



Black bass populations of the Tongue River Reservoir, Montana
by Russell Frank Penkal

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE
in Fish and Wildlife Management
Montana State University
© Copyright by Russell Frank Penkal (1977)

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 dolomieu*) was 181% larger than that of largemouth bass (*Micropterus salmoides*), large-mouth 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.

STATEMENT OF PERMISSION TO COPY

In presenting this thesis in partial fulfillment of the requirements for an advanced degree at Montana State University, I agree that the Library shall make it freely available for inspection. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by my major professor, or, in his absence, by the Director of Libraries. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Signature Russell F. Penhal

Date April 7, 1977

BLACK BASS POPULATIONS OF THE TONGUE
RIVER RESERVOIR, MONTANA

by

RUSSELL FRANK PENKAL

A thesis submitted in partial fulfillment
of the requirements for the degree

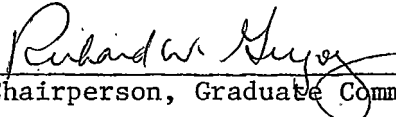
of

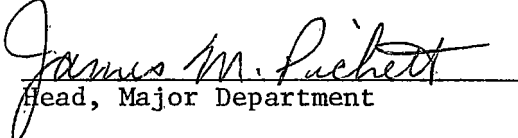
MASTER OF SCIENCE


in

Fish and Wildlife Management

Approved:


Chairperson, Graduate Committee


Head, Major Department


Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

April, 1977

ACKNOWLEDGMENT

I wish to express my gratitude toward those who assisted in this study. Dr. Richard W. Gregory directed the study and assisted in preparation of the manuscript. Drs. Calvin M. Kaya, John C. Wright and Martin A. Hamilton critically reviewed the manuscript. Victor Riggs and Janet Amestoy's field assistance was invaluable as they donated many sleepless nights for electrofishing. William Gardner, John Fraley and other graduate students also aided in the field work. Allen Elser, Montana Department of Fish and Game, Region 7, provided a large portion of the field equipment as well as assistance in the field. Decker Coal Company provided facilities for the research station. The statistical center at Montana State University aided in derivation of equations for confidence intervals of population estimates. My wife, Mary Jo, supplied needed encouragement and did the rough typing.

This study was primarily funded by the U.S. Environmental Protection Agency, Duluth, Minnesota, Research Grant No. R-803950, to Fisheries Bioassay Laboratory at Montana State University. Montana Department of Fish and Game funded the final portion of the study.

TABLE OF CONTENTS

	Page
VITA	ii
ACKNOWLEDGMENT	iii
LIST OF TABLES	vi
LIST OF FIGURES	x
ABSTRACT	xii
INTRODUCTION	1
DESCRIPTION OF STUDY AREA	2
METHODS	17
RESULTS	24
Shoreline Seining	24
Reproductive Success	24
Abundance of Forage Species	26
Age and Growth	27
Annulus Formation	27
Back Calculated Lengths and Weights	27
Fingerling Growth	39
Condition Factors	39
Population and Standing Crop	47
Age Structure	53
Population	53
Standing Crop	56
Mortality	59
Movement and Seasonal Population Changes	59
Smallmouth Bass	59
Largemouth Bass	65
Tag Loss	65
DISCUSSION	67
Reproductive Success	67
Age and Growth	72

TABLE OF CONTENTS
(Continued)

	Page
Population and Standing Crop	78
Mortality	84
Movement and Seasonal Population Changes	85
Smallmouth Bass	85
Largemouth Bass	87
Tag Loss	87
CONCLUSIONS	88
SUMMARY	89
APPENDIX	92
LITERATURE CITED	105

