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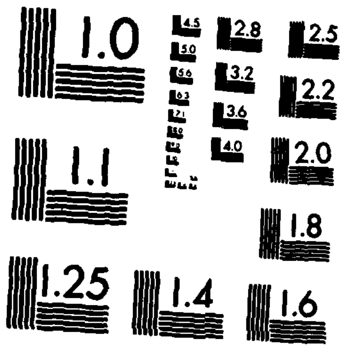

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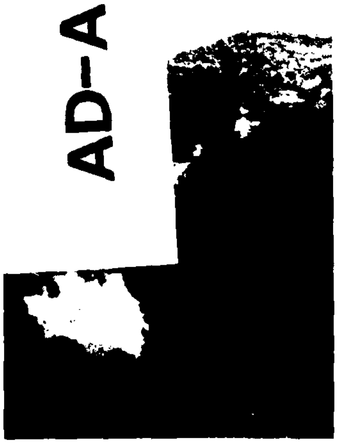

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INVESTIGATION OF WATER QUALITY AND FISHERIES OF THE BLACK RIVER LAKE-COCODRIE LAKE AREA, LOUISIANA

by

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Environmental Laboratory

DEPARTMENT OF THE ARMY
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This study was conducted from April 1984 to February 1985 for the purpose of documenting water quality, fish population characteristics, and concentrations of metals and selected hydrocarbons in the Black River Lake-Cocodrie Lake area of Concordia Parish, La. Black River Lake and Cocodrie Lake are old oxbows of Black River that were isolated from the river when the Smithland Cutoff was completed in 1953.

Fish communities throughout the study area were dominated in numbers by gizzard and threadfin shad, with buffaloes and carp dominating fish biomass. Sport fishes were present in each of the habitats, with white crappie accounting for the largest numbers and weight.

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The standing crop of fishes in Black River Lake was dominated by white crappie, buffaloes, and carp, and compared favorably with the previous estimates. In contrast, the standing crop of fishes in Cocodrie Lake was lower than other habitats and was dominated by gizzard and threadfin shad.

Recruitment of gizzard shad, threadfin shad, bluegill, white crappie, and channel catfish is occurring throughout the study area, although to a lesser degree in Cocodrie Lake. The relative condition of largemouth bass and white crappie is good, in comparison to the relative condition of these same species in similar habitats.

Black River Lake is much deeper than Cocodrie Lake and experienced thermal and chemical stratification during the summer months. Cocodrie Lake remained mixed and well oxygenated during the study period. Numerous culverts and ditches were observed to transport extensive turbid inflows during high-flow periods. In general, water quality conditions in Black River Lake were similar to those observed in Black River.

Concentrations of chlorinated hydrocarbons and trace metals/nonmetals were minimal in both bottom sediments and fish tissue samples. The mean mercury concentration was above US Food and Drug Administration action standards in smallmouth buffalo tissue samples in Black River Lake.

PREFACE

The study described in this report was sponsored by the District Engineer, US Army Engineer District (USAED), Vicksburg, Vicksburg, Miss., as a part of the Upper Tensas-Cocodrie Area Study, which is under the Boeuf-Tensas Basinwide Study assigned to the Mississippi River and Tributaries Project. The work was assigned to the US Army Engineer Waterways Experiment Station (WES) under the direction of the Environmental Laboratory (EL). The USAED, Vicksburg, Project Managers were Messrs. Dwight Smith and David Hale.

This report presents results of a study designed to document the water quality, fish population characteristics, and concentrations of metals and selected hydrocarbons in the Black River Lake-Cocodrie Lake area of Concordia Parish, La. Sampling was conducted on a bimonthly basis beginning in April 1984 and concluding in February 1985.

The report was prepared by Messrs. Larry G. Sanders and Richard E. Coleman, under the supervision of Dr. Thomas E. Wright, Chief, Aquatic Habitat Group (AHG), and Dr. C. J. Kirby, Chief, Environmental Resources Division; and by Mr. Robert C. Gunkel, under the supervision of Dr. Thomas L. Hart, Chief, Aquatic Processes and Effects Group; Mr. Donald L. Robey, Chief, Ecosystem Research and Simulation Division; and Dr. John Harrison, Chief, EL.

Special appreciation is expressed to Messrs. Thomas E. Berry and John A. Baker and Ms. Linda E. Winfield, AHG, for field and laboratory support. Mr. Richard L. Kasul, AHG, is thanked for assistance with data analysis.

During the field portion of this study, COL Robert C. Lee, CE, was Commander and Director of WES and Mr. Fred R. Brown was Technical Director. During the report preparation, COL Allen F. Grum, USA, was Director and Dr. Robert W. Whalin was Technical Director. At the time of publication, COL Dwayne G. Lee, CE, was Commander and Director.

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CONTENTS

INVESTIGATION OF WATER QUALITY AND FISHERIES OF THE BLACK RIVER LAKE-COCODRIE LAKE AREA, LOUISIANA

PART I: INTRODUCTION

Background

1. Black River Lake, Workinger Bayou, Cocodrie Lake, Cross Cocodrie Bayou, and Cocodrie Bayou are adjoining bodies of water located near the central border of Concordia and Catahoula Parishes, Louisiana. When the Smithland Cutoff was completed in 1953 the natural course of the Black River was diverted and the old riverbed that existed formed Black River Lake. Recently, locals within the area have expressed concern that both the water quality and the fishery have declined in Black River and Cocodrie Lakes. In order to address these concerns, the Aquatic Habitat Group, Environmental Laboratory, Waterways Experiment Station, conducted water quality and fishery studies from April of 1984 to March of 1985.

Objectives

2. Specific project objectives were to:

a. Describe seasonal population characteristics of the fishes in the Black River Lake - Cocodrie Lake area and estimate the standing crop of fishes in Black River and Cocodrie Lakes.

b. Determine concentrations of selected metals and chlorinated hydrocarbons in Black River Lake and Cocodrie Lake sediments and in tissue samples of three species of fishes collected from each lake.

c. Assess water quality of the Black River Lake-Cocodrie Lake area.

Study Area

3. Black River Lake, Workinger Bayou, Cocodrie Lake, Cross Cocodrie Bayou, and Cocodrie Bayou are adjoining bodies of water (Figure 1). Black River Lake is located to the west and Cocodrie Bayou is located furthest to the east. This system is located near the central border of Concordia and Catahoula Parishes, near Jonesville, Louisiana (Figure 1). With the exception

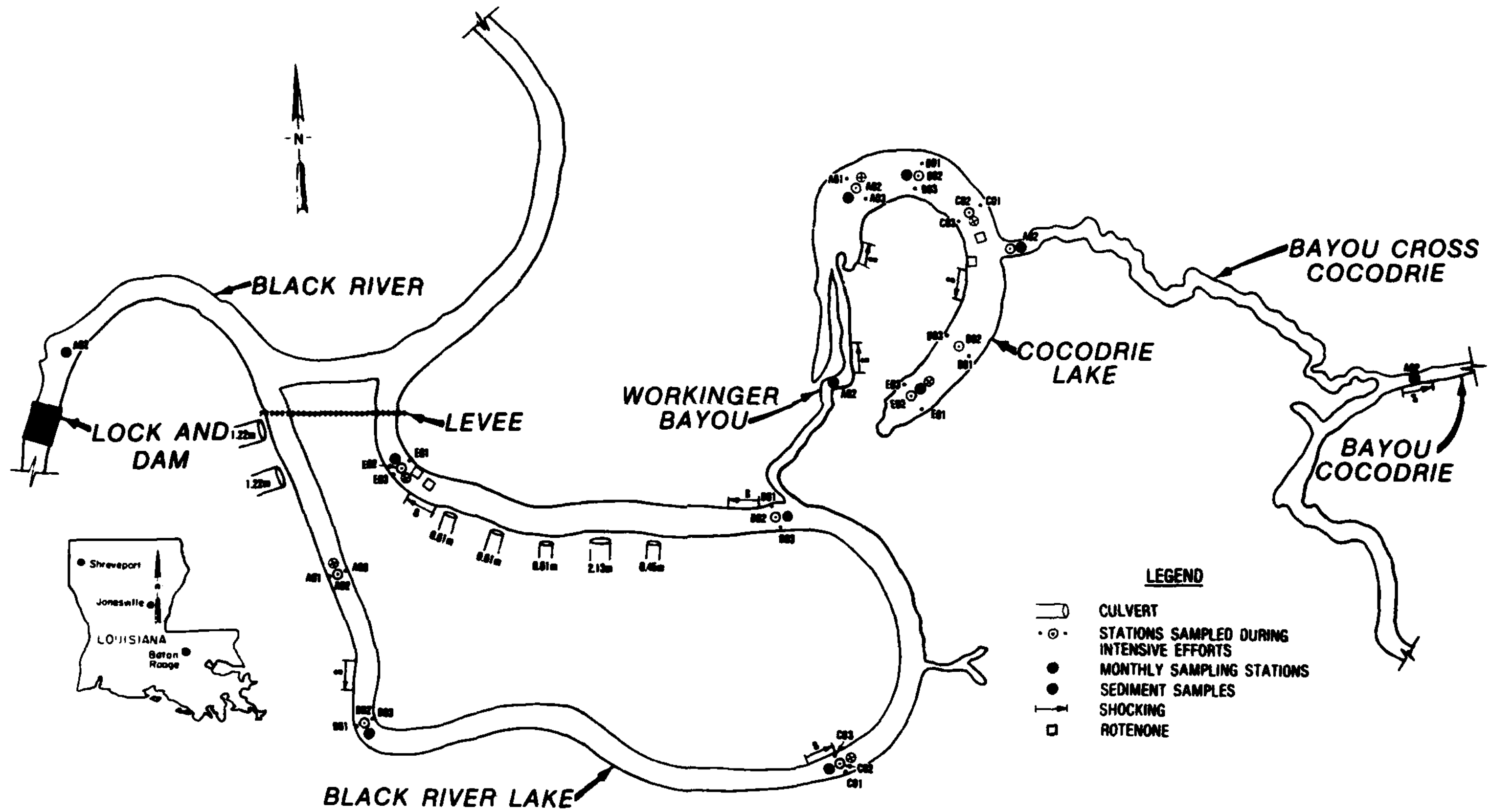

Figure 1. Black River Lake Study Area.

of Black River, all of the other lakes and bayous studied are essentially a large interconnected system with Black River Lake being connected to Cocodrie Lake by Workinger Bayou and Cocodrie Lake being connected to Cocodrie Bayou by Cross Cocodrie Bayou (Fig. 1).

4. Black River Lake is a relatively narrow (maximum width ~ 0.23 km) deep body of water (mean depth 8.5-9.0 m). In comparison Cocodrie Lake is wide (maximum width ~ 0.76 km) and somewhat shallower (mean depth 2.5-3.5 m). All of the bayous investigated were similar physically being narrow and having mean depths of 2.5-3 m. Both Black River and Cocodrie Lakes receive agricultural runoff following heavy rains. Map analysis in conjunction with field observations has shown the runoff in Cocodrie Lake to be controlled primarily by general topography. Observations in Black River Lake have been similar, except that numerous culverts exist which direct additional agricultural runoff into Black River Lake. These culverts range from 0.45 to 2.21 m in diameter and appear to be confined to the northeast and northwest end of the lake. The location, method of inflow, type of structure, and diameter of these structures is depicted on the map in Figure 1. In addition, following periods of intense rainfall, water appears to move into the system from Cocodrie Bayou. All of the areas investigated are for the most part surrounded by vegetation, however, a good deal of the shoreline on Cocodrie Lake is sparsely vegetated. The entire system is surrounded by agricultural land used primarily for growing soybeans and milo.

PART II: METHODS

Field Methods

Physical/chemical

5. Two different sampling strategies were employed to assess the water quality of the Black River Lake-Cocodrie Lake system. Monthly samples were collected from 3 stations in Black River Lake, 2 stations in Cocodrie Lake and from a single station each in Cocodrie Bayou, Cross Cocodrie Bayou, Workinger Bayou, and Black River (Figure 1). At each station, measurements of temperature, pH, dissolved oxygen, and conductivity were taken at 1 m intervals using a Hydrolab Model 8000. Secchi disc measurements were also taken at each station. Water samples were collected using a Van Dorn water sampler, returned to the laboratory, and analyzed for total phosphorus, nitrite (NO_2) and nitrate (NO_3), total and dissolved solids, turbidity, and chlorophyll _a_ and _b_. All water samples collected, with the exception of chlorophyll _a_ and _b_, were collected from mid depth when there was no thermal stratification, however, when stratification was detected, samples were collected from the surface, mid-depth and bottom. Samples collected to be analyzed for chlorophyll _a_ and _b_ were integrated (x2 Secchi depth). Samples to be analyzed for phosphorus, NO_2 and NO_3 were fixed with sulfuric acid and placed on ice.

6. In addition to the routine monthly collection efforts, two intensive sampling efforts were conducted to coincide with spring high flows. The number of sampling stations was increased during these efforts with a total of 15 in both Black River and Cocodrie Lakes (Figure 1). The first intensive effort was conducted in June 1984 near the peak of the hydrograph for this system and in August 1984 just following the peak of the hydrograph. Sampling was conducted in the same manner as previously described except that water samples collected during these periods were not analyzed for total and dissolved solids or NO_2 and NO_3.

7. Sediment samples to be analyzed for trace metals/non metals and hydrocarbons were collected from 6 stations within the study area, 3 each in Black River Lake and Cocodrie Lake (Figure 1). Samples were collected using a ponar grab sampler and were placed in glass containers, placed on dry ice, and returned to the laboratory for analysis.

8. In addition to water quality and sediment samples, fish were collected from Black River Lake and Cocodrie Lake for tissue analysis. White crappie (*Pomoxis annularis*), smallmouth buffalo (*Ictiobus bubalus*), and gizzard shad (*Dorosoma cepedianum*) were collected from each lake using electroshocking. Fish were filleted and a 100 gram sample of muscle tissue from each species was wrapped in aluminum foil and frozen until analysis could be conducted. Care was taken during dissection to remove any bone or epidermal tissue from the fillets. Fish tissue samples were analyzed for the same trace metals/non metals and pesticides/hydrocarbons as were the sediment samples.

Biological

9. To estimate the standing crop of fishes in Black River Lake and Cocodrie Lake, two one acre plots were rotenoned in each of the lakes (Figure 1). Block off nets (mesh size 12.7 mm stretched mesh) were used to surround each of the plots sampled. Plots were selected such that one plot was located near the shoreline and the other in open water. All plots were square in configuration with the block off net surrounding the plot located near the shoreline comprising three sides of the square and the shoreline the other side. Open water plots were surrounded on all four sides by the block off nets. Nets used in Cocodrie Lake and the net used near the bank in Black River Lake were 3.1 m deep, and the open water plot in Black River Lake was surrounded by a net which was approximately 6.2 m deep. Prior to application of rotenone, a minimum of 20 depth soundings were taken inside each net 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. Following application of rotenone, fish were collected from each plot over a 48 hour period. All fish collected were taken to shore where individual lengths and weights were recorded. Potassium permanganate was applied around the outside perimeter of each plot to detoxify any rotenone which might escape through the net due to wind action or boat activity. Application of potassium permanganate averaged 2 hr per plot to reduce incidental kill.

10. In addition to standing crop estimates fish were collected every 2 months from 8 stations within the study area: 4 in Black River Lake (Figure 1); 2 in Cocodrie Lake; 1 in Workinger Bayou; and 1 in Cocodrie Bayou. This was done so that analysis of seasonal population characteristics and trends such as length-frequency of numerically dominant species, species

composition, relative abundance, reproductive success and population condition might be made. During each bi-monthly effort, fish were collected from the stations selected using electroshocking. At each station, shocking was conducted parallel to the shoreline for fifteen minutes, after which time fish collected were taken to the shore, identified, measured and weighed. Fish too small for identification in the field were preserved and returned to the laboratory for identification. For the purpose of obtaining data on reproductive success and population condition, gonads and livers were dissected from three species. Those species selected were largemouth bass (*Micropterus salmoides*) white crappie (*Pomoxis annularis*), and channel catfish (*Ictalurus punctatus*).

Laboratory Methods

Physical/chemical

11. Water samples collected for turbidity measurements were analyzed using a Hach 2100 turbidometer. Chemical analysis was conducted by the Analytical Laboratory Group, Environmental Engineering Division, EL. Samples collected for analysis of total phosphorus, NO_2 and NO_3 and suspended solids were processed following guidelines of USEPA (1977). Samples collected for analysis of dissolved solids were processed following guidelines of APHA (1976).

12. Fish muscle tissue and sediment samples were processed following guidelines of APHA (1976). Trace metals/non metals included in the analysis were barium (Ba), cadmium (Cd), chromium (Cr), silver (Ag), zinc (Zn), arsenic (As), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), cobalt (Co), cyanide (Cn), selenium (Se), iron (Fe), and manganese (Mn). Digest solutions were analyzed for chromium, copper, iron, manganese, nickel, and zinc by flame atomic absorption and emission (EPA, 1974, 1977). Cadmium and lead were measured by flameless atomic absorption using a graphite furnace. Mercury concentrations were determined using cold vapor flameless atomic absorption (EPA, 1977). Arsenic and selenium were determined by atomic absorption using gaseous hydride techniques.

13. Samples for cyanide analyses were prepared following methods of APHA (1976). The distillate was analyzed for Cn using the automated pyridine-barbituric acid method.

14. The chlorinated hydrocarbons were extracted from fish and sediment samples following guidelines established by the EPA (1974 and 1975). Pesticides included in the analyses were: aldrin, chlordane, DDD, DDE, DDT, diazinon, dieldrin, endo sulfan, endrin, ethion, heptachlor, heptachlor epoxide, lindane, malathion, methyl parathion, methal trithion, methoxychlor, mirex, parathion, perthane, toxaphene, trithion, 2,4D, 2,4,5-T, and silvex. The PCB's measured were Arochlor isomers 1242, 1248, 1254, and 1260.

15. Quality control measures included the running of blanks, spiked samples, and standard reference samples and the use of background correction. In addition, some homogenized samples were split and each portion analyzed separately, providing an indication of analytical variability.

Biological

16. Fish samples returned to the laboratory for identification were identified with the aid of a dissecting microscope. When individual samples were extremely large a subsampling procedure was incorporated whereby 10 percent (by weight) of the sample was taken and all fish in the subsample individually identified, weighed, and measured.

PART III: RESULTS

Fisheries

Species composition

17. A total of 20,055 fish weighing 1422.1 pounds were collected from the study area, both from electroshock and rotenone surveys. There were 15 families and 37 species represented (Table 1). Thirty-three species were collected in Black River Lake, 26 from Cocodrie Lake, 20 from Workinger Bayou, and 16 from Bayou Cocodrie, reflecting the more intensive sampling effort in Black River Lake and Cocodrie Lake. A complete list of species, including economic classification (Lagler 1956) is included in Table 1. Common names of species and numbers collected by electroshocking in each habitat are listed in Tables 2-5. Results of the rotenone surveys will be presented in the standing crop section of this report.

18. The consolidated electroshocking catch was dominated numerically by the Clupeidae, including gizzard and threadfin shad, which totaled 73.7 percent of the catch (Figure 2). The sunfish family, Centrarchidae, excluding largemouth bass, included eight species and made up 10.6 percent of the numerical catch. Bluegill and white crappie dominated at 5.1 percent and 3.9 percent, respectively. No other family exceeded 5 percent of the total catch. Largemouth bass comprised 2.6 percent of the catch.

19. The Catostomidae, primarily bigmouth and smallmouth buffalo, totaled 41.1 percent of the consolidated electroshocking weight, followed by the Cyprinids (common carp) which made up 23.8 percent of the total weight. The Lepisostidae, principally spotted and shortnose gar, comprised 10.4 percent of the total weight. Combined, these three families accounted for 75.3 percent of the weight but only 11.7 percent of the numbers. The Clupeidae, which accounted for 73.7 percent of fish numbers, comprised only 8.9 percent of the total weight. Commercial fish constituted 9.0 percent of the total numbers and 64.2 percent of the total weight, while sport fish made up 12.5 percent of the numbers and 14.3 percent of the weight (Table 6).

20. Black River Lake. Relative abundance and temporal distribution of fish collected in Black River Lake by electroshocking are depicted in Figure 3. Gizzard and threadfin shad comprised 73.9 percent of the catch and were the most frequently caught fish in three (April, October, December) of

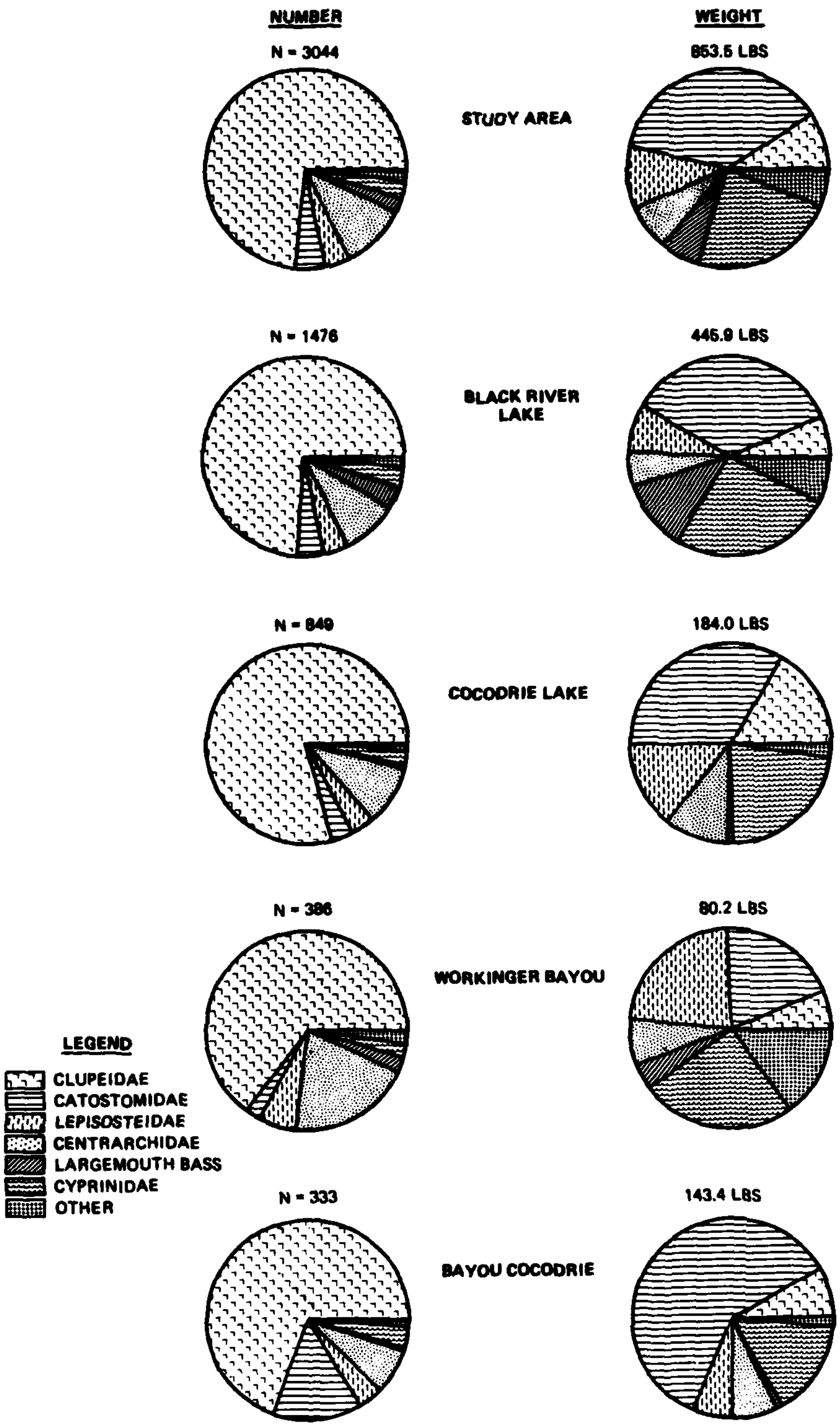

Figure 2. Relative abundance of major groups of fish caught by electroshocking from the Black River Lake-Cocodrie Lake study area, consolidated for all sampling periods.

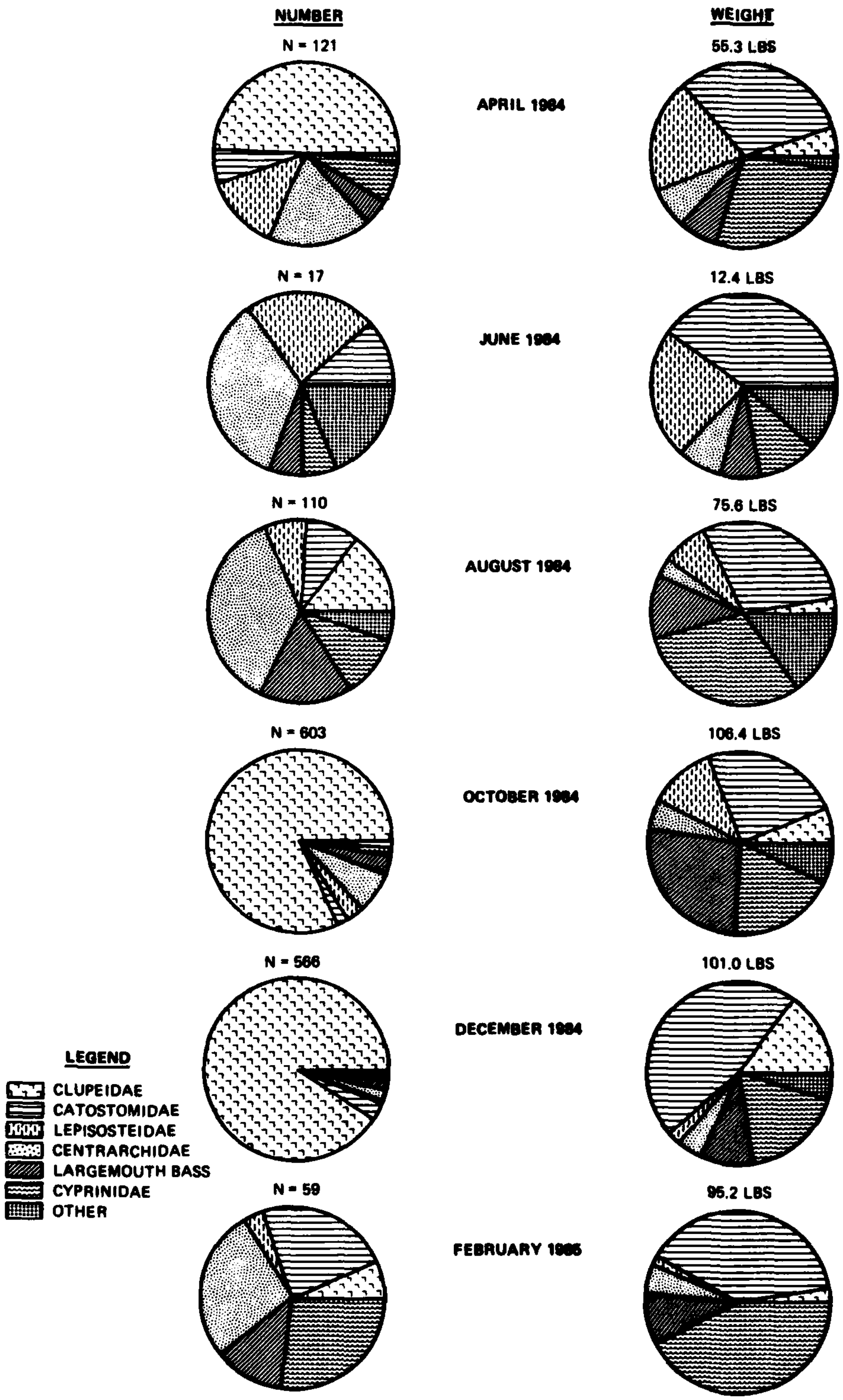

Figure 3. Relative abundance of major groups of fish caught by electroshocking from Black River Lake, Louisiana, shown by numbers (N) and weight for each sampling period.

the six sampling periods (Table 2). Sunfish ranked second numerically at 9.3 percent of the catch with bluegill comprising 5.9 percent and white crappie at 1.7 percent. Sunfish were more abundant during the remaining three sampling periods (February, June, August), tied with the common carp as the most fish in February (16). Sunfish were generally more abundant during months when the total number of fish captured was lowest. Largemouth bass were caught during all six sampling periods and accounted for 4.3 percent of the total fish caught. Bigmouth buffalo, common carp, spotted gar, and shortnose gar were also caught in all sampling periods and accounted for 3.7, 3.6, 2.8 and 0.5 percent of the catch, respectively. Commercial fish represented 8.9 percent of the fish and sport fish 12.5 percent.

