

A COMPARISON OF PRE- AND POST-IMPOUNDMENT FISH POPULATIONS IN THE MOUNTAIN FORK RIVER IN SOUTHEASTERN OKLAHOMA

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The purpose of this paper is to compare the composition and diversity of fish collections before and after the impoundment of the Mountain Fork River by Broken Bow Dam. The number of species reported has declined from 84 to 65 and diversity is lower after impoundment.

INTRODUCTION

The impoundment of a river by a mainstem dam obviously causes environmental changes which significantly affect the occurrence and distribution of fish populations. In the lake area, the change from lotic to lentic habitat is an obvious and significant alteration. The regulation of water releases and the prevention of flooding are influential in modifying downstream habitat. In this study, post-impoundment fish populations in the Mountain Fork River, its tributaries, and Broken Bow Lake are compared with preimpoundment populations.

Reeves (1) and Finnell, *et al.* (2) conducted pre-impoundment fish surveys on the Mountain Fork River. Reeves (1) reported 73 species from the River and its tributaries excluding cutoff lakes, sloughs, ponds, and swampy areas: Finnell, *et al.* (2) reported 70 species. Collection records at the Oklahoma State University Museum, Stillwater, verified the occurrence of two additional species.

Post-impoundment surveys were conducted in 1971, 1973, and 1975 by the Tulsa District, Corps of Engineers, in 1972 and 1973 by the Oklahoma Department of Wildlife Conservation (ODWC) and in 1977 by the Oklahoma State Department of Health (OSDH) (3). Collection records at the University of Tulsa, and from Earls (4) verified the occurrence of two additional species after impoundment.

The Mountain Fork River, in the Ouachita Mountains of southeastern Oklahoma, is the largest tributary of the Little River. The watershed is about 81 km in length and drains an area of 2,181 km², of which 1,953 km² are above Broken Bow Dam. The elevation of the river is about 731.5 m in the headwaters and about 94.5 m at the mouth. The mainstem length of the river is 155 km and it has an average gradient of 2.1 m/km. The drainage pattern is dendritic to trellis. The river is characterized by alternating riffles and pools, and the stream substrate is bedrock. Rock formations consist of sandstones, shales, limestones and cherts of Cambrian to Pennsylvanian age. Areas with large boulders in the river bed are common. Springs are common and influence the water temperature, particularly during times of low flow. The water quality of the Mountain Fork River and Broken Bow Lake is excellent (3).

Broken Bow Dam, at river km 32.5 on the Mountain Fork River, has a normal surface area of 5,747 ha, and a shoreline of 290 km. Construction of the dam was started in November 1961, impoundment began in October 1968, and the lake reached conservation pool level in May 1969. The conservation pool covers 35 km of the river channel. Project purposes are flood control, water supply, hydroelectric power, recreation, and fish and wildlife conservation. A reregulation dam is located 7.6 km downstream from the powerplant and provides storage to maintain a minimum downstream flow of 100 cfs for fish and wildlife.

MATERIAL AND METHODS

Pre-impoundment collections were made using gill nets, seines, rotenone, and hook and line. Post-impoundment collections above and below the lake were by electroshocking, gill nets, seines, and hook and line. Dyre Creek Cove was treated with rotenone by the ODWC in 1972 and 1973. Earls (4) conducted a creel census above and below the lake. Several of the same

areas were sampled before and after impoundment (Fig. 1).

For purposes of comparison before and after impoundment, the river was divided into three reaches: the upper reach is upstream from the conservation pool of the lake (about the mouth of Boktukolo Creek); the middle reach is from the upper end of the lake to the dam; and the lower reach is downstream from the dam to the mouth of the river. These reaches are similar to those used by Finnell, *et al.* (2). Only species taken from the mainstem, tributaries, and lake are included in this study.

