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Investigations of Population Structure and Relative Abundance of Year-Classes of Buffalo Fishes, Ictiobus Spp., In Lake Sakakawea, North Dakota

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INVESTIGATIONS OF POPULATION STRUCTURE AND RELATIVE ABUNDANCE OF YEAR-CLASSES OF BUFFALO FISHES, *ICTIOBUS* SPP., IN LAKE SAKAKAWEA, NORTH DAKOTA

by
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This Thesis, submitted by David W. Willis in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, is hereby approved by the Faculty Advisory Committee under whom the work has been done.

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Date April 14, 1978

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TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

This study was undertaken to investigate the population and abundance of year-classes of the buffalo fishes in Lake Sakakawea, North Dakota. Fish used in this study were obtained from Grasteit Dakota Fisheries, a commercial fishing operation headquartered in Newtown, North Dakota.

Only bigmouth buffalo (Ictiobus cyprinellus) and smallmouth buffalo (Ictiobus bubalus) were collected during this study; no black buffalo (Ictiobus niger) were captured. The age and growth of these fish was found to be quite similar to that in other Missouri River mainstem reservoirs. The mean condition factor (K-TL) for the bigmouth was found to be 1.88 and for the smallmouth was found to be 1.83. These values are higher than any reported for the other mainstem reservoirs, and were probably due to the preponderance of large fish in our populations. The length-weight regression was calculated to be Log W = -3.63 + 2.60 log L for the bigmouths and Log W = -5.94 + 3.42 log L for the smallmouths.

Lake Sakakawea reached full pool for the first time in 1967. Year-classes before this time are strong for both species of buffalo, making up over 73% of the smallmouths and over 69% of the bigmouths that were aged. After this full pool elevation was reached there was a dramatic decrease in year-class strength due to loss of optimal spawning areas. An exception was the 1969 year-class, which was of moderate strength, probably due to the fact that water levels were 0.8 feet above the full pool elevation.

INTRODUCTION

Buffalo fishes are currently among the most important commercial fish in Lake Sakakawea (Berard, 1976). Little information exists for North Dakota populations and their growth and year-class composition need documentation while the older, pre-full pool fish are still alive. An analysis of year-class composition is also important because the reservoir reached full pool for the first time in 1967, and reproduction of buffalo fishes under reservoir conditions is controlled by fluctuating water levels and quality of spawning beds that are flooded at the time of spawning each year.

Water levels required for successful spawning, hatching, and survival of fishes in large multi-purpose reservoirs on the Missouri River are not uniformly available each year. Quality of spawning beds also is related to water levels, because buffalo fishes require submerged vegetation for best spawning success. After the reservoir reached full pool in 1967, submerged vegetation would be expected to be less available and reproduction less successful.

The purposes of this study are to 1) record year-class composition of buffalo fish in Lake Sakakawea, and 2) obtain information such as age and growth and length-weight relationships on these populations.

DESCRIPTION OF STUDY AREA

Lake Sakakawea is one of six reservoirs on the mainstream of the Missouri River. Fort Peck in Montana closed in 1938, Garrison Reservoir (Lake Sakakawea) in North Dakota closed in 1953, Lake Oahe in North and South Dakota closed in 1958, Big Bend Reservoir (Lake Sharpe) in South Dakota closed in 1963, Fort Randall Reservoir (Lake Francis Case) in South Dakota closed in 1952, and Gavins Point Reservoir (Lewis and Clark Lake) in South Dakota closed in 1955 (Neel, 1963).

Lake Sakakawea was created by the closing of Garrison Dam near Riverdale, North Dakota, on April 15, 1953 (personal communication, Eugene DeTeinne, 1977). It impounds the runoff from 180,940 square miles of the Missouri River basin (Hildebrand, 1967). The dam was constructed by the U.S. Army Corps of Engineers primarily for flood control and irrigation, with recreation, navigation, and hydro-electric power production being secondary objectives. This reservoir is the largest of the mainstream reservoirs, containing 24,500,000 acre-feet of water and a surface area of 326,000 acres when full to capacity (Neel, 1963). It is 200 miles long with an average width of three miles, a maximum depth of 180 feet, and a shoreline of approximately 1,600 miles (Duerre, 1965).

LITERATURE REVIEW

Distribution

Bigmouth

The bigmouth buffalo (Ictiobus cyprinellus) ranges from Saskatchewan and the Red River of the North drainages of the Canadian plains to the Ohio Valley; south through the central part of the Mississippi Valley to Alabama, Louisiana, and Texas. In the Great Lakes it has been recorded from western Lake Erie, where it is probably native (Hubbs and Lagler, 1964). Trautman (1957), however, reported that buffalo fish were stocked in western Lake Erie in 1920. Areas where the bigmouth has been recorded include the Missouri River and its reservoirs in Montana (Brown, 1971); the Missouri River drainage in South Dakota (Bailey and Allum, 1962); the Missouri River and its tributaries in Nebraska (Morris et al., 1974); Minnesota (Eddy and Underhill, 1974); Iowa (Harlan and Speaker, 1951); the Illinois and Mississippi Rivers in Illinois (Forbes and Richardson, 1920); Ohio (Wickliff and Trautman, 1939; Trautman, 1957); the Missouri and Mississippi drainages in Missouri (Pflieger, 1975); Kansas (Cross, 1967); Oklahoma (Moore, 1952); Tennessee (Kuhne, 1939); the Mississippi drainage in Texas (Knapp, 1953); Louisiana (Douglas and Davis, 1967); Mississippi (Cook, 1959); and the Tennessee River drainage in Alabama (Smith-Vaniz, 1968). The bigmouth buffalo has been successfully introduced into Arizona (Moore, 1957; Johnson and Minckley, 1972) and California (Evans, 1950). In Canada, the bigmouth buffalo has been reported in Ontario, Manitoba, and Saskatchewan (Scott and Crossman, 1973); from the Ontario side of Lake Erie (Scott, 1957); in southern Manitoba (Hinks, 1943); and in the lakes of the Qu'Appelle drainage in Saskatchewan (Johnson, 1963).

