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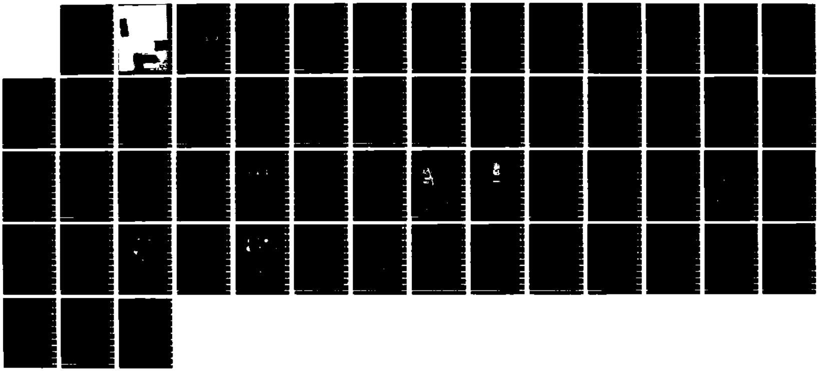

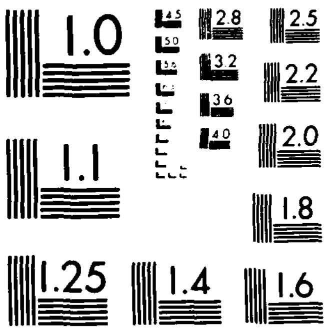

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> A study was conducted to evaluate the effectiveness of five different collecting gears in sampling larval fishes associated with dikes and revetments. The tests were conducted on the Lower Mississippi River at mile 508.8 and miles 447-448. The five collecting gears used were: plankton nets fished at discrete depths in the water column of a dike pool and the main channel; a push sled; a diaphragm pump; an electroshocker; and basket implants.

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20. ABSTRACT (Continued).

These gears were used during the day and night to describe diel and temporal changes in the larval fish community in main channel, dike pool, dike, revetment, and sandbar habitats.

The discrete depth net gear was effective in documenting the vertical, diel, and temporal distribution of ichthyoplankton drift in the main channel and dike pool habitats. Similarities and differences in ichthyoplankton abundance and diversity occurred between habitats. The most notable observation was the comparable abundance among like depth strata between habitats in May. In June, the surface stratum at each habitat contained a far greater abundance of larvae than the samples collected at lower depths.

The push sled was effective for sampling shallow water in the vicinity of sandbars. Use of the sled revealed diel and temporal differences in the shallow-water ichthyoplankton. Night samples had a much greater abundance of larvae than day samples, especially in July. Carpsuckers, shad, and minnows were dominant in May, whereas minnows and carpsuckers comprised nearly all the larvae collected in July.

The diaphragm pump, electroshocker, and implant baskets were used to sample ichthyoplankton associated with dike and revetment habitats. Of these gears, the diaphragm pump was the most effective. Samples collected along dikes and revetments contained a greater abundance and diversity of larvae than open-water samples. Based on the samples collected using the electroshocker, the presence of an electrical field did not improve catch efficiency. Of the three gears used to sample larval fish from dikes and revetments, the implant baskets were least effective.

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PREFACE

The study described in this report was sponsored by the Office, Chief of Engineers (OCE), US Army, under the Environmental and Water Quality Operational Studies (EWQOS) Program, Work Unit VII.B, Waterways Field Studies. The EWQOS Program has been assigned to the US Army Engineer Waterways Experiment Station (WES) under the direction of the Environmental Laboratory (EL). The OCE Technical Monitors for EWQOS were Mr. Earl Eiker, Dr. John Bushman, and Mr. James L. Gottesman.

This report presents results of a study designed to evaluate five different gears for sampling fish larvae from habitats within the mainline levees of the Lower Mississippi River. Habitats of particular concern were those associated with dikes and revetments. The study was conducted at river mile 508.8 and river miles 447-448 from May through July 1982.

This report was prepared by Mr. Timothy R. Bosley, Dr. C. H. Pennington, Mr. Michael E. Potter, and Dr. Scott S. Knight, under the supervision of Dr. Thomas D. Wright, Chief, Aquatic Habitat Group, and Dr. Conrad J. Kirby, Chief, Environmental Resources Division. Dr. Jerome L. Mahloch was Program Manager, EWQOS, and Dr. John Harrison was Chief, EL. The report was edited by Ms. Jessica S. Ruff of the WES Information Products Division.

COL Allen F. Grum, USA, was the previous Director of WES. COL Dwayne G. Lee, CE, is the present Commander and Director. Dr. Robert W. Whalin is Technical Director.

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CONTENTS

EVALUATION OF LARVAL FISH SAMPLING GEARS FOR USE ON LARGE RIVERS

PART I: INTRODUCTION

Background

1. From 1978 through 1980 the US Army Engineer Waterways Experiment Station (WES) conducted larval fish studies in the Mississippi River between river mile 480 and 530 (Greenville, Miss., to Lake Providence, La.) as part of the Environmental and Water Quality Operational Studies (EWQOS) Program sponsored by the Office, Chief of Engineers, US Army. The larval fish studies were performed as a portion of a larger investigation to evaluate the impacts of channel alignment structures (dikes and revetments) on water quality, macroinvertebrates, and fishes in large rivers. This investigation was also intended to clarify the biological characteristics of natural habitats (sandbars, abandoned channels, natural banks, etc.) in addition to the habitats modified by navigation structures.

2. The larval fish studies consisted of collecting samples from near the water's surface (0.5- to 1.0-m depth) in main channel, natural bank, revetted bank, secondary channel, abandoned channel, and dike pool habitats using 0.5-m-diam conical nets with 0.505-mm-mesh netting. No samples were collected from deeper strata or in shallow-water areas associated with navigation structures. Therefore, the contribution of these areas to the larval fish community in the Lower Mississippi River was unknown.

3. In this study, WES personnel designed new gears or modified existing ones to evaluate their feasibility and comparative performance for collecting larval fishes. These gears were evaluated from May through July 1982.

Objectives

4. To address data gaps of previous studies, sampling efforts focused on middle and near-bottom depths of the main channel and dike pools, the interstitial spaces between the rocks of the riprap dikes and revetments, and the shallow waters associated with sandy middle bars of dike fields. The objective of this study was to evaluate the effectiveness of the five gears for sampling larval fishes associated with dikes and revetments.

PART II: REVIEW OF SAMPLING METHODS AND GEARS

5. Whenever a survey seeks to document the diversity and abundance of larval fishes present at a particular location, samples should be collected from the entire array of aquatic habitats present. This is necessary to obtain a clear understanding of each habitat's contribution to the overall ichthyoplankton composition. Balon's (1975) description of reproductive guilds of fishes illustrated the wide variety of habitats utilized by fishes for spawning and embryonic and larval development. Faber (1967) noted that larval fishes in two northern Wisconsin lakes varied between littoral and limnetic regions in species composition and the stage of development for certain species. The observations by Balon (1975) and Faber (1967) lend support to the wisdom of a multi-habitat sampling program.

6. The gear that provides the most reliable estimate of larval fish diversity and abundance in a habitat should be used when engaged in a synoptic ichthyoplankton survey (Bowles and Merriner 1978). No single collection gear is most appropriate for all habitats, and each sampling site has features that make it unique. Differences in structural habitat complexity among sampling sites require flexibility and variety in sampling gears (Dovel 1964). Selection of sampling gear can be difficult if unique features of the sampling site prevent the use of conventional gear or substantially interfere with gear efficiency. All gear selection should be justified by demonstrating that an accurate representation of ichthyoplankton has been achieved under site-specific conditions.

Towed Gear

7. Swedberg (1967), using a 8-m otter trawl that was towed near the surface, and Netsch, Houser, and Vogele (1971), using a 1-m-diam conical net with a depressor and bridle assembly, conducted ichthyoplankton studies in reservoirs on the Missouri and White Rivers,

respectively. In both studies the sampling gear was towed directly off the back of the boat. Two important problems may arise when nets are towed in the turbulent wake of the propwash: (a) altered numbers and distribution of ichthyoplankton in the water mass being sampled, and (b) incorrect flowmeter operation (thus, inaccurate filtration volume estimation). Should the two problems arise while sampling is being conducted, the reliability of the data may be seriously impaired, and results may be imprecise. To eliminate errors caused by towing a net in the propwash wake, Gallagher and Conner (1980) towed a 1-m-diam conical net off the side of the boat near the surface in a study of ichthyoplankton distribution in the Lower Mississippi River. This arrangement maintained the net away from the water influenced by the propwash throughout the duration of sampling.

8. Dovel (1964) designed a surface sampling arm for collecting ichthyoplankton which consisted of a 1-m-diam conical net mounted on a hinged frame deployed off the side of the boat. The net is adjustable vertically to compensate for variations in wave amplitude, thereby keeping the mouth of the net entirely below the water's surface throughout the sampling period. The usual towing speed for the sampler is 0.5 to 1.5 m/sec. A flowmeter is mounted in the mouth of the net to obtain an accurate measure of volume of water filtered. Advantages of this gear include: (a) the net collects organisms from undisturbed water outside the wake produced by the boat and propwash; (b) no towing cables precede the mouth of the net; (c) the net is removed from the water using a hand winch; and (d) the sampling arm frame is collapsible to facilitate deployment of other sampling gear when surface sampling is not occurring. Collecting organisms from undisturbed water and the absence of towing cables preceding the net enhance efficiency and minimize bias.

9. Dovel (1964) also developed a benthic plankton sled for sampling ichthyoplankton located near the bottom of the Patuxent River and Chesapeake Bay. Channel depths ranged from 3.6 to 45.7 m. The benthic plankton sled is towed in the same manner as conventional conical net gear. The sled is deployed and retrieved while the towing boat is

stationary with respect to the water current, thus minimizing contamination of the sample from water above the bottom depth stratum. The sampling gear consists of a 1-m-diam conical net mounted onto a metal sled with a flat runner on each side. The bottom of the net is 28 cm above the runners. An apron of netting is suspended between the runners immediately below the net to stir up the bottom ichthyoplankters and allow them to be scooped into the net. The sled alone weighed 18 kg, with an additional 9 kg of lead weight added to each runner. A total sled weight of 36 kg was adequate to maintain the sled on or near the bottom at all sampling sites.

10. Cooper (1977) modified the surface sampling arm and benthic plankton sled of Dovel (1964) for use with a 0.5-m-diam conical net in boats up to 8 m long operating at speeds less than 2.5 m/sec. The gear was used for simultaneous two-level sampling of ichthyoplankton in Lake Erie.

11. To estimate the ichthyoplankton present in lower depth strata, the Tennessee Valley Authority (TVA) developed a sampling procedure for stratified oblique tows (Graser 1977a, b). The TVA used a 0.5-m-square beam net (0.505-mm mesh) with a counterbalance weight. Oblique tows were made through a specific depth stratum by a stairstep retrieval of the net. The net is raised at 1-min intervals during a 10-min tow (nine lifts). Lift frequency may be altered to suit a specific station or sampling objective. The length of cable that must be deployed for the net to fish at a specific depth is calculated prior to sampling and is recorded for field reference. Motion of the boat is stopped with respect to water flow during the lowering or raising of the net through a stationary water mass to minimize contamination from water outside the sample depth interval. The stratified oblique sampling procedure was used in an investigation of the spatiotemporal distribution of clupeid larvae in Barkley Reservoir, Tenn. (Graser 1979).

12. Discrete-depth ichthyoplankton sampling has been conducted using several different techniques. Van den Avyle and Fox (1980) used a 0.25-m^2 Tucker trawl with a 0.505-mm-mesh net in Center Hill

Reservoir, Tenn. Five-minute tows were made at each of five depths: surface, 2, 4, 6, and 8 m. Lewis and Siler (1980) used a 0.91-m-diam conical net towed for 10 min at 2.5-m depth intervals from the surface to 15 m in Lake Norman, N. C. Hatch (1980) used a 0.5-m net (0.355-mm mesh) towed for 3 min each at the surface, middle, and bottom in Presque Isle Harbor, Lake Superior. In each study, the net was towed at 1.0 m/sec and the boat was held stationary to water flow before and after towing to minimize contamination from water outside the sample depth.

13. Tuberville (1979) compared the use of discrete-depth and oblique tows among several midchannel depth strata to estimate vertical distribution of ichthyoplankton in Nickajack Reservoir, Tenn. Discrete-depth samples were collected at 0.5, 7.5, 15.0, and 22.5 m, whereas stratified oblique samples were collected from 18 m to the surface using either six 3.0-m depth intervals or two 9.0-m depth intervals. Tuberville (1979) determined that the discrete-depth sampling method provides a maximum of information for the depth the net is towed because the entire sample comes from the same stratum.

14. Brown and Langford (1975) developed a tow net for sampling juvenile cyprinids in several shallow rivers in England. The gear consisted of a metal frame with a semicircular mouth (0.75-m diam) covered by 2.5-mm-mesh nylon netting with a net bag of 1.25-mm mesh. Three spherical floats attached to the frame enabled the net to be pulled slightly below the surface, and two skids underneath the net facilitated its passage over the riverbed in shallow water. The net is towed 10 m behind a boat at 1.1 m/sec for 40 to 60 m. This gear was used along stands of emergent vegetation and over submergent vegetation, and very little rooted vegetation entered the net.

