US Army Corps
of Engineers

**ENVIRONMENTAL AND WATER QUALITY
OPERATIONAL STUDIES**

TECHNICAL REPORT E-86-6

AQUATIC BIOTA ASSOCIATED WITH CHANNEL STABILIZATION STRUCTURES AND ABANDONED CHANNELS IN THE MIDDLE MISSOURI RIVER

by

Gary J. Atchison, Roger W. Bachmann, John G. Nickum,
James B. Barnum, Mark B. Sandheinrich

Iowa Cooperative Fishery Research Unit
Iowa State University
124 Science II
Ames, Iowa 50011

[redacted]

July 1986

Final Report

Approved For Public Release; Distribution Unlimited

[redacted]

Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

Under EWQOS Work Unit VA

Monitored by Environmental Laboratory
US Army Engineer Waterways Experiment Station
PO Box 631, Vicksburg, Mississippi 39180-0631

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Technical Report E-86-6

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
AQUATIC BIOTA ASSOCIATED WITH CHANNEL STABILIZATION STRUCTURES AND ABANDONED CHANNELS IN THE MIDDLE MISSOURI RIVER

5. TYPE OF REPORT & PERIOD COVERED
Final report

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Gary J. Atchison, Roger W. Bachmann, John G. Nickum, James B. Barnum, Mark B. Sandheinrich

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Iowa State University
Iowa Cooperative Fishery Research Unit
124 Science II, Ames, Iowa 50011

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
EWQOS Work Unit VA

11. CONTROLLING OFFICE NAME AND ADDRESS
DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

12. REPORT DATE
July 1986

13. NUMBER OF PAGES
94

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
US Army Engineer Waterways Experiment Station
Environmental Laboratory
PO Box 631, Vicksburg, Mississippi 39180-0631

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

[redacted]

18. SUPPLEMENTARY NOTES

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aquatic animals
Channels (Hydraulic engineering)
Fishes
Missouri River
Water quality
[redacted]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Biological and physical data were collected from main-stem habitats on the Missouri River between river miles 661 and 678 during 1983. Sampling was conducted to describe water quality and fish and benthic macroinvertebrate populations associated with dike, revetment, and abandoned channel habitats.

Water quality measurements were rather uniform, except for some small differences between some measurements made in the abandoned channels and those

(Continued)

20. ABSTRACT (Continued).

in the main river, indicating a well-mixed system.

Thirty-nine fish species comprised the juvenile and adult catch. The revetted bank samples were dominated by larger species, such as the blue sucker and flathead catfish. The dike field had a similar assemblage of larger species with blue sucker, channel catfish, flathead catfish, and goldeye predominating. The dike fields also provided habitat for a wide variety of minnows. The abandoned channels yielded the greatest species richness and overall greatest numbers of fish.

The overall abundance of fish larvae in the abandoned channels was much higher than in the main channel and the catch was dominated by sunfishes and gizzard shad. The main channel habitats were found to be of importance for freshwater drum, carp suckers, and common carp. Peak times of larval fish abundance occurred between early June and mid-August.

There were differences in the densities and taxonomic composition of the benthic invertebrate communities in the different habitats. The abandoned channel habitats were characterized by fine sediment particles, high benthos densities, and lower number of taxa than found on the rock substrate of the dikes and revetments. The dike pool habitats were characterized by high current velocities, a diversity of sediment types, and low benthic diversity. The dikes and revetments were similar in having large rock substrates and high current velocities. Attached forms such as *Hydra* were important as were other invertebrates commonly associated with coarse substrates (caddisflies, stoneflies, and clinging mayflies).

PREFACE

This work is part of the Environmental and Water Quality Operational Studies (EWQOS) Program sponsored by the Office, Chief of Engineers (OCE), and is being managed by the US Army Engineer Waterways Experiment Station (WES) Environmental Laboratory (EL) under EWQOS Work Unit VA, Environmental Impact of Selected Channel Alignment and Bank Revetment Alternatives in Waterways. The OCE Technical Monitors for EWQOS were Mr. Earl E. Eiker, Dr. John Bushman, and Mr. James L. Gottesman.

The basic objective of the EWQOS Program is to provide new or improved technology for the planning, design, construction, and operation of Corps of Engineers projects in an effort to solve selected environmental problems. This report presents results of a study of physical, chemical, and biological characteristics of the Missouri River and associated revetted banks, dike fields, and abandoned channels of the Iowa-Nebraska border north of Omaha, Nebraska. Fieldwork was conducted in the summer and fall of 1983 by the Iowa Cooperative Fisheries Research Unit under Intra-Army Order No. WESRF 83-139 dated 11 January 1983. The order was modified with Exchange Order No. 1 dated 31 March 1983 and change order No. 2 dated 5 December 1983.

The report was prepared by Drs. Gary J. Atchison, Roger W. Bachmann, John G. Nickum, James B. Barnum, and Mr. Mark B. Sandheinrich. The project was administered at WES by Dr. C. H. Pennington, EL.

Field and laboratory work was coordinated by Dr. Barnum and Mr. Sandheinrich, and conducted by the following graduate students in the Department of Animal Ecology, Iowa State University: Messrs. Fredrick Barrows, Kenneth Kortge, John Olson, John Ringle, Thomas Robertson, Burt Shephard, and Roger Vancil. Mr. Adam Leff provided particular support and assistance to all phases of the larval fish subproject. Mr. Kortge provided special expertise in midge identification and assisted in formatting this report. Additional field assistance was provided by Messrs. Larry Sanders and Mike Potter, EL. The report was edited by Ms. Jamie W. Leach of the WES Information Products Division.

Program Manager at WES for EWQOS was Dr. Jerome L. Mahloch. Chief of EL was Dr. John Harrison.

Director of WES during publication of this report was COL Allen F. Grum, USA. Technical Director was Dr. Robert W. Whalin.

This report should be cited as follows:

Atchison, G. J., et al. 1986. "Aquatic Biota Associated With Channel Stabilization Structures and Abandoned Channels in the Middle Missouri River," Technical Report E-86-6, prepared by Iowa State University, Ames, Iowa, for the US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

CONTENTS

AQUATIC BIOTA ASSOCIATED WITH CHANNEL STABILIZATION STRUCTURES AND ABANDONED CHANNELS IN THE MIDDLE MISSOURI RIVER

PART I: INTRODUCTION

Background

1. This study was designed to assess the water quality and biota of dike, revetted bank, and abandoned channel habitats on a segment of the Missouri River bordered by Iowa and Nebraska. Methodologies used were developed during earlier phases of the Environmental and Water Quality Operational Studies (EWQOS) Program managed by the US Army Engineer Waterways Experiment Station (WES).

2. The Missouri River below Sioux City, Iowa, has a narrow, single, smooth channel with a series of gentle bends and a well-stabilized bank (Hallberg, Harbough, and Witinok 1979). Dikes built perpendicular to the flow cut off side channels, contract channel width, and prevent banks on the inside of the channel from eroding. Revetments, constructed on the outside of the river bend parallel to the flow, maintain channel alignment and stabilize banks. Abandoned channels are essentially lentic habitats that maintain a connection, at least during high river discharge, with the main channel. Although abandoned channels are not very numerous, most of the river shoreline supports either dike fields or revetments. Thus, the Missouri River is greatly modified by control structures from Sioux City, Iowa, to its confluence with the Mississippi River.

Objectives

3. A review of pertinent literature demonstrates that relatively little is known of the impacts of these channel modifications on river water quality or biota. The specific objectives of this study were to

describe water quality and fish and benthic maroinvertebrate populations associated with dike, revetment, and abandoned channel habitats along the Missouri River bordered by Iowa and Nebraska. In addition, larval fish populations were sampled in these habitats and in the river midchannel.

PART II: LITERATURE REVIEW

4. The Missouri River has undergone many man-made changes since Lewis and Clark explored its waters in 1804. These alterations have resulted in modifications of the river's chemical, physical, and biological characteristics. The purpose of this review is to describe the historical changes in the river channel and review studies of the water quality, macroinvertebrate fauna, and fish communities in the channelized and unchannelized river.

Channel Modifications

5. Physical modification of the channel began as early as 1832 with the removal of snags to facilitate steamboat travel up the Missouri River (Burke and Robinson 1979). In 1912, Congress authorized the Army Corps of Engineers to stabilize the river banks and provide a navigation channel that was 1.8 m deep and 61 m wide from Kansas City to the mouth. The River and Harbor Act of 1945 extended the navigation channel upstream to Sioux City, Iowa, and increased the depth and width of the channel to 2.7 and 91.4 m, respectively.

6. The formation and maintenance of the navigation channel have been accomplished by building dikes and revetments that concentrate the river flow, and force it to scour out a deep channel. Both stabilization structures are built with boulders and crushed rock fill.

7. Six large multipurpose dams were constructed on the upper Missouri River from 1940-1964 as part of the Pick-Sloan plan. These dams and their associated reservoirs store water for flood control, power production, irrigation, and navigation. The river is unencumbered from Gavins Point Dam at Yankton, South Dakota, to its mouth 1,290 km downstream. Only 143 km of the river remain unchannelized below Fort Randall Dam (Kallemeyn and Novotny 1977).

8. River channelization and construction of dams have resulted in a shorter, narrower channel with reduced fluctuations in flow rates compared to the premodified river (Funk and Robinson 1974; Hallberg,

Harbough, and Witinok 1979). For the Iowa-Nebraska portion of the Missouri River, Hallberg, Harbough, and Witinok (1979) reported the following changes between 1923 and 1976: 9-percent (29 km) decrease in river length; 80-percent (25,000 ha) decrease in channel area; 66-percent (12,200 ha) decrease in water area; 99.9-percent (4,700 ha) decrease in island area; and 99.7-percent (8,100 ha) decrease in sandbar area.

9. Prior to impoundment, flooding typically occurred twice a year in the river valley. Spring flooding resulted from snowmelt runoff from the plains, whereas a "June rise" was associated with melting snow in the mountains and rain in the prairie states (Russell 1965). Impoundments now moderate the flow and contain the river within its banks to a great extent (Hallberg, Harbough, and Witinok 1979).

Water Quality

10. There are few detailed studies of the Missouri River's physical and chemical parameters. Most information has been gathered incidental to the study of the aquatic biota.

11. Turbidity was considered a major factor influencing water quality and river biota prior to construction of the main-stem impoundments. Berner (1951) reported turbidity values commonly greater than 3,000 ppm (using a US Geological Survey turbidity rod) in the lower Missouri River. The recorded average annual turbidity recorded at Kansas City ranged from between 1,300 and 3,200 ppm between 1918 and 1952 (Neel, Nicholson, and Hirsch 1963, methods not described). After the main-stem reservoirs were completed, Neel, Nicholson, and Hirsch (1963) found that average annual turbidities declined 65 percent. Todd and Bender (1982) reported turbidity values ranging from 21 to 525 Nephelometric Turbidity Units (NTU) for river mile 532 from 1971 to 1977. Values were generally higher in May than in July or October. Kallemeyn and Novotny (1977) reported turbidity levels ranging from 16 to 24 Jackson Turbidity Units (JTU) for main channel stations between river miles 709 and 704.

12. Berner (1951) found that dissolved oxygen varied inversely

with the amount of suspended organic material and decreased to less than 3.5 mg/ℓ in some areas. Dissolved oxygen concentrations below impoundments do not generally drop below 5 mg/ℓ (Todd and Bender 1982). Mainstem impoundments also modify other characteristics by serving as mixing basins which delay normal seasonal trends and buffer extreme physical and chemical values.

Fish

13. Most studies of fish in the Missouri River have concentrated on population estimates and various aspects of species' life history characteristics and biology (Claflin 1963; Johnson 1963; Cvancara 1964; Langemeier 1965; Morris 1965; Russell 1965; Swedberg 1965; Beal 1967; Zweiacker 1967; Held 1969, Cross and Huggins 1975; Helms 1975; Hesse, Wallace, and Lehman 1978; Modde and Schmulbach 1973; Cada and Hergenrader 1980; Hesse, Bliss, and Zuerlien 1982; Hesse and Newcomb 1982; Rosen, Hales, and Unkenholz 1982). In the first comprehensive study of fish in the Missouri River, 60 species were observed in the channelized river from the mouth to the Iowa border (Fisher 1962). Pflieger (1971) reported 63 species in the Missouri Basin.

14. Unchannelized portions of the river have higher fish densities than channelized sections (Schmulbach, Gould, and Groen 1975). Numerous backwater habitats occur in these sections and comprise a total aquatic surface area per linear kilometre three times greater than an equal distance of channelized river (Morris et al. 1968).

15. The backwaters and marshes are important spawning and nursery sites for many riverine species, although these sites make up only 15 percent of the surface area of the unchannelized Missouri River (Kozel and Schmulbach 1976; Kallemeyn and Novotny 1977). Persons (1979) reported that at least 15 species spawned in backwater areas and found the catch of fish larvae in tow nets from backwaters to be more than ten times greater than that found in the main channel drift reported in other studies.

16. Channelization and the loss of habitat variability has

resulted in decreased species diversity and productivity (Funk and Robinson 1974). Fish are more abundant in the unchannelized reaches than in channelized reaches of the river (Schmulbach, Gould, and Groen 1975). Groen and Schmulbach (1978) found higher catch, harvest rates, angler-hours/kilometre, number fish caught/kilometre, and weight harvested, and larger average size of creeled fish in the unchannelized than the channelized river. Morris (1969) and Morris, Morris, and Witt (1972) estimated that twice as many flathead catfish occur per kilometre in unchannelized versus channelized river.

17. The reduction of suitable fish habitat by navigation and stabilization projects has probably contributed significantly to the declining catch and changes in composition of the catch of the commercial fishery when compared to prechannelized periods. Funk and Robinson (1974) reported that the annual commerical harvest declined 80 percent between 1947 and 1963, from 204,100 kg to 40,800 kg. Channel catfish (*Ictalurus punctatus*) and buffalo (*Ictiobus bubalus* and *I. cyprinellus*) dominated the catch prior to 1900, but carp (*Cyprinus carpio*) now predominate in the catch, making up 50 to 80 percent of the total (Whitley and Campbell 1973). Blue catfish (*Ictalusus furcatus*), pallid sturgeon (*Scaphirhynchus albus*), paddlefish (*Polydon spathula*), centrarchids, and sauger (*Stizostedion canadense*) are seldom taken (Funk and Robinson 1974).

18. Species composition of the fish communities differs between altered and unaltered habitats. Fish in the channelized sections are associated with notched revetments, notched spur dikes, and notched wing dike habitats (Kallemeyn and Novotny 1977). River shiner (*Notropis blennius*), emerald shiner (*Notropis atherinoides*), red shiner (*Notropis lutrensis*), and sand shiner (*Notropis stramineus*) are common in the channelized reaches. Bigmouth shiner (*Notropis dorsalis*) and plains minnow (*Hybognathus placitus*) are found in addition to these cyprinids in the unchannelized sections (Berner 1951; Schmulbach, Gould, and Groen 1975). Of the larger species, carp, channel catfish, and river carpsucker (*Carpiodes carpio*) predominate in the channelized river (Kallemeyn and Novotny 1977; Groen and Schmulbach 1978), but sauger, channel catfish,

and white bass (*Morone chryops*) are prevalent in the catch from the unchannelized sections (Groen and Schmulbach 1978). Burress, Kreiger, and Pennington (1982) collected 26 species in nine habitats of the modified and unmodified river. Carp, white sucker (*Catostomus commersoni*), yellow perch (*Perca flavescens*), and river carpsucker comprise two thirds of the catch.

Benthic Macroinvertebrates

19. Previous studies of the macroinvertebrate biota in the Missouri River have primarily made comparisons from the various habitats of the channelized and unchannelized river. These comparisons have found variations in species composition, diversity, and benthic standing crop between habitats.

20. The sediment dwelling benthic community in the channelized and unchannelized river is dominated by chironomids and oligochaetes (Russell 1965; Morris et al. 1968; McMahon, Wolf, and Diggins 1972; Burress, Kreiger, and Pennington 1982). Though the main channel has the least invertebrate density and diversity of any habitat within the river, the benthic biomass and diversity of the main channel are higher in unchannelized portions than in channelized portions of the river (McMahon, Wolf, and Diggins 1972; Morris et al. 1968). Wolf, McMahon, and Diggins (1972) found that the main channel habitats of seminatural areas (below main-stem impoundments but above Sioux City, Iowa, so not channelized) had three times the density of organisms of channel habitats in the channelized river. Russell (1965) estimated the standing crop of invertebrates from habitats in the channelized river to be 0.50 kg/ha, compared with 1.18 kg/ha for habitats in the unchannelized sections.

21. Highest densities of benthic invertebrates occur in areas with mud or mud/fine sand substrate and extensive backwaters (Burress, Kreiger, and Pennington 1982). Wolf, McMahon, and Diggins (1972) reported that cattail marshes had the highest densities of invertebrates of any habitats sampled, containing up to 18 times more organisms than the main channel of the channelized river. Volesky (1969) estimated

that 50 percent or more of the benthic standing crop of the Missouri River originated in the cattail marshes, though the marshes only comprise 15 percent of the river's surface area.

22. There is little similarity between the species composition of the sediment dwelling benthic community versus that of the drift community (Russell 1965; Morris et al. 1968; Namminga 1969; Modde and Schmulbach 1973; Nord and Schmulbach 1973). The species composition of the drift, however, is similar to that of the attached communities (Morris et al. 1968; Modde and Schmulbach 1973). Trichoptera, Ephemeroptera, and Diptera dominate the drift and attached (epibenthic) communities (Modde and Schmulbach 1973; Nord and Schmulbach 1973; Burress, Kreiger, and Pennington 1982). Unchannelized sections of the Missouri River support higher standing crops of attached macroinvertebrates than the channelized sections (Morris et al. 1968; McMahon, Wolf, and Diggins 1972; Nord and Schmulbach 1973). Species density and composition seem to be influenced by current velocity. Nord and Schmulbach (1973) found that Hester-Dendy samplers in "slow water" had greater species diversity but lower density than "fast water" samplers. Based upon these Hester-Dendy samples, *Hydropsyche* (Trichoptera) dominated the attached community in swift current, but *Neureclepsis* (Trichoptera) was predominant in slower water. Burress, Kreiger, and Pennington (1982) reported oligochaetes were most common at current velocities of 11 to 30 cm/sec in the upper Missouri River. The average numbers of dipterans, trichopterans, and ephemeropterans in this study tended to increase as current velocities increased to 70 cm/sec.

PART III: STUDY AREA

General Description

23. The Missouri River originates at Three Forks, Montana, at the confluence of the Gallatin, Jefferson, and Madison Rivers. The river flows 4,058 km through seven states to its junction with the Mississippi River above St. Louis, Missouri. The Missouri Basin drains approximately 1,354,564 km^2 of central North America, about one sixth of the continental United States (Slizeski, Andersen, and Dorough 1982).

24. The name "Missouri" is a native American word meaning "muddy water" (Kirby and Abbott 1929). The Missouri River is highly turbid as a result of the soft clay, sandstone, and shale in the runoff from the erodible badlands that enters the river via the Yellowstone River in North Dakota (Neel, Nicholson, and Hirsch 1963). Runoff from irrigated farmlands in the Dakotas, Nebraska, and Iowa also adds to the silt load in the river.

25. The large watershed area and the steep slope of the river result in high discharge rates and a rapid current. The average discharge below Sioux City, Iowa, ranges from 800 m^3/sec at Omaha, Nebraska, to 1,530 m^3/sec at Hermann, Missouri. Mean main channel current velocities range from 1.1 m/sec at Hermann, Missouri, to 1.8 m/sec at Omaha, Nebraska (Burke and Robinson 1979).

26. The riverbed in the main channel is composed of gravel and sand with relatively little organic matter (Russell 1965). Reduced current along channel margins and the downstream side of dikes and in the backwaters results in the accumulation of suspended silt and organic material in these areas.

27. The alluvial nature of the river basin, in addition to the swift current, resulted in a constant shifting of the channel and a continuous deposition and resuspension of sediment within the channel. Prior to channelization "the river followed a meandering course of bends and reaches impeded by soft and shifting bars, shoals, snags, and debris, which frequently caused the formation of two or more

shallow channels" (Army Corps of Engineers 1946, in Berner 1951).

Sampling Sites

28. This study was conducted on the Missouri River between river miles 661 and 678 (Figure 1). Two dike fields were chosen for study (Figure 2), one between river miles 676.5 and 678 on the right bank (DF1) and the other between river miles 670 and 673 on the left bank (DF2). DF1 consisted of 10 stonefill dikes and associated pools with the field about 1.6 km long. DF2 consisted of 19 stonefill dikes along 3.5 km of river. Samples were taken from two dikes and four dike pools (slack water area between adjacent dikes) in each dike field (Figure 2). A single transect was established on each dike structure to be sampled and four transects were designated in each pool. The dikes extended into the river variable distances due to the extensive filling in with sediment around them; the range was 4 to 10 m into the water and all had portions extending above the surface of the water. The stone fill was composed of large rock ranging in size from about 5 to 50 cm. The dike pools were quite variable in size, depth, and water velocity. Current velocity ranged from almost standing water to the velocity of the open channel water, with mean velocities for the dike fields ranging from 0.2 to 1.3 m/sec. Based upon the maximum depths at which benthic macroinvertebrates were collected by dredge, pools in DF1 reached 3 to 4 m and in DF2 reached 5 to 10 m. Sediments were composed primarily of sand with mud occasionally occurring in the shallows and occasionally gravel in the deepest areas.

29. Two revetted banks were studied with RV1 extending about 2.3 km along the left bank across from DF1 and RV2 extending about 3.5 km along the right bank across from DF2 (Figure 2). Four transects (two on the upstream face and two on the downstream face) were sampled on each of these stone fill pile revetments. Rocks ranged in size from about 25 to 100 cm. Mean current velocity measured during the sampling trips ranged from about 1.5 to 2.9 m/sec along these revetments. Depths ranged from 1.5 to 3.4 m based on soundings taken during electrofishing.