The presence of the bigmouth buffalo in North Dakota was reported by Dotson (1964). It has been recorded in the Red River of the North (Eigenmann, 1895; Copes and Tubb, 1966); Lake Tewaukon (Russell, 1975); the Sheyenne River (Peterka, 1977); the Cannonball River (personal communication, Robert Reigh, 1977); Heart Butte Reservoir (Duerre, 1969); Painted Woods Lake (Duerre, 1969): Lake Sakakawea (Benson, 1968); and the Missouri River and Lake Oahe (Duerre, 1965; Berard, 1973).

Smallmouth

The smallmouth buffalo (*Ictiobus bubalus*) ranges from the Great Plains portion of Hudson Bay of Canada to the Ohio River system in Pennsylvania; south through the Mississippi lowlands to the Gulf Coast and the northeastern coast of Mexico. In the Great Lakes region, it is known only from the St. Joseph River in southern Michigan and is perhaps now extirpated in the basin (Hubbs and Lagler, 1964). Areas where the smallmouth has been recorded include the Missouri and Yellowstone Rivers in Montana (Brown, 1971); the Missouri River drainage in South Dakota (Bailey and Allum, 1962); the Missouri River and its tributaries in Nebraska (Morris et al., 1974); Minnesota (Eddy and Underhill, 1974); the upper reaches of the Mississippi River in Iowa (Harlan and Speaker, 1951); the Illinois and Mississippi Rivers in Illinois (Forbes and Richardson, 1920); Ohio (Trautman, 1957); the Missouri and Mississippi drainages in Missouri (Pflieger, 1975); Kansas (Cross, 1967); Oklahoma (Moore, 1952); Tennessee (Kuhne, 1939); New Mexico (Jester, 1973); Louisiana (Douglas and Davis, 1967); Mississippi (Cook, 1959); and the Tennessee River system and the Mobile Bay drainage in Alabama (Smith-Vaniz, 1968). The smallmouth buffalo has also been successfully introduced in Arizona (Johnson and Minckley, 1972).

ott and Crossman (1973) state that no valid record of the smallmouth buffalo fish in Canada exists.

The presence of the smallmouth buffalo in North Dakota was reported by Dotson (1964). It has been recorded in the Red River of the North, at the mouth of the Sheyenne River (personal communication, Gene Van Eeckhout, 1977); the South Dakota portion of the James River (Elsen, 1977); Jamestown Reservoir (Duerre, 1969); the Cannonball, Heart, Knife, Little Missouri, and Yellowstone Rivers (personal communication, Robert Reigh, 1977); Lake Sakakawea (Benson, 1968); and the Missouri River and Lake Oahe (Duerre, 1965; Berard, 1973).

Habitat

Bigmouth

The bigmouth buffalo inhabits the slow, sluggish, or still water of larger rivers, oxbow and flood plain lakes, sloughs, bayous, and shallow lakes. It is well adapted to reservoirs (Moore, 1957; Trautman, 1957; Cook, 1959; Johnson, 1963; Hubbs and Lagler, 1964; Brown, 1971; Scott and Crossman, 1973; Pflieger, 1975). It also is very tolerant of turbid water (Trautman, 1957; Cook, 1959; Scott and Crossman, 1973; Pflieger, 1975).

Smallmouth

The smallmouth buffalo inhabits the deeper, swifter and, when possible, clearer waters of deep rivers (Trautman, 1957; Cook, 1959; Hubbs and Lagler, 1964; Brown, 1971; Pflieger, 1975). It often is found in reservoirs (Cook, 1959; Brown, 1971), and seldom inhabits turbid waters (Trautman, 1957; Cook, 1959; Pflieger, 1975).

Food

Bigmouth

Young-of-the-year fish feed heavily on cladocerans and copepods. Some chironomids and a small amount of phytoplankton are also taken. These young fish utilize more benthic organisms than do juveniles and adults (Johnson, 1963; McComish, 1967; Starostka and Applegate, 1970). Juvenile and adult buffalo fish are considered to be pelagic or planktonic feeders and utilize their gill rakers to strain food from the water. They feed heavily on entomostraca, with the cladocerans and copepods being the dominant food source. Diptera larvae (especially chironomids), vegetation, and algae also contribute small, but varying amounts to the food utilized (Harlan and Speaker, 1951; Cook, 1959; Johnson, 1963; Cross, 1967; McComish, 1967; Minckley et al., 1970; Starostka and Applegate, 1970; Brown, 1971; Tafanelli et al., 1971; Eddy and Underhill, 1974; Pflieger, 1975).

Smallmouth

McComish (1967) reports that the young-of-the-year fish feed on cladocerans and copepods. Juveniles and adults are considered to be benthic feeders with molluscs and insect larvae as the primary food sources. Some aquatic vegetation, crustaceans, and attached algae are also utilized (Harlan and Speaker, 1951; Cook, 1959; Cross, 1967; McComish, 1967; Minckley et al., 1970; Brown, 1971; Tafanelli et al., 1971).

Spawning and Reproduction

Bigmouth

Johnson (1963) found that males began to mature in the size range of 305-328 mm, and most were sexually mature when in the size range 356-379 mm. Of 360 females less than 482 mm long (probably 7 to 9 years old), only 19 were sexually mature. Canfield (1922) reported that pond-reared fish spawned when 4 years old. Swingle (1957) found that bigmouth buffalo one year old or older, and weighing one pound or more, were satisfactory for brood fish. Nelson (1961) found that fish in Gavins Point Reservoir in South Dakota matured at age III (having lived through 3 winters), while Shields (1957a) reported that fish in Fort Randall Reservoir matured at age III to IV. These data indicate that the faster growth rate of fish in southern latitudes with longer growing seasons allows them to mature at a younger age.