21. Although shad dominated the catch numerically, they accounted for only 6.5 percent of the total weight caught. Total fish weight was dominated by bigmouth and smallmouth buffalo, which constituted 35.2 percent, and common carp, which made up 26.3 percent of the catch. Largemouth bass accounted for 13.2 percent of the weight while other sunfish accounted for 5.2 percent. Spotted gar comprised 6.4 percent of the total weight. Overall, commercial fish accounted for 61.7 percent of the biomass and sport fish accounted for 19.0 percent (Table 6).

22. Cocodrie Lake. Relative abundance and temporal distribution of fish collected by electroshocking in Cocodrie Lake are depicted in Figure 4. Gizzard and threadfin shad comprised 79.0 percent of the catch and were the most frequently caught fish in all sampling periods. Sunfish ranked second numerically with 10.4 percent of the catch, led by white crappie which totaled 7.5 percent. No sunfish were caught in June, when sample numbers were low, or December, when sample numbers were highest. Only four largemouth bass were caught, two each in August and October, and these fish contributed only 0.5 percent of the total numbers. Buffaloes accounted for 3.3 percent of the catch and common carp comprised 2.5 percent. Commercial fish represented 6.9 percent of the numbers and sport fish 10.7 percent.

23. Shad accounted for 16.5 percent of the total weight. The catch was again dominated by buffaloes and common carp, which represented 34.1 percent and 22.4 percent of the total. Largemouth bass made up only 0.5 percent of weight, while the remaining sunfish constituted 10.4 percent. Spotted and shortnose gar made up 13.9 percent of the weight. Overall, commercial fish represented 58.6 percent of the weight and sport fish 11.3 percent (Table 6).

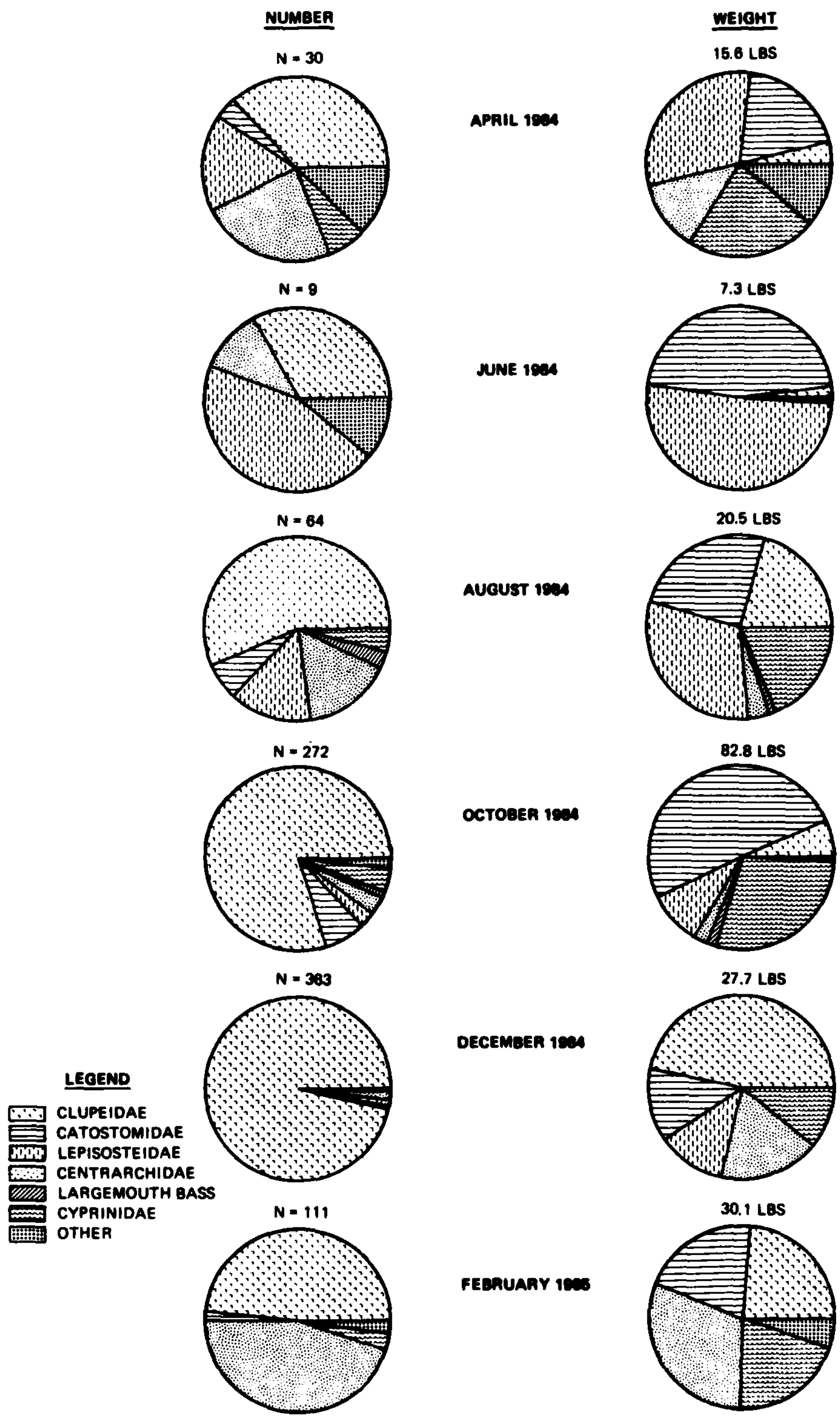

Figure 4. Relative abundance of major groups of fish caught by electroshocking from Cocodrie Lake, Louisiana, shown by numbers (N) and weight for each sampling period.

24. Workinger Bayou. Relative abundance and temporal distribution of fish collected by electroshocking in Workinger Bayou are depicted in Figure 5. Clupeids, primarily threadfin shad, dominated the overall catch (64.8 percent) and were more abundant during the April and December periods. Sunfish ranked second at 20.0 percent and were more abundant during the February, August, and October sampling periods. Only five fish were caught in June, two of which were spotted gar. Commercial fish comprised 5.7 percent and sport fish 19.2 percent of numbers (Table 6). Common names and numbers of each species collected for each sampling period are shown in Table 4.

25. Carp, gar (primarily spotted gar), and suckers dominated the weight with 25.4 percent, 22.8 percent, and 19.6 percent of the total respectively. Sunfish accounted for 7.6 percent of the total weight and largemouth bass comprised 3.9 percent. Commercial fish made up 49.4 percent of the weight caught and sport fish 11.3 percent (Table 6).

26. Bayou Cocodrie. Relative abundance and temporal distribution of fish in Bayou Cocodrie are depicted in Figure 6. Gizzard and threadfin shad again dominated the numbers, totaling 69.4 percent of the total catch. Shad were more prevalent in five of the six sampling periods, and were a close second during the sixth period. Suckers, primarily bigmouth buffalo, were second in numbers at 14.1 percent. Commercial fish comprised 18.9 percent of the catch and sport fish 13.1 percent (Table 6). Common names and numbers of each species collected for each sampling period are shown in Table 5.

27. Bigmouth buffalo dominated the catch by weight from Bayou Cocodrie. The Catostomids accounted for 60.0 percent of weight and carp accounted for 16.6 percent. Seventy-eight percent of the weight was composed of commercial species and only 4.7 percent were sport species (Table 6).

Standing crop

28. Black River Lake. An average of 202.6 pounds per acre of fish were recovered from two one-acre rotenone plots in Black River Lake (Table 7). The Centrarchidae, represented by ten separate species, were the principal fishes occurring and comprised 25.6 percent of the total fish biomass. White crappie accounted for the bulk of this amount (17.2 percent of the total), while largemouth bass made up 3.6 percent. The standing crop of Centrarchidae averaged 51.8 pounds per acre which included 34.8 pounds of white crappie, 7.2 pounds of largemouth bass, and 6.0 pounds of bluegill per acre.

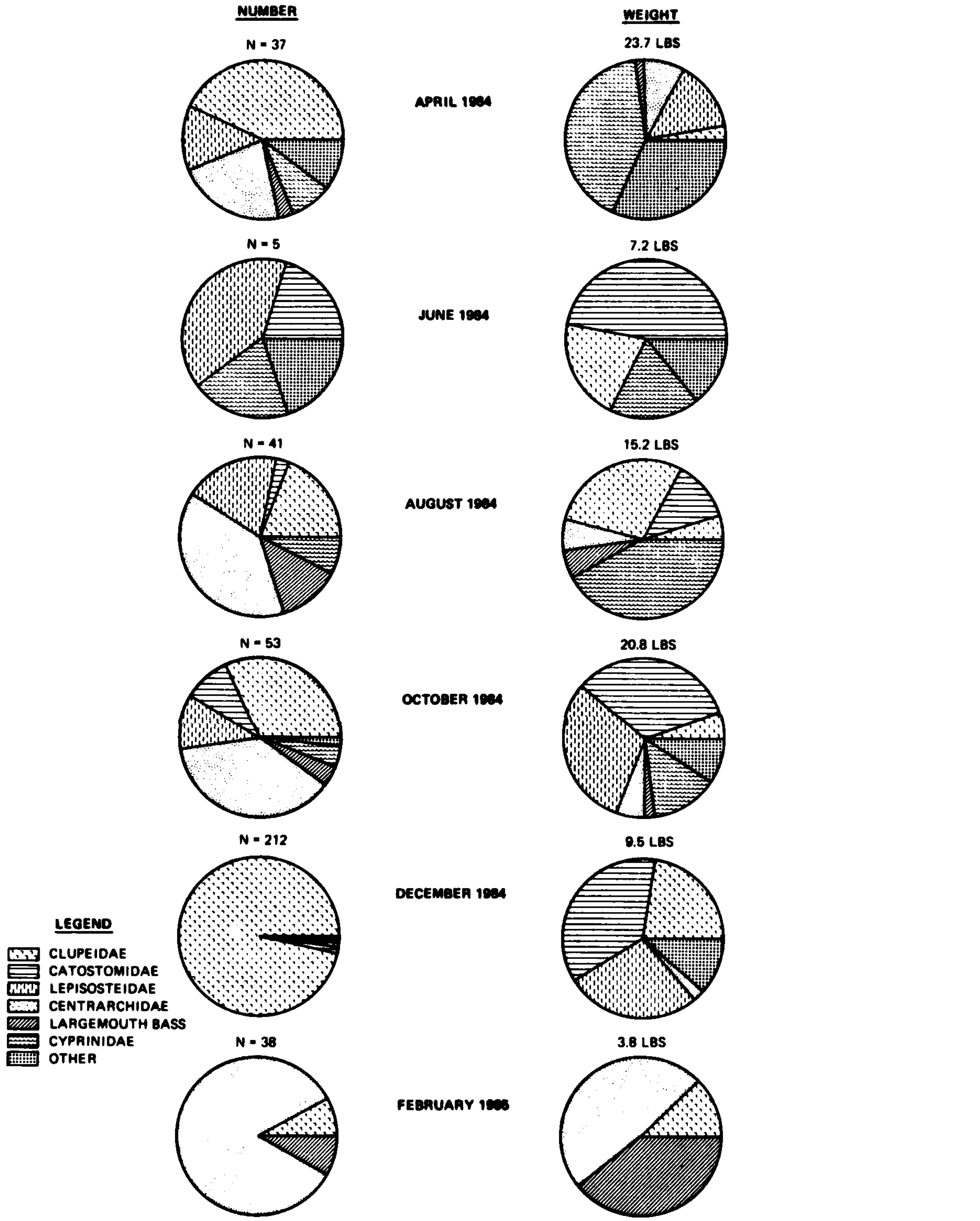

Figure 5. Relative abundance of major groups of fish caught by electroshocking from Workinger Bayou, Louisiana, shown by numbers (N) and weight for each sampling period.

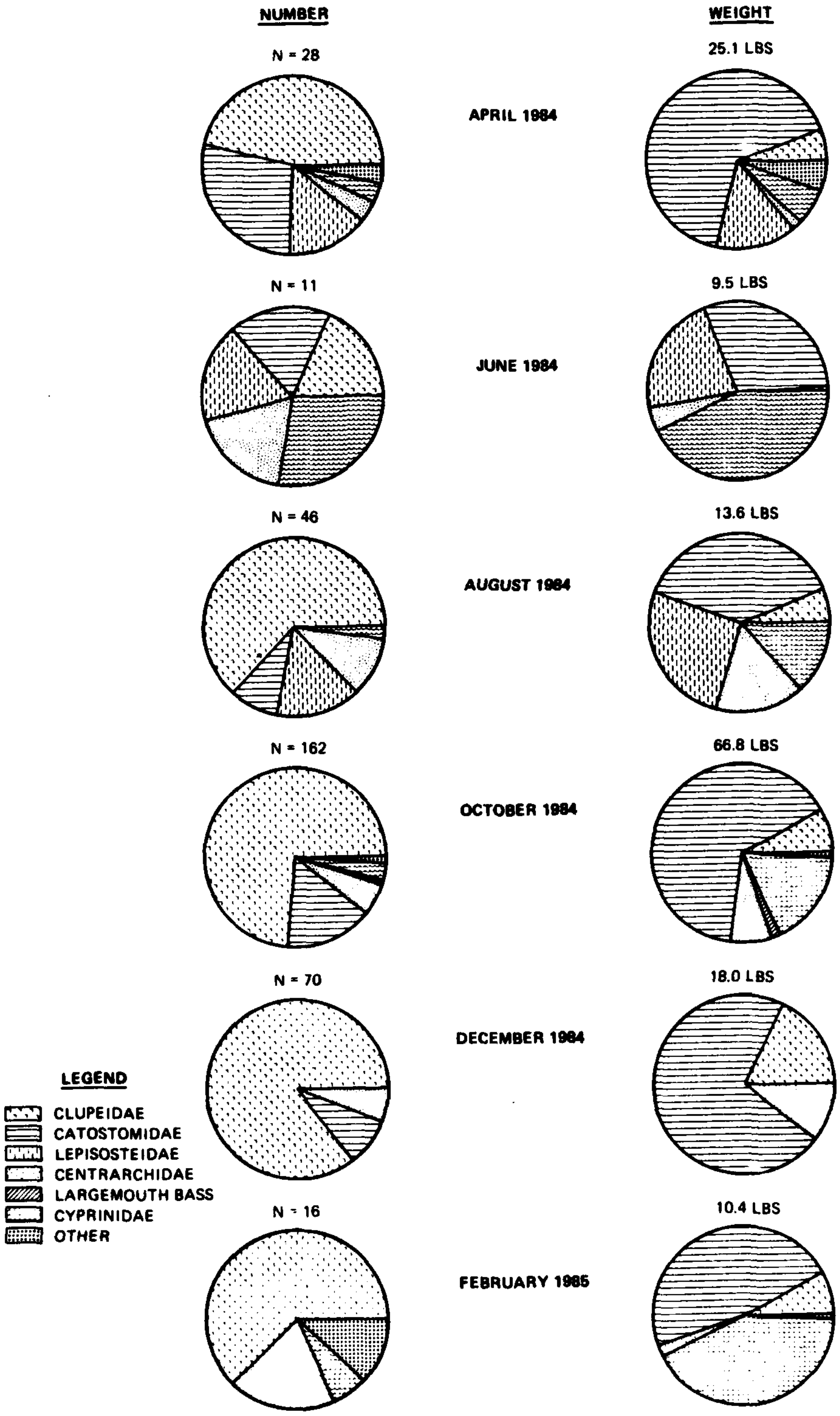

Figure 6. Relative abundance of major groups of fish caught by electroshocking from Bayou Cocodrie, Louisiana, shown by numbers (N) and weight for each sampling period.

29. The Catostomidae comprised 20.1 percent of the total standing crop and averaged 40.8 pounds per acre. The Cyprinidae, made up 17.2 percent of the biomass and averaged 34.9 pounds per acre. The Lepisostidae (gar) and Clupeidae (shad) accounted for 12.6 percent and 9.2 percent of the biomass and constituted 25.5 and 18.5 pounds per acre, respectively.
Species with the largest biomass per acre were white crappie (17.2 percent), common carp (17.2 percent), smallmouth buffalo (14.4 percent), shortnose gar (12.0 percent), freshwater drum (10.4 percent), bigmouth buffalo (5.7 percent), and gizzard shad (5.7 percent). Combined these seven species accounted for 167.4 pounds per acre of the total standing crop. No other species accounted for more than 3.6 percent of the total standing crop.

30. Commercial species comprised 52.6 percent of the total fish biomass and their standing crop averaged 106.6 pounds per acre. The principal commercial fish were the common carp, smallmouth buffalo, freshwater drum, and bigmouth buffalo. The standing crop of sport fishes averaged 57.5 pounds per acre and comprised 28.4 percent of the total fish biomass. White crappie, largemouth bass, and bluegill were the dominant sport species.

31. Cocodrie Lake. An average of 81.7 pounds per acre of fish was recovered from two one-acre rotenone plots in Cocodrie Lake (Table 7). The Clupeidae, gizzard and threadfin shad, were the principal fishes occurring and comprised 44.8 percent of the total fish biomass. The standing crop of Clupeidae was 36.7 pounds per acre, with 30.7 pounds per acre of gizzard shad and 6.0 pounds per acre of threadfin shad.

32. The Centrarchidae, primarily white crappie, comprised 17.0 percent of the total standing crop and averaged 13.8 pounds per acre. The common carp represented 8.7 percent of fish biomass and totaled 7.1 pounds per acre. The only other family to exceed five percent of the total biomass was Catostomidae, which accounted for 5.4 percent of the total and constituted 4.5 pounds per acre.

33. Principal fishes occurring included the gizzard shad, white crappie, freshwater drum, common carp, and threadfin shad which comprised 37.5, 15.0, 11.0, 8.7, and 7.3 percent of the fish biomass, respectively. Combined these species accounted for 65.0 pounds per acre of the total standing crop. No other species accounted for more than 4.5 percent of the total standing crop.

34. Commercial species comprised 34.3 percent of the total fish biomass and their standing crop averaged 28.0 pounds per acre. The principal commercial fish were freshwater drum, common carp, and smallmouth buffalo. The standing crop of sport fishes averaged 17.7 pounds per acre and comprised 21.7 percent of the total fish biomass. White crappie were by far the dominant sport fish. Only three largemouth bass were recovered representing 1.1 percent of the total. Bluegill accounted for only 0.9 percent of the total fish biomass and totaled 0.7 pounds per acre.

Length frequency

35. Length frequency distributions (Total Length) were constructed for selected species in Black River Lake (Figure 7) and Cocodrie Lake (Figure 8) if the numbers were large enough to make the plots meaningful. Due to the selectivity of sampling methodology and the length of time involved, graphs are illustrated separately for both electroshocking and rotenone surveys. Species selected for analysis include gizzard and threadfin shad, channel catfish, largemouth bass (Black River Lake only), bluegill, and white crappie. Insufficient numbers of channel catfish were collected by electroshocking; thus only those channel catfish recovered from rotenone sampling are included in this analysis.

36. Gizzard shad. Gizzard shad collected from Black River Lake and Cocodrie Lake showed a wide variation in sizes ranging from less than 60 mm to greater than 360 mm, including large numbers of juveniles and adults. Larger fish were more prevalent in electroshocking samples in Black River Lake, whereas larger fish in Cocodrie Lake were more numerous in rotenone samples. Overall size distributions were comparable in the two lakes.

37. Threadfin shad. Threadfin shad collected from Black River Lake and Cocodrie Lake showed similar variations in size ranging from 40-100 mm (Figures 7 and 8), with only a few fish above or below this range. Large numbers were collected in both rotenone and electroshocking samples. The preponderance of threadfin shad in electroshocking samples in Black River Lake and Cocodrie Lake occurred in October and December; 881 of 905 in Black River Lake and 158 of 165 in Cocodrie Lake (Tables 2 and 3).

38. Channel catfish. Size distribution of channel catfish ranged from less than 40 mm to 360 mm in Black River Lake and from less than 40 mm to 260 mm in Cocodrie Lake (Figures 7 and 8). Young-of-the-year were present in the sample in small numbers in Black River Lake and in slightly higher numbers

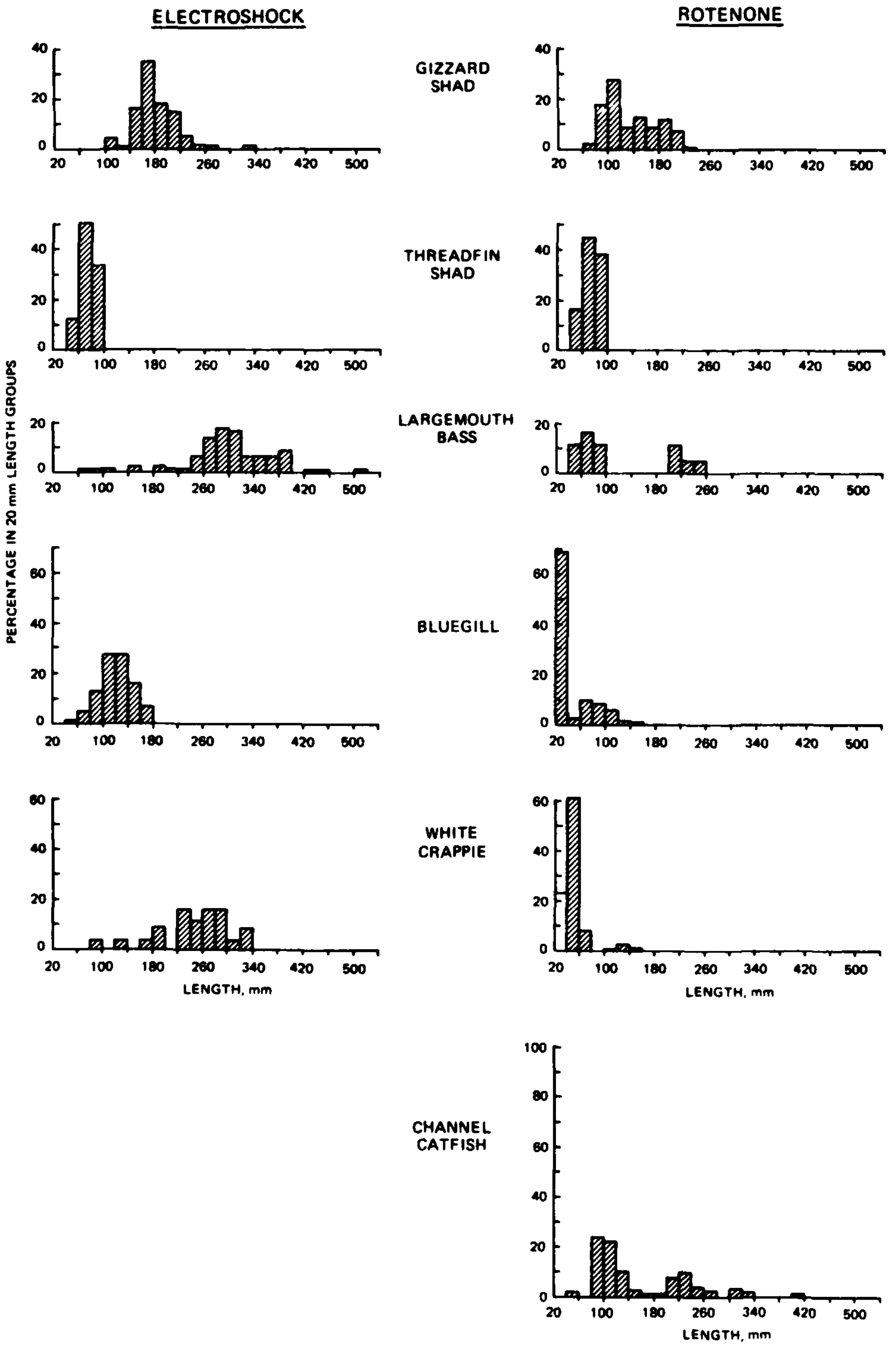

Figure 7. Length-frequency analysis of major groups of fish collected in electroshock and rotenone surveys from Black River Lake, Louisiana.