15. A group of sampling devices called high-speed samplers were developed by marine zooplankton and ichthyoplankton researchers to collect organisms at greater speeds than were possible with conventional towed net gear. The high-speed sampler is able to capture organisms before they escape the path of the sampler's mouth, thus reducing one source of sampling error. Descriptions of this type of gear are given

by: Arnold (1952), the Gulf I-A high-speed sampler; Gehringer (1952), the Gulf III high-speed sampler; Bary et al. (1958), the closing mouth high-speed sampler (usable for either horizontal or vertical tows); and Clarke (1964), the "jet net" high-speed sampler. However, marine high-speed samplers are not appropriate for most freshwater ichthyoplankton sampling due to their large size and cost.

16. Noble (1970, 1971) described the use of the standard Miller high-speed sampler (Miller 1961), a smaller gear appropriate for collecting ichthyoplankton in freshwater habitats. His studies were conducted in Lake Oneida, New York. An initial evaluation of the standard Miller high-speed sampler (a dark-green opaque fiberglass cylinder with a 10-cm-diam mouth) towed during daylight for 5 min at 3.6 m/sec indicated that avoidance by yellow perch larvae occurred when larvae were 8 mm long and increased as larvae became longer. Several modifications that increased catches were: (a) increasing towing speed to 4.9 m/sec; (b) using an electric shocking grid in front of the sampler; (c) using clear, translucent rather than dark, opaque samplers; and (d) sampling at night. However, increasing the mouth diameter from 10 to 15 cm did not increase sampler efficiency.

17. A comparison of sampling performance for yellow perch larvae between paired 1-m-diam conical nets (towed at 0.9 m/sec for 5 min) and paired standard Miller high-speed samplers (towed at 3.6 m/sec for 5 min) indicated significantly greater catches per unit volume in the Miller samplers during six sampling dates from late May to mid-June. Differences between gears in the mean length of larvae caught on each sampling date were usually small and not statistically significant. Relative efficiency of the Miller samplers, expressed as the ratio of the mean catch per unit volume in Miller samplers to that in conical nets, increased steadily over time to a relative efficiency of 5.62, when yellow perch larvae reached 16.5-mm mean length. A statistically significant positive correlation ($r = 0.92$) between relative efficiency and mean length of larvae indicated that avoidance of conical nets

increased at a faster rate than for Miller samplers as yellow perch larvae grew longer.

18. According to Zaitsev (1971) and Faber (1976), many species of fishes spend a portion of their life history, including all or part of their larval period of development, in the upper 0.5 m (and sometimes the upper few centimetres) of the water column. Organisms that inhabit the top of the water column are referred to as "neuston," which Zaitsev (op. cit.) defines as the "plants and animals of small to medium size inhabiting the aquatic (hyponeuston) and aerial (epineuston) sides of the surface film of water bodies." A problem with conical nets and similar gear, whether towed or stationary, is that they do not sample the surface film very efficiently. If the rim of a 1-m-diam conical net just breaks the surface of the water during a tow, and if all the water is accepted, then less than 3 percent of the net's effective sampling area is filtering the 0- to 5-cm stratum. The surface film of water is rarely accepted by a sampler unless the mouth of the sampler rises in part above the surface. When towing conventional ichthyoplankton sampling gear near the surface, it may be anticipated that organisms in the surface film either flow over the net or are pushed aside.

19. Because conventional towed net gear ineffectively samples larval fishes inhabiting the surface film of water, special gear is required to collect neustonic ichthyoplankton. All of the gears discussed below are deployed and towed off the side of the boat, thereby sampling water undisturbed by the propwash. None of the gears include a flowmeter, so it is not possible to obtain an accurate value for the amount of water filtered. However, an estimate of the water filtered can be calculated based on the cross-sectional area of water being filtered and the distance towed.

20. David (1965) designed a neuston sampler consisting of a wooden structure that floats on the water surface and a net that is attached to the bottom of the floating structure. The 0.333-mm-mesh net has a 0.30- × 0.15-m mouth and terminates in a 7.62-cm-diam bucket. When the sampler is placed in the water, the net mouth is immersed to a

depth of 10 cm in still water. The David neuston sampler is designed to be towed at 2.6 to 3.1 m/sec in undisturbed water.

21. Faber (1976) used a neuston sampler designed by Scarrett (1973) to collect larval fishes in the Northumberland Strait, New Brunswick. Ichthyoplankton was sampled at the surface with a 1.3-mm-mesh net having a 3.7- × 0.9-m mouth.

22. Sameoto and Jaroszynski (1969) developed an otter surface sampler for collecting neustonic ichthyoplankton. The mouth of the sampler consists of a 3.2-mm aluminum sheet metal box open at both ends, 40 cm square, and 60 cm long. Fins are attached to the outside of the box to keep the sampler on the water surface. A net and collection bag, both 0.308-mm mesh, are attached to the metal box. The otter surface sampler is normally towed at 4.1 m/sec, but performs well when towed up to 5.7 m/sec. An advantage of this sampler over other neuston samplers is that it can be used in both calm and choppy water.

23. Zaitsev (1971) designed a five-stage sampler in an effort to collect neuston from several depth microhorizons. This sampler consists of five rectangular partitions stacked vertically, each with a 0.6- × 0.2-m mouth. A separate net is attached to each of the partitions. A styrofoam float is attached to the lower part of the left and right sides of the top partition. The top partition samples the 0- to 5-cm stratum, and each of the lower partitions samples a 20-cm stratum. Thus, the Zaitsev neuston sampler collects ichthyoplankton from the upper 85 cm of the water column. Lindsay, Radle, and Wang (1978) modified the Zaitsev sampler by using only three partitions to evaluate the distribution of larval silversides in the Delaware and Indian Rivers. A 0.116-mm-mesh net was attached to each partition. The sampler was as much as 240 times more efficient than 0.5-m-diam conical nets in collecting silverside larvae. The larvae were found most abundantly in the 0- to 5-cm stratum.

Push Nets

24. Miller (1973) designed a paired push net system for collecting larval fishes. The push net frame holds the 0.6-m-square net mouths 2 m in front of the boat. The frame is adjustable vertically to ensure that the mouth of each net always remains below the water surface while the nets are fishing. Each net has a body of 0.505-mm-mesh Nitex and a bag of 0.333-mm-mesh Nitex. Larval fishes 2 to 25 mm long were caught in good condition.

25. Two push net gears intended for collecting juvenile fishes may be applicable to larval fish sampling if the net meshes used in the described gear are changed to a smaller size that would retain fish larvae. Herke (1969) designed a surface push trawl to sample juvenile fishes in tidal marshes, and Kriete and Loesch (1980) described a push net for sampling juvenile pelagic fishes.

Water Pumps

26. Coughlan and Fleming (1978) noted that two interrelated criteria dictate the design of a water pump and filter system for sampling planktonic organisms. These criteria are: (a) the need to create a current of sufficient velocity at the sampling orifice so that plankters (including fish larvae) cannot escape, and (b) the ability to obtain a sample of adequate volume in a reasonable length of time. If the velocity of the water entering the orifice is lower than the velocity of a horizontally moving sampler relative to the surrounding water, a pressure field is created ahead of the orifice that can deflect, or be detected by, larvae. When the velocity of water entering the orifice is equal to the towing speed there should be no deflection, but larvae might still avoid the orifice by detecting vibrations caused by the intake hose or the pump. Increasing the velocity of the water entering the orifice above the towing speed creates a suction field extending, ideally, beyond the zone of detection.

27. Gibbons and Fraser (1937) and Aron (1958) reviewed the development and use of pumps and filter systems by oceanographers and limnologists. The use of a water pump and filter system for obtaining plankton samples began nearly 100 years ago in marine phytoplankton research. Collection systems in marine research have advanced from early makeshift gears operated on a small scale to modern sophisticated systems capable of filtering large quantities of water from great depths. Marine systems have been described by Gibbons and Fraser (1937); Aron (1958); O'Connell and Leong (1963); Beers, Stewart, and Strickland (1967); and Lenz (1972). All but the latter system are similar, consisting of a submersible centrifugal pump with a depth sensor, a long rubber hose extending from the pump to a large onboard collection chamber with a flowmeter, a system of graded filters for preliminary sorting of captured organisms, and a rubber hose for returning filtered water overboard. Lenz (1972) used a vacuum pump onboard the ship to pull water from the sample depth. All other features of his collection system are comparable to the other systems. However, pump and filter systems developed for collecting marine plankton, including fish larvae, are generally too large for easy use in most freshwaters.

28. Smaller portable pump and filter systems have been developed for collecting freshwater ichthyoplankton. Manz (1964) designed a pump and filter system for sampling walleye eggs and bottom fauna in offshore spawning areas of western Lake Erie. The system used a gasoline-powered centrifugal pump with a 1,767 ℓ/min capacity. The pump draws water into a 208-ℓ steel tank with a rubber-sealed and bolted lid. A copper screen filter (16 meshes/2.5 cm) with a removable stainless steel bucket is placed in the tank, and the pump draws water through the filter and bucket. A 7.62-cm-diam suction hose connects the sampling orifice mounted to a check valve on the tank. During operation, water, eggs, bottom organisms (invertebrates and fish larvae), and debris are sucked from the bottom into a sled-mounted intake hose pulled along the bottom at 1.3 m/sec. All objects larger than the filter mesh are retained, while water and smaller objects pass from the tank and are pumped overboard.

At the end of the sampling period, the intake line and tank are pumped dry. The filter and bucket are removed from the tank and the contents are washed into two graded filters for initial separation of the retained material. The sampler has been used at depths of 1.5 to 12.2 m and over various sediments (mud, silt, sand, gravel, boulder, shelf rock, or combinations of two or more). It worked especially well over coarser sediments, but finer sediments tended to clog the filter.

29. Gale and Mohr (1978) developed a pump and filter system for collecting ichthyoplankton in the Susquehanna River. A gasoline-powered water pump (type not specified) with a pumping capacity of 2,500 ℓ/min was located aboard a pontoon boat. A 10-cm-diam intake pipe was mounted on a small sled that was lowered and raised by a hand winch. Samples were taken 50 cm from the surface and 10 cm from the bottom. The water entering the intake pipe passed through the pump into a discharge pipe. The end of the discharge pipe was connected via a watertight seal to a conical net (0.505-mm mesh) and collection bucket towed immediately behind the boat. In a separate test, it was determined that most of the larvae that entered the intake pipe were recovered in the collection bucket (the small number of missing fish were probably pulverized by the pump). Most of the recovered larvae were in fairly good condition. An efficiency test compared the catches of water pump and stationary net samples collected at the surface. For the stationary net samples the boat was pointed upriver and held in place for 5 min. The number of larvae/10 m^3 was usually about the same for each sampling method. A t-test detected no significant difference ($P < 0.05$) between sampling methods in the number of larvae captured.

30. The pump sampler offered several advantages over conventional towed net gear. First, sample volume was closely regulated by altering the pump for duration at a constant pumping rate, eliminating the need for a flowmeter. Second, obtaining replicate samples took minimal effort. While the net from one sample was washed down, the next sample was obtained. Third, the pump sampler could collect samples at stations too shallow for towed net gear. Despite these advantages, the pump had

some disadvantages. All larvae were killed during collection, and a relatively small volume of water was sampled by pumping (compared to the filtration volume from towed net gear); thus, larvae occurring in low numbers might be missed.

31. Yocum, Evans, and Hawkins (1978) compared the use of a Hale 30LC-1750 diaphragm pump (314 ℓ/min capacity) and a Jacuzzi 1JM centrifugal pump (332 ℓ/min capacity). Both filtration systems included a 0.5-m-diam conical net (0.156-mm mesh) and a collection bucket. Each type of pump has certain characteristics that may determine suitability for a particular application. Diaphragm pumps are more complex and therefore have a higher initial cost and require more routine maintenance. These disadvantages are offset by the ability of this type of pump to pass fish, gravel, grass, and other debris without clogging. The diaphragm pump consistently self primed during the study. Centrifugal pumps are more difficult to prime and are more susceptible to loss of suction due to small leaks. However, lower initial cost, lighter weight for a specific pumping capacity, greater efficiency for a given motor size, and greater inherent mechanical reliability make the centrifugal pumps more advantageous for field use if a minimal amount of debris is present in the sampled water.

Larvae Trap

32. Collins (1975) developed an emergent larvae trap for lake spawning salmonids. The trap is a pyramid constructed of fiberglass screen sides and an open base of angle iron with an inverted glass jar retainer at the apex. The pyramid has a slope of 56 deg and samples a bottom area of 0.25 m^2. A copper mesh tunnel is placed over the mouth of the retaining jar, which allows salmonid larvae to pass into the jar but excludes larger predatory fishes. When setting the trap over an area of salmonid eggs, it must first be inverted and submerged to fill the jar with water before the trap is lowered to the substrate. Field trials indicate that, as long as the base has a good fit with the

substrate, the trap is very efficient in capturing emergent larvae. If the trap has a poor fit with the substrate, many larvae swim underneath the base and escape from the trap. If properly anchored, the emergent larvae trap may also be placed over salmonid redds in streams having slow to moderate currents.