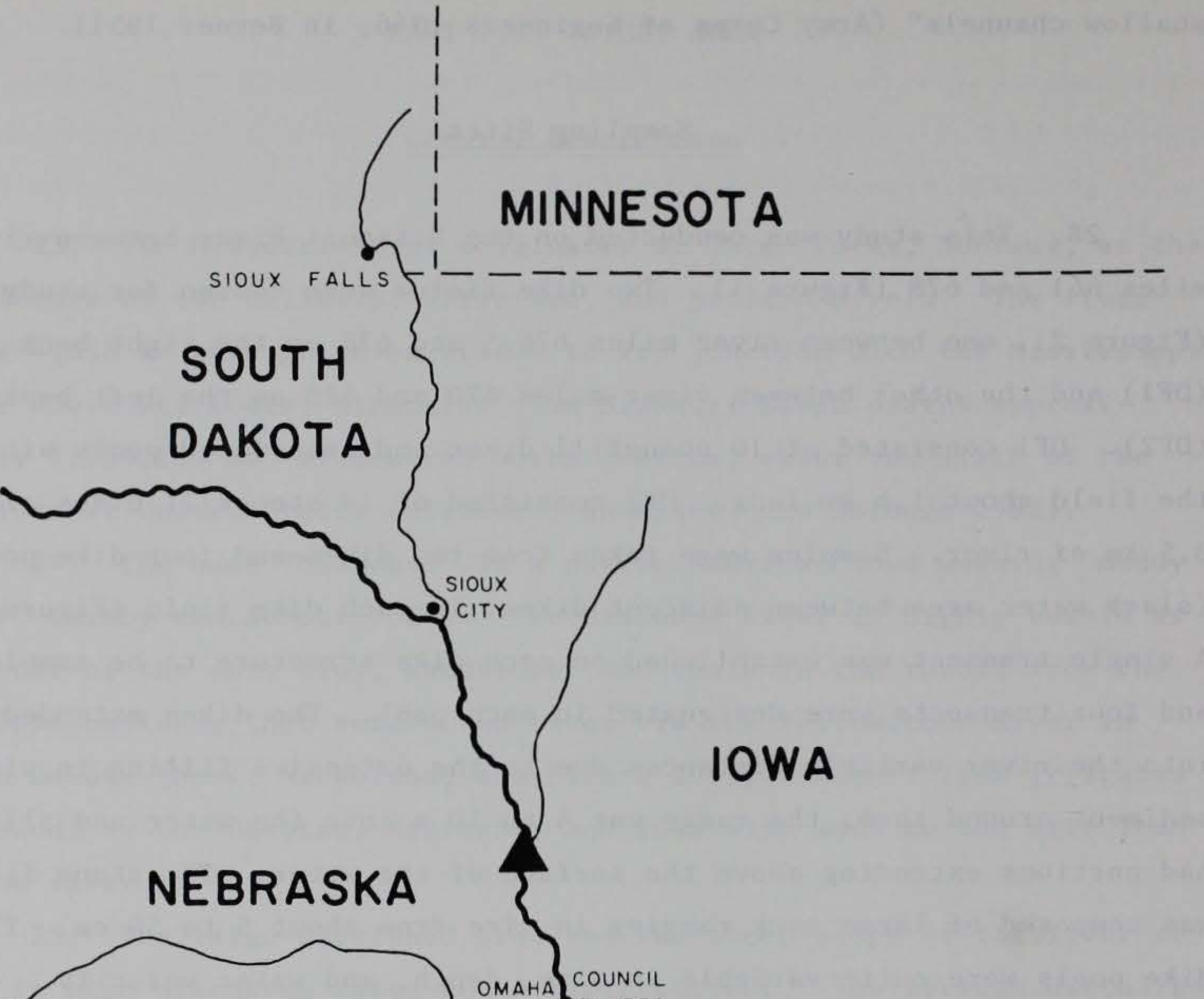
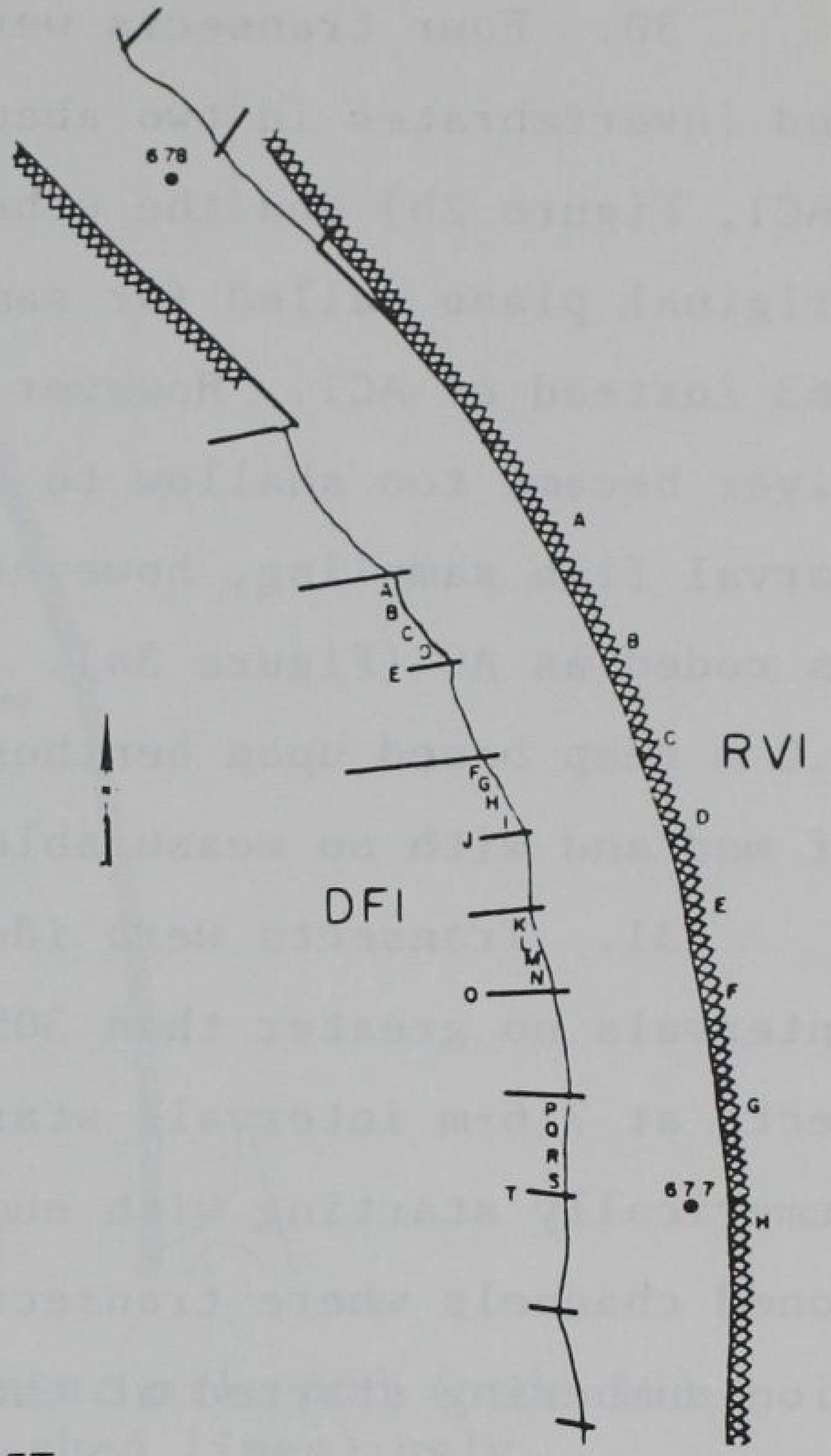
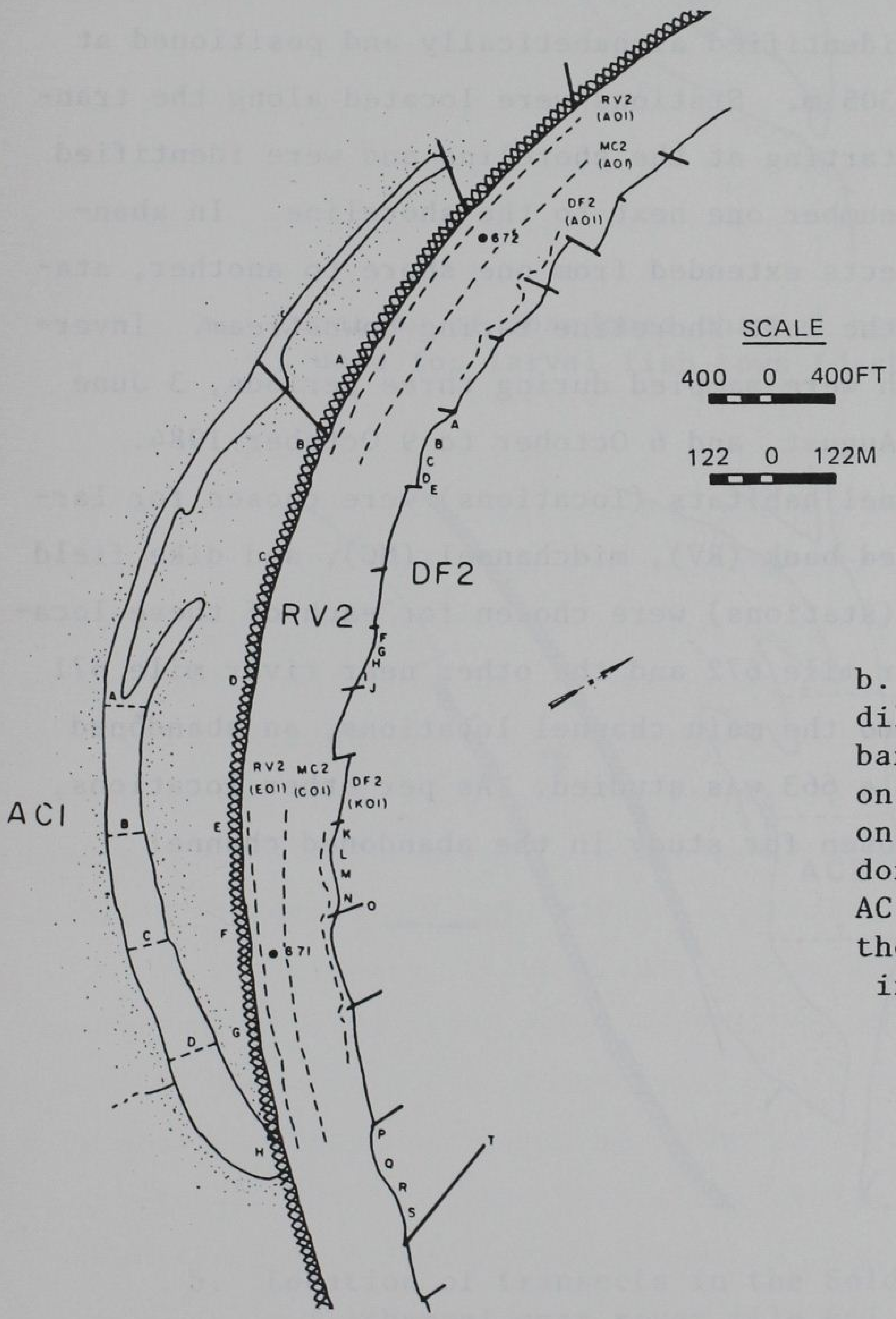


Figure 1. General location of study area (large triangle)

a. Location of transects in dike field (code DF1) on the right bank of river near mile 677 and on revetted bank (code RV1) on left bank





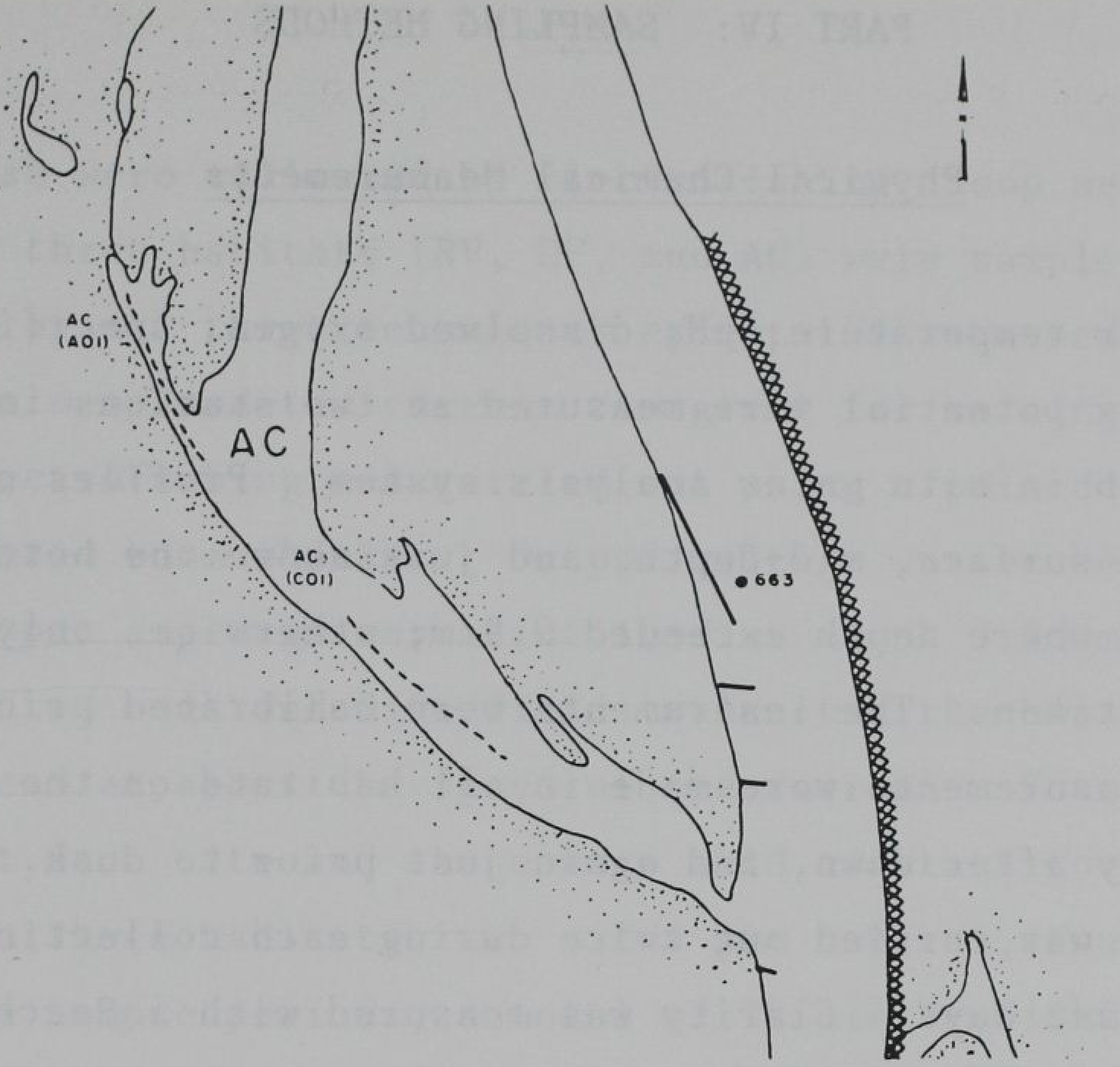
b. Location of transects in dike field (code DF2) on left bank of river near mile 671, on revetted bank (code RV2) on the right bank, and abandoned channel transects (code AC1) used for fish and benthos samples. Dashed lines indicate larval fish tows

Figure 2. Dike field study areas

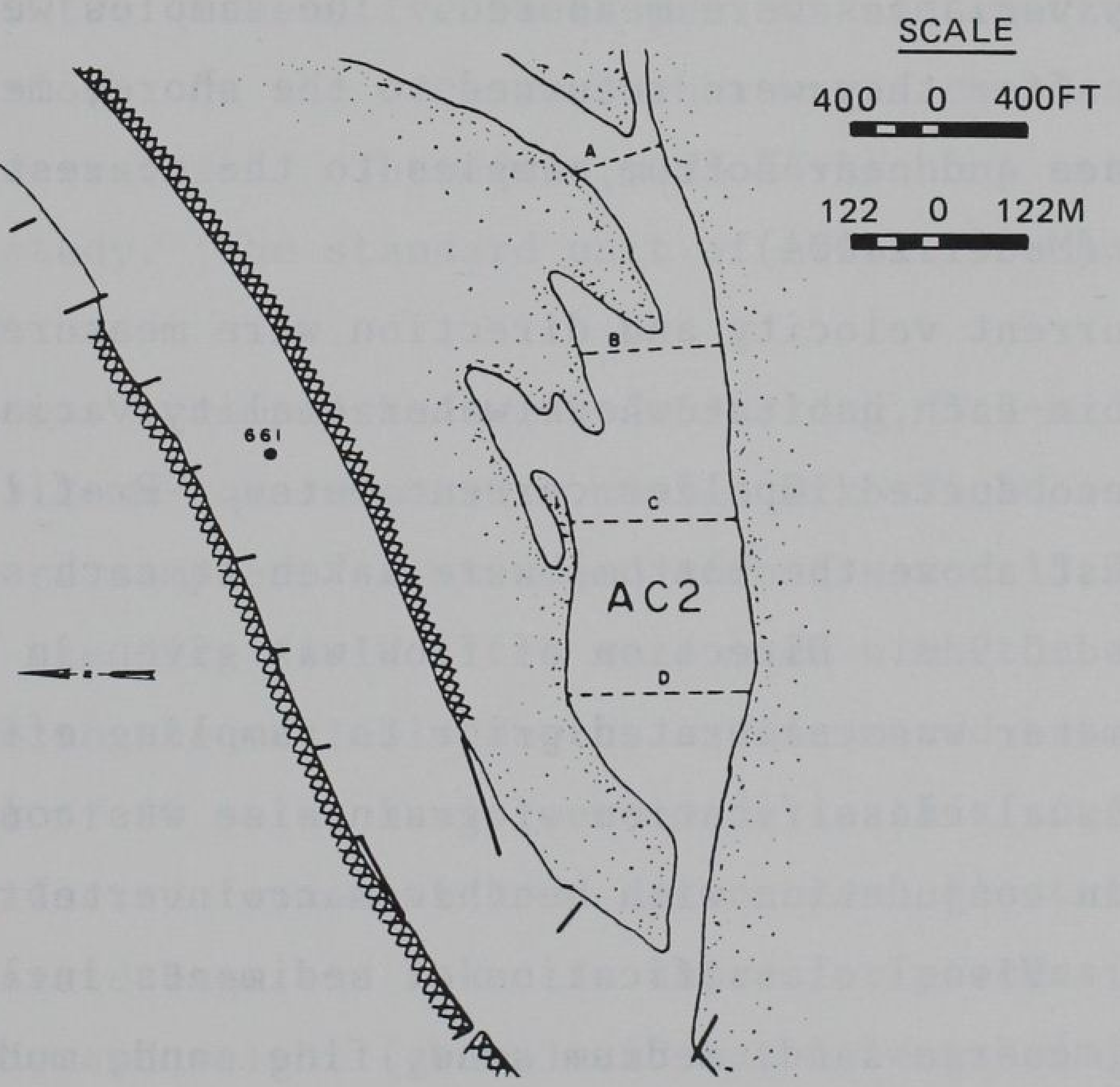
30. Four transects were used to collect adult and juvenile fish and invertebrates in two abandoned channels, one near river mile 671 (AC1, Figure 2b) and the other near river mile 661 (AC2, Figure 3b). Original plans called for sampling an abandoned channel near river mile 663 instead of AC1. However, the outlet channel connecting it to the river became too shallow to navigate, thus the new site was chosen. The larval fish sampling, however, was continued at this site and the site is coded as AC (Figure 3a). AC1 and AC2 were shallow habitats (0.5 to 3.0 m deep based upon benthos sampling) with sediments composed mostly of mud and with no measurable current velocity.

31. Transects were identified alphabetically and positioned at intervals no greater than 305 m. Stations were located along the transects at 7.6-m intervals starting at the shoreline and were identified numerically starting with number one next to the shoreline. In abandoned channels where transects extended from one shore to another, station numbering started at the left shoreline facing downstream. Invertebrates and nonlarval fish were sampled during three periods, 3 June to 7 June, 8 August to 12 August, and 6 October to 9 October 1984.

32. Three main channel habitats (locations) were chosen for larval fish sampling: revetted bank (RV), midchannel (MC), and dike field (DF). Two sampling sites (stations) were chosen for each of these locations: one site near river mile 672 and the other near river mile 671 (Figure 2b). In addition to the main channel locations, an abandoned channel (AC) near river mile 663 was studied. As per other locations, two sampling sites were chosen for study in the abandoned channel (Figure 3a).



a. Location of abandoned channel near mile 663 (code AC) used for larval fish tows (dashed lines) only



b. Location of transects in the Soldier's Bend abandoned channel near river mile 661 (code AC2)

Figure 3. Abandoned channel study areas

PART IV: SAMPLING METHODS

Physical-Chemical Measurements

33. Water temperature, pH, dissolved oxygen, specific conductance, and redox potential were measured at two stations in each habitat using a Hydrolab in situ water analysis system. Profiles consisting of readings at the surface, mid-depth, and just above the bottom were taken at each station where depth exceeded 0.9 m; otherwise, only surface measurements were taken. The instruments were calibrated prior to sampling efforts, and measurements were made in all habitats on the same day, once immediately after dawn, and again just prior to dusk. This sampling procedure was carried out twice during each collecting period, on the first and last days. Clarity was measured with a Secchi disk at each of the two stations in each habitat where water quality variables were measured. Measurements were to the nearest 0.076 m. Turbidity samples were collected at each of the two stations in each habitat where water quality variables were measured. The samples were immediately chilled, and after they were returned to the shore, measurements were made of surface and near bottom samples to the nearest 1 NTU with a Hach Turbidimeter (Model 2100A).

34. Current velocity and direction were measured at each of the two stations in each habitat where water quality variables were measured using an Endeco ducted impeller current meter. Profiles (surface, mid-depth, and just above the bottom) were taken at each station where the depth exceeded 0.9 m. Direction of flow was given in compass degrees. The current meter was calibrated prior to sampling efforts.

35. Visual classification of grain size was conducted on sediments taken in conjunction with benthic macroinvertebrate samples from each habitat. Visual classification of sediments included the following: gravel, coarse sand, medium sand, fine sand, mud and fine sand, mud and coarse sand, silt, mud, mud and silt, mud and clay, clay, and clay and fine sand.

Fish

36. Fish were collected by electrofishing, hoop netting, and seining. All three habitats (RV, DF, and AC) were sampled during each sample period by all three techniques except the revetted bank habitats which were too deep and the current too great for seining.

37. Electrofishing was carried out using a pulsed direct current (DC) boat-mounted boom shocker. Output voltage varied between 336 and 504 V; the output amperage was maintained at about 8.2 amps. When sampling the revetted bank and dike field transects, the boat was allowed to drift downstream at about the speed of the current. Four transects were established at each site and these were held constant for all sample periods. With three habitats, two sites per habitat, four transects per site and three sample periods, a total of 72 electrofishing samples were taken during this study.

38. Hoop nets with 0.9-m-diam and 25-mm-square mesh netting were fished at eight stations per site, two sites per habitat. Nets were set at each station for two consecutive 24-hr periods and checked and emptied after each period. On the occasions where nets could not be retrieved, new nets were reset. Therefore, 288 24-hr hoop net sets were completed in this study. The standard unit of effort for hoop netting was one 24-hr set.

39. Seining was accomplished with 4.6-m-long, 1.2-m-deep common sense seines with 3.2-mm-square measure mesh. Dike field and abandoned channel habitats were sampled. A standard effort was a 15.2-m haul of the net. Hauls in the dike field sites were made with the current and varied in width due to the variable depths as one moved out from the shoreline. A total of 96 seine hauls were made in this study.

40. Fish collected from each hoop net or each electrofishing run were placed in separate bags and taken to shore for processing. Each fish was identified, and weight (grams) and total length (millimetres) were recorded. Fish collected by seining were placed into separate gallon containers for each haul and preserved in 10-percent buffered Formalin. Two weeks after collection these fish were rinsed in water for

48 hr and then stored in 45-percent isopropanol. Each fish was identified, weighed (grams), and total length (millimetres) recorded. Reference collections were made for each species collected.

Larval Fish

41. Sampling was conducted over a 4-month period from the week of 17 April to the week of 14 August 1983. Samples were collected weekly (during the middle of the week) with the exception of the week of 1 July when silted-in boat ramps prevented the sampling crew from getting on the river. A total of 17 weeks of sampling were conducted and a total of 270 samples taken.

42. Two samples (replications) were taken at each sampling station on each date. Revetment sites were sampled as close to the shore as possible. Mid-channel sites were taken approximately halfway between opposite banks. Dike field sites were sampled shoreward from the point where the dike caused the current to be reduced. The abandoned channel sites were sampled approximately 25 m from shore, but due to low water levels on some sampling dates, this distance was changed.

43. Samples were collected using a 0.5-m conical plankton net with 0.5-mm mesh, with a polyvinyl chloride (PVC) collecting tube attached to the end. The collecting gear consisted of an iron beam attached horizontally to the bow of the boat, with about 1 m extending past either side of the boat. The net was mounted on a circular yoke and a 2-m beam that hinged with the horizontal crossbar. This allowed the net to be quickly lowered to its sampling position and raised when needed. In the lowered position the net was at a sampling depth of 0.55 m and was far enough away from the boat so as not to be influenced by the wake. A General Oceanics Model 2030 flow meter was suspended in the center of the mouth of the net. The flow meter was used to estimate the volume of water filtered during each tow. All tows were taken in a downstream direction with a 5-min duration at speeds approximately 70 cm/sec faster than the current. After each tow the contents of the

sampling tube were rinsed into 250-ml Nalgene plastic bottles and preserved immediately in 10-percent Formalin.

44. Samples containing little detritus were separated and sorted using a white enamel sorting pan. When samples contained large amounts of detritus, the contents were stained with rose bengal (which stains animal tissue bright pink) and viewed under a dissecting microscope to help in separating fish from detritus. After separation, larvae were counted and identified to the lowest possible taxon using existing literature accounts and keys (Auer 1982; Holland and Huston 1983). Developmental stage (prolarvae versus postlarvae) and length were also recorded. After analysis, larval fish specimens were kept to form a reference collection.

45. A large part of the data given in this report is of two forms: relative frequency and catch per unit effort (CPE). Relative frequency is the percent of the total catch, while CPE is a measure of density (No./100 m^3 water sampled). CPE for individual species or habitat type is the mean of densities for each sampling date. All species composition data are for larvae and juveniles combined.

Benthic Macroinvertebrates

46. A petite ponar grap sampler (15.2 cm by 15.2 cm) was used to sample benthic invertebrates in sediments in the abandoned channels and dike pools. Grab samples of the bottom sediments were taken during each sampling period from a single station at each dike pool transect and from four stations at each abandoned channel transect. Revetted banks and dikes were sampled using rock removal techniques. Stones were removed to a depth of 27 cm with the aid of a 0.5-m^2 quadrat with attached mesh bag (0.5-mm mesh opening). Samples were taken at a single station on the upstream and downstream faces on tow dikes in each dike field and from four stations at each revetted bank during each sampling period.

47. Benthic samples were sieved in the field through 0.5-mm mesh sieves and preserved in 10-percent buffered formalin in the field. In the laboratory samples were transferred to 70-percent ethanol and rose

bengal solution for a minimum of 48 hr prior to sorting. Circline magnifying lamps (3× power) were employed in sample sorting. A reference collection of all taxa was maintained and identification was to the lowest practical taxon (genus and species when possible).

48. Oligochaetes and midges were mounted in a 1:1 mixture of CMCP-9 and CMC-AF on microscope slides and identified under magnification to 1000×. All other invertebrates were identified with the aid of a steromicroscope to 100×.

PART V: RESULTS

Water Quality

49. Average values for water temperatures, dissolved oxygen, pH, redox potential, turbidity, specific conductance, Secchi depth, and current speeds for the various sites, depths, and months are presented in Table 1. The data confirm previous observations on the Missouri River. First, the water is always turbid as shown by turbidity measurements, most of which are greater than 15 NTU and by the low Secchi disk readings with none of the averages greater than 0.39 m. Second, the Missouri River has high current speeds. In August we found average velocities of 2.23 m/sec and 2.86 m/sec for the two revetted bank stations. Lesser velocities were found in the more protected dike fields. The abandoned channels had no measurable currents. The conclusion drawn is that the dike fields and revetted bank sites were part of a well-mixed system as shown by the almost uniform values for average temperature, dissolved oxygen, pH, redox potential, specific conductance, and turbidity. The abandoned channels were similar to the main river, but had some small differences. In June and August the specific conductance values were slightly lower than those in the other two habitats, indicating a difference in dissolved solids content. There was also some trend toward vertical chemical stratification, as shown by the dissolved oxygen measurements at site AC1 during August. The shallower site at AC2 did not show these low values.

50. Statistical comparisons were made between sites in the same habitats, among habitats for the same months, and among months for the same habitats using the general linear models (GLM) procedure on the Statistical Analysis System (SAS). A few of the differences in water chemistry between averages for sites in the same habitat were statistically significant; however, they are not considered to be of any biological significance. In general, there were a few significant differences for parameters measured in the abandoned channels compared with those in the dike fields and revetted banks, but again these were not considered

to be of any biological significance. Lastly, many of the parameters such as temperature, dissolved oxygen, and specific conductance showed significant seasonal changes in one or more habitats. These are largely to be expected.

51. Differences were noted in the bottom substrates in the four habitats. In the lentic abandoned channels 81 percent of the samples were mud and 13 percent were mud and clay. Coarse sand with mud made up another 4 percent and 1 percent were silt. In the dike pools where currents were greater, coarser substrates were more important. Fine sand dominated in 60 percent of the samples. Coarse sand made up 18 percent, mud with fine sand 5 percent, silt 5 percent, and mud 4 percent, and gravel, clay, clay with fine sand, and mud with silt each were most important in 1 percent of the samples. The dike samples and revetments were dominated by large rocks with various amounts of fine sediments between and underneath.

52. The differing combinations of current velocities and substrate types in the four habitats studied provided a basis for biological differences between them. The low values for dissolved oxygen in some of the subsurface samples from the abandoned channel site AC1 in August may also have had some effect, though other water quality measures were generally similar.

Fish

Evaluation of sampling methods

53. The Missouri River is a difficult system to sample for fish. High current velocities, differences in substrate, and variability in channel morphometry altered the catch efficiency of the sampling methods among the three habitat types. Active sampling methods (seining and electrofishing) were especially susceptible to physical variability among sites. This made the validity of statistical comparisons of CPE for these methods biologically questionable. Passive sampling methods (hoop netting) were probably less susceptible to these extrinsic factors.

54. Seining was the least effective of the three methods for

quantitative fish sampling but did provide information on smaller fish species. Water depth and current prevented sampling of revetted banks. Dike field sites could not be seined with the entire 4.6-m length of seine because water depth increased rapidly a short, but variable distance from the bank. Often only a 2-m length of seine could be used. Differences in substrate types within the dike field also altered fish sampling effort. Sand provided a firm substrate in sampling areas immediately behind wing dams, but soft, silty sediment hindered movement and seining speed in the downstream sections of the pool. The seine could only be fully and effectively used in the abandoned channels. Though lengths of seine hauls were consistent in the dike fields and abandoned channels, sampling effort was different within and between the two habitats. Therefore, only qualitative comparisons in species numbers and relative fish abundance between habitats could be made.

