# FISH MOVEMENTS BETWEEN THE MISSISSIPPI RIVER AND AN OXBOW LAKE, ARKANSAS-MISSISSIPPI

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## INTRODUCTION

Fish production in floodplain river ecosystems is significantly influenced by the duration and magnitude of flooding events (Welcomme 1976, 1979, 1986; Goulding 1980). Oxbow lakes and other backwater areas, if accessible, are utilized by many riverine fish species for spawning and foraging during high-water periods (Sparks 1995). Unfortunately, levee construction has reduced the floodplain area of the Lower Mississippi River by more than 90% (Sheehan and Rasmussen 1993).

In the "Delta" region of Mississippi, oxbow lakes of the Mississippi River support commercial and recreational fisheries (Lucas and King 1986). However, many of these lakes are excluded from the floodplain by levees, and thus have no seasonal interactions with the river. In contrast, oxbow lakes located on the river-side of the levees (in the floodplain) establish connections with the main channel (every year or less often), and thus are influenced by river-lake exchanges of water, nutrients, and fishes. Fish populations in these oxbows may be regulated more by river-lake fish exchanges than by angler harvests. However, there is relatively little published information on the nature and extent of river-lake fish movements in floodplain river ecosystems, particularly in the Lower Mississippi River.

Our study was designed to assess seasonal fish movements through a floodplain canal connecting an oxbow lake to the Mississippi River. We characterized the fish stocks using the canal during the high-water period in the winter-spring, and described the direction of fish movements (toward the river or lake) in the canal.

## STUDY AREA

This study was conducted in a canal associated with Lake Beulah (Arkansas-Mississippi), a 390-hectare oxbow lake of the Lower Mississippi River (river mile 584). The Lake Beulah canal (about 1.5 km long) forms a seasonal connection with the Mississippi River (Figure 1), usually from December to June, when the river stage reaches about 9.1 m (above mean sea level) at the U.S. Army Corps of Engineers (USACOE) gauging station in Greenville, Mississippi (USACOE, unpublished data). The canal and lake proper have densely forested riparian zones that become inundated during high-water events.

## METHODS

Limnological conditions and fish assemblages were sampled 2 - 4 times monthly (total of 14 sampling dates) in the Lake Beulah canal, January-May 1994. Water temperature and instream habitat features were measured at a fixed sampling station in the middle reaches of the canal. Channel width (m), mid-channel depth (m), and current velocity (cm/s, Gurley Current Meter) were measured, and discharge ($m^3/s$) was estimated using the U.S. Geological Survey midsection method (Orth 1983). The direction of flow (river-to-lake or lake-to-river) was observed in upper, middle, and lower reaches of the canal.

Hoop nets were used to collect data on fish stocks and their movements in the canal. On each sampling date, a total of 6 – 10 hoop nets (4.3-m long, four 1.07-m diameter hoops, 2.5-cm mesh) were set at different locations (one net per location) spanning the entire length of the canal; nets were spaced at least 100 m apart to reduce gear competition. Hoop nets were oriented parallel to the bank, with the mouth (fish entrance into net) facing

the river or facing the lake, to determine the direction of fish movements. Nets were set in water 1 - 8 m deep with both ends of the net tied to natural structure to prevent the gear from collapsing during periods of low or changing flow conditions. Initially, nets were fished for 4 - 7 days (1 day = 24 hours); however, sampling effort was reduced to 1 - 4 days to reduce damage and loss of gear related to high discharge, bank erosion, and vandalism.

Gill-netting was conducted to collect additional data on fish stocks. On each sampling date, gill nets were set at 1 - 2 locations in the canal. At each location, two experimental gill nets (2.4 x 30.5 m long; five 6.1-m panels with mesh sizes of 2.5, 3.18, 3.81, 5.08, and 7.62 cm; multifilament nylon) were fished for approximately 24 hours in shallow (< 3 m) and deep water (≥ 3 m).

Fish collected in hoop and gill nets were identified to species, measured to the nearest 1 cm (total length), and then released. Common and scientific names of all fish species (Robins et al. 1991) collected are listed in Table 1 (common names only are used in the text).

