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Environmental Effects of Western Coal Surface Mining

Part VI. Smallmouth Bass and Largemouth Bass in the Tongue River Reservoir, Montana, 1975-76

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ENVIRONMENTAL EFFECTS OF WESTERN COAL SURFACE MINING

PART VI - SMALLMOUTH BASS AND LARGEMOUTH BASS IN THE TONGUE RIVER RESERVOIR, MONTANA, 1975-76

by

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FOREWORD

This report, sixth in a series on environmental effects of surface coal mining in the west, is a documentation of the population of smallmouth and largemouth bass in the Tongue River Reservoir. This water body is adjacent to a large surface mine which will be the largest in the world if present plans materialize, other mines exist in the drainage basin. Studies such as this one will be vital to a long-term assessment of any major impacts of such development.

Approaching impact assessment by field population studies has both positive and negative features. By use of direct measures of species populations of high value to the public, the problem of interpreting small changes in growth, mortality, and reproduction displayed by surrogate species in laboratory tests is avoided. Such field assessments, however, lack precision to detect subtle changes and so must be accompanied by repeated assessments to achieve the needed sensitivity to detect impact from the mining activity.

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Deputy Director
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ABSTRACT

Population parameters of smallmouth bass (*Micropterus dolomieui*) and largemouth bass (*M. salmoides*) were studied during 1975 and 1976, before expansion of surface coal mining adjacent to the Tongue River Reservoir in southeastern Montana. Reproductive success, as determined by alongshore seining, varied in different areas of the reservoir and may be correlated to turbidity. Population estimates were obtained at night during spring and fall 1976 with boat electrofishing gear. For yearling and older smallmouth bass the fall population of 13.0 fish/ha and the standing crop of 2.03 kg/ha represented 80 and 84 percent of the totals for basses in the reservoir. The largemouth bass population and standing crop during fall 1976 was 3.2 fish/ha and 0.32 kg/ha. The dominance by smallmouth bass of all year classes for both species except age-1, was attributed to a much higher mortality of underyearlings among largemouth bass. This higher mortality of largemouth bass may be correlated to a lack of shoreline vegetation in the reservoir. Summer mortality of age-2 and older smallmouth bass, estimated from the reduction in numbers of marked fish, was about 40 percent. Smallmouth bass growth and condition were better in the upper than lower end of the reservoir; the difference may be due to forage fish availability. Growth and length-weight relationships were above average for both species when compared with basses in other northern waters, indicating no noticeable effect from nearby surface coal mine operations at the time of the study.

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ACKNOWLEDGEMENT

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SECTION I

INTRODUCTION

The Tongue River watershed, including the Tongue River Reservoir, lies in the Fort Union Coal Basin, an area that encompasses a large portion of eastern Montana (Figure 1) as well as parts of northern Wyoming and western North Dakota. The Fort Union Basin, and other coal deposits in the northern Great Plains, contain nearly half of the nation's known coal reserves. To meet the nation's growing energy demands, surface coal mining in the Fort Union Basin is rapidly increasing.

The largest surface coal mine in the Tongue River area is the Decker Mine, located on the southwest shore of the Tongue River Reservoir in eastern Montana, just north of the Wyoming border. The Decker Mine began operation in 1972, and is currently being expanded to the southeastern shore of the Reservoir; permit application has been made for expansion northward along the western shore. As the mine expands, and production increases, the Decker Mine complex is projected to be the largest surface coal mine in the world. In addition to the Decker Mine, other mines are located in the Tongue River watershed, farther up river in Wyoming. Resource development plans also call for construction of mine-mouth coal-fired power plants in that same region.

Historically, water from the Tongue River has been used for agriculutral purposes and the raising of livestock. In 1939 an earthfill dam was completed on the Tongue River, forming a reservoir for flood control and irrigation water storage. In recent years the reservoir has also become an important recreation area.

The potential impacts from coal mining and proposed coal combustion facilities on the Tongue River system are largely unknown. To provide a basis for measuring that impact, a variety of studies have been undertaken by the Montana Cooperative Fishery Research Unit, U.S. Fish and Wildlife Service, on the present status of the aquatic biota of the river and reservoir. The research reported here is the result of a study conducted during 1975 and 1976 on the populations of smallmouth bass (*Micropterus dolomieui*) and largemouth bass (*M. salmoides*) in the Tongue River Reservoir. Minimal research has previously been reported on these two species in Montana; the only two published papers concern the growth of largemouth bass in Montana ponds (Brown 1952; Brown and Logan 1960). The immediate objective of the present research was to study the age and growth, reproductive success, and population size of these two species in the Reservoir, and to see what discernable impact, if any, present coal mining operations might be having on these fishes. The longer range objective was to provide information against which comparisons can be made in the future as mining operations in the Tongue River watershed increase.

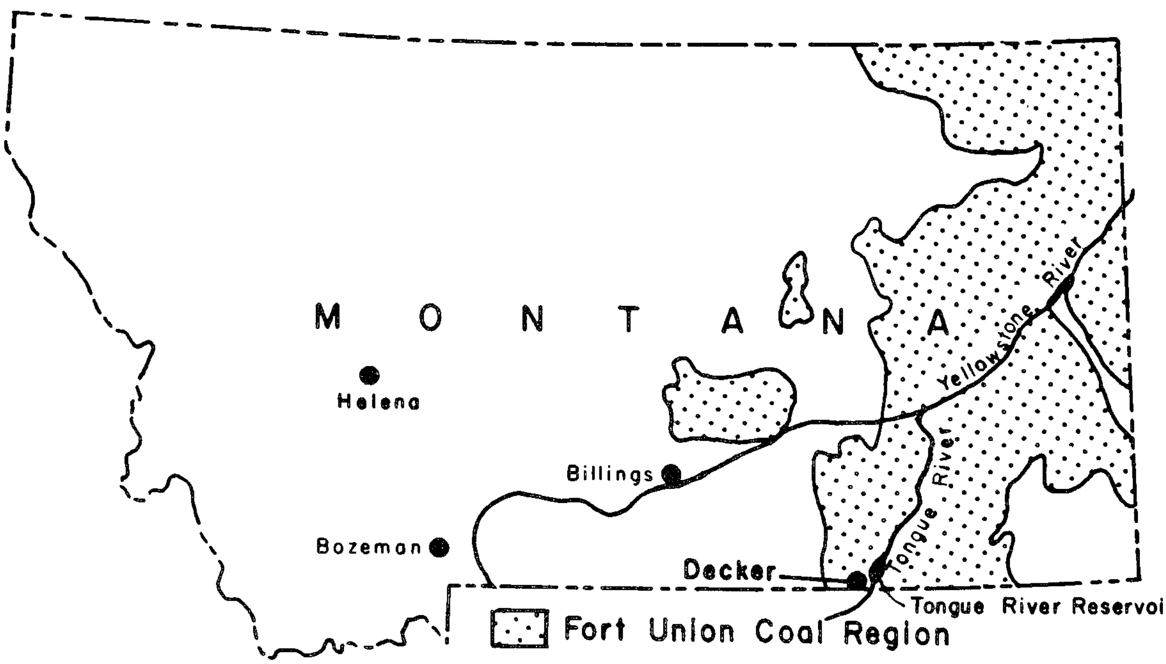

Figure 1. Map of Montana showing location of Tongue River Reservoir.

Additional studies on the aquatic biota of the Tongue River and Reservoir will be reported separately. These include reports on the microbiological community within the Decker Mine settling pond (Turbak et al., in press), the limnology of the Tongue River Reservoir (Whalen 1979), and the distribution and behavior of walleyes (*Stizostedion vitreum*) and saugers (*S. canadense*) in the reservoir (Riggs and Gregory, in press). Information from these and the present study will be of value in formulating recommendations for institution of appropriate safeguards to protect aquatic life as mining and combustion operations expand in this region of the country which has relatively little water and a fragile environment.

SECTION II

CONCLUSIONS

1. Reproductive success of largemouth bass and smallmouth bass in the Tongue River Reservoir was limited by the amount of suitable spawning substrate and the turbidity.

2. Growth and length-weight relationships of both species were excellent for a northern latitude impoundment. These relationships for largemouth bass were superior to those for smallmouth bass.

3. The smallmouth bass fall populations and standing crops were average when compared to reports on other impoundments; by comparison the same measurements for largemouth bass were extremely low. The low measurements for largemouth bass are probably attributable to a lack of suitable habitat and/or significantly higher mortality rates between the fingerling and yearling stages.

