

STANDING CROPS OF BENTHIC
MACROINVERTEBRATES IN SELECTED
BACKWATER AREAS OF NAVIGATION
POOL 8, UPPER MISSISSIPPI RIVER

A Thesis Submitted to
the Graduate Faculty of
University of Wisconsin - La Crosse
in Partial Fulfillment of
the Requirements for the Degree
MASTER OF SCIENCE - BIOLOGY

by

James Norcross Davies, II

August 1974

UNIVERSITY OF WISCONSIN
La Crosse, Wisconsin 54601

COLLEGE OF ARTS, LETTERS, AND SCIENCES

Candidate: JAMES NORCROSS DAVIES, II

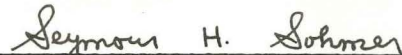
We recommend acceptance of this thesis to the College of Arts, Letters, and Sciences in partial fulfillment of this candidate's requirements for the degree Master of Science in Biology. The candidate has completed his oral defense of the thesis.



Thesis Committee Chairman

26 July 1974

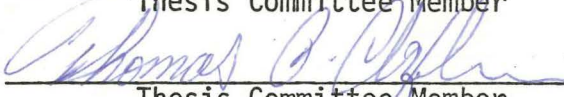
Date



Thesis Committee Member

26 July 1974

Date



Thesis Committee Member

26 July 1974

Date

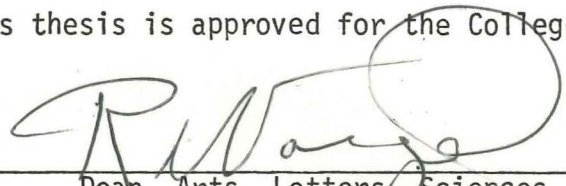


Thesis Committee Member

July 26, 1974

Date

This thesis is approved for the College of Arts, Letters, and Sciences



Dean, Arts, Letters, Sciences

Sept 6, 1974

Date

ABSTRACT

Bottom samples were taken bimonthly between May 11 and October 6, 1973, in selected backwater areas of the Mississippi River. The study was initiated to determine standing crops of the benthic organisms of those areas and to provide baseline data for possible future studies related to habitat alteration.

The benthic biomass varied greatly during the sampling period at all transects, ranging from 0.11 gm/m² to 59.87 gm/m² with the average being 6.37 gm/m². Analyses of Variance (F-distribution) indicated that there were significant differences (99% level of confidence) in biomass between all transects and all sites on all sample dates. Flood conditions were responsible for the low biomasses noted on the May 11 to June 9 sample dates.

Members of the Ephemeroptera, Diptera and Oligochaeta were dominant species over the duration of the sampling period.

ACKNOWLEDGEMENTS

My appreciation is extended to the following persons: my parents, Mrs. Donna Pedersen, Randy Gajewski, Charles Craig, James Rebhan, Jon Weber, Drs. Held, Claflin, and Sohmer, my students, and the faculty of the Biology Department at UW - La Crosse.

TABLE OF CONTENTS

	Page
LIST OF TABLES	v
LIST OF FIGURES.	vi
INTRODUCTION	1
Description of Study Area	1
METHODS AND MATERIALS.	5
RESULTS.	7
DISCUSSION	20
LITERATURE CITED	24
APPENDIX	25

LIST OF TABLES

Table	Page
1. Average biomass (gms/m ²) distributed according to site at all transects between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River	10
2. Average number of organisms/m ² distributed according to site at all transects between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River	11
3. Relative importance (percentage) of the major groups of organisms collected between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River	12
Appendix	
Table	
4. Biomass (gms/m ²) obtained at the 6 sites of transect A from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.	25
5. Biomass (gms/m ²) obtained at the 6 sites of transect B from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.	26
6. Biomass (gms/m ²) obtained at the 6 sites of transect C from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.	27
7. Biomass (gms/m ²) obtained at the 6 sites of transect D from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.	28
8. Biomass (gms/m ²) obtained at the 6 sites of transect E from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.	29
9. Biomass (gms/m ²) obtained at the 6 sites of transect F from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.	30
10. Biomass (gms/m ²) obtained at the 6 sites of transect G from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.	31
11. Taxonomic list of organisms obtained at all transects between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River	32

LIST OF FIGURES

Figure	Page
1. Map of the study area, Navigation Pool 8, upper Mississippi River	3
2. Average biomass (gms/m ²) and average number of organisms/m ² distributed according to site at transect A between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River	13
3. Average biomass (gms/m ²) and average number of organisms/m ² distributed according to site at transect B between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River	14
4. Average biomass (gms/m ²) and average number of organisms/m ² distributed according to site at transect C between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River	15
5. Average biomass (gms/m ²) and average number of organisms/m ² distributed according to site at transect D between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River	16
6. Average biomass (gms/m ²) and average number of organisms/m ² distributed according to site at transect E between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River	17
7. Average biomass (gms/m ²) and average number of organisms/m ² distributed according to site at transect F between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River	18
8. Average biomass (gms/m ²) and average number of organisms/m ² distributed according to site at transect G between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River	19

INTRODUCTION

For many years the floodplain of the upper Mississippi River has been slowly encroached upon by man. New housing developments and gravel pit operations have altered the environment of the backwater areas in the vicinity of La Crosse, Wisconsin. Some areas are being filled and others are being dredged to provide the fill material. More recently, the area included in this study has been proposed as a possible highway corridor to link La Crosse, Wisconsin to the I-90 Interstate Highway System.

This type of area is diverse and capable of supporting large standing crops of benthic organisms. However, this type of area is also extremely sensitive to environmental changes resulting from pollution (Patrick, 1970). The stability of the benthic community is based on the species diversity. Any disruption of the habitat can upset that stability with subsequent adverse affects on other aquatic organisms which constitute the food web (Paine, 1966).

The objectives of the bottom fauna study were to (1) document the standing crops of benthic organisms in the study area, and (2) provide baseline data for possible future studies related to habitat alteration.

Description of Study Area.

The sample area included seven transects, all located in T15N; R7W;