Data analyses were performed using the Statistical Analysis System (SAS 1988). Hoop-net abundance data (number of fish per net per 24 hours) were log-transformed ($\log_e (x + 1)$) to satisfy the assumptions of parametric statistical testing. Paired $t$ tests were used to compare estimates of abundance and species richness from hoop nets facing the river and lake. Because catches of fish in hoop nets and other passive gears are directly influenced by fish movements (Hubert 1983), significant differences in catch rates from hoop nets facing the river and lake would indicate differences in the direction of fish movements in the canal. Statistical significance was declared at the 0.10 alpha level.

## RESULTS

The Mississippi River established a connection with Lake Beulah, via the canal, from 15 January to 31 May 1994 (Figure 2). The river exceeded its flood stage of 14.6 m from 18 April to 15 May (Figure 2), resulting in overbank flooding throughout most of the canal and the creation of an extensive floodplain. The river flowed into the canal when the river was rising, but the direction of flow reversed when the river level began to stabilize or decrease.

Limnological conditions in the Lake Beulah canal varied with seasonal changes in air temperature, precipitation, and river stage. Surface water temperature averaged 13.2 °C (range = 4 – 24) and increased during the study period. Canal depth and discharge increased with the river stage, but were generally similar during periods of river-to-lake and lake-to-river flows. Mid-channel depth averaged 5.2 m (range = 3.7 – 7.9), current velocity was 21.1 cm/s (7 – 63), and discharge was 15.6 $m^3/s$ (6.6 – 26.4). Massive bank erosion resulting in mud slides and fallen trees was observed in the canal, particularly following periods of heavy rainfall.

A total of 342 fish consisting of 13 families and 32 species was collected by hoop-netting (N = 291 fish) and gill-netting (N = 51 fish) in the Lake Beulah canal, January - May 1994 (Table 1). Clupeids (shads and skipjack herring; mostly gizzard shad) accounted for 38% of the total catch; catostomids (suckers), 14%; lepisosteids (gars), 11%; centrarchids (sunfishes) and ictalurids (catfishes), 10% each; moronids (temperate basses) and sciaenids (freshwater drum), 6% each; hiodontids (mooneyes), 2%; polyodontids (paddlefishes), 1%; and four other families, <1% each. Twenty-five fish species collected were of commercial and/or recreational importance (Table 1). Many of the stock-size fish collected exhibited average total lengths greater than the minimum quality sizes desired by anglers (Table 2).

Catch (total, forage, commercial, and recreational species) was higher ($P < 0.10$) in hoop nets set with the mouth facing the river than in nets facing the lake (Figure 3). Species richness was also higher ($P < 0.01$) in nets facing the river (3.5 species/day) than in nets facing the lake (1.0 species/day).

## DISCUSSION

A hydrological connection established in the canal between Lake Beulah and the Mississippi River during the January-May 1994 study period provided a dispersal corridor for river- and lake-dwelling fishes. Hydrological conditions in the Lake Beulah canal, a lotic environment when connected to the Mississippi River, were within the range of those reported in many warmwater streams (Winger 1981) and deemed adequate to support fish assemblages. The canal provided sufficient physical habitat space (water depth = 3.7 - 7.9 m, wetted channel width = 25 - 36 m) to allow for fish movements between the

river and lake. In March-April, when river levels peaked, overbank flows in the canal inundated the surrounding forest landscape creating an extensive floodplain.

Higher estimates of fish abundance and species richness in river-facing hoop nets (versus lake-facing nets) provided empirical evidence of fish movements from the Mississippi River into the Lake Beulah canal, and probably into the lake proper; conversely, lower estimates in lake-facing nets suggest that lake-to-river fish movements were less pronounced. Guillory (1979) also documented lateral movements of flood-adapted fishes from the main channel of the Mississippi River into backwater areas during winter-spring flooding. Flood-adapted fishes seek suitable backwater areas for spawning and feeding; however, their utilization of river floodplains may be curtailed by ephemeral or degraded habitats (Beecher et al. 1977; Kwak 1988).

Fishes (32 species) collected in the Lake Beulah canal have been identified in previous surveys of the middle and lower reaches of the Mississippi River (Barnickol and Starrett 1951) and adjacent oxbow lakes (Lucas and King 1986; Lucas 1990). Gizzard shad, an important prey species for piscivorous fishes inhabiting large rivers and oxbow lakes (Megrey 1980; Robison and Buchanan 1988), comprised most of the catch in the canal. Commercial and sport fishes that were abundant in the canal (gars, suckers, catfishes, temperate basses, sunfishes, freshwater drum) also comprise significant portions of the ichthyofauna of many Mississippi oxbows (Lucas and King 1986; Lucas 1990). Furthermore, many of the commercial and sport fishes collected in the canal exceeded the minimum sizes identified with quality fishing experiences (Anderson and Neumann 1996).

