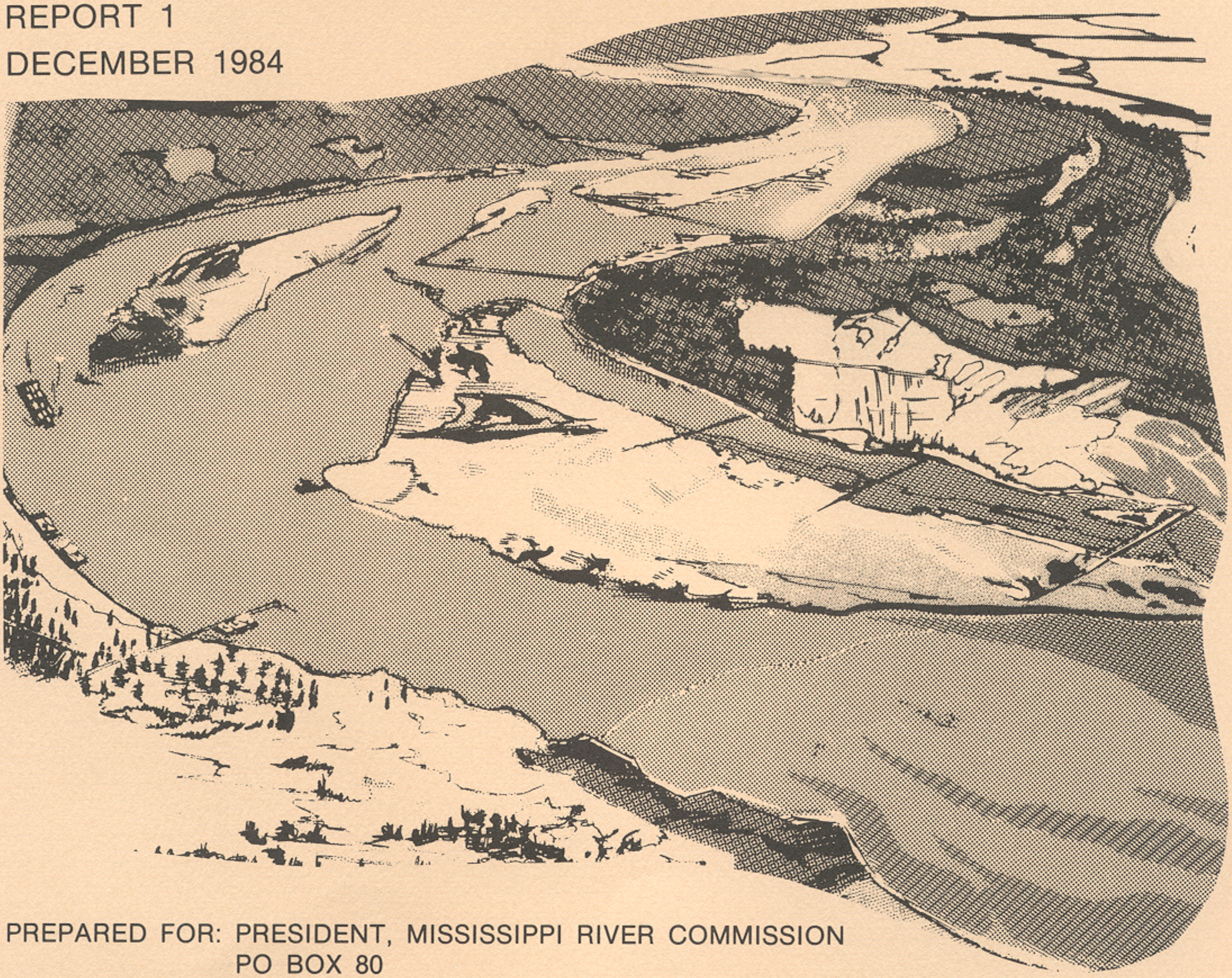
US Army Corps of Engineers
Mississippi River Commission

FISHERY AND ECOLOGICAL INVESTIGATIONS OF MAIN STEM LEVEE BORROW PITS ALONG THE LOWER MISSISSIPPI RIVER

LOWER MISSISSIPPI RIVER ENVIRONMENTAL PROGRAM

REPORT 1

DECEMBER 1984



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Twenty-five borrow pits along the main stem levee system of the Lower Mississippi River were investigated with regard to aquatic resources as part of the Lower Mississippi River Environmental Program. Objectives of the levee borrow pit investigation are to develop an inventory of environmental resources of the borrow pits and to develop environmental design criteria for borrow pits to be used during levee construction. The 25 borrow pits sampled were distributed along the Mississippi River from New Madrid, Missouri, to near Lutcher, Louisiana. (Continued)

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20. ABSTRACT (Continued).

Data on fishes, macrobenthos, water quality, and sediments were collected once in the summer of 1981; topographic surveys of each borrow pit were conducted in 1982.

Results of the investigation indicated that main stem levee borrow pits along the Lower Mississippi River support abundant and moderately diverse fish and macroinvertebrate populations. Total fish standing stock averaged 600 lb/acre; macroinvertebrate total density and standing stock averaged 2967 organisms/m^2 and 851 mg dry weight/m^2, respectively. Gizzard shad, buffalo, carp, and threadfin shad were the most abundant fishes, but significant numbers of white crappie, sunfishes, and catfishes were also present. The phantom midge, *Chaoborus punctipennis*, the midge *Tanypus stellatus*, and tubificid worms were the most abundant macroinvertebrates.

Step-wise regression analyses revealed that the duration of annual borrow pit flooding by Mississippi River waters was the single most important positive factor affecting fish and macrobenthos abundance in the borrow pits; mean borrow pit depth, Volume Development Index (a depth factor), and Shoreline Development Index were also significant factors influencing the abundance of some fish and macrobenthos species.

PREFACE

The Lower Mississippi River Environmental Program (LMREP) is being conducted by the Mississippi River Commission (MRC), US Army Corps of Engineers. It is a comprehensive program of environmental studies of the leveed floodplain of the Lower Mississippi River and the main stem Mississippi River and Tributaries Project (MR&T). Results will provide the basis for recommending environmental design considerations for the navigation and flood control features of the MR&T Project.

One component of the LMREP is the Levee Borrow Pit Investigation (LBPI). This report contains results of aquatic habitat and fishery investigations of main stem levee borrow pits, one work unit of the LBPI. Findings of detailed investigations of 25 main stem levee borrow pits carried out in 1981 and 1982 are presented, including information on fishery, benthic, hydrologic, bathymetric, sediment, and water quality studies.

This report was prepared by Mr. Stephen P. Cobb, MRC, Dr. C. H. Pennington, and Mr. John A. Baker, US Army Engineer Waterways Experiment Station (WES), and Mr. Jerry E. Scott, US Army Engineer District, Vicksburg (VXD).

Biological, sediment, and water quality data were collected by WES; topographic surveys and hydrologic studies were carried out by VXD.

The investigation was managed by the Planning Divisions of the MRC and the VXD and was sponsored by the Engineering Division, LMVD. Mr. Scott was the study manager for the borrow pit investigation; Mr. Cobb was the program manager for the LMREP. The investigation was conducted under the direction of the President of the Mississippi River Commission, MG William E. Read, CE.

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LOWER MISSISSIPPI RIVER ENVIRONMENTAL PROGRAM

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PART I: INTRODUCTION

Background

MR&T Project

1. Historically, flooding hampered settlement and development along the Lower Mississippi River and associated floodplain. For example, destructive floods occurred in 1849, 1850, 1912, 1913, 1916, 1927, 1938, and 1973. The Mississippi River Commision (MRC) was established by Congress in 1879 to carry out flood control efforts on the lower river. The devastating flood of 1927 prompted Congress to pass the Flood Control Act of 1928 authorizing the Mississippi River and Tributaries (MR&T) Project, a comprehensive plan for flood control and navigation on the main stem Lower Mississippi River and tributary streams. The MR&T project is carried out by the MRC, and consists primarily of levee systems, channel improvements and floodways.

Lower Mississippi River Environmental Program (LMREP)

2. The Mississippi River Commission is conducting the Lower Mississippi River Environmental Program (LMREP). This 7-year program is aimed at developing baseline environmental resource data on the leveed floodplain of the lower river and formulating environmental design considerations for channel improvement works (dikes, revetments and foreshore protection) and the main stem levee system, major features of the MR&T project. The LMREP was initiated in fiscal year 1981 and will be completed in fiscal year 1987. Fishery and wildlife resources and habitat are the primary focus of the LMREP. The LMREP is made up of five work units or investigations: levee borrow pit investigations, dike system investigations, revetment investigations, habitat inventories, and development of a Computerized Environmental Resources Data System (CERDS).

Levee Borrow Pit Investigation

3. Levee borrow pits. Earthen material used to construct the main stem levees is obtained from adjacent lands, usually on the riverward side of the levee structure. Depressions in the land's surface resulting from excavation of material are termed borrow pits and the soil obtained is called borrow material. Thus, a generally continuous series of borrow pits is found along the riverward toe of the main stem levee system throughout its length. Sport and commercial fishing in borrow pits is productive and these waters are commonly known as valuable fishing areas. Human use of borrow pits also includes utilization as a water supply for cattle and other livestock which are grazed along the levee rights-of-way.

4. Objectives. The Levee Borrow Pit Investigation (LBPI) of the LMREP was designed to provide data on the fishery, benthos, wildlife, physical, and chemical aspects of main stem levee borrow pits. Specific objectives of the LBPI mirror those of the overall LMREP and are:

a. To develop an inventory of fish and wildlife resources of main stem levee system borrow pits.

b. To formulate environmental design considerations for main stem levee system borrow pits.

5. Data acquisition. The LBPI was initiated with the conduct of fish and aquatic sampling by the US Army Engineer Waterways Experiment Station (WES) from June through August 1981. Topographic surveys of selected pits were conducted in 1982 by the US Army Engineer District, Vicksburg (VXD). Wildlife surveys were carried out by WES on a quarterly basis for 2 years beginning in December 1981. The LBPI is scheduled for completion in September 1985. This report presents results of the fishery and aquatic ecology investigations conducted as part of the LBPI.

6. Area investigated. The Lower Mississippi River flows from the confluence of the Ohio and Middle Mississippi Rivers at Cairo, Illinois, to the Gulf of Mexico, a distance of approximately 1000 river miles (RM). The portion of the river and floodplain containing the levee borrow pits investigated extends from Cairo, Illinois, at RM 953.8 Above Head of Passes (AHP) to the Head of Passes (RM 0 AHP) at Venice, Louisiana. The Head of Passes is the beginning of the crow-foot delta formed by branching of the main river channel into several distributaries which pass flow into the Gulf

of Mexico. Southwest Pass, the main navigation channel, traverses 20 RMs from the Head of Passes to the Gulf.

7. The Mississippi River is the fourth largest drainage basin in the world (1,245,000 square miles), exceeded in size only by watersheds of the Amazon, Congo, and Nile Rivers. The river drains 41 percent of the contiguous 48 United States and a portion of Canada.

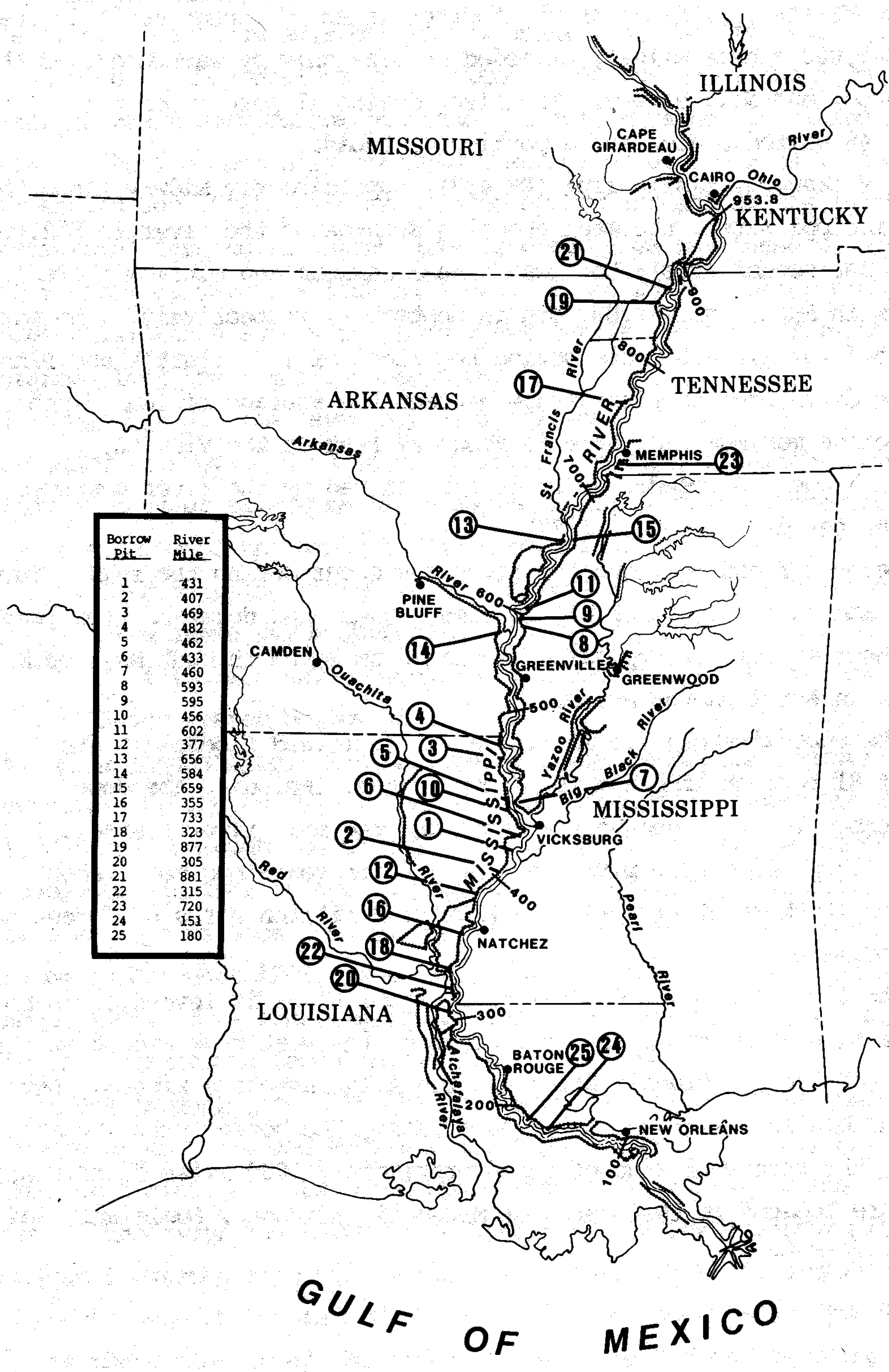
8. At Vicksburg, Mississippi (RM 437), approximately midway along the Lower Mississippi River, the mean annual discharge of the river is 552,000 cubic feet per second (cfs); the mean annual maximum and minimum flows are 948,000 cfs in April and 261,000 cfs in September, respectively. The maximum flow recorded was 2,278,000 cfs during the flood of 1927 (Tuttle and Pinner, 1982). The difference in river stage between the average minimum discharge and the average maximum discharge is about 27 feet on the Vicksburg, Mississippi, gage. Suspended sediment transported by the river averages 695,000 tons per day (Robbins, 1977).

9. Overbank flooding along the river may occur during the fall, winter, and spring and varies considerably in time, stage, and duration from year to year. Highest stages are typically reached from March through May; peak flows occur in April on the average.

10. The approximately 2.5 million acres of leveed floodplain are composed of 81 percent land and 19 percent water, including abandoned channels, oxbow lakes, levee borrow pits, and the main river channel. Floodplain lakes and borrow pits containing water year-long total about 71,000 acres (Ryckman et al., 1975). About 1.2 million acres of forest occur on the floodplain.

11. The floodplain of the Lower Mississippi River is leveed along both banks. The main stem levees are continuous on the west bank except at the confluences of the St. Francis River and the Arkansas-White Rivers. Levee segments and bluffs alternate on the east bank. The borrow pits investigated occur along the riverward side of the approximately 1600 miles of main stem levee and are located in the States of Missouri, Arkansas, Louisiana, and Mississippi (Figure 1).

Figure 1. Schematic drawing of main stem levee system along the Lower Mississippi River showing location of levee borrow pits investigated



Lower Mississippi River Main Stem Levee System

Levees

12. The floodplain of the Lower Mississippi River is provided flood protection by the main stem Mississippi River Levee System. The main stem levee system consists of 2202.1 miles of authorized levees: 1608.3 miles of main line levees along the banks of the Lower Mississippi River, 449.2 miles of Atchafalaya Basin Floodway levees, 59.2 miles of Red River South Bank levees, and 85.4 miles of Arkansas River South Bank levees. To date 2195.3 miles of the main stem Mississippi River Levee System are in place with 1561.2 miles completed to design grade and section. In addition, 484.8 miles of the required 698.0 miles of main stem levee seepage berms have been completed. The main line levees, along which the borrow pits investigated lie, are largely complete with 1601.5 miles of the authorized 1608.3 miles of levees in place and 1168.5 miles constructed to design grade and section.

13. The main line levee on the west bank of the Lower Mississippi River is comprised of three main sections. The levee starts at Cape Girardeau, Missouri, and stretches about 310 levee miles to the north bank of the St. Francis River (RM 672). It begins again at Helena, Arkansas (RM 666) and extends about 70 miles to approximately 4 miles north of the confluence of the White River in southern Arkansas (RM 605). The levee resumes on the southern side of the Arkansas River (RM 596) and extends continuously from this point to Venice, Louisiana, a distance of approximately 650 miles, the longest levee segment in the main stem system.

14. The east bank main line levee is made up of five main sections which tie into high ground or bluff lines to provide flood protection. The levee orginates at Hickman, Kentucky (RM 922), and extends approximately 32.5 miles to Kentucky Point across the river from New Madrid, Missouri (RM 892). The levee resumes at Tiptonville, Tennessee (RM 873), and extends to the north bank of the Obion River (RM 820), a distance of approximately 35 miles. At Memphis, Tennessee (RM 735), the levee begins again and stretches uninterrupted to just north of Vicksburg, Mississippi (RM 437). Commencing again at Baton Rouge, Louisiana (RM 230), the levee extends to Point a La Hache,

Louisiana (RM 44.9). The final section extends from Bayou Lamoque, Louisiana (RM 33), to Baptiste Collette Bay (RM 11.5), near the Head of Passes. This last section is not part of the MR&T Project.

15. The levee varies in elevation of the design grade and in cross-sectional area depending on local topography, soil conditions, the height reached by floodwaters, and numerous other engineering factors. Typically the levee rises 25 feet above the ground elevation north of New Orleans, Louisiana, with heights of about 10 feet south of New Orleans (Figure 2). The levee reaches a height of 40 feet in some locations. Levee side slopes vary from about 1 on 4 to 1 on 6.5. Seepage berms, embankments of earth constructed on the landward side of the levee, are used to control underseepage and add to levee stability.

Levee Borrow Pits

16. Borrow pits form a chain of water bodies along the riverward base of the 1600-mile main line levee system. In 1973, approximately 44,700 surface acres of levee borrow pits were associated with the main stem levee system (Ryckman et. al, 1974). Of these, 10,600 acres were estimated to be filled with water year-round and 34,100 acres were intermittently filled with water during the year. Only borrow pits less than 20 acres in size were included in these figures, larger pits being categorized as lakes. Thus, these acreage figures are very conservative since many borrow pits greater than 20 acres are present. Based on these acreages, however, borrow pits account for approximately 42.5 percent of the abandoned channel lakes, oxbow lakes, and other floodplain water bodies along the Lower Mississippi River and 10.1 percent of total aquatic habitat, i.e., riverine plus floodplain water bodies. In addition, the raising of over 400 miles of the existing main stem levee and construction of seepage berms is estimated to create an additional 11,400 acres of new borrow pits.

17. In a 50-mile reach of the Lower Mississippi River (RM 480-530), Cobb and Clark (1981) reported 826 acres of main stem levee borrow pits at low-flow conditions, 1165 acres at medium-flow conditions, and 4789 acres at overbank high-flow stages. Borrow pits comprised 4, 4, and 8 percent of total aquatic habitat (floodplain plus riverine water bodies) and 17, 22, and

53 percent of floodplain water bodies during these three river stages. In terms of size, then, levee borrow pits are a significant aquatic resource along the Lower Mississippi River.

18. Borrow pits are not distributed evenly along the Lower Mississippi River main line levees. They are concentrated in the central portion of river between Lake Providence, Louisiana (RM 500), and Old River, Louisiana (RM 300). This 200-mile reach contains approximately 70 percent of the existing borrow pits.

19. Borrow pits are typically subrectangular in shape, have a gently sloping bottom and shallow depths, and range in size from 1 to over 100 acres (Figures 2 and 3). Detailed topographic and morphometric studies of 25 borrow pits showed that sizes ranged from 3.3 to 53.4 acres and averaged 19.2 acres. Mean depths in the borrow pits varied from 0.54 to 7.16 feet and averaged 3.12 feet. Borrow pit volume averaged 109,040 cubic yards and ranged from 4056 to 348,228 cubic yards. Average annual days borrow pits were inundated by Mississippi River floodwaters varied from 24 to 117 days and averaged 81.3 days. A detailed discussion of borrow pit physical, morphometric, and hydrologic features is contained in Part III of this report and in Buglewicz (in press).

PART II: METHODS AND MATERIALS

Site Selection

20. A random sample of 213 Lower Mississippi River main stem levee borrow pits was taken, and surface area, distance to the river channel, location with respect to river features such as bendways, shoreline length, and shoreline development index (SDI) were computed for each pit. Pits were located along the entire length of the Lower Mississippi River. Analysis of these data (Buglewicz, in press) revealed three groups of borrow pits based on distance to river, size, shoreline length, and SDI. Using this information, 25 borrow pits (Table 1) were selected for detailed study which were generally representative of these groupings. Local conditions such as legal access to borrow pit property and the fact that a few pits were dried up at

Figure 2. Cross section of a typical Lower Mississippi River main stem levee and borrow area. The 2-foot minimum cover is a layer or cap of relatively impervious soil left in the bottom of the borrow pit to retard underseepage.

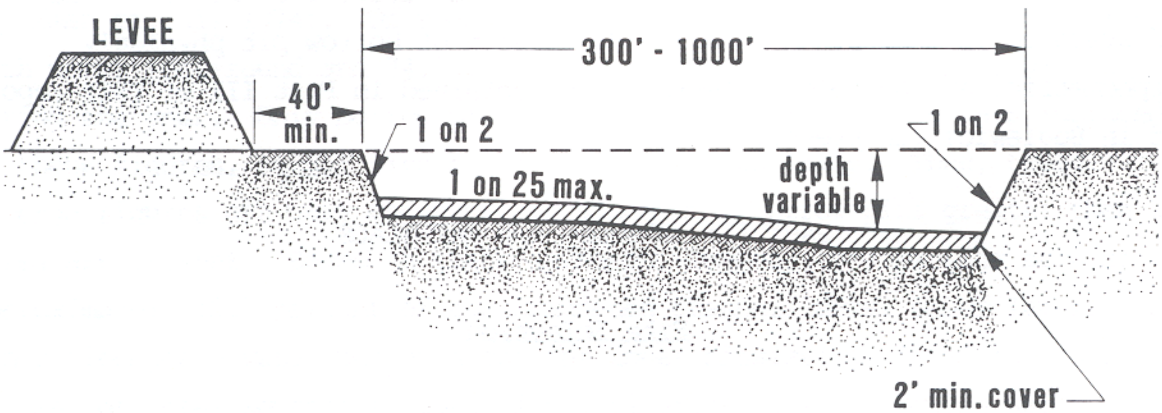


Figure 3. Photograph of a typical main stem levee borrow pit along the Lower Mississippi River. The borrow pit depicted is BP 4 located at River Mile 482, R.

the time of sampling necessitated some changes in the borrow pits selected. None the less, the 25 borrow pits chosen for this study are representative of borrow pits associated with the main stem levee system.

Methods

Field Collections

21. General. For the purpose of collecting benthic, water quality, and sediment data, two transects were established in each of the borrow pits sampled. Transects were identified alphabetically, with Transect A being located on the upstream end of the pit (relative to Mississippi River flow) and Transect B being located on the downstream end of the pit. Three stations were positioned along each transect and were identified numerically. Station 1 was positioned near the shoreline on the leveeward side of the pit, Station 2 was positioned at the center of the transect, and Station 3 was positioned near the shoreline on the riverward side of the pit. Thus, a total of six sampling stations per borrow pit and a total of 150 stations for all 25 borrow pits were sampled.

22. Morphometry and hydrology. Basic topographic and hydrologic data were developed for each of the 25 borrow pits studied. A detailed, controlled topographic survey was made of each borrow pit by a professional survey party. To develop contours, cross sections or ranges were positioned generally perpendicular to the long axis of the borrow pit and spaced at 500-foot intervals. A minimum of three ranges per borrow pit were surveyed, with additional swing topographic shots made between ranges. Ground or water bottom elevation was measured at approximately 10- to 50-foot intervals along each range. Water edge and top bank of each borrow pit were located by the stadia-azimuth method to aid in establishing contours.

23. Sediments. At each sampling station, a separate sample was collected with a petite ponar grab for grain size and organic content (ash-free dry weight) analysis, resulting in six sediment samples per borrow pit and a total of 150 samples. Samples were packed in ice and delivered to the laboratory no later than 24 hours after collection.

24. Water quality. Water quality variables were measured at surface, mid-depth, and bottom in the water column at each sampling station using a Hydrolab 6D Surveyor water quality measurement system. The water quality measurement system was calibrated prior to each sampling effort. The variables measured were temperature ($\pm$0.1°C), dissolved oxygen ($\pm$0.1 milligram/liter (mg/l)), pH ($\pm$0.1 unit), conductivity ($\pm$10.0 microumhos/centimeter (umhos/cm)), and oxidation-reduction potential (ORP) ($\pm$20 millivolts (mv)). In shallow depths (less than 1 meter (m)), only surface measurements were made. A water sample was collected from the surface at the center station of each transect, packed in ice, and returned to the laboratory for turbidity analysis. Secchi disc readings ($\pm$0.1 m) were taken at each of the sampling stations.

25. Benthic macroinvertebrates. Two 0.023-m^2 samples were collected at each station using a petite ponar grab sampler. Twelve samples per borrow pit were collected for a total of 300 samples. Samples were washed in the field using 0.5-millimeter (mm)-mesh sieve buckets and preserved in 10-percent formalin.

26. Fisheries. Two 1-acre plots per borrow pit were sampled for fishes with rotenone. Block nets 3.1 m deep and 192 m long and with 12.7-mm stretched mesh were used to delimit each plot. Typically, plots were square in configuration (64-m sides) with the block nets comprising three sides of the square and the shoreline the fourth side. However, due to the shape and dimensions of some pits sampled, the net configuration had to be changed which, in turn, altered the shoreside length. In each borrow pit, one plot was located on the leveeward side and one plot was located on the riverward side. Prior to application of rotenone, a minimum of 20 depth soundings were taken inside each plot and a mean depth calculated to determine the quantity of rotenone needed to reach the effective concentration of 1 mg/l. Rotenone was applied in each plot using standard rotenone techniques.

27. To minimize incidental fish kills, potassium permanganate was applied around the outside perimeter of the net at each plot to detoxify any rotenone that might have passed through the net. Application of potassium permanganate averaged 2 hours per plot.

28. Fish were collected for 48 hours following application of rotenone using 0.6- and 1.9-cm-square mesh dip nets. Fish from each plot were individually measured and collectively weighed by species.

29. In cases where very large numbers of a fish species were collected from a plot, a standard subsampling procedure was followed. A minimum of 100 fish were individually measured and collectively weighed; the remaining fish were counted and weighed, with a 10-percent minimum subsampled taken for individual length measurements.

30. Small fish (young of the year, minnows, etc.) were preserved in 10-percent formalin and returned to the laboratory for processing at a later date. All fish processed in the field were buried as required by collecting permits.

Laboratory Procedures

31. Water quality. A Hach turbidimeter, Model 2100 A, was used to measure turbidity levels (±1.0 NTU). The turbidimeter was calibrated prior to each measurement. Turbidity standards used in calibration were 0.61 NTU, 10.0 NTU, 100.0 NTU, and 1000.0 NTU.

32. Sediments. A US Standard sieve size analysis was performed on all sediment samples collected (Department of the Army, 1970). Estimates of organic content using the ash-free dry weight method were made on all sediment samples collected in accordance with American Public Health Association (APHA) (1980).

33. Benthic macroinvertebrates. Benthic samples were transferred to 70-percent ethanol, stained with rose bengal, and stored for a minimum of 48 hours prior to sorting. Samples were handpicked under 3X magnification, sorted by major taxonomic groupings, and placed in 70-percent ethanol. Oligochaetes were placed in a lactophenol clearing solution to aid in specific taxonomic identification. All macroinvertebrates were taken to the species level when possible.

34. For the purpose of obtaining standing stock estimates for benthic macroinvertebrates, aluminum pans were numbered, fired at 550°C for 30 minutes, allowed to cool in desiccators, and constant tare weights were obtained. All organisms from each sample were placed in pre-fired, tared containers and dried for 24 hours at 60°C. Samples were then placed in

desiccators, and allowed to cool for several hours (minimum of 3 to 4). Three consecutive constant weights (±0.1 mg) were then obtained and averaged. Biomass was averaged and expressed to the nearest 0.1 mg.

35. Fisheries subsampling. Initial total weight of fish was measured for each sample. A sample was then placed in a large container partially filled with water and stirred until fish were homogeneously distributed. Subsamples were removed from the container using a hand net to sample the vertical and horizontal distribution of the suspended fish. This process was continued until 5 percent of the total sample by weight was removed from the container. The resultant sample was placed in 70-percent ethanol. Methods for processing the 5-percent subsample were identical to those described in paragraph 29.

Data Mangement and Analysis

36. Data management. All field and laboratory data were recorded on data sheets. The data sheets were designed so that data could be keypunched directly from the sheet to minimize errors and save time in hand-transferring data.

37. Data were entered into a database management system, the Statistical Analysis System (SAS). Raw data printouts were edited, and all observed errors were corrected. SAS was used to generate various summary statistic outputs for each class of data.

38. Morphometry and hydrology. Topographic mapping was accomplished using a plotter. One-foot contour interval maps of each pit were drawn by hand at scales of 1 inch = 20 feet, 1 inch = 50 feet, and 1 inch = 1000 feet, depending on pit size. Pit volume and surface area were derived using a Hewlett-Packard 9830-A computer with a digitizer. The controlling elevation for each pit was used as the water surface elevation in calculating surface area and pit volume. The controlling elevation is the low point of the borrow pit basin rim and is the elevation below which water cannot gravity drain from the pit or, conversely, the elevation river water must reach to enter the pit. Controlling elevation was determined using topographic data from the Mississippi River Comprehensive Hydrographic Survey of 1973-1975, survey data, and field observations of local drainage patterns for each pit.

39. Topographic data were used to derive a suite of physical variables and indices for characterizing the morphometric and hydrologic features of the pits. Pit volume (V) was computed by summing the volumes of the pit basin contained within each 1-foot contour interval. The water surface area (A) was considered the area delineated by the controlling elevation contour.

40. Maximum depth (MXD) of each pit was derived from inspection of the topographic survey maps. Mean depth (MD) was calculated as follows:

$$MD = \frac{V}{A}$$

where

V = volume
A = surface area

Volume Development Index (VDI) (Welch, 1948) was computed as follows:

$$VDI = 3\,\frac{MD}{MXD}$$

41. VDI is an expression of basin or pit shape and represents the ratio of the calculated volume of the pit to the volume of a cone with basal area and height equal to the surface area and maximum depth of the pit. Thus, if VDI equals unity, the pit basin would resemble a cone. If VDI is < 1, the pit basin would be very slender while values of VDI > 1 indicate a more bowl-shaped basin. VDI is also a measure of depth uniformity in a borrow pit and may be classified as a depth variable since, after cancellation of terms, it is a ratio of mean depth to maximum depth.

42. Shoreline Length (SL) was the length of the controlling elevation contour. Shoreline Development Index (SDI) was based on the following formula, given in Welch (1948) and was used extensively in reservoir studies by Jenkins (1974):

$$SDI = \frac{SL}{3.5 \quad A}$$

where

SL = shoreline length, feet
A = surface area, square feet

43. SDI is the ratio of the actual borrow pit shoreline length to the circumference of a circle with the same area. The degree of shoreline irregularity and amount of littoral zone increase with increasing values of SDI.

44. Mean Basin Slope (MBS) in percent was computed as:

$$MBS = \frac{1/2C_0 --- C_{n-1} + 1/2C_n}{n} \cdot \frac{MD}{A}$$

where

C = length of each 1-foot contour interval
n = number of contours
MD = maximum depth
A = surface area

The larger the value of MBS, the steeper the average slope of the borrow pit basin.

45. Borrow pit flooding by Mississippi River waters was characterized by computing the average days flooded (ADF) per year for each pit. ADF was determined using Mississippi River annual hydrographs for the Cairo, Memphis, Helena, Arkansas City, Greenville, Vicksburg, Natchez, Red River Landing, Baton Rouge, and New Orleans gage readings for the period 1973 through 1981. Borrow pit flooding was assumed to occur when river stage exceeded the controlling elevation of a pit taking into account major topographic features that could influence stages in the pit vicinity. The number of days each year that river stage exceeded the controlling elevation was averaged over the 8-year period of record to obtain ADF. This method does not take into account all variations in topographic relief on the floodplain that could affect floodwater stages required to inundate individual borrow pits.

46. The period of record was started in 1973 because high flood stages and durations on the Mississippi River resulted in long-term inundation of all main stem levee borrow pits. Also, there has been a range of high- and low-water years during this period. Percent days flooded (PDF) was calculated by dividing ADF by 365 and multiplying by 100. Thus, ADF and PDF are synonomous expressions of the same variable.

47. Water quality. Only average water quality data for each borrow pit were analyzed in detail because: (a) the time of measurement and collection

of data varied among borrow pits; (b) most pits were too shallow for multiple depth measurements; (c) there was little difference between surface and bottom values within a given pit; and (d) there was little difference in water quality measurements among transects within a given pit.

48. Benthic macroinvertebrates. Eight taxa of benthic macroinvertebrates were selected for detailed statistical analysis based on their relative abundance and frequency of occurrence in the total set of 300 benthic samples. A ninth category, termed "other benthos", was established and contained all other taxa. The eight taxa are: *Chaoborus punctipennis* (Diptera), *Chironomus* sp. 2 (Diptera), *Coelotanypus* sp. (Diptera), *Glyptotendipes* sp. (Diptera), Naididae (Oligochaeta), *Tanypus stellatus* (Diptera), Tubificidae (Oligochaeta), and Nematoda. All species of Tubificidae were combined for analysis because a majority of the specimens collected were immature and could not be identified due to the lack of mature male reproductive organs.

