DREDGED MATERIAL RESEARCH PROGRAM

MISCELLANEOUS PAPER D-78-[illegible]

ENVIRONMENTAL IMPACT OF DREDGED MATERIAL DISPOSAL ON THE UPPER MISSISSIPPI RIVER AT CROSBY SLOUGH

by

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August 1978

Final Report

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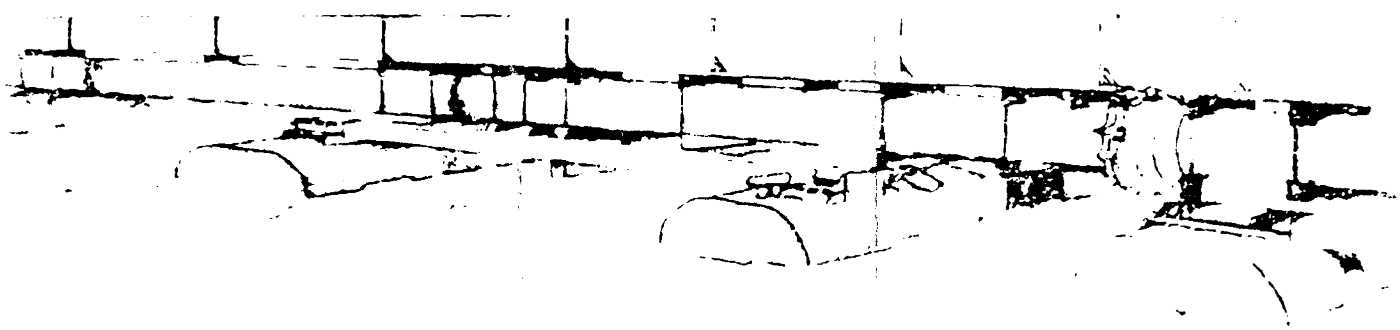

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SUBJECT: Transmittal of Miscellaneous Paper D-78-3

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1. The miscellaneous paper transmitted herewith represents the results of one of the research efforts (work units) of the Corps of Engineers' Dredged Material Research Program (DMRP). This study was conducted by the Habitat Development Project (HDP) of the DMRP. The HDP had as its main objectives the development of wetland and upland habitats on dredged material and the evaluation of the impact of disposal in shallow water and upland sites.

2. This report, "Environmental Impact of Dredged Material Disposal on the Upper Mississippi River at Crosby Slough," presents the findings of the monitoring of the biological, physical, and chemical effects of a single disposal operation near Island 117, Pool 8, Upper Mississippi River. No effects that could not be attributed to normal variation were observed. These results may reflect the system's ability to assimilate relatively small impacts or a weakness in the state-of-the-art in detecting and interpreting environmental impacts. Extrapolation of these data to other sites should be approached carefully.

3. This work unit (2A04) has application to the assessment of overall environmental impact of the habitat development disposal alternative and is one of many research efforts in the HDP with a similar objective. This and related work units will be synthesized in a report entitled "Upland and Wetland Habitat Development with Dredged Material: Ecological Considerations" (2A08).

JOHN L. CANNON
Colonel, Corps of Engineers
Commander and Director

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

This study was designed to investigate the environmental effects of disposal of material from maintenance dredging on the aquatic habitat around Island 117, Pool 8, Upper Mississippi River. Dredging impacts of disposal of dredged material in the past have included the conversion of productive aquatic and semiaquatic habitat to sandy shoals and islands, as well as the impairment of backwater circulation.

(Continued)

20. ABSTRACT (Continued).

Various biological, physical, and chemical variables were measured prior to, during, and after the discharge of dredged material. On 28-29 August 1974 the WILLIAM A. THOMPSON deposited 11,144 yd^3 of sand on Island 117, about 17 percent of the average job size at this site.

Disposal activity at Island 117 during 1974 produced no measurable effect on those variables considered. The reasons for the negligible impact may have been as follows: (1) a relatively small amount of material was deposited at this site in 1974 (11,144 yd^3 compared to a 19-year average job size of 65,500 yd^3); (2) dredged material was not allowed to pass over the crest of Island 117 into backwater areas as it had in past years because of court-ordered dredged material placement limitations imposed by the State of Wisconsin; and (3) the variance of the baseline data, caused by annual, seasonal, and diel fluctuations, was significant for most variables.

Changes recorded in benthos biomass were due to natural production phenomena rather than the effects of deposition of dredged material. The principal change was an increase in benthos biomass following the disposal operation due to the appearance of young mayfly nymphs in the samples. Similarly, there were no changes in catch per unit of effort or composition of fish catches attributable to the 1974 disposal activity. The species of fish captured were likely dictated by gear selectivity on a habitat basis, different gear being more or less effective in different habitats.

There was a general increase in mean particle size of sediments at the 50 sample sites from early to late summer. However, the trend was not consistent, particularly at or near the disposal site; consequently, these changes were probably due to natural sedimentation phenomena. The core sample stations were located in the backwater areas. Since dredged material did not reach these areas in 1974, any effects of the disposal operation could not have been demonstrated by these samples.

If 1974 disposal activities affected water quality in the study area, these effects were masked by the natural background variation in the variables considered. Turbidity and nitrite-nitrogen, which were increased by disposal of dredged material in 1973, were not significantly altered during 1974.

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PREFACE

The work described in this report was performed under Contract No. DACW37-74-C-0101, entitled "Environmental Impact of Upland Disposal of Dredged Material at Island 117 (Crosby Island), Pool 8, Upper Mississippi River," dated June 1974, between the U. S. Army Engineer District, St. Paul (NCS), and the River Studies Center, University of Wisconsin-La Crosse. The St. Paul District administered the contract, which was part of the Habitat Development Project (HDP), Dredged Material Research Program (DMRP). The DMRP was conducted by the Environmental Laboratory (EL) of the U. S. Army Engineer Waterways Experiment Station (WES). COL Rodney E. Cox, CE, NCS, was contracting Officer.

This report describes a study designed to assess the environmental impact associated with land disposal of sandy material on the aquatic habitat around Island 117, located in Navigation Pool 8, Upper Mississippi River. The study was conducted during the period of June 1974 to June 1975. The report was prepared by Dr. John W. Held. Assisting in the field investigation and in the laboratory analyses were Messrs. David Bahr, Michael Bur, and Randy Olson.

The contract was managed by Mr. John Lunz of EL under the general supervision of Dr. Hanley K. Smith, Project Manager of HDP, and Dr. John Harrison, Chief, EL. COL G. H. Hilt, CE, and COL J. L. Cannon, CE, were Directors of WES during the conduct of the study and the preparation of the report. Mr. F. R. Brown was Technical Director.

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LIST OF FIGURES

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
inches	2.54	centimetres
feet	0.3048	metres
miles (U. S. statute)	1.609344	kilometres
cubic yards	0.7645549	cubic metres

PART I: INTRODUCTION

Background

1. The Environmental Laboratory (EL) of the U. S. Army Engineer Waterways Experiment Station (WES) conducted an extensive study of dredging and disposal activities as part of its Dredged Material Research Program (DMRP). An integral part of the broad research program is the study of the impacts of (a) dredged material disposal on upland areas; and (b) management schemes applied to upland disposal sites.

2. The Crosby Slough area of the Mississippi River Floodway (St. Paul District) is representative of over 300 miles* of the Upper Mississippi River system. This reach is characterized by frequent maintenance dredging of sandy material and the lack of long-term dredged material disposal sites. The problems that exist in this part of the river system due to dredging are related to the instability of this sandy material after it is pumped onto emergent upland islands. Shoreline and aeolian erosion transport the dredged material either back into the channel from which it came or into backwater areas, thus affecting circulation through, and flushing of productive natural habitats.

Purpose

3. In light of work carried out by the University of Wisconsin-La Crosse (UW-L) as subcontractor to the North Star Research Institute in

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is found on page vi.

1973 and in conjunction with the present study being carried out by UW-L for the U. S. Army Engineer District, St. Paul, on the revegetation of a dredged material island (Island 117), UW-L was contracted to perform an investigation to assess the environmental impacts of (a) upland disposal of dredged material associated with operation and maintenance dredging adjacent to Island 117, Wisconsin; and (b) the effect of fertilization on water quality as a result of revegetation efforts on the upland dredged material disposal site for the purposes of substrate stabilization and enhancement of wildlife habitat.

PART II: RESEARCH OUTLINE

Background

4. The River and Harbor Act of 3 July 1930 provided the U. S. Army Corps of Engineers (CE) authorization for a 9-ft channel navigation project on the Upper Mississippi River, extending from Minneapolis, Minnesota, to the mouth of the Missouri River. This legislation provided for a navigation channel depth of 9 ft to be achieved by construction of a system of locks and dams, supplemented by dredging.

5. The 9-ft channel project resulted in increased capacity for commercial navigation. This potential has been reflected in increased benefits to the economies of the upper Midwest. Similarly, the maintenance of authorized pool elevations has increased the acreage of aquatic habitat for many species of fish and wildlife, resulting in increased biological productivity of the aquatic communities involved.

6. Recently, however, some river biologists have questioned whether the environmental benefits of the 9-ft channel were not in fact short-term benefits. Evidence indicates that the river system is experiencing degradation of many environmental values due to accelerated eutrophication. The gradual isolation of productive areas lateral to the main channel has resulted in decreased current velocities and increased sedimentation rates. The resultant decrease in depth has promoted rapid encroachment of rooted aquatic vegetation. With continual addition of allochthonous nutrients into these areas and the apparent recycling of autochthonous material, nutrient accumulation has been indicated (Claflin, 1974a). After preliminary investigations of the alteration of habitats suitable for recreation, fish,

and wildlife, attention was focused on the environmental impacts of 9-ft channel maintenance dredging and disposal activities.

The Problem

7. Maintenance dredging in Pool 8 is accomplished primarily by the WILLIAM A. THOMPSON, a 20-in. hydraulic dredge. Placement of the dredged material is limited by the THOMPSON's 1800 ft of floating pontoon line and 900 ft of shorepipe. Subsequent to the court-ordered injunction (spring, 1974) by the State of Wisconsin, the normal overdredging depth of 13 ft was reduced to 11 ft, and placement of the dredged material on Wisconsin shores was severely limited. The cost per cubic yard of material dredged by the THOMPSON during the 1973 navigation season was $0.347 (U. S. Army Engineer District, St. Paul, 1974).

8. The present least-cost method of dredged material disposal into water outside of the channel and onto upland areas has reduced the acreage of biologically productive aquatic habitat. The principal direct adverse impact of this method has been the conversion of aquatic and semiaquatic habitats to less productive sandy shoals or islands as a result of placement of dredged material. The habitats affected consist primarily of main channel border, including some of the wing and closing dams constructed prior to the 9-ft channel, and adjacent shallow waters and wetlands. The indirect impacts, resulting from secondary movement of the dredged material, include impairment of backwater circulation and the redeposition of dredged material (sand) in productive backwater areas.

9. The adverse environmental impacts can best be summarized by the following statement from the final Environmental Impact Statement (EIS) on the operation and maintenance of the 9-ft channel, prepared by the St. Paul District:

> The present method of dredge spoil placement results in the unavoidable loss of aquatic and terrestrial habitat in areas adjacent to the navigation channel and subsequent displacement of associated wildlife. The placement of spoil frequently results in dredged material spreading out into off-channel areas affecting several types of shallow aquatic habitats, as well as submerged wing and closing dams which provide excellent habitat for the production of aquatic invertebrates and fish. Some of the spoil material is eroded and may be redeposited in the entrances of flowing sloughs, which are important to the biology of extensive backwater areas.......... (U. S. Army Engineer District, St. Paul, 1974:xii)

10. Reports indicate that dredging and disposal activities impair aquatic productivity and that backwater sloughs and lakes are being isolated from the flow of the river (Claflin, 1974a). The degree to which natural sedimentation phenomena and/or placement and secondary movement of maintenance dredged material are responsible is unclear. Baseline scientific data on the aquatic ecosystems and controlled experimental conditions before and after dredging and disposal operations are usually lacking. Such was not the case at Island 117 (Crosby Island); for this reason, the WES selected this site on the Upper Mississippi River for a study of the environmental impact of upland disposal of dredged material.

The Study Area

11. Navigation Pool 8, Upper Mississippi River, is 37.5 km long, the third longest in the St. Paul District (Figure 1). The pool has a total area of 21,020 ha, of which 8,248 ha is water surface, and has a shoreline

Fig. 1. Location and description of Pool 8, Upper Mississippi River. Island 117 is located on the east side of the main channel at river mile 690. (From U. S. Army Engineer District, St. Paul, [illegible] [illegible])

perimeter of 137 km. Lock and Dam 8 is located 679.2 river miles above the mouth of the Ohio River.

12. This investigation was conducted in the vicinity of Island 117 (Crosby Island), located in the middle of Pool 8. Island 117 extends from river mile 689.7 northward to mile 690.5 and is situated on the east (Wisconsin) side of the main channel (Figures 1 and 2). The Minnesota shore is only 0.3 km to the west of the island, just across the main channel. The Wisconsin shore, however, is 4.5 km to the east, a distance characterized by extensive backwater sloughs, marshes, and wooded islands. The mouth of Crosby Slough, a large feeder channel that delivers fresh water to an extensive backwater area, is just a few meters east of the head of Island 117.

13. Island 117 is a traditional disposal site for dredged material and, in fact, did not exist prior to maintenance dredging. The volume of material dredged each year in Pool 8 is approximately 154,000 yd^3. Island 117 receives about 41,400 yd^3/yr (19-yr average). Since material was deposited on Island 117 only 12 of the 19 yr, the average job size at this site was 65,500 yd^3. The range of volumes deposited on Island 117 is 123,000 yd^3 in 1973 to 11,144 yd^3 in 1974 (St. Paul District, personal communication).

14. During 1973, the UW-L River Studies Center conducted an environmental assessment of Pool 8. During this 1973 study period, the WILLIAM A. THOMPSON deposited 123,000 yd^3 of dredged material on Island 117. Notice of this activity afforded the opportunity to establish sampling stations around Island 117 (sites 2-41, Figure 2) and to determine the impact of the dredged material disposal operation on the aquatic environment.

Fig. 2. Aerial photograph (1967) of Island 117 and surrounding area. Numbers 2 through 51 refer to the sites sampled during this study

Of the chemical and physical variables measured before, during, and after this 1973 disposal operation, biologically significant differences attributed to the discharge of dredged material were noted in the increased levels of nitrogen (nitrite and nitrate) and turbidity. These local increases were the result of slurry runoff from the disposal site. There was also a significant reduction in the biomass of benthos macroinvertebrates (particularly mayfly nymphs and molluscs) at sensitive sampling stations close to the dredging site (Claflin, 1974b).

15. The UW-L River Studies Center, under contract with the St. Paul District, conducted a revegetation study on Island 117 during the summer of 1974. Attempts were made to establish various plant species in order to stabilize the dredged material and to enhance wildlife habitat.

16. The 1974 impact study, the subject of this report, was in large degree an extension of the 1973 investigation mentioned in paragraph 14. During 1974, ten additional sites were included with the 40 original sites in order to obtain adequate samples of the various habitats present in the vicinity of Island 117 (Figure 2).

Study Objectives

General

17. The following is quoted from the St. Paul District EIS for the 9-ft channel:

> Secondary impacts of channel maintenance are difficult to ascertain and probably impossible to quantify. If a specific action somehow modifies the environment of a particular species so that the carrying capacity for that species is reduced, then a lower density population for the species will result within the affected area. Channel maintenance

> could affect a larger percentage of a species population than that occupying a spoil disposal area if a critical stage in the life cycle of that species were affected or a critical link in that species food chain were affected. For example, if dredge spoil disposal removed the food supply of a group of species, it would be obvious that the species would decline in numbers or be eliminated. A reduction of aquatic invertebrates would adversely affect those species of fish dependent upon them as a primary food source. It is impossible to state at the present time the number of species which may be affected in the above manner or the degree to which these effects may be occurring. Channel maintenance not only secondarily affects the natural resources of the river, but also affects the utilization of those resources. (U. S. Army Engineer District, St. Paul, 1974:215-216)

18. The above quotation exemplifies the lack of understanding of the direct and indirect impacts of channel maintenance dredging and disposal activities on the aquatic ecosystem. This lack of understanding is due in large part to the paucity of reliable baseline information on this river system and to past difficulties in coordinating maintenance operations and scientific investigations. It was felt, therefore, that Island 117 presented a unique opportunity to study the impact of the disposal of dredged material during the 1974 maintenance dredging season. The experimental scheme was designed to measure several variables before, during, and after 1974 disposal operations.

19. The intent of this investigation was to (a) assess the effects of 1974 disposal operations on the aquatic system around Island 117; (b) compare these effects with results from the 1973 dredging study; and (c) determine whether fertilization of the island as part of the revegetation project had a measurable effect on water quality around the island.

20. It should be noted here that this project was undertaken with the assumption that 1974 dredging at Island 117 would be similar to past years. In short, it was not. Dredging during 1974 at Island 117 differed in two respects: (a) the volume of material dredged from the channel and placed on the island was small (11,144 yd^3); and (b) the dredged material was not permitted to pass over the crest of Island 117. Consequently, there was no slurry runoff into the slough along the east side of the island as has occurred in past years. The reason for these changes was a federal court ruling in May 1974 that limited dredging to 11 ft (instead of 13 ft) and gave the State of Wisconsin the right to impose dredged material placement limitations within the capacity of the DREDGE THOMPSON. The ruling resulted in a smaller amount of dredged material and no overtopping of Island 117. Also, the decision to dredge during 1974 was not made until 20 July, and dredging occurred at the end of the anticipated sampling schedule (28-29 August). For these reasons, much of the baseline information gathered throughout the summer was of little value in assessing the impacts of the 1974 disposal operations.

21. The following paragraphs describe the specific study objectives pertaining to the various biological, physical, and chemical indicators investigated.

Benthos

22. The main purpose of the benthos investigation was to determine whether 1974 disposal activity at Island 117 had any effect on benthos biomass. Samples were taken at 50 sites just prior to and immediately following discharge of dredged material, which occurred on 28 and 29 August 1974.

23. A postoperational benthos sample was taken on 27 June 1973 at 40 sites around Island 117 as part of an environmental assessment of Pool 8 (U. S. Army Engineer District, St. Paul, 1974). This provided an opportunity to sample on the same date in 1974 to determine if there were differences in annual benthos biomass and/or if there was appreciable recolonization of sites affected by the large amount of dredged material (123,000 yd^3) that was deposited from the 1973 dredging.

Fish survey

24. The intent of the fisheries investigation was to conduct a survey of fishes in the study area. Questions often arise regarding the possible effects of dredging and disposal activities on the fish community. Of particular concern is whether or not the dredged material disposal activity would affect the use of an area by sport and commercial fish species. Generally, however, there has been no assessment of the fish community in the area under question. It was determined, therefore, that a survey of fishes in the vicinity of Island 117 during the 1974 study period would contribute additional information about the aquatic resources of this area.

25. Results of an earlier satellite study of the northern pike (*Esox lucius*) spawning habitat in the study area were considered in this investigation. The northern pike is both a recreational resource and an important top carnivore in the trophic scheme of the Upper Mississippi River. The spawning habitat requirements of the northern pike are rather stringent; consequently, the future status of the species depends in part on maintaining its spawning habitat.

Sediment analysis

26. The sediment studies were designed to detect possible effects on backwater areas by dredged material placement on Island 117. Under the assumption that dredging activities during 1974 would follow the pattern of previous years, core sample stations were established along possible routes of sediment movement in the backwater areas east of the island. These stations were to be sampled prior to and following discharge of dredged material. Analysis of sediment particle size at all 50 chemistry-benthos sites before and after dredged material disposal was also scheduled in order to provide background information on normal seasonal changes in sediment particle size in these areas.

Water chemistry

27. The water chemistry study was designed to establish baseline data on several variables. Samples were taken from 40 sites on the anniversary date of the 1973 impact study to determine if there were significant annual variations in the variables considered. Samples from all 50 sites were taken every two weeks prior to disposal operations, in addition to one 24-hr sample, to measure natural seasonal and diel fluctuations in water quality. Samples were then taken during and after discharge of dredged material to determine if 1974 disposal operations significantly altered water quality.

28. A separate study on island 117 during 1974, the revegetation project, involved the placement on the island of approximately 567 kg of nutrients in the form of a commercial fertilizer (5.6 kg/ha) and vacuum-dried sewage sludge (224 kg/ha). One objective of the water chemistry analyses, therefore, was to determine if leaching of these nutrients from the revegetation project into the river was occurring.

PART III: METHODS AND MATERIALS

Benthos

Sampling sites and dates

29. Fifty sites were sampled for benthos during 1974 (Figure 2). The first 40 sites (2-41) were identical with those sampled during 1973. Ten additional sites (42-51) were chosen in 1974 in order to obtain adequate samples of the habitat types in the vicinity of Island 117.

30. Benthos were sampled on three occasions during 1974: 27 June, 16 August, and 31 August. The first sample (27 June) was the anniversary date of samples taken during the 1973 study. The latter two dates (16 and 31 August 1974) were predisposal and postdisposal samples, respectively.

Sampling methods

31. Three bottom grabs were taken with a petite Ponar dredge at each site on each date. The composite of the three grabs represented a bottom surface area of 696.8 cm^2. The samples were screen washed (No. 30 mesh) in the field and preserved in a rose bengal-formalin solution (Lackey and May, 1971). The organisms were separated in the laboratory by the sugar flotation technique (Anderson, 1959). They were identified and counted according to size groups within each taxon. Macroinvertebrates of major significance (from the pre- and post-disposal samples) were identified to species. Mean wet weight values were determined for each size group, except for the molluscs, for which the weights of the soft parts were individually determined.

32. Molluscs were excluded from the results that were to be used to compare 1973 with 1974 and from those to be used to compare preoperational and postoperational 1974 data. Soft part percentages were calculated

differently in this study and were, therefore, not comparable with 1973 data. Furthermore, it was felt that inclusion of this taxon, which included individuals from relatively low population densities but which represented high biomass, could easily mask trends and bias results.

33. A computer program of a one-way analysis of variance (ANOVA) was used to analyze statistically the benthos and chemistry data (Winer, 1962). All tests of significance were determined at the 99-percent level.

Fish Survey

34. Population estimates of mobile fish populations in the Upper Mississippi River are quite impractical, if not impossible, to make. Consequently, it is difficult to assess the direct impact of any habitat alteration on fish populations. It is possible in some cases, however, to establish trends of habitat utilization based on such indices as catch per unit of effort (c/f).

35. It was the intent and design of this fisheries investigation to (a) document, by survey methods, those fish species occurring in the vicinity of Island 117, and (b) determine whether there were any trends in habitat utilization within the study area by the fish community.

Fish sampling areas

36. Some fish-collection techniques, such as boomshocking and gill netting, do not lend themselves to the site approach taken in this study. Boomshocking, for example, might cover a distance characterized by as many as 12 benthos-water chemistry sites. Furthermore, a limited number of frame nets and gill nets could be set and picked within a 24-hr period.

For these reasons, the study area was subdivided into five fish-collection areas (Figure 3). These five subareas could easily be treated as separate units of area. It was further felt that, in a general way, each subarea represented a somewhat different habitat type.

Fish sampling methods

37. Fish were collected by gill nets, frame nets, boomshocking, and shore seining. Net placements and seine hauls within each subarea (I-V) are shown in Figure 3. Boomshocking areas generally included the entire littoral zone in each subarea.