Backwater habitats of floodplain rivers provide spawning, nursery, and/or feeding habitats used by most river-dwelling fish species (Risotto and Turner 1985; Scott and Nielsen 1989; Dewey and Jennings 1992). Sexually mature individuals were observed -- based on body size (Gabelhouse 1984) and/or male coloration (Robison and Buchanan 1988) -- in the majority of fish populations sampled. Many of the adult fishes collected by spring hoop-netting in river-facing nets were probably moving toward the lake in search of suitable spawning habitat. The Lake Beulah environment, protected from the strong currents of the Mississippi River, was characterized by shallow and deep water areas, an extensive littoral zone with an abundance of aquatic vegetation and submerged structures, and heavily forested shorelines which become seasonally inundated; such features provide spawning, nursery, and foraging habitats for a wide variety of floodplain fishes (Larimore et al. 1973; Guillory 1979; Kwak 1988).

Fish stocks identified in this study represent fisheries resources harvested by commercial and recreational anglers (though the nature and extent of fishing effort is unknown) in the Mississippi River and many of its oxbows in the Delta region. Seasonal flooding from the Mississippi River is necessary to sustain the movement of riverine fishes into the Lake Beulah system. Findings from other studies indicate that river-to-lake fish movements occur during winter-spring flooding in the Mississippi River system and in other floodplain river ecosystems in temperate regions. Additional research is needed to define species-specific patterns of fish movements between the main channel and oxbow lakes, and to quantify the effects of these movements on lake fish populations and the fisheries they support.

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Table 1. Numbers of fishes collected by hoop-netting and gill-netting in the Lake Beulah canal, Arkansas-Mississippi, January - May 1994.

| Common name | Scientific name | Hoop nets | Gill nets | Total |
|---|---|---|---|---|
| Paddlefish | Polyodon spathula | | 4 | 4 |
| Spotted gar[1] | Lepisosteus oculatus | 3 | 2 | 5 |
| Longnose gar[1] | Lepisosteus osseus | 2 | | 2 |
| Shortnose gar[1] | Lepisosteus platostomus | 27 | 5 | 32 |
| Bowfin[1] | Amia calva | 1 | | 1 |
| Skipjack herring | Alosa chrysochloris | | 5 | 5 |
| Gizzard shad | Dorosoma cepedianum | 99 | 16 | 115 |
| Threadfin shad | Dorosoma petenense | 11 | | 11 |
| Goldeye | Hiodon alosoides | 2 | 5 | 7 |
| Common carp[1] | Cyprinus carpio | 1 | | 1 |
| Golden shiner | Notemigonus crysoleucas | 1 | | 1 |
| Smallmouth buffalo[1] | Ictiobus bubalus | 33 | | 33 |
| Bigmouth buffalo[1] | Ictiobus cyprinellus | 3 | 1 | 4 |
| Black buffalo[1] | Ictiobus niger | 2 | | 2 |
| River carpsucker[1] | Cyprinus carpio | 4 | 2 | 6 |
| Highfin carpsucker[1] | Cyprinus velifer | 1 | 1 | 2 |
| Spotted sucker[1] | Minytrema melanops | 1 | | 1 |
| Black bullhead[1] | Ameiurus melas | 1 | | 1 |
| Channel catfish[1] | Ictalurus punctatus | 28 | 2 | 30 |
| Blue catfish[1] | Ictalurus furcatus | | 1 | 1 |
| Flathead catfish[1] | Pylodictis olivaris | 1 | 1 | 2 |
| Inland silverside | Menidia beryllina | 1 | | 1 |
| White bass[1] | Morone chrysops | 14 | 3 | 17 |
| Yellow bass[1] | Morone mississippiensis | 2 | 1 | 3 |
| Flier[1] | Centrarchus macropterus | 1 | | 1 |
| Orangespotted sunfish[1] | Lepomis humilis | 1 | | 1 |
| Bluegill[1] | Lepomis macrochirus | 6 | | 6 |
| Longear sunfish[1] | Lepomis megalotis | 22 | | 22 |
| White crappie[1] | Pomoxis annularis | 3 | | 3 |
| Black crappie[1] | Pomoxis nigromaculatus | 2 | | 2 |
| Sauger[1] | Stizostedion canadense | | 1 | 1 |
| Freshwater drum[1] | Aplodinotus grunniens | 18 | 1 | 19 |
| Total | | 291 | 51 | 342 |

[1] Fish species of commercial and/or recreational value in Arkansas and Mississippi.