33. Porter (1973) designed an emergence trap and holding box to capture salmonids swimming out of a redd. The oval-shaped trap had netting on the upstream half, canvas on the downstream half, and a canvas apron around the trap's edge. A canvas tunnel extended from the emergence trap to the holding box. The emergence trap was held in place with stakes and supported by steel rods. The holding box was designed to prevent fish mortality due to force of the water passing through the box. A V-shaped baffle in the holding box deflected most of the water through the screen sides of the box. Captured fish remain in the eddy behind the baffle away from the main flow of water. The holding box can be detached from the tunnel and the captured fish transferred to a container.

34. Breder (1960) designed a trap for larval fish which is made of Plexiglas. The trap had a 15.2-cm-square base and was 30.5 cm high. Wings for guiding larvae into the trap extended from opposite sides at the open end of the trap into the trap, where they came together to form a narrow aperture for admitting fish larvae. The width of the aperture was adjustable to control the size of fish that could enter. Styrofoam floats were attached to the outside of the trap and, depending on how the trap was anchored, it could fish at the surface, bottom, or an intermediate depth. In field trials, Breder (1960) found that the traps caught the most larvae in surface and bottom sets. The trap was far more efficient in capturing larvae when set in calm water conditions.

35. Casselman and Harvey (1973) designed two Plexiglas larval fish traps that were sophisticated modifications of Breder's (1960) design. The traps were larger, included a leader (Plexiglas or fine-mesh fabric) and wings with recurved outer ends to turn back fish attempting to escape, and a larger holding pot that facilitated fish

removal. Although designed to catch northern pike larvae, the traps have captured osmerids, umbrids, esocids, cyprinids, catostomids, ictalurids, gasterosteids, centrarchids, and percids from lotic and lentic habitats.

36. Kindschi, Hoyt, and Overmann (1979) developed a larvae trap to determine nocturnal distribution patterns in Rough River Lake, Ky. The trap was constructed of 1-mm-mesh wire screen and was 0.3 m in diameter and 1 m long, with funnels at each end. Traps were set at the surface and 6 m deep. At each depth, two pairs of traps were set: one pair was illuminated, and the other pair was unlighted. During sampling, only the illuminated traps captured larvae. The larval and juvenile fish caught included five taxa, with sunfishes comprising 80 percent of the specimens. All brook silverside and most sunfish specimens were captured near the surface, whereas gizzard shad, log perch, and crappie were captured primarily at 6 m.

37. Faber (1981, 1982) designed an illuminated trap for capturing larval fishes at littoral sites in Lac Heney, Quebec. The trap consisted of a rectangular Plexiglas box that had an upper light chamber (14.5 × 14.5 × 23 cm), a lower animal chamber (14.5 × 14.5 × 26.5 cm) with entrance slots for larvae on the sides, and a collection bag and plankton bucket (both with 0.12-mm mesh) extending from the floor of the animal chamber. A removable watertight light bottle, which was placed into the light chamber, contained a 6-V battery and light bulb controlled by a mercury switch. The presence of a light in the trap was shown to be essential for catching fish larvae, as evidenced by the absence of larvae in all nonilluminated trap sets. The larvae trap was set for 60 min at a depth of 60 to 80 cm. Fifty percent of the 24 known species in the lake were captured as newly hatched and older larvae. The number of specimens in the 60-min samples varied from 6 to 1,135.

38. Paulson and Espinosa (1975) developed a lighted fish trap for sampling the juvenile threadfin shad component in limnetic areas of Lake Mead, Nev. Each trap, constructed of 6.3-mm-mesh galvanized wire screen, was 0.9 m long, 0.5 m in diameter, and supported at each end by

a ring of 3.2-mm-diam steel rod (the trap was oriented horizontally while fishing). A 0.3-m-long funnel was placed at each end. At the apex of each funnel was a 10-cm-diam opening. A closable access hole (0.15 m square) was cut in the top of the trap to permit removal of captured fish. For this trap to be appropriate for sampling larval fish, two modifications are necessary: (a) the use of much smaller size mesh (i.e., 0.505 mm), and (b) reduction of the size of the apex opening to exclude the entry of predatory organisms. The light source consisted of two 6-V batteries and a 6-V light bulb inside a waterproof jar, which was placed inside the trap. Traps were suspended to desired depths by nylon rope secured to fiberglass buoys. Only night sets of illuminated traps captured juvenile shad. No fish were captured during nonilluminated night sets and all day sets (illuminated and nonilluminated). Trap avoidance seemed to be the main reason for unsuccessful day sets.

Other Gears

Diver-operated plankton collector

39. Ennis (1972) designed a diver-operated ichthyoplankton collector to overcome the difficulties associated with sampling in shallow areas, especially where the bottom is uneven. The sampler consisted of two battery-powered motor-driven towing vehicles that were strapped together and a 0.5-m-diam conical net (0.366-mm mesh) mounted in front of the paired vehicles. The sampler could be operated at the surface by a snorkel diver (up to 30 min) and underwater by a diver (up to 15 min) at 1.6 m/sec at a constant depth or through an oblique path.

Plankton purse seine

40. Murphy and Clutter (1972) used a 30- × 6.5-m miniature purse seine, constructed of 0.333-mm-mesh Nitex, to sample anchovy larvae. The seine was patterned after that described in Hunter, Aasted, and Mitchell (1966) except for the smaller mesh netting used in the body. The net was set in the form of an incomplete circle off the port side of a boat. Closure of the net occurred during the initial stages of

hauling. The operation from starting the set to pursing required less than 5 min. Pulling the net onto the boat required two people working 10 to 15 min. A diel comparison was made involving the purse seine versus a 1-m-diam conical net (0.366-mm-mesh Nitex). During the day the purse seine was at least an order of magnitude more efficient in capturing larvae over 5.5 mm in length. The largest specimen caught by the conical net was 14.5 mm long and by the purse seine, 29.4 mm. The conical net was relatively more efficient at night, catching 60 percent as many larvae (3.5- to 19.5-mm length range) as the purse seine. The largest specimen caught at night by the conical net was 21.5 mm long and by the purse seine, 50 mm. The differences in catch between the two gears was attributed primarily to detection distance and larval swimming speed.

Channel net

41. Lewis et al. (1970) developed a channel net to catch larval Atlantic menhaden in an estuary. The mouth of the net, constructed of 3-mm-mesh nylon, was attached to a metal frame that measured 1 × 3 m. The bag of the net was dyed green to reduce its visibility. The channel net could be anchored at the surface, bottom, or an intermediate depth. Bozeman and Dean (1980) used a channel net of this design to collect larval and juvenile estuarine fishes from an intertidal creek in South Carolina.

Drop net

42. Drop nets for sampling nekton were developed by Moseley and Copeland (1969) and Kjelson, Tarner, and Johnson (1975). Although neither gear was designed especially for collecting larval fishes, ichthyoplankton could be collected if the net mesh was one of appropriate size (e.g., 0.505-mm mesh). The drop net developed by Moseley and Copeland (1969) measured 5 m square and 5 m deep, with a net size of 1-cm stretched mesh. It was weighted at the bottom with a heavy chain and was prevented from sinking by floats attached at the top edges. A pursing line was also at the bottom of the net. The net was supported above the water by a portable floating frame, with electromagnets holding up

the net. When the electrical current was reversed, the net dropped through the water column. Upon impact, the chain line penetrated the sediment. Immediately after the net was dropped from the frame, the pursing operation was begun, and as the net was pursed the captured organisms were pushed to the enclosed top. When the net was completely pursed it was lifted from the bottom and hauled aboard a boat, and the captured organisms were removed.

43. A drop net designed by Kjelson, Tarner, and Johnson (1975) was developed for sampling in very shallow water. The 3-mm-mesh nylon net was 2 m square and 1 m deep. The net had floats on the top and a heavy chain and purse line on the bottom. The net, suspended above the water from a stationary frame, was released by pulling a trip line. The pursing operation then began, after which the net was pulled into a boat or onto the shore and the captured organisms were removed. To allow for disturbance caused by setting either drop net at the desired sampling position, a waiting period of 10 min was used between hanging and releasing the net.

Buoyed and anchored net

44. In an effort to sample river plankton simultaneously at several depths, Hardenberg (1937) attached five 0.35-m-diam conical nets on a line with an anchor at the bottom and a float at the top of the line to hold the nets stationary. A small float was attached near the bag of each net. At the end of sampling, the anchor was dislodged from the river bottom and the nets were pulled to the surface into a boat. None of the nets was equipped with a flowmeter. An approximation of filtration volume was obtained based on known net diameter, rate of water flow, and sampling duration.

45. Dovel (1964) and Graham and Venno (1968) designed buoyed and anchored net gear, resembling that of Hardenberg (1937) for use in tidal estuaries. Dovel's modifications included using a heavy weight instead of an anchor, using three 1-m-diam conical nets (bottom, middepth, and near-surface), and mounting a flowmeter in each net to obtain an accurate measure of filtration volume. Graham and Venno used paired

0.5-m-diam conical nets near the bottom, at two intermediate depths, and near the surface. Each set of paired nets was mounted to a hanger attached to the line. The hanger ensured that the mouth of each net was always oriented toward the current, which enhanced sampling efficiency.

46. Bagenal (1974) designed a buoyant net for catching larval and juvenile cyprinids in open water and vegetated areas of shallow ponds. The gear consisted of a 1-m-diam conical net that was encircled outside the mouth by a 32-mm-diam plastic pipe. The pipe provided buoyancy for the net, which was held to the bottom by a 1.52-m-diam iron ring. A release mechanism and trip line were incorporated. The net and metal ring were set onto the bottom from a boat and remained submerged at least 1 hr to allow the larval fish to return to the area. When the trip line was pulled, the buoyed net rose through the ring to the surface, capturing larvae in its ascent path.

Dip net

47. A dip net is very useful for sampling ichthyoplankton in areas of aquatic vegetation, along the banks of ponds and streams, or in other habitats inaccessible to towed or push net gear. Gale and Mohr (1978) described a bucketed dip net to collect zooplankton and larval fishes. The dip net consisted of a handle and circular frame, a net made from monofilament nylon mesh and nylon ski cloth, and a plastic collection bucket. Nets of different mesh sizes could be snapped onto the frame, depending on the size of organisms to be caught. In order to minimize back pressures that develop inside the net and inhibit sampling efficiency, Gale recommended using a net with openings no smaller than 150 μ (for zooplankton); collecting in short, slow sweeps; and "back flushing" frequently to dislodge particles that clogged the pores of the net.

Shallow-water push net

48. A push net sampler for collecting larval fishes in shallow water was described by Burch (1981). The sampler was constructed of a 2.5-cm-square hollow aluminum tube that formed a rectangular frame with two 0.5-m openings to which two 0.5-m-diam conical nets were mounted.

The frame was bolted to a track 1 m high. The net frame could be positioned along the track to enable sampling from the substrate to 1.5 m above. A 0.66-m-diam bicycle tire positioned behind the net, with a pole-mounted handle bar, enables the sampler to be pushed along the substrate and allows maneuverability. The advantages of the push net sampler include the capability for variable sampling depths and operation by a single person; also, because nothing precedes the net mouth, avoidance by free-swimming larvae is decreased. The sampler is usable on sand, gravel, and rubble substrates and in currents up to 1 m/sec. Although designed for use in shallow lotic systems, the push net sampler could be used in other shallow environments, such as ponds, or along lake and river shorelines.

PART III: METHODS

Study Area

49. The Lower Mississippi River within the study area is confined on both sides by main-line levees constructed for flood control. Leveed floodplain width ranges from 3.2 to 9.6 km. Backwater habitats between the levees and the main river channel have seasonal connections with the river and are submerged during flood stage. No tributaries enter the river within this reach, and the study area is considered to be typical of the Lower Mississippi River upstream of Baton Rouge, La.

50. Two areas along the river between Greenville, Miss., and Vicksburg, Miss., were selected to conduct the gear evaluation study. The vertical distribution study was conducted in the lower pool of the Lower Cracraft dikes and the adjacent main channel at river mile 508.8 (Figure 1). The diaphragm pump, electroshocker, and implant baskets were tested at the Marshall Point dikes and Marshall Point revetment between river miles 447 and 448. The push sled was tested along the sandbar between dikes 1 and 2 and below dike 2 at the Marshall Point dikes (Figures 2 and 3).

