EFFECTS OF YAZOO BACKWATER REFORMULATION PROJECT ON FISH HABITAT

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PREFACE

This report describes fish assemblages in the Yazoo Backwater area, Mississippi, and evaluates impacts of proposed flood control measures on fish habitat. This report is an appendix to the Supplemental Environmental Impact Statement for the Yazoo Backwater Reformulation Study being prepared by the US Army Engineer District, Vicksburg (CEMVK).

Numerous individuals contributed to this evaluation as a member of the HEP Team: Marvin Cannon and Gary Young, CEMVK; Garry Lucas and Dennis Riecke, Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP); Larry Marcy and Ken Quackenbush, United States Fish and Wildlife Service (USFWS); Dwayne Templet, Geo Marine Inc. CEMVK furnished project specifications including floodplain acres. Interagency meetings were held in March 1994, November 1994, and March 1995. During these meetings, the Team determined approaches for habitat quantification (floodplain habitat delineation for larval fishes), selected evaluation species, and agreed on Habitat Suitability Index Scores. Team members were updated during a meting in January 1999.

The following individuals at WES assisted with field work: Steven G. George, Sherry L. Harrel, James Morrow, Erik H. Nelson, Catherine Murphy, and Larry G. Sanders. Field assistance and identification of juvenile and adult fishes were provided by Neil H. Douglas, Northeast Louisiana University. Bob Wallus identified larval fishes. Gary Young was project biologist for CEMVK.

During the conduct of this study Dr. John Keeley was Director, Environmental Laboratory, Dr. Conrad J. Kirby was Chief, Ecological Research Division, and Dr. Edwin Theriot was Chief of the Aquatic Ecology Branch at CEWES. Commander and Director of CEWES during publication of this report was COL Robin R. Cababa, CE.

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ABSTRACT

Potential effects of flood control measures in the Yazoo Backwater Area, which encompasses the lower Big Sunflower River system, lower Steele Bayou system, and numerous tributaries and oxbow lakes, were quantified for 35 plans. Baseline data on fishes were collected in representative habitats during Spring and Summer 1994. Juvenile and adult fishes were collected in the outlet channel of the Steele Bayou water control structure by hoop nets and in isolated and contiguous oxbow lakes of Delta National Forest by gill nets. Light traps were used to collect larval fishes in floodplain habitats upstream and downstream of the control structure, lakes of Delta National Forest, and floodplain of lower Big Sunflower River system.

Twenty-three species of juvenile/adult fishes were collected with gill or hoop nets. The numerically dominate groups of gar, gizzard shad, common carp, buffalo, catfish, crappie, and freshwater drum are characteristic of Mississippi delta fish assemblages. Species richness was highest below Steele Bayou structure, lowest in Delta National Forest Lakes. Flathead catfish and freshwater drum comprised almost 80% of the fish collected in the channel below Steele Bayou structure; gizzard shad, common carp, bigmouth buffalo, and white crappie were abundant in the borrow areas below the structure. Gar, bowfin, and bullheads were common in the Delta National Forest lakes.

A total of 281 light trap samples collected 10,184 larval fishes representing 17 taxa. Species richness was highest in the fringing floodplain connected to the outlet/inlet channel of the structure. Abundant larval fishes in the floodplain were buffalo, white crappie, shad, freshwater drum, and sunfishes. Mean number of larval fish was highest in borrow areas below the structure (195 fish per trap, mostly sunfishes) and in Lake George (89 fish per trap, mostly buffalo). Black bass larvae were rare, except in an isolated section of a Delta National Forest lake where they were the dominant taxa. Mean dissolved oxygen ranged from 4-5 mg/l at all locations during sampling, but stratification occurred in the Delta National Forest Lakes and behind Steele Bayou Control Structure. Fish kills were noted behind the structure during July.

Habitat Evaluation Procedures were used to determine losses in floodplain spawning and rearing habitat for six species: blacktail shiner, smallmouth buffalo, flathead catfish, largemouth bass, white crappie, and freshwater drum. Of the 115,044 acres of floodplain inundated at least once every two years, agricultural fields and bottomland hardwood forests were the most common floodplain habitat. Bottomland hardwoods, and to a lesser extent cleared lands, have higher spawning than rearing value for most species. Permanent waterbodies on the floodplain are preferentially used by larval fishes during rearing, but these habitats were relatively uncommon within the 2-year floodplain. Consequently, spawning losses were higher than rearing losses.

Plans that included non-structural flood-damage reduction (e.g., reforestation) resulted in a net gain in Average Annual Habitat Units (AAHU) for spawning and rearing of fishes. The highest gains were for combination plans that included conservation easements and reforestation on lands below 91 ft NGVD. Pump size (14,000 vs 17,500 cfs) had marginal effect on total AAHU for combination plans, but water level management substantially increased AAHU.

PART I. INTRODUCTION

The Yazoo Backwater Area encompasses 926,000 acres between the east bank Mississippi River levee and Will M. Whittington Auxiliary Channel. The area is a ponding area, or floodplain sump, that receives water from Deer Creek, Steele Bayou, Big Sunflower River, and Little Sunflower River. The Steele Bayou Flood Control Structure regulates water elevation in the sump. When the water elevation of the Yazoo River exceeds the gate elevation, the structure is closed to prevent further flooding into the sump. When the gates are closed, headwater floods from Steele Bayou and Big Sunflower River increase sump elevation that may persist through mid-summer. Measures to alleviate flooding in the backwater area are being studied by the Vicksburg District, Corps of Engineers.

We evaluated 35 flood control plans (Table 1). These plans can be grouped into four categories:

a. Nonstructural plans (Plans 1 and 2) - Both plans exclude pumping but include conservation easements on forested and agricultural land and retention of agricultural land use; the second Plan also includes reforestation of agricultural land as a non-structural flood damage reduction measure.

b. Combination of structural and non-structural plans (Plans 3 - 26, 30-35) – The structural component of these plans is to construct a pumping station near Steele Bayou water control structure , and depending on the plan, two capacities are being considered to pump water from the sump into the Yazoo River: 14,000 cfs and 17,500 cfs. The nonstructural components include conservation easements on forested and agricultural lands, retention of land use on agricultural land, reforestation of agricultural land, and water level management in the sump.

c. Structural plans (Plans 27 and 28) - These plans include only the construction of pumping stations at different capacities (14,000 cfs for Plan 27; 17,500 cfs for Plan 28).

d. Levee Plan (Plan 29) - Levees would be placed along the Big Sunflower River that would divert water away from the sump and into the Yazoo River through the existing Little Sunflower River drainage structure.

There is concern that reduction of stage elevations on the floodplain associated with the Backwater Project may negatively impact fish habitat. Fish communities are a mixture of the Yazoo River system and Lower Mississippi River ichthyofaunas. Studies of the Mississippi River (Baker et al. 1991), Steele Bayou (Killgore and Hoover 1991), Upper Yazoo River (Killgore and Hoover 1993), and Big Sunflower River (Hoover and Killgore 1994) indicate that a diverse ichthyofauna can potentially utilize the floodplain for spawning and rearing. Many of these fishes undergo regular migrations to utilize inundated floodplains as spawning, nursery, and foraging areas (Guillory 1979, Ross and Baker 1983, Finger and Stewart 1987, Copp 1989, Scott and Nielson 1989), while others reside year-round in permanent pools and oxbow lakes on the floodplain (Lietman et al. 1991). For both types of fish, seasonally inundated floodplains provide additional feeding areas that coincide with periods of increased energetic needs for reproduction and growth (Whitaker 1977, de la Cruz 1978, Lambou 1990).

Reproduction of most wetland fishes is closely related to timing, extent, and duration of flooding, and annual variations in periodic flooding of rivers affects reproductive success and year-class strength of many species (Starrett 1951, Guillory 1979, Larson et al. 1981). Flow rate influences abundance of larval fish within different floodplain habitats (Turner et al. 1994) and contributes to downstream movement of ichthyoplankton (Harvey 1987, Copp and Cellot 1988), many of which may accumulate behind the Steele Bayou Control Structure. Lateral movements of adult fish on the floodplain, however, decrease exponentially with reductions in stage elevation (Kwak 1988). Spawning failure may occur if water levels remain low and population numbers are high (Starrett 1951). However, those waterbodies that are connected to main river channels, either continuously or during floods, could function as important fish nursery areas (Beecher et al. 1977; Dewey and Jennings 1992; Hoover et al. 1995).

This document describes potential impacts of the project on fish habitat. The objectives of our study were:

a. To describe baseline aquatic habitat and associated fish assemblages in the Yazoo Backwater Area.

b. To quantify changes in fish habitat associated with each project plan using the Habitat Evaluation Procedure (HEP).

PART II. BASELINE CONDITIONS

Streams in the project area were engineered in the 1960's for flood and low-water control; channel improvements consisted of clearing, cleanout, enlargement, bendway cutoffs, and weirs (US Army Corps of Engineers 1955; CEMVK, pers. comm.). Streams are slow-flowing, but experience substantial variation in river stage. Water levels may fluctuate by more than 20 ft annually in the Big Sunflower River; high stages typically occur in late winter and early spring, low stages in late autumn and early winter. Historically, water quality was not considered limiting; April-August dissolved oxygen in 1971 was high (D.O. = 4.4-8.6) and turbidity moderate (40-250 JTU's) at three stations within the study area (Parker and Robison 1972). In 1993, however, hypoxia (D.O. $\leq$ 3.0) and high turbidities (250-614 NTU's) were not uncommon, particularly during spring and early summer (Hoover and Killgore 1994).

Bottomland hardwood forests cover more than a third of the 2-year floodplain, and large continuous tracts occur in Delta National Forest. Agriculture is intensive and occupies over one third of the two-year floodplain. Most acreage is devoted to soybean cultivation, lesser acreage’s are fallow and rice. Within the Yazoo Backwater Project Area, 129,013 acres are flooded at least once every two years. Floodplain habitats that are seasonally inundated include agricultural land, fallow land, and bottomland hardwoods. Permanent floodplain waterbodies include oxbow lakes, scatters, brakes, and tributary mouths.