4. Based on the present and related concurrent studies on fishes and the limnology (including water chemistry) of the Tongue River Reservoir, there is no evidence that the present level of surface coal mining activity adjacent to the reservoir is having a measurable effect on the growth rate and reproductive success of either largemouth bass or smallmouth bass in the reservoir.

SECTION III

RECOMMENDATIONS

1. Additional studies should be initiated on the fishes of the Tongue River and Reservoir as surface coal mining continues and expands in the areas immediately adjacent to the reservoir and the river above the reservoir.

2. These studies should include measurements of growth rates, reproductive success, and standing crop of the important fishes, including largemouth bass and smallmouth bass, in the reservoir, and should be correlated with further limnological measurements, including water chemistry parameters.

3. Although the State of Montana Department of Fish and Game has conducted periodic creel surveys on the reservoir, additional surveys should be initiated as the level of surface coal mining activity increases. Results of such surveys will permit distinguishing possible effects on the fish populations resulting from surface mining activity and those from increased fishing pressure; this latter may well prove to have the greater impact.

SECTION IV

DESCRIPTION OF THE STUDY AREA

The Tongue River Reservoir in Big Horn County, southeastern Montana, is 32 km north of Sheridan, Wyoming, the closest population center. At storage capacity the reservoir has an average depth of 6.1 m, a maximum length of 12.5 km, and a maximum breadth of 1.4 km (Garrison et al. 1975). Height of the earthfill dam, which was completed in 1939, is 27.7 m; spillway elevation is 1043.7 m above mean sea level (U.S. Geological Survey 1976). Surface area and length of shoreline at spillway elevation are 1277 ha and 60 km, respectively. Total storage capacity in 1947 was 85.6 hm^3 (U.S. Geological Survey 1976), but sedimentation has undoubtedly reduced this capacity. In 1976 the maximum depth at spillway elevation was 18 m and the bottom of the outlet was 15.2 m from the surface of the spillway. Because of an annual water level fluctuation of 3 to 6 m, submerged and emergent vegetation have not become established. Thermal stratification occurs for a short period in late spring and early summer but disappears quickly due to wind mixing and discharge of water from the outlet. Dissolved oxygen concentrations decrease to values less than 3 mg/liter at depths greater than 8 m in late summer (Whalen and Leathe 1976).

The reservoir was first stocked with warm water fishes in 1963. Largemouth bass were stocked as fingerlings in 1964, 1972, and 1973. Smallmouth bass were first captured in the reservoir in 1972; however, records of the Montana Fish and Game Dept. include no plantings of smallmouth bass. This species probably entered the Tongue River system and then the reservoir from adjacent strip-mine ponds near Sheridan, Wyoming. During the time of study the reservoir had only light use by fishermen (Elser et al. 1977).

The reservoir was divided into three sections on the basis of habitat type (Fig. 2). The shallow inflow section (area A) had an approximate maximum depth of 6 m and was most affected by summer water level reduction. During summer 1975, this area was completely dewatered due to large withdrawals, and had the highest turbidities recorded throughout the study (Fig. 3). Favorable bass spawning substrate (pebbles and cobbles) made up only 14 percent of the shoreline substrate in area A while unsuitable substrate (silt and clay) made up 51 percent (Table 1).

The central portion of the reservoir was designated area B, and the lower portion area C. Physical characteristics of area B were intermediate to those of areas A and C. Water level fluctuations had less effect on habitat because the water was deeper (14 m maximum). Turbidities were much lower than in area A (Fig. 2). Pebbles and cobbles made up 43 percent of the dominant shoreline substrate and silt and clay accounted for 19 percent (Table 1).

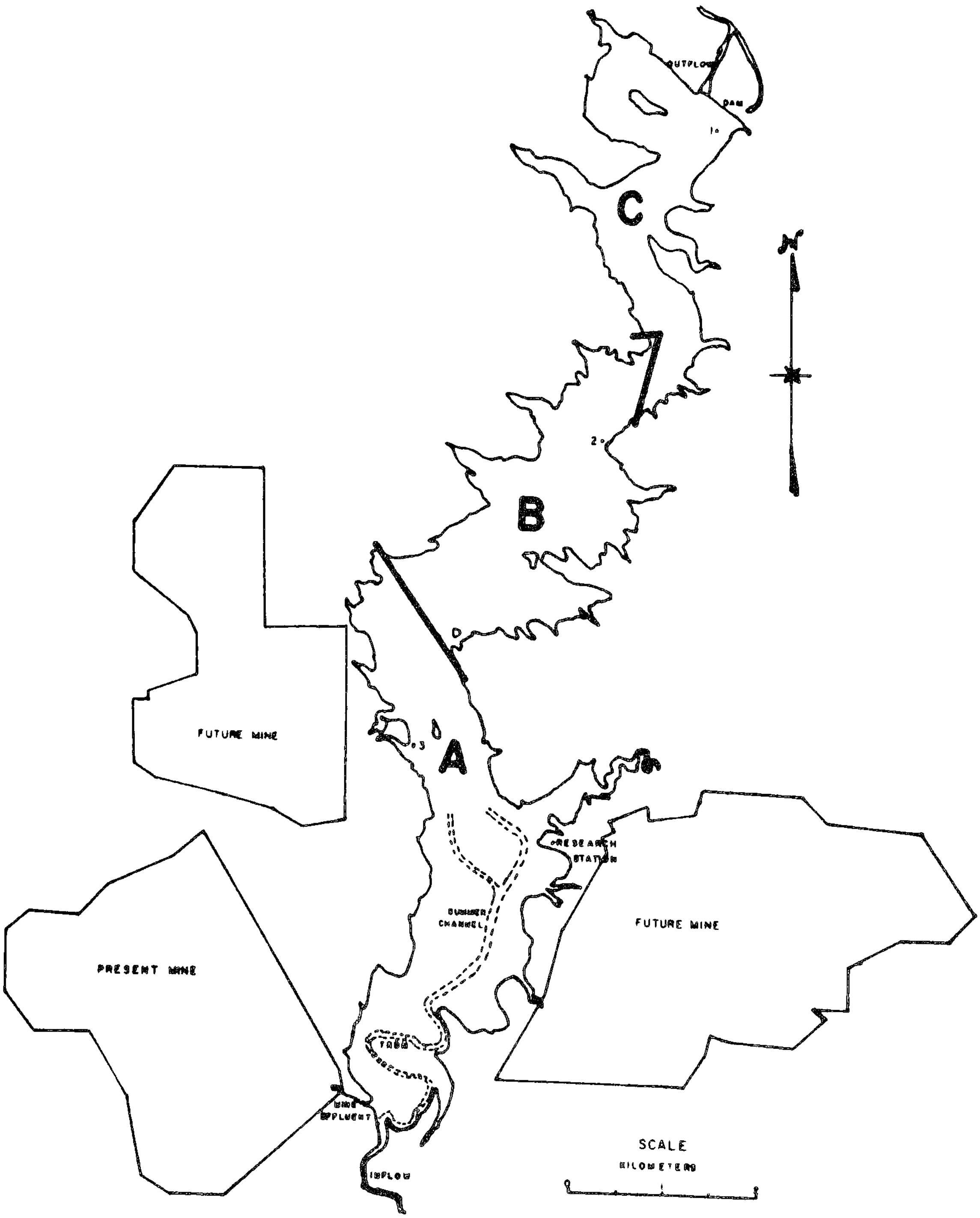

Figure 2. The three study areas of the Tongue River Reservoir.

