Arkansas Water Resources Center

AN EVALUATION OF THE EFFECTS OF DREDGING WITHIN THE ARKANSAS RIVER NAVIGATION SYSTEM, VOLUME IV

The Effects Upon The Fish Populations

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AN EVALUATION OF THE EFFECTS OF DREDGING WITHIN THE ARKANSAS RIVER NAVIGATION SYSTEM

VOLUME V

THE EFFECTS UPON THE FISH POPULATIONS

THE FINAL REPORT TO THE
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INTRODUCTION

The Arkansas River extends for 1,450 miles from the eastern slopes of the Rocky Mountains in Colorado, southeasterly through Kansas, Oklahoma, and Arkansas, where it enters the Mississippi River in Desha County. The 448 mile navigation channel which was constructed on the lower portion of this river includes portions of two of its major tributaries, the Verdigris River in Oklahoma and the lower White River in Arkansas. The Arkansas portion of this navigation system consists of three different segments: (1) the lower White River, from its confluence with the Mississippi River to 10 miles upstream, (2) the Arkansas Post Canal, a nine-mile, man-made structure connecting the White River with the Arkansas River, and (3) the main Arkansas River from its juncture with the Arkansas Post Canal at navigation mile 19, upstream to Fort Smith.

Frequent dredging of sand and silt from the channel is required at numerous locations along the system to maintain appropriate dimensions for navigation. Sand deposition in the channel generally takes place during periods of high river flow and is most prevalent immediately downstream from the locks and dams, although it occurs in other areas as well. The excavated sand and silt are deposited in various types of designated dredge disposal areas on or near the river banks.

In order to accurately assess the effects of these dredged material disposal areas upon the fishes of the Arkansas River, it is first necessary to determine what species are present in the river and how they are distributed ecologically and geographically. The investigation reported here dealt with the fishes of the Arkansas portion of the McClellan-Kerr Arkansas River Navigation System, extending from navigation mile 0 at the mouth of the White River in Desha County, to navigation mile 308 at Fort Smith in Sebastian County. This navigation channel was completed to Fort Smith in 1970. The present report consists of two parts: Part One deals with the fish distributional patterns, and Part Two evaluates the effects of dredged material disposal areas on fish populations. Because there were no ichthyological investigations of the fishes of the Arkansas River in Arkansas prior to the construction of the navigation system, the present distributional study also provides a basis for future comparisons.

PART ONE: FISH DISTRIBUTIONAL PATTERNS

I. OBJECTIVES

The fish distributional patterns were evaluated throughout the study reach by determining:

(1) the distribution of species ecologically and geographically,

(2) the relative and actual abundance of species,

(3) the sport, commercial, and scientific value of fishes, and

(4) the existence of rare and endangered species.

II. METHODS

The distributional information on the fishes of the Arkansas River Navigation System was obtained largely during an ichthyological survey conducted from 15 June 1974, through 15 December 1974. One hundred ten collections of fishes were made during this period in all sections of the navigation system from Fort Smith to the mouth of the White River (Map 1). The sampling sites were fairly evenly distributed throughout the study reach and included numerous dredge disposal areas as well as other habitat types available. The following types of collecting gear and sampling techniques were used: (1) Seines (52 samples)- 10' x 4' and 20' x 4' nylon seines of 1/8" mesh, 30' x 6' nylon seines of ¼" mesh, and a 40' x 6' nylon bag seine of ¼" mesh were all used in appropriate habitats to collect fishes. Diurnal and nocturnal samples were taken at numerous localities.

(2) Gill nets (14 total sampling days)- Standard 125' x 6' experimental monofilament nylon gill nets consisting of panels of ½, 1, 1¼, 1½, and 2 inches bar measure mesh were used. The six gill nets used were anchored or staked on the bottom either individually or with two or three of them tied together to block off an area. They were always set late in the afternoon and were checked early the next morning, shortly after sunrise.

(3) Hoop nets (10 total sampling days)- Two 10' hoop nets having 1" square mesh, 2' front diameter, and 7 fiberglass hoops, and six 12' hoop nets with 2" square mesh and having 3' front diameters and 7 fiberglass hoops were used.

(4) Rotenone (13 samples)- Arkansas Game & Fish Commission biologists supervised the chemical sampling of fishes with rotenone at various sites during July and August, 1974. Some of these rotenone collections were large population samples normally taken each year at fixed localities by the Game & Fish Commission, but most of these collections were small samples from isolated backwater localities, including several dredge disposal sites.

(5) Electric shocker (21 samples)- A 220 volt, boat-mounted AC electric shocker was used to shun fishes in a variety of habitats.

The different sampling techniques permitted the collection of fishes from all types of habitats found in the Arkansas River system. The most difficult sampling conditions existed in the swift, deep water of the main navigation channel. Hoop nets attached to

anchors were the only satisfactory means of collecting fishes from this habitat; therefore, only scant information was obtained from this type of environment. Proceeding shoreward from the center of the channel, gill nets, the electric shocker, and seines in addition to the hoop nets were adequate for collecting fishes in slow to moderate currents of varying depths. In the backwater habitats with little or no current, all of the collecting gear except hoop nets were very effective. The rotenone samples were taken exclusively from backwater environments. A list of the species collected by each of the ssmpling methods used is presented in Table 1.

Most of the fishes collected were preserved in a 10% formalin solution and transported to the laboratory for identification, enumeration, and further data collection. Most of the large specimens were identified in the field and quantitative data were recorded at that time before the fishes were discarded.

Other data used to compile fish distributional records since the completion of the navigation channel to Fort Smith were obtained from:

(1) 23 seine samples made by the writer in the upper portion of the study reach from April 1972, through April 1974;

(2) Game and Fish Commission records of four rotenone samples from Dardanelle Reservior (2 in 1973 and 2 in 1974), one rotenone sample from Ozark Reservior in 1973, and one rotenone sample from Pool 13

in 1973; and

(3) one sample of approximately 122 hoop nets of commercial fishermen recorded by the writer on 23 August 1974, along navigation miles 194-202 below Dardanelle Lock and Dam.

Therefore, a total of 140 fish collections from the navigation system were used to determine present distributional patterns. Interviews with two commercial fishermen, each having more than 25 years experience fishing the Arkansas River, also provided useful information.

III. ANNOTATED LIST OF FISHES

The following annotated list of fishes includes all species collected from all parts of the navigation system (140 samples) since its completion to Fort Smith. The common and scientific names used for species follow Bailey et al. (1970) with two exceptions: (1) the grass carp, *Ctenopharyngodon idellus* Cuvier and Valenciennes, which has only recently been introduced into the United States, and (2) the plains shiner, *Notropis percobromus* (Cope), which is not recognized by Bailey et al. as a valid species. The writer follows Moore (1968), Eddy (1969), and Hubbs (1972) in recognizing the latter form as a distinct species. Family designations follow Moore (1968).

A separate distribution map is provided for each species collected from the navigation system (Maps 2-107). The points on

these maps represent all verified recent collection localities for each species, and do not include the relatively few known distributional records of species prior to the construction of the navigation system. Table 2 shows the number of specimens of each species collected, the number of collections a species appeared in, and the percent of the total collections (140) in which each species was represented.

The annotated list also includes all known information about the relative and actual abundance of species as well as pertinent ecological data. Fishes with special, commercial, sport, or scientific value are also indicated.

Family Petromyzontidae-Lampreys

1. Chestnut lamprey, *Ichthyomyzon castaneus* Girard (Map 2).

Adult lampreys are uncommon in the Arkansas River, but are occasionally taken by commercial fishermen in all parts of the navigation system. This parasitic fish poses no threat to the commercial or sport fisheries of the river, and is itself in no immediate danger of being eliminated, because it still has access to suitable spawning habitat.

The parasitic adults of this species attach themselves, by means of their disc-like mouths, to large fishes such as buffalo and carp. They use sharp denticles to rasp away the flesh in the area of attachment so that they may feed upon the blood and body

fluids of the host. The adult lampreys inhabit the larger rivers and lakes which have the greatest populations of large fishes. They ascend the clear tributary streams in the spring where they spawn in moderate current over gravel and sand bottoms. The eggs hatch into larval forms (ammocoetes) which burrow into beds of dead leaves or other organic matter on the stream bottom. The nonparasitic ammocoetes are filter feeders, straining microscopic food particles from the water. After this larval stage has been completed, the newly transformed adults move downstream to larger bodies of water in search of large fish to parasitize, (Cross, 1967).

Family Polyodontidae-Paddlefishes

2. Paddlefish, *Polyodon spathula* (Walbaum) (Map 3)

This species has shown a gradual decline in numbers over most of its range since 1900, because of habitat alteration and overfishing (Trautman, 1957; Cross, 1967; and Pflieger, 1971). Black (1940) stated that the paddlefish was common in the Arkansas River below Little Rock, and was "not rare" as far west as Fort Smith. It inhabits sluggish backwaters and oxbow lakes of large rivers where it feeds almost exclusively on plankton strained from the water by its fine gill rakers. The paddlefish, commonly referred to in Arkansas as the "spoonbill cat", normally attains a length of around 50 inches and a weight of 20 pounds, although specimens in

excess of 100 pounds have been reported from the state. Only two specimens were collected during the present study, both from the upperportion of the river near Fort Smith, but it is known to occur in suitable backwater habitat throughout the navigation channel itself. Commercial fishermen reported that the average size of the paddlefish taken by them has increased since the construction of the navigation system. This is probably a reflection of the increase in planktonic biomass associated with the greater volume of water present.

Purkett (1961) described the upstream reproductive migrations of paddlefish and reported that they ascend larger tributaries in early spring when the water is high and muddy to spawn over large gravel bars. Dams block these migrations, causing accumulations of these fish below them where they are frequently snagged by fishermen using large treble hooks. Pflieger (1971) stated that the paddlefish thrives in large man-made impoundments if they have large tributaries that are suitable for spawning. It is possible that Dardanelle and Ozark Reservoirs provide the conditions necessary for the recovery and continued existence of populations of this declining species. Paddlefish are not presently caught in significant numbers by commercial fishermen anywhere in the Arkansas River.

Family Acipenseridae-Sturgeons

3. Shovelnose sturgeon, *Scaphirhynchus platorynchus* (Rafinesque) (Map 4)

This is a declining species over much of its range (Buchanan) 1974) but it is still fairly common in all portions of the Arkansas River navigation system (especially the lower White River). It occurs primarily in the most difficult habitat to sample the swift, deep currents over sandy bottoms, where it feeds on benthic organisms and some plant material. Its poor representation in the recent samples does not accurately indicate the common occurrence of this species. It is frequently taken by commercial fishermen who sell the larger specimens (maximum size around 5 pounds). Even though it is common in the navigation system, it is a small species and rarely attains a size desirable by commercial fishermen. The shovelnose sturgeon easily becomes entangled in gill nets and other entrapment devices, and many individuals are killed annually as a result.

This sturgeon migrates upstream and into tributaries to spawn in the spring, and large concentrations of them are observed below the Arkansas River dams, where fishermen snag them with hooks or catch them on worms. In other parts of the country, sturgeon populations have been drastically reduced by the damming of streams (Cross, 1967 and Held, 1969). Coker (1930) attributed the decline in the numbers of this species in the Mississippi River to the

restriction of channels for navigation purposes. Because of its food habits and habitat, maintenance dredging of the Arkansas River channel is probably harmful to the sturgeon populations.

Family Amiidae-Bowfins

4. Bowfin, *Amia calva* Linnaeus (Map 5)

This is a species most commonly found in oxbow lakes, bayous, and sluggish rivers of the coastal plain lowlands (Black, 1940 and Cross, 1967). The bowfin, also called the "grennel" in Arkansas, may attain a length of two feet and a weight of five pounds. It was most common in the quiet backwaters of the lowland portion of the Arkansas River navigation system, and decreased in numbers upstream toward Fort Smith. No large populations of this predatory fish were found to exist anywhere in the main Arkansas River, and it has no commercial and only negligible sport value.

Family Lepisosteidae-Gars

5. Spotted Gar, *Lepisosteus oculatus* (Winchell) (Map 6)

The spotted gar is the least common of the three species of gars collected during the present study (this species comprised only 6.5% of all gars collected). The spotted gar is less tolerant of turbidity than the other gars and prefers clear, quiet waters containing an abundance of aquatic vegetation. This was the only species of gar taken from heavily-vegetated Merrisach Lake, just off the Arkansas Post Canal. Spotted gars were captured infrequently

throughout the navigation system in Arkansas. It is also the smallest species of gar, usually reaching a length of three feet and weighing around six pounds. Like all gars, it is predaceous, feeding on small fishes. It migrates to the mouths of smaller streams to spawn in late spring.

6. Longnose gar, *Lepisosteus osseus* (Linnaeus) (Map 7)

Common throughout the navigation system, it was the most abundant species of gar in Dardanelle Reservoir and in less turbid areas of the river. This species typically inhabits clear backwaters and oxbow lakes, but is also found frequently in moderate to swift current in the river. The longnose gar is one of the most numerous large predatory fishes of the Arkansas River and serves an important function of helping to regulate the numbers of prey species, particularly the gizzard shad. This gar frequently attains a length of four feet and a weight of 15-20 pounds (although larger specimens are known), and is one of the few fishes capable of utilizing the largest size classes of the abundant gizzard shad (see species number 9) as food (Cross, 1967 and Goodyear, 1967). It is therefore, a desirable and useful species.

7. Shortnose gar, *Lepisosteus platostomus* Rafinesque (Map 8)

This is the most turbidity tolerant species of gar, and consequently is common throughout the Arkansas River. It was the most abundant gar in the main river channel away from the reservoirs and, like the common longnose gar, is beneficial in regulating the

population sizes of prey species. This gar is a somewhat smaller species than the longnose gar and is often mistakenly identified as immature alligator gar (a rare species) by both commercial and sport fishermen.

Family Clupeidae-Herrings And Shads

8. Skipjack herring, *Alosa chrysochloris* (Rafinesque) (Map 9)

This species is an open-water, schooling, big-river fish found in clear, swift currents (Trautman, 1957). It is fairly intolerant of turbidity and siltation (Cross and Huggins, 1975) and is found predominately in the less turbid portions of the Arkansas River Navigation System where little maintenance dredging occurs, such as in Pool 13, Ozark and Dardanelle Reservoirs, and the lower White River. Individuals are infrequently taken, however, from the middle portions of the system by commercial fishermen. This species feeds primarily on small fishes and may reach a length of 16 inches and a weight of one to two pounds. It is occasionally taken on artificial lures and minnows by fishermen who discard it on the river banks. Little is known about the reproductive habits of this species.

9. Gizzard shad, *Dorosoma cepedianum* (Lesuer) (Map 10)

This is the most abundant species of fish in the Arkansas River Navigation System, comprising 51.3% of all fishes collected by number in this study. This open-water species feeds on plankton and detritus strained from the water and is only accidentally

caught by fishermen. Small gizzard shad are important food fishes for most of the gamefishes in the Arkansas River, but this shad rapidly attains a large size (12-16 inches long and weighing 1-3 pounds), becoming unavailable as food for most predators. Gizzard shad were usually found in large schools over a variety of bottom types and in many different habitats in both clear and turbid water. They typically spawn in backwater areas and scatter their eggs near the surface. This delicate species is very susceptible to sudden environmental changes, often exhibiting "die-offs" from temperature shock or oxygen depletion (Cross, 1967).

10. Threadfin shad, *Dorosoma petenense* (Gunther) (Map 11)

An abundant species throughout the navigation system, the threadfin shad comprised 15.7% of all fishes collected by number, and was second in abundance only to the gizzard shad. Although the threadfin shad is native to the Arkansas River, it has been stocked heavily throughout the system, especially in Dardanelle Reservoir, by the Arkansas Game & Fish Commission, because it is a small species and remains available as food for predators during all of its life cycle. This shad feeds almost exclusively on plankton and is even less tolerant to sudden temperature changes than the gizzard shad (Strawn, 1963). Frequent winter die-offs of shad observed in Arkansas reservoirs, including Dardanelle, largely consist of threadfin shad and are generally no cause for alarm. The habitat of *Dorosoma petenense* is similar to that of the gizzard shad,

except that the threadfin is more frequently found in strong current (Pflieger, 1971).

Family Salmonidae-Trouts

11. Rainbow trout, *Salmo gairdneri* Richardson (Map 12)

The single 12-inch specimen collected from a dredge disposal area backwater just downstream from Lock and Dam 13 on April 1974, with a 30 foot seine was probably a straggler from an upstream tributary. The rainbow trout is not native to Arkansas, but has been introduced in various places to establish a put-and-take fishery, particularly in the White River below Bull Shoals and Norfork Reservoirs. The Arkansas River has no habitat suitable for such a fishery, and the specimen taken probably came from the nearby Illinois River in Oklahoma, where rainbow trout are regularly stocked.

Family Esocidae-Pikes

12. Grass pickerel, *Esox americanus* Lesueur (Map 13)

Collected only from backwaters of the lower White River and Merrisach Lake, this species probably occurs only rarely in the Arkansas River (which it could enter from its clearer tributaries). It is the smallest species of the pike family (reaching only 12 inches in length and up to 1 pound in weight) and is most commonly found in small, clear creeks of the Ouachita Mountains and less commonly in Ozark Mountain streams. It prefers heavily vegetated

waters where it feeds on small fishes.

13. Chain pickerel, *Esox niger* Lesueur (Map 14)

Like the previous species, the chain pickerel is native to Arkansas, but is not a normal resident of the Arkansas River. Occasional stragglers may enter the river from tributary streams of the sluggish, lowland type. The only specimen collected was from a lower White River backwater. This species attains a much larger size (state record: 5 pounds) than the grass pickerel and occurs in larger lowland streams in quiet, vegetated waters. It is an excellent game fish, but is not common enough in the Arkansas River to be important.

Family Hiodontidae-Mooneyes

14. Goldeye, *Hiodon alosoides* (Rafinesque) (Map 15)

The goldeye is a big-river fish found commonly throughout the navigation system. This species inhabits moderate currents and, to a much lesser extent, the backwaters where it feeds on insects and small fishes. It is frequently taken on artificial lures and minnows below the dams by fishermen who discard it on the river banks. The goldeye is not sought after by commercial fishermen in the United States, but it is harvested commercially in Canada where its smoked flesh is sold (Lagler, 1956). Specimens 15 inches long and weighing 1-2 pounds are common in the Arkansas River. The goldeye is very tolerant of turbidity.

15. Mooneye, *Hiodon tergisus* Lesueur (Map 16)

This species, unlike its close relative the goldeye, is intolerant of siltation and turbidity and is rare in the Arkansas River. It occurs primarily in the clear, large tributaries and individuals may occasionally wander downstream into the more turbid waters of the navigation system. Two specimens were taken in a dredge disposal area backwater near the mouth of Little Bayou Meto.

Family Cyprinidae-Minnows and Carps

16. Stoneroller, *Campostoma anomalum* (Rafinesque) (Map 17)

This species is a common inhabitant of small, clear, gravel bottomed streams and headwater creeks of the Ozark and Quachita Mountains, but also is moderately tolerant of siltation and turbidity (Cross, 1967). This minnow feeds on algae which it scrapes from rocks with its chisel-like lower jaw. The stonerollers which were infrequently collected from the upper portion of the Arkansas River were probably wanderers from nearby tributary creeks, although small populations are known to exist in other Arkansas reservoirs. The absence of specimens in the collections from the lower portions of the Arkansas River supports the belief that these stonerollers were stragglers.

17. Goldfish, *Carassius auratus* (Linnaeus) (Map 18)

The goldfish is a commonly used bait minnow which might occasionally be found anywhere in the Arkansas River system, although

only three specimens were found in the present study. This introduced species has not established breeding populations in the Arkansas River system or in any other natural bodies of water in the state, despite ample opportunities to do so. It is apparently intolerant of turbidity and siltation and prefers shallow backwaters with dense aquatic vegetation.

18. Grass carp, *Ctenopharyngodon idellus* Cuvier and Valenciennes (Map 19)

This large species was introduced into Merrisach Lake and other impoundments along various portions of the Arkansas River for the control of aquatic vegetation. Specimens were collected with gill nets below Dardanelle Lock and Dam and in Merrisach Lake with rotenone. Commercial fishermen and anglers now report taking this species all along the navigation system, even though it has not been directly introduced into that system. Its value in controlling aquatic vegetation in natural bodies of water in Arkansas has not yet been determined, and in sparsely vegetated regions of the Arkansas River it may compete with the introduced carp or other native species. It is not known whether breeding populations capable of surviving cold winter temperatures will become established in the future in the navigation system or what their ecological impact would be. The grass carp (also called the White amur) is capable of attaining a large size (20-30 pound individuals are common in some impoundments under favorable conditions), and it is

a very good food fish.

19. Carp, *Cyprinus carpio* Linnaeus (Map 20)

One of the most common large fishes in all parts of the navigation system, this introduced species comprises a large percentage by weight of the catches of commercial fishermen, It is generally considered an undesirable species, because it reduces the population levels of many desirable fishes through competition and habitat alteration. Spawning carp were observed in the Arkansas River from April through July, particularly during periods of flooding when they scattered their eggs over vegetation in shallow water. Carp eat a variety of plant and animal materials and are frequently caught by fishermen who can attest to their fighting ability.

20. Cypress minnow, *Hybognathus hayi* Jordan (Map 21)

This is a southern species that strictly occurs in the coastal plain lowlands. Its present status in Arkansas is undetermined, but the widespread destruction of its optimum habitat has likely decreased its abundance in the state. The only specimens collected in the present study were from the lower White River, and it is unlikely that this species occurs anywhere in the main Arkansas River, with the possible exception of the mouths of a few lowland tributaries. It is probably intolerant of turbidity.

21. Silvery minnow, *Hybognathus nuchalis* Agassiz (Map 22)

Most common in the lower White River, becoming less abundant

upstream in the Arkansas River. It was very rare upstream from Little Rock, and no specimens were collected above Lock and Dam 9, although Black (1940) reported it from two localities in the Arkansas River near Fort Smith. The reasons for its apparent decline in the upstream portions of the navigation system are not known. The silvery minnow prefers backwater areas where it feeds on algae and detritus. Trautman (1957) and Pflieger (1971) reported that this species is intolerant of high turbidity and siltation, particularly in its backwater spawning habitat.

22. Flathead chub, *Hybopsis gracilis* (Richardson) (Map 23)

This is mainly a Great Plains species that reaches the southeastern limits of its range in the Mississippi River of Arkansas. It is rare in Arkansas, and the one specimen collected from navigation mile 0 at the mouth of the White River on 8 July 1974, was the first specimen reported from Arkansas since 1939. The flathead chub inhabits large silty rivers with strong current and sandy bottoms, where it feeds on insects. It does not occur in the Arkansas River or its tributaries in Arkansas.

23. Silver chub, *Hybopsis storeriana* (Kirtland) (Map 24)

This species is found throughout the navigation system. This minnow inhabits large, sandy rivers and is very tolerant of turbidity and siltation. It is common at most localities, but is rarely collected during daylight hours. It apparently remains in deep current during the daytime, moving shoreward at dusk to feed

on insects and other small invertebrates.

24. Golden shiner, *Notemigonus crysoleucas* (Mitchell) (Map 25)

This minnow is widely distributed throughout the navigation system, but it is not abundant at any locality. The golden shiner is the most commonly sold bait species in Arkansas accounting for it widespread occurrence. It prefers quiet, clear backwaters and lakes having abundant vegetation, but it is somewhat tolerant of turbidity.

25. Pallid shiner, *Notropis amnis* Hubbs and Greene (Map 26)

One specimen was collected from a dredge materials disposal area near the mouth of Little Bayou Meto, and was probably a straggler from that tributary. This shiner inhabits the backwaters of medium to large streams and is intolerant of turbidity. Its normal habitat in the coastal plain lowlands has been greatly reduced, and the only recent records of this rare species in Arkansas are from a few scattered localities in the Quachita River system (Buchanan, 1974).

26. Emerald shiner, *Notropis atherinoides* Rafinesque (Map 27)

This is the second most abundant shiner throughout the Arkansas River Navigation System. It is typically a fish of large lowland rivers, where it is found over a variety of bottom types in current as well as backwater areas. Smith et al. (1971) reported this species to be the most abundant fish in the upper Mississippi River.

27. River shiner, *Notropis blennius* (Girard) (Map 28)

Widely distributed throughout the navigation system, but only occasionally taken in large numbers at any locality, this species is a big-river fish, preferring the main channels with a sandy bottom and moderate current. It is tolerant of turbidity.

28. Bigeye shiner, *Notropis boops* Gilbert (Map 29)

This is a fish typical of the clear upland streams with high gradients where it inhabits silt-free pools, usually with dense growths of algae. The 14 specimens collected above and below Lock and Dam 13 undoubtedly represent stragglers from nearby clear tributary creeks, since suitable habitat for this species does not exist in the Arkansas River.

29. Ghost shiner, *Notropis buchanani* Meek (Map 30)

This shiner is uncommon in the Arkansas River, although it is typically an inhabitant of large creeks and rivers over most of its range. Cross (1967) stated that the ghost shiner inhabits streams in Kansas that are frequently turbid; however, in Missouri it is found in moderately clear backwaters (Pflieger, 1971), and mainly in clear waters in Ohio (Trautman, 1957). It has been collected from both the upper and lower sections of the Arkansas River in Arkansas, where it is usually found near the mouths of tributary streams in slow current over a sandy bottom.

30. Ironcolor shiner, *Notropis chalybaeus* (Cope) (Map 30)

A rare species in Arkansas, this unusual record of three

specimens from a dredge materials disposal area in the Arkansas River near the mouth of Little Bayou Meto probably represents stragglers from that tributary. It is strictly a lowland fish and is usually found only in clear water with little current and abundant vegetation.

31. Striped shiner, *Notropis chrysocephalus* (Rafinesque) (Map 32)

This shiner is another species that is probably an accidental in the Arkansas River. It is typically found in clear upland streams over a gravelbottom, and only rarely in the lowlands. The three specimens collected were from a dredge material disposal area near the mouth of Little Bayou Meto.

32. Pugnose minnow, *Notropis emiliae* (Hay) (Map 33)

This primarily is a lowland species which was commonly collected in the lower portion of the navigation system, gradually becoming less common upstream, and only rarely collected above Little Rock. It typically inhabits clear oxbow lakes and stream backwaters and is not abundant at any locality in the Arkansas River.

33. Ribbon Shiner, *Notropis fumeus* Evermann (Map 34)

An inhabitant of clear lowland streams, this shiner infrequently enters the Arkansas River from a few of its lowland tributaries. It probably occurs more frequently in the lower White River. The 11 specimens were caught near the mouth of Little Bayou Meto.

34. Red shiner, *Notropis lutrensis* (Baird and Girard) (Map 35)

This species is by far the most abundant minnow throughout the Arkansas River portion of the navigation system. The red shiner is one of the most tolerant of high turbidity and siltation and is found in large numbers in dredge materials disposal area backwaters, as well as in slow to swift current over sandy bottoms. In Arkansas it is found mainly in the Arkansas River, and seems to be replaced in the larger, clearer lowland tributaries by the blacktail shiner. Pflieger (1971) stated that the red shiner is the most abundant and widely distributed minnow in the prairie region of the United States. In Kansas and Oklahoma it is least common in the largest rivers, but thrives in small, turbid, intermittent creeks, a reversal of the Arkansas distributional pattern (Cross, 1967; and Miller and Robison, 1973). Black (1940) described the red shiner as common in the Arkansas River tributaries in western Arkansas, only straggling into the main parts of the big, silty river. However, Black did not have adequate samples from the main Arkansas River to accurately determine its abundance there. This shiner is probably an important food item for several species of fishes. Its spawning habits in the Arkansas River have not been determined.

35. Plains shiner, *Notropis percobromus* (Cope) (Map 36)

The writer follows Moore (1968), Eddy (1969), and Hubbs (1972) is recognizing *Notropis percobromus* as a separate species. Other

investigators (Bailey and Allum, 1962; and Miller and Robison, 1973) place this species in synonymy with the emerald shiner, *Notropis antherinoides*. Both forms are frequently taken in the same seine haul in Arkansas River near Fort Smith, and very few intergrades occur, although differences have not been quantified for these populations. The plains shiner is a big-river fish and is common only in the upper portion of the navigation system above Dardanelle Lock and Dam. It is seemingly restricted to that section of the river in Arkansas.

36. Duskystripe shiner, *Notropis pilsbryi* Fowler (Map 37)

Accidental in the Arkansas River, this species inhabits clear, high-gradient, gravel-bottomed streams of the Ozark Mountains. The two specimens collected from two different localities below Lock and Dam 13 were probably stragglers from clear tributary creeks. This species is intolerant of turbidity.

37. Silverband shiner, *Notropis shumardi* (Girard) (Map 38)

This shiner is extremely rare in the Arkansas River, despite the fact that it is restricted in distribution throughout its range entirely to large rivers. This shiner was first reported from the Arkansas River near Fort Smith by Jordan and Gilbert (1886). Black (1940) also collected this species from three localities on the upper Arkansas River, and assumed that it occurred throughout the course of the river in Arkansas. Black's assumption was based largely on the occurrence of the silverband shiner throughout the

Missouri, lower Mississippi, and lower Red Rivers. This species inhabits the open channels in strong current over a sand or gravel bottom, probably accounting at least partially for its infrequent occurrence in seine collections in the navigation system. Three specimens were collected along a dredge disposal area below Lock and Dam 13. Little is known about the biology of this species or its former abundance in the Arkansas River.

38. Weed shiner, *Notropis texanus* (Girard) (Map 39)

Although it is common in the lower White River, the weed shiner was not collected from any other portion of the navigation system. This strictly lowland species is most abundant in clear streams and bayous with mud and ditritus bottoms, occasionally wandering into the large, silty river. Any specimens from the lower Arkansas River would probably be stragglers from tributaries.

39. Blacktail shiner, *Notropis venustus* (Girard) (Map 40)

An abundant species of moderate sized lowland streams and rivers, the balcktail shiner is common in the lower White River, and less common in the lower Arkansas River, gradually decreasing in numbers upstream. It is taken only rarely above Little Rock. This shiner prefers clear water and moderate current and is nowhere abundant in the navigation system, the largest collection containing 28 specimens. The blacktail shiner hybridizes with the red shiner, and occasional hybrids were collected throughout the lower half of the navigation system.

40. Mimic shiner, *Notropis volucellus* (Cope) (Map 41)

The most abundant species of minnow in the lower White River, the mimic shiner was very rare in all other portions of the navigation system. Two specimens were taken near Fort Smith, so it probably can be found very rarely at other localities along the river, although it should be most common in lowland areas. It is apparently more common in Arkansas in smaller rivers, and seems to be replaced in the larger rivers by the ghost shiner, *Notropis buchanani*. The taxonomy of the mimic shiner has not been satisfactorily worked out and at least two ecologically distinct forms occur in Arkansas, one of them highly tolerant of turbidity.

41. Steelcolor shiner, *Notropis whipplei* (Girard) (Map 42)

Primarily an inhabitant of clear, gravel-bottomed mountain streams in the Ozark and Ouachita uplands, the two specimens collected below Lock and Dam 13 represent stragglers of this turbidity intolerant species.

42. Bluntnose minnow, *Pimephales notatus* (Rafinesque) (Map 43)

This species was collected only from two widely separated localities in the upper and lower portions of the Arkansas River. Even though this species is most abundant in clear streams of moderate gradient, it is fairly tolerant of turbidity and is found in a variety of habitats in the state. It occurs throughout the Mississippi River, but is common only in its headwaters (Smith et al., 1971). The bluntnose minnow is probably somewhat more common

in the Arkansas River than the present data indicate.

43. Bullhead minnow, *Pimephales vigilax* (Baird and Girard) (Map 44)

This species is widely distributed and fairly common throughout the navigation system. It is primarily a lowland species where it inhabits backwaters of moderate to large rivers, but is frequently found in moderate current in the Arkansas River. The bullhead minnow is also found in lakes, and it is very tolerant of turbidity.

Family Catostomidae-Suckers

44. River carpsucker, *Carpiodes carpio* (Rafinesque) (Map 45)

Very abundant throughout the Arkansas River Navigation System, this species is extremely tolerant of turbidity. No other sucker in the river even approaches this species in abundance. In Arkansas it occurs mainly in the moderate and large rivers, and is less commonly found in smaller streams. In the Arkansas River it was most numerous in sandy-bottomed backwaters, but it was also commonly captured in currents of various velocities. It is a bottom feeder mainly eating microscopic plants and animals. River carpsuckers weighing 1-4 pounds are common in the catches of commercial fishermen. Larger specimens are less frequently taken.

45. Quillback, *Carpiodes cyprinus* (Lesueur) (Map 46)

This rather turbidity-intolerant sucker was previously known in Arkansas only from the White River. It is not common anywhere

in the Arkansas River System, but most specimens taken in the present study were found in the lower portions of the system. One large specimen was collected in the upper portion of the river below Lock and Dam 13, and commercial fisherman reported that this species is also rarely taken at other localities. Miller and Robison (1973) did not list this species as occurring in Oklahoma, although Cross (1967) reported it from the Arkansas River in Kansas. It is not common enough to be of commercial significance in the navigation system.

46. Highfin carpsucker, *Carpiodes velifer* (Rafinesque) (Map 47)

Like the previous species, the highfin carpsucker is intolerant of turbidity. It was collected only in the lower White River, and is extremely rare, if it occurs at all, in the Arkansas River. Miller and Robison (1973) listed this species as occurring sporadically in the clearer tributaries of the Arkansas River in Oklahoma, but there is no evidence of the existence of this species in the upper Arkansas River or its tributaries in Arkansas. It is found commonly in Arkansas only in the upper and middle portions of the White River in backwater areas.

47. Blue sucker, *Cycleptus elongatus* (Lesueur) (Map 48)

The blue sucker is a very difficult species to capture because of its habitat preference, and, as a result, little is known about the biology of this species. It is found in the deepest, swiftest currents of large rivers, and is moderately tolerant of turbidity

(Cross, 1967). The blue sucker is widely distributed in the Arkansas River Navigation System, and commercial fishermen reported that it is frequently caught in the spring (sometimes as many as 100 specimens a day), presumably during spawning migrations. It is reported to be one of the finest food fishes, although it is not abundant enough to be commercially important. The blue sucker has declined in abundance over much of its former range in the United States (Trautman, 1957; and Cross, 1967), and the Arkansas River population is probably one of the largest and most stable in the entire range of the species.

48. Lake chubsucker, *Erimyzon sucitta* (Lacepede) (Map 49)

Collected only from the lower White River and Merrisach Lake, this uncommon sucker typically inhabits vegetated backwater areas in the coastal plain lowlands. It is not abundant anywhere in Arkansas, and is believed to have declined in numbers in the state due to habitat destruction. It would be rarely, if ever, found in the lower Arkansas River, because of it intolerance to turbidity and sandy habitat.

49. Northern hogsucker, *Hypentelium nigricans* (Lesueur) (Map 50)

Typically an inhabitant of clear mountain streams with gravel bottoms, this species is accidental in the lower White River, and would not be expected to occur in the Arkansas River. It is very intolerant of turbidity.

50. Smallmouth buffalo, *Ictiobus bubalus* (Rafinesque) (Map 51)

This species is the most common buffalofish in the Arkansas River, although it is reportedly less tolerant of turbidity than the bigmouth buffalo and of current than the black buffalo (Cross, 1967). This commercially valuable species is found both in backwaters and in moderate current, where it feeds on benthic organisms. It occurs in considerable numbers all along the Arkansas River Navigation System. Its numbers have probably been somewhat reduced by competition with the introduced and less desirable carp. The smallmouth buffalo does not get as large as the other two species of buffalo, but it comprises the largest percentage by weight of the three in the catches of commercial fishermen.

51. Bigmouth buffalo, *Ictiobus cyprinellus* (Valenciennes) (Map 52)

The bigmouth buffalo is widely distributed and moderately common throughout the navigation system, but does not approach the smallmouth buffalo in numbers, even in Dardanelle Reservoir. This turbidity-tolerant species inhabits quiet backwaters where it is primarily a plankton feeder (mainly zooplankton); it also feeds on the benthic organisms to a small extent. This species is commonly caught by commercial fishermen, but is of lesser commercial importance than the smallmouth buffalo, partly because it is not as desirable a food fish as that species (even though it attains a larger size). Twenty pound specimens are not uncommon.

52. Black buffalo, *Ictiobus niger* (Rafinesque) (Map 53)

An uncommon species in the navigation system, black buffalo are occasionally taken by commercial fishermen along most of the system. This large species prefers a stronger current than the other buffalofishes and, consequently, may be a little more common in the deeper, swifter currents of the Arkansas River than the present data indicate. It feeds largely on benthic organisms, as does the smallmouth buffalo. Because it is only rarely captured, the black buffalo is of minor commercial significance.

53. Spotted sucker, *Minytrema melanops* (Rafinesque) (Map 54)

This species occurs all over the state in various habitats, but is most common in the lowland portions of moderate-sized rivers. It is rather intolerant of turbidity and is probably of accidental occurrence in the Arkansas River at the widely scattered collection localities. It is not common at any locality in the navigation system, and is of no commercial or sport significance.

54. Golden redhorse, *Moxostoma erythrurum* (Rafinesque) (Map 55)

This species is the most abundant in Arkansas in small, clear gravel and bedrock-bottomed streams of the Ozark and Ouachita Mountains. It is fairly tolerant of turbidity and siltation and is occasionally found in the upper portion of the navigation system near the mouths of tributaries draining soils of limestone origin (Cross, 1967). The golden redhorse was not found in the lowland portion of the Arkansas River proper, but one large specimen (13

inches long, weighing 2.0 pounds) was taken from the lower White River. This species is an excellent food fish and individuals weighing two pounds are occasionally taken in Dardanelle Reservoir.

55. Shorthead redhorse, *Moxostoma macrolepidotum* (Lesuer) (Map 56)

Formerly known in Arkansas only from the White and Illinois Rivers in clear water over gravel bottoms in moderate current, this species was collected from both the upper and lower portions of the Arkansas River. Commercial fishermen reported that redhorse suckers, probably this species of the golden redhorse, are caught occasionally in the spring in all parts of the Arkansas River during spawning migrations. It is an excellent food fish, but is too rare in the Arkansas River to be commercially important.

Family Anguillidae-Freshwater Eels

56. American eel, *Anguilla rostrata* (Lesueur) (Map 57)

This species is found occasionally throughout the navigation system, but is very common in the lower White River and the Arkansas Post Canal, where many individuals came to the surface along the banks lined with riprap in response to a current from the electric shocker. The juvenile eels migrate upstream in the large rivers where they reach maturity over a period of years. The adults then travel downstream to the Atlantic Ocean where they spawn south of Bermuda. The adults die after spawning and the young subsequently migrate toward the North American Coast, where they ascend

the large rivers sometimes going hundreds of miles upstream into small tributary creeks. Eels feed on other fishes and are occasionally caught by fishermen (Cross, 1967 and Trautman, 1957).

Family Ictaluridae-Freshwater Catfishes

57. Blue catfish, *Ictolurus furcatus* (Lesueur) (Map 58)

A common catfish throughout the navigation system, this species is of some commercial significance, although it is not abundant in the catches of commercial fishermen. It usually occurs in swift current only occasionally entering sluggish backwaters. The state record for this species, a 47-pound fish, was caught in the Arkansas River at Dardanelle in 1970; commercial fishermen reported that they sometimes catch larger individuals. The blue catfish is a good food fish, and is occasionally taken by anglers.

58. Black bullhead, *Ictalurus melas* (Rafinesque) (Map 59)

This species is rare in the Arkansas River (only two specimens collected). This species prefers quiet backwaters with soft bottoms and high turbidity. It is uncommon in large streams with sandy bottoms and current. Stragglers probably enter the Arkansas River from tributaries.

59. Yellow bullhead, *Ictalurus natalis* (Lesueur) (Map 60)

An uncommon, but widely distributed fish in the navigation system; it was found more frequently than the black bullhead. The yellow bullhead is mainly a fish of small to moderate-sized streams,

but is tolerant of different habitat types, and is probably the most common bullhead in Arkansas. This species is a good food fish, like all catfish, but is not common enough in the Arkansas River to be of commercial or sport value.

60. Channel catfish, *Ictalurus punctatus* (Rafinesque) (Map 61)

The channel catfish is the most abundant catfish throughout the navigation system, and one of the most abundant commercially important species. Extremely tolerant of turbidity, this fish is found commonly in backwater areas, but frequently moves into moderate current at night to feed on fishes, invertebrates, and dead organic matter. It is frequently taken by anglers. Like the blue catfish, it spawns in dark cavity-like nests in stream banks, under ledges, under man-made objects, or in debris. The channel catfish is an excellent food fish and attains a large size. Specimens in the Arkansas River weighing 10-15 pounds are common; larger ones are caught only rarely.

61. Tadpole madtom, *Noturus gyrinus* (Mitchill) (Map 62)

This species is widely distributed in the navigation system, but not common. This small catfish (maximum size 3-4 inches) is most common in the backwaters of lowland streams having abundant vegetation, but is occasionally found in clear, gravel-bottomed creeks along the upland margins. The Arkansas River contains little suitable habitat for this species, accounting for the small numbers found.

62. Brindled madtom, *Noturus miurus* Jordan (Map 63)

Accidental to the Arkansas River, this small species is intolerant of turbidity. It typically inhabits clear streams in the uplands of Arkansas, only occasionally being found in lowland drainages. Three specimens were taken from a dredged material disposal area backwater, downstream from Lock and Dam 13. The occasional wanderers into the Arkansas River are probably restricted to the upperportion of the system.

63. Freckled madtom, *Noturus nocturnus* Jordan and Gilbert (Map 64)

The freckled madtom is another accidental catfish in the navigation system. Three specimens were collected from navigation mile 0 at the mouth of the White River. Miller and Robison (1973) believe that this species is a competitor of the tadpole madtom, which probably excludes it from the main Arkansas River. Little is known of its biology.

64. Flathead catfish, *Pylodictis olivaris* (Rafinesque) (Map 65)

Common in all parts of the navigation system, the flathead catfish is an important commercial and sport species. It is very tolerant of turbidity and is second in abundance among the catfishes only to the channel catfish with which it is frequently collected. A 1:5:6 flathead to channel catfish ratio was found in the present study. Schoumacher (1968) reported a 1:49.0 flathead to channel catfish ratio for the Mississippi River bordering Iowa. This species inhabits deep pools adjacent to strong current and is

found in moderate to swift water more frequently than the channel catfish. Commercial fishermen capture large numbers of this and other species of catfishes during high spring waters. In June 1974, one commercial fisherman was found to take more than 1,000 pounds of catfish from his hoop nets in a single day from the river below Dardanelle Lock and Dam (personal communication, Larry Rider, Arkansas Game & Fish Commission biologist). Sudden large rises in water level result in large commercial catches of catfishes at all times of the year. More large specimens of flathead catfish are caught than of any other catfish. Fifty to one-hundred pound specimens are reported to have been taken from the Arkansas River. The flathead catfish feeds mainly on fishes and is potentially a good game fish, although it is most active at night when few fishermen are on the river.

Family Cyprinodontidae-Killifishes

65. Golden topminnow, *Fundulus chrysotus* (Gunther) (Map 66)

A rarely collected species of the coastal plain lowlands, this beautifully-colored fish inhabits clear oxbow lakes and bayou pools adjacent to large lowland rivers. Specimens were taken from Merrisach Lake and an Arkansas River backwater area which was heavily vegetated (an unusual habitat type in the Arkansas River). It is considered accidental to the lower portion of the navigation system due to a definite lack of suitable habitat.

66. Blackstripe topminnow, *Fundulus notatus* (Rafinesque) (Map 67)

This species is collected only from the lower White River. It possibly occurs rarely in other lowland parts of the navigation system, but it is fairly intolerant of turbidity.

67. Starhead topminnow, *Fundulus notti* (Agassiz) (Map 68)

Mainly a lowland species with habitat requirements similar to those of the golden topminnow with which it is sometimes taken. However, it has also been found in streams along the edge of the Ouachita Mountains (Buchanan, 1973). It is somewhat more common in Arkansas than the golden topminnow. Four specimens were collected from the same lower Arkansas River backwater pool where *Fundulus chrysotus* was found. One specimen was collected from Merrisach Lake. The starhead topminnow is very rare in the navigation system.

68. Blackspotted topminnow, *Fundulus olivaceus* (Storer) (Map 69)

Widely distributed throughout the navigation system, but not common, this species occurs in both upland and lowland habitats all over Arkansas. In the Arkansas River it prefers backwater areas with a slight current, where it is a topwater feeder on zooplankton and insects.

Family Poeciliidae-Livebearers

69. Mosquitofish, *Gambusia affinis* (Baird and Girard) (Map 70)

The mosquitofish is similar to the previous species in distributional pattern, only more common in the navigation system.

The small mosquitofish is most common near the surface of the shallowest backwaters and pools where it feeds on insects, larvae, and zooplankton. It has been widely stocked in the United States for mosquito control. This is the only fish native to Arkansas that has internal fertilization and gives birth to its young, rather than laying eggs.

Family Aphredoderidae-Pirate Perches

70. Pirate perch, *Aphredoderus sayanus* (Gilliams) (Map 71)

The pirate perch is rare in the navigation system, occurring sporadically in its lower half where it probably enters from tributaries. This small fish (typically 2-4 inches) is most common in Arkansas in lowland streams, but can frequently be found in clear creeks along the southern and eastern edges of the Ozark and Ouachita Mountains.

Family Atherinidae-Silversides

71. Brook silverside, *Labidesthes sicculus* (Cope) (Map 72)

Brook silverside is common throughout the navigation system, but rarely abundant. Its numbers in the Arkansas River are surprising, because it is most commonly found in clear, quiet pools of Ozark and Ouachita Mountain headwater streams; several investigators have stated that it is intolerant of siltation and continuous high turbidity (Pflieger, 1971; and Miller and Robison, 1973). More than 41% of the collections contained this small species.

72. Mississippi silverside, *Menidia audens* Hay (Map 73)

Strictly a fish of the large, moderately turbid rivers and near-river lakes of the lower Mississippi Valley, this species is one of the most widespread and abundant fishes in the navigation system. It occurred in more than 54% of the collections (greater than 90% of the seine collections), where it outnumbered the related brook silverside by almost a 7 to 1 margin. In view of its present extreme abundance in the Arkansas River at Fort Smith, it is difficult to understand why Black (1940) and his predecessors failed to collect this species from the Arkansas River. Black did speculate that the Mississippi silverside might possibly occur in some of the lakes along the lower portions of the river. Miller and Robison (1973) more recently did not list the Mississippi silverside from the Oklahoma portion of the Arkansas River, and it is possible that this species has only recently extended its range as far west as Fort Smith, either through introductions or in response to the altered conditions of the river since the completion of the navigation channel. It is frequently taken in the same seine haul with the brook silverside, and is a valuable forage species for the sport fishes (Echelle and Mense, 1968).

Family Percichthyidae-Temperate Basses

73. White bass, *Morone chrysops* (Rafinesque) (Map 74)

The white bass is a common gamefish through the navigation

system. White bass travel in large schools where they feed mainly on gizzard and threadfin shad in the sandy-bottomed backwaters as well as in currents (Trautman, 1957). This species thrives in large impoundments and is numerous in tributary mouths where they spawn in open, shallow water without constructing nests in early spring. Many fishermen take advantage of these spawning concentrations in the Arkansas River, which usually begin in late February and reach a peak in late March. Specimens ranging in weight from one to four pounds are common.

74. Yellow bass, *Morone mississippiensis* Jordan and Eigemann (Map 75)

Found occasionally only in the lower portions of the navigation system, this species typically inhabits the oxbow lakes adjacent to large lowland rivers, and to a lesser extent, the backwaters of the large rivers themselves. It is probably found sporadically a little farther upstream in the Arkansas River than the present data indicate, but it is not common enough to be an important game species.

75. Striped bass, *Morone saxatilis* (Walbaum) (Map 76)

Introduced into the Arkansas River as a game fish by the Game & Fish Commission, this marine fish migrates up coastal tributaries to spawn. It is an open water species and can attain a weight of over 40 pounds in freshwater (Arkansas state record: 40.0 pounds). Fry and fingerlings were stocked mainly in the upper portion of the navigation system during the late 1960's, and no stocking has occurred

since 1970 (personal communication, Bill Keith, Arkansas Game & Fish Commission). A few of the navigation pools below Little Rock were also stocked with fingerlings during the 1960's. Commercial fishermen presently take large specimens from their gill nets occasionally in the spring, particularly below Dardanelle Lock and Dam. Fishermen also sometimes catch this species in the upper half of the river. The collections of 1974 produced fingerling striped bass throughout the Arkansas River in Arkansas, indicating that succesful spawning had occurred, although the species is not abundant. The young striped bass were almost always collected from sandy dredge spoil backwaters, some of which appparently provide excellent nurseries.

Family Centrarchidae-Sunfishes

76. Flier, *Centrarchus macropterus* (Lacepede) (Map 77)

Strictly a coastal plain lowland species, the flier is accidental in the lower Arkansas River. This small sunfish typically inhabits quiet, clear, heavily-vegetated backwaters, bayous, and swamps, and is rarely found in significant numbers at any locality in the state.

77. Green sunfish, *Lepomis cyanellus* Rafinesque (Map 78)

This species is widely distributed throughout the navigation system, but common only in Dardanelle Reservoir, where it was stocked in large numbers by the Game & Fish Commission. It is

tolerant of extreme turbidity and is most common in Arkansas in small streams and ponds where it is frequently caught by fishermen. The green sunfish is not an important game species in the Arkansas River, but like other smaller species of sunfishes, it may be valuable for eating the eggs of carp and other undesirable species. It has been stocked for that purpose, along with other centrarchids, by the Game & Fish Commission (personal communication, William E. Keith, Chief of Fisheries, Game & Fish Commission).

78. Warmouth, *Lepomis gulosus* (Cuvier) (Map 79)

The warmouth is widely distributed in the navigation system where it is common at some localities, but abundant at none. In Arkansas it is most common in lakes having abundant vegetation and either clear or slightly turbid water. It is not as turbidity-tolerant as some sunfishes, and avoids current. The warmouth mainly feeds on invertebrates and small fish (Larimore, 1957).

79. Orangespotted sunfish, *Lepomis humilis* (Girard) (Map 80)

This species is widely distributed, but not very common in the navigation system. This small sunfish is mainly an inhabitant of small streams and lakes in both the lowlands and the upland border of Arkansas, and is highly tolerant of turbidity. It is too small to be of value as a game fish. The orangespotted sunfish was not as abundant as would be expected in suitable habitat in the Arkansas River, possibly because of competition with the abundant bluegill and longear sunfishes.

80. Bluegill, *Lepomis macrochirus* Rafinesque (Map 81)

The most abundant sunfish in all parts of the Arkansas River Navigation System, this important game fish is widely stocked by the Game and Fish Commission. Bank fishermen along the Arkansas River were frequently observed to catch large numbers of eating-sized fish. It is most numerous in backwaters of the river and in the reservoirs.

81. Dollar sunfish, *Lepomis marfinatus* (Holbrook) (Map 82)

Collected only in Merrisach Lake off the Arkansas Post Canal, this rather rare, small, lowland species is typically an inhabitant of clear, heavily-vegetated swamps and bayous. It would be found rarely, if ever, in the main Arkansas River. The dollar sunfish reaches the northern inland limits of its range in the lowlands of Arkansas.

82. Longear sunfish, *Lepomis megalotis* (Rafinesque) (Map 83)

The third most abundant sunfish in the Arkansas River, this species was commonly collected throughout the navigation system. It is found all over Arkansas in a variety of habitats, but prefers backwater areas having clear water. The longear sunfish, even though commonly caught by anglers in the Arkansas River, is of little importance as a game fish because of its small size. Most adults taken from Dardanelle Reservoir were in the 3-5 inch size class. This sunfish feeds primarily on a variety of invertebrate animals and small fish.

83. Redear sunfish, *Lepomis microlophus* (Gunther) (Map 84)

This species has been collected at a few widely scattered localities, but is very uncommon in the navigation system. This species has been widely stocked in lakes and ponds all over Arkansas, because it attains the largest size of any member of the sunfish Genus *Lepomis* (state record: 2 pounds, 8 ounces). In balanced pond populations redears weighing a half-pound or more are common (Cross, 1967). The redear is primarily a southern species native to the oxbow lakes and streams of the coastal plain lowlands of Arkansas. It is rather intolerant of current and turbidity and is usually found in waters with at least a moderate amount of vegetation and cover such as stumps and logs. This valuable sunfish is not common enough in the Arkansas River to be of any significance to anglers.

84. Spotted sunfish, *Lepomis punctatus* (Valenciennes) (Map 85)

This species is primarily a lowland species, but penetrates into some of the mountain border streams of Arkansas, where it occurs in clear, vegetated pools. It was collected only in Merrisach Lake and from another backwater off the Arkansas Post Canal. This sunfish might rarely occur as an accidental in the lower portions of the main Arkansas River.

85. Bantam sunfish, *Lepomis symmetricus* Forbes (Map 86)

The bantam sunfish is mainly a southern lowland species restricted to oxbow lakes and bayous having clear water and abundant vegetation. This miniature sunfish is rarely reported from Arkansas,

but is probably somewhat more common than the present data indicate, because it is usually confused with the young of other species. It was collected only in Merrisach Lake and would rarely, if ever, be found in the main Arkansas River.

86. Spotted bass, *Micropterus punctulatus* (Rafinesque) (Map 87)

Widely distributed, but rather uncommon throughout the navigation system; this species was never found in abundance. This game fish is occasionally taken by anglers all along the Arkansas River, where it is generally found in backwaters having a moderate current. This species is most abundant in the larger mountain streams of the Ozark and Ouachita uplands, and is only somewhat tolerant of turbidity. Unlike the other black basses, the spotted bass feeds largely on crayfish and insects, and individuals larger than 2-3 pounds are rare (state record: 6 pounds, 9 ounces).

87. Largemouth bass, *Micropterus salmoides* (Lacepede) (Map 88)

This species is widely distributed and common throughout the navigation system in suitable habitat. This bass has been widely stocked in reservoirs, because it is a highly prized game fish that attains a large size (Commonly 3-6 pounds in the Arkansas River; state record: 12 pounds, 6 ounces). Many anglers fish only for this species which inhabits backwaters with moderate cover. The largemouth bass feeds mainly on other fishes and is only moderately tolerant of turbidity and siltation (Cross, 1967 and Trautman, 1957). It was common in dredged material disposal areas having plenty of

cover and at least some deep backwaters, and was absent from those lacking this combination of features. Certain dredged material deposit areas improvements could be made to provide better habitat for this important fish.

88. White crappie, *Pomoxis annularis* Rafinesque (Map 89)

Widely distributed and common in suitable habitat (Siefert, 1968) throughout the navigation system, this highly prized food fish was the second most abundant sunfish in the Arkansas River. Anglers frequently catch this species around fallen trees and logs in quiet water, where they feed on minnows and other small fishes. White crappie are very tolerant of turbidity (Trautman, 1957) and do quite well in the Arkansas River as long as sufficient cover and spawning sites are available.

89. Black crappie, *Pomoxis nigromaculatus* (Lesueur) (Map 90)

This species is as widely distributed in the Arkansas River as the white crappie, but is not nearly as abundant as that species. The black crappie is apparently not as tolerant of turbidity as the white crappie, and also requires more cover in the form of submerged timber or aquatic vegetation (Pflieger, 1971). Adequate cover for this species is frequently absent along significant stretches of the Arkansas River. Food habits and nesting sites are similar for both crappies, and both are equally desirable food species. The black crappie is common enough in the Arkansas River to be of some importance to anglers.

Family Elassomatidae-Pygmy Sunfishes

90. Banded pygmy sunfish, *Elassoma zonatum* Jordan (Map 91)

This is primarily a lowland species, where it occurs most commonly in swamps and the backwaters of bayous. This tiny fish (less than one inch long) was found in a backwater off the lower White River (only one specimen collected), and would rarely, if ever, occur in the main Arkansas River. It feeds on zooplankton and small insects and requires clear water with dense growths of aquatic vegetation.

Family Percidae Perches

91. Mud darter, *Etheostoma asprigene* (Forbes) (Map 92)

Three specimens were collected from a backwater off the lower White River. This small fish is an inhabitant of coastal plain lowland streams in Arkansas, and an occasional straggler from a tributary could probably be found in the main Arkansas River.

92. Greenside darter, *Etheostoma blennioides* Rafinesque (Map 93)

Found in the swift riffles of clear, high-gradient streams of the Ozark and Quachita Mountains, this species is only accidental in the upper portion of the Arkansas River. Four specimens were collected from a dredged material disposal areas backwater and had probably come from a nearby tributary creek.

93. Bluntnose darter, *Etheostoma chlorosomum* (Hay) (Map 94)

Abundant in the lower White River and occurring only sporad-

ically throughout the Arkansas River, this small fish is most common in lowland lakes and streams. It is frequently found in clear upland border streams in the state, where it tends to avoid current. It is not tolerant of turbidity and probably enters the Arkansas River from tributaries.

94. Fantail darter, *Etheostoma flabellare* Rafinesque (Map 95)

An inhabitant of the riffles of clear mountain streams, this fish is accidental to the Arkansas River. One specimen was taken in the upper portion of the navigation system.

95. Swamp darter, *Etheostoma fusiforme* (Girard) (Map 96)

One specimen of this rare Arkansas species was collected from Merrisach Lake off the Arkansas Post Canal. It is normally found in clear, vegetated oxbow lakes and bayous of the coastal plain lowlands, and would be accidental to the Arkansas River proper.

96. Cypress darter, *Etheostoma proeliare* (Hay) (Map 97)

Three specimens were collected in the upper Arkansas River at navigation mile 280, near the mouth of Clear Creek. This primarily lowland species might rarely wander into the river from tributaries at other localities, most likely in the lower portion of the system. It prefers clear water having vegetation and little or no current.

97. Redfin darter, *Etheostoma whipplei* (Girard) (Map 98)

Accidental in the Arkansas River, this species is typically an inhabitant of clear, small to medium-sized streams over gravel-bottomed riffles. Three specimens were collected near creek mouths

in the upper portion of the Arkansas River.

98. Banded darter, *Etheostoma zonale* (Cope) (Map 99)

This darter is another straggler into the upper Arkansas River from clear tributary streams. One specimen was collected from a dredged material deposit backwater below Lock and Dam 13. As with most darters, no suitable permanent habitat exists for this species in the Arkansas River.

99. Logperch, *Percina caprodes* (Rafinesque) (Map 100)

Occasionally taken in the lower White River, and collected more infrequently at widely scattered localities throughout the Arkansas River, this darter is most common in clear streams of moderate size. Small populations probably exist in favorable habitat along the Arkansas River Navigation System, particularly in some areas of Dardanelle Reservoir.

100. Blackside darter, *Percina maculata* (Girard) (Map 101)

Two specimens were collected from the upper portion of the navigation system. This darter inhabits clear streams of moderate size and is accidental in the Arkansas River. It might rarely be found at other downstream localities.

101. Longnose darter, *Percina nasuta* (Bailey) (Map 102)

One specimen was collected from a dredged materials deposit downstream from Lock and Dam 13. It probably came from one of the know populations in nearby tributaries (Lee Creek or the Mulberry River), and is accidental to the Arkansas River. This fish prefers

moderate to large, clear streams.

102. Dusky darter, *Percina sciera* (Swain) (Map 103)

Collected from near both ends of the navigation system in Arkansas, this darter probably occurs sporadically throughout the Arkansas River as an accidental species, particularly in the lowlands.

103. River darter, *Percina shumardi* (Girard) (Map 104)

By far the most common darter in the Arkansas River proper, this species is probably the only darter adapted for maintaining permanent stable populations in the navigation system. The present data are probably not truly indicative of its actual abundance in the river, because it tended to occupy the swift currents that were too deep for conventional collecting gear (seines) in the daytime; it moved into shallow water of moderate current over sandbars at dusk to feed, and was then more easily captured. It was found at scattered localities throughout the Arkansas River.

104. Sauger, *Stizostedion canadense* (Smith) (Map 105)

Widely distributed and not uncommon throughout the navigation system, this species seems to have increased in abundance since the construction of the locks and dams. It is frequently taken by those anglers who know where and how to fish for it, and it is a desirable sport fish. The sauger is an inhabitant of the largest rivers of the state, and is replaced in the more moderate-sized, clearer streams by its relative, the walleye, with which it is often confused.

The sauger is rather tolerant of turbidity and prefers a strong current, where it feeds on fishes. Because it occurs more commonly in strong current, it is probably more common in the Arkansas River than its representation in our collections indicates.

Family Sciaenidae-Drums

105. Freshwater drum, *Aplodinotus grunniens* (Rafinesque) (Map 106)

The third most commonly collected species in the navigation system, the drum was abundant at all localities. It comprises a large proportion (by weight and numbers) of the catches of commercial fishermen and is a good food fish, although many anglers discard it. Fifteen to twenty pound individuals are not uncommon. The drum feeds on all types of benthic invertebrates, but will utilize other food sources as well.

Family Mugilidae-Mullets

106. Striped mullet, *Mugil cephalus* Linnaeus (Map 107)

This is a widespread marine species that occasionally ascends large rivers. One specimen was collected in the lower White River below Norrell Lock and Dam by Andrew Hulsey (Director, Arkansas Game and Fish Commission) who observed a school of these fish. Fishermen also reported taking this species occasionally in that same area. It probably also ascends the lower Arkansas River, but it not common or important. This is the first documented record of the striped mullet from Arkansas (the writer examined the frozen

2 foot specimen at the Game and Fish Commission Building in Little Rock), but the species also ascends the Red River as far as Lake Texoma in Oklahoma (Miller and Robison, 1973).

IV. INTRODUCED AND ERRONEOUSLY REPORTED SPECIES

Several fishes which are native to Arkansas and the Arkansas River System have increased in abundance in the river due to intentional, widespread introductions (Table 3). The threadfin shad is a desirable forage species because it does not attain a large size. It is now the second most abundant fish in the river (Table 2). The golden shiner, while not abundant, has been widely distributed through bait releases. Green sunfish, bluegills, redear sunfish and largemouth bass are commonly stocked in reservoirs by the Arkansas Game and Fish Commission, a practice which has undoubtedly increased their numbers in the navigation system.

At least six species not native to Arkansas have been introduced into the Arkansas River (Table 3). The carp is an Asian species, introduced into the United States in 1877 to control aquatic vegetation. It has not controlled vegetation in our natural waters and has become a widespread nuisance, becoming established in Arkansas in the late 1800's. The carp has been abundant in the Arkansas River for at least four decades.

The goldfish is another Asian fish which was introduced into the United States, largely as an ornamental species. It was

brought into this country even before the carp (Trautman, 1957), but was not widely reported from natural bodies of water until the late 1800's when it became commonly used as a bait species. Black (1940) found no records of the goldfish in Arkansas, but it has now been reported from several scattered localities in the state (Buchanan, 1973). No known breeding populations have become established in Arkansas, and all collection records for goldfish probably represent bait and aquarium releases. This species, like the carp, was present in the Arkansas River prior to the construction of the navigation channel.

The rainbow trout, a native of western Rocky Mountain streams, was introduced into a few northern Arkansas streams prior to 1890 (Meek, 1891). More recently it has been successfully introduced into cold tailwaters below dams. No trout have been stocked in the Arkansas River, and the one specimen collected during the present investigation probably was a straggler from the Illinois River in Oklahoma.

The striped bass was stocked in the Arkansas River during the construction of the navigation channel (late 1960's) and has apparently maintained small breeding populations.

Two non-native fishes, the grass carp and the African cichlid fish, *Tilapia mariae* Boulenger, have both entered it from tributary lakes and streams. *Tilapia mariae* was recently stocked (1974) in Dardanelle Reservoir in the discharge embayment which receives

heated water from the turbine-cooling system of Arkansas Power and Light Company's nuclear power plant. This substrate-spawning cichlid fish is native to the lowland rivers and freshwater coastal lagoons of West Africa, where it attains a maximum size of about one to two pounds (Whitehead, 1962). The survival of this tropical species in other parts of Dardanelle Reservoir and the Arkansas River is very unlikely, because it is intolerant of cold winter temperatures. Its prolonged survival in the discharge embayment ot the nuclear power plant is also doubtful, because of winter fluctuations in the amount of heated effluent upon which this species depends.

Only one species of fish has been erroneously reported from the Arkansas River Navigation System, mainly because there has been almost no information published on the fishes of this river in Arkansas. The U.S. Army Corps of Engineers Operation and Maintenance Environmental Statement (1973) stated, "Largemouth, spotted, and white bass, crappie, sunfishes, walleye, sauger, and catfishes comprise the majority of game fishes thriving in the river systems." No specimens of walleye, *Stizostedion vitreum* (Mitchill), were collected from the navigation system during the present study, and no valid records of the occurrence of this species in the Arkansas River exist. The walleye is primarily an inhabitant of moderately large, clear rivers and reservoirs of the Ozark and Ouachita Mountains, and is replaced in the larger, more turbid rivers (such

as the Arkansas River) by its close relative, the sauger. Walleyes attain a larger size (state record: 19 pounds, 2 ounces) than saugers (state record: 3 pounds, 15 ounces), and the two species are frequently confused by fishermen, probably accounting for the erroneous reports of walleye in the navigation system. Certain Arkansas River tributaries, such as the Mulberry River and the Illinois Bayou, have good walleye populations, and it is possible that individuals occasionally wander into the Arkansas River from them.

The spotted bass, although widely distributed throughout the navigation system, is not common enough to be considered "thriving", and is not one of the more significant game species.

V. DISCUSSION AND CONCLUSIONS

Changes in the Fish Fauna Due to the Construction of the Arkansas River Navigation System

It is not possible to adequately assess any changes in fish populations that may have occurred due to the construction of the navigation system, because of the lack of information about Arkansas River fishes prior to the completion of this system. No survey of the fishes of the Arkansas portion of the river was ever conducted, and the only distributional information available is from a few seine collections near Fort Smith, and a few scattered, nonstandardized Game and Fish Commission rotenone samples in the 1960's,

also from the upper portion of the river. More importantly, no valid quantitative data exist on commercial or sport fish populations prior to the construction of the navigation system.

The first known scientific collection of fishes from the mainstream of the Arkansas River was made in 1856 at Fort Smith by Charles Girard, a naturalist with the Pacific Railroad Survey (Girard, 1856; 1858). Additional seine collections were made from the Arkansas River by Jordan and Gilbert in 1884 (Jordan and Gilbert, 1886), Meek during the early 1890's (Meek, 1894; 1896), and by John D. Black in the late 1930's (Black, 1940), all from near Fort Smith. Almost no information has been published on Arkansas River fishes in over 35 years.

Table 4 lists all known species of fishes collected from the Arkansas River proper both before (mainly prior to 1940) and after the construction of the navigation system. This table does not include species taken from the lower White River portion and from Merrisach Lake, which were not collected from the Arkansas River proper during the present study. A total of 94 species of fishes have been reported from the main Arkansas River. Forty-three species were reported before the construction of the navigation system, and 89 species were collected after its completion. This discrepancy in numbers reflects the lack of collections from all parts of the river before the navigation system was built. Thirty-eight of the 94 known species were collected both before and after its construction.

The present study produced 51 species not previously reported from the main Arkansas River; five species previously reported from the river have not been collected since the construction of the navigation system:

(1) Alligator gar, *Lepisosteus spatula* Lacepede

This species is in precipitous decline in Arkansas and elsewhere over its range, and is now very rare in the Arkansas River (Buchanan, 1974). Jordan and Gilbert (1886) reported the alligator gar from the Arkansas River at Fort Smith, and Black (1940) stated that it was abundant in the lakes and near-lakes of the lower White and Arkansas Rivers. The official Arkansas sport fishing record for alligator gar was caught in the Arkansas River at Dardanelle on 31 July 1964, and weighed 215 pounds. The decline of this species is due primarily to habitat alteration, and commercial fishermen attest to the drastic decline of this gar in the Arkansas River in recent years. Although no authenticated records of alligator gar are available from the navigation system since its construction, there are a few scattered reports of this species being taken by commercial fishermen. One large individual was reportedly taken in gill nets in the spring of 1974, below Dardanelle Lock and Dam.

(2) Plains minnow, *Hybognathus placitus* Girard

A fish of the large, turbid rivers of the Great Plains, where it is found in the main channels over a sandy bottom. Black (1940)

listed this species as common in the Arkansas River near Fort Smith, and Miller and Robison (1973) stated that it is one of Oklahoma's ubiquitous fishes. The plains minnow reaches the mid-eastern periphery of its range in Arkansas. The reasons for its apparent absence from the Arkansas River in recent years are not known.

(3) Speckled chub, *Hybopsis aestivalis* (Girard)

Jordan and Gilbert (1886) reported this species as abundant in the Arkansas River at Fort Smith, and Black (1940) collected it from the river near the mouth of Piney Creek in Logan County. The speckled chub inhabits the main channels of large, turbid rivers, where it occurs in shallow, flowing water over a clean sandy bottom. There is an abundance of apparently suitable habitats in the upper portion of the navigation system, and the current absence of the speckled chub is difficult to explain.

(4) Arkansas River shiner, *Notropis girardi* Hubbs and Ortenburger

The only known record of this species from Arkansas is that provided by Black (1940) who collected several specimens in the Arkansas River at the mouth of Piney Creek in Logan County, on 23 July 1939. This shiner is found most commonly in the main channels of the Arkansas River and its large, sandy tributaries in Kansas, Oklahoma, and Texas. It reaches the eastern periphery of its range in western Arkansas, where it has not recently been collected.

(5) Suckermouth minnow, *Phenacobius mirabilis* (Girard)

This species was originally described from the Arkansas River

at Fort Smith (type locality) by Girard (1856). Jordan and Gilbert (1886) reported that it was common in Lee Creek near its mouth, and Meek (1896) collected it in the Poteau River at Fort Smith. In 1940, Black stated that it was a very rare species in Arkansas, and it is doubtful whether the suckermouth minnow presently occurs anywhere in the state.

It is possible that further collecting in the Arkansas River would eventually produce individuals of one or more of the above five species, as well as other species not yet reported; however, sufficient samples have now been taken from all parts of the river to indicate that they would be very uncommon. All except the alligator gar reach the peripheries of their ranges in western Arkansas, and future recruitment of individuals of these species from more stable upstream populations in Oklahoma is always a possiblity.

Although comparative quantitative data are not available for commercial and game fish species, it is possible to speculate about the effects of the construction of the navigation system on these fishes. Game fish populations have apparently increased in most areas of the navigation system, especially in the larger navigation pools and reservoirs. This is largely due to the greater volume of water present, but other environmental modifications, such as decreased salinity must have also been important. Some commercial species have probably also benefited from the environmental changes by increasing in numbers and possibly average size of individuals.

However, the difficulty of catching the commercial species has increased, because the commercial fishermen are excluded from fishing in the navigation channel itself due to the amount of large traffic. Further generalizations are not warranted in view of the lack of data.

Ecogeographic Distributional Patterns

The Arkansas River has long been a major dispersal route for fishes, because it traverses the different physiographic regions from the eastern slopes of the Rocky Mountains, through the Great Plains, the Interior Highlands, and the Gulf Coastal Plain Lowlands to join the Mississippi River (itself a major dispersal route) (Buchanan, 1974; Cross, 1967; Pflieger, 1971). Elements of the fish fauna of these regions can be found in the Arkansas portion of the river either as accidental transients, or as permanent residents in suitable habitat. The known specific ecological requirements of each species of fish have been previously described in the annotated list. The present distributional patterns of the fishes of the Arkansas River Navigation System can be better understood by grouping the species into six categories based on their general habitat requirements and geographic affinities. There are a few problematic fishes that do not clearly fit the category into which they have been placed, either becasue (1) they tend to occupy different habitats in their ranges outside Arkansas, (2) they are primarily upland

species that were found in the lowland portion of the navigation system because they were accidental to the clearer lower White River, or occupied marginal habitat in that stream, or (3) are introduced species.

Fishes of the navigation system (including the lower White River and Arkansas Post Canal and its associated waters of Merrisach Lake) were grouped into the following ecogeographic categories:

(1) Big-river species (Table 5)

These fishes are either strictly or mainly inhabitants of the large rivers, where they are found in current. All are at least moderately tolerant of turbidity, and, with the exception of the silverband shiner, are common in the Arkansas River. Some, such as the river shiner and silverband shiner, are almost entirely restricted to large, silty streams, whereas most of the other fishes on this list can be found in clear water in the large tributaries (Cross, 1967; Pflieger, 1971; Trautman, 1957). The Mississippi silverside is the only one of these species that can also be found in large numbers in oxbow lakes adjacent to the large rivers.

(2) Common species of the navigation system which are widely distributed in different types of habitats in Arkansas (Table 6)

This is the largest ecogeographic category and the most difficult to adequately characterize. All species in this group are at least fairly common in the Arkansas River and apparently have stable, reproducing populations there. These species are also commonly

found in different habitats (such as large reservoirs, small headwater creeks, and lowland bayous) either in the upland-, or lowlands, or in both. Many fishes in this group are desirable game or forage species that have been widely stocked over the state. The shortnose gar, emerald shiner, and red shiner could easily be called big-river fishes, but they are found frequently enough in smaller tributaries to warrant inclusion here.

(3) Uncommon species apparently maintaining small populations in the navigation system (Table 7)

Only marginal or restricted areas of suitable habitat exist in the navigation system for most of the species on this list. Consequently, they are fairly uncommon in the navigation system, but do appear to maintain permanent, small populations, either through recruitment from larger populations in nearby tributaries, or through successful reproduction. Most of these fishes are primarily lowland species. The mimic shiner, quillback, and blackstriped topminnow are known to maintain populations only in the lower White River portion of the navigation system, and are probably only accidental to other portions.

(4) Upland species apparently accidental to the navigation system (Table 8)

This is one of the most clear-out categories, because these fishes are known to occur in habitats drastically different from any found in the Arkansas River. These species are inhabitants of

clear mountain streams and are apparently only accidental to the upper portion of the navigation system in Arkansas. They would not be expected to maintain even small population in the Arkansas River for extended or indefinite periods of time; however, the stoneroller and bigeye shiner commonly enter the river from its tributary creeks. Other upland species than those listed in Table 8 probably also wander into the main channel of the river on occasion.

(5) Lowland species apparently accidental to the navigation system (Table 9)

This is another large group which is difficult to characterize. All of these fishes were found primarily in the lowland portion of the navigation system, and all were probably accidental to the system. Most of these species are strictly inhabitants of the coastal plain streams, bayous, and oxbow lakes, and occasionally wander into the navigation system from them. A few, such as the pickerels, starhead topminnow, pirate perch, and spotted sunfish, have scattered populations in upland border streams as well. The flathead chub is primarily a fish of the silty rivers of the Great Plains, its range extending down the Mississippi River where a specimen was captured at navigation mile 0. The striped mullet is a marine species that occasionally migrates inland up the large rivers. The swamp darter, dollar sunfish, and bantam sunfish were collected only in the clear, heavily-vegetated waters of Merrisach Lake. All species in this category are very rare in the navigation

system.

(6) Species accidental to the navigation system from both upland and lowland tributaries (Table 10)

These are species which are known to occur in both upland and lowland tributaries of the navigation system, and might occur as accidentals at almost any locality in the main channel. The goldfish is widespread, butuncommon, because of bait releases, and the grass carp, another introduced species, has entered the river at several upland and lowland localities from tributary lakes in which it has been stocked.

The upper portion of the navigation system in Arkansas lies in a separate physiographic region, than the lowland portion of the system. The city of Little Rock is approximately on the dividing line between the upper Arkansas Valley Physiographic Region (which extends from Fort Smith to Little Rock) and the Gulf Coastal Plain Physiographic Region (extending from Little Rock to navigation mile 0 at the lower end of the system). The Arkansas River in the Arkansas Valley Physiographic Region drains an area of high relief composed largely of sandstones and shales of Mississippian and Pennsylvanian Ages; it is characterized by a narrow alluvial valley. At Little Rock, the river enters the Gulf Coastal Plain Region where it flows through a breed valley of low relief, underlain by deep alluvial deposits of sands, gravels, silts, and clays (Corps of Engineers Operation and Maintenance Environmental Statement,1973).

Using Little Rock as the dividing line, the species composition of the two physiographic regions of the navigation system were compared (Tables 11 and 12). Of the 106 species of fishes collected from the navigation system, 63 were found in both physiographic regions, 17 were found only in the Arkansas Valley Physiographic Region, and 26 were found only in the portion of the system flowing through the Gulf Coastal Plain Physiographic Region. These figures superficially seem to indicate distinct differences between the fish faunas of the two physiographic regions, but this is somewhat misleading. Most of the fishes found exclusively in the upper portion of the river were accidentals from tributary streams. Only the plains shiner and the silverband shiner could be considered normal big-river inhabitants, and the silverband shiner should occur (although rarely) in all parts of the system. Likewise, those fishes collected exclusively from the Gulf Coastal Plain portion of the system are almost entirely accidentals to the river, occurring in it only because of the proximity of the river to their optimum habitat. The yellow bass is the only species that could be called a typical inhabitant of the lowland portions of large rivers. There are some species that occur more abundantly in one physiographic region or the other. For example, the pugnose minnow and blacktail shiner are most abundant in the lowland portions of the navigation system, becoming gradually less common upstream into the Arkansas Valley Physiographic Region. Other species, such as the golden

redhorse and shorthead redhorse, show the reverse of this pattern. Therefore, it appears that the differences in physiographic regions have little impact on the distributional patterns of most species which maintain permanent stable populations in the navigation system, particularly those species of commercial or sport significance.

A comparison of the fishes found in the Arkansas River with those found in the Arkansas Post Canal and lower White River (Table 13) indicates some differences in species composition among these three different components of the navigation system. Of the 106 species collected, 31 species were taken exclusively from the Arkansas River, 11 only from the White River, and 4 only from Merrisach Lake which broadly opens into the upper end of the Arkansas Post Canal. The canal itself is basically a mixing zone between the fishes of the Arkansas and White Rivers, and no species were found only in the canal.

Comparing just the Arkansas and White Rivers, 35 species were found only in the Arkansas, and 13 only in the White. This difference is undoubtedly due to the more numerous samples taken from the Arkansas River, and to the fact that only the lower 9 miles of the White River are involved in the navigation system. Of the 35 species found in the Arkansas River, but not in the White River, only the plains shiner and silverband shiner have never been previously reported from any other part of the White River or one of

its tributaries in Arkansas. Of the 13 species collected from the White River, but not from the Arkansas River, the cypress minnow, flathead chub, weed shiner, blackstripe topminnow, mud darter, and the striped mullet have not previously been reported from the Arkansas River or its tributaries in Arkansas. Fifty-four species were taken from both the Arkansas and White Rivers, indicating the great similarities in the fish faunas of the lowland portions of these two rivers. A comparison of the fishes of the entire drainage basins of the Arkansas and White Rivers in Arkansas reveals that approximately 141 native and introduced species are known from the Arkansas River and its tributaries, and 163 native and introduced species are known from the smaller White River and its tributaries (out of 196 species known from the entire state). The White River has a richer, more diverse fauna than the Arkansas River, because of its large number of Interior Highland endemic species in its upper reaches. This reflects its greater isolation and its lack of significance as a fish dispersal route. Additional species would likely be found in the lower White River with more sampling, and its diversity would probably approach and even surpass that of the lower Arkansas River.

Seasonal and Diurnal Distributional Patterns

Most species of fishes in the navigation system exhibit at least some sort of seasonal variation in distributional patterns. The most commonly observed seasonal changes involve spawning migrations of various types. Very little information was obtained during the present study on these seasonal patterns in the Arkansas River, and all available information was presented above in the individual species accounts.

Some fishes, such as the chestnut lamprey, ascend the clear tributaries for considerable distances to spawn in the spring. Other species migrate only short distances up the tributaries, or just to the vicinity of the tributary mouths to spawn. Still others exhibit shorter migrations, going from the deeper waters to more shallow areas for nesting and/or spawning. Some fishes begin their spawning migrations in February or March (such as the white bass and sauger). Other fishes spawn at different times through the spring and summer. There is some evidence of fall breeding in a few species.

Many species show marked feeding migrations over a 24-hour period. Night seining and elctrofishing, particularly in the dredge spoil areas, resulted in the collection of large numbers of fishes that were rarely or never collected by these methods during daylight hours. Saugers, white bass, and various catfishes were some of the game species showing marked crepuscular or

nocturnal movements into the shallow waters along many of the dredge spoils. They moved in to feed on a variety of forage species which also were more abundant in the shallow waters after dark. These diurnal migrations were most pronounced during the summer months, and less well-developed during the winter, although further research is needed to more clearly define the extent and seasonal development of this phenomenon.