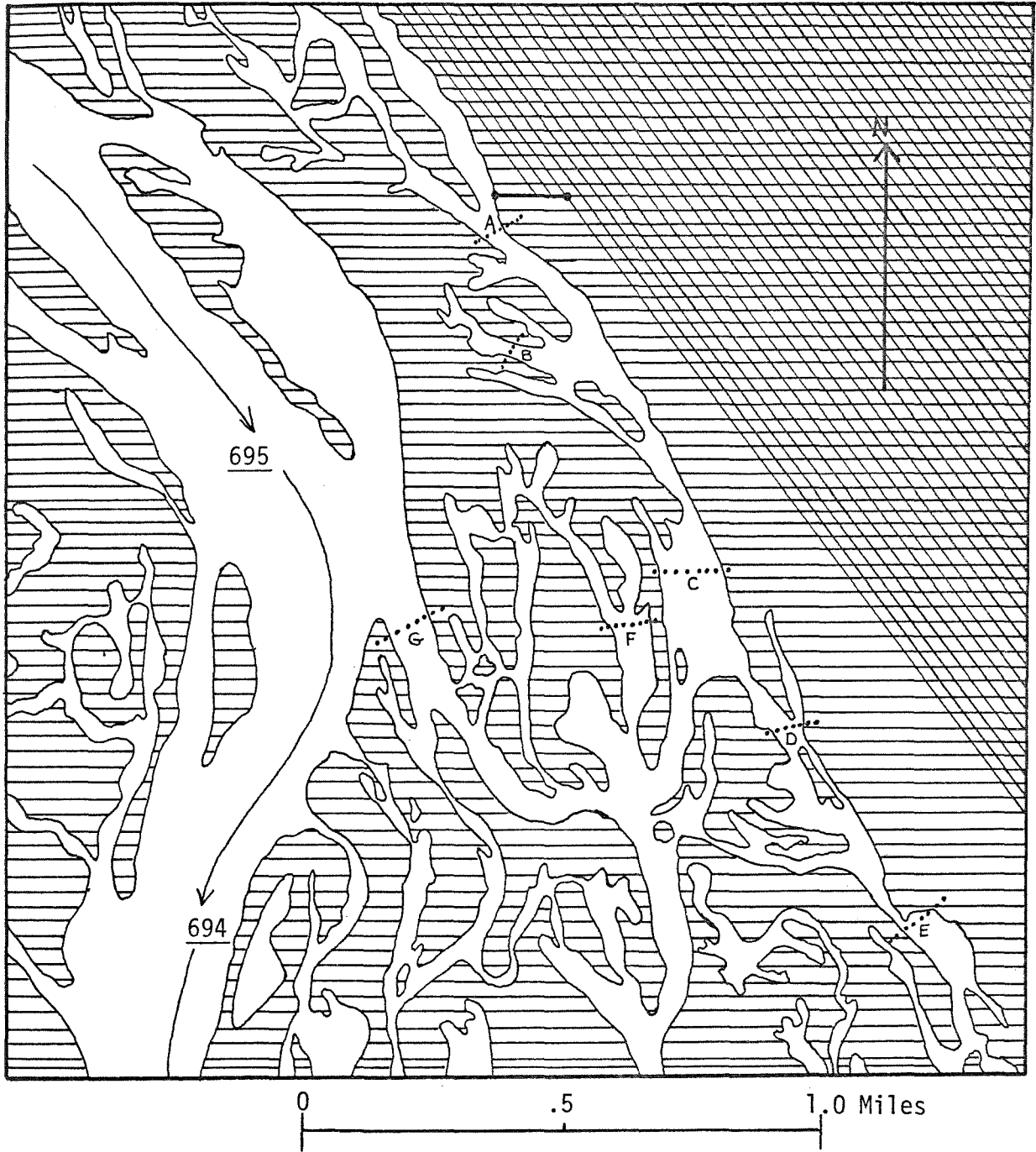
Sections 16, 17, 20, and 21 of La Crosse County, Wisconsin. Each transect consisted of 6 sample sites and was selected on the basis of different characteristics of water flow, bottom type and depth ranges. Transect numbering ran from east to west (Fig. 1). All depths listed are in reference to mean river level, 631 feet msl, in Navigation Pool 8, upper Mississippi River.

Transect A was a shallow area with a mixture of mud and clay substrate. The water was deepest at site A₁ (3.2 m) and shallowest at site A₆ (0.42 m). The transect was approximately 75 m long. Water flow was slight due to the fact that it has been cut off from the river except for a 2-meter culvert which lies 1.2 km north of the transect. However, during flood stage a large volume of water was discharged through the area. No aquatic vegetation was present during the sample period.


Transect B was located southwest of transect A and was a small finger lake with soft mud bottom which contained large amounts of vegetative detritus. All sites were shallow and ranged between 0.52 m and 0.48 m. The transect was approximately 55 m long. The water was stationary except during river levels greater than 3 m above mean level. Vegetation included Potamogeton crispus, P. Richardsonii, Ceratophyllum demersum, Lemna minor and filamentous algae.



Transect C extended across a deep dredged pool with fine silt substrate. Depth varied from 8.53 m at site C₁ to 16.76 m at site C₅. The transect was approximately 160 m long. The area is lake-like and becomes stratified during the summer (Davies [1967] unpublished data).

Fig. 1. Map of the study area, Navigation Pool 8, upper Mississippi River.



LEGEND

-  - land areas
- 695 - mile marker
- - transect

-  - La Crosse, Wisconsin
-  - Main channel, Mississippi River.
- Pool elevation = 631.0 ft. msl

Water flow was negligible at all times. Rooted aquatic vegetation was absent from this area.

Transect D was located below a small chute which empties from the area that included transect C. The area was clearly divided into two sections; the natural area with a soft mud substrate and the area affected by heavy sand siltation from the upstream area. All sites were quite shallow with sites D₂ and D₃ being exposed during mean river level. The transect was approximately 50 m long. Water flow was slow at sites D₁ and D₂ because they were protected by a spit of land just north of their location (Fig. 1). Flow at sites D₃ through D₆ was rapid, but restricted at low water levels by large masses of Vallisneria americana, which was the only observed species of rooted vegetation.

Transect E was approximately 1 km south of transect D and was also divided into two different habitats formed by sedimentation. Sites E₁-E₄ were all approximately 7 m deep with mud and clay substrate. Sites E₅ and E₆ were, respectively, 4.2 m and 3.5 m deep with washed sand sediments. The transect was approximately 110 m in length. A slow eddy at sites E₁-E₄ was created by a spit of land which extended from the shore north of the transect (Fig. 1). This area was the site of a dredging operation, this being the cause of the spit and the sample site depths. Water flow was swift at sites E₅ and E₆. No aquatic vegetation was observed.

Transect F was a large finger lake with soft mud sediments. Depth range from 0.6 m to 1.1 m with the transect being approximately 90 m long. Water flow was not detectable except when river levels were above

3 m. Heavy vegetation was present at sites F₁-F₅. The vegetation included dense masses of Ceratophyllum demersum and Lemna minor.

Transect G was located at the opening of Running Slough from the Mississippi River (Fig. 1). The bottom substrate consisted of washed sand of various sizes. All sites were approximately 4.5 m in depth and the transect was approximately 100 m long. Water flow was rapid at all times. No aquatic vegetation was observed.

METHODS AND MATERIALS

Bottom samples were collected bimonthly from May 11 to October 6, 1973, at each of the six sites on seven transects. One grab was taken at each site. All samples were taken with a Peterson Dredge (27.94 cm) which has a grab area of 778.4 cm². All samples were immediately washed through a No. 8 brass screen (wire diameter = 0.07 cm; opening = 0.24 cm) to remove heavy debris and then through a No. 30 standard sieve (wire diameter = 0.029 cm to 0.042 cm; opening = 0.059 cm). The No. 30 sieve is defined by Keup, Ingram, and Mackenthum (1966) as the mesh which will retain only the macroorganisms. The specimens were picked in the field and transferred to 20 dram vials containing 70% ethanol and formalin (3 to 1 mixture) for analysis in the laboratory.

Specimens were sorted into groups and counted in the laboratory. Weights were obtained on a Mettler H20T Scale after the specimens were blotted dry for 30 seconds with paper toweling. The scale was allowed to stabilize for 15 seconds before weights were recorded. The specimens were retained for identification using Pennak's (1953) Fresh-water Invertebrates of the United States.

All weights were multiplied by 12.8 to convert to grams/square meter. The average weights (gms/m²) and the average number of organisms per square meter were obtained by averaging the actual weights and numbers of organisms from the six sites within a given transect on a given sample date.

Analyses of variance was calculated using the Hewlett-Packard 2000C on running time-shared basic language. The two-way analyses of variance (F-distribution) program was from the HP Contributed Library. The two-way F-test is discussed by Mendenhall (1971).

