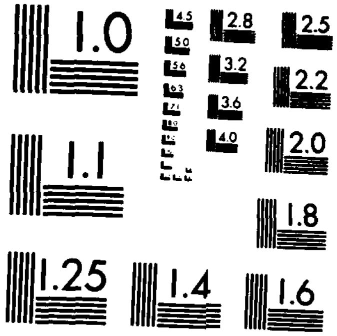
AD-A164 745 AQUATIC STUDIES OF THE MAIN CHANNEL BORDER HABITAT OF POOL 5A ON THE UPPER MISSISSIPPI RIVER(U) ECOLOGICAL ANALYSTS INC NORTHBROOK IL G SEEGERT ET AL. JAN 84 1/4

UNCLASSIFIED F/G 6/6 NL


1.0
4.5
5.0
5.6
6.3
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

(2)

AQUATIC STUDIES OF THE MAIN CHANNEL BORDER HABITAT OF POOL 5A ON THE UPPER MISSISSIPPI RIVER

Prepared for

Department of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Prepared by

Greg Seegert
Greg Seegert
Project Manager

Randall Lewis
Randall Lewis
Aquatic Biologist

Ronald Bockelman
Ronald Bockelman
Aquatic Biologist

Ecological Analysts, Inc.
612 Anthony Trail
Northbrook, Illinois 60062

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

January 1984

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.
AD A164 745

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (*and Subtitle*)
AQUATIC STUDIES ON THE MAIN CHANNEL BORDER HABITAT OF POOL 5A ON THE UPPER MISSISSIPPI RIVER.

5. TYPE OF REPORT & PERIOD COVERED

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(*s*)
Greg Seegert
Randall Lewis
Ronald Bockelman

8. CONTRACT OR GRANT NUMBER(*s*)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Ecological Analysts, Inc.
612 Anthony Trail
Northbrook, IL 60062

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
U.S. Army Engineer District, St. Paul
1135 USPO & Custom House
St. Paul, MN 55101-1479

12. REPORT DATE
January 1984

13. NUMBER OF PAGES

14. MONITORING AGENCY NAME & ADDRESS(*if different from Controlling Office*)

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*)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (*Continue on reverse side if necessary and identify by block number*)
MISSISSIPPI RIVER
CHANNELS (WATERWAYS)
ECOLOGY

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

This report contains an extensive study of the periphyton, macroinvertebrate, and fish communities of Pool 5A on the Mississippi River. The focus of the study was the main channel border (MCB), the zone between the nine-foot navigation channel and the main river bank. The MCB is the area potentially affected by channel maintenance activities. The objectives were: 1). provide information that will increase the Corps' ability to make predictions regarding the effects of channel maintenance or construction activities; 2). identify ways to minimize or mitigate adverse impacts during channel maintenance or

DD FORM 1 JAN 73 1473 EDITI [illegible] NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

construction activities; and 3). identify ways to maximize beneficial impacts that will occur during such activities.

AQUATIC STUDIES OF THE MAIN CHANNEL BORDER HABITAT OF POOL 5A ON THE UPPER MISSISSIPPI RIVER

Prepared for

Department of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Prepared by

Greg Seegert
Greg Seegert
Project Manager

Randall Lewis
Randall Lewis
Aquatic Biologist

Ronald Bockelman
Ronald Bockelman
Aquatic Biologist

Ecological Analysts, Inc.
612 Anthony Trail
Northbrook, Illinois 60062

January 1984

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF TABLES (Cont.)

LIST OF TABLES (Cont.)

LIST OF TABLES (Cont.)

LIST OF TABLES (Cont.)

LIST OF TABLES (Cont.)

LIST OF TABLES (Cont.)

LIST OF TABLES (Cont.)

LIST OF TABLES (Cont.)

LIST OF TABLES (Cont.)

LIST OF TABLES (Cont.)

LIST OF FIGURES

LIST OF FIGURES (Cont.)

1. INTRODUCTION

1.1 OVERVIEW

In 1982, Ecological Analysts (EA), under contract to the St. Paul District Corps of Engineers (COE) conducted an extensive study of the periphyton, macroinvertebrate, and fish communities of Pool 5A on the Mississippi River. The focus of the study was the main channel border ([MCB], the zone between the nine-foot navigation channel and the main river bank, islands, or submerged definitions of the old main river channel) habitat because the MCB is the area potentially most greatly affected by COE's channel maintenance activities such as wing or closing dam construction/repair, riprapping, and disposal of dredged material. Pool 5A was originally selected for study because it is one of the shorter pools in the St. Paul District, has a diversity of MCB habitats, and has a COE service base located in Fountain City, Wisconsin to provide easy access (Anderson et al. 1983).

Pool 5A extends from river mile (RM) 728.8 to 738.2 and has a surface area of 2,485 hectares, 201 hectares (8 percent) of which are MCB (Anderson et al. 1983). The remaining area consists of river lakes and ponds, sloughs, side streams and channels, the main navigational channel, and the tail-water area below lock and dam 5. In 1980, Anderson et al. (1983) conducted an extensive hydrographic and physical survey of Pool 5A, the results of which were used to develop a four-tiered habitat classification scheme that considered velocity, depth, substrate type, and general habitat type. Velocity was categorized as high ($\geq$0.15 mps) or low (<0.15 mps) as measured during surveys during low flow conditions in July 1980. Substrate was broken down into sand, rock, and silt. The depth categories were 0-3 m and 3-6m. For wing dams, the 0-3 m category was subdivided into two additional categories; 0-1.5 m and 1.5-3 m. General habitat type considered the following types of rock areas; riprap, closing dams, wing dams, and for silt and sand, considered areas associated with structures and those not associated with structures. Of the 28 possible velocity, depth, substrate, and habitat combinations, 18 were found to be present in Pool 5A in sufficient numbers to warrant further studies (Anderson et al. 1983). Areas representative of these 18 MCB combinations were the subject of fisheries investigations conducted in August and September of 1980 (Anderson et al. 1983). Based on the results of the 1980 survey, 10 MCB areas were chosen for further study as part of the present study (Figure 1-1). Each of the 10 locations is described in detail in Section 1.2. Similarly, most of the sampling protocols used during the present study (e.g., type of electrofishing, seine mesh size, placement of nets, type of macrophyte beds to be sampled) were selected based on the findings of the 1980 survey.

Broadly stated, the objectives of the present study were:

(1) provide information that will increase COE's ability to make predictions regarding the effects of channel maintenance or construction activities;

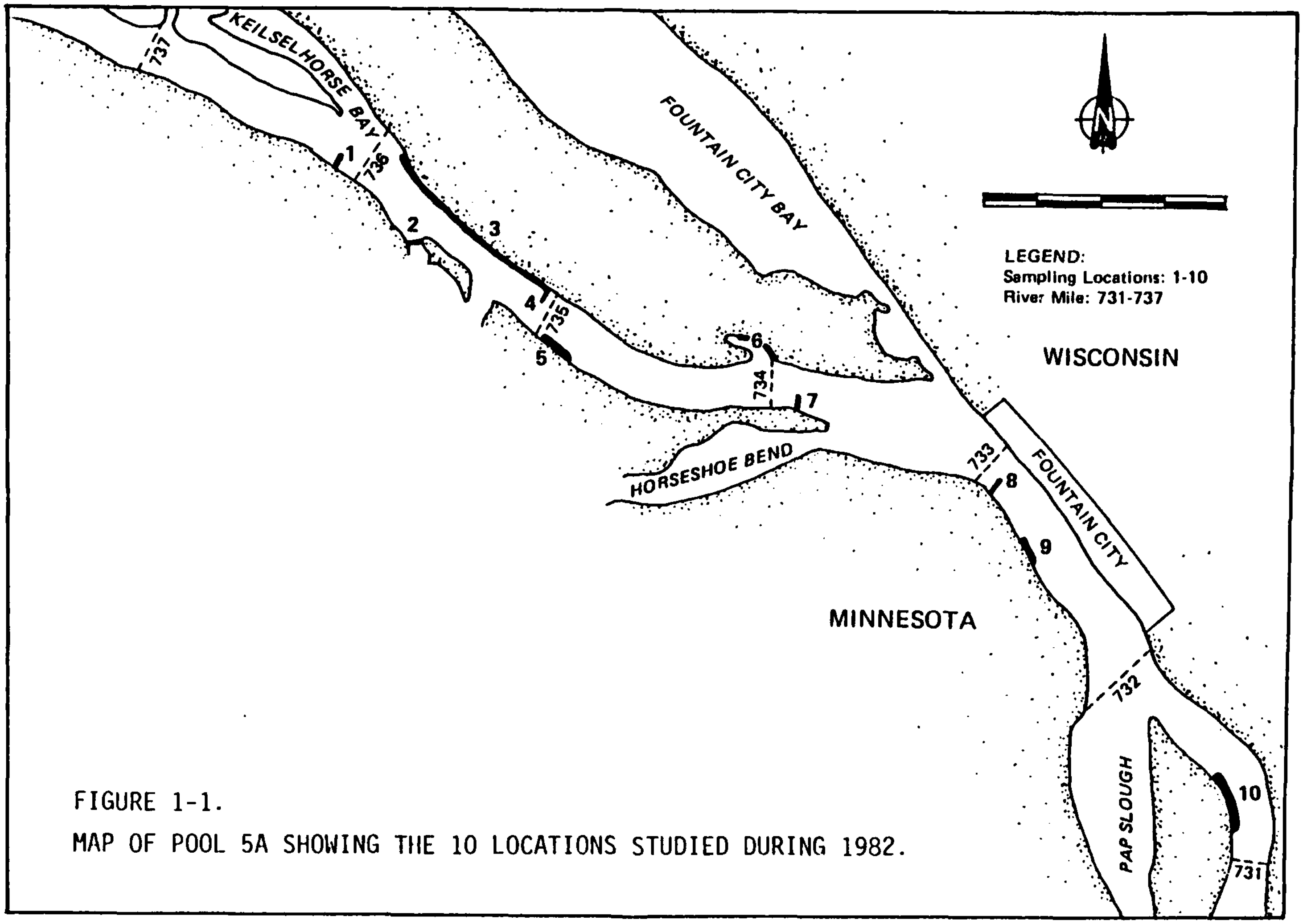


FIGURE 1-1.
MAP OF POOL 5A SHOWING THE 10 LOCATIONS STUDIED DURING 1982.

(2) identify ways to minimize or mitigate adverse impacts that are otherwise likely to occur during channel maintenance or construction activities; and

(3) identify ways to maximize beneficial impacts that will occur during such activities.

To address these broad objectives, the following specific objectives were identified:

1. Describe and evaluate the structure, composition, and abundance of fish assemblages associated with selected MCB habitat types.

2. Describe and evaluate seasonal or monthly changes in structure, composition, and abundance of fish assemblages associated with selected MCB habitat types.

3. Describe and evaluate diel changes in structure, composition, and abundance of fish assemblages associated with selected MCB habitat types.

4. Develop information on utilization of selected MCB habitat types by fish as nursery areas.

5. Describe and evaluate the distribution, structure, and standing crop of macroinvertebrate assemblages among selected MCB habitats.

6. Describe and evaluate the seasonal changes in distribution, structure and standing crop of macroinvertebrate assemblages among selected MCB habitats.

7. Describe and evaluate the vertical distribution of macroinvertebrates within substrates of selected MCB habitats.

8. Describe and evaluate the distribution, structure, and standing crop of periphyton assemblages in selected MCB habitats.

9. Describe and evaluate seasonal changes in the distribution, structure, and standing crop of periphyton assemblages in selected MCB habitats.

10. Describe and evaluate physicochemical conditions and seasonal or monthly changes in these conditions in selected MCB habitats.

Because of the volume of data collected, this report is divided into the major technical areas encompassed by the study. The physicochemical data gathered during all the biological studies is presented in Section 2. The results of the periphyton, macroinvertebrate, and fisheries studies are presented and discussed in Sections 3, 4, and 5, respectively. These sections are self-contained in that each contains the methods, results, discussion, and literature associated with that particular technical discipline. Appendices for each of these sections are contained in a separate volume. Table 1-1 summarizes the tasks that were conducted each month.

TABLE 1-1

SCHEDULE OF TASKS PERFORMED IN POOL 5A OF THE UPPER MISSISSIPPI RIVER DURING 1982

TASK	MAY	JUN	JUL	AUG	SEP	NOV
PHYSICOCHEMICAL						
pH		X	X			
Temperature	X	X	X		X	X
Dissolved Oxygen	X	X	X	X	X	X
Conductivity	X	X	X		X	X
Secchi Depth		X	X		X	
Velocity		X	X	X	X	
Velocity (detailed)[a]		X		X	X	
Flow[b]	X	X	X	X	X	X
PERIPHYTON						
Species Composition and Abundance		X	X	X	X	
Species Distribution				X		
BENTHOS						
Rock Substrate Survey		X		X	X	
Silt and Sand Substrate Survey		X		X	X	
Wood Substrate Survey			X	X		
Aquatic Plant Habitat Survey				X		
Rock Substrate Vertical Distribution Survey				X		
Sand and Silt Substrate Vertical Distribution Survey				X		
Crayfish Survey		X		X	X	
Mussel Survey				X		
FISH						
Adult Electrofishing	X	X		X	X	X
Juvenile Electrofishing	X	X		X	X	X
Seining	X	X		X	X	X
Frame Netting	X	X		X	X	X
Trammel Netting	X	X		X	X	X
Scour Hole Netting				X	X	X
Minnow Traps	X	X		X		
Dipnetting	X	X	X	X		

---

[a] Measurements made at transects at Locations 3 (rip-rap bank), and 4 and 8 (wing dams).

[b] As measured at Lock and Dam 5.

1.2 DESCRIPTIONS OF THE 10 SAMPLING LOCATIONS

Location 1, Wingdam - RM 736.2 - West Shore

This location was selected to be representative of a medium-depth wingdam in a slow current area. Upstream of the structure, the substrate from the beach to approximately 20m offshore was uniformly sand. The upstream shoreline dropped off quite rapidly to depths of approximately 4m (Figure 1-2). Vegetation along the upstream shoreline consisted of a lowland forest assemblage that was inundated during high water periods, but was considerably removed from the water during normal flows. Immediately downstream of the wingdam, the shoreline cut westward in association with a nearshore scour hole, forming a limited area of cove-like habitat. This area offered a variety of structures, including emergent and submergent vegetation, fallen trees, sand shoals and steep drop-offs. A much greater variety of habitats was available within this small cove area than in the entire region upstream of the wingdam.

Location 2, Closing Dam - RM 735.7 - West Shore

This location offered a wide variety of habitats (Figure 1-3). Upstream of the closing dam (toward the main channel), both shorelines of this side channel were sandy. The upstream, western-most, shoreline dropped off moderately to approximately 2m during summer low flow. This shoreline was approximately 40 percent shaded by overhanging lowland forest. The opposite (eastern) shoreline had a collection of debris (trees and root tangles) deposited during spring high water; however, during summer low flow periods, this potentially useful fish habitat, was considerably above the waterline. The dam caused a reduction of current velocity upstream of it, which, in turn, has resulted in the extensive deposition of sand in the upstream approach area. Specifially, an extensive, shallow sand shoal has been deposited along the eastern peninsula, just upstream of the closing structure.

The rock dam itself provides an extensive riffle habitat that extends completely across the mouth of the side channel. A scour hole extends from immediately behind the closing structure to a distance of approximately 30m downstream. Small cove areas, in association with the scoured area, occurred along each shoreline at the base of the closing dam. These cove areas offered unique MCB habitat; reduced current and submerged logs and tree root masses for cover. Steep drop-offs extended from both coves into the scour hole. It appears that this side channel may eventually close off completely, at least during low flow periods, if the deposition of sand on the shoal along the northern tip of the peninsula continues.

Location 3, Riprapped Shoreline - RM 735.1-735.9 - East Shore

This location, which began at the downstream mouth of Keilselhorse Bay, encompassed 1.3km of shoreline (Figure 1-3). Shoreline and nearshore habitats were quite uniform throughout this distance. Lowland forest vegetation encroached and overhung the entire shoreline with fallen

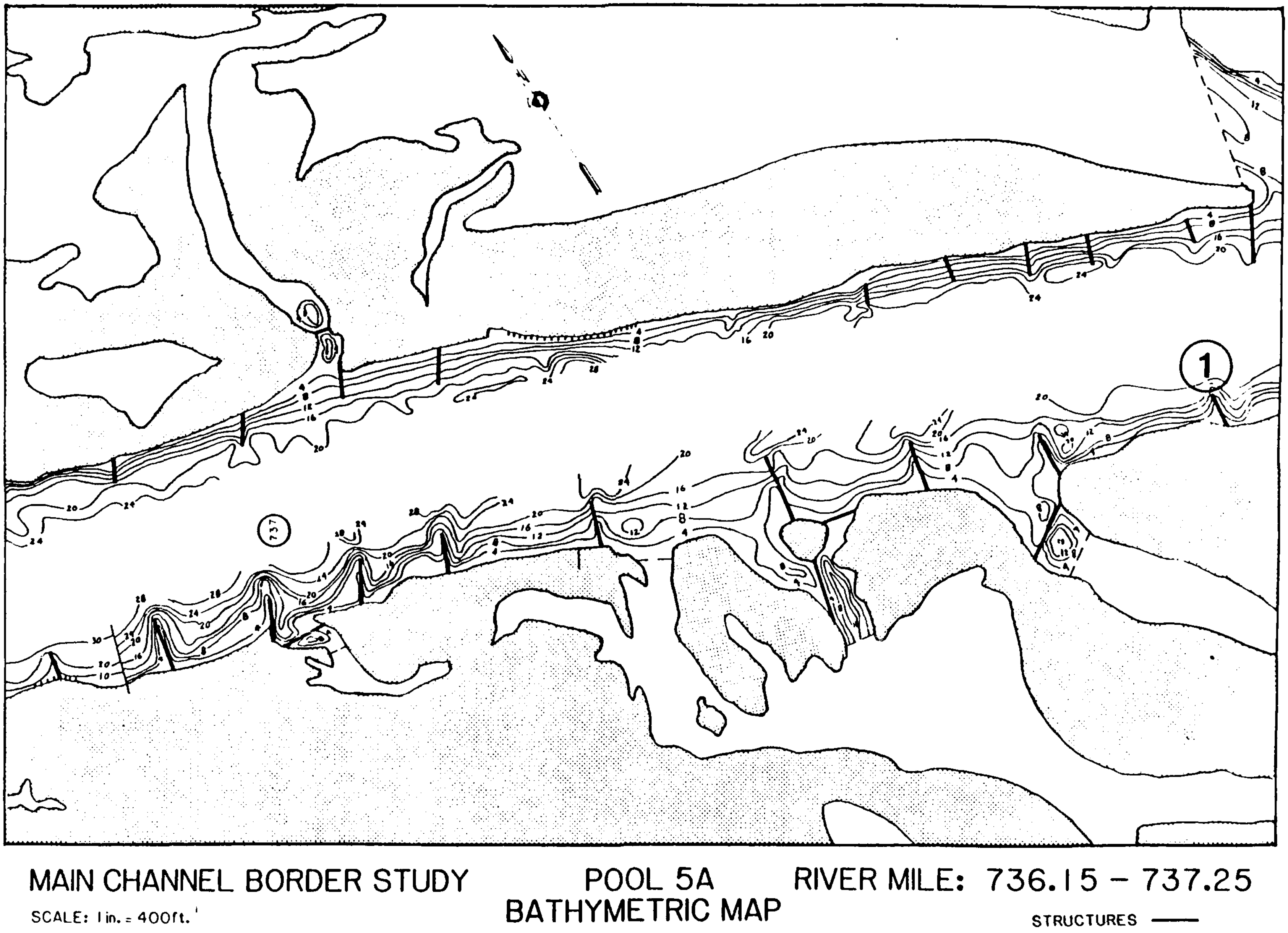


FIGURE 1-2. BATHYMETRIC MAP SHOWING DEPTH CONTOURS (FT) NEAR LOCATION 1.

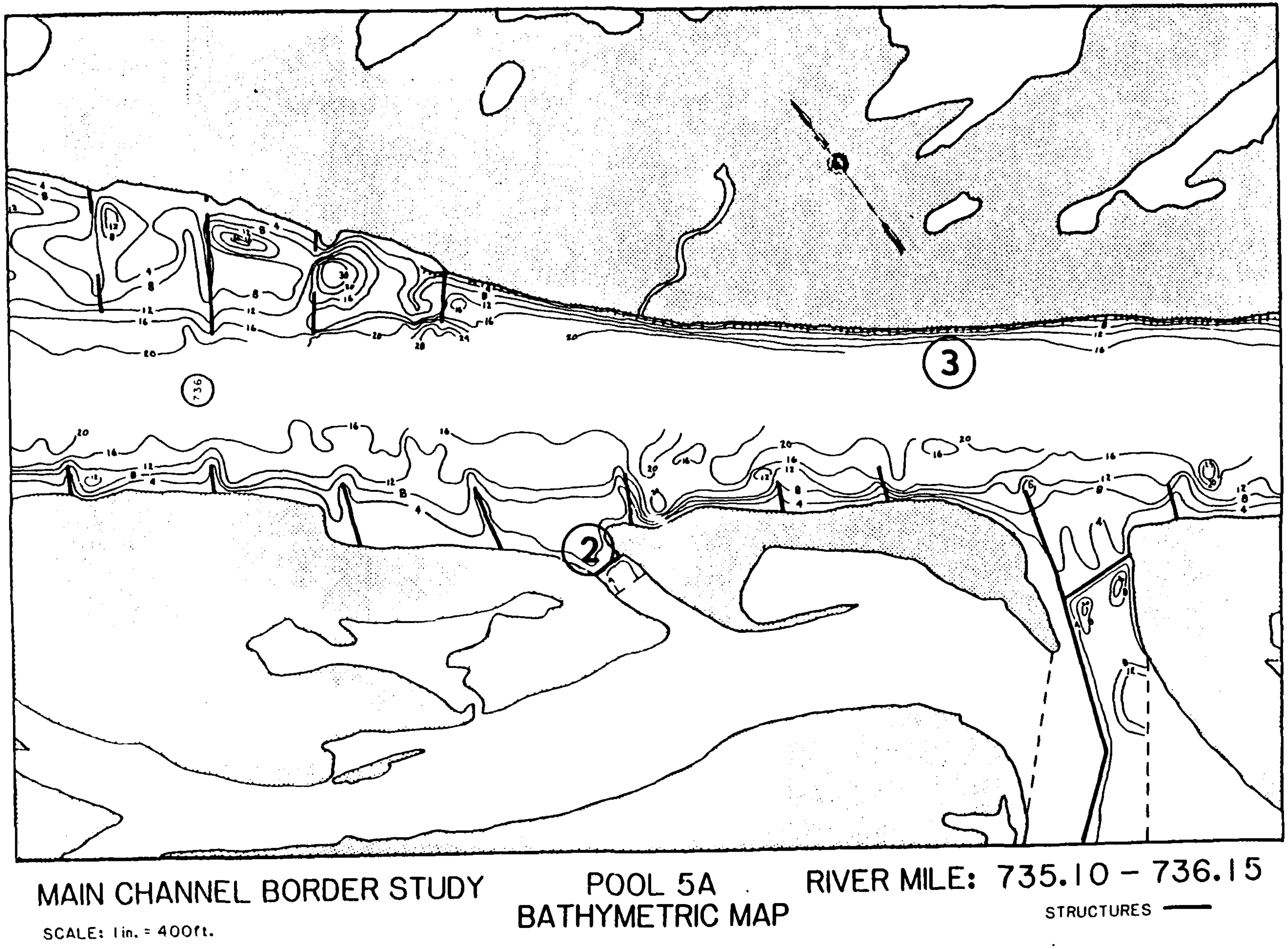


FIGURE 1-3. BATHYMETRIC MAP SHOWING DEPTH CONTOURS (FT) NEAR LOCATIONS 2 and 3.

trees and debris, such as logs and root-masses, scattered throughout its length. The riprapped shoreline dropped off rapidly to approximately 3-4m within a short distance from shore. The upper one-third of the shoreline encroached to the main channel and was somewhat deeper, closer to shore, than the downstream portion of the location (Figure 1-3). The upstream and downstream ends of the location were both marked by wing dams.

Monthly chemistry data showed that this location was often influenced by water from Kieselhorse Bay. Temperature, dissolved oxygen and specific conductance often differed between this location and locations on the opposite shore.

Location 4, Wingdam - RM 735.1 East Shore

This location was selected to be representative of a medium-depth fast current wingdam. This wingdam was contiguous with the riprapped bank selected as Location 3 (Figure 1-4). It was impossible to clearly define a dividing point between the habitat associated with the wingdam and that associated with the riprapped bank. Therefore, the upstream limit of this location was arbitrarily established as 30m upstream from the wingdam (to allow for positioning of trammel and frame nets). Within 30m upstream of this section, the riprapped bank itself, with overhanging vegetation, was the major habitat available. Sand has been deposited along the face of the wingdam, nearshore and for a short distance (approximately 10m) offshore. The wingdam extends approximately 50m offshore and throughout most of its length, the upstream face of the structure drops off sharply to depths of 3-4m. Downstream of the wingdam, extensive scour holes occur. Approximately 10m offshore, a scour hole about 7m deep (as measured in August and September) extended downstream for about 30m. Downstream of the offshore end of the structure, a scour hole nearly 9m deep extended approximately 46m downstream. Immediately downstream of the base of the wingdam, a slight embayment or cove occurred. This cove provided a still-water habitat with a variety of structural features. Several submerged logs and root tangles were scattered throughout the embayment. The shoreline provided both steep and shallow dropoffs. Substrates included silty and sandy shoals, with exposed rock near the wingdam base. This cove area was contiguous with the nearshore scour hole described previously.

Location 5, Sand Shoreline - RM 734.8-735.0 West Shore

This location was extremely uniform throughout its length. The substrate consisted of well-sorted sand along the entire shoreline area. The shore rapidly dropped off to depths of 1-2m within 5m from shore and was generally void of submerged structures. Shoreline vegetation was generally well separated from the water. The upstream end of the location presented an extensive sand shoal associated with a "box" wingdam positioned at the mouth of a side channel (Figure 1-4). The downstream limit of the location was identified by a wingdam. This location presented the most redundant, "structureless" habitat of all locations.

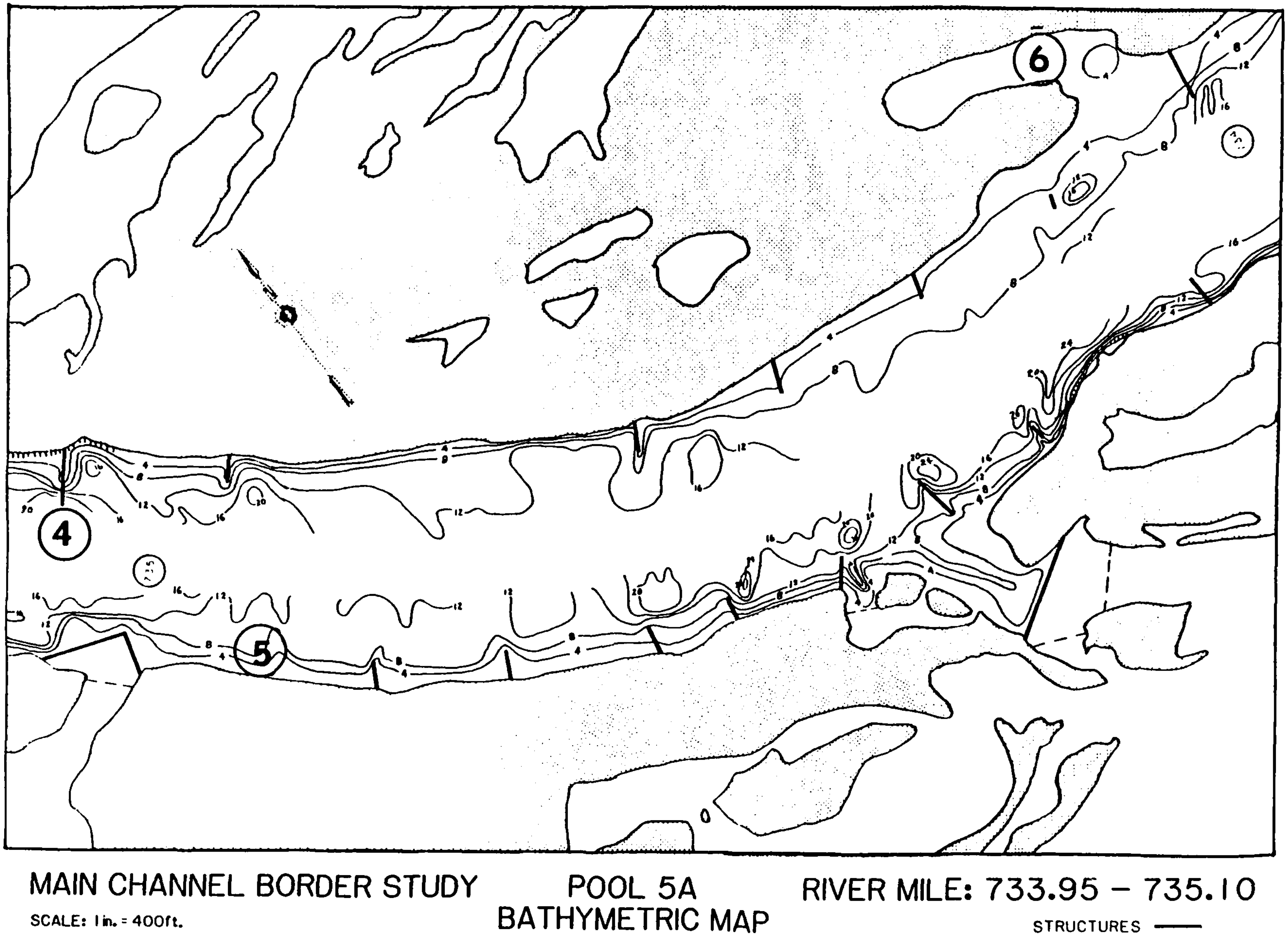


FIGURE 1-4. BATHYMETRIC MAP SHOWING DEPTH CONTOURS (FT) NEAR LOCATIONS 4, 5, AND 6.

Location 6, Silt Bay - RM 734.1 East Shore

This bay encompassed a wide variety of habitats and the amount of available habitat was quite variable in relation to seasonal water level fluctuations. During spring and fall high flows, the bay opened broadly to the MCB (Figure 1-4). However, during low flows, the bay was nearly cut off from the MCB by a sand bar and shoal that extended from the west side of the bay mouth and only a narrow (about 10m wide) channel approximately 1.5m deep connected the bay with the MCB. Sand appeared to be continually deposited along the mouth of the bay, and eventually this bay may be completely separated from the MCB during most periods of the year.

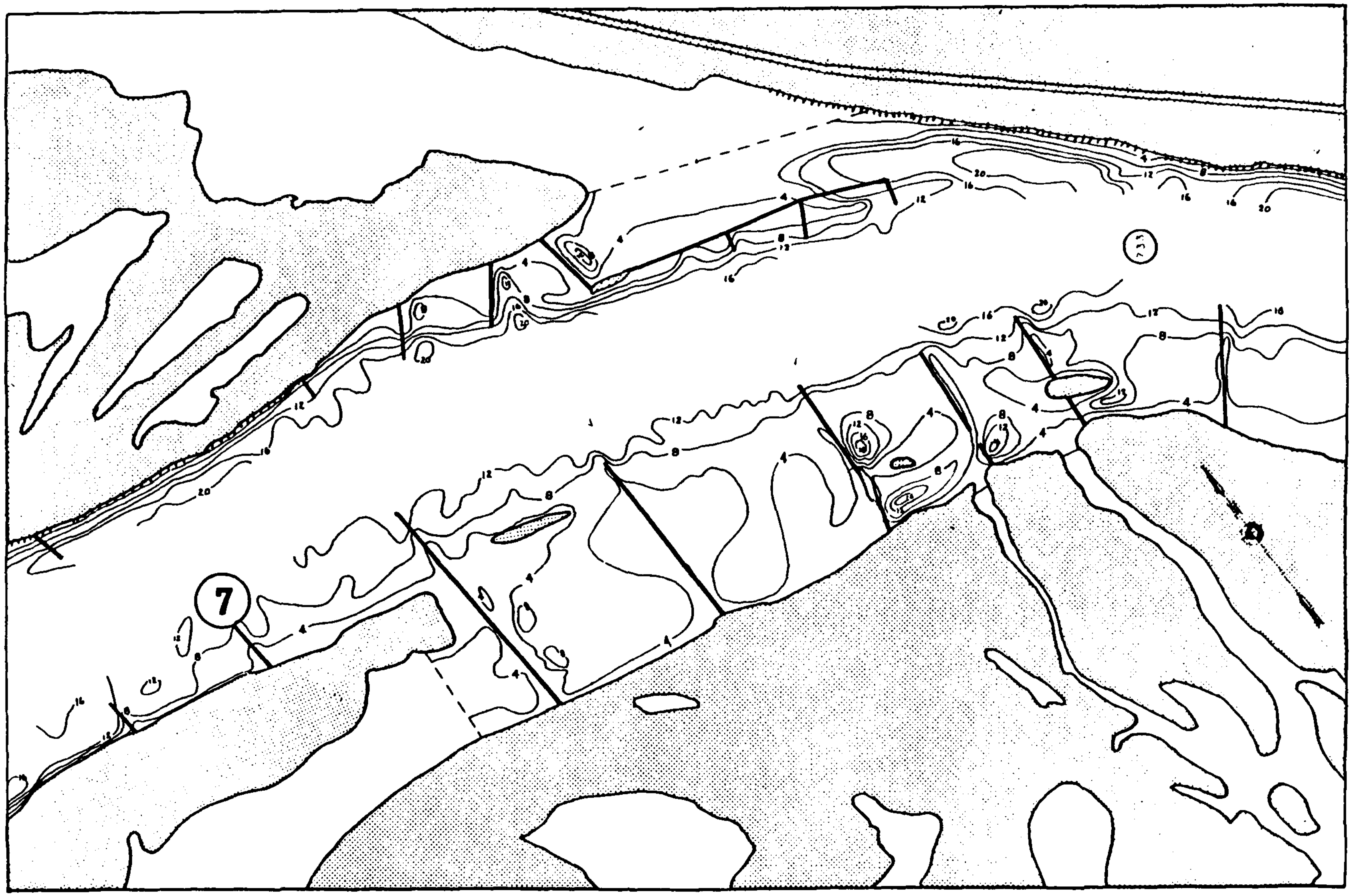
Within the bay, shoreline areas were quite variable. The western shoreline was encroached by young willows and cottonwoods and emergent aquatic vegetation. The innermost (northern) limit of the bay supported shoreline stands of cattail and sedge. The eastern shoreline supported mature lowland forest contiguous with the water's edge. Substrates along the bay shoreline were mostly sand and silty-sand except along the eastern shoreline where exposed rock of a riprap or wingdam structure remains. The open water areas of the bay ranged from about 1.5m deep (during low flow) near the mouth to less than 0.3m deep in the inner bay. Substrates were sandy-silt throughout most of the open water areas.

Location 7, Wingdam - RM 733.8 West Shore

Location 7 was another fast-current wingdam but was shallower (Figure 1-5) than the fast-current wingdam at Location 4 (Figure 1-4). The area sampled at this location encompassed the shoreline area from approximately 30m upstream to 30m downstream of the structure. This wingdam was situated on a sand spoil area. The upstream shoreline was a bare sand bank about 3m high. The river bottom dropped off steeply to depths of 1.5m a short distance (about 3m) from shore. The substrates were uniformly sandy with few or no rocks, logs or other submerged features. From the base of the wingdam downstream, the shoreline supported dense growths of small willows that extended into the water during even summer low flow conditions. The wingdam structure was, essentially, the only noteworthy habitat feature available at this location.

Location 8, Wingdam - RM 732.8 West Shore

This wingdam was selected to be representative of a shallow wingdam in slow current. The wingdam extends approximately 150m offshore and was the longest of the wingdams examined in this study (Figure 1-6). It was positioned on the inside of a large, sweeping, bend in the river. Current velocity is greatly reduced in the inside of this bend and large amounts of sand have been deposited. The wingdam has been almost completely covered from the shoreline to a distance of approximately 46m offshore. The base of the wingdam and shoreline areas immediately upstream and downstream were extensive shallow, sandy shoals. The shoals extend upstream as far as the next wingdam at RM 733.0 and downstream to Location 9 at RM 732.6. Shoreline areas supported mature



MAIN CHANNEL BORDER STUDY POOL 5A RIVER MILE: 732.80 – 733.95

BATHYMETRIC MAP

SCALE: 1 in. = 400ft.

STRUCTURES ——

FIGURE 1-5. BATHYMETRIC MAP SHOWING DEPTH CONTOURS (FT) NEAR LOCATION 7.

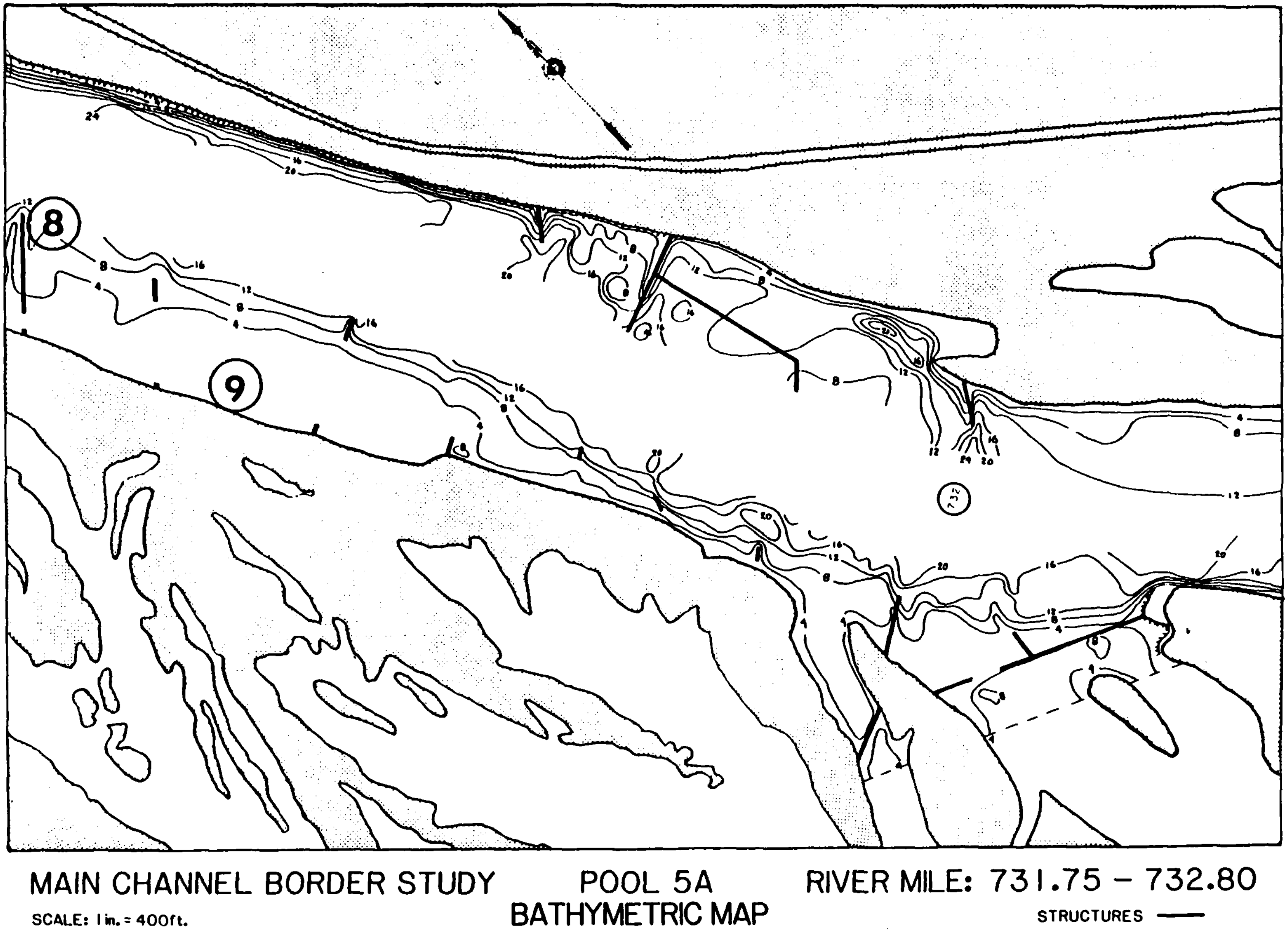


FIGURE 1-6. BATHYMETRIC MAP SHOWING DEPTH CONTOURS (FT) NEAR LOCATIONS 8 AND 9.

lowland forest that shaded nearly all of the river bank. The bottom sloped gradually from shore to depths of only 1m (during low flow) approximately 46m from shore. The offshore portions of the wingdam remain exposed rock with extensive sand deposits both along the face and back of the structure.

Location 9, Sand Flat - RM 732.6 West Shore

This location was a large, shallow shoal area of fine sediment material deposited between two wingdams. The location was near the downstream limits of a sweeping bend in the river, within slow, depositional current velocities. As a result of sedimentation of fines (sand, silt and clay) only a very gradual increase in depth with distance from shore occurs (Figure 1-6). For example, during low flow periods, depths of less than 1.5m persist offshore nearly to the main channel. Mature lowland forest overhangs the entire shoreline. Submerged trees, logs and root masses were numerous along the entire length of the shoreline at this location. Sediments ranged from well sorted, compacted sand offshore, to sandy-silt and muck nearshore.

Location 10, Sand Flat - RM 731.3 West Shore

Location 10, which was positioned on the inside of a sharp bend in the river, encompassed a wide variety of habitats. The upstream one-third of the location was within an area of higher current velocities and as a consequence, the bottom dropped off sharply to depths of approximately 1.5m (as measured in August) within 3-5m of shore (Figure 1-7). Sediments in this reach generally were well-compacted fine and coarse sands, frequently occurring as a thin layer over hard gray clay. Downstream, the current velocities were reduced nearshore and a depositional zone was apparent. In contrast to the upstream reach, the downstream two-thirds of the location sloped only very gradually from shore toward the main channel and an extensive shoal area, with water depths of less than 1m in August, extended from nearshore to the main channel. Substrates within this shoal were generally silty-sand near the shore and sandy offshore. Near shore, in depths less than 0.5m, macrophyte growth (Potamogeton pectinatus, Heteranthra dubia and Vallisneria americana) occurred in moderate to dense stands.

With the transition from eroding to depositional current velocities, variations in the nature of the shoreline also occurred. The upstream 50m of this location was a steep sand bank, about 4m high, void of vegetation. This abruptly changed to an undercut bank, lined with young willows and alders. This undercut bank persisted for about 100m, gradually becoming less undercut and eventually transforming into a gently sloping shoreline, lined with small brush. The shoreline along the downstream shoal area was clean sand beach, generally void of any vegetation.

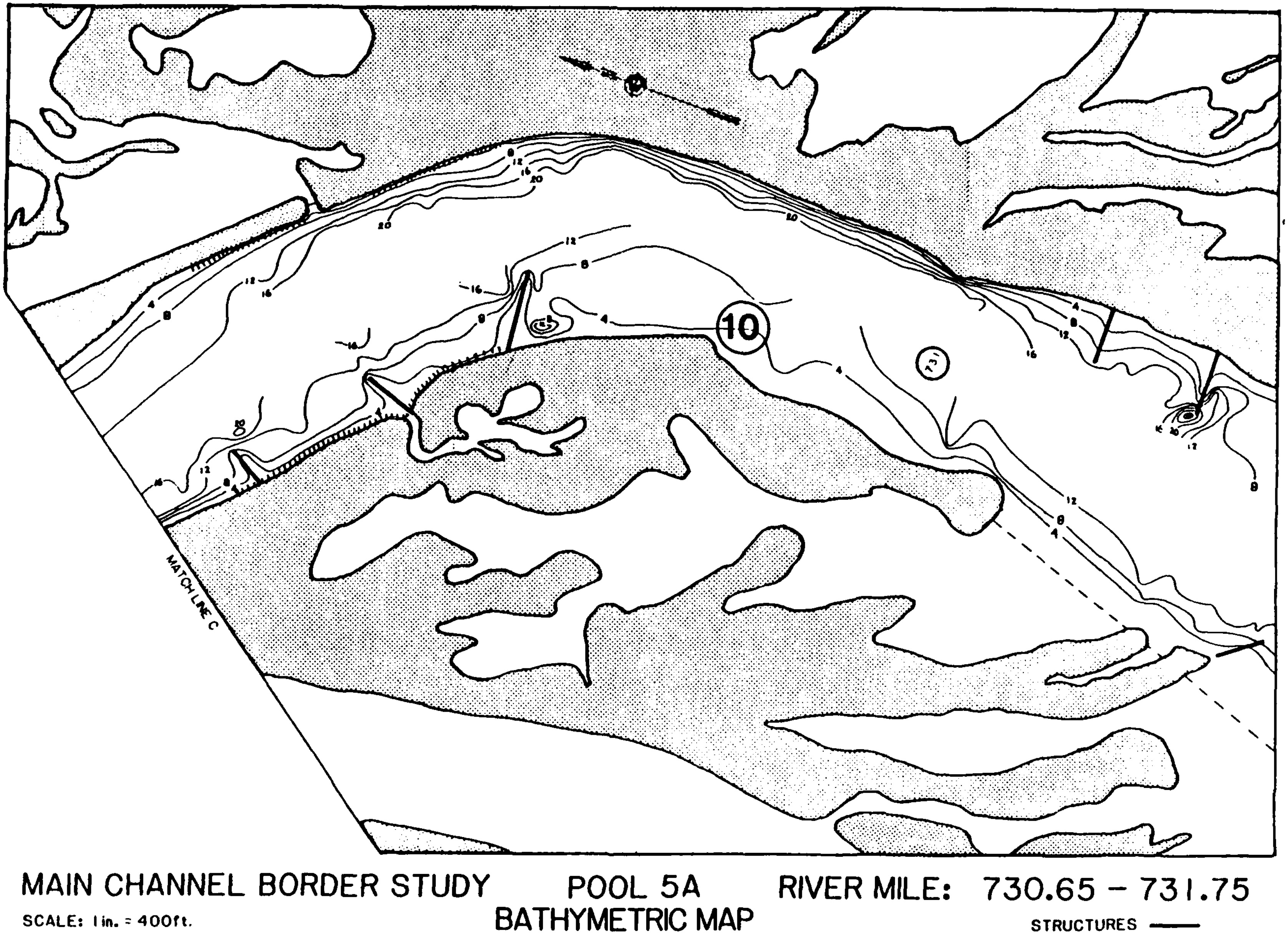


FIGURE 1-7. BATHYMETRIC MAP SHOWING DEPTH CONTOURS (FT) NEAR LOCATION 10.

2. PHYSICOCHEMICAL PARAMETERS

2.1 INTRODUCTION

Because the locations used during this study were originally selected based on their physical characteristics, a series of physicochemical measurements were made at each location in conjunction with each sampling effort. Physicochemical parameters are also important because they affect the distribution of fish, macroinvertebrates, and periphyton. Furthermore, many of these parameters (e.g., water depth and velocity, temperature) also affect the efficiency of the various gears used to capture periphyton, macroinvertebrates, and particularly fish.

2.2 METHODS

Physicochemical parameters were measured at two stations at each of the 10 fish sampling locations during each of the June, August, September, and November sampling periods. Each pair of stations was selected to represent as closely as possible the physical and chemical condition of the water as it entered and passed through each location. At each of the two stations, dissolved oxygen, temperature, specific conductance and current velocity were measured at the bottom, 0.6 depth, and surface. Dissolved oxygen, temperature, and specific conductance were measured using a Hydrolab Surveyor Model 6D, which was calibrated daily. pH measurements were made at each location in June and July using the Hydrolab, but were discontinued because of the constancy of the results among all the locations. Current velocity was measured using a Marsh-McBirney Model 201 electromagnetic current meter. Secchi disc transparency was also measured at each of the two stations. Average daily discharge and river stage values measured at Lock and Dam 5 during the five fisheries field collections were compiled.

Dissolved oxygen, temperature, specific conductance, current velocity, and Secchi disc transparency were also measured concurrent with each macroinvertebrate and periphyton collection period. Measurements were made at each location sampled. Measurements were made at the bottom, 0.6 depth and surface utilizing the equipment described above.

Additional current velocity measurements were made at two wing dams (Locations 4 and 8) during the three periods when periphyton and macroinvertebrate sampling was conducted. A cross-section of approach velocities to each wing dam structure was made by taking measurements at 0.5 meter intervals in the water column along a transect located approximately 15 meters upstream of each wing dam. A map of current velocity at the surface (i.e., top) of each wing dam was prepared by measuring current velocity near the substrate-water interface at 7.5 meter intervals along the length of the wing dam.

At Location 3 (the riprapped bank), current velocity was measured at 0.5 meter intervals in the water column along four transects situated perpendicular to the bank. Each transect was evenly spaced along the length of the riprapped bank, with the first transect (transect 1) being located at the upstream end of Location 3 and the last transect (transect 4) located approximately 50m upstream of the wing dam that was Location 4

(Figures 1-3 and 1-4). The measurements along each transect were made at distances of 2, 4, 6, 8, 10, and 12m from shore.

2.3 RESULTS AND DISCUSSION

For each of the six physicochemical parameters measured (temperature, dissolved oxygen, pH, conductivity, current velocity, and secchi depth), few inter-location differences were noted. This was expected because many of the locations were situated quite close together and the dynamic nature of riverine environments typically prohibits distinct vertical or horizontal (lateral) stratification. Exceptions to this uniformity among results were that temperature (and less often DO) were different at Location 6 (the silt bay) compared to all the other locations and that conductivities were usually lower at Location 3 (the riprapped bank) than at the other locations. Except, of course, for velocity, no correlations between these parameters and flow were apparent. Similarly, other than the expected changes in temperature and DO, monthly or seasonal variation among these parameters were not pronounced. Conductivity increased from spring to mid-summer and then declined for the remainder of the study. The detailed velocity profiles that were measured at Locations 3 (the riprapped bank), 4 and 8 (wing dams) showed that velocities were comparable at Locations 3 and 8, but were noticeably faster at Location 4. In June, velocities at Locations 3 and 8 typically were near 0.3 mps compared to typical values of 0.4-0.5 mps at Location 4. In August, velocities at Locations 3 and 8 were usually near 0.1 mps, compared to values approximately double this at Location 4. In September, velocities at Locations 3 and 8 were usually close to 0.2 mps, whereas values at Location 4 were typically between 0.3 and 0.4 mps.

2.3.1 pH

pH varied only from 7.7 to 7.9 among all the locations on the three dates on which it was measured (Table 2-1). These values are comparable to the mean values (7.8-8.0) measured on these dates upstream at Lock and Dam 3 (USGS 1983). Similarly, data collected at L and D 3 show that pH values in the UMR are consistent (7.3-8.5) throughout the year.

2.3.2 Temperature

Temperature followed the expected seasonal pattern. Temperatures in May and September were comparable (14-15C, Table 2-1). Temperatures in June, July and November averaged approximately 20, 25, and 4C, respectively. No temperature data were available for August because of a malfunction in the temperature mode of the Hydrolab. In June and September, temperatures were noticeably warmer at Location 6 (the silt bay) compared to all the other locations. This difference was most pronounced in measurements made at the surface where it was observed that temperatures at Location 6 were 1-3C warmer than the other locations (Tables A-3, A-4, and A-7, Appendix A). This difference was almost certainly the result of Location 6 being shallow and sheltered, and thus easily affected by solar heating.

TABLE 2-1 SUMMARY OF THE RANGE OF VALUES EXHIBITED BY 7 PHYSICOCHEMICAL PARAMETERS MEASURED IN POOL 5A DURING 1982. MEASUREMENTS TYPICALLY WERE MADE AT 0.6 DEPTH

Date	Temperature (C)		Dissolved Oxygen (mg/l)		pH (units)		Conductivity (μhos/cm)		Secchi depth (cm)	Velocity (mps)		Flow[a] (cfs)
	Location 6	All Other Locations	Location 6	All Other Locations	Location 6	All Other Locations	Location 6	All Other Locations	All Locations	Location 6	All Other Locations	All Locations
5 May[b]	14.0	13.5-15.5	11.0	9.7-11.9	-	-	255	160-330	-	-	-	69,201
8 May[b]	14.0	13.8-14.5	12.5	11.7-13.4	-	-	240	240-350	-	-	-	65,804
8 Jun[c]	20.3	19.6-20.2	9.2-10.6	8.4-9.1	7.8	7.7-7.8	369-371	365-418	51-61	0-.03	.11-.48	52,139
15 Jun[c]	20.5-21.0	19.5-20.0	4.6-9.0	8.1	7.8	7.7-7.9	240-388	400-422	-	-	-	35,134
14 Jul[d]	-	25.0-25.4	-	9.4-10.7	-	7.7	-	480-495	66	-	.03-.38	30,942
20 Aug[b]	-	-	10.0-11.4	9.1-11.6	-	-	-	-	-	< .03	<.03-.15	13,020
25 Sep[b]	17.5	15.0-15.5	11.1-11.2	9.2-10.3	-	-	337-347	360-413	58-89	0	.03-.38	27,983
13 Nov[b]	3.6	3.6	16.3-16.8	16.0-17.5	-	-	205-270	290-415	-	-	-	46,767

[a] Flow measured at Lock and Dam 5.

[b] Includes data from all 10 locations.

[c] Includes data from Locations 3, 4, 6, 8, and 10.

[d] Includes data from Locations 3, 4, and 8.

2.3.3 Dissolved Oxygen

DO concentrations were quite similar (8-12 mg/l) in all months except November (Table 2-1). DO followed the same spatial pattern as temperature. That is, DO values were similar at all the locations except Location 6, the silt bay. As with temperature, these differences were evident only in June, August and September, and were most pronounced in the surface samples. In these months, DO surface concentrations were 2-3 mg/l higher at Location 6b (approximately 100m inside the mouth of the cove), than at any of the other locations (Tables A-3, A-4, and A-7, Appendix A). During these same months, DO concentrations in the bottom waters at Location 6b were comparable or only slightly (<1 mg/l) higher than at the other locations, suggesting that the higher values in the surficial water were a result of photosynthetic activity in the euphotic zone.

2.3.4 Conductivity

Conductivity values typically were between 300 and 500 µumhos/cm (Table 2-1). As shown in Figure 2-1, mean conductivity values increased steadily from May through July, and then declined during the remainder of the study. Conductivity values upstream at Lock and Dam (LD) 3 followed a similar pattern; however, the magnitude of these changes was less at LD 3. The low conductivity values in Pool 5A and at LD3 in May coincided with high spring flows indicating that the runoff entering the UMR at that time had a low conductivity and served to "dilute" the background levels normally present in Pool 5A. The conductivity values observed at LD 3 were consistently higher than those observed in Pool 5A (Figure 2-1). Part of this difference may be attributable to the fact that the values at LD 3 reflect conditions in the main channel only; whereas, the values measured during this study were indicative of MCB conditions. For example, it was noted that conductivity values at Location 3 (the riprapped bank), which was situated just downstream of the mouth of Kielselhorse Bay, were consistently lower than at any of the other locations (Appendix A). This difference was most apparent when flows were high (Tables A-1, A-2 and A-8). Lower values were also frequently noted at wing dam-Location 4 (again reflecting the influence of water from Kieselhorse Bay) and at Location 6, the silt bay. Within a given month, conductivity values at the remaining 7 locations were comparable.

2.3.5 Secchi Depth

Secchi depth was determined in June, July and September only. On 8 June, secchi depths ranged from 51-61 cm and all 10 locations were judged to be comparable (Table A-3). The four locations sampled on 14 July all had secchi depth readings of 66 cm (Table A-5). In September, secchi depth values (84-89 cm) were again comparable at all locations, except Location 6 (the silt bay), which had a value of 58 cm (Table A-7).

2.3.6 River Flow

River flows were extremely variable during the study, not only among months but even within months (Figure 2-1). Ranges and means for daily flows measured at LD5 during each sampling period, were as follows:

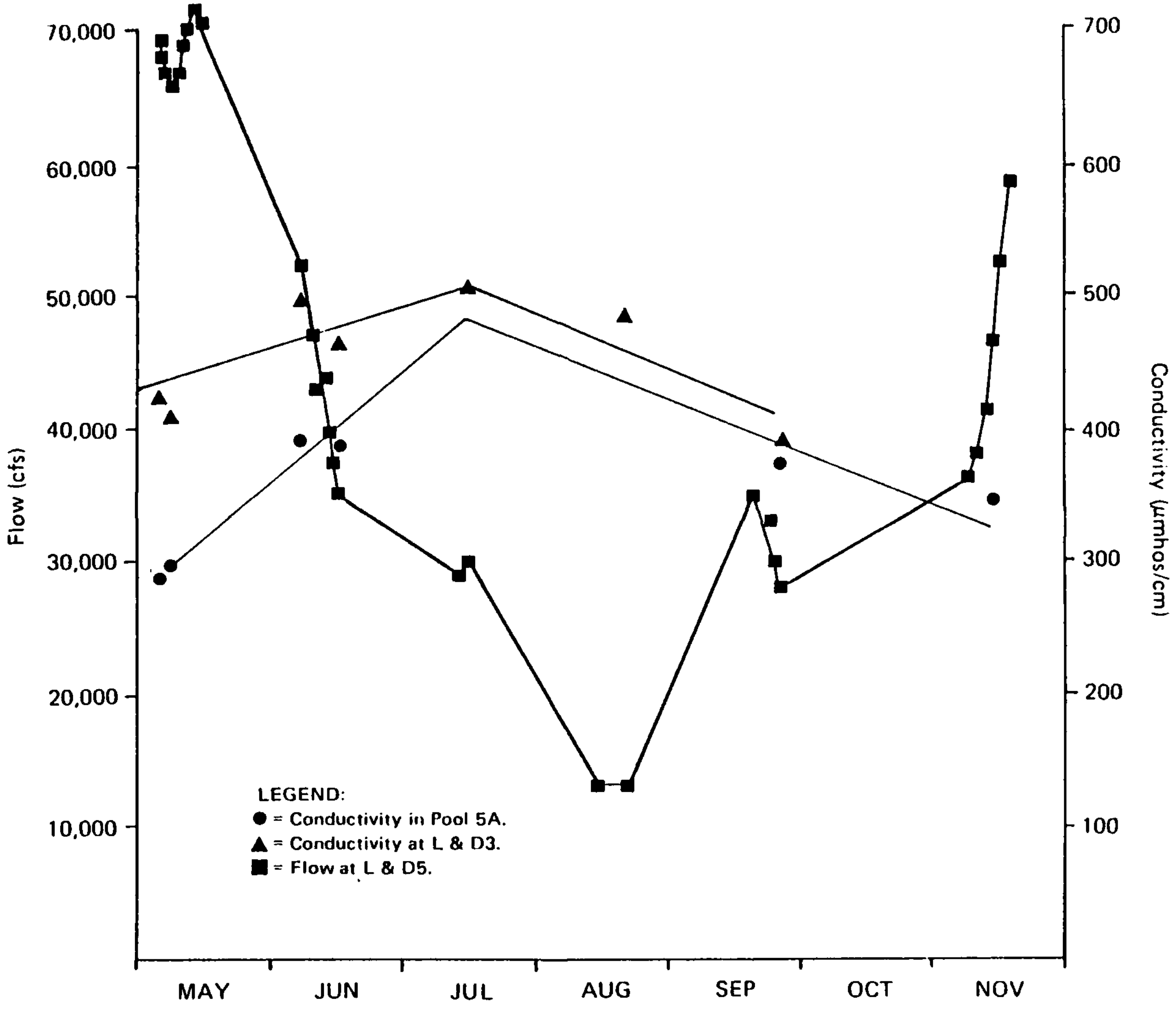


Figure 2-1. Relationship between conductivity and river flow in the Upper Mississippi River in 1982.

Month	Mean (cfs)	Range (cfs)
May	69,044	(65,804-72,584)
June	42,728	(35,134-52,139)
July	29,979	(29,016-35,134)
August	13,063	(11,588-13,360)
September	32,039	(27,983-35,802)
November	46,849	(36,655-58,771)

During the entire study period, flows ranged from 11,588 cfs on 22 August to 72,584 cfs on 12 May. On a monthly basis, flows were very high in May, high in June and November, moderate (i.e., normal) in July and low in August. Intra-month variations were also substantial. For example, during June, flows were 52,139 cfs at the beginning of the sampling period, but dropped to 35,134 cfs by the end of the period. Conversely, in November, flows were 36,655 cfs at the beginning of the sampling period, but rose to 58,771 cfs by the end of the period. Flows were stable only during the July and August sampling periods. It seems reasonable to conclude that the substantial inter- and intra-month variations described above significantly affected the results of the biological portions of this study, particularly the fisheries results.

2.3.7 Velocity

Velocities were usually highest at Location 7 (wing dam) and always were lowest at Location 6, the silt bay (Appendix A). As expected, velocities generally varied in concert with flows. For example, flows in July and September were comparable (30,000 cfs) and the range of velocities each month was identical (0.03-0.38 mps, Table 2-1). The relationship between flow and velocity was not exact, however. For example, flows were 10 percent lower in November than in June, but the mean velocity at 0.6 depth for all locations combined (except Location 6, the silt bay) was 48 percent higher in November than in June. The increase in velocity noted in November may have been caused by ice in the backwaters which prevented water from entering the backwaters and forcing more of the flow down the ice-free main channel of the river. During the low flow period in August, velocities were ≤.15 mps at all locations.

In August, it was noted that the 75 percent reduction in flow (compared to June) caused a mean reduction in velocity of 73 percent. Moreover, the results among the nine locations (the results from Location 6, the silt bay, were not included in calculating the 73 percent reduction) were quite similar. Percent reductions for eight of the locations were between 67 percent (Location 8, wing dam) and 86 percent (Location 2, closing dam); only Location 3 (the riprapped bank) was noticeably different, with a 51 percent reduction. The results in September were more variable; a 46 percent reduction in flow (compared to June) caused reductions in velocity of 31 percent (Location 1, wing dam) to 91 percent (Location 10, sand flat). Collectively, the August and September results showed that velocities were reduced most at Locations 10 (sand flat), 7 (wing dam), and 2 (closing dam), while velocities were reduced least at Locations 9 (sand flat), 1 (wing dam), and 3 (riprapped bank). In November, Locations 2, 7, and 10 were again among the locations most affected, while Locations 3, 9, and 1 were again among those least affected.

2.3.8 Velocity Profiles

Location 4 (wing dam) - In June, velocities 15 m upstream of Location 4 were generally between 0.3 and 0.5 mps, and little variation with depth was apparent until very close to the bottom (Figure 2-2). As expected, velocities were greatest at the point along the transect furthest from shore (i.e., at 45m). During August low flow conditions, velocities were typically between 0.1 and 0.2 mps along the two shoreward transects and generally near 0.2 mps along the 45 m transect. In September, velocities were typically between 0.2 and 0.3 mps along the two shoreward transects and between 0.2 and 0.4 mps along the 45 m transect.

Measurements made along the water-bottom interface showed that, in June, bottom velocities increased steadily all the way out to the end of the wing dam (Figure 2-3). However, in August and September, maximum velocities occurred near the midpoint of the wingdam. Figure 2-3 also shows that although depths between the 15 and 37.5 m transects on the wingdam were comparable (0.7-1.0 m) in August and September, velocities were much higher in September than in August.

In August, approach velocities and velocities along the top of the wing dam were similar. However, in June and September, velocities on the top of the wing dam were typically 0.2-0.3 mps faster than approach velocities measured at the corresponding depth in the water column (Figures 2-2 and 2-3).

Location 8 (wing dam) - Velocities 15 m upstream of Location 8 were typically between 0.2 and 0.4 mps in June, between 0.1 and 0.2 mps in September, and less than 0.1 mps in August. Thus, during each month, velocities 15 m upstream of Location 8 were typically 0.1 mps slower than 15 m upstream of Location 4. This supports the designations of fast and slow for Locations 4 and 8, respectively. Velocities 15 m upstream of Location 8 were quite uniform both laterally and vertically (except right on the bottom) (Figure 2-4).

Bottom measurements made along the nearly 150 m length of the wingdam at Location 8 showed that velocities varied from 0.2 to 0.6 mps in June, from 0.1 to 0.3 mps in September, and were <0.1 mps in August (Figure 2-5). Bottom velocities were fairly uniform across the entire length of the wingdam.

In August, velocities measured at the top of the wing dam were slower than approach velocities measured at a corresponding depth (Figures 2-4 and 2-5). The reverse occurred in June when, except near shore, velocities on the top of the wing dam were faster than approach velocities. In September, approach velocities and velocities on the top of the wing dam were comparable.

To determine the general relationship between river flow and current velocity, mean velocity was calculated each month at Locations 4 and 8 by averaging all the velocity measurements (except those measured on the

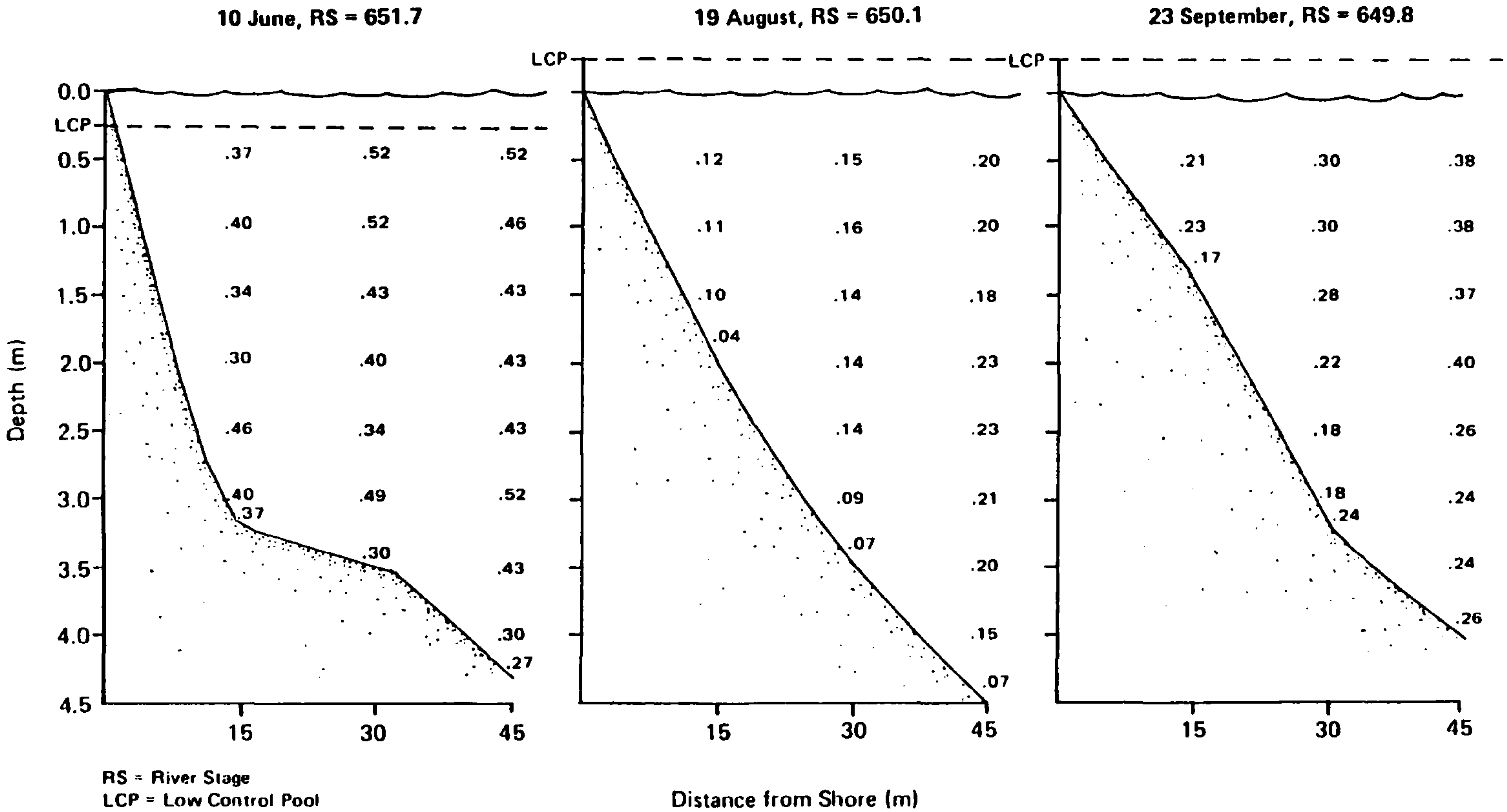


Figure 2-2. Results of current velocity profiles determined in Pool 5A 15 m upstream of Location 4 in June, August, and September 1982.

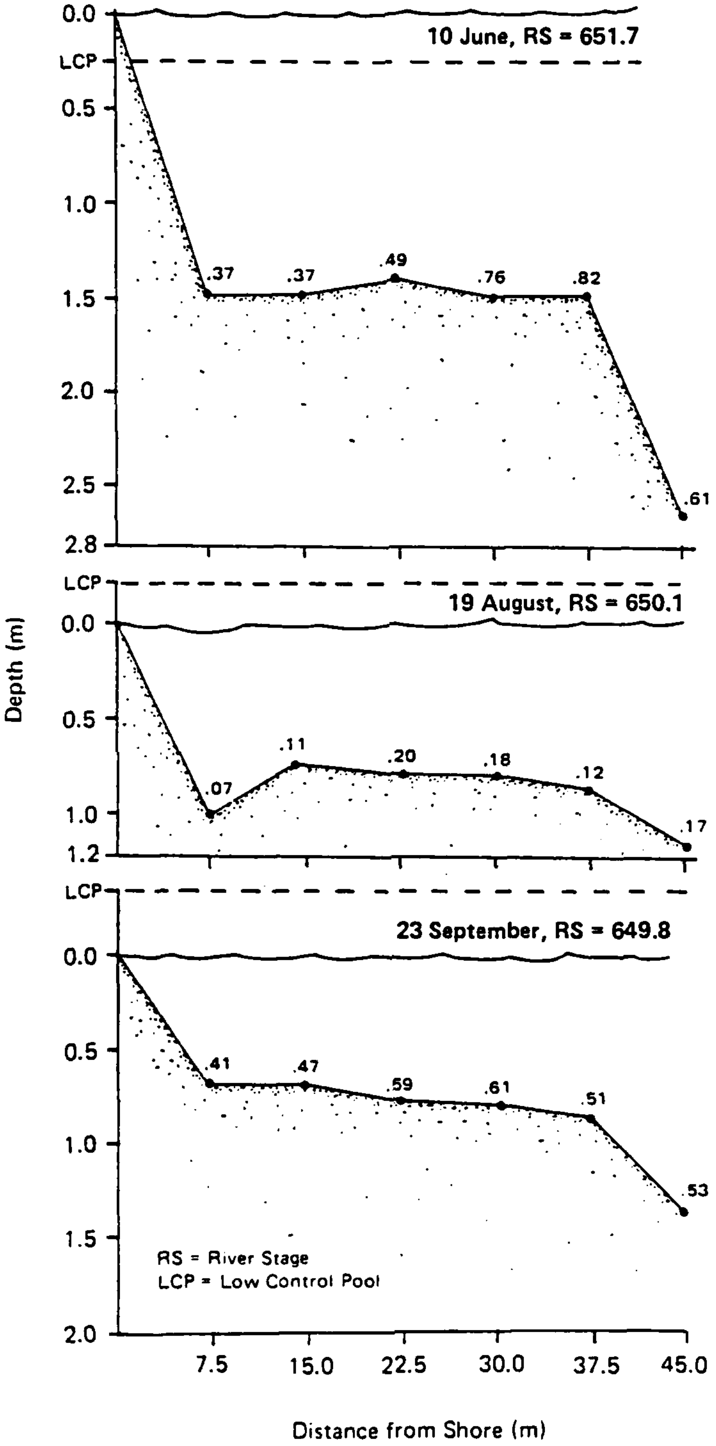


Figure 2-3. Results of current velocity measurements made on the surface (top) of the wing dam at Location 4 in Pool 5A, June, August, and September 1982.

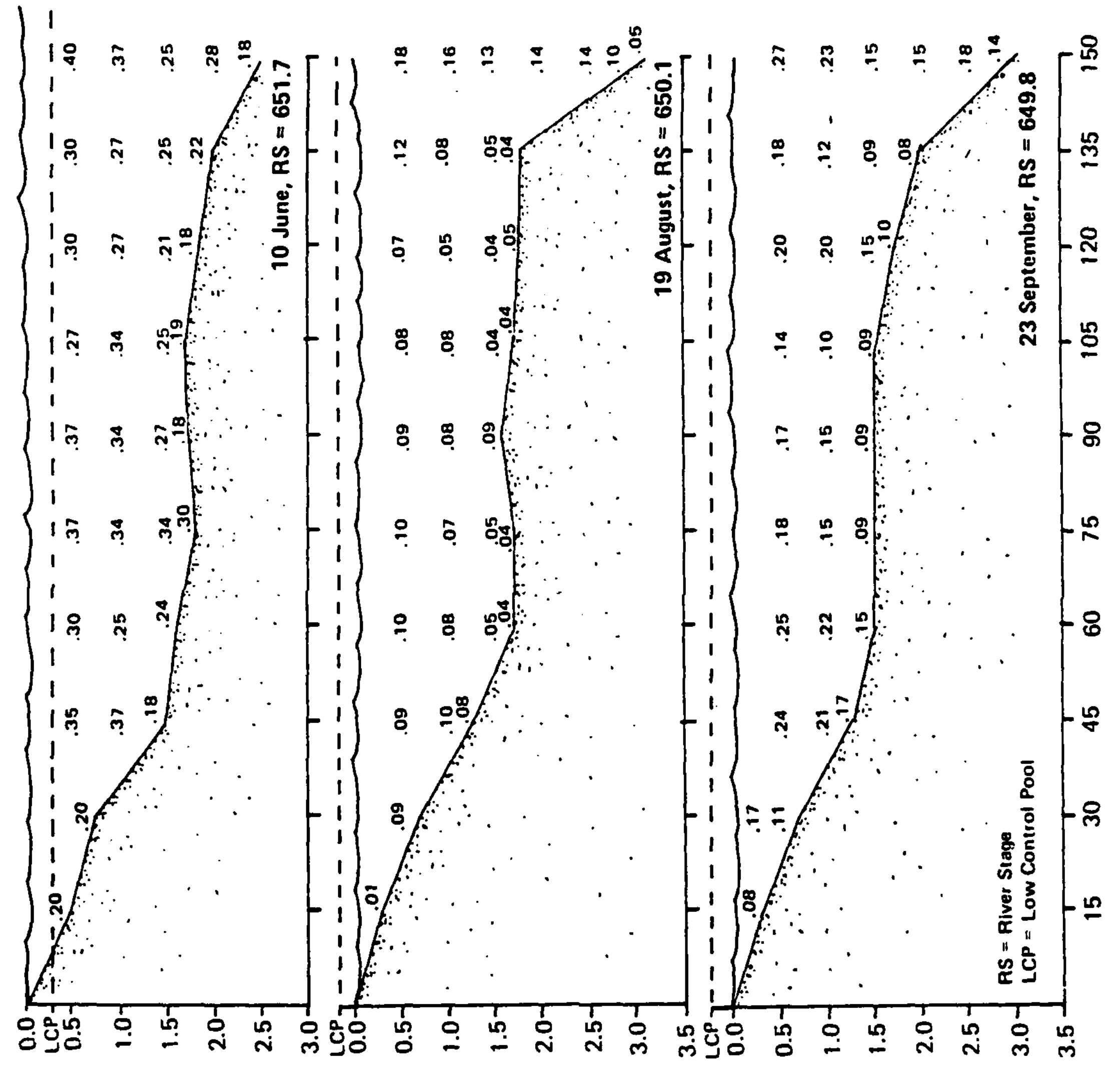


Figure 2-4. Results of current velocity profiles determined in Pool 5A 15 m upstream of Location 8 in June, August, and September 1982.

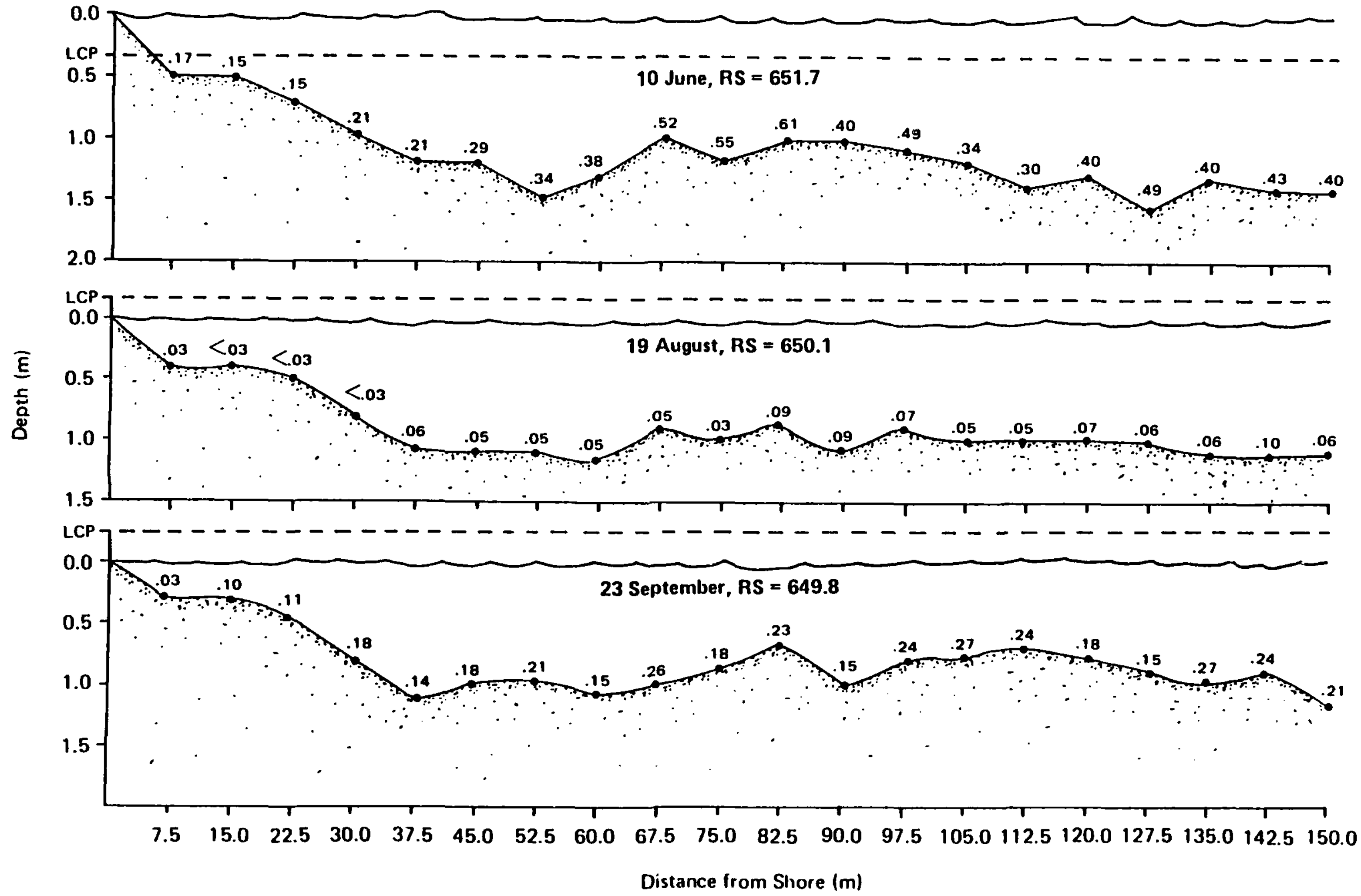


Figure 2-5. Results of current velocity measurements made on the surface (top) of the wing dam at Location 8 in Pool 5A, in June, August, and September 1982.

bottom of the river) made 15m upstream of each wing dam. It was found that a given percentage reduction in flow yielded a comparable reduction in velocity. For example, a 70 percent reduction in flow from the value on 10 June to that on 19 August elicited reductions in mean velocity of 62 and 69 percent at Locations 4 and 8, respectively. Similarly, a 32 percent reduction in flow from 10 June to 23 September caused reductions in velocity of 31 and 38 percent at Locations 4 and 8, respectively.

Location 3 (riprapped bank) - Regardless of sampling month, velocities, on the average, were highest along transect 2, followed in order, by transects 3, 1, and 4 (Figures 2-6 to 2-8). The reduced velocities at transect 1 were the result of the shelter provided by the point of land that formed the upstream end of the mouth of Kieselhorse Bay (Figure 1-1). The benthos sampling location referred to as 3-Slow was located at transect 1. The reduced velocities at transect 4 were caused by the wing dam located approximately 50m downstream. As expected, velocities were noticeably higher in June than in August or September. Similarly, velocities in September were higher than in August. The dropoff to deep water at transects 1 and 4 was not as steep as at transects 2 and 3. Thus, there was a noticeable slack-water area associated with the nearshore (0-6 m) zone along transects 1 and 4.

2.5 REFERENCES

U.S. Geological Survey. 1983. Water Resources Data for Wisconsin. Madison, Wisconsin. 426 p.

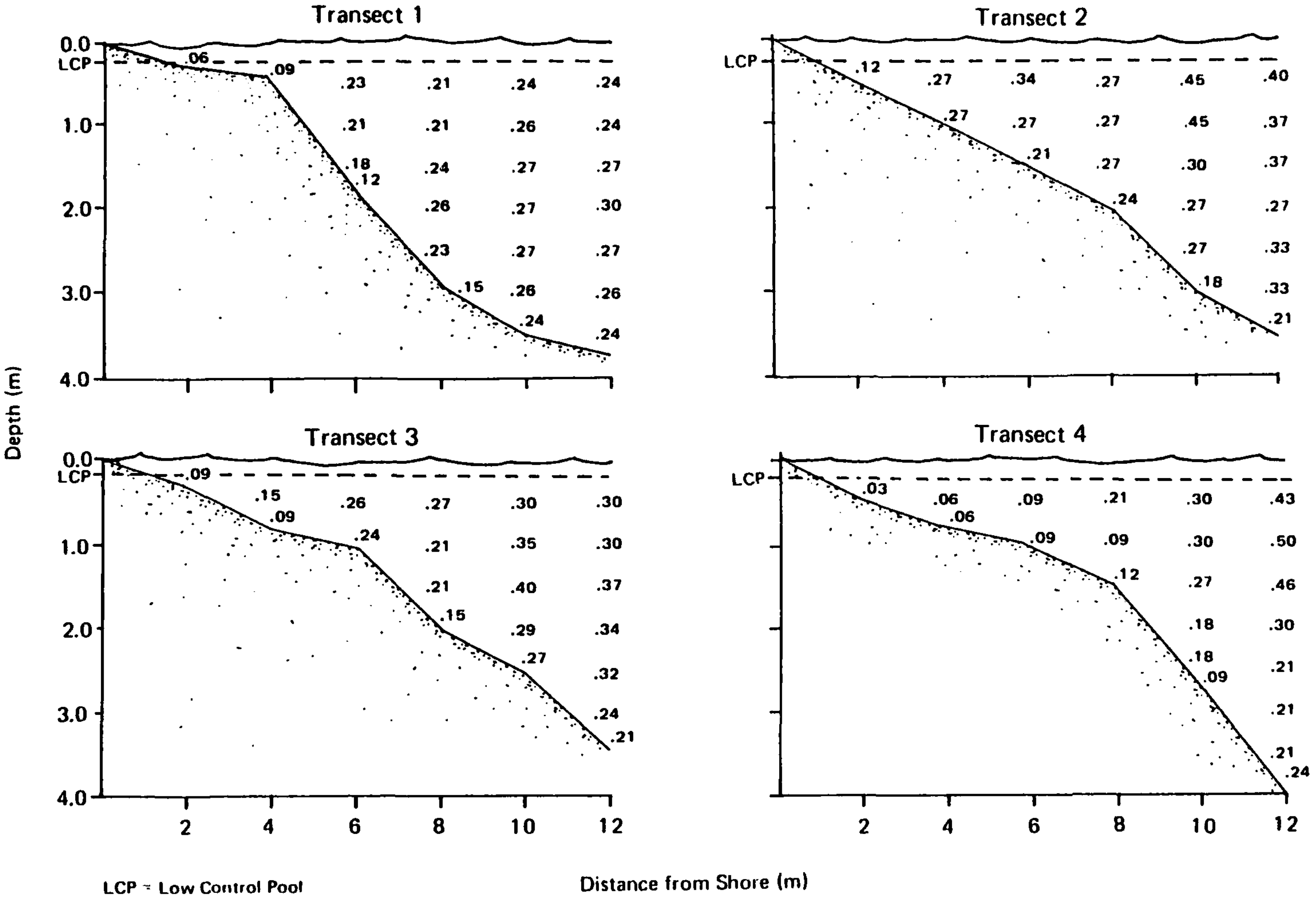


Figure 2-6. Results of velocity profiles determined in Pool 5A along four transects at Location 3 in June 1982 at a river stage of 651.7.

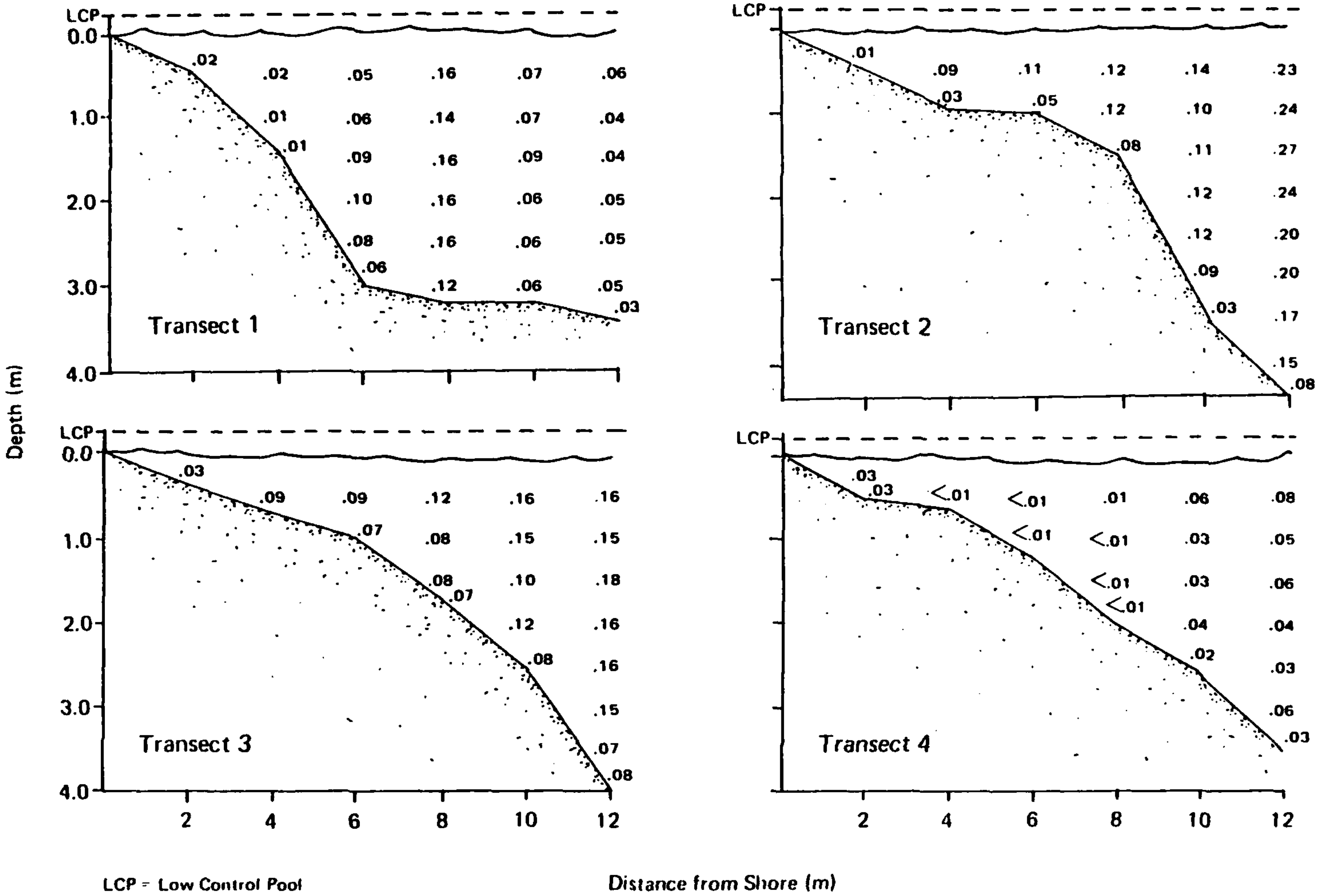


Figure 2-7. Results of velocity profiles determined in Pool 5A along four transects at Location 3 in August 1982 at a river stage of 650.1.

