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BLACK BASS POPULATIONS OF THE TONGUE RIVER RESERVOIR, MONTANA

by

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of the requirements for the degree

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in

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Vita

Russell Frank Penkal was born June 5, 1952 in Cleveland, Ohio to Walter and LaVerne Penkal. He graduated from Valley Forge High School, Parma, Ohio in 1970 and entered Montana State University in September, 1971 where he received a B.S. degree in Fish and Wildlife Management in March, 1975. He began graduate studies at Montana State University in Fish and Wildlife Management during March, 1975. In August, 1973 he married Mary Joyce Dynes of Bozeman, Montana. He has one son, Matthew, born October 24, 1975.

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ABSTRACT

Black bass population parameters were studied during the summers of 1975 and 1976 prior to expansion of coal strip mining adjacent to the Tongue River Reservoir. The reservoir was divided into three subsections (A, B, and C) based on habitat type. Spawning conditions were favorable both years as suitable spawning temperatures occurred at a time of rising or stable water levels. Bass reproductive success was limited within the reservoir by suitable spawning substrate and turbidity. Shoreline seining in areas A, B, and C resulted in 0.0, 2.3 and 7.5 smallmouth fingerlings per haul and 1.2, 3.7 and 16.9 largemouth fingerlings per haul in the three respective areas. Although the spawning population of smallmouth bass (*Micropterus dolomieui*) was 181% larger than that of largemouth bass (*Micropterus salmoides*), largemouth fingerlings were more abundant both years. Growth and length-weight relationships are favorable for both species in a northern water. Largemouth bass had greater growth, length-weight relationships, and condition values than smallmouth bass. Differences in smallmouth bass growth and condition between areas, highest in areas A and B and lowest in area C, may be related to availability of forage fish. Turbidity levels in the Tongue River Reservoir had no apparent effect on black bass growth. Greater fingerling growth in 1976 compared to 1975 was attributed to earlier warming of the reservoir and earlier spawning in 1976. Spring and fall population estimates were obtained during 1976 with boat electrofishing gear. The fall age-1 and older smallmouth bass population of 13.0 fish/ha and standing crop of 2.03 kg/ha represented 80 and 84% of the total black bass population and standing crop, respectively. The fall largemouth bass population and standing crop was 3.2 fish/ha and 0.32 kg/ha, respectively. The dominance of all year classes of black bass, except age-1, by smallmouth bass may be attributed to a much higher fingerling to age-1 mortality of largemouth bass. Summer mortality of age-2 and older smallmouth bass, estimated from the reduction of marked fish, was 39.7%. Tag returns, population estimates and distribution of marked fish indicated smallmouth bass concentrated in areas A and C during the spring and in area B during the fall. The observed fall concentration may be attributed to competition for forage fish or habitat selection.

INTRODUCTION

Accelerated demand on western coal as an energy source necessitates accurate knowledge of eastern Montana's present aquatic ecosystems. Baseline information should be established to detect future environmental changes caused by increased mining activity. For this reason, biological parameters of black bass in the Tongue River Reservoir were investigated during 1975 and 1976, prior to expansion of coal strip mining adjacent to the reservoir. The objective was to provide detailed information on the populations, life history, and age and growth of black bass and correlate the results with concurrent water quality studies. The study will also increase the amount of information on smallmouth bass (*Micropterus dolomieui*) and largemouth bass (*Micropterus salmoides*) in Montana, about which very little is known at present.

Decker Coal Company is presently operating a large surface mine near the southwest end of the reservoir. Mining will extend to the east side of the reservoir within one year and a northward expansion of the present mine is expected within the next several years (Fig. 2). Mine effluent from present and future mines will empty directly or indirectly into the Tongue River Reservoir.

DESCRIPTION OF STUDY AREA

The Tongue River Reservoir, located in Big Horn County of southeastern Montana, is 32 kilometers north of Sheridan, Wyoming, the closest population center. 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 downstream for another 271 kilometers to its confluence with the Yellowstone River near Miles City, Montana.

The soils of the surrounding area, situated in the eastern sedimentary plains, have a texture of loamy sand to clay loam and receive 30 to 40 centimeters of precipitation annually. The parent material is primarily sandstone, siltstone and shale of the Tongue River Member of the Fort Union Formation. Carbonaceous material and clinker beds are also common. Seven major coal seams lie within the Tongue River Member (Draft Environmental Impact Assessment for the Proposed East Decker Coal Mine unpublished).

The Tongue River Reservoir was completed in 1940 for irrigation and flood control. Height of the earthfill dam is 27.7 meters with a spillway elevation of 1043.7 meters above sea level (U.S.G.S. 1975). At storage capacity the reservoir has an average depth of 6.1 meters, a maximum length of 12.5 kilometers, and a maximum breadth of 1.4 kilometers (Garrison, Whalen, and Gregory 1975). Surface area and length of shoreline at spillway elevation are 1277 hectares and 60 kilometers, respectively. The shoreline development index is 4.74. Total storage capacity in 1947 was 85.6 hm^3 (U.S.G.S. 1975), but subsequent sedimentation has undoubtedly reduced this capacity to some extent. Average annual inflow and discharge is 459 hm^3 and 414 hm^3, respectively (U.S.G.S. 1975). Present maximum depth at spillway elevation is 18 meters while the bottom of the outlet is located 15.2 meters from the surface of the spillway. Because of an annual water level fluctuation of three to six meters, submerged and emergent vegetation have not become established. The recent history of water storage fluctuation of the Tongue River Reservoir is depicted in Figure 1. Thermal stratification occurs for a short period in late spring and early summer but disappears quickly due to wind mixing and deep water withdrawal. Dissolved oxygen concentrations decrease to values less than 3 mg/l at depths greater than 8 meters in late summer (Whalen and Leathe 1976). Some physical characteristics of the reservoir are listed in Table 1.

The reservoir and part of the river upstream were chemically treated in 1957 to remove rough fish. Rainbow trout (*Salmo gairdneri*) were planted from 1958 through 1960 but planting was

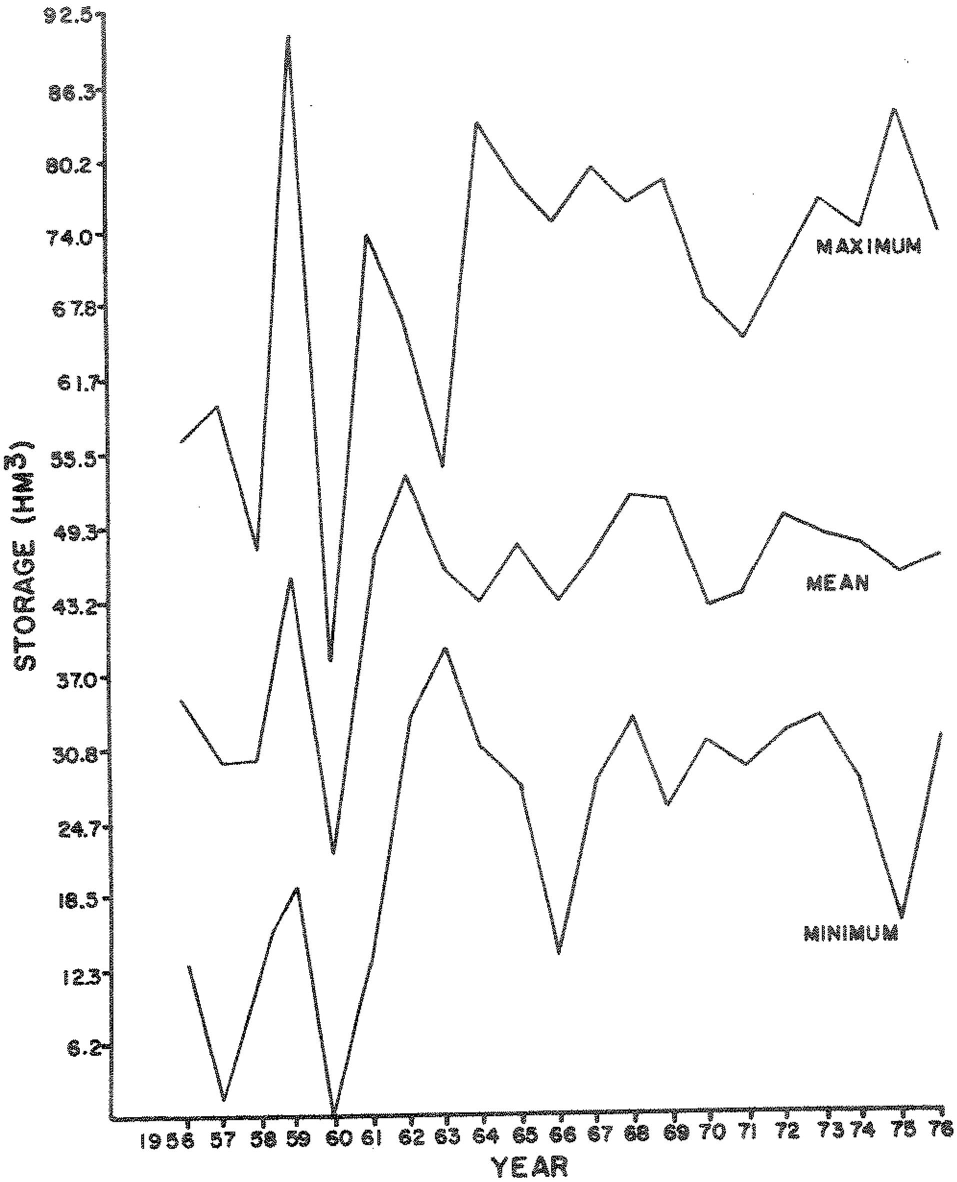

Figure 1. Water storage history, Tongue River Reservoir (Montana Dept. of Nat. Resources unpublished data).

TABLE 1. MORPHOMETRIC DATA OF THE TONGUE RIVER RESERVOIR AT SPILLWAY ELEVATION (1043.7 m)

Maximum depth[1]	18.0 m
Mean depth[1]	6.1 m
Depth of outlet[4]	15.2 m
Maximum length[2]	12.5 km
Maximum breadth[1]	1.4 km
Mean breadth[1]	1.1 km
Surface area[3]	1277 ha
Volume[4]	85.6 hm^3
Length of shoreline[2]	60 km
Index for shoreline development[2]	4.74

[1](Garrison *et al.* 1975).
[2]Measured with a cartometer from topographic maps.
[3]Measured with a planimeter from topographic maps.
[4](U.S.G.S. 1975).

discontinued when trout populations remained low and densities of rough fish increased. In 1963, a warm water fisheries program was implemented. Species introduced include northern pike (*Esox lucius*), channel catfish (*Ictalurus punctatus*), largemouth bass (*Micropterus salmoides*) and walleye (*Stizostedion vitreum*). Northern pike are the only fish presently stocked as they are unable to reproduce naturally. Largemouth bass planting history is as follows: 1964 - 150,000 fingerlings 2.5 cm long, 1972 - 199,290 fingerlings 5.0 cm long, and 1973 - 27,540 fingerlings 5.1 cm long. Smallmouth bass first appeared in the reservoir in 1972, however, records of the Montana Fish and Game Department indicate smallmouths were never planted in the reservoir. This species probably entered the Tongue River system and then the reservoir from adjacent strip-mine ponds near Sheridan, Wyoming (Elser 1973). No stocking records exist for other species but crappie (*Pomoxis* sp.) were present when the reservoir was rehabilitated (Elser personal communication).

The reservoir was divided into three subsections based on habitat type (Fig. 2). Area A, the inflow section, was shallow with a maximum depth of six meters at the water quality station (Whalen unpublished data) and was most affected by summer water level reduction. In 1975, an abnormal year, area A was completely dewatered. During 1976, the spring surface area, 564.3 ha, and shoreline length, 23.6 km, were reduced 64 and 45%, respectively (Table 2). Area A

TABLE 2. SPRING AND FALL SHORELINE LENGTHS AND SURFACE AREAS IN THE TONGUE RIVER RESERVOIR, 1976. PERCENT REDUCTION IN PARENTHESIS.

Area	Length of Shoreline (km)			Surface Area (ha)		
	Spring	Fall		Spring	Fall	
A	23.6	13.1	(44.5)	564.3	205.5	(63.6)
B	17.8	12.5	(29.8)	394.2	250.4	(36.5)
C	18.2	14.6	(19.8)	318.0	253.9	(20.2)
Total	59.6	40.2	(32.6)	1276.5	709.8	(44.4)

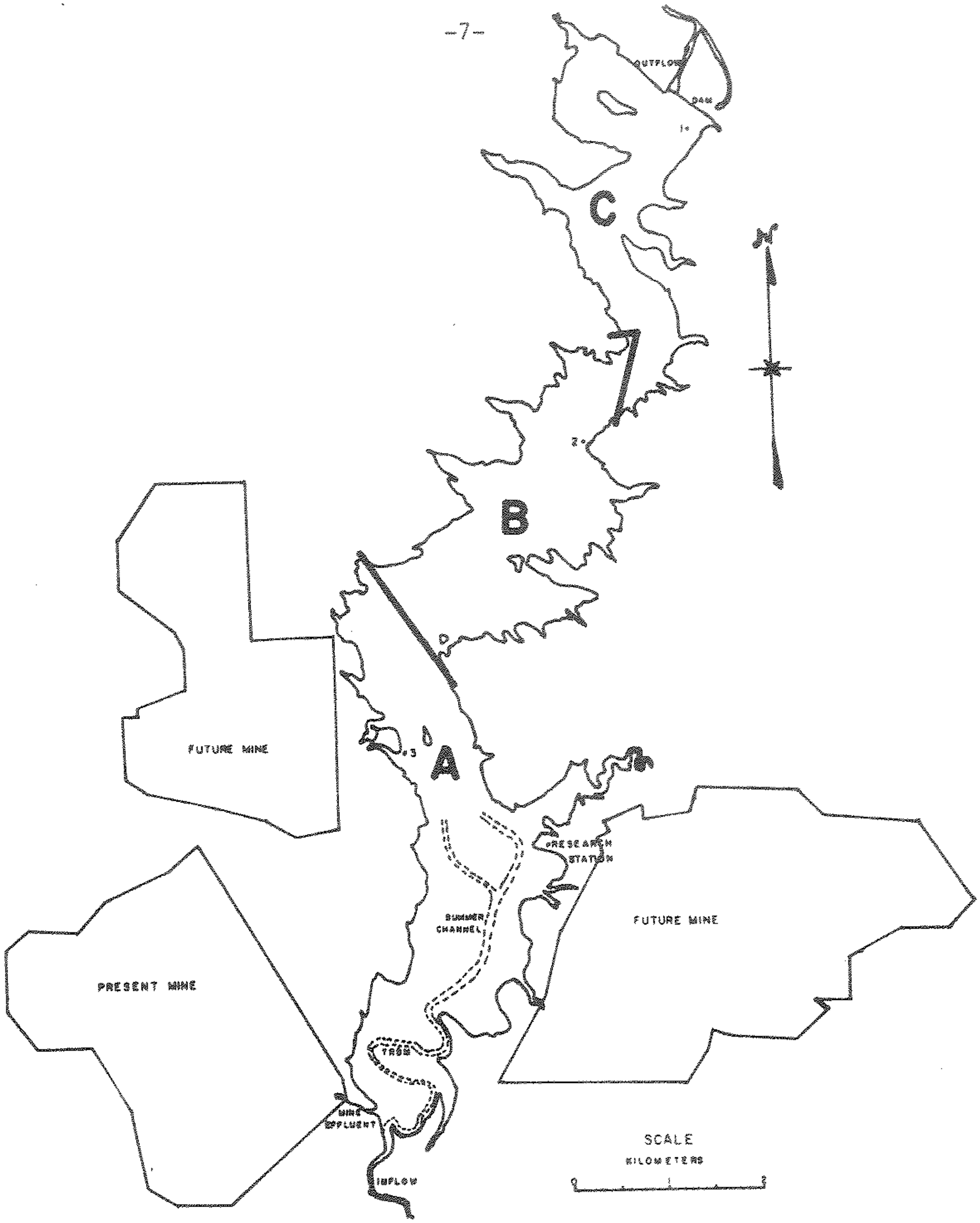

Figure 2. The three study areas of the Tongue River Reservoir.

had the greatest turbidities throughout both study years (Fig. 3). The mean difference in turbidity between areas A and B was six times greater than between B and C. Favorable black bass spawning substrate, pebbles and cobbles, comprised the smallest percentage (14.4%) of area A (Table 3), while unsuitable substrate, silt and clay, comprised the largest percentage (50.7%). There was less than 1 C difference in mean temperature of the first six meters of water between the three areas (Whalen unpublished data).

Physical characteristics of area B, the mid reservoir section, were intermediate to areas A and C. The maximum depth was 14 meters at the water quality station (Whalen unpublished data). Summer drawdown for downstream irrigation in 1976 reduced the spring surface area, 394.2 ha, and shoreline length, 17.8 km, by 36.5 and 29.8%, respectively (Table 2). Turbidities were much lower in area B than A (Fig. 3). Pebbles and cobbles comprised 42.9% of the dominant substrate in area B (Table 3).

Habitat in area C, the outflow section, was least affected by water level fluctuations as it had the greatest maximum depth, 18 meters (Whalen unpublished data). Spring surface area, 318 ha, and shoreline length, 18.2 km, in 1976 were reduced 20.2 and 19.8%, respectively, by fall (Table 2). Of the three areas, turbidities were lowest in area C, especially during the spring (Fig. 3).

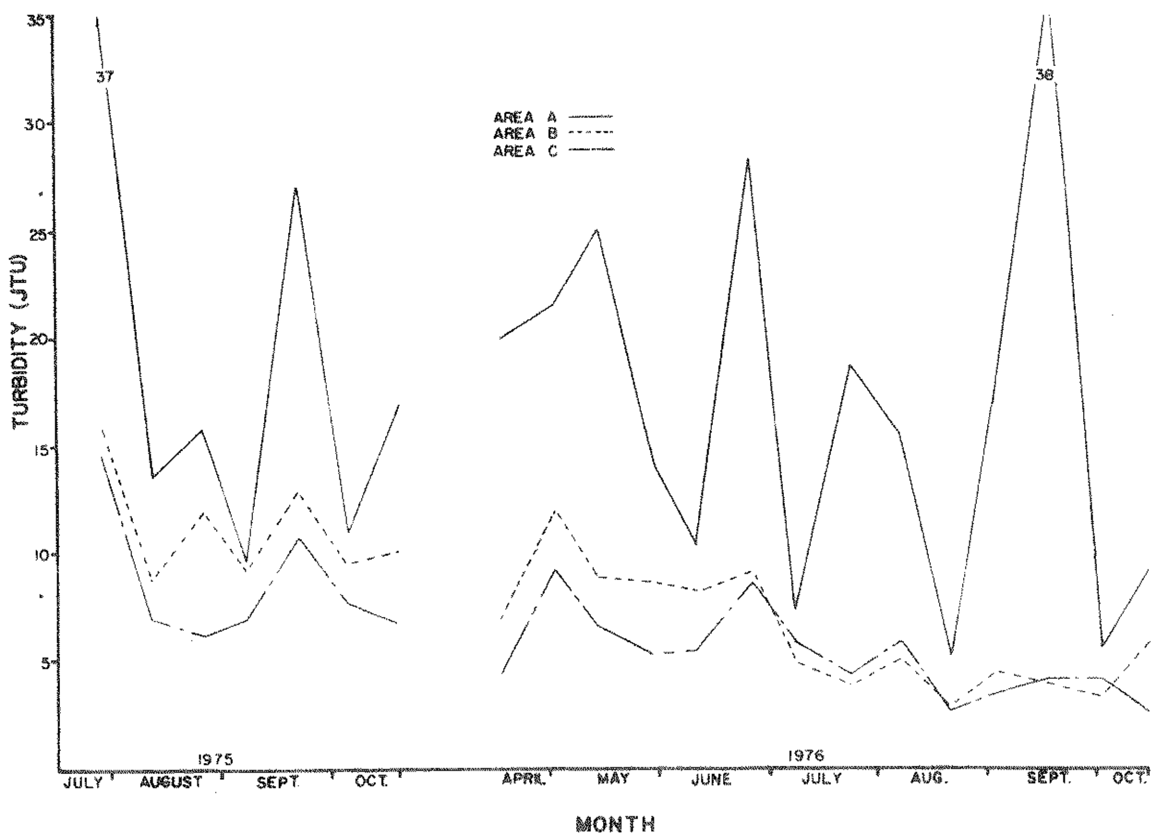

Figure 3. Turbidity levels in three areas of the Tongue River Reservoir (Whalen unpublished data).

TABLE 3. SUBSTRATE ANALYSIS OF THE TONGUE RIVER RESERVOIR.