N. C. Fasset's (1957) Manual of Aquatic Plants was used for identification of all rooted vegetation.

RESULTS

The greatest standing crops were noted at transect A over the duration of the sample period. The peak standing crops were noted on July 7, 1973 (biomass = 49.62 gm/m²; # organisms/m² = 2929) and August 4 (biomass = 59.87 gms/m²; # organisms/m² = 2371). Rapid reductions in standing crops were noted from July 7 to July 21 and from August 4 to October 6. The lowest biomass (2.87 gm/m²) and number of organisms/m² (164) were observed on October 6 (Fig. 2, Tables 1 & 2). The only organisms of significance at transect A was Hexagenia bilineata which represented 85% of all organisms collected between May 11 and October 6 (Table 3). Other groups were Diptera (9.1%), Mollusca (2.5%) and Oligochaeta (2.6%).

Increasing standing crops were noted at transect B between June 9 and July 7. The peak standing crop was observed on July 7 (biomass = 17.69 gms/m² and # of organisms/m² = 947). Reductions in standing crops occurred between July 7 and October 6 (Fig. 3, Tables 1 & 2). Specimens of H. bilineata were dominant from May 26 to August 4 at transect B. These members of Ephemeroptera represented 76% of all organisms collected (Table 3). Dipterans (17.9%) were dominant after August 4. Oligochaetes comprised 5.2% of the organisms collected.

Two peak standing crops were observed at transect C. The first peak was noted June 9 (biomass = 4.75 gm/m²; # of organisms/m² = 586).

The second peak occurred on September 26 (biomass = 11.58 gms/m²; # of organisms/m² = 1621). Rapid reductions in standing crops were noted after September 26 (Fig. 4, Tables 1 & 2). Oligochaetes were dominant at transect C over the duration of the study. The oligochaetes represented 79.1% of all organisms collected. Dipterans (20.9%) were the only other organisms collected at transect C (Table 3).

Transect D maintained stable standing crops throughout the sample period, except during the May samples. The only minor peak was observed for the June 9 sample date. Biomass on that date was 9.50 gms/m² and the number of organisms was 435 (Fig. 5, Tables 1 & 2). Transect D was the most diverse habitat and no organism group was dominant on any sample date. Dipterans were commonly collected throughout the study period and represented 41.3% of the total numbers of organisms (Table 3). Other significant groups included the Mollusca (29.3%), Ephemeroptera (19.2%) and Oligochaeta (7.3%).

No major standing crop peaks were observed at transect E. A minor peak was noted on July 7 (biomass = 8.56 gms/m²; # of organisms/m² = 458). Another minor peak occurred on August 18 with a biomass of 7.31 gms/m² and the number of organisms/m² being 980 (Fig. 6, Tables 1 & 2). Three groups of organisms, Ephemeroptera, Diptera, and Oligochaeta, were significant at transect E. The ephemeropterans (38.4%) were dominant between May 11 and July 7. The dipterans (34.6%) and oligochaetes (21.9%) were dominant after July 7. The phylum Mollusca comprised 4.8% of the total number of organisms collected (Table 3).

The biomass at transect F fluctuated throughout the sample period

with the only peak occurring on July 7. On this date, the biomass was 7.16 gms/m² and the number of organisms/m² was 524 (Fig. 7, Tables 1 & 2). Dipterans were common at transect F throughout the sample period, with major dominance after July 7. The dipterans represented 56.9% of all organisms collected. Ephemeropterans (20.5%) were dominant from May to July (Table 3). Oligochaetes were also significant during the sample period, representing 17.4% of all organisms collected.

The lowest standing crops were recorded for transect G throughout the sample period. The largest standing crop was recorded on October 6 (biomass = 4.10 gms/m²; # of organisms = 2). However, the greatest number of organisms/m² (21) was collected on July 7. The biomass on July 7 was 1.53 gms/m² (Fig. 8, Tables 1 & 2). The phylum Mollusca (69.1%) was dominant at transect G over the duration of the study. The only other group represented at this transect was Diptera (Heleidae), which comprised 30.9% of the organisms collected (Table 3).

Table 1. Average biomass (gms/m²) distributed according to site at all transects between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River.

Sample Date	May 11	May 26	June 9	June 23	July 7	July 21	Aug. 4	Aug. 18	Sept. 1	Sept. 26	Oct. 6
Sample Time	1	2	3	4	5	6	7	8	9	10	11
Transect A	6.98	6.00	6.48	21.93	49.62	39.00	59.87	23.02	7.16	3.55	2.87
Transect B	1.81	2.31	5.34	14.62	17.69	5.27	3.16	0.93	0.11	0.21	0.11
Transect C	0.11	0.52	7.21	4.75	1.92	3.00	3.51	4.71	7.17	11.58	1.63
Transect D	0.24	1.12	9.50	4.46	6.78	6.44	7.35	6.80	3.21	3.77	3.42
Transect E	4.87	4.11	5.13	5.09	8.56	6.76	5.75	7.31	4.03	5.00	2.98
Transect F	2.42	0.913	2.93	4.73	7.16	4.57	2.63	3.51	2.52	2.91	0.78
Transect G	0.98	1.38	1.33	1.74	1.53	1.47	1.52	1.67	1.05	1.94	4.10

Table 2. Average number of organisms/m² distributed according to site at all transects between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River.

Sample Date	May 11	May 26	June 9	June 23	July 7	July 21	Aug. 4	Aug. 18	Sept. 1	Sept. 26	Oct. 6
Sample Time	1	2	3	4	5	6	7	8	9	10	11
Transect A	390	356	266	1055	2926	2015	2371	1028	445	226	164
Transect B	81	89	345	635	947	285	157	126	41	87	15
Transect C	6	66	586	349	356	317	386	597	893	1621	264
Transect D	38	49	435	303	390	349	286	347	145	187	134
Transect E	175	164	303	302	458	337	571	970	382	446	187
Transect F	102	83	305	245	524	461	258	501	390	535	121
Transect G	11	13	13	13	21	9	9	13	4	6	2

Table 3. Relative importance (percentage) of the major groups of organisms collected over the duration of the sample period at all transects.

TRANSECT	A	B	C	D	E	F	G
Ephemeroptera	85.0	76.0	0.0	19.2	38.4	20.5	0.0
Diptera	9.1	17.9	20.9	41.3	34.6	56.9	30.9
Mollusca	2.5	0.0	0.0	29.3	4.8	1.8	69.0
Oligochaeta	2.6	5.2	79.1	7.3	29.9	17.4	0.0
Miscellaneous	0.7	0.7	0.0	2.7	0.2	3.2	0.0

URF
UNIVERSITY

Fig. 2. Average biomass (gms/m²) and average number of organisms/m² distributed according to site at transect A between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River.