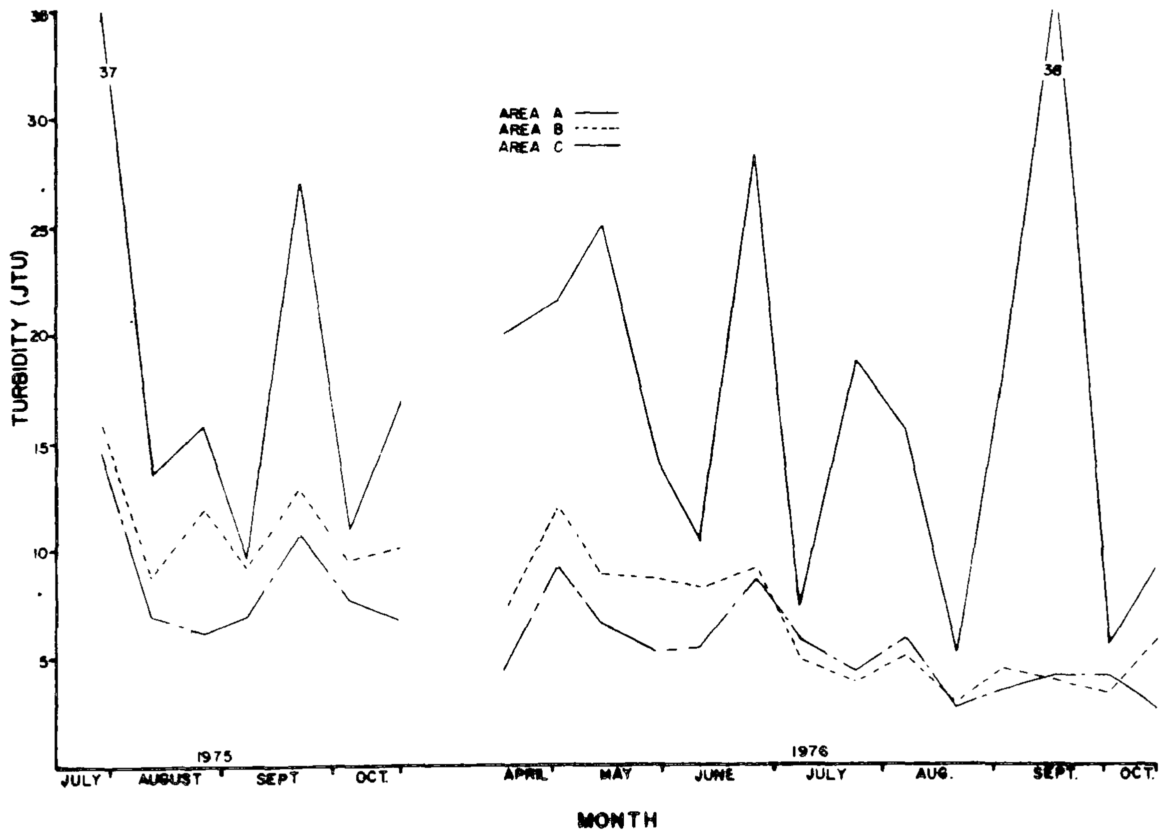

Figure 3. Turbidity (Jackson turbidity units) in three areas of the Tongue River Reservoir. (S. C. Whalen, Montana Cooperative Fishery Research Unit, unpublished data.)

TABLE 1. SHORELINE SUBSTRATE OF THE TONGUE RIVER RESERVOIR.

	Area A	Area B	Area C	Total
Number of 0.25 km study sections	69	63	65	197
Percent of Sections:				
Silt to clay (less than 0.062 mm)	50.7	19.0	13.8	28.4
Very fine to medium sand (0.062 - 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 (2 - 64 mm)	1.4	25.4	33.8	19.8
Cobbles (64 - 256 mm)	13.0	17.5	26.2	18.8
Boulders (greater than 256 mm)	4.3	4.8	15.4	8.1

Area C had a maximum depth of 18 m, and as a result fish habitat was least affected by water level declines. Turbidities were generally lower in this area especially during the spring and early summer (Fig. 3). Pebbles and cobbles comprised 60 percent of the shoreline substrate while silt and clay accounted for only 14 percent (Table 1).

There was less than one degree (Celsius) difference in mean temperature of the upper 6 m of water among areas A, B, and C (Whalen 1979).

SECTION V

METHODS

The dominant particle size of shoreline substrate was analyzed during mid-July 1976 when the reservoir surface elevation was 1042 m. Vertical distribution of the substrate above the silted portion of the basin was fairly uniform. This analysis should represent substrate available to bass at preferred spawning depths (1-7m). A topographic map of the reservoir was used to divide the shoreline into 0.25-km study sections. Each section was visually classified according to the size of its dominant substrate based on the Wentworth Classification System (Welch 1948). The number of sections classified alike were totaled and percentages were computed for each area.

Relative abundance of black bass fingerlings was based on collections with 30.5-m beach seines and 15.3-m bag seines during August and September in both 1975 and 1976. Each haul with the larger and smaller seines sampled approximately 19 and 9.5 m of shoreline, respectively. Seine results were equally weighted by (1) hauling the bag seine twice at each sample area or (2) multiplying the bag seine results by a factor of two. Both seines had a mesh size of 6.4 mm (bar measure).

Older bass were collected at night with a Type VI Smith Root electrofishing boat, a Coffelt variable voltage pulsator, Model VVP-10, and a 230-V, 4000-w, AC generator. The electrode array was designed according to Novotny and Priegel (1974) for direct current output. The entire shoreline of areas B and C were fished three times during the spring and early summer of 1976. The entire shoreline of the Tongue River Reservoir was electrofished twice during late August to mid-September 1976. All electrofishing occurred at night.

Fish total length and weight were measured to the nearest 1 mm and 10 gms. Fishes collected in the spring and fall were given different kinds of fin clips. Ages of bass were determined by examining celluolose acetate scale impressions on a projector at 66x. Fish age assignments were made by adding one year to the ages indicated by the number of annuli laid down before the calendar year in which the fishes were collected. Scales were collected below the lateral line from the area covered by the right pectoral fin when appressed to the body. Total lengths were partitioned into 1 cm intervals and scales were collected from at least 20 fish (where possible) in each length interval.

Population estimates, 95 percent confidence intervals, age structures, and standing crops were computed using methods similar to those summarized by Vincent (1971). The Schumacher-Eschmeyer equation (Formula 3.12 in Ricker 1975) was used to compute population estimates in the spring, and the Chapman modification of the Petersen formula (Formula 3.7 in Ricker 1975) was used in the fall.

Vincent (1971) calculated the total population and its variance by summing sub-estimates for several total-length intervals within the population. He divided the population into different size groups to reduce effects of unequal sampling efficiency for different sizes of fish. In this study, the populations were partitioned into 2 or 3 size groups depending on sample size. Age structure was determined by proportioning the population into total-length groups according to the relationship between age and total length (as determined by scales). Standing crop was estimated by multiplying the average weight of fish of each age group (total length group) times their estimated number (see Vincent 1971).

A spring and early summer population estimate of smallmouth bass was calculated by treating the three spring and early summer electrofishing runs as the mark run, and the fall electrofishing circuits as the recapture run. Too few largemouth bass were collected to obtain an estimate of their spring population. Smallmouth bass fall population estimates were calculated for areas A and B combined and area C. An estimate of the smallmouth bass population and its variance for the entire reservoir was computed by summing the estimates of both areas. Summer mortality of age-2 and older smallmouth bass was estimated from the reduction of spring-marked smallmouth bass in the fall population. Because of the small sample size of largemouth bass, a fall population estimate could be computed only for the entire reservoir.

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 bass and smallmouth bass ($r = 0.960$ to 0.978), so Method 2 described by Tesch (1971) was used for back-calculation.

Condition factors were computed for basses over 150 mm in total length with the following formula (Carlander 1969):

$$K = 10^5 \, W/L^3$$

where W = weight in grams;

L = total length in millimeters.

The method of least squares was used to derive linear regressions.

SECTION VI

RESULTS

Age and growth

Smallmouth bass were 92, 157, 232, 309, and 340 mm in length at the first through fifth annulus (Table 2). The corresponding mean calculated weights were 9, 52, 181, 454, and 618 gms, respectively. The length-weight relationship for smallmouth bass in the Tongue River Reservoir was log W = -5.350 + 3.216 log L.

Largemouth bass were 86, 191, 267, 342, and 388 mm in length at the first through fifth annulus (Table 2). Corresponding mean calculated weights were 8, 107, 314, 697, and 1046 gms, respectively. The length-weight relationship was log W = -5.319 + 3.221 log L.

Smallmouth bass had greater total lengths, at similar annuli in areas A and B thru C (Table 3). Fish were heavier, over a similar range of lengths, in area B (log W = -5.322 + 3.208 log L, n = 1212) than C (log W = -5.201 + 3.147 log L, n = 831) (Fig. 4). Too few fish were collected in area A to obtain a representative length-weight relationship. For six total-length intervals, the unweighted grand mean condition (K) was significantly greater for smallmouth bass in area B than in area C (Table 4).

Too few largemouth bass were collected in each area to determine differences in growth. Condition factors were generally larger, although not significantly, for fish collected in areas A and B than in area C (Table 4.)

Reproductive success

Smallmouth bass fingerlings were most abundant in area C, less abundant in area B, and absent in area A; 7.5, 2.3, and 0 fingerlings were collected per standard seine haul in each area, respectively (Table 5). Largemouth bass fingerlings were found in all threee areas of the reservoir but showed a similar distribution of abundance; 16.9, 3.7, and 1.2 largemouth bass fingerlings were collected per standard seine haul in areas C, B, and A, respectively.