None of the project plans are expected to negatively impact river channels. Therefore, evaluation of aquatic resources was confined to floodplain habitats and the area immediately associated with the proposed pump location. Field data were collected over a wide range of habitat conditions to provide:

a. expanded species lists and comprehensive characterization of the ichthyofauna

b. relative abundance of individual species

c. relationships between fish abundance and floodplain habitats

Methods

During Spring and early Summer 1994, fishes were sampled at three locations that corresponded to peak abundance (during and immediately following spawning seasons), physically heterogeneous stations, and pronounced and progressive changes in physical habitat (summer declines in water level):

a. Lower Big Sunflower River. This area corresponded to the floodplain of the lower Big Sunflower River between Cypress Bend and Campbellville which included five habitats: bottomland hardwoods, agricultural land, fallow land, oxbow lake (Lake George), and tributary mouth (Silver Creek). Hardwoods and cleared lands were seasonally connected to the river; the oxbow lake and tributary mouth were permanently connected. Larval fishes were sampled March-June 94 in each floodplain habitat. Based on field data from the upper Yazoo system, this period encompasses portions of two modes of total larval fish abundance, and portions of the spawning season for all evaluation species (Turner et al. 1994).

b. Steele Bayou Water Control Structure. This structure, at the downstream boundary of the Yazoo Backwater Project Area, is near the proposed pump location and could concentrate fishes in large numbers. The channel provides a migratory route for adult fishes. Fringing floodplain habitats provide spawning and nursery grounds representative of the sump. Borrow areas that retain water during the summer are numerous along the levee. Therefore, composition of fishes that potentially occur throughout the project area were readily evaluated at this location. Adult and juvenile fish were sampled in the outlet channel downstream of the structure on 22-24 June 94. Larval fish were sampled in the floodplain immediately above and below the structure April and May 94. During June and July 1994 when the gates were closed, larval fish were sampled in fringing floodplains immediately upstream of the structure and in two borrow areas below the structure adjacent to the levee.

c. Oxbow Lakes. There are approximately 180 permanent floodplain waterbodies in the project area that range in size from less than an acre to over 500 acres (excluding Eagle Lake). Most of these waterbodies are oxbow lakes that are either permanently isolated or seasonally connected to mainstem rivers. Larval fish were collected in two waterbodies from April-July 1994: Plaquemine Bayou and Howlett Bayou. Plaquemine Bayou, an oxbow lake of the Big Sunflower River in Sharkey County near Delta National Forest, is separated by a road into an isolated and a seasonally connected segment. Howlett Bayou, a tributary of the Little Sunflower River in the Delta National Forest, includes an isolated lake, Fish Lake, and a seasonally connected lake, Lost Lake. Each was concurrently sampled in April, May, and July to evaluate composition of larval fishes relative to degree of connectivity. Adult and juvenile fishes were sampled once in each lake during July 1994.

Slotted light traps (Killgore 1994) were used to collect larval fish; standard effort was 5-10 traps per site during each sampling event. Trap contents were poured through a 425 µm-mesh plankton net and field preserved in 5% formalin. Fishes were identified from trap samples to the lowest taxonomic category. Groups that are speciose (sunfish, minnows, darters) present special problems in that the larvae were difficult to identify to species with any reliability. For those taxa, specimens were identified to genus with the exception of *Cyprinella* and *Notropis*, collectively referred to as Cyprinids, and the darters *Etheostoma* and *Percids*. Fishes that exhibited fully differentiated fins were classified as juveniles. Larvae and juveniles were treated as separate taxa. Temporal trends in relative abundance of larval fish were expressed for each site, including oxbow lakes that are isolated and contiguous with the river.

Adult and juvenile fishes fishes were collected with gillnets (90' X 6' with 0.75, 1.5, 2.0, 2.5, 3.0, 3.5" stretch mesh) and hoopnets (15' long, 3' diameter, 1" square mesh). Standard effort in oxbow lakes were overnight sets of 3 gillnets. Channel samples consisted of 10 hoopnets set overnight. All fish were measured for total length to the nearest mm and released.

Concurrent with all fish collections, depth, dissolved oxygen, temperature, pH, and conductivity were measured using a Hydrolab or Cole-Palmer probes. Turbidity was measured with a Hach 2100P turbidimeter. Water depth was measured at 10 points along a cross-sectional transect in the channel, or at each trap location in floodplains, using a stadia rod (< 20 ft) or depth recorder (> 20 ft).

Results and Discussion

Total number of fish known for the Yazoo drainage (delta and hills) is 123 (Ross and Brenneman 1991). A total of 81 species of fish have been collected in the delta of the Yazoo River system; 57 species were collected or observed in the Big Sunflower River system and Yazoo Backwater area (Table 2). Ichthyofauna is taxonomically dominated by minnows, sunfishes, and to a lesser extent, by catfishes and suckers. Most species collected in the Yazoo Backwater are considered "moderately tolerant" or "tolerant" of degraded water quality and habitat (Jester et al. 1992). This reflects high turbidities and hypoxic conditions characteristic of the system and previous alteration of the streams 30 years ago (U.S. Army Engineers 1955).

Twenty-three species of juvenile/adult fishes were collected with gill or hoop nets overall (Table 3). Species richness was highest below Steele Bayou structure; lowest in Delta National Forest Lakes, particularly Plaquemine Lake. Flathead catfish and freshwater drum comprised almost 80% of the fish collected in the channel below Steele Bayou structure; gizzard shad, common carp, bigmouth buffalo, and white crappie were abundant in the floodplain below the structure. However, spotted and shortnose gars, bowfin, and bullheads were more common in the Delta National Forest Lakes above the structure. Buffalo were more common in connected lakes, whereas bowfin were more common in isolated lakes. Ranges of total lengths of fishes included sizes appropriate for commercial and recreational exploitation (Table 3).

A total of 281 light trap samples collected 10,184 larval fishes representing 17 taxa (Table 4). Species richness was relatively uniform, except at Steele Bayou Control structure. Number of species was highest in the fringing floodplain connected to the outlet/inlet channel of the structure but was lowest in borrow areas below the structure. Mean number of larval fish collected was also relatively uniform among sampling stations with a few exceptions. Mean number was considerably higher in borrow pits below the structure (195 fish) and in Lake George (89 fish). Mean number was lowest in Plaquemine Lake (6.9-10.2 fish) and in fallow fields (5.9 fish). Overall, species richness was relatively lower than comparable systems in the lower Mississippi River system (Finger and Stewart 1987; Killgore and Baker 1996).

Shad and crappie larvae were commonly collected at all sampling stations. In the Big Sunflower floodplain, buffalo larvae were caught in the agricultural field, but were most abundant in the oxbow lake. Buffalo were uncommon in the Delta National Forest Lakes and around the Steele Bayou Control Structure. Drum larvae exhibited similar trends, but were most common in the fallow field and bottomland hardwood forest of the Big Sunflower floodplain. Common carp larvae were moderately abundant in the Big Sunflower floodplain and below the structure. Sunfish (*Lepomis* sp.) larvae were collected at all sampling stations, but were the overwhelming dominant taxa in borrow areas below Steele Bayou structure. Black bass larvae were rare, except in the isolated section of Plaquemine lake where they were the dominant taxa. Darter larvae were also rare, except in Fish Lake where they comprised 7.4% of the total number of fish collected. All other taxa contributed less than 1.5% of the total individuals collected at any one particular sampling station.

Fish spawned principally from March through June (Figure 1). Peak spawning of most species occurred in early or mid-April (shad, buffalo, crappie) and early and mid-May (drum, black bass, darters) when water temperatures ranged from 20-25 °C. Fishes that spawned in summer were primarily comprised of sunfishes, and to a lesser extent minnows. Appearance of individual taxa was similar among the three sampling locations (Big Sunflower floodplain, Delta National Forest Lakes, Steele Bayou Control Structure). Taxa that exhibited a punctuated, or short-term spawning strategy based on presence of larvae were buffalo, drum, and black bass; carp, shad, crappie, and sunfish had longer spawning periods.

Mean values for conductivity (200-300 μmhos/cm) and pH (7.2-7.7) were similar among the three sampling locations. However, turbidity was substantially higher in the Big Sunflower River floodplain (mean=306 NTU) than in the Delta National Forest Lakes (mean=114 NTU) and around the Steele Bayou Control Structure (mean=120 NTU). Mean dissolved oxygen ranged from 4-5 mg/l at all sampling locations, but stratification occurred in the Delta National Forest Lakes and behind Steele Bayou Control Structure. Stratification was most prevalent behind the closed structure due to stagnant conditions and high water temperatures. As summer progressed, the thermocline moved from approximately six feet below the water surface up to only 1-2 feet. During July, fish kills were noted behind the structure.

PART III. IMPACT ANALYSES

Habitat Evaluation Procedures (HEP) (USFWS, 1980) were used to quantify changes in fish spawning and rearing habitat for pre- and post-project conditions. Habitat Units (HU's), calculated by multiplying a Habitat Suitability Index (HSI) value ranging from 0.0 (unusable habitat) to 1.0 (optimum habitat) by a measurement of area (e.g., acres of flooded bottomland hardwood), were used to express the quality and quantity of fish habitat for different project plans.

The underlying assumption of this approach is that the abundance and distribution of evaluation species respond in a predictable fashion to changes in habitat quality defined by the variables in the HSI model. However, changes in HU's may not be directly associated with population density but areas with higher HU's are assumed to have potential to support more fish than areas with lower HU's.

Methods

Habitat Suitability Index Scores

A technique was required to objectively choose evaluation species from a speciose community. Species need to provide broad representation of habitat preferences and reproductive biology, and must be sensitive to the different project impacts. To accomplish this, species collected in the Project area were grouped into guilds based on substrate used by spawning adults and on characteristic habitat (swiftwater vs slackwater) (Table 5). Six evaluation fish species were selected by consensus of the interagency HEP Team (see Preface for details on HEP Team) that represented approximately 75% of the taxa: smallmouth buffalo, blacktail shiner, largemouth bass, white crappie, flathead catfish, and freshwater drum.