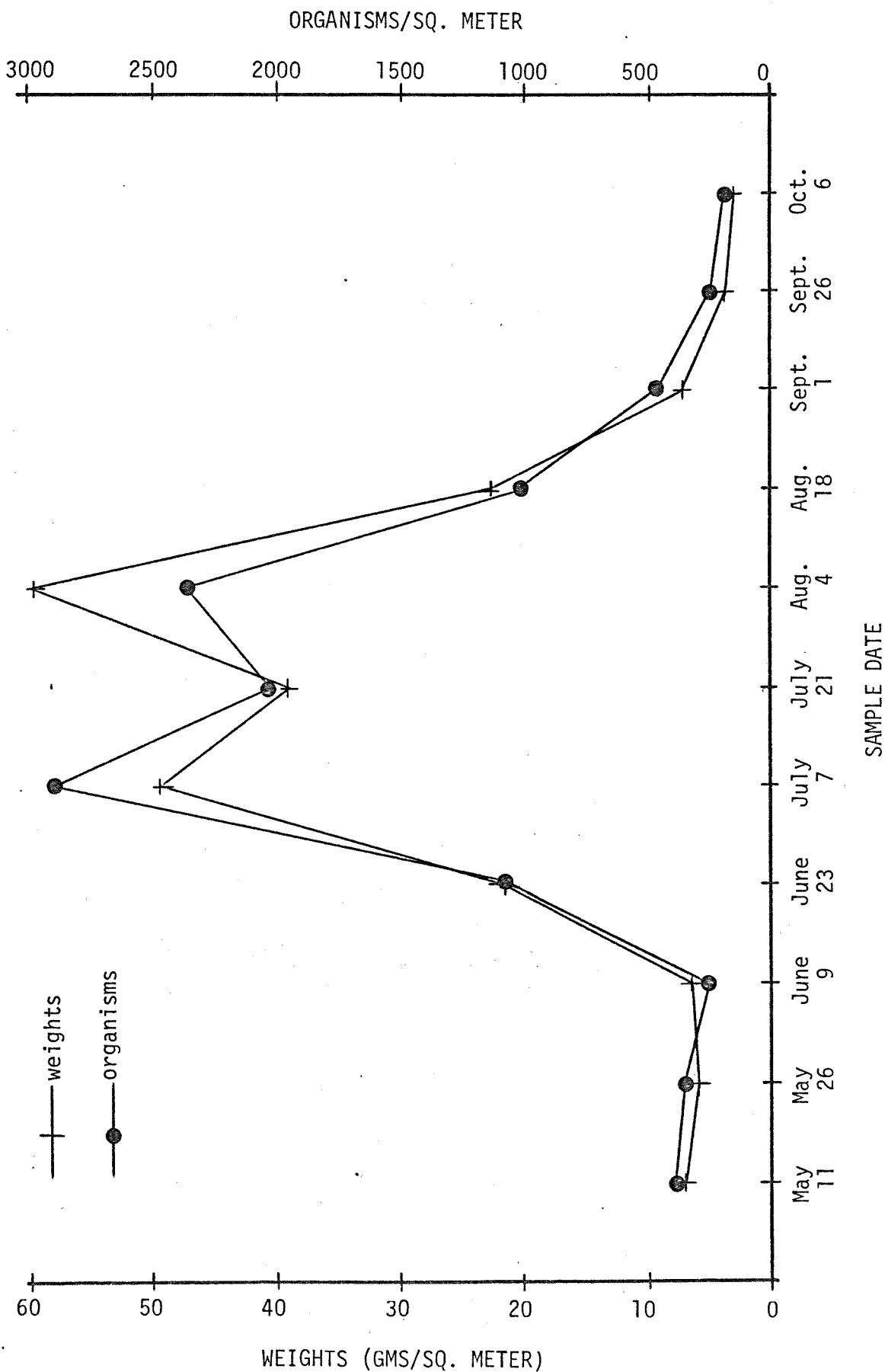


Fig. 3. Average biomass (gms/m²) and average number of organisms/m² distributed according to site at transect B between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River.

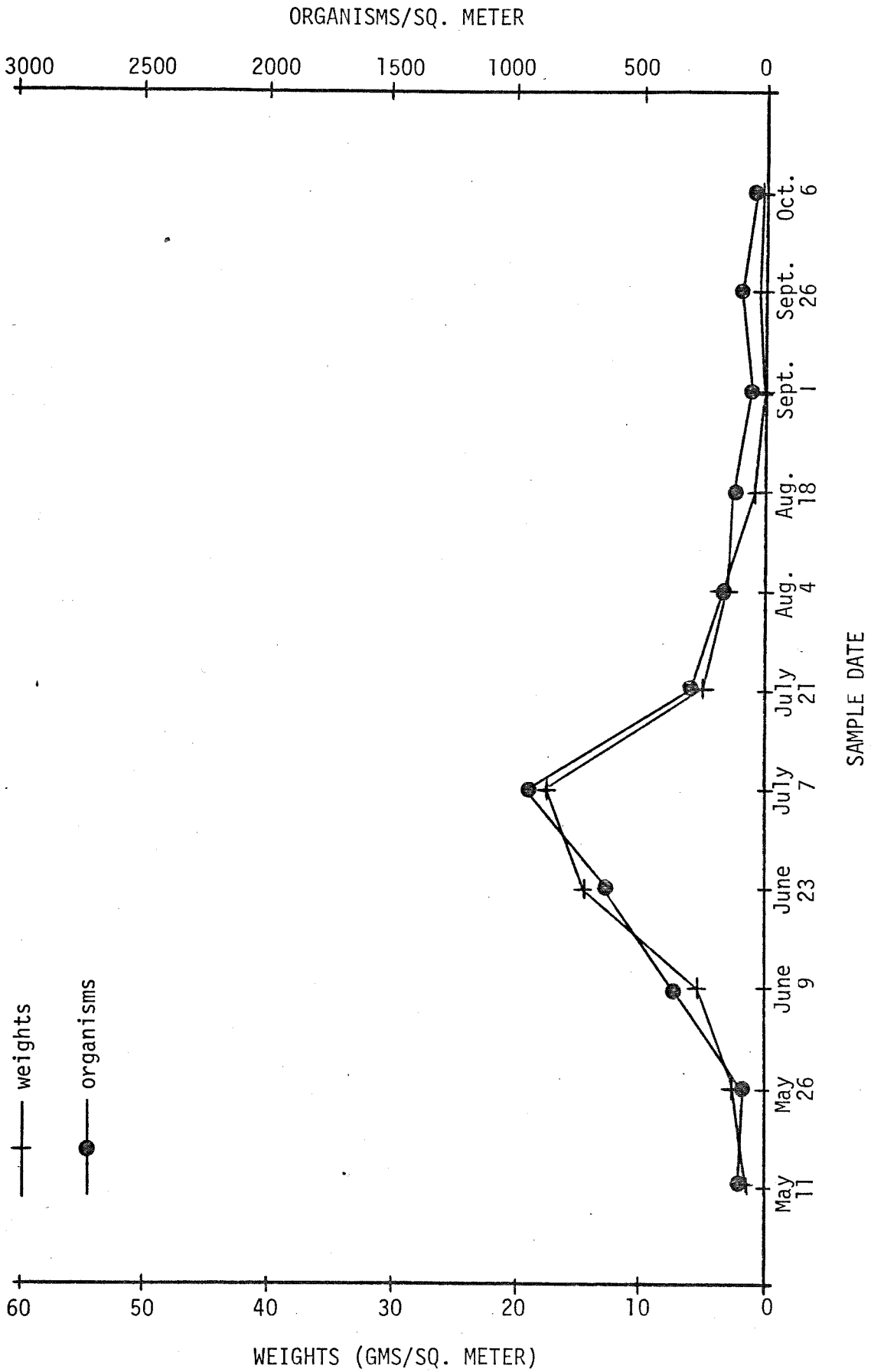


Fig. 4. Average biomass (gms/m²) and average number of organisms/m² distributed according to site at transect C between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River.