38. Frame nets were normally set perpendicular to the current with the lead tied to the shore. The frame nets were constructed of two front rectangular frames (1.8 × 0.9 m), five hoops (0.8-m diameter), and 1.3-cm square mesh netting. The leads (15.2 × 0.9 m) were of 0.6-cm square mesh netting.

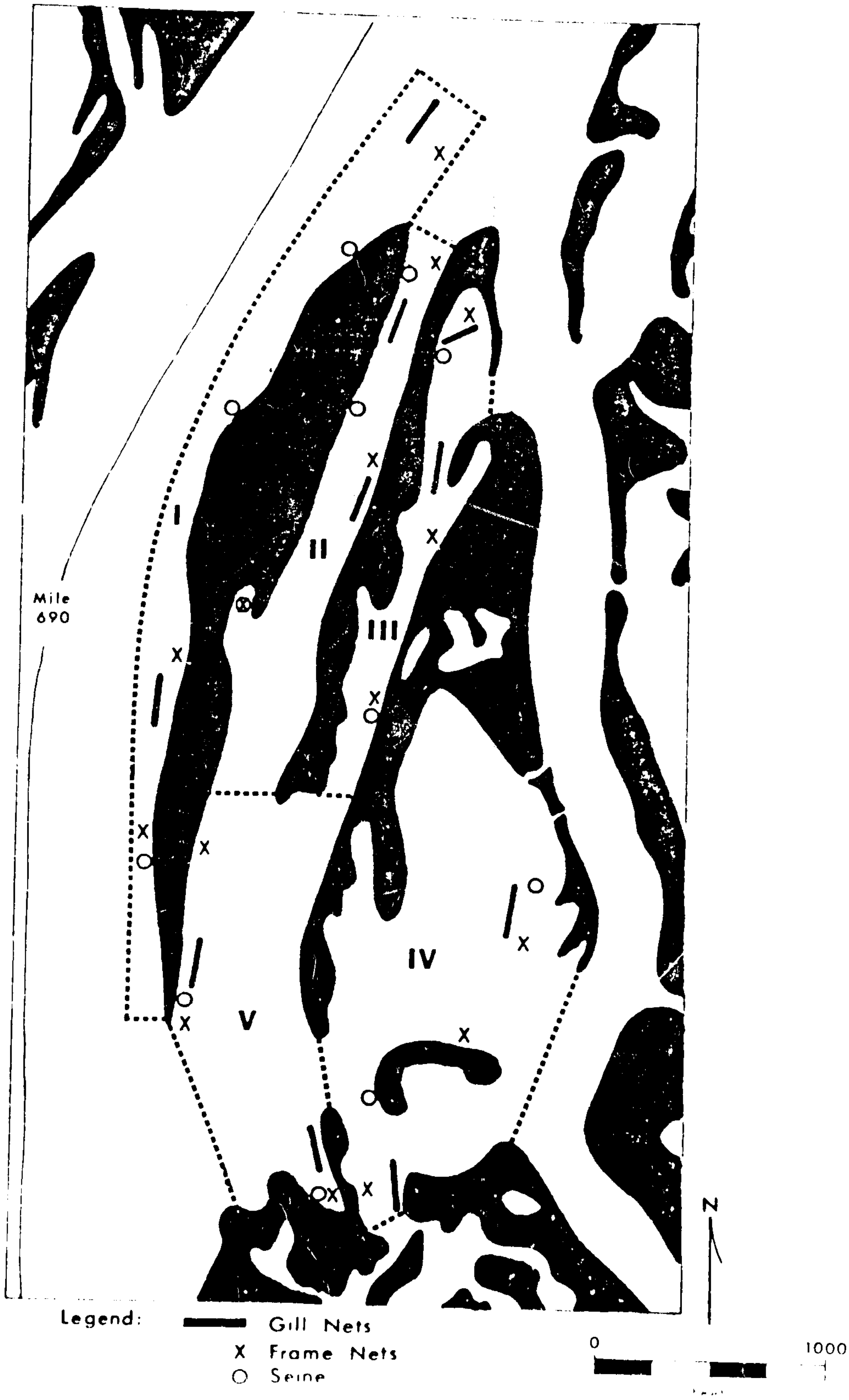
39. The experimental gill nets were set on the river bottom, parallel with the current. The nets were 50 × 1.8 m and consisted of 10-m sections of 3.8, 5.0, 6.4, 7.6, and 10.0-cm square mesh.

40. Shore seining was done by sweeping the seine along 35 m of shoreline. The seine (9.2 × 1.8 m) consisted of 0.3-cm square mesh netting.

41. Boomshocking was conducted during the night-time hours. The shocking unit generated 230 volts AC (180 cycle). Fish netted during a 30-min shocking run were held in a tank and later transferred to another boat for processing.

42. All large specimens were identified, weighed, and measured in the field. Small specimens were stored in 10 percent formalin and processed in the laboratory.

Fig. 3. Location of fish sampling areas I through V and the exact location of gill net sets, frame net sets, and shore-seining stations in the vicinity of Island 117, Upper Mississippi River



43. Shocking, gill net, and frame net data were converted to c/f. The c/f for shocking was the number of fish captured in 30 min of shocking. For experimental gill nets and frame nets, the c/f was the number of fish fish captured in 24 hr by each net.

Fish sampling schedule

44. Three fish collection periods were included in this study: 10-15 July, 13-19 August, and 29 August-2 September 1974. (For ease of identification on tables and figures, these periods of fish sampling will hereafter be referred to as July, August, and September, respectively.) Gill nets and frame nets were set in a different subarea each day during the five-day period. Boomshocking was conducted in one night during each of the three sampling periods.

Northern pike netting

45. During the spring of 1974 (prior to this contract period), frame netting for spawning northern pike was conducted in selected areas of the river near Island 117, including net sites in fish-collection area V. Nets were placed at sites corresponding to benthos-water chemistry sites 49 (net 1), 13 (net 2), and 14 (net 3). All captured northern pike were examined for sex and ripeness, weighed, and measured. Scales were removed from approximately a hundred specimens for age determination.

Sediment Analysis

Sample collection

46. Dredge samples for particle-size analysis were collected from each of the 50 benthos sites (Figure 2) during predisposal and postdisposal periods (21-28 June and 31 August-1 September 1974, respectively). Samples

were obtained in the same manner as benthos samples, i.e., with a petite Ponar dredge (232.3-cm^2 area) to an average depth of 8 cm. Samples were placed in labeled plastic bags for processing.

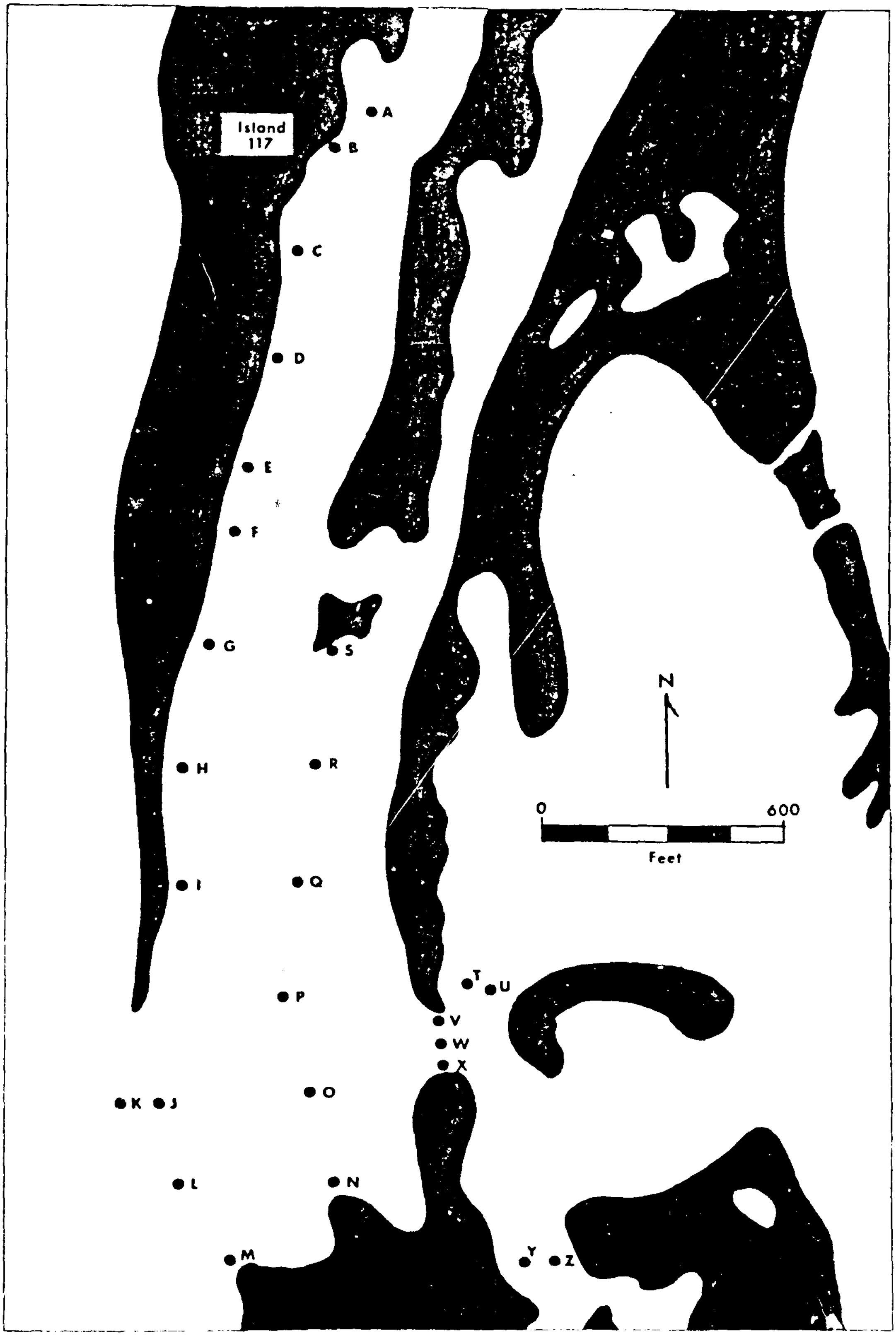
47. Core samples were taken from 26 sites during two periods, 14-31 July (predredging) and 1-31 September (postdredging) 1974. The 26 core sample sites (A to Z; Figure 4) were placed along possible routes of movement of dredged material, which in past years has resulted from dredged material outwash along the back (east) side of Island 117. Core samples were taken to a minimum depth of 0.5 m with a modified Wildco-Ballchek core sampler and post pounder. Beginning at the surface layer, 15-cm sections of the core sample were extruded into labeled containers for laboratory processing.

Sample processing and analysis

48. All sediment samples were oven-dried at 107°C for 24 hr and then weighed. The individual samples (or core sections) were crushed to particle size by mortar and pestle and placed in a nest of six sieves with the following mesh sizes: 2.0, 1.0, 0.5, 0.25, 0.125, and 0.063 mm. The sieves were shaken for 5 min, and the fraction of sediment on each sieve was weighed, as well as the fraction that passed through the 0.063-mm sieve. According to Krumbein and Sloss (1963), sieving was an appropriate method of mechanical analysis for the particle sizes encountered in this study.

49. The Wentworth grade scale (Wentworth, 1922) for standardized terminology (below) was used.

Fig. 4. Core sampling stations A through Z, located east of Island 117, Upper Mississippi River



Grade limits (Diameter, mm)	Name
2-1	Very coarse sand
1-0.5	Coarse sand
0.5-0.25	Medium sand
0.25-0.125	Fine sand
0.125-0.063	Very fine sand
<0.063	Silt and clay

50. Size distributions of the sediments from the 50 benthos sites were determined by plotting the cumulative percentages of succeeding grades on semilog paper and drawing a smooth curve through the points. The median diameter of particle size for each sample was found by following the 50-percent line to the intersection with the curve and reading the size value on the logarithmic abscissa. Since the median diameter represented the middlemost grain, with an equal weight frequency of grains on both sides, it was the average grain diameter of the sediment (Krumbein and Sloss, 1963).

51. Mechanical analysis of the top three 15-cm sections of each core sample followed the procedures outlined above. A visual comparison was then made between the percentages of size distribution for both dates (before and after disposal) at each of the 26 core sites.

Water Chemistry

Sample collection

52. Water samples were collected in the vicinity of Island 117 on the following dates during 1974:

Date	Sites (Figure 2)	Comments
8 July	2-51	-
22 July	2-51	-
22-23 July	6, 13, 46	Every 3 hr (diel)

Date	Sites (Figure 2)	Comments
14 Aug	2-51	-
19 Aug	2-20, 22, 24, 34, 36, 42, 43, 45, 47, 50	Initial predisposal data
27 Aug	2-20, 22, 24, 34, 36, 42, 43, 45, 47, 50	One day before disposal
28 Aug	2-20, 22, 24, 34, 36, 42, 43, 45, 47, 50	Day of disposal operations
30 Aug	2-20, 22, 24, 34, 36, 42, 43, 45, 47, 50	One day after disposal operations
6 Sept	2-51	One week after disposal operations

53. The number of sites sampled before, during, and after the disposal operation had to be reduced due to the late date of the dredging and disposal operations (28-29 August) and the short period of time of these operations (2 days).

54. Water samples were collected at mid-depth with a 2-ℓ Kemmerer bottle. Water temperatures were recorded immediately in the field. The samples to be analyzed for dissolved oxygen (DO) were fixed on site with Winkler reagents. All samples were stored in a cool, dark container until the analyses were completed.

Water sample analysis

55. DO concentrations were made using the azide modification of the Winkler technique. Determinations were made spectrophotometrically (at 450 mμ) aboard the UW-L research vessel within minutes of sample collection.

56. Turbidity was measured with a 110-volt turbidimeter (Model 1860 Hach: Hach Chemical Corporation, Ames, Iowa). Nitrate-nitrogen, nitrite-nitrogen, and orthophosphate concentrations were measured with a Bausch and Lomb Spectronic 20, using the reagents and procedures of the Hach Chemical Corporation

57. Measurements of dissolved organic carbon (DOC) were made by the UW-L Department of Chemistry. Samples were taken at 15 selected sites before, during, and after the disposal operation (19, 28, and 30 August, respectively). Samples were acidified in the field and refrigerated. The freeze-dried samples were later analyzed by the van Slyke wet combustion method, which measured the differential monometric pressure of evolved carbon dioxide (Steyermark, 1961).

PART IV: RESULTS AND DISCUSSION

58. The raw data from the measurement of the variables are given in Appendix A. These data were used in the preparation of the figures and tables as well as in the statistical analysis discussed herein.

Benthos

Comparison of 1973 and 1974

59. The differences in benthos biomass at 41 sites between 27 June 1973 and 27 June 1974 were variable and in most cases minor (Figures 5 and 6). (All benthos biomass totals discussed in this section exclude molluscs; see paragraph 32.) There did appear to be a trend in the biomass differences between the main channel sites (sites 2-12; mean biomass increase of 0.459 g/m^2 from 1973 to 1974) and the remaining off-channel sites (sites 13-41; mean biomass decrease of 0.772 g/m^2 from 1973 to 1974) (Figure 6). These differences, however, were likely the result of normal benthic production phenomena rather than recolonization of the channel sites following 1973 disposal of dredged material, because increases in biomass were noted upstream from the 1973 deposition area (at sites 6 and 7) as well as at downstream sites. Furthermore, back-channel sites 14-18 would have been affected in the same manner as channel sites 6-12 by 1973 disposal operations, but these back-channel sites exhibited a decrease in biomass from 1973 to 1974.

60. The peaks in benthos biomass at sites 13 and 20 (Figure 5) were due to large contributions by mayflies (*Ephemeroptera; Ephemeridae*) and oligochaetes.

Fig. 5. Benthos biomass (excluding molluscs) of bottom samples taken on 27 June 1973 and 27 June 1974 from 40 sites in the vicinity of Island 117, Upper Mississippi River (From Table A1)

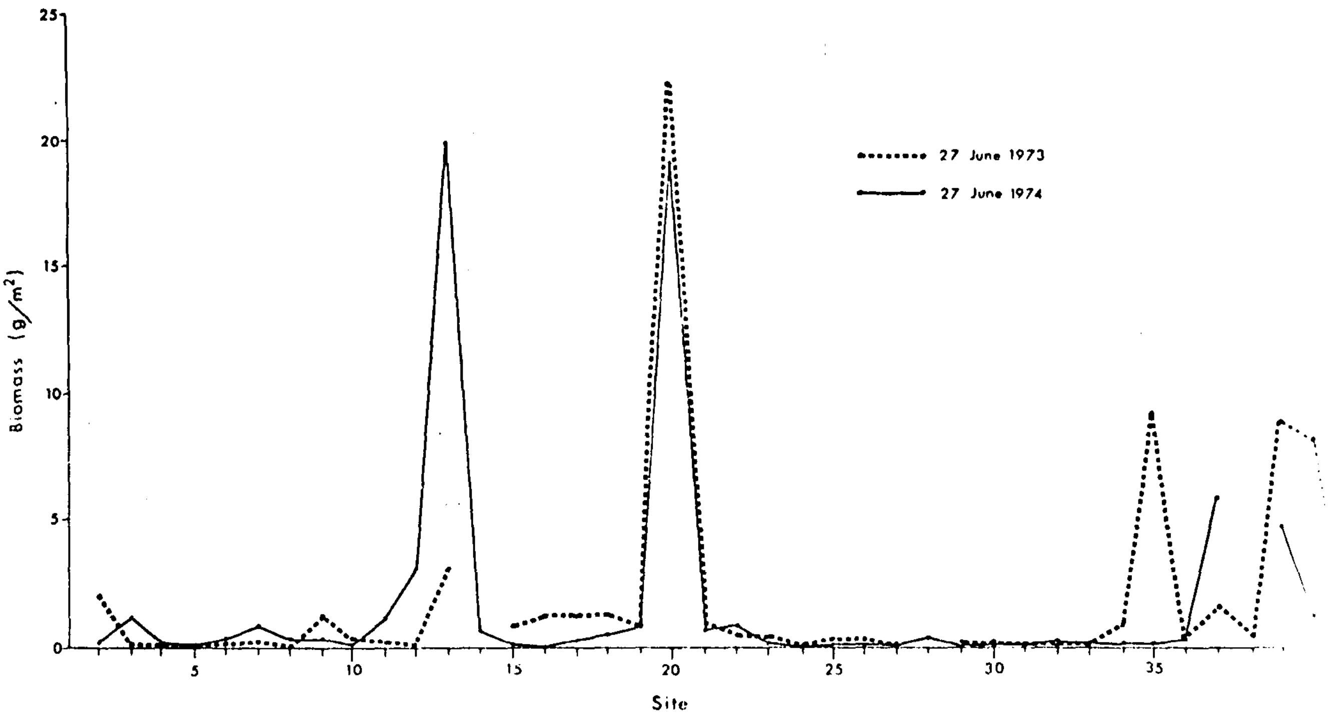
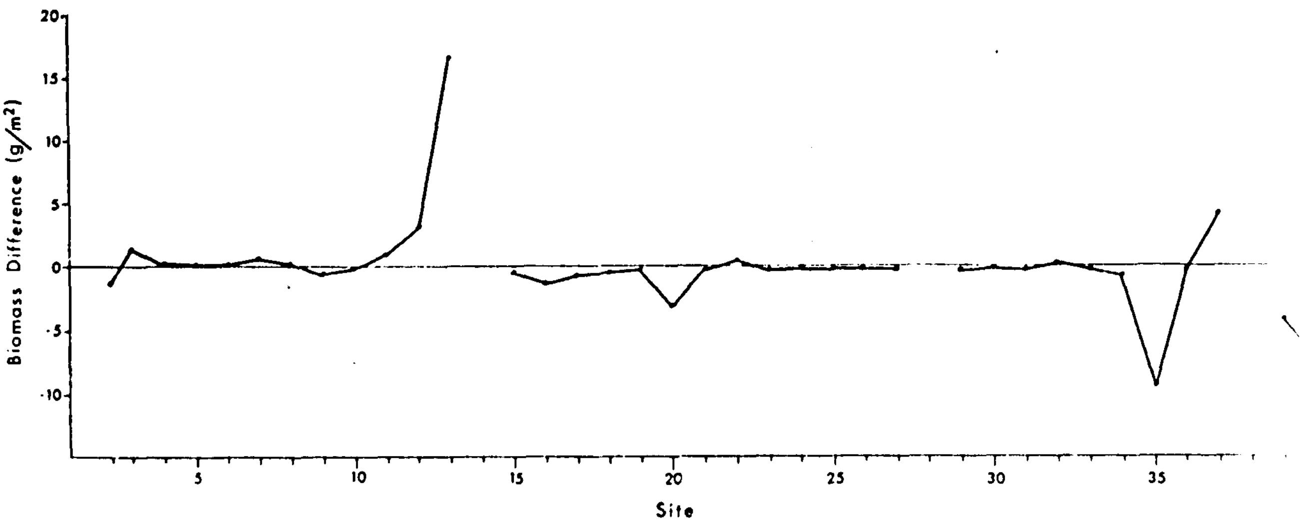


Fig. 6. Differences in benthos biomass (excluding molluscs) between samples taken on 27 June 1973 and 2 June 1974 from 40 sites in the vicinity of Island 117, Upper Mississippi River (From Table A1)



Before and after disposal operations, 1974

61. The difference between the preoperational (16 August) and postoperational (31 August) benthos samples in 1974 was an increase in benthos biomass from the former to the latter (Figures 7 and 8, and Table A2). Of the 50 sites sampled, 43 sites exhibited an increase in biomass on 31 August and 7 sites exhibited a decrease. The mean change between these dates was a 2.023-g/m^2 increase.

62. The increased biomass on 31 August 1974 was due primarily to a nine-fold increase (by number and biomass) of mayfly nymphs. Between 16 and 31 August, mean mayfly numbers increased from $4.2/m^2$ to $37.8/m^2$ and mean biomass increased from 0.094 to 0.855 g/m^2.