Habitat Suitability Index (HSI) values, used in HEP to express quality of habitat for evaluation species, were developed by consensus of an interagency team of biologists (Delphi technique) supplemented by field and literature data. The HEP Team recommended to conduct a separate aquatic floodplain evaluation for spawning and rearing. Identification of preferred spawning sites for evaluation species is based on indirect information. High turbidity prevents direct observation of egg deposition and, with few exceptions, there are no taxonomic keys for fish eggs. Thus, HSI values for spawning were developed by consensus of state and federal fishery biologists that comprised the HEP Team (Table 6). HSI spawning scores for drum were not included because they are reported to spawn in river channels (Fremling 1978; Robison and Buchanan 1988) and larval freshwater drum were not collected in floodplain habitats of the Yazoo drainage (Killgore and Hoover 1993).

For spawning, the Team also recommended to eliminate portions of floodplain where duration of flooding was less than 8 days and depth of flooding was less than 1 foot. A minimum 1 foot depth was considered necessary for adults to move onto the floodplain. Duration of flooding is important for egg incubation since eggs can be stranded and desiccated if water levels drop before hatching. Incubation times range from 2-14 days (Table 7). Incubation times are based on life history summaries (Breder and Rosen 1966; Carlander 1969; Carlander 1977; Becker 1983; Robison and Buchanan 1988) and field notes of water temperature in the Big Sunflower River. Hatching times are probably rapid in warm floodplain waters of the Mississippi delta, but documentation is lacking. Thus, we considered 8 days a conservative estimate for duration of flooding that emphasizes upper limits of incubation times to maximize likelihood of spawning and to provide a margin for temporal variability in spawning activities (e.g., adult movement onto floodplain, nest construction, nest guarding behavior, fry leaving nest).

Recommended HSI values for rearing were based initially from field data collected in the Big Sunflower System during spring and early summer 1994 and then modified by the HEP Team (Table 8). HSI values were quantitatively developed for buffalo, minnows (blacktail shiner), crappie (white), and freshwater drum. Frequency of capture was standardized to a 0-1 scale (Figure 2). Floodplain habitat with the highest frequency of larval fish for a given taxa was assigned a HSI value of 1.0, and the frequencies recorded for remaining habitats scaled accordingly.

Buffalo and crappie were most abundant in the oxbow lake (Figure 2). These data, considered with the original HSI scores developed by consensus, suggest that buffalo and white crappie spawn in seasonally inundated floodplains (agricultural fields, fallow fields, and bottomland hardwoods), but move into the river as larvae, or remain in the oxbow lakes. This scenario is supported by observations of buffalo spawning (Yeager 1936; Johnson 1963; Burr and Heidinger 1983) and by documented concentrations of larval crappie, offshore in deep water (Hoover et al. 1995).

Larval minnows are most common in tributary mouths indicating that these fishes prefer permanent water bodies adjacent to the river (Figure 2). In other systems, larval minnows are also more abundant in tributaries, close to the main channels (Dewey and Jennings 1992; Turner et al. 1994). Blacktail shiners are distinctive, however, as crevice spawners with complex mating and defensive behaviors (Heins 1990). Agricultural and fallow fields would not provide spawning habitat as favorable as bottomland hardwoods and tributary mouths that generally have an abundance of woody debris. We believe that larvae move into or remain in tributary mouths, or move out into the main channel. Tributaries and channels as rearing habitat for blacktail shiners are documented (Killgore and Baker 1996; Hoover et al. 1995).

Freshwater drum larvae were abundant in bottomland hardwoods (Figure 2), but we reduced the HSI score (Table 8) based on the following rationale. Eggs and protolarvae occur in upper levels of offshore waters, especially in reservoirs and pools; meso and meta-larvae occur near the bottom in main channels migrating to the surface at night or during high turbidity (Fremling 1978; Matthews 1984; Holland-Bartels et al. 1990; Dewey and Jennings 1992). Large numbers observed in Mississippi Delta hardwoods are believed to have resulted from an unusual hydrologic condition. In 1994, water pooled for a prolonged period (3 weeks) and at unusually high stages (> 37'), coinciding with this species' late April-early May spawning season (Pflieger 1977). We believe that spawning took place offshore in the old channel, and that larvae drifted inshore into adjacent bottomland hardwoods that experienced abnormally prolonged, and extensive flooding. Absence or low numbers of drum from other floodplain habitats may have resulted from different hydraulic conditions downstream or from lower population densities. Drum inhabit shallow shorelines, briefly, as small (20-40 mm) juveniles and seining data for 1993 (Hoover and Killgore 1994) suggest that drum are more abundant in the old channel (Cypress Bend) of the lower Big Sunflower than in the channelized reach (Holly Bluff cut-off). Abundance (per 10 seine hauls) of drum were:

	Big Sunflower River	
	Old Channel (near Choctaw Bayou)	Channelized River (Holly Bluff Cutoff)
9 May 93	0	0
2 Jun 93	61	0
29 Jun 93	11	1
20 Jul 93	0	0

Larval largemouth bass and flathead catfish were not collected. There is no evidence to suggest that black bass larvae prefer seasonally inundated floodplain (agricultural fields / bottomland hardwoods) as rearing habitat. Since largemouth bass are primarily a lentic species, they likely prefer permanent floodplain water bodies. A study of oxbow lakes in the Tallahatchie River (Killgore and Miller 1994) confirmed presence of black bass in this habitat, albeit at low densities. Thus, oxbow lakes and tributary mouths had high HSI values for largemouth bass and remaining habitats had low ratings.

Based on the prevalence of small juvenile flathead catfishes in riffles (Carlander, 1969; Pflieger 1975; Robison and Buchanan 1988), it is presumed that larvae move into flowing water after absorbing the yolk-sac and that post-yolk sac larvae do not rear in the floodplain (R. Wallus, pers. comm.). Furthermore, flathead catfish spawn during the summer when the floodplain is not extensively inundated (Floyd et al. 1984; Holland-Bartels et al. 1990). Based on this rationale, all floodplain habitats received relatively low HSI scores for flathead catfish larvae; oxbow lakes and SBT were rated higher than the seasonally inundated habitats because they may be accessible during the summer rearing.

Habitat Units

Pre- and post-project Habitat Units were calculated for the following floodplain habitats.

a. seasonally inundated agricultural land
b. seasonally inundated fallow land
c. seasonally inundated bottomland hardwoods
d. oxbow lakes seasonally connected to the mainstem river
e. small, permanent backwaters (scatters, brakes, and tributary mouths) seasonally connected to the mainstem river.

The project area, which extends north to near Hwy 12, and west to the main-line Mississippi River levees, was divided into four reaches and floodplain acres were presented by reach. Location of each reach was:

Reach 1: The western boundary of the Backwater area inclusive of Steele Bayou and Deer Creek systems extending down to the proposed pumping plant location. Larval fish were sampled in the floodplain immediately above and below the structure, in fringing floodplains immediately upstream of the structure, and in borrow areas below the structure adjacent to the levee.

Reach 2: The middle segment of the Backwater area encompassing western tributaries of Big Sunflower River excluding Little Sunflower River.

Reach 3: That portion of the Backwater area inclusive of lower Big Sunflower and Little Sunflower Rivers. Larval fishes were sampled in bottomland hardwoods, agricultural land, fallow land, oxbow lake (Lake George), and tributary mouth (Silver Creek) in this reach.

Reach 4: The eastern boundary of the Backwater area that extends east to the lower auxiliary channel and encompassing eastern tributaries of the Big Sunflower River. In this reach, larval fish were collected in oxbow lakes of the Big Sunflower and several waterbodies in Delta National Forest.

Floodplain acres were determined for each reach using three criteria: defining the upper limit of the floodplain, incorporating variation in the hydroperiod during the spawning and rearing season within the upper limit of the floodplain, and identifying the areal extent of each floodplain habitat. First, a flood frequency value was necessary to represent the upper limit of a typical flood that is biologically meaningful to fish over a long time period. A 2-year frequency flood was considered the most appropriate value for two primary reasons:

a. Most evaluation species reach sexual maturity at Age One or Two. Thus, a flood that typically occurs once every two years is considered necessary to maintain reproductive populations in the basin. The more extreme hydrologic events may result in higher fish abundance, but do not represent flooding regimes that maintain baseline population levels over the life of the project (i.e., 50 year project life).

b. The life span of small-sized evaluation species is 2-3 years and some may only reproduce once. Thus, a flood frequency less than 2-years may result in successive reproductive failures by species with short life spans. Flood frequencies greater than two years is an overestimate of the usable floodplain utilized by species with short life spans. Larger-sized species can live up to 10 years, but those that utilize floodplains to reproduce on an annual basis require regular flooding to maintain population integrity.

Flood frequency analysis provides a basis to select the 2-year flood using statistical principles commonly applied by hydraulic engineers; Engineering Manual 1110-2-1415, titled “Engineering and Design-Hydrologic Frequency Analysis” is the primary reference. The upper limit of the two-year floodplain was determined using the Log-Pearson Type III distribution. This analysis compiled the maximum stage, regardless of time period, that occurred during a given year and ranked these values in descending order of magnitude. The period of record for this project was from 1943-1997, thus the sample size was 54. The median stage value (50 percent percentile) of the ranked data corresponded to the upper limit of the 2-year frequency flood and this elevation was used as a maximum flood stage in subsequent analysis.

Collectively, the peak reproductive period of most fishes in southern forested wetlands extends from March through June when water temperature ranges from 15-25 ^{o}C (Hoover and Killgore 1998; this study). Using a program called ENV_FISH1.EXE, the Hydraulics Branch of MVK computed average daily acres flooded within the 2-year floodplain during the reproductive period of fishes (March-June) over the period of record (1943-1997). The daily averages incorporated variation in the hydroperiod (onset, duration, and magnitude of flooding), including flood peaks, within the 2-year floodplain.