	Area A	Area B	Area C	Total
Number of 0.25 kilometer sections	69	63	65	197
Number of sections capable of being seined	28	51	22	101
Percent of Sections:				
Silt to Clay (less than .062 mm)	50.7	19.0	13.8	28.4
Very Fine to Medium Sand (.062 - 0.5 mm)	30.4	14.3	6.2	17.3
Coarse to Very Coarse Sand (0.5 - 2 mm)	0.0	19.0	4.6	7.6
Pebbles (4 - 64 mm)	1.4	25.4	33.8	19.8
Cobbles (64 - 256 mm)	13.0	17.5	26.2	18.8
Boulders (more than 256 mm)	4.3	4.8	15.4	8.1

Pebbles and cobbles comprised 60.0% of the dominant substrate (Table 3). Chemical and physical parameters for the three areas are summarized from Whalen, Garrison, and Gregory (1975) and Whalen and Leathe (1976) (Table 4).

The extended runoff in 1975 (Fig. 4) created above average reservoir water levels in the early summer. To accommodate dam repairs, a high discharge rate persisted throughout the summer and caused very low water levels in the fall. The maximum water level fluctuation for 1975 was 9 meters (Fig. 5). This abnormal year is depicted in the water storage history (Fig. 1). Maximum water level fluctuation in 1976, a more typical year, was four meters (Fig. 5).

Turbidity levels were higher in areas B and C in 1975 than 1976 and may be related to the greater runoff in 1975. Turbidities in these two areas decreased as the summer progressed both years and again may be correlated to diminished input from the river. Yearly or seasonal trends could not be depicted in area A probably due to wind mixing of the shallow water column in this area and re-suspension of the sediments (Figs. 3 and 4).

The reservoir attained bass spawning temperatures, 15 to 18 C, two to three weeks earlier in 1976 than 1975 (Fig. 6). Ice-off occurred on April 23 in 1975 and April 3 in 1976.

TABLE 4. RANGES AND MEANS OF SELECTED PHYSICAL AND CHEMICAL PARAMETERS FROM THREE AREAS OF THE TONGUE RIVER RESERVOIR, AUGUST, 1975 TO SEPTEMBER, 1976.

Parameter	Area A	Area B	Area C
Depth at station, m (Spillway elevation)	6	14	18
Temperature (C)	6.1-24.1 15.3	1.2-23.8 12.1	5.5-23.5 13.9
Specific conductance (umhos.cm^{-1})	246-929 677.0	240-1032 683.5	196-948 681.5
pH	7.80-9.03	7.52-9.05	7.65-8.93
Dissolved oxygen (mg/l)	2.5-17.6 10.1	0.8-19.6 9.7	0.2-13.3 7.8
Turbidity (JTU)	6.0-45.0 20.6	1.3-21.5 7.7	1.9-24.0 7.1
Total alkalinity (mg/l of $CaCO_3$)	73.0-261.5 193.5	79.5-284.5 187.5	83.0-229.5 182.0
Ca^{++} (me/l)	1.05-3.98 2.91	1.45-4.31 3.01	1.45-3.83 2.93
Mg^{++} (me/l)	0.82-4.19 3.14	0.82-4.59 3.09	0.99-4.28 3.03
Na^{++} (me/l)	0.28-2.04 1.35	0.34-2.27 1.26	0.34-1.94 1.32
K^{+} (me/l)	0.03-0.13 0.09	0.04-0.16 0.09	0.04-0.16 0.09
$SO_4^{=}$ (me/l)	0.62-5.28 3.60	0.82-6.25 3.67	0.82-5.18 3.71
Cl^{-} (me/l)	0.02-0.12 0.08	0.02-0.14 0.08	0.03-0.14 0.08
Fe (ug/l)	0.000-0.085 0.031	0.000-0.090 0.018	0.000-0.093 0.019
NH_3-N (ug/l)	0-236 18	0-142 16	0-220 15
NO_3-N (ug/l)	0-204 9	0-157 28	0-52 11
PO_4-P (ug/l)	0-100 7	0-52 9	0-27 11
Total-P (ug/l)	16-134 37	10-119 46	32-260 78

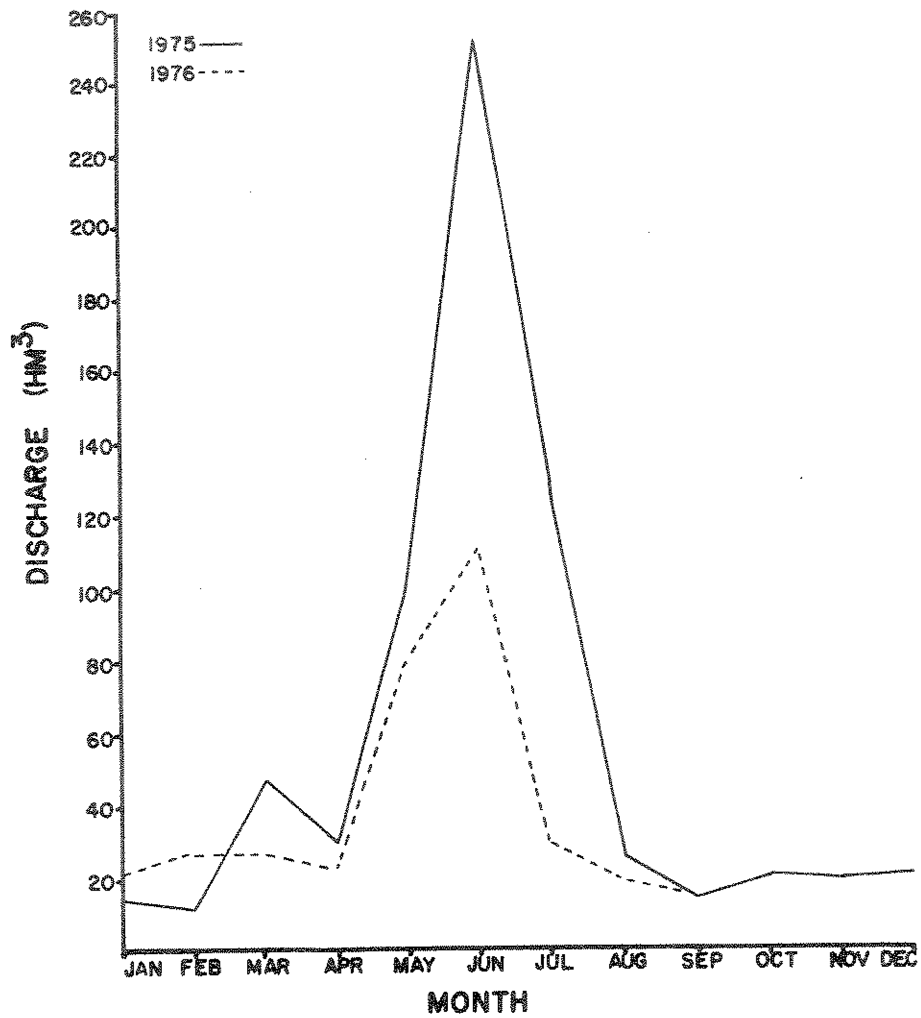

Figure 4. Discharge of the Tongue River above the Tongue River Reservoir (U.S.G.S. 1975 and U.S.G.S. unpublished data).

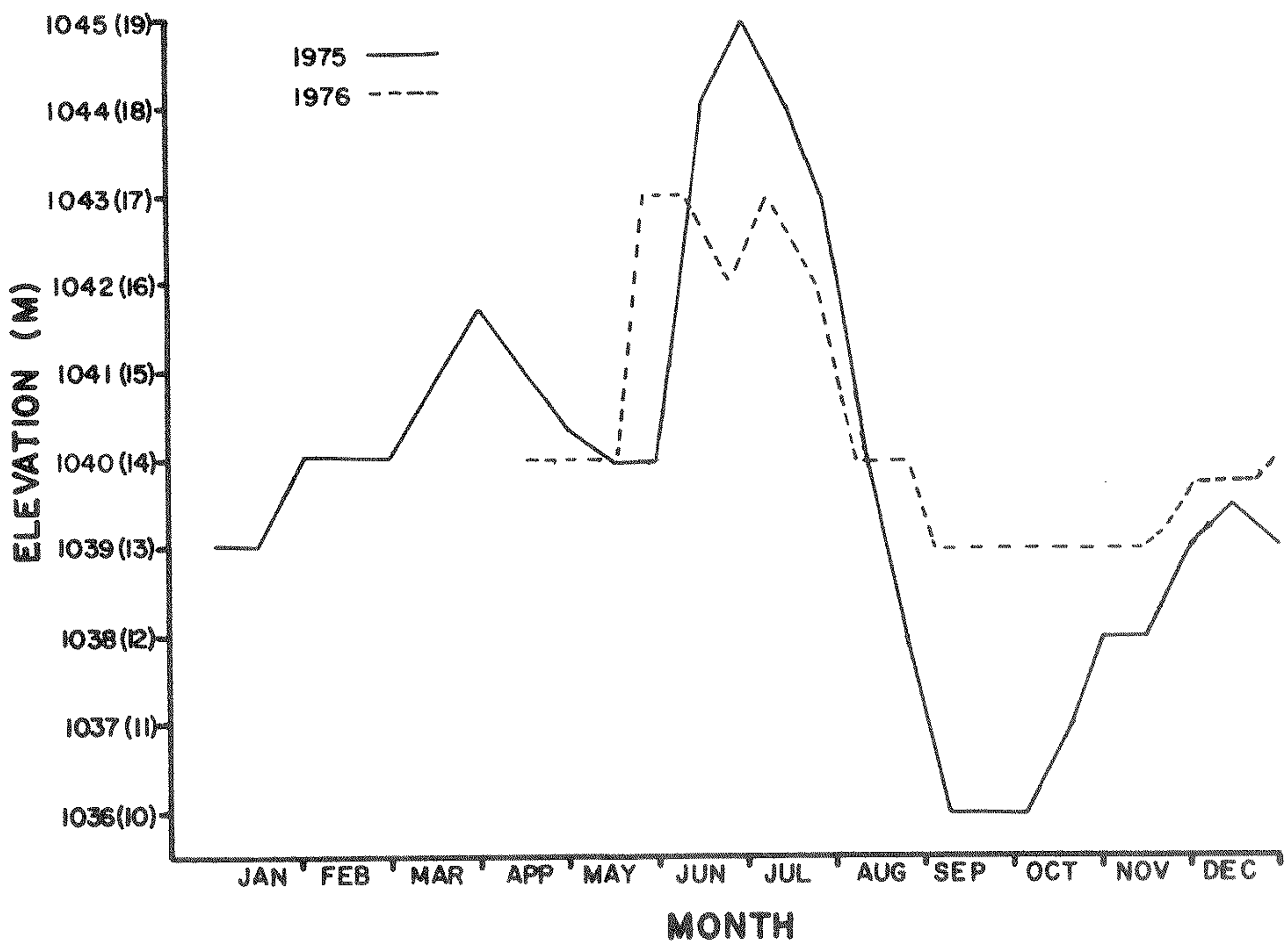

Figure 5. Surface elevation of the Tongue River Reservoir during 1975 and 1976. Corresponding maximum depth in parenthesis. (Montana Dept. of Nat. Resources unpublished data and Whalen unpublished data)

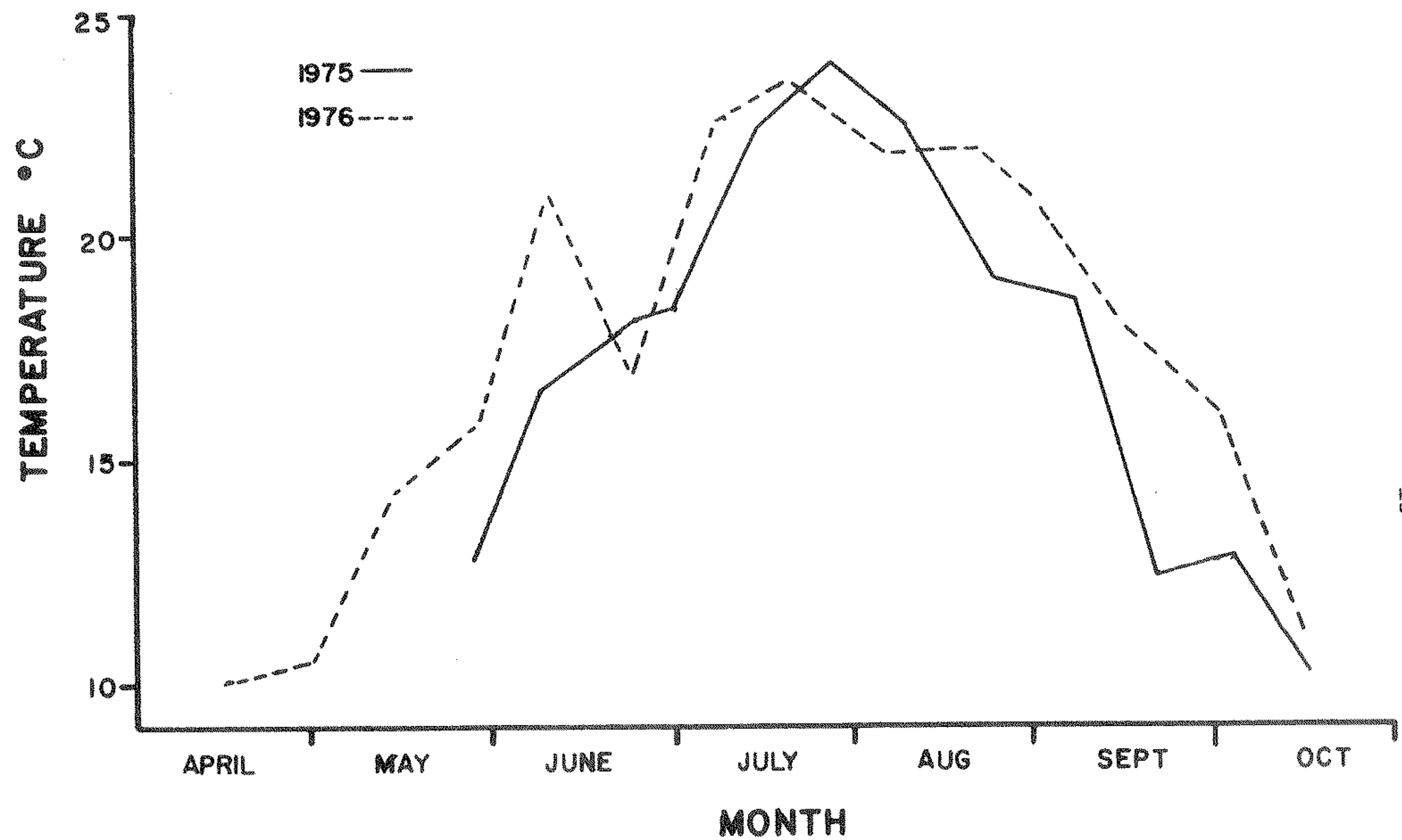

Figure 6. Mean water temperature of the Tongue River Reservoir (Whalen unpublished data).

The 25 fish species collected in the reservoir during the study include:

Rainbow trout	*Salmo gairdneri*
Brown trout	*Salmo trutta*
Northern pike	*Esox lucius*
Carp	*Cyprinus carpio*
Goldfish	*Carassius auratus*
Golden shiner	*Notemigonus crysoleucas*
Flathead chub	*Hybopsis gracilis*
River carpsucker	*Carpoides carpio*
Shorthead redhorse	*Moxostoma macrolepidotum*
Longhorse	*Catostomus catostomus*
White sucker	*Catostomus commersoni*
Black bullhead	*Ictalurus melas*
Yellow bullhead	*Ictalurus natalis*
Channel catfish	*Ictalurus punctatus*
Stonecat	*Noturus flavus*
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*
Yellow perch	*Perca flavescens*
Sauger	*Stizostedion canadense*
Walleye	*Stizostedion vitreum*

METHODS

Analysis of dominant particle size of shoreline substrate occurred during mid July, 1976 when reservoir surface elevation was 1041.7 meters. The reservoir bottom substrate was visually sized according to the Wentworth Classification System (Welch 1948). A topographic map of the reservoir was used to divide the shoreline into 0.25 km sections. Each section was classified according to the size of its dominant substrate. The number of sections classified alike were totaled and percentages computed for each area.

Relative abundance of black bass fingerlings and forage species was determined by shoreline seining during August and early September of 1975 and 1976. A 30.5 meter beach seine and a 15.25 meter bag seine were used in 1975 while only the larger seine was employed in 1976. Both seines had a mesh size of 6.4 mm. Each haul covered an average shoreline length of 19.1 meters and 9.6 meters for the beach and bag seines, respectively. Seine results were equally weighted by: (1) hauling the bag seine twice at each location or (2) multiplying the bag seine results by a factor of two. No particular seining schedule was followed during 1975 while the sampling technique was standardized in 1976. During 1976, seining sites were chosen from each area by randomly selecting those 0.25 km lengths of shoreline which were possible to seine (Fig. 7). Three sampling

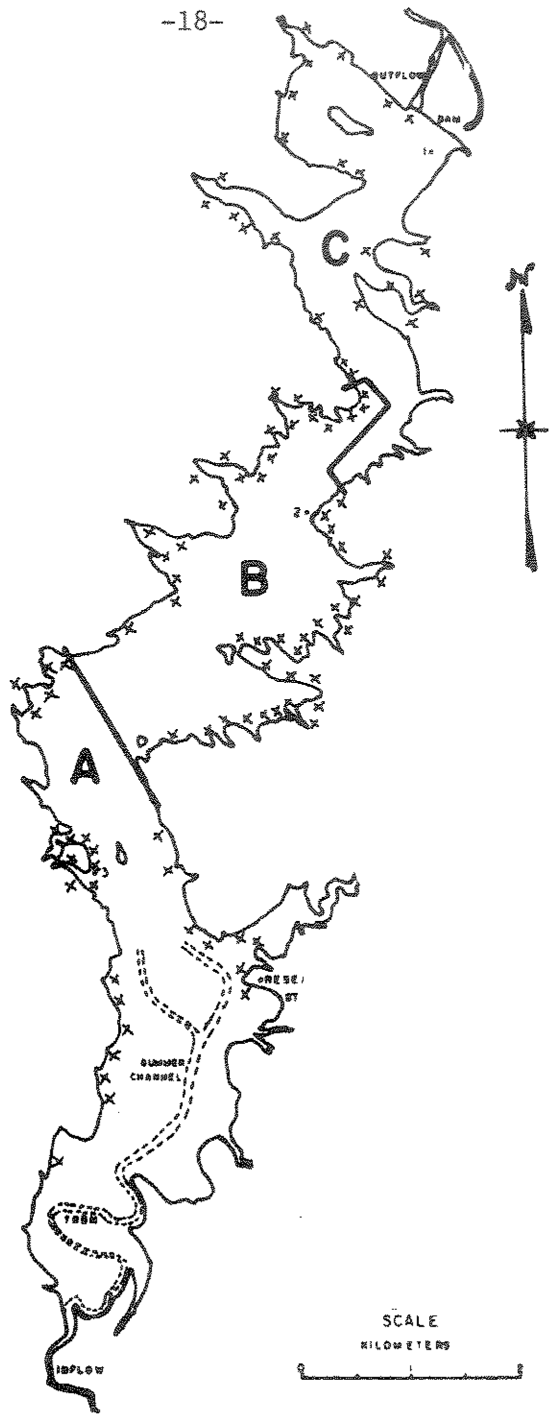

Figure 7. Seining locations on the Tongue River Reservoir.

periods were chosen to determine the effects of reservoir drawdown on the seining results. The three periods were the first of August, mid August and the first of September. Twenty seine hauls, five each in areas A and C and ten in area B, were made during each period. Area B was sampled twice as heavily because it had approximately twice the length of shoreline amenable to seining as did the other two areas. Also, area B is the transition zone between two habitat types and a larger sample size insures a more representative distribution of sampling sites throughout area B.

Most black bass age-1 and older were captured via hook and line in 1975. Attempts to capture bass with frame trap nets and gill nets proved to be unsuccessful. In 1976, a Type VI Smith Root electrofishing boat was employed in conjunction with a Coffelt variable voltage pulsator, Model VVP-10, and a 230-volt, 4000 watt, A.C. generator. Electrofishing with direct current (D.C.) proved to be more effective than with alternating current (A.C.). Efficiency of D.C. electrofishing was improved for fall sampling by converting a boom cathode to a second anode and adding a series of cathodes along each side of the boat (Novotny and Priegal 1974). All electrofishing was done at night with the aid of boat-mounted flood lights. Fish total length and weight were measured to the nearest millimeter and 10 grams, respectively. Left pelvic fins were removed from all fish in 1975 while a right pelvic clip was used in the spring and a lower caudal clip in the fall of 1976. Fish over 200 mm were tagged with a Floy FD67 anchor tag having a 16 mm monofilament base. Scale samples were taken from all fish in 1975. Scales were sampled from all fish over 200 mm in total length during the spring and all fish over 250 mm during the fall of 1976. An attempt was made to collect scales from a minimum of 10 fish per centimeter length interval below 200 (spring) or 250 mm (fall). Scales were taken from under the posterior tip of the left pectoral fin. Cellulose acetate scale impressions were examined on a scale projector at 66 X. Fish were released in the same cove or bay usually less than two shoreline kilometers from capture.

