Decreasing Abundance of the Arkansas River Shiner in the South Canadian River, Oklahoma.

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During the past 30 yr the Arkansas River shiner (*Notropis girardi*) has been extirpated from 90% of its former range in Oklahoma and from all of its range in Kansas. In Oklahoma, this species occurs only in the South Canadian River in south-central Oklahoma between the Texas state line and Lake Eufaula. Long-term monitoring of this species at three sampling sites between 1977 and 1997 has indicated that it is declining both in total number of individuals collected and in relative abundance throughout the Canadian River system.

INTRODUCTION

The Arkansas River shiner (*Notropis girardi*) is endemic to the Arkansas River system in Oklahoma, western Arkansas, northeastern New Mexico, and northern Texas (*1*). Within this broad geographic distribution, the species has been extirpated since the 1970s from most of its range (*2*,*3*). Today it is common only in the Canadian River of Oklahoma, Texas, and New Mexico (*2*).

The earliest recorded collection of the Arkansas River shiner (50 specimens) in the South Canadian River, Oklahoma, occurred on 30 Oct 1920 (*4*). Museum records at the Oklahoma Museum of Natural History (OKMNH) indicate that it was collected in large numbers (>200 specimens) in 1928, 1932, 1958, 1961, 1962, and 1963. Houser and coworkers (unpublished records, OKMNH) collected 2,640 Arkansas River shiners from the lower South Canadian above the dam site during the 1962 pre-impoundment survey of Eufaula Reservoir.

This study addresses the status of the Arkansas River shiner in the mainstream of the South Canadian River above Lake Eufaula in Oklahoma. The Federal Clean Water Act of 1972 stipulates that all waters capable of supporting a fishery or a swimming area be unimpaired by water pollution. In 1976, the Oklahoma State Department of Health began extensive surveys of fish populations in Oklahoma waters to decide the level of protection required for various Oklahoma streams and to measure the progress toward the fishery goal of the Federal Law. Since 1995, the Oklahoma Department of Environmental Quality (ODEQ) has conducted these surveys. This report is based on those surveys.

METHODS

Study Sites: Three 200-m segments of the South Canadian River were established between 1976 and 1978 as long-term sampling sites: Site 1, 1.6 km west of Bridgeport (T13N R11W Sec 26), Blaine County; Site 2, 11.2 km south of Wanette (T5N R02E Sec 12), Pottawatomie County; and Site 3, 1.6 km northeast Calvin (T6N R10E Sec 22), Hughes County (Fig. 1).

The South Canadian River is a typical southern Great Plains river, which is usually wide and shallow, with wet-dry seasonal fluctuation in flows and extremes in water quality. We observed seasonal, yearly, and diurnal changes in weather, which greatly affected the river. In addition, high winds periodically would shift large amounts of sand from sandbars, filling pools. This river has been described as one of the "most ecologically dynamic regions existing" (*5*,*6*).

The aquatic habitats at these three long-term sampling sites were significantly different. At Site 1, near Bridgeport, the westernmost site, the upper 100 m had a deep (1.0-1.3 m), fast channel. The cutting action of the fast current produced an undercut bank that was lined with trees where roots provided shade and cover for

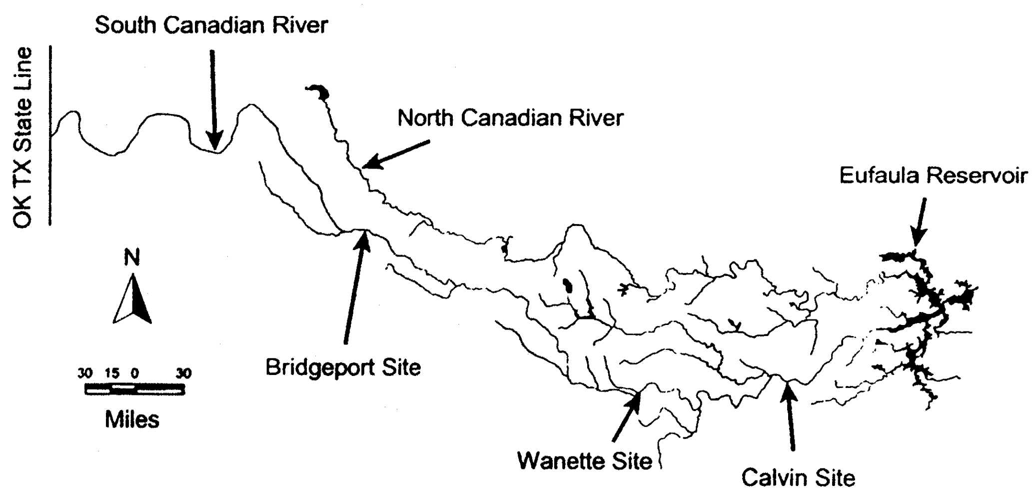

Figure 1. Long-term sampling sites on the South Canadian River, Oklahoma.

