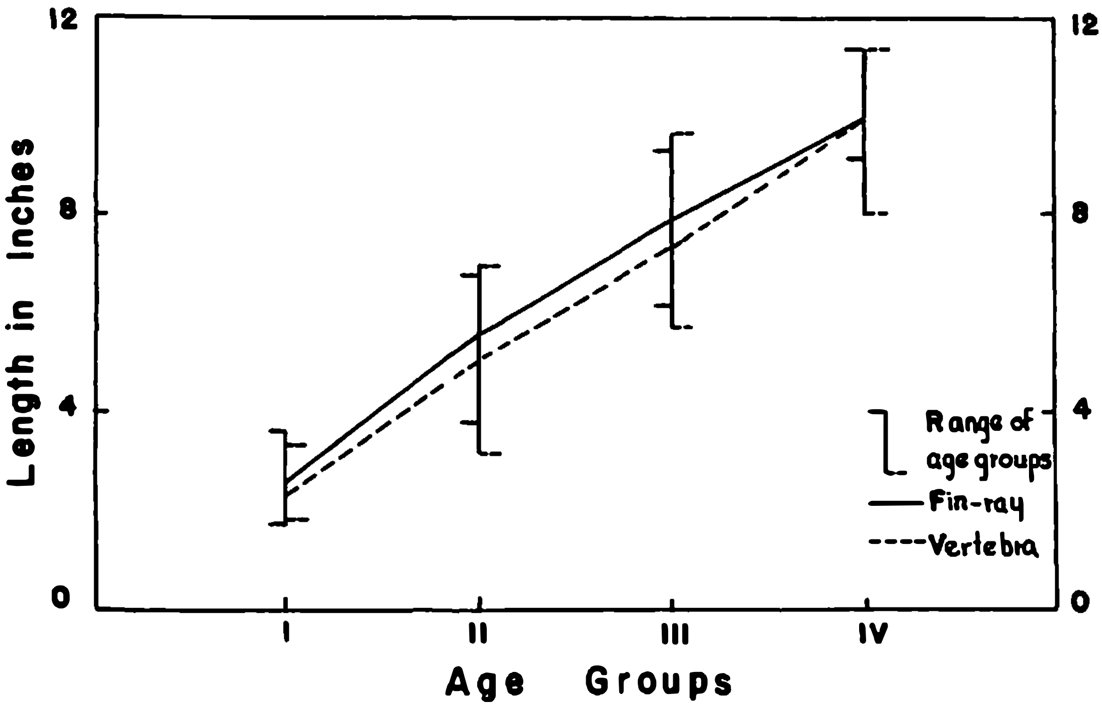

Figure 5. — Absolute growth calculated from the fin ray method and the vertebrae method. Brackets indicate range of age groups for each method. Lake Darling, North Dakota, 1957.

