AGE AND GROWTH OF WALLEYE AND SAUGER OF THE TONGUE RIVER RESERVOIR, MONTANA

by

VICTOR LEONARD RIGGS

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of

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Approved:

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Chairperson, Graduate Committee

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Head, Major Department

____
Graduate Dean

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VITA

Victor Leonard Riggs was born October 18, 1952 in Miles City, Montana to Leonard and Laura Riggs. He graduated from Custer County High School in June, 1971 and enrolled at Miles Community College at Miles City the following autumn. He received an A. A. degree in Fish and Wildlife Management from M.C.C. in June, 1973. In September, 1973 he enrolled in the undergraduate program at Montana State University and graduated with a B.S. in Fish and Wildlife Management in December, 1975. He began graduate work in Fish and Wildlife Management in January, 1976.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Surface coal mining is presently underway adjacent to the Tongue River Reservoir in southeastern Montana. A baseline study of the walleye (Stizostedion vitreum) and sauger (Stizostedion canadense) populations of the reservoir was conducted as a result of the present mining operation and the plans for expanded mining. The age and growth of 640 walleye and 546 sauger were studied from gillnet, trapnet and electrofishing collections made in 1975, 1976 and 1977. The results indicate excellent growth rates for walleye and sauger for a northern latitude reservoir. The 1973 sauger year class dominated the catch for 1975, 1976 and 1977. The 1972 walleye year class dominated the catch for the same three years. The greatest annual growth increment for walleye and sauger occurred in the first year of life. Young-of-the-year walleye captured during August, 1976 averaged 189.5 mm in length. The Tongue River above the reservoir was used by spawning walleye in late March and early April of 1977. The movement of tagged fish from the reservoir into the river and back to the reservoir was noted. Surface coal mining does not appear to have any detrimental effects on the two species considered at this time.

INTRODUCTION

Baseline information is needed to detect potential changes in aquatic ecosystems which may occur as a result of expanded mining of western coal. Population, age and growth and life history parameters of the walleye (*Stizostedion vitreum*) and sauger (*Stizostedion canadense*) populations of the Tongue River Reservoir were studied for this reason.

Decker Coal Company is presently operating a large surface coal mine near the southwest end of the reservoir and is in the process of expanding to a second location near the southeast shore (Figure 1). A northward extension of the present mine is planned within the next few years.

The field work was conducted during the summer and fall of 1975, 1976 and the spring of 1977. A section of river directly above the reservoir was examined in the spring of 1977 to determine its use as a spawning area for walleye and sauger.

DESCRIPTION OF STUDY AREA

The Tongue River Reservoir, located 23 kilometers north of Sheridan, Wyoming in Big Horn County, Montana (Figure 1), is the only major impoundment on the Tongue River. The Tongue River originates in the Big Horn Mountains of Wyoming and flows in a northeast direction for 105 river kilometers until reaching the reservoir. The drainage area above the reservoir is 4584 km^2 (U.S.G.S., 1975). The river continues for 271 kilometers beyond the reservoir to its confluence with the Yellowstone River at Miles City, Montana.

The earthfill dam is 27.7 meters high and was completed in 1940 for irrigation and flood control. At spillway level (1043.3 meters) the reservoir floods an area of about 1415 hectares (U.S.G.S. and Mt. Dept. of State Lands, 1977). At storage capacity the reservoir has a maximum length of 12.5 kilometers, a maximum width of 1.4 kilometers and an average depth of 6.1 meters (Garrison, Whalen and Gregory 1975). The surface area, length of shoreline at spillway elevation and the shoreline development index are 1277 hectares, 60 kilometers and 4.74, respectively (Penkal, 1976). The reservoir had an initial storage capacity of about 8939 hectare-meters in May of 1939 (Dendy and Champion, 1973). By 1948, sedimentation had decreased the capacity to about 8557 hectare-meters. With similar rates of sedimentation the 1975 capacity was estimated to be about 7398 hectare-meters (U.S.G.S.

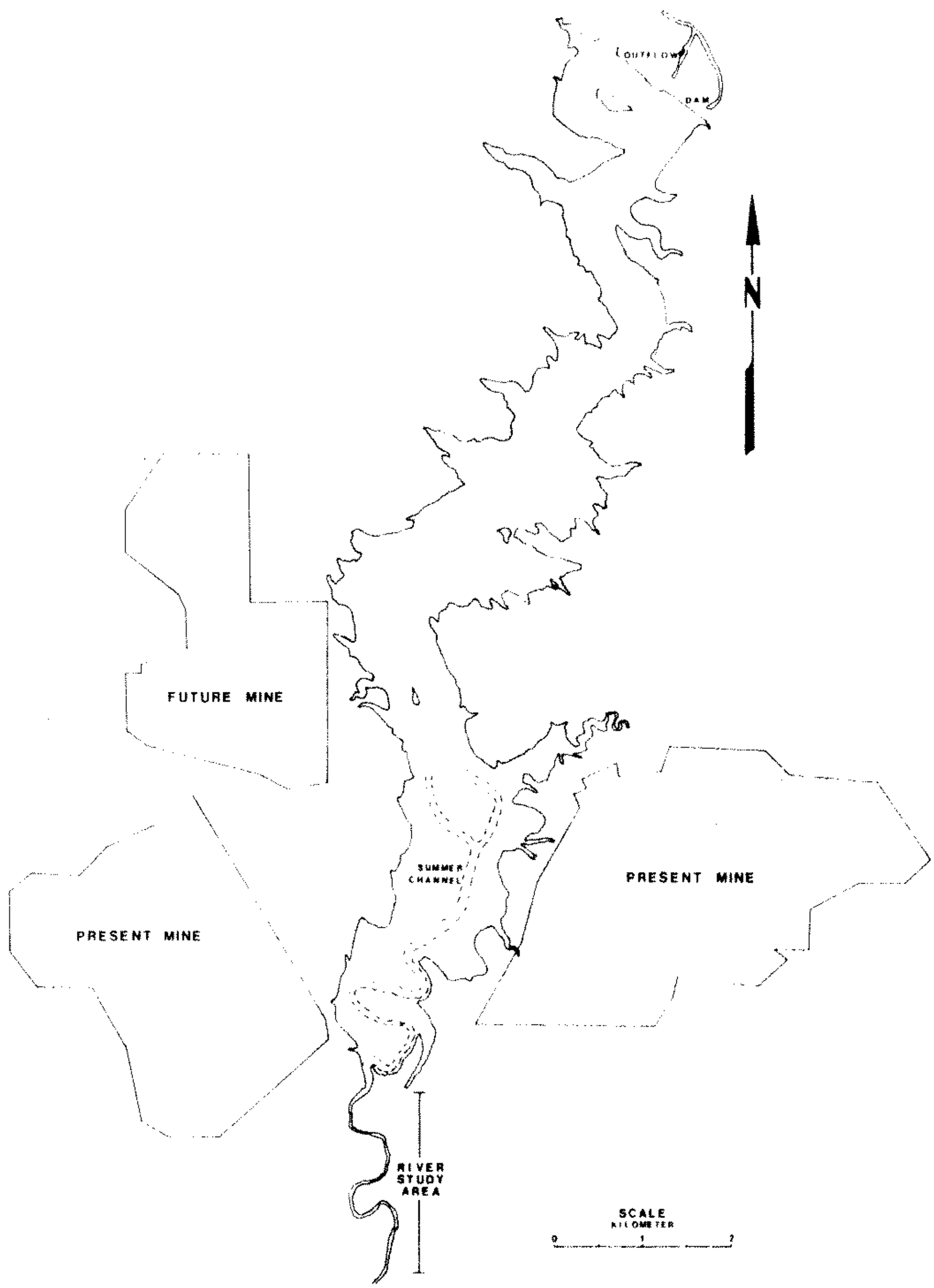

Figure 1. Map of study area.

and Mt. Dept. of State Lands, 1977). Some physical parameters of the Tongue River Reservoir are listed in Table 1.

Table 1. Morphometric data of the Tongue River Reservoir at spillway elevation (1043.3 m)

Maximum depth[1]	18.0 m
Mean depth[1]	6.1 m
Depth of outlet[3]	15.2 m
Maximum length[2]	12.5 km
Maximum breadth[1]	1.4 km
Mean breadth[1]	1.1 km
Surface area[2]	1277 ha
Volume[3]	7398 ha·m
Length of shoreline[2]	60 km
Index for shoreline development[2]	4.74

[1](Garrison, et al. 1975)

[2](Penkal, 1976).

[3](U.S.G.S. and Mt. Dept. of State Lands, 1977).

Peak runoff usually occurs during late May and early June, but 1975 was an exceptional year with runoff persisting from early May to mid-July (Figure 2). An extensive late summer draw-down coupled with the high runoff in 1975 resulted in a reservoir fluctuation of about 8 meters (Figure 3). The years of 1976 and 1977 were closer to normal

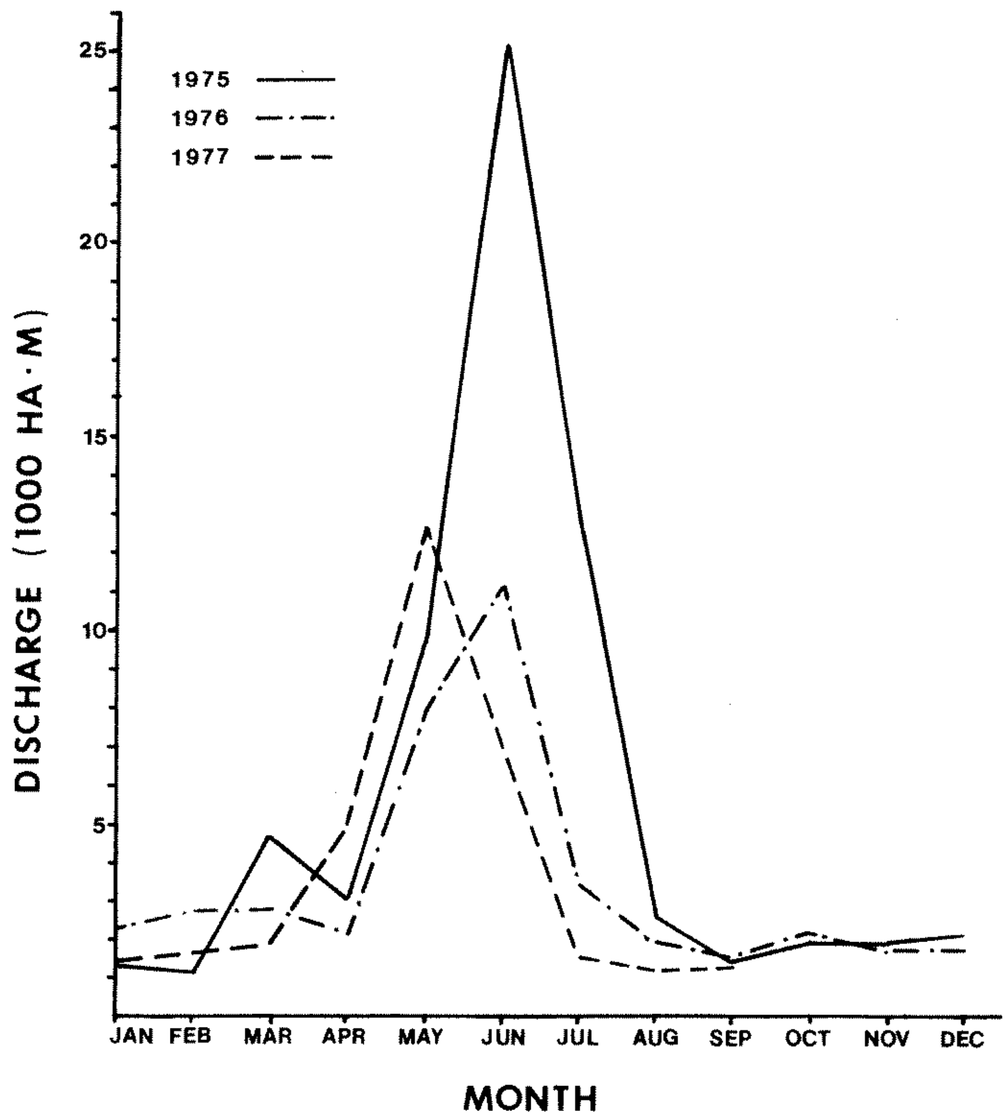

Figure 2. Discharge rates of the Tongue River, near Decker, Montana (U.S.G.S. 1975, U.S.G.S. 1976, and U.S.G.S. unpublished data).