LIST OF TABLES

Table	Page
1. MORPHOMETRIC DATA OF THE TONGUE RIVER RESERVOIR AT SPILLWAY ELEVATION (1043.7 m)	5
2. SPRING AND FALL SHORELINE LENGTHS AND SURFACE AREAS IN THE TONGUE RIVER RESERVOIR, 1976. PERCENT REDUCTION IN PARENTHESIS	6
3. SUBSTRATE ANALYSIS OF THE TONGUE RIVER RESERVOIR . . .	10
4. RANGES AND MEANS OF SELECTED PHYSICAL AND CHEMICAL PARAMETERS FROM THREE AREAS OF THE TONGUE RIVER RESERVOIR, AUGUST, 1975 TO SEPTEMBER, 1976	12
5. SHORELINE SEINING BY AREAS FOR 1975 AND 1976 COMBINED, TONGUE RIVER RESERVOIR	24
6. SHORELINE SEINING FOR 1975 AND 1976 WITH ALL AREAS COMBINED AND WEIGHTED EQUALLY, TONGUE RIVER RESERVOIR	25
7. SMALLMOUTH BASS BACK CALCULATED LENGTHS (mm) AND WEIGHTS (g), TONGUE RIVER RESERVOIR, 1976	29
8. AVERAGE ANNUAL TOTAL LENGTH INCREMENTS IN MM OF BLACK BASS. NUMBER OF SCALES EXAMINED IN PARENTHESIS	31
9. LARGEMOUTH BASS BACK CALCULATED LENGTHS (mm) AND WEIGHTS (g), TONGUE RIVER RESERVOIR, 1976	33
10. BACK CALCULATED TOTAL LENGTHS (mm) AND WEIGHTS (g) OF BLACK BASS IN THE ENTIRE TONGUE RIVER RESERVOIR	36
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 SUPERSCIPT ARE SIGNIFICANTLY DIFFERENT	40

LIST OF TABLES
(Continued)

Table	Page
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	41
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	42
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	49
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	50
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	51
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	52

LIST OF TABLES
(Continued)

Table	Page
18. AGE STRUCTURE OF BLACK BASS IN THE TONGUE RIVER RESERVOIR, FALL 1976	54
19. AGE STRUCTURE OF SPRING AND FALL SMALLMOUTH BASS POPULATIONS EXCLUDING AGE-1 FISH	55
20. BLACK BASS STANDING CROP ESTIMATES BY AGE, TONGUE RIVER RESERVOIR, FALL 1976	57
21. AGE STRUCTURE OF SPRING AND FALL STANDING CROPS OF SMALLMOUTH BASS EXCLUDING AGE-1 FISH	58
22. GROWTH OF SMALLMOUTH BASS IN VARIOUS WATERS	73
23. GROWTH OF LARGEMOUTH BASS IN VARIOUS WATERS	74
24. POPULATION (number/ha) AND STANDING CROP (kg/ha) ESTIMATES OF SMALLMOUTH BASS FROM VARIOUS WATERS	79
25. POPULATION (number/ha) AND STANDING CROP (kg/ha) ESTIMATES OF LARGEMOUTH BASS FROM VARIOUS WATERS	80
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	95
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	96
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	97

LIST OF TABLES
(Continued)

Table	Page
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	98
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	99
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	100
32. FALL PETERSEN CATCH STATISTICS FOR SMALLMOUTH BASS POPULATION ESTIMATES IN THE ENTIRE TONGUE RIVER RESERVOIR, 1976. THE 95% CONFIDENCE INTERVALS ARE IN PARENTHESIS	101
33. PETERSEN CATCH STATISTICS FOR ESTIMATING SPRING SMALLMOUTH 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	102
34. ESTIMATED AVERAGE LENGTH AND WEIGHT OF SMALLMOUTH BASS AT TIME OF CAPTURE	103
35. CALCULATIONS FOR SURVIVAL OF AGE-2 AND OLDER SMALLMOUTH BASS BASED ON ESTIMATED REDUCTION OF CLIPPED FISH FROM SPRING TO FALL	104

LIST OF FIGURES

Figure	Page
1. Water storage history, Tongue River Reservoir (Montana Dept. of Nat. Resources unpublished data) . . .	4
2. The three study areas of the Tongue River Reservoir . . .	7
3. Turbidity levels in three areas of the Tongue River Reservoir (Whalen unpublished data)	9
4. Discharge of the Tongue River above the Tongue River Reservoir (U.S.G.S. 1975 and U.S.G.S. unpublished data)	13
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)	14
6. Mean water temperature of the Tongue River Reservoir (Whalen unpublished data)	15
7. Seining locations on the Tongue River Reservoir . . .	18
8. Total length at annulus of smallmouth and largemouth bass in areas A, B, and C of the Tongue River Reservoir	30
9. Length-weight relationship of smallmouth bass, collected in the fall, in areas B and C of the Tongue River Reservoir.	32
10. Length-weight relationship of largemouth bass, collected in the fall, in three areas of the Tongue River Reservoir.	34
11. Total length of black bass at annulus in the Tongue River Reservoir	37
12. Length-weight relationship of largemouth (LMB) and smallmouth (SMB) bass in the Tongue River Reservoir	38

LIST OF FIGURES
(Continued)