Spawning begins at 58° F but is slow until 60-62° F with the heaviest spawning at 60-65° F (Canfield, 1922). Time of spawning varies from as early as March in Alabama (Swingle, 1957) to early June in South Dakota (Shields, 1957a, 1957b). Eggs are spawned at random over mud bottoms or submerged vegetation (Harlan and Speaker, 1951; Cook, 1959; Brown, 1971; Eddy and Underhill, 1974). The period of incubation can be as short as 5 days (Swingle, 1957) but may vary from 8-14 days depending on water temperature (Harlan and Speaker, 1951; Brown, 1971).

Brown (1971) reported the fecundity of a 10 lb (4.55 kg) female to be 600,000 eggs while Harlan and Speaker (1951) reported that a 10 lb (4.55 kg) female would contain 400,000 eggs. Johnson (1963) reported that a fish 665 mm long and weighing 6.53 kg. contained an estimated 763,936 eggs. He also found that the size of mature eggs ranged from 1.2 to 1.8 mm.

Smallmouth

Jester (1973) reported that males were mature when the mean length of the age group was 225 mm and females were mature when the mean length of the age group was 275 mm. He indicated that size rather than age determined the time of sexual maturity. Walburg and Nelson (1966) found that male buffalo matured at an earlier age and smaller size than females in Lewis and Clark Lake, South Dakota. Some males were mature at age VII and all were mature by age IX. Some females were mature at age X and all were mature at age XI. Shields (1957a) found that fish matured at age III in Fort Randall Reservoir, South Dakota. Nelson (1961) found that the fish in Gavins Point Reservoir, South Dakota, matured at age IV.

Heard (1958) reported that spawning begins in Oklahoma in March and April when water temperatures reach 60° F. Shields (1957b) reported spawning in Gavins Point Reservoir, South Dakota, in late May, 1956, and Nelson (1961) reported that spawning occurred in the same lake in early June, 1960. Shields (1957a) reported spawning in Fort Randall Lake, South Dakota, in early June. Moody (1970) found that fish spawned in Elephant Butte Lake, New Mexico, in late April at 68° F with a peak in mid-June at 76° F. Jester (1973) reported that eggs are broadcast at random over shoals, with a preference shown for vegetated areas when available. Harlan and Speaker (1951) and Brown (1971) reported that the incubation period is about 10 days.

Diseases and Parasites

Bigmouth

Johnson (1963) reported that ectoparasitic copepods were found on fish in Saskatchewan in the Qu'Appelle River drainage. They were identified as Argulus appendiculosus. Young fish taken from this area were found to be heavily infected with myxosporidian spores. Hoffman's (1967) check-list contains 15 species of parasites known to infect bigmouth buffalo fish, including 2 species of Trematoda, 5 of Cestoda, 2 of Nematoda, 3 of Acanthocephala, 1 of Hirudinea, and 2 of Crustacea.

Smallmouth

Jester (1973) reported that smallmouth buffalo may develop a light infestation of fungus, Saprolegnia parasitica, during spawning seasons and when fish were caught in gill nets. Davis (1953) reported myxosporidian cysts, Myxobolus sp., on gill filaments of smallmouth buffalo fish. He also reported that the smallmouth is one of the most susceptible fishes to columnaris disease, which is caused by Cytophaga columnaris. Hoffman's (1967) check-list contains 29 species of parasites which infect the smallmouth buffalo, including 17 species of Protozoa, 2 of Trematoda, 8 of Cestoda, 2 of Nematoda, 4 of Acanthocephala, and 1 of Crustacea.

Relation of Year-class Strength to Water Levels

Elrod and Hassler (1971) studied year-class strength in Lake Sharpe and found that the 1961 and 1962 year-classes, from before the full pool was reached, accounted for much of the bigmouth buffalo catch.

Gasaway (1970) found that the reproduction of bigmouth buffalo fish in Lake Francis Case peaked from 1954 to 1956 and declined thereafter, except for a good year-class in 1965. Smallmouth buffalo also showed good reproduction immediately after impoundment but then declined. There was good reproduction of smallmouths in 1967, which was a year of high water levels.

Walburg and Nelson (1966) found strong year-classes of bigmouth buffalo produced in Lewis and Clark Lake only in 1956 and 1957. Smallmouth buffalo fish reproduced strongly in 1956, 1957, and 1958; year-classes were weak after 1959.

These studies suggest that buffalo fishes in mainstem Missouri River reservoirs reproduce strongly for only a few years after impoundment while the reservoirs are filling and flooding new spawning areas each year. After they are filled, annual reproduction and year-class strength may be weak.

METHODS AND MATERIALS

The buffalo fish used in this study were obtained from Grasteit Dakota Fisheries, a commercial fishing operation headquartered in Newtown, North Dakota. Fish were captured by seining and gill netting. The seines used were 300 and 600 feet long, 6 feet high, and had a bar mesh size of 2 inches (4 inch stretch). Gill nets used were 300 feet long, 6 feet high, and had a bar mesh size of 4 inches (8 inch stretch). Fish captured by each method were recorded separately to obtain length-frequency data for each type of gear.

All fish sampled were collected throughout the summer of 1977. Due to the speed with which the commercial fishermen cleaned the fish, only part of each day's catch could be recorded. Fish were sampled as they were unloaded from the commercial fishermen's truck in order that the data might be as random as possible.

Scales were taken from near the lateral line on those fish used for age and growth studies. Total length, weight, and, when possible, sex were recorded for fish to be used in this determination. Scales were impressed on acetate slides and read (aged) with the use of a Bausch and Lomb microprojector. Scales were read twice, readings were compared, and any discrepancies were checked closely. A straight line relationship between scale radius and body length was assumed, and lengths at each annulus were back-calculated as described by Lagler (1952). Reading these scales also allowed the age class composition to be determined.

Length-weight relationships were determined by the method of least squares using the equation Log W = log a + n log L as described by Lagler (1952).