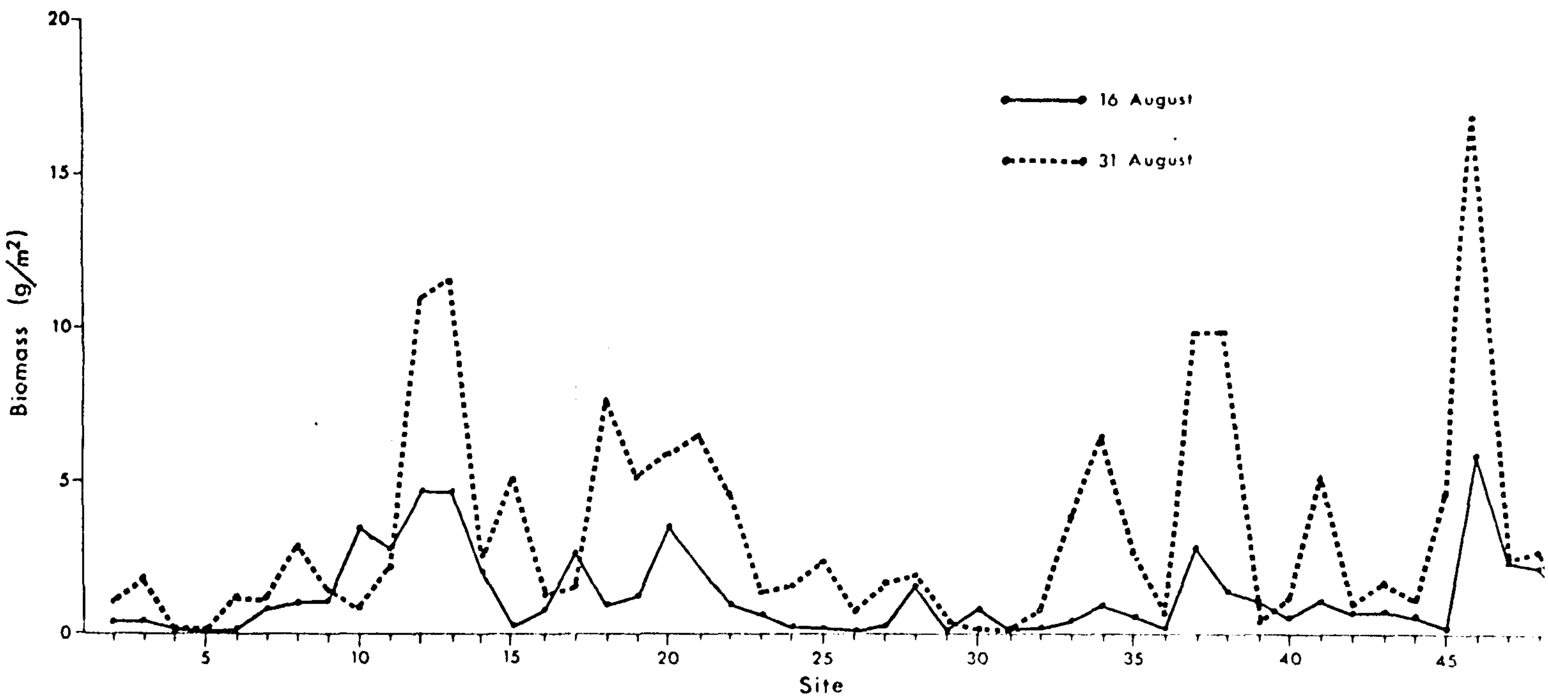
63. The increase in benthos biomass on the postdisposal date appeared to be the result of natural production phenomena rather than being attributable to the small amount of dredging and disposal during 1974. An increase was noted in all habitat types.

64. A regression correlation was run between site sediment particle size and benthos biomass (excluding molluscs) from two 1974 sampling periods, 27 June and 31 August (Table A3). There was a weak linear correlation (negative) between the two variables on both dates.

Benthos composition

65. Excluding molluscs, the Oligochaeta accounted for the greatest percentage of the benthos biomass in all three 1974 sampling periods (Figure 9), ranging from 44.3 to 68.0 percent of the total sample (Table A4). The dominant oligochaete at all sites for the two dates analyzed was *Tubifex tubifex*, which represented 87.1 to 89.2 percent of the oligochaetes by number (Table A5). Of lesser importance was the oligochaete

ig. 7. Benthos biomass (excluding molluscs) of bottom samples taken before (16 August 1974) and after (31 August 1974) disposal operations from 50 sites in the vicinity of Island 117, Upper Mississippi River (From Table A2)



. 8. Differences in benthos biomass (excluding molluscs) between samples taken before (16 August 1974) and after (31 August 1974) disposal operations from 50 sites in the vicinity of Island 117, Upper Mississippi River (From Table A2)

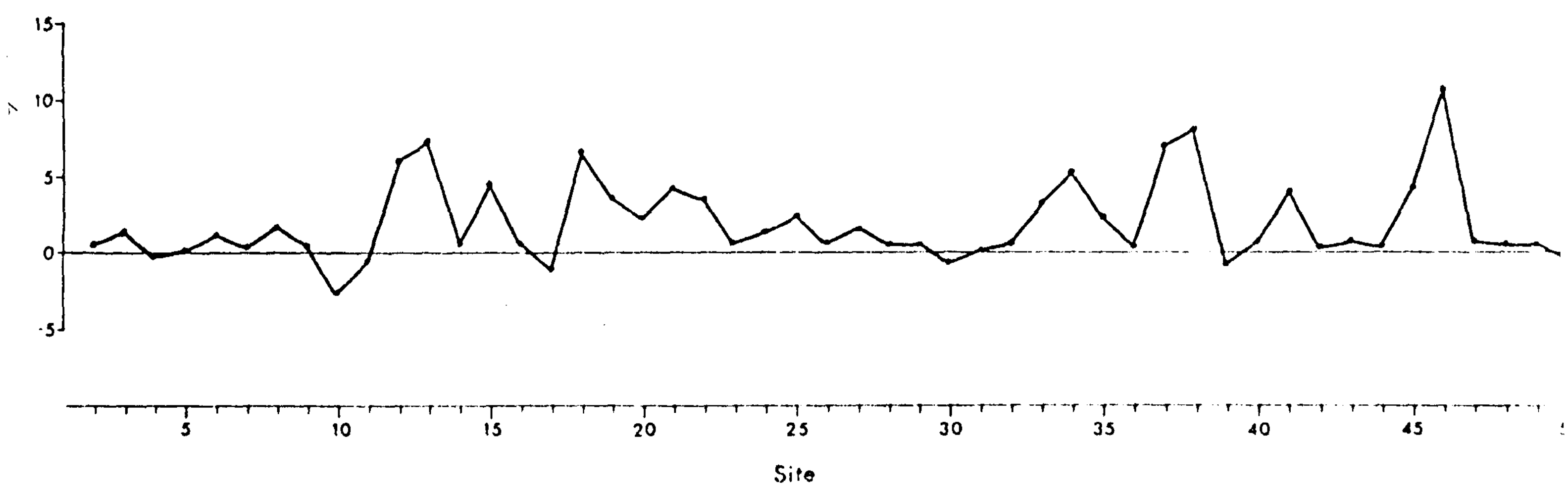
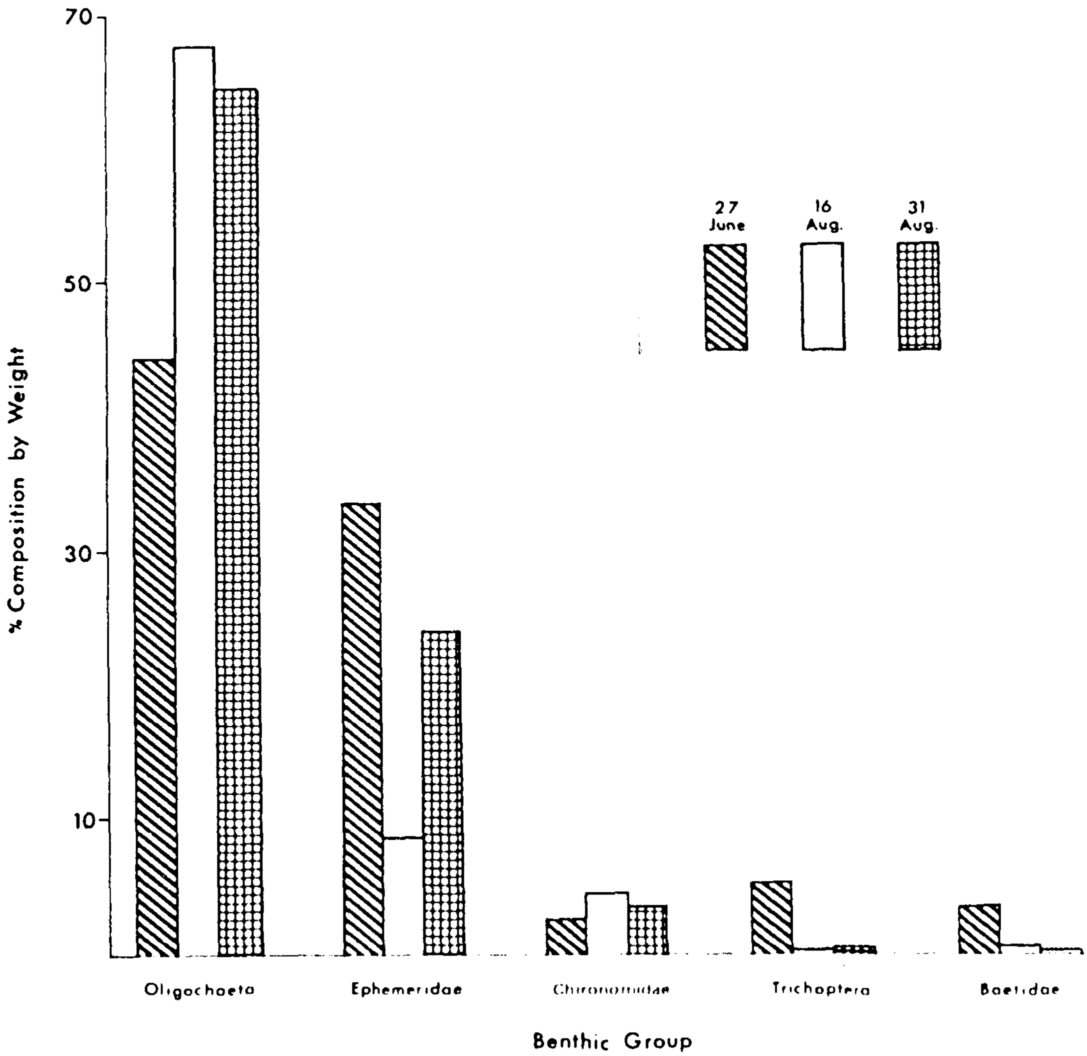


Fig. 9. Percent composition by weight of the major groups of benthic macroinvertebrates found in bottom samples taken on 27 June, 16 August, and 31 August 1974 from 50 sites in the vicinity of Island 117, Upper Mississippi River (From Table A4)



Limnodrilus hoffmeisteri (7.1 to 7.6 percent by number).

66. Mayfly nymphs (*Ephemeridae*) were also of major significance, contributing from 8.2 to 33.6 percent of the benthos biomass (Figure 9, Table A4). The two species present were *Hexagenia limbata* and *H. bilineata*. *H. limbata* was generally more abundant (53.4 to 65.1 percent, by number, of the ephemerids), but there was considerable site-to-site variation (Table A6).

Fish Survey

Diversity

67. Nearly 12,000 individuals of 55 species of fish were captured in the five collection areas throughout this study (Table 1). (For a taxonomic listing of species, refer to Table A7.) Of the major freshwater fish families, the Centrarchidae were represented by 8 species and 5070 individuals. Of the Centrarchidae, the bluegill (*Lepomis macrochirus*) and the white crappie (*Pomoxis annularis*) were most numerous. The family Cyprinidae contributed nearly as many individuals (4863) but were represented by many more species (15). Emerald shiners (*Notropis atherinoides*), bullhead minnows (*Pimephales vigilax*), and river shiners (*Notropis blennius*) were the dominant cyprinids. The sucker family (*Catostomidae*) with 7 species and 609 fish and the perch family (*Percidae*) with 531 fish of 8 species were third and fourth, respectively, in family importance.

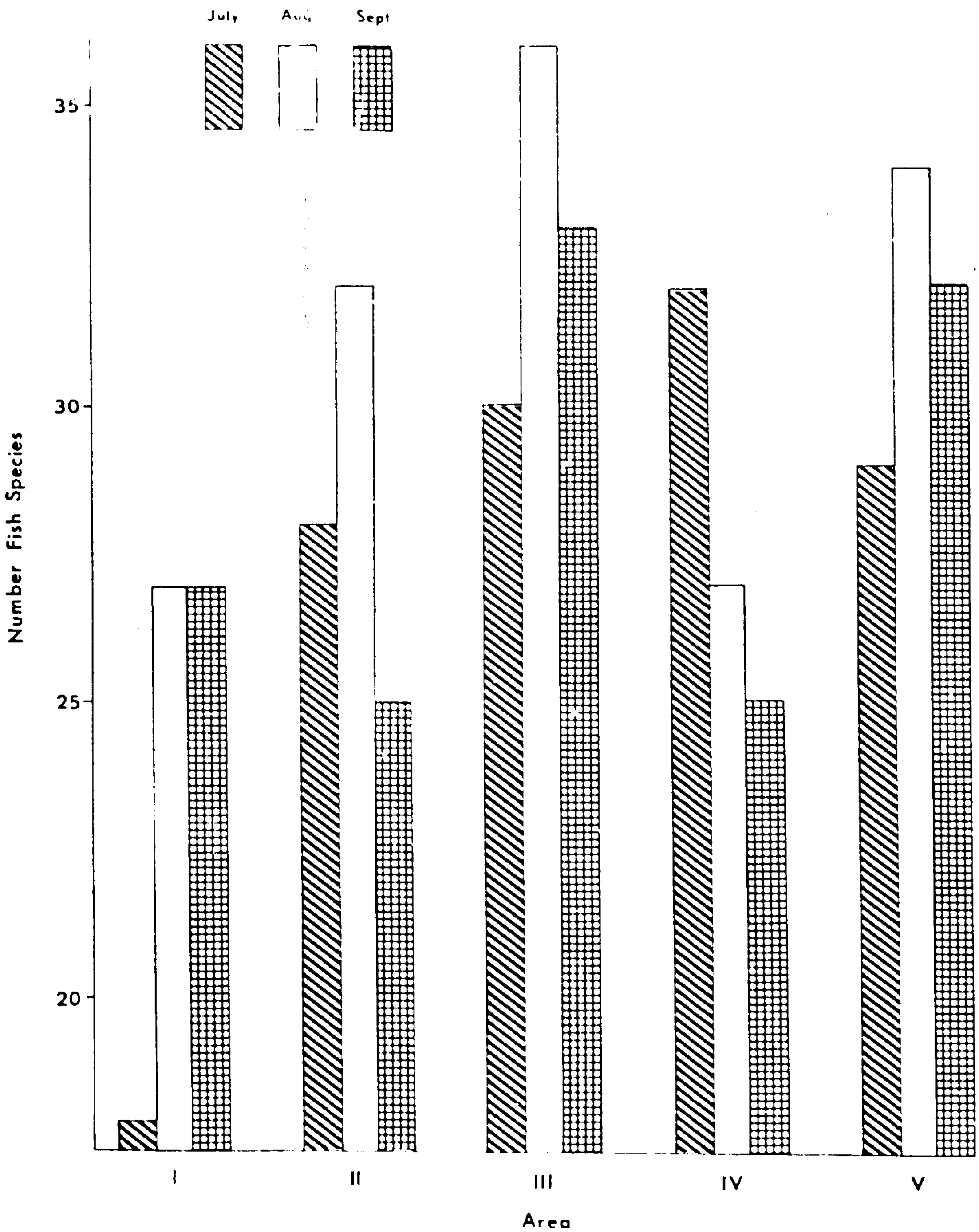
68. Most of the species captured in the study area have been mentioned as fishes of the Upper Mississippi River by Smith et al. (1971) or as fishes of Wisconsin by Johnson and Becker (1970). Smith et al. (1971) listed two species taken in the study as being "rare" or "accidental"

in the Upper Mississippi River; namely, the silver lamprey (*Ichthyomyzon unicuspis*) and the brook stickleback (*Culaea inconstans*). The goldeye (*Hiodon alosoides*) and the mud darter (*Etheostoma aspringene*) were taken during this study and have been listed as "rare" by Johnson and Becker (1970). The status of the weed shiner (*Notropis texanus*), captured during this study, has been listed by Hine (1973) as "changing."

69. Area II (along the east side of Island 117) contributed the greatest number of species (45) during the entire sampling period (Table 1). The fewest number of species taken from any area during the summer was 36 from Area I, the main channel side of Island 117. The greatest number of species taken during any one sampling period was 36 species from Area III in mid-August (Figure 10). Areas II and IV also exhibited their peak in diversity during this August sampling period.

70. It appeared doubtful that disposal of dredged material had an appreciable effect on fish diversity. The low number of species in Area I was likely a reflection of reduced habitat diversity in the littoral areas bordering the main channel. It could be argued, perhaps, that this reduction in habitat diversity was due to the deposition of dredged material since Island 117 is composed entirely of dredged material. But Area II exhibited a relatively high species diversity in the fish community, and this area has been similarly affected by the disposal history of Island 117. Furthermore, fewer species were taken from all areas during the postdisposal sampling period except in Area I (27 species on both pre- and postoperational dates), where a reduction in diversity caused by 1974 disposal operations might have been expected.

Fig. 10. Numbers of fish species taken by all collection methods during the summer of 1974 from five areas in the vicinity of Island 117, Upper Mississippi River



Numbers and catch per unit of effort

71. The greatest numbers in the total catch were taken during the September sampling period, particularly in Areas II and III (Figure 11). These large total catches per area were due primarily to successful shore seining. For two of the sampling periods (July and September), Area I had the fewest numbers in total catch. Reasons for the paucity of fish from Area I were probably (a) reduced habitat diversity, as previously mentioned, and (b) sampling bias, since gill net and frame net success in the main channel border area was precarious because of wakes from barge traffic, a strong current, and tampering with nets by recreationalists.

72. Based on c/f data, the gill net success was much greater in Area I for the postdisposal data than the above data indicated (Figure 12). The c/f for experimental gill nets, boomshocking, and frame nets for each area on three dates were quite variable, however, and likely reflected gear selectivity on a habitat basis (Figures 12, 13, and 14). For example, the c/f was consistently high for gill nets in Area V; for shocking in Areas I, III, and V; and for frame netting in Area IV.

73. There was no discernible trend in c/f due to disposal of dredged material. With the exception of the gill net c/f in Area I, the c/f's for gill nets and shocking were quite consistent in all areas throughout the study period.

Composition of the catch by area

74. The Cyprinidae comprised the greatest percentage of the catches in Areas I and II on most dates; and the Centrarchidae dominated the catches in Areas III, IV, and V (Figure 15). An exception was the increased percentage of cyprinids in Areas II and V in September.

Fig. 11. Total numbers of fish taken by all collection methods during the summer of 1974 from five areas in the vicinity of Island 117, Upper Mississippi River

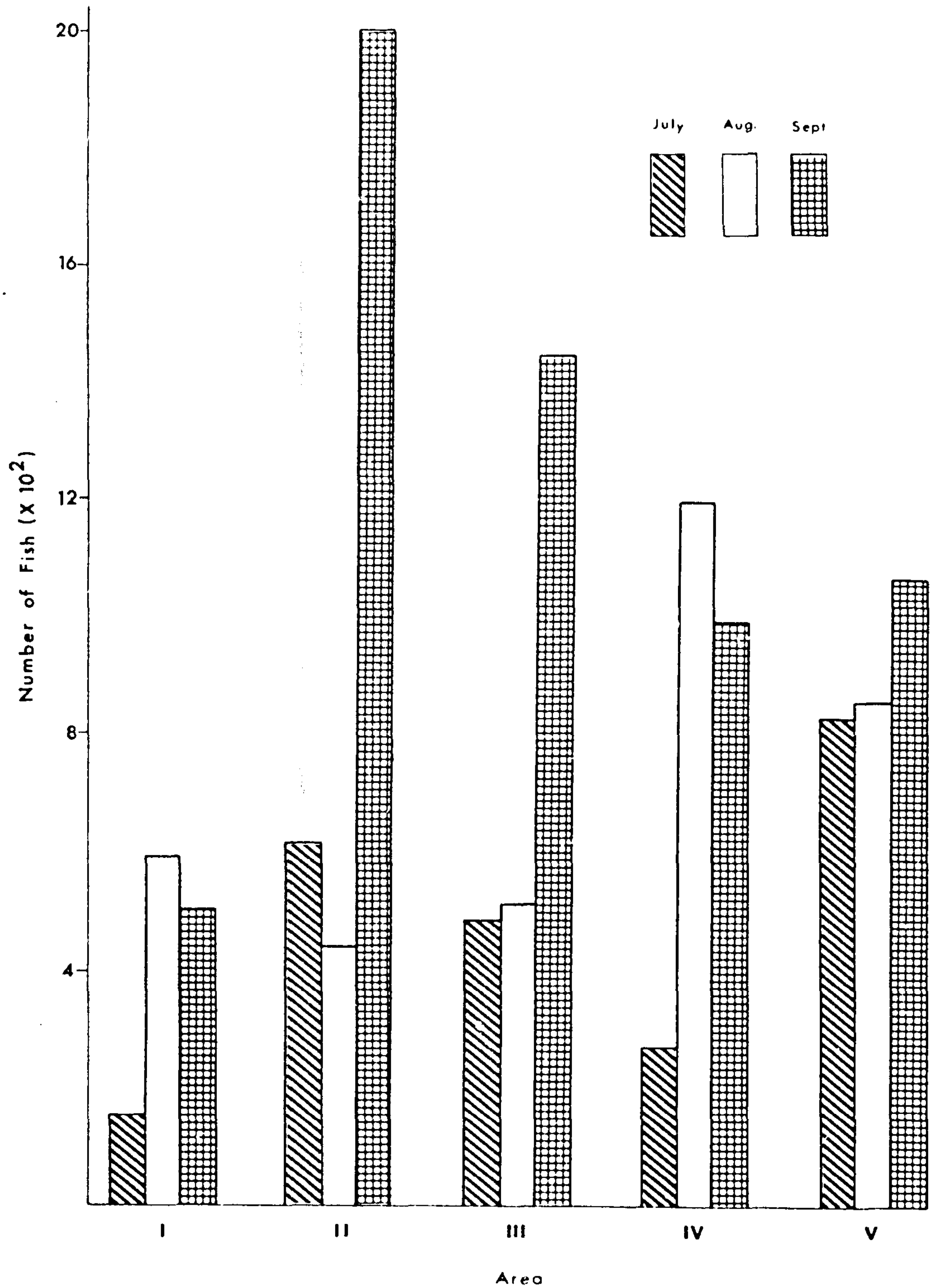


Fig. 12. Catch per unit of effort of gill nets set during the summer of 1974 in five areas in the vicinity of Island 117, Upper Mississippi River