Description and Use of Gears

Discrete depth nets

51. Samples were obtained from dike pool and main channel habitats in mid-May and early June using General Oceanics serial opening-and-closing conical nets (0.5-m diameter; 0.505-mm mesh). Two sets of samples were collected from each habitat at the surface (1 m below the water surface), middepth, and bottom (1 m above the bottom) every 3 hr during a diel period. The three closed nets were lowered into the water from an anchored boat and opened via a messenger and double-trip mechanism (Figure 4). The nets were allowed to fish for the period of time (based on the current velocity) in which the volume of water filtered

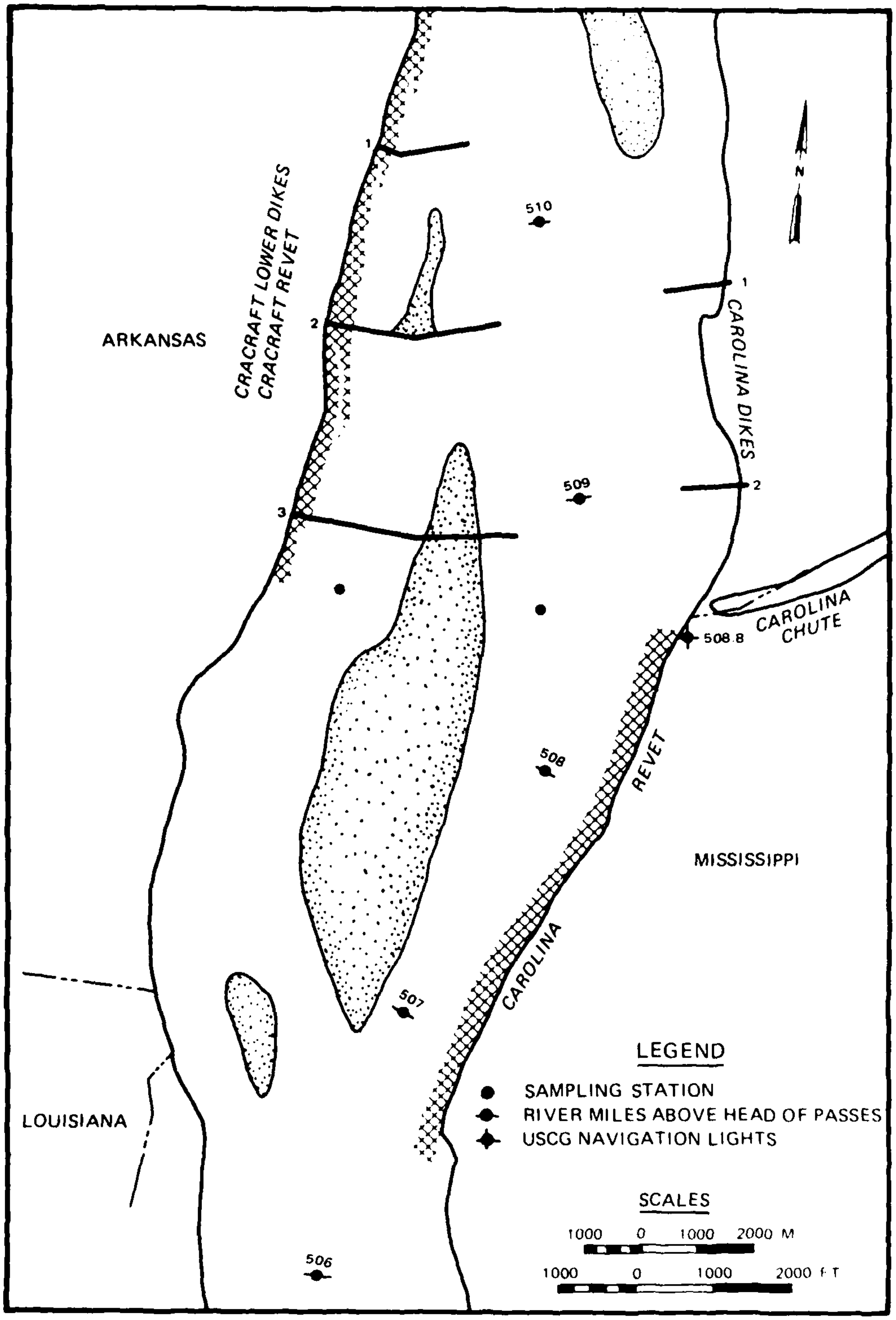

Figure 1. Lower Cracraft dikes with station locations for discrete depth study

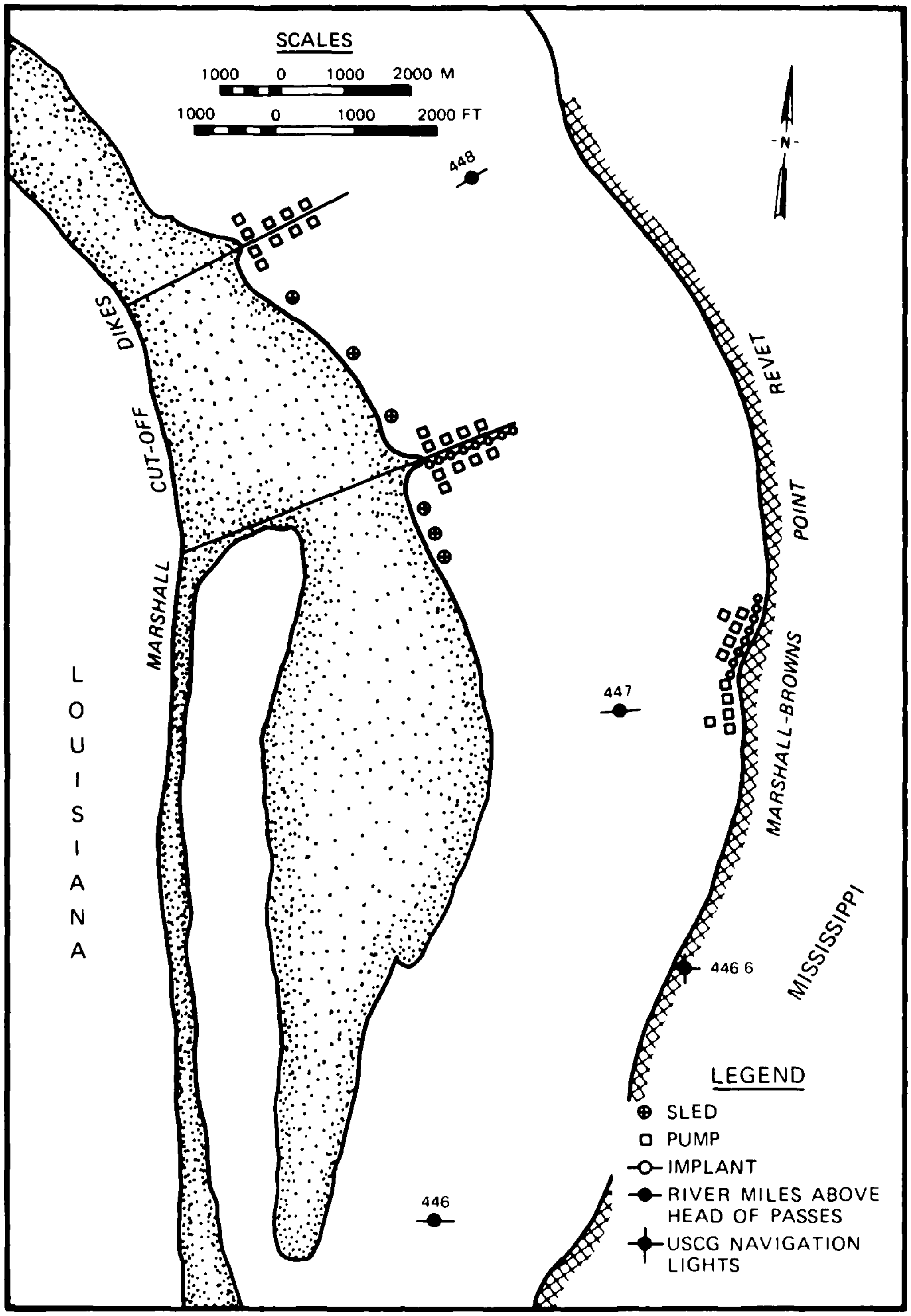

Figure 2. Marshall Point dikes and revetment with station locations of push sled, diaphragm pump, and basket implants during the May effort

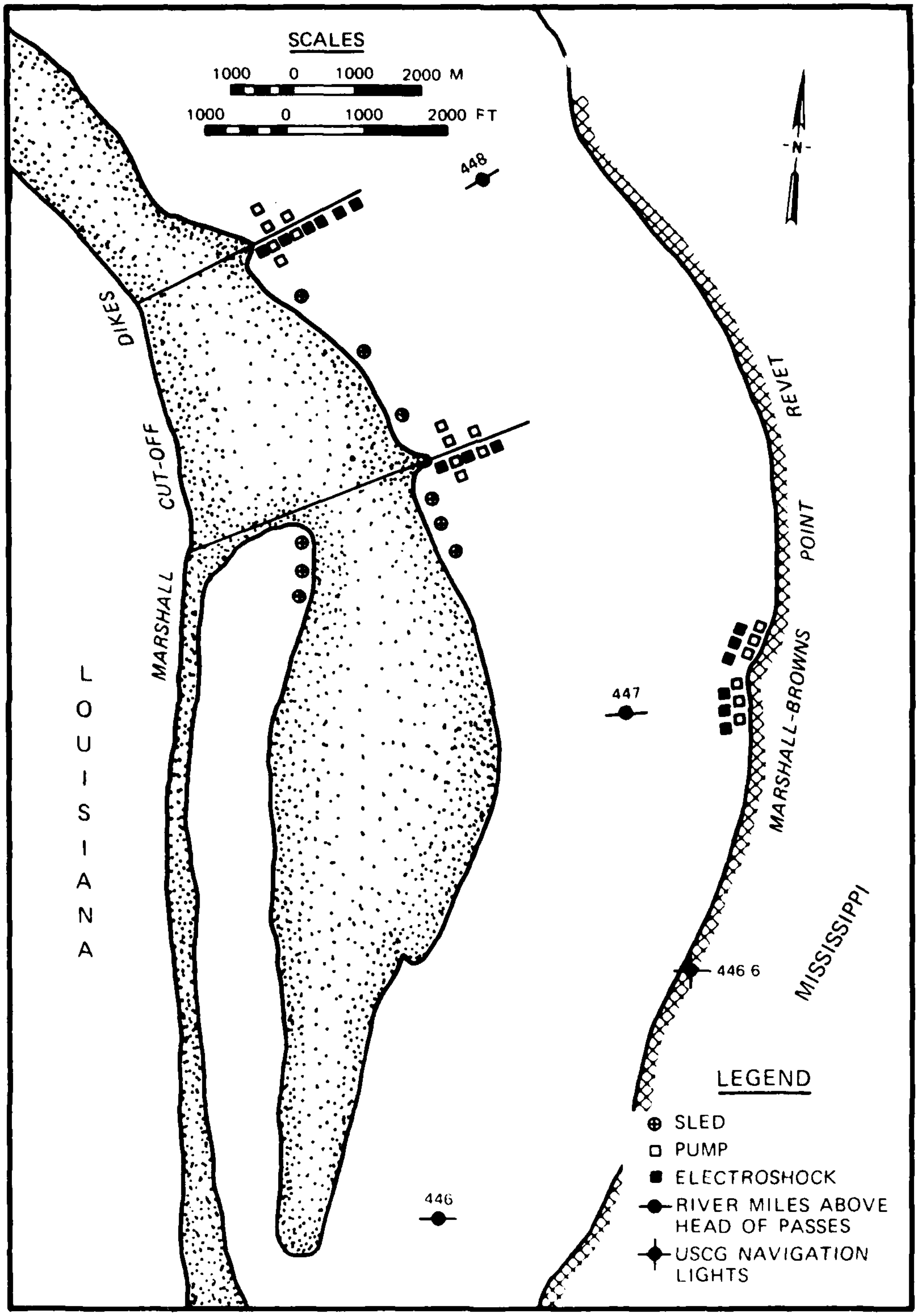

Figure 3. Marshall Point dikes and revetment with station locations of push sled, diaphragm pump, and electroshocker during July effort

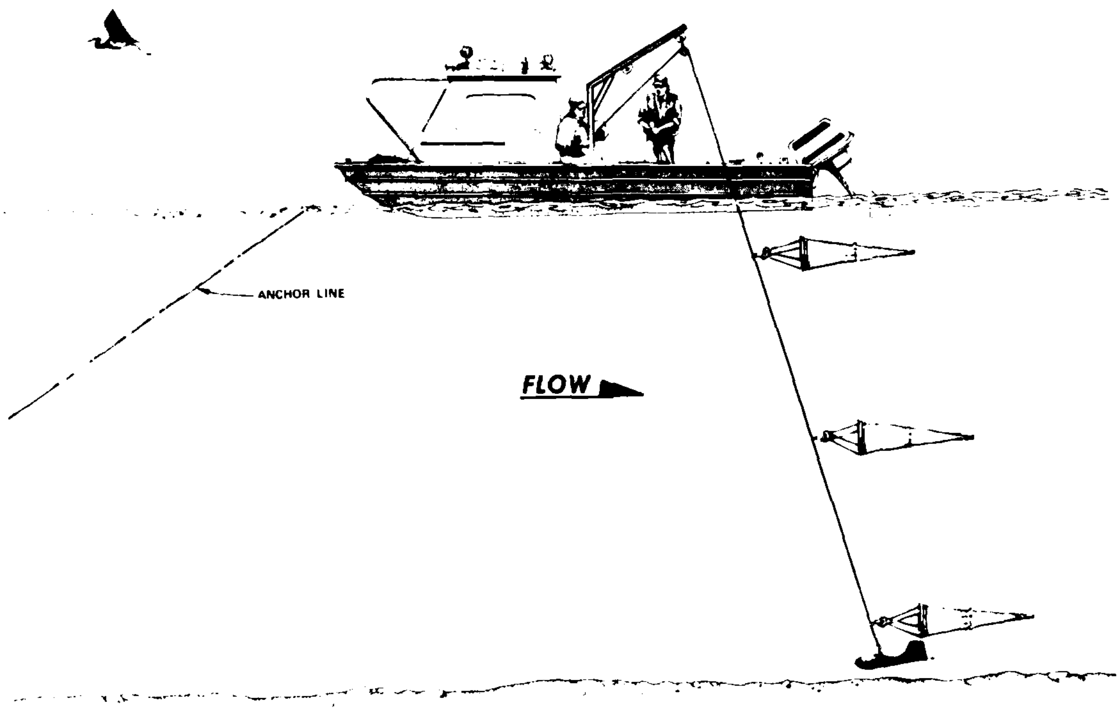

Figure 4. Schematic of sampling gear used for discrete depth study of main channel and pool habitats of Lower Cracraft dikes

(measured with a flowmeter) would approximate the volume of water filtered at a towed speed of 70 cm/sec for 5 min. The nets were closed via the messenger and double-trip mechanism (pursing closure of nets stopped filtering) and retrieved. At main channel stations, only surface and middepth samples were obtained because the bottom net repeatedly failed to deploy correctly, due to fouling of the trip mechanism. Two persons were required to mount and dismount nets and one to record data, prepare sample labels, and store samples.

