AN ABSTRACT OF THE THESIS OF

William G. Layher for the Master of Science

in Environmental Biology presented on October, 1976

Title: Food Habits and Related Studies of Flathead Catfish

Abstract approved: [signature]

The ecological role of the flathead catfish, Pylodictis olivaris (Rafinesque), in large reservoirs has not been completely understood. During the time period of April, 1975, through November, 1975, 200 flathead catfish were collected from Milford Reservoir in North-Central Kansas. One hundred and seventy-two of these fish were used in a food study. Stomach contents were analyzed by month for each length group (100 mm length groups) of flathead catfish and also were analyzed separately for each age group (year class). Frequency of occurrence and numerical analysis were used as methods for analysis. Volumetric analysis of stomach contents was also performed. Flathead catfish between 201 mm in length and 500 mm in length were found to rely heavily on benthic macroinvertebrates and fishes as forage. Flathead catfish over 500 mm in length were almost exclusively piscivorous, utilizing gizzard shad (Dorosoma cepedianum) as their most important food item. After age VI

flathead catfish did not feed on benthic macroinvertebrates. As age determination was necessary, an age and growth study was also performed. Length-weight relationships, coefficients of condition and growth data were computed separately for male flathead catfish, female flathead catfish and all flathead catfish collected. A body length-pectoral spine relationship was derived using measurements from 199 flathead catfish. The value of the y-intercept from the body length-pectoral spine relationship was then used in a formula to back-calculate total length of the fish at each annuli.

FOOD HABITS AND RELATED STUDIES OF FLATHEAD CATFISH

A Thesis

Submitted to the

Division of Biological Sciences

Emporia Kansas State College

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

William G. Layher

October, 1976

Approved for the Major Department

Approved for the Graduate Council

ACKNOWLEDGMENTS

The writer expresses his gratitude to Dr. Robert Boles, Dr. Dwight Spencer, and Dr. Thomas Eddy for serving on the graduate committee overseeing this research. This research would not have been possible without their advice and encouragement.

The writer also is indebted to Mr. Cal Groen, Milford Reservoir Fisheries Biologist, Kansas Forestry, Fish and Game Commission whose aid and assistance were invaluable. Appreciation is also expressed to Mr. Maynard Sherbert and family of Wakefield, Kansas, who spent many hours collecting and measuring specimens for this project. Mr. Ron Strong programed the computer which was used for calculations. This project would never have been completed without the aid of these people.

Last, but certainly not least, the author expresses gratitude to his wife, Barbara, for enduring many lonely hours during her first year of marriage while the author was working on this project, and for typing this manuscript.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The flathead catfish, Pylodictis olivaris (Rafinesque), is commonly found in rivers of eastern Kansas, but only occasionally in streams of western Kansas (Cross, 1967). Many specimens weighing more than 18,144 grams (40 pounds) are taken from rivers in the state each year. Unverified reports of fish taken in excess of 45,360 grams (100 pounds) have even been recorded for this species from Kansas waters (Deacon, 1961). Because of its fighting ability, edibility, and potential for reaching a large size, it is held in high regard by fishermen (McCoy, 1953). Cal Groen, Milford Reservoir fisheries biologist, expressed surprise at the large number of "big catfish" which are taken from the impoundment each year (Groen, 1975). The 1974 creel census results showed 1,755 flathead catfish averaging 9.37 pounds each, and totaling 16,488 pounds, were harvested from Milford Reservoir.

Brown and Dendy (1961) found that flathead catfish from Alabama rivers were mainly piscivorous. The types of fishes utilized as forage seem to be correlated with the size of the predator (Brown and Dendy, 1961). Other authors have indicated that the abundance of forage fishes (Langemeier, 1965) or the relative abundance of forage fishes to invertebrates (Minckley and Deacon, 1959) may influence the kinds of foods selected by flathead catfish. Swingle (1954) originally stated that only flathead catfish over 406 mm (16 inches) should be placed in the carnivorous, or "C" classification, but later Swingle (1967) indicated that all catfish should be placed in the "C" group for population analysis. Turner and Summerfelt (1970) found flathead catfish greater than

500 mm (19.7 inches) in length to feed extensively on gizzard shad and freshwater drum. Flathead catfish under 102 mm (four inches) in length from the Big Blue River in Kansas contained mostly larvae of Ephemeroptera, Trichoptera, and Diptera. Crayfish and fish were found to be most abundant in flatheads between 104 mm (4.1 inches) and 254 mm (10 inches) in size. Larger fish from the same river appeared to be entirely piscivorous (Minckley and Deacon, 1959). Minckley and Deacon (1959) found that flathead catfish from the Neosho River in the 104 mm (4.1-inch) to 254 mm (10-inch) size range relied mainly on Ephemeroptera nymphs as their most important food item. Clemens (1954) examined six flathead catfish from Oklahoma reservoirs and found three to contain insects and three to contain unidentified fishes. The information available concerning feeding habits of reservoir populations of flathead catfish remains scanty. Until now only two studies, Clemens (1954), and Turner and Summerfelt (1970), have been completed on this topic. Both studies involved fish from Oklahoma reservoirs. Turner and Summerfelt (1970) stated: "Knowledge of flathead catfish predation on game fishes and the nature of competition between flathead catfish and game fishes is valuable for assessment of dynamics of reservoir fish populations."

In addition to the food habits of flathead catfish, another area of interest is age and growth. More information seems to be available about age and growth than food habits. Applegate and Smith (1951), Sneed (1951), and Sneed and Leonard (1951) reported on calculation of growth from sections of pectoral spines taken from channel catfish. Jenkins (1952) explained that similarities in spine structure among catfishes render the cross-section and ring method applicable to flathead catfish. Others have also used either pectoral or dorsal spine sections for age and growth determination (McCoy, 1953; Minckley and Deacon, 1959; Cross and Hastings, 1956; and Langemeier, 1965). Carlander (1969) summarized data on age and growth of the flathead catfish.

Fishing pressure on flathead catfish in Milford Reservoir and the fish's role in the ecology of the reservoir are currently undetermined. These unknowns, along with the lack of literature concerning food habits of flathead catfish in large impoundments and a paucity of age and growth data stimulated this study.

The primary objective of this study was to determine what flathead catfish utilized as food sources during the period from April, 1975, through November, 1975. Stomach contents were analyzed according to the size and age of the flathead catfish collected. Since age was used in determining variations in flathead feeding habits, an age and growth study was also performed. Length-weight relationships for males, females, and all flathead catfish were determined.

Description of Study Area

Milford Reservoir (Fig. 1) was constructed by the U. S. Army Corps of Engineers as a flood control impoundment and water was first impounded in 1967. The dam is located four miles northeast of Junction City, Kansas, on the Republican River. Milford Reservoir at conservation level has a surface area of 16,020 acres and 163 miles of shoreline. A description of Milford Reservoir has been printed in a Job Progress Report (Dingell-Johnson Project F -15-R-8, Job no. B-1-8, Northeast Region) by the Kansas Forestry, Fish and Game Commission and is entitled Management Needs to Improve Fishing Waters, which renders its description here unnecessary. All of the flathead catfish collected in this study came from the upper end of the reservoir above the town of Milford, Kansas.

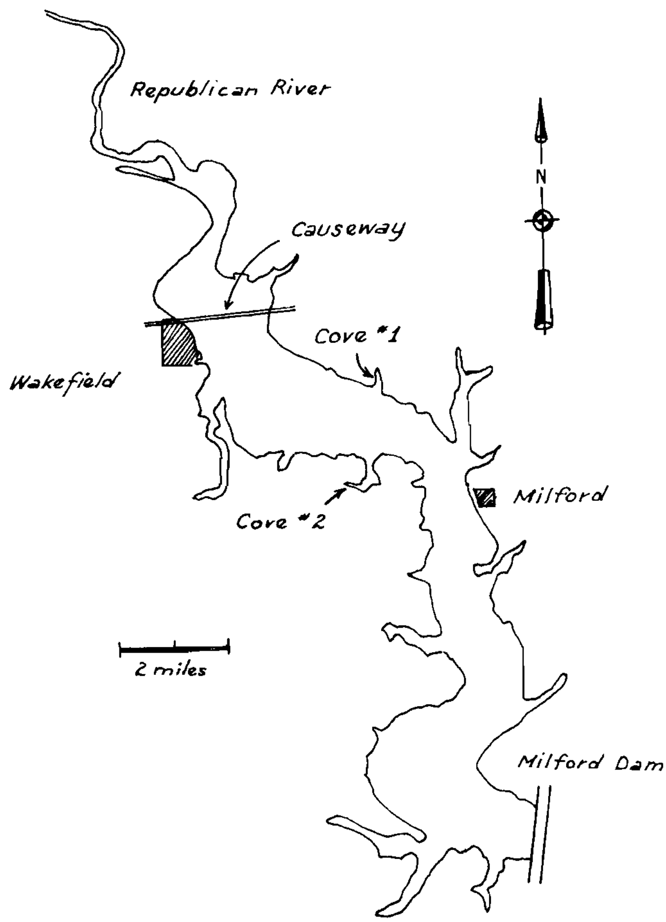

Figure 1. Map of Milford Reservoir.

The majority of these fish was collected near the causeway (land-fill bridge) which crosses the reservoir at Wakefield, Kansas (Fig. 1).

MATERIALS AND METHODS

Collection of Fish, Spines, and Stomachs

Two hundred flathead catfish were collected from Milford Reservoir from April, 1975 through November, 1975. Of this number, 102 were taken on rod and reel. The 102 fish caught by angling methods were all taken from the causeway which crosses the north end of the lake (Fig. 1). Thirty-nine flatheads were taken on trotlines from the submerged timber area at the mouth of the Republican River, as it empties into the reservoir. Trammel and gill nets set parallel and perpendicular to the causeway and across the old river channel in the timbered area each accounted for 23 flathead catfish. The trammel net had a small mesh of 3.5 inches, a large mesh of 12 inches, and was 300 feet in length. It was set on April 18, May 28, July 12, 13, August 6, 12, and 13. The net was checked every 12 to 24 hours as were the gill nets. Six gill nets 30 feet in length with mesh sizes from one inch to 3.5 inches in size were tied together. These nets were used May 28 and June 29. On September 16 Marketable Fisheries Investigation gill nets (NMFS 2-272-R-1) with meshes of 3.0 inches, 3.5 inches, and 4.0 inches were employed. Nine hundred feet of these nets were tied together and were used on October 14 and 17. On November 6 and 7 a gill net with four-inch mesh was set. An additional 13 fish were collected from two rotenoned cove samples. Cove number one has a steep rocky shoreline whereas cove number two had a clay-silt-loam bottom with a sloping shoreline (Groen, 1975). Test netting and rotenone sampling were accomplished in cooperation with the Kansas Forestry, Fish and Game Commission.

One pectoral spine was removed from each fish in a manner described for channel catfish by Sneed (1951), except that no pliers were needed. Pressure applied counter clockwise with the palm of the hand was usually enough to tear the "relaxed spine" from the socket. Often, when the fish was laid on its dorsal surface and its ventral surface was gently rubbed, it would relax its pectoral spines by adducting them. Dorsal spines were collected from approximately one-half of the fish for a comparison of the growth rings with those on the pectoral spines. The spines were placed in envelopes designated with a tag number for later identification. The numbers were recorded on a chart and used later to identify the fish's weight, length, collection method and date of collection.

Total length was measured to the nearest millimeter using a measuring board when one was available, otherwise a steel tape was used. Weights were recorded in grams when collected by Cal Groen or the author, but many of the smaller fish in the study were collected by a local sport fisherman, Maynard Sherbert, of Wakefield, Kansas, and were weighed by him to the nearest one-eighth of a pound.

Stomachs were extracted from 172 of the 200 flathead catfish collected. The 172 stomachs do not include those from fish taken by rotenone poisoning.

After spine removal and recording of length and weight the fish was eviscerated. The esophagus and duodenum were tied tightly with 100-pound test nylon cord to retain stomach contents. Stomachs were removed by cutting posterior to the duodenum ties and anterior to the esophagus ties. After removal, stomachs were injected with 10 per cent formalin and each was tagged with plastic tape on which there was a number corresponding to the spine samples from the same fish. The stomach was then placed in a 10 per cent formalin solution.

Treatment of Spines

Dorsal and pectoral spine sections were made by sawing sections from the distal end of the basal recess as described by Jenkins (1952). The saw was similar to that described by Sneed and Leonard (1951).

Spine sections were sanded with fine sand paper (320-A) until light would readily pass through the section. A Bausch and Lomb, Tri-Simplex Microprojector equipped with a 12X lens (field diameter = 279 mm) was used to project the spine image on a table top covered with white paper. Annuli appeared as dark bands while growth zones appeared lighter. False annuli were uncommon but easily recognized as fainter lines often not encircling the lumen. Annuli were measured to the nearest mm along the longest spine radius. This was done because annuli were farther apart along that radius, making them easier to distinguish, and a morphological reference point was needed for consistent measurements. Pectoral spines were used for age and growth calculations, whereas dorsal spines were used to confirm the number of annuli and their approximate location.

Annuli were more concentric in dorsal spines than in pectoral spines and often one or more annuli were found in dorsal spines than in pectoral spines, especially in larger fish.

Stomach Analysis

Stomach contents were analyzed in the lab after being preserved in formalin. Organisms found in the stomach were determined taxonomically to species when possible. Number of individuals of each species and individual lengths of forage fishes in each stomach were recorded.