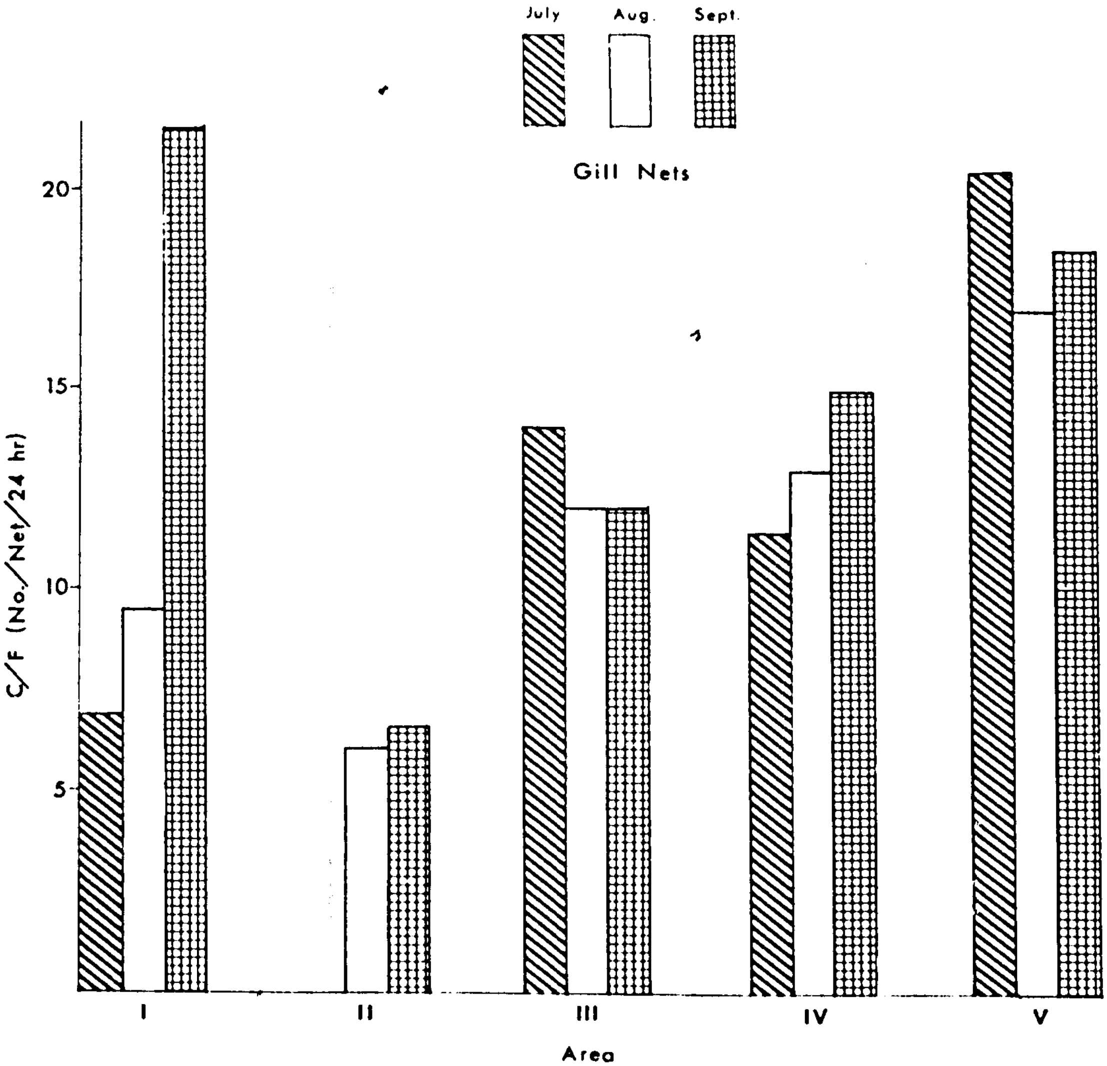


Fig. 13. Catch per unit of effort of boomshocking conducted during the summer of 1974 in the vicinity of Island 117, Upper Mississippi River

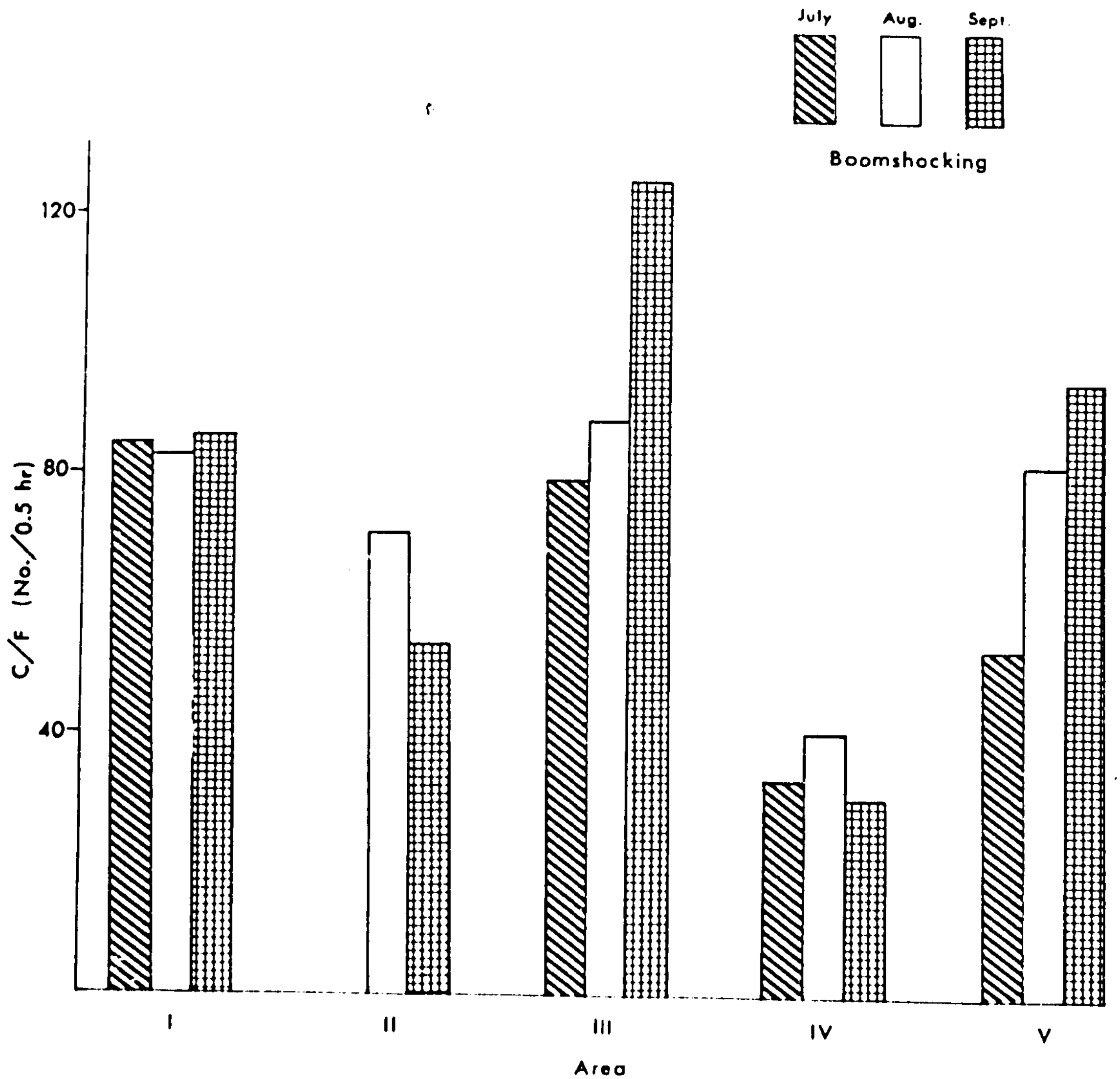


Fig. 14. Catch per unit of effort of frame nets set during the summer of 1974 in five areas in the vicinity of Island 117, Upper Mississippi River

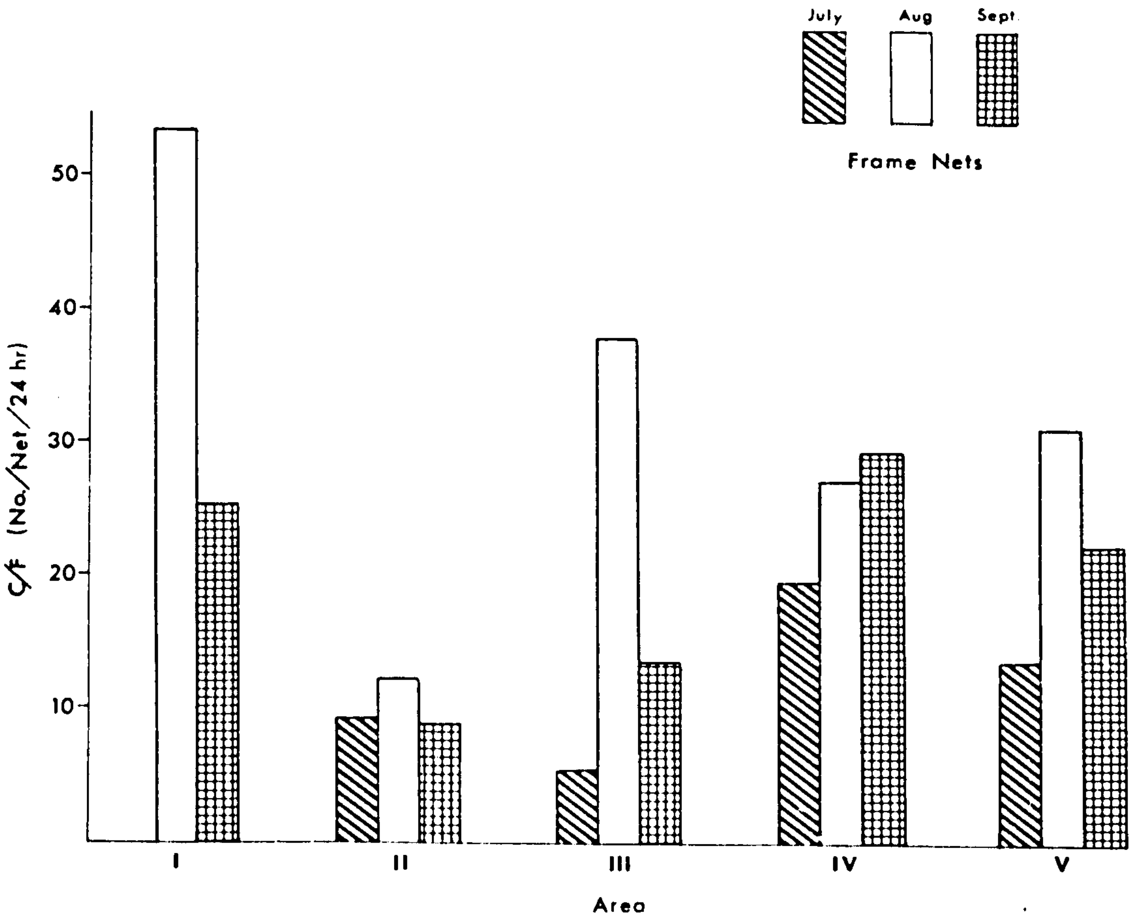
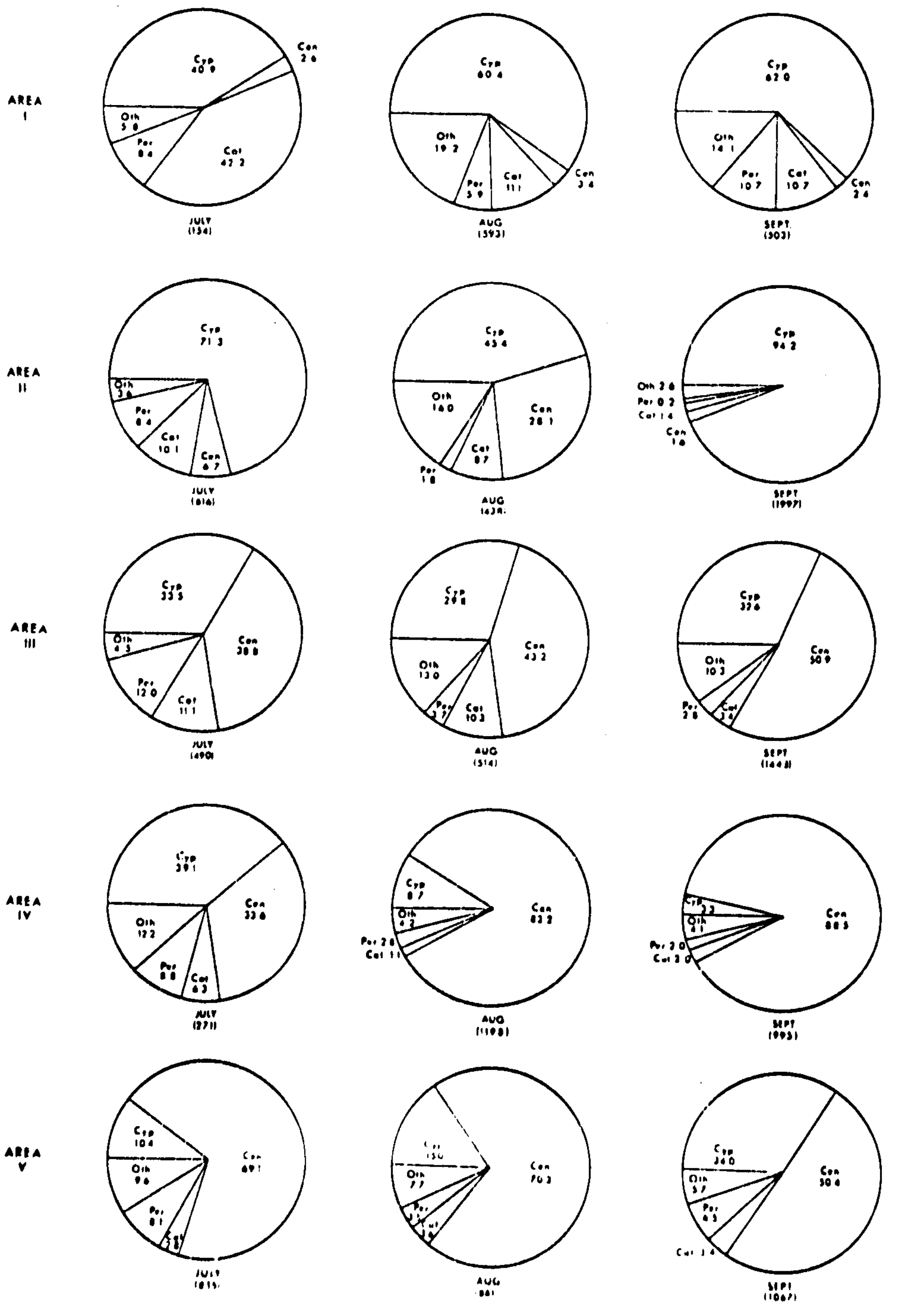


Fig. 15. Percent composition of fish families in catches taken by all collection methods during the summer of 1974 from five areas in the vicinity of Island 117, Upper Mississippi River



75. Based on the relative consistency in composition of the fish catches per area, there appeared to be no effects of disposal of dredged material on the composition. The distribution of the dominant groups was probably a reflection of preferences for the different habitats in these areas.

Northern pike netting

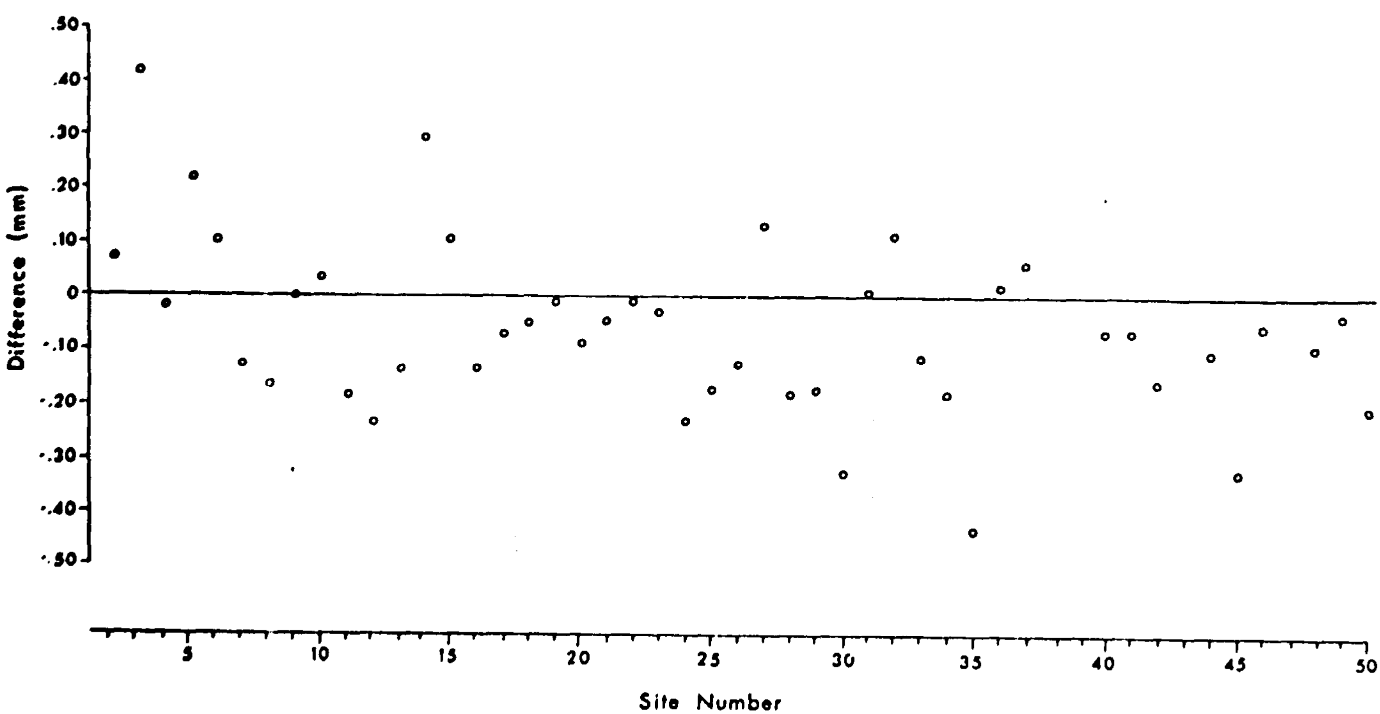
76. Results from the satellite study on northern pike spawning indicated that these fish do use the study area for spawning activities (Table 2). Nets 1, 2, and 3 were placed in Area V during the spawning run (early April), and catch success (based on nets in other reaches of the river) was quite good. Age and growth data indicated that 77 percent of this spawning population was comprised of two- and three-year-old northern pike. Past growth histories of this population were comparable or better than other populations studied in Wisconsin and Minnesota.

Sediment Analysis

Site sediment analysis

77. There was considerable variation in the changes in mean sediment particle size from the 50 sites between pre- and postoperational periods (Figure 16). Changes in mean particle size ranged from an increase of 0.44 mm to a decrease of 0.45 mm. Changes at most sites, however, were in the ±0.20-mm range. Of 45 sites where comparisons could be made, 12 sites exhibited an increase in mean particle size from predisposal to postdisposal dates; 32 sites exhibited a decrease in mean particle size; and there was no change at one site.

Fig. 16. Differences in mean particle size of sediments taken before and after disposal operations (197: 50 sites in the vicinity of Island 117, Upper Mississippi River (Mean particle sizes in Table A3)



78. Outwash from disposal operations occurred at site 4. It would be difficult, however, to attribute the increases in mean particle size at downstream sites 5 and 6 (Figure 16) to the disposal operations, since increases between the two dates were also noted at sites 2 and 3, the two sites immediately upstream from the discharge site.

79. Dredged material was not allowed to run over the crest of Island 117 into backwater areas during 1974 as it was in 1973. Consequently, the backwater areas were not directly influenced by the disposal activity during 1974, and any changes in mean particle size at the backwater sites were due to natural sedimentation phenomena and/or sampling error.

80. The time interval between bottom grabs at these 50 sites was approximately 65 days (24-28 June to 31 August-1 September 1974). Due to unusually high water levels at the beginning of the study period, the pool elevation between these sampling dates varied considerably. The downstream pool elevation at Lock and Dam 7 between 24 and 28 June 1974 ranged from 637.32 to 634.31 ft, and the pool elevation for the period 31 August - 1 September 1974 was 631.41 to 631.17 ft, a difference of approximately 3-6 ft. It would not be unusual, therefore, to witness natural changes in mean particle size of the sediments during a nine-week period of fluctuating water levels and current velocities.

Core samples

81. Differences in composition of the top 15 cm of samples taken on two dates at core stations A-Z were variable (Table A8). Since dredged material did not enter the core sampling area between the two dates, these differences in composition reflect changes in sedimentation due to fluctuating water levels and current velocities, as well as possible sampling error.

82. Only two sites exhibited major increases in the percent composition of large particles (0.5 mm and over) in the top 15 cm (Table A8); namely, site D (+28.6 percent) and site N (+20.0 percent). Site N also exhibited a corresponding major decrease (-60.9 percent) in composition of small particles (less than 0.25 mm). Since sites D and N were located at some distance from each other and likely under different influences, these differences in composition probably reflected the difficulty of exact site location on the second (postdisposal) sampling date.

83. Only site V had a major decrease (-26.8 percent) in composition of large particles (0.5 mm and over) (Table A8). This site also had a corresponding increase (+34.9 percent) in composition of smaller particles (less than 0.25 mm). This change in the top 15 cm at site V could have resulted from the trapping of particles by rooted vegetation that encroached on site V during the study.

84. Sampling problems were reflected in major changes in composition of the 15- to 30- and 30- to 45-cm fractions between the two dates at some sites, such as H and P (Table A8). If the second core sample was taken beside the first core, a great difference would not be expected in composition of the 30- to 45-cm fraction, a difference that occurred at sites H and P. Furthermore, sites in the near vicinity, such as site W (90 m from site P), exhibited a marked consistency of composition of the deeper fractions.

85. This part of the study was designed to detect changes in sediments caused by deposition of dredged material and to trace the movement of dredged material in the backwater areas. Since dredged

material was not allowed to pass over the crest of Island 117 in 1974, no direct effects of the disposal operation could be detected by core sampling.

Water Chemistry

1974 results

86. Water samples for chemical analysis were collected on eight dates during 1974: 8 and 22 July; 14, 19, 27, 28, and 30 August; and 6 September. Samples were taken from all 50 sites on the first three and last sampling dates. Due to the short period of time during which the disposal operation took place, only 28 selected sites were sampled just prior to, during, and immediately following discharge of dredged material.

87. Temperature means for the eight dates ranged from 18.24 to 27.18^{o}C, the highest average being from early summer and the lowest from early fall, 8 July and 6 September, respectively (Table 3). The range of temperatures measured at each site on any day reflected the time of day the particular site was sampled.

88. Mean turbidity readings, shown in Table 3, ranged from 22.8 to 45.3 Jackson Turbidity Units (JTU). Levels of turbidity were higher in the early summer. As previously discussed, early summer pool elevations during 1974 were somewhat higher than normal. This could account for the higher turbidity readings during this time.

89. The general trend in mean concentration of nitrate- and nitrite-nitrogen was a decrease from early summer to early fall. Nitrate-nitrogen means ranged from 0.117 to 0.424 mg/ℓ, and means of nitrite-nitrogen ranged from 0.003 to 0.040 mg/ℓ (Table 3).

90. Orthophosphate mean concentrations ranged from 0.236 to 0.607 mg/ℓ throughout the summer (Table 3). Unlike nitrate- and nitrite-nitrogen levels, concentrations of orthophosphate were lower in the early summer. This trend, as explained by Hutchinson (1957), could be due to uptake of phosphates by littoral vegetation in the spring.

91. Means of DO ranged from 6.34 to 10.86 mg/ℓ (Table 3). On most dates, various sites exhibited supersaturation conditions. In most cases, these sites were sampled in the afternoon or evening, and the supersaturation of oxygen likely reflected the high level of photosynthetic activity in these areas on that particular day.

Seasonal, annual, and diel variations

92. ANOVA's were calculated for data from all eight dates sampled during 1974 to test the null hypothesis of equal means of temperature, turbidity, nitrate-nitrogen, nitrite-nitrogen, orthophosphate, and DO (Table 3). In short, differences were found among means for all variables tested.

93. A comparison was similarly made between means determined from 40 sites sampled 27 June 1973 and means from 50 sites sampled 8 July 1974 (Table 4). Differences were found between all variables except orthophosphate. The ranges of measurements taken in 1973 fell within the 1974 ranges except that for nitrate-nitrogen, which was extremely high in 1973.

94. Diel variation in the variables measured was significant. An ANOVA was run on samples taken from three sites (6, 13, and 46) every 3 hr for 24 hr on 22-23 July 1974 (Table 5). There were differences in temperature, turbidity, nitrate-nitrogen, orthophosphate, and DO. The means of only nitrate-nitrogen were considered equal.