To facilitate the presentation of their data, Finnell, *et al.* (2) separated fish into four categories: sport, pan, coarse, and forage fish. The sport fish are the black basses (*Micropterus* spp.), white bass (*Morone chrysops*), channel catfish (*Ictalurus punctatus*), white crappie (*Pomoxis annularis*), and black crappie (*P. nigromaculatus*). The panfish are the sunfish (*Lepomis* spp.), bullheads (*Ictalurus* spp.), and the grass pickerel (*Esox americanus*). The coarse fish are the nongame and commercial species, and the remaining species, including minnows, darters, and others with small adult forms are classed as forage fish. In the following discussions, post-impoundment data are compared with results obtained by Finnell, *et al.* (2) using identical categories. Scientific and common names are those used by the American Fisheries Society (5). A species diversity value was calculated for each reach and the total system before and after impoundment using the diversity index (6).

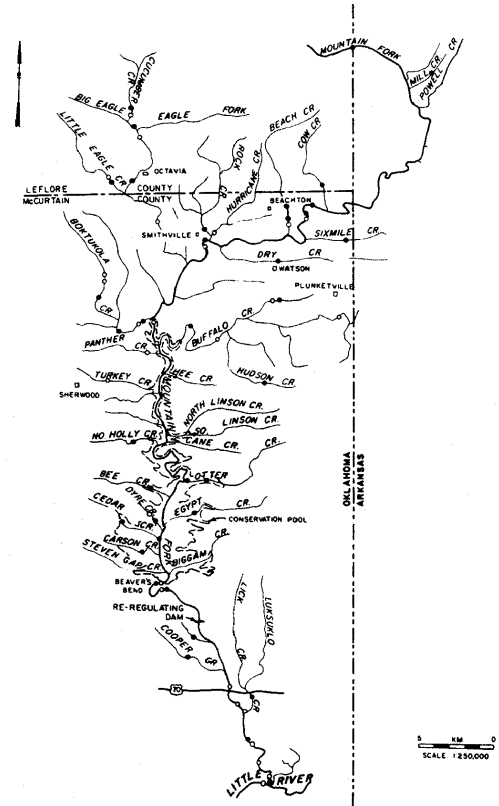


FIGURE 1. Collection stations in Mountain Fork River and Broken Bow Lake before (●) and after (○) impoundment.

$$\bar{d} = \sum_{i=1}^S (n_i/n) \log_2 (n_i/n)$$

RESULTS

Prior to impoundment, 84 species were reported from the Mountain Fork and its tributaries. From post-impoundment collections, 65 species have been identified. Fifty-six species were common to pre- and post-impoundment collections (Table 1).

Before impoundment, the bigeye shiner (*Notropis boops*), longear sunfish (*Lepomis megalotis*), and green sunfish (*Lepomis cyanellus*) were abundant and common in all reaches of the river. The smallmouth bass (*Micropterus dolomieu*) was the most common sport fish in the upper and middle reaches, and largemouth bass (*Micropterus salmoides*) and channel catfish filled that role in the lower reach.

Post-impoundment collections indicate that the longear sunfish and green sunfish are still common in all reaches of the river, including the lake. The bigeye shiner is still abundant upstream from the lake, but collections taken downstream and in the lake area indicate that it is much less common downstream than prior to impoundment and that it is absent from the lake. Three species have increased in abundance in certain sections of the river since impoundment; the emerald shiner (*Notropis atherinoides*), bluegill (*Lepomis macrochirus*), and largemouth bass. The OSDH collected large numbers of emerald shiners in the river and its tributaries upstream from the lake. In contrast, Reeves (1) found it only in the lower reach, apparently