Push sled

52. Larval fishes were collected during the day and night using a sled-mounted push net along several 30-m-long transects parallel to a sandbar shoreline. At the beginning of each transect, the sled was placed in the water with the mouth of the net (0.455 × 0.305 m; 0.505-mm mesh) above the surface. The mouth was lowered into the water, and the

sled was pushed along the transect (Figure 5). As the sled was pushed, the bottom of the net was slightly above the substrate surface and the top of the net was slightly below the water surface. At the end of the

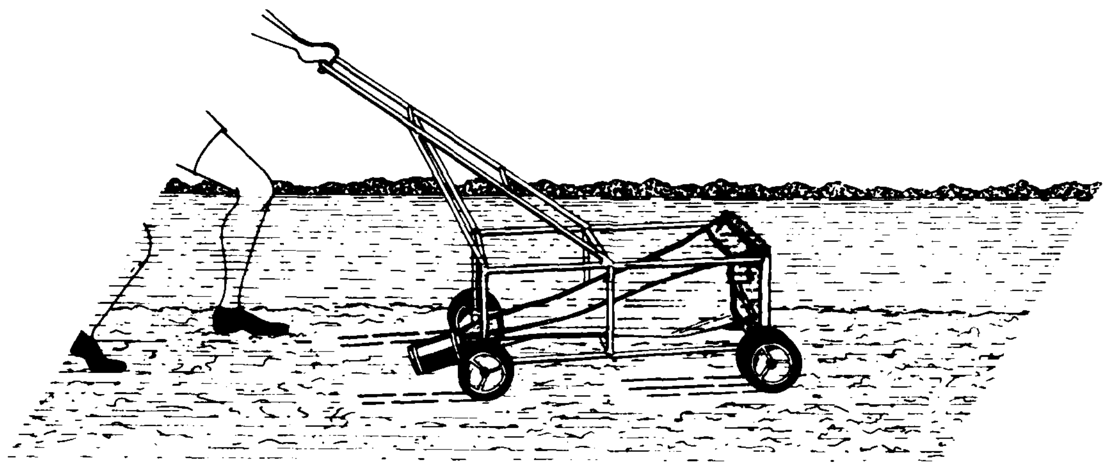

Figure 5. Schematic of push sled being used on sandbar habitat of Marshall Point dikes

transect, the mouth was raised above the surface to stop filtering water. The sled was then carried to the shoreline. A flowmeter mounted in the mouth of the net provided an estimate of water volume filtered for each sample.

Diaphragm pump

53. A Homelite Model 111DP3 diaphragm pump was used to collect day and night samples from dike and revetted bank stations. Flexible polyvinyl chloride (PVC) suction and discharge hoses of 7.62 cm diameter were attached to the pump. A person in the boat started and stopped the pump and recorded data. A second person moved the opening of the intake hose over crevices between rocks along the sampling station. A third person held the boat away from the shore and moved the boat along the sampling station, keeping pace with the person holding the intake hose (Figure 6). Each sample involved 5 min of pumping (1,514 ℓ of water filtered). The discharge hose passed water into a 0.5-m-diam conical net (0.505-mm mesh) and collection bucket mounted on the side of the

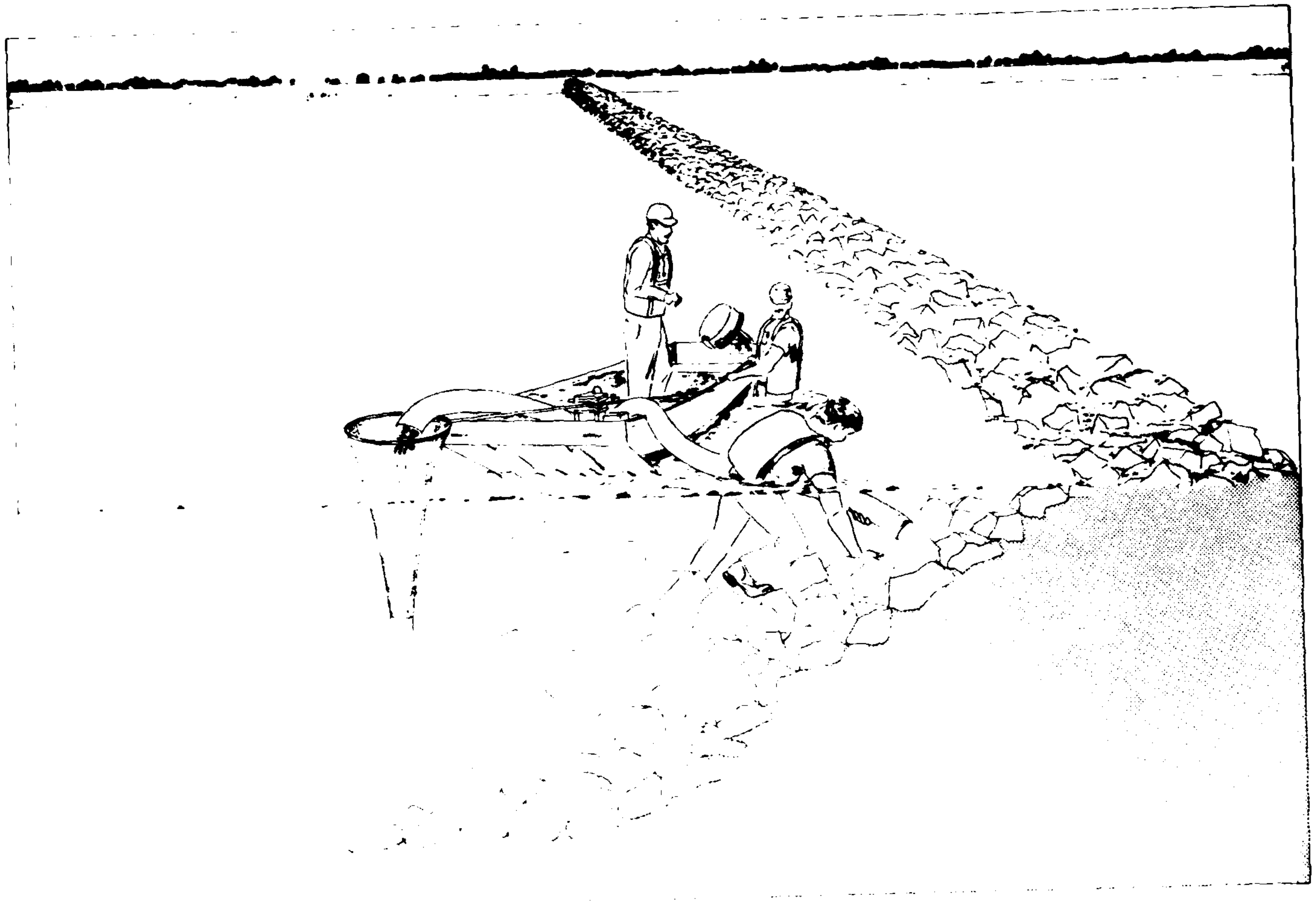

Figure 6. Schematic of diaphragm pump and associated gear used to sample Marshall Point dikes (the same gear and similar technique were used when sampling Marshall Point revetment)

boat. Open-water samples were collected 25 m from the structures and were used as controls.

Electroshocker

54. A boat equipped with electroshocking gear was anchored at selected stations on the downstream side of a dike and at stations along a revetted bank. The boat was anchored close enough for the electrodes to touch the submerged structures. Both day and night samples were collected at each station, from the port and starboard sides of the boat, using 0.5-m-diam conical nets (0.505-mm mesh) fitted on yokes attached to handles (Figure 7). The nets were held 0.5 m below the water surface for 5 min, and a flowmeter was mounted in each net to estimate filtration volume. At each station samples were obtained under control conditions (determine natural drift of larvae off the rocks while the electroshocker is not activated) and during several levels of shocking (DC 120, 180, and 240 V; AC 100, 160, and 240 V) to determine the effect of an electrical field on the susceptibility of larvae to being captured. Three people were required to obtain these samples: one to manipulate each of the nets and one to operate the electroshocking equipment and record data.

Implant basket

55. Wire implant baskets, consisting of an inner basket surrounded by a 0.505-mm-mesh net and enclosed in a protective outer wire basket, were buried to a sufficient depth so that the top was flush with the surface of the rocks on the dike or revetted bank. The inner basket was filled with small rocks, and the net surrounding the inner basket was pushed to the bottom of the basket (Figure 8). All baskets at a location (dike or revetted bank) were attached to a length of 0.635-cm-diam aircraft cable. Soon after implanting, the baskets were submerged by rising water levels.

56. The baskets remained inundated from late January through late May, at which time they were removed. At each location, half of the baskets were removed in the day and half at night. The entire implant assembly (inner basket with rocks, raised net, and outer basket) was

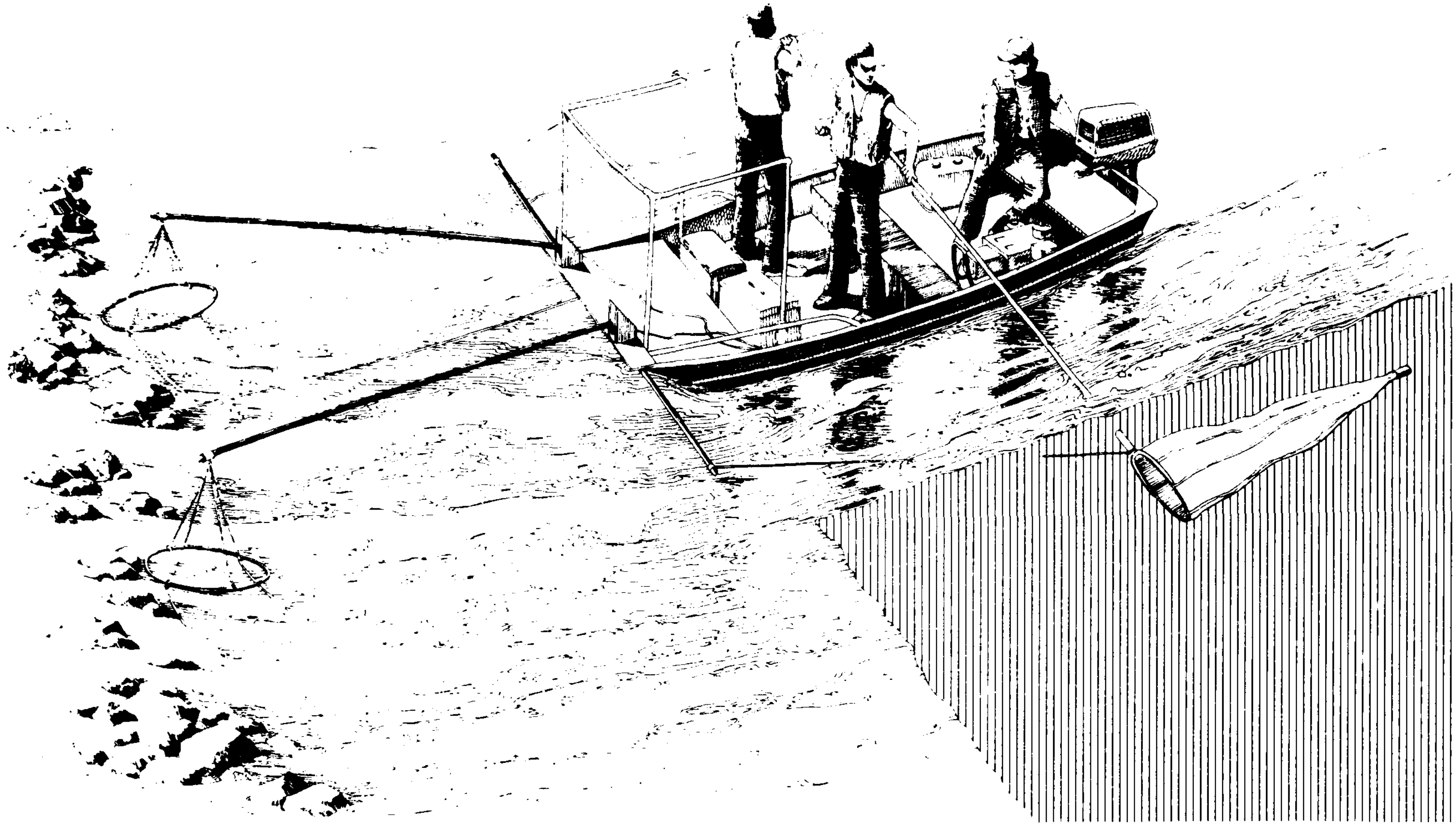

Figure 7. Schematic of electroshocker and associated gear used to sample Marshall Point dikes (the same gear and similar technique were used when sampling Marshall Point revetment)