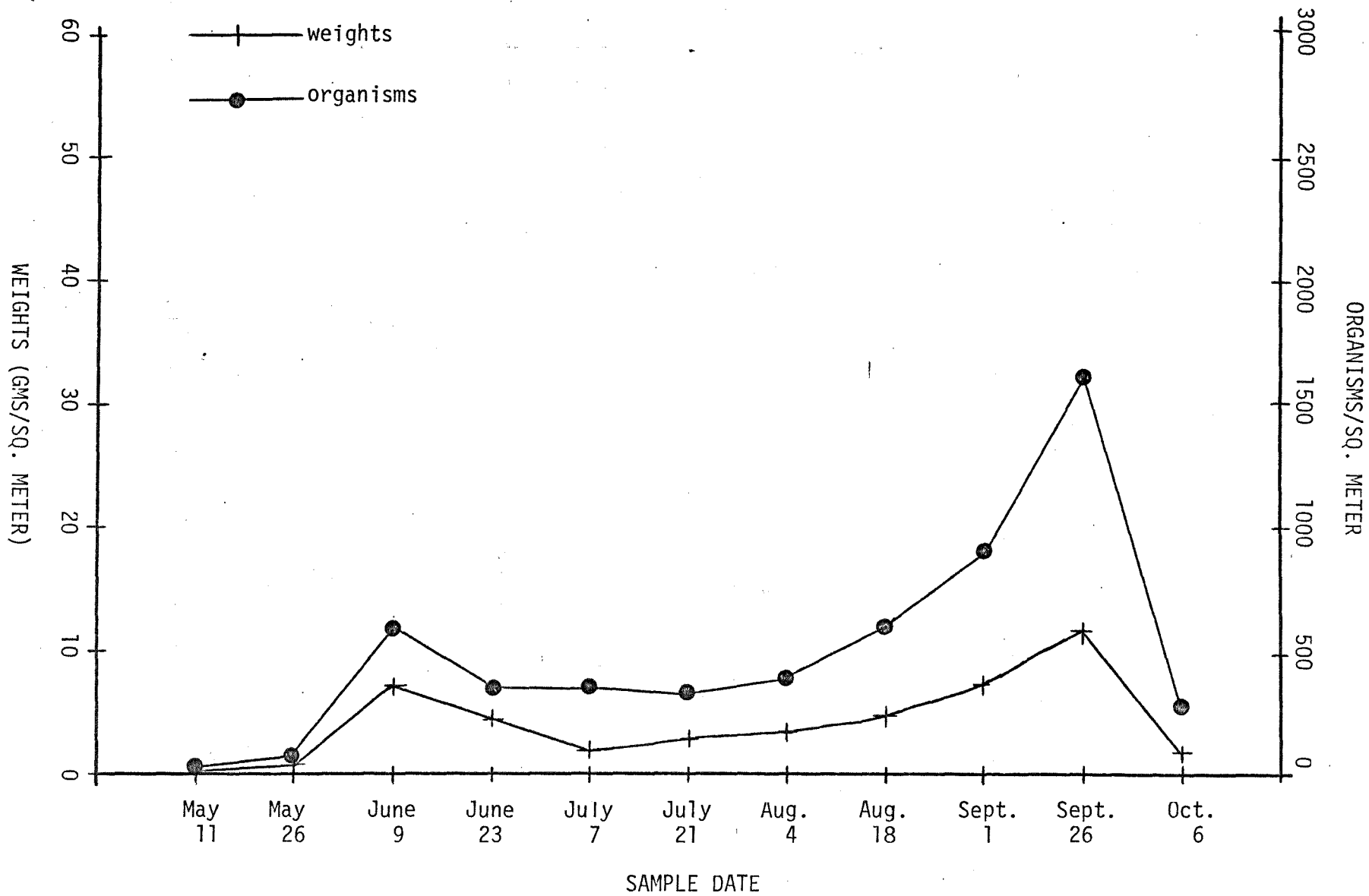


Fig. 5. Average biomass (gms/m²) and average number of organisms/m² distributed according to site at transect D between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River.

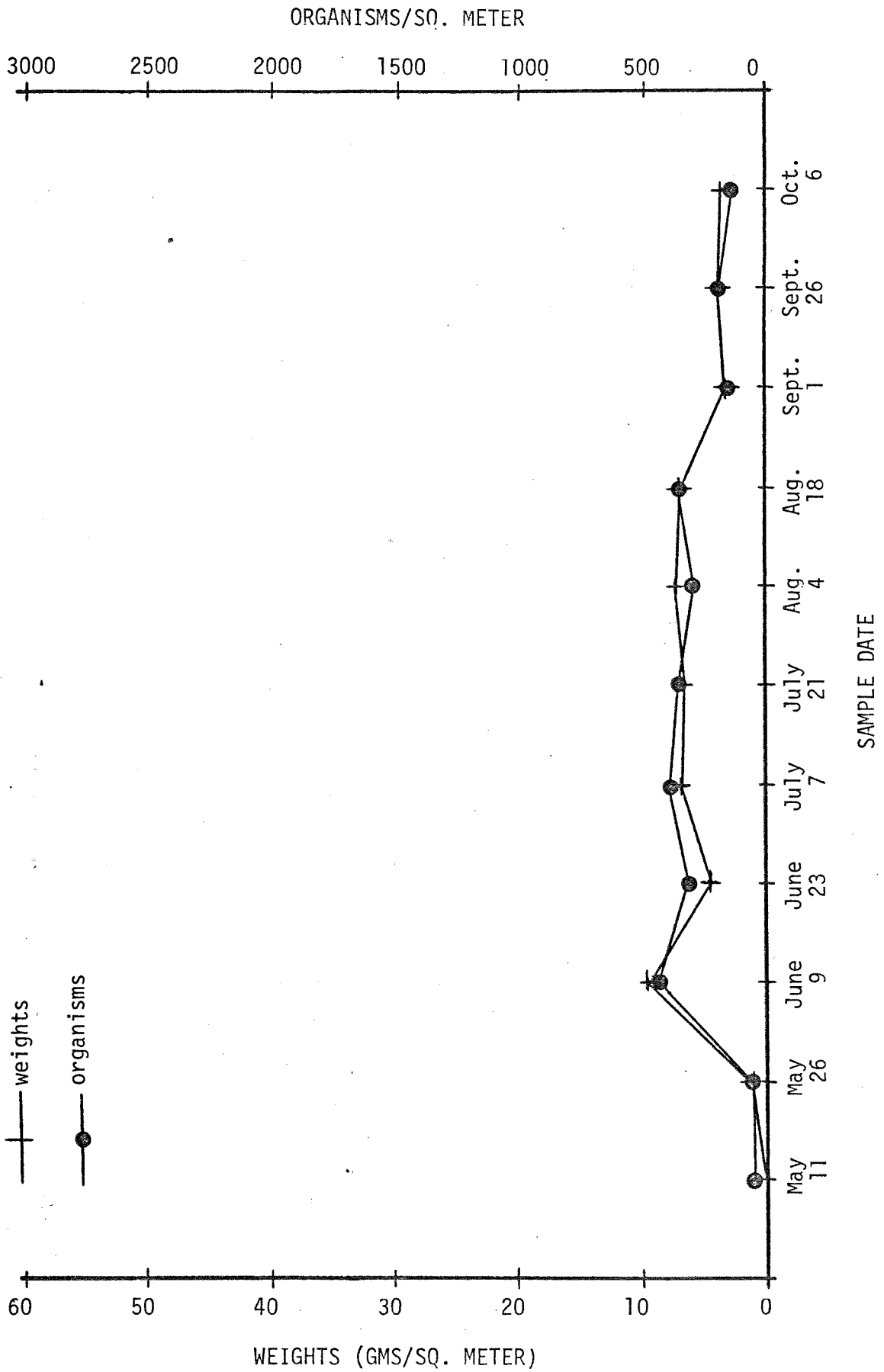


Fig. 6. Average biomass (gms/m²) and average number of organisms/m² distributed according to site at transect E between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River.

