THE GUADALUPE-SAN ANTONIO-NUECES

RIVER BASINS PROJECT

Phase I: Review of Existing Biological Data

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A Final Report to

TEXAS WATER DEVELOPMENT BOARD
Contract 6-9259

January 31, 1973

ACKNOWLEDGEMENTS

It is impossible in a study as broad as this to recognize all the individuals, institutions, and agencies who made contributions to its success. To acknowledge even the major contributors is difficult, but we feel an attempt, incomplete though it may be, should be made.

We gratefully acknowledge the support of the funding agencies, the Texas Water Development Board and Southwest Texas State University.

Special recognition is extended to Mr. Lewis B. Seward, Principal Engineer, Project Development; Seth Burnett, Director of Operations Division; and personnel of the Operations Division, Texas Water Development Board, who were instrumental in planning, awarding, and supervising the project contract.

Numerous individuals in the administration, faculty, and staff of Southwest Texas State University were involved in this project in many capacities. We extend our thanks to them. Particularly, members of the Biology Department contributed much knowledge, interest, and encouragement. Dr. Herbert Hannan, Chairman of the Biology Department and Dr. W. E. Norris, Dean of the College of Arts and Sciences, were especially helpful in acquiring and administering this contract.

We are particularly indebted to the Texas Parks and Wildlife Department whose personnel in its state, regional, and district offices enthusiastically contributed information, time, and effort in gathering data.

Many other State and Federal agencies were instrumental in helping assemble data. The Texas Water Quality Board, Texas State Department of Health, U. S. Army Corps of Engineers, Texas Water Resources Institute, Environmental Protection Agency, Bureau of Sports Fisheries and Wildlife, and U. S. Geological Survey, in particular, warrant our thanks.

Other agencies making notable contributions were: San Antonio River Authority, Guadalupe-Blanco River Authority, City of Corpus Christi Water Department, E. I. du Pont de Nemours and Company at Victoria, Coastal Bend Council of Governments, Alamo Area Council of Governments, City of San Antonio, and Central Power and Light Company.

We would like to acknowledge the help of several individuals who were particularly helpful. Dr. Clark Hubbs and Dr. Gus Fruh of the University of Texas; Dr. Kirk Strawn, Texas A. & M. University; Dr. Elmer Cheatum, Southern Methodist University; Dr. Jacob Uhrich, Trinity University; and Mr. Marion Toole, former Chief Aquatic Biologist for the Texas State Parks and Wildlife Department contributed greatly to the project.

We owe a special thanks to numerous research assistants without whom this project would have been impossible. Particularly we are indebted to our graduate assistants John Schenck, Michael Peters, Charles Bayer, and Billy Colbert.

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INTRODUCTION

The drainage basins of the Guadalupe, San Antonio, and Nueces rivers cover a large area of south and south-central Texas. Until recently the growth of large population centers and industrial development has been limited mostly to the San Antonio and coastal areas. Also, the impoundment of waters of the streams and use of underground water has not been extensive. Thus, with exceptions, there has been relatively little concern about the quality of waters in these streams or the impact that urbanization, agriculture, and other influences have had on the biota of the stream systems.

The area encompassed by these three river basins is now experiencing unprecedented population growth and utilization. Urbanization and industrialization are increasing rapidly, particularly in the upper San Antonio River Basin, the central and coastal reaches of the Guadalupe River, and the coastal stretch of the Nueces River. Also, increasing demands upon underground water supplies in the three basins threaten the flow of springs that are a major source of recharge for these stream systems.

As a consequence of these developments, the quality and availability of water in these drainage systems will be of major concern in the immediate future. It is imperative that steps be taken now to insure that development in these basins proceed with the recognition that increased utilization will alter the existing ecosystems in the three drainage systems. This development must proceed in a manner that will result in the least possible detriment to the environment.

This concern over the future of these three drainage basins led to the initiation of this project. The Texas Water Development Board, in collaboration with the Aquatic Station of Southwest Texas State University, determined that the greatest need at present is to conduct ecological investigations on these river basins in order to define more clearly the condition of existing aquatic ecosystems. This will give insight into the current quality of water within the streams, form a basis for future comparisons to determine the effects of development in the basins, and eventually allow accurate predictions of effects that certain types of development in the basins will have on the stream ecosystems.

It was determined that a logical approach to the overall problem of defining the ecosystems of these river basins was to critically review all available data in an initial phase (Phase I), then conduct investigations to provide additional information essential to a more thorough understanding of the ecosystems in a second phase (Phase II). This is a report of Phase I of this project.

The major objectives of Phase I are: 1) to inventory and compile all ecological data available on the Guadalupe, San Antonio, and Nueces river basins, 2) to evaluate these data, 3) to define, when possible, the aquatic ecosystems, and 4) to make recommendations for further ecological studies essential in accurately defining the ecosystems and in assessing the impact of possible altered regimens and quality of stream flow in the aquatic ecosystems.

THE STUDY AREA

The study area (Fig. 1) encompasses the Guadalupe, San Antonio, and Nueces river basins. It covers approximately 27,200 square miles in south-central Texas (273). The main streams in the study area arise in Kerr, Bandera, and Edwards counties in the Balconian Biotic Province. The study area is bounded on the west and south by Kinney, Maverick, Dimmit, Webb, Jim Wells, and Nueces counties and on the north and east by Gillespie, Kendall, Blanco, Hays, Travis, Caldwell, Bastrop, Fayette, Gonzales, Lavaca, DeWitt, Victoria, and Calhoun counties. The San Antonio River joins with the Guadalupe River which empties into San Antonio Bay. The Nueces River flows into the Nueces Bay which joins Corpus Christi Bay. The approximate average annual runoff is 1,100,000 acre-ft for the Guadalupe River, 396,000 acre-ft for the San Antonio River, and 610,000 acre-ft for the Nueces River (273). The following is a more detailed discussion of each of the three river basins in the study area.

Description of the Guadalupe River Basin

The following discussion of the Guadalupe River Basin is based upon the description given by Kuehne (119). It has been modified and updated with information from other sources, which are cited. A map of the Guadalupe River Basin is given in Fig. 2.

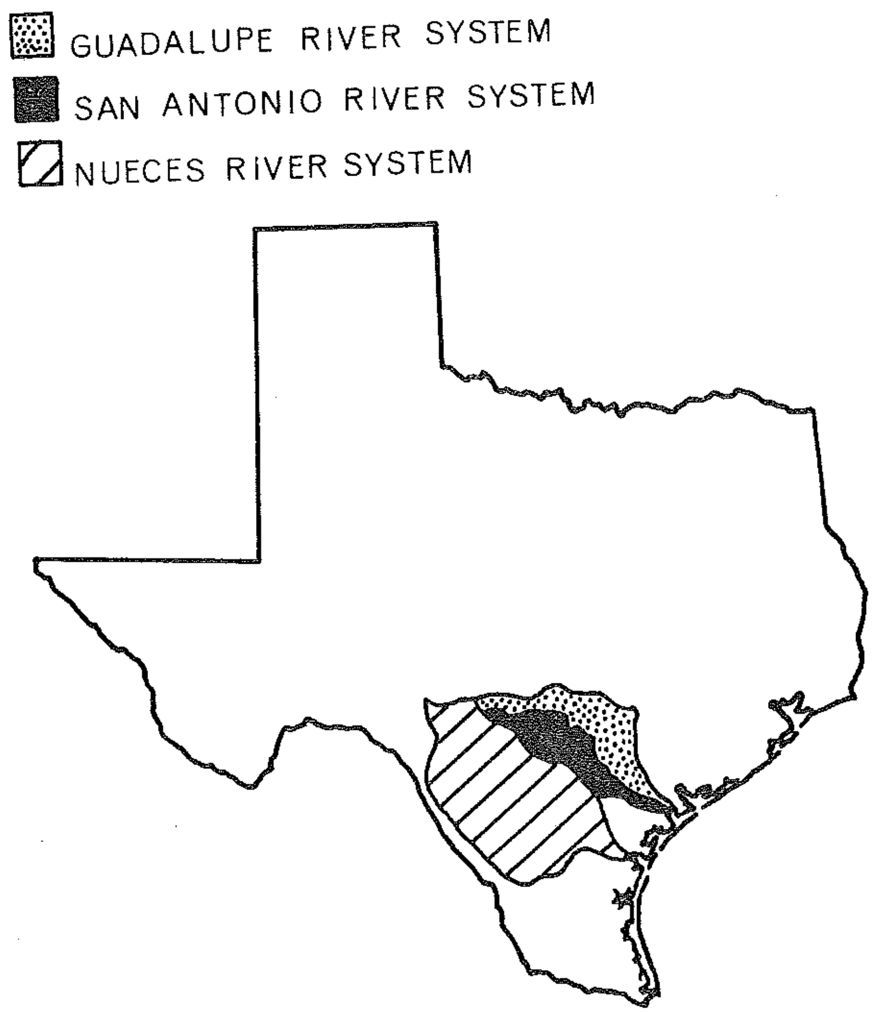

Figure 1. Study area: Guadalupe, San Antonio, and Nueces river basins in Texas.

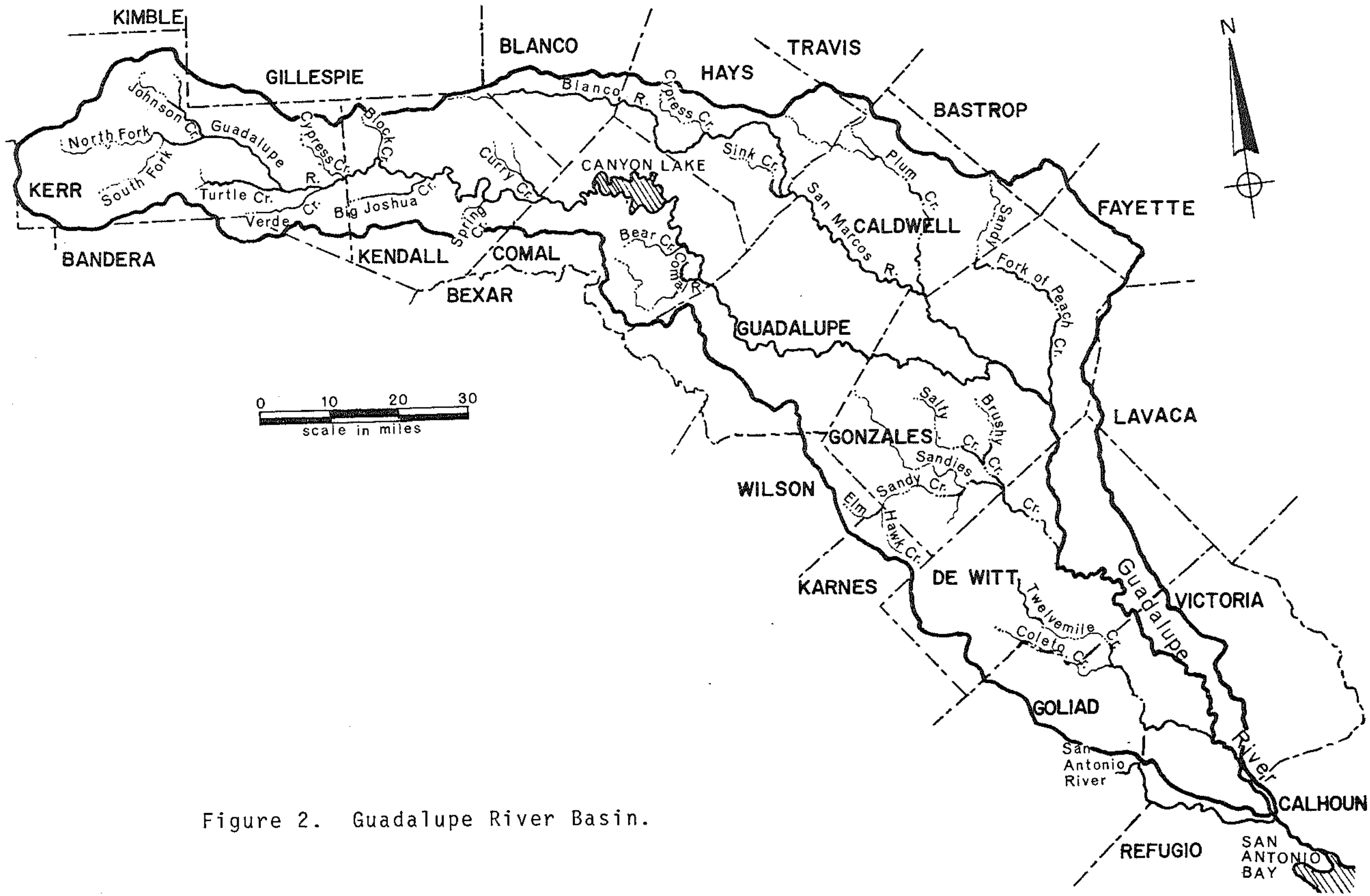

Figure 2. Guadalupe River Basin.

The Guadalupe River has its origin in the Edwards Plateau west of Kerrville at an elevation of 2,000 ft and flows southeastward into San Antonio Bay over 400 miles away. The stream traverses five natural subdivisions of the state and itself assumes several distinct forms during its course.

On the Edwards Plateau the river is quite typical of the swift, shallow, and rocky streams of this hilly limestone region. Near its source from permanent springs the stream is extra clear, swift, and shallow. Various aquatic plants grow in these upstream areas. Scattered stands of cypress occur along banks near the headwaters and persist throughout the length of the stream. In eastern Kerr County the river develops a slight murkiness, which persists in the remainder of its course through the Hill Country. Pools are longer, somewhat deeper, and less often separated by long reaches of shallow riffles. Aquatic plants are rare below the clear water area. The upper reaches of the river flow through Cretaceous Edwards and Glen Rose limestone formations (5).

The only major impoundment on the Guadalupe River, Canyon Reservoir, is located on the Edwards Plateau at river mile (R.M.) 306. This reservoir, a joint project of the U.S. Army Corps of Engineers and the Guadalupe-Blanco River Authority, was completed in 1964. The river bed at Canyon Dam has an altitude of about 755 ft, the top of the conservation pool is at 919 ft, and the designed maximum level of the flood pool is 951 ft above mean sea level. The conservation pool has a designed area of 8,241 acres, a shoreline of about 81 miles, a length of about 25 miles, and a volume of about 1.60 x $10^{10} ft^3$. The drainage basin emptying into the reservoir has an area of about 10,360 square miles (113).

East of the Balcones Fault zone near New Braunfels (R.M. 277) the Guadalupe leaves the Edwards Plateau and enters the Blackland Prairie. From here to the coast the river is characterized by a broad, flat valley and meandering pattern. The rocky bed and long, swift riffles disappear. From the spring-fed Comal River (R.M. 275) the Guadalupe receives a large and nearly constant water supply, which gives the stream the highest and most stable flow of any Texas stream. Only minor areas of flowing water remain within the Blackland Prairie region, since three power dams have converted the river into a series of long, riverine lakes. These are Lakes Dunlap, McQueeney, and Placid, built in 1929 and 1930. They are narrow, moderately deep, somewhat murky, and have heavy bottom deposits of mud.

East of Seguin the river enters the sandy Post Oak Belt near its westernmost boundary. The appearance of the stream changes little. The valley remains broad, the water murky, and the pools long and separated by short, graveled riffles. Consolidated bedrock is rarely found. Lake Gonzales (H-4) and Lake Wood (H-5) have converted much of this area into standing water. Like those near Seguin, these lakes are murky, partially silted, and invaded by vegetation in many parts. Near Gonzales the Guadalupe receives the San Marcos River, which increases the volume of flow but also is a source of saltwater, sludge, and silt pollution.

Southeast of Gonzales the Guadalupe River fronts against the Fayette Prairie, an isolated belt of blackland, but there is no change in the appearance of the stream until it emerges from the Post Oak Belt well onto the Coastal Prairie. The channel then becomes wider, riffles are fewer in number, and the water is always murky and remains turbid for long periods after high water. Oxbows and abandoned channels are numerous along the present channel, which has many meanders. As the Guadalupe approaches San Antonio Bay the banks become low, shoreline trees disappear, and the river enters the bay in a large open marsh. Several distributary channels carry water to the bay during floods.

In its course to the sea the Guadalupe receives many minor tributaries, most of which are extremely undependable in flow. The majority are restricted to pools during dry years. The few constantly running tributaries are at the edge of semiarid Edwards Plateau and owe their existence to large springs which flow continuously regardless of fluctuations in rainfall. Most notable of these spring-fed tributaries are the San Marcos and Comal rivers.

The San Marcos River originates at a series of springs that emerge from the Edwards Limestone in the Balcones Fault Zone in the city limits of San Marcos (R.M. 78) in Hays County. The average flow of the combined springs is 155 ft^3/sec. A dam has been constructed and the 45 acre impoundment, known as Spring Lake, has been commercialized by private interests. From the lake the stream flows into an area that has been improved and used as swimming areas.

The water of the stream is clear and remains so to the mouth of the Blanco River, about 4 miles downstream. At this point the water begins to be more turbid and becomes progressively more turbid to its mouth.

The stream banks are clays, black and yellow, with an overlay of alluvium. These banks slough off occasionally and contribute to the turbidity downstream. The stream bottom is gravel mixed with considerable sand. This is covered with a thin layer of silt in pools.

Pools predominate and they are long and measure four to eight feet in depth. There are a few riffle areas where the water flows swiftly over boulders. Generally the river has cut deep, narrow channels in the river bed which connect one pool with another. Trees along the banks form a partial canopy over much of the stream. Water undercuts these trees and many fall into the river causing frequent log jams. These jams, together with single trees that have fallen into the stream, are the main sources of cover for fish.

Rises are frequent in the river and once or twice a year violent floods occur. These floods move considerable amounts of gravel which is deposited in pools or forms gravel bars along banks.

The 63 mile course of the river has numerous small dams, 10 to 14 feet high, which impound small amounts of water to generate power used for various purposes. All of the dams were constructed before the 1930's and the pools behind the dams have been heavily silted. Their major influence at present is that they prohibit free movement of aquatic organisms during normal flow.

After flowing 63 miles and draining some 1200 square miles, the San Marcos River empties into the Guadalupe River about four miles west of Gonzales.

The Blanco River is a major tributary to the San Marcos River. It arises in northeast Kendall County and flows about 90 miles across southern Blanco County and Hays County and joins the San Marcos River about two miles southeast of San Marcos. In its course it crosses the lower edge of the Edwards Plateau through rugged, eroded limestone hills, flows off the Balcones Escarpment, then traverses about 10 miles of the Blackland Prairie to its juncture with the San Marcos River. The soil type on the plateau is predominately Valera with shallow calcareous soils over limestone while that of the Blackland Prairie consists mainly of dark lime clays underlain with marls, limestone, and sands. The river runs alternately through still pools, gravel and rubble rapids, and long broad stretches of shallow water over solid bedrock with washed out crevices and potholes. The major sources of water are springs and surface runoff and these fluctuate widely with local weather conditions. Rises are frequent but the average rainfall is irregular and the river frequently ceases to flow and water stands in pools or dries up entirely. The water is clear in the headwaters but becomes constructed before the 1930's and the pools behind the dams have been heavily silted. Their major influence at present is that they prohibit free movement of aquatic organisms during normal flow.

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The Comal River originates at numerous springs, collectively called Comal Springs, which flow from Edwards Limestone formations along the Balcones Fault Zone in the city limits of New Braunfels. The springs have an average flow of about 277 ft^3/sec, making this the largest spring in Texas. The spring area has been dammed and developed as a municipal recreational area with swimming and boating facilities. Immediately downstream from the park area the spring water is used for cooling of an electrical power generating plant. The river then flows about 2.5 miles before flowing into the Guadalupe River. Because of this extremely short course, it is termed the shortest river in Texas. Throughout its length the river runs through deep pools alternating with deep, swift narrow channels. Banks are very steep and trees in many localities overhang the stream forming a canopy. The water is very clear and dense aquatic vegetation grows in quieter areas throughout the stream.

Description of the San Antonio River Basin

The following description of the San Antonio River Basin is modified from that of Kuehne (119). A map of the San Antonio River Basin is given in Fig. 3.

The San Antonio River originates in the city of San Antonio and flows about 238 miles before joining the Guadalupe River only a few miles from San Antonio Bay. The two main tributaries

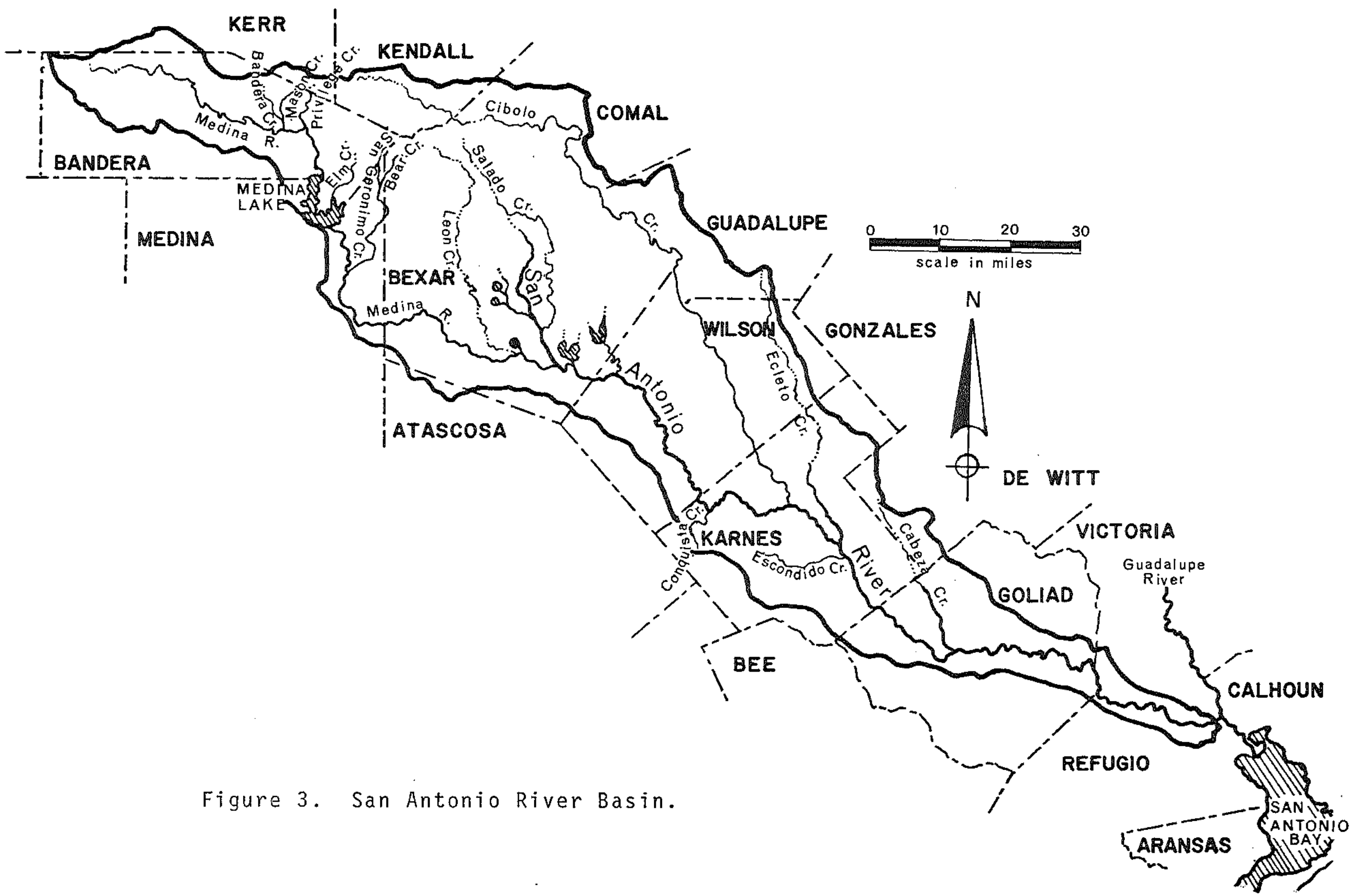


Figure 3. San Antonio River Basin.

are the Medina River, which enters in southern Bexar County (R.M. 213.5), and Cibolo Creek, which enters near Karnes City (R.M. 133).

Average annual rainfall in the river basin ranges from about 27 to about 32 inches.

According to early accounts the San Antonio River was a sizeable stream rising from springs in the Olmos Creek valley at the present site of Brackenridge Park. These springs received their water from the Edwards Plateau underground reservoir but appeared in a zone of minor faults in Upper Cretaceous limestones several miles removed from the edge of the Plateau. Fluctuations of the springs were much greater than those associated directly with the Balcones Fault Zone at New Braunfels and San Marcos, though the average discharge was comparable to that of Comal Springs. San Pedro Creek was a moderate-sized spring-fed tributary of the river and rose as San Pedro Springs from similarly faulted and fractured limestones.

These big springs are now virtually extinct. They have been dry most of the time since 1930 and the main river flow has been maintained by a shallow well in the spring area. Discharge of surplus water from several artesian wells in downtown San Antonio augments the stream somewhat. The reason for the cessation of flow in these springs is simply that the water demands of San Antonio and the surrounding area have drawn the underground reservoir level below that of the spring openings and flow has stopped.