49. The density (number/sample) of each macroinvertebrate taxon, total density, total standing stock (milligrams/sample dry weight), and number of taxa per sample were computed for each sample. The mean value for these benthic variables for each station and each borrow pit were computed using SAS.

50. One-way analysis of variance was performed on average density of the eight selected macroinvertebrate taxa, mean number of taxa, total density, and standing stock variables to assess differences among borrow pits. Both transformed and log-transformed data were used. In addition, step-wise regression procedures (Steel and Torrie, 1980) were used to explore relationships between benthic variables and borrow pit physical and hydrologic variables using the SAS regression analysis procedure. Untransformed data were used in the step-wise regression analysis.

51. Sediment. The percent silt-clay fraction (percent of sample that passed through 0.062-mm-mesh seive screen) was computed for each sediment sample. Average percent silt-clay fraction was used to characterize the sedimentary environment. Mean percent silt-clay fraction, mean ash-free dry weight, mean grain size and associated standard deviation, coefficient of variation, skewness, kurtosis, and quartiles (Steel and Torrie, 1980) were computed using SAS.

52. Fisheries. Fish were grouped into eight taxonomic catagories for data analysis and data presentation. The groupings were based primarily on phylogenetic and ecological similarity, abundance and, to some degree, convenience. For example, the Ictaluridae, largemouth bass, crappie, and sunfish groups include those species regarded as sport and game fishes by fishermen, whereas the Clupeidae includes species considered as the forage base. The eight groups are: Clupeidae, Ictaluridae, Catostomidae, largemouth bass (*Micropterus salmoides*), crappie (*Pomoxis annularis* and *P. nigromaculatus*), sunfish (the remaining Centrarchidae), Cyprinidae, and other (those species not included in the above groupings).

53. Total numbers and pounds of fish per acre were calculated for each borrow pit and for the different species or species groups in each borrow pit. One-way analysis of variance was used to test for significant differences in number, pounds per acre, and number of species between pits. A randomized complete block design was used to test for variability between sides (leveeward versus riverward side) of the pit in numbers, species, and pounds per acre.

54. Relationships among various fishery and physical and hydrologic variables were examined using step-wise regression analysis (Steel and Torrie, 1980). Weights and numbers of total fish of dominant species were regressed on physical and hydrologic borrow pit characteristics (i.e., mean basin slope, average annual days flooded, shoreline development index, mean depth, maximum depth, volume, and volume development index). Correlation analyses of fish weights and numbers for the various taxa were conducted. In addition, correlation analyses of the weight and number of each species or taxon of fish versus that of every other species were computed. The level of significance for all statistical tests was alpha = 0.05.

55. A length-frequency plot was constructed for selected species if the numbers were large enough to make the plot meaningful. For most species the lowest number considered sufficient to plot was 100. When two pits had essentially the same size distributions of a species, only one was plotted, and the identification of the similar pit was noted. The selected species included gizzard shad, bigmouth buffalo, smallmouth buffalo, channel catfish, bluegill, white crappie, black crappie, largemouth bass, and freshwater drum.

PART III: RESULTS AND DISCUSSION

Morphometry and Hydrology

General

56. The 25 borrow pits sampled were located on the riverward side of the main stem Mississippi River levee system and were distributed along both banks of the river from New Madrid, Missouri (RM 881 AHP), to the vicinity of Donaldsonville, Louisiana (RM 151 AHP) (Figure 1 and Table 1). Seventeen pits were on the right descending bank, and eight pits were on the left descending bank of the river.

57. Borrow pits ranged in size from 3.3 to 53.4 acres. Depth in the pits was generally shallow. Sixty-four percent of the pits had a mean depth less than 3 feet and a maximum depth less than 6.5 feet. Four pits had a mean depth greater than 5 feet, and five pits had a maximum depth greater than 10 feet (Table 2).

58. Shoreline Development Index (SDI) varied from 1.2 to 3.4 and indicated that pits had a regular to moderately irregular shoreline (Table 2). This is a result of the construction method used for building levees which produces borrow areas generally rectangular or oval in shape.

59. Average length of time borrow pits were inundated by overflow water from the Mississippi River differed significantly among pits and ranged from 24 to 117 days annually. The average days flooded per year for all pits was 81.3 days (Table 2). However, the borrow pits may not be inundated during low-flow years.

60. Annual hydrographs for the Mississippi River at Vicksburg, Mississippi, for the years 1979-1981 are shown in Figure 4. The two years prior to sampling (1979 and 1980) had spring peak stages and low summer stages. Spring high flows occurred from March through early June in 1979 and during April in 1980. In 1981, however, peak stages occurred later in the spring, in June. Summer and fall stages were lower in 1980 and 1981 than in 1979, a wet year. The borrow pits studied were flooded an average of 117 days

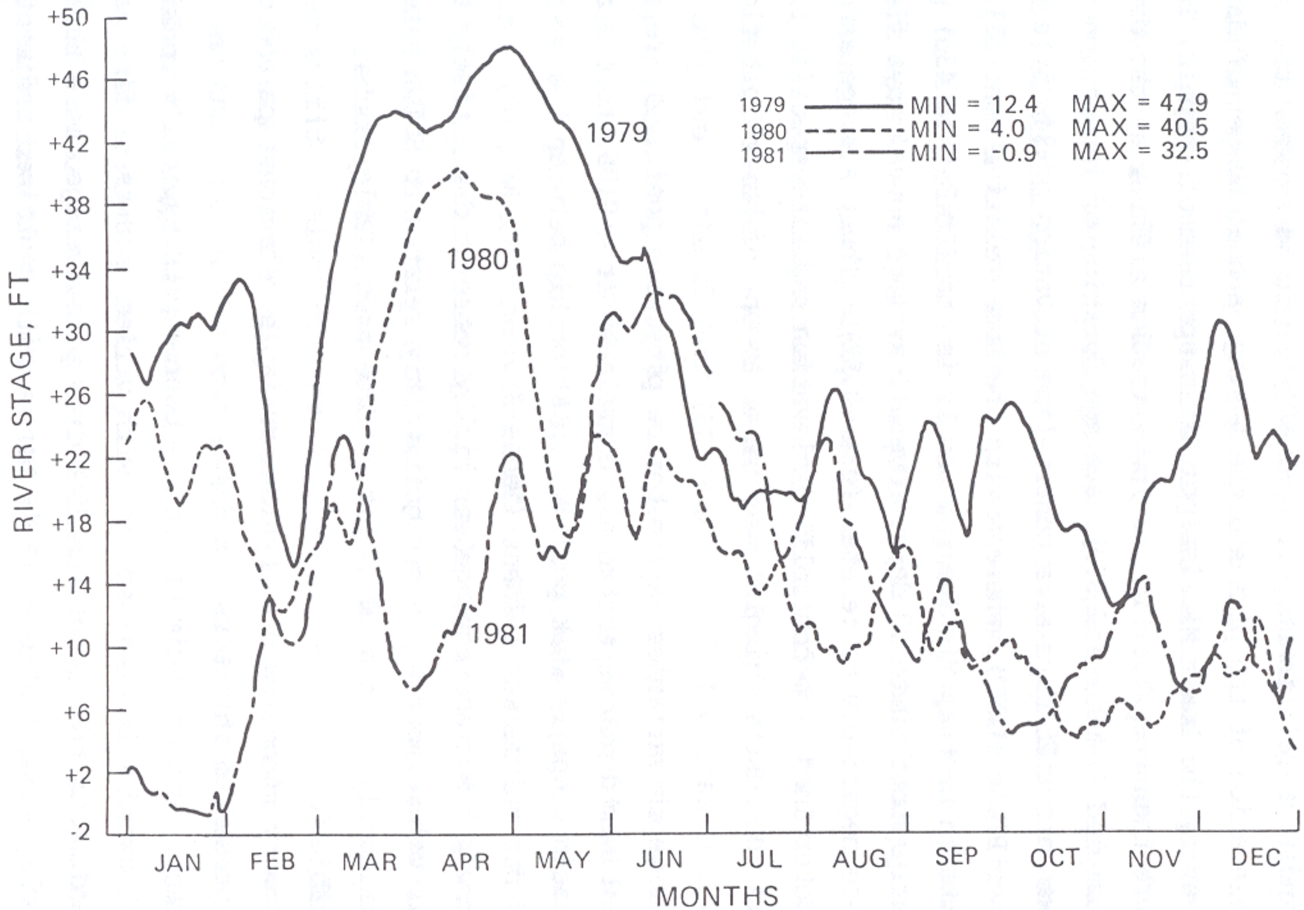


Figure 4. Annual hydrographs for the Lower Mississippi River at the Vicksburg, Mississippi, gaging station, 1979, 1980, and 1981

in 1979, a high water year on the Lower Mississippi River. Flooding was moderate in 1980 and averaged 40 days per pit. The spring of 1981, the year biological data were collected, flooding averaged only 16 days per pit, and five borrow pits were not inundated.

61. An indirect relationship (r = -0.60) was found between the controlling elevation of the pits and the average annual number of days flooded. However, the Lower Mississippi River upstream of Memphis, Tennessee, fluctuates more than the river in the lower reaches. Thus, at the Missouri borrow pits sampled (RM 881 and 877), average duration of inundation from river water was about 25 days at a controlling elevation of 34-35 feet, Lower Water Reference Plane (LWRP), whereas with the same relative controlling elevation, pits in central Mississippi and Louisiana (RM 315 to 433) were flooded annually about 60 to 90 days. Overall average annual days flooded and river mile were negatively correlated (r = -0.52). Thus, average annual days flooded, as determined from controlling elevation and site-specific river stage data, is the most meaningful measure of amount of borrow pit flooding (Table 3).

62. Water depth variables in the borrow pits were positively related. Maximum and minimum depth were strongly correlated (r = 0.85) to one another and to mean basin slope; a weak positive relationship between the depth variables and pit volume was evident (Table 3).

63. Borrow pit surface acreage was highly correlated positively to shore length and pit volume, but was not significantly related to SDI. Water depth was not significantly correlated to pit surface area (Table 3).

Physical Variables

64. A summary of borrow pit physical variable relationships and correlations is presented in Tables 2 and 3.

65. Sediment. Bottom sediments in the borrow pits typically consisted of loosely consolidated silt-clay deposits with varied amounts of fine sand (Table 4). Sediments from 16 of the 25 borrow pits averaged more than 90 percent silt-clay among stations. Five borrow pits contained sediments that averaged from 75 to 90 percent silt-clay material; sediments from four borrow pits averaged from 55 to 75 percent silt-clay. Individual stations in borrow pits (BP) 10 and 13 had silt-clay fractions of only 24.6 and 17.7 percent.

Within-pit variation in gross sediment composition was low (c.v. < 15 percent) in all but eight borrow pits. Grain size distribution was skewed toward the finer fractions. Borrow pits with a high coefficient of variation for average percent silt-clay fraction generally had a small silt-clay fraction at one or two stations. Sediments at the majority of stations in these pits consisted of predominantly silt-clay material (Table 4).

66. Organic content of borrow pit sediments was highly variable among pits on an average basis and ranged from 3.4 to 10 percent. Seventeen pits had an average sediment organic content of greater than 5 percent (Table 4).

67. Water quality. Average values of water quality variables for each borrow pit are listed in Table 5. There was no discernible trend among pits for any of the variables measured. For example, upstream versus downstream or west bank versus east bank borrow pits could not be distinguished from one another based on water quality measurements.

68. Mean water temperature ranged from 26.7°C at BP 10 to 34.8°C at BP 19. Mean dissolved oxygen ranged from 0.6 mg/l at BP 18 to 11.0 mg/l at BP 8. Only two of the 25 pits (BP 18 and BP 20) had dissolved oxygen concentrations of less than 4.0 mg/l. The mean pH ranged from a neutral value of 7.0 at BP 18 to 9.5 at BP 19. Mean conductivity ranged from 56 to 515 umhos/cm. All pits, except BP 18, had comparable mean oxidation-reduction potentials (ORP) which ranged from 195 to 389 mv. The ORP of oxygenated waters is not quantitatively interpretable (Wetzel, 1975; Gunnison and Brannon, 1981). For the purpose of this study, ORP was used solely to indicate reducing conditions and the conditions suitable for generation of hydrogen sulfide (values of less than 100 mv) (Cole, 1979). The low ORP at BP 18 (65 mv) was not surprising because the dissolved oxygen was also low (0.6 mg/l), and the sediment was covered with a noticeable black layer of what appeared to be reduced iron material.

69. Mean turbidity in the pits ranged from 8 (BP 13) to 85 (BP 5) NTU, with 20 of the 25 pits having turbidities between 10 and 50 NTU. Mean Secchi depths ranged from 10 cm in seven of the pits to 55 cm in BP 3.

Borrow Pit Descriptions

70. The following descriptions address primarily borrow pit bathymetry, flooding regimes, shoreline characteristics, and sediments since these appear to be the most important biologically. A complete presentation on the physical data of the borrow pits can be found in Buglewicz (in press).

71. Borrow Pit 21 (RM 881, R). This pit located in Missouri, was relatively small (9.2-acre) and shallow (mean depth = 1.7 feet), had a relatively convoluted shoreline, and flooded comparatively seldom, an average of 24 days per year (Table 2). Sediments averaged 67.4 percent silt-clay (Table 4). Sediments were relatively coarse (46 to 62 percent silt-clay) at four stations but were finer (97-99 percent silt-clay) at Stations A2 and A3. Coarsest sediments occurred at the two stations on the leveeward side of the pit; stations with the finest sediments on each transect occurred on the riverward side of the pit (Table 6). SDI was 2.0.

72. Borrow Pit 19 (RM 877, R). Borrow Pit 19 was a small (7.4-acre), shallow pit (mean depth = 0.54 feet; maximum depth = 1.1 feet). The shoreline was moderately convoluted (SDI = 2.0). The pit flooded 63 days per year on the average (Table 2). Sediments were > 90 percent silt-clay except at Station A3 on the riverward side of the pit, which had 67.3 percent silt-clay (Table 6). The silt-clay fraction averaged 90 percent in bottom sediments (Table 4).

73. Borrow Pit 17 (RM 773, R). Borrow Pit 17 was relatively large (38.1-acre) and moderately deep. Depth averaged 3 feet; 22 percent of the pit was ≥ 5 feet deep. The pit flooded relatively little, an average of 25 days annually. The SDI was 2.3 (Table 2). Bottom sediments averaged 92.4 percent silt-clay (Table 4); the two leveeward stations had 10-15 percent less fines than the other four stations (Table 6).

74. Borrow Pit 23 (RM 720, L). This borrow pit was of moderate size (17.7-acre) with an average depth of 2.8 feet and a maximum depth of 6.2 feet. Approximately 26.5 percent of the pit surface area was ≥ 5 feet in depth. The high degree of flooding from the river, an average of 115 days annually (Table 2), was unique among the borrow pits sampled in this reach. Sediments in the borrow pit were 97 percent or more silt-clay, except at riverward Station B3, which had 86 percent silt-clay material (Table 6).

Sediments averaged 97.0 percent silt-clay (Table 4). The extensive amount of flooding probably was related to the presence of the highly flocculent silt-clay substrate.

75. Borrow Pit 15 (RM 659, L). Borrow Pit 15 was large (53.3-acre) and averaged 3.9 feet deep with a maximum depth of 7.5 feet. Approximately 44.6 percent of the pit was 5 feet or more in depth. The SDI was relatively low (1.6). The riverward side of the pit had a very irregular shoreline; the leveeward side had a straight bank. The pit was divided by a chain of islands lying parallel to the levee. The pit flooded an average of 56 days annually (Table 2). Bottom sediments were 83 to 91 percent silt-clay at the upstream transect, whereas coarser sediments were present at the downstream Transect B (58 to 74 percent silt-clay) (Table 6). The average percent silt-clay was 72.9 (Table 4).

76. Borrow Pit 13 (RM 656, R). Borrow Pit 13 was a large pit, 53.4-acres in surface area, with relatively deep water in the south end. While average depth was 3.9 feet, maximum depth was 16.9 feet; 30.9 percent of the pit was 5 feet or deeper and 8.3 percent was $\geq$ 10 feet. The pit was elbow-shaped and lay in a sharp bend in the levee. A dirt road bisected the pit laterally into subequal sections. A ditch ran longitudinally down the center of the pit and connected the two halves through a culvert in the dirt road. Small islands were scattered throughout the pit. The shoreline was very irregular on the leveeward side (SDI = 2.6). Flooding by river water averaged 56 days per year (Table 2). Sediments were heterogeneous and averaged 54.6 percent silt-clay. Leveeward stations had relatively fine material (78 and 82 percent silt-clay), whereas riverward stations had a coarser substratum (42 percent silt-clay) (Table 6).

77. Borrow Pit 11 (RM 609, L). No site-specific physical or hydrologic data were collected from this pit. Sediments were uniform, ranging in silt-clay fraction from 98.7 to 99.9 percent (Table 6).

78. Borrow Pit 9 (RM 595, L). This borrow pit was small (3.3-acre) and shallow (mean depth = 1.7 feet; maximum depth = 3.5 feet); 1.6 percent of the surface acreage was 5 feet deep or more. The borrow pit was generally oval in shape and the SDI was small (1.4) (Table 2) although the bank line on the western and northern sides was irregular. Flooding occurred in the pit an

average of 84 days annually (Table 2). Sediments were uniformly unconsolidated silt-clay and ranged among stations from 93 to 99 percent silt-clay material (Table 6).

79. Borrow Pit 8 (RM 593, L). Borrow Pit 8 was of moderate size (16.2-acre), shallow (mean depth = 2.2 feet), and flooded an average of 98 days each year. The shoreline was relatively straight on the leveeward side, but more sinuous on the riverward side; the SDI was 2.0 (Table 2). The pit was divided into three portions by haul roads with gaps near the middle of the pit making the three sections confluent. Bottom sediments were heterogeneous; silt-clay sediments occurred at Stations A1, A2, B2, and B3, while relatively coarse sediments were present at Stations A3 and B1 (Table 6). The silt-clay fraction averaged 81.7 percent.

80. Borrow Pit 14 (RM 584, R). Borrow Pit 14 was a small pit located at a landward bend in the levee, adjacent to a large (47.6-acre), long narrow pit. The adjacent pit flooded an average of 89 days annually, and it was assumed that BP 14 flooded similarly. Sediments consisted of 91 to 99 percent silt-clay at the middle and riverward stations, but were much coarser at the two landside stations (29 to 69 percent silt-clay) (Tables 2 and 6). The average percent silt-clay fraction was 80.5 (Table 4).

81. Borrow Pit 4 (RM 482, R). Borrow Pit 4 was a large (32.1-acre), shallow pit (mean depth = 2 feet), subrectangular in shape. Seventeen percent of the pit was $\geq$ 5 feet deep. The pit flooded annually an average of 84 days. The shoreline was long but relatively straight (SDI = 2.3), except at the upstream end which was somewhat tortuous (Table 2). Bottom sediments averaged 96.5 percent silt-clay (Table 4) and ranged among stations from 88.3 to 99.5 silt-clay (Table 6).

82. Borrow Pit 3 (RM 469, R). This was a new pit, which had been excavated about 2 years prior to sampling. Borrow Pit 3 was large (39.6-acre) and generally shallow (average depth = 2.6 feet), with a small portion of deep water (maximum depth = 8.2 feet). Approximately 5.4 percent of the pit was $\geq$ 5 feet deep. The pit had a generally regular shoreline (SDI = 1.2). Flooding averaged 84 days per year (Table 2). Bottom sediments ranged from 72 to 96 percent silt-clay at all stations (Table 6) and averaged 87.6 percent silt-clay (Table 4).

83. Borrow Pit 5 (RM 462, R). Borrow Pit 5 was rectangular with a cove projecting from the downstream corner on the riverward side. The borrow pit was 12.7 acres in size and shallow (mean depth = 1.5 feet). Flooding occurred an average of 84 days annually. The SDI was low (1.5) due to the rectangular shape (Table 2). Two small islands were present. Sediments were greater than 99.5 percent silt-clay (Table 6) at all stations and averaged 99.6 percent silt-clay (Table 4).

84. Borrow Pit 7 (RM 460, L). Rectangular in shape, this borrow pit was relatively small (5.2-acre) and shallow (mean depth = 2.6 feet, maximum depth = 4.5 feet). The shoreline was generally straight on the leveeward side and somewhat more irregular on the riverward side, resulting in a SDI of 1.6. Flooding averaged 111 days annually (Table 2). Bottom sediments were > 95.8 percent silt-clay (Table 6) and averaged 98.5 percent silt-clay. One small island was present.

85. Borrow Pit 10 (RM 456, R). This was a relatively small borrow pit (9.1-acre) that was shallow in part (mean depth = 2.8 feet); about half of the pit was ≥ 5 feet in depth. The pit was rectangularly shaped with a regular shoreline (SDI = 1.6). It flooded an average of 104 days annually (Table 2). Sediments were relatively coarse at the riverward stations (32.3 and 24.6 percent silt-clay), but were finer at Stations A1 and A2 (> 86.0 percent fines) and Stations B1 and B2 (> 73.0 percent silt-clay) (Table 6). The average percent silt-clay fraction was 67.2 (Table 4).

86. Borrow Pit 6 (RM 433, R). Borrow Pit 6 was a small (4.5-acre), subrectangular pit that was comparatively deep (mean depth = 3.8 feet); 56 percent of the pit was ≥ 5 feet in depth. The shoreline was generally regular, resulting in a low SDI of 1.5. The pit flooded an average of 89 days annually (Table 2). Sediments were 93 to 99 percent silt-clay at 5 stations and 80 percent at the remaining station (Table 6). The silt-clay fraction averaged 94.4 percent (Table 4).

87. Borrow Pit 1 (RM 431, R). Borrow Pit 1 was of moderate size (13.9-acre) and deep (mean depth = 6.5 feet); 72 percent of the area was ≥ 5 feet deep. The pit was rectangular in shape (SDI = 1.6) and flooded 84 days

annually on the average. It was the last in a chain of similar pits separated only by old haul roads and interconnected by culverts. Mean basin slope was high (0.06) indicating steep sloping sides (Table 2). Sediments were uniform (> 95 percent silt-clay fraction) throughout the pit (Table 6) and averaged 97.8 percent silt-clay .

88. Borrow Pit 2 (RM 407, R). This borrow pit was moderately large (18.6-acre) with deep water along the riverward side (mean depth = 5.7 feet); 71.2 percent of the pit was 5 feet or deeper and 21.4 percent was 10 feet or more in depth. The pit had the general shape of an elongate rectangle. The shoreline was sinuous on the leveeward side and straight on the riverward side, resulting in a low SDI of 1.5. Flooding occurred an average of 71 days annually (Table 2). Sediments were uniformly silt-clay and had a 94 percent or greater silt-clay fraction (Table 6); the silt-clay fraction averaged 96.9 percent (Table 4).

89. Borrow Pit 12 (RM 377, R). This was a borrow pit of moderate size (9.3-acre) and was relatively shallow (mean depth = 2.1 feet); no water deeper than 4.0 feet was present. The pit had a generally straight bank line on three sides; the riverward side, however, was irregular and had a cove that extended toward the river. The SDI was 1.5. The pit was shallowest on the leveeward side and deepest riverward. Flooding occurred an average of 84 days yearly (Table 2). Sediments at riverward stations were relatively coarse (58 and 77 percent silt-clay), while other stations had sediments composed of 90 percent or more silt-clay (Table 6). The silt-clay fraction averaged 85.8 percent (Table 4).

90. Borrow Pit 16 (RM 355, R). This was an L-shaped borrow pit, the juncture of the two wings being a haul road through which passed a culvert interconnecting the two sections. One section was rectangular and lay parallel to the levee; the second section was oval and had the main axis oriented perpendicular to the levee. The pit was 7.4 acres in surface area and shallow (mean depth = 1.4 feet; maximum depth = 3.0 feet). The shoreline was straight on the side toward the levee and irregular on the riverward side. This configuration resulted in a SDI value of 1.8. Flooding occurred 84 days annually on the average (Table 2). Sediments were silt-clays (percent silt-clay > 95 percent) at the middle and riverward stations but were slightly coarser

(percent fines = 83 to 86 percent) at the leveeward stations (Table 6). The average percent silt-clay fraction was 75.1 percent (Table 4).

91. Borrow Pit 18 (RM 323, R). No detailed physical data are available for this borrow pit. The pit was relatively small (approximately 2.5 acres) and had an irregular shoreline. Sediments were 97 percent or more silt-clay (Table 6) and averaged 98.8 percent silt-clay (Table 4).

92. Borrow Pit 22 (RM 315, R). Borrow Pit 22 was located just upstream of the Old River Control Structure. The pit was small (6.7 acres) and relatively deep (mean depth = 7.2 feet); 65 percent of the pit was 5 feet or deeper and 33 percent was 10 feet or deeper. The side toward the levee had a very convoluted shoreline, while the riverward bank was generally straight. This configuration resulted in a comparatively large SDI of 2.6. The pit was narrow, with deeper water in the center and steep banks; two fingerlike projections protruded on the side toward the levee. One small island occurred on the north end (Table 2). Sediments ranged from 89 to 99 percent silt-clay among stations (Table 6) and averaged 95.3 percent silt-clay (Table 4).

93. Borrow Pit 20 (RM 305, R). This small borrow pit (6.8 acres) was moderately deep (mean depth = 4.6 feet) with 65 percent of the basin 5 feet or more in depth. The pit had a gently sloping bottom on the side toward the levee and had a steep bank riverward where the deepest water was found. Generally rectangular in shape, the pit had straight shorelines and a corresponding SDI of 1.3. The pit flooded 99 days annually on the average (Table 2). Sediments ranged from 90.3 to 99.2 percent silt-clay fraction (Table 6) and averaged 95.9 percent silt-clay (Table 4).

94. Borrow Pit 25 (RM 180, L). Borrow Pit 25 was large, narrow, and rectangular with a surface area of 36.9 acres. The borrow pit was deep (mean depth = 5.6 feet); 66.9 percent was 5 feet or deeper and 7.6 percent was 10 feet or deeper. Shorelines were regular and straight, but the elongated shape of the rectangular pit resulted in a high SDI of 3.4. The pit had generally steep-sloped banks. Flooding averaged 81 days annually (Table 2). Sediments consisted of 92.4 percent or more silt-clay fraction (Table 6) and averaged 97 percent silt-clay (Table 4).

95. Borrow Pit 24 (RM 151, L). Borrow Pit 24 was large (22.1 acres). It had an elongate, rectangular, moderately deep basin with an average depth of 4.3 feet; 60.6 percent of the pit was 5 feet or deeper. Flooding by river water averaged 117 days annually. Although the shoreline was straight on the riverward side, the SDI was large (3.1) due to the elongate, narrow configuration of the pit (Table 2). Sediments were 98.5 percent or greater silt-clay (Table 6); the silt-clay fraction averaged 99.1 percent (Table 4).

Benthic Macroinvertebrates

General

96. A total of 300 benthic macroinvertebrate samples were collected from the 25 Mississippi River main stem levee borrow pits. Ninety-five distinct taxa of macroinvertebrates were identified among the 20,688 individual organisms collected (Table 7). Terrestrial invertebrates were not included in the analysis. Individuals of the phantom midge *Chaoborus punctipennis*, the midge family (Chironomidae), and tubificid worms dominated borrow pit macrobenthos on a numerical basis averaging 28, 34, and 21 percent of total macrobenthos numbers across all 25 pits. Standing stock of benthic macroinvertebrates averaged 19.8 mg/sample or 851 mg/m^2 dry weight. Mean macroinvertebrate density among borrow pits was 69.0 organisms per sample or 2967 organisms/m^2.

97. Across all 25 borrow pits, larvae and pupa of the phantom midge *Charoborus punctipennis*, larvae of the midge *Tanypus stellatus*, and tubificid worms were the numerically dominant benthic macroinvertebrate taxa. The midges *Glyptotendipes* sp., *Coelotanypus* sp., and *Chironomus* sp. 2; naidid oligochaetes; corixids; and Nematoda were also relatively abundant in some pits (Tables 6 and 8).

Borrow Pit Assemblages

98. Borrow Pit 21 (RM 881, R). Twenty-six taxa of macroinvertebrates were collected. Tubificids (12 species) collectively comprised 27.9 percent of total density. Average total density (33.3 organisms/sample) was relatively low compared to other pits, as was total standing stock (7.9 mg/sample) (Table 8). Interestingly, BP 21 flooded the least of any pit sampled (24 days annually) (Table 2).

99. Branchiura sowerbyi and immatures were the most abundant taxa. Chaoborus punctipennis comprised 15.6 percent of total numbers; Tanypus stellatus and naidid worms were the other most abundant species (Figure 5, Table 8). Dero digitata was the most common species of naidid. Twenty-two percent of macroinvertebrate numbers consisted of several species not found in large numbers: Sphaerium transversum, Gammarus sp., Hyalella azteca, Coelotanypus sp., Bezzia sp., Cryptochironomus sp., Glyptotendipes sp., Larsia sp., Polypedilum convictum, and miscellaneous unindentified Coleoptera and leeches (Table 7).

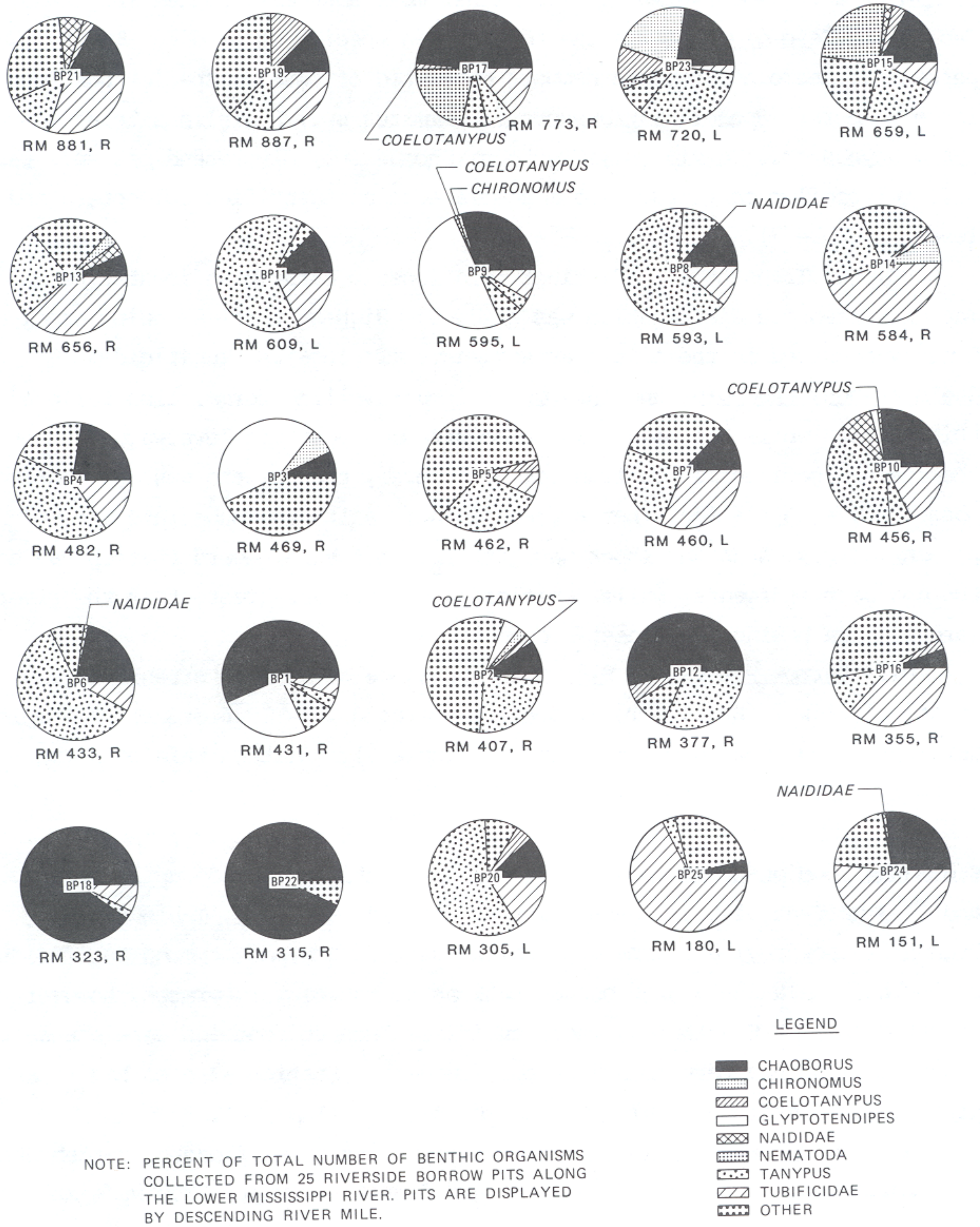
100. On Transect A, a distinct relationship between sediment type and macroinvertebrate distribution was evident. Highest total standing stock and density occurred in the silt-clay sediments (Table 6). Tubificids, Coelotanypus, Chaoborus and Tanypus, all mud-dwelling forms, also followed this pattern while the naidid worms occurred only at the leveeward station in the coarser sediments. On Transect B, however, the pattern was not distinct, possibly due to the fact that a predominantly silt-clay substrate was present. Total standing stock was greatest at the leveeward station having the coarsest sediments, while tubificid abundance was greatest at the riverward station having the finest sediments.

101. Borrow Pit 19 (RM 877, R). Abundance of macroinvertebrates was relatively low in BP 19. Total density averaged only 10.6 organisms/sample; total standing stock was 7.6 mg/sample (Table 8). Sixteen taxa of macroinvertebrates were collected (Table 7).

102. Tubificidae comprised 23.6 percent of total density; Tanypus stellatus, Coelotanypus sp., and Chaoborus punctipennis made up 14.0, 16.0, and 11.3 percent of total density, respectively (Figure 5, Table 8). Branchiura sowerbyi and immature tubificids were the most common tubificids collected. Relatively high concentrations of macroinvertebrates, however, occurred only at Station A3, where tubificids and chironomids were abundant. Other stations had very sparse benthic numbers. Station A3 also had relatively coarse sediments (67.3 percent silt-clay) (Table 6).

103. Borrow Pit 17 (RM 773, R). Twenty-five taxa of macroinvertebrates were collected. Total standing stock and density averaged 27.9 mg/sample and 58.2 organisms/sample (Table 8).

Figure 5. Relative abundance of major benthic macroinvertebrate groups from 25 Lower Mississippi River main stem levee borrow pits



NOTE: PERCENT OF TOTAL NUMBER OF BENTHIC ORGANISMS COLLECTED FROM 25 RIVERSIDE BORROW PITS ALONG THE LOWER MISSISSIPPI RIVER. PITS ARE DISPLAYED BY DESCENDING RIVER MILE.