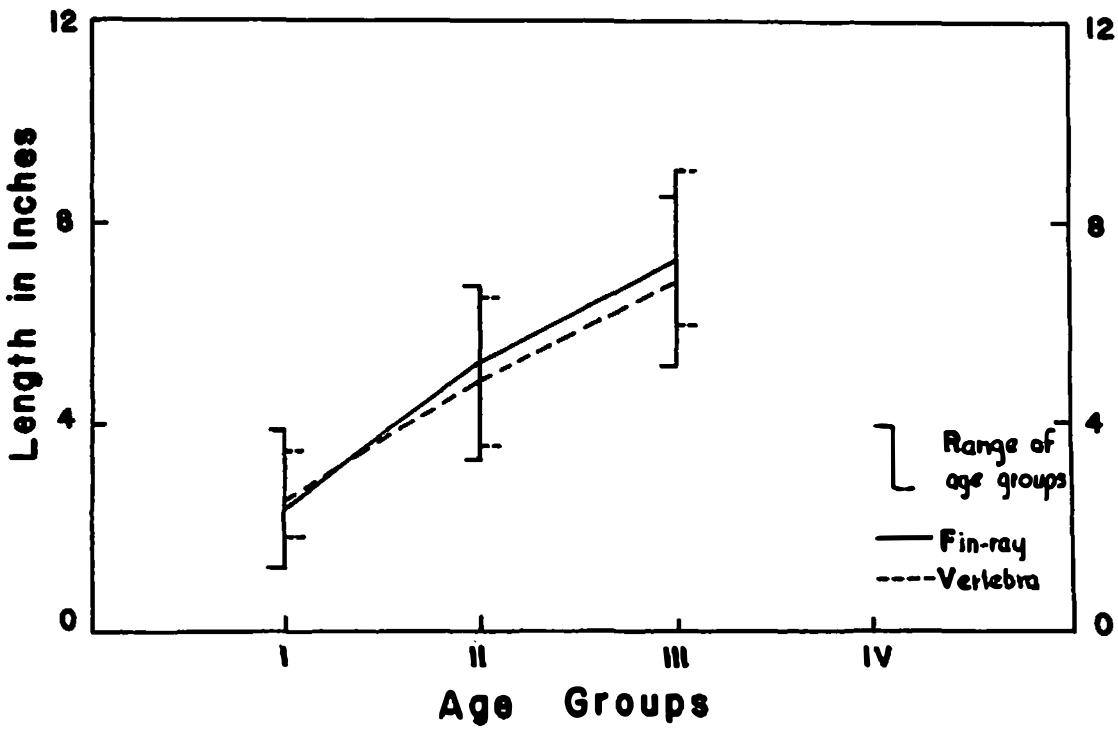

Figure 6. — Absolute growth calculated from the fin ray method and the vertebrae method. Brackets indicate range of age groups for each method. Lake Ashtubula, North Dakota, 1957.

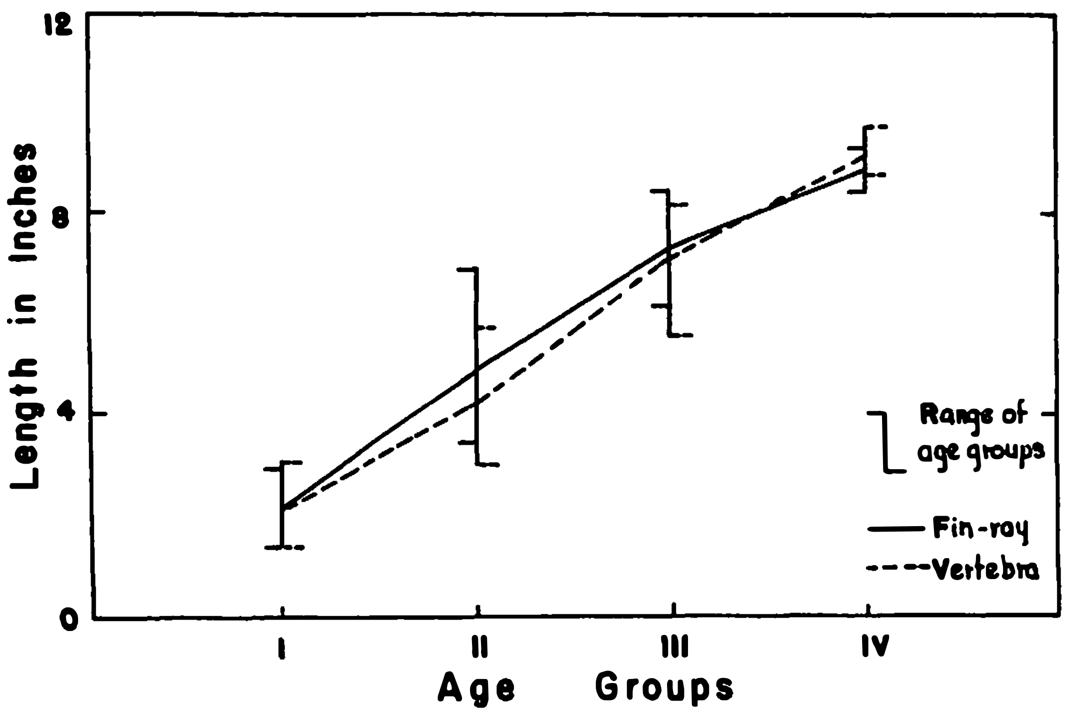

Figure 7. — Absolute growth calculated from the fin ray method and the vertebrae method. Brackets indicate range of age groups for each method. Heart Butte Reservoir, North Dakota, 1957.