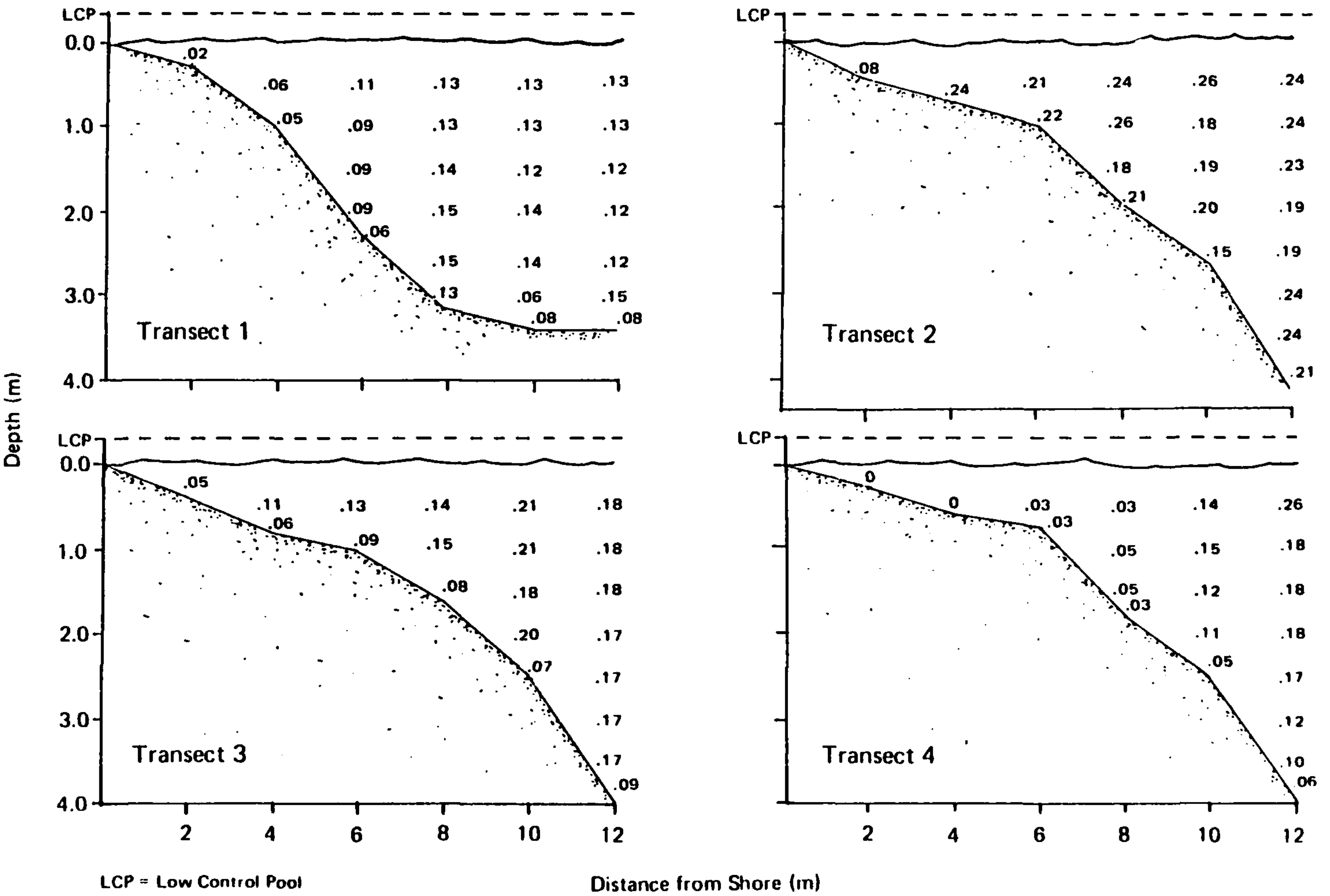


Figure 2-8. Results of velocity profiles determined in Pool 5A along four transects at Location 3 in September 1982 at a river stage of 649.8.

3. PERIPHYTON

3.1 INTRODUCTION

Periphyton is a community of organisms that grow attached to underwater substrates (Weber 1973a). Broadly defined, periphyton may include bacteria, fungi, algae, protozoans, and invertebrates (Cooke 1956; Sladeckova 1962). However, the definition of periphyton is most commonly restricted to the community of attached algae (Wetzel 1975).

Periphytic algae are important primary producers in rivers and streams (Cummins 1975; Wilhm et al. 1978). They are important for photosynthetic production of oxygen and as a source of food or shelter for many macroinvertebrates and fish. Under favorable conditions such as sufficient light, suitable substrates, and low water velocities, algal populations are able to develop profusely. Periphyton attach to a variety of substrates from rocks to fine silt. The variability of natural substrates and the changing physical and biotic factors that influence periphyton distribution often create an extremely heterogeneous assemblage (Wetzel and Westlake 1969).

Periphyton is an excellent indicator of water quality (Weber 1973a). Species composition and seasonal abundance are related to physical and chemical factors such as water temperature, light intensity, substrate type, current, and nutrient concentrations. Because diatoms are often a major component of the periphyton, they have received considerable attention. Many ecological requirements of diatoms have been documented (Patrick 1948; Lowe 1974), and species diversity, as well as indicator species, have proven useful in evaluating water quality (Patrick 1973).

Most periphyton studies conducted in the Upper Mississippi River have utilized artificial substrates to assess biomass production (Fremling et al. 1979), chlorophyll *a* production, and community composition (Seng and Johnson 1973; Lewis et al. 1974; Clark and Seng 1974; Clark 1975, 1976; Heffelfinger 1977). Although artificial substrates have proven very useful for monitoring effects of environmental disturbances (Weber 1973b), they may not always reflect the characteristics of periphyton growing on nearby natural substrates. Periphyton composition and abundance on artificial substrates are affected not only by the duration of exposure (Hoagland et al. 1982), but also by sloughing or scouring that may occur during the exposure period (Hoagland 1983). The materials used for channel maintenance and bank stabilization structures in the main channel border of the river provide a considerable quantity of "natural" substrates that are continuously available for colonization and growth by periphyton and other trophic levels. This study examines the extent to which these substrates are utilized by periphyton and the nature of the communities present on representative structures in Pool 5A.

3.2 METHODS

Periphyton communities growing on natural substrates (rocks, riprap) along representative riprapped banks (Locations 3H and 3L) and wingdams (Locations 4H and 8L; Figure 1-1) in Pool 5A were sampled monthly from June through September 1982. The H and L suffixes used in location designations indicated areas of relatively high and low current velocity, respectively. At each location, ten rocks from various depths were selected for sampling. Two

Epilithic Algal Bar Clamp Samplers were attached by a diver to each rock, and the rock was then brought to the surface for periphyton collection. These samplers were designed to seal a sample of known area on the substrate while the substrate was naturally positioned in the water (Pryfogle 1975). Thus periphyton was collected with very little disruption of community composition and with reductions in the loss of periphytic organisms that normally occurs when substrates are removed from water. The scrapings from one sampler were maintained as a separate replicate for subsequent biomass and chlorophyll a measurements; scrapings from the other sampler were composited into a single sample per location for periphyton identification and enumeration. Biomass/chlorophyll a samples were stored on ice in the dark until laboratory processing, whereas other samples were preserved in the field with M^3 (Meyer 1971).

An underwater survey of periphyton distribution at the four locations was conducted by a diver in August 1982. The survey of the wingdams was conducted in conjunction with current velocity measurements. At 15 meter intervals along the length of the wingdam, the diver examined the rock substrates at various depths on the downstream, top, and upstream sides of the structure. Rocks containing visually distinct periphytic growth forms were brought to surface, representative scrapings of algae were preserved with M^3, and the distribution of the growth forms was noted. On the riprapped bank, rocks from various depths along approximately 50 meters of shoreline were similarly surveyed and collected.

In the laboratory, each biomass/chlorophyll a replicate was mixed in a blender for approximately 30 seconds and split into two subsamples of equal volume. Biomass subsamples were placed in crucibles, dried overnight at 105 C, cooled in a desiccator for approximately 2 hours, and weighed to the nearest 0.1 milligram. After combustion at 500 C for 1 hour, the ash in these samples was wetted with deionized water to restore waters of hydration, and the samples were again dried at 105 C, cooled, and weighed. Biomass standing crops determined by these gravimetric methods were expressed as milligrams per square decimeter of substrate (mg/dm^2, ash free dry weight).

Chlorophyll a subsamples were filtered with a small volume of magnesium carbonate suspension onto glass fiber filters, which were then frozen for at least 24 hours. Samples were macerated in a tissue grinder with 90 percent aqueous acetone and transferred to centrifuge tubes. After steeping overnight at 4 C under dark conditions, samples were clarified by centrifugation. Optical density then was determined spectrophotometrically before and after the addition of 1.0 N hydrochloric acid (APHA 1976). Chlorophyll a standing crops, corrected for phaeophytin a, were expressed as micrograms per square decimeter of substrate (µg/dm2). Phaeophytin a concentrations were expressed in similar units.

Each composite sample for periphyton identification and enumeration was thoroughly mixed in a blender for approximately 30 seconds, transferred to a labeled sample container, and adjusted to a volume of 250 milliliters. Ten percent of each sample was removed to prepare Hyrax diatom slides. Five aliquots of the remaining sample (diluted when necessary) were placed in separate settling chambers designed for use on a Zeiss inverted microscope. Periphyton was allowed to settle overnight, and one diameter of each circular chamber was then examined at 1,000X magnification. Periphytic algae containing protoplasts were identified, usually to species, and counted as cells except for filamentous forms, which were routinely counted in 10-μm length units. Empty diatom valves and frustules were considered dead and were separately enumerated in centric and pennate categories. Periphyton densities were expressed as number of cells or units per square millimeter of substrate (No./mm2).

Hyrax diatom slides were prepared from quantitative monthly samples and most qualitative samples collected during the August distribution survey. Diatom samples were boiled in nitric acid and potassium dichromate and, after appropriate settling times, rinsed several times with deionized water. A portion of the cleaned material was placed on a cover glass, allowed to air dry, and mounted onto a microscope slide with Hyrax mounting media. For each sample, 500 diatom valves were identified and enumerated at 1,250X magnification under oil immersion. The relative abundance of diatom taxa was expressed as the percentage of the total valves counted for each slide. Nondiatoms collected during the August distribution survey were identified from wet mounts examined at 500X magnification.

Although many taxonomic references were used to identify diatoms, publications by Patrick and Reimer (1966, 1975) and Hustedt (1927-1966, 1930, 1937-1938, 1949) were extensively employed in this study. Nomenclature generally followed Stoermer and Kreis (1978), which contains currently accepted synonyms of most diatoms encountered in Pool 5A. The reader is referred to Lange-Bertalot (1977, 1980), Lange-Bertalot and Simonsen (1978), and Simonsen (1979) for other proposed changes in diatom nomenclature that were not generally used in the present study. Prescott (1962) was used to identify most nondiatoms, although several other references (e.g., Desikachary 1959; Taft and Taft 1971; Whitford and Schumacher 1973) were consulted for specific taxa.

Biomass and chlorophyll a data were used to calculate the Autotrophic Index (Weber 1973a, b), which incorporates these two standing crops to indicate the relative proportion of heterotrophic (nonalgal) and autotrophic (photosynthetic) components in the periphyton. Density data were used to calculate several measures of community structure. These indices included diversity (Shannon 1948, using base 2 logarithms), evenness (Pielou 1966), and redundancy (Hamilton 1975). Additionally, densities of taxa composing at least 1.0 percent of total density at any location each month were analyzed by a multivariate technique based on Bray and Curtis (1957). This technique simultaneously compared the abundances of these taxa and then produced a coefficient which described the degree of affinity between two locations. Greater similarity among locations was indicated by smaller coefficients. Average group-linkage cluster analysis (normal classification or Q-mode analysis; Boesch 1977) was then used to produce dendrograms that grouped into clusters locations with high degrees of similarity (i.e., low Bray and Curtis coefficients). These clusters were in turn grouped at successively higher levels as indicated by their decreasing similarity. Natural clusters of locations with similar communities were indicated on the dendrograms by a sudden increase in the linkage coefficient (Boland 1976). Additionally for this report, locations linked at coefficients less than approximately 0.3 were considered quite similar, whereas locations linked at coefficients greater than approximately 0.5 were considered dissimilar. Other statistical applications were primarily restricted to the replicate biomass and chlorophyll a data and were carried out using the Statistical Analysis System (SAS), a general purpose statistical computer program. Significance was defined as $P \leq 0.05$ for all statistical hypothesis testing.

3.3 RESULTS AND DISCUSSION

3.3.1 Composition

From the quantitative and qualitative samples collected during 1982, 275 algal taxa representing 71 genera and 7 major taxonomic divisions were identified in Pool 5A (Table 3-1). More than 75 percent of the taxa were diatoms (Bacillariophyta), reflecting not only the diversity of this algal group in Pool 5A, but also the added emphasis placed on diatom identifications (i.e., proportional counts of Hyrax slides). Green algae (Chlorophyta) and blue-green algae (Cyanophyta) were also well represented by 32 and 26 taxa, respectively. Five or fewer taxa were identified from each of the other major algal divisions. Detailed information on the composition and abundance of periphyton in Pool 5A is presented in Appendix B.

Twenty-one taxa were considered numerically important because they composed at least 5 percent of total periphyton density in one or more quantitative samples (Table 3-2). Nearly all of these taxa were blue-green algae (12 taxa) or diatoms (7 taxa). The number of important diatoms was artificially reduced by grouping into one taxon several very small species of Navicula (e.g., N. minima, N. seminuloides, and N. seminulum) that could not be consistently differentiated with accuracy during quantitative analyses. Conversely, the number of important blue-green algae was somewhat inflated by single occurrences of multicellular colonies (e.g., Aphanocapsa elachista and Microcystis incerta). The filamentous green alga Cladophora glomerata and the filamentous red alga Audouinella violacea were only occasionally important, but the quantitative method used in this study probably did not provide accurate abundance estimates of these large forms.

All of the important diatoms on natural substrates in Pool 5A have been observed on artificial substrates deployed elsewhere in the Upper Mississippi River. Additionally, Melosira varians, Navicula tripunctata, and small Navicula species were not only present but also numerically important in Pool 14 near Quad Cities (Hefflefinger 1977). Diatoms that were considered dominant in other studies (Hefflefinger 1977; Kuhl 1976, 1978) but not in Pool 5A included species that are generally most abundant in cool seasons (e.g., Diatoma vulgare, Fragilaria vaucheriae, Gomphonema olivaceum) and are typically found on artificial substrates (e.g., Cocconeis placentula, Gomphonema parvulum, Nitzschia dissipata). The filamentous blue-green algal genera Lyngbya, Oscillatoria, and Phormidium were important in Pool 5A and have commonly been dominant nondiatoms in other studies, although within each genus important species have varied among sites. Kuhl (1978) also reported Chroococcus as a dominant blue-green alga near Monticello, Minnesota. The green alga Cladophora glomerata has been absent or numerically unimportant in most artificial substrate studies, even though it was sometimes abundant on nearby structures (Hefflefinger 1977), primarily because exposure periods of the substrates were too short to permit extensive development of this relatively slow-growing alga.

TABLE 3-1 ALGAE IDENTIFIED IN PERIPHYTON SAMPLES COLLECTED FROM NATURAL SUBSTRATES IN POOL 5A, UPPER MISSISSIPPI RIVER, 1982

- BACILLARIOPHYTA (Diatoms)
  - Centrales
    - Actinocyclus normanii fo. subsalsa (Juhl.-Dannf.) Hustedt
    - Biddulphia laevis (Ehrenberg) Hustedt
    - Cyclotella atomus Hustedt
    - Cyclotella kutzingiana Thwaites
    - Cyclotella meneghiniana Kuetzing
    - Cyclotella pseudostelligera Hustedt
    - Melosira ambigua (Grunow) O. Mueller
    - Melosira distans (Ehrenberg) Kuetzing
    - Melosira granulata (Ehrenberg) Ralfs
    - Melosira granulata var. angustissima O. Mueller
    - Melosira italica (Ehrenberg) Kuetzing
    - Melosira varians C.A. Agardh
    - Skeletonema potamos (Weber) Hasle
    - Stephanodiscus astraea (Ehrenberg) Grunow
    - Stephanodiscus astraea var. minutula (Kuetzing) Grunow
    - Stephanodiscus hantzschii Grunow
    - Stephanodiscus invisitatus Hohn and Hellerman
    - Stephanodiscus minutus Grunow ex Cleve and Moller
    - Stephanodiscus niagarae Ehrenberg
    - Stephanodiscus tenuis Hustedt
    - Thalassiosira fluviatilis Hustedt
    - Thalassiosira pseudonana (Hustedt) Hasle and Heimdal
    - Thalassiosira? rudolfii (Bachmann) Hasle
    - Small unidentified centrics
  - Pennales
    - Achnanthes clevei Grunow
    - Achnanthes clevei var. rostrata Hustedt
    - Achnanthes exigua Grunow
    - Achnanthes hauckiana Grunow
    - Achnanthes hauckiana var. rostrata Schultz
    - Achnanthes hungarica (Grunow) Grunow
    - Achnanthes lanceolata (Brebisson) Grunow
    - Achnanthes lanceolata var. dubia Grunow
    - Achnanthes lanceolata var. omissa Reimer
    - Achnanthes lewisiana Patrick
    - Achnanthes linearis (W. Smith) Grunow
    - Achnanthes minutissima Kuetzing
    - Achnanthes? peragalli Brun and Heribaud
    - Achnanthes pinnata Hustedt
    - Amphora normanii Rabenhorst
    - Amphora ovalis (Kuetzing) Kuetzing
    - Amphora ovalis var. affinis (Kuetzing) VanHeurck ex DeToni
    - Amphora ovalis var. pediculus(Kuetzing)VanHeurck ex DeToni
    - Amphora perpusilla (Grunow) Grunow
    - Amphora veneta Kuetzing
    - Asterionella formosa Hassall
    - Bacillaria paxillifer (O.F. Muller) Hendy
    - Caloneis bacillum (Grunow) Cleve
    - Caloneis spp.
    - Capartogramma crucicula (Grunow ex Cleve) Ross
    - Cocconeis diminuta Pantocsek
    - Cocconeis pediculus Ehrenberg
    - Cocconeis placentula Ehrenberg
    - Cocconeis palcentula var. euglypta (Ehrenberg) Cleve
    - Cocconeis placentula var. lineata (Ehrenberg) VanHeurck
    - Cymatopleura solea (Brebisson and Godey) W. Smith
    - Cymbella mexicana (Ehrenberg) Cleve
    - Cymbella microcephala Grunow
    - Cymbella minuta Hilse ex Rabenhorst
    - Cymbella prostrata (Berkley) Cleve
    - Cymbella sinuata Gregory
    - Cymbella tumida (Brebisson) VanHeurck
    - Diatoma tenue Agardh
    - Diatoma vulgare Bory
    - Diploneis elliptica (Kuetzing) Cleve
    - Entomoneis ornata (J.W. Bailey) Reimer
    - Eunotia praerupta Ehrenberg
    - Fragilaria brevistriata Grunow
    - Fragilaria brevistriata var. inflata (Pantocsek) Hustedt
    - Fragilaria capucina var. mesolepta Rabenhorst
    - Fragilaria construens (Ehrenberg) Grunow
    - Fragilaria construens var. binodis (Ehrenberg) Grunow
    - Fragilaria construens var. venter (Ehrenberg) Grunow
    - Fragilaria crotonensis Kitton
    - Fragilaria leptostauron (Ehrenberg) Hustedt
    - Fragilaria leptostauron var. dubia (Grunow) Hustedt
    - Fragilaria pinnata Ehrenberg
    - Fragilaria pinnata var. lancettula (Schumann) Hustedt
    - Fragilaria vaucheriae (Kuetzing) Petersen
    - Fragilaria rhomboides var. amphipleuroides (Grunow) Cleve
    - Gomphonema abbreviatum Agardh
    - Gomphonema angustatum (Kuetzing) Rabenhorst

- BACILLARIOPHYTA (cont.)
    - Gomphonema gracile Ehrenberg
    - Gomphonema olivaceoides Hustedt
    - Gomphonema olivaceum (Lyngbye) Kuetzing
    - Gomphonema parvulum (Kuetzing) Kuetzing
    - Gomphonema sphaerophorum Ehrenberg
    - Gomphonema subclavatum (Grunow) Grunow
    - Gomphonema subclavatum var. commutatum (Grunow) A. Mayer
    - Gomphonema subclavatum var. mexicanum (Grunow) Patrick
    - Gomphonema tenellum Kuetzing
    - Gomphonema tergestinum (Grunow) Fricke
    - Gomphonema spp.
    - Gyrosigma acuminatum (Kuetzing) Rabenhorst
    - Gyrosigma sciotense (Sullivan and Wormley) Cleve
    - Gyrosigma spencerii (Quekett) Griffet and Henfrey
    - Gyrosigma spp.
    - Meridion circulare (Greville) Agardh
    - Navicula accomoda Hustedt
    - Navicula anglica var. subsalsa (Grunow) Cleve
    - Navicula atomus (Kuetzing) Grunow
    - Navicula biconica Patrick
    - Navicula capitata Ehrenberg
    - Navicula capitata var. hungarica (Grunow) Ross
    - Navicula clementis Grunow
    - Navicula confervacea (Kuetzing) Grunow
    - Navicula contenta var. biceps (Arnott) VanHeurck
    - Navicula costulata Grunow
    - Navicula cryptocephala Kuetzing
    - Navicula cryptocephala var. veneta (Kuetzing) Rabenhorst
    - Navicula decussis Oestrup
    - Navicula exigua Gregory ex Grunow
    - Navicula graciloides A. Mayer
    - Navicula halophila (Grunow) Cleve
    - Navicula heufleri Grunow
    - Navicula ingenua Hustedt
    - Navicula integera (W. Smith) Ralfs
    - Navicula krasskei Hustedt
    - Navicula lamii Manguin
    - Navicula lanceolata (Agardh) Kuetzing
    - Navicula latens Krasske
    - Navicula luzonensis Hustedt
    - Navicula menisculus var. upsaliensis Grunow (Grunow)
    - Navicula minima Grunow
    - Navicula minuscula Grunow
    - Navicula mutica Kuetzing
    - Navicula mutica var. stigma Patrick
    - Navicula mutica var. tropica Hustedt
    - Navicula notha Wallace
    - Navicula pelliculosa (Brebisson ex Kuetzing) Hilse
    - Navicula placentula (Ehrenberg) Kuetzing
    - Navicula protracta Grunow
    - Navicula pseudoreinhardtii Patrick
    - Navicula pseudoscutiformis Hustedt
    - Navicula pupula Kuetzing
    - Navicula pupula var. capitata Skvortzow and Meyer
    - Navicula pupula var. rostrata Hustedt
    - Navicula radiosa var. parva Wallace
    - Navicula radiosa var. tenella (Brebisson ex Kuetzing) Grunow
    - Navicula reinhardtii var. elliptica Heribaud
    - Navicula rhynchocephala var. amphiceros (Kuetzing) Grunow
    - Navicula rhynchocephala var. germainii (Wallace) Patrick
    - Navicula salinarum var. intermedia (Grunow) Cleve
    - Navicula schroeteri var. escambia Patrick
    - Navicula scutelloides W. Smith ex Gregory
    - Navicula secreta var. apiculata Patrick
    - Navicula seminuloides Hustedt
    - Navicula seminulum Grunow
    - Navicula subhamulata Grunow
    - Navicula symmetrica Patrick
    - Navicula tantula Hustedt
    - Navicula tridentula Krasske
    - Navicula tripunctata (O.F. Mueller) Bory
    - Navicula tripunctata var. schizonemoides (VanHeurck) Patrick
    - Navicula vanheurckii Patrick
    - Navicula viridula var. avenacea (Brebisson ex Grunow) VanHeurck
    - Navicula viridula var. linearis Hustedt
    - Navicula viridula var. rostellata (Kuetzing) Cleve
    - Navicula sp. 1
    - Navicula spp.
    - Neidium dubium (Ehrenberg) Cleve
    - Neidium dubium fo. constrictum Hustedt
    - Neidium spp.
    - Nitzschia acicularis (Kuetzing) W. Smith
    - Nitzschia amphibia Grunow

TABLE 3-1 (CONT.)

BACILLARIOPHYTA (cont.)

- Nitzschia angustata (W. Smith) Grunow
- Nitzschia bacata Hustedt
- Nitzschia capitellata Hustedt
- Nitzschia dissipata (Kuetzing) Grunow
- Nitzschia filiformis (W. Smith) Schutt
- Nitzschia flexa Schumann
- Nitzschia fonticola Grunow
- Nitzschia frustulum (Kuetzing) Grunow
- Nitzschia frustulum var. perminuta Grunow ex VanHeurck
- Nitzschia frustulum var. perpusilla (Rabenhorst) Grunow
- Nitzschia hungarica Grunow
- Nitzschia Tauenburgiana Hustedt
- Nitzschia linearis (Agardh) W. Smith
- Nitzschia palea (Kuetzing) W. Smith
- Nitzschia paleacea Grunow
- Nitzschia parvula W. Smith
- Nitzschia romana Grunow
- Nitzschia sigmoidea (Nitzsch) W. Smith
- Nitzschia subcapitellata Hustedt
- Nitzschia sublinearis Hustedt
- Nitzschia thermalis (Ehrenberg) Auerswald
- Nitzschia tryblionella Hantzsch
- Nitzschia spp.
- Opephora ansata Hohn and Hellerman
- Opephora martyi Heribaud
- Pinnularia nodosa (Ehrenberg) W. Smith
- Pinnularia spp.
- Rhoicosphenia curvata (Kuetzing) Grunow ex Rabenhorst
- Stauroneis smithii var. incisa Pantocsek
- Surirella angusta Kuetzing
- Surirella ovalis Brebisson
- Surirella ovata Kuetzing
- Surirella tenera Gregory
- Surirella delicatissima W. Smith
- Synedra goulardi Brebisson
- Synedra parasitica (W. Smith) Hustedt
- Synedra parasitica var. subconstricta (Grunow) Hustedt
- Synedra rumpens Kuetzing
- Synedra rumpens var. familiaris (Kuetzing) Hustedt
- Synedra rumpens var. fragilarioides Grunow
- Synedra rumpens var. meneghiniana Grunow
- Synedra ulna (Nitzsch) Ehrenberg
- Synedra spp.

CHLOROPHYTA (Green Algae)

- Ankistrodesmus falcatus (Corda) Ralfs
- Bulbochaete spp.
- Chlamydomonas spp.
- Cladophora glomerata (Linnaeus) Kuetzing
- Closterium moniliferum (Bory) Ehrenberg
- Coelastrum microporum Naegeli ex A. Braun
- Cosmarium spp.
- Crucigenia quadrata Morren
- Crucigenia tetrapedia (Kirchner) West and G.S. West
- Dictyosphaerium pulchellum Wood
- Kirchneriella subsolitaria G.S. West
- Lagerheimia quadriseta (Lemmermann) G.M. Smith
- Oocystis borgei Snow
- Oocystis pusilla Hansgirg
- Pediastrum duplex Meyen
- Scenedesmus abundans (Kirschner) Chodat

CHLOROPHYTA (cont.)

- Scenedesmus acuminatus (Lagerheim) Chodat
- Scenedesmus bicellularis Chodat
- Scenedesmus bijuga (Turpin) Lagerheim
- Scenedesmus denticulatus Lagerheim
- Scenedesmus dimorphus (Turpin) Kuetzing
- Scenedesmus opoliensis P. Richter
- Scenedesmus quadricauda (Turpin) Brebisson
- Selenastrum minutum (Naegeli) Collins
- Sphaerocystis schroeteri Chodat
- Stigeoclonium tenue (C.A. Agardh) Kuetzing
- Stigeoclonium spp.
- Tetraedron caudatum (Corda) Hansgirg
- Tetraedron minimum (A. Braun) Hansgirg
- Tetrastrum heterocanthum (Nordstedt) Chodat
- Tetrastrum staurogeniaeforme (Schroeder) Lemmermann
- Unidentified coccoid greens

CHRYSOPHYTA (Yellow-green Algae)

- Arachnochloris minor Pascher
- Chromulina spp.

CRYPTOPHYTA (Cryptomonads)

- Rhodomonas minuta Skuja

CYANOPHYTA (Blue-green Algae)

- Anabaena spp.
- Aphanizomenon *flos-aquae* (*Linnaeus*) Ralfs
- Aphanocapsa elachista West and West
- Chroococcus dispersus (Keissler) Lemmermann
- Lyngbya aerugineo-caerulea (Kuetzing) Gomont
- Lyngbya aestuarii (Mertens) Liebmann
- Lyngbya diguetii Gomont ex Hariot
- Lyngbya epiphytica Hieronymus ex Engler and Prante
- Lyngbya major Meneghini
- Lyngbya martensiana Meneghini
- Merismopedia tenuissima Lemmermann
- Microcoleus paludosus (Kuetzing) Gomont
- Microcystis aeruginosa Kuetzing emend Elenkin
- Microcystis incerta *Lemmermann*
- Oscillatoria agardhii Gomont
- Oscillatoria chalybea Mertens ex Jurgens
- Oscillatoria geminata Meneghini
- Oscillatoria limosa (Roth) C.A. Agardh
- Oscillatoria splendida Greville
- Oscillatoria tenuis Agardh
- Oscillatoria spp.
- Phormidium retzii (C.A. Agardh) Gomont
- Phormidium spp.
- Schizothrix rivularis (Wolle) Drouet
- Unidentified blue-green coccoids
- Unidentified blue-green filaments

EUGLENOPHYTA (Euglenoids)

- Euglena acus Ehrenberg
- Euglena spp.
- Phacus caudatus Huebner
- Trachelomonas dybowskii Drezepolski
- Trachelomonas schauinslandii Lemmermann

RHODOPHYTA (Red Algae)

- Audouinella violacea (Kuetzing) Hamel
- Thorea ramosissima Bory

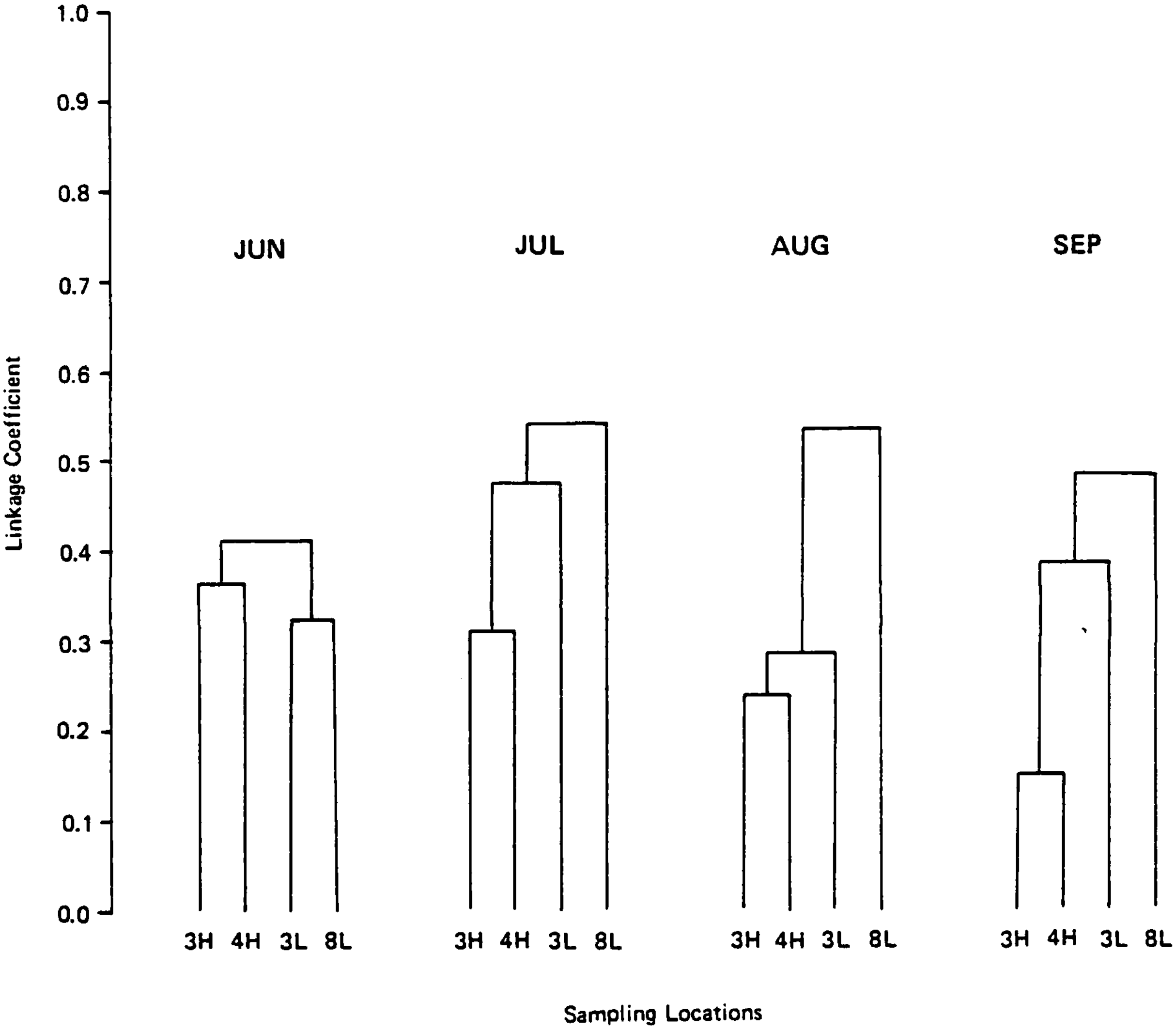
TABLE 3-2 ABUNDANCE (units/mm^2) OF IMPORTANT ALGAL TAXA, MAJOR TAXONOMIC GROUPS, AND TOTAL PERIPHYTON ON NATURAL SUBSTRATES IN POOL 5A, UPPER MISSISSIPPI RIVER, 1982

	Month and Sampling Location							
	June				July			
Taxa	3H	3L	4H	8L	3H	3L	4H	8L
Bacillariophyta								
Amphora perpusilla	476	79	499	351	272	227	658	340
Melosira varians	363	45	408	805	408	91	907	998
Navicula heufleri	91	79	79	34	635	907	567	204
Navicula tripunctata	272	45	193	522	136	45	272	272
Navicula - small unidentified	2,993	2,143	5,204	2,154	3,809	2,358	3,764	1,519
Nitzschia amphibia	45	23	23	34	408	363	91	45
Rhoicosphenia curvata	23	11	11	125	2,358	454	363	113
Total Centrales	1,451	635	828	1,361	1,587	454	2,018	3,084
Total Pennales	4,626	2,800	7,449	4,614	14,421	6,530	9,728	6,621
Total Bacillariophyta	6,077	3,435	8,276	5,975	16,009	6,984	11,746	9,705
Chlorophyta								
Cladophora glomerata	249	0	113	102	136	1,905	136	91
Total nonfilamentous	567	476	249	159	1,633	907	1,111	884
Total filamentous	249	125	125	181	136	1,905	136	91
Total Chlorophyta	816	601	374	340	1,769	2,812	1,247	975
Chrysophyta								
Total Chrysophyta	0	0	0	0	0	0	0	0
Cryptophyta								
Total Cryptophyta	0	0	0	0	0	0	0	0
Cyanophyta								
Aphanizomenon flos-aquae	0	0	0	0	0	0	0	975
Aphanocapsa elachista	0	0	0	0	0	0	0	0
Chroococcus dispersus	726	0	0	0	0	0	0	0
Lyngbya diguetii	0	238	272	612	1,950	1,406	1,406	159
Lyngbya epiphytica	431	170	34	249	1,995	952	1,043	2,653
Microcystis incerta	0	0	0	0	0	0	0	0
Oscillatoria agardhii	295	79	136	68	499	2,041	1,088	136
Oscillatoria limosa	0	0	0	0	2,857	0	2,766	998
Oscillatoria tenuis	0	0	0	45	363	0	1,769	907
Oscillatoria spp.	0	0	0	0	0	0	0	0
Phormidium retzii	0	0	0	0	0	0	0	0
Unidentified blue-green coccoids	0	283	227	476	0	0	0	0
Total nonfilamentous	726	283	227	476	0	0	0	0
Total filamentous	1,179	488	578	998	8,753	4,852	8,367	5,828
Total Cyanophyta	1,905	771	805	1,474	8,753	4,852	8,367	5,828
Euglenophyta								
Total Euglenophyta	0	0	0	11	0	0	0	23
Rhodophyta								
Audouinella violacea	0	0	0	0	0	0	2,585	0
Total Rhodophyta	0	0	0	0	0	0	2,585	0
Total Periphyton	8,798	4,807	9,456	7,800	26,530	14,648	23,945	16,530

TABLE 3-2 (CONT.)

	Month and Sampling Location							
	August				September			
Taxa	3H	3L	4H	8L	3H	3L	4H	8L
Bacillariophyta								
Amphora perpusilla	476	544	635	590	1,043	998	952	680
Melosira varians	91	159	340	23	454	91	1,995	1,134
Navicula heufleri	408	771	590	159	454	204	1,542	1,633
Navicula tripunctata	68	0	45	0	0	23	0	91
Navicula - small unidentified	7,324	6,190	5,102	1,315	10,567	10,771	8,480	3,583
Nitzschia amphibia	680	1,134	363	45	862	1,451	317	272
Rhoicosphenia curvata	91	113	113	68	1,361	272	45	181
Total Centrales	1,315	1,655	3,673	1,769	1,451	1,406	4,444	3,401
Total Pennales	13,129	14,467	10,544	3,152	18,412	16,734	17,414	11,247
Total Bacillariphyta	14,444	16,122	14,217	4,921	19,863	18,140	21,859	14,648
Chlorophyta								
Cladophora glomerata	0	91	0	0	0	159	227	136
Total nonfilamentous	1,179	1,179	1,020	998	726	794	635	680
Total filamentous	0	181	0	45	0	159	227	136
Total Chorophyta	1,179	1,361	1,020	1,043	726	952	862	816
Chrysophyta								
Total Chrysophyta	0	23	45	0	0	0	0	0
Cryptophyta								
Total Cryptophyta	0	0	0	0	0	0	0	45
Cyanophyta								
Aphanizomenon flos-aquae	0	0	0	68	0	0	0	0
Aphanocapsa elachista	0	4,535	0	0	0	0	0	0
Chroococcus dispersus	0	0	0	0	0	249	0	0
Lyngbya diguetii	930	884	658	181	907	1,292	136	317
Lyngbya epiphytica	3,152	3,832	2,109	1,270	3,175	3,447	1,995	2,177
Microcystis incerta	0	0	0	0	1,814	0	0	0
Oscillatoria agardhii	295	363	68	113	363	0	499	136
Oscillatoria limosa	2,336	2,109	2,381	680	136	45	1,043	0
Oscillatoria tenuis	476	1,020	1,973	1,156	408	0	771	1,814
Oscillatoria spp.	0	0	0	0	0	0	2,630	0
Phormidium retzii	0	295	227	91	0	0	0	1,769
Unidentified blue-green coccoids	0	0	0	0	0	0	0	0
Total nonfilamentous	181	5,261	363	272	1,814	612	0	454
Total filamentous	7,687	9,478	7,936	3,673	5,805	5,623	9,251	6,394
Total Cyanophyta	7,868	14,739	8,299	3,945	7,619	6,236	9,251	6,848
Euglenophyta								
Total Euglenophyta	0	45	0	0	0	0	0	0
Rhodophyta								
Audouinella violacea	0	0	0	113	0	0	0	862
Total Rhodophyta	0	0	0	113	0	0	0	862
Total Periphyton	23,491	32,289	23,582	10,022	28,208	25,328	31,972	23,219

Note: Taxa composing at least 5 percent of total density in any quantitative sample were considered important.



Note: Lower coefficients indicate greater similarity, and locations linked at coefficients less than approximately 0.3 were considered quite similar, whereas those linked at greater than approximately 0.5 were considered dissimilar.

FIGURE 3-1. SIMILARITY DENDROGRAMS BASED ON BRAY AND CURTIS (1957) MEASURES OF PERIPHYTON ABUNDANCE ON NATURAL SUBSTRATES IN POOL 5A, UPPER MISSISSIPPI RIVER, 1982.

Clustering techniques based on Bray and Curtis similarity measures indicated a shift in affinities among locations in Pool 5A during 1982 (Figure 3-1). Initially in June, all four locations had generally similar periphyton composition and abundance, although there was some clustering by current velocity characteristics. The high velocity locations remained quite similar in July, but the low velocity locations became dissimilar not only to the other locations but also to each other. Location 8L continued to be dissimilar to other locations in August, but Location 3L became very similar to the high velocity locations. Finally in September, the locations on the riprapped bank were very similar to each other, Location 4H continued somewhat similar to these locations, and Location 8L remained dissimilar to the other three locations. Thus, over the four month period studied, the clustering of periphyton communities gradually shifted from spatial separations primarily based on velocity characteristics to one based at least partially on structure type.

3.3.2 Distribution

The qualitative survey of periphyton distribution on the two wingdams revealed that although growth in general was sometimes restricted, individual growth forms were widely and uniformly distributed throughout the zones supporting periphyton. On the 150-m long wingdam that included Location 8L, periphyton was visually absent from most of the 30 to 40 meters nearest shore. Rocks in this region were covered with sand. The rest of this wingdam was generally covered to a water depth of approximately 1.5 meters with algal tufts composed primarily of the blue-green algae Phormidium retzii and Lyngbya martensiana and with the bristly appearing bryozoan Pottsiella erecta, which in turn was covered with the blue-green alga Lyngbya epiphytica. Near the main channel end of the structure, the algal tufts became restricted to the top of the wingdam. A few sparsely branched filaments of the red alga Thorea ramossima were collected approximately 80 meters from shore. This species is very rarely reported from North American temperate waters although Prescott (1962) predicted its occurrence in western Great Lakes region. Another alga with restricted distribution was Cladophora glomerata. This species was observed on a few rocks near shore in water less than 0.2-m deep. This particular habitat was considered more typical of riprapped banks than of wingdams.

On the 50-m long wingdam that contained Location 4H, periphyton was more obviously restricted to near the top of the structure. Although some growth extended down the sides, periphyton was sparser on the leading edge of this wingdam. The predominant growth forms were the same as those at Location 8L (i.e., tufts of blue-green algae and stalks of bryozoans). Additionally, isolated patches of visually different blue-green algal growths (Lyngbya aestuarii, Oscillatoria splendida, O. agardhii, O. limosa) occurred randomly at Location 4H. The bryozoan Cordylophora lacustris was also found on this wingdam and was most prevalent on the leading edge near the main channel. Cladophora glomerata was again present in habitats typical of riprapped banks.

A distinct zonation of growth forms was evident in both high and low current velocity regions of the riprapped bank containing Locations 3H and 3L. Cladophora glomerata predominated from the splash zone, where filaments appeared healthy but were moderately colonized by various species of diatoms and Lyngbya, to water depths of approximately 0.2 meters, where old filaments were heavily colonized by diatoms and Lyngbya epiphytica. This Cladophora zone typically extended less than 1.0 meter from shore because of the steep slope of the structure. Rocks at water depths between 0.2 and 1.5 meters contained blue-green algal tufts composed of *Lyngbya aerugineo-caerulea*, *L. aestuarii*, *L. martensiana*, *Oscillatoria splendida*, *Phormidium retzii*, and *Schizothrix rivularis*, as well as stalks of the bryozoan *Pottsiella erecta*. Isolated bright blue-green patches of *L. aestuarii* also occurred in this zone which typically extended less than 5.0 meters from shore. Periphytic algal growths were conspicuously absent at depths greater than 1.5 meters.

3.3.3 Abundance and Standing Crop

The following ranges were observed for periphyton density and standing crop in Pool 5A:

Total Density	4,807 - 32,289 units/mm2
Chlorophyll *a*	265 - 2,747 µg/dm2
Biomass	109 - 599 mg/dm2

Biomass and chlorophyll *a* standing crops tended to be slightly higher in Pool 5A than in other areas of the Upper Mississippi River (Table 3-3), probably because artificial substrates were used in the other studies. Total densities in Pool 5A were within the range of values reported from other sites, even though other studies did not differentiate between "live" and "dead" diatoms and used different units for reporting algal abundance. Dead centric diatoms very often outnumbered live centric diatoms in Pool 5A; an opposite trend was noted for pennate diatoms (Figure 3-2). Generally, periphyton abundance and standing crop appeared fairly typical for the Upper Mississippi River, although differences in methodology among studies precluded conclusive statements to this effect.

Temporally, abundance and standing crop were lower in June than in the subsequent three months (Figure 3-3). Total densities generally increased during the study period, chlorophyll *a* exhibited slightly reduced values between July and September peaks, and biomass was highest at most locations in July. Artificial substrate studies have shown additional spring (April or May) and fall (October or November) peaks in abundance or standing crop (Clark 1975, Webber and Knutson 1977, Kuhl 1978), but the occurrence of these peaks on natural substrates in the Upper Mississippi River has not been documented. Less favorable flow conditions in spring and fall may limit the development of periphyton on natural substrates during these seasons, especially on wingdams. Periphyton composition varied little monthly, as diatoms were either numerically dominant or they codominated with blue-green algae.

Very few consistent spatial differences were noted in the abundance and standing crop data. Total densities were somewhat greater at high velocity locations than at low velocity locations in three of the four months studied (Figure 3-3). Abundance and standing crop were often lowest at Location 8L during June through September. No consistent differences among locations were observed in densities of dead diatoms (Figure 3-2). Chlorophyll *a* standing crops were also often lowest at Location 8L, but statistical analyses revealed significant differences only in June when values were lowest at Location 3L (Table 3-4). However for chlorophyll *a*, considerable variablity was injected into the error term of the statistical model by collecting samples from various water depths (Section 3.3.5). Biomass standing crops at Location 8L

TABLE 3-3 RANGES OF PERIPHYTON STANDING CROP AND DIVERSITY FROM SELECTED AREAS IN THE UPPER MISSISSIPPI RIVER DURING JUNE THROUGH SEPTEMBER

Study Area	Year	Biomass (mg/dm^2)	Chlorophyll *a* ($\mu g/dm^2$)	Total Density ($No./mm^2$)	Shannon Diversity	Reference
Pool 5A	1982	109-599	265-2,747	4,807-32,289	3.24-4.93	Present study
Becker, MN	1975	*	0-238	*	2.54-3.71	Kuhl 1976
Monticello, MN	1976	*	10-110	518-63,151	*	Webber and Knutson 1977
	1977	*	28-302	766-11,577	*	Kuhl 1978
Pool 14 near Quad Cities, IL	1973	8-244	17-2,017	3,430-35,600	1.49-4.37	Seng and Johnson 1973 Lewis et al. 1974
	1974	4-166	4-979	294-131,465	1.21-4.05	Clark and Seng 1974, Clark 1975
	1976	37-503	215-2,199	12,143-119,457	2.25-4.19	Heffelfinger 1977
Sam Gordy's Slough, RM 725	1976	26-341	*	*	*	Fremling et al. 1979
	1977	117-186	*	*	*	Fremling et al. 1979
Blackbird Slough, RM 728	1976	179-180	*	*	*	Fremling et al. 1979
Fountain City Bay, RM 737	1976	125	*	*	*	Fremling et al. 1979
	1977	36-572	*	*	*	Fremling et al. 1979
	1978	52-215	*	*	*	Fremling et al. 1979
West Newton Chute, RM 747	1976	97-420	*	*	*	Fremling et al. 1979
	1977	63-325	*	*	*	Fremling et al. 1979

Notes: 1. Periphyton was collected from natural substrates in the present study; artificial substrates were used in all other studies.

2. Asterisk (*) indicates the parameter was not determined.

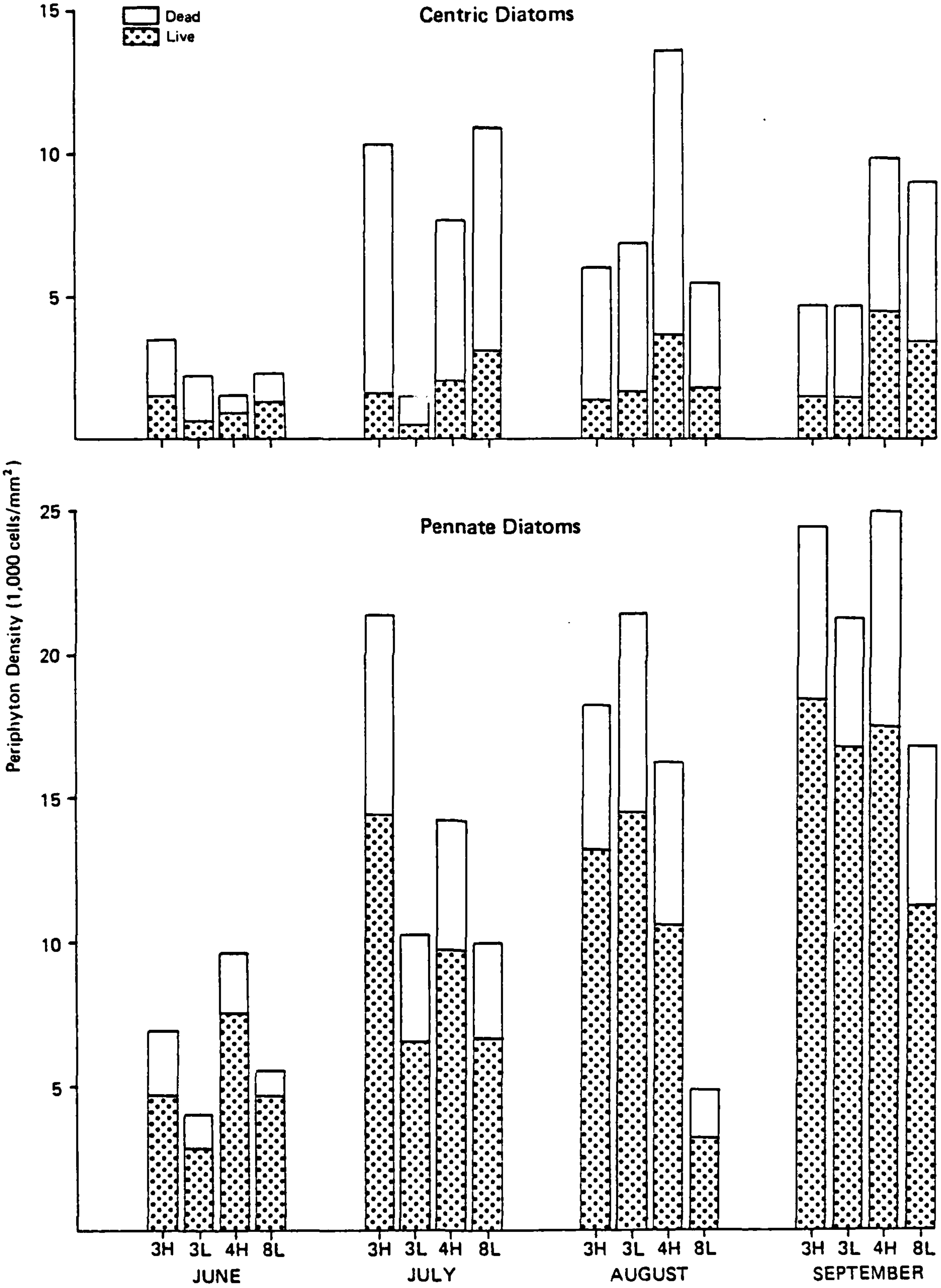


FIGURE 3-2. DENSITIES OF LIVE AND DEAD DIATOMS IN PERIPHYTON COLLECTED FROM NATURAL SUBSTRATES IN POOL 5A, UPPER MISSISSIPPI RIVER, 1982.

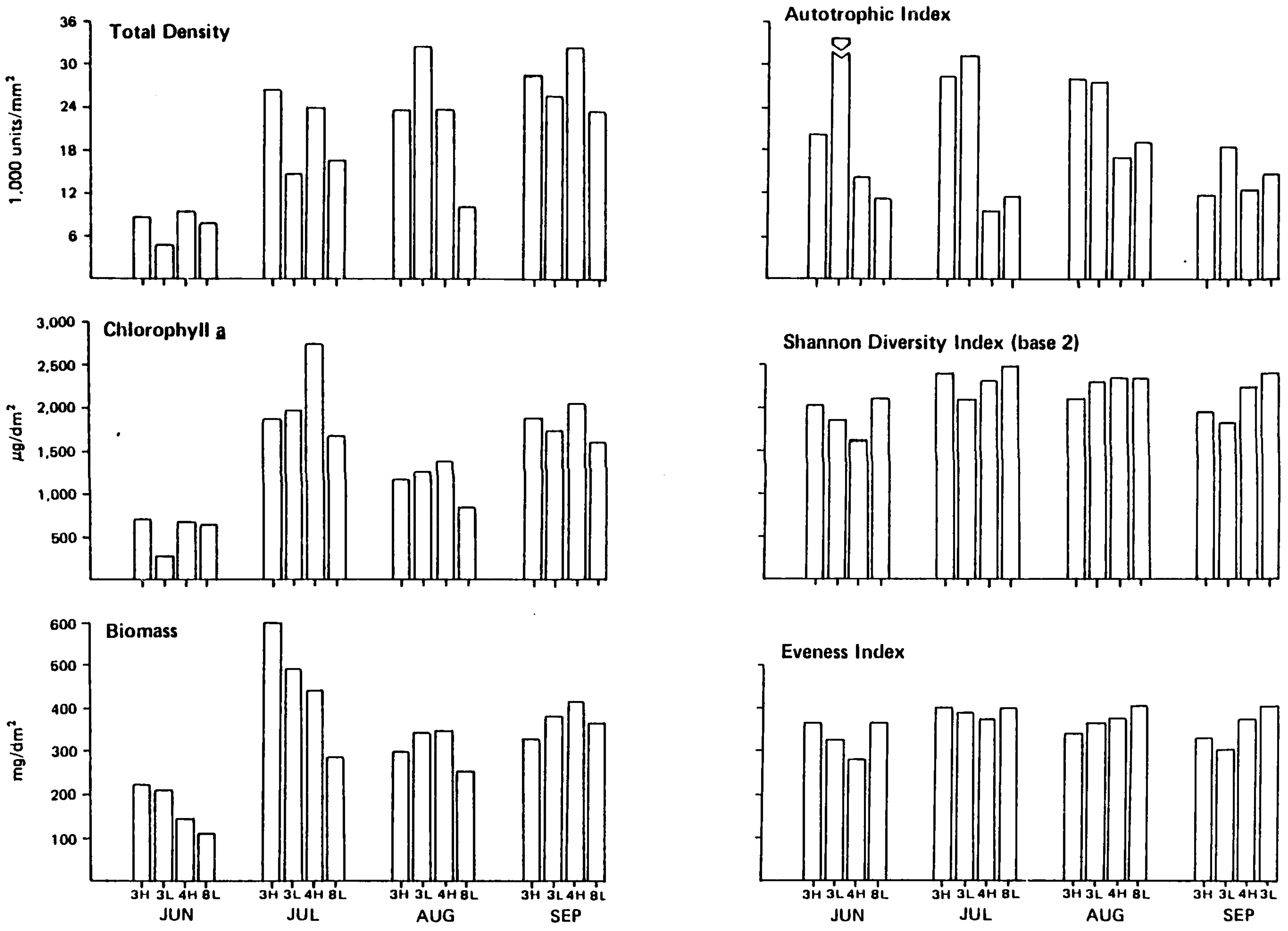


FIGURE 3-3. SPATIAL AND TEMPORAL VARIABILITY OF PERIPHYTON STANDING CROP, AUTOTROPHIC INDEX, AND DIVERSITY MEASURES ON NATURAL SUBSTRATES IN POOL 5A, UPPER MISSISSIPPI RIVER, 1982.

TABLE 3-4 ANALYSIS OF VARIANCE FOR CHLOROPHYLL a STANDING CROP OF PERIPHYTON ON NATURAL SUBSTRATES IN POOL 5A, UPPER MISSISSIPPI RIVER, 1982

Month	Source of Variation	Degrees of Freedom	SS	F	P > F
JUN	Location	3	7.621	6.67	0.001
	Error	36	13.703		
	Total	39	21.324		
JUL	Location	3	3.858	2.15	0.112
	Error	36	21.582		
	Total	39	25.440		
AUG	Location	3	1.877	0.98	0.414
	Error	36	23.031		
	Total	39	24.908		
SEP	Location	3	0.597	0.58	0.623
	Error	36	12.243		
	Total	39	12.840		

Comparisons of Mean Value by Location(a)

	Lowest			Highest
JUN	3L	8L	4H	3H

Note: Standing crops transformed by natural logarithms ($\mu g/dm^2 + 1$).

(a) Locations listed in order of increasing mean values, and locations underscored by a continuous line were not significantly different (P > 0.05, Duncan's Multiple Range Test).

were significantly lower than those at Location 3H in June and at all other locations in July (Table 3-5). No significant spatial differences occurred for biomass in August and September.

3.3.4 Autotrophic Index and Diversity

Autotrophic Index (AI) values ranged from 158 to 863 on natural substrates in Pool 5A during 1982 (Figure 3-3). This index indicates the trophic nature of the periphyton community, although historically it has most frequently been used for water quality monitoring studies employing artificial substrates (Weber 1973b). Values larger than approximately 200 often indicate heterotrophic associations or poor water quality, although accumulations of nonviable organic materials may also cause an increase in AI values (APHA 1981). In Pool 5A, AI values for the wingdams (Locations 4H and 8L) were less than 250, except in August when they increased to approximately 300 (Figure 3-3). On the riprapped bank, values were usually greater than 400, except in September when they were more similar to those observed for the wingdams. Based on these results, AI values between 150 and 250 appeared to be typical of healthy periphyton communities growing on rock substrates in Pool 5A.

The three most probable factors causing AI values to exceed 250 were 1) degradation of previously established periphytic algae, 2) large standing crops of heterotrophic organisms, and 3) substantial accumulations of nonliving organic matter. Because chlorophyll *a* degrades to phaeophytin *a* when algae become nonviable, concentrations of the latter pigment were used to assess effects of the first factor. Phaeophytin *a* standing crops (Appendix B) indicated that degradation of previously established algal communities probably was not responsible for the high AI values observed on the riprapped bank (especially the maximum value at Location 3L in June), but that this factor may have contributed to the increased values that occurred on the wingdams in August. The occurrence of bryozoans caused a general increase in AI values, but the August survey did not reveal any major spatial differences in the distribution of these organisms. In comparison, macroinvertebrate standing crop and biomass was similar on all structures in June, but in August and September was much greater on the wingdams than on the riprapped banks. Although not measured quantitatively, accumulations of sediment and nonliving organic matter appeared to be greater on the riprapped bank than on the wingdams, especially in July. Quantities of sand, silt, and detritus were notably greater in the July samples from Locations 3H and 3L than in the samples from the wingdam locations. Thus, increased sedimentation rates probably were directly or indirectly responsible for most high AI values in Pool 5A.

Diversity and evenness ranged from 3.24 to 4.93 and from 0.56 to 0.81, respectively. Based on these values, periphyton communities in Pool 5A were considered moderately to highly diverse. In fact, the necessity of grouping several small *Navicula* species into a single taxon caused a reduction in calculated values. Diversity on natural substrates in Pool 5A tended to be greater than diversity on artificial substrates in other areas of the Upper Mississippi River (Table 3-3). There were no major temporal or spatial changes in periphyton diversity during the study period (Figure 3-3). Minor spatial differences in diversity that were evident in June and September were also apparent for evenness.

TABLE 3-5 ANALYSIS OF VARIANCE FOR BIOMASS STANDING CROP OF PERIPHYTON ON NATURAL SUBSTRATES IN POOL 5A, UPPER MISSISSIPPI RIVER, 1982

Month	Source of Variation	Degrees of Freedom	SS	F	P > F
JUN	Location	3	3.622	3.71	0.020
	Error	36	11.705		
	Total	39	15.327		
JUL	Location	3	2.509	3.63	0.022
	Error	36	8.303		
	Total	39	10.812		
AUG	Location	3	0.476	0.61	0.612
	Error	36	9.346		
	Total	39	9.822		
SEP	Location	3	0.420	0.73	0.538
	Error	36	6.851		
	Total	39	7.271		

Comparisons of Mean Value by Location$^{(a)}$

	Lowest			Highest
JUN	8L	4H	3L	3H
	———	———	———	
		———	———	———
JUL	8L	4H	3L	3H
		———	———	———

Note: Standing crops transformed by natural logarithms (mg/dm^2 + 1).

(a) Locations listed in order of increasing mean values, and locations underscored by a continuous line were not significantly different (P > 0.05, Duncan's Multiple Range Test).

3.3.5 Effects of Physical-Chemical Characteristics and Structure Type

Most physical and chemical parameters showed little spatial variation within the Pool 5A study area during each month (Chapter 2). No unusual temporal differences were noted among the months of periphyton collections. The consistency of these physical and chemical characteristics, as well as the uniformity of substrates sampled for periphyton, were reflected by the relatively stable composition, abundance, and standing crop of the algal communities. Two physical factors that did differ among locations and therefore were evaluated for their effects on periphyton were current velocity characteristics (high vs. low) and water depth.

Periphyton abundance and standing crop were generally greater in areas of high velocity (Locations 3H and 4H averaged) than in areas of low velocity (Locations 3L and 8L averaged; Figure 3-4). Other studies have shown a similar positive effect of current on periphyton growth or metabolism (Whitford 1960, McIntire 1966). Surprisingly, densities of dead diatoms (especially dead centric diatoms) were also greater at high velocity locations. Although most dead pennate diatoms probably originated in the periphyton, the composition and high proportional abundance of dead centric diatoms suggested that they were derived from the phytoplankton community. Sedimentation rates of dead phytoplankters would normally be expected to be greater in areas of relatively low current velocity, but an opposite trend was evident in Pool 5A. These results suggested a mechanism other than sedimentation was removing plankton from the water column. This mechanism probably involved entrapment of planktonic organisms in the structural matrix of the periphyton community and/or removal by benthic macroinvertebrates (e.g., bryozoans and net-spinning caddisfly larvae). Statistically, there was no general tendency for biomass and chlorophyll *a* standing crops to be significantly different on high versus low velocity locations. Diversity appeared unrelated to velocity, whereas Auotrophic Index values were slightly but consistently greater in areas of low velocity.

In July and August, the water depth of each replicate sample was recorded, allowing an evaluation of the effect of this physical variable on periphyton standing crops. Regression analyses revealed that depth affected chlorophyll *a* standing crops at the riprapped bank locations but not at the wingdam locations (Figure 3-5). The mechanism by which water depth affects algal production is attenuation of light as it penetrates down from the water's surface. No spatial differences in the rate of light attenuation were expected based on turbidity measurements. Probable causes of the differing effects of water depth on the two structures were adaptations of the algal communities growing on the continuously submerged wingdams or differences in the amount of incident solar radiation reaching the water surface. However, if periphyton communities were adapting to typically lower light intensities on the wingdams, shifts in species composition greater than those observed in the present study might be expected. Differences in incident light could also affect the relatively high and uniform chlorophyll *a* standing crops on the windgams, especially if the riprapped banks were often characterized by reduced intensities. Shading by riparian vegetation on the banks might reduce the amount of light reaching the water surface enough that attenuation with depth caused light to be a limiting factor. The steep slope of the riprapped banks facilitated these shading effects. Under these circumstances, average light intensity could actually be greater on the wingdams.

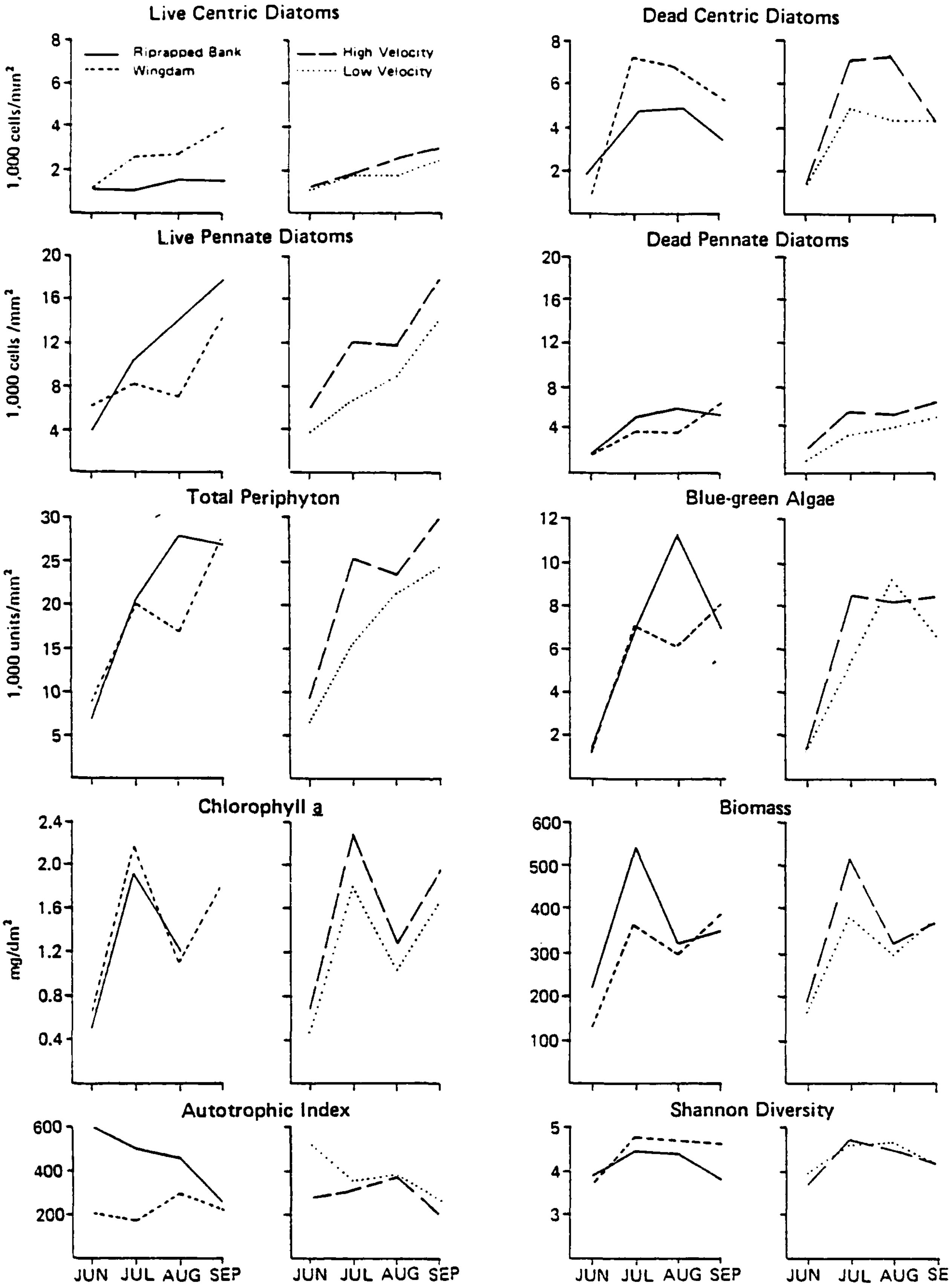
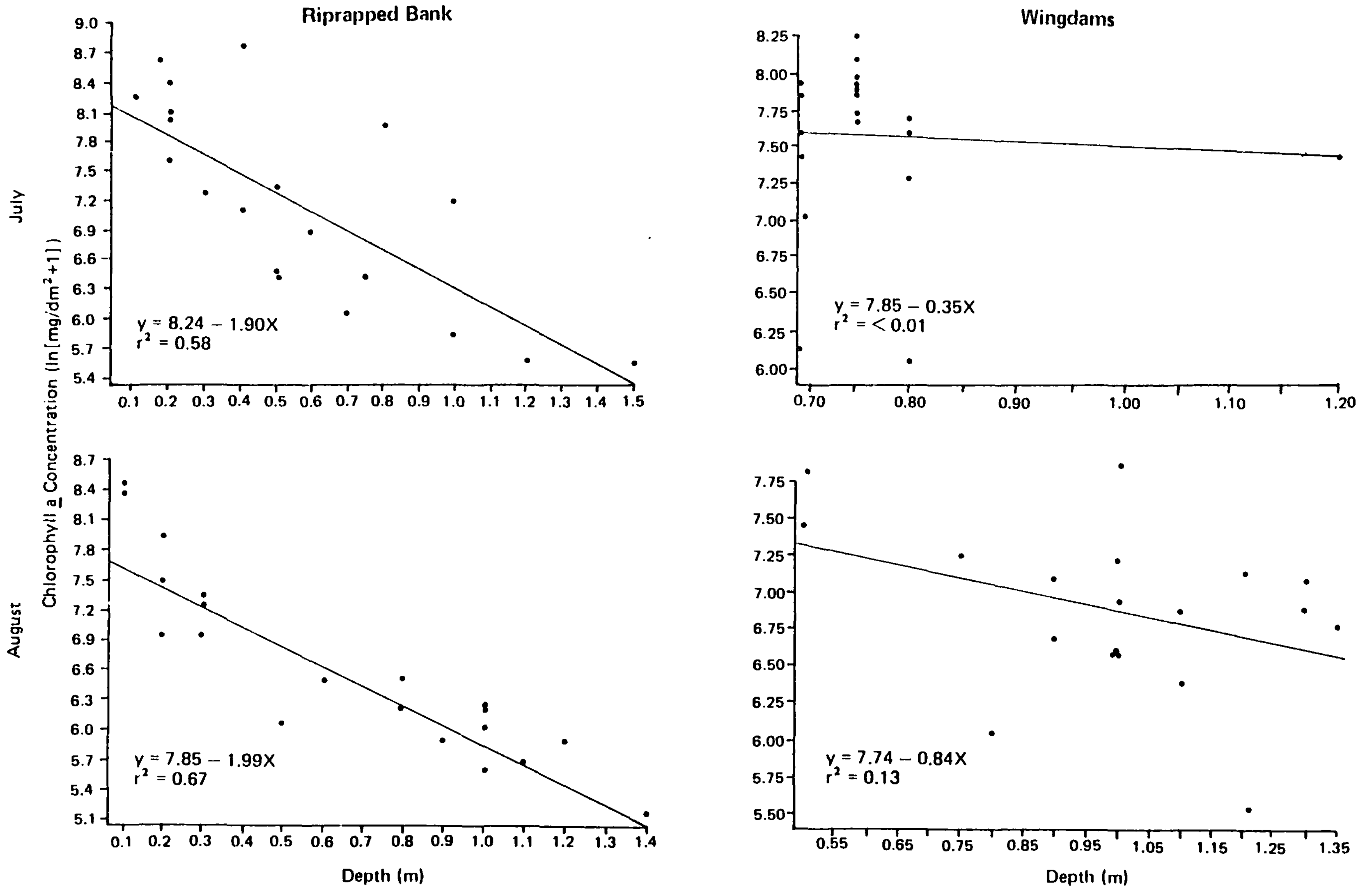


Figure 3-4. Effects of structure type and current velocity on periphyton collected from natural substrates in Pool 5A, Upper Mississippi River, 1982.



Note: Variable scales for both axes.

FIGURE 3-5. EFFECTS OF WATER DEPTH ON CHLOROPHYLL a STANDING CROP OF PERIPHYTON ON NATURAL SUBSTRATES IN POOL 5A, UPPER MISSISSIPPI RIVER, JULY AND AUGUST, 1982.

Regression analyses of biomass standing crop failed to show a major effect of water depth, with the possible exception of the August data from wingdams (Figure 3-6). Because biomass measures the organic content of algal and nonalgal organisms, the relatively uniform standing crops may have resulted from the replacement of algal components by heterotrophic organisms as depth increased. Proportionate replacement by nonliving organic matter could have also produced the observed results.

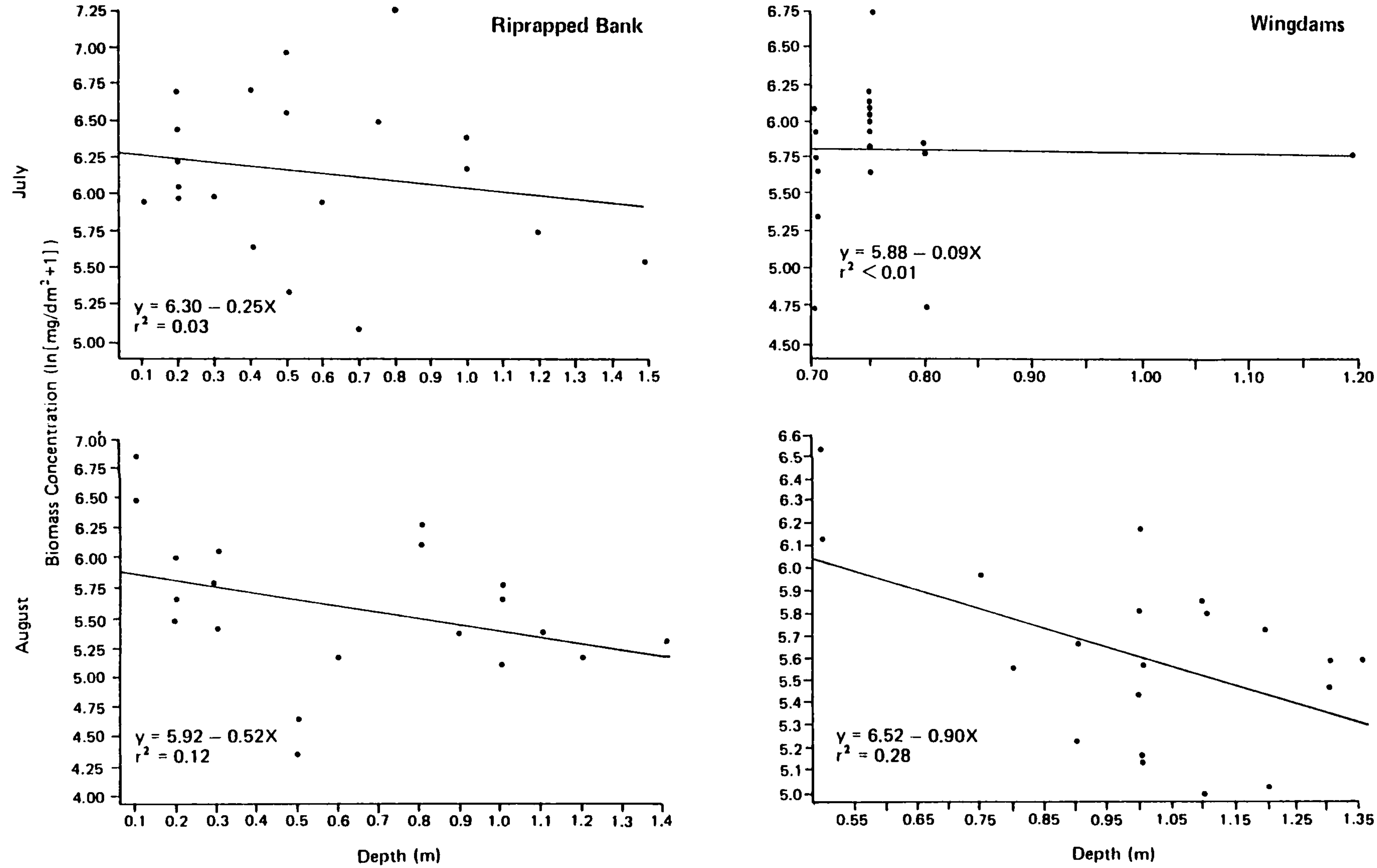
The effects of structure type on periphyton were also examined by averaging values for the two riprapped bank locations (3H and 3L) and those for the two wingdams (4H and 8L). Differences between the two structures were less consistent than those related to current velocity (Figure 3-4). Centric diatoms (both live and dead) tended to be more abundant on wingdams, whereas pennate diatoms were often more abundant on the riprapped bank. Densities of total periphyton and blue-green algae were very similar except in August when values were much higher on the riprapped bank. Although biomass was often greater on the bank, statistical testing failed to show consistent significant differences among locations for either biomass or chlorophyll a standing crops. As was previously discussed, Autotrophic Index values were greater on the riprapped bank; conversely, diversity was often slightly greater on the wingdams. Overall, differences between the two structure types were considered minor, with the possible exception of unusual variation noted for the effect of depth on chlorophyll a standing crops.

3.3.6 The Suitability and Importance of Channel Maintenance Structures as Periphyton Substrates

The present study demonstrated that riprapped banks and wingdams support a diverse and productive periphyton community. In that portion of the Upper Mississippi River where the navigation channel is maintained, these structures make an important contribution to total periphyton production in the main channel border area. Because most other periphyton studies of the river have utilized artificial substrates, it is difficult to determine the proportion of natural periphyton production that occurs on these channel maintenance structures. Undoubtedly, considerable production occurs in the shallow sloughs and bays that are at least partially protected from the main current. However, in these areas periphyton often must compete with aquatic macrophytes for nutrients or more importantly for the available light.

Although this study found few statistically significant differences in standing crop between the two structure types, wingdams probably support greater total periphyton production than riprapped banks. Visual observations confirmed the greater effect of water depth on periphyton colonizing the banks, and most production on these structures occurs probably in the narrow zone in the water column that is less than 0.5 meters deep, and perhaps in the extremely small portion of the water column that is less than 0.2 meters deep. Periphyton is less restricted on the wingdams and exhibits fairly uniform growth to depths exceeding 1.0 meters. Additionally, the combined area of the numerous wingdams in Pool 5A exceeds the total area of riprapped banks (COE 1983). Thus wingdams provide a greater total area for periphyton colonization and growth than do riprapped banks.

The only major factor that appeared to limit periphyton distribution in the photic zone was burial of a portion of one wingdam (Location 8L) by sand and



Note: Variable scales for both axes.

FIGURE 3-6. EFFECTS OF WATER DEPTH ON BIOMASS STANDING CROP OF PERIPHYTON ON NATURAL SUBSTRATES IN POOL 5A, UPPER MISSISSIPPI RIVER, JULY AND AUGUST, 1982.

silt. Most adverse effects of various channel maintenance activities will probably be related to the dislocation and ultimate deposition of sediments. Increased concentrations of suspended solids would reduce water transparency and may severely limit periphyton production on the important wingdams if light attenuation is increased substantially. The effects associated with the increased turbidity may be spatially widespread within downstream areas of the pool but temporally should be limited to the period of the activity. A more permanent effect may result from activities that cause increased siltation on the structures. The duration of these effects will depend on the amount of sediment deposited and the ability of high river flows to scour and disperse the sediments. Spatially, these effects should be limited to structures in immediate downstream vicinity of the activity. Any activities that involve the addition of riprap or other rocky structures will have positive effects by providing additional stable substrates for periphyton colonization and growth.

3.4 SUMMARY AND CONCLUSIONS

Periphyton communities on the riprapped bank and wingdams studied in Pool 5A from June through September 1982 were composed primarily by diatoms, green algae, and blue-green algae. Numerically, diatom species of *Navicula* and blue-green algal species of *Lyngbya* and *Oscillatoria* were most important. Most differences in dominant taxa between Pool 5A and other areas of the Upper Mississippi River were probably related to differences in substrates employed (e.g., natural vs. artificial) and seasons studied (e.g., summer vs. spring and autumn). Underwater surveys conducted by a diver in August revealed that algal growth forms and bristly bryozoans were fairly uniformly distributed to depths of approximately 1.5 meters on the wingdams and at depths between 0.2 and 1.5 meters on the riprapped bank. When rocks were present in depths of 0.2 meters or less, substantial growth of the green alga *Cladophora glomerata* occurred; this habitat or zone was most typical of the riprapped bank. A few filaments of the rarely encountered red alga *Thorea ramossima* were collected from the Location 8L wingdam during the distribution survey, and another red alga *Audouinella violacea* was occasionally important in quantitative samples for both wingdams studied.

Biomass and chlorophyll *a* standing crops tended to be slightly higher in Pool 5A than in other areas of the Upper Mississippi River; total densities were within the range of values reported from other sites. Temporally, periphyton abundance and standing crop were lower in June than in the subsequent three months. Very few consistent spatial differences were noted, although abundance and standing crop were frequently lower at Location 8L than at the other three locations. Statistical testing only occasionally demonstrated significant spatial differences in standing crop. Based on the present results, Autotrophic Index values between 150 and 250 appeared typical for periphyton communities growing on rock substrates in Pool 5A. Increased sedimentation rates probably were directly or indirectly responsible for most of the higher values, although degradation of previously established algal communities may have also been partially responsible for increases observed in August. Periphyton communities in Pool 5A were considered moderately to highly diverse based on measures of community structure (e.g., Shannon-Weaver diversity).

Most physical and chemical parameters showed little variation within the Pool 5A study area and, therefore, were not expected to cause differences in the periphyton community. When average values for high current velocity locations were compared to averages for low velocity locations, periphyton abundance and standing crop were generally greater in high velocities. Regression analyses of July and August data revealed that water depth had a major effect on chlorophyll a standing crop for the riprapped bank locations but little or no effect for the wingdam locations. Similar analyses showed depth was not a major factor affecting biomass on either structure type. Another major difference between the structure types was that in June, July, and August, the riprapped bank had consistently higher Autotrophic Index values than did the two wingdam locations.

Riprapped banks and wingdams both supported diverse and productive periphyton communities. These structures make a biologically important contribution to total periphyton production in the Upper Mississippi River where the navigation channel is maintained, because other suitable substrates are generally absent in most of the main channel border area. Wingdams probably support greater total periphyton production than riprapped banks because water depth more greatly affected standing crop on the banks and because the combined length of wingdams is probably greater. Most adverse effects of channel maintenance activities will probably be caused by suspension and/or deposition of disrupted sediments, but these effects most likely will be spatially or temporally restricted. Activities that increase the amount of riprap in the photic zone will provide additional substrates for periphyton colonization and growth.

3.5 RECOMMENDATIONS

The successful collection of quantitative results in the present study raises several questions concerning periphyton communities on channel maintenance structures in the Upper Mississippi River. Now that the importance of these structures has been documented, more information is needed on periphyton abundance and standing crop in other regions of Pool 5A and in other pools of the river. Many of the spatial differences observed in the present study were between Location 8L on the Minnesota side of the river and the other locations which were more proximally located on the Wisconsin side. Although the individual structures presently studied were selected as representative based on extensive physical and morphometric data (Anderson et al. 1983), the fact that the naturally occurring periphyton communities have been largely ignored in most or all previous studies precludes drawing conclusions that the present results are typical for the Upper Mississippi River. This information gap becomes especially undesirable if these periphyton results are used to predict effects of various channel maintenance activities on the attached algal communities in other regions of the upper river. However, the present results can be very useful in designing efficient and cost-effective future studies that may be needed or desired to fill these voids in the periphyton data base.

Although additional studies are needed to document periphyton composition, structure, and standing crop in months or seasons not included in the present study, the number and type of channel maintenance structures that can be sampled may be restricted because of high river flows, low water temperatures, and subsequent concerns for diver safety. However, because most maintenance activities will probably occur in summer, that season should receive continued emphasis. Periphyton abundance and standing crop were relatively uniform from July through September, but July collections may be preferred because standing crop is at or near maximum while conditions are ideal for safe sampling by a diver. Therefore, a single July study of three to five wingdams and one to three riprapped banks on each side (Wisconsin vs. Minnesota) of Pool 5A would provide the biologial data needed to document spatial variations (or lack thereof) within the pool. These structures should be located in upstream, middle, and downstream areas of the pool. Similarly, a single July study of three to five pools (including Pool 5A) would provide the data necessary to document that results for Pool 5A are typical for the Upper Mississippi River. One structure of each type on each side of the river near the middle of each pool should be sampled. These two studies could be conducted concurrently, and the extensive physical and morphometric data used in the original designation of Pool 5A as representative could be effectively used to select individual structures and pools for sampling.

The field and laboratory procedures used in the present study worked very well and, with minor modifications, are recommended for future studies. It is now apparent that sampling at various depths introduces undesirable variability in chlorophyll a data used for statistical evaluations of spatial differences among riprapped banks. Based on the present results, future sampling of these banks should be restricted to single depth, unless determining the total periphyton production of the structures is the objective of the study. A depth of 0.1 meters is recommended for these collections. Depth is less of a factor on the wingdams, and sampling along the tops of these submerged structures is recommended, provided they are covered by at least 0.5 meters of water. The Epilithic Algal Bar-Clamp Samplers performed very well, and these or similar samplers that can be attached on submerged substrates should be used for future studies. There was sufficient periphyton in each bar-clamp sample not only for biomass and clorophyll a determinations, but also to obtain an additional subsample for algal identification and enumeration. In future studies only a single bar-clamp sample need to be taken from each rock, thereby reducing the amount of time required for collections. Replication is recommended to remain at ten per structure, with compositing of aliquots to form a single sample for identification and enumeration.

The methods of enumeration were not adequate for large forms such as Cladophora that may actually dominate periphyton biovolume and biomass and even strongly influence composition by its abundant epiphytes. This inadequacy probably was of little consequence in the present study because most samples were collected from depths greater than 0.5 meters where Cladophora was not abundant. If future studies sample riprapped banks at the recommended 0.1 meter depth or if Cladophora is visually abundant in the samples, a separate analysis should be performed for large forms that may not be numerically abundant. Examination of several aliquots (e.g., 5) with a dissecting microscope capable of 40X magnifications is recommended. Cell counts should be made of Cladophora and other large forms.

3.6 REFERENCES CITED

American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1976. Standard Methods for the Examination of Water and Wastewater. 14th edition. APHA, Washington. 1,193 pp.

American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1981. Standard Methods for the Examination of Water and Wastewater. 15th edition. APHA, Washington, D.C. 1,134 pp.

Anderson, D., D. McConville, and J. Smith. 1983. Physical and biological investigations of the main channel border (MCB) habitat of Pool 5A, on the Upper Mississippi River in 1980. St. Paul District Corp of Engineers, St. Paul, Minnesota.

Boesch, D.R. 1977. Application of Numerical Classification in Ecological Investigations of Water Pollution. U.S. EPA Report No. 600/3-77-033.

Boland, D.H.P. 1976. Trophic Classification of Lakes Using LANDSAT-1 (ERTS-1) Multispectral Scanner Data. U.S. EPA Report No. 600/3-76-037.

Bray, J.R. and J.T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. Ecol. Monogr. 32:137-166.

Clark, L.H. 1975. Periphytic algal studies, in Operational Environmental Monitoring in the Mississippi River near Quad-Cities Station, August 1974 through January 1975 (R.M. Gerhold, ed.), pp. 323-361. Semiannual Report by Industrial BIO-TEST Laboratories to Commonwealth Edison Co., Chicago, Ill.

Clark, L.H. 1976. Periphytic algal studies, in Operational Environmental Monitoring in the Mississippi River near Quad-Cities Station, February 1975 through January 1976 (R.M. Gerhold, ed.), pp. 331-365. Annual Report by NALCO Environmental Sciences to Commonwealth Edison Co., Chicago, Ill.

Clark, L.H. and T.N. Seng. 1974. Artificial substrate studies, in Operational Environmental Monitoring in the Mississippi River near Quad-Cities Station, February 1974 through July 1974 (R.P. Markel, ed.), pp. 223-264. Semiannual Report by Industrial BIO-TEST Laboratories to Commonwealth Edison Co., Chicago, Ill.

Cooke, W.B. 1956. Colonization of artificial bare areas by microorganisms. Bot. Rev. 22:613-638.

Cummins, K.W. 1975. The ecology of running waters: theory and practice, in proceedings of the Sandusky River Basin Symposium (D.B. Baker, W.B. Jackson, and B.L. Prater, eds.), pp. 277-293. International Joint Commission, Windsor, Ontario.

Desikachary, T.V. 1959. Cyanophyta. Indian Council of Agricultural Research, New Delhi. 686 pp.

Shannon, C.E. 1948. A mathematical theory of communication. Bell System Tech. J. 27:379-423, 623-656.

Simonsen, R. 1979. The diatom system: ideas on phylogeny. Bacillaria 2:9-71.

Sladeckova, A. 1962. Limnological investigation methods for the periphyton ("aufwuchs") community. Bot. Rev. 28:286-350.

Stoermer, E.F. and R.G. Kreis, Jr. 1978. Preliminary checklist of diatoms (Bacillariophyta) from the laurentian Great Lakes. J. Great Lakes Res. 4(2):149-169.

Taft, C.E. and C.W. Taft. 1971. The Algae of Western Lake Erie. Bull. Ohio Biol. Surv. (New Series) 4(1):1-185.

Webber, O. and K.M. Knutson. 1977. Attached algae studies in the Mississippi River at Monticello during 1976, in Environmental Monitoring and Ecological Studies Program for the Monticello Nuclear Generating Plant, Monticello, Minnesota, 1976 Annual Report, Section 2.1. Northern States Power Co., Minneapolis.

Weber, C.I., ed. 1973a. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. U.S. EPA Report No. 670/4-73-001.