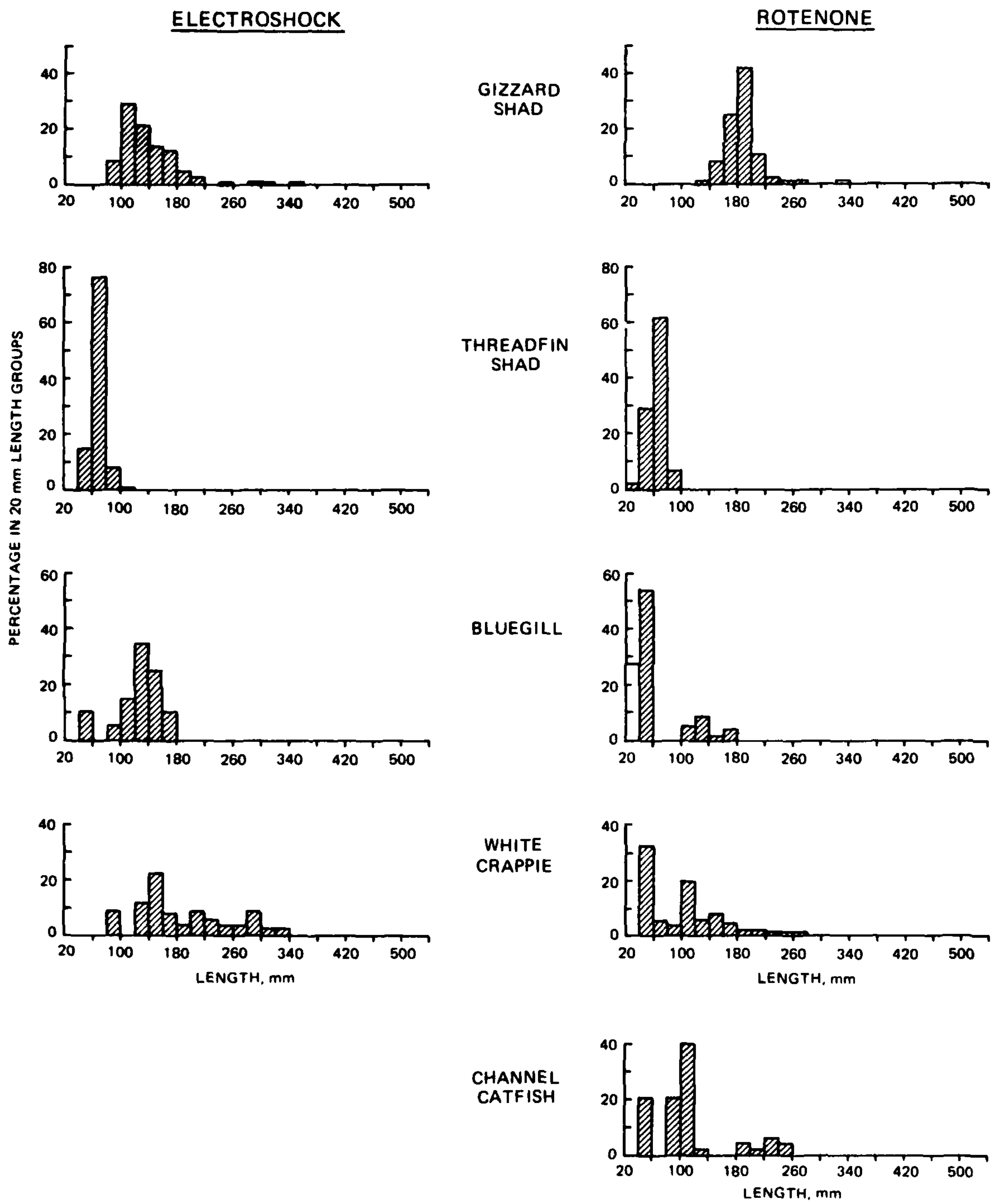

Figure 8. Length-frequency analysis of major groups of fish collected in electroshock and rotenone surveys from Cocodrie Lake, Louisiana.

in Cocodrie Lake. A few larger fish were collected in Black River Lake, but overall size distribution among the two lakes appears consistent.

39. Largemouth bass. Young-of-the-year bass were particularly evident in the rotenone sample during July, ranging in size from 30 - 100 mm (Figure 7). Fish of this size were also captured during electroshock sampling, though in very low numbers. The distinction between Age 1 and Age 2 bass is unclear, nonetheless it appears that both groups are present. Larger bass are also present in Black River Lake, but they were not abundant. The largest bass collected during the study was 505 mm.

40. Bluegill. Young-of-the-year were particularly evident in the July rotenone samples, ranging from 20 - 60 mm. Bluegill in the 80 - 170 mm range were numerous; however, the length modes overlapped and probably represented several year classes. The largest bluegill collected was from Black River Lake and measured 173 mm. Very few bluegill exceeded 160 mm in length.

41. White crappie. The relatively large numbers of white crappie collected in both Black River Lake and Cocodrie Lake were predominantly smaller fish. This was particularly true in the July rotenone sample in Cocodrie Lake. A few larger sized fish were recovered in electroshock samples in both lakes, with the largest fish at 340 mm coming from Black River Lake. Size distribution ranged from approximately 40 mm to 340 mm on both lakes.

Condition factor (K)

42. The condition factor (K) is a comparison of fish weight relative to fish length (Ricker 1970). Simply stated, the heavier any fish is for a given length, the larger the K value. The condition factor is used primarily to compare fish populations from different areas in regard to their relative well being and there is no ideal K value established for any given species of fish. Mean values of K normally increase with age to about Age 5, then level out and in some instances decrease slightly as fish become older. For this analysis, only fish larger than 25 grams were included to eliminate the possibility of distortions due to weighing errors at smaller sizes.

43. Largemouth bass. Condition factors computed for largemouth bass collected in Black River Lake and Cocodrie Lake are shown in Figure 9. It should be noted that no bass were caught in Cocodrie Lake during the months of February, April, or June, and the figures depicted in Cocodrie Lake represent only three bass in July (rotenone survey), one in August, and two in October

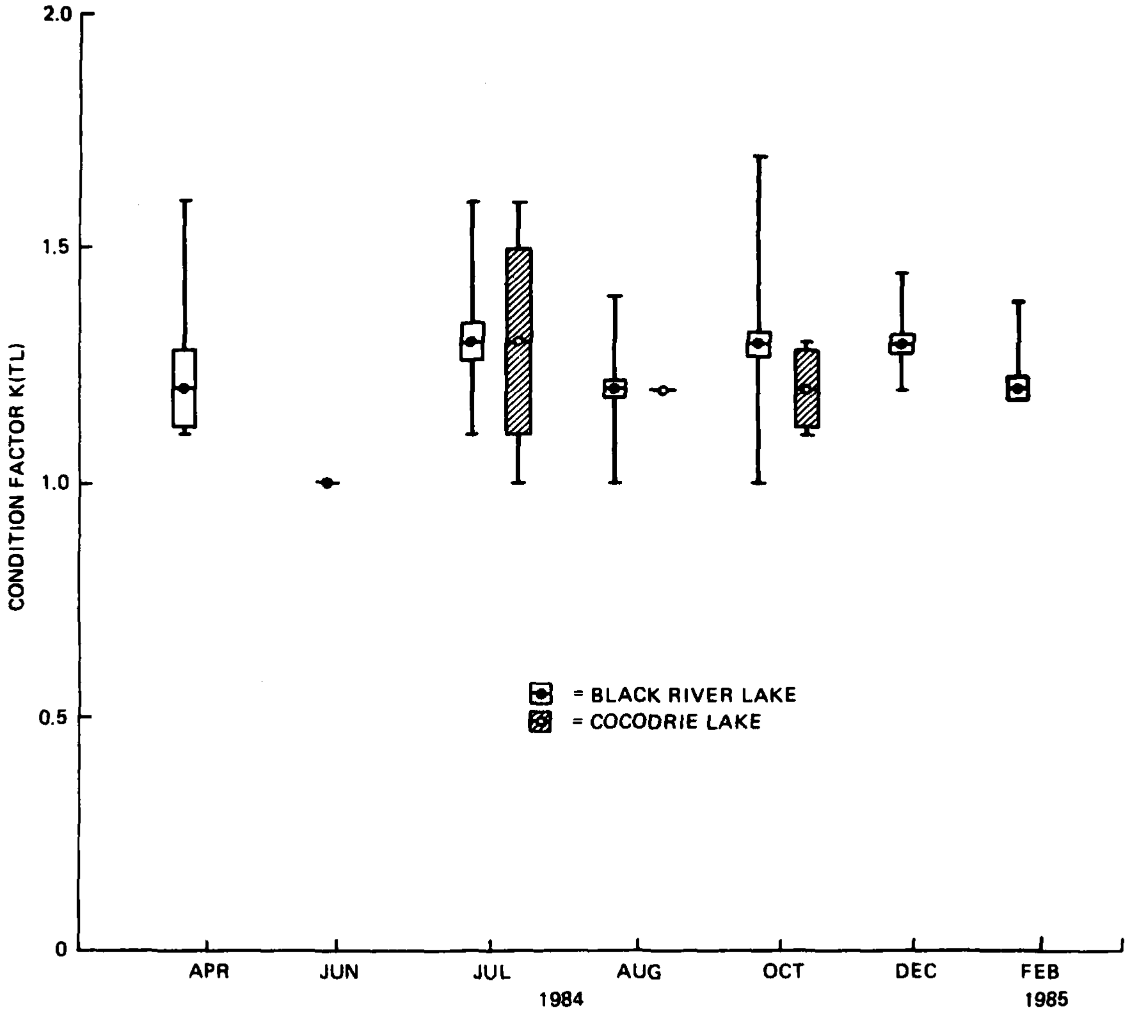

Figure 9. Condition Factors K of largemouth bass collected in electroshock and rotenone surveys from Black River Lake and Cocodrie Lake, Louisiana. Included are the mean K, standard error about the mean, and range showing minimum and maximum values.

(electroshock survey). Largemouth bass were collected in each of the sampling months in Black River Lake (total of 69), however only one bass was collected in June. Average K for largemouth bass in Black River Lake was 1.28 and ranged from 0.97 to 1.67. Average K for largemouth bass in Cocodrie Lake was 1.23 and ranged from 1.08 to 1.63. Values of K in Black River Lake decreased slightly during the spring months, as expected, probably due to spawning activity.

44. White crappie. Condition factors computed for white crappie collected in Black River Lake and Cocodrie Lake are shown in Figure 10. No white crappie were collected in August and October in Black River Lake, or during June and August in Cocodrie Lake. A total of 319 white crappie in Black River Lake and 178 in Cocodrie Lake were used in this analysis. Average K in Black River Lake was 1.22 and ranged from 0.59 to 1.99. Average K in Cocodrie Lake was 1.16 and ranged from 0.83 to 2.49. Values of K decreased in the spring in Black River Lake, presumably reflecting the spawning activity of fish during this period.

45. Bluegill. Condition factors computed for bluegill in Black River Lake and Cocodrie Lake are shown in Figure 11. No bluegill were collected in June and December in either lake. A total of 95 fish in Black River Lake and 28 fish in Cocodrie Lake were used in this analysis. Average K for bluegill in Black River Lake was 1.78 and ranged from 1.10 to 2.80. Average K for bluegill in Cocodrie Lake was 1.73 and ranged from 1.20 to 2.31. Values of K decreased slightly throughout the summer months and then increased slightly in the fall, corresponding with the spawning season of bluegill. Values were comparable to those reported by Carlander (1977) for bluegill in other U.S. waters.

Reproductive success

46. Largemouth bass. The Gonadal-Somatic Indices (GSI) of largemouth bass collected in electroshock surveys in the Black River Lake - Cocodrie Lake study area are depicted in Figure 12. GSI is defined as the ratio of the weight of gonads to the body weight of a fish and is useful in determining spawning activity of a species. The average GSI of females collected in February was 4.93 and ranged from 2.48 to 6.90. GSI of females collected in April also averaged 4.93 and ranged from 1.69 to 7.11. During June only one female was collected with a GSI of 1.23, and during August the average

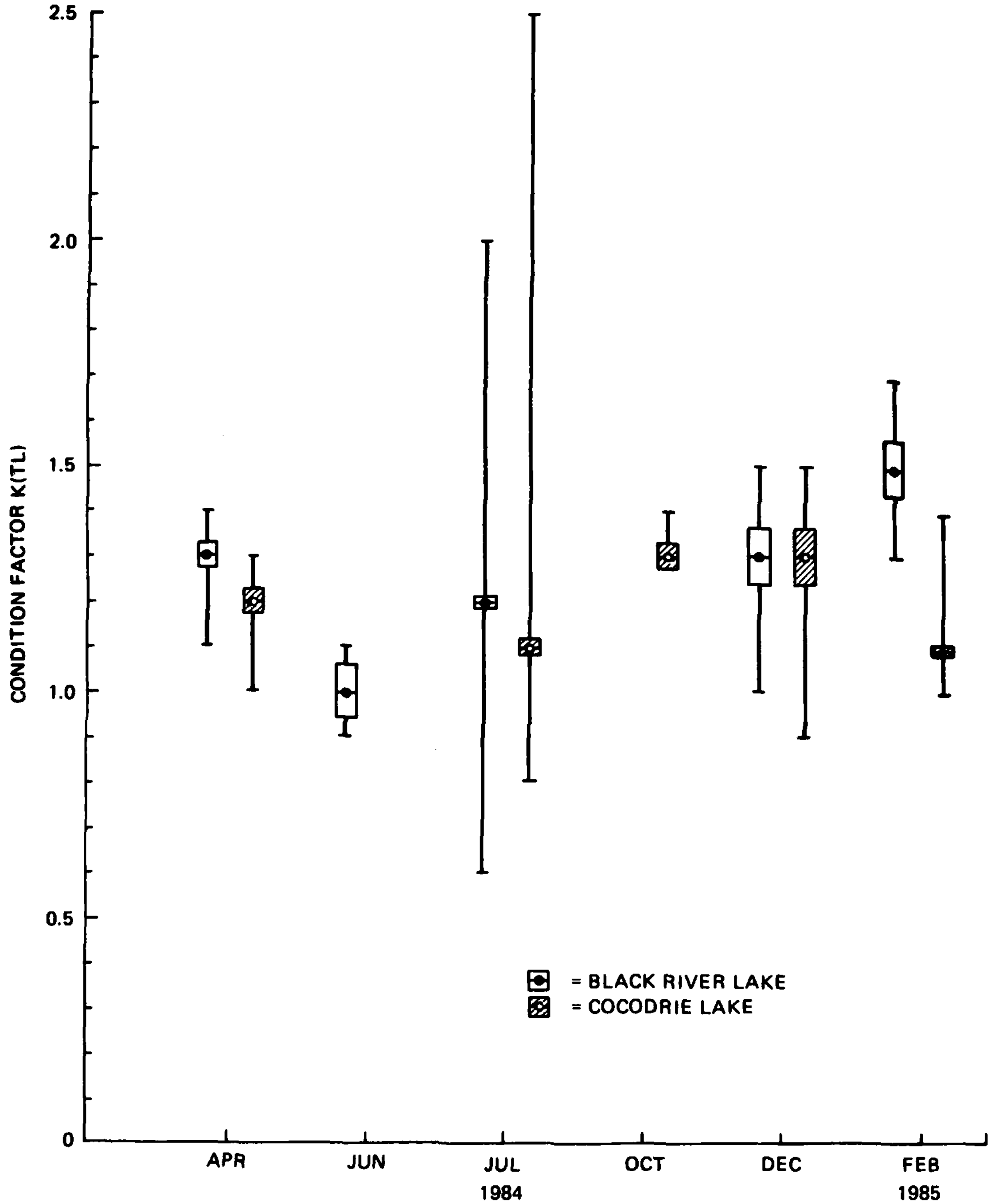

Figure 10. Condition Factors K of white crappie collected in electroshock and rotenone surveys from Black River Lake and Cocodrie Lake, Louisiana. Included are the mean K, standard error about the mean, and range showing minimum and maximum values.

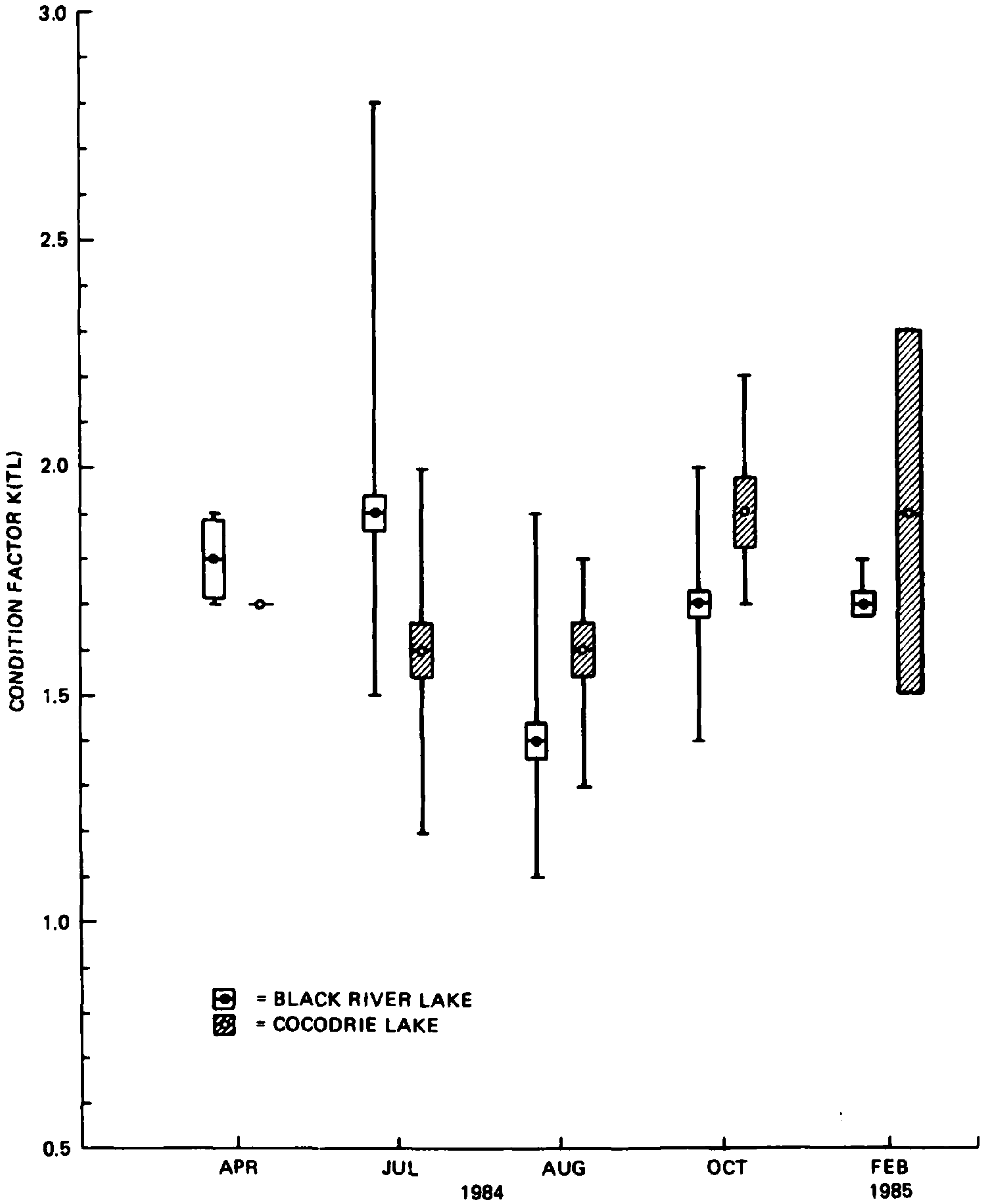

Figure 11. Condition Factors K of bluegill sunfish collected in electroshock and rotenone surveys from Black River Lake and Cocodrie Lake, Louisiana. Included are the mean K, standard error about the mean, and range showing minimum and maximum values.

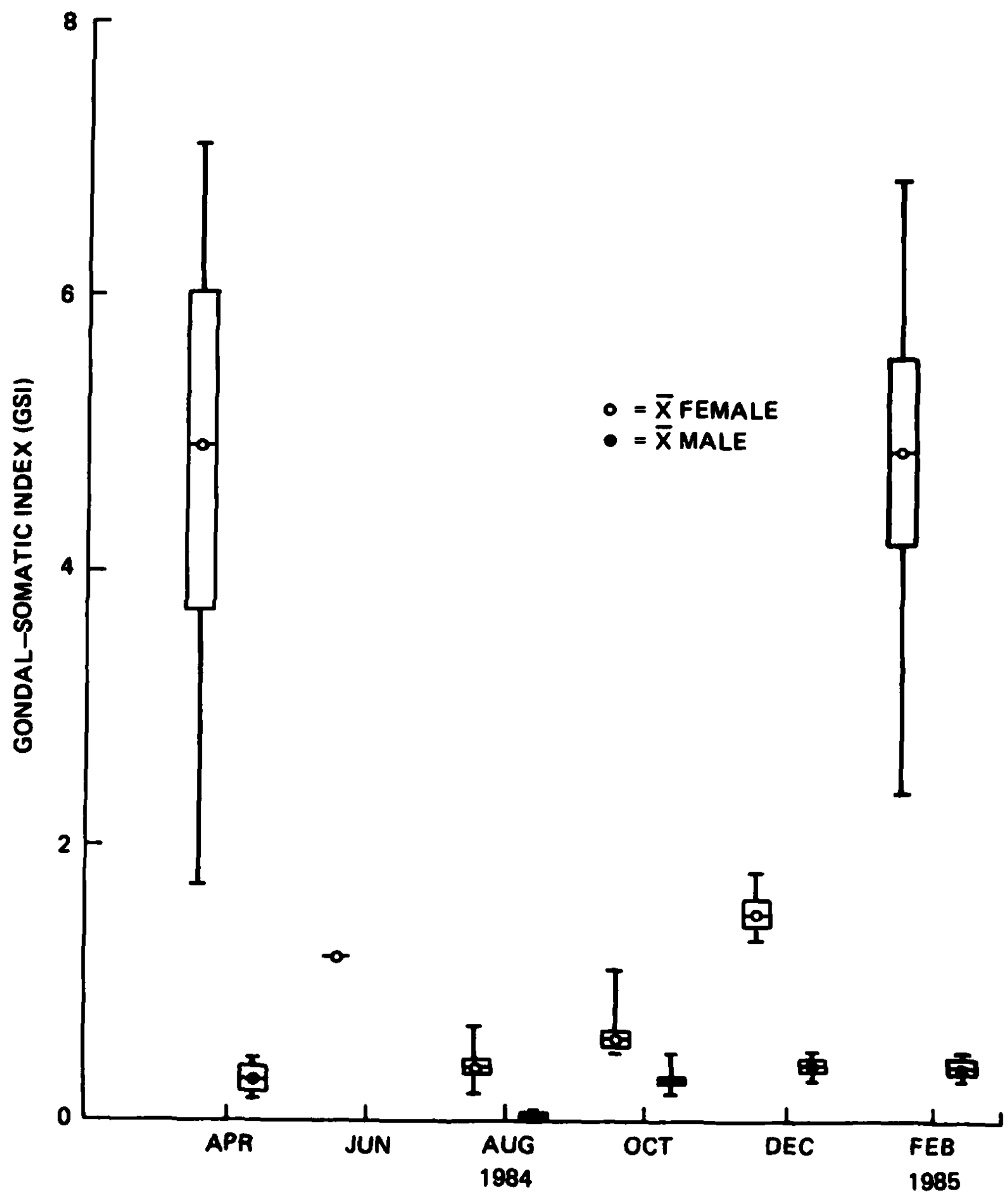

Figure 12. Gonadal-Somatic Indices (GSI) of largemouth bass collected in electroshock surveys from Black River Lake, Workinger Bayou, Cocodrie Lake, and Bayou Cocodrie, Louisiana. Included are the mean GSI, standard error about the mean, and range showing minimum and maximum values.

decreased to a low of 0.45, ranging from 0.21 to 0.74. The GSI of male largemouth bass reflected this same trend, but the average value and magnitude of changes were much less, with a high average in April of 0.44 and a low in August of 0.05.

47. White crappie. The GSI of white crappie collected in electroshock surveys in the Black River Lake - Cocodrie Lake study area are depicted in Figure 13. The average GSI of females collected in February was 1.05 and ranged from 0.28 to 4.15. The GSI of females collected in April averaged 4.98 and ranged from 2.83 to 7.98. During June, the average dropped to 0.53, ranging from 0.08 to 0.81, and in August the lowest average GSI for females was recorded at 0.51. The GSI of male white crappie showed a similar trend, with average values of 0.64 in February, 0.39 in April, 0.13 in June, and 0.81 in October.

Water Quality

48. Results of water quality studies indicate that Black River Lake and Cocodrie Lake differed in physical, chemical, and biological characteristics. These differences were related to lake morphometry (Table 8), drainage area, and landuse activities. In addition, Workinger Bayou, Bayou Cross Cocodrie, and Bayou Cocodrie can be grouped with Black River Lake or Cocodrie Lake based on similarities in water quality. Workinger Bayou was similar to Black River Lake based on several chemical characteristics. In addition, Bayou Cross Cocodrie and Bayou Cocodrie were chemically similar to Cocodrie Lake. Black River exhibited water quality characteristics not significantly different from either lake.

In-situ parameters

49. Black River Lake. Black River Lake experienced isothermal conditions in the late fall and winter months, and stratified conditions during the summer. In addition, anoxic or near-anoxic conditions developed during the thermally stratified period. Associated with hypolimnetic oxygen depletion was an increase in specific conductance (Figures 14-16).