55. Problems with consistent effort in electrofishing were different, but also limited quantitative analysis of catch data. The efficiency of electrofishing the revetted banks was low due to great current velocity, variable water depth, and lag time for the fish to surface after stunning. Several paddlefish (*Polydon spathula*) were observed while electrofishing the revetted banks, but observers were unable to capture any due to their large size and the fast current. The distance electrofished was constant at about 460 m, but the time required to electrofish these areas varied due to current velocity. The average time spent on each sampling run of the revetted banks was 3 min (ranging from 2.25 to 3.7 min). Depth averaged between 2 and 3 m, but ranged from 1.5 to 3.4 m along the revetments.

56. Electrofishing efficiency was also limited in the dike field sites by the current and short distance between wing dams. Swift current prevented complete and thorough sampling close to the bank and dike. Distance covered was determined by the length of the dike pool, about 180 m. Time required to sample each pool varied between 1.5 and 4.25 min (mean = 2.8 min).

57. Abandoned channel sites were effectively electrofished. Lack of current allowed rapid retrieval of most of the stunned fish that rose

to the water's surface. Depths averaged about 1 m (ranging from 0.5 to 2 m) and time electrofished averaged 4 min (ranging from 3 to 4.5 min).

58. Hoop netting was the best sampling method in all habitats. A consistent effort (24-hr set) was used in each habitat, although the efficiency of hoop nets probably varied from site to site and between placements within a site. Hoop nets were selective for larger fish and did not sample most species and size ranges sampled by seines.

Composition of the catch

59. The 28 species of fish collected by seining from the dike field and abandoned channel sites were dominated by species from the families Cyprinidae and Centrarchidae (Table 2). A total of 873 fish (21 species) were captured in the dike field sites, and 829 fish (20 species) in the abandoned channel sites. Forty-eight seine hauls were made in each habitat during the three sampling periods.

60. Cyprinids made up 87 percent of the total number of fish captured with seines in the dike field (Table 2). The most abundant species were sand shiners (33 percent of total catch), emerald shiners (26 percent), red shiners (13 percent), and fathead minnows (9 percent) (scientific names for all fish species sampled are listed in Tables 2-4). The most abundant species outside the family Cyprinidae was gizzard shad, comprising only 7 percent of the total catch. These species were not evenly represented over the three sample periods. Sand shiners were the most numerous in June samples, fathead minnows in August, and red shiners in October (Table 2). Emerald shiners were most abundant in the samples from August and October.

61. Approximately 60 percent of the seine catch in the abandoned channel sites were centrarchids and 31 percent were cyprinids (Table 2). Junvenile bluegill comprised 42 percent of the catch followed by white crappie (15 percent), red shiners (13 percent), and emerald shiners (10 percent). All of the red shiners were caught in June, and all of the gizzard shad (5 percent of the total catch) were caught in August. Most of the emerald shiners and sand shiners (5 percent of the catch) were caught in June, and most of the bluegill and white crappies were caught in August. The October catch was very low, comprising only

6.6 percent of the total number of fish collected from the abandoned channel with seining.

62. Most of the noncyprinid fish caught by seining in the dike fields and abandoned channels were juveniles. Judging from size, many of the cyprinids were also young-of-the-year (Tables 3 and 4).

63. A total of 625 fish, representing 22 species, were collected during 72 electrofishing runs; 24 runs in each of the 3 habitats (Table 5). Of the 78 fish captured in the dike fields, goldeye (24 percent), gizzard shad (18 percent), river carpsucker (13 percent), flathead catfish (13 percent), and carp (12 percent) were most abundant. A total of 12 species were represented in the dike field samples. No major seasonal trends were apparent.

64. Electrofishing yielded 197 fish of 15 species from the revetted bank sites (Table 5). The catch was dominated by six species: flathead catfish (26 percent), carp (14 percent), goldeye (14 percent), blue sucker (11 percent), gizzard shad (11 percent), and river carpsucker (9 percent). Most of the flathead catfish were caught in August, and most of the gizzard shad and carp in October.

65. The abandoned channel sites yielded the greatest number of fish of all habitats sampled with electrofishing: 350 fish representing 17 species. Gizzard shad were most abundant (46 percent of the catch) with 88 percent of them captured in October. Carp (15 percent), river carpsucker (12 percent), and bigmouth buffalo (10 percent) were also relatively abundant. Most of the carp were caught in August. Tables 6, 7, and 8 provide details on fish numbers, length, and weight at each site sampled with electrofishing gear.

66. A total of 821 fish, representing 22 species, were caught in 288 hoop net sets of 24 hr each (96 in each of 3 habitats) (Table 9). The collections from the dike field sites were dominated by blue suckers (41 percent of the total of 164 fish) and channel catfish (26 percent). The blue suckers increased in abundance through the sampling periods with 69 percent coming from the October collections. Most of the channel catfish were captured in June. A total of 14 species were caught in hoop nets set in the dike fields.

67. Blue suckers also dominated the hoop net catch from the revetted bank sites. Two hundred sixty-six fish were caught (16 species) and blue suckers comprised 58 percent of the total. Flathead catfish and shortnose gar were also abundant. The blue suckers were well represented in the catch from each site and each sampling period, but their numbers peaked in October. Flathead catfish were most abundant in August, and the shortnose gar were most plentiful in October.

68. Hoop net sets in the abandoned channels yielded 391 fish of 16 species. The six most abundant fish in the catch were white crappie (27 percent), river carpsucker (20 percent), black bullhead (12 percent), black crappie (11 percent), bigmouth buffalo (7 percent), and gizzard shad (7 percent). All of these species were most abundant in June samples, although white crappie were well represented in both summer periods. See Tables 10, 11, and 12 for details on fish numbers, length, and weight at each site sampled with hoop nets.

69. An analysis of variance (ANOVA) of hoop net CPE was made for the following: between sites within the same habitat (Table 13), among habitats for the same month (Table 14), and among sample periods for the same habitat (Table 15). Hoop net CPE was defined as the number of fish captured per 24-hr net-set. The GLM procedure of SAS was used. Decisions to reject null hypotheses were made at the 0.05 level.

70. For each species, catches from the two sites within the revetted bank habitat were statistically the same (Table 13). The same is true for the sites within the dike field habitat, except for goldeye in June when all 12 fish came from DF1. Many site-to-site differences were seen in the abandoned channel habitat, mostly in the June samples. More river carpsucker, bigmouth buffalo, white crappie, and black crappie were caught in AC1 than AC2 in June. More shortnose gar and black bullhead were caught in AC2 than AC1 in June. All of the smallmouth buffalo in August, and the gizzard shad and black bullhead in October came from AC2, and all of the river carpsucker in October came from AC1.

71. Significant differences in site-to-site totals within habitats were also found. In June, there were site-to-site differences in each habitat. In August the two revetted bank sites were different,

and in October the two dike field sites yielded different catches.

72. Few consistent differences in species composition and abundance were found between habitat types (Table 14). However, as expected, blue sucker, channel catfish, and flathead catfish were most abundant in fast waters of the revetted banks and dike fields, and were seldom found in the abandoned channels. River carpsucker, black bullhead, bluegill, white crappie, and black crappie primarily inhabited the abandoned channel sites.

73. Seasonal changes did not statistically affect the composition of the catch within a habitat (Table 15). As with the analysis of differences between habitats, high site variability weakened any statistical comparisons of CPE within a habitat between months. In the abandoned channel habitat, more fish were caught in June than in August and October combined, yet ANOVA detected no significant difference because the site AC1 yield was 69.3 percent of the June catch. The only biologically and statistically significant seasonal effect in the abandoned channel was that more blue gill were caught in June than in August or October. In the dike field habitat the catch of channel catfish was significantly greater in June than later sampling periods. No seasonal trends were evident with any species collected in revetted bank habitats.

Larval Fish

Ichthyoplankton composition

74. During this study a total of 5,302 specimens were collected.* Larvae of the postlarval developmental stage were the most common type collected, while juveniles were the least common type collected (Table 17). Sixteen taxonomic groups were identified. Of these groups, nine were identified to species, and six were identified to the genus level. The remaining taxonomic group was identified to the family level

---

* Table 16 shows the distribution of sampling effort for the entire sampling period.

(Cyprinidae) and included all cyprinids except common carp (*Cyprinus carpio*). In this group at least seven species could tentatively be recognized but not positively identified.

75. The total catch was dominated by three species (or species complexes): gizzard shad (*Dorosoma cepedianum*), sunfish (*Lepomis* spp.), and freshwater drum (*Aplodinotus grunniens*). These three categories together made up 72.6 percent of the total catch. Representatives of the subfamily Ictiobinae (mainly carpsuckers, *Carpiodes* spp.), common carp, and other cyprinids were also fairly abundant, making up 20.4 percent of the total catch (Table 18). The remaining taxa were found in low numbers, with each species making up less than 1 percent of the total catch. Seasonal CPE for the total catch is given in Figure 4.

Location differences

76. The main differences between the locations, or habitat types, was the high relative abundance of larvae found in the abandoned channel as compared to the three main channel locations. More than half of all fish were collected in the abandoned channel, and total CPE was found to be twice that of any other location (Table 19). For the majority of sampling dates, mean CPE for the abandoned channel was much higher than the main channel CPE (Figure 5).

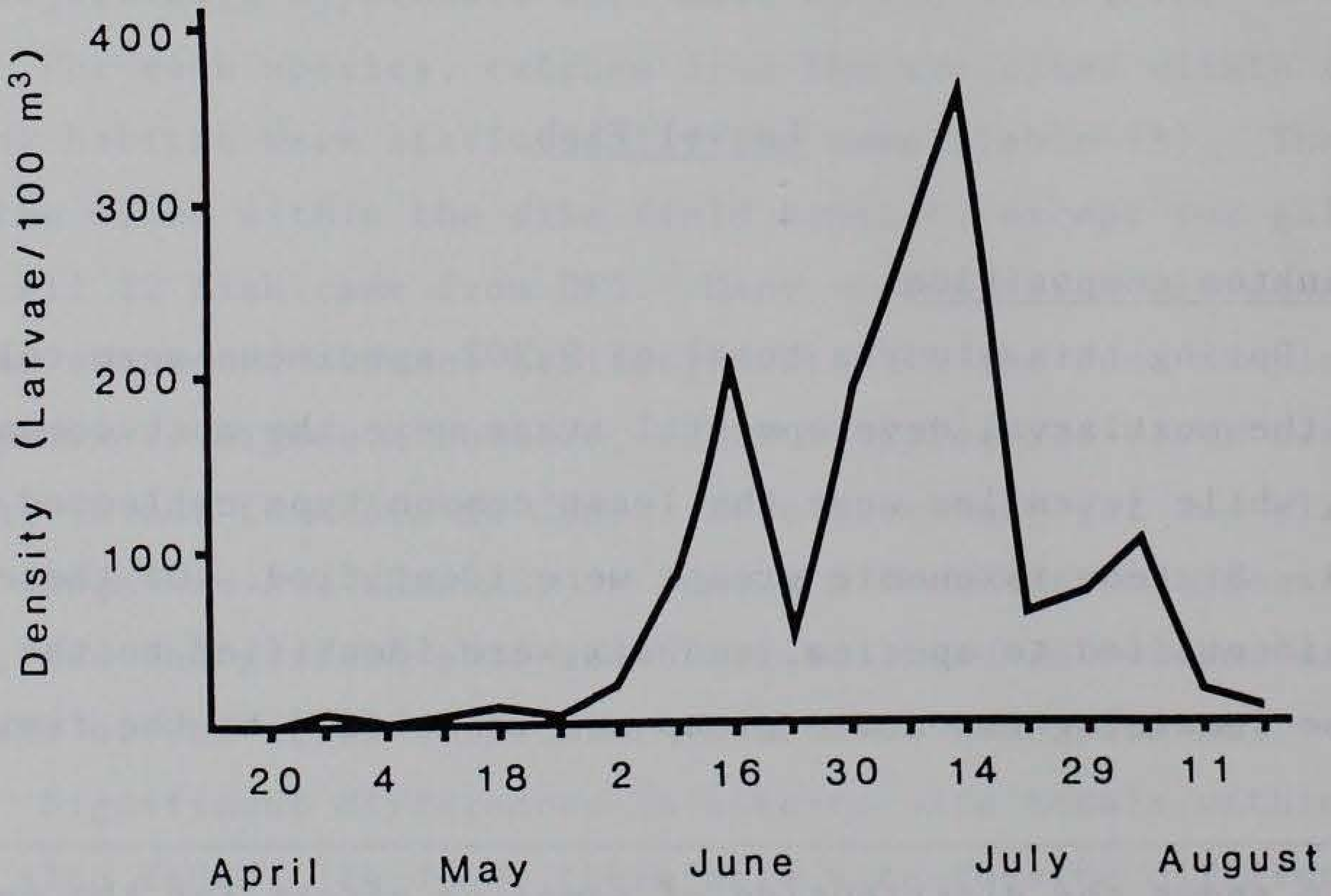


Figure 4. Mean seasonal CPE for all locations

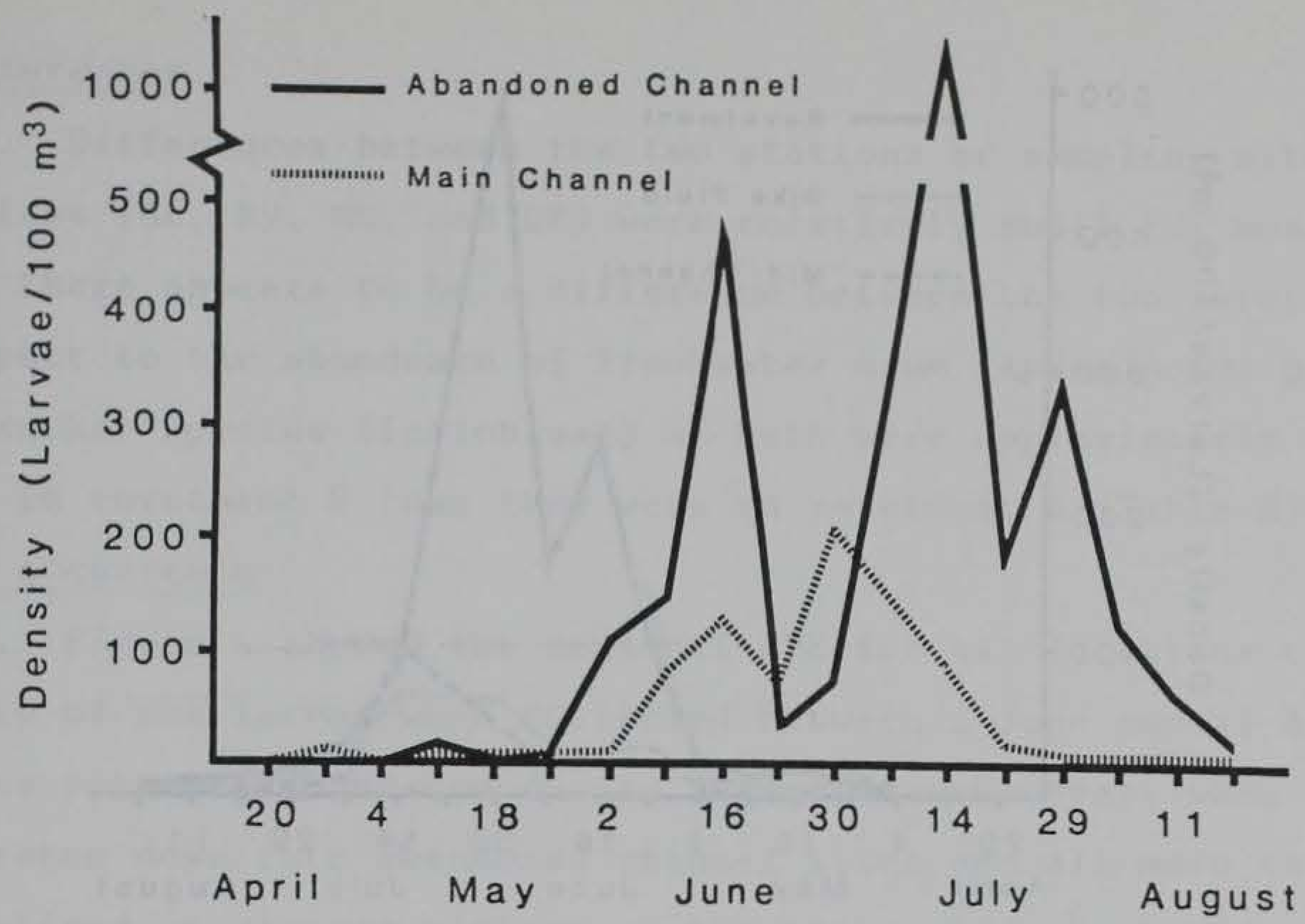


Figure 5. Mean seasonal CPE for the abandoned channel and main channel

77. Comparisons of main channel samples indicated that the revetment sites had the highest relative abundance of larvae, followed by the dike field sites, with mid-channel sites lowest (Table 19). The revetment sites provided more than twice the total CPE of either the dike field sites or mid-channel sites. Figure 6 compares the seasonal CPE for the three main channel locations.

78. The number of taxa collected at each location did not differ greatly between locations, with the exception of the mid-channel sites, which had about half the number of taxa as the other locations (Tables 20 and 21). However, the species that were present in the mid-channel were more evenly distributed in numbers or abundance (as shown by the diversity index) than the revetment sites or the abandoned channel (Table 19).

79. The abandoned channel had the lowest diversity index due to the relatively high numbers of gizzard shad and sunfish species. These two categories made up 95 percent of all fish caught in the abandoned channel.

80. The main channel locations (RV, MC, and DF) had a more even distribution of species than the abandoned channel, but were still

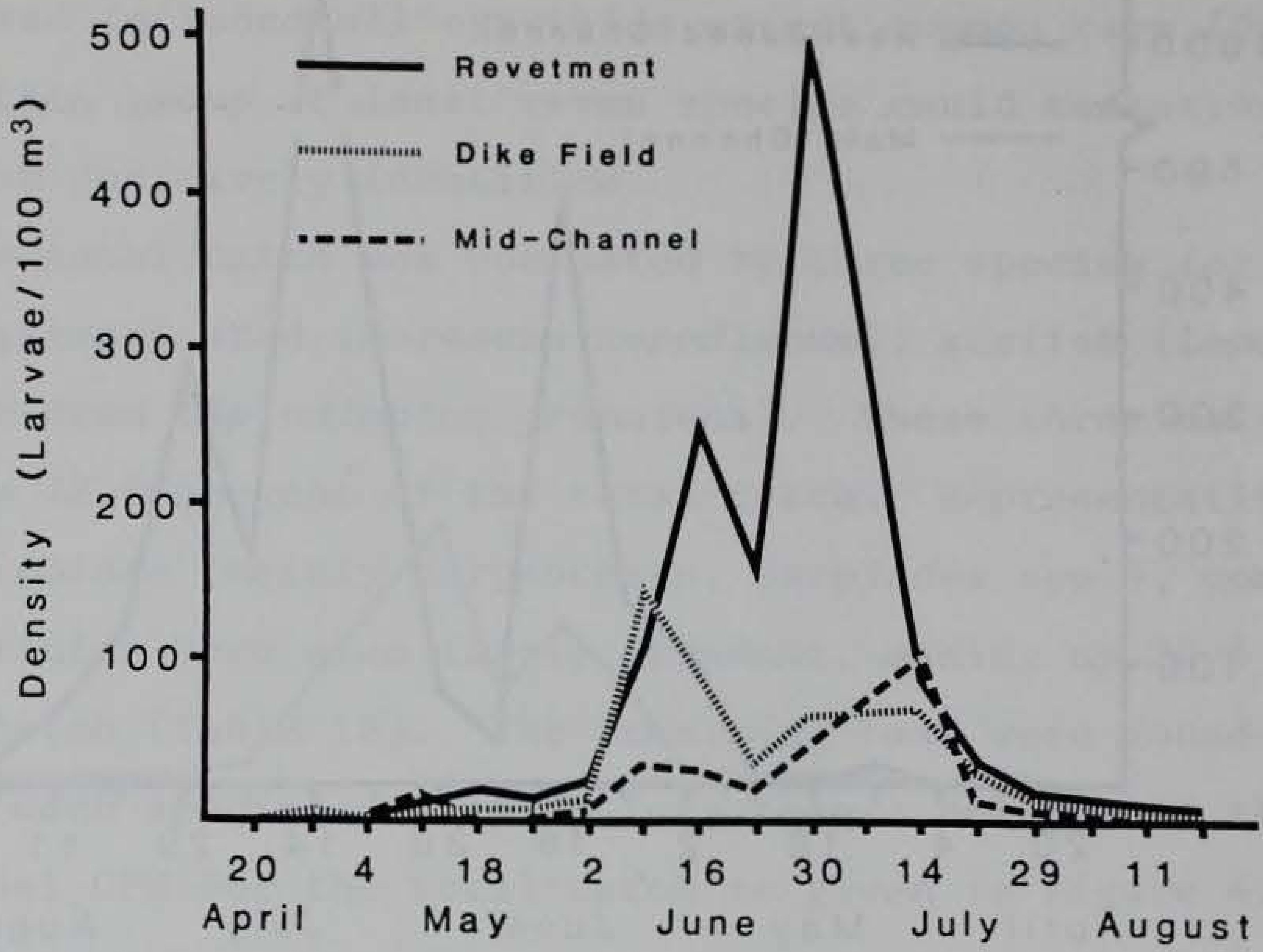


Figure 6. Mean seasonal CPE, comparing the main channel locations

dominated by three taxa: freshwater drum, carpsuckers, and common carp. These species made up more than 75 percent of the catch from each location.

81. Differences in the abundance of species between habitat types were evident for only a small number of species (Table 21). The biggest difference was found to be between the abandoned channel and the main channel locations. Sunfish species and gizzard shad were found almost exclusively in the abandoned channel (99.0 percent and 95.7 percent of these species, respectively, were caught in the abandoned channel). The dominant main channel species mentioned earlier were almost entirely lacking from the abandoned channel.

82. In the main river channel, walleye and sauger (*Stizostedion* spp.) and freshwater drum were found in greater proportions (78.2 percent and 75.1 percent, respectively) in the revetment locations than in either the mid-channel or dike field locations. All other species caught in the main channel were much more evenly distributed between locations. There were few discernible differences other than the trend (mentioned earlier) of revetments having the highest abundance of larvae, with dike fields and mid-channel sites having fewer larvae.

Site differences

83. Differences between the two stations or sampling sites for each habitat (AC, RV, MC, and DF) were relatively small for most species. However, there appears to be a difference between the two revetment sites with respect to the abundance of freshwater drum (*Aplodinotus grunniens*) and carpsucker species (Ictiobinae) as both were approximately twice as abundant in revetment E than they were in revetment A (Table 21).

Temporal occurrence

84. Figure 4 showed the seasonal CPE for all locations combined. A majority of the larvae were collected between 2 June and 11 August, with three peaks of abundance during this time. However, when seasonal CPE is broken down into abandoned channel sites and all main channel sites combined, a clearer picture of the temporal distribution is obtained. In the main channel most larvae (>90 percent) were collected from early June through the last week in July, with two abundance peaks occurring on 16 June and 30 June. In the abandoned channel most larvae (>90 percent) were collected from early June through mid-August, with three peaks of abundance on 16 June, 14 July, and 29 July (Figure 5).

85. The differences in temporal occurrence of larvae for the three main channel habitat types are shown in Figure 6. All three habitats show two abundance peaks, which occur around mid-June and late June to early July. A majority of larvae for all three habitats were collected between 2 June and 21 July.

86. The temporal occurrence of each individual taxon is given in Table 18. Seasonal CPE was determined for the six most abundant taxa (excluding "other cyprinids"). Predominantly main channel species (freshwater drum, common carp, walleye/sauger, and carpsuckers) showed single abundance peaks. Walleye/sauger bred the earliest (late May), and were followed by carpsuckers (early June), and finally common carp and freshwater drum, both of which had their peak abundance in late June (Figure 7). The predominantly abandoned channel species, gizzard shad and sunfishes, showed two peaks of abundance. Gizzard shad bred between early June and late July, while sunfishes bred between mid-July and mid-August (Figure 8).