Figure	Page
13. Condition versus total length regressions of smallmouth bass in areas A, B, and C of the Tongue River Reservoir	44
14. Condition versus total length regressions of largemouth bass in areas A, B, and C of the Tongue River Reservoir	45
15. Condition versus total length regressions of largemouth (LMB) and smallmouth (SMB) bass, Tongue River Reservoir	46
16. Movement of smallmouth bass marked in the spring or summer and recaptured during the summer or fall, 1976, Tongue River Reservoir	60
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	61

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 dolomieu*) 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 electro-fishing 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 dolomieu*) 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 km² (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 hm³ (U.S.G.S. 1975), but subsequent sedimentation has undoubtedly reduced this capacity to some extent. Average annual inflow and discharge is 459 hm³ and 414 hm³, 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

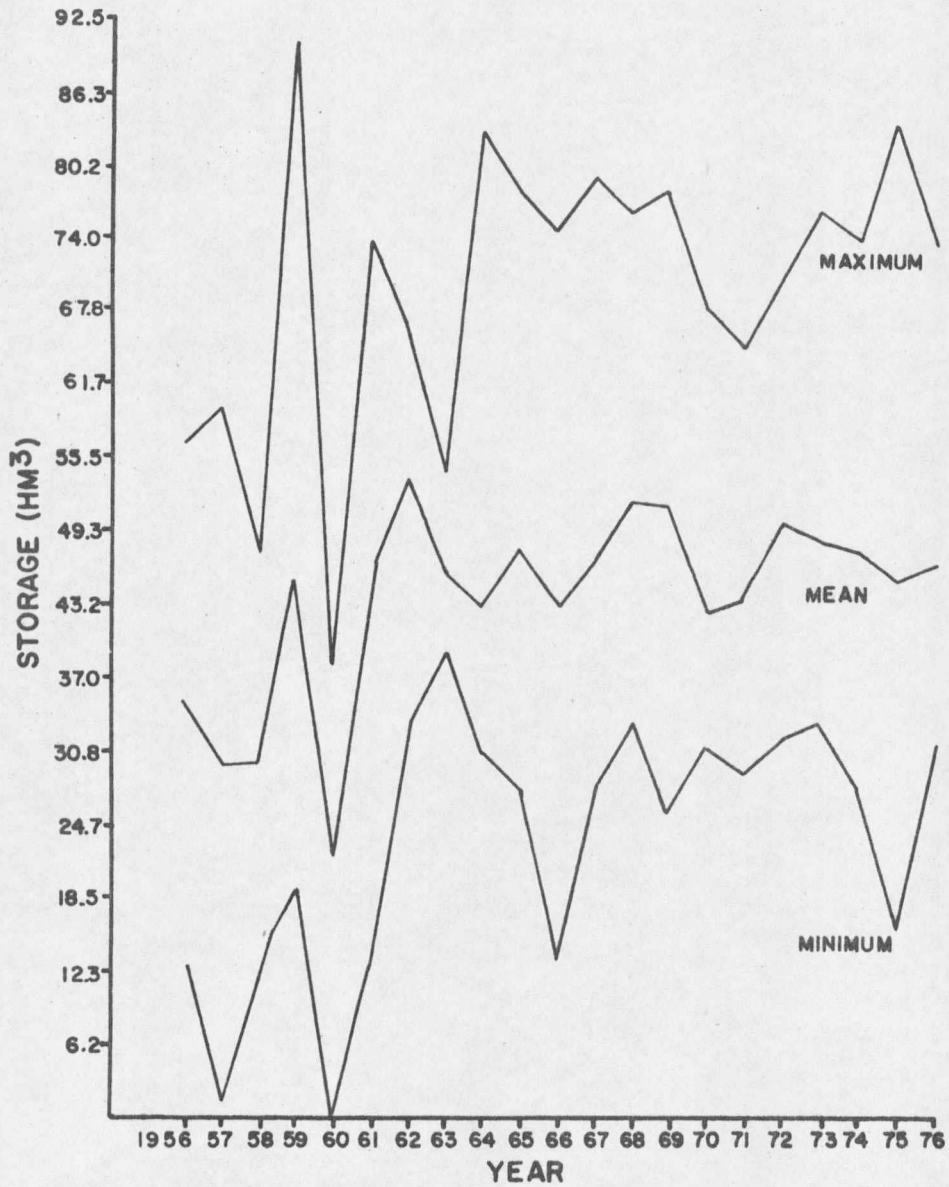


Figure 1. Water storage history, Tongue River Reservoir (Montana Dept. of Nat. Resources unpublished data).

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).

²Measured with a cartometer from topographic maps.

³Measured 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)