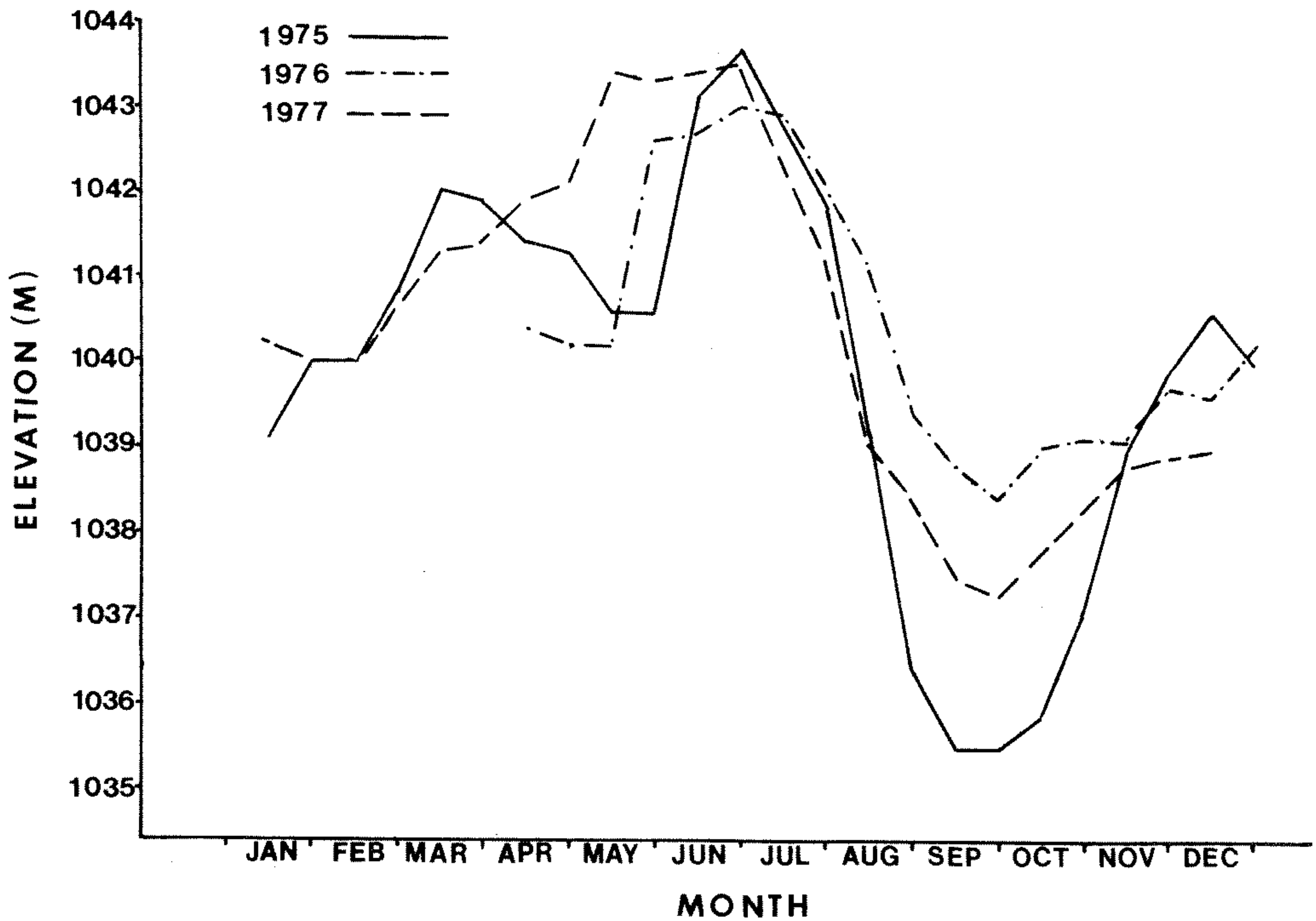

Figure 3. Water level elevations for the Tongue River Reservoir, Montana (Montana Department Natural Resources, unpublished data)

with fluctuations of 5 and 6 meters, respectively. The greater water level fluctuation in 1975 is apparent in the water storage history of the reservoir (Figure 4). The river study section was approximately 3.1 river kilometers in length and contained areas of gravel substrate which appeared suitable for walleye and sauger spawning. During this study period, reservoir ice-off occurred on April 23, 1975, April 3, 1976 and April 6, 1977.

A warm water fisheries program was implemented at the reservoir in 1963. Prior to this time, rainbow trout (Salmo gairdneri) had been planted but their numbers remained low, while rough fish populations remaining from a rehabilitation project in 1957 increased. The warm water species planted included northern pike (Esox lucius), channel catfish (Ictalurus punctatus), largemouth bass (Micropterus salmoides) and walleye. White and black crappie (Pomoxis sp.) were present prior to the 1957 rehabilitation and are abundant today (Penkal, 1976). Smallmouth bass (Micropterus dolomieui) first appeared in 1972 and are believed to be the result of overflow from stripmine ponds near Sheridan, Wyoming (Elser, 1975). Sauger first appeared in the reservoir in 1973 and are believed to stem from a Wyoming Game and Fish plant in the Tongue River near the Montana-Wyoming border in 1967 (Elser, McFarland and Schwehr, 1977). Walleye were planted as follows: 1965--750,000 fry, 1966--100,000 fry, 1967--197,750 fry, 1968--601,214 fry, and 1969--92,480 fry. Of the warm water fishes only northern pike

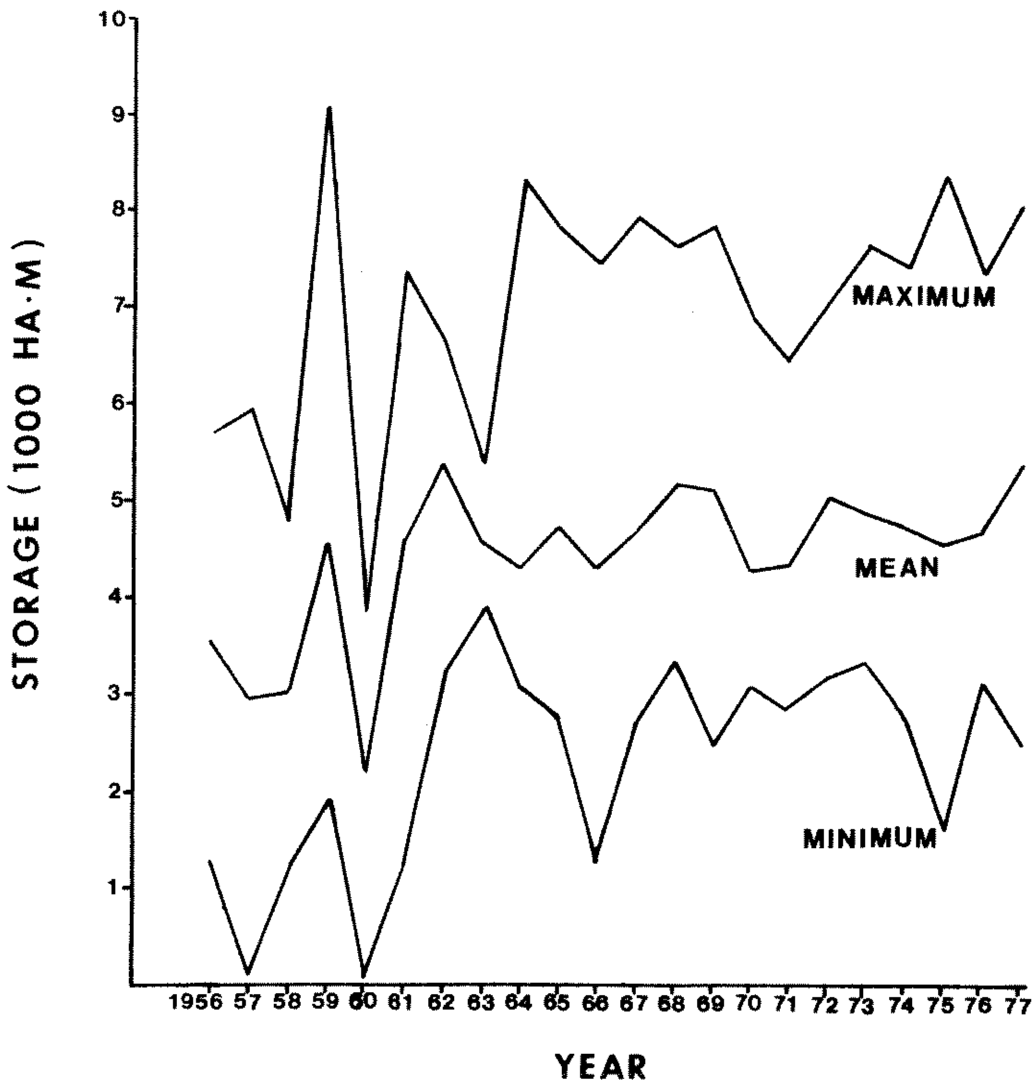

Figure 4. Water storage history of the Tongue River Reservoir, Montana (Montana Dept. of Nat. Resources, unpublished data).

are not self-sustaining. A list of the species present in the reservoir is presented in Table 2.

Table 2. Species of fish present in the Tongue River Reservoir, Montana

Common Name	Scientific Name
Trout	Salmonidae
Rainbow trout	*Salmo gairdneri*
Brown trout	*Salmo trutta*
Minnow	Cyprinidae
Carp	*Cyprinus carpio*
Goldfish	*Carassius auratus*
Golden shiner	*Notemigonus crysoleucas*
Flathead chub	*Hybopsis gracilus*
Sucker	Catostomidae
River carpsucker	*Carpoides carpio*
Shorthead redhorse	*Moxostoma macrolepidotum*
Longnose sucker	*Catostomus catostomus*
White sucker	*Catostomus commersoni*
Catfish	Ictaluridae
Black bullhead	*Ictalurus melas*
Yellow bullhead	*Ictalurus natalis*
Channel catfish	*Ictalurus punctatus*
Stonecat	*Noturus flavus*
Sunfish	Centrarchidae
Rock bass	*Ambloplites rupestris*
Green sunfish	*Lepomis cyanellus*
Pumpkinseed	*Lepomis gibbosus*
Smallmouth bass	*Micropterus dolomieui*
Largemouth bass	*Micropterus salmoides*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Pike	Esocidae
Northern pike	*Esox lucius*
Perch	Percidae
Yellow perch	*Perca flavescens*
Sauger	*Stizostedion canadense*
Walleye	*Stizostedion vitreum*

METHODS

Walleye and sauger were captured using trap nets and gill nets in 1975, 1976 and 1977. During September of 1976, electrofishing proved successful for collecting young-of-the-year walleye and two- and three-year-old sauger. Electrofishing was employed in the spring of 1977 to sample the river study section. All reservoir electrofishing was conducted at night and all river electrofishing during the day. Direct current (D.C.) was used in both instances. The gear employed for shocking consisted of a modified Smith Root, Model VI electrofishing boat (Penkal, 1976), a Model VP-10 Coffelt variable voltage pulsator and a 230 volt, 4000 watt, A.C. generator. All fish lengths and weights were taken to the nearest 1 mm and 10 grams, respectively. Fish were tagged with Floy FD67 anchor tags in 1975 and 1976. Floy FD68B anchor tags were used in 1977. A right pelvic clip was used in 1976 and a left pelvic clip in 1977 as a check against tag loss. Sex was determined by examining ripe fish for eggs or milt and by gonadal examination of sacrificed fish.

Scale samples were collected for age and growth purposes. All scales were taken from the left side, just posterior to the pectoral fin. Cellulose acetate scale impressions were examined with a scale projector. Total scale radius and radius at annuli were measured from the center of the focus to the median anterior margin. The measurements were made at 66X. The anterior edge of the scale was used as the annulus for the period January 1 to whenever spring growth produced an annulus.

A curvilinear length-scale radius relationship exists for walleye and sauger in the Tongue River Reservoir. The equation best describing this relationship is:

$$L = aS^b$$

or

$$\log L = \log a + b \log S$$

where L = length, S = scale radius

and a and b are constants determined by linear regression using logarithms of the length and scale radius data. The method of back calculation is that described by Hile (1941).

The predicted weights were estimated using the relationship described by the equation (Ricker, 1975):

$$W = aL^b$$

or

$$\log W = \log a + b \log L$$

where W = weight, L = length

and a and b are constants determined by linear regression using logarithms of the length and weight data.