Population and standing crop

Electrofishing gear was used to sample along the entire shoreline of the Tongue River Reservoir during the fall 1976. During the first circuit, 1,156 smallmouth bass and 198 largemouth bass were marked. During the second circuit 1,371 smallmouth bass and 259 largemouth bass were captured; 12.3 percent of the smallmouth bass and 9.3 percent of the largemouth bass had been marked during the previous circuit (Table 6).

TABLE 2. BACK-CALCULATED TOTAL LENGTHS (mm) AND WEIGHTS (g) OF SMALLMOUTH BASS AND LARGEMOUTH BASS IN THE TONGUE RIVER RESERVOIR.

Year Class	Number of Scales Examined	Annulus 1	2	3	4	5	6	7
				Smallmouth Bass				
1970 a/	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						
Grand Mean		92	157	232	309	340	401	
Calculated Weight		9	52	181	454	618	1051	
				Largemouth Bass				
1969 a/	2	100	244	319	382	416	445	459
1970 a/	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						
Grand Mean		86	191	267	342	388	444	459
Calculated Weight		8	107	314	697	1046	1615	1798

a/ Not included in Grand Mean except for oldest age groups.

TABLE 3. SMALLMOUTH BASS BACK-CALCULATED LENGTHS (mm) AND WEIGHTS (g), TONGUE RIVER RESERVOIR, 1976.

	AREA A						AREA B							AREA C						
Year Class	n[a]	1	2	3	4	5	n	1	2	3	4	5	6	n	1	2	3	4	5	6
1970							3	103	202	289	346	386	410	1	92	126	178	233	291	346
1971	3	99	157	235	321	356	12	97	168	241	325	343		7	93	151	215	287	325	
1972	1	96	230	256	327		9	101	163	255	301			3	92	158	245	297		
1973	6	85	165	217			76	90	161	210				31	86	147	192			
1974	39	90	149				130	91	148					102	87	130				
1975	3	92					40	85						54	81					
Grand Mean		92	175	236	324	356		95	168	249	324	365	410		89	142	208	272	308	346
Calculated Weight		10	76	192	513	687		11	66	232	566	790	1148		8	37	127	302	450	654

a/ n = Number of scales examined.

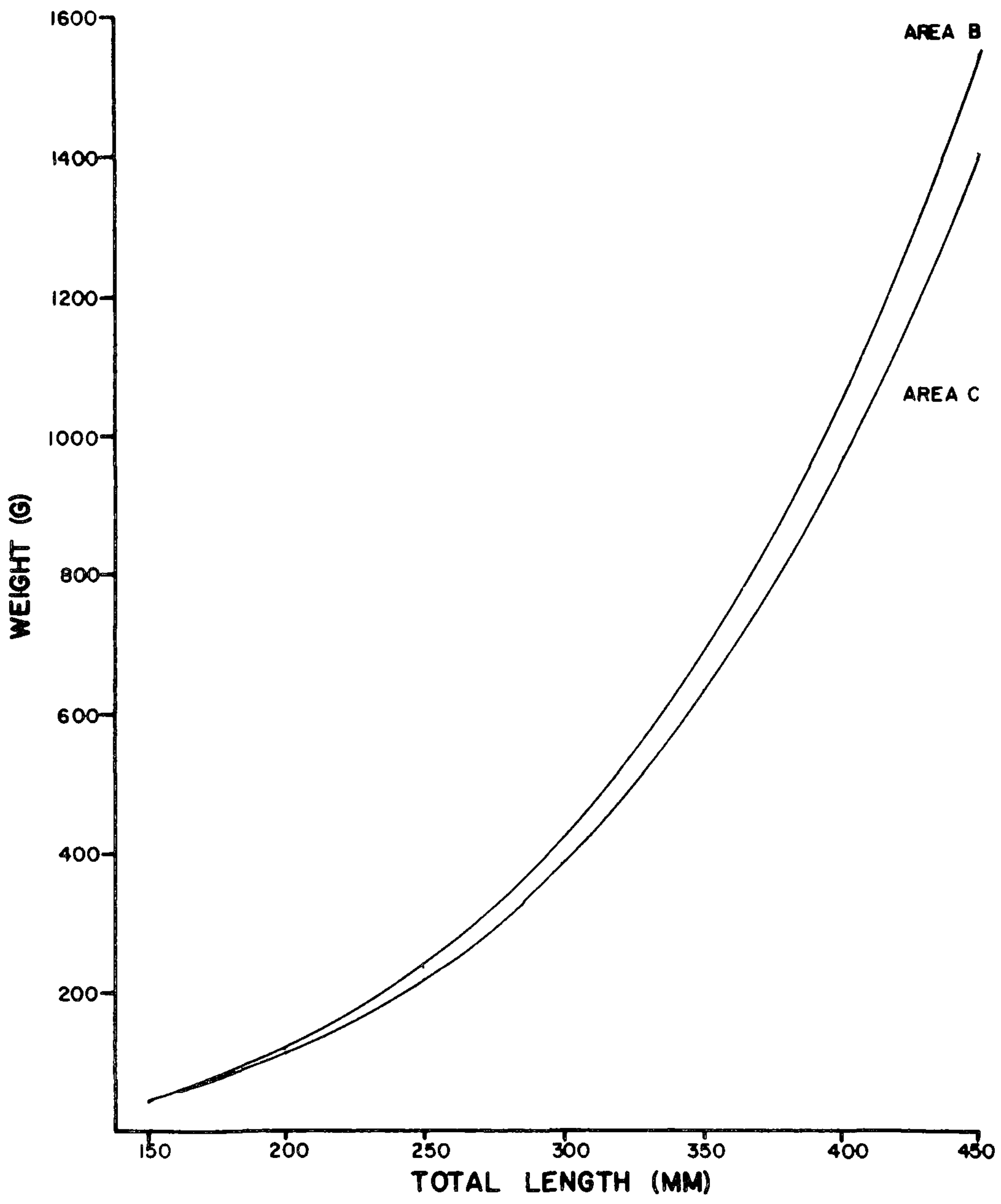

Figure 4. Length-weight relationship of smallmouth bass collected in areas B and C of the Tongue River Reservoir, fall 1976

TABLE 4. MEAN CONDITION (K) BY 50-MM LENGTH INTERVALS OF SMALLMOUTH BASS AND LARGEMOUTH BASS COLLECTED IN THE TONGUE RIVER RESERVOIR, FALL 1976. (Grand means with corresponding superscript[a/] are significantly different. Standard deviations are in parenthesis).

Interval	Section A			Section B			Section C		
	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[b/]	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)

[b/] Interval not included in unweighted mean.

TABLE 5. SHORELINE SEINING BY AREAS FOR 1975 AND 1976 COMBINED, TONGUE RIVER RESERVOIR. (Number of seine hauls are shown in parentheses.)

Species and total length (mm)[a]	Area A (23) No. per haul	Area A (23) %	Area B (58) No. per haul	Area B (58) %	Area C (41) No. per haul	Area C (41) %
Smallmouth Bass						
<100	0.0	0.0	2.3	4.7	7.5	16.3
100 - 200	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	0.7	1.1	0.7	1.4	0.4	0.9
Others[b]	62.6	96.9	40.2	81.4	19.9	42.6
Total	64.6		49.4		46.7	

a/ Bass < 100 mm long were primarily young of the year; those 100-200 mm long were primarily yearlings.

b/ Includes in decreasing order of abundance: yellow perch *(Perca flavescens)*, black and white crappie *(Pomoxis nigromaculatus* and *P. annularis)*, carp and goldfish *(Cyprinus carpio* and *Carrassius auratus)*, golden shiner *(Notemigonus crysoleucas)*, shorthead redhorse *(Moxostoma macrolepidotum)*, black and yellow bullhead *(Ictalurus melas* and *I. natalis)*, pumpkinseed *(Lepomis gibbosus)*, northern pike *(Esox lucius)*. Fish sampled only occasionally with seines include walleye *(Stizostedion vitreum)*, sauger *(S. canadense)*, white sucker *(Catostomus commersoni)*, longnose sucker *(C. catostomus)*, rock bass *(Ambloplites rupestris)*, channel catfish *(Ictaluras punctatus)*, and green sunfish *(Lepomis cyanellus)*.

