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Effects of Channelization on Fish Populations of the Cache River and Bayou DeView

Morris Mauney
Virginia Tech

George L. Harp
Arkansas State University

The Effects of Channelization on Fish Populations Of the Cache River and Bayou DeView

MORRIS MAUNEY
Department of Fisheries Science
Virginia Polytechnic Institute and State University
Blacksburg, W. Va. 24061

GEORGE L. HARP
Department of Biological Sciences
Arkansas State University
State University, Ark. 72467

ABSTRACT

This study was designed to better understand the possible effects of channelization by comparing natural and previously channelized sections of the Cache River and Bayou DeView. Forty-five fish species were collected in natural reaches, but only 24 species were collected in channelized reaches. *Cyprinus carpio* and *Dorosoma cepedianum* constituted 40 and 20 percent of the total fish biomass in channelized reaches, respectively, but only 22 and 2 percent of the total biomass in natural reaches. The mean weight of total fishes and game fishes only per surface ha in natural sections were 276 and 46 kg, respectively, but these values in channelized sections were only 88 and 2 kg, respectively. Mean species diversity indices for natural and channelized sections of the Cache River were 3.1 and 1.8, respectively, and mean redundancy values for these sections were .30 and .55, respectively. Species diversity indices and redundancy values for Bayou DeView followed this trend.

INTRODUCTION

In recent years the public has become increasingly aware of the multiple ramifications of projects resulting in environmental alteration. The simplistic view that stream channelization will result in flood control and increased land productivity only, is not so readily embraced. It is now more widely recognized that certain political, sociological, economic, and aesthetic considerations may reduce or completely negate the immediately envisioned benefits of a given project. Assessment of the overall impact of stream channelization is still hampered because the environmental interrelationships are not well understood. This is due primarily to a paucity of data and inadequate methodology for obtaining it. The Cache River basin provides a unique opportunity for impact assessment because the opposing forces of conservationists and developers have so clearly polarized and because part of the basin has been channelized previously in the interest of flood control.

Initial channelization of upper reaches of the Cache River and Bayou DeView was done by local landowners in the 1920's. Efforts to obtain public funds for flood relief in this basin began in the 1930's. Two studies addressing the feasibility and desirability of Federal participation in major flood control works, the first completed on 4 December 1941 and the second on 19 October 1945, recommended no improvement. A third report was submitted to the Corps of Engineers on 4 February 1949 and recommended improvement of the main channels of the Cache River and Bayou DeView. This report resulted in authorization by the Flood Control Act of 17 May 1950.

Subsequent to authorization, the project was reviewed as a part of the Mississippi River and Tributaries Project. That portion of the report pertaining to the lower White and Cache River basin was forwarded to the Memphis District, Corps of Engineers on 11 December 1959. Included was a report from USDI's Fish and Wildlife Service, dated 2 September 1959, evaluating the effects of the proposed project and recommending adoption of specific mitigation measures. Their input was authorized by the Fish and Wildlife Coordination Act of 1958. The Corps recommended against mitigation measures, as they were not considered economically feasible. Based on the 1959 report, the Flood Control Act of 27 October 1965 authorized improvement measures (U. S. Army Corps of Engineers, 1973).

In preparing a pre-construction report in 1966, the Corps found that woodlands in the basin were being cleared at such a rapid rate that they asked the Fish and Wildlife Service to reevaluate the Project and submit another report. The reevaluation report was submitted in 1969, but was deemed to be too general in nature. The Corps asked for another report, which was submitted to them in 1970. It recommended water control structures for oxbow lakes and 30,000 A (12,000 ha) for public use. In October 1971, environmental groups filed a civil suit in U. S. District Court at Little Rock, and in May 1972, the Court dismissed the case, ruling that the Government of 1969 in their environmental impact statement (EIS). This EIS and the Corps evaluation, which became known as the "mitigation report", were forwarded to Congress in 1972 (U.S. Army Corps of Engineers, 1973).

Dredging on the lower Cache River was begun during July 1972. In the fall of 1972 Senator John McClellan introduced a bill providing 30,000 A (12,000 ha) of woodlands for public use with an additional 40,000 A (16,000 ha) to be preserved by environmental easements, with or without public access. He introduced another bill which provided $1 million for purchase of mitigation lands. Congressman Bill Alexander introduced similar legislation in the House. Congress passed both bills. President Richard Nixon vetoed the Rivers and Harbors Omnibus Bill, which contained the authority to start the mitigation program, but signed the appropriation bill that contained the $1 million for land acquisition (U. S. Army Corps of Engineers, 1973).