Fig. 7. Average biomass (gms/m²) and average number of organisms/m² distributed according to site at transect F between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River.

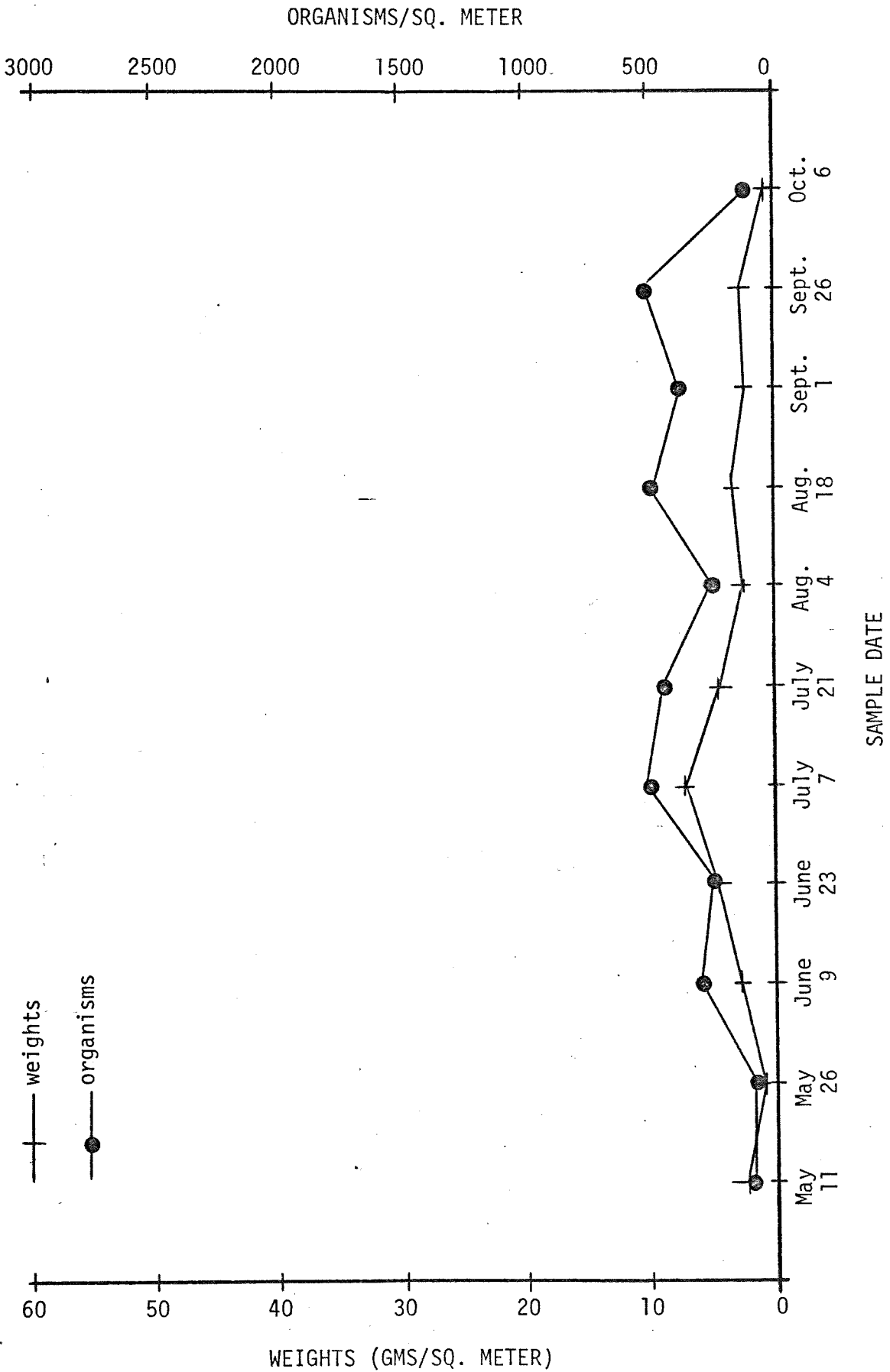
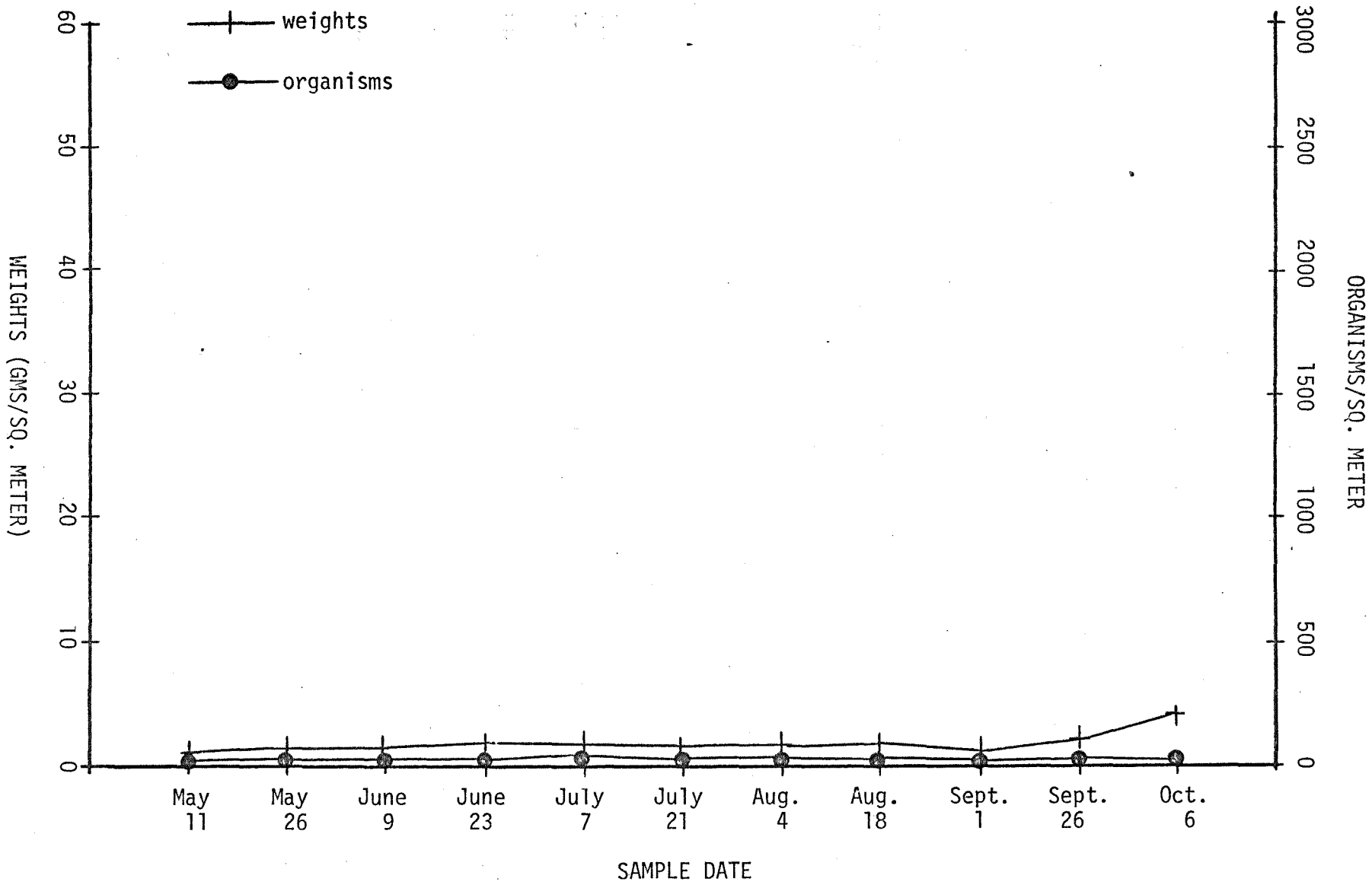