TABLE 6. PETERSEN CATCH STATISTICS FOR AGE-1 AND OLDER SMALLMOUTH BASS IN THE TONGUE RIVER RESERVOIR, FALL 1976. (The 95% confidence intervals are in parentheses.)

	Area A + 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 [a]	1006 (496-1516)			4874 (3812-5936)		

	Area C								
	101-170 mm total length interval			171-220 total length interval			221-411 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)		
Population estimate for entire reservoir	9303 (7200-11,206)								

[a] Corrected for 0.9% age 0 fish in catch.

The estimated 9,023 smallmouth bass was 80 percent of the total bass fall population, while largemouth bass, estimated at 2,296, comprised the other 20 percent. The smallmouth bass standing crop, 1443 kg, was 84 percent of the total bass standing crop, while the largemouth bass standing crop, 272 kg, made up the other 16 percent. Expressed as a function of surface area during fall, the smallmouth bass population and standing crop was 13.0 fish/ha and 2.03 kg/ha, respectively, while the largemouth bass population and standing crop was 3.2 fish/ha and 0.38 kg/ha (Table 7).

The 1974 year class made up 73 percent of the 1976 smallmouth bass fall population, whereas the same year class of largemouth bass made up only 9 percent of the population of this species (Table 8). Fluctuations in strengths of year classes have been attributed to environmental conditions such as wind, food, water temperature, and water level fluctuation during egg, fry, and fingerling stages (Forney 1972; Latta 1963; Summerfelt 1975; Kramer and Smith 1962; von Geldron and Mitchell 1975). In view of the abundance in 1976 of smallmouth bass of the 1974 year class, it can be assumed that smallmouth bass produced a large fingerling crop during 1974. However, largemouth bass made up 81 percent of the 628 fingerlings seined in 1974 (A. A. Elser, Montana Department of Fish and Game, unpublished data). This large apparent change in abundance suggests either that largemouth bass had a much higher mortality rate than smallmouth bass between the fingerling and yearling stages (largemouth bass made up only 11 percent of the yearling bass seined during 1975) or that fingerling largemouth bass were more vulnerable to the collecting gear than fingerling smallmouth bass (Table 9). The 1976 fall population estimate for the 1974 year class consisted of 3 percent largemouth bass and 97 percent smallmouth bass. The mortality pattern for the 1973 year class was similar to that of the 1974 year class. The 461 fingerlings seined during 1973 were 88 percent largemouth bass and 12 percent smallmouth bass (A. A. Elser, Montana Department of Fish and Game, unpublished data) whereas the 1976 fall population estimate of the 1973 year class consisted of 10 percent largemouth bass and 90 percent smallmouth bass (Table 8). A greater mortality of age-2 and older largemouth bass compared with that of smallmouth bass may also contribute to the dominance of smallmouth bass in the older bass populations. Survival of both largemouth bass and smallmouth bass fingerlings from fall 1975 to fall 1976 was similar; 36 percent of the fingerlings seined in 1975 were smallmouth bass while 31 percent of the yearlings seined (Table 9) and 44 percent of the fall population estimate of yearlings in 1976 were smallmouth bass (Table 8).

Mortality

During spring 1976, 1,551 age-2 and older smallmouth bass were marked, and 2,068 were captured during the fall; 11.4 percent of which had marks. The resultant estimate for the spring age-2 and older smallmouth bass population in the entire Tongue River Reservoir was 13,549 (11,896-15,202) fish (Table 10). The fall population estimate of age-2 and older smallmouth bass (7,695) was 43 percent smaller than the spring estimate. Total summer mortality of age-2 and older smallmouth bass, estimated from a decrease in marked fish from spring to fall was 40 percent (Table 11).

TABLE 7. POPULATION AND STANDING CROP ESTIMATES FOR AGE-1 AND OLDER SMALLMOUTH BASS AND LARGEMOUTH BASS IN THE TONGUE RIVER RESERVOIR, FALL 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 parentheses.)

	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)

TABLE 8. AGE STRUCTURE OF THE BASS POPULATIONS AND STANDING CROPS IN THE TONGUE RIVER RESERVOIR, FALL 1976.

		Smallmouth Bass				Largemouth Bass			
		Fish		Weight		Fish		Weight	
Age	Year Class	No.	%	kg	%	No.	%	kg	%
1	1975	1508	16.4	65	4.5	1954	84.8	74	27.3
2	1974	6700	72.8	1009	70.0	199	8.6	73	26.9
3	1973	818	8.9	235	16.3	89	3.9	46	17.0
4	1972	62	0.7	37	2.6	18	0.8	17	6.3
5	1971	98	1.1	76	5.3	33	1.4	41	15.1
6	1970	17	0.2	19	1.3	6	0.3	9	3.3
7	1969					6	0.3	11	4.1
Total		9203		1441		2305		271	

TABLE 9. FISHES CAUGHT BY ALONGSHORE SEINING IN THE TONGUE RIVER RESERVOIR, 1975 AND 1976. (Number of seine hauls is shown in parenthesis.)

Species and Total length (mm)[a]	1975 August 14 - September 5 (62)		1976 July 30 - September 5 (60)	
	No. per haul	%	No. per haul	%
Smallmouth bass				
< 100	4.0	9.6	2.1	3.3
100-200	2.5	6.0	0.4	0.7
Largemouth bass				
< 100	7.0	16.7	6.4	10.4
100-200	0.3	0.8	0.9	1.4
Others	28.2	67.1	52.1	84.2
Total	42.0		61.9	

[a] Bass < 100 mm long were primarily young of the year; those 100-200 mm long were primarily yearlings.

TABLE 10. PETERSEN CATCH STATISTICS FOR ESTIMATING SMALLMOUTH BASS POPULATIONS IN THE TONGUE RIVER RESERVOIR, SPRING 1976. (Data are 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.)

	Total fish marked	Total fish captured	Total marked fish captured
Area A	23	46	1
Area B	431	1212	120
Area C	1097	810	115
Total	1551	2068	236
Population Estimate	13,549 (11,896-15,202)		

Movement and seasonal population changes of smallmouth bass, 1976

During the spring and early summer 1,709 smallmouth bass two years and older were handled during three electrofishing runs along the shoreline in areas B and C. The population estimates for area C and B were 4,063 and 2,048 bass (Table 12).

During the spring and early summer 454 and 1,097 age-2 and older smallmouth bass were marked in areas A and B combined and C, respectively. During the fall, the estimated number (538) of right pelvic fin clipped fish in areas A and B combined increased, while the number in area C (398) significantly decreased (Table 11). An estimated movement of 980 fish out of area C and into areas A and B combined (40.0 percent of the spring smallmouth bass population in area C after mortality) would account for the increased number of marked fish in areas A and B combined. This was calculated by allowing for mortality and assuming similar behavior between marked and unmarked fish. This resulted in a population of 1,469 age-2 and older fish in area C which is 1,005 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 2,216 fish, 2,679 less than the fall estimate of areas A and B combined. This suggests 3,684 smallmouth bass were added to the fall population from area A. When accounting for mortality, 6,105 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 7,438 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 12). 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 indicated a net movement (spring to fall) of 1,005 and 2,679 smallmouth bass out of area A and into areas C and B, respectively; a small percent of the 2,679 fish remained in area A (Table 10). During the same period, a net 980 fish moved out of area C and into area B. This, along with a 39.7 percent mortality, accounts for the 139 percent increased population in area B and the 39 percent reduced population in area C.

Tagged smallmouth bass also demonstrated a pattern of downstream movement with declining water levels. Of nine smallmouth bass tagged in areas A and B during the spring and summer of 1976 and recaptured during the fall of the same year, five moved downstream toward the dam, one moved upstream, and three showed no significant movement (Fig. 5). Of 50 fish tagged in these two areas during the fall and recaptured the same season, 16 moved downstream, one upstream, and 33 showed no significant movement. Four fish moved out of area A into area B, and two moved from area B into area C (Figures 5 and 6). Overall, average detectable movement downstream and upstream was 2.0 and 2.5 km, respectively.

TABLE 11. CALCULATIONS FOR SUMMER MORTALITY OF AGE-2 AND OLDER SMALLMOUTH BASS, 1976. (Fish were marked in the spring and recaptured in the fall.)

Area	M[a]	C[b]	R[c]	R/C	Number Remaining (R/C) X N	Mortality
A + B	454	1175	121	0.1030	538	1-(936/1551)
C	1097	773	115	0.1608	398	
Total	1551				936	0.397

[a] M = Number age-2 and older fish marked in spring.

[b] C = Total number of age-2 and older fish captured in fall.