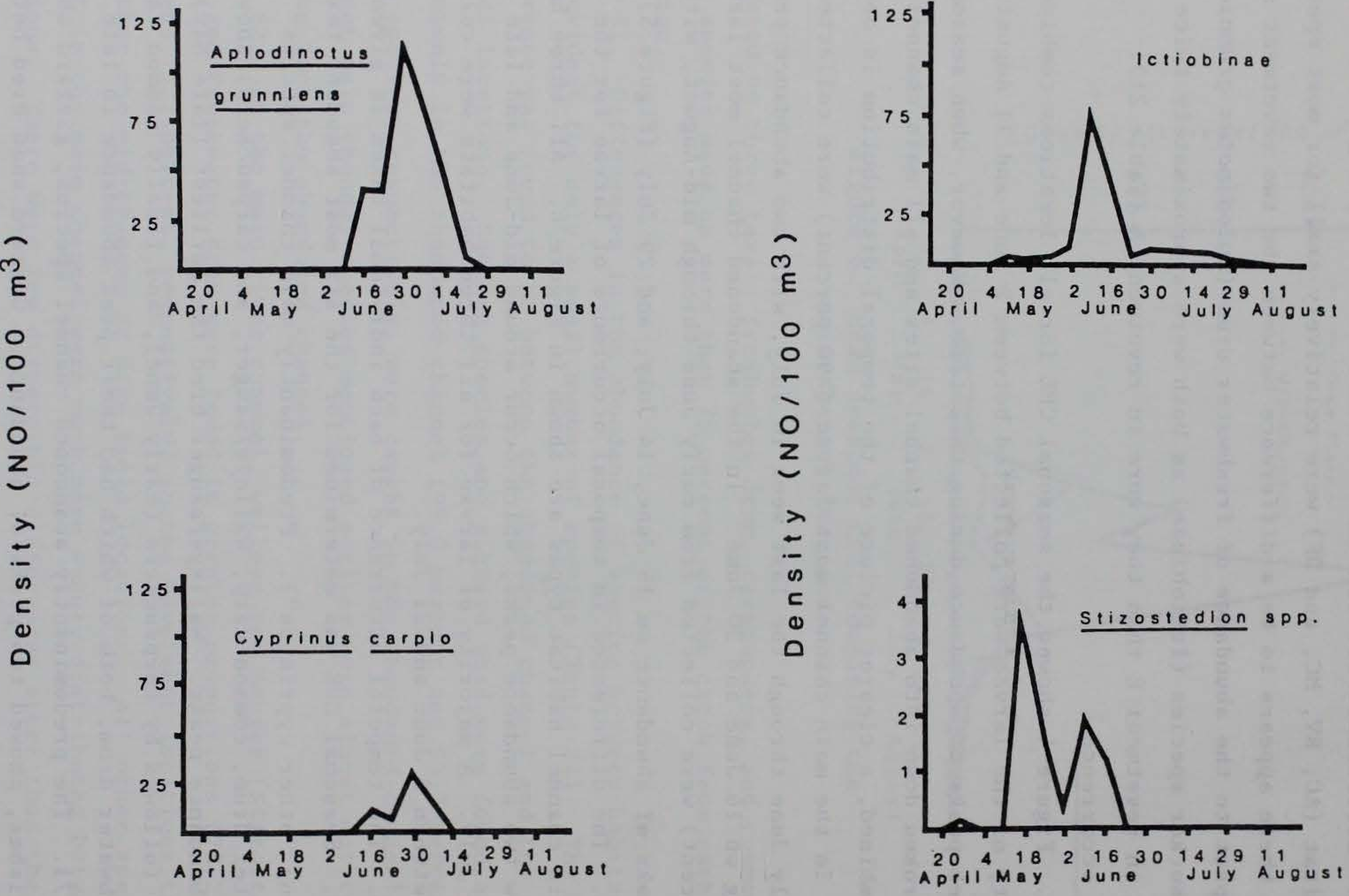


Figure 7. Mean seasonal CPE for selected main channel species (*Aplodinotus grunniens*, freshwater drum; Ictiobinae, carpsuckers; *Cyprinus carpio*, common carp; and *Stizostedion* spp., walleye and sauger). CPE for *Stizostedion* probably represents a single abundance peak due to low numbers of larvae collected

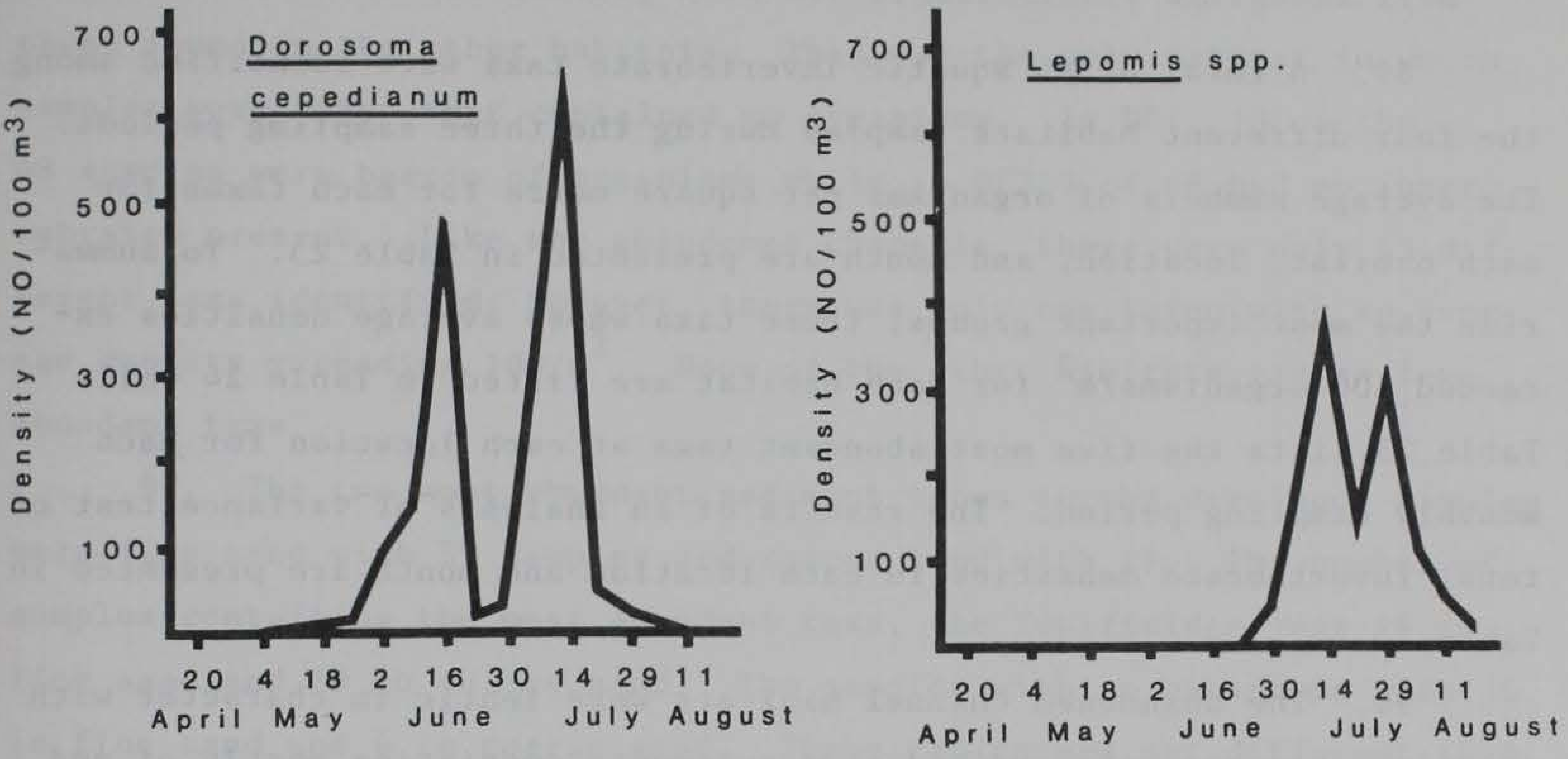


Figure 8. Mean seasonal CPE for selected abandoned channel species (CPE from AC catch only)

Size distribution

87. Size distribution for the six most abundant taxa is given in Table 22. Several taxa showed an uneven (skewed) size distribution for the locations at which they were collected; 98 percent of the freshwater drum were of the size classes 0-5 mm and 5-10 mm. Carpsuckers showed an even more skewed distribution with 97 percent of the specimens belonging to the 5- to 10-mm size class.

88. Two taxa showed size differences between locations. Common carp collected in the mid-channel sites had a majority (59 percent) of its distribution in the juvenile size class 20 mm and up, while dike field and revetment sites were dominated by 5- to 10-mm larvae (91 percent of total). Cyprinids other than common carp showed a similar disparity between locations. In the main channel, 99 percent of the specimens were of the size classes 0-5 mm and 5-10 mm, while in the abandoned channel only 22 percent of the larvae were in these same two size classes. In addition, the size class in the abandoned channel that contained the most fish was the 20-mm and up juvenile class.

Benthic Macroinvertebrates

89. A total of 85 aquatic invertebrate taxa were identified among the four different habitats sampled during the three sampling periods. The average numbers of organisms per square metre for each taxon for each habitat, location, and month are presented in Table 23. To summarize the most important groups, those taxa whose average densities exceeded 100 organisms/m^2 for each habitat are listed in Table 24 while Table 25 lists the five most abundant taxa at each location for each monthly sampling period. The results of an analysis of variance test of total invertebrate densities in each location and month are presented in Table 26.

90. The abandoned channel habitats were lentic in character with no measurable currents and had fine sediments consisting mostly of mud and mud with clay. The highest densities of organisms were found in this habitat throughout the period of the study. The shallower site, AC2, consistently had higher densities of organisms than the deeper site. This might be related to the lower dissolved oxygen values sometimes found at site AC1. While only 43 different taxa were found, this habitat had the greatest number (11) of taxa with densities of 100/m^2 or greater. It also had the greatest taxonomic stability over time. There were only 9 different taxa in the list of the five most frequent taxa found in the two locations over the three sampling periods (Table 25). The maximum possible number would be 30 ($5 \times 2 \times 3$) different taxa. Oligochaetes and midges were most important in this habitat.

91. The dike pool habitats had the greatest diversity of sediment types with fine sands and coarse sands being most important. There were also samples with silt, mud, gravel, clay with fine sand, and clay. There were also high current velocities measured in the dike pools. June averages in DF1 and DF2 were 0.85 and 1.30 m/sec. In August they were 0.60 and 0.38 m/sec and in October 0.20 and 0.48 m/sec. Since the water was moving in a swirling motion in the dike pools, the current would not be uniform across the bottom sediments. This would be a factor in developing the variety of sediment types found in this habitat.

Total densities of organisms were always lower than those found in the abandoned channels but usually were not significantly different from those found in the other habitats. This was the only habitat in which samples were taken that contained no organisms. In DF1, 10 of the 48 samples were barren of organisms while in DF2 9 of 48 had no invertebrates present. Like the abandoned channels, there were only 43 different taxa identified; however, there was only one taxon with an average density exceeding $100/m^2$. None of the other habitats had so few abundant taxa.

92. The two most abundant sediment types in the dike pool samples were fine sand with 57 samples and coarse sand with 17. The number of samples containing the most abundant taxa, the Tubificidae, was 29 in fine sand and 10 in coarse sand. The samples with no organisms were 16 in fine sand and 4 in coarse sand. These ratios are not different than would be expected on the basis of a random distribution between the two sediment types. Thus, there is no evidence that the differences in the size of sand sediments are important in determining differences in species distribution among the samples in this habitat. There was somewhat less stability in taxonomic composition over time with 14 different taxa ranked in the five most abundant ones in the two locations over the three sampling periods.

93. The dike samples were taken by removing the large rocks from the surfaces of the dikes. There were also fine sediments present between and underneath the rocks that contributed organisms to the samples. No current velocities were taken specifically at the dike faces; however, the current readings in the adjacent dike pools would indicate the generally high velocities found in these habitats with averages ranging from 0.2 to 1.3 m/sec. Total numbers of organisms found in these habitats were also lower than those found in the abandoned channels but were comparable to those found in the dike pools and revetments. There were no consistent differences between densities found on the upstream (DFA) and downstream (DFB) faces of the dikes.

94. There was a high degree of taxonomic diversity in this habitat with 75 different taxa found. There were also 9 taxa with average

densities greater than $100/m^2$, making this habitat second only to the abandoned channels in this measure. Stability as indicated by the number of different taxa in the five most frequent taxa for each location for each sampling period was low with a high number of 17. Some of the most important invertebrate groups include *Hydra* which had a peak in June, Hydropsychidae immatures, *Stenonema*, and *Potamyia*.

95. The revetments had a substrate similar to the dikes with large rocks and some finer sediments in the cracks between them. Water velocities were greatest in this environment. For June the averages for RV1 and RV2 were 1.59 and 1.55 m/sec, respectively. In August they were 2.32 and 2.86, respectively. Only the RV2 average is available for October and it was 1.45 m/sec. The total organism densities in the revetments were always lower than those in the abandoned channels and were generally similar to those in the other habitats. Diversity was high with 64 different taxa found; 5 taxa had average densities exceeding $100/m^2$. Fifteen different taxa were found in the list of five most abundant taxa for the two locations and three sampling periods showing less taxonomic stability than the abandoned channels. The bloom of *Hydra* made this the most abundant taxa. Other important taxa include *Dero digitata, Stenonema, Potamyia,* and *Isonychia*.

96. There were a number of differences in the taxa found in the different habitats. Of the dipterans, *Chironomus, Coelotanypus, Procladius, Tanypus,* Ceratopogonidae, and *Chaoborus* were found predominantly in the abandoned channel habitats. On the other hand, Chironomidae pupae, *Nanocladius, Orthocladius, Tanytarsus*, members of the *Thienemannimyia* group, and *Thienemiella* were found almost exclusively in the large rock structures of the dikes and revetments. The midge, *Robackia*, was found almost entirely in the dike pools. Members of the Trichoptera were found almost entirely in the large rock habitats as were the members of the Plecoptera. The Ephemeroptera were also mostly found in the dikes and revetments with the exception of representatives of the genera *Caenis* and *Hexagenia* that were found in the habitats with softer sediments as well. Most of the Oligochaetes were most abundant in the fine sediments of the abandoned channels; however, *Diro digitata*

was generally found in all habitats while the Tubificidae were often quite abundant in all habitats. The flatworm *Dugesia* sp. became important in the rock substrates in October while *Hydra* sp. had a peak of abundance in those same habitats in June. Other taxa had densities so low that it is not possible to generalize on their distributions.

PART VI: DISCUSSION

Water Quality

97. In general the major water quality problem in this portion of the river is the high level of suspended particulate materials as indicated by high turbidity measurements and low Secchi disk measurements. Some low oxygen values were measured at the bottom in the deeper abandoned channel; however, this is to be expected in a eutrophic standing water body. Except for some small differences between some measurements made in the abandoned channels and those in the main river, the water quality measurements were rather uniform, indicating a well-mixed system.

Fish

98. Relatively little fishery research has been carried out on the Iowa/Nebraska portion of the Missouri River. Schmulbach, Gould, and Groen (1975) caught 44 species of fish along the Missouri River between Sioux City, Iowa, and Rulo, Nebraska. Kallemeyn and Novotny (1977) collected 39 species from sites between river miles 704 and 709 below Sioux City, Iowa. Hesse, Bliss, and Zuerlein (1982) found a total of 59 species of fish in the river between river miles 532 and 645. We found a total of 39 species. Sampling methodologies, however, greatly varied from study to study, as did sampling effort, making comparisons of results difficult.

99. One species that showed up in our June seine samples that was not reported in these previous studies was the rainbow smelt, *Omerus mordax* (Table 2). These were juveniles. Larval smelt were also collected (Table 18). Likely, these had their origin in the upstream impoundments. Burress, Kreiger, and Pennington (1982) also caught larvae rainbow smelt.

100. The channelized portion of the Missouri River is a harsh environment for fish sampling as well as fish habitation. This is especially true along the revetted banks. Although extremely high current

velocity (Table 1) and lack of fish cover seem to be the rule, we caught more fish (both numbers of individuals and number of species) electrofishing and hoop netting these areas than in the more diverse and protected dike pool habitat. The revetted bank samples were dominated by larger species, such as blue sucker and flathead catfish, that are adapted to open, rapid flowing water.

101. The dike field had a similar assemblage of larger species with blue sucker, channel catfish, flathead catfish, and goldeye predominating. The dike fields also provided habitat for a wide variety of minnows. Emerald shiners, sand shiners, and fathead minnows dominated the seine samples. Gizzard shad were also well represented. Because of the large number of dikes along the river, the dike pools are probably very important habitats for the production of fish more adapted to slower currents, species that probably used to be plentiful around sandbars.

102. Previous studies (Schmulbach, Gould, and Groen 1975; Kallemeyn and Novotny 1977; Hesse, Bliss, and Zuerlein 1982) found channel catfish of more importance in the catch than in this study. These other investigations, however, used hoop nets baited with cheese, thus attracting channel catfish; ours were unbaited. The high relative abundance of blue suckers found along the revetments and in the dike fields was also in contrast to these previous studies. None reported large numbers of this species and Schmulbach, Gould, and Groen (1975) listed it as uncommon. Kallemeyn and Novotny (1977) did find that blue suckers preferred habitats with swift currents. Seventy-five percent of the blue suckers that they caught were in the revetment habitat.

103. The abandoned channels yielded the greatest species richness and overall greatest numbers of fish. These sites were very productive areas for gizzard shad, minnows, and sunfish. They are probably the most productive sites that we studied, but there are so few of these habitats remaining along the river that their current overall relative importance to the fishery is debatable. The abandoned channel habitat is vulnerable to drainage and complete separation from the main channel. One of our original abandoned channel sites had to be eliminated from

the study, and a second substituted in its place because of low water levels and inaccessibility by boat from the river.

104. Gear selectivity and efficiency differences were a major confounding factor in evaluating fish communities during this study. For example, had we used a follow-up boat in electrofishing the revetted banks, we could easily have doubled the catch and may have increased the number of species sampled. The same may be true of the dike field electrofishing. This would have increased the efficiency of our sampling, but still would have provided difficulty in statistically comparing catches from site to site. Active fishing gear will not give consistent effort for evaluation of CPE data in habitats such as these. The habitat and site differences preclude uniform effort. This situation will probably always plague large river fishery research.

105. One aspect of gear selectivity that warrants further study is the method of setting hoop nets along the revetted banks and perhaps the dike fields. How important is the distance of the set from the bank? We feel that the catch of gar versus blue sucker along the revetments is dependent upon this placement. Blue suckers were caught in deeper sets and gar were more likely to be caught in nets set closer to the bank.

106. Only hoop net data could be statistically analyzed. Effort was similar and all habitats were sampled. However, variation in species numbers and fish abundance between sites within habitats resulted in few significant trends among habitats.

Larval Fish

107. The overall abundance of fish larvae in abandoned channels was much higher than larvae abundance in the main channel. This disparity between backwater (abandoned channel) sites and main channel sites has been shown by other researchers (Persons 1979; Conner, Pennington and Bosley 1983). Sunfishes and gizzard shad used the abandoned channel almost to the exclusion of the other habitat types. On the lower Mississippi River, Conner, Pennington, and Bosley (1983) found that shad and

sunfishes made up 99 percent of the catch in their abandoned channel site. However, Persons (1979) found suckers to be the most abundant species in Missouri River open backwater ponds, followed by sunfishes, freshwater drum, and common carp. Gizzard shad ranked only sixth in abundance.

108. The main channel habitats, while not supporting the same densities of larvae as the abandoned channels, were found to be of importance for several species. Freshwater drum, carpsuckers, and common carp dominated the ichthyoplankton community in all main channel sites. These results are consistent with the findings of Hergenrader et al. (1982), with the exception that other cyprinids, during some years of their study, were more abundant than common carp.

109. Of the three main channel locations, the revetment site supported the highest abundance of larvae. There is some evidence that revetments may provide breeding and/or nursery substrate for walleye and sauger. More than 75 percent of these two species were collected in revetment sites. Balon (1975), in his work on fish reproductive guilds, reported that both walleye and sauger are lithophils. The rock and gravel from the revetments may provide preferred spawning substrate for these species.

110. Another species, the freshwater drum, was found in higher proportions at the revetment sites. This may not be due to breeding behavior, but to some physical characteristic of the eggs. Freshwater drum is a pelagic spawner with buoyant eggs that float until the time of hatching (Pflieger 1975). It is possible that drum eggs were concentrated along the revetments by river currents, resulting in higher larval fish densities.

111. Dike fields were also an important habitat for larval fish, having a higher abundance of larvae than the mid-channel sites. The small pools formed by the dikes may provide habitat for species that require slower water velocities when spawning.

112. It seems likely that certain revetments or dike fields provide better spawning and nursery habitats than others. In this study, it was found that the two revetment sites had differing ichthyoplankton

compositions. Carpsuckers and freshwater drum were both found in greater proportions at revetment E than they were at revetment A. This difference could be due to many factors. Some of the probable factors are differences in spawning substrate and current speed, and proximity to a better food supply (drift from the abandoned channel).

113. It is apparent that there is less habitat diversity in the main channel today than there was before revetments and dikes were installed. However, these structures do provide valuable habitat for the fish species presently found in the river.

114. Peak times of larval fish abundance occurred between early June and mid-August. Fishes in the abandoned channel have a somewhat longer spawning season than those in the main channel, but seem more ephemeral than those in the main channel. Peak abundances in the abandoned channels occur during a short time period and are of large magnitude (Figure 5), suggesting a more "explosive" spawning behavior. In the main channel, larval fish abundance is more evenly spread among the sampling dates, suggesting a more even and continuous spawning season.

115. Larval fish size classes were not evenly represented in the collections. Several taxa showed a skewed size distribution. A majority of the freshwater drum and carpsuckers belonged to the two smallest size classes (<10 mm). Larger larvae were almost entirely lacking from the samples. This unevenness might be due to differences in larval behavior at various stages of development. Larvae of the larger size classes may occupy greater depths (below the depth sampled) in the water column due to increased mobility or differences in body density as yolk material is absorbed. Both common carp and other cyprinids showed size differences between locations or habitat types.

116. The smaller larvae were found in locations where the juveniles were low in abundance, while juveniles were common in areas where smaller larvae were lacking. These observations might also be due to differences in the behavior of larvae and juveniles. As the larvae mature into juveniles and gain additional mobility, there might be a tendency for them to move to more preferred habitat: mid-channel

waters in the case of common carp, and shallower backwaters with little current in the case of other cyprinids.

Benthic Macroinvertebrates

117. The benthic invertebrate communities represented in this study were similar to those found by other researchers (e.g. Russell 1965; Morris et al. 1968; McMahon, Wolf, and Diggins 1972; Burress, Krieger, and Pennington 1982). We also found that there were differences in the densities and taxonomic composition of the communities in the different habitats. As others have found, the abandoned channel habitats were lakelike with no dominant currents and had fine sediment particles, high benthos densities, but lower numbers of taxa than found on the rock substrates of the dikes and revetments. We also found that midges and oligochaetes were most important, though we did not find the same dominance of *Chaoborus* as Beckett et al. (1983) found in similar habitats on the lower Mississippi River.

118. The dike pool habitats were characterized by high current velocities and a greater diversity of sediment types than found in the other habitats studied. We found mostly fine and coarse sands but these areas did not have quite the same diversity of sediment types that Beckett et al. (1983) found in similar habitats on the lower Mississippi. We did find, as they did, that there was a low diversity of organisms in this habitat. This was also the only habitat where we had samples that had no organisms at all. Presumably the combination of the higher current velocities and the more unstable sand substrates produces an environment that is less favorable for benthic organisms. In common with the lower Mississippi River studies, we also found that oligochaete worms dominated this habitat.

119. The dikes and revetments were similar in having large rock substrates and high current velocities. The main difference was higher currents at the revetments than at the dike faces. Attached forms such as *Hydra* were important as were other invertebrates commonly associated with coarse substrates such as caddisflies, stoneflies, and clinging

mayflies. The softer sediments between and underneath the larger rocks presumably were important for the worms and midges also found in these habitats. Both of these habitats had the highest numbers of taxa found in comparison with the sediment substrates, though the densities were less than those found in the abandoned channels. This is consistent with the findings of Burress, Krieger, and Pennington (1982) on the Missouri River in North Dakota. On the other hand, Mathis et al. (1981) found that the dike structures on the lower Mississippi River had higher organism densities than did the abandoned channels. In another study on the lower Mississippi, Mathis, Bingham, and Sanders (1982) found organism densities on dike structures on the order of $100{,}000/m^2$. These are much higher than our samples which ranged from about 1,000 to 4,000 organisms/m^2. There may be differences in basic primary productivity between these stretches of river or perhaps the combination of high current and high turbidity found in the Missouri River is unfavorable for the development of dike structure organisms.

PART VII: CONCLUSIONS AND RECOMMENDATIONS

120. Conclusions of this study are as follows:

- a. Water quality was uniform except for some differences between the abandoned channels and the main river, indicating a well-mixed system.
- b. Fish catch along revetted banks was dominated by blue sucker and flathead catfish and by blue sucker, channel catfish, flathead catfish, and goldeye in dike fields. The dike fields also provided habitat for a variety of minnows. Greatest species richness and numbers of fish were obtained from the abandoned channels.
- c. Catch of larval fish was greatest in the abandoned channels and was dominated by sunfishes and gizzard shad. Main channel habitats were important for freshwater drum, carp suckers, and common carp larvae. Peak abundance of fish larvae occurred between early June and mid-August.
- d. Abandoned channel habitats were characterized by fine sediment particles, high invertebrate densities, and lower number of taxa than on the rock substrates of dikes and revetments. Dike pool habitats were characterized by high current velocities, diverse sediment types, and low invertebrate densities. Dikes and revetments were similar in having large rock substrates, high current velocities, and a diversity of invertebrates commonly associated with coarse substrates such as caddisflies, stoneflies, and clinging mayflies.

121. The following recommendations were formulated from the results of this study:

- a. Abandoned channels are an important fish habitat, especially as spawning and nursery areas. These habitats should be protected and, where possible, enhanced as they currently form habitat critical to the Middle Missouri River.
- b. Future work on adult and juvenile fish might focus on the development of an appropriate monitoring approach. Methods currently available for big river fishing studies should be evaluated so that an effective sampling program can be developed.
- c. Future larval fish research might include comparison of modified river bank (revetments and dike fields) with natural, unmodified river banks. A more comprehensive study of which species of fish utilize revetments and dike fields for spawning is also needed. A larger

number of sampling stations, sampling at additional depths, and night sampling would provide the data required to completely assess the relative importance of each habitat type.

REFERENCES

Auer, N. A. ed. 1982. "Identification of Larval Fishes of the Great Lakes Basin with Emphasis on the Lake Michigan Drainage," Special Pub. 82-3, Great Lake Fishery Commission, Ann Arbor, Mich.

Balon, E. K. 1975. "Reproductive Guilds of Fishes: A Proposal and Definition," Journal of the Fisheries Research Board of Canada, Vol 32, pp 821-864.

Beal, C. D. 1967. "Life History Information of the Blue Sucker, *Cycleptus elongatus* (Lesuer) in the Missouri River," M. A. Thesis, University of South Dakota, Vermillion, p 136.

Beckett, D. C., Bingham, C. R., Sanders, L. G., Mathis, D. B., and McLemore, E. M. 1983. "Benthic Macroinvertebrates of Selected Aquatic Habitats of the Lower Mississippi River," Technical Report E-83-10, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Berner L. M. 1951. "Limnology of the Lower Missouri River," Ecology, Vol 32, pp 1-12.

Burke, T. D., and Robinson, J. W. 1979. "River Structure Modifications to Provide Habitat Diversity," Presented at: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats, Fort Collins, Colo.

Burress, R. M., Krieger, D. A., and Pennington, C. H. 1982. "Aquatic Biota of Bank Stabilization Structures on the Missouri River, North Dakota," Technical Report E-82-6, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Cada, G. F., and Hergenrader, G. L. 1980. "Natural Mortality Rates of Freshwater Drum Larvae in the Missouri River," Transactions of the American Fisheries Society, Vol 109, pp 479-483.

Claflin, T. 1963. "Age and Growth of the Goldeye, *Hiodon alosoides* (Rafinesque), in the Missouri River," M. A. Thesis, University of South Dakota, Vermillion.

Conner, J. V., Pennington, C. H., and Bosley, T. R. 1983. "Larval Fish of Selected Aquatic Habitats on the Lower Mississippi River," Technical Report E-83-4, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Cross, F. B., and Huggins, D. G. 1975. "Skipjack Herring, *Alosa chrysochloris* in the Missouri River Basin," Copeia, Vol 2, pp 382-385.

Cvancara, V. A. 1964. "Age and Growth of the Northern Redhorse, *Moxostoma macrolepidotum* (Lesuer) in the Missouri River," M. A. Thesis, University of South Dakota, Vermillion.

Fisher, H. J. 1962. "Some Fishes of the Lower Missouri River," American Midland Naturalist, Vol 68, pp 424-429.

Funk, J. L., and Robinson, J. W. 1974. "Changes in the Channel of the Lower Missouri River and Effects on Fish and Wildlife," Missouri Department of Conservation, Aquatic Series 11.

Groen, C. L., and Schmulbach, J. C. 1978. "The Sport Fishery of the Unchannelized and Channelized Middle Missouri River," Transactions of the American Fisheries Society, Vol 107, pp 412-418.