The San Antonio River Basin transects several of the major physiographic regions of the state. The main river originates in and flows through the northern edge of the South Texas Brushlands. However, the area is not typical of the brushlands and also shows characteristics of the Blackland Prairie, Coastal Prairie, and Post Oak Belt on which it borders.

The valley of the San Antonio River is very narrow and the channel is not deeply developed above the junction of the Medina River. Small pools and riffles alternate and the fairly clear water contains aquatic plants. These conditions are interrupted in downtown San Antonio as the river flows through artificial, walled channels. Below the junction of the Medina River the valley broadens noticeably and the main channel is more deeply entrenched. Riffles are absent and the stream is consistently narrow and steady in flow with only brush and debris in the channel creating any tendency to pool. Except for one or two artificial pools south of San Antonio and a natural pool near Falls City (R.M. 157), the river averages about 20 ft wide and 3 ft deep with a sandy bottom in the main current and deep, soft muds toward the banks. Murkiness begins to appear upstream from the junction with the Medina River and the turbidity becomes more pronounced as the river flows toward the Gulf.

Below the junction of Cibolo Creek (R.M. 133) the San Antonio River valley broadens further and large pools develop. Only rarely do true riffles occur along outcrops of resistant rock, but shallow, swift areas with sandy bottoms commonly separate the pools. The average channel width is 35 to 50 ft and pools are from 3 to 7 ft deep. The turbidity of the water increases but the channel is usually not so badly choked with mud and log jams as the region above the mouth of Cibolo Creek.

The Medina River originates at small springs on the north and west forks of the river in northwest Bandera County and flows southeasterly for about 150 miles through Bandera, Medina, and Bexar counties to a confluence with the San Antonio River about 12 miles south of San Antonio. The drainage area of the Medina River is 1,225 square miles. The headwaters are well up in the Edwards Plateau and it flows through the plateau in Bandera and upper Medina counties. The river then flows off of the Balcones Escarpment and flows across the Coastal Plains for about 65 miles to the San Antonio River. The entire upper reach of the river is fed by numerous springs, but much of the water is lost to the underground reservoir in that area. To the point of leaving the escarpment the river bed is almost totally limestone while below the escarpment the bed is mostly gravel to near Lacoste (R.M. 49), where it changes to sandy loam. Waters are clear to about this region then the turbidity increases considerably to the junction with the San Antonio River. In the lower reaches the valley widens, the bed graduates to heavy black loam, and pools become deeper in deeply cut banks (167).

The only major impoundment on the Medina River is Medina Lake (R.M. 78), located on the Edwards Plateau. The dam for this lake was completed in 1912. It was financed by private capital and its waters are used principally for irrigation.

The 164 ft concrete dam creates a lake of 254,000 acre-ft. Due to erratic rainfall and over-utilization of the lake, the water level has fluctuated widely with the lake being almost completely dry on many occasions. Medina Lake is usually relatively clear. The upper third of the lake is sometimes slightly turbid and the lower two thirds clear with intermittent intense algal blooms (168).

Cibolo Creek has its headwaters in the southern part of Kendall County and flows about 150 miles as the boundary of Bexar County with Comal and Guadalupe counties, across Wilson County and into the San Antonio River near Karnes City in Karnes County. On the Edwards Plateau the stream is intermittent and usually flows only shortly after rains on the watershed. After leaving the Balcones Escarpment (R.M. 90), the creek flows through the southwestern edge of the Blackland Prairie and the Post Oak Belt before entering the San Antonio River. In the lower reaches the creek has a broad, flat, well developed valley and flow is more constant, though still erratic (119, 247).

Two major reservoirs have recently been constructed in the San Antonio River Basin immediately southeast of San Antonio. The watersheds of both reservoirs are very restricted and surface runoff is not sufficient to maintain either of the reservoirs, thus both are held at a constant level by pumping water from the San Antonio River. Calaveras Dam, an earth-fill dam, is 70 ft above the streambed and forms Calaveras Lake which has a volume of 63,000 acre-ft with a surface area of 3,550 acres.

Braunig Lake is formed by a 90 ft high earth-fill dam and has a capacity of 26,500 acre-ft and a surface area of 1,350 acres. Both lakes are owned by the San Antonio Public Service Board and are utilized for cooling fuel burning hydroelectric plants.

Description of the Nueces River Basin

The Nueces River Basin covers about 16,800 square miles in South Central Texas, making it the second largest drainage basin entirely within the state (180). A map of the Nueces River Basin is given in Fig. 4.

The Nueces River heads in two forks in the southern part of the Edwards Plateau. The west fork drains western Uvalde County, while the east, or main fork, begins at a spring in northwestern Real County. After the forks join, the Nueces River flows southward across the Edwards Plateau, off the Balcones Escarpment, and then easterly and southeasterly across the South Texas Brushlands into Corpus Christi Bay some 415 miles from its source.

On the plateau, both forks and the main river are in deeply cut limestone canyons and are fed by numerous springs. These spring waters and most surface runoff enters permeable materials along the stream beds and flow is subsurface in many reaches with water reemerging downstream. The flow of the Nueces River is, therefore, highly erratic and is usually very low, though it maintains some flow, as a general rule, except during drought

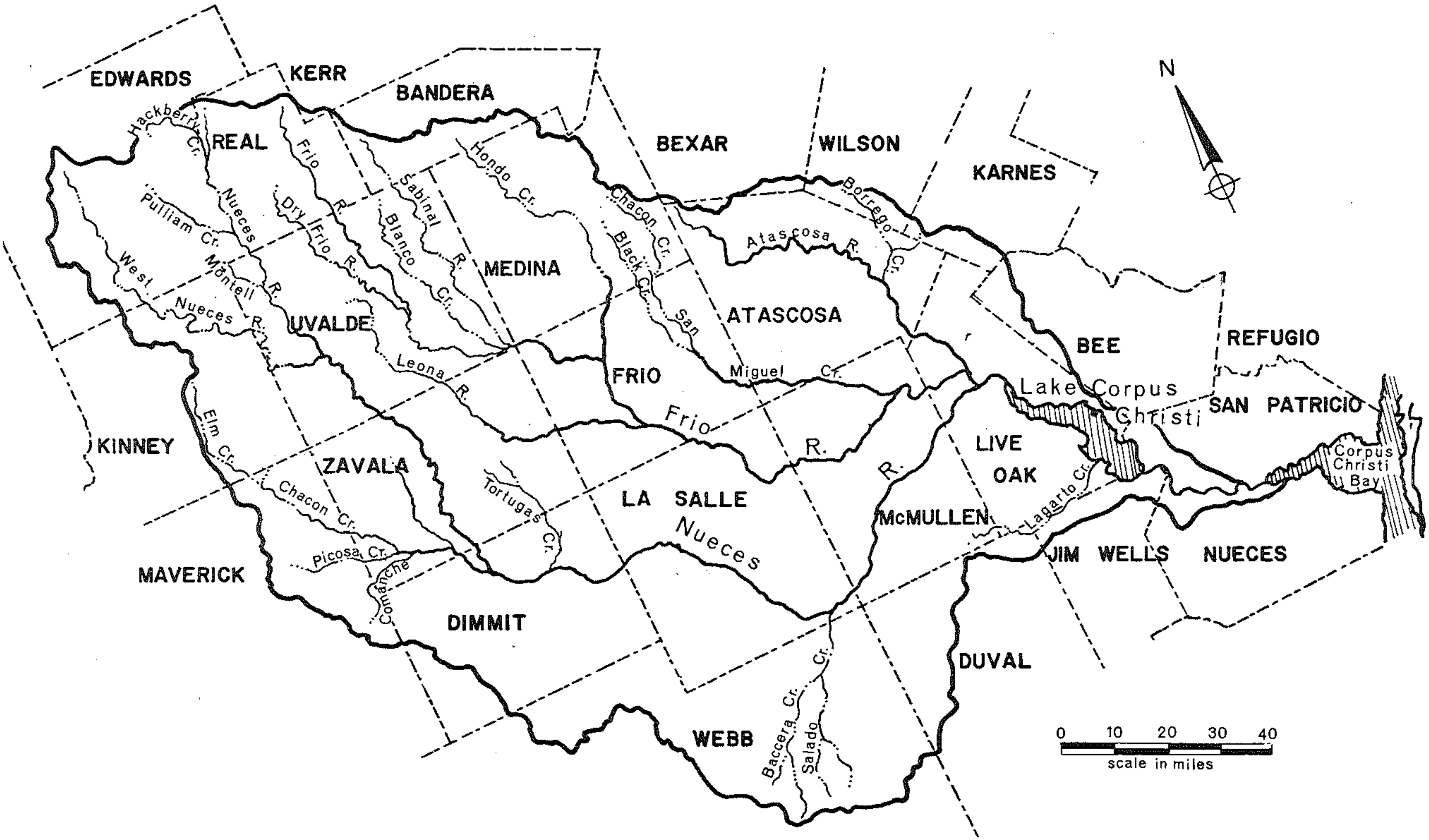


Figure 4. Nueces River Basin.

periods. There are many natural pools in the stream course and numerous small dams contribute to pool formation. The majority of the pools have gravel bottoms, while a few pools and most of the stream beds are scoured to bedrock.

At the Balcones Escarpment most of the water in the Nueces River enters faults and becomes a part of the underground reservoir. As a result, the river to the south of the escarpment is dependent almost entirely on rains south of the escarpment. Much of this water is lost to evaporation and seepage into permeable sand formations, so the Nueces River is composed of a series of many long, narrow pools with little or no flow between them except during flood stages. The banks are typically sharply cut terrace deposits of silt and fine sands. Large trees and dense undergrowth cover the terraces almost to the water line. The water is usually turbid and warm. A large number of channel dams form impoundments used largely for irrigation and recreation (173, 180, 223).

The only major impoundment on the Nueces River is Lake Corpus Christi which was completed in 1934 five miles southwest of Mathis (R.M. 47.2). The lake originally covered 5,500 acres and had a volume of 55,000 acre-ft (222). Due to heavy silting, a new dam was completed in 1958 some 1,000 yards downstream from the original dam. The newer dam has a crest gate elevation of 94 ft above mean sea level and an increased lake capacity to 304,000 acre-ft. The lake was financed by the Lower Nueces River Water Supply District and was created for the purpose of providing a large raw water supply for the City of Corpus Christi (35). Because of the large volume of the new lake, silt settles farther up the lake and the water is relatively clear, with most turbidity readings below 25 ppm (222).

The Frio River system is a major tributary to the Nueces River. It originates as a system of small streams in Real and Uvalde counties and has a total length of about 270 miles. The river has three major forks: the Dry Frio, the East Frio, and the main Frio. The main Frio is also divided into two forks at its headwaters which arise from springs. The river in this area has cut deep canyons to a wide flat bottom where water flows from 1/4 to 4 inches deep in solution channels. A few larger pools are present, mostly formed by small dams. The headwaters of the East Frio and the Dry Frio are much the same, except that the Dry Frio has a more "V" shaped bed and more natural pools.

At R.M. 211 just southeast of Concan the Frio River and the Dry Frio both flow onto Edwards Limestone and the entire normal flow of both streams is absorbed. From this fault south, the water in the river is restricted to a few holes in the stream bed.

Just before leaving Uvalde County the Frio is joined by the Sabinal River and emerges onto the Coastal Prairie (184). In this lower section of the stream, banks are sharply cut through terrace or natural dike deposits. Little flow occurs in the lower reach of the river except during heavy rains.

There are scattered long, narrow pools and in a few places small riffles over gravel bars occur. After receiving the intermittent flow of the Leona River, the Atascosa River, and numerous small tributaries, the Frio River joins with the Nueces River near Three Rivers in Live Oak County.

The Atascosa River heads just below the Balcones Escarpment in northern Atascosa County and flows about 75 miles southward into Live Oak County where it joins the Frio River just before the Frio joins the Nueces River. The river is normally dry with a few scattered pools and a few small riffles in a bed cut sharply into terrace deposits. Deep irrigation wells around Pleasanton have apparently lowered the water table and greatly reduced the natural flow of the river. The City of Corpus Christi has several large artesian wells near Campbellton for an auxiliary water supply. When Lake Corpus Christi is low, these wells are opened and the Atascosa River flows below Campbellton in transporting the water to Lake Corpus Christi (180).

FISHES

Hubbs (85) gave the following discussion of the history of ichthyology in Texas. "Knowledge of the distribution of Texas fresh-water fishes has accumulated for more than 100 years. Naturalists accompanying the Railway and Boundary Surveys in the 1850's collected a few fishes, especially on the wagon road between San Antonio and El Paso (Girard, 1858 and 1859). The next more or less intensive work was done in 1884 (Jordan and Gilbert, 1886) and 1891 (Evermann and Kendall, 1894). Locality data for many of the early collections are either inadequate or inaccurate (Clark Hubbs, 1954; Miller, 1955; and Clark Hubbs and Springer, 1957). Interest lagged again until the 1920's when Carl L. Hubbs, then at the University of Michigan Museum of Zoology, started intensive studies of North American fresh-water fishes. Many collections from Texas waters were made in conjunction with these studies. Intensive surveys of Texas streams were initiated in 1938 by Dr. Kelshaw Bonham at the A. and M. College of Texas. This work was continued and data gathered by his successors and associates including F. W. Tabor, Cecil Reid, G. W. Soulen, F. T. Knapp, G. K. Reid, Jr., and R. J. Baldauf. Unfortunately most of the collection reports are not published and many of the specimens cannot be located. Field work at The University of Texas began in 1946 under the supervision of W. F. Blair. Since 1949 I have been in charge of this program. At about the same time the Texas Game and Fish Commission began intensive stream surveys at the instigation of Marion Toole. Additional information has been accumulated by Royal D. Suttkus, George A. Moore, Carl D. Riggs, and William J. Koster as part of their studies of adjacent states. Kirby Walker, Gordon Gunter, Henry Hildebrand, and J. L. Baughman have concentrated their studies on marine and brackish water environments."

The only major contribution to our knowledge of the general distribution of fishes throughout the entire study area is that of Hubbs in 1957 (85). He discussed the distribution patterns of fishes in Texas in relation to terrestrial biotic areas and stream systems. He concluded that the basic factors controlling distribution patterns of fishes are climatic and geological, these determining the properties of water.

In recent years several universities in Texas have employed ichthyologists who are collecting fishes from various areas in Texas. In addition, further information is now available from various other researchers and state agencies. Thus, an attempt to update the distributional patterns of fishes in the study area is warranted.

In order to bring up to date our knowledge of the fishes in the study area, all available published and unpublished fisheries data were utilized. Little effort was put forth to collect papers published prior to 1894 since Evermann and Kendall (51) reviewed and summarized essentially all of the data that existed at that time. In addition, data were utilized from collection reports which must be submitted to the Texas Parks and Wildlife Department by individuals who are issued scientific collecting permits. Also, raw data on fishes were obtained from the various Regional and District offices of the Texas Parks and Wildlife Department.

The scientific names of fishes in this report are the most recently accepted names and follow those given by Hubbs (95). The common names of the fishes are those given by Bailey, et al. (7).

Collection Records of Fishes

From the Guadalupe River System there were recorded 9 orders, 18 families, 43 genera, and 85 species. Of these, 9 orders, 17 families, 41 genera, and 75 species appear to be valid (Table 1). Six orders, 15 families, 38 genera, and 72 species were recorded for the San Antonio River System. Of these, 6 orders, 17 families, 37 genera, and 64 species appear to be valid (Table 1). For the Nueces River System, 9 orders, 26 families, 52 genera, and 89 species were recorded. Of these, 9 orders, 25 families, 51 genera, and 76 species appear to be valid (Table 1).

A composite checklist of fish species recorded in the entire study area, including the Nueces, Guadalupe, and San Antonio river systems is presented in Table 1. The sources of information on which the checklist is based are given for each river system at the end of the table.

Tables 2, 3, and 4 give a checklist of fishes in each of the major streams and lakes of each of the three river systems. A list of sources of data for each stream or lake is given at the end of each table.

Species distributions in each of the three river systems are given for each species for which sufficient information was available (Figs. 5-93). Only data which contained sufficient information to pinpoint the collection localities were plotted. Figures 2, 3, and 4 in the introduction will allow more accurate determination of collection localities of the species on the distribution maps.

Table 1. Composite checklist of fish species from the Nueces (NRS), Guadalupe (GRS), and San Antonio river systems (SARS). Family names are given in all capitals and the scientific name of each species is followed by the common name in parenthesis. X indicates that the species was recorded from that river system. X* indicates that it is questionable if the species identification was correct or if the correct collection location was given. # indicates that the species was not recorded from that river system but the river system is within the recorded range of the species.

Fish	Stream System		
	GRS	SARS	NRS
LEPISOSTEIDAE			
Lepisosteus spatula (alligator gar)	X	X	X
Lepisosteus platostomus (shortnose gar)			X*
Lepisosteus oculatus (spotted gar)	X	X	X
Lepisosteus osseus (longnose gar)	X	X	X
ELOPIDAE			
Elops saurus (ladyfish)	#	#	X
CLUPEIDAE			
Alosa chrysochloris (skipjack herring)	#	#	#
Brevoortia gunteri (finescale menhaden)			X
Brevoortia patronus (Gulf menhaden)			X
Dorosoma petenense (threadfin shad)	X	#	X
Dorosoma cepedianum (gizzard shad)	X	X	X
ENGRAULIDAE			
Anchoa mitchilli (bay anchovy)			X
Anchoa hepsetus (striped anchovy)			X*
SALMONIDAE			
Salmo gairdneri (rainbow trout)	X		
CHARACIDAE			
Astyanax mexicanus (Mexican tetra)	X	X	X
CYPRINIDAE			
Cyprinus carpio (carp)	X	X	X
Carassius auratus (goldfish)	X	X	#
Notemigonus crysoleucas (golden shiner)	X	X	X
Opsopoeodus emiliae (pugnose minnow)	X	X	X
Hybopsis aestivalis (speckled chub)	X	X	#
Notropis atherinoides (emerald shiner)	X*		

Table 1. (Continued)

Fish	Stream System		
	GRS	SARS	NRS
Notropis oxyrhynchus (sharpnose shiner)	X*		
Notropis amabilis (Texas shiner)	X	X	X
Notropis shumardi (silverband shiner)	X		
Notropis chalybaeus (ironcolor shiner)		X*	
Notropis texanus (weed shiner)	X	X	X
Notropis simus (bluntnose shiner)			X*
Notropis blennius (river shiner)		X*	
Notropis amnis (pallid shiner)	X	X	
Notropis venustus (blacktail shiner)	X	X	X
Notropis lutrensis (red shiner)	X	X	X
Notropis proserpinus (proserpine shiner)		X*	
Notropis stramineus (sand shiner)	X	X	X
Notropis atrocaudalis (blackspot shiner)			X*
Notropis volucellus (mimic shiner)	X	X	X*
Notropis buchanani (ghost shiner)	X	X	X
Notropis boops (bigeye shiner)	X*		
Dionda episcopa (roundnose minnow)	X	X	X
Hybognathus nuchalis (silvery minnow)	#		
Hybognathus placitus (plains minnow)	#	#	#
Pimephales vigilax (bullhead minnow)	X	X	X
Pimpehales promelas (fathead minnow)	X	X	X
Campostoma anomalum (stoneroller)	X	X	X
CATOSTOMIDAE			
Cycleptus elongatus (blue sucker)	#	#	#
Ictiobus bubalus (smallmouth buffalo)	X	X	X
Carpiodes carpio (river carpsucker)	X	X	X
Moxostoma congestum (grey redhorse)	X	X	X
Moxostoma erythrurum (golden redhorse)	X*		
Moxostoma duguesnii (black redhorse)	X*		
Minytrema melanops (spotted sucker)	X		
Erimyzon sucetta (lake chubsucker)	X	X	
Erimyzon oblongus (creek chubsucker)	X*		
AMEIURIDAE (=ICTALURIDAE)			
Ictalurus punctatus (channel catfish)	X	X	X
Ictalurus furcatus (blue catfish)	X	X	X
Ictalurus melas (black bullhead)	X	X	X
Ictalurus natalis (yellow bullhead)	X	X	X
Ictalurus nebulosus (brown bullhead)	X*	X*	X*
Trogloglanis pattersoni (toothless blindcat)		X	
Pylodictis olivaris (flathead catfish)	X	X	X
Satan eurystomus (widemouth blindcat)		X	
Noturus gyrinus (tadpole madtom)	X	X	X
Noturus nocturnus (freckled madtom)		X*	

Table 1. (Continued)

Fish	Stream System		
	GRS	SARS	NRS
ANGUILLIDAE			
Anguilla rostrata (American eel)	X	#	X
BELONIDAE			
Strongylura marina (Atlantic needlefish)			X
CYPRINODONTIDAE			
Lucania parva (rainwater killifish)		X	
Fundulus grandis (gulf killifish)			X
Zygonectes notatus (blackstripe topminnow)	X	X	
Zygonectes olivaceus (blackspotted topminnow)	X*		
Cyprinodon variegatus (sheepshead minnow)	X	#	X
POECILIDAE			
Gambusia geiseri (largespring gambusia)	X		
Gambusia gaigei (Big Ben gambusia)			X*
Gambusia affinis (mosquitofish)	X	X	X
Gambusia georgei (San Marcos gambusia)	X		
Poecilia latipinna (sailfin molly)	X	X	X
Poecilia formosa (amazon molly)	X	X	X
ATHERINIDAE			
Menidia audens (Mississippi silverside)		X*	
Menidia beryllina (tidewater silverside)	X	X	X
Labidesthes sicculus (brook silverside)	X*		
PERCICHTHYIDAE			
Morone chrysops (white bass)	X	X	X
CENTRARCHIDAE			
Micropterus dolomieui (smallmouth bass)	X		
Micropterus punctulatus (spotted bass)	X	X	
Micropterus treculi (Guadalupe bass)	X	X	X
Micropterus salmoides (largemouth bass)	X	X	X
Chaenobryttus gulosus (warmouth)	X	X	X
Chaenobryttus cyanellus (green sunfish)	X	X	X
Lepomis symmetricus (bantam sunfish)		X*	
Lepomis punctatus (spotted sunfish)	X	X	X
Lepomis microlophus (redear sunfish)	X	X	X
Lepomis macrochirus (bluegill)	X	X	X
Lepomis humilis (orangespotted sunfish)	X		
Lepomis auritus (redbreast sunfish)	X	X	X
Lepomis megalotis (longear sunfish)	X	X	X
Lepomis marginatus (dollar sunfish)	X*		

Table 1. (Continued)

Fish	Stream System		
	GRS	SARS	NRS
<u>Enneacanthus obesus</u> (banded sunfish)		X*	
<u>Ambloplites rupestris</u> (rock bass)	X		X
<u>Pomoxis annularis</u> (white crappie)	X	X	X
<u>Pomoxis nigromaculatus</u> (black crappie)	X	X	X
PERCIDAE			
<u>Hadropterus scierus</u> (dusky darter)	X	#	
<u>Hadropterus shumardi</u> (river darter)	X	X	
<u>Percina caprodes</u> (logperch)	X	X	
<u>Percina macrolepida</u> (big scale logperch)	X		
<u>Etheostoma chlorosomum</u> (bluntnose darter)	X	X	
<u>Etheostoma gracile</u> (slough darter)	X	X	X
<u>Etheostoma fusiforme</u> (swamp darter)			X*
<u>Etheostoma spectabile</u> (orangethroat darter)	X	X	X*
<u>Etheostoma lepidum</u> (greenthroat darter)	X	X	X
<u>Etheostoma grahami</u> (Rio Grande darter)			X*
<u>Etheostoma fonticola</u> (fountain darter)	X		X*
<u>Etheostoma microperca</u> (least darter)			X*
CARANGIDAE			
<u>Oligoplites saurus</u> (leatherjacket)			X
GERRIDAE			
<u>Eucinostomus argenteus</u> (spotfin mojarra)			X
<u>Eucinostomus lefroyi</u> (mottled mojarra)			X
<u>Gerres cinereus</u> (yellowfin mojarra)			X
POMADASYIDAE			
<u>Pomadasys crocro</u> (burro grunt)			X*
SCIAENIDAE			
<u>Aplodinotus grunniens</u> (freshwater drum)	#	X	X
<u>Bairdiella chrysura</u> (silver perch)			X
<u>Scianenops ocellata</u> (red drum)			X
<u>Leiostomus xanthurus</u> (spot)			X
<u>Micropogon undulatus</u> (Atlantic croaker)			X
<u>Pogonias cromis</u> (black drum)			X
<u>Cynoscion nebulosus</u> (spotted seatrout)			X
SPARIDAE			
<u>Lagodon rhomboides</u> (pinfish)			X
<u>Archosargus probatocephalus</u> (sheepshead)			X

Table 1. (Continued)

Fish	Stream System		
	GRS	SARS	NRS
CICHILIDAE			
Cichlasoma cyanoguttatum (Rio Grande perch)	X	X	X
Tilapia mossambica (Mozambique tilapia)	X	X	
MUGILIDAE			
Mugil cephalus (striped mullet)	X	X	X
Mugil curema (white mullet)	X	X	X
GOBIIDAE			
Gobiomorus dormitator (bigmouth sleeper)	#	#	X
Gobiosoma bosci (naked goby)	X*		X
BOTHIDAE			
Paralichthys lethostigma (southern flounder)			X
SOLEIDAE			
Trinectes maculatus (hogchoker)	X		X
Achirus lineatus (lined sole)			X

Sources of data:

Guadalupe River System - 1, 2, 11, 20, 21, 26, 28, 43, 47, 51, 81, 83, 86, 87, 88, 89, 90, 92, 93, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 119, 156, 158, 159, 182, 192, 193, 195, 199, 202, 203, 210, 213, 220, 223, 224, 227, 236, 243, 253, 257, 260, 261, 262, 265, 266, 267, 269, 285, 295, 298, 299, 301, 302, 304, 305, 306, 307, 308, 309, 312, 314, 315, 316, 317.