104. Chaoborus punctipennis was the numerical dominant (46.7 percent of total density), averaging 27.2 organisms/sample (Figure 5, Table 8). Nematodes (21.0 percent) and tubificids (15.1 percent) were numerical subdominants. Branchiura sowerbyi, Limnodrilus maumeensis, and L. hoffmeisteri were the species of Tubificidae found. Seven species of chironomids were collected: Chironomus sp. 2, Coelotanypus sp., Glyptotendipes sp., Labrundinia sp., Procladius sp., Tanypus stellatus, and Tanytarsus sp. The naidid species Dero digitata, D. flabelliger, and Haemonais waldvogeli were also collected (Table 7).

105. C. punctipennis density was greatest on silt-clay sediments that occurred at the middle and riverward stations on both transects; this same pattern also held for tubificids and T. stellatus. Nematodes were only abundant at Station B1 (Table 6).

106. Total standing stock was similar at Stations A2 and A3 but was highest on Transect A at leveeward Station A1. The reverse trend was evident on Transect B where the riverward station had the greatest biomass (Table 6). The high standing stock at Station A1 was due to the presence of large but relatively uncommon macroinvertebrates in the samples, e.g., corixids, and leeches, rather than an abundance of Diptera, Tubificidae, and Nematoda.

107. Borrow Pit 23 (RM 720, L). Sixteen taxa of macroinvertebrates were obtained from the pit. Average total density (159.9 organisms/sample) and average standing stock (63.3 mg/sample) were the highest recorded from the 25 borrow pits sampled (Table 8).

108. Three dipteran larvae, Tanypus stellatus, Chaoborus punctipennis, and Chironomus sp. 2, were numerical co-dominants and comprised 33.1, 22.3, and 21.8 percent of total density, respectively (Figure 5, Table 8). Coelotanypus sp. was also relatively abundant at Stations A1 and B3 (Table 6). Three other species of chironomids were collected in small numbers: Einfeldia sp., Polypedilum illinoiense, and Procladius sp. The biting midge Bezzia sp. was also found (Table 7). The tubificid and nematode worms were sparse in BP 23, a somewhat atypical situation. Spatial distribution in the relatively homogeneous sediments was patchy for co-dominant species. High concentrations typically occurred at one or two stations for each species with much smaller numbers at other stations; Chironomus sp. 2 was very abundant at

Station B3. C. punctipennis density was highest at stations in the middle of the pit while T. stellatus distribution was irregular (Table 6). Total standing stock was an order of magnitude greater at Station B3 than at other stations due to the occurrence of a very large number (191 organisms per sample) of the comparatively large-bodied Chironomus sp. 2.

109. Borrow Pit 15 (RM 659, L). Twenty-three taxa of macroinvertebrates were collected. Average total standing stock was 6.4 mg/sample, among the lowest of any borrow pit sampled. Average total density was moderately large, 54.5 organisms/sample (Table 8).

110. Tanypus stellatus, Chaoborus punctipennis, and Chironomus Sp. 2 co-dominated the macroinvertebrate assemblage and comprised 33.0, 22.3, and 21.8 percent of total density, respectively (Figure 5, Table 8). Nematodes were abundant only at Station B1. C. punctipennis and T. stellatus were most abundant at Stations A2 and B3; these stations had sediments with the highest silt-clay content. Total standing stock was greatest at Stations A2, B1, B2, and B3. Station A1 had very low numbers and total standing stock. The presence of a large number of nematodes at Station B1 accounted for the relatively high standing stock at this station; relatively large quantities of C. punctipennis and T. stellatus resulted in the comparatively large total standing stock at Stations A2 and B3. Diptera distribution appeared positively related to the silt-clay content of sediments on individual transects (Table 6).

111. Borrow Pit 13 (RM 656, R). A total of 16 macroinvertebrate taxa were collected. Average total density and standing stock were relatively low, 33.2 organisms/sample and 7.6 mg/sample, respectively (Table 8).

112. Tubificidae and Tanypus stellatus were numerical dominants in BP 13 (Figure 5, Table 8). Chaoborus punctipennis, Chironomus sp. 2, Polypedilum illionese, and Procladius sp. were present in small numbers. The naidids Dero digitata, Dero sp. 1, and Haemonais waldvogeli also occurred. Branchiura sowerbyi, Limnodrilus maumeensis, and immatures were the tubificids collected (Table 7).

113. Spatial distribution of Tanypus stellatus had a positive relationship to percent silt-clay composition of bottom on Transect B, but was

uniformly distributed among stations on Transect A. Tubificid concentrations were greatest at Stations A2 and B3 which had comparatively coarse sediments (18 and 42 percent silt-clay), an uncharacteristic sediment type for high numbers of tubificids. Also, total standing stock was inversely related to percent silt-clay fraction in the sediments (Table 6).

114. Borrow Pit 11 (RM 609, L). Macrobenthos was dominated by the midge *Tanypus stellatus* which comprised 62.4 percent of total density (Figure 5, Table 8). Tubificids (18.7 percent) and *Chaoborus punctipennis* (12.5 percent) were also present. *Chironomus* sp. 2, *Cryptochironomus* sp., *Bezzia* sp., *Coelotanypus* sp., and *Procladius* sp. were the other Diptera found. Immatures comprised all but a few specimens of Tubificidae.

115. Eleven taxa of macroinvertebrates were collected; the average number of species per sample was 4.7 (Table 8). Average total density and standing stock were relatively low, 57.8 organisms/sample and 8.6 mg/sample, respectively (Table 8).

116. *T. stellatus* had much greater densities at the leveeward stations on each transect with lower concentrations on both transects at the middle and riverward stations. Tubificid numbers were largest at both bank stations on Transect B, but were largest only at leveeward Station A1 on Transect A; tubificid density was very low at middle Stations A2 and B2 and at riverward Station A3. *Chaoborus punctipennis* concentrations were greatest at middle Stations A2 and B2. Total standing stock was largest at the two leveeward stations (Table 6). No relationships between macrobenthic distributions and sediment type were evident.

117. Borrow Pit 9 (RM 595, L). The midge larvae *Glyptotendipes* sp. was the dominant species (48.2 percent of total density); *Chaoborus punctipennis* was a subdominant form (29.1 percent of total density) (Figure 5, Table 8). Tubificidae, five other species of chironomids (*Coelotanypus* sp., *Polypedilum illinoense*, *Procladius* sp., *Tanypus neopunctipennis*, and *Tanytarsus* sp.), *Bezzia* sp., the bivalves *Corbicula fluminea* and *Sphaerium transversum*, leeches, *Perithemis* sp., *Physa* sp., and unidentified Nematoda comprised most of the remaining assemblage. In addition to immatures, Tubificidae were represented by *Limnodrilus hoffmeisteri*, *L. maumeenis*, and *Aulodrilus pigueti* (Table 7).

118. The number of macroinvertebrate taxa collected was 25, one of the largest species richness values found in any borrow pit. Average total density was moderately high (95.4 organisms/sample). Average total standing stock was also comparatively large (40.4 mg/sample) (Table 8).

119. Patchiness in distribution was extreme for the two most abundant taxa (Table 6). An average of 273 Glyptotendipes sp. were collected at Station A1 on the leveeward side, while an average of less than two specimens per sample were collected at the other five stations; none occurred at Stations A3, B1, and B2. The largest number of Tubificidae were found at Station B1. A high density of C. punctipennis occurred at Station B1 (90 organisms/sample) but few individuals occurred at Stations B2 and B3. On Transect A, comparable concentrations of C. punctipennis were found at Stations A2 and A3 (21 and 34 organisms/sample), while an average of only 1 specimen/sample was taken at Station A1. Total standing stock was also very patchy. Since sediment type was uniform among stations, this variable appeared to have little influence on distribution patterns of the most abundant macroinvertebrate.

120. Borrow Pit 8 (RM 593, L). The macroinvertebrate assemblage was highly dominated by Tanypus stellatus (63.6 percent of total density); the other common taxa were Chaoborus punctipennis and Tubificidae which comprised 12.7 and 11.3 percent of total density (Figure 5, Table 8). The dipteran larvae Bezzia sp., Chironomus sp. 2, Coelotanypus sp., Cryptochironomus sp., Glyptotendipes sp., Polypedilum convictum, and Procladius sp. occurred in small numbers as did the tubificids Branchiura sowerbyi, Limnodrilus hoffmeisteri, and L. maumeensis and the naidids Dero digitata, D. flabelliger, and Pristina longidentata (Table 7).

121. Species richness was moderate; 21 taxa of macroinvertebrates were collected. Average total density (100.2 organisms/sample) and average total standing stock (42.2 mg/sample) were relatively large (Table 8).

122. T. stellatus density was highest at the silt-clay sediments at Stations A1, A2, B2, and B3, and lowest at Station A3 where sediments were much coarser (42.8 silt-clay). An intermediate T. stellatus density was found at Station B1 where sediments had a moderate amount (67.2 percent) of silt-clay. On Transect A, C. punctipennis was most abundant on the coarser sediments at Station A3, but the reverse was true on Transect B. Tubificidae

were most abundant in the coarser sediments at Stations A3 and B1. On Transect A, total standing stock was greatest at Stations A1 and A3 (coarsest sediments), while total standing stock was uniformly distributed among Transect B stations (Table 6).

123. Borrow Pit 14 (RM 584, R). Tubificid worms and *Tanypus stellatus* dominated the macrobenthos, comprising 41.1 and 22.4 percent of total density (Figure 5, Table 8). *Chironomus* sp. 2 was third in abundance (8.6 percent of total density). A variety of chironomids, *Coelotanypus* sp., *Cryptochironomus* sp., *Dicrotendipes* sp., *Glyptotendipes* sp., *Polypedilum illinoense*, *Procladius* sp., and *Rheotanytarsus* sp., were also present in small numbers. Naidids, including *Dero digitata*, and Nematoda also occurrred. The Tubificidae were represented by *Aulodrilus pigueti*, *Limnodrilus hoffmeisteri*, and *L. maumeensis* (Table 7).

124. Twenty-four taxa of macroinvertebrates were obtained in BP 14. Total density averaged 43.3 organisms/sample; average total standing stock was 7.0 mg/sample (Table 8).

125. Tubificidae were most abundant in the relatively coarse sediments at Stations A1 and B1 but were much less abundant on the silt-clay substrata at the other stations. This relationship is incongruous with known sediment relationships of tubificids, but was also found in BP 8, BP 13, BP 15, and BP 19. *Tanypus stellatus* and *Chironomus* sp. exhibited the same general spatial distribution pattern on Transect A, but not Transect B. Total standing stock was heterogeneous in distribution. The highest value occurred at Station A1 where largest concentrations of the most abundant species occurred. Relatively large standing stocks also were present at Stations A3, B1, and B2; no relationship to sediment type was apparent (Table 6).

126. Borrow Pit 4 (RM 482, R). The midge *Tanypus stellatus* was the numerically dominant macroinvertebrate and comprised 40.9 percent of total density. *Chaoborus punctipennis* and Tubificidae were subdominant taxa (21.3 and 15.5 percent of total density) (Figure 5, Table 8). Six species of Tubificidae were collected in addition to immatures: *Aulodrilus pigueti*, *Branchiura sowerbyi*, *Limnodrilus cervix*, *L. hoffmeisteri*, *L. maumeensis*, and *Tubifex* sp. *Tubifex* sp. represented about one-third of the tubificids

collected. Coelotanypus sp., Cryptochironomus sp., Dicrotendipes sp., Microchironomus sp., Paracladopelma sp., Phaenopsectra sp., Polypedilum illinoense, and Procladius sp. comprised the relatively diverse midge assemblage. The amphipod Hyalella azteca, the biting midge Bezzia sp., the naidid Dero nivia, and the snail Lymnea sp. were also collected (Table 7).

127. Benthic samples contained 27 taxa of macroinvertebrates, among the highest species richness of the 25 pits sampled. Total density (47.0 organisms/sample) and average total standing stock (12.2 mg/sample) were comparatively small (Table 8).

128. Transect A had greatest densities of Tanypus stellatus and Tubificidae at the two shore stations, while on Transect B the middle and riverward stations had the greatest numbers of Tanypus stellatus and the riverward station had the most Tubificidae. Chaoborus was most abundant at Station B3, while densities were similar among Transect A stations (Table 6). Since sediments were similar among all six stations, this variable appeared not to be a major factor in determining abundance patterns.

129. Borrow Pit 3 (RM 469, R). The dominant macroinvertebrate was Glyptotendipes sp. (38.7 percent of total density) although this species was abundant at only Station B3 (Figure 5, Table 8). The pit was characterized by the high number of chironomid species (16), three of which were collected only from BP 3: Cladotanytarsus sp., Micropsectra sp., and Goeldichironomus holoprasinus. Few tubificids were present (Table 7).

130. Species richness was high; 25 taxa of macroinvertebrates were collected. Average total density was very low (17.3 organisms/sample), while average total standing stock was moderately high (15.5 mg/sample) (Table 8).

131. The inordinately high standing stock level as compared to the low total density is a result of a large biomass value for replicate sample number one at Station A1 (110.7 mg). Since only 5 organisms were present in this sample, 3 dipteran larvae and 2 oligochaetes, this value is questionable.

132. Borrow Pit 5 (RM 462, R). The macroinvertebrate assemblage was unique in that small individuals (mainly nymphs) of the water boatmen Trichocorixa sp. dominated the benthos and comprised 51.1 percent of total

density (Figure 5, Table 8). Tanypus stellatus was a subdominant (25.5 percent of total density). Coelotanypus sp., Procladius sp., Chironomus sp. 2, Glyptotendipes sp., and Tanypus neopunctipennis were also present. Tubificidae accounted for 6.7 percent of total density and were represented by Branchiura sowerbyi, Limnodrilus hoffmeisteri, L. maumeensis, and immatures (Tables 7 and 8).

133. Average total density was relatively high (86.9 organisms/sample) as was average total standing stock (21.7 mg/sample). A total of 15 taxa were collected (Table 8).

134. Trichocorixa sp. was most abundant at the two riverward stations and least abundant at Stations A2 and B1 (Table 6). Total standing stock followed the same trend since Trichocorixa sp. was the dominant form. T. stellatus was most abundant at the middle and riverward stations on each transect. No relationship between sediment type and macroinvertebrate distributions was evident because the sediments were homogeneous in the pit.

135. Borrow Pit 7 (RM 460, L). The macrobenthos was co-dominated by tubificid worms, Tanypus stellatus, and Chaoborus punctipennis, which comprised 28.1, 24.2, and 15.7 percent of total density, respectively (Figure 5, Table 8). Procladius sp. made up 12.4 percent of total density. A few specimens of Cryptochironomus sp., Glyptotendipes sp., Phaenopsectra sp., and Pseudochironomus sp. were collected. Tubificids consisted of Limnodrilus angustipenis, L. cervix, L. hoffmeisteri, L. maumeensis, and immatures. Two species of naidids, Dero digitata and Dero sp. 1, were present in small numbers (Table 7).

136. Average total density was relatively low (17.8 organisms/sample), as was average total standing stock (13.1 mg/sample). A total of 16 taxa were obtained (Table 8).

137. Total standing stock for both transects was largest at riverward stations and lowest at leveeward stations. Tanypus stellatus density was highest at Stations A2 and B1. Tubificidae were most abundant at the riverward stations (A3 and B3) and at leveeward Station B1. Macrobenthic distribution patterns were apparently not related to sediment types since sediments were uniformly silt-clay (Table 6).

138. Borrow Pit 10 (RM 456, R). The macrobenthic assemblage was numercially dominated by Naididae (38.3 percent); *Dero digitata* averaged 77 percent of the naidids. *Chaoborus punctipennis* and Tubificidae were subdominants, comprising 25.9 and 17.7 percent of total benthos, respectively (Figure 5, Table 8). *Tanypus stellatus*, *Tanytarsus* sp., and *Glyptotendipes* sp. were also common. A variety of other chironomids were present in small numbers: *Polypedilum illinoensis*, *Endochironomus nigricans*, *Chironomus* sp., *Chironomus* sp. 2, *Coelotanypus*, *Dicrotendipes*, and *Procladius* sp. The amphipod *Hyalella azteca* was also collected. Four species of *Limnodrilus* were found: *L. hoffmeisteri*, *L. cervix*, *L. maumeensis*, and *L. spiralis* (Table 7).

139. Total macroinvertebrate density averaged 148.0 organisms per sample, the third highest density observed in the 25 pits sampled. Total standing stock was 28.3 mg/sample. Thirty taxa of macroinvertebrates were collected, the second highest diversity encountered among the 25 borrow pits (Table 8).

140. Total numbers of Naididae were very large at riverward Stations A3 and B3 (160 and 170 organisms/sample), but were very low ($\leq$ 2.0 organisms/sample) at the other stations. Riverward stations had coarse sediments (24-33 percent silt-clay) to which naidids are more adapted. *C. punctipennis*, a mud-dwelling form, was distributed in a reverse pattern to the naidids, being most abundant at Stations A1, A2, B1, and B2 where relatively fine sediments were found. Tubificidae were also most abundant at riverward Station A3, but were evenly distributed among Transect B stations (Table 6).

141. Borrow Pit 6 (RM 433, R). Total macrobenthos density averaged 96.5 organisms/sample; total standing stock was 29.0 mg/sample. A total of 33 macroinvertebrate taxa were collected, the highest of any borrow pit sampled (Table 8).

142. *Tanypus stellatus* was the numerically dominant macroinvertebrate (58.0 percent of total density); *Chaoborus punctipennis* was subdominant (21 percent of total density) (Figure 5, Table 8). The macroinvertebrate assemblage also contained small numbers of Tubificidae (*Limnodrilus hoffmeisteri*, *L. maumeensis*, *Potamothrix variagatus*, and immatures), Naididae (*Dero digitata*, *D. flabelliger*, *D. nivea*, *D.* sp. 1, *Nais* sp. and *Nais variabilis*) and a variety of chironomids (*Chironomus* sp. 2, *Coelotanypus* sp., *Cryptochironomus* sp., *Parachironomus* sp., *Polypedilum illinoensis*, *Procladius*

sp., and *Psectrocladius* sp.). The mysid shrimp *Taphromysis louisianae* was found (Table 7).

143. *Tanypus stellatus* abundance was greatest on Transect A, with highest density occurring at Station A3. Lesser numbers of *T. stellatus* were collected on Transect B; highest density occurred at Station B2. *C. punctipennis* was most abundant at middle and riverward stations on both transects; coarser sediments occurred at the stations with lowest *C. punctipennis* numbers (Table 6).

144. Total standing stock was comparable among Transect A stations and generally lower than on Transect B. Standing stock was greatest at Stations B1 and B2 (Table 6).

145. Borrow Pit 1 (RM 431, R). Total benthic macroinvertebrate density averaged 58.2 organisms/sample; total standing stock (34.1 mg/sample) was among the largest recorded. Twenty-five taxa of macroinvertebrates were collected (Table 8).

146. The phantom midge, *Chaoborus punctipennis*, dominated the benthic assemblage, comprising 53.6 percent of total density (Figure 5, Table 8). *Glyptotendipes* sp. was subdominant (24.9 percent of total density). The tubificids *Limnodrilus hoffmeisteri*, *L. maumeenis*, *L. cervix*, and immatures comprised 6.5 percent of total density. The chironomids *Chironomus* sp. 1, *Coelotanypus* sp., *Cryptochironomus* sp., *Dicrotendipes* sp., *Harnischia* sp., *Polypedilum convictum*, *P. illionense*, *Procladius* sp., and *Tanypus stellatus* comprised most of the remaining macrobenthos. *Trichocorixa* sp. and *Gammarus* sp. were also collected (Table 7).

147. *Chaoborus punctipennis* was most abundant at the middle station on each transect and Station B1. *Glyptotendipes* sp. was abundant at only Station A3 and very sparse or absent at other stations. Total standing stock was greatest (64.3 mg/sample) at Station A3 where large numbers of *Glyptotendipes* sp. occurred; approximately equal standing stock levels were measured at Stations A1 and A2. On Transect B, total standing stock was highest at Stations B1 and B2, corresponding to relatively high densities of *C. punctipennis*. Since sediment composition was similar at all stations, no relationship between macrobenthos spatial distributions and sediment type was evident (Table 6).

148. Borrow Pit 2 (RM 407, R). Total macroinvertebrate density was comparatively low (42.9 organisms/sample), as was total standing stock (11.5 mg/sample). A total of 18 taxa of macroinvertebrates were collected (Table 8).

149. Nymphs of the water boatmen *Trichocorixa* dominated total macroinvertebrate density (44.5 percent); *Tanypus stellatus* was subdominant (23.8 percent total density) (Figure 5, Table 8). *Chaoborus punctipennis* and *Glyptotendipes* sp. occurred in smaller numbers (9.8 and 4.8 percent total density). The chironomids *Chironomus* sp. and sp. 2, *Coelotanypus* sp., *Polypedilum* sp., and *Procladius* sp. were also present in low densities, as were larvae of the hydrophilid beetles *Berosus* sp. and *Helochares* sp., the gastropod *Physa* sp., the naidids *Dero* sp. and *Pristina longidentata*, the amphipod *Hyalella azteca*, and the tubificid *Limnodrilus maumeensis* (Table 7).

150. *Trichocorixa* were abundant (77.5 organisms/sample) only at Station B1 with moderate numbers (21.5 organisms/sample) at Station B2. *T. stellatus* was most common on Transect A; the greatest density occurred at Station A2. Total standing stock was somewhat evenly distributed among Transect A stations. On Transect B, the largest standing stock values were found at shore Stations B1 and B3. Macroinvertebrate distributions showed no relationship to sediment composition, which was uniform across stations (Table 6).

151. Borrow Pit 12 (RM 377, R). Total macroinvertebrate density was relatively low (43.8 organisms/sample). Total standing stock was the least (3.2 mg/sample) observed at the 25 borrow pits surveyed. Species richness was also low; only 15 taxa were collected (Table 8).

152. *Chaoborus punctipennis* larvae dominated the pit (50.7 percent total density); *Tanypus stellatus* was a subdominant (30.8 percent of total density) (Figure 5, Table 8). Six other species of chironomid larvae were collected in small numbers: *Chironomus* sp. 2, *Coelotanypus* sp., *Cryptochironomus* sp., *Harnischia* sp., *Microchironomus* sp., and *Procladius* sp. Tubificids were also uncommon; a few specimens of *Limnodrilus hoffmeisteri* and *L. maumeensis* occurred. The amphipod *Hyalella azteca* was collected at one station (Table 7).

153. Chaoborus punctipennis numbers were concentrated at Stations A2 and A3, which had fine sediments. Few C. punctipennis were collected at other stations. Tanypus stellatus was most abundant at the mid-pit Stations A2 and B2. Standing stock was greatest at Stations A2, A3, and B2 where the preponderance of C. punctipennis and T. stellatus were found (Table 6).

154. Borrow Pit 16 (RM 355, R). Total macroinvertebrate density was large and averaged 134.8 organisms/sample; total standing stock was also high (41.2 mg/sample). Nineteen taxa of macroinvertebrates were collected (Table 8).

155. The macrobenthic assemblage was co-dominated by two taxa: Trichocorixa sp. nymphs and Tubificidae (29.7 and 36.1 percent respectively, of total density) (Figure 5, Table 8). Tanypus stellatus comprised 11.0 percent of total density. Limnodrilus hoffmeisteri and L. maumeensis were the most abundant tubificids collected aside from immatures. The naidid Dero digitata, nematodes, leeches, Taphromysis louisianae, and chironomid larvae (Chironomus sp. 2, Coelotanypus sp., Cryptochironomus sp., Harnischia sp., Microchironomus sp., Polypedilum sp., Procladius sp., and the gastropod Lymnaea sp. were also collected in small quantities (Table 7).

156. Trichocorixa sp. was most abundant on Transect B; largest concentrations occurred at Stations B1 and B2. On Transect A, Trichocorixa density was greatest at Station A1. Tubificidae were also most numerous on Transect B; largest numbers were found at Stations B2 and B3. Tubificids were most abundant on Transect A at Station A2. T. stellatus was most numerous on Transect A, with highest concentrations occurring at Station A2 whereas on Transect B, numbers were lowest at the middle station. Total standing stock was largest on Transect B; largest values were at the leveeward and riverward stations. Mid-pit Station A2 had the largest total standing stock on Transect A (Table 6).

157. Borrow Pit 18 (RM 323, R). Total macroinvertebrate density averaged 183.0 organisms/sample, the largest for any pit sampled. Average total standing stock was also relatively large, 31.7 mg/sample. Species richness, however, was low, only 8 taxa were collected (Table 8).

158. *Chaoborus punctipennis* was the dominant macroinvertebrate, comprising 89.8 percent of total density (Figure 5, Table 8). One species of chironomid, *Chironomus* sp. 2, *Dineutus* sp., *Berosus* sp., *Limnodrilus hoffmeisteri*, *L. maumeensis*, and *Bezzia* sp. made up the remainder of the assemblage (Table 7).

159. Densities of *C. punctipennis* were greatest on Transect B (215-274 organisms/sample) but comparatively uniform among stations. On Transect A, *C. punctipennis* numbers were greatest at Station A1 and A2. Total standing stock distribution among stations reflected the distribution of *C. punctipennis* density (Table 6). This borrow pit had very low dissolved oxygen concentrations.

160. Borrow Pit 22 (RM 315, R). Total macroinvertebrate density was very low (15.7 organisms/sample), as was standing stock (3.3 mg/sample). Ten taxa of macroinvertebrates were collected, a relatively low species richness (Table 8).

161. *Chaoborus punctipennis* was the dominant benthic species, comprising 82.8 percent of total density (Figure 5, Table 8). A few specimens of *Coelotanypus* sp., *Cryptochironomus* sp., *Microchironomus* sp., *Polypedilum* sp., and *Xenochironomus* sp. were collected. A few *Hexagenia limbata* were present, the only occurrence of this mayfly among the 25 borrow pits sampled. Nematodes and immature tubificids were present in small numbers (Table 7). *C. punctipennis* was most abundant at riverward stations, as was total standing stock (Table 6).

162. Borrow Pit 20 (RM 305, R). Macrobenthos total density was low (46.1 organisms/sample) as was total standing stock (6.7 mg/sample). Twelve macroinvertebrate taxa were collected (Table 8).

163. *Tanypus stellatus* was the dominant species, averaging 54.9 percent of total density (Figure 5, Table 8). Tubificidae was a numerical subdominant, making up 16.9 percent of total density. *C. punctipennis* comprised 12.6 percent of total density. Also occurring in small numbers were the dipterans *Bezzia* sp., *Chironomus* sp. 2, *Coelotanypus* sp., *Microchironomus* sp., and *Procladius* sp., the mysid *Taphromysis louisianae*, the naidid *Haemonais waldvogeli*, and the tubificids *Branchiura sowerbyi*, *Limnodrilus hoffmeisteri*, and *L. maumeensis* (Table 7).

164. On Transect A, T. stellatus density was greater at middle Station A2 than at the shore stations, while on Transect B numbers of this species were about equal among stations. Tubificidae density was smallest at Stations A2 and B3 and similar at other stations. C. punctipennis was most abundant at middle Stations A2 and B2; none occurred at the leveeward stations. No relationship between sediment composition and macrobenthos distributions was evident (Table 6).

165. Borrow Pit 25 (RM 180, L). Total macrobenthic density was relatively low (28.3 organisms/sample) as was total standing stock (5.8 mg/sample). A total of 15 macroinvertebrate taxa was collected (Table 8).

166. The macrobenthos was dominated by tubificid worms, which comprised 66.9 percent of total density (Figure 5, Table 8). The dipterans Chaoborus punctipennis, Chironomus sp., Glyptotendipes sp., Pentaneura sp., Polypedilum convictum, P. illinoense, Procladius sp., and Tanypus stellatus; Hirudinea; the mayfly Caenis sp.; the naidid Dero digitata; and the tubificids Branchiura sowerbyi, Limnodrilus cervix, L. hoffmeisteri, and L. maumeensis composed the remaining benthic assemblage (Table 7).

167. Tubificidae density was largest at shore stations on both transects. No relationship between sediment composition and spatial distribution of tubificids was evident. Total standing stock was largest at Stations A2 and A3, but was similar at Transect B stations (Table 6).

168. Borrow Pit 24 (RM 151, L). Average total macrobenthic density was comparatively large (91.5 organisms/sample); total standing stock was 17.8 mg/sample. Twenty-two taxa of macroinvertebrates were collected (Table 8).

169. Tubificidae was the dominant taxa, comprising 49.51 percent of total density; Chaoborus punctipennis was a subdominant member of the macrobenthic assemblage, making up 25.9 percent of total density (Figure 5, Table 8). Tubificids were represented by Aulodrilus pigueti, Limnodrilus cervix, L. hoffmeisteri, L. maumeensis, and immatures. Other macroinvertebrates present, but in small numbers, were the mayfly Caenis sp.; the dipterans Coelotanypus sp., Cryptochironomus sp., Einfeldia sp., Glyptotendipes sp., Phaenopsectra sp., Procladius sp., Tanypus stellatus and T. neopunctipennis; Hirudinea; the naidid Dero digitata, D. flabelliger, and Nais sp.; and Nematoda (Table 7).

170. Tubificidae were most abundant on Transect B, where greatest numbers occurred at Stations B2 and B3. On Transect A, tubificid density was largest at Stations A1 and A2. *C. punctipennis* density followed the same spatial distribution pattern as the tubificids. No relationship between spatial distribution of the two dominant taxa and sediment composition was evident since the latter was very similar at all stations. Total standing stock was directly proportional to tubificid and *C. punctipennis* density on Transect B, but this relationship did not hold on Transect A where Station A2 had the greatest densities but the lowest standing stock (Table 6).

Comparisons Among Borrow Pits

171. Macrobenthic assemblages. The 25 borrow pits generally had similar species comprising the macrobenthic assemblage, but the relative abundance of the constituent taxa varied widely among pits. Overall *Chaoborus punctipennis*, *Tanypus stellatus*, and tubificid worms were the most abundant taxa (Figure 5, Table 8).

172. Total density in four borrow pits was dominated by a single species that comprised ≥ 50 percent of total density with no other taxa composing more than 15 percent of total density. Seven pits had macrobenthic assemblages that consisted of two or more co-dominant species (two or more species in about equal abundance comprising most of total density), and fourteen pits had a single dominant taxa constituting 40 percent or more of total density and one or more subdominant taxa that made up at least 15 percent of total density.

173. The four pits that had a single dominant taxa were BP 18 and 22 in which *Chaoborus punctipennis* was the dominant macroinvertebrate, BP 8 in which *Tanypus stellatus* was the dominant, and BP 25 which was dominated by Tubificidae (Table 9).

174. Borrow pits that had two or more co-dominant taxa comprising most of the macrobenthic assemblage were BP 3, 7, 15, 16, 19, 21, and 23 (Table 9). *C. punctipennis*, *T. stellatus*, *Trichocorixa* sp., Tubificidae, Naididae, Nematoda, and *Chironomus* sp. 2 were among the co-dominant taxa.

175. Of the fourteen pits that had a dominant/subdominant type of assemblage, three had C. punctipennis as the dominant, T. stellatus was dominant in four, Trichocorixa sp. in two, and Glyptotendipes sp. and Naididae dominated one pit each. The subdominant taxa were the same taxa as the dominant taxa except that Nematoda was a subdominant in one pit (Table 9). These comparisons of assemblages illustrate the general similarity of the benthic assemblage composition among the pits sampled.

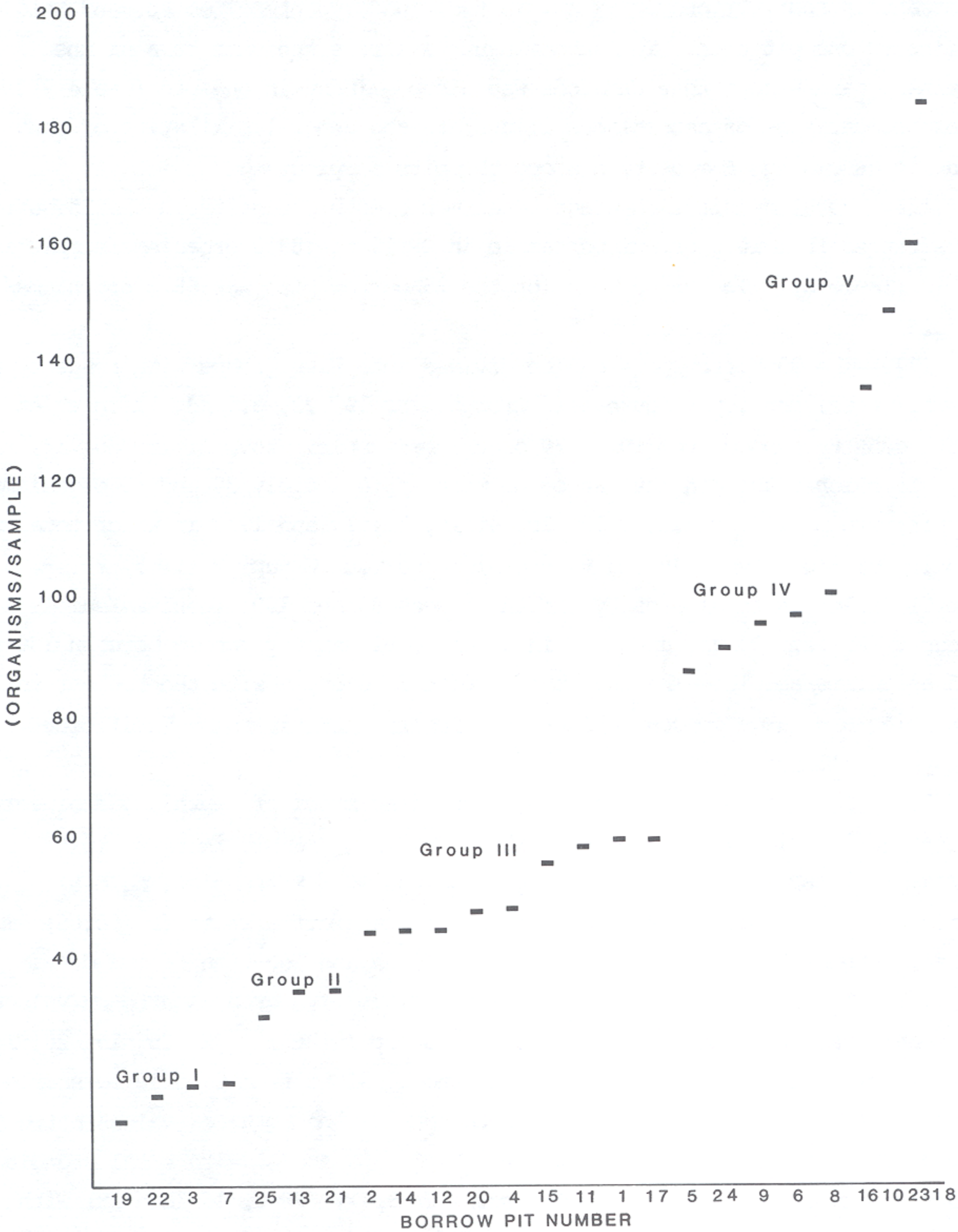
176. Total density. Average total macrobenthic density in the 25 borrow pits ranged from 10.6 organisms/sample in BP 19 to 183.0 organisms/sample in BP 18 (Table 8). The grand mean for the 25 borrow pits was 68.2 organisms/sample.