Construction stopped on the lower Cache River in December 1972 because of high water. Also at this time the 8th Circuit Court of Appeals ruled the 1972 EIS inadequate. In February 1973, environmentalists filed a motion with the U. S. District Court at Little Rock for an injunction to stop construction. The Court ruled that construction must stop but allowed for completion of the section which was started. In May 1973, the construction contract was terminated (U. S. Army Corps of Engineers, 1973).

A more thorough EIS was released in November 1973, and a series of public hearings were held in the Cache River basin. Also during 1973 several states and additional environmental groups joined the original plaintiffs in the suit to block the Cache River Basin Project, primarily because of alleged adverse impact on waterfowl populations. The various parties could not find an area of compromise, and a special task force was appointed to this end. Based on their recommendations, in October 1978 Congress approved a $2.8 million appropriation for work in the Cache River basin, with half of this amount to be spent immediately for the purchase of mitigation lands. No channelization can take place until the Environmental Protection Agency approves, however. The current plan restricts channelization to the lower 14 mi (22.5 km) of the Cache River. The upper 140 mi (225 km) of the Cache River, channelized in the 1920's, would be cleared of silt, debris, and vegetation to improve flow, but the

channel would not be enlarged. Further, "green belt" strips would be acquired along the midsections of the Cache River and Bayou DeView. Several alternatives for dealing with this portion of the waterways would be considered, including constructing a leveed floodway, digging a bypass channel or clearing the channel without enlarging it. As of the summer of 1979, the Environmental Protection Agency has not approved channelization work.

STUDY AREA

The Cache River basin drains southward along the western edge of the Mississippi Embayment. It extends from Butler County, Missouri, near the Arkansas line, to White River near Clarendon, Monroe County, Arkansas. With a length of about 229 km and a maximum width of 29 km, the Cache River basin has a total area of about 5,227 sq km. Except for a portion of the headwaters draining off the western slope of Crowley's Ridge, the basin is a long, narrow alluvial plain. The recent alluvium overlays Tertiary sediments (Fisk, 1944) and consists of a substratum of about 46 m of coarse sands and gravels deposited in the early stages of valley fill by streams with heavy loads and finer-grained top layers deposited later when the carrying capacity of the streams decreased (Krinitsky and Wire, 1964). The surface layer consists of a very dense, relatively impervious, dark reddish-brown clay one to three m thick interlayered between varicolored clays and silts. In some areas sand overlays the clay (Krinitsky and Wire, 1964).

Land use in the basin is predominantly agricultural, with soybeans, cotton, and rice being the major crops. Natural vegetation in the basin includes such wetland types as Tupelo gum, cypress, cottonwoods, oaks, river birch, and willows. Annual rainfall is approximately 122 cm, with the heaviest amounts falling from December to June (U. S. Army Corps of Engineers, 1973). Because of the flat terrain, streams in the area are sluggish, and runoff is slow, which aids recharge of the ground water reservoir (Albin et al., 1967).

The upper reaches of the Cache River have been channelized by local authorities or landowners to State Hwy 18 1.6 km E of Grubbs, Jackson County, Arkansas. Below this point it follows a fairly well-defined course through the floodplain. The top bank of the channel is 27-152 m wide with depths of 1-8 m. Bayou DeView, the main tributary of the Cache River, arises on Crowley's Ridge north of Jonesboro, Arkansas. It parallels the Cache River until it joins it 17 km upstream from the mouth of the Cache River. Its total length is 172 km. This stream has been channelized by local people from its headwaters to the U. S. Hwy 64 crossing. Areas adjacent to the channelized portions are intensively farmed except for Bayou DeView State Game Area and lands owned by private hunting clubs. The lower 68 km of Bayou DeView flow naturally through swamp areas such as the Dagmar Wildlife Management Area, having a rather poorly-defined channel. These areas contain dense stands of Tupelo gum and cypress trees (U. S. Army Corps of Engineers, 1973).