50. Thermal structure at stations B02, C02, and E02 exhibited weak stratification patterns during April (Figure 1). Continual warming of surface

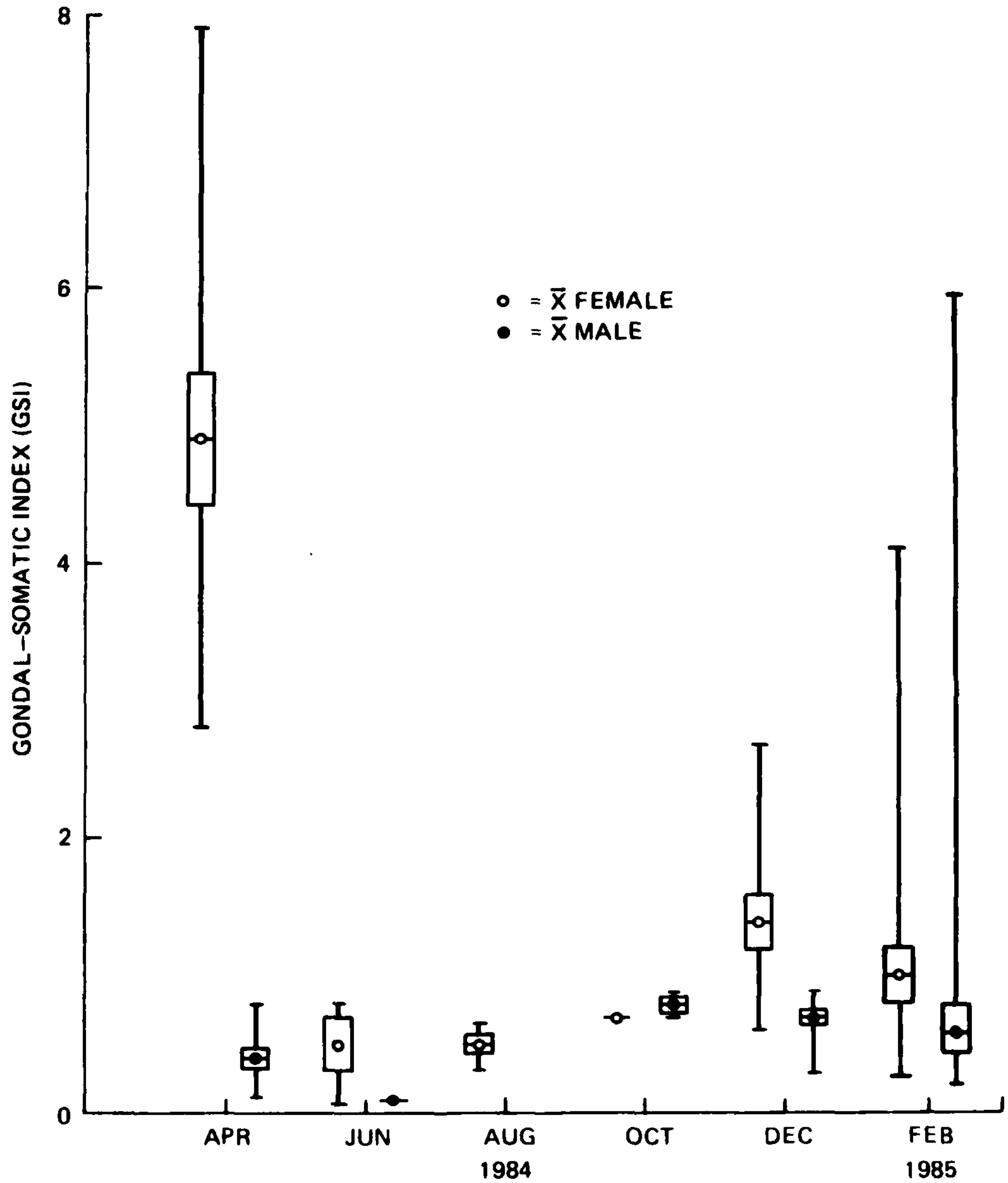

Figure 13. Gonadal-Somatic Indices (GSI) of white crappie collected in electroshock surveys in Black River Lake, Workinger Bayou, Cocodrie Lake, and Bayou Cocodrie, Louisiana. Included are the mean GSI, standard error about the mean, and range showing minimum and maximum values.

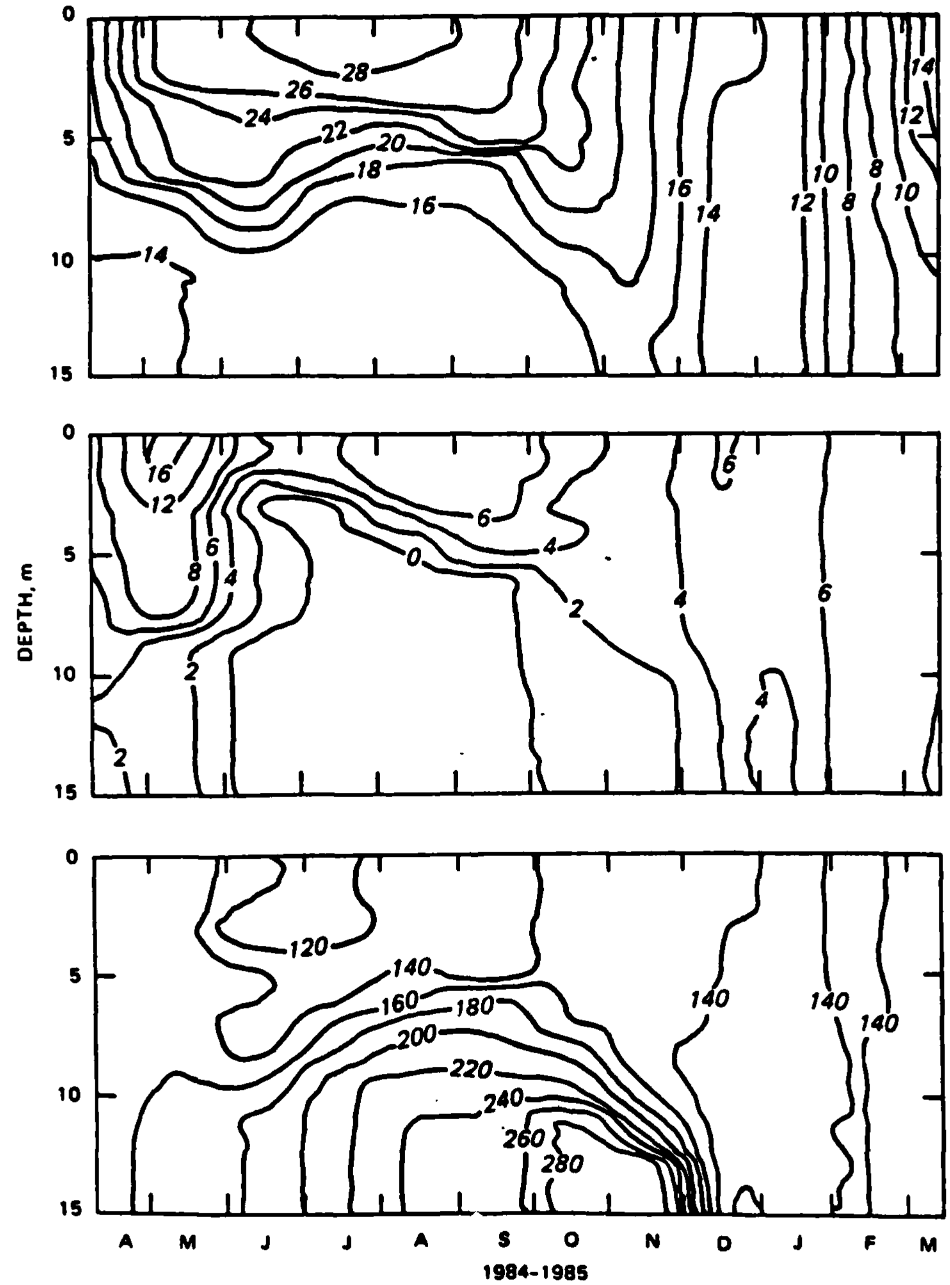

Figure 14. Temporal and vertical patterns in temperature (°C) (upper panel), dissolved oxygen (mg/L) (middle panel), and specific conductance (umhos/cm) (lower panel) at station B02 in Black River Lake, April 18, 1984 through March 7, 1985.

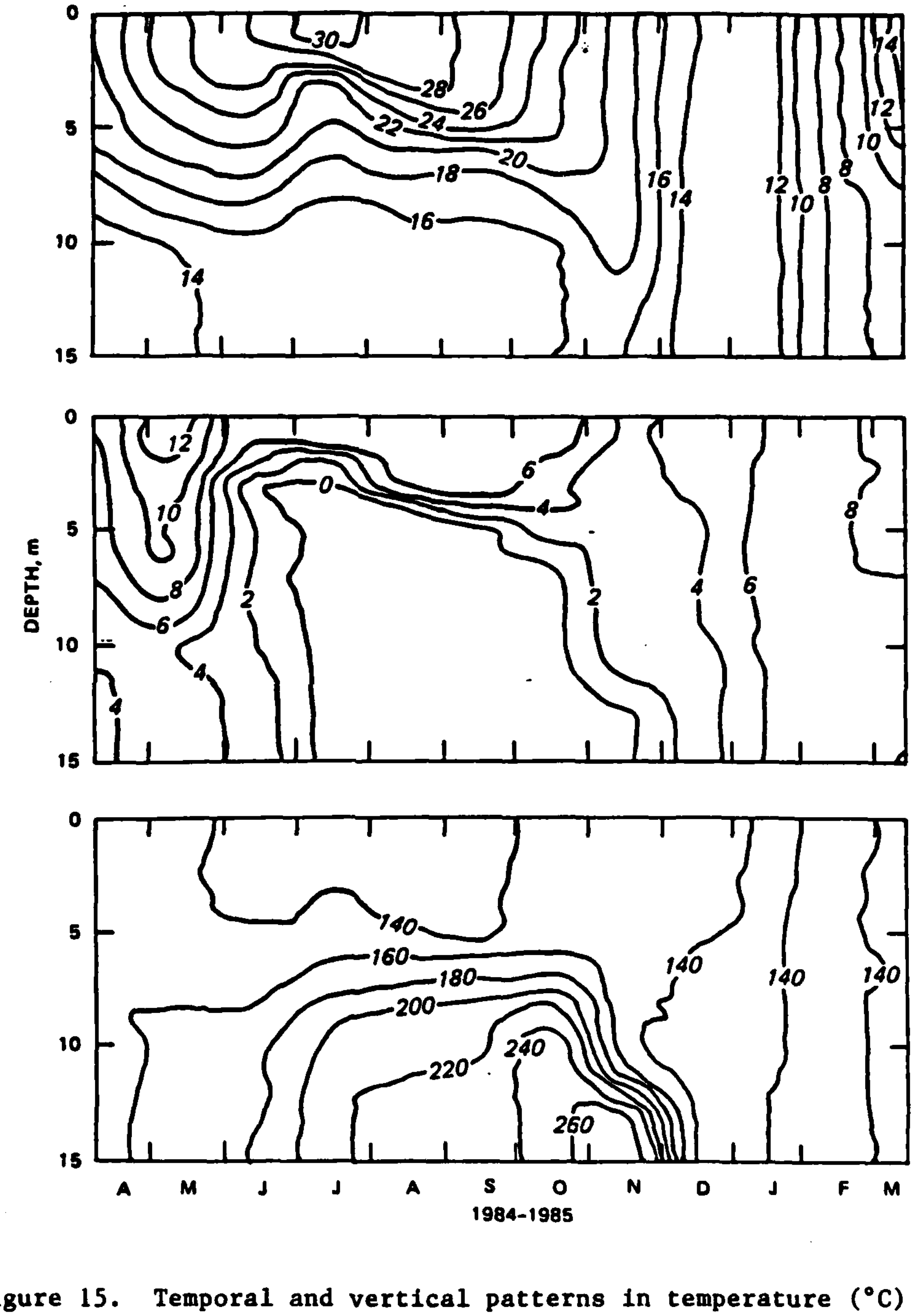

Figure 15. Temporal and vertical patterns in temperature (°C) (upper panel), dissolved oxygen (mg/L) (middle panel), and specific conductance (umhos/cm) (lower panel) at station C02 in Black River Lake, April 18, 1984 through March 7, 1985.

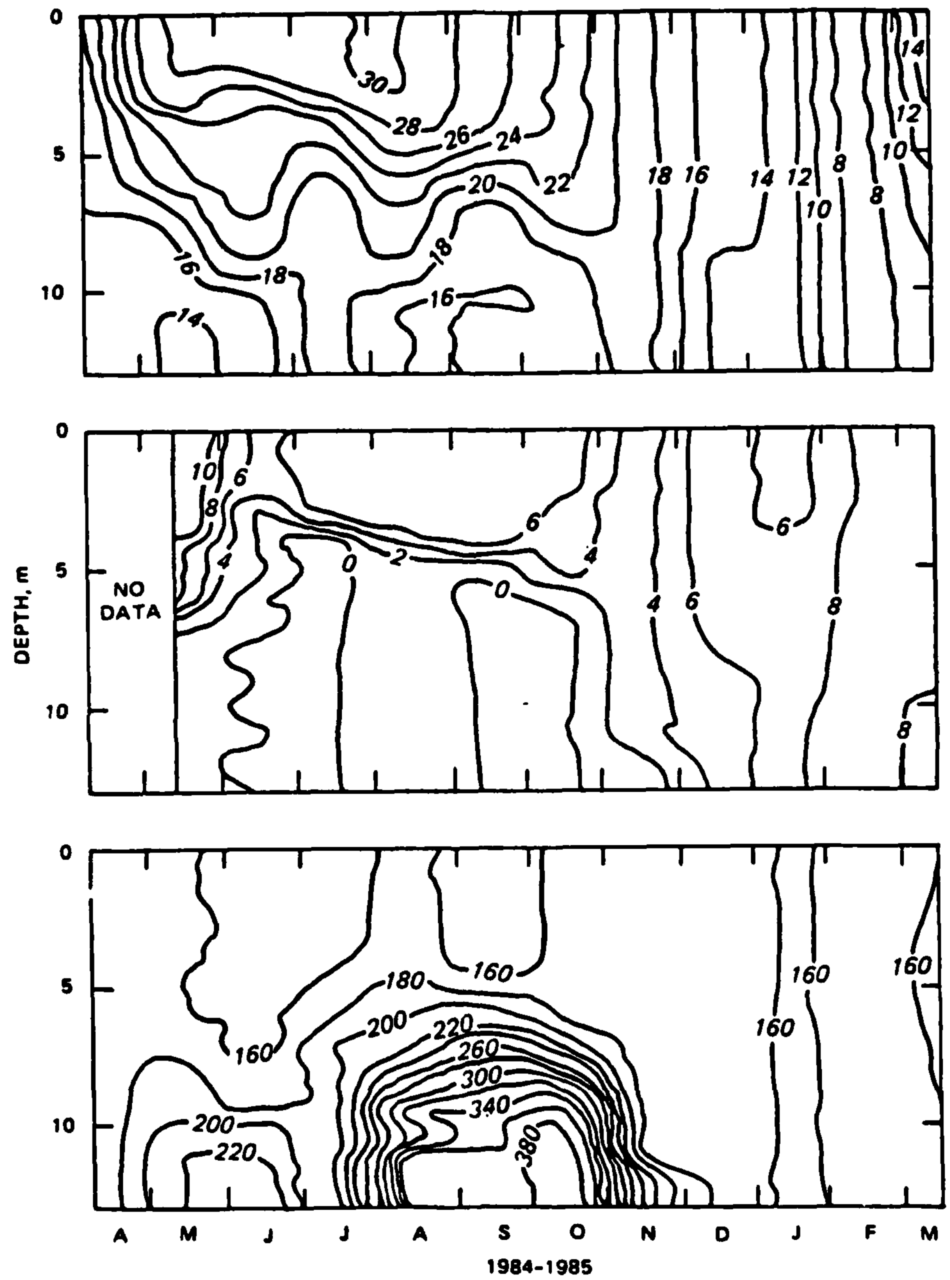

Figure 16. Temporal and vertical patterns in temperature (°C) (upper panel), dissolved oxygen (mg/L) (middle panel), and specific conductance (umhos/cm) (lower panel) at station E02 in Black River Lake, April 18, 1984 through March 7, 1985.

waters resulted in well established stratified conditions throughout the lake from 13.5 to 14° C.

51. The period of thermal stratification lasted from May until November. Surface water temperatures warmed to maxima ranging from 29.0 to 30.6° C by 16 May (Figures 14-16). Surface (i.e., the 1-m depth) water temperature on 16 May ranged from 24.9 to 27.4° C, with bottom water temperatures ranging in July while bottom water temperatures ranged from 14.9 to 18.8° C. During the stratified period, the epilimnion reached a depth of 3 m with marked temperature gradients present in the metalimnion.

52. Thermal stratification at station E02 was disrupted for several weeks in August (Figure 16). A possible cause of this mixing event could be the large amount of precipitation recorded in August. Precipitation was recorded during eight of the nine days before the August sampling, with two events having accumulations of 3.0 and 4.1 cm. A large area of agricultural land drains via a culvert into the area of station E02 (Figure 1). Such an inflow could have provided sufficient energy to cause mixing in this portion of the lake.

53. Surface water temperatures began to cool and the epilimnion began to deepen in September. By October surface water temperatures had decreased to approximately 24° C and the mixed zone had increased to a depth of 5 m. Bottom temperatures at this time ranged from 15.7 to 16.7° C.

54. Isothermal conditions, first apparent on 14 November, persisted into February. Surface water temperatures decreased to approximately 19° C, while bottom water temperatures ranged from 16 to 18.4° C. Conditions on 6 February, 1985 were well mixed with only slight vertical and horizontal gradients in water temperature (7.6 to 7.9° C) throughout the lake.

55. A significant warming trend occurred during late February and by 7 March a thermocline had developed at a depth of 5-6 m. Surface and bottom water temperatures on this date ranged from 15.1 to 15.6° C and 8.9 to 9.8° C, respectively.

56. Associated with thermal stratification was the depletion of hypolimnetic oxygen (Figures 14-16). The establishment of anoxic or near anoxic conditions was evident in June and continued into November. The large anoxic zone ranged from 3-4 m below the surface to the bottom. Surface water dissolved oxygen values during this anoxic period generally ranged from 5.5 to

7.5 mg/L. During the mixed period of late November through February dissolved oxygen values ranged from approximately 4 to 8 mg/L.

57. During the August mixing event dissolved oxygen concentrations of bottom waters at station E02 increased from 0 mg/L to approximately 2 mg/L. However, anoxia was re-established by the next sampling on 18 September.

58. Associated with thermal stratification and anoxia were increased levels of specific conductance at all three stations, indicating an increase in the concentration of dissolved materials in the bottom waters. During winter mixed period specific conductance values were approximately 140 umhos/cm at stations B02 and C02, and 160 umhos/cm at station E02 (Figure 1). During the stratified period, bottom values increased to 300, 274, and 390 umhos/cm for stations B02, C02, and E02, respectively. Specific conductance values were consistently higher at station E02 throughout the study period. The annual mean value at station E02 was 186 umhos/cm, while both B02 and C02 had annual means of 161 umhos/cm. These between station differences may reflect the influence of local runoff and point discharges to the lake.

59. <u>Cocodrie Lake.</u> Seasonal changes in temperature occurred, however temperatures were generally uniform from surface to bottom throughout the year. Dissolved oxygen and specific conductance values were vertically uniform throughout the study period (Figures 17 and 18).

60. Cocodrie Lake exhibited thermal stratification only at station B02 and only from late June to early July. Maximum water temperatures were reached in July and ranged from approximately 30° C at the surface to 29° C at the bottom. A weak thermocline was observed in Bayou Cross Cocodrie on June 19 and in Workinger Bayou on June 19 and July 17; differences between surface and bottom temperatures at this time were 6° C and 4° C, respectively. Minimal seasonal temperatures were reached in February when both surface and bottom temperatures were approximately 3° C.

61. Cocodrie Lake did not develop an extensive anoxic zone, although a zone of low dissolved oxygen (< 2 mg/L) appeared at station B02 from the first part of June until mid-July. This zone of low dissolved oxygen water was apparently related to the establishment of weak thermal stratification and the lack of mixing. Generally, dissolved oxygen conditions were uniform from surface to bottom throughout the year (Figures 17 and 18).

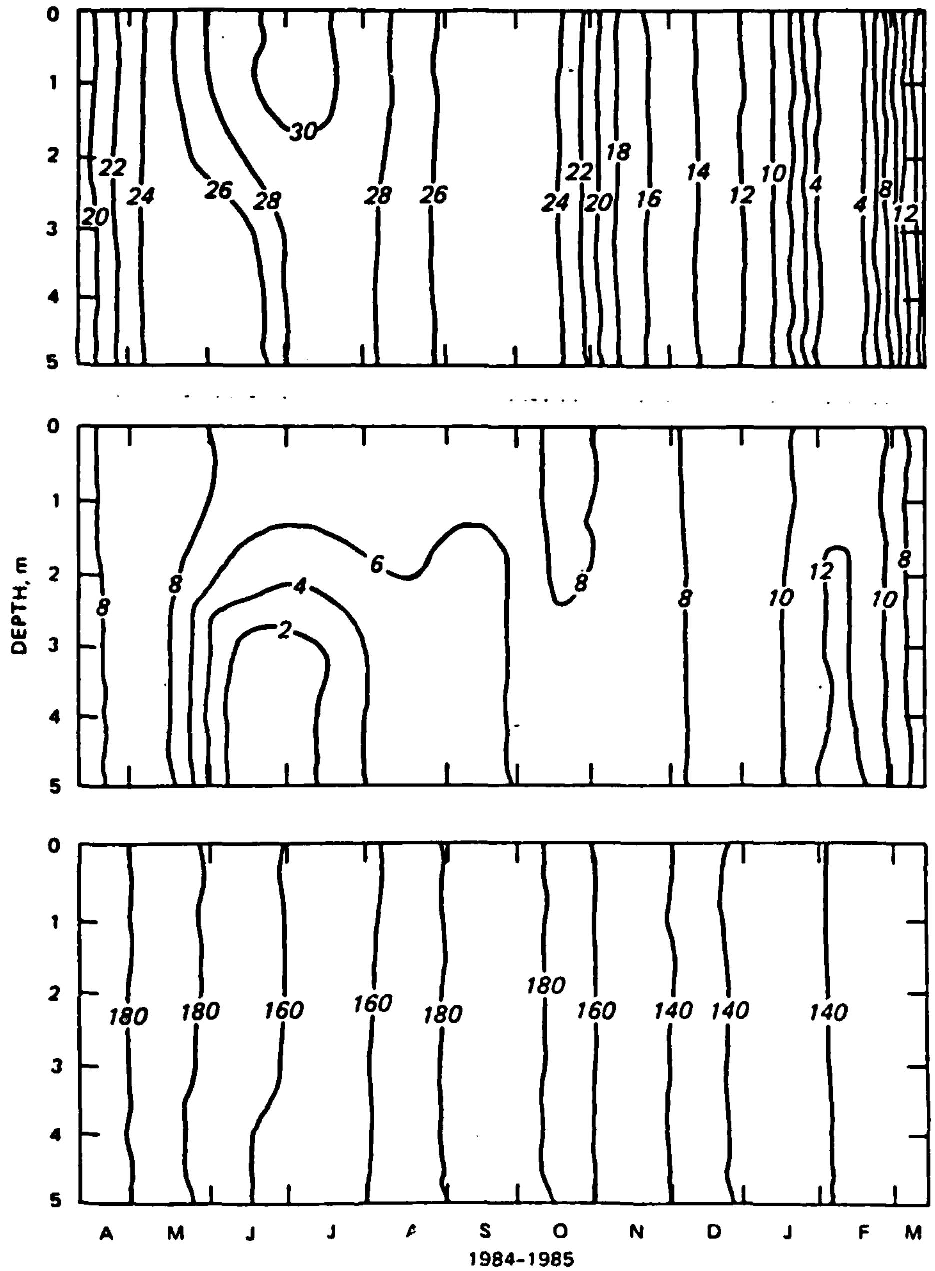

Figure 17. Temporal and vertical patterns in temperature (°C) (upper panel), dissolved oxygen (mg/L) (middle panel), and specific conductance (umhos/cm) (lower panel) at station B02 in Cocodrie Lake, April 18, 1984 through March 7, 1985.

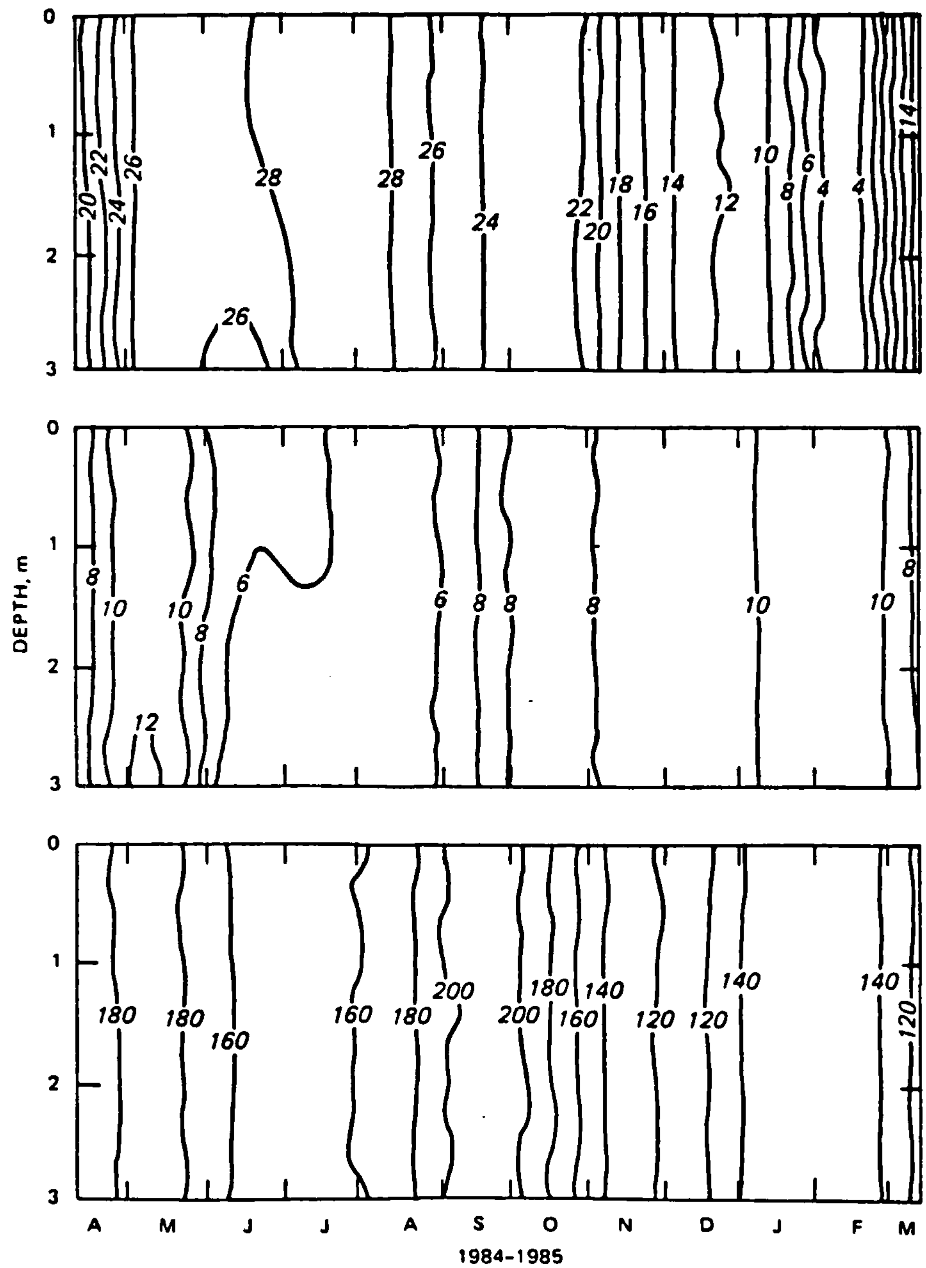

Figure 18. Temporal and vertical patterns in temperature (°C) (upper panel), dissolved oxygen (mg/L) (middle panel), and specific conductance (umhos/cm) (lower panel) at station E02 in Cocodrie Lake, April 18, 1984 through March 7, 1985.

62. Specific conductance values in Cocodrie Lake were seasonally variable but spatially uniform throughout the study period (Figures 17 and 18). Values ranged from 115 to 210 umhos/cm; the annual mean was 152 umhos/cm.