San Antonio River System - 11, 51, 83, 88, 119, 168, 169, 170, 171, 177, 178, 187, 190, 194, 201, 208, 219, 221, 223, 227, 228, 232, 233, 236, 237, 240, 246, 247, 248, 263, 265, 268, 278, 295, 296, 299.

Table 1. (Continued)

Nueces River System - 51, 83, 84, 87, 89, 106, 116, 159, 165, 166, 174, 181, 183, 184, 185, 186, 191, 197, 202, 207, 217, 221, 222, 223, 229, 231, 232, 237, 240, 244, 245, 246, 247, 251, 254, 256, 263, 264, 268, 296, 297, 299, 300, 303, 310, 311, 313.

Table 2.--Checklist of the fishes found in the major streams and lakes of the Guadalupe River System. X indicates that the species was recorded from that locality. X* indicates that it is questionable if the species identification was correct or if the correct collection location was given.

Species	Stream or Lake									
	Guadalupe River	San Marcos River	Blanco River	Comal River	Canyon Lake	Dunlap Lake	H-4 Lake	Meadow Lake	McQueeney Lake	H-5 Lake
Lepisosteus spatula	X									
Lepisosteus oculatus	X						X	X		X
Lepisosteus osseus	X	X	X		X	X	X	X	X	X
Dorosoma petenense	X	X	X		X			X		X
Dorosoma cepedianum	X	X	X	X	X	X	X	X	X	X
Salmo gairdneri	X				X					
Astyanax mexicanus	X	X	X		X	X				
Cyprinus carpio	X		X		X	X			X	X
Carassius auratus			X	X					X	
Notemigonus crysoleucas	X	X	X		X			X	X	X
Opsopoeodus emiliae	X	X				X	X		X	
Hybopsis aestivalis	X	X	X	X						
Notropis atherinoides		X*	X*							
Notropis oxyrhynchus						X*				
Notropis amabilis	X	X	X	X		X				
Notropis shumardi			X							
Notropis boops	X*									
Notropis texanus	X	X								
Notropis amnis	X	X								
Notropis venustus	X	X	X	X	X	X	X			
Notropis lutrensis	X	X	X	X	X	X	X			
Notropis stramineus	X	X	X	X						
Notropis volucellus	X	X	X	X			X			
Notropis buchanani	X		X			X	X			
Dionda episcopa	X	X	X	X						
Pimephales vigilax	X	X	X	X	X	X	X		X	X
Pimephales promelas	X	X	X							
Campostoma anomalum	X	X	X		X					
Ictiobus bubalus	X	X					X		X	X
Carpiodes carpio	X	X	X		X	X	X		X	
Moxostoma congestum	X	X	X		X	X	X	X	X	X
Moxostoma erythrurum						X	X	X		
Moxostoma dequesnii	X*									
Minytrema melanops	X									

Table 2. (Continued)

Species	Stream or Lake									
	Guadalupe River	San Marcos River	Blanco River	Comal River	Canyon Lake	Dunlap Lake	H-4 Lake	Meadow Lake	McQueeney Lake	H-5 Lake
Erimyzon sucetta	X									
Erimyzon oblongus	X*									
Ictalurus punctatus	X	X	X	X	X	X	X	X	X	X
Ictalurus furcatus	X				X					
Ictalurus melas	X	X	X		X					
Ictalurus natalis	X	X	X	X	X	X	X	X	X	
Ictalurus nebulosus		X*		X*						
Pylodictis olivaris	X	X	X		X	X	X	X	X	X
Noturus gyrinus		X					X	X		
Anguilla rostrata	X	X								
Zygonectes notatus	X	X	X	X		X	X	X		
Zygonectes olivaceus							X*			
Cyprinodon variegatus	X									
Gambusia geiseri	X	X		X						
Gambusia affinis	X	X	X	X	X	X	X	X	X	X
Gambusia georgei		X								
Poecilia latipinna	X	X	X	X	X	X	X			X
Poecilia formosa		X								
Menidia beryllina	X				X				X	X
Labidesthes sicculus		X*								
Morone chrysops					X		X		X	X
Micropterus dolomieui		X								
Micropterus punctulatus	X	X	X							
Micropterus treculi	X	X			X	X		X	X	
Micropterus salmoides	X	X	X	X	X	X	X	X	X	X
Chaenobryttus gulosus	X	X	X	X	X	X	X	X	X	X
Chaenobryttus cyanellus	X	X	X		X	X	X	X	X	X
Lepomis punctatus	X	X	X	X	X	X	X		X	
Lepomis microlophus	X	X	X	X	X	X	X		X	X
Lepomis macrochirus	X	X	X	X	X	X	X	X	X	X
Lepomis humilis	X		X		X					
Lepomis auritus	X	X	X	X	X	X	X	X	X	
Lepomis megalotis	X	X	X	X	X	X	X	X	X	X
Lepomis marginatus						X*	X*		X*	X*
Ambloplites rupestris	X	X		X						
Pomoxis annularis	X	X	X		X	X	X	X	X	X
Pomoxis nigromaculatus	X				X	X	X		X	
Hadropterus scierus	X	X	X	X						
Hadropterus shumardi	X	X								
Percina caprodes	X	X	X		X		X			

Table 2. (Continued)

Species	Stream or Lake									
	Guadalupe River	San Marcos River	Blanco River	Comal River	Canyon Lake	Dunlap Lake	H-4 Lake	Meadow Lake	McQueeney Lake	H-5 Lake
Percina macrolepida	X									
Etheostoma chlorosomum	X						X			X
Etheostoma gracile							X			
Etheostoma spectabile	X	X	X							
Etheostoma lepidum	X	X		X						
Etheostoma fonticola	X	X		X						
Cichlasoma cyanoguttatum	X	X	X	X	X	X	X	X	X	X
Tilapia mossambica		X			X					
Mugil cephalus	X									
Mugil curema	X									
Gobiosoma bosci									X	
Trinectes maculatus	X									

Sources of data:

Guadalupe River - 1, 2, 11, 20, 21, 51, 81, 83, 86, 87, 89, 90, 100, 104, 105, 106, 107, 108, 109, 119, 159, 199, 202, 223, 236, 243, 260, 261, 267, 270, 295, 299, 301, 312, 313, 315, 316, 317.

San Marcos River - 11, 26, 28, 43, 47, 51, 81, 83, 87, 88, 93, 97, 98, 99, 103, 104, 105, 106, 108, 109, 158, 192, 236, 243, 302, 304, 305, 306, 307, 309, 312, 313, 314, 315, 316, 317.

Blanco River - 51, 92, 108, 109, 182, 220, 227, 236, 295, 298, 308, 309, 314, 315, 316.

Comal River - 11, 51, 104, 106, 119.

Canyon Lake - 243, 262, 295, 315, 316, 317.

Table 2. (Continued)

Lake Dunlap - 119, 210, 224, 266, 269.

H-4 Lake - 119, 193, 223, 269.

Meadow Lake - 266, 269.

Lake McQueeney - 119, 210, 266, 269.

H-5 Lake - 119, 223, 269.

Table 3. Checklist of the fishes found in the major streams and lakes of the San Antonio River System. X indicates that the species was recorded from that locality. X* indicates that it is questionable if the species identification was correct or if the correct collection location was given.

Species	Stream or Lake			
	San Antonio River	Medina River	Cibolo Creek	Medina Lake
Lepisosteus spatula	X	X		
Lepisosteus oculatus	X	X	X	
Lepisosteus osseus	X	X	X	X
Dorosoma cepedianum	X	X	X	X
Astyanax mexicanus	X	X	X	X
Cyprinus carpio	X	X	X	X
Notemigonus crysoleucas	X	X	X	X
Opsopoeodus emiliae	X	X	X	
Hybopsis aestivalis	X	X	X	
Notropis amabilis		X		
Notropis chalybaeus		X*		
Notropis texanus	X	X		
Notropis amnis	X			
Notropis venustus	X	X		X
Notropis lutrensis	X	X	X	X
Notropis proserpinus	X*		X*	
Notropis stramineus	X	X		
Notropis volucellus	X	X		
Notropis buchanani	X	X		X
Dionda episcopa		X	X	
Pimephales vigilax	X	X	X	X
Pimephales promelas	X			X
Campostoma anomalum	X	X		X
Ictiobus bubalus	X	X	X	X
Carpiodes carpio	X	X	X	X
Moxostoma congestum	X	X	X	X
Erimyzon sucetta			X	
Ictalurus punctatus	X	X	X	X
Ictalurus furcatus	X			X
Ictalurus melas	X	X	X	X
Ictalurus natalis	X	X	X	X
Ictalurus nebulosus	X*			
Pylodictis olivaris	X	X	X	X
Noturus gyrinus	X			X
Noturus nocturnus	X*			
Lucania parva	X			
Zygonectes notatus	X	X	X	

Table 3. (Continued)

Species	Stream or Lake			
	San Antonio River	Medina River	Cibolo Creek	Medina Lake
Gambusia affinis	X	X	X	X
Poecilia latipinna	X	X	X	X
Poecilia formosa	X		X	
Menidia audens		X*		
Menidia beryllina	X			
Morone chrysops		X		X
Micropterus punctulatus		X		X
Micropterus treculi		X		
Micropterus salmoides	X	X	X	X
Chaenobryttus gulosus	X	X	X	X
Chaenobryttus cyanellus	X	X	X	X
Lepomis symmetricus				X*
Lepomis punctatus	X	X		X
Lepomis microlophus	X	X	X	X
Lepomis macrochirus	X	X	X	X
Lepomis auritus	X	X	X	X
Lepomis megalotis	X	X	X	X
Enneacanthus obesus			X*	
Pomoxis annularis	X	X	X	X
Pomoxis nigromaculatus		X		
Hadropterus shumardi	X		X	
Percina caprodes	X	X	X	X
Etheostoma chlorosomum	X			
Etheostoma gracile	X			
Etheostoma spectabile		X		
Etheostoma lepidum		X		
Aplodinotus grunniens	X			
Cichlasoma cyanoguttatum	X	X	X	X
Tilapia mossambica	X			
Mugil cephalus	X			
Mugil curema	X			

Sources of data:

San Antonio River - 51, 88, 119, 219, 228, 237, 246, 263, 296, 299.

Table 3. (Continued)

Medina River - 51, 83, 170, 227, 236, 240, 265, 295, 296.

Cibolo Creek - 51, 247, 278, 296, 299.

Medina Lake - 168, 169, 177, 178, 187, 190, 194, 201, 223, 232, 233, 240, 248, 265, 296.

Table 4. Checklist of the fishes in the major streams and lakes of the Nueces River System. X indicates that the species was recorded from that locality. X* indicates that it is questionable if the species identification was correct or if the correct collection location was given.

Species	Stream or Lake							
	Nueces River	West Nueces River	Frio River	Dry Frio River	Sabinal River	Leona River	Atascosa River	Lake Corpus Christi
Lepisosteus spatula	X		X					X
Lepisosteus platostomus	X*							
Lepisosteus oculatus	X	X	X		X		X	X
Lepisosteus osseus	X		X		X		X	X
Elops saurus	X							
Brevoortia gunteri	X							
Brevoortia patronus	X							
Dorosoma petenense	X							X
Dorosoma cepedianum	X	X	X		X	X	X	X
Anchoa mitchilli	X							
Anchoa hepsetus	X*							
Astyanax mexicanus	X	X	X	X	X	X	X	X
Cyprinus carpio	X					X	X	X
Notemigonus crysoleucas	X		X			X	X	X
Opsopoedus emiliae	X		X				X	X
Notropis amabilis	X	X	X	X	X	X		
Notropis texanus	X				X			X
Notropis simus	X*							
Notropis venustus	X	X	X	X	X	X		X
Notropis lutrensis	X	X	X	X	X	X	X	X
Notropis stramineus			X		X	X		
Notropis atrocaudalis								X*
Notropis buchanani	X	X				X		
Dionda episcopa	X	X	X	X	X			
Pimephales vigilax	X		X			X	X	X
Pimephales promelas	X		X				X	X
Campostoma anomalum	X		X	X	X			
Ictiobus bubalus	X	X	X		X	X	X	X
Carpiodes carpio	X					X		
Moxostoma congestum	X	X	X		X			
Ictalurus punctatus	X	X	X		X	X	X	X

Table 4. (Continued)

Species	Stream or Lake							
	Nueces River	West Nueces River	Frio River	Dry Frio River	Sabinal River	Leona River	Atascosa River	Lake Corpus Christi
Ictalurus furcatus	X							X
Ictalurus melas	X		X			X	X	X
Ictalurus natalis	X	X	X	X	X	X	X	X
Ictalurus nebulosus	X*							
Pylodictis olivaris	X		X				X	X
Noturus gyrinus	X						X	X
Anguilla rostrata								X
Strongylura marina	X							
Fundulas grandis	X							
Cyprinodon variegatus	X							X
Gambusia gaigei				X*				
Gambusia affinis	X	X	X	X	X	X	X	X
Poecilia latipinna	X						X	X
Poecilia formosa	X							X
Menidia beryllina	X							X
Morone chrysops	X							X
Micropterus treculi		X						
Micropterus salmoides	X	X	X	X	X	X	X	X
Chaenobryttus gulosus	X	X	X		X	X	X	X
Chaenobryttus cyanellus	X	X	X		X	X	X	X
Lepomis punctatus	X		X					
Lepomis microlophus	X	X	X	X	X	X		X
Lepomis macrochirus	X	X	X	X	X	X	X	X
Lepomis auritus	X	X	X		X	X	X	X
Lepomis megalotis	X	X	X	X	X	X	X	X
Ambloplites rupestris					X			
Pomoxis annularis	X		X				X	X
Pomoxis nigromaculatus	X		X					X
Etheostoma gracile	X		X					
Etheostoma fusiforme						X*		
Etheostoma spectabile	X*		X*					
Etheostoma lepidum	X	X	X	X		X		
Etheostoma grahami	X*							
Etheostoma fonticola	X*							
Etheostoma microperca	X*							
Oligoplites saurus	X							

Table 4. (Continued)

Species	Stream or Lake							
	Nueces River	West Nueces River	Frio River	Dry Frio River	Sabinal River	Leona River	Atascosa River	Lake Corpus Christi
Eucinostomus argenteus	X							
Eucinostomus lefroyi	X							
Gerres cinereus	X							
Pomadasys crocro	X							
Aplodinotus grunniens	X		X				X	X
Bairdiella chrysura	X							
Scianenops ocellata	X							
Leiostomus xanthurus	X							
Micropogon undulatus	X							
Pogonias cromis	X							
Cynoscion nebulosus	X							
Lagodon rhomboides	X							
Archosargus probatocephalus	X							
Cichlasoma cyanoguttatum	X	X	X	X	X	X	X	X
Mugil cephalus	X							
Mugil curema	X							
Gobiomorus dormitator	X							
Gobiosoma bosci	X							
Paralichthys lethostigma	X							
Trinectes maculatus	X							
Achirus lineatus	X							

Sources of data:

Nueces River - 51, 83, 89, 159, 181, 183, 197, 217, 223, 240, 244, 245, 247, 256, 263, 268, 297, 299, 300, 310, 311.

West Nueces River - 183, 223, 240, 244, 297.

Table 4. (Continued)

Frio River - 51, 87, 106, 159, 181, 184, 185, 221, 223, 247, 263, 268, 297, 313.

Dry Frio River - 184, 185, 297.

Sabinal River - 51, 83, 186, 223, 297.

Leona River - 51, 232, 240, 297.

Atascosa River - 181, 247, 297.

Lake Corpus Christi - 165, 166, 174, 191, 207, 222, 229, 237, 246, 251, 254, 263, 264, 268, 297, 303.

Sources of information on which the distribution maps for each river system are based are as follows:

Guadalupe River System (Figs. 5 - 41) - 1, 2, 11, 26, 28, 43, 47, 81, 83, 97, 98, 99, 101, 103, 104, 106, 107, 108, 109, 119, 156, 158, 159, 182, 192, 193, 195, 199, 202, 203, 210, 213, 220, 223, 224, 227, 243, 253, 257, 260, 261, 262, 266, 267, 269, 270, 295, 298, 299, 301, 302, 304, 305, 306, 307, 308, 309, 312, 313, 314, 315, 316, 317;

San Antonio River System (Figs. 41 - 66) - 51, 83, 168, 169, 170, 171, 177, 178, 187, 190, 194, 201, 208, 221, 223, 227, 228, 232, 233, 236, 240, 247, 248, 265, 268, 278, 295, 296, 299;

Nueces River System (Figs. 66 - 93) - 51, 83, 84, 106, 159, 166, 174, 181, 183, 184, 185, 186, 191, 197, 202, 207, 217, 222, 223, 229, 232, 237, 240, 245, 246, 247, 254, 256, 263, 264, 268, 296, 297, 299, 303.

In several instances there are species names which occur on species checklists but not on species distribution maps. These are due to questionable identification or location records, or to the inclusion in checklists of species names taken from publications which give only general species distributional ranges that include all or some part of the drainage systems in the study area, but no precise locations. In addition, several fishes indicated in generalized distributional studies as having ranges that may extend into the study area are omitted

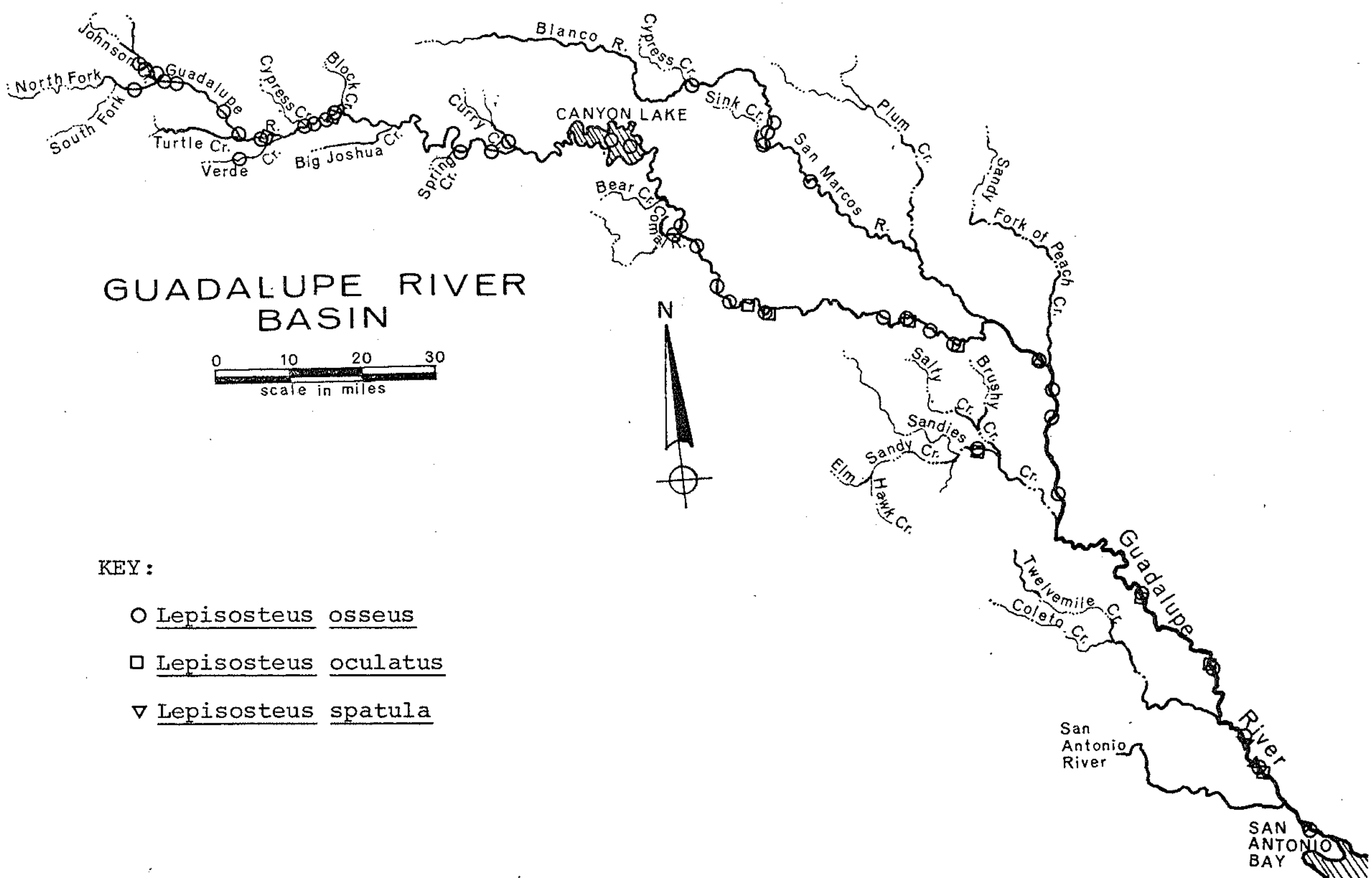

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
N
KEY:
○ Lepisosteus osseus
□ Lepisosteus oculatus
▽ Lepisosteus spatula
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Spring Cr.
Curry Cr.
CANYON LAKE
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Bear Cr.
Comal R.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 5

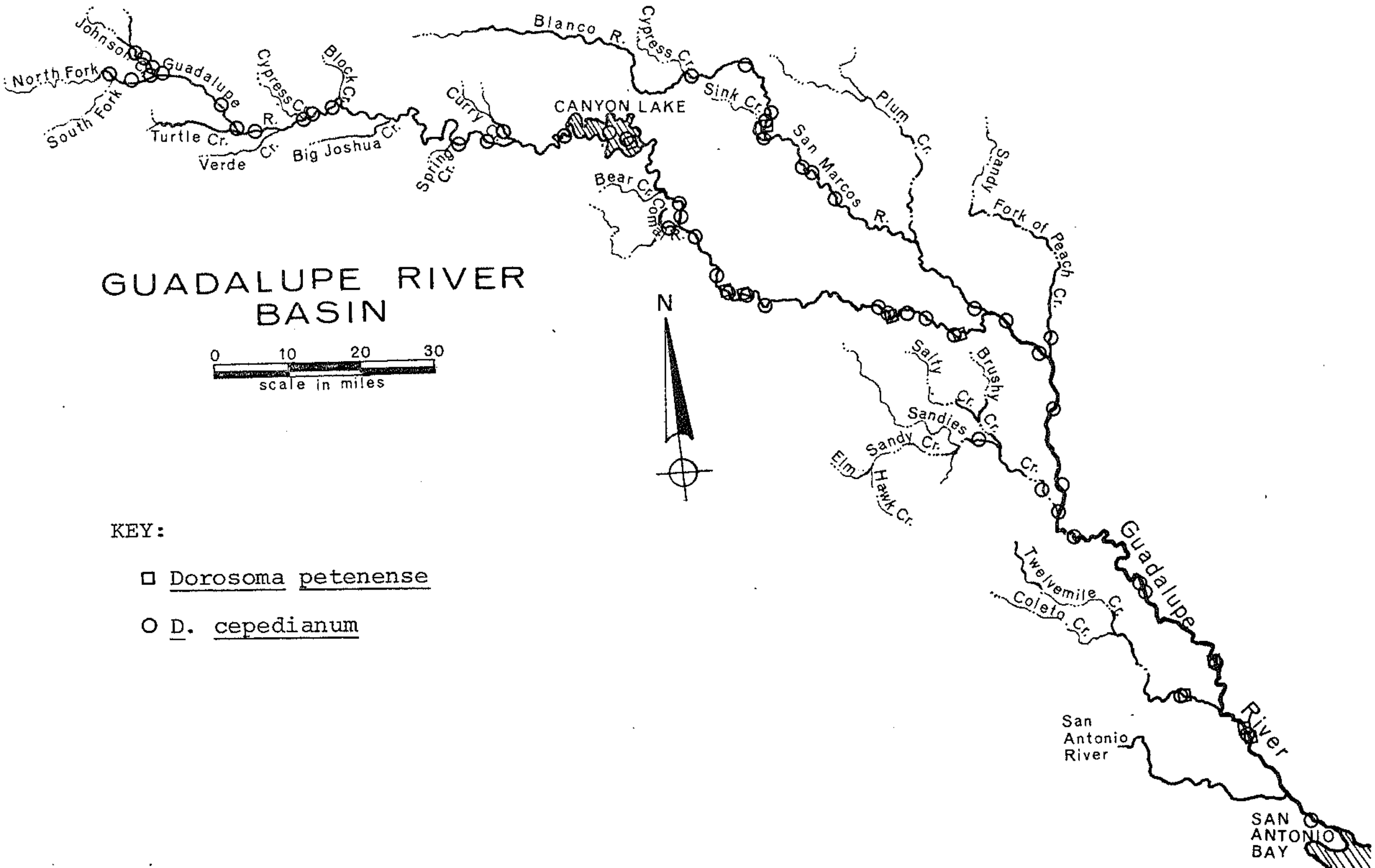

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
N
KEY:
□ Dorosoma petenense
○ D. cepedianum
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
CANYON LAKE
Blanco R.
Cypress Cr.
Sink Cr.
Bear Cr.
Comal R.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Cr.
Twelvemile Cr.
Coleto Cr.
Guadalupe River
San Antonio River
SAN ANTONIO BAY