Table 2. Total lengths (TL) of stock-size fishes collected by hoop-netting and gill-netting in the Lake Beulah canal (Arkansas-Mississippi), January - May, 1994.

| Species | N | TL (cm) Mean | TL (cm) Range | Minimum TL (cm) of quality-size fish[1] |
|---|---|---|---|---|
| Common carp | 1 | 39 | - | 41 |
| Blue catfish | 1 | 77 | - | 51 |
| Channel catfish | 30 | 25 | 10-54 | 41 |
| Flathead catfish | 1 | 67 | - | 51 |
| White bass | 17 | 26 | 21-41 | 23 |
| Yellow bass | 3 | 23 | 22-25 | 18 |
| Bluegill | 6 | 13 | 10-16 | 15 |
| White crappie | 3 | 31 | 30-33 | 20 |
| Black crappie | 1 | 16 | - | 20 |
| Sauger | 1 | 38 | - | 30 |
| Freshwater drum | 18 | 32 | 20-56 | 30 |

[1] Anderson and Neumann (1996).

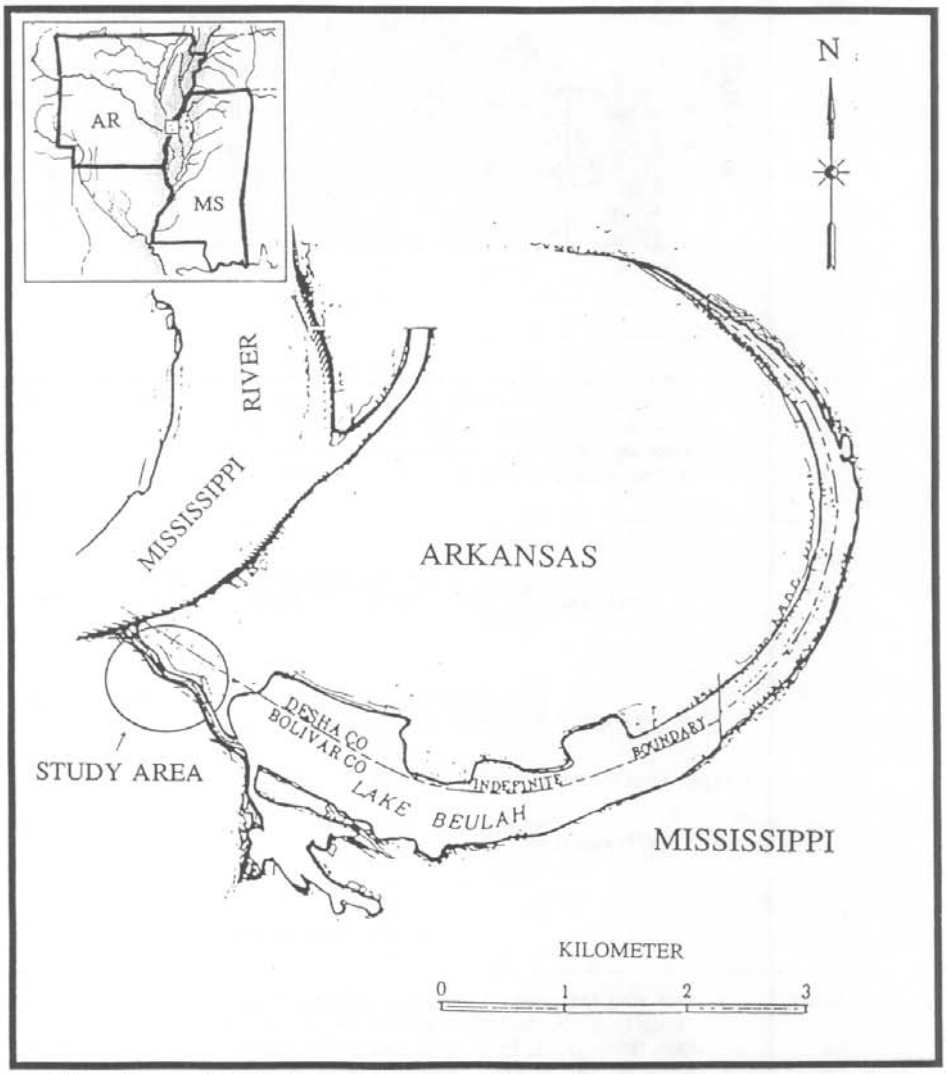


Figure 1. Lake Beulah and its canal (study area) form a seasonal connection with the Mississippi River (river mile 584), Arkansas-Mississippi. (This figure was modified from a map drafted by the U.S. Army Corps of Engineers.)