Threatened Arkansas Fishes Found in the Navigation System

Table 14 lists the species found in the navigation system which were included in the Arkansas Department of Planning's list of threatened Arkansas fishes (Buchanan, 1974). No species in the "Endangered" category (one in imminent danger of becoming extinct in Arkansas) was collected from the system. The paddlefish and shovelnose sturgeon are species in precipitous decline over most of their ranges and are in need of careful watching, as is the alligator gar which still occurs sporadically in the river, but was not collected during the present study. The sturgeon and paddlefish are still fairly common in the navigation system, but their populations should be monitored in the future. The flathead chub, pallid shiner, ironcolor shiner, and swamp darter are all peripheral species which reach the margins of their ranges in Arkansas. They are rare in the state, but are locally common in more favorable portions of their ranges outside Arkansas. The striped mullet is rare, because it is mainly a marine species and is only a straggler

in the state's fauna.

The rare, uncommon, and straggler species of the navigation system have potential value as "indicator organisms". Environmental changes that are actually or potentially harmful to the more common fishes of the navigation system will almost certainly affect these rarer species first. Future ichthyological surveys of the navigation system should be able to detect and possibly predict drastic changes in fish populations and in species diversity with the help of these indicator species.

Present Status of the Fishes of the Navigation System and Future Prospects

Of the 106 species collected during the present investigation, 46 (43%) probably represent stragglers that are accidental to the navigation system (Tables 8-10). These are mainly from the lowland tributaries and are not believed to maintain populations in the main channel itself. Their occasional presence in the system indicates the value of this large river as a dispersal route. The accidental species as well as the 20 fishes that apparently do maintain only small populations in the system (Table 7 plus the silverband shiner from Table 5) are useful as indicators of ecological conditions in the river. Forty species were common or abundant throughout most of the navigation system (Tables 5 and 6). Many of these species are of sport or commercial significance.

The total assemblage of fishes present in the system indicates that the system currently supports a rich, diverse fish fauna with good populations of most native forms. A few species known to occur in the Arkansas River many years prior to the construction of the navigation system were not collected during the present study, and alligator gar, appear to have declined somewhat in abundance. The decline or absence of these species cannot be definitely attributed to the construction of the system, because of a lack of pre-construction data.

Although the fish communities of the Arkansas System are presently in good condition, the potential for a rapid change in this status definitely exists. Future environmental changes could easily result from any one or a combination of the following:

(1) the predicted great increase in commercial shipping on the system will increase the danger of oil spills and navigation accidents which could release a variety of chemicals into the water.

(2) increase in industrial and municipal development along the river, resulting in an increase in various wastes discharged into the waters.

(3) activities in the tributaries of the system, such as draining marginal lakes, bayous, and swamps, channelization, and damming of streams, could have far-reaching effects in the main Arkansas and White Rivers.

(4) the effects of widespread dredging to maintain a proper

navigation channel. The effects of dredging and disposal of dredged materials on the fishes are considered in the next section.

The need for constant surveillance and monitoring of the fish populations of the Arkansas River Navigation System is evident, because of the potential for future environmental changes.

PART TWO: EFFECTS OF DREDGED MATERIAL DISPOSAL AREAS ON FISH POPULATIONS

I. OBJECTIVES

To determine the general and/or specific effects of dredging and dredged material disposal areas on fish populations in the Arkansas River Navigation System, and to make recommendations for improving dredged material deposit location, construction, and utilization.

II. METHODS

The effects of the dredge deposit areas on fishes were determined by comparing habitat quality and various population parameters of fishes in the dredged material disposal areas with those of non-dredged material deposit areas in all parts of the navigation system. Species composition, numbers, quality, diversity, and biomass were all used wherever possible to compare fish samples and/or populations. Fish samples were taken with the various types of gear and collecting techniques previously described in Part One. Most of the data were collected from June through August, 1974; no significant information on seasonal changes was obtained due to time limitations of the project and to unusually high water flows in the fall and winter of 1974 and 1975.

The data collected from this preliminary, reconnaissance study of the fishes of dredge disposal and non-dredge disposal areas were

mainly qualitative. Although some quantitative data were also gathered from various parts of the navigation system, lack of time and manpower prevented the extensive replication of samples necessary for the proper statistical analysis of those data. Quantitative evaluations of fishes were obtained by:

(1) Rotenone samples- Backwater areas of various sizes were blocked off with nets to prevent the movement of fishes either into or out of the sample area. Adequate amounts of rotenone were applied to kill all fishes in the sample area. The fishes were then collected as they came to the surface for up to two days depending upon the size and depth of the area treated with rotenone. All fishes collected were indentified, weighed, and measured. This sampling technique provided a good determination of the standing crop of fishes for a given area.

(2) Electrofishing- Paired quantitative fish samples were taken with the electric shocker at seven localities (Table 15). During these daylight samples, the shocker was first operated for one hour in a dredged material deposit area, and then upstream from that area for another hour in a non-dredged materials area of similar depth and current. All fishes stunned by the shocker in each area were gathered with long-handled dipnets (the same personnel and amount of effort were used in both areas). The collected fishes were subsequently identified, weighed, and measured, thus permitting various quantitative comparisons between the two samples.

(3) Gill netting- Paired samples with the 125-foot experimental gill nets were taken at six localities (Table 16). Six gill nets were set simultaneously, three in a dredged materials disposal area, and three upstream in a non-dredge deposit area. The nets were set just before dusk and were picked up the following morning. The fishes caught at each site were identified, weighed, and measured.

III. EVALUATION OF DREDGED MATERIAL DISPOSAL AREAS

Extent of Dredged Material Sites and Dredging Activities

According to the Corps of Engineers Operation and Maintenance Environmental Statement (1973) about 25 of the approximately 70 sites designated as possible dredged material areas throughout the navigation system are now being used for the deposition of dredged materials as will be used in the future. Most of the active dredged material disposal areas observed during the present investigation were approximately 1.0 to 1.5 miles long, and occupied portions of the backwaters and banks along one or both sides of the navigation channel. Very few disposal sites were less extensive than this, and some of them were much larger. The dredged material disposal areas below Lock and Dam 3 and below Toad Suck Ferry Lock and Dam were each 5 miles long, and the disposal areas below Terry Lock and Dam and Dardanelle Lock and Dam were 3 miles long.

For the present study, a dredged material disposal area was defined as any site where materials from maintenance dredging were

deposited and which was separated by a distance of at least two navigation miles, both upstream and downstream, from any other dredged material disposal sites. Using these criteria, it was determined that 27 active dredged material disposal area existed along the navigation system from navigation mile 0 to mile 308, during the summer of 1974. This was an average of one dredged material disposal area for every 11.4 navigation miles, or assuming that the average extent of a dredged material disposal area was 1.5 miles, there was one disposal area for each 7.6 miles of the navigation system. Of course, the dredge disposal sites were not evenly distirbuted throughout the system, but were most prevalent immediately downstream from the locks and dams where there was a greater tendency for sand to accumulate in the navigation channel. Therefore, any effects of dredging and dredged material disposal sites would also be less evenly distributed throughout the system.

Fish samples were taken with various types of gear from 17 of the 27 active dredged material disposal sites in all parts of the navigation system in Arkansas (Map 108). Of the 140 fish collections made since the completion of the navigation channel, 70 were taken from these 17 dredged material disposal sites, and 70 were from non-dredged material disposal area.

Basic Types of Dredged Material Disposal Areas

Disposal areas were highly variable in their construction, physical features, and suitability for fish populations. No two

disposal areas were alike with respect to all of these features, and it was not possible to make generalizations about the fish populations of dredged material disposal sites as compared with non-dredged material disposal areas. Just as in the non-dredged material disposal areas, some dredged material disposal supported diverse fish populations with many desirable gamefish, whereas other dredged material disposal sites exhibited very poor fish habitat and few desirable gamefish. All but one of the dredged material areas were at least partially defined and enclosed by bank stabilization and channel rectification and alignment structures. These structures were either rock revetments, dikes, or various series and combinations of revetments and dikes. Based on the physical characteristics of the kinds of defining structures involved and the method of depositing the dredged materials, five major types of dredged material disposal areas could be recognized along the navigation system (Figures 1-5). Each of the 27 active dredged material disposal sites can be arbitrarily placed into one of the following five categories (although the most extensive dredged material disposal areas were usually combinations of these five types, the large areas were classified according to dredged material type that was most extensively represented):

(1) Dredged Material Disposal Type I- (Figure 1) Seven of the active dredged material disposal areas were of this type. The type I dredged material disposal area was characterized by rock dikes extending

outward toward the navigation channel, perpendicular to the current flow. Most of the dredged materials were deposited in broad areas of this type, the water was very shallow in the compartments between the dikes. The current in the disposal areas was variable, depending on the lengths of the dikes, the proximity of the main channel, and the amount of spoiling activity. Very little deep backwater areas existed in disposal areas of this type.

(2) Dredged Material Disposal Type II- (Figure 2) Nine dredged material disposal areas were in this category. This was the most common type of disposal area and was similar to type I in having the same basic defining dike structures; however, the dredged materials were deposited mainly between the outer ends of the dikes, creating a backwater area between the dredged materials and the bank. The backwater areas thus created varied in extent and depth from one locality to another. In heavily-used areas the backwaters were sometimes completely cut off from the main river by the dredged material bank, but usually there was a passageway connecting the backwater with the main channel.

(3) Dredged Material Disposal Type III- (Figure 3) Two type III dredged material disposal areas were found. This type consisted of a long rock revetment that paralleled the current flow and river banks, with the upstream end closed to divert the current and the downstream end broadly open producing an extensive, deep backwater area. The dredged materials were usually deposited on the bank in a broad area, with very little material being placed in the water.

(4) Dredged Material Disposal Type IV- (Figure 4) Eight of these dredged material disposal areas were found. This type area was basically characterized by a combination of the features exhibited by the first three types. Various combinations of dikes and revetments enclosed the disposal areas. In most cases the enclosure was complete, but sometimes gaps in the revetments permitted the passage of water and fishes into and out of the disposal compartments. The dredged materials were placed on the bank and in the water in the compartments formed by the rock dikes and revetments. The degree of compartment filling depended upon the amount of dredging activity carried out in the nearby navigation channel. Type IV dredged material disposal areas were the most variable in physical features and in available fish habitat.

(5) Dredged Material Disposal Type V- (Figure 5) The only type V dredged material disposal was located at navigation mile 9 of the lower White River. The dredged materials were deposited on and along the bank, and the dredged material disposal area was not defined by dikes or revetments. Portions of other dredged material disposal sites were sometimes not clearly defined by these structures, but the lower White River site was the only one that was predominantly in the type V category.

Qualitative and Quantitative Comparisons

Fishes were collected from all types of dredged material and non-dredged material habitats present throughout the navigation

system. Certain qualitative and quantitative comparisons of the fishes of the dredged material and non-dredged material areas may be made. Table 17 shows that 87 species of fishes were collected from non-dredged material areas. Seventeen species were taken only from dredged material sites, 19 species only from non-dredged material habitats, and 70 species were found in both types of areas. Those fishes found only in one of the other type of environment were mostly accidentals to the navigation system and were collected in very small numbers. All species which were common throughout the navigation system, including the inportant game and commercial fishes, were well-represented in both dredged material and non-dredged material samples.

Seven paired fish samples collected with the electric shocker from adjacent dredged material and non-dredged material areas (Table 15) are compared with respect to pound of fishes taken in each area in Figures 6-10. Figure 6 shows that in 5 out of 7 pairs of fish samples, more total pounds of fish were collected from the non-dredged material habitat. Only at sample sites S2 and S6 (both involving type IV dredged material disposal areas) were more pounds of fish taken from the dredged material areas during the one hour shocking period. The highly productive non-dredged material samples at sites S3 and S4 were both taken near the mouths of tributary streams. In general, tributary mouths throughout the study reach provided by far the best fish habitat of any type area.

The fishes collected with the electric shocker in the paired samples may also be evaluated by grouping them into four categories based upon economic importance and/or their trophic level relationships:

(1) Game fishes- All species of sport fishing value including the black basses and other sunfishes, the temperate basses, the catfishes, and saugers.

(2) Commercial fishes- This group includes all edible species, other than the gamefish, which are legally caught and sold by commercial fishermen. It does not include the catfishes which comprise a large portion of the legal catches of commercial fishermen. The fishes which are included in this group are the carp, drum, some paddlefish and sturgeons, and all members of the sucker family, such as the buffalo fishes, carpsuckers, and red horses.

(3) Forage fishes- These are here defined as species (usually small) which partially or totally serve as food items for the predaceous species. This group consists mainly of shad and minnows.

(4) Gars (and bowfins)- These are predatory, non-game, non-commercial species that provide a useful function of helping to regulate the population densities of other species.

The advantages and limitations of the electric shocker as a daytime collecting device must be understood in order to correctly interpret the available data. In general, the shocker is a good sampling method for most game fish and commercial species which are

territorial and prefer backwater areas. These fishes usually floated to the surface near the anode after they were stunned by the current. Although catfishes were very susceptible to the electric current, they did not surface as readily after being stunned, but frequently rolled over on their backs and remained on the bottom, or they came to the surface after the shocking boat had left the general area. Game and commercial species that preferred deeper, swifter water more easily avoided the effects of the electric current. Forage species were quite susceptible to the shocker, particularly the shad, but because of their small size and their schooling tendencies, they were less frequently collected than many other fishes. Gars were the most resistant fishes to the electric current as reflected by the data in Figure 10. In spite of these limitations of the electric shocker, it was a very useful collecting method for comparing catch per unit effort in dredge spoil and non-dredge spoil areas.

A comparison of the pounds of game fish collected during the paired electric shocker samples (Figure 7) reveals basically the same trends noted in comparing the total pounds of fish from the dredge spoil and non-dredge spoil areas. However, most of the dredge spoil sites sampled had moderate game fish populations. Commercial species showed the same trend (Figure 8). The small amounts of forage fishes and gars (Figures 9 and 10) collected at all sites reflect the biases of the equipment rather than actual population

trends.

The data from the paired electrofishing samples may be examined in still another way. Most biologists believe that the diversity of species in an aquatic environment reflects the amount of habitat diversity and the stability of that environment-the greater the diversity of fishes, the more desirable are the ecological conditions. It is further believed that harmful environmental modifications of an aquatic habitat will be reflected by decreased species diversity in that habitat. One way of expressing fish diversity is to simply list the number of species found in an area. More complicated mathematical expressions of species diversity are available which take into account the number of individuals of each species present (Odum, 1971; and Poole, 1974). However, these diversity indices generally do not take into consideration the important trophic level relationships within fish communities. Table 18 presents the number of species and one type of species diversity index for each quantitative fish sample collected with the electric shocker in adjacent dredged material and non-dredged material areas. The species diversity index used was described by Odum (1971) as $d=\frac{S-1}{\log N}$, where S= the number of species, and N= the number of individuals. This index is also referred to as a measure of species richness or variety (Harima and Mundy, 1974). The species similarity of each of the seven adjacent pairs of dredged material and non-dredged material samples were compared using the species similarity

index of Odum (1971), $S=\frac{2C}{A\ B}$, where A=the number of species in sample A, and B=the number of species in sample B, and C=the number of species common to both samples. The closer this index is to 1.0, the greater the similarity between the two samples in species composition, numbers, and proportions.

The data in Table 18 indicate again that dredged material disposal areas cannot simply be lumped together into one category in comparison with all non-dredged material areas. There are dredged material sites that have good species divesity and some that show poor diversity, just as there are non-dredged material areas with good or poor diversity of fishes. It is pertinent that at site S4, where many more pounds of fishes were collected from the non-dredged material area, the dredged material area actually had a greater diversity of species.

In general, fewer pounds of fishes were taken from localities with low species diversity. Those localities having higher diversity indices also apparently had a greater biomass of gamefish. Paired sample areas that were more similar to each other in species composition and importance (as indicated by the species similarity index) tended to be those in which fewer species were collected. Apparently the fewer species at these localities were represented by ubiquitous, big-river fishes, with less common species occurring in areas of greater habitat diversity.

The weight data from the six pairs of gill net samples are

presented in Figures 11-15. These figures represent average catch in pounds per netting night, because multiple collections were obtained from some of the localities. A comparison of the pounds of fish caught in total and in the various categories in the adjacent dredged material and non-dredged material areas reveals a pattern opposite to that found in the paired samples taken with the electric shocker. At five of the six paired gill net sample localities, more pounds of fish were collected from the dredged material areas than from the corresponding non-dredged material areas (Figure 11). This same general pattern is seen when the data for the game fish only are examined, however, differences between the dredged material and non-dredged material sites are not as pronounced (Figure 12). Fewer clearcut differences between the paired samples are found in pounds of commercial fishes (Figure 13) and pounds of forage fishes (Figure 14). At three of the gill netting localities, the weight of the gars collected was much greater in the dredged material areas, while at the other three sites only slightly more pounds of gars were obtained from the dredged material areas.

Again, the advantages and limitations of the collecting gear and methods used must be considered when interpreting the data. The 125-foot gill nets consisted of five, 25-foot panels of graded mesh size (described more fully in Part One above), and were designed to sample a wide size-range of fishes of different species, unlike the gill nets of commercial fishermen which consist entirely of large

mesh netting to catch only the larger commercial species. The experimental gill nets were designed to fish the bottom six feet of water in the selected areas. The marked differences in pounds of fish caught in the dredged material and non-dredged material areas with the gill nets as compared to the electric shocker were due to the different times of day that these two types of collecting devices were used. The gill nets were always fished overnight, while all electric shocker quantitative collections were made during daylight hours when very little mass movement of fishes occurred. Night seining, electric shocking, and gill netting along various parts of the navigation system revealed that many species of fishes have mass shoreward migrations into extremely shallow water at dusk and after dark. This movement was detected in several forage species, but was particularly well-developed in predatory species including most of the game fish and gars. These mass nocturnal movements of fish popultions undoubtedly accounted for the greater numbers and pounds of fishes collected from the dredged material areas than from the non-dredged material areas with the gill nets, because all dredged material disposal sites sampled contained much more extensive shallow water habitat than the adjacent non-dredged material areas. The most varied and marked nocturnal fish migrations were directed toward those dredged material deposits having extensive shallow water areas very near the swift current of the main channel. Species that were rarely collected in the daytime, such as the sauger, were frequently

abundant after dark, particularly along Type I dredged material deposits. The differences in fish movement patterns in the dredged material and non-dredged material areas are further illustrated by the species similarity indices presented in Table 19. The index values were generally lower for the paired gill net samples than for the paired electric shocker samples (Table 18), indicating the decreased similarity in gill net catches in the dredged material and adjacent non-dredged material areas. Table 19 also shows the number of species and the calculated diversity index for each gill net sample site. These data reflect the fewer number of species collected with gill nets than with the electric shocker. However, the same general trends in diveristy indices appear to apply to samples collected by both methods: sites from which the most pounds of fishes were collected tended to also have higher species diversity indices.

It has previously been stated that the dredged material disposal areas throughout the navigation system varied greatly in the quality of fish habitat present, and that each disposal area had its own particular combination of physical and biological features. Further research would be required to more adequately quantify the seasonal and long-term changes in the fish populations of individual dredged material disposal sites. Similarly, the non-dredged material areas investigated also showed wide variation in amount of suitable fish habitat. The suitability of an area for game fish populations

is of prime concern to most persons interested in the fishes of the Arkansas River. It has previously been noted that the areas which supported the largest game fish populations also had a greater variety of other species, often including rare forms. The quality of the game fish habitat in the dredged material disposal areas, as well as in the non-dredged material areas, is related to many interacting environmental variables, however, two features were observed to be of the utmost importance for providing good game fish habitat: (1) the presence of deep backwater areas with little or no current, and (2) the presence of adequate cover.

These two characteristics insure a heterogeneous environment necessary for maintaining stable, permanent populations of black basses, crappies, catfishes, and other game species. Any activity that reduces the environmental heterogeneity of an area, such as the removal of dead trees, logs, stumps, and other objects, or the filling in of backwater areas with sand, invariably reduces the amount to suitable game fish habitat. In general, the more extensive the backwater area and the greater the amount of cover present, the larger the game fish populations will be.

Dredged material disposal Types I and V (Figures 1 and 5) contained no extensive backwater areas, and the only cover present usually was the underwater riprap forming the bases of the dikes. Consequently, these types of dredged material deposits had poor game fish populations. However, they were valuable as nocturnal

feeding areas for many game species. In some sections of the navigation system, such as immediately downstream from Toad Suck Ferry Lock and Dam, Type I dredged material disposal areas provided the only shallow water feeding sites available.

Type III dredged material deposits had good permanent game fish populations and were suitable spawning and nursery areas for most game species. Dredged material disposal Types II and IV were common along the navigation system and were highly variable with respect to game fish populations. Again, those spoil areas having extensive backwater and good cover, such as logs, brush, and trees, supported good bass and crappie populations; those areas lacking these attributes did not support significant populations of desirable fishes. Along certain narrow stretches of the river, dredged material disposal Types II and IV provided the only backwaters present. Shallow backwater areas along dredged material deposits that were not suitable for adult game fish were important as summer nurseries and feeding grounds for fingerling white, striped, largemouth, spotted bass and crappies and other game species. In fact, fingerling striped bass were collected only from shallow dredged material backwaters. While these areas did not provide suitable habitat for adult game fish, they were usually rich in the zooplankton organisms necessary for the survival and growth of the young fishes.

Chemical sampling of fishes with rotenone was conducted in

isolated pool and backwater areas throughout the navigation system. Most of the locations sampled were small in area and volume of water treated and consisted of less than 0.5 surface acres. Some of the sites were even isolated pools on the tops of dredged material banks. However, four localities in the upper portion of the navigation system were sampled more extensively with rotenone to obtain data on the standing crop of fishes in terms of numbers and biomass. Three of these localities were non-dredged material areas and the fourth was a dredged material disposal site. All four sites had extensive backwater areas and good cover, and all were sampled in the summers of 1973 and 1974 by biologists from the Arkansas Game and Fish Commission. The four localities sampled quantitatively with rotenone were:

(1) Pool 13 (Navigation Mile 304)- This site was a backwater area adjacent to the main channel at the mouth of Garrison Creek. It contained optimum fish habitat. The area sampled was blocked off with nets and consisted of 4.0 surface acres with an average depth of 15 feet and a maximum depth of 30 feet. Abundant cover was provided by rocks (riprap), dead trees, and brush. Population samples were conducted on 26-27 September 1973, and on 25-26 July 1974.

(2) Ozark Reservoir, Dredged Material Disposal Type II (Navigation Mile 282)- The sample area consisted of approximately 5.0 surface acres, with an average depth of 10 feet and a maximum depth of 20 feet. This was an active dredged material disposal site, but most

of the dredged materials had been piled near the outer ends of the dikes, leaving an extensive, deep backwater behind the dredged material banks. This backwater was broadly connected to the main channel along its northeast end. Riprap and submerged brush provided adequate cover for game fish populations. Fish samples were taken on 9-10 August, and on 1-2 August 1974.

(3) Dardanelle Reservoir #1 (Navigation Mile 216)- This reservoir sample site was a cove or backwater along the south bank adjacent to the navigation channel. The sample area was approximately 3.0 surface acres, with an average depth of 7 feet. Cover consisted of brush, marginal vegetation and rocks. Samples were made on 17-18 September 1973, and 18-19 September 1974.

(4) Dardanelle Reservoir #2 (Near Navigation Mile 212)- This locality was a cove inside the warm water discharge embayment of Arkansas Power and Light Company's nuclear power plant. The cove was 4.0 surface acres in size, with an average depth of 4 feet. Cover consisted of logs, stumps, and dead trees. Fish samples were taken on 5-6 September 1973, and 10-11 September 1974.

The data from the rotenone samples at the above four localities are graphically presented in Figures 16-25. Standing crop estimates for both the 1973 and 1974 samples at each site are expressed in terms of pounds of fish per acre and number of fish per acre. While standing crop estimates have many useful applications, they do not necessarily indicate the magnitude of the total annual fish pro-

duction of a given sample area.

Figure 16 indicates that the three non-dredged material sites had a greater biomass of fishes when the 1974 samples were taken than they did during the 1973 sampling period, while the dredged material disposal area was approximately the same in both years. However, a comparison of the game fish weight data for the four areas indicates a significant reduction in weight of game fish taken from the dredged material disposal area in 1974, whereas game fish biomass increased at each of the three non-dredged material sites (Figure 17). It is possible that dredging operations caused this change at the dredged material disposal site, but further investigation would be needed to accurately determine this.

The dredged material disposal area did not support nearly as much biomass of commercial species as did the other three sites (Figure 18), but it was by far the most productive areafor forage fishes (Figure 19). It is not known why the Pool 13 sample site supported a much larger population of gars than did the other three areas (Figure 20), but that area also had the greatest biomass of game species, again illustrating the productivity of tributary mouths.

The data comparing the number of fish per acre at the four localities indicate that the dredged materials disposal area compared favorably with the non-dredged material areas (Figure 21). However, this was due to a large increase in the numbers of shad at the dredged

material disposal site in 1974 (Figure 24), because all other categories of fishes showed declines in number of individuals at that site. The number of fishes in all categories at the Pool 13 site were moderately low, indicating that the average size of fishes was large, because that area was the most productive in terms of biomass. Both Dardanelle Reservoir sample sites had the highest numbers of game and commercial fishes in 1974, indicating very successful spawns of these fishes in the reservoir.

IV. RECOMMENDATIONS FOR IMPROVING DREDGED MATERIAL DISPOSAL LOCATION, CONSTRUCTION, AND UTILIZATION

Field observaitons and the qualitative and quantitative data on fish populations gathered during the present study provided the basis for six general recommendations for minimizing the effects of dredging and dredged material disposal areas on the fishes of the Arkansas River Navigation System. These recommendations were formulated strictly from a biological point of view without neccessarily considering the feasibility of their implementation from an engineering and channel maintenance standpoint. These recommendations, which are intended to improve fish habitat in existing dredged material disposal areas and to influence the location of future disposal sites, may be grouped into two categories according to whether they affect dredged material disposal location, or construction, and utilization.

Improving Dredged Material Disposal Location

1. Dredged materials should be located as far from the mouths of tributary streams as possible.

Tributary mouths were previously described as providing the most abundant and diverse habitat for game fish and many other species. Even small streams have extensive areas of fish habitat near their confluence with the Arkansas River. The deposition of dredged materials in and near tributary mouths greatly decreases the amount of suitable fish habitat. These areas are also prime spawning sites and nursery areas. If dredging is necessary near the mouths of tributaries, the materials removed should be placed well up on the banks out of the water. Three active dredged material disposal sites were located at least partially in and around tributary mouths with prime game fish habitat:

(1) Little Bayou Meto near Navigation Mile 44-45,

(2) Fourche la Fave River along Navigation Miles 146 and 147, and

(3) Petit Jean River at Navigation Mile 187.

It was not determined to what extent, if any, the fish populations had been affected by the dredging activities near these tributary mouths. Periodic estimates of the standing crops of fishes by rotenone sampling would be needed to provide this information.

2. Dredged materials should not be deposited in old river cutoffs or existing bends.

Although river cutoffs and bends were not studied during the present investigation, many of them were observed to have good potential game fish habitat. One rotenone sample was taken from a dredged material disposal area in Williamette Bend in connection with samples from the adjacent mouth of Little Bayou Meto. A great diversity of species, including rare forms and game fish, existed in the backwaters of this bend. It is probable that other bends and cutoffs are just as productive for fishes. Other bends used as dredged material disposal areas were Yell Bend at navigation mile 70 (a small dredged material deposit), and Ellis Island Cutoff at navigation mile 170-171 (almost entirely filled with dredged materials).

Improving Dredged Material Disposal Site Construction and Utilization

3. Dredged material disposal areas should be constructed with extensive areas of deep and shallow backwaters wherever possible.

Dredged material disposal Types II and III provided the most desirable fish habitat as long as no large amounts of dredged materials were deposited in the backwater areas. In certain regions where the river channel is narrow, such as below Dardanelle Lock and Dam and Toad Suck Ferry Lock and Dam, dredged materials provided the only backwater areas present for considerable distances. The complete filling of these backwaters with dredged materials would

eliminate the only suitable fish habitat along several miles of the river. Dredged material disposal Type IV also creates desirable backwater fish habitat when first constructed, but this type is designed to be eventually filled with dredged materials throughout the backwater compartments.

4. The available fish cover should not be removed from dredged material deposit backwaters; it should also not be covered with dredged materials.

Cover in the form of logs, stumps, brush, dead trees, rocks, and other objects are necessary to provide good game fish habitat and spawning sites in backwater areas. Fish habitat in these areas could be further enhanced by depositing trees, logs, and other objects in them which have been removed from the navigation channel during normal channel maintenance operations. Again, dredged material disposal Types II and III provide the most suitable backwater areas for the deposition of dead trees and other cover snagged from the main channel.

5. Maintaining permanent passageways for fishes between dredged material deposit backwaters and the main river.

When the noramlly high spring waters of the navigation system have receded by early summer, extensive land-locked, isolated pools are left behind on the tops of some dredged material deposits. Large numbers of adult and young-of-the-year game fish are frequently stranded in these pools which slowly decrease in depth as the summer

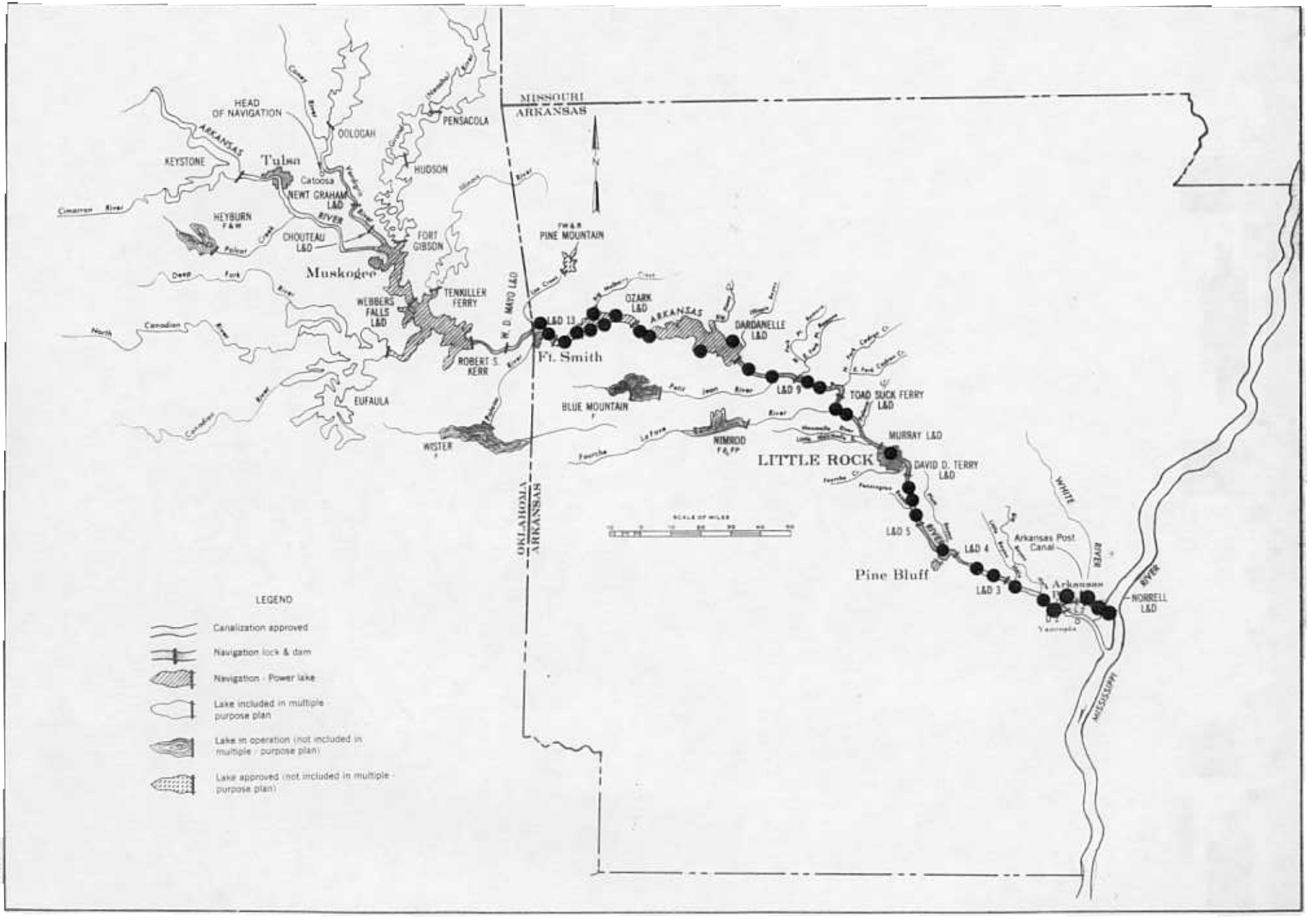
progresses. These fishes are either eaten by predators or are eventually killed when the water temperature exceeds their tolerance limits. Type IV dredged material disposal areas most commonly exhibited this undesirable feature, although it was also occasionally observed in other dredged material disposal types. Because these areas are often the only suitable nursery habitat for game species along some parts of the navigation system, such as below Lock and Dam 9, the reproductive success of several important species in these areas is probably strongly affected. The maintenance of small passageways between these isolated, but extensive, dredged material deposit backwaters and the main channel of the river would allow the fishes to escape from these areas as the high waters receded.

6. Improvement of spawning habitat during periods of high water.

Most fish reproduction occurs during the spring and early summer in the Arkansas River. High water flows and flooding of adjacent low-lying areas are common during this period, and dredged material banks that are normally out of the water become inundated and are used as spawning sites by a number of species of fishes. These dredged material areas usually have shifting, unstable bottoms and consequently do not provide good spawning habitat for game fishes. The planting of some type of fast-growing cover crop on the dredged material disposal areas when they are exposed during low water periods would stabilize these areas and provide much more suitable

spawning habitat when high spring waters occur. This would have the additional function of providing food for wildlife during normal flows. Extensive plantings of grasses, legumes, or other suitable vegetation along the navigation system would do much to offset the adverse effects of the dredging process itself and the reduction in environmental heterogeneity associated with many of the dredged material disposal areas.

MAP I. COLLECTING SITES ON ARKANSAS RIVER NAVIGATION SYSTEM.



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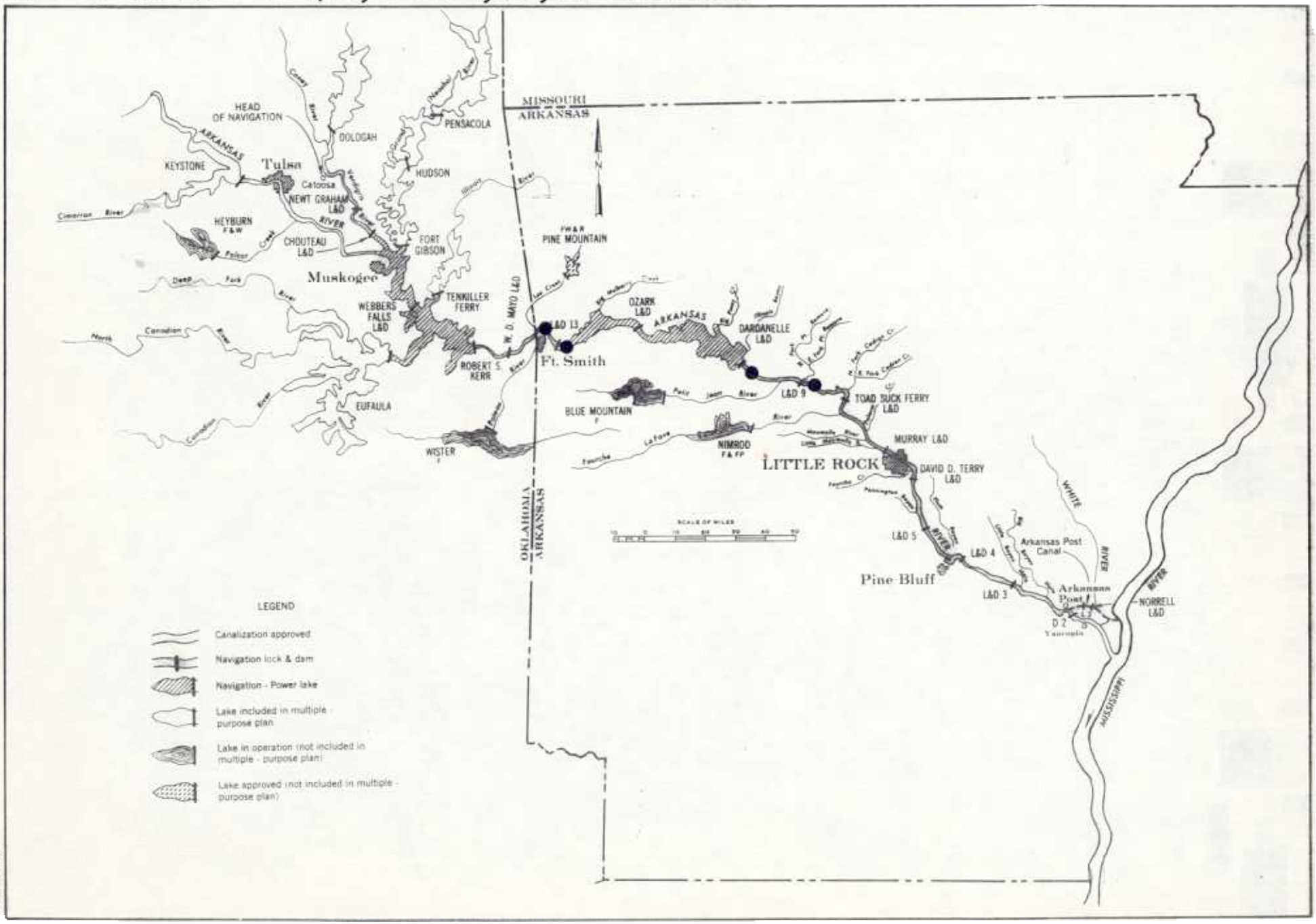
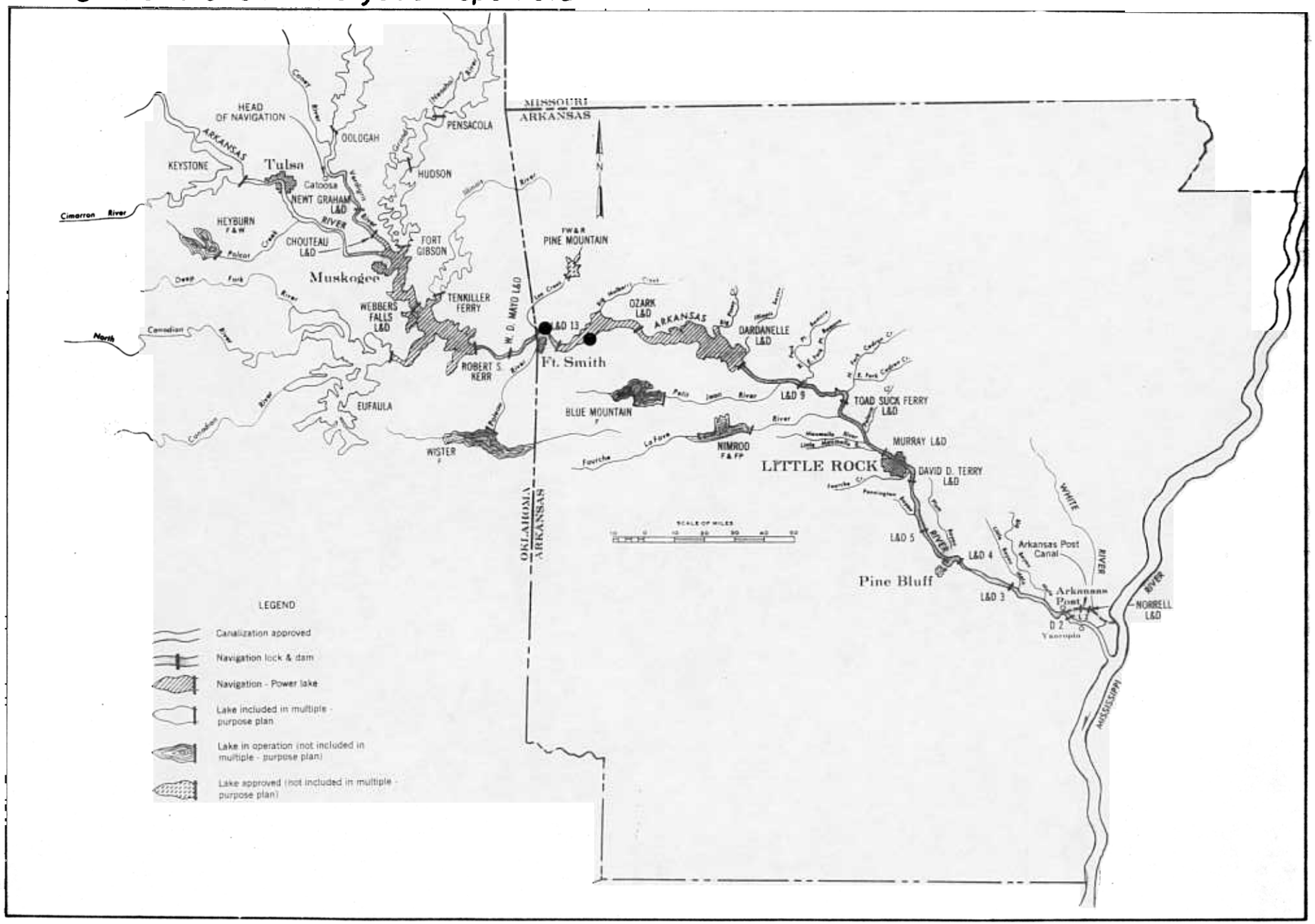
MAP 2. Chestnut Lamprey - *Ichthyomyzon castaneus*



MAP 3. Paddlefish – *Polyodon spathula*



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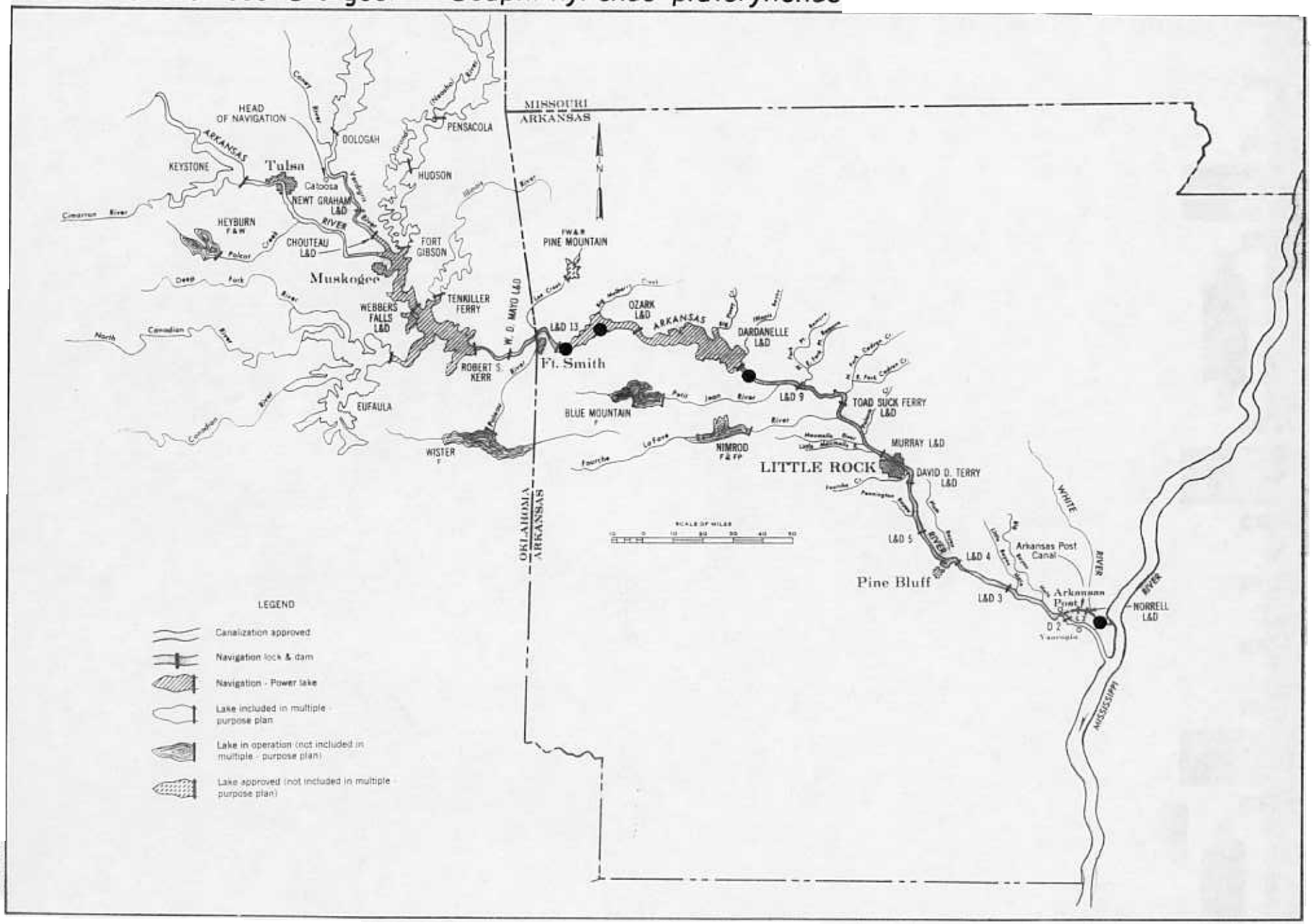
MAP 4. Shovelnose Sturgeon – *Scaphirhynchus platorynchus*



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MAP 5. Bowfin – *Amia calva*

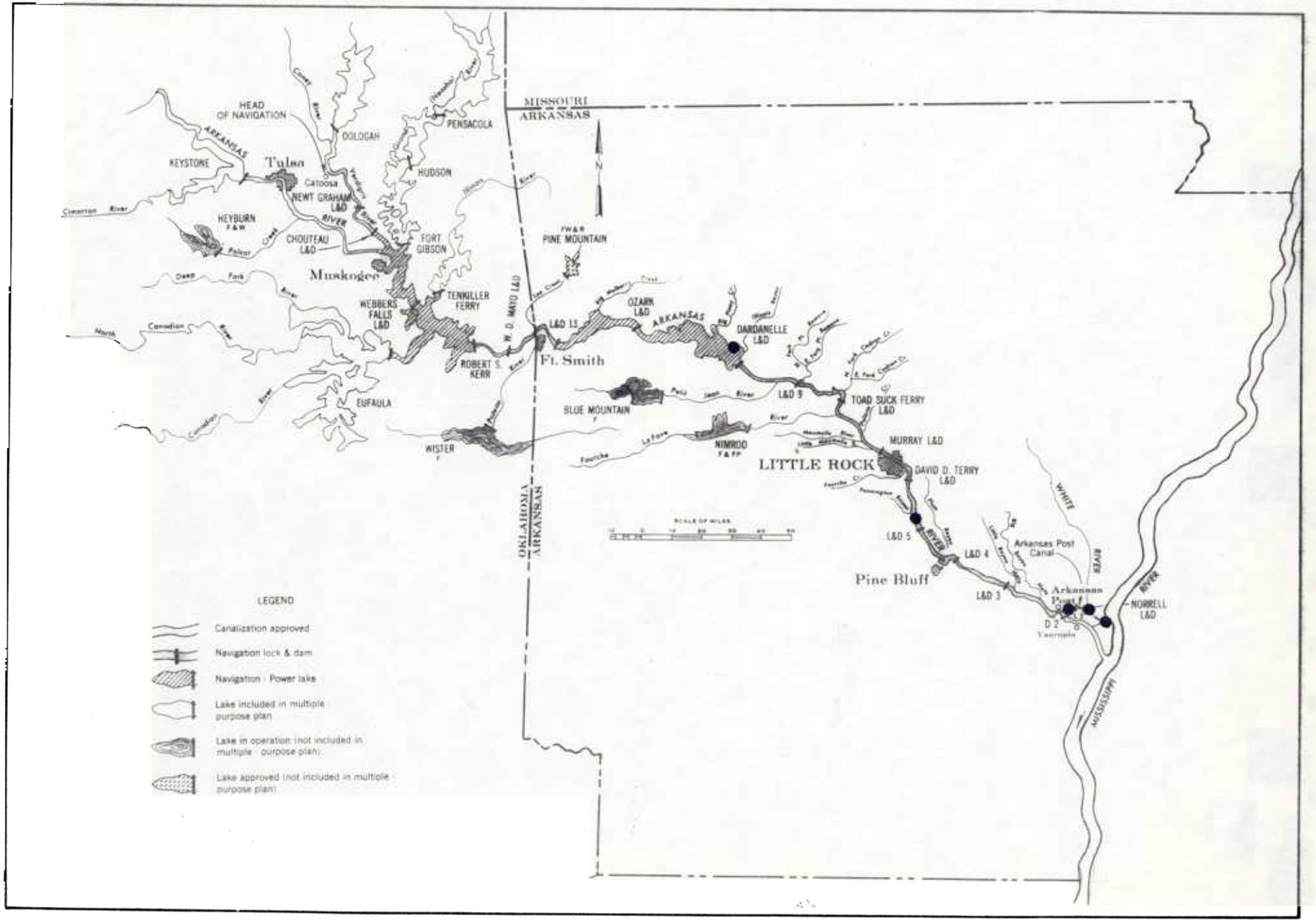
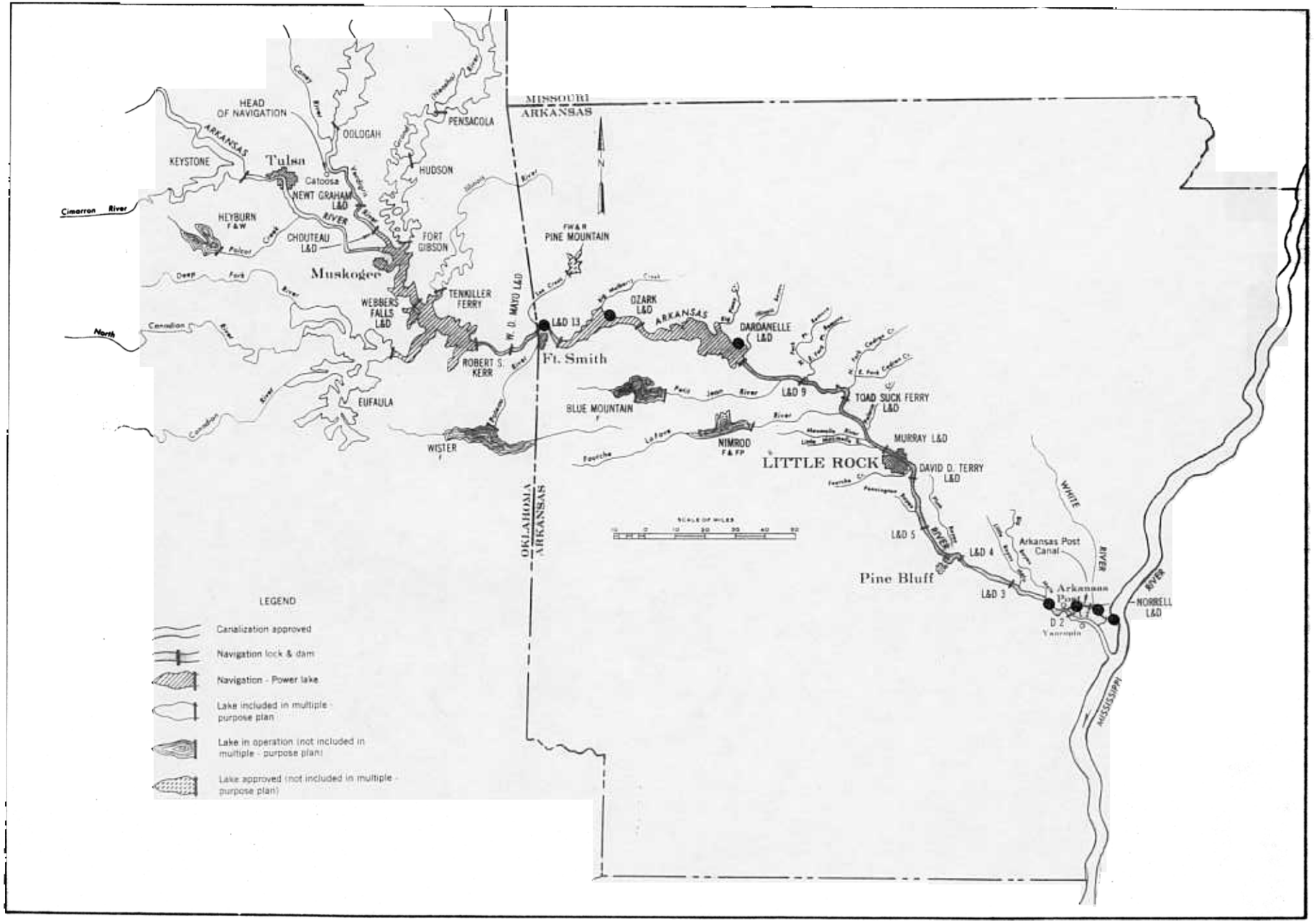
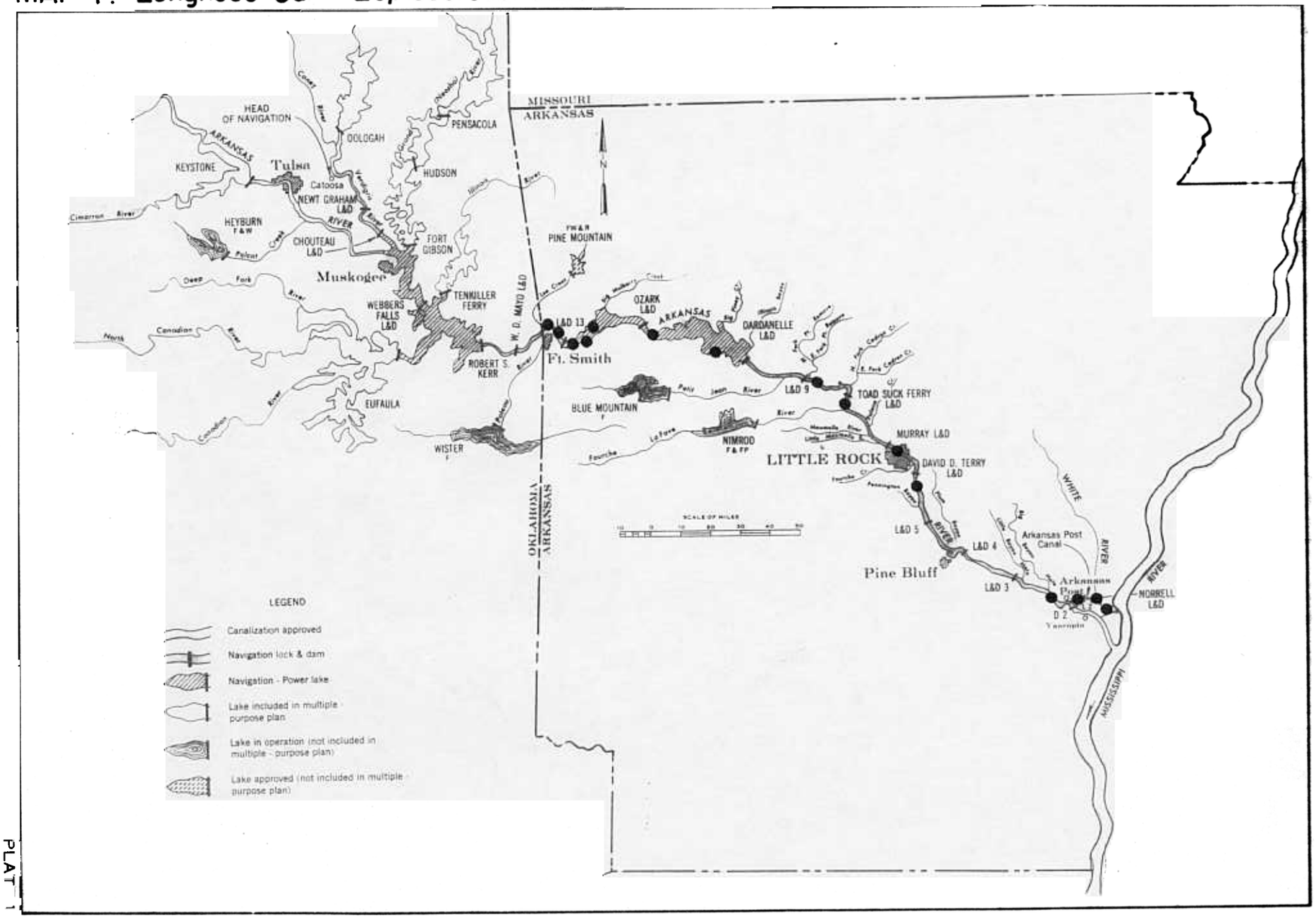


PLATE 1

MAP 6. Spotted Gar *Lepisosteus oculatus*

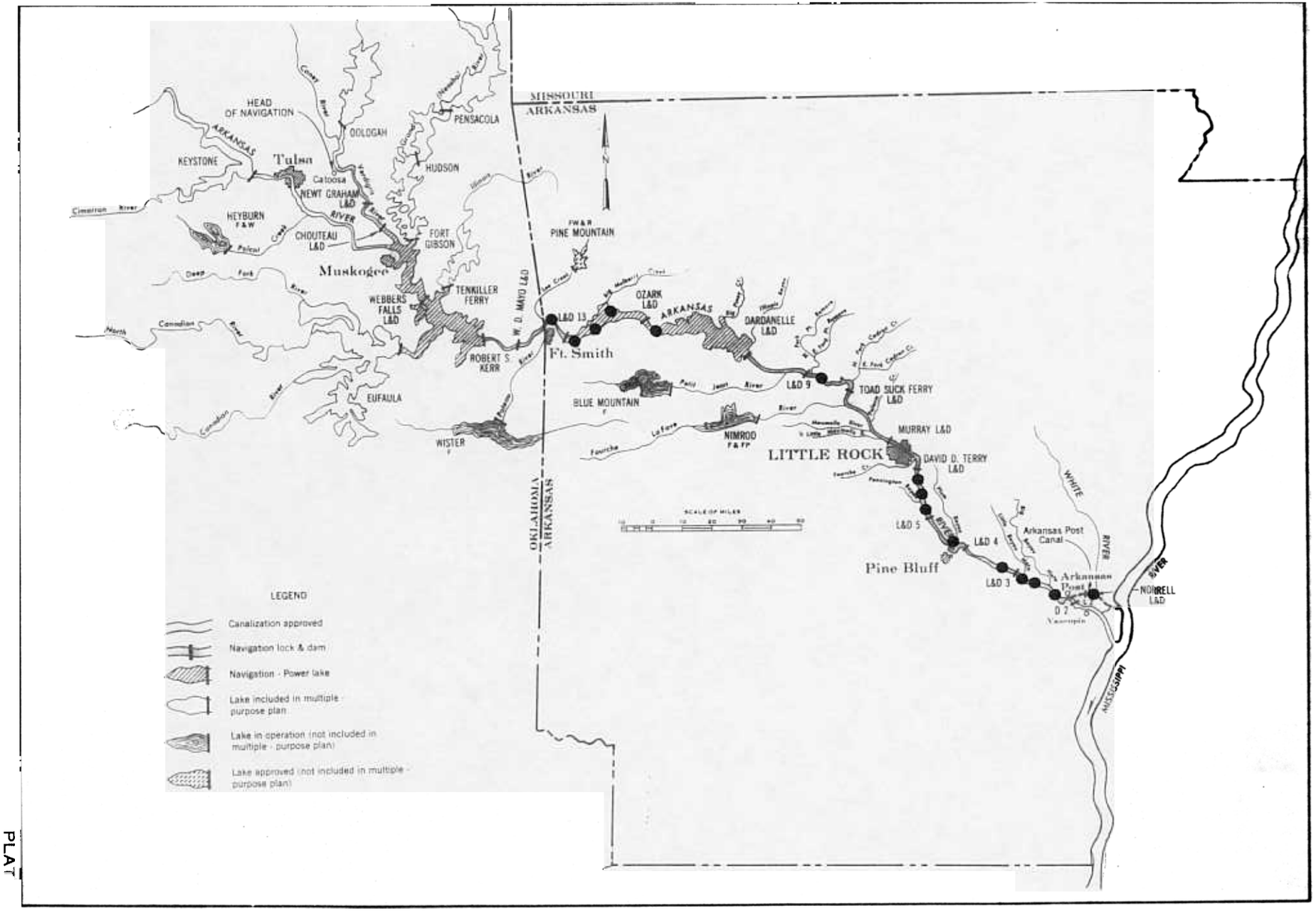


MAP 7. Longnose Gar - *Lepisosteus osseus*

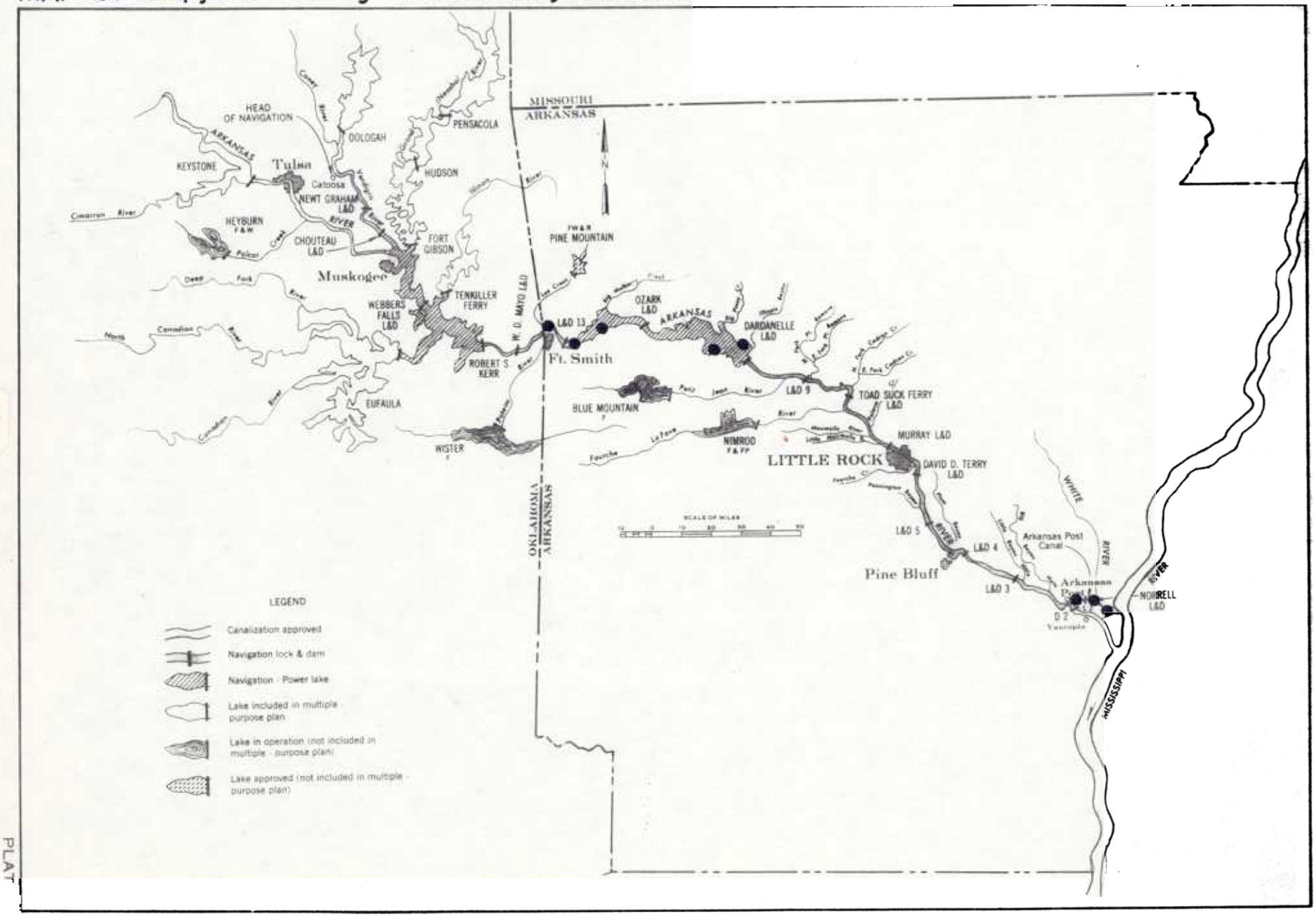


PLAT 1

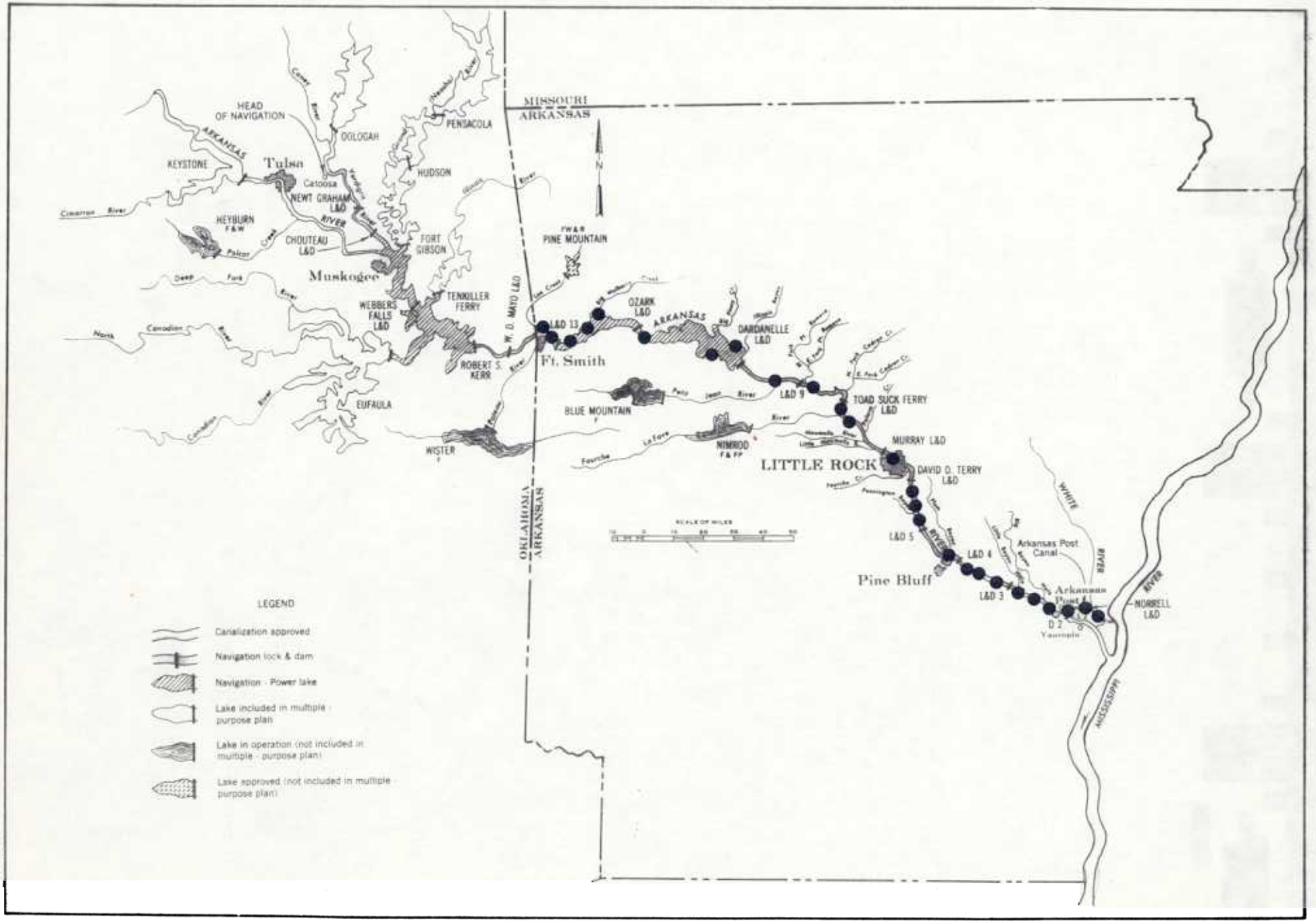
MAP 8. Shortnose Gar - *Lepisosteus platostomus*



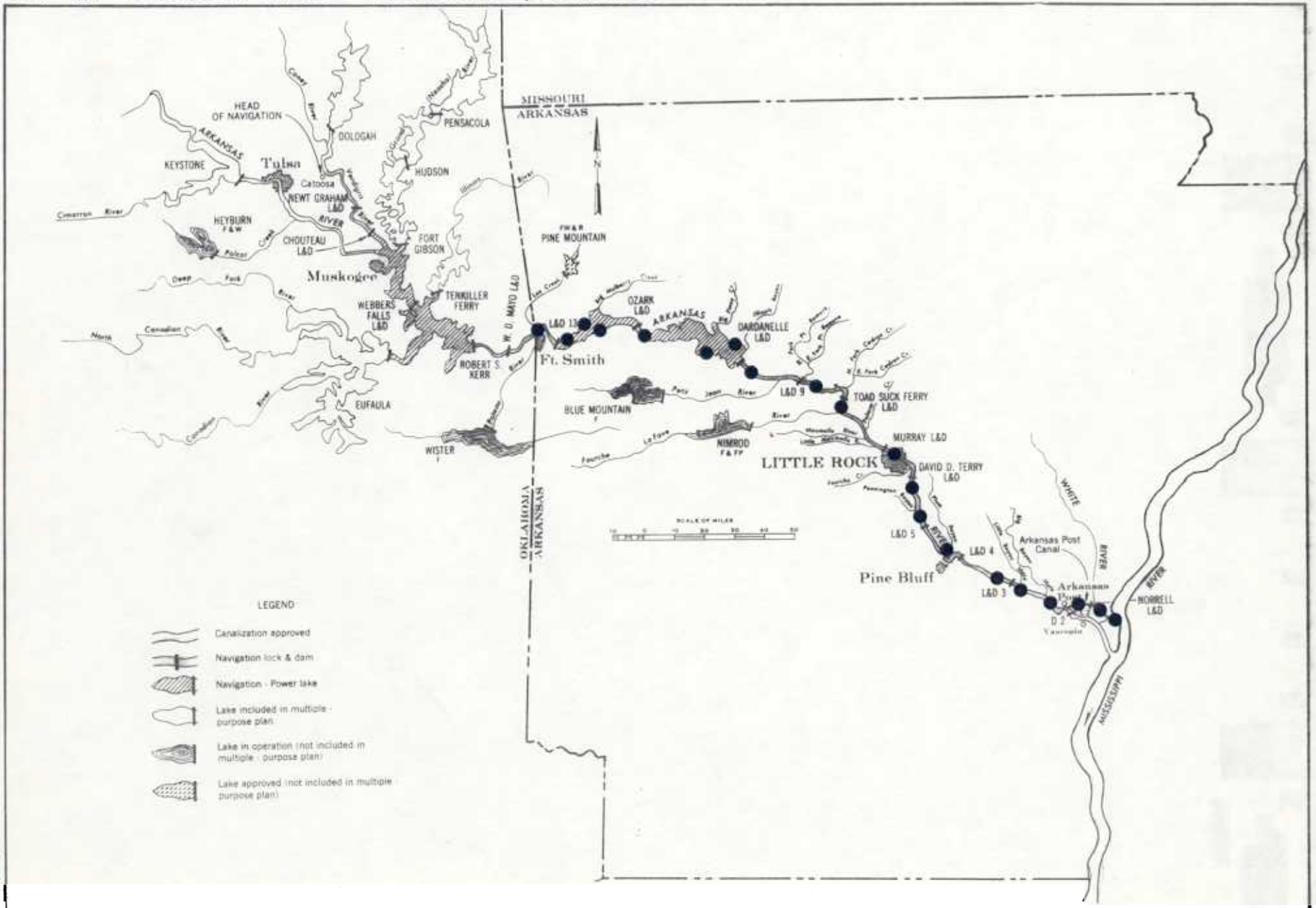
MAP 9. Skipjack Herring - *Alosa chrysochloris*



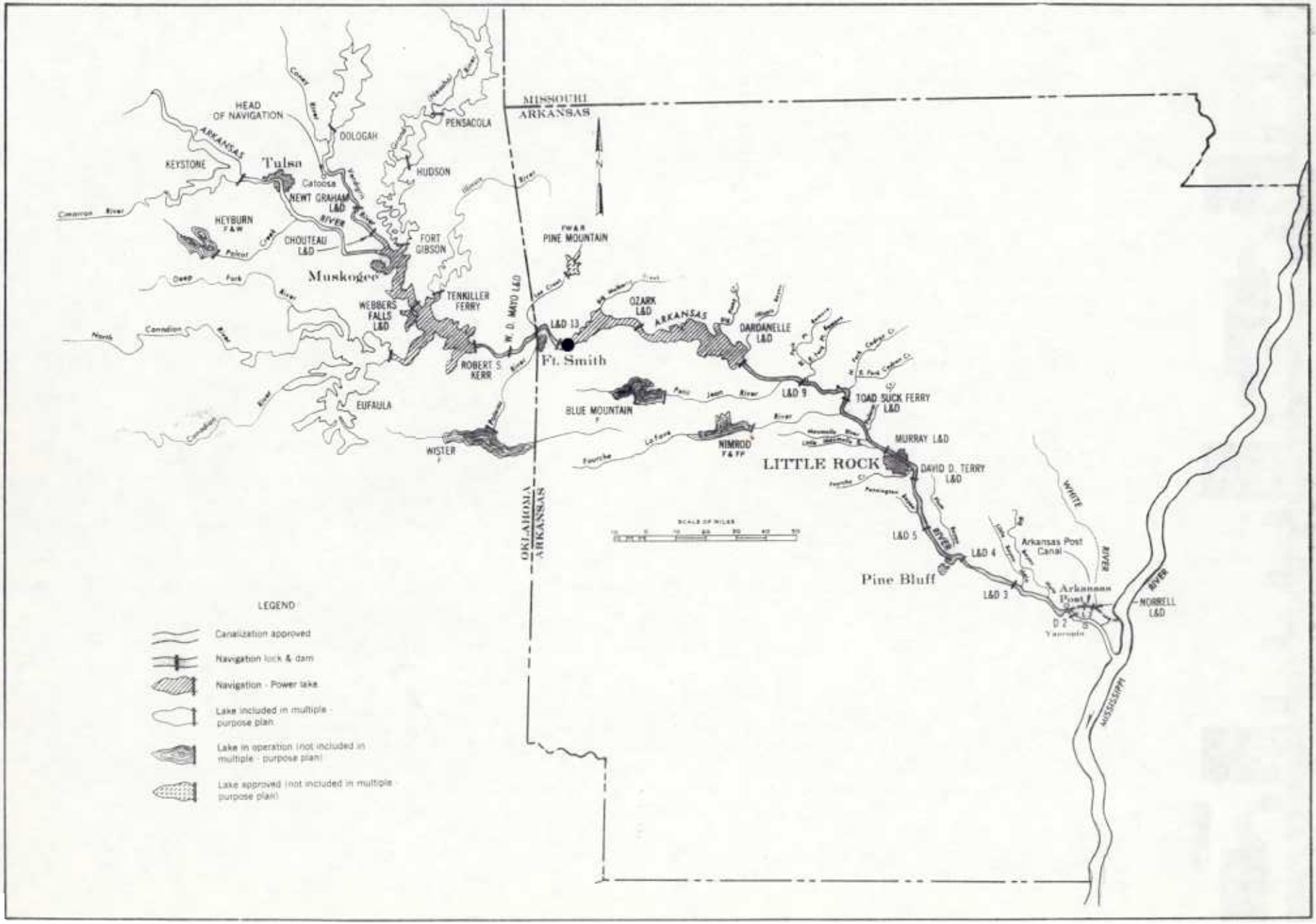
MAP 10. Gizzard shad – *Dorosoma cepedianum*



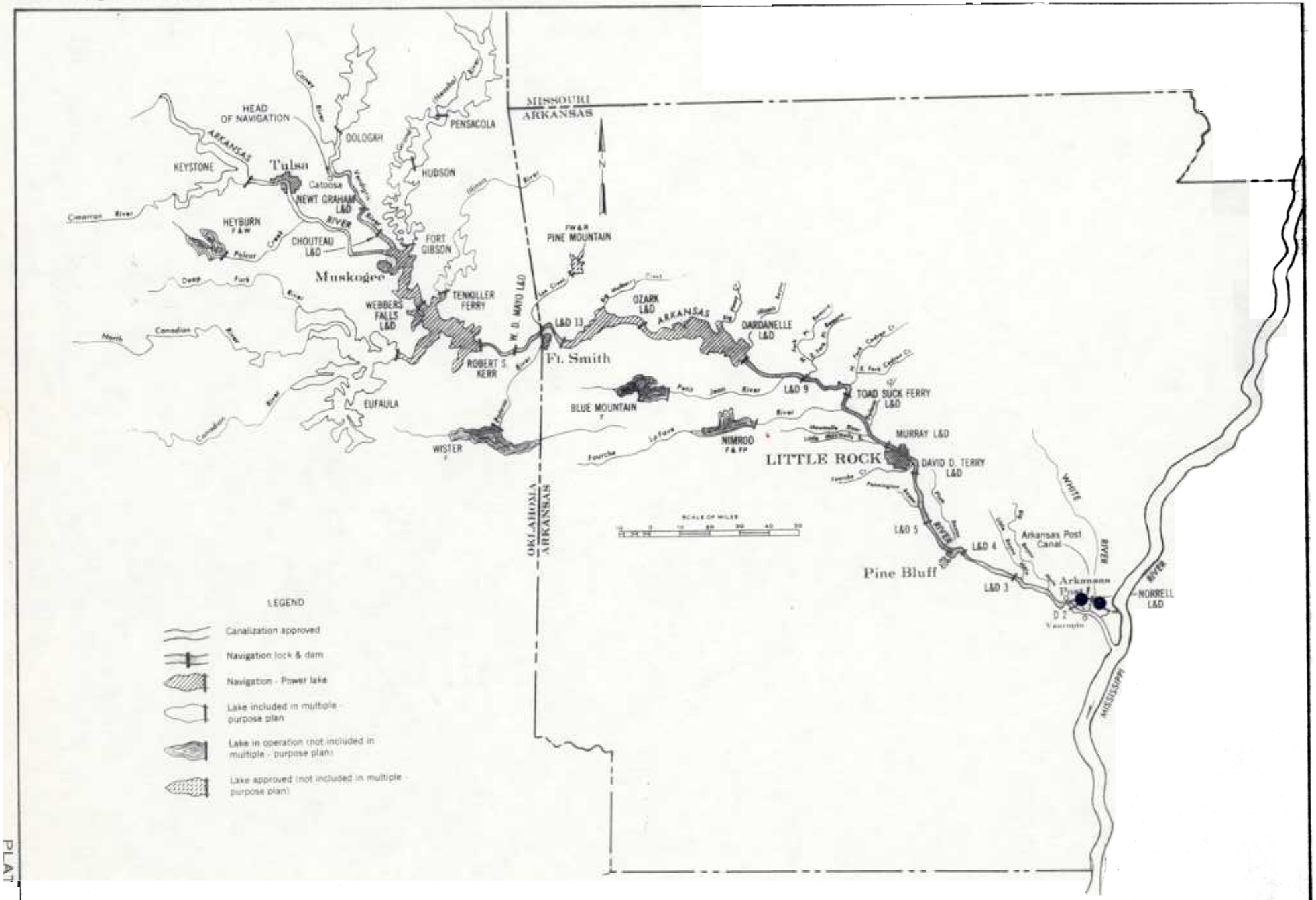
MAP II. Threadfin Shad – *Dorosoma petenense*