Because scales were not randomly sampled, a weighting procedure was applied to better represent the true mean total length and weight at age. This was accomplished by: (1) summing for each one centimeter total length interval, the total length and weight for all fish collected in that interval, (2) proportioning the summations according to age using percentages computed from scale data, and (3) totaling the summations allocated to each age and dividing by the estimated total number of fish in that age interval in the sample.

Scale samples collected during the fall were used to back calculate length at annulus formation. The relationship between total length and anterior scale radius appeared linear for both largemouth and smallmouth bass (r = .960 to .978) so Method 2 described by Tesch (1971) was used for back calculations. Back calculations were also weighted by one centimeter total length intervals. The average back calculated lengths for each one centimeter interval were multiplied by the proportion:

$$\frac{\text{number of fish age X in the Y total length interval}}{\text{estimated total number of fish age X in the total sample.}}$$

The weighted one centimeter intervals were then summed to get the final back calculations.

Condition factors for bass over 150 mm in total length were computed using the formula (Carlander 1969):

$K = \frac{W(10^5)}{L^3}$: where W equals weight in grams (g) and L is total length in millimeters (mm).

The length-weight relationship was estimated from the following equation (formula 9.3 in Ricker 1975):

log W = log a + b (log L): where W is weight (g) and L equals total length (mm).

Schumacher and Eschmeyer population estimates (formula 3.12 in Ricker 1975) were computed for areas B and C from three spring or early summer electrofishing runs along the entire shoreline. A simple mark and recapture estimate, using Chapman's modification of the Petersen formula (formula 3.7 in Ricker 1975), was calculated from two fall electrofishing circuits. A spring Petersen estimate of smallmouth bass population size in the entire reservoir was also computed by treating the two fall electrofishing circuits as the recapture run and the three spring electrofishing circuits as the mark run. Right pelvic and lower caudal fin clipped bass were considered marked fish for the spring and fall estimates, respectively.

Fall age structures, standing crops, and 95% confidence intervals were computed using methods summarized by Vincent (1971). The same format was followed for the spring estimates but modification was required for calculation of confidence intervals (Appendix page 93).

To assist in interpreting population estimates between areas, net movement of tagged fish was determined by measuring the shortest possible route between the mark and recapture point (not shoreline distance). This distance was termed minimum detectable movement. When the exact locations of capture and recapture were not known, the minimum distance was computed.

Tag loss was determined by comparing the ratio of tagged to untagged fin clipped fish in the population at time of capture to the ratio at time of recapture.

Surface areas and shoreline lengths, measured with a planimeter and a cartometer, respectively, were obtained from 1947 topographic maps.

Statistical tests were applied as described by Dixon and Massey (1969) at the $p<.05$ level of confidence. The method of least squares was used to derive linear regressions.

RESULTS

Shoreline Seining

Reproductive Success

The mean number of smallmouth bass fingerlings collected per seine haul during 1975 and 1976 was 0.0, 2.3 and 7.5 for areas A, B and C, respectively. Largemouth fingerlings demonstrated a similar trend of 1.2, 3.7 and 16.9 in the three respective areas (Table 5). Smallmouth fingerlings appeared twice as numerous in 1975 than in 1976 with 4.0 and 2.1 per haul, respectively. Largemouth bass

TABLE 5. SHORELINE SEINING BY AREAS FOR 1975 AND 1976 COMBINED, TONGUE RIVER RESERVOIR.

	Area A (23)		Area B (58)		Area C (41)	
	N/H	%	N/H	%	N/H	%
Smallmouth Bass Fingerlings	0.0	0.0	2.3	4.7	7.5	16.3
100 - 200 mm[1]	0.1	0.2	2.5	5.1	2.0	4.3
Largemouth Bass Fingerlings	1.2	1.9	3.7	7.5	16.9	36.2
100 - 200 mm[1]	0.7	1.1	0.7	1.4	0.4	0.9
Others	62.6	96.9	40.2	81.4	19.9	42.6
Total	64.6		49.4		46.7	

[1]Interval dominated by yearlings.
N/H = Number of fish captured per seine haul.
( ) = Number of seine hauls.

fingerling capture rate was similar during 1975 with 7.0 per haul, and 1976 with 6.4 per haul. Largemouth fingerlings were almost two times more numerous in the seines than smallmouth fingerlings in 1975 and were over three times more numerous in 1976 (Table 6).

TABLE 6. SHORELINE SEINING FOR 1975 AND 1976 WITH ALL AREAS COMBINED AND WEIGHTED EQUALLY, TONGUE RIVER RESERVOIR.

	1975 August 14 - September 5 (62)		1976 July 30 - September 5 (60)	
	N/H	%	N/H	%
Smallmouth Bass				
Fingerlings	4.0	9.6	2.1	3.3
100 - 200 mm[1]	2.5	6.0	0.4	0.7
Largemouth Bass				
Fingerlings	7.0	16.7	6.4	10.4
100 - 200 mm[1]	0.3	0.8	0.9	1.4
Others	28.2	67.1	52.1	84.2
Total	42.0		61.9	

[1]Interval dominated by yearling.
N/H = Number of fish captured per seine haul.
( ) = Number of seine hauls.

The number of fish captured per seine haul can be compared between years only if: (1) the fingerlings behaved similarly both years (i.e., remained in shallow water), (2) differences in water levels at time of seining between years (two meters) did not alter fingerling distribution and (3) differences in water levels did not affect the efficiency of the seines. It appeared that random selection of the seining sites was most responsible for variation between sampling periods which masked trends caused by differences in water levels. The shoreline was more amenable to seining at low water levels due to reduction of obstacles (trees, logs, rocks, etc.), and reduction of the shoreline slope. The large increase in the number of largemouth fingerlings collected in area C during the last seining period in 1976 may be related to this. It is likely that shoreline seining over represented the true abundance of fingerlings in 1975.

Abundance of Forage Species

Total mean number of fish collected per seine haul for both years combined was 64.6, 49.4 and 46.7 in areas A, B and C, respectively (Table 5). Of the total, black bass comprised 3.2, 18.7, and 57.7% of the catch in the three respective areas. Crappie, yellow perch, carp, and goldfish fry comprised 63.7% of the total catch for both years combined while golden shiners, considered an important bass forage fish, comprised only 3.8%.

The mean number of fish collected in 1976, 61.9 per haul, was greater than in 1975, 42.0 per haul (Table 6). This occurred despite lower water levels during the seining period in 1975.

Black bass comprised 33.1 and 15.8% of the catch in 1975 and 1976, respectively.

Age and Growth

Annulus Formation

During 1975 and 1976 a distinct trend was noted for time of annulus formation between ages with the younger fish establishing current annuli first. Each year class laid down annuli one to two weeks later than the previous year class. The exception occurred during 1976 when age-4 and age-5 fish established annuli at approximately the same time. Smallmouth bass established annuli approximately three to four weeks later in 1975 than in 1976. Too few largemouths were collected to establish time of annulus formation but they appeared to follow a similar trend as smallmouth bass.

Back Calculated Lengths and Weights

Regressions of total length versus anterior scale radius and weight versus total length were used to back calculate total length and weight, respectively (Table 26).

The grand mean total lengths at annuli were similar for smallmouth bass in areas A and B but were consistently smaller in area C (Table 7). One-year old smallmouth bass were five millimeters smaller in area C while the older fish were 20 to 30 mm shorter

(Fig. 8). The grand mean annual total length increments were correspondingly smaller in area C, 64 mm, than area A, 71 mm, or B, 70 mm (Table 8).

Calculated weights at annuli of smallmouth bass were, likewise, very similar in areas A and B but smaller in area C (Table 7). This is partially attributable to the smaller length attained at annulus for smallmouth bass in area C. The other factor is the less favorable length-weight relationship for smallmouth bass in area C. This relationship is shown in Figure 9 for areas B and C. Area A was not included because larger lengths were not representatively sampled in this area.

Grand mean total lengths at annuli of largemouth bass (Table 9) did not show the same trends between areas as did smallmouth bass. After age-1, largemouth bass were smaller in area B than the other two areas. At the fifth annulus, fish in areas A and B had similar mean total lengths. Two and three-year old largemouth bass in area A had the greatest absolute growth, while C was intermediate. After the third annulus, fish in area C had the largest absolute growth with A intermediate (Fig. 8). Largemouth bass grand mean total length increments were 78, 78 and 83 mm in areas A, B and C, respectively (Table 8).

The back calculated weights at annuli simply followed the trend of the total lengths, as largemouth bass of the longest

TABLE 7. SMALLMOUTH BASS BACK CALCULATED LENGTHS (mm) AND WEIGHTS (g), TONGUE RIVER RESERVOIR, 1976.

Area A						
Year Class	n	1	2	3	4	5
1971	3	99	157	235	321	356
1972	1	96	230	256	327	
1973	6	85	165	217		
1974	39	90	149			
1975	3	92				
Weighted Grand Mean*		90	153	226	323	356
Calculated Weight		10	50	168	508	687

Area B							
Year Class	n	1	2	3	4	5	6
1970	3	103	202	289	346	386	410
1971	12	97	168	241	325	343	
1972	9	101	163	255	301		
1973	76	90	161	210			
1974	130	91	148				
1975	40	85					
Weighted Grand Mean*		90	150	217	318	350	410
Calculated Weight		9	46	149	508	691	1148

Area C							
Year Class	n	1	2	3	4	5	6
1970	1	92	126	178	233	291	346
1971	7	93	151	215	287	325	
1972	3	92	158	245	297		
1973	31	86	147	192			
1974	102	87	130				
1975	54	81					
Weighted Grand Mean*		85	131	199	286	321	346
Calculated Weight		7	29	110	355	514	654

n = Number of scales examined.
*weighted on basis of % year class in population.

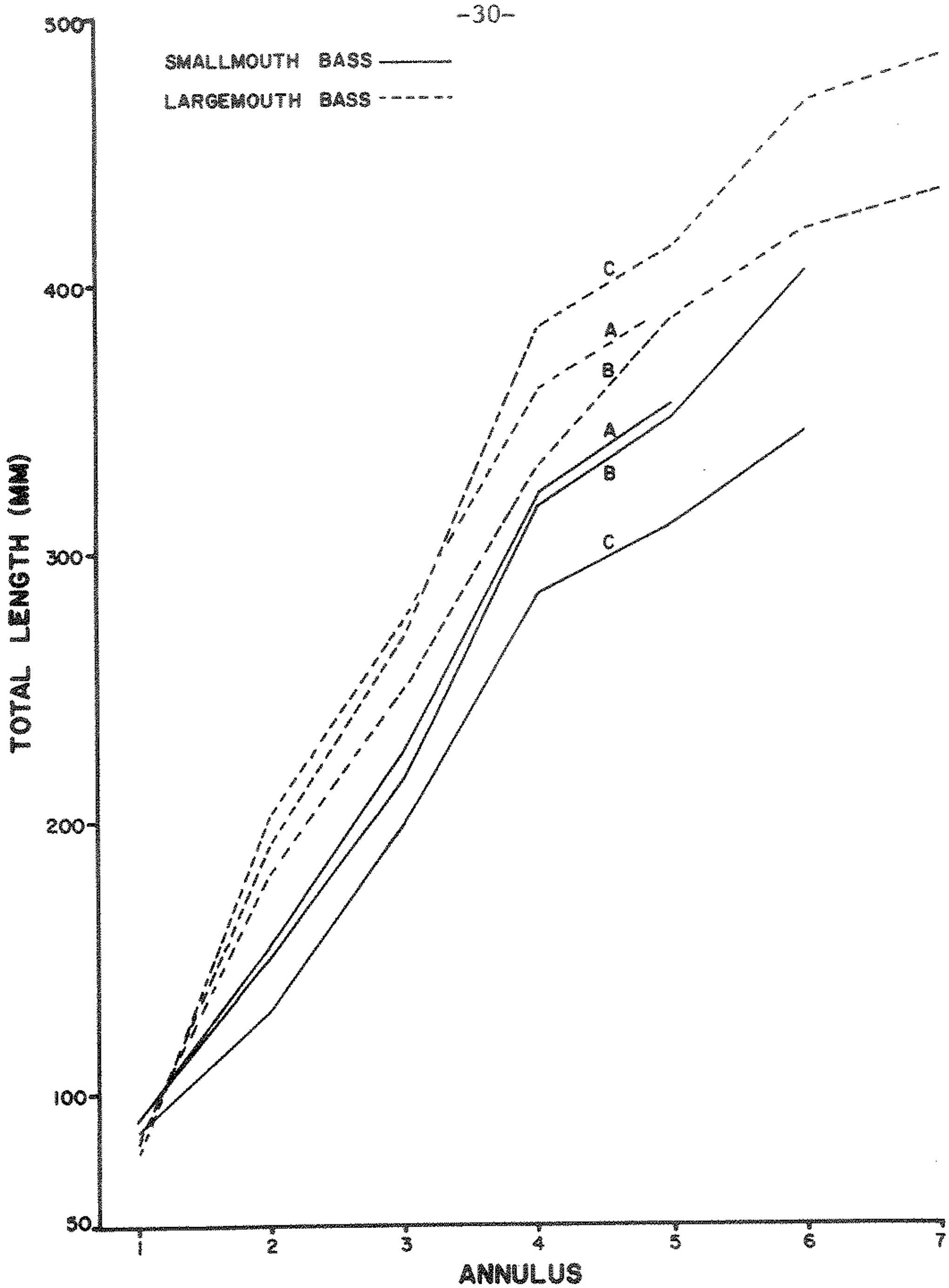

Figure 8. Total length at annulus of smallmouth and largemouth bass in areas A, B, and C of the Tongue River Reservoir.

TABLE 8. AVERAGE ANNUAL TOTAL LENGTH INCREMENTS IN MM OF BLACK BASS. NUMBER OF SCALES EXAMINED IN PARENTHESIS.

Age	Area A	Area B	Area C	Entire Reservoir
		Smallmouth Bass		
1	90 (52)	90 (270)	85 (198)	89 (520)
2	63 (49)	60 (230)	46 (144)	55 (423)
3	73 (10)	67 (100)	68 (42)	69 (152)
4	97 (4)	101 (24)	87 (11)	99 (39)
5	33 (3)	32 (15)	35 (8)	33 (26)
6	---	60 (3)	25 (7)	56 (10)
7	---	---	---	---
Unweighted Grand Mean	71	70[a]	64[a]	67
		Largemouth Bass		
1	78 (125)	81 (199)	83 (110)	81 (434)
2	124 (19)	99 (42)	108 (55)	108 (116)
3	73 (14)	70 (19)	77 (18)	75 (51)
4	86 (7)	81 (8)	115 (5)	90 (20)
5	28 (6)	57 (5)	30 (4)	41 (15)
6	---	32 (2)	54 (2)	49 (4)
7	---	14 (1)	17 (1)	15 (2)
Unweighted Grand Mean	78	78[a]	83[a]	79[b]

[a] sixth and seventh year increments not included.
[b] seventh year increments not included.

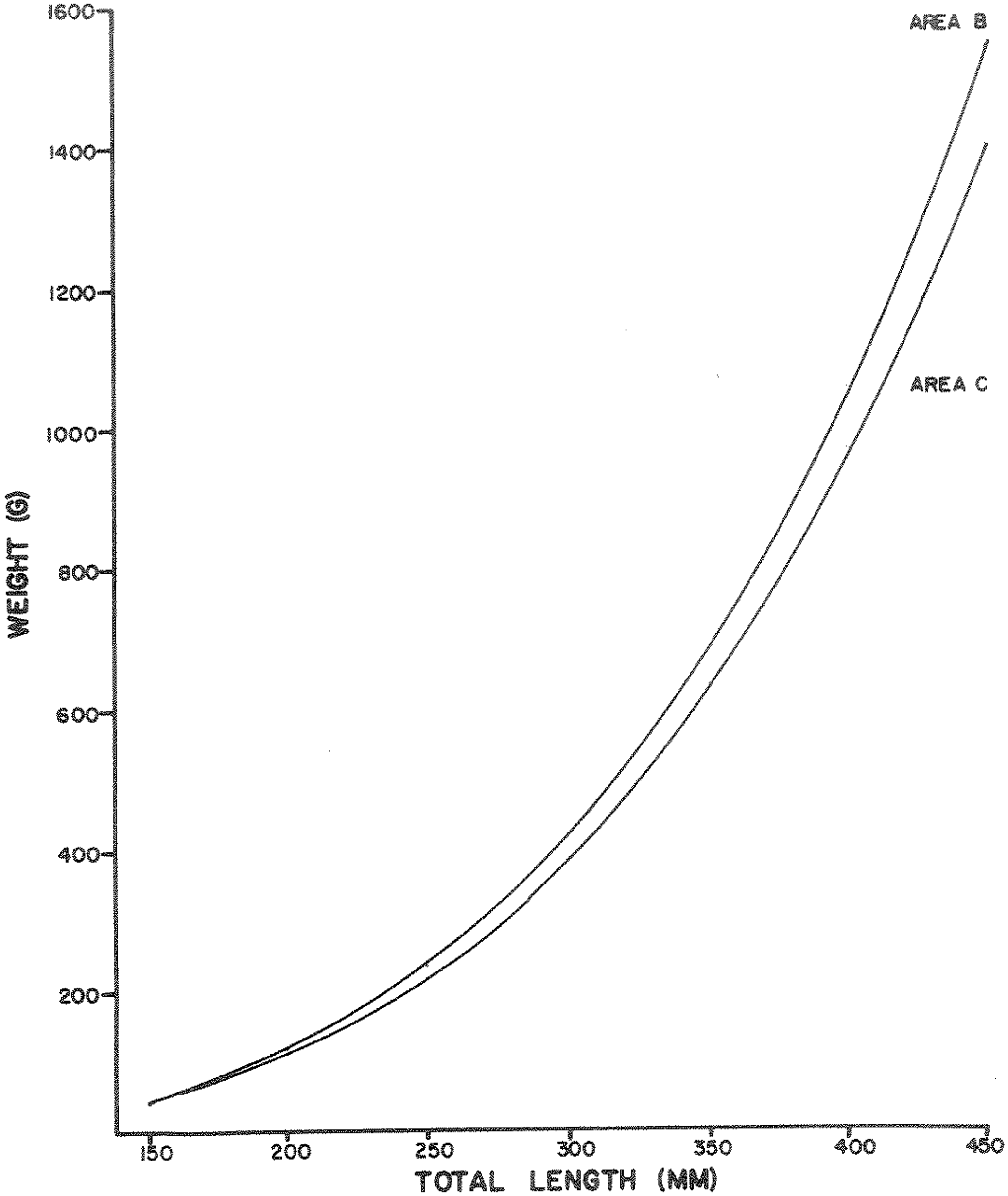

Figure 9. Length-weight relationship of smallmouth bass, collected in the fall, in areas B and C of the Tongue River Reservoir.

TABLE 9. LARGEMOUTH BASS BACK CALCULATED LENGTHS (mm) AND WEIGHTS (g), TONGUE RIVER RESERVOIR, 1976.

Area A

Year Class	n	1	2	3	4	5
1971	6	97	226	286	359	389
1972	1	80	242	326	371	
1973	7	81	170	258		
1974	5	85	211			
1975	106	76				
Weighted Grand Mean*		78	202	275	361	389
Calculated Weight		6	128	351	855	1092

Area B

Year Class	n	1	2	3	4	5	6	7
1969	1	110	233	295	356	390	420	434
1970	1	84	245	332	358	390	419	
1971	3	86	169	281	351	386		
1972	3	79	177	230	293			
1973	11	89	151	235				
1974	23	86	190					
1975	157	80						
Weighted Grand Mean*		81	180	250	331	388	420	434
Calculated Weight		7	89	257	637	1064	1374	1528

Area C

Year Class	n	1	2	3	4	5	6	7
1969	1	89	255	343	407	442	469	484
1970	1	90	252	351	411	433	465	
1971	2	85	194	291	352	388		
1972	1	117	245	332	394			
1973	13	88	175	248				
1974	37	86	191					
1975	55	79						
Weighted Grand Mean*		83	191	268	383	413	467	484
Calculated Weight		8	107	311	960	1218	1795	2009

n = Number of scales examined.
*weighted on basis of % year class in population.