Regression lines and correlation coefficient factors were calculated from the results obtained from the specimens from each of the three lakes, following the methods presented by Goulden (1952) and Sneed (1951). The regression lines were plotted to determine the relationship between the fin rays and the vertebrae (Figures 8, 9, and 10), and also relationships between the length of fish and the radius of the fin-ray section at the time of capture (Figures 11, 12, and 13).

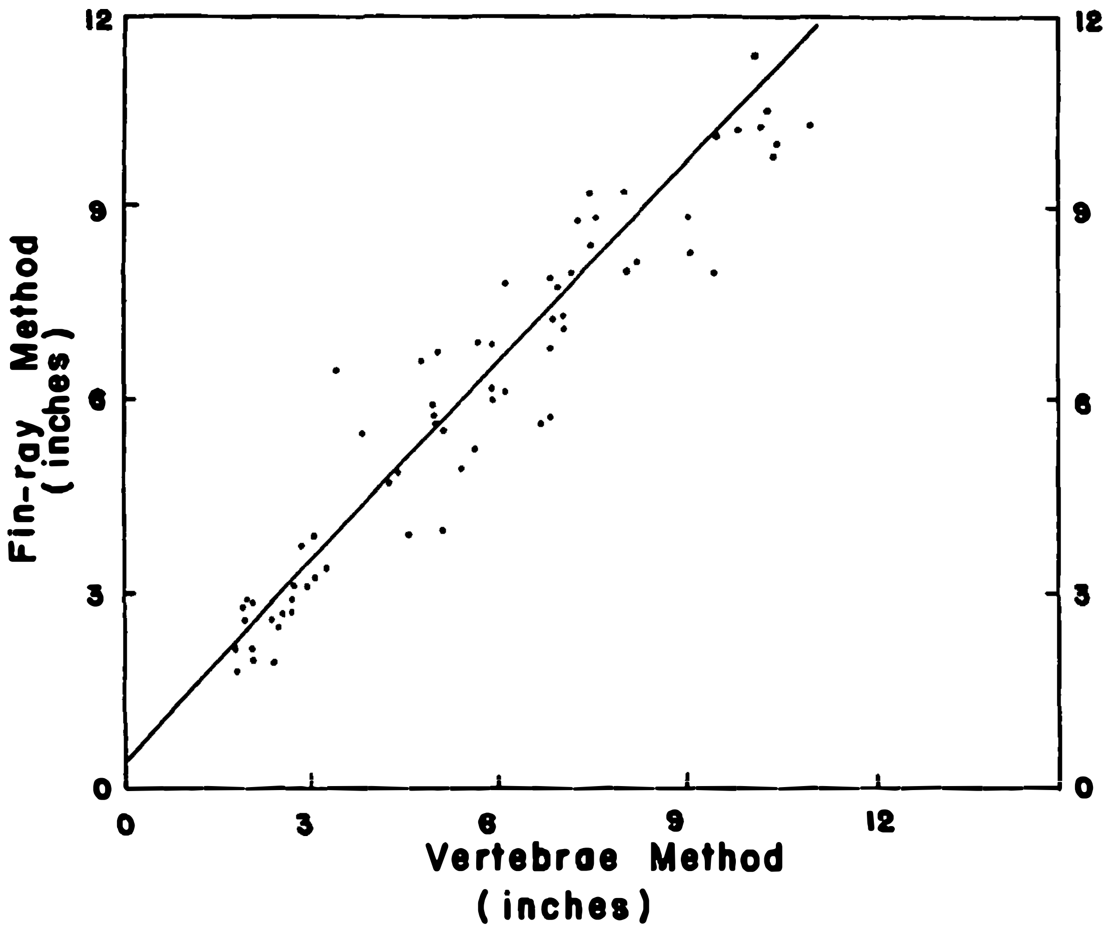

Figure 8. — Relationship between calculated lengths from the fin ray method and the vertebrae method. Lake Darling, North Dakota, 1957.