Contents were measured by volume to the nearest 0.1 ml, using water displacement.

Calculations

Simple linear regression was used to compute regression lines for body length-pectoral spine radius relationships. Regression lines were computed for each year class of fish collected. It was statistically preferable to compute the regression of length on radius rather than radius on length (Tesch, 1971).

The regression line equation was used to obtain the y-intercept which was used in a modification of the direct proportionality formula proposed by Fraser (1916) and Lee (1920) as cited by Tesch (1971).

Length-weight relationships were determined by following the procedure outlined by Lagler (1956). Separate relationships were computed for males, females, and all fish combined. Sex was determined only for 167 dissected specimens from which the stomach had been removed.

A length frequency histogram described by Tesch (1971) using the Peterson method was constructed to aid in age determination.

Stomach contents were analyzed by total volume. Contents were separated into taxonomic groups and percentage of food items by month for each length group and age group of flathead catfish was determined. Frequency of occurrence and percentage of numerical occurrence of stomach contents were also determined. A Monroe 1880 computer was utilized for calculations.

RESULTS AND DISCUSSION

Collection

Table I indicates how many flathead catfish were collected each month using various collection methods. Angling accounted for approximately one-half of the catfish collected, but was only effective during the months of June, July, and August. Angling methods took fish mainly of small to medium size. Small specimens often regurgitated stomach contents when taken from the water.

Flathead catfish caught on trotlines were usually of a medium to large size. As Table I indicates, this method was effective only during May and June.

Nets were used to obtain fish throughout most of the study. Several types of nets were used and the numbers of fish caught in each are listed in Table I.

Rotenone poisoning was performed on two coves. This method took only small specimens and was utilized on only one date. One flathead catfish was obtained from the stomach of another flathead catfish.

Body Length-Pectoral Spine Relationship

A plot of total fish length against spine radius was made using the method of least square fit. A total of 199 coordinates was entered into the computer for this calculation. The equation for this straight line relationship corresponds to the following formula:

(1) total fish length = c + b (spine radius).

The constant c is equal to the y-intercept while the constant b is equal

Table I. Summary of flathead catfish taken utilizing various collection methods.

Collection Method	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Total	Length Range (mm)
Angling			5	43	54				102	255- 972
Trotline		24	15						39	533-1067
Trammel net	7	2			14				23	672-1016
Gill net (1"-3.5" mesh)		5	2						7	598- 750
NMSF (net)						5	3		8	550- 983
Gill net (4" mesh)								8	8	580- 759
Rotenone				13					13	222- 614
From another fish's stomach		1							1	142

to the slope of the line. Using the computer to solve these constants the following equation was found to represent the body length-pectoral spine relationship:

(2) total fish length = 56.05 mm + 3.53 (spine radius).

Figure 2 graphically summarizes this relationship. The empirical data fit the calculated regression line quite well, although it appears there may be a slight degree of curvilinearity.

The y-intercept is often interpreted as the length of the fish at the time which scales, or in this case, pectoral spines, begin to form. In some species this may be correct, but occasionally the y-intercept is negative in certain species, ruling out the possibility that the y-intercept is equal to fish length at the time of scale or spine formation (Lagler, 1956).

Regression lines were calculated by the Lee method for each age group separatly (Lagler, 1956). According to this method y-intercept values increase with age. Calculations of the body length-spine relationships were computed in this study for each year class from 1974 through 1962. No definite relationship was determined; however, it can be seen from Table II that the y-intercept (c) does vary from age group to age group. The extremely low intercept of the 1974 year class was probably due to the fact there were only two specimens for that age group. From the large values of some of the year classes it can be seen that the interpretation of the y-intercept, as the length when pectoral spines first appear, is not correct. With a larger sample size this interpretation might be more nearly correct. If there were more fish in a given year class, it can be seen that the body length-pectoral spine relationship would be affected.

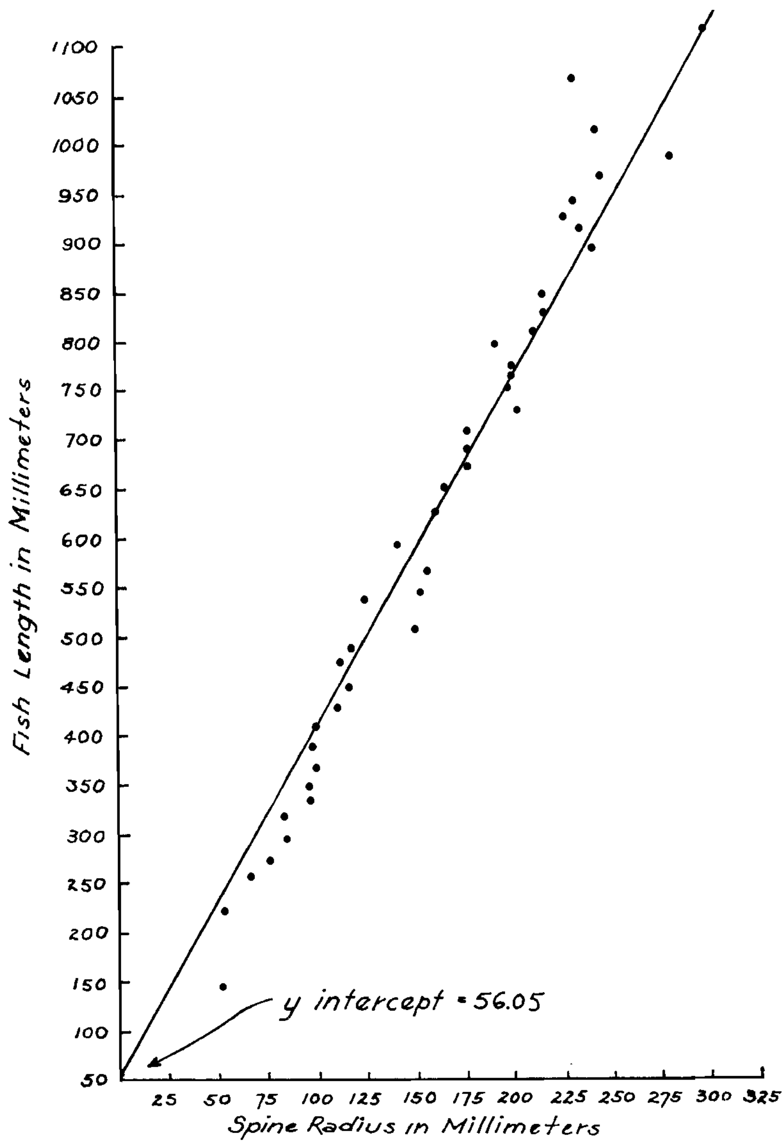

Figure 2. Body length-pectoral spine relationship for 199 flathead catfish.

Table II. Body length-pectoral spine relationships for each individual year class of flathead catfish collected.

Year Class	No. of Specimens	Body Length-Pectoral Spine Relationship y-intercept slope
1974 (1 yr. olds)	2	fish length = -1,203.83 + 26.33 (spine radius)
1973 (2 yr. olds)	14	= 249.59 + .85
1972 (3 yr. olds)	27	= 111.94 + 2.60
1971 (4 yr. olds)	37	= 233.22 + 1.86
1970 (5 yr. olds)	40	= 208.54 + 2.55
1969 (6 yr. olds)	26	= 256.55 + 2.09
1968 (7 yr. olds)	22	= 228.67 + 2.72
1967 (8 yr. olds)	7	= 342.49 + 2.48
1966 (9 yr. olds)	12	= 46.67 + 3.87
1965 (10yr. olds)	5	= 87.77 + 3.89
1962 (13yr. olds)	2	= 658.09 + 1.33

Length-Weight Relationship

Length-weight relationships were determined for 84 male and 83 female catfish. A length-weight relationship was also determined for 199 fish by combining known males and females, and all other fish whose sex was undetermined. The length-weight relationship of most fish can be shown by the following formula (after Lagler, 1956):

(3) $W = aL^n$.

In this case W equals the fish's weight and L, its length. The letter *a* stands for a constant and *n* is an exponent.

This formula can be converted to a logarithmic relationship expressed as follows:

(4) $\log W = \log a + n \log L$.

The values for a and n can be found by utilizing the following formulas:

(5) $$\log a = \frac{\sum \log W \cdot \sum (\log L)^2 - \sum \log L \cdot \sum (\log L \cdot \log W)}{N \cdot \sum (\log L)^2 - (\sum \log L)^2} .$$

The letter N equals the number of individual catfish for which the formula is being derived. The exponent n can now be found since we know the value for log of a by the following equation:

(6) $$n = \frac{\sum \log W - (N \cdot \log a)}{\sum \log L} .$$

The length-weight relationship was determined by utilizing each fish's length and weight. Data were not grouped. The following relationships were found: 1) males, $\log W = -5.673 + 3.261 \log L$; 2) females, $\log W = -6.429 + 3.545 \log L$; 3) combined, $\log W = -5.929 + 3.355 \log L$. These values are comparable to those found by other researchers listed in Table III.

It can be seen in Figures 3, 4, and 5 that female fish apparently gain more weight for a given length after an initial growing period than do males. The plot of all fish's length-weight relationship falls between that of males and females, which would be expected.

A value of three for n in equation (4) indicates that fish grow symmetrically if the specific gravity remains constant. A value other than three indicates allometric growth. If the value for n is greater than three, the fish becomes heavier for its length (Tesch, 1971). The latter apparently was the case for flathead catfish in this study.

Tesch (1971) indicated that the value of a will fluctuate with

Table III. Length-weight relationships for flathead catfish from various waters (Carlander, 1969).

Location	Length-weight Relationship
Watts Bar Lake, Tenn. (Harris, 1966)	log W = -6.080 + 3.421 log TL
Des Moines River, Iowa (Muncy, 1957)	= -5.334 + 3.138
Grand Lake, Oklahoma (Jenkins, 1954)	= -4.917 + 3.233
Oklahoma waters (Houser and Bross, 1963; McCoy, 1955)	= -4.974 + 3.255
Neosho and Big Blue River, Kansas (Minckley and Deacon, 1959)	= -5.387 + 3.099
Alabama waters (Swingle, 1965)	= -4.75 + 2.89 = -5.45 + 3.18 = -6.15 + 3.44

seasonal changes, time of day, and with habitat, while the value for n will remain fairly constant. No attempt was made by the author to ascertain the validity of this statement for flathead catfish, but the fluctuation is probably due to the variability of stomach content volume.

Fisheries biologists may find the length-weight relationship useful in the field. In computing the poundage of fish cropped from a lake, only fish length needs to be taken. The weight can be derived from either the graphs (Figs. 3, 4, and 5) or the formula for the length-weight relationship.

Weights were calculated for each fish by inserting its length into the length-weight relationship equation derived from all fish in this

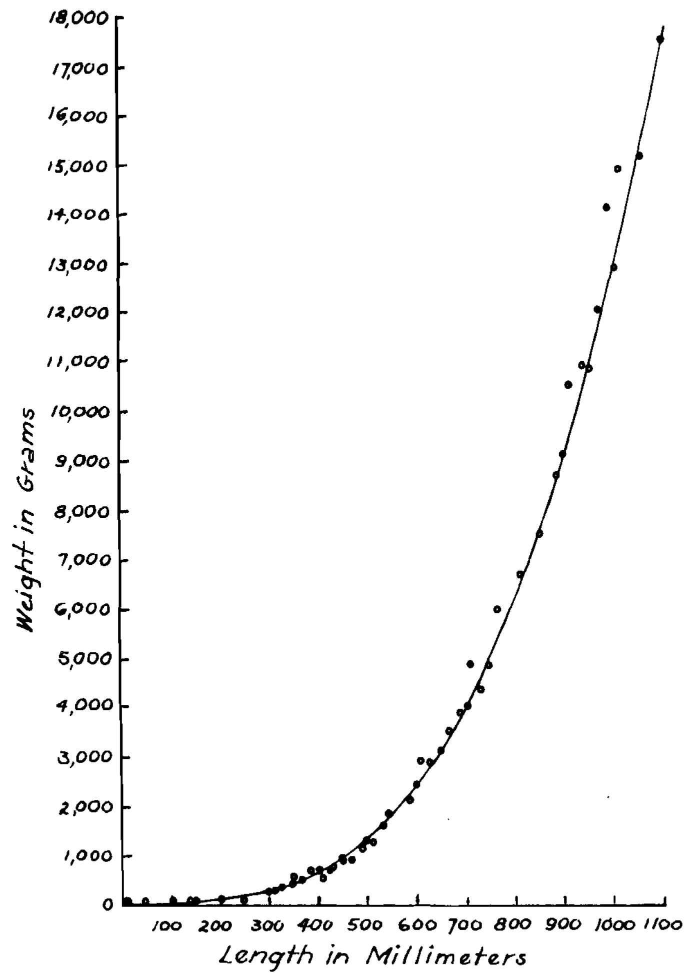

Figure 3. Length-weight relationship for 84 male flathead catfish.