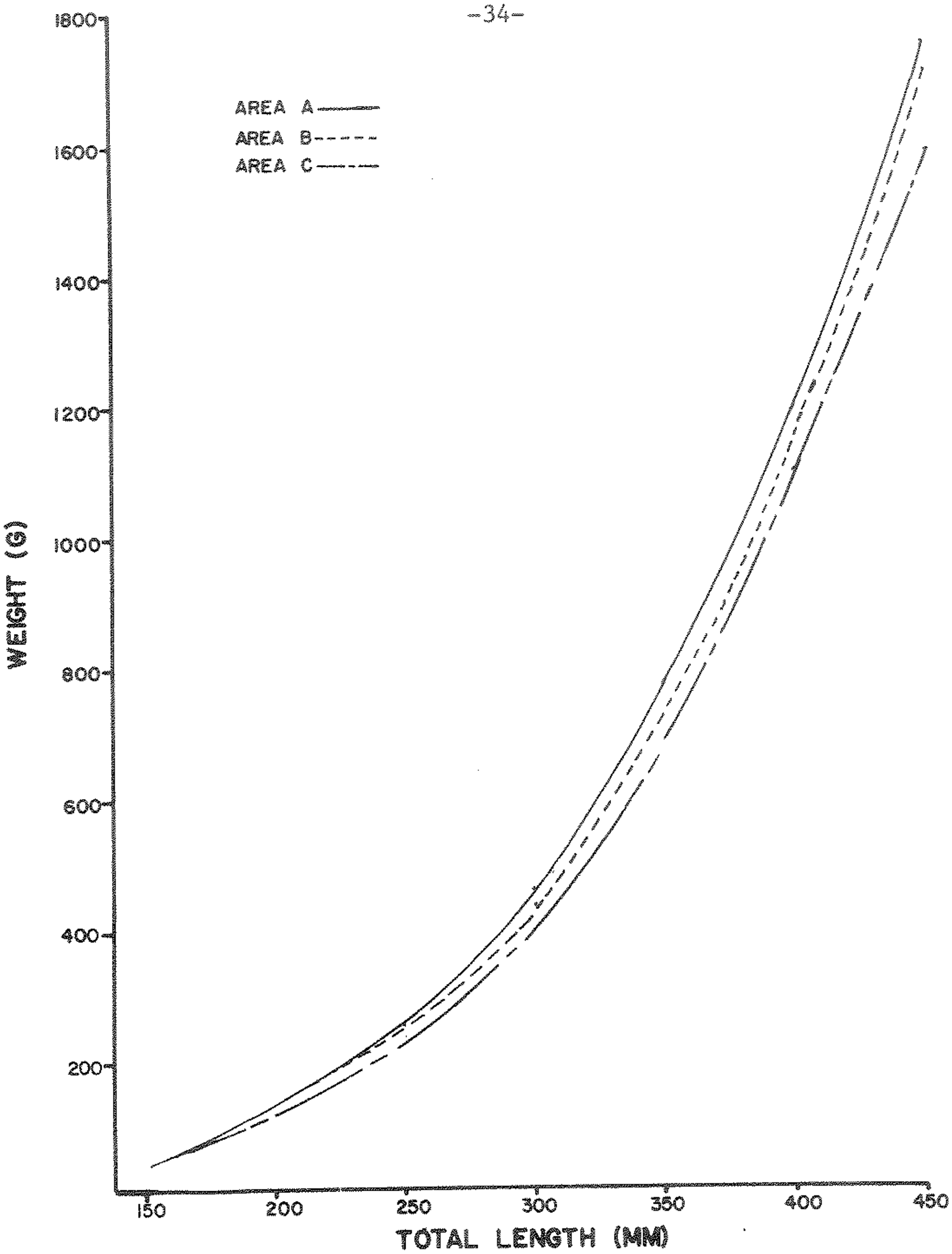

Figure 10. Length-weight relationship of largemouth bass, collected in the fall, in three areas of the Tongue River Reservoir.

lengths had the greatest weights (Table 9). The superior weight of older fish in area C was totally due to the greater length attained at annulus rather than a better length-weight relationship (Fig. 10). Largemouths in area C demonstrated the poorest length-weight relationship and A the best, which is similar to the pattern established by smallmouth bass.

Back calculated lengths and weights for both species in the entire Tongue River Reservoir are presented in Table 10. The grand mean total length of age-1 smallmouth bass, 89 mm, is larger than the same aged largemouth bass, 81 mm, while all older age classes of largemouth bass are longer than the same aged smallmouth bass. This is presented graphically in Figure 11. The greatest difference in annual total length increments occurred in the second year of growth. During this period largemouth bass growth averaged 53 mm greater than smallmouth growth (Table 8). This was the period of largest annual increment for largemouth bass, 108 mm. The largest increment for smallmouth bass, 99 mm, occurred during the fourth year of life and averaged 9 mm greater than growth for largemouth bass during the same period (Table 8).

Age-1 smallmouth bass were slightly heavier than the same aged largemouth bass, while largemouth bass were heavier for all older ages (Table 10). Largemouth bass demonstrated a superior length-weight relationship (Fig. 12).

TABLE 10. BACK CALCULATED TOTAL LENGTHS (mm) AND WEIGHTS (g) OF BLACK BASS IN THE ENTIRE TONGUE RIVER RESERVOIR.

Year Class	n	Annulus 1	2	3	4	5	6	7
				Smallmouth Bass				
1970	4	102	192	274	331	373	401	
1971	22	96	165	236	318	340		
1972	13	100	162	253	300			
1973	113	89	158	206				
1974	271	90	142					
1975	97	83						
Weighted Grand Mean*		89	144	213	312	345	401	
Calculated Weight		8	39	137	469	648	1051	
				Largemouth Bass				
1969	2	100	244	319	382	416	445	459
1970	2	87	249	342	385	412	442	
1971	11	92	204	286	355	388		
1972	5	87	203	270	329			
1973	31	87	166	246				
1974	65	86	192					
1975	318	79						
Weighted Grand Mean*		81	189	264	354	395	444	459
Calculated Weight		6	94	274	704	1002	1459	1623

n = Number of scales examined.
* weight on basis of % year class in population.

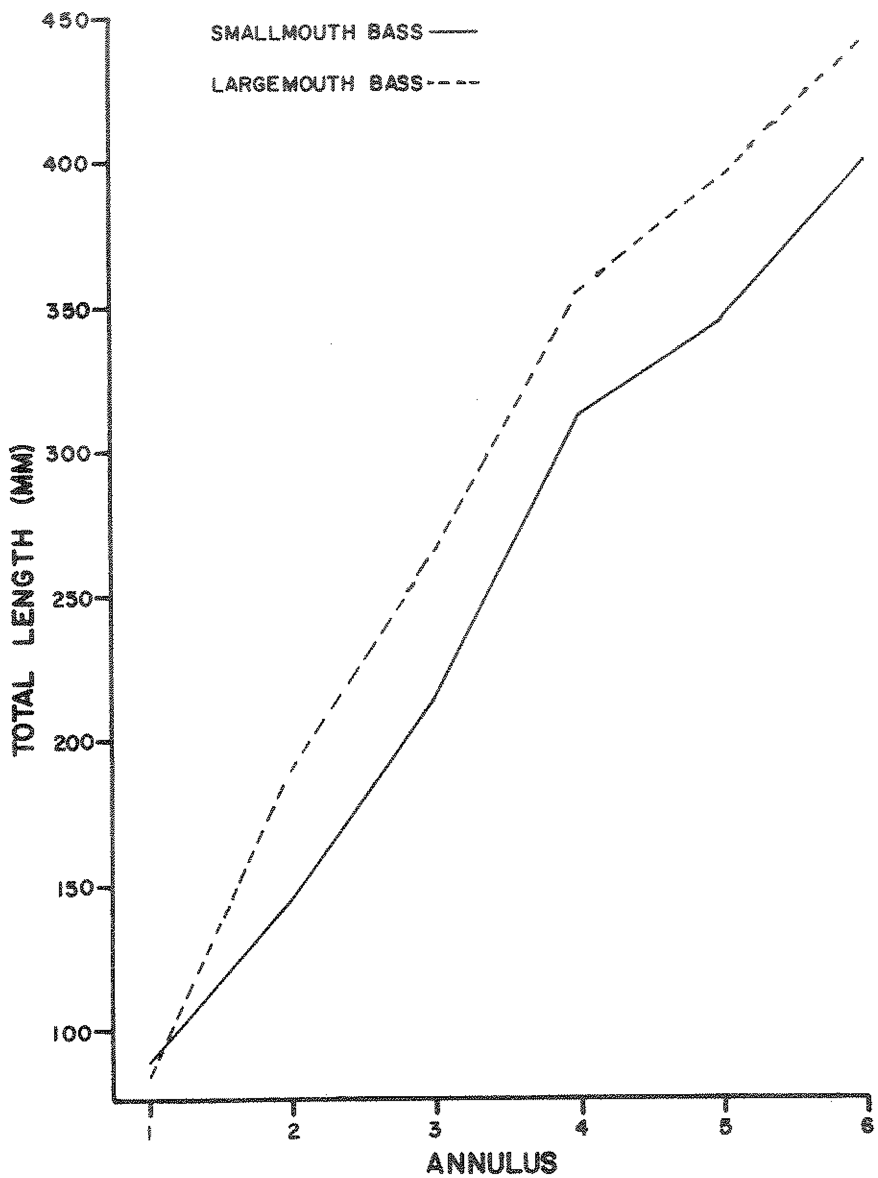

Figure 11. Total length of black bass at annulus in the Tongue River Reservoir.

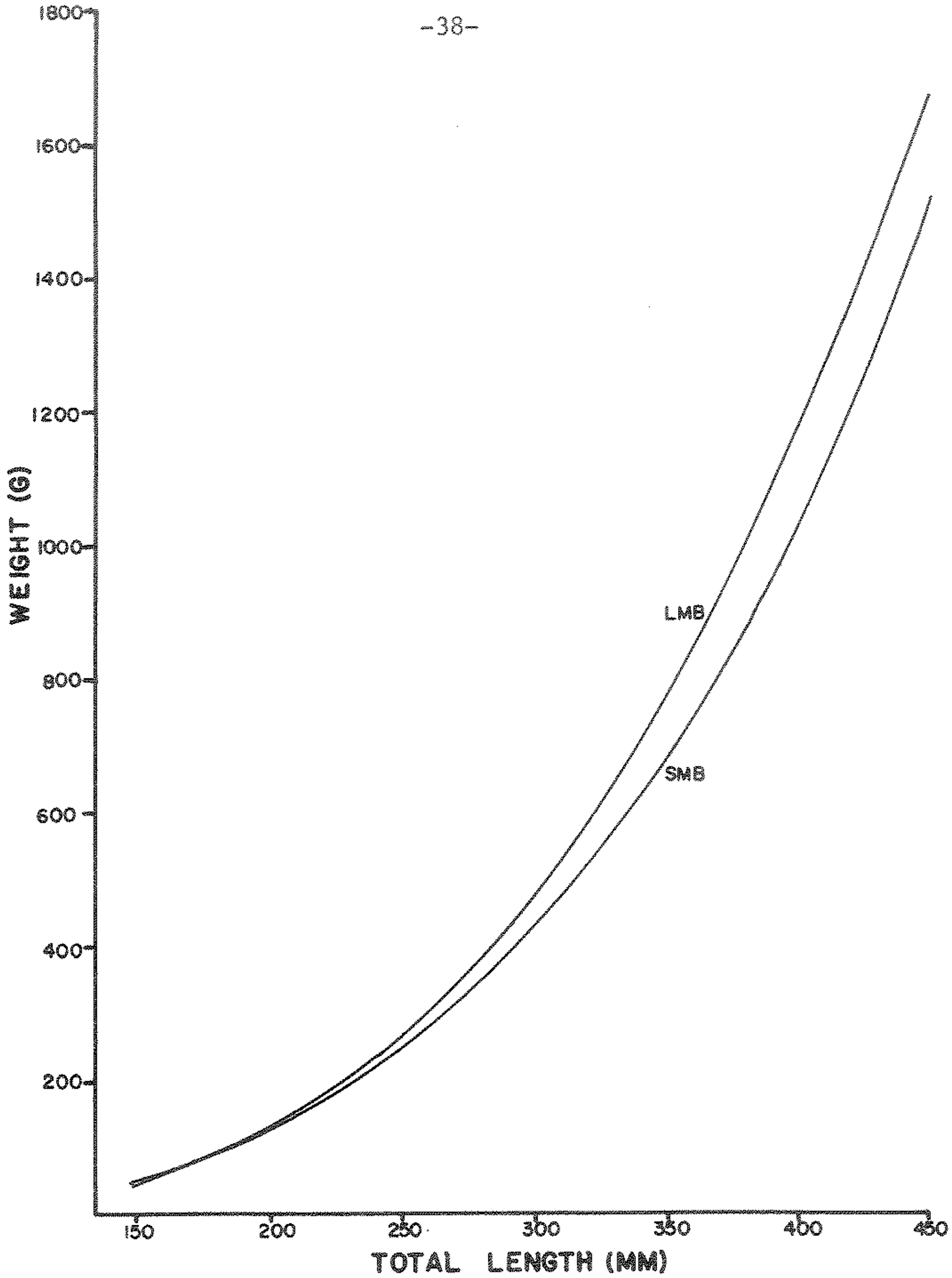

Figure 12. Length-weight relationship of largemouth (LMB) and smallmouth (SMB) bass in the Tongue River Reservoir.

Fingerling Growth

There was no significant difference in mean total length between smallmouth fingerlings collected in areas B and C during similar time periods. Mean lengths were significantly larger during 1976 than 1975 for all time periods and both areas (Table 11).

During different sampling periods largemouth fingerlings in both areas B and C had the significantly largest means, thus, demonstrating no trends between areas. No significant difference in mean length was noted between years during similar time periods in area B while 1976 mean total lengths were significantly larger than 1975 total lengths in area C (Table 12).

During 1975 largemouth fingerlings were significantly longer during mid August, 59.3 mm, and early September, 62.9 mm, than were smallmouth fingerlings, 56.5 and 60.5 mm, respectively. In 1976 the trend was reversed as smallmouth bass were significantly longer during mid August, 71.4 mm, and early September, 76.4 mm, than largemouth fingerlings, 54.2 and 70.0 mm, respectively (Table 13).

Condition Factors

Condition factors were calculated by 50 mm total length intervals to elimate length related bias. The grand mean condition of smallmouth bass in area B was significantly greater than in area C. The grand mean for area A was not directly comparable because two

TABLE 11. MEAN TOTAL LENGTH ($\bar{X}$) IN MM, STANDARD DEVIATION (s) AND SAMPLE SIZE (n) OF SMALLMOUTH BASS FINGERLINGS, TONGUE RIVER RESERVOIR. MEANS WITH CORRESPONDING SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT.

	1975			1976		
	n	X	s	n	X	s
Area B						
Early August	--	---	---	27	59.4	6.3
Mid August	19	50.0[a]	4.6	21	71.5[a]	9.9
Early September	28	59.2[b]	5.0	9	74.1[b]	9.3
Area C						
Early August	--	---	---	23	57.2	6.9
Mid August	41	57.2[c]	7.0	12	71.3[c]	8.8
Early September	28	61.8[d]	7.2	27	77.2[d]	7.0

TABLE 12. MEAN TOTAL LENGTH ($\bar{X}$) IN MM, STANDARD DEVIATION (s) AND SAMPLE SIZE (n) OF LARGEMOUTH BASS FINGERLINGS, TONGUE RIVER RESERVOIR. MEANS WITH CORRESPONDING SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT.

	1975			1976		
	n	$\bar{X}$	s	n	$\bar{X}$	s
Area A						
Mid August	6	57.2	9.1	1	46.0	---
Area B						
Mid August	20	56.7^{b}	8.2	66	54.4	8.8
Early September	17	66.2^{c}	8.5	72	65.3^{d}	7.8
Area C						
Mid August	52	60.6^{b}	7.1	--	--	---
Early September	54	$61.8^{a,c}$	6.0	119	$72.9^{a,d}$	6.1

TABLE 13. COMPARISON OF SMALLMOUTH AND LARGEMOUTH BASS FINGERLING MEAN TOTAL LENGTH ($\bar{X}$) IN MM, STANDARD DEVIATION (s) AND SAMPLE SIZE (n), TONGUE RIVER RESERVOIR. MEANS WITH CORRESPONDING SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT.

	1975		1976	
	Mid August	Early September	Mid August	Early September
Smallmouth Bass				
n	60	56	33	36
$\bar{X}$	56.5^{a}	60.5^{b}	71.4^{c}	76.4^{d}
s	6.4	6.2	9.5	7.6
Largemouth Bass				
n	78	71	67	191
$\bar{X}$	59.3^{a}	62.9^{b}	54.2^{c}	70.0^{d}
s	7.5	6.7	8.8	6.8

50 mm total length intervals were not represented, however, mean condition of comparable length intervals was usually greatest in area A (Table 27). The condition versus total length regressions are presented in Figure 13. Smallmouths in area B are shown to have a greater condition than fish in area C for all lengths. The slope of the B regression is significantly greater than the C regression, indicating that, as smallmouth bass get longer, the difference in condition between the two areas increases. The regression for area A is the only one not significantly greater than zero because the larger length intervals were not represented.

Grand mean conditions of largemouth bass were similar for areas A and B and lower for area C (Table 27). The condition versus total length regressions for each area are presented in Figure 14. Fish in the 150 to 200 mm total length interval were in best condition in area C, intermediate in B and poorest in area A. For largemouth bass longer than 250 mm, the pattern was reversed. The fish were in best condition in areas A or B and poorest in C. All the regression coefficients were significantly greater than zero. The slope of regression A was significantly greater than C while B was not significantly different from C.

Largemouth bass had greater interval and grand mean condition values than smallmouth bass (Table 28). The black bass condition

Area	Regression	n	r	p value Ha: Slope>0
A	$K = 1.371 + 4.289 \times 10^{-4}L$	46	.160	.32
B	$K = 1.207 + 1.184 \times 10^{-3}L$	1212	.256	<.0005
C	$K = 1.228 + 7.531 \times 10^{-4}L$	831	.162	<.0005

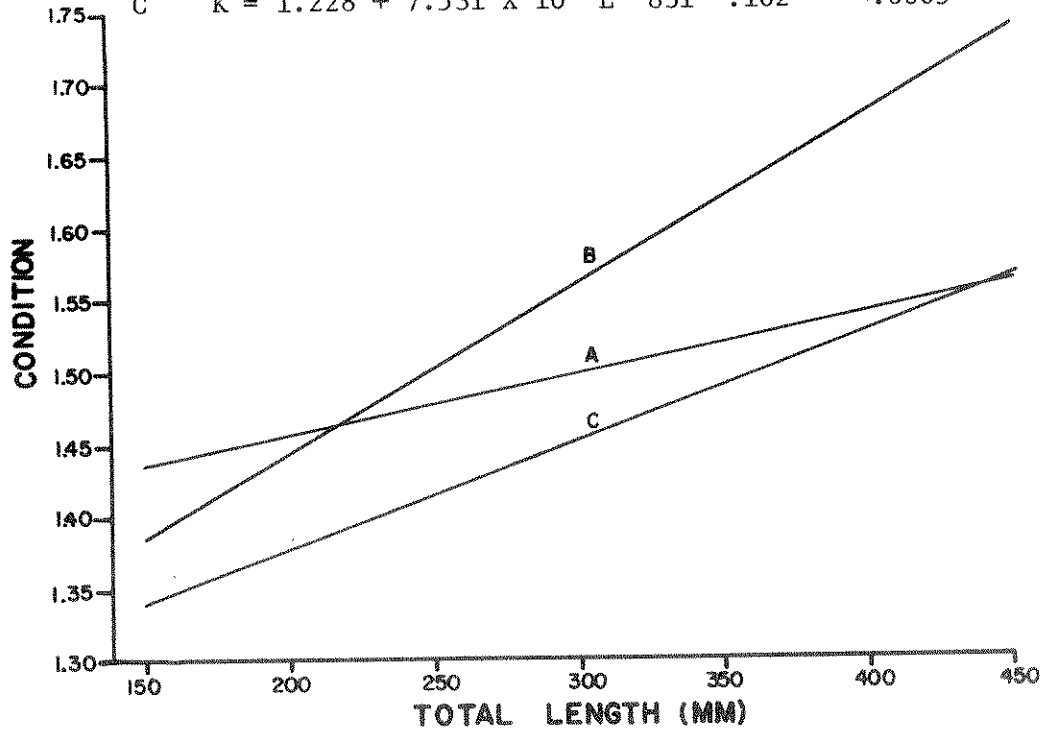

Figure 13. Condition (K) versus total length (L) regressions of smallmouth bass in areas A, B and C of the Tongue River Reservoir.