63. Black River, Workinger Bayou, and Bayous Cocodrie and Cross Cocodrie. Temperature and dissolved oxygen data indicate that Black River, Workinger Bayou, Bayou Cocodrie, and Bayou Cross Cocodrie were predominately well mixed throughout the year (Figures 19 and 20). Temperatures varied seasonally and were generally uniform from surface to bottom. A weak thermocline was observed in Bayou Cross Cocodrie on June 19 and in Workinger Bayou on June 19 and July 17. The difference between surface and bottom waters at this time was 6°C and 4°C for Bayou Cross Cocodrie and Workinger Bayou, respectively. Dissolved oxygen concentrations in Workinger Bayou, Bayou Cross Cocodrie, and Bayou Cocodrie did not indicate anoxic conditions during the summer. Dissolved oxygen concentrations in Black River were approximately 4.0 mg/L throughout the summer.

Water chemistry and chlorophyll a

64. Analyses of variance performed on transect data and routine monthly data indicate that differences between stations within Black River Lake were statistically insignificant; the same conclusion was drawn for stations within Cocodrie Lake. Therefore, stations within Black River Lake and Cocodrie Lake were combined to calculate lake-wide means for each lake for comparison of chemistry and chlorophyll.

65. Comparisons of the six study sites using analysis of variance indicate significant differences for turbidity, total solids, suspended solids, and chlorophyll a. Grouping of sites using Dungan's Multiple Range Test indicated inconsistencies and overlapping of similar groups. However, the groupings did reveal that Cocodrie Lake, Bayou Cocodrie, and Bayou Cross Cocodrie were similar, as were Black River Lake and Workinger Bayou in turbidity and solids. Black River exhibited similarities to both groups. The grouping of sites for chlorophyll a revealed that the three bayous had the highest chlorophyll a concentrations, but that Workinger Bayou and Bayou Cross Cocodrie were not dissimilar to Cocodrie and Black River Lakes. Table 9 lists selected mean annual water quality values for the six study sites.

66. Black River Lake. Turbidity concentrations for Black River Lake were highest in the spring and lowest in the summer (Figure 21). Mid-depth turbidities for the period April through June were approximately 50 NTU.

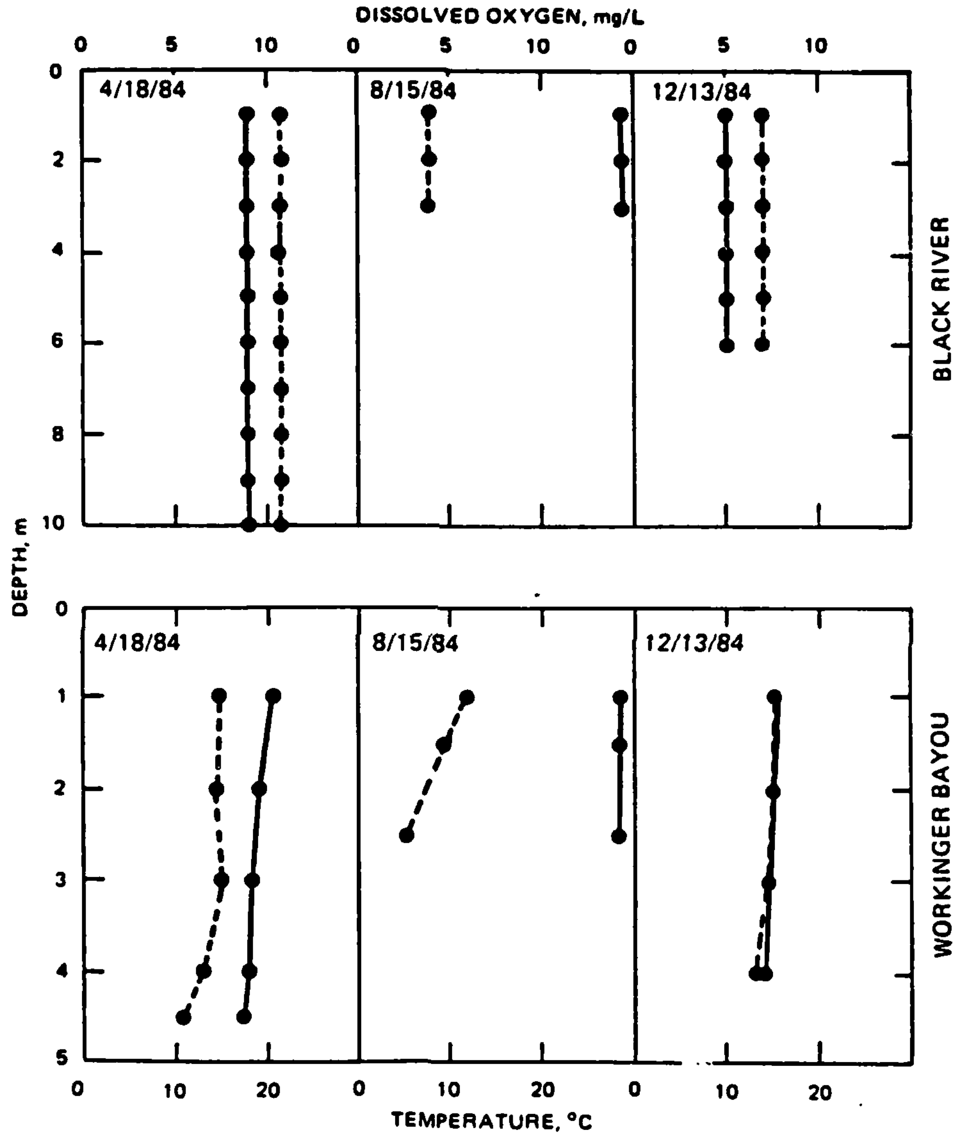

Figure 19. Temperature (°C) (solid line) and dissolved oxygen (mg/L) (dashed line) profiles on April 18, August 15, and December 13, 1984 at station A02 in Black River (upper panel) and station A02 in Workinger Bayou (lower panel).

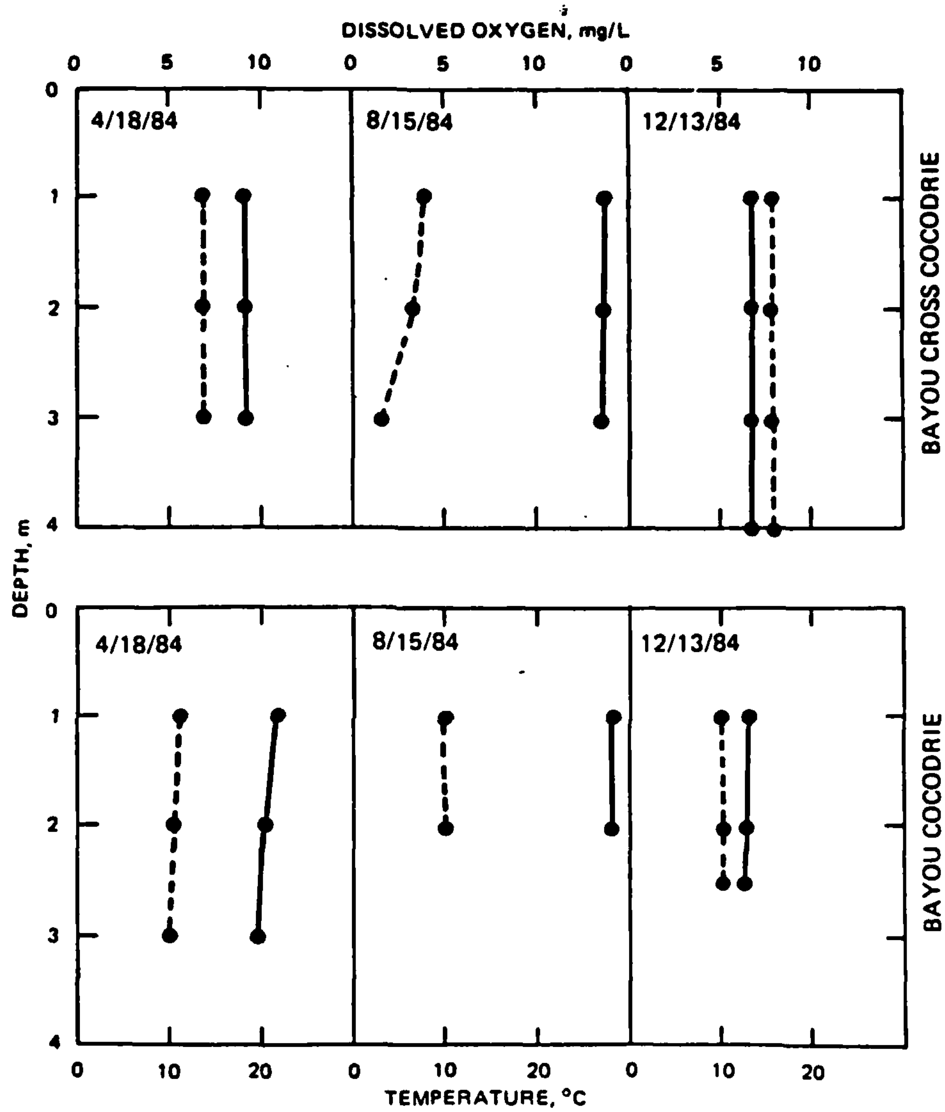

Figure 20. Temperature (°C) (solid line) and dissolved oxygen (mg/L) (dashed line) profiles on April 18, August 15, and December 13, 1984 at station A02 in Bayou Cross Cocodrie (upper panel) and station A02 in Bayou Cocodrie (lower panel).

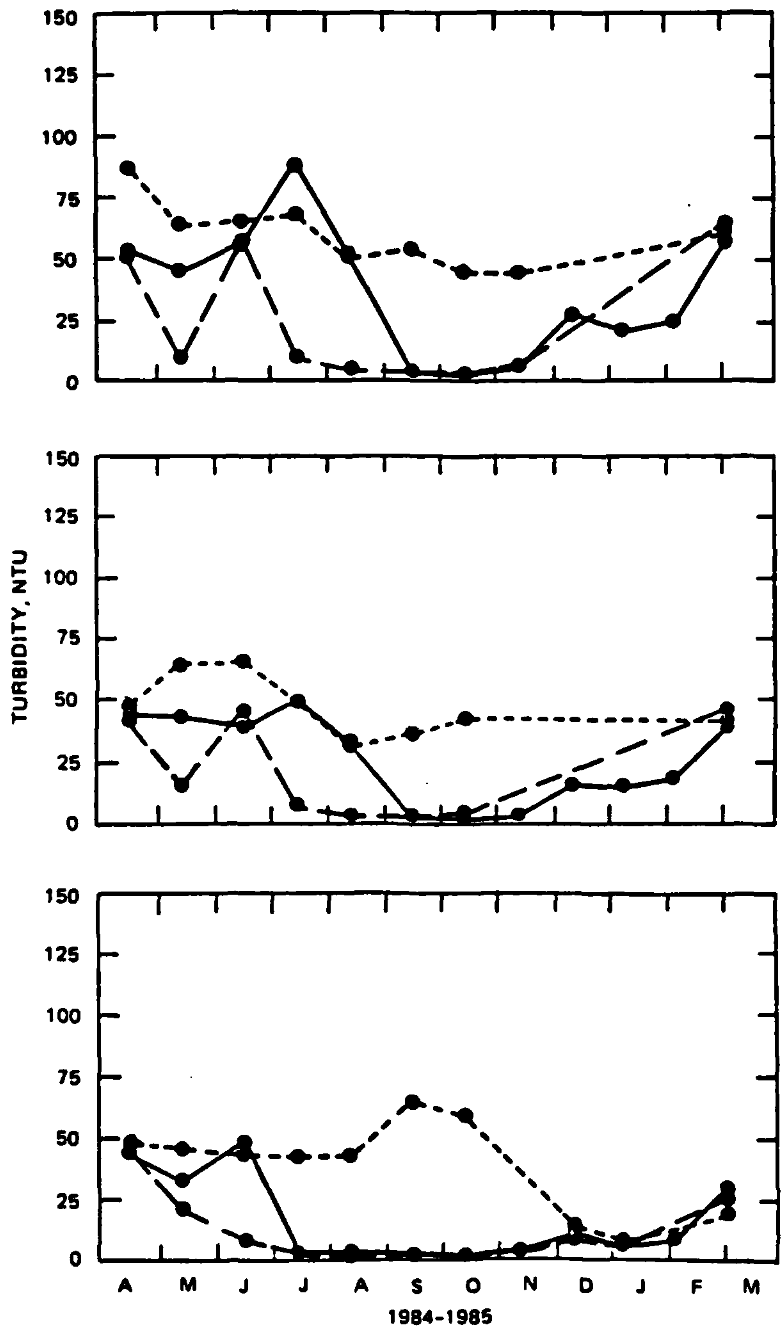

Figure 21. Temporal changes in turbidity (NTU) for surface (large dashed line), mid-depth (solid line), and bottom (small dashed line) samples at stations B02 (upper panel), C02 (middle panel), and E02 (lower panel) in Black River Lake.

These values decreased to below 25 NTU in July and remained at this level until December, when slight increases were observed. Stations B02 and C02 were slightly more turbid then station E02. The highest turbidity concentration (88 NTU) occurred at station B02. Patterns in total and suspended solid concentrations were similar to those observed for turbidity. Maximum concentrations for total and suspended solids were 240 and 95 mg/L, respectively.

67. Total phosphorus patterns may be somewhat masked by the fact that the analytical limit of detectability was 0.1 mg/L. Surface total phosphorus concentrations in Black River Lake tended to be near detection limit for most of the year (Figure 22). However, there was an increase in bottom values during the anoxic period, indicating that the release of phosphorus from the sediments was a potentially important nutrient source for Black River Lake. In addition, mid-depth concentrations increased slightly during anoxic periods.

68. Nitrate-nitrogen concentrations in Black River Lake are high in spring and low in summer (Figure 23). In April, levels of nitrates were approximately 0.5 mg/L. By June, surface and bottom concentrations had decreased to 0.1 mg/L and below. Mid-depth concentrations did not decrease to these levels until July, August, and September for stations C02, B02, and E02, respectively. Nitrate concentrations at all 3 stations began to increase at all depths in December. Nitrite-nitrogen concentrations for Black River Lake were at or below detection limit (i.e., <0.01 mg/L).

69. Black River Lake experienced increased chlorophyll _a_ concentrations starting in June (Figure 24). Concentrations continued to increase to a July peak of 63.52 μg/L for station B02, while stations C02 and E02 had July peaks of 40.79 and 24.65 μg/L, respectively. After July, chlorophyll _a_ declined until December when concentrations at all stations were approximately 10.00 μg/L.

70. Cocodrie Lake. Turbidity concentrations in Cocodrie Lake were approximately 75 NTU during the period April through June (Figure 25). In July these concentrations decreased to approximately 25 NTU and remained low until November. Increases in turbidity were observed in December and levels remained high through the March sampling. The maximum turbidity concentration (149 NTU) was observed in February at station B02. Patterns in total and suspended solid concentrations were similar to those observed for turbidity.

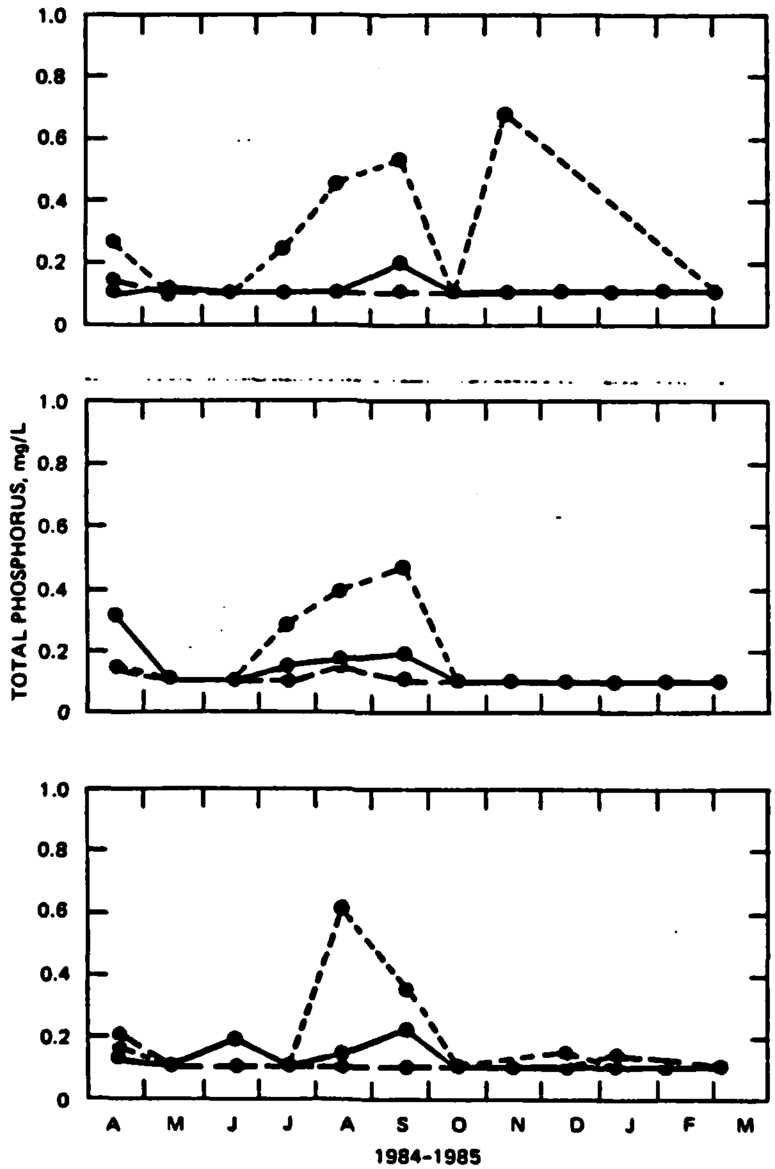

Figure 22. Temporal changes in total phosphorus (mg/L) for surface (large dashed line), mid-depth (solid line), and bottom (small dashed line) samples at stations B02 (upper panel), C02 (middle panel), and E02 (lower panel) in Black River Lake.

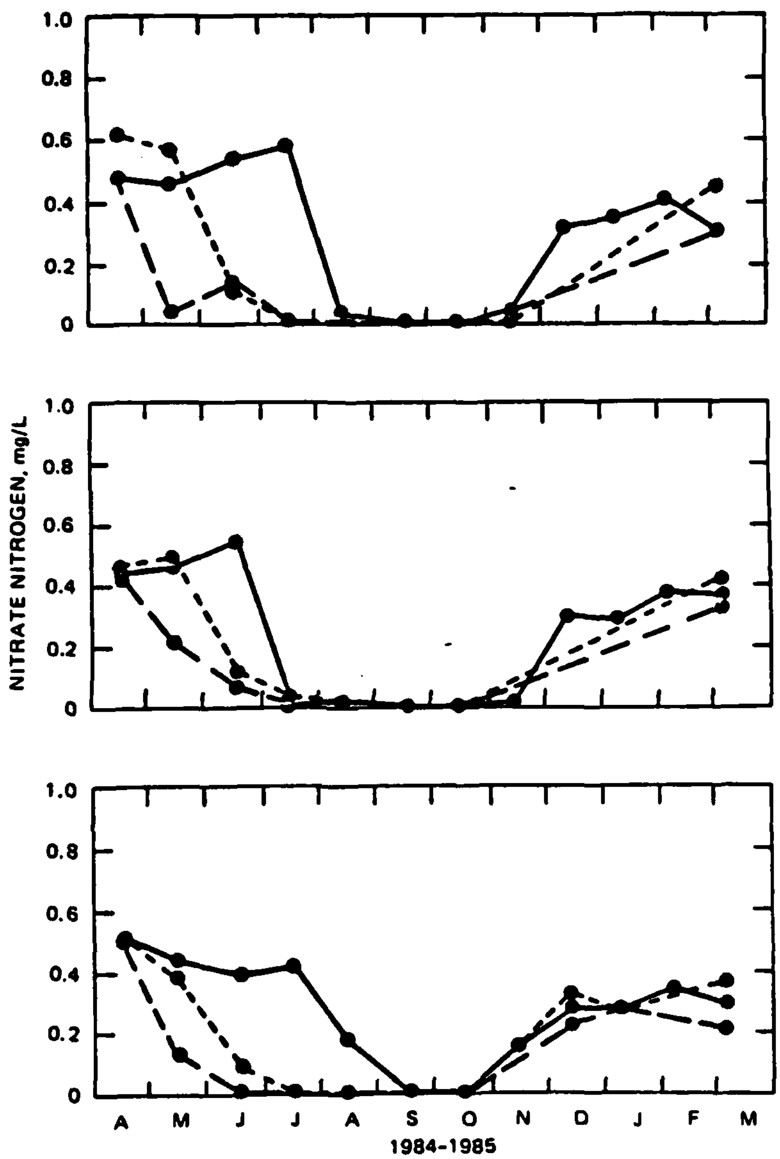

Figure 23. Temporal changes in nitrate nitrogen (mg/L) for surface (large dashed line), mid-depth (solid line), and bottom (small dashed line) samples at stations B02 (upper panel), C02 (middle panel), and E02 (lower panel) in Black River Lake.

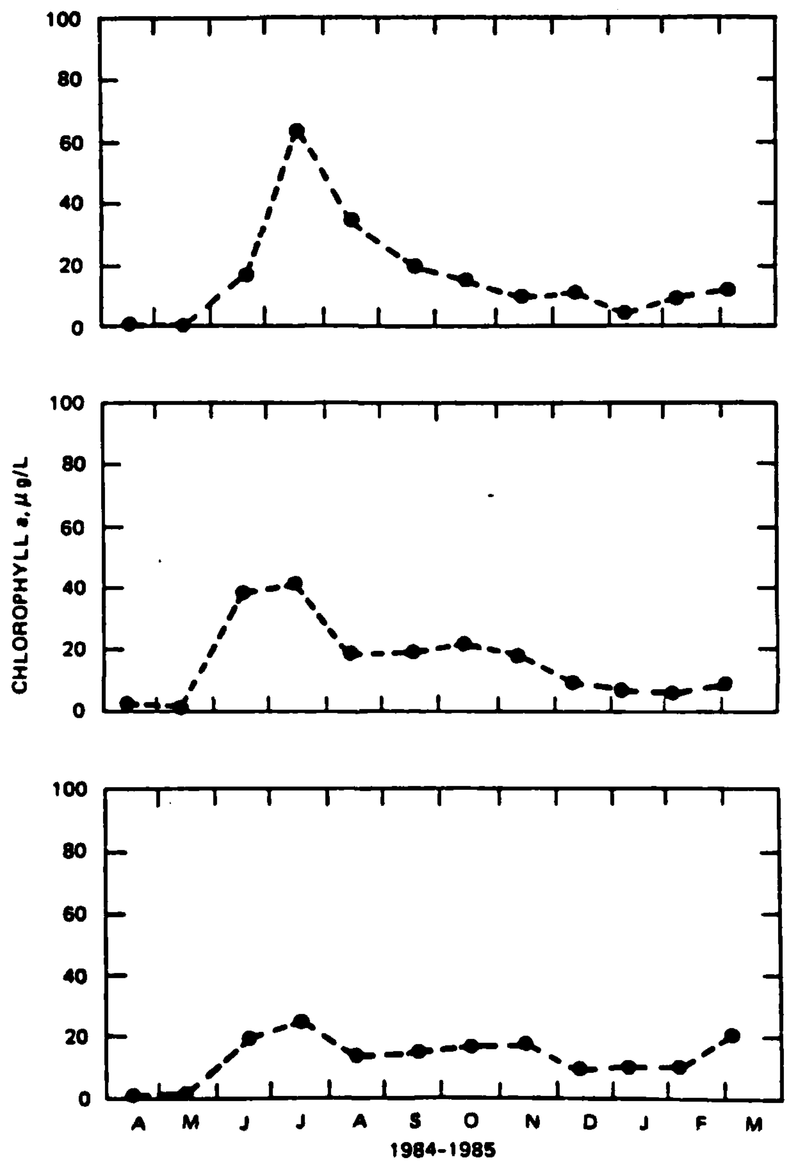

Figure 24. Temporal changes in chlorophyll a (ug/L) for integrated samples at stations B02 (upper panel), C02 (middle panel), and E02 (lower panel) in Black River Lake.

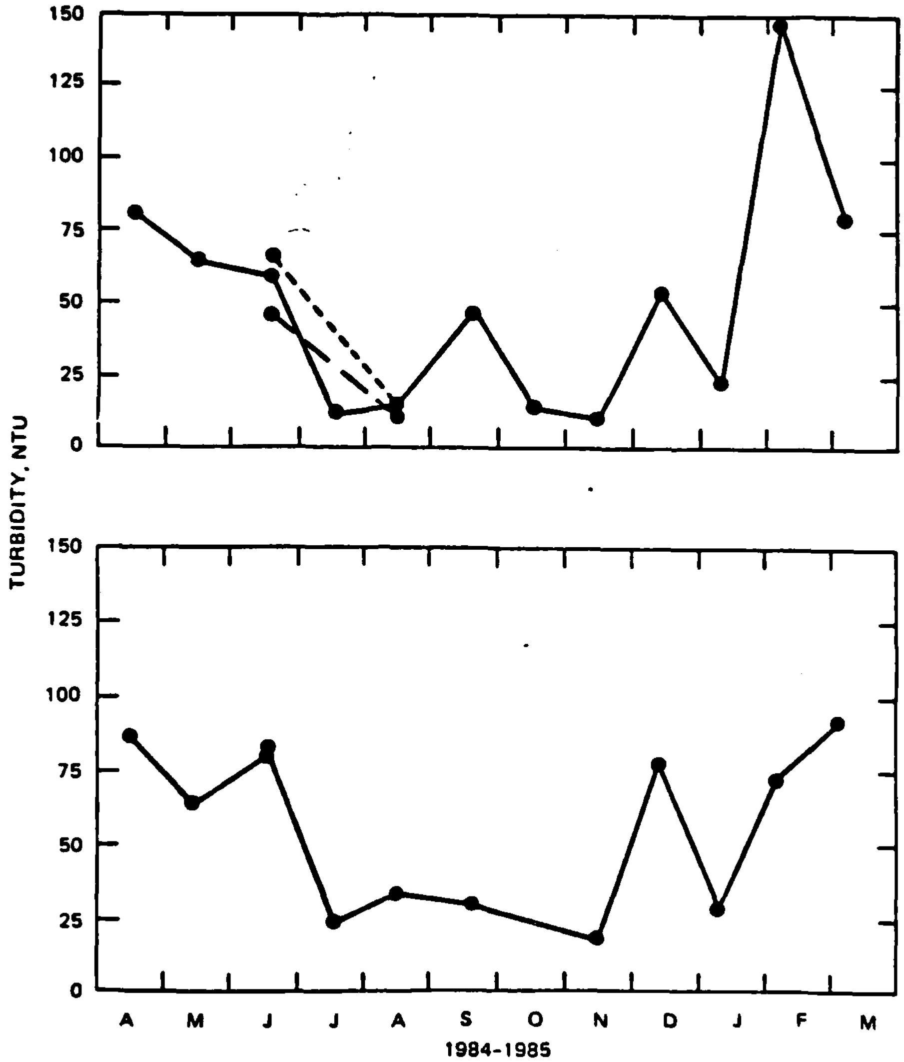

Figure 25. Temporal changes in turbidity (NTU) for surface (large dashed line), mid-depth (solid line), and bottom (small dashed line) samples at stations B02 (upper panel) and E02 (lower panel) in Cocodrie Lake.