Weber, C.I. 1973b. Recent developments in the measurement of the response of plankton and periphyton changes in their environment, in Bioassay Techniques and Environmental Chemistry (G.E. Glass, ed.), pp. 119-138. Ann Arbor Sci. Publ., Ann Arbor, Mich.

Wetzel, R.G. 1975. Limnology. Saunders, Philadelphia. 743 pp.

Wetzel, R.G. and D.F. Westlake. 1969. Periphyton, in A Manual on Methods for Measuring Primary Production in Aquatic Environmental (R.A. Vollenweider, ed.), pp. 33-40. Davis, Philadelphia.

Whitford, L.A. 1960. The current effect and growth of freshwater algae. Trans. Am. Microsc. Soc. 79:302-309.

Whitford, L.A. and G.J. Schumacher. 1973. A Manual of Fresh-water Algae. Sparks Press, Raleigh, N.C. 324 pp.

Wilhm, J., J. Cooper, and H. Namminga. 1978. Species composition, diversity, biomass, and chlorophyll of periphyton in Greasy Creek, Red Rock Creek, and the Arkansas River, Oklahoma. Hydrobiologia 57:17-23.

Fremling, C.R., D.N. Nielsen, D.R. McConville, R.N. Vose, R.A. Faber, and L.J. Dieterman. 1979. The Feasibility and Environmental Effects of Opening Side Channels in Five Areas of the Mississippi River (West Newton Chute, Fountain City Bay, Sam Gordy's Slough, Kruger Slough and Island 42). Final report to U.S. Fish and Wildlife Service, Twin Cities, Minn.

Hamilton, M.A. 1975. Indexes of diversity and redundancy. J. Water Pollut. Control Fed. 47:630-632.

Heffelfinger, J. 1977. Periphytic algal studies, in Operational Environmental Monitoring in the Mississippi River near Quad-Cities Station, February 1976 through January 1977 (R.M. Gerhold, ed.), pp. 555-584. Annual Report by NALCO Environmental Sciences to Commonwealth Edison Co., Chicago, Ill.

Hoagland, K.D. 1983. Short-term standing crop and diversity of periphytic diatoms in a eutrophic reservoir. J. Phycol. 19(1):30-38.

Hoagland, K.D., S.C. Roemer, and J.R. Rosowski. 1982. Colonization and community structure of two periphyton assemblages, with emphasis on the diatoms (Bacillariophyceae). Amer. J. Bot. 69(2):188-213.

Hustedt, F. 1927-1966. Die Kieselagen Deutschlands, Osterreichs und der Schweiz, in L. Rabenhorst's Kryptogamen-flora, Vol. 7. Part 1, 920 pp. Part 2, 845 pp. Part 3, 816 pp.

Hustedt, F. 1930. Bacillariophyta (Diatomeae), in A. Pascher's Die Susswawasserflora Mitteleuropas, 10. G. Fischer, Jena. 455 pp.

Hustedt, F. 1937-1938. Systematische und okologische untersuchungen uber die diatomeenflora von Java, Bali und Sumatra. Arch. Hydrobiol. Suppl. 15:131-177; 16:187-295, 393-506.

Hustedt, F. 1949. Susswasser-Diatomeen aus dem Albert-National park in Belgisch-Kongo. Exploration du Parc National Albert, Mission H-DAMAS (1935-1936), 8:1-199.

Kuhl, G.M. 1976. Attached algae studies in the Mississippi River at the SHERCO Plant Site during 1975, in SHERCO-Sherburne County Generating Plant Units 1 and 2, 1974-1975 Annual Report, Environmental Monitoring and Ecological Studies Program (Preoperational), Section 4.5. Northern States Power Co., Minneapolis.

Kuhl, G.M. 1978. 1977 attached algae studies of the Mississippi River near the Monticello Nuclear Generating Plant, in Environmental Monitoring and Ecological Studies Program, 1977 Annual Report for the Monticello Nuclear Generating Plant, Monticello, Minnesota, Section 2.1. Northern States Power Co., Minneapolis.

Lange-Bertalot, H. 1977. Eine revision zur taxonomie der Nitzschiae Lanceolatae Grunow. Nova Hedwigia 28:253-307.

Lange-Bertalot, H. 1980. New species, combinations and synonyms in the genus Nitzschia. Bacillaria 3:41-77.

Lange-Bertalot, H. and R. Simonsen. 1978. A taxonomic revision of the Nitzschiae Lanceolatae Grunow. 2. European and related extra-european freshwater and brackish water taxa. Bacillaria 1:11-111.

Lewis, R.B., L.H. Clark, T.N. Seng, J.A. Heffelfinger, and G.P. Czajkowski. 1974. Biological monitoring studies, in Operational Environmental Monitoring in the Mississippi River near Quad-cities Station, August 1973 through January 1974 (H.O. Eiler and J.J. Delfino, eds.), pp. 100-189. Semiannual Report by Industrial BIO-TEST Laboratories to Commonwealth Edison Co., Chicago, Ill.

Lowe, R.L. 1974. Environmental Requirements and Pollution Tolerance of Freshwater Diatoms. U.S. EPA Report No. 670/4-74-005. 333 pp.

McIntire, C.D. 1966. Some effects of current velocity on periphyton communities in laboratory streams. Hydrobiologia 27:559-570.

Meyer, R. 1971. A Study of Phytoplankton Dynamics in Lake Fayetteville as a Means of Assessing Water Quality. Arkansas Water Resources Research Center, Univ. Arkansas, Fayetteville. Publ. No. 10. 59 pp.

Patrick, R. 1948. Factors affecting the distribution of diatoms. Bot. Rev. 14:473-524.

Patrick, R. 1973. Use of algae, especially diatoms, in the assessment of water quality, in Biological Methods for the Assessment of Water Quality (J. Cairns, Jr. and K.L. Dickson, eds.), pp. 76-95. American Society for Testing and Materials, Philadelphia. Spec. Tech. Publ. No. 528.

Patrick, R. and C.W. Reimer. 1966. The Diatoms of the United States Exclusive of Alaska and Hawaii. Vol. I. Fragilariaceae, Eunotiaceae, Achnanthaceae, and Naviculaceae. Acad. Nat. Sci., Phila., Monogr. 13. 688 pp.

Patrick R. and C.W. Reimer. 1975. The Diatoms of the United States Exclusive of Alaska and Hawaii. Vol. II, Part I. Entomoneidaceae, Cymbellaceae, Gomphonemaceae, and Epithemiaceae. Acad. Nat. Sci., Phila., Monogr. 13. 213 pp.

Pielou, E.C. 1966. The measurement of diversity in different types of biological collections. J. Theoret. Biol. 13:131-144.

Prescott, G.W. 1962. Algae of the Western Great Lakes Area. W.C. Brown, Dubuque, Iowa. 977 pp.

Pryfogle, P.A. 1975. Seasonal distribution of periphytic diatom communities of Tymochtee Creek, in Proceedings of the Sandusky River Basin Symposium (D.B. Baker, W.B. Jackson, and B.L. Prater, eds.), pp. 154-173. International Joint Commission, Windsor, Ontario.

Seng, T.N. and L.A. Johnson. 1973. Artificial substrate studies in Operational Environmental Monitoring in the Mississippi River near Quad-Cities Station, February 1973 through July 1973 (H.O. Siler and J.J. Defino, eds.), pp. 134-183. Semiannual Report by Industrial BIO-TEST Laboratories to Commonwealth Edison Co., Chicago, Ill.

4. BENTHIC MACROINVERTEBRATES

4.1 INTRODUCTION

Macroinvertebrates are a major component in the energy transfer between primary producers and consumers at a higher trophic level. Macroinvertebrates may be either primary consumers, secondary consumers (carnivores), or detritivores (Odum 1971). In large rivers and streams, macroinvertebrates are particularly important in energy flow through the detritus cycle. Detritus, which originates from primary production within the stream (photosynthesis), inflowing materials from runoff, stream inflow, or municipal or industrial wastes, ultimately settles to the bottom and provides a food base for the majority of the benthic fauna. Macroinvertebrates recycle nutrients and energy that would otherwise be locked in the sediment or washed downstream and lost to the food web for that reach of the river. Because macroinvertebrates are a vital component in energy flow and the aquatic food chain, changes in the macroinvertebrate community may induce changes in the populations of higher trophic levels.

Macroinvertebrates display a variety of life histories. Many forms spend their entire life cycle within the bottom substrates, whereas others are larval stages of terrestrial adults. Most benthic species at least occasionally leave the bottom substrates and drift in the water column (Bishop and Hynes 1969). Benthic macroinvertebrates leave the benthic environment and enter the water column to feed, avoid noxious substances low dissolved oxygen concentrations, or as a means of dispersal to reduce inter- or intra-specific competition, and (in the case of aquatic insects) as a result of pupation or emergence activity.

Results of the present study are based upon data gathered from June through September 1982. The macroinvertebrate study described herein provides a detailed assessment of the spatial distributional patterns of macroinvertebrates indigenous to the principal habitats of the Mississippi main channel border regions. Community structure within the various habitats was assessed by species composition, abundance, relative abundance and biomass data. Community structure was also evaluated based upon the proportional occurrence of groups of organisms classified according to their respective feeding habits and food resources. Five principal substrates or habitat types were examined: rock, sand, silt, wood, and macrophytes. The sampling regime was designed to address the following four objectives:

1. Describe and evaluate the distribution, structure, and standing crop of macroinvertebrate assemblages among selected main channel border (MCB) habitats;
2. Describe and evaluate the differences among selected MCB habitats in distribution, structure, and standing crop of macroinvertebrate assemblages;
3. Describe and evaluate the temporal changes in distribution, structure and standing crop of macroinvertebrate assemblages among selected MCB habitats; and,

4. Describe and evaluate the vertical distribution of macroinvertebrates within the substrate of selected MCB habitats.

4.2 METHODS

4.2.1 Field Procedures

Macroinvertebrates were sampled at six sites and three aquatic macrophyte beds in Pool 5A of the Mississippi River during 1982 (Figure 1-1). Samples were collected during late spring (11-15 June), mid-summer (18-24 August) and early fall (20-23 September).

The general areas for sampling were identified by the Corps prior to initiation of the field program. Areas sampled included rock structures of a wing dam and a riprapped bank, a sandy area, a silty area and an area with aquatic macrophyte growth. The areal limits of rock habitat were determined based upon current velocity and depth measurements and visual inspection of substrates during the initial field survey. Each study area was mapped during the initial field trip and included a scaled identification of specific collection locations. Collection locations were randomized during the initial survey and detailed field notes and records maintained on the area maps were used to ensure that samples in subsequent collections were taken from the same approximate localities.

Rock Substrate Survey

Macroinvertebrate samples were collected from four types of channel maintenance structures:

1. Riprapped bank with low current velocity (Location 3 Slow);
2. Riprapped bank with high current velocity (Location 3 Fast);
3. Wing dam with high current velocity (Location 4 Fast); and
4. Wing dam with low current velocity (Location 8 Slow).

Within each structure, three habitat types were sampled:

1. Shallow (<1.5 m) with visible growth of periphyton;
2. Shallow, without visible growth of periphyton; and
3. Deep (>1.5 m).

Five replicate samples from each habitat were collected in late spring (11-14 June, shortly after high water), mid-summer (18-22 August), and fall (20-22 September). Each sample consisted of material removed from two rocks. Rocks were collected by a biologist trained as a scuba diver. The diver collected each rock individually by slipping a U.S. Standard No. 30 (595 μm aperture) mesh nitex bag around the rock from the downstream side. Material was removed from the rock by immersion in a weak acid-alcohol solution and gently brushing and hand-picking.

Organisms and material removed from the rock and any material captured in the collection bag was washed in a sieve bucket of U.S. Standard No. 30 mesh (595 μm aperture). Organisms and sieve residue were gently washed with filtered river water and transferred to jars, fixed and preserved in 5 percent buffered formalin containing rose-bengal dye. The exposed area of each rock sampled was measured using a ruler, tape measure and plastic sheet embossed with a grid of square centimeters. The exposed surface was restricted to the area directly exposed to the water and not buried by sand or silt.

Detailed field notes were maintained that list several biotic and abiotic observations and measurements for each sample collected.

Silt and Sand Substrate Survey

Macroinvertebrates were collected from ten randomly selected locations within both the silt and sand substrates (Locations 6 and 10, respectively) during late spring (15 June), summer (23 August), and early fall (23 September). Samples were collected by a diver utilizing a hand held core tube. Six core samples were collected at each of the ten locations. The upper ten centimeters from three cores were composited into one sample for macroinvertebrate analysis. The upper ten centimeters of the other three cores were composited for particle size (PSA) and organic carbon (OC) analysis. Samples for macroinvertebrate identification, enumeration and biomass determination were washed in the field on a U.S. Standard No. 30 mesh (595 μm aperture) sieve. Sieve residue was transferred to jars, fixed and preserved in 5 percent formalin containing rose-bengal dye. Samples for PSA and OC analyses were directly placed in jars, iced and shipped to EA's analytical lab for analysis.

Detailed field notes were maintained for each location. Particular emphasis was placed upon visual characterization of each replicate core sample. Substrates were visually characterized in 10 percent increments in accordance with the modified Wentworth scale (Roelofs 1944) and any evidence of layering or sediment partitioning was noted.

Wood Substrate Survey

Macroinvertebrates were sampled from artificial substrates containing wood. A total of 22 substrates, modeled after Anderson and Mason (1968), were sampled. Each sampler consisted of barbecue baskets filled with approximately 20 willow sticks of uniform length and diameter (approximately 12 in x 1 in, respectively). Willow sticks were collected during the June field trip and allowed to "season" on site, underwater, for a least one month. On 14 July, the sticks were retrieved, scoured and placed in the basket samplers. Three artificial substrates were placed on the bottom in each of the three rock habitats identified on the wing dams at Locations 4 Fast and 8 Slow. In addition, five substrates were randomly placed on the bottom in both the sand (Location 10) and silt (Location 6) habitats. Samplers were anchored and their location marked on shore or with a float. Artificial substrates were allowed a five week colonization period and were retrieved on 18 August by a diver using a U.S. Standard No. 30 mesh nitex bag. Care was taken to enclose the sampler within the bag from the downstream side and lift it slowly from the bottom to prevent loss of organisms. The sampler was cleaned and processed in the same manner as the rock habitat samples. Wood dowels were transferred to the laboratory for measuring to compute surface area per sampler.

Aquatic Plant Habitat Survey

Macroinvertebrates associated with three predominant species of aquatic macrophytes were sampled on 24 August. Wild celery (Vallisneria americana), water stargrass (Heteranthera dubia) and sago pondweed (Potamogeton pectinatus) were determined to be the predominant macrophyte species in Pool 5A. Three separate macrophyte beds were identified immediately downstream from Location 10 (Figure 1-1), each predominated by one of these three species. Five randomly positioned samples were collected within each bed. Samples of both macrophyte growth and bottom sediments were collected. Macroinvertebrates living in association with stands of macrophytes were collected using a quadrat sample (.25m^2) with an attached U.S. No. 30 mesh net. The sampler was lowered vertically and placed firmly on the bottom by a diver. Macrophytes partially entrapped within the frame were sampled by cutting around the exterior of the frame. Macrophytes within the frame were clipped off at the substrate surface. The quadrat and net were then lifted from the upstream direction to prevent loss of organisms. The entire contents of the sample were placed in plastic bags with a small amount of water, placed on ice and shipped to the laboratory for analysis.

Sediment samples for macroinvertebrate, PSA and OC analyses were collected in close proximity or at the precise locations where quadrat samples were collected. Five samples for macroinvertebrates and five samples for PSA/OC were collected in each of the three macrophyte beds. Macroinvertebrate and sediment samples were collected, composited and processed in the field in the same manner described for the silt and sand habitat samples.

Crayfish Collections

Crayfish were sampled in sand and silt habitats and in each of the three rock habitats on the wing dam (Locations 4 Fast and 8 Slow) and riprapped bank (Locations 3 Slow and 3 Fast) structures. Samples were collected in late spring, mid-summer and early fall. In addition, the three macrophyte beds were sampled for crayfish concurrent with the macroinvertebrate sampling in mid-summer. At each habitat, two baited minnow traps (0.64 cm wire mesh, 2.54 cm throat) were set for 24 hours. Traps were baited with cut-up fish and placed at least 10 meters apart and securely anchored on the river bottom. Crayfish collected in each trip were transferred to labeled containers and preserved in 10 percent buffered formalin.

Rock Substrate Vertical Distribution Study

Vertical distribution of macroinvertebrates within rock substrates was assessed by examination of artificial substrates placed by the Corps in two wing dams during the fall of 1981. Two milk crates (38 cm x 38 cm x

38 cm) filled with rocks of a size representative of wing dams were stacked vertically and buried at two locations on each wing dam. Two stacks were placed in areas with fast current (Location 4) and two stacks were placed in slow current (Location 8). On 21 August 1982, each crate was covered with a U.S. No. 30 mesh net, carefully lifted to avoid loss of material, and immediately placed in a wash tub. Rocks were individually cleaned in a weak acid-alcohol solution by brushing and hand-picking over a U.S. No. 30 mesh sieve bucket. Organisms and material collected were transferred to a labeled container and fixed and preserved in 5-10 percent formalin containing rose-bengal dye. Materials collected in the wash tub were also rinsed on a U.S. Standard No. 30 mesh sieve and the residue retained was combined with materials cleaned from the rocks. The surface area of each rock was measured and recorded. Interstitial sediments were visually characterized for texture and the volume of interstitial material was estimated.

Sand and Silt Substrate Vertical Distribution Study

The vertical distribution of macroinvertebrates within the sand and silt habitats was examined on 23 August 1982 by serially sectioning core samples. Five locations were randomly selected within each habitat. Six cores were collected at each location. Each core was sectioned into three 10 cm long segments: 0-10 cm, 10-20 cm and 20-30 cm. Three core sections from each stratum were composited for macroinvertebrate analysis from each location. Three core sections were likewise composited from each location for PSA and OC analysis. Composited samples for macroinvertebrate analysis were washed on a U.S. Standard No. 30 mesh sieve and transferred to labeled plastic jars, fixed and preserved in 5-10 percent formalin containing rose-bengal dye. Samples for PSA and OC were placed directly in labeled jars, iced and shipped to the laboratory for analysis.

Mussel Survey

The distribution and relative abundance of mussels was examined concurrent with the periphyton distribution survey conducted in midsummer. The four rock structures were surveyed for mussels by hand-picking, crawling, wading, and pollywogging. In addition, the diver conducting the periphyton distribution survey hand-picked specimens and noted any distributional patterns of mussels on the rock structures.

4.2.2 Laboratory Procedures

Identification and Enumeration

All macroinvertebrate samples collected in the benthos study, except the macrophyte samples, were sieved in the field on U.S. Standard No. 30 mesh sieve or sieve bucket.

Macrophyte samples were received in the laboratory packed in ice. These samples were processed immediately upon receipt in the laboratory. The plants were agitated in a weak acid alcohol solution to remove attached organisms. Organisms and residue released were washed on a U.S. No. 30 mesh sieve. The next step was to float the plants, a few stems at a time in a shallow pan containing weak acid-alcohol solution under a 5X magnification lens. Macroinvertebrates were hand-picked and placed in the sieve with materials collected by agitation. The entire contents of the sieve were then transferred to a labeled container, fixed and preserved in 10 percent buffered formalin. The macrophytes were rinsed in distilled water and retained for biomass determinations.

In cases where excessive amounts of detrital material were collected, or extremely large numbers of a redundant assemblage were collected, subsampling was employed. Core samples for the habitat survey did not require any subsampling; however, because of the extremely large number of redundant assemblages, rock samples, artificial substrates, milk-crate samples and macrophyte samples did require subsampling. When sample splitting was required, the methods outlined by Weber (1973) were employed. A second type of subsampling technique was used to subsample certain particularly abundant groups of organisms such as oligochaetes and chironomids. Subsampling at this level was conducted only after the entire sample or portion of a sample had been sorted and the total number of individuals of each particular group was known. Subsequently, individuals to be subsampled were placed in a shallow square plexiglass pan marked with a numbered grid of one centimeter squares. Organisms were evenly distributed within the pan and, using a table of random numbers, organisms were removed from the corresponding grids until a predetermined portion of the organisms was removed. In identification and enumeration of a particular subsample, a record of fragments was maintained for later extrapolation of data from subsample to whole sample densities.

Prior to analysis, each sample was rinsed on a U.S. No. 60 mesh sieve to remove preservative. The sample material was then sorted, a small portion at a time, under a dissection microscope at 10X magnification. All organisms, except oligochaetes and chironomids were identified and enumerated during this initial sorting procedure. Oligochaetes and chironomids were placed on glass slides in a non-resinous mounting media for examination under a compound binocular microscope at 40-1000 X magnification. To avoid possible overcounts, only head-ends of fragmented organisms were enumerated.

All macroinvertebrates were identified to the lowest taxonomic level practicable (usually genus or species) using appropriate comprehensive taxonomic keys and literature. The taxonomy of Oligochaeta followed that of Brinkhust and Jamieson (1971), Hiltunen and Klemm (1980), and Stimpson et al. (1982). Identification of Lumbriculidae and Naididae was based on external characteristics. Some Tubificidae were identified by the characteristic shape and configuration of the somatic chaetae at all life stages while others were identifiable only when the specimen was sexually mature enough to display reproductive organs. Immature specimens that could not be specifically identified were divided into two groups: those with capilliform chaetae and those without capilliform chaetae.

Amphipoda taxonomy followed that of Bousfield (1958) and Holsinger (1976). Identification of Hirudinea specimens was based on Klemm (1982), and Gastropoda were determined according to the description of Burch (1982). Sphaeriidae were identified according to Burch (1973). In general, the aquatic insects were identified utilizing the keys by Hilsenhoff (1981, 1982); however, additional literature was consulted in the identification of the various aquatic insect groups. Ephemeroptera and Trichoptera taxonomy followed that of Edmunds et al. (1976) and Wiggins (1977), respectively. The nomenclature suggested by Hamilton et al. (1969) was used for Chironomidae. A voucher collection of all macroinvertebrate taxa was compiled and maintained. Specimens were preserved on glass slides or in vials containing 70 percent ethanol and glycerin. In addition, records of any communications with outside taxonomic consultants were included with the collection.

Biomass

Dry weight standing crop biomass was estimated for all taxa collected at each of the rock, sand, silt and macrophyte habitats sampled. Biomass estimates were made by collecting a large qualitative sample from each habitat. Samples were collected by a variety of techniques such as hand-picking and dip-netting. Samples were sufficiently large to include a minimum of at least ten individuals per taxon. These samples were used to obtain an accurate measure of individual dry-weight for each taxon. Large predatory forms were either killed or removed and maintained in separate containers. Samples were placed on ice and immediately shipped to the laboratory for biomass determinations. In the laboratory, organisms were sorted, alive, under a dissection microscope and placed in preweighed numbered crucibles. Organisms were sorted into groups at the lowest practicable txonomic level, frequently genus or species and rarely at a level higher than family. When specimens within any one category exhibited distinct size class or instar differences, specimens were maintained in separate crucibles. To assure that seasonal trends in biomass will be evident, organisms were sorted into the same categories during each of the three sampling periods.

Organisms were dried in a Blue M drying oven at 105 C for four hours. Samples were then cooled in a desiccator and subsequently weighed to the nearest 0.1 mg on a Torbal Model EA-1AP Balance. Individual dry weight biomass was calculated for each taxon by dividing the total weight per taxon by the number of individuals processed. Standing crop biomass was then extrapolated by multiplying the individual dry weights by the densities (number/m^2) of the same respective taxa determined in abundance samples collected in each habitat.

Aquatic macrophyte biomass was measured for each sample immediately after processing for removal of macroinvertebrates. Plants were dried in a Blue M Model drying oven at 105 C for four hours and weighed to the nearest 0.1 gram.

Sediment Organic Content Analysis

Promptly upon receipt at EA's laboratory, organic content (OC) of each sediment sample was determined. The OC, expressed as a percentage of the sample dry weight, was determined by a loss-on-ignition method (USEPA 1979). First, the sample was thoroughly mixed and a small (50g) subsample was removed. All pieces of wood, plant material, macroinvertebrates, and mollusk shells larger than 10 mm in any dimension were picked from the subsample. A 40g subsample was then dried at 110 C until there was no further weight loss. After cooling the residue in a desiccator and weighing to the nearest milligram, the samples were placed in a 440 C oven for 1 hour. After again cooling the residue in a desiccator and weighing to the nearest milligram, the OC was determined by dividing the weight lost by the sample while in the 440 C oven by the weight of the sample at the time it was placed in the 440 C oven.

Sediment Grain Size Analysis

Grain size distribution of each sediment sample was determined by a combination of direct (mechanical analysis) and indirect (hydrometer analysis) methods. Samples were homogenized, then analyzed for particle size by sieving and the hydrometer method (Method D422-63, ASTM 1973). Sieving was conducted with a series of U.S. Standard sieves and a soil test sieve shaker. The particle size categories utilized included:

Sediment Type	Particle Size (mm)
Gravel	>2.0
Very coarse sand	1.0-2.0
Coarse sand	0.500-1.0
Medium sand	0.250-0.500
Fine sand	0.150-0.250
Very fine sand	0.075-0.150
Silt	0.005-0.075
Clay	0.001-0.005
Colloid	<0.001

Statistical Analysis

Density data were used to calculate several measures of community structure. These indices included diversity (Shannon 1948, using base 2 logarithms), evenness (Pielou 1966), and redundancy (Hamilton 1975). Additionally, densities of taxa composing at least 1.0 percent of total density at any location during two months were analyzed by a multivariate technique based on Bray and Curtis (1957). This technique simultaneously compared the abundances of taxa and then produced a coefficient which described the degree of affinity between two locations. Greater similarity among locations was indicated by smaller coefficients. Average group-linkage cluster analysis (normal classification or Q-mode analysis; Boesch 1977) was then used to produce dendrograms that grouped into clusters locations with high degrees of similarity (i.e., low Bray and Curtis coefficients). These clusters were in turn grouped at sucessively higher levels as indicated by their decreasing similarity. Natural clusters of locations with similar communities were indicated on the dendrograms by a sudden increase in the linkage coefficient (Boland 1976). Additionally for this report, locations linked at coefficients less than approximately 0.3 were considered quite similar, whereas locations linked at coefficients greater than approximately 0.5 were considered dissimilar.

In order to determine how variables such as time of year, sampling location, structure type, habitat and substrate affected the macroinvertebrate density, these variables were statistically compared for total benthos and for selected dominant taxa and groups. For each month, location, structure, habitat or substrate, mean density values were calculated for the desired spatial or temporal comparison. The ranks of the mean values were then compared using the Kruskal-Wallis (KW) test to determine if there were any statistical differences among them. When three or more values were compared, Duncan's Multiple Range Test was used to identify exactly where the statistical differences were.

The statistical comparisions that were made are summarized in the tables in the text. Most of these summary tables are presented in Section 4.7 of this chapter. Each table follows a similar format. The means for the categories of the variable being compared are presented followed by the Chi2 value achieved testing the hypothesis that there were no differences among the categories. The probability (Prob.) of achieving that particular Chi2 is also shown. The difference between or among means was considered significant if the probability was ≤ 0.05 (signified in the next column of the table by the entry "yes"). The last column on the table contains the results of the Duncan Multiple Range Test (when applicable). Differences identified by Duncan's test were not considered valid unless the KW test showed that a significant difference(s) actually existed. However, because Duncan's test did show how the mean values tended to group together (even though the groups were not statistically different), it was decided to present the results of Duncan's test even when the KW test indicated that no significant difference was present. Finally, there were a few occasions when the KW test showed that there was a significant difference between the means being compared but Duncan's test could not identify where this difference was.

4.3 RESULTS AND DISCUSSION

Two hundred and eighteen distinct macroinvertebrate taxa were collected from MCB habitats of Pool 5A in 1982 (Table 4-1). Of the ten phyla present, Annelida (especially Naididae and Tubificidae) and Arthropoda (primarily Insecta) yielded the greatest number of taxa. Detailed information on the composition and abundance of the benthic macroinvertebrates in Pool 5A is presented in Appendix C.

4.3.1 Rock Substrate Survey

Community Composition

Mayfly (Heptageniidae) nymphs, net-spinning caddisfly (Hydropsychidae and Polycentropodidae) larvae and pupae, and midge-fly (Chironomidae) larvae and pupae were the numerically dominant macroinvertebrates colonizing the rock structures of Pool 5A in 1982 (Tables 4-2 through 4-4). Typically, these taxa were also important components of the biomass on these rock structures (Tables 4-5 through 4-7). However, small-bodied midges, which were frequently numerically dominant, composed a relatively small portion of the biomass. Conversely, though infrequently collected, the large-bodied organisms (e.g., the dragonfly nymph Neurocordulia spp. and the caddisfly larvae Pycnopsyche sp.) were relatively large components of the biomass.

TABLE 4-1 BENTHIC MACROINVERTEBRATE TAXA COLLECTED FROM MAIN CHANNEL BORDER HABITATS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, 1982

- Porifera
  - Demospongia
    - Haplosclerina
      - Spongillidae
        - *Spongilla* sp.
- Cnidaria
  - Hydrozoa
    - Hydroidea
      - Clavidae
        - *Cordylophora lacustris*
      - Hydridae
        - *Hydra* sp.
- Platyhelminthes
  - Turbellaria
    - Unidentified Turbellaria
    - Tricladida
      - Planariidae
        - *Dugesia* sp.
- Nematoda
  - Unidentified Nematoda
- Nemertinea
  - Prostomatidae
    - *Prostoma rubrum*
- Ectoprocta
  - Phylactolaemata
    - Ctenostamata
      - Paludicellidae
        - *Paludicella articulata*
        - *Pottsiella erecta*
    - Plumatellina
      - Plumatellidae
        - Unidentified Plumatellidae
      - Lophopodidae
        - *Pectinatella magnifica*
- Entoprocta
  - Urnatellidae
    - *Urnatella gracilis*
- Annelida
  - Oligochaeta
    - Plesiopora
      - Enchytraeidae
        - Unidentified Enchytraeidae
      - Naididae
        - *Arcteonais lomondi*
        - *Dero digitata*
        - *Dero vaga*
        - *Dero* sp.
        - *Nais alpina*
        - *Nais barbata*
        - *Nais behningi*
        - *Nais bretscheri*
        - *Nais communis*
        - *Nais pardalis*
        - *Nais pseudobtusa*
        - *Naix simplex*
        - *Nais variabilis*
        - *Piguetiella michiganensis*
        - *Pristina aequiseta*
        - *Pristina foreli*
        - *Pristina osborni*
        - *Specaria josinae*
        - *Stylaria fossularis*
        - *Stylaria lacustris*
        - *Uncinais uncinata*
      - Tubificidae
        - *Aulodrilus pigueti*
        - *Aulodrilus pluriseta*
        - *Bothrioneurum vejdoskyanum*
        - *Branchiura sowerbyi*
        - *Ilyodrilus templetoni*
        - *Isochaetides freyi*
        - *Limnodrilus cervix*
        - *Limnodrilus hoffmeisteri*
        - *Limnodrilus udekemianus*
        - *Potamothrix moldaviensis*
      - Lumbriculidae
        - Unidentified Lumbriculidae
      - Branchiobdellidae
        - Unidentified Branchiobdellidae
  - Hirudinea
    - Rhynchobdellida
      - Glossiphoniidae
        - *Actinobdella inequiannulata*
        - *Helobdella elongata*
        - *Helobdella stagnalis*
        - *Helobdella triserialis*
    - Pharyngobdellida
      - Erpobdellidae
        - *Erpobdella punctata*
- Arthropoda
  - Crustacea
    - Isopoda
      - Asellidae
        - *Asellus* sp.
    - Amphipoda
      - Talitridae
        - *Hyalella azteca*
      - Gammaridae
        - *Crangonyx* sp.
        - *Gammarus pseudolimnaeus*

TABLE 4-1 (CONT.)

- Decapoda
  - Astacidae
    - *Orconectes virilis*
    - *Palaemonetes kadiakensis*
- Arachnida
  - Acarina
    - Unidentified Hydracarina
- Insecta
  - Collembola
    - Unidentified Collembola
  - Ephemeroptera
    - Baetidae
      - *Baetis* sp.
      - *Centroptilum* sp.
      - *Pseudocloeon* sp.
    - Oligoneuriidae
      - *Isonychia* sp.
    - Heptageniidae
      - *Heptagenia flavescens*
      - *Spinadus* sp.
      - *Stenacron interpunctatum*
      - *Stenacron minnetonka*
      - *Stenonema ares*
      - *Stenonema integrum*
      - *Stenonema quinquespinum*
      - *Stenonema terminatum*
      - *Stenonema* sp. *pulchellum* grp.
    - Tricorythidae
      - *Tricorythodes* sp.
    - Caenidae
      - *Brachycercus* sp.
      - *Caenis* sp.
    - Baetiscidae
      - *Baetisca* sp.
    - Leptophelbiidae
      - *Paraleptophlebia* sp.
    - Potamanthidae
      - *Potamanthus* sp.
    - Ephemeridae
      - *Hexagenia limbata*
    - Polymitarcyidae
      - *Ephoron* sp.
  - Odonata
    - Gomphidae
      - *Dromogomphus* sp.
      - *Gomphus* sp.
    - Corduliidae
      - *Neurocordulia molesta*
      - *Neurocordulia yamaskanensis*
    - Coenagrionidae
      - *Argia* sp.
      - *Enallagma* sp.
  - Plecoptera
    - Peronarcidae
      - *Pteronarcys pictetti*
    - Perlidae
      - *Acroneuria abnormis*
      - *Acroneuria* sp.
      - *Paragnetina media*
      - *Perlesta placida*
    - Perlodidae
      - *Isoperla* sp.
  - Hemiptera
    - Nepidae
      - *Ranatra fusca*
    - Pleiidae
      - *Plea striola*
    - Corixidae
      - Unidentified Corixidae
  - Megaloptera
    - Sialidae
      - *Sialis* sp.
  - Neuroptera
    - Sisyridae
      - *Climacia* sp.
  - Trichoptera
    - Psychomyiidae
      - *Psychomyia flavida*
    - Polycentropodidae
      - *Cyrnellus fraternus*
      - *Neureclipsis* sp.
      - *Polycentropus remotus*
      - *Polycentropus* sp.
    - Hydropsychidae
      - *Cheumatopsyche* sp.
      - *Hydropsyche orris*
      - *Hydropsyche frisoni*
      - *Hydropsyche simulans*
      - *Hydropsyche* sp.
      - *Potamyia flava*
      - *Symphitopsyche bifida* grp.
    - Hydroptilidae
      - *Hydroptila waubesiana*
      - *Hydroptila albicornis*
      - *Ochrotrichia* sp.
      - *Orthotrichia* sp.
    - Brachycentridae
      - *Brachycentrus numerosus*

TABLE 4-1 (CONT.)

- Limnephilidae
  - *Pycnopsyche* sp.
- Leptoceridae
  - *Ceraclea flava*
  - *Ceraclea tarsipunctata*
  - *Ceraclea transversus*
  - *Leptocerus americanus*
  - *Nectopsyche diarina*
  - *Nectopsyche candida*
  - *Oecetis cinerascens*
  - *Oecetis* sp.

Lepidoptera

- Pyralidae
  - *Paraponyx* sp.

Coleoptera

- Gyrinidae
  - *Dineutus* sp.
- Psephenidae
  - *Ectopria nervosa*
- Elmidae
  - *Dubiraphia* sp.
  - *Dubiraphia vittata*
  - *Stenelmis* sp.
  - *Macronychus glabratus*

Diptera

- Chaoboridae
  - *Chaoborus punctipennis*
- Ceratopogonidae
  - Unidentified Ceratopogonidae
- Simuliidae
  - *Simulium* sp.
- Chironomidae
  - Chironominae
    - *Chernovskiia orbicus*
    - *Chironomus* sp.
    - *Cladotanytarsus* sp.
    - *Cryptochironomus* sp.
    - *Dicrotendipes* sp.
    - *Endochironomus* sp.
    - *Glyptotendipes* sp.
    - *Harnischia* sp.
    - *Kriboxenus* sp.
    - *Micropsectra curvicornis*
    - *Micropsectra* sp.
    - *Microtendipes* sp.
    - *Parachironomus* cf. *pectinatellae*
    - *Parachironomus* sp.
    - *Paralauterborniella* sp.
    - *Paratanytarsus* sp.
    - *Paratendipes albimanus* type
    - *Paratendipes connectens* type
    - *Phaenopsectra* sp.
    - *Polypedilum* ss *convictum* type
    - *Polypedilum* ss *fallax* group
    - *Polypedilum* ss *scalaenum* type
    - *Polypedilum* ss *simulans* type
    - *Rheotanytarsus* sp.
    - *Robackia demeijerei*
    - *Stempellina* sp.
    - *Stenochironomus* sp.
    - *Stictochironomus* sp.
    - *Tanytarsus* sp.
    - *Tribelos* sp.
    - *Xenochironomus* (*Anceus*) sp.
    - *Xenochironomus* sp.
    - *Zavrelia* sp.
  - Tanypodinae
    - *Ablabesmyia* sp.
    - *Coelotanypus* sp.
    - *Labrundinia* sp.
    - *Natarsia* sp.
    - *Procladius* sp.
    - *Tanypus stellatus*
    - *Thienemannimyia* series
  - Orthocladiinae
    - *Corynoneura* sp.
    - *Cricotopus* ss *bicinctus* grp.
    - *Cricotopus* ss *cylindraceus* grp.
    - *Cricotopus* ss *intersectus*
    - *Cricotopus* ss *tremulus* type
    - *Cricotopus* ss *trifascia*
    - *Cricotopus* *Isocladius* *sylvestris* type
    - *Epoicocladius* sp.
    - *Eukiefferiella claripennis*
    - *Nanocladius* sp.
    - *Orthocladius* sp.
    - *Parakiefferiella* sp.
    - *Synorthocladius* sp.
    - *Thienemanniella* sp.
  - Diamesinae
    - *Potthastia* sp.

TABLE 4-1 (CONT.)

- Atheridicae
  - *Atherix variegata*
- Empididae
  - Unidentified Empididae
- Mollusca
  - Gastropoda
    - Mesogastropoda
      - Amnicolidae
        - *Amnicola* sp.
        - *Somatogyrus* sp.
      - Valvatidae
        - *Valvata tricarinata tricarinata*
      - Pleuroceridae
        - *Pleurocera* sp.
    - Basomatophora
      - Physidae
        - *Physa* sp.
      - Planorbidae
        - *Gyraulus* sp.
        - *Helisoma* sp.
      - Ancylidae
        - *Ferrissia* sp.
  - Pelecypoda
    - Heterodonata
      - Sphaeriidae
        - *Musculium transversum*
        - *Pisidium* sp.
        - *Sphaerium striatinum*
    - Eulamellibranchia
      - Unionidae
        - Ambleminae
          - *Amblema plicata*
          - *Fusconaia undata*
          - *Quadrula nodulata*
          - *Quadrula pustulosa*
        - Unioninae
          - *Anodonta corpulenta*
          - *Anodonta imbecillis*
          - *Carunculina parva*
          - *Lampsilis ventricosa*
          - *Lasmigona complanata*
          - *Leptodea fragilis*
          - *Leptodea laevissima*
          - *Ligumia recta latissima*
          - *Obliquaria reflexa*
          - *Obovaria olivaria*
          - *Proptera alata*
          - *Truncilla donaciformis*
          - *Truncilla truncata*

TABLE 4-2 MEAN DENSITY (No./m^2) AND PERCENT OCCURRENCE OF THE DOMINANT (≥5%) BENTHIC MMACROINVERTEBRATES COLLECTED FROM ROCK STRUCTURES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, JUNE 1982

	Riprapped Bank											
	3 Slow						3 Fast					
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.		deep	
Taxa	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Isopoda												
Asellus sp.	72[a]	(3.6)	119	(5.4)	50	(2.8)	9	(0.5)	2	(0.2)	25	(1.3)
Amphipoda												
Hyalella azteca	306	(15.2)	251	(11.4)	117	(6.5)	20	(1.2)	7	(0.7)	24	(1.2)
Ephemeroptera												
Total Heptageniidae	98	(4.8)	122	(5.6)	47	(2.6)	82	(4.8)	25	(2.4)	64	(3.3)
Trichoptera												
Total Polycentropodidae	27	(1.3)	29	(1.3)	100	(5.5)	46	(2.7)	38	(3.6)	50	(2.6)
Immature Hydropsychidae	3	(0.1)	157	(7.2)	0	(0.0)	0	(0.0)	1	(0.1)	2	(0.1)
Cheumatopsyche sp.	574	(28.5)	296	(13.5)	519	(28.8)	941	(55.0)	444	(42.9)	734	(38.1)
Hydropsyche orris	18	(0.9)	7	(0.3)	28	(1.5)	36	(2.1)	211	(20.4)	486	(25.2)
Total Hydropsychidae	601	(29.8)	467	(21.3)	559	(31.1)	979	(57.2)	669	(64.7)	1,303	(67.6)
Coleoptera												
Total Elmidae	17	(0.9)	14	(0.6)	24	(1.3)	2	(0.1)	0	(0.0)	0	(0.0)
Diptera												
Endochironomus sp.	146	(7.2)	147	(6.7)	91	(5.1)	58	(3.4)	29	(2.8)	11	(0.6)
Rheotanytarsus sp.	353	(17.5)	485	(22.1)	441	(24.5)	328	(19.2)	176	(17.0)	287	(14.9)
Total Chironomidae	712	(35.3)	974	(44.4)	760	(42.2)	528	(30.8)	270	(26.1)	422	(21.9)
Total Benthos	2,019		2,196		1,801		1,711		1,035		1,926	
Species diversity	3.42		3.77		3.39		2.34		2.52		2.77	
Evenness	0.69		0.71		0.71		0.58		0.64		0.64	
Redundancy	0.33		0.30		0.30		0.44		0.38		0.37	
Current velocity (ft/sec)	0.1-0.2		0.2-0.3		0.4		0.4		0.9		0.7	
Depth (m)	0.5		0.6-1.2		1.6-2.1		0.6		1.1-1.3		2.0	

[a] Densities are mean of five replicate samples.

TABLE 4-2 (CONT.)

Taxa	Wing Dam											
	4 Fast						8 Slow					
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.		deep	
	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Isopoda												
Asellus sp.	28	(1.7)	14	(0.4)	9	(0.3)	15	(0.9)	9	(0.6)	22	(1.2)
Amphipoda												
Hyalella azteca	5	(0.3)	0	(0.0)	3	(0.1)	7	(0.4)	4	(0.3)	13	(0.7)
Ephemeroptera												
Total Heptageniidae	57	(3.5)	0	(0.0)	7	(0.3)	25	(1.5)	0	(0.0)	23	(1.3)
Trichoptera												
Total Polycentropodidae	15	(0.9)	5	(0.1)	7	(0.3)	12	(0.7)	6	(0.4)	12	(0.7)
Immature Hydropsychidae	0	(0.0)	0	(0.0)	66	(2.5)	6	(0.4)	0	(0.0)	0	(0.0)
Cheumatopsyche sp.	704	(43.1)	1,291	(32.9)	765	(29.1)	456	(26.3)	446	(27.4)	378	(21.4)
Hydropsyche orris	276	(16.9)	1,799	(45.8)	1,206	(45.8)	384	(22.2)	361	(22.2)	344	(19.4)
Total Hydropsychidae	992	(60.7)	3,193	(81.3)	2,135	(81.1)	874	(50.5)	828	(50.9)	769	(43.5)
Coleoptera												
Total Elmidae	85	(5.2)	25	(0.7)	83	(3.2)	82	(4.7)	87	(5.3)	61	(3.4)
Diptera												
Endochironomus sp.	14	(0.8)	4	(0.1)	4	(0.2)	4	(0.2)	6	(0.4)	15	(0.8)
Rheotanytarsus sp.	245	(15.0)	305	(7.8)	212	(8.0)	502	(29.0)	504	(31.0)	648	(36.7)
Total Chironomidae	410	(25.1)	558	(14.2)	364	(13.8)	667	(38.5)	646	(39.7)	798	(45.1)
Total Benthos	1,636		3,929		2,632		1,732		1,627		1,768	
Species diversity	2.65		2.09		2.32		2.68		2.58		2.69	
Evenness	0.62		0.50		0.58		0.63		0.63		0.64	
Redundancy	0.39		0.51		0.44		0.38		0.38		0.37	
Current velocity (ft/sec)	1.3-1.5		1.2-1.4		1.4-1.7		1.1		0.8-1.1		0.5-0.6	
Depth (m)	1.2-1.4		1.1-1.3		1.7-2.0		1.3		1.2-1.3		1.8-2.0	

TABLE 4-3 MEAN DENSITY (No./m^2) AND PERCENT OCCURRENCE OF THE DOMINANT (>5%) BENTHIC MACROINVERTEBRATES COLLECTED FROM ROCK STRUCTURES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

	Riprapped Bank											
	3 Slow						3 Fast					
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.		deep	
Taxa	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Turbellaria												
Dugesia sp.	159[a]	(3.1)	33	(1.0)	36	(1.7)	53	(1.1)	21	(1.4)	140	(4.0)
Amphipoda												
Hyalella azteca	1,110	(21.5)	64	(2.0)	16	(0.7)	1,074	(22.4)	34	(2.3)	24	(0.7)
Ephemeroptera												
Immature Heptageniidae	532	(10.3)	814	(25.2)	358	(17.0)	631	(13.2)	139	(9.4)	252	(7.2)
Stenacron interpunctatum grp.	243	(4.7)	900	(27.9)	524	(24.8)	459	(9.6)	210	(14.2)	155	(4.4)
Total Heptageniidae	774	(15.0)	1,717	(53.2)	882	(41.8)	1,090	(22.7)	349	(23.6)	408	(11.6)
Trichoptera												
Cyrnellus fraternus	46	(0.9)	94	(2.9)	107	(5.1)	100	(2.1)	102	(6.9)	472	(13.4)
Total Polycentropodidae	66	(1.3)	108	(3.4)	113	(5.4)	111	(2.3)	115	(7.8)	481	(13.7)
Cheumatopsyche sp.	10	(0.2)	7	(0.2)	4	(0.2)	31	(0.6)	45	(3.1)	139	(4.0)
Hydropsyche orris	10	(0.2)	2	(0.1)	2	(0.1)	15	(0.3)	13	(0.9)	121	(3.4)
Total Hydropsychidae	22	(0.4)	14	(0.4)	8	(0.4)	53	(1.1)	61	(4.2)	322	(9.2)
Diptera												
Dicrotendipes sp.	1,440	(27.9)	393	(12.2)	129	(6.1)	882	(18.4)	476	(32.2)	639	(18.2)
Glyptotendipes sp.	512	(9.9)	249	(7.7)	223	(10.6)	277	(5.8)	144	(9.7)	572	(16.3)
Microtendipes sp.	26	(0.5)	30	(0.9)	46	(2.2)	25	(0.5)	41	(2.8)	313	(8.9)
Rheotanytarsus sp.	3	(0.1)	8	(0.3)	1	(<0.1)	48	(1.0)	7	(0.4)	29	(0.8)
Ablabesmyia sp.	160	(3.1)	151	(4.7)	132	(6.3)	140	(2.9)	51	(3.5)	160	(4.6)
Cricotopus bicinctus group	41	(0.8)	0	(0.0)	0	(0.0)	366	(7.6)	0	(0.0)	0	(0.0)
Total Chironomidae	2,576	(49.9)	1,038	(32.1)	769	(36.4)	2,074	(43.3)	797	(53.9)	1,975	(56.1)
Total Benthos	5,162		3,231		2,110		4,795		1,477		3,519	
Species diversity	3.21		3.25		3.69		3.24		3.12		3.66	
Evenness	0.63		0.65		0.73		0.67		0.72		0.74	
Redundancy	0.37		0.36		0.28		0.34		0.29		0.26	
Current velocity (ft/sec)	0.1		<0.1		0.1-0.2		<0.1		0.1		0.3	
Depth (m)	0.3-0.8		0.8-1.1		1.5-2.0		0.2-0.5		0.6-1.2		1.6-2.1	

(a) Densities are mean of five replicate samples.

TABLE 4-3 (CONT.)

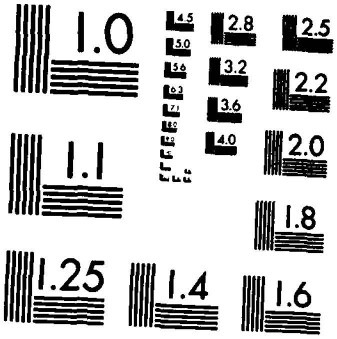
	Wing Dam											
	4 Fast						8 Slow					
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.		deep	
Taxa	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Turbellaria												
Dugesia sp.	1,047	(9.4)	3,867	(22.3)	2,053	(14.6)	238	(3.1)	328	(7.2)	751	(15.5)
Amphipoda												
Hyalella azteca	266	(2.4)	6	(<0.1)	20	(0.1)	5	(0.1)	8	(0.2)	2	(0.1)
Ephemeroptera												
Immature Heptageniidae	86	(0.8)	0	(0.0)	0	(0.0)	4	(0.1)	10	(0.2)	7	(0.2)
Stenacron interpunctatum grp.	184	(1.7)	12	(0.1)	57	(0.4)	12	(0.2)	92	(2.0)	79	(1.6)
Total Heptageniidae	280	(2.5)	17	(0.1)	88	(0.6)	28	(0.4)	142	(3.1)	123	(2.5)
Trichoptera												
Cyrnellus fraternus	0	(0.0)	375	(2.2)	5	(<0.1)	0	(0.0)	14	(0.3)	4	(0.1)
Total Polycentropodidae	9	(0.1)	381	(2.2)	5	(<0.1)	4	(0.1)	23	(0.5)	6	(0.1)
Cheumatopsyche sp.	1,729	(15.6)	2,400	(13.9)	1,716	(12.2)	1,221	(15.8)	560	(12.2)	603	(12.4)
Hydropsyche orris	4,437	(40.0)	6,683	(38.6)	6,329	(45.1)	2,876	(37.3)	1,342	(29.3)	1,702	(35.1)
Total Hydropsychidae	6,909	(62.2)	10,239	(59.1)	8,998	(64.0)	4,440	(57.5)	2,111	(46.1)	2,512	(51.7)
Diptera												
Dicrotendipes sp.	254	(2.3)	88	(0.5)	122	(0.9)	281	(3.6)	171	(3.7)	40	(0.8)
Glyptotendipes sp.	106	(1.0)	230	(1.3)	225	(1.6)	418	(5.4)	473	(10.4)	233	(4.8)
Microtendipes sp.	81	(0.8)	85	(0.5)	69	(0.5)	8	(0.1)	25	(0.5)	3	(0.1)
Rheotanytarsus sp.	238	(2.1)	470	(2.7)	655	(4.7)	393	(5.1)	213	(4.7)	448	(9.2)
Ablabesmyia sp.	69	(0.6)	19	(0.1)	61	(0.4)	106	(1.4)	126	(2.8)	65	(1.4)
Cricotopus bicinctus *group*	75	(0.7)	14	(0.1)	0	(0.0)	32	(0.4)	0	(0.0)	0	(0.0)
Total Chironomidae	1,724	(15.5)	2,010	(11.6)	2,047	(14.6)	2,262	(29.3)	1,604	(35.1)	1,104	(22.7)
Total Benthos	11,106		17,313		14,051		7,719		4,574		4,854	
Species diversity	3.26		2.85		2.94		3.26		3.75		3.28	
Evenness	0.64		0.59		0.60		0.67		0.70		0.65	
Redundancy	0.37		0.41		0.40		0.34		0.31		0.35	
Current velocity (ft/sec)	0.3-0.7		0.6		0.6		0.3		0.2		0.2	
Depth (m)	0.3-1.0		0.8-1.2		1.6-2.0		1.0-1.2		1.0-1.2		1.8-2.1	

TABLE 4-4 MEAN DENSITY (No./m^2) AND PERCENT OCCURRENCE OF THE DOMINANT (>5%) BENTHIC MACROINVERTEBRATES COLLECTED FROM ROCK STRUCTURES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER SEPTEMBER 1982

	Riprapped Bank											
	3 Slow						3 Fast					
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.		deep	
Taxa	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Hydrozoa												
Hydra sp.	18[(a)]	(0.3)	7	(0.2)	63	(1.6)	54	(1.1)	229	(4.2)	354	(6.6)
Turbellaria												
Dugesia sp.	62	(1.0)	57	(1.5)	46	(1.2)	169	(3.4)	146	(2.7)	129	(2.4)
Oligochaeta												
Total Naididae	432	(7.0)	94	(2.4)	40	(1.0)	290	(5.8)	141	(2.6)	80	(1.5)
Amphipoda												
Hyalella azteca	934	(15.1)	163	(4.1)	25	(0.7)	458	(9.2)	49	(0.9)	41	(0.8)
Ephemeroptera												
Stenacron interpunctatum grp.	387	(6.3)	578	(14.7)	255	(6.6)	320	(6.4)	629	(11.4)	481	(9.0)
Total Heptageniidae	566	(9.2)	696	(17.7)	303	(7.8)	437	(8.7)	900	(16.4)	593	(11.1)
Trichoptera												
Cyrnellus fraternus	341	(5.5)	304	(7.7)	874	(22.6)	387	(7.7)	340	(6.2)	877	(16.4)
Total Polycentropodidae	579	(9.4)	501	(12.7)	910	(23.6)	543	(10.9)	514	(9.4)	984	(18.5)
Immature Hydropsychidae	6	(0.1)	18	(0.5)	31	(0.8)	85	(1.7)	84	(1.5)	117	(2.2)
Cheumatopsyche sp.	9	(0.1)	14	(0.4)	70	(1.8)	115	(2.3)	48	(0.9)	83	(1.6)
Hydropsyche orris	3	(0.1)	7	(0.2)	15	(0.4)	21	(0.4)	39	(0.7)	31	(0.6)
Total Hydropsychidae	18	(0.3)	39	(1.0)	119	(3.1)	221	(4.4)	170	(3.1)	234	(4.4)
Oecetis sp.	104	(1.7)	52	(1.3)	251	(6.5)	60	(1.2)	106	(1.9)	234	(4.4)
Total Leptoceridae	212	(3.4)	121	(3.1)	359	(9.3)	128	(2.6)	210	(3.8)	378	(7.1)
Diptera												
Dicrotendipes sp.	695	(11.3)	635	(16.1)	514	(13.3)	790	(15.8)	1,282	(23.3)	577	(10.8)
Glyptotendipes sp.	1,202	(19.5)	954	(24.2)	913	(23.7)	956	(19.1)	958	(17.4)	941	(17.6)
Parakiefferiella sp.	147	(2.4)	10	(0.3)	15	(0.4)	84	(1.7)	40	(0.7)	46	(0.9)
Total Chironomidae	2,785	(45.1)	1,993	(50.7)	1,870	(48.5)	2,437	(48.7)	2,908	(52.9)	2,374	(44.5)
Total Empididae	320	(5.2)	73	(1.9)	54	(1.4)	106	(2.1)	57	(1.0)	19	(0.4)
Total Benthos	6,180		3,935		3,860		5,002		5,501		5,333	
Species diversity	3.70		3.66		3.47		3.60		3.63		3.91	
Evenness	0.72		0.73		0.72		0.73		0.72		0.78	
Redundancy	0.29		0.27		0.28		0.27		0.28		0.23	
Current velocity (ft/sec)	0.1		0.2		0.2		0.3		0.7		0.7	
Depth (m)	0.2-0.6		0.5-1.5		1.8-2.2		0.2-0.5		0.6		1.8-2.1	

(a) Densities are mean of five replicate samples.

AD-A164 745 AQUATIC STUDIES OF THE MAIN CHANNEL BORDER HABITAT OF 2/4
POOL 5A ON THE UPPER MISSISSIPPI RIVER(U) ECOLOGICAL
ANALYSTS INC NORTHBROOK IL G SEEGERT ET AL. JAN 84
UNCLASSIFIED F/G 6/6 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE 4-4 (CONT.)

	Wing Dam											
	4 Fast						8 Slow					
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.		deep	
Taxa	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Hydrozoa												
Hydra sp.	31	(0.2)	31	(0.2)	5	(<0.1)	258	(2.6)	322	(4.5)	692	(7.9)
Turbellaria												
Dugesia sp.	917	(6.8)	364	(2.4)	2,996	(16.2)	305	(3.0)	465	(6.5)	412	(4.7)
Oligochaeta												
Total Naididae	107	(0.8)	30	(0.2)	35	(0.2)	163	(1.6)	26	(0.4)	82	(0.9)
Amphipoda												
Hyalella azteca	47	(0.4)	5	(<0.1)	7	(<0.1)	41	(0.4)	50	(0.7)	77	(0.9)
Ephemeroptera												
Stenacron interpunctatum grp.	186	(1.4)	10	(0.1)	5	(<0.1)	0	(0.0)	12	(0.2)	15	(0.2)
Total Heptageniidae	293	(2.2)	43	(0.3)	28	(0.2)	83	(0.8)	72	(1.0)	78	(0.9)
Trichoptera												
Cyrnellus fraternus	318	(2.4)	278	(1.8)	367	(2.0)	192	(1.9)	260	(3.6)	195	(2.2)
Total Polycentropodidae	365	(2.7)	294	(1.9)	376	(2.0)	202	(2.0)	268	(3.7)	201	(2.3)
Immature Hydropsychidae	1,225	(9.1)	1,945	(12.8)	726	(3.9)	516	(5.1)	236	(3.3)	186	(2.1)
Cheumatopsyche sp.	3,560	(26.4)	2,597	(17.1)	3,004	(16.2)	674	(6.7)	415	(5.8)	771	(8.8)
Hydropsyche orris	4,238	(31.5)	6,207	(40.9)	8,211	(44.3)	3,840	(38.1)	1,214	(17.0)	2,212	(25.2)
Total Hydropsychidae	9,059	(67.3)	10,772	(70.9)	11,953	(64.5)	5,067	(50.2)	1,902	(26.6)	3,200	(36.4)
Oecetis sp.	180	(1.3)	1,053	(6.9)	1,386	(7.5)	802	(7.9)	919	(12.8)	1,678	(19.1)
Total Leptoceridae	223	(1.7)	1,087	(7.2)	1,435	(7.7)	862	(8.5)	1,001	(14.0)	1,775	(20.2)
Diptera												
Dicrotendipes sp.	170	(1.3)	161	(1.1)	39	(0.2)	209	(2.1)	210	(2.9)	163	(1.9)
Glyptotendipes sp.	276	(2.1)	292	(1.9)	242	(1.3)	704	(7.0)	866	(12.1)	630	(7.2)
Parakiefferiella sp.	347	(2.6)	321	(2.1)	129	(0.7)	459	(4.6)	439	(6.1)	173	(2.0)
Total Chironomidae	1,568	(11.6)	1,662	(10.9)	1,125	(6.1)	2,462	(24.4)	2,411	(33.7)	1,839	(20.9)
Total Empididae	263	(2.0)	259	(1.7)	106	(0.6)	145	(1.4)	166	(2.3)	210	(2.4)
Total Benthos	13,470		15,189		18,532		10,090		7,165		8,791	
Species diversity	3.31		3.07		2.68		3.67		4.07		3.60	
Evenness	0.63		0.60		0.54		0.70		0.80		0.70	
Redundancy	0.37		0.40		0.46		0.31		0.21		0.30	
Current velocity (ft/sec)	1.4		1.7		2.2		0.8		0.9		0.7	
Depth (m)	0.4-1.0		1.0-1.5		1.8-2.2		0.7-1.0		0.7-1.2		1.5-2.2	

TABLE 4-5 MEAN DRY WEIGHT (g/m^2) AND PERCENT COMPOSITION, BY WEIGHT, OF THE DOMINANT ($\geq 5\%$) BENTHIC MACROINVERTEBRATE TAXA COLONIZING ROCK STRUCTURES IN POOL 5A OF THE MISSISSIPPI RIVER, JUNE 1982

	Riprapped Bank											
	3 Slow						3 Fast					
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.		deep	
Taxa	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%
Amphipoda												
Hyalella azteca	0.070	(6.4)	0.028	(2.6)	0.032	(2.4)	0.007	(0.4)	0.003	(0.1)	0.010	(0.2)
Gammarus pseudolimnaeus	0.060	(5.4)	0.090	(8.3)	0.030	(2.3)	0.012	(0.7)	0.001	(<0.1)	0.000	(0.0)
Ephemeroptera												
Stenacron interpunctatum grp.	0.051	(4.7)	0.189	(17.5)	0.102	(7.6)	0.222	(12.7)	0.131	(4.8)	0.267	(5.0)
Total Heptageniidae	0.056	(5.1)	0.214	(19.8)	0.103	(7.7)	0.223	(12.7)	0.131	(4.8)	0.270	(5.0)
Trichoptera												
Cyrnellus fraternus	0.020	(1.8)	0.015	(1.4)	0.099	(7.4)	0.046	(2.6)	0.050	(1.8)	0.043	(0.8)
Polycentropus sp.	0.040	(3.6)	0.041	(3.8)	0.108	(8.1)	0.008	(0.5)	0.004	(0.1)	0.023	(0.4)
Total Polycentropodidae	0.059	(5.4)	0.056	(5.2)	0.207	(15.5)	0.054	(3.1)	0.054	(2.0)	0.066	(1.2)
Cheumatopsyche sp.	0.327	(29.8)	0.178	(16.5)	0.524	(39.2)	1.035	(59.4)	0.715	(26.4)	1.306	(24.3)
Hydropsyche orris	0.027	(2.4)	0.011	(1.0)	0.156	(11.7)	0.231	(13.2)	1.571	(58.0)	2.903	(54.0)
Total Hydropsychidae	0.380	(34.6)	0.223	(20.6)	0.724	(54.2)	1.277	(73.2)	2.360	(87.1)	4.674	(86.9)
Pycnopsyche sp.	0.049	(4.4)	0.146	(13.5)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)
Diptera												
Total Chironomidae	0.327	(29.8)	0.117	(10.8)	0.152	(11.4)	0.079	(4.5)	0.019	(0.7)	0.059	(1.1)
Total Benthos	1.098		1.079		1.336		1.743		2.710		5.380	

TABLE 4-5 (CONT.)

Taxa	Wing Dam											
	4 Fast						8 Slow					
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.		deep	
	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%
Amphipoda												
Hyalella azteca	0.002	(<0.1)	0.000	(0.0)	<0.001	(<0.1)	0.002	(0.1)	0.001	(<0.1)	0.004	(0.2)
Gammarus pseudolimnaeus	0.003	(0.1)	0.000	(<0.1)	0.002	(<0.1)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)
Ephemeroptera												
Stenacron interpunctatum grp.	0.098	(2.8)	0.000	(0.0)	0.012	(0.2)	0.031	(1.0)	0.000	(0.0)	0.041	(1.9)
Total Heptageniidae	0.101	(2.9)	0.000	(0.0)	0.012	(0.2)	0.044	(1.5)	0.000	(0.0)	0.041	(1.9)
Trichoptera												
Cyrnellus fraternus	0.014	(0.4)	0.006	(<0.1)	0.003	(<0.1)	0.010	(0.3)	0.006	(0.2)	0.011	(0.5)
Polycentropus sp.	0.006	(0.2)	0.000	(0.0)	0.011	(0.2)	0.002	(0.1)	0.000	(0.0)	0.001	(0.1)
Total Polycentropodidae	0.021	(0.6)	0.006	(<0.1)	0.014	(0.2)	0.012	(0.4)	0.006	(0.2)	0.012	(0.5)
Cheumatopsyche sp.	1.479	(42.4)	2.401	(19.5)	0.949	(13.9)	0.388	(13.0)	0.763	(19.3)	0.310	(14.0)
Hydropsyche orris	1.511	(43.3)	9.267	(75.3)	5.260	(76.9)	2.009	(67.5)	2.477	(62.8)	1.292	(58.4)
Total Hydropsychidae	3.052	(87.5)	12.185	(99.0)	6.642	(97.1)	2.479	(83.3)	3.353	(85.0)	1.861	(84.1)
Pycnopsyche sp.	0.171	(4.9)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.350	(8.9)	0.082	(3.7)
Diptera												
Total Chironomidae	0.037	(1.1)	0.045	(0.4)	0.022	(0.3)	0.147	(4.9)	0.091	(2.3)	0.048	(2.2)
Total Benthos	3.488		12.306		6.839		2.976		3.945		2.212	

TABLE 4-6 MEAN DRY WEIGHT (g/m^2) AND PERCENT COMPOSITION, BY WEIGHT, OF THE DOMINANT (≥5%) BENTHIC MACROINVERTEBRATE TAXA COLONIZING ROCK STRUCTURES IN POOL 5A OF THE MISSISSIPPI RIVER, AUGUST 1982

	Riprapped Bank											
	3 Slow						3 Fast					
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.		deep	
Taxa	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%
Turbellaria												
Dugesia sp.	0.102	(5.3)	0.021	(1.6)	0.023	(2.7)	0.034	(2.2)	0.013	(2.1)	0.090	(3.4)
Amphipoda												
Hyalella azteca	0.200	(10.5)	0.019	(1.4)	0.003	(0.4)	0.314	(20.9)	0.010	(1.6)	0.007	(0.3)
Ephemeroptera												
Immature Heptageniidae	0.111	(5.8)	0.288	(21.4)	0.074	(8.9)	0.144	(9.6)	0.032	(5.1)	0.058	(2.2)
Stenacron interpunctatum grp.	0.050	(2.6)	0.319	(23.7)	0.176	(21.1)	0.236	(15.7)	0.048	(7.7)	0.055	(2.1)
Total Heptageniidae	0.161	(8.5)	0.608	(45.2)	0.250	(30.0)	0.380	(25.3)	0.080	(12.7)	0.113	(4.3)
Odonata												
Neurocordulia sp.	0.080	(4.2)	0.095	(7.1)	0.000	(0.0)	0.000	(0.0)	0.037	(5.9)	0.047	(1.8)
Trichoptera												
Cyrnellus fraternus	0.046	(2.4)	0.094	(7.0)	0.042	(5.0)	0.100	(6.6)	0.102	(16.4)	0.472	(17.9)
Total Polycentropodidae	0.084	(4.4)	0.122	(9.1)	0.044	(5.3)	0.121	(8.0)	0.126	(20.1)	0.489	(18.5)
Cheumatopsyche sp.	0.018	(0.9)	0.012	(0.9)	0.006	(0.8)	0.051	(3.4)	0.052	(8.2)	0.195	(7.4)
Hydropsyche orris	0.013	(0.7)	0.003	(0.4)	0.002	(0.3)	0.009	(0.6)	0.039	(6.2)	0.142	(5.4)
Total Hydropsychidae	0.033	(1.7)	0.024	(1.8)	0.013	(1.5)	0.069	(4.6)	0.095	(15.2)	0.387	(14.7)
Pycnopsyche sp.	0.041	(2.1)	0.141	(10.5)	0.000	(0.0)	0.015	(1.0)	0.000	(0.0)	0.026	(1.0)
Diptera												
Total Chironomidae	0.490	(25.8)	0.178	(13.2)	0.131	(15.8)	0.415	(27.6)	0.215	(34.4)	0.714	(27.1)
Gastropoda												
Pleurocera sp.	0.217	(11.5)	0.000	(0.0)	0.160	(19.2)	0.000	(0.0)	0.000	(0.0)	0.136	(5.2)
Physa sp.	0.333	(17.5)	0.000	(0.0)	0.071	(8.5)	0.000	(0.0)	0.000	(0.0)	0.560	(21.2)
Pelecypoda												
Musculium transversum	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)
Sphaerium striatinum	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)
Total Sphaeriidae	0.000	(0.0)	0.000	(0.0)	0.004	(0.5)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)
Total Benthos	1.898		1.340		0.833		1.501		0.625		2.637	

TABLE 4-6 (CONT.)

Taxa	Wing Dam											
	4 Fast						8 Slow					
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.		deep	
	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%
Turbellaria												
Dugesia sp.	0.670	(5.7)	2.475	(10.8)	1.314	(7.1)	0.152	(1.1)	0.210	(2.4)	0.481	(8.2)
Amphipoda												
Hyalella azteca	0.078	(0.6)	0.002	(<0.1)	0.006	(<0.1)	0.001	(<0.1)	0.002	(0.3)	0.001	(<0.1)
Ephemeroptera												
Immature Heptageniidae	0.066	(0.6)	0.000	(0.0)	0.000	(0.0)	0.001	(<0.1)	0.002	(<0.1)	0.002	(<0.1)
Stenacron interpunctatum grp.	0.141	(1.2)	0.010	(<0.1)	0.043	(0.2)	0.007	(<0.1)	0.053	(0.6)	0.046	(0.8)
Total Heptageniidae	0.215	(1.8)	0.013	(0.1)	0.068	(0.4)	0.015	(0.1)	0.079	(0.9)	0.069	(1.2)
Odonata												
Neurocordulia sp.	0.357	(3.0)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.143	(1.6)	0.000	(0.0)
Trichoptera												
Cyrnellus fraternus	0.000	(0.0)	0.375	(1.6)	0.005	(<0.1)	0.000	(0.0)	0.014	(0.2)	0.004	(<0.1)
Total Polycentropodidae	0.018	(0.2)	0.381	(1.7)	0.005	(<0.1)	0.004	(<0.1)	0.026	(0.3)	0.006	(0.1)
Cheumatopsyche sp.	2.900	(24.5)	4.142	(18.1)	2.878	(15.6)	1.982	(14.9)	1.197	(13.7)	0.673	(11.5)
Hydropsyche orris	5.888	(49.7)	13.051	(57.0)	12.361	(66.8)	4.380	(32.9)	4.139	(47.2)	1.842	(31.5)
Total Hydropsychidae	9.183	(77.5)	18.328	(80.0)	16.174	(87.5)	6.965	(52.3)	5.501	(62.7)	2.864	(49.0)
Pycnopsyche sp.	0.096	(0.8)	0.000	(0.0)	0.000	(0.0)	0.167	(1.3)	0.000	(0.0)	0.139	(2.4)
Diptera												
Total Chironomidae	0.320	(2.7)	0.175	(0.8)	0.178	(1.0)	0.612	(4.6)	0.536	(6.1)	0.256	(4.4)
Gastropoda												
Pleurocera sp.	0.467	(3.9)	0.000	(0.0)	0.000	(0.0)	4.308	(32.3)	1.758	(20.0)	1.750	(29.9)
Physa sp.	0.027	(0.2)	0.071	(0.3)	0.042	(0.2)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)
Pelecypoda												
Musculium transversum	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.879	(6.6)	0.082	(0.9)	0.073	(1.2)
Sphaerium striatinum	0.103	(0.9)	1.205	(5.3)	0.249	(1.3)	0.000	(0.0)	0.103	(1.2)	0.032	(0.5)
Total Sphaeriidae	0.183	(1.6)	1.205	(5.3)	0.264	(1.4)	0.896	(6.7)	0.235	(2.7)	0.124	(2.1)
Total Benthos	11.853		22.896		18.493		13.319		8.767		5.844	

TABLE 4-7 MEAN DRY WEIGHT (g/m^2) AND PERCENT COMPOSITION, BY WEIGHT, OF THE DOMINANT (≥5%) BENTHIC MACROINVERTEBRATE TAXA COLONIZING ROCK STRUCTURES IN POOL 5A OF THE MISSISSIPPI RIVER, SEPTEMBER 1982

	Riprapped Bank											
	3 Slow						3 Fast					
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.		deep	
Taxa	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%
Turbellaria												
Dugesia sp.	0.067	(5.2)	0.062	(5.3)	0.050	(4.7)	0.183	(7.5)	0.157	(5.8)	0.139	(4.3)
Amphipoda												
Hyalella azteca	0.122	(9.4)	0.021	(1.8)	0.007	(0.7)	0.128	(5.3)	0.009	(0.3)	0.005	(0.2)
Ephemeroptera												
Stenacron interpunctatum grp.	0.248	(19.1)	0.295	(25.3)	0.163	(15.3)	0.250	(10.3)	0.585	(21.8)	0.548	(17.0)
Total Heptageniidae	0.257	(19.8)	0.301	(25.8)	0.166	(15.6)	0.256	(10.5)	0.599	(22.3)	0.554	(17.1)
Odonata												
Neurocordulia sp.	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.362	(14.9)	0.011	(0.4)	1.086	(33.6)
Trichoptera												
Cyrnellus fraternus	0.031	(2.4)	0.046	(4.7)	0.079	(7.4)	0.186	(7.7)	0.095	(3.5)	0.281	(8.7)
Polycentropus sp.	0.045	(3.5)	0.077	(6.6)	0.008	(0.7)	0.162	(6.7)	0.162	(6.0)	0.043	(1.3)
Total Polycentropodidae	0.078	(6.0)	0.125	(10.8)	0.086	(8.1)	0.358	(14.8)	0.257	(9.6)	0.328	(10.2)
Cheumatopsyche sp.	0.009	(0.7)	0.014	(1.2)	0.072	(6.8)	0.119	(4.9)	0.018	(0.7)	0.104	(3.2)
Hydropsyche orris	0.006	(0.5)	0.013	(1.1)	0.028	(2.7)	0.041	(1.7)	0.047	(1.7)	0.019	(0.6)
Total Hydropsychidae	0.016	(1.2)	0.029	(2.5)	0.110	(10.3)	0.167	(6.9)	0.072	(2.7)	0.137	(4.2)
Diptera												
Total Chironomidae	0.390	(30.1)	0.399	(34.2)	0.262	(24.5)	0.682	(28.1)	0.930	(34.6)	0.688	(21.3)
Gastropoda												
Pleurocera sp.	0.075	(5.8)	0.000	(0.0)	0.116	(10.8)	0.136	(5.6)	0.409	(15.2)	0.000	(0.0)
Physa sp.	0.122	(9.4)	0.079	(6.7)	0.097	(9.0)	0.000	(0.0)	0.000	(0.0)	0.059	(1.8)
Pelecypoda												
Sphaerium striatinum	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)
Total Sphaeriidae	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)	0.012	(0.4)	0.000	(0.0)
Total Benthos	1.297		1.166		1.068		2.427		2.690		3.231	

TABLE 4-7 (CONT.)

Taxa	Wing Dam											
	4 Fast						8 Slow					
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.		deep	
	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%
Turbellaria												
Dugesia sp.	0.587	(3.0)	0.233	(1.8)	1.917	(10.1)	0.195	(1.2)	0.298	(2.3)	0.124	(1.0)
Amphipoda												
Hyalella azteca	0.011	(0.1)	0.001	(<0.1)	0.002	(<0.1)	0.007	(<0.1)	0.425	(3.3)	0.013	(0.1)
Ephemeroptera												
Stenacron interpunctatum grp.	0.069	(0.4)	0.004	(<0.1)	0.002	(<0.1)	0.000	(0.0)	0.004	(<0.1)	0.008	(0.1)
Total Heptageniidae	0.088	(0.5)	0.011	(0.1)	0.010	(<0.1)	0.032	(0.2)	0.016	(0.1)	0.041	(0.3)
Odonata												
Neurocordulia sp.	0.000	(0.0)	0.715	(5.4)	1.129	(5.9)	0.865	(5.3)	0.000	(0.0)	0.502	(4.1)
Trichoptera												
Cyrnellus fraternus	0.041	(0.2)	0.036	(0.3)	0.022	(0.1)	0.033	(0.2)	0.044	(0.3)	0.033	(0.3)
Polycentropus sp.	0.085	(0.4)	0.010	(0.1)	0.000	(0.0)	0.008	(<0.1)	0.005	(<0.1)	0.007	(0.1)
Total Polycentropodidae	0.126	(0.6)	0.066	(0.5)	0.038	(0.2)	0.046	(0.3)	0.055	(0.4)	0.041	(0.3)
Cheumatopsyche sp.	3.916	(20.1)	1.922	(14.6)	3.575	(18.8)	1.079	(6.5)	0.631	(4.8)	0.894	(0.7)
Hydropsyche orris	11.781	(60.6)	7.696	(58.3)	7.883	(41.4)	8.179	(49.6)	2.623	(20.2)	5.398	(43.8)
Total Hydropsychidae	16.017	(82.4)	9.822	(74.4)	11.534	(60.6)	9.383	(56.9)	3.354	(25.8)	6.383	(51.8)
Diptera												
Total Chironomidae	0.235	(1.2)	0.266	(2.0)	0.293	(1.5)	0.640	(3.9)	0.289	(2.2)	0.717	(5.8)
Gastropoda												
Pleurocera sp.	0.441	(2.3)	0.472	(3.6)	0.000	(0.0)	4.025	(24.4)	7.717	(59.3)	3.467	(28.2)
Physa sp.	0.000	(0.0)	0.000	(0.0)	1.083	(5.7)	0.000	(0.0)	0.000	(0.0)	0.000	(0.0)
Pelecypoda												
Sphaerium striatinum	1.045	(5.4)	0.438	(3.3)	2.175	(11.4)	0.000	(0.0)	0.000	(0.0)	0.472	(3.8)
Total Sphaeriidae	1.089	(5.6)	0.996	(7.5)	2.304	(12.1)	0.228	(1.4)	0.030	(0.2)	0.472	(3.8)
Total Benthos	19.450		13.202		19.037		16.475		13.012		12.313	

A diverse and abundant bryozoan fauna also colonized the rock structures of Pool 5A. Live or deteriorating colonies of the bryozoan Pottsiella erecta (verified by Dr. Anthony F. Maciorowski, Ecological Analysts, Inc.) were abundant at all locations. In a study of Lake Erie bryozoans, Maciorowski (1974) also found P. erecta to be part of an intricate sessile community. The collection of P. erecta in Pool 5A represents a northward extension of its reported range (Maciorowski 1974). However, it may have been overlooked in many studies because of its plant-like appearance (Pennak 1953).

Spatial Differences among Rock Structures

Despite the differences in hydrology, the benthos collected from rock structures of one type (either wing dam or riprapped bank) had similar species composition. During most samplings in 1982, the wing dams (Locations 4 Fast and 8 Slow) yielded greater densities and biomass than the riprapped bank locations (3 Slow and 3 Fast) (Figure 4-1). In a 1980 study of the benthic organisms inhabiting Pool 5A rock strctures (Anderson et al. 1983), the wing dam macroinvertebrate faunas also had substantially greater densities and biomass than the riprapped bank communities.

The benthic communities colonizing the wing dam and riprapped bank structures exhibited numerous statistically significant ($P \leq 0.05$) density differences during each sampling date (Table 4-8; Tables 4-44 through 4-47 in Section 4.7). Differences among the dominant taxa and total benthos were greatest in September and smallest in June. For all of 1982 and for each sampling date (except June), the total benthos was significantly greater on the wing dam than on the riprapped bank. Hydropsychid caddisflies, which were the dominant organisms on the wing dams, had significantly greater densities on the wing dams than on the riprapped banks throughout 1982. Chironomids, which usually dominated the riprapped bank communities, had significantly larger populations on the riprapped bank than on the wing dams only in September.

Although the faunal composition of the two wing dam locations was similar, density and biomass differences between the two wing dam communities (Locations 4 Fast and 8 Slow) was evident. Total benthos, biomass and species diversity values at Location 8 (the slow current velocity wing dam) were intermediate between those at Location 4 (the fast current velocity wing dam) and those at the riprapped bank (Figure 4-1). The consistently larger hydropsychid caddisfly assemblage at Location 4 Fast was the primary reason for the greater density and biomass, and lower species diversity values at this location when compared with the other locations.

The hydropsychid population at wing dam Location 4 Fast was always significantly greater than at the riprapped bank locations (3 Slow and 3 Fast) (Table 4-9; Tables 4-48 through 4-51 in Section 4.7). It was also greater than at wing dam Location 8 Slow in June.

Spatial differences in total benthos (Figure 4-2) and biomass (Figure 4-3) among rock structures were relatively small in June, probably because of the high river flow and similar steady current velocity at all

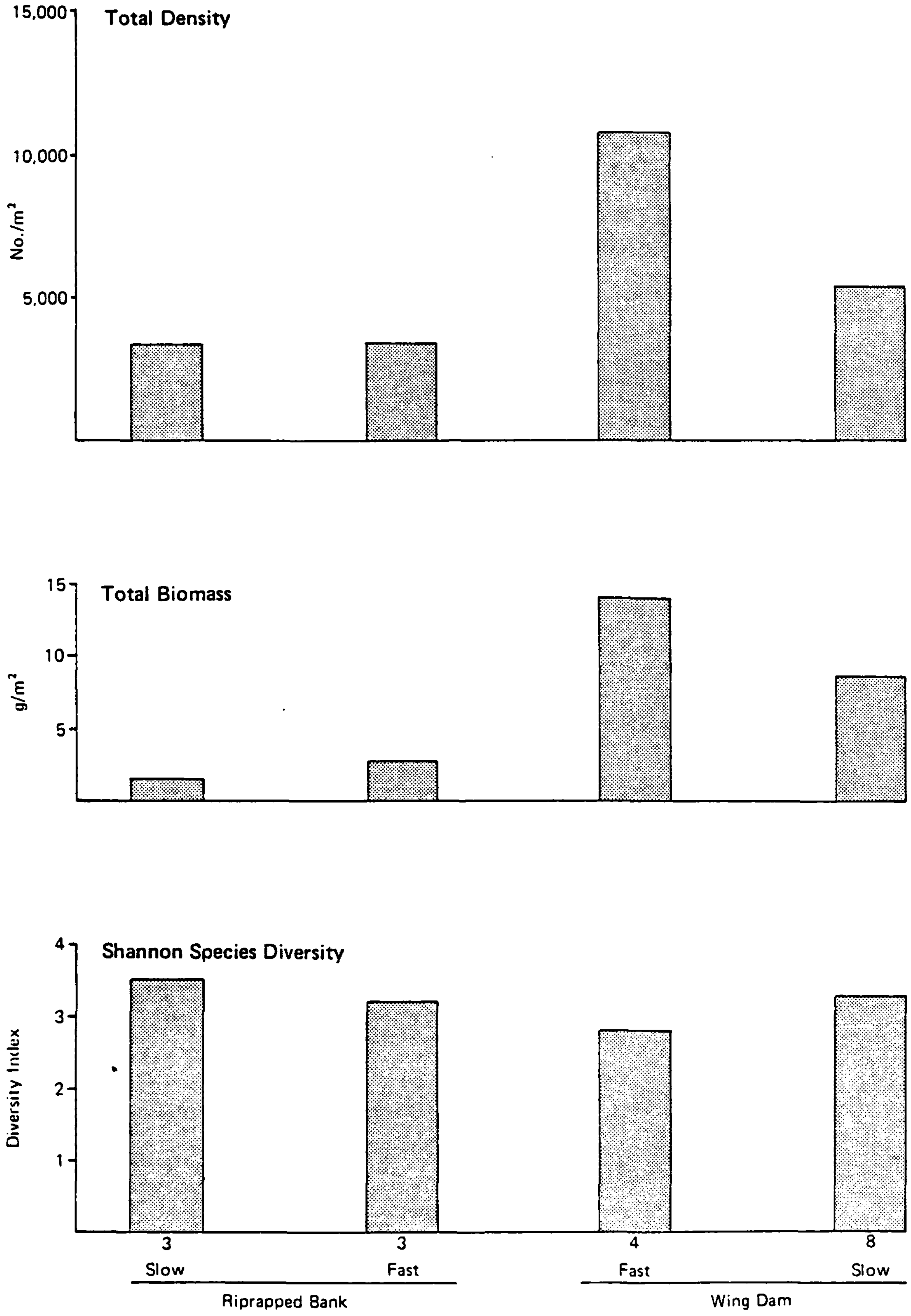


Figure 4-1. Mean density, biomass and species diversity at four rock structure locations in Pool 5A of the Upper Mississippi River, 1982.

TABLE 4-8 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY STRUCTURE TYPE) FROM ROCK STRUCTURE SAMPLES, 1982

Taxa or Group	June		August		September		1982	
	Riprap Bank	Wing Dam	Riprap Bank	Wing Dam	Riprap Bank	Wing Dam	Riprap Bank	Wing Dam
Total Benthos	1781(a)	2220	3382	9936*	4969	12,206*	3371	8121*
Hydra sp.	0	0	10	36	121	223	43	86
Dugesia sp.	2	2	73	1381*	102	910*	59	764*
Total Naididae	2	1	39	35	180*	74	74*	37
Asellus sp.	46	16	28	7	5	4	26*	9
Hyalella azteca	121*	5	387*	51	278*	38	262*	31
Immature Heptageniidae	6*	0	454*	18	140*	24	200*	14
Stenacron interpunctatum group	66*	17	415*	73	442*	38	308*	43
Total Heptageniidae	73*	18	870*	113	582*	99	509*	77
Cyrnellus fraternus	32*	8	154*	66	521*	268	235*	114
Total Polycentropodidae	48*	9	166*	71	672*	284	295*	122
Immature Hydropsychidae	27	12	7	322*	57	806*	30	380*
Cheumatopsyche sp.	585	674	39	1371*	56	1837*	227	1294*
Hydropsyche orris	131	729*	27	3895*	19	4320*	59	2981*
Total Hydropsychidae	763	1465*	80	5868*	133	6992*	325	4775*
Oecetis sp.	<1	0	23	109*	134	1003*	52	370*

TABLE 4-8 (CONT.)

Taxa or Group	June Riprap Bank	June Wing Dam	August Riprap Bank	August Wing Dam	September Riprap Bank	September Wing Dam	1982 Riprap Bank	1982 Wing Dam
Total Leptoceridae	7*	1	60	128	235	1064*	101	398
Total Elmidae	10	70*	29	62	37	75*	25	69*
Dicrotendipes sp.	8*	4	660*	159	749*	159	472*	107
Endochironomus sp.	80*	8	56	42	7	14	48*	21
Glyptotendipes sp.	19*	8	330	281	987*	501	445	263
Microtendipes sp.	12*	1	80	45	93*	30	62*	26
Rheotanytarsus sp.	345	403	16	403*	9	89*	123*	298
Ablabesmyia sp.	6*	<1	132*	74	198*	33	112*	36
Cricotopus bicinctus group	1	8*	68	20	21	117*	30	48*
Parakiefferiella sp.	<1	<1	<1	0	57	311*	19	104*
Total Chironomidae	611	574	1538	1792	2394*	1844	1514	1403
Total Empididae	2	4	11	97*	105	191*	39	97*

(a) Monthly numbers are mean of 30 samples.
Year numbers are mean of 90 samples.
* = Significantly greater density value (Kruskal-Wallis Test).

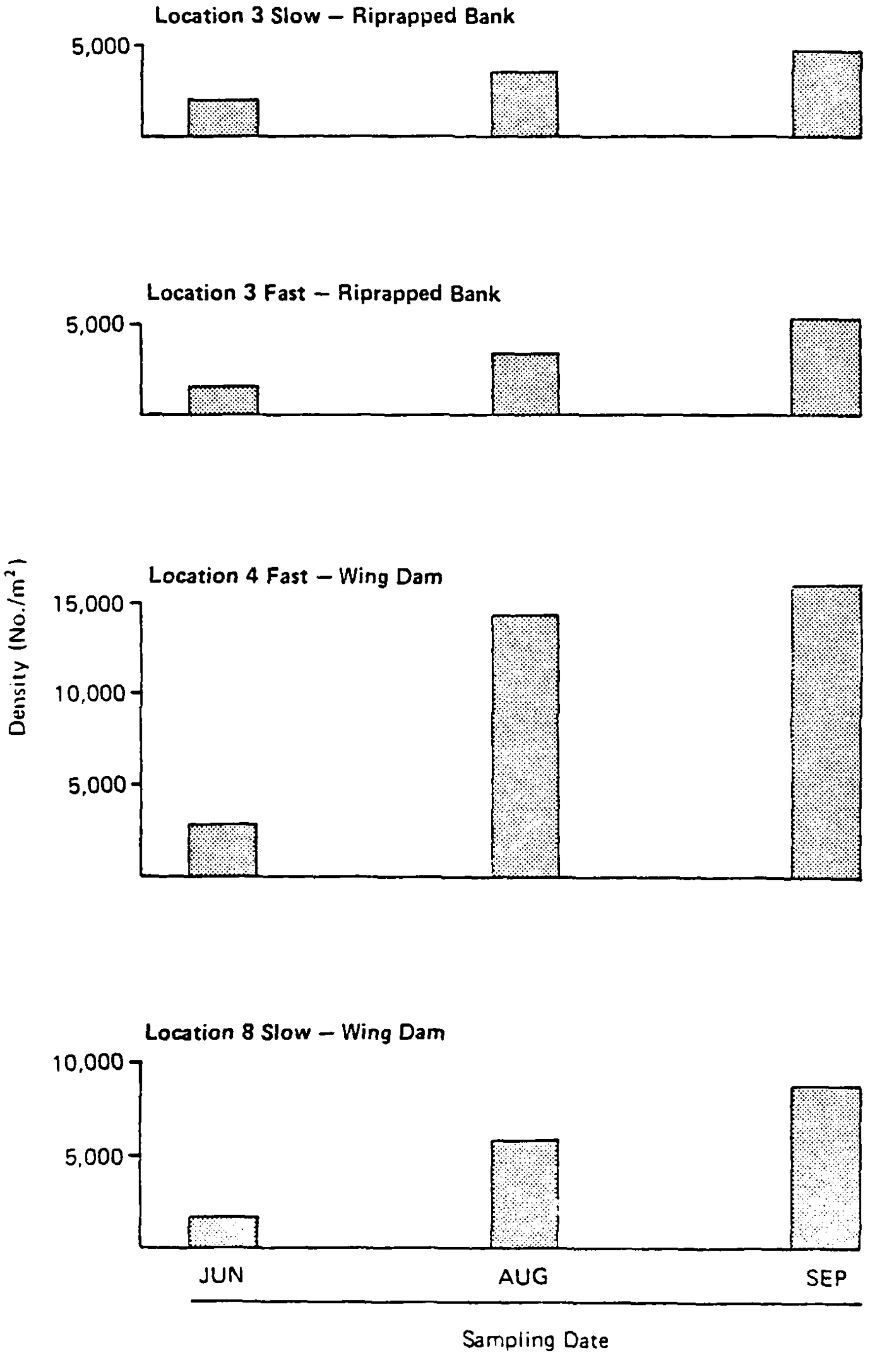


Figure 4-2. Seasonal differences in total benthos (No./m^2) at four rock structure locations in Pool 5A of the Upper Mississippi River, 1982.