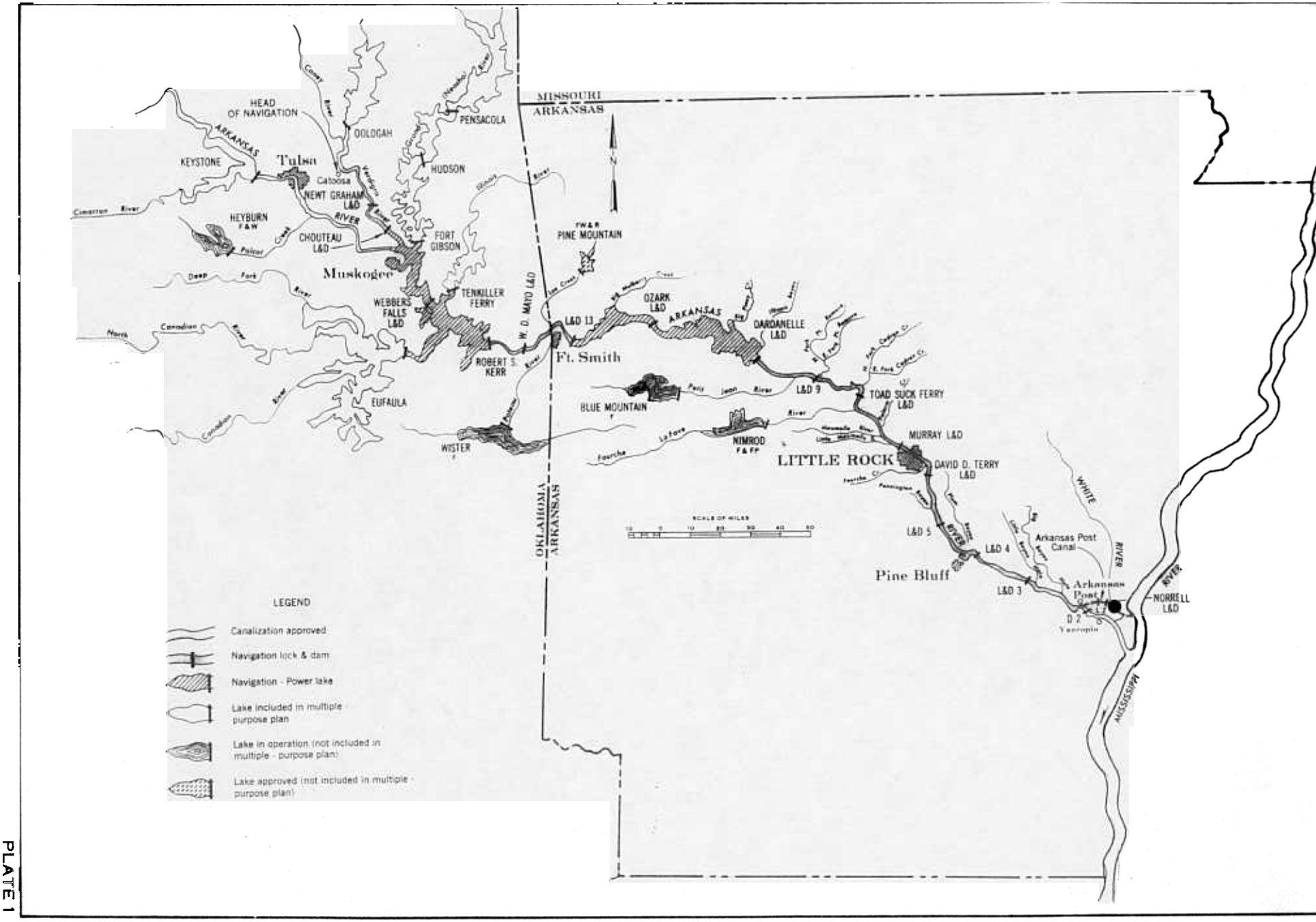
MAP 12. Rainbow Trout - *Salmo gairdneri*



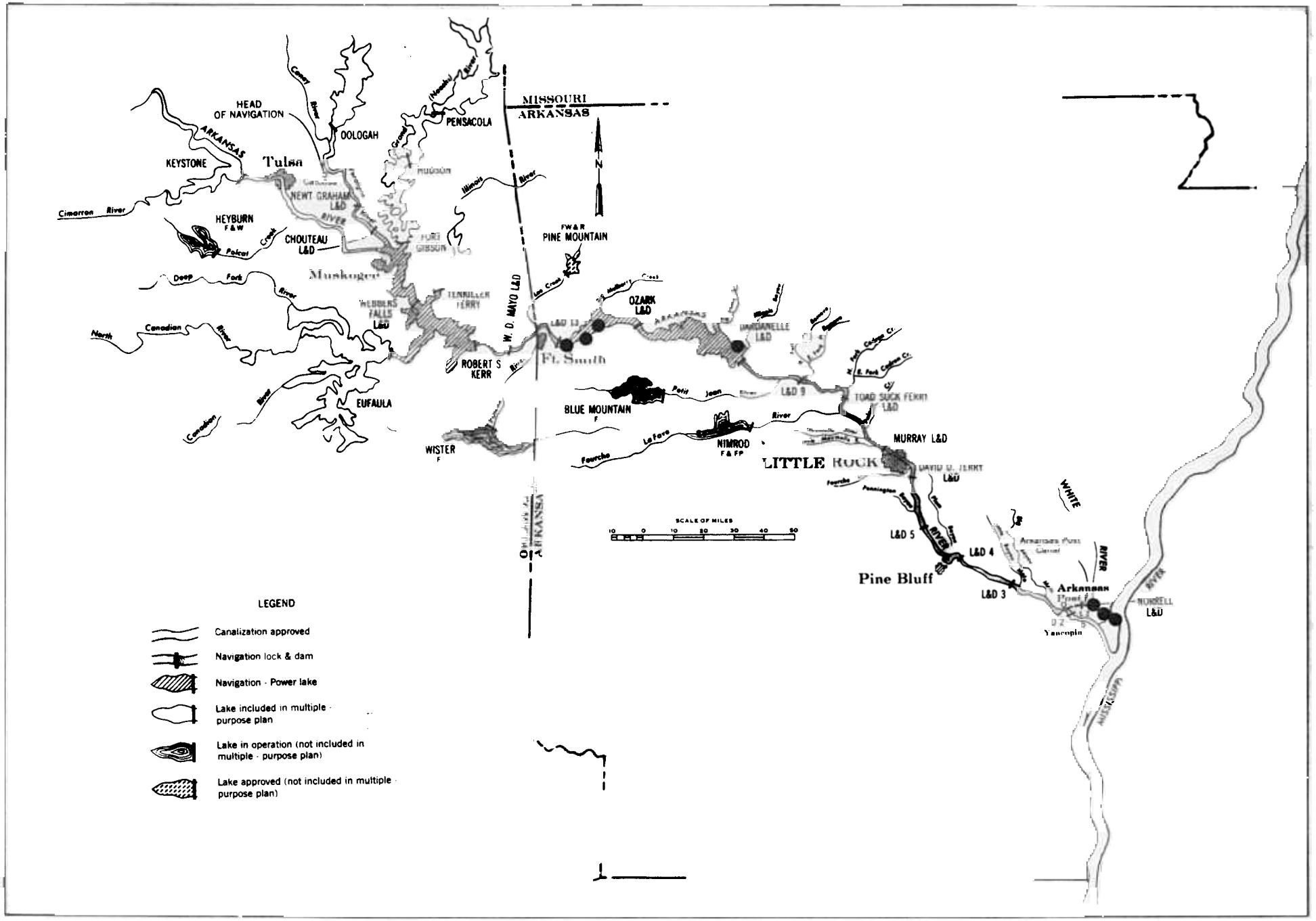
MAP 13. Grass Pickerel – *Esox americanus*



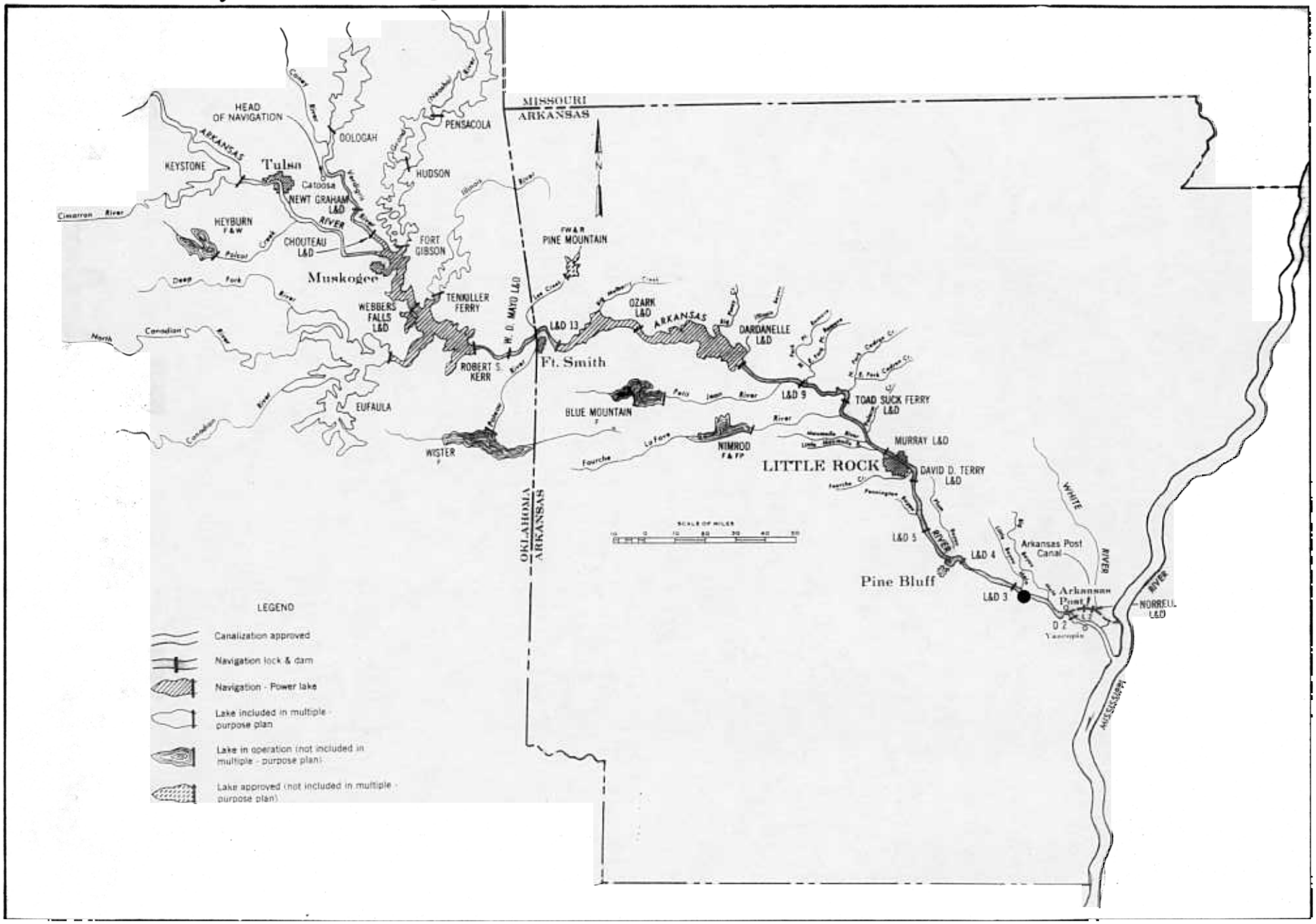
MAP 14. Chain Pickerel - *Esox niger*



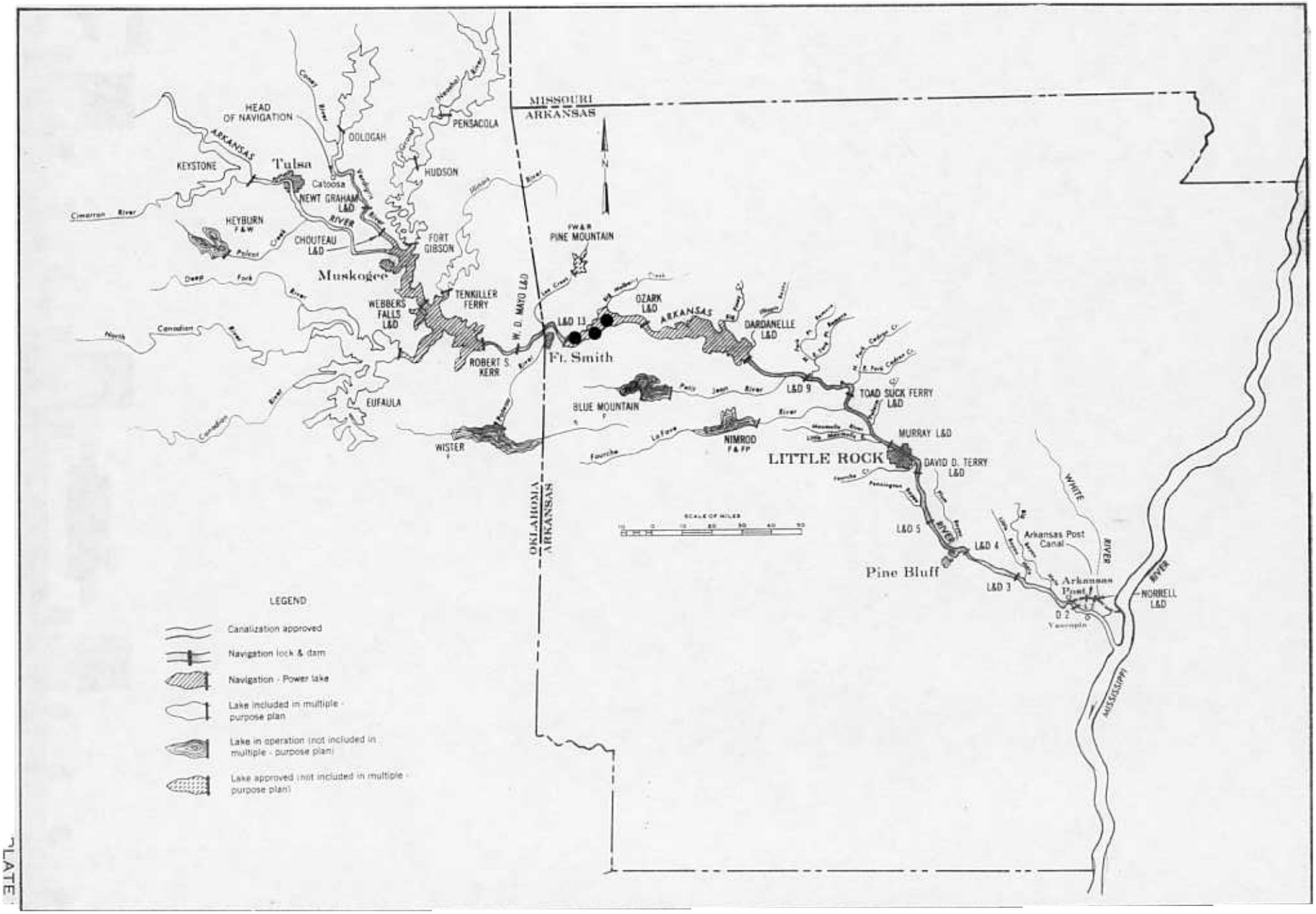
MAP 15. Goldeye - *Hiodon alosoides*



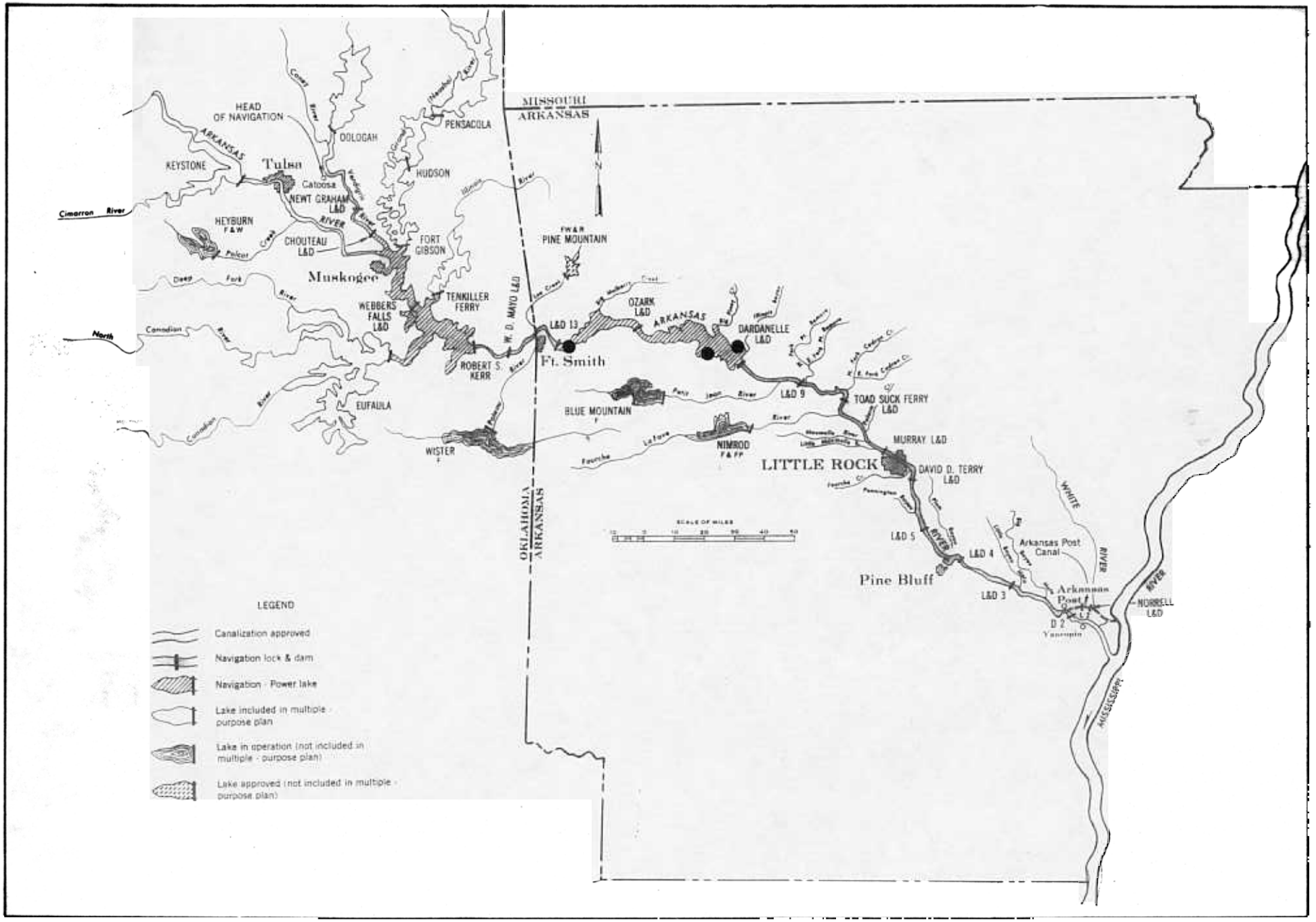
MAP 16. Mooneye - *Hiodon tergisus*



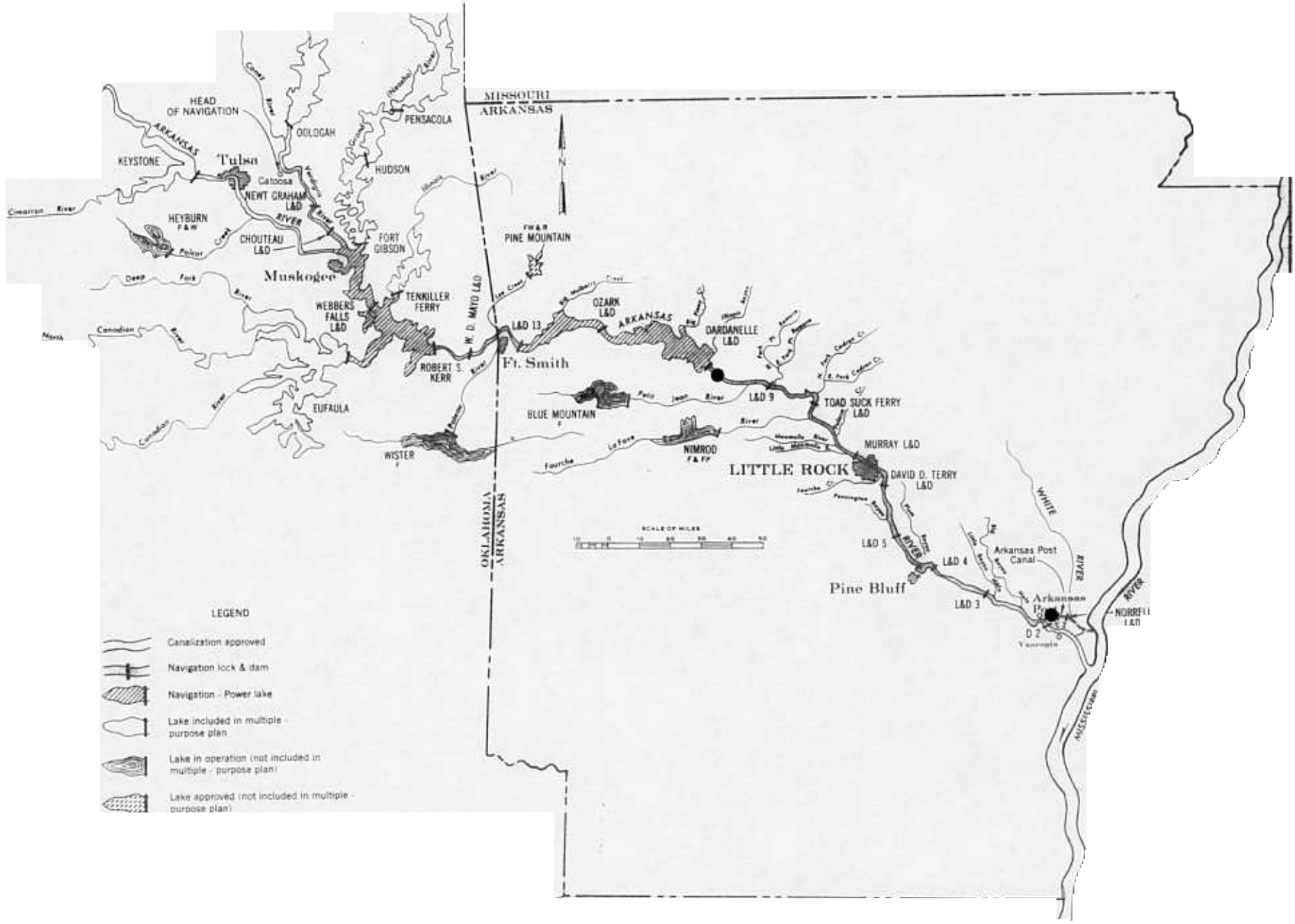
MAP 17. Stoneroller *Campostoma anomalum*



MAP 18. Goldfish - *Carassius auratus*



MAP 19. Grass Carp - *Ctenopharyngodon idellus*



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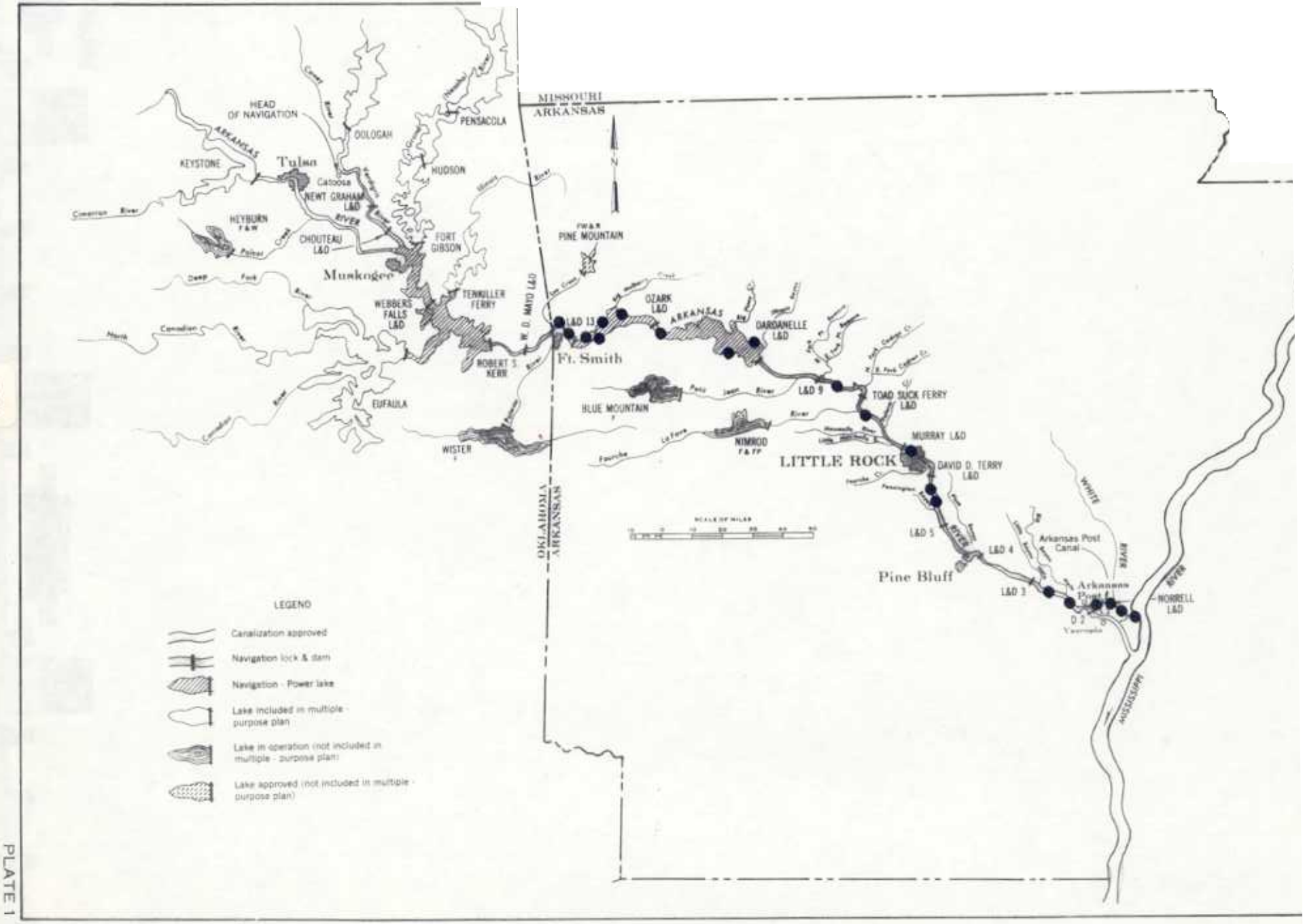
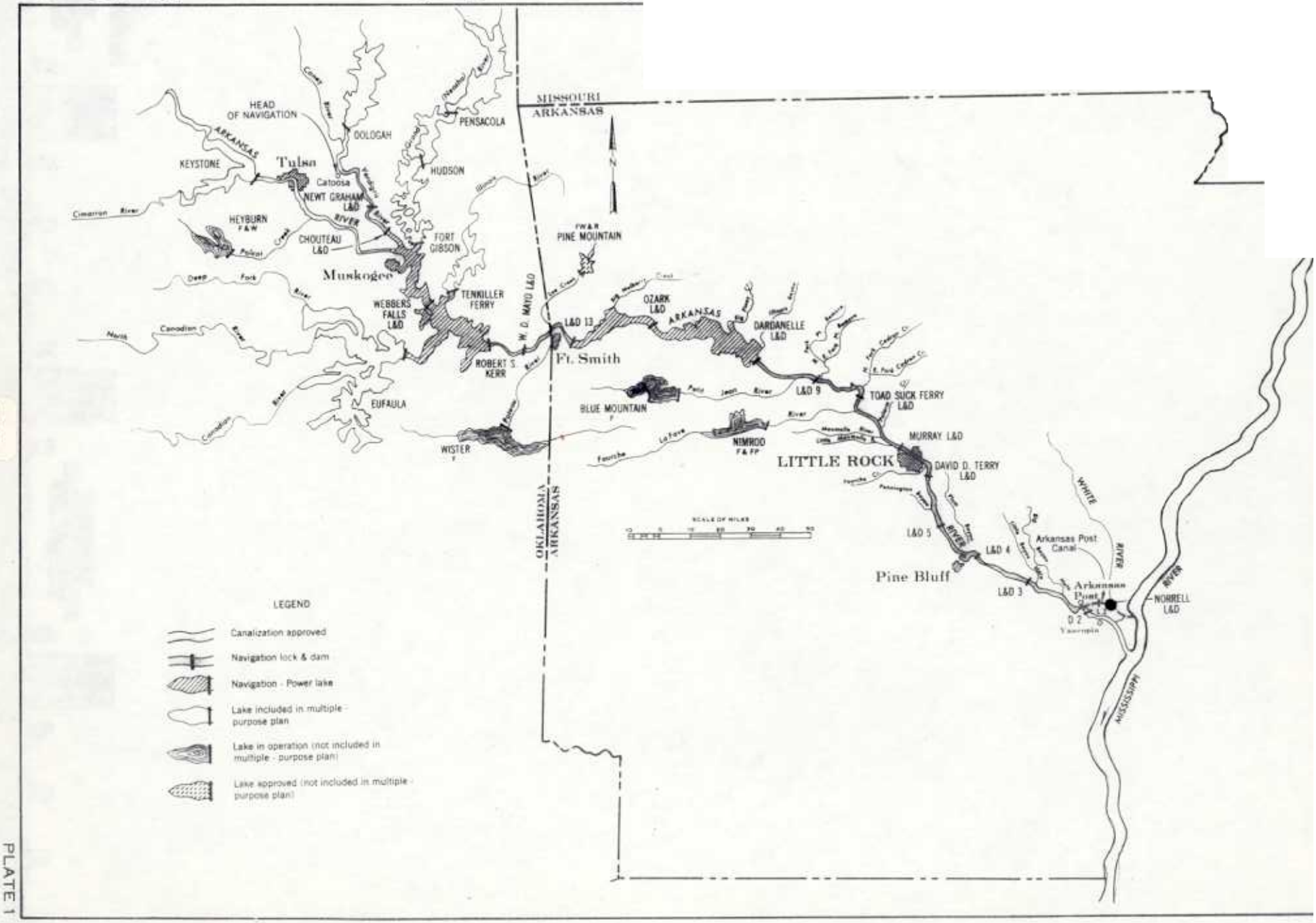
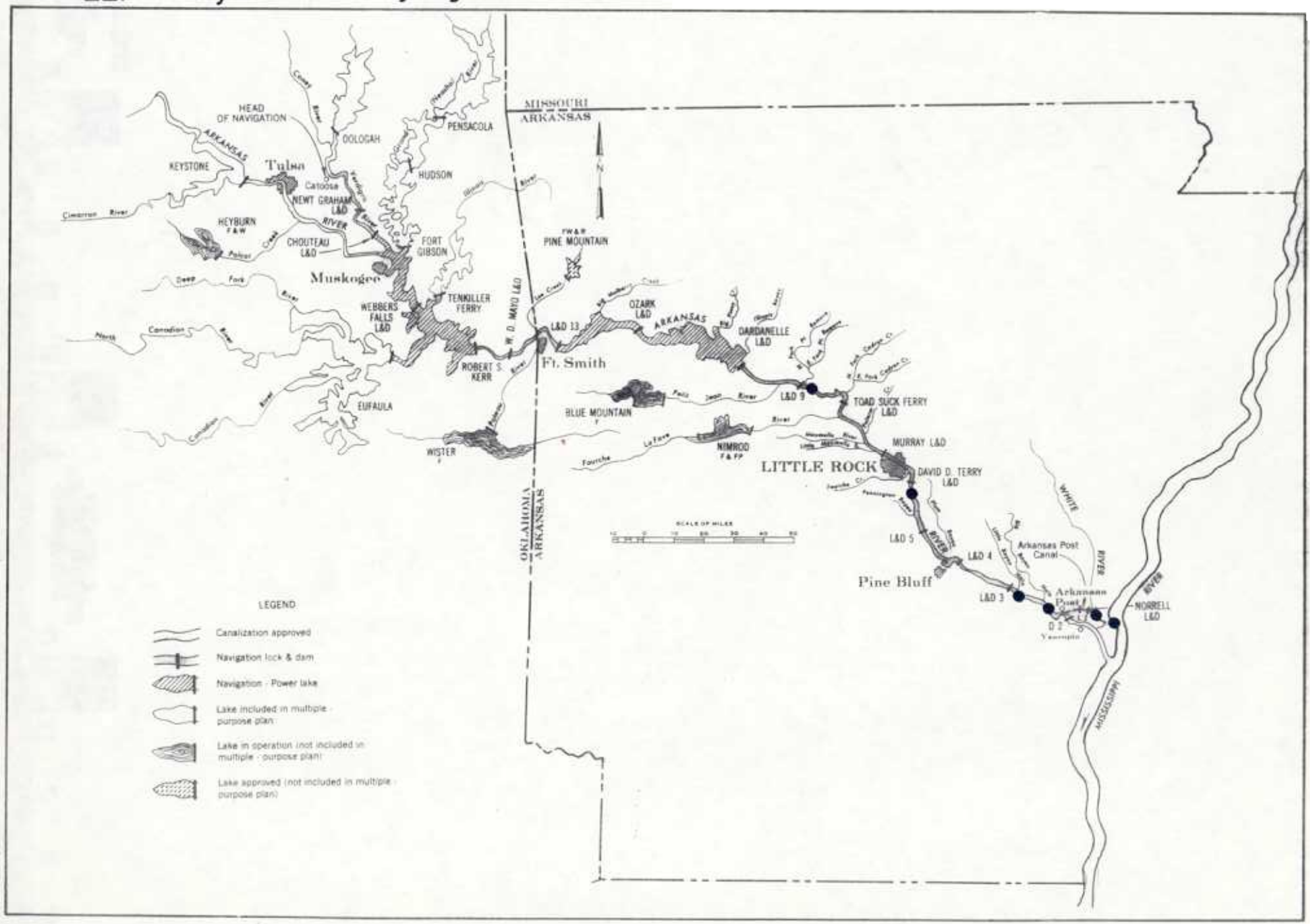
MAP 20. Carp - *Cyprinus carpio*



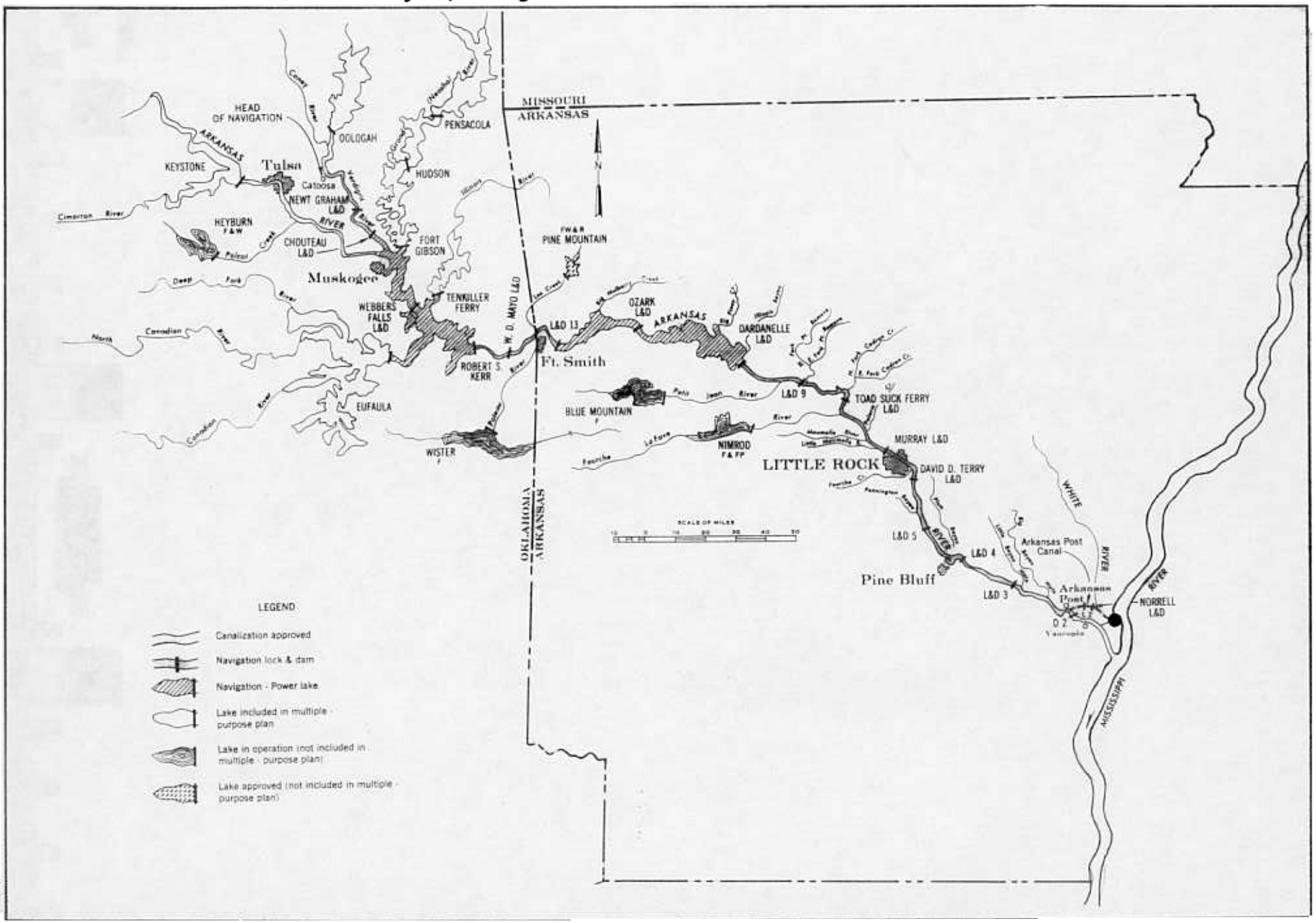
MAP 21. Cypress Minnow - *Hybognathus hayi*



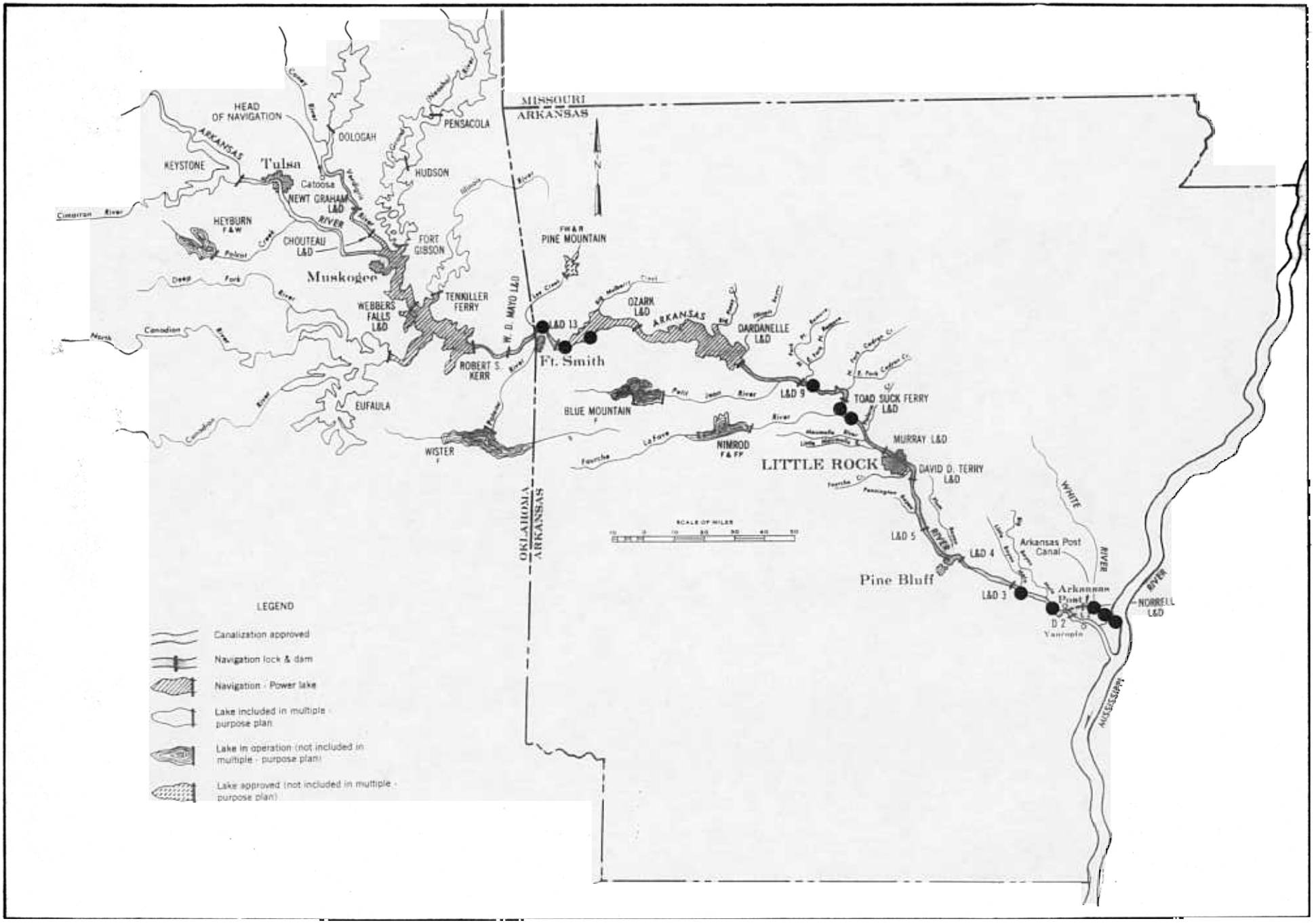
MAP 22. Silvery Minnow - *Hybognathus nuchalis*



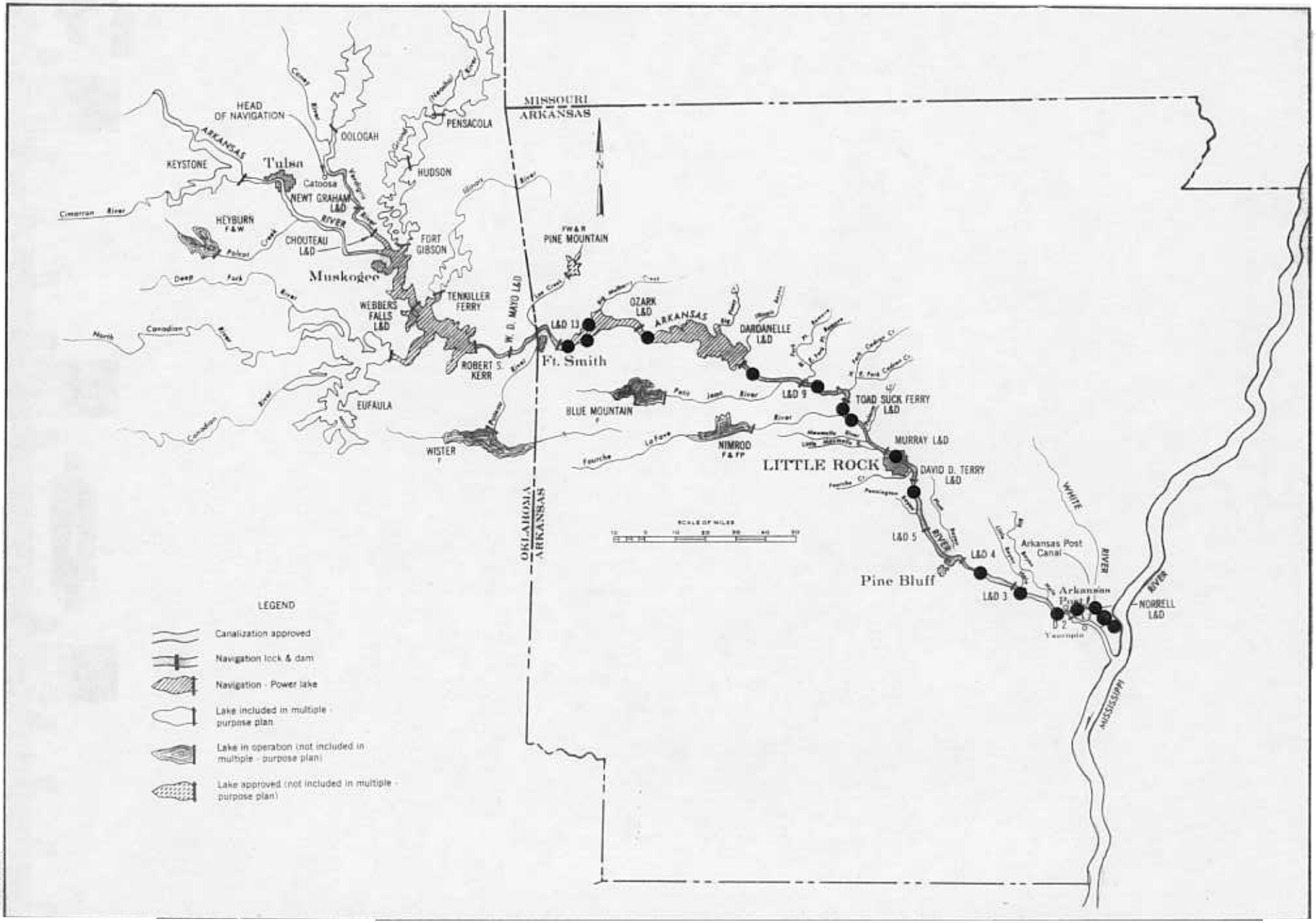
MAP 23. Flathead Chub – *Hybopsis gracilis*



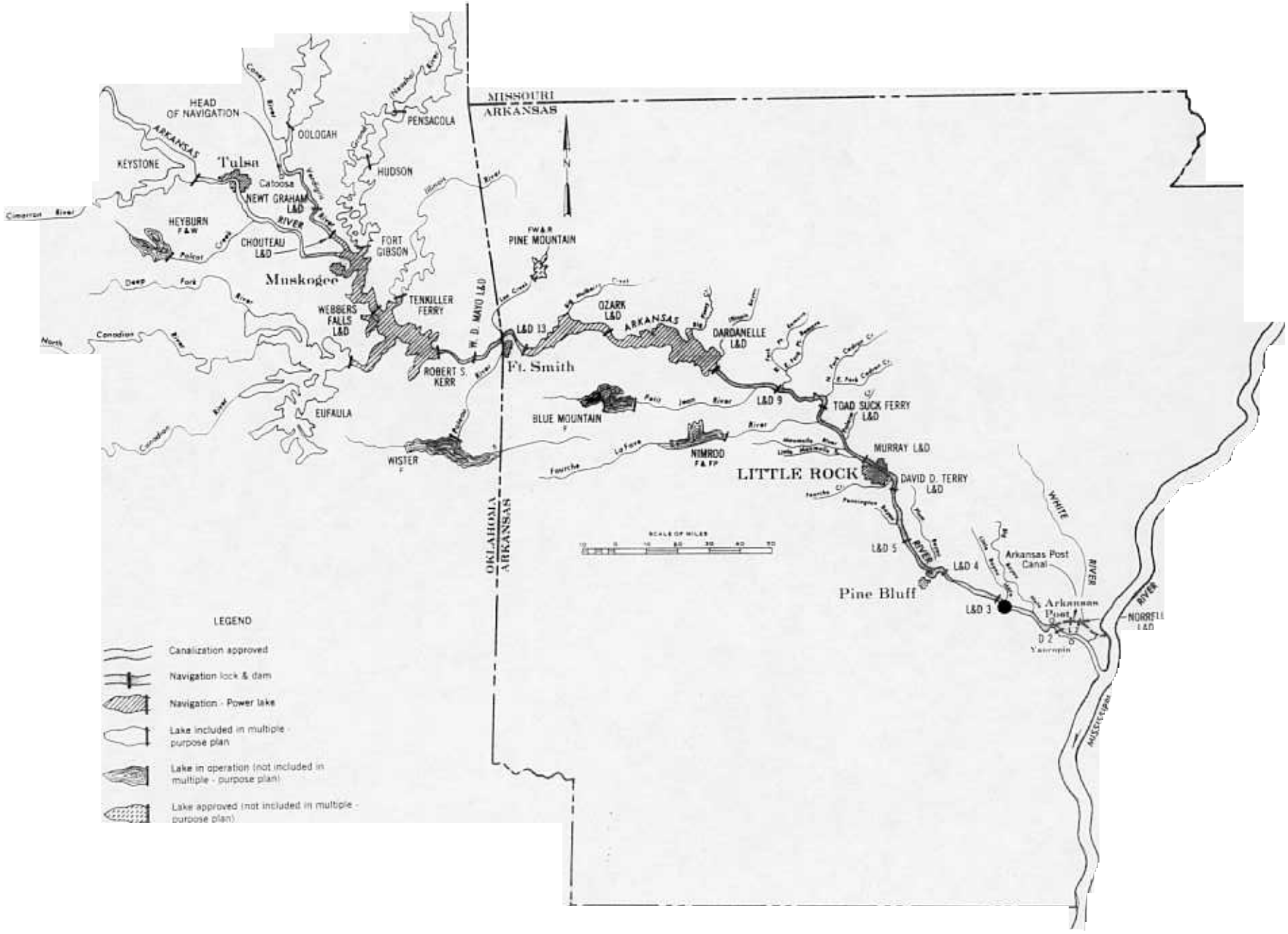
MAP 24. Silver Chub - *Hybopsis storeriana*



MAP 25. Golden Shiner - *Notemigonus crysoleucas*



MAP 26 Pallid Shiner – *Notropis amnis*



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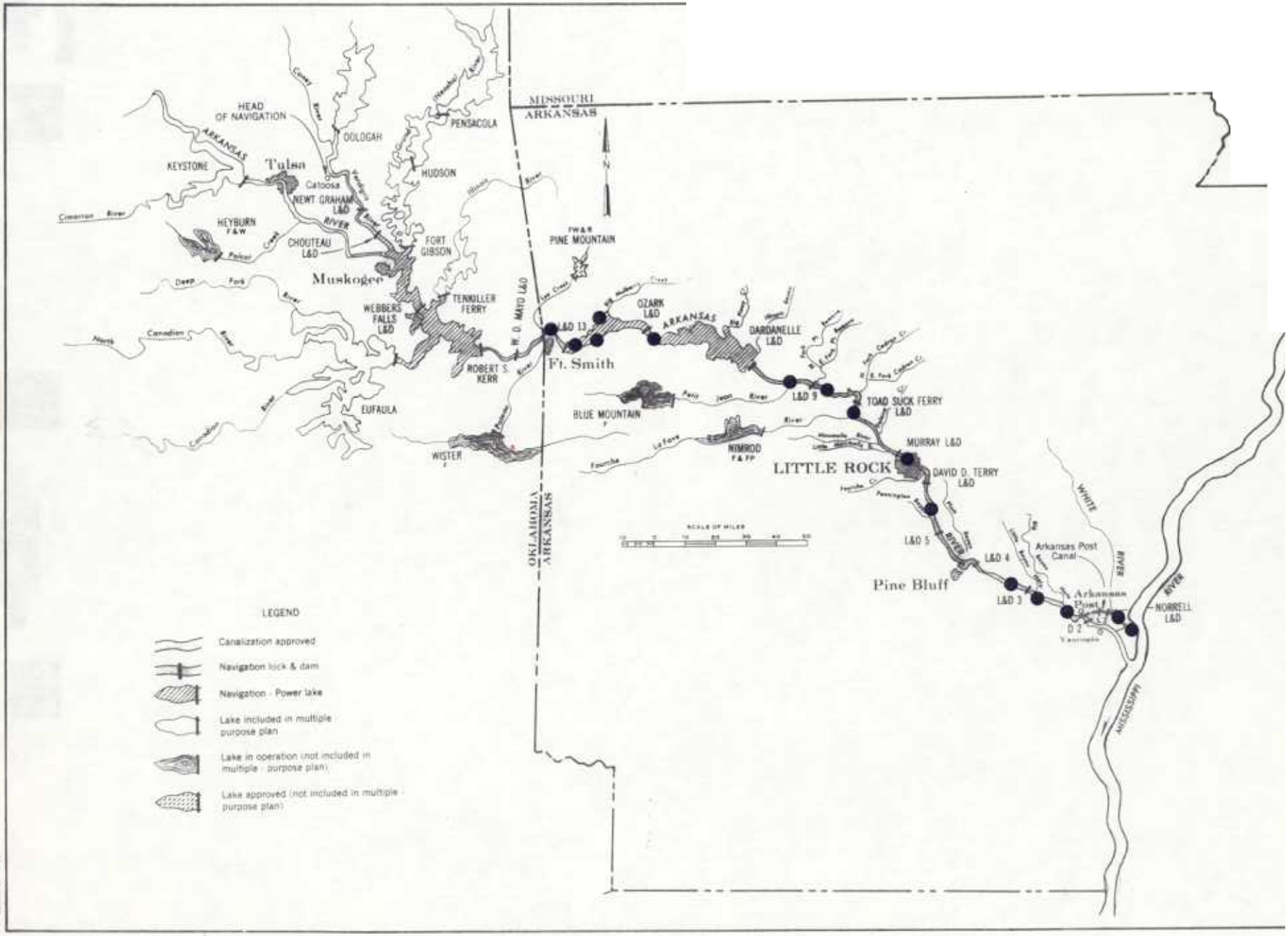
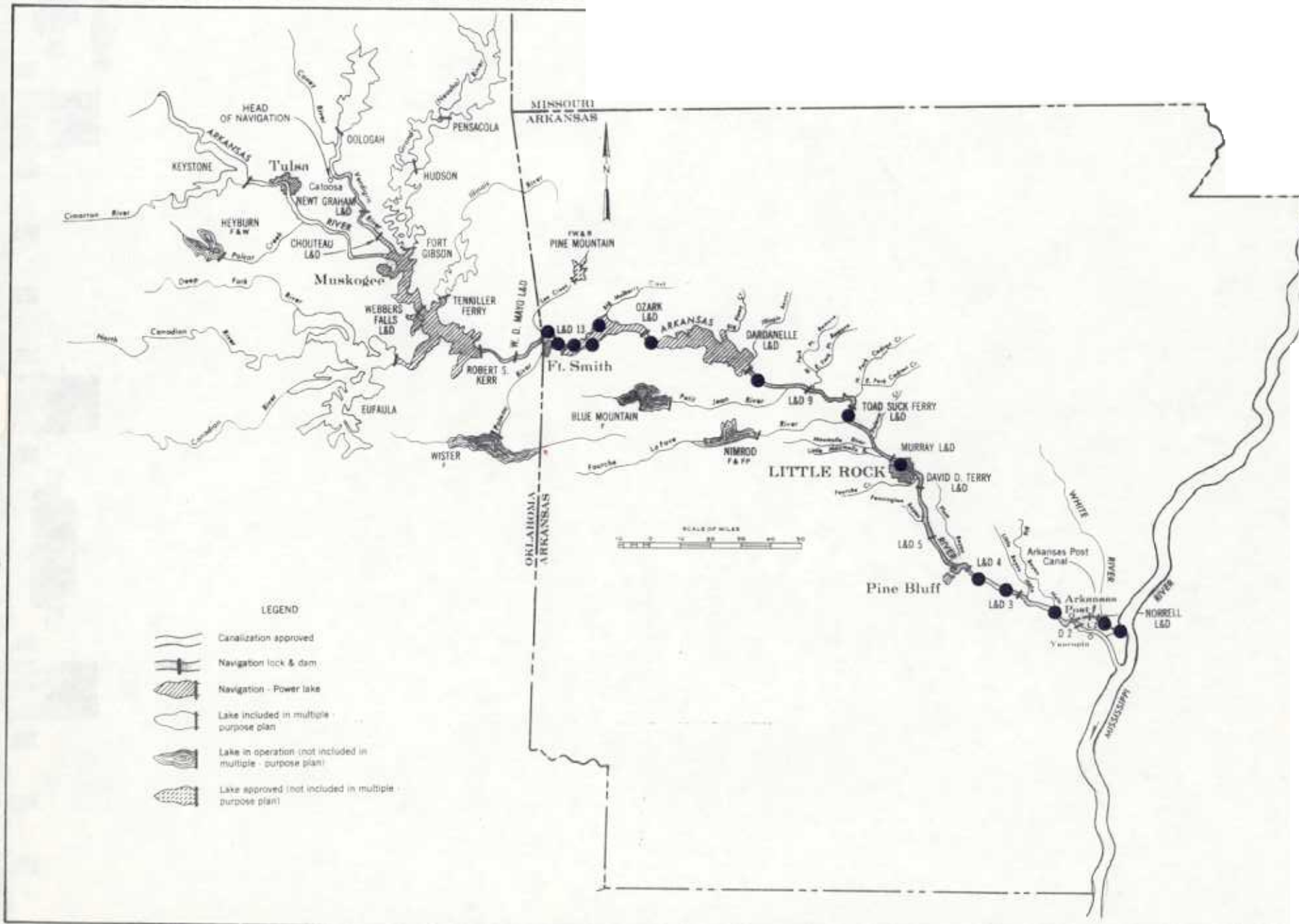
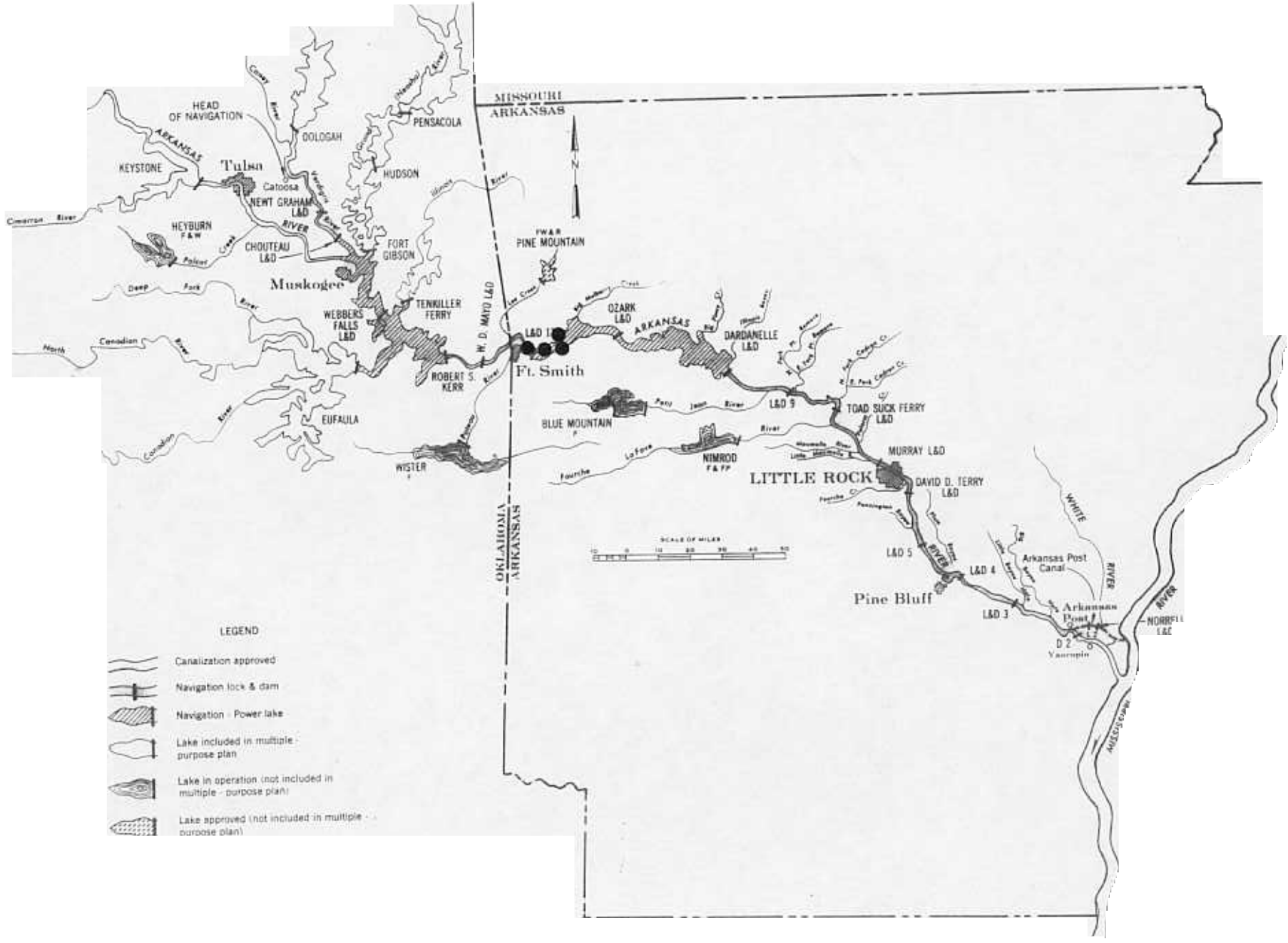
MAP 27. Emerald Shiner – *Notropis atherinoides*



MAP 28. River Shiner – *Notropis blennius*



MAP 29. Bigeye Shiner – *Notropis boops*



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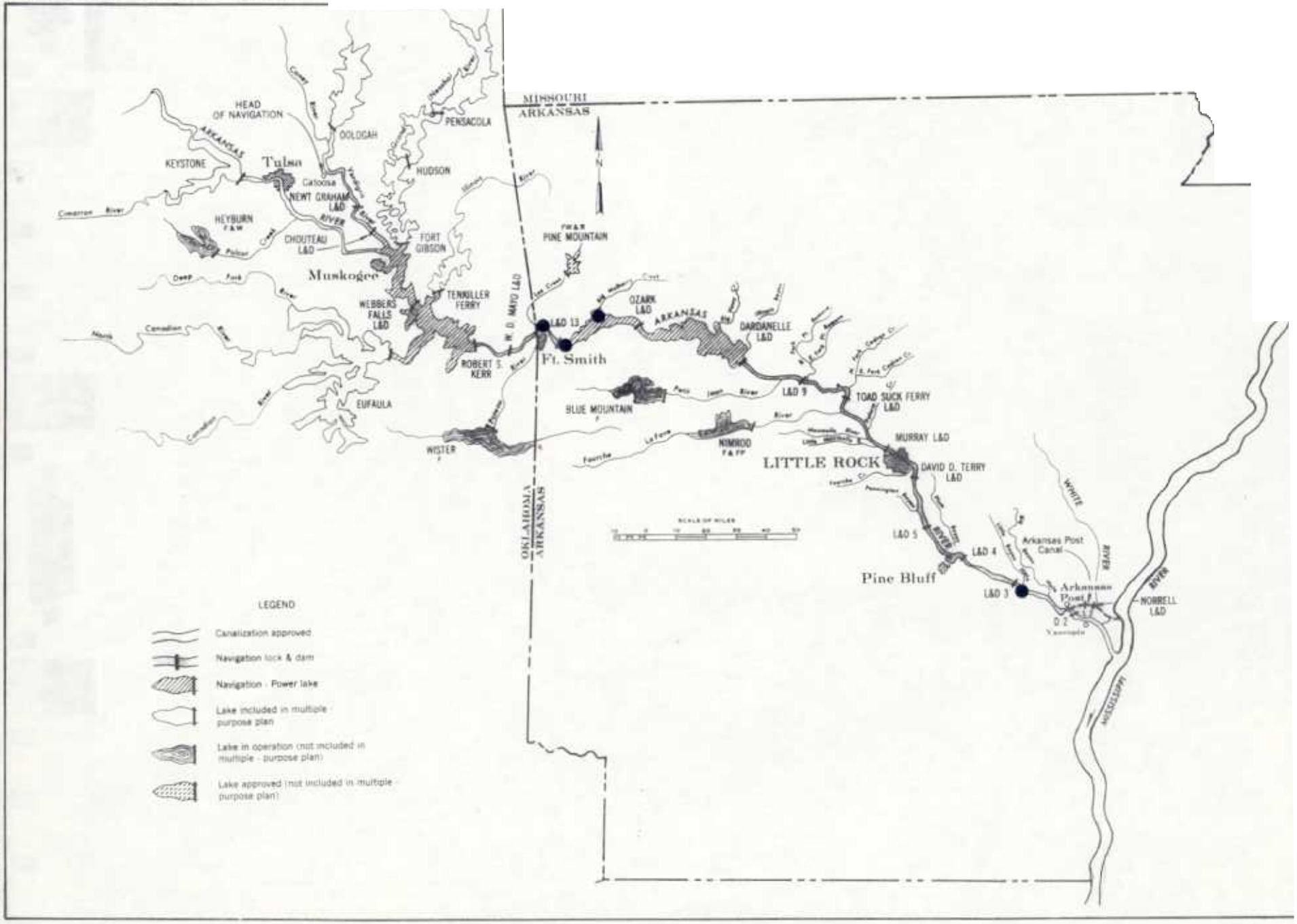
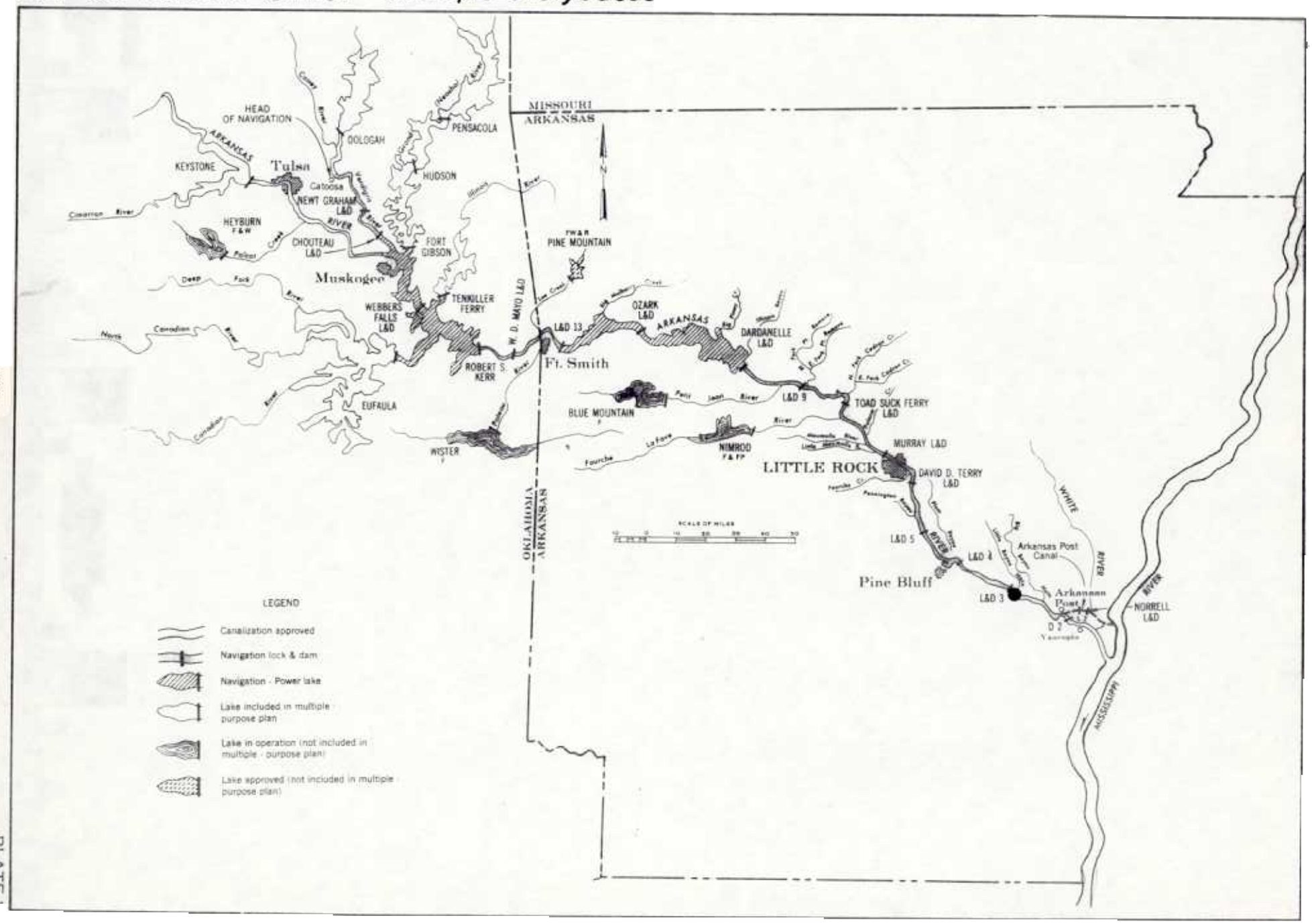
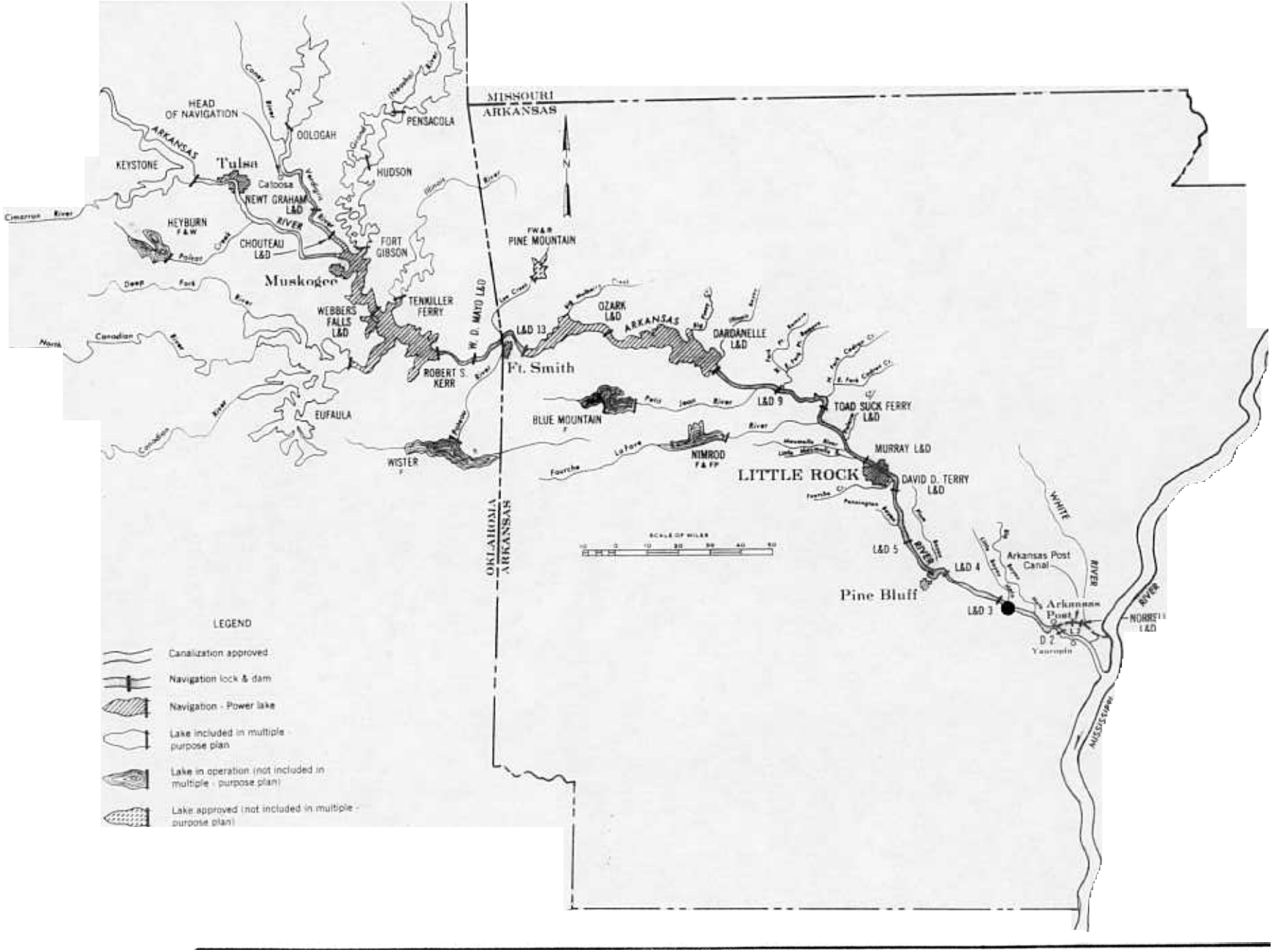
MAP 30. Ghost Shiner -



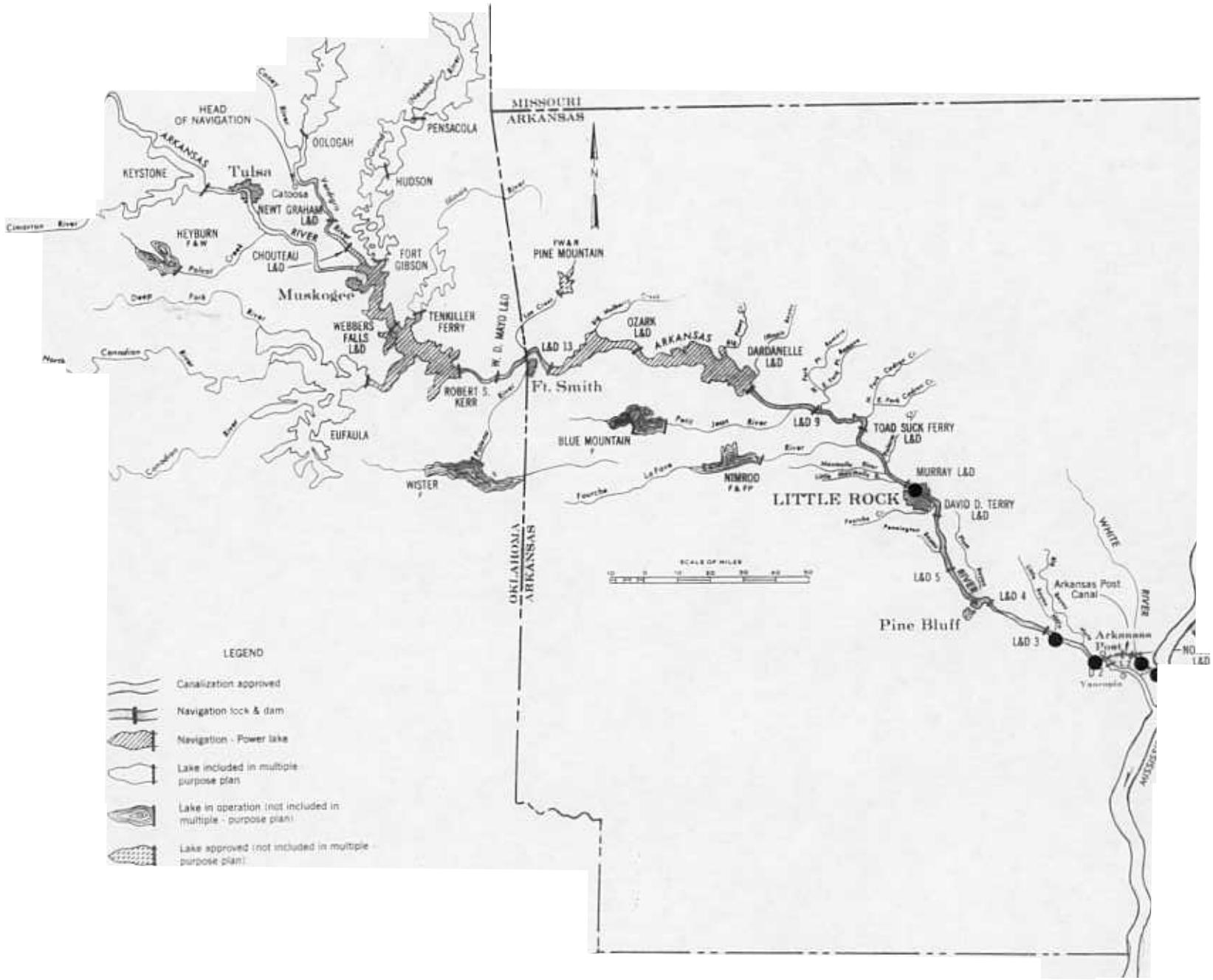
MAP 31. Ironcolor Shiner – *Notropis chalybaeus*



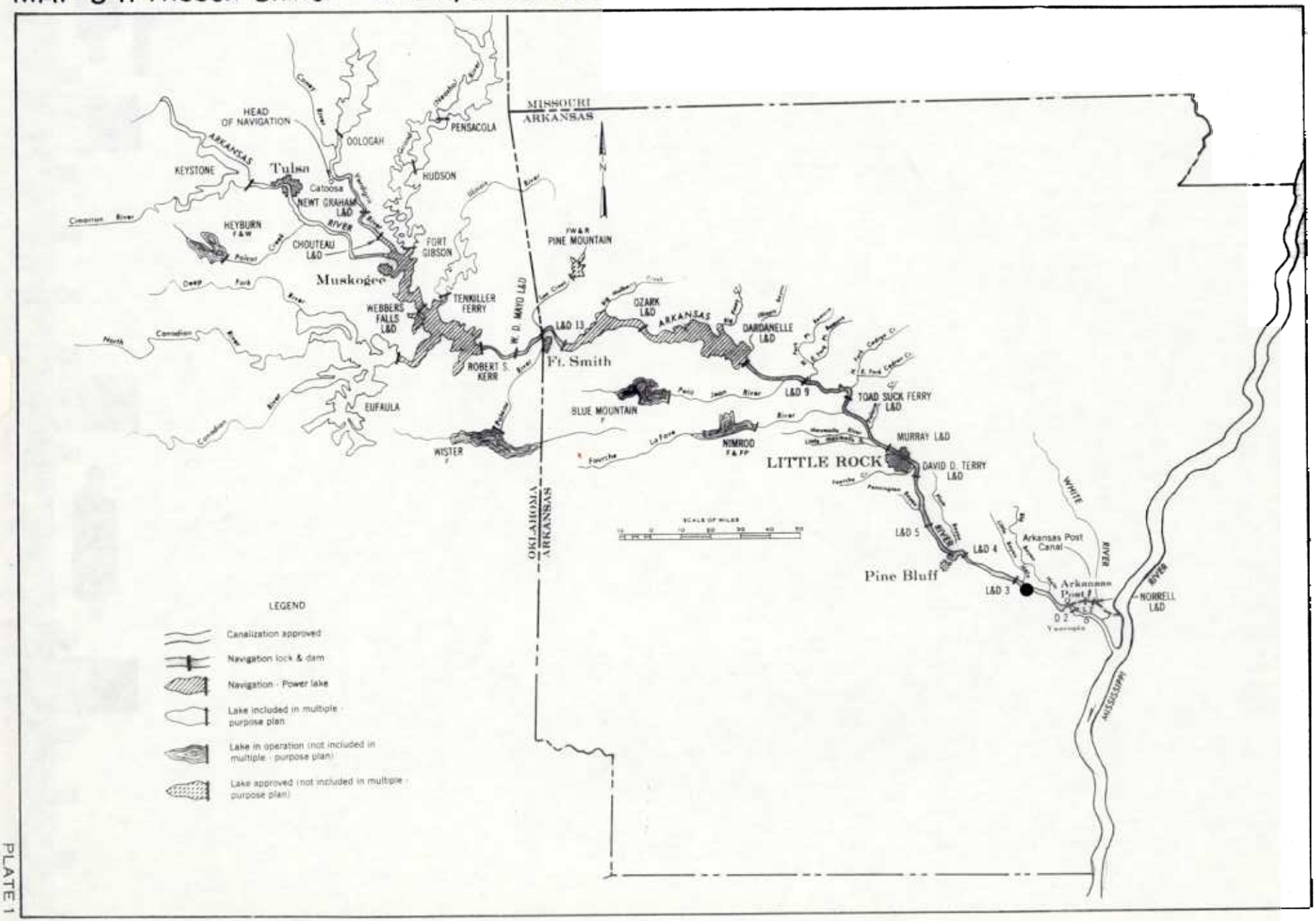
MAP 32. Striped Shiner – *Notropis chrysocephalus*