Suitable spawning habitat for fishes, as previously defined, were areas inundated for at least 8 consecutive days with a minimum depth of 1 ft. Defined rearing habitat, in contrast, was not limited by period of inundation or water depth as free swimming larvae can *potentially* use any area inundated within the 2-year floodplain. Average daily acres of spawning and rearing habitat were computed for baseline conditions and for each Plan.

Satellite imagery that closely corresponded to the 2-year floodplain was used to determine percent of each land use category by reach. These percentages were multiplied by average daily acres to obtain area for each of the five floodplain habitats by reach. We assumed percent land use would remain the same for baseline conditions and each Plan.

Habitat Units (HU) were the product of HSI, cumulative for all evaluation species, and average daily acres of a respective floodplain habitat (e.g., fallow land) within a reach. Total HU were the sum of all floodplain habitats and reaches, and assuming no substantial changes in land use over the 50-year project life, total HU were considered Average Annual Habitat Units (AAHU). Net change in AAHU for each Plan were relative to baseline conditions. For plans that included reforestation, an annualized HSI score was calculated, multiplied by total acres to be reforested, and the product was subtracted from baseline conditions to obtain net change in AAHU. The annualized HSI reflected a 20 year transition from cleared to forested lands and was calculated as 2.34 and 0.69 for spawning and rearing, respectively.

Results and Discussion

There are 129,013 average daily acres of floodplain habitat inundated at least once every two years during the reproductive season (Mar-Jun) in the Yazoo Backwater area. Of the 129,013 acres, 72,316 acres (56%) are inundated greater than or equal to 8 days with depth of flooding greater than or equal to 1 ft (i.e., spawning acres). Floodplain acreage was highest in Reach 1 (Steele Bayou system) and lowest in Reaches 2 and 4 (Figure 3). Agricultural fields and bottomland hardwoods were the most common floodplain habitat in all reaches (Figure 4). Hardwood forests were most prevalent in the lower Big Sunflower and Little Sunflower Rivers (Reach 3).

Flooded bottomland hardwoods and permanent floodplain waterbodies had higher individual and cumulative HSI values for spawning than cleared lands (Figure 5). Evaluation species that deposit eggs on flooded vegetation (smallmouth buffalo) or construct nests (white crappie, largemouth bass) may utilize cleared lands (Table 6), but values are disproportionately lower when compared to permanent waterbodies and bottomland hardwood forests. Conversely, crevice spawning fishes (flathead catfish, blacktail shiner) require structurally complex habitats to successfully spawn and probably avoid cleared lands.

Cumulative HSI values for rearing in cleared lands were also low (Figure 5). Except for smallmouth buffalo and freshwater drum, individual HSI values were less than 0.05 (Table 8). Only invasive and ubiquitous species (shad and common carp) are commonly found in cleared lands (Hoover and Killgore 1998). Absence of cover, particularly in shallow water, makes fish more vulnerable to predation and possible stranding during receding water levels. Although fish may spawn in seasonally-inundated lands, larvae probably move into the river or permanent floodplain waterbodies that provide deeper water and structural complexity. Larval fish abundance generally coincides with the presence of vegetation, shade, submerged branches or other forms of structure (Wallus et al. 1990; Hoover and Killgore, 1998). Thus, permanent floodplain waterbodies (oxbow lakes, scatters, brakes, and tributary mouths) provided the highest habitat value for rearing although they were the least abundant (Figure 4). Consequently, spawning losses were higher than rearing losses because agricultural fields and hardwood forests were more prevalent in the Backwater area.

Of the 35 flood control plans, those that included non-structural flood damage reduction (e.g., reforestation) resulted in a net gain in AAHU for spawning (Table 9) and rearing (Table 10). Highest gains were for combination plans that included conservation easements and reforestation (Plans 13, 14, 25, 26, 34, 35). There were four combination plans (Plans 10, 11, 22, 23) that did not include reforestation but resulted in a net gain in AAHU because of water level management in the sump and easements on lands below 90 ft NGVD; easements on lands below 80-85 ft NGVD resulted in a loss in AAHU. Pump size (14,000 vs 17,500 cfs) had marginal effect (2-3%) on total AAHU. However, water level management substantially increased AAHU compared to similar plans without water management. All structural plans (Plans 27 and 28) and the levee Plan (Plan 29) resulted in a net loss of AAHU for spawning and rearing. Of the two nonstructural plans (Plans 1 and 2), only Plan 2 resulted in a net gain in AAHU because it included reforestation of agricultural land below 90 ft NGVD.

PART IV. CONCLUSIONS

1. Ichthyofauna of the Yazoo Backwater, consisting of at least 57 species, is taxonomically dominated by minnows, sunfishes, and to a lesser extent, by catfishes and suckers. Numerically dominant groups of fish were gar, shad, carp, buffalo, catfish, crappie, and drum. Species richness was highest around Steele Bayou structure; lowest in Delta National Forest Lakes.

2. Fish spawned principally from March through June. Number of larval fish species was highest in the fringing floodplain connected to the outlet/inlet channel of Steele Bayou structure and in oxbow lakes contiguous with the river. Overall, permanent waterbodies on the floodplain provide higher habitat value to rearing fishes than cleared lands. Buffalo, crappie, shad, and drum were the dominant species of larvae. Species richness of larval fish is low compared to other floodplain river systems with large tracts of contiguous hardwood forests.

3. Thermal stratification is pronounced during late spring and summer, particularly in the floodplain behind Steele Bayou structure. Low dissolved oxygen, along with high water temperatures, contributes to physiological stress and may result in substantial mortality of fishes. Measures to increase hydraulic circulation (e.g., pumping) when the structure is closed during late spring and summer may increase dissolved oxygen in the sump.

4. Combination plans that include conservation easements on forested and agricultural land, reforestation of agricultural lands, and water level management in the sump have the greatest gains in AAHU.

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Table 1. Features of each Plan, Yazoo Backwater Project.

Plan	Features			
	Structural	Easement		
		Existing Woodlands	Existing Open Lands	Water Management
1	N/A	Preserve below 100.3 ft NGVD	Use retained	N/A
2	N/A	Preserve below 100.3 ft NGVD	Reforest below 90 ft NGVD	N/A
3	14,000-cfs pump[a]	Preserve below 85 ft NGVD	Use retained below 85 ft NGVD	N/A
4	14,000-cfs pump[a]	Preserve below 85 ft NGVD	Use retained below 85 ft NGVD	Below 80 ft NGVD[b]
5	14,000-cfs pump[a]	Preserve below 85 ft NGVD	Use retained below 85 ft NGVD	Below 85 ft NGVD[c]
6	14,000-cfs pump[a]	Preserve below 85 ft NGVD	Reforest below 85 ft NGVD	70-73 ft NGVD[d]
7	14,000-cfs pump[a]	Preserve below 85 ft NGVD	Reforest below 85 ft NGVD	Below 80 ft NGVD[b]
8	14,000-cfs pump[a]	Preserve below 85 ft NGVD	Reforest below 85 ft NGVD	Below 85 ft NGVD[c]
9	14,000-cfs pump[a]	Preserve below 90 ft NGVD	Use retained below 90 ft NGVD	N/A
10	14,000-cfs pump[a]	Preserve below 90 ft NGVD	Use retained below 90 ft NGVD	Below 80 ft NGVD[b]
11	14,000-cfs pump[a]	Preserve below 90 ft NGVD	Use retained below 90 ft NGVD	Below 85 ft NGVD[c]
12	14,000-cfs pump[a]	Preserve below 90 ft NGVD	Reforest below 90 ft NGVD	N/A
13	14,000-cfs pump[a]	Preserve below 90 ft NGVD	Reforest below 90 ft NGVD	Below 80 ft NGVD[b]
14	14,000-cfs pump[a]	Preserve below 90 ft NGVD	Reforest below 90 ft NGVD	Below 85 ft NGVD[c]
15	17,500-cfs pump[a]	Preserve below 85 ft NGVD	Use retained below 85 ft NGVD	N/A
16	17,500-cfs pump[a]	Preserve below 85 ft NGVD	Use retained below 85 ft NGVD	Below 80 ft NGVD[b]

Table 1. Continued.

Plan	Features			
	Structural	Easement		
		Existing Woodlands	Existing Open Lands	Water Management
17	17,500-cfs pump[a]	Preserve below 85 ft NGVD	Use retained below 85 ft NGVD	Below 85 ft NGVD[c]
18	17,500-cfs pump[a]	Preserve below 85 ft NGVD	Reforest below 85 ft NGVD	N/A
19	17,500-cfs pump[a]	Preserve below 85 ft NGVD	Reforest below 85 ft NGVD	Below 80 ft NGVD[b]
20	17,500-cfs pump[a]	Preserve below 85 ft NGVD	Reforest below 85 ft NGVD	Below 85 ft NGVD[c]
21	17,500-cfs pump[a]	Preserve below 90 ft NGVD	Use retained below 90 ft NGVD	N/A
22	17,500-cfs pump[a]	Preserve below 90 ft NGVD	Use retained below 90 ft NGVD	Below 80 ft NGVD[b]
23	17,500-cfs pump[a]	Preserve below 90 ft NGVD	Use retained below 90 ft NGVD	Below 85 ft NGVD[c]
24	17,500-cfs pump[a]	Preserve below 90 ft NGVD	Reforest below 90 ft NGVD	N/A
25	17,500-cfs pump[a]	Preserve below 90 ft NGVD	Reforest below 90 ft NGVD	Below 80 ft NGVD[b]
26	17,500-cfs pump[a]	Preserve below 90 ft NGVD	Reforest below 90 ft NGVD	Below 85 ft NGVD[c]
27	14,000-cfs pump[e]	N/A	N/A	70-73 ft NGVD[d]
28	17,500-cfs pump[e]	N/A	N/A	N/A
29	Levee	N/A	N/A	N/A
30	14,000-cfs pump	Preserve below 100.3 ft NGVD	N/A	N/A
31	14,000-cfs pump	N/A	Reforest below 87 ft NGVD and south of Highway 14	Below 75 ft NGVD[f]
32	14,000-cfs pump	N/A	Reforest below 87 ft NGVD	70-73 ft NGVD[d]
33	14,000-cfs pump	N/A	Reforest below 91 ft NGVD	70-73 ft NGVD[d]

Table 1. Concluded.