The mean condition factor, K-TL, of the entire population was determined using the formula given by Lagler (1952). The following equation was used:

$$K\text{-}TL = \frac{100,000\ W}{L^3}$$

where W = weight and L = total length.

Hand seines were used to search for young-of-the-year fish. Both shallow bays and inflowing streams were seined in an attempt to collect the young fish. Three by four foot frame nets also were used in the bays in the search for these fish.

The entire body cavity contents were removed from 20 bigmouth and 20 smallmouth buffalo fish (10 males and 10 females each). These were given to Dr. H.L. Holloway, University of North Dakota, for parasite studies.

RESULTS

All fish taken during the course of thi study proved to be either smallmouth or bigmouth buffalo. No black buffalo (Ictiobus niger) were collected even though a close watch for them was made. Dotson (1964) reported that four buffalo fish from Lake Sakakawea were identified as the black buffalo in 1959. The range of the black buffalo fish is considered to be the central and southern United States, and the most northerly report of them, other than Dotson, is by Moen (1970) who reported them in Lake Mitchell, near the South Dakota-Nebraska border.

Age and Growth

Bigmouth

Two hundred two fish were used for an age and growth determination of the entire bigmouth buffalo population. The mean back-calculated lengths of each age group were calculated and are listed in Table 1. Fifteen males and 36 females were identified in this group of 202 fish and the mean age and growth of each sex was determined and is contained in Table 2. Year-class composition was also revealed during the age and growth determinations and these data are in Table 3.

Table 1. Age and growth of bigmouth buffalo captured in Lake Sakakawea during 1977

	Year-		TL (mm.) at each annulus													
Age group	class	No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
III	1974	1	79	199	317											
increment			79	120	118											
IV	1973	6	98	210	303	374										
increment			98	112	93	71										
V	1972	0														
increment																
VI	1971	10	103	239	327	393	441	479								
increment			103	136	88	66	48	38								
VII	1970	0														
increment																
VIII	1969	26	108	221	306	378	424	465	501	553						
increment			108	113	85	72	46	41	36	32						
IX	1968	0														
increment																
X	1967	19	107	219	311	380	428	465	497	524	552	577				
increment			107	112	92	69	48	37	32	27	28	25				
XI	1966	43	119	238	325	392	435	471	504	533	561	586	610			
increment			119	119	87	67	43	36	33	29	28	25	24			
XII	1965	33	121	243	333	399	443	477	510	540	565	589	612	634		
increment			121	122	90	66	44	34	33	30	25	24	23	22		
XIII	1964	39	128	245	332	394	436	473	511	544	572	599	622	644	667	
increment			128	117	87	62	42	37	38	33	28	27	23	22	23	
XIV	1963	25	129	247	335	394	445	490	526	560	593	623	651	675	699	722
increment			129	118	88	59	51	45	36	34	33	30	28	24	24	23
		202														

Table 2. Age and growth by sex for bigmouth buffalo captured in Lake Sakakawea during 1977

		TL(mm) at each annulus													
Sex	No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
male	15	123	238	316	380	436	474	507	537	562	586	609	628	650	
increment		123	115	78	64	56	38	33	30	25	24	23	19	22	
female	36	119	239	325	387	436	474	510	540	569	596	620	647	678	720
increment		119	120	86	62	49	38	36	30	29	26	25	27	31	42

Table 3. Year-class composition of bigmouth buffalo captured in Lake Sakakawea during 1977

Year-class	Age group	No.	%
1976	I	0	0.00
1975	II	0	0.00
1974	III	1	0.49
1973	IV	6	2.97
1972	V	0	0.00
1971	VI	10	4.95
1970	VII	0	0.00
1969	VIII	26	12.87
1968	IX	0	0.00
1967	X	19	9.41
1966	XI	43	21.29
1965	XII	33	16.34
1964	XIII	39	19.31
1963	XIV	25	12.37
		202	100.00

Smallmouth

One hundred thirty-eight fish were used for an age and growth determination of the entire smallmouth buffalo population. The mean back-calculated lengths of each age group are listed in Table 4. Ten males and 24 females were identified in this group of 138 fish and the mean age and growth of each sex are listed in Table 5. Year-class composition was revealed during the age and growth determinations and these data are in Table 6.

Length-weight

Bigmouth

A length-weight regression for the bigmouth buffalo in Lake Sakakawea was calculated utilizing 241 fish. No regression was calculated for each sex because of the small sample size. The regression equation was calculated to be:

$$\text{Log } W = -3.63 + 2.60 \log L.$$

Table 7 lists the mean weight by length for 241 fish using 20 mm intervals.

Smallmouth

A length-weight regression for the smallmouth buffalo in Lake Sakakawea was calculated utilizing 139 fish. No regression was calculated for each sex because of the small sample size. The regression equation was calculated to be:

$$\text{Log } W = -5.94 + 3.42 \log L.$$

Table 8 lists the mean weight by length for 139 fish using 20 mm intervals.

Table 4. Age and growth of smallmouth buffalo captured in Lake Sakakawea during 1977

Age group	Year-class	No.	TL(mm.) at each annulus 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
III	1974	11	76	158	259												
increment			76	82	101												
IV	1973	6	78	179	268	341											
increment			78	101	89	73											
V	1972	0															
increment																	
VI	1971	3	81	182	250	301	360	396									
increment			81	101	68	51	59	36									
VII	1970	1	59	167	299	352	387	417	437								
increment			59	108	132	53	35	30	20								
VIII	1969	11	104	196	272	340	386	426	463	492							
increment			104	92	76	68	46	40	37	29							
IX	1968	0															
increment																	
X	1967	5	110	214	289	347	388	420	446	475	505	532					
increment			110	104	75	58	41	32	26	29	30	27					
XI	1966	58	103	203	291	343	386	421	456	488	516	544	571				
increment			103	100	88	52	43	35	35	32	28	28	27				
XII	1965	11	101	203	291	336	381	411	444	477	506	537	565	595			
increment			101	102	76	57	45	30	33	33	29	31	28	30			
XIII	1964	22	109	197	277	338	381	419	452	482	512	538	562	589	614		
increment			109	88	80	61	43	38	33	30	30	26	24	27	25		
XIV	1963	6	107	208	287	351	891	423	454	479	508	538	563	590	611	632	
increment			107	101	81	64	40	32	31	25	29	30	25	27	21	21	
XV	1962	4	101	202	282	352	389	424	460	506	538	570	591	614	635	661	683
increment			101	101	80	70	37	35	36	46	32	32	21	23	21	26	22
		138															