FIGURE 6

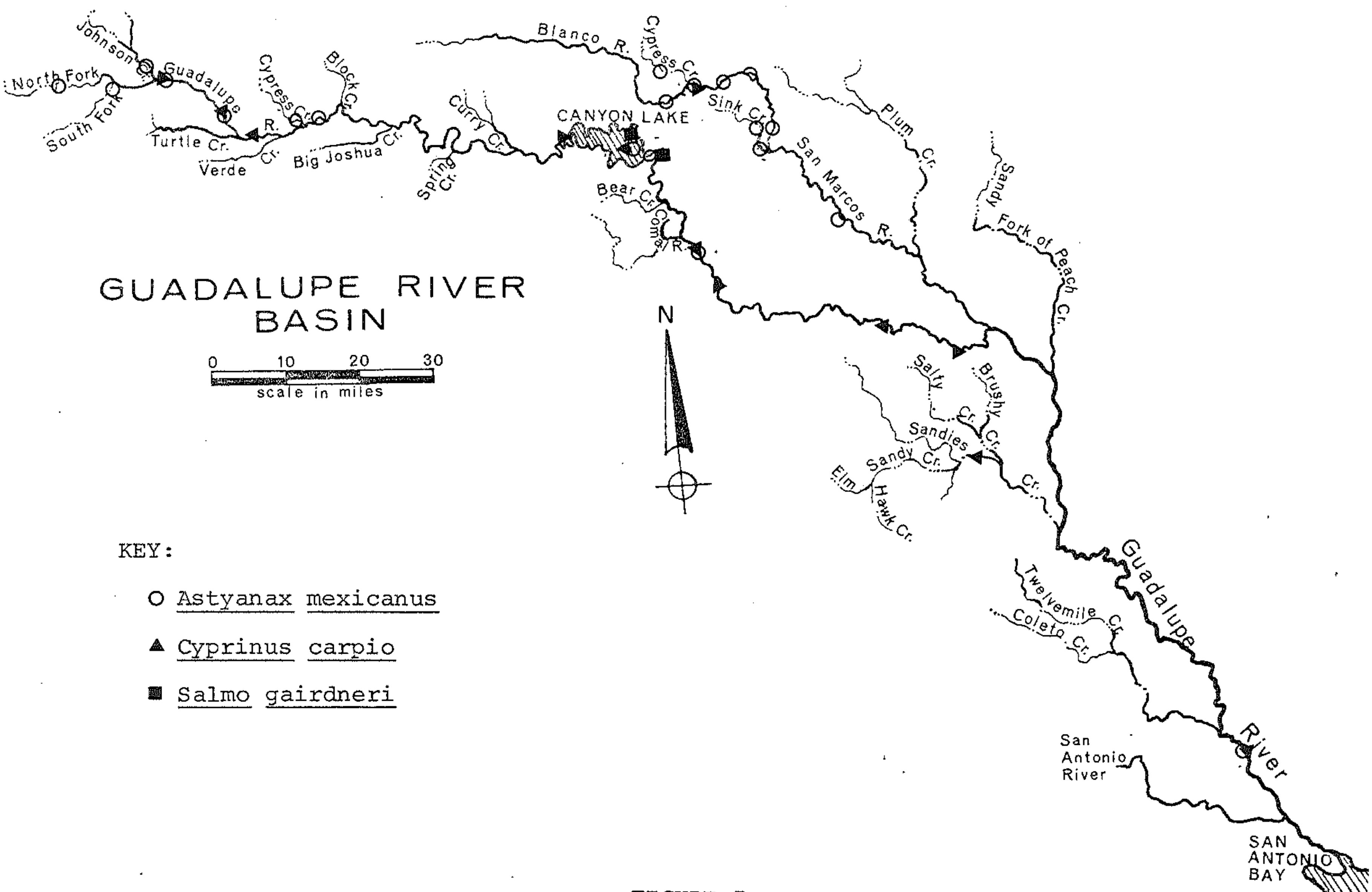

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
N
KEY:
Astyanax mexicanus
Cyprinus carpio
Salmo gairdneri
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Sink Cr.
Bear Cr.
Comal R.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 7

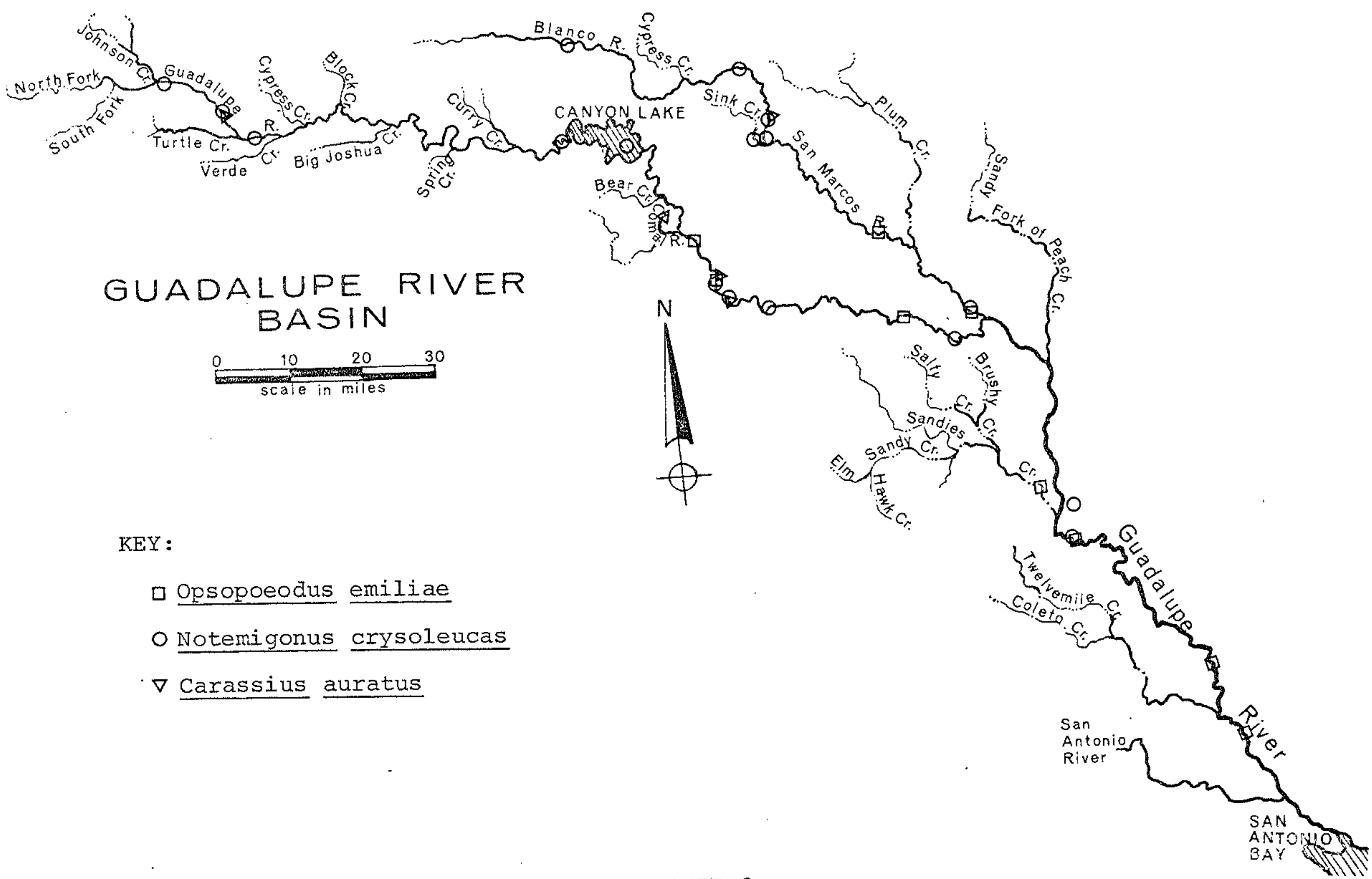

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
□ Opsopoeodus emiliae
○ Notemigonus crysoleucas
▽ Carassius auratus
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Spring Cr.
Curry Cr.
CANYON LAKE
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Bear Cr.
Comal R.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Twelvemile Cr.
Coleto Cr.
Guadalupe River
San Antonio River
SAN ANTONIO BAY
N

FIGURE 8

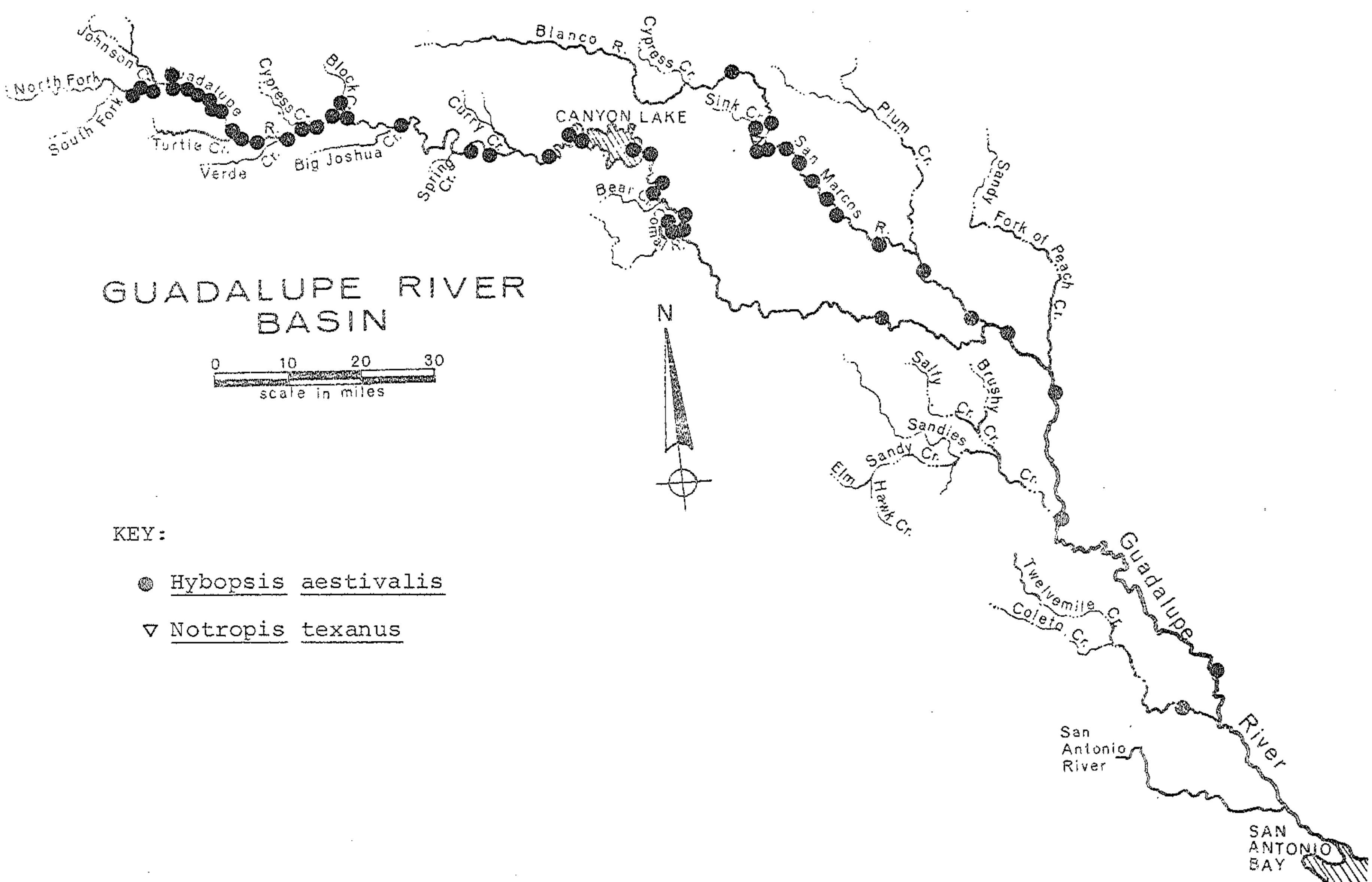

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Hybopsis aestivalis
Notropis texanus
N
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
CANYON LAKE
Bear Cr.
Comal R.
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 9

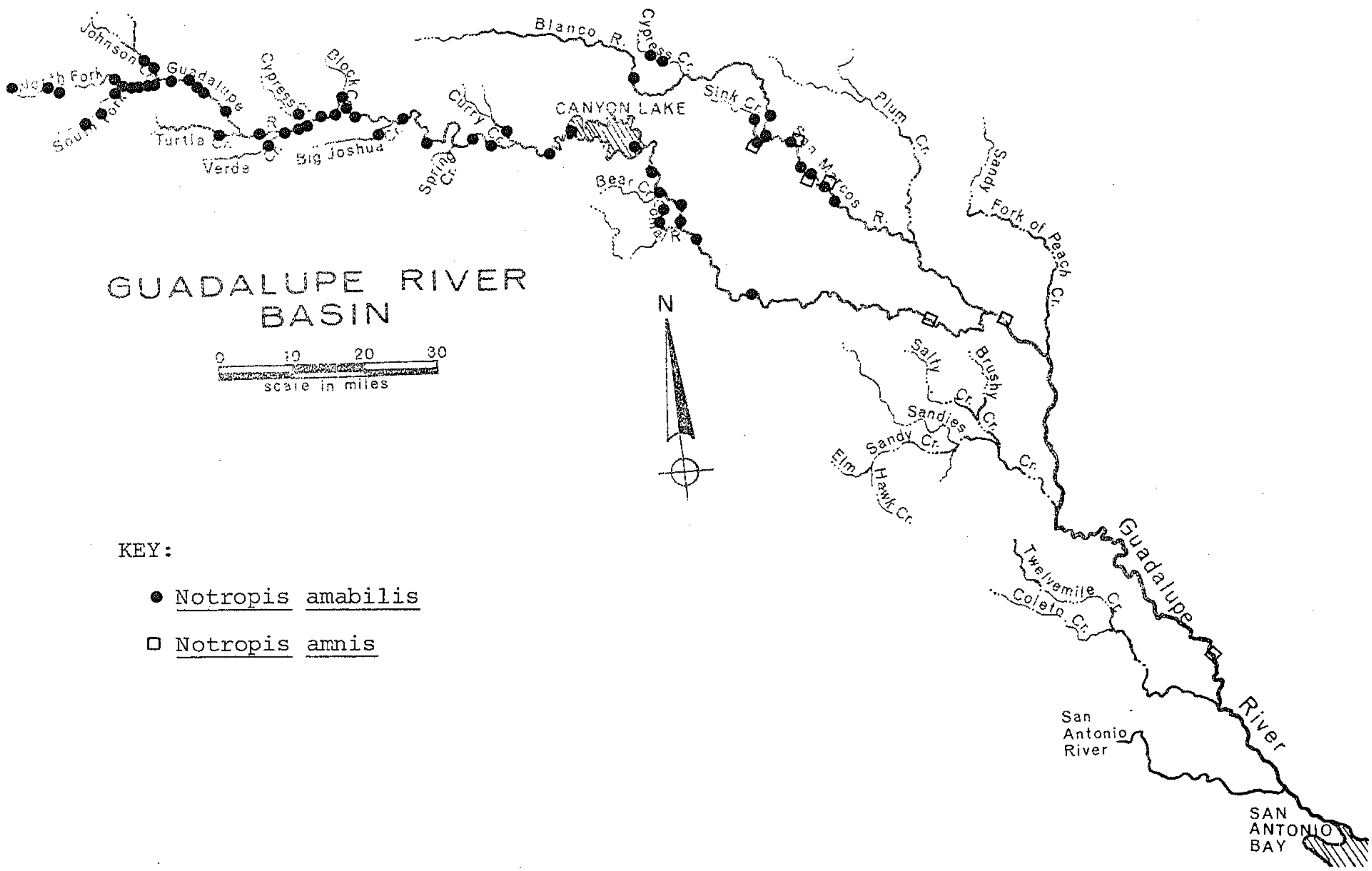

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
N
KEY:
● Notropis amabilis
□ Notropis amnis
Johnson Cr.
Guadalupe
South Fork
Turtle Cr.
Verde Cr.
Cypress
R.
Big Joshua Cr.
Block C.
Spring Cr.
Curry Cr.
CANYON LAKE
Blanco R.
Cypress Cr.
Sink Cr.
Bear Cr.
Plum Cr.
Sandy Fork of Peach Cr.
R.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Cr.
Guadalupe
Twelvemile Cr.
Coleto Cr.
San Antonio River
River
SAN ANTONIO BAY

FIGURE 10

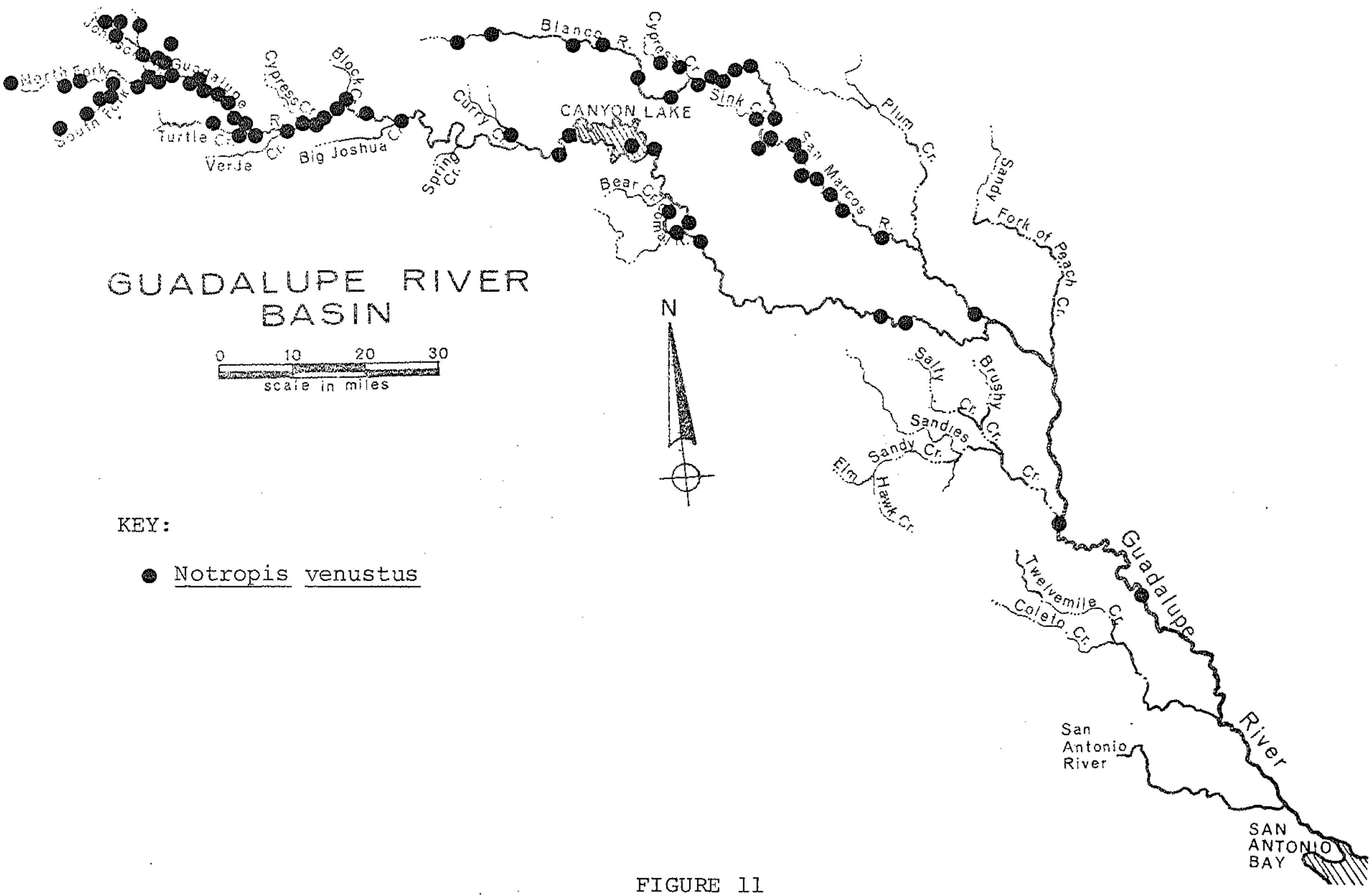

GUADALUPE RIVER
BASIN
0
10
20
30
scale in miles
N
KEY:
Notropis venustus
North Fork
South Fork
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
CANYON LAKE
Bear Cr.
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 11

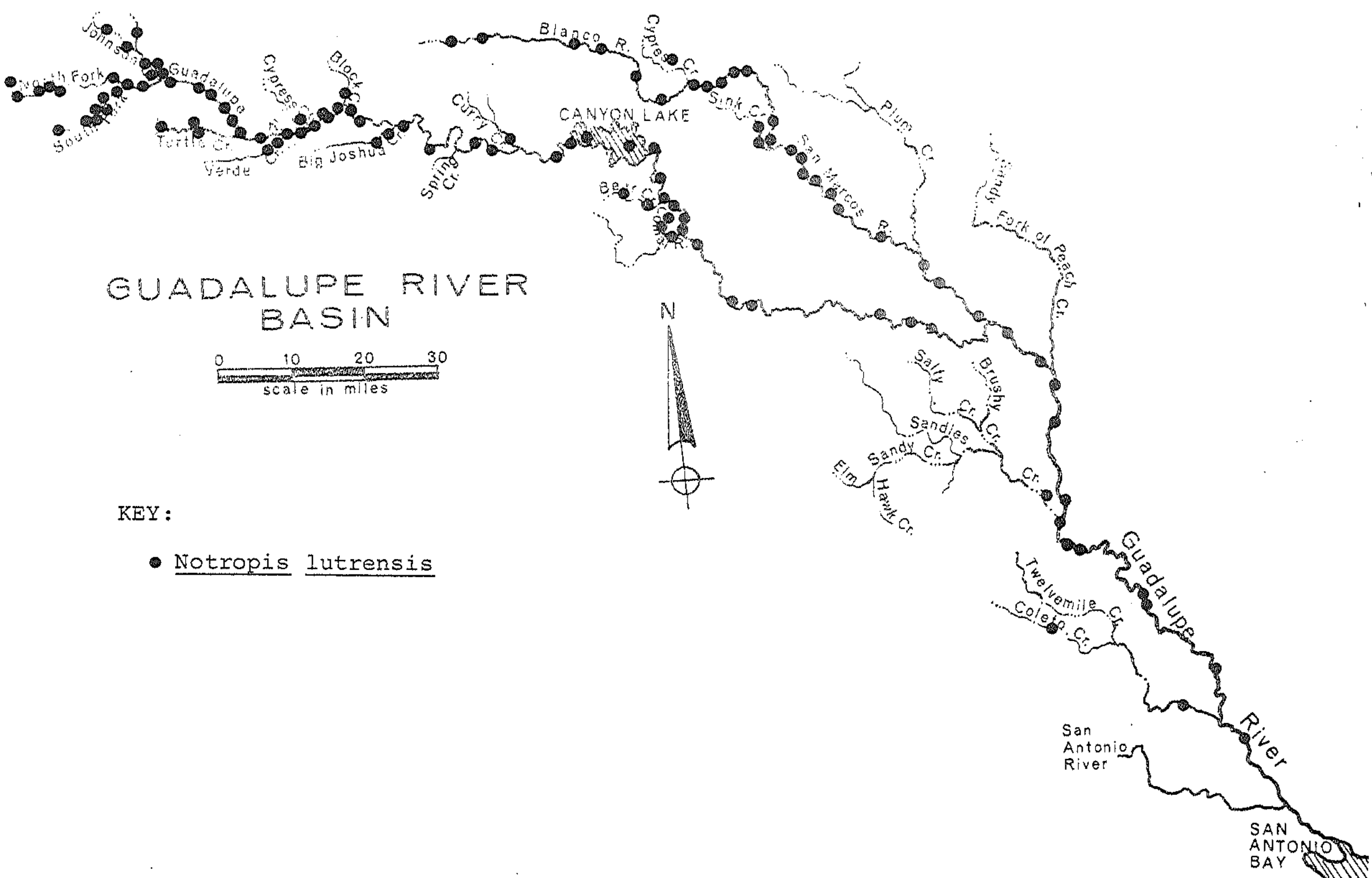

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
N
KEY:
● Notropis lutrensis
North Fork
South Fork
Johnson
Guadalupe
Turtle Cr.
Verde
Cypress
Block Cr.
Big Joshua Cr.
Spring Cr.
Curry Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Twelvemile Cr.
Coleto Cr.
Guadalupe River
San Antonio River
SAN ANTONIO BAY