Area	Regression	n	r	p value Ha: Slope>0
A	$K = 1.726 + 1.661 \times 10^{-3} L$	26	.717	<.0005
B	$K = 1.286 + 1.433 \times 10^{-3} L$	56	.578	<.0005
C	$K = 1.415 + 7.750 \times 10^{-4} L$	72	.393	.01

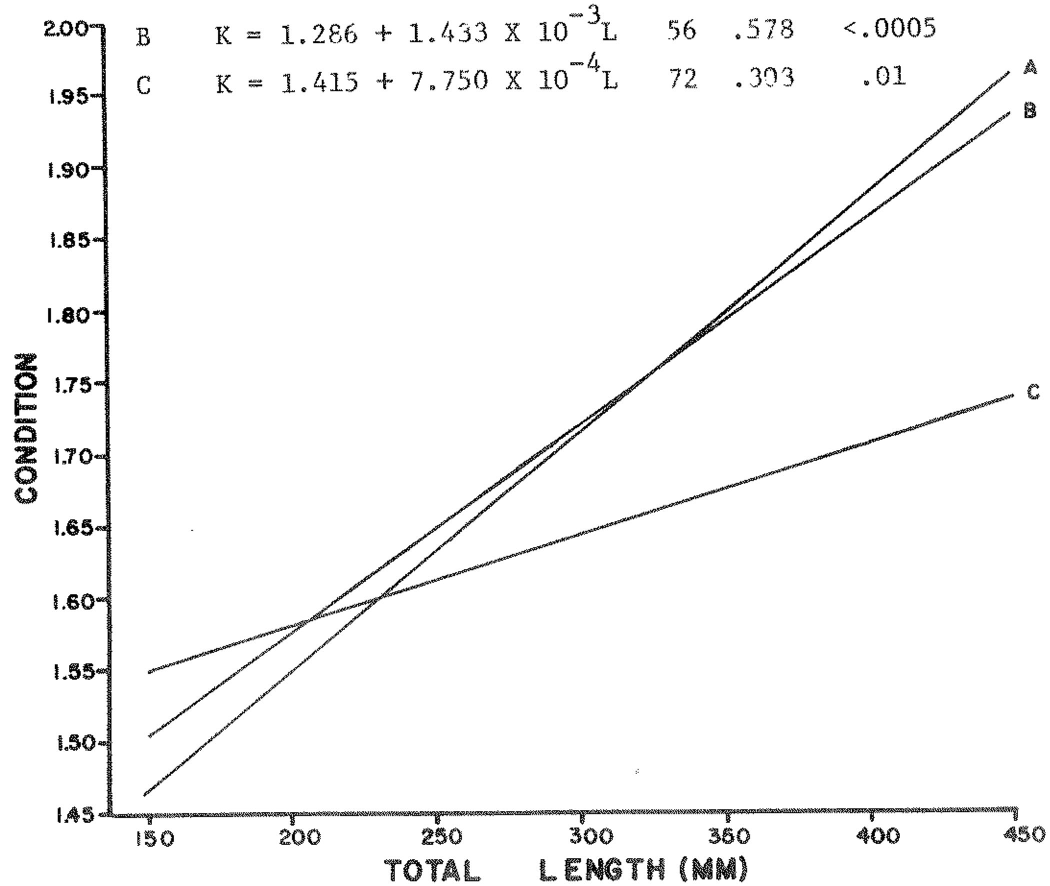

Figure 14. Condition (K) versus total length (L) regressions of largemouth bass in areas A, B and C of the Tongue River Reservoir.

	Regression	n	r	p value Ha: Slope>0
LMB	$K = 1.302 + 1.277 \times 10^{-3} L$	154	.513	<.0005
SMB	$K = 1.171 + 1.220 \times 10^{-3} L$	2089	.267	<.0005

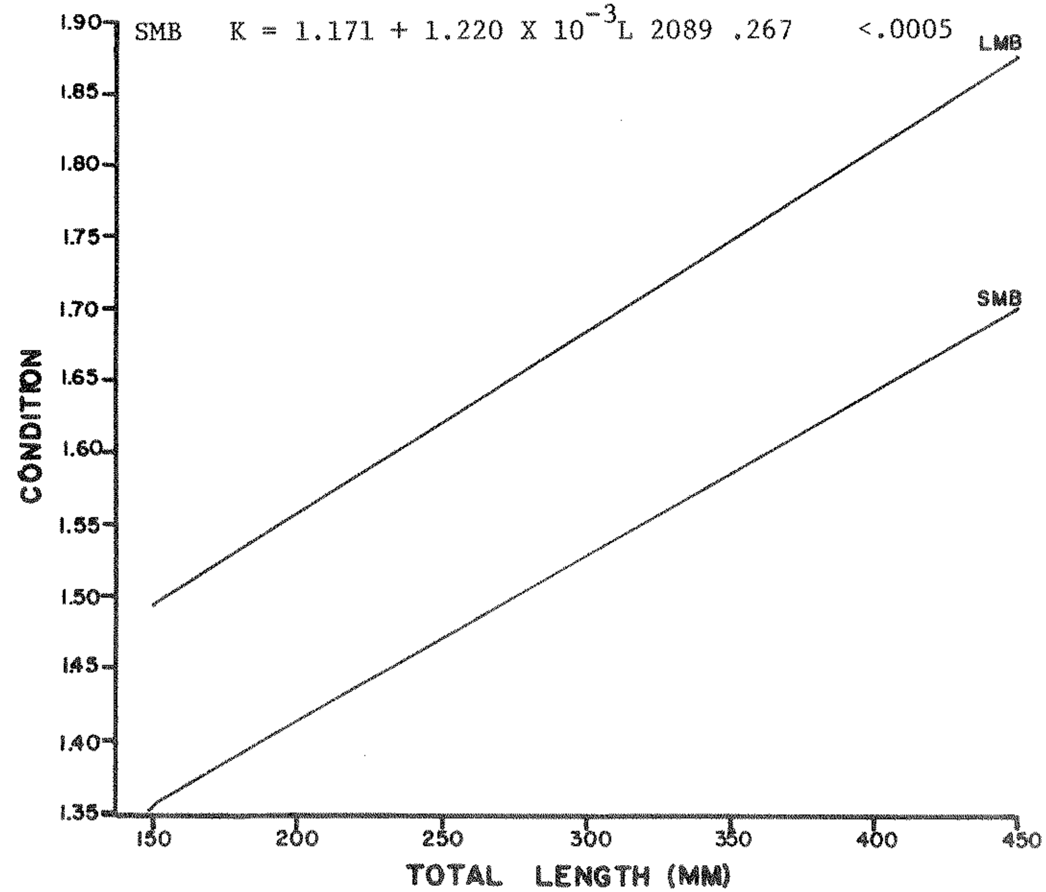

Figure 15. Condition (K) versus total length (L) regressions of largemouth (LMB) and smallmouth (SMB) bass, Tongue River Reservoir.

versus total length regressions for the entire reservoir are plotted on Figure 15. While the slopes of the two regressions are not significantly different, the means along the two lines are.

The correlation coefficients for all condition versus total length regressions were small, 0.160 to 0.717, demonstrating that factors other than length are also responsible for the observed variation in condition values.

Population and Standing Crop

Fish age assignments in this study were made by adding one year to the number of annuli visible prior to annulus formation for the current year. For example, age-0+ fish collected in the spring before annulus formation and age-1+ fish collected in the fall of the same year are called age-1. Spring sampling did not representatively sample age-1 fish while all age classes, except fingerlings, were included in the fall population estimates.

Catch statistics for black bass population estimates are listed in Tables 29 through 33. Too few largemouth bass were collected to estimate their population during the spring. Largemouth estimates for fall could only be computed for the entire reservoir as the small sample size prevented estimation in each of the three areas. Spring smallmouth bass estimates were calculated for areas B and C but high water and turbidity prevented sampling area A. Fall estimates of smallmouth populations were possible for areas B and C but not for area A, where lowered water levels resulted in the capture of only 48 specimens. By combining areas A and B as one section and summing the estimate with that from area C, a fall smallmouth bass population estimate for the entire reservoir was obtained. A spring estimate was also computed for the entire reservoir by treating the right pelvic fin clipped smallmouth bass, marked in the spring, as recaptures during the fall.

Spring smallmouth bass population (number) and standing crop (biomass) estimates for age-2 and older fish in areas B and C are presented in Table 14. During this time there were twice the number of fish estimated in area C, 4063, as in area B, 2048. Even though standing crop estimates were 30% larger in area C than B, confidence intervals overlapped, as the average weight of individual fish was comparatively greater in area B (Table 34).

The fall population of age-2 and older smallmouth bass (Table 15) in area C, 2474 fish, was 39% smaller than the spring population. The standing crop of this group of fish increased 32% from spring to fall, from 240 to 316 kg. The fall population of age-2 and older smallmouth bass in area B, 4895 fish, represented an increase of 139% over the spring population while the standing crop increased

TABLE 14. POPULATION AND STANDING CROP ESTIMATES FOR AGE-2 AND OLDER SMALLMOUTH BASS IN AREAS B AND C DURING THE SPRING OF 1976. NUMBERS ARE EXPRESSED AS A FUNCTION OF SHORELINE LENGTH AND SURFACE AREA AT SPILLWAY ELEVATION (1043.7 m). THE 95% CONFIDENCE INTERVALS ARE IN PARENTHESIS.

	Area B	Area C
Population Estimate	2048 (1587 - 2887)	4063 (3585 - 4688)
Number/km of Shoreline	115 (89 - 162)	223 (197 - 258)
Number/hectare	5.2 (4.0 - 7.3)	12.8 (11.3 - 14.7)
Standing Crop Estimate	172 (134 - 243)	240 (212 - 277)
kg/km of Shoreline	9.7 (7.5 - 13.7)	13.2 (11.6 - 15.2)
kg/hectare	0.4 (0.3 - 0.6)	0.8 (0.7 - 0.9)

by 470%, 172 to 982 kg. During the fall, area B had a 98% larger population and a 211% larger standing crop of age-2 and older smallmouth bass than did area C.

Fall population estimates of age-1 and older smallmouth bass in areas B and C are presented in Table 16. Area B had a 67% and 192% larger population and standing crop, respectively, than area C.

The spring estimate of age-2 and older smallmouth bass for the entire Tongue River Reservoir was 13,549 fish (Table 33). The fall

TABLE 15. POPULATION AND STANDING CROP ESTIMATES FOR AGE-2 AND OLDER SMALLMOUTH BASS IN AREAS B AND C DURING THE FALL OF 1976. NUMBERS ARE EXPRESSED AS A FUNCTION OF SHORELINE LENGTH AND SURFACE AREA AT SPRING (1043.7 m) AND FALL (1039.4 m) SURFACE ELEVATIONS. THE 95% CONFIDENCE INTERVALS ARE IN PARENTHESIS.

	Area B	Area C
Population Estimate	4895 (3873 - 5917)	2474 (1959 - 2989)
Number/km of Shoreline Spring Elevation	275 (218 - 332)	136 (108 - 164)
Fall Elevation	392 (310 - 473)	169 (134 - 205)
Number/hectare Spring Elevation	12.4 (9.8 - 15.0)	7.9 (6.2 - 9.4)
Fall Elevation	19.6 (15.5 - 23.6)	9.7 (7.7 - 11.8)
Standing Crop Estimate	982 (777 - 1187)	316 (250 - 382)
kg/km of Shoreline Spring Elevation	55 (44 - 67)	17 (14 - 21)
Fall Elevation	79 (62 - 95)	24 (19 - 29)
kg/hectare Spring Elevation	2.5 (2.0 - 3.0)	1.0 (0.8 - 1.2)
Fall Elevation	3.9 (3.1 - 4.7)	1.2 (1.0 - 1.5)

TABLE 16. POPULATION AND STANDING CROP ESTIMATES FOR AGE-1 AND OLDER SMALLMOUTH BASS DURING THE FALL OF 1976. NUMBERS ARE EXPRESSED AS A FUNCTION OF SHORELINE LENGTH AND SURFACE AREA AT SPRING (1043.7 m) AND FALL (1039.4 m) ELEVATIONS. THE 95% CONFIDENCE INTERVALS ARE IN PARENTHESIS.

	Area B	Area C
Population Estimate	5537 (4406 - 6668)	3323 (2644 - 3996)
Number/km of Shoreline		
Spring Elevation	311 (248 - 375)	183 (145 - 220)
Fall Elevation	443 (352 - 533)	228 (181 - 274)
Number/hectare		
Spring Elevation	14.0 (11.2 - 16.9)	10.4 (8.3 - 12.6)
Fall Elevation	22.1 (17.6 - 26.6)	13.1 (10.4 - 15.7)
Standing Crop Estimate	1015 (808 - 1222)	348 (277 - 418)
kg/km of Shoreline		
Spring Elevation	57.0 (45.4 - 68.7)	19.1 (15.2 - 23.0)
Fall Elevation	81.2 (64.6 - 97.8)	23.8 (19.0 - 28.6)
kg/hectare		
Spring Elevation	2.57 (2.05 - 3.10)	1.09 (0.87 - 1.31)
Fall Elevation	4.05 (3.23 - 4.88)	1.37 (1.09 - 1.65)

TABLE 17. POPULATION AND STANDING CROP ESTIMATES FOR AGE-1 AND OLDER BLACK BASS IN THE ENTIRE TONGUE RIVER RESERVOIR DURING THE FALL OF 1976. NUMBERS ARE EXPRESSED AS A FUNCTION OF SHORELINE LENGTH AND SURFACE AREA AT SPRING (1043.7 m) AND FALL (1039.4 m) ELEVATIONS. THE 95% CONFIDENCE INTERVALS ARE IN PARENTHESIS.

	Smallmouth Bass	Largemouth Bass
Population Estimate	9203 (7200 - 11206)	2296 (1282 - 3310)
Number/km of Shoreline		
Spring Elevation	154 (121 - 188)	39 (22 - 56)
Fall Elevation	229 (179 - 279)	57 (32 - 82)
Number/hectare		
Spring Elevation	7.2 (5.6 - 8.8)	1.8 (1.0 - 2.6)
Fall Elevation	13.0 (10.1 - 15.8)	3.2 (1.8 - 4.7)
Standing Crop Estimate	1443 (1129 - 1756)	272 (152 - 392)
kg/km of Shoreline		
Spring Elevation	24.2 (18.9 - 29.5)	4.6 (2.5 - 6.6)
Fall Elevation	37.0 (28.1 - 43.7)	6.8 (3.8 - 9.8)
kg/hectare		
Spring Elevation	1.13 (0.88 - 1.38)	0.21 (0.12 - 0.31)
Fall Elevation	2.03 (1.59 - 2.47)	0.38 (0.21 - 0.55)

estimate of age-2 and older fish, 7695 (Table 32), represented a decrease of 43.2%.

Age-1 and older fall smallmouth and largemouth bass population and standing crop estimates for the entire Tongue River Reservoir are presented in Table 17. The estimated 9023 smallmouth bass was 80% of the total black bass population while largemouth bass, estimated at 2296, comprised the other 20%. The smallmouth bass standing crop, 1443 kg, was 84% of the total black bass standing crop while the largemouth bass standing crop, 272 kg, was responsible for the other 16%. Of the total number of largemouth bass captured during the fall 29, 45, and 26% were collected in areas A, B and C, respectively.

Age Structure

Population

Age structures of fall smallmouth and largemouth bass populations are quite different (Table 18). The largemouth population was predominated by age-1 fish, 84.6%, while age-1 smallmouth bass comprised only 16.4% of the population. Two year old fish comprised 72.8% of the smallmouth population and only 8.8% of the largemouth population. The number in each year class then decreased fairly consistently except for age-5 fish of both species which were more numerous than either age-4 or age-6 fish.

TABLE 18. AGE STRUCTURE OF BLACK BASS IN THE TONGUE RIVER RESERVOIR, FALL 1976.

	Smallmouth Bass						Largemouth Bass	
	Area B		Area C		Entire Reservoir		Entire Reservoir	
Age	No.	%	No.	%	No.	%	No.	%
1	642	11.6	849	25.5	1508	16.4	1954	84.6
2	4157	75.1	2288	68.9	6700	72.8	199	8.8
3	615	11.1	160	4.8	818	8.9	89	3.9
4	48	0.9	9	0.3	62	0.7	18	0.8
5	62	1.3	15	0.5	98	1.1	33	1.4
6	13	0.1	2	0.1	17	0.2	6	0.3
7	--	---	--	---	--	---	6	0.3
Total	5537		3323		9203		2296	

TABLE 19. AGE STRUCTURE OF SPRING AND FALL SMALLMOUTH BASS POPULATIONS EXCLUDING AGE-1 FISH.

	Spring				Fall			
	Area B		Area C		Area B		Area C	
Age	No.	%	No.	%	No.	%	No.	%
2	1793	84.9	3508	86.3	4157	84.9	2288	92.5
3	196	9.6	422	10.4	615	12.6	160	6.5
4	63	3.0	66	1.6	48	1.0	9	0.4
5	35	1.7	58	1.4	62	1.3	15	0.6
6	15	0.7	9	0.2	13	0.3	2	0.1
Total	2048		4063		4895		2474	

The age structures of age-2 and older smallmouth bass populations are quite similar between spring and fall and between areas B and C. The numbers of fish in each age class in areas B and C varied according to the population changes during the spring and fall. In the spring, area C had more fish in each age class, except age-6, than area B, while during the fall area B had more fish in all age-2 and older age classes (Table 19). It appears that greater recruitment is occurring in area C than B as age-1 smallmouth bass were more numerous in this area during the fall (Table 18).

Standing Crop

The smallmouth bass fall standing crop was dominated by age-2 fish, which made up 70.0% of the total. Age-3 fish were the second largest contributor, comprising 16.3% of the total smallmouth standing crop. Five and one year old fish had the third and fourth largest standing crop, respectively (Table 20).

Age-1 and age-2 fish made up 54.1% of the largemouth bass standing crop in the fall. Age-1 fish comprised 27.4% of the standing crop due to their sheer dominance in the population. The next largest contributors to the standing crop were age-2 and age-3 fish (Table 20).

The standing crop age structure of age-2 and older smallmouth bass demonstrated similar trends between spring and fall. The

TABLE 20. BLACK BASS STANDING CROP ESTIMATES BY AGE, TONGUE RIVER RESERVOIR, FALL 1976.

	Smallmouth Bass						Largemouth Bass	
	Area B		Area C		Entire Reservoir		Entire Reservoir	
Age	Kg.	%	Kg.	%	Kg.	%	Kg.	%
1	33	3.2	32	9.1	65	4.5	74	27.3
2	704	69.4	259	74.6	1009	70.0	73	26.7
3	184	18.1	39	11.2	235	16.3	46	17.1
4	27	2.7	6	1.7	37	2.6	17	6.2
5	50	4.9	10	2.9	76	5.3	41	15.0
6	17	1.7	2	0.2	19	1.4	9	3.5
7	--	---	--	---	--	---	11	4.2
Total	1015		348		1443		272	

TABLE 21. AGE STRUCTURE OF SPRING AND FALL STANDING CROPS OF SMALLMOUTH BASS EXCLUDING AGE-1 FISH.

	Spring				Fall			
	Area B		Area C		Area B		Area C	
Age	Kg.	%	Kg.	%	Kg.	%	Kg.	%
2	95	55.3	154	64.1	704	71.7	259	82.0
3	27	15.6	41	17.1	184	18.7	39	12.3
4	23	13.5	16	6.8	27	2.7	6	1.9
5	16	9.1	22	9.0	50	5.1	10	3.2
6	11	6.5	7	3.1	17	1.7	2	0.6
Total	172		240		982		316	

greatest difference appeared to be in the age-2 fish, which increased in the fall standing crop by 16.4 and 17.9% in areas B and C, respectively (Table 21). This occurred in area B despite the fact age-2 fish comprised the same proportion of the population from spring to fall (Table 19).

Mortality

Total summer mortality of age-2 and older smallmouth bass, estimated from a decrease in right pelvic fin clipped fish, was 39.7% (Table 35). This is similar to the 43.2% reduction from spring to fall in the population estimates of age-2 and older smallmouth bass for the entire reservoir (Tables 32 and 33).

Movement and Seasonal Population Changes

Smallmouth Bass

One of eight smallmouth bass tagged in the fall of 1975 and recaptured in the spring of 1976 demonstrated significant movement. It was recaptured 1.8 km south of the point of release in area B. This movement coincided with increasing water levels.

Only one of thirteen smallmouth bass demonstrated movement in areas B and C during the spring and summer of 1976 (Number 2 in Fig. 16). Area A was not efficiently sampled.