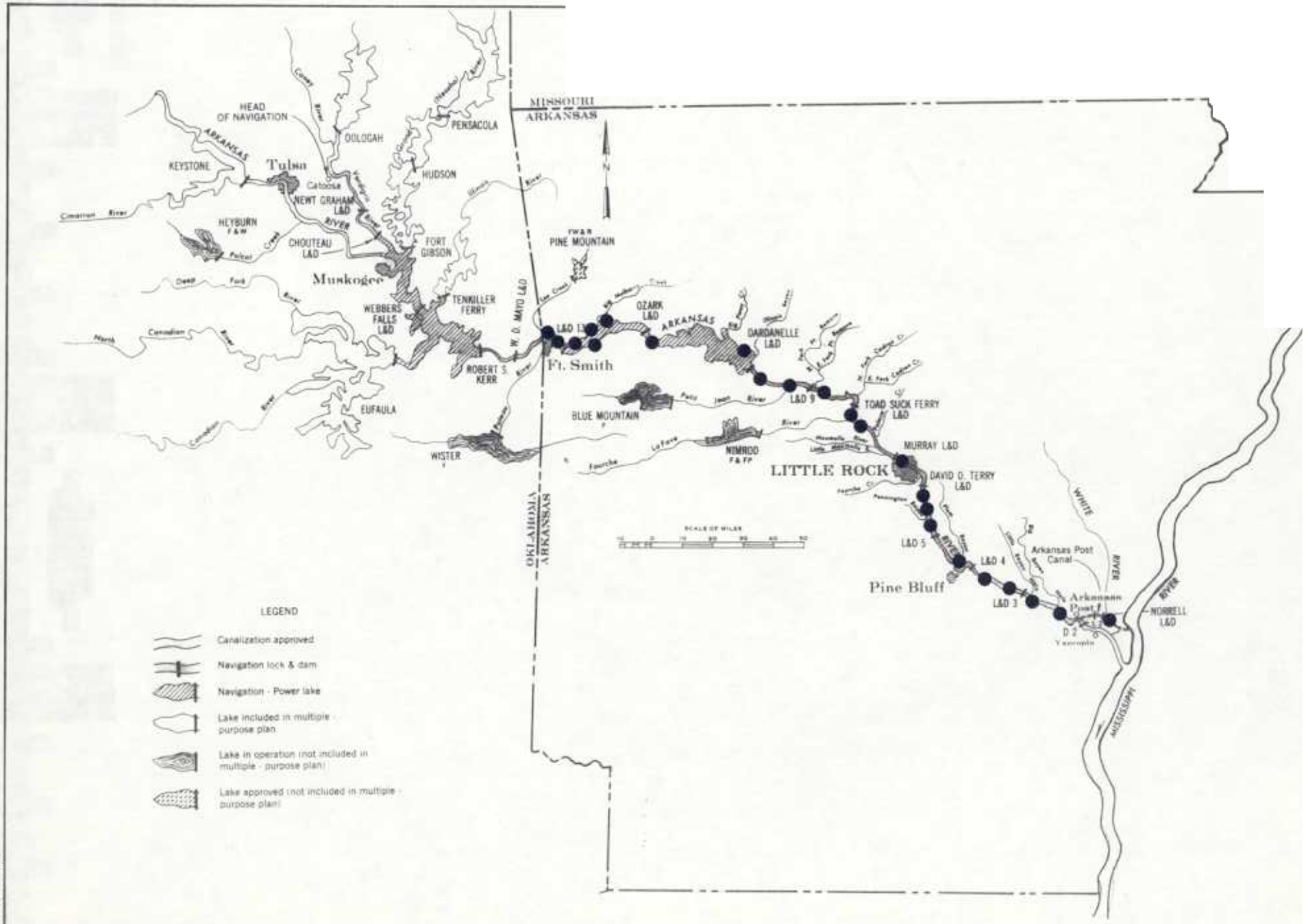
MAP 33. Pugnose minnow - *Notropis emiliae*



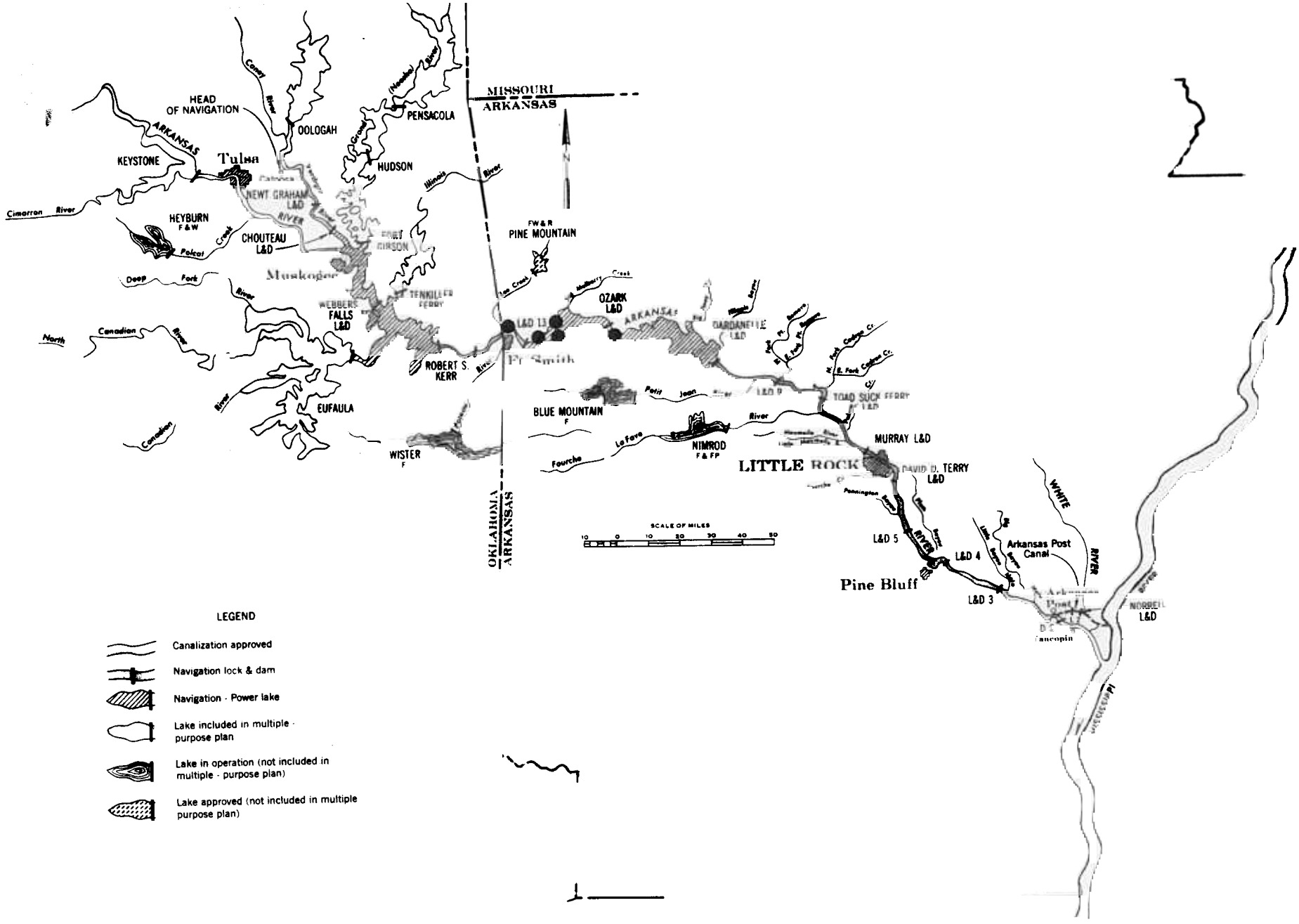
MAP 34. Ribbon Shiner – *Notropis fumeus*



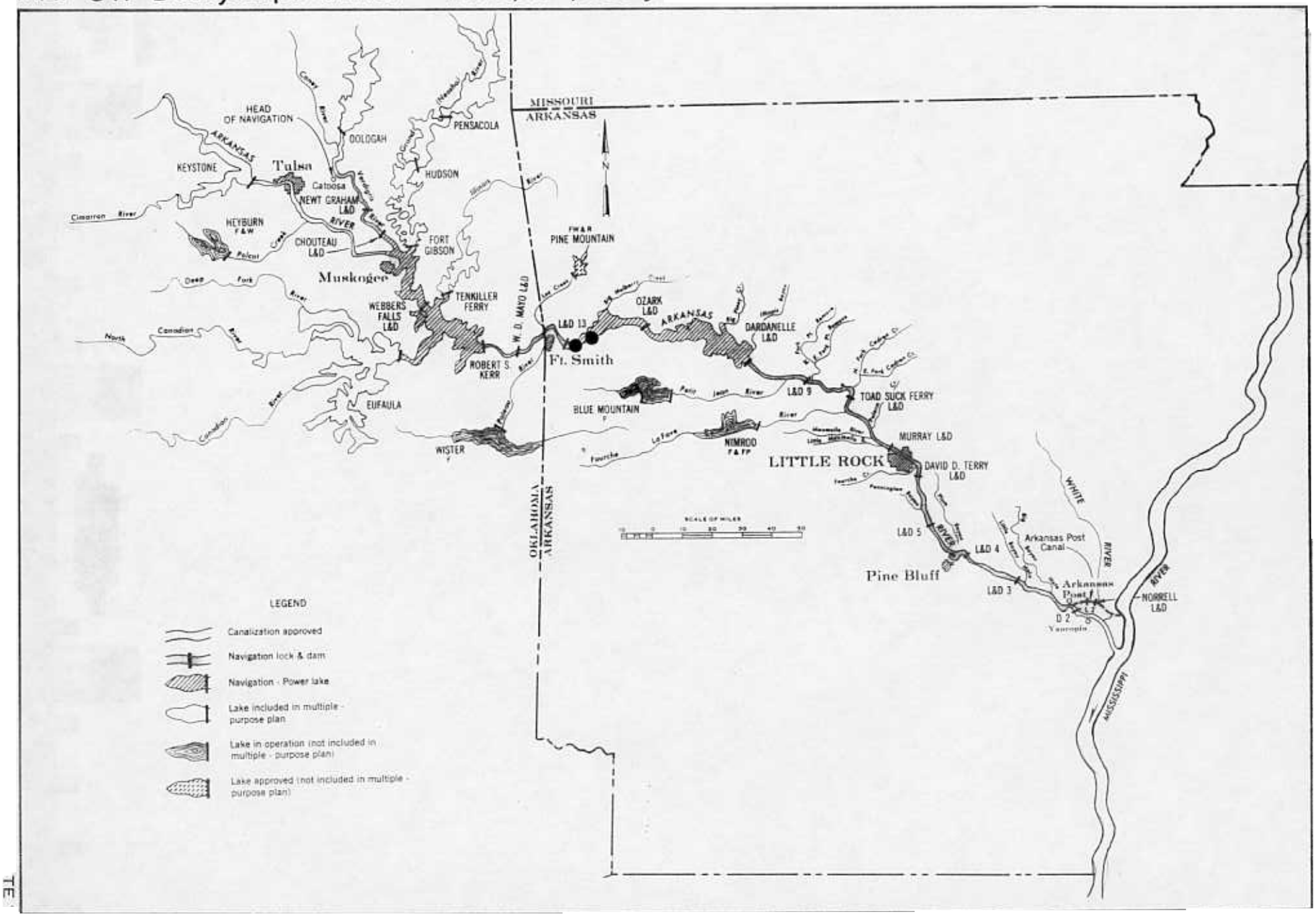
MAP 35. Red Shiner – *Notropis lutrensis*



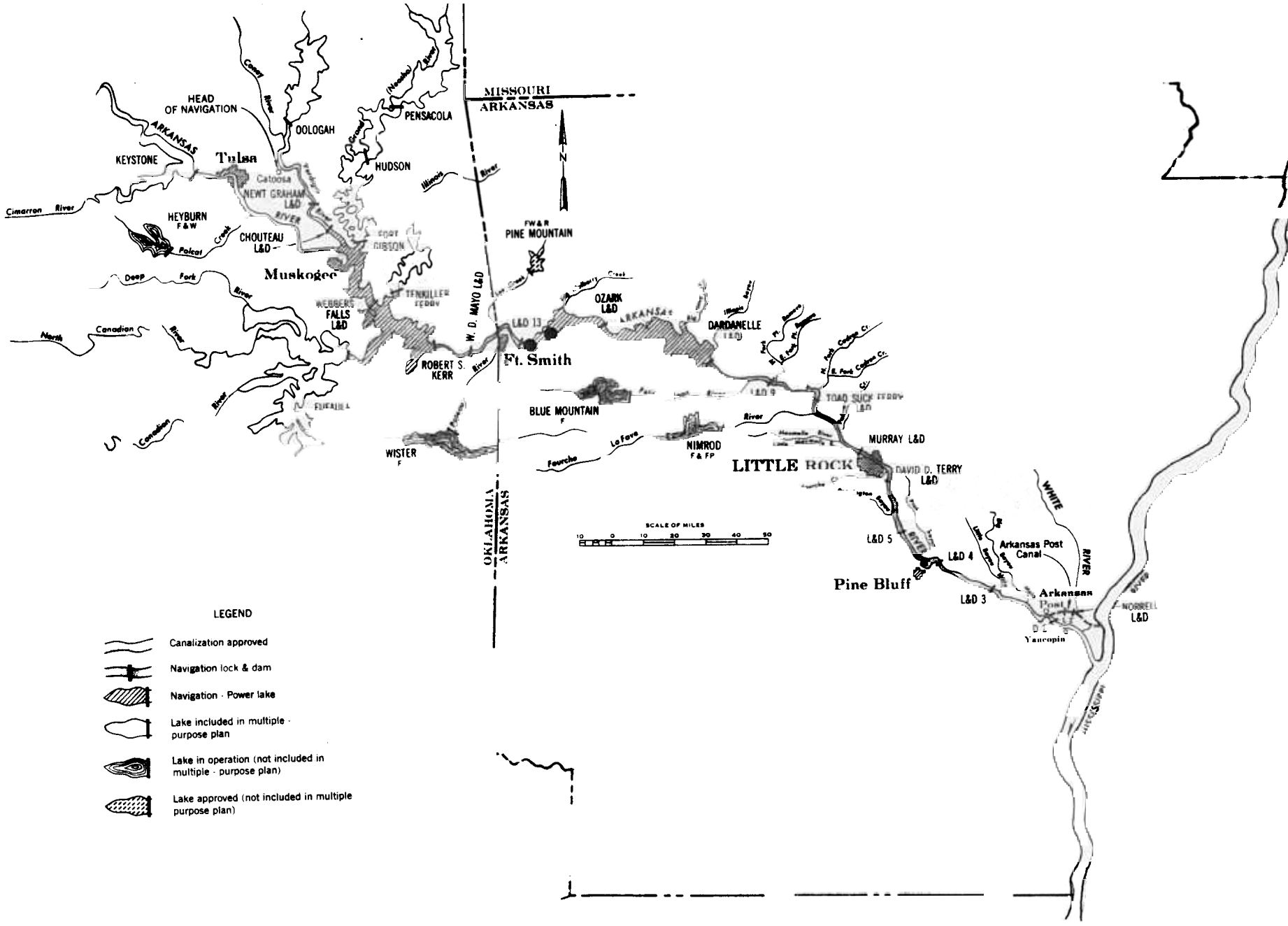
MAP 36. Plains Shiner – *Notropis percobromus*



MAP 37. Duskystripe Shiner – *Notropis pilsbryi*

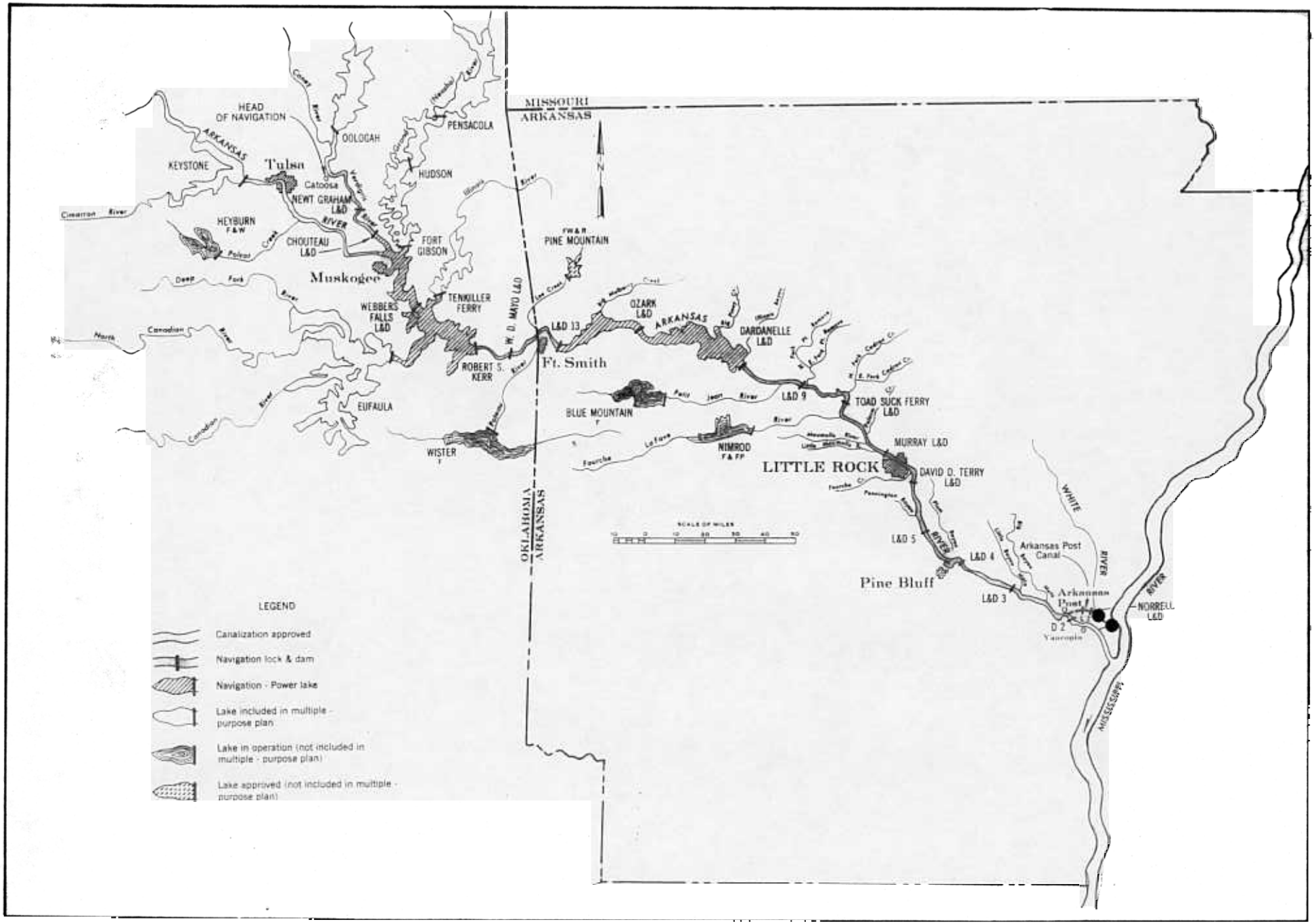


MAP 38 Silverband Shiner – *Notropis shumardi*

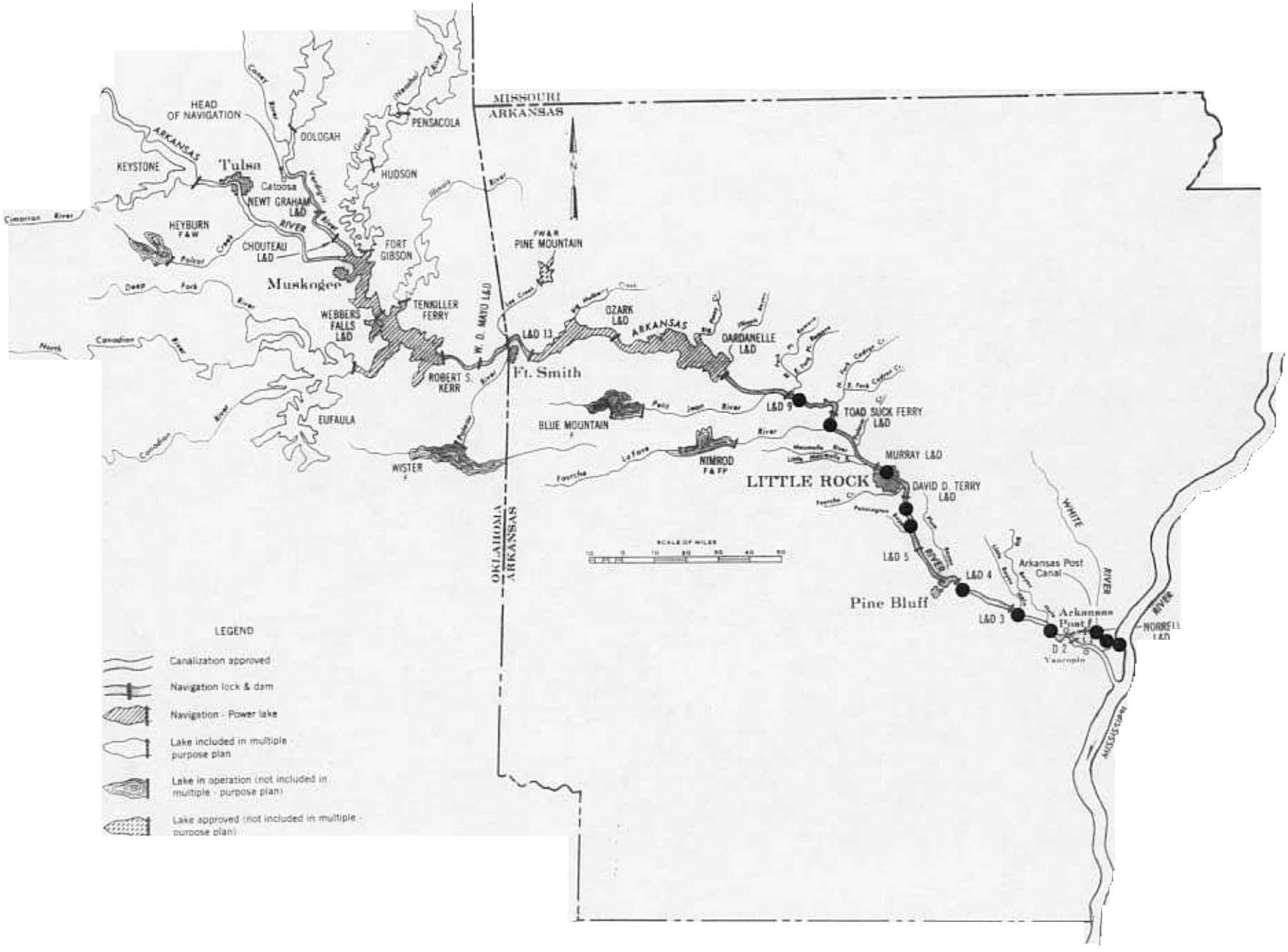


PLATE

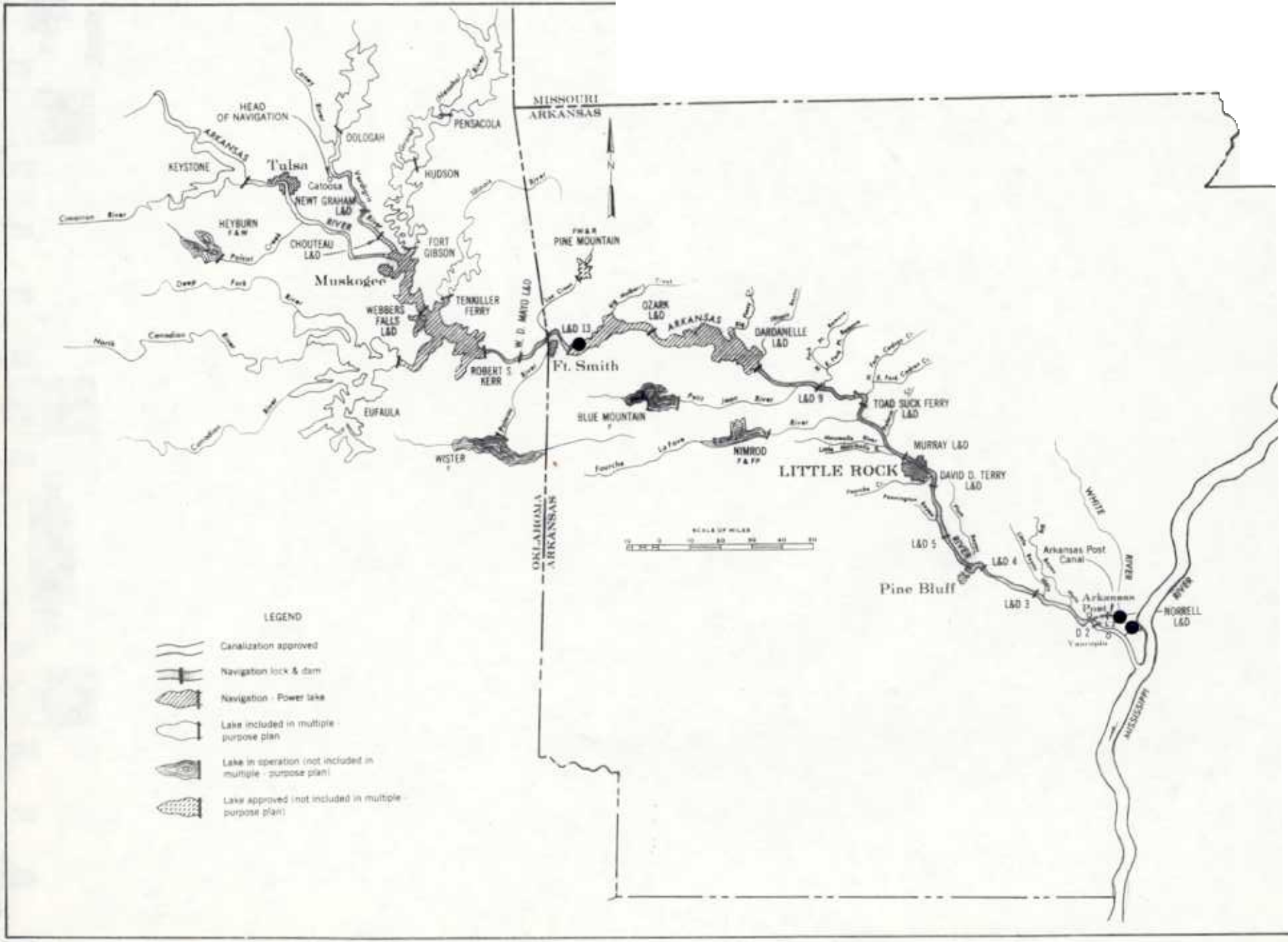
MAP 39. Weed Shiner – *Notropis texanus*



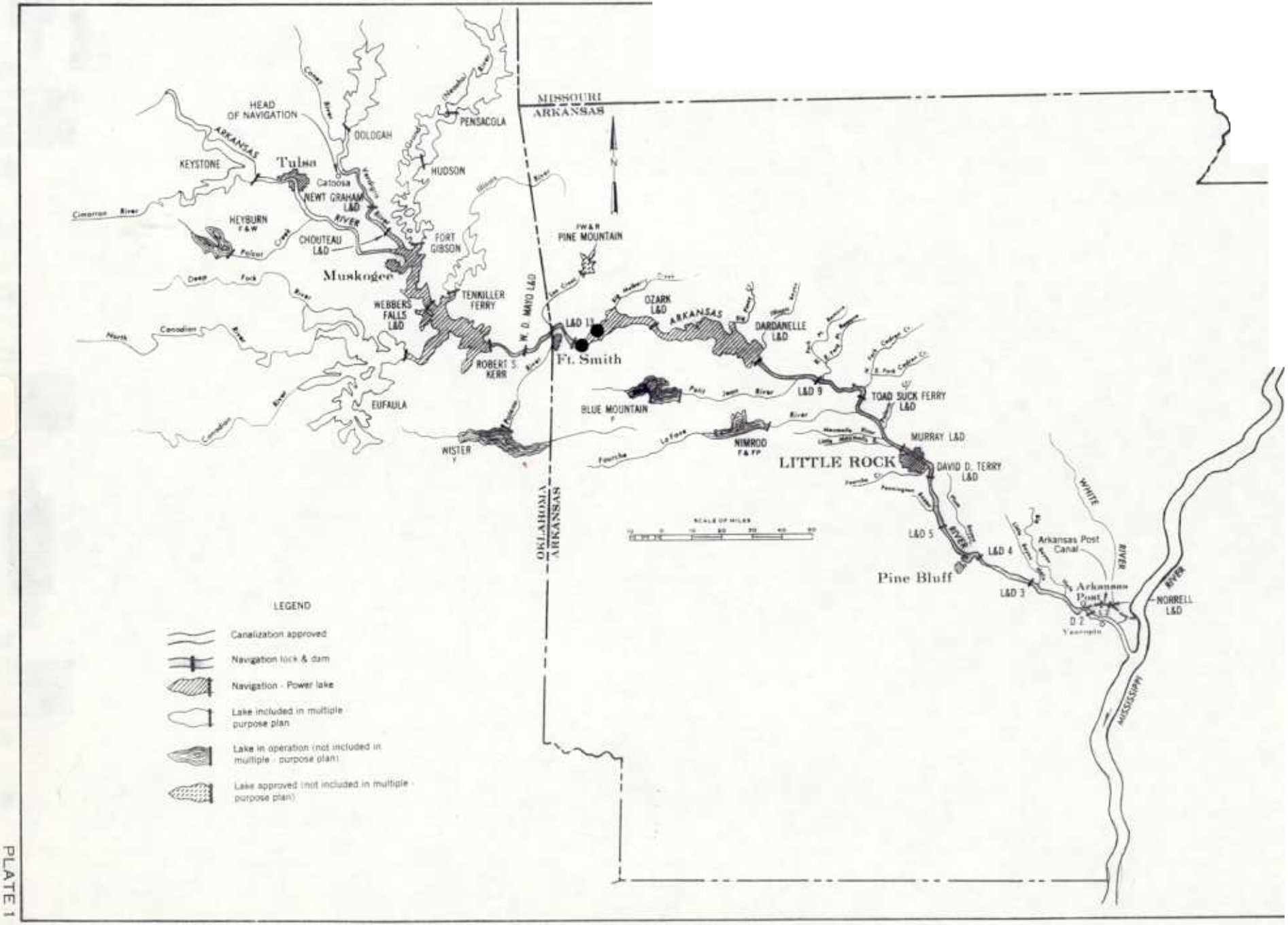
MAP 40. Blacktai Shiner – *Notropis venustus*



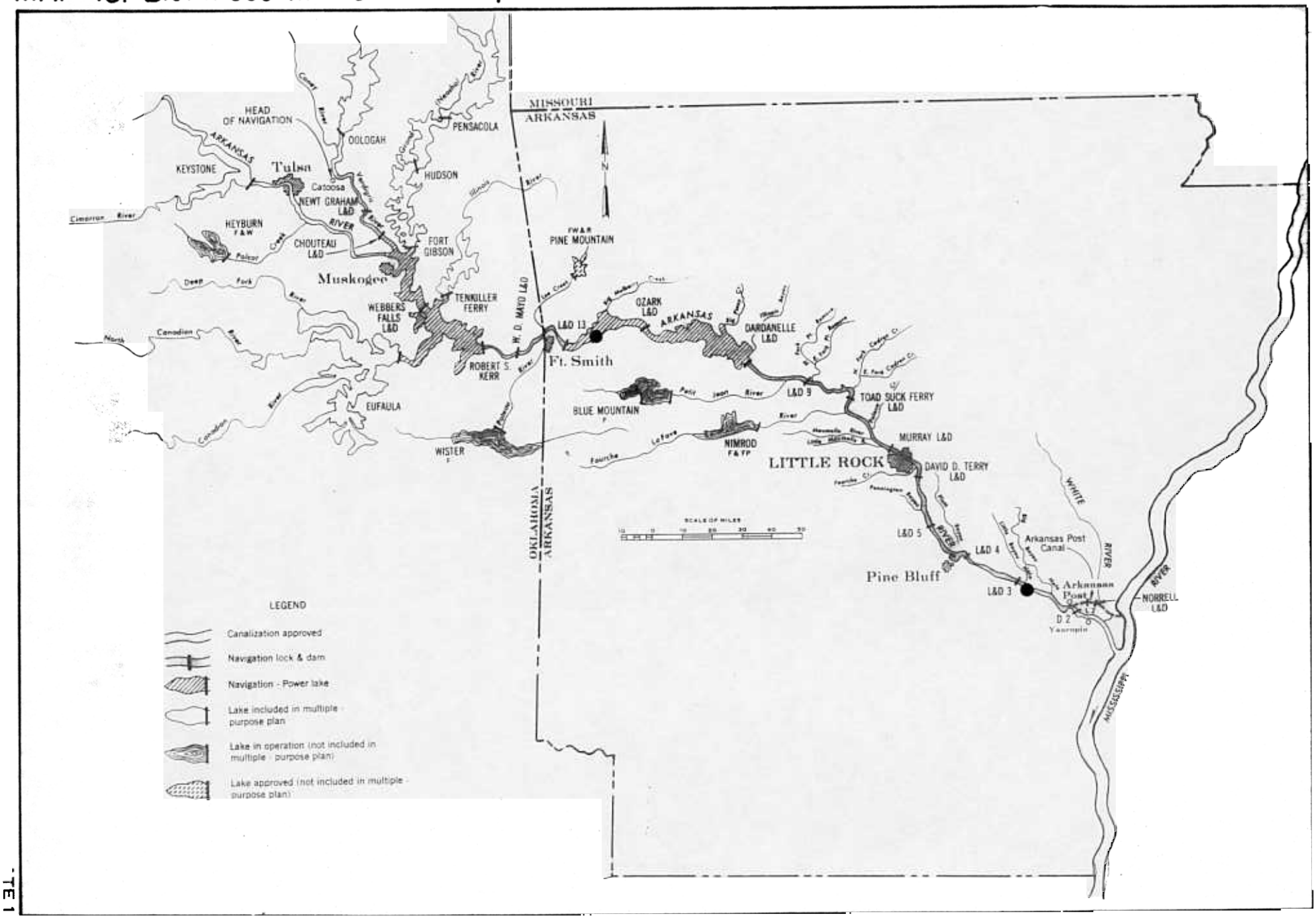
MAP 41. Mimic Shiner – *Notropis volucellus*



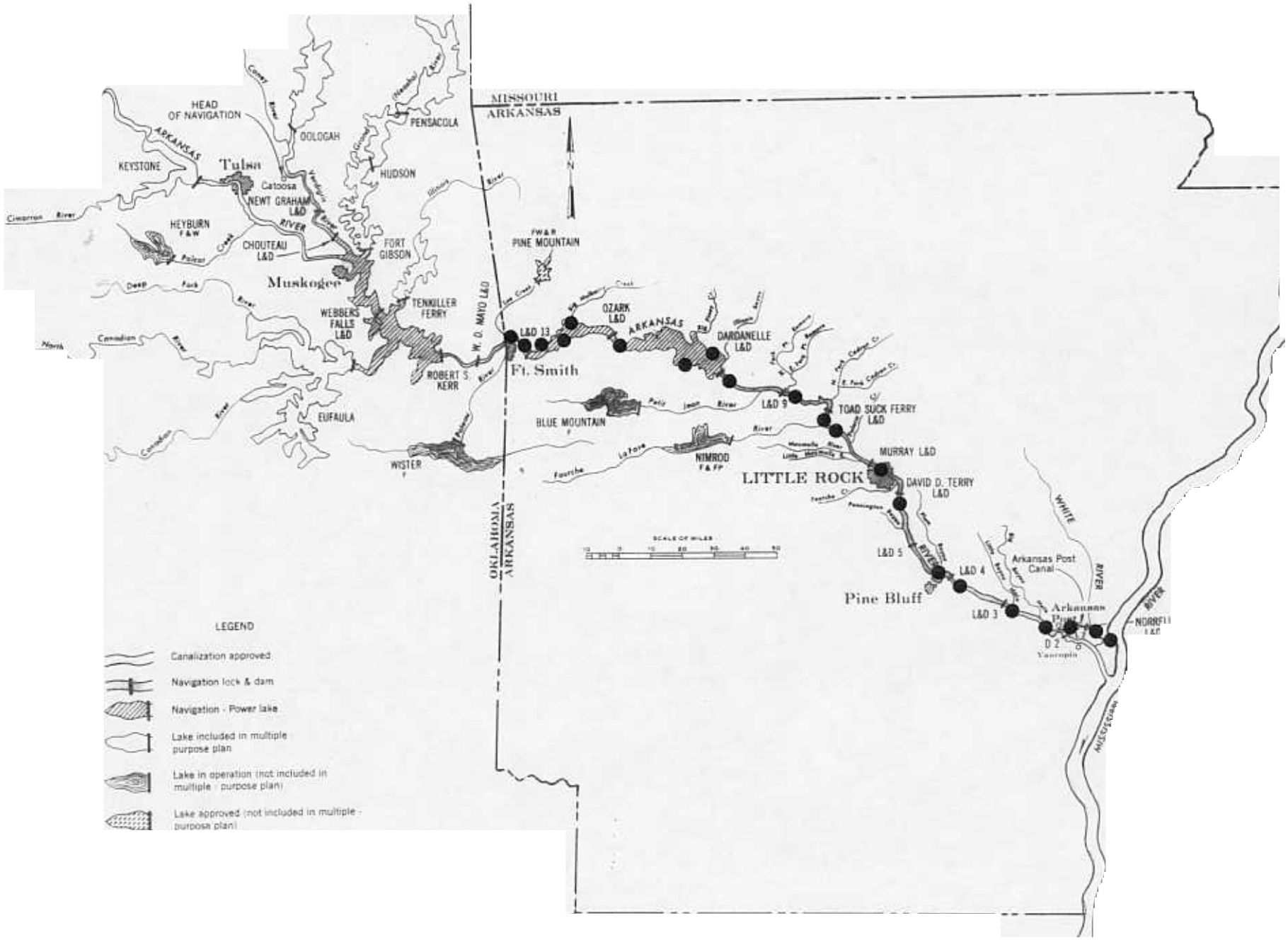
MAP 42. Steelcolor Shiner - *Notropis whipplei*



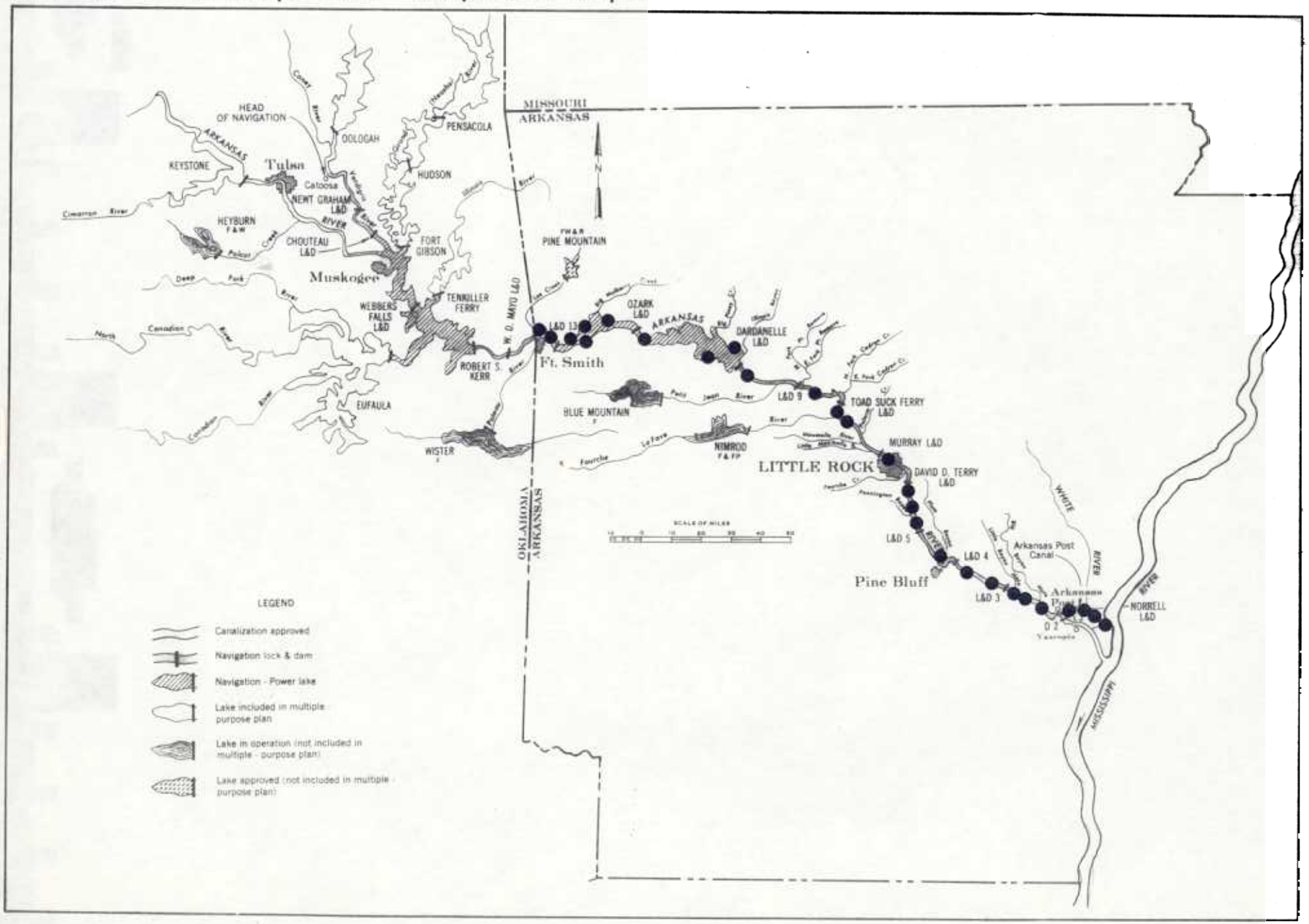
MAP 43. Bluntnose Minnow – *Pimephales notatus*



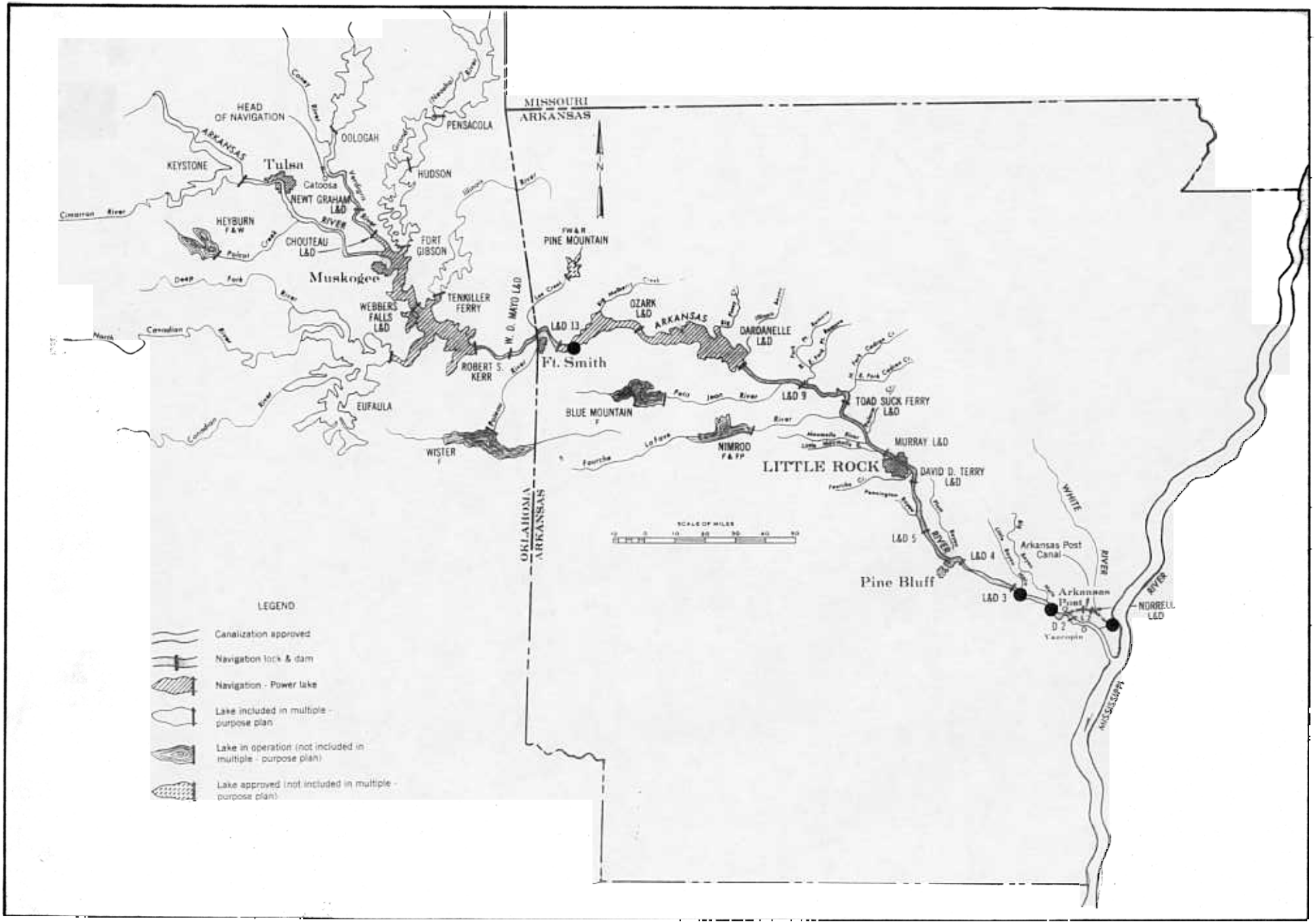
MAP 44. Bullhead Minnow – *Pimephales vigilax*



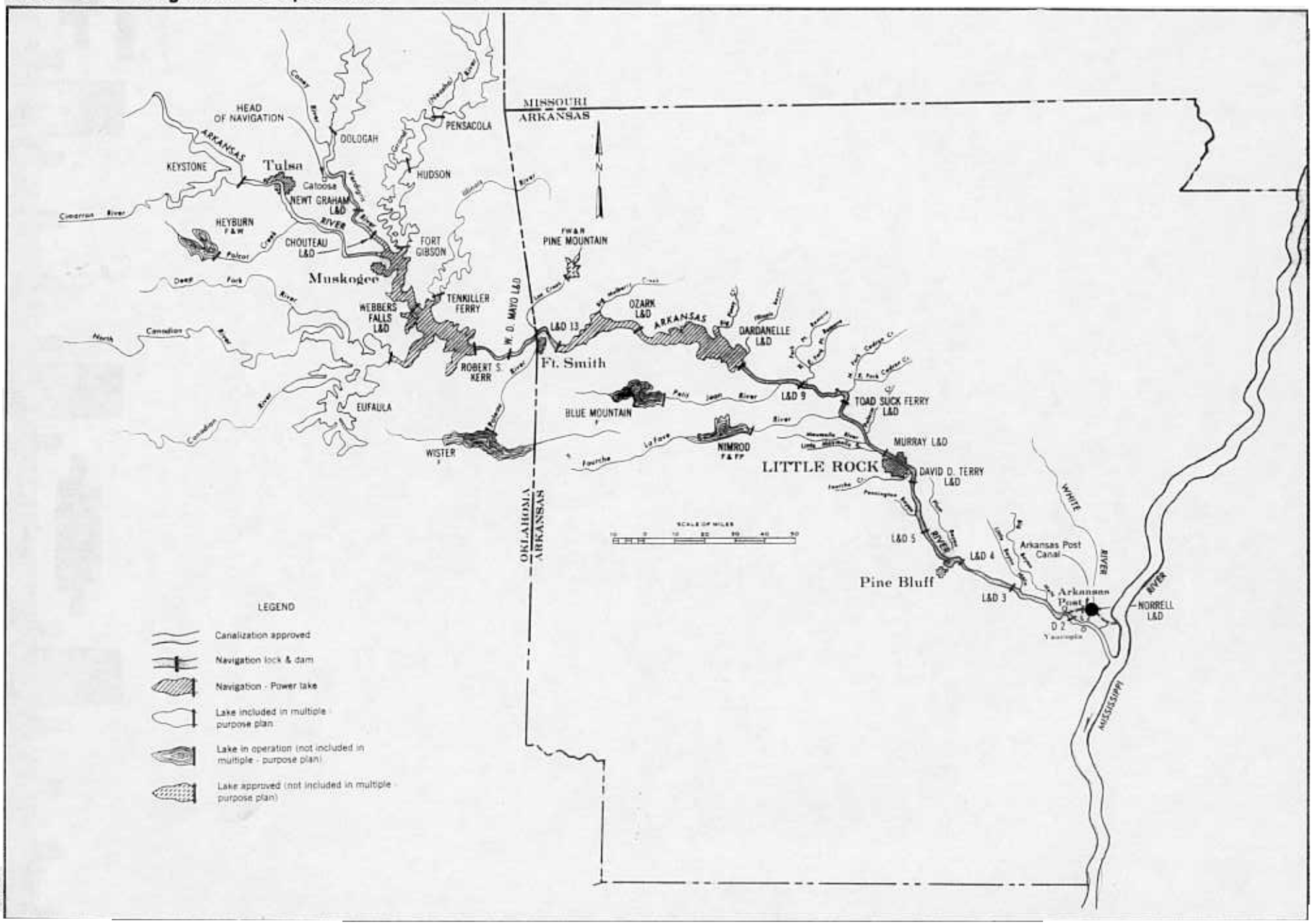
MAP 45. River Carpsucker – *Carpiodes carpio*



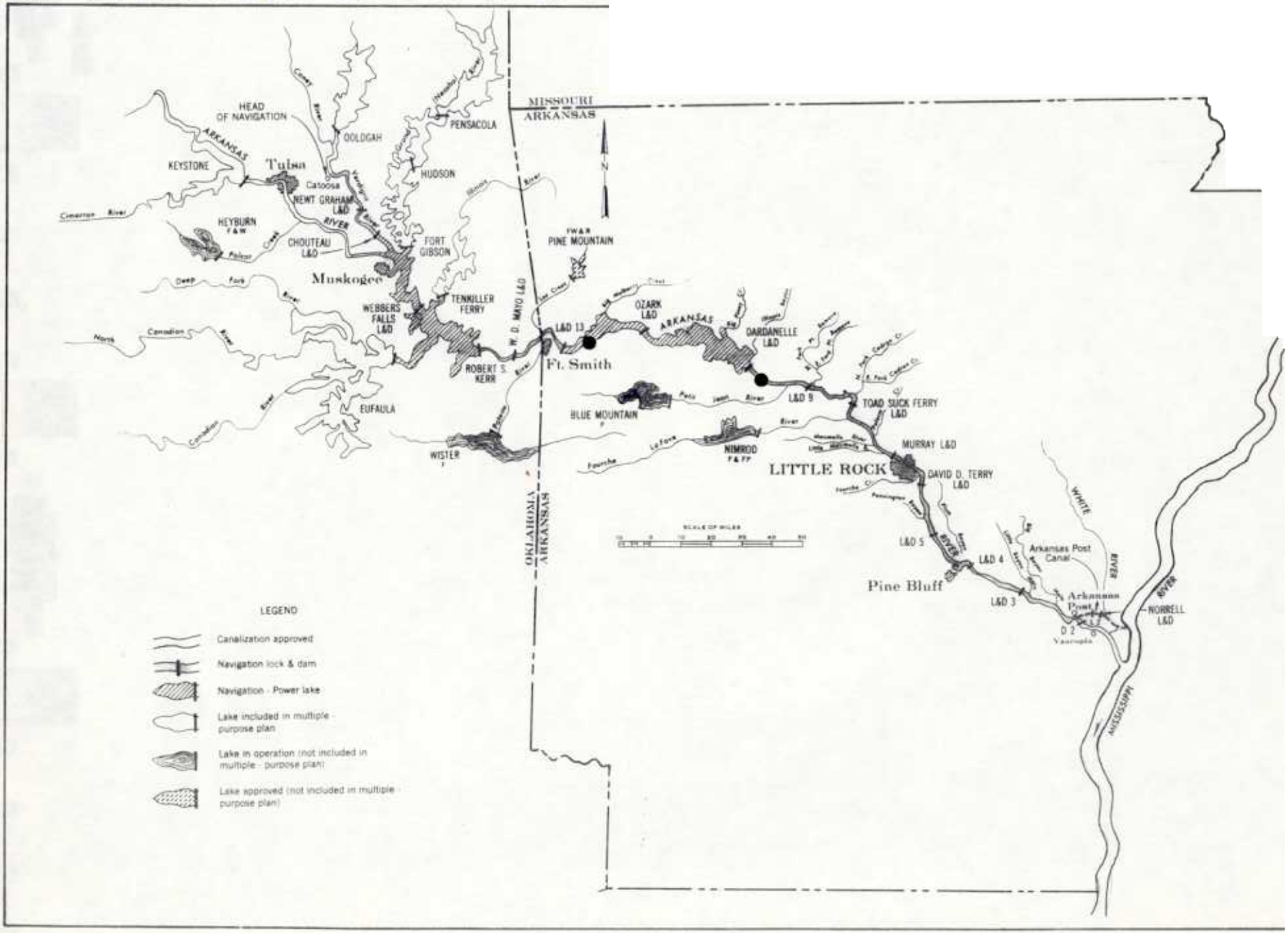
MAP 46 Quillback *Carpiodes cyprinus*



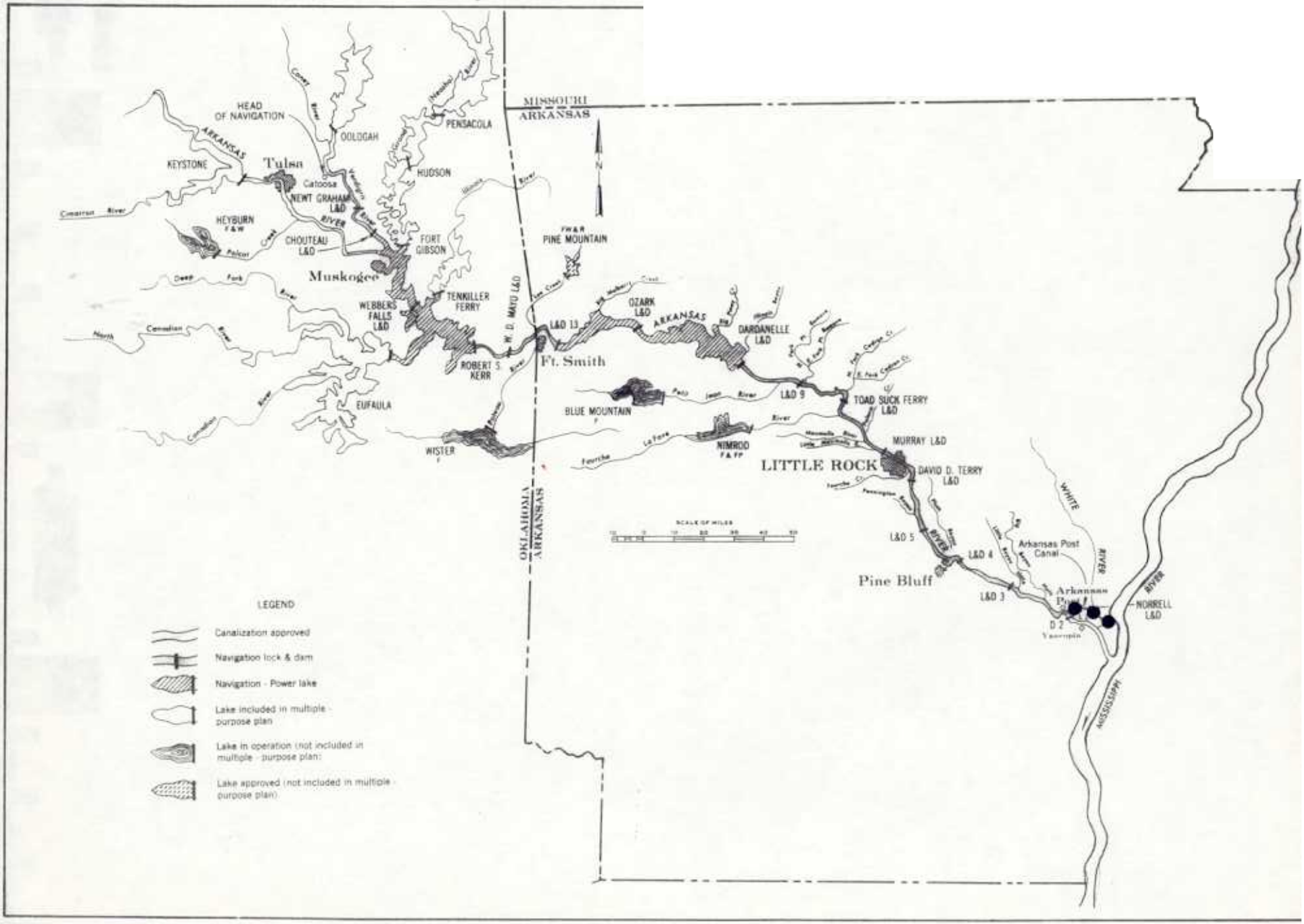
MAP 47. Highfin Carpsucker – *Carpiodes velifer*



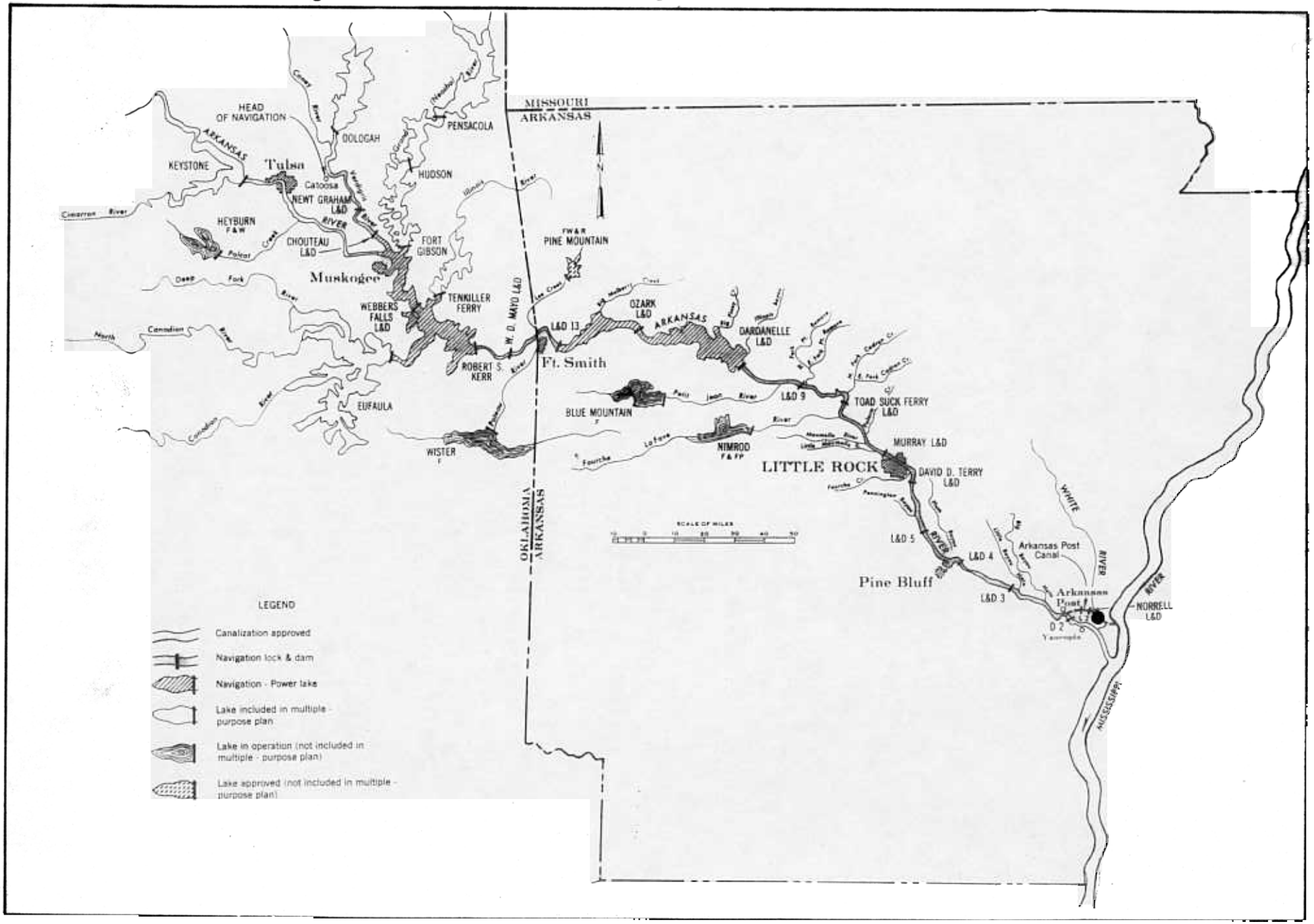
MAP 48. Blue Sucker – *Cycleptus elongatus*



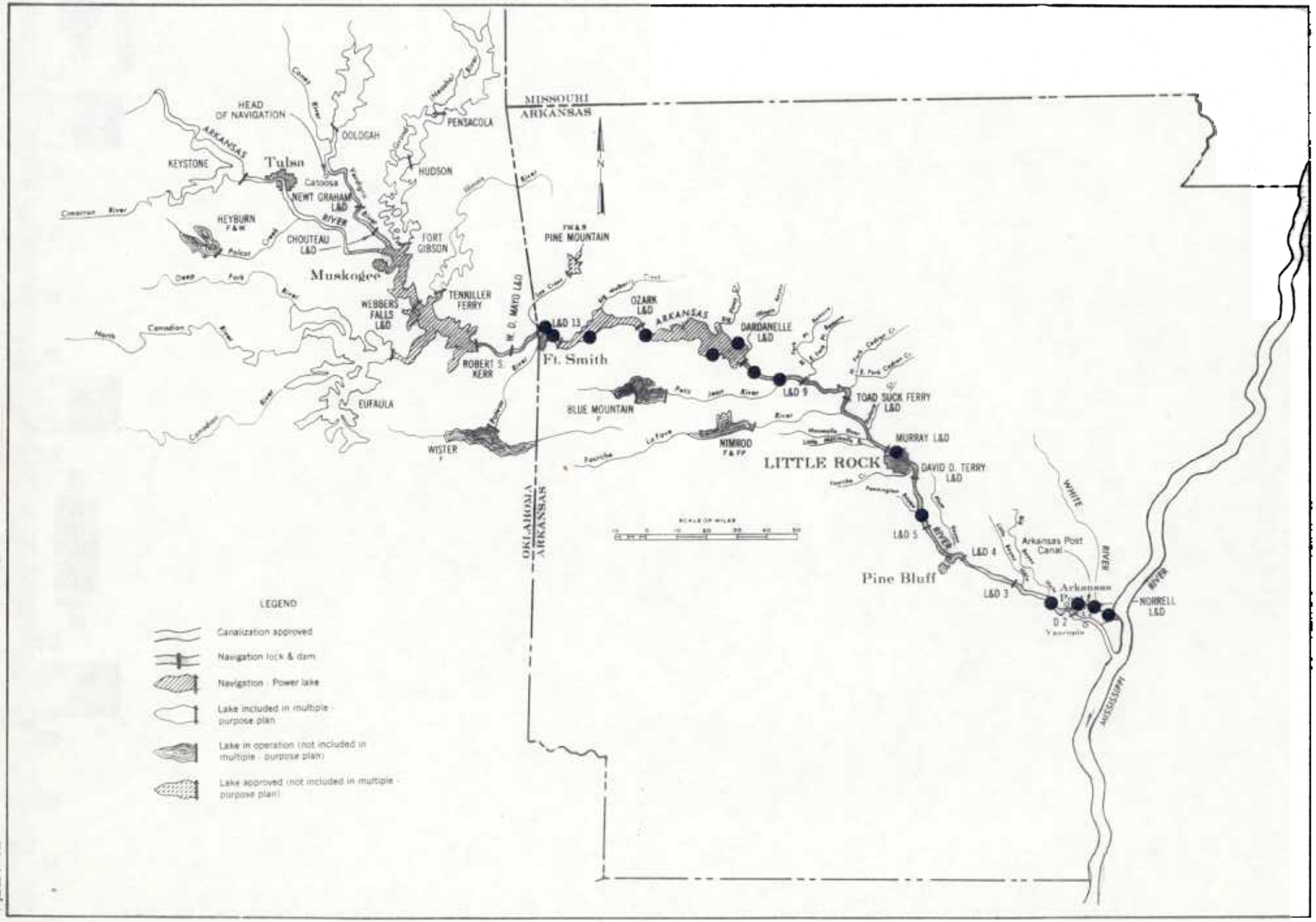
MAP 49. Lake Chubsucker – *Erimyzon sucetta*



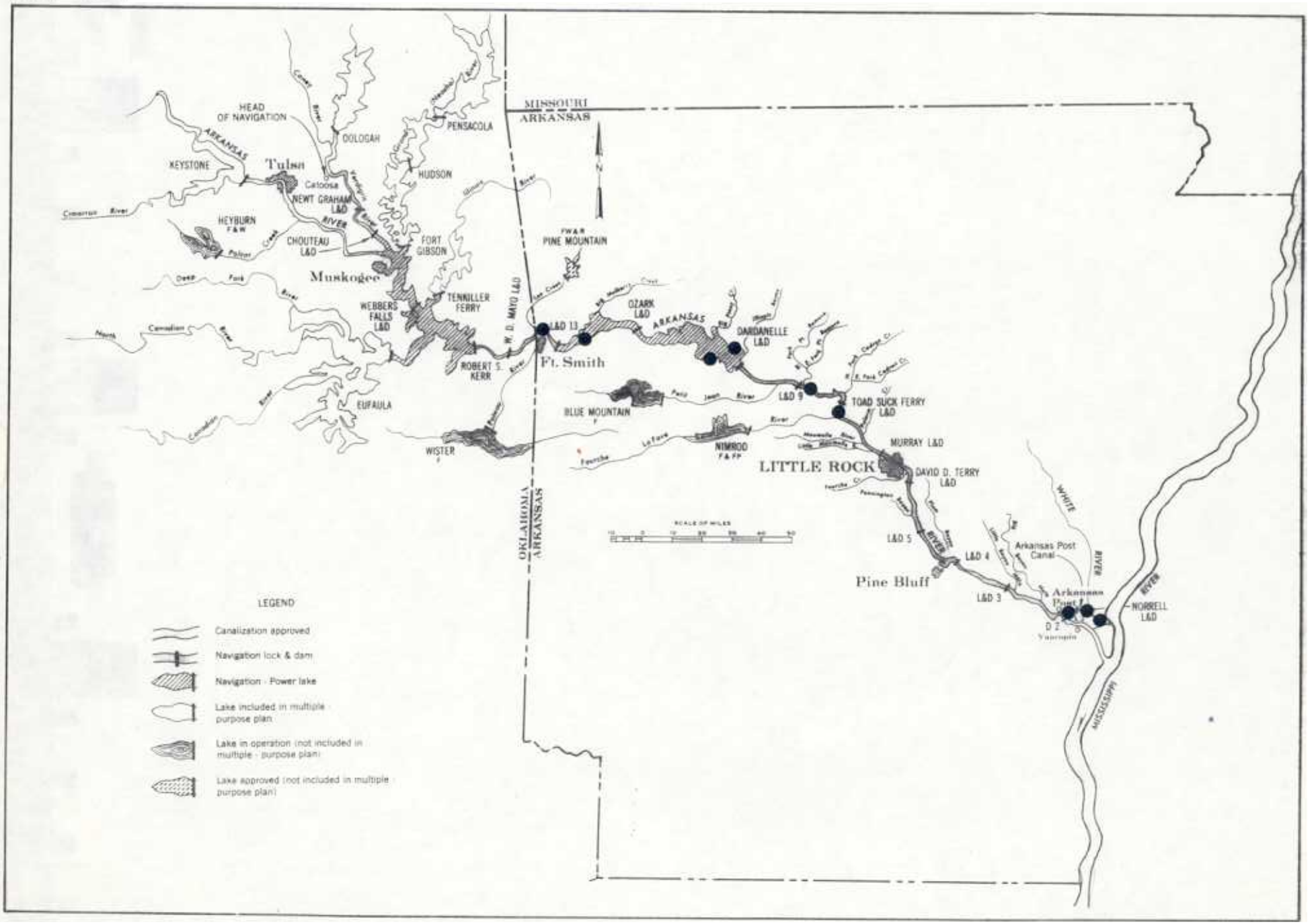
MAP 50 Northern Hogsucker – *Hypentelium nigricans*



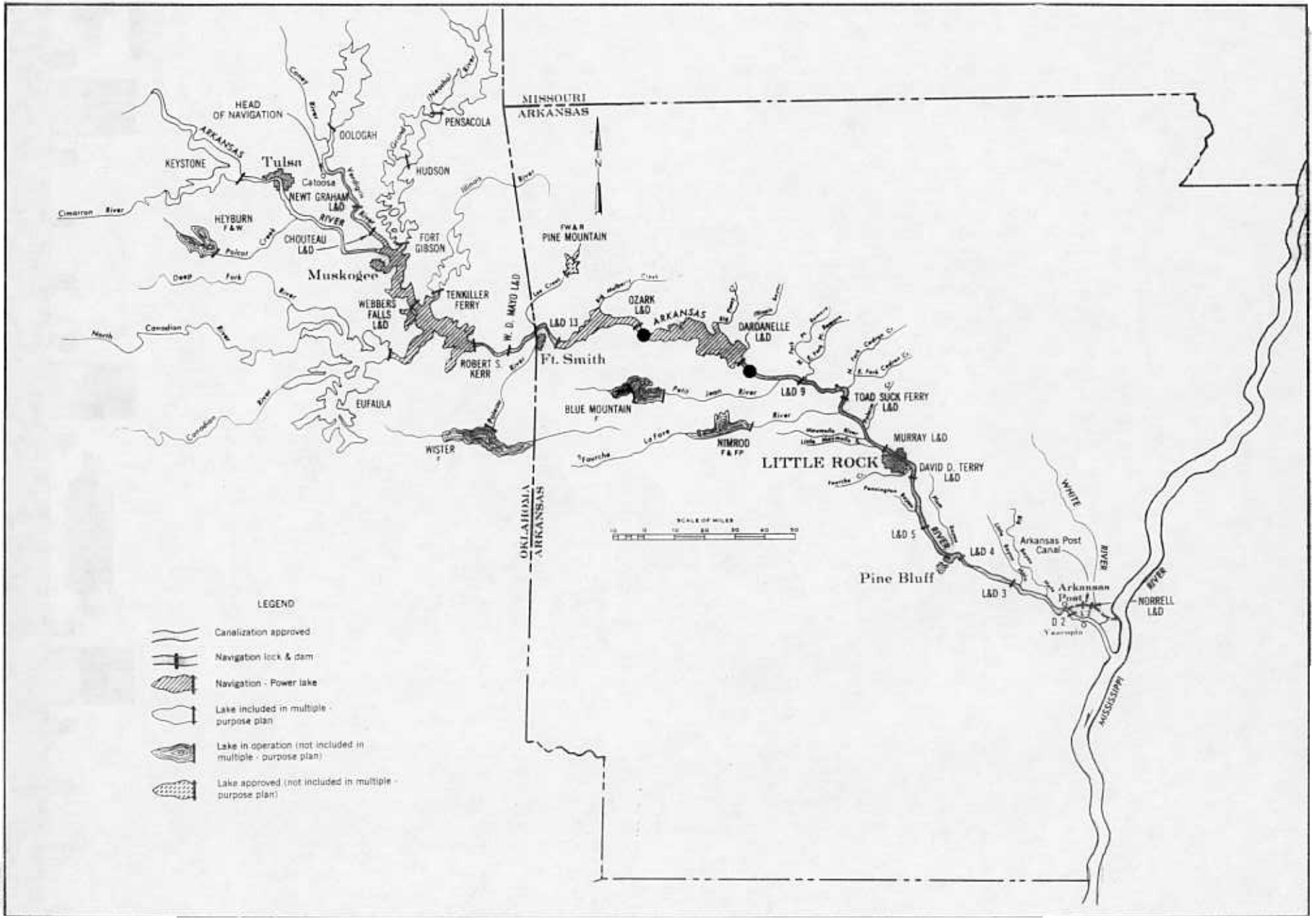
MAP 51. Smallmouth Buffalo – *Ictiobus bubalus*



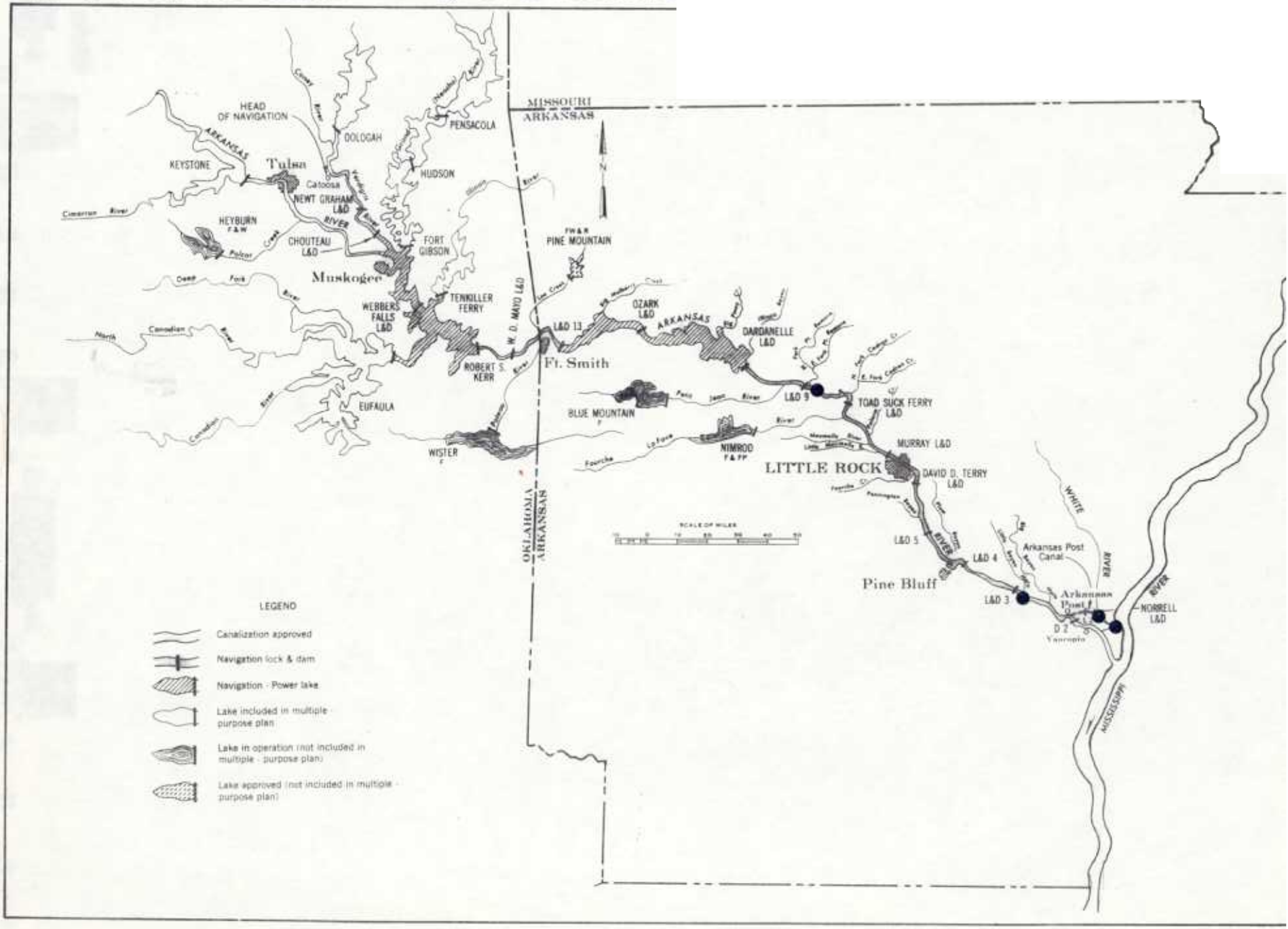
MAP 52.