Plan	Features			
	Structural	Easement		
		Existing Woodlands	Existing Open Lands	Water Management
34	14,000-cfs pump	N/A	Reforest below 91 ft NGVD	70-73 ft NGVD, reintroduce up to 87 ft NGVD[g]
35	14,000-cfs pump	N/A	Reforest below 88.5 ft NGVD	70-73 ft NGVD, reintroduce up to 87 ft NGVD[g]

[a] Pump would be operated to provide flood damage reduction for cleared lands above the easement elevation.
[b] 1 December to 1 March.
[c] 80 ft, 1 December to 1 January and 15 February to 1 March; 85 ft, 1 January to 15 February.
[d] Operation of the drainage structure at Steele Bayou would be modified to maintain a 70 to 73-ft elevation at Steele Bayou during low-water periods.
[e] Pump would be operated to provide flood damage reduction for cleared lands above elevation 80 ft NGVD, except during 1 December to 1 March when pump would be operated at 85 ft NGVD.
[f] Year round.
[g] Operation of the drainage structure at Steele Bayou would be modified to maintain a 70 to 73-ft elevation at Steele Bayou during low-water periods and to reintroduce Mississippi River flows up to 87 ft NGVD.

Table 2. Larval, juvenile, and adult fishes of the Yazoo Backwater Project Area compared to juvenile/adult fishes of Upper Yazoo River System (Killgore and Hoover, 1993). Larval fishes were collected on the floodplain of the lower Big Sunflower River, floodplain and borrow pits adjacent to the Steele Bayou Control structure, and oxbow lakes in Delta National Forest. Adult and juvenile fishes were collected in the channel of lower Big Sunflower River, outlet channel below Steele Bayou Control Structure, and oxbow lakes in Delta National Forest. The symbol '+' indicates that the species was collected.

Common and Scientific Names	Yazoo Backwater		Upper Yazoo River
	Larval Fish	Adult and Juvenile Fish	
Family Petromyzontidae, lampreys			
Ichthyomyzon castaneus, chestnut lamprey			+
Family Polyodontidae, paddlefishes			
Polyodon spathula, paddlefish		+	+
Family Lepisosteidae, gars			
Lepisosteus oculatus, spotted gar	+	+	+
L. osseus, longnose gar		+	+
L. platostomus, shortnose gar	+	+	+
Family Amiidae, bowfins			
Amia calva, bowfin		+	+
Family Anguillidae, freshwater eels			
Anguilla rostrata, American eel		+	+
Family Clupeidae, herrings			
Dorosoma cepedianum, gizzard shad	+	+	+
D. petenense, threadfin shad	+	+	+
Family Hiodontidae, mooneyes			
Hiodon alosoides, goldeye			+
H. tergisus, mooneye			+
Family Cyprinidae, carps and minnows			
Ctenopharyngodon idella, grass carp		+	
Cyprinella camura, bluntface shiner			+
C. lutrensis, red shiner		+	+
C. venusta, blacktail shiner		+	+
Cyprinus carpio, common carp	+	+	+
Hybognathus nuchalis, silvery minnow			+
Hypophthalmichthys nobilis, bighead carp		+	
Luxilis chrysocephalus, striped shiner			+
Lythrurus umbratilis, redfin shiner			+
Macrohybopsis aestivalis, speckled chub		+	+
M. storeriana, silver chub			+
Notemigonus crysoleucas, golden shiner	+	+	+
Notropis atherinoides, emerald shiner		+	+
N. buchanani, ghost shiner		+	+
N. rafinesquei, Yazoo shiner			+
N. sabinae, Sabine shiner			+
N. shumardi, silverband shiner			+
N. volucellus, mimic shiner		+	+
Opsopoeodus emiliae, pugnose minnow		+	+
Pimephales notatus, bluntnose minnow			+
P. promelas, fathead minnow		+	
P. vigilax, bullhead minnow		+	+
Notropis sp., minnow/shiner	+		

Table 2. Continued

Common and Scientific Names	Yazoo Backwater Larval Fish	Yazoo Backwater Adult and Juvenile Fish	Upper Yazoo River
Family Catostomidae, suckers			
Carpiodes carpio, river carpsucker		+	+
Carpiodes velifer, highfin carpsucker			
Cycleptus elongatus, blue sucker		+	+
Ictiobus bubalus, smallmouth buffalo		+	+
I. cyprinellus, bigmouth buffalo		+	+
I. niger, black buffalo		+	+
Ictiobus sp., buffalo	+		
Moxostoma poecilurum, blacktail redhorse			+
Family Ictaluridae, bullhead catfishes			
Ameiurus melas, black bullhead		+	+
A. natalis, yellow bullhead		+	+
Ictalurus furcatus, blue catfish		+	+
I. punctatus, channel catfish		+	+
Noturus gyrinus, tadpole madtom		+	+
N. nocturnus, freckled madtom		+	+
Pylodictis olivaris, flathead catfish		+	+
Family Esocidae, pikes			
Esox americanus, grass pickerel		+	+
Esox niger, chain pickerel			
Family Aphredoderidae, pirate perches			
Aphredoderus sayanus, pirate perch	+	+	+
Family Cyprinodontidae, killifishes			
Fundulus chrysotus, golden topminnow		+	+
F. dispar, starhead topminnow			+
F. notatus, blackstripe topminnow		+	+
F. olivaceus, blackspotted topminnow			+
Fundulus sp., topminnow	+		
Family Poeciliidae, livebearers			
Gambusia affinis, mosquitofish		+	+
Family Atherinidae, silversides			
Labidesthes sicculus, brook silverside			+
Menidia beryllina, inland silverside		+	+
Unidentified silverside	+		
Family Percichthyidae, temperate basses			
Morone chrysops, white bass	+	+	+
M. saxatilis, striped bass			+
Family Centrarchidae, sunfishes			
Centrarchus macropterus, flier	+	+	+
Elassoma zonatum, banded pygmy sunfish	+	+	+
Lepomis cyanellus, green sunfish		+	+
L. gulosus, warmouth		+	+
L. humilis, orangespotted sunfish		+	+
L. macrochirus, bluegill		+	+
L. marginatus, dollar sunfish		+	+
L. megalotis, longear sunfish		+	+
L. microlophus, redear sunfish			+
L. punctatus, spotted sunfish		+	+
L. symmetricus, bantam sunfish		+	+
Lepomis sp., unidentified sunfish	+		
Micropterus punctulatus, spotted bass			+
M. salmoides, largemouth bass		+	+
Pomoxis annularis, white crappie	+	+	+
P. nigromaculatus, black crappie	+	+	+

Table 2. Concluded.

Common and Scientific Names	Yazoo Backwater Larval Fish	Yazoo Backwater Adult and Juvenile Fish	Upper Yazoo River
Family Percidae, perches			
Etheostoma asprigene, mud darter			+
E. caeruleum, rainbow darter			+
E. chlorosomum, bluntnose darter		+	+
E. fusiforme, swamp darter		+	
E. gracile, slough darter		+	+
E. whipplei, redfin darter			+
*Etheostoma*_ sp.			
Percina sciera, dusky darter			+
Stizostedion canadense, sauger			+
Unidentified percids	+		
Family Sciaenidae, drums			
Aplodinotus grunniens, freshwater drum	+	+	+
Total Number of Species	19	57	77

Table 3. Relative abundance of large fishes collected in the Yazoo Backwater Project Area during summer 1994. Values are percentages of total number collected by gillnets (n=3 per site) and hoopnets (n=20 only in channel below structure). Size range of fishes (total length in mm) are indicated in parentheses. The outlet channel and borrow pit connected to the channel were sampled below Steele Bayou Structure. Lakes sampled above the structure were in or adjacent to the Delta National Forest.

	Below Structure		Above Structure			
	Channel	Floodplain	Fish Lake (isolated)	Lost Lake (connected)	Plaquemine (isolated)	Plaquemine (connected)
Paddlefish						
Paddlefish (245-805)	<1.0					
Gars						
Spotted gar (373-600)			25.0	13.7		
Longnose gar (470-1000)	<1.0					
Shortnose gar (347-723)	4.4	1.8		2.0		15.4
Bowfins						
Bowfin (166-628)	<1.0	1.8	25.0	9.8		
Herrings						
Gizzard shad (130-464)	1.2	21.8		17.6	71.0	
Carps and minnows						
Bighead carp (675)		1.8				
Common carp (447-750)	1.6	14.5	16.7	5.9	14.3	
Suckers						
Smallmouth buffalo(192-581)	3.2	1.8	8.3	33.3		7.7
Bigmouth buffalo (425-626)		12.7	8.3	3.9		61.5
Black buffalo (302-645)		5.5		2.0		
Bullhead catfishes						
Black bullhead (214-320)	<1.0	1.8	8.3	2.0	14.3	
Yellow bullhead (190-339)	<1.0			3.9		
Blue catfish (190-675)	1.6					
Channel catfish (204-535)	6.4					
Flathead catfish (212-993)	41.8					
Sunfishes						
Warmouth (140-200)		7.3				
Bluegill (176)		1.8				
Spotted sunfish (185-395)	1.8			2.0		
White crappie (117-380)		20.0		2.0		
Black crappie (129-204)		3.6	8.3			
Largemouth bas (332)		1.8				
Drums						
Freshwater drum (155-575)	36.7			2.0		15.4
Total number of fish	251	55	12	51	7	13
Number of species	13	15	7	13	3	4

Table 4. Relative abundance of larval fishes collected in the Yazoo Backwater Project Area during spring and summer 1994. Values are percentages of total number collected by light traps at the designated site. Sample size is the number of light traps fished overnight.