Table 5. Age and growth by sex for smallmouth buffalo captured in Lake Sakakawea during 1977

Sex	No.	TL(mm) at each annulus 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
male	10	114	218	296	354	397	435	459	483	502	526	549				
increment		114	104	78	58	43	38	24	24	19	24	23				
female	24	95	197	276	341	384	421	455	486	515	541	565	594	616	642	680
increment		95	102	79	65	43	37	34	31	29	26	24	29	22	26	38

Table 6. Year-class composition of smallmouth buffalo captured in Lake Sakakawea during 1977

Year-class	Age group	No.	%
1976	I	0	0.00
1975	II	0	0.00
1974	III	11	7.97
1973	IV	6	4.35
1972	V	0	0.00
1971	VI	3	2.17
1970	VII	1	0.73
1969	VIII	11	7.97
1968	IX	0	0.00
1967	X	5	3.62
1966	XI	58	42.03
1965	XII	11	7.97
1964	XIII	22	15.94
1963	XIV	6	4.35
1962	XV	4	2.90
		138	100.00

Table 7. Mean weight by length of bigmouth buffalo captured in Lake Sakakawea during 1977

Length (mm.)	No.	Range (grams)	Mean (grams)
340-359	1	690	690
360-379	0		
380-399	1	1020	1020
400-419	2	980-1000	990
420-439	2	1110-1200	1155
440-459	1	1040	1040
460-479	0		
480-499	4	1890-2470	2200
500-219	5	1700-2160	1966
520-539	5	2360-2960	2580
540-559	11	2410-3280	2800
560-579	12	2670-3610	3181
580-599	14	2850-4400	3645
600-619	24	3330-5270	4087
620-639	38	3860-5330	4345
640-659	33	4130-5320	4783
660-679	29	4380-7540	5086
680-699	20	4520-6950	5601
700-719	15	5780-8630	7067
720-739	10	5540-8350	6697
740-759	6	7130-9810	8308
76[illegible]79	6	6760-9260	8240
780-799	1	9350	9350
800-819	0		
820-839	0		
840-859	1	11170	11170
	241		

Table 8. Mean weight by length of smallmouth buffalo captured in Lake Sakakawea during 1977

Length (mm.)	No.	Range (grams)	Mean (grams)
260-279	1	370	370
280-299	2	370- 390	380
300-319	4	400- 480	443
320-339	3	450- 520	497
340-359	2	570- 750	660
360-379	3	670- 890	783
380-399	1	860	860
400-419	2	850-1190	1020
420-439	2	1100-1480	1290
440-459	2	1460-1660	1560
460-479	1	1620	1620
480-499	0		
500-519	3	1960-2200	2063
520-539	3	2130-2640	2383
540-559	9	2300-3290	2840
560-579	16	2530-3570	3193
580-599	21	2540-4080	3378
600-619	26	3290-4550	3792
620-639	16	3690-4940	4211
640-659	13	3900-4970	4375
660-679	5	4370-5230	4912
680-699	1	4990	4990
700-719	1	5860	5860
720-739	2	5070-7040	6055
	139		

K-Condition

A mean condition factor, K-TL, was determined for 241 bigmouth and 138 smallmouth buffalo for use in comparison with other populations. The mean condition factor for each sex was calculated by using 16 male and 37 female bigmouths and 10 male and 24 female smallmouths (Table 9).

Table 9. Condition factors (K-TL) for bigmouth and smallmouth buffalo taken from Lake Sakakawea in 1977

Species	Sex	No.	K-TL
Bigmouth	Combined	241	1.88
Bigmouth	Female	37	1.85
Bigmouth	Male	16	1.73
Smallmouth	Combined	138	1.83
Smallmouth	Female	24	1.76
Smallmouth	Male	10	1.55

Length-frequency

A total of 1035 fish were measured and included in these length-frequency data. Of these, 795 were identified as bigmouth buffalo and 240 as smallmouth buffalo.

Table 10 lists the number and percentage of bigmouth buffalo of each 20 mm size range caught in gill nets or seines. Table 11 delineates the same figures for the smallmouth buffalo. Table 12 is a summary of both the gill net and seine frequencies for both species of buffalo and also lists the mean length of the fish caught in each type of gear.

Table 10. Length-frequency of bigmouth buffalo captured by both gill nets and seines in Lake Sakakawea during 1977

	GILL NET		SEINE	
Length (mm.)	No.	%	No.	%
340-359	0	0.00	1	0.31
360-379	0	0.00	0	0.00
380-399	0	0.00	0	0.00
400-419	0	0.00	0	0.00
420-439	0	0.00	1	0.31
440-459	0	0.00	1	0.31
460-479	0	0.00	0	0.00
480-499	0	0.00	3	0.94
500-519	3	0.63	8	2.51
520-539	3	0.63	4	1.25
540-559	6	1.26	14	4.39
560-579	15	3.15	26	8.15
580-599	28	5.88	42	13.17
600-619	64	13.45	46	14.42
620-639	87	18.28	46	14.42
640-659	82	17.23	27	8.47
660-679	66	13.87	34	10.66
680-699	49	10.29	27	8.47
700-719	36	7.56	18	5.64
720-739	19	3.99	15	4.70
740-759	10	2.10	5	1.57
760-779	6	1.26	1	0.31
780-799	1	0.21	0	0.00
800-819	0	0.00	0	0.00
820-839	0	0.00	0	0.00
840-859	1	0.21	0	0.00
	476	100.00	319	100.00