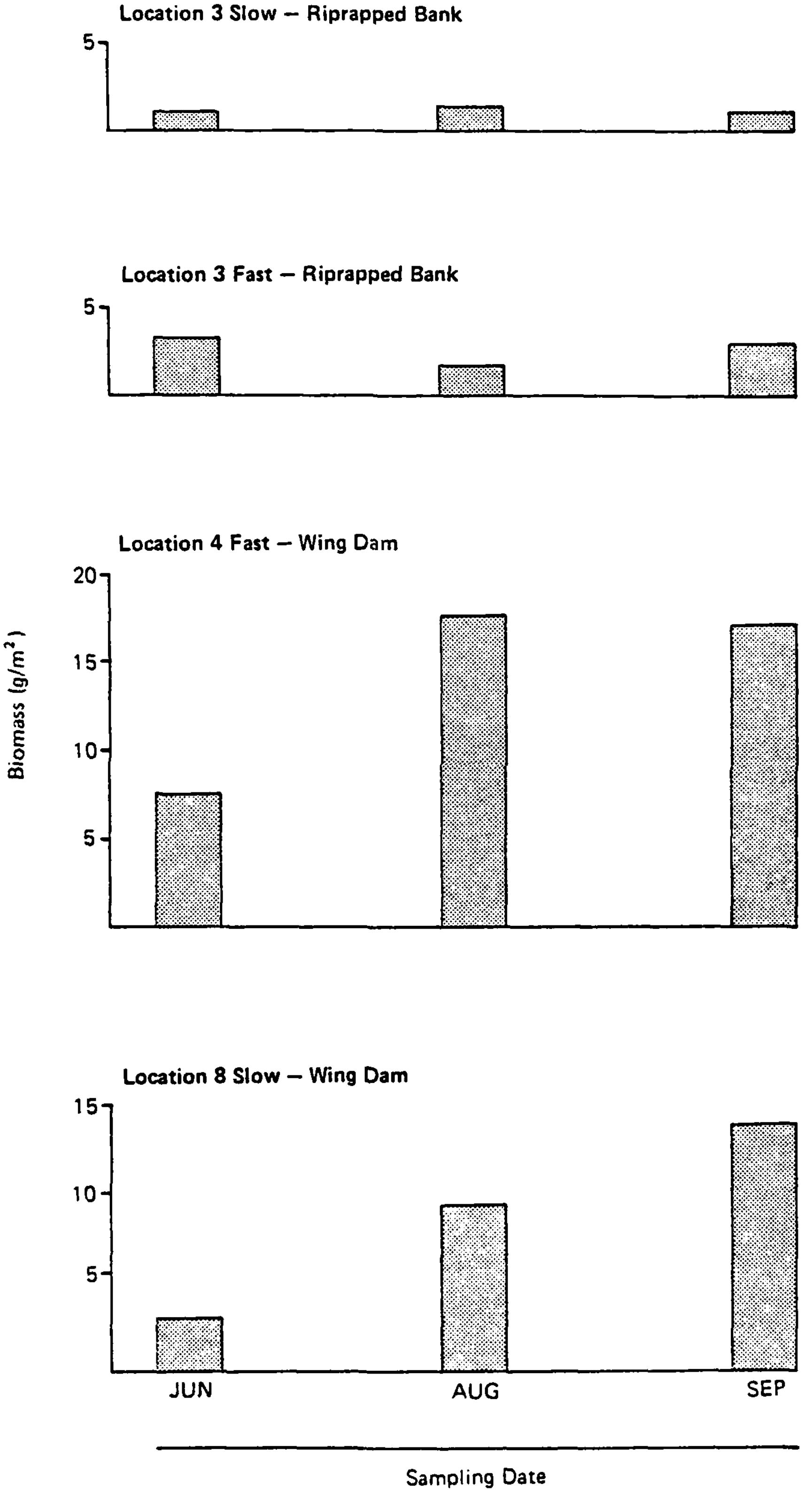


Figure 4-3. Seasonal differences in total biomass (g/m^2) at four rock structure locations in Pool 5A of the Upper Mississippi River, 1982.

locations (see Section 2). However, community differences among locations were pronounced during the lower flows of August and September when the physical differences among locations was accentuated.

In June, the total benthos among locations was not significantly different (Table 4-9); however, significant differences (especially between wing dam Location 4 Fast and the riprapped bank locations) were observed in August and September. In general, significant density differences among the dominant taxa were quite variable among the four locations in June. However, in August and especially in September, the differences among locations were most often observed between locations of different structure type (i.e., wing dams vs. the riprapped banks).

Clustering techniques based on Bray and Curtis (1957) similarity measures also exhibited these seasonal location differences (Figure 4-4). In June, all locations had essentially similar communities; however, the location with the lowest current velocity (riprapped bank Location 3 Slow) yielded the most dissimilar community. In August and September, the clustering of the benthos community was by structure type, not location or relative current velocity. Thus, the riprapped bank faunas (both Fast and Slow) were very similar to each other but very dissimilar from the wing dam communities.

All habitats on the riprapped bank locations (3 Slow and 3 Fast) were generally dominated by midge-fly larvae and pupae (Tables 4-2 through 4-4). The predominant midge taxa included *Rheotanytarsus* sp. in June, and *Dicrotendipes* sp. and *Glyptotendipes* sp. in August and September. Other commonly collected taxa included the amphipod *Hyalella azteca*, the mayflies *Stenacron interpunctatum* group (*S. interpunctatum* and *S. minnetonka*) and the net-spinning caddisflies *Cyrnellus fraternus* and *Cheumatopsyche* sp. (probably *campyla*).

The wing dam locations (4 Fast and 8 Slow) yielded a somewhat different community structure than the riprapped banks. Hydropsychid caddisflies (*Hydropsyche orris* and *Cheumatopsyche* sp.) were the most abundant organisms collected from the wing dams in 1982 followed by chironomid midges (*Rheotanytarsus* sp. in June and August, and *Glyptotendipes* sp. in September), and the planaria *Dugesia* sp.

The midge *Rheotanytarsus* sp., a filter feeder which typically occurs in running water (Beck 1977), was abundant at all locations in June when the river flow was high. It remained abundant on the wing dams in August. *Rheotanytarsus* sp. was also the dominant chironomid in a study of macroinvertebrates colonizing Lower Mississippi River stone dikes (Mathis et al. 1982). The midges *Glyptotendipes* sp. and *Dicrotendipes* sp. were most commonly collected from structures with lower current velocities (the riprapped bank locations and wing dam Location 8 Slow). These taxa achieved greatest densities and percent occurrence in August and September when river flows were lowest. Beck (1977) reported most species of *Glyptotendipes* and *Dicrotendipes* were characteristic only of standing water. In a 1980 study of Pool 5A (Anderson et al. 1983), *Glyptotendipes* sp. was also most abundant in low current velocity habitats. The amphipod *Hyalella azteca* and the mayfly *Stenacron interpunctatum* group, which are also commonly collected in lentic

TABLE 4-9 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY LOCATION) FROM ROCK STRUCTURE SAMPLES, 1982

Taxa or Group	June				August				September				All 1982			
Total Benthos	3F[(a)]	8S	3S	4F	*3F	3S	8S	4F	*3S	3F	8S	4F	*3F	3S	8S	4F
Platyhelminthes																
Dugesia sp.	8S	3F	4F	3S	*3F	3S	8S	4F	*3S	3F	8S	4F	*3S	3F	8S	4F
Amphipoda																
Hyalella azteca	*4F	8S	3F	3S	*8S	4F	3F	3S	*4F	8S	3F	3S	*8S	4F	3F	3S
Ephemeroptera																
Stenacron interpunctatum group	*8S	4F	3F	3S	*8S	4F	3F	3S	*8S	4F	3S	3F	*8S	4F	3F	3S
Trichoptera																
Cyrnellus fraternus	*4F	8S	3S	3F	*8S	3S	4F	3F	*8S	4F	3S	3F	*8S	4F	3S	3F
Cheumatopsyche sp.	*8S	3S	3F	4F	*3S	3F	8S	4F	*3S	3F	8S	4F	*3S	3F	8S	4F
Hydropsyche orris	*3S	3F	8S	4F	*3S	3F	8S	4F	*3S	3F	8S	4F	*3S	3F	8S	4F
Total Hydropsychidae	*3S	8S	3F	4F	*3S	3F	8S	4F	*3S	3F	8S	4F	*3S	3F	8S	4F
Oecetis sp.	3F	4F	8S	3S	*3F	3S	8S	4F	*3F	3S	4F	8S	*3F	3S	4F	8S
Diptera																
Dicrotendipes sp.	*8S	3F	4F	3S	*4F	8S	3S	3F	*4F	8S	3S	3F	*4F	8S	3S	3F
Glyptotendipes sp.	*3F	4F	8S	3S	4F	3S	3F	8S	*4F	8S	3F	3S	4F	8S	3F	3S
Rheotanytarsus sp.	*4F	3F	3S	8S	*3S	3F	8S	4F	*3S	3F	4F	8S	*3F	3S	4F	8S
Total Chironomidae	*3F	4F	8S	3S	3S	3F	8S	4F	*4F	3S	8S	3F	4F	3S	3F	8S

(a) 3S = Location 3 Slow
3F = Location 3 Fast
4F = Location 4 Fast
8S = Location 8 Slow
* = Location densities are significantly different (Kruskal-Wallis Test).
Locations are listed in order of increasing mean density values.
Locations underlined are not significantly different (Duncan's Multiple Range Test).

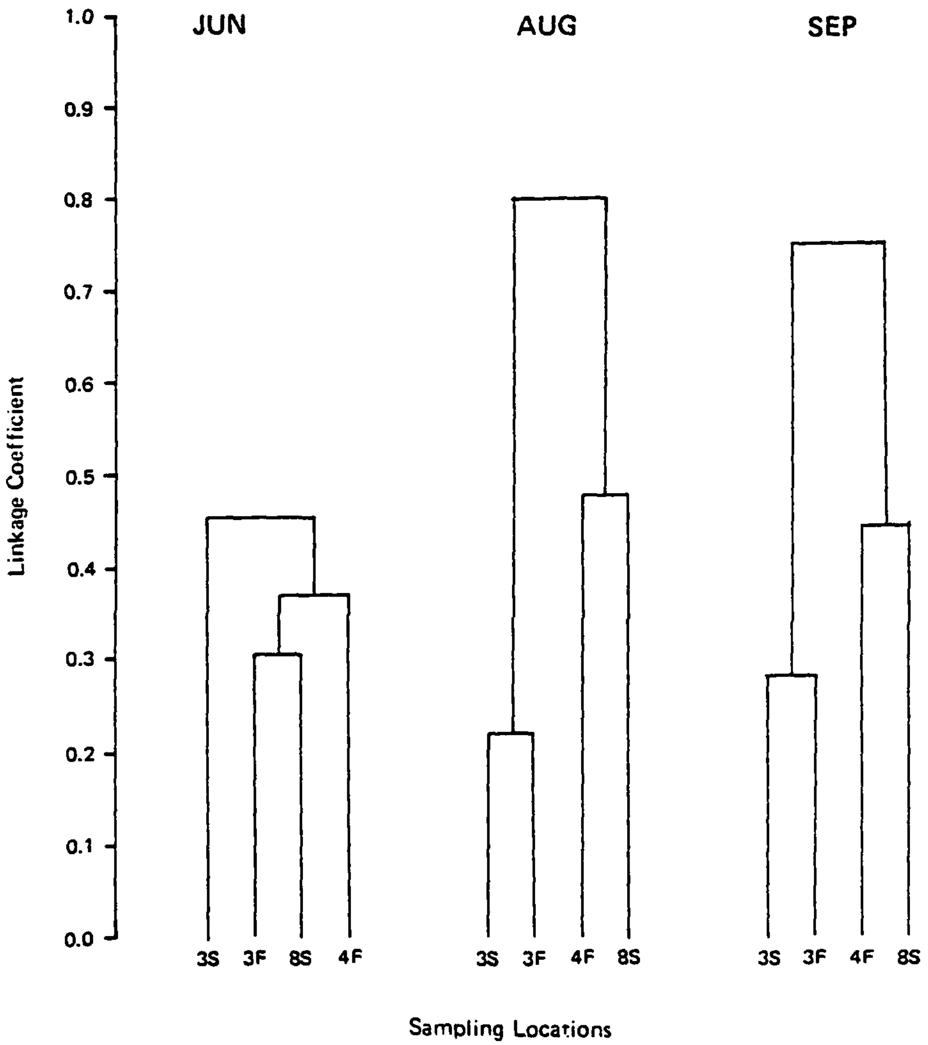


Figure 4-4. Similarity dendrograms based on Bray and Curtis (1957) measures of macroinvertebrate densities at rock structure locations in Pool 5A of the Upper Mississippi River, 1982. Locations 3S (slow) and 3F (fast) are riprapped banks, and Locations 4F (fast) and 8S (slow) are wing dams.

habitats, were frequently abundant at the riprapped bank location but always a minor component of the wing dam fauna. Flowers and Hilsenhoff (1978) reported Stenonema interpunctatum from rivers with reduced current velocities and suggested that among the heptageniids it had an unusually high tolerance for silty environments and slow currents.

The net-spinning caddisflies Cyrnellus fraternus and Cheumatopsyche sp., which were occasionally abundant on the riprapped banks, are most often present in areas of slow current velocities while Hydropsyche orris (the dominant species on the wing dams) typically inhabits faster water (Fremling 1960b; Beckett and Miller 1982). Fremling (1960b) reported the primary ecological requirements of hydropsychid caddisflies to be (1) a silt-free solid substrate for net-spinning and case construction and (2) a constant current to carry food into their nets. Both of these required physical characteristics were present at the two wing dam locations. The hydropsychids generally had greater densities and percent occurrences on the wing dam with high current velocities (Location 4 Fast) than on the low velocity wing dam (Location 8 Slow). The larger hydropsychid population at Location 4 Fast was probably related to the faster currents and subsequent greater food source for these net-spinning organisms. In a 1980 survey of Pool 5A rock structures, Anderson et al. (1983) also reported significantly greater numbers of hydropsychid caddisflies in high current velocity areas. In other studies of the epilithic macroinvertebrate faunas of the Mississippi River, hydropsychid caddisflies were the dominant organisms on concrete block substrates in fast, rocky channel border habitats near Monticello, Minnesota (Hopwood 1974); on rock artificial substrates in channel border areas of Pool 14 (Clark and Seng 1974); and on a stone dike in the Lower Mississippi River (Mathis et al. 1982).

The macroinvertebrate biomass from the riprapped bank and wing dam locations were dominated by the numerically dominant taxa and various large-bodied organisms that occurred sporadically at all locations (Tables 4-5 through 4-7). In general, the total biomass was much greater on the wing dams (Locations 4 Fast and 8 Slow) than on the riprapped banks (Locations 3 Slow and 3 Fast) (Figure 4-1). This was primarily attributable to the greater hydropsychid caddisfly populations on these structures in comparison to the populations on the riprapped bank.

Spatial Differences by Habitat

Community differences related to habitat (With Periphyton, Without Periphyton, and Deep) were evident at all locations throughout 1982, but these differences among habitats were not consistent at all locations. Because of the variable current velocities and periphytic algae growth among locations, consistent community differences among habitats were not expected.

During all samplings at Location 3 Slow (riprapped bank), the total benthos was always greater from the shallow habitats (With Periphyton and Without Periphyton) than from the Deep habitat (Figure 4-5). The greatest community differences at this location occurred in August and September when the amphipod Hyalella azteca and chironomid midges were most abundant on the With Periphyton habitat. These population

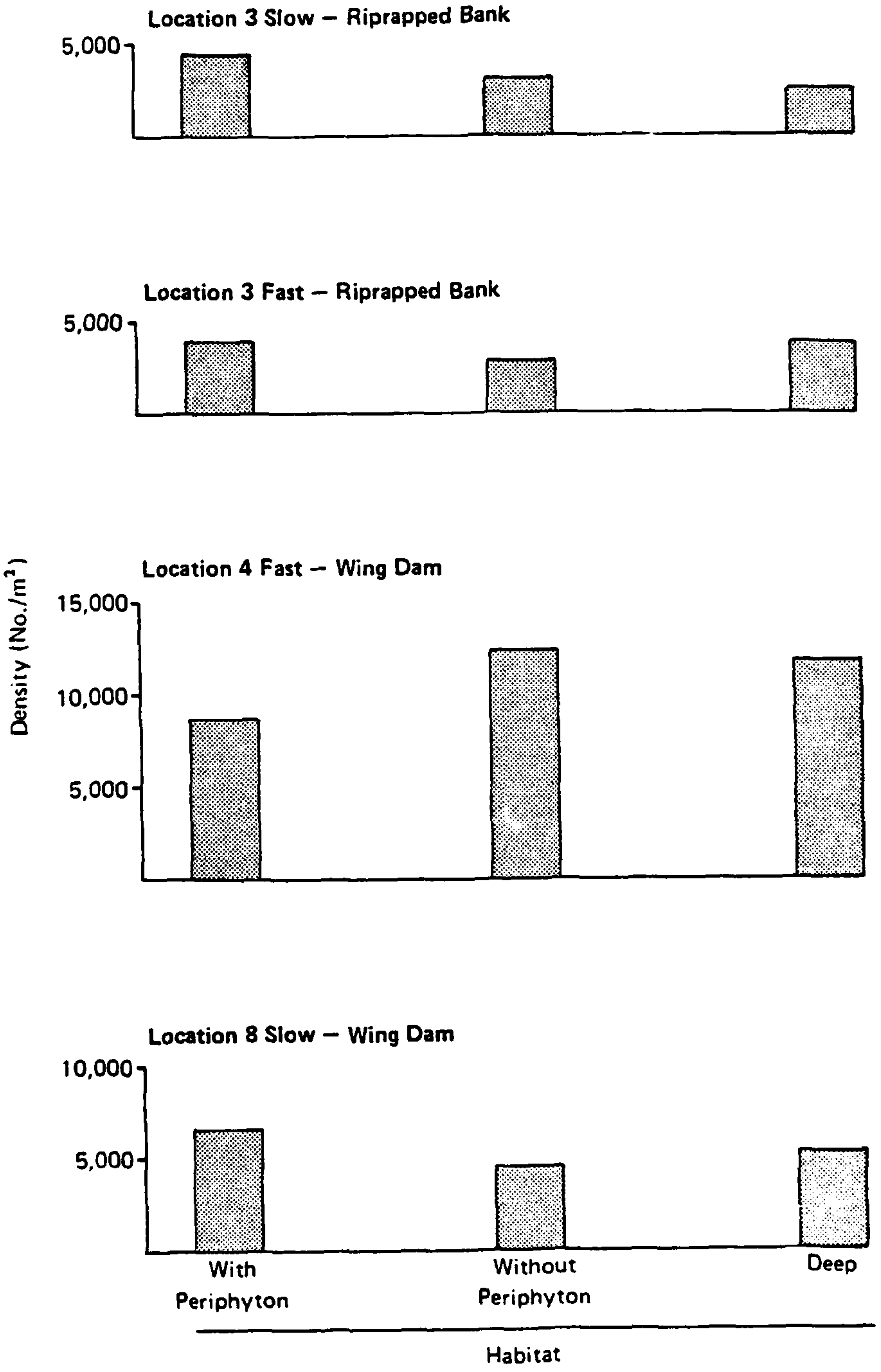


Figure 4-5. Total benthos (No./m^2) at three habitat types on four rock structures in Pool 5A of the Upper Mississippi River, 1982.

differences were probably related to the increase in periphytic algae which was most evident at this habitat in the August and September samplings (see Section 3). Strong (1972) also reported that the greatest abundance of Hyalella azteca occurred within algal communities in water less than 2 meters deep. Similarity coefficients calculated for Location 3 Slow revealed that individual habitats tended to cluster together (e.g., 3 Slow With Periphyton and 3 Slow Without Periphyton) and with the other riprapped bank (Location 3 Fast) habitats (Figure 4-6). The total biomass at Location 3 Slow was similar at all habitats throughout the year (Figure 4-7) and no consistent differences were evident.

The total benthos was generally similar at all habitats of Location 3 Fast (riprapped bank); however, differences were detected in community structure. As had been the case at Location 3 Slow, Hyalella azteca was most abundant at Location 3 Fast in the habitat With Periphyton. In addition, the Deep habitat of Location 3 Fast contained greater densities of net-spinning caddisflies (Hydropsychidae and Polycentropodidae) than the shallower habitats. Apparently, the slightly faster current velocities at the greater depths (Section 2, Figures 2-6 through 2-8) provided a more favorable habitat for these rheophilic organisms. The similarity coefficients calculated for the Location 3 Fast habitats were generally clustered with each other and with the other riprapped bank location except in June when communities were similar at all locations (Figure 4-6). The greater densities of net-spinning caddisflies at the Deep habitat of Location 3 Fast resulted in a greater biomass at this habitat in June and August, and for the year (Figure 4-7).

The three habitats within Location 4 Fast (wing dam) all had similar faunas; however, the Without Periphyton and Deep habitats generally had greater densities (Figure 4-5) and biomass (Figure 4-7) than the With Periphyton habitat. These differences were probably related to the increased current velocities at the habitats on the wing dam farther from shore (Section 2, Figure 2-3) and the resulting larger hydropsychid caddisfly density.

Similar communities were present in all three habitats at Location 8 Slow (wing dam) in 1982. Total densities and biomass were similar at all habitats in June; however, the With Periphyton habitat yielded the greatest density and biomass in August and September. These differences were attributed to the greater number of hydropsychid caddisflies (especially Hydropsyche orris) and chironomid midges in the With Periphyton habitat.

The similarity coefficients for the habitats at the wing dams (Locations 4 Fast and 8 Slow) generally clustered by location (Figure 4-6). Comparison among the three habitat types on the wing dams revealed the With Periphyton habitat was the most dissimilar habitat on four of six occasions and the Deep habitat was dissimilar on the other two occasions. However, these differences did not occur consistently at an individual location during all three sampling periods.

When densities at all habitat types (regardless of location) were averaged and compared statistically, significant differences among habitats were most evident in September (Table 4-10; Tables 4-52 through

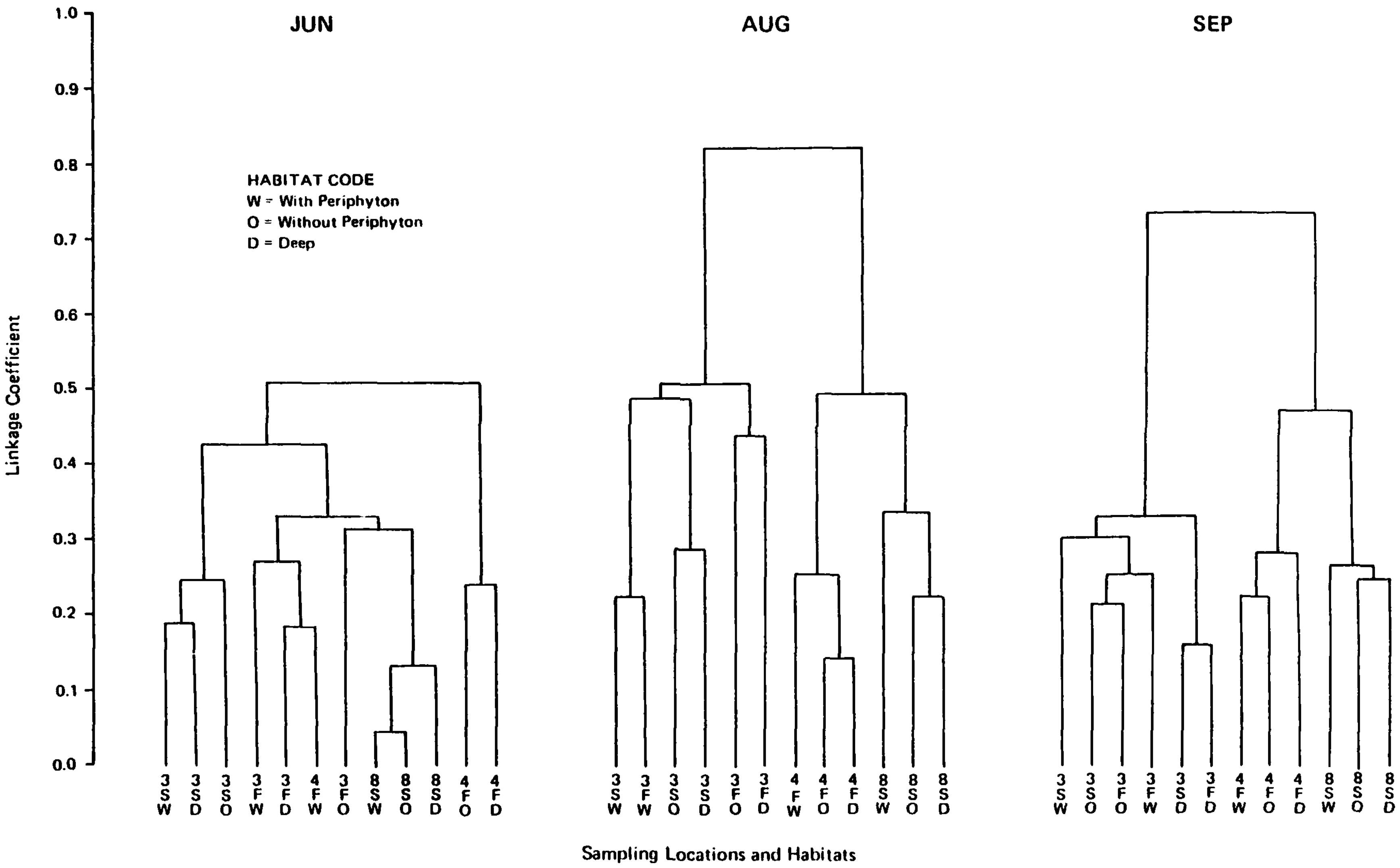


Figure 4-6. Similarity dendrograms based on Bray and Curtis (1957) measures of macroinvertebrate densities at rock structure habitats in Pool 5A of the Upper Mississippi River, 1982.

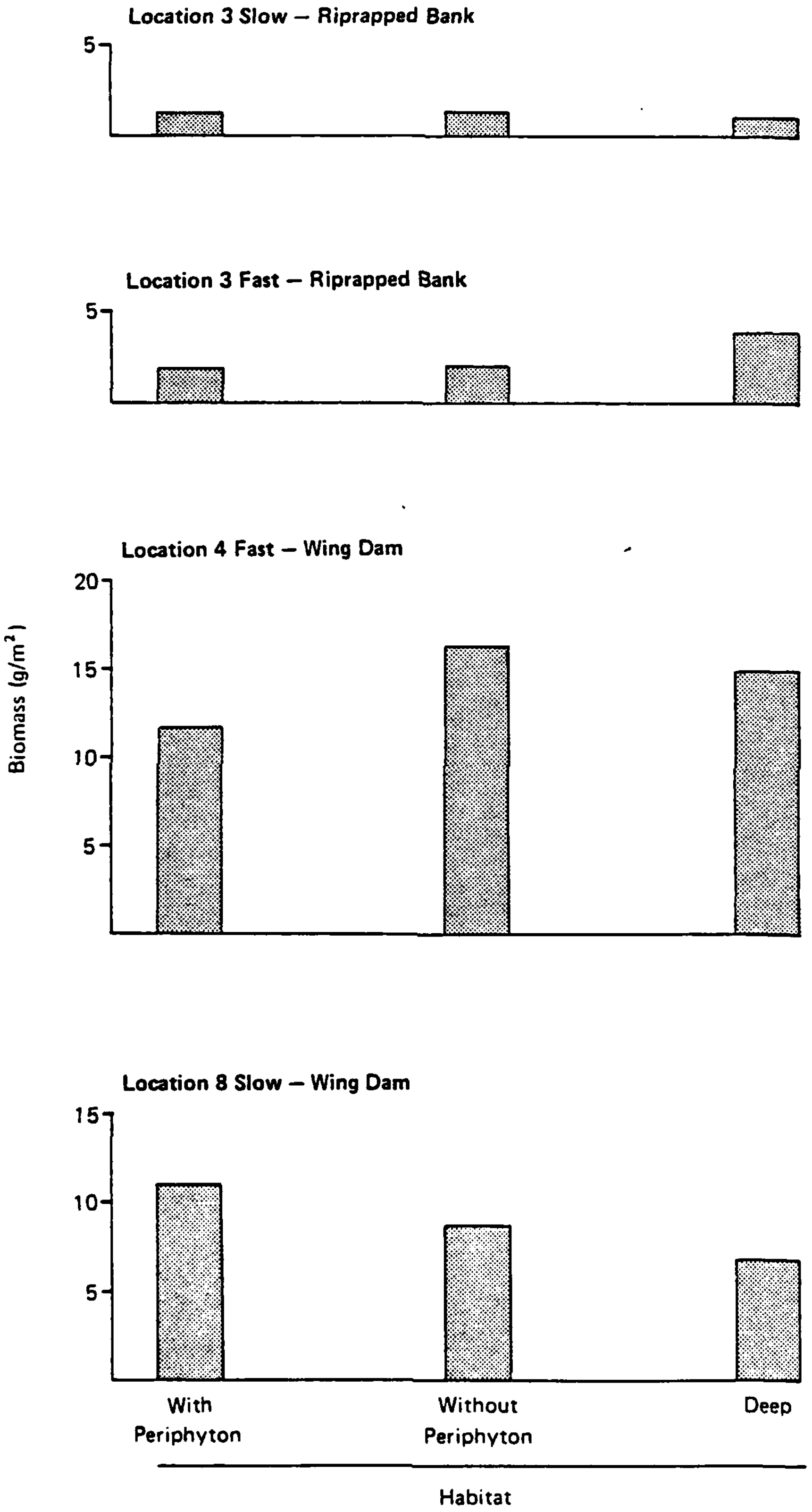


Figure 4-7. Total biomass (g/m^2) at three habitat types on four rock structures in Pool 5A of the Upper Mississippi River, 1982.

TABLE 4-10 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY HABITAT) FROM ROCK STRUCTURE SAMPLES, 1982

Taxa or Group	June			August			September			All 1982		
Total Benthos	W/[(a)]	Deep	W/0	Deep	W/0	W/	W/0	W/	Deep	W/0	Deep	W/
Platyhelminthes												
Dugesia sp.	W/	Deep	W/0	W/	Deep	W/0	W/0	W/	Deep	W/	W/0	Deep
Amphipoda												
Hyalella azteca	Deep	W/0	W/	Deep	W/0	W/	*Deep	W/0	W/	*Deep	W/0	W/
Ephemeroptera												
Stenacron interpunctatum	*W/0	Deep	W/	Deep	W/	W/0	Deep	W/	W/0	Deep	W/	W/0
Trichoptera												
Cyrnellus fraternus	W/0	W/	Deep	W/	W/0	Deep	*W/0	W/	Deep	W/	W/0	Deep
Cheumatopsyche sp.	Deep	W/0	W/	Deep	W/	W/0	W/0	Deep	W/	W/0	Deep	W/
Hydropsyche orris	W/	Deep	W/0	W/	W/0	Deep	W/0	W/	Deep	W/	W/0	Deep
Total Hydropsychidae	W/	Deep	W/0	W/	Deep	W/0	W/0	W/	Deep	W/	W/0	Deep
Oecetis sp.	W/	Deep	W/0	W/0	W/	Deep	*W/	W/0	Deep	W/	W/0	Deep
Diptera												
Dicrotendipes sp.	Deep	W/	W/0	*Deep	W/0	W/	Deep	W/	W/0	Deep	W/0	W/
Glyptotendipes sp.	Deep	W/	W/0	W/0	Deep	W/	Deep	W/0	W/	Deep	W/0	W/
Rheotanytarsus sp.	W/	W/0	Deep	W/	W/0	Deep	W/	W/0	Deep	W/	W/0	Deep
Total Chironomidae	W/	Deep	W/0	*W/0	Deep	W/	Deep	W/0	W/	Deep	W/0	W/

(a) W/ = Shallow habitat with visible growth of periphyton
W/0 = Shallow habitat without visible growth of periphyton
Deep = Deep habitat
* = significant difference is present among the three habitats ($P \leq 0.05$, Kruskal-Wallis Test).
Habitats are listed in order of increasing density values.
Habitats underlined are not significantly different (Duncan's Multiple Range Test).

4-55 in Section 4.7). Significantly greater populations of Naididae, Hyalella azteca, Cricotopus bicinctus group and Empididae at the With Periphyton habitat in September were probably related to the relatively heavy periphytic algae growth that was evident at this time of year (see Section 3). The greater number of Cyrnellus fraternus, and Oecetis sp. from the Deep habitat of the rock structures may have been related to the relatively higher current velocities at this habitat. Although not significantly different, other rheophilic organisms (i.e., Dugesia sp., Hydropsyche orris and Rheotanytarsus sp.) were also most abundant at the Deep habitat of the rock structures. These population differences were usually noted during the other sampling periods, but the differences were not statistically significant.

Temporal Differences

A general trend of increasing density (Figure 4-2) and biomass (Figure 4-3) was noted at all locations from June through September. Significantly greater mean densities were observed from June to August and from August to September on the riprapped bank structures (Table 4-11; Tables 4-56 and 4-57 in Section 4.7) and from June to August on the wing dams (Table 4-12; Tables 4-58 and 4-59 in Section 4.7). These increases were most evident at the wing dam locations (4 Fast and 8 Slow) from June to August. A significant increase in hydropsychid caddisfly density (especially Hydropsyche orris) was the primary reason for the June-August increase in total benthos at the wing dams. These bivoltine organisms have an emergence and ovipositing peak during the early summer with another peak during the latter part of summer (Fremling 1960b; Beckett 1982). This summer egg laying was the probable source of the increased larval densities observed in August. Beckett (1982) also noted increased H. orris densities on artificial substrates during the same time period in the Ohio River. He attributed the increase to the greater availability of maturing instars resulting from reproduction during the summer and early fall.

In most temperate aquatic systems, the lowest macroinvertebrate density and biomass are generally noted in the spring during the period of emergence of over-wintering insects (Hynes 1972). During the summer, the hatching of eggs and rapid growth of young instars result in maximum densities and biomass. Attrition from natural death and predation in the fall and winter brings the benthos densities back to the typically low spring densities.

Seasonal fluctuations in species composition in 1982 were most evident at the riprapped bank locations (3 Slow and 3 Fast). Net-spinning organisms (e.g., the caddisfly Cheumatopsyche sp. and the midge Rheotanytarsus sp.) were the dominant taxa on the riprapped bank locations during the high river flows in June. These taxa decreased significantly after June (Table 4-11) and were replaced by increased populations of the mayfly Stenacron interpunctatum group, the caddisfly Cyrnellus fraternus, and the midges Dicrotendipes sp., Glyptotendipes sp. and Ablabesmyia sp. during the low flow periods of August and September. These dominant taxa in August and September typically occur in lentic environments or in low current areas of riverine environments.

TABLE 4-11 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY SAMPLING DATE) FROM RIPRAPPED BANK STRUCTURE SAMPLES, 1982.

Taxa or Group	Mean Density (No./m^2)			CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different		
	June	Aug	Sept						
Total Benthos	1781$^{(a)}$	3382	4969	38.61	0.0001	yes	JUN	AUG	SEP
Hydra sp.	0	10	121	28.30	0.0001	yes	JUN	AUG	SEP
Dugesia sp.	2	73	102	47.84	0.0001	yes	JUN	AUG	SEP
Total Naididae	2	39	180	56.95	0.0001	yes	JUN	AUG	SEP
Asellus sp.	46	28	5	11.39	0.0034	yes	JUN	AUG	SEP
Hyalella azteca	121	387	278	1.27	0.5310	no	JUN	AUG	SEP
Imm. Heptageniidae	6	454	140	42.25	0.0001	yes	JUN	SEP	AUG
Stenacron interpunctatum group	66	415	442	45.03	0.0001	yes	JUN	AUG	SEP
Total Heptageniidae	73	870	582	49.85	0.0001	yes	JUN	AUG	SEP
Cyrnellus fraternus	32	154	521	45.42	0.0001	yes	JUN	AUG	SEP
Total Polycentropodidae	48	166	672	54.28	0.0001	yes	JUN	AUG	SEP
Imm. Hydropsychidae	27	7	57	19.05	0.0001	yes	AUG	JUN	SEP
Cheumatopsyche sp.	585	39	56	53.84	0.0001	yes	JUN	AUG	SEP
Hydropsyche orris	131	27	19	9.09	0.0106	yes	JUN	AUG	SEP
Total Hydropsychidae	763	80	133	47.55	0.0001	yes	JUN	AUG	SEP
Oecetis sp.	0	23	134	50.35	0.0001	yes	JUN	AUG	SEP
Total Leptoceridae	7	60	235	60.90	0.0001	yes	JUN	AUG	SEP
Total Elmidae	10	29	37	13.78	0.0010	yes	JUN	AUG	SEP
Dicrotendipes sp.	8	660	749	59.18	0.0001	yes	JUN	AUG	SEP
Endochironomus sp.	80	56	7	37.64	0.0001	yes	JUN	AUG	SEP
Glyptotendipes sp.	19	330	987	68.32	0.0001	yes	JUN	AUG	SEP
Microtendipes sp.	12	80	93	20.05	0.0001	yes	JUN	AUG	SEP
Rheotanytarsus sp	345	16	9	57.30	0.0001	yes	JUN	AUG	SEP
Ablabesmyia sp.	6	132	198	58.25	0.0001	yes	JUN	AUG	SEP
Cricotopus bicinctus	1	68	21	1.92	0.3825	no	JUN	AUG	SEP
Parakiefferiella sp.	0	0	57	22.89	0.0001	yes	JUN	AUG	SEP
Total Chironomide	611	1538	2394	38.15	0.0001	yes	JUN	AUG	SEP
Total Empididae	2	11	105	37.82	0.0001	yes	JUN	AUG	SEP

(a) Densities are mean of 30 samples.

TABLE 4-12 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY SAMPLING DATE) FROM WING DAM STRUCTURE SAMPLES, 1982.

Taxa or Group	Mean Density (No./m^2) June	Aug	Sept	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different		
Total Benthos	2220[(a)]	9936	12206	56.13	0.0001	yes	JUN	AUG	SEP
Hydra sp.	0	36	223	21.64	0.0001	yes	JUN	AUG	SEP
Dugesia sp.	2	1381	910	59.07	0.0001	yes	JUN	AUG	SEP
Total Naididae	1	35	74	25.96	0.0001	yes	JUN	AUG	SEP
Asellus sp.	16	7	4	8.26	0.0160	yes	JUN	AUG	SEP
Hyalella azteca	5	51	38	11.54	0.0031	yes	JUN	AUG	SEP
Imm. Heptageniidae	0	18	24	7.47	0.0239	yes	JUN	AUG	SEP
Stenacrun interpunctatum group	17	73	38	5.30	0.0707	no	JUN	SEP	AUG
Total Heptageniidae	19	113	99	23.22	0.0001	yes	JUN	AUG	SEP
Cyrnellus fraternus	8	66	268	55.74	0.0001	yes	JUN	AUG	SEP
Total Polycentropodidae	9	71	284	55.45	0.0001	yes	JUN	AUG	SEP
Imm. Hydropsychidae	12	322	806	53.86	0.0001	yes	JUN	AUG	SEP
Cheumatopsyche sp.	674	1371	1837	15.43	0.0004	yes	JUN	AUG	SEP
Hydropsyche orris	729	3895	4320	37.40	0.0001	yes	JUN	AUG	SEP
Total Hydropsychidae	1465	5868	6992	37.17	0.0001	yes	JUN	AUG	SEP
Oecetis sp.	0	109	1003	67.29	0.0001	yes	JUN	AUG	SEP
Total Leptoceridae	1	128	1064	74.43	0.0001	yes	JUN	AUG	SEP
Total Elmidae	70	62	75	1.45	0.4847	no	JUN	AUG	SEP
Dicrotendipes sp.	4	159	159	58.24	0.0001	yes	JUN	AUG	SEP
Endochironomus sp.	8	42	14	18.15	0.0001	yes	JUN	SEP	AUG
Glyptotendipes sp.	8	281	501	64.39	0.0001	yes	JUN	AUG	SEP
Microtendipes sp.	1	45	30	20.62	0.0001	yes	JUN	AUG	SEP
Rheotanytarsus sp.	403	403	89	39.69	0.0001	yes	JUN	AUG	SEP
Ablabesmyia sp.	0	74	33	37.38	0.0001	yes	JUN	AUG	SEP
Cricotopus bicinctus	8	20	117	24.87	0.0001	yes	JUN	AUG	SEP
Parakiefferiella sp.	0	0	311	59.36	0.0001	yes	JUN	AUG	SEP
Total Chironomidae	574	1792	1844	52.79	0.0001	yes	JUN	AUG	SEP
Total Empididae	4	97	191	51.26	0.0001	yes	JUN	AUG	SEP

(a) Densities are mean of 30 samples.

The net-spinning organisms at wing dam Locations 4 Fast and 8 Slow exhibited a trend opposite to that observed at the riprapped bank locations. Hydropsychid caddisflies (at both locations) and *Rheotanytarsus* sp. (at Location 4 Fast) increased significantly in density from June to September (Table 4-12; Tables 4-58 and 4-59 in Section 4.7). The caddisfly *Hydropsyche orris* dominated the wing dam communities (Locations 4 Fast and 8 Slow) throughout 1982 and, in general, increased progressively in density and biomass from June to September. *Rheotanytarsus* sp. dominated the chironomid assemblage on the wing dams in June and August. *Rheotanytarsus* densities declined significantly in September as *Glyptotendipes* sp. and *Parakiefferiella* sp. increased in importance. The increased densities of lentic organisms from June to September was observed at the riprapped bank locations and also occurred at the wing dam locations; however, the increased numbers of these taxa on the wing dams was overshadowed by the dramatic increase in hydropsychid caddisflies densities.

Seasonal trends in density observed on the rock structures were generally similar at all three habitat types (Tables 4-60 through 4-62 in Section 4.7). Most of the dominant taxa and the total benthos exhibited increased densities from June to September at each habitat type; however, the isopod *Asellus* sp. and the midges *Endochironomus* sp. and *Rheotanytarsus* sp. decreased in density from June to September. The amphipod *Hyalella azteca* was the only major exception to the above trends. At the Without Periphyton and Deep habitats, *Hyalella* had similar densities throughout 1982. However, at the With Periphyton habitat, densities of this species increased significantly from June to August and remained relatively abundant in September.

4.3.2 Silt and Sand Substrate Survey

The silt and sand habitats of Pool 5A (Locations 6 and 10, respectively) had substantial physical and hydrologic differences, and their associated benthic communities reflected these differences. Burrowing organisms such as the naidid *Dero digitata*, tubificid worms, the mayfly *Hexagenia* sp. and the midge *Chironomus* sp., were commonly collected from the depositional (silt) habitat at Location 6 (Tables 4-13 through 4-15). These taxa were either rare or much less abundant at Location 10. The erosional (sand) habitat at Location 10 was colonized by a sparse, variable benthic fauna. The macroinvertebrate biomass at Locations 6 and 10 was dominated by a combination of the numerically dominant taxa and large-bodied molluscs (Amnicolidae, Sphaeriidae and Unionidae) (Tables 4-16 through 4-18).

Spatial Variations

The total density, total biomass and mean species diversity values were consistently greater at Location 6 (silt bay) than at Location 10 (sand flat) during 1982. In fact, the total benthos at Location 6 was significantly greater than at Location 10 during each sampling date and for the year (Table 4-19; Tables 4-63 through 4-66 in Section 4.7). Anderson et al. (1983) also noted greater density, biomass and diversity in low-current, silty habitats of Pool 5A than in high-current, sandy habitats.

TABLE 4-13 MEAN DENSITY (No./m^2) AND PERCENT OCCURRENCE OF THE DOMINANT (≥5%) BENTHIC MACROINVERTEBRATES COLLECTED FROM SILT AND SAND HABITATS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, JUNE 1982

Taxa	Location 6		Location 10	
	No./m^2	%	No./m^2	%
Nematoda				
Unidentified Nematoda	653(a)	(50.8)	115	(26.1)
Oligochaeta				
Immatures w/o cap. chaetae	77	(6.0)	0	(0.0)
Bothrioneurum vejdovskyanum	77	(6.0)	19	(4.4)
Branchiura sowerbyi	77	(6.0)	0	(0.0)
Total Tubificidae	269	(20.9)	19	(4.4)
Ephemeroptera				
Brachycercus sp.	38	(3.0)	96	(21.7)
Trichoptera				
Cheumatopsyche sp.	0	(0.0)	57	(13.0)
Hydropsyche orris	0	(0.0)	38	(8.7)
Total Hydropsychidae	19	(1.5)	96	(21.7)
Diptera				
Polypedilum convictum type	0	(0.0)	38	(8.7)
Rheotanytarsus sp.	0	(0.0)	38	(8.7)
Total Chironomidae	134	(10.5)	96	(21.7)
Total Benthos	1287		442	
Species diversity	1.78		0.95	
Evenness	0.89		0.98	
Redundancy	0.11		0.22	

(a) Mean of 10 replicate samples.

TABLE 4-14 MEAN DENSITY (No./m^2) AND PERCENT OCCURRENCE OF THE DOMINANT ($\geq$5%) BENTHIC MACROINVERTEBRATES COLLECTED FROM SILT AND SAND HABITATS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

	Location 6		Location 10	
Taxa	No./m^2	%	No./m^2	%
Oligochaeta				
Arcteonais lomondi	346[a]	(5.3)	0	(0.0)
Dero digitata	423	(6.4)	0	(0.0)
Total Naididae	768	(11.7)	154	(6.3)
Immature w/o cap. chaetae	423	(6.4)	115	(4.7)
Aulodrilus pigueti	403	(6.1)	0	(0.0)
Branchiura sowerbyi	768	(11.7)	19	(0.8)
Total Tubificidae	2075	(31.6)	173	(7.1)
Ephemeroptera				
Hexagenia sp.	403	(6.1)	231	(9.5)
Diptera				
Chironomus sp.	1441	(21.9)	0	(0.0)
Polypedilum scalaenum type	0	(0.0)	134	(5.5)
Stempellina sp.	0	(0.0)	423	(17.3)
Stempellina sp. pupa	0	(0.0)	134	(5.5)
Stictochironomus sp.	0	(0.0)	173	(7.1)
Total Chironomidae	2594	(39.5)	1153	(47.2)
Gastropoda				
Somatogyrus sp.	0	(0.0)	134	(5.5)
Total Amnicolidae	0	(0.0)	231	(9.5)
Pelecypoda				
Total Sphaeriidae	250	(3.8)	134	(5.5)
Total Benthos	6571		2440	
Species diversity	3.11		2.74	
Evenness	0.87		0.92	
Redundancy	0.13		0.08	

(a) Mean of 10 replicate samples.

TABLE 4-15 MEAN DENSITY (No./m^2) AND PERCENT OCCURRENCE OF THE DOMINANT (>5%) BENTHIC MACROINVERTEBRATES COLLECTED FROM SILT AND SAND HABITATS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, SEPTEMBER 1982

Taxa	Location 6		Location 10	
	No./m^2	%	No./m^2	%
Nematoda				
Unidentified Nematoda	2209(a)	(23.5)	115	(3.9)
Oligochaeta				
Dero digitata	1153	(12.2)	0	(0.0)
Piguetiella michiganensis	0	(0.0)	288	(9.8)
Total Naididae	1383	(14.7)	288	(9.8)
Immature w/o cap. chaetae	480	(5.1)	634	(21.6)
Aulodrilus pigueti	884	(9.4)	115	(3.9)
Branchiura sowerbyi	865	(9.2)	77	(2.6)
Total Tubificidae	2498	(26.5)	903	(30.7)
Ephemeroptera				
Hexagenia sp.	442	(4.7)	250	(8.5)
Total Ephemeridae	634	(6.7)	250	(8.5)
Diptera				
Ceratopogonidae	288	(3.1)	154	(5.2)
Chironomus sp.	711	(7.6)	0	(0.0)
Polypedilum simulans type	134	(1.4)	154	(5.2)
Stictochironomus sp.	0	(0.0)	192	(6.5)
Total Chironomidae	1460	(15.5)	442	(15.0)
Gastropoda				
Amnicola sp.	0	(0.0)	231	(7.8)
Pelecypoda				
Pisidium sp.	38	(0.4)	154	(5.2)
Total Sphaeriidae	365	(3.9)	231	(7.8)
Total Benthos	9414		2939	
Species diversity	3.23		2.56	
Evenness	0.84		0.93	
Redundancy	0.16		0.08	

(a) Mean of 10 replicate samples.

TABLE 4-16 MEAN DRY WEIGHT (g/m^2) AND PERCENT COMPOSITION, BY WEIGHT, OF THE DOMINANT (≥5%) BENTHIC MACROINVERTEBRATES COLLECTED FROM SILT AND SAND HABITATS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, JUNE 1982

Taxa	Location 6		Location 10	
	g/m^2	%	g/m^2	%
Nematoda				
Unidentified Nematoda	0.052	(7.9)	0.009	(4.3)
Oligochaeta				
Total Tubificidae	0.213	(32.1)	0.015	(7.2)
Ephemeroptera				
Brachycercus sp.	0.011	(1.6)	0.020	(9.5)
Trichoptera				
Cheumatopsyche sp.	0.000	(0.0)	0.093	(43.9)
Hydropsyche orris	0.000	(0.0)	0.058	(27.5)
Total Hydropsychidae	0.004	(0.5)	0.142	(71.4)
Pelecypoda				
Musculium transversum	0.234	(35.2)	0.000	(0.0)
Pisidium sp.	0.055	(8.3)	0.000	(0.0)
Total Sphaeriidae	0.288	(43.5)	0.000	(0.0)
Total Benthos	0.663		0.212	

TABLE 4-17 MEAN DRY WEIGHT (g/m^2) AND PERCENT COMPOSITION, BY WEIGHT, OF THE DOMINANT (≥5%) BENTHIC MACROINVERTEBRATES COLLECTED FROM SILT AND SAND HABITATS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

Taxa	Location 6		Location 10	
	g/m^2	%	g/m^2	%
Oligochaeta				
Total Tubificidae	1.639	(31.7)	0.137	(9.1)
Ephemeroptera				
Hexagenia sp.	0.597	(11.6)	0.078	(5.2)
Trichoptera				
Nectopsyche diarina	0.000	(0.0)	0.135	(9.0)
Diptera				
Total Chironomidae	1.440	(27.9)	0.138	(9.2)
Gastropoda				
Amnicola sp.	0.000	(0.0)	0.180	(12.0)
Somatogyrus sp.	0.000	(0.0)	0.252	(16.8)
Total Amnicolidae	0.000	(0.0)	0.467	(31.2)
Pelecypoda				
Immature Sphaeriidae	0.292	(5.7)	0.037	(2.4)
Musculium transversum	1.003	(19.4)	0.000	(0.0)
Pisidium sp.	0.000	(0.0)	0.219	(14.6)
Total Sphaeriidae	1.295	(25.1)	0.256	(17.1)
Leptodea fragilis	0.000	(0.0)	0.138	(9.2)
Total Unionidae	0.000	(0.0)	0.208	(13.9)
Total Benthos	5.164		1.496	

TABLE 4-18 MEAN DRY WEIGHT (g/m^2) AND PERCENT COMPOSITION, BY WEIGHT, OF THE DOMINANT ($\geq 5\%$) BENTHIC MACROINVERTEBRATES COLLECTED FROM SILT AND SAND HABITATS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, SEPTEMBER 1982

Taxa	Location 6		Location 10	
	g/m^2	%	g/m^2	%
Oligochaeta				
Total Tubificidae	1.973	(25.7)	0.713	(30.2)
Ephemeroptera				
Hexagenia limbata	1.137	(14.8)	0.000	(0.0)
Total Ephemeridae	1.288	(16.8)	0.085	(3.6)
Diptera				
Total Chironomidae	1.358	(17.7)	0.075	(3.2)
Gastropoda				
Amnicola sp.	0.000	(0.0)	0.609	(25.8)
Pelecypoda				
Immature Sphaeriidae	0.329	(4.3)	0.146	(6.2)
Musculium transversum	1.667	(21.7)	0.000	(0.0)
Pisidium sp.	0.370	(4.8)	0.292	(12.4)
Total Sphaeriidae	2.366	(30.9)	0.438	(18.5)
Anodonta imbecillis	0.000	(0.0)	0.228	(9.7)
Total Benthos	7.668		2.363	

TABLE 4-19 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA FROM SILT AND SAND SAMPLES, 1982

Taxa or Group	June Silt Loc. 6	June Sand Loc. 10	August Silt Loc. 6	August Sand Loc. 10	September Silt Loc. 6	September Sand Loc. 10	1982 Silt Loc. 6	1982 Sand Loc. 10
Total Benthos	1287*(a)	442	6571*	2440	9414*	2824	5757*	1902
Nematoda	653*	115	288*	0	2209*	115	1050*	77
Total Naididae	0	0	768*	154	1383	288	717*	147
Immature Tubificidae w/o cap.	77	0	423*	115	480	634	327	250
Total Tubificidae	269*	19	2075*	173	2498*	903	1614*	365
Hexagenia spp.	38	0	403	231	634	250	359	160
Total Chironomidae	134	96	2594*	1153	1460*	442	1396*	564
Pisidium sp.	19	0	0	115	38	154	19	90
Total Sphaeriidae	58	0	250	134	365	231	224	122

(a) Monthly numbers are mean of 10 replicate samples.
Year numbers are mean of 30 samples.
* = Significantly greater density value (Kruskal-Wallis Test).

Nematodes, oligochaetes (Naididae and Tubificidae) and midge-fly larvae were the dominant organisms collected from Location 6 (Tables 4-13 through 4-15). The mayfly Hexagenia sp. was also commonly collected from Location 6 in August and September. Fremling et al. (1979) reported a similar assemblage of organisms in the silty backwater habitats of Pool 5A in 1975-1978. These taxa also dominated the benthos of backwater habitats in other reaches of the UMR (Dorris and Copeland 1962; Steffen et al. 1973; Gale 1975; Eckblad et al. 1977; Neuswanger et al. 1982). In contrast to the present study, the earlier surveys revealed Hexagenia to be a larger component of the backwater community. This difference may be related to differences in substrate composition and/or to the fact that Location 6 is not a true backwater area.

The substrates collected from Location 6 (silt bay) during 1982 were primarily fine sands and silt (Tables 4-20 through 4-22). Fremling et al. (1979) reported comparable sediments in most backwater habitats of Pool 5A sampled in 1975-1978; however, clay was generally a larger substrate component in 1975-1978. The comparatively fewer Hexagenia nymphs collected at Location 6 in 1982 was probably related to the lesser amounts of clay in the substrate. Hexagenia nymphs have difficulty burrowing into coarse substrates such as sand, and prefer the finer sediments (silt and clay) for optimal burrowing (Hunt 1953). The nymphs from Location 6 (and also Location 10) were generally early instars. Fremling (1960a) found Hexagenia principally in soft mud but also reported large populations of small nymphs on sand-silt substrates.

The sediments collected from Location 10 (sand flat) were dominated by medium and coarse sands with lesser amounts of fine sands and silt (Tables 4-20 through 4-22). The unstable sand bottom and relatively small amount of organic matter at Location 10 consistently yielded less than 50 percent of the total benthos and biomass reported from Location 6. Sand provides a relatively poor habitat for benthic macroinvertebrates yielding few specimens of only a few species (Hynes 1972; Lewis 1983).

Location 10 (sand flat) was dominated by a variety of organisms in 1982. Chironomids were commonly collected and were especially abundant in August (1153 individuals/m^2). The dominant midges, Stempellina sp. and Stictochironomus sp., apparently can tolerate the rigorous environment at Location 10. They were rare or absent at Location 6. Anderson et al. (1983) also collected the greatest number of Stictochironomus from sand habitats in Pool 5A. The naidid worm Piguetiella michiganensis was abundant at the sand habitat in September but absent at the silt habitat. In a study of Pool 14 in the UMR, Lewis (1979) also reported greater densities of P. michiganensis from predominantly sandy locations when compared with populations from other substrate types.

Statistical comparisons of the dominant taxa colonizing the silt and sand habitats revealed several significant population differences during each sampling period and for the year (Table 4-19). During most sampling periods, the Nematoda, total Tubificidae and total Chironomidae densities were significantly greater at Location 6 than at Location 10. In addition, the total Naididae population was significantly larger at

TABLE 4-20 PERCENT COMPOSITION, BY WEIGHT, OF THE SEDIMENT PARTICLE SIZES AND ORGANIC CARBON LEVELS FROM SILT AND SAND SUBSTRATES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, JUNE 1982

	Location 6 - Silt Bay										
Sediment Type	A	B	C	D	E	F	G	H	I	J	$\bar{x}$
Gravel*	11.7	10.7	16.0	12.7	14.0	17.0	9.9	12.3	10.9	8.5	12.4
Very coarse sand	0.2	0.4	0.2	0.3	0.3	0.9	0.3	0.2	0.4	1.8	0.5
Coarse sand	0.6	1.7	1.3	1.9	1.6	1.2	0.9	0.9	4.1	6.2	2.0
Medium sand	6.4	5.2	7.6	10.1	10.2	6.4	20.2	6.6	14.9	13.3	10.1
Fine sand	43.1	22.6	25.0	23.3	23.1	19.7	41.3	27.0	24.2	25.1	27.4
Very fine sand	12.1	11.9	8.9	9.2	8.1	10.2	7.6	11.6	13.5	14.4	10.8
Silt	19.7	41.7	35.6	36.0	35.3	37.0	15.7	34.8	26.1	25.6	30.8
Clay	4.7	3.6	3.4	4.4	5.2	4.5	1.8	5.3	4.1	2.8	4.0
Colloid	1.3	2.3	2.1	2.2	2.2	3.1	2.3	1.3	1.8	2.3	2.1
Organic Carbon	5.1	5.0	2.6	5.1	5.1	6.7	3.2	5.1	3.6	3.7	4.5

	Location 10 - Sand Flat										
Sediment Type	A	B	C	D	E	F	G	H	I	J	$\bar{x}$
Gravel	0.2	3.2	20.0	17.6	0.1	1.4	2.1	1.2	4.1	7.8	5.8
Very coarse sand	1.2	9.8	1.8	4.6	1.5	5.8	3.2	5.2	3.9	4.6	4.2
Coarse sand	25.8	38.0	7.4	21.4	32.2	42.1	26.2	33.7	24.4	22.4	27.4
Medium sand	63.1	35.8	22.1	25.7	52.4	37.8	50.3	51.0	48.4	44.7	43.1
Fine sand	6.6	5.2	8.7	7.8	5.0	6.2	8.9	4.2	9.2	12.3	7.4
Very fine sand	0.7	0.4	4.6	6.2	0.4	0.7	0.2	0.2	0.6	3.6	1.8
Silt	2.4	8.1	23.1	11.2	8.4	6.1	9.1	4.4	9.4	4.1	8.6
Clay	<0.1	<0.1	8.1	3.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.1
Colloid	<0.1	<0.1	4.4	2.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	0.7
Organic Carbon	0.5	0.8	5.9	6.0	0.5	0.5	0.5	0.5	0.4	0.8	1.6

---

* Particle size classifications are defined in Section 4.2.2 Laboratory Procedures.

TABLE 4-21 PERCENT COMPOSITION, BY WEIGHT, OF THE SEDIMENT PARTICLE SIZES AND ORGANIC CARBON LEVELS FROM SILT AND SAND SUBSTRATES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

	Location 6 - Silt Bay										
Sediment Type	A	B	C	D	E	F	G	H	I	J	$\bar{x}$
Gravel*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coarse sand	0.3	0.7	1.3	0.2	0.2	0.6	0.2	0.3	0.4	0.1	0.4
Medium sand	1.4	0.1	2.1	6.9	1.3	2.7	6.9	2.2	3.3	4.7	3.2
Fine sand	7.6	19.0	17.5	34.1	39.1	18.5	51.2	18.8	21.6	18.1	24.6
Very fine sand	31.1	37.2	34.7	17.5	27.6	16.5	21.6	15.6	15.3	12.9	23.0
Silt	55.6	39.0	38.4	35.3	27.8	55.7	16.1	53.9	48.2	52.0	42.2
Clay	2.0	2.0	2.0	2.0	2.0	2.0	2.0	4.1	2.0	2.0	2.2
Colloid	2.0	2.0	4.0	4.0	2.0	4.0	2.0	5.1	9.2	9.2	4.4
Organic Carbon	3.9	3.2	3.7	2.5	2.6	3.9	2.3	3.9	3.5	4.0	3.4

	Location 10 - Sand Flat										
Sediment Type	A	B	C	D	E	F	G	H	I	J	$\bar{x}$
Gravel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coarse sand	3.1	51.1	4.4	8.6	27.0	39.8	23.9	36.9	32.0	25.1	25.2
Medium sand	14.5	39.1	9.5	13.1	58.3	42.9	57.4	55.1	51.4	64.0	40.5
Fine sand	14.2	8.0	5.5	13.3	11.2	11.0	14.6	6.3	12.0	7.9	10.4
Very fine sand	39.4	0.6	15.9	29.8	1.5	2.3	1.1	0.4	2.5	0.8	9.4
Silt	21.7	0.2	48.4	27.2	1.0	2.0	1.0	0.7	0.6	1.7	10.4
Clay	2.0	0.5	6.1	2.0	0.5	1.0	1.0	0.5	1.5	0.5	1.6
Colloid	5.1	<0.5	10.2	6.0	<0.5	1.0	1.0	<0.5	<0.5	<0.5	2.4
Organic Carbon	2.5	0.3	1.5	2.2	0.4	0.4	0.4	0.3	0.4	0.4	0.9

* Particle size classifications are defined in Section 4.2.2 Laboratory Procedures.

TABLE 4-22 PERCENT COMPOSITION, BY WEIGHT, OF THE SEDIMENT PARTICLE SIZES AND ORGANIC CARBON LEVELS FROM SILT AND SAND SUBSTRATES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, SEPTEMBER 1982

Location 6 - Silt Bay

Sediment Type	A	B	C	D	E	F	G	H	I	J	$\bar{x}$
Gravel*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coarse sand	0.4	0.1	0.7	0.8	0.5	0.3	0.3	0.3	0.3	1.4	0.5
Medium sand	1.5	4.4	2.6	3.2	2.8	10.4	4.0	3.5	19.0	16.4	6.8
Fine sand	7.5	47.3	9.5	27.9	17.8	44.2	34.1	18.9	37.6	39.8	28.5
Very fine sand	26.9	22.3	26.2	33.3	31.9	16.3	24.0	14.0	14.9	12.9	22.3
Silt	55.6	22.9	53.9	31.8	42.0	23.8	33.6	55.2	24.2	25.5	36.9
Clay	3.1	3.0	5.1	3.0	3.0	3.0	2.0	6.1	4.0	2.0	3.4
Colloid	5.0	<0.5	2.0	<0.5	2.0	2.0	2.0	2.0	<0.5	2.0	1.7
Organic Carbon	4.7	3.3	0.5	1.8	3.3	3.1	2.7	3.9	2.4	1.9	2.8

Location 10 - Sand Flat

Sediment Type	A	B	C	D	E	F	G	H	I	J	$\bar{x}$
Gravel	0.0	0.8	14.9	2.6	0.6	6.9	3.4	2.2	5.0	0.7	3.7
Coarse sand	2.8	40.8	14.6	42.9	40.3	40.5	34.8	36.6	30.4	33.5	31.7
Medium sand	10.5	45.8	37.2	40.0	47.3	37.9	51.1	50.5	48.5	56.6	42.5
Fine sand	14.4	7.9	15.5	7.0	8.5	10.2	8.1	7.6	9.8	5.8	9.5
Very fine sand	36.1	1.2	10.1	2.2	1.4	1.6	0.5	0.8	3.6	1.0	5.9
Silt	30.2	3.5	1.7	5.3	1.9	2.9	2.1	2.3	2.7	2.4	5.5
Clay	2.0	<0.5	2.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.4
Colloid	4.0	<0.5	2.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6
Organic Carbon	3.0	0.3	2.8	0.4	0.4	1.5	0.6	0.8	0.5	0.4	1.7

---

* Particle size classifications are defined in Section 4.2.2 Laboratory Procedures.

Location 6 than Location 10 in August and for the year. Of the taxa or groups compared, none were significantly more abundant at Location 10.

The fine sediments of the silt bay allowed for colonization by burrowing organisms (e.g., tubificids, Hexagenia) which find it difficult to survive medium and coarse sands that predominated in the sand flat. In addition, the greater organic carbon content in the sediments of the silt bay provided more food for macroinvertebrates. The larger sediment particle sizes and lower organic content of the sand flat substrate provided an unhospitable habitat for most macroinvertebrates. Generally, increased densities were noted at this location only when the sand was overlain with silt, thus providing a more stable environment with foodstuff readily available.

Temporal Variations

As was observed in the rock habitat survey, the density and biomass of the silt and sand faunas increased progressively from June to September. The greatest change occurred from June to August when the densities and biomass increased 6-fold at both locations. The low density and biomass observed in June was probably related to a combination of attrition of the populations during the winter and the late spring emergence of the insects. In addition, the faunas at Location 10 (sand flat), and possibly Location 6 (silt bay), may have been reduced or influenced by the high flows and resultant scouring that preceded the June sampling. Population densities and biomass increased at Locations 6 and 10 in August and September as young-of-the-year forms appeared and individual weights increased.

4.3.3 Wood Substrate Survey

The wood, artificial substrate samplers collected in August were dominated by hydropsychid caddisfly larvae and chironomid larvae (Table 4-23). These insect families also dominated the benthos in an artificial substrate study on rock structures of Pool 5A in 1980 (Anderson et al. 1983). The hydropsychid caddisflies and the crayfish Orconectes virilis were the most important components of the biomass (dry weight) from these samplers (Table 4-24). Samplers placed at Locations 6 (the silt bay) and 8 Slow Deep (wing dam) were vandalized and removed during the colonization period.

The wood substrates on the wing dams (Locations 4 Fast and 8 Slow) were colonized by a fauna similar to the community that was colonizing the natural substrates of the wing dams in the August rock substrate survey (Table 4-3). The caddisflies Hydropsyche orris and Cheumatopsyche sp., and the midge Rheotanytarsus sp., which are all net-spinning filter feeders, dominated both wood and rock substrates on the wing dams. The planaria Dugesia sp. and the midge Polypedilum convictum type were also commonly collected from both substrates in August; however, P. convictum type always composed less than 5 percent of the rock community. Simpson and Bode (1980) also collected the filter feeder P. convictum along with Rheotanytarsus sp. and Cheumatopsyche sp., which they indicated was a community indicative of an abundance of suspended foodstuff.

TABLE 4-23 MEAN DENSITY (No./m^2) AND PERCENT OCCURRENCE OF THE DOMINANT ($\geq$5%) BENTHIC MACROINVERTEBRATES COLLECTED FROM WOOD ARTIFICIAL SUBSTRATE SAMPLERS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

	Location 4 Fast						Location 8 Slow				Location 10 Sand Flat	
	w/ peri.		w/o peri.		deep		w/ peri.		w/o peri.			
Taxa	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Turbellaria												
Dugesia sp.	2,145[a]	15.0	294	0.8	542	2.3	2,187	7.5	228	1.5	3	<0.1
Trichoptera												
Imm. Hydropsychidae	1,018	7.1	4,373	11.2	1,835	7.8	1,581	5.4	1,407	9.5	44	0.4
Cheumatopsyche sp.	3,360	23.4	5,571	14.3	4,438	18.8	5,378	18.4	777	5.2	207	2.0
Hydropsyche orris	4,019	28.0	21,338	54.7	9,177	38.9	9,802	33.5	2,909	19.6	85	0.8
Total Hydropsychidae	8,906	62.1	31,855	81.7	15,590	66.1	17,222	58.8	5,169	34.9	455	4.3
Diptera												
Glyptotendipes sp.	240	1.7	174	0.5	382	1.6	768	2.6	1,021	6.9	6,782	63.8
Polypedilum convictum	650	4.5	1,102	2.8	1,125	4.8	1,351	4.6	1,231	8.3	44	0.4
Rheotanytarsus sp.	524	3.7	3,102	8.0	1,847	7.8	3,237	11.1	3,610	24.3	110	1.0
Total Chironomidae	2,450	17.1	5,608	14.4	5,361	22.7	7,201	24.6	7,789	52.5	8,449	79.4
Total Benthos	14,348		38,981		23,604		29,305		14,829		10,636	
Species diversity	3.21		2.36		3.02		3.22		3.91		2.49	
Evenness	0.62		0.47		0.60		0.62		0.71		0.48	
Redundancy	0.38		0.53		0.40		0.38		0.30		0.53	

(a) Mean of two replicate samples.

TABLE 4-24 MEAN DRY WEIGHT (g/m^2) AND PERCENT COMPOSITION, BY WEIGHT, OF THE DOMINANT (≥5%) BENTHIC MACROINVERTEBRATES COLLLECTED FROM WOOD ARTIFICIAL SUBSTRATE SAMPLERS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

	Location 4 Fast					
	w/peri.		w/o peri.		deep	
Taxa	g/m^2	%	g/m^2	%	g/m^2	%
Decapoda						
Orconectes virilis	28.912	(67.3)	0.000	(0.0)	0.000	(0.0)
Trichoptera						
Cheumatopsyche sp.	5.645	(13.1)	8.635	(12.9)	7.677	(27.7)
Hydropsyche orris	5.346	(12.4)	50.358	(75.1)	17.894	(64.7)
Total Hydropsychidae	11.749	(27.3)	62.756	(93.6)	26.166	(94.6)
Diptera						
Total Chironomidae	0.456	(1.1)	0.808	(1.2)	0.466	(1.7)
Total Benthos	42.977		67.046		27.670	

	Location 8 Slow				Location 10	
	w/peri.		w/o peri.		Sand Flat	
Taxa	g/m^2	%	g/m^2	%	g/m^2	%
Decapoda						
Orconectes virilis	2.805	(8.1)	0.000	(0.0)	15.966	(85.6)
Trichoptera						
Cheumatopsyche sp.	8.712	(25.2)	1.663	(11.3)	0.232	(1.2)
Hydropsyche orris	14.899	(43.0)	8.988	(61.0)	0.091	(0.5)
Total Hydropsychidae	25.042	(72.3)	11.104	(75.4)	0.606	(3.2)
Diptera						
Total Chironomidae	2.088	(6.0)	2.570	(17.5)	1.014	(5.4)
Total Benthos	34.614		14.723		18.647	

Statistical comparisons of the dominant taxa colonizing the artificial substrates revealed few significant ($P \leq 0.05$) differences in density (Tables 4-67 through 4-69 in Section 4.7). Although large density differences were evident among individual habitats, habitat type and locations, the large variability in replicate densities probably reduced the sensitivity of the comparisons. Despite the calculation of a conversion factor for each sampler, the complex environment of the wood artificial substrate allows for large variability from one sampler to the next. The only significant difference observed was the comparison of _Glyptotendipes_ sp. by location. The progressively greater densities of _Glyptotendipes_ at Locations 4 Fast, 8 Slow, and 10 (the sand flat) was consistent with the occurrence of this taxa in the rock habitat survey. In both studies, the density of _Glyptotendipes_ was inversely related to current velocity.

As was noted in the rock substrate survey (Table 4-6), the macroinvertebrate biomass of the wood substrates at the wing dams was dominated by hydropsychid larvae (Table 4-24). In addition, midges were an important component of the biomass at Location 8 Slow. The large-bodied crayfish _Orconectes virilis_, which occurred sporadically in the samples, dominated the biomass at the With Periphyton habitat at Location 4 Fast. Artificial substrates collected from Pool 5A rock structures in 1980 were also dominated by crayfish and hydropsychid caddisflies (Anderson et al. 1983). In contrast to the present study, however, the 1980 study reported greater biomass from the slow current areas than from the fast current habitats.

The total benthos and biomass of the wood substrate fauna on the wing dams (Tables 4-23 and 4-24, respectively) were two to four times greater than the community on the natural rock substrates of the wing dams in August (Tables 4-3 and 4-6). The greater densities from the wood substrates compared to the rock substrates were probably related to the rough surface of the wood (and thus greater actual surface area) and the more diverse habitats provided by this type of sampler.

The community structure of the fauna from the artificial substrates at the sand substrate (Location 10) was much different than the fauna observed on the wing dams. In addition, the sand substrate yielded lower density, biomass and species diversity values. Substantially lower densities of rheophilic taxa (e.g., hydropsychid caddisflies and the midges _Polypedilum convictum_ type and _Rheotanytarsus_ sp.) were present at Location 10 than were present in the faster current velocities of wing dam Locations 4 Fast and 8 Slow. The midge _Glyptotendipes_ sp. was the dominant organism (64 percent of the benthos, numerically) at Location 10 in August. This midge was also commonly collected from the wood samplers on the wing dam at Location 8 Slow and from the slow-current locations during the rock substrate survey (Table 4-3). _Glyptotendipes_ sp. was the dominant chironomid on artificial substrates from Pool 5A in 1980 (Anderson et al. 1983), and was especially abundant on the structures having a low current velocity.

The biomass from the wood substrates at Location 10 was dominated by the crayfish _Orconectes virilis_ (86 percent of the total dry weight; Table 4-24). The total biomass from Location 10 was generally much less than the biomass from the wing dam habitats primarily because of fewer hydropsychid caddisflies.

Current velocity strongly influenced the fauna of the artificial substrates in August and probably was a major factor in the community differences between the wing dams (Location 4 Fast and 8 Slow) and the sand flat (Location 10). In an artificial substrate study of Ohio River macroinvertebrates, Beckett and Miller (1982) noted similar community differences in slow-water and fast-water areas. As in the present study, they reported a strong preference of the rheophilic taxa Hydropsyche orris, Polypedilum convictum and Rheotanytarsus sp. for fast-water areas. However, in addition to the influence of current velocity on substrate colonization in Pool 5A, community differences between samplers at the sand flat and wing dams were probably also related to differences in the habitat/fauna adjacent to the samplers. Artificial substrates are colonized primarily by drifting and swimming organisms (Weber 1973) so the community of the wing dam samplers probably resulted from direct recruitment (i.e., drifting, swimming and crawling) from the heavily colonized rocks of the wing dams. Since the benthic fauna near the sand flat sampler was very sparse, these artificial substrates were probably colonized by organisms drifting onto the samplers. Thus, the community and density differences at this location may also have been related to the method of colonization.

4.3.4 Aquatic Plant Habitat Survey

Aquatic Plant Survey

In the August sampling of three macrophyte beds, samples from the Heteranthera dubia (water stargrass) bed yielded the greatest total benthos in terms of no./m2 of bottom substrate (Table 4-25); however, the total benthos as no./g of macrophyte (dry weight) was greatest from Potamogeton pectinatus (sago pondweed) (Table 4-26). Vallisneria americana (wild celery) yielded the lowest macroinvertebrate densities utilizing both types of density determinations. Heteranthera and Potamogeton are both narrow-leafed species that provide greater leaf surface area (when comparing equal amounts of plants) and larger subsequent macroinvertebrate populations than the broader-leafed Vallisneria. Gerris and Bristow (1979) also found that macrophytes with finely-divided leaves (Myrophyllum and Potamogeton) supported greater densities than the broad-leafed Vallisneria. The higher species diversity values from Vallisneria in Pool 5A (Table 4-25) was probably related to the comparatively lower densities and percent occurrence of the dominant taxa at this location.

Chironomid midges dominated the macroinvertebrate fauna collected from all three species of aquatic macrophytes sampled in Pool 5A (Tables 4-25 and 4-26). In a similar macrophyte study, samples collected from an Indiana lake (Gerking 1957) and a Canadian lake (Gerrish and Bristow 1979) were also dominated by midges.

Cricotopus bicinctus group and Glyptotendipes sp. were the dominant midges collected from all macrophyte samples in August (Tables 4-25 and

TABLE 4-25 MEAN DENSITY (No./m^2) AND PERCENT OCCURRENCE OF THE DOMINANT ($\geq$5%) MACROINVERTEBRATES COLONIZING THREE SPECIES OF AQUATIC MACROPHYTES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

Taxa	*Vallisneria americana* No./m^2	*Vallisneria americana* %	*Heteranthera dubia* No./m^2	*Heteranthera dubia* %	*Potamogeton pectinatus* No./m^2	*Potamogeton pectinatus* %
Oligochaeta						
Total Naididae	1,190(a)	5.0	1,741	2.9	1,242	3.7
Amphipoda						
Hyalella azteca	1,382	5.9	12,365	20.3	3,264	9.7
Trichoptera						
Nectopsyche sp.	653	2.8	4,134	6.8	576	1.7
Total Leptoceridae	742	3.1	4,198	6.9	589	1.8
Diptera						
Endochironomus sp.	2,355	10.0	4,787	7.8	1,024	3.0
Glyptotendipes sp.	4,173	17.7	14,170	23.2	4,326	12.9
Rheotanytarsus sp.	1,216	5.2	1,664	2.7	2,547	7.6
Cricotopus bicinctus group	6,694	28.3	10,496	17.2	15,475	46.0
Total Chironomidae	16,742	70.9	37,952	62.2	26,944	80.1
Total Benthos	23,629		61,043		33,638	
Species diversity	3.59		3.30		2.86	
Evenness	0.72		0.68		0.63	
Redundancy	0.28		0.32		0.37	

(a) Mean of five replicate samples.

TABLE 4-26 MEAN DENSITY PER GRAM OF MACROPHYTE (No./g) AND PERCENT OCCURRENCE OF THE DOMINANT (≥5%) MACROINVERTEBRATES COLONIZING THREE SPECIES OF AQUATIC MACROPHYTES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

Taxa	*Vallisneria americana*		*Heteranthera dubia*		*Potamogeton pectinatus*	
	No./g	%	No./g	%	No./g	%
Oligochaeta						
Total Naididae	11[a]	(5.6)	8	(2.9)	36	(4.1)
Amphipoda						
Hyalella azteca	11	(5.8)	53	(20.6)	86	(9.8)
Trichoptera						
Nectopsyche sp.	5	(2.6)	19	(7.4)	15	(1.7)
Total Leptoceridae	6	(3.0)	19	(7.5)	15	(1.7)
Diptera						
Endochironomus sp.	19	(9.8)	20	(7.8)	28	(3.2)
Glyptotendipes sp.	35	(17.8)	60	(23.3)	108	(12.3)
Rheotanytarsus sp.	10	(5.3)	7	(2.7)	67	(7.7)
Cricotopus bicinctus group	57	(28.7)	42	(16.2)	398	(45.5)
Total Chironomidae	140	(71.1)	156	(60.8)	698	(79.8)
Total Benthos	198		256		874	

(a) Mean of five replicate samples.

4-26). Cricotopus bicinctus group, which was the dominant organism from the Potamogeton and Vallisneria samples (approximately 46 and 28 percent of the total, respectively), is classified as an epiphytic species (Beck 1977), commonly occurring on aquatic plants. Glyptotendipes sp. was the dominant organism (27 percent of the benthos) on the macrophyte Heteranthera. Glyptotendipes sp. had significantly greater densities on Heteranthera than the two other macrophyte species (Table 4-27). This midge taxon was also abundant on the rock structures of Pool 5A located in slow current areas (Table 4-3) and in the slow current locations during the wood artificial substrate study (Table 4-23).

The amphipod Hyalella azteca was commonly collected from all three macrophytes in 1982 and was especially numerous (12,365 individuals/m^2) on Heteranthera (Table 4-25). The population on Heteranthera was significantly greater than the populations on the other macrophytes (Table 4-27). In a 1966-1967 study of the Mississippi River, Gale (1975) found Hyalella azteca to be abundant in vegetated backwaters. In a survey of a floodplain lake in Pool 9, Hyalella azteca was the dominant benthic organism within a bed of the emergent macrophyte Sagittaria (Eckblad et al. 1977). The population within the Sagittaria bed was significantly greater than the population in open-water areas.

Chironomids were the dominant components of the biomass at the Potamogeton and Heteranthera locations (54 and 46 percent, respectively), and composed a large portion (20 percent) of the macroinvertebrate biomass from Vallisneria (Table 4-28). The biomass of macroinvertebrates from macrophytes sampled by Gerking (1957) was also dominated by midges (nearly 60 percent of the total weight). The dominant component of the biomass at the Vallisneria location was the mussel Carunculina parva which accounted for 27 percent of the total. Carunculina parva and all other taxa that were important components of the biomass were generally large-bodied organisms which were not numerically abundant.

Aquatic Plant Sediment Survey

Oligochaetes (Naididae and Tubificidae) and midges (Chironomidae) were the dominant organisms colonizing the substrates near all three macrophyte beds sampled in Pool 5A (Table 4-29). The total benthos from the Vallisneria americana substrate (32,507 organisms/m^2) was nearly double the densities present near Heteranthera dubia (17,752) and near Potamogeton pectinatus (14,140). The densities near Vallisneria were significantly greater than the densities from the other locations (Table 4-30).

This wide range of densities may be related to the differences in hydrology and sediment types at the three locations. The Vallisneria bed was in a relatively deep (0.5 m), protected area with little or no current; the Potamogeton was in a shallow (0.2 m), open area with a steady current (0.1 ft/sec at the time of sampling); and the Heteranthera bed was in an intermediate area. The sediment particle size analysis reflected these differences. Of the three locations, the sediments at the Vallisneria location had the highest amounts of fine sands, and the lowest amounts of medium and coarse sands (Table 4-31). The opposite was true for the Potamogeton sediments.

TABLE 4-27 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA FROM MACROPHYTE
AUGUST 1982

Taxa or Group	Mean Density (No./m^2) HET*	POT	VAL	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total Benthos	61,043	33,638	23,629	8.54	0.0140	yes	HET POT VAL
Total Naididae	1741	1242	1190	0.42	0.8106	no	HET POT VAL
Hyalella azteca	12,365	3264	1382	12.50	0.0019	yes	HET POT VAL
Nectopsyche sp.	4134	576	653	9.55	0.0084	yes	HET POT VAL
Total Leptoceridae	4198	589	742	9.55	0.0084	yes	POT VAL
Endochironomus sp.	4787	1024	2355	9.03	0.0109	yes	HET POT VAL
Glytotendipes sp.	14,170	4326	4173	7.26	0.0265	yes	HET POT VAL
Rheotanytarsus sp.	1664	2547	1216	4.02	0.1340	no	HET POT VAL
Cricotopus bicinctus	10,496	15,475	6694	4.02	0.1340	no	HET POT VAL
Total Chironomidae	37,952	26,944	16,742	4.16	0.1249	no	HET POT VAL

* HET = *Heteranthera dubia*
POT = *Potamogeton pectinatus*
VAL = *Vallisneria americana*

TABLE 4-28 MEAN DRY WEIGHT (g/m^2) AND PERCENT COMPOSITION, BY WEIGHT, OF THE DOMINANT ($\geq 5\%$) MACROINVERTEBRATES COLLECTED FROM THREE AQUATIC MACROPHYTE SPECIES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

Taxa	*Vallisneria americana*		*Heteranthera dubia*		*Potamogeton pectinatus*	
	g/m^2	%	g/m^2	%	g/m^2	%
Amphipoda						
Hyalella azteca	0.101	1.2	1.076	11.4	0.343	7.4
Decapoda						
Palaemonetes kadiakensis	0.546	6.7	0.000	0.0	0.546	11.9
Odonata						
Enallagma sp.	0.054	0.6	0.535	5.7	0.131	2.8
Hemiptera						
Ranatra fusca	0.000	0.0	0.000	0.0	0.444	9.7
Trichoptera						
Nectopsyche sp.	0.091	1.1	0.703	7.5	0.112	2.4
Total Leptoceridae	0.133	1.6	0.796	8.5	0.153	3.3
Diptera						
Total Chironomidae	1.658	20.0	4.289	45.7	2.500	54.4
Gastropoda						
Pleurocera sp.	0.730	8.8	0.162	1.7	0.000	0.0
Physa sp.	1.629	19.7	1.476	15.7	0.127	2.8
Pelecypoda						
Carunculina parva	2.203	26.6	0.000	0.0	0.000	0.0
Total Benthos	8.278		9.392		4.599	

TABLE 4-29 MEAN DENSITY (No./m^2) AND PERCENT OCCURRENCE OF THE DOMINANT (≥5%) BENTHIC MACROINVERTEBRATES COLLECTED FROM SEDIMENTS NEAR THREE AQUATIC MACROPHYTE SPECIES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

	Vallisneria americana		*Heteranthera dubia*		*Potamogeton pectinatus*	
Taxa	No./m^2	%	No./m^2	%	No./m^2	%
Nematoda	1,422[a]	4.4	2,037	11.5	1,191	8.4
Oligochaeta						
Nais variabilis	1,921	5.9	1,037	5.8	1,037	7.3
Piguetiella michiganensis	3,689	11.4	1,768	10.0	1,345	9.5
Stylaria lacustris	4,304	13.2	999	5.6	154	1.1
Total Naididae	11,719	36.1	5,034	28.4	3,074	21.7
Immature w/o cap. chaetae	2,767	8.5	3,112	17.5	1,537	10.9
Total Tubificidae	5,110	15.7	4,534	25.5	2,152	15.2
Amphipoda						
Hyalella azteca	1,537	4.7	576	3.3	999	7.1
Diptera						
Glyptotendipes sp.	3,497	10.8	922	5.2	769	5.4
Rheotanytarsus sp.	845	2.6	231	1.3	769	5.4
Total Chironomidae	7,108	21.9	2,882	16.2	4,995	35.3
Total Benthos	32,507		17,752		14,140	
Species diversity	4.17		4.02		3.93	
Evenness	0.82		0.85		0.87	
Redundancy	0.18		0.15		0.13	

(a) Mean of five replicates.

TABLE 4-30 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA FROM MACROPHYTE CORE SAMPLES, AUGUST 1982

Taxa or Group	Mean Density (No./m^2) HET*	POT	VAL	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total Benthos	17,752	14,140	32,507	9.14	0.0104	yes	HET POT VAL
Nematoda	2036	1191	1421	0.73	0.6925	no	HET POT VAL
Nais variabilis	1037	1037	1921	3.38	0.1850	no	HET POT VAL
Piguetiella michiganensis	1768	1345	3689	2.10	0.3491	no	HET POT VAL
Stylaria lacustris	999	154	4303	9.06	0.0108	yes	HET POT VAL
Total Naididae	5034	3074	11,719	9.98	0.0068	yes	HET POT VAL
Imm. Tubificidae w/o cap. chaetae	3112	1537	2767	3.38	0.1850	no	HET POT VAL
Total Tubificidae	4534	2152	5110	4.46	0.1075	no	HET POT VAL
Hyalella azteca	576	999	1537	1.75	0.4158	no	HET POT VAL
Glyptotendipes sp.	922	768	3497	9.50	0.0087	yes	HET POT VAL
Rheotanytarsus sp.	231	768	845	1.90	0.3858	no	HET POT VAL
Total Chironomidae	2882	4995	7108	7.59	0.0224	yes	HET POT VAL

---

*HET = *Heteranthera dubia*
POT = *Potamogeton pectinatus*
VAL = *Vallisneria americana*

TABLE 4-31 PERCENT COMPOSITION, BY WEIGHT, OF THE SEDIMENT PARTICLE SIZES AND ORGANIC CARBON LEVELS IN CORE SAMPLES COLLECTED FROM SUBSTRATES NEAR THREE AQUATIC MACROPHYTE SPECIES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

	Location																	
	Vallisneria americana						*Heteranthera dubia*						*Potamogeton pectinatus*					
Sediment Type	A	B	C	D	E	$\bar{x}$	A	B	C	D	E	$\bar{x}$	A	B	C	D	E	$\bar{x}$
Gravel*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coarse sand	15.8	10.2	6.0	11.1	9.4	10.5	9.7	9.1	13.0	25.8	28.2	17.2	26.8	26.6	30.4	17.1	18.2	23.8
Medium sand	46.0	35.5	30.2	41.8	26.4	36.0	43.4	40.4	44.9	37.4	39.0	41.0	40.4	43.9	36.5	45.0	48.1	44.8
Fine sand	22.1	27.0	28.1	28.3	27.0	26.5	31.6	31.4	27.1	19.9	20.2	26.1	20.1	17.9	15.2	22.4	26.0	20.3
Very fine sand	11.4	20.2	27.0	14.2	36.0	21.8	11.6	14.1	11.3	13.5	9.2	11.9	10.2	8.6	5.5	9.6	6.2	8.0
Silt	4.7	5.6	7.2	3.1	0.2	4.2	2.2	4.0	1.7	1.4	2.4	2.3	2.5	3.0	2.4	5.9	1.5	3.1
Clay	<0.5	1.5	0.5	1.0	1.0	0.8	1.5	0.5	1.5	0.5	0.5	0.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Colloid	<0.5	<0.5	1.0	0.5	<0.5	0.3	<0.5	0.5	0.5	1.5	0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Organic Carbon	1.1	0.7	0.7	11.3	1.2	3.0	0.7	0.5	0.5	0.5	0.4	0.5	0.4	0.4	2.0	0.1	0.3	0.6

---

* Particle size classifications are defined in Section 4.2.2 Laboratory Procedures.