Fig. 8. Average biomass (gms/m²) and average number of organisms/m² distributed according to site at transect G between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River.



DISCUSSION

Each of the transects was selected for its physical characteristics; specifically, water flow, bottom type and depth ranges. The average biomasses for all transects were compared and found to be significantly different (99% confidence level) on all sample dates. The analyses of variance (F-distribution) was also performed between individual transect sites and these were found to be significantly different (99%) on all sample dates. The differences between the transects and between the sites on all sample dates can likely be attributed to numerous causes. Most of the transects (except D and E) were similar, in relation to substrate, along the length of the transect. However, the depth varied from site to site, especially during river level fluctuations. This fact might explain the differences between sites. Carlson (1967) substantiated this when he noted that different groups of organisms would dominate various depths. At transects D and E, not only depth varied, but also the substrate type was different within the transects. The substrate variation was due to heavy sand deposition. Another possible reason for differences between transects and between sites might be the sampling procedures. In areas of sand only (parts of transects D and E and transect G), the Peterson dredge did not obtain complete grabs of the substrate. All other areas had soft substrates from which full grabs were made throughout the sample period. Other variables include emergences of insects, dominance shifts, and water temperature fluctuations.

Low biomasses were observed at all transects on May 11 and May 26. These low biomasses were probably due to high water levels. Flood or near flood conditions, due to heavy rainfall and rapid snow melt, occurred continually between April 12 and June 2, 1973 (U. S. Weather Service, personal communication). Studies by Keup, et. al. (1966), Hamilton (1961), Chutter (1968) and Ellis (1936) all reported adverse effects upon benthic organisms during flood conditions due to subsequent siltation. Hynes (1960) showed that benthic fauna was affected in two ways by sedimentation. First, the silt loads suspended in the water rendered plant and algal growth impossible by reducing light penetration. Consequently, no food was available to herbivores and detritus feeders, and they relied on allochthonous nutrients as a source of energy. Secondly, when inert solids settle out of the water, they smother the bottom-dwelling organisms which are incapable of moving to a more suitable area. Elsworth (1958) found that the nymph of the mayfly Pseudocloeon vinosum and Simulium sp. larva were only found in areas which were unaffected by heavy silt loads. Elsworth did not discuss species which were collected during this study, but his data substantiates the fact that silt loads during flooding was capable of eliminating non-tolerant species.

Four of the transects included in this study (transects A, B, C, & F) can be classified as lake-like rather than river-like. This classification is based on water flow (<0.5 km/hr during 10 lowest months) and substrate type (organic or inorganic silt) as defined by Pennak (1971). These lake-like habitats provided the greatest overall standing crops throughout the sample period, particularly between early June and late

August. A study by Peterka (1972) of Lake Ashtabula, North Dakota, indicated that most species of benthic organisms reached peak biomass levels between late May and early August. Peterka's research substantiated the data from this study, but it was still obvious that biomass levels recorded during this study were lower than expected on the early sample dates, probably due to high water conditions. The rapid increases in biomass from May 26 to June 23 could be attributed to immigration of organisms into the sample areas following the high water conditions.

Distinct dominance shifts were noted at transects B and F, with the ephemeropteran numbers decreasing due to emergence and Dipteran numbers increasing due to hatching of eggs (Heuschele, 1969). A smaller shift in dominance was observed at transect E where ephemeropterans were most common from May to July, but after mayfly emergences, dipterans and oligochaetes were the only organisms of significance. C. A. Carlson (1967) reported this type of dominance shift during his study of the benthic fauna of the Mississippi River, above Dam 19, Keokuk, Iowa, when he said, "As the most abundant insects emerged during each summer (1960-1961), other elements of the benthos increased in abundance."

The effects of dredging in the study area will require further research, but the effect on transects D and E clearly indicated that these areas are being altered. Dredging of the main channel of the Mississippi is also altering these areas. The slough opening from the main channel at transect G (Fig. 1) is capable of carrying heavy loads of sand and silt from the channel into the backwater areas. As

the backwater channels become more intricate, the water velocity decreases and heavy sand deposition occurs. The overall effect is rapid filling of the already shallow backwater areas and subsequent reduction of water flow necessary to maintain the benthic fauna.

LITERATURE CITED

- Carlson, C. A. 1967. Summer bottom fauna of the Mississippi River, above dam 19, Keokuk, Iowa. *Ecology* 49: 162-168.
- Chutter, F. M. 1968. The effects of silt and sand on the invertebrate fauna of streams and rivers. *Hydrobiologia* 34: 57-76.
- Davies, J. N. 1967. A limnological comparison of three lakes in Northern Wisconsin. Unpublished paper.
- Ellis, M. M. 1936. Erosion silt as a factor in aquatic environments. *Ecology* 17: 29-42.
- Elsworth, J. F. 1958. Hydrobiological studies on the Great Berg River, Western Cape Province. *Trans. R. S. Afr.* 35: 125-226.
- Fasset, N. C. 1957. *A Manual of Aquatic Plants*. University of Wisconsin Press, Madison, Wisconsin. 405 pp.
- Hamilton, J. D. 1961. The effect of sand-pit washings on a stream fauna. *Verh. int Verein. Limnol.* 14:435-439.
- Heuschele, A. S. 1969. Invertebrate life cycle patterns in the benthos of a floodplain lake in Minnesota. *Ecology* 50: 998-1010.
- ✓ Hynes, H. B. N. 1960. *The Biology of Polluted Waters*. Liverpool University Press, Liverpool. 202 pp.
- Keup, L. E., W. M. Ingram, and K. M. Mackenthun. 1966. The role of bottom-dwelling macrofauna in water pollution investigations. *Public Health Service Public. No. 999-WP-38: 1-23.*
- ✓ Mendenhall, W. 1971. *Introduction to Probability and Statistics*. Wadsworth Publishing Company, Inc., California: 243-248.
- Paine, R. T. 1966. Food web complexity and species diversity. *Amer. Nat.* 100: 65-75.
- Patrick, R. 1970. Benthic stream communities. *Amer. Sci.* 58: 546-549.
- Pennak, R. W. 1953. *Fresh-water Invertebrates of the United States*. Ronald Press Company, New York. 769 pp.
- _____. 1971. Toward a classification of lotic habitats. *Hydrobiologia* 38: 321-334.
- Peterka, J. J. 1972. Benthic invertebrates in Lake Ashtabula Reservoir, North Dakota. *Amer. Mid. Nat.* 88(2): 408-418.