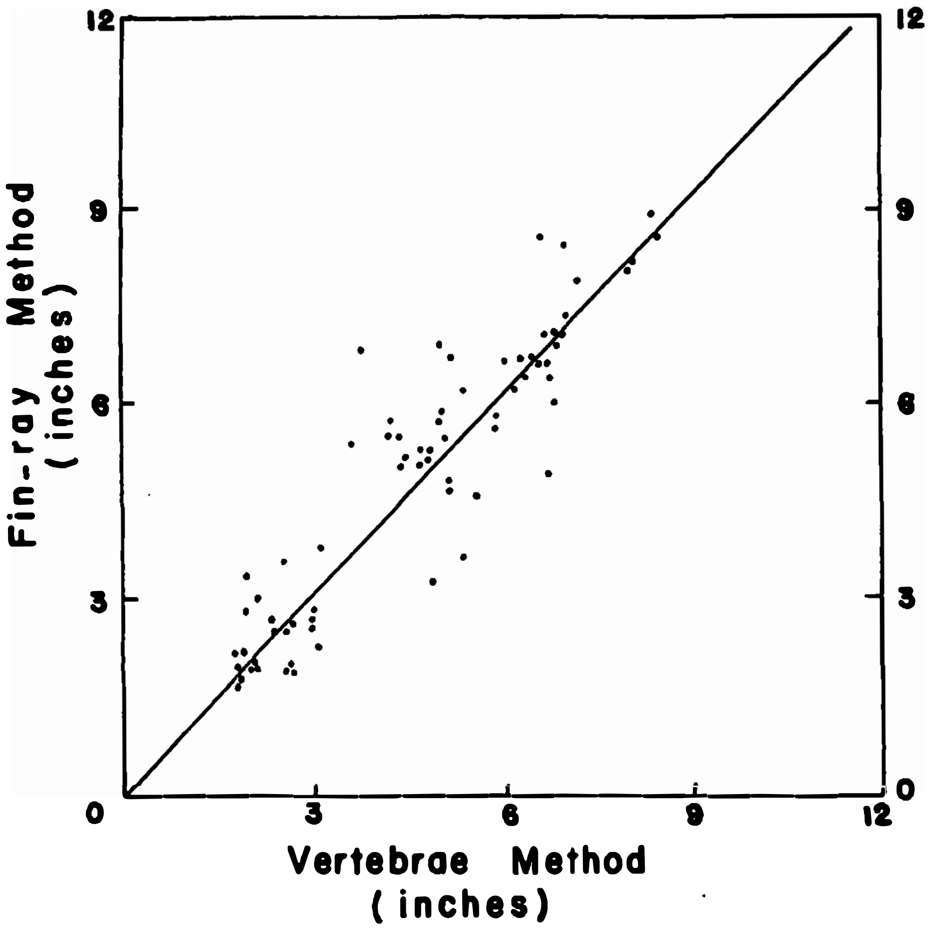

Figure 9. -- Relationship between calculated lengths from the fin ray method and the vertebrae method. Lake Ashtubula, North Dakota, 1957.