METHODS AND MATERIALS

Nine stations were established in the Cache River basin. Of the three stations located on Bayou DeView, the headwater station was channelized, and the two lower stations were located in natural reaches. Six stations were located on the Cache River; the upper three were channelized, and the lower three stations were in natural sections (Fig. 1). Selected physicochemical determinations were made at each station, and values varied within comparable ranges in channelized and natural sections (Mauney, 1974).

During 22-30 June and 31 August fishes were collected from the nine stations by the use of various seines and rotenone. Classification was accomplished with the keys of Eddy (1957), Pflieger (1968), and Moore (1968). Nomenclature is in accordance with Bailey et al. (1970). In calculating number and weight of game vs total fishes the following 12 species were considered game fishes: *Esox americanus vermiculatus, E. niger, Centrarchus macropterus, Lepomis cyanellus, L. gulosus, L. humilis, L. macrochirus, L. microlophus, Micropterus punctulatus, M. salmoides, Pomoxis annularis,* and *P. nigromaculatus.*

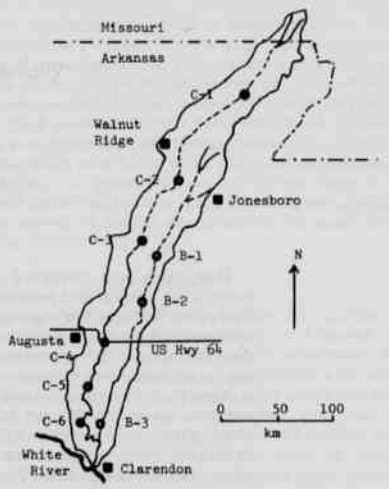

Figure 1. The Cache River Basin. Study stations are designated by C (Cache River) or B (Bayou DeView). Dashes represent channelized stream sections. Solid perimeter line represents the watershed divide.

Total number of individuals (n), number of individuals per species (n_i), and number of species present (s) were used to calculate diversity per individual (d), and redundancy (R) (Wilhm and Dorris, 1966). Sterling's approximation for factorials was used in all calculations. Computations were made with an IBM 360 computer. Coefficient of condition, ksl (Lagler, 1956), was determined for *Ictiobus bubalus* collected from the Cache River. They were divided into size classes of 5.0 cm intervals. Coefficient of condition was equal to the weight of a fish in g times 100,000 divided by the cube of the standard length in mm. Data pertaining to weights and numbers of fish at Station B-1 were not used in computations because of the bias introduced by a small dam and rock riprap, which was not present at any other sampling station.

RESULTS

Forty-seven species of fishes were collected in the Cache River basin, 32 from the Cache River proper and 42 from Bayou DeView (Table 1). The channelized reaches of the two rivers yielded a total of 24 species, while a total of 45 species were taken from natural sections. Three species of fishes were taken only from channelized sections, but 23 species occurred only in the natural reaches.

Large numbers of *Cyprinus carpio* and *Dorosoma cepedianum* were found in both natural and channelized sections. *C. carpio* constituted 40 and 22 percent and *D. cepedianum* constituted 20 and 1.5 percent by weight of the total fish biomass in channelized and natural sections, respectively. The mean weight of total fishes per surface ha in channelized sections was 88 kg, and in natural sections the value was 276 kg. The mean weight of game fishes per surface ha in channelized portions was 1.5 kg, or 3.3 percent of that found in natural reaches (46 kg). The mean weight of non-game fishes per surface ha was also greater in natural sections (230 kg) than in channelized sections (86 kg). The number of harvestable game fishes (15+ cm in total length) per surface ha was reduced by 99.5 percent in channelized sections. The mean number of all fishes per kg was 16 for natural sections and 197 for channelized sections.