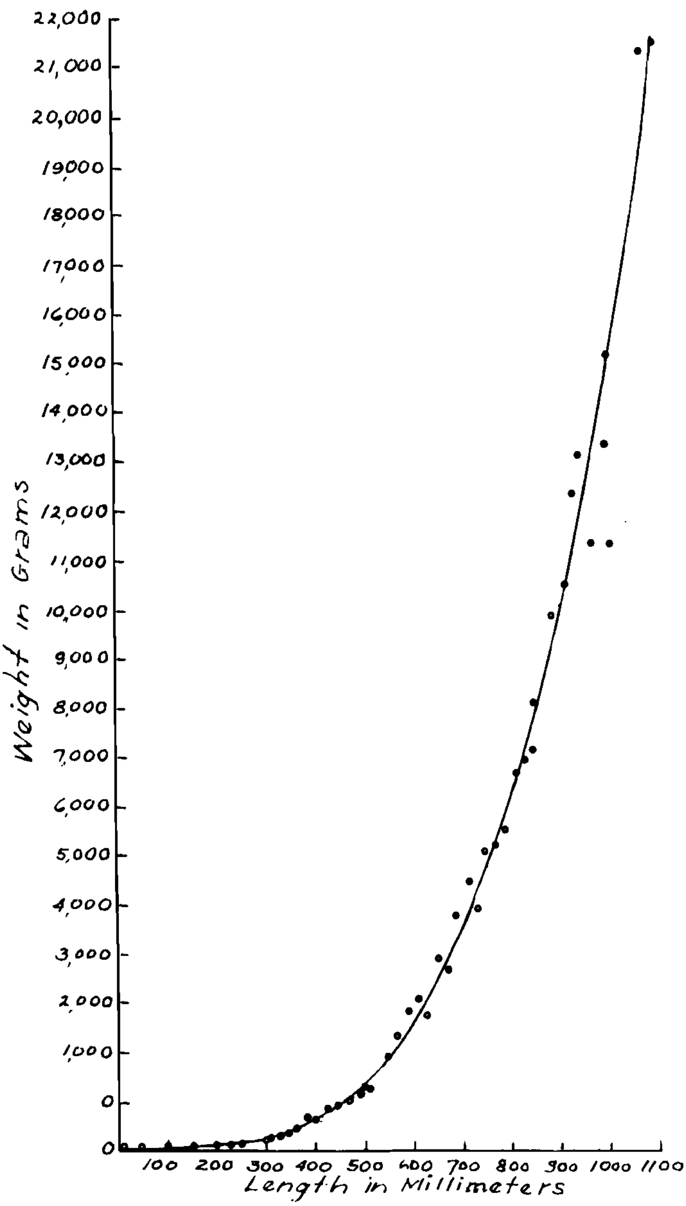

Figure 4. Length-weight relationship for 83 female flathead catfish.

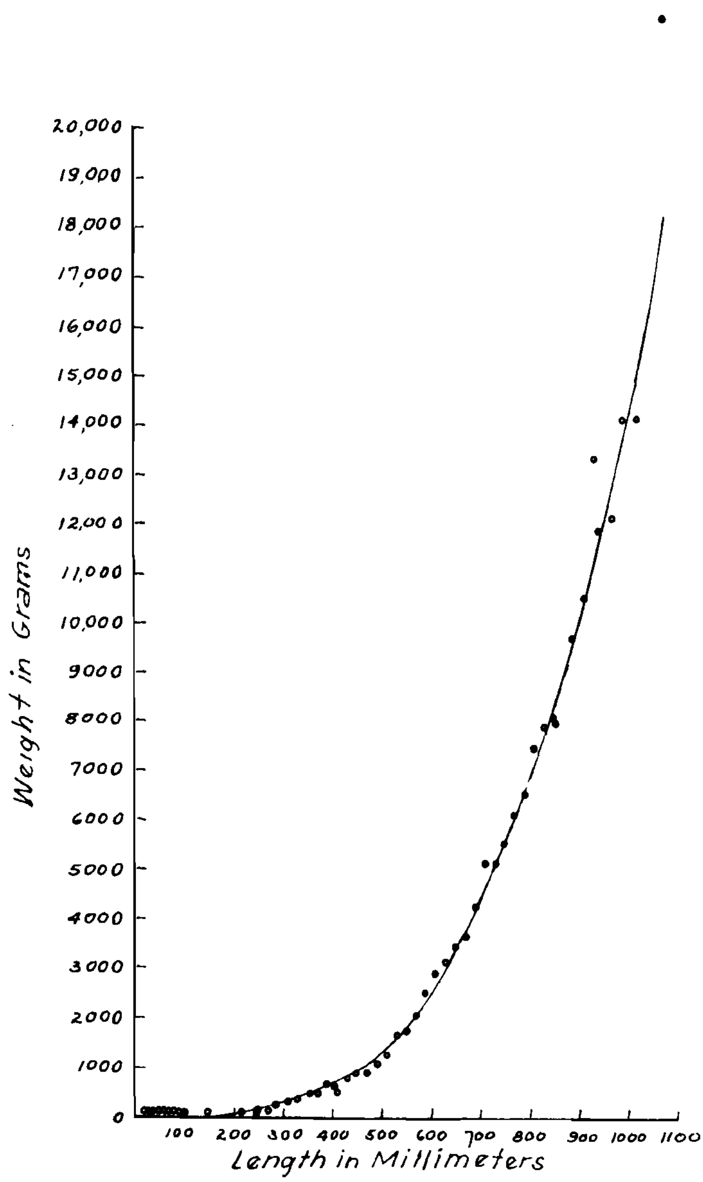

Figure 5. Length-weight relationship for 199 flathead catfish.

study. It can be seen that, with few exceptions, calculated weights and empirical weights are close to each other in value (Table IV).

Condition

Condition factors were calculated for each fish using the following formula (after Lagler, 1956):

$$(7)\quad K_{tl} = \frac{W \times 10^5}{L^3} .$$

A more accurate coefficient of condition could probably be derived using the value of n found in the length-weight relationship and changing the equation to read:

$$(8)\quad K_{tl} = \frac{W \times 10^5}{L^n} \quad \text{(Tesch, 1971)} .$$

Hile (1936) noted that the use of the formula based on the cube law (7) cannot be used in back-calculating weight for a given length fish because many times the value of n (equation 8) is not three (a value of three would indicate symmetrical growth), as some fish increase more than others in one dimension as they grow.

It can be seen from Table V that there was a general trend for the coefficient of condition to increase with increasing length. This is more readily seen in values for females than for males and is probably because most of the large female flathead catfish were caught in April and May (Table VI) prior to the supposed time of spawning which, according to Minckley and Deacon (1959), occurs in Kansas from late June to the middle of July. Turner and Summerfelt (1971) reported that ovary weights make up 8-16 per cent of the female flathead catfish's body weight. Knowing this, one should be able to compare average condition factors of female fish by month and determine, in general, when spawning occurs.

Table IV. Length, empirical weight, calculated weight and the difference between empirical and calculated weights for each fish sampled.

Length (mm)	Empirical Weight (gm)	Calculated Weight (gm)	Difference (gm)
141	37	19	- 18
220	108	86	- 22
225	113	93	- 20
248	138	129	- 9
253	154	139	- 15
271	168	174	+ 6
285	200	206	+ 6
293	230	226	- 4
294	249	229	- 20
306	221	262	+ 41
312	227	279	+ 52
318	227	298	+ 71
318	340	298	- 42
318	340	298	- 42
323	454	454	0
330	227	337	+ 100
330	454	337	- 117
330	227	337	+ 110
337	454	362	- 92
337	340	362	+ 22
338	418	366	- 52
343	454	385	- 69
343	454	385	- 69
343	340	385	+ 45
344	454	388	- 66
344	454	388	- 66
344	454	388	- 66
346	454	395	- 59
356	454	436	- 18
356	340	436	+ 96
359	454	448	- 7
362	454	460	+ 6
362	420	460	+ 40
363	577	465	- 88
365	454	473	+ 19
365	454	473	+ 19
367	454	482	+ 28
368	454	486	+ 32
370	472	495	+ 23
375	567	519	- 48
380	680	547	- 133
381	454	547	- 7
382	680	552	- 128
384	709	561	- 148

Table IV. Continued

Length (mm)	Empirical Weight (gm)	Calculated Weight (gm)	Difference (gm)
387	680	577	- 103
390	541	592	+ 51
392	567	601	+ 34
394	567	612	+ 45
394	907	612	- 295
400	567	644	+ 77
402	582	655	+ 73
405	618	671	+ 53
406	340	676	+ 336
413	680	716	+ 36
416	680	735	+ 155
419	680	752	+ 72
422	794	771	- 23
422	680	771	+ 91
425	907	789	- 118
427	790	802	+ 12
432	907	834	- 73
432	794	834	+ 40
433	794	839	+ 45
433	680	839	+ 159
438	907	873	- 34
439	850	879	+ 29
445	907	920	+ 13
445	907	920	+ 13
445	907	920	+ 13
445	907	920	+ 13
450	794	955	+ 161
450	980	955	- 25
451	1021	964	- 59
458	795	1014	+ 219
461	1021	1038	+ 27
462	850	1045	+ 195
467	1020	1084	+ 64
470	907	1107	+ 200
470	1125	1107	- 18
471	1021	1114	- 7
476	907	1153	+ 246
476	1134	1153	+ 19
476	907	1153	+ 246
476	907	1153	+ 246
477	968	1162	+ 194
483	1134	1213	+ 79
483	1134	1213	+ 79
489	1247	1265	+ 18
495	1134	1315	+ 181
501	1362	1371	+ 9

Table IV. Continued

Length (mm)	Empirical Weight (gm)	Calculated Weight (gm)	Difference (gm)
505	1134	1409	+ 275
508	1362	1435	+ 73
514	1361	1493	+ 132
516	1200	1514	+ 314
533	1361	1687	+ 326
533	1589	1687	+ 98
539	1816	1754	- 62
540	1589	1762	+ 173
540	1800	1762	- 38
546	1755	1828	+ 73
550	2040	1875	- 165
560	2050	1991	- 59
562	1850	2018	+ 168
563	2268	2028	- 240
570	2220	2133	- 87
572	1814	2138	+ 324
575	2470	2178	- 292
580	2900	2244	- 656
584	2155	2296	+ 141
590	2370	2377	+ 7
597	2041	2472	+ 431
598	3150	2483	- 667
600	2850	2512	- 338
600	2600	2512	- 88
603	2268	2553	+ 285
604	3850	2570	-1280
610	3402	2655	- 747
616	2722	2742	+ 20
620	3060	2805	- 255
622	2495	2838	+ 343
622	2600	2838	+ 238
623	2722	2851	+ 129
623	2949	2851	- 98
627	2250	2911	+ 661
628	3450	2931	- 519
628	2722	2931	+ 209
632	3420	2922	- 498
647	3950	3236	- 714
648	3250	3251	+ 1
654	3091	3357	+ 266
660	3500	3459	- 41
662	3150	3491	+ 341
672	3850	3673	- 177
673	3402	3690	+ 288
676	3750	3750	0
680	3700	3828	+ 128

Table IV. Continued

Length (mm)	Empirical Weight (gm)	Calculated Weight (gm)	Difference (gm)
682	4600	3864	- 736
685	4000	3917	- 83
686	4990	3936	-1054
687	5330	3963	-1367
691	4000	4036	+ 36
697	4200	4159	- 41
698	3969	4178	+ 209
704	4550	4295	- 255
705	4875	4315	- 560
710	5200	4426	- 774
711	4536	4446	- 90
712	6804	4467	-2237
720	4850	4634	- 216
720	5100	4634	- 466
724	4900	4721	- 179
730	5100	4853	- 247
731	5600	4875	- 725
735	4800	4966	+ 166
736	5775	4989	- 786
737	4990	5012	+ 22
740	5050	5082	+ 32
741	4424	5015	+ 681
743	6500	5152	-1348
750	7650	5309	-2341
752	5350	5358	+ 8
756	4700	5458	+ 758
758	5600	5508	- 92
759	5500	5534	+ 34
764	6150	5649	- 501
765	6650	5675	- 975
775	6300	5929	- 371
775	5216	5929	+ 713
775	6100	5929	- 171
790	6700	6324	- 376
796	6300	6486	+ 186
800	7300	6607	- 693
800	6745	6607	- 138
805	5750	6745	+ 995
812	9025	6934	-2091
813	7711	6966	- 745
815	8250	7031	-1219
826	8100	7345	- 755
830	6900	7464	+ 564
830	8625	7464	-1161
845	8150	7925	- 225
892	10886	9506	-1380

Table IV. Continued

Length (mm)	Empirical Weight (gm)	Calculated Weight (gm)		Difference (gm)
895	8618	9616		+ 998
910	10500	10162		- 338
914	10433	10328		- 105
927	13381	10814		-2567
940	10886	11350		+ 464
940	14061	11350		-2711
940	10896	11350		+ 454
964	12250	12359		+ 109
965	12247	12388		+ 141
972	11884	12705		+ 821
983	14062	13183		- 879
991	14288	13552		- 736
1003	12247	14093		+1846
1016	14515	14723		+ 208
1016	15422	14723		- 699
1067	22226	17378		-4848
	651990		Total	-26834
4% error	(1437.36 lbs.)			(59.15 lbs.)

Table V. Coefficients of condition by length groups for 84 male flathead catfish, 83 female flathead catfish, and 199 flathead catfish.