Maximum solid concentrations of 303 and 243 were observed in February for total and suspended solids, respectively.

71. Total phosphorus concentrations for Cocodrie Lake were highest during April ranging from 0.29 to 0.45 mg/L (Figure 26). Concentrations generally declined during the summer to approximately 0.2 and 0.1 mg/L for stations E02 and B02, respectively.

72. Nitrate-nitrogen concentrations for Cocodrie Lake were seasonally higher in the spring and lower in summer (Figure 27). Concentrations from April to June ranged from 0.345 to 0.580 mg/L. In July these concentrations decreased to the detection limit of 0.01 mg/L and remained at detection limit until November. In November nitrate-nitrogen concentrations began to increase. Nitrite-nitrogen was not detected in Cocodrie Lake.

73. Seasonal patterns in chlorophyll *a* concentration indicated an increase in algal productivity during summer months (Figure 28). Chlorophyll *a* concentrations increased through the summer, with a maximum peak of approximately 71 ug/ℓ occurring in September. Following the September peak, concentrations decreased markedly.

74. Black River, Workinger Bayou, and Bayous Cocodrie and Cross Cocodrie. Turbidity concentrations for Black River indicated seasonal variation and ranged from 17 to 71 NTU (Figure 29). Workinger Bayou turbidity values were seasonally high in spring and winter with values around 35 NTU. These concentrations decreased in the summer and late fall to approximately 10 NTU (Figure 29).

75. Bayous Cocodrie and Cross Cocodrie had spring turbidities of approximately 50 and 75 NTU, respectively (Figure 30). These concentrations decreased in July and remained at or below 25 NTU until December, when concentrations began to increase. Both bayous had highest concentrations (approximately 150 NTU) in February.

76. Black River total phosphorus values were generally at detection limit with slight increases during April and December (Figure 31). Similarly, Workinger Bayou values were at detection limit except for several minor increases in winter and spring.

77. Bayous Cocodrie and Cross Cocodrie exhibited similar seasonal trends. Phosphorus values ranged from 0.29 to 0.43 mg/L in April, but declined in the summer months to approximately detection limit. Concentrations later increased during winter (Figure 32).

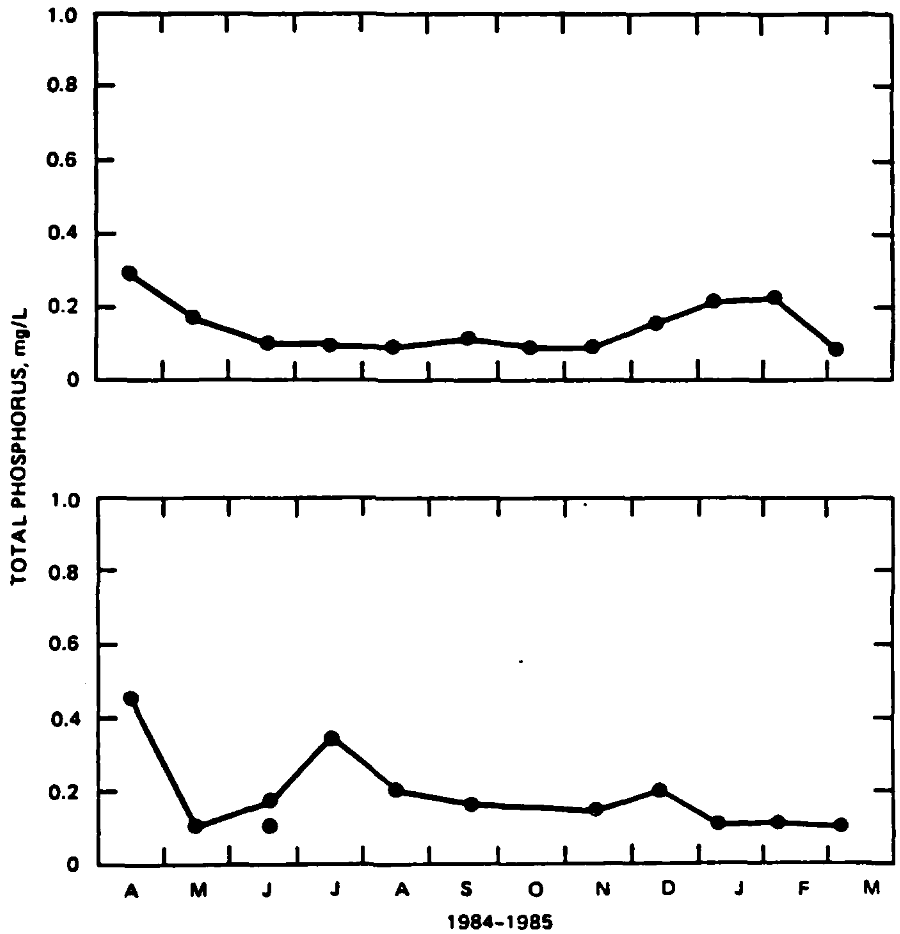

Figure 26. Temporal changes in total phosphorus (mg/L) for mid-depth samples at stations B02 (upper panel) and E02 (lower panel) in Cocodrie Lake.

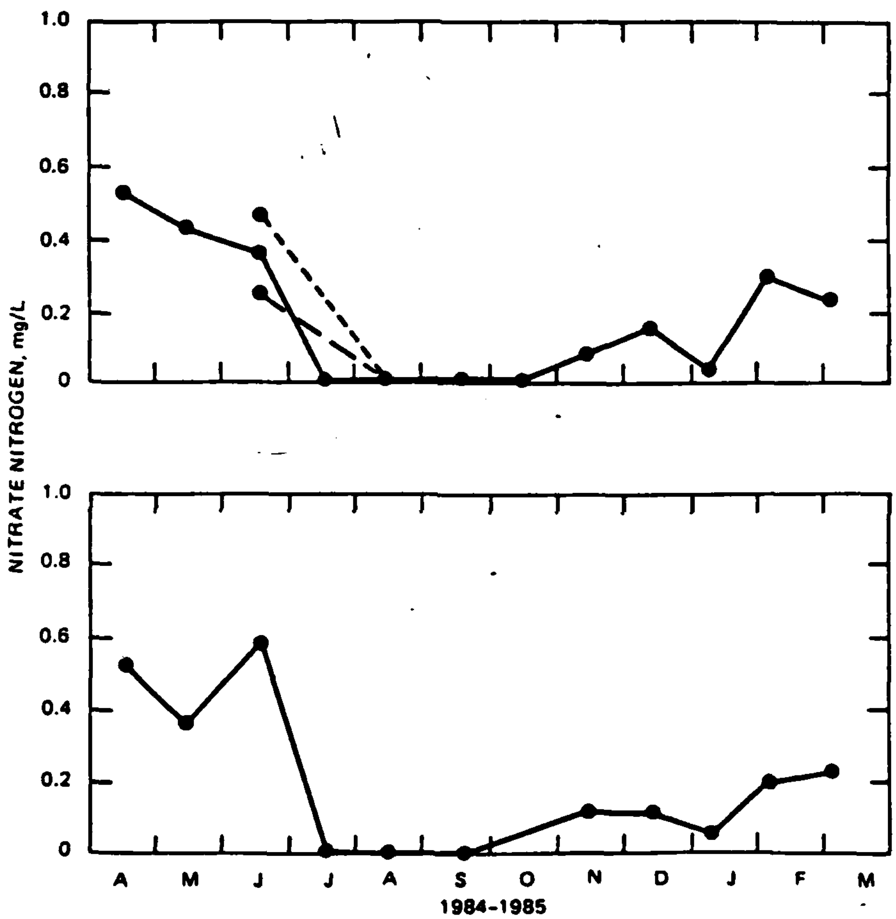

Figure 27. Temporal changes in nitrate nitrogen (mg/L) for surface (large dashed line), mid-depth (solid line), and bottom (small dashed line) samples at stations B02 (upper panel) and E02 (lower panel) in Cocodrie Lake.

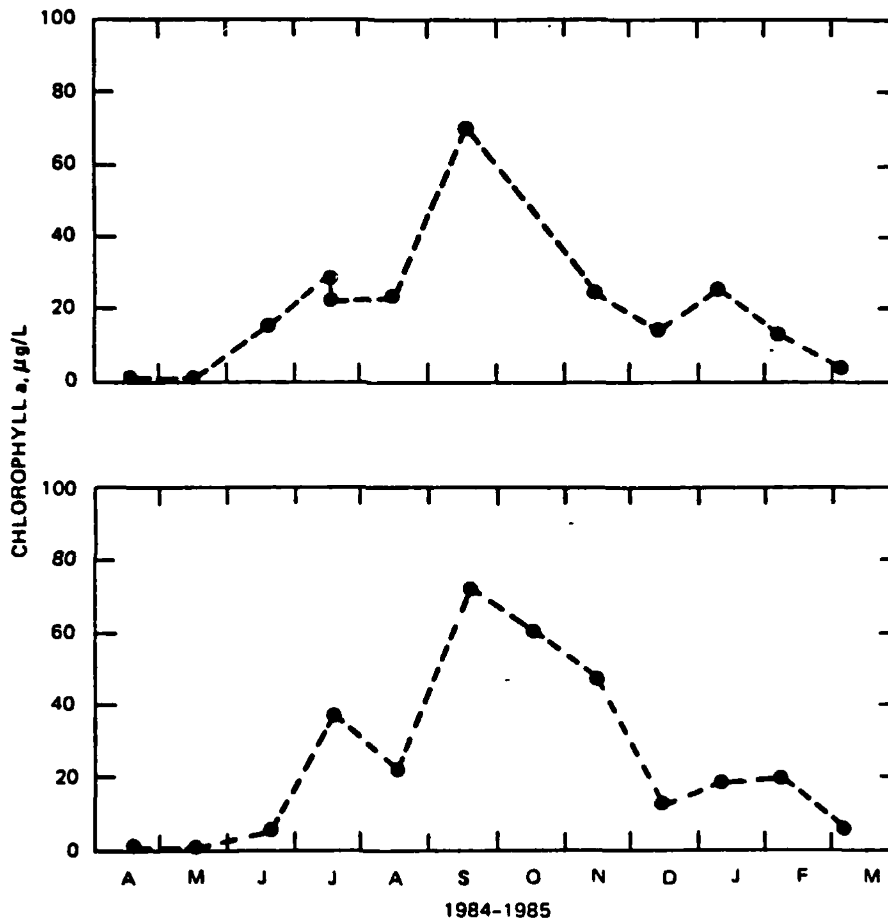

Figure 28. Temporal changes in chlorophyll a (ug/L) for integrated samples at stations B02 (upper panel), and E02 (lower panel) in Cocodrie Lake.

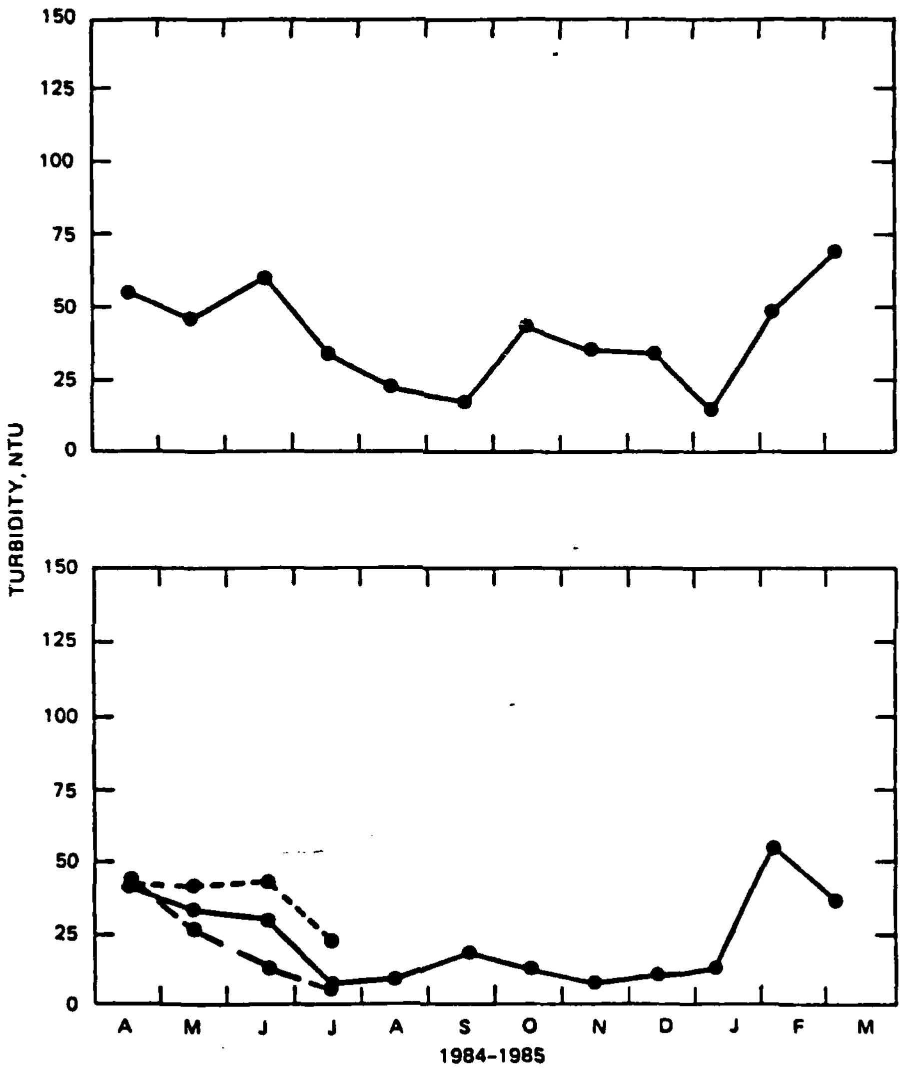

Figure 29. Temporal changes in turbidity (NTU) for surface (large dashed line), mid-depth (solid line), and bottom (small dashed line) samples at stations A02 in Black River (upper panel) and Workinger Bayou (lower panel).

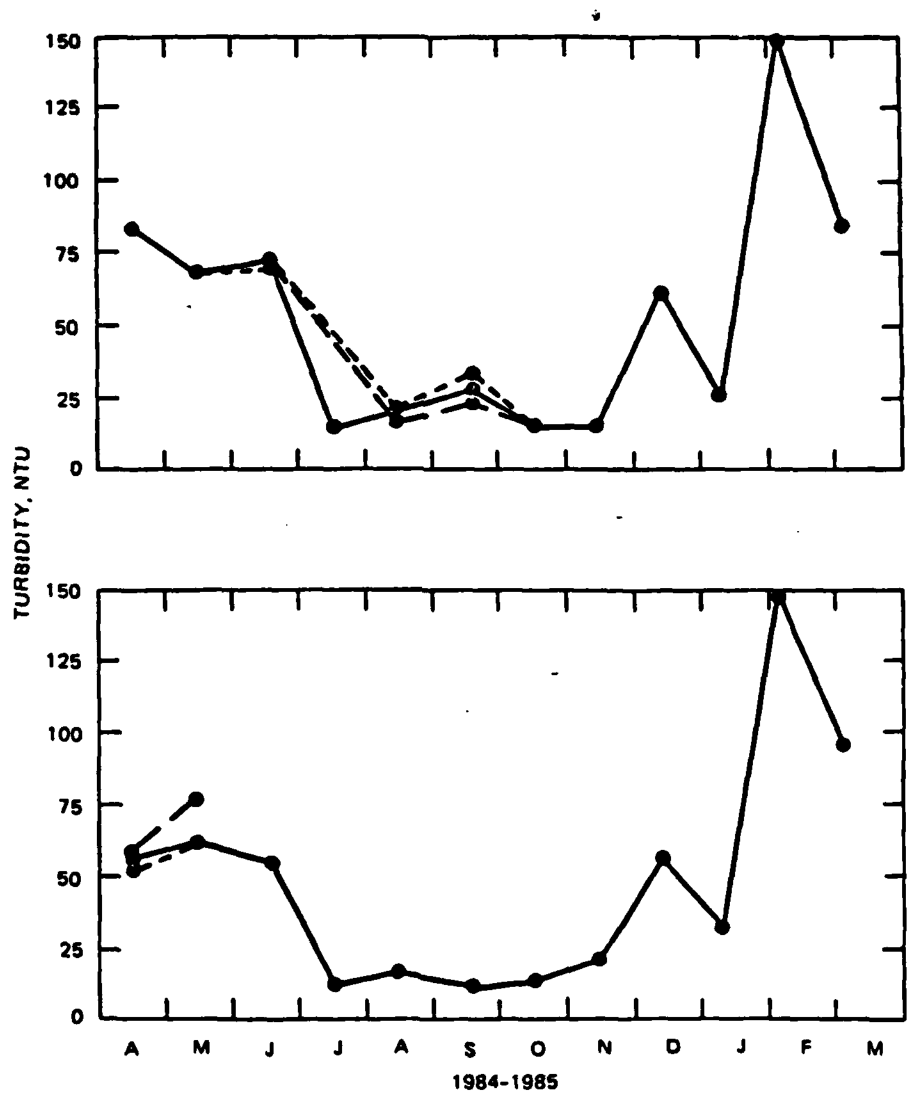

Figure 30. Temporal changes in turbidity (NTU) for surface (large dashed line), mid-depth (solid line), and bottom (small dashed line) samples at stations A02 in Cross Cocodrie Bayou (upper panel) and Cocodrie Bayou (lower panel).

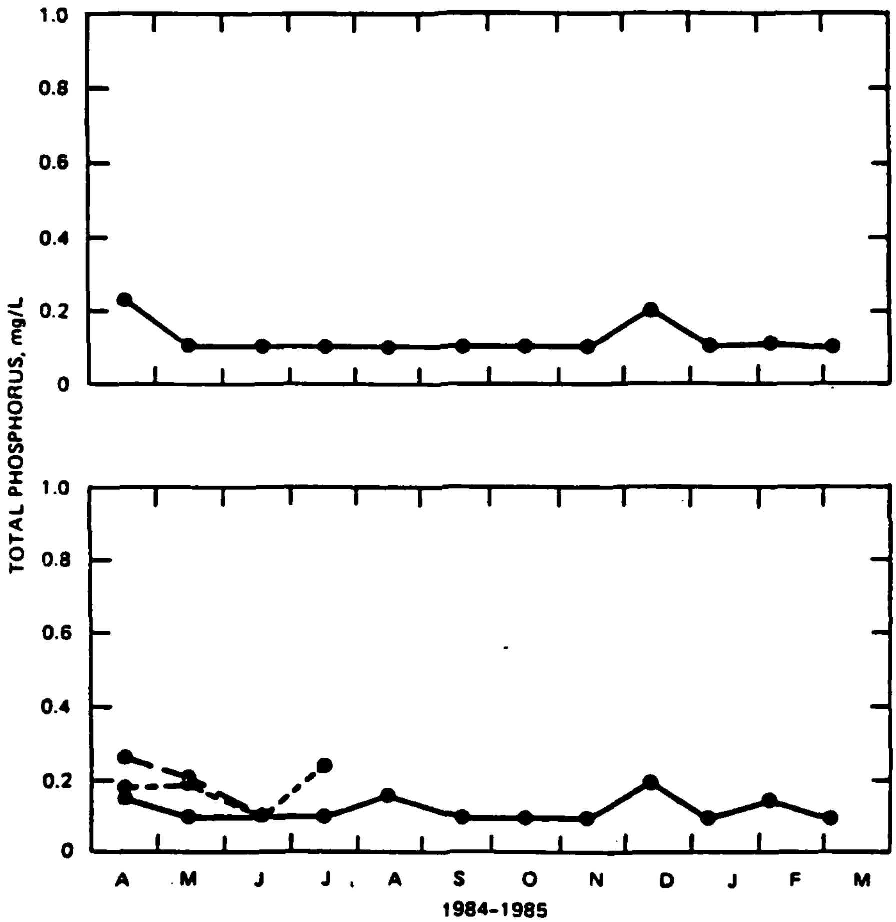

Figure 31. Temporal changes in total phosphorus (mg/L) for surface (large dashed line), mid-depth (solid line), and bottom (small dashed line) samples at stations A02 in Black River (upper panel) and Workinger Bayou (lower panel).

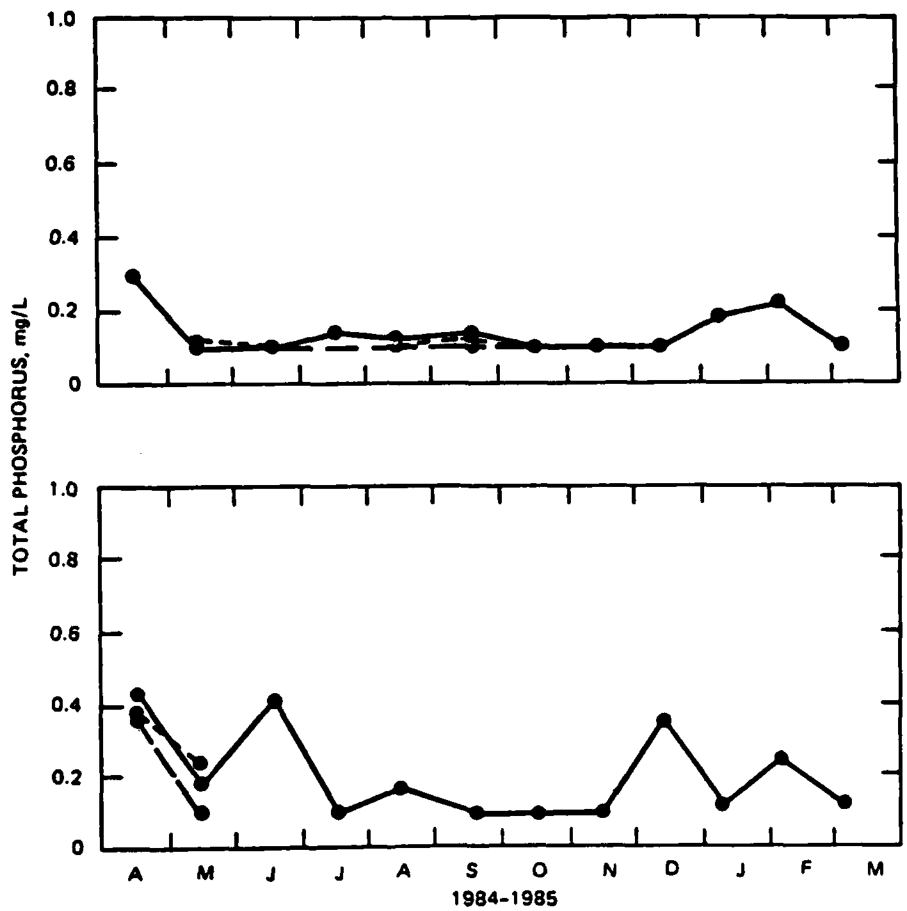

Figure 32. Temporal changes in total phosphorus (mg/L) for surface (large dashed line), mid-depth (solid line), and bottom (small dashed line) samples at stations A02 in Cross Cocodrie Bayou (upper panel) and Cocodrie Bayou (lower panel).

78. Nitrate-nitrogen decreased during the summer in Workinger Bayou, Bayou Cocodrie, and Bayou Cross Cocodrie, but increased in Black River (Figures 33 and 34). Concentrations as high as 0.3 mg/L were evident in April for Workinger Bayou, Bayou Cocodrie, and Bayou Cross Cocodrie; these decreased to detection limit by July, and remained at this level until October-November. In contrast, concentrations in Black River increased from 0.112 mg/L in April to a maximum of 0.508 mg/L in July.

79. Chlorophyll *a* concentrations were low throughout the year in Black River, while seasonal increases were observed during the summer for Workinger Bayou, Bayou Cocodrie, and Bayou Cross Cocodrie (Figures 35 and 36). Concentrations began increasing in all three bayous in June and maximum peaks were reached in July. Workinger Bayou had a maximum chlorophyll *a* concentration of 87.79 μg/L, while Bayou Cocodrie and Bayou Cross Cocodrie had maxima of 97.99 and 60.52 μg/L, respectively. Chlorophyll *a* concentrations decreased after the mid-summer peak to approximately 15 μg/L from January to March.

Trace Metals/Non-Metals and Pesticides/ Chlorinated Hydrocarbons

Tissue analysis

80. Metals/non-metals. Present knowledge of the uptake and accumulation of metals in fishes is limited. Published reports are often conflicting (McFarlane and Frawzin, 1980) and there is disagreement as to the appropriate target organs. Of the metals tested, FDA standards have been established only for mercury (Hg).