177. The 25 borrow pits can be divided into five groups with respect to average total density (Figure 6): Group I (BP 19, 22, 3, and 7), in which total density ranged from 10 to 20 organisms/sample; Group II (BP 25, 13, and 21), in which total density ranged between approximately 30 and 40 organisms/sample; Group III (BP 2, 14, 12, 20, 4, 15, 11, 1, and 17), in which total density varied between 40 and 60 organisms/sample; Group IV (BP 5, 24, 9, 6, and 8), in which total density ranged between 85 and 100 organisms/sample; and Group V (BP 16, 10, 23, and 18), in which total density ranged between 130 and 185 organisms/sample. The four borrow pits in Group V with the highest total densities had large concentrations of Chaoborus punctipennis, Tubificidae, or Tanypus stellatus.

178. Total standing stock. Total standing stock of benthic macroinvertebrates varied widely among borrow pits from 3.2 mg/sample in BP 22 to 63 mg/sample in BP 23; average standing stock was 19.8 mg/sample (Table 8). Analysis of variance (ANOVA) revealed significant differences ($P > 0.05$) among pits in standing stock using both untransformed and log-transformed data.

179. The 25 borrow pits may be divided into five groups based on values of mean total standing stock (Figure 7): Group I (BP 12, 22, 25, 15, 20, 14, 13, 19, 21, and 11) with total standing stock values from 5 to 10 mg/sample, Group II (BP 2, 4, 7, 3, 25, and 5) with total standing stock values between 10 and 25 mg/sample, Group III (BP 17, 10, 6, 18, and 1) with total standing stock values between 25 and 35 mg/sample, Group IV (BP 9, 16, and 18) with total standing stock between 40 and 45 mg/sample, and Group V (BP 23) with total standing stock greater than 60 mg/sample.

Figure 6. Total density of benthic macroinvertebrates from 25 Lower Mississippi River main stem levee borrow pits



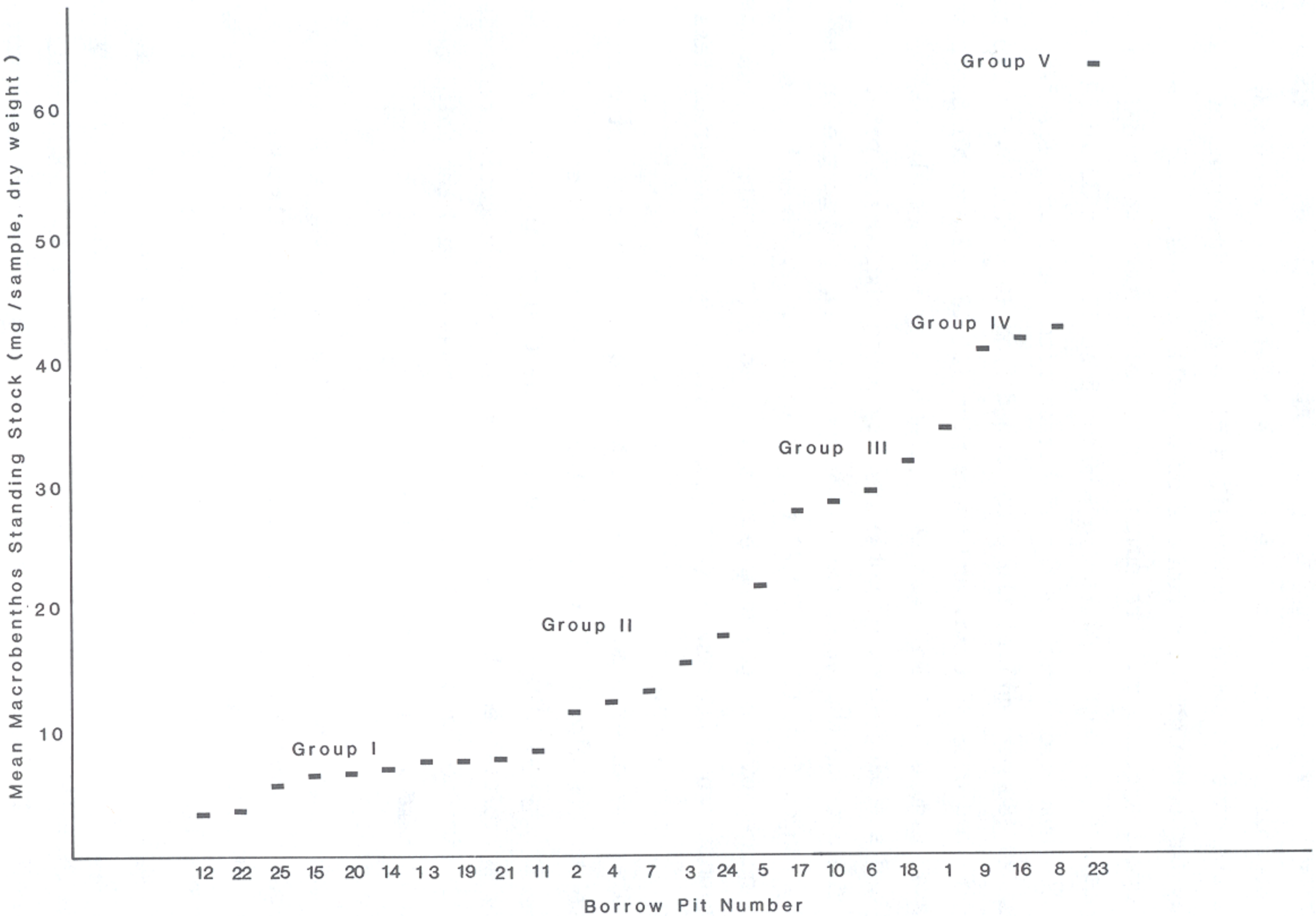


Figure 7. Total standing stock of benthic macroinvertebrates from 25 Lower Mississippi River main stem levee borrow pits

180. A significant positive correlation ($r = 0.77$, $P > 0.01$) was found between average total standing stock and average total density of macrobenthos in the borrow pits. This relationship indicates that the greater the total number of organisms present, the greater the total weight (Figure 8). This is not always the case in benthic communities since a few specimens of a large species may far outweigh large numbers of a small species.

181. Species richness. The number of macroinvertebrate taxa (mainly nominal species) per borrow pit averaged from 8 in BP 18 to 33 in BP 6 (Table 8). The mean number of taxa for the 25 borrow pits was 20.5. Species richness in 20 (80 percent) of the pits ranged from 16 to 27 taxa. Two pits (BP 10 and 6) had over 30 taxa, and three pits (BP 18, 22 and 20) had fewer than 15 taxa (Figure 9). No consistent relationship was seen between diversity and standing stock or total density among the borrow pits.

182. The average number of macroinvertebrate taxa per sample in the borrow pits ranged from 1.7 in BP 22 to 9.3 in BP 6. Eighteen borrow pits had an average number of taxa per sample of six or more (Table 8). One-way ANOVA revealed significant differences ($P > 0.05$) in the average number of taxa per sample among borrow pits.

183. The most diverse major group of benthic macroinvertebrates in the borrow pits was the Diptera of which 33 taxa, composed of 28 genera, were collected. Thirty-one dipteran taxa were in the family Chironomidae. The other major macroinvertebrate groups with relatively high species richness were the Tubificidae containing 12 taxa in seven genera and the Naididae containing 12 taxa in five genera (Table 7).

Dominant Taxa

184. Chaoborus punctipennis. Predaceous phantom midge larvae and pupae were the most abundant and ubiqitous macroinvertebrates collected from the 25 borrow pits (Figure 5, Table 8). C. punctipennis averaged 19.0 organisms/sample and occurred in all pits sampled. It was most abundant in BP 18 (164.3 organisms/sample) with substantial average densities also present in BP 1, 6, 9, 10, 17, 23, and 24. Analysis of variance on log-transformed data showed significant differences ($P > 0.05$) among borrow pits for C. punctipennis average density; BP 18 had a significantly greater density than the other 24 pits. The lowest concentrations of C. punctipennis were found in BP 5 and 14.

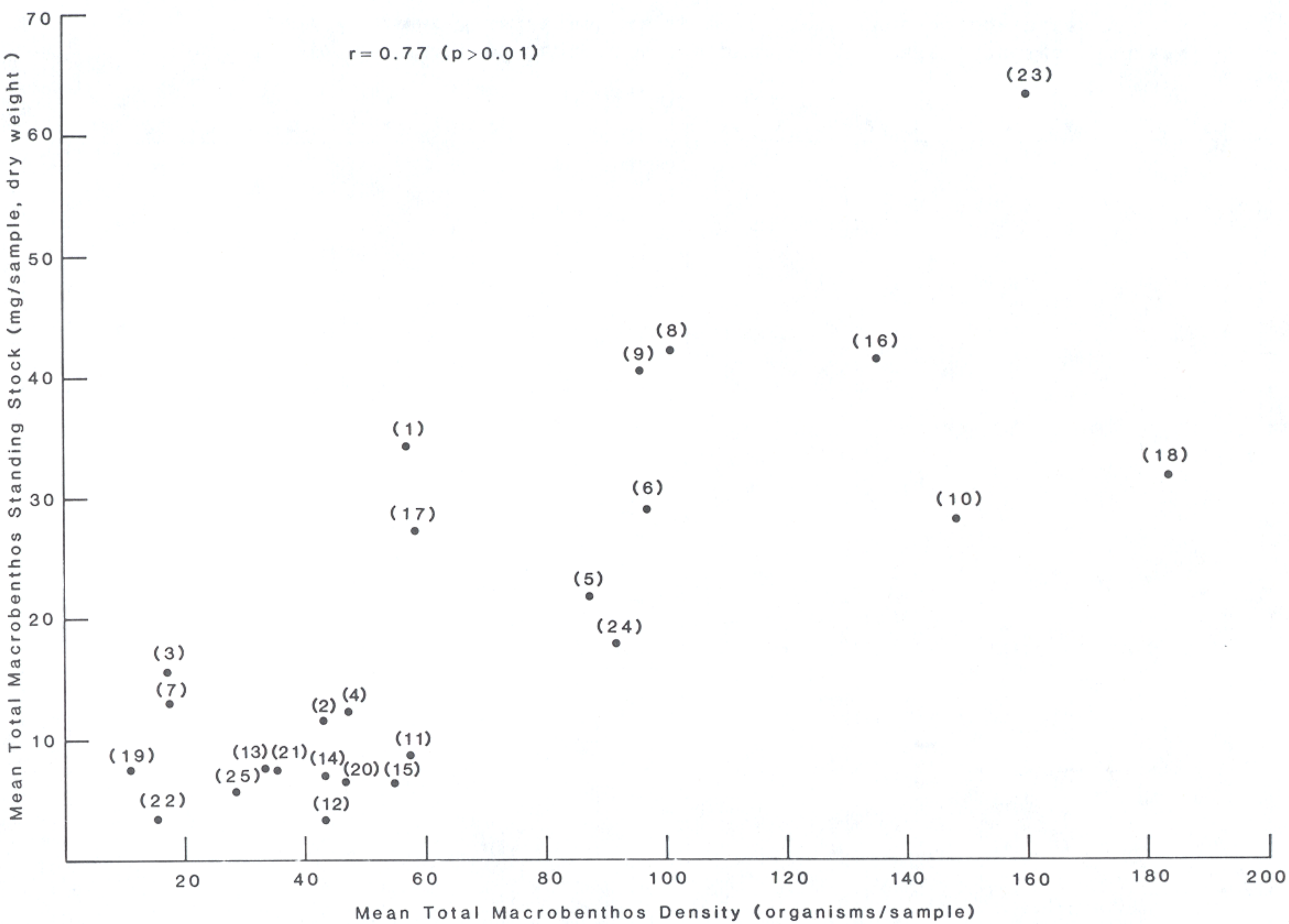


Figure 8. Relationship between total density and standing stock of benthic macroinvertebrates from 25 Lower Mississippi River main stem levee borrow pits

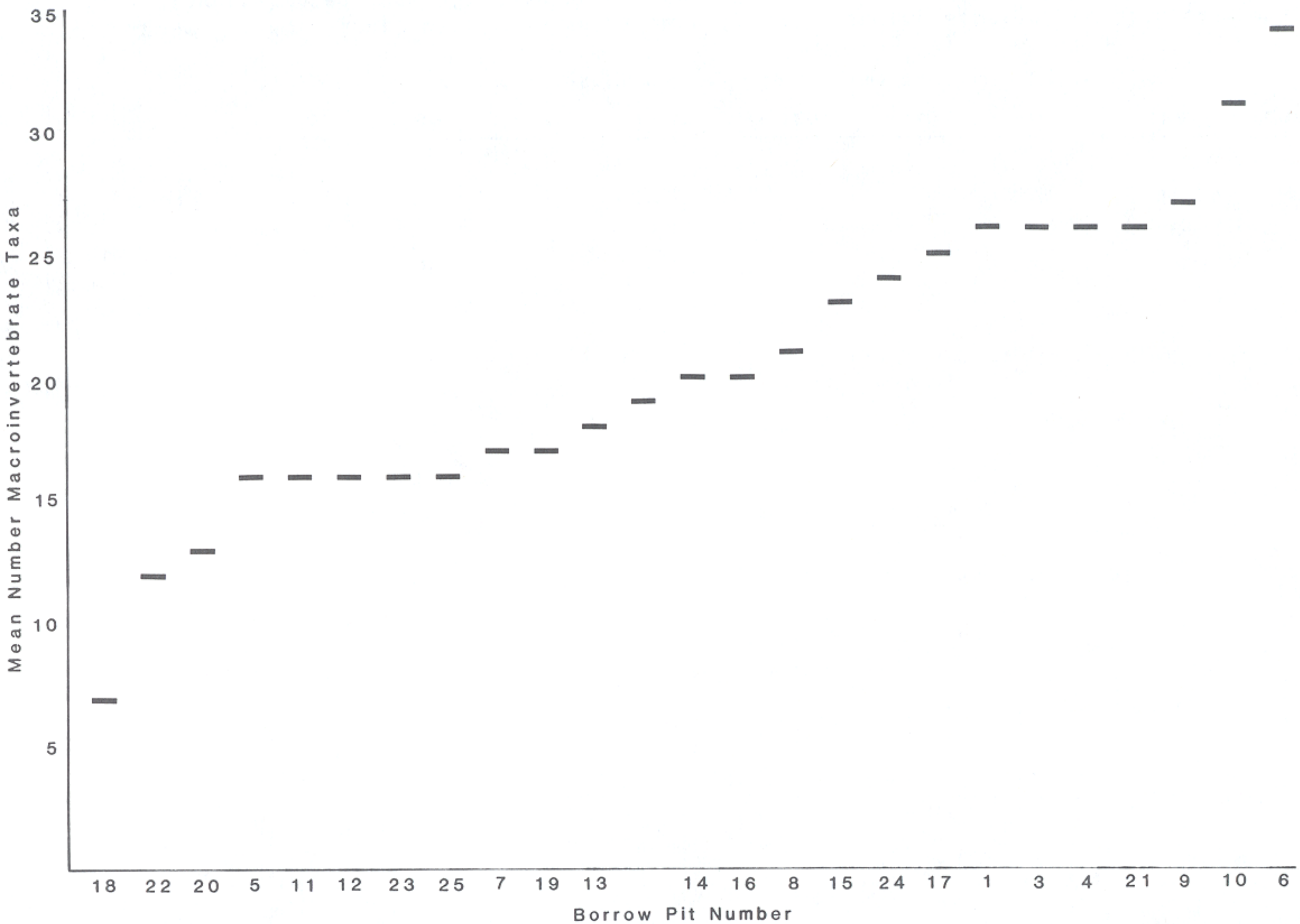


Figure 9. Total number of benthic macroinvertebrate taxa (species richness) from 25 Lower Mississippi River main stem levee borrow pits

185. Tanypus stellatus. This predaceous or omnivorous chironomid larva was the second most numerous benthic macroinvertebrate inhabiting the borrow pits overall, having relatively high densities in more pits than C. punctipennis. T. stellatus averaged 15.1 organisms/sample among the 25 borrow pits and occurred in 23 pits. It was absent from BP 18 and 22. The highest densities of this species occurred in BP 6, 8, and 23; substantial quantities of T. stellatus were also present in BP 5, 11, and 20 (Table 8). Differences among borrow pits in average T. stellatus density were significant ($P > 0.05$); patterns in these differences were complex, with no distinct borrow pit groupings.

186. Tubificidae. This family of deposit-feeding oligochaetes was third in overall abundance in borrow pit macrobenthic assemblages. Tubificidae were present in all 25 borrow pits sampled and averaged 11.4 organisms/sample. Twelve taxa were collected (Table 7); however, many specimens were immature and could not be identified to species due to the lack of mature male reproductive organs. Hence, these organisms were analyzed in detail only at the familial level. Limnodrilus hoffmeisteri, L. cervix, L. maumeensis, Aulodrilus pigueti, and Branchiura sowerbyi were the most common tubificid species. Tubificid average densities varied widely among borrow pits; largest concentrations occurred in BP 16 and 24; substantial numbers were also found in BP 10 and 25. Lowest densities were present in BP 3, 12, and 22 (Table 8). Differences among borrow pits in tubificid density were significant at the 5-percent level of probability.

187. Gyptotendipes sp. This chironomid larva was not abundant overall in the 25 borrow pits (mean density = 3.1 organisms/sample). However, it was abundant in BP 9 (mean density = 46.0 organisms/sample) and relatively abundant in BP 1 at one station; Glytotendipes sp. occurred in 15 of the 25 borrow pits (Table 8). Among borrow pit differences in density were significant at the 5-percent level of probability.

188. Coelotanypus sp. Larva of this predaceous chironomid occurred in 22 of the 25 borrow pits sampled (Table 7), but had a low average density overall (1.9 organisms/sample) (Table 8). Densities of C. sp. 2 where significantly different among borrow pits ($P > 0.05$). The average concentration at BP 23 of 16.8 organisms/sample was significantly greater than that of other pits.

189. Chironomus sp. 2. This chironomid has blood gills and was present in 14 of the 25 borrow pits sampled (Table 7). Chironomus sp. 2 average densities were significantly different ($P > 0.05$) among pits. While not abundant on the average in the 25 borrow pits (mean density = 1.0 organism/sample), it was relatively common in BP 23 for which the mean density of 34.8 organisms/sample was significantly greater ($P > 0.05$) than that of the other pits (Table 8).

190. Naididae. Oligochaetes of the family Naididae were present in macrobenthic assemblages of 19 of the 25 borrow pits sampled. Dero digitata was the most abundant naidid collected. Naidids averaged only 3.5 organisms/sample among the 25 borrow pits, but were moderately abundant in BP 10 where mean density averaged 56.7 organisms/sample (Table 8). Among borrow pit differences in total Naididae density were significant at the 5-percent level of probability. Eleven species of Naididae were collected (Table 7).

191. Corixidae. Nymphs of the water boatmen Trichocorixa sp. occurred in 15 borrow pits and were relatively abundant in BP 2, 5, and 16, where mean density was 19.1, 44.4, and 40.0 organisms/sample, respectively (Table 8). Among borrow pit differences in Corixidae density were significant of the 5-percent level of probability. Corixids were the dominant macroinvertebrate in BP 2 and 5. These aquatic Hemiptera, while agile swimmers, feed on bottom material and attach to structures on the bottom (Pennak, 1978).

Macrobenthos, Physical and Hydrologic Relationships

192. Step-wise regression techniques were used to explore relationships between the dependent macrobenthic variables and independent or fixed morphometric and hydrologic variables of borrow pits (refer to methods and materials section). These analyses were performed to determine if physical or flooding characteristics of the borrow pits that could be controlled during levee construction were positively related to the structure of macrobenthic assemblages. Morphometric, hydrologic, and sediment variables used in the analysis were mean depth, maximum depth, shoreline length, shoreline development index (SDI), volume, volume development index (VDI), average annual days flooded, percent of the borrow pit 5 feet or deeper, surface area, percent sediment organics, and percent sediment silt-clay fraction. Results of these analyses are presented in Table 10.

193. Total macroinvertebrate density and standing stock were positively related to the average number of days borrow pits were flooded annually by riverine overflow. Average days flooded annually explained 75 percent of the variation among borrow pits in total density, and this relationship was highly significant ($P > 0.0001$). Sixty-eight percent of the among borrow pit variation in total standing stock was explained by average days flooded ($P > 0.0001$) (Table 10).

194. Macrobenthos species richness was positively associated with VDI. Ninety-two percent of the variation in diversity among borrow pits sampled was accounted for by VDI. The VDI values increase as borrow pit basin shape becomes more bowl-shaped. Thus, as VDI increases, the wetted surface area of the basin and the amount of bottom area (benthic habitat) per unit of surface area increase. Also, inspection of the formula VDI = 3 mean depth/maximum depth reveals that as VDI increases, depth in the borrow pit increases and becomes more uniform and, hence, there is less relief in bottom topography. A linear combination of VDI and surface area explained 93 percent of the among pit variation, or 1 percent more than VDI alone. The influence of these factors on benthic diversity is unclear and may or may not be direct, i.e., VDI may affect benthic diversity through influences on other habitat variables. More bottom surface area and thereby benthic habitat per unit of surface area could result in more diversity of microhabitats and thus greater species richness. However, greater uniformity in depth intuitively seems contradictory to this concept. Surface area of borrow pits in linear combination with VDI was also directly related to number of taxa (Table 10).

195. Average density of *Chaoborus punctipennis*, a consistently abundant macroinvertebrate in the borrow pits, was directly associated with VDI (Table 10). Approximately 62 percent of the variation among borrow pits in *C. punctipennis* abundance was accounted for by variation of VDI values ($P > 0.0001$). The relationship between *C. punctipennis* and VDI is not evident unless greater uniformity in depths, or more bottom area per unit surface area in a borrow pit provides more favorable habitat conditions for this species.

196. Variation in *Tanypus stellatus* average density among borrow pits was directly related to average annual days flooded and negatively related to

mean basin slope. Average annual days flooded accounted for 47 percent of the variation in _T. stellatus_ density among the 25 borrow pits sampled, which was highly significant ($P > 0.0006$); a linear combination of the two variables explained an additional 7-percent or 54 percent of the variation. The relationship between amount of riverine flooding and abundance of _T. stellatus_, a predaceous midge larva, is unknown. However, the increased biological productivity expected with greater amounts of flooding, due to organic matter introduction, could be a factor. _Coelotanypus_ sp. density was also positively associated with average annual days flooded, which explained 30 percent of the variation in the number of this chironomid among pits (Table 10).

197. A linear combination of days flooded, VDI and decreasing percent fine material in sediments explained 45 percent of the variation among borrow pits in Naididae densities. The indirect relationship with percent silt-clay sediment fraction is consistent with the fact that naidids are generally more numerous on coarse sediments than sediments comprised of silt-clay. Nematod density was positively associated with increasing borrow pit surface area and negatively associated with maximum depth. Surface area alone accounted for 36 percent of among pit variation in average density while a linear combination of surface area and maximum depth accounted for 44 percent of the variation.

198. Tubificid worms were one of the three most abundant macrobenthic invertebrates in the borrow pits. Approximately 48 percent of the among borrow pit variation in tubificid density was explained by variations in SDI (Table 10). SDI is a measure of how convoluted is the shoreline of a borrow pit; in effect, the SDI value indicates the amount of littoral zone. This relationship is highly significant ($P > 0.0004$). The nature of the positive relationship between the abundance of deposit-feeding tubificid worms and the relative amount of borrow pit shoreline per unit surface is unknown, but could be associated with the amount of terrestrial organic matter entering the borrow pits via leaf fall from shoreline trees and shrubs. Tubificidae density was negatively correlated with maximum depth. A linear combination of SDI and maximum depth explained 54 percent of among pit variation in density.

Comparisons to Mississippi River Floodplain Lake Assemblages

199. The levee borrow pits investigated along the main line Mississippi River had macrobenthic assemblages typified by one or more of the following taxa: the phantom midge *Chaoborus punctipennis*, chironomid larvae principally *Tanypus stellatus*, and tubificid oligochaetes. Similar macrobenthic assemblages were reported for floodplain lakes or abandoned channels along the Lower Mississippi River in the vicinity of Greenville, Mississippi (Mathis et al., 1981). These investigators reported *C. punctipennis*, tubificids, and the bivalve *Sphaerium transversum* as the dominant macroinvertebrates in Carolina Chute; *T. stellatus* as the dominant benthic macroinvertebrate in Lake Port Chute; Tubificidae as the most abundant macroinvertebrates taxa in Moon Chute; and Tubificidae and *S. transversum* as the most numerous macroinvertebrates in Lake Lee, a large oxbow lake. Beckett et al., (1983) also reported *C. punctipennis* and Tubificidae as the dominant constituents of the macrobenthic assemblage in Matthews Bend, an abandoned channel floodplain lake near Greenville, Mississippi. In two small abandoned channel floodplain lakes on the Lower Mississippi River floodplain in the vicinity of Vicksburg, Mississippi, *C. punctipennis*, *T. stellatus*, *S. transversum*, and tubificids were the most abundant benthic macroinvertebrates (Stephen P. Cobb, MRC, unpublished data). Thus, it appears that levee borrow pits along the Lower Mississippi River have benthic macroinvertebrate assemblages similar in taxonomic composition to natural floodplain lake habitats.

Fisheries

Species Composition.

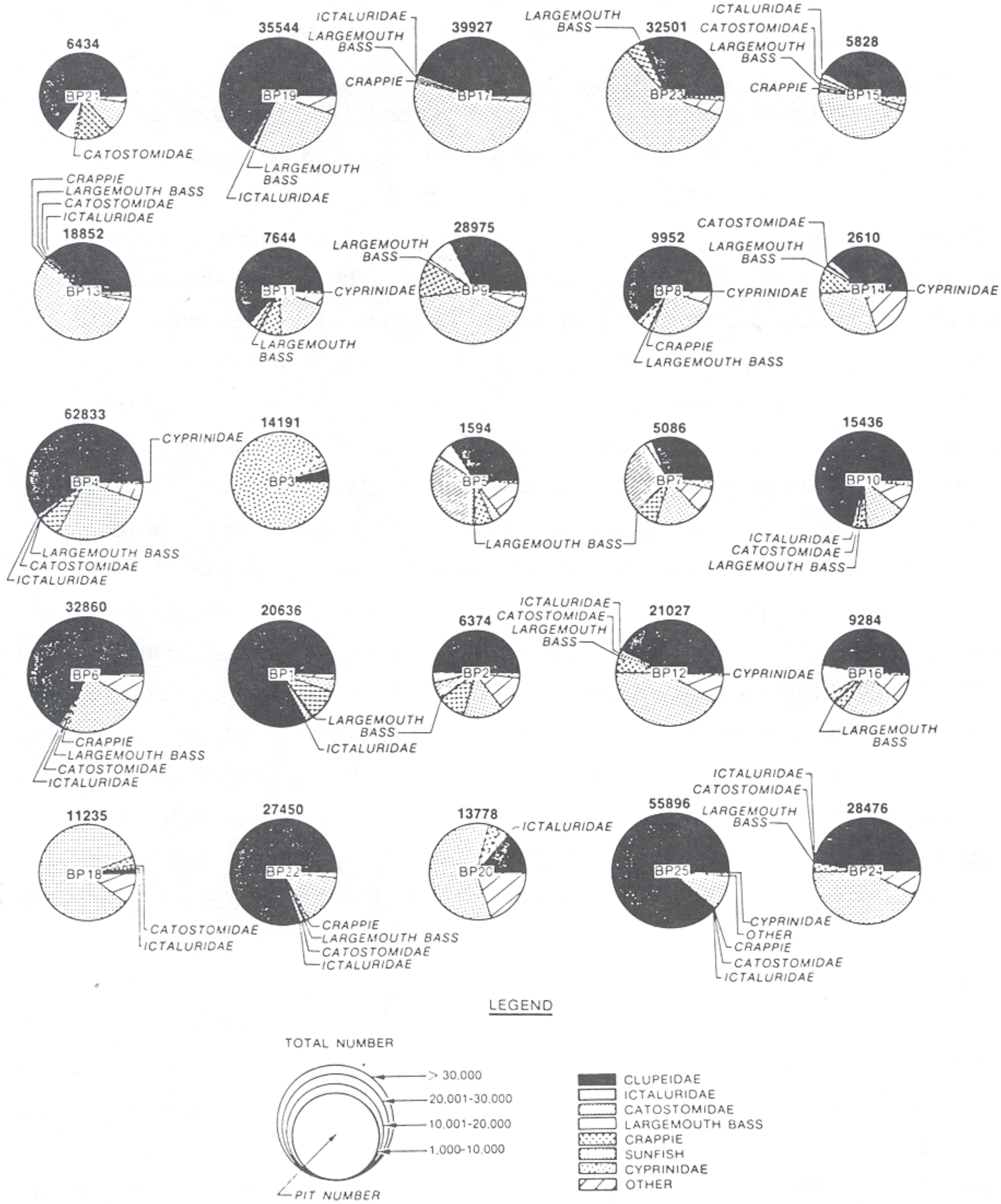
200. During this investigation, a total of 514,430 fish that weighed 29,768 pounds were collected; 58 species and 18 families were found (Table 11). Most of the specimens (82.5 percent) were classified to the species level, and all but 180 very small individuals in the family Catostomidae were assigned to genus. The numbers of fish collected from individual borrow pits ranged from 1594 (BP 5) to 62,833 (BP 4) and averaged 10,288 individuals per surface acre.

201. The average number of species collected per borrow pit was 27 and ranged from 18 in BP 3 to 35 in BP 6 (Table 12). The families Cyprinidae and Centrarchidae had the greatest representation, with 10 species each. The common carp dominated the catch of cyprinids and accounted for 86.4 percent of their total numbers. The bluegill, orange-spotted sunfish, and white crappie were the most numerous of the Centrarchidae and comprised 32.5, 29.2, and 18.6 percent of total numbers caught, respectively. The Centrarchidae were numerically dominant in seven borrow pits; Cyprinidae and Catostomidae were most abundant in one pit each (Figure 10). The Clupeidae dominated the catch in 16 of the 25 borrow pits.

202. Gizzard shad was the most abundant species (34.8 percent of the total catch) in both numbers and weight (Table 12). Shad comprised 34.8 percent and 31.2 percent of the total numbers and standing stock, respectively. Bingham (1969) studied two lakes in the Mississippi delta region and found gizzard shad to comprise over 50 percent of fish standing stock. Gizzard shad accounted for 36 percent of fish standing stock in six Mississippi River oxbows in Louisiana (Lambou, 1960) and 16 percent of the total weight of fish removed from a Mississippi River borrow pit near Baton Rouge (Robichaux, 1961). The relative abundance of the gizzard shad in this and other studies indicates that this species is one of the most characteristic of Lower Mississippi River borrow pits.

203. Threadfin shad also occurred frequently and ranked second in numerical abundance (19.5 percent of the total); Lepomis spp. ranked third (17.5 percent). No other species exceeded 6.0 percent of total numbers caught. Bigmouth buffalo comprised only 0.5 percent of the total number of fish collected but was second in weight (23.0 percent of the total standing stock). Carp and smallmouth buffalo comprised 2.7 and 0.3 percent of the total catch and 7.5 and 7.3 percent of the total weight, respectively. Seven species (skipjack herring, chain pickerel, red shiner, highfin carpsucker, brindled madtom, logperch, and striped mullet) were represented by single specimens from six pits.

Figure 10. Relative abundance of major groups of fish from 25 borrow pits along the main stem levee system of the Lower Mississippi River. The borrow pits are ordered by river mile, reading left to right, top to bottom.



204. Abundance estimates were significantly different among pits for all fish groups except the Ictaluridae. There was no relation between abundance of fish in a borrow pit and the number of species. For example, the borrow pit with the least number of fish did not have the fewest species nor was the pit with greatest number of individuals the most diverse.

205. Commercial fish species (Tables 11 and 12) comprised only 4.8 percent of total number caught but accounted for 48.3 percent of total standing stock. Sport fish numbers averaged 1452.1 per surface acre and comprised 14.1 and 11.8 percent of total catch and standing stock, respectively. Abundance of sunfish and crappie, the most numerous sport species, generally decreased in borrow pits supporting high numbers of commercial species, particularly buffaloes and the common carp.

206. There was a significant difference in total number of fish caught between the riverward and leveeward sides of the borrow pits. More numbers of fish were collected from the deeper riverward side (12,132 per acre) than from the shallower leveeward side (8930 per acre) (Table 13). Numbers of shad and sunfish were significantly greater on the riverward side of the borrow pits; Cyprinidae were most abundant on the shallower leveeward side. Ictaluridae, Catostomidae, and crappie were usually found in greater numbers on the riverward side. Abundance of other species was essentially the same at both locations within the borrow pits. Generally, larger individuals of a species were captured from the deeper side of the pits and the smaller specimens from the shallow side. It is interesting to note that the average number of largemouth bass, a preferred sport fish, collected from the riverward and leveeward sides was about equal, 28 and 27, respectively.

Standing Stock

207. An average of 595 pounds per acre of fish was caught in the borrow pits. Total standing stock ranged from 51 to 3199 pounds per acre in BP 3 and BP 7, respectively (Figure 11). The Clupeidae (mainly gizzard shad) occurred in 19 of the 25 borrow pits and comprised 32.8 percent of total standing stock. Standing stock estimates for Clupeidae averaged 195

Figure 11. Standing stock and relative composition of major groups of fish from 25 borrow pits from along the main stem levee system of the Lower Mississippi River. The borrow pits are ordered by river mile reading left to right, top to bottom.

pounds per acre and ranged from 3.4 to 414 pounds per acre in BP 18 and BP 8, respectively (Figure 11). The Catostomidae comprised 35.4 percent of the total standing stock and averaged 211 pounds per acre. They accounted for the greatest percentage of the standing stock in five borrow pits. The standing stock of Catostomidae ranged from less than 1 pound per acre in BP 3 to 2345 pounds per acre in BP 7.

208. Gizzard shad, bigmouth buffalo, common carp, and smallmouth buffalo accounted for the greatest percentage of the standing stock in the borrow pits and comprised 31.2, 23.0, 7.5, and 7.3 percent of the total standing stock, respectively. No other species that was collected accounted for more than 5 percent of total standing stock. Standing stock estimates differed significantly among borrow pits, as did standing stock for each taxonomic group except for the Ictaluridae and largemouth bass.

209. Commercial species averaged 48.3 percent of total standing stock (288 pounds per acre). The principal commercial fishes were the bigmouth buffalo, common carp, and smallmouth buffalo. Standing stock of sport species averaged 70 pounds per acre and comprised only 11.8 percent of total standing stock. Channel catfish, white crappie, and bluegill were the dominant sport species and comprised 3.7, 2.8, and 1.9 percent of total standing stock, respectively. Standing stock of largemouth bass was 6.4 pounds per acre, approximately 1 percent of total standing stock.