[c] R = Number of marked fish captured.

TABLE 12. SCHUMACHER AND ESCHMEYER CATCH STATISTICS FOR AGE-2 AND OLDER SMALLMOUTH BASS IN TWO AREAS OF THE TONGUE RIVER RESERVOIR, 1976.
(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.

Fish No.	Date Tagged	Date Recaptured
1	5/30	9/15
2	6/14	8/16
Unnumbered	summer	fall

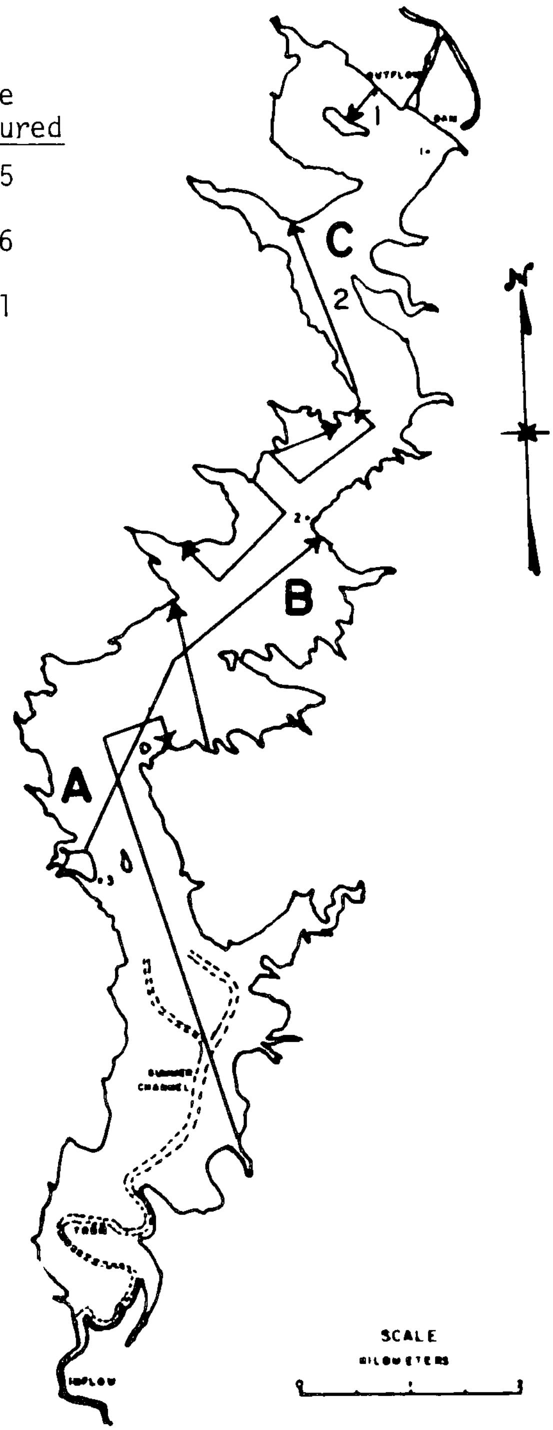

Figure 5. Movement within the Tongue River Reservoir of smallmouth bass marked in the spring or summer and recaptured during the summer or fall, 1976.

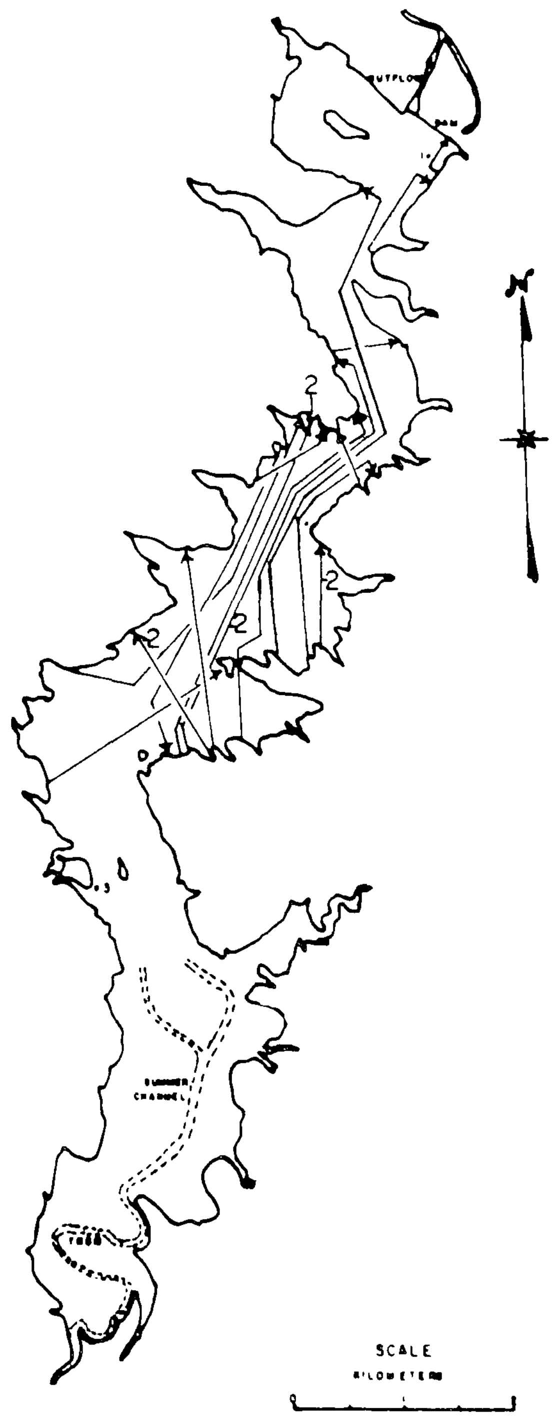

Figure 6. Movement of smallmouth bass marked and recaptured in the Tongue River Reservoir during fall (8/30 - 9/16), 1976. (Number indicates more than one fish moved in a similar direction.)

Only four fish were recaptured in the fall which had been tagged in area C in the spring or summer of 1976. None of these four fish moved significantly from their tagging location (Figure 5). Only three of 11 fish, which were tagged in area C during the fall and recaptured the same season, showed measurable movement. One moved across the reservoir and the other two moved an average of 0.6 km downsteam (Figure 6).

SECTION VII

DISCUSSION

Age and growth

Growth of smallmouth bass in the Tongue River Reservoir was above average for fish of this species in a northern water body. Though smallmouth bass growth was slower than in Minnesota it was faster than for fish of this species in Wisconsin (Bennett 1938), Maine (Watson 1955), or Michigan (Latta 1963). The length-weight relationship for smallmouth bass in the Tongue River Reservoir was similar to those for fish from Clear Lake, Wisconsin (Marinac 1976) and Tadenac Lake, Ontario (Turner and MacCrimmon 1970).

Growth of largemouth bass in the Tongue River Reservoir was faster than that reported for this specie in Wisconsin (Bennett 1937), Minnesota (Kuehn 1949), or Montana (Brown 1952; Brown and Logan 1960). Lengths of older largemouth bass were similar to those reported by Tharratt (1966) in California. Largemouth bass in the reservoir were heavier at similar lengths than those in Beaver and Bull Shoals Reservoirs, Missouri (Bryant and Houser 1971) and similar to those in Gladstone Lake, Minnesota (Maloney et al. 1962).

Excellent growth of basses in the Tongue River Reservoir may be correlated to nutrient levels, low population densities, fluctuating water levels, and for smallmouth bass, recent exploitation of a new habitat. Whalen and Leathe (1976), who studied primary and secondary production in the reservoir, concluded that the reservoir is a moderately productive system. Cooper et al. (1963) observed that growth of largemouth bass increased when densities decreased in a Pennsylvania pond. The largemouth bass population in the Tongue River Reservoir research represents only 3 percent of the mean (by surface area) for 170 U.S. reservoirs, whereas the smallmouth bass population equaled the average for 45 reservoirs (Jenkins 1975). Heman et al. (1969) reported that increased growth of largemouth bass coincided with drawdown of a central Missouri reservoir. Summer drawdown, after spring runoff, reduced the surface area of the Tongue River Reservoir by 44 percent from spring to fall 1976.

Growth (total length at annulus) of smallmouth bass was faster in areas A and B than in area C, possibly because forage fish were more abundant in A and B. Results of alongshore seining (which collected fish generally smaller than 150 mm in length) indicated that area A had the highest density of fish (64.6 fish per haul), whereas area C had the lowest (46.7 per haul; Table 5). As summer progressed, surface area decreased faster in areas A and B than in C, concentrating fish more in A and B. Areas A and B had a larger percentage of low-gradient littoral zones which usually supported a higher concentration of forage fish than did the steep-gradient areas common in area

C. Length-weight relationships and condition factors (Table 4) also indicated the superior condition of fish in areas A and B.