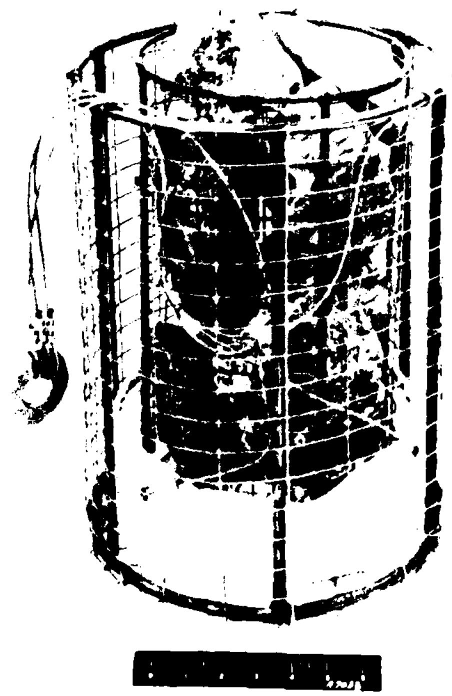

Figure 8. Implant basket as prepared prior to implant into Marshall Point dikes or Marshall Point revetment

pulled by a winch into the boat. Before a basket was pulled up, the net was raised along the sides and above the top of the inner basket. The contents within the inner basket were dumped into a washtub, the materials adhering to the net were rinsed into the tub, and the materials on the rocks were scrubbed, using a toothbrush, into the tub (the scrubbed rocks were discarded). Contents of the washtub were then sieved (0.505-mm mesh), and the materials retained in the sieve were rinsed into a collection jar.

Laboratory Procedures

57. All samples were transferred to jars and immediately fixed in 10-percent buffered formalin. Each sample was processed under a

dissecting microscope by examining a small portion at a time until all fish eggs, larvae, and juveniles had been removed. Larvae were sorted, counted, and identified to the lowest possible taxon by means of comparison with reference series, laboratory notes, and literature. So few eggs and juveniles were encountered that only larvae limited to post-hatching stages with visible finfold tissue, as described by Snyder, Snyder, and Douglas (1977), will be considered in this report. All specimens were transferred to 3- to 5-percent buffered formalin for permanent storage in the Louisiana State University Fisheries Collection of the School of Forestry and Wildlife Management.

Evaluation Procedure

58. Results are reported as catches per unit effort (C/f), or numbers of larvae per 100 m^3 of water filtered as estimated from flowmeter readings (flowmeters were not used in conjunction with the diaphragm pump and implant baskets). Pumping time was used to estimate water volume in order to calculate densities for the diaphragm pump method. Larvae caught with the implant baskets are reported as the numbers caught per group of baskets (day or night) at each location. Each gear was evaluated for its usefulness based upon the relative difficulty of using the gear and the abundance and diversity of larvae caught in each habitat for which it was used.

PART IV: RESULTS AND EVALUATION

59. Seven major fish groups were used in the evaluation of larval fish sampling gears. The composition of these groups is described below.

- a. Shad (*Alosa* spp., *Dorosoma* spp.).
- b. Drum (*Aplodinotus grunniens*).
- c. Carpsucker (*Carpiodes carpio*).
- d. Buffalo (*Ictiobus* spp.).
- e. Sunfish (*Lepomis* spp.).
- f. Grass carp (*Ctenopharyngodon idella*).
- g. Other (*Hiodon* spp., *Scaphirynchus* spp., *Lepisosteus* spp., *Cyprinus carpio*, minnow (Cyprinidae, *Notropis* spp., *Hybopsis* spp., *Pimephales* spp.), Catostomidae (excluding *Carpiodes* and *Ictiobus*), *Menidia beryllina*, *Pomoxis* spp., *Morone* spp., *Ictalurus punctatus*, *Ictalurus furcatus*, [illegible] spp., damaged fish, fish pieces).

Discrete Depth Nets

60. The discrete depth conical net gear proved to be effective in documenting the vertical, diel, and temporal aspects of ichthyoplankton drift in main channel and pool habitats in the Lower Mississippi River. A total of 22 taxa were collected using this gear (Table 1).

61. At both habitats, at each depth, shad comprised a larger percentage of the larvae collected in May than in June (Figures 9 and 10). Although the C/f for total larvae collected in the pool was consistently higher than in the main channel at all depths throughout the diel sampling, the percentage of shad was higher in the main channel samples. Also noticeable was the much higher C/f for drum, carpsucker, and grass carp in the pool samples at all depths.

62. In the main channel during May, the C/f for surface and middepth samples was usually similar, with the surface having the higher abundance during five of the eight sampling periods (the largest difference occurred at 2330 hr). In the pool the surface samples had the

Table 1

Larval Fish Taxa Collected with Each Gear

Larval Fish Taxa	Discrete Depth Net Gear	Push Sled	Diaphragm Pump	Electro-shocker	Implant Baskets
Acipenserida - sturgeons					
Pallid and/or shovelnose sturgeon (*Scaphirhynchus* spp.)	X				
Lepisosteidae - gars					
Gars (*Lepisosteus* spp.)	X	X			
Clupeidae - herrings					
Skipjack herring (*Alosa chrysochloris*)	X				
Gizzard shad (*Dorosoma cepedianum*)		X			
Threadfin shad (*Dorosoma petenense*)		X	X	X	
Gizzard and/or threadfin shad (*Dorosoma* spp.)	X	0	X	X	
Clupeidae	0	0	0	0	X
Hiodontidae - mooneyes					
Goldeye (*Hiodon alosoides*)	X	X	X		
Mooneye (*Hiodon tergisus*)	X	X			
Mooneyes (*Hiodon* spp.)	0				
Cyprinidae - carps and minnows					
Grass carp (*Ctenopharygodon idella*)	X	X	X	X	
Common carp (*Cyprinus carpio*)	X				
Speckled chub (*Hybopsis aestivalis*)	X	X	X	X	
Silver chub (*Hybopsis storeriana*)	X	X	X	X	
Emerald shiner (*Notropis atherinoides*)		X			
Pugnose minnow (*Notropis emiliae*)		X			
Silverband shiner (*Notropis shumardi*)		X			
Blacktail shiner (*Notropis venustus*)		X			
Mimic shiner (*Notropis volucellus*)		X			
Shiners (*Notropis* spp.)	X	0		X	
Bullhead minnow (*Pimephales vigilax*)	X	X		X	
Cyprididae	0	0	0	0	
Catostomidae - suckers					
River carpsucker (*Carpiodes carpio*)	X	X	X	X	X
Buffalos (*Ictiobus* spp.)	X	X	X		
Catostomidae	0		0		
Ictaluridae - catfishes					
Blue catfish (*Ictalurus furcatus*)				X	
Channel catfish (*Ictalurus punctatus*)		X		X	
Madtoms (*Noturus* spp.)				X	
Poeciliidae - livebearers					
Mosquitofish (*Gambusia affinis*)			X		
Atherinidae - silversides					
Inland silverside (*Menidia beryllina*)	X	X			
Percichthyidae - temperate basses					
White, yellow or striped bass (*Morone* spp.)	X	X	X		
Centrarchidae - sunfishes					
Warmouth (*Lepomis gulosus*)	X				
Orangespotted sunfish (*Lepomis humilis*)	X				
Bluegill (*Lepomis macrochirus*)	X	X		X	
Sunfish (*Lepomis* spp.)	0				
White crappie (*Pomoxis annularis*)	X				
Black crappie (*Pomoxis nigromaculatus*)	X				
Sciaenidae - drums					
Freshwater drum (*Aplodinotus grunniens*)	X	X	X	X	X
Damaged fish					
Damaged specimens - family indistinguishable	0	0	0	0	—
Total No. of Taxa	22	21	11	13	3

NOTE: X - denotes what can be considered a separate taxon for any particular gear; 0 - denotes larvae collected and placed in a particular taxonomic category, but cannot be considered separate taxon for that particular gear.

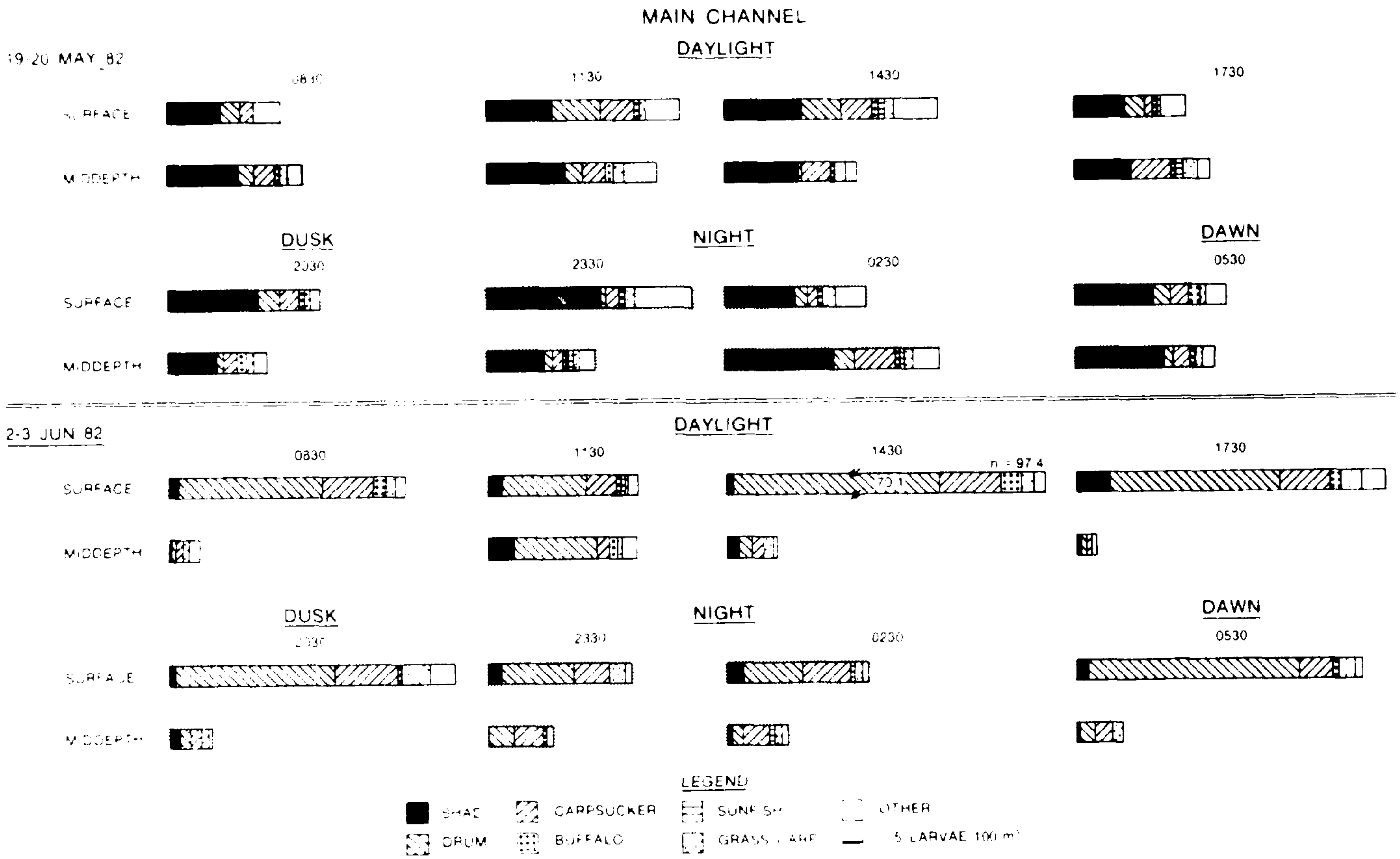

Figure 9. Abundance of major groups of larvae during May and June discrete depth studies in the main channel associated with the Lower Cracraft dikes (composition of seven major fish groups defined in paragraph 59)