TABLE 1. *Fishes of Mountain Fork River*

Species	Pre-impoundment distribution			Post-impoundment distribution		
	Upper	Middle	Lower	Upper	Lake	Lower
<i>Ichthyomyzon castaneus</i>			x			x
<i>I. gagei</i>				x		x
<i>Lepisosteus oculatus</i>		x	x		x	x
<i>L. osseus</i>	x	x	x			x
<i>Anguilla rostrata</i>			x			
<i>Alosa chrysochloris</i>			x			
<i>Dorosoma cepedianum</i>			x	x		x
<i>D. petenense</i>					x	x
<i>Hiodon alosoides</i>			x			
<i>H. tergisus</i>			x			x
<i>Esox americanus</i>	x	x	x	x		x
<i>Camptostoma anomalum</i>	x	x	x	x	x	x
<i>Cyprinus carpio</i>						x
<i>Hybognathus nuchalis</i>			x			
<i>Dionda nubila</i>						x
<i>Notemigonus crysoleucas</i>			x	x	x	x
<i>Notropis amnis</i>			x			
<i>N. atherinoides</i>			x	x		x
<i>N. atrocaudalis</i>			x			
<i>N. boops</i>	x	x	x	x		x
<i>N. buchanaui</i>				x		
<i>N. chalybaeus</i>		x				
<i>N. cornutus</i>			x			x
<i>N. emiliae</i>			x			
<i>N. fumeus</i>	x	x	x			
<i>N. lutrensis</i>						x
<i>N. ortenburgeri</i>			x			
<i>N. perpallidus</i>			x			
<i>N. rubellus</i>			x			x
<i>N. stramineus</i>			x			
<i>N. umbratilis</i>	x	x	x			x
<i>N. venustus</i>			x			x
<i>N. volucellus</i>			x			
<i>N. whipplei</i>	x	x	x	x	x	x
<i>Pimephales notatus</i>	x	x	x	x	x	x
<i>P. vigilax</i>				x		x
<i>Semotilus atromaculatus</i>	x	x	x			x
<i>Carpionotus carpio</i>		x	x			
<i>Erimyzon oblongus</i>	x	x	x	x		x
<i>Ictiobus bubalus</i>	x		x			x
<i>I. niger</i>		x	x	x		
<i>Minytrema melanops</i>	x		x	x		x
<i>Moxostoma carinatum</i>		x	x			x
<i>M. duquesnei</i>			x	x		x
<i>M. erythrurum</i>	x	x	x	x	x	x
<i>Ictalurus melas</i>	x		x	x	x	x
<i>I. natalis</i>	x	x	x	x	x	x
<i>I. punctatus</i>			x		x	x
<i>Noturus eleutherus</i>			x			x
<i>N. gyrinus</i>			x			x
<i>N. nocturnus</i>	x		x	x		x
<i>Pylodictis olivaris</i>	x	x	x	x	x	x
<i>Aphredoderus sayanus</i>			x			
<i>Fundulus notatus</i>	x	x	x	x	x	x
<i>F. olivaceus</i>				x		
<i>Gambusia affinis</i>			x		x	x
<i>Labidesthes sicculus</i>	x	x	x	x	x	x
<i>Morone chrysops</i>			x			
<i>Centrarchus macropterus</i>			x			
<i>Elassoma zonatum</i>			x			
<i>Lepomis cyanellus</i>	x	x	x	x	x	x
<i>L. gulosus</i>		x	x	x	x	x
<i>L. humilis</i>			x			
<i>L. macrochirus</i>	x	x	x	x	x	x
<i>L. marginatus</i>			x			
<i>L. megalotis</i>	x	x	x	x	x	x

TABLE 1. (continued)

Species	Pre-impoundment distribution			Post-impoundment distribution		
	Upper	Middle	Lower	Upper	Lake	Lower
<i>L. microlophus</i>					x	
<i>L. punctatus</i>			x			x
<i>L. symmetricus</i>			x			
<i>Micropterus dolomieu</i>	x	x	x	x	x	x
<i>M. punctulatus</i>	x	x	x	x	x	x
<i>M. salmoides</i>	x	x	x	x	x	x
<i>Pomoxis annularis</i>			x		x	x
<i>P. nigromaculatus</i>			x	x	x	x
<i>Ammocrypta vivax</i>			x			x
<i>Etheostoma asprigene</i>		x	x			x
<i>E. chlorosomum</i>			x			
<i>E. flabellare</i>			x			
<i>E. fusiforme</i>			x			
<i>E. gracile</i>			x			
<i>E. histrio</i>			x			x
<i>E. nigrum</i>	x		x			x
<i>E. parvipinne</i>			x			
<i>E. proeliare</i>			x			
<i>E. radiosum</i>	x	x	x	x		x
<i>E. spectabile</i>			x		x	x
<i>Percina caprodes</i>	x	x	x	x	x	x
<i>P. copelandi</i>	x	x	x	x		x
<i>P. maculata</i>	x		x			
<i>P. phoxocephala</i>			x			x
<i>P. pantherina</i>	x			x		
<i>P. sciera</i>	x		x	x		x
<i>Aplodinotus grunniens</i>	x		x			x