210. Standing stock of fish from two oxbow lakes in the delta region of Mississippi were estimated by Bingham (1969). Mossy Lake had an estimated standing stock of 530 pounds per acre, while two sample plots from Wolf Lake produced estimates of 51 and 299 pounds per acre. Shad was the dominant species in each lake. Centrarchids comprised 40 percent of fish standing stock in Mossy Lake and 20 percent in Wolf Lake. Lambou (1960) determined an average standing stock of 201 pounds per acre of fish from six oxbow lakes in Louisiana. Estimates ranged from 156 pounds per acre at Lake Concordia to 267 pounds per acre at Lake Providence. Centrarchids and channel catfish comprised 40 percent of average standing stock. In another study, Lambou (1959) sampled seven backwater lakes along the Mississippi, Atchafalaya, and Pearl Rivers. Standing stock estimates ranged from 142 to 651 pounds per acre, with an average of 397

pounds per acre. Overall, commercial and sport species comprised 47.3 and 26.0 percent, respectively, of the fish standing stock. Robichaux (1961) sampled a pond and a Mississippi River borrow pit in East Baton Rouge Parish, Louisiana. The borrow pit standing stock was estimated at 1495 pounds of fish per acre whereas the pond had 412 pounds per acre. Commercial species accounted for 62 percent of the standing stock in the borrow pit, while sport species comprised 73 percent of the standing stock in the pond.

211. Other Louisiana habitats have been studied by Bryan and Sabins (1979). From their study of the Atchafalaya Basin, they obtained average standing stock estimates of 768 pounds per acre in lower basin locations and 495 pounds per acre in upper basin locations. The lower basin, which receives direct mainstream influence, favors the occurrence of sport fishes, while the upper basin, which lacks direct mainstream influence, favors carp, shad, buffalo, and bowfin, typical of unmanaged eutrophic lakes at similar latitudes.

212. Although there was notable variation in the relative proportion in the standing stock of the taxonomic groups among borrow pits in our study, each pit was typically dominated by rough fish (buffalo, carp, gar, and bowfin) and forage fish (shad, small sunfish, and minnows), with a smaller percentage of sport species (largemouth bass, crappie, sunfish, and catfish).

213. The standing stock of fish removed from the riverward side of the borrow pits was significantly greater than the standing stock along the leveeward side and averaged 774 and 448 pounds per acre, respectively. Among the taxonomic groups, only Clupeidae and Ictaluridae had standing stocks which differed significantly between the riverward side and leveeward side samples. However, for each group, the riverward side of the borrow pit always had a higher mean standing stock (Table 13).

214. Standing stock estimates for the 25 borrow pits sampled during this study are fairly consistent with past estimates made in similar types of habitat in Louisiana and Mississippi. However, when compared with backwater sites on the Upper Mississippi River and some southeastern reservoirs, the standing stock of fish in Lower Mississippi River borrow

pits is much greater. For example, Christenson and Smith (1965) obtained standing stock estimates from Upper Mississippi River backwater lakes near La Crosse and Fountain City, Wisconsin, ranging from 39 to 605 pounds per acre. Brown and Ball (1943) estimated standing stock in Third Sister Lake, Michigan, to be 86 pounds per acre based on rotenone treatment.

215. Standing stock estimates averaged 174 pounds per acre from 139 reservoirs in Region 4 (Aggus and Morais, 1979). Estimates ranged from 16 to 805 pounds per acre with clupeids being dominant. The mean standing stock was 451 pounds per acre, with estimates ranging from 100 pounds per acre at Deep Creek Reservoir, Maryland, to 1550 pounds per acre at Cherokee Reservoir, Tennessee. The harvest, by weight, was 40 percent sport fish, 34 percent forage fish, and 26 percent rough fish. Estimated standing stocks in five lakes in the Ocala National Forest, Florida (Meehean, 1942), ranged from 22.2 to 110 pounds per acre. There was a positive relation between pounds per acre and degree of ecological maturity of the lakes. Largemouth bass comprised 15 percent of the fish standing stock (fairly consistent precentage in all five lakes), while other centrarchids accounted for 41 percent of the standing stock weight.

Length-Frequency Analysis

216. Data on fish length-frequencies came from two sources, those fish measured in the field and those returned to the laboratory. For most species, all individuals were measured in the field, and the length-frequency distributions obtained should accurately reflect the size distributions of these species. For species such as bluegill and gizzard shad, which often had very dense populations, approximately 10 percent of the adults were individually measured in the field. The exceptions to this generalization were a few borrow pits that had relatively few adults of these species, resulting in all large fish being measured. Fishes smaller than about 100 mm total length (TL) were preserved and analyzed in the laboratory. In most cases, these small fishes were very numerous, and a 5-percent subsample was randomly selected for individual measurement.

217. Length-frequency plots are based on only those fish that were actually measured, and therefore the height (relative percent) of the

identifiable length modes will not reflect accurately the relative number of fish in these modes. However, the position of the modes along the abscissa should provide accurate estimates of the mean lengths of the fish constituting these modes.

218. Without data on fish ages, we can make no definitive statements comparing growth rates among pits. However, certain reasonable assumptions can be made concerning observed differences in length-frequency distributions. One assumption is that the variation in basic productivity among the pits is not great, at least not differing by orders of magnitude. This assumption seems reasonable since the borrow pits all lie within the levees of the Lower Mississippi River floodplain. A second assumption is that the time of spawning for any given species does not differ greatly between borrow pits at the northern and southern extremes of the study area. There is likely to be some difference, of course, but it is almost certainly less than 10-14 days for pits at the extreme northern and southern limits. The third and most critical assumption is that the growth rate for any given species does not differ among pits so greatly that two successive year-classes would overlap in terms of length-frequency. This assumption may be somewhat unrealistic, especially for a species such as bluegill in which overcrowding and resultant stunting often cause fish in one body of water to be a full year's growth behind those in another body of water. However, in the absence of actual age-length information, we will assume that this relationship holds.

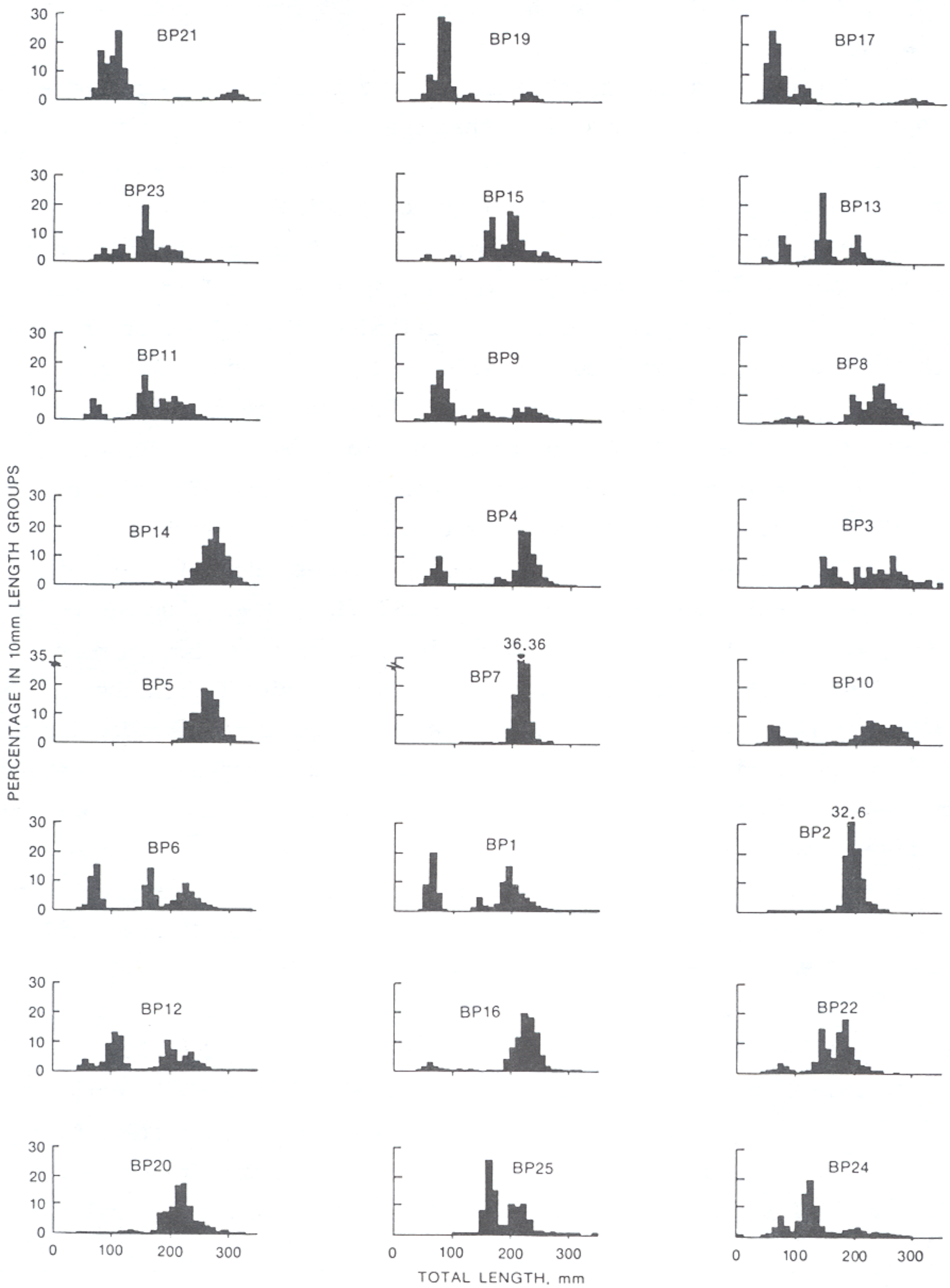
219. Gizzard Shad. Gizzard shad are reported to spawn from late April into August in Wisconsin (Becker, 1983) and from early April through May in Missouri (Pflieger, 1975). In the Lower Mississippi River Valley, gizzard shad reproduction probably occurs from late April to early June in most years (Carlander, 1969), with May being the month during which the highest densities of larval shad occur (Schramm and Pennington, 1981; Conner, Pennington, and Bosley, 1983). However, late March and the entire month of April 1981 were unusually warm and dry (mean temperature 3-4° C above normal; rainfall more than 4 inches below normal) in the Lower Mississippi River Valley, and it seems likely that gizzard shad and other

fishes may have spawned earlier than normal. The model length distributions of young-of-year (YOY) gizzard shad in many borrow pits (BP 8, 12, 13, 15, 17, 21, 23, and 24) suggest at least two and in one instance (BP 19) three spawning peaks during 1981 (Figure 12). The yearly occurrence of multiple spawning can also be inferred from the abundance modes noted by Schramm and Pennington (1981) and Conner, Pennington, and Bosley (1983).

220. If we assume that spawning began in early to mid-April in the more southern borrow pits, and from 1 to 2 weeks later in the more northern ones, then gizzard shad from these pits are indicated to have grown at about 0.97-1.10 mm TL/day. No evidence was found for any significant north-south gradient in growth rate, and few striking differences in growth of particular size-classes were evident. However, BP 2 and BP 6 are in the same reach of the river, and they were sampled at nearly the same time (16 and 22 June), yet BP 2 had a dominant size-class of gizzard shad in the 180 mm to 210 mm TL range, precisely intermediate between two strong size-classes in BP 6 (150-170 mm and 210-240 mm). The two modes in BP 6 almost certainly correspond to Age 1 and 2 fish, but without actual data it is impossible to know whether the dominant mode in BP 2 age represented relatively fast-growing Age 1 fish or relatively slow-growing Age 2 fish.

221. Assuming that the length modes indicate year-classes, the growth of gizzard shad over their first 3-4 years of life in the borrow pits is comparable to that for much of the south-central United States (Carlander, 1969). Growth rates of gizzard shad in the borrow pits do not appear to be different from those in the Mississippi River (Pennington, Baker, and Bond, 1983). In the river, gizzard shad averaged about 130 mm TL in April, nearly identical to the median figure for the south-central United States given by Carlander (1969). By June, when the first borrow pits were sampled, these fish had grown to 150-170 mm, closely corresponding to the length of presumed Age 1 fish from the borrow pits.

Figure 12. Length-frequency of gizzard shad from Lower Mississippi River main stem levee borrow pits



222. Some borrow pits indicated missing or weak year-classes. Almost no YOY gizzard shad were collected from BPs 2, 3, 5, 7, 14, 20, or 25. In BPs 1, 2, 7, 17, 19, 21, and 22, one or more older year-classes were weak or missing.

223. Bigmouth and smallmouth buffalo. The life histories of these two species are sufficiently similar that they are combined in the following discussion. The time of spawning of bigmouth and smallmouth buffalo in the Lower Mississippi River is not precisely known. Pflieger (1975), Smith (1979), and Becker (1983), state that one or both of these species spawns in "May," "spring," and "late April and May" in Missouri, Illinois, and Wisconsin, respectively. Carlander (1969) gives dates of March through June for smallmouth buffalo, and May and June for bigmouth buffalo, although the bigmouth buffalo he refers to were from northern populations. Southern Illinois bigmouth buffalo spawned in late April 1982 (Burr and Heidinger, 1983) and late April-early May 1978 (Morris and Burr, 1982). The critical factor seems to be water temperature, which must reach or exceed 16° C (Swingle, 1957; Carlander, 1969; Becker, 1983). The spawning season in the Lower Mississippi River thus may occur as early as March, but it probably peaks in April or early May in most years. This is likely to be the primary spawning period for another reason: both species of buffalo spawn over rather shallow, flooded areas (Guillory, 1979; Becker, 1983), and April and May are normally the months during which this habitat is most abundant due to high spring rainfall and high river levels. Studies of the occurrence of larval fishes in the Lower Mississippi River substantiate this conclusion. The peak abundance of buffalo is generally in April to early May in this area (Schramm and Pennington, 1981; Conner, Pennington, and Bosley, 1983).

224. Both species grow rapidly, reaching about 130-175 mm TL at 1 year of age, 230-300 mm TL at 2 years, and 300-375 mm TL after 3 years; they continue to grow rapidly through at least their first 7-13 years (Carlander, 1969; Pflieger, 1975; Becker, 1983). The length-frequency modes on Figures 13 and 14 have been tentatively identified to year-class on the basis of these reported growth rates, although without actual age

Figure 13. Length-frequency of bigmouth buffalo from Lower Mississippi River main stem levee borrow pits

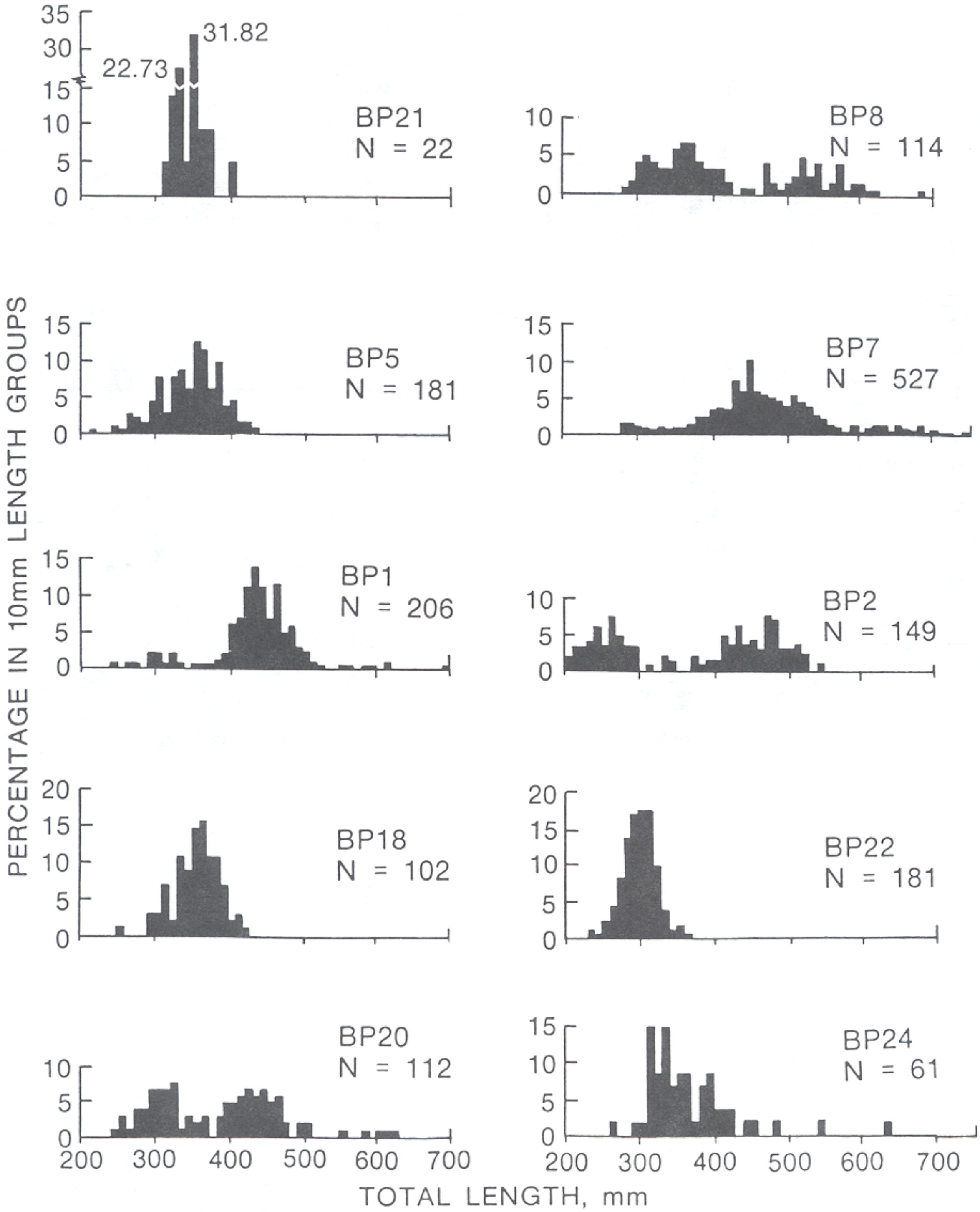
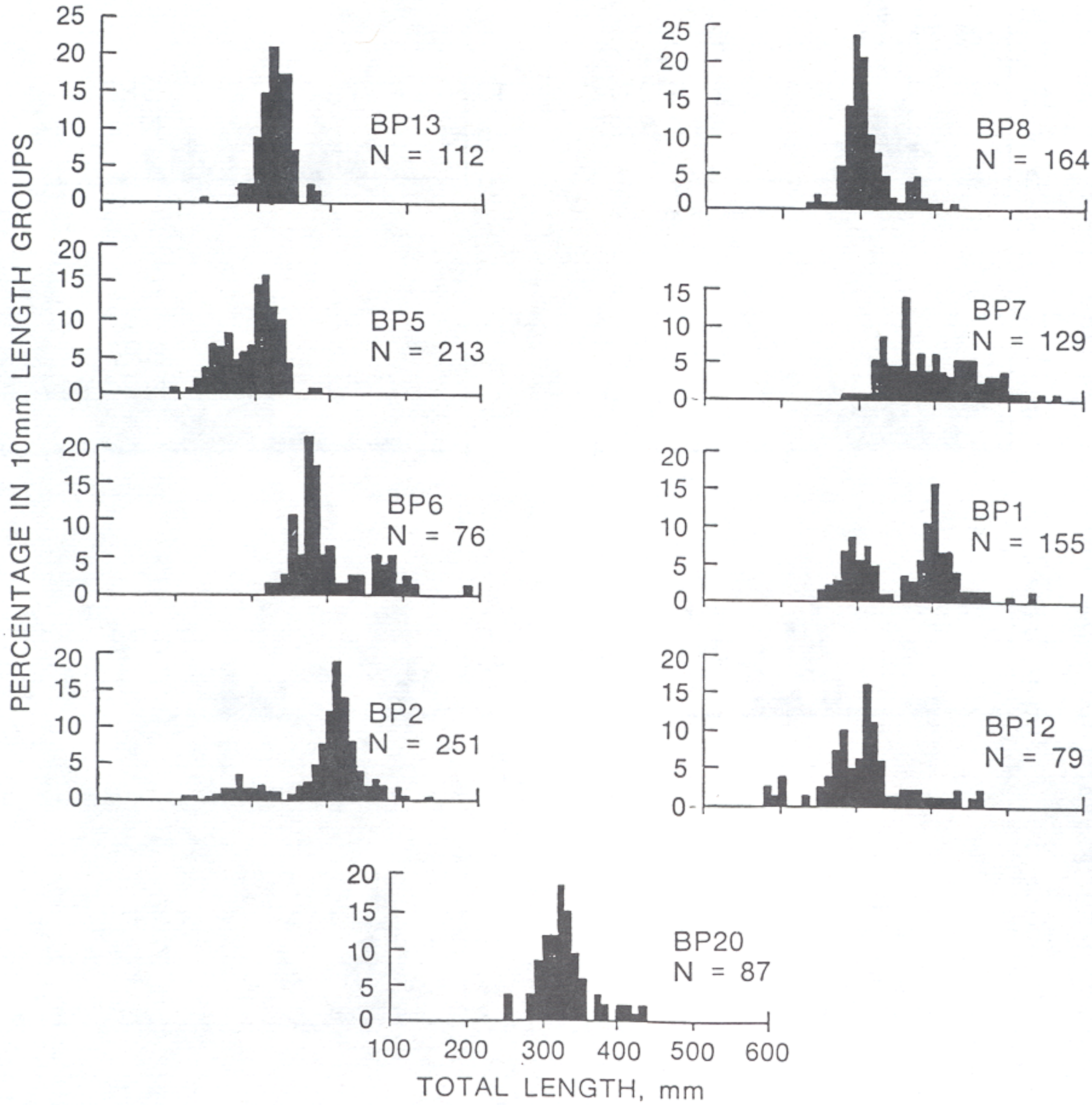


Figure 14. Length-frequency of smallmouth buffalo from Lower Mississippi River main stem levee borrow pits. The size distribution of smallmouth buffalo in BP 11 was similar to BP 8.



data on the fish we can make no definitive statements. Despite this, unless the growth rates vary by at least an order of magnitude, there appears to be little difference among the borrow pits in terms of growth of buffalo.

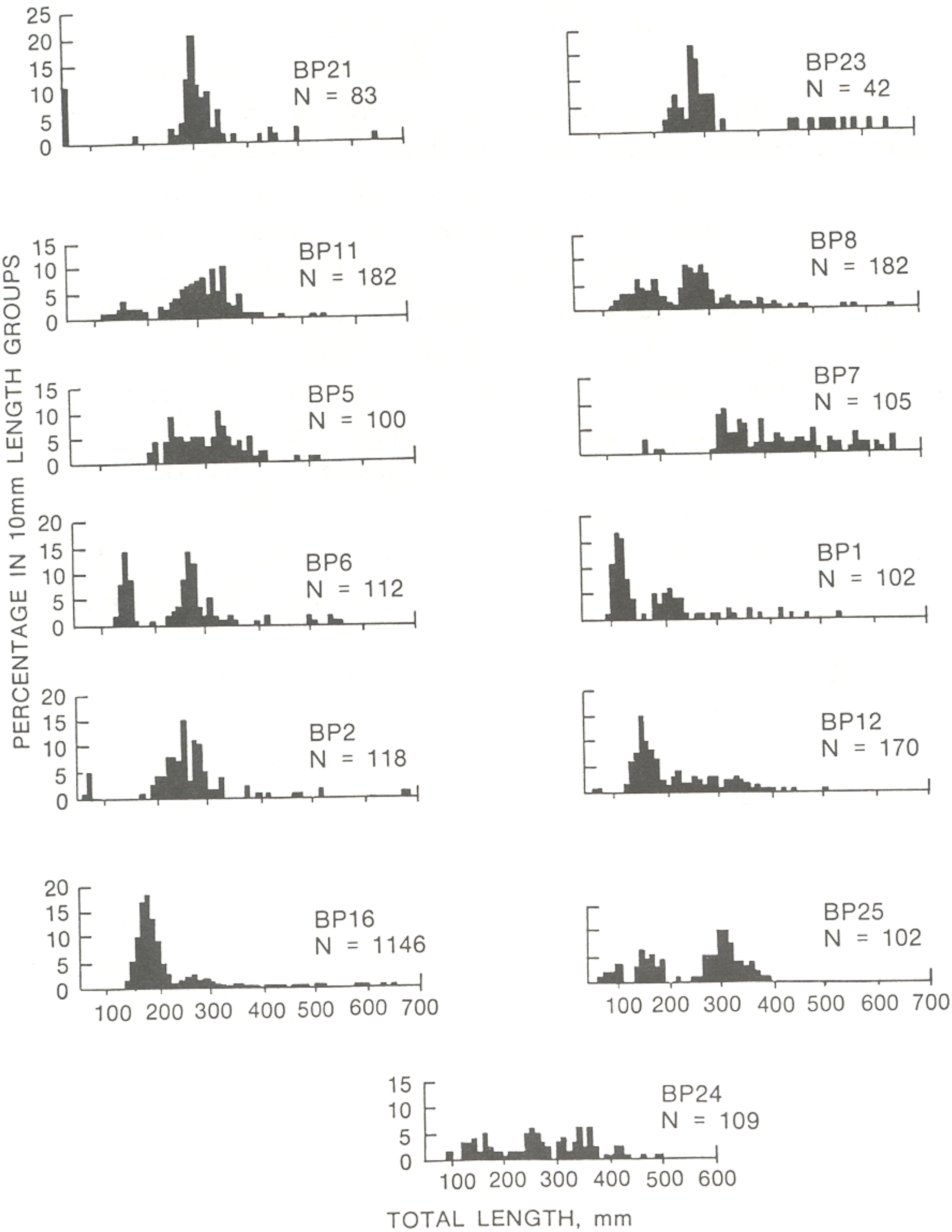
225. The 10 borrow pits which had relatively large numbers of bigmouth buffalo (Figure 13) did show some differences in their overall age-class structures. Three pits (BPs 18, 21, and 22) had fish of only one year-class, probably 1979, a year of extensive overbank flows on the Lower Mississippi River (Figure 4). Other pits, such as BPs 7 and 8, had relatively large numbers of fish of several year-classes. Borrow pits which had high numbers of smallmouth buffalo also showed a great deal of variability in their length-frequency distributions (Figure 14). Borrow pits 8 and 11 (not plotted; distribution nearly identical to that of BP 8) and BPs 13, and 20 had fish of only a single year-class, apparently 1979, while BP 3 had primarily 1978 fish. The potential for differences among nearly adjacent pits is well illustrated by BPs 1 and 6, which were separated by only about 2 river miles. Borrow pit 1 had predominantly Age 2 and 3 smallmouth buffalo, while BP 6 had Age 3 and 4 fish. Despite the apparent similarity in reproduction and habitat, the year-class distributions of the two buffalo species showed little correspondence among the borrow pits.

226. The complete absence of Age 0 to 1 buffalo (1981 and 1980 year-classes) in the borrow pits is notable since these pits and the floodplain surrounding them seem to be ideal spawning areas for these species. One hypothesis can be advanced to explain this absence of young buffalo. Both 1981 and 1980 were relatively low-water years in the Lower Mississippi River (Figure 4); duration of inundation by floodwaters averaged 40 days per borrow pit in 1980 and only 16 days in 1981. The total amount of inundated floodplain was relatively small in both 1980 and 1981, so that the spawning habitat preferred by these species may have been limiting. Duration of flooding in 1981 was probably a major factor in the reduced reproductive success in that year. Becker (1983) has noted that in the absence of suitable flooded areas, buffalo may fail to spawn

at all. Also, buffalo eggs take from 8-14 days to hatch, and the water may have receded from the few available sites too quickly during these dry years, causing high mortalities of eggs and larval buffalo. This possibility is supported by the results of two studies on larval fishes in the Lower Mississippi River. Schramm and Pennington (1981) sampled larval fishes from a number of river habitats during 1978, a relatively high-water year, while Conner, Pennington, and Bosley (1983) sampled many of these same habitats during 1980, a relatively dry year. These two studies provided evidence of both earlier spawning and higher abundances of buffalo larvae (not separable to species) in 1978 than in 1980.

227. Channel catfish. Little is apparently known about the spawning time or rate of growth of channel catfish in the Lower Mississippi River. The determining factor for reproduction appears to be water temperatures reaching 21-24° C (Carlander, 1969; Farabee, 1979; Becker, 1983). These temperatures are reached and spawning occurs in May through July in Wisconsin and Missouri (Pflieger, 1975; Becker, 1983), in June and July in Oklahoma and South Carolina (Carlander, 1969), and in May and June in the impoundments of the Upper Mississippi River (Farabee, 1979). Based on temperature, channel catfish probably spawn from late April through May in the study area. There is some indication that two clutches of eggs are spawned, 2 to 3 weeks apart (Carlander, 1969). Assuming a growth rate of approximately 0.8-1.0 mm TL/day during their first summer, the length-frequency plots (Figure 15) indicate a May spawning peak in the borrow pits. Young-of-year fish in BP 25 (RM 180) averaged 75 mm TL on 4 August, for example, suggesting an early May spawning. However, two more northern borrow pits (BPs 17 and 19, at RM 773 and 877), which had predominantly YOY fish, indicated either a late May or very early June reproduction, or possibly somewhat slower growth, as these fish averaged only 50 mm and 40 mm TL on 20 and 26 July, respectively. One other possible explanation for this difference is that the fish in these latter two pits may represent those of the second spawn, the first being unsuccessful for some reason.

Figure 15. Length-frequency of channel catfish from Lower Mississippi River main stem levee borrow pits



228. Carlander (1969) found little evidence for regional differences in growth of channel catfish, though more of the faster growing populations seemed to be in the south. No large differences in growth rate were noted among fish from ponds, lakes, streams, or large rivers. Channel catfish reach 75-150 mm TL after 1 year, 125-200 mm TL after 2 years, 175-300 mm TL after 3 years, and continue to grow rapidly for at least 6 to 7 years (Carlander, 1969). Based on these growth rates, year-class assignments have been made for the obvious length-frequency modes in Figure 15. Nearly every borrow pit in which channel catfish were very numerous (13 of 25 pits) showed a wide range in fish sizes, with the 1978-1980 year-classes (Age 1 through Age 3) predominating. The individual pits did vary somewhat, however, in the relative strengths of these year-classes. For example, the 1979 year-class was strongly represented in almost all pits shown on Figure 15. However, a number of pits (BP 2, 5, 7, 21, and 23) apparently lacked Age 1 (1980) fish, and other pits indicated that the 1981 year-class would also be weak or lacking. This inconsistent representation of year-classes may have its basis in the relative river levels of the years, as discussed in the section on buffalo.

229. Bluegill. Bluegill spawn from late May into early August at 19-27° C in Wisconsin (Becker, 1983). The height of the reproductive season is generally during June over much of the Upper Mississippi River System (Farabee, 1979). Based on the occurrence of larvae, bluegill do not appear to spawn much earlier than this in the Lower Mississippi River. In 1980, larval sunfishes (mostly bluegill) first occurred on 30 May in an abandoned channel, but the peaks of larval sunfish abundance were not until 24 July and 20 August. In 1978 the first occurrence of larvae and the major peaks in abundance were similar to 1980. Sunfish in an oxbow lake (probably very similar in terms of seasonal temperature regime to the borrow pits) did not appear to spawn appreciably earlier than those in river backwaters (Schramm and Pennington, 1980). However, as noted for gizzard shad, it does seem reasonable to assume that spawning might have begun slightly earlier in 1981, possibly as early as mid-May, due to the unusually warm spring.

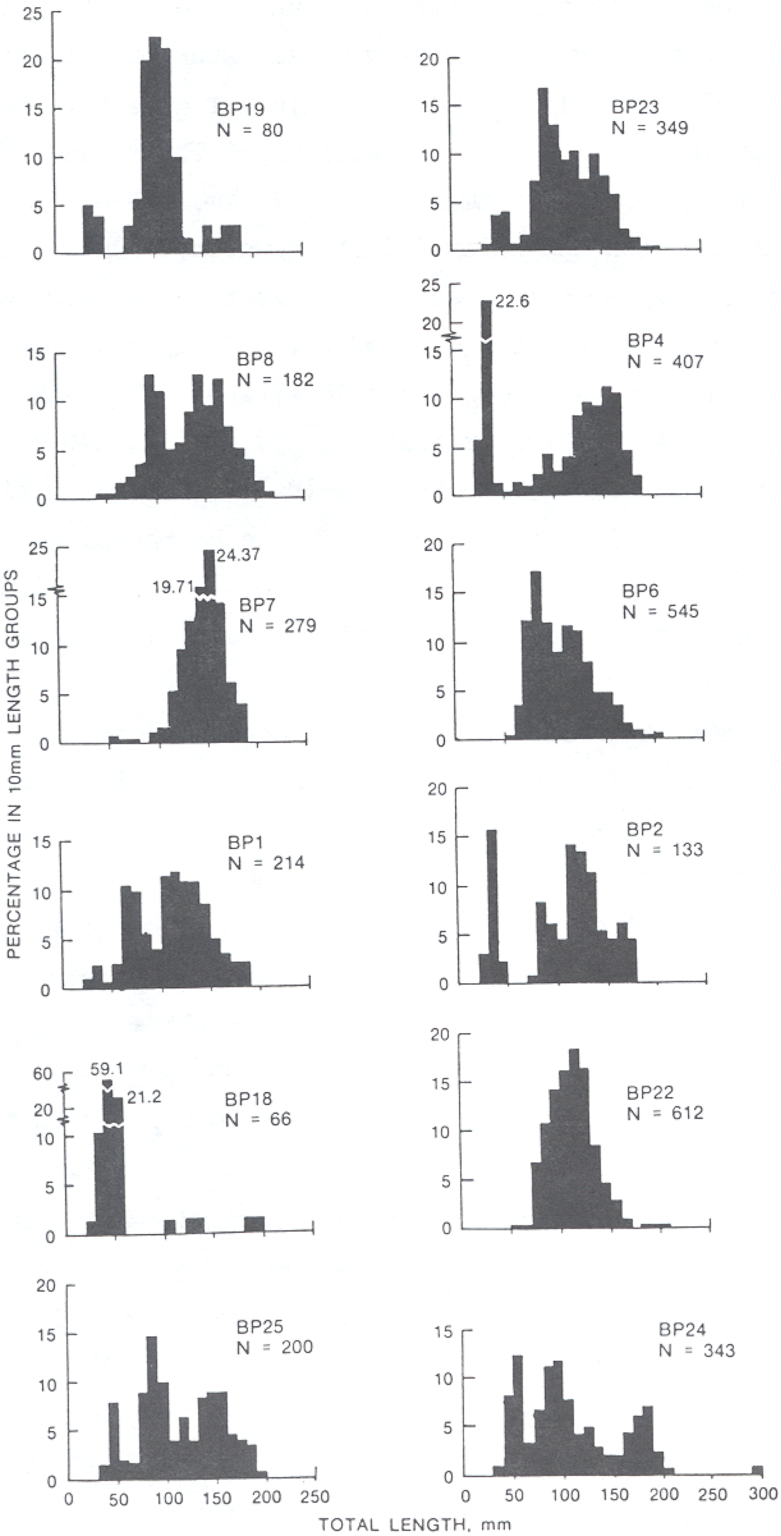
230. Carlander (1977) notes growth rates for YOY bluegill ranging from 0.1-0.6 mm TL/day, but the average seems to be about 0.3-0.4 mm/day for most populations. Growth of bluegill is notoriously variable due to the wide range of environmental conditions found in areas they inhabit, and also to their propensity to form very dense, stunted populations. Becker (1983) and Pflieger (1975) indicated similar growth rates of bluegill in Wisconsin and Missouri, respectively. Their fish reached the following sizes at Ages 1-5: 55 mm, 110 mm, 145 mm, 160 mm, and 175 mm, respectively. Christenson and Smith (1965), however, found much faster growth rates for this species in Mississippi River backwaters, with many fish reaching 210 mm TL by Age 5. Carlander (1977) also reported relatively fast growth from several Georgia rivers, where TL at the first six annuli were: 81 mm, 142 mm, 193 mm, 224 mm, 254 mm, and 279 mm TL.