Hallberg, G. R., Harbough, J. M., and Witinok, P. M. 1979. "Changes in the Channel Areas of the Missouri River in Iowa from 1879 to 1976," Iowa Geological Survey Special Report Series No. 1, p 32.

Held, J. 1969. "Some Early Summer Foods of the Shovelnose Sturgeon in the Missouri River," Transactions of the American Fisheries Society, Vol 98, pp 514-517.

Helms, D. R. 1975. "Age and Growth of Shovelnose Sturgeon, *Scaphirhynchus platorynchus* (Rafinesque), in the Mississippi River, Proceedings of the Iowa Academy of Science, Vol 81, pp 73-75.

Hergenrader, G. L., Harrow, L. G., King, R. G., Cadd, G. F., and Schlesinger, A. B. 1982. "Larval Fishes in the Missouri River and the Effects of Entrainment," The Middle Missouri River, Hesse, L. W., Hergenrader, G. L., Lewis, H. S., Reetz, S. D., and Schlesinger, A. E., eds., The Missouri River Study Group, Norfolk, Nebr., Biology with Special References to Power Station Effects, Missouri, pp 185-225.

Hesse, L. W., and Newcomb, B. A. 1982. "On Estimating the Abundance of Fish in the Upper Channelized Missouri River," North American Journal Fisheries Management, Vol 2, pp 80-83.

Hesse, L. W., Bliss, Q. P., and Zuerlein, G. J. 1982. "Some Aspects of the Ecology of Adult Fishes in the Channelized Missouri River with Special Reference to the Effects of Two Nuclear Power Generating Stations," The Middle Missouri River, Hesse, L. W., Hergenrader, G. L., Lewis, H. S., Reetz, S. D., and Schlesinger, A. E., eds., The Missouri River Study Group, Norfolk, Nebr., pp 225-276.

Hesse, L. W., Wallace, C. R., and Leman, L. 1978. "Fishes of the Channelized Missouri River: Age-growth, Length-frequency, Length-weight, Coefficient of Condition, Catch Curves and Mortality of 25 Species of Channelized Missouri River Fishes," Nebraska Technical Series No. 4, Nebraska Game and Parks.

Holland, L. E., and Huston, M. L. 1983. "A Compilation of Available Literature on the Larvae of Fishes Common to the Upper Mississippi River," US Fish and Wildlife Service, National Fishery Research Laboratory, LaCrosse, Wis.

Johnson, D. H. 1963. "The Food Habits of the Goldeye, *Hiodon alosoides*, of the Missouri River and Lewis and Clark Reservoir, South Dakota," M. A. Thesis, University of South Dakota, Vermillion.

Kallemeyn, L. W., and Novotny, J. F. 1977. "Fish and Food Organisms in Various Habitats of the Missouri River in South Dakota, Nebraska, and Iowa," FWS/OBS-77/25, OBS National Stream Alteration Team, Columbia, Mo.

Kirby, M. E., and Abbott, H. C. 1929. "A Profile of the 1880 Channel of the Missouri River," Proceedings of the South Dakota Academy of Science, Vol 13, pp 34-37.

Kozel, D. J., and Schmulbach, J. C. 1976. "Utilization of Marsh and Sandbar Habitats by Fishes in the Unchannelized Missouri River," Proceedings of the South Dakota Academy of Science, Vol 55, p 177.

Langemeier, R. N. 1965. "Effects of Channelization on the Limnology of the Missouri River, Nebraska, with Emphasis on Food Habits and Growth of the Flathead Catfish," M. A. Thesis, University of Missouri, Columbia.

Mathis, D. B., Bingham, C. R., and Sanders, L. G. 1982. "Assessment of Implanted Substrate Samplers for Macroinvertebrates Inhabiting Stone Dikes of the Lower Mississippi RIver," Technical Report E-82-1, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Mathis, D. B., Cobb, S. P., Sanders, L. G., Magoun, A. D., and Bingham, C. R. 1981. "Aquatic Habitat Studies on the Lower Mississippi River, River Mile 480 to 530," Technical Report E-80-1, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

McMahon, J., Wolf, J., and Diggins, M. 1972. "Chironomidae, Ephemeroptera, and Trichoptera in the Benthos of Unchannelized and Channelized Portions of the Missouri River," Proceedings of the South Dakota Academy of Science, Vol 51, pp 168-181.

Modde, T. C., and Schmulbach, J. C. 1973. "Seasonal Changes in the Drift and Benthic Macroinvertebrates in the Unchannelized Missouri River in South Dakota," Proceedings of the South Dakota Academy of Science, Vol 52, pp 118-126.

Morris, J., Morris, L., and Witt, A. 1972. "The Fishes of Nebraska," Nebraska Game and Parks Commission, Lincoln, Nebr.

Morris, L. A. 1965. "Age and Growth of the River Carpsucker, *Carpiodes carpio*, in the Missouri River," American Midland Naturalist, Vol 73, pp 423-429.

__________. 1969. "Flathead Catfish Investigations in the Missouri River," Project No. F4R14, Job No. 23, Nebraska Game and Parks Commission, Lincoln, Nebr.

Morris, L. A., Langemeier, R. N., Russell, T. R., and Witt, A., Jr. 1968. "Effects of Main Stem Impoundments and Channelization Upon the Limnology of the Missouri River, Nebraska," Transactions of the American Fisheries Society, Vol 97, pp 380-388.

Namminga, H. 1969. "An Investigation of the Macroscopic Drift Fauna of the Missouri River," M. A. Thesis, Unversity of South Dakota, Vermillion.

Neel, J. K., Nicholson, H. P., and Hirsch, A. 1963. "Main Stem Reservoir Effects of Water Quality in the Central Missouri River 1952-1957," US Department of Health, Education, and Welfare, Public Health Service, Region VI, Water Supply and Pollution Control, Kansas City, Mo.

Nord, A. E., and Schmulbach, J. C. 1973. "A Comparison of the Macroinvertebrate Attached Communities in the Unstabilized and Stabilized Missouri River," Proceedings of the South Dakota Academy of Science, Vol 52, pp 127-139.

Persons, W. W. 1979. "The Use of Open and Closed Ponds of the Missouri River, Iowa, as Spawning and Nursery Areas," M. S. Thesis, Iowa State University, Ames.

Pflieger, W. L. 1971. "A Distributional Study of Missouri Fishes," University of Kansas Museum of Natural History Publication 20, pp 225-570.

________. 1975. "The Fishes of Missouri," Missouri Department of Conservation, Jefferson City, Mo.

Rosen, R. A., Hales, D. C., and Unkenholz, D. G. 1982. "Biology and Exploitation of Paddlefish in the Missouri River Below Gavins Point Dam," Transactions of the American Fisheries Society, Vol 111, pp 216-222.

Russell, T. R. 1965. "Age, Growth, and Food Habits of the Channel Catfish in Unchanneled and Channeled Portions of the Missouri River, Nebraska, with Notes on Limnological Observations," M. A. Thesis, University of Missouri, Columbia.

Schmulbach, J. C., Gould, G., and Groen, C. L. 1975. "Relative Abundance and Distribution of Fishes in the Missouri River Gavins Point Dam to Rulo, Nebraska," Proceedings of the South Dakota Academy of Science, Vol 54, pp 194-222.

Slizeski, J. L., Andersen, J. L., and Dorough, W. G. 1982. "Hydrologic Setting, System Operation, Present and Future Stresses," The Middle Missouri River, Hesse, L. W., Hergenrader, G. L., Lewis, H. S., Reetz, S. D., and Schlesinger, A. E., eds., The Missouri River Study Group, Norfolk, Nebr., pp 15-38.

Swedberg, D. V. 1965. "Age and Rate of Growth of Freshwater Drum, Lewis and Clark Lake, Missouri River," Proceedings of the South Dakota Academy of Science, Vol 44, pp 160-168.

Todd, R. D., and Bender, J. F. 1982. "Water Quality Characteristics of the Missouri River Near Fort Calhoun and Cooper Nuclear Stations," The Middle Missouri River, Hesse, L. W., Hergenrader, G. L., Lewis, H. S., Reetz, S. D., and Schlesinger, A. E., eds., The Missouri River Study Group, Norfolk, Nebr., pp 39-68.

Volesky, D. F. 1969. "A Comparison of the Macrobenthos from Selected Habitats in Cattail Marshes of the Missouri River," M. A. Thesis, University of South Dakota, Vermillion.

Whitley, J. R., and Campbell, R. S. 1973. "Some Aspects of Water Quality and Biology of the Missouri River," Transactions, Missouri Academy of Science, Vol 7, pp 60-72.

Wolf, J., McMahon, J., and Diggins, M. 1972. "Comparisons of Benthic Organisms in Semi-natural and Channelized Portions of the Missouri River," Proceedings of the South Dakota Academy of Science, Vol 51, pp 160-167.

Zweiacker, P. L. 1967. "Aspects of the Life History of the Shovelnose Sturgeon, *Scaphirhynchus platorynchus* (Rafinesque) in the Missouri River," M. A. Thesis, University of South Dakota, Vermillion.

Table 1

Mean Values for Water Quality Parameters Measured at the Surface (SS), Mid-depth (MD), and Near the Bottom (BS)

Month Site		Temp (C)	Dis. Oxygen (mg/l)	pH	Redox Pot. (mv)	Turb (NTU)	Spec. Cond (µmho/cm)	Secchi Depth (m)	Current Speed (m/sec)
June 1983									
Site AC1	SS	22.0	11.3	8.3	304	21.5	996	0.34	
	MD	21.5	10.3	8.3	297		998		
	BS	20.6	8.7	8.2	299		1001		
Site AC2	SS	23.4	10.0	8.2	300	17.0	1161	0.30	
Site DF1	SS	17.8	9.9	8.4	294	15.5	1013	0.28	0.85
	MD	17.8	9.5	8.2	273		1000		
	BS	17.8	9.5	8.3	275		1000		
Site DF2	SS	17.8	9.7	8.4	293	16.5	1038	0.27	1.30
	MD	18.0	9.6	8.4	275		1033		
	BS	18.0	9.6	8.4	275	17.0	1033		
Site RV1	SS	17.8	9.7	8.4	295	16.5	1069	0.26	1.59
	MD	18.0	9.9	8.2	350		1050		
	BS	18.0	10.2	8.2	350		1050		
Site RV2	SS	17.8	9.7	8.4	296	22.0	1082	0.26	1.55
	MD	17.8	9.4	8.3	272		1117		
	BS	17.8	9.4	8.4	275		1117		
August 1983									
Site AC1	SS	28.5	7.5	7.7	190	17.3	805	0.28	
	MD	28.1	4.2	7.4	193		810		
	BS	28.1	4.2	7.4	194	19.7	811		
Site AC2	SS	27.5	8.4	7.8	212	24.8	854	0.27	
Site DF1	SS	27.2	7.8	8.1	174	16.3	852	0.36	0.60
	MD	27.3	6.9	8.0	172		854		
	BS	27.3	6.8	8.0	172	16.2	854		
Site DF2	SS	27.1	7.7	8.1	196	19.3	852	0.36	0.38
	MD	27.2	7.4	8.1	194		853		
	BS	27.2	7.3	8.1	193	20.3	854		
Site RV1	SS	27.3	7.7	8.1	174	15.9	853	0.39	2.23
	MD	27.3	7.3	8.1	174		853		
	BS	27.3	7.2	8.1	174	16.4	854		
Site RV2	SS	27.2	7.8	8.1	196	17.7	852	0.38	2.86
	MD	27.3	7.4	8.0	190		853		
	BS	27.3	7.3	8.1	190	17.0	853		
October 1983									
Site AC1	SS	15.2	9.1	8.0	197	11.1	758	0.36	
	MD	15.4	8.2	8.0	201		760		
	BS	15.3	7.9	7.9	202	20.5	760		
Site AC2	SS	14.3	9.7	8.3	172	20.5	738	0.21	
Site DF1	SS	16.3	8.3	8.1	200	16.0	788	0.34	0.20
	MD	16.2	8.1	8.1	189		790		
	BS	16.2	8.1	8.1	188	17.2	790		
Site DF2	SS	16.3	8.5	8.1	208	17.3	789	0.33	0.48
	MD	16.3	8.2	8.1	202		789		
	BS	16.2	8.2	8.1	201	16.6	789		
Site RV1	SS	16.3	8.6	8.1	206	16.7	788	0.33	
	MD	16.3	8.4	8.1	205		789		
	BS	16.3	8.3	8.1	204	17.7	789		
Site RV2	SS	16.2	8.6	8.1	206	17.4	788	0.32	1.45
	MD	16.2	8.5	8.1	206	13.0	788		
	BS	16.2	8.3	8.1	204	17.1	788		

Table 2

Number of Each Fish Species Collected by Seining During Three Sample Periods at Three Locations, Missouri River Between River Mile 661 and 678 in 1983

Common Name	Scientific Name	Dike Field Jun	Dike Field Aug	Dike Field Oct	Abandoned Channel Jun	Abandoned Channel Aug	Abandoned Channel Oct
Gizzard shad	*Dorosoma cepedianum*	0	51	6	0	42	0
Rainbow smelt	*Osmerus mordax*	8	0	0	0	0	0
Central stoneroller	*Campostoma anomalum*	0	1	1	0	0	0
Carp	*Cyprius carpio*	0	1	0	0	1	1
Speckled chub	*Hybopsis aestivalis*	2	0	0	0	0	0
Silver chub	*Hybopsis storeriana*	0	4	16	0	0	0
Shiner	*Notropis* spp.	3	7	0	1	11	1
Emerald shiner	*Notropis atherinoides*	38	90	95	69	9	3
River shiner	*Notropis blennius*	0	0	6	0	0	0
Red shiner	*Notropis lutrensis*	21	0	92	108	0	0
Spotfin shiner	*Notropis spilopterus*	0	0	0	1	0	0
Bigmouth shiner	*Notropis dorsalis*	0	0	12	0	0	0
Sand shiner	*Notropis stramineus*	210	38	37	31	8	0
Fathead minnow	*Pimephales promelas*	5	72	4	2	9	0
River carpsucker	*Carpiodes carpio*	0	37	0	0	4	0
River redhorse	*Moxostoma carinatum*	0	0	0	0	1	0
Golden redhorse	*Moxostoma erythrurum*	0	4	0	0	1	0
Channel catfish	*Ictalurus punctatus*	0	0	1	0	0	0
White bass	*Morone chrysops*	1	4	0	0	6	0
Green sunfish	*Lepomis cyanellus*	0	3	0	3	2	3
Orangespotted sunfish	*Lepomis humilis*	0	0	0	2	5	1
Bluegill	*Lepomis macrochirus*	0	0	0	89	229	29
Largemouth bass	*Micropterus salmoides*	0	0	0	1	3	3
White crappie	*Pomoxis annularis*	0	1	0	2	112	13
Black crappie	*Pomoxis nigromaculatus*	0	0	0	0	4	0
Yellow perch	*Perca flavescens*	0	0	0	0	1	1
Sauger	*Stizostedion canadense*	0	0	1	0	0	0
Walleye	*Stizostedion vitreum*	0	0	0	1	1	0
Freshwater drum	*Aplodinotus grunniens*	0	1	0	0	15	0
		288	314	271	310	464	55

Table 3

Number, Mean Length (mm), Mean Weight (g), and Standard Deviation of Fish Caught During Three Sample Periods by Seining Dike Fields in the Missouri River

Species	Variable	June			August			October		
		Site 1	Site 2	Total	Site 1	Site 2	Total	Site 1	Site 2	Total
Gizzard shad	Number	0	0	0	14	37	51	3	3	6
	Mean Length	-	-	-	66	56	59	94	91	92
	Std. Dev.	-	-	-	18	11	14	10	10	9
	Mean Weight	-	-	-	4.0	2.2	2.6	7.5	6.1	6.8
	Std. Dev.	-	-	-	4.0	1.4	2.5	2.4	1.7	2.0
Rainbow smelt	Number	8	0	8	0	0	0	0	0	0
	Mean Length	69	-	69	-	-	-	-	-	-
	Std. Dev.	5	-	5	-	-	-	-	-	-
	Mean Weight	1.6	-	1.6	-	-	-	-	-	-
	Std. Dev.	0.5	-	0.5	-	-	-	-	-	-
Central stoneroller	Number	0	0	0	1	0	1	0	1	1
	Mean Length	-	-	-	44	-	44	-	48	48
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	0.9	-	0.9	-	1.0	1.0
	Std. Dev.	-	-	-	-	-	-	-	-	-
Carp	Number	0	0	0	1	0	1	0	0	0
	Mean Length	-	-	-	51	-	51	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	2.0	-	2.0	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Speckled chub	Number	2	0	2	0	0	0	0	0	0
	Mean Length	36	-	36	-	-	-	-	-	-
	Std. Dev.	0.7	-	0.7	-	-	-	-	-	-
	Mean Weight	0.4	-	0.4	-	-	-	-	-	-
	Std. Dev.	0.1	-	0.1	-	-	-	-	-	-
Silver chub	Number	0	0	0	0	4	4	15	1	16
	Mean Length	-	-	-	-	38	38	65	54	65
	Std. Dev.	-	-	-	-	6	6	9	-	9
	Mean Weight	-	-	-	-	0.5	0.5	2.5	1.0	2.4
	Std. Dev.	-	-	-	-	0.2	0.2	1.2	-	1.2
Shiner sp.	Number	1	2	3	6	1	7	0	0	0
	Mean Length	36	34	34	34	21	32	-	-	-
	Std. Dev.	-	2	2	3	-	6	-	-	-
	Mean Weight	0.4	0.3	0.3	0.3	0.1	0.3	-	-	-
	Std. Dev.	-	0.1	0.1	0.1	-	0.1	-	-	-
Emerald shiner	Number	11	27	38	40	50	90	29	66	95
	Mean Length	49	52	51	36	43	40	58	56	57
	Std. Dev.	8	8	8	5	12	10	9	11	11
	Mean Weight	1.0	1.1	1.1	0.4	0.8	0.6	1.5	1.5	1.5
	Std. Dev.	0.4	0.5	0.4	0.1	0.8	0.6	0.7	0.8	0.8
River shiner	Number	0	0	0	0	0	0	4	2	6
	Mean Length	-	-	-	-	-	-	53	51	52
	Std. Dev.	-	-	-	-	-	-	2	0	2
	Mean Weight	-	-	-	-	-	-	1.4	1.0	1.3
	Std. Dev.	-	-	-	-	-	-	0.2	0.1	0.2
Red shiner	Number	0	21	21	0	0	0	38	54	92
	Mean Length	-	41	41	-	-	-	33	36	35
	Std. Dev.	-	8	8	-	-	-	13	11	12
	Mean Weight	-	0.9	0.9	-	-	-	0.5	0.7	0.6
	Std. Dev.	-	0.6	0.6	-	-	-	0.7	0.9	0.8
Bigmouth shiner	Number	0	0	0	0	0	0	8	4	12
	Mean Length	-	-	-	-	-	-	47	46	47
	Std. Dev.	-	-	-	-	-	-	7	9	7
	Mean Weight	-	-	-	-	-	-	0.9	0.8	0.9
	Std. Dev.	-	-	-	-	-	-	0.4	0.6	0.4
Sand shiner	Number	145	65	210	11	27	38	28	9	37
	Mean Length	38	32	36	36	35	35	45	45	45
	Std. Dev.	8	8	8	7	8	8	6	8	6
	Mean Weight	0.6	0.4	0.6	0.4	0.5	0.4	0.9	0.9	0.9
	Std. Dev.	0.4	0.3	0.4	0.3	0.3	0.3	0.4	0.3	0.3

(Continued)

Table 3 (Concluded)

Species	Variable	June			August			October		
		Site 1	Site 2	Total	Site 1	Site 2	Total	Site 1	Site 2	Total
Fathead minnow	Number	3	2	5	28	44	72	2	2	4
	Mean Length	34	32	34	35	32	33	43	45	44
	Std. Dev.	0.6	4	2	7	6	7	10	4	6
	Mean Weight	0.4	0.4	0.4	0.5	0.4	0.4	0.8	0.8	0.8
	Std. Dev.	0	0.1	0.1	0.3	0.2	0.2	0.5	0.2	0.3
River carpsucker	Number	0	0	0	14	23	37	0	0	0
	Mean Length	-	-	-	47	48	47	-	-	-
	Std. Dev.	-	-	-	10	10	10	-	-	-
	Mean Weight	-	-	-	1.3	1.4	1.3	-	-	-
	Std. Dev.	-	-	-	0.9	0.8	0.8	-	-	-
Golden redhorse	Number	0	0	0	4	0	4	0	0	0
	Mean Length	-	-	-	46	-	46	-	-	-
	Std. Dev.	-	-	-	4	-	4	-	-	-
	Mean Weight	-	-	-	1.0	-	1.0	-	-	-
	Std. Dev.	-	-	-	0.3	-	0.3	-	-	-
Channel catfish	Number	0	0	0	0	0	0	0	1	1
	Mean Length	-	-	-	-	-	-	-	73	73
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	-	3.2	3.2
	Std. Dev.	-	-	-	-	-	-	-	-	-
White bass	Number	0	1	1	0	4	4	0	0	0
	Mean Length	-	126	126	-	58	58	-	-	-
	Std. Dev.	-	-	-	-	7	7	-	-	-
	Mean Weight	-	21	21	-	2.2	2.2	-	-	-
	Std. Dev.	-	-	-	-	0.7	0.7	-	-	-
Green sunfish	Number	0	0	0	2	1	3	0	0	0
	Mean Length	-	-	-	36	55	43	-	-	-
	Std. Dev.	-	-	-	5	-	11	-	-	-
	Mean Weight	-	-	-	0.8	2.5	1.4	-	-	-
	Std. Dev.	-	-	-	0.4	-	1.0	-	-	-
White crappie	Number	0	0	0	1	0	1	0	0	0
	Mean Length	-	-	-	51	-	51	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	1.2	-	1.2	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Sauger	Number	0	0	0	0	0	0	0	1	1
	Mean Length	-	-	-	-	-	-	-	123	123
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	-	11.1	11.1
	Std. Dev.	0	0	0	0	0	0	0	0	0
Freshwater drum	Number	0	0	0	0	1	1	0	0	0
	Mean Length	-	-	-	-	53	53	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean weight	-	-	-	-	1.5	1.5	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Total Number	170	118	288	122	192	314	127	144	271

Table 4

Number, Mean Length (mm), Mean Weight (g), and Standard Deviation of Fish Caught During Three Sample Periods by Seining Abandoned Channels Along the Missouri River

Species	Variable	June			August			October		
		Site 1	Site 2	Total	Site 1	Site 2	Total	Site 1	Site 2	Total
Gizzard shad	Number	0	0	0	0	42	42	0	0	0
	Mean Length	-	-	-	-	38	38	-	-	-
	Std. Dev.	-	-	-	-	12	12	-	-	-
	Mean Weight	-	-	-	-	0.8	0.8	-	-	-
	Std. Dev.	-	-	-	-	0.9	0.9	-	-	-
Carp	Number	0	0	0	0	1	1	0	1	1
	Mean Length	-	-	-	-	122	122	-	262	262
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	32	32	-	233	233
	Std. Dev.	-	-	-	-	-	-	-	-	-
Shiner sp.	Number	0	1	1	0	11	11	0	1	1
	Mean Length	-	29	29	-	24	24	-	28	28
	Std. Dev.	-	-	-	-	10	10	-	-	-
	Mean Weight	-	0.1	0.1	-	0.2	0.2	-	0.1	0.1
	Std. Dev.	-	-	-	-	0.2	0.2	-	-	-
Emerald shiner	Number	64	5	69	4	5	9	0	3	3
	Mean Length	44	46	44	25	31	28	-	37	37
	Std. Dev.	7	12	7	2	2	4	-	7	7
	Mean Weight	0.6	0.7	0.6	0.6	0.2	0.4	-	0.4	0.4
	Std. Dev.	0.3	0.5	0.3	0.5	0.1	0.4	-	0.2	0.2
Red shiner	Number	88	20	108	0	0	0	0	0	0
	Mean Length	44	45	44	-	-	-	-	-	-
	Std. Dev.	8	9	8	-	-	-	-	-	-
	Mean Weight	1.0	1.0	1.0	-	-	-	-	-	-
	Std. Dev.	0.6	0.7	0.6	-	-	-	-	-	-
Spotfin shiner	Number	0	1	1	0	0	0	0	0	0
	Mean Length	-	44	44	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	0.5	0.5	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Sand shiner	Number	22	9	31	3	5	8	0	0	0
	Mean Length	32	31	32	27	31	30	-	-	-
	Std. Dev.	5	7	5	7	7	7	-	-	-
	Mean Weight	0.3	0.3	0.3	0.1	0.3	0.3	-	-	-
	Std. Dev.	0.2	0.2	0.2	0.1	0.2	0.2	-	-	-
Fathead minnow	Number	1	1	2	1	8	9	0	0	0
	Mean Length	29	59	44	19	24	24	-	-	-
	Std. Dev.	-	-	21	-	6	6	-	-	-
	Mean Weight	0.2	2.4	1.3	0.1	0.2	0.1	-	-	-
	Std. Dev.	-	-	1.6	-	0.1	0.1	-	-	-
River carpsucker	Number	0	0	0	0	4	4	0	0	0
	Mean Length	-	-	-	-	75	75	-	-	-
	Std. Dev.	-	-	-	-	11	11	-	-	-
	Mean Weight	-	-	-	-	6.3	6.3	-	-	-
	Std. Dev.	-	-	-	-	2.9	2.9	-	-	-
River redhorse	Number	0	0	0	1	0	1	0	0	0
	Mean Length	-	-	-	157	-	157	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	40	-	40	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Golden redhorse	Number	0	0	0	0	1	1	0	0	0
	Mean Length	-	-	-	-	41	41	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	0.6	0.6	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
White bass	Number	0	0	0	3	3	6	0	0	0
	Mean Length	-	-	-	47	62	54	-	-	-
	Std. Dev.	-	-	-	6	2	9	-	-	-
	Mean Weight	-	-	-	1.3	2.5	1.9	-	-	-
	Std. Dev.	-	-	-	0.3	0.1	0.7	-	-	-

(Continued)

Table 4 (Concluded)