FIGURE 12

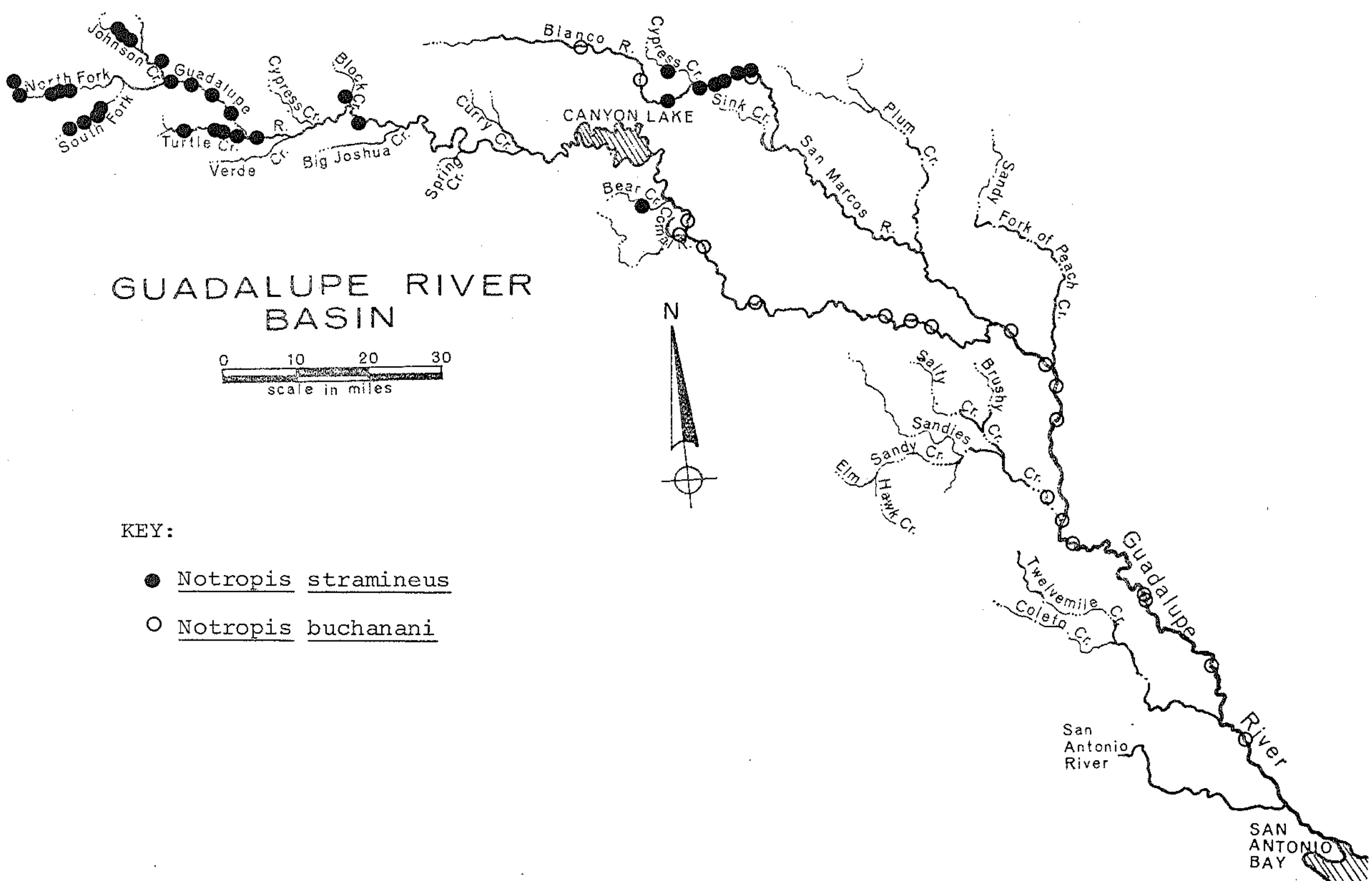

GUADALUPE RIVER
BASIN
0 10 20 30
scale in miles
N
KEY:
Notropis stramineus
Notropis buchanani
North Fork
South Fork
Johnson Cr.
Guadalupe
Turtle Cr.
Verde Cr.
Cypress Cr.
R.
Block Cr.
Big Joshua Cr.
Spring Cr.
Curry Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Sink Cr.
Bear Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 13

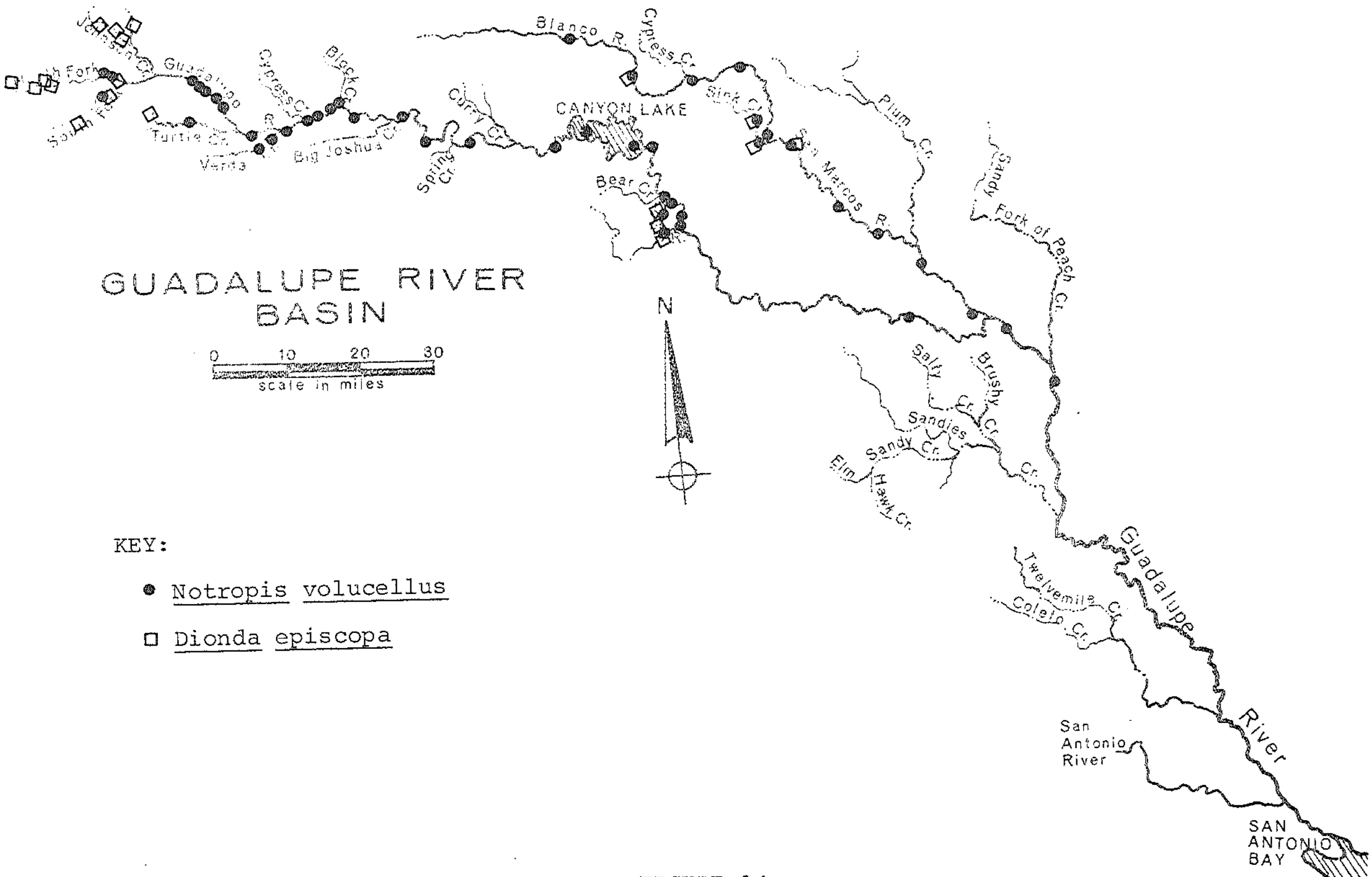

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Notropis volucellus
Dionda episcopa
Blanco R.
Cypress Cr.
CANYON LAKE
Sink Cr.
Plum Cr.
Sandy Fork of Peach Cr.
San Marcos R.
Bear Cr.
Curry Cr.
Spring Cr.
Block Cr.
Cypress Cr.
Big Joshua Cr.
Verde
Turtle Cr.
Guadalupe
South Fork
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Twelvemile Cr.
Coleto Cr.
Guadalupe River
San Antonio River
SAN ANTONIO BAY
N

FIGURE 14

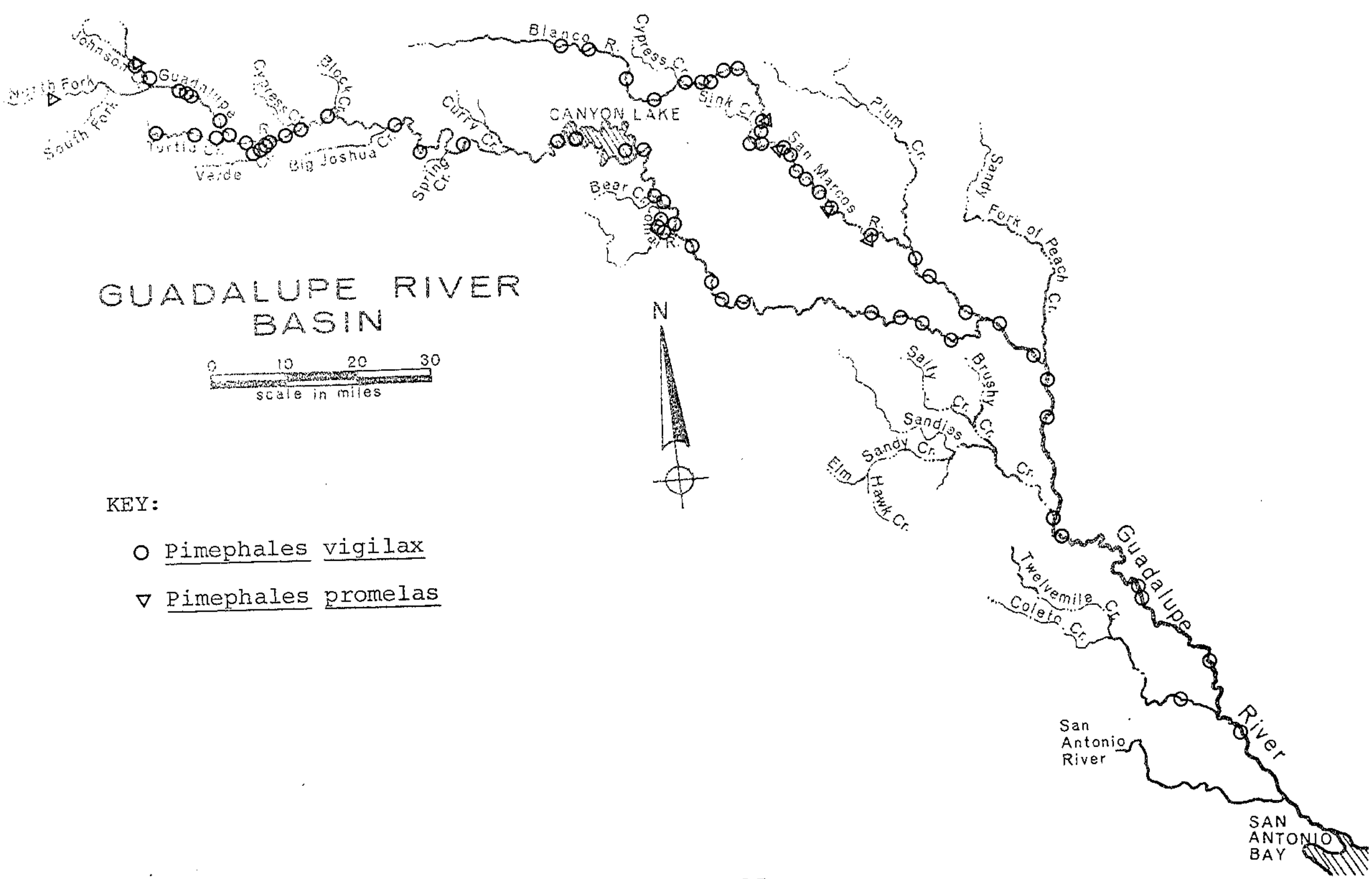
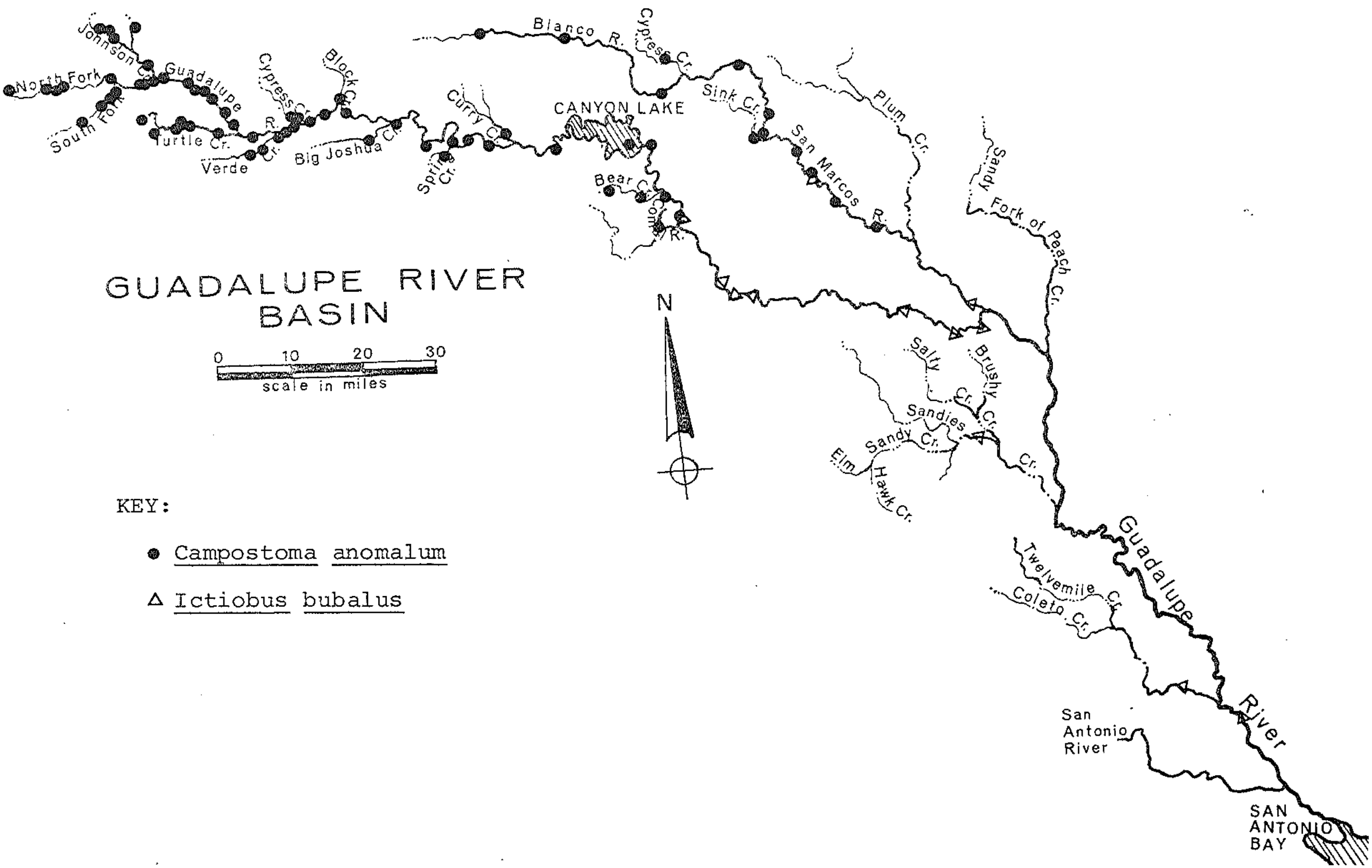

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
○ Pimephales vigilax
▽ Pimephales promelas
N
Johnson Cr.
North Fork
South Fork
Guadalupe
Turtle Cr.
Verde
Cypress Cr.
Block Cr.
Big Joshua Cr.
Spring Cr.
Curry Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Sink Cr.
Bear Cr.
Comal R.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 15



GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
N
KEY:
Campostoma anomalum
Ictiobus bubalus
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
CANYON LAKE
Bear Cr.
Comal R.
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 16

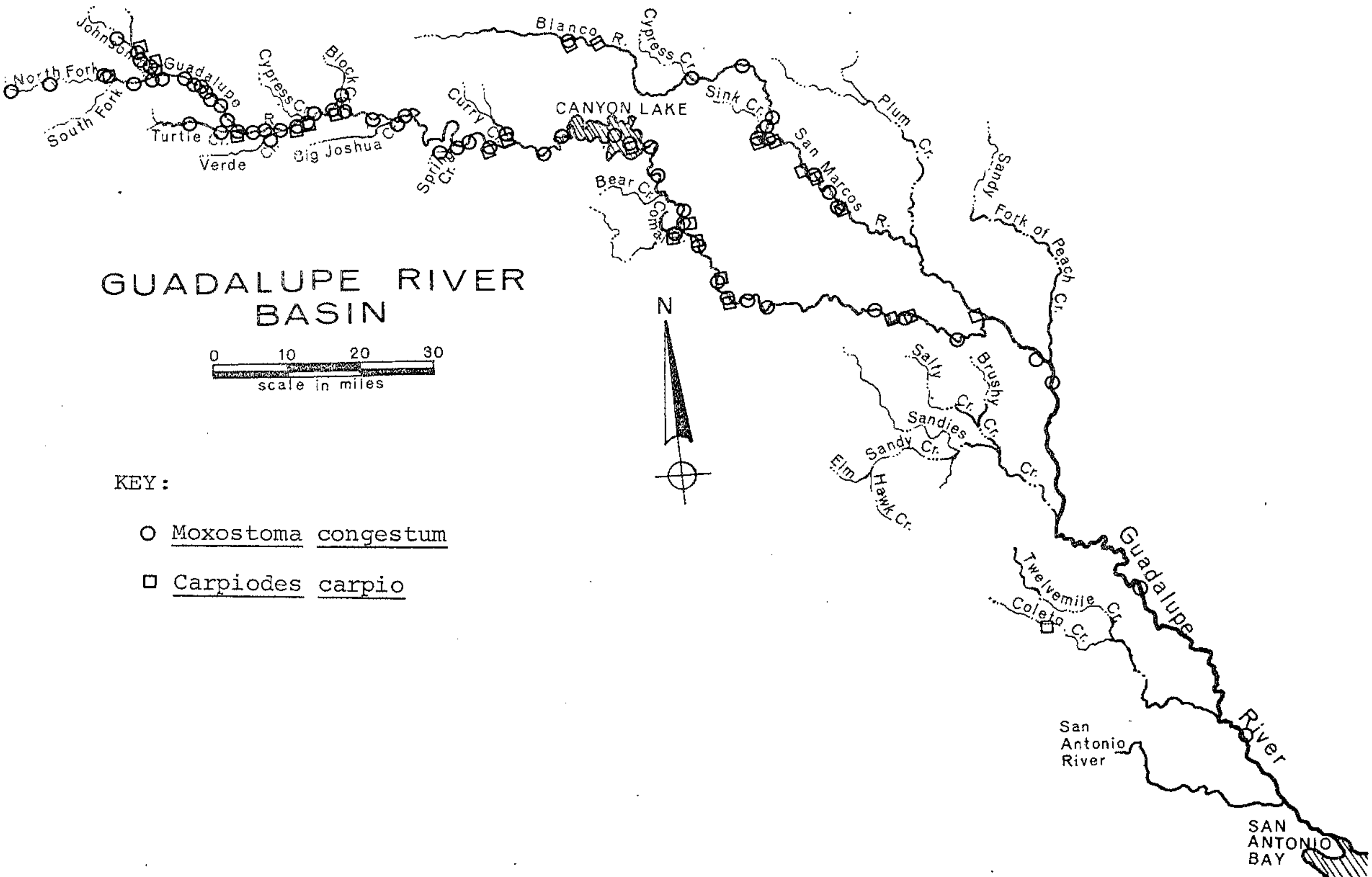

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Moxostoma congestum
Carpiodes carpio
North Fork
South Fork
Johnson Cr.
Guadalupe
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
CANYON LAKE
Bear Cr.
Comal
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY
N

FIGURE 17

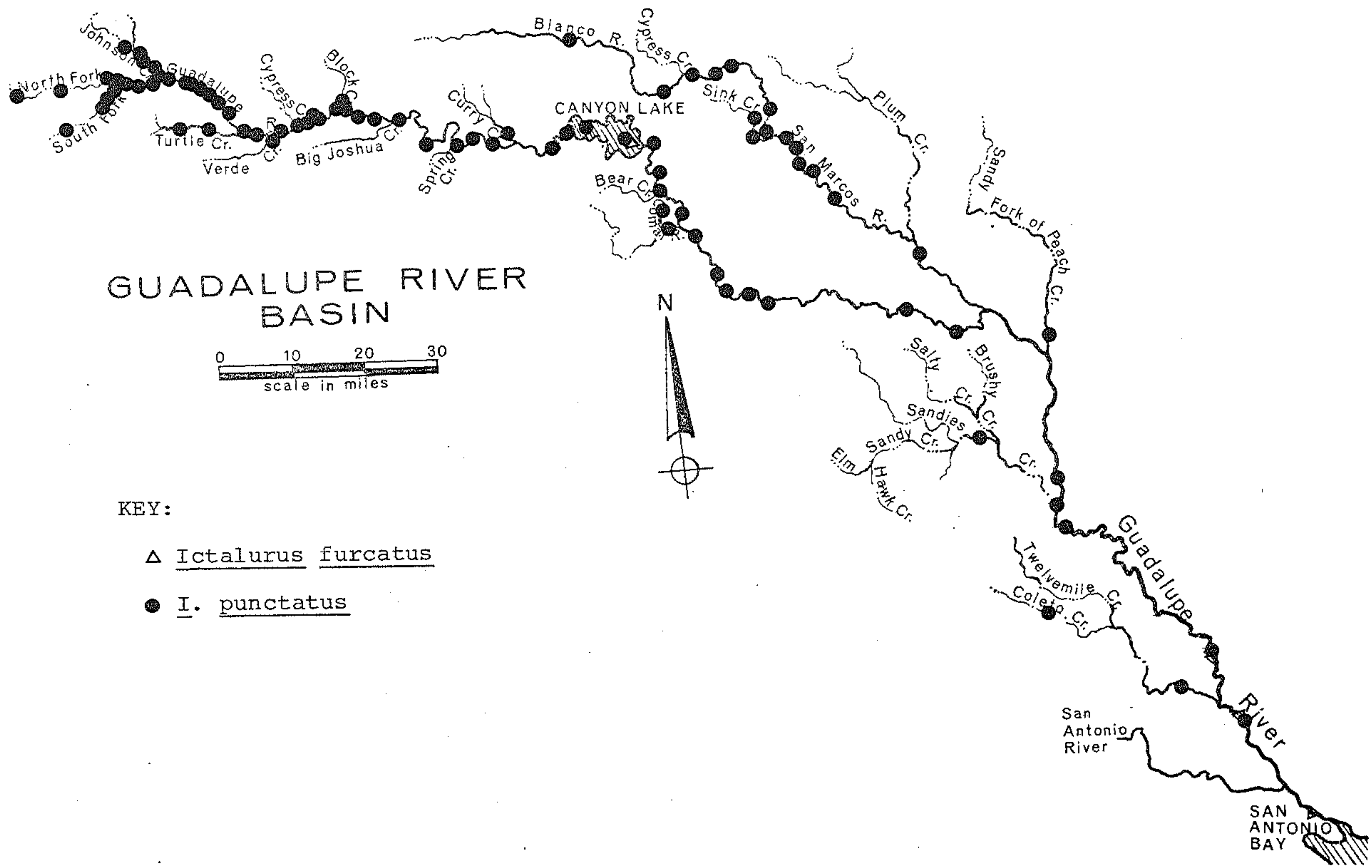
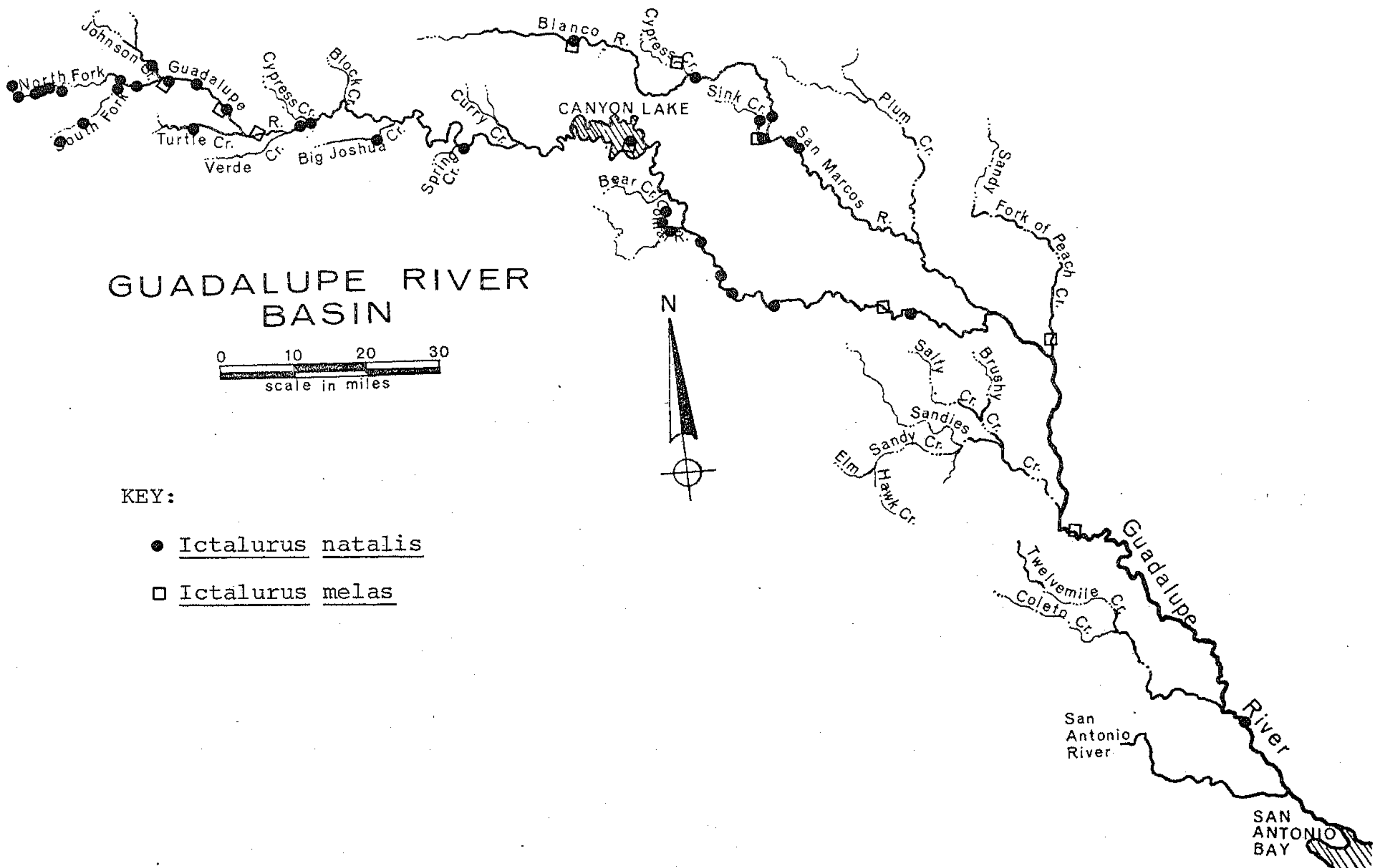