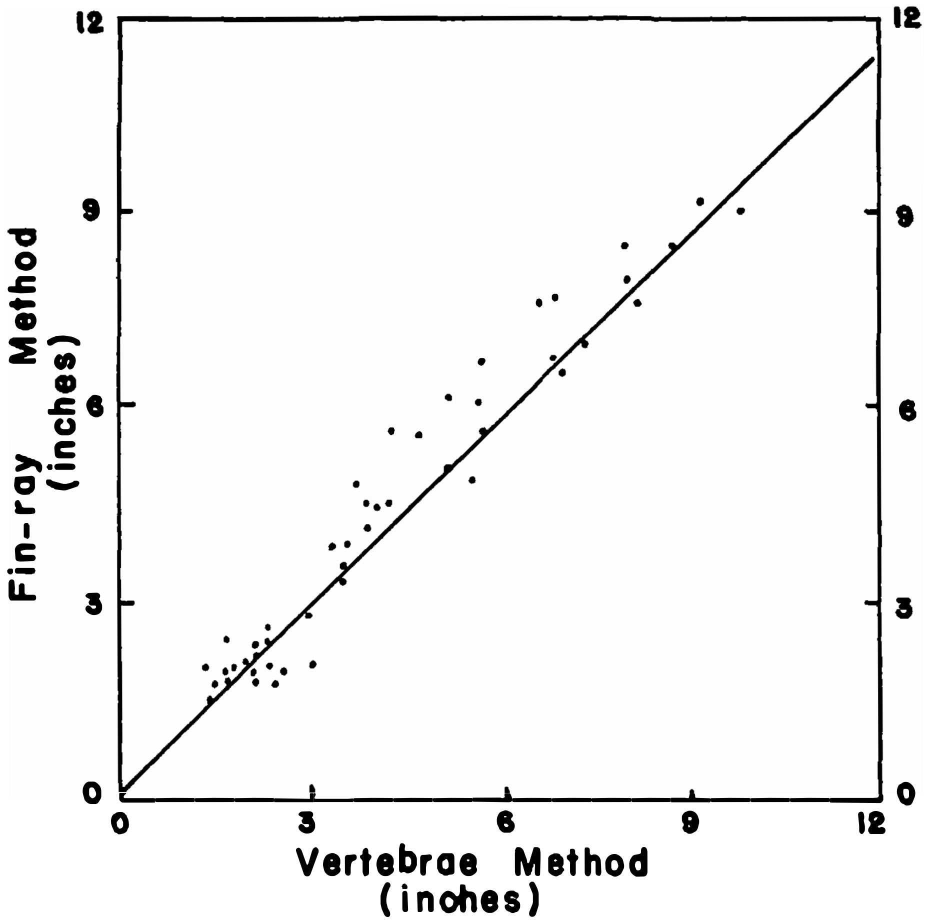

Figure 10. -- Relationship between calculated lengths from the fin ray method and the vertebrae method. Heart Butte Reservoir, North Dakota, 1957.