not in large numbers, and Finnell, *et al.* (2) did not collect the species. The bluegill is also abundant in the lake and fairly common downstream and spotted bass (*Micropterus punctulatus*) and largemouth bass are the predominant game species.

Nine species were collected in the river only after impoundment. The threadfin shad (*Dorosoma petenense*) was introduced into the lake as a forage fish by the ODWC in 1971 and 1972. The redear sunfish (*Lepomis microlophus*) and the carp (*Cyprinus carpio*) were collected from cutoff lakes in the Mountain Fork flood plain before impoundment. The bullhead minnow (*Pimephales vigilax*) and the southern brook lamprey (*Ichthyomyzon gagei*) were previously reported from the Little River and some of its other tributaries. The occurrence of these last two species upstream from the lake suggests that they may have been in the Mountain Fork system prior to impoundment.

We could find no previous records of the Ozark minnow (*Dionda nubila*) and red shiner (*Notropis lutrensis*) in the Mountain Fork Basin. The Ozark minnow and red shiner are probably bait bucket introductions. This drainage is south of the normal range of the Ozark minnow.

The ghost shiner (*Notropis buchanani*) and the blackspotted topminnow (*Fundulus olivaceus*) were collected upstream from the lake. Both species are apparently rare. The OSDH collected one ghost shiner in Buffalo Creek and we collected a single specimen of the blackspotted topminnow from an area called "The Narrows".

Pre-impoundment collections show that 24 species were found in all reaches of the river. After impoundment, 20 species were collected from all reaches. Fifteen species were common to both periods. The ribbon shiner (*Notropis fumeus*) is the only species not collected since impoundment. This species was common in the river and its tributaries prior to impoundment.

Species present in all reaches after impoundment, but not before, are the gizzard shad (*Dorosoma cepedianum*), golden shiner (*Notemigonus crysoleucas*), black bullhead (*Ictalurus melas*), warmouth (*Lepomis gulosus*), and black crappie.

Post-impoundment collection records show that 28 species reported prior to impoundment have not been collected since impoundment. The ribbon shiner, creek chubsucker, slough darter (*Etheostoma gracile*), and river carpsucker (*Carpiodes*

carpio) were relatively common in pre-impoundment collections while the other species were rare.

Reach Above Broken Bow Lake

Before impoundment, 33 species were reported from the upper reach (Table 1). The most abundant species were the bigeye shiner, longear sunfish, green sunfish, bluntnose minnow (*Pimephales notatus*), and orangebelly darter. The predominant sport fish was the smallmouth bass and the most common coarse species was the golden redhorse (*Moxostoma erythrurum*).

Eight species were collected only before impoundment. The ribbon shiner and blackside darter (*Percina maculata*) have not been collected anywhere since impoundment. The other species have been taken in the downstream reach. Pre-impoundment collection records show these species were found primarily in tributaries. It is possible they are still present, but were missed in post-impoundment surveys.

From post-impoundment collections above Broken Bow Lake, 36 species have been identified (Table 1). The most abundant species were the emerald shiner and bigeye shiner. The spotted bass has replaced the smallmouth bass as the primary sport fish, Finnell, *et al.* (2) found that the three black basses were the only sport fish collected in the upper reach. Since impoundment, Earls (4) found both white and black crappies in fishermen's creels in the river upstream from the lake.

We collected five species of coarse fish, but no one species dominated this category, and none were abundant. Finnell, *et al.* (2) found that the golden redhorse dominated this category. They collected only two other species, the spotted sucker (*Minytrema melanops*) and the flathead catfish (*Pylodictis olivaris*).