MISSOURI
ARKANSAS
HEAD OF NAVIGATION
ARKANSAS
KEYSTONE
Tulsa
Catoosa
NEWT GRAHAM L&D
RIVER
HEYBURN F&W
CHOUTEAU L&D
Muskogee
FORT GIBSON
OOLOGAH
PENSACOLA
HUDSON
Verdigris River
Grand River
Neosho River
Illinois River
Cimarron River
Deep Fork River
Canadian River
North Canadian River
WEBBERS FALLS L&D
TENKILLER FERRY
ROBERT S. KERR
EUFAULA
WISTER
FWA PINE MOUNTAIN
W. D. MAYO L&D
L&D 13
Ft. Smith
OZARK L&D
ARKANSAS
DARDANELLE L&D
L&D 9
TOAD SUCK FERRY L&D
BLUE MOUNTAIN
NIMROD F&FP
Petit Jean River
Fourche La Fave River
MURRAY L&D
LITTLE ROCK
DAVID D. TERRY L&D
Fourche Creek
Pennington Bayou
L&D 5
Pine Bluff
L&D 4
L&D 3
Arkansas Post Canal
Arkansas Post
WHITE RIVER
NORRELL L&D
MISSISSIPPI RIVER
OKLAHOMA
ARKANSAS
SCALE OF MILES
LEGEND
Canalization approved
Navigation lock & dam
Navigation - Power lake
Lake included in multiple purpose plan
Lake in operation (not included in multiple - purpose plan)
Lake approved (not included in multiple purpose plan)

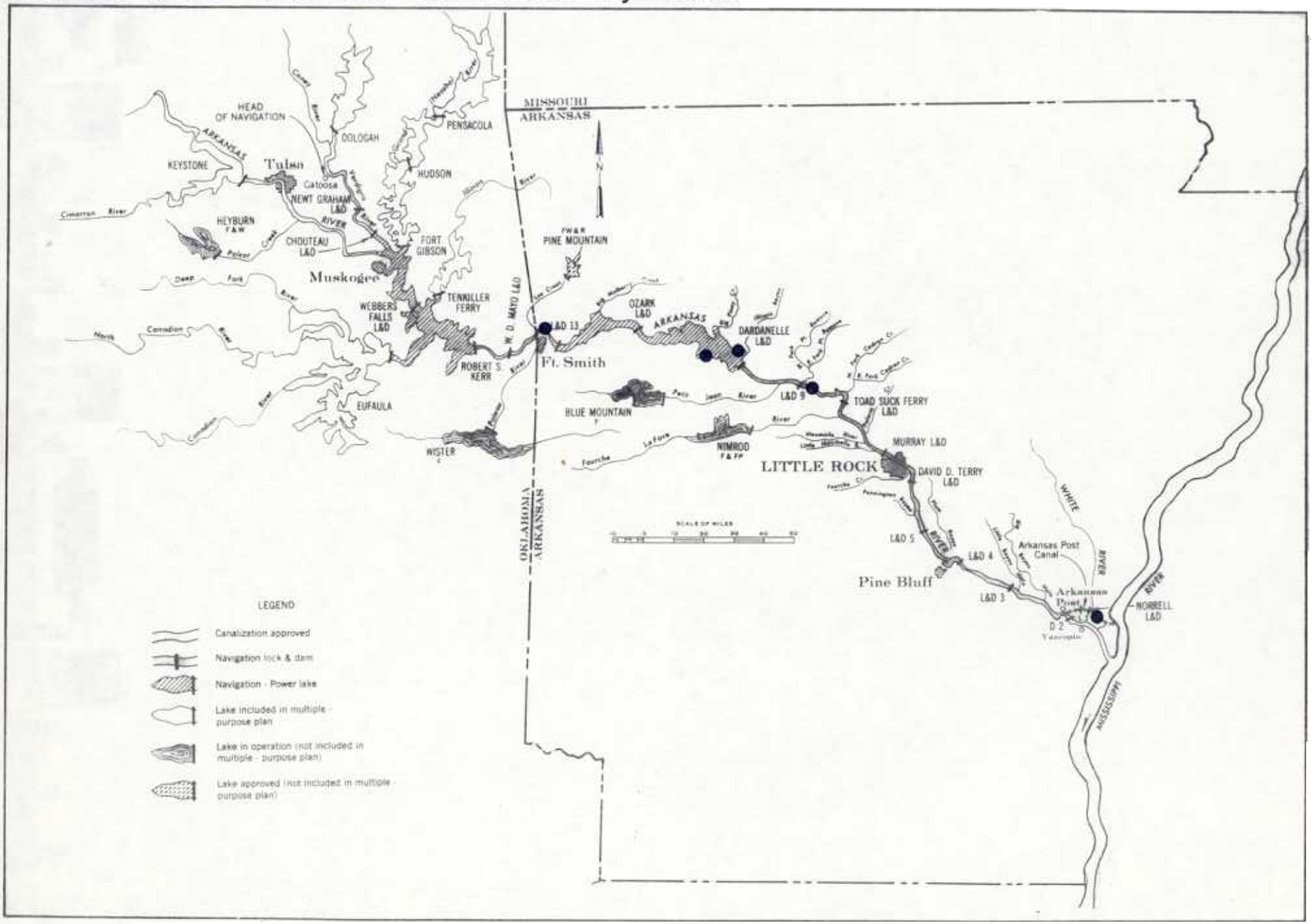
MAP 53 Black Buffalo - *Ictiobus niger*



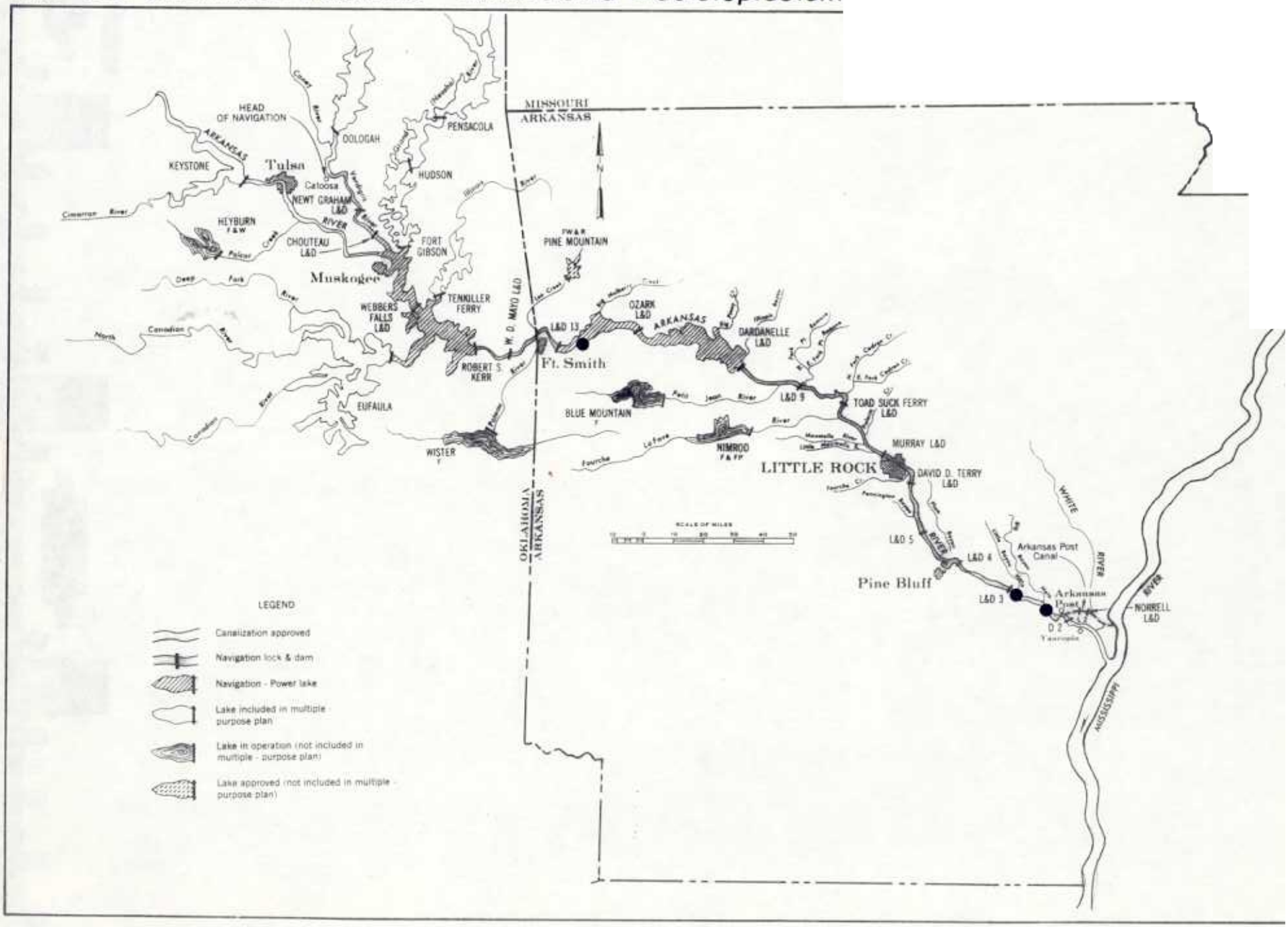
MAP 54. Spotted Sucker – *Minytrema melanops*



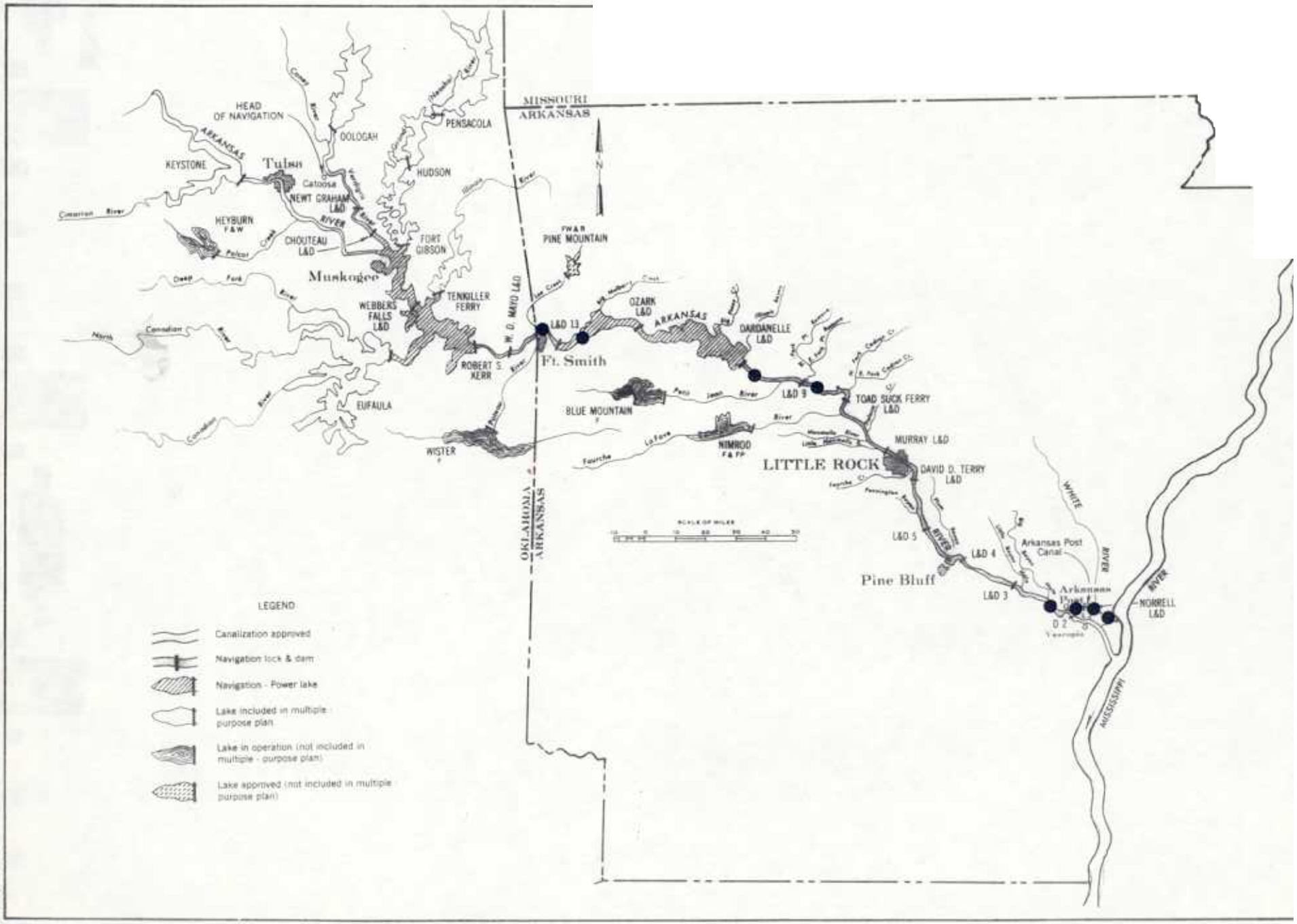
MAP 55. Golden Redhorse - *Moxostoma erythrurum*



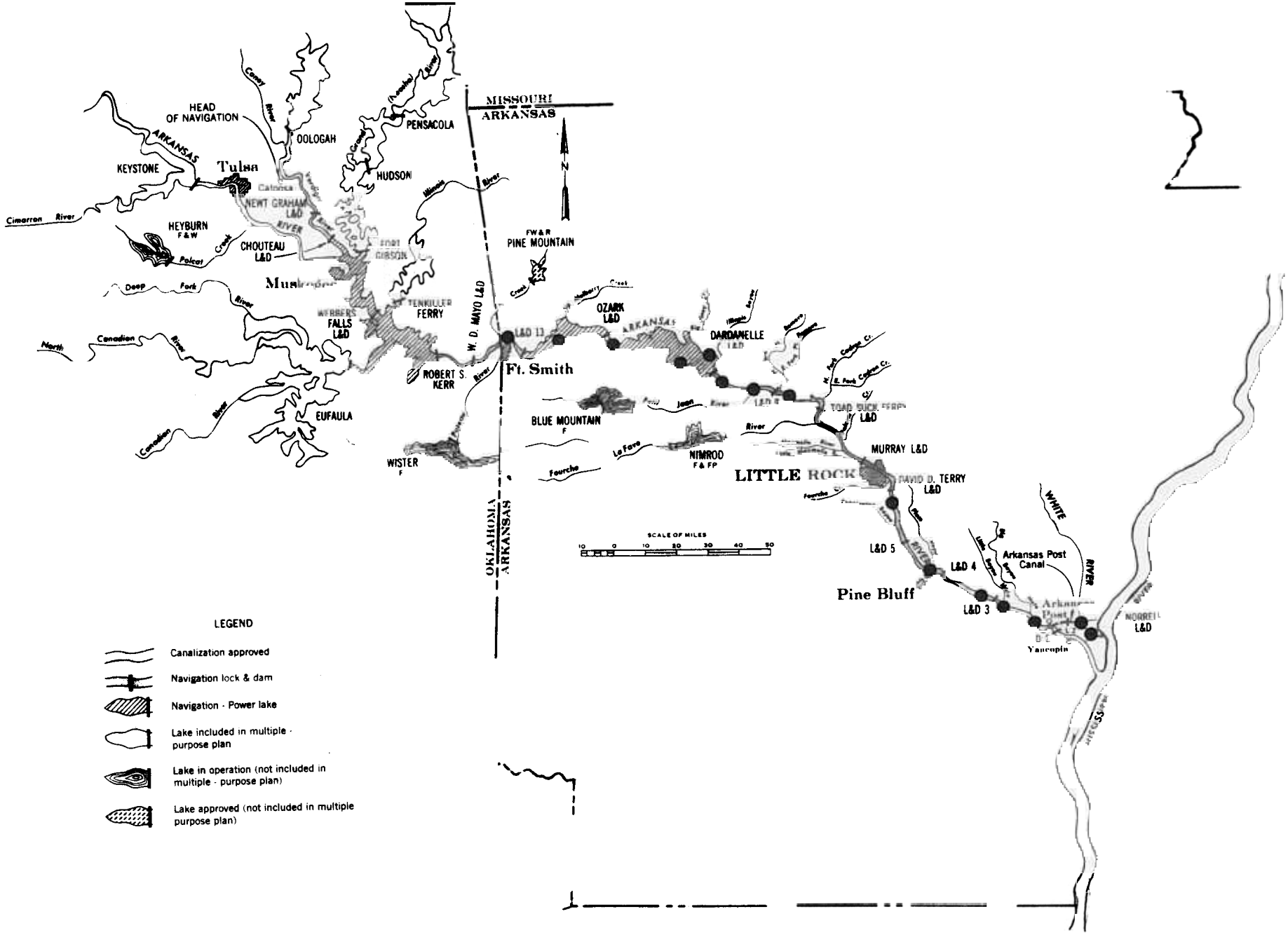
MAP 56. Shorthead Redhorse - *Moxostoma macrolepidotum*



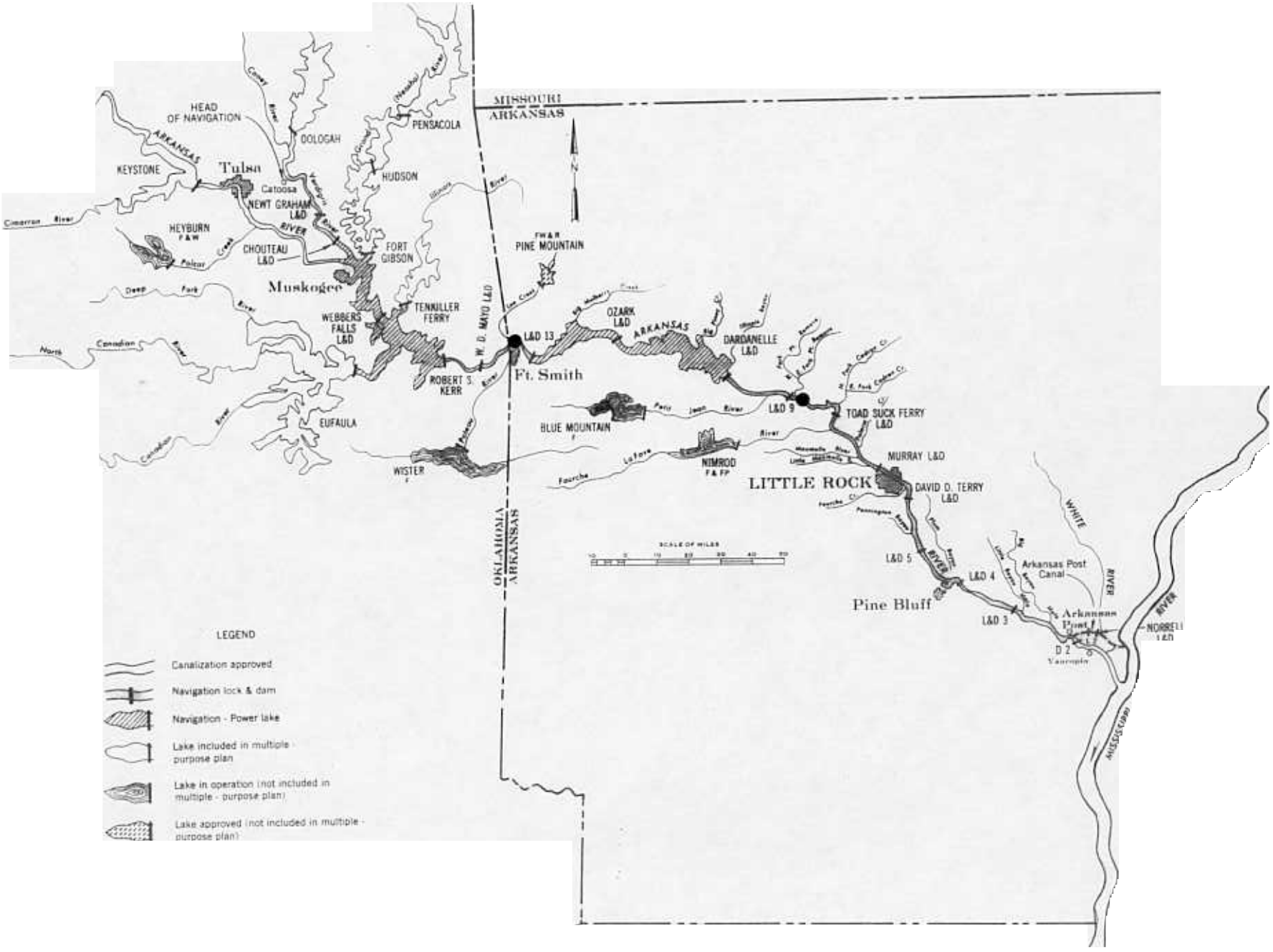
MAP 57. American Eel – *Anquilla rostrata*



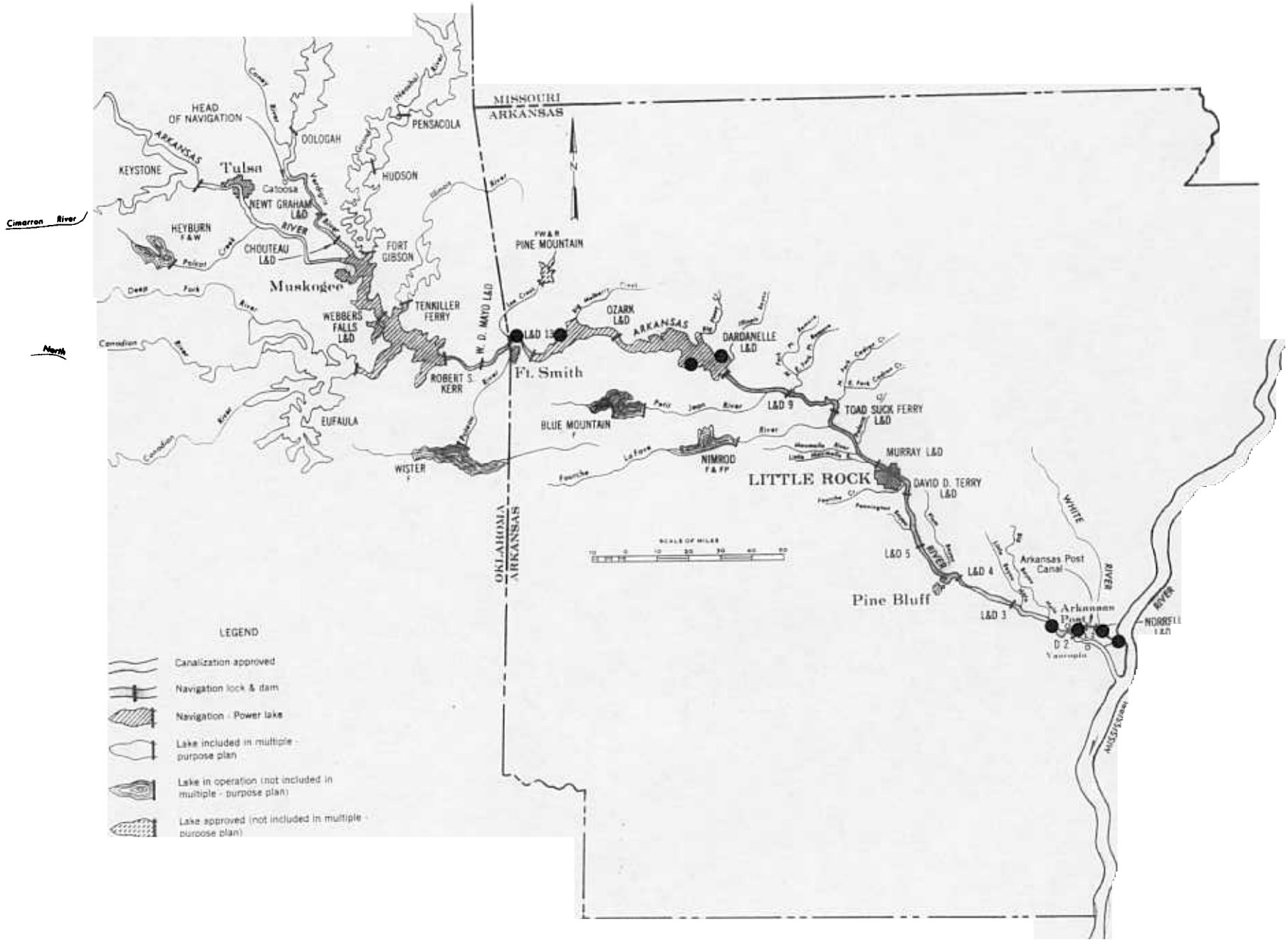
MAP 58. Blue Catfish – *Ictalurus furcatus*



MAP 59. Black Bullhead – *Ictalurus melas*



MAP 60. Yellow Bullhead - *Ictalurus natalis*



MAP 61.

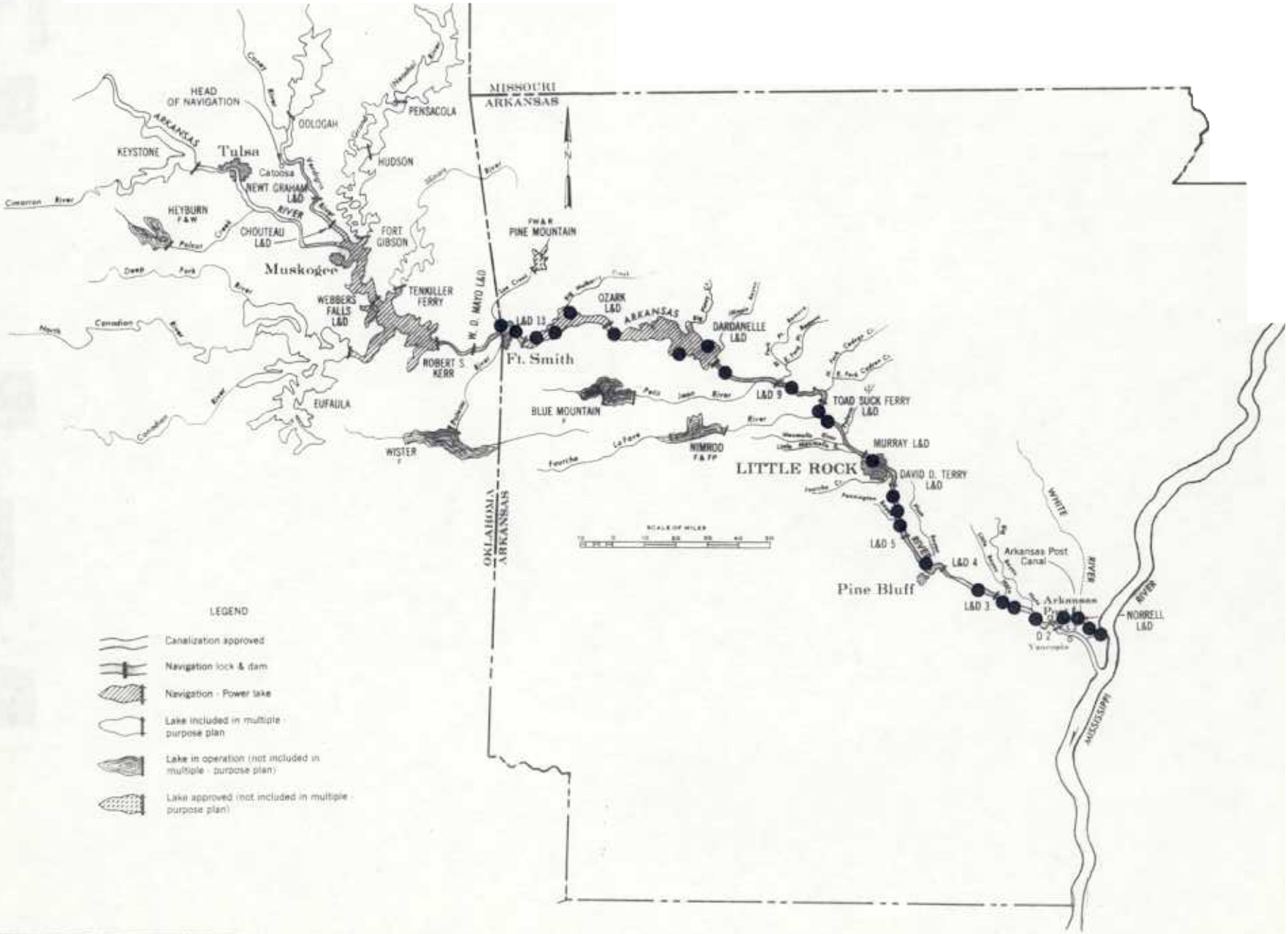


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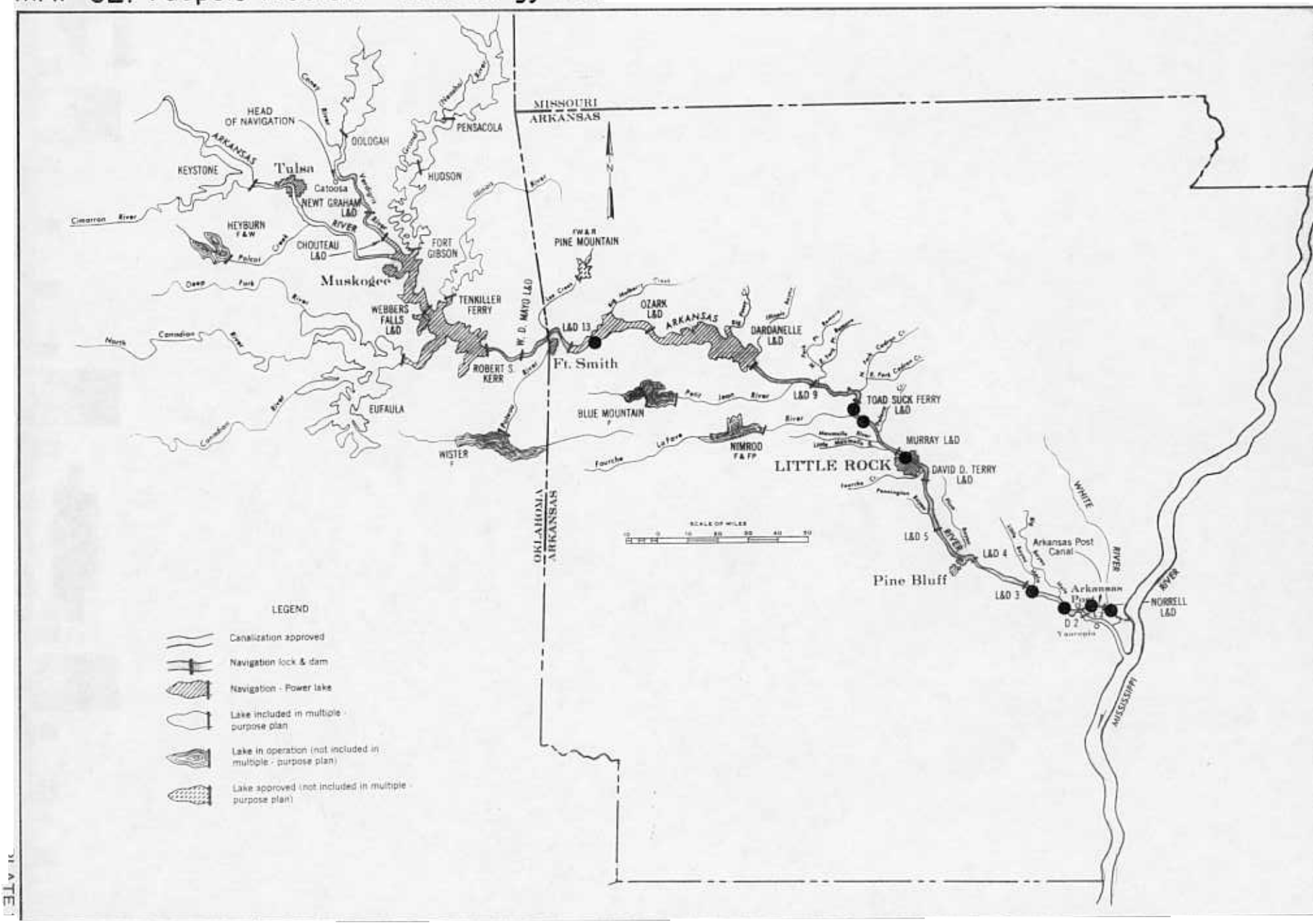
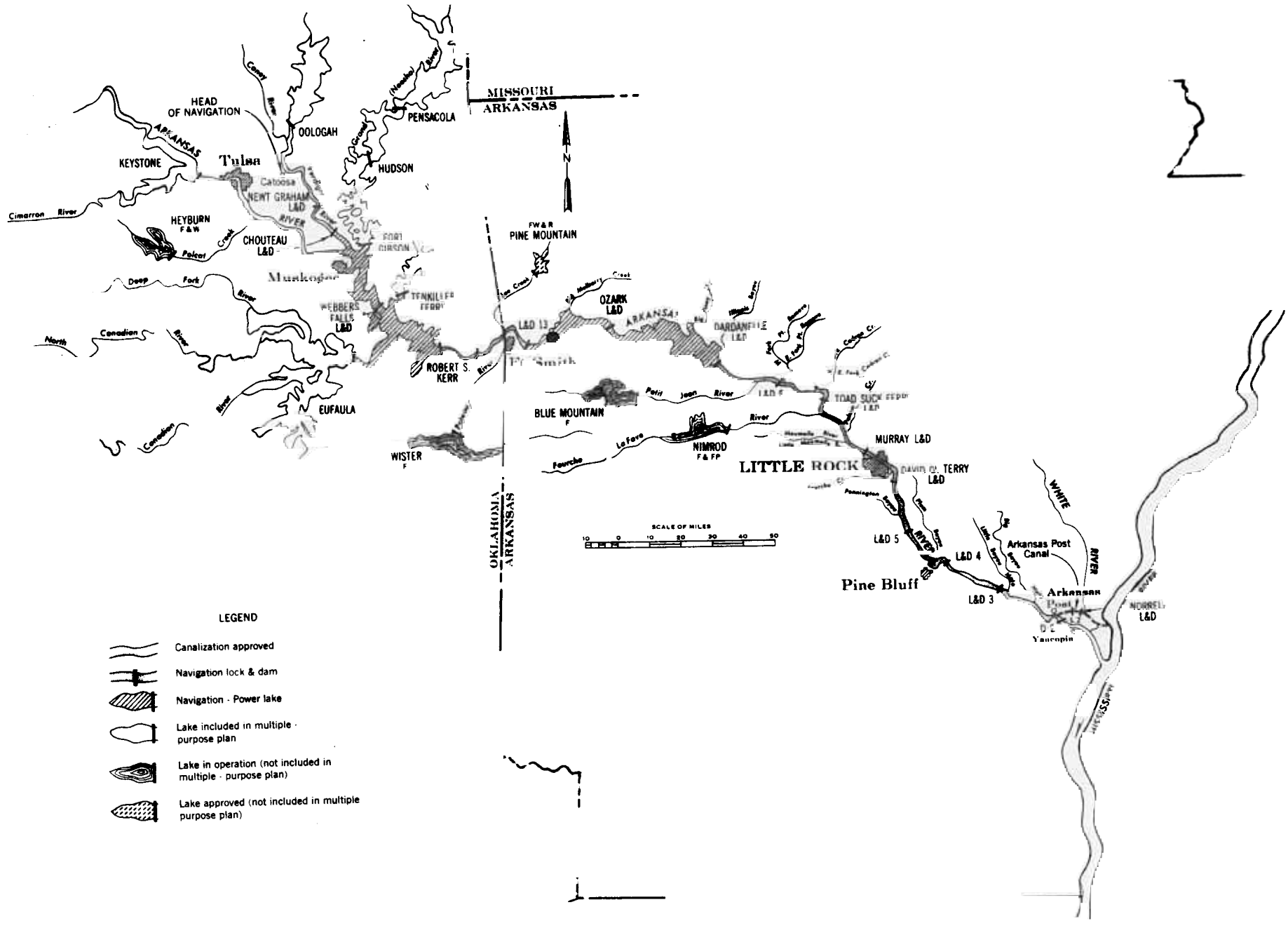
PLATE 1

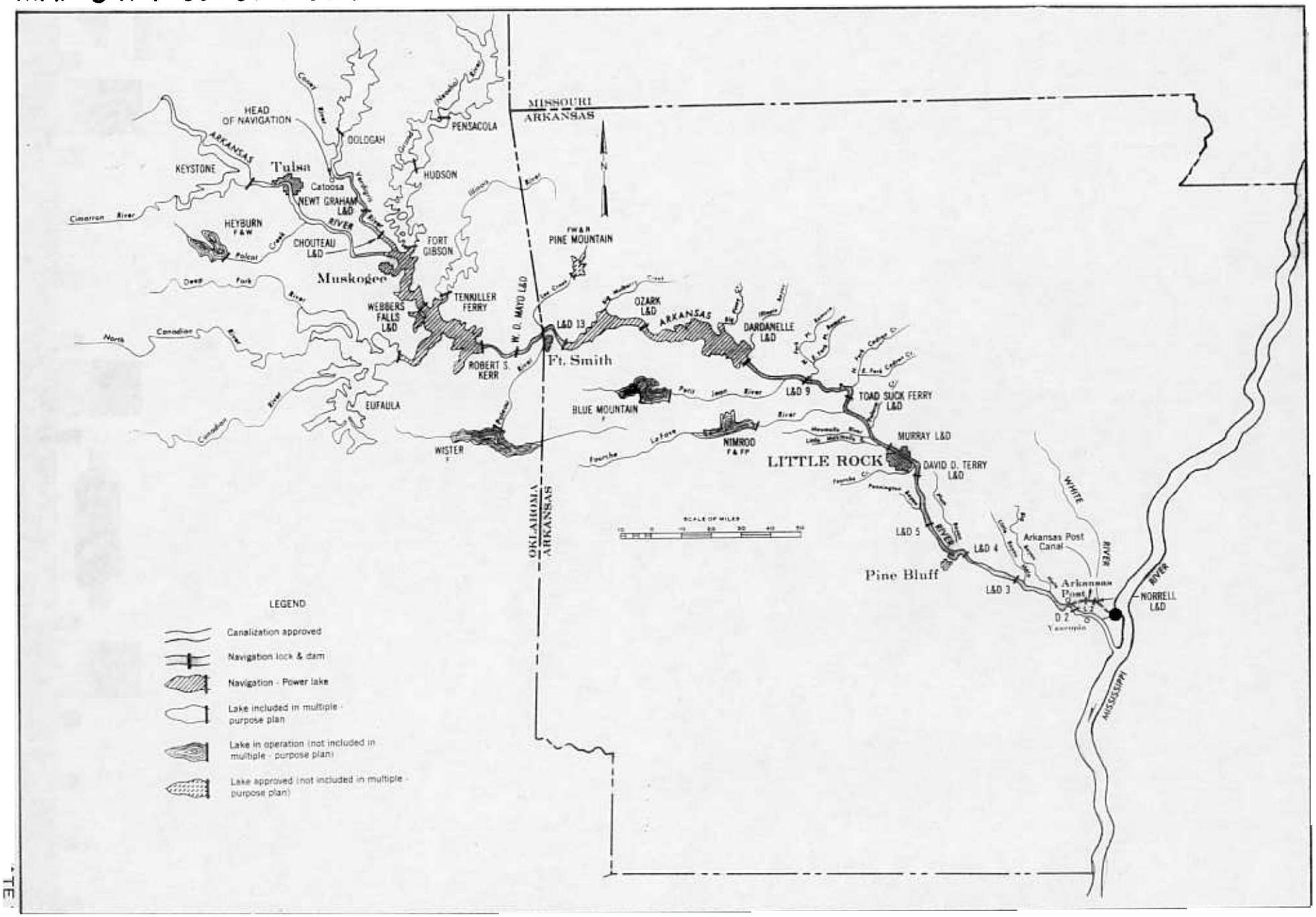
MAP 62. Tadpole Madtom - *Noturus gyrinus*



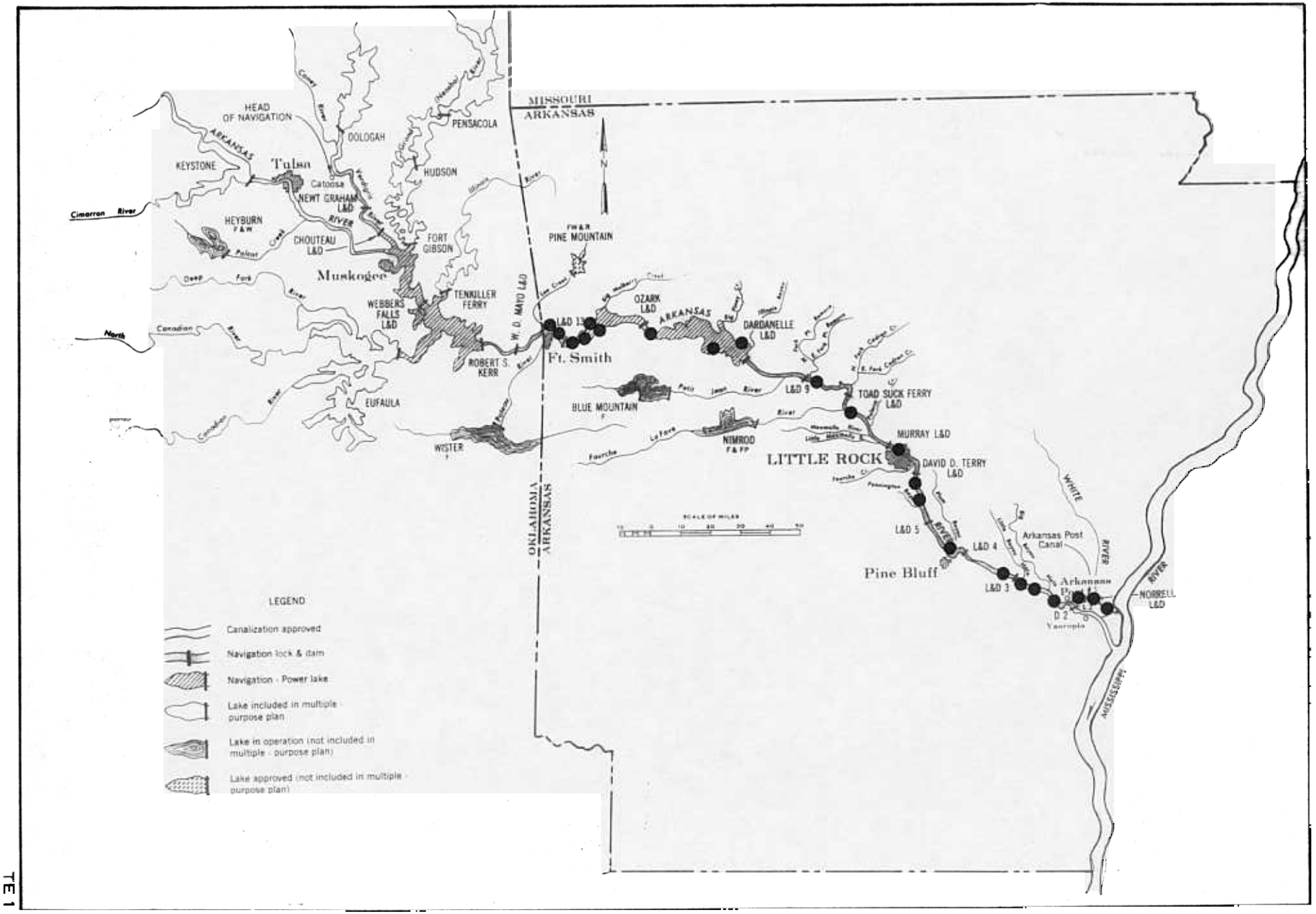
MAP 63. Brindled Madtom - *Noturus miurus*



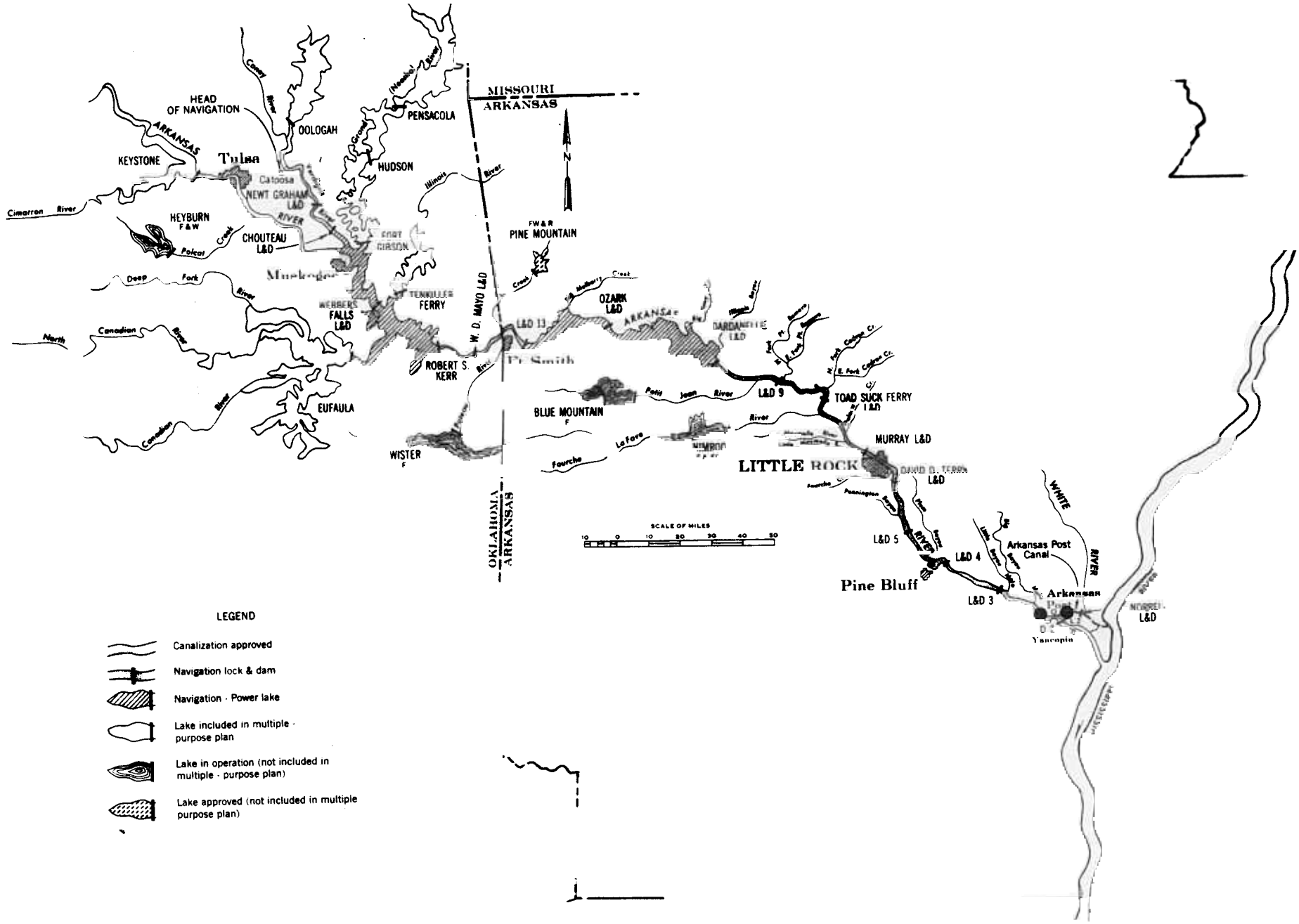
MAP 64. Freckled Madtom - *Noturus nocturnus*



MAP 65. Flathead Catfish - *Pylodictis olivaris*

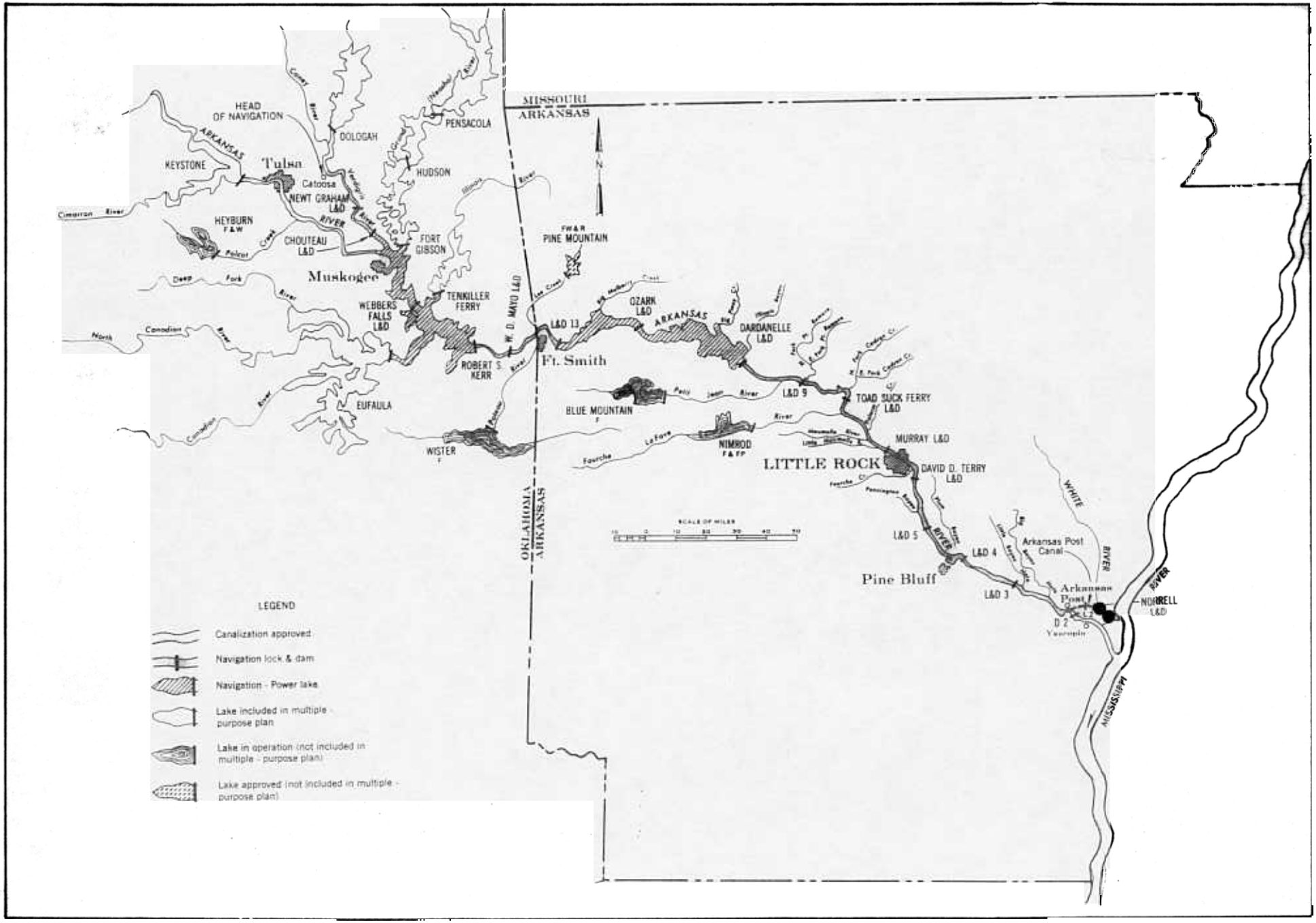


MAP 66 Golden Topminnow – *Fundulus chrysotus*

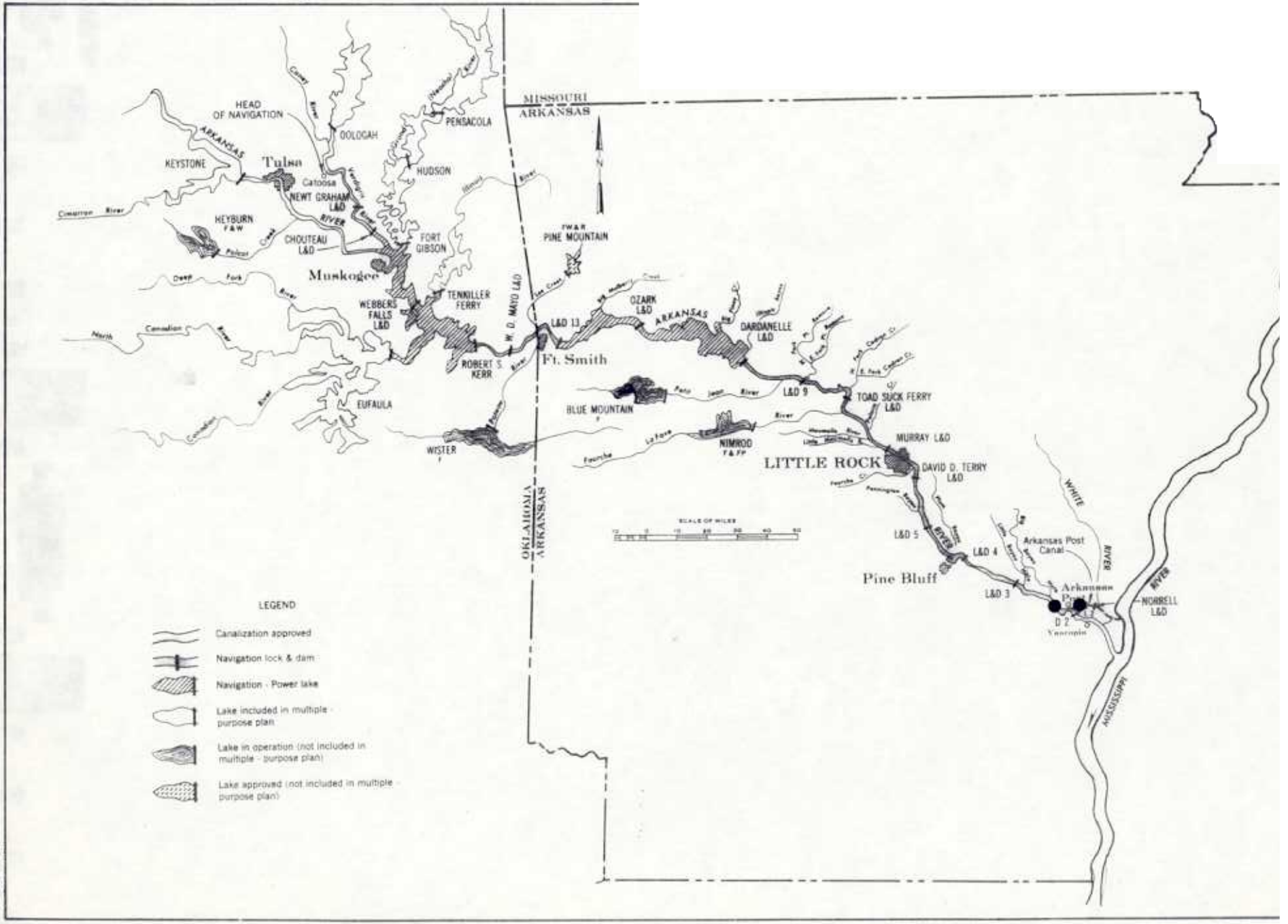


PLATE

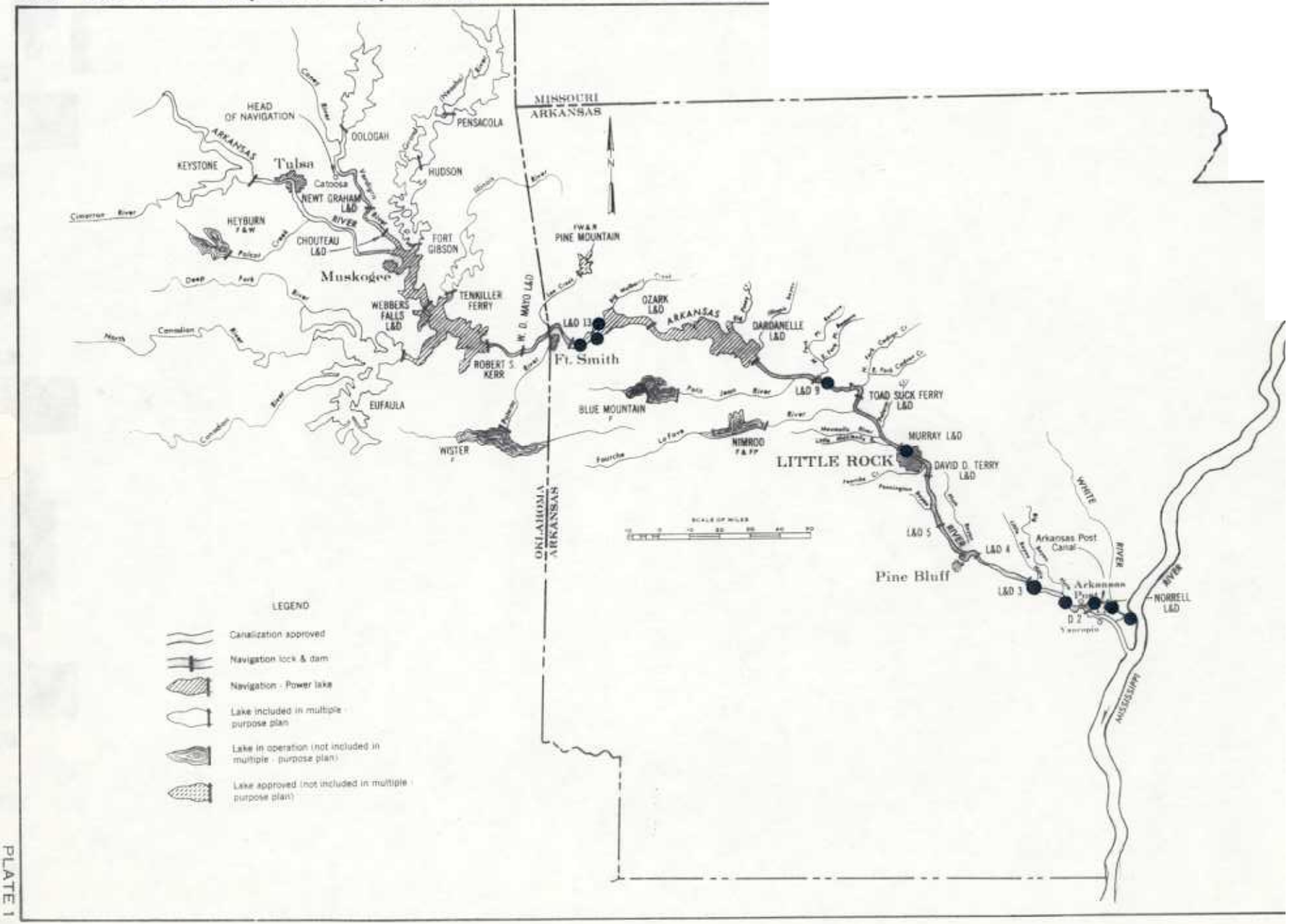
MAP 67. Blackstripe Topminnow - *Fundulus notatus*



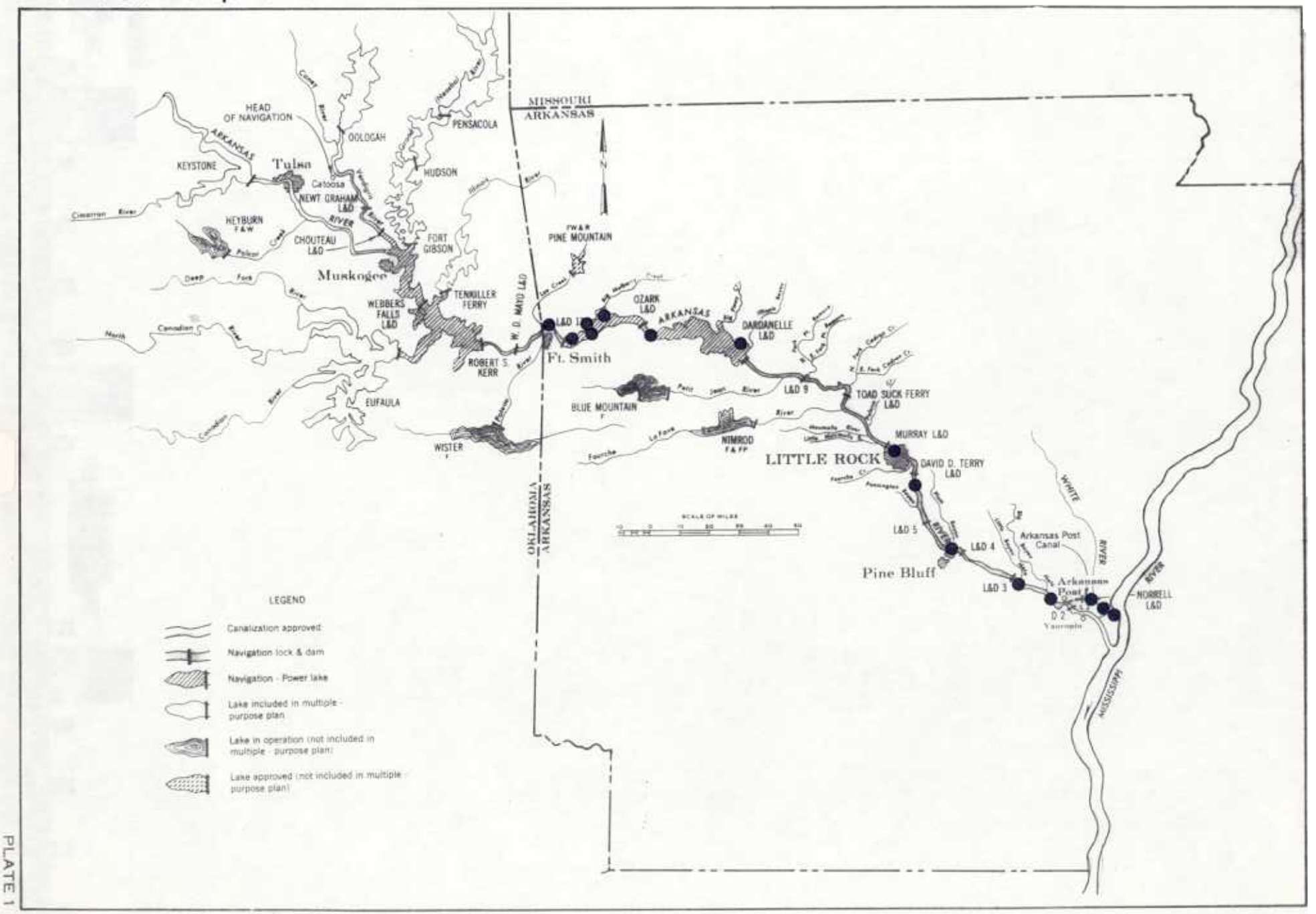
MAP 68. Starhead Topminnow - *Fundulus notti*



MAP 69. Blackspotted Topminnow - *Fundulus olivaceus*

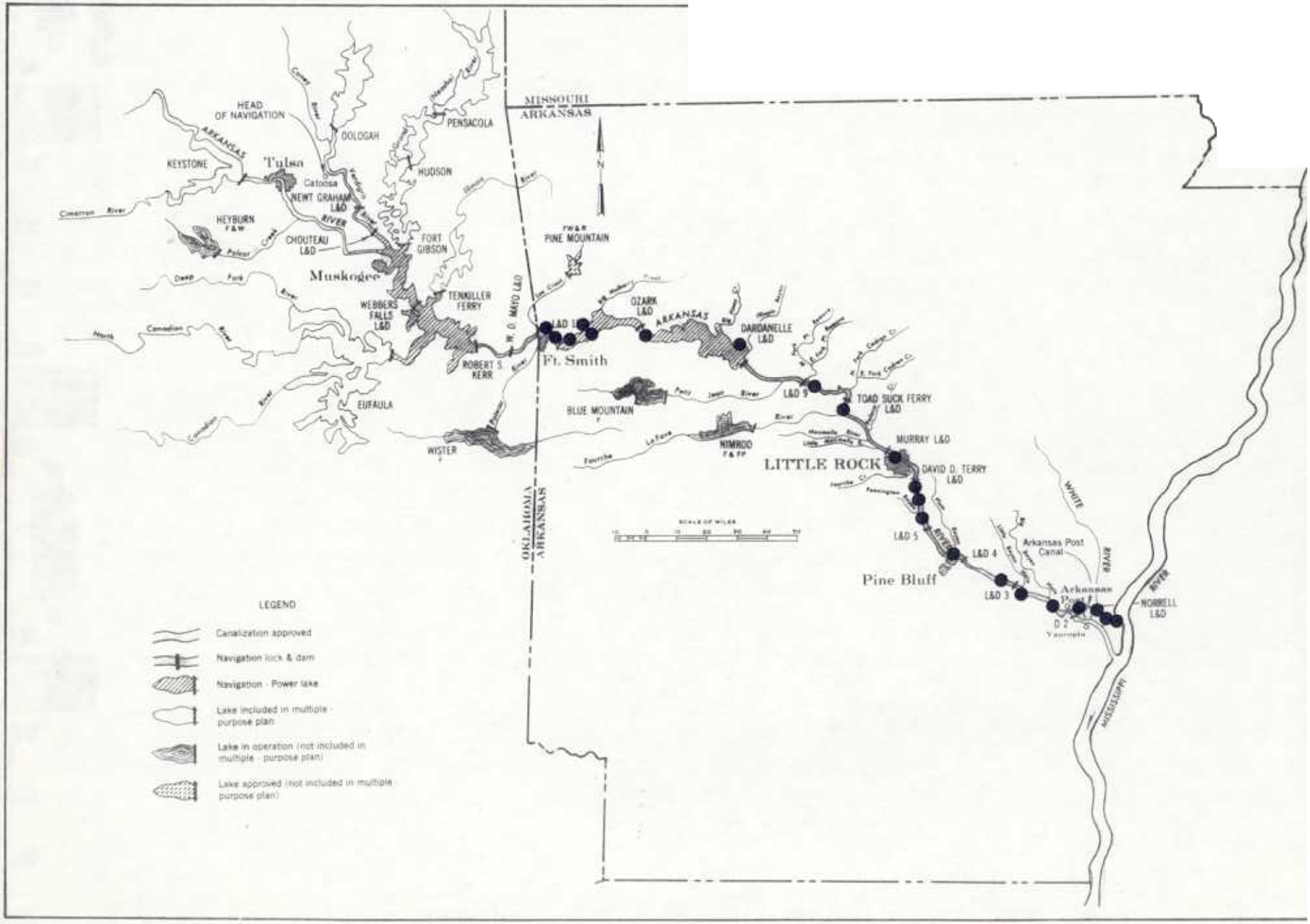


MAP 70. Mosquitofish – *Gambusia affinis*

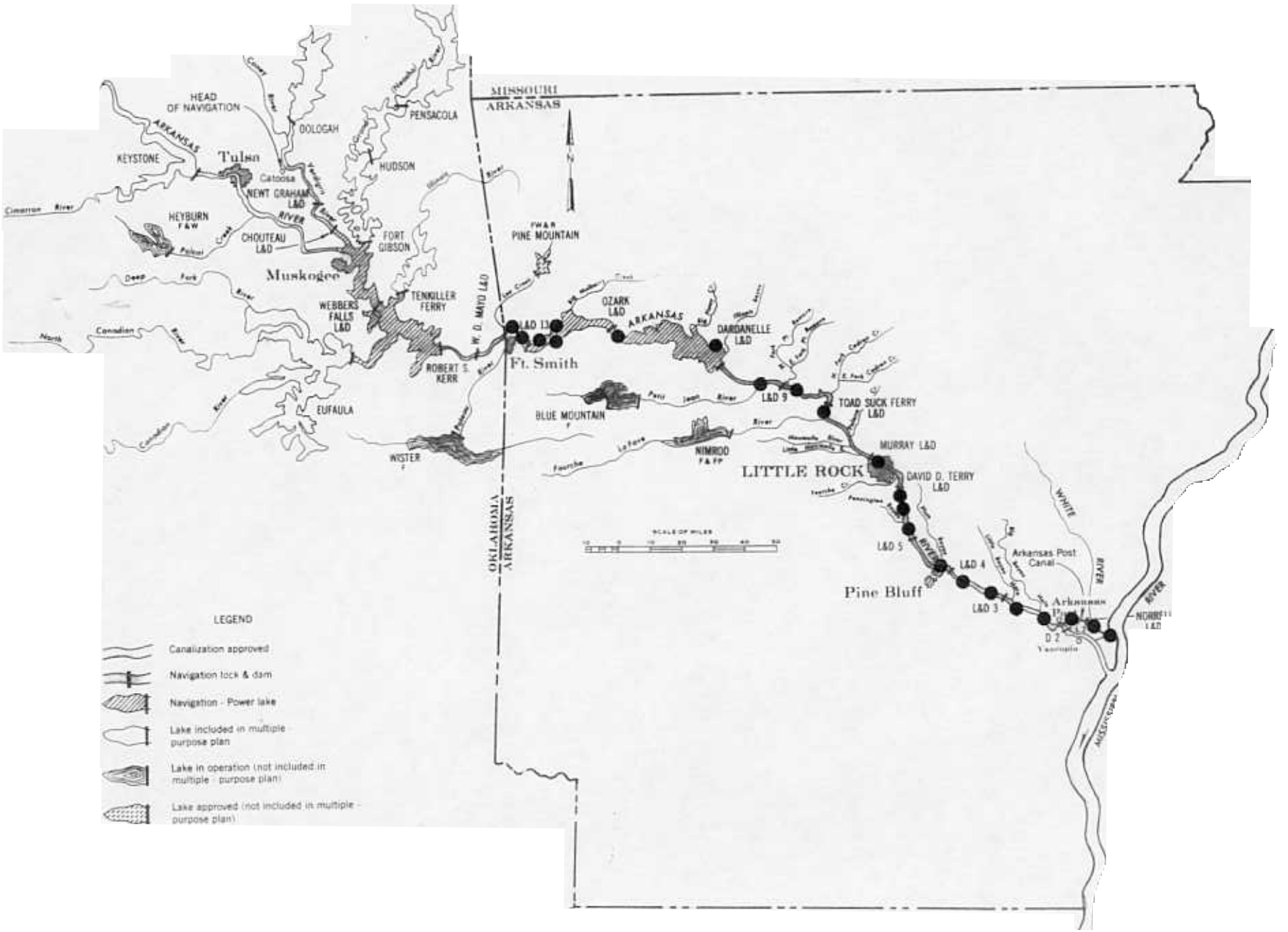


MAP 71. Pirate Perch - *Aphredoderus sayanus*

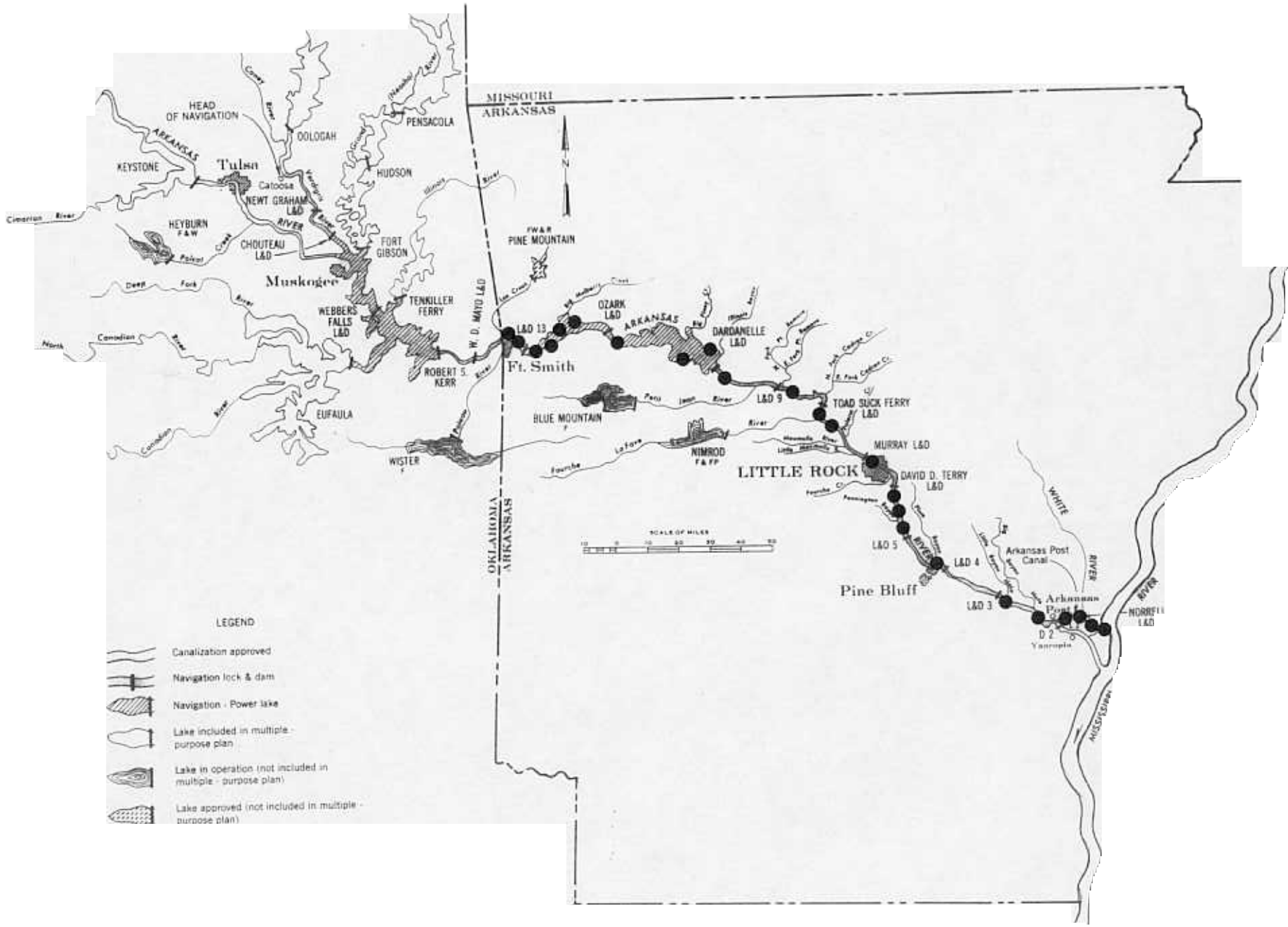
MAP 72. Brook Silverside – *Labidesthes sicculus*



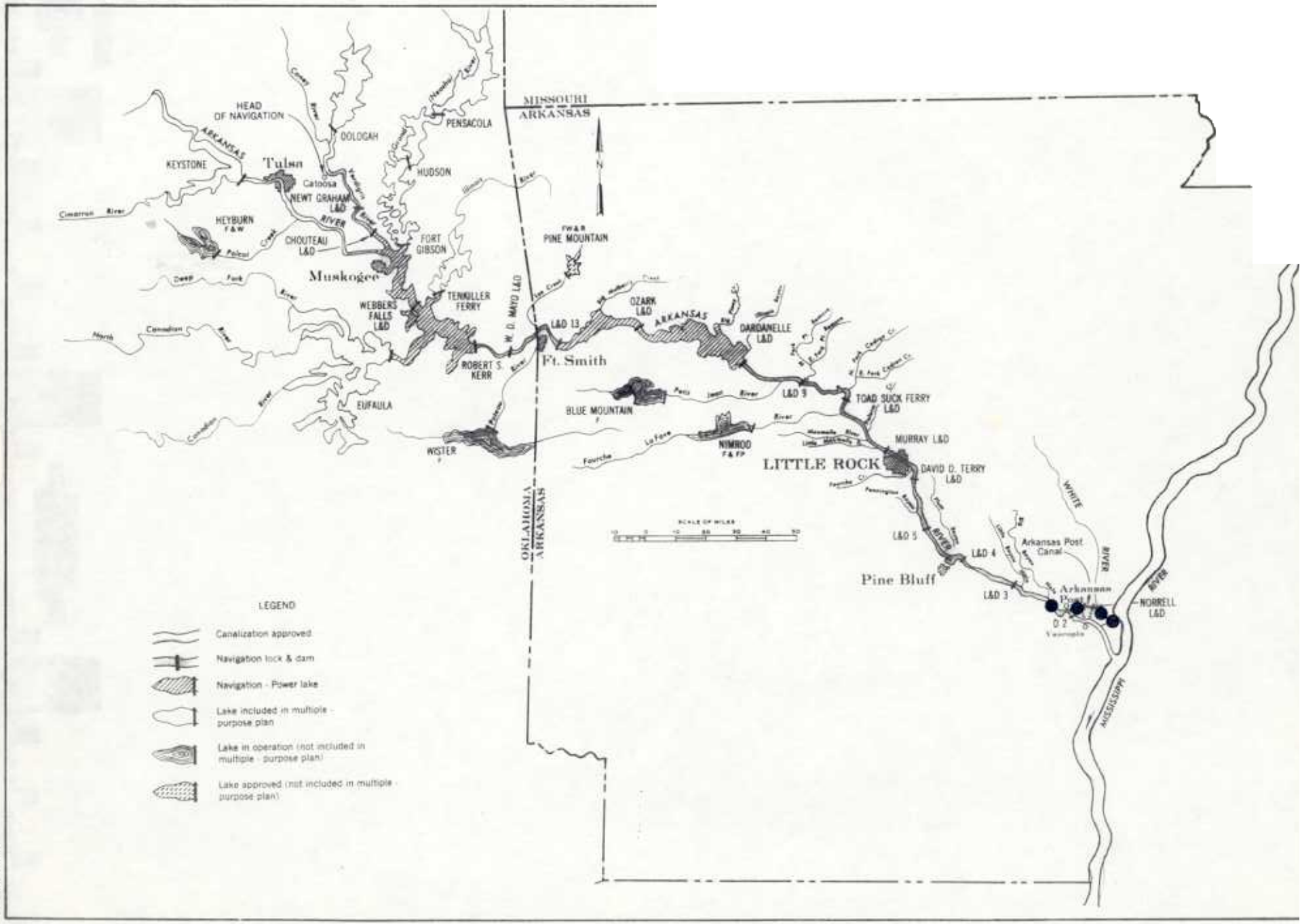
MAP 73. Mississippi Silverside - *Menidia audens*



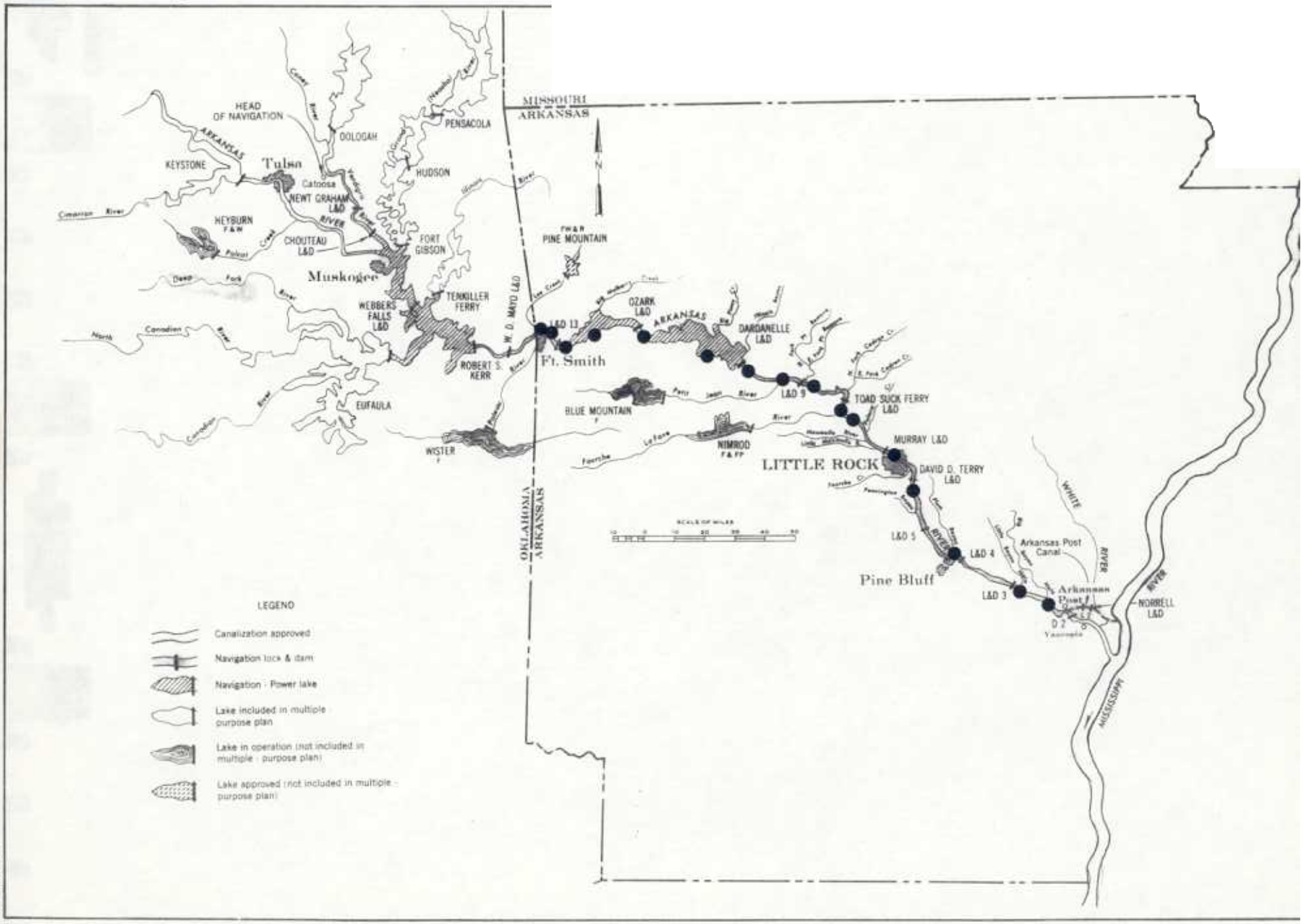
MAP 74 White Bass - *Morone chrysops*



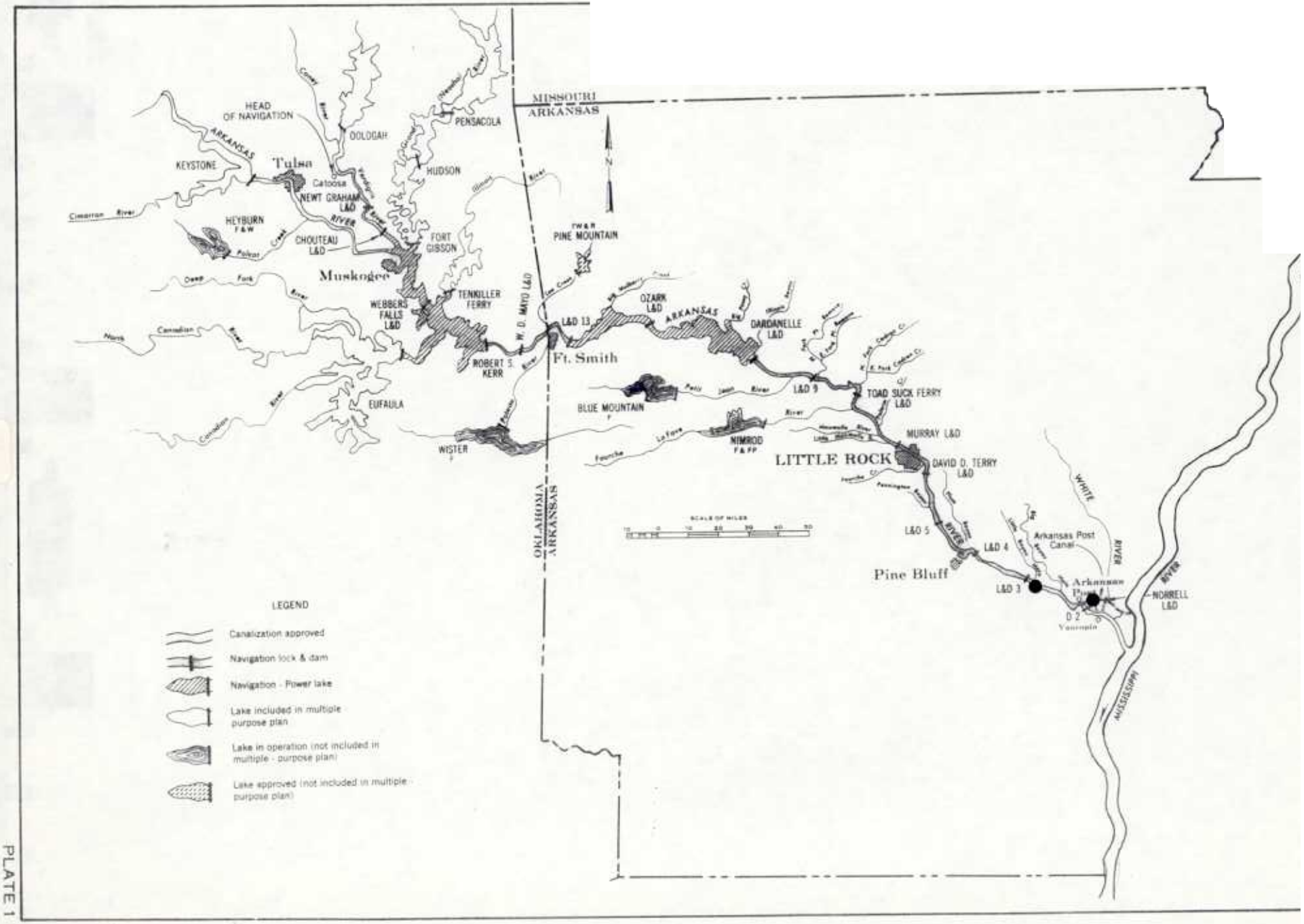
MAP 75. Yellow Bass - *Morone mississippiensis*