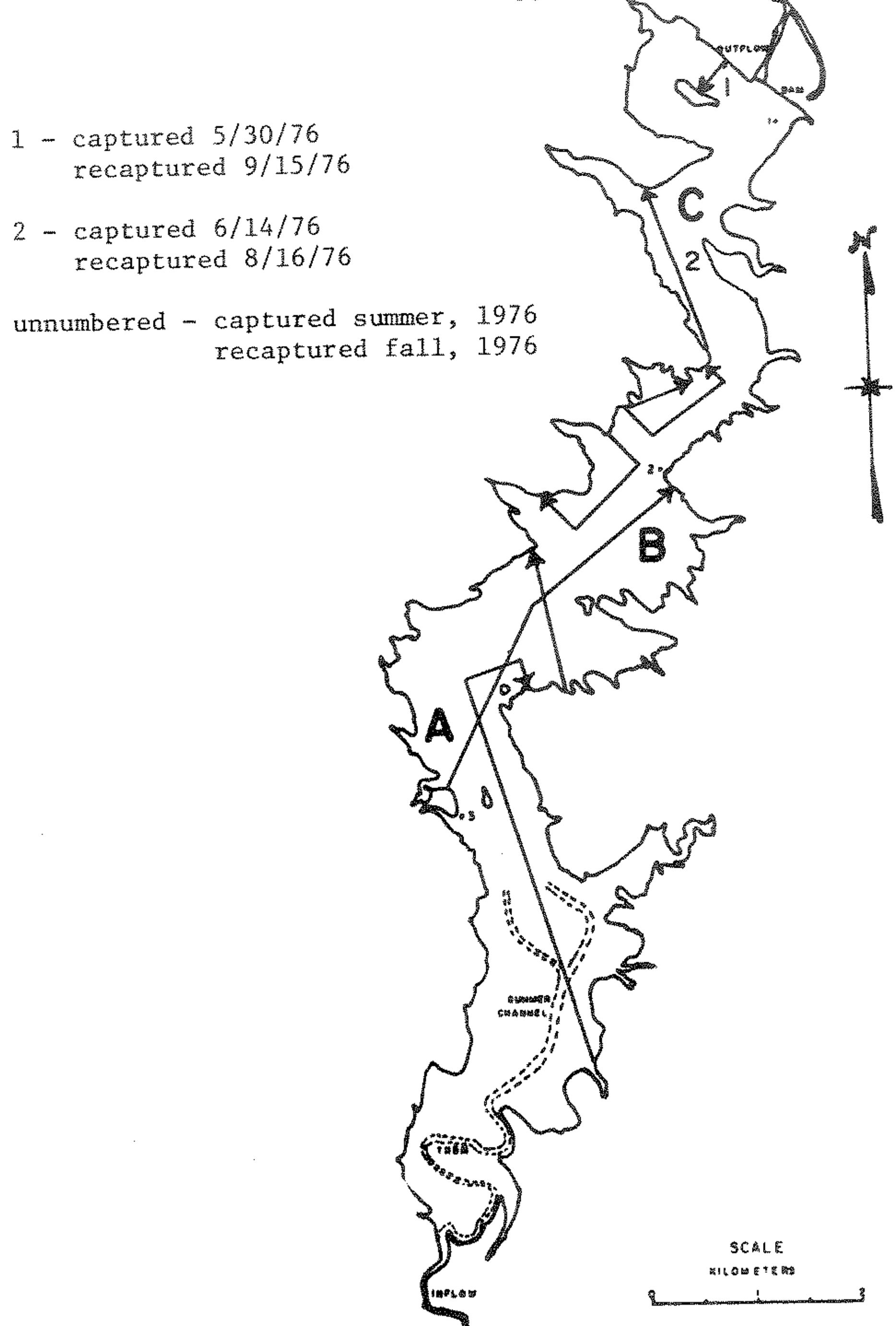

Figure 16. Movement of smallmouth bass marked in the spring or summer and recaptured during the summer or fall, 1976, Tongue River Reservoir.

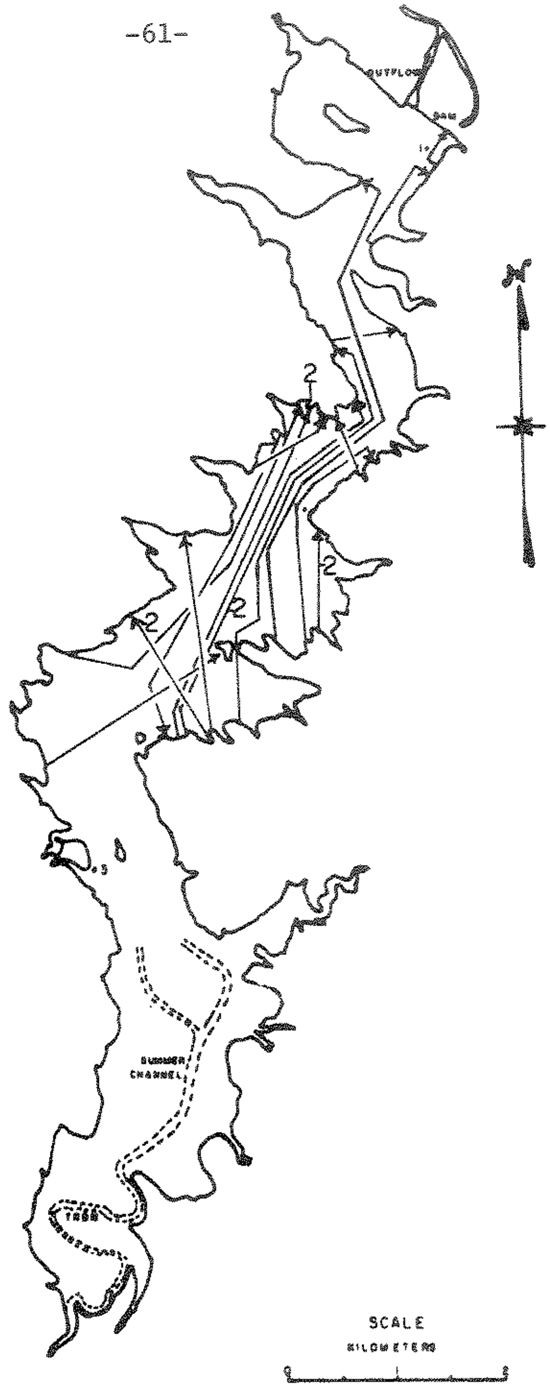

Figure 17. Movement of smallmouth bass marked and recaptured in the Tongue River Reservoir during the fall (8/30 - 9/16), 1976. Number indicates more than one fish moved in a similar direction.

Movement of smallmouth bass, recaptured during the fall of 1976, increased during this period, as 7 of 13 (54%) marked in the spring and summer (Fig. 16) and 20 of 61 (33%) marked in the fall (Fig. 17) demonstrated a detectable movement. Twenty-four moved northward toward the dam with declining water levels while three moved southward. Four of these smallmouth bass moved out of area A into area B and two moved from area B into C. The rest of the movement occurred within area B (Figs. 16 and 17).

The maximum distance a smallmouth moved was 5.0 km. The mean detectable movement was 1.7 km. Overall, 80, 34 and 17% of the recaptured smallmouth bass showed a detectable movement in areas A, B and C, respectively. The sample size in each respective area was 5, 65, and 30.

The 139% increase in the age-2 and older smallmouth population from spring to fall in area B demonstrates that smallmouth bass were concentrating in this area (Tables 14 and 15). Tag returns (Figs. 16 and 17) and the small number of smallmouth bass collected in area A (48) during the fall suggest that smallmouth bass moved out of area A before sampling and were responsible for the increased population in area B. During the same period, the age-2 and older smallmouth population in area C decreased by 39% (Tables 14 and 15). As tag returns and growth differences did not indicate a large interchange of fish in area C with other areas, the decrease might be attributed to mortality.

The spring to fall distribution of right pelvic fin clipped fish suggests a slightly different movement pattern. During the spring and early summer 454 and 1097 age-2 and older smallmouth bass were marked in areas A and B combined and C, respectively. During the fall, the estimated number of right pelvic fin clipped fish in areas A and B combined, 538, increased while the number in area C, 398, significantly decreased (Table 35). Apparently more marked fish moved into area B from C than had died or migrated out of area B. Assuming equal mortality in all areas of the reservoir and equal mortality between marked and unmarked fish, the spring to fall survival of age-2 and older fish was 0.603 (Table 35). An estimated movement of 980 fish out of area C and into area A and B combined, 40.0% of the spring area C smallmouth population after mortality, would account for the increased number of marked fish in area A and B combined. This was calculated by allowing for mortality and assuming similar behavior between marked and unmarked fish. This results in a population of 1469 age-2 and older fish in area C or 1005 less than the fall estimate. When the spring estimate for area B, minus mortality, is summed with the 980 fish from area C the result is 2216 fish, 2679 less than the fall estimate of area

A and B combined. This suggests 3684 smallmouth bass were added to the fall population from area A. When accounting for mortality, 6105 fish is the estimate for the number of age-2 and older smallmouth bass in area A during the spring. This compares to the estimated 7438 fish in area A during the spring which was computed by subtracting the spring estimates for areas B and C from the spring estimate for the entire reservoir. This figure may be slightly high because the spring smallmouth population in area B may have been underestimated due to the small number of recaptures in the larger length interval (Table 29). Nevertheless, apparently sufficient numbers of smallmouth bass were present in area A during the spring to account for the increase in the fall population.

In summary, the distribution of recaptured marked fish indicates a net movement from spring to fall of 1005 and 2679 smallmouth bass out of area A and into areas C and B, respectively (a small percent of 2679 fish remained in area A, Table 33). During the same period a net 980 fish moved out of area C and into area B. This, along with a 39.7% mortality, accounts for the 139% increased population in area B and the 39% reduced population in area C.

It is not known why tag returns did not indicate movement out of area C, although it may be due to the small sample size. The slower growth in area C was still evident despite a 68% population increase due to fish moving into area C. Perhaps this masked an even greater growth difference between areas since the difference in mean length at annulus for age-2 and older fish between area C and B decreased from 19 mm in the spring to 15 mm in the fall (Table 34). One would expect growth differences to increase as the fish got older.

Largemouth Bass

Largemouth bass demonstrated a similar northward movement during the fall. Of six recaptured fish, three moved out of area A into B and two moved from B into C. The largest movement was 5.5 km. The mean detectable movement was 2.2 km.

Tag Loss

During 1975, 103 smallmouth and 14 largemouth bass were tagged with Floy anchor tags. In the spring and summer of 1976, 225 smallmouth and 22 largemouth bass were tagged. During the fall marking run, 499 smallmouth and 29 largemouth bass were tagged.

Tags were placed midway below the soft dorsal fin during 1975 and the fall of 1976 while they were placed directly behind the soft dorsal in the spring and early summer of 1976. Between 1975 and the spring of 1976 three of eight (38%) smallmouth bass had lost the Floy tags. Of 26 fish, tagged in the spring of 1976 and recaptured in the summer, 58% had shed tags. It was estimated 63% had shed their tags from spring to fall in 1976 (n = 62). During the two week period in the fall of 1976, 13% of the 40 recaptured smallmouths lost tags.

One of the two largemouth bass tagged in 1975 and recaptured one year later lost its tag. A tag loss of 33% was estimated from spring to fall in 1976 (n = 6) and 0% during the two week period in the fall (n = 6).

DISCUSSION

Reproductive Success

Distribution of fingerlings, as evident from results of shoreline seining, suggest that factors limiting reproductive success of both smallmouth and largemouth bass within the Tongue River Reservoir are suitable spawning substrate and turbidity. Latta (1963) found most smallmouth nests on gravel and rubble with a few on a combination of sand and rootlets of aquatic vegetation. He observed that none of the three nests located in silt and detritus over gravel were successful after carp activity in the cove increased turbidity. Smallmouth bass chose sand or gravel nesting sites in Tadenac Lake, Ontario and when adequate gravel was not available, lined nests with woody debris or broken clam shells (Turner and MacCrimmon 1970). A rubble substrate was preferred in Iowa streams but nests over bedrock were not uncommon (Cleary 1956). Walters (1974) suggested that unsuccessful smallmouth bass reproduction in a pond environment was related to lack of suitable substrate.

Smallmouth fingerlings seemed associated with the presence of preferred spawning substrate in the Tongue River Reservoir. They were most abundant in area C, least abundant in area A, and intermediate in area B (Tables 3 and 5). The absence of smallmouth fingerlings in area A cannot be totally related to lack of suitable substrate because 14.4% of the shoreline in this area is dominated by pebbles or cobbles. At least one other factor such as turbidity must be involved.

Abundance of largemouth fingerlings followed the same trends between areas as smallmouth bass, however, largemouth fingerlings were present in area A (Table 5). Largemouth bass appear to reproduce in a wider variety of conditions than smallmouth bass. Walters (1974) found largemouth bass fingerlings in 14 of 15 ponds while smallmouth bass reproduced in only 7 of 15. Kramer and Smith (1962) found largemouth bass spawning on roots of aquatic vegetation and on needlerush over sand while Miller and Kramer (1971) noted a preference for sandstone rubble.

There was an inverse relationship between abundance of black bass fingerlings and turbidity in the Tongue River Reservoir (Fig. 3 and Table 5). During the spawning period in 1976, approximately the last week in May, the turbidity was 14, 9 and 5 JTU in areas A, B and C, respectively (Fig. 3). Buck (1956) demonstrated a similar inverse relationship between levels of turbidity in farm ponds and reproductive success of largemouth bass. Largemouths reproduced in 7 of 12 clear ponds, 4 of 12 intermediate ponds and 0 of 9 muddy ponds. Cleary (1956) noted that streams which remained turbid for long periods of time seldom produced smallmouth fingerlings or good smallmouth bass fishing. Area A remained turbid throughout the year while turbidities in B and C decreased from spring to fall (Fig. 3).

Since all three areas were subjected to similar temperature regimes, its effect on reproductive success was probably similar in each area. As the few nests observed during 1975 were in 1.0 to 1.8 meters of water, the direct destruction of nests by wind was probably not a large influence on the abundance of fingerlings in each area. The indirect effect of wind increasing turbidities, especially in area A, is probably a more important factor.

Largemouth bass fingerlings were 60 and 125% more abundant than smallmouth fingerlings in areas B and C, respectively, if seining was representative (Table 5). Likewise, largemouth fingerlings were 75 and 205% more abundant than smallmouths for the entire reservoir in 1975 and 1976, respectively (Table 6), despite a 181% larger smallmouth spawning population (Table 18). The relative spawning population was assumed to be age-4 and older bass collected during the fall of 1976. Back calculated lengths of these fish (Table 10) were within the length range of mature female smallmouth (Latta 1963) and largemouth bass (Kramer and Smith 1962). The standing crop of the sexually mature smallmouths was 69% greater than largemouths (Table 20). Walters (1974) found a greater number of largemouth than smallmouth fingerlings in all 5 ponds in which both species reproduced and related this to a lower survival rate of young smallmouth bass rather than a greater reproductive potential of the largemouth bass. Because the largemouth spawning population in the Tongue River Reservoir is composed of slightly older and larger fish than the smallmouth population, the mean fecundity of the individual spawning largemouth might be greater than the average spawning smallmouth. Coomer (1976) demonstrated a direct relationship between the total length and fecundity of three species of black bass. Also, largemouth bass appeared to possess more eggs than did smallmouth bass of the same length. Fajen (1975) felt that largemouth bass were more fecund than any of the other black basses yet studied. Other possible factors affecting the observed proportion of largemouth to smallmouth fingerlings in the Tongue River Reservoir are a higher smallmouth egg or fry mortality, a larger percent of female smallmouth bass not spawning at all, or a lower seining efficiency for smallmouth bass fingerlings.

The most easily controlled factor, which may limit bass reproduction in reservoirs, is water level fluctuation. An untimely drawdown can expose the nest and eggs or increase the effects of wind. Neves (1975) found that a decreased water level was the primary cause for lower nest success during 1971 in South Branch Lake, Maine. Latta (1963), Turner and MacCrimmon (1970), Kramer and Smith (1962), and Miller and Kramer (1971) have shown that black bass spawn when water temperatures reach 15 to 18 C. During both study years, these temperatures occurred when water levels were either rising or stable and created favorable spawning conditions in the Tongue River Reservoir (Figs. 5 and 6).

Bass spawned the last week of May in 1976 and the third week of June in 1975. The 3-week difference was due to a cold late spring which delayed warming of the reservoir in 1975 (Fig. 6). The water temperature continued to increase throughout the summer in 1975 while during June 1976 there was a 4 C decrease in water temperature. The temperature never dropped below 16 C, however. Forney (1972), Fry and Watt (1957), Kramer and Smith (1962) and others have noted that higher water temperatures after spawning are directly related to greater survival of eggs and fry. This may explain the greater number of smallmouth fry collected in 1975 if seining was representative. However, numbers of largemouth bass were similar both years. Kramer and Smith (1962) noted that a sharp drop in water temperature followed by a rise is a stimulus for repeated spawning. It is believed smallmouth bass spawned during only one period in 1975 and 1976, as a definite unimodel length frequency was obtained. Although the length frequency for largemouth bass was not as distinct, no bimodel trend was evident either year. Either too much time had elapsed between spawning and the decline in water temperature in 1976 to allow repeated spawning or the temperature decline was insufficient.

Age and Growth

Smallmouth bass annuli formed earlier in 1976 than 1975 and coincided with the earlier reservoir warming in 1976 (Fig. 6). Younger bass formed annuli first which may be due to differences in growth patterns corresponding to stage of maturity. Latta (1963) made similar observations.

Growth (total length at annulus) of smallmouth and largemouth bass in the Tongue River Reservoir is favorable for a northern lake (Tables 22 and 23). Smith and Moe (1944) demonstrated superior smallmouth bass growth in Minnesota while the rate of growth in Wisconsin (Bennett 1938), Maine (Watson 1955) and Michigan (Latta 1963) was slower. Largemouth bass growth in the Tongue River Reservoir was greater than citings for Wisconsin (Bennett 1937), Minnesota (Kuehn 1949) and Montana (Brown 1952, Brown and Logan 1960). Lengths of older largemouth bass in this study were comparable to those reported by Tharratt (1966) in California.

TABLE 22. GROWTH OF SMALLMOUTH BASS IN VARIOUS WATERS.

Locality	Length in mm at each annulus							
	1	2	3	4	5	6	7	8
Lake Michigan Latta 1963	99	160	206	246	292	335	371	401
Big Lake, Maine Watson 1955	76	147	218	279	330	376	409	434
Wisconsin Bennett 1938	61	145	224	290	340	376	404	430
Tongue River Reservoir Montana 1976	89	144	213	312	345	401		
Minnesota Smith and Moe 1944	99	185	277	310	462	521		
Norris Reservoir Tennessee Stroud 1948	117	259	358	411	445	457	472	

TABLE 23. GROWTH OF LARGEMOUTH BASS IN VARIOUS WATERS.

Locality	Length in mm at each annulus								
	1	2	3	4	5	6	7	8	9
Western Montana Ponds Brown and Logan 1960	48	97	145	196	251	292	328	351	373
Montana Ranch Ponds Brown 1952	53	163	261	274					
Minnesota Kuehn 1949	89	170	236	292	333	366	414	447	460
Wisconsin Bennett 1937	84	188	267	318	356	384	414	442	460
Tongue River Reservoir Montana 1976	81	189	264	354	395	444	459		
California Tharratt 1966	142	264	325	368	401	432			
Tennessee Stroud 1948	175	315	373	409	445	490	528		

The length-weight relationship (Table 26 and Fig. 12) for smallmouth bass compared favorably with those from Clear Lake, Wisconsin (Marinac 1976) and Tadenac Lake, Ontario (Turner and MacCrimmon 1970). Largemouth bass in the Tongue River Reservoir were heavier at similar lengths compared to studies from Beaver and Bull Shoals Reservoirs, Missouri (Bryant and Houser 1971) and Gladstone Lake, Minnesota (Maloney, Schupp and Scidmore 1962).

Excellent growth of black bass in the Tongue River Reservoir may be correlated to favorable nutrient levels, low population densities, fluctuating water levels and, for smallmouth bass, recent exploitation of a new habitat. Whalen and Leathe (1976), studying primary and secondary production, concluded that the Tongue River Reservoir is a moderately productive system. Cooper, Hidu, and Anderson (1963) observed that growth of largemouth bass increased when densities decreased while Heman, Campbell, and Redmond (1969) noticed that increased growth coincided with reservoir drawdown. Lambou (1959) found largemouth bass in excellent condition in Louisiana back-water lakes which flood every spring and provide expanded habitat for increasing fish populations.

Largemouth bass had a superior absolute growth rate, length-weight relationship, and condition value than smallmouth bass (Figs. 11, 12, 15 and Tables 10, 26, 28). Chance *et al.* (1975) and Stroud

(1948) noted a similar growth pattern for both species in Norris Reservoir.

Forney (1961) found subpopulations of smallmouth bass in Oneida Lake with small but consistent growth differences. In this study smallmouth bass growth, length-weight relationship and condition were most favorable in areas A and B and least in area C (Figs. 8, 9, 13 and Tables 7, 26, 34). Primary production was similar in each area (Whalen and Leathe 1976) and cannot be correlated to growth. Availability of forage fish may be responsible for the differences in growth between areas, as area A had the highest density of forage-size fish, 64.6 fish per haul, and C the lowest, 46.7 fish per haul (Table 5). As summer progressed, surface area in areas A and B decreased faster than in area C, concentrating fish more in these areas (Table 2). Areas A and B had a larger percent of low gradient beaches which contain a larger concentration of forage-size fish than cliff shoreline common in area C.