81. Mean Hg levels in samples collected from the three fish species varied among species and among lakes. In Cocodrie Lake, white crappie showed the highest concentration with a mean of 0.690 mg/kg (Table 10) and ranged from 0.494 to 0.886 mg/kg. Smallmouth buffalo had the next highest concentration with a mean of 0.260 mg/kg and ranged from 0.131 and 0.380 mg/kg. Gizzard shad tissue samples taken from this lake were below detection limits in all cases. In comparison, samples collected from Black River Lake showed smallmouth buffalo tissue samples to have a mean concentration of Hg (1.01 mg/kg) which exceeded the FDA action limit of 1.0 mg/kg (FDA, 1980). Mean values ranged from 0.663 to 1.500 mg/kg. The mean value for Hg concentration in white crappie tissue samples was 0.610 mg/kg and ranged from 0.471

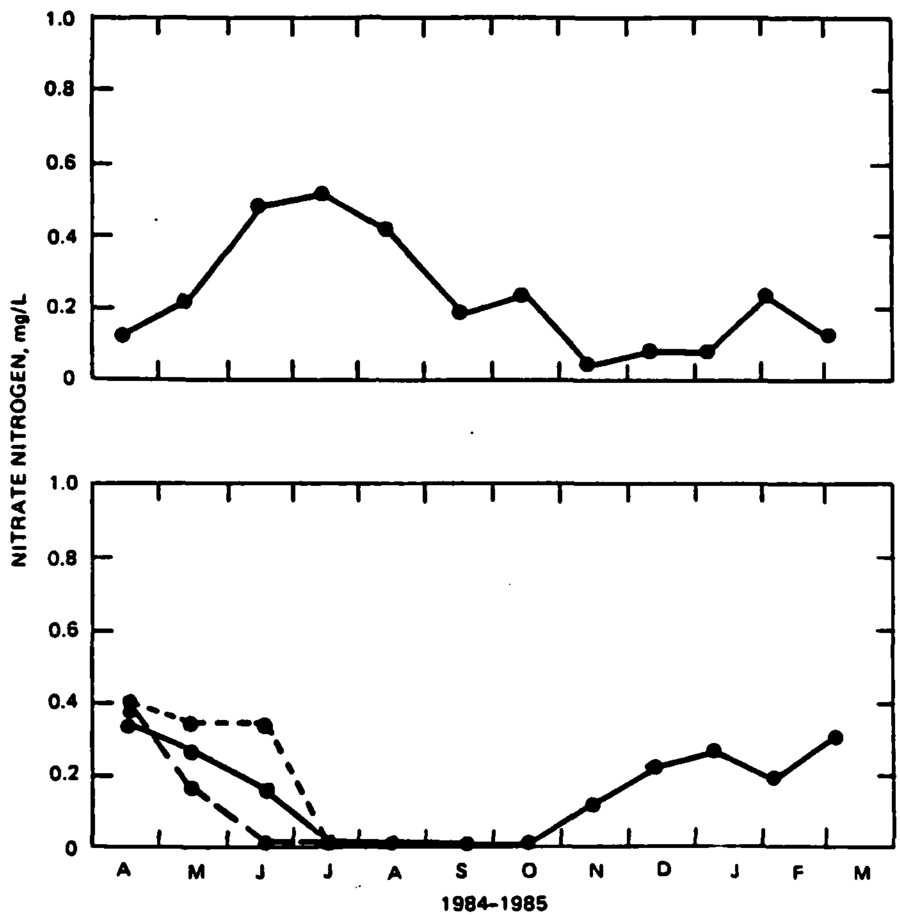

Figure 33. Temporal changes in nitrate nitrogen (mg/L) for surface (large dashed line), mid-depth (solid line), and bottom (small dashed line) samples at stations A02 in Black River (upper panel) and Workinger Bayou (lower panel).

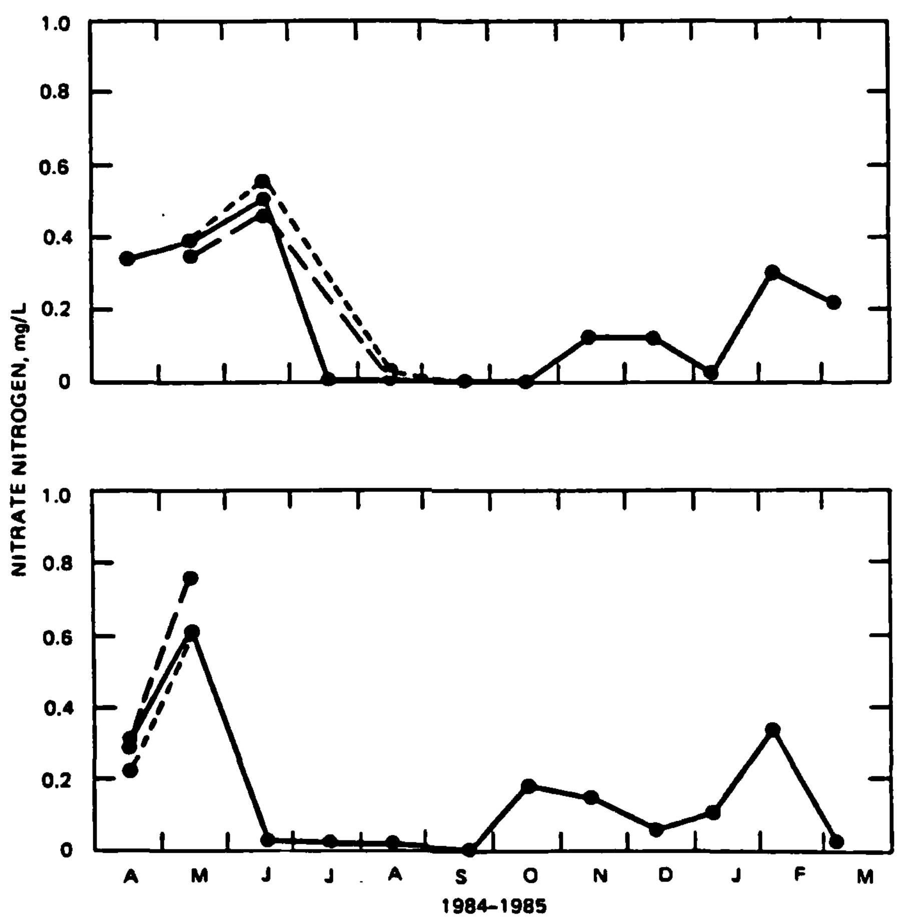

Figure 34. Temporal changes in nitrate nitrogen (mg/L) for surface (large dashed line), mid-depth (solid line), and bottom (small dashed line) samples at stations A02 in Cross Cocodrie Bayou (upper panel) and Cocodrie Bayou (lower panel).

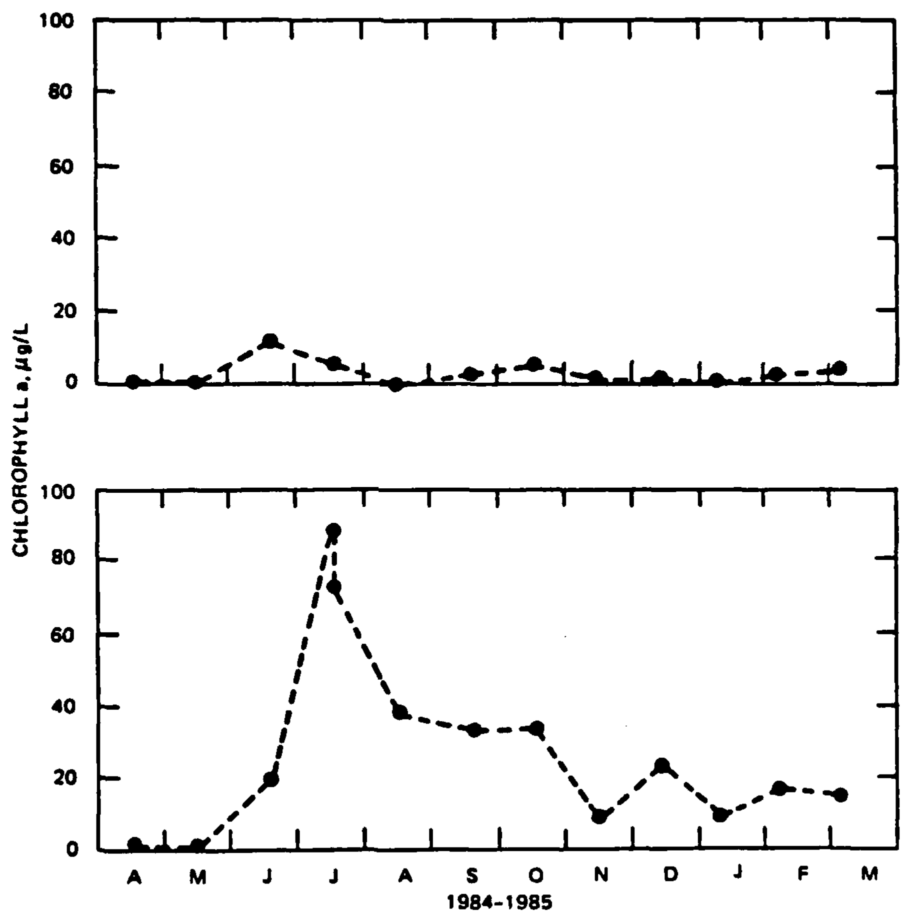

Figure 35. Temporal changes in chlorophyll a (ug/L) for integrated samples at stations A02 in Black River (upper panel) and Workinger Bayou (lower panel).

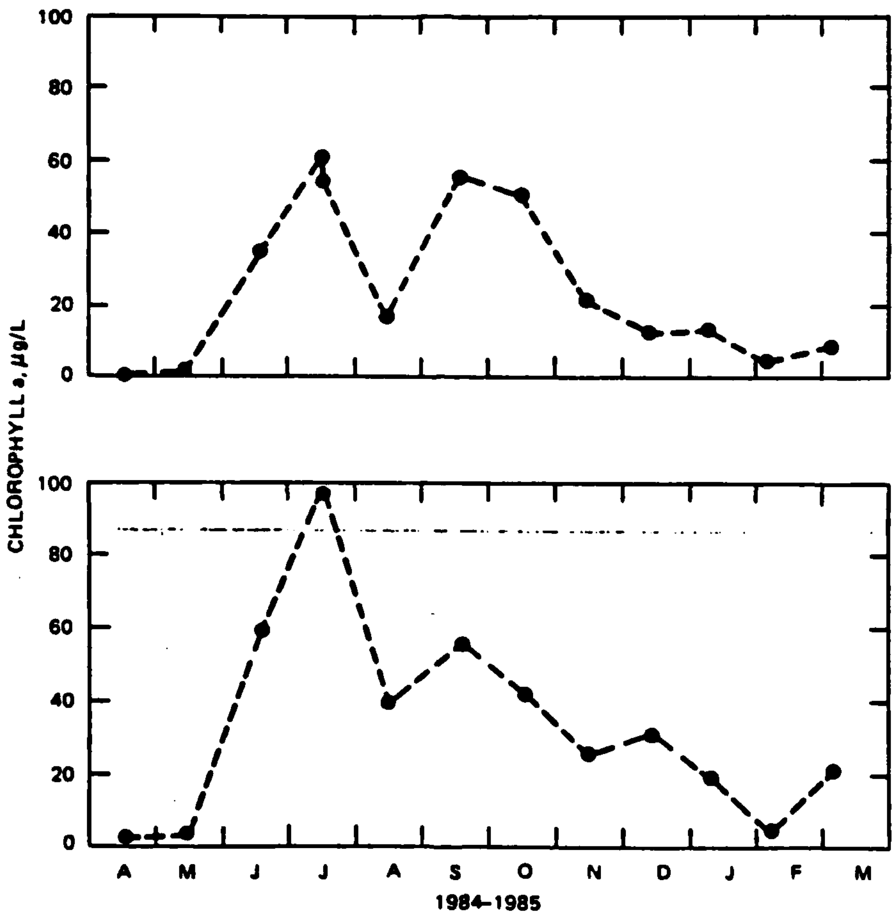

Figure 36. Temporal changes in chlorophyll a (ug/L) for integrated samples at stations A02 in Cross Cocodrie Bayou (upper panel) and Cocodrie Bayou (lower panel).

to 0.740 mg/kg. Gizzard shad exhibited the lowest concentration with a mean value for samples collected of 0.140 mg/kg.

82. The analysis for the additional 14 metals showed 5 of these to be below detection limits in all samples tested. The results for the remaining 9 which were found in detectable concentrations in most of the samples collected are listed in Table 10.

83. Pesticides/chlorinated hydrocarbons. Detectable concentrations were found for only 7 of the 30 hydrocarbons for which tests were made (Table 10) and in no instance where FDA standards have been set did a single pesticide or isomeric group of pesticides or Arochlor approach these standards.

Sediment analysis

84. Metals/non-metals. At present there are no EPA action limits or standards for metals/non-metals in lake or river sediments; however, the United States Geological Survey has established alert levels of certain metals/non-metals in sediments. Alert levels are not used for regulatory or enforcement action; they are utilized instead as an evaluation mechanism for assessing impacts of point and nonpoint sources on water, fish, and sediments. When sufficient data is available from a number of areas, alert levels may be used to evaluate and rank these areas in order of their severity of potential impacts.

85. Of the 15 metals/non-metals tested, only 2, mercury (Hg) and selenium (Se) were below detection limits in both Black River and Cocodrie Lakes. No substantial differences were noted in concentrations of the various metals/non-metals between lakes and in all cases where alert levels have been established, all of the compounds tested were well below alert level values (Table 11).

86. Pesticides/chlorinated hydrocarbons. As is the case with the metals/ non-metals, there are no EPA action limits or standards for pesticide concentrations in sediments of lakes and streams, however, alert levels do exist for most of the compounds for which tests were made.

87. Of the 30 hydrocarbons tested, 25 were below detection limits. Aldrin, heptachlor, heptachlor epoxide, diazinon, and the PCB Arochlor 1248 were found in most of the samples collected from both Black River and Cocodrie Lakes with no substantial differences in levels of these compounds noted between lakes. The PCB Archlor 1248 exceeded the alert level (0.020 mg/kg)

for this compound in all samples collected from both Black River and Cocodrie Lakes. Values ranged from 0.021 mg/kg to 0.052 mg/kg in Black River Lake and from 0.036 mg/kg to 0.063 mg/kg (Table 11) in Cocodrie Lake. Results of the analysis for all other compounds for which detectable concentrations were found, showed them to be well below established alert levels (Table 11).

PART IV: DISCUSSION

Fisheries

88. Relative proportions of major groups of fishes caught in each habitat by electroshocking are comparable. Gizzard and threadfin shad were the most abundant species numerically in each habitat, and sunfish ranked second in each area except Bayou Cocodrie where buffalofishes ranked second. Buffaloes and common carp ranked first and second in fish weight in each habitat except Workinger Bayou, where their ranking was reversed. Seasonal trends in composition were similar in each habitat, with shad dominating fish numbers and buffaloes and carp dominating fish biomass. Commercial fish species comprised from 5.7 to 18.9 percent of total numbers and 49.4 to 78.0 percent of the total weight, whereas sport fish accounted for 6.9 to 19.2 percent of the total numbers and 4.7 to 19.0 percent of the total weight in each habitat (Table 6).

89. Cobb, et al. (1984) found gizzard and threadfin shad to be the most abundant species in Lower Mississippi River borrow pits and concluded these species to be one of the most characteristic in these areas. Bigmouth buffalo comprised a significant portion of the fish biomass in these areas, ranking second behind shad. Commercial fish species comprised 4.8 percent of the total numbers caught and 48.3 percent of the weight, while sport fishes accounted for 14.1 and 11.8 percent of the total catch and weight, respectively. 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).

90. Central Louisiana lakes with relatively stable water levels and little or no inflow or outflow normally average around 200 - 300 pounds per acre standing crop of fish (Mike Ewing, District Fisheries Biologist, Louisiana Department of Wildlife and Fisheries - personal communication). Of this amount, about 5 to 10 pounds per acre will be largemouth bass, a preferred sport species. Lambou (1960) determined an average standing crop 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 crop. In another study, Lambou (1959) sampled seven backwater lakes along the Mississippi, Atchafalaya, and Pearl Rivers, and found standing crop estimates ranging from 142 - 651 pounds per acre. Overall, he found that commercial and sport species comprised 47.3 and 26.0 percent, respectively, of the fish standing crop. Robichaux (1961) sampled a pond and a Mississippi River borrow pit in East Baton Rouge Parish, Louisiana, and estimated the borrow pit standing crop at 1495 pounds per acre whereas the pond had 412 pounds per acre. Commercial species accounted for 62 percent of the standing crop in the borrow pits, while sport species comprised 73 percent of the standing crop in the pond.

91. Previous rotenone surveys of Bayou Cocodrie by the Louisiana Department of Wildlife and Fisheries estimated a standing crop of 419 pounds per acre, with ranges from 255 pounds per acre in 1971 to 722 pounds per acre in 1973 (Williams, 1974). An unpublished report by the Louisiana Department of Wildlife and Fisheries in 1978 estimated standing crop in Black River Lake at 139 pounds per acre. Saline Lake, a backwater lake in the southern part of Concordia Parish, Louisiana, averaged 188.3 pounds per acre standing crop from 1971-1978, ranging from a low of 105.1 pounds per acre in 1971 to a high of 417.4 pounds per acre in 1975 (Baxter, 1980).

92. Other Louisiana habitats have been studied by Bryan and Sabins (1979). From their study of the Atchafalaya Basin, they obtained average standing crop 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 sportfishes, while the upper basin, which lacks direct mainstream influence, favors carp, shad, buffalo, and bowfin, species typical of unmanaged eutrophic lakes at similar latitudes.

93. Standing crops of fish from two oxbow lakes in the Delta Region of Mississippi were estimated by Bingham (1969). Mossy Lake had an estimated standing crop 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. Centrachids comprised 40 percent of fish standing crop in Mossy Lake and 20 percent in Wolf Lake.

94. Gizzard shad in the Lower Mississippi River Valley normally reproduce 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). Growth appears to be about 0.97 - 1.10 mm day in Mississippi River borrow pits (Cobb, et al., 1984). Size distribution and growth of gizzard shad in both Black River Lake and Cocodrie Lake is nearly identical to the median figure for the south-central United States given by Carlander (1969), where Age 0 fish average 70 - 90 mm in August and Age 1 gizzard shad average 150 - 170 mm in April.

95. Threadfin shad have a short life span with few individuals reaching two years of age (Miller, 1963). A few fish may reach a size of up to 178 mm in southern states (Carlander, 1969) but most fish are somewhat smaller. Sizes of threadfin shad collected in both Black River Lake and Cocodrie Lake were consistent with reported averages, ranging from 40 - 100 mm (Figures 7 and 8) and showed a similar distribution both lakes.

96. Two spawning peaks per year are recognized for threadfin shad populations, one in the spring and another in the fall. It is possible that spring spawners were prevalent in the July rotenone sample in both Black River Lake and Cocodrie Lake, and that fall spawners were prevalent in the electroshocking surveys in both lakes.

97. Size distribution of channel catfish collected in July in both Black River Lake and Cocodrie Lake appears consistent and is comparable with similar data from other habitats (Figure 7 and 8). Young of the year fish apparently range from 30 - 60 mm and Age 1 probably range from about 80 - 140 mm. From the data it is difficult to distinguish the separation point for older year classes. In all likelihood some overlap does exist among subsequent year classes. Larger fish in the 300 - 340 mm range are also present and are probably in the 4th or possibly 5th year of growth. Carlander (1969) reported that channel catfish reach 75 - 100 mm after one year, 125 - 200 mm after two years, 175 - 300 mm after three years, and continue to grow rapidly for at least six to seven years. He found little evidence for regional differences in growth of channel catfish, though more of the faster growing populations seemed to be in the south.

98. Size distribution and growth of largemouth bass in Black River Lake appears comparable to other central Louisiana and south-central United States waters. Young-of-the-year largemouth bass in central Louisiana should average around 100 mm in early July (Mike Ewing, District Fisheries Biologist, Louisiana Department of Wildlife and Fisheries - personal communication). Cobb, et al., (1984) reported that young-of-the-year bass in Lower Mississippi

River borrow pits ranged up to 150 mm, bass from 150 - 225 mm were probably Age 1, and bass from 226 - 300 mm were at least Age 2. Growth in the borrow pits appeared to be comparable to the average for south central United States waters as reported by Carlander (1977).

99. Length frequency modes of bluegill in both Black River Lake and Cocodrie Lake were similar and indicated that growth of bluegill is comparable to Carlander's (1977) averages for the southern United States. The absence of larger sizes may possibly be explained by failure of older year classes or by stunting of the population at sizes under this limit.

100. Carlander (1977) notes growth rates for young-of-the-year bluegill ranging from 0.1 - 0.6 mm TL/day, with the average about 0.3 - 0.4 mm TL/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) reported similar growth rates of bluegill in Wisconsin and Missouri, respectively, with Age 1 fish reaching 55 mm, and Ages 2 - 5 reaching 110 mm, 145 mm, 160 mm, and 175 mm, respectively. Christenson and Smith (1965) found growth rates in Mississippi River backwaters to be much faster, with many fish reaching 210 mm by Age 5. Carlander (1977) also reported faster 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.

101. Carlander (1977) indicates that the growth rate of young crappie ranges from about 0.50 - 1.30 mm TL/day. During the first month or two of life, growth rate appears to be closer to 1.0 mm TL/day, but later in the summer and fall a rate of 0.5 - 0.75 mm TL/day seems to be more realistic. He reports the following data on sizes (TL) 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, 344 mm. Young of the year white crappie range from 30 - 110 mm in Lower Mississippi River borrow pits, with fish in southern borrow pits apparently growing faster (or spawning earlier) than fish in northernmost borrow pits Cobb, et al. (1984).

102. The abundance of small white crappie in the study area suggests two possibilities. The first is a stunted population with large numbers of older fish that are undersized. The second possibility is an unusually strong 1984 year class. Carlander (1977) relates that white crappie are prone to

produce strong year classes which suppress subsequent ones for several years. Without data on ages of these fish, we cannot specifically determine which of these possibilities exist in the study area. It is also significant that white crappie is the most prevalent game fish in the study area, since this species is known to be more tolerant of highly turbid conditions than other game species (Buck, 1956).

103. The average condition factors for largemouth bass, white crappie, and bluegill were comparable to values reported by Carlander (1977) for these species in other southern United States waters.

104. Largemouth bass in the study area apparently spawned beginning in April and completed spawning activity sometime around the June/July time frame. From that point the GSI bottomed out and then began a gradual increase throughout the fall months. The bi-monthly sampling regime precluded an exact determination of the peak of spawning activity, however the data were corroborated by Mike Ewing, District Fisheries Biologist with the Louisiana Department of Wildlife and Fisheries, who confirmed that largemouth bass in this area normally begin spawning in April when the water temperature reaches approximately 18-19° C (Mike Ewing - personal communication).

105. It should be noted that largemouth bass are more abundant in Black River Lake than in any of the other habitats sampled in the area. The presence of numerous young-of-the-year and succeeding age classes in Black River Lake indicate that survival, and thus success, of the Black River Lake bass population appears adequate. However, in the other habitats sampled largemouth bass are noticeably less abundant. The reasons for this condition are possibly related to the higher turbidity levels in the other habitats during the peak months of spawning activity. Turbidity in Cocodrie Lake was consistently higher throughout the year and was highest during the beginning of spawning activity in February. Largemouth bass reproduction may be affected by turbidity, and bass may fail to spawn where suspended sediments settle on the bottom and form a layer of soft silt (Bulkley, 1975).

106. Apparently some spawning activity for white crappie occurs as early as February and continues through April, being completed by June. Average GSI values were highest for males in February, dropping steadily to a low in June and then increasing for the remainder of the year. Average GSI values for females were highest in April, dropping quickly to lows in June and August, then increasing steadily throughout the fall. Again, the sampling

regime in this study precludes an exact determination of the spawning activity peak. White crappie are known to spawn from February until early May in the area when water temperatures reach approximately 16° C (Mike Ewing - personal communication).

107. The presence of numerous small white crappie and the overall abundance of this species in the study area indicates that white crappie reproductive success is excellent. As indicated previously, there are some indications of stunting with sizes of younger and older fish possibly overlapping in some age groups. White crappie are known to be more tolerant of turbidity than some other sport species (Buck, 1956), a fact which may explain their overall abundance with respect to other sport species.

Water Quality

108. Water quality differences between Black River Lake and Cocodrie Lake were attributable to morphometry, meteorologic conditions, drainage basin size, land-use activities, and other factors. Major differences were related to the sources of turbidity and suspended solids, and their ultimate impact on water quality.

109. A major difference between Black River Lake and Cocodrie Lake was the thermal structure within each lake. Black River Lake's long, narrow, and relatively deep morphology, as well as the lake's alignment with respect to prevailing winds, may act to reduce the amount of wind mixing. This would result in the establishment of thermal gradients during a major portion of the year. Cocodrie Lake, on the other hand, is shallow and has more surface area exposed to prevailing winds. Hence, Cocodrie Lake may experience greater mixing, leading to the observed well-mixed conditions throughout the study period.

110. Associated with the establishment of stratified conditions at Black River Lake were changes in the dissolved oxygen regime. The isolation of hypolimnetic waters in Black River Lake led to the extensive depletion of dissolved oxygen and the establishment of an anoxic zone throughout the lake from June to November. Epilimnetic waters containing higher levels of dissolved oxygen were limited to the upper 3-m stratum. In Cocodrie Lake, well-mixed conditions allowed for the maintenance of high dissolved oxygen concentrations throughout the lake.

111. Coincident with the establishment of anoxic conditions in lake waters are releases of nutrients and metals from sediment (Wetzel 1975). Sediment releases may be an important source of reduced forms of iron and manganese, which could be a potential water quality concern. Evidence of this was seen in the bottom waters of Black River Lake. Increased specific conductance in the bottom waters during the stratified period indicated increased dissolved material concentrations in the hypolimnion and reflected the development of chemical stratification in Black River Lake. Of particular interest were increases in phosphorus concentrations in bottom waters. These increases, which could provide a significant nutrient source for algae, were clearly related to sediment releases since external loading during the summer would have been minimal.

112. As water temperatures warmed and turbidity decreased, chlorophyll a concentrations increased to seasonal maxima. Black River Lake had peak concentrations in July, while Cocodrie Lake had two peaks, one in July and a high peak September. This temporal shift in maximum chlorophyll a was apparently the result of Cocodrie Lake's higher turbidity and suspended solids concentrations.

113. Turbidity and solids concentrations were consistently higher in Cocodrie Lake than Black River Lake throughout the year. This reflects the combined effects of high rates of runoff, sediment resuspension due to wind action, and the possible influence of turbid Bayou Cocodrie inflows. Such influences were far less pronounced at Black River Lake.

114. Similarities between turbidity, total and suspended solids, and secchi depths allow for the grouping of sites within the study area. Workinger Bayou was similar to Black River Lake and Bayous Cocodrie and Cross Cocodrie were similar to Cocodrie Lake. Black River was not significantly different from either group, but did have higher turbidity, and suspended and total solid concentrations than Black River Lake.

115. Turbidity sources and associated problems arise from erosion, runoff, and sediment resuspension. The removal of natural vegetation for agricultural uses has increased the potential for soil erosion and siltation. In addition, the loss of standing timber has exposed the lakes to increased wind and wave action, and subsequent resuspension of sediments. The resuspension of sediments has been observed as a source of turbidity in other shallow lakes (Carper and Bachmann 1984). Coincident with the resuspension of sediments is

the enhancement of nutrients and other constituents into the water column (Mortimer 1941).

116. The drainage area surrounding both Black River and Cocodrie Lakes has been altered in the last 15 years for agricultural uses. This predominately agricultural area has been cleared of standing timber and modified with a large number of drainage ditches and culverts, which drain vast areas of fertilized crop land.

117. Local contacts have observed considerable flows entering Workinger Bayou and Black River Lake, apparently due to the effects of inflows to Cocodrie Lake from Bayou Cocodrie during large storm events. Field observations on June 8, the day after a major storm event (18.3 cm recorded at the Jonesville Lock), partially support the suggestion that water from Bayou Cocodrie is transported through Cocodrie Lake to Black River Lake during major hydrologic events. Turbidity values were considerably increased from Bayou Cocodrie to the confluence of Workinger Bayou and Black River Lake. However, this turbidity plume decreased substantially at stations on either side of the confluence. Turbidity concentrations increased again at stations in the west branch of Black River Lake, indicating local inflows. Additionally, annual mean values of suspended solids indicate higher values in Cocodrie Lake, and Bayous Cross Cocodrie and Cocodrie than those observed in Workinger Bayou and Black River Lake. This indicates that these flows do not appear to be a major influence of Black River Lake's water quality.