Five species were collected only after impoundment. All these species except the blackspotted topminnow were present in the middle or lower reaches before impoundment and so have extended their range in the river. The blackspotted topminnow was reported by Reeves (1) to be in the Little River before impoundment but we have found no other post-impoundment record of it in the Mountain Fork.

The leopard darter (*Percina pantherina*) is endemic to the Little River System and is found in the upper reaches of the Mountain Fork and its tributaries (7). These areas have been declared a portion of the critical habitat for this species. The limited distribution of this species led to the hypothesis that impoundment of the river might result in a drastic reduction in numbers. However, several specimens, including juveniles, were collected from the upper reach in November 1975. The collection of juveniles indicates that the populations are successfully reproducing.

Middle Reach (Lake Area)

Before impoundment, 31 species were reported from the middle reach (Table 1). The most common species were the longear sunfish, bigeye shiner, stoneroller, and green sunfish, respectively. The predominant sport fish was the smallmouth bass, and the most common coarse fish was the golden redhorse.

From post-impoundment collections, 27 species have been identified from the lake. The most common species were bluegill, green sunfish, and longear sunfish. The brook silverside (*Labidesthes sicculus*) and the threadfin shad were also abundant. The most abundant game species was the largemouth bass.

Fourteen species collected before impoundment were not collected in the lake area after impoundment. Except for the ironcolor shiner and the ribbon shiner, the other species have been taken in either the upstream or downstream reach since impoundment. Ten species were collected from the lake area that were not reported before impoundment. With the exception of the threadfin shad and the redear sunfish, these species were in the lower reach of the river before impoundment.

Finnell, *et al.* (2) found the composition of the fish populations in the middle reach to be similar to that of the upper reach with the three species of black basses representing the sport fish category, and the golden redhorse as the dominant coarse fish. Post-impoundment collections show this reach has undergone a drastic change since stream habitat has been converted to lake habitat. Fourteen species are either no longer present in the lake or at least rare in occurrence; nine are forage species, four are coarse species, and one is a pan-

fish. Ten new species are now present in the lake; three are sport fish and two are panfish. The largemouth bass has replaced the smallmouth bass as the dominant sport fish, but the longear sunfish remains as the main panfish. In the lake, the threadfin shad and the brook silverside have replaced the bigeye shiner and the stoneroller as the major forage fish. The bigeye shiner, formerly the most abundant forage fish in the river, was not collected from the lake. The golden redhorse is still the dominant coarse species. Rainbow trout (*Salmo gairdneri*) have been stocked in the lake but were not considered since they do not reproduce.

Downstream Reach

Before impoundment, 82 species were reported from the downstream reach (Table 1). The most common species were the bigeye shiner, green sunfish, longear sunfish, and steelcolor shiner. The largemouth bass was the dominant sport fish, but spotted bass, channel catfish, and smallmouth bass were not uncommon.

From post-impoundment collections, 60 species have been identified from the downstream reach. Six species were collected that had not been previously reported from this reach: the southern brook lamprey, threadfin shad, carp, Ozark minnow, red shiner, and bullhead minnow. The occurrence of these species has been discussed previously. The orangebelly darter, stoneroller, longear, and green sunfish were the most common. The brook silverside and orangethroat darter (*Etheostoma spectabile*) were also relatively common. The spotted bass and the largemouth bass have replaced the smallmouth bass as the primary sport fish.

A comparison of populations before and after impoundment shows some dramatic changes have occurred in the fish populations in the lower reach. Post-impoundment collection records reveal 28 species reported before impoundment have not been collected since then. Prior to impoundment, the bigeye shiner and the steelcolor shiner were the most abundant forage fish and the orangebelly darter and stoneroller were also relatively common. After impoundment, the orangebelly darter and the stoneroller were the most common forage species while the steelcolor shiner and the bigeye shiner decreased considerably in abundance. Two other forage fish that have increased in abundance since impoundment are the brook silverside and the orangethroat darter.