GUADALUPE RIVER
BASIN
0 10 20 30
scale in miles
KEY:
△ Ictalurus furcatus
● I. punctatus
North Fork
South Fork
Johnson Cr.
Guadalupe
Turtle Cr.
Verde Cr.
Cypress Cr.
Big Joshua Cr.
Block Cr.
Spring Cr.
Curry Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Bear Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY
N

FIGURE 18



KEY:

● Ictalurus natalis

□ Ictalurus melas

FIGURE 19

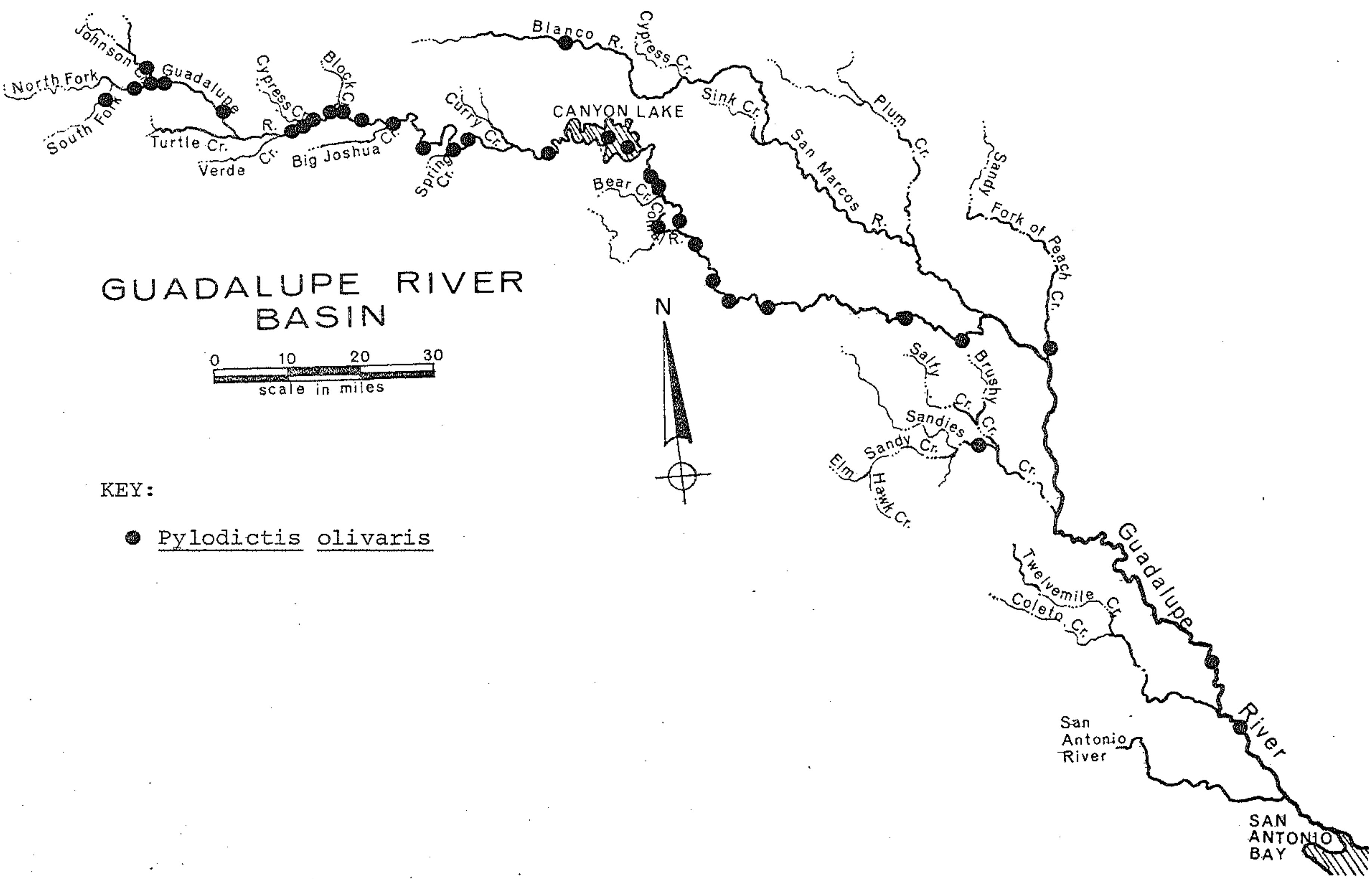

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Pylodictis olivaris
N
North Fork
South Fork
Johnson Cr.
Guadalupe
Turtle Cr.
Verde Cr.
R.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
Blanco R.
Cypress Cr.
Sink Cr.
CANYON LAKE
Bear Cr.
Comal R.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 20

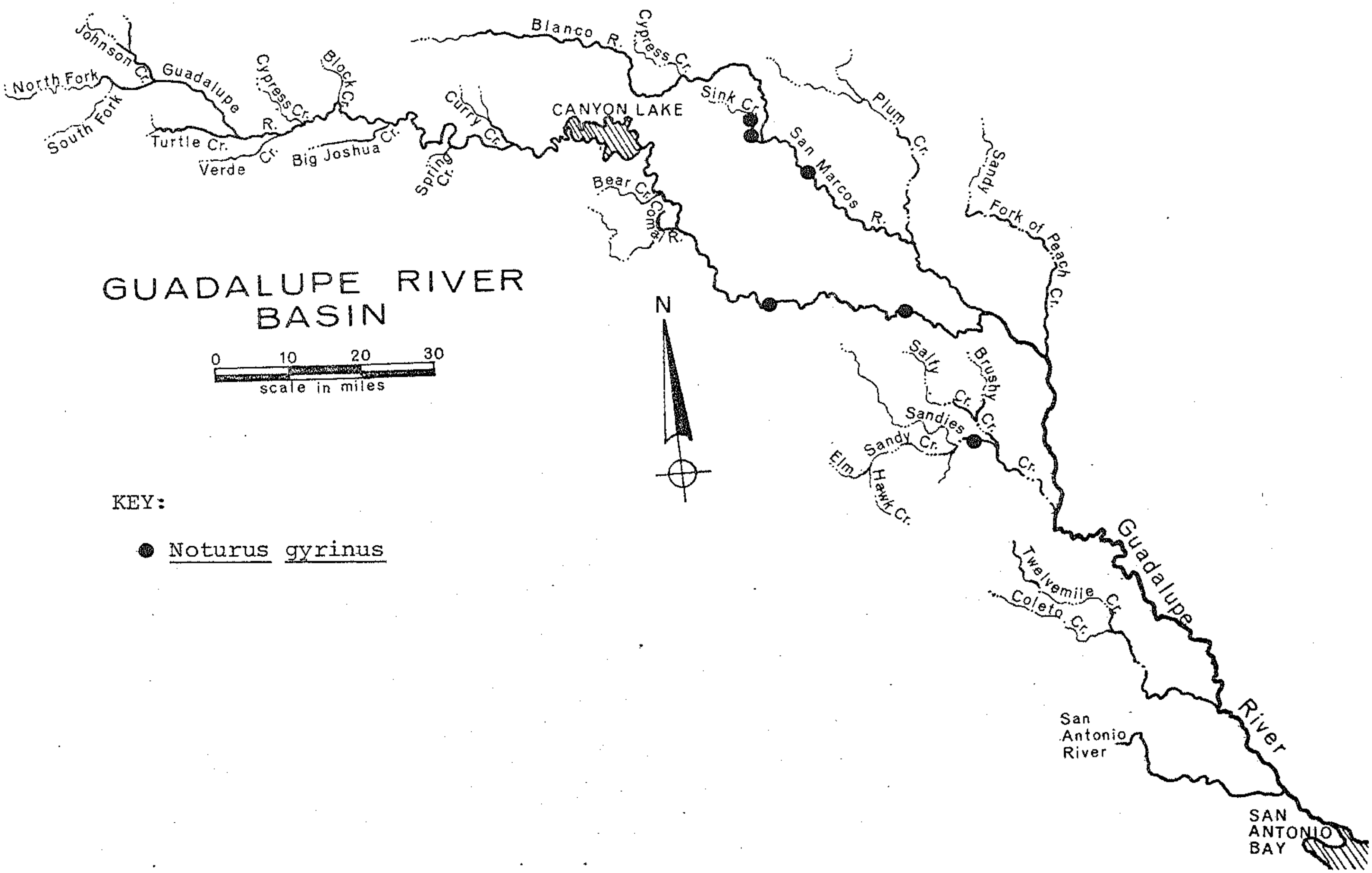

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Noturus gyrinus
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
CANYON LAKE
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Bear Cr.
Coma R.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY
N

FIGURE 21

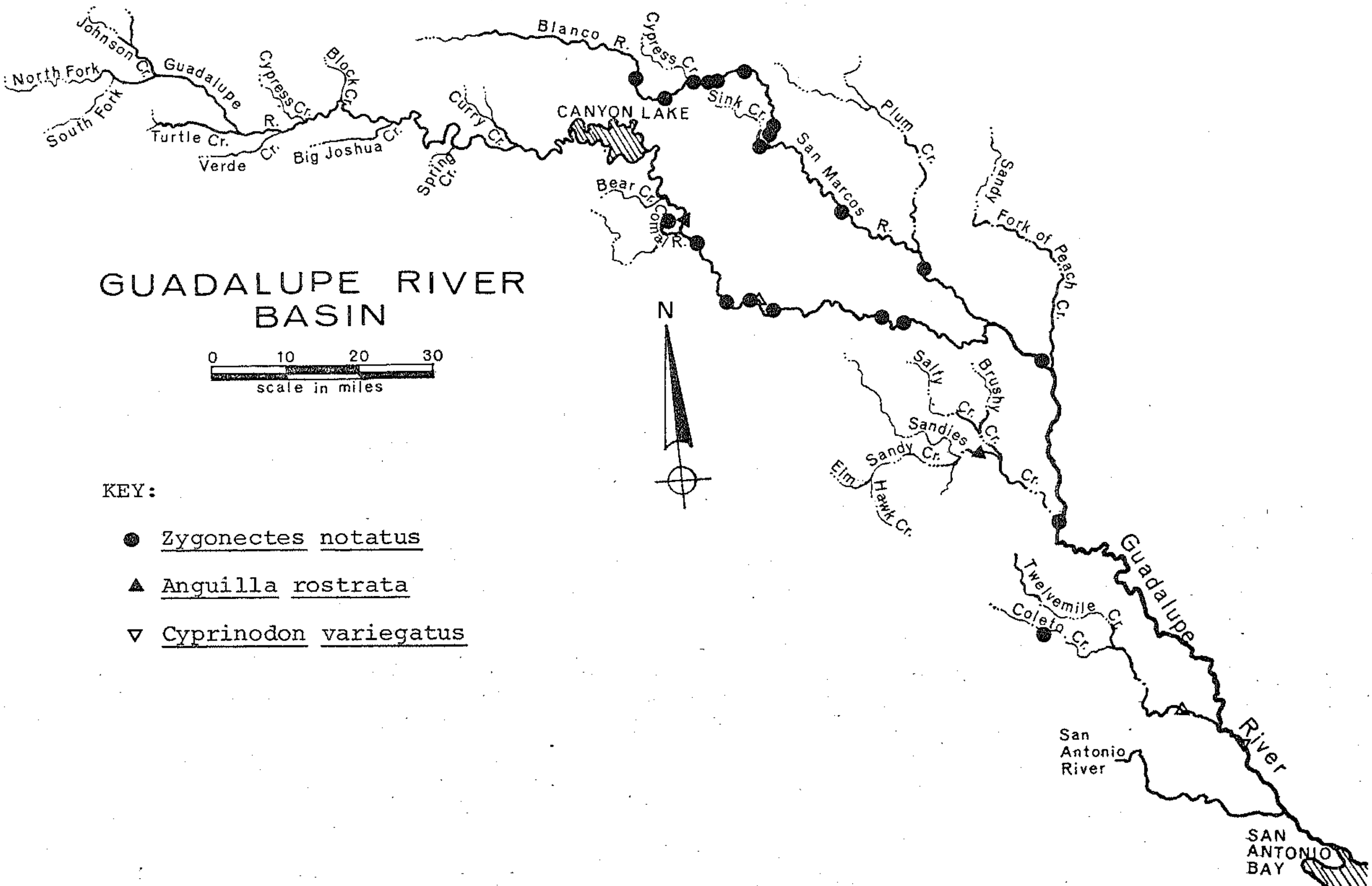

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Zygonectes notatus
Anguilla rostrata
Cyprinodon variegatus
N
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Spring Cr.
Curry Cr.
CANYON LAKE
Bear Cr.
Comal R.
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 22

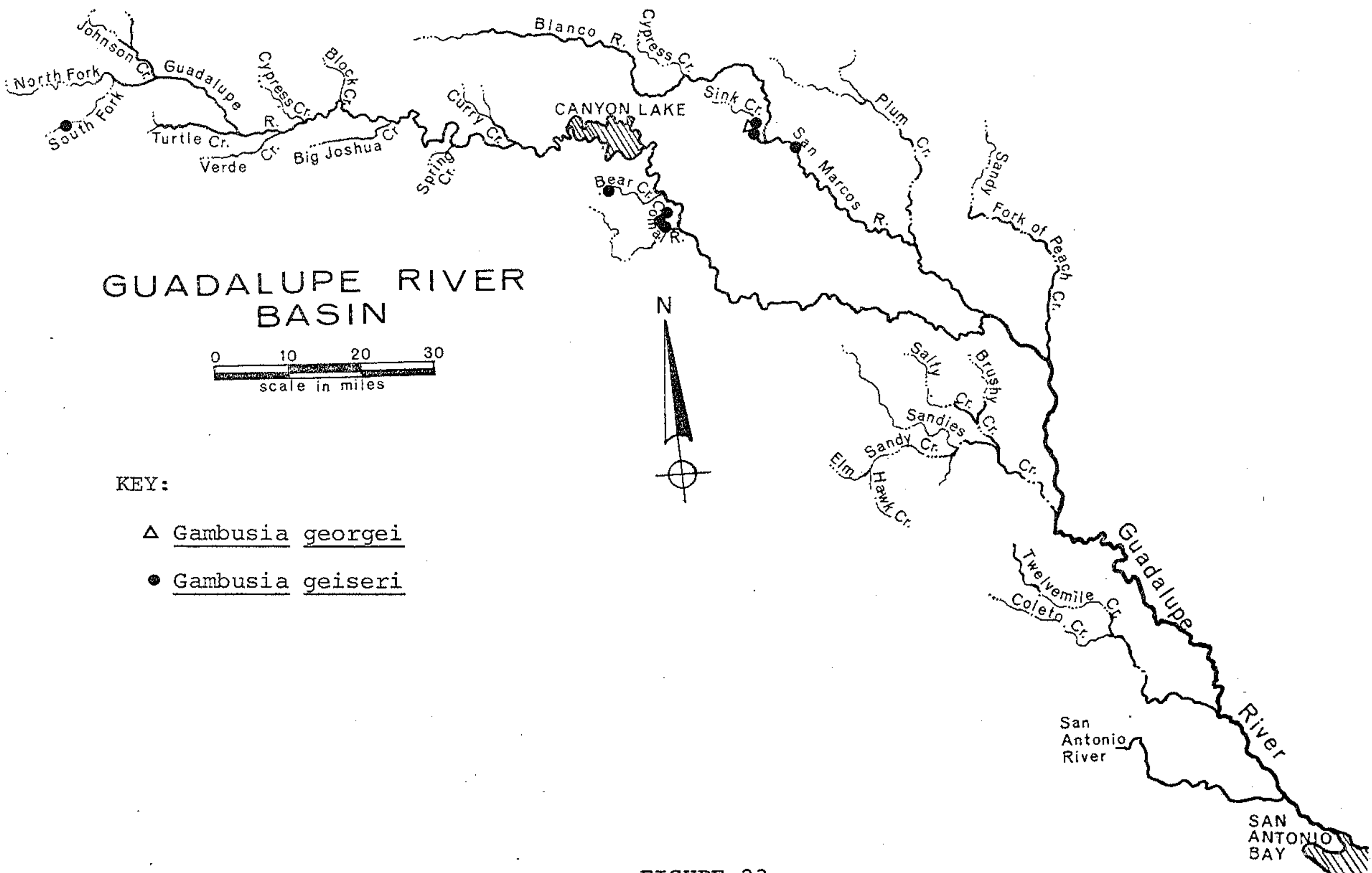

GUADALUPE RIVER
BASIN
0 10 20 30
scale in miles
N
KEY:
△ Gambusia georgei
● Gambusia geiseri
North Fork
South Fork
Johnson Cr.
Guadalupe
Turtle Cr.
Verde Cr.
Cypress Cr.
R.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Sink Cr.
San Marcos R.
Bear Cr.
Comal R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 23

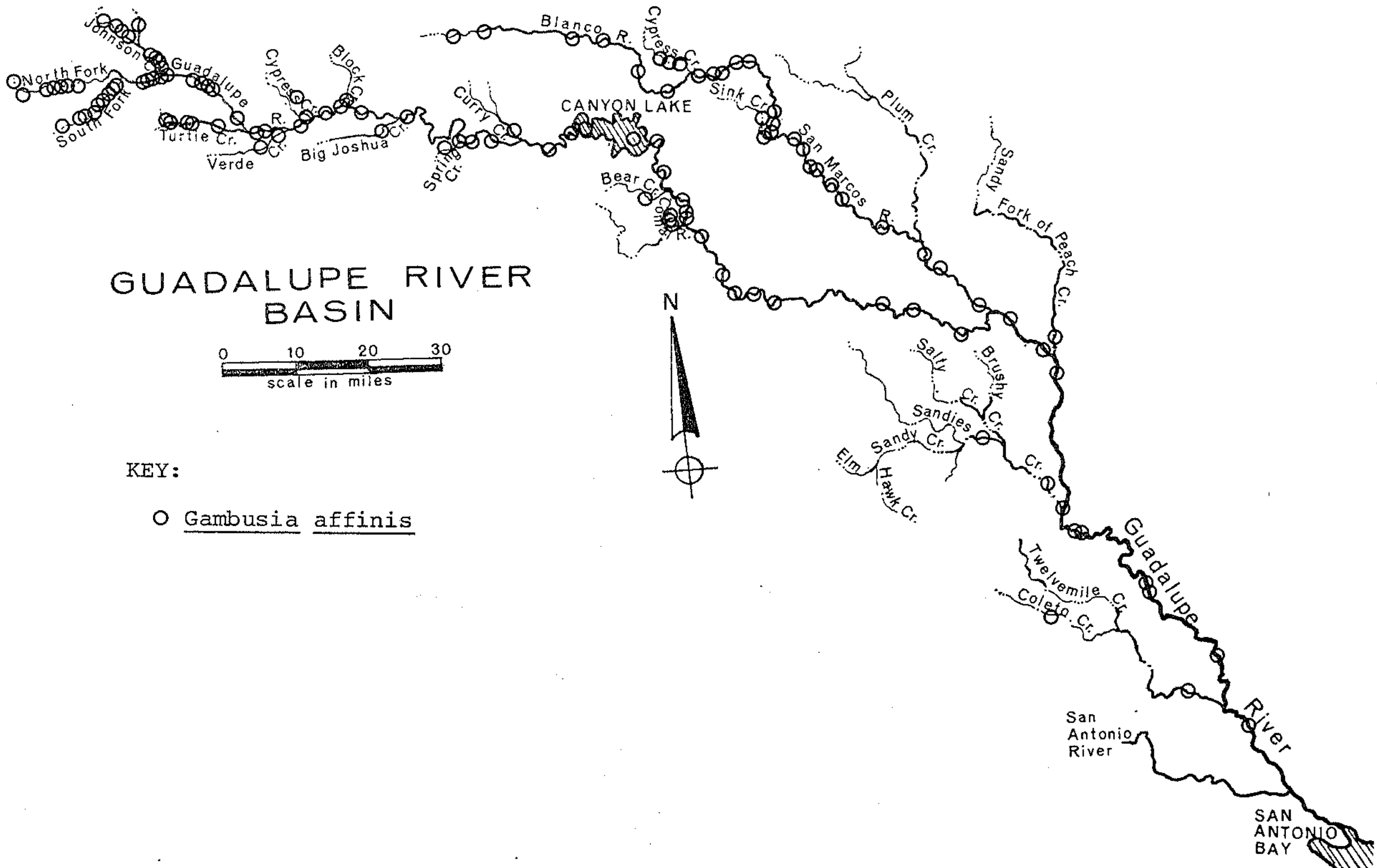

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
N
KEY:
O Gambusia affinis
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Spring Cr.
Curry Cr.
CANYON LAKE
Bear Cr.
Comal R.
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 24

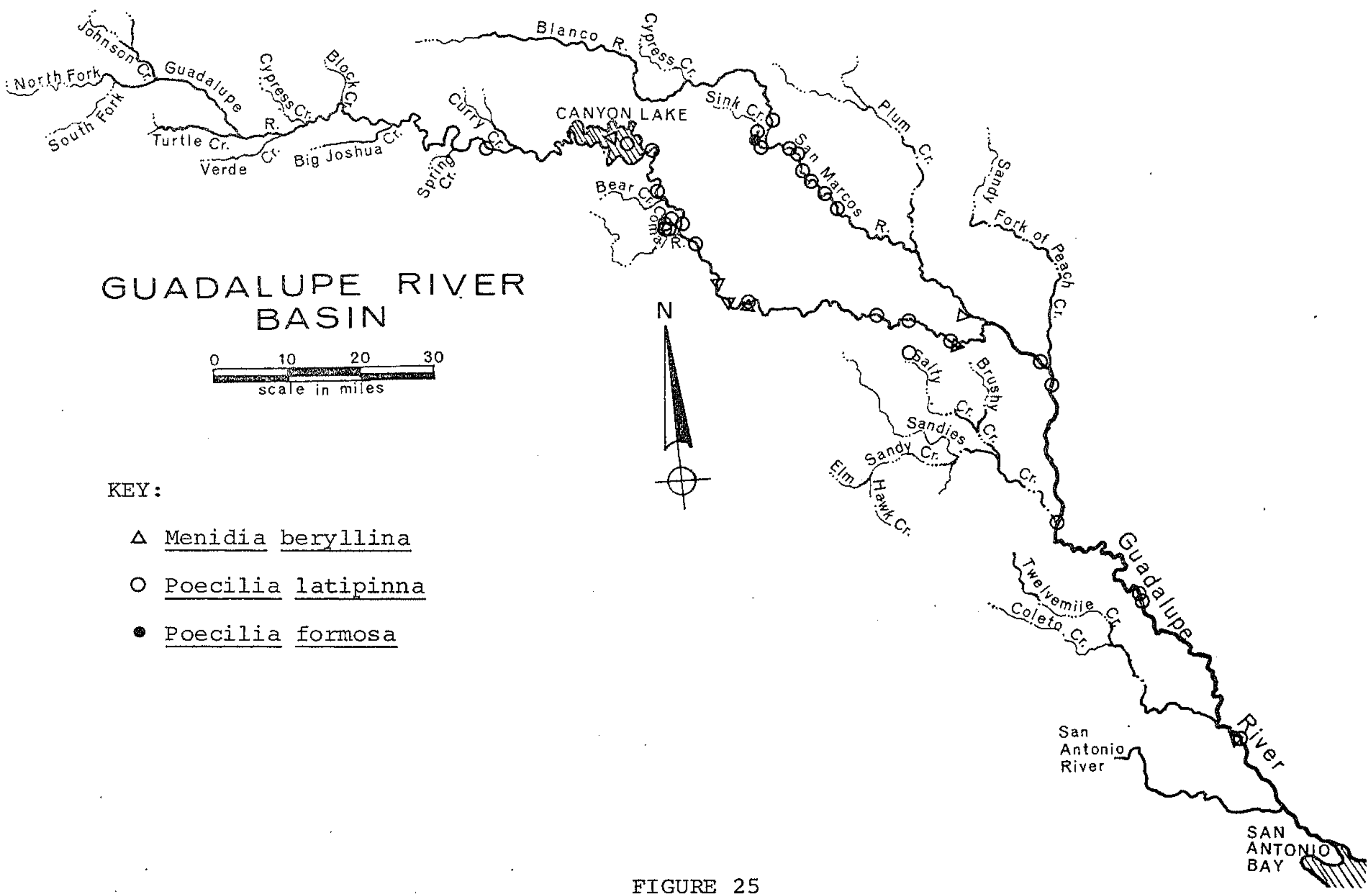

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Δ Menidia beryllina
O Poecilia latipinna
● Poecilia formosa
North Fork
South Fork
Johnson Cr.
Guadalupe
Turtle Cr.
Verde Cr.
Cypress Cr.
R.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Bear Cr.
Comal R.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
N
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Twelvemile Cr.
Coleto Cr.
Guadalupe River
San Antonio River
SAN ANTONIO BAY