Effects of 1974 disposal operations

95. Disposal of dredged material occurred on 28 and 29 August 1974. ANOVA's were determined for samples collected on 27, 28, and 30 August. (An exception was the preoperational date (19 August) of sample collection for DOC.) There were differences between means for temperature, nitrate-nitrogen, nitrite-nitrogen, orthophosphate, and DO for these three dates (Table 6). Only the means for turbidity and DOC were considered equal (Tables 6 and 7). It is noteworthy that turbidity, one of the variables affected by 1973 disposal operations (Claflin, 1974b), was not affected in 1974.

96. Two other operational series were tested for variance: predisposal versus during disposal (Table 8) and predisposal versus postdisposal (Table 9). From the former test, differences were found between means of nitrate-nitrogen, orthophosphate, and DO. From the pre- versus postdisposal test, differences were noted in temperature, nitrate-nitrogen, and orthophosphate.

97. Differences in temperature and DO were due to natural changes in the environment. Only means for nitrate-nitrogen and orthophosphate differed significantly throughout all three disposal series analyses. Nitrate-nitrogen on 27, 28, and 30 August was 0.151, 0.240, and 0.117 mg/ℓ, respectively; and orthophosphate means on the same dates were 0.607, 0.519, and 0.521 mg/ℓ, respectively. The increase in nitrate-nitrogen on 28 August was witnessed at most sites, including those which could not have been influenced by the disposal operation. In light of these inconsistencies, it is questionable whether the discharge of dredged material was responsible for the differences in these water chemistry variables

98. In summary, any one of the above disposal operation series analyses might suggest some effects of 1974 discharge of dredged material on those water chemistry variables tested. It would be difficult, however, to attribute significant differences between certain means to the 1974 activity because of (a) the variations noted during the disposal operation fell within the natural annual, season, and diel variations; (b) the absence of trends throughout the disposal series analyses of those parameters that did differ significantly; and (c) the small amount of dredged material that was actually deposited during 1974, and the short period of time of this operation.

Impact of revegetation study

99. Revegetation efforts on Island 117 during 1974 included the placement of approximately 567 kg of nutrients in the form of a commercial fertilizer (5.6 kg/ha) and vacuum-dried sewage sludge (224 kg/ha) on a small portion of the island. Analyses of water samples taken around the island throughout the summer as part of the study of the disposal operation detected no leaching of nutrients into the river; and according to the project director of the revegetation study, separate water chemistry analyses by the revegetation crew also did not detect leaching of nutrients from the experimental plots (T. O. Claflin, personal communication).

PART V: SUMMARY AND RECOMMENDATIONS

Summary

100. This study was designed to investigate the environmental effects of the upland discharge of dredged material on the aquatic habitat around Island 117, Pool 8, Upper Mississippi River. Adverse impacts attributed to the disposal of dredged material in the past have included the conversion of productive aquatic and semiaquatic habitat to sandy shoals and islands, and the impairment of backwater circulation.

101. Various biological, physical, and chemical variables were measured prior to, during, and after disposal of 11,144 yd^3 of sand on Island 117 (about 17 percent of the average job size at this site) by the dredge WILLIAM A. THOMPSON on 28-29 August 1974.

102. Dredging and disposal activity at Island 117 during 1974 produced no measurable effects on those variables considered. Reasons for the negligible impact may have been as follows: (a) the relatively small amount of dredged material that was discharged at this site in 1974; (b) dredged material was not allowed to pass over the crest of Island 117 into backwater areas as it had in past years; (c) the variance of the baseline data, caused by annual, seasonal, and diel fluctuations, was significant for most variables. If the disposal operation had any impact, the effects were masked by this natural variation.

103. Changes recorded in benthos biomass were due to natural production phenomena rather than to the effects of disposal of dredged material or recolonization since the 1973 operation. The principal

change was an increase in benthos biomass following the disposal operation due to the appearance of young mayfly nymphs in the samples. Similarly, there were no changes in catch per unit of effort or composition of fish catches attributable to 1974 disposal activity. Species capture was likely dictated by gear selectivity on a habitat basis.

104. There was a general increase in mean particle size of sediments at the 50 sample sites from early to late summer. However, the trend was not consistent, particularly at or near the disposal site; consequently, these changes were probably due to natural sedimentation phenomena. The core sample stations were located in the backwater areas. Since dredged material did not reach these areas in 1974, any effects of disposal of dredged material were not demonstrated by these samples.

105. Background variation in the chemical variables considered masked any effects of dredged material disposal. Turbidity and nitrite-nitrogen, which were increased by the discharge of dredged material in 1973, were not significantly altered during 1974.

Recommendations

106. There have been many suggestions as to alternatives to the present method of 9-ft channel maintenance on the Upper Mississippi River. These alternatives are discussed at length in the St. Paul District's EIS (U. S. Army Engineer District, St. Paul, 1974) and need not be reiterated here. Three procedural modifications of the present

dredging and disposal method, however, are applicable to Pool 8: (a) revegetation of disposal sites for stabilization; (b) reduced overtopping of disposal areas; and (c) backchannel dredging to reopen some partially occluded sloughs. Further study of the present river system is needed before the feasibility and success of these alternatives can be predicted.

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Table 1. Numbers of each fish species taken by all collection methods from five collection areas in the vicinity of Island 117 during the summer of 1974.

Species	AREA* I	II	III	IV	V	Species Total
Black Bullhead		1			1	2
Black Crappie	2	5	99	83	143	332
Bluegill	21	134	891	847	938	2831
Bluntnose Minnow		8			132	140
Bowfin			4	6	2	12
Brassy Minnow			3			3
Brook Silversides	13	44	120	1	8	186
Brook Stickleback				1		1
Bullhead Minnow	68	535	6			609
Carp	6	25	45	20	48	144
Channel Catfish	5	2	4	5	4	20
Common Shiner		123	30	48	6	207
Emerald Shiner	453	1124	7	1	125	1710
Flathead Catfish	1				2	3
Freshwater Drum	4	35	28	30	53	150
Gizzard Shad	118	34	26	8	60	246
Golden Redhorse	32	9	22	13	15	91
Golden Shiner	3	1	39	52	76	171
Goldeye	1					1
Highfin Carpsucker		1				1
Iowa Darter					1	1
Johnny Darter		49	22	50	72	193
Largemouth Bass	1	19	69	38	62	189
Logperch	1	4	25	1	4	35
Longnose Gar	5	1	3	5	6	20
Mooneye	8	2	7	12	18	47
Mud Darter				3	4	7
Northern Pike	5	4	11	11	18	49
Orangespotted Sunfish			1	2		3
Pugnose Minnow		7	77	27	90	201
Pumpkinseed		4	10	4	7	25

(Continued)

*See Fig. 3 for location of collection areas.

Table 1 (Concluded)

Species	AREA I	II	III	IV	V	Species Total
Quillback	8	5	1		4	18
River Carpsucker	4	6	1			11
River Shiner	154	340	1		49	544
Rockbass	2	16	12	7	25	62
Sand Shiner		18				18
Sauger	13	3	17	4	11	48
Shorthead Redhorse	126	47	94	28	53	348
Shortnose Gar	1	1	5	6	6	19
Silver Chub	11		1		1	13
Silver Lamprey		1				1
Silvery Minnow		2				2
Smallmouth Bass	4	6	6	2	130	148
Smallmouth Buffalo	1	2		1	3	7
Spotfin Shiner	4	260	107	77		448
Spottail Shiner	34	18	202	10	17	281
Spotted Sucker	2	1	21	2	13	39
Tadpole Madtom		1	2	20	17	40
Trout-perch	1					1
Walleye	17	5	25	4	12	63
Weed Shiner		58	271	8	35	372
Western Sand Darter	72	2	18			92
White Bass	31	19	28	19	12	109
White Crappie	6	11	62	986	43	1108
Yellow Perch		2	11	16	61	90
Catostomid y-o-y**	12	56	18	6	2	94
Centrarchid y-o-y					372	372
Etheostoma y-o-y					2	2
AREA TOTALS						
No. individuals	1250	3051	2452	2464	2763	11,980
No. species	36	45	42	38	42	55

**y-o-y = young of the year

Table 2. Netting success for northern pike in Area V* (near Island 117) during April 1974.

Date	Number Mature Pike/Net Net Number 1	2	3	Total Pike	Average No. Pike per Net
5 April	8	3	-	11	3.7
6 April	17	14	23	54	18.0
12 April	15	-	6	21	10.5
13 April	12	0	16	28	9.3
Net Totals	52	17	45	114	

*See Fig. 3 for location of Area V.

TABLE 3. Statistics and analysis of variance (ANOVA) for six water-quality parameters measured during eight sampling periods during 1974 [illegible] vicinity of Island 117.

Parameter: Water Temperature (° C)

Date (1974)	N	Mean	Range	s
8 July	50	27.180	21.0-30.0	1.621
22 July	50	26.670	25.0-28.0	0.812
14 August	50	24.420	22.5-25.5	0.709
19 August	28	24.589	23.0-27.0	1.071
27 August	28	23.660	22.0-25.0	1.000
28 August	27	24.185	22.5-25.5	0.681
30 August	25	21.040	19.0-22.0	1.144
6 September	49	18.244	15.5-20.0	1.436

ANOVA: N = 307; df = 7,299; F = 300.933; Significance = 99%

Parameter: Turbidity (JTU) (See Table A9)

Date (1974)	N	Mean	Range	s
8 July	50	45.32	25-110	15.842
22 July	50	41.72	28-66	8.562
14 August	50	26.32	16-45	7.955
19 August	28	31.642	25-48	4.699
27 August	28	25.178	18-45	5.457
28 August	27	22.814	15-53	7.395
30 August	25	25.160	16-45	5.632
6 September	39	31.230	11-57	12.003

ANOVA: N = 297; df = 7,289; F = 29.178; Significance = 99%

Parameter: Nitrate N (mg/ℓ) (See Table A10)

Date (1974)	N	Mean	Range	s
8 July	50	0.424	0.28-0.54	0.055
22 July	50	0.338	0.25-0.40	0.032
14 August	50	0.273	0.19-0.34	0.036
19 August	28	0.167	0.05-0.24	0.053
27 August	28	0.151	0.08-0.22	0.039
28 August	27	0.240	0.16-0.39	0.049
30 August	25	0.117	0.06-0.19	0.029
6 September	49	0.133	0.06-0.21	0.046

ANOVA: N = 307; df = 7,299; F = 261.143; Significance = 99%

Parameter: Nitrite N (mg/ℓ) (See Table A11)

Date (1974)	N	Mean	Range	s
8 July	50	0.040	0.031-0.361	0.005
22 July	48	0.010	0 -0.019	0.00[illegible]
14 August	50	0.007	0.001-0.026	0.004
19 August	27	0.003	0 -0.110	0.00[illegible]
27 August	28	0.004	0.001-0.008	0.00[illegible]
28 August	27	0.004	0 -0.010	0.00[illegible]
30 August	22	0.003	0.001-0.008	0.002
6 September	31	0.004	0.001-0.010	0.002

ANOVA: N = 283; df = 7,275; F = 501.242; Significance = 99

Parameter: Orthophosphate (mg/ℓ) (See Table A12)

Date (1974)	N	Mean	Range	s
8 July	50	0.314	0.12-0.73	0.156
22 July	50	0.236	0.14-0.48	0.061
14 August	50	0.544	0.35-0.77	0.074
19 August	28	0.486	0.33-0.64	0.078
27 August	28	0.[illegible]07	0.43-0.75	0.079
28 August	27	0.519	0.38-0.69	0.103
30 August	25	0.521	0.40-0.73	0.089
6 September	49	0.300	0.16-0.55	0.085

ANOVA: N = 307; df = 7,299; F = 81.151; Significance = 99

Parameter: Dissolved Oxygen (mg/ℓ) (See Table A13)

Date (1974)	N	Mean	Range	s
8 July	49	7.465	4.90-9.80	1.249
22 July	50	6.342	3.62-8.52	1.073
14 August	50	7.012	4.00-8.75	0.806
19 August	28	9.140	6.77-10.50	0.791
27 August	20	8.728	7.58-10.34	0.758
28 August	27	10.864	9.10-14.00	1.264
30 August	25	9.007	7.94-10.04	0.670
6 September	47	9.421	6.77-11.55	1.083

ANOVA: N = 296; df = 7,288; F = 80.288; Significance = 99

Note: N = number; s = one standard deviation; df = degrees of freedom; and F = Fisher's F-test.

TABLE 4. Statistics and analysis of variance (ANOVA) for six water-quality parameters measured on 27 June 1973 and 8 July 1974 in the vicinity of Island 117.

Date	N	Mean	Range	s
Parameter: Water Temperature (° C)				
27 June 1973	40	23.375	23.0-24.0	0.353
8 July 1974	50	27.180	21.0-30.0	1.621
ANOVA: N = 90; df = 1,88; F = 211.670; Significance = 99%				
Parameter: Turbidity (JTU)				
27 June 1973	40	65.025	48-110	14.788
8 July 1974	50	45.320	25-110	15.842
ANOVA: N = 90; df = 1,88; F = 36.456; Significance = 99%				
Parameter: Nitrate N (mg/ℓ)				
27 June 1973	40	1.039	0.790-1.180	0.108
8 July 1974	50	0.424	0.280-0.540	0.055
ANOVA: N = 90; df = 1,88; F = 1205.200; Significance = 99%				

Date	N	Mean	Range	s
Parameter: Nitrite N (mg/ℓ)				
27 June 1973	40	0.036	0.029-0.045	0.003
8 July 1974	50	0.040	0.031-0.061	0.005
ANOVA: N = 90; df = 1,88; F = 24.472; Significance = 99%				
Parameter: Orthophosphate (mg/ℓ)				
27 June 1973	40	0.282	0.240-0.360	0.031
8 July 1974	50	0.314	0.120-0.730	0.156
ANOVA: N = 90; df = 1,88; F = 1.542; Significance = None				
Parameter: Dissolved Oxygen (mg/ℓ)				
27 June 1973	40	8.154	7.30-10.00	0.455
8 July 1974	49	7.465	4.90-9.80	1.249
ANOVA = N = 89; df = 1,87; F = 11.004; Significance = 99%				

Note: N = number; s = one standard deviation; df = degrees of freedom; and F = Fisher's F-test.

TABLE 5. Statistics and analysis of variance (ANOVA) for six water-quality parameters measured at 3-hr intervals during a 24-hr period [illegible] 1974) at three sites (6, 13, and 46) in the vicinity of Island 117.

Parameter: Water Temperature (° C)

Time	N	Mean	Range	s
9 A.M.	3	26.000	26.0	0
12 P.M.	3	27.167	27.0-27.5	0.228
3 P.M.	3	27.667	26.0-27.0	0.577
6 P.M.	3	26.667	26.0-27.0	0.577
9 P.M.	3	26.000	26.0	0
12 P.M.	3	25.000	25.0	0
3 A.M.	3	25.000	25.0	0
6 A.M.	3	25.000	25.0	0

ANOVA: N = 24; df = 7,16; F = 34.475; Significance = 99%

Parameter: Turbidity (JTU)

Time	N	Mean	Range	s
9 A.M.	3	39.666	39-40	0.577
12 P.M.	3	37.333	30-46	8.082
3 P.M.	3	32.000	27-37	5.000
6 P.M.	3	23.000	19-26	3.605
9 P.M.	3	41.666	39-44	2.516
12 P.M.	2	47.500	45-50	3.535
3 A.M.	3	32.333	31-34	1.527
6 A.M.	0	--	--	--

ANOVA: N = 20; df = 7,12; F = 7.223; Significance = 99%

Parameter: Nitrate N (mg/ℓ)

Time	N	Mean	Range	s
9 A.M.	3	0.373	0.33-0.40	0.037
12 P.M.	3	0.356	0.34-0.37	0.015
3 P.M.	3	0.379	0.35-0.40	0.026
6 P.M.	3	0.333	0.31-0.35	0.020
9 P.M.	3	0.300	0.29-0.31	0.009
12 P.M.	3	0.296	0.24-0.29	0.026
3 A.M.	3	0.310	0.29-0.33	0.020
6 A.M.	3	0.293	0.27-0.32	0.025

ANOVA: N = 24; df = 7,16; F = 8.345; Significance = 99%

Parameter: Nitrite N (mg/ℓ)

Time	N	Mean	Range	s
9 A.M.	3	0.010	0.010-0.011	0
12 P.M.	3	0.010	0.008-0.013	0.00[illegible]
3 P.M.	3	0.014	0.013-0.019	0.003
6 P.M.	3	0.010	0.003-0.015	0.006
9 P.M.	3	0.011	0.010-0.013	0.001
12 P.M.	3	0.014	0.010-0.018	0.004
3 A.M.	3	0.015	0.010-0.019	0.004
6 A.M.	3	0.007	0.006-0.010	0.00[illegible]

ANOVA: N = 24; df = 7,16; F = 1.579; Significance = None

Parameter: Orthophosphate (mg/ℓ)

Time	N	Mean	Range	s
9 A.M.	3	0.186	0.16-0.22	0.030
12 P.M.	3	0.393	0.25-0.53	0.140
3 P.M.	3	0.213	0.20-0.22	0.011
6 P.M.	3	0.206	0.19-0.22	0.015
9 P.M.	3	0.270	0.25-0.29	0.019
12 P.M.	3	0.296	0.20-0.38	0.090
3 A.M.	3	0.166	0.16-0.18	0.011
6 A.M.	3	0.276	0.23-0.31	0.041

ANOVA: N = 24; df = 7,16; F = 4.144; Significance 99%

Parameter: Dissolved Oxygen (mg/ℓ)

Time	N	Mean	Range	s
9 A.M.	3	5.093	4.78-5.25	0.271
12 P.M.	3	6.419	6.42	0.003
3 P.M.	3	6.496	6.07-6.88	0.406
6 P.M.	3	7.739	7.47-8.17	0.376
9 P.M.	3	6.689	6.54-6.88	0.173
12 P.M.	2	6.010	5.95-6.07	0.083
3 A.M.	3	5.949	5.25-6.30	0.606
6 A.M.	3	5.643	5.02-6.07	0.551

ANOVA: N = 23; df = 7,15; F = 12.828; Significance = 99[illegible]

Note: N = Number; s = one standard deviation; df = degrees of freedom; and F = Fisher's F-test.

TABLE 6. Statistics and analysis of variance (ANOVA) of six water-quality parameters measured 27, 28 and 30 August 1974 (before, during after disposal operations, respectively) in the vicinity of Island 117.

Date (1974)	N	Mean	Range	s	Date (1974)	N	Mean	Range	s
Parameter: Water Temperature (° C)					Parameter: Nitrite N (mg/ℓ)				
27 August	28	23.660	22.0-25.0	1.000	27 August	28	0.004	0.001-0.008	0.002
28 August	27	24.185	22.5-25.5	0.681	28 August	27	0.004	0 -0.010	0.002
30 August	25	21.040	19.0-22.0	1.144	30 August	22	0.003	0.001-0.008	0.002
ANOVA: N = 80; df = 2,77; F = 79.749; Significance = 99%					ANOVA: N = 77; df = 2,74; F = 1.828; Significance = 99%				
Parameter: Turbidity (JTU)					Parameter: Orthophosphate (mg/ℓ)				
27 August	28	25.178	18-45	5.457	27 August	28	0.607	0.43-0.78	0.079
28 August	27	22.814	15-53	7.395	28 August	27	0.519	0.38-0.69	0.103
30 August	25	25.160	16-45	5.632	30 August	25	0.521	0.40-0.73	0.089
ANOVA: N = 80; df = 2,77; F = 1.278; Significance = None					ANOVA: N = 80; df = 2,77; F = 8.223; Significance = 99%				
Parameter: Nitrate N (mg/ℓ)					Parameter: Dissolved Oxygen (mg/ℓ)				
27 August	28	0.151	0.08-0.22	0.039	27 August	20	8.728	7.58-10.34	0.758
28 August	27	0.240	0.16-0.39	0.049	28 August	27	10.864	9.10-14.00	1.264
30 August	25	0.117	0.06-0.19	0.029	30 August	25	9.007	7.94-10.04	0.670
ANOVA: N = 80; df = 2,77; F = 65.502; Significance = 99%					ANOVA: N = 72; df = 2,69; F = 36.597; Significance = 99%				

Note: N = number; s = one standard deviation; df = degrees of freedom; and F = Fisher's F-test.

TABLE 7. Statistics and analysis of variance (ANOVA) for dissolved organic carbon (in mg/ℓ) measured on 19, 28 and 30 August 1974 in the vicinity of Island 117. (See Table A14)

Date	N	Mean	Range	s
Parameter: Dissolved Organic Carbon (mg/ℓ)				
19 August 1974	15	9.01	7.8-12.2	1.000
28 August 1974	15	7.86	7.0-8.3	0.333
30 August 1974	13	6.23	2.9-8.9	1.860

Date	N	df	F	signif.
ANOVA:				
19 vs. 28 August	30	1,28	4.09	None
19 vs. 30 August	28	1,26	4.84	None
28 vs. 30 August	28	1,26	3.22	None

Note: N = number; s = one standard deviation; df = degrees of freedom; and F = Fisher's F-test.

TABLE 8. Statistics and analysis of variance (ANOVA) for six water-quality parameters measured before (27 August) and during disposal o[illegible] (28 August) during 1974 in the vicinity of Island 117.

Date (1974)	N	Mean	Range	s
Parameter: Water Temperature (° C)				
27 August	28	23.660	22.0-25.0	1.000
28 August	27	24.185	22.5-25.5	0.681
ANOVA: N = 55; df = 1,53; F = 5.125; Significance = None				
Parameter: Turbidity (JTU)				
27 August	28	25.178	18-45	5.457
28 August	27	22.814	15-53	7.395
ANOVA: N = 55; df = 1,53; F = 1.828; Significance = None				
Parameter: Nitrate N (mg/ℓ)				
27 A[illegible]	28	0.151	0.08-0.22	0.039
28 Au[illegible]	27	0.240	0.16-0.39	0.049
ANOVA: N = 55; df = 1,53; F = 55.382; Significance = 99%				

Date (1974)	N	Mean	Range	s
Parameter: Nitrite N (mg/ℓ)				
27 August	28	0.004	0.001-0.008	0.002
28 August	27	0.004	0 -0.010	0.002
ANOVA: N = 55; df = 1,53; F = 0.650; Significance = None				
Parameter: Orthophosphate (mg/ℓ)				
27 August	28	0.607	0.43-0.75	0.079
28 August	27	0.519	0.38-0.69	0.103
ANOVA: N = 55; df = 1,53; F = 12.476; Significance = 99%				
Parameter: Dissolved Oxygen (mg/ℓ)				
27 August	20	8.728	7.58-10.34	0.758
28 August	27	10.864	9.10-14.00	1.264
ANOVA: N = 47; df = 1,45; F = 44.943; Significance = 99%				

Note: N = number; s = one standard deviation; df = degrees of freedom; and F = Fisher's F-test.

TABLE 9. Statistics and analysis of variance (ANOVA) for six water-quality parameters measured before (27 August) and after disposal opera[illegible] (30 August) during 1974 in the vicinity of Island 117.