In a similar survey sediments in macrophyte beds of an Indiana lake (Gerking 1957), oligochaetes were also the doiminant organisms and of the three locations sampled, community densities were also greatest in the sediments near *Vallisneria americana*. Gerking suggested that the greater densities were the result of extensive root system of *Vallisneria* and the stable habitat it created. He estimated that the sediment near aquatic macrophytes would have twice as many organisms as a nonvegetated substrate. In the present survey of Pool 5A, the mean density of organisms from sediments in the macrophyte beds (21,467 individuals/m^2) was nearly ten times the density (2440/m^2) in the nearby sand habitat (Location 10) and about three times the density (6571/m^2) in the nonvegetated silt bay (Location 6) (Table 4-14).

Stylaria lacustris, *Piguetiella michiganensis* and *Nais variabilis* were the dominant naidid oligochaetes collected from the macrophyte sediments in August (Table 4-29). Significantly higher densities of *S. lacustris* collected near *Vallisneria* (4304 individuals/m^2) resulted in significantly greater total Naididae densities at this location (Table 4-30). Since naidids generally dominate the oligochaete assemblage of aquatic plants (Brinkhurst 1971; Table 4-25), the large densities of these taxa in the macrophyte sediments was not surprising. *Stylaria lacustris* and *N. variabilis* were commonly collected from both macrophytes (Table C-8, Appendix C) and their associated sediments; however, *P. michiganensis* was not present in the macrophyte collections. This species apparently either prefers the bottom sediments or is not sufficiently mobile to colonize the macrophytes. *Stylaria lacustris* and *N. variabilis* are both capable of swimming (Brinkhurst 1971).

Tubificid oligochaetes were abundant at all locations in August and composed a large percentage (26 percent) of the benthos in the *Heteranthera* sediments. The fine-grained sediments near *Vallisneria* yielded the greatest tubificid densities of the three locations sampled. Because their burrowing habits, tubificids generally are most abundant in the softer (fine-grained) substrates. The lower tubificid densities near *Potamogeton* probably resulted from the greater current velocity and subsequent unstable sand substrate at this location. The tubificids collected from the macrophyte sediments were dominated by immature individuals without capilliform chaetae.

The amphipod *Hyalella azteca* was commonly collected from all locations during the macrophyte sediment survey (Table 4-29). *Hyalella* was also commonly collected in the macrophyte survey (Table 4-25). In a similar study, Eckblad et al. (1977) reported *H. azteca* to be the dominant organism from the sediments in a bed of the macrophyte *Sagittaria*.

Glyptotendipes sp. and *Rheotanytarsus* sp. were the dominant chironomids collected from the macrophyte sediment samples in August (Table 4-32). These two taxa also dominated the chironomid assemblage collected from the macrophyte samples (Table 4-25). In the present study *Glyptotendipes* was especially numerous (3497 individuals/m^2) and significantly most abundant (Table 4-30) in the sediments at the *Vallisneria* bed. Beck

TABLE 4-32 MEAN DRY WEIGHT (g/m^2) AND PERCENT COMPOSITION, BY WEIGHT, OF THE DOMINANT (≥5%) BENTHIC MACROINVERTEBRATES COLLECTED FROM SEDIMENTS NEAR THREE AQUATIC MACROPHYTE SPECIES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

Taxa	*Vallisneria americana* g/m^2	*Vallisneria americana* %	*Heteranthera dubia* g/m^2	*Heteranthera dubia* %	*Potamogeton pectinatus* g/m^2	*Potamogeton pectinatus* %
Turbellaria						
Dugesia sp.	1.037	10.1	0.038	0.4	0.038	0.9
Oligochaeta						
Total Naididae	0.727	7.1	0.191	1.9	0.062	1.5
Total Tubificidae	4.024	39.4	3.571	36.3	1.695	41.6
Diptera						
Total Chironomidae	0.704	6.9	0.326	3.3	0.464	11.4
Gastropoda						
Physa sp.	1.293	12.6	0.886	9.0	0.000	0.0
Ferrissia sp.	0.532	5.2	0.067	0.7	0.000	0.0
Pelecypoda						
Musculium transversum	0.000	0.0	0.000	0.0	0.583	14.3
Pisidium sp.	0.187	1.8	0.519	5.3	0.259	6.4
Total Sphaeriidae	0.202	2.0	0.519	5.3	1.028	25.2
Amblema plicata	0.000	0.0	3.304	33.6	0.000	0.0
Total Unionidae	0.027	0.3	3.304	33.6	0.000	0.0
Total Benthos	10.223		9.827		4.071	

(1977) reported that species of Glyptotendipes occurred primarily in lotic habitats; however, in the present study, this taxa was collected throughout Pool 5A, but most abundant in lentic habitats.

In addition to yielding the greatest densities, the Vallisneria sediments also had the greatest total macroinvertebrate biomass of the three beds sampled. Biomass from the macrophyte sediments was dominated (36-42 percent of the total weight) by tubificid oligochaetes (Table 4-32). Other important components of the biomass were the large-bodied molluscs. The snail Physa sp. (from Vallisneria sediments), the mussel Amblema plicata (from Heteranthera sediments), and fingernail clams Musculium transversum and Pisidium sp. (from Potamogeton sediments) composed relatively large percentages of the biomass. Although these large-bodied molluscs were important components of the biomass, they did not compose more than 3 percent of the total number of individuals at any location. The naidid oligochaetes and chironomid midges, which were numerically dominant at these locations (Table 4-29), made up a much smaller percentage of the biomass because of their small body size.

4.3.5 Crayfish Collections

Only a few individuals were collected in the 1982 crayfish survey of rock structures and macrophyte beds. All individuals were collected in June and all were mature (65-75 millimeter) Orconectes virilis. One individual was collected in the baited crayfish trap at Location 8 Slow Deep. In the minnow trap study (Section 5), one crayfish was collected at Location 2 and two individuals were sampled from Location 9.

4.3.6 Rock Substrate Vertical Distribution Study

Differences in the vertical distribution of the benthic fauna colonizing rock artificial substrates were apparent in the August sampling of the wing dams (Locations 4 Fast and 8 Slow). The density and biomass of the organisms per surface area of rock sampled (Tables 4-33 and 4-34, respectively) were much greater from the top sampler (0-38 cm below the surface of the wing dam) than from the bottom sampler (38-76 cm deep). In addition to density and biomass differences, the community composition was also affected by depth. These differences resulted primarily from the reduced current velocities and increased sedimentation in the bottom samplers.

Statistical comparisons of density differences related to vertical distribution for both locations revealed significantly larger populations of total Heptageniidae, Dicrotendipes sp., Ablabesmyia sp. and total Chironomidae in the top samplers than in the bottom samplers (Table 4-35). Large differences were observed in the vertical distribution of the other dominant taxa and groups; however, because of the large variability in the sample replicates these differences were not statistically significant.

The benthic fauna colonizing the top milkcrate samplers was dominated in August by hydropsychid caddisflies (Cheumatopsyche sp. and Hydropsyche orris), chironomid midges (especially Polypedilum convictum type), and the planaria Dugesia sp. These communities were generally similar in

TABLE 4-33 VERTICAL DISTRIBUTION (DENSITY[(a)] AND PERCENT OCCURRENCE) OF THE DOMINANT (>5%) BENTHIC MACROINVERTEBRATES COLONIZING ROCK ARTIFICIAL SUBSTRATES BURIED IN WING DAMS IN POOL5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

	Location 4 Fast								Location 8 Slow							
	nearshore				farshore				nearshore				farshore			
	top		bottom		top		bottom		top		bottom		top		bottom	
Taxa	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Turbellaria																
Dugesia sp.	685	3.3	2,620	33.8	-[(b)]	-	472	3.6	537	8.6	0	0.0	981	11.4	0	0.0
Oligochaeta																
Immatures w/o cap. chaetae	0	0.0	262	3.4	-	-	450	3.5	93	1.5	14	5.9	47	0.5	113	27.6
Branchiura sowerbyi	0	0.0	126	1.6	-	-	43	0.3	47	0.8	3	1.2	23	0.3	38	9.2
Limnodrilus hoffmeisteri	0	0.0	199	2.6	-	-	107	0.8	12	0.2	0	0.0	0	0.0	27	6.6
Total Tubificidae	0	0.0	608	7.8	-	-	633	4.9	152	2.4	16	7.1	82	1.0	185	45.4
Amphipoda																
Hyalella azteca	0	0.0	0	0.0	-	-	0	0.0	23	0.4	41	17.7	12	0.1	0	0.0
Ephemeroptera																
Stenacron intepunctatum grp.	0	0.0	0	0.0	-	-	11	0.1	339	5.4	0	0.0	117	1.4	0	0.0
Total Heptageniidae	44	0.2	0	0.0	-	-	21	0.2	397	6.4	8	3.5	257	3.0	0	0.0
Trichoptera																
Immature Hydropsychidae	1,077	5.2	31	0.4	-	-	322	2.5	47	0.8	5	2.4	245	2.9	0	0.0
Cheumatopsyche sp.	6,778	32.5	2,243	28.9	-	-	3,012	23.1	1,659	26.6	19	8.2	1,869	21.8	0	0.0
Hydropsyche orris	7,148	34.3	231	3.0	-	-	2,766	21.2	759	12.2	3	1.2	2,278	26.6	0	0.0
Total Hydropsychidae	16,070	77.1	2,683	34.6	-	-	6,593	50.6	2,792	44.8	27	11.8	4,765	55.6	0	0.0
Diptera																
Dicrotendipes sp.	207	1.0	0	0.0	-	-	21	0.2	82	1.3	24	10.6	82	1.0	0	0.0
Polypedilum convictum	1,425	6.8	105	1.4	-	-	322	2.5	129	2.1	0	0.0	362	4.2	0	0.0
Ablabesmyia sp.	65	0.3	21	0.3	-	-	43	0.3	327	5.2	8	3.5	199	2.3	3	0.7
Total Chironomidae	3,492	16.8	461	6.0	-	-	922	7.1	1,180	18.9	43	18.8	2,056	24.0	21	5.3
Pelecypoda																
Immature Sphaeriidae	22	0.1	576	7.4	-	-	3,441	26.4	257	4.1	3	1.2	35	0.4	164	40.1
Total Sphaeriidae	54	0.3	755	9.7	-	-	4,041	31.0	364	5.8	3	1.2	48	0.6	174	42.8
Total Benthos	20,846		7,751		-		13,040		6,237		230		8,578		407	
Species Diversity	2.89		3.20		-		3.20		4.18		3.68		3.70		2.66	
Evenness	0.52		0.57		-		0.60		0.73		0.79		0.63		0.62	
Redundancy	0.48		0.44		-		0.40		0.28		0.26		0.37		0.43	

(a) Density expressed per rock surface area within each sampler.
(b) Sampler was lost.

TABLE 4-34 VERTICAL BIOMASS DISTRIBUTION (g/m^2 AND % COMPOSITION, BY WEIGHT) OF THE DOMINANT ($\geq$5%) BENTHIC MACROINVERTEBRATES COLONIZING ROCK ARTIFICIAL SUBSTRATES BURIED IN WING DAMS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

	Location 4 Fast							
	Nearshore				Farshore			
	top		bottom		top		bottom	
Taxa	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%
Turbellaria								
Dugesia sp.	0.439	(0.9)	1.677	(5.5)	-*	-	0.302	(0.7)
Oligochaeta								
Total Tubificidae	0.000	(0.0)	0.480	(1.6)	-	-	0.500	(1.2)
Amphipoda								
Hyalella azteca	0.000	(0.0)	0.000	(0.0)	-	-	0.000	(0.0)
Decapoda								
Orconectes virilis	23.518	(46.1)	17.045	(56.4)	-	-	5.826	(14.1)
Trichoptera								
Cheumatopsyche sp.	11.367	(22.3)	3.761	(12.4)	-	-	5.051	(12.2)
Hydropsyche orris	10.887	(21.3)	0.352	(1.2)	-	-	4.213	(10.2)
Total Hydropsychidae	24.452	(47.9)	4.474	(14.8)	-	-	10.393	(25.1)
Diptera								
Total Chironomidae	0.648	(1.3)	0.086	(0.3)	-	-	0.171	(0.4)
Gastropoda								
Pleurocera sp.	0.000	(0.0)	1.105	(3.7)	-	-	0.000	(0.0)
Pelecypoda								
Immature Sphaeriidae	0.105	(0.2)	2.467	(8.2)	-	-	14.728	(35.6)
Musculium transversum	0.000	(0.0)	1.114	(3.7)	-	-	3.743	(9.0)
Sphaerium striatinum	0.495	(1.0)	1.432	(4.7)	-	-	5.371	(13.0)
Total Sphaeriidae	0.600	(1.2)	5.058	(16.7)	-	-	23.842	(57.6)
Total Benthos	51.019		30.222		-		41.371	

* Sampler was lost.

TABLE 4-34 (CONT.)

	Location 8 Slow							
	Nearshore				Farshore			
	top		bottom		top		bottom	
Taxa	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%
Turbellaria								
Dugesia sp.	0.344	(1.3)	0.000	(0.0)	0.628	(2.2)	0.000	(0.0)
Oligochaeta								
Total Tubificidae	0.120	(0.5)	0.013	(7.3)	0.065	(0.2)	0.146	(11.0)
Amphipoda								
Hyalella azteca	0.007	(<0.1)	0.012	(6.6)	0.003	(<0.1)	0.000	(0.0)
Decapoda								
Orconectes virilis	9.493	(35.6)	0.000	(0.0)	15.751	(54.8)	0.000	(0.0)
Trichoptera								
Cheumatopsyche sp.	2.969	(11.1)	0.034	(19.2)	3.345	(11.6)	0.000	(0.0)
Hydropsyche orris	1.534	(5.8)	0.006	(3.1)	4.601	(16.0)	0.000	(0.0)
Total Hydropsychidae	5.373	(20.2)	0.040	(22.9)	8.995	(31.3)	0.000	(0.0)
Diptera								
Total Chironomidae	0.248	(0.9)	0.009	(5.2)	0.432	(1.5)	0.005	(0.3)
Gastropoda								
Pleurocera sp.	5.882	(22.1)	0.059	(33.6)	1.535	(5.3)	0.000	(0.0)
Pelecypoda								
Immature Sphaeriidae	1.234	(4.6)	0.013	(7.4)	0.168	(0.6)	0.785	(58.9)
Musculium transversum	0.688	(2.6)	0.000	(0.0)	0.344	(1.2)	0.235	(17.6)
Sphaerium striatinum	1.761	(6.6)	0.000	(0.0)	0.044	(0.2)	0.079	(6.0)
Total Sphaeriidae	4.071	(15.3)	0.013	(7.4)	0.556	(1.9)	1.099	(82.5)
Total Benthos	26.643		0.176		28.743		1.333	

TABLE 4-35 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY DEPTH) FROM ROCK VERTICAL DISTRIBUTION SAMPLES, AUGUST 1982.

Taxa or Group	Density (No./m^2) Bottom	Top	CHI^2	Prob.	Significant Difference
Total Benthos	5357	11887	1.13	0.2888	no
Dugesia sp.	773	735	1.13	0.2888	no
Imm. Tubificidae w/o cap.	210	47	2.00	0.1573	no
Branchiura sowerbyi	52	23	0.50	0.4795	no
Limnodrilus hoffmeisteri	83	4	2.00	0.1573	no
Total Tubificidae	360	78	2.00	0.1573	no
Hyalella azteca	10	12	0.28	0.5959	no
Stenacron interpunctatum	3	152	1.53	0.2159	no
Total Heptageniidae	8	232	4.50	0.0339	yes
Imm. Hydropsychidae	90	456	2.00	0.1573	no
Cheumatopsyche	1318	3435	0.50	0.4795	no
Hydropsyche orris	750	3395	2.00	0.1573	no
Total Hydropsychidae	2326	7876	2.00	0.1573	no
Dicrotendipes sp.	11	123	4.50	0.0339	yes
Polypedilum convictum	107	639	3.12	0.0771	no
Ablabesmyia sp.	19	197	4.50	0.0339	yes
Total Chironomidae	362	2243	4.50	0.0339	yes
Imm. Sphaeriidae	1046	105	0.50	0.4795	no
Total Sphaeriidae	1243	155	0.50	0.4795	no

composition, structure and density to the faunas sampled at the corresponding wing dams in the August rock substrate survey (Table 4-3). The proportionally greater numbers of the caddisfly Cheumatopsyche sp. in the top milkcrate samples, when compared to the Cheumatopsyche densities of the rock substrate survey, was probably related to the reduced current velocities in these buried samplers. Cheumatopsyche (like the other dominant caddisfly Hydropsyche orris) requires a steady current for net spinning and filtering food; however, unlike Hydropsyche orris, Cheumatopsyche occupies areas of reduced current (Fremling 1960b). The reduced currents in the milkcrate samplers probably also attributed to the lower densities of the rheobiotic midge Rheotanytarsus sp.

Macroinvertebrate density and biomass decreased with increased depth at both locations; however, colonization of the bottom samplers was substantially less at Location 8 Slow when compared to Location 4 Fast. However, the top-bottom differences were not statistically significant at either location (Table 4-36). At Location 4 Fast, the lower portions of the bottom crates were partially filled (approximately one-half gallon) with silty sand; whereas, the bottom crates at Location 8 Slow were entirely filled (approximately two gallons) with silt and sand. The lower current velocities at Location 8 Slow (see Section 2) resulted in more sedimentation at this wing dam location and the subsequent loss of interstitial space. Because of the large amounts of silt and sand in the bottom crates at Location 8 Slow, macroinvertebrates could not colonize the rocks in the milkcrates. The few organisms collected (primarily oligochaetes and sphaeriid clams) were probably present in the interstitial sediments between the rocks. At Location 4 Fast, macroinvertebrates colonized the rocks themselves as well as the interstitial sediments in the bottom crates. Thus, the community of the bottom crates at Location 4 Fast was composed of a combination of rock- and sediment-dwelling organisms.

At Location 8 Slow, the biomass and density of the top samplers was 20-fold greater than from the bottom crates; however, the differences with depth at Location 4 Fast was much less. In addition, the vertical community composition differences at Location 4 Fast were less obvious than at Location 8 Slow. The hydropsychid caddisflies, which dominated all other samples, were sparse or absent in the bottom crates from Location 8 Slow. Hyalella azteca and chironomids (nearshore), and tubificids and sphaeriids (farshore) were the dominant organisms from the Location 8 Slow bottom samplers.

A similar vertical distribution study was conducted in the Speed River, Ontario, in which Coleman and Hynes (1970) reported macroinvertebrates evenly distributed throughout the 30.5 cm depth of the sampler. However, their study was conducted in a riffle of a trout stream thereby reducing sedimentation and providing favorable, interstitial habitat for deep colonization into the substrate.

Hydropsychid caddisflies were also the dominant organism in a 1979 sampling of a stone dike in the Lower Mississippi River (Mathis et al. 1982). Rock artificial substrates, which were implanted to the depth of each basket, yielded an average density of 102,485 organisms/m^2 of exposed dike surface (i.e., the numbers estimated below a 1m x 1m quadrat

TABLE 4-36 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY LOCATION AND DEPTH) FROM ROCK VERTICAL DISTRIBUTION SAMPLES, AUGUST 1982.

Taxa or Group	Mean Density (No./m^2)				CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different			
	Location 4		Location 8								
	Bottom	Top	Bottom	Top							
Total Benthos	10395	20846	318	7407	5.04	0.1692	no	4t	4b	8t	8b
Dugesia sp.	1546	685	0	759	3.75	0.2898	no	4b	8t	4t	68
Imm. Tubificidae w/o cap.	356	0	63	70	4.82	0.1853	no	4b	8t	8b	4t
Branchiura sowerbyii	84	0	20	35	4.18	0.2428	no	4b	8t	8b	4t
Limnodrilus hoffmeisteri	153	0	13	6	4.07	0.2539	no	4b	8b	8t	4t
Total Tubificidae	620	0	101	117	4.82	0.1853	no	4b	8t	8b	4t
Hyalella azteca	0	0	20	18	2.65	0.4485	no	8b	8t	4b	4t
Stenacron interpunctatum	5	0	0	228	4.15	0.2455	no	8t	4b	4t	8b
Total Heptageniidae	11	44	5	327	4.82	0.1853	no	8t	4t	4b	8b
Imm. Hydropsychidae	177	1077	3	146	4.82	0.1853	no	4t	4b	8t	8b
Cheumatopsyche sp.	2628	6778	9	1764	5.68	0.1283	no	4t	4b	8t	8b
Hydropsyche orris	1498	7148	1	1518	4.82	0.1853	no	4t	8t	4b	8b
Total Hydropsychidae	4638	16070	14	3778	4.82	0.1853	no	4t	4b	8t	8b
Dicrotendipes sp.	11	205	12	82	4.88	0.1812	no	4t	8t	8b	4b
Polypedilum convictum	213	1425	0	245	5.04	0.1692	no	4t	8t	4b	8b
Ablabesmyia sp.	32	65	5	263	5.68	0.1283	no	8t	4t	4b	8b
Total Chironomidae	692	3492	32	1618	5.68	0.1283	no	4t	8t	4b	8b
Imm. Sphaeriidae	2009	22	83	146	4.50	0.2123	no	4b	8t	8b	4t
Total Sphaeriidae	2398	54	88	206	3.96	0.2653	no	4b	8t	8b	4t

sampler as if it were laid on top of the dike). In the present study, the total densities in terms of exposed wing dam surface (Table 4-37) at wing dam Locations 4 Fast (67,498 organims/m^2) and Location 8 Slow (36,507 organisms/m^2) were substantially less than the densities observed in the Lower Mississippi River. The differences in density were probably related to sampling technique and habitat differences, including colonization period, current velocity and rock sizes utilized.

4.3.7 Silt and Sand Substrate Vertical Distribution Study

Differences in density and biomass were obvious in the vertical distribution study of the silt and sand habitats of Pool 5A (Tables 4-38 and 4-39). At the silt habitat (Location 6), 94 percent of the total organisms were collected in the 0-10 cm (top) sections of the core samples; only 6 percent from the 10-20 cm (middle) depths; and no organisms were present in the 20-30 cm (bottom) sections. The biomass was distributed in a similar manner except the percent of the total was even greater at the 0-10 cm depth. The density distribution observed at the sand habitat (Location 10) was very similar to the distribution at Location 6: 94 percent of the organisms in the 0-10 cm sections; 5 percent from the 10-20 cm depth; and one organism (1 percent) present in the 20-30 cm sections. The biomass of organisms at Location 10 was distributed in the same manner as the density.

A fine sand and silt substrate was present at all depths in the silt habitat (Table 4-40). Progressively greater percentages of silt and smaller amounts of sand occurred with increasing substrate depth. However, a fine floculent sediment was observed overlaying the upper portions (0-10 cm) of the core samples at Location 6. This layering may have significantly influenced the benthos because most of the benthic fauna in a silt-clay substrate occurs in the top 5 centimeters of the substrate (Ford 1962).

A predominantly medium and coarse sand sediment was present at all substrate depths sampled in the sand habitat (Location 10) (Table 4-40). The progressively greater silt and lower sand percentages at greater substrate depths, which was observed at Location 6, was also found at Location 10.

When compared to the benthic community at sand flat Location 10, the community at silt bay Location 6 contained greater densities and biomass at the 0-10 cm and 10-20 cm depths, and also for total (0-30 cm) depth. The benthic community at the 0-10 cm depth of Location 6 was dominated by chironomid midges (predominantly Chironomus sp. and Xenochironomus [Anceus] sp.) and tubificid oligochaetes (in particular Branchiura sowerbyi). Tubificid oligochaetes have been reported to depths of 15 centimeters in silt-clay substrates, but maximum concentrations occur between two and four centimeters (Milbrink 1973). In this study, tubificids were present only at the 0-10 cm depth.

Chironomus sp. continued to dominate the benthos at the 10-20 cm depth of Location 6 (Table 4-38). In a similar vertical distribution study, Cole (1953) reported larvae of Chironomus plumosus at a depth of 12 centimeters below the mud surface. Most species of Chironomus are

TABLE 4-37 TOTAL DENSITY[a] PER EXPOSED WING DAM SURFACE (No./m^2) OF THE DOMINANT (≥5%) BENTHIC MACROINVERTEBRATES COLONIZING ROCK ARTIFICIAL SUBSTRATES BURIED IN WING DAMS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

	Location 4 Fast						Location 8 Slow					
	top (0-38 cm)		bottom (38-76 cm)		Total (0-76 cm)		top (0-38 cm)		bottom (38-76 cm)		Total (0-76 cm)	
Taxa	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Turbellaria												
Dugesia sp.	437	(3.3)	8150	(15.0)	8587	(12.7)	3604	(10.2)	0	(0.0)	3604	(9.9)
Oligochaeta												
Immature w/o cap. chaetae	0	(0.0)	1857	(3.4)	1857	(2.8)	333	(0.9)	309	(22.9)	642	(1.8)
Branchiura sowerbyi	0	(0.0)	444	(0.8)	444	(0.7)	167	(0.5)	101	(7.5)	268	(0.7)
Limnodrilus hoffmeisteri	0	(0.0)	804	(1.5)	804	(1.2)	28	(0.1)	70	(5.2)	98	(0.3)
Total Tubificidae	0	(0.0)	3244	(6.0)	3244	(4.8)	555	(1.6)	499	(37.0)	1054	(2.9)
Amphipoda												
Hyalella azteca	0	(0.0)	0	(0.0)	0	(0.0)	83	(0.2)	52	(3.9)	135	(0.4)
Ephemeroptera												
Stenacron interpunctatum grp.	0	(0.0)	28	(0.1)	28	(<0.1)	1081	(3.1)	0	(0.0)	1081	(3.0)
Total Heptageniidae	28	(0.2)	56	(0.1)	84	(0.1)	1553	(4.4)	18	(1.3)	1571	(4.3)
Trichoptera												
Immature Hydropsychidae	686	(5.2)	915	(1.7)	1601	(2.4)	693	(2.0)	7	(0.5)	700	(1.9)
Cheumatopsyche sp.	4317	(32.5)	13,722	(25.3)	18,039	(26.7)	8371	(23.8)	25	(1.8)	8396	(23.0)
Hydropsyche orris	4553	(34.3)	7762	(14.3)	12,315	(18.2)	7208	(20.5)	4	(0.3)	7212	(19.8)
Total Hydropsychidae	10,236	(77.1)	24,145	(44.5)	34,381	(50.9)	17,935	(51.0)	35	(2.6)	17,970	(49.2)
Diptera												
Dicrotendipes sp.	132	(1.0)	56	(0.1)	188	(0.3)	388	(1.1)	31	(2.3)	419	(1.1)
Polypedilum convictum type	908	(6.8)	1109	(2.0)	2017	(3.0)	1165	(3.3)	0	(0.0)	1165	(3.2)
Ablabesmyia sp.	42	(0.3)	167	(0.3)	209	(0.3)	1247	(3.5)	18	(1.3)	1265	(3.5)
Total Chironomidae	2225	(16.8)	3604	(6.6)	5829	(8.6)	7678	(21.8)	111	(8.2)	7789	(21.3)
Pelecypoda												
Immature Sphaeriidae	14	(0.1)	10,423	(19.2)	10,437	(15.5)	693	92.0)	426	(31.6)	1119	(3.1)
Total Sphaeriidae	35	(0.3)	12,447	(23.0)	12,482	(18.5)	970	(2.8)	454	(33.7)	1432	(3.9)
Total Benthos	13,278		54,220		67,498		35,159		1348		36,507	

(a) Density estimates are for a m^2 of exposed wing dam surface, i.e., the numbers estimated below a 1m x 1m quadrat sampler as if it were laid on top of the wing dam.

TABLE 4-38 VERTICAL DISTRIBUTION (DENSITY AND PERCENT OCCURRENCE) OF THE DOMINANT (>5%) BENTHIC MACROINVERTEBRATES COLONIZING SILT AND SAND HABITATS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

	Location 6 - Silt Bay								Location 10 - Sand Flat							
	0-10 cm		10-20 cm		20-30 cm		Total (0-30 cm)		0-10 cm		10-20 cm		20-30 cm		Total (0-30 cm)	
Taxa	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Oligochaeta																
Dero digitata	346[a]	5.5	0	0.0	0	0.0	346	5.2	0	0.0	0	0.0	0	0.0	0	0.0
Piquetiella michiganensis	0	0.0	0	0.0	0	0.0	0	0.0	38	1.7	38	33.3	0	0.0	77	3.2
Total Naididae	653	10.4	0	0.0	0	0.0	653	9.8	77	3.4	38	33.3	0	0.0	115	4.8
Immatures w/o cap. chaetae	576	9.2	0	0.0	0	0.0	576	8.6	115	5.1	0	0.0	0	0.0	115	4.8
Aulodrilus pigueti	346	5.5	0	0.0	0	0.0	346	5.2	0	0.0	0	0.0	0	0.0	0	0.0
Branchiura sowerbyi	807	12.9	0	0.0	0	0.0	807	12.1	0	0.0	0	0.0	0	0.0	0	0.0
Total Tubificidae	1,921	30.7	0	0.0	0	0.0	1,921	28.7	154	6.8	0	0.0	0	0.0	154	6.4
Amphipoda																
Hyalella azteca	0	0.0	0	0.0	0	0.0	0	0.0	115	5.1	0	0.0	0	0.0	115	4.8
Ephemeroptera																
Hexagenia limbata	77	1.2	38	9.1	0	0.0	115	1.7	0	0.0	0	0.0	0	0.0	0	0.0
Hexagenia sp.	346	5.5	38	9.1	0	0.0	384	5.7	38	1.7	0	0.0	0	0.0	38	1.6
Total Ephemeridae	423	6.8	77	18.2	0	0.0	500	7.5	38	1.7	0	0.0	0	0.0	38	1.6
Diptera																
Ceratopogonidae	192	3.1	0	0.0	0	0.0	192	2.9	115	5.1	0	0.0	0	0.0	115	4.8
Chironomus sp.	922	14.7	154	36.4	0	0.0	1,076	16.1	0	0.0	0	0.0	0	0.0	0	0.0
Glyptotendipes sp.	0	0.0	0	0.0	0	0.0	0	0.0	307	13.6	0	0.0	0	0.0	307	12.7
Polypedilum convictum type	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	38	100.0	38	1.6
P. scalaenum type	0	0.0	0	0.0	0	0.0	0	0.0	307	13.6	0	0.0	0	0.0	307	12.6
P. simulans type	115	1.8	0	0.0	0	0.0	115	1.7	115	5.1	0	0.0	0	0.0	115	4.8
Stempellina sp.	0	0.0	0	0.0	0	0.0	0	0.0	231	10.2	0	0.0	0	0.0	231	9.5
Stictochironomus sp.	0	0.0	0	0.0	0	0.0	0	0.0	115	5.1	77	66.7	0	0.0	192	7.9
Xenochironomus (Anceus) sp.	769	12.3	0	0.0	0	0.0	769	11.5	0	0.0	0	0.0	0	0.0	0	0.0
Ablabesmyia sp.	154	2.5	38	9.1	0	0.0	192	2.9	0	0.0	0	0.0	0	0.0	0	0.0
Procladius sp.	154	2.5	38	9.1	0	0.0	192	2.9	0	0.0	0	0.0	0	0.0	0	0.0
Total Chironomidae	2,651	42.3	269	63.6	0	0.0	2,920	43.6	1,499	66.1	77	66.7	38	100.0	1,614	66.7
Pelecypoda																
Immature Sphaeriidae	0	0.0	38	9.1	0	0.0	38	0.6	0	0.0	0	0.0	0	0.0	0	0.0
Musculium transversum	0	0.0	38	9.1	0	0.0	38	0.6	0	0.0	0	0.0	0	0.0	0	0.0
Pisidium sp.	77	1.2	0	0.0	0	0.0	77	1.1	115	5.1	0	0.0	0	0.0	115	4.8
Total Sphaeriidae	77	1.2	77	18.2	0	0.0	154	2.3	115	5.1	0	0.0	0	0.0	115	4.8
Total Benthos	6,263		423		0		6,696		2,267		115		38		2,421	
Species Diversity	3.16		0.70		-				2.69		0.92		0.00			
Evenness	0.87		0.97		-				0.91		0.92		-			
Redundancy	0.14		0.03		-				0.09		0.08		-			

(a) Mean of five replicate samples.

TABLE 4-39 VERTICAL BIOMASS DISTRIBUTION (MEAN DRY WEIGHT IN g/m^2) OF THE DOMINANT (>5%) BENTHIC MACROINVERTEBRATES COLONIZING SILT AND SAND HABITATS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

	Location 6 - Silt Bay								Location 10 - Sand Flat							
	0-10 cm		10-20 cm		20-30 cm		Total (0-30 cm)		0-10 cm		10-20 cm		20-30 cm		Total (0-30 cm)	
Taxa	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2	%
Oligochaeta																
Total Tubificidae	1.518	28.2	0.000	0.0	0.000	0.0	1.518	23.8	0.121	7.2	0.000	0.0	0.000	0.0	0.121	6.8
Ephemeroptera																
Hexagenia limbata	0.455	8.5	0.227	22.7	0.000	0.0	0.682	10.7	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0
Hexagenia sp.	1.086	20.2	0.121	12.0	0.000	0.0	1.207	18.9	0.013	0.8	0.000	0.0	0.000	0.0	0.013	0.7
Total Ephemeridae	1.541	28.7	0.348	34.7	0.000	0.0	1.889	29.6	0.013	0.8	0.000	0.0	0.000	0.0	0.013	0.7
Diptera																
Total Chironomidae	1.472	27.4	0.149	14.9	0.000	0.0	1.621	25.4	0.180	10.6	0.092	97.6	0.005	100.0	0.277	15.5
Pelecypoda																
Immature Sphaeriidae	0.000	0.0	0.203	20.2	0.000	0.0	0.203	3.2	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0
Musculium transversum	0.000	0.0	0.302	30.1	0.000	0.0	0.302	4.7	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0
Pisidium sp.	0.604	11.2	0.000	0.0	0.000	0.0	0.604	9.5	1.204	71.3	0.000	0.0	0.000	0.0	1.204	67.3
Total Sphaeriidae	0.604	11.2	0.505	50.3	0.000	0.0	1.109	17.4	1.204	71.3	0.000	0.0	0.000	0.0	1.204	67.3
Total Benthos	5.374		1.002		0.000		6.376		1.689		0.095		0.005		1.789	

TABLE 4-40 PERCENT COMPOSITION, BY WEIGHT, OF THE SEDIMENT PARTICLE SIZES AND ORGANIC CARBON LEVELS IN CORE SAMPLES TAKEN FROM THREE DEPTHS IN SILT AND SAND SUBSTRATES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, AUGUST 1982

Depth and Substrate Type	Location 6 - Silt Bay						Location 10 - Sand Flat					
	A	B	C	D	E	$\bar{x}$	A	B	C	D	E	$\bar{x}$
UPPER (0-10 cm)												
Gravel*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coarse sand	0.1	0.8	0.3	0.2	0.5	0.4	22.1	39.1	15.4	22.7	37.0	27.3
Medium sand	2.0	1.2	5.3	8.0	19.2	7.1	40.2	46.0	61.2	47.2	48.0	48.5
Fine sand	40.7	17.0	43.6	26.6	43.1	34.2	18.1	8.2	16.8	22.9	10.0	15.2
Very fine sand	25.0	26.0	16.0	13.9	9.8	18.1	9.8	2.0	4.4	3.5	1.3	4.2
Silt	23.1	48.9	29.7	43.9	24.3	34.0	8.7	4.2	2.2	1.6	2.2	3.8
Clay	2.0	2.0	2.0	2.1	2.1	2.0	1.1	0.5	<0.5	1.1	0.5	0.7
Colloid	7.1	4.1	3.1	5.3	1.0	4.1	<0.5	<0.5	<0.5	1.0	<0.5	0.6
Organic Carbon	1.5	4.1	2.4	3.7	2.3	2.8	0.7	0.5	9.6	0.5	0.3	2.3
MIDDLE (10-20 cm)												
Gravel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coarse sand	0.2	0.6	0.4	0.2	0.3	0.3	6.7	22.6	25.3	5.7	34.2	18.9
Medium sand	0.7	2.8	0.8	3.3	4.9	2.5	7.7	33.3	53.3	10.8	44.2	30.0
Fine sand	14.3	6.1	17.1	25.7	27.3	18.1	5.8	7.3	13.8	20.9	13.7	12.3
Very fine sand	32.2	22.6	22.8	22.1	15.2	23.0	24.1	5.5	4.0	35.0	3.1	14.3
Silt	52.6	61.8	53.6	41.3	46.1	51.1	42.3	24.2	3.6	23.6	3.3	19.4
Clay	<0.5	4.1	2.1	2.1	4.1	2.6	5.2	2.0	<0.5	1.0	0.5	1.8
Colloid	<0.5	2.0	3.2	5.3	2.1	2.6	8.2	5.1	<0.5	3.0	1.0	3.6
Organic Carbon	1.6	2.1	3.0	3.2	1.2	2.2	3.2	2.6	3.5	1.9	1.4	2.5
LOWER (20-30 cm)												
Gravel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coarse sand	0.2	12.5	0.2	0.2	0.2	2.7	0.2	39.1	17.8	5.9	13.9	15.4
Medium sand	1.1	30.8	0.9	1.0	2.3	7.2	2.0	37.0	35.6	9.4	31.7	23.1
Fine sand	4.3	7.8	3.3	1.9	6.5	4.8	6.0	8.8	14.9	19.4	9.5	11.7
Very fine sand	16.2	8.8	26.6	17.2	13.8	16.5	31.1	3.0	7.8	31.4	14.6	11.4
Silt	70.0	35.0	59.1	69.6	67.8	60.3	47.3	9.1	17.8	28.9	25.3	25.7
Clay	4.1	3.1	2.2	4.5	4.2	3.6	3.1	2.0	3.1	3.0	3.0	2.8
Colloid	4.1	2.0	7.7	5.6	5.2	4.9	10.3	1.0	3.0	2.0	2.0	3.7
Organic Carbon	4.4	3.8	4.5	2.3	2.6	3.5	1.5	1.3	1.5	1.8	1.7	1.6

* Particle size classifications are defined in Section 4.2.2 Laboratory Procedures.

burrowers in soft substrates and are tolerant of a variety of habitats (Simpson and Bode 1980).

Generally chironomid larvae only penetrate a few centimeters of the substrate and 95 percent of the larvae occur in the upper 10 centimeters of the substrate (Oliver 1971). In the present study, the top 10 centimeters of substrate at Locations 6 and 10 yielded 91 and 93 percent, respectively, of the total number of midges collected.

Despite a decrease in density, Hexagenia nymphs at silt bay Location 6 made up a greater portion of the benthic fauna at the 10-20 cm depth (18 percent) than at 0-10 cm (7 percent). The characteristic burrowing habit of Hexagenia nymphs and their tolerance to low dissolved oxygen levels (Fremling 1970) allow this taxon to survive at lower depths in the substrate. Because Hexagenia nymphs burrow to a maximum depth of approximately 12.7 centimeters (Hunt 1953), the lower densities in the 10-20 cm cores and their absence in the 20-30 cm core were expected.

Fingernail clams (Musculium transversum and immature individuals) were a relatively large component of the benthos (18 percent of the total organisms) and biomass (50 percent of the total weight) at the 10-20 cm depth of Location 6. Gale (1976) found small individuals of M. transversum as deep as 16 centimeters in clayey silt substrates in Pool 19 of the UMR. He reported the maximum and mean penetration to be least in sand substrates. Sand is a poor substrate for burrowing organisms because of the problems in maintaining burrows and the relatively small amount of organic matter.

The relatively sparse benthic community at Location 10 (2421 organisms/m^2) was dominated (67 percent of the benthos) by chironomid midges (Table 4-38). Glyptotendipes sp., Polypedilum scalaenum type and Stempellina sp. were the dominant midges collected in the 0-10 cm section of the core samples. Only four organisms (primarily midges) were collected in the 10-20 and 20-30 cm core sections from the sand habitat.

As expected, the density, biomass, species diversity and structure of the communities observed at the silt and sand locations in the vertical distribution study were nearly identical to the respective communities sampled in the silt and sand habitat survey in August (Tables 4-14 and 4-17). In both samplings, oligochaetes and chironomids were the dominant taxa from silt bay Location 6 and chironomids dominated the benthic community at sand flat Location 10. However, greater densities of Xenochironomus (Anceus) sp. and Glyptotendipes sp. were noted at Locations 6 and 10, respectively, in the vertical distribution study.

4.3.8 Freshwater Mussel Survey

A total of 17 freshwater mussel species were collected from the rock structures and habitats surveyed in Pool 5A during 1982 (Table 4-41). The mussel fauna sampled in this portion of Pool 5A was found to be low in density and diversity. Recent surveys of Pool 5A revealed an equally sparse diversity and density of mussels (Fuller 1980, Thiel 1981). However, earlier surveys in this reach of the UMR yielded substantially more species. Surveys by Grier in 1920 (Grier 1922) and Ellis in

TABLE 4-41 FRESHWATER MUSSEL SPECIES COLLECTED IN RECENT SURVEYS OF POOL 5A IN THE UPPER MISSISSIPPI RIVER, 1977 - 1982

Scientific Name	Common Name	1978 [a]	1977-1979 [b]	1982 [c]
Unionidae				
Ambleminae				
Amblema plicata (Lamarck)	Three-ridge	X	X	X
Fusconaia undata (Barnes)	Pig-toe	X	X	X
Quadrula nodulata (Rafinesque)	Warty-back	-	-	X
Q. pustulosa (Lea)	Pimple-back	X	X	X
Unioninae				
Anodonta corpulenta (Cooper)	Stout Floater	X	X	X
A. imbecillis (Say)	Paper Pond Shell	-	-	X
Carunculina parva (Barnes)	Lilliput Shell	X	-	X
Lampsilis ventricosa (Barnes)	Pocketbook	-	X	X
Lasmigona complanata (Barnes)	White Heel-splitter	-	-	X
Leptodea fragilis (Rafinesque)	Fragile Paper-shell	-	X	X
L. laevissima (Lea)	Pink Paper-shell	X	-	X
Ligumia recta latissima (Rafinesque)	Black Sandshell	-	-	X
Obliquaria reflexa (Refinesque)	Three-horned Warty-back	X	X	X
Obovaria olivaria (Rafinesque)	Hickory-nut	X	X	X
Plagiola lineolata (Rafinesque)	Butterfly	-	X	-
Proptera alata (Say)	Pink Heel-splitter	-	-	X
Strophitus undulatus (Say)	Strange Floater	-	X	-
Truncilla donaciformis (Lea)	Fawn's Foot	X	X	X
T. truncata (Rafinesque)	Deer-toe	X	-	X
Total Species		10	11	17

---

[a] Philadelphia Academy of Science (Fuller 1980).

[b] Wisconsin Department of Natural Resources (Thiel 1981).

[c] Ecological Analysts, Inc.

1930-1931 (van der Schalie and van der Schalie 1950) collected 37 and 38 species, respectively.

In the present study of Pool 5A, the wing dams (Locations 4 Fast and 8 Slow) and sand habitat (Location 10) yielded more species than did the riprapped banks (Location 3 Slow and 3 Fast) and the silt habitat (Location 6) (Table 4-42). In addition, the occurrence (and abundance) of mussels at the wing dams and sand habitat, although sporadic, was generally much greater than the riprapped bank and silt habitat. Most of the sand habitat was not favorable for mussels; however, mussels were commonly collected in the portions of this habitat that had a stable substrate. The steady current near the wing dams and sand habitat were more favorable for mussel colonization than the low or insignificant current velocities at the riprapped bank and silt habitats. In addition, the stable interstitial substrate of the wing dams and the areas of stable substrate at the sand habitat provided a favorable habitat for many species.

The survey of the riprapped bank habitats (Locations 3 Slow and 3 Fast) by a diver yielded only a few individuals of Anodonta imbecillis, Lampsilis ventricosa, Leptodea fragilis and Proptera alata. The wing dams had both more species and greater numbers of mussels than the riprapped bank. Location 8 Slow had the greatest mussel concentration of all habitats sampled (Table 4-43); however, the individuals were scattered and not abundant at any particular location along the wing dam. A diverse but sparse mussel fauna was also present at Location 4 Fast. In general, most of the individuals from Locations 4 Fast and 8 Slow were collected from the area immediately upstream and downstream from the wing dams. The remaining individuals were collected from interstitial sand pockets among the rocks of the wing dams. Amblema plicata was the dominant species at Location 8 Slow (48 percent of the total fauna). Location 4 Fast was not dominated by any species; however, A. plicata was also relatively common at this structure (3 individuals, 20 percent of the total). Amblema plicata was also the dominant species in the 1978 (Fuller 1980) and 1977-1979 (Thiel 1981) surveys of Pool 5A (28 and 33 percent of the fauna, respectively).

The rock habitat survey of Pool 5A also yielded several mussel species during 1982. Most individuals were juveniles attached to the rocks by their byssal threads. The byssal threads allow these fragile juveniles to colonize and survive in this harsh environment. Juveniles of L. fragilis and Truncilla donaciformis were the most commonly collected species. As was noted during the diver survey, wing dams also yielded a greater number of species and individuals during the rock habitat survey than did the riprapped bank structures.

4.4 SUMMARY AND CONCLUSIONS

4.4.1 Rock Substrate Survey

The macroinvertebrate communities of the wing dams sampled in Pool 5A were generally dominated (in terms of numerical density and biomass) by hydropsychid caddisflies, which is typical for stable, fast-water environments in the Midwest. The communities of the slower current

TABLE 4-42 FRESHWATER MUSSEL SPECIES COLLECTED BY ALL SAMPLING TECHNIQUES IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, 1982

Species	Riprapped Bank		Wing Dam	Silt Bay	Wing Dam	Sand Flat
	3 Slow	3 Fast	4 Fast	6	8 Slow	10
Unionidae						
Ambleminae						
Amblema plicata	-	-	X	-	X	X
Fusconaia undata	-	-	X	-	X	-
Quadrula nodulata	-	-	-	-	X	-
Q. pustulosa	-	-	X	-	X	-
Unioninae						
Anodonta corpulenta	-	-	-	-	X	X
A. imbecillis	X	X	-	X	-	X
Carunculina parva	-	-	-	X	-	X
Lampsilis ventricosa	-	X	X	-	X	X
Lasmigona complanata	-	-	-	-	X	X
Leptodea fragilis	X	X	X	-	X	X
L. laevissima	-	-	-	-	X	-
Ligumia recta latissima	-	-	X	-	-	-
Obliquaria reflexa	-	-	X	-	X	-
Obovaria olivaria	-	-	X	-	X	-
Proptera alata	-	X	X	-	X	-
Truncilla donaciformis	-	-	X	-	X	X
T. truncata	-	-	-	-	X	-
Total Species	2	4	10	2	14	8

TABLE 4-43 NUMBER AND PERCENT OCCURRENCE OF FRESHWATER MUSSEL SPECIES COLLECTED DURING THE WING DAM SURVEYS IN POOL 5A OF THE UPPER MISSISSIPPI RIVER, 1982

Species	Wing Dam			
	4 Fast		8 Slow	
	No.	%	No.	%
Unionidae				
Ambleminae				
Amblema plicata	3(a)	20.0	86	47.8
Fusconaia undata	1	6.7	27	15.0
Quadrula nodulata	0	0.0	1	0.6
Q. pustulosa	1	6.7	18	10.0
Unioninae				
Anodonta corpulenta	0	0.0	2	1.1
Lampsilis ventricosa	1	6.7	6	3.3
Lasmigona complanata	0	0.0	1	0.6
Leptodea fragilis	4	26.7	10	5.6
L. laevissima	0	0.0	1	0.6
Ligumia recta latissima	1	6.7	0	0.0
Obliquaria reflexa	0	0.0	14	7.8
Obovaria olivaria	2	13.3	1	0.6
Proptera alata	1	6.7	1	0.6
Truncilla donaciformis	1	6.7	11	6.1
T. truncata	0	0.0	1	0.6
Total Number	15		180	

(a) Numbers represent the total individuals collected along a 45 meter long wing dam (Location 4 Fast) and a 150 meter long wing dam (Location 8 Slow).

riprapped bank locations were usually dominated by chironomid midges and heptageniid mayflies, which is characteristic of a depositional habitat. The comparatively greater densities and biomass at the wing dam locations in 1982 were attributed to the higher current velocities at these locations and the resultant greater densities of rheobiotic organisms. The density, biomass and diversity values for the wing dam at Location 8 Slow in 1982 were intermediate between the values for the wing dam at Location 4 Fast and those at the riprapped bank locations (Figure 4-1). These differences were attributed to the intermediate current velocity values recorded at this location.

Spatial comparisons by habitat type revealed generally similar communities at all habitats. However, significantly greater populations of Naididae, _Hyalella azteca_, _Cricotopus bicinctus_ group and Empididae were collected from the With Periphyton habitat of the rock structures. These taxa are often found in association with periphytic algae. These differences were most evident in August and September when the periphytic algae growth was most luxuriant. Because of the greater current velocities farther from shore, the Deep habitats generally yielded greater densities of rheophilic organisms than the slower-velocity shallow habitats.

In general, most locations exhibited a trend of increasing density and biomass from June to September (Figures 4-2 and 4-3, respectively). The most dramatic increase occurred at the wing dam locations from June to August. This large increase was the result of the greater densities of hydropsychid caddisflies.

The riprapped bank and wing dam locations had similar communities during the high flows of June; however, the low flows of August and September resulted in quite different communities at these two structure types. In August and September, lotic organisms increased in density at the fast-water wing dam locations while lentic taxa became more important on the slow-water riprapped banks.

4.4.2 Silt and Sand Substrate Survey

Nematodes and burrowing organisms such as the naidid _Dero digitata_, tubificid oligochaetes, the mayfly _Hexagenia_ and the midge _Chironomus_ sp. dominated the silt habitat community in 1982. The sparse fauna at the sand habitat was generally dominated by a variety of organisms, especially oligochaetes and chironomids. The density, diversity and biomass of the silt habitat fauna was usually much greater than the community in the sand habitat. Similarly, most of the dominant taxa and groups had significantly greater densities in the silt habitat. The unstable sand and lower organic content of the sand flat sediments contributed to the sparse fauna at this location. During 1982, the total density and biomass increased progressively from June to September at both the silt and the sand habitats.

4.4.3 Wood Substrate Survey

The wood artificial substrates placed at the wing dams yielded a fauna similar in composition and diversity to that collected from their respective locations during the rock habitat survey. However, the total benthos and biomass from the wood substrates was two to four times greater than the densities from the natural rock substrates. The greater densities from the wood artificial substrates was probably related to relatively rough surface of the wood and the more diverse habitats provided by this type of substrate. Hydropsychid caddisflies generally dominated the wing dam fauna by number and weight. Conversely, the samplers at the sand habitat (Location 10) were dominated by the midge Glyptotendipes sp. The fauna on the samplers at the sand flat was unlike the nearby benthic fauna, indicating the samplers were probably colonized primarily by drifting organisms. When present, crayfish composed a large portion of the wood substrate biomass.

4.4.4 Aquatic Plant Habitat Survey

The macroinvertebrate communities associated with all three macrophyte species studied were dominated by chironomid midges. The total benthos was greatest from the Heteranthera dubia bed in terms of No./m^2 of bottom substrate and from Potamogeton pectinatus in terms of No./g of macrophyte (dry weight). The relatively low densities collected from Vallisneria americana were attributed to the broader leaves of this species and proportionally smaller surface area (when comparing equal amounts of plants). Macrophytes with finely-divided leaves generally support greater numbers of invertebrates. The macroinvertebrate biomass of the macrophyte samples was dominated by chironomids and various uncommon but large-bodied organisms. Heteranthera and Vallisneria yielded the greatest macroinvertebrate biomass in terms of g/m^2.

The sediments in the three macrophyte beds were colonized primarily by naidid and tubificid oligochaetes, and chironomid midges. The density of the benthos from the Vallisneria sediments was significantly greater than from the two other locations. The greater densities near Vallisneria was probably related to a combination of the favorable hydrology at this location and the stabilizing influence of Vallisneria's extensive root system. The sediment community was apparently heavily influenced by the fauna on the macrophytes because, except for the greater number of oligochaetes in the sediment samples, both communities had relatively similar composition. Densities from the macrophyte sediments were nearly ten times the density in the nearby open-water sand habitat (Location 10) and three times the density in the silt bay (Location 6).

Tubificids dominated the biomass from the macrophyte sediments in August. Although they were not numerically abundant, large-bodied molluscs were also large components of the biomass. Total biomass was greatest from the Vallisneria and Heteranthera sediments.

4.4.5 Crayfish Collection

During the 1982 crayfish study, only four individuals were collected in the combined crayfish and minnow trap collections. All individuals were collected in June and all were relatively large (65-75 millimeters), female Orconectes virilis.

4.4.6 Rock Substrate Vertical Distribution Study

The densities and biomass (in terms of surface areas of all rocks sampled) was much greater from the top sampler (0-38 cm deep) within each wing dam than from the bottom sampler (38-76 cm deep). Samplers at Location 8 Slow had substantially lower densities than those at Location 4 Fast; this was particularly evident for the bottom samplers. The lower densities at Location 8 Slow were attributed to the lower current velocities and greater sedimentation at this structure.

The communities of the top samplers were similar to the communities at their respective locations that were sampled during the rock substrate survey. Hydropsychid caddisflies dominated the top samplers at both wing dams. Because of the reduced currents and greater sedimentation, the fauna from the bottom samplers at Location 4 Fast yielded greater tubificid oligochaetes and sphaeriid clams, and fewer hydropsychids than the top sampler community. The bottom sample fauna at Location 8 Slow was very sparse and entirely different in composition from the top samplers.

4.4.7 Sand and Silt Substrate Vertical Distribution Study

The vertical distribution of the benthic macroinvertebrates was relatively restricted in the silt and sand habitats of Pool 5A. At both locations, 94 percent of the organisms were collected from the top 10 centimeters of substrate. The few individuals collected from the 10-30 centimeter depths were generally burrowing organisms (e.g., the mayfly Hexagenia and the midge Chironomus), which can tolerate this type of environment. As expected, the fauna found during the vertical distribution study was nearly identical to communities found at these locations during the silt and sand substrate survey.

4.4.8 Freshwater Mussel Survey

Seventeen species of freshwater mussels were collected from the MCB habitats of Pool 5A in 1982. The wing dam locations yielded denser and more diverse mussel assemblages than did the riprapped bank locations; however, mussels were not abundant at any of the locations sampled during the present survey. Juvenile mussels were frequently found in the rock habitat survey, attached to the rocks by their byssal threads.

Recent surveys have also indicated a sparse mussel fauna in Pool 5A. The sand substrate that typically occurs in most main channel and main channel border areas of Pool 5A is not conducive to colonization by freshwater mussels. However, based on the comparatively greater densities found there, wing dams apparently provide areas of stable sediments in Pool 5A which are favorable for mussels.

4.4.9 General Summary

The 1982 survey of MCB rock structures indicated that wing dams yield more macroinvertebrate biomass and significantly greater total densities than the riprapped banks. These differences were related primarily to the significantly greater populations of hydropsychid caddisflies on the wing dams. Other community differences between structure types were also noted for the less abundant taxa. Generally, riprapped banks (which had slower currents) had greater populations of lentic species (primarily grazers, collectors and gatherers) and the fast current wing dams yielded greater populations of lotic species (especially net-spinning filter feeders).

The ecological value of these differences can be weighed in terms of fish food importance. In a study of food habits of fish in Pool 19, Hoopes (1960) found that hydropsychid caddisflies were important components of stomach contents in several fish species and especially valuable for shovelnose sturgeon; however, of the hydropsychid caddisflies, the species Cheumatopsyche campyla and Hydropsyche orris were not significant as food organisms in the fish examined. Although the value of these dominant species in Pool 5A in terms of fish food is questionable, their importance in the UMR as filter feeders and in lower level energy transfer is immense.

Regardless of the variations in specific food utilization, aquatic macroinvertebrates, in general, are extremely important food items for most fish species at some point in their development. In terms of macroinvertebrate biomass, the total biomass was generally greater on the wing dams (especially Location 4 Fast) than on the riprapped banks. Current velocity appeared to be the controlling factor. At most habitats on the rock structures, the biomass increased as the current velocity increased.

Habitat type on the rock structures (i.e., With Periphyton, Without Periphyton, and Deep) exhibited no consistent differences among each other in terms of total benthos or total biomass. Although a greater number of algal-preferring organisms were collected at the With Periphyton habitat in August and September, the total benthos was not significantly greater than at the other habitats.

The vertical distribution study within wing dams indicated that samplers at both wing dams (but especially at Location 4 Fast) were heavily colonized at the 0-38cm depth, but that colonization was less at greater depths (38-76 cm below the surface of the wing dam). Deep colonization was especially restricted at Location 8 Slow, probably because of the slower currents and greater sedimentation at this wing dam. The differences in the vertical distribution of macroinvertebrates between the two wing dam communities indicated that the higher current velocities at Location 4 Fast resulted in less sedimentation than at Location 8 Slow, thereby allowing for greater vertical colonization. In addition, the variable currents at the greater depths within Location 4 Fast would probably result in a greater number and variety of microhabitats present within this wing dam. Thus, one would expect that wing dams like Location 4 Fast with faster currents would have more organisms than wing dams like Location 8 Slow.

In summary, the macroinvertebrate studies of the Pool 5A rock structures indicated that wing dams, especially wing dams in fast current (generally >0.3 m/sec), are more productive in terms of density and biomass than the riprapped bank locations. In addition, the wing dams with faster currents have much greater vertical colonization within the rocks of the structure than the wing dams in slow current. The greater vertical colonization at Location 4 Fast is a further indication of the greater importance of fast-water wing dams in terms of macroinvertebrate production. Of all the MCB habitats sampled in 1982 (except the macrophyte habitat), wing dams yielded the greatest macroinvertebrate densities and biomass. When density calculations included the organisms from vertical as well as horizontal substrate colonization, the macroinvertebrate densities on the wing dams were also greater than the densities at the macrophyte habitats.

Although they make up a small portion of the total MCB habitat, channel-training structures such as wing dams and riprapped banks are extremely productive habitats in Pool 5A. In addition, these structures provide a favorable substrate for both lotic and lentic organisms that require an epilithic habitat.

The present study also indicated that water depth, and presence or absence of periphyton growth has little effect upon macroinvertebrate colonization of the rock structures. The macroinvertebrate community, however, was greatly affected by season. The densities and biomass increased progressively from June to September. The increased densities in late summer, which were attributed primarily to the early- and late-summer hatching and maturation of aquatic insects, indicated that mid-summer would be the most favorable time for maintenance activities on the rock structures. Although macroinvertebrate densities are greastest during this period and many individuals would potentially be disturbed by this activity, recolonization of the structure (by drifting organisms and through reproduction) would be much faster than in any other season. Maintenance activity in the spring (prior to periods of reproduction when population densities are low) and fall (prior to the period of winter inactivity) would more severly affect the organisms in terms of the total ecosystem and the community at the individual structure.

In the 1982 survey of Pool 5A MCB habitats, the sand substrate generally yielded one-half the total densities and biomass that occurred in the silt substrates. The sand substrate was the least productive of all locations and habitats sampled in Pool 5A. The protected environment of the silt bay (Location 6) provided a stable silty substrate with sufficient foodstuff available, which was favorable for a variety of lentic organisms. The sand flat (Location 10) was much less productive than the silt bay, probably because of the unstable nature of the substrate and lesser amounts of organic carbon (i.e., food) present. Although a large portion of the benthic fauna in the silt bay (nematodes and oligochaetes) is not heavily utilized as fish food (Neuswanger et al. 1982), this backwater area is a relatively productive habitat of the MCB and contains large populations of important UMR fish food items (e.g., Hexagenia and chironomids). The silt bay (Location 6) and all similar habitats in the MCB should be protected from any physical, chemical or biological alteration resulting from channel maintenance activity.

The macroinvertebrate density and biomass from the silt substrate was similar to the totals from the rock samples at the slow velocity wing dam (Location 8 Slow). However, several of the dominant taxa from the silt substrate (e.g., nematodes and oligochaetes) are not important fish food items so the value of this substrate is somewhat diminished. In addition, vertical colonization of the silt and sand was very limited. Most of the organisms (94 percent) were restricted to the first (i.e., top) 10 centimeters of the substrate. In contrast, the vertical distribution study showed that rocks on wing dams were heavily colonized to a depth of 38 centimeters and in fast current areas like Location 4 Fast, remained heavily colonized at the 38-76 centimeter depth.

The density and biomass from the wood artificial substrates was two to four times greater than the community on the rocks of the wing dam. Although similar faunas were present on both types of substrates, the rough surface of the wood substrates allowed greater colonization and a greater variety of microhabitats than on the rock substrates. Apparently, the willow matting utilized in wing dam construction provides an excellent substrate for macroinvertebrate colonization. In a 1980 survey of wing dams, Fremling (in Anderson et al. 1983) noted that after 50 years the willow matting was still in place. Thus, the willow matting should be considered as a permanent substrate of the wing dam that is particularly important in terms of macroinvertebrate production.

The artificial substrate communities were affected by both current velocity and the habitat adjacent to the samplers. The influence of current on the samplers was evident because rheophilic organisms were dominant at the faster-water wing dams while lentic taxa were most abundant at the slower-water sand flat. The samplers on the wing dams were probably colonized directly from the fauna on the rocks of the wing dam as evidenced by the similar communities on both the natural and artificial substrates. However, because of the sparse benthic fauna near the samplers at the sand flats, these artificial substrates were probably colonized primarily by drifting organisms and not by organisms from the adjacent substrates. These data suggest that the wing dams not only provide favorable habitats for rheophilic, epilithic organisms in a portion of the UMR where this habitat type is scarce but are also a source of these organisms for recruitment to other areas of the UMR.

As expected, the aquatic macrophytes yielded the greatest densities per square meter of bottom substrate of all habitats sampled in 1982. The density estimates for the macrophyte samples are based on the area of bottom substrate sampled since the surface area of the macrophytes within the samples could not be determined. Because of the extensive macrophyte stems and leaves in each sample, the actual macroinvertebrate density (no./m^2 of macrophyte surface area) was probably much less than the density as no./m^2 of bottom substrate. The mean densities of macroinvertebrates associated with the macrophytes were 4 times the densities on the wing dams and 12 times the densities on the riprapped banks. Because of the numerous small-bodied organisms on the macrophytes (e.g., naidids and chironomids), the macroinvertebrate biomass from the macrophytes was less than half the wing dam biomass for fast current (Location 4 Fast) and slightly less than the biomass on the slow current wing dam (Location 8 Slow).

Sediments within macrophyte beds yielded ten times the total density that occurred in nearby open-water sand areas and three times the total from the silt substrate. The biomass from the macrophyte sediments was also greater than the biomass from the silt and sand substrates. However, as was found in the silt substrate samples, the macrophyte sediments were dominated by tubificid oligochaetes which are important as fish food for only a few nongame species. The greater densities and biomass from the macrophyte sediments were attributed to stabilizing influence of the macrophytes on the sediments and to the influence of the macrophyte fauna on the sediment community. Macrophytes and macrophyte sediments are productive habitats of the MCB and require protection from any adverse effects of channel maintenance or construction activities.

As was observed in other macroinvertebrate studies on the Pool 5A rock structures, the wing dams yielded greater densities of freshwater mussels than was collected from the riprapped bank locations. Adult individuals were collected from the interstitial sediments of the rocks and immediately upstream and downstream from the wing dams. Juvenile mussels were attached to the rocks by their byssal threads. Although densities were low at all locations, the slow current wing dam (Location 8 Slow) had the greatest number and species of mussels. Apparently the stable substrate and steady current of the slow current wing dam provided appropriate conditions for freshwater mussel colonization.

4.5 RECOMMENDATIONS

The field and laboratory methods utilized in the rock habitat survey worked well in characterizing the rock structures of Pool 5A. However, several changes are recommended for future samplings.

Community fluctuations were well characterized from June through September, however, faunal changes on the rock structures and other MCB habitats from mid-fall through mid-spring remain undocumented. Although sampling by scuba diving is difficult during cold-water periods, data from these seasons would be valuable.

Because of inadequate periphytic algae growth, the With Periphyton and Without Periphyton habitats were difficult to distinguish in June. This particular comparison should be made only in August or September when periphyton growth is most luxuriant.

Although it is extremely difficult to predict how current velocities will vary over the course of a study, channel training structures which are expected to retain their Fast or Slow classification throughout the study should be selected. In the present study, the current velocities at Location 3 Fast decreased during the low flow in August so that velocities and subsequent communities at Locations 3 Fast and 3 Slow were very similar.

The silt and sand habitat survey provided an excellent comparison of the communities colonizing these Pool 5A habitats. However, the silt habitat was strongly influenced by the main channel. The large sand percentage in the sediments at this location and the relatively low densities of the burrowing mayfly <u>Hexagenia</u> indicated that a more protected backwater area would better represent a typical UMR silt habitat. On the other hand, Location 6 probably is representative of MCB silt habitats. Future studies need to decide whether it is more important to sample a.pure substrate type (i.e., silt) or to sample a habitat (i.e., MCB habitats).

The crayfish collections were not successful during 1982 for a variety of reasons. The collection of crayfish in many wood artificial substrate and milkcrate samplers indicates that a longer collection period is needed if crayfish traps are used. Also, partially burying of the traps might also aid in these collections.

The present study detailed the macroinvertebrate occurrence on the rock structures and other MCB habitats of Pool 5A, but to assess the importance of these various habitats properly, fish stomach studies should be conducted in conjunction with the macroinvertebrate surveys. The fish stomach studies would determine which benthic species are being utilized for food, their relative importance, and the season(s) in which they are most important. It would provide a means for assigning the value of a particular structure or habitat to other levels in the ecosystem.

4.6 REFERENCES CITED

Anderson, D., D. Wilcox, D. McConville and J. Smith. 1983. Physical and biological investigations of the main channel border (MCB) habitat of Pool 5A on the Upper Mississippi River in 1980. Corps of Engineers, St. Paul district, St. Paul, Minnesota.

Anderson, J.B. and W.T. Mason, Jr. 1968. A comparison of benthic macroinvertebrates collected by dredge and basket sampler. Journ. Water Poll. Contr. Federation 40(2):252-259.

Beck, W.M., Jr. 1977. Environmental requirements and pollution tolerance of common freshwater Chironomidae. Report no. EPA-600/4-77-024, U.S. Environmental Protection Agency, 261 p.

Beckett, D.C. 1982. Phenology of Hydropsyche orris (Trichoptera: Hydropsychidae) in the Ohio River: changes in larval age structure and substrate colonization rates. Env. Entom. 11(6): 1154-1158.

Beckett, D.C. and M.C. Miller. 1982. Macroinvertebrate colonization of multiplate samplers in the Ohio River: the effects of dams. Can. J. Fish. Aquat. Sci. 39 (12): 1622-1627.

Bishop, J.E. and H.B.N. Hynes. 1969. Downstream drift of the invertebrate fauna in a stream ecosystem. Arch. Hydrobiol. 66(1): 56-90.

Boesch, D.R. 1977. Application of numerical classification in ecological investigations of water pollution. U.S. EPA Report No. 600/3-77-033.

Boland, D.H.P. 1976. Trophic classification of lakes using LANDSAT-1 (ERTS-1) multispectral scanner data. U.S. EPA Report No. 600/3-76-037.

Bray, J.R. and J.T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. Ecol. Mono. 32:137-166.

Bousfield, E.L. 1958. Freshwater amphipod crustaceans of glaciated North America. Canadian Field-Naturalist 72:55-113.

Brinkhurst, R.O. and B.R. Jamieson. 1971. Aquatic Oligochaeta of the world. University of Toronto Press, Toronto, Canada, 860 p.

Burch, J.B. 1973. Biota of freshwater ecosystems-identification manual No. 3-freshwater sphaeriacean clams (Mollusca: Pelecypoda) of North America. Water Pollution Contr. Res. Ser. Rpt. 18050 ELDO. U.S. Environmental Protection Agency, 31 p.

Burch, J.B. 1982. Freshwater snails (Mollusca: Gastropoda) of North America. Report no. EPA-600/3-82-033. U.S. Environmental Protection Agency, 294 p.

Clark, L.H. and T.N. Seng. 1974. Artificial substrate studies, in Operational Environmental monitoring in the Mississippi River near

Quad-Cities Station, February 1974 through July 1974. Report to Commonwealth Edison Company, Chicago, Illinois, by Industrial BIO-TEST Laboratories, Inc., Norhtbrook, Illinois. pp. 223-264.

Cole, G.A. 1953. Notes on the vertical distribution of organisms in the profundal sediments of Douglas Lake, Michigan. Amer. Midl. Nat. 49(1):252-256.

Coleman, M.J. and H.B.N. Hynes. 1970. The vertical distribution of the invertebrate fauna in the bed of a stream. Limnol. Oceanog. 15:31-40.

Dorris, T.C. and B.J. Copeland. 1962. Limnology of the Middle Mississippi River. III. Mayfly populations in relation to navigation water-level control. Limnol. Oceanog. 7:240-247.

Eckblad, J.W., N.L. Peterson, K. Ostlie and A. Temte. 1977. The morphometry, benthos and sedimentation rates of a floodplain lake in Pool 9 of the Upper Mississippi River. Am. Midl. Nat. 97(2):433-443.

Edmunds, G.F., Jr., S.L. Jensen, and L. Berner. 1976. The mayflies of North and Central America. Univ. of Minnesota Press, Minneapolis. 330 p.

Flowers, R.W. and W.L. Hilsenhoff. 1978. Life cycles and habitats of Wisconsin Heptageniidae (Ephemeroptera). Hydrobiologia 60(2):159-171.

Ford, J.B. 1962. The vertical distribution of larval Chironomidae (Dipt.) in the mud of a stream. Hydrobiologia 19(3):262-272.

Fremling, C.R. 1960a. Biology of a large mayfly, Hexagenia bilineata (Say) of the Upper Mississippi River. Iowa State University Research Bulletin 482:841-852.

Fremling, C.R. 1960b. Biology and possible control of nuisance caddisflies of the Upper Mississippi River. Iowa State University Research Bulletin 483:854-879.

Fremling, C.R. 1970. Mayfly distribution as a water quality index. Water Poll. Control Res. Series, U.S.E.P.A., Program No. 16030 DQH, 39 p.

Fremling, C.R., D.N. Nielsen, D.R. McConville, R.N. Vose, and R.A. Faber. 1979. The feasibility and environmental effects of opening side channels in five areas of the Mississippi River (West Newton Chute, Fountain City Bay, Sam Gordy's Slough, Kruger Slough and Island 42). Final report to U.S. Fish and Wildlife Service, Twin Cities, Minn.

Fuller, S.L.H. 1980. Freshwater mussels of the Upper Mississippi River: Observations at selected sites within the 9-foot navigation channel project for the St. Paul District, U.S. Army Corps of Engineers, 1977-1979. Acad. Nat. Sci. Phila. Vol. I, Text 175 pp; Vol. II, Appendices, 441 p.

Gale, W.F. 1975. Bottom fauna of a segment of Pool 19, Mississippi River, near Fort Madison, Iowa, 1967-1968. Iowa State J. Res. 49:353-372.

Gale, W.F. 1976. Vertical distribution and burrowing behavior of the fingernail clam, Sphaerium transversum. Malacologia 15(2):401-409.

Gerking, S.D. 1957. A method of sampling the littoral macrofauna and its application. Ecology 38:219-226.

Gerrish, N. and J.M. Bristow. 1979. Macroinvertebrate associations with aquatic macrophytes and artificial substrates. J. Great Lakes Res. 5(1):69-72.

Grier, N.M. 1922. Final report on the study and appraisal of mussel resources in selected areas of the Upper Mississippi River. Am. Midl. Nat. 8:1-33.

Hamilton, A.L., O.A. Saether and D.R. Oliver. 1969. A classification of the neartic Chironomidae: Fisheries Research Board Canada Tech. Rpt. 145, 42 p.

Hamilton, M.A. 1975. Indexes of diversity and redundancy. J. Water Pollut. Control Fed. 47:630-632.

Hilsenhoff, W.L. 1981. Aquatic insects of Wisconsin. Pub. no. 2, Natural History Council, University of Wisconsin-Madison, 60 p.

Hilsenhoff, W.L. 1982. Using a biotic index to evaluate water quality in streams. Tech. Bull. No. 132, Wisconsin Dept. of Natural Resources, 22 p.

Hiltunen, J.K. and D.J. Klemm. 1980. A guide to the Naididae (Annelida: Clitellata: Oligochaeta) of North America. Report No. EPA-600/4-80-031. U.S. EPA, Cincinnati. 48 pp.

Holsinger, J.R. 1976. The freshwater amphipod crustaceans (Gammaridae) of North America. Water Pollution Control Res. Ser., U.S. Environmental Protection Agency, Rpt. No. 18050 ELDO 4.72. 89 p.

Hoopes, D.T. 1960 Utilization of mayflies and caddisflies by some Mississippi River fishes. Trans. Am. Fish. Soc., 89:32-34.

Hopwood, A.J. 1974. Thermal effects of a nuclear power plant on the Mississippi River at Monticello, Minnesota. Bulletin 69. Water Resources Research Center. University of Minnesota. 134 p.

Hunt, B.P. 1953. The life history and economic importance of a burrowing mayfly, Hexagenia limbata, in southern Michigan lakes. Mich. Cons. Dept., Bull. Inst. Fish. Res. No. 4, 151 p.

Hynes, H.B.N. 1972. The ecology of running waters. Univ. of Toronto Press, Canada. 555 p.

Klemm, D.J. 1982. Leeches (Annelida: Hirudinea) of North America. Report No. EPA-600/3-82-025, U.S. Environmental Protection Agency, 177 p.

Lewis, R.B. 1979. Benthic macroinvertebrate study, in Operational environmental monitoring in the Mississippi River near Quad-Cities Station, 1968 through 1978 (C.C. Alstaetter, ed.). Prepared for Commonwealth Edison Co. by Hazleton Environmental Sciences, Corp., Northbrook, Illinois, pp. 6.1-6.148 + appendix.

Lewis, R.B. 1983. Benthic macroinvertebrates, in Operational ecological study in the Cedar River near Duane Arnold Energy Center, January through December 1982. Prepared for Iowa Electric Light and Power Company, Cedar Rapids by Ecological Analysts, Inc., Northbrook, Illinois. pp. 4-1 through 4-24.

Maciorowski, A.F. 1974. The occurrence of the freshwater bryozoan Pottsiella erecta (Potts) 1884 (Gymnolaemata: Paludicellidae) in Lake Erie. Ohio J. of Sci. 74(4):245-247.

Mathis, D.C., C.R. Bingham and L.D. Sanders. 1982. Assessment of implanted substrate samplers for macroinvertebrates inhabiting stone dikes of the Lower Mississippi River. Misc. paper E-82-1. U.S. Army Engineer Waterways Exp. Station. Vicksburg, Mississippi.

Merritt, R.W. and K.W. Cummins. 1978. An introduction to the aquatic insects of North America. Kendall/Hunt Publ. Co., Dubuque, Iowa, 441 p.

Milbrink, G. 1973. On the vertical distribution of oligochaetes in lake sediments. Report No. 53. Inst. of Freshwater Research. pp. 34-50.

Neuswanger, D.J., W.W. Taylor and J.B. Reynolds. 1982. Comparison of macroinvertebrate herpobenthos and haptobenthos in side channel and slough in the Upper Mississippi River. Freshwater Invert. Biol. 1(3):13-24.

Odum, E.P. 1971. Fundamentals of ecology. W.B. Sanders Co., Philadelphia. 474 p.

Oliver, D.P. 1971. Life history of the Chironomidae. Ann. Rev. of Ent. 16:211-230.

Pennak, R.W. 1953. Freshwater invertebrates of the United States. Ronald Press Co., New York, 769 p.

Pielou, E.C. 1966. The measurement of diversity in different types of biological collections. J. Theoret. Biol. 13:131-144.

Roelofs, E.W. 1944. Water soils in relation to the lake productivity. Tech. Bull. 190, Agr. Exp. Sta. State College, Lansing, Mich.

Shannon, C.E. 1948. A mathematical theory of communication. Bell System Tech. J. 27:379-423, 623-656.

Stimpson, K.W. and R.W. Bode. 1980. Common larvae of Chironomidae (Diptera) from New York State streams and rivers. Bull. No. 439. New York State Museum, 105 p.

Steffen, R.F., J.G. Rasgus and G.P. Czajkowski. 1973. Thermal effects program, in Operational environmental monitoring in the Mississippi River near Quad-Cities Station, February 1973 through July 1973. Report to Commonwealth Edison Company, Chicago, Illinois, by Industrial BIO-TEST Laboratories, Inc., Northbrook, Illinois. pp. 183-227.

Stimpson, K.W., D.J. Klemm and J.K. Hiltunen. 1982. A guide to the freshwater Tubificidae (Annelida: Clitellata: Oligochaeta) of North America. Report no. EPA-600/3-82-033, U.S. Environmental Protection Agency, 61 p.

Strong, D.R., Jr. 1972. Life history variation among populations of an amphipod (Hyalella azteca). Ecology 53:1103-1111.

Thiel, P.A. 1981. A survey of the unionid mussels in the Upper Mississippi River (Pools 3 through 11). Tech. Bull. No. 124. Department of Natural Resources. Madison, Wisconsin. 25 p.

U.S. Environmental Protection Agency. 1979. Methods for chemical analysis of water and wastes. EPA-600/4-79-020. USEPA, Cincinnati, Ohio. 460 p.

van der Schalie, H. and A. van der Schalie. 1950. The mussels of the Mississippi River. Amer. Midl. Nat. 44(2):448-466.

Weber, C.I., ed. 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. U.S. EPA Report No. 670/4-73-001.

Wiggins, G.B. 1977. Larvae of the North American caddisfly genera (Trichoptera). Univ. of Toronto Press, Canada, 401 p.

4.7 SUPPLEMENTAL MACROINVERTEBRATE STATISTICS TABLES

The following tables contain summary data of benthic macroinvertebrate statistical comparisons for studies conducted in Pool 5A of the Upper Mississippi River in 1982.

TABLE 4-44 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY STRUCTURE TYPE) FROM ROCK STRUCTURE SAMPLES, JUNE 1982.

Taxa or Group	Mean Density (No./m^2) Riprap Bank	Mean Density (No./m^2) Wing Dam	CHI^2	Prob.	Significant Difference
Total Benthos	1781(a)	2220	0.18	0.6681	no
Asellus sp.	46	16	2.97	0.0850	no
Hyalella azteca	121	5	28.80	0.0001	yes
Imm. Heptageniidae	6	0	3.98	0.0459	yes
Stenacron interpunctatum	66	17	21.62	0.0001	yes
Total Heptageniidae	73	18	21.07	0.0001	yes
Cyrnellus fraternus	32	8	17.14	0.0001	yes
Total Polycentropodidae	48	9	34.62	0.0001	yes
Imm. Hydropsychidae	27	12	1.26	0.2612	no
Cheumatopsyche sp.	585	674	0.55	0.4598	no
Hydropsyche orris	131	729	24.53	0.0001	yes
Total Hydropsychidae	763	1465	8.83	0.0030	yes
Total Leptoceridae	7	1	5.49	0.0191	yes
Total Elmidae	10	70	28.01	0.0001	yes
Dicrotendipes sp.	8	4	5.05	0.0246	yes
Endochironomus sp.	80	8	27.39	0.0001	yes
Glyptotendipes sp.	19	8	4.50	0.0339	yes
Microtendipes sp.	12	1	4.76	0.0292	yes
Rheotanytarsus sp.	345	403	0.40	0.5250	no
Ablabesmyia sp.	6	<1	4.89	0.0271	yes
Cricotopus bicinctus	1	8	7.73	0.0054	yes
Total Chironomidae	611	574	0.18	0.6681	no
Total Empididae	2	4	0.44	0.5059	no

(a) Mean of 30 samples.

TABLE 4-45 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY STRUCTURE TYPE) FROM ROCK STRUCTURE SAMPLES, AUGUST 1982.

Taxa or Group	Mean Density (No./m^2)		CHI^2	Prob.	Significant Difference
	Riprap Bank	Wing Dam			
Total Benthos	3382(a)	9936	28.64	0.0001	yes
Hydra sp.	10	36	0.14	0.7117	no
Dugesia sp.	73	1381	29.76	0.0001	yes
Total Naididae	39	35	3.64	0.0565	no
Asellus sp.	28	7	3.67	0.0555	no
Hyalella azteca	387	51	24.90	0.0001	yes
Imm. Heptageniidae	454	18	25.57	0.0001	yes
Stenacron interpunctatum	415	73	27.24	0.0001	yes
Total Heptageniidae	870	113	32.57	0.0001	yes
Cyrnellus fraternus	154	66	30.98	0.0001	yes
Total Polycentropodidae	166	71	34.10	0.0001	yes
Imm. Hydropsychidae	7	322	35.32	0.0001	yes
Cheumatopsyche sp.	39	1371	44.26	0.0001	yes
Hydropsyche orris	27	3895	44.26	0.0001	yes
Total Hydropsychidae	80	5868	44.26	0.0001	yes
Oecetis sp.	23	109	7.73	0.0054	yes
Total Leptoceridae	60	128	2.36	0.1242	no
Total Elmidae	29	62	3.20	0.0736	no
Dicrotendipes sp.	660	159	24.24	0.0001	yes
Endochironomus sp.	56	42	0.61	0.4333	no
Glyptotendipes sp.	330	281	2.41	0.1206	no
Microtendipes sp.	80	45	0.84	0.3593	no
Rheotanytarsus sp.	16	403	39.48	0.0001	yes
Ablabesmyia sp.	132	74	8.83	0.0030	yes
Cricotopus bicinctus	68	20	0.51	0.4733	no
Total Chironomidae	1538	1792	2.32	0.1278	no
Total Empididae	11	97	19.74	0.0001	yes

(a) Mean Of 30 samples.

TABLE 4-46 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY STRUCTURE TYPE) FROM ROCK STRUCTURE SAMPLES, SEPTEMBER 1982.

Taxa or Group	Mean Density (No./m^2)				
	Riprap Bank	Wing Dam	CHI^2	Prob.	Significant Difference
Total Benthos	4969(a)	12206	33.59	0.0001	yes
Hydra sp.	121	223	0.55	0.4598	no
Dugesia sp.	102	910	33.42	0.0001	yes
Total Naididae	180	74	6.02	0.0141	yes
Asellus sp.	5	4	0.54	0.4643	no
Hyalella azteca	278	38	8.31	0.0039	yes
Imm. Heptageniidae	140	24	22.03	0.0001	yes
Stenacron interpunctatum	442	38	36.39	0.0001	yes
Total Heptageniidae	582	99	30.41	0.0001	yes
Cyrnellus fraternus	521	268	8.10	0.0044	yes
Total Polycentropodidae	672	284	16.41	0.0001	yes
Imm. Hydropsychidae	57	806	33.85	0.0001	yes
Cheumatopsyche sp.	56	1837	43.09	0.0001	yes
Hydropsyche orris	19	4320	44.26	0.0001	yes
Total Hydropsychidae	133	6992	44.26	0.0001	yes
Oecetis sp.	134	1003	34.80	0.0001	yes
Total Leptoceridae	235	1064	29.60	0.0001	yes
Total Elmidae	37	75	7.32	0.0068	yes
Dicrotendipes sp.	749	159	23.95	0.0001	yes
Endochironomus sp.	7	14	0.22	0.6361	no
Glyptotendipes sp.	987	501	10.48	0.0012	yes
Microtendipes sp.	93	30	5.12	0.0237	yes
Rheotanytarsus sp.	9	89	33.08	0.0001	yes
Ablabesmyia sp.	198	33	29.60	0.0001	yes
Cricotopus bicinctus	21	117	16.65	0.0001	yes
Parakiefferiella sp.	57	311	31.73	0.0001	yes
Total Chironomidae	2394	1844	4.72	0.0298	yes
Total Empididae	105	191	12.59	0.0004	yes

(a) Mean of 30 samples.

TABLE 4-47 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY STRUCTURE TYPE) FROM ROCK STRUCTURE SAMPLES, 1982

Taxa or Group	Mean Density (No./m^2) Riprap Bank	Mean Density (No./m^2) Wing Dam	CHI^2	Prob.	Significant Difference
Total Benthos	3371[a]	8121	28.38	0.0001	yes
Hydra sp.	43	86	0.06	0.8057	no
Dugesia sp.	59	764	20.63	0.0001	yes
Total Naididae	74	37	5.58	0.0181	yes
Asellus sp.	26	9	5.28	0.0215	yes
Hyalella azteca	262	31	51.77	0.0001	yes
Immature Heptageniidae	200	14	37.15	0.0001	yes
Stenacron interpunctatum group	308	43	80.29	0.0001	yes
Total Heptageniidae	509	77	59.51	0.0001	yes
Cyrnellus fraternus	235	114	23.35	0.0001	yes
Total Polycentropodidae	295	122	32.87	0.0001	yes
Immature Hydropsychidae	30	380	28.65	0.0001	yes
Cheumatopsyche sp.	227	1294	84.97	0.0001	yes
Hydropsyche orris	59	2981	123.09	0.0001	yes
Total Hydropsychidae	325	4775	112.54	0.0001	yes
Oecetis sp.	52	370	8.70	0.0032	yes
Total Leptoceridae	101	398	2.48	0.1149	no
Total Elmidae	25	69	33.28	0.0001	yes
Dicrotendipes sp.	472	107	18.00	0.0001	yes
Endochironomus sp.	48	21	9.70	0.0018	yes
Glyptotendipes sp.	445	263	3.24	0.0717	no
Microtendipes sp.	62	26	7.79	0.0053	yes
Rheotanytarsus sp.	123	298	39.20	0.0001	yes
Ablabesmyia sp.	112	36	22.39	0.0001	yes
Cricotopus bicinctus group	30	48	16.24	0.0001	yes
Parakiefferiella sp.	19	104	3.87	0.0492	yes

TABLE 4-47 (CONT.)

Taxa or Group	Mean Density (No./m^2) Riprap Bank	Mean Density (No./m^2) Wing Dam	CHI^2	Prob.	Significant Difference
Total Chironomidae	1514	1403	0.01	0.9362	no
Total Empididae	39	97	13.90	0.0002	yes

(a) Mean of 90 samples.

TABLE 4-48 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY LOCATION) FROM ROCK STRUCTURE SAMPLES, JUNE 1982.