Largemouth bass did not show the same growth trend between areas (Fig. 8 and Table 9) but the length-weight relationship (Fig. 10 and Table 26) and condition values (Fig. 14 and Table 27) were more favorable for largemouths collected in areas A and B than C. Why growth did not follow the same pattern is not known but may be due to sampling error (sample size) or to a greater mobility of largemouth bass between areas.

Differences in turbidity levels in the Tongue River Reservoir have no apparent adverse effect on the growth or condition of age-1 and older black bass. Other factors such as predator density or prey availability may mask any effects of turbidity. Buck (1956) and Hastings and Cross (1962) reported lower growth rates of largemouth bass in waters of higher turbidities.

Fingerling growth did not appear to be adversely affected by turbidity when comparing area B and C (Tables 11 and 12). Although sample size in area A was inadequate, the smallest largemouth fingerlings were collected in this area. Repeated or late nesting in area A may account for this observation.

Smallmouth bass fingerlings were longer in 1975 than 1976 (Table 11) probably because the reservoir reached spawning temperature, 15 to 18 C, two to three weeks earlier in 1976 than 1975 (Fig. 6). The means of the largest sample of largemouth fingerlings during similar time periods were significantly longer in 1976 than 1975 while other means were not significantly different (Table 12). Kramer and Smith (1960) correlated total length of largemouth fingerlings at the end of the growing season to the mean daily water temperature.

Largemouth bass fingerlings were slightly but significantly longer than smallmouth fingerlings in 1975 while smallmouth fingerlings were longer in 1976 (Table 13). Smallmouths may have spawned earlier than largemouths in 1976 and approximately the same time in 1975. Rawstron and Hashagen (1972) noted that smallmouths spawned earlier in Merle Collins Reservoir. The reservoir warmed more slowly after reaching 15 C in 1976 than 1975, thus, the time between favorable smallmouth and largemouth spawning temperatures may have been greater in 1976 than 1975 (Fig. 6).

Population and Standing Crop

Population (number) and standing crop (biomass) estimates are difficult to compare between studies because: (1) estimates refer to different size ranges (and ages) of fish, (2) for exploited stocks the estimates are not of the stock at carrying capacity but carrying capacity minus harvest, and (3) area used to calculate number or weight per unit area may contain different proportions of habitat (Paragamian and Coble 1975). The difficulty of comparing values is evident in Tables 24 and 25. Population and standing crop values in the Tongue River Reservoir are best expressed by length of shoreline, because the reservoir basin is heavily silted and habitat is limited to the shoreline edges. On a total area basis, the smallmouth bass standing crop is average compared to 45 United States reservoirs (Jenkins 1975) while largemouth bass standing crop was only 3% of average (Tables 24 and 25).

TABLE 24. POPULATION (number/ha) AND STANDING CROP (kg/ha) ESTIMATES OF SMALLMOUTH BASS FROM VARIOUS WATERS.

Location	Minimum Size or Age in Estimate	Population Estimate	Standing Crop	Citation
Red Cedar River, WI	Age 1	132	15.0	Paragamian and Coble 1975
Plover River, WI	Age 1	118	17.5	Paragamian and Coble 1975
Clear Lake, WI	225 mm	8.0-9.5	1.0-1.2	Marinac 1976
South Branch Lake, ME	255 mm	2.6	1.6-2.7	Bandolin 1973
Bull Shoals Lake, MO	Age 0[a]	22.4-24.7	1.3-1.6	Rainwater and Houser 1975
45 Reservoirs	Age 0[a]	---	1.4	Jenkins 1975
Tongue River Reservoir	Age 1	7.2-13.0	1.1-2.0	This Study

[a]Minimum age assumed (cove poisoning).

TABLE 25. POPULATION (number/ha) AND STANDING CROP (kg/ha) ESTIMATES OF LARGEMOUTH BASS FROM VARIOUS WATERS.

Location	Minimum Size or Age In Estimate	Population Estimate	Standing Crop	Citation
Gladstone Lake, MI	152 mm	13.5-25.8	10.0-16.1	Maloney *et al.* 1962
Browns Lake, WI	152 mm	62.2	37.3	Mraz and Threinen 1975
Beaver Lake, MO	Age 0[a]	132-337	4.0-14.3	Rainwater and Houser 1975
Bull Shoals Lake, MO	Age 0[a]	299-606	7.5-11.1	Rainwater and Houser 1975
Lake Carl Blackwell, OK	Age 1	1.7	1.4	Zweiacker and Brown 1971
170 Reservoirs	Age 0[a]	----	10.0	Jenkins 1975
Tongue River Reservoir	Age 1	1.8-3.2	0.2-0.4	This Study

[a]Minimum age assumed (cove poisoning).

Although largemouth bass had five to six years to establish before smallmouth bass entered the reservoir, smallmouths now dominate the bass population. The fall black bass population in 1976 was 80% smallmouth and 20% largemouth bass (Table 17). If only age-3 and older fish are compared, the ages most harvested by fishermen, the fall black bass population was 86% smallmouth bass (Table 18). The fisherman catch composition reflected this abundance, as 72 and 94% of the bass creeled in 1975 and 1976, respectively, were smallmouths (Elser unpublished data). Walters (1974) and Bennett and Childers (1957) have noted poor survival of smallmouth bass in a pond environment with largemouth bass and green sunfish. Largemouth, spotted and smallmouth bass made up 66, 22 and 12% of the black bass standing crop, respectively, in 26 reservoirs which contained all three species (Jenkins 1975). In the Tongue River Reservoir, smallmouth bass comprised 84% of the black bass fall standing crop and largemouth bass the other 16% (Table 17).

Bass habitat in the Tongue River Reservoir more closely resembles smallmouth bass lakes, described by Belding (1926) and Hubbs and Bailey (1938), than largemouth bass lakes (Carlander 1975). Smallmouth bass lakes were characterized by a surface area over 40 hectares, clear water, scanty vegetation, large areas of rock and gravel, a depth not less than 6 to 9 meters and moderate summer temperature. The Tongue River Reservoir meets these specifications in areas B and C. Area A does not meet the criteria for water clarity and, except during spring and early summer, depth.

Largemouth habitat in northern lakes is typified by shallow weedy areas. Due to extreme water level fluctuations, aquatic vegetation is not present in the Tongue River Reservoir and terrestrial vegetation is flooded only for a short period in early summer. Therefore, suitable habitat may be limiting adult largemouth populations. Rideout and Oatis (1975) noted a similar change in species composition in Quabbin Reservoir, a fluctuating impoundment in Massachusetts. During the first ten years of impoundment, largemouth bass dominated the catch while smallmouth bass dominated the creel in the last ten years. They attributed this change to smallmouth bass exploiting the cool, clear water and rubble shoreline habitat and to a greater tolerance of smallmouth bass to water level fluctuations. Rawstron and Hashagen (1972) proposed that competition between smallmouth and largemouth bass during the first year of life may have increased relative abundance of smallmouth bass in Merle Collins Reservoir, an irrigation impoundment.

The 1974 year class comprised 73% of the 1976 fall smallmouth population, while the same year class of largemouth bass made up only 8.8% of their population (Table 18). Fluctuations in year class formation have been attributed to environmental conditions such as wind, water temperature, water level, and food, during egg, fry and fingerling stages (Forney 1972, Latta 1963, Summerfelt 1975, Kramer and Smith 1962, von Geldron and Mitchell 1975). It can be assumed that smallmouth bass produced a large fingerling crop during 1974. However, largemouth bass comprised 81% of the 628 fingerlings seined in 1974 (Elser unpublished data). This suggests largemouth bass had a much higher mortality rate than smallmouth bass between the fingerling stage and age-1, as largemouth bass comprised only 11% of the yearlings seined during 1975 (Table 6). The 1976 fall population estimate of age-2 bass, comprised of 3% largemouth and 97% smallmouth bass (Table 18), further supports the likelihood of a high first year mortality. This may be a partial explanation for the dominance of all smallmouth bass age classes, except age-1, over largemouth bass. Even though fry and fingerling production was high in 1974, limited habitat for yearling largemouth bass may have prevented the population from expanding. Survival of both largemouth and smallmouth fingerlings from the fall of 1975 to the fall of 1976 was comparable, as 36% of the fingerlings seined in 1975 were smallmouth bass and 31% of yearlings seined and 44% of the fall population estimate of yearlings in 1976 were smallmouth bass (Tables 6 and 18).

It is possible that largemouth bass fingerling production in 1975 did not greatly exceed the concurrent carrying capacity for yearlings. If so, mortality factors may have operated equally for both species. The mortality pattern for the 1973 year class was similar to the 1974 year class. The 461 fingerlings seined during 1973 were 88% largemouth and 12% smallmouth bass (Elser unpublished data) while the 1973 year class in the 1976 fall population was 10% largemouth and 90% smallmouth bass (Table 18). A greater mortality of age-2 and older largemouth bass compared to smallmouth bass may also contribute to the dominance of smallmouth bass in the older bass population. Differential mortality could be determined by continuing to follow the 1975 and 1976 age classes in succeeding years.

Mortality

Total estimated summer mortality of age-2 and older smallmouth bass in the Tongue River Reservoir was 39.7%. In six studies cited by Coble (1975) the annual total mortality ranged from 43% to 66%. Clady (1977) believed most of the annual natural mortality of age-3 to age-4 bass occurred during the period of rapid growth (June through August). He observed a natural mortality of only 23.8% for smallmouth bass between August and June of the following year, while annual natural mortality was 60%. If total annual mortality of smallmouth bass in the Tongue River Reservoir falls within the range cited by Coble (1975), the pattern of higher summer than winter mortality would be similar to that found by Clady (1977).

Movement and Seasonal Population Changes

Smallmouth Bass

Fajen (1962) noted that smallmouth bass were less faithful to a particular home range in two Ozark streams, usually one pool, when shifting gravel threatened the security of the pool. The percent of tag returns showing a detectable movement, 80, 34 and 17% in areas A, B and C, respectively, suggest that movement in the Tongue River Reservoir is related to habitat stability. The reduction in surface area from spring to fall, 45, 30 and 20% in areas A, B and C, respectively, demonstrates that fall drawdown reduces habitat most in area A and least in area C (Table 2). Also, much of the remaining surface area in area A was shallow mud flats not suitable for smallmouth bass.

Population estimates and distribution of fin clipped fish indicates that not only does water level reduction result in movement due to elimination of habitat (area A) but also causes movement in a section with habitat less effected by water levels (area C).

Possible reasons for a net movement of fish out of area C and into area B are a greater competition for food due to a lower forage fish density (and the smaller percent of shoreline areas where forage fish congregate) and habitat selection for areas of greater forage availability. Habitat selection for a suitable substrate for the winter dormancy period may also be involved. Munther (1970) observed that smallmouth bass preferred a broken rock substrate in the Middle Snake River. Smallmouth bass rested on or below the rock substrate at night but did not use a rounded cobblestone or sand substrate. High concentrations of smallmouth bass over a rock substrate were observed in the Tongue River Reservoir, especially during the fall. In the lab Munther saw that most smallmouth bass stayed below the rock substrate when water temperatures were 6.7 to 7.8 C. Munther also noted that smallmouth bass formed fall and winter concentrations in pools at least 3.6 meters deep. Area B in the Tongue River Reservoir has large amounts of broken rock substrate in the deeper water which perhaps is being preferentially selected for in the fall.

Latta (1963) and Forney (1961) observed that smallmouth bass generally restrict their range to a limited area of shoreline. Fraser (1955) noted that 78% of the smallmouth bass recaptured during the same season were within 0.8 km of their release point and during the second season 72% were recaptured within 3.2 km of release. He did observe an extensive local movement of up to 3.2 km and correlated this to a sudden inflow of a cold water mass. The total length of area C is less than 5 km so bass would be capable of moving that distance.

Largemouth Bass

Largemouth bass tag returns demonstrated a similar pattern as smallmouth bass. The greatest percent of movement was in areas A and B and least in C. Fall returns indicated a northward movement toward the dam coinciding with water level declines. Largemouth bass were collected in largest numbers in area B, indicating a concentration in this area.

Tag Loss

The high rate of Floy tag loss indicates that a reliable population estimate would not be obtained if no other mark was used. The tag would not suffice for even short term marking as 13% of the smallmouth bass shed tags in two weeks. Tags were retained better when placed below the soft dorsal than behind it.

CONCLUSIONS

Because on-going limnological studies of the Tongue River Reservoir have determined that mine effluent has no measurable effect on reservoir water quality (Whalen and Leathe 1976), it is unlikely that black bass reproduction, growth, and survival will be affected by present coal strip mining. Future analysis of bass populations can detect adverse effects of expanded strip mine operations.

Presently, black bass are of little importance to the total fishery in Montana and have received scant attention from fishery managers. As human populations increase with the expanding coal industry in eastern Montana, more pressure will be placed upon the warm water fishery and intensive fishery management may be required. Bass management in the Tongue River Reservoir should be directed primarily at smallmouth bass as the habitat appears particularly suited for this species. Water levels should not be allowed to decline during the spawning season. Reduced sediment loads (turbidity) would also enhance reproduction. Future creel and population studies would determine if restrictive fishing regulations are required.

SUMMARY

1. Reproductive success of black bass within the Tongue River Reservoir was limited by suitable spawning substrate and turbidity.

2. Largemouth fingerlings were more abundant than smallmouth fingerlings in 1976 despite a much larger smallmouth spawning population. Reasons for the observed relative abundance may be a greater fecundity of largemouth bass, greater survival of largemouth fingerlings, a high percent of female smallmouth bass not spawning or differential seining efficiency.

3. Seining results indicated smallmouth reproductive success was greater in 1975 while largemouth bass were equally represented both years.

4. Growth and length-weight relationships of both smallmouth and largemouth bass are excellent for a northern water. This may be related to favorable nutrient levels, low population densities, fluctuating water levels, and recent exploitation of new habitat.

5. Largemouth bass growth, length-weight relationships, and condition values were superior compared to smallmouth bass.

6. Growth, length-weight relationships, and condition values were superior for smallmouth bass in areas A and B compared to C. Growth of largemouth bass did not show the same trends but length-weight relationships and condition values did. These differences may be due to forage fish abundance and availability. Turbidity levels had no apparent effect on age-1 and older black bass growth in each area.

7. Black bass fingerling growth did not seem to be affected by differences in turbidity levles in areas B and C. Too few were collected in area A to determine trends in this area.

8. The fall smallmouth bass population and standing crop were average compared to other reservoirs and lakes while the largemouth bass population and standing crop were extremely low.

9. Although largemouth bass were introduced five to six years before the entrance of smallmouth bass, smallmouth bass comprised 80% of the fall bass population. This was reflected in the 1976 bass harvest which was 94% smallmouth bass.

10. Adult largemouth bass populations may be limited due to lack of habitat because the reservoir is more typical of a smallmouth bass lake. Seining data and population estimates suggest that

a much higher largemouth than smallmouth bass mortality rate between the fingerling and yearling stage may be responsible for the greater number of smallmouth than largemouth bass in all age-2 and older age classes. This is evident as largemouth bass dominated the fingerling catch in 1973 through 1976. A differential mortality for bass older than age-2 may also be involved.

11. Total summer mortality of smallmouth bass was 39.7% for fish age-2 and older.

12. Tag returns, spring and fall population estimates and distribution of marked fish indicate that smallmouth bass were concentrated in areas A and C in the spring. During the fall fish moved into area B from areas A and C. Movement out of area A was mandatory, as water level declines reduced smallmouth habitat. Movement from area C and into B may have been in response to forage fish availability and winter habitat selection. Limited data on largemouth bass suggested a similar distribution pattern.

APPENDIX

Modifications Required for Constructing
Confidence Intervals for Schumacher and Eschmeyer
Population Estimtes When Using Vincent's Method (1971)

Vincent's method (1971) for estimating population size involves computing Petersen estimtes for several total length intervals within the population ($\hat{N}_a$: where ^ indicates an estimate of the true value of the parameter). These subpopulation estimates are summed to obtain an estimate of the total population ($\hat{N}_T$). Likewise, subpopulation variances [var($\hat{N}_a$)] are summed to get a variance for the estimate of the total population [var($\hat{N}_T$)]. The Schumacher-Eschmeyer estimator, unlike the Petersen, calculates for 1/N, therefore, the variances cannot be summed. Point estimates for the total population were computed by inverting the subpopulation estimates ($1/\hat{N}_a \rightarrow \hat{N}_a$) and summing ($\hat{N}_T = \hat{N}_1 + \hat{N}_2 + \ldots . \hat{N}_K$: where K equals the number of subpopulation estimates). Assuming independence between the subpopulation estimates, the following relationship was used to convert the variance of $1/\hat{N}_a$ (from equations 3.13 and 3.14 in Ricker 1975) to the variance of $\hat{N}_a$ (formula 13.5.11 in Colquhoun 1971):

$$\frac{\mathrm{Var}(y/x)}{(U_y/U_x)^2} \simeq \frac{\sigma_y^2}{U_y^2} + \frac{\sigma_x^2}{U_x^2} - \frac{2\,\mathrm{Cov}(x,y)}{U_x U_y} \qquad (1)$$

where: any two variables x,y have means U_x, U_y and variances σ_x^2, σ_y^2.

When $1/\hat{N}_a$ is substituted for y/x and Var for σ the equation is reduced to (formula 2.7.17 in Colquhoun 1971):

$$\mathrm{Var}(1/\hat{N}_a) \simeq (1/U_{\hat{N}_a})^4\ \mathrm{Var}(\hat{N}_a) \qquad (2)$$

Rearranging the equation, the final result is:

$$\mathrm{Var}(\hat{N}_a) \simeq \mathrm{Var}(1/\hat{N}_a)U_{\hat{N}_a}{}^4 \qquad (3)$$

The subpopulation variances $[\mathrm{Var}(\hat{N}_a)]$ were then summed to get a variance for the total population $[\mathrm{Var}(\hat{N}_T)]$. The justification was derived from formula 2.7.4 in Colquhoun (1971):

$$\mathrm{Var}(N_T) = \mathrm{Var}(N_1 + N_2 + \ldots.\ N_K) = \frac{s_1^{\ 2}}{n_1} + \frac{s_2^{\ 2}}{n_2} + \ldots.\ \frac{s_K^{\ 2}}{n_K}$$

where: n_a = sample size of each estimate

$s_a^{\ 2}$ = sample variance.

Since n_a for all cases equals 1, the following is true:

$$\mathrm{Var}(N_T) = s_1^{\ 2} + s_2^{\ 2} + \ldots\ s_K^{\ 2}$$

The estimate of the total population $(\hat{N}_T)$ was inverted to get $1/\hat{N}_T$. The variance of $\hat{N}_T$ was substituted back into equation 2 resulting in $\mathrm{Var}(1/\hat{N}_T)$. Confidence intervals for $1/\hat{N}_T$ were then calculated according to Ricker (1975) and inverted to get confidence intervals for $\hat{N}_T$.

TABLE 26. TOTAL LENGTH VERSUS ANTERIOR SCALE RADIUS AND WEIGHT VERSUS TOTAL LENGTH REGRESSIONS FOR BLACK BASS COLLECTED IN THE FALL IN THE TONGUE RIVER RESERVOIR.

	Regressions	r	n
	Total Length Versus Anterior Scale Radius		
1975 Smallmouth Bass	L = 47.6 + 0.997 S	0.963	149
1976 Smallmouth Bass	L = 52.5 + 1.017 S	0.960	471
1976 Largemouth Bass	L - 31.3 + 0.954 S	0.978	309
	Weight Versus Total Length		
Smallmouth Bass			
Area A[1]	log W = -5.065 + 3.097 log L	0.988	46
Area B	log W = -5.322 + 3.208 log L	0.977	1212
Area C	log W = -5.201 + 3.147 log L	0.980	831
Entire Reservoir	log W = -5.350 + 3.216 log L	0.980	2089
Largemouth Bass			
Area A	log W = -5.449 + 3.277 log L	0.997	26
Area B	log W = -5.335 + 3.230 log L	0.995	56
Area C	log W = -5.173 + 3.157 log L	0.990	72
Entire Reservoir	log W = -5.139 + 3.221 log L	0.994	153

L = Total length (mm).
S = Anterior median scale radius (mm) x 66.
W = Weight (g).
[1]larger total lengths were not representatively sampled.

TABLE 27. MEAN CONDITION (K) BY 50 MM LENGTH INTERVALS OF BLACK BASS COLLECTED IN THREE SECTIONS OF THE TONGUE RIVER RESERVOIR DURING THE FALL OF 1976. GRAND MEANS WITH CORRESPONDING SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT. STANDARD DEVIATIONS ARE IN PARENTHESIS.