	Males				Females				*Total			
Class Interval	No.	Avg. Length (mm)	Avg. Weight (gm)	Avg. K_{tl}	No.	Avg. Length (mm)	Avg. Weight (gm)	Avg. K_{tl}	No.	Avg. Length (mm)	Avg. Weight (gm)	Avg. K_{tl}
140- 159	1	141	37	1.32					1	141	37	1.32
160- 179												
180- 199												
200- 219												
220- 239									1	220	108	1.01
240- 259	1	248	138	.90	1	255	113	.68	2	252	126	.79
260- 279									1	271	168	.84
280- 299									3	291	226	.91
300- 319	2	312	284	.92	3	316	265	.87	5	314	272	.87
320- 339	4	336	397	1.10	2	334	284	.76	7	332	368	1.00
340- 359	6	348	454	1.08	4	347	397	.95	10	348	431	1.03
360- 379	5	369	480	.95	2	365	454	.94	9	366	478	.97
380- 399	4	385	603	1.05	6	390	657	1.10	10	388	635	1.08
400- 419	4	406	551	.82	3	412	647	.92	7	409	592	.86
420- 439	6	427	786	1.00	5	432	804	.99	11	429	794	1.00
440- 459	5	450	885	.97	2	445	907	1.03	7	448	891	.99
460- 479	4	474	935	.88	4	470	1021	.98	11	471	979	.95
480- 499	3	485	1172	1.03	1	495	1134	.93	4	488	1162	1.00
500- 519	3	509	1286	.97	2	507	1281	.97	5	509	1284	.97
520- 539	3	535	1604	1.03					3	535	1604	1.03
540- 559	2	545	1815	1.12					4	544	1796	1.11
560- 579					2	569	2369	1.28	5	566	2091	1.15
580- 599	2	591	2098	1.02	3	589	2807	1.37	5	590	2523	1.23
600- 619	2	607	2835	1.26	3	607	3057	1.37	6	606	2949	1.32
620- 639	2	626	2836	1.16	3	621	2759	1.15	8	624	3025	1.14
640- 659	1	654	3091	1.11	1	647	3950	1.46	3	650	3430	1.25

Table V. Continued

Class Interval	Males No.	Males Avg. Length (mm)	Males Avg. Weight (gm)	Males Avg. K_{tl}	Females No.	Females Avg. Length (mm)	Females Avg. Weight (gm)	Females Avg. K_{tl}	*Total No.	*Total Avg. Length (mm)	*Total Avg. Weight (gm)	*Total Avg. K_{tl}
660- 679	2	675	3576	1.16	2	666	3675	1.24	4	670	3626	1.20
680- 699	3	687	3967	1.22	4	687	4730	1.46	9	687	4215	1.30
700- 719	2	707	4875	1.37	3	709	5405	1.51	5	708	5193	1.45
720- 739	3	734	5392	1.36	3	727	4913	1.28	8	729	5139	1.32
740- 759	3	750	4825	1.14	5	750	6060	1.43	8	750	5597	1.32
760- 779	2	770	5933	1.30	3	771	6183	1.34	5	771	6083	1.33
780- 799					2	793	6500	1.30	2	793	6500	1.30
800- 819	2	809	6731	1.26	2	808	7775	1.47	6	808	7464	1.41
820- 839					3	829	7875	1.38	3	829	7875	1.38
840- 859					1	845	8150	1.35	1	845	8150	1.35
860- 879												
880- 899	1	895	8618	1.20	1	892	10886	1.53	2	894	9752	1.36
900- 919	1	910	10500	1.39	1	914	10433	1.37	2	912	10467	1.38
920- 939					1	927	13381	1.68	1	927	13381	1.68
940- 959	1	940	10886	1.31	1	940	14061	1.69	3	940	11948	1.43
960- 979	2	968	12067	1.33	1	965	12247	1.36	3	967	12127	1.34
980- 999	1	983	14062	1.48	1	991	14288	1.47	2	987	14175	1.47
1000-1019	2	1016	14969	1.42	1	1003	12247	1.21	3	1012	14061	1.35
1020-1039												
1040-1059												
1060-1079					1	1067	22226	1.83	1	1067	22226	1.83

* Includes those fish for which the sex was undetermined.

A significant drop in the condition factors of female fish should be noted after spawning. Turner and Summerfelt (1971) stated that all age IV female flathead catfish were mature and all age V male flathead catfish were mature in samples taken from Lake Carl Blackwell, Oklahoma. Back-calculations of growth in this study indicated the average length of males at age V to be 502 mm while the average length of females at age V was 526 mm. It was then assumed that most flathead catfish over 500 mm in size were sexually mature. Average condition factors by month for male and female catfish 500 mm in length and larger are summarized in Table VI. There appears to be a slight decrease in average condition of females in June and continuing into July. This is probably due to spawning activity by females. There also appears to be a similar decrease in the average condition factor of males, who clean and guard the nest, during the same approximate time period. Both sexes appear to begin recovering their condition during August to November at which time the study was terminated. Small sample sizes used in calculating coefficients of condition reported in Table VI render any definite conclusion impossible.

Table VI. Average Ktl's by month for male and female flathead catfish greater than 500 mm in length.

	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Male	1.435 (2)	1.251 (6)	1.120 (1)	1.055 (10)	1.220 (14)	1.323 (3)	1.230 (1)	1.400 (3)
Female	1.436 (5)	1.495 (19)	1.380 (5)	1.145 (2)	1.219 (10)	1.175 (2)	1.300 (1)	1.380 (5)

The number in parentheses indicates number of specimens from which the average Ktl was derived.

Age and Growth

Calculations of growth history were made using a modification of the direct proportionality formula. This method was advocated by Summerfelt (1975) and can be found in Ricker (1971). The formula for calculating growth is as follows:

$$(9) \quad L_n - C = \frac{S_n}{S} (L-C) .$$

Where L_n equals length of fish when annulus 'n' was formed; L equals length of fish at the time the spine sample was obtained; S_n equals radius of annulus 'n' (at length 'L_n'); S equals total spine radius; and C is the correction factor (y-intercept from the body-spine relationship). This formula can be changed algebraically to read:

$$(10) \quad L_n = C + \frac{S_n}{S} (L-C) .$$

In this study each fish's growth history was back-calculated using the above formula (equation 10) and utilizing the correction factor (y-intercept) of 56.05 mm. Jenkins (1952) and McCoy (1953) assumed the y-intercept of the body-spine relationship to be zero and back-calculated lengths of fish by direct proportion using a nomograph.

Upon back-calculation of the length of a fish when the first annulus was laid down, it was evident that in some cases one or more annuli were missing. This was first observed in the 1971 year class (age group IV) when some fish had what appeared to be too large back-calculated lengths at the first observed annulus. Often it was an easy matter to look at back-calculated lengths at various annuli from other fish and put the fish with the missing annulus or annuli into an appropriate year class. Caution must be exercised in doing this. Time of year the fish was collected may affect the decision as to which year class it actually belongs. For instance, a fish collected in November will have nearly a new growth zone laid down which must be taken into account when considering whether or not a fish is missing an annulus or annuli. In some year classes the first annulus was missing on all specimens (Table VII). Langemeier (1965) and Mayhew (1969) encountered this same problem. Minckley and Deacon (1959) stated that deterioration of the central portion of the spine did not inhibit accurate aging of the flathead catfish. In this study it was found to be a major problem in age determination of fish four years old and older.

Data on age and growth are summarized for 84 male flathead catfish (Table VIII), 83 female flathead catfish (Table IX), and 196 flathead catfish of both sexes including 29 catfish for which the sex was not determined (Table X). A plot of both total length derived from back-calculations at each annulus and annual increments of length is presented in Figure 6. From the graph, one can see little difference between growth patterns of male and female flathead catfish.

While there is little difference in growth in length of females compared to males, there does seem to be considerable difference in their back-calculated weights using the length-weight relationship derived for all flathead catfish sampled from the reservoir (Tables VIII and IX). It appears there is a decrease in the annual increment of length for both sexes after the eighth year of life (Fig. 6). Even so, it appears from Tables VIII and IX that there is still a considerable gain in weight after this time. Male and female flathead catfish appear to have relatively equal average weights through the third year of life, but from that time on females appear to weigh considerably more than males. Weights represented in Tables VIII, IX and X are based on calculations

Table VII. Loss of annuli in pectoral spine of flathead catfish.

Age Group	Frequency No. of Fish	Number of Pectoral Spines Missing Annulus Number					
		1	2	3	4	5	6
I	2	-	-	-	-	-	-
II	14	-	-	-	-	-	-
III	27	-	-	-	-	-	-
IV	37	6	1	-	-	-	-
V	40	22	8	1	-	-	-
VI	26	8	2	-	-	-	-
VII	22	17	12	6	2	-	-
VIII	7	7	5	1	1	-	-
IX	12	12	9	4	-	-	-
X	5	5	5	-	-	-	-
XI	0	-	-	-	-	-	-
XII	0	-	-	-	-	-	-
XIII	2	2	2	-	-	-	-
XIV	1	1	1	1	-	-	-
XV	0	-	-	-	-	-	-
XVI	1	1	1	1	1	-	-
Totals	196	81	56	14	4	-	-

Table VIII. Age and growth data of 84 male flathead catfish.

Species and Sex	Year Class	No. Age Group Sampled	Weight Range	Mean Weight	Length Range	Mean Length	K-Factor Range	Mean Ktl Factor	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
Flathead males	1974	1		37		141		1.32	136															
	1973	7	138- 632	386	248- 420	328	0.85-1.35	1.04	174	226														
	1972	9	227- 567	430	330- 406	361	0.51-1.12	0.92	150	224	315													
	1971	20	454- 2722	1052	330- 628	458	0.82-1.26	1.01	162	223	308	398												
	1970	16	709- 6650	3037	384- 775	618	0.84-1.49	1.11	198	239	321	430	545											
	1969	14	454- 5600	2082	343- 752	527	0.83-1.50	1.11	168	218	300	379	443	492										
	1968	7	567- 5750	3558	400- 813	612	0.89-1.45	1.19	163	225	288	357	411	496	560									
	1967	1		10500		910		1.39	---	279	352	445	481	553	658	839								
	1966	6	3402-15422	10299	673-1016	887	1.12-1.48	1.35	---	236	330	445	614	687	764	809	848							
	1965	2	4700-11884	8292	756-972	864	1.09-1.29	1.19	---	---	335	456	509	612	693	747	810	852						
	1962	2	10886-12250	11568	940-964	952	1.3.-1.37	1.34	---	---	332	442	569	683	769	785	827	859	883	904	928			
								1/	168	228	312	406	502	551	672	795	836	855	883	904	928			
									(6.6	9.0	12.3	16.0	19.8	21.7	26.5	31.3	32.9	33.7	34.8	35.6	36.5)			
								2/	168	60	84	94	96	49	121	123	41	19	47	21	24			
									(6.6	2.4	3.3	3.7	3.8	1.9	4.8	4.8	1.6	0.7	1.8	0.8	0.9)			
								3/	35	97	279	676	1380	1888	3673	6456	7656	8260	9204	9904	10864			

1/ Calculated Growth at Annulus (weighted)

2/ Annual Growth Increment

3/ Back-calculated Weights at Time each Annulus was Formed

() Inches

Table IX. Age and growth data of 83 female flathead chatfish.

Species	Year Class	No. Age Group Sampled	Weight Range	Mean Weight	Length Range	Mean Length	K-Factor Range	Mean Ktl Factor	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
Flathead females	1973	4	113- 680	447	255- 390	347	0.68-1.23	1.26	187	265														
	1972	11	227- 1200	506	312- 516	370	0.71-1.13	0.92	143	218	320													
	1971	12	227- 2470	812	330-575	415	0.63-1.48	1.01	150	212	291	372												
	1970	18	567- 5600	3044	394- 758	596	0.93-1.75	1.27	208	252	323	430	535											
	1969	10	907- 6500	3020	438- 743	602	0.87-1.58	1.19	174	235	303	405	478	551										
	1968	13	1134- 8625	5800	476- 845	739	1.05-1.81	1.35	---	226	318	393	495	604	686									
	1967	5	6804-12247	8737	712-1003	852	1.21-1.89	1.42	---	292	358	520	593	679	749	817								
	1966	6	4875-22226	11166	790-1067	868	1.39-1.83	1.55	---	258	339	440	555	649	715	789	833							
	1965	3	6100-13381	10516	775- 927	889	1.31-1.68	1.45	---	---	316	463	569	664	754	811	839	874						
	1961	1		14288		991		1.47	---	---	---	421	593	711	805	819	886	937	954	964	970	984		
								1/	167	234	316	416	526	615	715	805	840	890	954	964	970	984		
									(6.6	9.2	12.4	16.4	20.7	24.2	28.1	31.7	33.1	35.0	37.6	38.0	38.2	38.7)		
								2/	167	67	82	100	110	89	100	90	35	50	64	10	6	14		
									(6.6	2.6	3.2	3.9	4.3	3.5	3.9	3.5	1.4	2.0	2.5	0.4	0.2	0.6)		
								3/	34	106	272	735	1614	2729	4529	6745	7780	9441	11912	12359	12618	13213		

1/ Calculated Growth at Annulus (weighted)

2/ Annual Growth Increment

3/ Back-calculated Weights at Time each Annulus was Formed

() Inches

Table X. Age and growth data of 196 flathead catfish.