Table 1. Species list of the fishes of Cache River and Bayou Deview

Common Name	Scientific Name
Spotted Gar	*Lepisosteus oculatus* (Winchell) CB*
Longnose gar	*Lepisosteus osseus* (Linnaeus) C
Shortnose gar	*Lepisosteus platostomus* Rafinesque C
Bowfin	*Amia calva* Linnaeus CB
Gizzard shad	*Dorosoma cepedianum* (Lesueur) CB
Grass pickerel	*Esox americanus vermiculatus* Lesueur CB
Chain pickerel	*Esox niger* Lesueur B
Carp	*Cyprinus carpio* Linnaeus CB
Silvery minnow	*Hybognathus nuchalis* Agassiz C
Golden shiner	*Notemigonus crysoleucas* (Mitchill) CB
Emerald shiner	*Notropis atherinoides* Rafinesque CB
Bigeye shiner	*Notropis boops* Gilbert CB
Pugnose minnow	*Notropis emiliae* (Hay) CB
Blacktail shiner	*Notropis venustus* (Girard) CB
Bullhead minnow	*Pimephales vigilax* (Baird and Girard) CB
Smallmouth buffalo	*Ictiobus bubalus* (Rafinesque) CB
Spotted sucker	*Minytrema melanops* (Rafinesque) B
Golden redhorse	*Moxostoma erythrurum* (Rafinesque) CB
Yellow bullhead	*Ictalurus natalis* (Lesueur) B
Channel catfish	*Ictalurus punctatus* (Rafinesque) CB
Tadpole madtom	*Noturus gyrinus* (Mitchill) CB
Flathead catfish	*Pylodictis olivaris* (Rafinesque) CB
Pirate perch	*Aphredoderus sayanus* (Gilliams) CB
Northern studfish	*Fundulus catenatus* (Storer) B
Blackspotted topminnow	*Fundulus olivaceus* (Storer) CB
Brook silverside	*Labidesthes sicculus* (Cope) B
Mosquitofish	*Gambusia affinis* (Baird and Girard) CB
Flier	*Centrarchus macropterus* (Lacepede) B
Green sunfish	*Lepomis cyanellus* Rafinesque CB
Warmouth	*Lepomis gulosus* (Cuvier) B
Orangespotted sunfish	*Lepomis humilis* (Girard) CB
Bluegill	*Lepomis macrochirus* Rafinesque CB
Longear sunfish	*Lepomis microlophus* (Gunther) CB
Spotted bass	*Micropterus punctulatus* (Rafinesque) C
Largemouth bass	*Micropterus salmoides* (Lacepede) CB
White crappie	*Pomoxis annularis* Rafinesque CB
Black crappie	*Pomoxis nigromaculatus* (Lesueur) C
Mud darter	*Etheostoma asprigene* (Forbes) CB
Bluntnose darter	*Etheostoma chlorosomum* (Hay) CB
Slough darter	*Etheostoma gracile* (Girard) CB
Harlequin darter	*Etheostoma histrio* Jordan and Gilbert CB
Cypress darter	*Etheostoma proeliare* (Hay) B
Logperch	*Percina caprodes* (Rafinesque) B
Blackside darter	*Percina maculata* (Girard) B
Dusky darter	*Percina sciera* (Swain) B
Sauger	*Stizostedion canadense* (Smith) CB
Freshwater drum	*Aplodinotus grunniens* Rafinesque CB

*C denotes Cache; B denotes Bayou DeView; CB denotes both.

Mean species diversity indices for natural and channelized sections of the Cache River were 3.1 and 1.8, respectively. Mean redundancy was 45 percent less in natural reaches than in channelized reaches, 0.30 vs 0.55. These values were of comparable magnitude in Bayou DeView (Table 2). Due to limitations caused by imposed experimental design, species diversity indices were calculated for Jenkins and Harp's (1971) data for Big Creek, the headwaters of Bayou DeView (Table 3). Individual coefficients of conditions were determined for 27 *Ictiobus bubalus* from natural sections and 22 from channelized sections. The Student's t test showed no significant differences between mean condition coefficients of populations in natural vs channelized reaches (Table 4).

Table 2. Community structure of channelized and natural stream sections of Cache River and Bayou DeView.

Station	s	n	$\bar{d}$	R
Channelized*	16	367	2.093	.50
Natural*	17	653	2.846	.31
Natural*	35	645	3.702	.28
Channelized	13	998	1.683	.56
Channelized	15	9951	1.606	.59
Natural	19	548	3.517	.16
Natural	17	309	2.316	.46

* Denotes stations located on Bayou DeView.

Table 3. Total number of species and species diversity indices for stations located on Bayou DeView, arranged in a downstream sequence.

Station	s	$\bar{d}$
JB-1* Natural	8	2.394
JB-2 Natural	9	2.181
JB-3 Natural	10	2.161
JB-4 Natural	10	2.078
JB-5 Channelized	11	1.811
B-1 Channelized	17	2.094
B-2 Natural	17	2.846
B-3 Natural	34	3.702

* JB denotes stations studied by Jenkins and Harp (1971), B denotes stations utilized in the present study.