Date (1974)	N	Mean	Range	s	Date (1974)	N	Mean	Range	s
Parameter: Water Temperature (° C)					Parameter: Nitrite N (mg/ℓ)				
27 August	28	23.660	22.0-25.0	1.000	27 August	28	0.004	0.001-0.008	0.002
30 August	25	21.040	19.0-22.0	1.144	30 August	22	0.003	0.001-0.008	0.002
ANOVA: N = 53; df = 1,51; F = 79.097; Significance = 99%					ANOVA: N = 50; df = 1,48; F = 4.177; Significance = None				
Parameter: Turbidity (JTU)					Parameter: Orthophosphate (mg/ℓ)				
27 August	28	25.178	18-45	5.457	27 August	28	0.607	0.43-0.75	0.079
30 August	25	25.160	16-45	5.632	30 August	25	0.521	0.40-0.73	0.089
ANOVA: N = 53; df = 1,51; F = 0; Significance = None					ANOVA: N = 53; df = 1,51; F = 13.623; Significance = 99%				
Parameter: Nitrate N (mg/ℓ)					Parameter: Dissolved Oxygen (mg/ℓ)				
27 August	28	0.151	0.08-0.22	0.039	27 August	20	8.728	7.58-10.34	0.758
30 August	25	0.117	0.06-0.19	0.029	30 August	25	9.007	7.94-10.04	0.670
ANOVA: N = 53; df = 1,51; F = 12.440; Significance = 99%					ANOVA: N = 45; df = 1,43; F = 1.725; Significance = None				

Note: N = number; s = one standard deviation; df = degrees of freedom; and F = Fisher's F-test.

APPENDIX A: Raw Data

TABLE A1. Standing crops of benthos (g/m^2) collected on 27 June 1973 and 27 June 1974 from 40 sites in the vicinity of Island 117

Site Number	Benthos Biomass (g/m^2)				Biomass Differences (g/m^2)	
	27 June '73 (Total)	27 June '73 (Minus Molluscs)	27 June '74 (Total)	27 June '74 (Minus Molluscs)	Total Biomass Difference (1973-1974)	Biomass Difference (Minus Molluscs) (1973-1974)
2	1.644	0.653	0.360	0.351	- 1.284	- 0.302
3	0.052	0.052	1.540	1.262	1.488	1.210
4	0.098	0.098	0.125	0.125	0.027	0.027
5	0.045	0.045	0.083	0.083	0.038	0.038
6	0.105	0.105	0.329	0.329	0.224	0.224
7	0.257	0.257	1.280	0.860	1.023	0.603
8	0.082	0.082	0.378	0.327	0.296	0.245
9	1.282	1.282	673.400	0.400	672.118	- 0.882
10	3.308	0.335	0.652	0.178	- 2.656	- 0.157
11	3.197	0.224	1.262	1.130	- 1.935	0.906
12	0.448	0.000	9.455	3.133	9.007	3.133
13	22.165	3.335	283.699	19.989	261.534	16.654
14	--	--	0.671	0.671	--	--
15	1.811	0.820	0.074	0.074	- 1.737	- 0.746
16	2.209	1.218	0.034	0.034	- 2.175	- 1.184
17	3.206	1.224	0.410	0.333	- 2.796	- 0.891
18	1.288	1.288	0.710	0.584	- 0.578	- 0.704
19	0.938	0.938	0.705	0.705	- 0.233	- 0.233
20	35.583	22.204	22.823	19.029	-12.760	- 3.175
21	0.963	0.963	13.237	0.723	12.274	- 0.240
22	0.589	0.589	1.765	0.907	1.176	0.318
23	1.416	0.425	0.338	0.300	- 1.078	- 0.125
24	0.074	0.074	0.000	0.000	- 0.074	- 0.074
25	0.215	0.215	0.060	0.060	- 0.155	- 0.155
26	1.017	0.274	0.029	0.029	- 0.988	- 0.245
27	0.143	0.143	0.010	0.010	- 0.133	- 0.133
28	--	--	1.223	0.423	--	--
29	1.211	0.220	0.016	0.002	- 1.195	- 0.218
30	0.041	0.041	0.017	0.017	- 0.024	- 0.024
31	0.264	0.264	0.078	0.078	- 0.186	- 0.186
32	0.175	0.175	0.267	0.267	0.092	0.092
33	0.161	0.161	0.120	0.067	- 0.041	- 0.094
34	12.821	0.929	0.050	0.037	-12.771	- 0.892
35	31.099	9.296	0.085	0.012	-31.014	- 9.284
36	22.047	0.491	5.195	0.401	-16.852	- 0.090
37	72.055	1.689	6.615	5.825	-65.440	4.136
38	27.313	0.554	--	--	--	--
39	54.536	8.941	329.298	4.789	274.762	- 4.152
40	32.073	8.288	16.609	1.060	-15.464	- 7.228
41	6.543	0.597	7.695	6.382	1.152	5.785

TABLE A2. Standing crops of benthos (g/m^2) collected before (16 August) and after (31 August) 1974 disposal operations from 50 sites in the vicinity of Island 117.

Site Number	Benthos Biomass (g/m^2) 16 Aug. '74 (Total)	16 Aug. '74 (Minus Molluscs)	31 Aug. '74 (Total)	31 Aug. '74 (Minus Molluscs)	Biomass Differences (g/m^2) Total Biomass Difference (1973-1974)	Biomass Difference (Minus Molluscs) (1973-1974)
2	26.728	0.406	2.967	1.003	-23.761	0.597
3	0.461	0.461	2.072	1.821	1.611	1.360
4	0.131	0.131	0.040	0.040	- 0.091	-0.091
5	0.011	0.011	0.186	0.186	0.175	0.175
6	0.231	0.153	1.309	1.306	1.078	1.153
7	4.271	0.831	1.526	1.279	- 2.745	0.448
8	1.419	1.161	4.247	2.884	2.828	1.723
9	2.631	1.083	2.386	1.484	- 0.245	0.401
10	3.532	3.532	51.679	0.850	48.147	-2.682
11	2.793	2.793	2.239	2.239	- 0.554	-0.554
12	21.722	4.602	499.593	10.913	477.871	6.311
13	6.515	4.121	316.720	11.535	310.205	7.414
14	2.291	2.062	4.023	2.533	1.732	0.471
15	0.291	0.257	5.172	5.172	4.881	4.915
16	26.446	0.762	1.440	1.380	-25.006	0.618
17	2.644	2.635	1.687	1.616	- 0.957	-1.019
18	1.317	0.903	7.784	7.595	6.467	6.692
19	1.232	1.232	5.060	5.060	3.828	3.828
20	5.036	3.512	[illegible]	5.901	0.919	2.389
21	2.437	2.268	[illegible]	6.564	4.754	4.296
22	1.101	0.970	6.[illegible]	4.612	5.591	3.647
23	0.977	0.576	1.406	1.406	0.429	0.830
24	0.175	0.175	1.609	1.609	1.434	1.434
25	0.127	0.127	2.472	2.472	2.345	2.345
26	0.326	0.098	0.778	0.778	0.452	0.680
27	124.36[illegible]	0.290	3.832	1.783	-120.528	1.493
28	1.824	1.566	5.247	1.925	3.423	0.359
29	0.054	0.054	0.430	0.387	0.376	0.333
30	65.238	0.827	1.687	0.145	-63.551	-0.682
31	0.129	0.129	0.138	0.138	0.009	0.009
32	0.147	0.137	0.762	0.754	0.615	0.617
33	0.565.	0.462	3.946	3.878	3.381	3.416
34	68.503	0.979	24.871	6.522	-43.632	5.543
35	0.650	0.578	2.757	2.708	2.107	2.130
36	2.454	0.206	0.598	0.598	- 1.856	0.392
37	2.927	2.855	9.937	9.937	7.010	7.082
38	1.407	1.407	31.955	9.778	30.548	8.371
39	7.691	1.191	42.581	0.450	34.890	-0.741
40	131.185	0.449	35.545	1.232	-95.640	0.783
41	1.245	1.065	6.611	5.072	5.365	4.007
42	0.817	0.702	3.340	0.833	2.523	0.131
43	0.735	0.735	1.711	1.711	0.976	0.976
44	0.536	0.536	8.917	1.036	8.381	0.500
45	1.114	0.232	4.601	4.576	3.487	4.344
46	6.925	5.996	20.633	16.952	13.708	10.956
47	2.692	2.408	2.473	2.473	- 0.219	0.065
48	5.322	2.240	5.454	2.639	0.132	0.399
49	4.205	1.123	0.656	0.656	- 3.549	0.467
50	8.033	4.830	12.001	4.635	3.968	-0.195
51	7.257	1.003	[illegible]	4.016	- 1.169	3.013

TABLE A3. Correlation between mean sediment particle size and benthos biomass (minus molluscs) of samples collected on 27 June and 31 August 1974 in the vicinity of Island 117.

Site	27 June 1974		Site	31 August 1974	
	Mean Particle Size (mm)	Benthos Biomass (g/m^2)		Mean Particle Size (mm)	Benthos Biomass (g/m^2)
2	0.32	0.351	2	0.40	1.003
3	0.38	1.262	3	0.82	1.821
4	0.47	0.125	4	0.45	0.040
5	0.53	0.083	5	0.76	0.186
6	0.63	0.329	6	0.74	1.306
7	0.53	0.860	7	0.40	1.279
8	0.57	0.327	8	0.40	2.884
9	0.48	0.400	9	0.48	1.484
10	0.34	0.178	10	0.38	0.850
11	0.58	1.130	11	0.39	2.239
12	0.36	3.133	12	0.12	10.913
13	0.33	19.939	13	0.19	11.535
14	0.32	0.671	14	0.64	2.533
15	0.53	0.074	15	0.64	5.172
16	0.76	0.034	16	0.62	1.380
17	0.63	0.333	17	0.56	1.616
18	0.64	0.584	18	0.59	7.595
19	0.37	0.705	19	0.36	5.060
20	0.27	19.029	20	0.18	5.901
21	0.35	0.723	21	0.30	6.564
22	0.33	0.907	22	0.32	4.617
23	0.38	0.300	23	0.35	1.406
24	0.76	0.000	24	0.52	1.609
25	0.68	0.060	25	0.50	2.472
26	0.68	0.029	26	0.55	0.778
27	0.36	0.010	27	0.50	1.783
28	0.48	0.423	28	0.29	1.925
29	0.67	0.002	29	0.49	0.387
30	0.67	0.017	30	0.33	0.145
31	0.43	0.078	31	0.44	0.138
32	0.37	0.267	32	0.49	0.754
33	0.70	0.067	33	0.58	3.878
34	0.76	0.037	34	0.57	6.522
35	0.65	0.012	35	0.20	2.708
36	0.40	0.401	36	0.42	0.598
37	0.16	5.825	37	0.22	9.937
38	--	--	38	0.18	9.778
39	--	--	39	0.27	0.450
40	0.36	1.060	40	0.29	1.232
41	0.30	6.382	41	0.23	5.072
42	--	--	42	0.49	0.833
43	--	--	43	0.52	1.711
44	--	--	44	0.27	1.036
45	--	--	45	0.25	4.576
46	--	--	46	0.18	16.952
47	--	--	47	0.20	2.473
48	--	--	48	0.14	2.639
49	--	--	49	0.14	0.656
50	--	--	50	0.14	4.635
51	--	--	51	0.13	4.016
	Correlation coefficient = -.422354 (17.84 percent of the variance in benthos biomass explained by Y = a + bX).			Correlation coefficient = -.394728 (15.58 percent of the variance in benthos biomass explained by Y = a + bX).	

TABLE A4. Composition of benthos samples taken at all sampling sites in the vicinity of Island 117 (Pool 8, Upper Mississippi River) during 1973 and 1974.

	27 June 1973		27 June 1974		16 Aug. 1974		31 Aug. 1974	
	Total g/m²	% Compos.*	Total g/m²	% Compos.*	Total g/m²	% Compos.*	Total g/m²	% Compos.*
Mollusca	271.006		1,353.555		491.662		1,005.927	
Oligochaeta	9.210	13.4	57.042	44.3	46.877	68.0	108.213	64.7
Ephemeridae	41.499	60.5	43.283	33.6	5.622	8.2	40.448	24.2
Amphipoda	1.632	2.4	4.864	3.8	2.394	3.5	3.874	2.3
Baetidae	5.654	8.2	5.045	3.9	0.347	0.5	0.175	0.1
Trichoptera	3.656	5.3	6.718	5.2	0.140	0.2	0.589	0.4
Chironomidae	3.752	5.5	3.399	2.6	3.179	4.6	6.084	3.6
Heleidae	0.752	1.1	1.728	1.3	0.135	0.2	0.699	0.4
Coleoptera	0.084	0.1	0.515	0.4	0.000	0.0	0.200	0.1
Diptera larva	1.158	1.7	0.201	0.2	0.534	0.8	1.615	1.0
Hirudinea	0.654	1.0	0.865	0.7	0.591	0.8	0.974	0.6
Isopoda	0.487	0.7	0.365	0.3	0.010	0.0	0.164	0.1
Miscellaneous	---	--	4.854	3.8	9.130	13.2	4.228	2.5
Total (excluding molluscs)	68.538	99.9	128.879	100.1	68.959	100.0	167.263	100.0
(including molluscs)	339.544	---	1,482.434	---	560.621	---	1,173.190	---

*Percent composition excludes molluscs.

TABLE A5. Relative abundance of oligochaete species found in benthos samples collected during two 1974 sampling periods (15-17 August and 31 August - 1 September) in the vicinity of Island 117. Percent composition of oligochaete species determined from subsamples.

Site	15-17 August 1974 Percent *Tubifex tubifex*	Percent *Limnodrilus hoffmeisteri*	Percent Other	Site	31 August - 1 September 1974 Percent *Tubifex tubifex*	Percent *Limnodrilus hoffmeisteri*	Percent Other
2	100	--	--	2	100	--	--
3	100	--	--	3	90	10	--
4	99	--	10	4	100	--	--
5	100	--	--	5	90	--	10
6	100	--	--	6	80	10	10
7	90	10	--	7	90	--	10
8	80	20	--	8	100	--	--
9	100	--	--	9	100	--	--
10	90	10	--	10	100	--	--
11	100	--	--	11	90	10	--
12	50	20	30	12	80	10	10
13	60	20	20	13	80	10	10
14	100	--	--	14	100	--	--
15	100	--	--	15	100	--	--
16	100	--	--	16	90	--	10
17	90	--	10	17	90	10	--
18	80	10	10	18	90	10	--
19	80	20	--	19	80	10	10
20	80	20	--	20	80	20	--
21	70	10	20	21	80	10	10
22	100	--	--	22	80	20	--
23	90	--	10	23	90	10	--
24	70	20	10	24	70	20	10
25	80	10	10	25	90	10	--
26	100	--	--	26	100	--	--
27	90	10	--	27	80	20	--
28	100	--	--	28	100	--	--
29	80	10	10	29	100	--	--
30	100	--	--	30	70	20	10
31	90	--	10	31	100	--	--
32	100	--	--	32	90	--	10
33	100	--	--	33	100	--	--
34	100	--	--	34	70	20	10
35	60	30	10	35	100	--	--
36	100	--	--	36	100	--	--
37	100	--	--	37	80	10	10
38	60	20	20	38	50	30	20
39	100	--	--	39	--*	--	--
40	90	--	10	40	100	--	--
41	80	20	--	41	90	--	10
42	90	--	10	42	100	--	--
43	80	20	--	43	70	20	10
44	80	20	--	44	70	30	--
45	100	--	--	45	80	10	10
46	50	30	20	46	100	--	--
47	50	20	30	47	100	--	--
48	100	--	--	48	100	--	--
49	70	20	10	49	100	--	--
50	100	--	--	50	90	10	--
51	--*	--	--	51	90	10	--
Total (percent)	87.2	7.6	5.3		89.2	7.1	3.7

Note: * = sample missing

TABLE A6. Relative abundance of mayfly species (Family Ephemeridae) found in benthos samples (696.8 cm^2 bottom area) collected during two 1974 sampling periods (15-17 August and 31 August - 1 September) in the vicinity of Island 117.

Site	15-17 August 1974				Site	31 August - 1 September 1974			
	Hexagenia bilineata		H. limbata			Hexagenia bilineata		H. limbata	
	No.	%	No.	%		No.	%	No.	%
2	4	80.0	1	20.0	2	10	47.6	11	52.4
3	2	16.7	10	83.3	3	16	40.0	24	60.0
4	2	28.6	5	71.4	4	3	100.0	--	--
5	--	--	--	--	5	--	--	--	--
6	--	--	--	--	6	24	46.2	28	53.8
7	4	36.4	7	63.6	7	32	57.1	24	42.9
8	--	--	--	--	8	20	45.5	24	54.5
9	--	--	--	--	9	2	40.0	3	60.0
10	--	--	--	--	10	1	50.0	1	50.0
11	--	--	--	--	11	1	50.0	1	50.0
12	3	33.3	6	66.7	12	16	36.4	28	63.6
13	--	--	2	100.0	13	--	--	1	100.0
14	1	100.0	--	--	14	1	100.0	--	--
15	1	100.0	--	--	15	1	33.3	2	66.7
16	3	37.5	5	62.5	16	7	46.7	8	53.3
17	--	--	2	100.0	17	3	20.0	12	80.0
18	3	75.0	1	25.0	18	52	54.2	44	45.8
19	--	--	2	100.0	19	52	59.1	36	40.9
20	--	--	3	100.0	20	--	--	2	100.0
21	2	50.0	2	50.0	21	28	43.8	36	56.2
22	1	33.3	2	66.7	22	3	42.9	4	57.1
23	--	--	--	--	23	2	66.7	1	33.3
24	9	50.0	9	50.0	24	24	42.9	32	57.1
25	2	40.0	3	60.0	25	5	35.7	9	64.3
26	--	--	--	--	26	16	57.1	12	42.9
27	3	42.9	4	57.1	27	40	38.5	64	61.5
28	--	--	--	--	28	--	--	--	--
29	2	66.7	1	33.3	29	2	33.3	4	66.7
30	--	--	1	100.0	30	3	50.0	3	50.0
31	--	--	--	--	31	1	25.0	3	75.0
32	4	50.0	4	50.0	32	7	58.3	5	41.7
33	8	42.1	11	57.9	33	40	50.0	40	50.0
34	1	33.3	2	66.7	34	12	37.5	20	62.5
35	--	--	1	100.0	35	32	57.1	24	42.9
36	--	--	1	100.0	36	40	52.6	36	47.4
37	--	--	--	--	37	--	--	--	--
38	--	--	--	--	38	--	--	2	100.0
39	--	--	--	--	39	--	--	--	--
40	--	--	--	--	40	--	--	1	100.0
41	--	--	1	100.0	41	1	33.3	2	66.7
42	--	--	1	100.0	42	15	40.5	22	59.5
43	5	20.8	19	79.2	43	9	28.1	23	71.9
44	--	--	--	--	44	--	--	--	--
45	--	--	--	--	45	--	--	--	--
46	1	25.0	4	75.0	46	--	--	3	100.0
47	1	100.0	--	--	47	--	--	--	--
48	--	--	--	--	48	--	--	1	100.0
49	1	14.3	6	85.7	49	--	--	--	--
50	3	37.5	5	62.5	50	1	33.3	2	66.7
51	--	--	3	100.0	51	--	--	--	--
TOTAL	66	34.9	123	65.1		522	46.6	598	53.4

TABLE A7. A taxonomic list of 55 species of fish collected in a survey conducted in 1974 in the vicinity of Island 117.

Class Agnatha
- Order Petromyzontiformes
  - Family Petromyzontidae
    - Silver Lamprey - *Ichthyomyzon unicuspis* Hubbs & Trautman

Class Osteichthyes
- Infraclass Holostei
  - Order Semionotiformes
    - Family Lepisosteidae
      - Longnose Gar - *Lepisosteus osseus* (Linnaeus)
      - Shortnose Gar - *Lepisosteus platostomous* Rafinesque
  - Order Amiiformes
    - Family Amiidae
      - Bowfin - *Amia calva* Linnaeus
- Infraclass Teleostei
  - Order Clupeiformes
    - Family Clupeidae
      - Gizzard Shad - *Dorosoma cepedianum* (Lesueur)
  - Order Osteoglossiformes
    - Family Hiodontidae
      - Goldeye - *Hiodon alosoides* (Rafinesque)
      - Mooneye - *Hiodon tergisus* Lesueur
  - Order Salmoniformes
    - Family Esocidae
      - Northern Pike - *Esox lucius* Linnaeus
  - Order Cypriniformes
    - Family Cyprinidae
      - Carp - *Cyprinus carpio* Linnaeus
      - Brassy Minnow - *Hybognathus hankinsoni* Hubbs
      - Silvery Minnow - *Hybognathus nuchalis* Agassiz
      - Silver Chub - *Hybopsis storeriana* (Kirtland)
      - Golden Shiner - *Notemigonus crysoleucas* (Mitchill)
      - Emerald Shiner - *Notropis atherinoides* Rafinesque
      - River Shiner - *Notropis blennius* (Girard)
      - Common Shiner - *Notropis cornutus* (Mitchill)
      - Pugnose Minnow - *Notropis emiliae* (Hay)
      - Spottail Shiner - *Notropis hudsonius* (Clinton)
      - Spotfin Shiner - *Notropis spilopterus* (Cope)
      - Sand Shiner - *Notropis stramineus* (Cope)
      - Weed Shiner - *Notropis texanus* (Girard)
      - Bluntnose Minnow - *Pimephales notatus* (Rafinesque)
      - Bullhead Minnow - *Pimephales vigilax* (Baird & Girard)

TABLE A7 (Concluded)

Family Catostomidae
River Carpsucker - Carpiodes carpio (Rafinesque)
Quillback - Carpiodes cyprinus (Lesueur)
Highfin Carpsucker - Carpiodes velifer (Rafinesque)
Smallmouth Buffalo - Ictiobus bubalus (Rafinesque)
Spotted Sucker - Minytrema melanops (Rafinesque)
Golden Redhorse - Moxostoma erythrurum (Rafinesque)
Shorthead Redhorse - Moxostoma macrolepidotum (Lesueur)

Order Siluriformes
Family Ictaluridae
Black Bullhead - Ictalurus melas (Rafinesque)
Channel Catfish - Ictalurus punctatus (Rafinesque)
Tadpole Madtom - Noturus gyrinus (Mitchill)
Flathead Catfish - Pylodictis olivaris (Rafinesque)

Order Percopsiformes
Family Percopsidae
Trout-perch - Percopsis omiscomaycus (Walbaum)

Order Atheriniformes
Family Atherinidae
Brook Silverside - Labidesthes sicculus (Cope)

Order Gasterosteiformes
Family Gasterosteidae
Brook Stickleback - Culaea inconstans (Kirtland)

Order Perciformes
Family Percichthyidae
White Bass - Morone chrysops (Rafinesque)

Family Centrarchidae
Rock Bass - Ambloplites rupestris (Rafinesque)
Pumpkinseed - Lepomis gibbosus (Linnaeus)
Orangespotted Sunfish - Lepomis humilis (Girard)
Blue gill - Lepomis macrochirus Rafinesque
Smallmouth Bass - Micropterus dolomieui Lacepede
Largemouth Bass - Micropterus salmoides (Lacepede)
White Crappie - Pomoxis annularis Rafinesque
Black Crappie - Pomoxis nigromaculatus (Lesueur)

Family Percidae
Western Sand Darter - Ammocrypta clara Jordan & Meek
Mud Darter - Etheostoma asprigene (Forbes)
Iowa Darter - Etheostoma exile (Girard)
Johnny Darter - Etheostoma nigrum Rafinesque
Yellow Perch - Perca flavescens (Mitchill)
Logperch - Percina caproides (Rafinesque)
Sauger - Stizostedion canadense (Smith)
Walleye - Stizostedion vitreum vitreum (Mitchill)

Family Sciaenidae
Freshwater Drum - Aplodinotus grunniens Rafinesque

TABLE A8. Composition of core samples taken from 26 sites behind Island 117 prior to and following 1974 disposal operations.