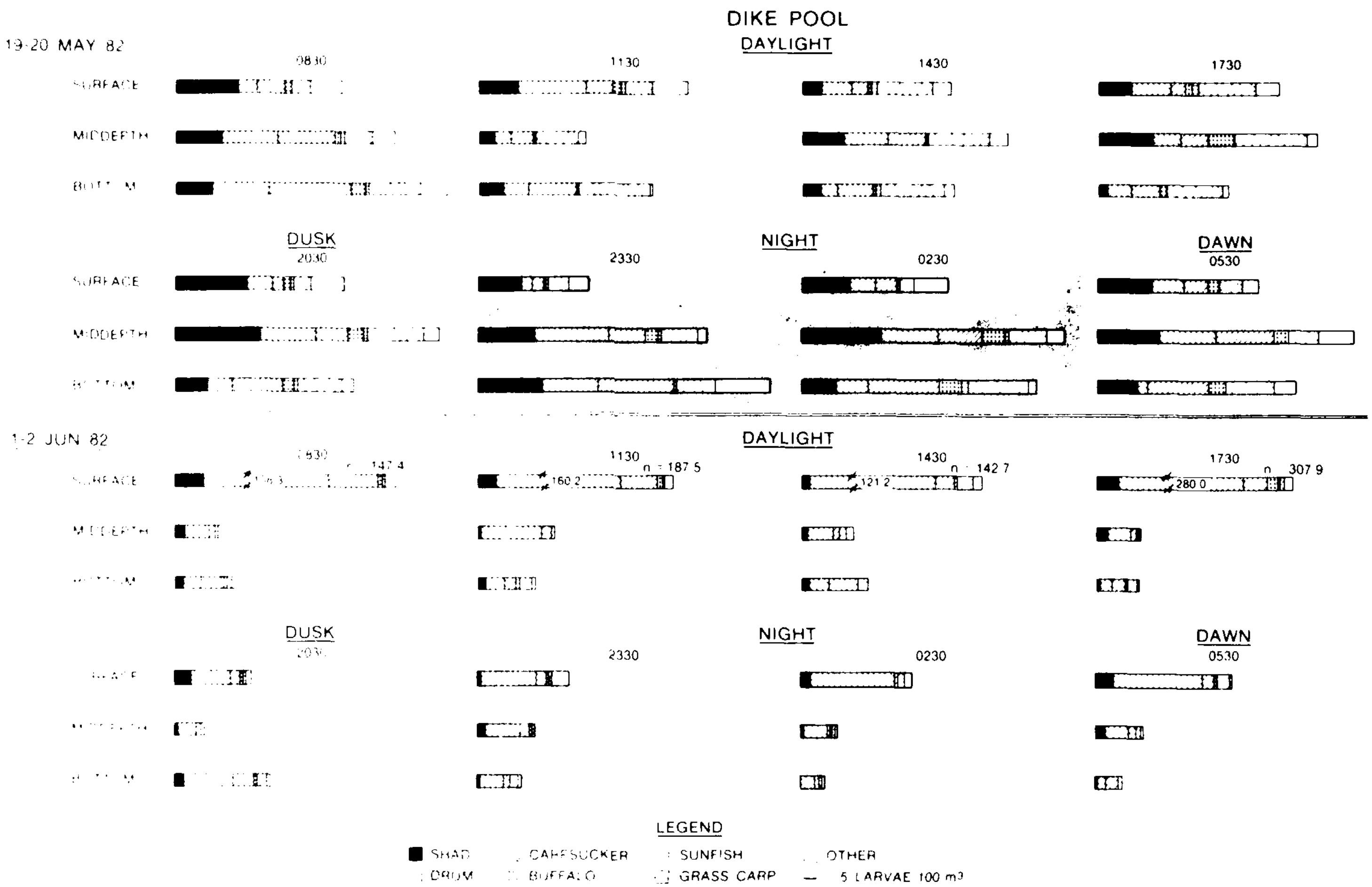

Figure 10. Abundance of major groups of larvae during May and June discrete depth studies in the lower pool of the Lower Cracraft dikes (composition of seven major fish groups defined in paragraph 59)

highest abundance of the three depths only once (at 1130 hr) and had the lowest of the three depths during six sampling periods. The middepth samples had the highest C/f during five sampling periods. The C/f was consistently higher (often greatly so) in the surface samples at both habitats in June, except for two cases (the 1130 hr pool samples and the 2030 hr main channel samples). The principal reason for this was the high numbers of drum larvae in the surface samples, especially evident in the pool daylight samples (at 0830, 1130, 1430, 1730 hr). However, even if drum larvae are excluded from consideration, the main channel surface samples had notably greater numbers than the middepth samples.

63. During May at each habitat, no depth preference among the species collected was evident, with the exception of freshwater drum. It was not surprising to collect drum larvae primarily at the surface because this species has semibuoyant eggs and larvae that float at or near the surface.

Advantages

64. Advantages to use of discrete depth nets were:

a. The three samples collected during a net set were filtered from the same mass of water. (This would be the case unless the water column is stratified.)

b. Because the nets open and close only at a particular sample depth, there was no contamination of samples by water from nonsample depths as the net was lowered and raised.

c. The gear worked smoothly prior to silt load problems (discussed below).

Disadvantages

65. Disadvantages associated with use of discrete depth nets were:

a. Due to the amount of equipment included in this gear, much time, effort, and care were required to conduct the sampling work in proportion to the number of samples obtained.

b. The heavy silt load in the Mississippi River caused the double-trip mechanism to jam and not perform well during the early June diel sampling trip (i.e., nonrelease and/or nonclosure of nets), which necessitated repeated efforts to obtain samples from particular depths, despite liberal use of lubricating fluid on the double-trip mechanism.

Push Sled

66. A total of 21 taxa were collected using the push sled, thus indicating its relatively high effectiveness for sampling shallow-water habitats in the Mississippi River (Table 1). In May, C/f for all larvae was three times as great in night samples than in day samples (Figure 11). The night samples in May contained eight taxa whereas day samples contained three taxa. Of the three taxa collected in both day and night samples, C/f for minnows and shad was higher at night. In July, C/f was about 16 times as great in night samples than in day samples. The C/f was higher in the July day and night samples compared to the respective sampling periods in May. The number of taxa captured was approximately equal in May and July, but the taxa collected in each month were somewhat different. Taxa common to both May and July samples were minnows, shad, drum, and carpsuckers. Taxa collected only in May were buffalo, grass carp, goldeye, and gar. Taxa collected only in July were sunfish and silversides. The large increase in C/f for July samples and the comparable number of taxa in May and July samples can be attributed mainly to the high numbers of minnows and carpsuckers. Most of the minnow and carpsucker larvae were collected at three stations that were not sampled in May. The three stations were established on the riverside of the pool below the second dike. The taxa collected in May but not in July are known to be early spawners in the Lower Mississippi River. Historical data for the Lower Mississippi River document that species diversity peaks in June. Diversity among taxa remained approximately the same in May and July.

Advantages

67. Advantages to use of the push sled were:

a. The larval fish sled was easy to use due to its small

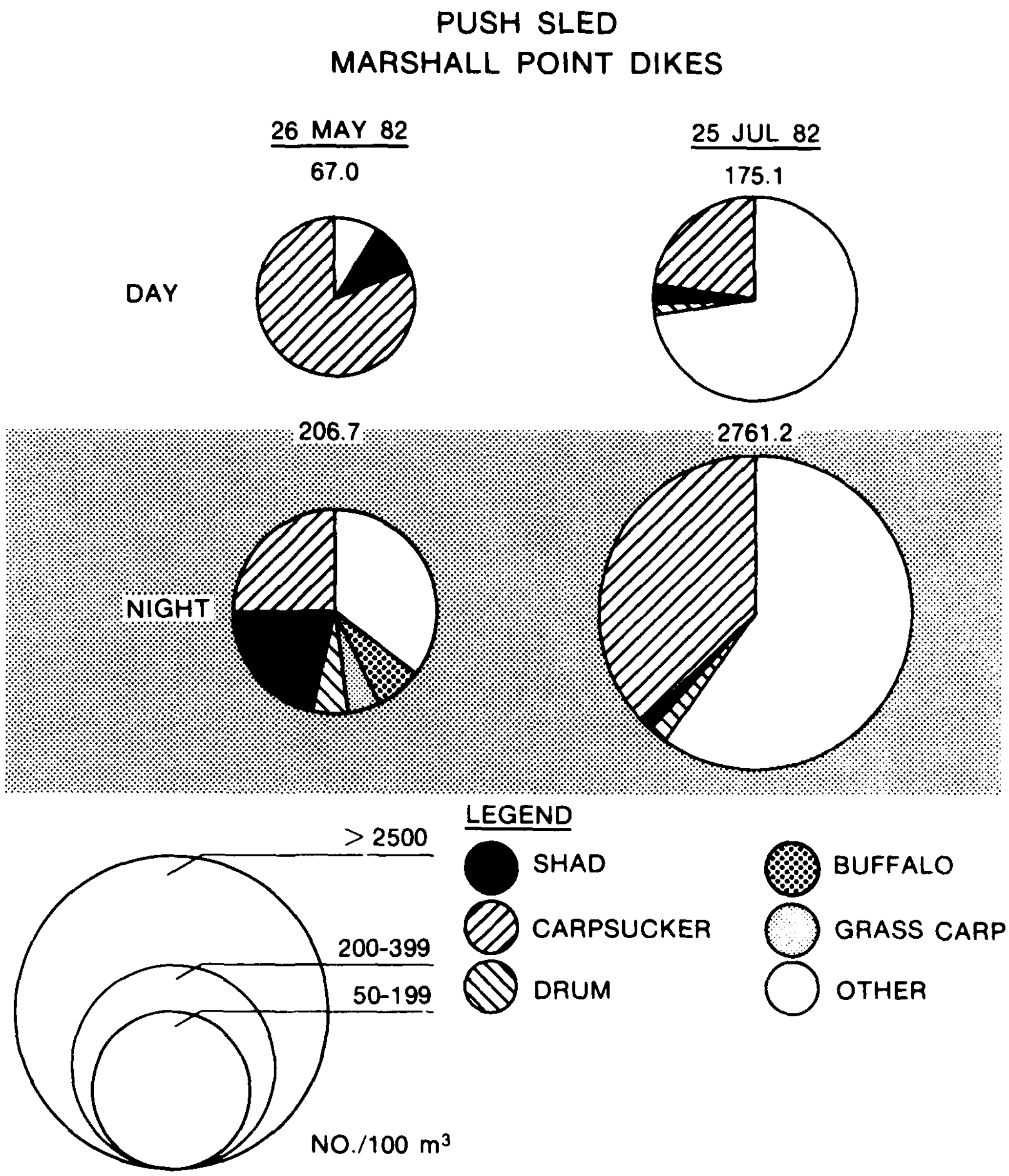

Figure 11. Abundance of major groups of larvae during May and July push sled studies on sandbar areas associated with Marshall Point dikes (composition of seven major fish groups defined in paragraph 59)

size and relatively light weight; therefore, samples could be obtained easily and quickly.

b. The sled performed well in shallow water depths that were inaccessible even to small boats.

c. The sled rolled smoothly over sandy substrate, thus allowing an even flow of water into the net.

Disadvantages

68. The sled did not roll easily over soft substrates that were occasionally encountered on the sandbars. This problem could be overcome by adding more roller surface area and was only a minor inconvenience with the sled used in this study.

Diaphragm Pump

69. The diaphragm pump was an effective gear for sampling along dike and revetment habitats. Eleven taxa were collected using this gear (Table 1). Overall, the day and night samples collected in late May and late July from both habitats displayed greater C/f and diversity compared to samples obtained 25 m from the dike or revetment (Figure 12). However, the greatest difference occurred between night and day samples in late May for both habitats.

70. Day samples at the dike were dominated by minnows (74 percent), with carpsuckers, shad, and suckers having far lower C/f . At night, carpsuckers were dominant, with minnows, shad, grass carp, drum, and buffalo present in decreasing C/f . The C/f for the night samples was twice as high as the day samples. At the revetment, the day samples contained only carpsuckers, while the night samples contained carpsuckers (50 percent), followed by grass carp (14 percent), minnows, buffalo, shad, and goldeye. In late July, the samples at each habitat were dominated by carpsuckers. At the revetment, C/f was nearly equal both day and night (no night sampling occurred at the dike due to equipment problems).

71. Overall, the diaphragm pump samples were indicative of the expected temporal differences in the ichthyoplankton in late May and late July. Taxonomic diversity was greater in May, which corresponded to the time of spawning for many species, while the July conditions, dominated by carpsuckers and drum, reflect reduced spawning activity.