A modified Schnabel population estimate (formula 3.17 in Ricker, 1975) was computed for walleye in the river study section for the spring of 1977.

A comparison of the ratio of tagged fish to untagged fin-clipped fish in the population at the time of capture to the ratio at the time of recapture, was used as the criteria for determining tag loss.

Statistical analyses were made according to Snedecor and Cochran (1967) at the p .05 level of confidence. Linear regressions were derived using the method of least squares.

RESULTS

Age and Growth--Sauger

Individual sauger displayed considerable variation in growth rates (Table 3). Within some age classes certain individuals were over 50% longer and 200% heavier than others of the same age. Some individuals reached 457.2 mm (18 inches) at three years of age while others not until age-7.

The 1973 sauger year class was dominant in the three collection years, making up 29.1% of the catch in 1975, 27.4% in 1976 and 43.8% in 1977. The ages of sauger collected ranged from one to seven, with only two age-7 fish being represented. The largest sauger taken during the study was 591 mm (23.3 inches) long and weighed 2660 grams (5.9 pounds). The largest sauger reported for the Tongue River Reservoir weighed 3266 grams (7.2 pounds). It was taken by an angler in 1975 and is the current state record.

Annulus Formation

Annulus formation occurred in the month of June in 1975 and 1976. In 1975, it was 67% complete by June 19 and 100% complete by July 11. In 1976, 80% completion was observed on June 29 and 100% completion by July 5. Nelson (1969) reported age group three and older sauger in Lewis and Clark Lake, South Dakota began forming annuli in mid-June and

Table 3. Length and weights of Tongue River Reservoir sauger in each age class at time of capture

Age Class	Total Length in Millimeters Number	Mean	Range	Weight in Grams Number	Mean	Range
			1975			
1	6	215.2	141-265	5	88.0	60- 120
2	23	315.4	265-404	15	277.0	140- 560
3	17	423.2	362-464	15	677.3	400- 870
4	12	480.5	420-540	8	915.0	600-1150
5	21	537.1	458-631	12	1352.0	1020-1750
			1976			
1	6	257.6	197-293	6	135.0	60- 180
2	101	305.0	216-365	100	215.9	50- 440
3	107	387.2	293-578	107	472.7	170-1870
4	76	462-3	347-530	76	859.9	350-1350
5	65	500.9	427-591	65	1163.0	720-2660
6	37	547.3	465-595	37	1497.0	862-2210
7	1	613.0		1	2100.0	
			1977			
1	--	--	--	--	--	--
2	--	--	--	--	--	--
3	4	378.2	327-425	4	435.0	300- 530
4	32	452.7	394-562	32	797.3	394-1040
5	26	495.4	404-527	26	1104.0	840-1240
6	10	535.7	449-587	10	1443.0	740-1900
7	1	587.0		1	1610.0	

completed the formation by early July. Carlander (1950) reported May and early-June as the time of annulus formation in sauger from Lake of the Woods, Minnesota.

Growth in Length

The relationship between body length and scale radius (Figure 5) was based on 546 sauger, ranging from 141 to 631 mm in length, taken during the three years of the study. It was assumed that no significant differences existed in the relationship from one year to the next and that combining the data was appropriate.

The average back calculated lengths at each age class show an increase when made from progressively older fish (Table 4). This phenomenon is unlike Lee's phenomenon, where a decrease in average calculated length at each age class is seen when the calculations are made from progressively older fish.

Table 4. Back calculated lengths of sauger from the Tongue River Reservoir, Montana

Age Class	Number of Fish	Total Length at the End of Each Year						
		1	2	3	4	5	6	7
1	12	146.4						
2	124	164.0	269.9					
3	129	174.5	310.0	371.7				
4	120	185.5	324.4	400.4	445.3			
5	112	193.6	330.4	409.4	460.2	495.5		
6	47	195.0	336.8	420.6	478.8	518.4	541.3	
7	2	156.1	339.7	428.5	495.1	546.2	573.0	590.9
Grand Average Calc. Length		179.5	310.7	396.2	457.2	502.8	542.6	590.9
Grand Average Increm. Length		179.5	130.4	73.3	49.6	36.8	23.1	17.9
Sum of Grand Ave. Increments		179.5	309.9	383.2	432.8	469.6	492.7	510.6

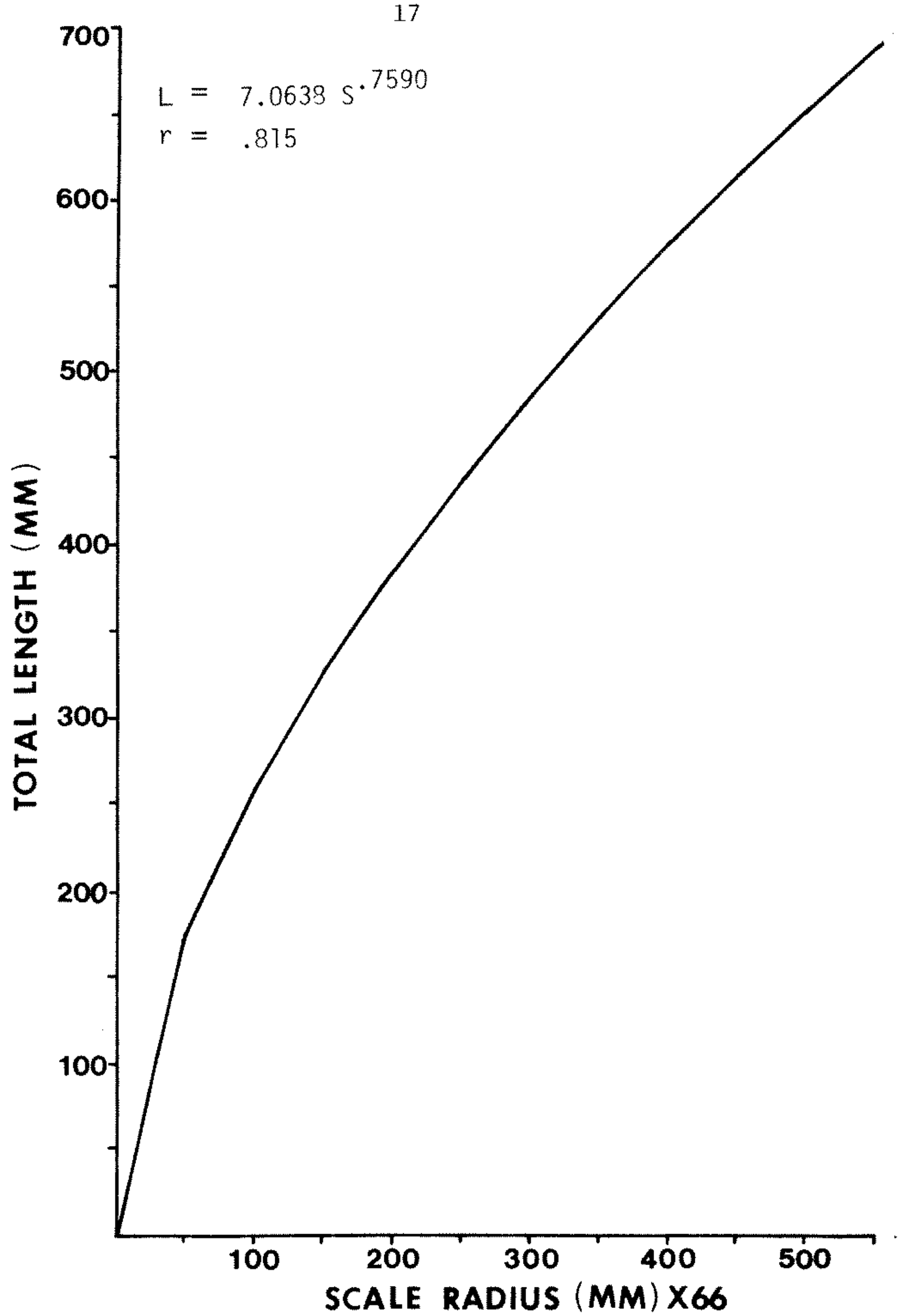

Figure 5. Length-scale radius relationship of sauger from the Tongue River Reservoir, Montana.

The general growth in length curves for sauger, based on the grand average calculated lengths and the sums of the grand average increments of length, are depicted in Figure 6. The difference between the two curves can be attributed to the phenomenon of greater calculated lengths when older age fish are used. The summation of the grand average increments were chosen as being most representative of the growth of sauger because they avoid the irregularities caused by the successive dropping out of age groups. This curve should represent the average growth that sauger might have if the opposite effect of Lee's phenomenon were not present. The greatest average annual increment for sauger occurred during the first year of life and then decreased steadily thereafter.

The back calculated lengths of Tongue River Reservoir sauger are greater than those reported for other Montana waters (Table 5). The only exception is the 1948 Fort Peck Reservoir study which had average lengths equalling those of the Tongue at age-6 and surpassing those of the Tongue at age-7. Tongue River Reservoir sauger grew faster than sauger from Garrison Reservoir, North Dakota, Lake Winnebago, Wisconsin and Lake of the Woods, Minnesota, except that the length value for Garrison Reservoir sauger at age-6 surpassed those of all other studies. The lengths of sauger from Lewis and Clark Lake were greater than those of the present study. Lake Oahe lengths were superior at all ages except age-1.

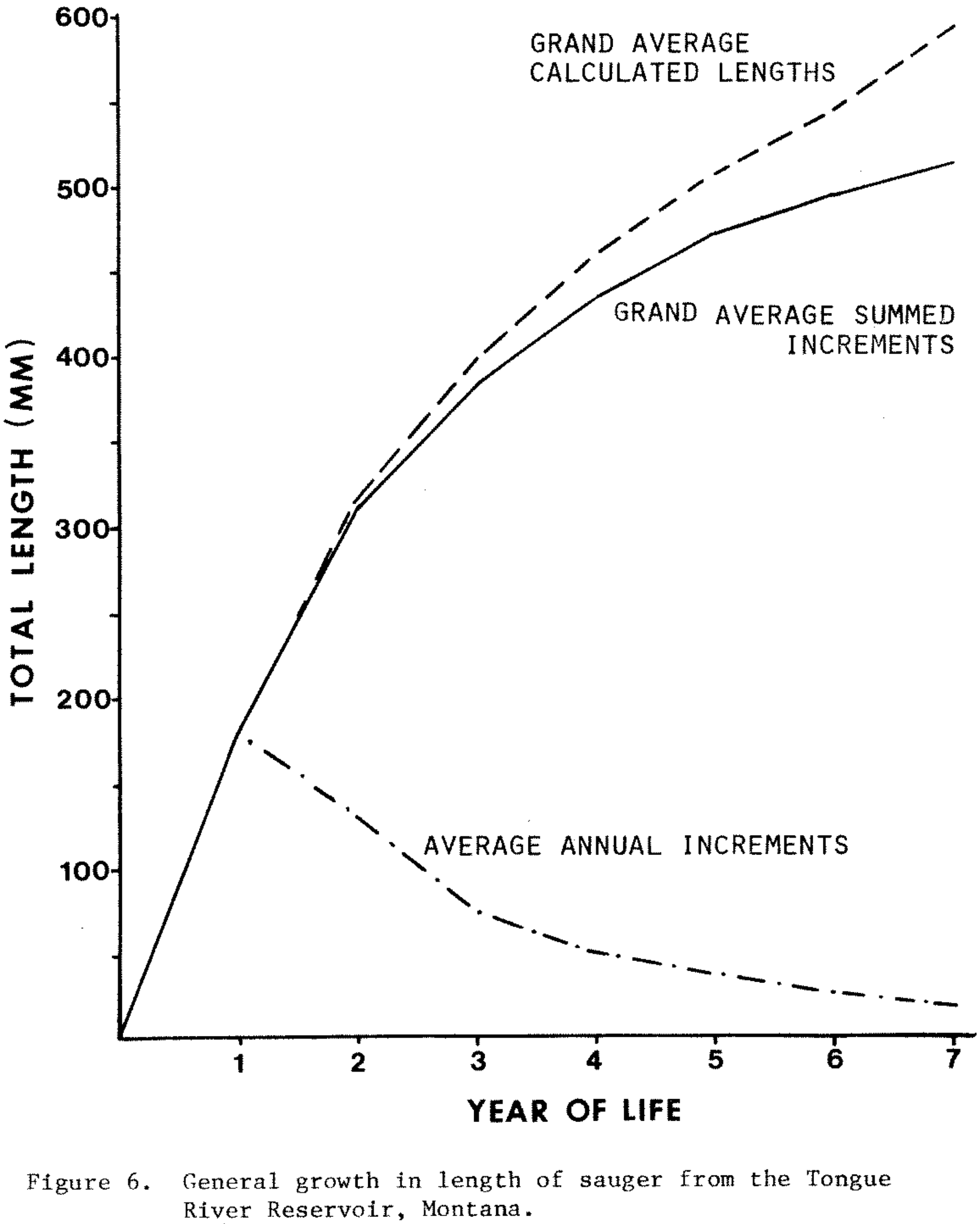

Figure 6. General growth in length of sauger from the Tongue River Reservoir, Montana.