Table 4. Biomass (gms/m²) obtained at the 6 sites of transect A from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.

Sample Date	May 11	May 26	June 9	June 23	July 7	July 21	Aug. 4	Aug. 18	Sept. 1	Sept. 26	Oct. 6
Site A ₁	5.26	4.75	12.16	25.38	13.73	13.78	17.40	4.32	10.40	2.35	0.42
Site A ₂	8.23	6.92	11.47	17.58	51.82	43.09	62.14	17.20	8.07	0.21	1.33
Site A ₃	3.98	2.73	7.11	23.06	28.54	55.04	64.14	3.07	10.64	0.22	0.15
Site A ₄	10.04	7.82	6.76	33.93	86.04	35.23	85.90	32.42	5.13	0.53	0.55
Site A ₅	12.01	11.23	0.66	23.95	75.28	61.59	68.23	50.71	3.34	6.46	7.82
Site A ₆	2.38	2.56	0.74	7.51	42.17	25.42	61.45	30.31	4.74	11.07	6.78

Table 5. Biomass (gms/m²) obtained at the 6 sites of transect B from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.

Sample Date	May 11	May 26	June 9	June 23	July 7	July 21	Aug. 4	Aug. 18	Sept. 1	Sept. 26	Oct. 6
Site B ₁	0.16	0.01	0.98	7.11	5.15	0.02	0.0	0.26	0.0	0.29	0.0
Site B ₂	1.19	3.66	3.98	23.94	37.10	6.18	1.25	0.36	0.0	0.46	0.27
Site B ₃	4.35	2.78	4.86	6.15	7.68	1.67	0.08	1.01	0.04	0.43	0.07
Site B ₄	4.59	4.95	8.17	19.98	23.94	10.52	7.76	2.24	0.16	0.09	0.0
Site B ₅	0.47	1.29	8.20	22.74	20.64	5.77	2.84	0.71	0.10	0.0	0.23
Site B ₆	0.09	1.11	5.16	7.43	11.13	6.54	6.41	1.13	0.31	0.0	0.03

Table 7. Biomass (gms/m²) obtained at the 6 sites of transect D from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.

Sample Date	May 11	May 26	June 9	June 23	July 7	July 21	Aug. 4	Aug. 18	Sept. 1	Sept. 26	Oct. 6
Site D ₁	0.64	0.66	8.04	7.93	6.43	17.67	16.30	15.77	8.07	7.76	14.05
Site D ₂	0.34	3.05	11.81	4.71	--	--	--	--	--	--	--
Site D ₃	0.17	2.73	21.00	4.55	10.27	--	--	--	--	--	--
Site D ₄	0.22	0.18	15.30	7.54	13.72	12.33	9.80	11.82	8.52	8.24	3.36
Site D ₅	0.0	0.0	0.98	1.43	4.69	2.42	16.32	12.46	1.30	4.75	1.14
Site D ₆	0.0	0.0	0.0	0.0	5.28	5.78	1.38	1.02	1.16	1.42	1.81

NOTE: -- indicates 'no sample' due to exposure as dry land.

Table 8. Biomass (gms/m²) obtained at the 6 sites of transect E from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.

Sample Date	May 11	May 26	June 9	June 23	July 7	July 21	Aug. 4	Aug. 18	Sept. 1	Sept. 26	Oct. 6
Site E ₁	8.09	5.13	10.42	9.88	19.39	5.28	1.29	4.76	1.92	3.00	1.42
Site E ₂	1.31	5.23	5.58	6.26	11.08	10.34	9.39	9.26	4.13	4.02	3.67
Site E ₃	6.86	3.41	4.58	5.18	12.84	11.27	8.05	11.55	7.27	8.80	6.23
Site E ₄	12.58	10.53	9.60	5.46	4.72	4.29	8.79	10.16	7.51	10.54	3.07
Site E ₅	0.0	0.0	0.0	3.29	3.07	7.56	5.87	6.86	3.54	1.90	0.39
Site E ₆	0.0	0.0	0.0	0.0	0.0	1.83	0.90	1.14	0.0	2.15	2.34

Table 9. Biomass (gms/m²) obtained at the 6 sites of transect F from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.

Sample Date	May 11	May 26	June 9	June 23	July 7	July 21	Aug. 4	Aug. 18	Sept. 1	Sept. 26	Oct. 6
Site F ₁	1.29	0.19	2.13	1.39	2.24	2.04	1.36	3.31	2.18	1.75	1.30
Site F ₂	6.79	1.42	3.07	2.47	8.39	4.34	2.01	1.25	3.71	4.95	0.65
Site F ₃	3.61	0.95	1.17	2.08	7.00	4.71	3.44	4.32	2.85	1.57	0.85
Site F ₄	0.61	0.70	4.98	4.64	12.87	7.65	3.64	5.38	3.17	1.41	0.35
Site F ₅	1.61	1.57	3.04	13.94	3.98	4.14	4.17	3.87	0.79	5.17	0.42
Site F ₆	0.20	0.62	3.25	3.50	7.79	4.34	1.17	2.74	2.48	2.75	1.07

Table 10. Biomass (gms/m²) obtained at the 6 sites of transect G from May 11 to October 6, 1973, in Navigation Pool 8, upper Mississippi River.

Sample Date	May 11	May 26	June 9	June 23	July 7	July 21	Aug. 4	Aug. 18	Sept. 1	Sept. 26	Oct. 6
Site G ₁	0.0	1.01	6.01	7.55	0.0	0.02	0.0	0.0	0.0	0.0	0.0
Site G ₂	0.02	6.34	0.08	0.0	1.79	0.0	1.05	0.0	1.69	0.0	0.0
Site G ₃	4.07	0.02	0.02	1.06	0.0	4.73	0.0	8.70	0.0	10.62	0.0
Site G ₄	0.03	0.0	0.0	0.0	6.14	0.0	0.0	0.0	0.0	0.0	24.57
Site G ₅	1.24	0.93	1.74	1.74	1.19	4.10	8.06	1.26	4.60	0.92	0.0
Site G ₆	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 11: Taxonomic list of organisms obtained at all transects between May 11 and October 6, 1973, in Navigation Pool 8, upper Mississippi River.

(Note: An asterisk indicates organisms which were collected less than five times over the duration of the study period.)

Platyhelminthes
Turbellaria
Planariidae*

Annelida
Oligochaeta
2 unidentified species
Hirudinea
Glossiphoniidae
Glossiphonia sp.*
Helobdella sp.

Arthropoda
Crustacea
Amphipoda
Hyalella sp.*
Isopoda
Asellus sp.*

Insecta
Ephemeroptera
Ephemeridae
Hexagenia bilineata
Baetidae
Ephemerella sp.*
Baetis sp.
Tricoptera
Leptoceridae
Leptocella sp.*
Odonata
Zygoptera
Coenagrion sp.*
Lestes sp.
Anisoptera
Aeschna sp.*

Diptera
Tendipedidae
Tendipes sp.
Culicidae
Culex sp.*
Chaoborus sp.
Heleidae
Palpomyia sp.
Tipulidae
Tipula sp.*

Mollusca
Gastropoda
Physidae
Physa sp.
Lymnaeidae
Lymnaea sp.
Planorbidae
Gyraulus sp.*

Pelecypoda
Sphaeriidae
Sphaerium sp.
Pisidium sp.
Unionidae
Tritogonia verrucosa*