FIGURE 25

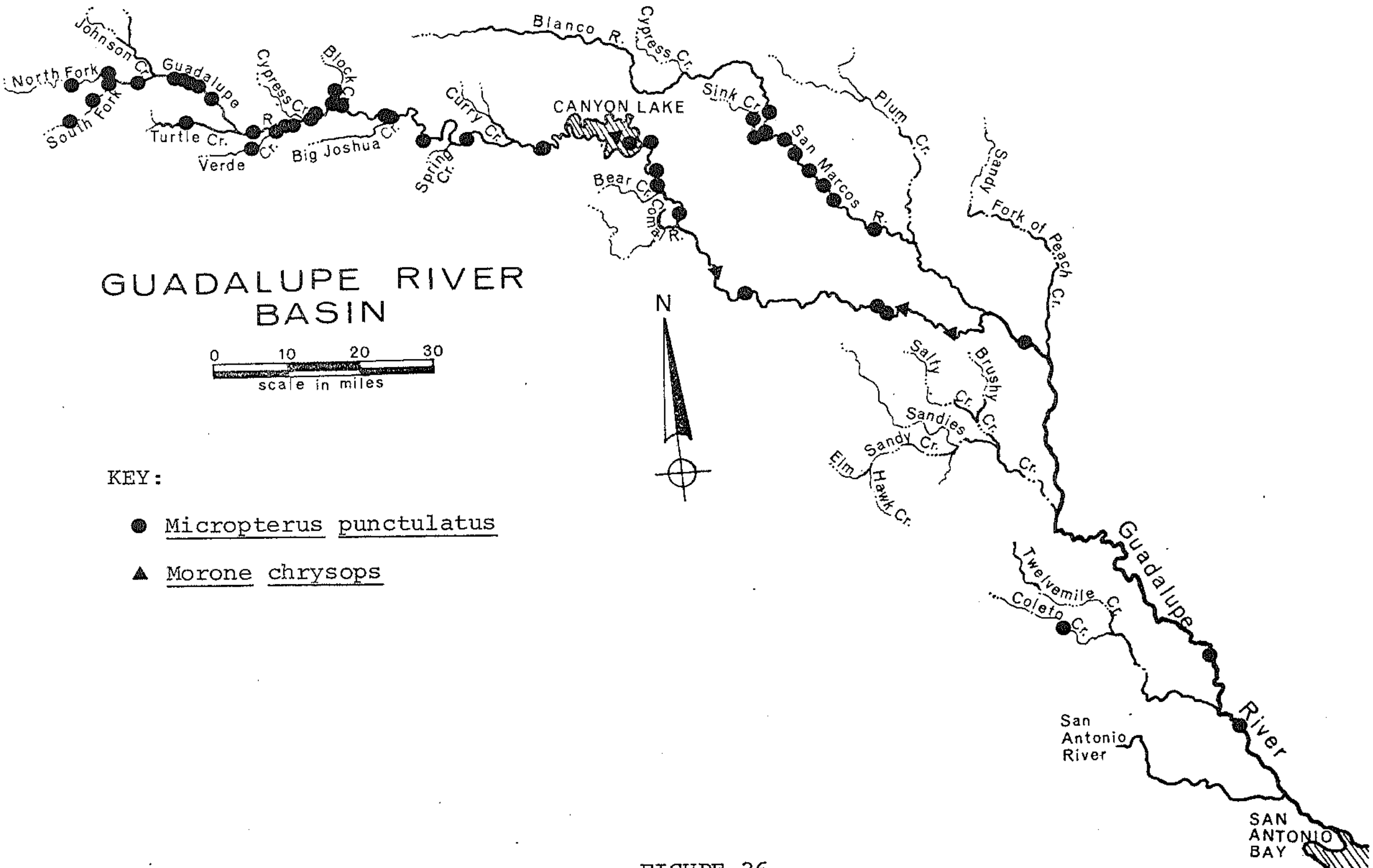

GUADALUPE RIVER
BASIN
0
10
20
30
scale in miles
KEY:
● Micropterus punctulatus
▲ Morone chrysops
North Fork
South Fork
Johnson Cr.
Guadalupe
R.
Turtle Cr.
Verde
Cr.
Cypress Cr.
Block C.
Big Joshua Cr.
Spring Cr.
Curry Cr.
CANYON LAKE
Bear Cr.
Comal R.
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos
R.
Plum
Cr.
Sandy
Fork of Peach
Cr.
Salty
Cr.
Brushy
Cr.
Sandies
Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe
River
Twelvemile
Cr.
Coleto
Cr.
San
Antonio
River
SAN
ANTONIO
BAY
N

FIGURE 26

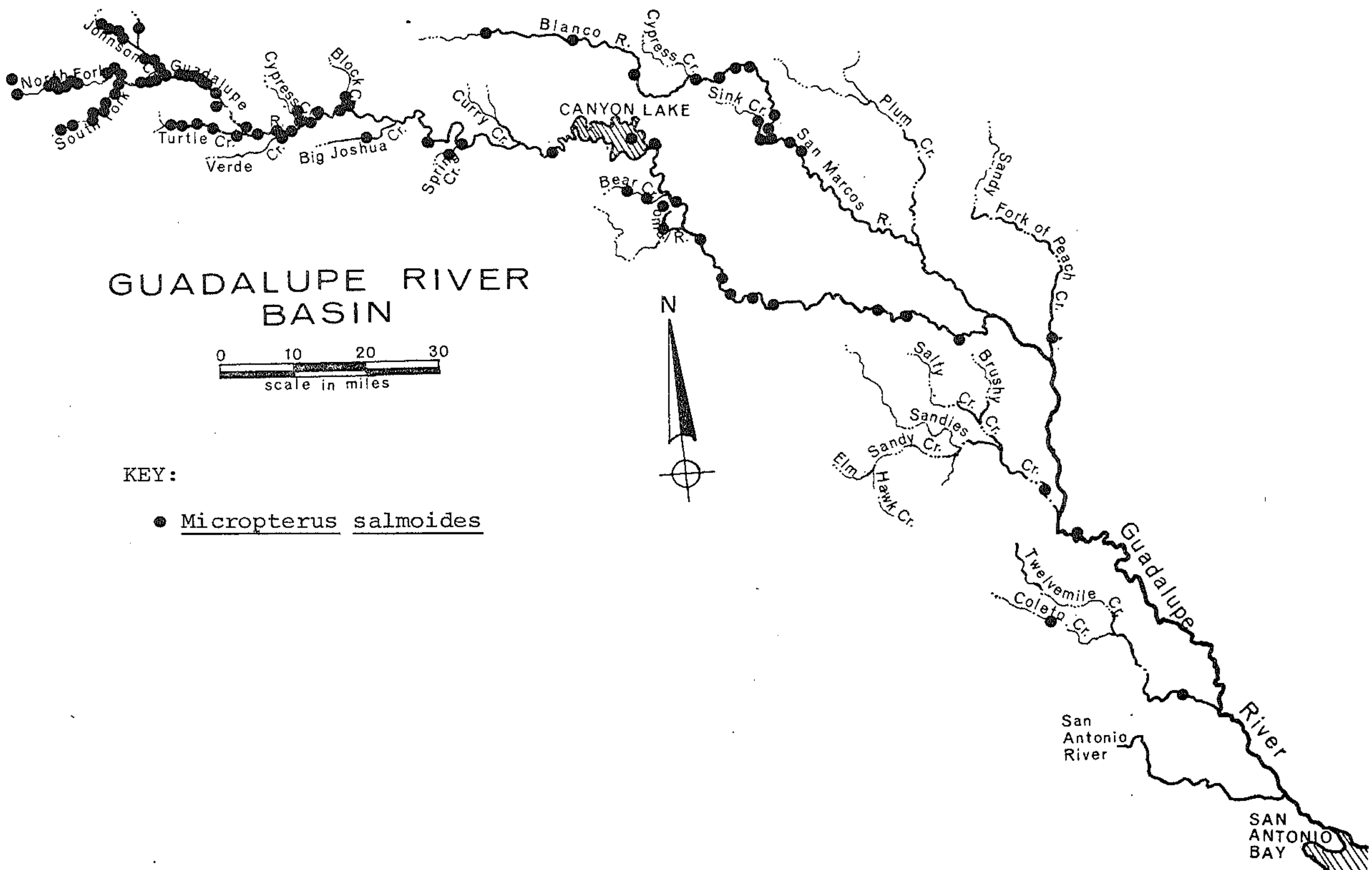

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Micropterus salmoides
N
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Spring Cr.
Curry Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Bear Cr.
Comal R.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 27

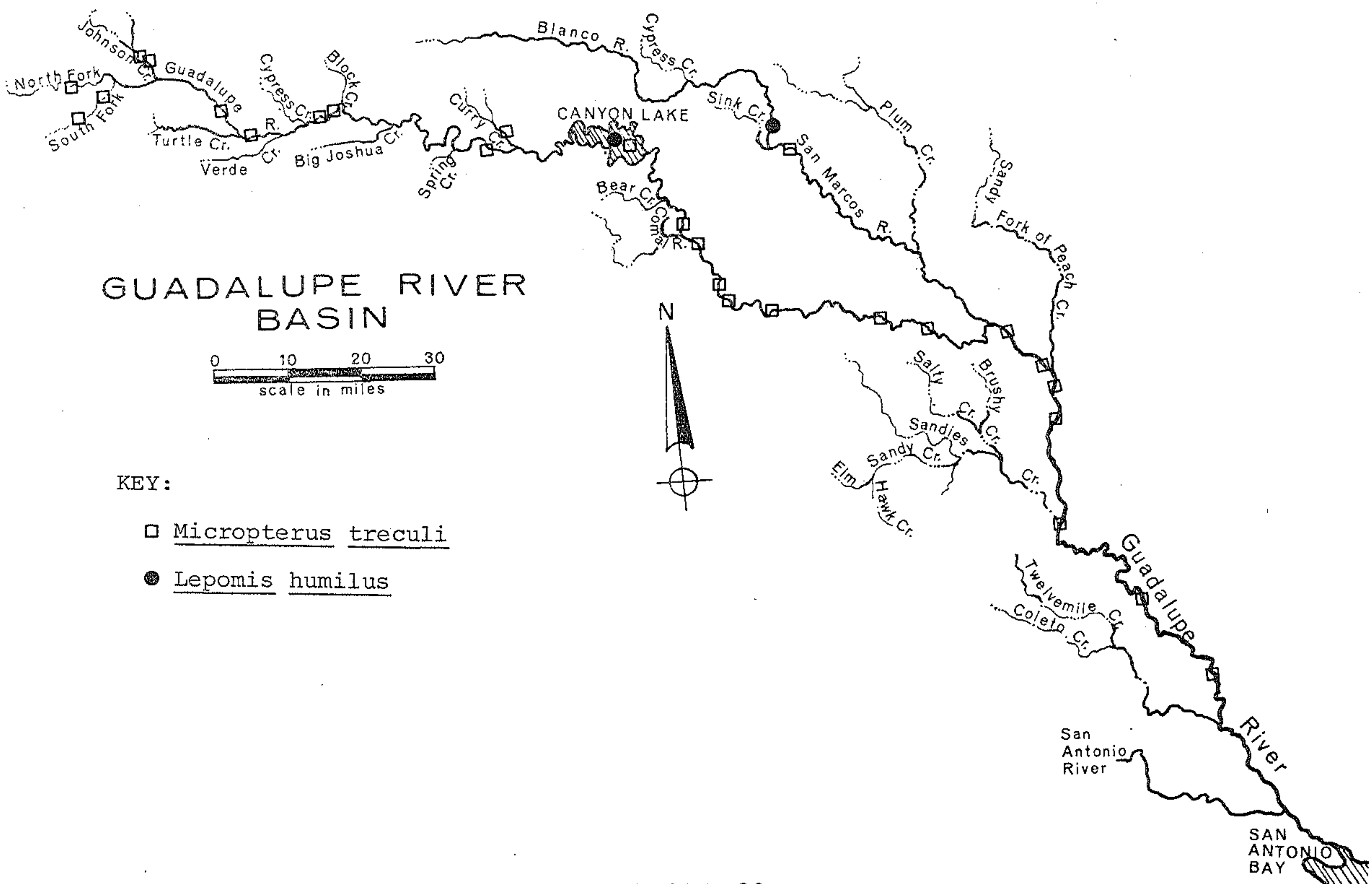
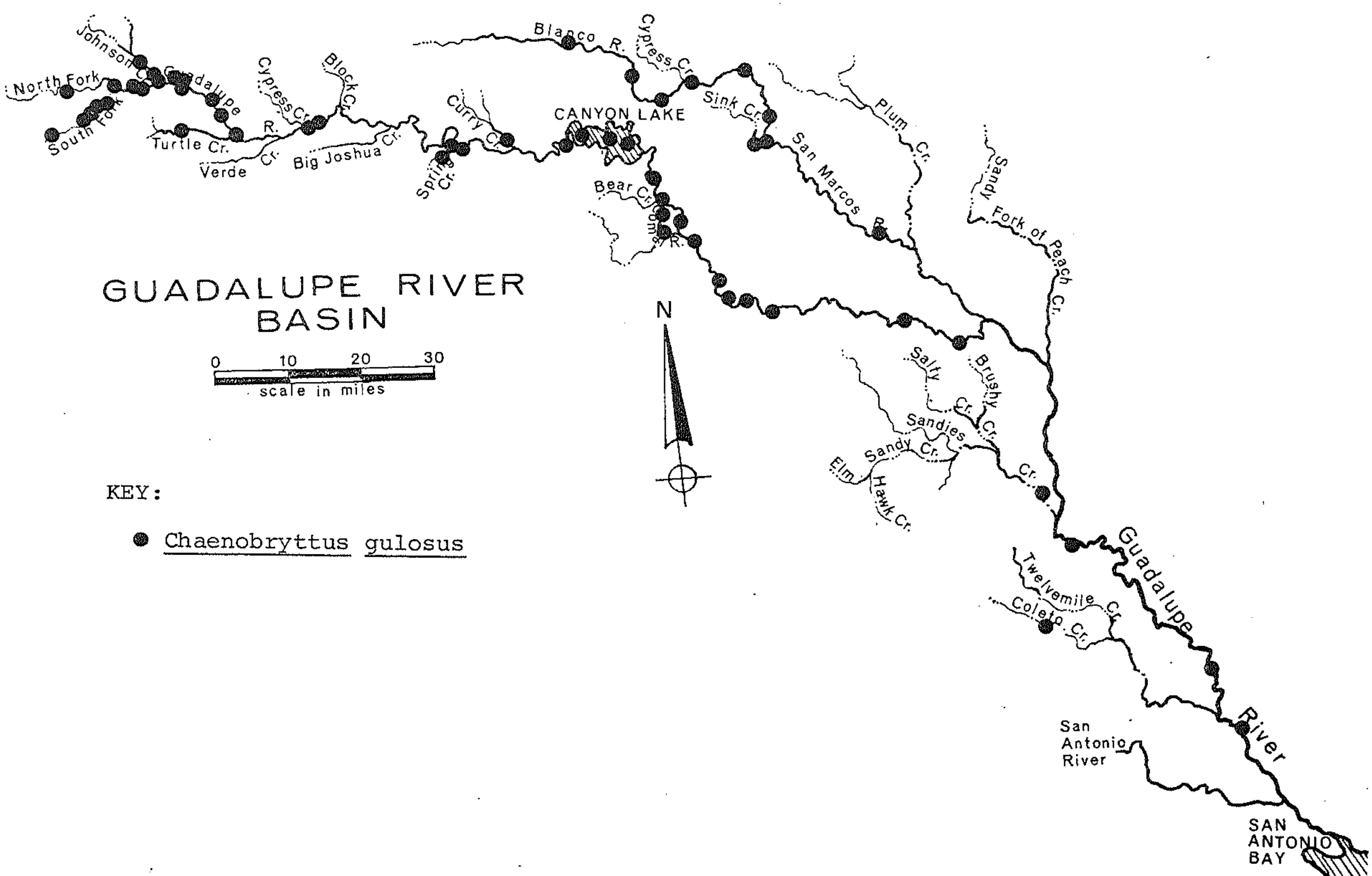

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Micropterus treculi
Lepomis humilus
N
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
CANYON LAKE
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Bear Cr.
Comal R.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 28



KEY:

● Chaenobryttus gulosus

FIGURE 29

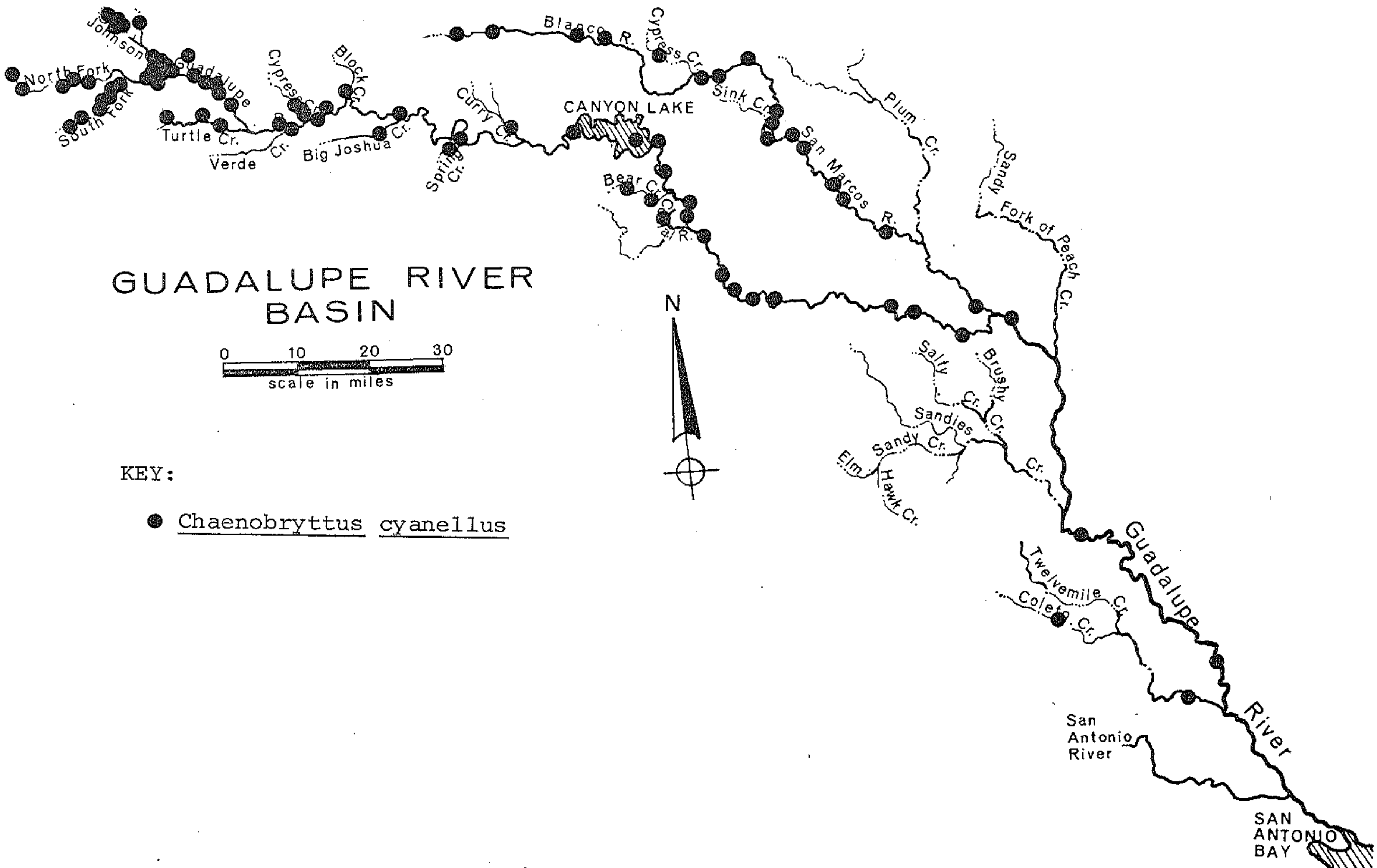

GUADALUPE RIVER
BASIN
0 10 20 30
scale in miles
KEY:
Chaenobryttus cyanellus
N
North Fork
South Fork
Johnson
Guadalupe
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Spring Cr.
Curry Cr.
CANYON LAKE
Bear Cr.
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 30

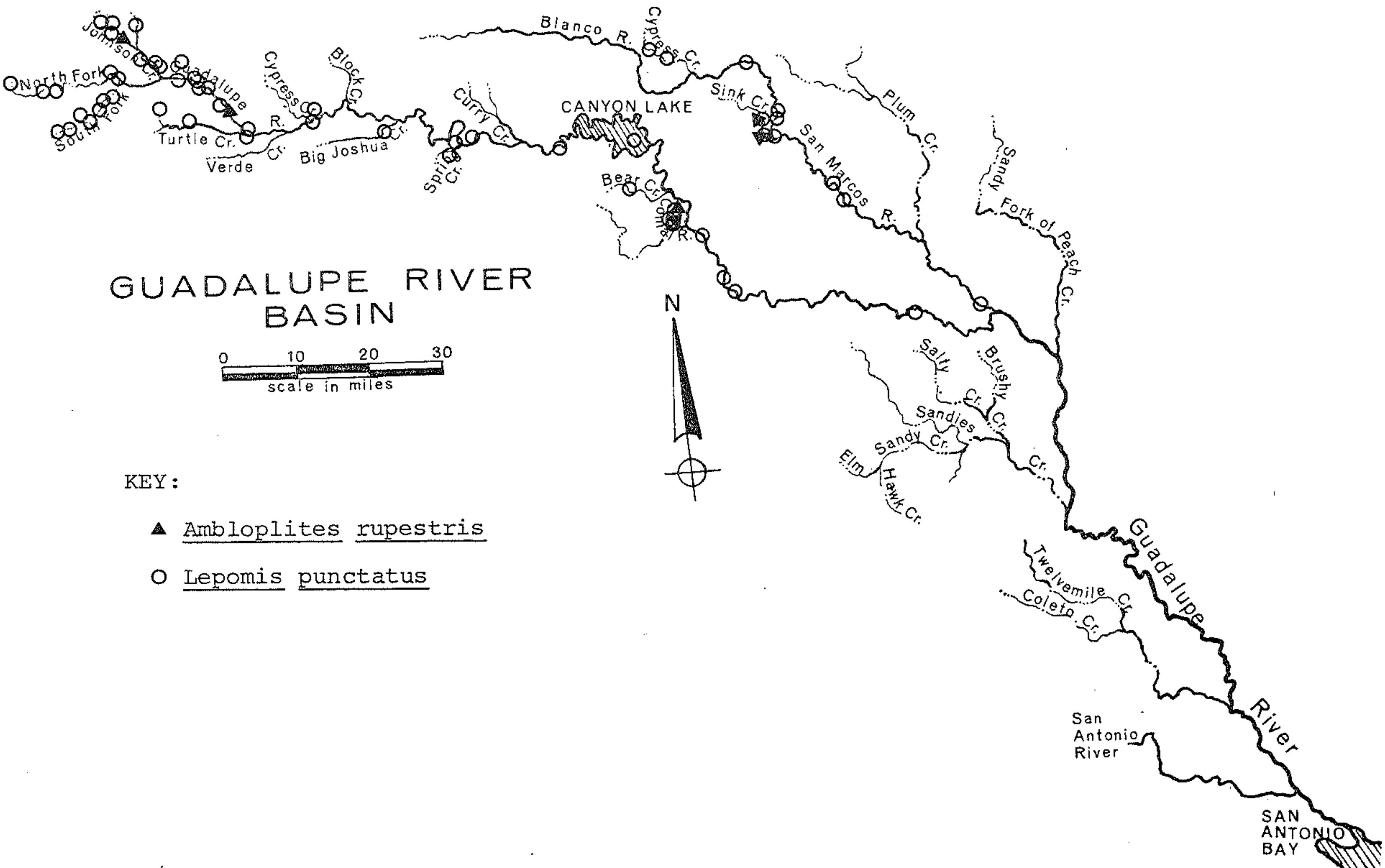

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
▲ Ambloplites rupestris
O Lepomis punctatus
N
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Bear Cr.
Comal R.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Twelvemile Cr.
Coleto Cr.
Guadalupe River
San Antonio River
SAN ANTONIO BAY