231. Assuming this average growth rate (0.3-0.4 mm/day), bluegill reproduction began no earlier than mid-May in the borrow pits, an estimate which is consistent with that based on temperature considerations. No obvious differences reflecting a north-south gradient in time of reproduction were noted (Figure 16).

232. If the major length-frequency modes indicate year-classes, then the growth of bluegills in most of the borrow pits is comparable to Carlander's (1977) averages for the southern United States. Little difference among the pits (Figure 16) was apparent. Few fish in the pits exceeded 200 mm TL (Age 4 or 5). Most borrow pits showed evidence of successful spawns in each of the past 4 years. A few, however, had weak or absent YOY peaks (BPs 6, 7, 8, 13, and 22), and three pits (BPs 7, 11, and 22) showed evidence of having only a single, dominant year-class. Borrow pit 18, in which a fish kill was observed just prior to sampling, had mostly YOY bluegill.

233. White crappie. This species is reported to spawn in May and June in Wisconsin (Becker, 1983) at water temperatures of 16-20° C, and in Missouri from mid-April through June, when the water temperature exceeds 13° C (Pflieger, 1975). Texas and Oklahoma populations spawn primarily in May (Carlander, 1977) at this temperature. The peak of spawning activity of white crappie in the Lower Mississippi River is probably from late March to late April in most years.

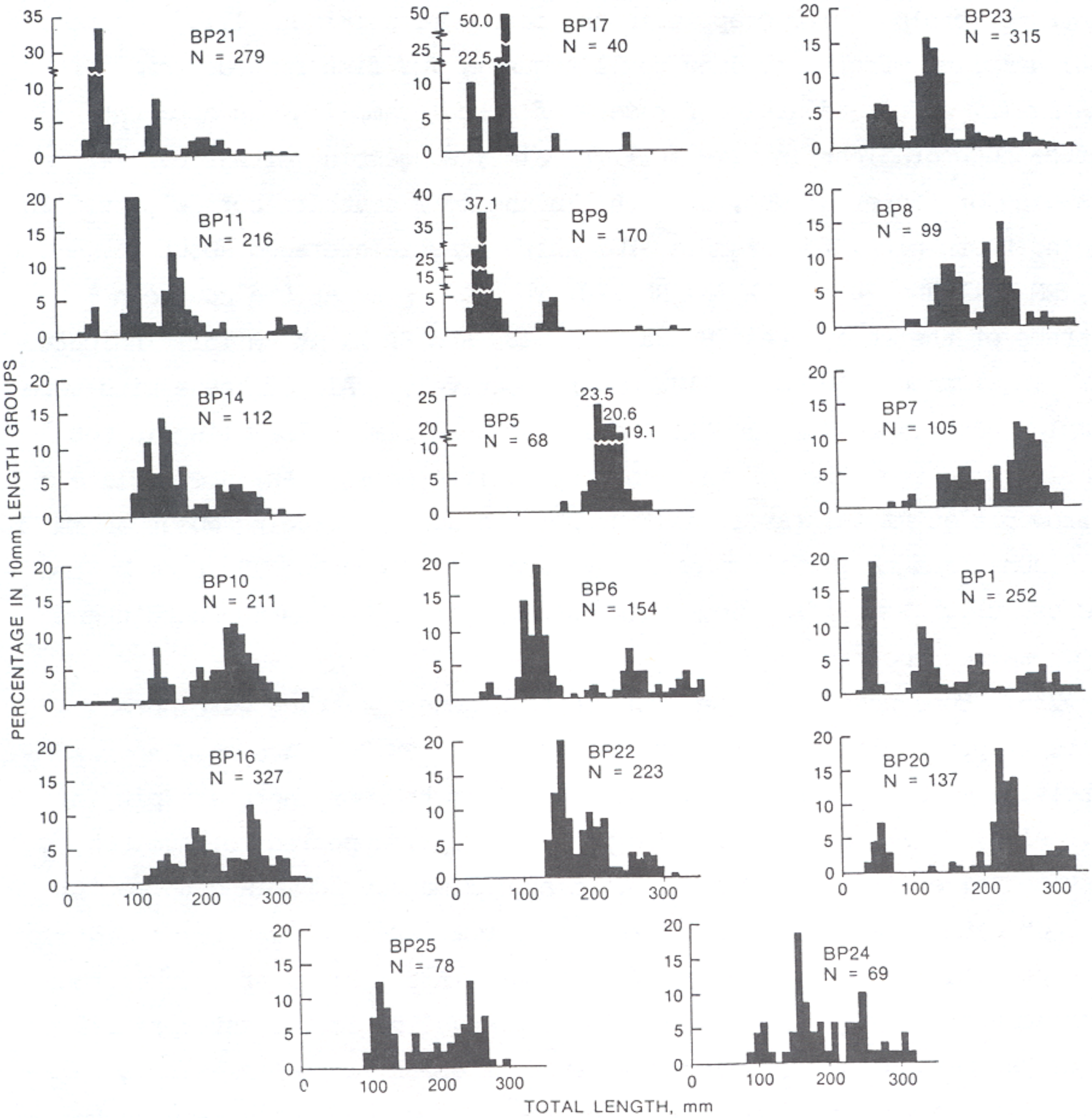
Figure 16. Length-frequency of bluegill from Lower Mississippi River main stem levee borrow pits. The size distribution similarities of bluegill are as follows: BP9 as BP23; BP10 as BP4; BP13 as BP6; BP15 as BP1; BP17, BP12, BP20 as BP2; BP11 as BP22; and BP14 as BP25.



234. Carlander (1977) indicates that the growth rate of young crappie ranges from about 0.50-1.3 mm TL/day. During the first month or two of life, the growth rate appears to be closer to 1.0 mm/day, but later in the summer and fall a rate of 0.5-0.75 mm/day seems to be more realistic. Carlander (1977) gives the following data on sizes at the first several annuli (formed at about spawning time) for white crappie from most of their range along the Gulf Coast, Age 1-5, respectively: 100 mm, 200 mm, 263 mm, 310 mm, and 344 mm. Using these sizes, we can make some statements concerning white crappie in the borrow pits (Figure 17). During the 1981 sampling efforts (9 June to 11 August), YOY fish ranged from 30 to 110 mm TL. After adjusting for date of actual sampling, an apparent north-south gradient in size still remains, suggesting either earlier spawning or faster growth, or both, in the more southern borrow pits. In two northern pits, for example, YOY white crappie averaged about 55 mm (BP 21, RM 881) and 70 mm (BP 23, RM 720) TL. Two pits at the southern extreme of the study area (BP 25 at RM 180 and BP 24 at RM 151) indicated mean TL of about 110 mm and 105 mm, respectively. All of these pits were sampled between 28 July and 11 August, so that time of sampling is not likely to be the cause of these observed differences. An intermediate borrow pit at RM 431 (BP 1) had YOY white crappie averaging about 35 mm TL on 9 June, and they would presumably have grown to about 75-90 mm by the end of July. Thus, fish from this borrow pit fit the north-south trend hypothesized above.

235. Some possible exceptions to this generalization were noted. White crappie collected on 26 July from BP 20, RM 305, averaged approximately 50 mm TL, about the same as those from the most northern pit, BP 21. Also, BP 17, a more northern pit at RM 773, appeared to have two distinct size classes of YOY fish, at approximately 50 mm and 85 mm TL. Without data on ages of these fish, we cannot determine whether the group at approximately 85 mm TL represents stunted Age 1 fish, or whether they represent relatively fast-growing Age 0 fish. The latter interpretation seems the more plausible, as the absence of older year-classes (Figure 17) would release more food for the young fish. However, notes made by the

Figure 17. Length-frequency of white crappie from Lower Mississippi River main stem levee borrow pits. The size distribution similarities of white crappie are as follows: BP4 as BP11, BP2 as BP7, and BP12 as BP1.



field crew indicated that this borrow pit was drying up, and that many fish were dying. If this is a regular occurrence, conditions in this borrow pit may be only marginal for fish growth and survival and would support the possibility that the approximately 85 mm TL fish are stunted Age 1 individuals.

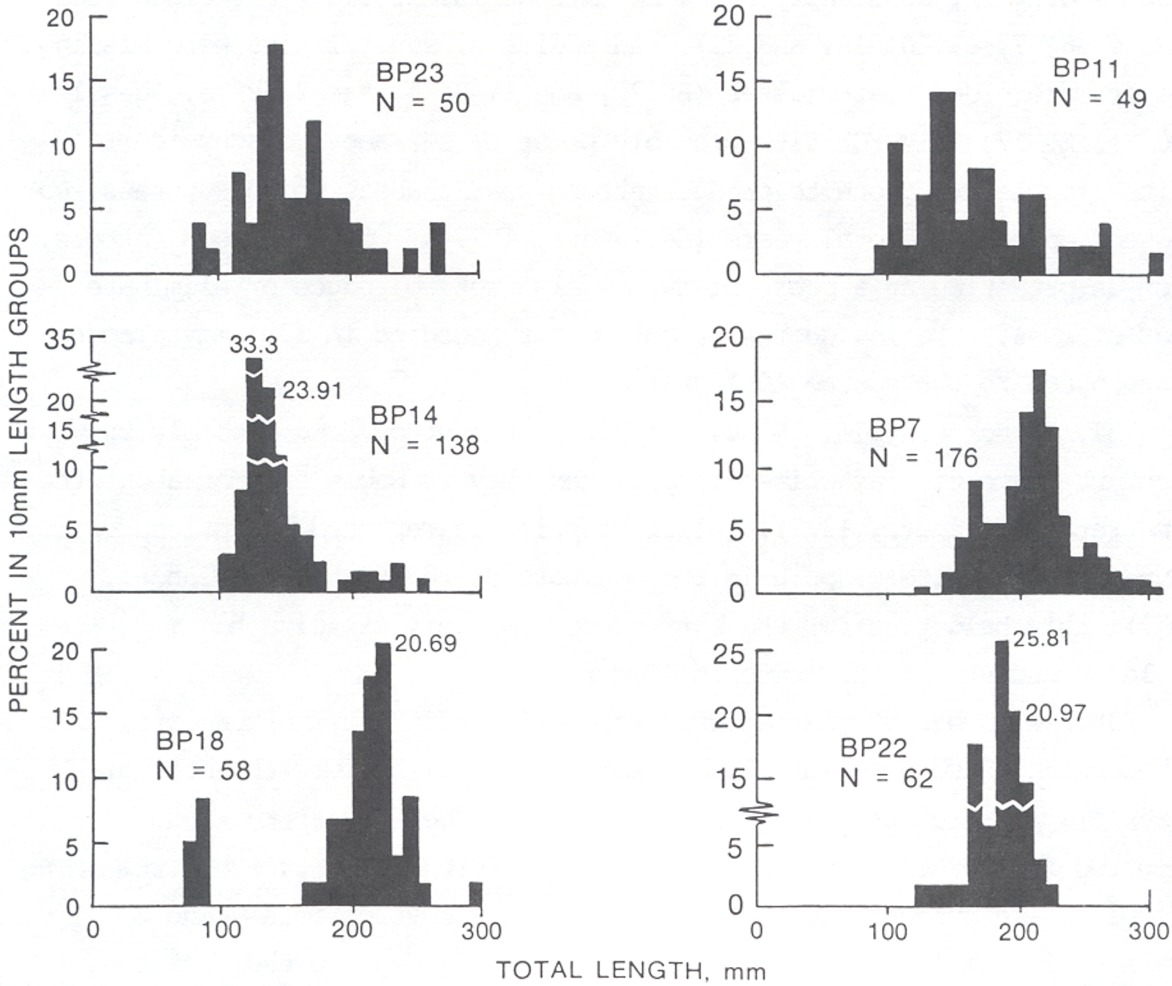
236. Seven borrow pits, not including those having too few white crappie overall, apparently had weak or nonexistent 1981 year-class fish (BPs 5, 6, 7, 8, 10, 16, and 22). In addition, several pits were missing one or more older year-classes (BP 20, Age 1; BP 9, Age 2; BP 5, Ages 1 and 2+; BP 17, only YOY fish probably present, see above discussion). White crappie are prone to produce strong year-classes which suppress subsequent ones for several years (Carlander, 1977). Other unknown factors, such as predation or a poor spawn, may also act to reduce or eliminate year-classes. The low degree of borrow pit flooding in 1981 may also have contributed to the sparse 1981 year-class.

237. Black crappie. Black crappie in the study area probably spawn about the same time as white crappie, and they probably grow at about the same rate (Carlander, 1977). Black crappie are reported to be less abundant than white crappie in the southern United States (Carlander, 1977); this held true for the borrow pits, as only six pits had moderate to large numbers of this species (Figure 18).

238. A number of year-classes were evident in many borrow pits, although only two pits (BPs 18 and 23) had YOY fish. Growth rates of black crappie from the borrow pits appeared to be similar to those reported from other southern US waters. Differences in growth rates among the pits were evident, however. Fish that are most certainly Age 2 averaged 180 mm TL in BP 22 and 215 mm in BP 18, despite the fact that these pits were in the same area (RM 315 and 323, respectively), were sampled at about the same time (28 and 23 July), and had similar densities of crappie. The reasons for such differences are not known.

239. Largemouth bass. Largemouth bass spawn in the early spring to early summer at water temperatures above 16^{o} C (Stroud and Clepper, 1975). In central Mississippi, largemouth bass usually spawn from mid-March through mid-April, when the water temperature in the shallow

Figure 18. Length-frequency of black crappie from Lower Mississippi River main stem levee borrow pits



spawning areas reaches 18-19° C. Young bass grow rapidly, reaching 35 mm by early May; thus, they average nearly 1.0 mm TL/day.

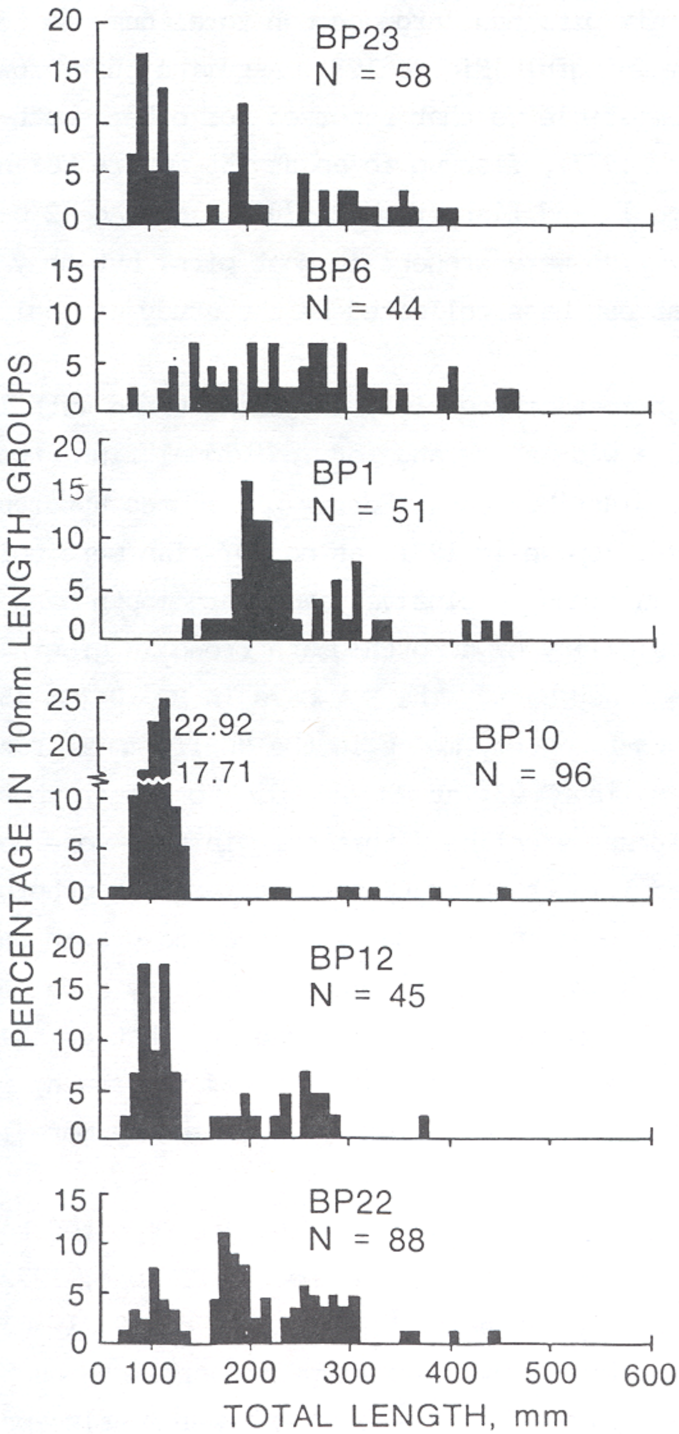
240. Although all individuals of this species were measured in each borrow pit, only six pits had large enough total numbers to make length-frequency plots meaningful (Figure 19). Assuming that growth in the borrow pits is comparable to that reported for other south-central US waters (Carlander, 1977), fish up to about 150 mm are YOY bass, fish from 150-225 mm are Age 1, and fish from 226-300 mm are Age 2 bass. Larger, presumably older, fish were present in most pits, but they were not abundant. The largest bass collected in the study was only about 450 mm TL.

241. Although most borrow pits, including those with few largemouth bass overall, had a wide size range of individual fish, two pits did have more unusual size distributions. Borrow pit 1 bass apparently did not produce a successful spawn in 1981, as no YOY fish were collected. In contrast, BP 10 had almost exclusively YOY largemouth bass.

242. The possibility of a north-south trend in growth was suggested by the length-frequency data. The YOY bass in BP 10 (RM 456) and BP 12 (RM 377) had length-frequency modes in the 90-110 mm TL range in early July while YOY bass in BP 23, at RM 720, did not reach this length until 1 month later. It seems unlikely that bass in this more northern pit would have spawned 1 month later than those in the southern pits, so that the observed differences must be due to differing growth rates. However, in a third pit at the southern extreme of the study area (BP 22, RM 315), the growth of YOY largemouth bass was closer to that of the more northern BP 23. This suggests that a north-south trend in growth, if it exists, is moderated by variability among borrow pits caused by more localized factors.

243. Freshwater drum. Freshwater drum are reported to spawn in May and June in the Upper Mississppi River pools (Farabee, 1979) and in Wisconsin (Becker, 1983) at water temperatures of 19-21° C. Pflieger (1975) reports spawning in Missouri from late April through May. That this species spawns in May and June in the Lower Mississippi River is substantiated by the times of occurrence of drum larvae. Schramm and

Figure 19. Length-frequency of largemouth bass from Lower Mississippi River main stem levee borrow pits



Pennington (1981) and Conner, Pennington, and Bosley (1983) found that the peak in abundance of larval freshwater drum occurred from late May through early July in 1978 and 1980, with two major peaks being indicated.

244. Freshwater drum spawn pelagically in open water, usually far from the shore (Becker, 1983), so that larvae probably do not generally occur in borrow pits. This was suggested in the two larval fish studies cited above, in which drum larvae were almost never collected in abandoned channels or natural oxbow lakes. Therefore, the drum occurring in the borrow pits were present entirely due to immigration from the river.

245. Growth of freshwater drum appears to depend more on local conditions than on latitude. This species is reported to reach 130, 200, 250, 290, and 335 mm TL at the first five annuli in Wisconsin (Becker, 1983). Fish from Missouri (Pflieger, 1975) are reported to be smaller at the first annulus, but somewhat larger at successive annuli, than the Wisconsin fish. Christenson and Smith (1965) found somewhat faster growth in the Mississippi River proper than has been reported for other waters. Farabee (1979) has noted that significant differences in growth often occur among pools in the Mississippi River.

246. Apparent year-classes are indicated for the freshwater drum from the borrow pits by the following length-frequency modes (Figure 20): Age 1, 150 mm TL; Age 2, 240 mm; Age 3, 290 mm; and Age 4, 325 mm. These fish were collected in June and July of 1981, and their length-frequencies compare favorably with freshwater drum from the adjacent length of the Mississippi River (Pennington, Baker, and Bond, 1983). The drum from the river in June were about 150 mm, 200-250 mm, 275-300 mm, 200-375+ mm, and 375+ mm for apparent Ages 1-5, respectively.

247. A number of interesting size distributions occurred in the borrow pits. With the exception of BP 11 (RM 602), the northernmost pits apparently lacked 1980 year-class fish, while pits south of BP 5 (RM 462) generally showed this year-class in strength. Since the presence of freshwater drum in the borrow pits depends upon the river becoming confluent with the pits (the drum probably do not spawn in the pits), this suggests some north-south gradient in the pattern of river confluency with the pits (see Morphometry and Hydrology, Part III). Most of the borrow

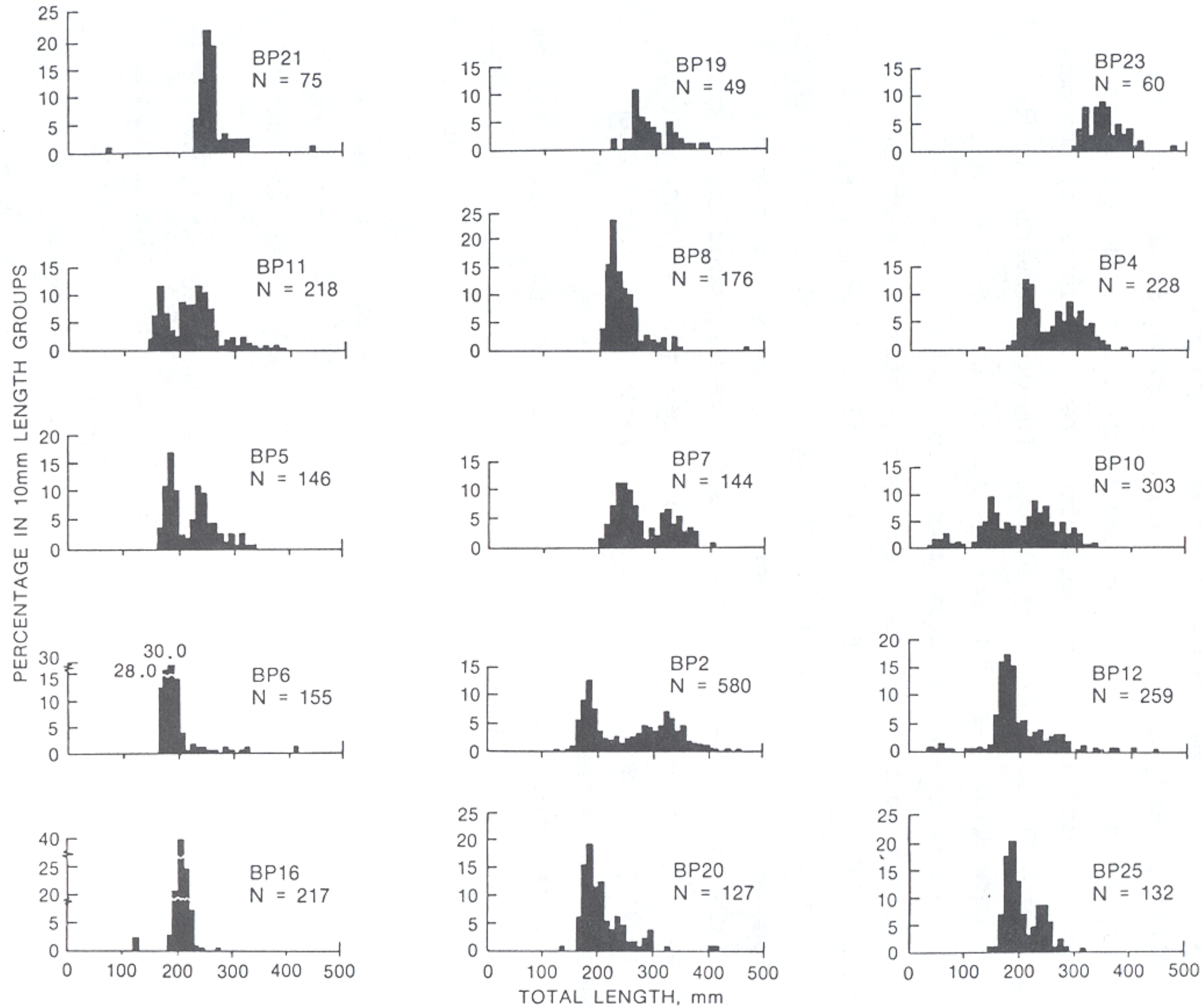


Figure 20. Length-frequency of freshwater drum from Lower Mississippi River main stem levee borrow pits

pits were dominated by fish of only one or two year-classes. When river levels rise, freshwater drum (and other species) undoubtedly move both in and out of the pits until decreasing river stages isolate the pits once again. The fish that remain in the borrow pits after the river recedes are probably a function both of the characteristics of the pits (pits having desirable characteristics are less likely to be vacated by drum) and of simple chance. The structure of the population in each pit is then set until the river again becomes joined to the pit and the process is repeated.

Fisheries, Physical and Hydrologic Relationships

248. In order to determine the relationship between borrow pit hydrologic and morphometric variables and fish standing stock and species composition, step-wise regression analyses were conducted. Ten morphological features of each borrow pit were correlated against numbers and weights of fish by family or species group and for summary statistics such as total number, biomass, and number of species. Only those physical variables which reduced the F-value in the regression analysis by at least 15 percent were incorporated into the equation. Results of the step-wise regression analysis are presented in Table 14.

249. Correlation analyses were also performed between weights and numbers of the different fish families and species groups to determine relationships between the taxonomic groups. Certain precautions should be noted when interpreting these data. The fact that there may be a significant decrease in standing crop of one species when another is present and that the standing crop may further decrease as the other species becomes more abundant does not necessarily indicate that interspecific competition is occurring. This analysis may not give proof of competition, but certainly aids in determining where competition may be suspected (Carlander, 1955). The wide range of species combinations and environmental conditions encountered during this study may further tend to mask the effects of interspecific competition. Results of the linear correlations are given in Tables 15 and 16.

250. Of the ten variables measured, days flooded was the most important in explaining the variation among borrow pits for the greatest number of species groups. Borrow pits which are flooded for a relatively great number of days during the year tend to support a higher total standing stock of fish than do pits which are flooded for a relatively few days during the year (Table 14). The average annual number of days a borrow pit is flooded is positively associated with standing stock of Catostomidae, Clupeidae, crappie, Cyrinidae, Ictaluridae, other fishes (a combination of gars, freshwater drum, and paddlefish), and total fish. Number per acre of fish was positively related to average annual days flooded for Catostomidae, crappie, and other fish.

251. Of the remaining nine variables, VDI and mean depth had the most influence on population differences among borrow pits (Table 14). The VDI was strongly associated with the number of fish species found in a borrow pit and with the number of Ictaluridae and largemouth bass. Mean depth was positively associated with standing stock of largemouth bass and showed a weak negative association with number of species and sunfish. The SDI was positively associated with both standing stock and numbers of sunfishes.

252. The significant negative correlation (r = -0.47) between total number and weight of fish suggests that borrow pits tend to be populated either by a few large fish or many smaller fish (Table 15). The total weight of all fish in a borrow pit is strongly correlated with the weight of suckers; these are large species, and almost all those collected in the borrow pits were adults.

253. Large weights of carp, suckers, catfishes, and "others" tend to co-occur in the borrow pits (Table 16). Both numbers and weights of largemouth bass and crappies are significantly correlated (r = 0.73 and r = 0.65, respectively). High weights of largemouth bass and crappies often "replace" high weights of suckers in borrow pits; that is, high weights of carp, catfishes, and "others" may occur with high weights of bass and crappies or high weights of suckers, but generally not both.

254. The weight and numbers of sunfish and shad (probably the major prey items for piscivorous fish such as crappies, bass, gar, and to some

extent catfishes) showed only a single significant correlation with the weight of any of these predator groups (Table 16). Sunfish numbers were positively correlated ($r = 0.49$) with the number of "others" in a pit.

Commercial and Recreational Fisheries Values

255. Borrow pits associated with the main stem levee system average 354 pounds/acre of commercial fish and 44 pounds/acre of sport fish. Thus, a potentially valuable fishery resource is found in the levee borrow pit system.

256. Commercial fishery. Maximum anticipated commercial fishery yield may be expressed as a function of fish standing stock and latitude (Jenkins, 1974). Using Jenkins' relationships, 90 percent of the commercial fish standing stock of levee borrow pits would be the expected annual yield. Approximately 80 percent of available standing stock of commercial fish in borrow pits would be available for harvest (Lantz, 1970). Using the average commercial fish standing stock value of 354 pounds/acre, it can be seen that 255 pounds/acre ($354 \times 0.9 \times 0.8 = 255$) would be the maximum expected annual main stem levee borrow pit commercial fish yield or harvest. Using a gross exvessel price of $1.25 per pound for catfishes and $0.50 per pound for all other commercial fishes results in an average price of $0.57 per pound or $145 per acre of borrow pit annually. Since there are 10,600 acres of main stem levee borrow pits, the estimated potential commercial fishery yield is 2,703,000 pounds valued at over $1.5 million. The utilization of this fishery is not clearly understood, but substantial commercial fishing activity has been observed in some borrow pits. Legal access to borrow pits and profitability of commercial fishing are limiting factors for the fishery.

257. Sport fishery. Sport fishing is popular in many levee borrow pits, particularly near population centers. However, the magnitude of sport fishing throughout the levee borrow pit system along the Lower Mississippi River has not been quantified.

258. An estimate of the potential sport fishing value of borrow pits was made using the average sport fish standing stock value for borrow pits (44 pounds/acre). It was assumed based on local sport fishing data that the average harvest per fisherman day is 0.5 pound and that the maximum

anticipated yield as a function of standing stock and latitude (Jenkins, 1974) is 90 percent of standing stock. It was also assumed that 94 percent of the sport fish standing stock would be available for harvest by fisherman (Lantz, 1970). Thus, it was caculated that the levee borrow pits would potentially support 18.6 man-days/acre of sport fishing (44 pounds/acre x 0.5 x 0.9 x 0.94 = 18.6). The total potential sport fishing resource made up by the 10,600 acres of main stem levee system borrow pits would be 197,160 man-days annually. Legal and physical access to levee borrow pits are limiting factors to use of the borrow pit sport fishery resource.

PART IV: CONCLUSIONS

259. The series of main stem levee borrow pits along the Lower Mississippi River constitute a significant resource with respect to fish production, aquatic habitat, and sport and commercial fisheries. The total standing stock of fish averaged 595 pounds per acre in the borrow pits, greater than in most water bodies in the southern United States. A high fishery productivity is suggested by the average standing stock found. Standing stock of benthic macroinvertebrates in the borrow pits is also comparatively high. Since many benthic organisms are utilized by various fish species as food, the abundance of benthic organisms is additional evidence of the value of borrow pits as fish habitat.

260. Borrow pits on the leveed floodplain appear to be important habitat for such fishes as largemouth bass, crappies, sunfishes, and gars. Large numbers of these species are produced in the borrow pits. Flooding probably relieves periodic overpopulation and crowding, and results in a net export of fish to Mississippi River channel habitats and floodplain lakes, and abandoned channels.

261. Certain riverine fishes probably use borrow pits as well as inundated floodplain areas as spawning grounds. For example, important riverine species such as bigmouth and smallmouth buffaloes and the common

carp may require backwater areas, including borrow pits, to maintain viable populations. Freshwater drum and some other fishes may only use the borrow pits facultatively.

262. The length of time that borrow pits are flooded annually on the average is the single most important factor that influences population densities, standing stock, and diversity of borrow pit fishes and benthic macroinvertebrates. The greater the average annual days flooded, the more productive the borrow pits.

263. The relative length of shoreline per unit surface area (shoreline development index), an expression of the amount of littoral zone used for fish spawning, detritus processing, and other ecological functions, is also of major importance in determining borrow pit productivity. The more convoluted the shoreline, the greater the abundance of bluegill and tubificid worms.

264. Water depth is also important in levee borrow pits with regard to production. The greater the average depth, the more abundant are largemouth bass. Uniformity of depth is also apparently important to the production of the dominant benthic macroinvertebrate *Chaoborus punctipennis*.

265. Borrow pit size and volume appear to have little effect on abundance of fishes and benthic macroinvertebrates.

266. A diversity of borrow pit types, sizes, and shapes is probably desirable overall to fishes and other aquatic biota so that many species with a variety of habitat requirements can benefit from these areas.

267. In summary, the main stem levee borrow pit data strongly suggest that borrow pits which flood longer annually, are deeper, and have a sinuous shoreline support the greatest number of species, highest population densities, and greatest standing stocks of fishes and benthic macroinvertebrates.

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TABLE 1
Location of the 25 Main Stem Mississippi River
Levee Borrow Pits Selected for Study

Borrow Pit	Location	River Mile	River Bank	Distance to Main River Channel (Mile)
1	Madison Parish, LA	431	R 1/	0.3
2	Tensas Parish, LA	407	R	7.4
3	East Carroll Parish, LA	469	R	0.4
4	East Carroll Parish, LA	482	R	0.4
5	East Carroll Parish, LA	462	R	0.6
6	Madison Parish, LA	433	R	1.3
7	Warren County, MS	460	L 2/	0.9
8	Bolivar County, MS	593	L	0.3
9	Bolivar County, MS	595	L	1.1
10	Madison Parish, LA	456	R	0.1
11	Bolivar County, MS	602	L	2.1
12	Concordia & Tensas Parishes, LA	377	R	0.7
13	Phillips County, AR	656	R	0.3
14	Desha County, AR	584	R	4.3
15	Coahoma County, MS	659	L	1.8
16	Concordia Parish, LA	355	R	0.2
17	Mississippi County, AR	733	R	2.3
18	Concordia Parish, LA	323	R	1.8
19	New Madrid County, MO	877	R	0.8
20	Concordia Parish, LA	305	R	0.3
21	New Madrid County, MO	881	R	2.5
22	Concordia Parish, LA	315	R	0.4
23	Shelby County, TN	720	L	1.0
24	St. James Parish, LA	151	L	0.1
25	Ascension Parish, LA	180	L	0.1

1/ Right descending bank.
2/ Left descending bank.