Taxa	Big Sunflower Floodplain					Delta National Forest				Steele Bayou Control Structure			
	Agfield n=20	Fallow n=24	BLH n=28	Trib Mouth n=30	Oxbow (Lake George) n=28	Fish Lake (isol.) N=20	Lost Lake (conn.) N=20	Plaq. Lake (isol.) n=20	Plaq. Lake (conn.) N=20	Above Dam n=21	Below Dam n=20	Borrow Pit (isol.) n=20	Borrow Pit (conn.) n=10
Shortnose Gar										<1.0			
Spotted Gar										<1.0	<1.0		
Shad	17.1	30.5	23.3	32.1	1.5	<1.0	14.5		21.2	70.4	39.6	1.4	2.9
Common carp	3.8	7.1	3.9	4.5	<1.0		2.2		1.0	2.7	12.5		
Golden shiner							<1.0		1.5	<1.0	1.5		
Buffalo	72.5	5.7	16.3	34.7	77.6		<1.0		7.9	1.9	<1.0		
Topminnows						<1.0					<1.0		
Pirate perch										<1.0			<1.0
Silversides											<1.0		
White bass									<1.0	<1.0			
Flier						<1.0				<1.0	<1.0		
B.P. Sunfish						<1.0		<1.0					
Lepomis sp.	1.4	12.8	15.4	9.1	1.6	6.0	41.0	<1.0	4.9	<1.0	14.8	98.1	95.6
Black bass						<1.0	5.3	48.9	1.0		1.5		
Crappie	2.3	14.2	5.0	7.1	19.0	84.3	34.4	49.6	59.1	22.5	25.6		
Darters						7.4	<1.0			<1.0	1.0		
Drum	2.9	29.8	36.0	8.6					3.0				
Unidentified	2.9	29.8	<1.0	3.7		<1.0	1.3				1.4	<1.0	1.4
Total number of individuals	444	141	773	616	2497	517	641	137	203	670	480	1114	1951
Number of Taxa	6	6	6	6	5	8	8	4	9	12	12	2	3
Mean ∀ SE	22.2 ∀8.3	5.9 ∀1.2	27.6 ∀6.5	20.5 ∀5.4	89.2 ∀28.0	25.9 ∀8.3	32.1 ∀5.0	6.9 ∀2.2	10.2 ∀4.3	31.9 ∀9.6	24.0 ∀3.7	55.7 ∀22.9	195.1 ∀30.5

Table 5. Habitat guilds for fishes of the Yazoo Backwater Project. Guilds are determined by substrates used in reproduction (vertical axis) and characteristic water velocities used by juveniles and adults (horizontal axis). Evaluation species are underlined.

	LACUSTRINE/GENERALISTS	SLACK WATER	SWIFT WATER
OPEN	Gizzard Shad Mosquitofish	Threadfin shad Cypress minnow Silvery minnow	Bighead carp Grass carp Emerald shiner Mimic shiner Freshwater drum
SAND/GRAVEL	Red shiner Green sunfish Orangespotted sunfish Bluegill Largemouth bass White crappie Black crappie	Paddlefish Ghost shiner Pugnose minnow River carpsucker Golden topminnowr Flier Banded pygmy sunfish Longear sunfish Warmouth Bantam sunfish	Speckled chub White bass
VEGETATION	Bowfin Common carp Golden shiner	Spotted gar Shortnose gar Grass pickerel Smallmouth buffalo Bigmouth buffalo Blackstripe topminnow Blackspotted topminnow Inland silverside Bluntnose darter Swamp darter Slough darter	Longnose gar Black buffalo
CREVICES	Bullhead minnow Black bullhead Yellow bullhead Channel catfish	Blue catfish Tadpole madtom Flathead catfish Pirate perch	Blacktail shiner Freckled madtom

Table 6. HSI scores for spawning of fish evaluation species, Yazoo Backwater Project. Scores are the same as those agreed upon by consensus of the interagency HEP team on January 13, 1995.

SPECIES	FLOODPLAIN HABITATS				
	CAG	FALLOW	BLH	OXBOW	SBT
Flathead catfish	0.04	0.11	0.71	0.61	0.92
Smallmouth buffalo	0.42	0.8	0.85	0.9	0.89
Blacktail shiner	0.05	0.15	0.59	0.7	0.75
White crappie	0.25	0.64	0.74	0.96	0.93
Largemouth bass	0.19	0.51	0.86	0.98	0.97

CAG = Cultivated Agricultural Land
FALLOW = Fallow Land
BLH = Bottomland Hardwoods
OXBOW = Oxbow Lake
SBT = Scatters, Brakes, and tributary mouths

Table 7. Egg incubation time and spawning period for fish evaluation species, Yazoo Backwater Project.

Species	Maximum egg incubation, Days		Spawning period, Months	
	Range	Median	Range	Peak
Smallmouth buffalo	8-14	11	March-May	March
Largemouth bass	3-7	5	April-May	April
White crappie	1-4	2.5	March-June	April
Flathead catfish	6-9	7.5	June-July	June
Blacktail shiner	3-8	5.5	June-July	July

Table 8. HSI scores for rearing (larvae) of fish evaluation species, Yazoo Backwater Project

SPECIES	FLOODPLAIN HABITATS				
	CAG	FALLOW	BLH	OXBOW	SBT
Flathead catfish	0	0	0.25	0.5	0.75
Smallmouth buffalo	0.17	0.01	0.06	1	0.11
Blacktail shiner	0	0	0.03	0	1
White crappie	0.02	0.04	0.08	1	0.12
Largemouth bass	0	0	0.25	1	1
Freshwater drum	0.05	0.15	0.5	0	0.19

CAG = Cultivated Agricultural Land
FALLOW = Fallow Land
BLH = Bottomland Hardwoods
OXBOW = Oxbow Lake
SBT = Scatters, Brakes, and tributary mouths

Table 9. Summary of floodplain *spawning* acres and Average Annual Habitat Units (AAHU)for each Plan of the Yazoo Backwater Project. Total spawning acres are average daily acres flooded during March-June within the two-year floodplain. Spawning acres do not include that portion of the floodplain where duration of flooding is less 8 days and depth of flooding is less than 1 ft. Total AAHU, calculated using HSI cumulative for all evaluation species, are summed for all floodplain habitats. AAHU gained are the product of reforested acres and an annualized HSI (2.34) that reflects a 20 year transition from cleared to forested lands. Net change in AAHU is relative to baseline conditions and includes AAHU gained from reforestation.

Plan	Total Acres Spawning	Total AAHU	Reforested Acres	AAHU Gained	Net Change In AAHHU
Baseline	72316	200106.94	0	0.00	0.00
1	72316	200106.94	0	0.00	0.00
2	72316	200106.94	34218	80070.12	80070.12
3	54279	150956.13	0	0.00	-49150.81
4	57090	159003.26	0	0.00	-41103.68
5	57054	158906.54	0	0.00	-41200.40
6	54279	150956.13	25538	59758.92	10608.11
7	57090	159003.26	26768	62637.12	21533.44
8	57054	158906.54	26748	62590.32	21389.92
9	60926	169134.67	0	0.00	-30972.27
10	68789	190874.87	0	0.00	-9232.07
11	68792	190883.79	0	0.00	-9223.15
12	60926	169134.67	28630	66994.20	36021.93
13	68789	190874.87	32410	75839.40	66607.33
14	68792	190883.79	32410	75839.40	66616.25
15	52544	146492.47	0	0.00	-53614.47
16	55244	154275.31	0	0.00	-45831.63
17	55245	154278.78	0	0.00	-45828.16
18	52544	146492.47	24592	57545.28	3930.81
19	55244	154275.31	25746	60245.64	14414.01
20	55245	154278.78	25746	60245.64	14417.48
21	59209	164415.40	0	0.00	-35691.54
22	67990	188634.06	0	0.00	-11472.89
23	67991	188637.52	0	0.00	-11469.42
24	59209	164415.40	27874	65225.16	29533.62
25	67990	188634.06	32048	74992.32	63519.43
26	67991	188637.52	32048	74992.32	63522.90
27	48777	136363.49	0	0.00	-63743.45
28	44297	124223.02	0	0.00	-75883.92
29	62254	170026.11	0	0.00	-30080.83
30	48777	136363.49	0	0.00	-63743.45
31	55110	153614.66	25747	60247.98	13755.70
32	61318	170188.36	28840	67485.60	37567.02
33	71824	198821.27	33957	79459.38	78173.71
34	73338	202908.84	34701	81200.34	84002.24
35	67604	187448.28	31861	74554.74	61896.08

Table 10. Summary of floodplain *rearing* acres and Average Annual Habitat Units (AAHU) for each Plan of the Yazoo Backwater Project. Rearing acres are average daily acres flooded during March-June within the two-year floodplain and include that portion of the floodplain where duration of flooding is less 8 days and depth of flooding is less than 1 ft. Total AAHU, calculated using HSI cumulative for all evaluation species, are summed for all floodplain habitats. AAHU gained are the product of reforested acres and an annualized AAHU (0.69) that reflects a 20 year transition from cleared to forested lands. Net change in AAHU is relative to baseline conditions and includes AAHU gained from reforestation.