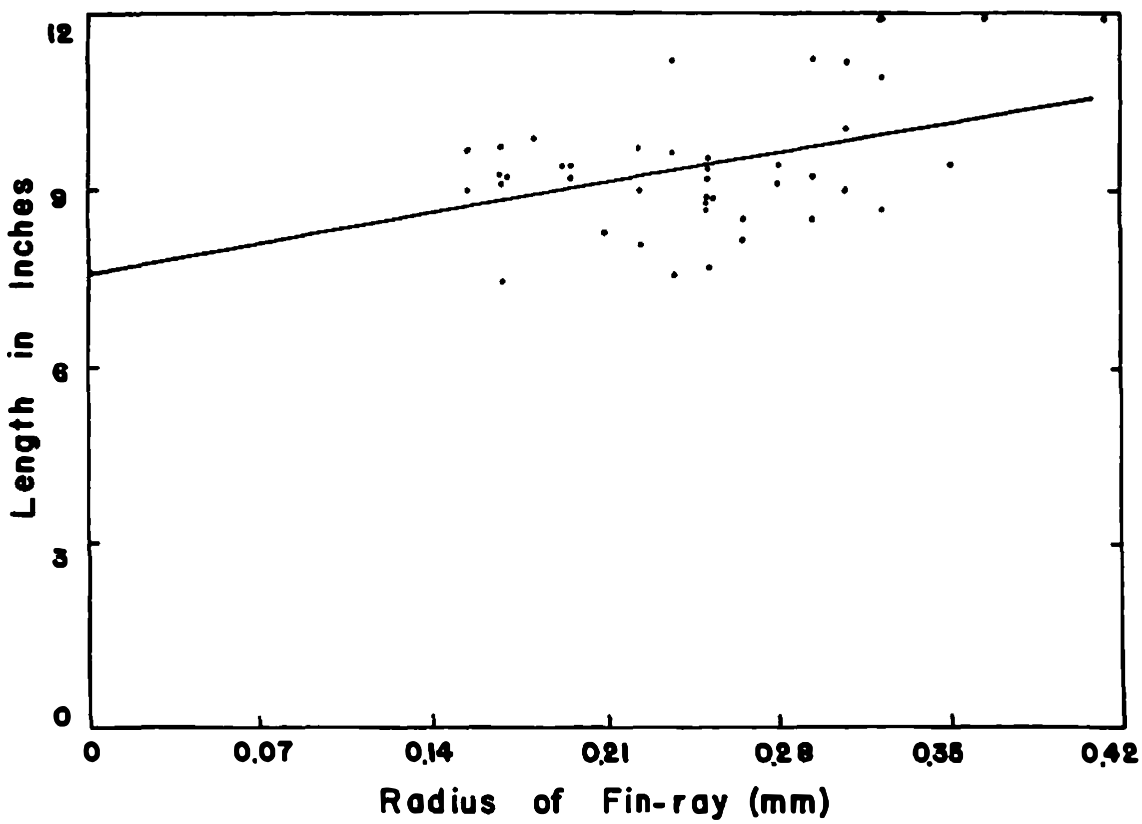

Figure 11. -- Relationship between length of fish at capture and the radius of the fin ray section. Lake Darling, North Dakota, 1957.