TABLE 2
Hydrologic, Morphometric, and Location Data for 25 Borrow Pits
Along the Main Stem Levee System of the Lower Mississippi River

Borrow Pit Number	River Mile	Surface Area	Mean Depth	Maximum Depth	% Area ≥5 ft Deep	% Area ≥10 ft Deep	Shoreline Length (ft)	Shoreline Development Index	Volume (cu yd)	Volume Development Index	Mean Basin Slope	Controlling Elevation (ft, NGVD)	Controlling Elevation (ft, LWRP) 1/	Average Annual Days Flooded
21	881,R 2/	9.2	1.70	3.5	0	0	4,545	2.0	23,167	1.5	0.02	287.0	34.0	24
19	877,R	7.4	0.54	1.1	0	0	4,090	2.0	6,479	1.5	0.01	279.1	26.1	63
17	773,R	38.1	2.96	5.7	21.9	0	10,498	2.3	183,100	1.6	0.03	235.0	35.0	25
23	720,L 3/	17.7	2.84	6.2	26.5	0	7,851	2.5	76,025	1.4	0.03	195.0	19.0	115
15	659,L	53.3	3.92	7.5	44.6	0	8,881	1.6	348,228	1.6	0.02	173.0	28.0	56
13	656,R	53.4	3.85	16.9	30.9	8.3	14,008	2.6	309,178	0.7	0.05	171.0	29.0	56
11	609,L	4.3	0.60	1.6	0	0	4,372	2.8	4,056	1.1	0.03	143.7	25.7	98
9	595,L	3.3	1.70	3.5	1.6	0	1,916	1.4	9,780	1.5	0.03	137.2	24.2	84
8	593,L	16.2	2.20	4.2	8.0	0	5,802	2.0	61,516	1.6	0.02	139.8	28.7	98
14	584,R	47.6	2.90	5.5	15.9	0	15,064	3.0	224,106	1.6	0.02	137.0	31.0	89
4	482,R	32.1	2.00	4.5	17.1	0	9,531	2.3	100,102	1.3	0.02	90.5	28.5	84
3	469,R	39.6	2.60	8.2	5.4	0	5,472	1.2	153,090	0.9	0.02	89.0	30.0	84
5	462,R	12.7	1.46	2.7	0	0	4,055	1.5	29,186	1.6	0.01	84.0	29.0	84
7	460,L	5.2	2.60	4.5	1.2	0	2,761	1.6	18,215	1.7	0.03	79.8	24.8	111
10	456,R	9.1	2.76	4.8	49.0	0	3,440	1.6	45,495	1.7	0.03	81.6	27.6	104
6	433,R	4.5	3.80	6.0	55.5	0	5,737	1.5	165,053	1.9	0.02	79.8	34.8	89
1	431,R	13.9	6.55	11.1	71.7	9.9	4,408	1.6	133,857	1.8	0.06	73.0	29.0	84
2	407,R	18.6	5.70	10.4	71.2	21.4	4,839	1.5	178,733	1.6	0.05	68.8	33.8	71
12	377,R	9.3	2.10	4.0	0	0	3,786	1.7	29,973	1.6	0.02	55.0	29.0	84
16	355,R	7.4	1.40	3.0	0	0	3,617	1.8	18,091	1.4	0.02	49.1	30.1	84
18	323,R	3.3	2.17	5.1	9.2	0	3,559	2.6	10,779	1.3	0.05	41.8	28.8	84
22	315,R	6.7	7.16	17.7	64.9	33.0	4,947	2.6	71,813	1.2	0.14	47.0	35.0	65
20	305,R	6.8	4.60	7.7	65.1	0	2,580	1.3	51,313	1.8	0.05	40.0	29.0	99
25	180,L	36.9	5.60	10.3	66.9	7.6	15,224	3.4	325,348	1.6	0.07	21.0	20.0	81
24	151,L	22.1	4.25	7.5	60.6	0	10,796	3.1	149,314	1.7	0.06	14.0	13.0	117

1/ Lower Water Reference Plane.
2/ R indicates right descending riverbank.
3/ L indicates left descending riverbank.

TABLE 3
Correlation Matrix for Hydrologic and Morphometric Data for 25 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River

Item	River Mile	Controlling Elevation	Average Days Flooded	Percent Days Flooded	Surface Area	Shoreline Length	Shoreline Development Index	Volume	Volume Development Index	Mean Depth	Maximum Depth	Mean Basin Slope
River Mile	1.00	0.98	-0.52	-0.53	0.14	0.001	-0.12	-0.07	-0.19	-0.49	-0.31	-0.50
Controlling Elevation		1.00	-0.58	-0.58	0.15	0.08	-0.01	-0.02	-0.17	-0.44	-0.28	-0.43
Average Days Flooded			1.00	0.99	-0.29	-0.16	0.02	-0.27	0.21	-0.03	-0.17	-0.02
Percent Days Flooded				1.00	-0.30	-0.18	0.01	-0.27	0.19	-0.03	-0.16	-0.01
Surface Area					1.00	0.83	0.24	0.91	-0.23	0.25	0.40	-0.09
Shoreline Length						1.00	0.71	0.81	-0.19	0.26	0.38	0.11
Shoreline Development Index							1.00	0.29	-0.25	0.11	0.21	0.38
Volume								1.00	-0.08	0.52	0.57	0.16
Volume Development Index									1.00	0.18	-0.32	-0.14
Mean Depth										1.00	0.85	0.78
Maximum Depth											1.00	0.79
Mean Basin Slope												1.00

TABLE 4
Sediment Characteristics of 25 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River

Borrow Pit	Average Percent Silt-Clay	Coefficient of Variation	Range	Skewness	Kurtosis
1	97.8	1.4	95.2-99.1	-1.78	3.8
2	96.9	1.6	94.1-98.6	1.12	1.4
3	87.6	12.4	72.1-96.0	-0.91	-1.5
4	96.5	4.3	88.3-99.5	-2.2	5.1
5	99.6	0.1	99.5-99.8	1.6	2.6
6	94.4	8.1	79.5-99.3	-2.0	3.9
7	98.5	1.4	95.8-99.4	-2.2	4.9
8	81.7	27.3	42.8-97.3	-1.4	0.8
9	97.1	3.2	92.9-99.5	-0.9	-1.8
10	67.2	46.4	24.6-98.3	-0.7	-1.8
11	99.5	0.4	98.7-99.9	-1.7	3.3
12	85.8	18.4	57.9-99.2	-1.3	1.3
13	54.6	45.9	17.7-82.3	-0.4	-1.3
14	80.5	33.9	29.5-99.0	-1.7	2.7
15	72.9	20.1	57.6-90.6	0.04	-2.4
16	75.1	21.2	45.5-88.3	-1.5	2.8
17	92.4	7.0	82.6-97.4	-1.0	-1.3
18	98.8	0.8	97.7-99.6	-0.9	-1.7
19	90.0	13.0	67.3-99.3	-2.0	4.3
20	95.9	4.0	90.3-99.2	-0.5	-1.7
21	67.4	36.4	45.5-99.0	0.72	-1.9
22	95.3	4.5	89.5-99.4	-0.8	-1.8
23	97.0	5.3	86.5-99.8	-2.4	5.7
24	99.1	0.4	98.5-99.6	-0.2	-0.5
25	97.0	2.9	92.4-99.1	-1.2	-0.4

TABLE 5
Mean Value of Water Quality Variables from 25 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River
(Borrow Pits are Ordered by Descending River Mile)

Borrow Pit	Temperature (C)	Dissolved Oxygen (mg/l)	Conductivity (umhos/cm)	pH	Turbidity (NTU)	Secchi Disc (cm)	Oxidation-Reduction Potential (mv)
21	31.5	7.9	56	7.8	74	10	389
19	34.8	7.7	287	9.5	40	10	225
17	33.3	9.4	234	8.1	16	32	285
23	27.8	4.2	245	8.1	18	10	298
15	32.8	5.6	368	7.7	11	37	320
13	34.4	8.9	317	8.4	8	35	303
11	29.8	5.9	373	8.7	19	10	234
9	31.4	10.2	432	8.2	13	25	281
8	31.3	11.0	285	8.5	23	20	250
14	31.5	7.6	225	8.8	57	10	201
4	32.8	10.1	372	8.5	17	27	283
3	31.7	9.3	315	8.6	10	55	266
5	34.5	5.7	240	8.5	85	10	195
7	33.1	6.3	323	7.5	51	10	243
10	26.7	6.6	321	7.6	14	30	261
6	31.8	4.2	341	7.6	18	30	298
1	28.5	5.2	353	8.1	10	40	308
2	32.0	5.6	205	8.1	42	16	235
12	31.7	5.7	310	7.8	18	20	266
16	30.3	4.1	367	8.2	12	15	255
18	29.7	0.6	515	7.0	18	28	65
22	31.6	6.7	227	8.3	17	48	271
20	31.6	3.4	250	7.2	45	16	343
25	32.1	5.3	336	7.8	10	32	261
24	31.0	4.9	443	7.8	19	18	291

TABLE 6
Spatial Distribution of Macrobenthos and Sediment Grain Size in 25 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River 1/ 2/

Borrow Pit 21, River Mile 881 R

TRANSECT A	Station A1	A2	A3
Tanypus	1	7	5
Tubificidae	2	6	9
Naididae	18	0	1
Coelotanypus	0	3	3
Standing Stock	4.5	9.4	8.2
% Silt-Clay	45.9	97.1	99.0

TRANSECT B	Station B1	B2	B3
Tanypus	9	5	0
Tubificidae	8	6	25
Naididae	1	3	5
Coelotanypus	3	0	2
Standing Stock	17.0	2.6	5.6
% Silt-Clay	45.5	55.3	61.6

Borrow Pit 17, River Mile 773 R

TRANSECT A	Station A1	A2	A3
Chaoborus	5	42	60
Tanypus	0	4	4
Tubificidae	0	10	8
Nematoda	4	9	0
Standing Stock	35.4	20.7	23.1
% Silt-Clay	82.6	95.6	97.0

TRANSECT B	Station B1	B2	B3
Chaoborus	4	10	42
Tanypus	1	3	13
Tubificidae	3	18	18
Nematoda	59	1	1
Standing Stock	2.7	26.5	59.0
% Silt-Clay	85.7	97.4	95.8

Borrow Pit 19, River Mile 877 R

TRANSECT A	Station A1	A2	A3
Chaoborus	1	3	1
Tanypus	0	2	2
Tubificidae	1	1	10
Coelotanypus	0	3	3
Standing Stock	1.9	7.2	28.8
% Silt-Clay	97.0	93.5	67.3

TRANSECT B	Station B1	B2	B3
Chaoborus	0	1	1
Tanypus	0	2	3
Tubificidae	1	1	1
Coelotanypus	0	1	3
Standing Stock	0.5	2.25	5.05
% Silt-Clay	89.2	99.3	93.5

Borrow Pit 23, River Mile 720 L

TRANSECT A	Station A3	A2	A1
Tanypus	48	33	18
Chaoborus	10	139	7
Chironomus sp.2	7	0	3
Coelotanypus	13	0	34
Standing Stock	42.5	29.4	21.5
% Silt-Clay	98.9	99.8	97.9

TRANSECT B	Station B3	B2	B1
Tanypus	20	124	74
Chaoborus	7	37	14
Chironomus sp.2	191	7	1
Coelotanypus	33	7	14
Standing Stock	215.9	39.0	31.3
% Silt-Clay	86.5	99.3	99.3

(Continued)

1/ Values for all taxa expressed as average number organisms/sample.

2/ All standing stock values expressed as average mg dry weight/sample.

TABLE 6 (Continued)

Borrow Pit 15, River Mile 659 L

TRANSECT A	A3	A2	A1
Nematoda	0	1	1
Tanypus	2	34	6
Chaoborus	1	21	5
Tubificidae	1	4	1
Standing Stock	1.3	6.2	2.9
% Silt-Clay	-	90.6	83.3

TRANSECT B	B3	B2	B1
Nematoda	2	4	73
Tanypus	16	7	2
Chaoborus	19	7	2
Tubificidae	4	1	13
Standing Stock	13.3	6.2	8.7
% Silt-Clay	74.1	57.6	58.7

Borrow Pit 13, River Mile 656 R

TRANSECT A	A1	A2	A3
Chaoborus	0	2	4
Tubificidae	3	30	5
Tanypus	7	8	7
Chironomus sp.2	0	6	1
Naididae	0	3	2
Standing Stock	2.7	8.7	5.0
% Silt-Clay	82.3	17.7	41.6

TRANSECT B	B1	B2	B3
Chaoborus	0	5	2
Tubificidae	4	7	25
Tanypus	12	11	3
Chironomus sp.2	0	0	0
Naididae	1	0	8
Standing Stock	5.5	7.1	16.5
% Silt-Clay	77.9	66.3	41.8

Borrow Pit 11, River Mile 609 L

TRANSECT A	A3	A2	A1
Tanypus	11	46	63
Tubificidae	2	2	16
Chaoborus	6	14	4
Standing Stock	6.7	9.1	12.3
% Silt-Clay	99.5	99.8	98.7

TRANSECT B	B3	B2	B1
Tanypus	23	28	45
Tubificidae	22	3	20
Chaoborus	2	12	5
Standing Stock	8.3	5.9	9.5
% Silt-Clay	99.6	99.9	99.5

Borrow Pit 9, River Mile 595 L

TRANSECT A	A3	A2	A1
Glyptotendipes	0	1	273
Chaoborus	34	21	1
Tubificidae	3	7	4
Standing Stock	60.7	13.7	100.8
% Silt-Clay	98.8	99.3	98.8

TRANSECT B	B3	B2	B1
Glyptotendipes	2	0	0
Chaoborus	4	17	90
Tubificidae	1	12	22
Standing Stock	18.2	11.4	37.7
% Silt-Clay	93.3	92.9	99.5

(Continued)

TABLE 6 (Continued)

Borrow Pit 8, River Mile 593 L

TRANSECT A	A3	A2	A1
Tanypus	27	80	77
Tubificidae	16	8	7
Chaoborus	28	10	14
Standing Stock	74.5	23.6	75.5
% Silt-Clay	42.8	97.0	88.7

TRANSECT B	B3	B2	B1
Tanypus	64	84	50
Tubificidae	4	9	24
Chaoborus	13	10	1
Standing Stock	29.9	29.2	20.4
% Silt-Clay	97.0	97.3	67.2

Borrow Pit 14, River Mile 584 R

TRANSECT A	A1	A2	A3
Tanypus	18	5	2
Tubificidae	58	5	12
Chironomus	18	3	3
Standing Stock	12.7	3.1	7.6
% Silt-Clay	29.5	99.0	99.0

TRANSECT B	B1	B2	B3
Tanypus	16	2	15
Tubificidae	21	7	4
Chironomus	0	1	0
Standing Stock	6.3	8.1	4.3
% Silt-Clay	69.5	94.7	91.4

Borrow Pit 4, River Mile 482 R

TRANSECT A	A1	A2	A3
Tanypus	20	2	15
Chaoborus	9	9	11
Tubificidae	7	1	7
Standing Stock	11.5	1.2	6.2
% Silt-Clay	97.3	97.2	98.9

TRANSECT B	B1	B2	B3
Tanypus	13	31	34
Chaoborus	2	22	15
Tubificidae	7	8	14
Standing Stock	13.3	14.3	26.5
% Silt-Clay	88.3	98.1	99.5

Borrow Pit 3, River Mile 469 R

TRANSECT A	A1	A2	A3
Glyptotendipes	3	4	4
Standing Stock	63.1	14.1	9.15
% Silt-Clay	95.5	94.2	72.1

TRANSECT B	B1	B2	B3
Glyptotendipes	1	0	28
Standing Stock	2.15	2.1	2.5
% Silt-Clay	96.0	80.4	—

(Continued)

TABLE 6 (Continued)

Borrow Pit 5, River Mile 462 R

TRANSECT A	Station A1	A2	A3
Tubificidae	4	7	9
Trichocorixa	49.5	8.5	117.5
Tanypus	14	20	25
Standing Stock	17.2	6.0	55.4
% Silt-Clay	99.5	99.8	99.6

TRANSECT B	Station B1	B2	B3
Tubificidae	6	14	0
Trichocorixa	10.5	20.5	60.0
Tanypus	14	34	46
Standing Stock	5.5	19.4	26.5
% Silt-Clay	99.5	99.6	99.5

Borrow Pit 7, River Mile 460 L

TRANSECT A	Station A3	A2	A1
Tanypus	3	5	3
Tubificidae	10	5	3
Chaoborus	4	2	0
Procladius	1	3	0
Standing Stock	24.3	13.8	7.3
% Silt-Clay	99.2	99.1	98.5

TRANSECT B	Station B3	B2	B1
Tanypus	3	3	9
Tubificidae	6	1	5
Chaoborus	3	4	4
Procladius	3	1	5
Standing Stock	18.8	7.4	6.7
% Silt-Clay	99.3	99.4	95.8

Borrow Pit 10, River Mile 456 R

TRANSECT A	Station A1	A2	A3
Chaoborus	33	37	5
Tubificidae	17	24	39
Dero digitata	1.5	0.5	119
Naididae	1.5	0.5	160
Standing Stock	24.3	37.5	9.3
% Silt-Clay	88.3	86.7	24.6

TRANSECT B	Station B1	B2	B3
Chaoborus	71	80	4
Tubificidae	28	20	29
Dero digitata	1.5	1.0	137
Naididae	1.5	3.0	170
Standing Stock	45.9	41.4	11.4
% Silt-Clay	98.3	73.0	32.3

Borrow Pit 6, River Mile 433 R

TRANSECT A	Station A1	A2	A3
Tanypus	47	80	117
Chaoborus	2	37	23
Tubificidae	37	6	3
Standing Stock	22.3	18.1	29.9
% Silt-Clay	79.5	97.3	98.9

TRANSECT B	Station B1	B2	B3
Tanypus	15	47	30
Chaoborus	9	21	28
Tubificidae	3	2	1
Standing Stock	48.1	38.7	17.2
% Silt-Clay	92.8	98.8	99.3

(Continued)

TABLE 6 (Continued)

Borrow Pit 1, River Mile 431 R

TRANSECT A	A1	A2	A3
Chaoborus	11	67	4
Glyptotendipes	1	1	83
Standing Stock	26.0	25.5	64.3
% Silt-Clay	97.8	99.1	97.9

TRANSECT B	B1	B2	B3
Chaoborus	42	51	12
Glyptotendipes	1	0	1
Standing Stock	40.3	47.3	1.4
% Silt-Clay	98.6	98.3	95.2

Borrow Pit 2, River Mile 407 R

TRANSECT A	A1	A2	A3
Trichocorixa	6.0	0.5	1.5
Tanypus	11.0	23.0	19.0
Chaoborus	0	3.0	4.0
Standing Stock	6.0	10.3	9.1
% Silt-Clay	94.1	97.9	96.9

TRANSECT B	B1	B2	B3
Trichocorixa	77.5	21.5	7.5
Tanypus	0	2.0	6.0
Chaoborus	1.0	6.0	11.0
Standing Stock	13.1	7.3	23.1
% Silt-Clay	96.2	97.5	98.6

Borrow Pit 12, River Mile 377 R

TRANSECT A	A1	A2	A3
Chaoborus	4	62	55
Tanypus	4	45	6
Standing Stock	0.4	6.6	6.7
% Silt-Clay	57.9	98.4	99.2

TRANSECT B	B1	B2	B3
Chaoborus	2	5	5
Tanypus	3	22	1
Standing Stock	0.9	3.3	1.1
% Silt-Clay	77.3	89.1	92.9

Borrow Pit 16, River Mile 355 R

TRANSECT A	A1	A2	A3
Trichocorixa	36	14	20
Tubificidae	28	40	23
Tanypus	17	35	8
Standing Stock	29.0	39.8	17.6
% Silt-Clay	82.6	95.6	97.0

TRANSECT B	B1	B2	B3
Trichocorixa	73	66	31
Tubificidae	41	68	92
Tanypus	16	3	10
Standing Stock	50.3	44.9	65.4
% Silt-Clay	85.7	97.4	95.8

(Continued)

TABLE 6 (Concluded)

Borrow Pit 18, River Mile 323 R

TRANSECT A	A1	A2	A3
Chaoborus	126	76	29
Standing Stock	34.9	29.1	4.2
% Silt-Clay	99.6	99.3	97.7

TRANSECT B	B1	B2	B3
Chaoborus	215	274	266
Standing Stock	35.1	46.5	40.9
% Silt-Clay	99.2	99.3	97.9

Borrow Pit 22, River Mile 315 R

TRANSECT A	A1	A2	A3
Chaoborus	7	12	26
Standing Stock	1.1	2.9	6.6
% Silt-Clay	99.4	97.3	90.2

TRANSECT B	B1	B2	B3
Chaoborus	3	4	26
Standing Stock	1.3	.3	7.3
% Silt-Clay	96.9	98.4	89.5

Borrow Pit 20, River Mile 305 R

TRANSECT A	A1	A2	A3
Tanypus	9	52	17
Tubificidae	11	5	9
Chaoborus	0	16	8
Standing Stock	3.1	11.4	7.5
% Silt-Clay	90.3	99.0	94.5

Borrow Pit 20, (Continued)

TRANSECT B	B1	B2	B3
Tanypus	23	28	23
Tubificidae	11	10	1
Chaoborus	0	7	4
Standing Stock	5.7	6.7	5.7
% Silt-Clay	93.0	99.1	99.2

Borrow Pit 25, River Mile 180 L

TRANSECT A	A3	A2	A1
Tubificidae	28	10	33
Standing Stock	6.6	3.5	7.8
% Silt-Clay	94.6.	98.1	92.4

TRANSECT B	B3	B2	B1
Tubificidae	13.5	12.5	44.5
Standing Stock	6.9	5.8	4.6
% Silt-Clay	99.1	98.6	99.0

Borrow Pit 24, River Mile 151 L

TRANSECT A	A3	A2	A1
Tubificidae	20	58	48
Chaoborus	23	35	7
Standing Stock	9.2	4.9	10.2
% Silt-Clay	98.7	99.6	98.5

TRANSECT B	B3	B2	B1
Tubificidae	106	91	23
Chaoborus	48	24	5
Standing Stock	46.9	29.4	6.5
% Silt-Clay	99.2	99.2	99.1

(Station columns as headed on each transect.)

TABLE 7
Occurrence of Benthic Macroinvertebrates in the 25 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River

Taxa [1]		Borrow Pit Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
BAETIDAE	Baetidae sp.	x		x			x																			
CAENIDAE	Caenidae sp.																	x								
	Caenis sp.	x	x				x			x					x											x
CERATOPOGONIDAE	*Bezzia* sp.	x		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		x		x
CHAOBORIDAE	*Chaoborus punctipennis* adult				x		x																			
	Chaoborus punctipennis larvae	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Chaoborus punctipennis pupa	x	x		x		x	x	x	x	x	x	x	x		x	x	x	x			x	x	x	x	x
CHIRONOMIDAE	*Chironomus* sp. 1	x	x	x	x	x				x	x				x	x		x		x		x		x		
	Chironomus sp. 2		x	x			x		x	x	x	x	x	x	x		x		x		x			x		
	Cladotanytarsus sp.			x																						
	Coelotanypus sp.	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	
	Cryptochironomus sp.	x			x	x	x	x	x			x	x	x	x	x	x			x		x	x		x	
	Dicrotendipes sp.	x		x	x						x				x											
	Einfeldia sp.															x								x	x	
	Einfeldia natchitochae															x										
	Endochironomus nigricans										x															
	Glyptotendipes sp.	x	x	x		x		x	x	x	x				x	x		x				x	x		x	x
CHIRONOMIDAE	*Goeldichironomus holoprasinus*			x																						
	Harnischia sp.	x											x			x	x									
	Labrundinia sp.																		x							
	Larsia sp.																				x	x				
	Microchironomus sp.				x								x	x			x			x	x	x	x			
	Micropsectra sp.			x																						
	Parachironomus sp.			x			x																		x	
	Paracladopelma sp.				x																					

(Continued)

[1] In alphabetical order by families.

TABLE 7 (Continued)

	Taxa 1/	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		Borrow Pit Number																								
	Pentaneura sp.																									x
	Phaenopsectra sp.	x		x	x			x																	x	
	Polypedilum sp.		x	x					x	x	x			x	x	x	x					x	x			
	Polypedilum convictum	x							x																	x
	Polypedilum illinoense	x		x	x		x				x			x	x	x								x		x
	Procladius sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x	x
	Psectrocladius sp.						x																			
	Pseudochironomus sp.							x																		
	Rheotanytarsus sp.			x											x											
	Tanypus neopunctipennis			x		x				x										x					x	
	Tanypus stellatus	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x	x
	Tanytarsus (*Geuerlus*) sp.									x	x					x		x								
	Xenochironomus sp.																						x			
CHRYSOMELIDAE	Chrysomelidae spp.										x															
COENAGRIONIDAE	Coenagrionidae spp.						x								x											
	Ischnura sp						x																			
COLEOPTERA	Coleoptera spp.						x			x				x												
CORBICULIDAE	*Corbicula fluminea*									x																
CORIXIDAE	*Trichocorixa* sp.	x	x	x	x	x	x	x	x	x	x	x			x	x	x					x				
ELMIDAE	*Dubiraphia* sp.																					x				
EPHEMERIDAE	*Hexagenia limbata*																						x			
GAMMARIDAE	*Gammarus* sp.	x																								
GYRINIDAE	*Dineutus* sp.																		x							

(Continued)

TABLE 7 (Continued)

	Taxa 1/	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		Borrow Pit Number																								
HALIPLIDAE	*Peltodytes* sp.				x																					
HIRUDINEA	Hirudinea sp.						x	x		x	x				x	x	x	x		x		x		x		x
HYDROPHILIDAE	*Berosus* sp.		x																x							
	Helochares sp.		x																							
ISOTOMIDAE	*Isotomurus* sp.						x		x																	
LEPTOCERIDAE	Leptoceridae sp.										x															
	Oecetis sp.		x										x					x		x			x			
LIBELLULIDAE	Libelulidae sp.								x																	
	Perithemis sp.									x																
LUMBRICULIDAE	Lumbriculidae sp.			x	x		x			x								x		x				x		
LYMNAEIDAE	*Lymnaea* sp.				x												x									
MYSIDAE	*Taphromysis louisianae*	x					x						x				x				x				x	
NAIDIDAE	*Dero digitata*						x	x	x		x			x	x	x	x	x				x			x	x
	Dero flabelliger						x		x									x				x			x	
	Dero nivea				x		x				x															
	Dero sp. 1	x	x			x	x	x			x			x												
	Haemonais waldvogeli																	x			x	x				
	Naididae spp.				x	x	x	x	x	x	x			x	x	x	x	x		x		x		x	x	
	Nais sp.						x				x														x	
	Nais variabilis						x																			
	Pristina sp.										x															
	Pristina longidentata		x	x					x																	
	Pristina longiseta longiseta						x																			
	Slavina appendiculata																	x								

(Continued)

TABLE 7 (Concluded)

	Taxa 1/	Borrow Pit Number																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
NAUCORIDAE	Naucoridae spp.																		x							
NEMATODA	Nematoda spp.	x		x						x	x	x	x		x	x	x	x		x		x	x	x	x	
PHYSIDAE	*Physa* sp.		x							x																
SIALIDAE	*Sialis* sp.														x			x				x				
SPHERIIDAE	*Sphaerium transversum*									x																
TALITRIDAE	*Hyalella azteca*	x	x		x		x				x		x									x				
TUBIFICIDAE	*Aulodrilus pigueti*				x		x			x	x				x	x				x		x		x	x	
	Branchiura sowerbyi				x	x			x					x		x		x		x	x	x				x
	Limnodrilus sp.	x		x	x			x	x																	
	Limnodrilus angustipenis							x																		
	Limnodrilus cervix	x			x			x			x														x	x
	Limnodrilus hoffmeisteri	x		x	x	x	x	x	x	x	x	x	x		x	x	x	x	x		x	x		x	x	x
	Limnodrilus maumeensis	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x		x	x	x
	Limnodrilus spiralis										x															
	Peloscolex ferox																								x	
	Potamothrix variegatus						x																			
	Potamothrix vejdovskyi																								x	
	Tubifex sp.				x																					
	Tubificidae immatures		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
TURBELLARIA	Turbellaria spp.																					x				
UNIONIDAE	*Carunculina texasensis*															x										

(Concluded)

TABLE 8

DENSITY, RELATIVE ABUNDANCE, STANDING STOCK, AND SPECIES RICHNESS OF BENTHIC MACROINVERTEBRATES FROM 25 BORROW PITS ALONG THE MAIN STEM LEVEE SYSTEM OF THE LOWER MISSISSIPPI RIVER

Pit #	*Chaoborus*	*Chironomus* Sp.2	*Coelotanypus*	*Glypotendipes*	Naididae	Nematoda	*Tanypus stellatus*	Tubificidae	Others	Total Density	Total Standing Stock 3/	Total No. Taxa	Average No. Taxa/Sample
1	31.2 1/	0.0	0.2	14.5	0.0	0.7	2.5	3.8	5.3	58.2	34.1	25	6.3
	53.6% 2/	0.0%	0.3%	24.9%	0.0%	1.2%	4.3%	6.5%	9.1%				
2	4.2	1.0	1.0	2.0	1.5	0.0	10.2	1.3	23.2	42.9	11.5	18	6.1
	9.7%	2.3%	2.3%	4.6%	3.5%	0.0%	23.7%	3.0%	50.5%				
3	1.2	1.8	0.3	6.7	0.2	0.2	0.3	0.3	6.5	17.3	15.5	25	6.0
	6.9%	10.4%	1.7%	38.7%	1.2%	1.1%	1.7%	1.7%	36.3%				
4	10.0	0.0	0.8	0.0	1.2	0.0	19.2	7.3	9.0	47.0	12.2	27	7.3
	21.2%	0.0%	1.7%	0.0%	2.6%	0.0%	40.8%	15.5%	18.0%				
5	0.2	0.0	3.2	0.3	0.3	0.0	25.5	6.7	50.7	86.9	21.7	15	6.4
	0.2%	0.0%	3.6%	0.3%	0.3%	0.0%	29.3%	7.7%	58.3%				
6	20.0	0.03	0.05	0.0	4.5	0.0	56.0	8.7	9.3	96.5	29.0	34	9.3
	20.7%	0.3%	0.5%	0.0%	4.7%	0.0%	58.0%	9.0%	6.7%				
7	2.8	0.0	0.0	0.2	0.5	0.0	4.3	5.0	5.3	17.8	13.1	16	5.7
	15.7%	0.0%	0.0%	1.1%	2.8%	0.0%	24.1%	28.0%	28.1%				
8	12.7	0.05	0.05	0.02	3.5	0.0	63.7	11.3	10.3	100.2	42.2	21	8.3
	12.6%	0.5%	0.5%	0.2%	3.5%	0.0%	63.5%	11.2%	7.7%				
9	27.8	1.5	1.7	46.0	0.0	0.5	3.3	8.2	6.2	95.4	40.4	25	7.3
	29.1%	1.5%	1.7%	48.2%	0.0%	0.5%	3.4%	8.6%	6.5%				
10	38.3	0.2	1.5	3.3	56.7	0.5	9.0	26.2	56.2	148.0	28.3	30	8.9
	25.8%	0.1%	1.0%	2.2%	38.3%	0.3%	6.0%	17.7%	8.6%				
11	7.2	0.8	0.7	0.0	0.0	0.2	36.0	10.8	2.0	57.7	8.6	11	4.7
	12.4%	1.3%	1.2%	0.0%	0.0%	0.3%	62.3%	18.7%	3.4%				
12	22.2	0.2	2.7	0.0	0.0	0.3	13.5	0.7	4.2	43.8	3.2	15	5.0
	50.6%	0.4%	6.1%	0.0%	0.0%	0.6%	30.8%	1.6%	9.5%				

(Continued)

1/ Average Number/Sample.
2/ Relative Abundance (percent of total density).
3/ Average mg Dry Weight/Sample.