Taxa or Group	Mean Density (No./m^2) 3 Slow	3 Fast	4 Fast	8 Slow	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different			
Total Benthos	2005	1557 .	2732	1708	6.28	0.0987	no	3F	8S	3S	4F
Dugesia sp.	4	0	3	0	4.79	0.1877	no	8S	3F	4F	3S
Total Naididae	3	0	1	1	2.51	0.4738	no	3F	8S	4F	3S
Asellus sp.	80	12	17	15	17.32	0.0006	yes	3F	8S	4F	3S
Hyalella azteca	225	17	3	8	39.81	0.0001	yes	4F	8S	3F	3S
Imm. Heptageniidae	10	1	0	0	8.62	0.0348	yes	8S	4F	3F	3S
Stenacron interpunctatum	76	56	21	14	21.83	0.0001	yes	8S	4F	3F	3S
Total Heptageniidae	89	57	21	16	21.66	0.0001	yes	8S	4F	3F	3S
Cyrnellus fraternus	28	36	7	9	24.76	0.0001	yes	4F	8S	3S	3F
Total Polycentropodidae	52	44	9	10	34.67	0.0001	yes	4F	8S	3F	3S
Imm. Hydropsychidae	53	1	22	2	3.17	0.3657	no	3F	8S	4F	3S
Cheumatopsyche sp.	463	706	920	427	12.42	0.0061	yes	8S	3S	3F	4F
Hydropsyche orris	18	244	1094	363	34.46	0.0001	yes	3S	3F	8S	4F
Total Hydropsychidae	542	984	2107	824	22.16	0.0001	yes	3S	8S	3F	4F
Total Leptoceridae	9	5	1	1	7.76	0.0512	no	8S	4F	3F	3S
Total Elmidae	18	1	65	76	35.61	0.0001	yes	3F	3S	4F	8S
Dicrotendipes sp.	12	4	5	2	10.19	0.0170	yes	8S	3F	4F	3S
Endochironomus sp.	128	32	7	8	35.11	0.0001	yes	4F	8S	3F	3S
Glyptotendipes sp.	33	6	7	9	19.52	0.0002	yes	3F	4F	8S	3S
Microtendipes sp.	22	1	3	0	14.47	0.0023	yes	8S	3F	4F	3S
Rheotanytarsus sp.	426	263	254	552	17.00	0.0007	yes	4F	3F	3S	8S
Ablabesmyia sp.	11	1	1	0	10.35	0.0158	yes	8S	4F	3F	3S
Cricotopus bicinctus	<1	1	5	10	9.66	0.0217	yes	3S	3F	4F	8S
Parakiefferiella sp.	0	1	0	1	0.20	0.9781	no	4F	3S	3F	8S
Total Chironomidae	815	406	444	704	17.28	0.0006	yes	3F	4F	8S	3S
Total Empididae	2	3	5	3	0.96	0.8119	no	3S	8S	3F	4F

TABLE 4-49 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY LOCATION) FROM ROCK STRUCTURE SAMPLES, AUGUST 1982.

Taxa or Group	Mean Density (No./m^2) 3 Slow	3 Fast	4 Fast	8 Slow	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total Benthos	3501	3263	14157	5716	37.67	0.0001	yes	3F 3S 8S 4F
Hydra sp.	5	14	38	35	0.45	0.9307	no	3S 3F 8S 4F
Dugesia sp.	76	71	2322	439	34.22	0.0001	yes	3F 3S 8S 4F
Total Naididae	69	10	66	4	11.39	0.0098	yes	8S 3F 4F 3S
Asellus sp.	53	2	8	5	15.04	0.0018	yes	3F 8S 4F 3S
Hyalella azteca	396	377	98	5	25.38	0.0001	yes	8S 4F 3F 3S
Imm. Heptageniidae	568	340	29	7	28.00	0.0001	yes	8S 4F 3F 3S
Stenacron interpunctatum	556	275	84	61	29.46	0.0001	yes	8S 4F 3F 3S
Total Heptageniidae	1125	616	128	98	34.62	0.0001	yes	8S 4F 3F 3S
Cyrnellus fraternus	83	225	127	5	32.65	0.0001	yes	8S 3S 4F 3F
Total Polycentropodidae	95	235	132	11	35.67	0.0001	yes	8S 3S 4F 3F
Imm. Hydropsychidae	<1	14	561	83	44.41	0.0001	yes	3S 3F 8S 4F
Cheumatopsyche sp.	7	72	1948	795	49.42	0.0001	yes	3S 3F 8S 4F
Hydropsyche orris	5	50	5816	1973	48.19	0.0001	yes	3S 3F 8S 4F
Total Hydropsychidae	14	145	8715	3021	49.84	0.0001	yes	3S 3F 8S 4F
Oecetis sp.	30	15	172	45	13.13	0.0044	yes	3F 3S 8S 4F
Total Leptoceridae	74	46	196	61	13.73	0.0033	yes	3F 3S 8S 4F
Total Elmidae	39	18	85	39	8.53	0.0363	yes	3F 8S 3S 4F
Dicrotendipes sp.	654	665	155	164	26.23	0.0001	yes	4F 8S 3S 3F
Endochironomus sp.	72	40	23	62	8.64	0.0345	yes	4F 3F 8S 3S
Glyptotendipes sp.	328	331	187	375	5.80	0.1220	no	4F 3S 3F 8S
Microtendipes sp.	34	126	78	12	16.51	0.0009	yes	8S 3S 4F 3F
Rheotanytarsus sp.	4	28	454	351	42.03	0.0001	yes	3S 3F 8S 4F
Ablabesmyia sp.	148	117	50	99	15.62	0.0014	yes	4F 8S 3F 3S
Cricotopus bicinctus	14	122	30	11	0.81	0.8461	no	8S 3S 4F 3F
Total Chironomidae	1461	1615	1927	1657	7.18	0.0665	no	3S 3F 8S 4F
Total Empididae	7	15	134	60	21.28	0.0001	yes	3S 3F 8S 4F

TABLE 4-50 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY LOCATION) FROM ROCK STRUCTURE SAMPLES, SEPTEMBER 1982.

Taxa or Group	Mean Density (No./m^2)				CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different			
	3 Slow	3 Fast	4 Fast	8 Slow							
Total Benthos	4659	5279	15730	8682	38.74	0.0001	yes	3S	3F	8S	4F
Hydra sp.	29	212	22	424	24.60	0.0001	yes	4F	3S	3F	8S
Dugesia sp.	55	148	1425	394	38.75	0.0001	yes	3S	3F	8S	4F
Total Naididae	189	170	57	90	8.16	0.0427	yes	4F	8S	3F	3S
Asellus sp.	5	5	4	5	0.67	0.8801	no	4F	8S	3F	3S
Hyalella azteca	374	183	20	56	16.38	0.0009	yes	4F	8S	3F	3S
Imm. Heptageniidae	114	167	27	20	23.52	0.0001	yes	8S	4F	3S	3F
Stenacron interpuctatum	407	477	67	9	38.11	0.0001	yes	8S	4F	3S	3F
Total Heptageniidae	522	643	121	78	30.97	0.0001	yes	8S	4F	3S	3F
Cyrnellus fraternus	506	535	321	216	10.25	0.0165	yes	8S	4F	3S	3F
Total Polycentropodidae	663	680	345	223	18.47	0.0004	yes	8S	4F	3S	3F
Imm. Hydropsychidae	18	95	1299	313	44.16	0.0001	yes	3S	3F	8S	4F
Cheumatopsyche sp.	31	82	3054	620	49.79	0.0001	yes	3S	3F	8S	4F
Hydropsyche orris	8	30	6218	2422	46.46	0.0001	yes	3S	3F	8S	4F
Total Hydropsychidae	59	208	10595	3390	49.71	0.0001	yes	3S	3F	8S	4F
Oecetis sp.	135	133	873	1133	36.11	0.0001	yes	3F	3S	4F	8S
Total Leptoceridae	231	239	915	1213	31.34	0.0001	yes	3S	3F	4F	8S
Total Elmidae	44	29	98	51	12.34	0.0063	yes	3F	3S	8S	4F
Dicrotendipes sp.	615	883	123	194	27.10	0.0001	yes	4F	8S	3S	3F
Endochironomus sp.	11	4	4	23	5.97	0.1133	yes	3F	4F	3S	8S
Glyptotendipes sp.	1023	952	270	733	20.14	0.0002	yes	4F	8S	3F	3S
Microtendipes sp.	36	150	53	8	25.01	0.0001	yes	8S	3S	4F	3F
Rheotanytarsus sp.	9	9	81	97	33.09	0.0001	yes	3S	3F	4F	8S
Ablabesmyia sp.	132	264	20	47	32.78	0.0001	yes	4F	8S	3S	3F
Cricotopus bicinctus	30	12	77	157	19.14	0.0003	yes	3F	3S	4F	8S
Parakiefferiella sp.	58	57	266	357	32.72	0.0001	yes	3F	3S	4F	8S
Total Chironomidae	2216	2573	1452	2237	12.45	0.0060	yes	4F	3S	8S	3F
Total Empididae	149	61	209	174	15.17	0.0017	yes	3F	3S	8S	4F

TABLE 4-51 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY LOCATION) FROM ROCK STRUCTURE SAMPLES, 1982

Taxa or Group	Mean Density (No./m^2) 3 Slow	3 Fast	4 Fast	8 Slow	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total Benthos	3388[a]	3366	10873	5369	36.53	0.0001	yes	3F 3S 8S 4F
Dugesia sp.	45	73	1250	278	23.02	0.0001	yes	3S 3F 8S 4F
Total Naididae	87	60	41	32	8.04	0.0451	yes	8S 4F 3F 3S
Asellus sp.	46	6	10	8	21.39	0.0001	yes	3F 8S 4F 3S
Hyalella azteca	332	192	40	23	65.40	0.0001	yes	8S 4F 3F 3S
Immature Heptageniidae	231	169	19	9	38.69	0.0001	yes	8S 4F 3F 3S
Stenacron interpunctatum group	346	269	57	28	81.39	0.0001	yes	8S 4F 3F 3S
Total Heptageniidae	578	439	90	64	60.07	0.0001	yes	8S 4F 3F 3S
Cyrnellus fraternus	206	265	151	77	26.07	0.0001	yes	8S 4F 3S 3F
Total Polycentropodidae	270	320	162	81	33.96	0.0001	yes	8S 4F 3S 3F
Immature Hydropsychidae	24	37	627	132	36.40	0.0001	yes	3S 3F 8S 4F
Cheumatopsyche sp.	167	287	1974	614	103.32	0.0001	yes	3S 3F 8S 4F
Hydropsyche orris	10	108	4376	1586	131.27	0.0001	yes	3S 3F 8S 4F
Total Hydropsychidae	205	446	7139	2411	123.66	0.0001	yes	3S 3F 8S 4F
Oecetis sp.	55	50	348	393	9.12	0.0278	yes	3F 3S 4F 8S
Total Leptoceridae	105	96	371	425	3.39	0.3355	no	3F 3S 4F 8S
Total Elmidae	34	16	83	55	44.24	0.0001	yes	3F 3S 8S 4F
Dicrotendipes sp.	427	517	94	120	18.34	0.0004	yes	4F 8S 3S 3F
Endochironomus sp.	70	25	11	31	24.50	0.0001	yes	4F 3F 8S 3S
Glyptotendipes sp.	461	430	155	372	7.23	0.0649	no	4F 8S 3F 3S
Microtendipes sp.	31	92	45	7	24.81	0.0001	yes	8S 3S 4F 3F
Rheotanytarsus sp.	147	100	263	333	39.71	0.0001	yes	3F 3S 4F 8S
Ablabesmyia sp.	97	127	23	49	24.96	0.0001	yes	4F 8S 3S 3F
Cricotopus bicinctus group	15	45	37	59	17.83	0.0005	yes	3S 4F 3F 8S
Parakiefferiella sp.	19	19	89	119	4.20	0.2409	no	3F 3S 4F 8S
Total Chironomidae	1497	1531	1274	1533	1.13	0.7702	no	4F 3S 3F 8S
Total Empididae	53	26	116	79	14.59	0.0022	yes	3F 3S 8S 4F

(a) Mean of 45 samples.

TABLE 4-52 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY HABITAT TYPE) FROM ROCK STRUCTURE SAMPLES, JUNE 1982.

Taxa or Group	Mean Density (No./m^2) w/peri*	Mean Density (No./m^2) w/o peri	Mean Density (No./m^2) Deep	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different		
Total Benthos	1774	2197	2032	0.20	0.9062	no	W/	DEEP	W/O
Dugesia sp.	1	2	2	0.00	0.9989	no	W/	DEEP	W/O
Total Naididae	2	2	1	0.95	0.6217	no	DEEP	W/	W/O
Asellus sp.	31	36	26	0.40	0.8198	no	DEEP	W/	W/O
Hyalella azteca	84	66	39	2.11	0.3475	no	DEEP	W/O	W/
Imm. Heptageniidae	1	6	1	0.39	0.8237	no	W/	DEEP	W/O
Stenacron interpunctatum	61	30	34	7.29	0.0261	yes	W/O	DEEP	W/
Total Heptageniidae	65	37	35	7.70	0.0212	yes	DEEP	W/O	W/
Crynellus fraternus	18	15	27	0.78	0.6771	no	W/O	W/	DEEP
Total Polycentropodidae	25	20	42	2.36	0.3070	no	W/O	W/	DEEP
Imm. Hydropsychidae	2	40	17	0.57	0.7528	no	W/	DEEP	W/O
Cheumatopsyche sp.	669	619	599	1.64	0.4414	no	DEEP	W/O	W/
Hydropsyche orris	179	595	516	4.02	0.1342	no	W/	DEEP	W/O
Total Hydropsychidae	861	1289	1191	0.69	0.7079	no	W/	DEEP	W/O
Total Leptoceridae	8	4	1	5.13	0.0770	no	DEEP	W/O	W/
Total Elmidae	47	31	42	1.83	0.4011	no	W/O	DEEP	W/
Dicrotendipes sp.	7	8	3	2.63	0.2681	no	DEEP	W/	W/O
Endochironomus sp.	55	46	30	1.88	0.3907	no	DEEP	W/O	W/
Glyptotendipes sp.	12	17	12	0.97	0.6144	no	DEEP	W/	W/O
Microtendipes sp.	5	12	3	1.05	0.5921	no	DEEP	W/	W/O
Rheotanytarsus sp.	357	368	397	0.05	0.9762	no	W/	W/O	DEEP
Ablabesmyia sp.	2	4	4	0.27	0.8741	no	W/	DEEP	W/O
Cricotopus bicinctus	8	4	<1	5.14	0.0763	no	DEEP	W/O	W/
Total Chironomidae	579	612	586	0.08	0.9603	no	W/	DEEP	W/O
Total Empididae	3	3	3	0.01	0.9966	no	DEEP	W/	W/O

* w/peri = Shallow habitat with visible growth of periphyton.
w/o peri = Shallow habitat without visible growth of periphyton.
Deep = Deep habitat.

TABLE 4-53 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY HABITAT TYPE) FROM ROCK STRUCTURE SAMPLES, AUGUST 1982.

Taxa or Group	Mean Density (No./m^2) w/peri*	Mean Density (No./m^2) w/o peri	Mean Density (No./m^2) Deep	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different		
Total Benthos	7197	6649	6133	4.55	0.1030	no	DEEP	W/O	W/
Hydra sp.	11	31	27	2.23	0.3286	no	W/	DEEP	W/O
Dugesia sp.	374	1062	745	0.76	0.6831	no	W/	DEEP	W/O
Total Naididae	84	22	5	5.32	0.0699	no	DEEP	W/O	W/
Asellus sp.	7	14	31	5.58	0.0614	no	W/	W/O	DEEP
Hyalella azteca	614	28	15	4.00	0.1356	no	DEEP	W/O	W/
Imm. Heptageniidae	313	240	154	2.27	0.3216	no	DEEP	W/O	W/
Stenacron interpuctatum	224	304	204	0.13	0.9361	no	DEEP	W/	W/O
Total Heptageniidae	543	556	375	0.18	0.9142	no	DEEP	W/	W/O
Crynellus fraternus	37	146	147	4.50	0.1055	no	W/	W/O	DEEP
Total Polycentropodidae	47	157	151	3.39	0.1832	no	W/	DEEP	W/O
Imm. Hydropsychidae	162	177	154	0.36	0.8361	no	DEEP	W/	W/O
Cheumatopsyche sp.	748	753	615	0.06	0.9704	no	DEEP	W/	W/O
Hydropsyche orris	1835	2010	2038	0.31	0.8548	no	W/	W/O	DEEP
Total Hydropsychidae	2856	3106	2960	0.10	0.9509	no	W/	DEEP	W/O
Oecetis sp.	55	50	92	0.82	0.6652	no	W/O	W/	DEEP
Total Leptoceridae	84	75	123	3.42	0.1805	no	W/O	W/	DEEP
Total Elmidae	38	43	55	3.16	0.2061	no	W/	W/O	DEEP
Dicrotendipes sp.	714	282	232	10.90	0.0043	yes	DEEP	W/O	W/
Endochironomus sp.	72	44	33	2.87	0.2383	no	DEEP	W/O	W/
Glyptotendipes sp.	328	274	313	0.41	0.8166	no	W/O	DEEP	W/
Microtendipes sp.	35	45	108	1.91	0.3842	no	W/	W/O	DEEP
Rheotanytarsus sp.	170	174	283	1.05	0.5907	no	W/	W/O	DEEP
Ablabesmyia sp.	119	87	105	0.89	0.6410	no	W/O	DEEP	W/
Cricotopus bicinctus	129	4	0	15.15	0.0005	yes	DEEP	W/O	W/
Parakiefferiella sp.	0	0	<1	0.10	0.9520	no	W/O	W/	DEEP
Total Chironomidae	2159	1362	1474	10.29	0.0058	yes	W/O	DEEP	W/
Total Empididae	72	44	45	2.87	0.2378	no	W/O	DEEP	W/

* w/peri = Shallow habitat with visible growth of periphyton
w/o peri = Shallow habitat without visible growth of periphyton
Deep = Deep habitat

TABLE 4-54 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY HABITAT TYPE) FROM ROCK STRUCTURE SAMPLES, SEPTEMBER 1982.

Taxa or Group	Mean Density (No./m^2)			CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different		
	w/peri*	w/o peri	Deep						
Total Benthos	8686	7948	9129	0.16	0.9219	no	W/O	W/	DEEP
Hydra sp.	90	147	278	3.24	0.1980	no	W/	W/O	DEEP
Dugesia sp.	363	258	896	1.22	0.5428	no	W/O	W/	DEEP
Total Naididae	248	73	59	9.93	0.0070	yes	DEEP	W/O	W/
Asellus sp.	5	8	2	1.56	0.4574	no	DEEP	W/	W/O
Hyalella azteca	370	67	37	8.81	0.0122	yes	DEEP	W/O	W/
Imm. Heptageniidae	97	108	41	4.32	0.1154	no	DEEP	W/	W/O
Stenacron interpunctatum	223	307	189	0.58	0.7481	no	DEEP	W/	W/O
Total Heptageniidae	345	428	250	1.13	0.5694	no	DEEP	W/	W/O
Cyrnellus fraternus	309	295	578	6.65	0.0359	yes	W/O	W/	DEEP
Total Polycentropodidae	422	394	618	2.63	0.2681	no	W/	W/O	DEEP
Imm. Hydropsychidae	458	571	265	0.00	0.9992	no	DEEP	W/	W/O
Cheumatopsyche sp.	1090	769	982	0.70	0.7055	no	W/O	DEEP	W/
Hydropsyche orris	2026	1867	2617	0.60	0.7392	no	W/O	W/	DEEP
Total Hydropsychidae	3591	3221	3876	0.87	0.6458	no	W/O	W/	DEEP
Oecetis sp.	286	532	887	9.81	0.0074	yes	W/	W/O	DEEP
Total Leptoceridae	356	605	987	11.44	0.0033	yes	W/	W/O	DEEP
Total Elmidae	49	51	67	0.99	0.6099	no	W/	W/O	DEEP
Dicrotendipes sp.	466	572	323	2.80	0.2466	no	DEEP	W/	W/O
Endochironomus sp.	4	9	18	1.81	0.4041	no	W/	W/O	DEEP
Glyptotendipes sp.	784	767	681	0.98	0.6126	no	DEEP	W/O	W/
Microtendipes sp.	30	88	67	2.86	0.2394	no	W/	DEEP	W/O
Rheotanytarsus sp.	40	53	54	1.18	0.5531	no	W/	W/O	DEEP
Ablabesmyia sp.	152	104	91	0.16	0.9216	no	DEEP	W/O	W/
Cricotopus bicinctus	142	50	14	12.70	0.0017	yes	DEEP	W/O	W/
Parakiefferiella sp.	259	203	91	4.74	0.0936	no	DEEP	W/O	W/
Total Chironomidae	2313	2244	1802	2.27	0.3207	no	DEEP	W/O	W/
Total Empididae	209	139	97	7.44	0.0243	yes	DEEP	W/O	W/

* w/peri = Shallow habitat with visible growth of periphyton
w/o peri = Shallow habitat without visible growth of periphyton
Deep = Deep habitat

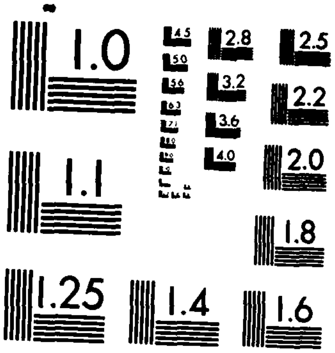
TABLE 4-55 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY HABITAT TYPE) FROM ROCK STRUCTURE SAMPLES, 1982

Taxa or Group	Mean Density (No./m^2) w/peri.[a]	w/o peri.	Deep	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different		
Total Benthos	5885[b]	5598	5765	1.02	0.6015	no	W/O	Deep	W/
Dugesia sp.	246	441	547	0.83	0.6608	no	W/	W/O	Deep
Total Naididae	111	32	22	3.65	0.1611	no	Deep	W/O	W/
Hyalella azteca	356	53	31	10.06	0.0065	yes	Deep	W/O	W/
Immature Heptageniidae	137	118	65	3.57	0.1677	no	Deep	W/O	W/
Stenacron interpunctatum group	170	214	142	1.65	0.4382	no	Deep	W/	W/O
Total Heptageniidae	318	340	220	2.41	0.3001	no	Deep	W/	W/O
Cyrnellus fraternus	121	152	251	2.81	0.2449	no	W/	W/O	Deep
Total Polycentropodidae	165	190	270	1.62	0.4452	no	W/	W/O	Deep
Immature Hydropsychidae	207	263	145	0.30	0.8628	no	Deep	W/	W/O
Cheumatopsyche sp.	835	714	732	1.30	0.5210	no	W/O	Deep	W/
Hydropsyche orris	1346	1490	1724	1.81	0.4048	no	W/	W/O	Deep
Total Hydropsychidae	2436	2539	2676	0.77	0.6811	no	W/	W/O	Deep
Oecetis sp.	114	194	326	0.97	0.6146	no	W/	W/O	Deep
Total Leptoceridae	150	228	370	0.83	0.6612	no	W/	W/O	Deep
Dicrotendipes sp.	396	287	186	3.55	0.1699	no	Deep	W/O	W/
Glyptotendipes sp.	375	353	335	0.30	0.8625	no	Deep	W/O	W/
Rheotanytarsus sp.	189	198	245	0.44	0.8036	no	W/	W/O	Deep
Ablabesmyia sp.	91	65	66	0.34	0.8424	no	W/O	Deep	W/
Cricotopus bicinctus group	93	19	5	26.13	0.0001	yes	Deep	W/O	W/
Parakiefferiella sp.	87	68	30	0.47	0.7908	no	Deep	W/O	W/
Total Chironomidae	1684	1406	1287	1.57	0.4572	no	Deep	W/O	W/
Total Empididae	95	62	48	3.42	0.1812	no	Deep	W/O	W/

(a) w/peri. = Shallow habitat with visible growth of periphyton
w/o peri. = Shallow habitat without visible growth of periphyton
Deep = Deep habitat

(b) Mean of 60 samples.

AD-A164 745 AQUATIC STUDIES OF THE MAIN CHANNEL BORDER HABITAT OF 3/4
POOL 5A ON THE UPPER MISSISSIPPI RIVER(U) ECOLOGICAL
ANALYSTS INC NORTHBROOK IL G SEEGERT ET AL. JAN 84
UNCLASSIFIED F/G 6/6 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE 4-56 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY SAMPLING DATE) FROM LOCATION 3 SLOW ROCK STRUCTURE SAMPLES, 1982.

Taxa or Group	Mean Density (No./m^2) June	Aug	Sept	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total Benthos	2005	3501	4659	13.37	0.0012	yes	JUN AUG SEP
Hydra sp.	0	5	29	7.60	0.0224	yes	JUN AUG SEP
Dugesia sp.	4	76	55	23.81	0.0001	yes	JUN SEP AUG
Total Naididae	3	69	189	26.91	0.0001	yes	JUN AUG SEP
Asellus sp.	80	53	5	17.31	0.0002	yes	SEP AUG JUN
Hyalella azteca	225	396	374	3.62	0.1637	no	JUN SEP AUG
Imm. Heptageniidae	10	568	114	24.90	0.0001	yes	JUN SEP AUG
Stenacron interpunctatum group	76	556	407	20.43	0.0001	yes	JUN SEP AUG
Total Heptageniidae	89	1124	522	25.67	0.0001	yes	JUN SEP AUG
Cyrnellus fraternus	28	83	506	22.89	0.0001	yes	JUN AUG SEP
Total Polycentropodidae	52	96	663	25.15	0.0001	yes	JUN AUG SEP
Imm. Hydropsychidae	53	<1	18	7.98	0.0185	yes	AUG SEP JUN
Cheumatopsyche sp.	463	7	31	28.61	0.0001	yes	AUG SEP JUN
Hydropsyche orris	18	5	8	2.97	0.2270	no	AUG SEP JUN
Total Hydropsychidae	542	14	59	28.81	0.0001	yes	AUG SEP JUN
Oecetis sp.	<1	30	135	23.11	0.0001	yes	JUN AUG SEP
Total Leptoceridae	9	74	231	28.69	0.0001	yes	JUN AUG SEP
Total Elmidae	18	39	44	4.31	0.1160	no	JUN AUG SEP
Dicrotendipes sp.	12	654	615	29.18	0.0001	yes	JUN SEP AUG
Endochironomus sp.	128	72	11	27.59	0.0001	yes	SEP AUG JUN
Glyptotendipes sp.	33	328	1023	32.97	0.0001	yes	JUN AUG SEP
Microtendipes sp.	22	34	36	2.76	0.2510	no	JUN AUG SEP
Rheotanytarsus sp.	426	4	9	29.45	0.0001	yes	AUG SEP JUN
Ablabesmyia sp.	11	148	132	28.38	0.0001	yes	JUN SEP AUG
Cricotopus bicinctus	<1	14	30	1.01	0.6049	no	JUN AUG SEP
Parakiefferiella sp.	0	<1	58	7.93	0.0189	yes	JUN AUG SEP
Total Chironomidae	815	1461	2216	9.88	0.0072	yes	JUN AUG SEP
Total Empididae	2	7	149	29.37	0.0001	yes	JUN AUG SEP

TABLE 4-57 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY SAMPLING DATE) FROM LOCATION 3 FAST ROCK STRUCTURE SAMPLES, 1982.

Taxa or Group	Mean Density (No./m^2) June	Aug	Sept	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different		
Total Benthos	1557	3223	5279	24.77	0.0001	yes	JUN	AUG	SEP
Hydra sp.	0	14	212	23.14	0.0001	yes	JUN	AUG	SEP
Dugesia sp.	0	71	148	24.99	0.0001	yes	JUN	AUG	SEP
Total Naididae	0	10	170	31.45	0.0001	yes	JUN	AUG	SEP
Asellus sp.	12	2	5	1.55	0.4597	yes	AUG	SEP	JUN
Hyalella azteca	17	377	183	5.37	0.0682	no	JUN	SEP	AUG
Imm. Heptageniidae	1	340	167	19.93	0.0001	yes	JUN	SEP	AUG
Stenacron interpunctatum group	56	275	477	27.29	0.0001	yes	JUN	AUG	SEP
Total Heptageniidae	57	616	643	26.12	0.0001	yes	JUN	AUG	SEP
Cyrnellus fraternus	36	225	535	23.59	0.0001	yes	JUN	AUG	SEP
Total Polycentropodidae	44	235	680	29.17	0.0001	yes	JUN	AUG	SEP
Imm. Hydropsychidae	1	14	95	18.48	0.0001	yes	JUN	AUG	SEP
Cheumatopsyche sp.	706	72	82	26.06	0.0001	yes	AUG	SEP	JUN
Hydropsyche orris	244	50	30	9.77	0.0076	yes	SEP	AUG	JUN
Total Hydropsychidae	984	145	208	21.10	0.0001	yes	AUG	SEP	JUN
Oecetis sp.	0	15	133	27.70	0.0001	yes	JUN	AUG	SEP
Total Leptoceridae	5	46	239	32.53	0.0001	yes	JUN	AUG	SEP
Total Elmidae	1	18	29	14.58	0.0007	yes	JUN	AUG	SEP
Dicrotendipes sp.	4	665	883	30.22	0.0001	yes	JUN	AUG	SEP
Endochironomus sp.	32	40	4	16.57	0.0003	yes	SEP	JUN	AUG
Glyptotendipes sp.	6	331	952	35.54	0.0001	yes	JUN	AUG	SEP
Microtendipes sp.	1	126	150	24.39	0.0001	yes	JUN	AUG	SEP
Rheotanytarsus sp.	263	28	9	28.03	0.0001	yes	SEP	AUG	JUN
Ablabesmyia sp.	1	117	264	31.82	0.0001	yes	JUN	AUG	SEP
Cricotopus bicinctus	1	122	12	1.01	0.6044	no	JUN	SEP	AUG
Parakiefferiella sp.	1	0	57	15.46	0.0004	yes	AUG	JUN	SEP
Total Chironomidae	406	1615	2573	26.92	0.0001	yes	JUN	AUG	SEP
Total Empididae	3	15	61	11.41	0.0033	yes	JUN	AUG	SEP

TABLE 4-53 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY SAMPLING DATE) FROM LOCATION 4 ROCK STRUCTURE SAMPLES, 1982.

Taxa or Group	Mean Density (No./m^2) June	Aug	Sept	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different		
Total Benthos	2732	14157	15730	29.58	0.0001	yes	JUN	AUG	SEP
Hydra sp.	0	38	22	3.45	0.1785	no	JUN	SEP	AUG
Dugesia sp.	3	2322	1425	30.38	0.0001	yes	JUN	SEP	AUG
Total Naididae	1	66	60	9.99	0.0068	yes	JUN	SEP	AUG
Asellus sp.	17	8	4	4.41	0.1102	no	SEP	AUG	JUN
Hyalella azteca	3	98	20	1.28	0.5263	no	JUN	SEP	AUG
Imm. Heptageniidae	0	29	27	3.27	0.1954	no	JUN	SEP	AUG
Stenacron interpunctatum group	21	84	67	1.55	0.4597	no	JUN	SEP	AUG
Total Heptageniidae	21	128	121	8.28	0.0159	yes	JUN	SEP	AUG
Cyrnellus fraternus	7	127	321	25.62	0.0001	yes	JUN	AUG	SEP
Total Polycentropodidae	9	132	345	25.63	0.0001	yes	JUN	AUG	SEP
Imm. Hydropsychidae	22	561	1299	33.15	0.0001	yes	JUN	AUG	SEP
Cheumatopsyche sp.	920	1948	3054	24.09	0.0001	yes	JUN	AUG	SEP
Hydropsyche orris	1094	5816	6218	19.88	0.0001	yes	JUN	AUG	SEP
Total Hydropsychidae	2107	8715	10595	24.05	0.0001	yes	JUN	AUG	SEP
Oecetis sp.	0	172	873	30.28	0.0001	yes	JUN	AUG	SEP
Total Leptoceridae	1	196	915	32.90	0.0001	yes	JUN	AUG	SEP
Total Elmidae	65	85	98	1.27	0.5291	no	JUN	AUG	SEP
Dicrotendipes sp.	5	155	123	29.57	0.0001	yes	JUN	SEP	AUG
Endochironomus sp.	7	23	4	6.32	0.0424	yes	SEP	JUN	AUG
Glyptotendipes sp.	7	187	270	31.04	0.0001	yes	JUN	AUG	SEP
Microtendipes sp.	3	78	53	21.68	0.0001	yes	JUN	SEP	AUG
Rheotanytarsus sp.	254	454	81	23.82	0.0001	yes	SEP	JUN	AUG
Ablabesmyia sp.	1	50	20	15.40	0.0005	yes	JUN	SEP	AUG
Cricotopus bicinctus	5	30	77	6.60	0.0369	yes	JUN	AUG	SEP
Parakiefferiella sp.	0	0	266	29.35	0.0001	yes	JUN	AUG	SEP
Total Chironomidae	444	1927	1452	31.09	0.0001	yes	JUN	SEP	AUG
Total Empididae	5	134	209	21.63	0.0001	yes	JUN	AUG	SEP

TABLE 4-59 SUMMARY OF STATISTICAL COMPARISON OF MACROINVERTEBRATE DENSITY DATA (BY SAMPLING DATE) FROM LOCATION 8 ROCK STRUCTURE SAMPLES, 1982.

Taxa or Group	Mean Density (No./m^2) June	Aug	Sep	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different		
Total Benthos	1709	5716	8682	32.49	0.0001	yes	JUN	AUG	SEP
Hydra sp.	0	35	424	24.36	0.0001	yes	JUN	AUG	SEP
Dugesia sp.	0	439	394	29.43	0.0001	yes	JUN	SEP	AUG
Total Naididae	1	4	90	17.08	0.0002	yes	JUN	AUG	SEP
Asellus sp.	15	5	5	3.93	0.1399	no	SEP	AUG	JUN
Hyalella azteca	8	5	56	18.41	0.0001	yes	AUG	JUN	SEP
Imm. Heptageniidae	0	7	20	4.33	0.1148	no	JUN	AUG	SEP
Stenacron interpunctatum group	14	61	9	8.38	0.0151	yes	SEP	JUN	AUG
Total Heptageniidae	16	98	76	16.95	0.0002	yes	JUN	SEP	AUG
Cyrnellus fraternus	9	6	216	29.89	0.0001	yes	AUG	JUN	SEP
Total Polycentropodidae	10	11	223	29.43	0.0001	yes	JUN	AUG	SEP
Imm. Hydropsychidae	2	83	313	29.17	0.0001	yes	JUN	AUG	SEP
Cheumatopsyche sp.	427	795	620	8.64	0.0133	yes	JUN	SEP	AUG
Hydropsyche orris	363	1973	2422	23.22	0.0001	yes	JUN	AUG	SEP
Total Hydropsychidae	824	3021	3390	22.50	0.0001	yes	JUN	AUG	SEP
Oecetis sp.	0	45	1133	34.61	0.0001	yes	JUN	AUG	SEP
Total Leptoceridae	1	61	1213	39.13	0.0001	yes	JUN	AUG	SEP
Total Elmidae	76	39	51	4.48	0.1063	no	AUG	SEP	JUN
Dicrotendipes sp.	2	164	194	29.87	0.0001	yes	JUN	AUG	SEP
Endochironomus sp.	8	62	23	15.26	0.0005	yes	JUN	SEP	AUG
Glyptotendipes sp.	9	375	733	34.11	0.0001	yes	JUN	AUG	SEP
Microtendipes sp.	0	12	8	4.58	0.1010	no	JUN	SEP	AUG
Rheotanytarsus sp.	552	351	97	23.60	0.0001	yes	SEP	AUG	JUN
Ablabesmyia sp.	0	99	47	22.33	0.0001	yes	JUN	SEP	AUG
Cricotopus bicinctus	10	11	157	21.37	0.0001	yes	JUN	AUG	SEP
Parakiefferiella sp.	1	0	357	29.39	0.0001	yes	AUG	JUN	SEP
Total Chironomidae	704	1657	2237	25.99	0.0001	yes	JUN	AUG	SEP
Total Empididae	3	60	174	30.42	0.0001	yes	JUN	AUG	SEP

TABLE 4-60 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY SAMPLING DATE) FROM THE WITH PERIPHYTON SAMPLES ON ROCK STRUCTURES, 1982.

Taxa or Group	Mean Density (No./m^2) June	Aug	Sept	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total Benthos	1774	7196	8686	36.38	0.0001	yes	JUN $\underline{\text{AUG SEP}}$
Hydra sp.	0	11	90	17.00	0.0002	yes	$\underline{\text{JUN AUG}}$ SEP
Dugesia sp.	1	374	363	35.75	0.0001	yes	JUN $\underline{\text{AUG SEP}}$
Total Naididae	1	84	248	29.26	0.0001	yes	$\underline{\text{JUN AUG}}$ SEP
Asellus sp.	31	7	5	6.59	0.0371	yes	JUN $\underline{\text{AUG SEP}}$
Hyalella azteca	84	614	370	6.38	0.0411	yes	$\underline{\text{JUN SEP}}$ AUG $\underline{\text{SEP AUG}}$
Imm. Heptageniidae	1	313	97	20.51	0.0001	yes	$\underline{\text{JUN SEP}}$ AUG
Stenacron interpunctatum group	61	224	223	4.36	0.1131	no	JUN $\underline{\text{AUG SEP}}$
Total Heptageniidae	65	543	345	11.70	0.0029	yes	JUN $\underline{\text{AUG SEP}}$
Cyrnellus fraternus	18	37	309	30.49	0.0001	yes	$\underline{\text{JUN AUG}}$ SEP
Total Polycentropodidae	25	47	422	34.24	0.0001	yes	$\underline{\text{JUN AUG}}$ SEP
Imm. Hydropsychidae	2	162	458	18.53	0.0001	yes	$\underline{\text{JUN AUG}}$ SEP
Cheumatopsyche sp.	669	748	1090	1.01	0.6035	no	$\underline{\text{JUN AUG SEP}}$
Hydropsyche orris	179	1835	2026	0.98	0.6111	no	JUN $\underline{\text{AUG SEP}}$
Total Hydropsychidae	861	2856	3591	0.22	0.8939	no	$\underline{\text{JUN AUG}}$ SEP $\underline{\text{AUG SEP}}$
Oecetis sp.	0	55	286	35.32	0.0001	yes	$\underline{\text{JUN AUG}}$ SEP
Total Leptoceridae	8	84	356	42.71	0.0001	yes	$\underline{\text{JUN AUG}}$ SEP
Total Elmidae	47	38	49	1.50	0.4719	no	$\underline{\text{JUN AUG SEP}}$
Dicrotendipes sp.	7	714	466	40.16	0.0001	yes	JUN $\underline{\text{AUG SEP}}$
Endochironomus sp.	55	72	4	20.81	0.0001	yes	$\underline{\text{JUN AUG}}$ SEP
Glyptotendipes sp.	12	328	784	40.66	0.0001	yes	$\underline{\text{JUN AUG}}$ SEP
Microtendipes sp.	5	35	30	9.47	0.0088	yes	JUN $\underline{\text{AUG SEP}}$
Rheotanytarsus sp.	357	170	40	29.29	0.0001	yes	JUN AUG SEP
Ablabesmyia sp.	2	119	152	30.86	0.0001	yes	JUN $\underline{\text{AUG SEP}}$
Cricotopus bicinctus	8	129	142	13.14	0.0014	yes	$\underline{\text{JUN AUG SEP}}$
Parakiefferiella sp.	1	0	259	28.08	0.0001	yes	$\underline{\text{JUN AUG}}$ SEP
Total Chironomide	579	2159	2313	33.23	0.0001	yes	JUN $\underline{\text{AUG SEP}}$
Total Empdidae	3	72	209	36.00	0.0001	yes	JUN AUG SEP

TABLE 4-61 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY SAMPLING DATE) FROM THE WITHOUT PERIPHYTON SAMPLES ON ROCK STRUCTURE, 1982.

Taxa or Group	Mean Density (No./m^2) June	Aug	Sept	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different		
Total Benthos	2197	6649	7948	22.01	0.0001	yes	JUN	AUG	SEP
Hydra sp.	0	31	147	13.33	0.0013	yes	JUN	AUG	SEP
Dugesia sp.	3	1062	258	30.23	0.0001	yes	JUN	SEP	AUG
Total Naididae	2	23	73	21.76	0.0001	yes	JUN	AUG	SEP
Asellus sp.	36	14	8	3.72	0.1553	no	JUN	AUG	SEP
Hyalella azteca	66	28	67	2.53	0.2828	no	JUN	AUG	SEP
Imm. Heptageniidae	6	240	108	9.51	0.0086	yes	JUN	SEP	AUG
Stenacron interpunctatum group	30	304	307	9.02	0.0110	yes	JUN	AUG	SEP
Total Heptageniidae	37	556	428	18.20	0.0001	yes	JUN	AUG	SEP
Cyrnellus fraternus	15	146	295	35.86	0.0001	yes	JUN	AUG	SEP
Total Polycentropodidae	20	157	394	39.73	0.0001	yes	JUN	AUG	SEP
Imm. Hydropsychidae	40	177	571	12.25	0.0022	yes	JUN	AUG	SEP
Cheumatopsyche sp.	619	753	769	2.99	0.2248	no	JUN	AUG	SEP
Hydropsyche orris	595	2010	1867	0.05	0.9752	no	JUN	AUG	SEP
Total Hydropsychidae	1289	3106	3221	0.52	0.7698	no	JUN	AUG	SEP
Oecetis sp.	0	50	532	33.78	0.0001	yes	JUN	AUG	SEP
Total Leptoceridae	4	75	605	39.27	0.0001	yes	JUN	AUG	SEP
Total Elmidae	31	43	51	2.82	0.2437	no	JUN	AUG	SEP
Dicrotendipes sp.	8	282	572	39.88	0.0001	yes	JUN	AUG	SEP
Endochironomus sp.	46	44	9	10.09	0.0064	yes	JUN	AUG	SEP
Glyptotendipes sp.	17	274	767	45.62	0.0001	yes	JUN	AUG	SEP
Microtendipes sp.	12	45	88	14.81	0.0006	yes	JUN	AUG	SEP
Rheotanytarsus sp.	368	174	52	19.03	0.0001	yes	JUN	AUG	SEP
Ablabesmyia sp.	4	87	104	20.98	0.0001	yes	JUN	AUG	SEP
Cricotopus bicinctus	4	4	50	9.09	0.0106	yes	JUN	AUG	SEP
Parakiefferiella sp.	0	0	203	22.13	0.0001	yes	JUN	AUG	SEP
Total Chironomidae	612	1362	2244	33.51	0.0001	yes	JUN	AUG	SEP
Total Empididae	3	44	139	28.39	0.0001	yes	JUN	AUG	SEP

TABLE 4-62 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY SAMPLING DATE) FROM DEEP HABITAT SAMPLES ON ROCK STRUCTURES, 1982

Taxa or Group	Mean Density (No./m^2) June	Aug	Sept	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total Benthos	2032	6133	9129	26.66	0.0001	yes	JUN AUG SEP
Hydra sp.	0	27	278	20.01	0.0001	yes	JUN AUG SEP
Dugesia sp.	2	745	896	36.66	0.0001	yes	JUN AUG SEP
Total Naididae	1	5	59	30.36	0.0001	yes	JUN AUG SEP
Asellus sp.	26	31	2	11.58	0.0031	yes	JUN AUG SEP
Hyalella azteca	39	31	37	3.32	0.1897	no	JUN AUG SEP
Imm. Heptageniidae	1	154	41	7.56	0.0228	yes	JUN SEP AUG
Stenacron interpunctatum group	34	204	189	5.42	0.0666	no	JUN AUG SEP
Total Heptageniidae	35	375	250	20.97	0.0001	yes	JUN AUG SEP
Cyrnellus fraternus	27	147	578	29.98	0.0001	yes	JUN AUG SEP
Total Polycentropodidae	42	151	618	28.91	0.0001	yes	JUN AUG SEP
Imm. Hydropsychidae	17	154	265	23.96	0.0001	yes	JUN AUG SEP
Cheumatopsyche sp.	599	615	982	1.91	0.3852	no	JUN AUG SEP
Hydropsyche orris	516	2038	2617	0.47	0.7912	no	JUN AUG SEP
Total Hydropsychidae	1191	2960	3876	0.13	0.9370	no	JUN AUG SEP
Oecetis sp.	0	92	887	40.16	0.0001	yes	JUN AUG SEP
Total Leptoceridae	1	123	987	49.39	0.0001	yes	JUN AUG SEP
Total Elmidae	42	55	67	1.75	0.4172	no	JUN AUG SEP
Dicrotendipes sp.	3	232	323	38.99	0.0001	yes	JUN AUG SEP
Endochironomus sp.	30	33	18	4.78	0.0916	no	JUN AUG SEP
Glyptotendipes sp.	12	313	681	44.30	0.0001	yes	JUN AUG SEP
Microtendipes sp.	3	108	67	14.61	0.0007	yes	JUN SEP AUG
Rheotanytarsus sp.	397	283	54	19.85	0.0001	yes	JUN AUG SEP
Ablabesmyia sp.	4	105	91	31.15	0.0001	yes	JUN AUG SEP
Cricotopus bicinctus	0	0	14	3.20	0.2019	no	JUN AUG SEP
Parakiefferiella sp.	0	0	91	28.21	0.0001	yes	JUN AUG SEP
Total Chironomidae	586	1474	1802	27.43	0.0001	yes	JUN AUG SEP
Total Empididae	3	45	97	19.03	0.0001	yes	JUN AUG SEP

TABLE 4-63 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA FROM SILT AND SAND SAMPLES, JUNE 1982

Taxa or Group	Mean density ($No./m^2$) Silt Loc 6	Sand Loc 10	CHI^2	Prob.	Significant Difference
Total Benthos	1287[(a)]	442	7.00	0.0082	yes
Nematoda	653	115	6.61	0.0102	yes
Imm. Tubificidae w/o cap.	77	0	1.29	0.2568	no
Total Tubificidae	269	19	4.32	0.0376	yes
Hexagenia sp.	38	0	0.57	0.4497	no
Total Ephemeridae	38	0	0.57	0.4497	no
Total Chironomidae	134	96	0.14	0.7055	no
Pisidium sp.	19	0	0.14	0.7055	no
Total Sphaeriidae	58	0	1.29	0.2568	no

(a) Mean of 10 replicate samples.

TABLE 4-64 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA FROM SILT AND SAND SAMPLES, AUGUST 1982

Taxa or Group	Mean density (No./m^2) Silt Loc 6	Sand Loc 10	CHI^2	Prob.	Significant Difference
Total Benthos	6571[(a)]	2440	13.17	0.0003	yes
Nematoda	288	0	7.00	0.0082	yes
Total Naididae	768	154	6.61	0.0102	yes
Imm. Tubificidae w/o cap.	423	115	3.86	0.0494	yes
Total Tubificidae	2075	173	9.37	0.0022	yes
Hexagenia sp.	403	231	0.63	0.4274	no
Total Ephemeridae	403	231	0.63	0.4274	no
Total Chironomidae	2594	1153	9.61	0.0019	yes
Pisidium sp.	0	115	2.29	0.1306	no
Total Sphaeriidae	250	134	0.52	0.4727	no

(a) Mean of 10 replicate samples.

TABLE 4-65 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA FROM SILT AND SAND SAMPLES, SEPTEMBER 1982

Taxa or Group	Mean density (No./m^2) Silt Loc 6	Mean density (No./m^2) Sand Loc 10	CHI^2	Prob.	Significant Difference
Total Benthos	9414[(a)]	2824	14.00	0.0002	yes
Nematoda	2209	115	14.00	0.0002	yes
Total Naididae	1383	288	3.43	0.0640	no
Imm. Tubificidae w/o cap.	480	634	0.17	0.6776	no
Total *Tubificidae*	2498	903	6.61	0.0102	yes
Hexagenia sp.	442	250	0.46	0.4963	no
Total Ephemeridae	634	250	3.43	0.0640	no
Total Chironomidae	1460	442	10.32	0.0013	yes
Pisidium sp.	38	154	1.12	0.2899	no
Total Sphaeriidae	365	231	0.89	0.3447	no

(a) Mean of 10 replicate samples.

TABLE 4-66 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY YEAR) FROM SILT AND SAND SAMPLES, 1982

Taxa or Group	Mean density (No./m^2)				
	Silt Loc 6	Sand Loc 10	CHI^2	Prob.	Significant Difference
Total Benthos	5757	1902	15.23	0.0001	yes
Nematoda	1050	77	23.59	0.0001	yes
Total Naididae	717	147	5.08	0.0242	yes
Imm. Tubificidae w/o cap.	327	250	2.48	0.1154	no
Total Tubificidae	1614	365	13.88	0.0002	yes
Hexagenia sp.	295	160	1.28	0.2581	no
Total Ephemeridae	359	160	2.64	0.1039	no
Total Chironomidae	1396	564	6.89	0.0087	yes
Pisidium sp.	19	90	1.54	0.2143	no
Total Sphaeriidae	224	122	1.97	0.1602	no

(a) Mean of 30 samples.

TABLE 4-67 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY HABITAT) FROM WOOD ARTIFICIAL SUBSTRATE SAMPLES, AUGUST 1982

	Mean Density (No./m^2)									
	4W*	40	4D	8W	80	10	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total Benthos	14348	38981	23604	29305	14829	10635	7.23	0.2040	No	40 8w 4d 80 4w 10
Dugesia sp.	2145	294	542	2187	228	3	5.48	0.3601	No	8w 4w 4d 40 80 10
Imm. Hydropsychidae	1018	4373	1835	1580	1407	44	8.69	0.1220	No	40 4d 8w 80 4w 10
Cheumatopsyche sp.	3360	5571	4438	5378	777	207	9.15	0.1031	No	40 8w 4d 4w 80 10
Hydropsyche orris	4019	21338	9177	9802	2909	85	10.23	0.0690	No	40 8w 4d 4w 80 10
Total Hydropsychidae	8096	31855	15590	17222	5169	455	10.31	0.0670	No	40 8w 4d 4w 80 10
Glyptotendipes sp.	240	174	382	768	1021	6782	9.85	0.0797	No	10 80 8w 4d 4w 40
Polypedilum convictum	650	1102	1124	1351	1231	44	6.23	0.2844	No	8w 80 4d 40 4w 10
Rheotanytarsus sp.	524	3102	1847	3237	3610	110	8.23	0.1440	No	80 8w 40 4d 4w 10
Total Chironomidae	2450	5608	5361	7201	7789	8449	6.77	0.2384	No	10 80 8w 40 4d 4w

* W = with periphyton.
0 = without periphyton.
D = deep.
10 = sand.

TABLE 4-68 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY HABITAT TYPE) FROM WOOD ARTIFICIAL SUBSTRATE SAMPLES, AUGUST 1982

Taxa or Group	Mean Density (No./M^2)							
	With*	W/O	Deep	Loc. 10	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total Benthos	21826	26905	23604	10635	2.54	0.4684	No	w/o deep with 10
Dugesia sp.	2166	261	542	3	4.23	0.2381	No	with deep w/o 10
Imm. Hydropsychidae	1299	2890	1835	44	6.29	0.0984	No	w/o deep with 10
Cheumatopsyche sp.	4369	3174	4438	207	4.96	0.1746	No	deep with w/o 10
Hydropsyche orris	6910	12123	9177	85	4.96	0.1746	No	w/o deep with 10
Total Hydropsychidae	13064	18512	15590	455	4.75	0.1910	No	w/o deep with 10
Glyptotendipes	504	598	382	6782	4.75	0.1910	No	10 w/o with deep
Polypedilum convictum	1001	1166	1124	44	4.65	0.1990	No	w/o deep with 10
Rheotanytarsus sp.	1881	3356	1847	110	5.44	0.1421	No	w/o with deep 10
Total Chironomidae	4826	6699	5361	8449	4.13	0.2473	No	10 w/o deep with

---

* WITH = Shallow, with periphyton habitat on wing dam.
W/O = Shallow, without periphyton habitat on wing dam.
DEEP = Deep habitat on wing dam
Loc.10 = Sand habitat.

TABLE 4- 69 SUMMARY OF STATISTICAL COMPARISONS OF MACROINVERTEBRATE DENSITY DATA (BY LOCATION) FROM WOOD ARTIFICIAL SUBSTRATES, AUGUST 1982

Taxa or Group	Mean Density (No./m^2) 4	8	10	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total Benthos	25644	22067	10635	2.37	0.3065	No	4 8 10
Dugesia sp.	994	1207	3	4.10	0.1285	No	4 8 10
Imm. Hydropsychidae	2408	1494	44	4.90	0.0861	No	4 8 10
Cheumatopsyche sp.	4456	3078	207	4.90	0.0861	No	4 8 10
Hydropsyche orris	11511	6355	85	5.42	0.0666	No	4 8 10
Total Hydropsychidae	18784	11195	455	5.13	0.0770	No	4 8 10
Glyptotendipes sp.	265	894	6782	9.23	0.0099	Yes	4 8 10
Polypedilum convictum	959	1291	44	5.42	0.0666	No	8 4 10
Rheotanytarsus sp.	1825	3423	110	5.77	0.0559	No	8 4 10
Total Chironomidae	4473	7495	8449	4.62	0.0995	No	4 8 10

5.0 FISH

5.1 INTRODUCTION

A comprehensive sampling program was undertaken to describe and evaluate the structure, composition and abundance of fish assemblages associated with MCB habitat types. Ten study areas (locations) in the MCB areas of Pool 5A were sampled for adult and juvenile fish during May, June, August, September, and November 1982. Weekly sampling for larval fish was conducted at each of the study areas from early May to mid-August to evaluate the use of these areas as fish nursery habitat. Five major sampling techniques (electrofishing, seining, frame netting, trammel netting, and dip netting) were used to address the following four basic objectives:

1) To describe and evaluate differences among the selected MCB habitat types in structure, composition and abundance of fish assemblages;

2) To describe and evaluate seasonal changes in structure, composition and abundance of fish assemblages associated with selected MCB habitat types;

3) To describe and evaluate diel changes in structure, composition and abundance of fish assemblages associated with selected MCB habitat types;

4) To develop information on the utilization of selected MCB habitat types by fish as nursery areas.

5.2 METHODS

5.2.1 Field Procedures

Electrofishing

Electrofishing was conducted during each of the five monthly sampling periods. Separate collections were made for adult or large fishes (hereafter referred to as adult electrofishing) and for small or juvenile fishes (hereafter referred to as juvenile electrofishing). Collections were made at each of the 10 sampling locations, once in daylight hours and once at night during each sampling period. A minimum of 24-48 hours was maintained between day and night shocking at each location. A pulsating DC shocker with variable voltage and amperes, pulse width and pulse frequency was used to sample both adult and juvenile fish. The pulse width and frequency, and amperage settings were established based on the trial collection efforts that yielded the best results. The settings used during all the adult electrofishing collections were 4-5 amperes, 300 volts, 40 percent pulse width, and a frequency of 80 pulses per second, except in November. In November, an output voltage of 300V was completely ineffective, so the voltage was increased to 600V.

Adult electrofishing runs were made in a downstream direction for approximately 10 minutes at each location. Two men were used to dip fish and both wore polarized glasses during daytime electrofishing. The 10 minutes, which was the actual time the electrical field was generated, was divided among the various habitat types within each sampling area. The area sampled at each location was kept constant during all sampling periods. Specific conductance was measured with a Hydrolab Surveyor Model 6D, during each of the five collection periods.

Electrofishing was also conducted specifically for juvenile and small fish species (e.g., minnows and darters). As was the case for the adult electrofishing, juvenile electrofishing was conducted during both daylight and nighttime at each of the ten study areas during the five monthly sampling periods. Shocker settings were 4-5 amperes, 20 percent pulse width, 120 pulses per second and 300V. These settings were used in all months, except November, when the output voltage was increased to 600V because of the lack of success at 300V. Five minute shocking runs were conducted at each location. The area sampled at each location was kept constant for all sampling periods. Two dippers using 0.64 mm mesh dipnets selectively dipped only small fish. Collectors wore polarized glasses during all daytime collection activities.

Frame Nets

A frame net baited with canned dog food was set in each of the 10 locations for two consecutive 24-hr periods during each of the five months. Each frame net was constructed of netting of 1.9 cm mesh and had 15.3 meters of lead net with similar size mesh. The nets were positioned dependent upon the situation and morphometry encountered at each location. The nets at wing dams and closing dams (Locations 1, 2, 4, 7, and 8) were set parallel to the current with the trap end of the net on the dam itself. The nets at the sand areas (Locations 5, 9 and 10) and along the riprapped bank (Location 3) were set at an angle of approximately 45° to shore with the trap end offshore. The net at Location 6 (the silt bay) was set to block off the entrance to the cove. Any net that did not fish properly during the 24 hours was emptied and reset for another 24 hr period. Each net was fished at the same place and manner in each location during all months.

Trammel Nets

Two consecutive 24-hr trammel net sets were made at each of the 10 locations during each of the five sampling months. Each net consisted of a 30.5m by 1.8m panel of 3.2cm bar mesh. Trammel nets were also set in the scour holes downstream of the dams at Locations 1, 2, and 4 during the August, September and November sampling periods. Two nets were set at Location 4, whereas single nets were set in the Location 1 and 2 scour holes. All trammel nets were set parallel to the frame nets, but were not fished on the days the frame nets were in place.

Bag Seine

Seining was conducted along the shoreline of each of the 10 locations during each of the five months using a 15.3 x 1.8 meter bag seine with 0.64-cm bar mesh. Two seine hauls were made during the daylight hours at each study area and two hauls at the same locations during the night. Because the seinable area was limited, only one seine haul was made at

Location 4, wing dam. Fluctuating water levels and location-specific habitat differences necessitated different seining techniques among locations and months. In June, August and September, when the river was low, Locations 6 (silt bay), 8 (wing dam), 9 and 10 (sand flats) were sampled by carrying the seine approximately 23m offshore and then heading straight into shore. At the other locations (and these locations in May and November) one end of the seine was tied to a boat and the other end tied to shore and a 15.3m semicircle was seined. In May, extremely high flows prevented seining at Locations 1-4. In addition, the high flows in May dictated that a 7.6m seine be used at Locations 6, 8, 9 and 10 during either the day or night sampling, or both. This net also had 0.64-cm bar mesh. Because the same size mesh was used with both seines and the level of effort at each location was comparable (though not identical), it is felt that these variations in sampling methodology had little or no impact on subsequent results.

Minnow Traps

Two baited minnow traps were set for 24 hours at each of the 10 locations during May, June and August. Each minnow trap had 0.64-cm mesh with 2.54-cm throats. After August, the minnow trap sampling was discontinued because of very poor catch results.

Dip Nets

The shoreline, wingdams and other shallow areas associated with the 10 locations were surveyed for fish eggs, and larval and juvenile fish by utilizing handheld dip nets with U.S. Standard 30 mesh netting. Two field crew members fished the 10 locations once a week from early May to mid-August. Both crew members wore polarized glasses and sampled within each study area for 15 minutes. The two 15-minute efforts constituted separate samples that were not composited.

Fish Processing

Fish collected by electrofishing, frame nets, and gill nets were processed in the field immediately after sampling was completed in an effort to return as many fish as possible to the water alive. Some of the fish collected by seining were also processed in the field; however, a portion of the seine catch were preserved in 10% formalin and returned to the laboratory for processing. All fish of questionable identity from any sampling technique were also returned to the laboratory for processing. Fish collected were identified to species, measured (total length in mm) and weighed (g). In general, subsampling was not used; however, abundant minnows, gizzard shad, and the denser dipnet samples did require subsampling. In the latter situations, a random sample of 30 individuals was weighed and measured. A total count and batch weight was taken of the remaining individuals.

Larval fish and fish eggs collected by dip nets were preserved in 10% formalin and labeled with the appropriate information identifying the sample. In the laboratory, processing consisted of sieving each sample using screens of not less than No. 45 mesh (0.354mm opening). For each sample, all fish eggs and larvae were picked from the debris with the aid of an illuminated magnifier and placed in a labeled vial containing 5 percent formalin. All fish eggs and larvae were identified to the lowest positive taxonomic level, using a stereozoom microscope equipped with a polarized filter. Specimens whose identification was questionable were cross-checked against specimens with confirmed identification in EA's reference collection. A reference collection of all taxonomically difficult species (adult and larval) was maintained. Questionable species were sent to outside consultants for confirmation. Length measurements were taken to the nearest 0.1mm utilizing a calibrated ocular micrometer. All specimens were identified and enumerated and at least 30 larval fish and 30 eggs of each species were randomly selected and measured.

5.2.2 Data Presentation and Statistical Analysis

Field data were entered onto standardized data sheets, computerized, and then compiled into a series of descriptive tables (e.g., raw catch, catch per unit effort [CPE], and percent composition) for each of the various combinations of dates, gear types, locations, replicates, and sampling times (i.e., day vs night). The CPE data was then used to compare these various combinations statistically. Most of the count (i.e., numerical) data did not meet the assumptions for analysis of variance, therefore non-parametric rank tests were used to analyze the data. Separate analyses were made for each gear type, and adult and juvenile electrofishing data were treated separately. The day and night catches were considered as replicates, except, of course, when the diel comparisons were being made. For each gear type, comparisons were made for total catch and for selected species.

For each comparison (month, substrate, location, and diel), a mean value was calculated for each category of the comparison variable. For each comparison, the Kruskal-Wallis (KW) test was used to determine if there were any statistical differences among the categories of comparison variable. For example, was the total adult electrofishing catch the same for all five monthsπ Finally, Duncan's Multiple Range Test, modified for use in the nonparametric case, was used to identify where the statistical differences were.

The statistical comparisons that were made are summarized in the tables that follow. Each table follows an identical format. The means for the categories of the variable being compared are presented followed by the chi-square (Chi^2) value achieved testing the hypothesis that there were no differences between the categories. The probability (Prob.) of achieving that particular Chi^2 is also shown. The difference between or among categories was considered significant if the probability was ≤ 0.05 (signified in the next column of the table by the entry "yes"). The last column on the table contains the results of the Duncan Multiple Range test. Differences identified by Duncan's test were not considered valid unless the KW test showed that a significant difference(s) actually existed. For example, for adult electrofishing (Table 5-15), the KW test showed that a significant difference (P = 0.0001) in total catch was present among the five months being compared and Duncan's test showed that November was different (lower) than all the other months, but all the other months were statistically equivalent. For mooneye, the KW test shows that there was no statistical difference among months (P = 0.2611); thus, the difference identified by Duncan's test is not statistically valid. However, because Duncan's test did show how the months tended to group together (even though the groups were not statistically different), it was decided to present the results of Duncan's test even when the KW test indicated that no significant difference was present. Finally, there were a few occasions when the KW test showed that there was a significant difference between the categories being compared but Duncan's test could not identify where this difference was (e.g., bluegill and freshwater drum, Table 5-19). Such situations are identified in the text discussing each table.

5.3 RESULTS AND DISCUSSION

5.3.1 Adult and Juvenile Fish

The four principal gear types (electrofishing, seining, frame netting, and trammel netting) yielded a combined total of 9,479 fish, representing 58 species (Table 5-1, Section 5.7, and Appendix D). The catch was dominated numerically by emerald shiners (1,644 individuals, 17%), gizzard shad (1,351, 14%), and shorthead redhorse (975, 10%) (Table 5-2). Twenty other species (shovelnose sturgeon, mooneye, carp, spottail shiner, spotfin shiner, bullhead minnow, silver chub, sand shiner, river shiner, quillback, silver redhorse, white bass, rock bass, bluegill, black crappie, smallmouth bass, western sand darter, walleye, sauger, and freshwater drum) each composed between 1 and 10% of the catch. Conversely, stonecat, slenderhead darter, and river darter were represented by single specimens. In addition, crystal darter (3 specimens), which is considered endangered in Wisconsin, and blue sucker (2) and goldeye (13), which are considered threatened in Wisconsin, were captured (Wisconsin DNR 1982).

Based on a review of the literature, Van Vooren (1983) recently reported that 83 species of fish have been reported from Pool 5A, indicating that the 58 species collected during this survey represents a sizeable portion of the fish community indigenous to Pool 5A. Of the 28 species listed by Van Vooren that were not collected during the present study, 27 were considered by Van Vooren to be either rare (2 species), uncommon (4 species), occasional (7 species), strays (7 species) or have not been collected at all in the last 10 years (7 species). Two of these 28 species, though not included in the results of the fisheries program, were observed or collected during this study. A paddlefish (Polyodon spathula) was "turned over" during shocking but was so large (about 40 kg) that it fell out of the dipnet and escaped. Also, one mud darter (Etheostoma asprigene) was collected during the benthos phase of this study and was not included as part of the regular fish sampling results. Only one species, the speckled chub (Hybopsis aestivalis) considered by Van Vooren to be common was not collected during the present study. However, it does not appear that this species is actually common in Pool 5A because it was not collected in any of the three most intensive studies of Pool 5A (Fremling et al. 1980, Anderson et al. 1983, this study), nor was it collected in eight years of sampling in Pool 5 (Dairyland Power 1982). Becker (1983) describes it as uncommon in the Mississippi River below its confluence with the Wisconsin River and the

TABLE 5-1 LIST OF FISH SPECIES COLLECTED FROM POOL 5A OF THE MISSISSIPPI RIVER IN 1982

Silver lamprey (*Ichthyomyzon unicuspis*)
Shovelnose sturgeon (*Scaphirhynchus platorynchus*)
Longnose gar (*Lepisosteus osseus*)
Shortnose gar (*Lepisosteus platostomus*)
Bowfin (*Amia calva*)
American eel (*Anguilla rostrata*)
Gizzard shad (*Dorosoma cepedianum*)
Goldeye (*Hiodon alosoides*)
Mooneye (*Hiodon tergisus*)
Northern pike (*Esox lucius*)
Minnows (*Cyprinidae*)
Shiners (*Notropis* spp.)
Carp (*Cyprinus carpio*)
Silver chub (*Hybopsis storeriana*)
Bullhead minnow (*Pimephales vigilax*)
Pugnose minnow (*Notropis anogenus*)
Sand shiner (*Notropis stramineus*)
Mimic shiner (*Notropis volucellus*)
Spottail shiner (*Notropis hudsonius*)
Emerald shiner (*Notropis atherinoides*)
Golden shiner (*Notemigonus crysoleucas*)
River shiner (*Notropis blennius*)
Spotfin shiner (*Notropis spilopterus*)
River carpsucker (*Carpiodes carpio*)
Highfin carpsucker (*Carpiodes velifer*)
Carpsucker spp. (*Carpiodes* spp.)
Quillback (*Carpiodes cyprinus*)
Bigmouth buffalo (*Ictiobus cyprinellus*)
Smallmouth buffalo (*Ictiobus bubalus*)
Blue sucker (*Cycleptus elongatus*)
Spotted sucker (*Minytrema melanops*)
White sucker (*Catostomus commersoni*)
Golden redhorse (*Moxostoma erythrurum*)
Shorthead redhorse (*Moxostoma macrolepidotum*)
Silver redhorse (*Moxostoma anisurum*)
Carpsucker/buffalo (Ictiobinae)
Channel catfish (*Ictalurus punctatus*)
Flathead catfish (*Pylodictis olivaris*)
Stonecat (*Noturus flavus*)
Tadpole madtom (*Noturus gyrinus*)
Troutperch (*Percopsis omiscomaycus*)
Burbot (*Lota lota*)
Brook silversides (*Labidesthes sicculus*)
White bass (*Morone chrysops*)
Bluegill (*Lepomis macrochirus*)
Orangespotted sunfish (*Lepomis humilis*)
Pumpkinseed (*Lepomis gibbosus*)
Rock bass (*Ambloplites rupestris*)
Largemouth bass (*Micropterus salmoides*)
Smallmouth bass (*Micropterus dolomieui*)
Black crappie (*Pomoxis nigromaculatus*)
White crappie (*Pomoxis annularis*)
Crystal darter (*Ammocrypta asprella*)
Johnny darter (*Etheostoma nigrum*)
Slenderhead darter (*Percina phoxocephala*)
River darter (*Percina shumardi*)
Logperch (*Percina caprodes*)
Western sand darter (*Ammocrypta clara*)
Sauger (*Stizostedion canadense*)
Walleye (*Stizostedion vitreum vitreum*)
Yellow perch (*Perca flavescens*)
Freshwater drum (*Aplodinotus grunniens*)

TABLE 5-2. SPECIES THAT COMPOSED ONE PERCENT OR MORE OF THE CATCH (ALL METHODS COMBINED) IN COLLECTIONS MADE IN POOL 5A OF THE UMR IN 1982. VALUES SHOWN REPRESENT ACTUAL CATCH AND PERCENT COMPOSITION (IN PARENTHESIS).

	Shovelnose sturgeon	Gizzard shad	Mooneye	Carp	Spottail shiner	Spotfin shiner	Emerald shiner	Bullhead minnow	Sand shiner	River shiner	Silver chub	Quillback
Electrofishing												
Day, Adult	-	90 (15)	10 (2)	25 (4)	2 (<1)	7 (1)	12 (2)	4 (1)	-	1 (<1)	-	3 (<1)
Night, Adult	-	125 (10)	29 (2)	42 (3)	1 (<1)	1 (<1)	2 (<1)	-	-	4 (<1)	10 (1)	20 (2)
Day, Juv	-	236 (35)	-	-	2 (<1)	70 (10)	197 (29)	26 (4)	-	56 (8)	2 (<1)	5 (1)
Night, Juv	-	233 (34)	1 (<1)	-	3 (<1)	7 (1)	307 (45)	11 (2)	3 (<1)	9 (1)	4 (1)	1 (<1)
Seining												
Day	-	178 (7)	6 (<1)	1 (<1)	126 (5)	214 (8)	738 (28)	229 (9)	58 (2)	466 (18)	11 (<1)	247 (9)
Night	-	484 (23)	17 (1)	4 (<1)	24 (1)	161 (8)	388 (19)	101 (5)	15 (1)	186 (9)	22 (1)	30 (1)
Trammel Net												
Rep A	58 (14)	1 (<1)	20 (5)	7 (2)	-	-	-	-	-	-	-	24 (6)
Rep B	52 (16)	-	14 (4)	15 (5)	-	-	-	-	-	-	-	17 (5)
Frame Net												
Rep A	-	1 (<1)	2 (<1)	3 (1)	-	-	-	-	-	-	16 (4)	-
Rep B	-	3 (1)	4 (1)	3 (1)	-	-	-	-	-	-	9 (3)	-
All Gear	110 (1)	1,351 (14)	103 (1)	100 (1)	158 (2)	460 (5)	1,644 (17)	371 (4)	76 (1)	722 (8)	74 (1)	347 (4)

TABLE 5- 2 (CONT.)

	Silver redhorse	Shorthead redhorse	White bass	Rock bass	Bluegill	Smallmouth bass	Black crappie	W. sand darter	Sauger	Walleye	Freshwater drum	Total Catch
Electrofishing												
Day, Adult	12 (2)	174 (28)	20 (3)	12 (2)	67 (11)	39 (6)	13 (2)	-	25 (4)	15 (2)	30 (5)	620
Night, Adult	19 (2)	432 (35)	51 (4)	46 (4)	61 (5)	32 (3)	56 (5)	-	114 (9)	47 (4)	91 (7)	1,242
Day, Juv	-	10 (1)	24 (4)	7 (1)	10 (1)	4 (1)	1 (<1)	1 (<1)	1 (<1)	-	16 (2)	681
Night, Juv	-	-	50 (7)	10 (1)	4 (1)	3 (<1)	1 (<1)	2 (<1)	-	-	18 (3)	682
Seining												
Day	7 (<1)	18 (1)	42 (2)	2 (<1)	100 (4)	3 (<1)	14 (1)	63 (2)	2 (<1)	1 (<1)	28 (1)	2,657
Night	2 (<1)	57 (3)	210 (10)	4 (<1)	70 (3)	3 (<1)	33 (2)	9 (<1)	12 (1)	10 (<1)	135 (7)	2,070
Trammel Net												
Rep A	25 (6)	102 (24)	26 (6)	6 (1)	2 (<1)	1 (<1)	40 (10)	-	7 (2)	12 (3)	22 (5)	421
Rep B	19 (6)	84 (25)	6 (2)	3 (1)	5 (2)	3 (1)	31 (9)	-	6 (2)	16 (5)	19 (6)	330
Frame Net												
Rep A	-	66 (16)	3 (1)	17 (4)	42 (10)	-	184 (43)	-	6 (1)	-	51 (12)	425
Rep B	-	31 (9)	5 (1)	18 (5)	46 (13)	-	164 (47)	-	9 (3)	1 (<1)	42 (12)	351
All Gear	84 (1)	975 (10)	437 (5)	125 (1)	407 (4)	88 (1)	537 (6)	75 (1)	186 (2)	102 (1)	452 (5)	9,479

Wisconsin DNR considers it to be threatened (WDNR 1982).

Three species--stonecat, burbot, and slenderhead darter--not reported by Van Vooren for Pool 5A were collected during this study. All could be classified as rare. The records for these three species are the first for Pool 5A.

In general, Van Vooren's abundance classification scheme appears to be very accurate. However, several discrepancies were noted. For example, shorthead redhorse was abundant during this study rather than common as Van Vooren suggests. Conversely, no speckled chubs, a species Van Vooren classifies as common, were captured during the present study. Similarly, only nine bigmouth buffalo were captured, another species Van Vooren classifies as common. Finally, Van Vooren classifies both white and black crappie as common, suggesting that they are equally abundant. However, black crappie was much more abundant (537 individuals) than white crappie (12 individuals) during the present study.

In August and September of 1980, the St. Paul District COE (Anderson et al. 1983) conducted a fisheries study that was the forerunner of the present study. The major differences between the two studies were: (1) they sampled 8 locations in addition to the ten locations included in this study; (2) they used otter trawling, a gear type not included in the present study; (3) this study used trammel nets, a gear not used by Anderson et al., and (4) this study was conducted during three seasons, not one. Given the similarities in design, it was not surprising that the results of the two studies were quite similar in terms of species composition. Anderson et al. (1983) reported capturing 52 species of fish, of which all but green sunfish (Lepomis cyanellus), northern hog sucker (Hypentilium nigricans), and mud darter were captured during the present study. Eight species not reported by Anderson et al. (1983) were captured during this study: shovelnose sturgeon, golden shiner, pugnose minnow, bowfin, highfin carpsucker, stonecat, tadpole madtom, and slenderhead darter. It is not surprising that the present study captured a few more species because although Anderson et al. sampled more locations, the present study was conducted over a longer period of time.

One important finding of both the Anderson et al. (1983) study and this study is the combined collection of 14 crystal darters, a species on Wisconsin's Endangered Species list. Within the last 10 years, it has been reported in the UMR only in Pools 5 and 5A (Van Vooren 1983). Dairyland Power captured three specimens in Pool 5 during their 1974-1981 sampling program (George Johnston, personal communication). Eddy and Underhill (1976) reported capturing one specimen near Winona, Minnesota (Pool 6) before 1960. The number captured recently suggests that a small, but viable, crystal darter population exists in Pool 5A. Dr. James Underhill (personal communication) believes that this species is present in the Mississippi River in greater numbers than commonly believed and that the lack of records from the the river reflects a lack of effort with the proper gear (i.e., small mesh seines) in suitable habitat (swift sandy areas with suitable cover). Dr. David McConville (personal communication) also reports occasionally collecting this species from the upper Mississippi River.

One other recent fisheries study (Fremling et. al., 1980) has been conducted in Pool 5A, but it concentrated on the backwater areas associated with Fountain City Bay, therefore making comparisons with the present study difficult. Fremling et. al. (1980) collected a total of 61 species during the period 1975 to 1978 using a combination of electrofishing, trapnetting, and seining. They reported 16 species not collected during the present study. Most of those, however, were species associated with backwater areas (e.g., black bullhead [Ictalurus melas], brown bullhead [I. nebulosus], green sunfish, and others) or strays from small tributaries (e.g., rainbow darter [Etheostoma caeruleum], blacknose dace [Rhinichthys atratulus], common shiner [Notropis cornutus], and others). In addition, one of the species (spottail darter [Etheostoma squamiceps]) reported by Fremling et al. (1980) is questionable as Pool 5A is considerably outside of its reported range (Lee et al. 1980). The specimen reported by Fremling et al. (1980) is no longer extant (McConville, personal communication). The only truly riverine species collected by Fremling and not collected during the present study was the river redhorse (Moxostoma carinatum), a species not previously reported in Pool 5A (Van Vooren 1983).

The most comprehensive studies done nearby but not in Pool 5A itself, are surveys that have been conducted annually by Dairyland Power (DP). They reported collecting 77 species of fish from Pool 5 during the period 1974-1981. Of the 19 species they reported that were not captured during the present study, 11 are considered to be rare or strays, 6 to be uncommon, and 2 to be occasional (DP 1982). Moreover, most of the occasional or uncommon species collected by DP are backwater species. Thus, the agreement between their studies and this study is good.

5.3.1.1 Diversity

Diversity values allow catch data to be described by a single statistic, thereby providing a simple means for evaluating the influence of selected variables on the catch. Therefore, Shannon-Weaver diversity values were calculated to determine whether certain locations produced more diverse catches consistently (or in certain months), whether diel differences in species composition were apparent and whether certain gears yielded more diverse catches. Diversity values were calculated only for electrofishing (adult and juvenile) and seining because the trammel netting conducted during this study used only one mesh size and thus was very size- (and hence species) specific. Similarly, frame netting is both size and species selective, with larger fish and centrarchids in particular being disproportionally represented (Pierce 1980, Pitlo 1982). Conversely, seining and electrofishing, though also having inherent biases, were considered appropriate for comparing the diversity of the fish community at each location because each yielded many more species than did trammel or frame netting (Section 5.3.3.2). However, even for these two gears, no valid comparisons could be made using the November data because of the low catch in this month.

Electrofishing

For May, June, August and September combined, adult electrofishing produced a slightly more diverse catch during the night than during the day (2.2 at night vs. 1.9 during the day, Table 5-3). Fernholz et al. (1980) also reported that diversities were higher in samples collected at night in Pool 8 and that diel differences were greatest in samples collected over sandy substrates and least over riprapped areas. This finding is consistent with the results of the present study where two of the sand flats (Locations 5 and 9) exhibited the greatest diel differences. Diel differences in the adult electrofishing catch (all locations combined) were not apparent in May or June, but were quite evident in August and September (Table 5-3). Similarly, maximum diversity values occurred at most locations in August or September. The lower diversities in June, compared to those in August or September, apparently were the result of the large number (248 individuals, 48 percent of the catch) of shorthead redhorse captured in June. Locations 3 (the silt bay) and 6 (the riprapped bank), which were the two most productive locations, also had the two highest mean diversity values among the 10 locations (Table 5-3). Similarly, Locations 7 and 8 (both wing dams), which were the two least productive locations, also ranked near the bottom in terms of diversity.

Mean diversity values for juvenile electrofishing were 0.6-0.7 diversity units lower compared to those calculated for adult electrofishing. This was undoubtedly a result of the pulser output settings purposely being set to capture smaller specimens and the fact that the large fish "turned over" by the electrofisher were not picked up. Thus, as described in Section 5.3.3.2, the juvenile electrofishing catch was dominated by gizzard shad and a few species of minnows. The mean diversity for the three months examined did not appear to exhibit any diel differences.

In contrast to the good correlation between productivity (i.e., total catch) and diversity for adult electrofishing, no such relationship was apparent for juvenile electrofishing. This lack of correlation is probably related to the juvenile catch being dominated by only a few species. Thus, a large catch of gizzard shad or emerald shiners would increase the total catch significantly but would decrease diversity because of its redundancy.

Seining

For May, June, August, and September combined, night seining produced a slightly more diverse catch ($\bar{d} = 2.2$) than did day seining ($\bar{d} = 1.8$), both replicates combined (Table 5-3). These values are nearly identical to the values of 2.2 and 1.9 that were calculated for night and day adult electrofishing, respectively. This suggests that these gears are comparable in their ability to sample a cross-section of the indigenous fish community, as demonstrated by the fact that both methods caught a very similar number of species (42 for adult electrofishing and 45 for seining). Diversity was highest at night at all locations except Location 9 (sand flat). Diel differences were most pronounced at Locations 3 (riprapped bank), 5 (sand flat), and 8 (wing dam). As was the case with adult electrofishing, diel differences in the diversity of the seining catch, were most apparent in August and September. Also, as with adult electrofishing, the highest diversity values in the seine catch were achieved in September.

TABLE 5-3. SUMMARY OF SHANNON-WEAVER DIVERSITY VALUES CALCULATED FOR SAMPLES COLLECTED BY ELECTROFISHING AND SEINING DURING THE DAY (D) AND NIGHT (N) IN POOL 5A, 1982

	LOCATION																					
	1		2		3		4		5		6		7		8		9		10		Mean		Range	
	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
Adult Electrofishing																								
May	-*	1.4	0.8	1.9	3.0	2.3	1.4	1.7	1.9	2.3	1.6	1.9	1.6	1.9	2.1	3.1	2.7	2.8	2.6	2.8	2.0	2.2	0.8-3.0	1.4-3.1
June	1.8	1.4	2.5	2.4	2.6	2.8	2.1	2.5	-	1.7	2.5	2.6	1.6	1.5	1.4	1.0	2.3	1.7	-	1.4	2.1	1.9	1.2-2.6	1.0-2.8
August	1.6	2.4	2.2	3.1	2.3	1.3	2.1	3.1	0.9	2.7	2.5	2.5	1.1	1.5	-	1.8	2.0	3.2	1.4	2.9	1.8	2.5	0.9-2.3	1.3-3.1
September	2.2	2.8	3.2	1.7	2.1	2.6	1.7	2.0	0.7	1.5	2.3	3.3	2.1	2.3	2.5	1.7	0.2	2.7	2.7	3.0	2.0	2.4	0.7-3.2	1.5-3.3
Mean $\bar{d}$	1.9	2.0	2.2	2.3	2.5	2.3	1.8	2.3	1.2	2.1	2.2	2.6	1.5	1.8	1.5	1.9	1.8	2.6	2.2	2.5	1.9	2.2	1.2-2.5	1.8-2.6
Juvenile Electrofishing																								
June	1.8	0.4	1.9	0.5	0.9	-	-	-	0.3	-	2.6	-	0.5	0.7	0.5	-	0.9	1.5	0.4	1.0	1.1	0.8	0.3-2.6	0.4-1.5
August	1.3	3.0	1.7	2.0	1.0	1.0	1.7	0.9	-	1.1	0.9	0.7	2.0	2.3	-	1.4	1.5	1.7	1.0	1.6	1.4	1.6	0.9-2.0	0.7-2.9
September	2.8	1.7	1.9	1.5	1.1	1.9	0.5	0.9	1.6	1.8	1.3	1.7	1.0	1.7	1.5	1.6	-	1.3	0.9	2.0	1.4	1.6	0.5-2.8	0.9-2.0
Mean $\bar{d}$	2.0	1.7	1.8	1.3	1.0	1.5	1.1	0.9	0.9	1.5	1.6	1.2	1.2	1.6	1.0	1.5	1.2	1.5	0.8	1.5	1.2	1.4	0.9-2.0	0.9-1.7
Seining, Rep A																								
May	-	-	-	-	-	-	-	-	0.6	1.8	-	-	0.9	-	-	-	-	0.9	1.5	-	1.0	1.4	0.6-1.5	0.9-1.8
June	-	1.7	1.0	1.8	0.9	3.0	-	1.5	1.1	1.4	2.5	2.1	-	1.0	1.1	1.8	0.8	1.4	1.5	1.3	1.3	1.7	0.8-2.5	1.0-3.0
August	-	1.7	3.0	2.8	1.8	2.0	0.3	-	2.5	2.0	3.1	2.1	0.9	2.2	1.5	2.7	2.4	2.8	3.1	2.9	2.1	2.1	0.3-3.1	1.7-2.9
September	-	1.9	2.2	-	-	2.3	-	-	1.9	2.3	2.6	3.0	2.1	2.5	2.6	2.1	1.9	2.4	2.5	2.7	2.3	2.4	1.5-2.6	1.9-3.0
Mean $\bar{d}$	-	1.8	2.1	2.3	1.3	2.4	0.3	1.5	1.5	1.9	2.7	2.4	1.3	1.9	1.7	2.2	1.7	1.9	2.1	2.3	1.6	2.1	0.3-2.7	1.5-2.4
Seining, Rep B																								
May	-	-	-	-	-	-	-	-	0.8	1.0	0.7	1.0	-	-	-	-	1.6	-	-	0.8	1.0	0.9	0.7-1.6	0.8-1.0
June	-	*	*	1.7	1.0	1.0	1.0	-	1.4	1.6	1.3	2.8	0.5	*	1.8	2.3	2.9	1.5	0.3	1.6	1.3	1.8	0.5-2.9	1.0-2.8
August	2.0	2.5	1.8	2.8	-	1.6	-	-	0.3	2.9	2.9	2.2	0.4	1.1	1.1	2.7	2.8	2.5	2.3	2.9	1.7	2.4	0.3-2.9	1.1-2.9
September	-	1.5	0.7	-	-	2.0	-	-	-	2.0	2.6	2.5	1.9	2.3	2.6	2.6	2.2	2.3	2.5	2.7	2.1	2.2	0.7-2.6	1.5-2.7
Mean $\bar{d}$	2.0	2.0	1.3	2.3	1.0	1.5	1.0	-	0.8	1.9	1.9	2.1	0.9	1.7	1.8	2.5	2.4	2.1	1.7	2.0	1.5	2.0	0.8-2.4	1.5-2.5
Seining, Both Replicates Combined																								
May	-	-	-	-	-	-	-	-	1.2	2.2	0.7	1.0	0.9	-	0.9	-	2.3	0.9	1.5	1.4	1.2	1.4	0.7-1.5	1.0-2.2
June	-	1.6	1.6	2.0	1.7	3.1	1.0	1.5	1.9	1.8	1.8	2.9	1.1	1.0	1.4	2.7	2.9	1.5	1.6	1.7	1.7	2.0	1.0-2.9	1.0-3.1
August	1.8	2.6	3.0	3.3	1.7	2.5	0.3	-	0.9	2.7	3.2	2.2	0.6	2.0	1.3	2.9	3.0	2.8	3.0	3.0	1.9	2.7	0.3-3.2	2.0-3.3
September	-	2.0	2.5	-	-	2.7	-	-	1.5	2.6	2.7	3.3	2.5	3.1	2.9	2.8	2.2	2.6	2.8	2.9	2.4	2.7	1.5-2.9	2.0-3.3
Mean $\bar{d}$	1.8	2.1	2.4	2.7	1.7	2.8	0.7	1.5	1.4	2.3	2.1	2.3	1.3	1.5	1.6	2.8	2.6	1.9	2.2	2.3	1.8	2.2	0.7-2.6	1.5-2.8

*No fish captured or only 1 fish captured ($\bar{d}$ = 0); data not included in calculation of the mean $\bar{d}$.

On an annual basis, there seemed to be little correlation between the productivity of a location (i.e., the total number of fish captured seining) and its diversity value. For example, Locations 2 (closing dam) and 3 (riprapped bank) ranked at or near the top in terms of diversity (Table 5-3) but ranked near the bottom in terms of total catch (Table 5-22). Furthermore, Location 6 (silt bay), which was by far the most productive location, only ranked in the middle in terms of diversity.

Intuitively, one might expect maximum diversity values for seining to occur in August when the total catch was greatest and the maximum number of species were captured. However, the August catch, though large and diverse, was also quite redundant. For example, two species--gizzard shad and emerald shiner--comprised 50 percent of the total catch. Because of how diversity is calculated, redundancy acts to lower $\bar{d}$. Thus, it seems likely that the large catch of these two species in August tended to lower the diversity values compared to what one might expect.

5.3.1.2 Length Frequency Distributions

Length-frequency (LF) tables were prepared for the species most commonly collected during this study to determine how the size classes collected were affected by selected variables. LF data for each month of the study were compiled for mooneye, carp, spotfin shiner, emerald shiner, shorthead redhorse, bluegill, sauger, walleye, and freshwater drum, all of which were common to abundant throughout the study. Species that were common (generally more than 20 individuals) only in certain months were analyzed only for those months. Examples of seasonally common species are shovelnose sturgeon, gizzard shad, spottail shiner, bullhead minnow, sand shiner, river shiner, quillback, silver redhorse, white bass, rock bass, smallmouth bass, black crappie, and western sand darter. Detailed LF information was prepared for all the above species (those common in all months and those common only in some months) and is presented in Appendix D.