TABLE 1. Ranges of water quality parameters collected at three long-term sampling sites on the South Canadian River, Oklahoma, 1977-1997.

Parameter	Bridgport	Wanette	Calvin
Dissolved Oxygen (mg/L)	1.5-16.8	4.5-14.8	2.6-16.0
Water Temperature (^{o}C)	0.1-33.5	0.1-34.0	0.1-35.0
pH	6.7-9.3	6.3-9.4	6.5-8.8
Conductivity (mS)	18-2,500	280-7,000	300-7,100
Kjeldhal Nitrogen (mg/L)	0.1-5.3	0.1-5.7	0.1-4.4
Nitrates (mg/L)	0.5-4.1	0.4-4.0	0.5-7.5
Total Nitrogen (mg/L)	0.1-6.2	0.6-6.0	0.4-8.8
Total Phosphorus (mg/L)	0.01-4.3	0.1-3.4	0.1-1.4
Total Chloride (mg/L)	10-457	10-369	25-665
Total Sulfate (mg/L)	20-1,611	20-444	20-492
Total Iron (mg/L)	100-17,800	100-12,530	100-17,280
Total Sodium (mg/L)	39-302	29-220	22-259
Turbidity (NTU)	1-1,000	1-410	1-325
Suspended Solids (mg/L)	1-3,033	4-1,860	1-2,170
Total Hardness (mg/L)	303-1,020	143-696	103-665
Chemical Oxygen Demand (mg/L)	0.1-1.7	8.3-114.8	5.0-97.7
Total Organic Carbon (mg/L)	5.0-37.2	5.0-31.3	5.0-39.2

TABLE 2. Summary of collections of Arkansas River shiners and other fish at long-term sampling sites on the South Canadian River, Oklahoma, 1977-97.

	Bridgport	Wanette	Calvin
Starting year	1977	1979	1977
Total number of individuals collected	116,699	134,030	213,122
Number of Arkansas River shiners			
Total	15,923	14,233	31,270
Annual mean	758	749	1489
Annual minimum	66	35	0
Annual maximum	3,809	3,858	8,132
Relative abundance (%) of Arkansas River shiners			
Total	14	11	15
Annual mean	13	9	11
Annual minimum	2	1	0
Annual maximum	34	49	41

fish. A deep (1.0-1.6 m), long (30 m), mainstream pool represented the central section of the site. The final 60 m of the collective channel had either shallow (usually <0.3 m) and fast-flowing runs or shallow instream pools. A small, clear tributary entered the sampling area from the west.

Site 2, near Wanette, was the most diverse habitat. The initial 70 m were at the lower end of a long (100-150 m), deep (1.0-1.3 m), wide (10-20 m), aquatic weed-filled backwater pool and were covered with a bottom of soft, deep (0.2-0.5 m), sandy silt with a black layer of organic ooze. The next 80 m had a narrow (30-40 m), deep (0.6-0.9 m), fast channel running next to the bank. The outside of the channel was an upward-sloping sandbar with shallow edges. The final 50 m had a uniform channel with shallow (0.1-0.3 m) runs and riffles, and shallow sandbars ending in a shallow mainstream pool.

Site 3, north of Calvin, was the most uniform habitat. The initial 20 m consisted of a deep (1.0 m), narrow (2-3 m) instream pool downstream from a bridge pier. The next 150 m consisted of a deep (0.3-1.0 m), fast run next to a large sandbar. The combination of sandbar slumping and wind erosion and the fast current formed a uniform habitat of deep run over a smooth bottom of fine sand, with no pools. In the last 30 m, the channel cut into the bank, forming a deep (0.3-1.2 m), slow run, with a deeper channel next to the bank. Usually, small drifts of tree limbs lined the channel next to the bank. Also within the sampling area was a deep (1.5-3.0 m), wide (20-30 m), isolated pool downstream from the bridge pier. A log drift usually formed on the upstream side of the pier. The river was open to the sun except in early morning or late evening. A small stream entered the site at its lower boundary.

From 1977-1997 several physiochemical variables were recorded for the three sampling sites (Table 1). During this period there was a high degree of both annual and seasonal fluctuation in these variables (*7*).