118. Turbidity sources in the study area are numerous and consist of agricultural runoff, possible resuspension of sediments, and possible influx of Bayou Cocodrie waters. In order to better understand the relative influences of the sources, more intensive studies are required. For instance the relative importance of sediment sources, both point and non-point, could be evaluated based on material budgets. The calculation of such budgets would require detailed evaluation of overland flow and careful monitoring of inflows.

Trace Metals/Non-Metals and Pesticides/ Chlorinated Hydrocarbons

119. The absence of FDA or EPA standards or action limits for trace metals/ non-metals (with the exception of mercury (Hg)) in fish tissue prevent

making any definitive statements concerning the levels of trace metals/non-metals which were detected with the exception of Hg. Mercury levels were above FDA action standards in smallmouth buffalo tissue samples collected from Black River Lake, however, fish of the same species were well below action standards in samples collected from Cocodrie Lake. Two other species, gizzard shad and white crappie, were below FDA action standards in both Black River and Cocodrie Lakes.

120. Analysis of fish tissue for pesticides/chlorinated hydrocarbons revealed that only a few of those pesticides/chlorinated hydrocarbons for which tests were run were present in detectable concentrations, and in all cases the values detected were below FDA action limits. These results are somewhat surprising due to the extensive amount of agricultural lands which surround the study area and the history of this section of the state with regard to pesticide contamination in fishes.

121. In 1978 a ban was placed on fishing in Lake Providence, Louisiana due to excessive concentrations of toxaphene and DDT and its metabolites in fish tissue. This ban was not lifted until 1982 and only then with the recommendation that hybrid stripers not be eaten. Residue data on other edible species at that time indicated levels just below FDA action levels (Gambrell et al. 1983). In addition, results of studies conducted by the Water Pollution Control Division (Louisiana Department of Environmental Quality, Office of Water Resources) from October, 1976 to December 1981 revealed widespread presence of DDT family compounds, dieldrin, toxaphene, and chlordane family compounds in fish tissue throughout Louisiana, with the heaviest concentrations noted in the northeast portion of the state (Landry et al. not dated). Of the 20 lakes and rivers investigated by the Water Pollution Control Division, Black River Lake was ranked tenth (4.70 mg/kg) and Cocodrie Lake was ranked twentieth (1.10 mg/kg) based on total pesticide/chlorinated hydrocarbon residue concentration from whole body fish tissue analysis. These analyses included primarily toxaphene and DDT family compounds, however, miscellaneous compounds which had a mean concentration of 0.10 mg/kg were also included. Toxaphene and DDT total family compounds were found in concentrations of 0.61 mg/kg and 1.20 mg/kg respectively in tissue samples collected from Black River Lake while Cocodrie Lake tissue samples showed a toxaphene concentration of 0.39 mg/kg and a DDT family compound concentration of 0.72 mg/kg. In contrast, tissue samples collected during

this study showed both toxaphene and DDT family compounds to be below detection limits in all samples collected. It should be noted that the study conducted by the Water Pollution Control Division utilized several (16) species of fish for analysis while our study was confined to 3. This fact plus differences in tissues analyzed (i.e. whole body versus fillets) could account for some of the differences noted.

122. Sediment samples collected from Black River and Cocodrie Lakes showed relatively small differences in metal/non-metal concentrations in bottom sediments among the two lakes. Mercury (Hg) and selenium (Se) were below detection limits in all samples collected. Values for all the other metals/non-metals for which tests were made were below USGS alert levels.

123. Samples of lake sediment from Black River and Cocodrie Lakes which were analyzed for pesticide/chlorinated hydrocarbons produced results which appear to be fairly atypical for lakes located in northeastern Louisiana. Sediment data from 64 sediment samples collected from various lakes in Louisiana between October, 1976 and December, 1981 revealed widespread presence of clordane, PCB Aroclors, and DDT and its metabolites (Landry et al. not dated). In contrast chlordane, DDT, and DDT family compounds were below detection limits in all sediment samples collected from Black River and Cocodrie Lakes, however, one PCB Arochlor, PCB 1248 was present in concentrations above USGS alert levels in all samples collected from both Black River and Cocodrie lakes.

PART V: SUMMARY AND CONCLUSIONS

124. Fish communities throughout the Black River Lake study area were similar in overall composition with gizzard and threadfin shad dominating fish numbers and buffaloes and carp dominating fish biomass. This trend was consistent during all seasons in Cocodrie Lake and Bayou Cocodrie. Centrarchids, primarily white crappie, were more prevalent during the early and late summer in Black River Lake and Workinger Bayou. Sport fishes were present in each of the habitats sampled with white crappie accounting for the largest numbers and weight.

125. The standing crop of fishes in Black River Lake was dominated by white crappie, buffaloes, and carp, and was essentially the same as previous estimates and compared favorably to other similar habitats. In contrast, the standing crop of fishes in Cocodrie Lake was lower than other habitats and was dominated by gizzard and threadfin shad. High turbidity levels during the spring spawning season may affect the standing crop of fishes in Cocodrie Lake.

126. Length frequency analysis of selected species indicates that recruitment of gizzard shad, threadfin shad, bluegill, white crappie, and channel catfish is occurring in both Black River Lake and Cocodrie Lake, although in lesser numbers in Cocodrie Lake. Shad and channel catfish populations appear normal and healthy, whereas populations of white crappie and bluegill, although numerous, consist primarily of smaller sized fish. The largemouth bass population in Black River Lake consists of several year classes including numerous young-of-the-year and older fish.

127. The relative condition of largemouth bass and white crappie in the study area is good, and compares favorably with these species in other areas.

Largemouth bass were noticeably sparse in all habitats except Black River Lake, where bass reproduction appears consistent with other similar Louisiana habitats. Reproductive activity of white crappie appears excellent throughout the study area.

128. Black River Lake experienced thermal and chemical stratification during the summer months which created anoxic conditions and resulted in release of nutrients from bottom sediments. Chlorophyll a concentrations reached a maximum in July and clearly indicated the existence of eutrophic conditions. Spatial and temporal patterns were apparent and possibly related

to local land use patterns. Culverts and ditches were present and were observed to transport extensive turbid inflows during high flow periods. Turbidity was highest at stations along the western reach of the lake. Chlorophyll values were also higher at these stations. In general, water quality conditions in Black River Lake were similar to those observed in Black River.

129. Cocodrie Lake remained mixed and well-oxygenated during the study period. Turbidity was high throughout the winter and spring months and following significant hydrologic events. The later phenomenon reflects the influence of local land uses and topography as well as inflows from Cross Cocodrie Bayou. Maximum chlorophyll values were reached in September following declines in turbidity.

130. Workinger Bayou exhibited water quality similar to Black River Lake. This observation suggests little interaction between Cocodrie Lake and Black River Lake, except during periods of high flows when net transport of water and material is from Cocodrie Lake toward Black River Lake.

131. Pesticides/chlorinated hydrocarbons and trace metals/non metals concentrations in bottom sediments and fish tissue which were examined were below both USGS alert levels and FDA action standards in both lakes with the exception of mercury concentrations noted in tissue samples from smallmouth buffalo collected in Black River Lake. Whether or not the apparent elevation of mercury is of significance is unknown.

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Table 1

Families, Species, and Economic Classification of Fish Captured in the Black River Lake - Cocodrie Lake Study Area

Family and Species	Economic Classification*
Polyodontidae - paddlefishes	
Paddlefish (*Polyodon spathula*)	3
Lepisosteidae - gars	
Spotted gar (*Lepisosteus oculatus*)	6
Longnose gar (*Lepisosteus osseus*)	6
Shortnose gar (*Lepisosteus platostomus*)	6
Amiidae - bowfins	
Bowfin (*Amia calva*)	4,6
Clupeidae - herrings	
Gizzard shad (*Dorosoma cepedianum*)	5
Threadfin shad (*Dorosoma petenense*)	5
Cyprinidae - minnows and carps	
Common Carp (*Cyprinus carpio*)	2,4
Blacktail shiner (*Notropis venustis*)	5
Pugnose minnow (*Notropis emiliae*)	5
Catostomidae - suckers	
Smallmouth buffalo (*Ictiobus bubalus*)	2,4
Bigmouth buffalo (*Ictiobus cyprinellus*)	2,4
Black buffalo (*Ictiobus niger*)	2,4
Ictaluridae - freshwater catfishes	
Blue catfish (*Ictalurus furcatus*)	3
Yellow bullhead (*Ictalurus natalis*)	1,3
Channel catfish (*Ictalurus punctatus*)	1,2,3
Madtom (*Noturus* spp.)	6
Flathead catfish (*Pylodictus olivaris*)	2,3

(Continued)

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

Table 1 (Concluded)

Family and Species	Economic Classification
Cyprinodontidae - killifishes	
Blackstripe topminnow (*Fundulas notatus*)	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
Striped bass (*Morone saxatilis*)	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
Spotted sunfish (*Lepomis punctatus*)	1
Largemouth bass (*Micropterus salmoides*)	1,3
White crappie (*Pomoxis annularis*)	1,3
Black crappie (*Pomoxis nigromaculatis*)	1,3
Percidae - perches	
Logperch (*Percina caprodes*)	5
Aphredoderidae - pirate perches	
Pirate perch (*Aphredoderus sayanus*)	5
Sciaenidae - drums	
Freshwater drum (*Aplodinotus grunniens*)	2,4

Table 2

Number of Fish Collected by Electroshocking Each Month from

Black River Lake, Louisiana

Common Name	Feb	Apr	Jun	Aug	Oct	Dec
Spotted Gar	1	15	2	7	16	1
Shortnose Gar	1	1	2	1	1	2
Bowfin	--	--	--	3	1	--
Gizzard Shad	4	37	--	15	19	111
Threadfin Shad	--	23	--	1	475	406
Common Carp	16	8	1	12	9	7
Blacktail Shiner	--	1	--	--	--	--
Smallmouth Buffalo	--	--	--	3	4	--
Bigmouth Buffalo	14	7	2	7	7	17
Black Buffalo	--	--	--	--	1	--
Channel Catfish	--	--	--	--	1	--
White Bass	--	2	3	--	--	1
Warmouth	--	--	--	1	--	1
Bluegill	10	10	3	31	32	1
Longear Sunfish	1	--	--	8	3	--
Largemouth Bass	7	5	1	18	22	10
White Crappie	5	10	3	--	--	7
Spotted Bass	--	2	--	1	7	1
Freshwater Drum	--	--	--	2	5	1
TOTAL	59	121	17	110	603	566

Table 3

Number of Fish Collected Each Month by Electroshocking from Cocodrie Lake, Louisiana

Common Name	Feb	Apr	Jun	Aug	Oct	Dec
Spotted Gar	--	3	3	7	7	1
Shortnose Gar	--	2	1	2	1	2
Gizzard Shad	51	9	3	34	88	321
Threadfin Shad	3	2	--	2	129	29
Common Carp	3	2	--	3	12	1
Smallmouth Buffalo	--	--	1	2	12	1
Bigmouth Buffalo	2	1	--	2	6	--
Black Buffalo	--	--	--	--	1	--
Flathead Catfish	--	1	1	--	--	--
Inland Silverside	--	--	--	--	1	--
White Bass	--	1	--	--	--	--
Yellow Bass	1	--	--	--	1	--
Bluegill	2	1	--	9	8	--
Longear Sunfish	--	--	--	1	--	--
Largemouth Bass	--	--	--	2	2	--
White Crappie	48	6	--	--	2	8
Freshwater Drum	1	2	--	--	2	--
TOTAL	111	30	9	64	272	363

Table 4

Number of Fish Collected Each Month by Electroshocking from Workman's Bayou, Louisiana

Common Name	Feb	Apr	Jun	Aug	Oct	Dec
Spotted Gar	--	4	2	8	4	1
Shortnose Gar	--	1	--	--	2	1
Bowfin	--	2	1	--	--	--
Gizzard Shad	3	16	--	7	9	4
Threadfin Shad	--	--	--	1	8	202
Common Carp	--	3	1	3	2	--
Smallmouth Buffalo	--	--	1	--	3	1
Bigmouth Buffalo	--	--	--	1	2	1
Blue Catfish	--	--	--	--	1	--
White Bass	--	1	--	--	--	--
Warmouth	6	--	--	--	1	--
Orangespotted Sunfish	2	--	--	--	--	--
Bluegill	11	3	--	16	12	--
Longear Sunfish	2	--	--	--	4	--
Spotted Sunfish	2	--	--	--	--	--
Largemouth Bass	3	1	--	5	2	--
Spotted Bass	1	--	--	--	2	--
White Crappie	7	5	--	--	1	1
Black Crappie	1	--	--	--	--	--
Freshwater Drum	--	1	--	--	--	1
TOTAL	38	37	5	41	53	212

Table 5

Number of Fish Collected Each Month by Electroshocking from Bayou Cocodrie, Louisiana

Common Name	Feb	Apr	Jun	Aug	Oct	Dec
Spotted Gar	--	1	--	1	--	--
Shortnose Gar	--	3	2	5	--	--
Longnose Gar	--	--	--	1	--	--
Gizzard Shad	8	13	2	15	34	40
Threadfin Shad	--	--	--	14	85	20
Common Carp	1	1	3	1	5	--
Smallmouth Buffalo	--	1	--	--	3	1
Bigmouth Buffalo	2	7	2	4	22	5
Blue Catfish	--	1	--	--	1	--
Warmouth	--	--	--	--	1	--
Bluegill	2	--	--	--	3	--
Longear Sunfish	--	--	--	--	2	--
Largemouth Bass	--	--	--	--	1	--
White Crappie	1	1	2	5	2	4
Spotted Bass	--	--	--	--	2	--
Freshwater Drum	2	--	--	--	1	--
TOTAL	16	28	11	46	162	70

Table 6

Percent by Numbers and Weight of Commercial and Sport Fish Collected in the Black River Lake - Cocodrie Lake Study Area (from Lagler 1956)

	Commercial		Sport	
	Numbers	Weight	Numbers	Weight
STUDY AREA (Consolidated)	9.0	64.2	12.5	14.3
Black River Lake	8.9	61.7	13.1	19.0
Cocodrie Lake	6.9	58.6	10.7	11.3
Workman's Bayou	5.7	49.4	19.2	11.3
Bayou Cocodrie	18.9	78.0	6.9	4.7

Table 7

Standing Crop of Fish Resulting From Two 1-Acre Rotenone Surveys in Each Lake; Black River Lake, Louisiana and Cocodrie Lake, Louisiana

Species	Black River Lake July 10, 1984 No.	Black River Lake lbs/ac.	Black River Lake Percent Biomass	Cocodrie Lake July 11, 1984 No.	Cocodrie Lake lbs/ac.	Cocodrie Lake Percent Biomass
White Crappie	7290	34.8	17.2	515	12.2	15.0
Threadfin Shad	1620	7.0	3.5	2273	6.0	7.3
Orangespotted Sunfish	1120	0.7	0.3	2	--	--
Bluegill Sunfish	1069	6.0	3.0	74	0.7	0.9
Warmouth	722	0.7	0.3	--	--	--
Freshwater Drum	392	21.1	10.4	65	9.0	11.0
Gizzard Shad	363	11.5	5.7	455	30.7	37.5
Green Sunfish	290	0.7	0.3	1	--	--
Longear Sunfish	112	0.4	0.2	3	--	--
Channel Catfish	86	5.5	2.7	49	1.0	1.2
Black Crappie	61	1.0	0.5	--	--	--
Flathead Catfish	60	--	--	21	--	--
Shortnose Gar	47	24.3	12.0	8	1.8	2.2
Carp	40	34.9	17.2	11	7.1	8.7
Mosquitofish	40	--	--	--	--	--
Smallmouth Buffalo	35	29.2	14.4	14	3.7	4.5
White Bass	28	1.1	0.5	30	2.5	3.1
Largemouth Bass	18	7.2	3.6	3	0.9	1.1
Bigmouth Buffalo	17	11.6	5.7	1	0.8	0.9
Lepomis, spp.	15	--	--	1	--	--
Spotted Sunfish	10	0.1	0.1	--	--	--
Pugnose Minnow	7	--	--	--	--	--
Blue Catfish	4	1.0	0.5	26	2.6	3.2
Spotted Gar	4	1.2	0.6	2	0.6	0.8
Blackstripe Topminnow	3	--	--	--	--	--
Spotted Bass	3	0.2	0.1	--	--	--
Yellow Bass	2	0.1	0.1	1	0.1	0.1
Paddlefish	1	2.3	1.1	1	1.1	1.4
Brook Silverside	1	--	--	--	--	--
Pirate Perch	1	--	--	--	--	--
Logperch	1	--	--	--	--	--
Noturus spp.	--	--	--	20	--	--
Bowfin	--	--	--	1	0.6	0.7
Striped Bass	--	--	--	1	0.2	0.2
Yellow Bullhead	--	--	--	1	0.1	0.1
TOTAL	13,462	202.6	100	3579	81.7	100

Table 8

Physical Characteristics For Black River Lake

And Cocodrie Lake

Characteristics	Black River Lake	Cocodrie Lake
Surface Area, km^2	3.55	4.74
Maximum Depth, m	15.0	5.0
Maximum Width, km	0.23	0.76
Maximum Length, km	25.36	9.14
Shoreline Length, km	51.02	19.35
Shoreline Development Ratio	7.6	2.5

Table 9

Mean Annual Water Quality Characteristics of Black River, Black River Lake, Workinger Bayou, Cocodrie Lake, Bayou Cross Cocodrie, And Bayou Cocodrie*

Variable	Black River	Black River Lake	Workinger Bayou	Cocodrie Lake	Bayou Cross Cocodrie	Bayou Cocodrie
Turbidity, NTU	41	27	23	53	54	50
Total Solids, mg/L	188	131	143	174	194	198
Suspended Solids, mg/L	33	15	18	44	43	60
Total Phosphorus, mg/L	0.12	0.12	0.12	0.17	0.14	0.20
Nitrate Nitrogen, mg/L	0.218	0.272	0.156	0.188	0.177	0.161
Nitrite Nitrogen, mg/L	0.01	0.01	0.01	0.01	0.01	0.01
Chlorophyll, a, ug/L	3.65	14.91	28.4	22.70	26.3	38.9
Secchi Disk Depth, m	0.3	0.8	0.6	0.3	0.3	0.3

* Water samples are mid-depth, except for chlorophyll which is integrated at twice secchi depth.

Table 10

Fish Tissue Analysis

Location		As	Cd	Cr	Cu	Cn	Pb	Hg	Ni	Se	Ag	Zn	Ba	Co	Fe	Mn
					Trace Metal/Non-Metal Analysis (concentration in mg/kg)											
Black River Lake																
White Crappie	$\bar{X}$	*	0.07	0.79	3.91	*	1.17	0.61	1.08	*	*	10.70	*	*	19.90	0.66
(*Pomoxis annularis*)	Range		0.060-0.13	0.28-1.80	3.10-4.40		1.00-1.30	0.47-0.74	0.30-2.30			8.40-15.30			7.50-23.90	0.56-0.84
Smallmouth Buffalo	$\bar{X}$	*	0.09	0.86	4.84	*	0.84	1.01	1.69	*	*	8.88	0.61	*	26.70	0.99
(*Ictiobus bubalus*)	Range		0.05-0.15	0.39-1.10	3.80-5.40		0.71-0.99	0.66-1.50	0.61-3.20			7.10-10.7	0.00-1.40		25.90-28.20	0.60-1.20
Gizzard Shad	$\bar{X}$	*	0.09	0.99	6.37	*	1.47	0.14	1.60	*	*	14.90	2.20	*	47.90	9.70
(*Dorosoma cepedianum*)	Range		0.05-0.11	0.80-1.10	5.90-6.70		1.40-1.50	0.13-0.14	0.84-2.40			12.20-16.40	2.00-2.40		33.50-64.90	11.30-6.80
Cocodrie Lake																
White Crappie	$\bar{X}$	*	0.05	0.80	5.40	*	0.94	0.69	2.20	*	*	16.80	0.50	*	21.70	1.60
(*Pomoxis annularis*)	Range		0.01-0.09	0.60-1.00	4.80-6.00		0.91-0.97	0.50-0.9	2.00-2.30			13.70-20.00			18.80-24.70	1.00-2.10
Smallmouth Buffalo	$\bar{X}$	*	0.06	0.92	7.20	*	1.10	0.26	1.40	*	*	18.00	3.10	*	24.70	3.00
(*Ictiobus bubalus*)	Range		0.06-0.07	0.80-1.0	5.80-8.60		0.73-1.40	0.13-0.38	1.30-1.50			17.20-18.80	0.90-5.40		24.40-25.10	2.90-3.10
Gizzard Shad	$\bar{X}$	*	0.05	1.40	7.00	*	1.70	*	2.80	*	*	17.60	2.50	*	39.60	10.80
(*Dorosoma cepedianum*)	Range		0.05-0.05	0.67-2.10	6.70-7.40		1.50-1.90		1.30-4.20			10.70-24.60	1.20-3.80		31.90-47.50	3.00-18.60
FDA action standard		**	**	**	**	**	**	1.00 mg/kg	**	**	**	**	**		**	**

(Continued)

* Below detection limits.
** No standard established for fish tissue.

Trace Metals/Non-Metals	
As - Arsenic	Ag - Silver
Cd - Cadimium	Zn - Zinc
Cr - Chromium	Ba - Barium
Cu - Copper	Co - Cobalt
Cn - Cyanide	Fe - Iron
Pb - Lead	Mn - Manganese
Hg - Mercury	Fl - Fluoride
Ni - Nickel	
Se - Selenium	

Table 10 (Concluded)

Location		Aldrin	Dldrn	Endoii	Endrn	Hptcl	Hptcle	Mirex	PCB1248	DIAZIN
		Pesticide and Chlorinated Hydrocarbon Analysis (only those hydrocarbons found in either sediments or fish tissue are listed)								
Black River Lake										
White Crappie	$\bar{X}$	*	0.0008	*	*	*	*	0.0017	*	*
(*Pomoxis annularis*)	Range		0.0008					0.002-0.0015		
Smallmouth Buffalo	$\bar{X}$	0.0013	0.0005	*	*	*	0.00075	0.0250	*	*
(*Ictiobus bubalus*)	Range	0.0006-0.0021	0.0005				0.0007-0.0008	0.012-0.036		
Gizzard Shad	$\bar{X}$	*	0.00055	*	*	*	0.00056	0.0127	*	*
(*Dorosoma cepedianum*)	Range		0.0005-0.0006				0.0001-0.0009	0.0013-0.024		
Cocodrie Lake										
White Crappie	$\bar{X}$	*	*	0.0008	0.0012	0.0007	0.0035	0.0078	*	*
(*Pomoxis annularis*)	Range			0.0008	0.0006-0.0018	0.0007	0.0007-0.0064	0.0078		
Smallmouth Buffalo	$\bar{X}$	0.0005	0.0007	*	*	0.0026	0.0012	0.0088	*	*
(*Ictiobus bubalus*)	Range	0.0005	0.0007			0.0026	0.001-0.0013	0.0088		
Gizzard Shad	$\bar{X}$	0.0015	0.0006	*	*	*	0.0009	*	*	*
(*Dorosoma cepedianum*)	Range	0.0015	0.0006				0.0009			
FDA action standards		0.3 mg/kg	0.3 mg/kg	**	**	0.3 mg/kg	0.3 mg/kg	0.1 mg/kg	+	

* Below detection limits.
** No standard established for fish tissue.
\+ An FDA action standard for PCB's has been established for total PCB of 5.0 mg/kg in fish and shellfish.

Chlorinated Hydrocarbons	
Aldrin - Aldrin	Endoii - B-Endosulfan
Hptcl - Heptaclor	Endrn - Endrin
Hptcle - Heptaclor Epoxide	Mirex - Mirex
PCB 248 - PCB-1248	
Diazin - Diazinon	
Dldrn - Dieldrin	

Table 11

Sediment Analysis

Location		As	Cd	Cr	Cu	Cn	Pb	Hg	Ni	Se	Ag	Zn	Ba	Co	Fe	Mn
Trace Metal/Non-Metal Analysis (concentrations in mg/kg)																
Black River Lake	$\overline{X}$	7.39	1.13	32.8	25.6	1.91	67.9	*	28.1	*	0.46	134	284	11.5	33700.0	977.0
	Range	6.16-9.63	1.01-1.21	26.9-36.5	23.1-27.3	1.91	25.2-128.0		23.2-30.9		0.28-0.75	116.0-160.0	220-327	9.6-12.6	24800-38200	582-1270
Cocodrie Lake	$\overline{X}$	5.0	1.06	31.0	31.0	*	52.3	*	27.8	*	0.25	135.0	235.7	9.3	28266.0	456.7
	Range	4.5-5.4	1.03-1.10	29.5-36.9	29.4-33.7		31.5-91.7		25.6-30.5		0.22-0.3	124-140	216-261	8.9-9.7	25100-33200	397.0-492.0
USGS alert levels		200	20	200	2,000	100	500	20	2,000	20	1,000	5,000	2,000			

Pesticide and Chlorinated Hydrocarbon Analysis

(only those hydrocarbons found in either sediments or fish tissue are listed)

		Aldrin	Hptcl	Hptcle	PCB1248	Diazin	Dldrn	Endoii	Endrn	Mirex
Black River Lake	$\overline{X}$	0.0012	0.0018	0.0016	0.0365	0.0303	*	*	*	*
	Range	0.0012	0.0017-0.0020	0.0012-0.0020	0.021-0.052	0.023-0.045				
Cocodrie Lake	$\overline{X}$	0.0013	0.0022	0.00055	0.0470	0.0326	*	*	*	*
	Range	0.0013	0.0019-0.0028	0.0005-0.0006	0.036-0.063	0.020-0.045				
USGS alert levels		0.020	0.020	0.020	0.020		0.020	0.020	0.020	0.020

*Below detection limits.

Trace Metals/Non-Metals

As - Arsenic	Ag - Silver
Cd - Cadimum	Zn - Zinc
Cr - Chromium	Ba - Barium
Cu - Copper	Co - Cobalt
Cn - Cyanide	Fe - Iron
Pb - Lead	Ma - Manganese
Hg - Mercury	Fl - Fluoride
Ni - Nickel	
Se - Selenium	

Chlorinated Hydrocarbons

Aldrin - Aldrin	Endoii - B-Endosulfan
Hptcl - Heptaclor	Endrn - Endrin
Hptcle - Heptaclor Epoxide	Mirex - Mirex
PCB248 - PCB - 1248	
Diazin - Diazinon	
Dldrn - Dieldrin	

END

DTIC

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