Table 11. Length-frequency of smallmouth buffalo captured by both gill nets and seines in Lake Sakakawea during 1977

	GILL NET		SEINE	
Length (mm.)	No.	%	No.	%
300-319	0	0.00	3	6.82
320-339	0	0.00	1	2.27
340-359	0	0.00	0	0.00
360-379	0	0.00	0	0.00
380-399	0	0.00	0	0.00
400-419	1	0.51	1	2.27
420-439	0	0.00	0	0.00
440-459	0	0.00	1	2.27
460-479	1	0.51	0	0.00
480-499	0	0.00	0	0.00
500-519	5	2.55	1	2.27
520-539	4	2.04	2	4.55
540-559	14	7.14	2	4.55
560-579	26	13.27	14	31.82
580-599	39	19.90	10	22.72
600-619	45	22.69	5	11.36
620-639	30	15.31	2	4.55
640-659	19	9.69	2	4.55
660-679	7	3.57	0	0.00
680-699	2	1.02	0	0.00
700-719	1	0.51	0	0.00
720-739	2	1.02	0	0.00
	196	100.00	44	100.00

Table 12. Length-frequency summary of bigmouth and smallmouth buffalo caught in both gill nets and seines in Lake Sakakawea during 1977

	Gill net	Seine	Combined
% bigmouth	70.83	87.88	76.81
% smallmouth	29.17	12.12	23.19
Mean length bigmouth (mm)	659	623	645
Mean length smallmouth (mm)	597	544	587

1977 Reproduction

Repeated seining throughout the summer along both Shell Creek and East Shell Creek produced no young-of-the-year buffalo. Seining and frame netting in various areas of the Van Hook Arm of Lake Sakakawea also produced no evidence of reproduction. Reproduction test netting along the entire length of Lake Sakakawea by the North Dakota Game and Fish Department yielded only one smallmouth and one bigmouth buffalo (personal communication, Emil Berard, 1977). These were collected in a frame net in White Earth Bay.

Water Levels

A list of the pool elevations of Lake Sakakawea from 1 January 1962 to 15 August 1977 were obtained from Eugene J. DeTienne, Powerplant Superintendent at Garrison Dam. These pool elevations are listed in the appendix.

DISCUSSION

Age and Growth

Bigmouth

Growth of bigmouth buffalo in Lake Sakakawea is comparable to that of buffalo in other mainstem Missouri River reservoirs, including Lake Oahe (Fogle, 1963) and Lewis and Clark Lake (Shields, 1957b; Walburg, 1964; Walburg and Nelson, 1966). Fish in Lake Francis Case, however, have a slightly faster growth rate (Shields, 1957a; Sprague, 1961). Fish further north in five Saskatchewan lakes have a markedly slower growth rate than do the fish in Lake Sakakawea (Johnson, 1963). According to Carlander (1969), fish in more southerly states have growth rates much higher than do our fish.

Growth of male and female fish is quite similar in Lake Sakakawea; most of the larger fish, however, were females. Johnson (1963) reports similar findings for Saskatchewan fish.

Smallmouth

Growth of the smallmouth buffalo in Lake Sakakawea is quite similar to that reported by Nelson (1961) for Lewis and Clark Lake. Buffalo in Lake Oahe (Fogle, 1963) and Lake Francis Case (Shields, 1957a), however, had faster growth rates than do our fish. Carlander (1969) reports on growth rates of fish in 12 southern reservoirs in Oklahoma, Missouri, and Tennessee; of these, one has a similar growth rate, five have slower growth rates, and six have faster growth rates than do the Lake Sakakawea fish. Jester (1973) reports a much faster growth rate of smallmouth buffalo in New Mexico than occurs here.

Growth of males and females is similar in Lake Sakakawea fish. Once again, larger fish are likely to be females.

Length-weight

The value of the constant "n" in length-weight equations for populations in good condition is considered to be approximately 3.0. Values of 2.60 for bigmouth buffalo and 3.42 for smallmouth buffalo populations in Lake Sakakawea are close to this value and are within the range of values reported by Carlander (1969).

K-Condition

The mean condition factor (K-TL) for both the bigmouth and smallmouth buffalo in Lake Sakakawea is higher than that for fish in Lake Oahe (Fogle, 1963), Lewis and Clark Lake (Shields, 1957b; Nelson, 1961), and Lake Francis Case (Shields, 1957a; Sprague, 1961). Carlander (1969) reportes a range of mean condition factors (K-TL) for the bigmouth buffalo of 1.39-1.66 and for the smallmouth buffalo of 1.29-1.53. All of these values are lower than those of the fish in Lake Sakakawea. This is probably due to the preponderance of old fish in Lake Sakakawea. As fish get older, their weight increases much more quickly than does their length, causing the K-TL to increase with length.

Length-frequency

As would be expected, gill nets, with their large mesh size and deeper water setting, captured larger fish than did the seines. This was true for both species of buffalo collected during this study.

The much greater catch of bigmouth buffalo fish (77% of the total catch) is probably due to habitat preferences. As stated in the literature review, the bigmouth is more often found in sluggish or still waters while the smallmouth is more often found in swifter waters.

Relation of Year-class Strength to Water Levels

As stated before, Lake Sakakawea reached full pool for the first time in 1967. Year-classes before this year (age groups XI to XV) are strong in both bigmouth and smallmouth populations, making up over 73% of the 138 smallmouths that were aged and over 69% of the 202 bigmouths that were aged. After the full pool elevation was reached, there was a dramatic decrease in year-class strength, with many year-classes so weak that they were not collected during this study. In 1969, however, the pool elevation rose to 1850.8 feet (0.8 feet above full pool level). The fish produced that year (age group VIII) constitute a moderate strength year-class, making up nearly 8% of the smallmouths aged and nearly 13% of the bigmouths that were aged.