TABLE 8 (Concluded)

Pit #	Chaborus	Chironomus Sp.2	Coelotanypus	Glypotendipes	Naididae	Nematoda	Tanypus stellatus	Tubificidae	Others	Total Density	Total Standing Stock 3/	Total No. Taxa	Average No. Taxa/Sample
13	2.2	1.2	0.2	0.0	2.3	0.0	8.0	12.3	7.8	33.2	7.6	16	6.5
	6.6%	3.6%	0.6%	0.0%	6.9%	0.0%	24.1%	37.0%	21.0%				
14	0.7	3.7	1.7	0.3	1.3	0.3	9.7	17.8	8.8	43.3	7.0	24	7.2
	1.6%	8.5%	3.9%	0.6%	3.0%	0.6%	22.4%	41.1%	18.0%				
15	9.2	0.0	2.7	0.2	2.3	13.5	11.2	4.0	12.7	54.5	6.4	23	7.5
	16.8%	0.0%	4.9%	0.3%	4.2%	24.7%	20.5%	7.3%	20.9%				
16	7.0	0.2	4.8	0.0	0.3	0.3	14.8	48.7	58.8	134.8	41.2	19	8.3
	5.1%	0.1%	3.5%	0.0%	0.2%	0.2%	10.9%	36.1%	43.6%				
17	27.2	0.0	1.0	0.3	0.8	12.2	4.2	8.8	4.3	58.2	27.9	25	6.7
	46.7%	0.0%	1.7%	0.5%	1.4%	20.9%	7.2%	15.1%	6.3%				
18	164.3	0.2	0.0	0.0	0.0	0.0	0.0	14.3	4.2	183.0	31.7	8	3.8
	89.7%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	7.8%	2.3%				
19	1.2	0.0	1.7	0.0	0.3	0.2	1.5	2.5	3.2	10.6	7.6	16	4.3
	11.3%	0.0%	16.0%	0.0%	2.8%	1.8%	14.1%	23.5%	30.1%				
20	5.8	0.2	2.5	0.0	0.2	0.0	25.3	7.8	4.5	46.1	6.7	12	5.4
	12.5%	0.4%	5.4%	0.0%	4.3%	0.0%	54.8%	16.9%	5.4%				
21	5.2	0.0	1.8	0.3	4.7	0.2	4.5	9.3	9.8	33.3	7.9	26	7.7
	15.6%	0.0%	5.4%	0.9%	14.1%	0.6%	13.5%	27.9%	21.9%				
22	13.0	0.0	0.2	0.2	0.0	0.3	0.0	0.3	1.7	15.7	3.2	10	1.8
	82.8%	0.0%	1.2%	1.2%	0.0%	1.9%	0.0%	1.9%	10.8%				
23	35.7	34.8	16.8	0.0	0.7	3.2	52.8	4.2	12.2	159.9	63.3	16	7.6
	22.3%	21.7%	10.5%	0.0%	0.4%	2.0%	33.0%	2.6%	7.3%				
24	23.7	0.0	0.5	0.8	6.8	0.2	0.7	45.3	18.5	91.5	17.8	22	6.9
	25.9%	0.0%	0.5%	0.8%	7.4%	0.2%	0.7%	49.5%	14.7%				
25	1.0	0.0	0.0	0.2	0.7	0.0	1.0	23.8	1.3	28.3	5.8	15	4.3
	3.5%	0.0%	0.0%	0.7%	2.5%	0.0%	3.52%	66.9%	22.8%				
TOTAL	474.0	46.6	47.0	75.5	88.5	32.8	377.2	284.6	341.9	1704.2			

TABLE 9
Macrobenthic Assemblages from 25 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River

Borrow Pit	Dominant Taxon	Subdominant Taxon	Co-dominant Taxon
18	*C. punctipennis*	-	-
22	*C. punctipennis*	-	-
8	*T. stellatus*	-	-
25	Tubificidae	-	-
3	-	-	*Glyptotendipes* sp.
			Polypedilum illinoense
			Dicrotendipes sp.
7	-	-	*T. stellatus*
			C. punctipennis
			Tubificidae
15	-	-	*T. stellatus*
			Nematoda
			C. punctipennis
16	-	-	*Trichocorixa* sp.
			Tubificidae
19	-	-	Tubificidae
			C. punctipennis
			T. stellatus
21	-	-	Tubificidae
			C. punctipennis
			Naididae
			T. stellatus
23	-	-	*T. stellatus*
			C. punctipennis
			Chironomus sp. 2
1	*C. punctipennis*	*Glyptotendipes* sp.	-
2	*Trichocorixa* sp.	*T. stellatus*	-
4	*T. stellatus*	*C. punctipennis*	-
		Tubificidae	
5	*Trichocorixa* sp.	*T. stellatus*	-
6	*T. stellatus*	*C. punctipennis*	-
9	*Glyptotendipes* sp.	*C. punctipennis*	-
10	Naididae	Tubificidae	-
		C. punctipennis	
11	*T. stellatus*	Tubificidae	-
12	*C. punctipennis*	*T. stellatus*	-
13	Tubificidae	*T. stellatus*	-
14	Tubificidae	*T. stellatus*	-
17	*C. punctipennis*	Nematoda	-
		Tubificidae	
20	*T. stellatus*	Tubificidae	-
24	Tubificidae	*C. punctipennis*	-

TABLE 10

Results of Step-wise Regression Analyses of Macrobenthic, Morphometric, Hydrologic, and Sediment Variables of 25 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River

Dependent Variable	Independent Variable	B-Value	Prob > F	R^2
Total Density	Days Flooded	9.46	.0001	.75
Number of Taxa	Volume Development Index	13.64	.0001	.92
Number of Taxa	Volume Development Index	11.82	.0001	.93
	Surface Area	0.15	.0531	
Chaoborus Density	Volume Development Index	9.53	.0001	.62
Chironomus sp. 2 Density	Days Flooded	.03	.1289	.11
Chironomus sp. 2 Density	Days Flooded	0.14	.0551	.23
	Volume Development Index	-6.45	.1111	
Coelotanypus Density	Days Flooded	0.03	.0080	.30
Glyptotendipes Density	Percent Sediment Organics	0.75	.0499	.18
Glyptotendipes Density	Percent Sediment Organics	1.61	.0140	.30
	Shoreline Length	-0.0009	.0934	
Naididae Density	Days Flooded	0.014	.0591	.17
Naididae Density	Days Flooded	0.06	.0265	.30
	Percent Sediment Fines	-0.05	.0685	
Naididae Density	Days Flooded	0.05	.0698	.45
	Percent Sediment Fines	-0.11	.0071	
	Volume Development Index	4.39	.0419	
Nematoda Density	Surface Area	0.09	.0034	.36
Nematoda Density	Surface Area	0.16	.0029	.44
	Maximum Depth	-0.24	.1114	
"Other Benthos" Density	Days Flooded	0.18	.0005	.46
Tanypus Density	Days Flooded	0.20	.0004	.47
Tanypus Density	Days Flooded	0.28	.0006	.54
	Mean Basin Slope	-207.96	.1095	
Tubificidae Density	Shoreline Development Index	5.83	.0004	.48
Tubificidae Density	Shoreline Development Index	9.50	.0025	.54
	Maximum Depth	-1.05	.1403	
Total Standing Stock	Days Flooded	0.25	.0001	.68

TABLE 11

Families, Species, and Economic Classification of Fishes Captured in 25 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River

Family and Species	Economic Classification 1/
Polyodontidae - paddlefishes	
Paddlefish (Polyodon spathula)	3
Lepisosteidae - gars	6
Spotted gar (Lepisosteus oculatus)	6
Longnose gar (Lepisosteus osseus)	6
Shortnose gar (Lepisosteus platostomus)	6
Amiidae - bowfins	
Bowfin (Amia calva)	4,6
Anguillidae - freshwater eels	
American eel (Anguilla rostrata)	2,3
Clupeidae - herrings	5
Skipjack herring (Alosa chrysochloris)	5
Gizzard shad (Dorosoma cepedianum)	5
Threadfin shad (Lorosoma petenense)	5
Hiodontidae - mooneyes	
Goldeye (Hiodon alosoides)	2,4
Esocidae - pikes	
Chain pickerel (Esox niger)	1,2,4
Cyprinidae - minnows and carps	2,4,5
Common carp (Cyprinus carpio)	2,4
Golden shiner (Notemigonus crysoleucas)	5
Emerald shiner (Notropis atherinoides)	5
River shiner (Notropis blennius)	5
Pugnose minnow (Notropis emiliae)	5
Ribbon shiner (Notropis fumeus)	5
Red shiner (Notropis lutrensis)	5
Taillight shiner (Notropis maculatus)	5
Silverband shiner (Notropis shumardi)	5
Bullhead minnow (Pimephales vigilax)	5
Catostomidae - suckers	
River carpsucker (Carpiodes carpio)	2,4
Quillback (Carpiodes cyprinus)	2,4
Highfin carpusucker (Carpiodes velifer)	2,4
Smallmouth buffalo (Ictiobus bubalus)	2,4
Bigmouth buffalo (Ictiobus cyprinellus)	2,4
Black buffalo (Ictiobus niger)	2,4
Spotted sucker (Minytrema melanops)	2,4

(Continued)

1/ Economic classification (from Lagler 1956): 1 = sport, 2 = commercial, 3 = fine food, 4 = coarse food, 5 = forage, 6 = other.

TABLE 11 (Concluded)

Family and Species	Economic Classification 1/
Ictaluridae - freshwater catfishes	
Blue catfish (Ictalurus furcatus)	3
Black bullhead (Ictalurus melas)	1,3
Yellow bullhead (Ictalurus natalis)	1,3
Brown bullhead (Ictalurus nebulosus)	1,3
Channel catfish (Ictalurus punctatus)	1,2,3
Tadpole madtom (Noturus gyrinus)	6
Brindled madtom (Noturus miurus)	6
Flathead catfish (Pylodictis olivaris)	2,3
Cyprinodontidae - killifishes	
Golden topminnow (Fundulus chrysotus)	5
Blackstripe topminnow (Fundulus notatus)	5
Blackspotted topminnow (Fundulus olivaceus)	5
Poeciliidae - livebearers	
Mosquitofish (Gambusia affinis)	5,6
Atherinidae - silversides	
Brook silverside (Labidesthes sicculus)	5
Inland silverside (Menidia beryllina	5
Percichthyidae - temperate basses	
White bass (Morone chrysops)	1,2,3
Yellow bass (Morone mississippiensis)	1,2,3
Centrarchidae - sunfishes	
Green sunfish (Lepomis cyanellus)	1
Warmouth (Lepomis gulosus)	1,3
Orangespotted sunfish (Lepomis humilis)	6
Bluegill (Lepomis macrochirus)	1,3
Longear sunfish (Lepomis megalotis)	6
Redear sunfish (Lepomis microlophus)	1,3
Spotted sunfish (Lepomis punctatus)	1
Largemouth bass (Micropterus salmoides)	1,3
White crappie (Pomoxis annularis)	1,3
Black crappie (Pomoxis nigromaculatus)	1,3
Percidae - perches	
Logperch (Percina caprodes)	5
Sauger (Stizostedion canadense)	1,2,3
Sciaenidae - drums	
Freshwater drum (Aplodinotus grunniens)	2,4
Mugilidae - mullets	
Striped mullet (Mugil cephalus)	2,5

Table 12

Summary of the Number and Weight of Fishes Captured in 25 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River

Fish Species	BP21	BP19	BP17	BP23	BP15	BP13	BP11	BP9	BP8	BP14	BP4	BP3	BP5	BP7	BP10	BP6	BP1	BP2	BP12	BP16	BP18	BP22	BP20	BP25	BP24	Total
Paddlefish	19[1] (93.7)[2]				2 (13.4)								1 (2.0)		7 (4.8)	4 (19.8)	1 (6.8)	6 (45.0)	2 (6.6)	7 (34.6)		2 (5.3)	11 (44.3)		20 (56.9)	82 (333.2)
Spotted gar	26 (11.9)	21 (2.0)	4 (4.2)	17 (26.4)	21 (23.8)	36 (42.8)	9 (19.4)		44 (92.3)	1 (1.8)	(15.9)	11 (0.7)	120 34 (62.6)	165 (247.1)	40 (25.8)	79 (125.4)	1 (1.1)	86 (143.5)	44 (65.5)	11 (24.0)	145 (69.4)		139 (156.1)	9 (7.7)	140 (138.4)	1203 (1307.6)
Shortnose gar	2 (4.0)	1 (0.7)				2 (1.3)		80 (0.4)	75 (130.3)			60 (1.3)	45 (122.1)	101 (115.7)	16 (19.2)		4 (6.6)		8 (15.6)	6 (9.0)	153 (29.8)		16 (17.6)	2 (2.9)	2 (0.4)	573 (475.8)
Longnose gar						2 (7.0)		2 (0.1)						1 (0.9)		1 (3.3)					2 (0.1)	2 (3.7)	1 (1.3)			11 (16.3)
Bowfin		2 (3.1)	1 (2.2)		3 (3.7)	3 (6.0)		1 (4.4)	1 (2.4)		8 (27.8)		1 (3.1)	12 (46.9)	3 (11.7)			18 (35.0)			18 (62.8)			3 (15.0)	1 (2.4)	75 (226.6)
American eel																			1 (*)	1 (*)		1 (0.1)	5 (1.3)		6 (1.5)	14 (2.9)
Skipjack herring																						1 (0.7)				1 (0.7)
Gizzard shad	4157 (130.9)	21800 (245.7)	17532 (179.2)	10251 (655.0)	2416 (297.1)	6973 (253.7)	4846 (251.7)	9178 (329.0)	5403 (825.4)	983 (354.8)	25070 (687.9)	458 (74.0)	540 (218.4)	1600 (210.0)	10282 (817.2)	14022 (628.1)	7840 (456.7)	3099 (380.0)	7379 (363.0)	4334 (669.8)	132 (6.8)	4545 (227.5)	1653 (290.1)	2295 (250.4)	12123 (485.8)	178911 (9288.1)
Threadfin shad		1980 (17.0)						160 (0.1)	819 (2.4)		12511 (40.1)	195 (0.9)			680 (4.2)	8039 (30.2)	9081 (25.8)	23 (0.1)	1500 (4.4)		60 (*)	17379 (158.0)	260 (2.0)	46856 (185.0)	1020 (5.7)	100563 (476.5)
Goldeye							1 (0.4)										25 (9.0)			1 (0.2)						27 (9.7)
Chain pickerel																				1 (0.9)						1 (0.9)
Common Carp	6 (26.4)	22 (32.2)	15 (5.7)	8 (64.4)	25 (84.2)	28 (68.8)	70 (179.4)	45 (2.6)	24 (114.8)	8 (50.2)	49 (21.8)	12811 (10,8)	16 (39.9)	184 (631.7)	231 (162.4)	5 (32.2)	8 (26.0)	118 (303.1)	89 (34.6)	51 (14.55)	12 (55.5)	15 (23.1)	23 (75.8)	1 (4.0)	8 (25.8)	13872 (2221.4)
Golden shiner				20 (0.2)	20 (0.4)			384 (6.0)																		444 (6.8)
Emerald shiner			40 (*)[3]	20 (*)				120 (0.1)											20 (*)							200 (0.2)
River shiner				20 (*)																						20 (*)
Pugnose minnow				20 (*)	42 (*)	280 (0.2)									20 (*)										20 (*)	382 (0.2)
Ribbon shiner				80 (0.1)																		20 (*)		200 (0.2)	20 (*)	320 (0.2)
Red shiner												40 (0.2)														40 (0.2)
Taillight shiner				240 (0.2)	132 (0.2)																					372 (0.2)
Silverband shiner											133 (0.2)															133 (0.2)
Bullhead minnow											20 (*)				40 (*)	200 (0.2)				20 (*)						280 (0.4)
River carpsucker	3 (4.8)	1 (2.2)		1 (2.2)	2 (3.5)	11 (18.1)	2 (2.9)	13 (3.1)	10 (17.0)		24 (44.3)		32 (27.6)	25 (33.3)	67 (5.1)	57 (72.5)	19 (16.8)	4 (5.7)	11 (8.4)	237 (172.4)		98 (56.4)	77 (64.8)	6 (8.4)	2 (0.7)	702 (569.9)
Quillback						1 (1.3)							1 (0.9)				2 (1.8)									4 (3.7)
Highfin carpsucker																	21 (20.5)									21 (19.0)
Smallmouth buffalo	21 (39.5)		5 (11.5)	1 (5.3)	31 (48.3)	112 (121.9)	77 (72.7)		164 (146.8)	1 (5.1)	24 (45.8)		213 (164.9)	129 (293.0)	21 (20.5)	76 (170.6)	155 (254.8)	251 (505.8)	79 (84.0)	17 (22.3)		35 (30.0)	87 (93.4)	18 (21.4)	17 (20.7)	1534 (2179.0)
Bigmouth buffalo	22 (29.5)	18 (27.3)	18 (32.8)		63 (92.6)	17 (19.8)	23 (45.8)		114 (351.3)	7 (28.0)	16 (41.4)		268 (380.9)	1174 (3878.8)	14 (26.4)	65 (190.0)	206 (616.9)	149 (294.2)	9 (41.2)	3 (6.4)	102 (162.9)	181 (148.8)	112 (217.5)	58 (106.7)	61 (95.2)	2700 (6836.5)
Black buffalo	6 (15.0)	1 (2.4)	12 (42.3)		26 (83.3)	4 (4.2)	12 (28.0)		65 (115.3)	1 (7.5)			28 (50.7)	80 (482.2)		3 (16.1)	3 (8.4)					3 (4.4)	23 (57.3)		2 (5.7)	269 (923.1)
Spotted sucker						3 (1.3)					3 (2.2)					1 (0.2)			1 (0.2)			1 (0.4)				9 (4.6)
Blue catfish							1 (0.7)										1 (0.2)	7 (11.0)	1 (1.1)			4 (2.0)	1 (0.7)	12 (4.0)	2 (0.2)	29 (20.1)
Black bullhead	20 (0.1)	40 (*)			2 (1.5)	5 (2.2)		2351 (13.0)	1 (0.7)	13 (2.9)		85 (0.9)	5 (2.4)	9 (5.1)	1 (0.7)	1 (0.7)		1 (0.2)	1 (0.9)		39 (37.9)	21 (0.2)				2595 (69.4)
Yellow bullhead	304 (4.8)	1 (0.2)	60 (0.1)	1 (0.9)	32 (2.0)	26 (3.1)		1 (1.5)	1 (0.4)	7 (0.2)	1 (0.4)	80 (0.4)		15 (9.7)	21 (0.9)	60 (0.2)					3 (2.0)	8 (2.0)			40 (*)	661 (29.8)
Brown bullhead										2 (0.7)								1 (0.2)								3 (0.9)
Channel catfish	143 (42.8)	390 (17.4)	259 (15.9)	42 (49.1)	20 (24.7)	32 (7.5)	182 (73.0)	20 (*)	182 (75.8)	46 (34.2)	489 (19.6)	15 (4.2)	100 (56.4)	105 (214.9)	191 (21.8)	112 (50.9)	102 (21.2)	257 (43.0)	270 (44.5)	1146 (161.6)		72 (4.0)	73 (27.3)	302 (37.2)	129 (53.6)	4679 (1100.8)
Tadpole madtom	1 (*)		40 (*)		60 (0.1)						133 (0.4)					60 (0.2)		20 (*)								314 (0.7)
Brindled madtom																20 (0.1)										20 (*)
Flathead catfish								1 (0.2)						1 (4.4)			4 (49.4)		3 (15.4)	4 (22.7)			11 (71.6)			24 (163.8)
Golden topminnow										2 (*)						20 (0.1)										22 (*)
Blackstripe topminnow				40 (*)	2 (*)																		20 (*)			62 (*)
Blackspotted topminnow		20 (*)			2 (*)			40 (0.2)		10 (*)	173 (0.2)			20 (*)		220 (0.2)		40 (*)	20 (*)		20 (*)					565 (0.9)
Mosquitofish	10 (*)	1780 (0.4)	100 (*)	40 (*)	4 (*)	20 (*)	20 (*)	600 (0.4)	120 (0.1)	177 (0.1)	989 (0.9)	60 (0.1)			220 (0.4)	40 (*)	20 (*)	40 (0.1)	140 (0.2)	180 (0.2)	759 (0.2)	60 (*)	2240 (0.9)	60 (0.1)	1440 (0.7)	9110 (4.9)

(Continued)

NOTE: Totals may not be exact due to rounding.

[1] Number of fish.

[2] Weight of fish in pounds.

[3] Value less than 0.05 pound.

Table 12 (Concluded)

Fish Species	BP21	BP19	BP17	BP23	BP15	BP13	BP11	BP9	BP8	BP14	BP4	BP3	BP5	BP7	BP10	BP6	BP1	BP2	BP12	BP16	BP18	BP22	BP20	BP25	BP24	Total
Brook silverside				60 (0.1)	20 (*)	100 (0.1)	40 (*)	60 (*)	60 (0.1)		398 (0.4)			40 (*)		1700 (2.4)		20 (*)	80 (*)			40 (*)		140 (0.2)		2758 (3.5)
Inland silverside			600 (0.4)	460 (0.7)	4 (*)		40 (*)	380 (0.4)	20 (*)	157 (0.1)	1255 (1.1)	20 (*)			320 (0.2)	280 (0.4)	72 (0.2)	20 (*)	880 (1.1)	540 (0.7)	100 (0.1)	200 (0.2)	180 (0.2)	160 (0.2)	380 (0.4)	6068 (6.8)
White bass											1 (1.3)				11 (3.3)		44 (20.7)		21 (7.9)	2 (0.4)		7 (3.1)	7 (3.7)			93 (40.8)
Yellow bass	5 (0.7)	1 (*)		762 (79.1)	39 (3.7)	41 (2.6)	32 (1.3)	5 (0.7)	20 (2.6)	133 (7.1)	158 (2.0)	2 (0.2)			3 (0.4)	50 (3.5)	49 (5.1)		44 (3.1)	55 (2.9)		25 (3.1)	5 (0.7)	13 (2.6)	2 (0.4)	1444 (121.9)
Green sunfish	1 (*)								24 (0.4)	9 (0.2)	1 (0.2)					4 (0.2)						29 (1.8)				68 (2.9)
Warmouth	146 (2.0)	403 (2.0)	104 (0.4)	106 (3.1)	73 (3.1)	258 (1.5)	65 (0.2)	149 (4.6)	90 (0.9)	1 (0.1)	1898 (4.0)			20 (0.1)	1 (0.2)	421 (3.7)	26 (0.2)	120 (0.4)	128 (1.8)		481 (0.9)	167 (2.4)	223 (1.1)	44 (0.2)	879 (6.8)	5803 (40.1)
Orangespotted sunfish	484 (1.3)	3280 (5.3)	5779 (14.5)	660 (2.2)	56 (0.2)	1264 (2.7)	60 (0.4)	1562 (8.8)	207 (4.0)	277 (2.0)	635 (3.7)	3 (0.1)	41 (0.2)		188 (1.1)	2038 (7.5)	124 (0.4)	81 (0.7)	1803 (4.0)	540 (1.5)		609 (2.4)	401 (0.9)	2300 (3.1)	3668 (6.4)	26060 (73.4)
Bluegill	23 (3.3)	251 (5.7)	375 (7.7)	2253 (108.7)	589 (36.4)	456 (23.4)	356 (24.9)	1754 (19.8)	422 (26.4)	343 (35.3)	12009 (48.9)	12 (1.3)	13 (1.8)	464 (42.5)	939 (8.2)	1125 (34.2)	461 (17.0)	681 (10.1)	727 (10.4)	25 (1.5)	1242 (5.5)	912 (34.8)	683 (8.4)	656 (14.5)	2243 (44.1)	29011 (575.2)
Longear sunfish	47 (0.2)	60 (0.2)	44 (0.2)	850 (11.9)	115 (2.0)	2217 (9.5)	233 (3.1)	1205 (6.8)	199 (7.3)	68 (2.0)	289 (2.0)			60 (0.4)	919 (4.8)	685 (8.6)	1 (*)	1 (*)	89 (0.7)	62 (0.2)		500 (9.5)	282 (0.9)	131 (1.8)	382 (2.0)	8439 (73.8)
Redear sunfish				98 (17.0)	34 (3.7)	3 (0.2)		4 (0.4)		19 (2.2)	20 (0.1)			1 (0.2)		1 (0.2)	1 (*)						2 (0.2)	4 (0.4)	1 (0.2)	188 (24.9)
Spotted sunfish											4 (0.2)				20 (0.2)	40 (0.4)										64 (0.9)
Largemouth bass	1 (0.9)	22 (1.1)	74 (0.9)	58 (18.3)	36 (11.2)	31 (8.2)	24 (27.3)	189 (5.5)	33 (7.7)	25 (14.8)	149 (20.7)	1 (0.2)	8 (3.7)	25 (20.9)	96 (10.4)	44 (23.8)	91 (22.0)	16 (30.6)	125 (9.3)	18 (16.1)	1 (*)	128 (28.4)	19 (19.8)	48 (3.5)	20 (12.1)	1282 (317.6)
White crappie	838 (17.2)	23 (0.4)	230 (2.0)	1436 (42.8)	59 (4.8)	143 (8.8)	564 (30.6)	3020 (11.9)	99 (32.4)	112 (20.3)	3476 (38.6)		68 (19.2)	125 (32.6)	306 (84.0)	314 (45.8)	1982 (45.6)	683 (108.2)	1052 (30.9)	347 (122.5)	129 (3.5)	223 (45.0)	554 (46.7)	98 (18.1)	749 (22.9)	16585 (835.1)
Black crappie	30 (4.8)		82 (0.2)	69 (6.8)	43 (7.5)	37 (7.3)	49 (7.3)	115 (2.0)		138 (9.7)	305 (0.9)		34 (11.7)	286 (56.6)	40 (*)		4 (0.2)	20 (*)	22 (0.7)	18 (5.3)	191 (17.6)	62 (11.2)	31 (4.4)	9 (0.7)	110 (8.2)	1695 (163.8)
Logperch																						1 (0.1)				1 (*)
Sauger																	4 (1.1)			1 (0.2)		1 (1.1)				6 (2.2)
Freshwater drum	75 (30.2)	49 (30.6)		60 (65.7)	50 (31.7)	49 (22.7)	218 (54.0)	36 (19.6)	176 (61.7)	35 (22.3)	228 (101.2)	8 (7.9)	146 (31.1)	144 (69.6)	743 (79.8)	155 (32.8)	83 (31.5)	580 (239.8)	439 (59.3)	217 (40.6)		79 (21.8)	127 (28.4)	132 (24.9)	46 (13.7)	3875 (1121.4)
Striped mullet																									3 (2.9)	3 (2.9)
Fish not identified to species:																										
Lepisosteus spp.												40 (*)														40 (*)
Dorosoma spp.																		20 (*)								20 (*)
Notropis spp.											60 (*)															60 (*)
Catostomidae												180 (*)														180 (*)
Lepomis spp.	45 (*)	5379 (2.6)	14555 (9.5)	14381 (15.6)	1807 (1.1)	6699 (2.9)	720 (0.4)	7501 (6.2)	1579 (1.5)	35 (*)	2294 (0.9)			300 (0.4)		2900 (2.2)	200 (0.1)	59 (*)	6039 (3.7)	1440 (1.1)	7647 (4.6)	2020 (2.2)	6512 (5.3)	2340 (1.5)	4940 (6.0)	89842 (68.3)
Total number:	6434	35544	39927	32501	5828	18852	7644	28975	9952	2610	62833	14191	1594	5087	15436	32860	20636	6374	21027	9284	11235	27450	13778	55896	28476	514430
Total weight:	464.2	399.9	330.2	1175.8	784.6	649.5	823.9	448.3	2020.0	602.1	1175.2	1023.3	1200.1	6397.6	1314.2	1506.9	1664.9	2157.1	818.6	1462.4	459.5	833.8	1242.2	714.3	1020.2	29768.1
Total species:	24	22	20	27	31	28	22	27	25	25	31	16	19	24	28	34	30	26	30	26	18	33	29	25	30	58

Table 13
Standing Stock Summary (lb/ac) of Major Groups of Fish Removed from the Leveeward (L) and Riverward (R) Sides of 25 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River

Pit	Clupeidae		Catostomidae		Ictaluridae		LM Bass		Crappie		Sunfish		Cyprinidae		Other	
No.	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
21	111.8	19.4	56.4	32.4	22.0	25.6	-	0.9	15.2	6.8	6.0	2.0	20.9	5.5	68.8	71.7
19	78.9	183.6	32.0	-	2.2	16.3	0.2	0.9	0.2	0.2	6.7	9.0	32.0	0.2	18.3	18.7
17	115.7	63.3	56.2	30.4	15.6	0.2	0.4	0.7	0.9	1.3	16.8	15.6	5.5	0.2	6.4	0.4
23	457.9	197.9	7.7	-	36.6	13.4	8.4	9.9	31.3	18.5	54.0	103.9	27.8	36.8	121.0	51.4
*15(a)	209.0		130.3		11.7		3.7		8.6		27.1		60.4		62.8	
(b)	88.2		97.4		16.8		7.5		4.0		20.0		24.5		13.7	
13	114.9	139.1	149.3	17.0	7.5	5.1	7.9	0.2	13.9	2.2	30.4	10.2	53.4	15.6	55.3	27.8
11	121.5	130.3	50.5	99.0	33.1	40.6	17.2	10.1	9.3	26.2	19.2	12.3	56.2	123.2	45.4	30.2
9	221.0	97.7	2.9	0.2	2.4	12.3	2.4	3.3	7.7	6.2	29.1	17.6	1.1	7.5	15.4	10.6
8	592.4	235.7	392.6	238.1	53.4	23.6	6.6	1.1	20.1	12.3	23.1	17.7	78.3	36.6	175.3	114.0
14	68.1	286.8	2.9	38.4	4.2	33.7	6.8	7.7	12.1	17.9	21.4	20.3	-	50.3	16.1	15.0
4	221.3	506.8	64.2	69.4	4.9	15.6	4.9	15.9	15.2	24.0	20.4	39.9	9.3	13.0	103.8	47.0
3	2.0	73.2	-	0.0	1.1	4.4	-	0.2	-	-	0.7	0.7	5.1	6.0	3.7	5.5
5	109.8	108.7	154.3	470.5	30.2	29.1	0.4	3.3	18.3	12.8	1.4	0.7	31.7	8.2	140.2	80.9
7	128.3	82.0	612.0	4076.8	28.0	206.1	3.1	17.9	20.1	69.2	11.2	66.2	107.8	523.8	110.7	369.7
10	437.0	384.5	26.9	24.7	3.7	19.6	4.0	6.2	14.3	69.7	8.4	5.9	123.5	39.0	58.6	87.5
6	249.6	409.0	88.8	360.7	19.8	32.2	8.2	15.6	7.9	37.7	31.6	24.5	0.4	32.2	73.9	133.6
1	172.6	310.2	87.7	830.3	6.0	64.6	2.4	19.4	6.0	39.9	2.4	15.0	9.5	16.5	52.2	29.6
2	47.2	332.9	435.0	371.0	16.5	37.7	3.7	26.9	38.1	70.1	2.5	8.8	93.0	210.1	182.5	280.9
12	71.0	295.5	70.3	63.5	35.3	26.7	5.1	4.2	22.7	8.8	7.0	13.2	16.5	18.3	57.3	102.1
16	125.7	544.3	33.7	167.3	19.8	164.2	15.9	0.2	18.1	109.8	3.9	0.2	15.2	130.3	64.4	49.8
18	2.2	4.6	48.7	114.0	22.7	17.2	0.0	-	7.9	13.2	4.7	6.4	55.6	-	58.0	104.7
22	110.5	276.0	83.3	156.5	3.7	4.4	10.1	18.1	24.7	31.5	30.2	23.2	14.8	8.4	15.9	22.7
20	165.1	127.2	67.7	365.5	6.0	93.7	7.7	11.9	11.7	39.7	5.3	10.8	11.0	65.0	64.8	189.8
25	174.4	261.2	50.0	86.4	7.1	34.2	2.2	1.3	6.0	12.8	7.7	13.7	0.0	4.0	9.9	42.8
24	239.0	252.6	31.3	91.5	18.7	35.1	3.1	9.0	21.4	9.9	44.1	21.2	11.2	14.6	124.8	100.1
TOTAL	4435.1	8322.2	2832.1	7703.6	429.0	955.6	131.9	184.9	355.7	640.7	435.4	459.0	864.7	1365.3	1642.7	1986.5
MEAN	170.6	346.8	108.9	321.0	16.5	39.8	5.1	7.7	13.7	26.7	16.7	19.1	33.3	56.9	63.2	82.8

* Fish were removed from levee side of borrow pit only; a and b represent two independent samples.

TABLE 14

Results of Step-wise Regression Analyses of Hydrologic, Morphometric and Fishery Variables From 25 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River

Dependent Variable	Independent Variable	B-Value	Prob > F	R^2
Catastomidae Weights	Days Flooded	2.85	.0196	.24
Clupeidae Weights	Days Flooded	2.34	.0001	.84
Crappie Weights	Days Flooded	0.23	.0001	.66
Cyprinidae Weights	Days Flooded	0.52	.0035	.35
Other Fish Weights	Days Flooded	0.88	.0001	.68
Ictaluridae Weights	Days Flooded	0.32	.0001	.59
Largemouth Bass Weights	Mean Depth	1.66	.0001	.77
Largemouth Bass Weights	Mean Depth	2.25	.0001	.81
	Volume	-.00002	.0413	
Largemouth Bass Weights	Mean Depth	3.33	.0003	.84
	Volume	-.00002	.0131	
	Mean Basin Slope	-75.47	.1259	
Sunfish Weights	Shoreline Development Index	8.64	.0001	.62
Total Fish Weight	Days Flooded	7.43	.0001	.60
Catostomidae Numbers	Days Flooded	3.02	.0007	.47
Clupeididae Numbers	Shoreline Length	2.23	.0001	.72
Clupeidae Numbers	Shoreline Length	3.16	.0001	.76
	Surface Area	-291.55	.0725	
Crappie Numbers	Days Flooded	9.30	.0018	.39
Cyprinidae Numbers	Surface Area	42.71	.0773	.15
Other Fish Numbers	Days Flooded	13.71	.0001	.66
Ictaluridae Numbers	Volume Development Index	228.91	.0064	.32
Ictaluridae Numbers	Volume Development Index	387.23	.0028	.42
	Percent Depth ≥ 5 Feet	-7.49	.0856	
Largemouth Bass Numbers	Volume Development Index	37.51	.0001	.55
Sunfish Numbers	Shoreline Development Index	3676.14	.0001	.64
Sunfish Numbers	Shoreline Development Index	5738.03	.0002	.69
	Mean Depth	-1254.72	.0827	
Number Fish Species	Volume Development Index	17.88	.0001	.95
Number Fish Species	Volume Development Index	14.07	.0001	.98
	Maximum Depth	0.89	.0002	
Number Fish Species	Volume Development Index	15.82	.0001	.98
	Maximum Depth	1.62	.0008	
	Mean Depth	-2.25	.0572	

Table 15
Correlation Matrix of Major Fish Group Weights and Numbers from 21 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River

Item	No. of Fish	No. of Catostomidae	No. of Clupeidae	No. of Cyprinidae	No. of Ictaluridae	No. of Crappie	No. of Sunfish	No. of Largemouth Bass	No. of Others (Gars, Drum, Paddlefish)
Weight of fish	-0.47*	0.92*	-0.25	-0.28	-0.17	-0.09	-0.35	-0.20	-0.10
Weight Catostomidae	-0.54*	0.95*	-0.25	-0.11	-0.17	-0.12	-0.35	-0.21	-0.21
Weight Clupeidae	-0.21	-0.21	0.27	-0.36	-0.05	0.22	0.06	0.23	0.38
Weight Cyprinidae	-0.75*	0.84*	-0.38	-0.13	-0.13	-0.19	-0.38	-0.28	-0.19
Weight Ictaluridae	-0.48	0.85*	-0.33	-0.22	-0.01	-0.17	-0.35	-0.34	-0.04
Weight crappie	-0.39	0.46*	-0.33	-0.09	-0.00	-0.07	-0.48	-0.20	0.00
Weight sunfish	0.45*	-0.17	0.14	-0.21	-0.07	0.03	0.60*	0.22	0.23
Weight largemouth bass	-0.15	0.35	-0.02	-0.32	-0.17	0.02	-0.14	0.11	0.24
Weight others (gars, drum, paddlefish)	-0.48	0.69*	-0.37	-0.26	-0.26	-0.12	-0.30	-0.35	0.10

* = significant at $P \le 0.05$.

Table 16

Correlation of Numbers and Weights of Fish from 21 Borrow Pits Along the Main Stem Levee System of the Lower Mississippi River

Item	Catostomidae	Clupeidae	Cyprinidae	Ictaluridae	Crappie	Sunfish	Largemouth Bass	Other (Gars, Drum, Paddlefish)
Catostomidae		-0.36	-0.06	-0.23	-0.21	-0.53*	-0.03	-0.31
Clupeidae	-0.19		-0.22	0.05	0.24	0.35	0.37	0.30
Cyprinidae (mostly carp)	0.89*	-0.06		-0.05	0.48*	-0.23	-0.23	-0.20
Ictaluridae	0.75*	0.08	0.74*		0.53*	0.19	0.53*	0.14
Crappie	0.37	0.36	0.61*	0.63*		0.43	0.73*	0.43
Sunfish	-0.03	0.33	-0.05	-0.10	-0.15		0.38	0.49*
Largemouth bass	0.32	0.33	0.38	0.32	0.65*	0.27		0.23
Others (gars, drum, paddlefish)	0.67*	0.14	0.78*	0.62*	0.57*	0.04	0.51*	

NOTE: The upper half of the matrix represents numbers against numbers and the lower half of the matrix represents weights against weights.

* = Significant at $P \leq 0.05$.