Species	Year Class	No. Age Group Sampled	Weight Range	Mean Weight	Length Range	Mean Length	K-Factor Range	Mean Ktl Factor	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
Flathead	1974	2	37- 108	73	141- 220	181	1.01-1.32	1.17	159															
	1973	14	113- 680	363	248- 420	324	0.68-1.35	0.98	172	243														
	1972	27	227- 1850	624	294- 572	387	0.51-1.14	0.94	144	219	325													
	1971	37	227- 3150	1067	330- 682	455	0.63-1.48	1.02	154	217	304	396												
	1970	40	567- 6650	3007	384- 775	606	0.84-1.75	1.20	201	246	316	419	534											
	1969	26	454- 6500	2611	343- 752	567	0.83-1.58	1.16	170	231	313	400	468	527										
	1968	22	567- 9025	5276	400- 845	705	0.89-1.81	1.31	163	225	304	384	473	577	653									
	1967	7	3969-12247	8308	698-1003	838	1.17-1.89	1.38	---	286	364	497	580	653	720	797								
	1966	12	3402-22226	10733	673-1067	877	1.12-1.83	1.45	---	250	335	443	584	668	740	799	840							
	1965	5	4700-13381	9662	756- 972	879	1.09-1.68	1.35	---	---	323	460	545	643	729	786	827	865						
	1962	2	10886-12250	11568	940- 964	952	1.31-1.37	1.34	---	---	332	442	569	683	769	785	827	859	883	904	928			
	1961	1		14288		991		1.47	---	---	---	421	593	711	805	819	886	937	954	964	970	984		
	1959	1		10896		940		1.31	---	---	---	---	563	672	771	801	816	841	856	866	880	900	915	925
								1/	164	230	316	412	517	591	700	796	837	869	894	909	926	942	915	925
									(6.5	9.1	12.4	16.2	20.4	23.3	27.6	31.3	33.0	34.3	35.2	35.8	36.5	37.1	36.0	36.4)
								2/	164	66	86	96	105	74	109	96	41	32	25	15	17	16	—	10
									(6.5	2.6	3.4	3.8	4.1	2.9	4.3	3.8	1.6	1.3	1.0	0.6	0.6	0.6	—	0.4)
								3/	32	100	292	711	1524	2388	4217	6486	7691	8710	9594	10139	10789	11429	10351	10740

1/ Calculated growth at annulus (weighted)
2/ Annual growth increment
3/ Back-calculated weight at time each annulus was formed
() Inches

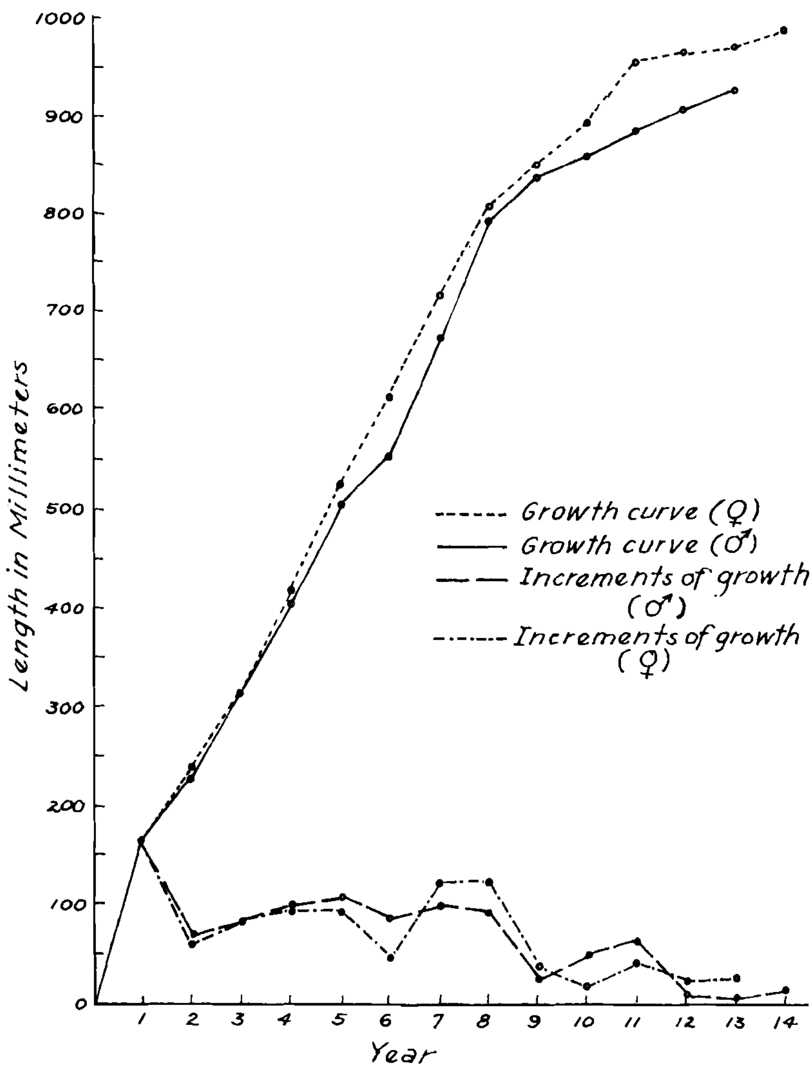

Figure 6. Growth curves and increments of growth for male and female flathead catfish.

derived by inserting the weighted growth (lengths) at each annulus into the length-weight relationship derived for all flathead catfish collected. If the length-weight relationships derived separately for males and females had been used, the males would have smaller weights represented at the end of each year of life and the females would have even larger weights than those shown in Tables VIII and IX. The weight difference can probably be attributed to at least some female flathead catfish reaching sexual maturity and producing ova during their fourth year of life.

Data in Table X show a larger increment the first year of life than any of the citings in Table XI. There could be several reasons for this. Milford Reservoir was recently constructed; therefore it is probably in its peak period of productivity. Total lengths at successive years of life after age I show the fish in Milford Reservoir to lag somewhat behind McCoy's findings for flathead catfish from Oklahoma lakes. This would be expected, for Northern Kansas has a shorter growing season than Oklahoma. Data in Table X appear to resemble closely those reported by Minckley and Deacon (1959) for flathead catfish from the Big Blue River in Kansas. They reported that the faster growth of this species in the Big Blue River than in the Neosho River (also in Kansas) was because the Big Blue River flathead catfish utilized fish for food earlier than those in the Neosho River. Jenkins (1952) reported faster growth in turbid, shallow, mud flats of the Neosho Arm of Grand Lake than in clear rocky areas of Grand Lake. Minckley and Deacon (1959) reported the fastest growth of flathead catfish was in turbid, shallow areas and downstream areas. The upper end of Milford Reservoir is silt bottom, relatively shallow, and usually turbid because of the Republican River's drainage of

Table XI. Average calculated lengths in inches to the end of each year of life of flathead catfish from various lakes and reservoirs.

Location	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Twenty-one Oklahoma Lakes (McCoy, 1953)	4.6	9.7	15.2	20.0	23.4	25.9	28.9	32.4	35.1	38.3	39.0	41.5	42.8	43.3
Big Blue River, Kansas (Minckley and Deacon, 1959)	5.6	10.3	14.4	19.0	24.8		27.6	30.4						
Neosho River, Kansas (Minckley and Deacon, 1959) Sampled 1957	4.8	9.5	11.4	15.8	16.5									
Neosho River, Kansas (Minckley and Deacon, 1959) Sampled 1958	3.2	8.7	12.8	14.9	17.5									
Milford Reservoir, Kansas (McKinley, 1973)	5.3	10.6	21.0	23.8										

Table XI. Continued

Location	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Lower Lake, Grand Lake, Oklahoma (Jenkins, 1952)	2.5	5.0	7.3	10.2	13.4	15.2	17.9	17.4						
Upper Lake, Grand Lake, Oklahoma (Jenkins, 1952)	3.4	6.9	11.3	16.2	18.3	21.4	24.6							
Neosho River Arm, Grand Lake, Oklahoma (Jenkins, 1952)	5.5	10.2	15.0	19.3	23.0	25.8	30.9	34.6	37.2	39.9	42.3			

farmland. This is the area where flatheads are most frequently caught by fishermen and also where most of the fish in this study were collected. Another probable reason for relatively fast growth of flathead catfish in Milford Reservoir is their early utilization of forage fishes, primarily gizzard shad, for food. McKinley's (1973) report of the growth of flathead catfish (Table XI) was based on only one specimen. McKinley may have missed an annulus representing the end of the third year of life.

A length frequency analysis was performed utilizing the Petersen method. Data used in the construction of this histogram, Figure 7, can be found in Table XII. The modes in a length frequency analysis suggest mean fish lengths at successive ages. These modes can be compared with lengths derived from age determinations made on scales or bones (in this study, pectoral spines). When these correspond it can be assumed that the marks (annuli) used for age determination have been validated (Tesch, 1971). When determining age solely from a length frequency histogram three criteria must be met; the sample must be: 1) composed of a large number of individuals, 2) collected in a restricted period of time (a single day, preferably), and 3) made up of a good representation of all of the size and age groups in the population. If these criteria are not met the use of the length frequency analysis is limited to: 1) estimation of mean lengths in younger age groups; and 2) validation of other methods of age assessment (Lagler, 1956).

The bar graph in Figure 7 indicates how many fish were collected in each length group. The lines superimposed on the bar graph represent how many fish of various ages were in each length group. Because of the extreme overlapping of age groups as far as length of the representative fish are concerned, it can be seen that this method is not very useful in

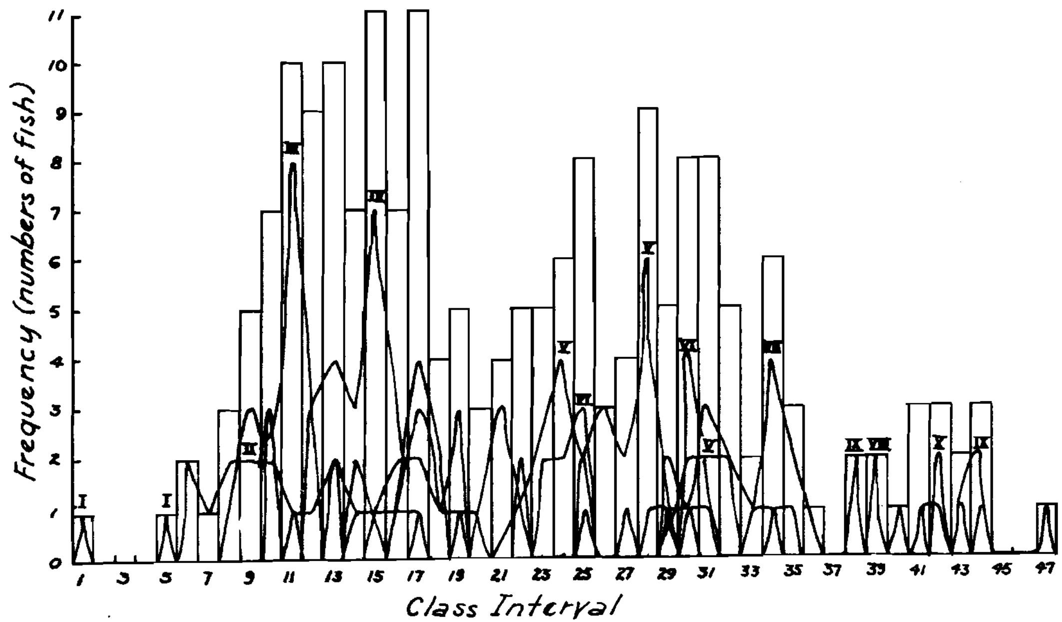

Figure 7. Length frequency histogram representing 196 flathead catfish (class intervals correspond to length groups in Table XII.

Table XII. Length frequency distribution of 196 flathead catfish.

	Class Interval (mm)	Age														
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
1.	140- 159	1														
2.	160- 179															
3.	180- 189															
4.	200- 219															
5.	220- 239	1														
6.	240- 259		2													
7.	260- 279		1													
8.	280- 299		2	1												
9.	300- 319		2	3												
10.	320- 339		2	2	3											
11.	340- 359		1	8			1									
12.	360- 379		1	5	3											
13.	380- 399		2		4	2	2									
14.	400- 419			2	3		1	1								

Table XII. Continued

	Class Interval (mm)	Age														
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
15.	420- 439		1	1	7		1	1								
16.	440- 459				2	2	1									
17.	460- 479			1	4	3	1									
18.	480- 499				2	1	1									
19.	500- 519			1		3	1									
20.	520- 539				2		1									
21.	540- 559			1	3											
22.	560- 579			2	1	2										
23.	580- 599					3	2									
24.	600- 619					4	2									
25.	620- 639				2	2	3	1								
26.	640- 659					3										
27.	660- 679					2		1		1						
28.	680- 699				1	6	1		1							

Table XII. Continued

	Class Interval (mm)	Age														
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
29.	700- 719					1		2	1	1						
30.	720- 739					2	4	1		1						
31.	740- 759					2	2	3			1					
32.	760- 779					2		2			1					
33.	780- 799							1		1						
34.	800- 819							4	1	1						
35.	820- 839							2	1							
36.	840- 859							1								
37.	860- 879															
38.	880- 899									2						
39.	900- 919								2							
40.	920- 939										1					
41.	940- 959									1				1		1
42.	960- 979										2			1		

Table XII. Continued

	Class Interval (mm)	Age														
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
43.	980- 999									1					1	
44.	1000-1019								1	2						
45.	1020-1039															
46.	1040-1059															
47.	1060-1079									1						

aiding in age determination of flathead catfish.