Gear Comparisons

No comparisons were made using the frame or trammel netting data as these gears are designed to catch only larger fish. For seining and electrofishing (adult and juvenile), the gears least likely to be unduly size-selective, few species were captured abundantly enough to allow comparisons across all three gear types. Comparisons were also difficult because the juvenile electrofishing data was biased because only the small fish among those stunned were retrieved. Gizzard shad caught by adult electrofishing were noticeably larger (115 mm) than those caught by seining (89 mm), while those caught by juvenile electrofishing were intermediate in size (99 mm) (Table 5-4). Interestingly, the three species of minnows (spotfin shiner, emerald shiner, and river shiner) caught abundantly enough to be compared between seining and juvenile electrofishing exhibited no distinct pattern regarding gear size selectivity. The spotfin shiners and river shiners caught juvenile electrofishing were slightly larger than those caught seining, while the emerald shiners caught by both methods were nearly identical in size. This suggests that both methods are sampling the same cross-section of the minnow community. White bass caught adult electrofishing were much

TABLE 5-4. COMPARISONS OF MEAN TOTAL LENGTHS (mm) FOR SELECTED FISHES CAUGHT DURING 1982 IN POOL 5A BY VARIOUS GEAR TYPES

	All Gears Combined	Seining	Day Seining	Night Seining	Adult Electro.	Day Adult Electro.	Night Adult Electro.	Juv. Electro.	Day Juv. Electro.	Night Juv. Electro.
Shovelnose sturgeon	748	-	-	-	-	-	-	-	-	-
Gizzard shad	95	88	89	88	115	121	108	99	104	95
Mooneye	276	-	-	-	-	-	-	-	-	-
Carp	501	-	-	-	533	511	546	-	-	-
Spottail shiner	67	66	67	61	-	-	-	-	-	-
Spotfin shiner	60	55	58	51	-	-	-	62	-	-
Emerald shiner	68	68	69	66	-	-	-	67	67	66
Bullhead minnow	50	49	49	49	-	-	-	-	-	-
Sand shiner	62	62	62	52	-	-	-	-	-	-
River shiner	73	72	71	73	-	-	-	80	-	-
Quillback	141	90	88	102	316	429	299	-	-	-
Silver redhorse	399	-	-	-	-	-	-	-	-	-
Shorthead redhorse	286	-	-	-	273	-	-	-	-	-
White bass	124	100	105	99	151	164	146	111	112	111
Rock bass	147	-	-	-	146	161	142	-	-	-
Bluegill	101	61	-	-	112	89	138	-	-	-
Smallmouth bass	209	-	-	-	211	211	212	-	-	-
Black crappie	177	-	-	-	171	173	170	-	-	-
Sauger	249	-	-	-	242	244	242	-	-	-
Walleye	314	-	-	-	305	296	313	-	-	-
W. sand darter	49	49	-	-	-	-	-	-	-	-
Freshwater drum	190	109	100	111	204	203	209	112	113	110

larger (151 mm), on the average, than those caught seining (100 mm) or juvenile electrofishing (111 mm) (Table 5-4). Similarly, the mean size (204 mm) of freshwater drum caught adult electrofishing was nearly twice that of those caught seining (109 mm) or juvenile electrofishing (112 mm). Also, the mean sizes of quillbacks and bluegills caught adult electrofishing were much larger than those caught seining. Thus, it seems reasonable to conclude that, for a given species, adult electrofishing captures considerably larger specimens than does seining, a not particularly surprising finding. However, juvenile electrofishing appears to capture specimens of nearly the same size as does seining. It is possible, however, that this may be an artifact of how the shocked fish were collected.

Diel Comparisons

Generally, species captured during the day were similar in size to those captured during the night, regardless of gear type. Shocking (whether adult or juvenile) during the day yielded slightly larger gizzard shad than at night (Table 5-4). Similarly, the mean size of most species of minnows caught seining was also slightly greater during the day than at night. Conversely, the mean size of freshwater drum caught seining was slightly greater at night. For adult electrofishing, the mean sizes of carp, walleye, freshwater drum, and particularly bluegill caught during the night were larger than those caught during the day. Conversely, gizzard shad, white bass, rock bass, and particularly quillback were represented by larger specimens during the daytime adult electrofishing collections. No trend was apparent for smallmouth bass, black crappie, and sauger. Collectively, these results suggest that despite diel fluctuations in abundance, diel variations in the size composition of the populations being sampled are not significant.

5.3.1.3 Length Frequencies of Selected Species

The species accounts provided below are based on the data presented in Appendix D.

Mooneye

Mooneye were captured in three basic size groups: those from 100-160 mm (11 percent of the total), those from 250 to 280 mm (27 percent), and those greater than 280 mm (56 percent). Individuals in the smallest size category were basically restricted to August and September. The mean size was similar in all months except September. In 1980, Anderson et al. (1983) also found three sizes of mooneye in Pool 5A; 130-170 mm, 200-250 mm, and 290-330 mm.

Sauger

No small (<130 mm) sauger were collected, and 76 percent of those collected were between 190 and 280 mm. Anderson et al. (1983) also collected very few small sauger from Pool 5A, but reported a more even size distribution among the adults they collected. The mean size of sauger increased throughout the duration of the present study so that by November the mean size was 318 mm. No individuals smaller than 250 mm were collected in November.

Spotfin Shiner

Sixty-three percent of the spotfin shiners collected were between 50 and 70 mm and are probably Age I fish (Carlander 1969). Similarly, Anderson et al. (1983) found that most of the spotfin shiners they collected in Pool 5A were between 50 and 80 mm. In the present study, 25 percent of the fish were <50 mm, probably young-of-the-year (YOY) fish. The 12 percent of the fish greater than 70 mm were probably Ages II and II+ fish.

Emerald Shiner

Seventy-eight percent of the emerald shiners collected were between 50 and 80 mm. Individuals in this size range could be Ages 0, I, or II (Carlander 1969) but are probably primarily Age I fish. YOYs (<50 mm) did not make up a sizeable proportion of the catch until November when they composed 37 percent of the catch. The mean size of emerald shiners collected each month declined throughout the study period reflecting recruitment of YOYs into the catch.

Carp

Only three carp smaller than 360 mm were captured during the study. The remaining 97 individuals were fairly uniformly distributed over the remainder of the size range, although 56 percent were >510 mm. No seasonal trend in mean size was apparent.

Shorthead Redhorse

Shorthead redhorse from 55 to 597 mm were captured indicating that individuals from Ages 0 to VIII were probably represented (Carlander 1969). Six, 40 mm size groups from 170 to 410 mm each composed 11 to 22 percent of the catch indicating that many age classes were represented. Only nine percent of the catch fell outside this range. The mean size did not appear to vary according to month.

Walleye

Of the 103 walleye captured, 61 percent were between 250 and 370 mm indicating those most were probably Ages II and III (Laarman 1963). Only four walleye were caught that were probably YOYs (<170 mm). Sixteen percent were between 170 and 250 mm (i.e., Age I fish). Similarly, 19 percent were >370 mm (presumably were Age III and older), the size frequently sought by anglers. No seasonal patterns were apparent. In 1980, Anderson et al. (1983) caught more small walleyes but fewer medium to large walleyes compared to the present study.

Freshwater Drum

The freshwater drum catch was composed of two principal size classes. Forty percent of the catch was between 50 and 130 mm and 33 percent was between 210 and 290 mm. Except for those within the above ranges, no other 40 mm size group was represented by more than 10 percent of the catch. Small freshwater drum (<90 mm) were common only in August and September and, as a result, the mean length in these months was much lower than in May, June or November. Anderson et al. (1983) also found a substantial peak between 50 and 130 mm and few fish from 130 to 200 mm. However, they reported that the remainder of the catch was uniformally distributed among fish from 200 to 390 mm.

Bluegill

The mean size of bluegills captured decreased throughout the duration of the study falling from a mean of 128 mm in May to only 50 mm in November. Presumably, the mean lengths in May and June were influenced by the collection of spawning adults. Conversely, YOYs were common (31 percent of the catch) in August and abundant (64 percent) in September. Anderson et al. (1983) also collected many YOY bluegills in August and September from Pool 5A.

Spottail Shiner

During August and September, the only months when this species was common, 94 percent of the specimens were between 50 and 80 mm. These are probably Age I and II fish (Carlander 1969); few YOY fish (<50 mm) were collected). Anderson et al. (1983) found a very similar pattern in Pool 5A in 1980, as they reported that almost all the spottail shiners they collected were between 60 and 80 mm.

Sand Shiner

Sixty-nine percent of the sand shiners collected were between 60 and 80 mm and 28 percent were between 40 and 60 mm. Few YOY fish were captured.

Bullhead Minnow

The catch of bullhead minnows was fairly well distributed over the interval from 20 to 70 mm, though the majority (54 percent) of those collected were between 50 and 70 mm. These larger fish were probably Ages I and II, whereas those <50 mm were probably a combination of Ages 0 and I. Anderson et al. (1983) found that in August of 1980 bullhead minnows covered the same size range reported here but also found a much larger number of fish that were clearly YOYs (<40 mm).

River Shiner

In the present study, 65 percent of the river shiners were between 60 and 80 mm. Similarly, Anderson et al. (1983) found that the majority of river shiners they collected were between 65 and 85 mm. During the present study, it could be seen that more YOY fish were recruited into the catch during each succeeding month. Anderson et al. (1983) collected more YOY fish in Pool 5A in 1980 than in the present study, however, most of their fish were caught with an otter trawl, a gear not used during the present study.

Western Sand Darter

Almost all (>95 percent) the western sand darters captured were between 40 and 60 mm.

Shovelnose Sturgeon

This species was only abundant in June. Of the 103 individuals captured in June, 76 percent were between 710 and 810 mm. Thus, all were sexually mature adults and were over 10 years old (Carlander 1969).

Gizzard Shad

During the present study, 74 percent of the gizzard shad were between 60 and 110 mm, 24 percent were between 110 and 160 mm and only 2 percent were <60 mm. Anderson et al. (1983) also found that most of the gizzard shad in Pool 5A were betwen 60 and 160 mm, however, they found that the majority of these were >110 mm, the reverse of what was found during the present study. However, most of the gizzard shad reported in both studies were undoubtedly YOY fish (Carlander 1969) with the difference in the distribution attributable to different growth rates in 1980 compared to 1982. Furthermore, the lack of medium-large (>200 mm) shad in both studies suggests that significant winter mortality of gizzard shad probably occurs each year in the UMR.

Rock Bass

The majority (57 percent) of the rock bass collected during the present study were between 120 and 180 mm, with the rest rather uniformly distributed among individuals from 60 to 240 mm. According to Laarman (1963) most of the individuals in the former group would probably be Age III fish. Anderson et al. (1983) also found many rock bass in Pool 5A between 120 and 180 mm in 1980. They also collected many between 80 and 110 mm. A peak at 80-100 mm was observed during this study but it was not pronounced.

Black Crappie

The majority (51 percent) of the black crappies collected were between 160 and 200 mm, with 13 percent between 140 and 160 mm, and 12 percent between 200 and 220 mm. Very few crappies were collected outside the 140-220 mm range. In contrast to this unimodal distribution, Anderson et al. (1983) reported a trimodal distribution in 1980. They found major peaks at 40-100 mm, 110-160 mm, and 210-280 mm and caught very few fish in the size range that was most important in this study, 180-200mm. They reported many black crappie >220 mm, whereas, very few (4 percent) this large were captured during this study. Because the sample sizes for both studies were large (>500 individuals) it appears that the number of large black crappies in Pool 5A has decreased between 1980 and 1982. Finally, in the present study, it was noted that the mean size of the fish captured increased towards the end of the study period.

Quillback

In the present study, most (73 percent) of the quillbacks were between 50 and 130 mm indicating that they probably were Age I fish (Carlander 1969). A secondary, much smaller peak at 370-450 mm was also observed. Anderson et al. (1983) reported an almost identical pattern in Pool 5A in 1980.

Silver Redhorse

Silver redhorse were only common in August. Based on the August sample of 49 fish, peaks occurred at 50-90 mm, 290-370 mm, and 450-530 mm. Anderson et al. (1983) reported a similar distribution pattern in Pool 5A in 1980.

Smallmouth Bass

In the present study, smallmouth bass were collected most abundantly at sizes of 90-130 mm and 170-210 mm. These two peaks probably represent Age I and II fish respectively. Anderson et al. (1983) saw a nearly identical pattern during their 1980 survey of Pool 5A. Not surprisingly, considerably more YOY fish (<90 mm) were collected in August and September than in June during the present study.

White Bass

Overall, 72 percent of the white bass captured were between 70 and 130 mm. However, significant monthly differences were apparent. In May and June few (27) white bass were captured, but all were >190 mm, however, in August and September, many (405) were collected, but most (>85 percent) were smaller than 160 mm.

5.3.2 Larval Fish

Dipnetting, which was conducted on a weekly basis from 8 May to 28 August 1982, yielded a total of 20,509 larval or juvenile fish representing 22 species or taxa (Table 5-5). All these species or taxa are ones that were collected during the adult sampling described in the preceding section. Cyprinidae (9,474 individuals), Catastominae (suckers and redhorses, 9,701 individuals), and Ictiobinae (carpsuckers and buffalofish, 978) dominated the catch, together accounting for 98 percent of the total catch. The only other taxa represented by more than 100 individuals was Lepomis spp. (133 individuals). The total catch exhibited two major peaks (Figure 5-1). The first peak occurred on 3 June and was dominated by Catastominae larvae. The second peak occurred on 14 August and was dominated by cyprinid larvae. A third smaller, but noticeable, peak occurred on 14-23 July; this peak was also dominated by cyprinid larvae. Temporal variations during the 18-week collection period were expected because the UMR fish assemblage is composed of early spring spawners (e.g., northern pike, sauger, walleye and yellow perch), late spring spawners (e.g., redhorses, white bass, and crappie), and early to mid-summer spawners (e.g., gizzard shad, most minnows and sunfishes). Kallemeyer and Novotny (1977) observed seasonal fluctuations in larval fish abundance on the Missouri River nearly identical to those

TABLE 5- 5 RESULTS OF DIP NETTING AT 10 LOCATIONS IN POOL 5A IN 1982. RESULTS ARE ACTUAL NUMBER CAPTURED FOR TWO FIFTEEN MINUTE REPLICATE SAMPLES COMBINED.

SPECIES	Location 1	2	3	4	5	6	7	8	9	10	Total
Gars	0	0	1	0	0	0	0	0	1	0	2
Northern Pike	0	0	0	0	1	0	0	0	0	0	1
Cyprinidae	464	1493	272	516	869	3996	206	790	691	177	9474
Common carp	3	24	5	8	1	1	3	34	2	12	93
Spotfin shiner	2	34	0	0	5	3	5	10	5	6	70
Emerald shiner	0	2	0	1	1	1	3	2	1	2	13
Bullhead minnow	0	1	0	0	0	1	0	0	0	4	6
River shiner	0	0	0	0	1	0	0	0	0	0	1
Shorthead redhorse	0	0	0	0	0	0	0	0	2	0	2
Catostominae	1093	1012	1345	1006	580	1983	1269	391	437	585	9701
Ictiobinae	11	46	7	3	29	87	567	36	74	118	978
Tadpole madtom	0	0	0	0	0	1	0	0	0	0	1
Burbot	0	0	0	0	0	0	0	0	1	0	1
Brook silverside	0	1	0	3	1	3	0	0	2	2	12
White bass	0	0	1	0	0	0	0	0	0	0	1
Bluegill	0	0	0	0	0	1	0	0	0	0	1
Black crappie	0	0	0	0	0	0	0	0	0	1	1
Lepomis spp.	8	15	6	44	1	41	0	6	1	11	133
Pomoxis spp.	0	1	0	0	0	0	0	0	0	0	1
Johnny darter	0	0	1	0	0	0	0	0	0	0	1
Yellow perch	0	0	0	0	0	2	0	0	0	0	2
Stizostedion spp.	0	0	1	0	0	13	0	0	0	0	14
Total	1581	2629	1639	1581	1489	6133	2053	1269	1217	918	20509

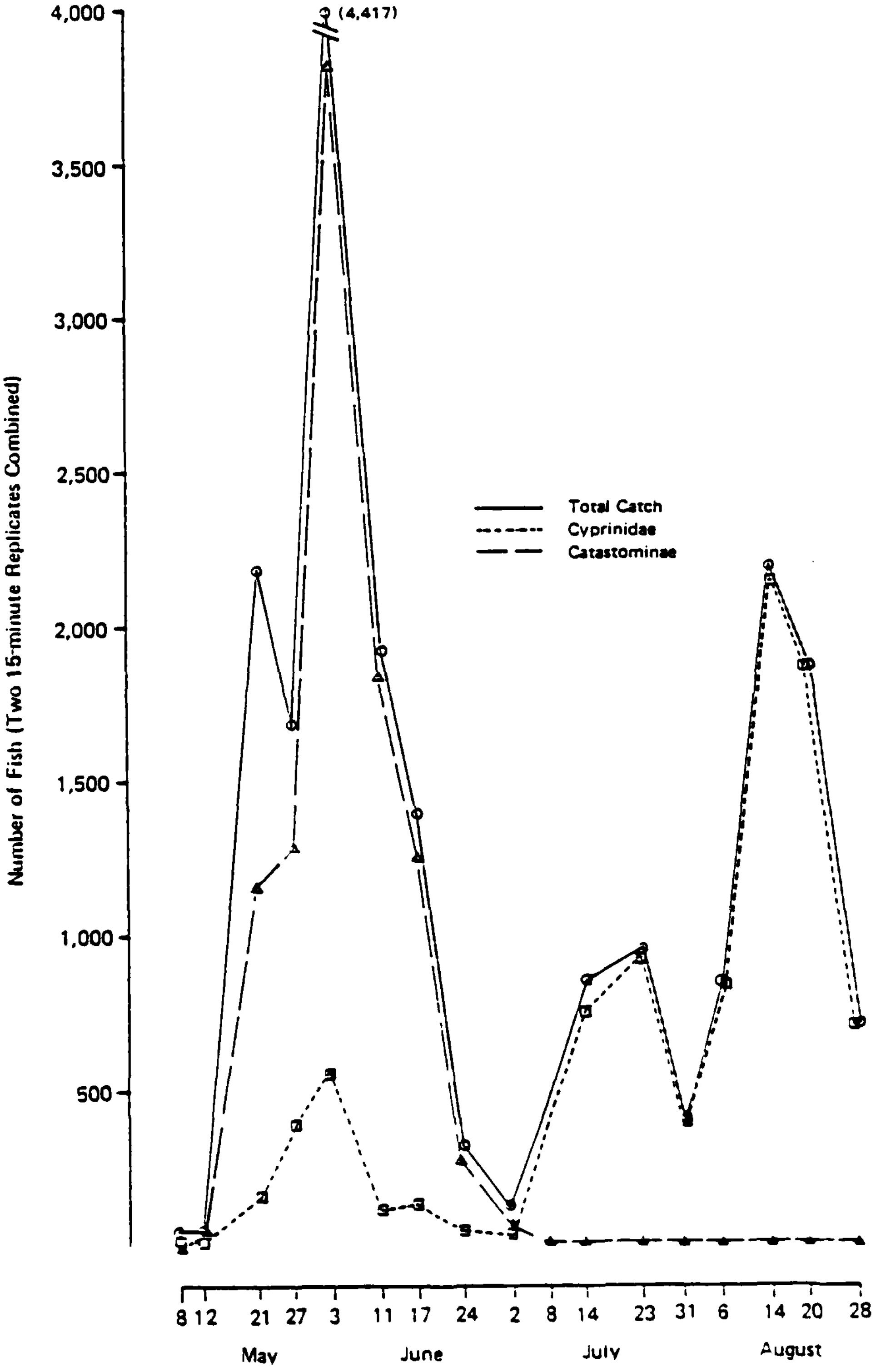


Figure 5-1. Comparisons of the weekly dip net catch in Pool 5A (10 locations combined) during the period of 8 May through 28 August 1982.

observed during this study. As in this study, they found that minnows and suckers occurred from May through August, with the August catch consisting primarily of minnows.

5.3.2.1 Catostominae

Catostominae larvae dominated the dipnet catch during the first half of the study (Figure 5-1), but were completely absent from 8 July through the remainder of the study. Numbers of larvae per 30 minutes of sampling effort (i.e., the two 15 minute replicates combined) were >1000 from 21 May through 17 June. Because of overlap in certain identifying characteristics, it was not possible to determine for certain whether these Catostominae larvae were redhorses (*Moxostoma* spp.) or some other sucker (e.g., white sucker, hog sucker, or spotted sucker).

5.3.2.2 Cyprinidae

On 8 July, when the number of Catostominae larvae dropped to zero, the number of Cyprinidae larvae began to increase, and dominated the catch for the remainder of the study (Figure 5-1). Three peaks in cyprinid numbers were observed; 3 June, 14-23 July, and 14-20 August. Multiple peaks were expected because of the large number of species making up this assemblage (11 species were identified in the adult collections) and the protracted spawning period some of the species have. Again, the overlap in key diagnostic characteristics prevents a definitive statement regarding the exact species composition making up these peaks. However, given their abundance in the adult collections and their known protracted spawning period (Scott and Crossman 1973; Brown 1974), it seems likely that the 14 to 23 July and the 14 August peaks were composed primarily of emerald shiners. This hypothesis is supported by the fact that all the individuals in a 14 July subsample that could be identified to species were emerald shiners.

5.3.2.3 Ictiobinae

Ictiobinae larvae were only abundant on 21 May when 855 were captured; this represents 87 percent of the total captured during the 17 week study.

5.3.2.4 Other Taxa

Stizostedion spp. (walleye/sauger) were captured only two dates in May; 13 on 21 May and one on 27 May. Of the 133 *Lepomis* spp. that were captured, none were captured before 17 June, and 95 percent were captured during the 5 week period from 2 July through 6 August. The remaining taxa either exhibited no seasonal trend or so few were captured that no statement can be made regarding seasonal occurrence.

5.3.2.5 Location and Substrate Comparisons

Analysis of the data showed that the total catch at Location 6 (silt bay) was statistically higher ($P<0.008$, Kruskal-Wallis test) than at any other location, but that the catch at all the other locations was comparable (Table 5-5). The total catch at Location 6 was 2-7 times higher than at any of the other locations. Further statistical analysis of the data showed that this difference was attributable to the large number of (nearly 4,000) of Cyprinidae larvae collected at Location 6. In contrast, the Catastominae catch was comparable statistically among all 10 locations.

The reason for the high catch at Location 6 is not entirely clear. However, preference for its quiet waters seems likely because even taxa that undoubtedly were hatched in rock or gravel substrate areas (e.g., Catostominae, Stizostedion spp.) were most abundant at Location 6. No difference between sand and rock substrates was apparent in the cyprinid catch (mean for sand = 579, mean for rock = 623). However, the catch of Catastominae was twice as high in rocky areas (mean = 1020) as in sandy areas (mean = 534). This suggests that members of this group use wing dams, closing dams, and riprapped banks as spawning sites in Pool 5A, a finding consistent with their known preference for hard substrates during spawning (Becker 1983).

5.3.3 Factors Affecting Catch and Species Composition

5.3.3.1 Temporal (Monthly) Comparisons

This section first discusses the catch each month and concludes by statistically comparing the monthly catch.

May

All methods combined captured 618 fish representing 35 species in May (Table 5-6). Shorthead redhorse (178 individuals), black crappie (67), and sauger (60) were the most commonly collected species. Those three species accounted for half the total May catch. As it eventually turned out, sauger and mooneye were more abundant in the catch in May than in any of the succeeding months. These were the only species that reached their peak abundance in May.

Frame Netting - Frame netting in May yielded 155 fish representing 14 species (Table 5-7 and Section 5.7). Black crappie (52 individuals) and shorthead redhorse (46) accounted for 63 percent of the frame net catch. Bluegill (15) and rock bass (13) were the only other species represented by more than 7 individuals. On a location-specific basis, Location 6 (silt bay) was, by far, the most productive location, accounting for 48 percent of the catch. Locations 3 (riprapped bank)(26 individuals) and 5 (sand flat)(14) were the only other locations accounting for more than 10 specimens.

Trammel Netting - Trammel netting in May resulted in the capture of 56 individuals representing 17 species (Table 5-8 and Appendix D). The catch was well distributed among the 17 species, with no species being represented by more than 14 individuals (Appendix D). Location 6 (silt bay) was the most productive location yielding 24 of the 56 (43 percent) specimens captured. Most locations produced 2 to 5 individuals.

Seining - The May seining results were greatly affected by the high flows (>65,000 cfs) that prevailed throughout the sampling period.

TABLE 5-6 RESULTS OF FISH SAMPLING AT 10 LOCATIONS IN POOL 5A, MAY 1982

Species	Number
Shovelnose sturgeon	7
Shortnose gar	1
Bowfin	1
Gizzard shad	1
Goldeye	1
Mooneye	32
Northern pike	2
Common carp	9
Spotfin shiner	23
Emerald shiner	9
Silver chub	6
Pugnose minnow	1
River carpsucker	1
Quillback	7
Highfin carpsucker	9
Smallmouth buffalo	4
Spotted sucker	21
Silver redhorse	12
Golden redhorse	7
Shorthead redhorse	178
Channel catfish	8
Flathead catfish	1
White bass	18
Rock bass	18
Bluegill	24
Smallmouth bass	3
Largemouth bass	2
White crappie	7
Black crappie	67
Western sand darter	20
Sauger	62
Johnny darter	2
Yellow perch	2
Walleye	26
Logperch	2
Freshwater drum	24
Total Number	618
Total Species	35

TABLE 5-7. SUMMARY OF SPECIES CAPTURED FRAME NETTING DURING 1982 IN POOL 5A.

Species	May	June	August	September	November
Gizzard shad	-	-	4	-	-
Golden shiner	-	-	1	-	-
Silver chub	2	13	2	8	-
Carp	-	-	4	2	-
Smallmouth buffalo	1	-	-	1	2
Spotted sucker	1	-	1	-	-
Shorthead redhorse	46	19	13	10	9
Mooneye	2	-	3	-	1
Channel catfish	6	5	1	4	1
Flathead catfish	1	3	-	1	1
Freshwater drum	4	10	15	38	26
White bass	2	-	3	3	-
Bluegill	15	21	33	19	-
Pumpkinseed	-	2	-	1	-
Rock bass	13	9	2	11	-
Black crappie	52	46	193	55	2
White crappie	7	-	-	2	-
Yellow perch	-	8	-	-	-
Walleye	-	-	-	1	-
Sauger	3	4	-	4	4
Total Species	14	11	13	15	8
Total Individuals	155	140	275	160	46

TABLE 5-8. RESULTS OF TRAMMEL NETTING (ACTUAL NUMBERS) IN 1982 AT 10 Locations IN POOL 5A

Location	May	June	August	September	November	All Months
1A	0	39 (35)*	14	5	8	-
B	0	15 (3)	10	1	1	-
	0	54 (38)	24	6	9	93 (38)
2A	0	3	12	2	4	-
B	3	3 (1)	2	0	2	-
	3	6 (1)	14	2	6	31 (1)
3A	1	0	7	0	3	-
B	7 (4)	3 (3)	12	1	4	-
	8 (4)	3 (3)	19	1	7	38 (4)
4A	2	1	12	0	2	-
B	3	3	8	5	1	-
	5	4	20	5	3	37
5A	0	23 (23)	23	1	3	-
B	4 (2)	40 (38)	14	1	2	-
	4 (2)	63 (61)	37	2	5	111 (63)
6A	16	8	62	25	8	-
B	8	13	32	23	9	-
	24	21	94	48	17	204
7A	2	5	19	3	2	-
B	3 (1)	1	10	2	2	-
	5 (1)	6	29	5	4	49 (1)
8A	0	3	21	4	0	-
B	3	1	17	1	2	-
	3	4	38	5	2	52
9A	0	2	30	1	1	-
B	0	4	16	5	3	-
	0	6	46	6	4	62
10A	2	2	35	4	1	-
B	2	1	24	3	0	-
	4	3	59	7	1	74
Total Number	56 (7)	170 (103)	380	87	58	751 (110)
No/net set	2.8	8.5	19	4.3	2.9	7.5
No/net set**	2.5	3.3	19	4.3	2.9	6.4

---

*Shovelnose sturgeon

**Excluding shovelnose sturgeon

Because of these high flows, sampling efforts were reduced at most locations and Locations 1 through 4 could not be sampled at all. As a result, seining produced only 68 fish representing 15 species. The catch was dominated by spotfin shiner and western sand darter; 21 and 20 individuals, respectively (Appendix D).

Electrofishing - Adult electrofishing in May yielded 332 fish representing 22 species (Table 5-9 and Appendix D). The day and night catch was comparable in terms of species (17 and 20, respectively), but night electrofishing produced three times as many individuals (246 vs 86) (Table 5-9). The day catch was well distributed with no species being represented by more than 14 individuals. However, the night catch was dominated by shorthead redhorse (98 individuals, 40 percent). Sauger and freshwater drum were also much more common at night than during the day. (For a further discussion of diel differences see Section 5.3.3.4). The 10 sampling locations each yielded from 8 (Location 6, silt bay) to 78 individuals (Location 3, riprapped bank), with most yielding from 27 to 50 individuals.

Day juvenile electrofishing produced only seven individuals and three species, of which spotfin shiner was the only species not captured during the adult electrofishing. Night electrofishing was not conducted due to equipment malfunctions.

June

The total June catch (all gears combined) of 1,914 fish was three times the catch in May (Table 5-9). The catch rose for all gears except frame netting. These 1,914 fish represented 44 species (Table 5-10), an increase of 9 over the total for May (Table 5-6). Emerald shiner (580 individuals) and shorthead redhorse (331) were the most commonly collected species. Four other species--spotfin shiner (134), river shiner (104), and black crappie and shovenose sturgeon (103 each)--each composed more than 5 percent of the numerical catch. the most unusual aspects of the June catch were the large number (103) of shovelnose sturgeon collected and the collection of two blue suckers and one crystal darter.

Frame Netting - In June, frame netting yielded 140 fish representing 11 species (Table 5-7). As in May, the three most commonly collected species were black crappie (46 individuals), bluegill (21), and shorthead redhorse (19). No other species composed more than 10 percent of the catch. Similarly, Location 6 (silt bay) again was clearly the most productive location, yielding 58 specimens or 41 percent of the catch (very similar to the 48 percent this location contributed in May). Except for Location 8 (wing dam), which yielded only 2 fish, all the other locations produced 6-15 fish.

Trammel Netting - Trammel netting yielded 170 fish (three times the number caught in May) representing 23 species (Table 5-8). Interestingly, shovelnose sturgeon (103 individuals) dominated the catch (61 percent numerically). Shorthead redhorse (20 individuals) composed 12 percent of the catch; no other species was represented by more than 6 specimens. The variation in catch among the 10 locations reflects the

TABLE 5-9. SUMMARY OF TOTAL CATCH (BY NUMBER) DURING THE FIVE MONTHS SAMPLING WAS CONDUCTED ON POOL 5A.

	May	June	August	September	November	Total
Shock						
A, D	86	188	118	225	3	620
A, N	246	325	357	254	60	1242
J, D	7	217	184	265	8	681
J, N	NS*	73	465	138	6	682
	339	803	1124	882	77	3225
Seine						
D, Rep A	30**	234	701	349	85	1399
D, Rep B	19**	180	426	614	19	1258
N, Rep A	11**	153	694	316	22	1196
N, Rep B	8**	234	451	175	6	874
	68	801	2272	1454	132	4727
Trammel						
Rep A	23	86	235	45	32	421
Rep B	33	84	145	42	26	330
	56	170	380	87	58	751
Frame						
Rep A	126	63	128	70	38	425
Rep	29	77	147	90	8	351
	155	140	275	160	46	776
All Gears	618	1914	4051	2583	313	9479

---

* Not sampled.

**Only six stations sampled.

TABLE 5-10 RESULTS OF FISH SAMPLING AT 10 LOCATIONS IN POOL 5A, JUNE 1982

Species	Number
Silver lamprey	2
Shovelnose sturgeon	103
Longnose gar	3
Shortnose gar	1
Bowfin	4
Goldeye	2
Mooneye	23
Northern pike	3
Common carp	23
Golden shiner	1
Spotfin shiner	134
Emerald shiner	579
Bullhead minnow	59
River shiner	104
Silver chub	30
Pugnose minnow	5
River carpsucker	4
Quillback	8
Highfin carpsucker	15
Blue sucker	2
Smallmouth buffalo	3
Bigmouth buffalo	1
Spotted sucker	1
Silver redhorse	13
Golden redhorse	4
Shorthead redhorse	331
Channel catfish	6
Stonecat	1
Tadpole madtom	1
Flathead catfish	8
White bass	9
Rock bass	38
Pumpkinseed	3
Orangespotted sunfish	1
Bluegill	65
Smallmouth bass	37
Largemouth bass	7
Black crappie	103
Crystal darter	1
Western sand darter	45
Sauger	41
Yellow perch	10
Walleye	19
Freshwater drum	61
Total Number	1,914
Total Species	44

variation in the shovelnose sturgeon catch. Location 5 (sand flat) produced 63 fish, of which 61 were shovelnose sturgeon, and Location 1 (wing dam) produced 54 fish, of which 38 were shovelnose sturgeon.

Seining - Seining in June yielded 801 fish representing 26 species (Table 5-9 and Appendix D). Three minnows--emerald shiner (386 individuals), spotfin shiner (123), and river shiner (70)--accounted for 72% of the catch, numerically. The catches during the day and night were similar, both numerically (day = 414 fish vs 383 at night) and taxonomically (day = 17 species vs 21 species at night). Similarly, emerald shiner and spotfin shiner ranked 1, 2 numerically during each of the four replicates, irrespective of whether the sampling was conducted during the day or night. Locations 6 (silt bay), 8 (wing dam), and 10 (sand flat) were noticeably more productive than the other locations yielding 195, 188, and 186 individuals, respectively. Combined, these three locations accounted from 71 percent of the catch. The most noteworthy event during the seining was the capture of one crystal darter at Location 5 during the day.

Electrofishing - The various electrofishing methods produced a combined total of 803 fish (nearly identical to the 801 fish captured seining) and 31 species (Table 5-9 and Appendix D). Overall, the day and night catch was nearly identical; 405 and 398 individuals, respectively. Similarly, day electrofishing yielded 25 species compared to 24 at night. However, diel differences were apparent when the adult and juvenile electrofishing catches were examined separately. Adult electrofishing was more productive (numerically) during the night (Table 5-9), while juvenile electrofishing was more productive (both numerically and in terms of diversity) during the day. The adult catch was dominated by shorthead redhorse (248 individuals, 48 percent), with bluegill, smallmouth bass, sauger, black crappie, and freshwater drum each contributing 31 to 33 individuals (6 percent each) (Appendix D). Together, these six species amounted to 79 percent of the adult electrofishing catch. The juvenile electrofishing catch was dominated almost exclusively by emerald shiner as it accounted for two-thirds of the catch. The most unusual species collected electrofishing were two blue suckers that were captured during night adult electrofishing at Location 2 (closing dam). On a location-specific basis, Locations 3 (riprapped bank)(149 individuals), 6 (silt bay)(143) and 5 (sand flat)(105) were the most productive, accounting for 52 percent of the total electrofishing catch.

August

August was much more productive than any of the other months during the study in terms of total catch, catch for each gear type, and diversity. All the methods combined accounted for 4,051 fish, nearly 43 percent of the total captured during the study (Table 5-9). Similarly, 50 of the 58 species captured during the study were collected in August (Table 5-11). Scour hole trammel netting, which was conducted for the first time in August, accounted for an additional 24 fish (Table 5-12). Some notable changes also occurred in the composition of the catch. Gizzard shad, which were not even collected in May or June, became the most abundant species in August, being represented by 1005 individuals and accounting

TABLE 5-11 RESULTS OF FISH SAMPLING AT 10 LOCATIONS IN POOL 5A, AUGUST 1982

Species	Number
Silver lamprey	2
Shovelnose sturgeon	1
Shortnose gar	2
Longnose gar	3
American eel	2
Gizzard shad	1,005
Goldeye	9
Mooneye	27
Northern pike	6
Carps/Minnows	6
Common carp	32
Golden shiner	1
Spottail shiner	93
Spotfin shiner	123
Emerald shiner	780
Bullhead minnow	84
Mimic shiner	8
Sand shiner	43
River shiner	230
Silver chub	15
River carpsucker	5
Quillback	171
Highfin carpsucker	10
White sucker	2
Blue sucker	1
Smallmouth buffalo	5
Bigmouth buffalo	5
Spotted sucker	4
Silver redhorse	49
Golden redhorse	18
Shorthead redhorse	247
Carpsuckers/Buffalos	5
Channel catfish	11
Tadpole madtom	1
Flathead catfish	7
Troutperch	8
Brook silverside	11
White bass	228
Rock bass	31
Pumpkinseed	1
Bluegill	191
Smallmouth bass	29
Largemouth bass	14
White crappie	1
Black crappie	279
Western sand darter	7
Sauger	25
Slenderhead darter	1

Table 5-11 (CONT)

Species	Number
Johnny darter	3
Yellow perch	8
Walleye	22
Logperch	18
Freshwater drum	185
Total Number	4,079
Total Species	50

for 25 percent of the catch (Table 5-11). Spottail shiner and sand shiner, two other species not collected previously, were also common in August, being represented by 93 and 43 specimens, respectively. Most species increased compared to their June levels, however, the catch of a few species (e.g., shorthead redhorse and shovelnose sturgeon) declined. The decline in the shovelnose sturgeon catch was particularly precipitious; declining from 103 in June to 1 in August. Unusual species captured in August included mimic shiner (8 individuals), American eel (2), silver lamprey (2), blue sucker (1) and slenderhead darter (1).

Frame Netting - The August frame net catch (275 individuals) was approximately double the June catch of 140 individuals (Table 5-7), however, the number of species collected in August (13) was comparable to the numbers in May and June (11-14) (Table 5-7). The frame net catch was dominated almost exclusively by black crappie, which accounted for 193 of the 275 (70 percent) of the fish captured. The only other species composing five percent or more of the catch were bluegill (12 percent) and freshwater drum (7 percent). Together, these three species accounted for 89 percent of the frame net catch. As one would expect, those locations that yielded the most black crappie were also the most productive overall. Location 1 (wing dam), primarily because of the 98 black crappie it produced, accounted for 38 percent of the total catch (Section 5.7). Locations 3 (riprapped bank, 38 black crappie) and 6 (silt bay, 28 black crappie) accounted for 16 and 13 percent of the total catch, respectively. Conversely, no fish were collected at Location 7 (wing dam)(Section 5.7).

Trammel Netting - The August trammel net catch (380 fish) was more than double the June catch of 170 fish (Table 5-9). These 380 fish represented 28 species with one blue sucker and one American eel being the most notable (Appendix D). Shorthead redhorse (108 individuals), black crappie (50) and quillback (33) accounted for half the fish collected trammel netting (Appendix D). Locations 6 (silt bay), 10 (sand flat) and 5 (sand flat) were the most productive, yielding catches of 94, 59, and 38 fish, respectively (Table 5-8).

Scour hole netting yielded only 24 fish representing 11 species of which shovelnose sturgeon was the only one not captured by regular trammel netting (Table 5-12).

Seining - Seining was very productive in August, yielding 2272 fish representing 33 species (Table 5-9 and Appendix D). Six species accounted for five percent or more of the catch: gizzard shad (583 individuals, 26%), emerald shiner (543, 24%), river shiner (213, 9%), white bass (146, 6%), quillback (129, 6%), and freshwater drum (106, 5%). Other commonly collected species included bluegill, spottail shiner, spotfin shiner, and bullhead minnow. Many of these species were collected much more frequently during either the day or the night. For example, spottail shiner, emerald shiner, river shiner, and quillback were noticeably more abundant during the day; whereas, gizzard shad, freshwater drum, white bass, and bluegill were collected much more abundantly at night (Appendix D). No diel pattern was apparent in the spotfin shiner or bullhead minnow catch. Overall, however, there was no difference in the total day catch (1127 individuals) compared to the

TABLE 5-12. SUMMARY OF FISH CAPTURED USING TRAMMEL NETS SET IN SCOUR HOLES AT THREE LOCATIONS ON POOL 5A, 1982.

	August				September				November				All Months, All Stations
	1	2	4A	4B	1	2	4A	4B	1	2	4A	4B	
Shovelnose sturgeon				1									1
Bowfin							1						1
Golden redhorse			2										2
Silver redhorse		1							1				2
Shorthead redhorse		2	3		1	2	1		2		1		12
Smallmouth buffalo									1				1
Mooneye										2			2
Goldeye							1			1			2
Northern pike		1											1
Channel catfish	1								1				2
Flathead catfish			3		1		1						5
White bass						1				1			2
Rock bass	1				2								3
Black crappie	3	1	3				6	1					14
White crappie						1							1
Smallmouth bass	1								1				2
Sauger									1	1			2
Walleye												1	1
Freshwater drum			1			3	1	1	85	2	2		95
Total Species	4	4	5	1	3	4	6	2	7	5	2	1	19
Total Individuals	6	5	12	1	4	7	11	2	92	7	3	1	151

catch at night (1145 individuals). Similarly, the catch at individual locations did not exhibit diel differences, except at Location 8 (wing dam) where the day catch (249 individuals) was much higher than the catch at night (73).

Location 6 (silt bay) was much more productive than any of the other locations yielding 954 individuals or 42 percent of the total seine catch (Appendix D). Locations 5 (sand flat), 8 (wing dam), and 10 (sand flat) were also considerably more productive compared to the other locations.

Electrofishing - A total of 1124 fish representing 34 species was captured electrofishing (Table 5-9 and Appendix D). Electrofishing during the night was considerably more effective than during the day, yielding 822 individuals, compared to only 302 during the day (Table 5-9). Similarly, the night adult catch (24 species) was considerably more diverse than the day adult catch (16 species). However, day and night juvenile electrofishing each yielded 13 species. Six species contributed 5 percent or more to the total adult catch of 475 individuals: gizzard shad (26 percent), shorthead redhorse (22), bluegill (11), freshwater drum (6), and white bass and smallmouth bass (5 each). Each of these species, except smallmouth bass, was collected more frequently during the night than during the day. The juvenile electrofishing catch was dominated by only two species. Gizzard shad (296 individuals) and emerald shiner (233) accounted for 82 percent of the juvenile electrofishing catch; both were collected more frequently at night.

Location 3 (riprapped back) was the most productive location by far, yielding 431 fish or 38 percent of the entire August electrofishing catch (Appendix D). Locations 6 (silt bay), 1 and 4 (wing dams) and 2 (closing dam) were also productive yielding 160, 121, 111, and 111 fish, respectively. Together, these five locations accounted for 83 percent of the August electrofishing catch.

September

Compared to August, the total September catch declined as did the catch for each of the individual gear types (Table 5-9). In September, a total of 2,607 fish were captured representing 46 species (Table 5-13). Thus, although the September catch was considerably smaller than the August catch, the number of species captured was comparable (50 in August vs 46 in September). Nine species accounted for 5 percent or more of the catch: gizzard shad (13 percent), river shiner (13), emerald shiner (10), bullhead minnow (8), shorthead redhorse (7), white bass (7), and spotfin shiner, freshwater drum, and quillback (6 each). Together, these nine species accounted for 76 percent of the catch.

Frame Netting - The September frame net catch of 160 fish was comparable to the totals in May and June, though considerably reduced from the level seen in August (Table 5-7). The 15 species captured in September was the highest during any month, but was still comparable to the 11-14 species captured during the preceding months (Table 5-7). As in other months, the catch was dominated by black crappie (55 individuals, 34%), with freshwater drum (38, 24) and bluegill (19, 12)

TABLE 5-13 RESULTS OF FISH SAMPLING AT 10 LOCATIONS IN POOL 5A, SEPTEMBER 1982

Species	Number
Silver lamprey	1
Bowfin	2
Gizzard shad	345
Goldeye	2
Mooneye	11
Northern pike	2
Common carp	15
Golden shiner	1
Spottail shiner	62
Spotfin shiner	166
Emerald shiner	260
Bullhead minnow	217
Sand shiner	30
River shiner	332
Silver chub	23
Pugnose minnow	4
River carpsucker	1
Quillback	155
White sucker	2
Smallmouth buffalo	3
Bigmouth buffalo	3
Spotted sucker	2
Silver redhorse	8
Golden redhorse	4
Shorthead redhorse	192
Carpsuckers/Buffalos	17
Carpiodes spp.	3
Channel catfish	10
Tadpole madtom	1
Flathead catfish	5
Troutperch	10
Brook silverside	9
White bass	183
Rock bass	37
Pumpkinseed	1
Orangespotted sunfish	1
Bluegill	112
Smallmouth bass	20
Largemouth bass	9
White crappie	5
Black crappie	99
Western sand darter	3
Sauger	38
Johnny darter	8
Yellow perch	1
Walleye	21
Logperch	14
Freshwater drum	157
Total Number	2,607
Total Species	46

also being common. Together, these three species accounted for 70 percent of the frame net catch. Locations 4 (wing dam, 41 individuals), 3 (riprapped bank, 35), and 6 (silt bay, 30) were much more productive than the other locations, and together accounted for two-thirds of the frame net catch.

Trammel Netting - A total of only 87 fish representing 17 species were captured trammel netting in September (Table 5-8 and Appendix D). These were the lowest totals since May when a comparable number (56) of fish and an identical number of species (17) were caught. Only two species--shorthead redhorse (25 individuals) and black crappie (17)--accounted for more than 10 specimens. Location 6 (silt bay) was, by far, the most productive location, producing 48 fish or more than half the total number captured (Table 5-8). No other location accounted for more than 7 specimens.

Scour hole netting at Locations 1 and 4 (wing dams) and 2 (closing dam) produced 24 individuals (the same number as in August) representing nine species of which flathead catfish was the only one not captured by regular trammel netting.

Seining - The total catch in September (1,454 individuals) was down by approximately one-third compared to August; however, the number of species caught in each of these months was comparable (33 and 32 in August and September, respectively). Twice as many fish were captured during the day (963) as at night (491) (Table 5-9). However, more species (29) were captured during the night than during the day (23) (Appendix D). The 10 most common species in August all ranked in the top 10 again in September; however, the rankings did differ between the two months:

	August			September		
Species	No.	Rank	%	No.	Rank	%
Gizzard shad	583	1	26	79	7	5
Emerald shiner	543	2	24	178	3	12
River shiner	213	3	9	322	1	22
White bass	146	4	6	102	6	7
Quillback	129	5	6	139	4	10
Freshwater drum	106	6	5	43	10	3
Bluegill	97	7	4	48	9	3
Spottail shiner	90	8	4	58	8	4
Spotfin shiner	88	9	4	130	5	9
Bullhead minnow	77	10	3	212	2	15
Totals	2072	-	91	1311	-	90

The most notable differences between the two months were the large declines in the number of emerald shiner and especially gizzard shad, and the large increases in the number of river shiner and particularly, bullhead minnow. Interestingly, however, the percentage that this group of 10 species composed of the total catch was nearly identical each month, 91 percent in August and 90 percent in September. As was the case in August, spottail shiner, river shiner, and quillback were considerably more abundant during the day in September, whereas white bass and freshwater drum were more abundant at night. The only species that exhibited a reversal in its diel pattern was bluegill, which were captured somewhat more commonly during the night in August, but which were much more common during the day in September.

In August, Location 6 (silt bay) accounted for 42 percent of the catch. In September, this station's dominance was even more pronounced as it accounted for 65 percent of the total catch. Location 10 (sand flat) was the only other location that was noticeably more productive than the other locations, accounting for 16 percent of the catch. Locations 9 (sand flat) and 8 (wing dam) contributed 6 and 5 percent, respectively, to the total catch. Thus, these four locations accounted for 92 percent of the total seine catch.

Electrofishing - A total of 882 fish representing 36 species were captured electrofishing in September (Appendix D). These totals represent a 21 percent decrease in the number of individuals, but an increase of two in the number of species. The 36 species collected electrofishing in September represents the greatest number caught by any one gear type in any month during the study. As shown below, four of the five species most commonly collected during adult electrofishing in August, were in the top five again in September. White bass, which ranked fourth in August, dropped to sixth in September.

	August			September		
Species	No.	Rank	%	No.	Rank	%
Gizzard shad	122	1	26	93	2	19
Shorthead redhorse	104	2	22	136	1	28
Bluegill	53	3	11	39	3	8
White bass	25	4	6	25	6	5
Freshwater drum	22	5	5	37	4	8
Totals	326		70	425		68

Also, the percentage of the catch that these five species composed was very similar each month; 68 percent in September compared to 70 percent in August. In August, all five of these species were captured more frequently at night, but in September only shorthead redhorse and freshwater drum were more abundant in the night collections. Overall, the day and night catches (225 and 254 fish, respectively) were comparable.

The juvenile electrofishing catch was dominated by gizzard shad (173 individuals), emerald shiner (77) and white bass (50). Together, these three species accounted for nearly three-quarters (74 percent) of the juvenile electrofishing catch. In August, these same three species accounted for 85 percent of the catch. Gizzard shad were collected much more frequently during the day than at night; however, no identifiable trend was found for the other two species. Probably because of the large diel difference in the gizzard shad catch, the overall catch during the day was approximately double the catch at night.

November

The November catch was the smallest of the five months both in terms of total catch (417 individuals) and diversity (35 species) (Table 5-14). Species that composed at least 5 percent of the catch were freshwater drum (120 individuals), river shiner (56), shorthead redhorse (39), sauger (22), and carp (21). Collectively, these five species accounted for 62 percent of the fish captured in November. The most unusual fish collected in November were two crystal darters and one river darter.

Frame Netting - Frame netting produced only 46 individuals and eight species in November (Table 5-7). Both totals were much lower than in any other month. Freshwater drum and shorthead redhorse were the most commonly collected species with 26 and 9 individuals, respectively. No other species was represented by more than 4 individuals. Because of a large catch of freshwater drum (23 individuals), Location 1 (wing dam) was, by far, the most productive location. No other location produced more than six individuals.

Trammel Netting - Trammel netting in November yielded 58 fish representing 14 species. These totals are very similar to the results in May when 56 fish and 17 species were captured. Shorthead redhorse, with 19 individuals collected, was the only species represented by more than seven individuals. Of the 58 fish captured, 17 were collected at Location 6 (silt bay), with the remaining locations contributing 1 to 9 individuals (Table 5-8).

In contrast to all the other gear types, scour hole trammel netting was more productive in November than in any other month. It produced 103 fish in four net-days (Table 5-12), twice the number collected in 20 net-days by regular trammel netting. It also produced four species that were not captured by regular trammel netting. The catch was dominated by freshwater drum; 89 individuals, of which 85 came from Location 1, wing dam.

Seine - Seining in November resulted in the collection of only 132 fish representing 17 species. These numbers are comparable to those seen in May (68 fish and 15 species) when only six locations were sampled. Day seining produced considerably more fish (104) and more species (16) than did night seining (28 and 10, respectively). River shiner was the most frequently collected species (47 individuals) with emerald shiner, spotfin shiner, bullhead minnow and bluegill each being represented by 10-14 individuals. Locations 6 (silt bay), 8 (wing dam), and 9 (sand flat) yielded 52, 34, and 19 individuals, respectively, and collectively accounted for 80 percent of the catch. No other location contributed more than 10 individuals.

Electrofishing - Electrofishing in November yielded only 77 fish representing 18 species (Table 5-9 and Appendix D). These represent the lowest totals for any of the sampling months. Of the 77 fish and 18 species captured, 60 fish and 14 species were collected during night adult electrofishing. Carp was the only species represented by more than 10 individuals. Locations 3 (riprapped bank), 6 (silt bay), and 9 and 10 (sand flats) produced 25, 14, and 9 individuals, respectively accounting

TABLE 5-14 RESULTS OF FISH SAMPLING AT 10 LOCATIONS IN POOL 5A, NOVEMBER 1982

Species	Number
Goldeye	1
Mooneye	12
Northern pike	4
Carps/Minnows	1
Common carp	21
Spottail shiner	3
Spotfin shiner	14
Emerald shiner	16
Bullhead minnow	11
Sand shiner	3
River shiner	56
Pugnose minnow	3
Notropis spp.	3
Quillback	6
White sucker	2
Smallmouth buffalo	7
Silver redhorse	5
Golden redhorse	1
Shorthead redhorse	39
Carpiodes spp.	7
Channel catfish	2
Tadpole madtom	1
Flathead catfish	1
Troutperch	5
Burbot	1
Brook silverside	3
White bass	1
Rock bass	4
Bluegill	15
Smallmouth bass	1
Black crappie	3
Crystal darter	2
Sauger	22
River darter	1
Johnny darter	2
Yellow perch	3
Walleye	15
Freshwater drum	120
Total Number	417
Total Species	35

for 78 percent of the total catch.

5.3.3.1.1 Statistical Analysis of Temporal Effects

Of the four variables examined, temporal effects (i.e., monthly variations) exerted the greatest influence on catch statistics. Total catch (whether by number or weight) was significantly affected by the month of collection for all adult gear types. Furthermore, on a species-specific basis, the catch of one-half to three-quarters of species compared was also significantly affected by month of collection.

Adult Electrofishing--The total adult electrofishing catch (by number) was significantly lower in November than in any other month; however, the other four months were statistically comparable (Table 5-15). Of the 15 species compared individually, month was a significant variable for seven. Gizzard shad, shorthead redhorse, white bass, and bluegill were most strongly affected, $P<0.01$. Interestingly, the peak catch for at least one of the seven species significantly affected by month of collection, occurred in every month except November. Thus, there was no one month that was best for all the species examined.

Other investigators have also reported that electrofishing catch rates vary with month or season on the UMR. Ellis (1978) reported that both total catch and the catch of individual species varied with month and, as in this study, reported that the month when peak catch occurred varied among individual species. He found that the number of species and the CPE were reduced during the fall whenever water temperatures dropped below 10 C and suggested that this was the result of the fishes reduced vulnerability to electrofishing (i.e., the gear was less effective), rather than an actual decrease in the number of fish present. In Pool 13, Pierce (1980) reported that "the numbers of various species in the catches changed dramatically from month to month because of variation in the number of cyprinids, especially emerald shiners, and centrarchids, especially bluegills; and freshwater drum." Although this statement was made in reference to all of his methods combined, he also reported that the electrofishing catch varied according to month. For example, he noted that centrarchids and cyprinids dominated the electrofishing catch in August; whereas, in October, freshwater drum was the most abundant species. He noted that "more fish species were present along MCB shoreline transects in August than in any other month." He suggested that a drop in bluegill electrofishing catch in October may have been the result of them moving into deeper water for the winter. Finally, Pierce (1980) noted that shocking effectiveness was strongly affected by flow ("few fish were caught on wing dams during high flow conditions"), depth (over submerged wing dams), and water transparency, and concluded that "low water transparency, strong water currents, and the depths of submerged wing dams made shocking ineffective over submerged wing dams in every month."

Based on the above studies and the results of the present study, it seems likely that the reduced catch observed in November was probably caused by a combination of high flows, low water temperatures (<4 C), as well as many species (e.g., most centrarchids, catfishes, gizzard shad) leaving the shoreline areas to spend the winter in the deeper portions of the

TABLE 5-15. SUMMARY OF STATISTICAL COMPARISONS OF MONTHLY ADULT ELECTROFISHING DATA (BY NUMBER, DAY AND NIGHT CATCH COMBINED)

Species or Group	Mean No./10 Min May	Jun	Aug	Sep	Nov	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	16.1	25.8	25.1	26.0	3.1	37.0	0.0001	yes	S J A M N
Gizzard shad	0	0	6.1	5.3	0	20.3	0.0004	yes	A S J M N
Mooneye	1.0	0.2	0.3	0.5	0.1	5.3	0.2611	no	M S A J N
Common carp	0.5	1.1	0.7	0.3	0.9	1.1	0.9018	no	J N A M S
Quillback	0.3	0	0.3	0.2	0.3	3.0	0.5646	no	A M N S J
Silver redhorse	0.5	0.6	0.3	0.2	0	3.5	0.4769	no	J M A S N
Golden redhorse	0.3	0.2	0.4	0.2	0	2.4	0.6723	no	A M S J N
Shorthead redhorse	5.4	12.7	5.8	7.5	0.3	39.1	0.0001	yes	J S A M N
White bass	0.7	0.3	1.3	1.5	0	13.4	0.0096	yes	S A M J N
Rock bass	0.2	0.9	0.9	0.9	0	5.9	0.2058	no	J A S M N
Bluegill	0.2	1.6	2.9	1.9	0.1	23.4	0.0001	yes	A S J M N
Smallmouth bass	0.1	1.5	1.2	0.7	0	9.5	0.0489	yes	J A S M N
Black crappie	0.5	1.5	1.0	0.6	0	9.0	0.0601	no	J A S M N
Sauger	2.8	1.6	0.8	1.4	0.5	12.2	0.0159	yes	M J S A N
Walleye	1.3	0.8	0.2	0.5	0.4	7.2	0.1271	no	M J S N A
Freshwater drum	0.9	1.6	1.6	1.9	0.1	12.5	0.0142	yes	S J A M N

pool (Horrall 1962, Jester 1972, Pierce 1980, Becker 1983). The latter two factors were probably the most important as relatively high catches occurred in May and June when flows equalled or exceeded those observed in November (Section 2).

When the adult electrofishing catch was compared according to weight (Section 5.7), the pattern observed was almost exactly the same as for the numerical catch. In both comparisons, significant differences were seen for total catch and for the same seven species. One difference that was noted was that on a numerical basis, the highest catches for white bass occurred in August and September, whereas, on a by-weight basis, the largest catch was in May. This reflects the fact that the May catch was probably composed of large, spawning adults, whereas the summer catch was primarily juvenile fish. The KW test showed a significant difference in the sauger catch (by weight), but Duncan's test did not reveal where this difference resided. However, it appears that the May and, perhaps September catches, were higher than in the other months.

Juvenile Electrofishing--Seasonal (i.e., monthly) effects were observed in the juvenile electrofishing catch, both for total catch and for selected species. Because gizzard shad and emerald shiner made up 71 percent of the total catch, the total catch was evaluated for seasonal effects without one or the other or neither of these species. However, regardless of whether or not these species were included, total catch still varied significantly according to month (Table 5-16). On a species-specific basis, it was found that the catch of gizzard shad, emerald shiner, white bass, and freshwater drum varied monthly. The catch of gizzard shad and emerald shiner peaked in August. Pierce (1980) also noted that cyprinids were most abundant in August. In the present study, it found that white bass and freshwater drum were significantly more abundant in September than in any other month. Similarly, Anderson et al. (1983) found white bass to be very abundant during their studies of Pool 5A which were conducted in August and September of 1980. Although the catch of emerald shiner was shown by the KW test to be significantly affected by month, Duncan's test did not reveal where this difference was. An inspection of the means presented on Table 5-16 reveals that the catches in June and August were noticeably higher than in the other three months, particularly compared to May and November.

Seining--Seining was the gear type most strongly affected by month of sampling, with total catch and the catch for 10 of the 13 species compared being significantly affected (Table 5-17). Total catch in August and September was statistically greater than in June, November, or May. Similarly, many individual species (e.g., gizzard shad, bullhead minnow, white bass, bluegill, and freshwater drum) also achieved their maximum abundance in either August or August/September (Table 5-17). Conversely, based on Duncan's test, only western sand darter appeared to be most abundant in the June/May period. However, this difference was not statistically different according to KW (P=0.1308). The KW test identified spottail shiner and river shiner exhibiting significant differences in seasonal abundance. Duncan's test did not identify where these differences resided; however, visual inspection of the monthly means shows that the means for August and September were considerably higher than in the other three months.

TABLE 5-16. SUMMARY OF MONTHLY STATISTICAL COMPARISONS OF JUVENILE ELECTROFISHING DATA (BY NUMBER, DAY AND NIGHT CATCH COMBINE

Species or Group	Mean No./5 Min May	Jun	Aug	Sep	Nov	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	1.2	24.5	60.6	34.4	1.3	48.8	0.0001	yes	A S J N M
Total catch except Gizzard shad	1.2	24.5	32.8	19.5	1.3	43.9	0.0001	yes	A J S N M
Total catch except Emerald shiner	1.2	7.1	38.1	27.8	1.2	46.7	0.0001	yes	A S J M N
Total catch except Gizzard shad and Emerald shiner	1.2	7.1	10.3	12.9	1.2	31.3	0.0001	yes	S A J M N
Gizzard shad	0	0	27.8	14.9	0	31.6	0.0001	yes	A S J M N
Spotfin shiner	0.3	0.7	2.9	2.1	0	4.9	0.2938	no	A S J M N
Emerald shiner	0	17.4	22.5	6.6	0.1	32.3	0.0001	yes	A J S N M
Bullhead minnow	0	2.0	0.6	0.1	0.1	1.5	0.8351	no	J A S N M
River shiner	0	2.7	1.5	0.8	0.5	4.4	0.3590	no	J A S N M
White bass	0	0	2.1	4.6	0	23.8	0.0001	yes	S A J M N
Freshwater drum	0	0	0.8	2.4	0	12.8	0.0125	yes	S A J M N

TABLE 5-17. SUMMARY OF STATISTICAL COMPARISONS OF MONTHLY SEINING DATA (BY NUMBER, DAY AND NIGHT CATCH COMBINED)

	Mean No./Seine Haul								
Species or Group	May	Jun	Aug	Sep	Nov	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	3.2	20.0	59.8	38.3	3.7	63.4	0.0001	yes	A S J N M
Gizzard shad	0	0	15.3	2.1	0	36.3	0.0001	yes	A S J M N
Spottail shiner	0	0	2.4	1.5	0.1	10.3	0.0355	yes	A S N J M
Spotfin shiner	1.0	3.1	2.3	3.4	0.4	18.4	0.0010	yes	S J A M N
Emerald shiner	0.2	9.7	14.3	4.7	0.4	47.1	0.0001	yes	A J S N M
Bullhead minnow	0	0.8	2.0	5.6	0.3	20.9	0.0003	yes	S A J N M
Sand shiner	0	0	1.1	0.8	0.1	2.4	0.6635	no	A S N J M
River shiner	0	1.8	5.6	8.5	1.3	17.8	0.0013	yes	S A J N M
Quillback	0.1	0.2	3.4	3.7	0	3.8	0.4367	no	S A J M N
Shorthead redhorse	0.2	0.9	0.5	0.5	0.0	13.3	0.0098	yes	J A S M N
White bass	0.1	0.1	3.8	2.7	0	25.5	0.0001	yes	A S J M N
Bluegill	0.1	0.3	2.6	1.3	0.4	13.0	0.0114	yes	A S N J M
Western sand darter	1.0	1.1	0.2	0.1	0	7.1	0.1308	no	J M A S N
Freshwater drum	0	0.3	2.8	1.1	0.0	21.6	0.0002	yes	A S J N M

The low catch rates in November were probably attributable to the high river flows as well as the typical movement of species such as gizzard shad, white bass, and freshwater drum into the deeper water during late fall (Horrall 1962, Jester 1972, Becker 1983). The low catch in May was undoubtedly related to the high (60,000-70,000 cfs) river flows which greatly reduced seining effectiveness.

Other investigators have also reported seasonal variations in seining catch. Kallemeyer and Novotny (1977) seined four stations on the Missouri River and reported considerable seasonal fluctuation in catch at all four stations, and that the differences were significant at two of them. In particular, they noted that the seine catch of gizzard shad was extremely variable. Also, as in our study, Kallemeyer and Novotny found that (1) gizzard shad were most abundant in July/August and (2) they were captured infrequently or not at all in the spring and fall. Pierce (1980) seined side channels in Pool 13 of the UMR and reported considerable seasonal catch variations and, as in our study, found August to be considerably more productive (406 fish) than October (47) or June (162 fish in 1978 and 30 in 1979).

Trammel Netting--Statistical comparisons of the trammel netting data, whether by number or weight, showed that month was a significant variable affecting total catch and the catch for five of the eight species examined (Table 5-18 and Section 5.7). Shovelnose sturgeon catch was not statistically compared because it obviously varied according to month. Mooneye, walleye, and freshwater drum were the only species for which month was not a significant variable. Because the abundance of shorthead redhorse and shovelnose sturgeon and the obviously skewed distribution of the shovelnose sturgeon data, the trammel net total catch data was also compared without one, or the other, or neither of these species. However, in all three of these cases, the seasonal pattern was the same and the Chi square values remained remarkably similar. It was previously noted that August was the most productive month for several gears. This trend was particularly noticeable in the trammel netting data. For example, the August catch (both by number and weight) of all five species found to have month as a significant variable affecting catch, was significantly higher than the catch during any other month. Conversely, the catch in the other four months was statistically comparable.

No other studies on the UMR have evaluated the effects of seasonality on trammel net catch. Pitlo (1982) grouped his trammel netting results with his results for gill and frame netting, and reported that although the spring and summer netting catch was higher than it was in the fall, this difference was not significant. However, he did report that significantly more species were captured in the spring and summer than in the fall. Trammel nets, because they are passive collecting devices, depend on the movement of fish to be effective. Thus, it is not surprising the catch rates are highest in the spring (when many fish exhibit significant migratory movements) or in the summer when their high metabolic rates require them to spend a considerable portion of each day searching for food.

TABLE 5-18. SUMMARY OF STATISTICAL COMPARISONS OF MONTHLY TRAMMEL NETTING DATA (BY NUMBER)

	Mean No./Net Day								
Species or Group	May	Jun	Aug	Sep	Nov	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	2.8	9.6	20.5	4.9	3.2	34.9	0.0001	yes	A J S N M
Total catch except Shovelnose sturgeon	2.4	3.7	20.5	4.9	3.2	37.3	0.0001	yes	A S J N M
Total catch except Shorthead redhorse	2.1	8.5	14.6	3.5	2.2	34.2	0.0001	yes	A J S N M
Total catch except Shovelnose sturgeon and Shorthead redhorse	1.7	2.6	14.6	3.5	2.2	34.8	0.0001	yes	A S J N M
Mooneye	0.5	0.4	0.6	0	0.4	3.6	0.4572	no	A M N J S
Quillback	0	0	1.8	0.5	0	16.0	0.0030	yes	A S J M N
Silver redhorse	0.1	0	1.9	0.2	0.2	30.7	0.0001	yes	A N S M J
Shorthead redhorse	0.7	1.1	5.9	1.4	1.0	25.2	0.0001	yes	A S J N M
White bass	0	0	1.6	0.1	0	11.3	0.0231	yes	A S J M N
Black crappie	0.1	0.1	2.7	1.0	0.1	19.4	0.0007	yes	A S M J N
Walleye	0	0.2	0.7	0.4	0.3	1.8	0.7778	no	A S N J M
Freshwater drum	0.1	0.3	1.3	0.5	0.1	5.7	0.2219	no	A S J M N

Frame Netting--As with the other gear types used in this study, the frame netting catch totals were significantly affected by month. Total catch, both by number and weight, varied significantly according to month of collection (Table 5-19 and Section 5.7). These differences were not pronounced, however, because Duncan's test showed that there was a broad overlap among the months in terms of total numerical catch (Table 5-19) and Duncan's test did not separate out any months on a by-weight basis (Section 5.7). Because black crappie comprised nearly half the frame net catch, catch statistics were also compared in the absence of black crappie data. When this was done, the Chi square values were reduced slightly, but month was still a significant variable (Table 5-19 and Section 5.7). With the black crappie data removed, Duncan's test could not identify which month(s) were significantly different, by either number or by weight.

Six species were examined to determine whether their catch varied monthly. Bluegill, black crappie, and freshwater drum were significantly affected by month, whereas, silver chub, shorthead redhorse, and rock bass were not affected. Black crappie was significantly more abundant in August than in any other month. Duncan's test did not show any difference among the numerical monthly means for bluegill, but did identify August, September, and June as being significantly different than May and November, on a by-weight basis. Duncan's test did not identify any monthly differences in the freshwater drum catch, either according to number or weight.

Summary of Temporal Comparisons--Table 5-20 summarizes the results of the temporal (monthly) comparisons for total catch and the 14 species collected in sufficient numbers by at least two gear types to warrant statistical analysis. It can be seen that (1) month was a significant variable affecting total catch for all five gear types (adult and juvenile electrofishing are considered here as separate gears), (2) the agreement between the comparisons based on number and weight was exact, whether for total catch or for individual species, and (3) for a given species, the effect (or lack of same) attributable to month was usually the same regardless of the gear (i.e., if month affected the catch for one gear type it usually affected the catch for all or most gear types). With regard to the third point, only the freshwater drum was abundant enough to be compared across all five gears. Freshwater drum catch was significantly affected by month for all gear types, except trammel netting. Four species, white bass (compared across four gear types), gizzard shad and bluegill (three gears each), and emerald shiner (two gears), were significantly affected for each of the gears considered. Conversely, the catches of walleye, rock bass, and mooneye (two gears each) were consistently unaffected by month. Month had no affect on the catches for two of the three gears analyzed for quillback. Month was significant for three of the four gears compared for shorthead redhorse. The results for spotfin shiner, bullhead minnow, and river shiner were contradictory. Thus, the importance of time (month) of collection in MCB habitats for these 14 common UMR fishes can be summarized as follows:

TABLE 5-19. SUMMARY OF STATISTICAL COMPARISONS OF MONTHLY FRAME NETTING DATA (BY NUMBER)

Species or Group	Mean No./Net Day May	Jun	Aug	Sep	Nov	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	9.1	7.8	15.9	8.4	2.5	22.4	0.0002	yes	A M S J N
Total catch except Black crappie	5.7	5.3	4.4	5.7	2.4	18.4	0.0010	yes	M S J A N
Silver chub	0.1	0.7	0.1	0.5	0	1.8	0.7690	no	J S M A N
Shorthead redhorse	2.5	1.1	0.7	0.6	0.5	4.8	0.3115	no	M J A S N
Rock bass	0.7	0.5	0.1	0.6	0	6.4	0.1706	no	M S J A N
Bluegill	0.9	1.1	1.8	1.0	0	9.6	0.0488	yes	A J S M N
Black crappie	3.3	2.5	11.5	2.7	0.1	19.9	0.0005	yes	A M S J N
Freshwater drum	0.2	0.5	0.8	2.0	1.4	14.8	0.0050	yes	S N A J M

TABLE 5-20. SUMMARY OF WHETHER MONTH WAS A SIGNIFICANT VARIABLE AFFECTING TOTAL CATCH OR THE CATCH OF INDIVIDUAL SPECIES (BY NUMBER OR WEIGHT) FOR FIVE GEAR TYPES.

	Adult Electrofishing		Juvenile Electrofishing	Seine	Trammel Net		Frame Net	
Species or Group	No.	Wt.	No.	No.	No.	Wt.	No.	Wt.
Total Catch	Y[1]	Y	Y	Y	Y	Y	Y	Y
Gizzard shad	Y	Y	Y	Y	-	-	-	-
Mooneye	N[2]	N	-[3]	-	N	N	-	-
Spotfin shiner	-	-	N	Y	-	-	-	-
Emerald shiner	-	-	Y	Y	-	-	-	-
Bullhead minnow	-	-	N	Y	-	-	-	-
River shiner	-	-	N	Y	-	-	-	-
Quillback	N	N	-	N	Y	Y	-	-
Shorthead redhorse	Y	Y	-	Y	Y	Y	N	N
White bass	Y	Y	Y	Y	Y	Y	-	-
Rock bass	N	N	-	-	-	-	N	N
Bluegill	Y	Y	-	Y	-	-	Y	Y
Black crappie	N	N	-	-	Y	Y	Y	Y
Walleye	N	N	-	-	N	N	-	-
Freshwater drum	Y	Y	Y	Y	N	N	Y	Y

---

[1] Y = Yes, month was a significant variable.
[2] N = No, month was not a significant variable
[3] - = No comparison was made.

Month Is			
Definitely Important	Probably Important	Probably Not Important	An Unknown Variable
Gizzard shad	Black crappie	Mooneye	Spotfin shiner
Emerald shiner		Rock bass	River shiner
White bass		Walleye	Bullhead minnow
Bluegill		Quillback	
Freshwater drum			
Shorthead redhorse			

5.3.3.2 Gear Effectiveness and Bias

No statistical comparisons were made among the four principal gear types because it is well known that each has inherent strenghths and weaknesses (Funk 1958, Holzer and Ironside 1977, Backial and Welcomme 1980, Hubert 1980, Pierce 1980, Pitlo 1982). However it is appropriate to consider how these limitations manifested themselves in this study. As mentioned previously, seining and electrofishing were the most productive methods and also produced the most diverse catches (see Section 5.3.1.1 for a detailed discussion of species diversity).

Electrofishing

Electrofishing (adult and juvenile combined) yielded 50 species of fish indicating that it was effective for capturing a large percentage of the species found in Pool 5A. Other investigators have also found electrofishing to be very effective on the UMR. Anderson et al. (1983) sampling the same locations used in the present study reported capturing more fish (by number and weight) and more species electrofishing than the other gears they used (seine, frame nets, otter trawling). Holzer and Ironside (1977) used a variety of gears to sample Lake Onalaska and concluded that electrofishing and fyke nets were the best gear types overall. They noted that electrofishing was especially effective for collecting largemouth bass and spotted suckers. Pitlo (1982) found DC electrofishing to be much more productive, on a catch-per-unit effort (CPE) basis, than the other gears he used (frame nets, trammel nets, and gill nets). However, he reported that the electrofishing CPE was variable "making it difficult to detect significant differences between the parameters being tested." He also suggested that DC electrofishing appeared to outperform AC electrofishing for sampling wing dams on the UMR. Fernholz et al. (1980) reported that electrofishing gears (AC and DC) captured "the largest number of fishes, representing the widest variety of size classes, but are ineffectual for some species." In summary, most investigators have concluded that electrofishing is one of the best gears available to the fisheries biologist, but that it still has limitations in terms of its effectiveness for smaller size classes (i.e., YOY fish) or species (e.g., minnows and darters) and for certain species (e.g., catfishes). This species and size selectivity was borne out in the present study where juvenile electrofishing collected 8 species of fish not collected adult electrofishing, despite the fact that twice the level of effort was expended adult electrofishing. Of the eight species, six (golden shiner, sand shiner, pugnose minnow, stonecat, brook silverside, and western sand darter) were smaller species. This suggests that the number of species captured during electrofishing studies can be increased substantially (here 14%) if more than one pulser output setting is used during the surveys.

Seining

Seining captured more fish and nearly as many species as electrofishing, and did capture more species (45) than adult electrofishing alone (42). In their study of Pool 5A, Anderson et al. (1983) also found that seining caught the second highest number of species, however, the difference between the number of species it caught and the number caught electrofishing (which caught the highest number of species) was more pronounced than in the present study. Similarly, in the present study seining produced 1.5 times as many fish as electrofishing, whereas Anderson et al. found the reverse situation, with electrofishing producing 1.9 times as many fish as seining. Other investigators have also noted the effectiveness of seining, particularly for minnows, darters, and the other small species frequently overlooked electrofishing. Ragland (1974) working in three side channels of the Mississippi River caught 3,568 fish representing 42 species for five methods combined; electrofishing, gill nets, trammel nets, hoop nets, and trap nets, but caught 5,098 fish representing 35 species by seining alone. Pierce (1980) also found that seining was an effective technique on the UMR. He reported that 4-5 seine hauls per month produced a total of 37 species of fish, whereas 112 net days of hoop netting and 19.5 hours of electroshocking per month yielded totals of 23 and 44 species, respectively. Similarly, Fremling et al. (1980), while sampling the Fountain City Bay area of Pool 5A, collected a total of 39 species of fish during a four year period, while, during the same period, seining alone yielded 46 species. Numerous authors have commented on the effectiveness of seining for capturing minnows and YOY fish. Pierce (1980) concluded that seining was the most effective method for capturing small fish. Holzer and Ironside (1977) stated that "the minnow seine provided important data on young-of-the-year fish and minnow species" and that "shoreline seining is an excellent method for sampling young-of-the-year largemouth bass". Fernholz et al. (1980) while working in Pool 5 stated that "beach seines are necessary to sample minnow populations." This effectiveness for small species was also noted in the present study. The six species (goldeye, mimic shiner, tadpole madtom, crystal darter [an endangered species], slenderhead darter, and river darter unique to seining were all small species, except for goldeye. No other gear type had more than two unique species. In addition, seining captured 5 other species (golden shiner, sand shiner, pugnose minnow, brook silverside, and western sand darter) that were not collected adult electrofishing. Thus, seining yielded 11 species not captured adult electrofishing. Collectively, the two electrofishing types (adult and juvenile) and seining accounted for 56 of the 58 species captured during this study suggesting that these two gears are a necessary part of any study designed to sample the entire fish community.

Trammel Netting

Trammel netting was intermediate between seining/electrofishing and frame netting in terms of the number of species it captured (36). However, the number of fish it captured (751) was much lower than the number captured seining (4727) or electrofishing (3225) (Table 5-9). Trammel netting yielded two species--shovelnose sturgeon and burbot--that were not captured by any other method. Several other studies on the UMR and the Missouri River have also used some type of entanglement net (i.e., trammel or gill nets). Pitlo (1982) used gill and trammel nets to sample wing and closing dams in Pools 9-19 of the UMR (Table 5-21). He reported that the trammel netting captured 1149 fish representing 33 species, totals similar to the 776 fish and 36 species captured with a comparable level of effort trammel netting during the present study. Pitlo (1982) reported that "trammel nets outperformed monofilament and multifilament small mesh gill nets." However, he also noted that both trammel and gill nets were ineffective during high flows because of being clogged by debris and were ineffective in the late fall because of leaf litter. Kallemeyer and Novotny (1977) used trammel and gill nets in the Missouri River. Because of differences in species composition between the UMR and the Missouri River, quantitative comparisons are not appropriate. However, it is interesting to note that they reported that shovelnose sturgeon were caught "almost exclusively in pools in gill nets and trammel nets." Similarly, in the present study, 110 shovelnose sturgeon were collected, all of which were captured by trammel netting. Ragland (1974) used trammel nets to sample MCB habitats on the Mississippi River south of St. Louis and found them to be very productive, yielding 275 fish representing 19 species in only 7 net days.

Frame Netting

In the present study, frame netting was less productive than all gear types except trammel netting, and produced by far the fewest number of species (20). Comparisons with other studies are difficult because: (1) most other studies have used hoop rather than frame nets, and (2) entrapment nets have been shown to be extremely variable in their effectiveness (see discussion that follows). As in this study, Anderson et al. (1983) found that frame nets produced the fewest number of species in Pool 5A among the four gears they used. However, at a level of effort approximately the same as in this study (Table 5-21), they found that frame netting was the second most productive gear, yielding 3726 fish. Pitlo (1982) sampled Pools 9-19 and found that frame nets yielded 2,071 fish representing 32 species. The number of species collected by Pitlo is higher than reported in this study but, as discussed later, the catch rate is roughly comparable (Table 5-21).

Numerous authors have commented on the size and species selectively of entrapment nets (i.e., frame, hoop, or fyke nets). Pitlo (1982) reported that frame nets captured significantly more fish and more species than did hoop nets when both were used to sample UMR wing dams. Pitlo also reported that there was evidence of gear selectivity for species and fish size in his study but did not cite specific examples because he felt the topic has adequately been addressed by other authors. Pierce (1980) reported that channel catfish and smallmouth buffalo were more vulnerable

TABLE 5-21. COMPARISONS OF FISH NUMBERS, NUMBER OF SPECIES, EFFORT, AND CATCH PER UNIT EFFORT FOR VARIOUS STUDIES THAT HAVE SAMPLED FISH POPULATIONS AT VARIOUS MCB HABITATS ON THE UMR.

	Gear							
	Trammel	Frame Net			Electrofishing*			
Investigator	Net	All Habitats	Rock	Sand	All Habitats	Sand	Rip-rap	Wingdam
Ragland (1974)								
Total fish	275	-	-	-	523	-	-	-
No. species	19	-	-	-	31	-	-	-
Effort (hr)	168	-	-	-	11.1	-	-	-
CPE	1.6	-	-	-	47.1	-	-	-
Holzer (1978)								
Total fish	-	-	-	-	1639	539	824	276
No. species	-	-	-	-	30	24	21	19
Effort (hr)	-	-	-	-	4.2	1.4	1.8	1.0
CPE	-	-	-	-	390	385	457	276
Pierce (1980)								
Total fish	-	-	-	-	1665	-	-	743
No. species	-	-	-	-	-	-	-	-
Effort (hr)	-	-	-	-	24	-	-	24
CPE	-	-	-	-	69.4	-	-	31.0
Pitlo (1982)								
Total fish	1149	2071	-	-	-	-	-	1202
No. species	33	32	-	-	-	-	-	28
Effort (hr)	2733	3467	-	-	-	-	-	12.4
CPE	0.42	0.60	-	-	-	-	-	96.9
Anderson et al. (1983)								
Total fish	-	3726	-	-	5556	-	-	-
No. species	-	27	-	-	41	-	-	-
Effort (hr)	-	1728	-	-	12	-	-	-
CPE	-	2.15	2.31	2.17	438	527	322.8**	322.8**
This Study								
Total fish	751	776	-	-	1862	-	-	-
No. species	36	20	-	-	42	-	-	-
Effort (hr)	2198	2156	-	-	16.2	-	-	-
CPE	0.34	0.36	-	-	115	-	-	-

* Ragland used a combination of AC and DC electrofishing, Pierce used AC electrofishing, and the remaining studies all used DC electrofishing.

**All rock areas combined.

to hoop netting than any of the other gears he used. Pierce also reported that baited (soybean cake) hoop nets caught significantly more fish than unbaited nets, but that some species were more susceptible to one type of the hoop net than the other. He found that significantly more smallmouth buffalo, carp, and channel catfish were caught in baited hoop nets, whereas unbaited nets caught significantly more flathead catfish, freshwater drum and black crappie. Also, more species of fish (21) were caught in unbaited nets than in baited nets (16). Finally, Pierce (1980) reported that hoop netting was the most effective gear for capturing large fish as he noted that the average size fish caught seining, electrofishing, and hoop netting was 64, 179, and 273 mm, respectively. Kallemeyer and Novotny (1977) reported that channel catfish dominated the hoop net catch in their study of the Missouri River and that none of the other gears effectively collected this species in areas with strong currents. Hubert (1980) used two types of hoop nets (bait nets, which were baited with cheese, and buffalo nets, which were baited with soybean cake) to compare MCB and side channel habitats in Pool 9. He reported that buffalo nets were twice as productive (5 fish/day) as bait nets (2.5 fish/day), that 14 species were significantly more abundant in the buffalo net catch, and that four species were more abundant in the bait net catch. However, three or four species dominated the catch in each net. Black crappie, shorthead redhorse, and freshwater drum accounted for 80 percent of the bait net catch. These same species plus smallmouth buffalo accounted for 81 percent of the buffalo net catch. These results are very similar to those in the present study where it was found that black crappie, shorthead redhorse, and freshwater drum accounted for 69 percent of the frame net catch, and these three plus bluegill accounted for 81 percent of the catch. In their 1980 study of Pool 5A, Anderson et al. (1983) also found that the frame net catch was dominated by only three species, white bass (43 percent), black crappie (34 percent) and gizzard shad (9 percent). Of these species, only black crappie was an important component of the catch reported in the present study and in Hubert's (1980) study. Freshwater drum and shorthead redhorse, two species important in the latter studies, accounted for only 4.5 percent of the frame net catch in the Anderson's study. One reason for this discrepancy may be the fact that the present study and Huberts were conducted over several months, whereas Anderson's study was conducted only in August and September, the period when white bass and gizzard shad numbers were at their peak in the present study. It seems reasonable to conclude that had Anderson's study included spring and fall sampling, the proportion of white bass and gizzard shad would have dropped appreciably.

Gear Summary

Although it is inappropriate to make statistical or quantitative comparisons among catch rates taken from various studies, qualitative comparisons of selected statistics are still of interest. Table 5-21 presents such statistics for six studies conducted on MCB habitats on the UMR. Trammel nets were used by Ragland (1974), Pitlo (1982), and this study. The CPE and number of species reported by Pitlo and this study are extremely similar. Conversely, Ragland (1974) caught fewer species but had a higher CPE than the other two studies.

Frame nets were used by Pitlo (1982), Anderson et al. (1983), and this study. Again, the CPEs reported by Pitlo and this study are quite similar. Pitlo reported considerably more species than the present study; however, this may be partly attributable to Pitlo's greater total effort. Anderson et al. (1983) caught an intermediate number of species compared to Pitlo and this study, but reported a considerably higher CPE. As suggested earlier, this may have been partly the result of Anderson's study being restricted to the summer and early fall, a period noted by several authors to be especially productive.

All six studies (Table 5-21) used electrofishing, with CPE values ranging from the 31.0 fish/hr for wingdams reported by Pierce (1980) to 527 fish/hr for sandy areas (Anderson et al. 1983). An examination of how or when the electrofishing was conducted explains much of this variability. The CPE values reported by Pierce are among the lowest presented on Table 5-21, Pierce was the only investigator who used AC electrofishing. The low CPE reported by Ragland (1974) may be related to the fact that he also used AC electrofishing for an unspecified proportion of his studies. Conversely, the high values reported by Holzer (1978) are probably at least partially attributable to the fact that he conducted all his surveys at night, the period when electrofishing catches are typically highest (Pitlo 1982, Anderson et al. 1983, this study). As suggested previously, the high CPE values reported by Anderson et al. (1983) may be partially related to the fact that their survey was conducted during late summer and early fall when high catch rates are often achieved (Pierce 1980, this study). The CPE of 115 fish/hr reported in the present study was intermediate between the low values reported by Ragland (1974) and Pierce (1980) and the high values reported by Holzer (1978) and Anderson et al. (1983), and was comparable to the value reported by Pitlo (1982) (Table 5-21).

5.3.3.3 Location Effects

The degree of influence exerted by collecting location varied among the gear types. It was not particularly important with regard to adult electrofishing, juvenile electrofishing, or trammel netting, but was quite important for seining and frame netting (Table 5-22). The ecological significance of the differences identified below is discussed in Section 5.4.

Adult Electrofishing

Total adult electrofishing catch, whether by number or weight, was not significantly different among the 10 sampling locations (Tables 5-23 and Section 5.7). Locations 3 (riprapped bank) and 6 (silt bay) had the highest mean total catch per 10 minutes but the values were not significantly different compared to the other locations. Similarly, of 15 species analyzed individually, only two (carp and smallmouth bass) were significantly affected. Carp were significantly more abundant at Location 3 (the riprapped bank) than at any other location. Similarly, smallmouth bass were significantly more abundant at Location 3 than at all locations, except 4 (wing dam). Most species reached their peak numerical or biomass abundance either at Location 6 (five species), Location 3 (four species), or Location 4 (three species). As in this

TABLE 5-22. SUMMARY OF TOTAL CATCH (BY NUMBER) AT 10 LOCATIONS ON POOL 5A, 1982.

	LOCATION										
	1	2	3	4	5	6	7	8	9	10	Total
DC-Shock											
Adult, Day	39	71	104	87	19	146	36	21	54	43	620
Adult, Night	62	85	267	135	165	148	61	74	94	151	1242
Juv., Day	92	89	54	48	51	229	27	21	43	27	681
Juv., Night	65	45	316	49	39	67	35	10	27	29	682*
	258	290	741	319	274	590	159	126	218	250	3225
Seine											
Day, Rep A	4	38	16	21	78	664	39	239	83	217	1399
Day, Rep B	4	14	12	15	113	665	33	256	39	107	1258
Night, Rep A	29	21	49	12	140	516	102	50	87	190	1196
Night, Rep B	17	35	21	0	80	309	50	72	82	208	874
	54	108	98	48	411	2154	224	617	291	722	4727
Trammel Net											
Rep A	66	21	11	17	50	119	31	28	34	44	421
Rep B	27	10	27	20	61	85	18	24	28	30	330
	93	31	38	37	111	204	49	52	62	74	751
Frame Net											
Rep A	108	21	57	33	24	117	10	14	17	24	425
Rep B	54	9	61	43	32	84	3	11	36	18	351
	162	30	118	76	56	201	13	25	53	42	776
All Gears	567	459	995	480	852	3149	445	820	624	1088	9479

* Includes data from June, August, September, and November only.

TABLE 5-23. SUMMARY OF STATISTICAL COMPARISONS OF ADULT ELECTROFISHING DATA (BY NUMBER, DAY AND NIGHT CATCH COMBINED) ACCORDING TO LOCATION

Species or Group	Mean No./10 min												Significant	Means Underlined Are Not
	1	2	3	4	5	6	7	8	9	10	CHI^2	Prob.	Difference	Significantly Different
Total catch	11.4	15.4	35.9	22.2	22.5	29.2	10.4	9.4	16.2	19.7	12.8	0.1728	no	3 6 5 4 10 9 2 1 7 8
Gizzard shad	0.3	0.3	7.0	0.0	1.3	7.8	0.1	0.0	4.2	1.7	6.5	0.6907	no	6 3 9 10 5 1 2 7 4 8
Mooneye	0.2	0.0	0.6	0.2	0.5	0.3	0.6	0.5	0.7	0.5	3.5	0.9415	no	9 3 7 5 10 8 6 1 4 2
Common carp	0.3	0.6	3.0	0.6	0.0	1.3	0.0	0.1	0.7	0.1	18.8	0.0271	yes	3 6 9 4 2 1 8 10 5 7
Quillback	0.1	0.0	0.1	0.0	0.1	0.5	0.3	0.3	0.3	0.6	5.4	0.7996	no	10 6 7 9 8 5 1 3 2 4
Silver redhorse	0.3	0.3	0.1	0.2	0.3	0.1	0.7	0.6	0.2	0.3	1.9	0.9929	no	7 8 5 1 10 2 4 9 3 6
Golden redhorse	0.0	0.3	0.8	0.5	0.1	0.1	0.1	0.1	0.1	0.2	3.7	0.9281	no	3 4 2 10 7 8 5 9 6 1
Shorthead redhorse	4.5	5.2	9.4	10.4	12.0	2.0	6.1	4.7	3.2	5.7	11.1	0.2703	no	5 4 3 7 10 2 8 1 9 6
White bass	0.6	0.8	0.8	0.4	1.7	1.0	0.2	0.2	0.7	1.2	5.0	0.8359	no	5 10 6 2 3 9 1 4 7 8
Rock bass	0.4	0.7	2.5	0.9	0.2	0.0	0.0	0.3	0.1	0.9	9.9	0.3585	no	3 10 4 2 1 8 5 9 6 7
Bluegill	1.3	1.0	1.0	1.6	0.7	6.3	0.1	0.2	0.3	0.8	9.6	0.3875	no	6 4 1 3 2 10 5 9 8 7
Smallmouth bass	0.0	0.7	3.5	2.2	0.0	0.0	0.2	0.3	0.1	0.1	24.4	0.0037	yes	3 4 2 8 7 9 10 1 5 6
Black crappie	0.8	0.6	1.0	0.9	0.6	1.7	0.1	0.1	0.4	0.8	6.6	0.6759	no	6 3 4 1 10 5 2 9 7 8
Sauger	1.0	1.4	1.4	0.9	3.2	1.5	0.3	0.5	1.6	2.5	5.8	0.7559	no	5 10 9 6 2 3 1 4 8 7
Walleye	0.1	0.1	1.2	0.7	0.9	0.9	0.1	0.4	1.1	0.8	8.5	0.4844	no	3 9 5 6 10 4 8 2 1 7
Freshwater drum	0.7	1.1	2.4	1.0	0.5	2.5	0.7	0.4	1.3	1.7	8.5	0.4891	no	6 3 10 9 2 4 7 1 5 8

study, Pierce (1980) concluded that sampling month was a more important variable than habitat (i.e., location) and reported that "the composition of electrofishing catches was remarkably similar for the side channel, main channel border shorelines, and emergent wing dams." Pitlo (1982) reported that water depth over each current modification structure and the location of the structure in relation to the thalweg were the two most important physical factors affecting fish populations. He found that electrofishing catches at deep structures (>5 ft) were much higher at structures located on the outside of river bends than at those located on the inside of bends or on straight sections of the river. Pennington et al. (1983) noted that proximity between locations influenced whether the electrofishing catches were comparable.