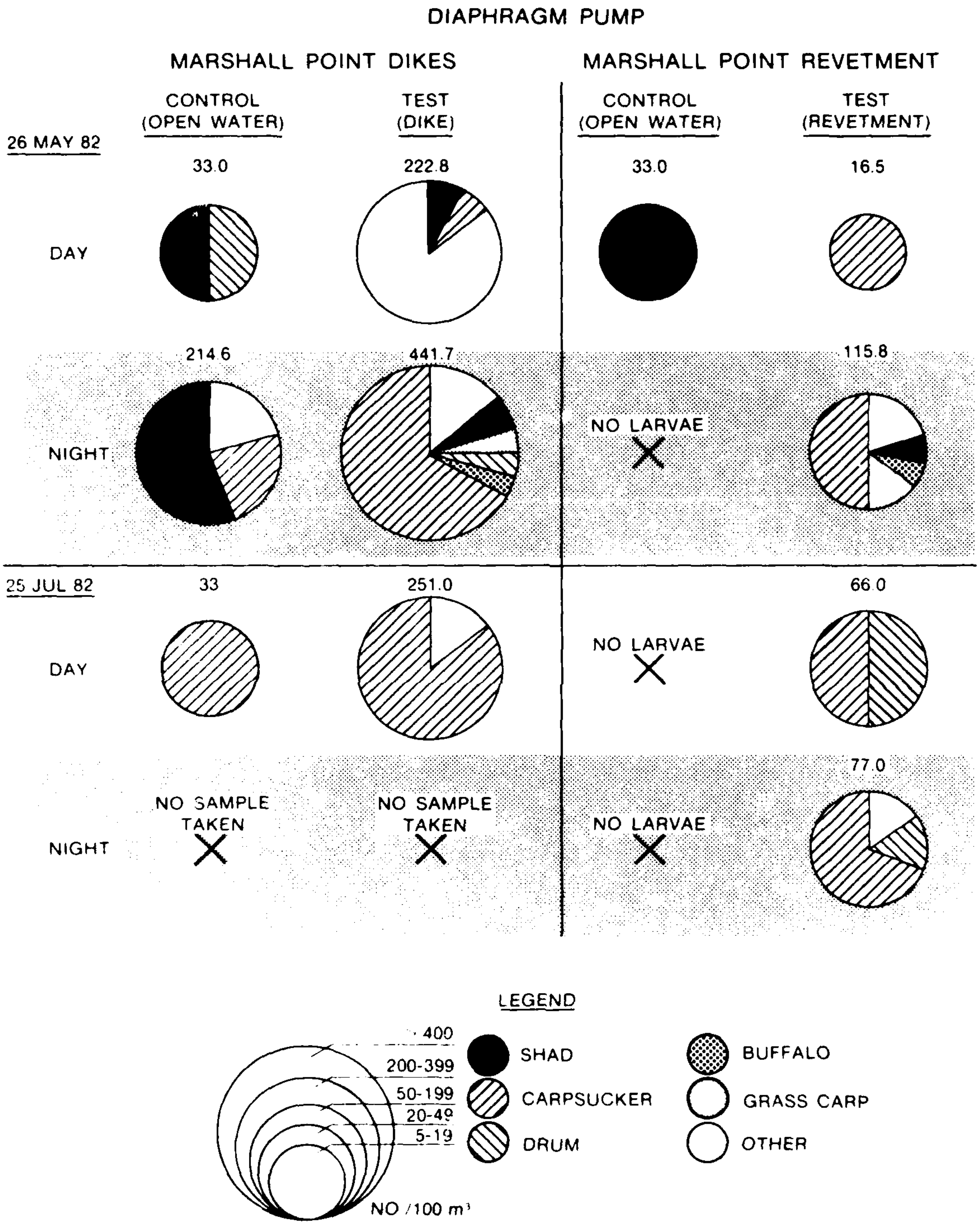

Figure 12. Abundance of major groups of larvae in test and control samples taken with diaphragm pump during May and July at Marshall Point dikes and Marshall Point revetment (composition of seven major fish groups defined in paragraph 59)

The expected spatial and diel differences were also evident in the diaphragm pump samples.

Advantages

72. Advantages to use of the diaphragm pump were:

a. Samples were obtainable in areas inaccessible to towed nets and other active gear that require no obstructions during deployment.

b. Operation of collection equipment was fairly simple.

c. Data can be quantified on the basis of surface area swept by the intake hose.

Disadvantages

73. Disadvantages associated with use of the diaphragm pump were:

a. A much smaller volume of water was filtered in a 5-min period compared to that for a 0.5-m-diam conical towed net sample.

b. The captured larvae sustained various degrees of damage among species (44 percent in good condition, mostly drum; 16 percent in fair condition; 40 percent in poor condition, mostly shad and minnows).

Electroshocker

74. The use of an electroshocker resulted in the collection of 13 taxa (Table 1). However, based on comparison with the results from day and night control samples at dike and revetment habitats in late July, it appears that the presence of an electrical field while collecting larval fish does not alter the catch (Figure 13). The two cases when ichthyoplankton C/f was far higher in the electroshock samples than in the control samples for the same habitat and time period (the DC 120-V day samples at the revetment and the AC 240-V night samples at the dike) are probably due to the presence of a much higher number of larvae present at the sampling station, regardless of the absence or presence (and its intensity) of an electrical field.

75. The dike and revetment did not display the same degree of diel differences in species occurrences. At the dike, carpsuckers were dominant both day and night under no shock and DC 120- to 240-V conditions. Drum were usually second in abundance. Shad were present in

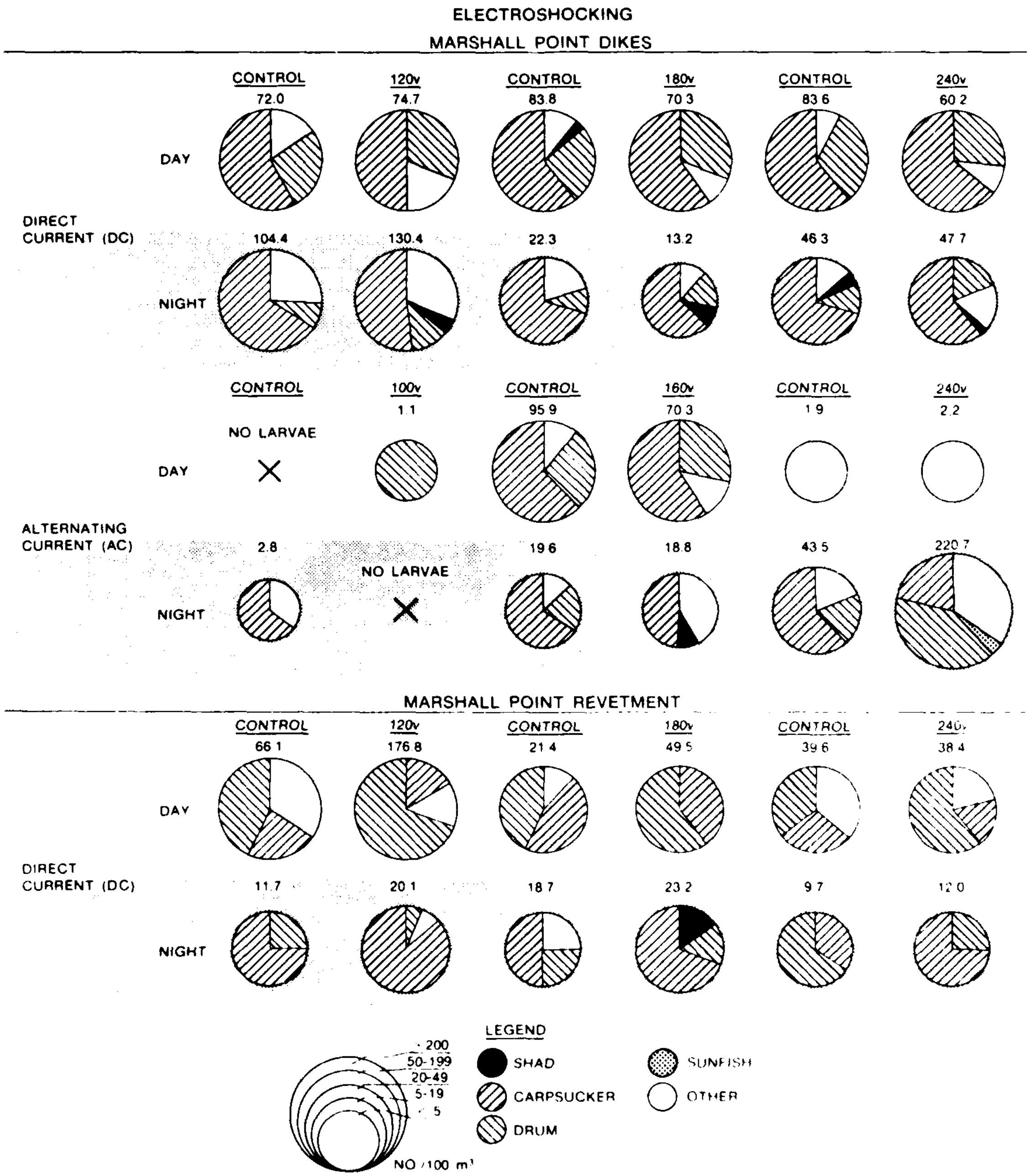

Figure 13. Abundance of major groups of larvae with varying voltages and types of electrical current during July study at Marshall Point dikes and Marshall Point revetment (composition of seven major fish groups defined in paragraph 59)

relatively low abundances in one-half of the samples. Minnows, madtoms, grass carp, sunfish, and blue catfish were additional taxa collected. At the revetment, drum were dominant during the day and carpsuckers were second highest in abundance. At night, carpsuckers were dominant in all samples except the control samples associated with DC 240 V. Shad and minnows were also variably present.

76. The results from the AC 100- to 240-V shocking at the dike showed marked differences in C/f and diversity. The AC 160-V shocking caught approximately four times as many larvae during the day than at night, with three taxa present during each time period. Carpsuckers were dominant both day and night in control and shock samples. The AC 100-V and associated control samples contained few to no larvae in the day and night samples. The AC 240-V samples and the associated control samples during the day contained two minnows each. The night AC 240-V samples contained over 220 specimens among four taxa (drum, minnows, carpsuckers, and sunfish), whereas the control samples contained one-fifth as many specimens and one less taxon (no sunfish).

Advantages

77. Advantages to use of the electroshocker were:

a. Samples could be obtained in and adjacent to rocky habitats inaccessible to towed net gear.

b. Sampling procedure was relatively simple and required unsophisticated equipment.

Disadvantages

78. It was not proven in this study that an electrical field created on dike and revetment habitats contributed to an appreciable increase in catch of larvae over control samples.

Implant Basket

79. The implant basket was not an effective gear for sampling ichthyoplankton associated with dike and revetment habitats. Only three taxa were collected using this gear (Table 1). No larvae were collected in baskets pulled up during the day or night at the revetment. At the

dike, one freshwater drum was collected in a basket pulled up during the day, while one shad and one carpsucker were collected in separate baskets pulled up during the night. At both habitats the baskets were heavily silted around the rocks placed in the inner basket (mostly coarse material in the dike-implanted baskets and medium and fine material in the revetment-implanted baskets). This greatly restricted the amount of space in the inner basket available for larval fish to inhabit. No further analysis of the implant basket ichthyoplankton data was performed.

Advantages

80. Advantages to use of implant baskets were:

- a. The baskets were relatively easy to implant and remove, although the fieldwork was labor intensive.
- b. Implant baskets were usable in habitats unsuitable for active gear (e.g., towed nets).

Disadvantages

81. Disadvantages associated with use of implant baskets were:

- a. Implant baskets were expensive to construct due to materials, required technical service (welding and net construction), and final assembly labor.
- b. An extensive amount of sediment collected around the rocks in the inner basket, thus occupying potential larval fish habitat space.

PART V: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

82. A wide variety of gears for sampling ichthyoplankton exists. The best gear to use for a research project is dependent on the habitat to be sampled, the research questions to be answered, and financial support available to conduct the research. Five gears were selected for testing among main channel, dike pool, dike, revetment, and sandbar habitats in the Lower Mississippi River.

83. The discrete depth net gear was effective in documenting the vertical, diel, and temporal distribution of ichthyoplankton drift in the main channel and dike pool habitats. The most notable observation was the comparable larval abundances among like depth strata between habitats in May samples, with shad being more dominant than in June samples (especially in the main channel). In June, samples from the surface stratum at each habitat contained a greater abundance of larvae than those collected at lower depths, with drum being dominant (especially in the dike pool habitat).

84. The push sled was very effective for sampling shallow-water sandbar habitats. Use of the sled revealed diel and temporal differences in shallow-water ichthyoplankton. The night samples had a much greater abundance of larvae, especially in July. Carpsuckers, shad, and minnows were dominant in May, whereas minnows and carpsuckers comprised nearly all the larvae collected in July samples.

85. The diaphragm pump, electroshocker, and implant baskets were used to sample ichthyoplankton associated with dike and revetment habitats. Of these gears, the diaphragm pump was the most effective. Samples collected along the dike and revetment habitats contained greater numbers and taxa than the background (control) samples. Overall, the samples contained more taxa in May, a time of spawning for many species, while July samples reflected the less diverse summer ichthyoplankton. Based on the samples collected using the electroshocker, the presence of

an electrical field does not alter ichthyoplankton catch. Of the three gears used to sample the dike and revetment, the implant baskets were clearly ineffective, although they functioned mechanically correct.

Recommendations

86. Discrete depth nets, the diaphragm pump, and the push sled should be utilized in a sampling program when describing larval fish in navigable rivers such as the Mississippi. Efforts should continue to refine the sampling techniques associated with the gears tested in this study, and additional gears should be developed and tested to sample additional habitats of interest. If these additional gears can be proven reliable, they should be incorporated into an array of gears used in a multihabitat sampling program.

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