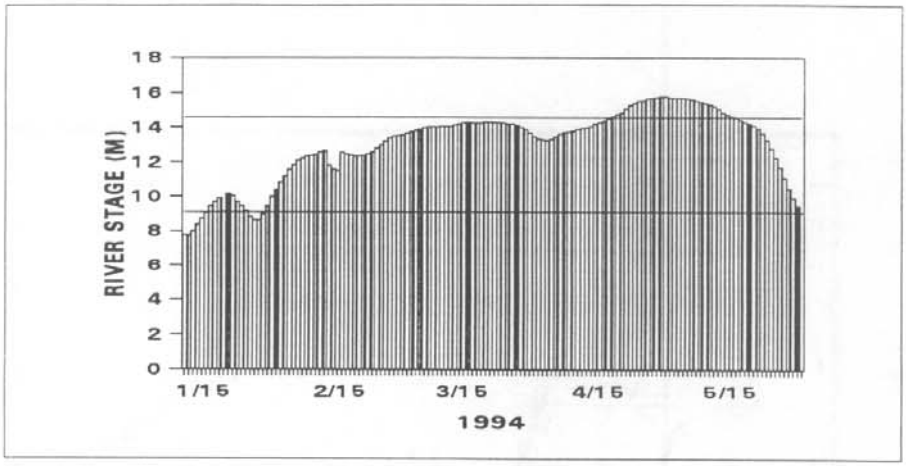


Figure 2. Daily measurements of the Mississippi River stage (elevation above mean sea level) recorded at the Greenville, Mississippi gauging station, January - May 1994. The lower horizontal line represents the stage at which the Mississippi River connects with Lake Beulah (9.1 m); the upper horizontal line represents the flood stage (14.6 m). (These data were provided by the U.S. Army Corps of Engineers.)

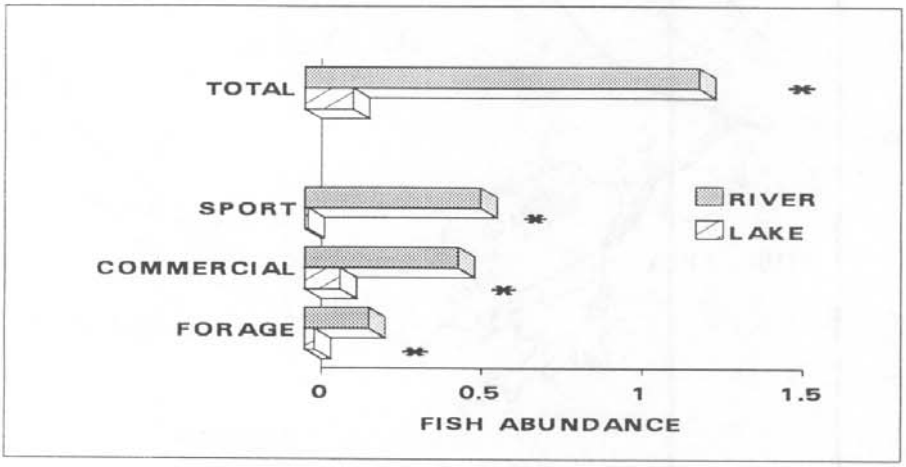


Figure 3. Fish abundance estimates (mean number per net per 24 hours) in river- and lake-facing hoop nets fished in the Lake Beulah canal, Arkansas-Mississippi, January - May 1994. In this figure, total = all fishes; sport = catfishes, temperate basses, sunfishes, and sauger; commercial = gars, bowfin, common carp, suckers, and freshwater drum; and forage = shads and minnows. Asterisks indicate significant differences between abundance estimates in river- and lake-facing nets ($P < 0.10$; paired *t* tests).