Collections: We annually collected fish at the three sites in the spring (May-June), summer (July-August), and occasionally fall (September-October) from 1977 to 1997. Because a fall sample was not taken at every site every year, only data collected during the spring and summer samples were included in the analysis. At each site, we used a 3.3-m X 1.3-m heavy-leaded seine with 3.0 mm mesh. We sampled the 200-m reach of the stream with 20 seine hauls of 10 m each. To ensure consistency in sampling, Pigg led all seining trips. Seining was limited to 1.5 h at each site. The fish were immediately placed in 10% formalin; the fish were carried to the ODEQ laboratory in Oklahoma City where they were washed with water, sorted, identified to species, measured, weighed, and transferred to 60% isopropyl alcohol solution for storage. All fish were subsequently deposited as collections at the Oklahoma State University Zoological Museum (OSUS) or OKMNH.

Abundance of the Arkansas River shiner was expressed as the total number of individuals collected annually at each site and as a percentage of the total number of all species collected at the same site. Pearson's correlation procedures were used to express the relationship between abundance of the species and time. Statistical significance was set at $P = 0.05$.

RESULTS

From 1977 to 1997 we made a total of 122 collections. The Arkansas River shiner was found in 108, or 96%, of the collections. We collected a total of 463,851 individuals of all species, of which 61,426 (13%) were Arkansas River shiners. The number of shiners collected annually ranged from 0 to 8,132 individuals. Abundance of the species relative to the total number of individuals of all species collected was similarly variable; values ranged from 0 to 49% for all years (Table 2). There was a general annual decrease in both the total number and the relative abundance of Arkansas River shiners collected at all three sampling sites (Fig. 2-3), and several of these relationships were significant ($P \leq 0.05$).

DISCUSSION

We observed significant declines in the Arkansas River shiner in two of our sites on the South Canadian River. These results are similar to those in other studies that document the decline in abundance of the species throughout much of its native range. Sublette and coworkers (*4*) suggested it was declining in New Mexico. Collection records from the University of New Mexico indicate that in 1939 this shiner occurred in variable numbers (4-362 specimens) in the tributaries above Ute and Coche Reservoirs in New Mexico in 1939 (*3*). Surveys from Coche Reservoir in 1939 produced 533 specimens, whereas similar surveys in 1987 from Revuelto Creek west of Logan, New Mexico in 1987 produced 438 specimens. Ten fish collections stored in the Eastern New Mexico University Fish Collections contained Arkansas River shiners. Surveys made between 1974 and 1980 from several New Mexico tributaries yielded 44-278 Arkansas River shiners, and six collections taken from the Canadian River yielded 1-72 specimens. In 1990, five collecting attempts above Ute Reservoir failed to find any individuals (*3*). Three seining visits below Ute Reservoir yielded 399 Arkansas River shiners, or 24% of the total fish captured (*3*). Three collections housed at the University of New Mexico from a 1996 survey yielded 184 speci-

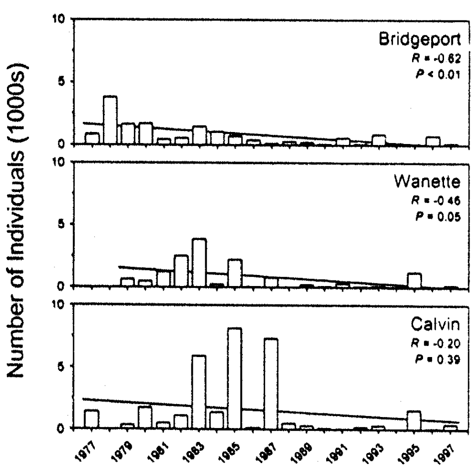

Figure 2. Number of Arkansas River shiners collected from three long-term sampling sites on the South Canadian River, Oklahoma, 1977-1997. *R* (Pearson correlation coefficient) and *P* values included.

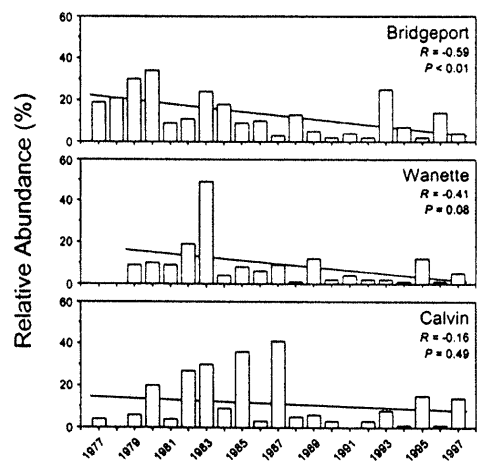

Figure 3. Relative abundance of Arkansas River shiners from three long-term sampling sites on the South Canadian River, Oklahoma, 1977-1997. *R* (Pearson correlation coefficient) and *P* values included.

mens. One collection had a relative abundance of 50% for the Arkansas River shiner (*4*).