Table 5. Calculated growth of sauger from various waters.

Locality	Number of Fish	Average Calculated Total Lengths at End of Year (mm) 1	2	3	4	5	6	7	8	9	10
Tongue River Res. (present study)	546	179.5	309.9	383.2	432.8	469.6	492.7	510.6			
Ft. Peck Res., MT 1948 (Peters,1964)[1]	124	129.5	223.5	297.2	363.2	429.3	492.8	520.7			
Ft. Peck Res., MT 1949 (Peters,1964)[1]	134	121.9	243.8	325.1	388.6	370.6	487.7				
Marias River, MT 1961 (Peters,1964)[1]	16	111.8	203.2	281.9	335.3	383.5	464.8				
Garrison Res., ND (Carufel, 1963)[1]	96 m	121.9	215.9	292.1	358.1	447.0					
	222 f	127.0	223.5	317.5	398.8	467.4	586.7				
Lake Winnebago, WI (Priegal, 1969)[1]	784 m	124.5	241.3	307.3	335.3	355.6	375.9	388.6	401.3		
	957 f	134.6	251.5	310.0	337.8	358.1	378.5	391.2	401.3		
Lake O' Woods, MN (Carlander, 1950)[2]	883	126.3	185.4	235.3	275.8	312.9	337.3	361.6	359.3	384.8	382.5
Lewis & Clark Lake (Nelson, 1969)	1112	188.0	324.0	404.0	466.0	514.0	560.0	596.0	626.0		
Lake Oahe, ND SD (Nelson, 1974)	506	158.0	311.0	401.0	464.0	517.0	551.0	589.0	594.0	612.0	

[1]Total length in inches converted to total length in mm.

[2]Standard length in inches converted to total length in mm (T.L./S.L. ratio of 1.159 derived by Carlander, 1950).

Growth in Weight

The length-weight relationship (Figure 7) was derived from the measurement of 521 sauger captured from 1975 through 1977. In the length-weight relationship formula ($W = aL^b$), the constant b will equal 3.0 if growth is isometric (Ricker, 1975). When b is greater or less than 3.0, growth is allometric. Values greater than 3.0 indicate weight increasing faster than the length and values less than 3.0 indicate length increasing faster than weight. In a normal fish population b will range between 2.5 and 4.0 (LeCren, 1951). The value of b for the Tongue River Reservoir sauger ($b = 3.23$) falls within the range of "normal" values established by LeCren (1951) and indicates allometric growth with the weight increasing faster than the length.

The predicted weights at ages one through seven were obtained by applying the length-weight equation to the summed grand average increments at annuli (Figure 8). While the greatest annual length increments occurred during the first year of life, the greatest annual weight increment did not occur until age-3. The average weight increment is fairly constant for ages two through five, but declines at ages six and seven.

The predicted weights for each 5 mm length interval are listed in Appendix Table 1A.

Age and Growth--Walleye

The growth rates of individual walleye varied considerably (Table 6). For example, certain individuals in the 1973 age-3 group

Table 6. Lengths and weights of Tongue River Reservoir walleye in each age class at time of capture.

Age Class	Total Length in Millimeters			Weight in Grams		
	Number	Mean	Range	Number	Mean	Range
			1975			
1	20	266.5	231-317	19	172.9	90- 300
2	7	354.6	300-430	7	395.7	300- 600
3	84	430.6	317-500	70	783.3	340-1260
4	31	484.8	422-629	27	1147.0	700-2980
5	7	572.4	542-601	7	1919.0	1580-2410
6	5	584.2	502-665	5	2050.0	1360-3280
7	4	646.2	612-709	4	2709.0	1542-3760
			1976			
0	64	189.5	159-216	64	59.4	30- 90
1	9	214.8	173-313	9	101.1	40- 300
2	60	326.5	194-412	60	320.2	130- 500
3	27	442.7	386-507	25	817.2	400-1380
4	93	490.4	411-578	90	1139.0	550-2080
5	36	538.7	445-615	35	1508.0	880-2630
6	12	588.8	531-635	12	2051.0	1360-3050
7	6	631.8	582-704	5	2306.0	1640-3100
8	4	681.5	604-891	4	2645.0	2240-3720
9	4	735.0	700-762	4	4607.5	3690-5556
10	--	--	--	--	--	--
11	1	787.0	--	1	5556.0	--
			1977 Reservoir[1]			
1	--	--	--	-	--	--
2	--	--	--	-	--	--
3	25	407.6	362-440	25	723.6	420-1740
4	3	479.0	475-484	3	1010.0	930-1130
5	80	524.8	398-595	80	1433.0	680-2080
6	30	555.4	477-621	30	1730.0	1070-2600
7	5	615.8	593-657	5	2306.0	2090-2790
8	7	657.9	590-699	7	2687.1	1890-3290
9	4	703.5	661-751	4	3927.5	2480-5330
			1977 River[2]			
1	--	--	--	-	--	--
2	--	--	--	-	--	--
3	5	384.6	319-415	5	682.0	490- 720
4	--	--	--	-	--	--
5	28	509.9	415-575	28	1286.0	840-2070
6	9	569.4	530-604	9	1707.0	1350-2020
7	18	589.3	560-632	18	1969.0	1570-2750
8	9	625.0	595-675	9	2442.2	2170-3100
9	6	669.2	610-755	6	3058.3	2360-4090
10	1	640.0		1	2680.0	

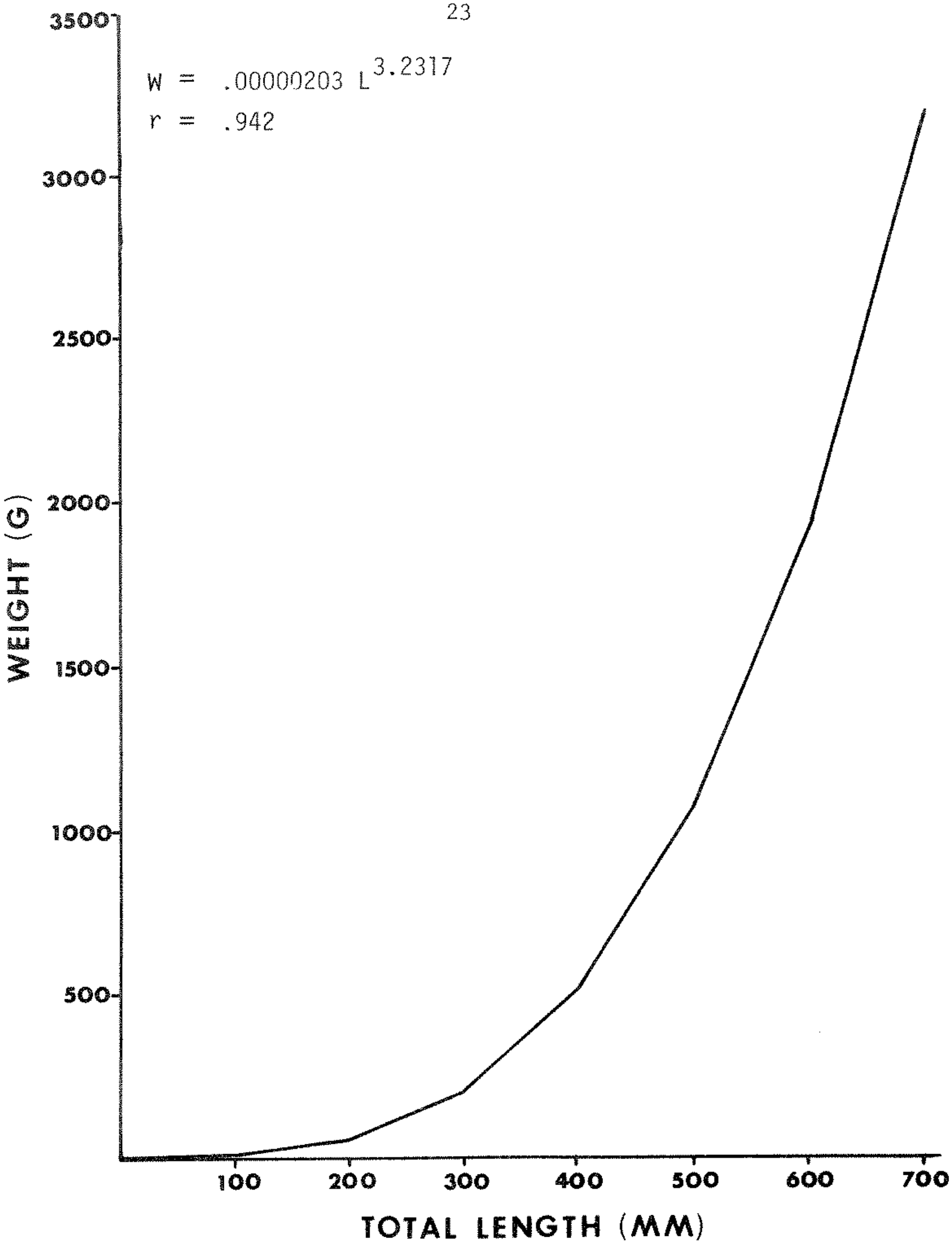

Figure 7. Length-weight relationship of sauger from the Tongue River Reservoir, Montana.

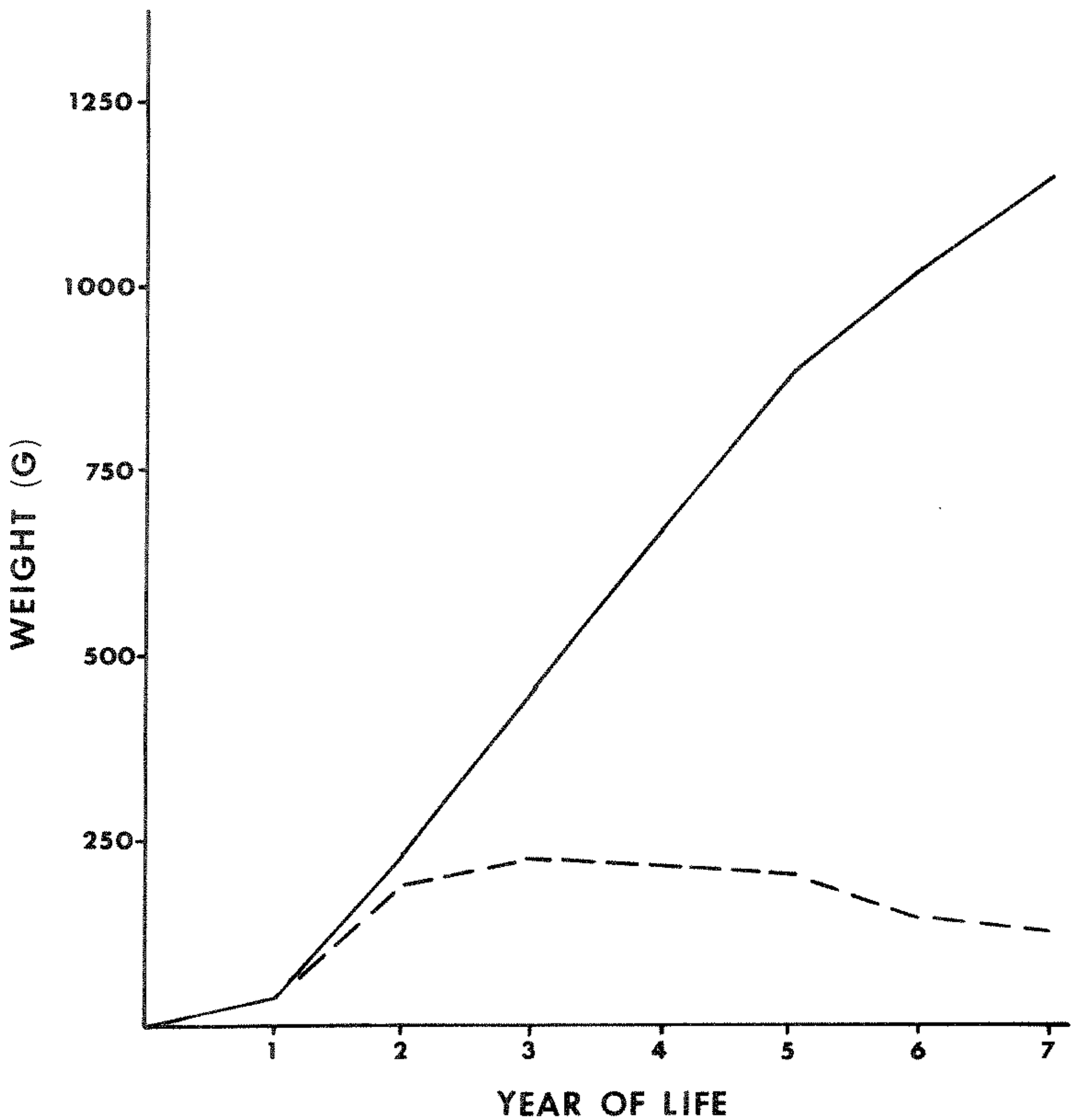

Figure 8. General growth in weight of sauger from the Tongue River Reservoir, Montana (Dashed line represents average annual weight increments).

were over 100% longer and 280% heavier than others of the same group. Some individuals reached 457.2 mm (18 inches) during their third year, while others not until their fifth year of life.