Table 4. Mean condition coefficient (ksl) of *Ictiobus bubalus* in natural and channelized sections.

Sex	Channelized	Natural
Undetermined	2.603 *n=4	3.050 n=4
Male	2.858 n=12	2.966 n=16
Female	2.804 n=6	3.033 n=7
Means	2.812 n=22	2.996 n=27

*n = sample size

DISCUSSION

The greater diversity of fish species in natural reaches and the differences in species composition in natural vs channelized reaches were apparently related to the greater degree of siltation in channelized sections, since other factors (e.g. stream order [Horton, 1945], physicochemical characteristics) were basically comparable. Siltation negatively affects the survival rate of eggs, spawning and nesting grounds, number of food organisms, visibility of sight feeders, number of habitats, and substrate stability (Ritchie, 1972). Any one or combination of these factors could cause the observed results.

The marked reduction in mean weight per surface ha for total fishes, game fishes, and non-game fishes at channelized stations may be attributed in part to a reduction in numbers of macroinvertebrate organisms. Latimer (1975) reported that the numerical standing crop of benthic macroinvertebrates in this basin was reduced by 55 percent in channelized sections. She also observed a reduction in macroinvertebrate diversity in channelized sections. The resulting simplified food web could logically result in less weight per individual in higher trophic levels. Restricted nesting areas could further contribute to reduced biomass of fishes in channelized reaches (Ritchie, 1972). The reduction in biomass of all fish species in channelized sections of the Cache River basin was 68 percent. Other studies have reported reductions of 32-85 percent in channelized stream sections (Congdon, 1971; Michalson, undated; Tarplee et al., 1971).

Channelization appears to affect game fishes, particularly those of harvestable size, more severely than non-game fishes. Game species are characteristically less hardy, and they are primarily sight feeders (e.g. *Micropterus* spp.) as opposed to taste or touch feeders (e.g. *Cyprinus carpio*). The mean weight reduction of game fishes in chan-

nelized sections of the Cache River basin was 96.7 percent, and reduction in the number of harvestable individuals (15+ cm in length) was 99.5 percent. Other investigators have reported the numbers of game fishes exceeding 15 cm in length to be reduced by 77-99 percent in channelized environments (Bayless and Smith, 1962; Congdon, 1971; Tarplee et al., 1971).

The negative effects of channelization on the Cache River basin are emphasized upon studying Gray's (1955) data. He collected *Alosa chrysochloris, Morone chrysops, M. mississippiensis* and *Lepomis gulosus* from the Cache River and *A. chrysochloris, Carpiodes cyprinus, M. mississippiensis* and *Micropterus punctulatus* from Bayou DeView. The absence of these species in our collections may be due in part to sampling bias, but the impact of channelization and subsequent siltation, as well as pesticides and other agriculturally oriented stresses, cannot be ignored.

Two important features of good game fish habitat are the presence of deep backwater areas with little or no current and the presence of adequate cover (Buchanan, 1976). Indeed presence of these features increases the total fish species diversity. Reduced environmental heterogeneity in the channelized portions of the Cache River basin is indicated by the species diversity indices (mean 1.8 vs 3.1 in natural reaches) and redundancy values (0.55 vs 0.30 in natural reaches). High redundancy values reflect dominance by a few species, whereas low redundancy values indicate a more even distribution of fishes among species (Wilhm and Dorris, 1968). Channelization results in a straight channel with near constant depth and width. This homogeneity contributes to reduced competition for some species through extirpation of those species unable to cope.

Due to imposed experimental design, effects of channelization vs longitudinal zonation were difficult to evaluate, because upper stations were channelized and lower ones were not. Species diversity would be expected to increase in down stream increments if longitudinal zonation alone were operating. Analysis of species diversity indices for a natural, channelized, then natural section sequence would best elucidate what effect, if any, channelization might have. To this end, species diversity indices were calculated for Jenkins and Harp's (1971) data for Big Creek, the headwaters of Bayou DeView (Table 3). The reduction in species diversity indices at the two channelized stations, JB-5 and B-1, clearly indicate the effect of channelization in this stream.

The lack of significant differences in mean condition coefficients of *Ictiobus bubalus* populations between channelized vs natural sections of the Cache River (Table 4) may reflect the migratory behavior of this species, extensive flooded conditions during this time (which may have provided ample detrital foods in all stream sections), sample size, or any combination of these phenomena.

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