Reproductive success

Smallmouth bass fingerlings appeared to be three times more abundant in area C than in area B, while smallmouth bass fingerlings were never collected in area A (Table 2). This can possibly be related to turbidity levels in the three areas; area A had the highest turbidities, C the lowest and B intermediate. Cleary (1956) noted that streams which remained turbid for long periods seldom produced smallmouth bass fingerlings or good smallmouth bass fishing. Area A remained turbid throughout the year, but turbidities in areas B and C decreased from spring to fall. Walters (1974) suggested that unsuccessful smallmouth bass reproduction in Missouri impoundments was related to a lack of suitable substrate. Since area A was not completely devoid of pebbles and cobbles (14 percent of the dominant shoreline substrate), lack of suitable substrate can probably be ruled out as the major factor limiting smallmouth bass reproduction in this area of the reservoir.

Largemouth bass fingerlings were found in all three areas of the reservoir but were 3.1 and 14.1 times more abundant in areas B and C, respectively, than in area A (Table 2). Buck (1956) demonstrated a similar inverse relationship between levels of turbidity in farm ponds and reproductive success of largemouth bass. Apparently, largemouth bass can reproduce, although not prolifically, in higher turbidities than can smallmouth bass.

Population and standing crop

Although largemouth bass were initially stocked in 1964 and smallmouth bass were not documented in the Tongue River Reservoir until 1972, smallmouth bass dominated the bass population (80 percent smallmouth bass) and standing crop (84 percent smallmouth bass) during the fall of 1976. This relative abundance is just the opposite of the average in 26 U.S. reservoirs which contained largemouth (66 percent), spotted (22 percent), and smallmouth bass (12 percent) (Jenkins 1975). Bennett and Childers (1957) and Walters (1974) noted a preponderance of largemouth bass over smallmouth bass when they occurred together in a pond environment. These differences in abundance may be attributed to inter-specific competition and/or to greater habitat suitability for one species during any one or more of the life stages.

Bass habitat in the Tongue River Reservoir more closely resembles that in smallmouth bass lakes described by Belding (1926) and Hubbs and Bailey (1938), than that of largemouth bass lakes described by Carlander (1975). Smallmouth bass lakes were characterized by a surface area of over 40 ha, clear water, scanty vegetation, large areas of rock and gravel, a depth not less than 6 to 9 m, and moderate summer temperature. The Tongue River Reservoir meets these specifications in areas B and C. Area A, the inflow section, does not meet the criteria for water clarity, large areas of rock and gravel, and (except during spring and early summer) depth. Area A was inhabited by smallmouth bass in spring and summer but moved into area B when water levels declined in late summer. Largemouth bass habitat in northern lakes is typified by shallow weedy areas. Due to extreme water level fluctuations, aquatic vegetation is lacking in the Tongue River Reservoir, and terrestrial vegetation is flooded only for a short period in early summer. Rideout and Oatis (1975) noted a change in species composition in Quabbin Reservoir, a fluctuating impoundment in Massachusetts, similar to that observed in the Tongue River Reservoir. Largemouth bass dominated the catch in Quabbin Reservoir during the 15th to 24th year of impoundment but smallmouth bass increased markedly in abundance and became heavily dominant from the 25th through 34th year. The largemouth bass population remained almost unchanged during this period. They attributed this change in relative abundance to the preference of smallmouth bass for the cool, clean water and rubble shoreline habitat and to their greater tolerance of water level fluctuations. They also noted that smallmouth bass were never stocked in the reservoir and probably entered from an adjacent pond. This most probably also occurred in the Tongue River Reservoir.

Rawstron and Hashagen (1972) proposed that competition between smallmouth and largemouth basses may have increased relative abundance of smallmouth bass in Merle Collins Reservoir, an irrigation impoundment in California. They implied that competition had its greatest influence during the first year of life. Competition during the first summer of life was not the cause of a comparatively much higher mortality of largemouth bass than smallmouth bass which occurred after the first fall of life and probably before the second fall.

Perhaps the major factor contributing to the observed relative abundance in the Tongue River Reservoir is that preferred smallmouth bass habitat (rubble and gravel shoreline) was abundant, while preferred largemouth bass habitat (shallow areas with aquatic vegetation) was almost nonexistent. This may explain the much greater mortality of largemouth bass than smallmouth bass from the fingerling to yearling stage. Even though fry and fingerling production was probably high in 1974, the limited habitat available for yearling largemouth bass (shallow weedy areas) may have prevented their survival in representative numbers. Perhaps this need for aquatic vegetation by largemouth bass can be correlated to the observation by Rideout and Oatis (1975) that smallmouth bass are more tolerant to water fluctuations than largemouth bass.

Habitat suitability rather than interspecific competition is probably the controlling factor for the observed bass abundance in the Tongue River Reservoir. Competition may be a significant factor only because largemouth bass must compete in habitat less than optimum for its needs. Munther (1970) documented that smallmouth bass seek rocky areas during winter which provide hiding areas beneath the substrate. In the Tongue River Reservoir there were concentrations of smallmouth bass over such areas during fall. Perhaps largemouth bass have similar needs that are tied to vegetation rather than substrate. This may be especially critical during the first winter of life. The fact that largemouth bass was the dominant bass specie in other environments (Jenkins 1975; Bennett and Childers 1957; Walters 1974) also suggests that habitat suitability is of prime concern.

Food did not appear to be a limiting factor for either species. Age and growth of all ages of both species of bass was excellent.

Survival of largemouth bass and smallmouth bass of the 1975 year class from the fingerling to yearling stages was similar. Possibly largemouth 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. Large withdrawals of water during the fall of 1975 (to facilitate dam repairs) resulted in low water levels which may have affected relative survival of the 1975 year class.

Mortality

The total estimated summer mortality (40 percent) of age-2 and older smallmouth bass in the Tongue River Reservoir was close to the range of annual total mortalities (43 to 66 percent) for six studies cited by Coble (1975). Clady (1977) believed that 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 percent for smallmouth bass from September to May, whereas annual natural mortality was 60 percent. 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 was similar to that found by Clady (1977). Perhaps the habit of smallmouth bass of becoming inactive beneath the substrate at temperatures lower than 7.8 C (Munther 1970) keeps winter mortality low. This period of winter smallmouth bass inactivity was evident in the Tongue River Reservoir as only one smallmouth bass was known to have been caught by fishermen during two winters of creel census (A. A. Elser, Montana Fish and Game Department, unpublished data).

Movement and seasonal population changes of smallmouth bass

Tag returns indicated a downstream movement of smallmouth bass during the late summer and fall. This movement coincided with a reduction in surface area particularly impacting habitat in upstream areas. Surface area declined by 45, 30, and 20 percent from spring to fall in areas A, B, and C, respectively. Also, much of the remaining surface area in area A was shallow mud flats not suitable for smallmouth bass. Much of the observed movement of bass may have been in response to deteriorating habitat. Fajen (1962) noted that smallmouth bass were less faithful to a particular home range, usually one pool, in two Ozark streams when shifting gravel threatened the security of the pool.

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 affected by water levels (area C).

Possible reasons for a net movement of fish out of area C and into area B are 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, Idaho and Oregon. 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 and boulder substrate with a large amount of interstitial space were observed in the Tongue River Reservoir, especially during the fall. In the laboratory, 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 in the fall.

SECTION VIII

POTENTIAL IMPACTS OF SURFACE COAL MINING

Surface run-off water in the immediate vicinity of the Decker Mine, and subsurface water resulting from disturbing the aquifer, are collected within the Mine in a sedimentation pond system. The sedimentation pond water is reused for dust control and for irrigation onto reclaimed mine spoils; excess water is pumped onto the flood plain of the Tongue River at the upper end of the Reservoir.

Turbak et al. (in press) have studied the quality of the settling pond water, including the heavy metals arsenic, cadmium, lead, mercury, and selenium, and data are reported for the mine effluent water for five dates from July 1976 to April 1977. Concentrations ranged from 1.1 to 1.9 μg/liter for arsenic and <1 to <5 for cadmium, both of these below the criteria published by EPA (1977). Reported concentrations for lead were <0.01 to <0.1 mg/liter and for selenium were <0.03 to 0.5 μg/liter. No specific numerical criteria for these two metals have been provided by EPA (1977); although it is recommended that acceptable concentrations be based on 96-hr LC50 values for sensitive resident aquatic species. The reported concentrations for mercury, 0.11 to 0.87 μg/liter, are in excess of the EPA (1977) criterion of 0.05 μg/liter, however these criteria are for receiving waters, not the discharge itself.