The 1972 walleye year class dominated the catch in the three years of the study. It constituted 56% of the reservoir catch in 1975, 37% in 1976 and 52% in 1977. Of the walleye captured in the river study area during the spring spawning migration of 1977, the 1972 year class was also dominant and made up 37% of the catch. The 1973 year class was noticeably weak. Its greatest contribution was in 1976 when it amounted to 11% of the reservoir catch. In 1975 and 1977, the 1973 year class constituted 5% and 2% of the catches, respectively, and none were collected in the river study area in 1977.

During the course of the study, age-0 to -11 walleyes were collected, but the older age groups (7-11) were lightly represented. No walleyes under age three were collected in 1977. The largest walleye captured during the study was 787 mm (31 inches) in length and weighed 5556 grams (12.25 pounds).

Annulus Formation

June was the month of annulus formation in 1976, with 22% completion being observed by June 9 and 100% by June 20. Too few walleye were collected in May and June of 1975 for annulus formation to be determined and no fish were collected after May in 1977.

Growth in Length

Measurements from 640 walleye ranging from 173 to 787 mm in length were used to derive the length scale radius relationship (Figure 9). This relationship was applied to the combined data for the years 1975, 1976 and 1977, and to the reservoir male-female groups and the river male-female groups from the 1977 sampling.

The tendency for greater average calculated lengths at younger ages when calculated from older fish is evident in the back calculated lengths from the combined years walleye data (Table 7). This phenomenon breaks down with the inclusion of the 10 and 11 year old fish, however, each of these age groups are represented by only one individual. The presence or absence of the trend is difficult to determine when considering the back calculated lengths for the reservoir and river male-female data (Tables 8 and 9). The age groups one through four are either poorly represented or not represented at all in the 1977 male and female samples, and it is in these age classes where the phenomenon is most evident in the back calculated lengths of the combined years samples.

The general growth in length curve for walleye derived from the grand average calculated lengths differs greatly from that derived from the summed increments of length (Figure 10). The summed increments of length are believed to be more representative of the growth of walleye because of the occurrence of a reverse Lee's phenomenon in the back

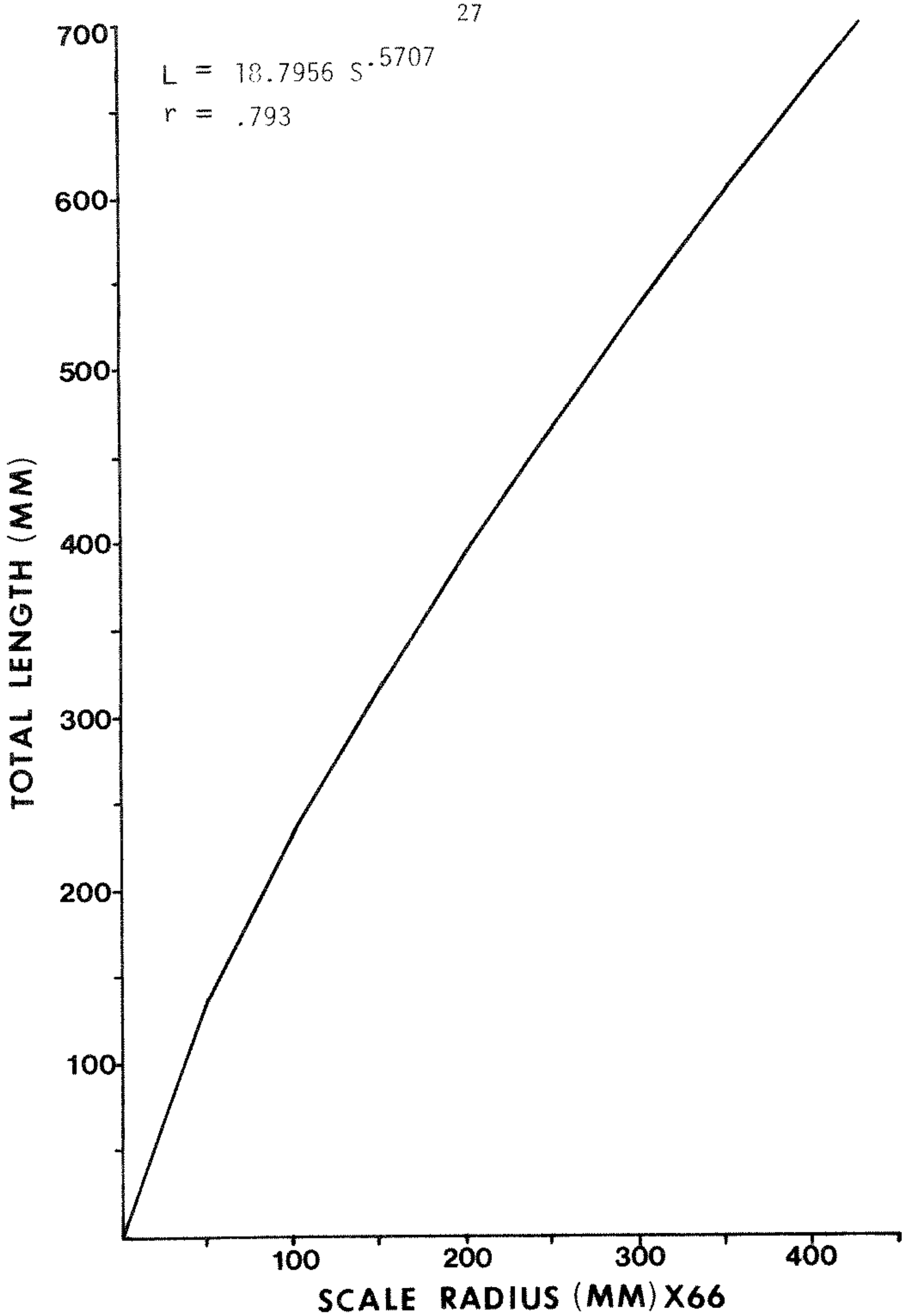

Figure 9. Length-scale radius relationship of walleye from the Tongue River Reservoir, Montana.

Table 7. Back calculated lengths of walleye from the Tongue River Reservoir, Montana, 1975-1977

Age Class	Number of Fish	Total Length at the End of Each Year										
		1	2	3	4	5	6	7	8	9	10	11
1	29	213.0										
2	67	230.5	303.7									
3	141	242.0	336.4	406.3								
4	127	245.8	352.4	429.7	479.4							
5	151	256.4	365.7	444.9	492.7	525.3						
6	56	256.6	376.1	457.4	508.8	541.7	558.4					
7	33	262.5	392.7	475.6	533.8	565.6	598.2	605.7				
8	20	258.2	391.4	483.7	540.3	583.2	604.0	630.6	647.2			
9	14	259.3	399.4	482.0	556.9	602.7	636.9	661.7	679.4	694.1		
10	1	219.0	346.4	434.4	497.2	534.0	578.2	598.6	621.6	627.8	640.0	
11	1	259.9	378.4	452.7	530.0	587.4	641.2	672.5	705.6	733.1	754.4	770.8
Grand Average Calc. Length		246.8	353.4	436.9	498.8	542.2	583.4	625.1	660.6	692.4	697.2	770.8
Grand Average Increm. Length		246.8	101.7	77.4	51.2	34.1	24.0	17.1	17.7	15.0	16.8	16.4
Sum of Grand Ave. Increments		246.8	348.5	425.9	477.1	511.2	535.2	552.3	570.0	585.0	601.8	618.2

Table 8. Calculated lengths of male and female walleye captured in the Tongue River Reservoir in 1977.

Age Class	Number of Fish	Sex	Total Length at the End of Each Year (mm) 1	2	3	4	5	6	7	8	9
1	0	M	-								
	0	F	-								
2	0	M	-								
	0	F	-								
3	5	M	247.4	328.8	329.4						
	4	F	266.9	347.2	412.5						
4	3	M	249.4	374.9	440.2	479.0					
	0	F	-	-	-	-					
5	35	M	252.0	355.4	432.7	478.7	504.8				
	27	F	266.3	377.7	461.0	514.3	552.8				
6	17	M	259.9	362.8	440.0	490.2	520.3	541.8			
	8	F	257.4	374.8	453.3	507.0	543.0	565.0			
7	3	M	268.1	396.7	480.1	529.0	565.9	594.3	609.3		
	1	F	262.9	399.0	492.8	556.0	596.9	627.0	657.0		
8	2	M	238.6	381.9	463.2	519.8	550.5	527.3	601.4	615.0	
	1	F	310.4	440.8	549.1	610.2	650.9	670.6	688.0	699.0	
9	2	M	236.7	375.2	443.7	514.6	568.6	605.6	630.9	651.3	664.5
	2	F	262.5	405.3	494.4	581.1	630.9	679.6	706.8	725.4	742.5
Grand Average		M	253.4	359.4	435.2	486.8	516.1	552.5	613.2	633.2	664.5
Calc. Length		F	265.5	377.6	459.4	519.8	558.5	598.1	689.6	716.6	742.5
Grand Average		M	253.4	106.0	75.8	48.9	28.9	24.3	19.8	17.0	13.2
Increm. Length		F	265.5	112.1	81.8	55.6	38.7	26.9	25.5	16.1	17.1
Sum of Grand		M	253.4	359.4	435.2	484.1	513.0	537.3	557.1	574.1	587.3
Ave. Increments		F	265.5	377.6	459.4	515.0	553.7	580.6	606.1	622.2	639.3

Table 9. Calculated lengths of male and female walleye captured in the river study section in 1977.