	Section A			Section B			Section C		
Interval	N	Mean K	Mean TL	N	Mean K	Mean TL	N	Mean K	Mean TL
					Smallmouth Bass				
151-200	7	1.444 (.192)	185 (16)	225	1.365 (.159)	177 (16)	378	1.342 (.189)	180 (15)
201-250	25	1.442 (.134)	229 (14)	757	1.491 (.177)	225 (15)	381	1.418 (.148)	220 (14)
251-300	9	1.607 (.138)	268 (15)	180	1.536 (.159)	268 (15)	56	1.434 (.106)	266 (14)
301-350	0	---	---	33	1.542 (.130)	319 (15)	9	1.366 (.173)	314 (7)
351-400	5	1.459 (.068)	383 (21)	14	1.458 (.209)	376 (14)	5	1.446 (.069)	388 (5)
401-450	0	---	---	3	1.694 (.171)	430 (21)	2	1.298 (.004)	418 (4)
Unweighted Grand Mean		1.488 (.080)	266 (85)		1.514^{a} (.109)	299 (95)		1.384^{a} (.058)	298 (94)
					Largemouth Bass				
151-200	4	1.455 (.047)	157 (19)	9	1.517 (.223)	154 (3)	2	1.334 (.117)	195 (4)
201-250	0	---	---	5	1.558 (.119)	229 (15)	11	1.599 (.186)	213 (13)
251-300	10	1.689 (.168)	280 (13)	26	1.686 (.150)	285 (11)	39	1.656 (.143)	279 (9)
301-350	2	1.766 (.172)	306 (6)	10	1.843 (.177)	319 (12)	13	1.604 (.079)	316 (17)
351-400	7	1.879 (.140)	387 (9)	2	1.814 (.379)	397 (2)	3	1.644 (.147)	380 (19)
401-450	3	1.827 (.190)	425 (15)	4	1.851 (.107)	434 (16)	2	1.761 (.036)	431 (6)
451-500*	0	---	---	0	---	---	2	1.846 (.065)	484 (26)
Unweighted Grand Mean		1.723 (.166)	311 (104)		1.712 (.148)	303 (104)		1.600 (.143)	302 (93)

*Interval not included in unweighted mean.

TABLE 28. MEAN CONDITION (K) OF BLACK BASS BY 50 MM INTERVALS AVERAGED FOR THE ENTIRE TONGUE RIVER RESERVOIR, FALL 1976. STANDARD DEVIATIONS ARE IN PARENTHESIS.

Interval	N	Mean K	Mean TL
		Smallmouth Bass	
151-200	610	1.352 (.174)	179 (15)
201-250	1163	1.466 (.170)	224 (14)
251-300	245	1.516 (.154)	268 (15)
301-350	42	1.504 (.156)	318 (13)
351-400	23	1.458 (.168)	378 (13)
401-450	6	1.513 (.229)	422 (15)
Unweighted Grand Mean		1.468[a] (.062)	298 (64)
		Largemouth Bass	
151-200	15	1.476 (.184)	161 (15)
201-250	16	1.586 (.165)	218 (15)
251-300	75	1.671 (.148)	281 (10)
301-350	25	1.701 (.143)	316 (15)
351-400	12	1.809 (.162)	387 (12)
401-450	9	1.823 (.126)	430 (13)
Unweighted Grand Mean		1.678[a] (.133)	299 (66)

[a] Grand means significantly different.

TABLE 29. SPRING SCHUMACHER AND ESCHMEYER CATCH STATISTICS FOR AGE-2 AND OLDER SMALLMOUTH BASS IN TWO AREAS OF THE TONGUE RIVER RESERVOIR, 1976. THE 95% CONFIDENCE INTERVALS ARE IN PARENTHESIS.

Area B

	111-180 mm Total Length Interval				181-420 mm Total Length Interval			
Period	Ct	Rt	Nm	Mt	Ct	Rt	Nm	Mt
5/27-6/14	39	--	39	0	27	0	27	0
6/15-7/3	160	3	157	39	26	0	26	27
7/4-7/20	159	20	139	196	47	6	41	53
Population Estimate	1573 (1381-1826)				475 (266-2181)			

Area C

	101-140 mm Total Length Interval				141-411 mm Total Length Interval			
Period	Ct	Rt	Nm	Mt	Ct	Rt	Nm	Mt
5/27-6/14	67	--	67	0	163	0	163	0
6/15-7/3	167	9	151	67	319	19	291	163
7/4-7/20	77	19	66	218	458	81	377	454
Population Estimate*	1483 (1170-2452)				2580 (2460-2713)			

* Corrected for 6.38% age-1 fish in catch.
Ct = Total fish captured.
Rt = Recaptured fish.
Nm - Number marked less removals.
Mt - Marked fish at large.

TABLE 30. FALL PETERSEN CATCH STATISTICS FOR AGE-1 AND OLDER SMALLMOUTH BASS IN TWO AREAS OF THE TONGUE RIVER RESERVOIR, 1976. THE 95% CONFIDENCE INTERVALS ARE IN PARENTHESIS.

Area B

	101-190 mm Total Length Interval			191-450 mm Total Length Interval		
	M	C	R	M	C	R
	116	109	12	556	588	71
Population Estimate*	989 (465-1495)			4557 (3551-5563)		

Area C

	101-170 mm Total Length Interval			171-220 mm Total Length Interval			221-411 mm Total Length Interval		
	M	C	R	M	C	R	M	C	R
	156	163	21	226	299	41	62	202	23
Population Estimate	1170 (756-1624)			1621 (1163-2079)			532 (332-732)		

* Corrected for 0.91% age-0 fish in catch.
M = Total number fish marked.
C = Total number fish captured.
R = Number marked fish captured.

TABLE 31. FALL PETERSEN CATCH STATISTICS FOR AGE-1 AND OLDER LARGEMOUTH BASS IN THE ENTIRE TONGUE RIVER RESERVOIR, 1976. THE 95% CONFIDENCE INTERVALS ARE IN PARENTHESIS.

	101-210 mm Total Length Interval			211-510 mm Total Length Interval		
	M	C	R	M	C	R
	161	155	12	37	104	10
Population Estimate	1943 (999-2887)			362 (162-562)		

M = Total number fish marked.
C = Total number fish captured.
R = Number marked fish captured.

TABLE 32. FALL PETERSEN CATCH STATISTICS FOR SMALLMOUTH BASS POPULATION ESTIMATES IN THE ENTIRE TONGUE RIVER RESERVOIR, 1976. THE 95% CONFIDENCE INTERVALS ARE IN PARENTHESIS.

	Area A and B Combined					
	101-190 mm Total Length Interval			191-450 mm Total Length Interval		
	M	C	R	M	C	R
	118	110	12	594	597	72
Population Estimate*	1006 (496-1516)			4874 (3812-5936)		

Population estimate for age-1 and older smallmouth bass for the entire reservoir (add A and B with C)

9203 (7200-11206)

Population estimate for age-2 and older smallmouth bass for the entire reservoir

9203 - 1508 = 7695

* Corrected for 0.90% age-0 fish in catch.
M = Total number fish marked.
C = Total number fish captured.
R = Number marked fish captured.

TABLE 33. PETERSEN CATCH STATISTICS FOR ESTIMATING SPRING SMALL-MOUTH BASS POPULATIONS IN THE ENTIRE TONGUE RIVER RESERVOIR, 1976. DATA IS FOR AGE-2 AND OLDER RIGHT PELVIC FIN CLIPPED FISH MARKED IN THE SPRING AND RECAPTURED IN THE FALL. THE 95% CONFIDENCE INTERVALS ARE IN PARENTHESIS.

	M	C	R
Area A	23	46	1
Area B	431	1212	120
Area C	1097	810	115
Total	1551	2068	236
Population Estimate		13549 (11896-15202)	

M = Total number fish marked.
C = Total number fish captured.
R = Number marked fish captured.

TABLE 34. ESTIMATED MEAN TOTAL LENGTH AND WEIGHT OF SMALLMOUTH BASS AT TIME OF CAPTURE.

Age	Area B N	Area B L	Area B W	Area C N	Area C L	Area C W
			Spring			
1	---	---	---	---	---	---
2	129	160	55	187	137	44
3	36	229	138	77	188	97
4	12	290	368	19	269	249
5	6	341	446	16	316	371
6	2	366	751	2	382	816
T		148	59		175	84
			Fall			
1	40	151	51	52	140	37
2	127	223	169	102	196	113
3	76	268	299	31	256	243
4	9	345	567	3	365	675
5	12	374	807	7	359	667
6	3	422	1319	1	383	810
T		224	186		194	118

N = Number of scale samples.
L = Mean total length (mm).
W = Mean weight (g).
T = Mean population length and weight.

TABLE 35. CALCULATIONS FOR SURVIVAL OF AGE-2 AND OLDER SMALLMOUTH BASS BASED ON ESTIMATED REDUCTION OF CLIPPED FISH FROM SPRING TO FALL.

Area	M	Area	C	R	R/C	Number Remaining (R/C) x N	Survival
A	23	A + B	1175	121	0.1030	538	936/1551
B	431	C	773	115	0.1608	398	
C	1097						
Total	1551					936	0.60348

M = Number age-2 and older right pelvic fin clipped smallmouth bass in spring.
C = Total number of age-2 and older smallmouth bass captured in the fall.
R = Number of marked fish captured.

LITERATURE CITED

Bandolin, L. A. 1973. Population dynamics and angler use of smallmouth bass in South Branch Lake, Maine. M. S. Thesis. Univ. Maine, Orono, Maine. 31 pp.

Belding, D. L. 1926. A new method of studying fish environment and determining suitability of waters for stocking. Trans. Amer. Fish. Soc. 56: 79-82.

Bennett, G. W. 1937. Growth of the largemouthed black bass, *Huro salmoides* (Lacepede), in the waters of Wisconsin. Copeia, No. 2. Pages 104-108.

____________. 1938. Growth of the smallmouth bass, *Micropterus dolomieui* (Lacepede), in Wisconsin waters. Copeia, No. 4. Pages 157-170.

____________ and W. F. Childers. 1957. The smallmouth bass, *Micropterus dolomieui*, in warm-water ponds. Jour. Wildl. Mgt. 21(4): 414-424.

Brown, C. J. D. 1952. Ranch fish ponds in Montana. Jour. Wildl. Mgt. 16(3): 275-278.

____________ and S. M. Logan. 1960. Age and growth of four species of warmwater game fish from three Montana ponds. Trans. Amer. Fish. Soc. 89(4): 379-382.

Bryant, H. E. and A. Houser. 1971. Population estimates and growth of largemouth bass in Beaver and Bull Shoals Reservoirs. Pages 349-357 *in* Gordon E. Hall, ed. Reservoir fisheries and limnology. Amer. Fish. Soc. Spec. Pub. 8. 511 pp.

Buck, D. H. 1956. Effects of turbidity on fish and fishing. Trans. North Amer. Wildl. Conf. 21: 249-261.

Carlander, K. D. 1969. Handbook of freshwater fishery biology. The Iowa State University Press, Ames, Iowa. 752 pp.

Carlander, K. D. 1975. Community relations of bass, large natural lakes. Pages 125-130 *in* R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, D. C. 533 pp.

Chance, C. J., A. O. Smith, J. Holbrook II, and R. B. Fitz. 1975. Norris Reservoir: A case history in fish management. Pages 399-407 *in* R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, D. C. 533 pp.

Clady, M. 1977. Abundance and production of young largemouth bass, smallmouth bass, and yellow perch in two infertile Michigan lakes. Trans. Amer. Fish. Soc. 106(1): 57-63.

Cleary, R. E. 1956. Observation on factors affecting smallmouth bass production in Iowa. Jour. Wildl. Mgt. 20(4): 353-359.

Coble, D. W. 1975. Smallmouth bass. Pages 21-33 *in* R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, D. C. 533 pp.

Colquhoun, D. 1971. Lectures on biostatistics. Oxford University Press, London. 425 pp.

Coomer, C. E. 1976. Population dynamics of black bass in Center Hill Reservoir, Tennessee. M. S. Thesis. Tenn. Tech. Univ., Cookville, Tennessee. 111 pp.

Cooper, E. L., H. Hidu and J. K. Anderson. 1963. Growth and production of largemouth bass in a small pond. Trans. Amer. Fish. Soc. 92(4): 391-400.

Dixon, W. J. and F. J. Massey, Jr. 1969. Introduction to statistical analysis. McGraw-Hill Co. New York. 638 pp.

Draft Environmental Impact Assessment for the Proposed East Decker Coal Mine (unpublished).

Elser, A. A. 1975. Fish distribution of the Tongue River Reservoir as related to major habitat areas, instream flow needs and proposed coal development. Pages 1-24 *in* Old West Regional Commission Annual Report. Project Number 10470022. (Mimeo.)

Fajen, O. F. 1962. The influence of stream stability on homing behavior of two smallmouth populations. Trans. Amer. Fish. Soc. 91(4): 346-349.

__________. 1972. The standing crop of fish in Courtois Creek. Missouri Dept. Conserv., Fed. Aid Fish Wildl. Restoration Proj. F-1-R-20, Work Plan No. 10, Job No. 1. 29 pp.

__________. 1975. Population dynamics of bass in rivers and streams. Pages 195-203 *in* R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, D. C. 533 pp.

Forney, J. L. 1961. Growth movement and survival of smallmouth bass (*Micropterus dolomieui*) in Oneida Lake, New York. N. Y. Fish and Game Jour. 8(2): 88-105.

__________. 1972. Biology and management of smallmouth bass in Oneida Lake, New York. N. Y. Fish and Game Jour. 19(2): 132-154.

Fraser, J. M. 1955. The smallmouth bass fishery of South Bay, Lake Huron. J. Fish. Res. Bd. Canada. 12(1): 147-177.

Fry, F. E. J. And K. E. F. Watt. 1957. Yields of year classes of smallmouth bass hatched in the decade of 1940 in Manitoulin Island waters. Trans. Amer. Fish. Soc. 85: 135-143.

Funk, J. L. 1955. Movement of stream fishes in Missouri. Trans. Amer. Fish. Soc. 85: 39-56.

Garrison, P. J., S. C. Whalen and R. W. Gregory. 1975. Limnology of the Tongue River Reservoir: Existing and potential impact of coal strip mining. First Progress Report, Montana CFRU, Montana State University, Bozeman, Montana. 32 pp.

Hastings, C. E. and F. B. Cross. 1962. Farm ponds in Douglas County, Kansas. Univ. Kans. Mus. Nat. Hist. Misc. Publ. 29. 21 pp.

Heman, M. S., R. S. Campbell and L. C. Redmond. 1969. Manipulation of fish populations through reservoir drawdown. Trans. Amer. Fish. Soc. 98(2): 293-304.

Hubbs, C. L. and R. M. Bailey. 1938. The smallmouthed bass. Cranbrook Institute Sci. Bull. 10. 89 pp.

Jenkins, R. M. 1975. Black bass crops and species associations in reservoirs. Pages 114-124 *in* R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, D. C. 533 pp.

Kramer, R. H. and L. L. Smith. 1960. First-year growth of the largemouth bass, *Micropterus salmoides* (Lacepede), and some related ecological factors. Trans. Amer. Fish Soc. 89(2): 222-233.

______________________________. 1962. Formation of year classes in largemouth bass. Trans. Amer. Fish. Soc. 91(1): 29-41.

Kuehn, J. H. 1949. Statewide average total length in inches at each year. Minn. Fish. Res. Lab., Supp. to Invest. Rept. No. 51 (2nd revision).

Lambou, V. W. 1959. Fish populations in backwater lakes in Louisiana. Trans. Amer. Fish. Soc. 88(1): 7-15.

Latta, W. C. 1963. The life history of the smallmouth bass *Micropterus d. dolomieui* at Waugoshonce Point, Lake Michigan. Mich. Dept. Conserv. Inst. Fish. Res. Bull. No. 5. 56 pp.

Maloney, J. E., D. R. Schupp and W. J. Scidmore. 1962. Largemouth bass populations and harvest, Gladstone Lake, Crow Wing County, Minnesota. Trans. Amer. Fish. Soc. 91(1): 42-52.

Marinac, P. 1976. The smallmouth bass population and fishery in a northern Wisconsin lake, Clear Lake, Oneida County. M. S. Thesis. Univ. Wisc., Stevens Point, Wisconsin. 60 pp.

Miller, K. D. and R. H. Kramer. 1971. Spawning and early life history of largemouth bass (*Micropterus salmoides*) in Lake Powell. Pages 73-84 *in* Gordan E. Hall, ed. Reservoir fisheries and limnology. Amer. Fish. Soc. Spec. Pub. 8. 511 pp.

Mraz, D. and C. W. Threinen. 1955. Angler's harvest, growth rate and population estimate of the largemouth bass of Browns Lake, Wisconsin. Trans. Amer. Fish. Soc. 85: 241-256.

Munther, G. L. 1970. Movement and distribution of smallmouth bass in the Middle Snake River. Trans. Amer. Fish. Soc. 99(1): 44-53.

Neves, R. J. 1975. Factors affecting fry production of smallmouth bass (*Micropterus dolomieui*) in South Branch Lake, Maine. Trans. Amer. Fish. Soc. 104(1): 83-87.

Novotny, D. W. And G. R. Priegal. 1974. Electrofishing boats, improved designs and operational guidelines to increase the effectiveness of boom shockers. Dept. of Nat. Res. Tech. Bull. No. 37. Madison, Wisconsin. 48 pp.

Paragamian, V. L. And D. W. Coble. 1975. Vital statistics of smallmouth bass in two Wisconsin rivers, and other waters. Jour. Wildl. Mgt. 39(1): 201-210.

Rainwater, W. C. and A. Houser. 1975. Relation of physical and biological variables to black bass crops. Pages 306-309 *in* R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, D. C. 533 pp.

Rawstron, R. R. and K. A. Hashagen. 1972. Mortality and survival rates of tagged largemouth bass (*Micropterus salmoides*) at Merle Collins Reservoir. Calif. Fish and Game. 58(3): 221-230.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin 191. Dept. of the Environment, Fisheries and Marine Service, Ottawa, Canada. 382 pp.

Rideout, S. G. and P. H. Oatis. 1975. Population dynamics of smallmouth and largemouth bass in Quabbin Reservoir. Pages 216-221 *in* R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, D. C. 533 pp.

Smith, L. L. and N. L. Moe. 1944. Minnesota Fish Facts. Minn. Dept. Cons., Bull. 7: 1-31.

Stroud, R. H. 1948. Growth of basses and black crappie in Norris Reservoir, Tennessee. Jour. Tenn. Acad. Sci. 23(1): 31-39.

Summerfelt, R. C. 1975. Relationship between weather and year-class strength of largemouth bass. Pages 166-174 *in* R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, D. C. 533 pp.

Tesch, F. W. 1971. Age and growth. Pages 98-126 *in* W. E. Ricker, ed. Methods for assessment of fish production in fresh waters. IBP Handbook No. 3. Blackwell, London. 348 pp.

Tharratt, R. C. 1966. The age and growth of centrarchid fishes in Folsom Lake, California. Calif. Fish and Game. 52(1): 4-16.

Turner, G. E. and H. R. MacCrimmon. 1970. Reproduction and growth of smallmouth bass, *Micropterus dolomieui*, in a Precambrian lake. J. Fish. Res. Bd. Canada. 27: 395-400.

United States Geological Survey. 1975. Water resources data for Montana. 604 pp.

Vincent, E. R. 1971. River electrofishing and fish population estimates. Prog. Fish Cult. 33(3): 163-169.

von Geldron, Jr. C. and D. F. Mitchell. 1975. Largemouth bass and threadfin shad in California. Pages 436-449 *in* R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, D. C. 533 pp.

Walters, S. J. 1974. A study of smallmouth and largemouth bass in impoundments in central Missouri. M. S. Thesis. Univ. Missouri, Columbia, Missouri. 56 pp.

Watson, J. E. 1955. The Maine smallmouth. Maine Dept. Inland Fish and Game, Fish Res. Bull. No. 3. 31 pp.

Welch, P. S. 1948. Limnological methods. McGraw-Hill Book Co., Inc. New York. 381 pp.

Whalen, S. C., P. J. Garrison and R. W. Gregory. 1976. Limnology of the Tongue River Reservoir, existing and potential impact of coal strip mining. Second Progress Report, Montana CFRU, Montana State University, Bozeman, Montana. 70 pp.

Whalen, S. C. and S. A. Leathe. 1976. Limnology of the Tongue River Reservoir, existing and potential impact of coal strip mining. Third Progress Report, Montana CFRU, Montana State University, Bozeman, Montana. 64 pp.

Zweiacker, P. L. and B. E. Brown. 1971. Production of a minimal largemouth bass population in a 3000-acre turbid Oklahoma pond. Pages 481-493 *in* Gordon E. Hall, ed. Reservoir fisheries and limnology. Amer. Fish. Soc. Spec. Pub. 8. 511 pp.