SITE A

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	1.0	0-15 cm	0.0
2-1	3.4	0-15 cm	1.7
1-0.5	19.3	0-15 cm	17.5
0.5-0.25	55.8	0-15 cm	66.1
0.25-0.125	15.2	0-15 cm	12.5
0.025-0.063	2.9	0-15 cm	1.6
<0.063	2.5	0-15 cm	0.6
>2	0.6	16-30 cm	0.2
2-1	3.0	16-30 cm	1.6
1-0.5	27.7	16-30 cm	16.0
0.5-0.25	61.1	16-30 cm	63.3
0.25-0.125	7.5	16-30 cm	15.0
0.125-0.063	0.2	16-30 cm	2.5
<0.063	0.0	16-30 cm	1.3
>2	0.4	31-45 cm	0.1
2-1	1.5	31-45 cm	0.8
1-0.5	16.9	31-45 cm	41.1
0.5-0.25	66.8	31-45 cm	55.5
0.25-0.125	11.0	31-45 cm	1.2
0.125-0.063	2.1	31-45 cm	1.0
<0.063	1.3	31-45 cm	0.3

SITE B

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.7	0-15 cm	2.4
2-1	7.4	0-15 cm	9.2
1-0.5	36.8	0-15 cm	45.5
0.5-0.25	51.1	0-15 cm	38.9
0.25-0.125	3.6	0-15 cm	4.2
0.025-0.063	0.3	0-15 cm	0.5
<0.063	0.1	0-15 cm	0.3
>2	0.5	16-30 cm	3.4
2-1	5.5	16-30 cm	4.0
1-0.5	33.5	16-30 cm	13.4
0.5-0.25	54.8	16-30 cm	72.7
0.25-0.125	5.6	16-30 cm	6.4
0.125-0.063	0.1	16-30 cm	0.1
<0.063	0.0	16-30 cm	0.0
>2	3.4	31-45 cm	0.0
2-1	6.1	31-45 cm	0.7
1-0.5	32.2	31-45 cm	6.2
0.5-0.25	54.6	31-45 cm	77.2
0.25-0.125	3.5	31-45 cm	15.5
0.125-0.063	0.1	31-45 cm	0.6
<0.063	0.0	31-45 cm	0.0

SITE C

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	1.1	0-15 cm	3.2
2-1	2.4	0-15 cm	7.7
1-0.5	20.4	0-15 cm	18.0
0.5-0.25	69.6	0-15 cm	65.3
0.25-0.125	6.2	0-15 cm	5.3
0.125-0.063	0.2	0-15 cm	0.3
<0.063	0.0	0-15 cm	0.1
>2	2.9	16-30 cm	1.0
2-1	6.8	16-30 cm	5.4
1-0.5	46.0	16-30 cm	34.7
0.5-0.25	42.5	16-30 cm	52.7
0.25-0.125	1.9	16-30 cm	4.8
0.125-0.063	0.0	16-30 cm	0.5
<0.063	0.0	16-30 cm	0.8
>2	0.8	31-45 cm	1.6
2-1	3.0	31-45 cm	2.4
1-0.5	36.5	31-45 cm	34.2
0.5-0.25	54.1	31-45 cm	53.4
0.25-0.125	5.4	31-45 cm	4.6
0.125-0.063	0.2	31-45 cm	0.3
<0.063	0.0	31-45 cm	0.3

SITE D

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.2	0-15 cm	1.4
2-1	2.2	0-15 cm	7.6
1-0.5	20.2	0-15 cm	42.2
0.5-0.25	64.2	0-15 cm	40.6
0.25-0.125	12.7	0-15 cm	7.2
0.125-0.063	0.4	0-15 cm	0.6
<0.063	0.2	0-15 cm	0.4
>2	0.6	16-30 cm	0.2
2-1	4.6	16-30 cm	2.6
1-0.5	29.8	16-30 cm	27.9
0.5-0.25	53.6	16-30 cm	59.3
0.25-0.125	10.6	16-30 cm	9.0
0.125-0.063	0.7	16-30 cm	0.5
<0.063	0.0	16-30 cm	0.5
>2	0.9	31-45 cm	1.7
2-1	8.6	31-45 cm	5.7
1-0.5	41.4	31-45 cm	44.8
0.5-0.25	44.1	31-45 cm	41.4
0.25-0.125	4.3	31-45 cm	5.9
0.125-0.063	0.2	31-45 cm	0.4
<0.063	0.0	31-45 cm	0.2

(Continued)

TABLE A8 (continued):

SITE E

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.3	0-15 cm	1.5
2-1	4.1		6.1
1-0.5	39.6		39.7
0.5-0.25	50.0		47.4
0.25-0.125	5.9		5.2
0.025-0.063	0.1		0.2
<0.063	0.0		0.0
>2	0.3	16-30 cm	0.1
2-1	3.1		3.0
1-0.5	17.1		35.9
0.5-0.25	38.6		55.1
0.25-0.125	23.9		5.8
0.125-0.063	8.5		0.2
<0.063	8.5		0.0
>2	0.0	31-45 cm	1.6
2-1	0.9		9.6
1-0.5	3.4		58.0
0.5-0.25	48.4		27.2
0.25-0.125	25.8		3.0
0.125-0.063	11.6		0.5
<0.063	9.9		0.0

SITE F

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.0	0-15 cm	0.8
2-1	1.0		4.0
1-0.5	14.4		18.4
0.5-0.25	60.8		52.7
0.25-0.125	13.9		19.2
0.025-0.063	5.9		3.0
<0.063	4.0		1.9
>2	0.6	16-30 cm	1.5
2-1	1.5		5.0
1-0.5	20.2		26.1
0.5-0.25	54.7		57.4
0.25-0.125	19.9		9.0
0.125-0.063	2.3		1.0
<0.063	0.8		0.0
>2	0.2	31-45 cm	1.7
2-1	2.4		2.7
1-0.5	18.9		9.3
0.5-0.25	45.0		68.0
0.25-0.125	29.8		13.6
0.125-0.063	3.1		3.8
<0.063	0.6		1.0

SITE G

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	--	0-15 cm	0.6
2-1	--		0.8
1-0.5	--		5.3
0.5-0.25	--		78.4
0.25-0.125	--		9.6
0.125-0.063	--		3.1
<0.063	--		2.2
>2	--	16-30 cm	0.0
2-1	--		0.6
1-0.5	--		4.8
0.5-0.25	--		48.4
0.25-0.125	--		42.3
0.125-0.063	--		2.8
<0.063	--		1.0
>2	0.4	31-45 cm	0.7
2-1	0.9		1.8
1-0.5	2.5		4.8
0.5-0.25	61.3		67.2
0.25-0.125	31.4		21.0
0.125-0.063	2.8		3.0
<0.063	0.8		1.6

SITE H

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.8	0-15 cm	0.7
2-1	4.6		1.8
1-0.5	6.0		11.1
0.5-0.25	39.9		67.8
0.25-0.125	20.5		10.6
0.125-0.063	16.1		4.8
<0.063	12.2		3.2
>2	1.9	16-30 cm	0.3
2-1	15.7		1.8
1-0.5	24.4		19.5
0.5-0.25	20.1		67.1
0.25-0.125	16.7		9.8
0.125-0.063	13.5		1.2
<0.063	7.8		0.2
>2	1.7	31-45 cm	0.4
2-1	8.4		1.6
1-0.5	11.5		17.2
0.5-0.25	30.2		64.9
0.25-0.125	21.8		14.0
0.125-0.063	13.1		1.7
<0.063	13.3		0.1

(Continued)

TABLE A8 (continued):

SITE I

Fraction mm	Depth	Preoperational Percent	Postoperational Percent
>2	0-15 cm	1.0	1.5
2-1	0-15 cm	1.5	3.1
1-0.5	0-15 cm	4.4	3.4
0.5-0.25	0-15 cm	60.4	46.4
0.25-0.125	0-15 cm	22.8	21.5
0.025-0.063	0-15 cm	6.1	12.7
<0.063	0-15 cm	3.7	11.5
>2	16-30 cm	0.2	0.1
2-1	16-30 cm	1.2	1.4
1-0.5	16-30 cm	2.5	3.3
0.5-0.25	16-30 cm	39.3	15.9
0.25-0.125	16-30 cm	29.8	29.1
0.125-0.063	16-30 cm	14.0	25.4
<0.063	16-30 cm	13.2	24.9
>2	31-45 cm	2.4	3.2
2-1	31-45 cm	1.6	6.6
1-0.5	31-45 cm	1.1	5.2
0.5-0.25	31-45 cm	29.2	4.8
0.25-0.125	31-45 cm	55.9	22.6
0.125-0.063	31-45 cm	6.5	22.0
<0.063	31-45 cm	3.3	35.5

SITE J

Fraction mm	Depth	Preoperational Percent	Postoperational Percent
>2	0-15 cm	0.4	1.1
2-1	0-15 cm	5.5	2.8
1-0.5	0-15 cm	7.9	3.5
0.5-0.25	0-15 cm	20.1	36.0
0.25-0.125	0-15 cm	31.1	24.0
0.025-0.063	0-15 cm	17.5	15.4
<0.063	0-15 cm	17.6	17.1
>2	16-30 cm	1.0	7.5
2-1	16-30 cm	4.7	9.7
1-0.5	16-30 cm	5.8	7.2
0.5-0.25	16-30 cm	45.8	9.5
0.25-0.125	16-30 cm	23.7	18.5
0.125-0.063	16-30 cm	9.9	18.9
<0.063	16-30 cm	9.1	28.6
>2	31-45 cm	0.1	--
2-1	31-45 cm	3.5	--
1-0.5	31-45 cm	5.7	--
0.5-0.25	31-45 cm	6.5	--
0.25-0.125	31-45 cm	46.6	--
0.125-0.063	31-45 cm	21.1	--
<0.063	31-45 cm	16.5	--

SITE K

Fraction mm	Depth	Preoperational Percent	Postoperational Percent
>2	0-15 cm	0.1	0.1
2-1	0-15 cm	0.4	0.3
1-0.5	0-15 cm	5.2	5.3
0.5-0.25	0-15 cm	61.9	72.1
0.25-0.125	0-15 cm	25.8	19.5
0.125-0.063	0-15 cm	5.8	2.2
<0.063	0-15 cm	0.8	0.6
>2	16-30 cm	0.1	0.4
2-1	16-30 cm	0.5	2.9
1-0.5	16-30 cm	1.0	19.9
0.5-0.25	16-30 cm	56.2	38.2
0.25-0.125	16-30 cm	27.0	17.2
0.125-0.063	16-30 cm	10.1	10.4
<0.063	16-30 cm	5.4	11.1
>2	31-45 cm	0.1	0.4
2-1	31-45 cm	0.2	4.2
1-0.5	31-45 cm	0.8	33.1
0.5-0.25	31-45 cm	50.1	32.6
0.25-0.125	31-45 cm	42.3	11.6
0.125-0.063	31-45 cm	5.1	6.5
<0.063	31-45 cm	1.5	11.7

SITE L

Fraction mm	Depth	Preoperational Percent	Postoperational Percent
>2	0-15 cm	0.4	0.6
2-1	0-15 cm	0.6	2.4
1-0.5	0-15 cm	3.6	6.[illegible]
0.5-0.25	0-15 cm	78.3	15.[illegible]
0.25-0.125	0-15 cm	13.4	31.4
0.125-0.063	0-15 cm	2.4	25.5
<0.063	0-15 cm	0.8	18.6
>2	16-30 cm	1.5	0.6
2-1	16-30 cm	1.2	5.2
1-0.5	16-30 cm	0.8	17.3
0.5-0.25	16-30 cm	63.1	33.5
0.25-0.125	16-30 cm	21.5	17.7
0.125-0.063	16-30 cm	9.0	12.6
<0.063	16-30 cm	2.8	13.1
>2	31-45 cm	0.1	0.7
2-1	31-45 cm	0.1	6.2
1-0.5	31-45 cm	0.7	69.1
0.5-0.25	31-45 cm	65.5	13.0
0.25-0.125	31-45 cm	30.4	3.7
0.125-0.063	31-45 cm	3.0	1.2
<0.063	31-45 cm	0.3	0.9

(Continued)

TABLE A8 (continued):

SITE M

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	1.1	0-15 cm	1.0
2-1	3.6	0-15 cm	4.9
1-0.5	5.8	0-15 cm	10.4
0.5-0.25	12.1	0-15 cm	18.5
0.25-0.125	39.1	0-15 cm	17.0
0.025-0.063	21.0	0-15 cm	22.4
<0.063	17.1	0-15 cm	25.7
>2	0.8	16-30 cm	--
2-1	3.9	16-30 cm	--
1-0.5	6.3	16-30 cm	--
0.5-0.25	21.1	16-30 cm	--
0.25-0.125	27.8	16-30 cm	--
0.125-0.063	19.9	16-30 cm	--
<0.063	20.6	16-30 cm	--
>2	0.4	31-45 cm	0.2
2-1	3.1	31-45 cm	3.8
1-0.5	14.6	31-45 cm	27.3
0.5-0.25	61.1	31-45 cm	38.0
0.25-0.125	13.8	31-45 cm	9.5
0.125-0.063	4.6	31-45 cm	9.1
<0.063	2.4	31-45 cm	12.3

SITE N

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.2	0-15 cm	0.1
2-1	2.0	0-15 cm	1.7
1-0.5	6.2	0-15 cm	26.6
0.5-0.25	13.0	0-15 cm	53.8
0.25-0.125	29.9	0-15 cm	7.9
0.025-0.063	25.7	0-15 cm	5.1
<0.063	23.1	0-15 cm	4.8
>2	0.3	16-30 cm	0.3
2-1	2.2	16-30 cm	4.5
1-0.5	6.0	16-30 cm	48.3
0.5-0.25	50.2	16-30 cm	44.1
0.25-0.125	24.0	16-30 cm	2.7
0.125-0.063	12.0	16-30 cm	0.1
<0.063	5.5	16-30 cm	0.0
>2	0.8	31-45 cm	0.8
2-1	5.7	31-45 cm	5.9
1-0.5	10.9	31-45 cm	50.4
0.5-0.25	18.7	31-45 cm	39.0
0.25-0.125	19.5	31-45 cm	3.8
0.125-0.063	18.2	31-45 cm	0.1
<0.063	26.3	31-45 cm	0.0

SITE O

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	1.0	0-15 cm	0.6
2-1	3.0	0-15 cm	3.4
1-0.5	5.1	0-15 cm	6.2
0.5-0.25	13.2	0-15 cm	10.6
0.25-0.125	38.7	0-15 cm	32.0
0.125-0.063	21.2	0-15 cm	26.4
<0.063	17.8	0-15 cm	20.9
>2	1.9	16-30 cm	0.7
2-1	2.1	16-30 cm	3.4
1-0.5	26.5	16-30 cm	20.6
0.5-0.25	56.4	16-30 cm	45.9
0.25-0.125	10.5	16-30 cm	16.3
0.125-0.063	1.7	16-30 cm	6.9
<0.063	0.9	16-30 cm	6.2
>2	0.1	31-45 cm	0.7
2-1	1.0	31-45 cm	3.7
1-0.5	14.6	31-45 cm	7.1
0.5-0.25	69.5	31-45 cm	43.8
0.25-0.125	12.6	31-45 cm	22.1
0.125-0.063	1.6	31-45 cm	12.5
<0.063	0.7	31-45 cm	10.0

SITE P

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	1.8	0-15 cm	0.0
2-1	3.8	0-15 cm	0.3
1-0.5	2.9	0-15 cm	4.5
0.5-0.25	21.9	0-15 cm	68.3
0.25-0.125	44.5	0-15 cm	18.3
0.125-0.063	16.1	0-15 cm	7.4
<0.063	9.0	0-15 cm	1.2
>2	0.4	16-30 cm	1.7
2-1	2.4	16-30 cm	3.2
1-0.5	3.8	16-30 cm	3.0
0.5-0.25	22.3	16-30 cm	32.2
0.25-0.125	34.3	16-30 cm	37.3
0.125-0.063	21.9	16-30 cm	14.6
<0.063	14.9	16-30 cm	8.0
>2	0.4	31-45 cm	2.0
2-1	1.5	31-45 cm	4.4
1-0.5	16.1	31-45 cm	4.1
0.5-0.25	45.3	31-45 cm	7.8
0.25-0.125	17.6	31-45 cm	31.1
0.125-0.063	9.5	31-45 cm	25.8
<0.063	9.7	31-45 cm	24.9

(Continued)

TABLE A8 (continued):

SITE Q

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.1	0-15 cm	0.2
2-1	0.8		2.8
1-0.5	3.9		12.8
0.5-0.25	34.1		50.7
0.25-0.125	29.9		16.5
0.025-0.063	19.3		9.6
<0.063	12.0		7.5
>2	0.3	16-30 cm	1.2
2-1	1.5		3.2
1-0.5	2.1		18.7
0.5-0.25	61.6		53.8
0.25-0.125	21.7		19.9
0.125-0.063	8.3		2.6
<0.063	4.5		0.6
>2	0.0	31-45 cm	0.2
2-1	0.1		2.0
1-0.5	0.9		14.4
0.5-0.25	52.2		58.8
0.25-0.125	29.5		21.2
0.125-0.063	14.1		3.2
<0.063	3.1		0.3

SITE R

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.1	0-15 cm	0.1
2-1	2.5		3.5
1-0.5	15.6		17.6
0.5-0.25	56.7		40.0
0.25-0.125	13.4		27.2
0.025-0.063	6.9		9.1
<0.063	4.8		2.5
>2	1.1	16-30 cm	1.2
2-1	1.8		3.5
1-0.5	11.6		16.7
0.5-0.25	64.9		48.4
0.25-0.125	17.2		23.1
0.125-0.063	3.1		5.6
<0.063	0.2		1.4
>2	0.4	31-45 cm	0.8
2-1	2.0		3.9
1-0.5	20.9		23.2
0.5-0.25	57.4		57.4
0.25-0.125	18.6		9.2
0.125-0.063	0.7		3.1
<0.063	0.1		2.4

SITE S

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.3	0-15 cm	0.1
2-1	2.7		1.0
1-0.5	19.2		8.7
0.5-0.25	62.5		73.6
0.25-0.125	14.1		10.0
0.125-0.063	1.0		5.0
<0.063	0.3		1.6
>2	0.3	16-30 cm	2.1
2-1	2.4		1.9
1-0.5	16.5		4.3
0.5-0.25	65.3		47.6
0.25-0.125	14.4		35.9
0.125-0.063	0.8		6.5
<0.063	0.1		1.6
>2	0.5	31-45 cm	0.2
2-1	2.3		3.9
1-0.5	15.9		12.5
0.5-0.25	63.7		68.1
0.25-0.125	14.9		11.8
0.125-0.063	1.8		2.5
<0.063	0.8		0.8

SITE T

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.2	0-15 cm	1.4
2-1	2.9		5.1
1-0.5	5.6		5.6
0.5-0.25	9.3		4.6
0.25-0.125	20.5		17.9
0.125-0.063	28.7		29.8
<0.063	32.8		35.7
>2	0.1	16-30 cm	2.3
2-1	2.4		7.5
1-0.5	6.4		8.5
0.5-0.25	9.3		9.5
0.25-0.125	19.7		15.1
0.125-0.063	30.4		25.0
<0.063	31.6		32.1
>2	3.3	31-45 cm	0.1
2-1	13.0		2.5
1-0.5	19.5		9.9
0.5-0.25	17.4		16.7
0.25-0.125	16.6		15.6
0.125-0.063	14.2		23.3
<0.063	16.1		31.8

(Continued)

TABLE A8 (continued):

SITE U

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.9	0-15 cm	2.8
2-1	3.6	0-15 cm	11.8
1-0.5	5.0	0-15 cm	10.5
0.5-0.25	4.2	0-15 cm	9.6
0.25-0.125	24.6	0-15 cm	14.2
0.025-0.063	26.1	0-15 cm	19.0
<0.063	35.6	0-15 cm	32.1
>2	0.9	16-30 cm	5.6
2-1	3.7	16-30 cm	13.4
1-0.5	6.0	16-30 cm	15.7
0.5-0.25	25.0	16-30 cm	18.0
0.25-0.125	35.3	16-30 cm	15.8
0.125-0.063	17.7	16-30 cm	13.5
<0.063	11.3	16-30 cm	17.9
>2	0.6	31-45 cm	--
2-1	5.6	31-45 cm	--
1-0.5	87.2	31-45 cm	--
0.5-0.25	5.1	31-45 cm	--
0.25-0.125	1.2	31-45 cm	--
0.125-0.063	0.5	31-45 cm	--
<0.063	0.0	31-45 cm	--

SITE V

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.1	0-15 cm	2.1
2-1	3.5	0-15 cm	10.0
1-0.5	46.6	0-15 cm	11.3
0.5-0.25	35.2	0-15 cm	27.1
0.25-0.125	10.1	0-15 cm	23.5
0.025-0.063	4.0	0-15 cm	16.0
<0.063	0.5	0-15 cm	[illegible]
>2	2.0	16-30 cm	0.4
2-1	12.9	16-30 cm	7.1
1-0.5	45.6	16-30 cm	34.8
0.5-0.25	19.4	16-30 cm	29.0
0.25-0.125	9.0	16-30 cm	11.3
0.125-0.063	8.2	16-30 cm	11.1
<0.063	3.0	16-30 cm	6.2
>2	0.4	31-45 cm	0.5
2-1	4.6	31-45 cm	7.3
1-0.5	17.1	31-45 cm	28.7
0.5-0.25	27.1	31-45 cm	23.5
0.25-0.125	21.5	31-45 cm	16.3
0.125-0.063	19.1	31-45 cm	15.0
<0.063	10.2	31-45 cm	8.6

SITE W

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	0.5	0-15 cm	0.2
2-1	7.6	0-15 cm	3.9
1-0.5	17.4	0-15 cm	12.0
0.5-0.25	27.6	0-15 cm	13.6
0.25-0.125	15.6	0-15 cm	25.3
0.125-0.063	19.5	0-15 cm	27.2
<0.063	11.8	0-15 cm	17.9
>2	0.4	16-30 cm	0.4
2-1	3.4	16-30 cm	3.5
1-0.5	10.5	16-30 cm	10.0
0.5-0.25	23.1	16-30 cm	24.0
0.25-0.125	27.9	16-30 cm	28.1
0.125-0.063	23.5	16-30 cm	22.4
<0.063	11.2	16-30 cm	11.6
>2	1.4	31-45 cm	0.0
2-1	7.6	31-45 cm	3.8
1-0.5	12.0	31-45 cm	12.9
0.5-0.25	35.4	31-45 cm	22.0
0.25-0.125	19.2	31-45 cm	24.9
0.125-0.063	15.9	31-45 cm	23.6
<0.063	8.5	31-45 cm	12.6

SITE X

Fraction mm	Preoperational Percent	Depth	Postoperational Percent
>2	3.8	0-15 cm	0.1
2-1	10.0	0-15 cm	0.8
1-0.5	10.3	0-15 cm	5.6
0.5-0.25	21.6	0-15 cm	20.6
0.25-0.125	23.4	0-15 cm	48.5
0.125-0.063	18.2	0-15 cm	23.0
<0.063	12.7	0-15 cm	1.5
>2	3.9	16-30 cm	0.5
2-1	10.7	16-30 cm	9.0
1-0.5	11.3	16-30 cm	15.9
0.5-0.25	14.0	16-30 cm	12.1
0.25-0.125	21.6	16-30 cm	26.5
0.125-0.063	23.2	16-30 cm	20.4
<0.063	15.2	16-30 cm	15.5
>2	0.4	31-45 cm	10.0
2-1	3.1	31-45 cm	13.3
1-0.5	8.9	31-45 cm	25.3
0.5-0.25	19.6	31-45 cm	18.3
0.25-0.125	32.4	31-45 cm	10.3
0.125-0.063	24.9	31-45 cm	13.2
<0.063	10.7	31-45 cm	9.6

(Continued)

TABLE A8 (Concluded)

SITE Y

Depth	Fraction mm	Preoperational Percent	Postoperational Percent
0-15 cm	>2	2.0	1.6
	2-1	6.6	4.9
	1-0.5	7.0	5.9
	0.5-0.25	12.9	10.0
	0.25-0.125	28.7	25.3
	0.025-0.063	23.6	22.1
	<0.063	19.3	30.2
16-30 cm	>2	0.0	--
	2-1	0.9	--
	1-0.5	11.2	--
	0.5-0.25	14.7	--
	0.25-0.125	49.0	--
	0.125-0.063	18.7	--
	<0.063	5.5	--
31-45 cm	>2	1.1	--
	2-1	3.6	--
	1-0.5	4.5	--
	0.5-0.25	21.7	--
	0.25-0.125	43.8	--
	0.125-0.063	20.1	--
	<0.063	5.3	--

SITE Z

Depth	Fraction mm	Preoperational Percent	Postoperational Percent
0-15 cm	>2	0.1	1.7
	2-1	0.8	5.2
	1-0.5	17.1	7.2
	0.5-0.25	23.9	6.9
	0.25-0.125	37.2	20.6
	0.125-0.063	17.5	26.6
	<0.063	3.5	31.9
16-30 cm	>2	0.4	3.6
	2-1	3.2	3.3
	1-0.5	5.5	8.1
	0.5-0.25	7.2	8.6
	0.25-0.125	47.0	16.4
	0.125-0.063	27.2	27.7
	<0.063	9.6	32.3
31-45 cm	>2	2.4	4.0
	2-1	5.1	8.6
	1-0.5	5.5	7.6
	0.5-0.25	7.7	6.4
	0.25-0.125	43.6	21.9
	0.125-0.063	26.5	21.5
	<0.063	9.3	30.0

TABLE A9. Turbidity measurements* taken during 1973 and 1974 in the vicinity of Island 117.