Data collected in this study show that both bigmouth and smallmouth buffalo reproduction is closely related to water levels. The age classes produced before the full pool elevation was reached are very strong in Lake Sakakawea, with a marked decline occurring after that time. This phenomenon has also occurred in both Lake Francis Case (Gasaway, 1970) and Lewis and Clark Lake (Walburg and Nelson, 1966).

APPENDIX

POOL ELEVATIONS ON LAKE SAKAKAWEA, 1962-1977

Year	Date	Pool	Date	Pool
1962	1 Jan.	1799.35	15 Jan.	1798.90
	1 Feb.	1797.61	15 Feb.	1797.13
	1 Mar.	1797.14	15 Mar.	1795.99
	1 Apr.	1797.83	15 Apr.	1799.11
	1 May	1799.22	15 May	1799.26
	1 June	1800.70	15 June	1802.97
	1 July	1809.77	15 July	1813.45
	1 Aug.	1816.28	15 Aug.	1817.29
	1 Sept.	1817.64	15 Sept.	1817.95
	1 Oct.	1818.38	15 Oct.	1818.63
	1 Nov.	1819.37	15 Nov.	1819.51
	1 Dec.	1819.73	15 Dec.	1819.66
1963	1 Jan.	1819.17	15 Jan.	1818.53
	1 Feb.	1816.60	15 Feb.	1816.90
	1 Mar.	1816.52	15 Mar.	1816.87
	1 Apr.	1817.52	15 Apr.	1817.90
	1 May	1816.88	15 May	1818.16
	1 June	1820.37	15 June	1824.67
	1 July	1829.89	15 July	1831.62
	1 Aug.	1831.39	15 Aug.	1831.00
	1 Sept.	1830.93	15 Sept.	1831.21
	1 Oct.	1830.91	15 Oct.	1830.77
	1 Nov.	1830.50	15 Nov.	1830.19
	1 Dec.	1828.68	15 Dec.	1827.22
1964	1 Jan.	1825.62	15 Jan.	1825.06
	1 Feb.	1823.56	15 Feb.	1822.21
	1 Mar.	1820.65	15 Mar.	1818.84
	1 Apr.	1817.52	15 Apr.	1817.21
	1 May	1816.39	15 May	1816.75
	1 June	1818.40	15 June	1821.25
	1 July	1825.46	15 July	1829.58
	1 Aug.	1830.88	15 Aug.	1830.73
	1 Sept.	1830.69	15 Sept.	1830.33
	1 Oct.	1829.59	15 Oct.	1828.84
	1 Nov.	1828.60	15 Nov.	1827.96
	1 Dec.	1825.84	15 Dec.	1824.95

Year	Date	Pool	Date	Pool
1965	1 Jan.	1823.64	15 Jan.	1822.80
	1 Feb.	1821.65	15 Feb.	1820.35
	1 Mar.	1819.11	15 Mar.	1817.99
	1 Apr.	1817.52	15 Apr.	1818.64
	1 May	1820.33	15 May	1822.82
	1 June	1824.53	15 June	1826.50
	1 July	1832.01	15 July	1836.75
	1 Aug.	1840.16	15 Aug.	1841.17
	1 Sept.	1842.55	15 Sept.	1843.56
	1 Oct.	1844.43	15 Oct.	1843.97
	1 Nov.	1843.46	15 Nov.	1842.42
	1 Dec.	1840.87	15 Dec.	1840.27
1966	1 Jan.	1838.16	15 Jan.	1837.49
	1 Feb.	1836.37	15 Feb.	1835.31
	1 Mar.	1834.17	15 Mar.	1833.82
	1 Apr.	1835.62	15 Apr.	1836.86
	1 May	1837.65	15 May	1838.75
	1 June	1840.51	15 June	1842.63
	1 July	1844.05	15 July	1844.46
	1 Aug.	1844.04	15 Aug.	1843.04
	1 Sept.	1842.23	15 Sept.	1841.26
	1 Oct.	1840.57	15 Oct.	1839.77
	1 Nov.	1838.58	15 Nov.	1837.14
	1 Dec.	1836.21	15 Dec.	1835.17
1967	1 Jan.	1834.72	15 Jan.	1833.74
	1 Feb.	1832.13	15 Feb.	1830.96
	1 Mar.	1829.33	15 Mar.	1828.80
	1 Apr.	1829.91	15 Apr.	1831.01
	1 May	1832.81	15 May	1834.27
	1 June	1837.23	15 June	1840.23
	1 July	1845.01	15 July	1848.71
	1 Aug.	1849.51	15 Aug.	1848.25
	1 Sept.	1846.16	15 Sept.	1845.11
	1 Oct.	1844.91	15 Oct.	1843.91
	1 Nov.	1842.93	15 Nov.	1842.03
	1 Dec.	1841.52	15 Dec.	1840.09

Year	Date	Pool	Date	Pool
1968	1 Jan.	1839.16	15 Jan.	1838.08
	1 Feb.	1837.34	15 Feb.	1836.72
	1 Mar.	1835.77	15 Mar.	1836.69
	1 Apr.	1838.38	15 Apr.	1837.78
	1 May	1837.23	15 May	1836.90
	1 June	1836.72	15 June	1839.31
	1 July	1843.82	15 July	1845.75
	1 Aug.	1846.65	15 Aug.	1846.33
	1 Sept.	1847.18	15 Sept.	1847.71
	1 Oct.	1847.08	15 Oct.	1845.81
	1 Nov.	1845.17	15 Nov.	1844.94
	1 Dec.	1844.50	15 Dec.	1843.08
1969	1 Jan.	1842.55	15 Jan.	1841.73
	1 Feb.	1840.33	15 Feb.	1839.16
	1 Mar.	1838.09	15 Mar.	1837.00
	1 Apr.	1839.34	15 Apr.	1842.02
	1 May	1842.62	15 May	1843.35
	1 June	1844.69	15 June	1845.65
	1 July	1848.01	15 July	1850.20
	1 Aug.	1850.48	15 Aug.	1849.97
	1 Sept.	1848.47	15 Sept.	1847.54
	1 Oct.	1846.55	15 Oct.	1845.60
	1 Nov.	1844.87	15 Nov.	1844.39
	1 Dec.	1843.38	15 Dec.	1841.85
1970	1 Jan.	1840.68	15 Jan.	1839.73
	1 Feb.	1838.43	15 Feb.	1837.82
	1 Mar.	1837.45	15 Mar.	1837.17
	1 Apr.	1837.25	15 Apr.	1837.55
	1 May	1837.32	15 May	1838.48
	1 June	1839.88	15 June	1842.93
	1 July	1846.08	15 July	1848.09
	1 Aug.	1848.81	15 Aug.	1848.74
	1 Sept.	1847.09	15 Sept.	1846.84
	1 Oct.	1846.78	15 Oct.	1846.06
	1 Nov.	1845.63	15 Nov.	1844.81
	1 Dec.	1843.99	15 Dec.	1842.61