Age Class	Number of Fish	Sex	Total Length at the End of Each Year (mm) 1	2	3	4	5	6	7	8	9	10
1	0	M	-									
	0	F	-									
2	0	M	-	-								
	0	F	-	-								
3	5	M	249.7	323.3	384.6							
	0	F	-	-	-							
4	0	M	-	-	-							
	0	F	-	-	-							
5	25	M	250.9	357.5	440.3	480.0	504.0					
	3	F	255.8	380.1	453.8	521.1	558.3					
6	9	M	267.7	393.3	476.1	520.1	550.1	569.4				
	0	F	-	-	-	-	-	-				
7	17	M	269.0	390.9	471.2	524.4	550.0	570.5	585.4			
	1	F	269.5	405.9	497.5	550.6	582.0	609.4	629.0			
8	8	M	260.4	394.4	477.1	517.2	565.1	586.0	605.6	620.6		
	1	F	271.5	404.6	520.9	579.2	609.1	632.8	648.0	660.0		
9	4	M	241.6	396.0	464.6	525.3	561.8	592.5	613.4	633.1	643.7	
	2	F	279.1	409.3	500.9	574.0	636.9	665.2	686.2	702.1	714.2	
10	1	M	219.0	346.4	434.4	497.2	642.0	578.2	598.6	621.6	627.8	640.0
	0	F	-	-	-	-	-	-	-	-	-	-
Grand Average Calc. Length		M	257.6	374.3	454.1	505.2	534.5	575.9	594.9	624.5	640.6	640.0
		F	266.7	395.6	483.1	548.7	591.4	643.1	662.4	688.1	714.2	-
Grand Average Increm. Length		M	257.6	116.7	79.8	45.6	29.4	21.8	17.1	17.1	9.7	12.2
		F	266.7	128.9	87.5	65.6	42.7	26.9	19.2	14.6	12.1	-
Sum of Grand Ave. Increments		M	257.6	374.3	454.1	499.7	529.1	550.9	568.0	585.1	594.8	607.0
		F	266.7	395.6	483.1	548.7	591.4	618.3	637.5	652.1	664.2	-

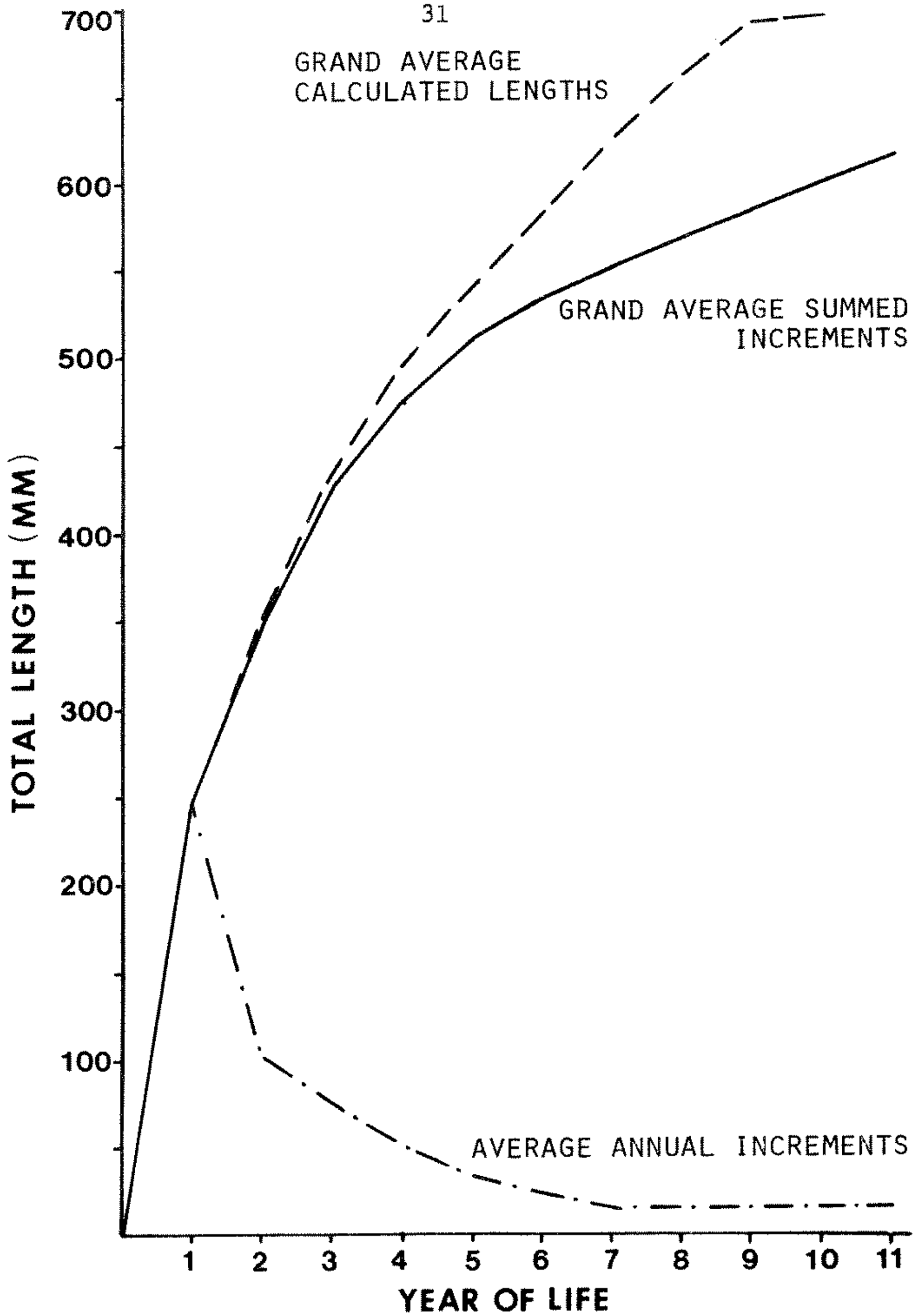

Figure 10. General growth in length of walleye from the Tongue River Reservoir, Montana.

calculated lengths. The greatest annual length increments occurred at age-1 and then decreased to a relatively constant level at ages 7 through 11.

Separate growth curves based on the summed increments of length were constructed for the male and female walleyes captured in the reservoir and river in 1977 (Figure 11). In both the reservoir and river samples, the growth of female walleyes was superior to that of males at all ages. This situation has been reported by others (Stroud, 1949; Tucker and Traub, 1970; and Marz, 1968), but others report that growth of male walleyes was superior to females at ages one and two (Lewis, 1970; Nelson, 1974; and Wolfert, 1977). At the end of the first year of life, female walleyes captured in the reservoir had a 12 mm advantage over the males and by age-9 this advantage had increased to 52 mm. For the river sample, the females had a 9 mm advantage at age-1 which increased to 68 mm at age-9. The river female curve is based on only nine fish and may not be representative of the females using the river for spawning purposes.

The calculated lengths of walleye of both sexes captured in the river were greater than those captured in the reservoir. For the males, this difference never amounted to more than 19 mm at any one age. The maximum difference for females was 38 mm at ages five and six.

A sample of 64 young-of-the-year walleye were collected between September 1 and September 16, 1976 (Table 10). These fish averaged

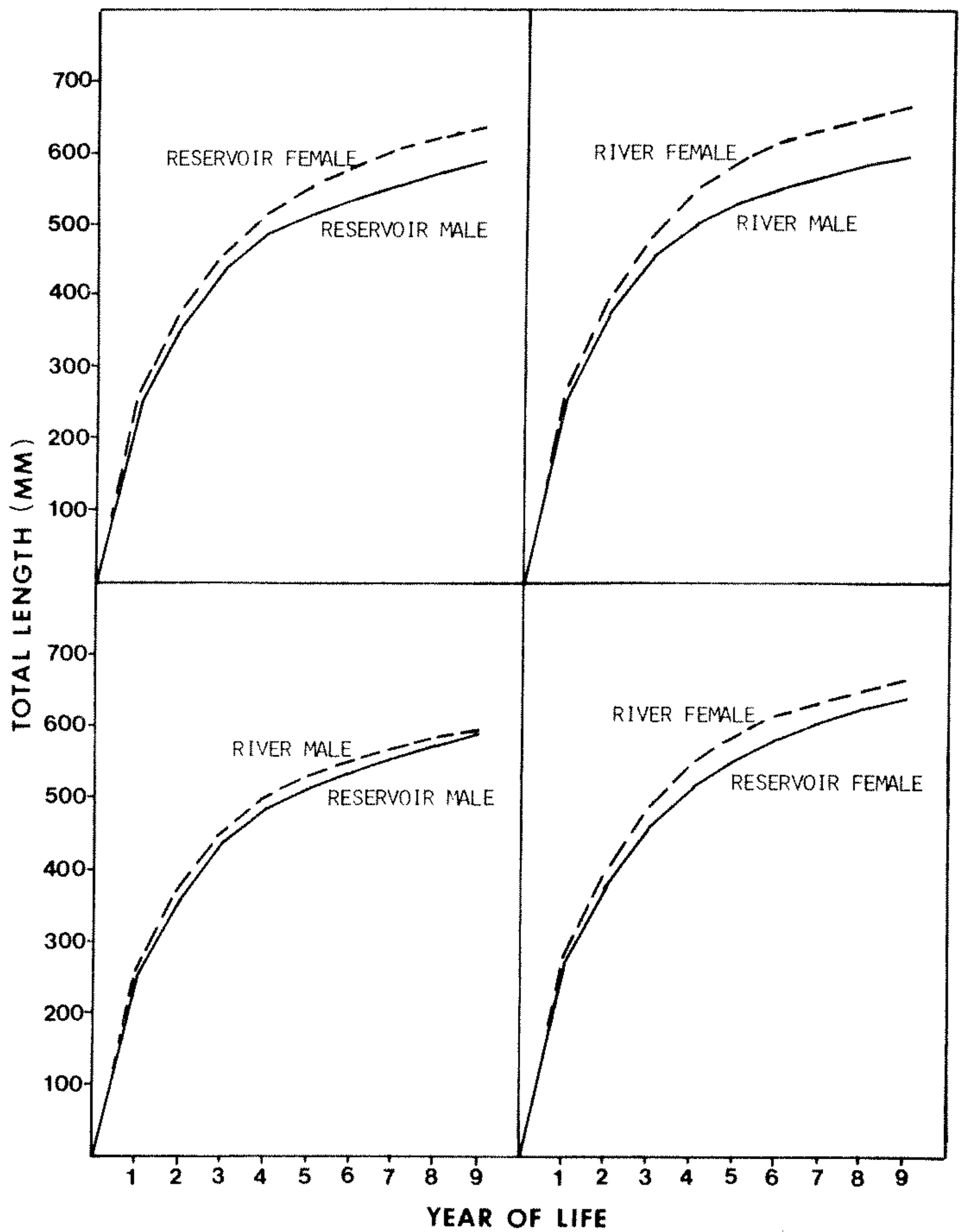

Figure 11. General growth curves for male and female walleye captured in the reservoir and river study areas in 1977.

Table 10. The length and weight of young-of-the-year walleye captured during September of 1976.

Date	Number of Fish	Average Length	Range of Lengths (mm)	Average Weight (g)	Range of Weights
1	4	170.5	159-184	35.0	30-50
2	18	178.2	168-190	55.6	30-70
4	3	177.3	169-189	40.0	30-50
10	2	196.0	193-199	55.0	50-60
12	3	198.3	196-201	70.0	60-70
13	2	201.5	199-204	70.0	60-80
14	8	198.4	179-216	65.0	50-90
15	7	195.0	189-201	62.9	60-70
16	17	198.0	180-209	65.9	60-80
Totals	64	189.5	159-216	59.4	30-90

189.5 mm in length and ranged from 159 mm to 216 mm. Priegal (1970) reported lengths of young-of-the-year walleye on September 1 for the years 1959 through 1967 to range from 83 mm to 148 mm in Lake Winnebago, Wisconsin. Young-of-the-year walleyes from Oneida Lake, New York ranged from 111 mm to 156 mm on September 1 for the years 1956 through 1961 (Forney, 1966). Wolfert (1977) reported lengths of 185 mm at the end of August and 230 mm by the end of September for young-of-the-year walleyes in western Lake Erie.

Lengths of Tongue River Reservoir walleye were superior to that reported for other Montana reservoirs with the exceptions of Hauser Lake which had greater lengths at ages three and four and Nelson Reservoir which had a greater length at age-6 (Table 11). Tongue River Reservoir walleye grow faster than walleye from Lake of the Woods,

Table 11. Calculated growth of walleye from various waters.

Locality	Number of Fish	Average Calculated Total Lengths at End of Year (mm)										
		1	2	3	4	5	6	7	8	9	10	11
Tongue River Res. (present study)	640	246.8	348.5	425.9	477.1	511.2	535.2	552.3	570.0	585.0	601.8	618.2
Nelson Res., MT 1959 (Peters,1964)[1]	71	94.0	193.0	269.2	345.4	469.9	650.2					
Lake Oahe, ND,SD (Nelson, 1974)	757	213.0	351.0	445.0	522.0	569.0	603.0	633.0	678.0			
Clear Lake, IA (Carlander & Whitney,1961)[1]	3079	177.8	287.0	373.4	434.3	480.1	525.8	558.8	604.5	642.6	685.8	698.5
Lake O' Woods, MN (Carlander,1945)[2]	2898	163.4	235.3	293.2	341.9	377.8	424.2	463.6	506.5	549.4	577.2	607.3
Norris Res., TN (Stroud,1949)[1]	1146	261.6	416.6	475.0	505.5	528.3	533.4	561.3	632.5			
Lake Gogebic, MI (Eschmeyer,1950)[1]	519	116.8	238.8	307.3	360.7	401.3	436.9	457.2	477.5	495.3	508.0	
Canton Res., OK (Lewis, 1970)[1]	870	309.9	426.7	495.3	553.7	607.1	650.2	703.6				
Killen Res., MT 1960 (Peters,1964)[1]	18	78.7	170.2	304.8	406.4	447.0						
Frenchman Res., MR 1958 (Peters,1964)[1]	34	185.4	337.8	401.3	459.7	449.6						
Hauser Lake, MT 1961 (Peters,1964)[1]	9	167.6	325.1	429.3	525.8							

[1] Total length in inches converted to total length in mm.