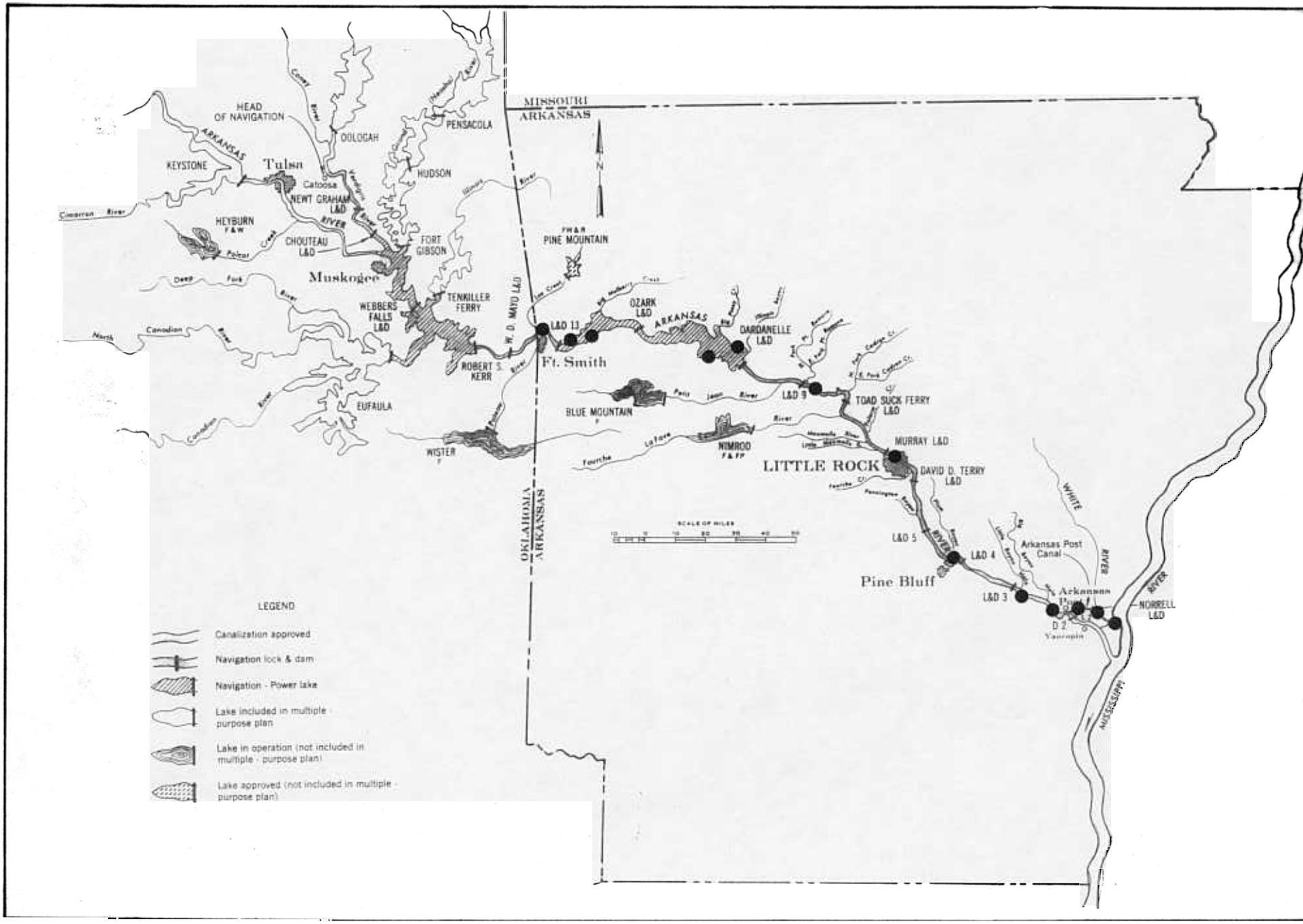
MAP 76. Striped Bass – *Morone saxatilis*



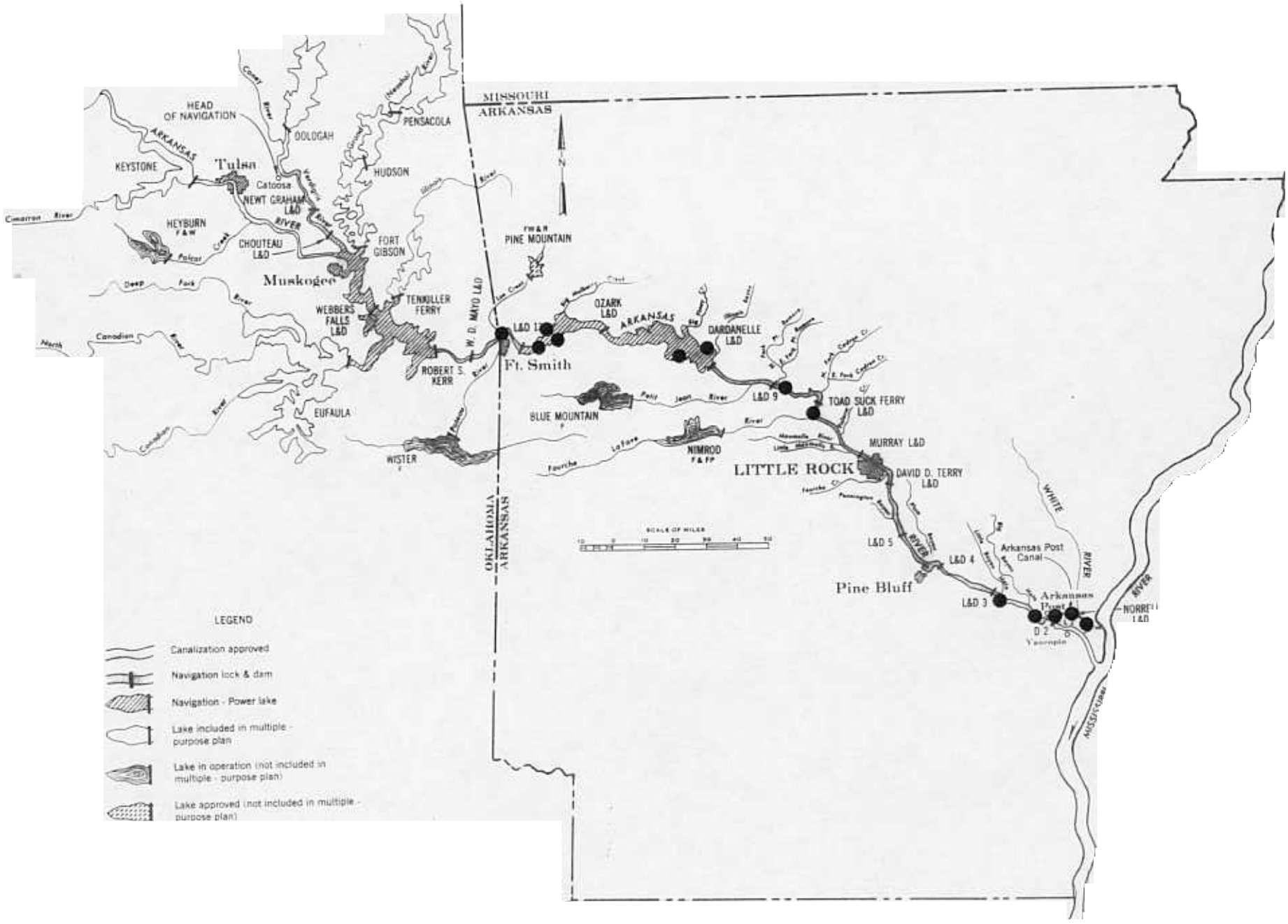
MAP 77. Flier - *Centrarchus macropterus*



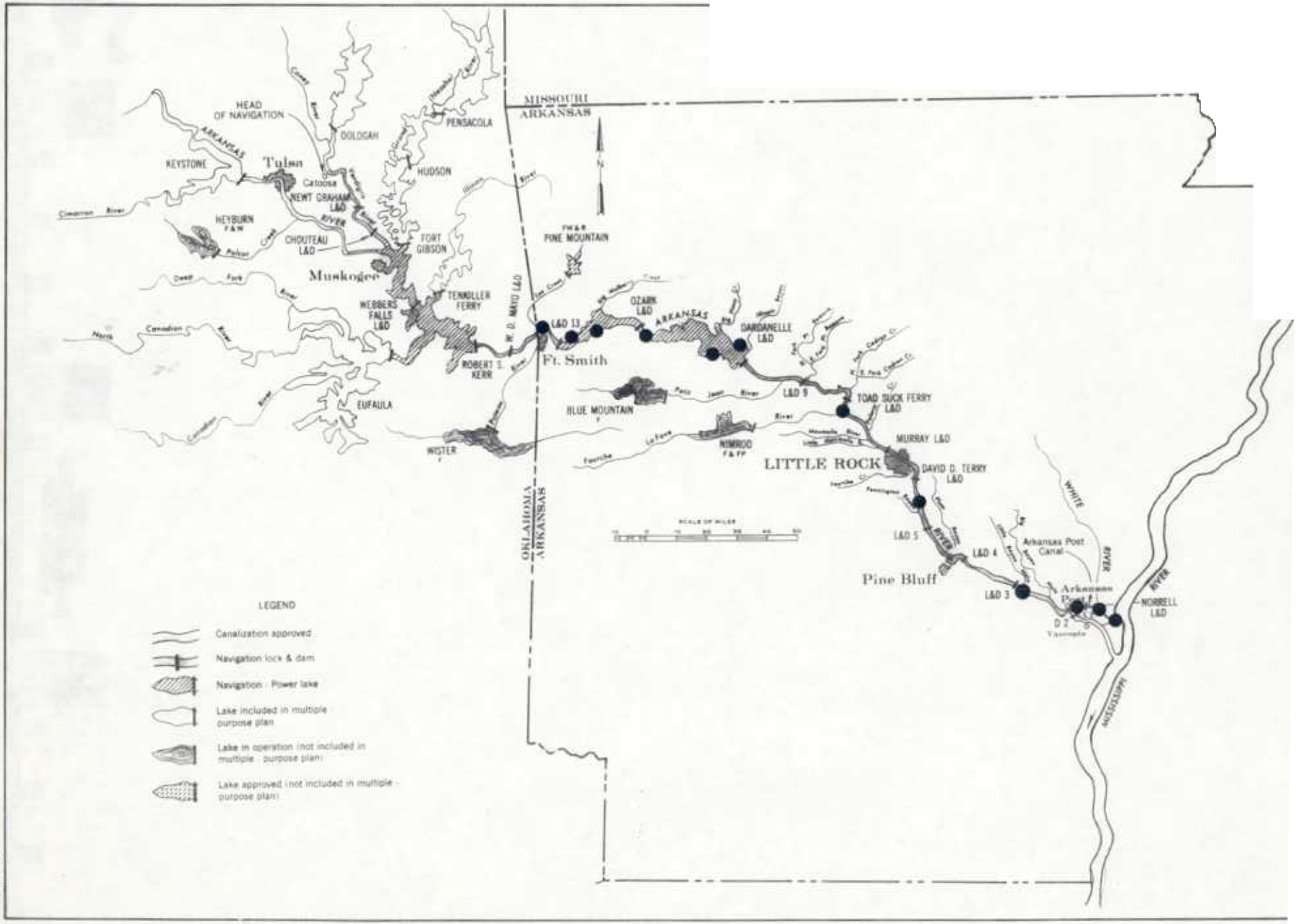
MAP 78. Green Sunfish - *Lepomis cyanellus*



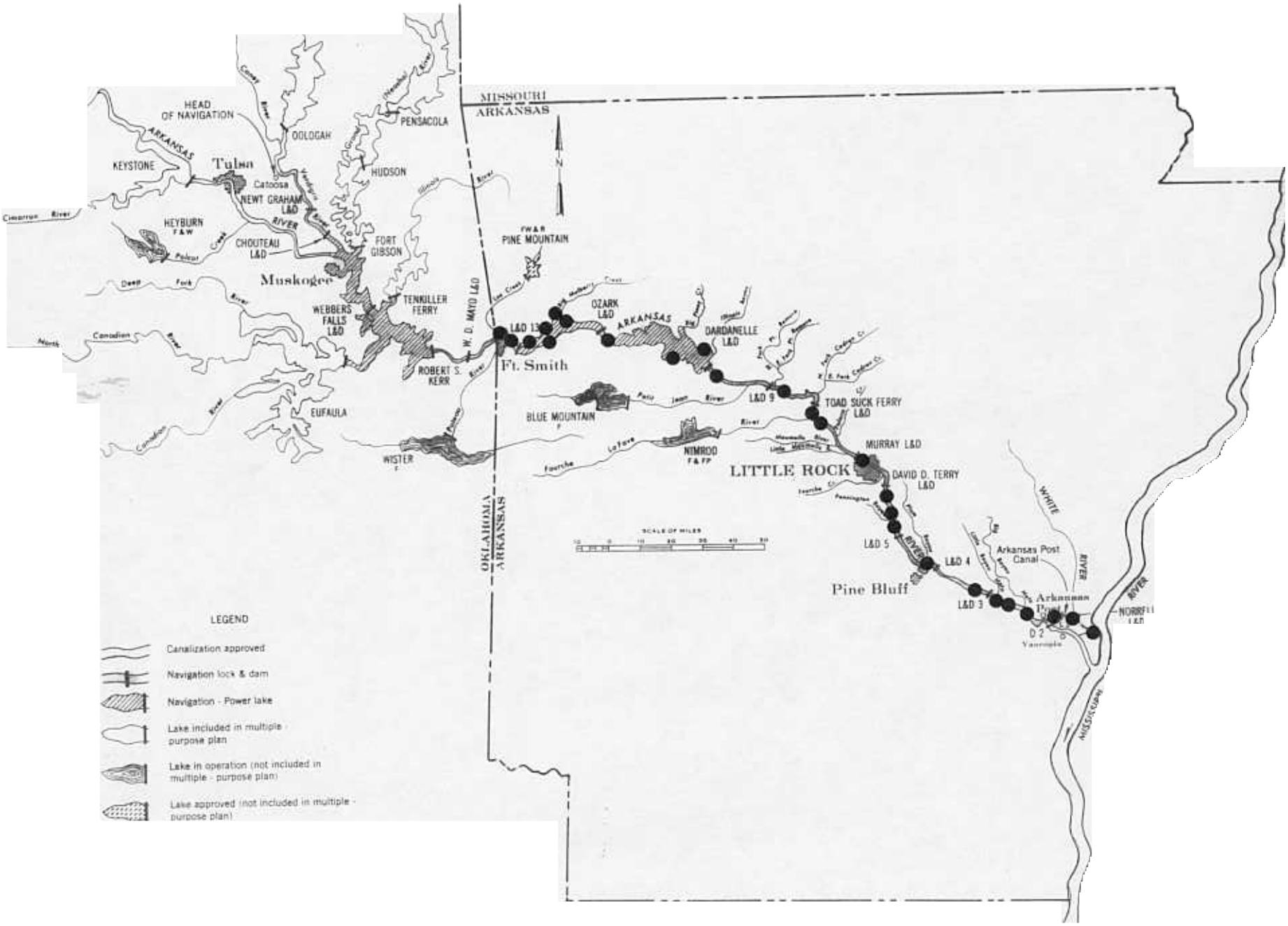
MAP 79. Warmouth - *Lepomis gulosus*



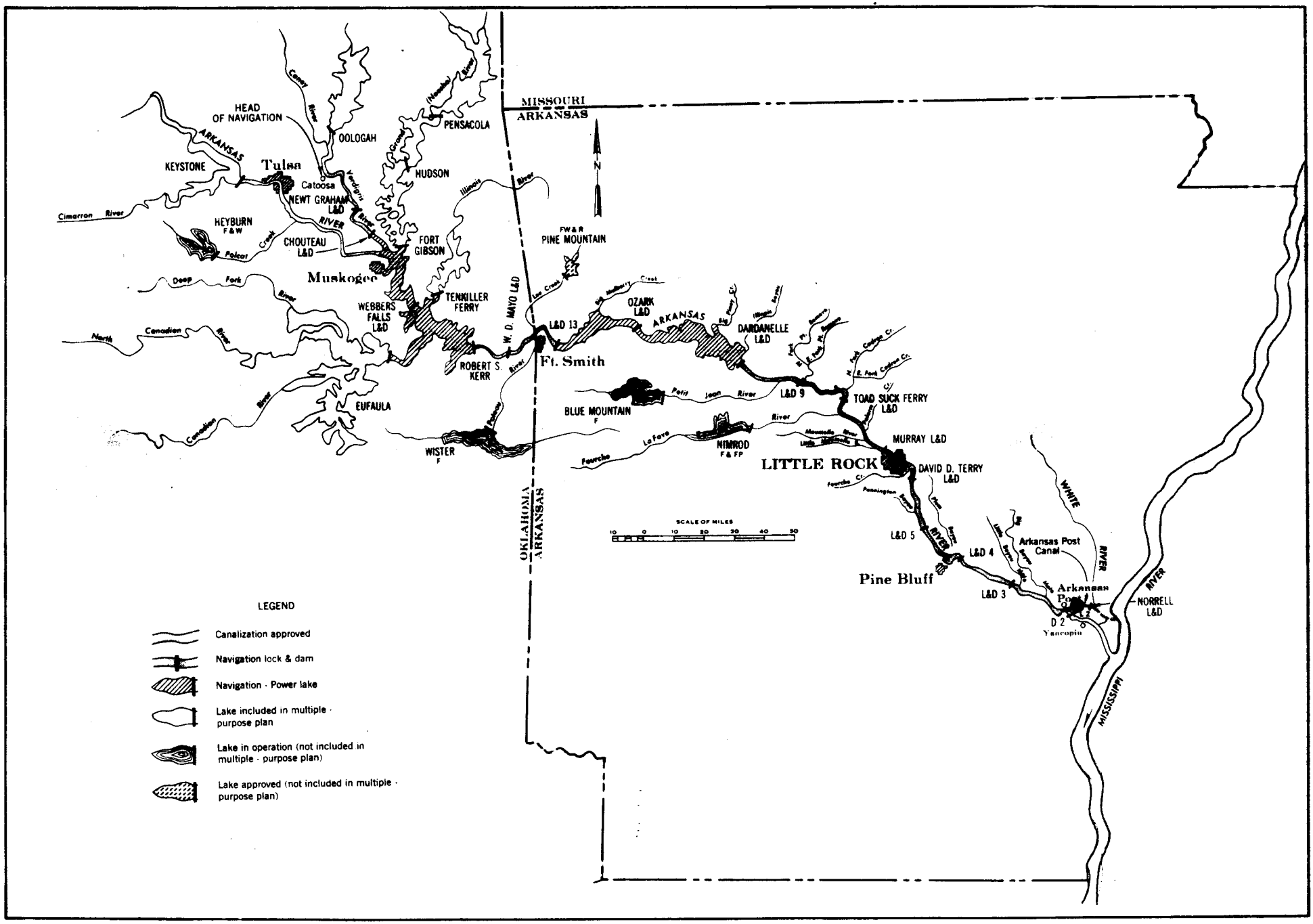
MAP 80. Orangespotted Sunfish - *Lepomis humilis*



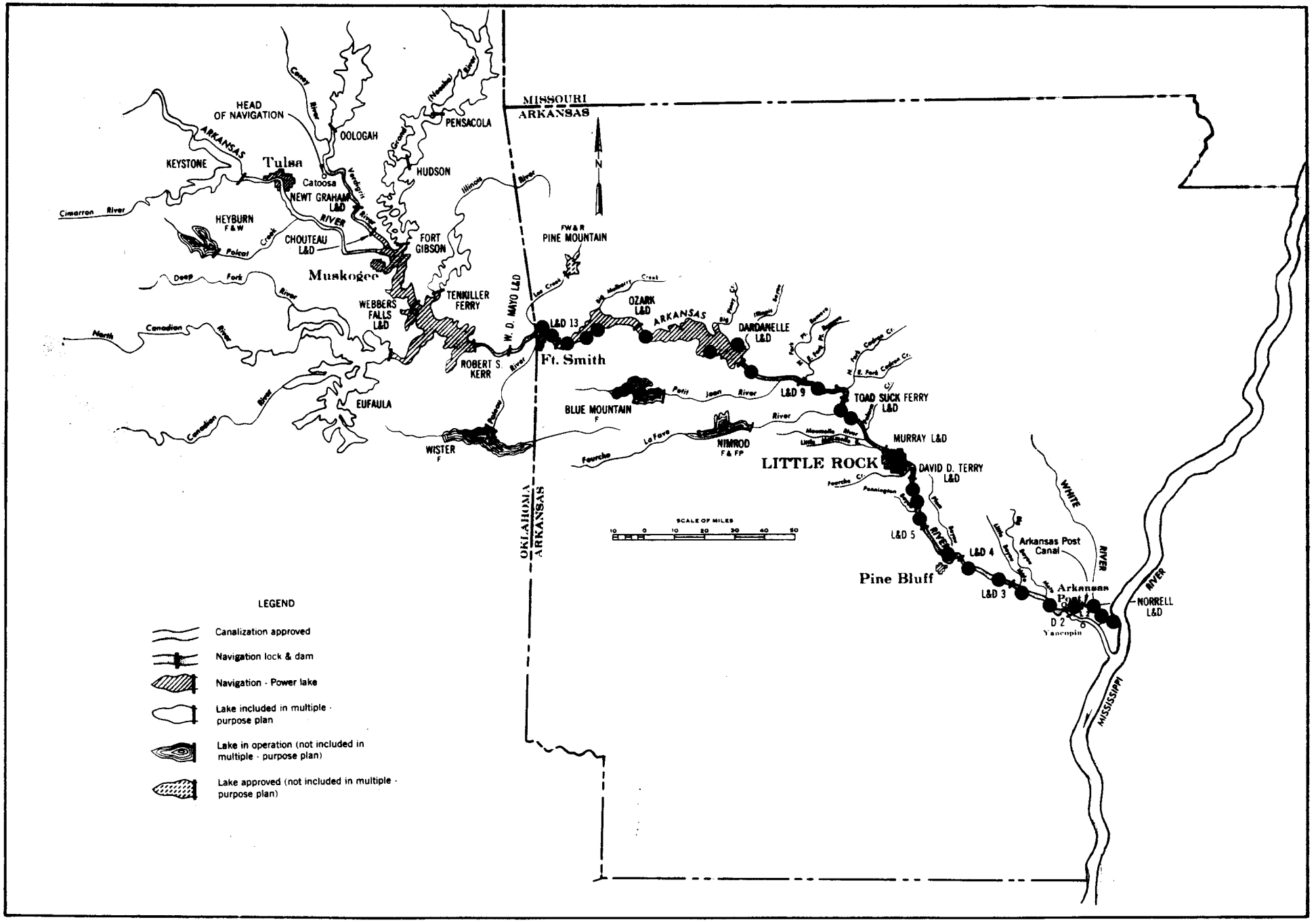
MAP 81 Bluegill - *Lepomis macrochirus*



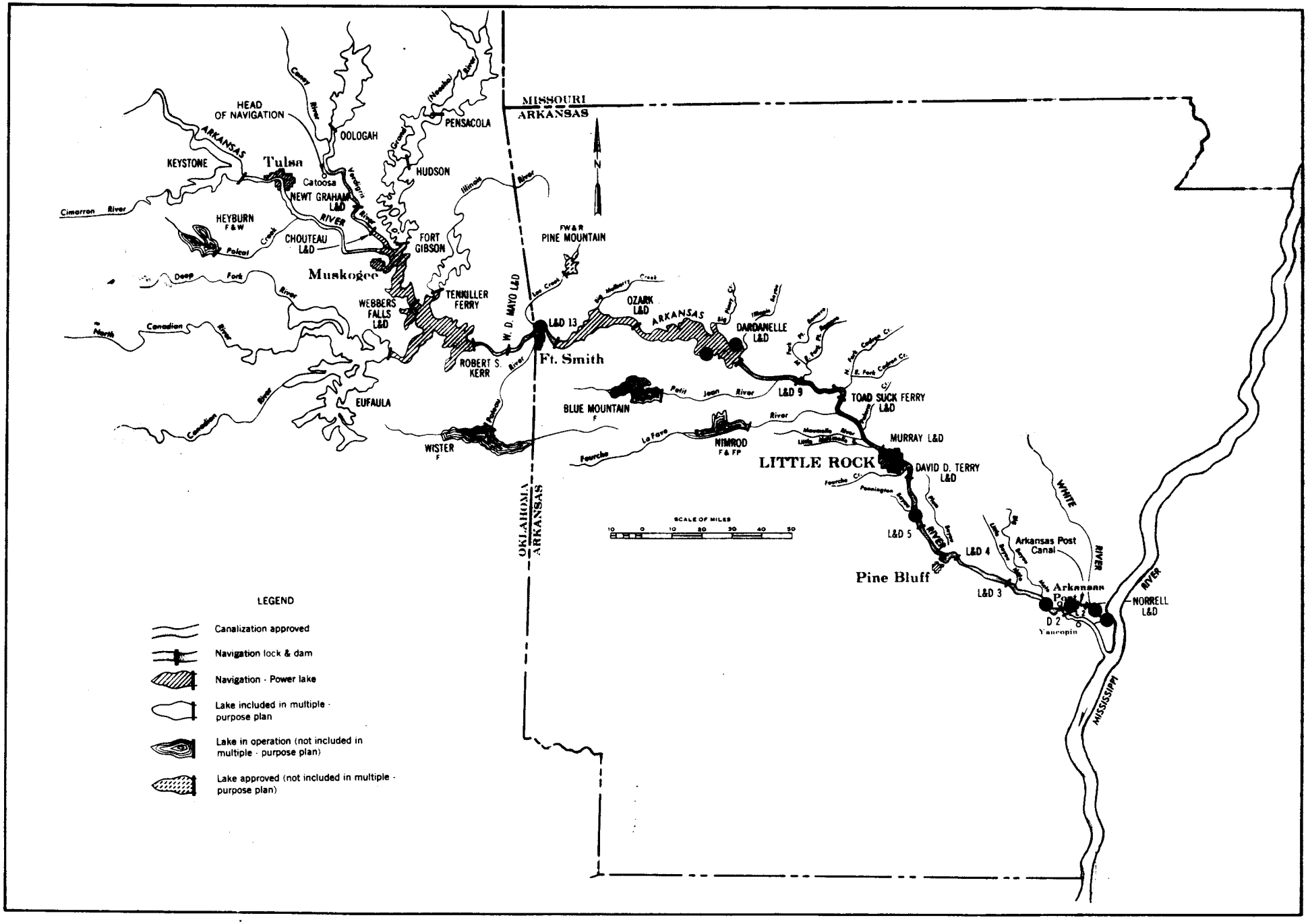
MAP 82. Dollar Sunfish - *Lepomis marginatus*



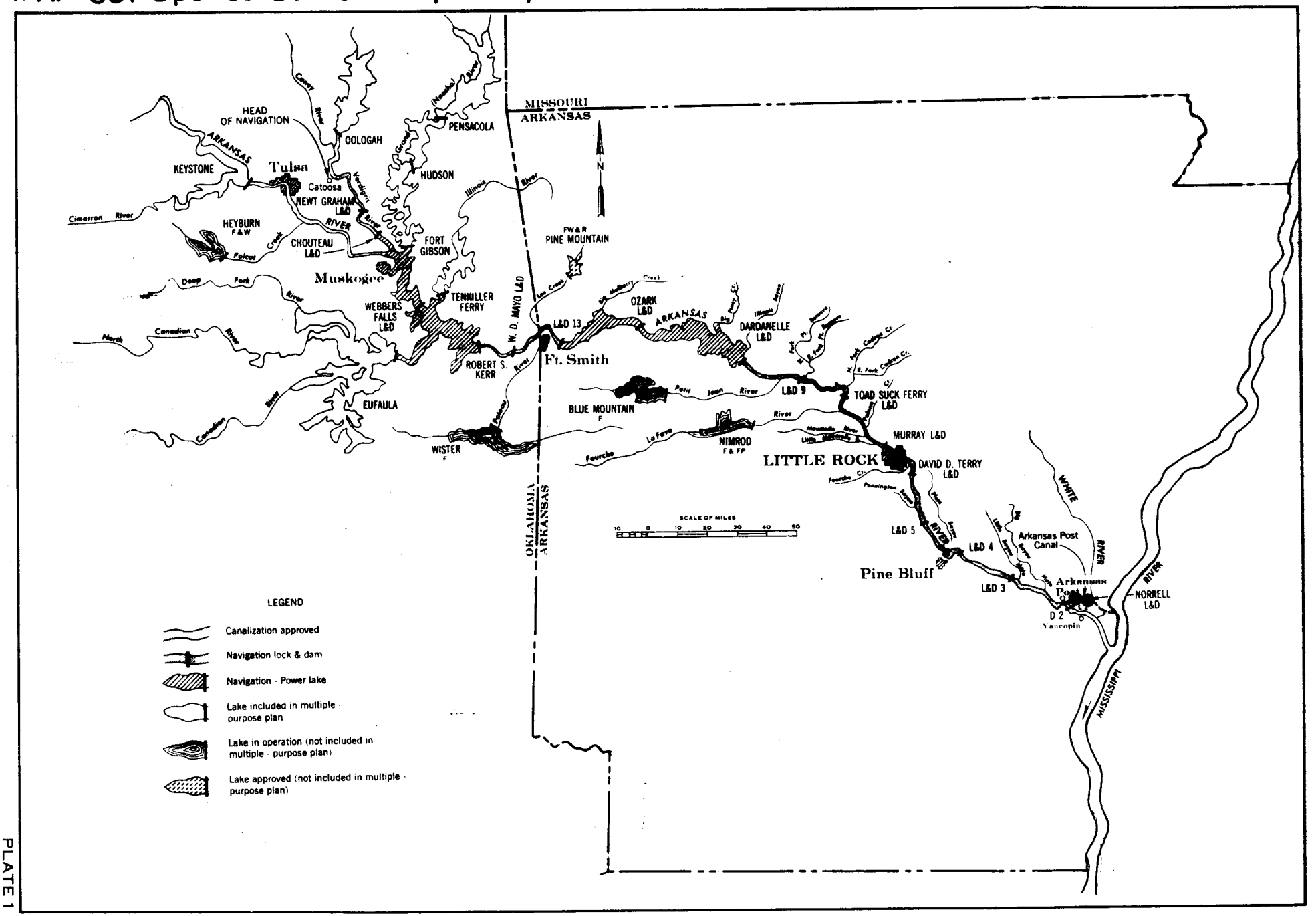
MAP 83. Longear Sunfish - *Lepomis megalotis*



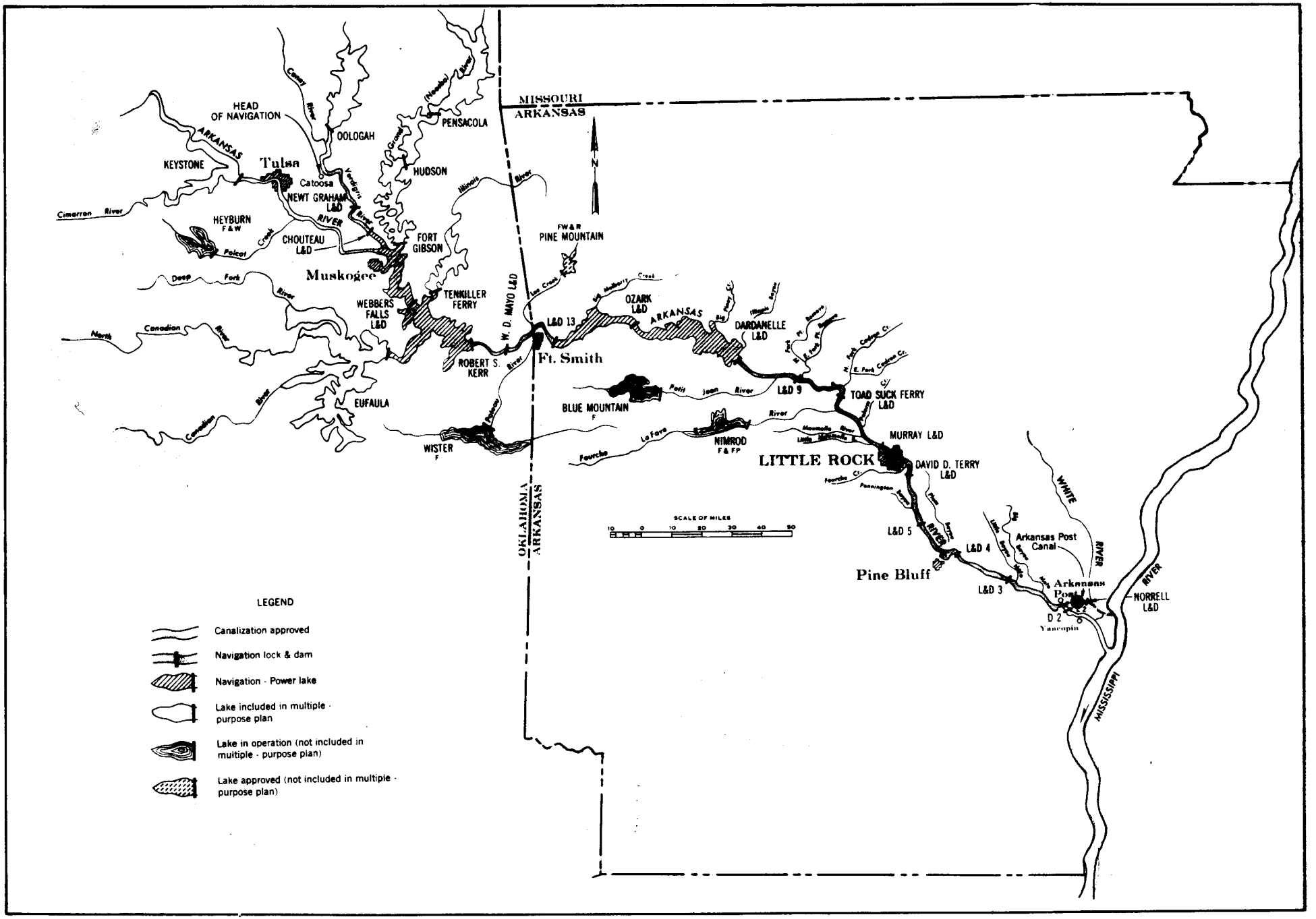
MAP 84. Redear Sunfish - *Lepomis microlophus*



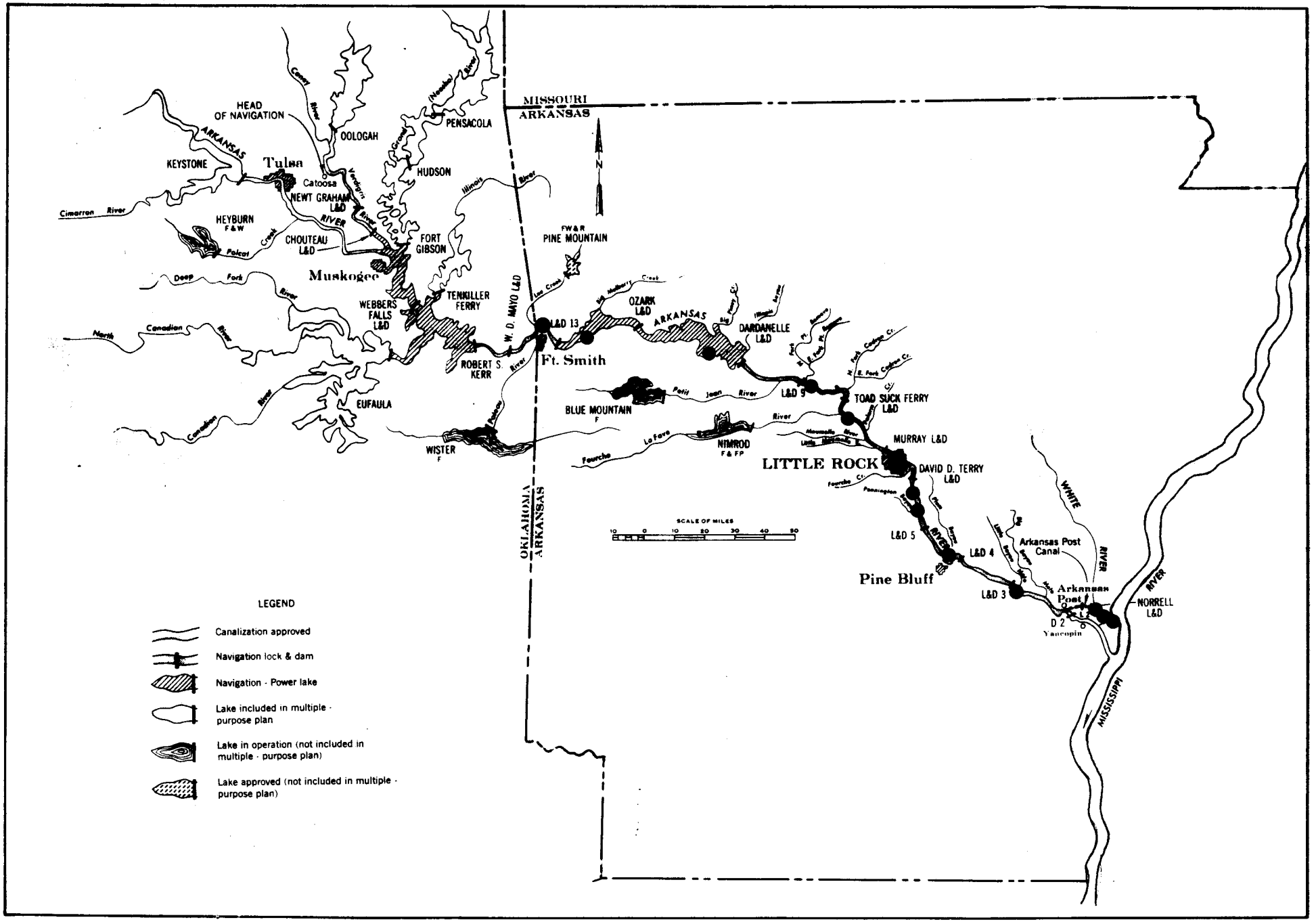
MAP 85. Spotted Sunfish - *Lepomis punctatus*



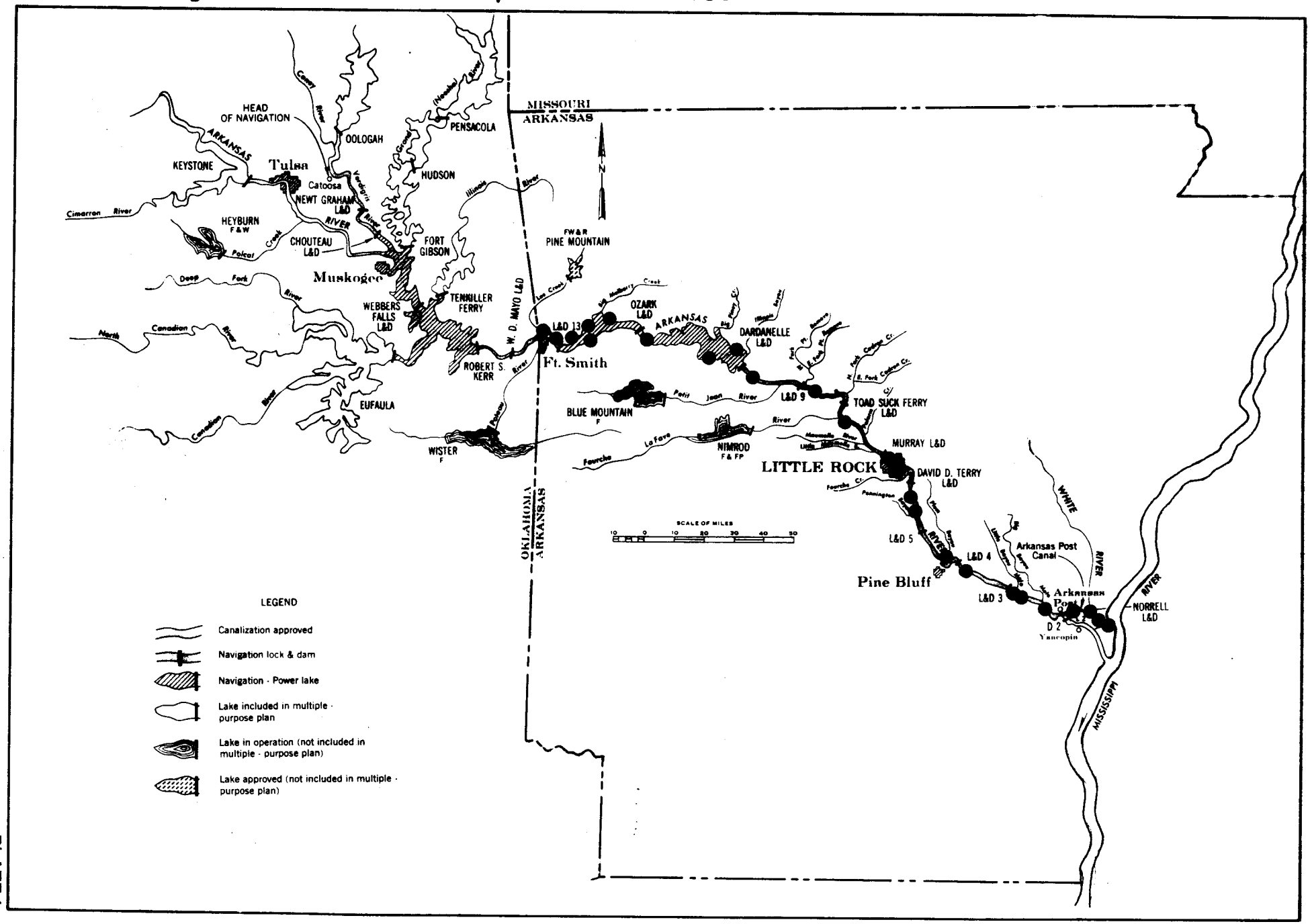
MAP 86. Bantam Sunfish - *Lepomis symmetricus*



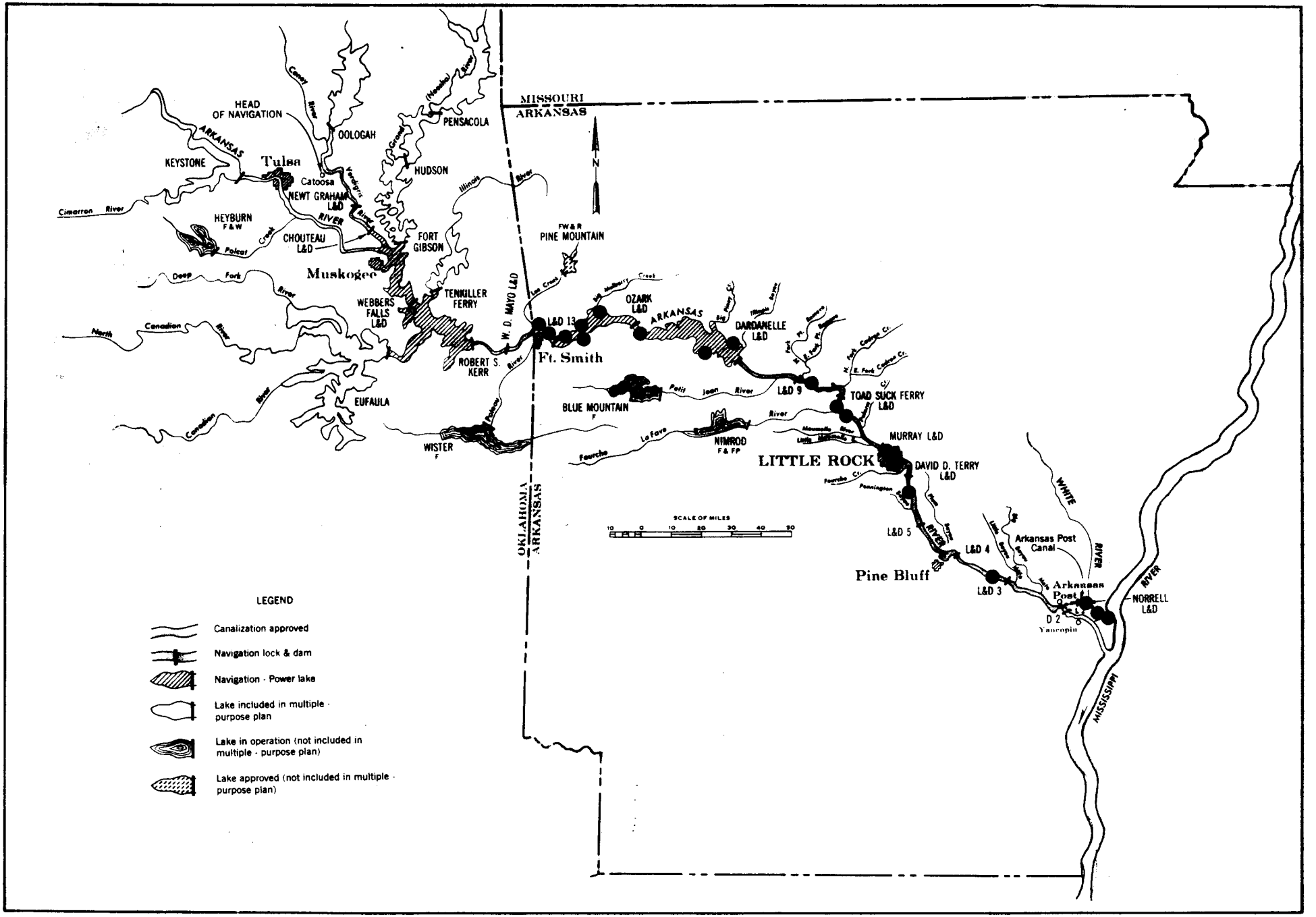
MAP 87. Spotted Bass - *Micropterus punctulatus*



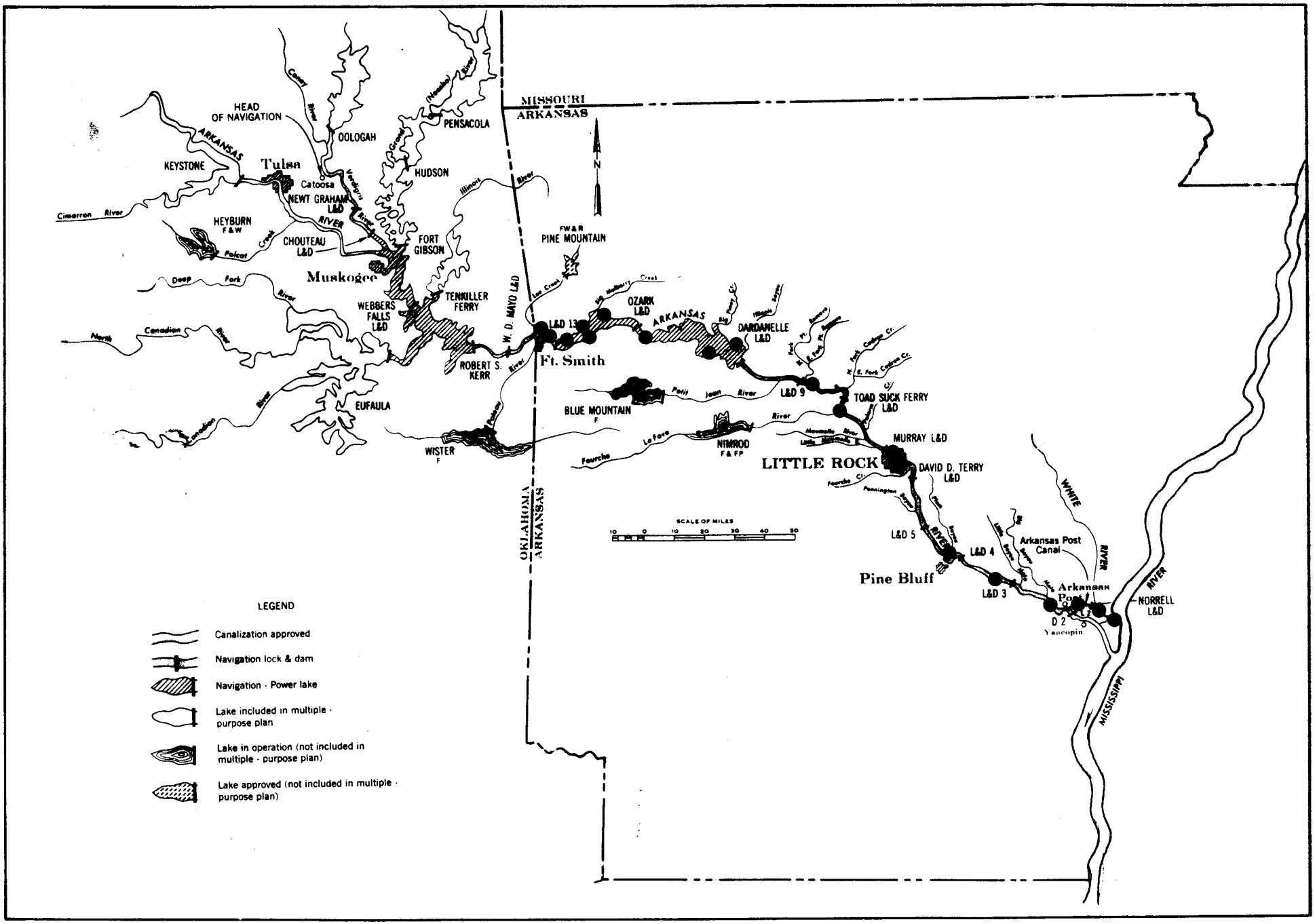
MAP 88. Largemouth Bass - *Micropterus salmoides*



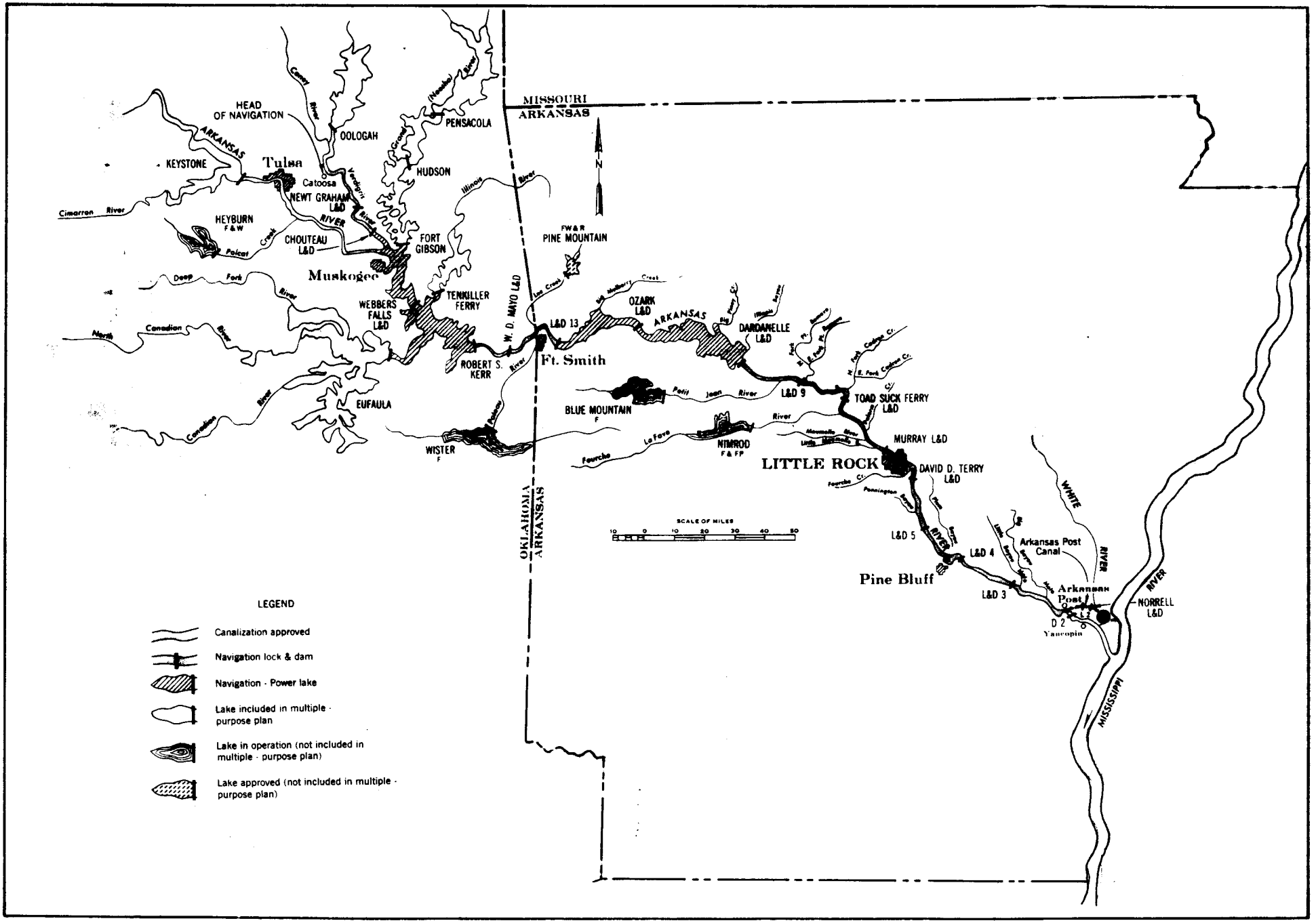
MAP 89. White Crappie - *Pomoxis annularis*



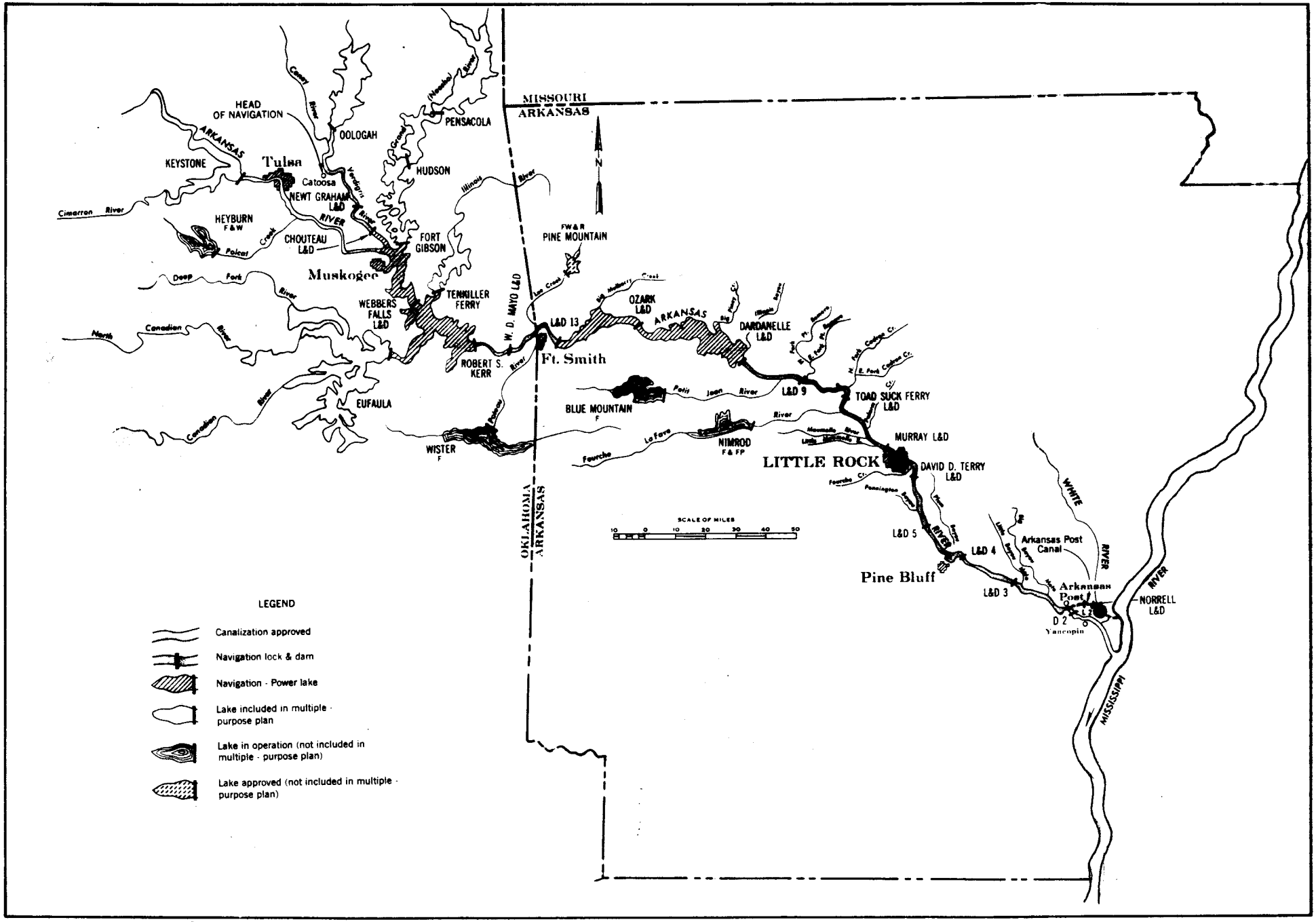
MAP 90. Black Crappie - *Pomoxis nigromaculatus*



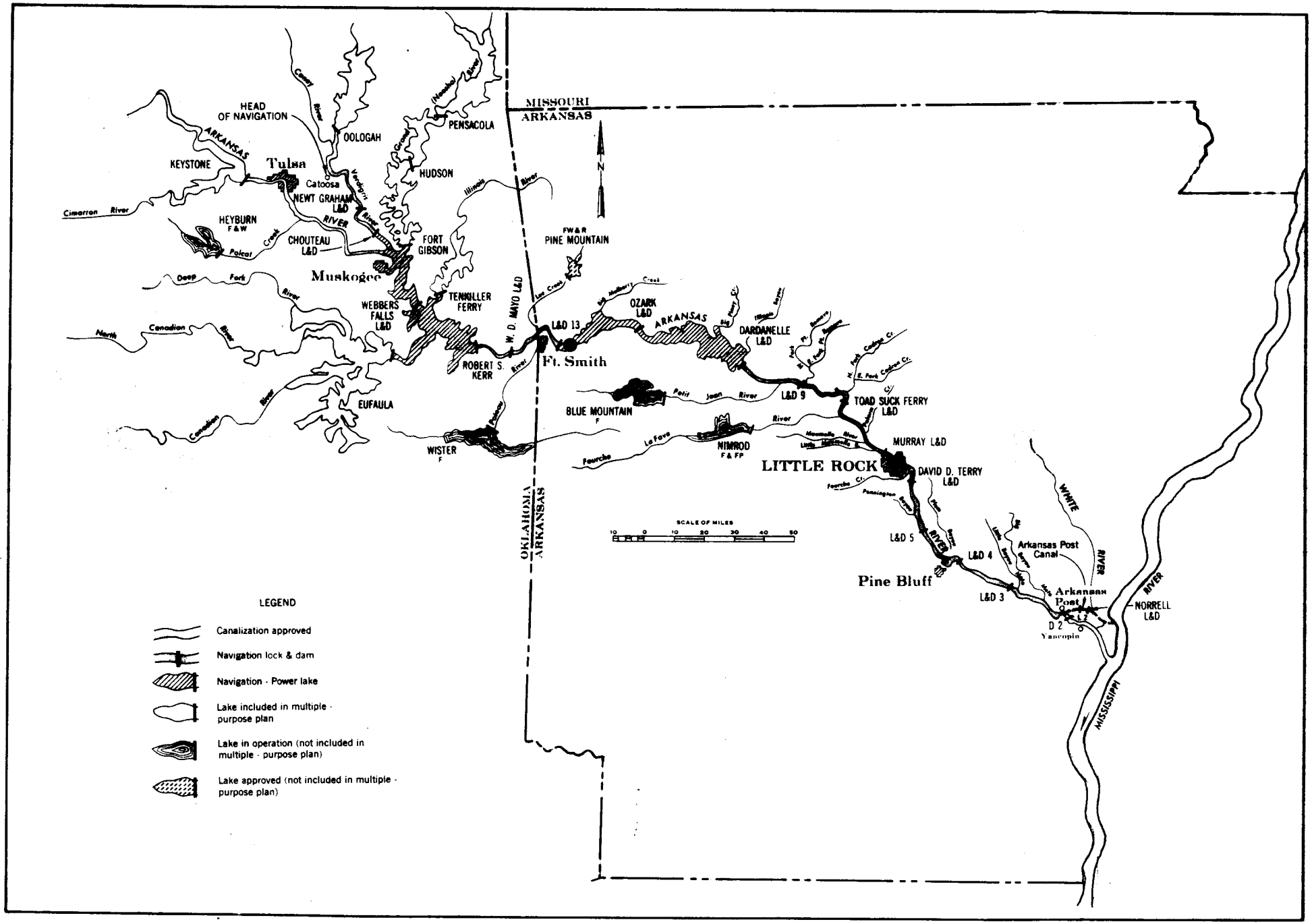
MAP 91. Banded Pygmy Sunfish - *Elassoma zonatum*



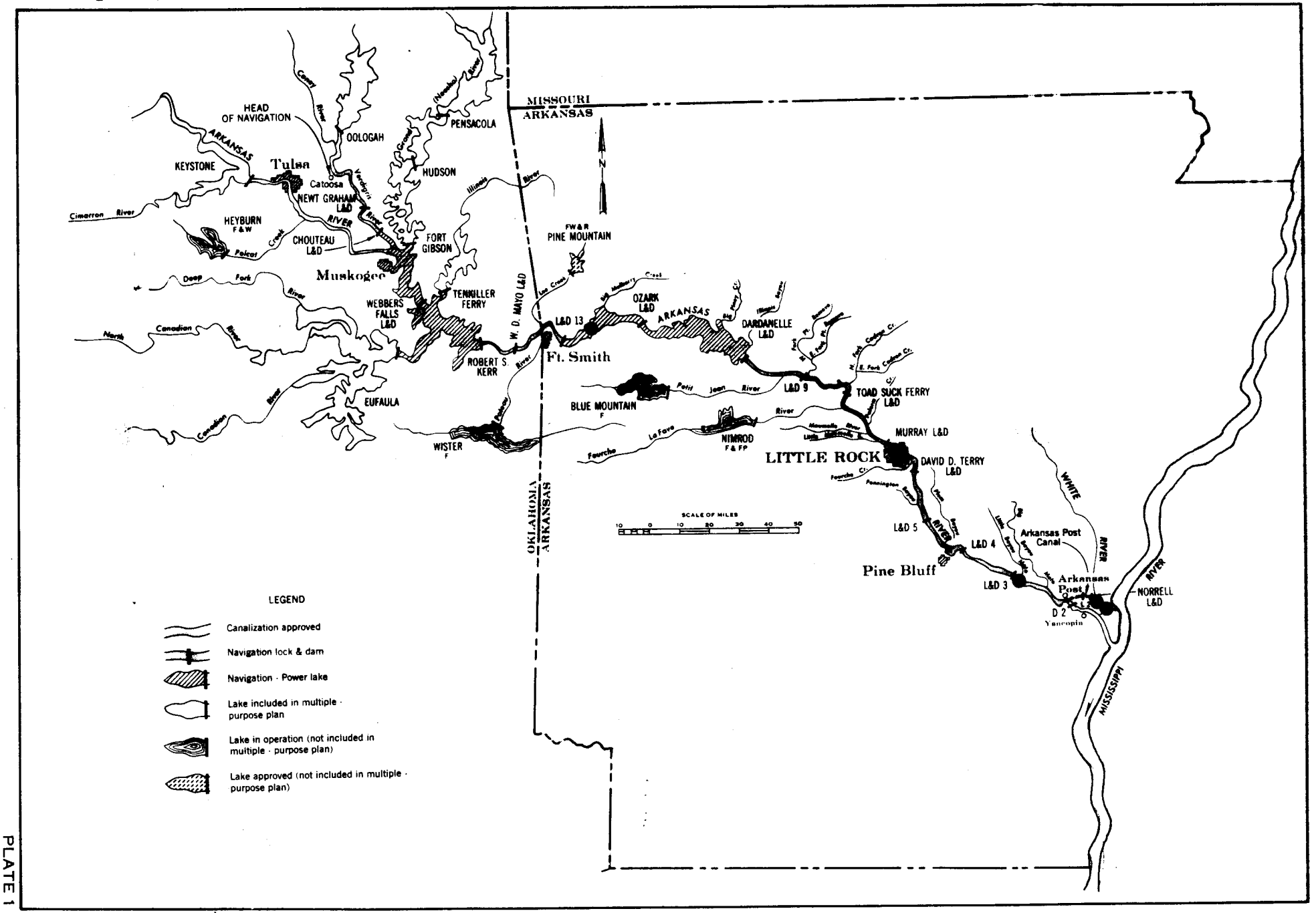
MAP 92. Mud Darter - *Etheostoma asprigene*



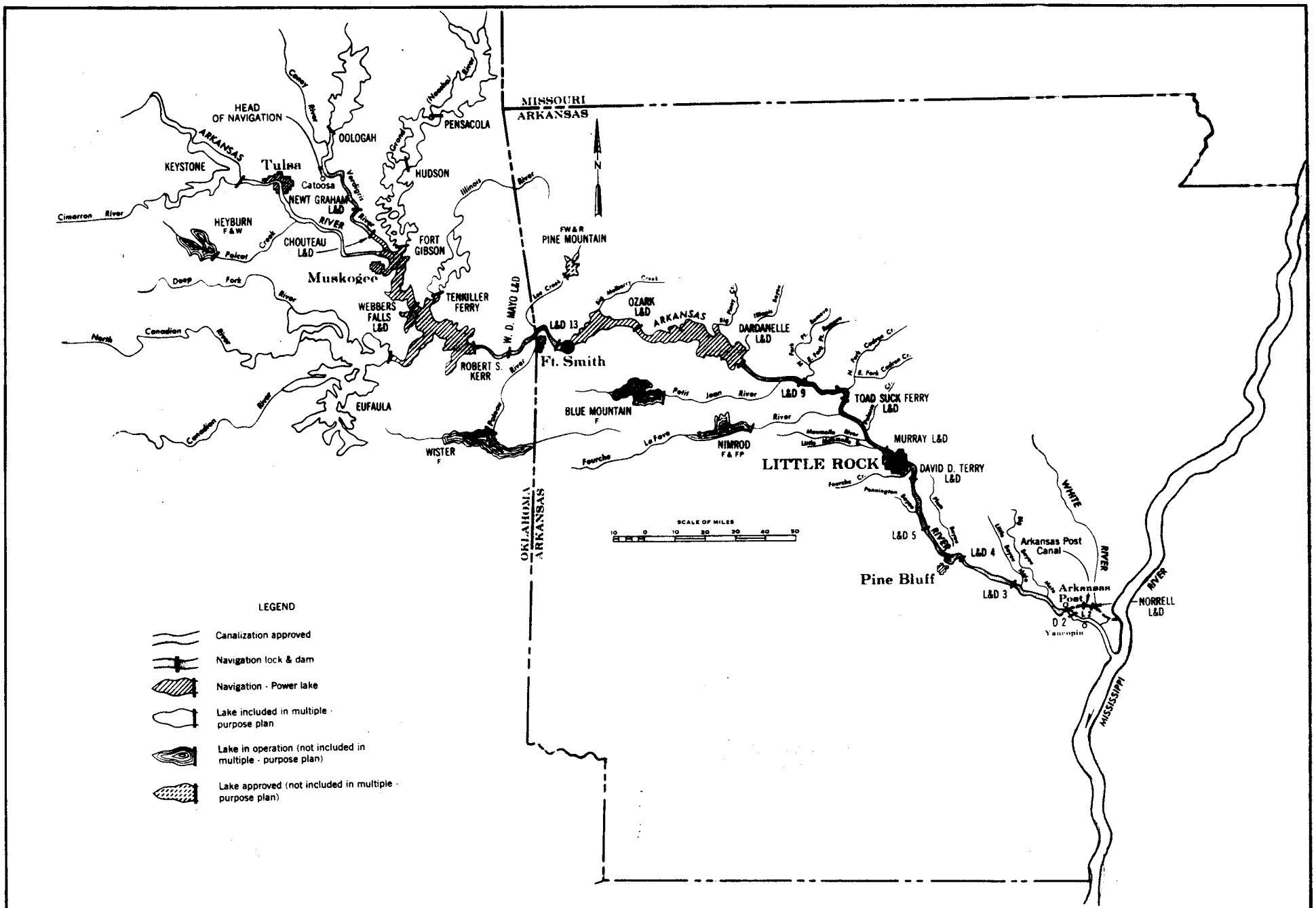
MAP 93. Greenside Darter - *Etheostoma blennioides*



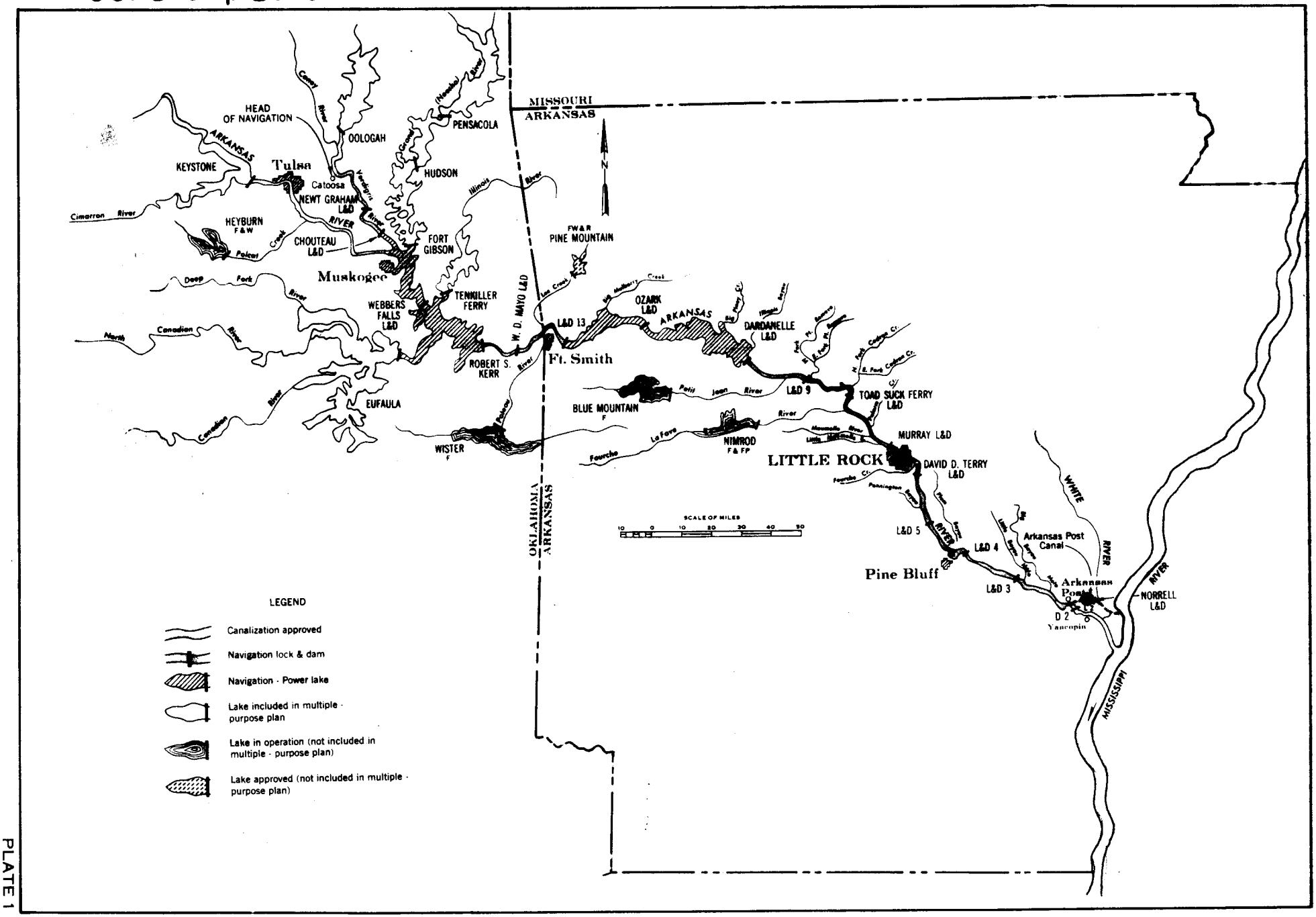
MAP 94. Bluntnose Darter - *Etheostoma chlorosomum*



MAP 95. Fantail Darter - *Etheostoma flabellare*



MAP 96. Swamp Darter - *Etheostoma fusiforme*



MAP 97 Cypress Darter - *Etheostoma proeliar*

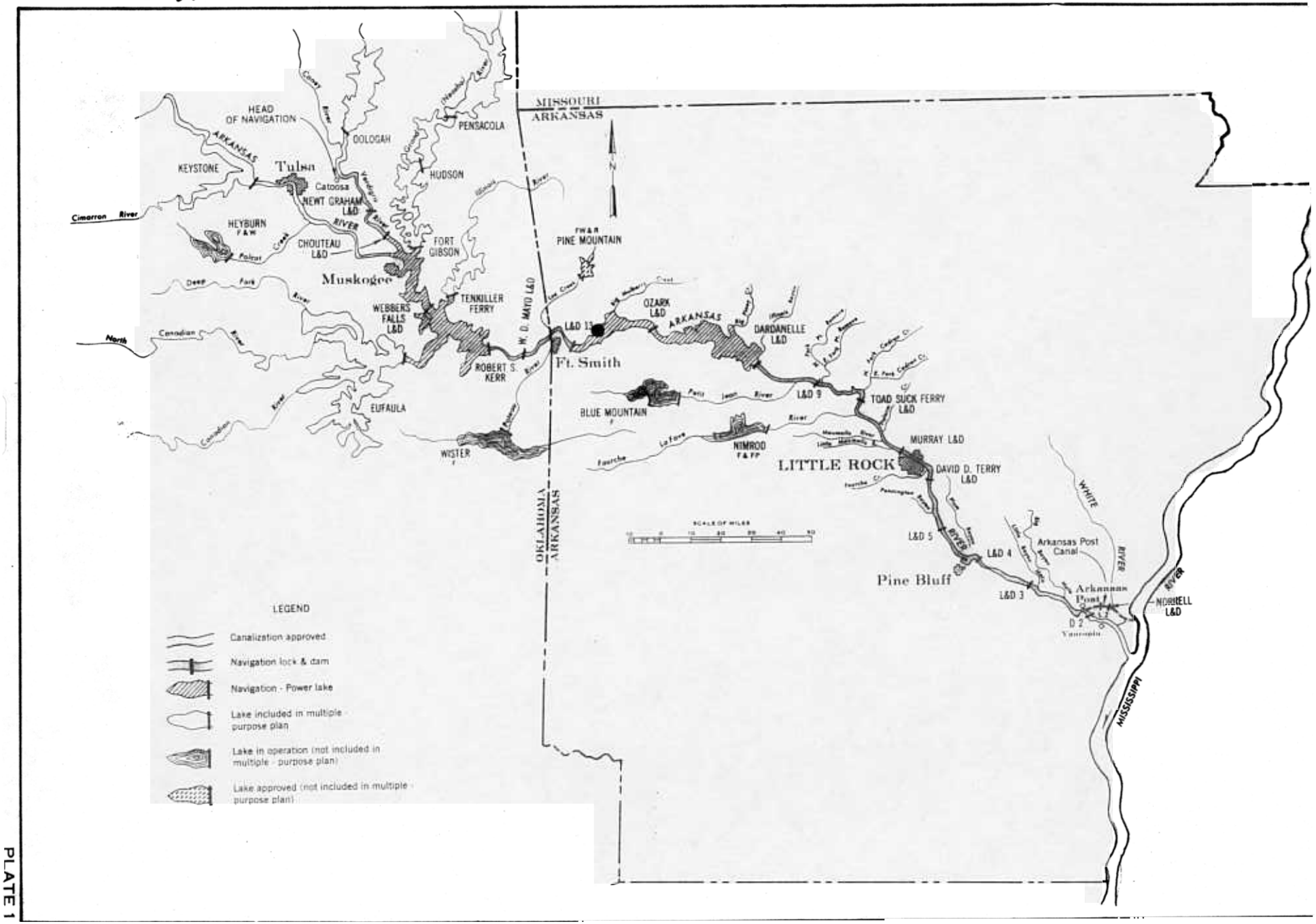
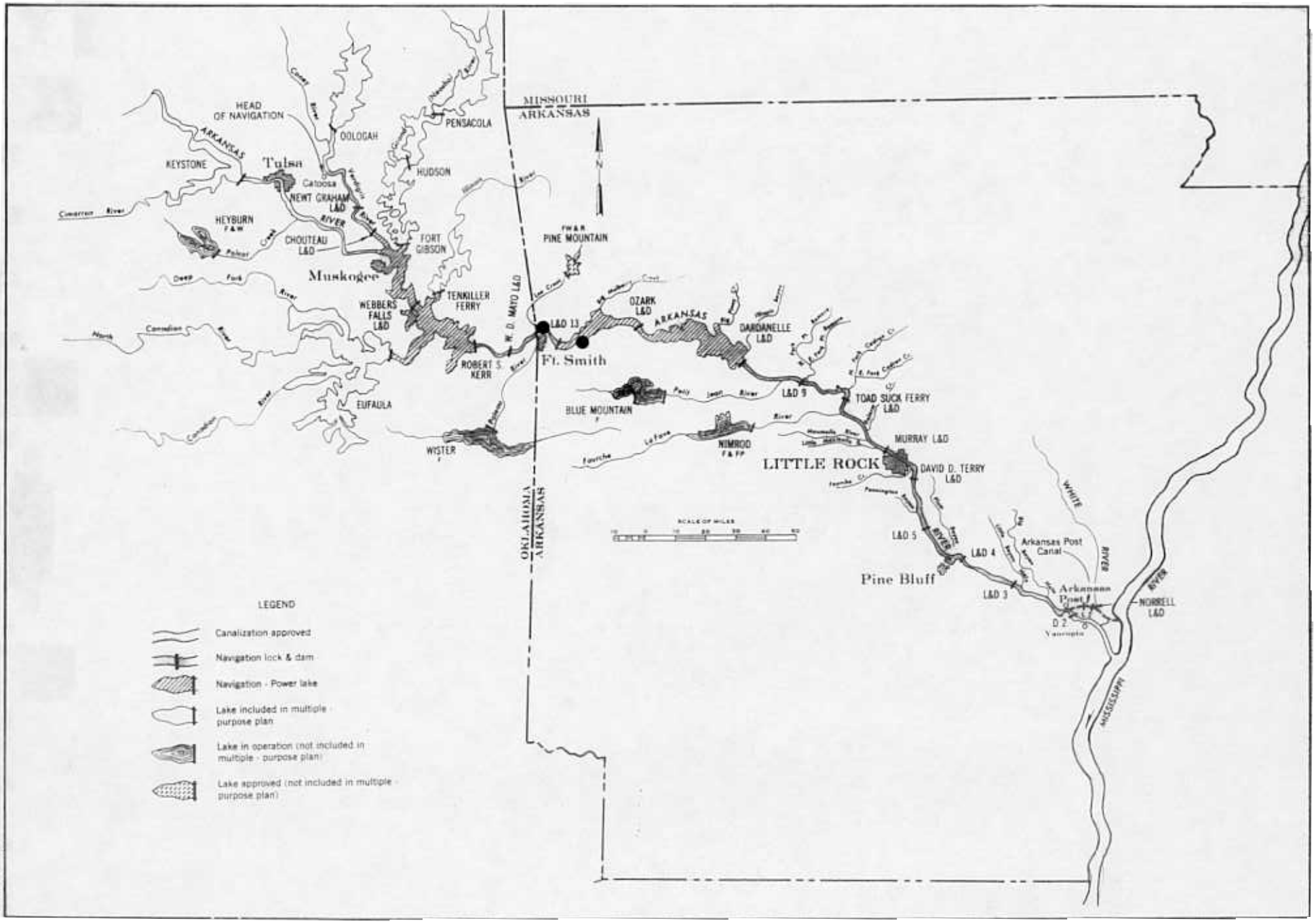