In 1990, two surveys from the river above Lake Meredith, Texas produced 248 specimens (*3*). Surveys in 1990 from below Lake Meredith yielded 68 Arkansas River shiners, which composed 28% of the fish captured (*3*). In 1995, two surveys from the river produced three specimens, or less then 0.1% of the fish captured (*8*).

In Oklahoma, Matthews and Hill (*5*), Harrison (*9*), Woods (*10*), Larson and Echelle (*3*), and Polivka (*11*) reported varying numbers of shiners (170-16,355 specimens). A review in 1991 of the distribution and abundance records of the Arkansas River shiner in Oklahoma verified major declines in this species in Oklahoma waters (*2*,*3*).

Matthews and Hill (*5*) and Polivka (*11*) indicated that daily fluctuations in water temperature, dissolved oxygen, and salinity strongly influenced the microhabitats selected by the Arkansas River shiner. Other studies (*5*, *9*) indicated the relative abundance of Arkansas River shiners in the South Canadian River is related to specific conductance, current velocity, turbidity, and water depth. The shiner avoids current velocities >1.0 m/s and depths >30 cm (*11*). Matthews and Hill (*5*) indicated the most successful species in the South Canadian River are those that have developed an ecological plasticity and show marked habitat flexibility. Two characteristics that help fish to adapt to the South Canadian River are a wide tolerance to stress factors and selective response to water quality factors. Although the Arkansas River shiner displays some intolerance for environmental extremes, it apparently has the ability to locate other, more favorable habitats. This ability is probably what allows it to survive in the diverse, fluctuating, and often harsh environment of the South Canadian River.

The presence of nonnative fishes may prove a far greater problem to native fish survival than all other environmental abuses combined (*12*). Introductions of the mosquitofish *(Gambusia affinis)* into Australian and New Zealand waters were followed by a significant decline in native fishes (*13*). Meffe (*14*) suggested that predation by mosquitofish has been an important cause of the decline in fishes native to the American Southwest. McKay (*15*) suggested that sheer numbers of mosquitofish could adversely affect the endemic fish fauna. Myers (*12*) called the mosquitofish "the fish destroyer" because it attacks the eggs and fry of native fishes and is a known piscivore. Mosquitofish can extirpate a population of native fishes, such as the Sonoran topminnow *(Poeciliopsis occidentalis)* by eating young and attacking, injuring, and directly or indirectly killing adults (*12*,*16*). Recent studies suggest numbers of mosquitofish are increasing in several Oklahoma rivers (*17*,*18*), including the South Canadian River (ODEQ, unpublished data). We suggest predation by mosquitofish on fry could easily have a significant impact on a species with lower fecundity, such as the Arkansas River shiner.

We also suggest there is a possible predator-prey relationship of red shiner (*Notropis lutrensis*) and juvenile Arkansas River shiners. Work by Gido and coworkers (*19*) on the possible predation of red shiners on juvenile Red River pupfish (*Cyprinodon rubrofluviatilis*) indicated that some predation occurred. Red shiners were collected in large numbers at all of our sampling sites, and composed 52% of all specimens collected from 1977 to 1997 (ODEQ, unpublished data). The potential for predation of red shiners on juvenile Arkansas River shiners could account for the overall decline of this species in the South Canadian river.

The ability of the Arkansas River shiner to thrive in the South Canadian River will probably always be compromised by the presence of nonnative species. However, its survival will be greatly enhanced by protecting and maintaining the habitat diversity which characterizes this river.

ACKNOWLEDGMENTS

We gratefully acknowledge the field assistance of R. Sawin, G. Cottam, and many others over the past 22 y and the outstanding support by M. S. Coleman, Executive Director, ODEQ, and J. A. Duncan, Director of ODEQ Customer Services. The authors gratefully acknowledge the generous assistance of W. Matthews who read the manuscript. We appreciate the editing work and suggestions by C. McDowell. We also gratefully acknowledge the outstanding job by three unknown reviewers during the preparation of this manuscript.

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Received: July 6, 1998; Accepted: January 11, 1999