Species	Variable	June			August			October		
		Site 1	Site 2	Total	Site 1	Site 2	Total	Site 1	Site 2	Total
Green sunfish	Number	0	3	3	0	2	2	0	3	3
	Mean Length	-	63	63	-	70	70	-	84	84
	Std. Dev.	-	8	8	-	10	10	-	16	16
	Mean Weight	-	4.6	4.6	-	6.0	6.0	-	9.5	9.5
	Std. Dev.	-	2.1	2.1	-	2.7	2.7	-	4.8	4.8
Orangespotted sunfish	Number	1	1	2	0	5	5	0	1	1
	Mean Length	39	57	48	-	66	66	-	76	76
	Std. Dev.	-	-	13	-	7	7	-	-	-
	Mean Weight	0.7	2.9	1.8	-	5.0	5.0	-	6.2	6.2
	Std. Dev.	-	-	1.6	-	1.8	1.8	-	-	-
Bluegill	Number	85	4	89	108	121	229	5	24	29
	Mean Length	48	47	48	25	28	27	44	48	47
	Std. Dev.	11	22	12	5	8	7	5	9	9
	Mean Weight	2.1	2.4	2.1	0.2	0.4	0.3	1.0	1.6	1.5
	Std. Dev.	4.3	3.4	4.3	0.1	0.3	0.2	0.4	0.8	0.8
Largemouth bass	Number	1	0	1	1	2	3	0	3	3
	Mean Length	159	-	159	51	78	69	-	72	72
	Std. Dev.	-	-	-	-	46	36	-	7	7
	Mean Weight	54	-	54	1.5	12.4	8.8	-	4.6	4.6
	Std. Dev.	-	-	-	-	15.9	12.9	-	1.6	1.6
White crappie	Number	1	1	2	4	108	112	4	9	13
	Mean Length	235	129	182	61	57	58	121	89	99
	Std. Dev.	-	-	75	13	19	19	60	41	48
	Mean Weight	161	22	91	2.5	3.3	3.3	34	14	20
	Std. Dev.	-	-	98	1.6	11.4	11.2	35	29	31
Black crappie	Number	0	0	0	2	2	4	0	0	0
	Mean Length	-	-	-	109	66	88	-	-	-
	Std. Dev.	-	-	-	74	5	49	-	-	-
	Mean Weight	-	-	-	30	3.4	16.9	-	-	-
	Std. Dev.	-	-	-	40	0.4	27.9	-	-	-
Yellow perch	Number	0	0	0	0	1	1	0	1	1
	Mean Length	-	-	-	-	50	50	-	179	179
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	1.1	1.1	-	50.3	50.3
	Std. Dev.	-	-	-	-	-	-	-	-	-
Walleye	Number	0	1	1	1	0	1	0	0	0
	Mean Length	-	28	28	105	-	105	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	0.1	0.1	8	-	8	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Freshwater drum	Number	0	0	0	0	15	15	0	0	0
	Mean Length	-	-	-	-	52	52	-	-	-
	Std. Dev.	-	-	-	-	5	5	-	-	-
	Mean Weight	-	-	-	-	1.3	1.3	-	-	-
	Std. Dev.	-	-	-	-	0.4	0.4	-	-	-
	Total Number	263	47	310	128	336	464	9	46	55

Table 5

Number of Each Fish Species Collected by Electrofishing During Three Sample Periods at Three Locations, Missouri River Between River Mile 661 and 678 in 1983

Common Name	Scientific Name	Dike Field			Revetted Bank			Abandoned Channel		
		Jun	Aug	Oct	Jun	Aug	Oct	Jun	Aug	Oct
Shortnose gar	Lepisosteus platostomus	0	0	0	0	1	1	0	1	3
Gizzard shad	Dorosoma cepedianum	6	1	7	4	0	17	17	2	141
Goldeye	Hiodon alosoides	10	3	6	12	6	9	1	0	0
Carp	Cyprius carpio	0	8	1	3	6	19	2	48	4
River carpsucker	Carpiodes carpio	1	5	4	7	1	9	18	18	6
Quillback	Carpiodes cyprinus	0	0	0	0	0	1	0	0	0
Blue sucker	Cycleptus elongatus	1	2	1	5	9	8	0	0	0
Smallmouth buffalo	Ictiobus bubalus	3	0	0	1	1	1	0	2	4
Bigmouth buffalo	Ictiobus cyprinellus	0	0	0	2	0	4	15	4	17
Shorthead redhorse	Moxostoma macrolepidotum	0	0	2	4	2	6	0	0	0
Black bullhead	Ictalurus melas	0	0	0	0	0	0	6	4	0
Channel catfish	Ictalurus punctatus	0	0	0	0	2	0	0	0	0
Flathead catfish	Pylodictis olivaris	2	7	1	7	45	0	0	0	0
White bass	Morone chrysops	0	0	1	0	0	1	0	0	4
Green sunfish	Lepomis cyanellus	0	0	0	0	0	0	0	0	2
Bluegill	Lepomis macrochirus	0	0	0	0	0	0	2	2	10
Largemouth bass	Micropterus salmoides	0	0	0	0	0	0	2	0	3
White crappie	Pomoxis annularis	0	0	1	0	0	0	0	3	3
Yellow perch	Perca flavescens	0	0	0	0	0	0	0	0	1
Sauger	Stizostedion canadense	0	0	0	0	0	2	0	1	0
Walleye	Stizostedion vitreum	0	0	1	0	0	0	1	0	0
Sauger x walleye hybrid		1	0	0	0	0	0	0	0	0
Freshwater drum	Aplodinotus grunniens	2	0	1	0	0	1	1	0	2
		26	26	25	45	73	79	65	85	200

Table 6

Number, Mean Length (mm), Mean Weight (g), and Standard Deviation

of Fish Caught During Three Sample Periods by Electrofishing

Dike Fields in the Missouri River

Species	Variable	June			August			October		
		Site 1	Site 2	Total	Site 1	Site 2	Total	Site 1	Site 2	Total
Gizzard shad	Number	6	0	6	0	1	1	1	6	7
	Mean Length	238	-	238	-	196	196	172	184	183
	Std. Dev.	75	-	75	-	-	-	-	68	62
	Mean Weight	149	-	149	-	70	70	48	82	78
	Std. Dev.	161	-	161	-	-	-	-	112	103
Goldeye	Number	10	0	10	2	1	3	2	4	6
	Mean Length	313	-	313	378	359	371	360	348	352
	Std. Dev.	34	-	34	12	-	14	30	11	17
	Mean Weight	254	-	254	520	405	482	415	379	391
	Std. Dev.	62	-	62	85	-	89	92	22	48
Carp	Number	0	0	0	1	7	8	0	1	1
	Mean Length	-	-	-	367	463	451	-	525	525
	Std. Dev.	-	-	-	-	28	42	-	-	-
	Mean Weight	-	-	-	900	1289	1240	-	2100	2100
	Std. Dev.	-	-	-	-	296	307	-	-	-
River carpsucker	Number	0	1	1	1	4	5	2	2	4
	Mean Length	-	375	375	320	324	323	367	342	350
	Std. Dev.	-	-	-	-	39	34	-	28	24
	Mean Weight	-	610	610	460	425	432	472	490	481
	Std. Dev.	-	-	-	-	139	121	293	156	192
Blue sucker	Number	0	1	1	1	1	2	0	1	1
	Mean Length	-	711	711	635	652	644	-	565	565
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	3000	3000	2450	2400	2425	-	1800	1800
	Std. Dev.	-	-	-	-	-	-	-	-	-
Smallmouth buffalo	Number	2	1	3	0	0	0	0	0	0
	Mean Length	358	480	398	-	-	-	-	-	-
	Std. Dev.	86	-	93	-	-	-	-	-	-
	Mean Weight	765	1360	963	-	-	-	-	-	-
	Std. Dev.	516	-	501	-	-	-	-	-	-
Shorthead redhorse	Number	0	0	0	0	0	0	1	1	2
	Mean Length	-	-	-	-	-	-	394	250	322
	Std. Dev.	-	-	-	-	-	-	-	-	102
	Mean Weight	-	-	-	-	-	-	790	162	476
	Std. Dev.	-	-	-	-	-	-	-	-	444
Flathead catfish	Number	0	2	2	3	4	7	1	0	1
	Mean Length	-	441	441	269	246	256	326	-	326
	Std. Dev.	-	110	110	58	105	82	-	-	-
	Mean Weight	-	990	990	215	218	216	310	-	310
	Std. Dev.	-	778	778	165	270	213	-	-	-
White bass	Number	0	0	0	0	0	0	1	0	1
	Mean Length	-	-	-	-	-	-	93	-	93
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	9	-	9
	Std. Dev.	-	-	-	-	-	-	-	-	-
Sauger	Number	0	0	0	0	0	0	0	1	1
	Mean Length	-	-	-	-	-	-	-	182	182
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	-	39	39
	Std. Dev.	-	-	-	-	-	-	-	-	-
Walleye	Number	0	0	0	0	0	0	0	1	1
	Mean Length	-	-	-	-	-	-	-	160	160
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	-	28	28
	Std. Dev.	-	-	-	-	-	-	-	-	-
Sauger x Walleye	Number	0	1	1	0	0	0	0	0	0
	Mean Length	-	318	318	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	245	245	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-

(Continued)

Table 6 (Concluded)

Species	Variable	June Site 1	June Site 2	June Total	August Site 1	August Site 2	August Total	October Site 1	October Site 2	October Total
Freshwater drum	Number	2	0	2	0	0	0	1	0	1
	Mean Length	262	-	262	-	-	-	125	-	125
	Std. Dev.	165	-	165	-	-	-	-	-	-
	Mean Weight	320	-	320	-	-	-	16	-	16
	Std. Dev.	411	-	411	-	-	-	-	-	-
	Total Number	20	6	26	8	18	26	9	17	26

Table 7

Number, Mean Length (mm), Mean Weight (g), and Standard Deviation of Fish Caught During Three Sample Periods by Electrofishing Along Revetted Banks on the Missouri River

Species	Variable	June			August			October		
		Site 1	Site 2	Total	Site 1	Site 2	Total	Site 1	Site 2	Total
Shortnose gar	Number	0	0	0	1	0	1	0	1	1
	Mean Length	-	-	-	567	-	567	-	440	440
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	80	-	800	-	310	310
	Std. Dev.	-	-	-	-	-	-	-	-	-
Gizzard shad	Number	1	3	4	0	0	0	4	13	17
	Mean Length	185	228	217	-	-	-	300	309	307
	Std. Dev.	-	78	67	-	-	-	8	65	57
	Mean Weight	53	118	102	-	-	-	271	353	334
	Std. Dev.	-	118	102	-	-	-	31	181	162
Goldeye	Number	4	8	12	3	3	6	5	4	9
	Mean Length	342	325	331	357	300	329	346	365	355
	Std. Dev.	16	24	23	24	50	47	15	21	19
	Mean Weight	298	262	274	413	305	359	357	464	404
	Std. Dev.	45	54	52	127	143	135	38	124	98
Carp	Number	1	2	3	1	5	6	4	15	19
	Mean Length	502	432	455	565	384	414	454	399	411
	Std. Dev.	-	21	43	-	117	128	91	61	69
	Mean Weight	1600	1225	1350	2300	1084	1287	1496	898	1024
	Std. Dev.	-	191	255	-	643	760	971	430	603
River carpsucker	Number	1	6	7	1	0	1	2	7	9
	Mean Length	402	360	366	509	-	509	372	323	334
	Std. Dev.	-	44	43	-	-	-	8	64	60
	Mean Weight	710	578	597	1850	-	1850	558	451	475
	Std. Dev.	-	171	163	-	-	-	46	220	197
Quillback	Number	0	0	0	0	0	0	0	1	1
	Mean Length	-	-	-	-	-	-	-	385	385
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	-	565	565
	Std. Dev.	-	-	-	-	-	-	-	-	-
Blue sucker	Number	3	2	5	2	7	9	6	2	8
	Mean Length	632	634	633	480	657	618	581	543	572
	Std. Dev.	110	4	78	28	96	115	95	83	88
	Mean Weight	2280	2145	2226	890	2913	2463	1839	1472	1748
	Std. Dev.	1320	290	948	184	1130	1326	1500	958	1329
Smallmouth buffalo	Number	1	0	1	1	0	1	0	1	1
	Mean Length	456	-	456	400	-	400	-	360	360
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	1520	-	1520	920	-	920	-	715	715
	Std. Dev.	-	-	-	-	-	-	-	-	-
Bigmouth buffalo	Number	0	2	2	0	0	0	0	4	4
	Mean Length	-	460	460	-	-	-	-	490	490
	Std. Dev.	-	112	112	-	-	-	-	34	34
	Mean Weight	-	1700	1700	-	-	-	-	1988	1988
	Std. Dev.	-	990	990	-	-	-	-	464	464
Shorthead sucker	Number	1	3	4	2	0	2	3	3	6
	Mean Length	409	365	376	400	-	400	341	310	326
	Std. Dev.	-	23	32	25	-	25	69	55	58
	Mean Weight	680	497	542	725	-	725	517	381	449
	Std. Dev.	-	74	110	163	-	163	318	178	242
Channel catfish	Number	0	0	0	0	2	2	0	0	0
	Mean Length	-	-	-	-	244	244	-	-	-
	Std. Dev.	-	-	-	-	97	97	-	-	-
	Mean Weight	-	-	-	-	138	138	-	-	-
	Std. Dev.	-	-	-	-	138	138	-	-	-
Flathead catfish	Number	2	5	7	15	30	45	0	0	0
	Mean Length	374	275	303	283	290	287	-	-	-
	Std. Dev.	16	56	67	74	91	85	-	-	-
	Mean Weight	520	217	304	263	322	303	-	-	-
	Std. Dev.	99	142	192	174	320	279	-	-	-

(Continued)

Table 7 (Concluded)

Species	Variable	June Site 1	June Site 2	June Total	August Site 1	August Site 2	August Total	October Site 1	October Site 2	October Total
White bass	Number	0	0	0	0	0	0	0	1	1
	Mean Length	-	-	-	-	-	-	-	122	122
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	-	20	20
	Std. Dev.	-	-	-	-	-	-	-	-	-
Sauger	Number	0	0	0	0	0	0	1	1	2
	Mean Length	-	-	-	-	-	-	490	536	513
	Std. Dev.	-	-	-	-	-	-	-	-	33
	Mean Weight	-	-	-	-	-	-	975	1620	1298
	Std. Dev.	-	-	-	-	-	-	-	-	456
Freshwater drum	Number	0	0	0	0	0	0	0	1	1
	Mean Length	-	-	-	-	-	-	-	355	355
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	-	680	680
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Total Number	14	31	45	26	47	73	25	54	79

Table 8

Number, Mean Length (mm), Mean Weight (g), and Standard Deviation of Fish Caught During Three Sample Periods by Electrofishing in Abandoned Channels Along the Missouri River

Species	Variable	June			August			October		
		Site 1	Site 2	Total	Site 1	Site 2	Total	Site 1	Site 2	Total
Shortnose gar	Number	0	0	0	1	0	1	3	0	3
	Mean Length	-	-	-	487	-	487	383	-	383
	Std. Dev.	-	-	-	-	-	-	43	-	43
	Mean Weight	-	-	-	365	-	365	199	-	199
	Std. Dev.	-	-	-	-	-	-	72	-	72
Gizzard shad	Number	9	8	17	0	2	2	133	8	141
	Mean Length	257	217	238	-	161	161	140	118	138
	Std. Dev.	93	96	94	-	68	68	20	21	20
	Mean Weight	205	133	171	-	55	55	27	15	26
	Std. Dev.	169	163	165	-	57	57	21	7	21
Goldeye	Number	1	0	1	0	0	0	0	0	0
	Mean Length	305	-	305	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	200	-	200	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Carp	Number	2	0	2	23	25	48	4	0	4
	Mean Length	358	-	358	394	307	349	284	-	284
	Std. Dev.	11	-	11	94	83	98	119	-	119
	Mean Weight	555	-	555	919	519	711	422	-	422
	Std. Dev.	78	-	78	593	438	551	532	-	532
River carpsucker	Number	18	0	18	16	2	18	6	0	6
	Mean Length	266	-	266	286	283	286	260	-	260
	Std. Dev.	53	-	53	54	37	52	78	-	78
	Mean Weight	269	-	269	324	305	322	264	-	264
	Std. Dev.	186	-	186	177	106	168	172	-	172
Smallmouth buffalo	Number	0	0	0	2	0	2	4	0	4
	Mean Length	-	-	-	270	-	270	182	-	182
	Std. Dev.	-	-	-	120	-	120	101	-	101
	Mean Weight	-	-	-	366	-	366	157	-	157
	Std. Dev.	-	-	-	394	-	394	256	-	256
Bigmouth buffalo	Number	14	1	15	2	2	4	17	0	17
	Mean Length	375	160	361	202	312	257	407	-	407
	Std. Dev.	68	-	86	28	141	104	88	-	88
	Mean Weight	915	75	859	185	628	406	1266	-	1266
	Std. Dev.	399	-	441	127	668	469	653	-	653
Black bullhead	Number	0	6	6	0	4	4	0	0	0
	Mean Length	-	222	222	-	228	228	-	-	-
	Std. Dev.	-	26	26	-	13	13	-	-	-
	Mean Weight	-	176	176	-	192	192	-	-	-
	Std. Dev.	-	69	69	-	39	39	-	-	-
White bass	Number	0	0	0	0	0	0	0	4	4
	Mean Length	-	-	-	-	-	-	-	86	86
	Std. Dev.	-	-	-	-	-	-	-	1	1
	Mean Weight	-	-	-	-	-	-	-	6	6
	Std. Dev.	-	-	-	-	-	-	-	1	1
Green sunfish	Number	0	0	0	0	0	0	0	2	2
	Mean Length	-	-	-	-	-	-	-	74	74
	Std. Dev.	-	-	-	-	-	-	-	5	5
	Mean Weight	-	-	-	-	-	-	-	6	6
	Std. Dev.	-	-	-	-	-	-	-	1	1
Bluegill	Number	2	0	2	1	1	2	7	3	10
	Mean Length	146	-	146	145	102	124	147	103	134
	Std. Dev.	6	-	6	-	-	30	29	48	39
	Mean Weight	70	-	70	65	20	42	71	32	59
	Std. Dev.	21	-	21	-	-	32	38	39	41
Largemouth bass	Number	2	0	2	0	0	0	2	1	3
	Mean Length	295	-	295	-	-	-	365	160	297
	Std. Dev.	0	-	0	-	-	-	30	-	120
	Mean Weight	312	-	312	-	-	-	820	47	562
	Std. Dev.	4	-	4	-	-	-	255	-	481

(Continued)

Table 8 (Concluded)

Species	Variable	June Site 1	June Site 2	June Total	August Site 1	August Site 2	August Total	October Site 1	October Site 2	October Total
White crappie	Number	0	0	0	1	2	3	3	0	3
	Mean Length	-	-	-	269	194	219	229	-	229
	Std. Dev.	-	-	-	-	7	44	38	-	38
	Mean Weight	-	-	-	280	105	163	189	-	189
	Std. Dev.	-	-	-	-	14	102	104	-	104
Yellow perch	Number	0	0	0	0	0	0	1	0	1
	Mean Length	-	-	-	-	-	-	134	-	134
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	24	-	24
	Std. Dev.	-	-	-	-	-	-	-	-	-
Sauger	Number	0	0	0	1	0	1	0	0	0
	Mean Length	-	-	-	270	-	270	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	145	-	145	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Walleye	Number	1	0	1	0	0	0	0	0	0
	Mean Length	186	-	186	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	50	-	50	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Freshwater drum	Number	0	1	1	0	0	0	2	0	2
	Mean Length	-	150	150	-	-	-	216	-	216
	Std. Dev.	-	-	-	-	-	-	176	-	176
	Mean Weight	-	35	35	-	-	-	252	-	252
	Std. Dev.	-	-	-	-	-	-	351	-	351
	Total Number	49	16	65	47	38	85	182	18	200

Table 9

Number of Each Fish Species Collected by Hoop Netting During Three Sample Periods at Three Locations, Missouri River Between River Mile 661 and 678 in 1983

		Dike Field			Revetted Bank			Abandoned Channel		
Common Name	Scientific Name	Jun	Aug	Oct	Jun	Aug	Oct	Jun	Aug	Oct
Shovelnose sturgeon	*Scaphirhynchus platorynchus*	4	1	2	12	1	1	1	0	0
Longnose gar	*Lepisosteus osseus*	0	0	1	0	0	3	0	0	0
Shortnose gar	*Lepisosteus platostomus*	0	3	0	0	2	19	4	2	1
Gizzard shad	*Dorosoma cepedianum*	0	0	0	0	0	0	16	5	6
Goldeye	*Hiodon alosoides*	12	1	0	1	2	3	0	0	0
Carp	*Cyprinus carpio*	0	3	0	0	1	0	2	7	2
River carpsucker	*Carpiodes carpio*	0	0	0	5	0	0	46	20	11
Blue sucker	*Cycleptus elongatus*	4	17	46	46	34	75	0	0	0
Smallmouth buffalo	*Ictiobus bubalus*	0	3	0	0	0	1	2	7	0
Bigmouth buffalo	*Ictiobus cyprinellus*	0	0	0	0	0	0	22	2	3
Shorthead redhorse	*Moxostoma macrolepidotum*	0	0	3	0	2	4	1	0	0
Black bullhead	*Ictalurus melas*	0	0	0	0	0	0	27	12	9
Channel catfish	*Ictalurus punctatus*	30	7	6	1	4	9	2	3	2
Flathead catfish	*Pylodictis olivaris*	0	9	4	2	24	4	0	0	0
White bass	*Morone chrysops*	0	0	0	0	1	1	0	0	0
Bluegill	*Lepomis macrochirus*	0	1	0	0	0	0	19	4	0
Smallmouth bass	*Micropterus dolomieui*	0	0	0	0	0	0	0	1	0
Largemouth bass	*Micropterus salmoides*	0	0	0	0	0	0	0	0	1
White crappie	*Pomoxis annularis*	0	4	1	0	1	0	49	26	30
Black crappie	*Pomoxis nigromaculatus*	0	0	0	0	0	1	34	5	4
Walleye	*Stizostedion vitreum*	1	0	0	0	1	0	0	0	0
Freshwater drum	*Aplodinotus grunniens*	1	0	0	0	4	1	0	3	0
		52	49	63	67	77	122	225	97	69

Table 10

Number, Mean Length (mm), Mean Weight (g), and Standard Deviation of Fish Caught During Three Sample Periods with Hoop Nets Set in Dike Fields in the Missouri River

Species	Variable	June			August			October		
		Site 1	Site 2	Total	Site 1	Site 2	Total	Site 1	Site 2	Total
Shovelnose sturgeon	Number	2	2	4	1	0	1	1	1	2
	Mean Length	676	555	616	632	-	632	537	599	568
	Std. Dev.	47	61	83	-	-	-	-	-	44
	Mean Weight	740	400	570	690	-	690	260	610	435
	Std. Dev.	99	226	24[illegible]	-	-	-	-	-	247
Longnose gar	Number	0	0	0	0	0	0	0	1	1
	Mean Length	-	-	-	-	-	-	-	-	437
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	-	-	179
	Std. Dev.	-	-	-	-	-	-	-	-	-
Shortnose gar	Number	0	0	0	2	1	3	0	0	0
	Mean Length	-	-	-	595	573	588	-	-	-
	Std. Dev.	-	-	-	35	-	28	-	-	-
	Mean Weight	-	-	-	845	700	797	-	-	-
	Std. Dev.	-	-	-	262	-	203	-	-	-
Goldeye	Number	12	0	12	1	0	1	0	0	0
	Mean Length	329	-	329	340	-	340	-	-	-
	Std. Dev.	30	-	30	-	-	-	-	-	-
	Mean Weight	283	-	283	315	-	315	-	-	-
	Std. Dev.	77	-	77	-	-	-	-	-	-
Carp	Number	0	0	0	0	3	3	0	0	0
	Mean Length	-	-	-	-	499	499	-	-	-
	Std. Dev.	-	-	-	-	50	50	-	-	-
	Mean Weight	-	-	-	-	1600	1600	-	-	-
	Std. Dev.	-	-	-	-	550	550	-	-	-
Blue sucker	Number	2	2	4	9	8	17	36	10	46
	Mean Length	382	390	386	455	551	500	607	587	603
	Std. Dev.	66	4	38	133	49	111	66	67	66
	Mean Weight	368	422	395	589	1439	989	2321	1970	2444
	Std. Dev.	180	74	117	393	390	578	768	718	763
Smallmouth buffalo	Number	0	0	0	0	3	3	0	0	0
	Mean Length	-	-	-	-	442	442	-	-	-
	Std. Dev.	-	-	-	-	37	37	-	-	-
	Mean Weight	-	-	-	-	1253	1253	-	-	-
	Std. Dev.	-	-	-	-	387	387	-	-	-
Shorthead redhorse	Number	0	0	0	0	0	0	1	2	3
	Mean Length	-	-	-	-	-	-	220	229	226
	Std. Dev.	-	-	-	-	-	-	-	20	15
	Mean Weight	-	-	-	-	-	-	115	143	134
	Std. Dev.	-	-	-	-	-	-	-	30	26
Channel catfish	Number	13	17	30	5	2	7	3	3	6
	Mean Length	332	312	320	318	374	334	255	363	309
	Std. Dev.	106	68	85	75	58	71	69	95	95
	Mean Weight	387	262	316	320	455	359	134	399	267
	Std. Dev.	448	232	342	317	262	288	114	306	252
Flathead catfish	Number	0	0	0	3	6	9	3	1	4
	Mean Length	-	-	-	360	460	426	426	310	397
	Std. Dev.	-	-	-	18	106	98	70	-	82
	Mean Weight	-	-	-	443	1108	887	1000	280	820
	Std. Dev.	-	-	-	21	558	553	541	-	570
Bluegill	Number	0	0	0	1	0	1	0	0	0
	Mean Length	-	-	-	164	-	164	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	85	-	85	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
White crappie	Number	0	0	0	3	1	4	1	0	1
	Mean Length	-	-	-	182	238	196	185	-	185
	Std. Dev.	-	-	-	42	-	44	-	-	-
	Mean Weight	-	-	-	83	185	109	65	-	65
	Std. Dev.	-	-	-	67	-	74	-	-	-

(Continued)

Table 10 (Concluded)

Species	Variable	June Site 1	June Site 2	June Total	August Site 1	August Site 2	August Total	October Site 1	October Site 2	October Total
Walleye	Number	1	0	1	0	0	0	0	0	0
	Mean Length	437	-	437	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	595	-	595	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Freshwater drum	Number	1	0	1	0	0	0	0	0	0
	Mean Length	314	-	314	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	350	-	350	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Total Number	31	21	52	25	24	49	45	18	63

Table 11

Number, Mean Length (mm), Mean Weight (g), and Standard Deviation of Fish Caught During Three Sample Periods with Hoop Nets Set Along Revetted Banks on the Missouri River