It can be seen from Figure 7 that peaks representing the first four age groups are fairly prominent and in order, but even these are not clearly represented. From that point, the modes are not as distinct as in the first four age groups and not necessarily in the expected order. This is due to much overlapping of age groups when the fish are grouped by lengths. The fact that samples were taken over a long period of time and represent a relatively small number of fish from the total population further reflects on the inaccuracy of this method.

Analysis of Stomach Contents

Stomach contents were analyzed to ascertain flathead catfish food sources in Milford Reservoir. Whether or not food sources change with season, length of the catfish, or age of the catfish were also studied.

Stomach contents were related to length groups of flathead catfish from which they were taken. Since the age of the predator was being studied in relation to its food sources, stomach contents were again grouped but this time by age of the catfish from which they were taken. These groupings were then analyzed by monthly intervals to reveal seasonal changes in diet, if any.

Frequency of occurrence of each food item was studied in relationship to the length and age of the predator and expressed as a percentage of frequency of occurrence. This provided a qualitative measure of organisms being fed upon but gave no quantitative measure of organisms utilized.

Numerical analysis was also applied to reveal the number of organisms of each type being fed upon. A grand total of all identifiable organisms was calculated by month for age and length groups. Numbers of organisms found were then expressed as a percentage for each grouping.

Volumetric analysis was also performed by age and length groups but not by month.

Analysis of Stomach Contents by Length of Fish

Table XIII shows the total number of stomachs analyzed for each length group by month and a total for all months during which specimens were collected. The months of May, July, and August were the most productive. In May, fish were easily taken by trotline in the timbered area at the upper end of the reservoir. In July and August they were easily caught by rod and reel next to the causeway by using artificial lures as bait. The ease with which they were taken along the causeway was probably because the fish spawn in the rocky rip-rap covering the causeway. After spawning, feeding activity may increase.

A good understanding of feeding habits of flathead catfish by season in relation to length and age was not acquired because collection methods most effective during various time periods were selective as to the size of catfish taken. Fish taken on trotlines were usually much larger than those caught by angling, although several specimens ranging from 8,618 gm (19 lbs.) to 11,884 gm (26.2 lbs.) were taken on artificial lures.

A total of 172 stomachs was removed from flathead catfish for analysis. Table XIII shows months in which stomachs were collected and numbers collected at various time intervals. Table XIV indicates how many of these stomachs contained recognizable food contents while Table XV shows the number of organisms identifiable to genus that were found.

Food items were not found in stomachs of fish under 300 mm in length (except those collected by rotenone which were not used in the food

Table XIII. Numbers of flathead stomachs examined from each length group.

	Length Groups (mm)									
Month	101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-1000	1001-1100
Apr.	1						2	4		1
May					2	4	10	2	7	3
June			1	2	1	2	1	1		1
July		1	14	15	5	6	1	1		
Aug.			23	20	6	8	8	1	2	
Sept.					2	1			2	
Oct.					3					
Nov.					1	1	6			
Total	1	1	38	37	20	22	28	9	11	5

Table XIV. Numbers of flathead stomachs examined from each length group containing recognizable food contents (includes unrecognizable fish tissue).

Month	Length Groups (mm)									
	101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-1000	1001-1100
Apr.							1	1		
May					1	2	5		4	1
June				2	1		1	1		1
July			4	10	3	4				
Aug.			16	11	4	4	2			
Sept.						1			2	
Oct.					3					
Nov.					1		3			
Total			20	23	13	11	12	2	6	2

Table XV. Numbers of food items by month, recognizable to genus, found in flathead catfish stomachs for each length group (not including plant material).

	Length Groups (mm)									
Month	101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-1000	1001-1100
Apr.							1			
May					1		5		4	
June				3	1			1		
July			4	13	4	13				
Aug.			21	16	4	17	2			
Sept.						3			2	
Oct.					3					
Nov.					4		4			
Total			25	32	17	33	12	1	6	

study). Contents from fish in the 301-400 mm length group were composed mainly of crayfish (Orconectes nais), which occurred in 46 per cent of the stomachs that contained food items. Crayfish also accounted for 48 per cent of the total number of organisms found in stomachs from fish in this length group. Gizzard shad (Dorosoma cepedianum) comprised 44 per cent of the total number of organisms and occurred in 19 per cent of the stomachs containing food items (Table XVI).

Crayfish accounted for 28 per cent of the total number of organisms found in specimens whose lengths were between 401-500 mm and in 26 per cent of the stomachs containing food items from this length group. A greater consumption of gizzard shad appeared evident in this length group than in smaller length groups. Gizzard shad were found in 45 per cent of the stomachs analyzed (Table XVII). In both of the above length groups small amounts of unidentifiable animal and plant tissues were found.

Only one crayfish was found in a stomach from a fish in the length group 501-600 mm (Table XVIII). This single crayfish comprised five per cent both by frequency of occurrence and numerical analysis. Gizzard shad were the most abundant food items and were found in 45 per cent of the stomachs that contained food items for this length group. They comprised 70 per cent by numerical analysis. Flathead catfish stomachs containing food items were collected during all months of the study for this length group, except April and September. Gizzard shad were recorded as a food item during each month stomachs were collected. Two larvae of Hexagenia sp. were found in one stomach. Another stomach contained a single aquatic beetle (Coleoptera). These were the only insects found in stomachs from all length groups analyzed.

Table XVI. Frequency of occurrence and numerical analysis by month of stomach contents from flathead catfish in the 301-400 mm length group.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish				3(50)* 3(75)**	9(47) 10(43)				12(46) 13(48)
Gizzard Shad				1(17) 1(25)	4(21) 11(48)				5(19) 12(44)
Unrecognizable Fish					2(11) 2(09)				2(08) 2(07)
Insects and Larvae									
Channel Catfish									
Drum									
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue					2(11) ----				2(08) ----
Unrecognizable Tissue			1(100) -----	2(33) ----	2(11) ----				5(19) ----
Total no. of stomachs containing food			1	6	19				26
Total no. of organisms in stomachs			0	4	23				27

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XVII. Frequency of occurrence and numerical analysis by month of stomach contents from flathead catfish in the 401-500 mm length group.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish			2(67)* 2(67)**	6(43) 7(50)	2(10) 2(09)				10(26) 11(28)
Gizzard Shad			1(33) 1(33)	5(36) 7(50)	11(52) 17(77)				17(45) 25(64)
Unrecognizable Fish					2(10) 3(14)				2(05) 3(08)
Insects and Larvae									
Channel Catfish									
Drum									
Flathead Catfish									
Green Sunfish									
Plant Tissue					1(05) ----				1(03) ----
Unrecognizable Tissue				3(21) ----	5(24) ----				8(21) ----
Total no. of stomachs containing food			3	14	21				38
Total no. of organisms in stomachs			3	14	22				39

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XVIII. Frequency of occurrence and numerical analysis by month of stomach contents from flathead catfish in the 501-600 mm length group.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish				1(17)* 1(20)**					1(05) 1(05)
Gizzard Shad		1(100) 1(100)	1(100) 1(100)	1(17) 1(20)	3(50) 4(80)		2(50) 3(75)	1(100) 4(100)	9(45) 14(70)
Unrecognizable Fish					1(17) 1(20)		1(25) 1(25)		2(10) 2(10)
Insects and Larvae				2(33) 3(60)					2(10) 3(15)
Channel Catfish									
Drum									
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue									
Unrecognizable Tissue				2(33) ----	2(33) ----	1(100) -----	1(25) ----		6(30) ----
Total no. of stomachs containing food		1	1	6	6	1	4	1	20
Total no. of organisms in stomachs		1	1	5	5	-	4	4	20

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Gizzard shad from flathead stomachs in the 601-700 mm and 701-800 mm length groups accounted for 36 and 30 per cent by frequency of occurrence and 91 and 63 per cent by numerical analysis respectively (Tables XIX and XX). These length groups represented the smallest catfish that utilized fishes other than gizzard shad as forage. One channel catfish (Ictalurus punctatus) was found in a stomach from the 601-700 mm length group of flathead catfish. It accounted for three per cent by numerical analysis of the food organisms found in stomachs of flatheads from this length group. Three other species of fishes were found in stomachs from the 701-800 mm length group. These were freshwater drum (Aplodinotus grunniens), flathead catfish (Pylodictus olivaris), and carp (Cyprinus carpio). Only one of each of these organisms was found in stomachs from the flatheads in the 701-800 mm length group. All were found in stomachs from fish collected in May.

Only two organisms were found in stomachs collected from fish taken in the 801-900 mm length group (Table XXI). One of these was a green sunfish (Lepomis cyanellus) which was used for bait on a trotline. The other organism was an unrecognizable species of fish. Both organisms represented 14 per cent by frequency of occurrence and 50 per cent by numerical analysis. Seventy-one per cent of the stomachs from this length group contained unrecognizable animal tissue.

Freshwater drum and gizzard shad were found with equal frequency in stomachs from the length group of 901-1000 mm flathead catfish. All drum were in stomachs collected during May, whereas the gizzard shad were in stomachs collected from both May and September (Table XXII). Flathead catfish in the 1001-1100 mm length group were piscivorous but the species of fish remains in their stomachs could not be identified (Table XXIII).

Table XIX. Frequency of occurrence and numerical analysis by month of stomach contents from flathead catfish in the 601-700 mm length group.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish									
Gizzard Shad				3(50)* 12(92)**	4(57) 15(88)	1(50) 3(100)			8(36) 30(91)
Unrecognizable Fish				1(17) 1(08)	1(14) 1(06)				2(09) 2(06)
Insects and Larvae									
Channel Catfish					1(14) 1(06)				1(05) 1(03)
Drum									
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue		2(50) ----							2(09) ----
Unrecognizable Tissue		2(50) ----	2(100) -----	2(33) ----	1(14) ----	1(50) ----		1(100) -----	9(41) ----
Total no. of stomachs containing food		4	2	6	7	2		1	22
Total no. of organisms in stomachs		-	-	13	17	3		-	33

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XX. Frequency of occurrence and numerical analysis by month of stomach contents from flathead catfish in the 701-800 mm length group.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish									
Gizzard Shad	1(33)* 2(100)**	1(14) 2(33)			2(67) 2(100)			2(40) 4(80)	6(30) 10(63)
Unrecognizable Fish		1(14) 1(17)	1(100) 1(100)					1(20) 1(20)	3(15) 3(19)
Insects and Larvae									
Channel Catfish									
Drum		1(14) 1(17)							1(05) 1(06)
Flathead Catfish		1(14) 1(17)							1(05) 1(06)
Green Sunfish									
Carp		1(14) 1(17)							1(05) 1(06)
Plant Tissue									
Unrecognizable Tissue	2(67) ----	2(29) ----		1(100) -----	1(33) ----			2(40) ----	8(40) ----
Total no. of stomachs containing food	3	7	1	1	3			5	20
Total no. of organisms in stomachs	2	6	1	-	2			5	16

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XXI. Frequency of occurrence and numerical analysis by month of stomach contents from flathead catfish in the 801-900 mm length group.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish									
Gizzard Shad									
Unrecognizable Fish	1(33)* 1(100)**								1(14) 1(50)
Insects and Larvae									
Channel Catfish									
Drum									
Flathead Catfish									
Green Sunfish			1(100) 1(100)						1(14) 1(50)
Carp									
Plant Tissue									
Unrecognizable Tissue	2(67) ----	2(100) -----		1(100) -----					5(71) ----
Total no. of stomachs containing food	3	2	1	1					7
Total no. of organisms in stomachs	1	-	1	-					2

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XXII. Frequency of occurrence and numerical analysis by month of stomach contents from flathead catfish in the 901-1000 mm length group.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish									
Gizzard Shad		1(17)* 1(25)**				2(67) 2(67)			3(33) 3(43)
Unrecognizable Fish						1(33) 1(33)			1(11) 1(14)
Insects and Larvae									
Channel Catfish									
Drum		3(50) 3(75)							3(33) 3(43)
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue									
Unrecognizable Tissue		2(50) ----							2(22) ----
Total no. of stomachs containing food		6				3			9
Total no. of organisms in stomachs		4				3			7

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XXIII. Frequency of occurrence and numerical analysis by month of stomach contents from flathead catfish in the 1001-1100 mm length group.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish									
Gizzard Shad									
Unrecognizable Fish		1(50)* 1(100)**	1(100) 1(100)						2(50) 2(100)
Insects and Larvae									
Channel Catfish									
Drum									
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue									
Unrecognizable Tissue	1(100) -----	1(50) ----							2(50) ----
Total no. of stomachs containing food	1	2	1						4
Total no. of organisms in stomachs	-	1	1						2

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XXIV summarizes the volumetric analysis of stomach contents. Crayfish were important only in the diet of length groups of 301-400 mm and 401-500 mm. Crayfish occurred only in stomachs from fish collected in June, July, and August (Table XXV). Gizzard shad were a more abundant food item for these length groups than were crayfish. They were the dominant food item by volume in all length groups of catfish for which stomachs were collected and most abundant for flathead catfish greater than 500 mm in length. The 801-900 mm group contained no gizzard shad, but few stomachs containing food items were collected from this length group.