Additional data on mercury concentrations in the mine effluent between October 1975 and August 1976 have been reported by Phillips (1978); based on reported analyses performed by the Montana Department of Health and Environmental Sciences, mercury concentrations ranged between 1.2 and 335 μg/liter. Phillips also reported concentrations of mercury in the Tongue River below the mine effluent at this same time as ranging from <0.2 to 2.3 μg/liter.

The most extensive data available on the water chemistry of the Tongue River in the region of the Decker Mine have been reported by Whalen (1979), who studied the chemical limnology of the reservoir. Whalen has considered the potential impact on the river and reservoir of the mine discharge, and has extrapolated from his data to consider also the impact from the proposed expanded mine areas. Water chemistry from Whalen are presented in Tables 13 and 14. Whalen has calculated the average annual discharge of the mine to be less than 0.1 percent of the Tongue River flow at point of receipt. On the basis of the values obtained from the chemical parameters measured both in the receiving water and present mine discharge, Whalen has concluded that the impact of the mine water discharge on the Tongue River is and will be negligible for those parameters measured, with the caveat that an unusually dry

TABLE 13. AVERAGES AND RANGES (IN PARENTHESES) OF SOME CHEMICAL AND PHYSICAL PARAMETERS OF THE TONGUE RIVER RESERVOIR, NOVEMBER 1975 TO NOVEMBER 1976.[a]

Parameter	Station 1[b] Reservoir Above Dam	Station 2 Mid-Reservoir	Station 3 Reservoir Upper region
Ca^{++} (meq/ℓ)	2.86 (1.26-3.80)	2.79 (1.30-4.31)	2.81 (1.09-3.63)
Mg^{++} (meq/ℓ)	2.99 (0.96-4.29)	2.91 (0.84-4.59)	2.99 (0.79-3.81)
Na^{++} (meq/ℓ)	1.25 (0.34-1.92)	1.23 (0.29-22.7)	1.26 (0.28-2.02)
K^{+} (meq/ℓ)	0.10 (0.04-0.16)	0.10 (0.04-0.16)	0.10 (0.03-0.13)
Total alkalinity (meq/ℓ $CaCO_3$)	3.70 (1.92-4.70)	3.59 (1.68-5.62)	3.69 (1.56-4.71)
$SO_4^{=}$ (meq/ℓ)	3.44 (0.81-5.18)	3.35 (0.66-6.24)	3.37 (0.54-5.27)
Cl^{-} (meq/ℓ)	0.08 (0.03-0.12)	0.08 (0.03-0.13)	0.08 (0.03-0.12)
SiO_2 (mg/ℓ)	5.6 (1.4-11.8)	5.7 (1.1-10.0)	6.8 (2.5-13.0)
NH_3-N (μg/ℓ)	24 (0-236)	18 (0-142)	21 (0-220)
NO_3-N (μg/ℓ)	27 (0-204)	26 (0-187)	27 (0-47)
NO_2-N (μg/ℓ)	3 (0-20)	3 (0-10)	3 (0-10)
PO_4-P (μg/ℓ)	10 (0-100)	8 (0-77)	12 (0-27)
Total-P (μg/ℓ)	40 (16-144)	41 (10-109)	71 (37-260)
Spec. cond. (μmhos/cm @25 C)	660 (246-929)	645 (221-1032)	654 (197-948)

TABLE 13. Continued.

Parameter	Station 1[b/] Reservoir Above Dam	Station 2 Mid-Reservoir	Station 3 Reservoir Upper region
pH	8.4 (7.5-8.9)	8.5 (7.5-9.0)	8.4 (7.9-9.0)
Turbidity (JTU)	7.3 (1.9-24)	8.6 (1.3-32)	20.3 (5.5-62)
Temperature (C)	10.6 (1.2-23.5)	10.9 (1.2-23.8)	11.4 (1.2-23.9)
Dissolved Oxygen (mg/ℓ)	8.5 (0.2-13.4)	9.3 (0.8-19.6)	10.1 (2.5-17.6)

[a/] From Whalen (1979).

[b/] Station locations shown in Figure 2.

TABLE 14. AVERAGE VALUES OF SELECTED PARAMETERS MEASURED IN THE DECKER MINE DISCHARGE WATER AND IN THE TONGUE RIVER ABOVE AND BELOW THE MINE DISCHARGE, JUNE 1975 TO NOVEMBER 1976. (All parameters expressed as mg/liter unless otherwise noted.)[a]

Parameter	Tongue River above mine	Mine discharge	Tongue River below mine
pH	8.6	8.5	8.4
Dissolved oxygen	10.1	9.8	9.8
Spec. Cond. (μmhos/cm @ 25 C)	693	1498	696
Turbidity (JTU)	15	18	14
Temperature (C)	14.7	14.9	14.7
Organic carbon	4.9	5.2	5.0
CO_3	4	12	4
HCO_3	238	597	240
Total alkalinity (as $CaCO_3$)	202	509	203
SiO_2	7.4	13.0	7.4
Fe	0.028	0.021	0.024
Cl	2.8	6.8	2.7
F	0.33	1.22	0.33
SO_4	166.4	295.1	166.4
Ca	61.2	33.1	61.0
Mg	37.8	42.4	37.8
Na	30.5	253.3	30.4
K	3.9	7.7	3.9
NO_2-N (μg/ℓ)	3	37	3
NO_3-N (μg/ℓ)	31	287	30

TABLE 14. Continued.

Parameter	Tongue River above mine	Mine discharge	Tongue River below mine
NH_3-N (μg/ℓ)	16	282	16
Total Kjehldahl nitrogen (μg/ℓ)	326	674	333
PO_4-P (μg/ℓ)	20	6	18
Total-P (μg/ℓ)	62	38	60
Sodium absorption ratio (SAR)	0.78	6.88	0.78

[a/] From Whalen (1979).

water year could alter this prediction. It should be noted that Whalen did not report concentrations of heavy metals.

The present study has concerned itself with the movement, age and growth, and life histories of largemouth bass and smallmouth bass in the Tongue River Reservoir. Any effect on these fishes as a result of altered water chemistry within the reservoir is not apparent from the results of the study. With the intensification of coal mining planned for this area, we believe that additional information is needed to plan for adequate safeguards to protect the aquatic biota of the Tongue River drainage system. Information is now available which will provide baseline data against which data from future studies may be compared.

An incremental increase in recreational use of the river and reservoir will undoubtedly result from expanded mining or coal conversion operations. These waters are currently subject to light fishing pressure but a human population influx could alter use patterns and fishing intensity.

In summary, we believe the following aspects should be studied in some detail in the near future:

1. Changes in water quality of the reservoir (salinity, turbidity, temperature, nutrient loading, heavy metal loading).

2. Changes in water quantity (dewatering for offstream storage and use, and resultant reductions in reservoir storage levels), particularly in area A.

3. Changes in fishing pressure and recreational use (including conflicts among various user types).

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

Population parameters of smallmouth bass (*Micropterus dolomieui*) and largemouth bass (*M. salmoides*) were studied during 1975 and 1976, before expansion of surface coal mining adjacent to the Tongue River Reservoir in southeastern Montana. Reproductive success, as determined by alongshore seining, varied in different areas of the reservoir and may be correlated to turbidity. Population estimates were obtained at night during spring and fall 1976 with boat electrofishing gear. For yearling and older smallmouth bass the fall population of 13.0 fish/ha and the standing crop of 2.03 kg/ha represented 80 and 84 percent of the totals for basses in the reservoir. The largemouth bass population and standing crop during fall 1976 was 3.2 fish/ha and 0.32 kg/ha. The dominance by smallmouth bass of all year classes for both species except age-1, was attributed to a much higher mortality of under-yearlings among largemouth bass. This higher mortality of largemouth bass may be correlated to a lack of shoreline vegetation in the reservoir. Summer mortality of age-2 and older smallmouth bass, estimated from the reduction in numbers of marked fish, was about 40 percent. Smallmouth bass growth and condition were better in the upper than lower end of the reservoir; the difference may be due to forage fish availability. Growth and length-weight relationships were above average for both species when compared with basses in other northern waters, indicating no noticeable effect from nearby surface coal mine operations at the time of the study.

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