Species	Variable	June			August			October		
		Site 1	Site 2	Total	Site 1	Site 2	Total	Site 1	Site 2	Total
Shovelnose sturgeon	Number	1	11	12	1	0	1	1	0	1
	Mean Length	583	639	634	640	-	640	582	-	582
	Std. Dev.	-	119	115	-	-	-	-	-	-
	Mean Weight	435	591	578	620	-	620	390	-	390
	Std. Dev.	-	459	440	-	-	-	-	-	-
Longnose gar	Number	0	0	0	0	0	0	3	0	3
	Mean Length	-	-	-	-	-	-	653	-	653
	Std. Dev.	-	-	-	-	-	-	217	-	217
	Mean Weight	-	-	-	-	-	-	975	-	975
	Std. Dev.	-	-	-	-	-	-	964	-	964
Shortnose gar	Number	0	0	0	0	2	2	15	4	19
	Mean Length	-	-	-	-	594	594	486	469	482
	Std. Dev.	-	-	-	-	114	114	63	68	62
	Mean Weight	-	-	-	-	732	732	388	394	389
	Std. Dev.	-	-	-	-	435	435	157	172	155
Goldeye	Number	0	1	1	1	1	2	2	1	3
	Mean Length	-	358	358	322	338	330	351	335	346
	Std. Dev.	-	-	-	-	-	11	8	-	11
	Mean Weight	-	440	440	250	335	292	400	365	388
	Std. Dev.	-	-	-	-	-	60	14	-	23
Carp	Number	0	0	0	0	1	1	0	0	0
	Mean Length	-	-	-	-	470	470	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	1450	1450	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
River carpsucker	Number	0	5	5	0	0	0	0	0	0
	Mean Length	-	379	379	-	-	-	-	-	-
	Std. Dev.	-	25	25	-	-	-	-	-	-
	Mean Weight	-	646	646	-	-	-	-	-	-
	Std. Dev.	-	200	200	-	-	-	-	-	-
Blue sucker	Number	23	23	46	11	23	34	29	46	75
	Mean Length	592	544	568	602	612	609	618	611	614
	Std. Dev.	101	111	108	54	81	73	51	70	63
	Mean Weight	1662	1316	1489	2059	2197	2153	2471	2436	2449
	Std. Dev.	881	791	846	642	1147	1004	780	1039	942
Smallmouth buffalo	Number	0	0	0	0	0	0	1	0	1
	Mean Length	-	-	-	-	-	-	465	-	465
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	1480	-	1480
	Std. Dev.	-	-	-	-	-	-	-	-	-
Shorthead redhorse	Number	0	0	0	1	1	2	1	3	4
	Mean Length	-	-	-	340	319	330	350	264	285
	Std. Dev.	-	-	-	-	-	15	-	73	74
	Mean Weight	-	-	-	460	270	365	465	254	307
	Std. Dev.	-	-	-	-	-	134	-	233	217
Channel catfish	Number	1	0	1	2	2	4	3	6	9
	Mean Length	612	-	612	294	289	291	293	273	279
	Std. Dev.	-	-	-	40	78	51	60	62	58
	Mean Weight	2500	-	2500	180	208	194	207	158	174
	Std. Dev.	-	-	-	71	159	102	117	136	125
Flathead catfish	Number	0	2	2	17	7	24	3	1	4
	Mean Length	-	426	426	353	456	383	356	365	358
	Std. Dev.	-	52	52	43	102	79	14	-	12
	Mean Weight	-	805	805	439	1144	644	438	490	451
	Std. Dev.	-	325	325	174	775	534	13	-	28
White bass	Number	0	0	0	0	1	1	1	0	1
	Mean Length	-	-	-	-	245	245	167	-	167
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	215	215	62	-	62
	Std. Dev.	-	-	-	-	-	-	-	-	-

(Continued)

Table 11 (Concluded)

Species	Variable	June Site 1	June Site 2	June Total	August Site 1	August Site 2	August Total	October Site 1	October Site 2	October Total
White crappie	Number	0	0	0	0	1	1	0	0	0
	Mean Length	-	-	-	-	230	230	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	155	155	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Black crappie	Number	0	0	0	0	0	0	1	0	1
	Mean Length	-	-	-	-	-	-	250	-	250
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	275	-	275
	Std. Dev.	-	-	-	-	-	-	-	-	-
Walleye	Number	0	0	0	0	1	1	0	0	0
	Mean Length	-	-	-	-	490	490	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	1040	1040	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Freshwater drum	Number	0	0	0	3	1	4	1	0	1
	Mean Length	-	-	-	207	204	206	150	-	150
	Std. Dev.	-	-	-	12	-	10	-	-	-
	Mean Weight	-	-	-	103	105	104	42	-	42
	Std. Dev.	-	-	-	25	-	21	-	-	-
	Total Number	25	42	67	36	41	77	61	61	122

Table 12

Number, Mean Length (mm), Mean Weight (g), and Standard Deviation of Fish Caught During Three Sample Periods with Hoop Nets Set in Abandoned Channels Along the Missouri River

Species	Variable	June			August			October		
		Site 1	Site 2	Total	Site 1	Site 2	Total	Site 1	Site 2	Total
Shovelnose sturgeon	Number	1	0	1	0	0	0	0	0	0
	Mean Length	515	-	515	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	320	-	320	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Shortnose gar	Number	0	4	4	0	2	2	1	0	1
	Mean Length	-	596	596	-	578	578	362	-	362
	Std. Dev.	-	87	87	-	64	64	-	-	-
	Mean Weight	-	655	655	-	682	682	158	-	158
	Std. Dev.	-	258	258	-	272	272	-	-	-
Gizzard shad	Number	12	4	16	1	4	5	0	6	6
	Mean Length	306	259	294	236	248	246	-	143	143
	Std. Dev.	40	82	54	-	32	29	-	11	11
	Mean Weight	296	194	250	155	152	153	-	24	24
	Std. Dev.	109	174	126	-	36	31	-	5	5
Carp	Number	1	1	2	3	4	7	1	1	2
	Mean Length	407	335	371	441	252	333	186	285	236
	Std. Dev.	-	-	51	3	42	106	-	-	70
	Mean Weight	795	497	646	1007	229	562	92	315	204
	Std. Dev.	-	-	211	81	88	423	-	-	158
River carpsucker	Number	39	7	46	13	7	20	11	0	11
	Mean Length	311	285	307	346	283	324	364	-	364
	Std. Dev.	49	88	56	44	90	69	47	-	47
	Mean Weight	387	367	384	503	345	447	623	-	623
	Std. Dev.	176	280	192	181	267	222	264	-	264
Smallmouth buffalo	Number	2	0	2	0	7	7	0	0	0
	Mean Length	262	-	262	-	274	274	-	-	-
	Std. Dev.	67	-	67	-	109	109	-	-	-
	Mean Weight	282	-	282	-	485	485	-	-	-
	Std. Dev.	202	-	202	-	513	513	-	-	-
Bigmouth buffalo	Number	19	3	22	2	0	2	3	0	3
	Mean Length	334	160	311	499	-	499	311	-	311
	Std. Dev.	102	10	112	58	-	58	75	-	75
	Mean Weight	685	72	602	1975	-	1975	528	-	528
	Std. Dev.	755	16	732	601	-	601	315	-	315
Shorthead redhorse	Number	1	0	1	0	0	0	0	0	0
	Mean Length	243	-	243	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	146	-	146	-	-	-	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Black bullhead	Number	2	25	27	8	4	12	0	9	9
	Mean Length	215	202	203	215	240	224	-	222	222
	Std. Dev.	58	41	41	10	16	17	-	33	33
	Mean Weight	176	143	145	130	186	149	-	129	129
	Std. Dev.	149	48	55	34	69	53	-	39	39
Channel catfish	Number	2	0	2	2	1	3	2	0	2
	Mean Length	278	-	278	200	235	212	208	-	208
	Std. Dev.	32	-	32	64	-	49	13	-	13
	Mean Weight	163	-	163	60	100	73	62	-	62
	Std. Dev.	59	-	59	50	-	42	13	-	13
Bluegill	Number	9	10	19	0	4	4	0	0	0
	Mean Length	134	124	129	-	145	145	-	-	-
	Std. Dev.	23	32	28	-	22	22	-	-	-
	Mean Weight	74	53	63	-	70	70	-	-	-
	Std. Dev.	53	27	41	-	29	29	-	-	-

(Continued)

Table 12 (Concluded)

Species	Variable	June			August			October		
		Site 1	Site 2	Total	Site 1	Site 2	Total	Site 1	Site 2	Total
Smallmouth buffalo	Number	0	0	0	0	1	1	0	0	0
	Mean Length	-	-	-	-	254	254	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	245	245	-	-	-
	Std. Dev.	-	-	-	-	-	-	-	-	-
Largemouth bass	Number	0	0	0	0	0	0	0	1	1
	Mean Length	-	-	-	-	-	-	-	32	32
	Std. Dev.	-	-	-	-	-	-	-	-	-
	Mean Weight	-	-	-	-	-	-	-	360	360
	Std. Dev.	-	-	-	-	-	-	-	-	-
White crappie	Number	39	10	49	11	15	26	16	14	30
	Mean Length	209	210	209	163	186	173	202	196	199
	Std. Dev.	43	53	44	14	30	26	31	27	29
	Mean Weight	120	133	123	55	89	75	110	107	109
	Std. Dev.	98	93	96	16	77	61	77	59	68
Black crappie	Number	30	4	34	4	1	5	2	2	4
	Mean Length	198	212	200	159	180	163	158	202	180
	Std. Dev.	32	15	31	25	-	24	1	56	41
	Mean Weight	101	122	104	62	90	68	53	62	58
	Std. Dev.	49	21	46	39	-	36	4	11	9
Freshwater drum	Number	0	0	0	3	0	3	0	0	0
	Mean Length	-	-	-	327	-	327	-	-	-
	Std. Dev.	-	-	-	10	-	10	-	-	-
	Mean Weight	-	-	-	458	-	458	-	-	-
	Std. Dev.	-	-	-	38	-	38	-	-	-
	Total Number	157	68	225	47	50	97	36	33	69

Table 13

Results of ANOVA on Hoop Netting Data Testing for Differences Between Sites in the Same Habitat During Three Sample Periods at Three Locations, Missouri River Between River Miles 661 and 678 in 1983 (N=8; n = no significant difference; s = significant difference at P < 0.05; - means none collected)

Species	June			August			October		
	DF	RV	AC	DF	RV	AC	DF	RV	AC
Shovelnose sturgeon	n	n	n	n	n	-	n	n	-
Longnose gar	-	-	-	-	-	-	n	n	-
Shortnose gar	-	-	s	n	n	n	-	n	n
Gizzard shad	-	-	n	-	-	n	-	-	s
Goldeye	s	n	-	n	n	-	-	n	-
Carp	-	-	n	n	n	n	-	-	n
River carpsucker	-	-	s	-	-	n	-	-	s
Blue sucker	n	n	-	n	n	-	n	n	-
Smallmouth buffalo	-	-	n	n	-	s	-	n	-
Bigmouth buffalo	-	-	s	-	-	n	-	-	n
Shorthead redhorse	-	-	n	-	n	-	n	n	-
Black bullhead	-	-	s	-	-	n	-	-	s
Channel catfish	n	n	n	n	n	n	n	n	n
Flathead catfish	-	-	-	n	n	-	n	n	-
White bass	-	-	-	-	n	-	-	n	-
Bluegill	-	-	n	n	-	n	-	-	-
Smallmouth bass	-	-	-	-	-	n	-	-	-
Largemouth bass	-	-	-	-	-	-	-	-	n
White crappie	-	-	s	-	n	n	n	-	n
Black crappie	-	-	s	-	-	n	-	n	n
Walleye	n	-	-	-	n	-	-	-	-
Freshwater drum	n	-	-	-	n	n	-	n	-
Site total	s	s	s	n	s	n	s	n	n

Table 14

Results of ANOVA on Hoop Netting Data Testing for Differences Among Habitats for the Same Month at Three Locations, Missouri River Between River Miles 661 and 678 in 1983 (Shared letters for locations mean no significant differences, P > 0.05; - means none collected; N=8)

Species	June			August			October		
	DF	RV	AC	DF	RV	AC	DF	RV	AC
Shovelnose sturgeon	a	a	a	a	a	a	a	a	a
Longnose gar	-	-	-	-	-	-	a	a	a
Shortnose gar	a	a	a	a	a	a	a	a	a
Gizzard shad	a	a	a	a	a	a	a	a	a
Goldeye	a	a	a	ab	b	a	a	b	a
Carp	-	-	-	a	a	a	-	-	-
River carpsucker	a	a	a	a	a	b	a	a	a
Blue sucker	a	b	a	ab	b	a	a	a	a
Smallmouth buffalo	a	a	a	a	a	a	a	a	a
Bigmouth buffalo	a	a	a	a	a	a	a	a	a
Shorthead redhorse	a	a	a	a	b	a	a	a	a
Black bullhead	a	a	a	a	a	b	a	a	a
Channel catfish	a	b	b	a	a	a	a	a	a
Flathead catfish	a	a	a	ab	b	a	a	a	a
White bass	-	-	-	a	a	a	a	a	a
Bluegill	a	a	b	a	a	a	-	-	-
Smallmouth bass	-	-	-	a	a	a	-	-	-
Largemouth bass	-	-	-	-	-	-	a	a	a
White crappie	a	a	a	a	a	b	a	a	b
Black crappie	a	a	a	a	a	a	a	a	b
Walleye	a	a	a	a	a	a	-	-	-
Freshwater drum	a	a	a	a	a	a	a	a	a
Location total	a	a	a	a	b	b	a	a	a

Table 15

Results of ANOVA on Hoop Netting Data Testing for Differences Among Sample Periods for the Same Habitat Sampled Along the Missouri River Between River Miles 661 and 678 in 1983 (Shared letters for dates mean no significant differences, P > 0.05; - means none collected)

	Abandoned Channels			Dike Fields			Revetted Banks		
Species	June	Aug.	Oct.	June	Aug.	Oct.	June	Aug.	Oct.
Shovelnose sturgeon	a	a	a	a	b	ab	a	a	a
Longnose gar	-	-	-	a	a	a	a	a	a
Shortnose gar	a	a	a	a	b	a	a	a	a
Gizzard shad	a	a	a	-	-	-	-	-	-
Goldeye	-	-	-	a	a	a	a	a	a
Carp	a	b	a	a	a	a	a	a	a
River carpsucker	a	a	a	-	-	-	a	a	a
Blue sucker	-	-	-	a	a	a	a	a	a
Smallmouth buffalo	a	a	a	a	a	a	a	a	a
Bigmouth buffalo	a	a	a	-	-	-	-	-	-
Shorthead redhorse	a	a	a	a	a	b	a	a	a
Black bullhead	a	a	a	-	-	-	-	-	-
Channel catfish	a	a	a	a	b	b	a	a	a
Flathead catfish	-	-	-	a	a	a	a	a	a
White bass	-	-	-	-	-	-	a	a	a
Bluegill	a	b	b	a	a	a	-	-	-
Smallmouth bass	a	a	a	-	-	-	-	-	-
Largemouth bass	a	a	a	-	-	-	-	-	-
White crappie	a	a	a	a	a	a	a	a	a
Black crappie	a	a	a	-	-	-	a	a	a
Walleye	-	-	-	a	a	a	-	-	-
Freshwater drum	a	a	a	a	a	a	a	a	a
Date totals	a	a	a	a	a	a	a	ab	b

Table 16

Distribution of Sampling Effort* During Larval Fish Collection in 1983

	Abandoned Channel (AC1)		Revetted Bank (RV2)		Mid-Channel (MC2)		Dike Field (DF2)	
DATE	A01	C01	A01	E01	A01	C01	A01	K01
4/20	XX	XX	XX	XX	XX	XX	XX	XX
4/28	XX	XX	XX	XX	XX	XX	XX	XX
5/04	XX	XX	XX	XX	XX	XX	XX	XX
5/11	XX	XX	XX	XX	XX	XX	XX	XX
5/18	XX	XX	XX	XX	XX	XX	XX	XX
5/26	XX	XX	XX	XX	XX	XX	XX	XX
6/02	XX		XX	XX	XX	XX	XX	XX
6/09	XX	XX	XX	XX	XX	XX	XX	XX
6/16	XX	XX	XX	XX	XX	XX	XX	XX
6/22	XX	XX	XX	XX	XX	XX	XX	XX
6/30	XX	XX	XX	XX	XX	XX	XX	XX
7/06								
7/14	XX	XX	XX	XX	XX	XX	XX	XX
7/21	XX	XX	XX	XX	XX	XX	XX	XX
7/29	XX	XX	XX	XX	XX	XX	XX	XX
8/04	XX	XX	XX	XX	XX	XX	XX	XX
8/11	XX	XX	XX	XX	XX	XX	XX	XX
8/18	XX	XX	XX	XX	XX	XX	XX	XX

* X's denote a single larval tow (net push); A01, C01, E01, and K01 are larval fish stations (see Figures 2 and 3).

Table 17

Breakdown of the Number and Types of Larval Fish Collected, April - August 1983

Specimen Type	Number	%	Ratio
Total Fish Collected	5302	100.0	
Damaged Fish	213	4.0	Non-damaged:Damaged
Non-damaged	5089	96.0	24:1
Larvae	4749	93.3	L:J = 14:1
Juveniles	340	6.7	
Prolarvae	1332	26.2	Pro:Post = 1:2.8
Postlarvae	3757	73.8	

Table 18

Summary of Abundance and Composition of Larvae and Juveniles

for the Four Sampling Locations (Abandoned Channel, Revetment, Mid-channel, Dike Field)

Taxon	Number of Specimens	Total Catch/Effort (No./100m ^{3})	% of all Specimens	% Occurrence in Samples	Temporal Occurrence	Peak Abundance
Dorosoma cepedianum	1579	21.0	29.8	25.2	5/18-8/11	6/16,7/14
Osmerus mordax	2	<0.1	.04	.74	4/20-6/16	----
Notropis atherinoides*	38	0.4	.72	3.3	4/20-8/4	----
Notropis strameneus*	3	<0.1	.06	.74	5/18-6/16	----
Pimephales promelas*	10	<0.1	.19	3.0	6/22-8/14	----
Cyprinus carpio	260	3.8	5.1	18.5	6/16-7/21	6/30
Other cyprinids	121	1.3	2.3	20.7	6/9-8/18	----
Moxostoma spp.	4	<0.1	.08	1.1	6/16	----
Catostomus commersoni	1	<0.1	.02	.37	6/16	----
Cycleptus elongatus	15	0.2	.28	5.6	5/11-6/16	----
Ictiobinae	686	7.7	13.0	51.1	5/11-8/4	6/9
Ictiobus spp.	25	0.3	.47	8.1	5/11-7/14	----
Carpiodes spp.	591	6.6	11.1	30.0	6/2-8/4	----
Unident. Ictiobinae	70	0.8	1.3	13.0	5/11-7/21	----
Ictaluris punctatus**	1	<0.1	.02	.37	5/4	----
Morone spp.**	1	<0.1	.02	.37	7/14	----
Pomoxis annularis	8	<0.1	.15	3.0	5/26-6/16†	----
Lepomis spp.	1250	13.6	23.6	13.0	6/30-8/18	7/14
Perca flavescens	13	0.1	.25	4.1	5/11-6/22	----
Stizostedion spp.	55	0.5	1.0	8.1	4/28-6/16	5/18
Etheostoma nigrum	13	0.1	.25	4.8	5/26-6/22	----
Other Etheostoma	1	<0.1	.02	.37	6/9	----
Aplodinotus grunniens	1020	13.5	19.2	25.6	6/16-8/18	6/30

* Only juveniles identified; larvae probably present but not identified.

** Found as juveniles only.

† This temporal occurrence for larvae only; one juvenile was found as late as 8/18.

Table 19

Summary of Abundance and Composition of Larvae and Juveniles for the Four Sampling Locations (Abandoned Channel, Revetment, Mid-channel, Dike Field)

Transect	Avg. Vol. of Water Sampled(m^3)	No. of Taxa Present	Total Catch/Effort (No./100m^3)	% of all Specimens (all sites)	% of all Specimens (main channel)	Dominant Species and % Between Sites	Diversity Index
AC			156.5	54.5	----	Lepomis 99.0	.54
A	33.8	10		24.4		D. cepedianum 95.7	
C	36.5	13		30.1			
RV			70.8	24.8	59.7	Stizostedion 78.2	.63
A	36.6	13		9.0		A. grunniens 75.1	
E	35.9	13		15.8			
MC			15.6	5.8	14.0	None over 75%	.71
A	35.7	7		3.0			
C	36.0	7		2.8			
DF			27.9	10.9	26.3	None over 75%	.71
A	36.4	16		6.5			
K	38.1	13		4.4			

Table 20

Species Composition by Sampling Site (Species listed in descending order of relative frequency)

ABANDONED CHANNEL A	ABANDONED CHANNEL C	REVETMENT A	REVETMENT E
Dorosoma cepedianum	Dorosoma cepedianum	Aplodinotus grunniens	Aplodinotus grunniens
Lepomis spp.	Lepomis spp.	Carpiodes spp.	Carpiodes spp.
Notropis atheriniodes	Other cyprinid	Cyprinus carpio	Cyprinus carpio
Other cyprinid	Notropis atherinoides	Other cyprinid	Stizostedion spp.
Perca flavescens	Aplodinotus grunniens	Stizostedion spp.	Other cyprinid
Cyprinus carpio	Pimephales promelas	Dorosoma cepedianum	Dorosoma cepedianum
Pomoxis annularis	Pomoxis annularis	Lepomis spp.	Ictiobus spp.
Notropis stramineus	Perca flavescens	Ictiobus spp.	Lepomis spp.
Pimephales promelas	Cyprinus carpio	Cycleptus elongatus	Cycleptus elongatus
Ictiobus spp.	Notropis stramineus	Perca flavescens	Moxostoma spp.
	Ictiobus spp.	Etheostoma nigrum	Etheostoma nigrum
	Stizostedion spp.	Pimephales promelas	Perca flavescens
	Etheostoma nigrum	Osmerus mordax	Etheostoma spp.

MID-CHANNEL A	MID-CHANNEL C	DIKE FIELD A	DIKE FIELD K
Aplodinotus grunniens	Aplodinotus grunniens	Aplodinotus grunniens	Aplodinotus grunniens
Cyprinus carpio	Cyprinus carpio	Cyprinus carpio	Cyprinus carpio
Carpiodes spp.	Carpiodes spp.	Carpiodes spp.	Carpiodes spp.
Other cyprinid	Other cyprinid	Dorosoma cepedianum	Dorosoma cepedianum
Cycleptus elongatus	Ictiobus spp.	Other cyprinid	Other cyprinid
Ictiobus spp.	Etheostoma nigrum	Stizostedion spp.	Ictiobus spp.
Dorosoma cepedianum	Dorosoma cepedianum	Ictiobus spp.	Stizostedion spp.
		Cycleptus elongatus	Lepomis spp.
		Etheostoma nigrum	Cycleptus elongatus
		Perca flavescens	Perca flavescens
		Osmerus mordax	Etheostoma nigrum
		Ictaluris punctatus	Pomoxis annularis
		Pomoxis annularis	Pimephales promelas
		Catostomus commersoni	
		Moxostoma spp.	
		Morone spp.	

Table 21

Species Composition by Sampling Site (%'s represent the proportion of each species found at a given site)

	LOCATION															
	AC-A		AC-C		RV-A		RV-E		MC-A		MC-C		DF-A		DF-K	
TAXON	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
D. cepedianum	653	(41.4)	858	(54.3)	11	(<1.0)	13	(<1.0)	1	(<1.0)	1	(<1.0)	27	(1.7)	15	(<1.0)
O. mordax	0		0		1	(50.0)	0		0		0		1	(50.0)	0	
N. atherinoides*	19	(50.0)	19	(50.0)	0		0		0		0		0		0	
N. stramineus*	1	(33.3)	2	(66.7)	0		0		0		0		0		0	
P. promelas*	1	(10.0)	7	(70.0)	1	(10.0)	0		0		0		0		1	(10.0)
C. carpio	2	(<1.0)	3	(1.1)	60	(22.4)	65	(24.3)	47	(17.5)	46	(17.2)	28	(10.4)	17	(6.3)
Other cyprinid	15	(12.4)	26	(21.5)	25	(20.7)	20	(16.5)	5	(4.1)	2	(1.7)	15	(12.4)	13	(10.7)
Moxostoma spp.	0		0		0		3	(75.0)	0		0		1	(25.0)	0	
C. commersoni	0		0		0		0		0		0		1	(100.0)	0	
C. elongatus	0		0		4	(26.7)	4	(26.7)	2	(13.3)	0		3	(20.0)	2	(13.3)
Ictiobinae	1	(<1.0)	1	(<1.0)	88	(12.8)	194	(28.3)	40	(5.8)	43	(6.3)	191	(27.8)	128	(18.7)
Ictiobus	1	(4.0)	1	(4.0)	4	(16.0)	7	(28.0)	1	(4.0)	2	(8.0)	5	(20.0)	4	(16.0)
Carpiodes	0		0		74	(12.5)	161	(27.2)	35	(5.9)	36	(6.1)	174	(29.4)	111	(18.8)
? Ictiobinae	0		0		10	(14.3)	26	(37.1)	4	(5.7)	5	(7.1)	12	(17.1)	13	(18.6)
I. punctatus**	0		0		0		0		0		0		1	(100.0)	0	
Morone spp.	0		0		0		0		0		0		1	(100.0)	0	
P. annularis	2	(25.0)	4	(50.0)	0		0		0		0		1	(12.5)	1	(12.5)
Lepomis spp.	597	(47.8)	640	(51.2)	6	(<1.0)	4	(<1.0)	0		0		0		3	(<1.0)
P. flavescens	3	(23.0)	2	(15.4)	2	(15.4)	2	(15.4)	0		0		2	(15.4)	2	(15.4)
Stizostedion spp.	0		1	(1.8)	20	(36.4)	23	(46.1)	0		0		7	(12.7)	4	(7.3)
E. nigrum	0		1	(7.8)	2	(15.4)	3	(23.1)	0		2	(15.4)	3	(23.1)	2	(15.4)
? Etheostoma	0		0		0		1	(100.0)	0		0		0		0	
A. grunniens	0		30	(2.9)	256	(25.1)	510	(50.0)	64	(6.3)	52	(5.1)	62	(6.1)	46	(4.5)

* Only juveniles identified; larvae probably present but not identified.