Plan	Total Acres Rearing	Total AAHU	Reforested Acres	AAHU Gained	Net Change In AAHU
Baseline	129013	140881.90	0	0.00	0.0
1	129013	140881.90	0	0.00	0.00
2	129013	140881.90	60478	41729.82	41729.82
3	99337	109310.24	0	0.00	-31571.66
4	99415	109389.51	0	0.00	-31492.39
5	99443	109417.78	0	0.00	-31464.12
6	99337	109310.24	46164	31853.16	281.50
7	99415	109389.51	46205	31881.45	389.06
8	99443	109417.78	46218	31890.42	426.30
9	110293	121174.62	0	0.00	-19707.28
10	117633	129029.75	0	0.00	-11852.15
11	117547	128915.57	0	0.00	-11966.33
12	110293	121174.62	51201	35328.69	15621.41
13	117633	129029.75	54655	37711.95	25859.80
14	117547	128915.57	54625	37691.25	25724.92
15	96163	106044.03	0	0.00	-34837.87
16	96244	106126.48	0	0.00	-34755.42
17	96247	106129.22	0	0.00	-34752.68
18	96163	106044.03	44605	30777.45	-4060.42
19	96244	106126.48	44645	30805.05	-3950.37
20	96247	106129.22	44646	30805.74	-3946.94
21	107839	118589.42	0	0.00	-22292.48
22	116645	128000.69	0	0.00	-12881.21
23	116649	128004.71	0	0.00	-12877.19
24	107839	118589.42	50006	34504.14	12211.66
25	116645	128000.69	54162	37371.78	24490.57
26	116649	128004.71	54164	37373.16	24495.97
27	88622	97969.27	0	0.00	-42912.63
28	81757	90703.88	0	0.00	-50178.02
29	118053	127132.52	0	0.00	-13749.38
30	88622	97969.27	0	0.00	-42912.63
31	108616	120105.61	50192	34632.48	13856.19
32	113940	124977.88	52979	36555.51	20651.49
33	127864	139693.06	59891	41324.79	40135.95
34	133665	146209.20	62530	43145.70	48473.00
35	125970	138202.43	58542	40393.98	37714.51

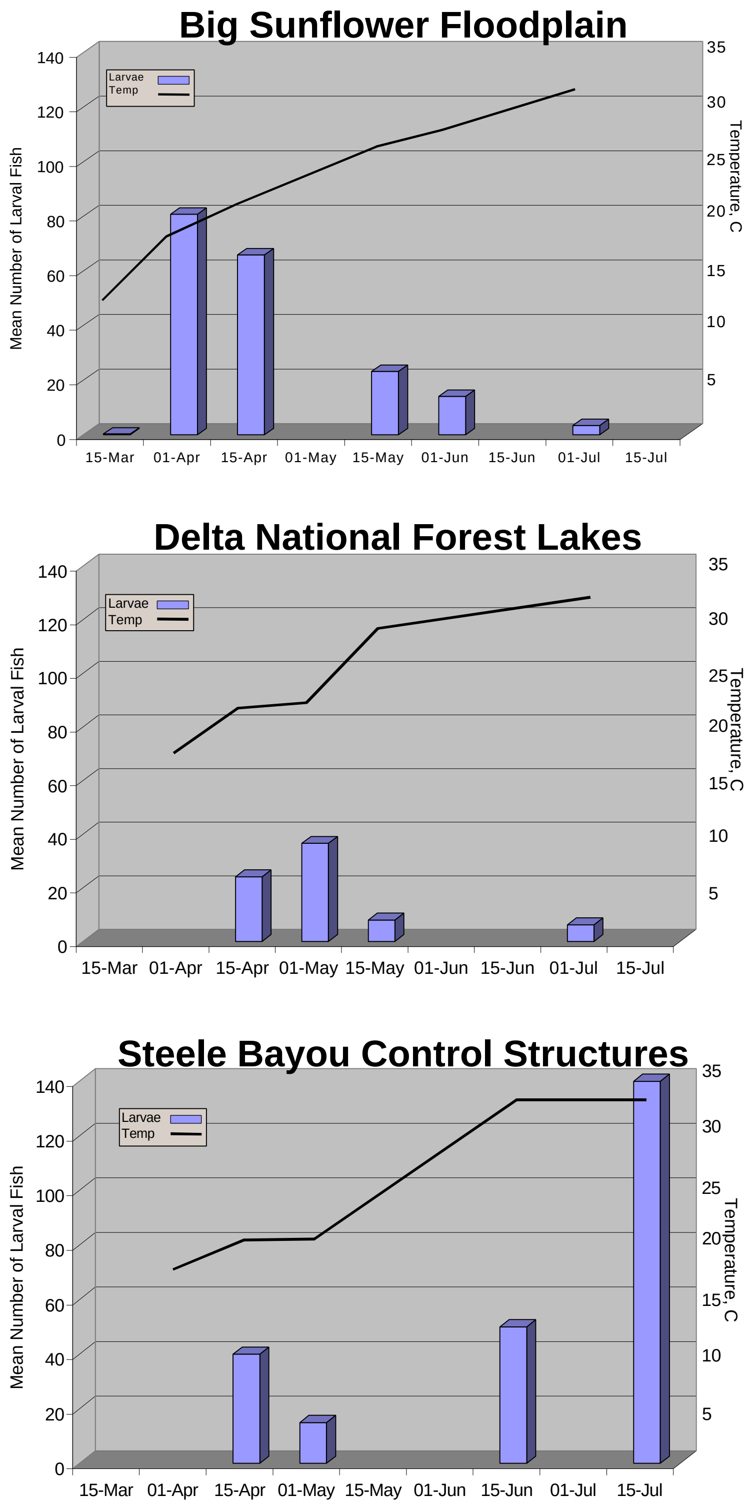

Figure 1. Mean number of larval fish collected with light traps during spring and summer 1994 at three locations in the Yazoo Backwater Area relative to water temperature and sampling date.

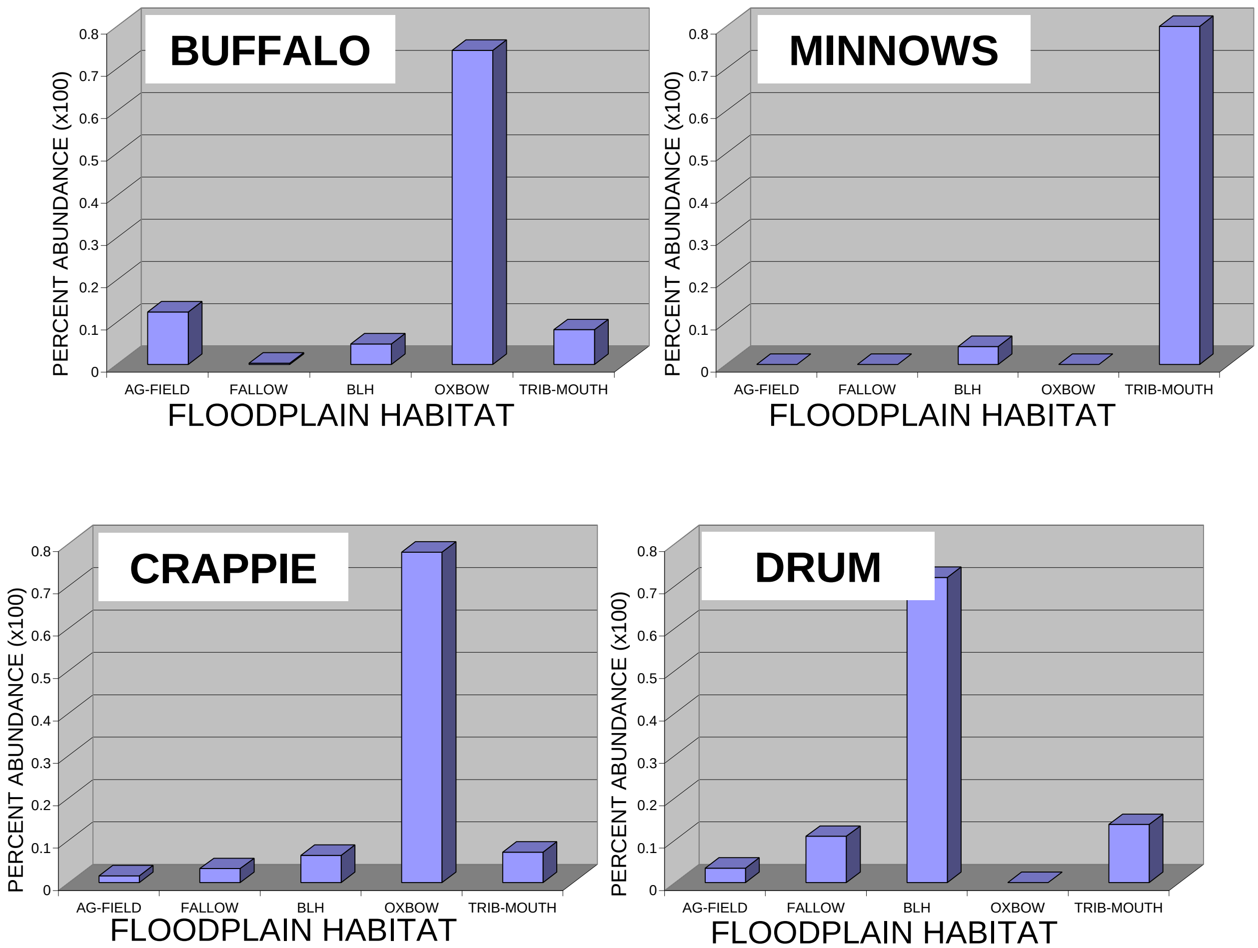

Figure 2. Percent abundance of larval fish collected in five floodplain habitats of Big Sunflower River System, March-July 1994. Sample sizes are: agricultural field (n=25), bottomland hardwood (n=33), oxbow lake (n=37), and tributary mouths (n=46).