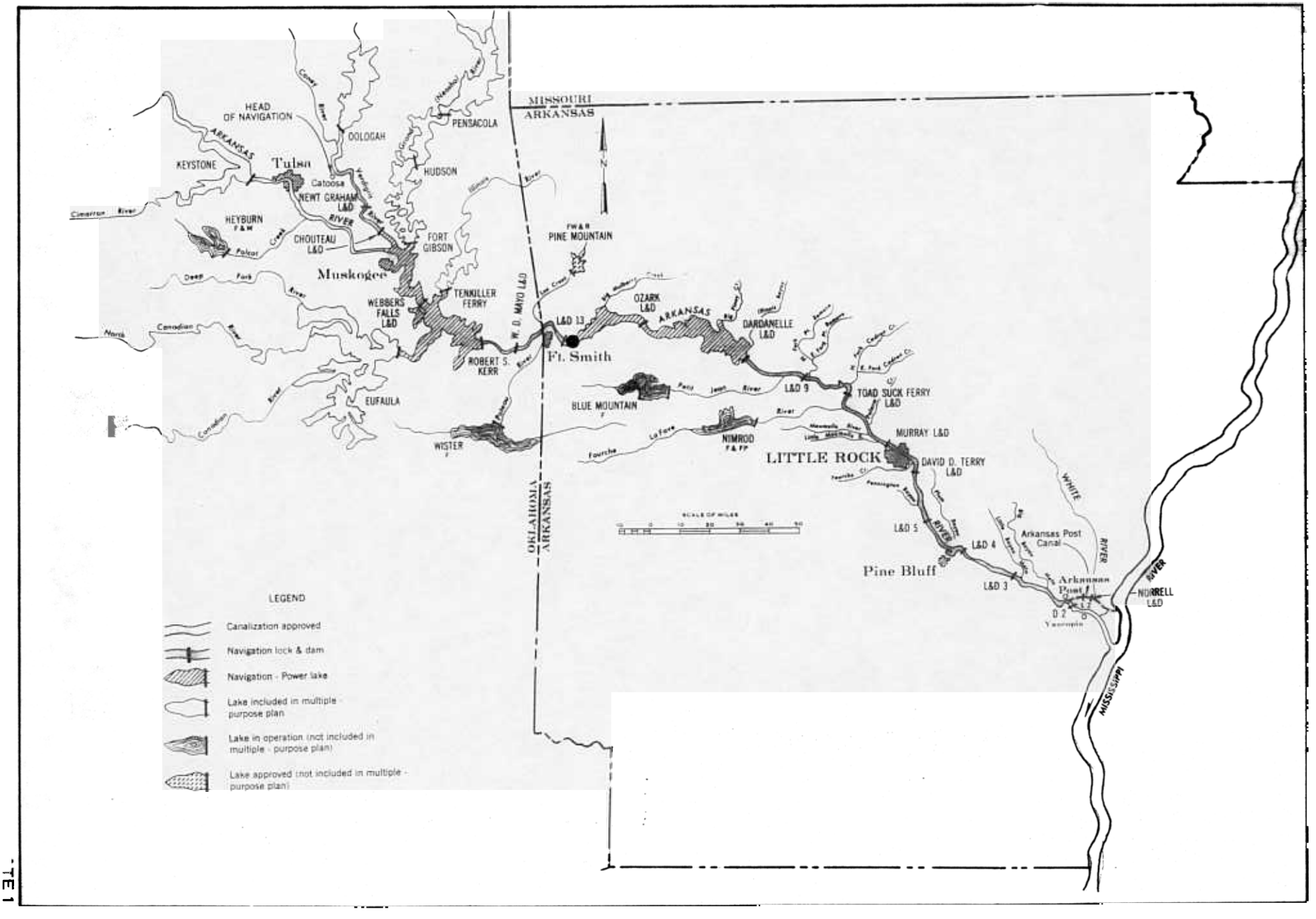
PLATE 1

MAP 98 Redfin Darter - *Etheostoma whipplei*

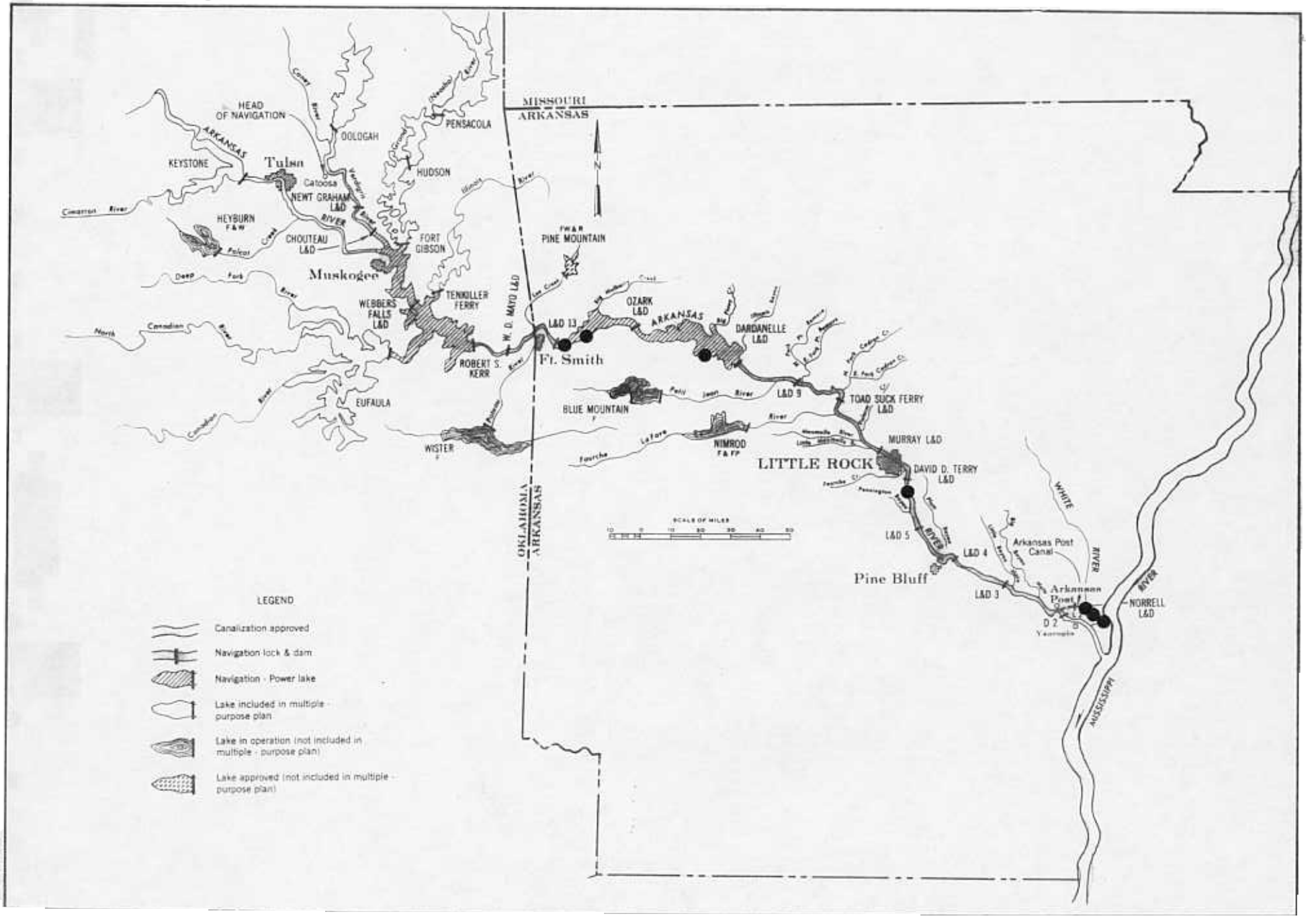


PLATE

MAP 99. Banded Darter – *Etheostoma zonale*

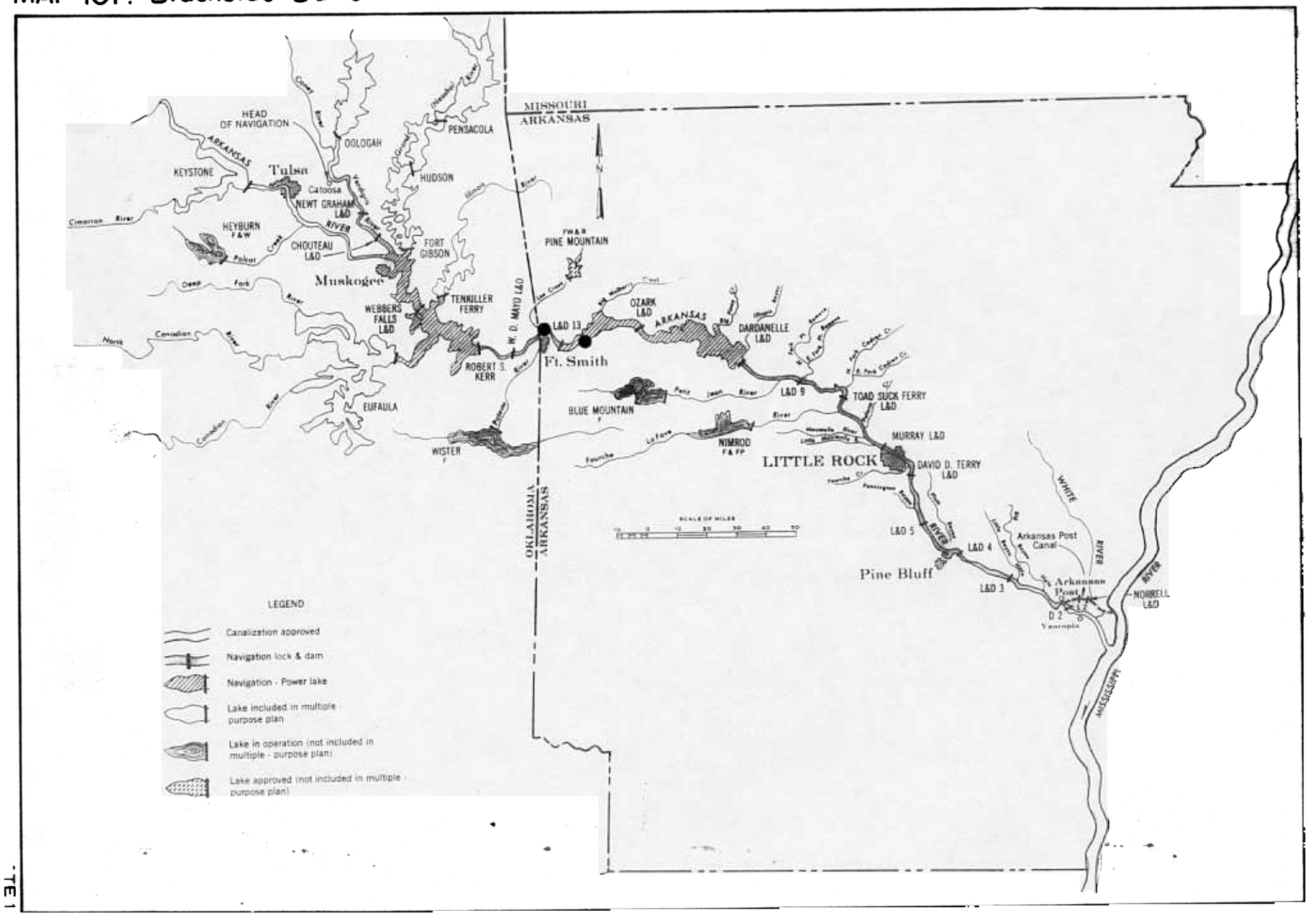


MAP 100. Logperch - *Percina*

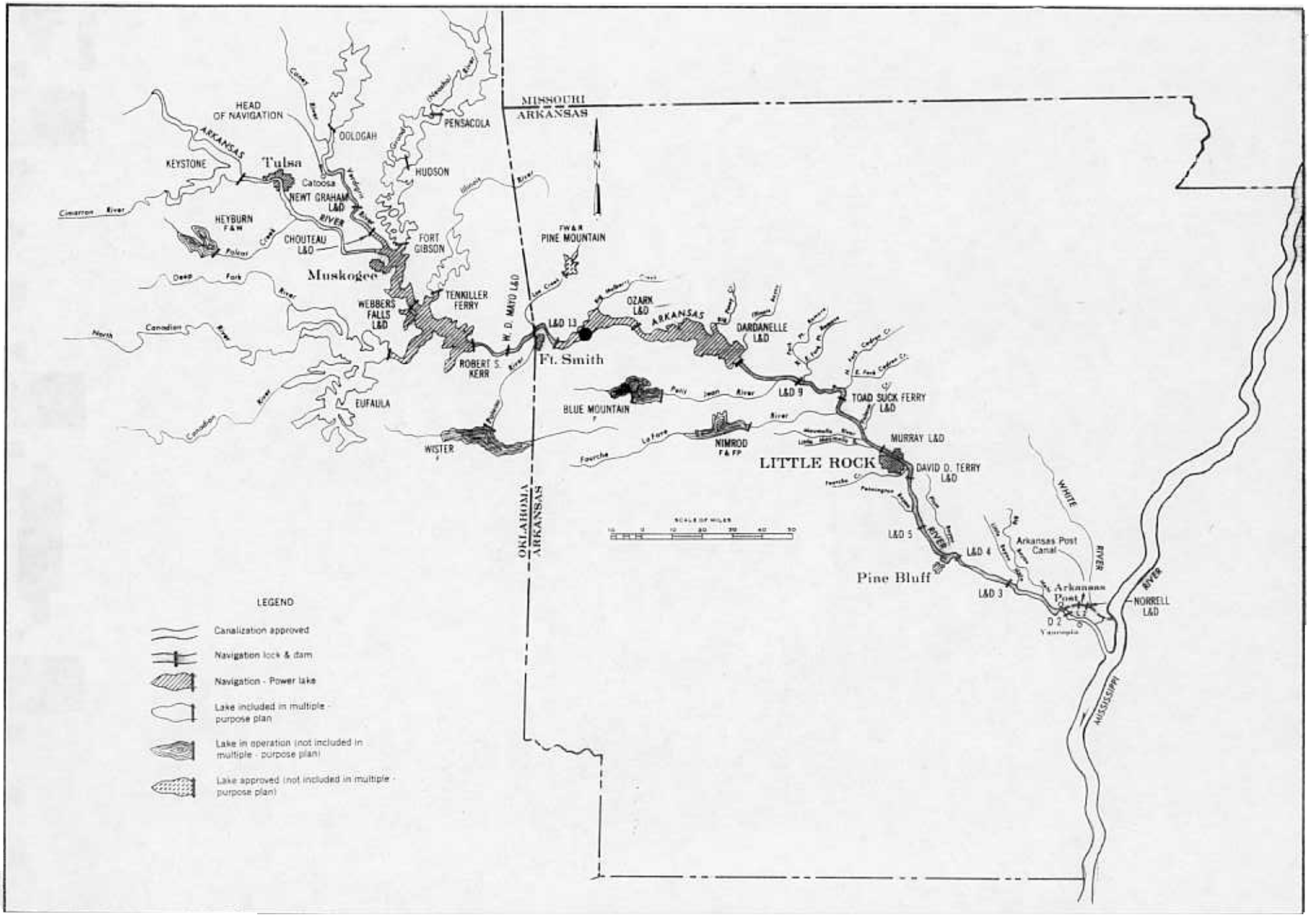


PLATE

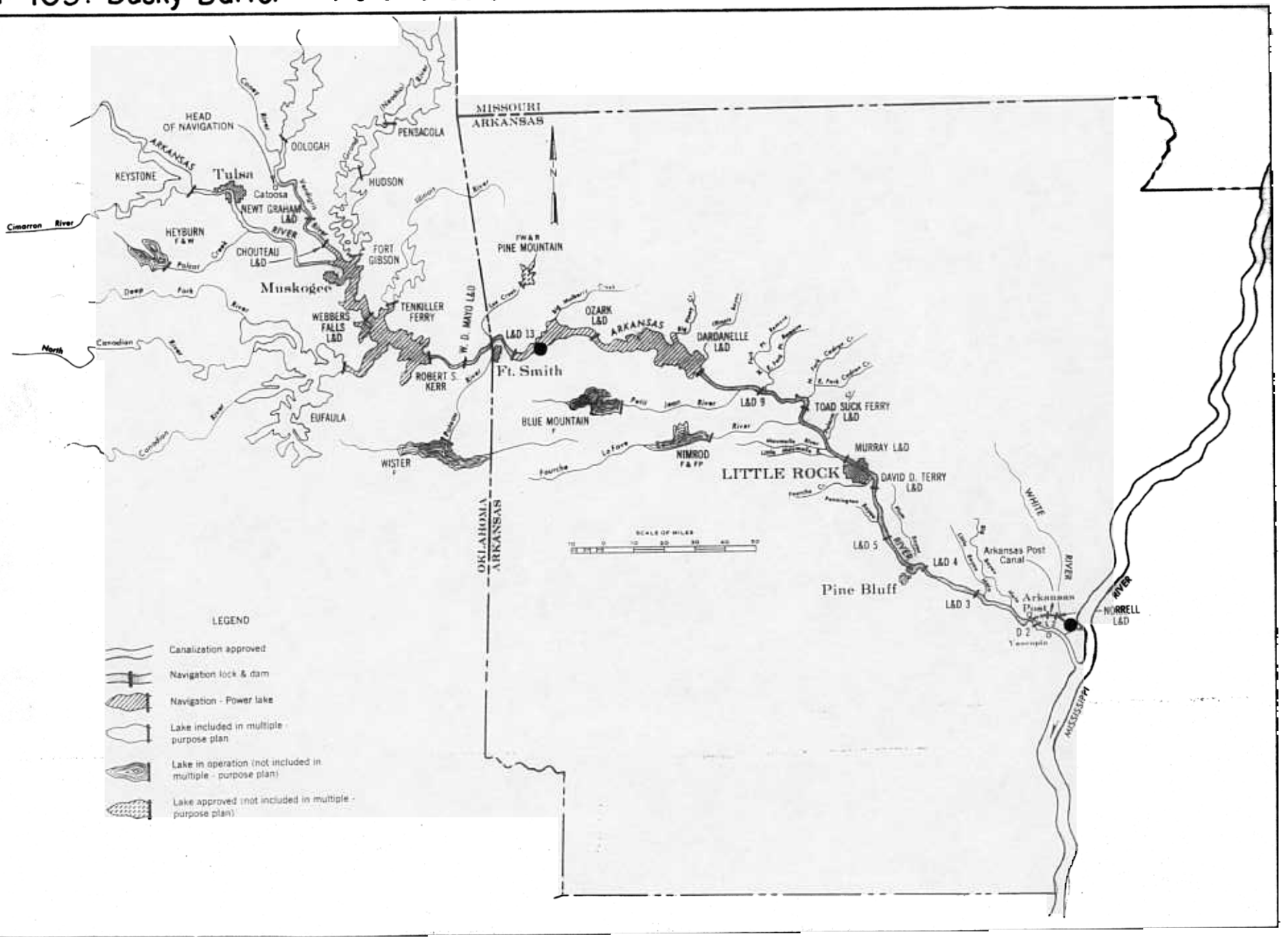
MAP 101. Blackside Darter – *Percina maculata*



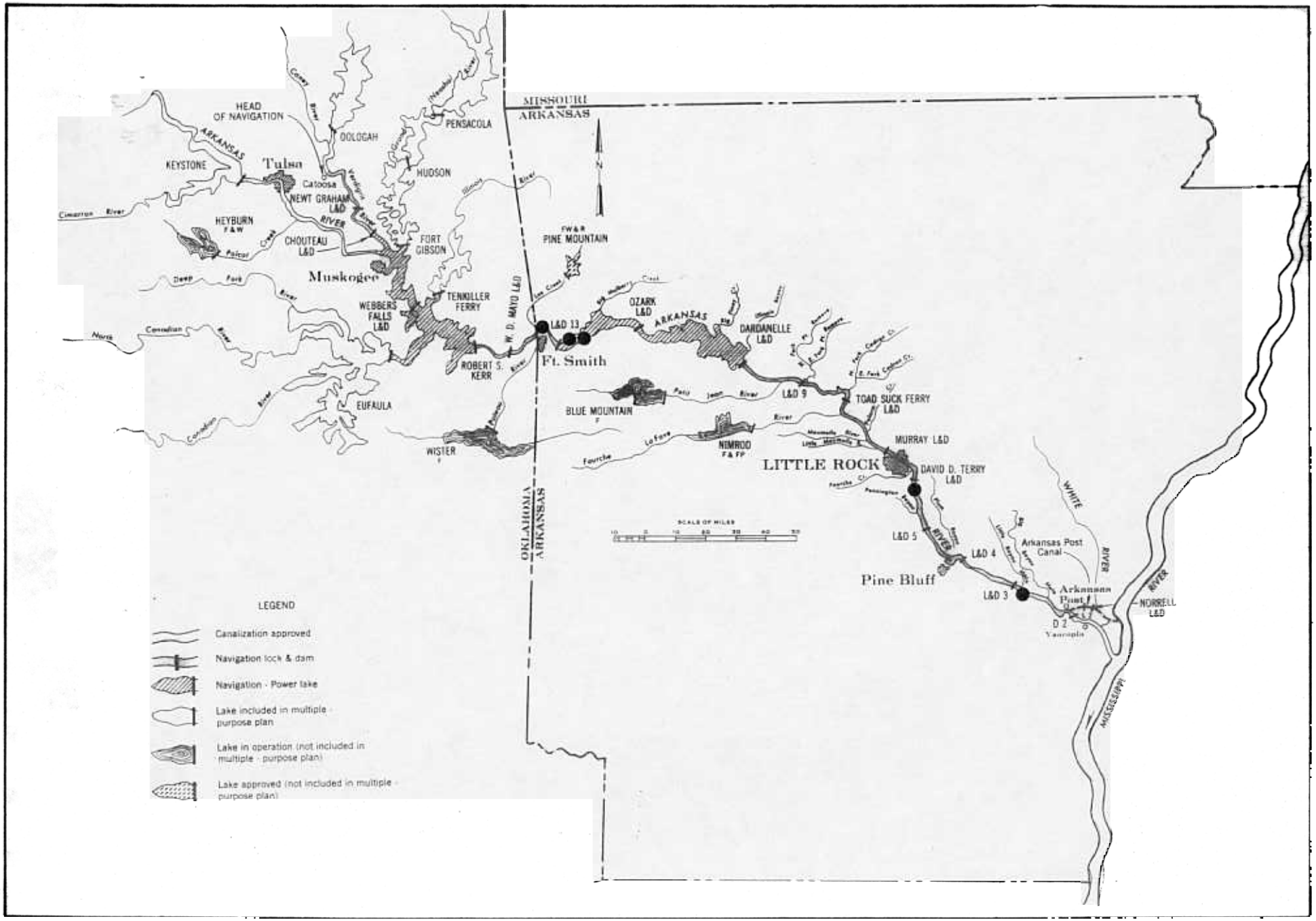
MAP 102. Longnose Darter *Percina nasuta*



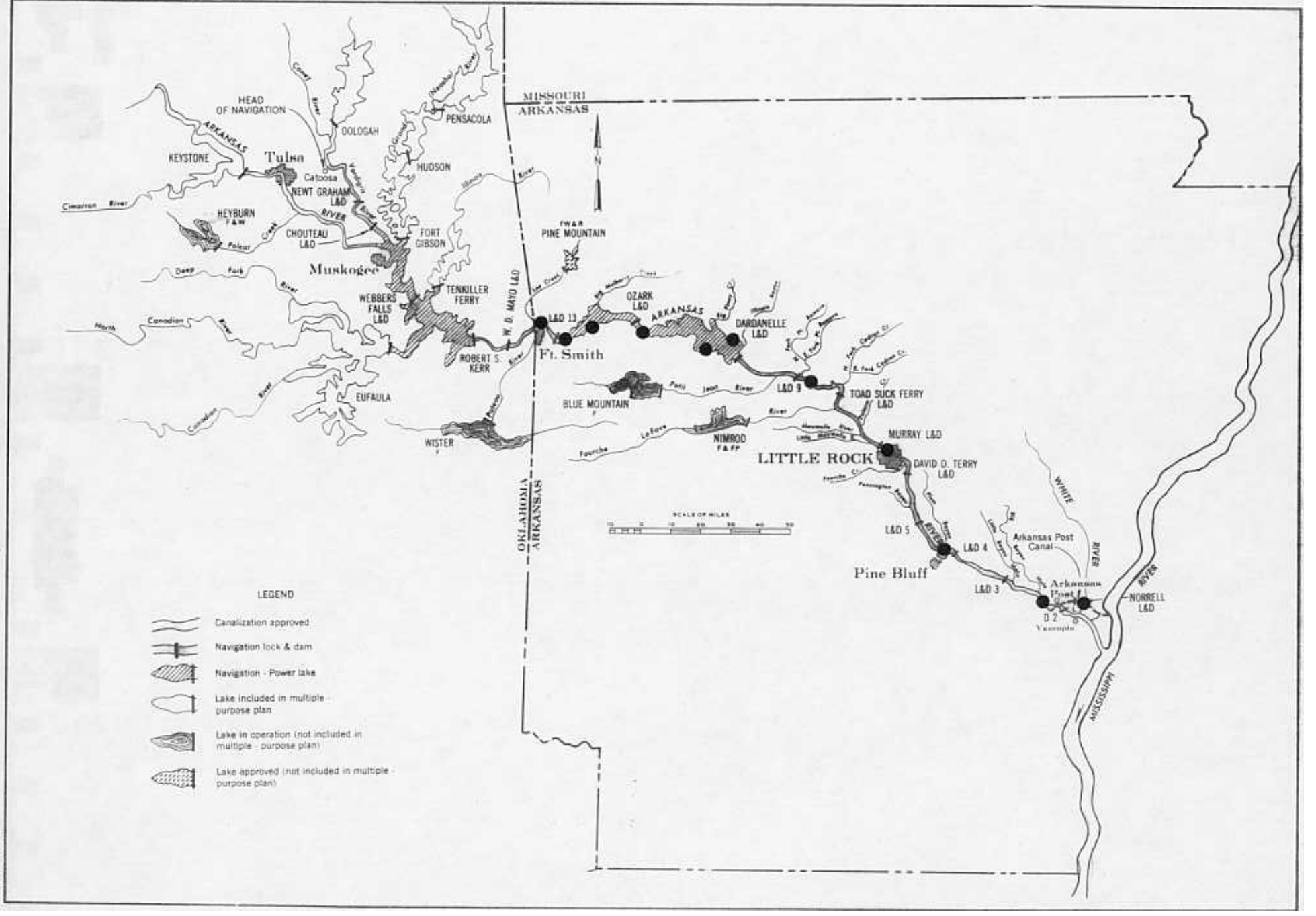
MAP 103. Dusky Darter *Percina sciera*



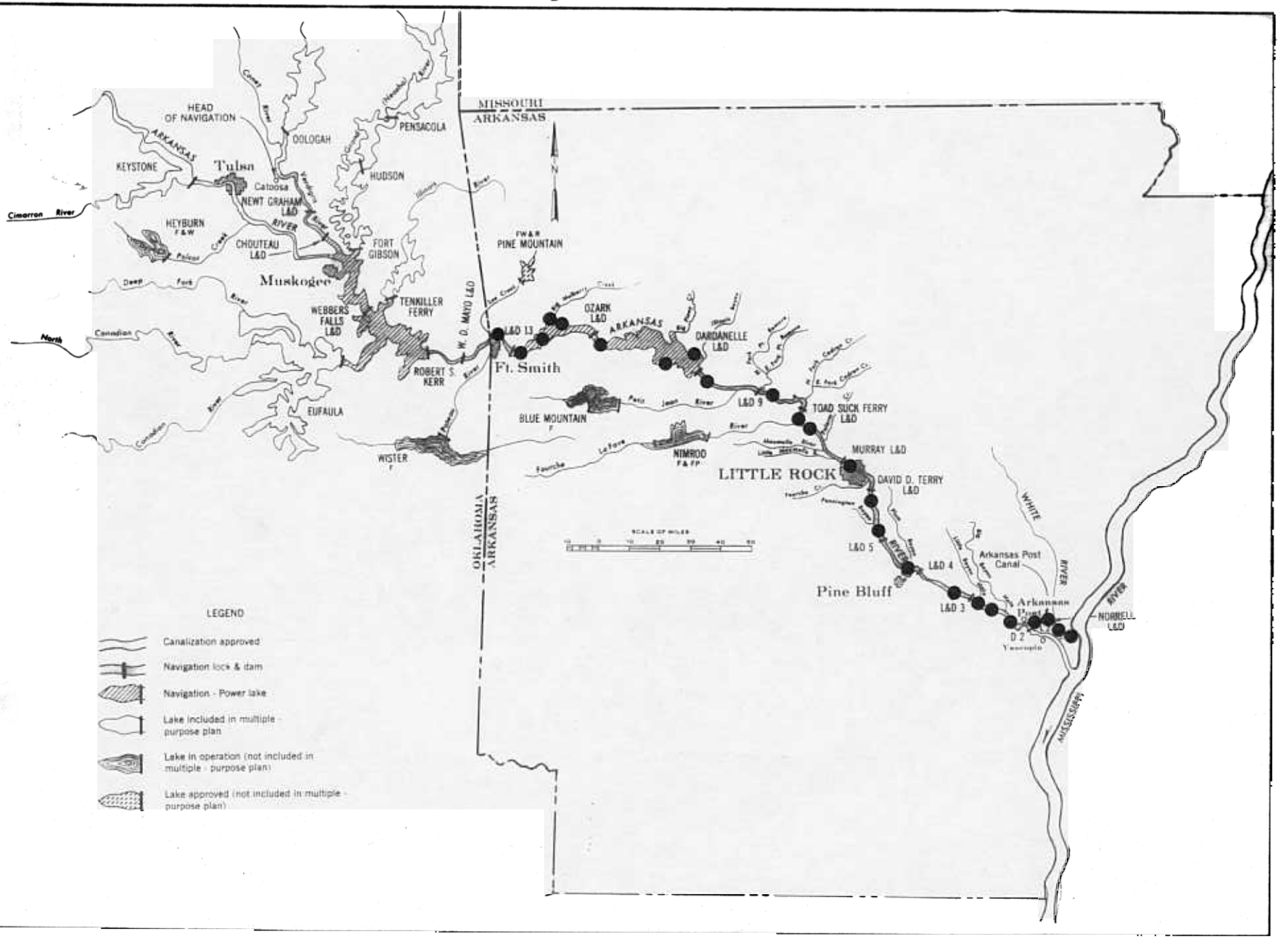
MAP 104. River Darter - *Percina shumardi*



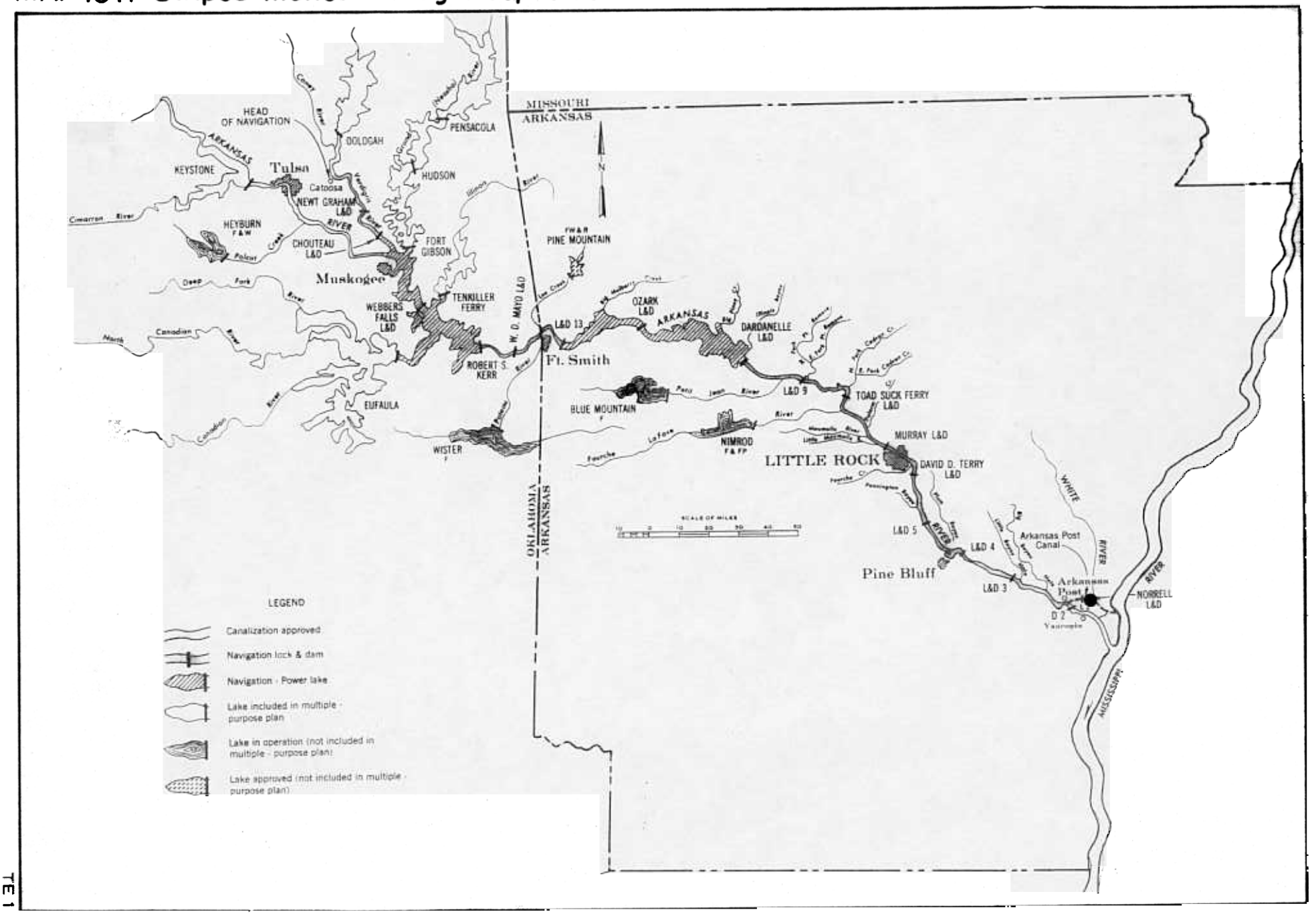
MAP 105. Sauger – *Stizostedion canadense*



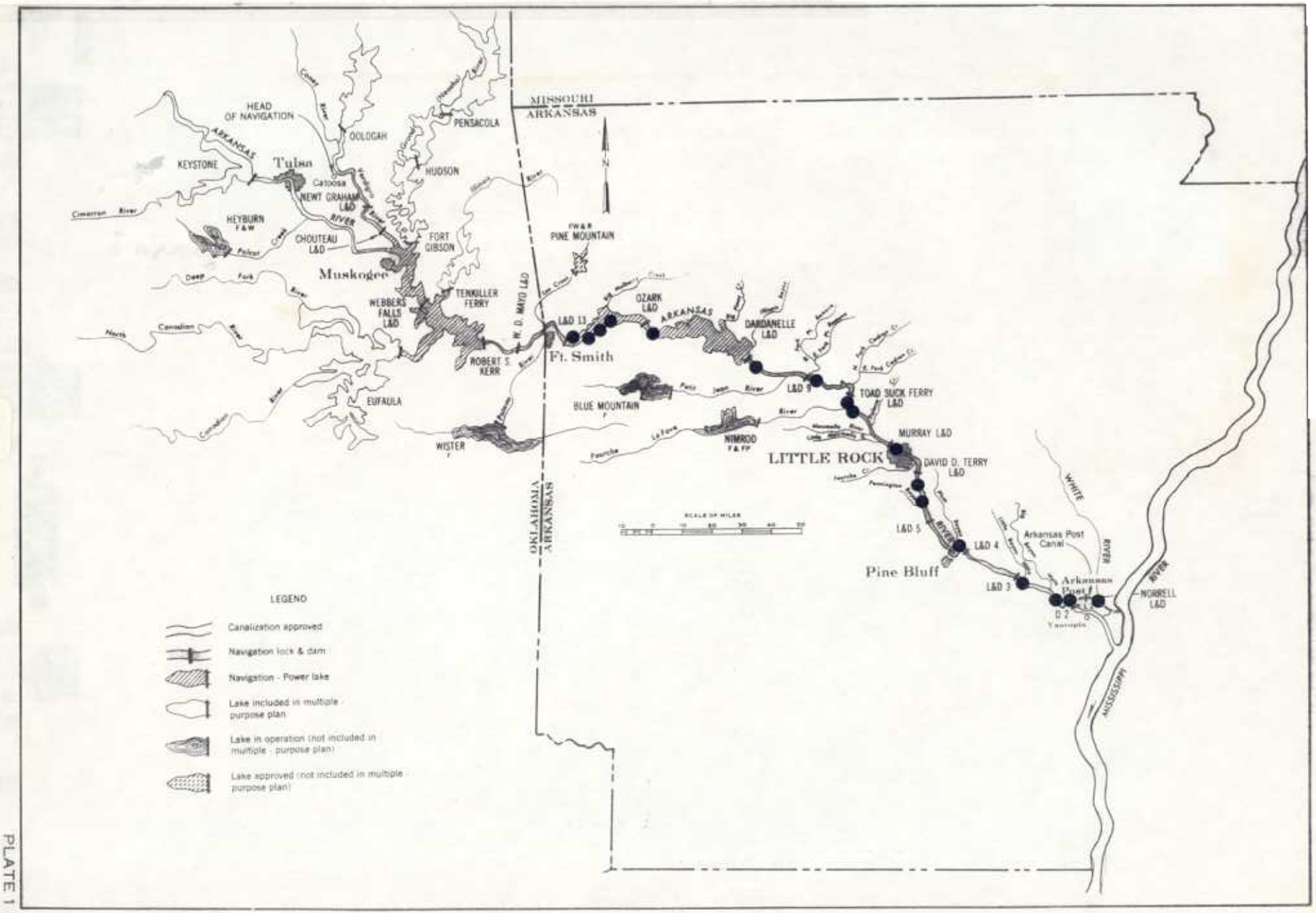
MAP 106 Freshwater Drum - *Aplodinotus grunniens*



MAP 107. Striped Mullet - *Mugil cephalus*



MAP 108. Dredged material disposal areas from which fish samples were taken.



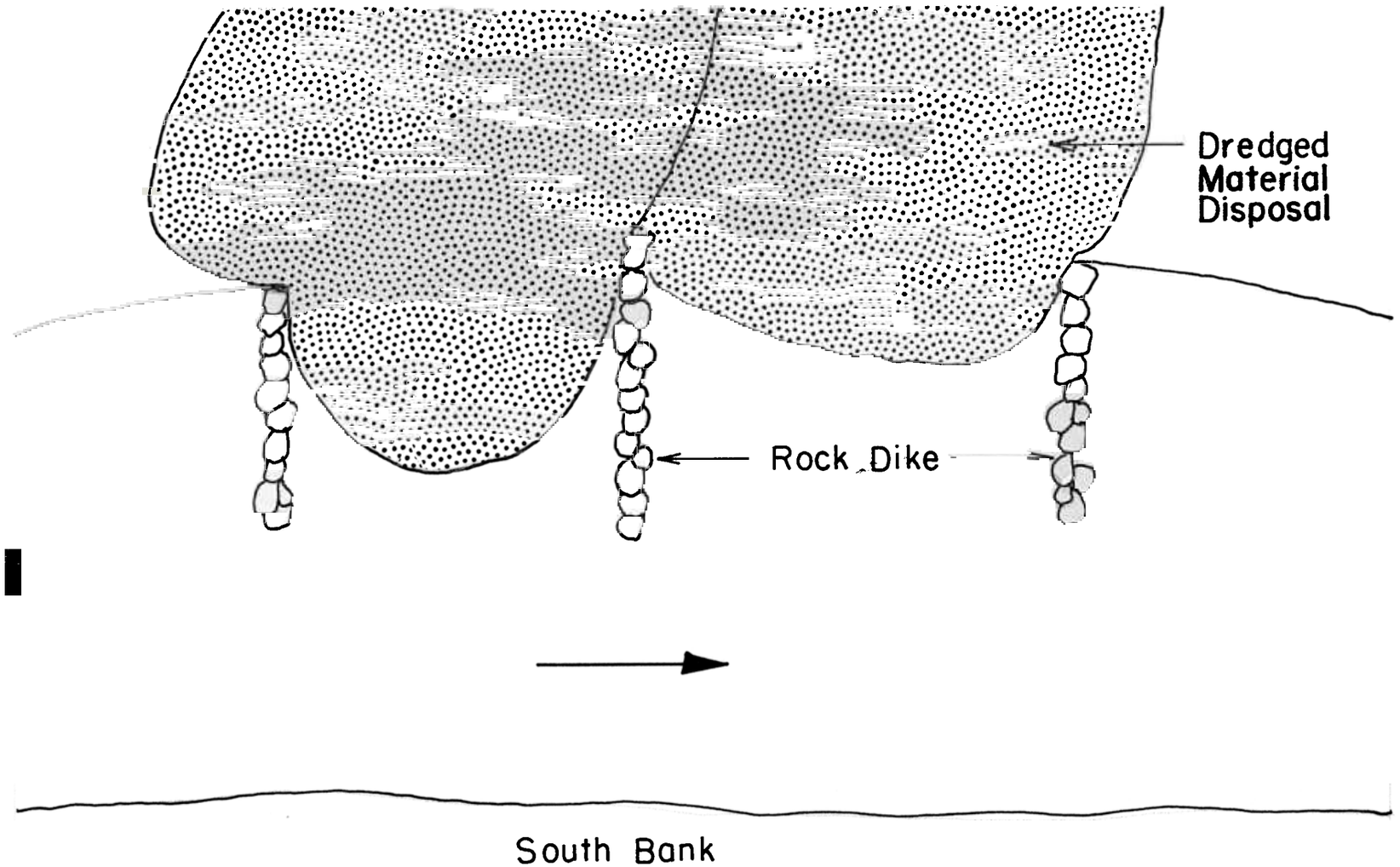


Figure 1. Type I dredged material disposal area.

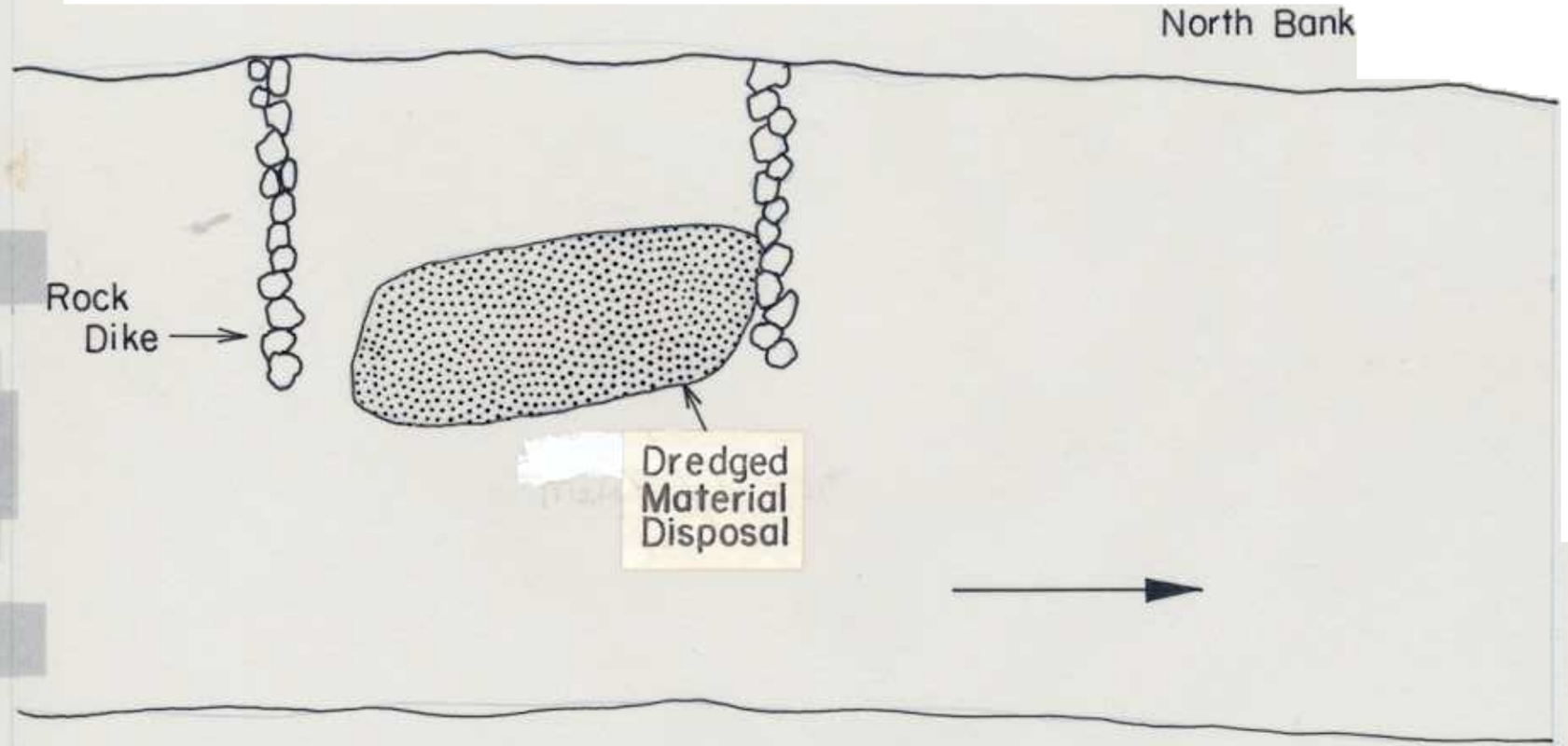


Figure 2. Type II dredged material disposal area.

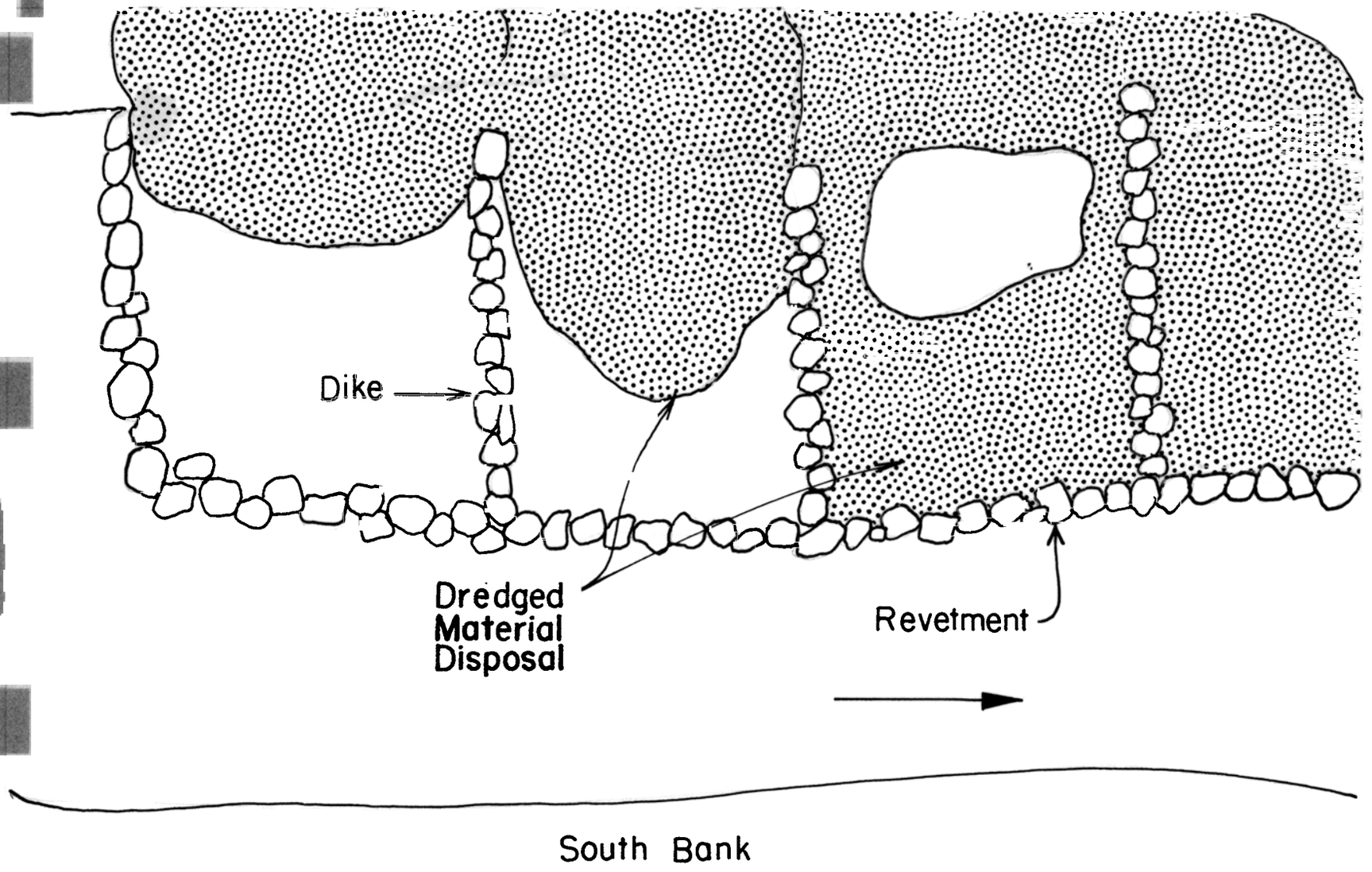


Figure 3. Type III dredged material disposal area

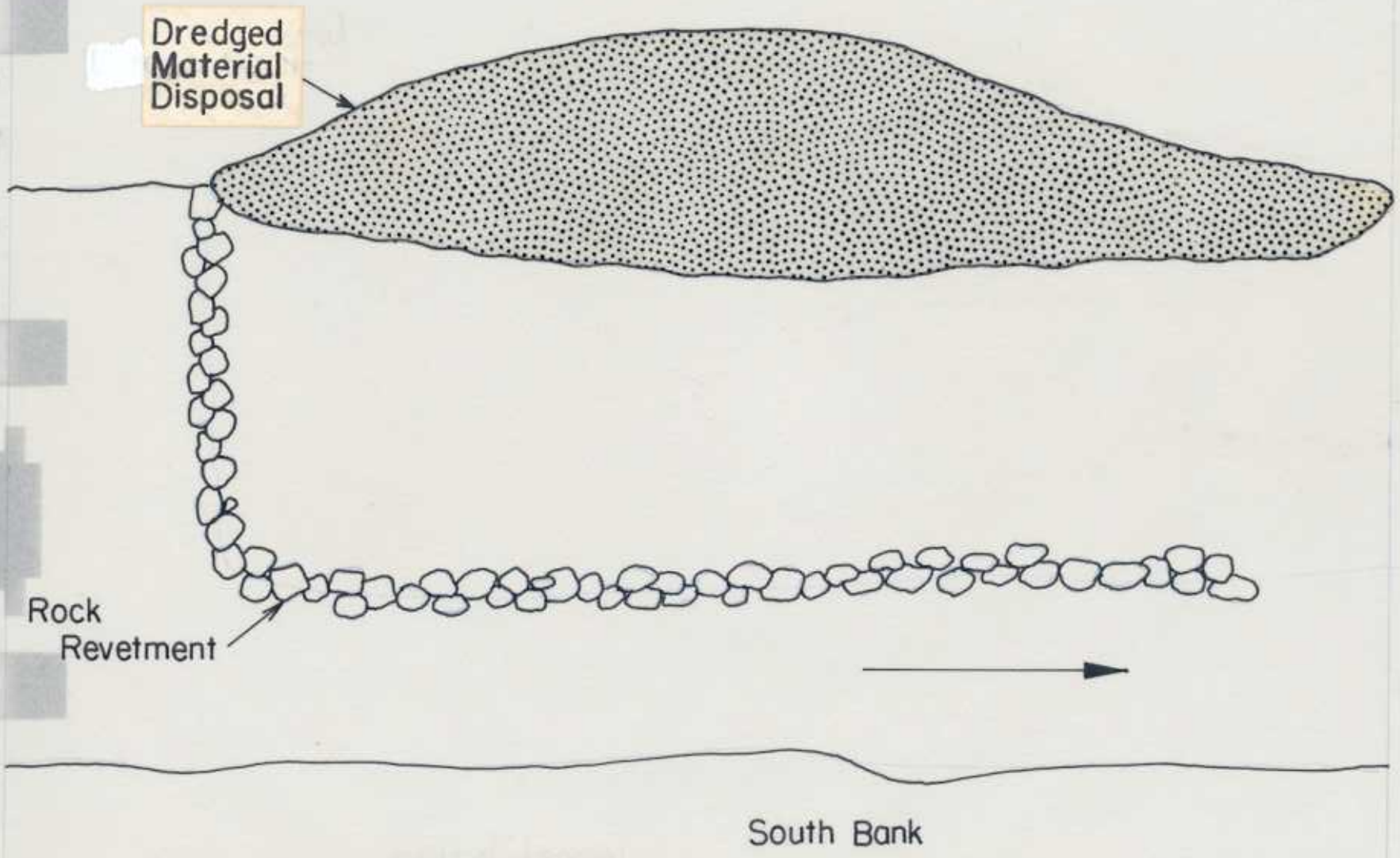


Figure 4. Type IV dredged material disposal area.

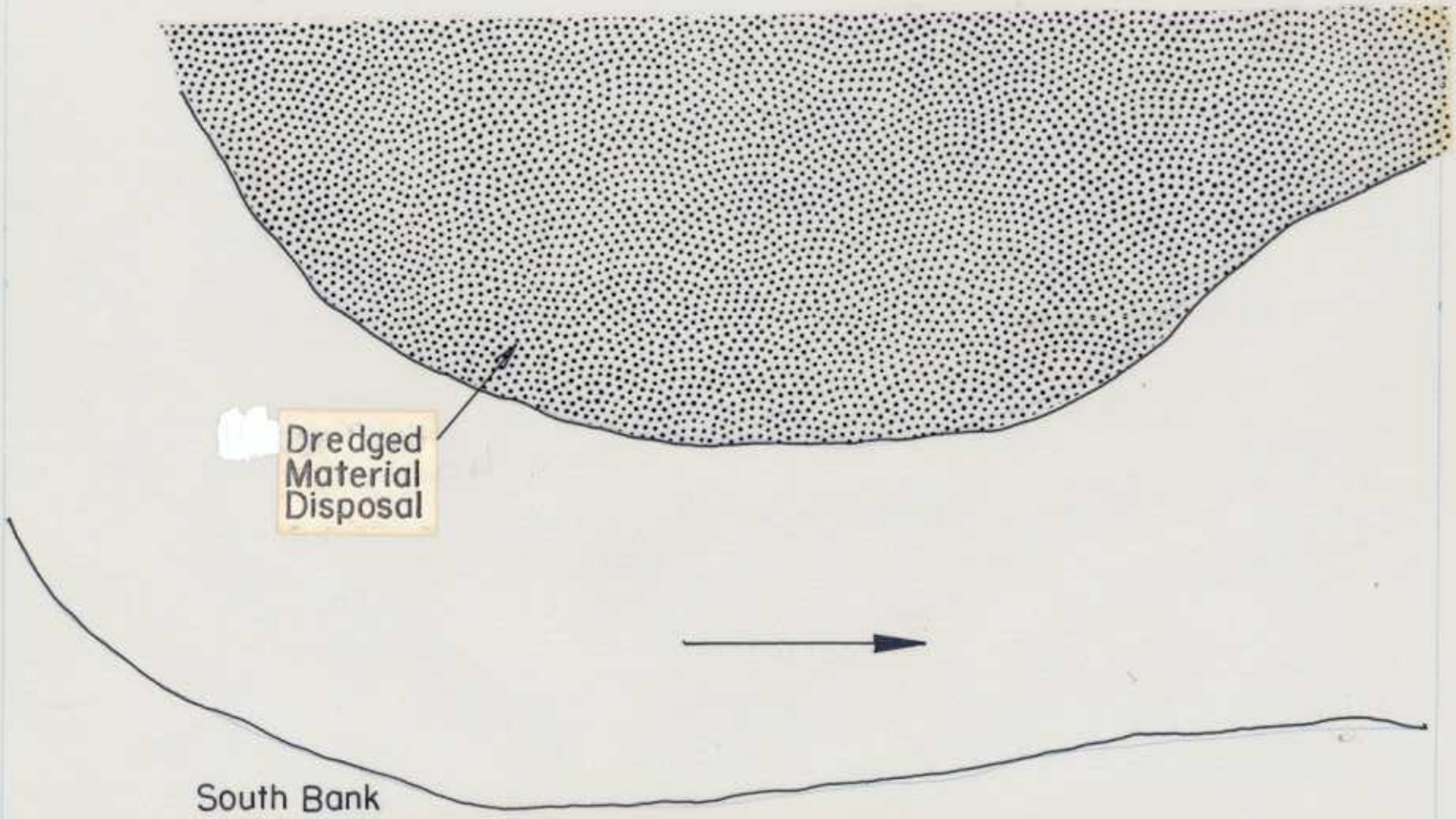


Figure 5. Type V dredged material disposal area.

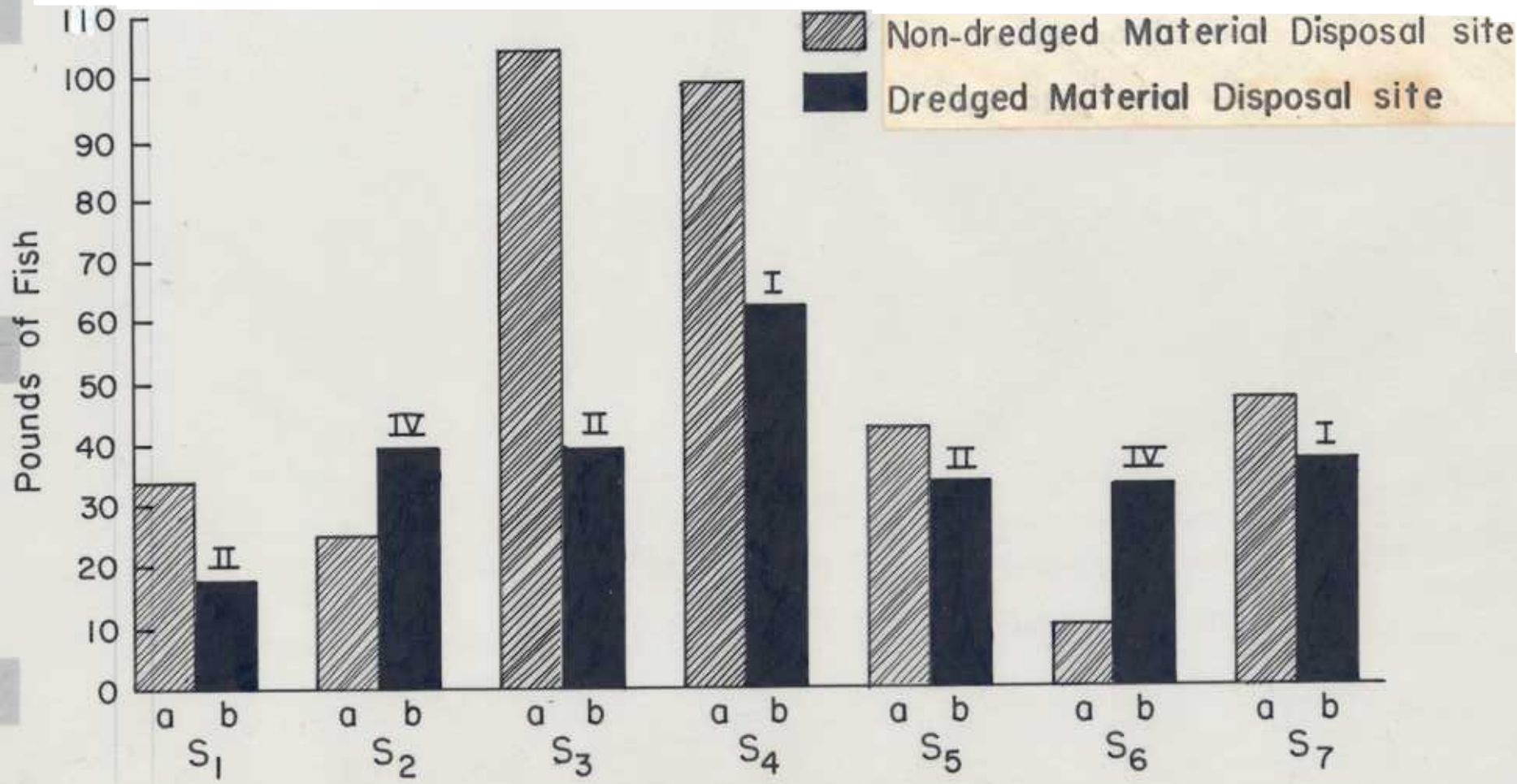


Figure 6. Total pounds of fish taken from the seven pairs of adjacent non-dredged material and dredged material disposal areas with the electric shocker during one hour shocking periods.

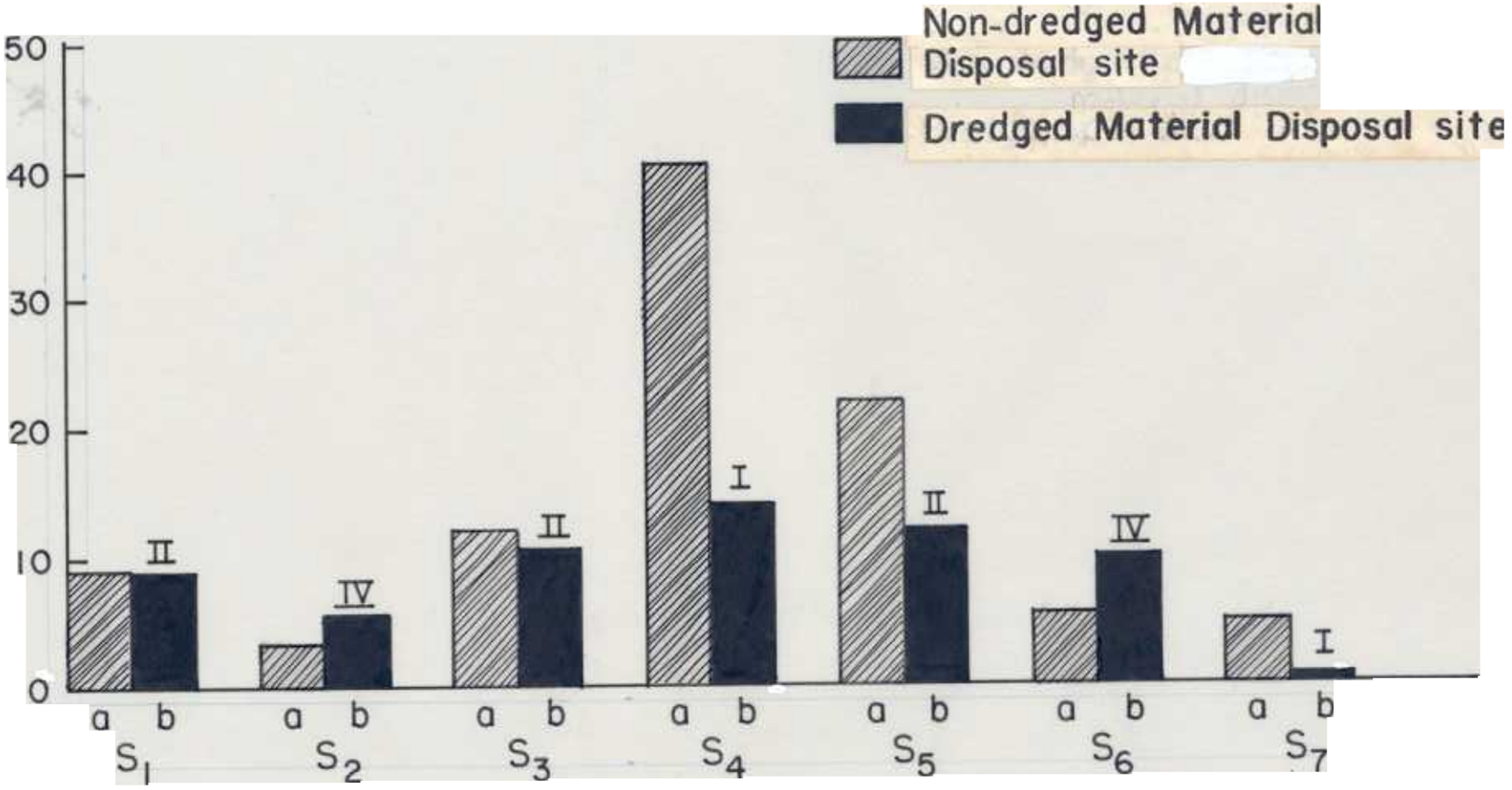


Figure 7. Pounds of game fish taken from the seven pairs of adjacent non-dredged material and dredged material disposal areas with the electric shocker during one hour shocking periods.

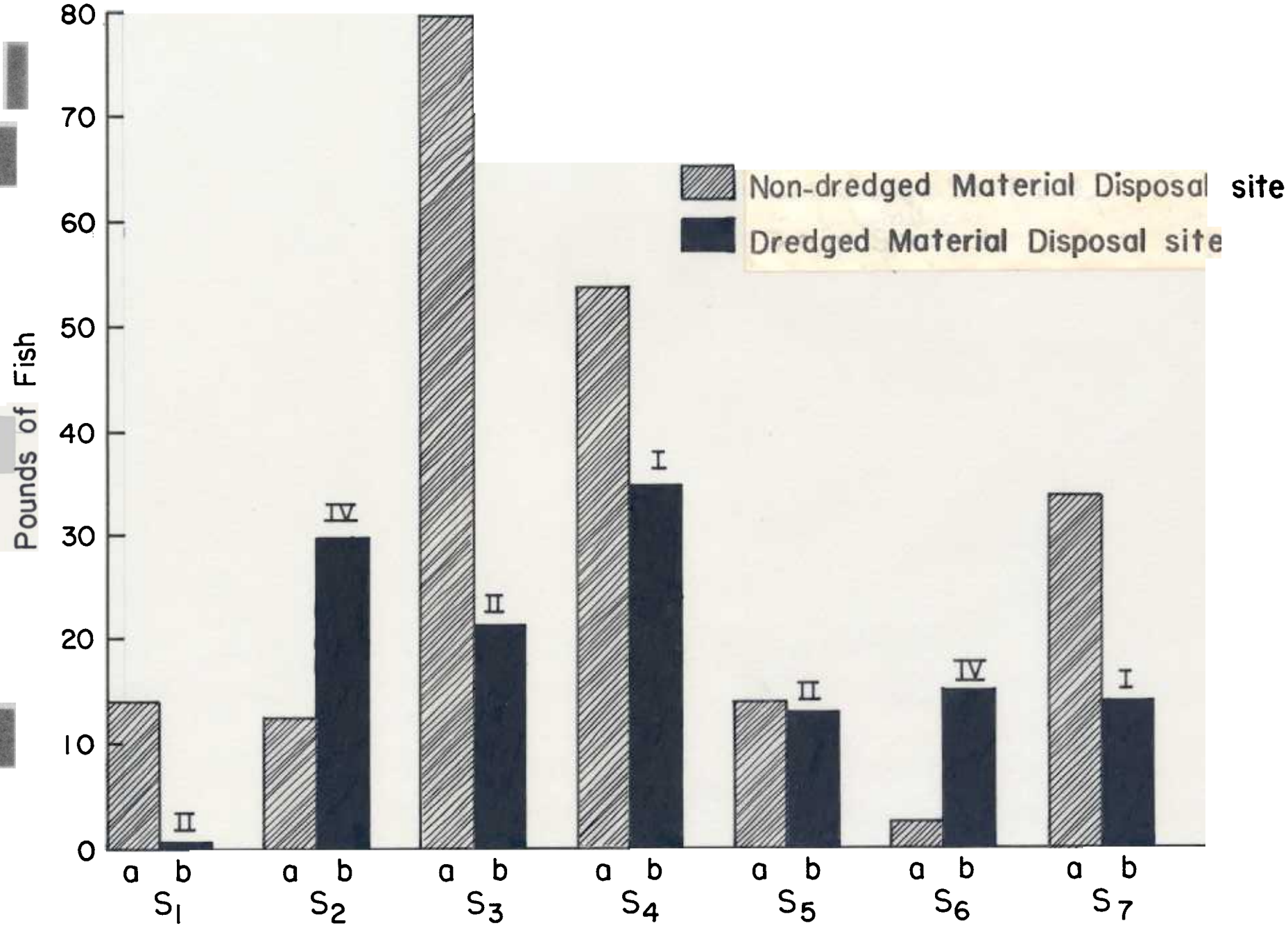


Figure 8. Pounds of commercial fishes taken from the seven pairs of adjacent non-dredged material and dredged material disposal areas with the electric shocker during one hour shocking periods.

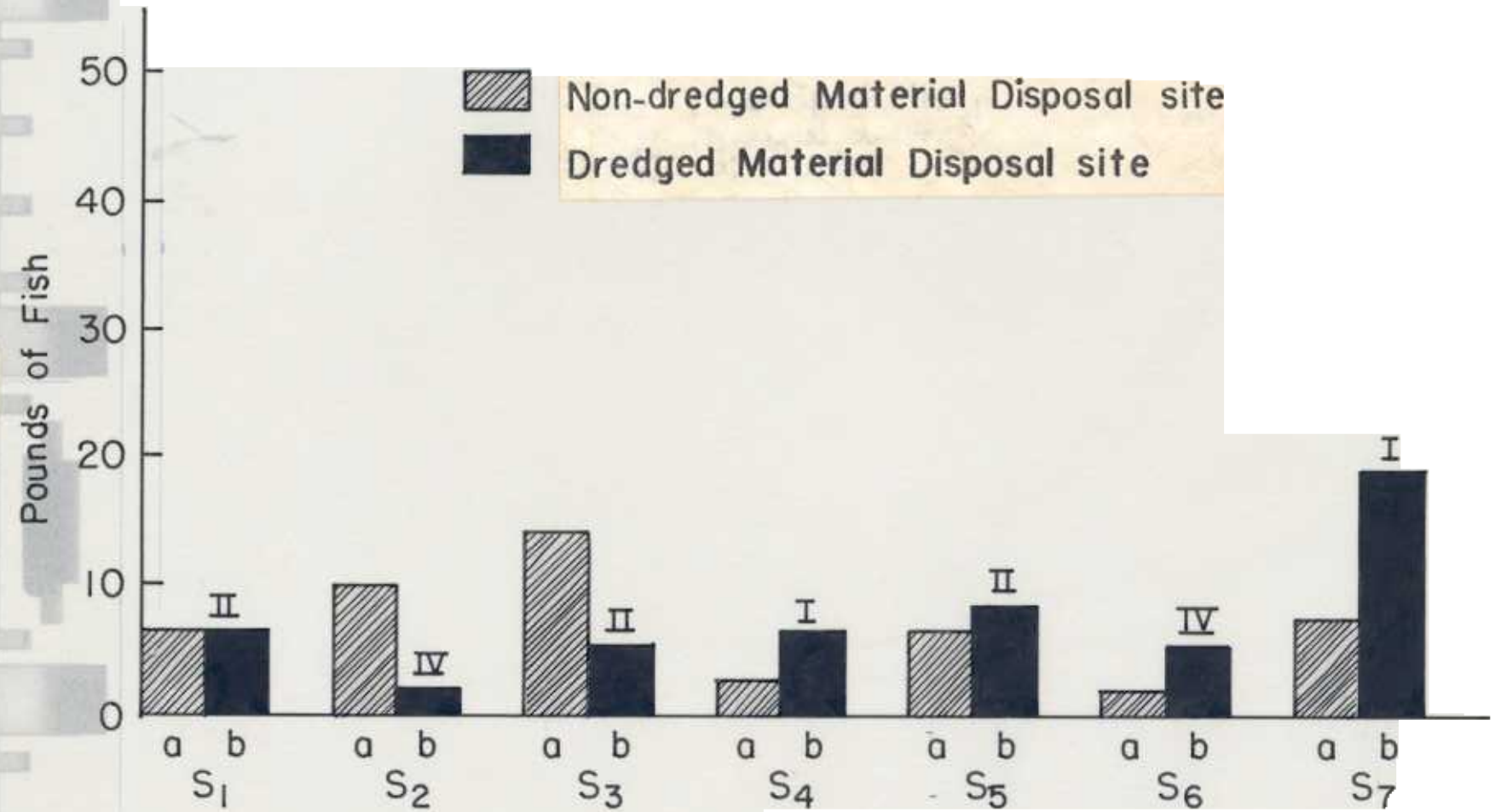


Figure 9. Pounds of forage fishes taken from the
and dredged material disposal areas wi

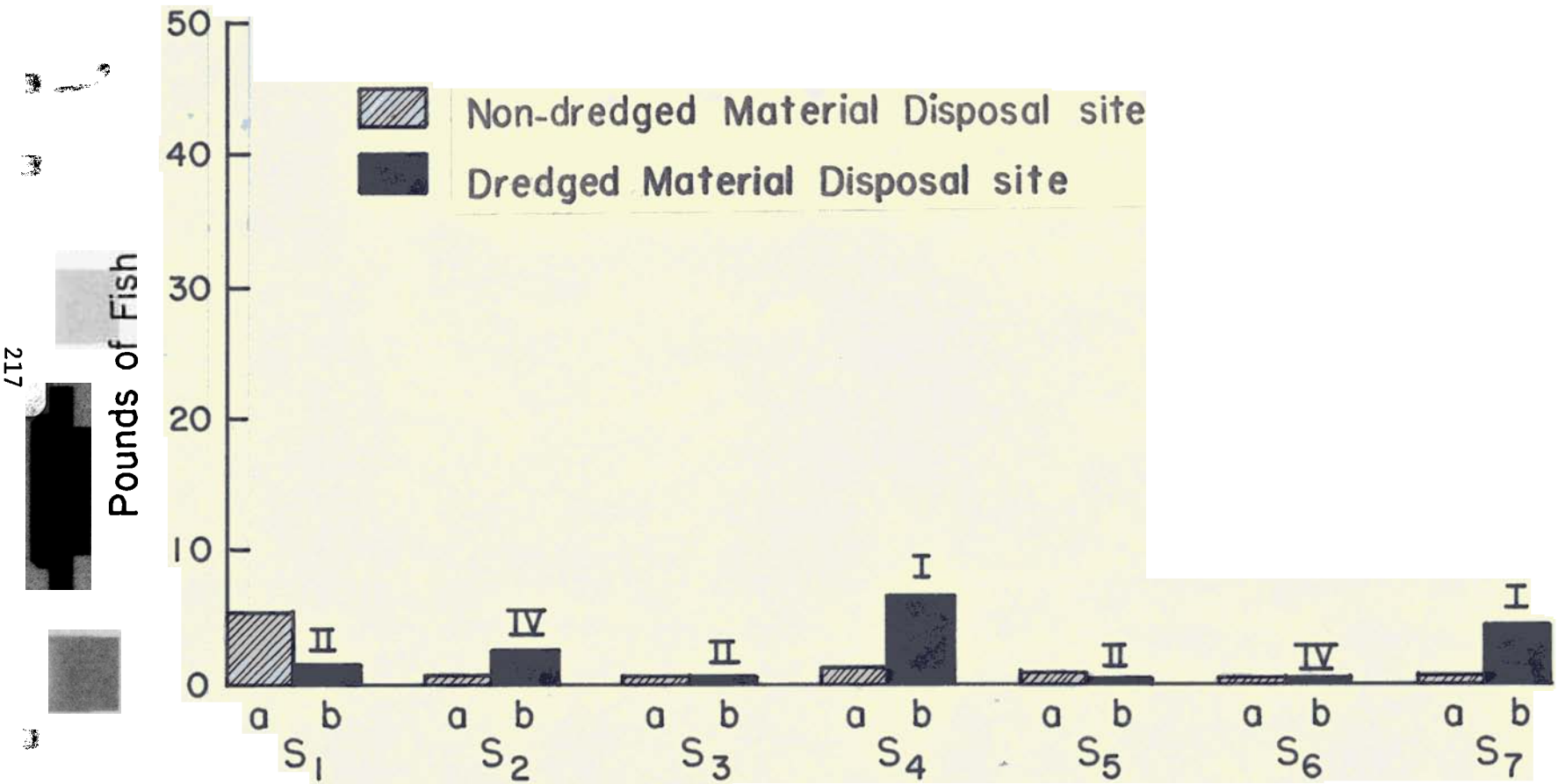
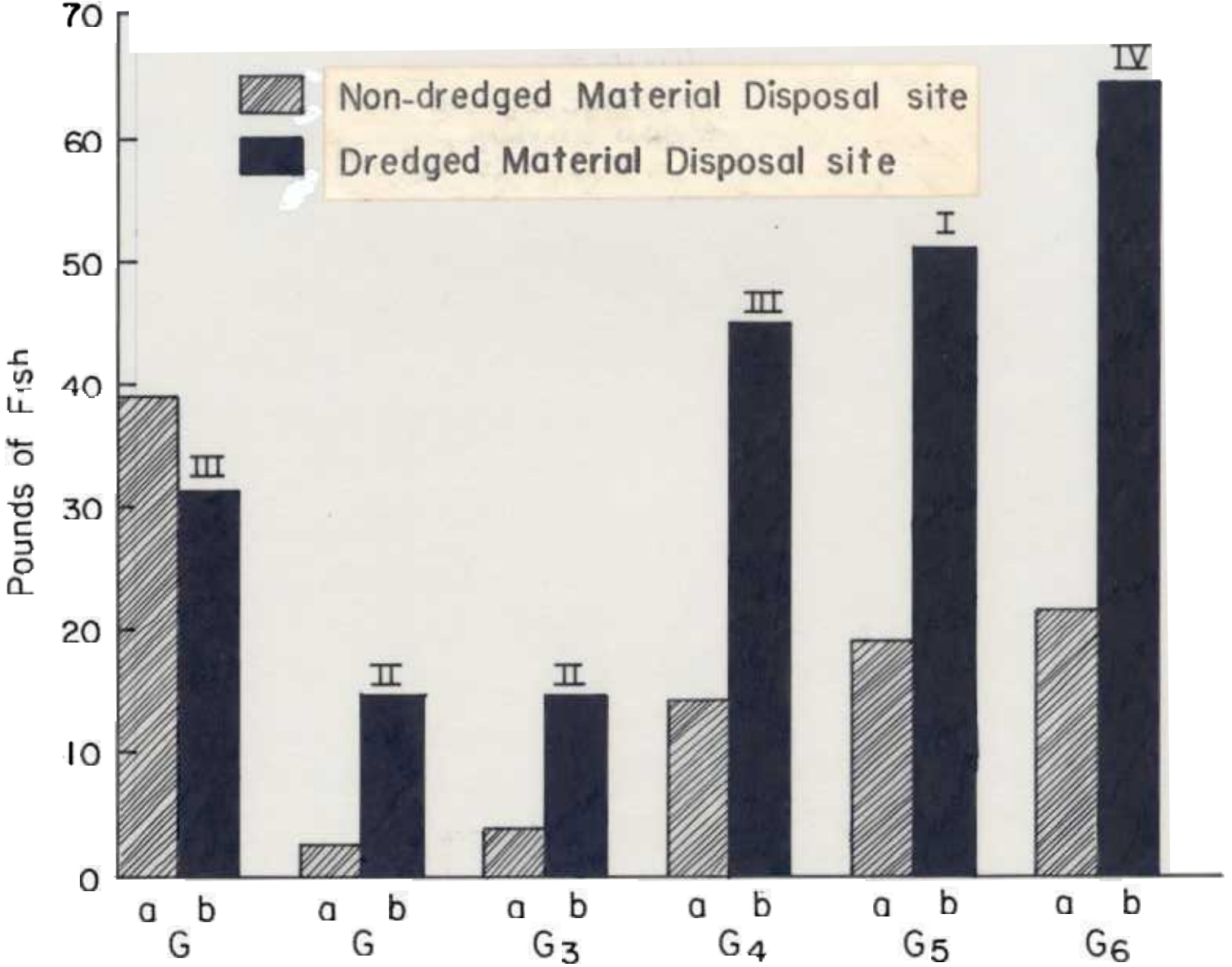


Figure 10 Pounds of gars taken from the seven pairs of adjacent non-dredged material and dredged material disposal areas with the electric shocker during one hour shocking periods.