Year	Date	Pool	Date	Pool
1971	1 Jan.	1842.02	15 Jan.	1841.14
	1 Feb.	1839.94	15 Feb.	1839.19
	1 Mar.	1840.43	15 Mar.	1840.75
	1 Apr.	1843.27	15 Apr.	1844.09
	1 May	1843.63	15 May	1843.15
	1 June	1842.99	15 June	1845.38
	1 July	1848.26	15 July	1849.00
	1 Aug.	1848.75	15 Aug.	1848.07
	1 Sept.	1847.07	15 Sept.	1847.55
	1 Oct.	1846.51	15 Oct.	1846.72
	1 Nov.	1846.56	15 Nov.	1846.13
	1 Dec.	1845.44	15 Dec.	1844.04
1972	1 Jan.	1843.37	15 Jan.	1842.43
	1 Feb.	1841.33	15 Feb.	1840.54
	1 Mar.	1840.22	15 Mar.	1842.00
	1 Apr.	1847.73	15 Apr.	1847.41
	1 May	1846.47	15 May	1845.74
	1 June	1845.81	15 June	1847.32
	1 July	1848.80	15 July	1848.99
	1 Aug.	1848.69	15 Aug.	1848.31
	1 Sept.	1848.69	15 Sept.	1848.31
	1 Oct.	1847.87	15 Oct.	1847.65
	1 Nov.	1847.30	15 Nov.	1846.73
	1 Dec.	1846.72	15 Dec.	1846.03
1973	1 Jan.	1845.33	15 Jan.	1844.18
	1 Feb.	1843.62	15 Feb.	1843.14
	1 Mar.	1842.78	15 Mar.	1843.49
	1 Apr.	1843.39	15 Apr.	1843.11
	1 May	1843.18	15 May	1843.89
	1 June	1845.47	15 June	1846.91
	1 July	1848.91	15 July	1849.35
	1 Aug.	1848.68	15 Aug.	1848.04
	1 Sept.	1847.24	15 Sept.	1847.12
	1 Oct.	1846.76	15 Oct.	1846.39
	1 Nov.	1845.63	15 Nov.	1844.81
	1 Dec.	1843.77	15 Dec.	1843.09

Year	Date	Pool	Date	Pool
1974	1 Jan.	1842.33	15 Jan.	1841.10
	1 Feb.	1840.43	15 Feb.	1839.55
	1 Mar.	1839.00	15 Mar.	1838.85
	1 Apr.	1838.57	15 Apr.	1839.52
	1 May	1839.75	15 May	1839.63
	1 June	1840.50	15 June	1842.74
	1 July	1846.60	15 July	1848.79
	1 Aug.	1849.00	15 Aug.	1848.91
	1 Sept.	1847.90	15 Sept.	1847.38
	1 Oct.	1847.10	15 Oct.	1846.25
	1 Nov.	1845.12	15 Nov.	1844.70
	1 Dec.	1844.01	15 Dec.	1843.25
1975	1 Jan.	1842.30	15 Jan.	1841.50
	1 Feb.	1841.03	15 Feb.	1839.86
	1 Mar.	1839.01	15 Mar.	1838.68
	1 Apr.	1838.68	15 Apr.	1838.88
	1 May	1842.65	15 May	1844.44
	1 June	1846.19	15 June	1848.17
	1 July	1851.30	15 July	1853.19
	1 Aug.	1854.77	15 Aug.	1853.19
	1 Sept.	1851.22	15 Sept.	1849.82
	1 Oct.	1848.20	15 Oct.	1847.14
	1 Nov.	1846.18	15 Nov.	1845.47
	1 Dec.	1843.96	15 Dec.	1842.39
1976	1 Jan.	1841.99	15 Jan.	1841.61
	1 Feb.	1840.92	15 Feb.	1840.17
	1 Mar.	1840.35	15 Mar.	1840.63
	1 Apr.	1842.54	15 Apr.	1842.33
	1 May	1842.54	15 May	1842.13
	1 June	1843.21	15 June	1845.54
	1 July	1847.79	15 July	1848.71
	1 Aug.	1848.07	15 Aug.	1847.20
	1 Sept.	1846.23	15 Sept.	1845.47
	1 Oct.	1845.07	15 Oct.	1845.08
	1 Nov.	1843.52	15 Nov.	1842.75
	1 Dec.	1841.67	15 Dec.	1840.39

Year	Date	Pool	Date	Pool
1977	1 Jan.	1840.00	15 Jan.	1838.54
	1 Feb.	1837.34	15 Feb.	1836.46
	1 Mar.	1836.17	15 Mar.	1836.05
	1 Apr.	1836.07	15 Apr.	1835.99
	1 May	1835.77	15 May	1835.49
	1 June	1836.02	15 June	1836.38
	1 July	1837,73	15 July	1837.44
	1 Aug.	1836.88	15 Aug.	1836.26

Source: Personal communication, Eugene J. DeTienne, Power-plant Superintendent, Riverdale, North Dakota

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