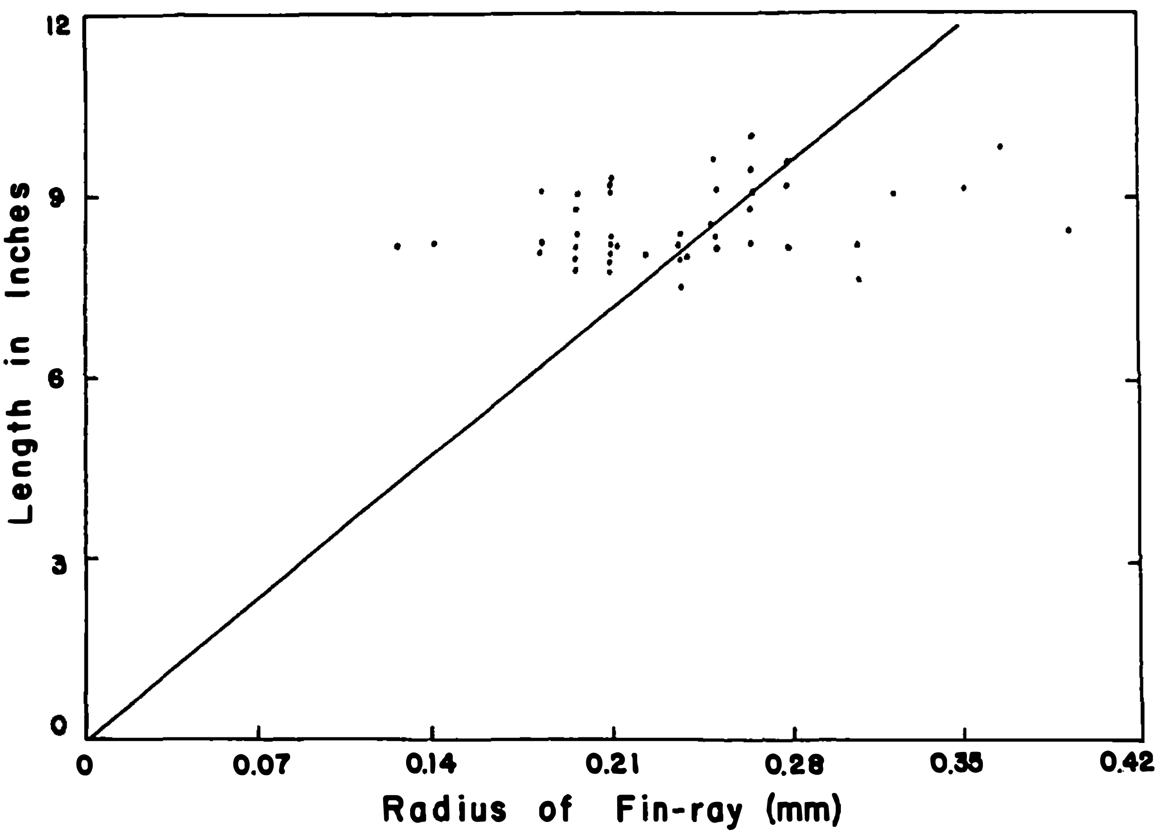

Figure 12. -- Relationship between length of fish at capture and the radius of the fin ray section. Lake Ashtubula, North Dakota, 1957.

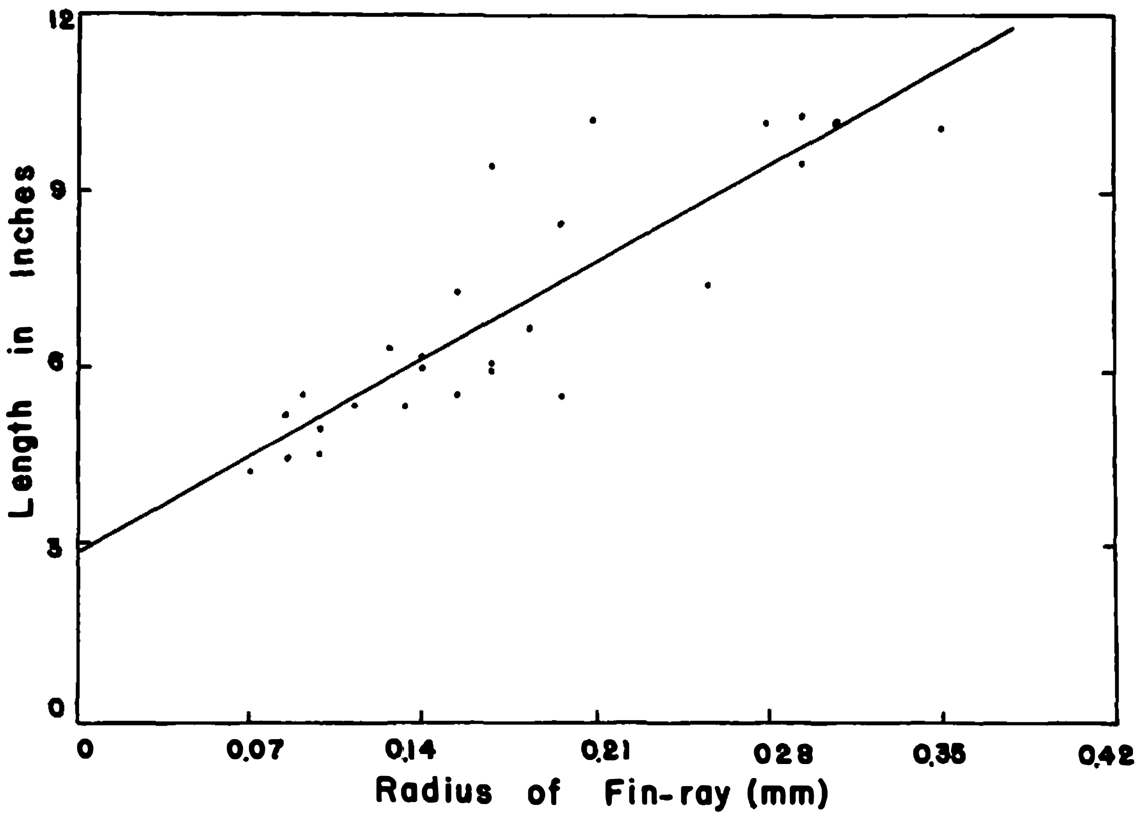

Figure 13. -- Relationship between length of fish at capture and the radius of the fin ray section. Heart Butte Reservoir, North Dakota, 1957.