Thirteen flathead catfish were collected from two coves during July by using rotenone. Seven of the specimens were in the 201-300 mm size range but were not used in this food study. Apparently the rotenone affected gizzard shad of small size before the flatheads were affected and the flatheads apparently then went on a "feeding frenzy". As many as 16 gizzard shad were removed from a single flathead catfish stomach. Because these conditions were abnormal, these specimens were utilized only in age and growth determinations. The fact that gizzard shad were found in stomachs of flathead catfish in the 201-300 mm size range indicates flatheads of this size are somewhat piscivorous.

In determining whether or not flathead catfish are opportunistic or selective feeders on gizzard shad one should find the amount of gizzard shad available as forage. The per cent by number of gizzard shad collected from cove number one sampled with rotenone was 98.9 (Table XXVI). Gizzard shad accounted for 96.4 per cent of the total number of fish collected in cove number two (Table XXVII). It would appear that one of the primary reasons flathead catfish utilize shad is because they are the

Table XXIV. Volumetric analysis of food items found in 172 flathead catfish stomachs from various length groups.

Food Items	Length Group (mm)							
	301-400	401-500	501-600	601-700	701-800	801-900	901-1000	1001-1100	Totals
Crayfish	44.0* 40.1**	50.4 37.4	0.1 0.1						94.5 7.0
Gizzard Shad	60.0 54.7	72.9 54.0	114.5 90.4	258.2 94.6	425.0 74.6		80.0 81.3		1010.6 74.9
Unrecognizable Tissue	0.5 0.5	7.6 5.6	2.3 1.8	8.9 3.3	16.3 2.9	1.0 3.7	9.3 9.4	2.0 20.0	47.9 3.6
Unrecognizable Fish	3.0 2.7	3.0 2.2	9.1 7.2	2.0 0.7	5.2 0.9	3.8 14.2		8.0 80.0	34.1 2.5
Plant Tissue	2.2 2.0	1.0 0.7		1.7 0.6					4.9 0.4
Insects and Larvae			0.7 0.6						0.7 0.1
Channel Catfish				2.0 0.7					2.0 0.1
Drum					27.0 4.7		9.3 9.4		36.3 2.7
Flathead Catfish					42.0 7.4				42.0 3.1

Table XXIV. Continued

Food Items	Length Group (mm)								
	301-400	401-500	501-600	601-700	701-800	801-900	901-1000	1001-1100	Totals
Green Sunfish						22.0			22.0
						82.1			1.6
Carp					54.0				54.0
					9.5				4.0
Total Volume	109.7	134.9	126.7	272.8	569.5	26.8	98.6	10.0	1349.0
	8.1	10.0	9.4	20.2	42.1	2.0	7.3	0.7	100.0

* Volume in milliliters
** Per cent of volume

Table XXV. Frequency of occurrence and numerical analysis by month of stomach contents from 172 flathead catfish.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish			2(14)* 2(15)**	10(29) 11(31)	11(19) 12(17)				23(15) 25(18)
Gizzard Shad	1(14) 2(67)	3(14) 4(33)	6(43) 8(62)	10(29) 21(58)	26(45) 49(71)	3(50) 5(83)	2(50) 3(75)	3(43) 8(89)	54(36) 100(66)
Unrecognizable Fish	1(14) 1(33)	2(09) 2(17)	2(14) 2(15)	1(03) 1(03)	6(10) 7(10)	1(17) 1(17)	1(25) 1(25)	1(14) 1(11)	15(10) 16(11)
Ineects and Larvae				2(06) 3(08)					2(01) 3(02)
Channel Catfish					1(02) 1(01)				1(01) 1(01)
Drum		4(18) 4(33)							4(03) 4(03)
Flathead Catfish		1(05) 1(08)							1(01) 1(01)
Green Sunfish			1(07) 1(08)						1(01) 1(01)
Carp		1(05) 1(08)							1(01) 1(01)
Plant Tissue		2(09) ----			3(05) ----				5(03) ----
Unrecognizable Tissue	5(07) ----	9(41) ----	3(21) ----	11(32) -----	11(19) -----	2(33) ----	1(25) ----	3(43) ----	45(30) -----
Total no. of stomachs containing food	7	22	14	34	58	6	4	7	152
Total no. of organisms in stomachs	3	12	13	36	69	6	4	9	152

* Frequency of occurrence
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XXVI. Fish collected by the use of rotenone from cove sample number one (Groen, 1975).

Species	Number	Percent of Total Number	(gm) Total Weight	Percent of Total Weight	Harvestable Game and Panfish by Species: Number	Percent by Number	Weight	Percent by Weight
GAME FISH								
Channel catfish	17	0.0	9,829	1.5	10	58.8	9,310	94.7
Flathead catfish	12	0.0	3,970	0.6	4	33.3	2,449	61.7
Walleye	2	0.0	198	0.0	0	0.0	0	0.0
White bass	29	0.0	2,832	0.4	8	27.6	2,348	82.9
Striped bass	1	0.0	14	0.0	0	0.0	0	0.0
Largemouth bass	27	0.0	3,881	0.6	4	14.8	3,267	84.2
Total	88	0.1*	20,724	3.2	26	29.5	17,374	83.8
PANFISH								
Black crappie	1	0.0	100	0.0	0	0.0	0	0.0
White crappie	104	0.1	1,293	0.2	10	7.1	1,016	78.6
Bluegill	185	0.3	4,387	0.7	4	2.2	296	6.7
Green sunfish	55	0.1	1,000	0.1	1	1.8	58	5.8
Total	345	0.5	6,780	1.0	15	4.4	1,385	20.4
ROUGH FISH								
Carp	29	0.0	16,257	2.5				
River carpsucker	3	0.0	427	0.1				
Quillback carpsucker	2	0.0	212	0.0				
Drum	316	0.4	11,688	1.8				
Gizzard shad	6	0.0	2,384	0.4				
Bigmouth buffalo	1	0.0	723	0.1				
Smallmouth buffalo	6	0.0	7,894	1.2				
Shortnose gar	1	0.0	5	0.0				
Total	364	0.5	39,590	6.1				

Table XXVI. Continued

Species	Number	Percent of Total Number	(gm) Total Weight	Percent of Total Weight	Harvestable Game and Panfish by Species Number	Percent by Number	Weight	Percent by Weight
FORAGE FISH								
Gizzard shad	71,460	98.9	581,255	89.7				
Golden shiner	1	0.0	8	0.0				
Creek chub	1	0.0	20	0.0				
Total	71,462	98.9	581,283	89.7				
GRAND TOTAL	72,259	100.0	648,377	100.0	41	0.0	18,759	2.9

* Apparent discrepancies in totals due to rounding figures off to nearest 0.1 percent.

Table XXVII. Fish collected by the use of rotenone from cove sample number two (Groen, 1975).

Species	Number	Percent of Total Number	(gm) Total Weight	Percent of Total Weight	Harvestable Game and Panfish by Species: Number	Percent by Number	Weight	Percent by Weight
GAME FISH								
Channel catfish	36	0.2	8,010	6.4	7	19.4	5,745	71.7
Flathead catfish	1	0.0	3,425	2.8	1	100.0	3,425	100.0
Walleye	1	0.0	12	0.0	0	0.0	0	0.0
Largemouth bass	26	0.2	187	0.2	0	0.0	0	0.0
White bass	53	0.4	781	0.5	1	1.9	188	24.1
Total	117	0.8	12,415	9.9	17	14.5	9,358	75.4
PANFISH								
White crappie	90	0.6	3,166	2.5	15	16.7	2,560	80.9
Bluegill	25	0.2	843	0.7	3	12.0	208	24.7
Green sunfish	5	0.0	42	0.0	0	0.0	0	0.0
Total	120	0.8	4,051	3.2	18	15.0	2,768	68.3
ROUGH FISH								
Carp	59	0.4	45,661	36.6				
River carpsucker	13	0.1	736	0.6				
Quillback carpsucker	2	0.0	104	0.1				
Bigmouth buffalo	1	0.0	2	0.0				
Drum	231	1.5	4,304	4.1				
Gizzard shad	2	0.0	582	0.5				
Total	308	2.0	51,389	41.2				
FORAGE FISH								
Gizzard shad	14,703	96.4	56,900	45.6				
Log perch	1	0.0	2	0.0				
Golden shiner	1	0.0	8	0.0				
Total	14,705	96.4	56,910	45.6				
GRAND TOTAL	15,250	100.0	124,765	100.0	35	0.2	12,126	2.9

main food fish available. Based on percentages of occurrence of species in the cove samples, it would seem that flathead catfish are opportunists, feeding on what is available.

Brown and Dendy (1961) found that the types of fishes utilized by the predator as forage were correlated with the size of the predator. In this study there were no positive data to support this assumption, although a tendency toward this type of feeding may have been present. Most of the fish used as forage by the flatheads were relatively small. The largest fish found in a stomach from a flathead catfish was a gizzard shad 246 mm in length. Table XXVIII presents the lengths of gizzard shad found in stomachs of flatheads representing various length groups. It is doubtful, from the data presented in this study, that flatheads will ever be effective in controlling rough fish (carp, large-mouthed buffalo, and small-mouthed buffalo) populations as long as forage fish, such as gizzard shad, are abundant.

Table XXVIII. Total lengths of gizzard shad found in stomachs of various length groups of flathead catfish.

Length Group of Flathead Catfish	No. of Measurable Shad in Stomachs	Length Range in mm	Avg. Length
301-400	12	41-110	70
401-500	23	31- 79	56
501-600	12	41-111	76
601-700	30	30-246	67
701-800	8	78-215	142
801-900	-	-	-
901-1000	3	95-166	128

Analysis of Stomach Contents by Age of Fish

Stomachs were analyzed from 167 flathead catfish whose ages were determined. Analyses of contents were performed in the same manner as used in relating food contents to length of flathead catfish, except data were grouped by age of the catfish, and not length. Tables XXIX, XXX, and XXXI show the number of stomachs examined from each year class, the number of stomachs containing recognizable food items, and the number of food organisms recognizable to genus from each age group.

Crayfish comprised 75 per cent, by number of organisms, of the diet of two-year-old fish (Table XXXII). Only 36 per cent of the organisms in stomachs taken from three-year-old fish were crayfish. The remaining 64 per cent were gizzard shad (Table XXXIII). Crayfish were not found in stomachs taken from fish over six years old. Tables XXXIV through XLI reveal that gizzard shad were the primary constituent of most age groups' diets. Volumetric analysis is summarized in Table XLII. Gizzard shad are so abundant in the reservoir that the author doubts if flathead catfish compete, to any significant degree, for food with game fishes.

Table XXIX. Numbers of flathead stomachs examined from each year class.

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
April	1				1		4		3						
May				1	5	2	4	4	3	3			1	1	
June					2		1	1	2						
July		6	7	11	10	8	1		1						
Aug.		4	12	19	10	13	7	1		2					
Sept.					3				1				1		
Oct.				2											
Nov.					3	1	3		2						
Totals	1	10	19	33	34	24	20	6	12	5			2	1	

Table XXX. Numbers of flathead catfish stomachs examined from each year class containing recognizable food contents (includes unrecognizable fish tissue).

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
April							1		1						
May				1	3		1	2	1	2			1	1	
June					1		1	1	1						
July		1	2	7	7	5									
Aug.		2	11	13	3	5	2								
Sept.					1				1				1		
Oct.				2											
Nov.					3		2		1						
Totals		3	13	23	18	10	7	3	5	2			2	1	

Table XXXI. Numbers of food items by month, recognizable to genus, found in flathead catfish stomachs for each year class.

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
April							1		2						
May				1			1	1		2			1		
June									1						
July		1	2	14	10	9									
Aug.		2	13	22	15	3	2								
Sept.					3				1				1		
Oct.				3											
Nov.					7				1						
Totals		3	18	18	35	12	4	1	5	2			2		

Table XXXII. Frequency of occurrence and numerical analysis by month of stomach contents from age II flathead catfish.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish				1(100)* 1(100)**	2(67) 2(67)				3(75) 3(75)
Gizzard Shad									
Unrecognizable Fish					1(33) 1(33)				1(25) 1(25)
Insects and Larvae									
Channel Catfish									
Drum									
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue									
Unrecognizable Tissue									
Total no. of stomachs containing food				1	3				4
Total no. of organisms in stomachs				1	3				4

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XXXIII. Frequency of occurrence and numerical analysis by month of stomach contents from age III flathead catfish.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish					5(42)* 5(38)**				5(33) 5(36)
Gizzard Shad				1(33) 1(100)	4(33) 8(62)				5(33) 9(64)
Unrecognizable Fish									
Insects and Larvae									
Channel Catfish									
Drum									
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue					3(25) ----				3(20) ----
Unrecognizable Tissue				2(67) ----					2(13) ----
Total no. of stomachs containing food				3	12				15
Total no. of organisms in stomachs				1	13				14

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XXXIV. Frequency of occurrence and numerical analysis by month of stomach contents from age IV flathead catfish.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish				3(27)* 3(23)**	2(17) 2(09)				5(17) 5(11)
Gizzard Shad		1(100) 1(100)		5(45) 10(77)	8(67) 21(91)		1(50) 3(100)		15(52) 35(80)
Unrecognizable Fish						3(100) 4(100)			3(10) 4(09)
Insects and Larvae									
Channel Catfish									
Drum									
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue									
Unrecognizable Tissue				3(27) ----	2(17) ----		1(50) ----		6(21) ----
Total no. of stomachs containing food		1		11	12	3	2		29
Total no. of organisms in stomachs		1		13	23	4	3		44