** Found only as juveniles.

Table 22

Distribution of Size for Selected Species

LOCATION & SPECIES	SIZE CLASS* 0-5 n	%	5.1-10 n	%	10.1-15 n	%	15.1-20 n	%	20.1 & Up n	%
AC										
D. cepedianum	11	<1.0	498	36.9	457	33.9	299	22.2	84	6.2
A. grunniens	26	86.6	4	13.4	0	0.0	0	0.0	0	0.0
Lepomis spp.	42	3.5	802	67.7	296	25.0	43	3.6	1	<1.0
C. carpio	-----		-----		-----		-----		-----	
Cyprinidae**	0	0.0	18	22.2	18	22.2	13	16.0	32	39.5
Ictiobinae	-----		-----		-----		-----		-----	
RV										
D. cepedianum	0	0.0	8	34.9	13	56.5	2	8.7	0	0.0
A. grunniens	479	61.6	294	37.8	3	<1.0	0	0.0	1	<1.0
Lepomis spp.	-----		-----		-----		-----		-----	
C. carpio	5	4.0	119	94.4	0	0.0	1	<1.0	1	<1.0
Cyprinidae**	35	74.5	11	23.4	0	0.0	0	0.0	1	2.1
Ictiobinae	0	0.0	271	98.9	1	<1.0	0	0.0	2	<1.0
MC										
D. cepedianum	-----		-----		-----		-----		-----	
A. grunniens	21	18.1	79	68.1	15	12.9	1	<1.0	0	0.0
Lepomis spp.	-----		-----		-----		-----		-----	
C. carpio	9	9.9	27	29.7	0	0.0	1	1.1	54	59.3
Cyprinidae**	-----		-----		-----		-----		-----	
Ictiobinae	1	1.2	72	86.7	4	4.8	4	4.8	2	2.4
DF										
D. cepedianum	0	0.0	6	14.6	19	46.3	13	31.7	3	7.3
A. grunniens	51	58.6	34	39.1	2	2.3	0	0.0	0	0.0
Lepomis spp.	-----		-----		-----		-----		-----	
C. carpio	4	8.7	37	80.4	1	2.2	0	0.0	4	8.7
Cyprinidae**	20	71.4	8	28.6	0	0.0	0	0.0	0	0.0
Ictiobinae	1	<1.0	310	98.7	1	<1.0	1	<1.0	1	<1.0

* Size class given as total length in mm.
** Excluding Cyprinus carpio.

Table 23

Frequency of Occurrence (F), Mean Density ($\bar{X}$), and Standard Error of the Mean (SE), for the Invertebrates Collected in Each Habitat in Each Sampling Period. Sampling Periods: J = June, A = August, O = October

		SEDIMENTS (No./m ^{2})												ROCK SURFACES (No./m ^{2})											
		AC1 N=16			AC2 N=16			DF1 N=16			DF2 N=16			DFA N=4			DFB N=4			RV1 N=4			RV2 N=4		
TAXA		F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE
DIPTERA																									
Chironomidae																									
Chironomidae P.	J	1	3	3	1	3	3				1	3	3	4	32	11	4	68	46	4	51	41	4	62	40
	A										1	3	3	3	8	3	4	16	7	1	1	1	1	3	3
	O										1	3	3	3	9	4	4	52	17	4	23	8	2	32	26
Chironomus	J	14	458	193	9	97	40				1	3	3	1	2	2	4	10	4				2	2	1
	A	11	138	47	9	38	16																1	1	1
	O	11	525	273	5	178	101										1	1	1				1	1	1
Coelotanypus	J	4	16	9	10	138	48	1	5	5				1	1	1									
	A	6	38	16	15	291	53																		
	O	13	199	73	12	1141	373																		
Cricotopus	J	7	32	11	5	52	28	1	3	3				4	87	21	3	136	67	4	143	75	4	163	29
	A				2	8	6	1	3	3				1	1	1	1	1	1	1	1	1			
	O				1	5	5							1	2	2	1	1	1	2	2	1			
Cryptochironomus	J				1	3	3	3	19	10	2	14	9	1	1	1	1	1	1	1	1	1			
	A	7	54	20	8	35	12	3	11	6				3	7	3	2	4	2	1	1	1	1	1	1
	O	13	191	61	8	70	25	4	11	5							4	8	4	3	10	6	3	4	1
Dicrotendipes	J													2	4	3	1	1	1				2	2	1
	A							1	3	3				2	3	2	2	5	3	1	1	1	1	2	2
	O													2	5	4	2	18	11	2	5	4	2	4	2
Glyptotendipes	J																1	1	1	1	4	4			
	A																								
	O	1	11	11	1	3	3							2	3	2	2	6	5				1	1	1
Hydrobaenus	J													2	3	2	4	8	4	3	14	10	2	3	2
	A																								
	O																								
Larsia	J																								
	A	2	14	9	1	5	5																		
	O																								

(continued)

Table 23 (continued)

		SEDIMENTS (No./m²)												ROCK SURFACES (No./m²)											
		AC1 N=16			AC2 N=16			DF1 N=16			DF2 N=16			DFA N=4			DFB N=4			RV1 N=4			RV2 N=4		
TAXA		F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE
Nanocladius	J													4	88	54	3	125	43	4	105	47	4	111	42
	A													3	13	8	4	24	16				1	1	1
	O													3	5	3	3	70	23	2	5	4	3	27	17
Natarsia	J																								
	A										2	8	6	3	11	7	1	1	1	3	5	3			
	O													1	2	2									
Orthocladius	J										1	5	5	4	97	35	3	242	134	4	252	112	4	202	40
	A	1	3	3										1	3	3	1	4	4	2	2	1	1	1	1
	O													3	30	21	4	52	16	3	22	8	4	19	11
Parachironomus	J				2	5	4							1	1	1	2	4	3	2	3	2	2	3	2
	A				1	3	3							3	7	3	2	6	4	1	1	1			
	O													2	3	2									
Paracladopelma	J							4	24	14	1	3	3	3	3	1	1	12	12	1	1	1	2	3	2
	A													1	1	1	1	1	1						
Paratanytarsus	J	2	8	6	1	3	3	1	3	3				3	6	3	4	18	3	2	15	10	3	23	8
	A	1	3	3				1	3	3				2	2	1	1	1	1	1	1	1			
	O																			1	3	3			
Polypedilum	J	1	3	3				4	49	27	3	8	4	3	5	3	4	24	8	4	13	5	3	16	6
	A				2	8	6	2	8	6				4	74	17	4	139	28	2	7	4	3	13	4
	O	2	42	34										1	9	9	2	15	9	3	8	4	3	12	9
Procladius	J	5	16	7	12	54	12																		
	A	10	64	20	12	197	60																		
	O	12	62	12	5	30	17																		
Rheotanytarsus	J							1	3	3				1	1	1	1	1	1	1	4	4	2	6	3
	A													1	1	1	2	2	1						
	O													2	7	5	2	2	1	2	3	2	3	4	1
Robackia	J																			1	3	3	1	1	1
	A							5	35	16	11	30	5												
	O							4	14	7	3	8	4	1	1	1									
Tanypus	J	12	312	112	12	1811	496	2	27	22	1	11	11												
	A	15	697	129	16	1211	191																		
	O	5	22	10	9	70	27																		

(Sheet 2 of 9)

(continued)

Table 23 (continued)

		SEDIMENTS (No./m^2)												ROCK SURFACES (No./m^2)											
		AC1 N=16			AC2 N=16			DF1 N=16			DF2 N=16			DFA N=4			DFB N=4			RV1 N=4			RV2 N=4		
TAXA		F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE
Tanytarsus	J	1	3	3							1	3	3	2	4	3	2	3	2	4	8	1	4	7	2
	A				1	3	3	1	3	3				4	15	4	4	22	10	1	1	1	2	2	1
	O				1	3	3							3	41	27	4	36	14	4	31	6	4	41	23
Thienemannimyia group	J													4	26	9	4	43	11	3	19	11	3	13	6
	A																								
	O													3	68	51	4	52	35	4	61	21	4	37	28
Thienemanniella	J													1	11	11	2	7	6	2	4	3	2	5	4
	A	2	8	6										4	58	8	4	45	13	2	12	10	2	23	13
	O													1	1	1									
Ceratopogonidae	J	11	113	35	11	113	35	2	8	6	3	8	4				2	3	2						
	A	13	307	111	7	81	56	1	3	3															
	O	11	149	40	9	46	15	4	14	7				1	1	1	3	7	3	3	5	2			
Chaoboridae																									
Chaoborus	J	4	19	10	2	8	6																1	1	1
	A	16	1846	418	12	129	42																		
	O	12	773	213	15	261	66	1	3	3															
Empididae																									
Empididae P.	J													1	1	1									
	A																								
	O																								
Hemerodromia	J																1	1	1	1	1	1			
	A													1	1	1							1	1	1
	O													2	11	8	3	4	1	3	5	3	1	6	6
Simuliidae	J																								
	A										1	3	3				1	1	1						
	O																								
Ephemeroptera																									
Baetidae																									
Baetidae Imm.	J				1	3	3							2	14	13	1	20	20						
	A																1	3	3						
	O																								
Baetis	J													4	21	10	4	48	20	3	40	13	3	20	9
	A													4	14	4	4	16	8	1	2	2	3	48	36
	O													3	28	14	2	5	3	4	13	7	2	2	1

(continued)

(Sheet 3 of 9)

Table 23 (continued)

		SEDIMENTS (No./m^2)												ROCK SURFACES (No./m^2)											
		AC1 N=16			AC2 N=16			DF1 N=16			DF2 N=16			DFA N=4			DFB N=4			RV1 N=4			RV2 N=4		
TAXA		F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE
Caenidae																									
Brachycercus	J																								
	A							4	14	7	1	3	3	2	4	3	1	3	3	1	2	2	1	1	1
	O													1	1	1									
Caenis	J													1	1	1	1	1	1	1	1	1	1	1	1
	A							1	3	3	2	8	6	4	434	67	4	334	72	4	102	28	4	152	66
	O	7	105	53	5	19	9							2	6	3	3	19	11	3	11	4	3	14	7
Ephemeridae																									
Hexagenia	J	8	49	16	1	3	3							4	52	31	4	129	103	3	39	26	4	51	20
	A							2	24	22	2	14	9	1	3	3	3	8	4	4	14	8	2	5	4
	O	6	27	10				1	3	3							1	1	1	1	1	1	3	4	1
Heptageniidae																									
Heptageniidae Imm.	J										1	3	3	3	112	64	4	278	165	4	206	99	4	347	94
	A													4	91	22	4	109	51	3	15	7	4	33	8
	O													3	18	13	4	66	25	4	46	22	4	33	17
Anepeorus	J													2	9	6	2	26	23	2	12	8	4	24	8
	A																								
	O																								
Heptagenia	J													4	22	9	2	45	37	4	38	17	4	55	19
	A																1	1	1	1	1	1			
	O																								
Stenonema	J													4	206	48	4	591	198	4	191	72	4	168	23
	A				1	3	3				1	5	5	4	198	54	4	145	64	4	76	27	4	83	35
	O													4	36	15	2	109	85	4	157	93	4	70	22
Stenacron	J													4	16	6	3	7	3	4	14	5	2	2	1
	A													1	4	4	1	1	1	2	4	2	1	2	2
	O																2	12	11	1	1	1			
Leptophlebiidae																									
Leptophlebiidae Imm.	J																1	1	1						
	A																								
	O																								

(Sheet 4 of 9)

(continued)

Table 23 (continued)

		SEDIMENTS (No./m^2)												ROCK SURFACES (No./m^2)											
		AC1			AC2			DF1			DF2			DFA			DFB			RV1			RV2		
		N=16			N=16			N=16			N=16			N=4			N=4			N=4			N=4		
TAXA		F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	N	$\bar{X}$	SE	F	X	SE
Paraleptophlebia	J																								
	A										1	3	3				2	3	2						
	O																								
Siphlonuridae																									
Isonychia	J													4	228	188	4	436	297	4	164	109	4	459	123
	A							1	3	3				4	35	16	4	80	35	1	1	1	4	13	5
	O													1	3	3	1	1	1				2	3	2
Hemiptera																									
Corixidae Imm.	J	2	11	7	9	38	12										2	4	2	1	1	1	1	1	1
	A	1	3	3	1	3	3																		
	O	2	8	6	6	41	16																		
ODONATA																									
Coenagrionidae																									
Ischnura	J																								
	A				1	3	3																		
	O																								
Nehalennia	J													1	1	1				2	2	1			
	A																								
	O				1	21	21										1	1	1	1	1	1			
Corduliidae																									
Neurocordulia	J																1	1	1						
	A													1	1	1	1	1	1						
	O																			1	1	1			
Gomphidae																									
Gomphus	J													1	1	1	1	1	1						
	A							1	3	3															
	O																								
Libellulidae																									
Ladona	J																								
	A													3	3	1									
	O																								
PLECOPTERA																									
Plecoptera Imm.	J										1	3	3	1	2	2	2	3	2						
	A																								
	O																								

(continued)

Table 23 (continued)

		SEDIMENTS (No./m²)												ROCK SURFACES (No./m²)											
		AC1 N=16			AC2 N=16			DF1 N=16			DF2 N=16			DFA N=4			DFB N=4			RV1 N=4			RV2 N=4		
TAXA		F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE	F	$\bar{X}$	SE
Perlidae																									
Acroneuria	J													1	12	12	3	32	17	2	23	15	3	8	4
	A													1	1	1	1	1	1						
	O																								
Perlodidae																									
Isoperla	J																1	3	3	1	1	1			
	A																								
	O																								
TRICHOPTERA																									
Hydropsychidae																									
Imm.	J										1	16	16	4	72	45	3	46	30	3	25	18	3	28	13
	A										1	5	5	4	606	297	4	506	406	4	26	6	4	325	181
	O													3	56	26	3	31	12	4	39	17	4	35	23
Cheumatopsyche	J													2	13	8	1	8	8	2	13	12	2	5	4
	A													3	40	14	3	72	42				2	21	17
	O													2	18	17	3	6	3	1	1	1	1	4	4
Hydropsyche	J										3	27	22	4	121	81	2	69	57	3	51	45	4	21	13
	A													4	8	1	3	6	3	1	2	2	3	40	37
	O													3	10	5	2	2	1	3	3	1	3	3	1
Potamyia	J													4	109	61	4	125	72	4	177	131	4	59	26
	A													4	386	224	4	405	254	3	9	3	4	382	258
	O													3	80	63	3	4	1	4	22	8	4	20	12
Hydroptilidae																									
Hydroptila	J																								
	A																1	1	1						
	O																			1	3	3			
Ochrotrichia	J										1	3	3	3	4	1	1	1	1				2	2	1
	A													1	2	2	2	2	1				1	1	1
	O													3	16	7	4	91	44	3	10	4	4	27	8
Leptoceridae																									
Ceraclea	J																1	1	1				2	3	2
	A													1	2	2							1	1	1
	O																1	1	1						

(Sheet 6 of 9)

(continued)

Table 23 (continued)

		SEDIMENTS (No./m²)												ROCK SURFACES (No./m²)											
		AC1 N=16			AC2 N=16			DF1 N=16			DF2 N=16			DFA N=4			DFB N=4			RV1 N=4			RV2 N=4		
TAXA		F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SD	F	$\overline{X}$	SE
Nectopsyche	J																1	1	1						
	A																			1	1	1			
	O	1	3	3																					
Polycentropidae																									
Neureclipsis	J													3	11	6	2	7	5	4	10	4	4	14	6
	A										1	3	3	4	131	32	4	159	59	1	9	9	3	71	44
	O													3	30	16	4	31	11	4	11	2	4	21	17
NON-INSECTS																									
Acarina	J	1	3	3	1	5	5							1	1	1				1	1	1			
	A																2	4	3				1	1	1
	O	3	27	22	2	5	4																		
Amphipoda																									
Talitridae																									
Hyalella azteca	J	2	5	4	2	5	4										1	1	1						
	A				1	5	5																		
	O				4	11	5																		
Isopoda																									
Asellidae																									
Asellus	J													1	1	1	2	2	1	2	13	9	2	2	1
	A																2	4	3	2	4	2	1	2	2
	O																1	1	1				1	9	9
Bryozoa	J														+		1	+	-	2	+	-	2	+	-
	A																1	+	-						
	O																						1	+	-
Hirudinea																									
Erpobdellidae																									
Erpobdella	J																								
	A	1	3	3																					
	O																								
Piscicolidae	J																								
	A																								
	O	1	3	3																					

(Sheet 7 of 9)

(continued)

Table 23 (continued)

		SEDIMENTS (No./m²)												ROCK SURFACES (No./m²)											
		AC1 N=16			AC2 N=16			DF1 N=16			DF2 N=16			DFA N=4			DFB N=4			RV1 N=4			RV2 N=4		
TAXA		F	X̄	SE	F	X̄	SE	F	X̄	SE	F	X̄	SE	F	X̄	SE	F	X̄	SE	F	X̄	SD	F	X̄	SE
HYDROIDA																									
Hydridae																									
Hydra	J							2	8	6	2	5	4	3	1936	1713	2	3331	2509	2	359	291	4	3040	886
	A										2	22	19	3	611	457				2	3	2			
	O													1	1	1	1	3	3	1	1	1			
NEMATODA	J	1	16	16	3	11	6										2	3	2				1	1	1
	A	2	49	46	5	205	145													1	1	1	1	3	3
	O																1	3	3						
OLIGOCHAETA																									
Branchiura	J	3	11	6	1	3	3																		
sowerbyi	A	12	302	92	11	425	124	1	3	3				2	10	9				4	69	55	2	13	9
	O	10	253	66	11	140	36													3	106	94	2	4	2
Dero digitata	J	16	2271	452	11	705	158	1	3	3	2	11	7	4	73	27	4	164	137	4	98	59	4	102	35
	A	13	1163	294	10	536	256																		
	O	14	1041	269	16	476	144	3	283	277	2	24	19	3	17	9	3	596	559	4	882	661	4	55	18
Ilyodrilus templetoni	J	1	5	5	1	3	3	1	3	3							1	1	1						
	A	1	5	5	3	32	24				1	3	3	1	2	2	1	3	3						
	O	5	178	81	8	59	22				2	16	14				4	16	5						
Limnodrilus																									
L. cervix	J	12	95	32	11	393	89	2	8	6	2	11	8	1	1	1	1	1	1	2	3	2	1	1	1
	A	13	315	123	7	81	27	4	49	37	5	162	78				2	15	14				1	1	1
	O	1	5	5	1	5	5				1	3	3												
L. claparedianus	J	2	5	4	1	8	8													1	3	3	1	1	1
	A				1	3	3	1	3	3	1	3	3				1	10	10						
	O																								
L. hoffmeisteri	J				4	22	14	2	19	13				1	3	3	1	9	9	1	4	4			
	A	4	32	18	2	16	14				2	5	4				1	7	7	1	1	1			
	O	1	3	3	1	22	22																		
L. maumeensis	J	1	3	3	2	19	16	3	14	9	2	5	4	1	1	1				1	1	1			
	A	2	8	6	4	51	28				1	3	3												
	O	5	54	33	13	538	134																		
L. profundicola	J	1	5	5	1	8	8																		
	A	1	5	5	2	8	6	1	8	8	2	5	4				1	1	1						
	O				4	16	8																		

(continued)

Table 23 (concluded)

		SEDIMENTS (No./m ^{2})												ROCK SURFACES (No./m ^{2})											
		AC1 N=16			AC2 N=16			DF1 N=16			DF2 N=16			DFA N=4			DFB N=4			RV1 N=4			RV2 N=4		
TAXA		F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE	N	$\overline{X}$	SE	F	$\overline{X}$	SE	F	$\overline{X}$	SE
L. udekemianus	J	1	3	3	1	3	3										1	2	2						
	A																								
Pirsina	O																								
osborni	J	11	180	47	9	245	111	1	5	5	2	8	6	3	8	4	3	6	3	2	2	1			
	A	13	1074	268	10	231	72	2	5	4				1	3	3	1	2	2	2	6	5	4	8	2
	O	15	2414	562	11	366	104				1	19	19				1	30	30	2	53	44	2	6	4
Tubificidae +cs	J	1	3	3																					
	A																								
	O				1	3	3																		
Tubificidae-cs	J	15	503	142	11	3385	636	7	129	73	5	97	62	4	53	28	3	71	60	3	75	59	4	12	5
	A	16	3590	973	16	9701	1302	9	430	296	14	928	393	4	54	26	3	163	114	4	78	52	4	49	26
	O	15	3501	564	16	9093	922	15	1849	1634	12	983	477	3	17	8	4	308	134	4	138	76	4	103	91
PELECYPODA																									
Sphaeridae																									
Sphaerium	J	2	14	11	5	70	31										1	1	1						
	A	1	3	3	5	16	7	1	5	5	2	5	4	1	1	1	3	16	12	3	3	1			
	O							1	3	3	1	3	3	2	30	22	3	22	12	4	28	19	3	8	4
PULMONATA																									
Physidae																									
Physa	J																1	1	1	1	1	1	1	1	1
	A																1	1	1	1	1	1			
	O													1	1	1									
Planorbidae																									
Planorbula	J																								
	A																						1	1	1
	O																								
TRICLADIDA																									
Planariidae																									
Dugesia	J																			1	1	1			
	A													1	6	6							2	89	52
	O													4	110	53	2	15	14	4	35	12	4	85	40
Phagocata	J																								
	A													1	21	21	3	22	12	2	8	6	1	1	1
	O																								

(Sheet 9 of 9)

Table 24

Lists of Taxa Sampled in the Four Habitats Whose Average Densities Over Time and Locations Exceeded 100 Organisms Per Square Meter

TAXA	NUMBER PER SQUARE METRE
ABANDONED CHANNELS	
Tubificidae-cs	4962
Dero digitata	1032
Pirsina osborni	752
Tanypus sp.	687
Chaoborus sp.	506
Coelotanypus sp.	304
Chironomus sp.	235
Branchiura sowerbyi	189
Limnodrilus cervix	149
Ceratopogonidae	135
Limnodrilus maumeensis	112
DIKE POOLS	
Tubificidae-cs	736
DIKE SURFACES	
Hydra sp.	980
Hydropsychidae Imm.	219
Stenonema sp.	214
Potamyia sp.	185
Dero digitata	141
Caenis sp.	132
Isonychia	130
Heptageniidae Imm.	112
Tubificidae-cs	111
REVETMENTS	
Hydra sp.	567
Dero digitata	189
Stenonema sp.	124
Potamyia sp.	111
Isonychia	107

Table 25

The Five Most Abundant Taxa Found at Each Location for Each

Monthly Sampling Period and Their Densities

in Organisms Per Square Metre

LOCATION	JUNE		AUGUST		OCTOBER	
	TAXA	DENSITY	TAXA	DENSITY	TAXA	DENSITY
AC1	Dero digitata	2271	Tubificidae-cs	3590	Tubificidae-cs	3501
	Tubificidae-cs	503	Chaoborus sp.	1846	Pirsina osborni	2414
	Chironomus sp.	458	Dero digitata	1163	Dero digitata	1041
	Tanypus sp.	312	Pirsina osborni	1047	Chaoborus sp.	773
	Pirsina osborni	180	Tanypus sp.	697	Chironomus sp.	525
AC2	Tubificidae-cs	3385	Tubificidae-cs	9701	Tubificidae-cs	9093
	Tanypus sp.	1811	Tanypus sp.	1211	Coelotanypus sp.	1141
	Dero digitata	705	Branchiura sowerbyi	425	Limnodrilus maumeensis	538
	Limnodrilus cervix	393	Dero digitata	536	Dero digitata	476
	Pirsina osborni	245	Coelotanypus sp.	291	Pirsina osborni	366
DF1	Tubificidae-cs	129	Tubificidae-cs	430	Tubificidae-cs	1849
	Polypedilum sp.	49	Limnodrilus cervix	49	Dero digitata	283
	Tanypus sp.	27	Robackia sp.	35	Robackia sp.	14
	Paracladopelma sp.	24	Hexagenia sp.	24	Ceratopogonidae	14
	Cryptochironomus sp.	19	Branchycercus sp.	14	Cryptochironomus sp.	11
DF2	Tubificidae-cs	97	Tubificidae-cs	928	Tubificidae-cs	983
	Hydropsyche sp.	27	Limnodrilus cervix	162	Dero digitata	24
	Cryptochironomus sp.	14	Robackia sp.	30	Pirsina osborni	19
	Dero digitata	11	Hydropsychidae Imm.	16	Ilyodrilus templetoni	16
	Limnodrilus cervix	11	Hydra sp.	22	Robackia sp.	8
DFA	Hydra sp.	1936	Hydra sp.	611	Dugesia sp.	110
	Isonychia	228	Caenis sp.	434	Tanytarsus sp.	41
	Stenonema sp.	206	Hydropsyche sp.	506	Thienemannimyia group	68
	Hydropsyche sp.	121	Potamyia sp.	386	Potamyia sp.	80
	Heptageniidae Imm.	111	Stenonema sp.	198	Hydropsychidae Imm.	56
DFB	Hydra sp.	3331	Hydropsychidae Imm.	506	Dero digitata	596
	Stenonema sp.	591	Potamyia sp.	405	Tubificidae-cs	308
	Isonychia	436	Caenis sp.	334	Stenonema sp.	109
	Heptageniidae Imm.	278	Tubificidae-cs	183	Ochrotrichia sp.	91
	Orthocladius sp.	242	Neureclipsis sp.	159	Nanocladius sp.	70
RV1	Hydra sp.	359	Caenis sp.	102	Dero digitata	882
	Orthocladius sp.	252	Tubificidae-cs	78	Stenonema sp.	157
	Heptageniidae Imm.	206	Stenonema sp.	76	Tubificidae-cs	138
	Stenonema sp.	191	Branchiura sowerbyi	68	Branchiura sowerbyi	106
	Potamyia sp.	177	Hydropsychidae Imm.	26	Pirsina osborni	53
RV2	Hydra sp.	3040	Potamyia sp.	382	Tubificidae-cs	103
	Isonychia	459	Hydropsychidae Imm.	325	Dugesia sp.	85
	Heptageniidae Imm.	347	Caenis sp.	152	Stenonema sp.	70
	Orthocladius sp.	202	Dugesia sp.	89	Hydropsychidae Imm.	35
	Stenonema sp.	168	Neureclipsis sp.	71	Dero digitata	55

Table 26

Analysis of Variance Statistics for the Effects of Sampling (7,72 d.f.) on Invertebrate Group Mean Densities (Organsims per Square Metre) and Duncan's Multiple Range Test of Significance. Groups with the Same Letter are not Significantly Different

MONTH	F	P	N	MEAN	LOCATION	GROUP
JUNE	9.09	0.0001	16	7214	AC2	A
			4	5848	DFB	A
			16	4176	AC1	AB
			4	4003	RV2	AB
			4	3476	DFA	ABC
			4	2070	RV1	BC
			16	328	DF1	C
			16	248	DF2	C
AUGUST	25.82	0.0001	16	13331	AC2	A
			16	9682	AC1	A
			4	2774	DFA	B
			4	2152	DFB	B
			4	1394	RV2	B
			16	1192	DF2	B
			16	613	DF1	B
			4	466	RV1	B
OCTOBER	11.76	0.0001	16	12624	AC2	A
			16	9585	AC1	A
			16	2177	DF1	B
			4	1746	RV1	B
			4	1719	DFB	B
			16	1058	DF2	B
			4	691	RV2	B
			4	676	DFA	B