DISCUSSION

The results obtained from the computations indicate that the relationship between the vertebra and fin-ray methods is highly significant. For example, it is evident in Tables 1 and 3 that the lengths at the end of various years of life, calculated from the fin-ray measurements, show very good agreement with the corresponding empirical length of younger fishes at time of capture. This is one of the criteria for validation of yearmarks (Lagler, 1956) and confirms the assumption that the observed marks on the fin ray are true yearmarks.

The relationship between the two methods is also shown in Figures 4, 5, 6, and 7 where the absolute growth and the annual increments of growth are plotted. The absolute growth for the fin-ray method tends to average somewhat higher than the vertebra method (Figures 5, 6, and 7), but the range of the age-groups as indicated is approximately the same for both methods. All of the measurements for absolute growth follow the same pattern when graphed and show close agreement. It was found that up to the second year of life there is an increase in the growth increment with a steady decrease in following years (Figure 4). The growth increment followed this pattern for both the vertebra and the fin-ray method with only two exceptions, age-group IV in Lake Darling and age-group III in Heart Butte Reservoir. These exceptions are probably due to the small samples available for study. It is evident that measurements from fin rays are more consistent while those from the vertebra tend to be sporadic and less predictable.

The correlation coefficients obtained from the comparison of growth calculated from fin-ray and vertebra methods are as follows: Lake Ashtubula, 0.919; Lake Darling, 0.968; and Heart Butte Reservoir, 0.964. As correlation is a measure of the degree of relationship between two variables having a common background or association, and, as a correlation coefficient of 1.00 indicates perfect correlation, the degree of correlation obtained in this problem indicates that the fin-ray method of aging is highly reliable for all practical purposes and may have application in age and growth studies. The relationship between the measurements of the age groups and the predicted regression line (Figures 8, 9, and 10) substantiates the calculated correlation. The majority of the points lie in close proximity to the regression line; the few that scatter are probably due either to minor errors in measurement or the variations of the individuals.

A comparison of the relationship between the length of the fish and the radius of the fin ray at time of capture does not indicate a high degree of correlation (Figures 11, 12, and 13). The intercepts for the three sets of data vary considerably and the points plotted have a tendency to scatter.

The variance in intercepts and the lesser degree of correlation between the predicted regression line and the points plotted are probably due to the method of sectioning the fins. The fin rays in the anterior portion of the fin are larger than those in the posterior portion; therefore, a measurement from a section of a fin ray from the anterior portion results in a larger radius. The fin is also larger at the base and the diameter of the fin ray decreases as it grows outward; hence, a measurement from a section at the base of the fin results in a larger radius. As more than one section from each fin was utilized for aging it was not possible to age each fish from the same location on the fin.

It is realized that no final determinations can be made from just one year's study; but, from the results obtained throughout the study, it is believed that the problem warrants further study and consideration. From a practical and economic standpoint, the use of the pelvic fin in age and growth studies of bullheads would have greater application for the fishery biologist than existing methods.

SUMMARY

This problem was directed toward determining the usefulness of soft fin rays in age and growth studies of the black bullhead. Validity of the experimental method was attempted by comparing results obtained from age and growth determinations of the fin-ray method with results from a commonly accepted method.

Collection of specimens was made during the summer of 1957 from three North Dakota lakes. Specimens were obtained from commercial fishermen and with the use of fyke-nets and pocket-nets.

Methods of preparing fin rays and vertebrae for aging were explored. The fin-ray method appears to overcome some disadvantages connected with present methods.

Results indicate that the fin-ray method as determined from pelvic fin studies is highly reliable and applicable to age and growth research. Correlation obtained between the fin-ray and vertebra methods was 0.919 or over in all samples.

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