[2] Standard length in inches converted to total length in mm. (T.L./S.L. ratio of 1.159 derived by Carlander, 1945).

Minnesota and Lake Gogebic, Michigan, but slower than walleye from Norris Reservoir, Tennessee and Canton Reservoir, Oklahoma. Walleye from Clear Lake, Iowa showed slower growth rates than Tongue River Reservoir walleye at ages one through six, but were superior at ages seven through eleven. Lake Oahe walleye had greater lengths at all ages except age-1. An earlier spawning season and a longer growing season are factors contributing to the better growth in the Tennessee and Oklahoma reservoirs.

Growth in Weight

The walleye length-weight relationship (Figure 12) is based on a combined sample size of 616. The value of the constant b, from the length-weight formula, equals 3.16. This value indicates allometric growth, where the increase in weight occurs faster than the increase in length and falls within the range of normal values established by LeCren (1951).

The predicted weight at ages one through eleven were obtained by applying the length-weight equation to the summed grand average increments of length at annulus (Figure 13). The yearly weight increments increased until age-3 and then declined steadily until age-7. Beyond age-7 the yearly weight increments remain fairly constant.

The predicted weights for walleye for each 5 mm length interval are listed in Appendix Table 2A.

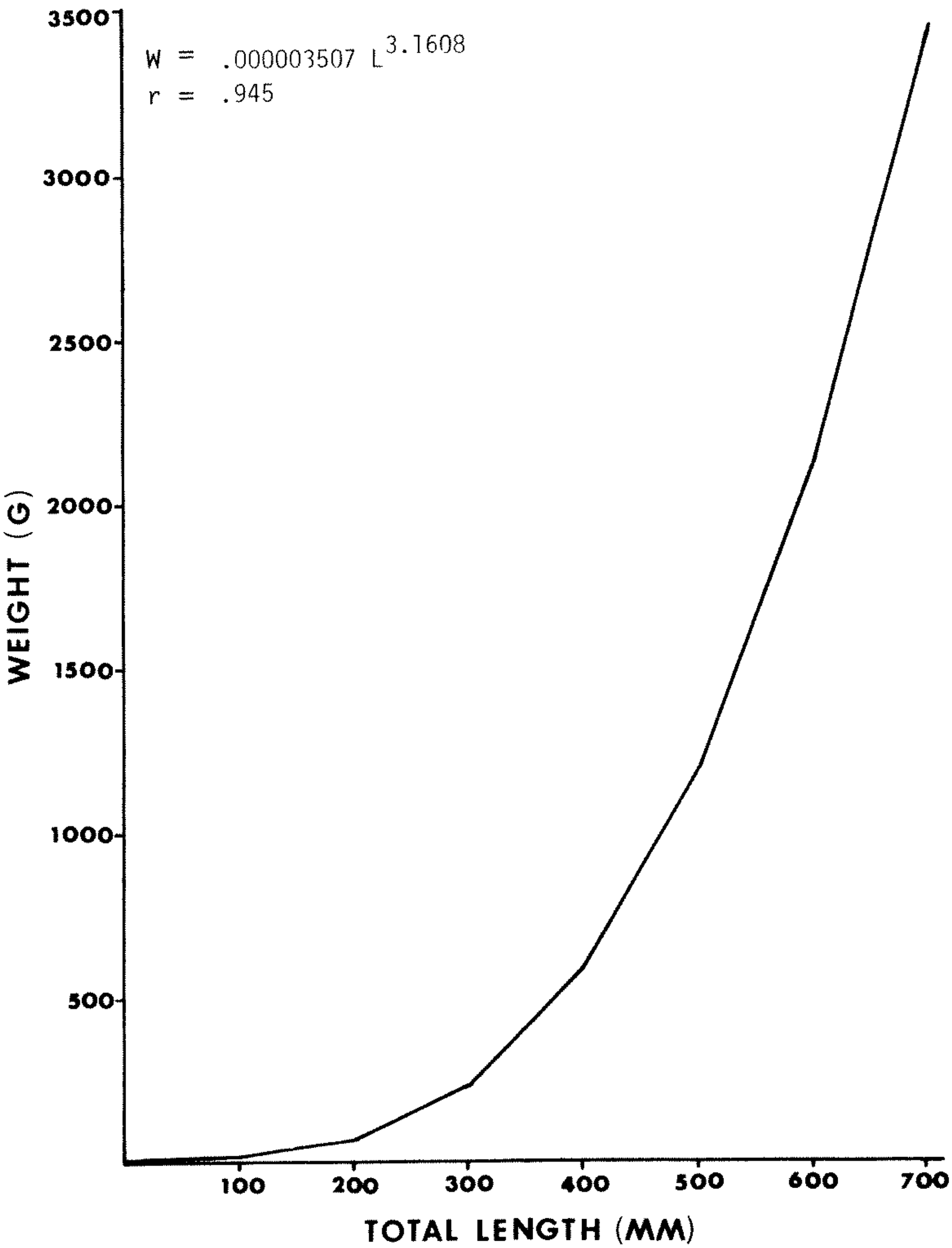

Figure 12. Length-weight relationship of walleye from the Tongue River Reservoir, Montana.

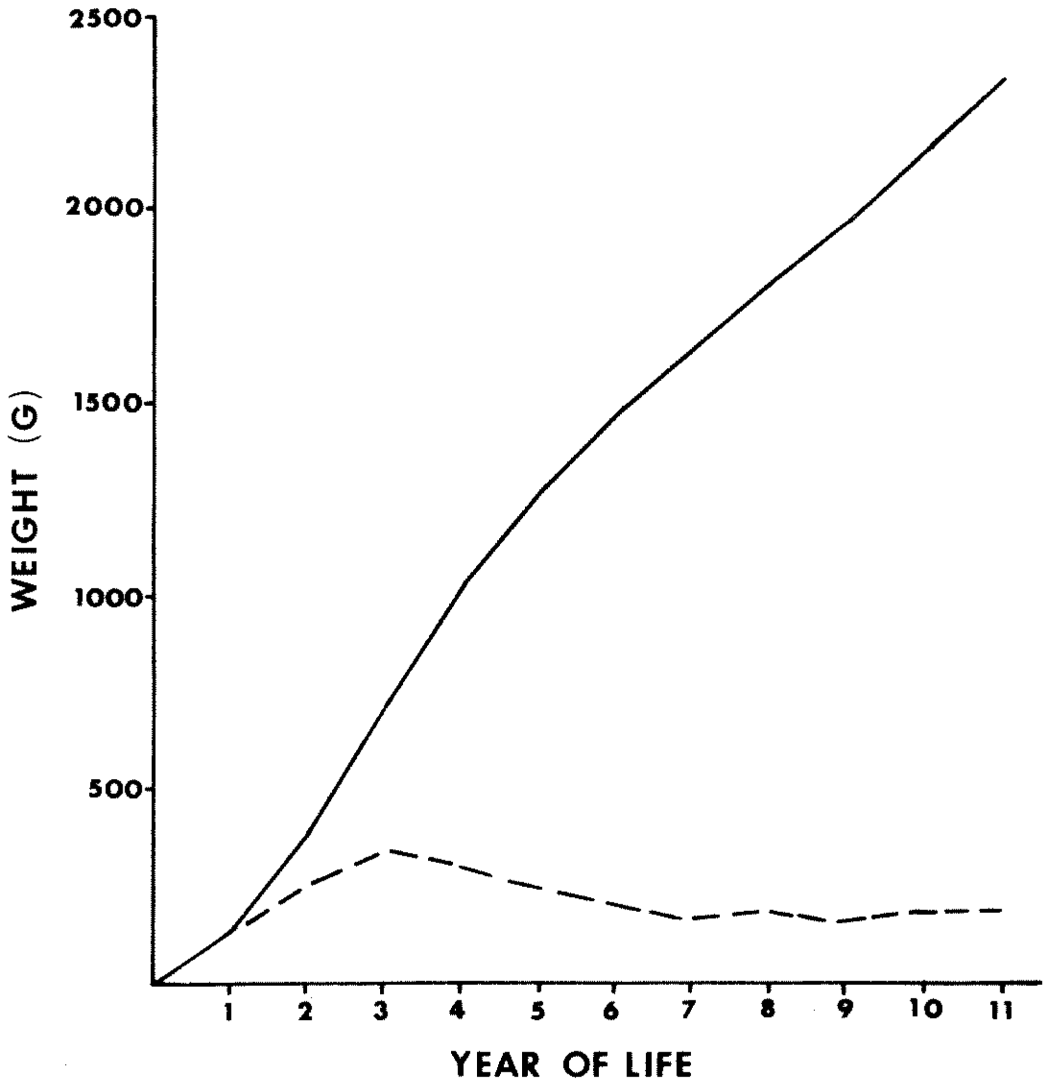

Figure 13. General growth in weight of walleye from the Tongue River Reservoir, Montana. (Dashed line represents average annual weight increments)

Population Estimate

A population estimate of male walleyes in the river study section was made in the spring of 1977. Only male walleyes were estimated because too few females were captured to obtain reliable data. The river was electrofished on March 26, 28, 31, April 1 and 4 to determine if walleye and sauger were using the river for spawning purposes. Increased river discharge and the corresponding increase in turbidity made river shocking impossible beyond April 4, 1977. On the five dates electrofished, 2 sauger and 86 walleye were captured. Of the 86 walleye captured, 80 were ripe males and 30 of these males were recaptured during the sampling period. This resulted in a male recapture rate of 37.5%. Using the Chapman method of population estimation it was determined that 129 male walleye were present in the river study section from March 26 to April 4. The 95% confidence limits were 86 to 251.

Movement of Tagged Walleyes

Four walleye (individuals 1-4 in Figure 14) captured in the reservoir in the fall of 1976 were recaptured in the river study area in the spring of 1977. The distances traveled in reaching the river study area from the point of initial capture range from 8.5 kilometers to 15.0 kilometers. One walleye (fish no. 1 in Figure 14) was captured in the summer channel of the river in the spring of 1976 and recaptured in the river study section in the spring of 1977.

1 -	Captured	10/21/76
	Recaptured	3/28/77
2 -	Captured	11/ 5/76
	Recaptured	3/28/77
3 -	Captured	11/ 6/76
	Recaptured	4/ 1/77
4 -	Captured	10/28/76
	Recaptured	4/ 4/77
5 -	Captured	4/10/76
	Recaptured	4/ 4/77

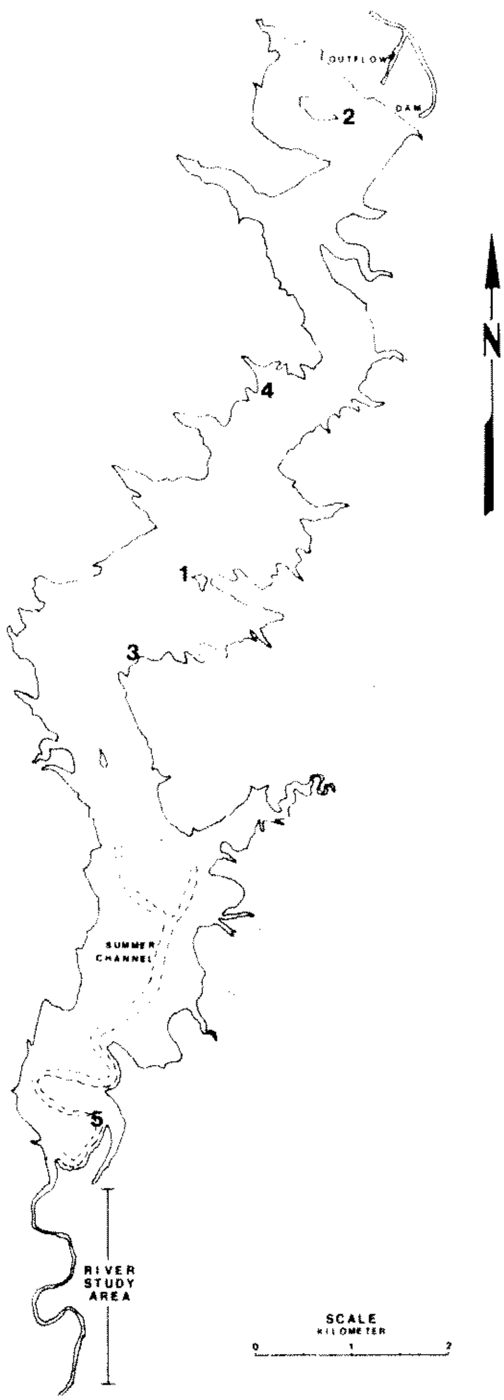

Figure 14. The movement of walleye from the reservoir into the river study area.