Juvenile Electrofishing

None of the juvenile electrofishing catch statistics, either for total catch or for individual species, were significantly affected by location (Table 5-24). The fact that the probability was reduced from .3991 to 0.1130 when gizzard shad and emerald shiner were eliminated from the total catch, suggests that their dominance in the catch and schooling nature of these two species serves to mask (by increasing variability) any trends which might otherwise be apparent.

Seining

Seining total catch was significantly affected by sampling location (Table 5-25). The mean total catch at Location 6 (silt bay) was significantly higher than at any other location. Conversely, the catch among the other nine locations was comparable. Of the 13 species examined individually, the means for four (emerald shiner, bullhead minnow, river shiner, and bluegill) were significantly influenced by location (Table 5-25). Bullhead minnow and river shiner were significantly more abundant at Location 6 than at any other location. Bluegill was more abundant at Location 6 than at any location, except Location 10 (sand flat). Emerald shiner was considerably more abundant at Locations 8 (wing dam) and 6 than at the other locations. Clearly, Location 6 was the most productive location for seining. In fact, Duncan's test identified Location 6 as being significantly more productive than any other location for gizzard shad, sand shiner, quillback, and freshwater drum even though the KW test did not indicate that the differences among the locations were significant.

Trammel Netting

The mean total trammel net catch, and the total catch without shovelnose sturgeon, without shorthead redhorse, and without either species were all significantly affected by location (Table 5-26). Similarly, for all of these comparisons, the mean catch was significantly higher at Location 6 (silt bay) than at any other location, and the catches at the other 9 locations were statistically comparable. Conversely, location did not significantly affect the mean catch for any of the eight species examined individually. This suggests that the variability shown by individual species was high and served to obscure whatever differences were present; whereas, the increased sample size (which served to reduce variability)

TABLE 5-24. SUMMARY OF STATISTICAL COMPARISONS OF JUVENILE ELECTROFISHING DATA (BY NUMBER, DAY AND NIGHT CATCH COMBINED) ACCORDING TO LOCATION.

Species or Group	Monthly Mean (No./5 Min)													
	1	2	3	4	5	6	7	8	9	10	CHI^2	Prob.	Sig. Diff.	Means Underlined Are Not Not Significantly Different
Total catch	33.1	22.3	79.0	18.8	18.2	52.4	12.3	6.4	15.4	11.9	9.4	0.3991	no	3 6 1 2 4 5 9 7 10 8
Total catch[a]	21.2	20.7	48.6	7.3	15.8	20.8	11.9	64.	11.5	10.6	7.4	0.5984	no	3 1 6 2 5 7 9 10 4 8
Total catch[b]	26.2	15.1	32.5	13.0	6.8	46.8	6.0	2.3	8.9	8.5	12.1	0.2091	no	6 3 1 2 4 9 10 5 7 8
Total catch[c]	14.3	13.5	2.1	1.5	4.4	15.2	5.6	2.3	5.0	7.3	14.3	0.1130	no	6 1 2 10 7 9 5 8 3 4
Gizzard shad	11.9	1.6	30.4	11.5	2.4	31.6	0.4	0	3.9	1.3	6.1	0.7312	no	6 3 1 4 9 5 2 10 7 8
Spotfin shiner	2.7	7.3	0.6	0	0.4	1.0	0.9	0	0.2	0.2	7.3	0.6093	no	2 1 6 7 3 5 9 10 4 8
Emerald shiner	6.9	7.2	46.4	5.8	11.4	5.6	6.3	4.1	6.4	3.4	3.9	0.9212	no	3 5 2 1 9 7 4 6 8 10
Bull-head minnow	2.1	1.1	0	0	0	2.0	0.2	0	0.7	0.2	3.0	0.9643	no	1 6 2 9 7 10 3 4 5 8
River shiner	2.3	0.6	0	0	0.6	2.9	1.3	1.2	2.8	0.4	6.5	0.6891	no	6 9 1 7 8 2 5 10 3 4
White bass	2.5	1.4	0.1	0	2.3	2.0	1.4	0.6	0.4	4.1	3.7	0.9292	no	10 1 5 6 2 7 8 9 3 4
Fresh-water drum	1.9	0.3	0	0.6	0.5	1.8	0.2	0.2	0.2	1.3	3.6	0.9383	no	1 6 10 4 5 2 9 7 8 3

---

[a] Except for gizzard shad.

[b] Except for emerald shiner.

[c] Except for gizzard shad and emerald shiner.

TABLE 5-25. SUMMARY OF STATISTICAL COMPARISONS OF SEINING DATA (BY NUMBER) ACCORDING TO LOCATION

Species or Group	Monthly Mean (No./Seine Haul) 1	2	3	4	5	6	7	8	9	10	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	3.4	6.8	6.5	4.8	20.6	113.4	12.4	38.9	15.3	36.1	32.7	0.0001	yes	6 10 8 5 9 7 2 3 4 1
Gizzard shad	0.8	0.6	0.7	0.1	3.9	22.7	4.2	1.0	0.5	0.9	4.1	0.9064	no	6 7 5 8 10 1 3 2 9 4
Spottail shiner	0	0.1	0	0	0	2.7	0	0.5	0.5	3.8	6.1	0.7318	no	10 6 9 8 2 1 3 4 5 7
Spotfin shiner	0.3	1.3	0.5	1.1	2.0	5.7	2.2	2.3	1.3	3.7	14.0	0.1223	no	6 10 8 7 5 2 9 4 3 1
Emerald shiner	0.6	1.3	1.1	1.5	8.5	12.7	2.2	17.8	5.6	7.5	24.8	0.0032	yes	8 6 5 10 9 7 4 2 3 1
Bullhead minnow	0.1	0.3	0.2	0	0.2	11.1	0.4	1.4	0.8	2.9	24.7	0.0033	yes	6 10 8 9 7 2 3 5 1 4
Sand shiner	0.1	0.3	0.1	0	0.4	2.9	0.1	0	0	0.1	2.1	0.9897	no	6 5 2 3 7 1 10 4 8 9
River shiner	0.2	0.2	0.5	0	1.0	21.2	0.7	2.4	1.7	6.2	19.5	0.0216	yes	6 10 8 9 5 7 3 1 2 4
Quill-back	0	0	0	0	0	13.0	0	0.9	0.5	0.3	7.9	0.5442	no	6 8 9 10 1 2 3 4 5 7
Short-head red-horse	0.1	0.6	0.5	0.2	0.7	0.5	0.4	0.4	0.5	0.4	5.3	0.8092	no	5 2 3 6 9 7 8 10 4 1
White bass	0.4	0.3	0.2	0.1	0.7	5.5	0.2	1.4	0.8	3.7	6.6	0.6827	no	6 10 8 9 5 1 2 3 7 4
Blue-gill	0.1	0.1	0.7	0	0.3	4.1	0.4	0.1	0.4	2.8	17.2	0.0460	yes	6 10 3 7 9 5 1 8 2 4
Western Sand-darter	0.1	0	0	0	1.2	0.3	0.4	0.5	0.1	1.3	8.1	0.5196	no	10 5 8 7 6 1 9 2 3 4
Fresh-water drum	0.3	0.3	0	0.1	0.5	5.1	0.2	0.8	1.0	0.5	9.3	0.4118	no	6 9 8 5 10 2 1 7 4 3

TABLE 5-26. SUMMARY OF STATISTICAL COMPARISONS OF TRAMMEL NETTING DATA (BY NUMBER) ACCORDING TO LOCATION

Species or Group	Monthly Mean (No./Net Day) 1	2	3	4	5	6	7	8	9	10	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	10.7	3.4	3.7	3.9	11.7	22.9	5.1	5.7	6.9	8.1	17.6	0.0397	yes	6 5 1 10 9 8 7 4 3 2
Total catch[a]	5.8	3.3	3.0	3.9	5.0	22.9	5.0	5.7	6.9	8.1	19.7	0.0198	yes	6 10 9 1 8 7 5 4 2 3
Total catch[b]	9.6	2.5	2.5	2.8	9.9	21.2	3.2	2.7	4.5	2.9	21.6	0.0103	yes	6 5 1 9 7 10 4 8 2 3
Total catch[c]	4.8	2.4	1.8	2.8	3.2	21.2	3.1	2.7	4.5	2.9	23.8	0.0047	yes	6 1 9 5 7 10 4 8 2 3
Mooneye	0.3	0.5	0.1	0.1	0	1.6	0.2	0.3	0.1	0.5	4.8	0.8516	no	6 10 2 8 1 7 9 3 4 5
Quillback	0	0	0.3	0	0.3	2.2	0.5	0.3	0.3	0.7	4.7	0.8632	no	6 10 7 8 3 9 5 1 2 4
Silver redhorse	0.5	0.2	0.2	0.3	0.5	0.2	0.7	0.5	1.1	0.4	3.5	0.9432	no	9 7 8 1 5 10 4 2 6 3
Shorthead redhorse	1.0	0.8	1.2	1.0	1.8	1.8	1.9	3.0	2.4	5.2	8.9	0.4484	no	10 8 9 7 6 5 3 4 1 2
White bass	0.1	0.1	0	0.1	0.2	1.6	0	0.4	0.8	0.2	1.6	0.9960	no	6 9 8 5 10 2 4 1 3 7
Black crappie	0.6	0.1	0.1	1.2	0.4	4.6	0.4	0.1	0.1	0.2	14.5	0.1070	no	6 4 1 5 7 10 2 9 8 3
Walleye	0	0.1	0	0.4	0.1	2.1	0	0.1	0.2	0	5.7	0.7705	no	6 4 9 2 5 8 1 3 7 10
Freshwater drum	1.4	0.3	0.4	0.1	0.4	1.5	0	0	0.3	0	11.1	0.2705	no	6 1 5 3 9 2 4 7 8 10

---

[a] Except for shovelnose sturgeon.
[b] Except for shorthead redhorse.
[c] Except for shovelnose sturgeon and shorthead redhorse.

in the total catch overcame these confounding influences. This hypothesis is supported by the fact that Duncan's test identified Location 6 as being different from all the other locations for four species (mooneye, quillback, black crappie, and walleye), despite the fact that the KW test did not show a significant difference to be present. Collectively, the total catch and species-specific catch data show that Location 6 was, by far, the most productive location for trammel netting.

Pitlo (1982) reported that netting catch (trammel, gill, and frame net data combined) was not affected by location when Pools 10, 11 and 13 on the UMR were compared with Pools 16 and 18. However, he did find that location relative to the thalweg did affect netting catch. He reported that locations on the outsides of river bends produced more fish and more species than did locations along straight sections of the river, which, in turn, were more productive and speciose than locations on the inside of river bends.

Frame Netting

Total mean frame net catch (by number and weight) both with and without black crappie was significantly affected by location (Tables 5-27 and Section 5.7). In addition, the mean bluegill and black crappie numerical catch was significantly affected by location, and the by-weight catch was significantly affected by location for these two species plus freshwater drum. Location 6 (silt bay) was generally the most productive location for frame netting, however, its dominance was not nearly so clear cut as it was for seining or trammel netting.

As discussed in the preceding section, Pitlo (1982) reported that netting catch was not affected when different pools in the UMR were compared, but was affected when the sampling location relative to the river thalweg was considered.

Location Summary

Table 5-28 summarizes the effect of sampling location on total catch and the catch for 15 common UMR species. Total catch, both by number and weight, was significantly affected by location for seining, trammel netting and frame netting, but was not affected for adult or juvenile electrofishing. On a species-specific basis, only bluegill appeared to be strongly affected by sampling location. It appears likely, however, that this lack of difference among the locations was, to some extent, an artifact caused by spreading the catch among 10 locations, thereby increasing the chances that high variability in the catch data obscured differences that were actually present.

In terms of total catch, Location 6 (silt bay) was clearly the most productive location for seining and trammel netting and was at or near the top for the other gear types. For individual species, Location 6 was also usually the highest ranked location, however, only occasionally was this difference statistically significant.

TABLE 5-27. SUMMARY OF STATISTICAL COMPARISONS OF FRAME NETTING DATA (BY NUMBER) ACCORDING TO LOCATION

Species or Group	Monthly Mean (No./Net Day)										CHI²	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
	1	2	3	4	5	6	7	8	9	10				
Total Catch	20.0	3.4	11.7	8.0	5.0	23.4	1.5	2.8	5.9	4.7	26.1	0.0020	yes	6 1 3 4 5 9 10 2 8 7
Total Catch except Black crappie	6.7	2.6	6.2	4.5	4.8	9.7	1.4	2.6	4.9	3.6	17.4	0.0424	yes	6 1 3 9 5 4 10 2 8 7
Silver chub	0	1.1	0.1	0	0.9	0	0.4	0	0.1	0.4	5.3	0.8052	no	2 5 10 7 9 3 1 4 6 8
Shorthead redhorse	1.2	0.2	2.9	0.7	1.8	0.5	0.4	0.6	0.9	1.4	5.4	0.8021	no	3 5 10 1 9 4 8 6 7 2
Rock bass	0.6	0	0.1	0.8	0.1	0.5	0.4	0.7	0.6	0.1	5.8	0.7641	no	4 8 1 9 6 7 5 10 3 2
Bluegill	0.2	0.4	0.2	0.2	0.3	5.8	0	0.5	1.4	0.7	17.7	0.0383	yes	6 9 10 8 2 5 3 4 1 7
Black crappie	13.3	0.8	5.5	3.4	1.2	13.6	0.1	0.2	1.0	1.2	20.7	0.0143	yes	6 1 3 4 5 10 9 2 8 7
Freshwater drum	3.4	0.6	1.9	1.7	0.7	0.2	0.1	0.2	0.4	0.6	16.7	0.0532	no	1 3 4 5 2 10 9 8 6 7

TABLE 5-28. SUMMARY OF WHETHER LOCATION WAS A SIGNIFICANT VARIABLE AFFECTING TOTAL CATCH OR THE CATCH OF INDIVIDUAL SPECIES (BY NUMBER OR WEIGHT) FOR FIVE GEAR TYPES.

Species or Group	Adult Electrofishing No.	Adult Electrofishing Wt.	Juvenile Electrofishing No.	Seine No.	Trammel Net No.	Trammel Net Wt.	Frame Net No.	Frame Net Wt.
Total Catch	N[1]	N	N	Y[2]	Y	Y	Y	Y
Gizzard shad	N	N	N	N	[3]-	-	-	-
Mooneye	N	N	-	-	N	N	-	-
Spotfin shiner	-	-	N	N	-	-	-	-
Emerald shiner	-	-	N	Y	-	-	-	-
Bullhead minnow	-	-	N	Y	-	-	-	-
River shiner	-	-	N	Y	-	-	-	-
Quillback	N	N	-	N	N	N	-	-
Shorthead redhorse	N	N	-	N	N	N	N	N
Silver redhorse	N	N	-	-	N	N	-	-
White bass	N	N	N	N	N	N	-	-
Rock bass	N	N	-	-	-	-	N	N
Bluegill	N	N	-	Y	-	-	Y	Y
Black crappie	N	N	-	-	N	N	Y	Y
Walleye	N	N	-	-	N	N	-	-
Freshwater drum	N	N	N	N	N	N	N	Y

---

[1] N = No, location was not a significant variable.
[2] Y = Yes, location was a significant variable.
[3] - = No comparison was made.

5.3.3.4 Diel Comparisons

Differences in the day and night catch were assessed for total catch and the catch of selected species captured by adult electrofishing (compared according to number and weight), juvenile electrofishing (number only), and seining (number only). Numerous diel differences were seen in the adult electrofishing catch, but few were seen in the juvenile electrofishing or seining catches.

Adult Electrofishing

Total adult electrofishing catch varied significantly according to time of day (i.e., day vs night) on both a numerical and weight basis (Table 5-29 and Section 5.7). Seven species also showed diel differences in catch rate regardless of whether the comparisons were based on number or weight. Diel differences were observed in the number of white bass collected (Table 5-29) but their weight was not significantly affected by time of collection (Section 5.7) The species in which diel differences in catch rate were most pronounced were shorthead redhorse ($P = 0.004$) and sauger ($P = 0.006$). Other investigators have also reported diel differences in electrofishing catch rates. In a previous electrofishing study of Pool 5A, Anderson et al. (1983) reported catching three times as many fish (weighing twice as much) during the night as during the day. In the present study, it was found that the catch rate (both in terms of numbers and weight) was twice as high during the night as during the day. Anderson et al. (1983) reported that white bass, freshwater drum, walleye, sauger, shorthead redhorse, smallmouth bass, rock bass and carp had statistically higher catch rates during the night than during the day. This same pattern was observed during the present study for the first five of these species (Table 5-29).

Fernholz et al. (1980) electroshocked wing dams, riprapped banks and sandy areas in Pool 8 of the UMR and reported that diversity of catch was higher at night at all three habitats than during the day. They also reported catching more fish at night from the riprapped and sandy areas than during the day, while the reverse held true for the wing dams.

Juvenile Electrofishing

Of the comparisons made using the juvenile electrofishing data, only the river shiner exhibited a significant diel difference in catch rates (Table 5-30). White bass and freshwater drum, two species that had significantly higher catch rates at night during the adult electrofishing, also had higher catch rates at night during juvenile electrofishing; however, the differences during juvenile electrofishing were not statistically significant.

Seining

The mean total catch per seine haul was slightly higher during the day than at night; however, the difference was not statistically significant (Table 5-31). Furthermore, of the 13 species compared individually, only shorthead redhorse and white bass exhibited significant diel catch rate differences (both species were significantly more abundant at night).

TABLE 5-29 SUMMARY OF STATISTICAL COMPARISONS OF DIEL ADULT ELECTROFISHING DATA (BY NUMBER)

Species or Group	Mean No./10 Min Day (D)	Mean No./10 Min Night (N)	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	12.9	25.5	15.9	0.0001	yes	$\underline{D}\quad\underline{N}$
Gizzard shad	2.1	2.5	0.0	0.9972	no	$\underline{D\quad N}$
Mooneye	0.2	0.6	6.3	0.0123	yes	$\underline{D}\quad\underline{N}$
Common carp	0.5	0.8	1.1	0.2900	no	$\underline{D\quad N}$
Quillback	0.1	0.4	5.6	0.0184	yes	$\underline{D}\quad\underline{N}$
Silver redhorse	0.2	0.4	1.2	0.2715	no	$\underline{D\quad N}$
Golden redhorse	0.4	0.1	1.3	0.2611	no	$\underline{D}\quad\underline{N}$
Shorthead redhorse	3.5	9.1	12.3	0.0004	yes	$\underline{D}\quad\underline{N}$
White bass	0.4	1.1	4.1	0.0441	yes	$\underline{D}\quad\underline{N}$
Rock bass	0.2	0.9	3.2	0.0753	no	$\underline{D}\quad\underline{N}$
Bluegill	1.4	1.3	0.1	0.7564	no	$\underline{D\quad N}$
Smallmouth bass	0.8	0.6	0.5	0.4928	no	$\underline{D\quad N}$
Black crappie	0.3	1.2	5.3	0.0213	yes	$\underline{D}\quad\underline{N}$
Sauger	0.5	2.3	11.8	0.0006	yes	$\underline{D}\quad\underline{N}$
Walleye	0.3	0.9	5.8	0.0160	yes	$\underline{D}\quad\underline{N}$
Freshwater drum	0.6	1.8	9.2	0.0024	yes	$\underline{D}\quad\underline{N}$

TABLE 5-30 SUMMARY OF STATISTICAL COMPARISONS OF DIEL JUVENILE ELECTROFISHING DATA (BY NUMBER)

Species or Group	Mean No./5 Min Day (D)	Mean No./5 Min Night (N)	CHI^2	Prob.	Significant Difference	Mean Underlined Are Not Significantly Different
Total catch	22.5	32.5	0.9	0.3462	no	$\underline{D \qquad N}$
Total catch except Gizzard shad	14.6	21.1	1.1	0.2930	no	$\underline{D \qquad N}$
Total catch except Emerald shiner	15.8	17.7	0.1	0.7981	no	$\underline{D \qquad N}$
Total catch except Gizzard shad and Emerald shiner	7.8	6.3	0.1	0.8296	no	$\underline{D \qquad N}$
Gizzard shad	8.0	11.4	0.2	0.7027	no	$\underline{D \qquad N}$
Spotfin shiner	2.1	0.3	1.2	0.2766	no	$\underline{D \qquad N}$
Emerald shiner	6.8	14.8	2.2	0.1362	no	$\underline{D \qquad N}$
Bullhead minnow	0.7	0.5	0.1	0.7515	no	$\underline{D \qquad N}$
River shiner	1.8	0.4	5.5	0.0191	yes	$\underline{D} \qquad \underline{N}$
White bass	0.8	2.3	2.8	0.0928	no	$\underline{D \qquad N}$
Freshwater drum	0.6	0.9	2.3	0.1289	no	$\underline{D \qquad N}$

TABLE 5-31 SUMMARY OF STATISTICAL COMPARISONS OF DIEL SEINING DATA (BY NUMBER)

Species or Group	Mean No./Seine Haul Day (D)	Night (N)	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	30.2	24.4	0.1	0.7893	no	D N
Gizzard shad	2.0	5.7	0.8	0.3794	no	D N
Spottail shiner	1.4	0.3	0.0	0.9021	no	D N
Spotfin shiner	2.4	2.0	1.5	0.2205	no	D N
Emerald shiner	8.4	4.6	0.4	0.5558	no	D N
Bullhead minnow	2.6	1.2	0.5	0.4926	no	D N
Sand shiner	0.7	0.2	0.0	0.9879	no	D N
River shiner	5.3	2.2	1.1	0.2934	no	D N
Quillback	2.8	0.4	0.1	0.7835	no	D N
Shorthead redhorse	0.2	0.7	7.9	0.0050	yes	D N
White bass	0.5	2.5	8.0	0.0046	yes	D N
Bluegill	1.1	0.8	0.0	0.9443	no	D N
W. Sand darter	0.7	0.1	2.2	0.1429	no	D N
Freshwater drum	0.3	1.6	3.8	0.0529	no	D N

Apparently, no other studies on the UMR have examined diel differences in catch rates via seining. However, two studies (Bogardus and Finni 1981, Finni and Clark 1981) conducted on the Wabash River south of Terre Haute, Indiana, are useful for comparative purpose. Bogardus and Finni (1981) seined two riffle areas repeatedly during the summer and fall of 1979. They found that the number of taxa collected during the day and night were similar at each riffle. No statistical comparisons were made, however, based on the data they presented, it appeared that the day and night catches were comparable at one of the riffles, while at the other riffle, the catch rates were consistently higher at night. Finni and Clark (1981) reported that catch rates during the day and night were similar at two of three riffles in the Wabash River sampled throughout the summer and fall. At the third riffle, the catch rate at night (44.7 fish per seine haul) was three times higher than during the day (15.8 fish per seine haul). Collectively, the results of these studies and the present study suggest that the number of species captured by night and day seining is comparable. Furthermore, although some species (e.g., white bass) may be collected more frequently at night or certain locations may yield more specimens at night, no overall trend related to time of collection is apparent.

Summary of Diel Comparisons

Because the catch rates for only three gears were compared, it is difficult to determine accurately whether diel differences are consistently an important factor affecting catch rates for fishes in the UMR. Pronounced diel differences were seen for adult electrofishing but few differences were seen in juvenile electrofishing or seining catch rates. Table 5-32 summarizes diel effects on catch rates for all species collected in sufficient numbers to allow statistical comparisons for at least two gear types. Of the nine species examined, only the catch rate of shorthead redhorse was consistently affected by time of collection (i.e., day vs night). Conversely, no diel differences were seen in the catch rates for spotfin shiner, emerald shiner, bullhead minnow, and gizzard shad (Table 5-32). Three of the remaining four species exhibited consistent patterns, although the observed differences in catch rates were not always statistically significant. The river shiner was caught more frequently during the day both by juvenile electrofishing and seining; however, only the juvenile electrofishing data were significantly affected. Catch rates for white bass and freshwater drum were consistently higher at night for all three gear types compared suggesting that the difference in diel catch rates for these two species is real, even though not always statistically significant. Thus, the diel abundance of these nine species can be summarized as follows:

Collected More Abundantly During the Day	Collected More Abundantly at Night	Time of Collection Not a Factor
River shiner	Shorthead redhorse	Gizzard shad
	White bass	Spotfin shiner
	Freshwater drum	Emerald shiner
		Bullhead minnow
		Quillback

TABLE 5-32. SUMMARY OF WHETHER TIME OF DAY WAS A SIGNIFICANT VARIABLE AFFECTING THE TOTAL CATCH OR THE CATCH OF INDIVIDUAL SPECIES (BY NUMBER AND WEIGHT) FOR THREE GEAR TYPES.

	Adult Electrofishing		Juvenile Electrofishing	Seine
Species or Group	No.	Wt.	No.	No.
Total Catch	Y[1]	Y	N[2]	N
Gizzard shad	N	N	N	N
Spotfin shiner	-[3]	-	N	N
Emerald shiner	-	-	N	N
Bullhead minnow	-	-	N	N
River shiner	-	-	Y	N
Quillback	Y	Y	-	N
Shorthead redhorse	Y	Y	-	Y
White bass	Y	N	N	Y
Freshwater drum	Y	Y	N	N

---

[1] Y = Yes, time of day was a significant variable.
[2] N = No, time of day was not a significant variable.
[3] - = No comparison was made.

Finally, based on the results of the adult electrofishing data alone, mooneye, black crappie, sauger, and walleye are more susceptible to capture at night than during the day.

5.3.3.5 Substrate Effects

One of the purposes of this study was to determine the impacts, positive or negative, of channel-training structures in Pool 5A. The location comparisons (Section 5.3.3.3) assessed the fish populations at individual structures (ie., locations). As a result of those analyses, it was found that Location 6, the only silty area among the 10 locations, was more productive than any of the other nine locations. However, most of the remaining nine locations were relatively comparable. In an attempt to determine whether other differences existed, these nine locations were divided into two groups, rock substrate and sand substrate. The rock substrate group included a riprapped bank (Location 3), a closing dam (Location 2), and four wing dams (Locations 1, 4, 7, and 8), while the sand group included the sand flats at Locations 5, 9, and 10. Within each group, the data from the individual locations making up that group were treated as replicates and the means for each group were ranked and compared statistically according to the procedures described earlier.

Adult Electrofishing

When the ranks of the mean catches per 10 minutes for total catch and for 15 species were compared between the rock and sand substrates, the only comparison for which a significant difference existed was smallmouth bass (Table 5-33 and Section 5.7). Smallmouth bass were significantly more abundant in the catch from the rock substrate than from the sand substrate. On a numerical basis, the mean catch per 10 minutes for rock (17.5) was very similar ($P = 0.7289$) to that for sand (19.4) (Table 5-33). However, on the basis of weight, the rock substrate produced nearly twice the biomass that the sand substrates did and the resultant probability (0.0696) was nearly significant at the 0.05 level (Section 5.7). This suggests that although the number of individuals captured from rock and sand substrates was similar, those captured from the rock substrates were larger, on the average. On a species-specific basis, this was most noticeable for shorthead redhorse. The mean numerical catch for shorthead redhorse was very similar for the rock and sand substrates (Table 5-33). However, on a by-weight basis, the difference was more pronounced and was nearly significant statistically ($P = 0.0541$, Section 5.7). Of the remaining species, only the gizzard shad was close ($P < 0.1$) to showing a significant catch rate difference according to substrate. The low probability values (0.0676 - 0.0696) for both the numerical and biomass comparisons suggest that gizzard shad prefer sandy substrates.

Anderson et al. (1983) sampled all the locations included in the present study plus an additional eight locations. They also made comparisons based on substrate, however, because of their larger sample sizes they had to work with, they were able to subdivide the rock substrates into riprapped banks, wing dams and closing dams, and the sandy substrates into areas associated with structures (e.g., wing dams) and those not associated with structures. Although this makes comparisons with the

TABLE 5-33. SUMMARY OF STATISTICAL ROCK/SAND COMPARISONS OF ADULT ELECTROFISHING DATA (BY NUMBER, DAY AND NIGHT CATCH COMBINED)

Species or Group	Mean (No./10 Min) Rock	Sand	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	17.5	19.4	0.1	0.7289	no	$\underline{R\qquad S}$
Gizzard shad	1.3	2.4	3.3	0.0676	no	$\underline{R\qquad S}$
Mooneye	0.3	0.6	1.3	0.2568	no	$\underline{R\qquad S}$
Common carp	0.8	0.3	1.5	0.2146	no	$\underline{R\qquad S}$
Quillback	0.1	0.4	1.5	0.2226	no	$\underline{R\qquad S}$
Silver redhorse	0.4	0.3	0.2	0.6969	no	$\underline{R\qquad S}$
Golden redhorse	0.3	0.1	0.2	0.6501	no	$\underline{R\qquad S}$
Shorthead redhorse	6.7	7.0	1.8	0.1749	no	$\underline{R\qquad S}$
White bass	0.5	1.2	2.1	0.1445	no	$\underline{R}\qquad\underline{S}$
Rock bass	0.8	0.4	0.4	0.5405	no	$\underline{R\qquad S}$
Blue gill	0.9	0.6	0.0	0.8506	no	$\underline{R\qquad S}$
Smallmouth bass	1.1	0.1	7.1	0.0076	yes	$\underline{R}\qquad\underline{S}$
Black crappie	0.6	0.6	0.2	0.6906	no	$\underline{R\qquad S}$
Sauger	0.9	2.5	2.5	0.1123	no	$\underline{R}\qquad\underline{S}$
Walleye	0.4	0.9	1.7	0.1947	no	$\underline{R}\qquad\underline{S}$
Freshwater drum	1.1	1.2	0.0	0.9182	no	$\underline{R\qquad S}$

present study somewhat difficult, some similarities were apparent. For example, for electrofishing, (1) they did not see any difference between rock and sand substrates when the comparisons were made on a numerical basis, (2) smaller fish were collected from (some) sandy areas compared to rocky areas, and (3) smallmouth bass strongly preferred rocky areas over sandy areas.

Holzer (1978) sampled wing dams, riprapped areas, and sandy areas on Pool 8 of the UMR. No statistical comparisons of the data were presented; however, the total catch per hour was quite similar at the sandy and riprapped areas; 385 and 457 fish, respectively. The catch at the wing dam was somewhat lower (276 fish/hour). As in this study, Holzer (1978) found that smallmouth bass strongly preferred rocky areas (riprapped areas in particular) and that gizzard shad preferred sandy areas. Preferences noted by Holzer (1978) for other species were as follows:

Riprap	Wing Dam	Sand
Bluegill	Flathead catfish	White bass
Rock bass	Carp	Sauger
Black crappie	Golden redhorse	Mooneye
Walleye		Carpsucker
Largemouth bass		Shorthead redhorse
Freshwater drum		

Holzer did not present any statistical comparisons to help interpret his data. However, based on the CPE values, the preferences listed above *most likely to be statistically valid were those for smallmouth bass,* bluegill, rock bass, black crappie, gizzard shad, mooneye, and carpsuckers.

In later studies in Pool 8, Fernholz et al. (1980) found that wing dams riprapped areas and sandy areas produced comparable numbers of fish; 560, 646, and 979, respectively. However, species-specific habitat preferences were apparent. Gizzard shad, mooneye, white bass, sauger, and quillback preferred the sandy areas; longnose gar and shorthead redhorse preferred the wing dam; and smallmouth bass, rock bass, bluegill, and black crappie preferred the riprapped areas. These findings are in agreement with the earlier, and related, studies by Holzer (1978) except that shorthead redhorse in Holzer's studies preferred sandy areas. The results of the present study (Table 5-33 and Section 5.7) agree closely with those presented by Holzer (1978) and Fernholz et al. (1980). Besides the agreement with regard to habitat preference, Fernholz et al. (1980) found, as was the case in the present study, that rocky areas supported larger fish than did sandy areas.

Pennington et al. (1983) shocked natural and revetted banks along the Lower Mississippi River and found that the composition of fishes in each habitat was similar. However, mean CPE values were higher along the populations of desireable sport and commercial fishes. Pierce (1980) presented no quantitative data but based on his studies of Pool 13, suggested that areas having more riprap, stumps, and logs usually produced more species and higher catch rates.

TABLE 5-34. SUMMARY OF STATISTICAL COMPARISONS OF ROCK/SAND JUVENILE ELECTROFISHING DATA (BY NUMBER, DAY AND NIGHT CATCH COMBINED)

Species or Group	Mean (No./5 Min)		CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
	Rock (R)	Sand (S)				
Total catch	28.7	15.2	0.0	0.8924	no	R S
Total catch except Gizzard shad	19.4	12.6	0.1	0.8061	no	R S
Total catch except Emerald shiner	15.9	8.1	0.3	0.6129	no	R S
Total catch except Gizzard shad and Emerald shiner	6.6	5.6	0.3	0.5989	no	R S
Gizzard shad	9.3	2.5	0.2	0.6703	no	R S
Spotfin shiner	1.9	0.2	0.9	0.3463	no	R S
Emerald shiner	12.8	7.1	0.3	0.6200	no	R S
Bullhead minnow	0.6	0.3	0.1	0.7714	no	R S
River shiner	0.9	1.3	0.1	0.7221	no	R S
White bass	1.0	2.3	0.3	0.5989	no	R S
Freshwater drum	0.5	0.7	0.0	0.8373	no	R S

TABLE 5-35. SUMMARY OF STATISTICAL COMPARISONS OF ROCK/SAND SEINING DATA (BY NUMBER, DAY AND NIGHT CATCH COMBINED)

Species or Group	Mean (No./Seine Haul) Rock (R)	Mean (No./Seine Haul) Sand (S)	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	12.1	24.1	11.0	0.0009	yes	R S
Gizzard shad	1.3	1.7	0.0	0.9378	no	R S
Spottail shiner	1.3	1.7	0.0	0.9378	no	R S
Spotfin shiner	1.4	2.3	4.2	0.0417	yes	R S
Emerald shiner	4.8	7.2	7.0	0.0083	yes	R S
Bullhead minnow	0.5	1.3	1.2	0.2673	no	R S
Sand shiner	0.1	0.1	0.0	0.9941	no	R S
River shiner	0.8	3.0	5.6	0.0180	yes	R S
Quillback	0.2	0.2	0.5	0.4964	no	R S
Shorthead redhorse	0.4	0.5	1.9	0.1720	no	R S
White bass	0.5	1.7	0.6	0.4584	no	R S
Bluegill	0.3	1.1	1.2	0.2770	no	R S
Western sand darter	0.2	0.8	2.6	0.1088	no	R S
Freshwater drum	0.3	0.6	0.9	0.3471	no	R S

TABLE 5-36. SUMMARY OF STATISTICAL COMPARISONS OF ROCK/SAND TRAMMEL NETTING DATA (BY NUMBER)

Species or Group	Mean (g/Net Day) Rock (R)	Mean (g/Net Day) Sand (S)	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	5.4	8.9	0.3	0.6016	no	$\underline{R \qquad S}$
Total catch except Shovelnose sturgeon	4.4	6.7	0.0	0.9352	no	$\underline{R \qquad S}$
Total catch except Shorthead redhorse	3.9	5.8	0.0	0.9625	no	$\underline{R \qquad S}$
Total catch except Shovelnose sturgeon and Shorthead redhorse	3.0	3.5	0.2	0.6938	no	$\underline{R \qquad S}$
Shovelnose sturgeon	0.9	2.3	0.0	0.9795	no	$\underline{R \qquad S}$
Mooneye	0.3	0.2	0.1	0.8206	no	$\underline{R \qquad S}$
Quillback	0.2	0.4	0.3	0.6016	no	$\underline{R \qquad S}$
Silver redhorse	0.4	0.6	0.0	0.9420	no	$\underline{R \qquad S}$
Shorthead redhorse	1.5	3.1	2.1	0.1480	no	$\underline{R} \qquad \underline{S}$
White bass	0.1	0.4	0.2	0.6563	no	$\underline{R \qquad S}$
Black crappie	0.4	0.2	0.2	0.5956	no	$\underline{R \qquad S}$
Walleye	0.1	0.1	0.0	0.9114	no	$\underline{R \qquad S}$
Freshwater drum	0.4	0.3	0.2	0.6532	no	$\underline{R \qquad S}$

TABLE 5-37. SUMMARY OF STATISTICAL COMPARISONS OF ROCK/SAND FRAME NETTING DATA (BY NUMBER)

Species or Group	Mean (No./Net Day) Rock(R)	Mean (No./Net Day) Sand(S)	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	7.9	5.5	0.0	0.8540	no	R S
Total catch except Black crappie	4.0	4.4	0.3	0.5692	no	R S
Silver chub	0.3	0.5	0.2	0.6718	no	R S
Shorthead redhorse	1.0	1.4	1.6	0.2037	no	R S
Rock bass	0.4	0.3	0.2	0.6875	no	R S
Bluegill	0.2	0.8	3.3	0.0716	no	R S
Black crappie	3.9	1.1	0.1	0.7547	no	R S
Freshwater drum	1.3	0.6	0.6	0.4436	no	R S

Juvenile Electofishing

Substrate was not a factor affecting numerical catch rates during juvenile electrofishing (Table 5-34).

Seining

Twice as many fish were captured seining over sandy areas as over rocky areas (Table 5-35). On a species-specific basis, spotfin shiner, emerald shiner, and river shiner were each caught more abundantly over sand than over rock. Species that appeared (i.e., no statistical difference could be demonstrated) to prefer sandy areas were white bass, bluegill, and western sand darter. No species appeared to prefer rocky areas.

Anderson et al. (1983) reported catching many more fish seining at sandy areas unassociated with structure than at rocky areas. They also reported that sandy areas unassociated with structure yielded more river shiners than did most rocky areas, whereas, sandy areas associated with structure yielded more white bass and quillback than did rocky areas.

The greater abundance of fishes collected in sandy areas compared to rocky areas noted in this study and by Anderson et al. (1983) may, to some extent, be a sampling artifact. Flat, sandy beaches such as those at Locations 5, 9, and 10 offer excellent places to seine; whereas, the rocky areas sampled during both studies are far from ideal. Fish undoubtedly escape by getting under the lead line in the rocky areas but this is impossible to quantify.

Trammel Netting

Trammel netting catch rates, either by number or weight, were not statistically affected by substrate (Table 5-36 and Section 5.7). According to Duncan's test, the catch of shorthead redhorse was higher over sandy areas than over rocky areas; however, these catches rates were not identified as being statistically different according to the KW test.

Frame Netting

Frame netting catch rates, either by number or weighty were not statistically affected by substrate (Table 5-37 and Section 5.7). However, Duncan's test identified the numerical catch rates of bluegill as being different for the two substrates and the probability generated by the KW test for both the numerical and biomass comparisons was relatively low (P = 0.07) suggesting that this difference may be real.

Anderson et al. (1983) saw few, if any, differences in frame net catch between the sandy and rocky areas they sampled. Only gizzard shad seemed to show a distinct preference, preferring the sandy areas over the rocky areas.

Summary of Sand vs Rock Comparisons

With only a few exceptions, substrate (i.e., sand vs rock) did not appear to affect catch rates significantly. Based on results of this study, only the following species exhibited distinct (though not necessarily statistically significant) habitat preferences:

Preferred Rock	Preferred Sand
Smallmouth bass	Mooneye
Black crappie	River shiner
	Quillback
	White bass
	Bluegill

Other species either exhibited no trend or the data were too tenuous to allow any definitive statement. It should also be noted that the above habitat preferences only compare sand and rock. As discussed earlier in this section and in Section 5.3.3.3, Location 6, which has a silt substrate, produced more fish for all gears except adult electrofishing, suggesting that silt (or quiet backwater areas) is the preferred habitat of many UMR fishes. Further discussion of the habitat preferences of UMR fishes is presented in the next section.

5.4 ECOLOGICAL INTERPRETATION OF RESULTS

The first objective of the fisheries study was to describe and evaluate differences among selected MCB habitat types in structure, composition, and abundance of fish assemblages (Section 5.1). The preceding sections have described the fish community at each location and/or habitat in detail as well as comparing the results of this study with those of other investigators. However, it is also appropriate to try to determine the reasons for the observed results and consider the ecological implications of the results, particularly in reference to channel-training structures.

Location 6 (silt bar) was clearly the most productive location (ie., habitat). The reason(s) for this productivity is less clear. Location 6 was distinct from all the other locations/habitats in that (1) it had little or no current and (2) it had a silt substrate. The fact that none of the other nine locations included in the study were at all comparable to Location 6, either in terms of current velocity or substrate type prevents one from completely ruling out the possibility that the results at Location 6 were in some way anomalous. However, the fact that Location 6 was consistently the most or one of the most productive locations regardless of gear type or month strongly suggests that such a possibility is remote. Acceptance of the fact that Location 6 indeed was more productive than the other nine locations leads to the question of whether this productivity was a result of its low current velocity, silty substrate, or some combination of both. Several pieces of evidence suggest that the lack of current was probably the more important factor. First, Location 6, though possessing the same substrate type (ie., silt) as one would find in most backwater areas of the UMR, did not possess a typical backwater fish community. For example, species such as largemouth bass, bullheads, bowfin, longnose gar and golden shiner that are typically quite common in the backwaters of the UMR and other large rivers (Fremling et al. 1980, ERT 1983, Becker 1983, Ecological Analysts, unpublished data), were uncommon or absent entirely at Location 6. Second, the catch at Location 6 contained a disproportionate number of species that prefer quiet-water areas. For example, species such as gizzard shad, bluegill, black crappie, bullhead minnow, and quillback generally were captured more frequently at Location 6 than at any other location (Section 5.3.3.3). Similiarly, when a group of six quiet-water species (gizzard shad, emerald shiner, bullhead minnow, quillback, carp and bluegill) were compared among all ten locations, it was found that they composed 47 percent of the catch at Location 6 compared to 21-39 percent at the other nine locations (Table 5-38). Finally, because most of the difference between the catch at Location 6 and that at the other locations was in the number of fish collected seining, seining data were examined more closely to determine which species composed the bulk of the catch. It was found that 11 species comprised 89 percent of the total seine catch and 92 percent of the catch at Location 6 (Table 5-39). These same 11 species composed 87 percent of the catch at the three sand locations (Locations 5, 9, and 10) combined. This indicates that this group composed a very similar percentage regardless of location suggesting that other factor(s) (eg. lack of current) contributed to the high absolute abundance of these species at Location 6. This hypothesis is supported by the fact that six of these species are typically collected more frequently over sand substrates than over silt/mud substrates (Table 5-39). Of the remaining five species, four show no preference, with only freshwater drum prefering silt or mud. Thus, based on their substrate preferences, one would expect these eleven species to compose a distinctly higher percentage of the catch at the three sand locations than at Location 6, the silt bay. In fact, however, the percentages are comparable, with the percentage from Location 6 actually being slightly higher, 92 percent versus 87 percent (Table 5-39). Collectively, the evidence suggests that Location 6 was so productive primarily because of the lack of current. However, because of its greater productivity (relative to sand substrates) of macroinvertebrates, it is also reasonable to conclude that at least some species of fish were attracted to Location 6 because of the food available there.

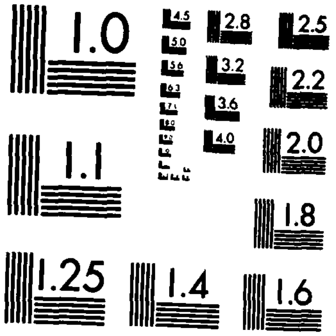
It was hoped that a clear-cut pattern would emerge regarding the relative merits of the various habitat types (ie., wing dams, riprapped banks, closing dams, sand flats, and silt bays). However, on a relative basis, only the silt bay habitat (Location 6) was distinctly more productive. The other locations (Section 5.3.3.3) and habitat types (Section 5.3.3.5) generally could not be distinguished statistically. For example, only smallmouth bass showed a statistically significant preference for rocky areas. This lack of distinctiveness among the habitat types makes it impossible to state that channel-training structures are beneficial to the fish community of Pool 5A. On the other hand, this study found no evidence that these structures are detrimental in any way.

TABLE 5-38. PERCENTAGE OF TOTAL CATCH COMPOSED OF SELECTED QUIET WATER PREFERRING SPECIES[a] IN POOL 5A OF THE UPPER MISSISSIPPI RIVER

	Location									
	Wing Dams				Closing Dam	Riprap Bank	Silt Bay	Sand Flats		
	1	4	7	8	2	3	6	5	9	10
Mean Velocity[b] (m/s)	.21	.33	.29	.25	.26	.23	<.01	.20	.18	.21
Adult Shock	17	10	7	6	16	30	58	9	30	17
Juvenile Shock	64	93	60	48	45	95	77	77	71	45
Seine	46	33	58	68	33	35	56	62	50	39
Trammel Net	1	0	6	10	3	13	18	6	10	7
Frame Net	1	8	0	16	10	3	26	5	32	19
All Gears Combined	26	29	26	30	21	35	47	32	39	25
	28				21	35	47	32		

(a) Selected species were gizzard shad, emerald shiner, bullhead minnow, carp, quillback, and bluegill.
(b) Defined as the annual mean of velocities measured at 0.6 depth.

AD-A164 745 AQUATIC STUDIES OF THE MAIN CHANNEL BORDER HABITAT OF 4/4
POOL 5A ON THE UPPER MISSISSIPPI RIVER(U) ECOLOGICAL
ANALYSTS INC NORTHBROOK IL G SEEGERT ET AL JAN 84
UNCLASSIFIED F/G 6/6 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE 5-39 PERCENTAGE OF SPECIMENS FOUND OVER VARIOUS SUBSTRATES OR HABITATS AS PRESENTED IN THE LITERATURE (BECKER 1983) AND AS FOUND DURING THIS STUDY OF POOL 5A

Species	(BECKER 1983) Percent of Specimens Collected Over Sand	Mud/Silt	Percent of Seine Catch at: Location 6 (silt)	Locations 5, 9, 10 (sand)	All Locations
Gizzard shad	substrate not important		18	7	14
Spottail shiner	39	26	2	6	3
Spotfin shiner	31	30	5	10	8
Emerald shiner	43	25	11	30	24
Bullhead minnow	44	29	10	5	7
Sand shiner	24	23	3	1	2
River shiner	46	16	19	12	14
Quillback	44	24	11	1	6
White bass	sand>mud>silt		5	7	5
Bluegill	29	28	4	5	4
Freshwater drum	prefers mud		5	3	3
All 11 Species Combined			92	87	89

Despite the lack of statistical differences, the weight of the evidence suggests that such structures are beneficial. Evidence supporting this contention are that (1) the fish captured on the rock substrates (ie., channel-training structures) were, on the average, larger than those collected from sandy areas (Section 5.3.3.5), (2) these structures should be important feeding areas because of the large number of benthic macroinvertebrates found on them (Section 4), particularly invertebrates that are important as food items to UMR fishes, (3) the occurrence of large numbers of Catastominae larvae near certain wing dams suggests that this group of fishes (and probably many other species) utilize channel-training structures as spawning areas, and (4) they provide a substrate (ie., rocks) and habitat type that is in short supply naturally in Pool 5A. This diversity, though good in itself, is vital to species such as shovelnose sturgeon, blue sucker, silver redhorse, rock bass, smallmouth bass, river darter, sauger, and walleye which depend on rocky areas during a portion or all of their life cycle.

5.5 SUMMARY AND RECOMMENDATIONS

5.5.1 Summary

Fisheries studies were conducted in May, June, August, September, and November of 1982 at 10 locations in Pool 5A of the UMR. Adult and juvenile fish were collected at each location by electrofishing (conducted separately for adults and juveniles), seining, trammel netting, and frame netting. Collectively, these methods yielded a total of 9,479 fish, representing 58 species. Electrofishing (adult and juvenile) caught the most species (50), followed by seining (45), trammel netting (36), and frame netting (20). Seining produced the most fish (4,727), followed by electrofishing (3,225), frame netting (776), and trammel netting (751).

Overall, the catch was dominated (numerically) by emerald shiners (1,644 individuals, 17% of the catch), gizzard shad (1,351, 14%) and shorthead redhorse (975, 10%). Twenty other species each composed between 1 and 10% of the catch. River darter, slenderhead darter, burbot, and stonecat were each represented by single specimens. The records for the latter three species are the first for Pool 5A. In addition, three crystal darters, a species on Wisconsin's endangered species list, were captured, as were two blue suckers and 13 goldeye; both species are on Wisconsin's threatened list.

Of the four variables examined, month of collection exerted the greatest effect on catch rates. Catch rates were low in May and especially in November, moderate in June and September, and high in August. The catch rates for all the gears were affected by month of collection. However, based on the Chi-square values for total catch and the number of species significantly affected, seining and trammel netting were the gears most strongly influenced by seasonality; electrofishing and frame netting were the least affected.

Location was a significant variable affecting total catch for all gears, except electrofishing. However, the degree to which location affected catch (either total or for individual species) was generally less than that seen for month. Location 6, the silt bay, was clearly the most productive location. However, the relative importance of the other nine locations varied according to gear type and it was difficult to distinguish whether any consistent pattern existed. Location 3, the riprapped bank, consistently produced high catches electrofishing, but not for the other three gear types. Primarily because of the high electrofishing catch, Location 3 was the only other location that stood out from the rest.

Diel differences were apparent in the adult electrofishing catch but not in the juvenile electrofishing catch or in the seining catch. Adult electrofishing produced twice as many individuals (1,242) during the night as it did during the day (620). For 15 species on which there was enough information to make meaningful comparisons, it was found that 12 species were collected more commonly during night adult electrofishing than during day adult electrofishing. Only one species (golden redhorse) was more common during the day, while bluegill and smallmouth bass were each captured in comparable numbers during the night and day. Overall, the only species whose catch was consistently affected by time of day were shorthead redhorse, white bass, and freshwater drum (all were collected more frequently at night).

Substrate (rock vs sand) had little effect on catch rates regardless of gear type. It did appear, however, that the fish caught at the rocky areas were , on the average, larger than those caught at the sandy areas. On a species-specific basis only smallmouth bass exhibited a clear-cut preference (they preferred rocky substrates). Black crappie also appeared to prefer rocky areas, while mooneye, river shiner, quillback, white bass, and bluegill appeared to prefer sandy areas. However, the preferences exhibited by these species were not as obvious as those shown by smallmouth bass.

Diversity values for seining and adult electrofishing were very similar, but were lower for juvenile electrofishing. Adult electrofishing and seining catches were more diverse at night than those during the day.

As expected, the mean size of fish caught adult electrofishing was larger than those caught seining or juvenile electrofishing. Time of day (i.e., day vs night) did not appear to affect the mean size of fish captured.

Dipnetting was conducted weekly from 8 May through 28 August. A total of 20,509 larvae were collected. Three groups (Cyprinidae, Catostominae, and Ictiobinae) accounted for 98 percent of the catch. Catostominae dominated the catch from 8 May through 24 June, while Cyprinidae dominated the catch for the remainder of the study. Major peaks were observed on 3 June and 14-20 August. The larval catch was significantly higher at Location 6 (silt bay) compared to all the other locations, while the other locations were all comparable. This difference was the result of the large number of cyprinid larvae captured at Location 6. Twice as many Catastominae larvae were captured at rocky areas as at sandy areas suggesting that they use channel-training structures in Pool 5A as spawning areas.

5.5.2 Recommendations

Based on the results of this study, the following recommendations are made regarding future fisheries studies to be initiated in the MCB habitats of Pool 5A or nearby pools:

(1) Electrofishing and seining produced large and diverse catches and should both be included in any studies attempting to sample the entire fish fauna.

(2) Trammel netting provided useful information on large fish species, particularly suckers and shovelnose sturgeon, and thus was a good complement to seining and electrofishing. It should be included in studies if the investigators are interested in the large fishes of Pool 5A.

(3) Frame netting added little new data to the study. Only 20 species were captured, all of which were also captured by trammel netting. Furthermore, the frame net catch was highly redundant. Given the effort involved in setting and retrieving these rather cumbersome nets and the lack of data gathered, the use of frame nets is probably unnecessary in the MCB habitats of Pool 5A or other northern pools of the UMR. The opposite may be true further south where catfishes are increasingly abundant and important.

(4) Juvenile electrofishing produced many more minnows than did adult electrofishing so it may prove to be a useful technique, especially as a complement to regular (i.e., adult) electrofishing. It is recommended, however, that all fish shocked be collected, not just the smaller individuals. This would allow a better comparison between adult and juvenile electrofishing and one could better determine whether both techniques are necessary.

(5) Comparatively few fish were caught in May when the water was high and even fewer were caught in November when the water was high and cold (<4C). Electrofishing and frame netting were least affected by high water, while seining and trammel netting were most affected. All gears were affected by the high, cold water in November. Based on these observations, sampling of MCB habitats should generally be restricted to times when water temperatures exceed 5C and flows are <40,000 cfs. Because of the excellent catch rates in September and especially in August, sampling efforts should be concentrated in the July through September period, when flows are low and stable. June and perhaps early October are also reasonable choices. Spring sampling should be avoided unless flows are low (for that time of year) or the migratory movements of early spring spawners are of particular interest. Flows are particularly crucial if one is trying to assess the impact or importance of particular structures or locations because the beach or riprap "area" sampled at 70,000 cfs will be totally different than the "same" area sampled at 15,000 cfs. Replicate sampling under similar flow regimes should be a prerequisite in any study designed to assess the importance of channel-training structures.

(6) Because Location 6, the silt bay, was the most productive area sampled, it and other protected areas (regardless of substrate) along the MCB should be preserved. Care should be taken not to allow such areas to be cut-off from the main channel, either by natural accretion or by channel maintenance activities.

(7) Because channel-training structures appear to be used spawning sites for selected UMR fishes, channel maintenance activities that will affect these structures should be minimized during the spring spawning period.

5.6 LITERATURE CITED

Anderson, D., D. Wilcox, D. McConville, and J. Smith. 1983. Physical and biological investigations of the main channel border (MCB) habitat of Pool 5A, on the Upper Mississippi River in 1980. St. Paul District Corps of Engineers, St. Paul, Minnesota. 176 pp.

Backiel, T., R.L. Welcomme. 1980. Editors. Guidelines for sampling fish in inland waters. FAO Technical Paper 33. Food and Agriculture Organization of the United Nations, Rome, Italy.

Becker, G. 1983. Fishes of Wisconsin. U. of Wisconsin Press, Madison, 1052 pp.

Bogardus, R. and G. Finni. 1981. Wabash River riffle study. WAPORA, Inc., Cincinnati, Ohio. 67 pp.

Brown, H. 1974. Handbook of the effects of temperature on some North American fishes. American Electric Power Co., Canton, Ohio. 524 pp.

Carlander, K.D. 1969. Handbook of freshwater fishery biology. Vol. 1. Iowa State Univ. Press, Ames, Iowa. 752 pp.

Dairyland Power. 1982. Summary table of the distribution and relative abundance of fishes of Pool 5 (based on samplings from 1974-1981) provided by George Johnston, Dairyland Power, LaCrosse, Wisconsin.

Eddy, S. and T. Surber. 1974. Northern fishes. University of Minnesota Press, Minneapolis, Minnesota. 414 pp.

Ellis, J.M. 1978. Fish communities in three successional stages of side channels of the Upper Mississippi River. M.S. Thesis, University of Missouri, Columbia, Missouri. 66 pp.

Environmental Research and Technology (ERT). 1983, Quad-Cities aquatic program, 1982 annual report. Fort Collins, Colorado. 226 pp.

Fernholz, W. et. al. 1980. Determine the significance of wing dams, riprap, and sand as fishery habitat, in Mississippi River Work Unit Annual Report 1979-80. Wisconsin Department of Natural Resources, LaCrosse, Wisconsin. pp 18-21.

Finni, G. and B. Clark. 1981. Wabash River biological studies; long-stretch adult fish surveys, riffle fish sampling, and benthic macroinvertebrates. WAPORA, Inc., Cincinnati, Ohio. 135 pp.

Fremling, C., D. Nielson, D. McConville, R. Vose, and R. Faber. 1980. The feasibility and environmental effects of opening side channels in five areas of the Mississippi River. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. Variously paged.

Funk, J.L. 1958. Relative efficiency and selectivity of gear used in the study of stream fish populations. Transactions of the 23rd North American Wildlife Conference: 236-248.

Holzer, J.A. 1978. Determination and significance of wing dams, riprap, and sand as fishery habitat, *in* Mississippi River Work Unit Annual Report, 1977-1978. Wisconsin Department of Natural Resources, LaCrosse, Wisconsin.

Holzer, J.A. and S. Ironside. 1977. Basic lake inventory of Lake Onalaska, LaCrosse, Wisconsin. Wisconsin Department of Natural Resources, LaCrosse, Wisconsin. 42 pp.

Horrall, R.M. 1962. A comparative study of two spawning populations of the white bass, *Roccus chrysops* (Rafinesque), in Lake Mendota, Wisconsin, with special reference to homing behavior. Univ. Wis., Madison. PhD. Thesis. 181 pp.

Hubert, W. 1980. Assessment of possible navigation impacts on channel fishes of Pool 9 utilizing data from 1980 reconnaissance study. Iowa Cooperative Fishery Research Unit, Ames, Iowa. 231 pp.

Jester, D. and B. Jensen. 1972. Life history and ecology of the gizzard shad, with reference to Elephant Butte Lake, Agricultural Exp. Station Res. Rpt 218, New Mexico State Univ., Las Cruces, New Mexico. 56 pp.

Kallemeyn, L.W. and J.F. Novotny. 1977. Fish and fish food organisms in various habitats of the Missouri River in South Dakota, Nebraska, and Iowa. U.S. Fish and Wildlife Service, National Stream Alteration Team, FWS/OBS - 77/25.

Laarman, P. 1963. Average growth rates of fishes in Michigan. Institute for Fisheries Research, U. of Michigan, Ann Arbor, Michigan. 9 pp.

Pennington, C., J. Baker and M. Potter. 1983. Fish populations along natural and revetted banks on the Lower Mississippi River. N. American J. Fish. Management. 3:204-211.

Pierce, R.B. 1980. Upper Mississippi River wing dam notching: the prenotching fish study. M.S. thesis, University of Wisconsin, Stevens Point, Wisconsin.

Pitlo, J., Jr. 1982. "Commercial Fisheries Investigations, Project Completion Report, Project No. 2-350-R: Wingdam Investigations ". Fisheries Section, Iowa Conservation Commission.

Ragland, D.V. 1974. "Evaluation of three side channels and the main channel border of the Mississippi River as fish habitat," Contract Report Y-74-1, U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Mississippi.

Van Vooren, A. 1983. Distribution and relative abundance of Upper Mississippi River fishes. Upper Mississippi River Conservation Committee, Fish Technical Section.

Scott, W.G. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Ottawa. 966 pp.

Wisconsin Department of Natural Resources. 1982. Endangered and threatened species list. Office of Endangered and Non-game Species, Publication 1-1520(82). Wisconsin DNR, Madison, Wisconsin. 6 p.

5.7 SUPPLEMENTAL TABLES

This section contains tables 5-40 through 5-51 which were referenced earlier in this chapter.

TABLE 5-40.SUMMARY OF FISH CAUGHT BY THE FOUR PRINCIPAL GEAR TYPES USED IN POOL 5A DURING 1982

Species	Electrofishing				Seining				Frame		Trammel		All Gears
	D*,A	N,A	D,J	N,J	D, Rep A	N, Rep A	D, Rep B	N, Rep B	Rep A	Rep B	Rep A	Rep B	
Silver lamprey	-	3	-	-	-	-	-	-	-	-	1	1	5
Shovelnose sturgeon	-	-	-	-	-	-	-	-	-	-	58	52	110
Longnose gar	-	2	-	-	-	1	-	1	-	-	2	-	6
Shortnose gar	-	2	-	-	-	-	-	-	-	-	2	-	4
Bowfin	-	1	-	-	-	-	-	-	-	-	1	4	6
American eel	-	1	-	-	-	-	-	-	-	-	-	1	2
Gizzard shad	90	125	236	233	164	304	14	180	1	3	1	-	1351
Goldeye	-	-	-	-	-	1	-	-	-	-	5	7	13
Mooneye	10	29	-	1	6	12	-	5	2	4	20	14	103
Northern pike	1	2	1	-	-	1	-	-	-	-	5	5	16
Carps/Minnows	-	-	-	-	-	6	1	-	-	-	-	-	7
Carp	25	42	-	-	1	2	-	2	3	3	7	15	100
Golden shiner	-	-	1	-	1	-	-	-	-	1	-	-	3
Spottail shiner	2	1	2	3	100	9	26	15	-	-	-	-	158
Spotfin shiner	7	1	70	7	105	69	109	92	-	-	-	-	460
Emerald shiner	12	2	197	307	326	201	412	187	0	0	0	0	1644
Bullhead minnow	4	-	26	11	119	47	110	54	-	-	-	-	371
Mimic shiner	-	-	-	-	-	7	-	1	-	-	-	-	8
Sand shiner	-	-	-	3	32	9	26	6	-	-	-	-	76
River shiner	1	4	56	9	207	105	259	81	-	-	-	-	722
Silver chub	-	10	2	4	7	8	4	14	16	9	-	-	74
Pugnose minnow	-	-	1	1	4	4	3	-	-	-	-	-	13
Notropis spp.	-	-	-	-	3	-	-	-	-	-	-	-	3
River carpsucker	1	3	-	-	1	-	-	-	-	-	6	-	11
Quillback	3	20	5	1	129	25	118	5	-	-	24	17	347
Highfin carpsucker	9	9	-	-	-	3	1	-	-	-	9	3	34
White sucker	-	2	-	-	-	-	-	-	-	-	4	-	6
Blue sucker	-	2	-	-	-	-	-	-	-	-	1	-	3
Smallmouth buffalo	2	2	-	-	-	2	-	-	3	1	8	3	21
Bigmouth buffalo	-	8	-	-	-	-	-	-	-	-	-	1	9
Spotted sucker	7	6	-	-	-	-	1	-	1	1	9	3	28
Silver redhorse	12	19	-	-	7	2	-	-	-	-	25	19	84
Golden redhorse	18	5	-	-	-	-	3	-	-	-	4	2	32
Shorthead redhorse	174	432	10	1	6	35	12	22	66	31	102	84	975

TABLE 5-40 (CONT.)

Species	Electrofishing				Seining				Frame		Trammel		All
	D*,A	N,A	D,J	N,J	D, Rep A	N, Rep A	D, Rep B	N, Rep B	Rep A	Rep B	Rep A	Rep B	Gears
Carpsuckers/Buffalos	-	-	-	-	2	15	1	4	-	-	-	-	22
Carpoides spp.	-	-	1	2	4	-	3	-	-	-	-	-	10
Channel catfish	-	2	-	-	-	8	-	1	13	4	4	3	35
Stonecat	-	-	-	1	-	-	-	-	-	-	-	-	1
Tadpole madtom	-	-	-	-	1	1	-	2	-	-	-	-	4
Flathead catfish	1	2	-	-	-	-	-	-	3	3	3	5	17
Troutperch	-	2	1	2	2	3	1	12	-	-	-	-	23
Burbot	-	-	-	-	-	-	-	-	-	-	1	-	1
Brook silverside	-	-	1	1	6	4	10	1	-	-	-	-	23
White bass	20	51	24	50	39	135	3	75	3	5	26	6	437
Rock bass	12	46	7	10	1	4	1	-	17	18	6	3	125
Pumpkinseed	-	-	1	1	-	-	-	-	1	2	-	-	5
Orangespotted sunfish	1	-	-	-	-	-	1	-	-	-	-	-	2
Bluegill	67	61	10	4	40	47	60	23	42	46	2	5	407
Smallmouth bass	39	32	4	3	1	2	2	1	-	-	1	3	88
Largemouth bass	14	3	3	-	9	1	-	1	-	-	-	1	32
White crappie	-	-	-	1	-	-	-	-	8	1	2	-	12
Black crappie	13	56	1	1	5	17	9	16	184	164	40	31	537
Crystal darter	-	-	-	-	1	-	2	-	-	-	-	-	3
Western sand darter	-	-	1	2	19	8	44	1	-	-	-	-	75
Sauger	25	114	1	-	2	12	-	4	6	9	7	6	186
Slenderhead darter	-	-	-	-	-	1	-	-	-	-	-	-	1
River darter	-	-	-	-	-	1	-	-	-	-	-	-	1
Johnny darter	1	-	-	-	7	3	2	2	-	-	-	-	15
Yellow perch	1	2	-	-	7	-	3	1	5	3	1	1	24
Walleye	15	47	-	-	1	7	-	3	-	1	12	16	102
Logperch	3	-	3	5	11	1	11	-	-	-	-	-	34
Freshwater drum	30	91	16	18	22	73	6	62	51	42	22	19	452
Total	620	1242	681	682	1399	1196	1258	874	425	351	421	330	9479

---

*D = Day
A = Adult
N = Night
J = Juvenile

TABLE 5-41. RESULTS OF FRAME NETTING (ACTUAL NUMBERS) IN 1982 AT 10 LOCATIONS IN POOL 5A

LOCATIONS	May	June	August	September	November	All Months	All Months**
1A	6	3	68 (67)*	4	27	-	
1B	3	8	36 (31)	6 (1)	1	-	
	9	11	104 (98)	9 (1)	28	162 (99))	63
2A	1	10 (1)	0	4 (2)	1	-	
2B	3	5 (2)	2 (1)	4 (1)	0	-	
	4	15 (3)	2 (1)	8 (3)	1	30 (7)	23
3A	26	5	12 (10)	11 (5)	3	-	
3B	0	4 (1)	32 (28)	24 (14)	1	-	
	26	9 (1)	44 (38)	35 (19)	4	118 (58)	60
4A	4 (1)	5 (1)	6 (6)	16 (5)	2	-	
4B	3	3	12 (3)	25 (18)	0	-	
	7 (1)	8 (1)	18 (9)	41 (23)	2	76 (34)	42
5A	11	0	4 (3)	7	2	-	
5B	3	7	13 (9)	5	4	-	
	14	7	17 (12)	12	6	56 (12)	44
6A	66 (47)	23 (13)	13 (8)	15 (5)	0	-	
6B	9 (2)	35 (16)	23 (20)	15 (2)	2 (2)	-	
	75 (49)	58 (29)	36 (28)	30 (7)	2 (2)	201 (115)	86
7A	1	7	0	1	1	-	
7B	0	2	0	1 (1)	0	-	
	1	9	0	2 (1)	1	13 (1)	12
8A	3 (1)	1	5	4	1	-	
8B	3	1	3 (1)	4	0	-	
	6 (1)	2	8 (1)	8	1	25 (2)	23
9A	5 (1)	0	11 (4)	1	0	-	
9B	5	6 (4)	24	1	0	-	
	10 (1)	6 (4)	35 (4)	2	0	53 (9)	44
10A	3	4 (1)	9 (1)	7	1	-	
10B	0	11 (7)	2 (1)	5 (1)	0	-	
	3	15 (8)	11 (2)	12 (1)	1	42 (11)	31
Total Number	155 (52)	140 (46)	275 (193)	160 (55)	46 (2)	776 (348)	428
No/net set	7.75	7	13.8	8.0	2.3	7.8	
No/net set**	5.1	4.7	4.1	5.3	2.2		4.3

---

*Black crappie

**Excluding black crappie

TABLE 5-42. SUMMARY OF STATISTICAL COMPARISONS OF MONTHLY ADULT ELECTROFISHING DATA (BY WEIGHT, DAY AND NIGHT CATCH COMBINED)

Species or Group	Mean g/10 Min May	 June	 Aug	 Sep	 Nov	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	6451.2	7740.1	5902.9	4317.3	3121.5	23.2	0.0001	yes	J M A S N
Gizzard shad	0	0	67.1	114.2	0	20.6	0.0004	yes	S A J M N
Mooneye	298.0	46.0	49.7	46.4	25.4	5.8	0.2127	no	M A S J N
Common carp	1130.8	2106.7	1264.0	456.5	2605.0	0.9	0.9185	no	N J A M S
Quillback	234.3	0	253.9	100.5	88.4	3.1	0.5346	no	A M S N J
Silver redhorse	701.9	608.8	407.5	195.7	0	3.6	0.4693	no	M J A S N
Golden redhorse	333.5	147.4	345.4	139.6	0	2.3	0.6793	no	A M J S N
Shorthead redhorse	1529.7	2799.0	1642.3	1694.1	75.3	34.8	0.0001	yes	J S A M N
White bass	133.7	54.1	31.5	25.4	0	10.9	0.0276	yes	M J A S N
Rock bass	21.4	73.8	62.4	86.0	0	5.9	0.2058	no	S J A M N
Bluegill	16.0	88.6	203.4	19.7	0.2	24.1	0.0001	yes	A J S M N
Smallmouth bass	15.1	267.0	242.8	69.5	0	9.8	0.0437	yes	J A S M N
Black crappie	26.5	123.7	90.5	64.8	0	9.0	0.0612	no	J A S M N
Sauger	236.5	146.7	100.1	217.7	78.7	10.6	0.0311	yes	M S J A N
Walleye	453.7	127.5	98.9	118.1	168.0	7.3	0.1205	no	M N J S A
Freshwater drum	214.8	418.2	183.5	251.5	72.3	9.9	0.0428	yes	J S M A N

TABLE 5-43 SUMMARY OF STATISTICAL COMPARISONS OF MONTHLY TRAMMEL NETTING DATA (BY WEIGHT)

Species or Group	Mean g/Net/Day					CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
	May	Jun	Aug	Sep	Nov				
Total catch	1997.0	8955.0	11182.4	2594.3	1897.3	31.5	0.0001	yes	A J S M N
Total catch except Shovelnose sturgeon	1688.7	2133.4	11182.4	2594.3	1897.3	34.1	0.0001	yes	A S J N M
Total catch except Shorthead redhorse	1547.0	8495.0	7945.3	1918.8	1479.6	31.5	0.0001	yes	J A S M N
Total catch except Shovenose sturgeon and Shorthead redhorse	1238.7	1673.3	7945.3	1918.8	1479.6	32.2	0.0001	yes	A S J N M
Mooneye	145.9	96.5	170.8	0	86.8	3.7	0.4471	no	A M J N S
Quillback	0	0	1291.6	174.8	0	16.5	0.0024	yes	A S J M N
Silver redhorse	163.3	0	2030.4	268.8	65.5	30.8	0.0001	yes	A S M N J
Shorthead redhorse	450.0	460.0	3237.1	675.4	417.7	25.7	0.0001	yes	A S J M N
White bass	0	0	401.1	33.0	0	11.3	0.0234	yes	A S J M N
Black crappie	14.0	7.0	409.8	123.7	8.0	19.6	0.0006	yes	A S M N J
Walleye	0	128.5	294.3	147.2	136.2	1.8	0.7807	no	A S N J M
Freshwater drum	56.8	130.9	277.2	120.6	13.0	5.3	0.2616	no	A J S M N

TABLE 5-44. SUMMARY OF STATISTICAL COMPARISONS OF MONTHLY FRAME NETTING DATA (BY WEIGHT)

Species or Group	Mean g/Net-Day					CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
	May	Jun	Aug	Sep	Nov				
Total Catch	1939.5	651.3	1909.4	1227.3	801.1	15.0	0.0047	yes	M A S N J
Total catch except Black crappie	1749.8	513.8	772.4	954.7	790.3	12.2	0.0162	yes	M S N A J
Silver chub	5.0	33.6	3.4	22.6	0	1.8	0.7669	no	J S M A N
Shorthead redhorse	1321.4	225.9	143.2	163.1	77.8	6.1	0.1958	no	M J S A N
Rock bass	69.3	43.1	6.6	49.7	0	6.5	0.1678	no	M S J A N
Bluegill	47.3	61.8	163.0	62.4	0	9.8	0.0433	yes	A S J M N
Black crappie	189.7	137.5	1137.0	272.7	10.8	21.7	0.0002	yes	A S M J N
Freshwater drum	13.9	54.1	114.8	347.7	479.9	13.6	0.0088	yes	N S A J M

TABLE 5-45. SUMMARY OF STATISTICAL COMPARISONS OF ADULT ELECTROFISHING DATA (BY WEIGHT, DAY AND NIGHT CATCH COMBINED) ACCORDING TO LOCATION.

Species or Group	Monthly Mean (g/10 min) 1	2	3	4	5	6	7	8	9	10	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	3830.9	4563.3	14349.0	8361.7	3633.7	4626.3	4035.2	3951.3	4299.6	3414.9	13.6	0.1366	no	3 4 6 2 9 7 8 1 5 10
Gizzard shad	8.5	12.7	93.9	0	32.7	80.3	2.6	0	95.7	36.3	6.2	0.7242	no	9 3 6 10 5 2 1 7 4 8
Mooneye	43.0	0	139.5	57.5	157.9	60.4	109.0	162.4	94.9	106.5	3.5	0.9434	no	8 5 3 7 10 9 6 4 1 2
Common carp	644.4	929.2	7920.3	1631.3	0	2003.1	0	220.7	1607.3	169.8	19.4	0.0221	yes	3 6 4 9 2 1 8 10 5 7
Quillback	81.6	0	79.1	0	107.5	143.2	300.3	160.5	187.8	294.1	5.0	0.8359	no	7 10 9 8 6 5 1 3 2 4
Silver redhorse	313.0	353.2	199.0	340.3	321.4	144.4	1059.7	598.6	142.8	355.4	1.8	0.9942	no	7 8 10 2 4 5 1 3 6 9
Golden redhorse	0	314.1	818.6	468.4	25.9	27.7	67.4	105.1	15.2	89.3	4.2	0.8968	no	3 4 2 8 10 7 6 5 9 1
Shorthead redhorse	1015.5	1343.1	2062.9	2999.9	2141.9	318.5	2044.9	1577.3	661.3	1315.5	13.0	0.1613	no	4 5 3 7 8 2 10 1 9 6
White bass	10.7	64.0	142.7	14.9	60.4	51.1	4.1	12.2	102.4	26.9	5.4	0.7975	no	3 9 2 5 6 10 4 8 1 7
Rock bass	43.2	35.9	193.3	57.7	3.1	0	0	38.9	5.2	109.8	10.2	0.3322	no	3 10 4 1 8 2 9 5 6 7
Bluegill	92.5	68.1	58.8	112.4	53.1	182.5	7.3	13.2	15.4	52.5	7.5	0.5831	no	6 4 1 2 3 5 10 9 8 7
Smallmouth bass	0	89.8	403.1	576.4	0	0	69.7	46.7	1.6	1.5	23.4	0.0054	yes	4 3 2 7 8 9 10 1 5 6
Black crappie	90.9	74.8	88.1	70.1	60.5	137.1	8.0	4.5	28.1	48.7	6.6	0.6765	no	6 1 3 2 4 5 10 9 7 8
Sauger	141.5	125.7	190.8	110.5	307.4	203.3	25.7	58.8	183.5	212.0	6.7	0.6664	no	5 10 6 3 9 1 2 4 8 7
Walleye	15.0	35.6	582.9	258.6	106.7	165.9	19.0	208.7	431.9	108.2	9.0	0.4377	no	3 9 4 8 6 10 5 2 7 1
Freshwater drum	17.3	222.5	743.3	299.1	44.3	301.8	217.2	248.1	85.1	102.2	10.3	0.3252	no	3 6 4 8 2 7 10 9 5 1

TABLE 5-46. SUMMARY OF STATISTICAL COMPARISONS OF TRAMMEL NETTING DATA (BY WEIGHT) ACCORDING TO LOCATION

Species or Group	Monthly Mean (g/Net Day) 1	2	3	4	5	6	7	8	9	10	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	9453.8	2059.7	2125.6	2611.9	10528.3	11938.0	3261.2	3225.8	3893.1	4154.7	17.3	0.0446	Yes	6 5 1 10 9 7 8 4 3 2
Total catch except Shovelnose sturgeon	3738.3	1944.3	1740.2	2611.9	2633.6	11938.0	3112.2	3225.8	3893.1	4154.7	20.0	0.0178	Yes	6 10 9 1 8 7 5 4 2 3
Total catch except Shorthead redhorse	8953.4	1718.4	1632.8	1603.7	9551.6	10893.4	2392.3	1739.9	2626.5	1659.6	22.1	0.0086	Yes	6 5 1 9 7 8 2 10 3 4
Total catch except Shovelnose sturgeon and Shorthead redhorse	3237.9	1603.1	1247.3	1603.7	1656.9	10893.4	2243.3	1739.9	2626.5	1659.6	24.1	0.0042	Yes	6 1 9 7 8 10 5 4 2 3
Mooneye	60.5	136.1	27.4	45.1	0	395.7	65.5	82.2	31.6	155.8	4.8	0.8493	No	6 10 2 8 7 1 4 9 3 5
Quillback	0	0	275.2	0	257.2	958.3	423.1	289.8	203.7	525.5	4.4	0.8817	No	6 10 7 8 3 5 9 1 2 4
Silver redhorse	568.8	307.9	217.8	390.0	505.9	300.0	774.3	739.6	843.5	408.2	3.2	0.9548	No	9 7 8 1 5 10 4 2 6 3
Shorthead redhorse	500.4	341.3	492.8	1008.2	976.8	1044.6	868.9	1485.8	1266.5	2495.1	9.0	0.4396	No	10 8 9 6 4 5 7 1 3 2
White bass	26.6	24.5	0	25.5	51.9	392.0	0	118.6	191.2	38.0	1.7	0.9959	No	6 9 8 5 10 1 4 2 3 7
Black crappie	81.2	12.0	9.1	153.4	48.4	670.2	53.4	41.9	15.5	40.2	14.3	0.1136	No	6 4 1 7 5 8 10 9 2 3
Walleye	0	40.0	0	183.7	52.9	885.5	0	35.3	215.0	0	5.7	0.7693	No	6 9 4 5 2 8 1 3 7 10
Freshwater drum	410.4	172.7	65.8	20.9	81.6	318.3	0	0	127.4	0	10.9	0.2861	No	1 6 2 9 5 3 4 7 8 10

TABLE 5-47 SUMMARY OF STATISTICAL COMPARISONS OF FRAME NETTING DATA (BY WEIGHT) ACCORDING TO LOCATION

Species or Group	Monthly Mean (g/Net Day) 1	2	3	4	5	6	7	8	9	10	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	3326.0	271.3	2781.6	1828.3	1265.7	1471.1	117.2	397.8	733.7	864.5	32.0	0.0002	Yes	1 3 4 6 5 10 9 8 2 7
Total catch except Black crappie	1981.3	204.7	2189.2	1500.3	1173.9	634.8	102.7	382.6	650.2	742.4	24.6	0.0034	Yes	3 1 4 5 10 9 6 8 2 7
Silver chub	0	47.2	3.6	0	42.8	0	13.3	0	3.6	18.4	5.4	0.8026	No	2 5 10 7 3 9 1 4 6 8
Shorthead redhorse	336.7	42.7	1596.8	192.0	896.9	34.2	42.4	172.9	193.4	354.7	7.7	0.5683	No	3 5 10 1 9 4 8 2 7 6
Rock bass	41.6	0	7.1	59.8	7.5	68.6	23.9	70.9	49.8	8.2	5.7	0.7716	No	8 6 4 9 1 7 10 5 3 2
Bluegill	7.9	26.1	17.8	16.2	27.9	322.6	0	63.0	145.9	41.5	16.9	0.0499	Yes	6 9 8 10 5 2 3 4 1 7
Black crappie	1344.7	66.6	592.4	328.0	91.8	836.3	14.5	15.2	83.4	122.2	19.5	0.0213	Yes	1 6 3 4 10 5 9 2 8 7
Freshwater drum	962.5	60.2	174.5	595.8	105.1	3.2	11.4	5.7	17.7	84.6	20.3	0.0163	Yes	1 4 3 5 10 2 9 7 8 6

TABLE 5-48 SUMMARY OF STATISTICAL COMPARISONS OF DIEL ADULT ELECTROFISHING DATA (BY WEIGHT)

Species or Group	Mean g/10 Min Day (D)	Mean g/10 Min Night (N)	CH	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	3474.3	7538.9	19.2	0.0001	yes	D N
Gizzard shad	38.8	33.8	0.0	0.9835	no	D N
Mooneye	63.1	123.1	5.8	0.0158	yes	D N
Common carp	976.7	2048.5	1.2	0.2656	no	D N
Quillback	61.5	209.4	5.4	0.0205	yes	D N
Silver redhorse	265.3	500.3	1.4	0.2357	no	D N
Golden redhorse	328.0	58.4	1.3	0.2626	no	D N
Shorthead redhorse	802.4	2293.8	11.7	0.0006	yes	D N
White bass	32.3	65.6	3.8	0.0511	no	D N
Rock bass	28.6	68.8	2.7	0.0980	no	D N
Bluegill	45.0	86.1	0.3	0.6100	no	D N
Smallmouth bass	128.8	109.0	0.4	0.5418	no	D N
Black crappie	24.2	98.0	5.5	0.0193	yes	D N
Sauger	55.4	256.5	10.1	0.0015	yes	D N
Walleye	71.5	315.1	5.8	0.0164	yes	D N
Freshwater drum	166.5	289.7	6.9	0.0088	yes	D N

TABLE 5-49 SUMMARY OF STATISTICAL COMPARISONS OF ROCK/SAND ADULT ELECTROFISHING DATA (BY WEIGHT, DAY AND NIGHT CATCH COMBINED

Species or Group	Mean (g/10 Min) Rock (R)	Sand (S)	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	6515.2	3782.7	2.9	0.0869	no	R ______ S
Gizzard shad	19.6	54.9	3.3	0.0696	no	R ______ S
Mooneye	85.2	119.7	1.3	0.2514	no	R ______ S
Common carp	1891.0	592.4	1.6	0.2083	no	R ______ S
Quillback	103.6	196.5	1.3	0.2550	no	R ______ S
Silver redhorse	477.3	273.2	0.2	0.6409	no	R ______ S
Golden redhorse	295.6	43.5	0.3	0.5838	no	R ______ S
Shorthead redhorse	1840.6	1372.9	3.7	0.0541	no	R ______ S
White bass	41.4	63.2	2.3	0.1331	no	R ______ S
Rock bass	61.5	39.4	0.4	0.5491	no	R ______ S
Bluegill	58.7	40.3	0.1	0.7612	no	R ______ S
Smallmouth bass	197.6	1.0	7.6	0.0059	yes	R S
Black crappie	56.1	45.8	0.1	0.8073	no	R ______ S
Sauger	108.8	234.3	2.5	0.1133	no	R S
Walleye	186.6	215.6	0.6	0.4360	no	R ______ S
Freshwater drum	291.2	77.2	1.0	0.3125	no	R S

TABLE 5-50. SUMMARY OF STATISTICAL COMPARISONS OF ROCK/SAND TRAMMEL NETTING DATA (BY WEIGHT)

Species or Group	Monthly Mean (g/Net Day) Rock (R)	Monthly Mean (g/Net Day) Sand (S)	CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
Total catch	3789.7	6192.0	0.2	0.6470	no	R ________ S
Total catch except Shovelnose sturgeon	2728.8	3560.5	0.1	0.8306	no	R ________ S
Total catch except Shorthead redhorse	3006.8	4612.5	0.1	0.7515	no	R ________ S
Total catch except Shovelnose sturgeon and Shorthead redhorse	1945.9	1981.0	0.6	0.4235	no	R ________ S
Shovelnose sturgeon	1060.9	2631.6	0.0	0.9727	no	R ________ S
Mooneye	69.5	62.5	0.1	0.8306	no	R ________ S
Quillback	164.7	328.8	0.3	0.6136	no	R ________ S
Silver redhorse	499.7	585.9	0.0	0.8641	no	R ________ S
Shorthead redhorse	782.9	1579.5	2.1	0.1468	no	R ________ S
White bass	32.5	93.7	0.2	0.6625	no	R ________ S
Black crappie	58.5	34.7	0.3	0.6076	no	R ________ S
Walleye	43.2	89.3	0.0	0.8742	no	R ________ S
Freshwater drum	111.6	69.6	0.2	0.6875	no	R ________ S

TABLE 5-51. SUMMARY OF STATISTICAL COMPARISONS OF ROCK/SAND FRAME NETTING DATA (BY WEIGHT)

Species or Group	Monthly Mean (g/Net Day)		CHI^2	Prob.	Significant Difference	Means Underlined Are Not Significantly Different
	Rock (R)	Sand (S)				
Total catch	1453.7	954.6	0.0	0.9659	no	R S
Total catch except for Black crappie	1060.1	855.5	0.0	0.9863	no	R S
Silver chub	10.7	21.6	0.2	0.6906	no	R S
Shorthead redhorse	397.3	481.7	1.4	0.2342	no	R S
Rock bass	33.9	21.8	0.2	0.6969	no	R S
Bluegill	21.8	71.8	3.2	0.0723	no	R S
Black crappie	393.6	99.1	0.1	0.7450	no	R S
Freshwater drum	301.7	69.1	0.5	0.4695	no	R S

6. OVERVIEW

Each preceding section has its own summary section so no further summarization of the results is necessary. It is appropriate, however, to attempt to integrate the results of the periphyton, benthos, and fisheries studies to the extent possible.

From a temporal standpoint, late summer (August in particular) seems to be the optimal time to sample. Flows typically are low and steady, and periphyton, benthos, and fish biomass and diversity are all at or near their respective peaks. Because of differences in the number and types of locations sampled, comparisons across all three biological disciplines are difficult. The periphyton and benthos studies both showed that wing dams, especially those located in fast currents, supported greater biomasses (and usually diversity) than did riprapped banks. However, the opposite trend was noted during the fisheries studies.

Both the fisheries and benthos studies demonstrated that silty MCB habitats, at least those offering a cove-like habitat, are highly productive. It was noted that a sand spit was beginning to close off the entrance to the silty cove (Location 6) that was sampled. One obvious recommendation of this study is that such areas be kept open to the main channel and that disposal of dredge spoils or other debris certainly should not be permitted in these areas.

Sandy areas were fairly unproductive in terms of both fish and benthos. However, Location 10, which contained beds of rooted aquatics, was very productive in terms of benthos and fairly productive from a fisheries standpoint. Again, the need for preserving such areas is obvious.

Unfortunately, this study did not produce clear-cut results demonstrating the ecological value of current modification structures. The benthos studies were the most decisive in demonstrating the value of rocky structures. They showed that the biomass on such structures was high; higher than at silty areas and much higher than at sandy areas. Their importance is further increased because they produce many more of the organisms important as food items for fish (i.e., aquatic insects). The fisheries studies were less decisive in demonstrating the importance of rocky areas. Conversely, no evidence was found to suggest that channel-training structures were in any way detrimental to the fish community of Pool 5A. Statistical comparisons of the rocky and sandy locations yielded few differences. The fisheries data did show, however, that rocky areas are generally inhabited by larger fish, meaning that they are important to sport and commercial fishermen. Part of the reasons such differences could not be demonstrated undoubtedly stems from the fact that wing dams are so difficult to sample effectively. As Fernholtz et al. (1980) aptly stated (with regard to a similar study), "the comparisons made in the study are not wing dam versus riprap versus sand, but the top of wing dams versus shoreline riprap versus shoreline sand." Certainly, of the three habitat types, wing dams are the most difficult to sample and, therefore, the most likely to be underrepresented in the catch totals.

With regard to comparisons between wing dams and riprapped banks, the results of the benthos (and to a lesser extent the periphyton studies) were the opposite of the fisheries results. Wing dams, particularly those in fast currents, appear to be better habitats for benthic macroinvertebrates than do riprapped banks. The opposite relationship was found during the fisheries studies. Although this discrepancy may be real, it is also possible that, as discussed above, fish populations on wing dams are consistently underestimated.

END
FILMED
3-86
DTIC