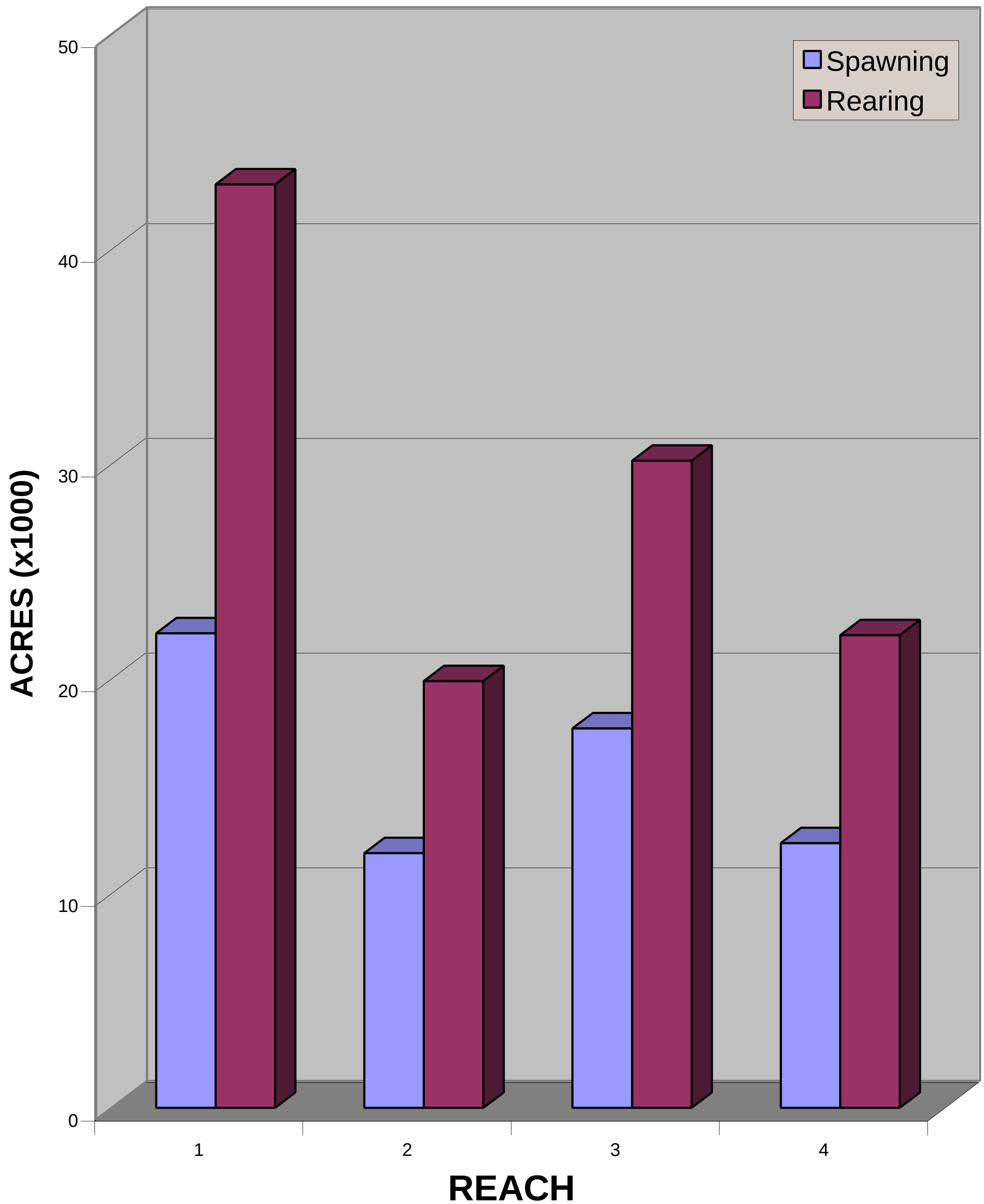

Figure 3. Number and rearing acres by reach in the Yazoo Backwater Area.

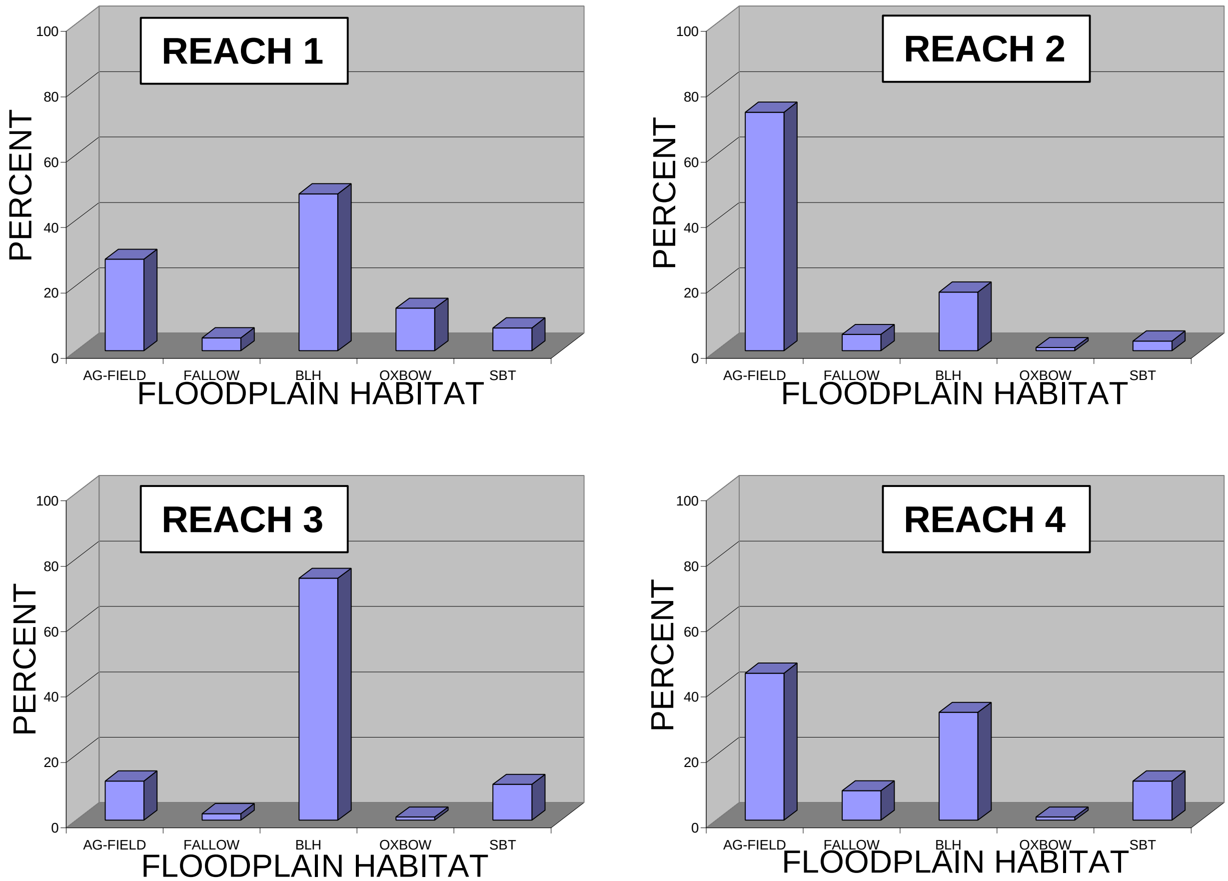

Figure 4. Relative percentage of floodplain habitats by reach in the Yazoo Backwater Area

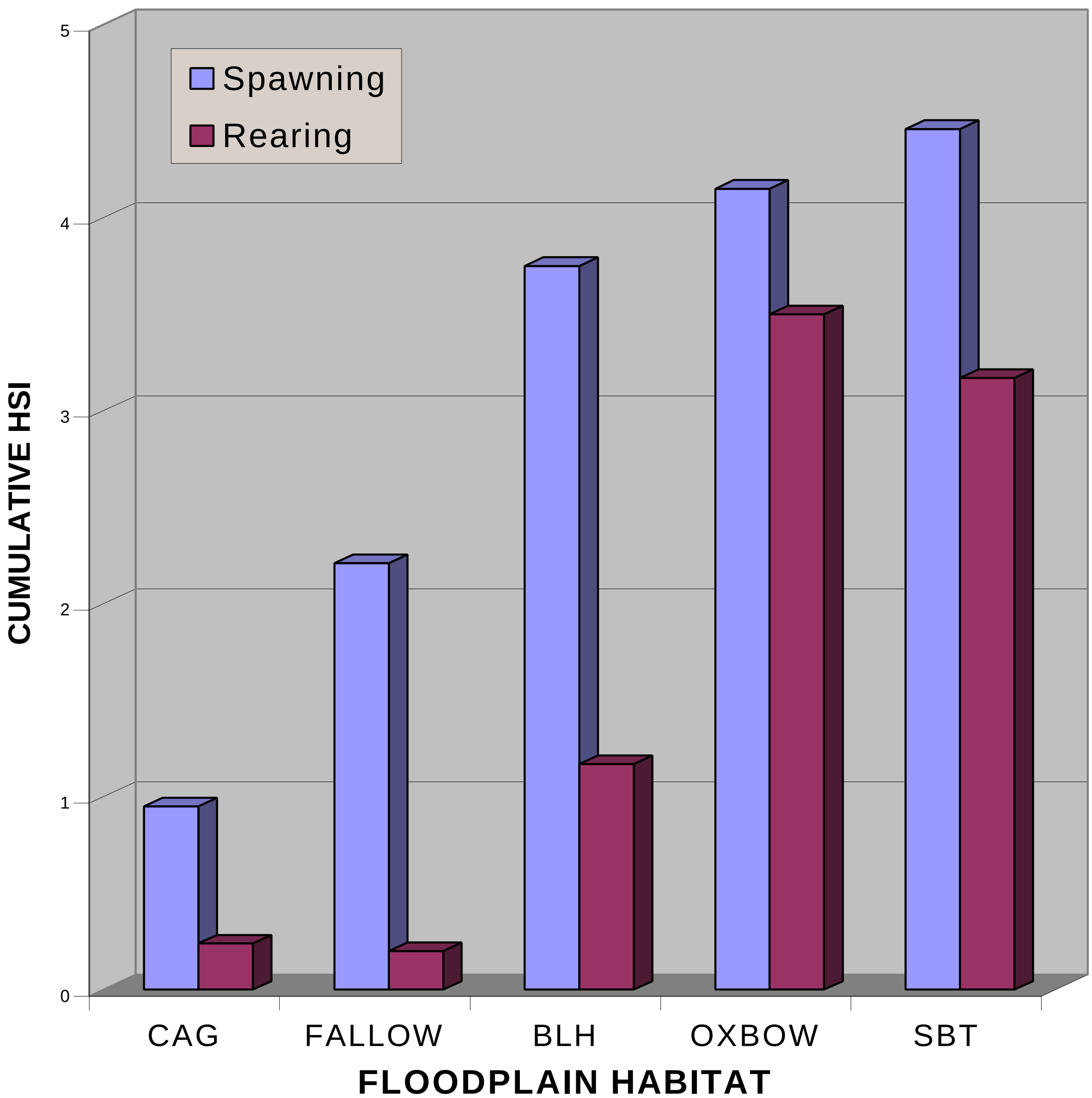

Figure 5. Cumulative HSI values for spawning and rearing, Yazoo Backwater Project