Before impoundment, the dominant coarse fish was the golden redhorse followed by the gizzard shad. Thirteen less abundant species of coarse fish were also collected. After impoundment, we collected 11 species of coarse fish. The golden redhorse and black redhorse were the most common; however, they were not the dominant fish as they were before impoundment.

The dominant panfish before impoundment were the longear and green sunfish. These species continued to dominate after impoundment. Seven species of panfish were reported before impoundment. We collected eight species, the black bullhead being the additional species.

In the sport fish category, seven species were collected before impoundment, and we found six species. We did not collect the white bass anywhere in the river or lake, and only four specimens were taken in the pre-impoundment survey.

Species Diversity

Species diversity (\bar{d}) results were obtained by pooling samples for each reach and then for the entire river. Only data from Finnell, et al. (2) were used to calculate \bar{d} values for pre-impoundment populations because it was the only source that provided reliable quantitative data. For post-impoundment populations, data of the Corps and OSDH were pooled to calculate \bar{d} values. The numbers in parentheses in Table 2 show the actual number of species reported from that reach.

A comparison of \bar{d} values before and after impoundment shows species diversity is lower since impoundment (Table 2). In the upper reach, more species were collected after impoundment; the lower \bar{d} value reflects the abundance of the emerald shiner and bigeye shiner, which comprised about 67 percent of the fish collected.

In the lake area, species diversity was not significantly reduced. The \bar{d} value of 2.90 indicates a diverse fish population when compared with that of other Oklahoma lakes (8).

Species diversity was highest in the lower reach both before and after impoundment. While this reach showed the biggest loss

TABLE 2. Species diversity values (\bar{d}) for pre- and post-impoundment populations.

	No. of Species		No. of Inds.		\bar{d}	
	Before	After	Before	After	Before	After
Upper Reach	33	35 (36)	2,581	7,883	3.33	2.62
Middle Reach	31	27	3,402	15,985	3.03	2.90
Lower Reach	70 (82)	58 (60)	3,950	3,051	4.61	4.24
Total System	70 (84)	62 (65)	9,933	26,919	4.04	3.76

of species, the \bar{d} value remained relatively high.

DISCUSSION

Impoundment of the Mountain Fork River has caused significant changes in the fish populations. The smallmouth bass has been replaced as the main sport fish by the largemouth bass and spotted bass. Several species have been eliminated or become rarer since the river was impounded and the number of species has declined from 84 to 65. Reduction in the number of fish species in a river system after impoundment appears to be a common phenomenon (9, 10, 11).

One of the most drastic effects of impoundment has been the disappearance of 28 species, particularly cyprinids, from the lower reach. Before impoundment, 20 species of cyprinids were reported from the lower reach; since impoundment only 11 species have been collected. It is possible that not all of these nine species have been eliminated from the river but they apparently are much rarer than they were before impoundment.

Although a reduction in the number of species downstream from the dam was expected, the apparent loss of nearly one-third of the species formerly present in the river is a significant impact. The disappearance of several of these species may be related to the daily water releases made from about 18 m below the lake surface. During the warm months these releases are 10-15 C colder than normal river water and also cause daily water level fluctuations. Species that are adapted to natural seasonal variations in flow and normal stream temperatures have disappeared or are reduced in numbers in the downstream reach most affected by the water releases.

Despite the fact that reservoir construction and operation has had a significant effect on the fish populations of the Mountain Fork River, \bar{d} values remained relatively high. While some aspects of the stream fishery obviously have been adversely affected (e.g., total stream miles, smallmouth bass, etc.), other aspects have been improved (e.g., access, diversity of sport fish species, etc.).

The stability of the fish populations in the three reaches of the Mountain Fork cannot be accurately evaluated or compared with pre-impoundment conditions by using the existing data base. It is likely that future surveys will add more species to the post-impoundment list, but it is unlikely that as many species will be found as existed before impoundment.

Since we do not expect that all effects of the impoundment would be complete within seven years, changes probably will continue to occur in the species composition and abundance of fishes in the Mountain Fork River. However, the data show that significant effects have already occurred in species composition and diversity.

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