Of the 86 walleyes tagged in the river study area during the spring of 1977, six were later recaptured in the reservoir (Figure 15). Of these six, three were recaptured twice and their movements from the first point of recapture to the second point of recapture are indicated by arrows. All of the 11 walleyes for which movement data were obtained were males.

Tag Loss

During the summer of 1976, one hundred sixty-eight sauger and 76 walleye were tagged and fin clipped to measure the extent of tag loss. During the spring of 1977, forty-six sauger and 184 walleye were so tagged. Floy FD-67 anchor tabs were used in 1976 and Floy FD-68B anchor tags were used in 1977. Tags in both years were placed behind the spinuous dorsal fin.

One of four (25%) sauger recaptured during the summer of 1976 had lost its tag. Of six sauger tagged in the summer of 1976 and recaptured in the spring of 1977, none had lost tags. In the spring of 1977, no tag loss was observed for the two sauger recaptured.

Only one fin clipped walleye was recaptured during 1976 and it had retained its tag. However, of six walleyes tagged in the summer of 1976 and recaptured in the spring of 1977, four had lost tags (67%). During the spring of 1977, fifty-five walleye were recaptured of which one one fish (2%) lost its tag.

1 - Captured 3/28/77
    Recaptured 4/ 8/77
    Recaptured 4/13/77
2 - Captured 3/28/77
    Recaptured 4/13/77
    Recaptured 4/17/77
3 - Captured 3/28/77
    Recaptured 4/23/77
4 - Captured 4/ 3/77
    Recaptured 4/25/77
    Recaptured 4/29/77
5 - Captured 3/28/77
    Recaptured 4/26/77
6 - Captured 3/28/77
    Recaptured 4/26/77

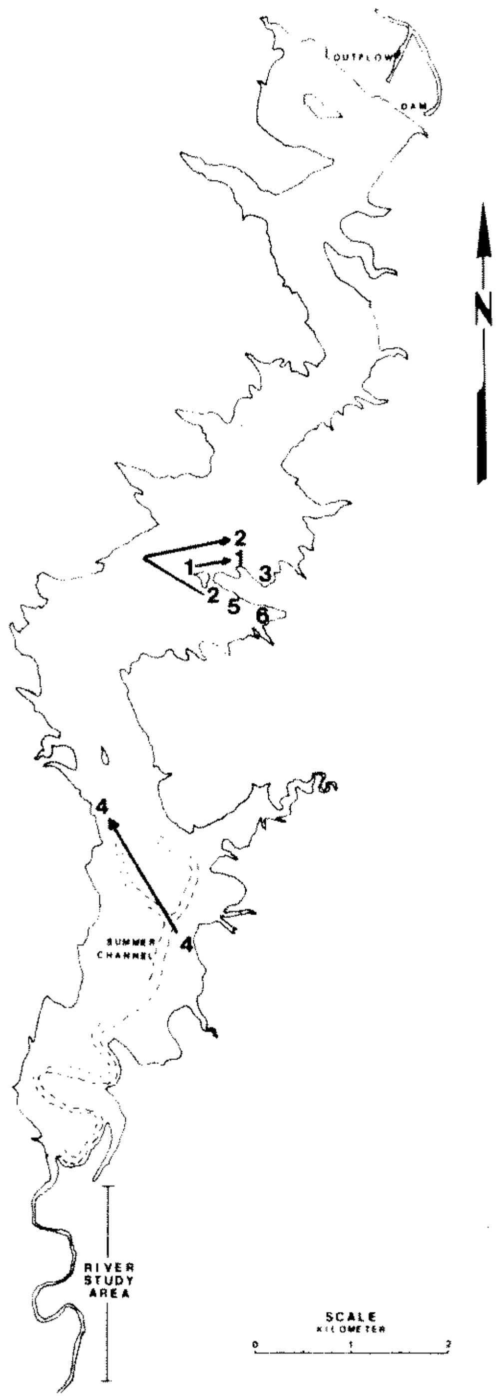

Figure 15. The movement of walleye from the river study area into the reservoir.

Much of the tag loss was due to the vinyl tubing slipping off of the anchor portion of the tag. Switching to the Floy FD-68B tag, which incorporates a plastic bulb on the end of the anchor, appeared to alleviate this kind of tag loss.

DISCUSSION

The growth of walleye and sauger in the Tongue River Reservoir is, in most cases, superior to that reported in other Montana waters, although extensive age and growth work has not been conducted for these two species in Montana.

The greater calculated lengths at younger ages, when successively older fish are used in making the calculations, is evident for both walleye and sauger in the Tongue River Reservoir. The presence of this phenomenon could be caused by some natural occurring factor or by sampling bias. If non-random sampling were the problem, one of two conditions need exist: (1) a sampling technique which would have a tendency towards the smaller fish in the younger age classes, or (2) a tendency towards the larger fish of the older age classes. Because of the variety of sampling techniques employed (gill nets, trap nets, and electrofishing), non-random sampling is not a viable explanation for the observed trend. When Carlander and Whitney (1961) reported a similar occurrence in the back calculated lengths for walleye in Clear Lake, Iowa they felt that missed annuli on a few of the older fish may have been responsible. It is not impossible that missed annuli are contributing to the occurrence of the phenomenon in walleye and sauger in the Tongue River Reservoir. Selective mortality bearing more heavily on the smaller fish of each age class, thus leaving the larger fish of each successive age class to be sampled for age and growth purposes, would explain the apparent decrease in growth rates observed. Predation has been shown to be selective towards the slower growing walleye during the first year (Chevalier, 1973), but such predation prior to the first annuli would have no effect on the back calculated lengths. The continuation of such size selective predation into the second and later years of life may be possible (Ricker, 1975), but it does not likely continue throughout all of the age groups. When the phenomenon was observed in the calculated lengths for walleye in Canton Reservoir, Oklahoma, Lewis (1970) felt that the growth reduction may have reflected the stabilization of an increasing walleye population to the pre-existing forage fish population. The oldest walleye and sauger taken during the study were age-11 and age-7, respectively. Because the age of these fish date back to the earliest known existence for the two species in the reservoir, it is quite possible that the observed decrease in growth rates is the result of an increase in numbers of these two species approaching the carrying capacity of the reservoir and thus, increased inter and intra-specific competition. Continued monitoring of the age and growth of the walleye and sauger populations may eventually result in calculations of relatively constant growth rates.

It is apparent from tag return data, that reservoir walleyes use the river for spawning purposes. What portion of the reservoir population to do so and the extent of the upstream migration can only be determined through further research. Whether or not reservoir sauger use the river for spawning purposes has yet to be determined. Since only ripe males and spent females were collected it appears that the majority of sauger spawning activity had taken place prior to the start of sampling on March 23, 1977.

At the present time, the surface coal mining operations in the vicinity of the reservoir are having no measurable effects on the walleye and sauger populations. It is felt however, that more knowledge is needed regarding river usage by these two species. Information on the timing of upstream migrations of adults and downstream migrations of fry as well as minimum flows and water quality requirents should be obtained prior to any development requiring large withdrawals of water from the river.

Human population increases due to mining and industrial development in the area of the reservoir will undoubtedly result in an increase in fishing pressure. The Montana Department of Fish and Game operated a creel survey station at the reservoir in 1975 and 1976 and a continued creel survey would be beneficial for measuring any effects on the walleye and sauger populations stemming from increased fishing pressure.

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APPENDIX

Table A. Predicted weight in grams at each 5 millimeter length interval of sauger from the Tongue River Reservoir, Montana

Length	Weight	Length	Weight	Length	Weight	Length	Weight	Length	Weight
5	.0	145	19.6	285	174.2	425	633.6	565	1590.1
10	.0	150	21.9	290	184.2	430	658.0	570	1636.0
15	.0	155	24.3	295	194.7	435	683.0	575	1682.8
20	.0	160	27.0	300	205.6	440	708.7	580	1730.6
25	.1	165	29.8	305	216.8	445	735.1	585	1779.3
30	.1	170	32.8	310	228.5	450	762.1	590	1828.9
35	.2	175	36.0	315	240.7	455	789.8	595	1879.5
40	.3	180	39.4	320	253.2	460	818.2	600	1931.0
45	.4	185	43.1	325	266.2	465	847.3	605	1983.5
50	.6	190	47.0	330	279.7	470	877.1	610	2037.0
55	.9	195	51.1	335	293.6	475	907.6	615	2091.4
60	1.1	200	55.4	340	308.0	480	938.8	620	2146.9
65	1.5	205	60.0	345	322.9	485	970.8	625	2203.3
70	1.9	210	64.9	350	338.3	490	1003.5	630	2260.8
75	2.3	215	70.0	355	354.2	495	1037.0	635	2319.3
80	2.9	220	75.4	360	370.5	500	1071.2	640	2378.8
85	3.5	225	81.1	365	387.4	505	1106.3	645	2439.4
90	4.2	230	87.1	370	404.8	510	1142.0	650	2501.0
95	5.0	235	93.4	375	422.8	515	1178.6	655	2563.8
100	5.9	240	99.9	380	441.3	520	1216.0	660	2627.5
105	6.9	245	106.8	385	460.3	525	1254.2	665	2692.4
110	8.0	250	114.0	390	470.9	530	1293.2	670	2758.4
115	9.3	255	121.6	395	500.1	535	1333.1	675	2825.5
120	10.6	260	129.4	400	520.8	540	1373.7	680	2893.7
125	12.1	265	137.7	405	542.2	545	1415.3	685	2963.0
130	13.8	270	146.2	410	564.1	550	1457.7	690	3033.5
135	15.6	275	155.2	415	586.6	555	1500.9	695	3105.1
140	17.5	280	164.5	420	609.8	560	1545.1	700	3177.9

Table 2A. Predicted weight in grams at each 5 millimeter length interval of walleye from the Tongue River Reservoir, Montana

Length	Weight	Length	Weight	Length	Weight	Length	Weight	Length	Weight
5	.0	145	23.8	285	201.5	425	712.4	565	1752.2
10	.0	150	26.5	290	212.8	430	739.2	570	1801.7
15	.0	155	29.4	295	224.7	435	766.7	575	1852.1
20	.0	160	32.5	300	236.9	440	794.9	580	1903.5
25	.1	165	35.8	305	249.6	445	823.9	585	1955.8
30	.2	170	39.3	310	262.8	450	853.5	590	2009.2
35	.3	175	43.1	315	276.4	455	883.8	595	2063.5
40	.4	180	47.1	320	290.5	460	914.9	600	2118.8
45	.6	185	51.4	325	305.1	465	946.7	605	2175.1
50	.8	190	55.9	330	320.2	470	979.2	610	2232.4
55	1.1	195	50.7	335	335.8	475	1012.5	615	2290.8
60	1.5	200	65.8	340	351.9	480	1046.6	620	2350.2
65	1.9	205	71.1	345	368.5	485	1081.4	625	2410.6
70	2.4	210	76.7	350	385.7	490	1117.1	630	2472.1
75	3.0	215	82.7	355	403.3	405	1153.5	635	2534.6
80	3.6	220	88.9	360	421.6	500	1190.7	640	2598.3
85	4.4	225	95.4	365	440.4	505	1228.8	645	2662.9
90	5.3	230	102.3	370	459.7	510	1267.7	650	2728.7
95	6.3	235	109.5	375	479.6	515	1307.3	655	2795.6
100	7.4	240	117.0	380	500.1	520	1347.9	660	2863.7
105	8.6	245	124.9	385	521.2	525	1389.3	665	2932.8
110	9.9	250	133.1	390	542.9	530	1431.5	670	3003.1
115	11.4	255	141.7	395	565.2	535	1474.7	675	3074.5
120	13.1	260	150.7	400	588.2	540	1518.7	680	3147.0
125	14.9	265	160.1	405	611.7	545	1563.5	685	3220.7
130	16.9	270	169.8	410	635.9	550	1609.3	690	3295.7
135	19.0	275	180.0	415	660.8	555	1656.0	695	3371.7
140	21.3	280	190.5	420	686.2	560	1703.7	700	3449.0