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XXXV. Frequency of occurrence and numerical analysis by month of stomach contents from age V flathead catfish.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish				2(20)* 3(27)**					2(07) 3(08)
Gizzard Shad				3(30) 4(36)	3(60) 14(88)	1(33) 3(100)		2(67) 7(100)	9(32) 28(72)
Unrecognizable Fish		1(25) 1(100)	1(50) 1(100)	1(10) 1(09)	1(20) 1(06)				4(14) 4(10)
Insects and Larvae				2(20) 3(27)					2(07) 3(08)
Channel Catfish					1(20) 1(06)				1(04) 1(03)
Drum									
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue		2(50) ----		1(10) ----					3(11) ----
Unrecognizable Tissue	1(100) -----	1(25) ----	1(50) ----	1(10) ----		2(67) ----		1(33) ----	7(25) ----
Total no. of stomachs containing food	1	4	2	10	5	3		3	28
Total no. of organisms in stomachs	-	1	1	11	16	3		7	39

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XXXVI. Frequency of occurrence and numerical analysis by month of stomach contents from age VI flathead catfish.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish				2(29)* 2(22)**					2(14) 2(14)
Gizzard Shad				3(43) 7(78)	3(43) 3(60)				6(43) 10(71)
Unrecognizable Fish					2(29) 2(40)				2(14) 2(14)
Insects and Larvae									
Channel Catfish									
Drum									
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue									
Unrecognizable Tissue				2(29) ----	2(29) ----				4(29) ----
Total no. of stomachs containing food				7	7				14
Total no. of organisms in stomachs				9	5				14

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XXXVII. Frequency of occurrence and numerical analysis by month of stomach contents from age VII flathead catfish.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish									
Gizzard Shad					2(40)* 2(100)**				2(14) 2(25)
Unrecognizable Fish	1(33) 1(50)		1(100) 1(100)					2(67) 2(100)	4(29) 4(50)
Insects and Larvae									
Channel Catfish									
Drum									
Flathead Catfish	1(33) 1(50)								1(07) 1(13)
Green Sunfish									
Carp		1(50) 1(100)							1(07) 1(13)
Plant Tissue									
Unrecognizable Tissue	1(33) ----	1(50) ----			3(60) ----			1(33) ----	6(43) ----
Total no. of stomachs containing food	3	2	1		5			3	14
Total no. of organisms in stomachs	2	1	1		2			2	8

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XXXVIII. Frequency of occurrence and numerical analysis by month of stomach contents from age VIII flathead catfish.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish									
Gizzard Shad									
Unrecognizable Fish			1(100)* 1(100)**						1(20) 1(50)
Insects and Larvae									
Channel Catfish									
Drum		1(25) 1(100)							1(20) 1(50)
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue									
Unrecognizable Tissue		3(75) ----							3(60) ----
Total no. of stomachs containing food		4	1						5
Total no. of organisms in stomachs		1	1						2

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XXXIX. Frequency of occurrence and numerical analysis by month of stomach contents from age IX flathead catfish.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish									
Gizzard Shad	1(25)* 2(100)**					1(50) 1(50)		1(100) 1(100)	3(30) 4(57)
Unrecognizable Fish		1(100) 1(100)				1(50) 1(50)			2(20) 2(29)
Insects and Larvae									
Channel Catfish									
Drum									
Flathead Catfish									
Green Sunfish			1(50) 1(100)						1(10) 1(14)
Carp									
Plant Tissue									
Unrecognizable Tissue	3(75) ----		1(50) ----						4(40) ----
Total no. of stomachs containing food	4	1	2			2		1	10
Total no. of organisms in stomachs	2	1	1			2		1	7

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XL. Frequency of occurrence and numerical analysis by month of stomach contents from age X flathead catfish.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish									
Gizzard Shad		1(14)* 1(33)**				1(100) 1(100)			2(25) 2(50)
Unrecognizable Fish									
Insects and Larvae									
Channel Catfish									
Drum		2(29) 2(67)							2(25) 2(50)
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue		1(14) ----							1(13) ----
Unrecognizable Tissue		3(43) ----							3(38) ----
Total no. of stomachs containing food		7				1			8
Total no. of organisms in stomachs		3				1			4

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XLI. Frequency of occurrence and numerical analysis by month of stomach contents from age XIII flathead catfish.

Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals
Crayfish									
Gizzard Shad		1(100)* 1(100)**				1(100) 1(100)			2(100) 2(100)
Unrecognizable Fish									
Insects and Larvae									
Channel Catfish									
Drum									
Flathead Catfish									
Green Sunfish									
Carp									
Plant Tissue									
Unrecognizable Tissue									
Total no. of stomachs containing food		1				1			2
Total no. of organisms in stomachs		1				1			2

* Frequency of occurrence.
** Numerical analysis.
() Percentage frequency of occurrence or percentage numerical analysis, rounded to nearest whole per cent.

Table XLII. Volumetric analysis of food contents from stomachs of flathead catfish grouped by age.

Food Items	Age Group													
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	Total
Crayfish		9.0*	24.0	36.4	9.1	11.0								89.5
		81.8**	50.7	17.2	4.7	21.7								7.1
Gizzard Shad			20.1	167.8	160.0	28.7	170.0		329.0				65.0	940.6
			42.5	79.4	83.3	56.5	61.2		87.7				100.0	74.1
Unrecognizable Fish		2.0		4.0	3.1	7.0	9.8	1.0	5.6					32.5
		18.2		1.9	1.6	13.8	3.5	12.2	1.5					2.6
Unrecognizable Tissue				3.1	15.4	4.1	1.8	0.6	18.7	4.5				48.2
				1.5	8.0	8.0	0.6	2.0	5.0	44.1				3.8
Plant Tissue			3.2		1.7									4.9
			6.8		0.9									0.4
Insects and Larvae					0.7									0.7
					0.4									0.1
Channel Catfish					2.0									2.0
					1.0									0.2
Drum								27.0		5.7				32.7
								94.4		55.9				2.6
Flathead Catfish							42.0							42.0
							15.1							3.3

Table XLII. Continued

Food Items	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	Total
Green Sunfish									22.0 5.9					22.0 1.7
Carp							54.0 19.5							54.0 4.3
Total		11.0 0.9***	47.3 3.7	211.3 16.6	192.0 15.1	50.8 4.0	277.6 21.9	28.6 2.3	375.3 29.6	10.2 .8			65.0 5.1	1269.1 100.0

* Volume in milliliters
** Per cent of volume
*** Per cent of total volume

SUMMARY

Studies of flathead catfish in large impoundments have been limited in number. While age and growth studies of these fish have been performed and documented in a number of cases, there have been but few literature citations concerning food sources utilized by flathead catfish. The writer attempted in this study to reveal some of the aspects of the fish's life history (age and growth) and ecological role (food habits) in a large impoundment, Milford Reservoir.

The following conclusions were made on the basis of an analysis of the data collected:

1. A positive y-intercept was found to exist in the body length-pectoral spine relationship calculated for all catfish collected. This intercept was used as a correction factor to back-calculate total lengths of fish at annuli formation. This constant (y-intercept) was found to vary with age classes for which it was computed.

2. A length-weight relationship was computed for all catfish collected and separately for males and females. The relationship was similar for males and females through the first three years of life. After this time females gained more weight per unit length than did males. Growth in length remained relatively equal for both sexes.

3. The greatest number of flathead catfish collected in any given year class was 40 specimens five years of age. The oldest individual catfish collected was 16 years of age.

4. First formed (early year) pectoral spine annuli in fish four years of age and older were often obliterated by the central lumen. The

amount of deterioration in the dorsal spine was often less than in the pectoral spine resulting in higher annuli counts in some dorsal spines than in pectoral spines.

5. Sexual maturity, at least in females, may be reached during the fourth year of life.

6. Spawning probably occurs in June and July in Milford Reservoir. The rocky, rip-rapped, land-fill bridges may provide excellent spawning grounds for these fish.

7. A sharp decline in increment of length after the ninth year of life was noted for both males and females. There was no such decline in weight increments, however.

8. Selectivity of size groups collected was encountered when certain collection methods were used. This may have biased some of the food study results.

9. Flathead catfish from 201 mm in length to 500 mm in length were found to rely on both benthic macroinvertebrates and fish for their diet. Few insect larvae were found in stomachs collected.

10. Flathead catfish over 500 mm in length were almost exclusively piscivorous. During the early part of the growing season several species of fishes were utilized as forage. After May and early June, the only fish species found in stomachs was gizzard shad.

11. The effectiveness of flathead catfish as a control on rough fish populations is not likely because of the large numbers of forage fishes in Milford Reservoir.

12. The relatively fast growth rate of flathead catfish in this reservoir was attributed to an abundance of forage fishes, which limited intraspecific and interspecific competition for food.

13. There was some variation in food consumed by flathead catfish with size, age, and season, but these variations were not great in reservoir populations of flathead catfish over 200 mm in length.

LITERATURE CITED

LITERATURE CITED

Applegate, J. and L. L. Smith. 1951. Determination of the age and rate of growth of channel catfish (Ictalurus lacustris punctatus) of the Upper Mississippi River from vertebrae. Trans. Amer. Fish. Soc. 80:119-139.

Brown, B. E. and J. S. Dendy. 1961. Observations on the food habits of the flathead and blue catfish in Alabama. Proc. S. E. Assoc. Game and Fish Comm. 15:210-222.

Carlander, K. D. 1969. Handbook of freshwater fishery biology. Vol. I. Life history data on freshwater fishes of the United States and Canada, exclusive of the Perciformes. Iowa State Univ. Press, Ames. 752 pp.

Clemens, H. P. 1954. Pre-impoundment studies of the summer food of three species of fishes in Tenkiller and Fort Gibson Reservoirs, Oklahoma. Proc. Okla. Acad. Sci. 33:72-79.

Cross, F. B. 1967. Handbook of fishes of Kansas. Univ. Kan. Mus. Nat. Hist., Misc. Publ. 45. 357 pp.

___________ and C. E. Hastings. 1956. Ages and sizes of 29 flathead catfish from the Kansas River, Douglas County, Kansas. Trans. Kan. Acad. Sci. 59:85-86.

Deacon, J. E. 1961. Fish populations following a drought in the Neosho and Marias des Cygnes Rivers of Kansas. Univ. Kan. Publ., Mus. Nat. Hist. 13:359-427.

Groen, C. 1975. Personal communications.

________. 1975. Memorandum to R. Schoonover, Chief, Fisheries Division. Kansas Forestry, Fish and Game Commission.

Hile, R. 1936. Age and growth of the cisco, Leucichthys artedi (LeSeur), in the lakes of the northern highlands, Wisconsin. Bull. Bur. Fish. U. S. 48:211-317.

Jenkins, R. M. 1952. Growth of flathead catfish, Pylodictis olivaris, in Grand Lake (Lake O' The Cherokees), Oklahoma. Proc. Okla. Acad. Sci. 33:11-20.

Lagler, K. E. 1956. Freshwater fishery biology. Wm. C. Brown Co. Dubuque, Iowa. 421 pp.

Langemeier, R. N. 1965. Effects of channelization on the limnology of the Missouri River, Nebraska, with emphasis on food habits and growth of the flathead catfish. M. A. Thesis. University of Missouri, Columbia. 134 pp.

Mayhew, J. K. 1969. Age and growth of flathead catfish in the Des Moines River, Iowa. Trans. Amer. Fish. Soc. 98:118-121.

McCoy, H. A. 1953. The rate of growth of flathead catfish in twenty-one Oklahoma lakes. Proc. Okla. Acad. Sci. 34:47-52.

McKinley, S. 1973. Management needs to improve fishing waters. Dingell-Johnson Project F-15-R-8, Job no. B-1-8. Northeast Region. Kansas Forestry, Fish and Game Commission. 86 pp.

Minckley, W. L. and J. E. Deacon. 1959. Biology of the flathead catfish in Kansas. Trans. Amer. Fish. Soc. 88:344-355.

Ricker, W. E. 1971. IBP handbook no. 3, methods for assessment of fish production in fresh waters. International Biological Programme. Birkenhead, Great Britain. 348 pp.

Sneed, K. E. 1951. A method for calculating the growth of channel catfish, Ictalurus lacustris punctatus. Trans. Amer. Fish. Soc. 80:174-183.

__________ and E. M. Leonard. 1951. Age and growth of the channel catfish, Ictalurus punctatus, in Lake Texoma. Trans. Kans. Acad. Sci. 37:73-78.

Summerfelt, R. C. 1975. Personal communications.

Swingle, H. S. 1954. Fish populations in Alabama rivers and impoundments. Trans. Amer. Fish. Soc. 83:48-57.

__________. 1967. Experiments with the flathead catfish (Pylodictis olivaris) in ponds. Proc. S. E. Assoc. Game and Fish Comm. 18:303-308.

Tesch, F. W. 1971. IBP handbook no. 3, methods for assessment of fish production in fresh waters. International Biological Programme. Birkenhead, Great Britain. 348 pp.

Turner, P. K. and R. C. Summerfelt. 1970. Food habits of adult flathead catfish, Pylodictus olivaris (Rafinesque), in Oklahoma reservoirs. Proc. S. E. Assoc. Game and Fish Comm. 24:387-401.

__________. 1971. Condition factors and length-weight relationships of the flathead catfish, Pylodictus olivaris (Rafinesque), in Lake Carl Blackwell. Proc. Okla. Acad. Sci. 51:36-40.