Site	27 June 1973	8 July 1974	22 July 1974	22-23 July (range)	14 Aug 1974	19 Aug 1974	27 Aug 1974	28 Aug 1974	30 Aug 1974	6 Sept 1974
2	15	25	45	--	36	29	23	24	25	45
3	15	45	46	--	37	30	25	23	25	30
4	15	38	45	--	34	29	25	--	27	27
5	40	38	44	--	34	34	30	53	24	25
6	20	38	40	0-45	18	36	25	20	24	41
7	50	29	47	--	20	35	25	25	23	27
8	75	28	58	--	30	28	20	28	22	36
9	90	25	49	--	24	32	29	35	45	40
10	95	29	36	--	23	33	25	25	--	50
11	95	34	41	--	25	32	25	16	--	38
12	95	55	41	--	24	38	20	22	--	27
13	100	45	30	0-39	23	48	18	18	28	31
14	100	29	38	--	22	28	36	25	33	31
15	100	34	29	--	25	32	45	20	29	30
16	100	31	33	--	21	34	28	19	29	27
17	100	29	35	--	21	26	18	21	22	25
18	95	33	32	--	18	32	23	20	28	25
19	95	32	45	--	20	33	23	22	24	84
20	100	54	29	--	20	30	24	18	22	
21	100	39	35	--	16	--	--	--	--	--
22	100	50	39	--	21	28	26	15	16	
23	100	57	30	--	22	--	--	--	--	--
24	100	47	48	--	25	25	25	16	26	33
25	100	46	51	--	25	--	--	--	--	--
26	100	50	62	--	20	--	--	--	--	--
27	100	49	58	--	19	--	--	--	--	--
28	100	53	51	--	25	--	--	--	--	--
29	95	43	38	--	25	--	--	--	--	24
30	95	45	39	--	17	--	--	--	--	27
31	95	43	36	--	23	--	--	--	--	29
32	100	47	39	--	23	--	--	--	--	27
33	100	45	39	--	22	--	--	--	--	19
34	100	48	38	--	28	37	27	18	18	30
35	100	38	36	--	24	--	--	--	--	30
36	95	46	38	--	16	29	28	23	26	21
37	95	55	35	--	18	--	--	--	--	57
38	95	51	33	--	40	--	--	--	--	30
39	95	44	28	--	34	--	--	--	--	28
40	95	55	38	--	39	--	--	--	--	27
41	90	58	37	--	42	--	--	--	--	31
42	--	35	38	--	36	35	26	24	17	27
43	--	59	41	--	34	29	20	26	26	30
44	--	33	66	--	20	--	--	--	--	
45	--	41	53	--	16	25	23	23	25	28
46	--	38	50	0-50	43	--	--	--	--	--
47	--	48	43	--	41	29	23	17	23	
48	--	74	47	--	45	--	--	--	--	26
49	--	97	49	--	23	--	--	--	--	18
50	--	51	47	--	30	30	20	20	22	26
51	--	110	41	--	29	--	--	--	--	11

*Turbidity is expressed in terms of Jackson Turbidity Units.

TABLE A10. Concentrations of nitrate nitrogen* measured during 1973 and 1974 in the vicinity of Island 117.

Site	27 June 1973	8 July 1974	22 July 1974	22-23 July (range)	14 Aug 1974	19 Aug 1974	27 Aug 1974	28 Aug 1974	30 Aug 1974	6 Sept 1974
2	1.020	.310	.340	--	.200	.210	.180	.270	.100	.140
3	1.170	.460	.350	--	.220	.240	.200	.300	.120	.160
4	0.960	.500	.350	--	.300	.210	.190	.000	.100	.080
5	0.980	.440	.330	--	.250	.200	.190	.300	.100	.210
6	1.180	.500	.330	.240-.400	.320	.200	.200	.290	.120	.210
7	1.180	.540	.360	--	.270	.220	.200	.220	.120	.090
8	0.820	.470	.360	--	.250	.120	.090	.240	.100	.100
9	1.080	.440	.350	--	.270	.200	.130	.220	.060	.160
10	1.080	.400	.380	--	.240	.170	.140	.220	--	.100
11	1.100	.370	.330	--	.300	.130	.080	.220	--	.060
12	1.040	.520	.310	--	.270	.050	.080	.200	--	.070
13	0.790	.380	.360	.270-.400	.300	.200	.120	.200	.070	.080
14	1.040	.320	.310	--	.230	.120	.130	.190	.140	.080
15	1.100	.380	.340	--	.240	.140	.150	.230	.090	.160
16	1.140	.380	.330	--	.270	.200	.180	.210	.110	.140
17	1.140	.380	.320	--	.320	.120	.150	.230	.140	.080
18	0.800	.430	.360	--	.240	.140	.160	.260	.130	.200
19	1.180	.280	.330	--	.320	.200	.190	.280	.160	.110
20	1.100	.500	.380	--	.220	.200	.110	.220	.100	.120
21	1.180	.430	.320	--	.310	--	--	--	--	.120
22	1.200	.440	.390	--	.250	.220	.220	.230	.100	.100
23	0.930	.480	.350	--	.240	--	--	--	--	.120
24	1.050	.440	.280	--	.300	.180	.130	.200	.120	.110
25	1.090	.480	.290	--	.250	--	--	--	--	.080
26	1.100	.520	.250	--	.270	--	--	--	--	.070
27	0.960	.470	.320	--	.310	--	--	--	--	.080
28	1.090	.430	.320	--	.250	--	--	--	--	.130
29	1.110	.420	.360	--	.320	--	--	--	--	.200
30	1.080	.410	.310	--	.340	--	--	--	--	.160
31	1.100	.430	.300	--	.310	--	--	--	--	.200
32	1.020	.390	.340	--	.190	--	--	--	--	.180
33	1.050	.370	.330	--	.300	--	--	--	--	.120
34	1.050	.370	.350	--	.310	.120	.090	.160	.140	.200
35	0.900	.410	.360	--	.320	--	--	--	--	.200
36	0.980	.370	.390	--	.270	.080	.130	.210	.140	.200
37	1.050	.400	.360	--	.310	--	--	--	--	.130
38	1.030	.360	.340	--	.250	--	--	--	--	.210
39	0.960	.460	.360	--	.230	--	--	--	--	.120
40	0.920	.430	.400	--	.300	--	--	--	--	.080
41	0.830	.400	.330	--	.260	--	--	--	--	.180
42	--	.440	.360	--	.230	.220	.180	.390	.190	.180
43	--	.440	.370	--	.290	.180	.170	.330	.170	.160
44	--	.500	.270	--	.310	--	--	--	--	.110
45	--	.390	.300	--	.310	.070	.130	.240	.110	.080
46	--	.370	.290	.280-.390	.230	--	--	--	--	.120
47	--	.460	.370	--	.250	.200	.170	.240	.110	.000
48	--	.460	.310	--	.250	--	--	--	--	.120
49	--	.360	.350	--	.280	--	--	--	--	.110
50	--	.460	.360	--	.280	.100	.150	.200	.090	.110
51	--	.440	.390	--	.310	--	--	--	--	.200

*Concentrations are expressed as milligrams per liter (mg/ℓ).

TABLE A11. Concentrations of nitrite nitrogen* measured during 1973 and 1974 in the vicinity of Island 117.

Site	27 June 1973	8 July 1974	22 July 1974	22-23 July (range)	14 Aug 1974	19 Aug 1974	27 Aug 1974	28 Aug 1974	30 Aug 1974	6 Sept 1974
2	.040	.041	.011	--	.001	.008	.003	.010	.000	.003
3	.045	.035	.013	--	.003	.003	.001	.008	.000	.003
4	.037	.041	.008	--	.001	.005	.005	.000	.000	.000
5	.035	.039	.008	--	.006	.001	.005	.001	.001	.006
6	.039	.039	.010	.008-.019	.013	.008	.005	.005	.003	.000
7	.037	.045	.013	--	.008	.001	.006	.005	.003	.006
8	.037	.049	.010	--	.006	.003	.005	.001	.001	.001
9	.035	.041	.019	--	.005	.008	.005	.005	.003	.001
10	.037	.033	.018	--	.003	.008	.003	.005	--	.003
11	.039	.035	.015	--	.003	.008	.003	.001	--	.270
12	.037	.039	.011	--	.006	.005	.001	.003	--	.220
13	.033	.047	.008	.008-.019	.005	.011	.001	.001	.006	.270
14	.037	.039	.013	--	.005	.001	.008	.008	.001	.210
15	.041	.043	.005	--	.010	.001	.008	.001	.005	.220
16	.037	.041	.010	--	.005	.003	.001	.003	.005	.000
17	.037	.045	.000	--	.008	.001	.008	.001	.001	.000
18	.041	.045	.010	--	.006	.001	.001	.001	.005	.003
19	.037	.039	.005	--	.010	.001	.003	.003	.001	.005
20	.035	.041	.018	--	.026	.001	.008	.005	.003	.004
21	.035	.049	.010	--	.008	--	--	--	--	.001
22	.035	.041	.008	--	.005	.001	.005	.006	.001	.003
23	.033	.041	.011	--	.011	--	--	--	--	.004
24	.031	.037	.010	--	.015	.003	.005	.001	.003	.005
25	.032	.037	.013	--	.011	--	--	--	--	.003
26	.035	.039	.010	--	.008	--	--	--	--	.007
27	.037	.041	.013	--	.010	--	--	--	--	.000
28	.032	.031	.006	--	.008	--	--	--	--	.007
29	.033	.040	.005	--	.008	--	--	--	--	.000
30	.041	.033	.008	--	.010	--	--	--	--	.000
31	.037	.033	.011	--	.008	--	--	--	--	.000
32	.041	.041	.011	--	.010	--	--	--	--	.000
33	.032	.033	.008	--	.005	--	--	--	--	.000
34	.033	.039	.008	--	.006	.001	.005	.003	.003	.000
35	.035	.043	.015	--	.008	--	--	--	--	.000
36	.037	.041	.015	--	.008	.001	.008	.008	.001	.000
37	.033	.041	.018	--	.008	--	--	--	--	.008
38	.033	.041	.011	--	.013	--	--	--	--	.000
39	.037	.043	.013	--	.005	--	--	--	--	.003
40	.035	.037	.019	--	.003	--	--	--	--	.000
41	.029	.040	.011	--	.003	--	--	--	--	.003
42	--	.043	.003	--	.013	.001	.003	.008	.008	.003
43	--	.040	.000	--	.005	.003	.005	.006	.005	.001
44	--	.041	.005	--	.008	--	--	--	--	.010
45	--	.031	.011	--	.013	.006	.006	.006	.005	.000
46	--	.047	.010	.003-.018	.001	--	--	--	--	.004
47	--	.045	.010	--	.008	.001	.008	.005	.005	.000
48	--	.043	.011	--	.001	--	--	--	--	.000
49	--	.045	.018	--	.018	--	--	--	--	.005
50	--	.040	.008	--	.001	.000	.008	.003	.006	.008
51	--	.061	.010	--	.001	--	--	--	--	.006

*Concentrations are expressed as milligrams per liter (mg/ℓ).

TABLE A12. Concentrations of orthophosphate* measured during 1973 and 1974 in the vicinity of Island 117.

Site	27 June 1973	8 July 1974	22 July 1974	22-23 July (range)	14 Aug 1974	19 Aug 1974	27 Aug 1974	28 Aug 1974	30 Aug 1974	6 Sept 1974
2	.310	.160	.250	--	.530	.550	.660	.640	.550	.310
3	.260	.180	.270	--	.530	.450	.580	.640	.450	.270
4	.260	.180	.250	--	.530	.450	.580		.530	.310
5	.290	.210	.200	--	.550	.440	.640	.530	.400	.290
6	.270	.250	.180	.180-.400	.500	.530	.610	.530	.500	.290
7	.300	.610	.200	--	.530	.640	.730	.530	.400	.290
8	.290	.400	.220	--	.640	.500	.730	.550	.480	.270
9	.240	.140	.160	--	.610	.400	.640	.580	.580	.270
10	.300	.220	.180	--	.430	.530	.610	.690	--	.310
11	.250	.480	.200	--	.530	.550	.690	.610	--	.270
12	.240	.010	.230	--	.660	.610	.610	.640	--	.220
13	.280	.160	.250	.160-.380	.640	.480	.500	.660	.550	.270
14	.300	.140	.250	--	.450	.330	.450	.640	.530	.210
15	.260	.160	.180	--	.640	.560	.640	.400	.550	.220
16	.240	.140	.200	--	.530	.500	.480	.500	.530	.250
17	.270	.160	.210	--	.640	.500	.640	.500	.480	.270
18	.250	.200	.230	--	.550	.500	.580	.380	.660	.260
19	.270	.160	.170	--	.600	.500	.430	.430	.730	.270
20	.280	.730	.480	--	.550	.430	.610	.380	.450	.330
21	.280	.690	.450	--	.580	--	--	--	--	.310
22	.260	.450	.290	--	.450	.330	.610	.480	.430	.480
23	.330	.640	.290	--	.610	--	--	--	--	.310
24	.240	.120	.200	--	.530	.530	.640	.430	.500	.380
25	.310	.380	.200	--	.580	--	--	--	--	.430
26	.320	.380	.250	--	.550	--	--	--	--	.400
27	.330	.200	.240	--	.500	--	--	--	--	.290
28	.260	.270	.210	--	.530	--	--	--	--	.000
29	.360	.200	.220	--	.530	--	--	--	--	.310
30	.320	.320	.250	--	.530	--	--	--	--	.290
31	.340	.270	.270	--	.530	--	--	--	--	.270
32	.310	.250	.240	--	.550	--	--	--	--	.220
33	.280	.310	.220	--	.530	--	--	--	--	.250
34	.270	.250	.200	--	.530	.350	.610	.430	.640	.270
35	.270	.400	.220	--	.500	--	--	--	--	.250
36	.340	.350	.170	--	.580	.450	.750	.380	.430	.220
37	.260	.310	.220	--	.530	--	--	--	--	.180
38	.300	.530	.230	--	.450	--	--	--	--	.400
39	.270	.270	.140	--	.480	--	--	--	--	.310
40	.260	.270	.250	--	.430	--	--	--	--	.250
41	.250	.430	.230	--	.350	--	--	--	--	.270
42	--	.290	.230	--	.500	.560	.580	.610	.660	.250
43	--	.250	.220	--	.500	.480	.610	.640	.640	.260
44	--	.310	.270	--	.550	--	--	--	--	.500
45	--	.270	.200	--	.610	.530	.610	.380	.500	.160
46	--	.270	.200	.160-.530	.610	--	--	--	--	.550
47	--	.220	.330	--	.690	.380	.690	.450	.430	.550
48	--	.290	.250	--	.480	--	--	--	--	.300
49	--	.350	.340	--	.770	--	--	--	--	.360
50	--	.270	.220	--	.580	.560	.500	.400	.450	.210
51	--	.610	.270	--	.430	--	--	--	--	.310

*Concentrations are expressed as milligrams per liter (mg/ℓ).

TABLE A13. Concentrations of dissolved oxygen* measured during 1973 and 1974 in the vicinity of Island 117.

Site	27 June 1973	8 July 1974	22 July 1974	22-23 July (range)	14 Aug 1974	19 Aug 1974	27 Aug 1974	28 Aug 1974	30 Aug 1974	6 Sept 1974
2	8.2	7.5	5.0	--	7.9	9.3	8.1	9.3	9.1	10.2
3	8.0	7.5	4.6	--	8.2	9.8	8.4	9.5	9.3	10.0
4	7.7	7.0	3.8	--	8.2	9.3	8.4	0.0	9.1	9.4
5	7.6	6.1	3.7	--	8.7	9.8	8.5	9.3	8.8	9.8
6	8.0	7.8	5.2	5.2-7.5	7.0	9.9	8.4	9.8	9.3	9.8
7	8.0	7.7	6.7	--	6.7	8.7	8.1	9.8	9.3	10.3
8	7.7	7.7	6.7	--	6.3	8.7	8.7	9.9	9.9	11.4
9	7.3	7.5	7.0	--	6.7	8.7	9.3	10.5	9.8	11.2
10	8.2	8.0	7.2	--	6.5	9.6	9.9	14.0	--	11.2
11	7.7	7.9	6.5	--	6.7	9.3	10.1	12.0	--	10.9
12	8.0	6.7	5.2	--	7.0	6.7	9.3	11.6	--	11.5
13	8.2	8.7	6.4	0.0-8.1	7.1	7.9	10.3	12.8	7.9	11.5
14	8.0	8.5	7.1	--	6.7	8.7	8.2	12.8	8.1	8.1
15	8.2	9.5	8.5	--	7.0	9.3	8.4	11.6	8.1	9.3
16	8.2	9.8	8.5	--	6.4	8.6	8.1	11.4	8.7	9.3
17	8.2	9.4	7.4	--	6.8	8.6	8.7	11.4	7.9	8.1
18	8.2	8.2	7.3	--	6.7	8.9	8.1	11.4	8.1	9.3
19	8.1	8.9	7.2	--	6.4	8.9	8.0	11.0	8.4	9.3
20	8.8	5.2	6.4	--	7.2	8.7	--	11.4	9.3	6.7
21	7.7	5.8	6.5	--	7.2	--	--	--	--	10.0
22	8.3	5.8	6.3	--	7.0	10.5	--	10.9	9.3	10.0
23	8.2	5.8	6.4	--	7.1	--	--	--	--	9.9
24	8.2	6.3	7.4	--	6.5	8.7	--	9.9	9.1	9.3
25	8.2	7.3	5.7	--	6.5	--	--	--	--	9.5
26	7.8	8.1	7.1	--	6.5	--	--	--	--	9.8
27	8.1	7.1	6.5	--	6.6	--	--	--	--	9.9
28	8.2	8.7	7.2	--	6.6	--	--	--	--	--
29	8.1	8.4	7.9	--	6.8	--	--	--	--	--
30	8.4	9.1	5.7	--	6.7	--	--	--	--	--
31	8.2	8.5	5.3	--	6.8	--	--	--	--	8.9
32	8.4	8.9	6.3	--	6.8	--	--	--	--	9.2
33	8.8	8.8	6.0	--	7.0	--	--	--	--	9.6
34	8.8	8.7	6.7	--	7.0	--	--	--	--	9.2
35	7.6	7.0	6.7	--	7.1	--	--	--	--	9.3
36	10.0	6.6	7.0	--	7.1	9.3	--	10.3	9.3	9.5
37	8.7	6.7	6.4	--	7.2	--	--	--	--	8.6
38	8.4	6.1	5.7	--	7.9	9.9	--	10.5	9.5	8.5
39	8.3	7.1	6.7	--	8.7	--	--	--	--	7.7
40	8.0	6.6	6.0	--	8.1	--	--	--	--	8.6
41	7.5	6.6	5.6	--	8.1	--	--	--	--	8.0
42	--	7.9	6.7	--	8.0	8.1	--	9.1	8.1	9.2
43	--	6.7	6.8	--	8.0	8.7	7.5	9.1	8.4	8.6
44	--	7.9	7.1	--	7.1	--	--	--	--	8.7
45	--	8.9	7.2	--	7.2	10.2	--	10.5	9.8	9.3
46	--	5.6	5.9	5.0-7.4	4.0	--	--	--	--	9.9
47	--	6.5	6.3	--	6.0	9.6	--	11.0	10.0	9.8
48	--	4.9	5.8	--	5.6	--	--	--	--	8.6
49	--	0.0	3.6	--	6.4	--	--	--	--	7.7
50	--	6.7	5.4	--	6.4	10.2	9.3	10.8	9.8	9.4
51	--	5.0	4.9	--	6.4	--	--	--	--	7.0

*Concentrations are expressed as milligrams per liter (mg/ℓ).

TABLE A14. Concentrations of dissolved organic carbon* measured on 19, 28, and 30 August 1974 in the vicinity of Island 117.

Site	19 August 1974	28 August 1974	30 August 1974
2	8.5	7.4	4.8
7	12.2	8.3	7.3
12	7.8	8.1	5.3
13	8.6	8.0	7.0
15	9.2	7.9	8.9
19	9.3	8.0	8.0
20	9.1	8.1	4.7
22	9.1	7.0	---
24	8.9	8.1	4.0
34	9.2	7.6	2.9
36	9.2	7.8	8.5
42	9.1	8.1	7.2
45	8.1	7.7	---
47	8.7	8.0	5.2
50	8.2	7.8	7.2

*Concentrations are expressed as milligrams per liter (mg/ℓ).

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Environmental impact of dredged material disposal on the Upper Mississippi River at Crosby Slough / by J. W. Held, River Studies Center, University of Wisconsin, La Crosse, Wis. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.

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1. Crosby Slough. 2. Dredged material. 3. Dredged material disposal. 4. Environmental effects. 5. Upper Mississippi River. I. United States. Army. Corps of Engineers. II. Wisconsin. University-La Crosse. River Studies Center. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper ; D-78-2.

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