70
60
50
40
30
20
10
0
Pounds of Fish
Non-dredged Material Disposal site
Dredged Material Disposal site
III
II
II
III
I
IV
a b
G
a b
G
a b
G3
a b
G4
a b
G5
a b
G6

an

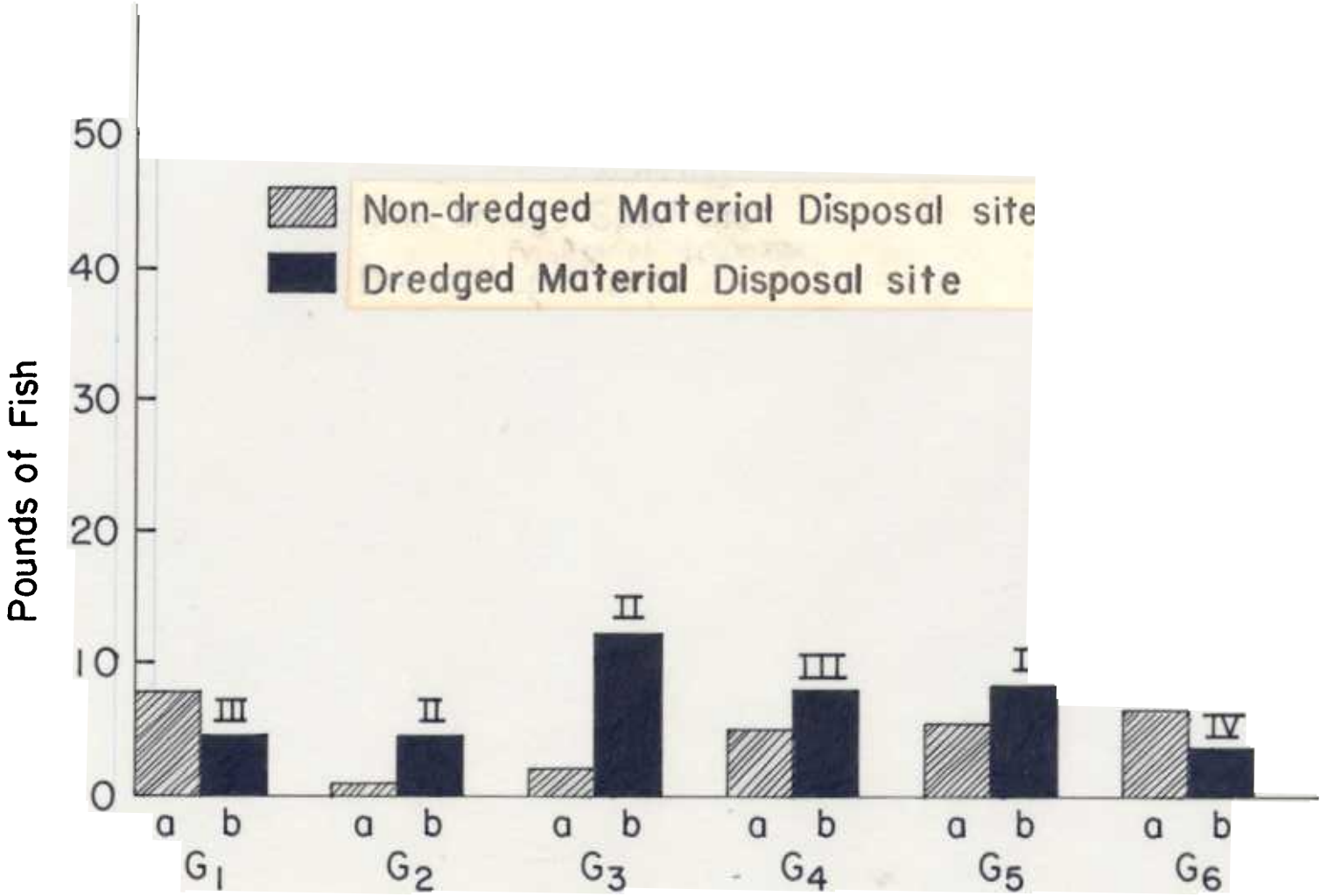


Figure 12. Pounds of game fish taken from the six pairs of adjacent non-dredged material and dredged material disposal areas with gill nets.

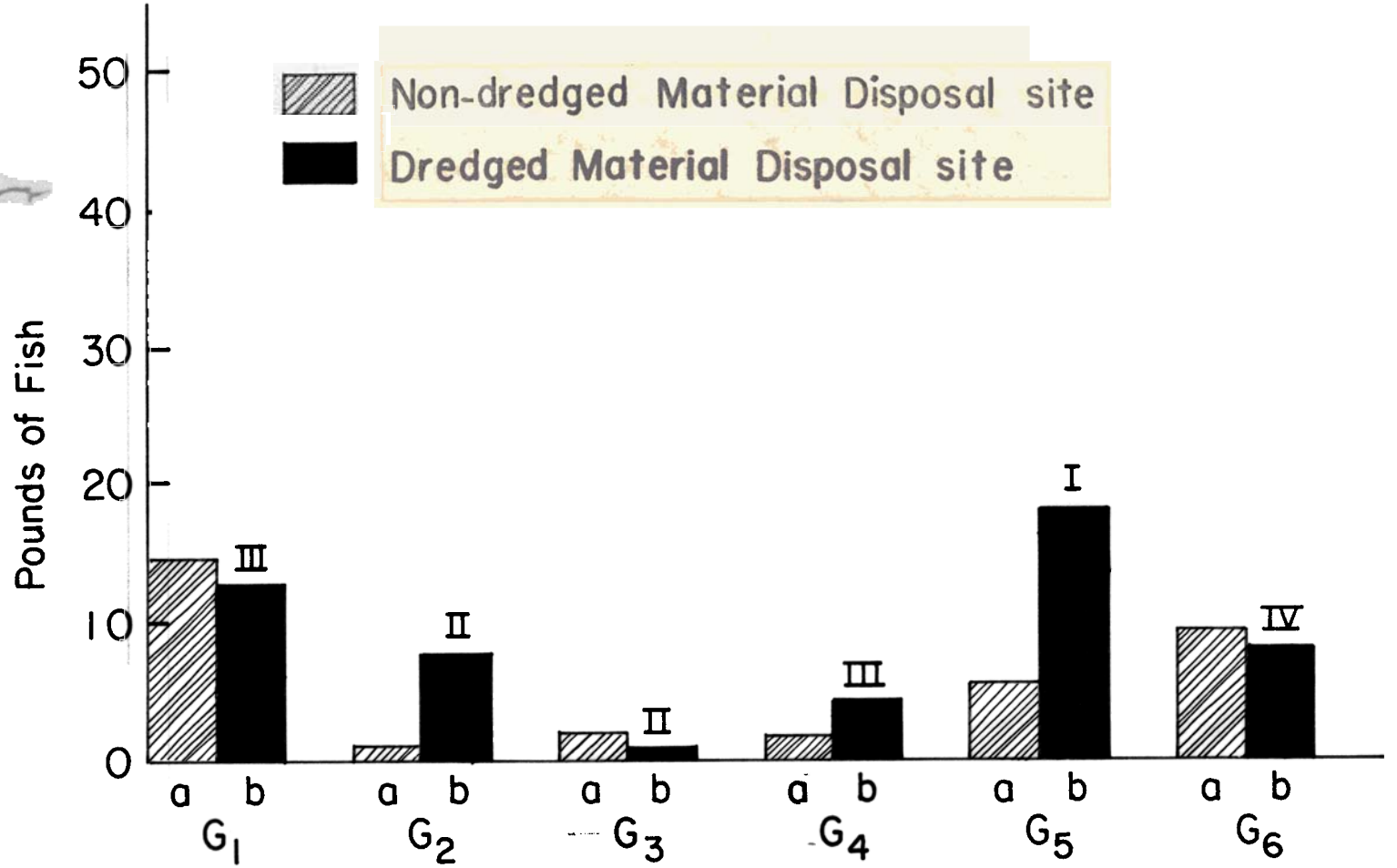


Figure 13. Pounds of commercial fishes taken from the six pairs of adjacent non-dredged material and dredged material disposal areas with gill nets.

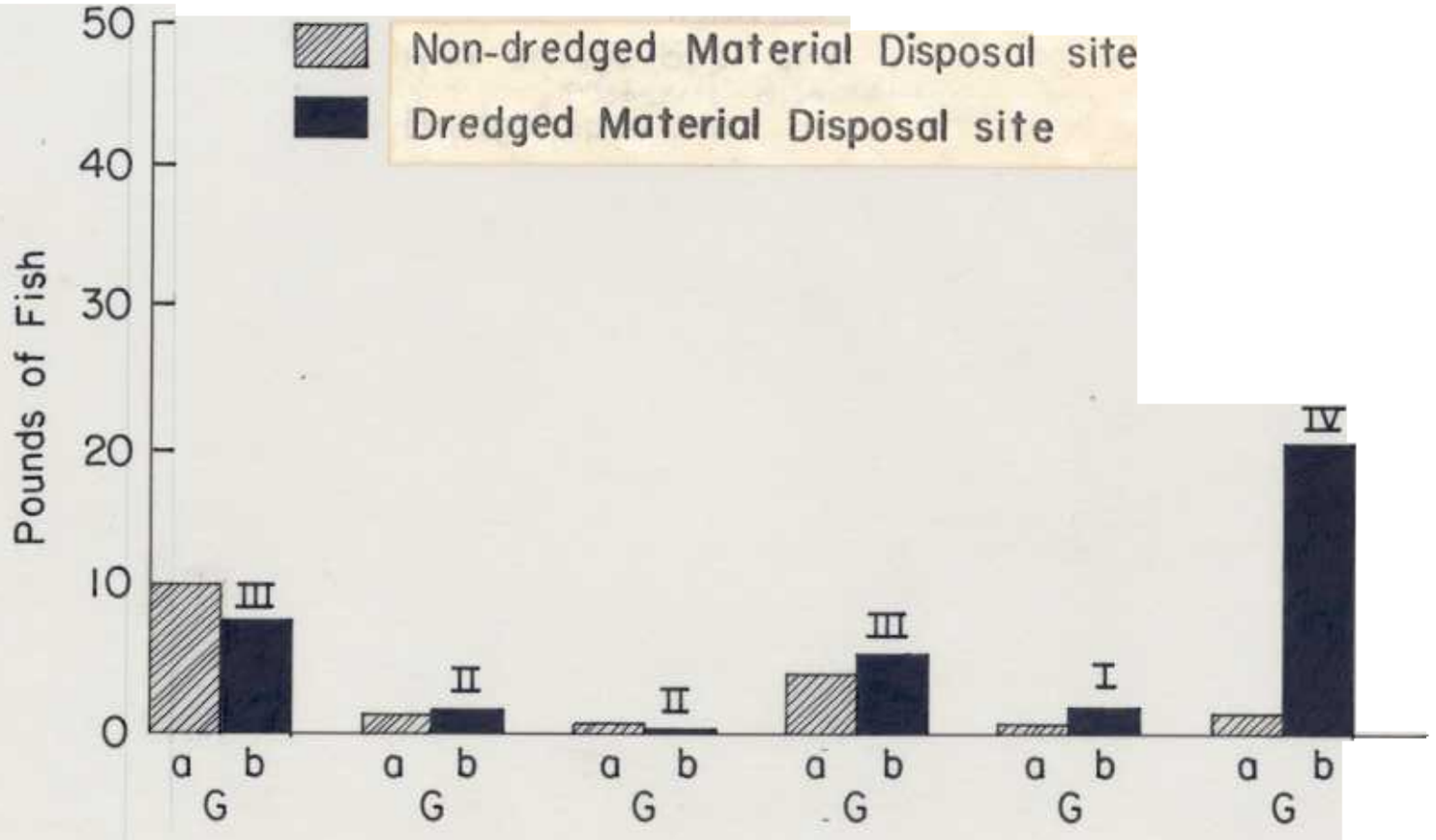


Figure 14. Pounds of forage fishes taken from the six pairs of adjacent non-dredged material and dredged material disposal areas with gill nets.

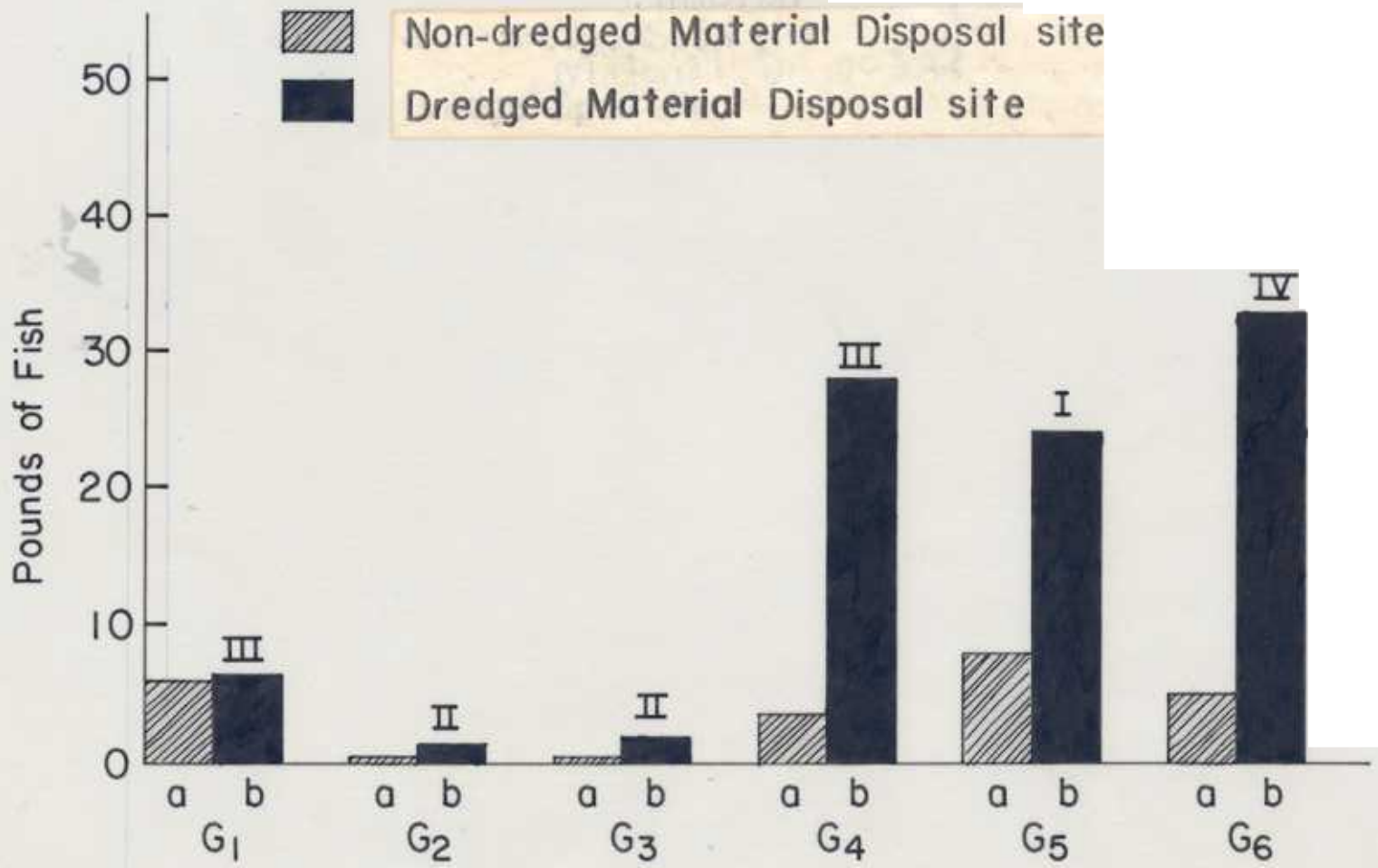


Figure 15. Pounds of gars taken from the six pairs of adjacent non-dredged material and dredged material disposal areas with gill nets.

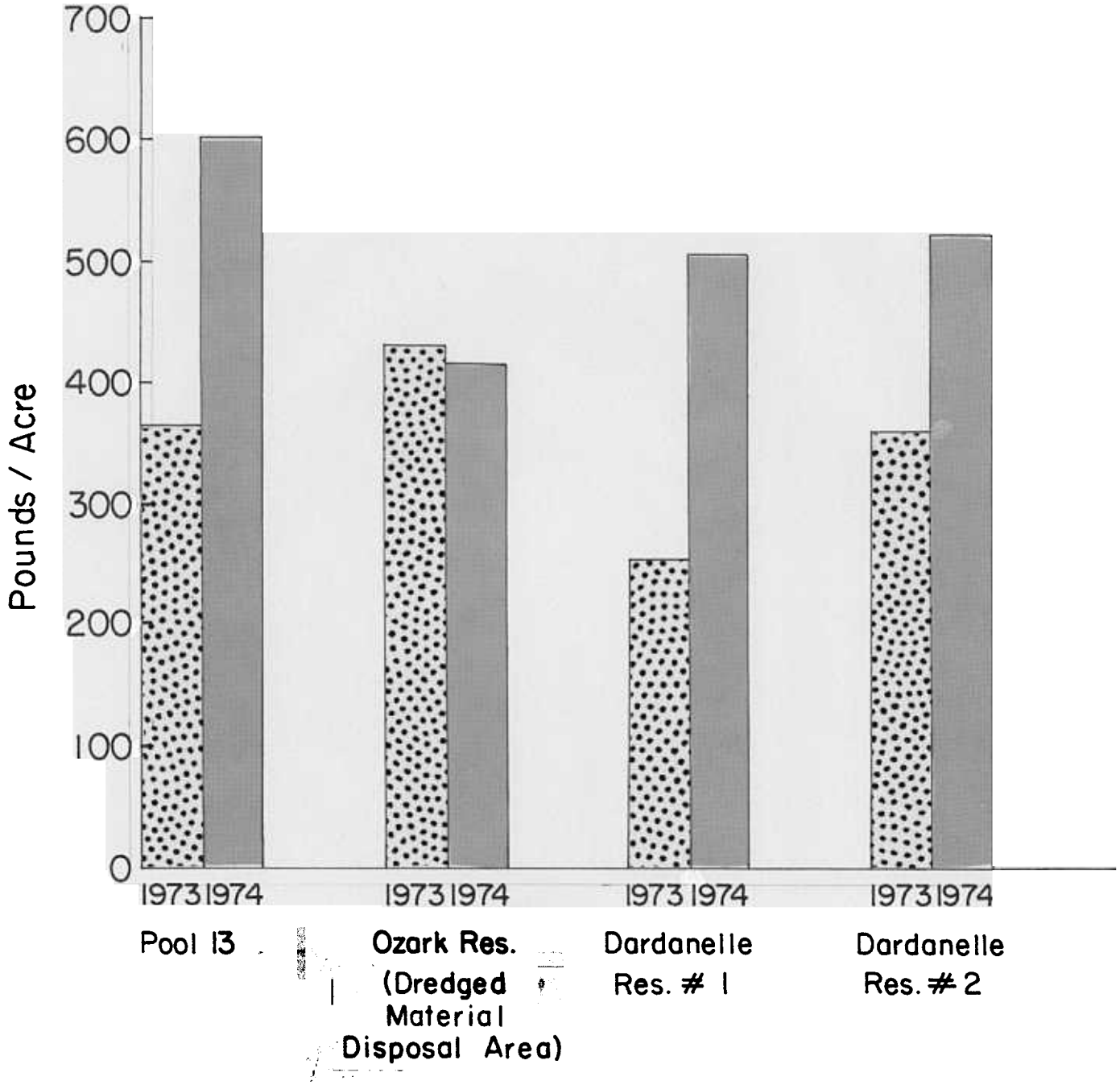


Figure 16. Total pounds of fish per acre collected with rotenone from the four large sample sites in 1973 and 1974.

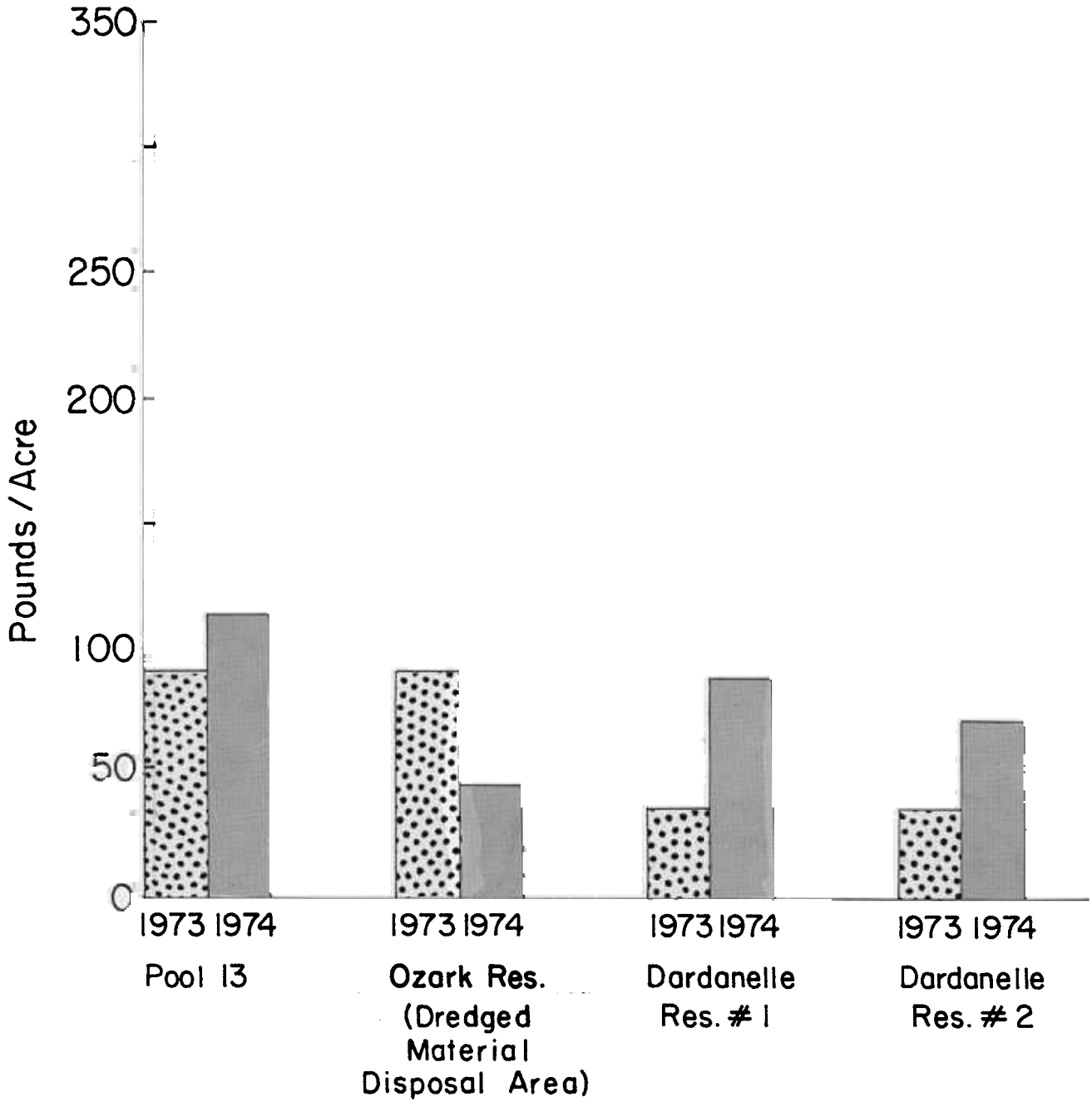


Figure 17. Pounds of game fish per acre collected with rotenone from the four large sample sites in 1973 and 1974.

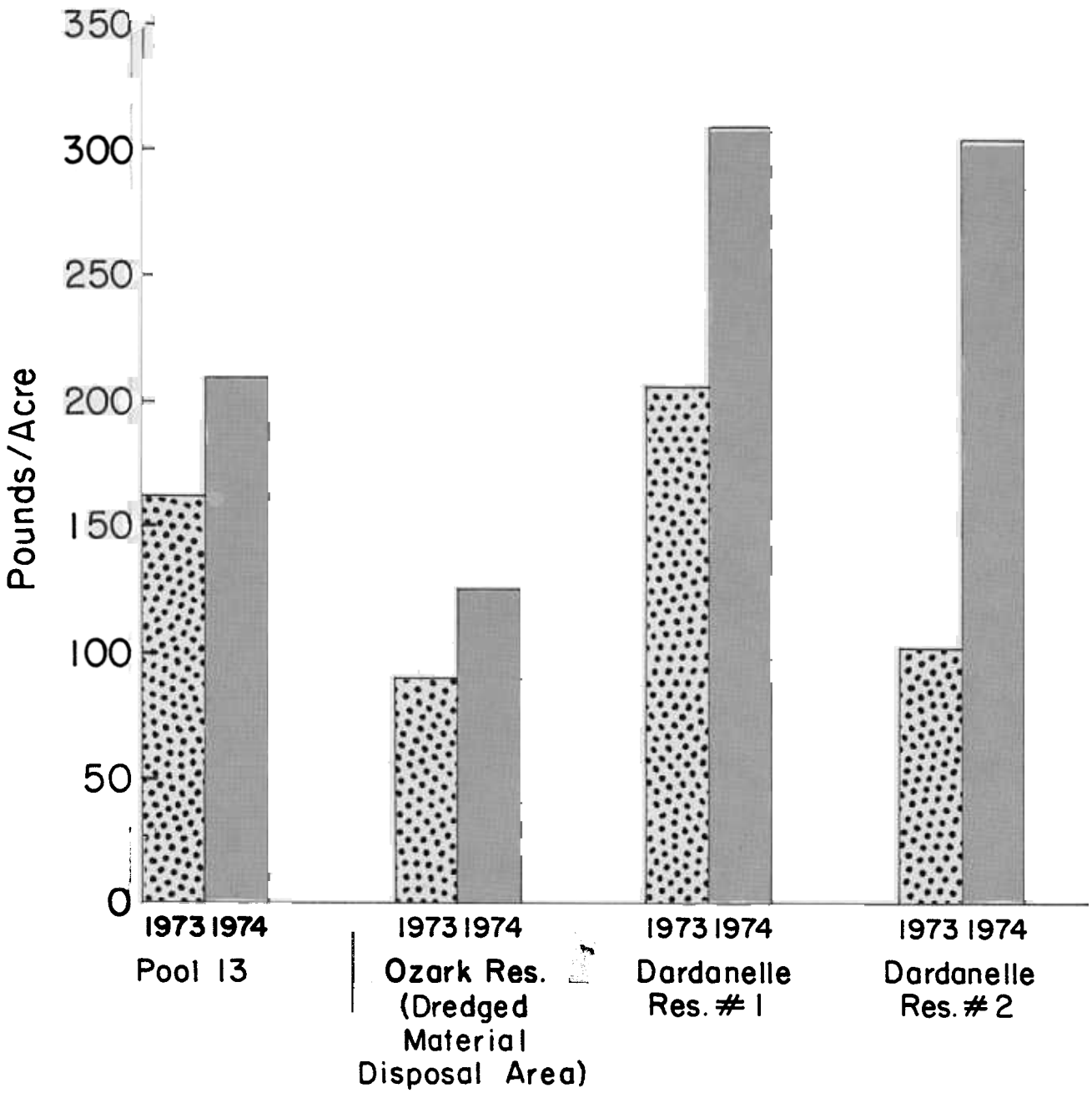


Figure 18. Pounds of commercial fishes per acre collected with rotenone from the four large sample sites in 1973 and 1974.

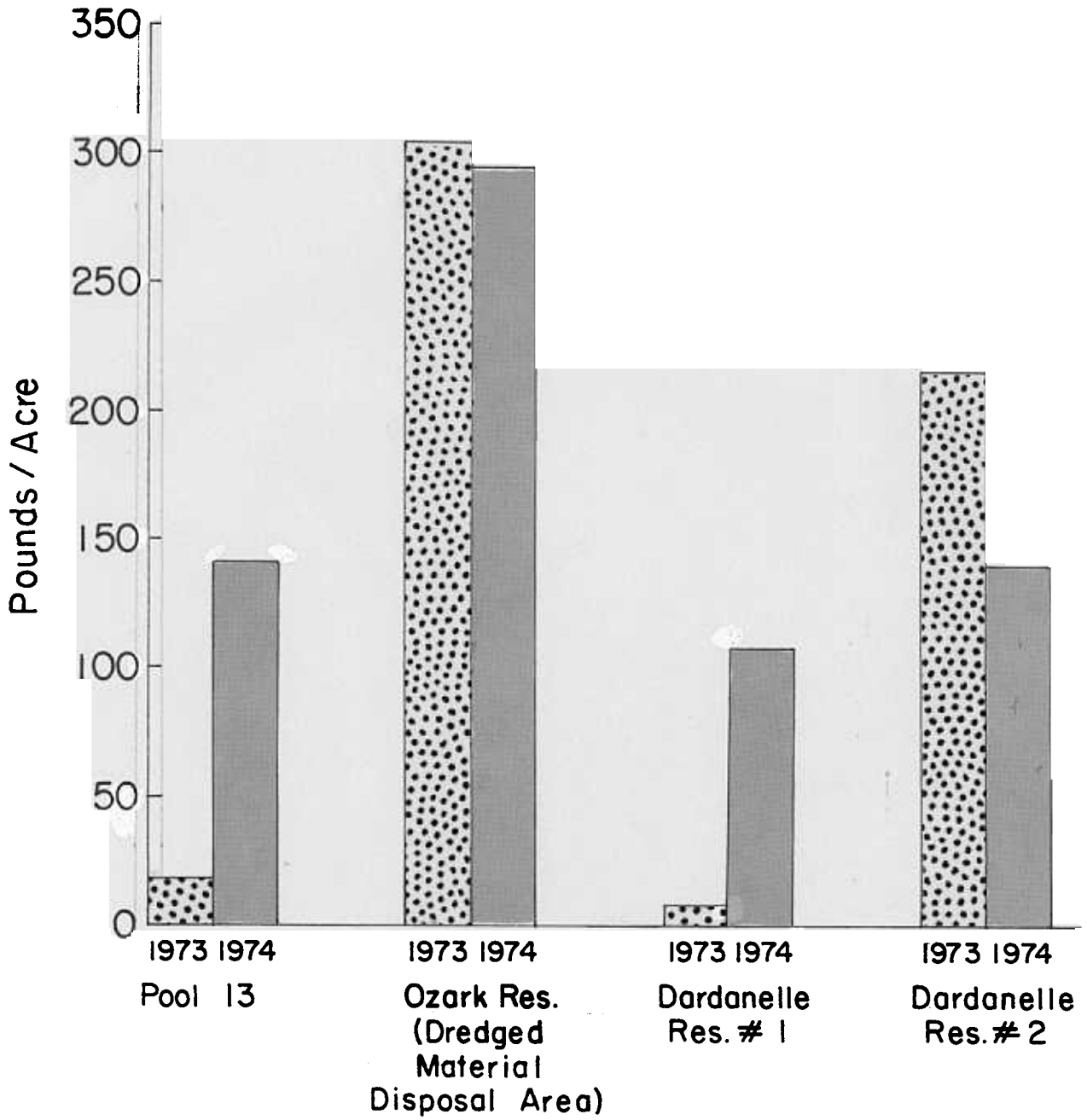


Figure 19. Pounds of forage fishes per acre collected with rotenone from the four large sample sites in 1973 and 1974.

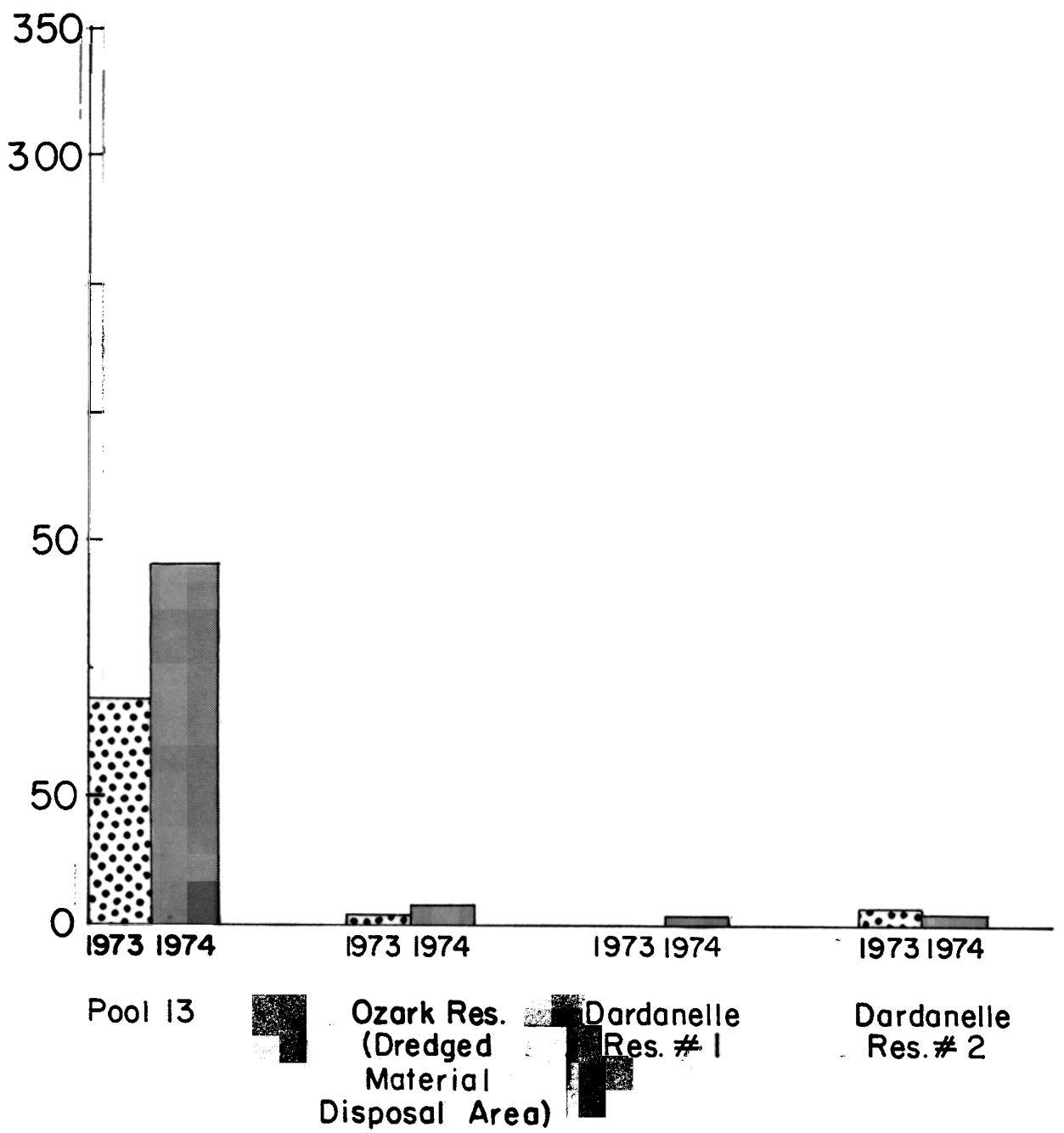


Figure 20. Pounds of gars and bowfins per acre collected with rotenone from the four large sample sites in 1973 and 1974.

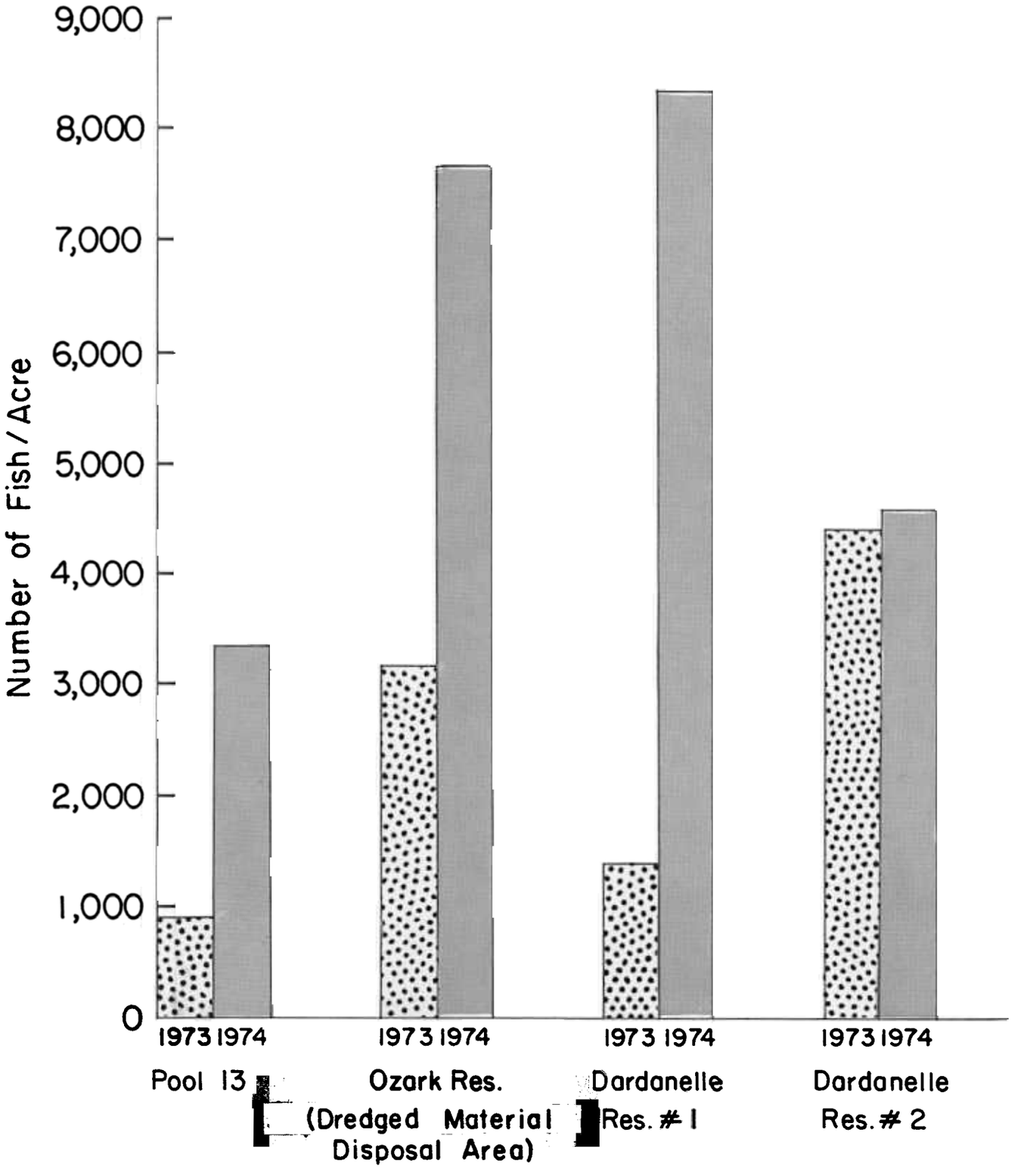


Figure 21. Total number of fish per acre collected with rotenone from the four large sample sites in 1973 and 1974.

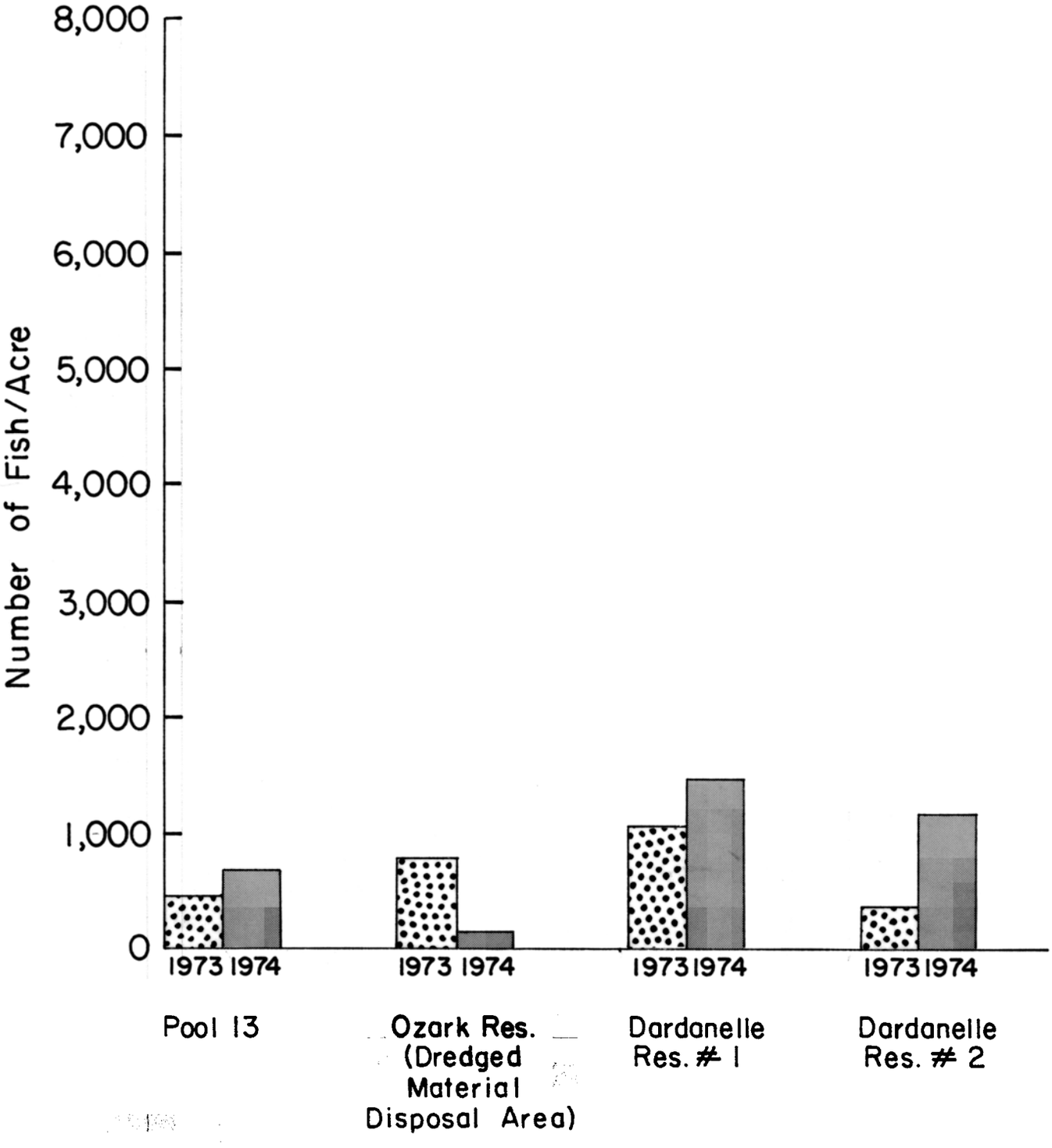


Figure 22. Number of game fish per acre collected with rotenone from the four large sample sites in 1973 and 1974.

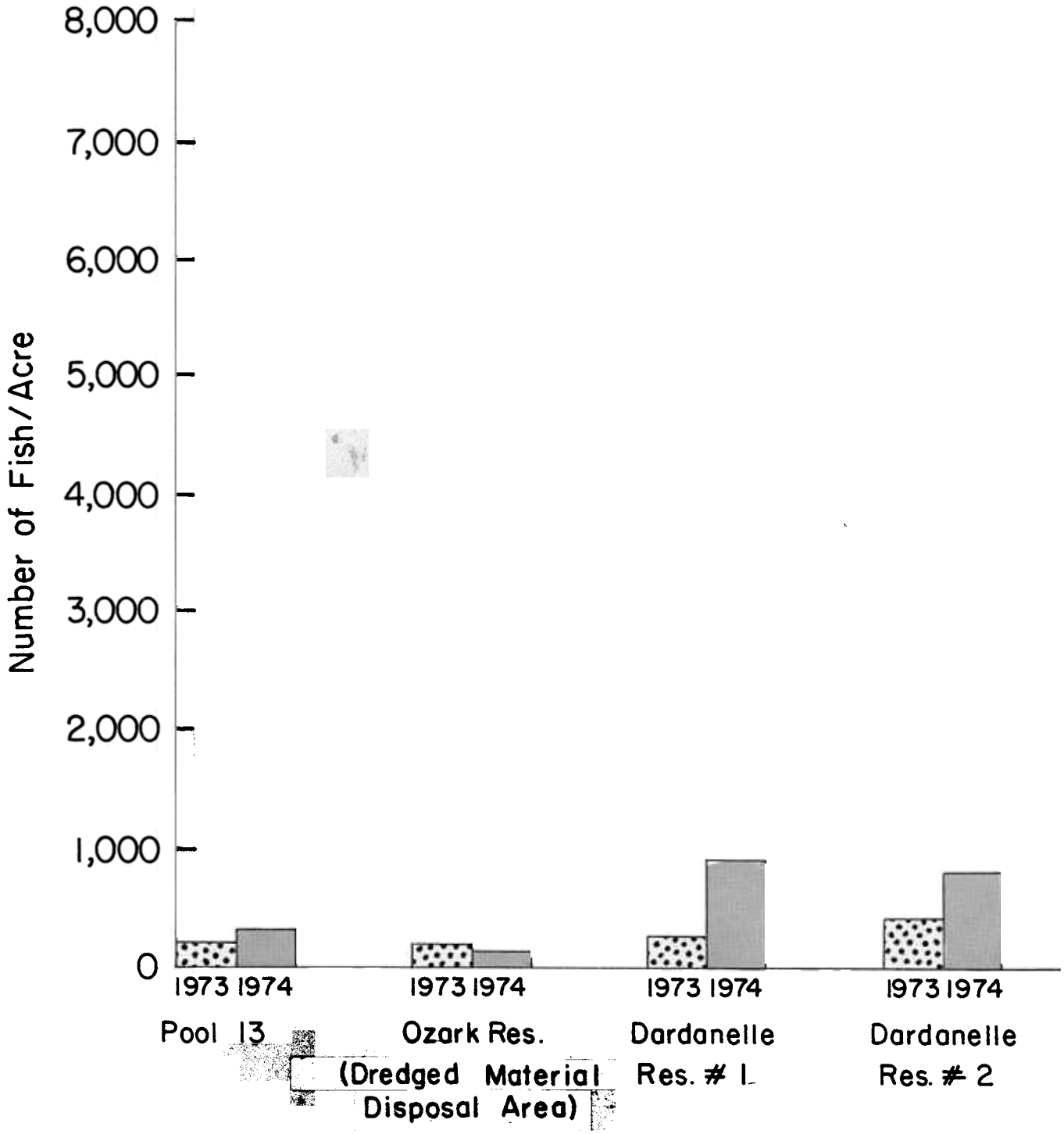


Figure 23. Number of commercial fishes per acre collected with rotenone from the four large sample sites in 1973 and 1974.

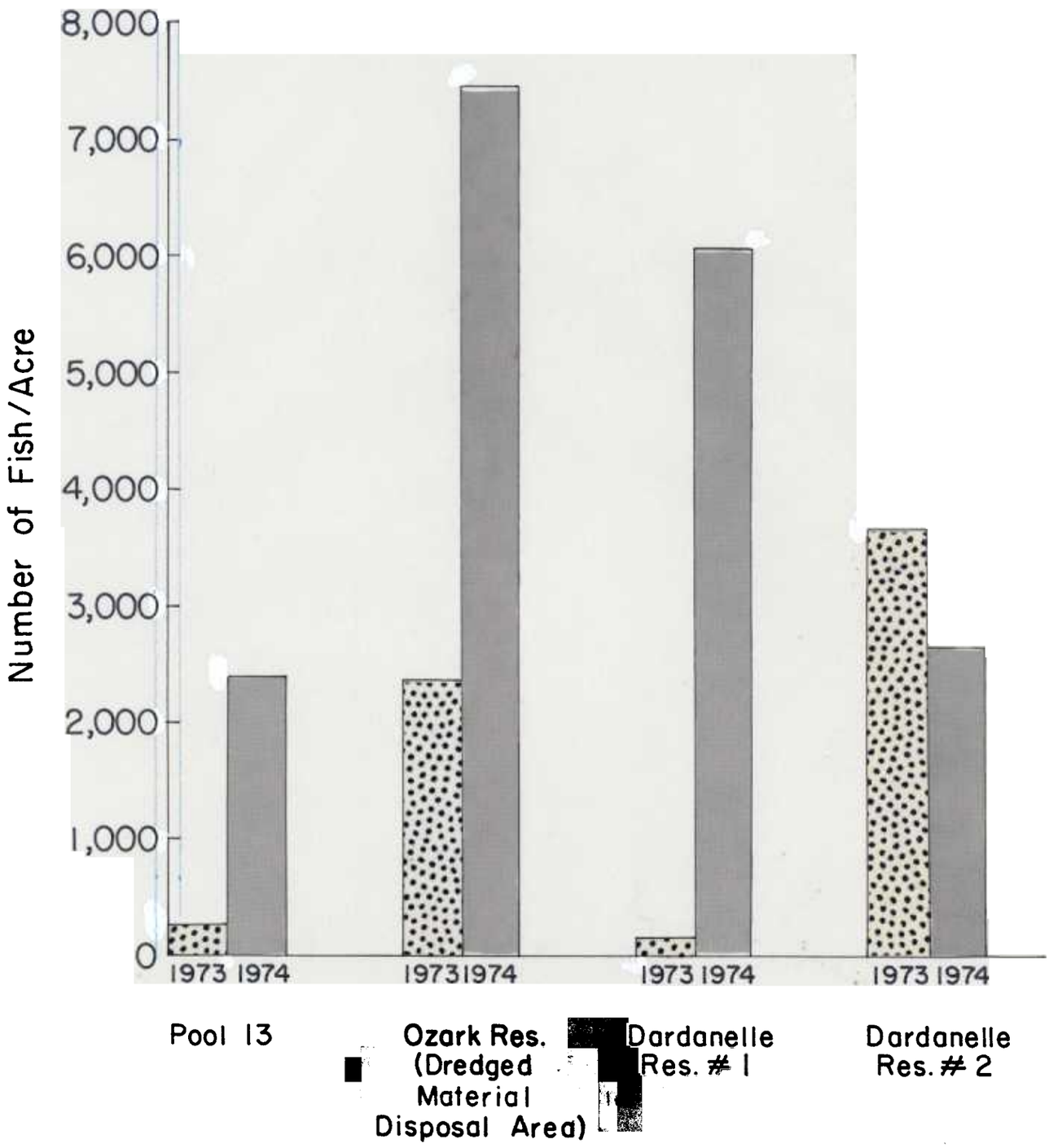


Figure 24. Number of forage fishes per acre collected with rotenone from the four large sample sites in 1973 and 1974.

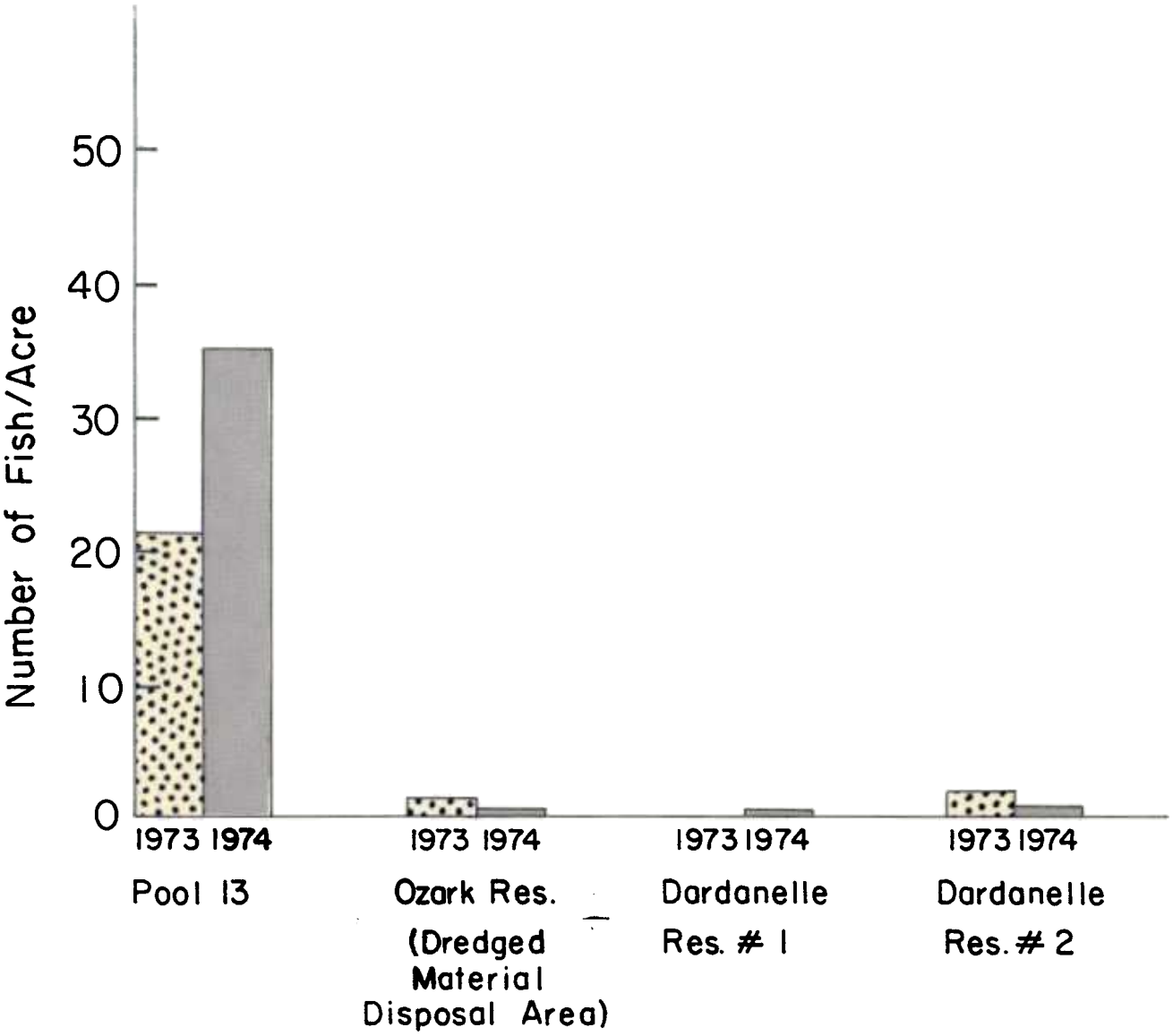


Figure 25. Number of gars and bowfins per acre collected with rotenone from the four large sample sites in 1973 and 1974.

Table 1. Fishes collected with each type of sampling gear from the Arkansas River Navigation System.

Species	Electric shocker	Rotenone	Seines	Gill nets	Hoop nets
Chestnut lamprey		X			
Paddlefish		X			
Shovelnose sturgeon				X	X
Bowfin	X	X		X	
Spotted gar	X	X			
Longnose gar	X	X	X	X	
Shortnose gar	X	X		X	
Skipjack herring	X	X	X	X	
Gizzard shad	X	X	X	X	
Threadfin shad	X	X	X	X	
Rainbow trout			X		
Grass pickerel		X			
Chain pickerel	X				
Goldeye	X		X	X	
Mooneye	X		X	X	
Stoneroller		X	X		
Goldfish		X	X		
Grass carp		X		X	
Carp	X	X	X	X	X
Cypress minnow			X		
Silvery minnow		X	X		

Table 1. (Continued)

Species	Electric shocker	Rotenone	Seines	Gill nets	Hoop nets
Flathead chub			X		
Silver chub	X	X	X	X	
Golden shiner		X	X		
Pallid shiner			X		
Emerald shiner		X	X		
River shiner		X	X		
Bigeye shiner		X	X		
Ghost shiner		X			
Ironcolor shiner		X			
Striped shiner		X			
Pugnose minnow		X	X		
Ribbon shiner		X			
Red shiner	X	X	X		
Plains shiner			X		
Duskystripe shiner		X	X		
Silverband shiner			X		
Weed shiner		X	X		
Blacktail shiner		X	X	X	
Mimic shiner		X	X		
Steelcolor shiner			X		
Bluntnose minnow		X			

Table 1. (Continued)

Species	Electric shocker	Rotenone	Seines	Gill nets	Hoop nets
Bullhead minnow	X	X	X		
River carpsucker	X	X	X	X	X
Quillback	X	X		X	
Highfin carpsucker				X	
Blue sucker				X	X
Lake chubsucker		X	X		
Northern hugsucker		X			
Smallmouth buffalo	X	X		X	X
Bigmouth buffalo		X		X	
Black buffalo				X	X
Spotted sucker		X			
Golden redhorse	X	X			
Shorthead redhorse	X	X		X	
American eel	X	X		X	
Blue catfish	X	X		X	X
Black bullhead	X	X			
Yellow bullhead	X	X			
Channel catfish	X	X	X	X	X
Tadpole madtom	X	X	X		
Brindled madtom		X			
Freckled madtom		X			

Table 1. (Continued)

Species	Electric shocker	Rotenone	Seines	Gill nets	Hoop nets
Flathead catfish	X	X		X	X
Golden topminnow		X	X		
Blackstripe topminnow			X		
Starhead topminnow		X	X		
Blackspotted topminnow		X	X		
Mosquitofish	X	X	X		
Pirate perch		X			
Brook silverside		X	X		
Mississippi silverside	X	X	X		
White bass	X	X	X	X	
Yellow bass	X	X			
Striped bass	X	X	X		
Flier		X			
Green sunfish	X	X	X		
Warmouth	X	X	X	X	
Orangespotted sunfish	X	X	X	X	
Bluegill	X	X	X	X	X
Dollar sunfish		X			
Longear sunfish	X	X	X	X	X
Redear sunfish	X	X	X	X	
Spotted sunfish		X			

Table 1 (Continued)

Species	Electric shocker	Rotenone	Seines	Gill nets	Hoop nets
Bantam sunfish		X			
Spotted bass	X	X	X		
Largemouth bass	X	X	X		
White crappie	X	X	X	X	X
Black crappie	X	X	X	X	X
Banded pygmy sunfish			X		
Mud darter		X			
Greenside darter			X		
Bluntnose darter		X	X		
Fantail darter			X		
Swamp darter		X			
Cypress darter			X		
Redfin darter		X			
Banded darter			X		
Logperch		X	X		
Blackside darter		X			
Longnose darter		X			
Dusky darter		X	X		
River darter		X	X		
Sauger	X	X	X	X	
Freshwater drum	X	X	X	X	X
Totals	42	86	63	34	14

Table 2. The number of specimens collected for each species, the number of collections a species appeared in, and the per cent of the total collections (out of 140) in which each species was represented.

Species	Number of specimens collected	Number of collections appeared in	% of total number of collections
Chestnut lamprey	4	2	1.4
Paddlefish	2	2	1.4
Shovelnose sturgeon	7	5	3.6
Bowfin	23	10	7.1
Spotted gar	20	9	6.4
Longnose gar	179	24	17.1
Shortnose gar	109	25	17.9
Skipjack herring	219	15	10.7
Gizzard shad	85,507	104	74.3
Threadfin shad	26,136	54	38.6
Rainbow trout	1	1	0.7
Grass pickerel	2	2	1.4
Chain pickerel	1	1	0.7
Goldeye	44	10	7.1
Mooneye	2	1	0.7
Stoneroller	9	5	3.6
Goldfish	3	3	2.1
Grass carp	5	2	1.4
Carp	1,330	50	35.7
Cypress minnow	13	1	0.7

Table 2. (Continued)

Species	Number of specimens collected	Number of collections appeared in	% of total number of collections
Silvery minnow	567	17	12.1
Flathead chub	1	1	0.7
Silver chub	107	17	12.1
Golden shiner	175	33	23.6
Pallid shiner	1	1	0.7
Emerald shiner	1,781	43	30.7
River shiner	445	38	27.1
Bigeye shiner	14	6	4.3
Ghost shiner	20	8	5.7
Ironcolor shiner	e	1	0.7
Striped shiner	3	1	0.7
Pugnose minnow	79	9	6.4
Ribbon shiner	11	2	1.4
Red shiner	3,058	70	50.0
Plains shiner	1,088	20	14.3
Duskystripe shiner	2	2	1.4
Silverband shiner	3	1	0.7
Weed shiner	82	5	3.6
Blacktail shiner	115	22	15.7
Mimic shiner	1,855	8	5.7
Steelcolor shiner	2	2	1.4

Table 2. (Continued)

Species	Number of specimens collected	Number of collections appeared in	% of total number of collections
Bluntnose minnow	19	2	1.4
Bullhead minnow	925	56	40.0
River carpsucker	1,778	81	57.9
Quillback	4	4	2.9
Highfin carpsucker	1	1	0.7
Blue sucker	9	3	2.1
Lake chubsucker	9	4	2.9
Northern hogsucker	1	1	0.7
Smallmouth buffalo	821	29	20.7
Bigmouth buffalo	233	13	9.3
Black buffalo	3	2	1.4
Spotted sucker	6	4	2.9
Golden redhorse	30	7	5.0
Shorthead redhorse	5	4	2.9
American eel	16	8	5.7
Blue catfish	286	20	14.3
Black bullhead	2	2	1.4
Yellow bullhead	38	11	7.9
Channel catfish	3,948	72	51.4
Tadpole madtom	14	9	6.4
Brindled madtom	3	1	0.7

Table 2. (Continued)

Species	Number of specimens collected	Number of collections appeared in	% of total number of collections
Freckled madtom	3	1	0.7
Flathead catfish	706	37	26.4
Golden topminnow	13	2	1.4
Blackstripe topminnow	50	3	2.1
Starhead topminnow	4	2	1.4
Blackspotted topminnow	118	20	14.3
Mosquitofish	288	32	22.9
Pirate perch	4	3	2.1
Brook silverside	737	58	41.4
Mississippi silverside	4,936	76	54.3
White bass	780	72	51.4
Yellow bass	37	5	3.6
Striped bass	100	22	15.7
Flier	2	2	1.4
Green sunfish	1,539	24	17.1
Warmouth	751	25	17.9
Orangespotted sunfish	120	17	12.1
Bluegill	8,423	80	57.1
Dollar sunfish	12	1	0.7
Longear sunfish	2,114	75	53.6
Redear sunfish	24	11	7.9

Table 2. (Continued)

Species	Number of specimens collected	Number of collections appeared in	% of total number of collections
Spotted sunfish	17	2	1.4
Bantam sunfish	54	1	0.7
Spotted bass	55	19	13.6
Largemouth bass	1,143	67	47.9
White crappie	3,400	46	32.9
Black crappie	1,055	35	25.0
Banded pygmy sunfish	1	1	0.7
Mud darter	3	1	0.7
Greenside darter	4	1	0.7
Bluntnose darter	228	7	5.0
Fantail darter	1	1	0.7
Swamp darter	1	1	0.7
Cypress darter	3	1	0.7
Redfin darter	3	3	2.1
Banded darter	1	1	0.7
Logperch	40	10	7.1
Blackside darter	2	2	1.4
Longnose darter	1	1	0.7
Dusky darter	3	2	1.4

Table 2. (Continued)

Species	Number of specimens collected	Number of collections appeared in	% of total number of collections
River darter	55	8	5.7
Sauger	51	16	11.4
Freshwater drum	8,685	55	39.3
Striped mullet	1	1	0.7
Total	166,746	--	--

Table 3. Native and non-native fishes introduced into the Arkansas River Navigation System.

INTRODUCED FISHES
Native to Arkansas
Threadfin shad, *Dorosoma cepedianum*
Golden shiner, *Notemigonus crysoleucas*
Green sunfish, *Lepomis cyanellus*
Bluegill, *Lepomis macrochirus*
Redear sunfish, *Lepomis microlophus*
Largemouth bass, *Micropterus salmoides*
Not native to Arkansas
Rainbow trout, *Salmo gairdneri*
Goldfish, *Carassius auratus*
Grass carp, *Ctenopharyngodon idellus*
Carp, *Cyprinus carpio*
Striped bass, *Morone saxatilis*
Tipapia mariae

Table 4. Fishes collected from the Arkansas River proper before (mainly prior to 1940) and after the construction of the navigation channel.

Species	Collected before channel construction	Collected after channel construction
Chestnut lamprey	X	X
Paddlefish	X	X
Shovelnose sturgeon	X	X
Bowfin		X
Spotted gar		X
Longnose gar	X	X
Shortnose gar		X
Alligator gar	X	
Skipjack herring		X
Gizzard shad	X	X
Threadfin shad		X
Rainbow trout		X
Goldeye	X	X
Mooneye		X
Stoneroller		X
Goldfish		X
Grass Carp		X
Carp		X
Plains minnow	X	
Silvery minnow	X	X
Speckled chub	X	

Table 4. (Continued)

Species	Collected before channel construction	Collected after channel construction
Silver chub	X	X
Golden shiner	X	X
Pallid shiner		X
Emerald shiner	X	X
River shiner	X	X
Bigeye shiner	X	X
Ghost shiner	X	X
Ironcolor shiner		X
Striped shiner	X	X
Pugnose minnow		X
Ribbon shiner		X
Arkansas River shiner	X	
Red shiner	X	X
Plains shiner	X	X
Duskystripe shiner		X
Silverband shiner	X	X
Blacktail shiner		X
Mimic shiner		X
Steelcolor shiner	X	X
Suckermouth minnow	X	
Bluntnose minnow	X	X

Table 4. (Continued)

Species	Collected before channel construction	Collected after channel construction
Bullhead minnow	X	X
River carpsucker	X	X
Quillback		X
Blue sucker		X
Smallmouth buffalo	X	X
Bigmouth buffalo	X	X
Black buffalo	X	X
Spotted sucker		X
Golden redhorse		X
Shorthead redhorse		X
American eel		X
Blue catfish	X	X
Black bullhead		X
Yellow bullhead		X
Channel catfish	X	X
Tadpole madtom		X
Brindled madtom		X
Flathead catfish	X	X
Golden topminnow		X
Starhead minnow		X
Blackspotted topminnow	X	X
Mosquitofish	X	X

Table 4. (Continued)

Species	Collected before channel construction	Collected after channel construction
Pirate perch		X
Brook silverside		X
Mississippi silverside		X
White bass	X	X
Yellow bass		X
Striped bass		X
Flier		X
Green sunfish	X	X
Warmouth		X
Orangespotted sunfish		X
Bluegill	X	X
Longear sunfish	X	X
Redear sunfish		X
Spotted bass	X	X
Largemouth bass	X	X
White crappie		X
Black crappie		X
Greenside darter		X
Bluntnose darter		X
Fantail darter		X
Cypress darter		X
Redfin darter		X

Table 4. (Continued)

Species	Collected before channel construction	Collected after channel construction
Banded darter		X
Longnose darter		X
Dusky darter		X
River darter	X	X
Sauger	X	X
Freshwater drum	X	X
Total	43	89

Table 5. Fishes collected from the Arkansas River Navigation System which are mainly or entirely restricted to the channels of big rivers.

Big River Species
Shovelnose sturgeon
Skipjack herring
Goldeye
Silver chub
River shiner
Plains shiner
Silverband shiner
River carpsucker
Blue sucker
Mississippi silverside
River darter
Sauger

Table 6. Common fishes of the Arkansas River Navigation System which are also widely distributed in different types of habitats elsewhere in Arkansas.

Species	
Paddlefish	Brook silverside
Longnose gar	White bass
Shortnose gar	Green sunfish
Gizzard shad	Warmouth
Threadfin shad	Orangespotted sunfish
Carp	Bluegill
Golden shiner	Longear sunfish
Emerald shiner	Largemouth bass
Red shiner	White crappie
Bullhead minnow	Black crappie
Smallmouth buffalo	Freshwater drum
Bigmouth buffalo	
American eel	
Blue catfish	
Channel catfish	
Flathead catfish	
Mosquitofish	

Table 7. Uncommon fishes apparently maintaining small populations in the Arkansas River Navigation System.

Species
Chestnut lamprey
Bowfin
Spotted gar
Silvery minnow
Ghost shiner
Pugnose shiner
Blacktail shiner
Mimic shiner
Quillback
Black buffalo
Golden redhorse
Shorthead redhorse
Yellow bullhead
Blackspotted topminnow
Yellow bass
Striped bass
Redear sunfish
Spotted bass
Logperch

Table 8. Upland fishes apparently accidental to the Arkansas River Navigation System.

Species
Rainbow trout
Stoneroller
Bigeye shiner
Duskystripe shiner
Steelcolor shiner
Brindled madtom
Fantail darter
Redfin darter
Banded darter
Blackside darter
Longnose darter

Table 9. Lowland fishes apparently accidental to the Arkansas River Navigation System.

Species
Grass pickerel
Chain pickerel
Cypress minnow
Flathead chub
Pallid shiner
Ironcolor shiner
Ribbon shiner
Weed shiner
Lake chubsucker
Golden topminnow
Blackstripe topminnow
Starhead topminnow
Pirate perch
Flier
Dollar sunfish
Spotted sunfish
Bantam sunfish
Banded pygmy sunfish
Mud darter
Swamp darter
Striped mullet

Table 10. Fishes accidental to the Arkansas River Navigation System from both upland and lowland tributaries.

Species
Mooneye
Goldfish
Grass carp
Striped bass
Bluntnose minnow
Highfin carpsucker
Northern hogsucker
Spotted sucker
Black bullhead
Tadpole madtom
Freckled madtom
Bluntnose darter
Cypress darter
Dusky darter

Table 11. Fishes collected only from the Arkansas Valley Physiographic Region of the Arkansas River Navigation System (upstream from Little Rock).

Species
Rainbow trout
Stoneroller
Goldfish
Bigeye shiner
Plains shiner
Duskystripe shiner
Silverband shiner
Steelcolor shiner
Black bullhead
Brindled madtom
Greenside darter
Fantail darter
Cypress darter
Redfin darter
Banded darter
Blackside darter
Longnose darter

Table 12. Fishes collected only from the Gulf Coastal Plain Physiographic Region of the Arkansas River Navigation System (downstream from Little Rock).

Species	
Grass pickerel	Blackstriped topminnow
Chain pickerel	Starhead topminnow
Mooneye	Yellow bass
Cypress minnow	Flier
Flathead chub	Dollar sunfish
Pallid shiner	Spotted sunfish
Ironcolor shiner	Bantam sunfish
Striped shiner	Banded pygmy sunfish
Ribbon shiner	Mud darter
Weed shiner	Swamp darter
Highfin carpsucker	Striped mullet
Lake chubsucker	
Northern hogsucker	
Freckled madtom	
Golden topminnow	

Table 13. Fishes collected from (1) the Arkansas River, (2) the Arkansas Post Canal and Merrisach Lake, and (3) the lower White River portions of the navigation system.

Species	Arkansas River	Arkansas Post Canal and Merrisach Lake	Lower White River
Chestnut lamprey	X		
Paddlefish	X		
Shovelnose sturgeon	X		X
Bowfin	X	X	X
Spotted gar	X	X	X
Longnose gar	X	X	X
Shortnose gar	X		X
Skipjack herring	X	X	X
Gizzard shad	X	X	X
Threadfin shad	X	X	X
Rainbow trout	X		
Grass pickerel		X	X
Chain pickerel			X
Goldeye	X		X
Mooneye	X		
Stoneroller	X		
Goldfish	X		
Grass carp	X	X	

Table 13. (Continued)

Species	Arkansas River	Arkansas Post Canal and Merrisach Lake	Lower White River
Carp	X	X	
Cypress minnow			X
Silvery minnow	X		X
Flathead chub			X
Silver chub	X		X
Golden shiner	X	X	X
Pallid shiner	X		X
Emerald shiner	X		X
River shiner	X		X
Bigeye shiner	X		
Ghost shiner	X		
Ironcolor shiner	X		
Striped shiner	X		
Pugnose minnow	X		X
Ribbon shiner	X		
Red shiner	X		X
Plains shiner	X		
Duskystripe shiner	X		
Silverband shiner	X		

Table 13. (Continued)

Species	Arkansas River	Arkansas Post Canal and Merrisach Lake	Lower White River
Weed shiner			X
Blacktail shiner	X		X
Mimic shiner	X		X
Steelcolor shiner	X		
Bluntnose minnow	X		
Bullhead minnow	X	X	X
River carpsucker	X	X	X
Quillback	X		X
Highfin carpsucker			X
Blue sucker	X		
Lake chubsucker		X	X
Northern hogsucker			X
Smallmouth buffalo	X	X	X
Bigmouth buffalo	X	X	X
Black buffalo	X		
Spotted sucker	X		X
Goldern redhorse	X		X
Shorthead redhorse	X		
American eel	X	X	X
Blue catfish	X		X

Table 13. (Continued)

Species	Arkansas River	Arkansas Post Canal and Merrisach Lake	Lower White River
Black bullhead	X		
Yellow bullhead	X	X	X
Channel catfish	X	X	X
Tadpole madtom	X	X	X
Brindled madtom	X		
Freckled madtom			X
Flathead catfish	X	X	X
Golden topminnow	X	X	
Blackstripe topminnow			X
Starhead topminnow	X	X	
Blackspotted topminnow	X	X	X
Mosquitofly	X		X
Pirate perch	X	X	X
Brook silverside	X	X	X
Mississippi silverside	X	X	X
White bass	X	X	X
Yellow bass	X	X	X
Striped bass	X		
Flier	X	X	
Green sunfish	X	X	X

Table 13. (Continued)

Species	Arkansas River	Arkansas Post Canal and Merrisach Lake	Lower White River
Warmouth	X	X	X
Orangespotted sunfish	X	X	X
Bluegill	X	X	X
Dollar sunfish		X	
Longear sunfish	X	X	X
Redear sunfish	X	X	X
Spotted sunfish		X	
Bantam sunfish		X	
Spotted bass	X		X
Largemouth bass	X	X	X
White crappie	X		X
Black crappie	X	X	X
Banded pygmy sunfish			X
Mud darter			X
Greenside darter	X		
Bluntnose darter	X		X
Fantail darter	X		
Swamp darter		X	
Cypress darter	X		

Table 13. (Continued)

Species	Arkansas River	Arkansas Post Canal and Merrisach Lake	Lower White River
Redfin darter	X		
Banded darter	X		
Logperch	X		X
Blackside darter	X		
Longnose darter	X		
Dusky darter	X		X
River darter	X		
Sauger	X		X
Freshwater drum	X	X	X
Striped mullet			X

Table 14. Threatened Arkansas fishes found in the Arkansas River Navigation System.

Species
Paddlefish
Shovelnose sturgeon
Flathead chub
Pallid shiner
Ironcolor shiner
Swamp darter
Striped mullet

Table 15. Location of the seven paired quantitative fish samples collected with the electric shocker from adjacent non-dredged material (S1a-7a) and dredged material disposal areas. Roman numerals indicate the type of dredge deposit area.

NON-DREDGED MATERIALS		DREDGED MATERIALS DEPOSIT		
Collection number	Navigation mile	Collection number	Navigation mile	Type
S1a	44.5	S1b	45.5-46	II
S2a	101.5	S2b	106	IV
S3a	122.7	S3b	123	II
S4a	8-9	S4b	8-9	I
S5a	27	S5b	28	II
S6a	148	S6b	146.7	IV
S7a	171-172	S7b	170-171	I

Table 16. Location of the six paired quantitative fish samples collected with gill nets from adjacent non-dredged materials (G1a-7a) and dredge disposal areas (G1b-7b). Roman numerals indicate the type of dredge deposit area.

NON-DREDGED MATERIALS SITES		DREDGED MATERIALS DISPOSAL SITES		
Collection number	Navigation mile	Collection number	Navigation mile	Type
G1a	8.4-9	G1b	8.4-9	III
G2a	23.0-24.4	G2b	23.0-24.4	II
G3a	70-71	G3b	70-71	II
G4a	101.6	G4a	107	III
G5a	248.5	G5b	247.4	I
G6a	289.1	G6b	290	IV

Table 17. Fishes collected from dredged material deposits and non-dredged material areas of the Arkansas River Navigation System.

Species	Dredged material areas	Non-dredged material areas
Chestnut lamprey	X	X
Paddlefish	X	X
Shovelnose sturgeon	X	X
Bowfin	X	X
Spotted gar	X	X
Longnose gar	X	X
Shortnose gar	X	X
Skipjack herring	X	X
Gizzard shad	X	X
Threadfin shad	X	X
Rainbow trout	X	
Grass pickerel		X
Chain pickerel		X
Goldeye	X	X
Mooneye	X	
Stoneroller	X	
Goldfish	X	X
Grass carp		X
Carp	X	X

Table 17. (Continued)

Species	Dredged material areas	Non-dredged material areas
Cypress minnow		X
Silvery minnow	X	X
Flathead chub		X
Silver chub	X	X
Golden shiner	X	X
Pallid shiner	X	
Emerald shiner	X	X
River shiner	X	X
Bigeye shiner	X	
Ghost shiner	X	X
Ironcolor shiner	X	
Striped shiner	X	
Pugnose minnow	X	X
Ribbon shiner	X	
Red shiner	X	X
Plains shiner	X	X
Duskystripe shiner	X	
Silverband shiner	X	
Weed shiner	X	X
Blacktail shiner	X	X

Table 17. (Continued)

Species	Dredged material areas	Non-dredged material areas
Mimic shiner	X	X
Steelcolor shiner	X	X
Bluntnose minnow	X	
Bullhead minnow	X	X
River carpsucker	X	X
Quillback	X	X
Highfin carpsucker	X	
Blue sucker	X	X
Lake chubsucker	X	X
Northern hogsucker		X
Smallmouth buffalo	X	X
Bigmouth buffalo	X	X
Black buffalo	X	X
Spotted sucker	X	X
Golden redhorse	X	X
Shorthead redhorse	X	X
American eel	X	X
Blue catfish	X	X
Black bullhead	X	X

Table 17. (Continued)

Species	Dredged material areas	Non-dredged material areas
Yellow bullhead	X	X
Channel catfish	X	X
Tadpole madtom	X	X
Brindled madtom	X	
Freckled madtom		X
Flathead catfish	X	X
Golden topminnow		X
Blackstripe minnow		X
Starhead topminnow		X
Blackspotted topminnow	X	X
Mosquitofish	X	X
Pirate perch	X	X
Brook silverside	X	X
Mississippi silverside	X	X
White bass	X	X
Yellow bass	X	X
Striped bass	X	X
Flier	X	X
Green sunfish	X	X

Table 17. (Continued)

Species	Dredged material areas	Non-dredged material areas
Warmouth	X	X
Orangespotted sunfish	X	X
Bluegill	X	X
Dollar sunfish		X
Longear sunfish	X	X
Redear sunfish	X	X
Spotted sunfish		X
Bantam sunfish		X
Spotted bass	X	X
Largemouth bass	X	X
White crappie	X	X
Black crappie	X	X
Banded pygmy sunfish		X
Mud darter		X
Greenside darter	X	
Bluntnose darter	X	X
Fantail darter	X	
Swamp darter		X
Cypress darter		X

Table 17. (Continued)

Species	Dredged material areas	Non-dredged material areas
Redfin darter	X	X
Banded darter	X	
Logperch	X	X
Blackside darter		X
Longnose darter	X	
Dusky darter	X	X
River darter	X	X
Sauger	X	X
Freshwater drum	X	X
Striped mullet		X
Total	87	89

Table 18. The number of species present, the species diversity index, and the species similarity index for each quantitative fish sample collected with the electric shocker from adjacent non-dredged material (S1a-S7a) and dredged material disposal areas (S1b-S7b).

Collection number	Number of species	Species Diversity Index	Species Similarity Index
S1a	9	4.81	0.78
S1b	9	4.27	
S2a	9	4.93	0.89
S2b	9	5.36	
S3a	18	7.97	0.67
S3b	9	5.22	
S4a	19	9.17	0.76
S4b	23	11.29	
S5a	16	8.44	0.56
S5b	9	4.76	
S6a	7	4.69	0.67
S6b	11	4.90	
S7a	13	6.16	0.57
S7b	8	3.76	

Table 19. The number of species present, the species diversity index, and the species similarity index for each quantitative fish sample collected with the gill nets from adjacent non-dredged material (G1a-G6a) and dredged material disposal (G1b-G6b) areas.

Collection number	Number of species	Species Diversity Index	Species Similarity Index
G1a	13	7.26	0.50
G1b	15	8.08	
G2a	5	4.73	0.57
G2b	9	6.15	
G3a	3	2.22	0.36
G3b	8	6.11	
G4a	7	4.78	0.57
G4b	7	3.99	
G5a	7	5.10	0.53
G5b	12	7.07	
G6a	14	7.54	0.62
G6b	15	6.35	

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