FIGURE 31

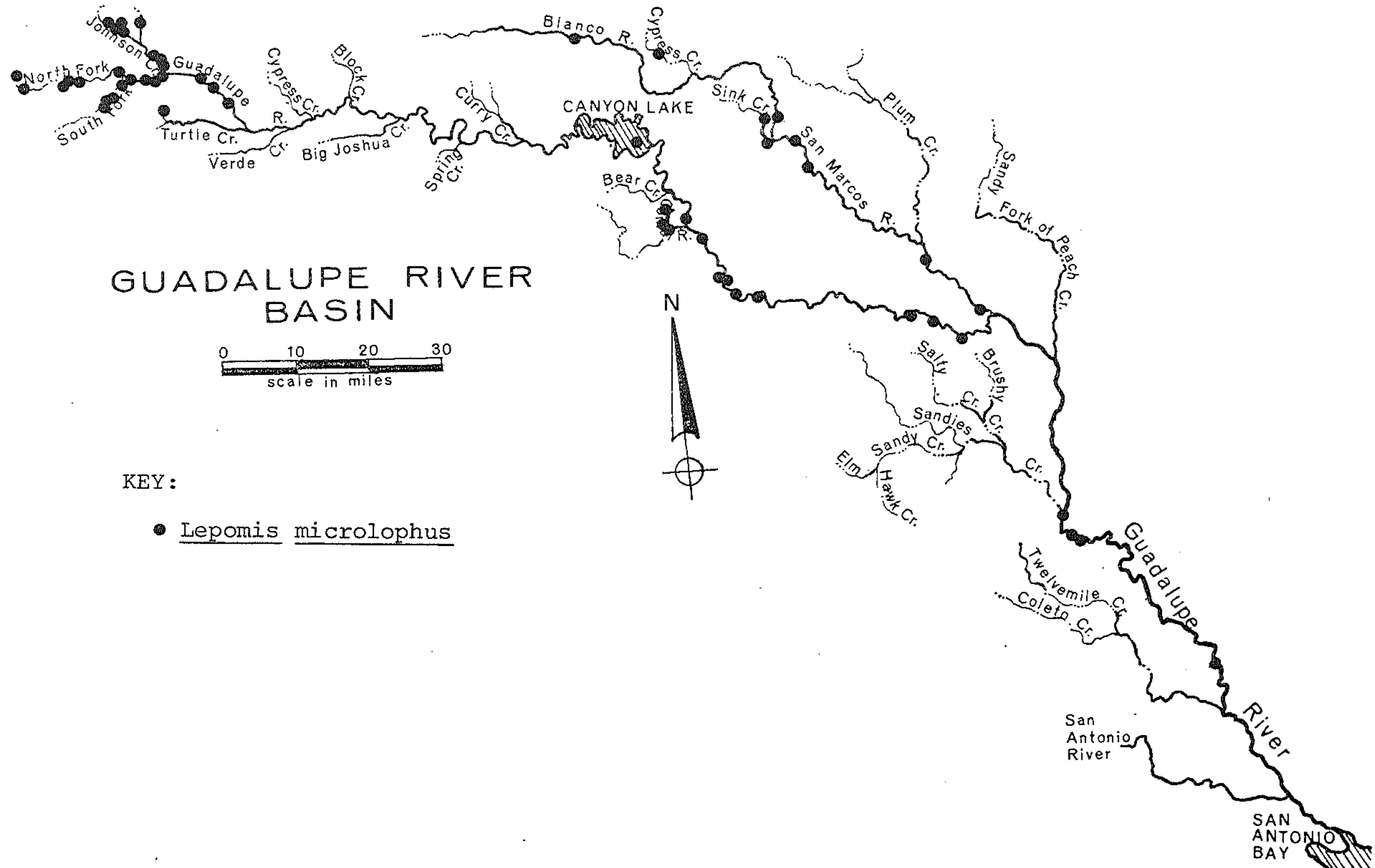

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Lepomis microlophus
N
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Sink Cr.
San Marcos R.
Plum Cr.
Bear Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 32

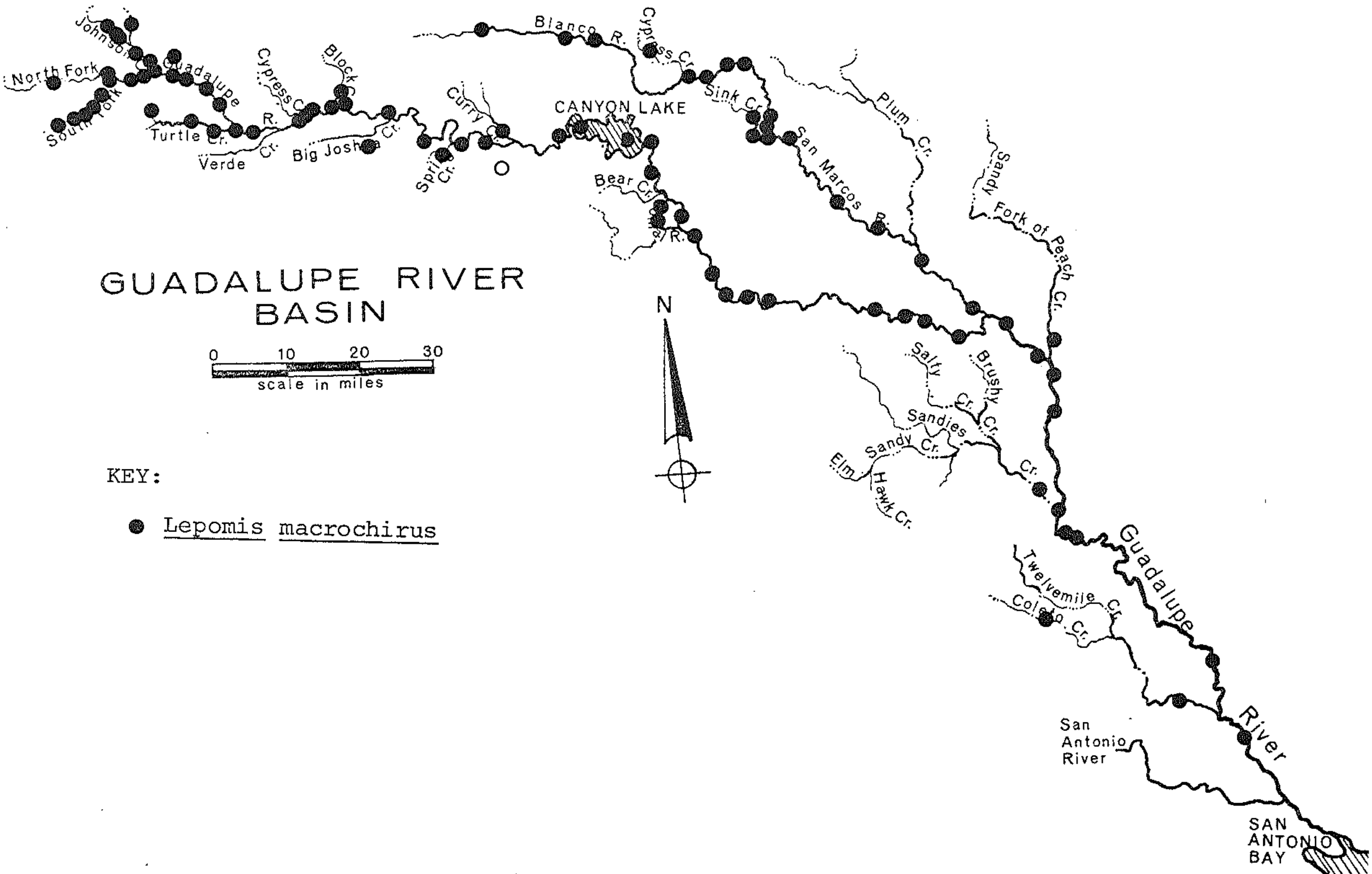

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Lepomis macrochirus
N
North Fork
South Fork
Johnson
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Big Joshua Cr.
Block Cr.
Curry Cr.
Spring Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Sink Cr.
Bear Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 33

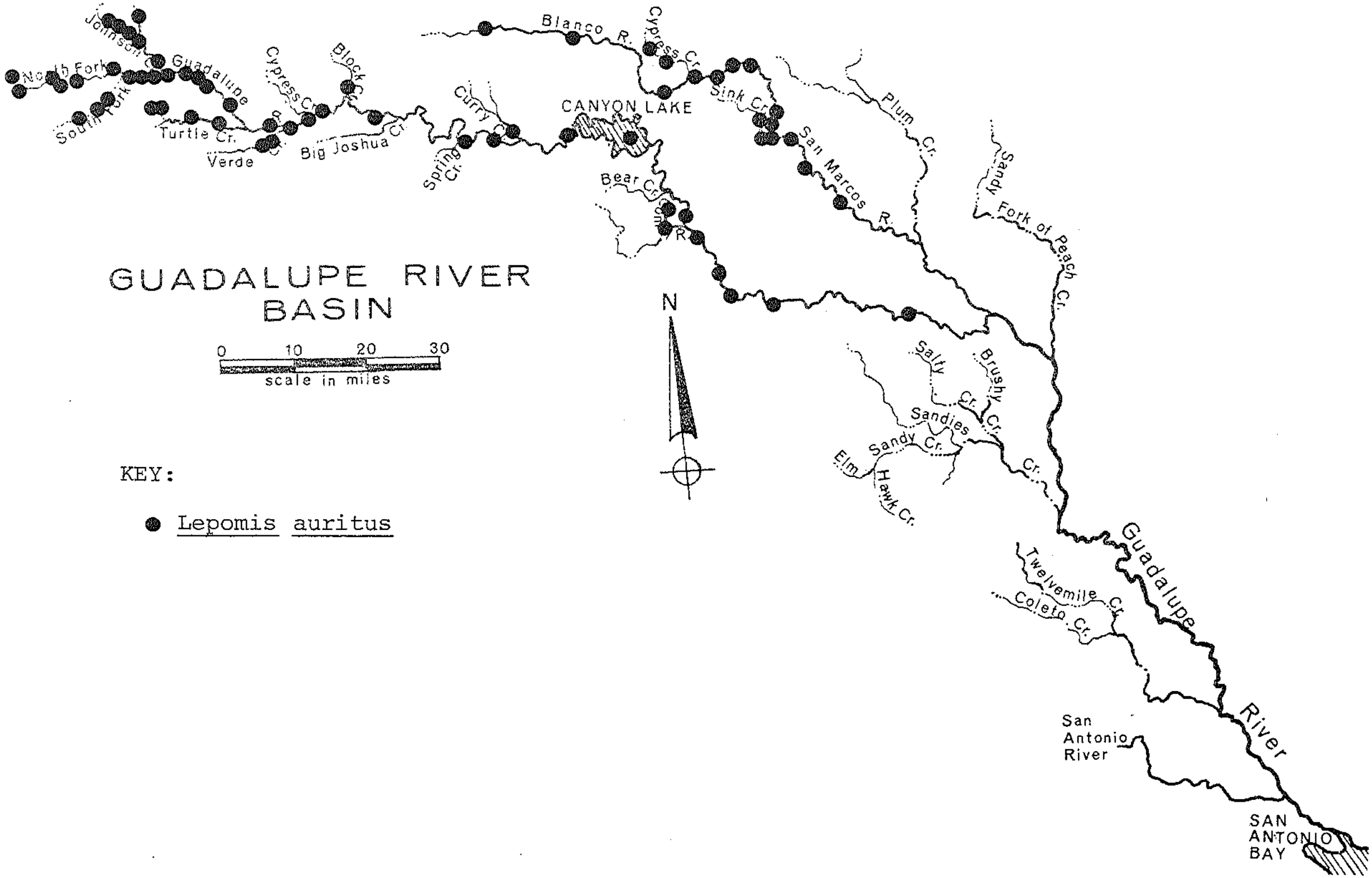

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Lepomis auritus
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
CANYON LAKE
Bear Cr.
Johnson Cr.
North Fork
South Fork
Guadalupe
Turtle Cr.
Verde
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
N
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 34

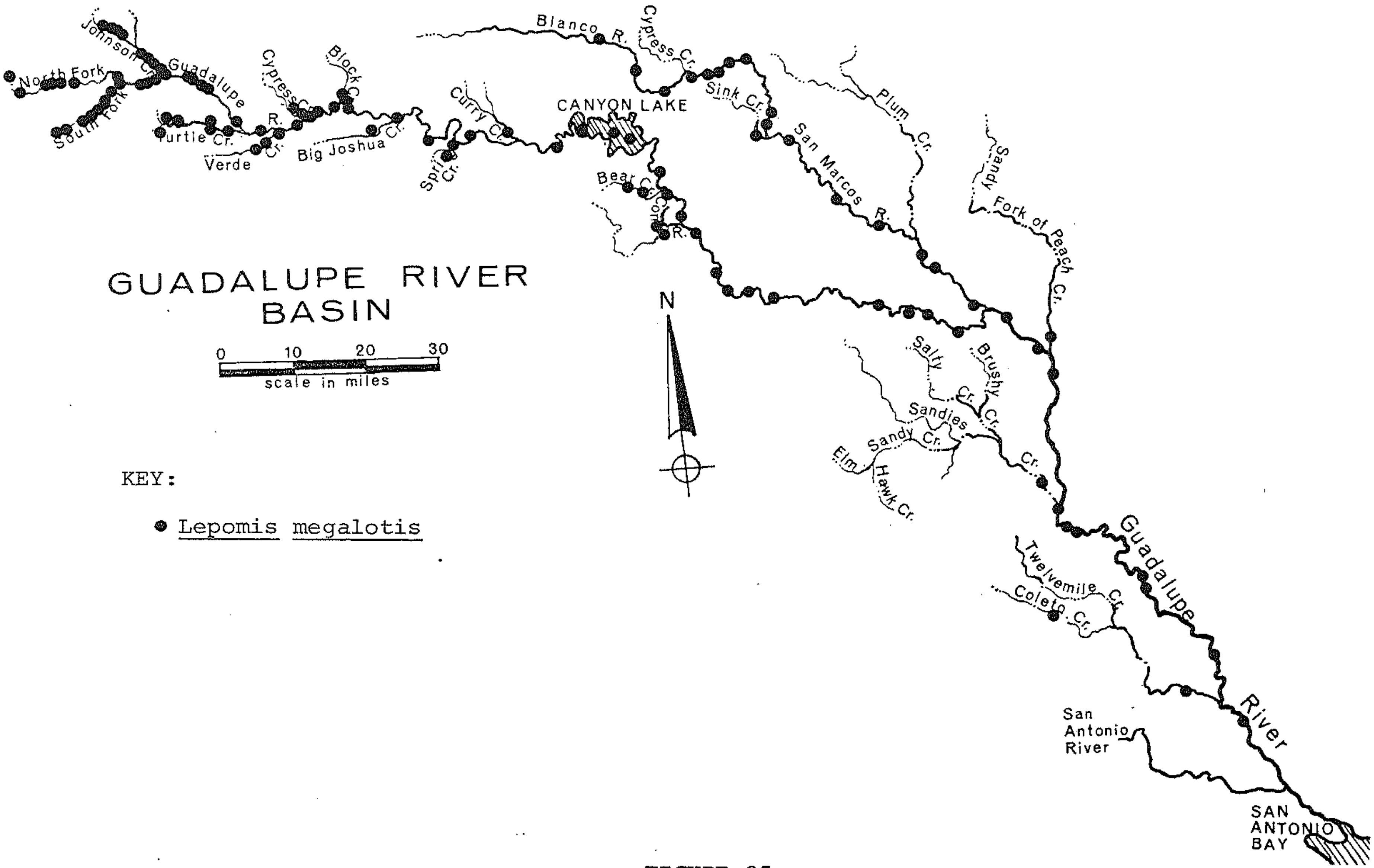

GUADALUPE RIVER
BASIN
0
10
20
30
scale in miles
KEY:
Lepomis megalotis
North Fork
South Fork
Johnson Cr.
Guadalupe
Turtle Cr.
Verde Cr.
Cypress Cr.
R.
Block Cr.
Big Joshua Cr.
Spring Cr.
Curry Cr.
CANYON LAKE
Bear Cr.
Comal R.
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY
N

FIGURE 35

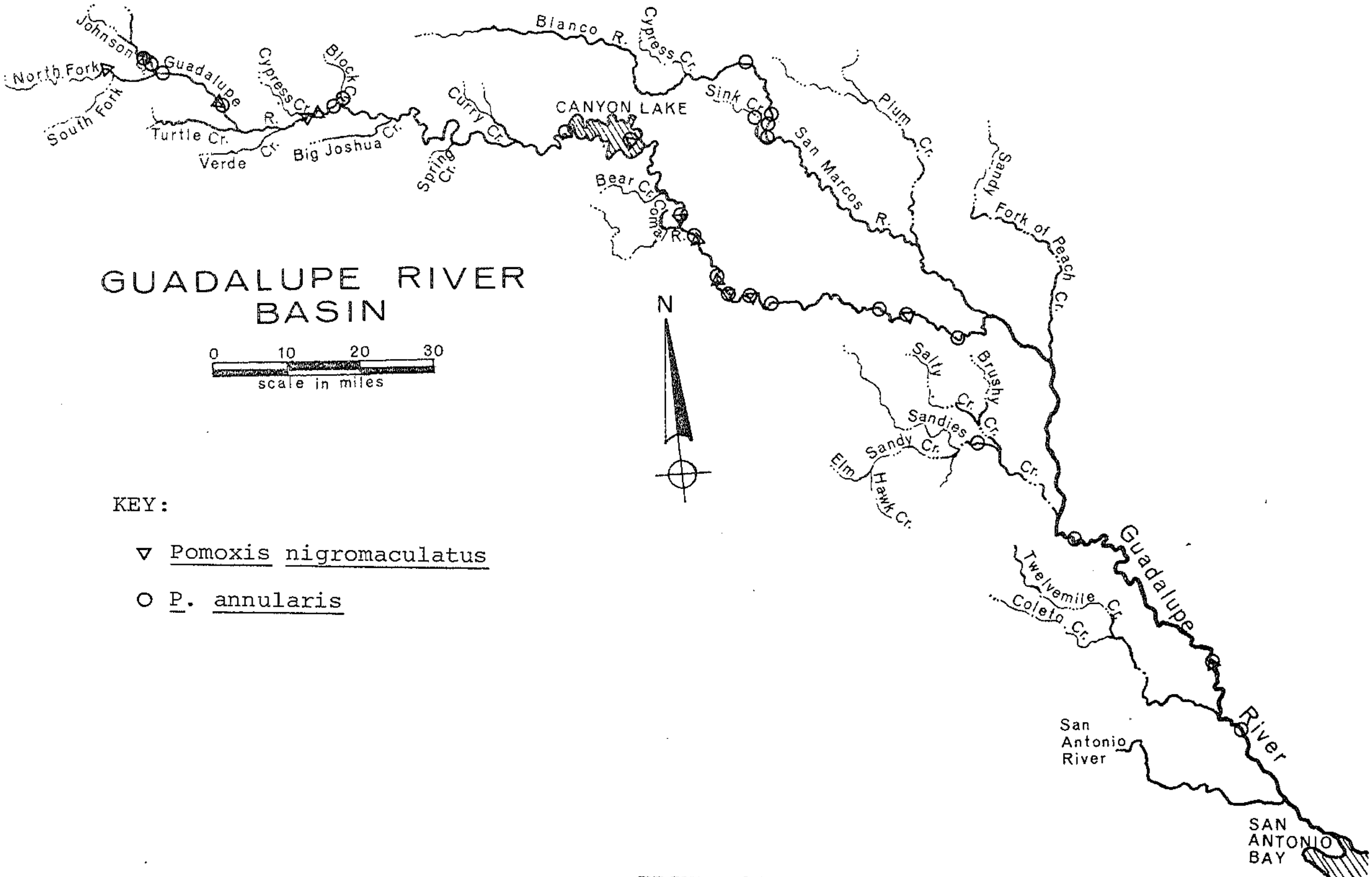

GUADALUPE RIVER BASIN
0
10
20
30
scale in miles
KEY:
Pomoxis nigromaculatus
P. annularis
North Fork
South Fork
Johnson
Guadalupe
Turtle Cr.
Verde Cr.
Cypress Cr.
R.
Block Cr.
Big Joshua Cr.
Spring Cr.
Curry Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Bear Cr.
Comal R.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY
N

FIGURE 36

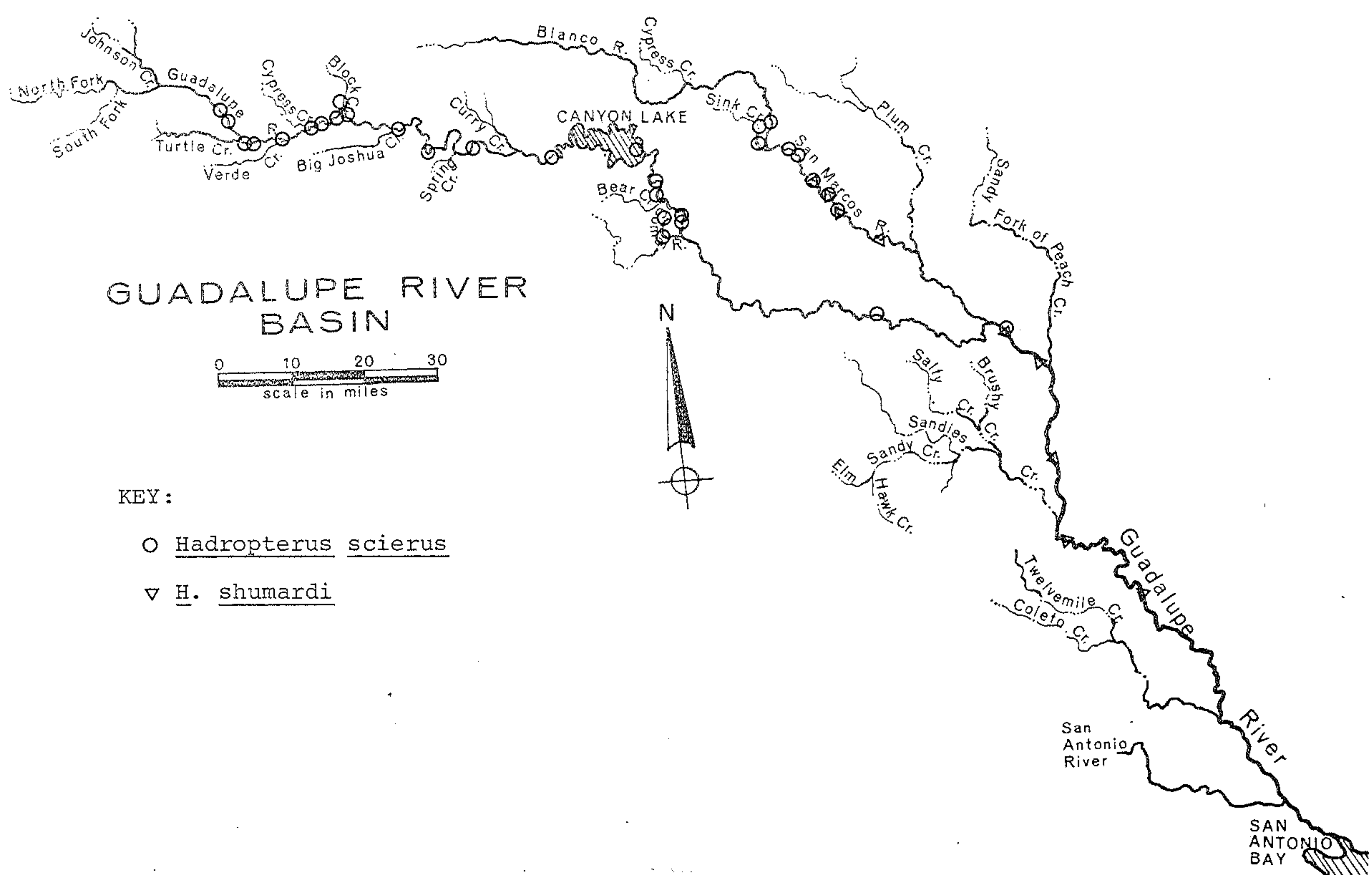

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
O Hadropterus scierus
▽ H. shumardi
North Fork
South Fork
Johnson Cr.
Guadalupe
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Spring Cr.
Curry Cr.
CANYON LAKE
Blanco R.
Cypress Cr.
Sink Cr.
Bear Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Twelvemile Cr.
Coleto Cr.
Guadalupe River
San Antonio River
SAN ANTONIO BAY
N

FIGURE 37

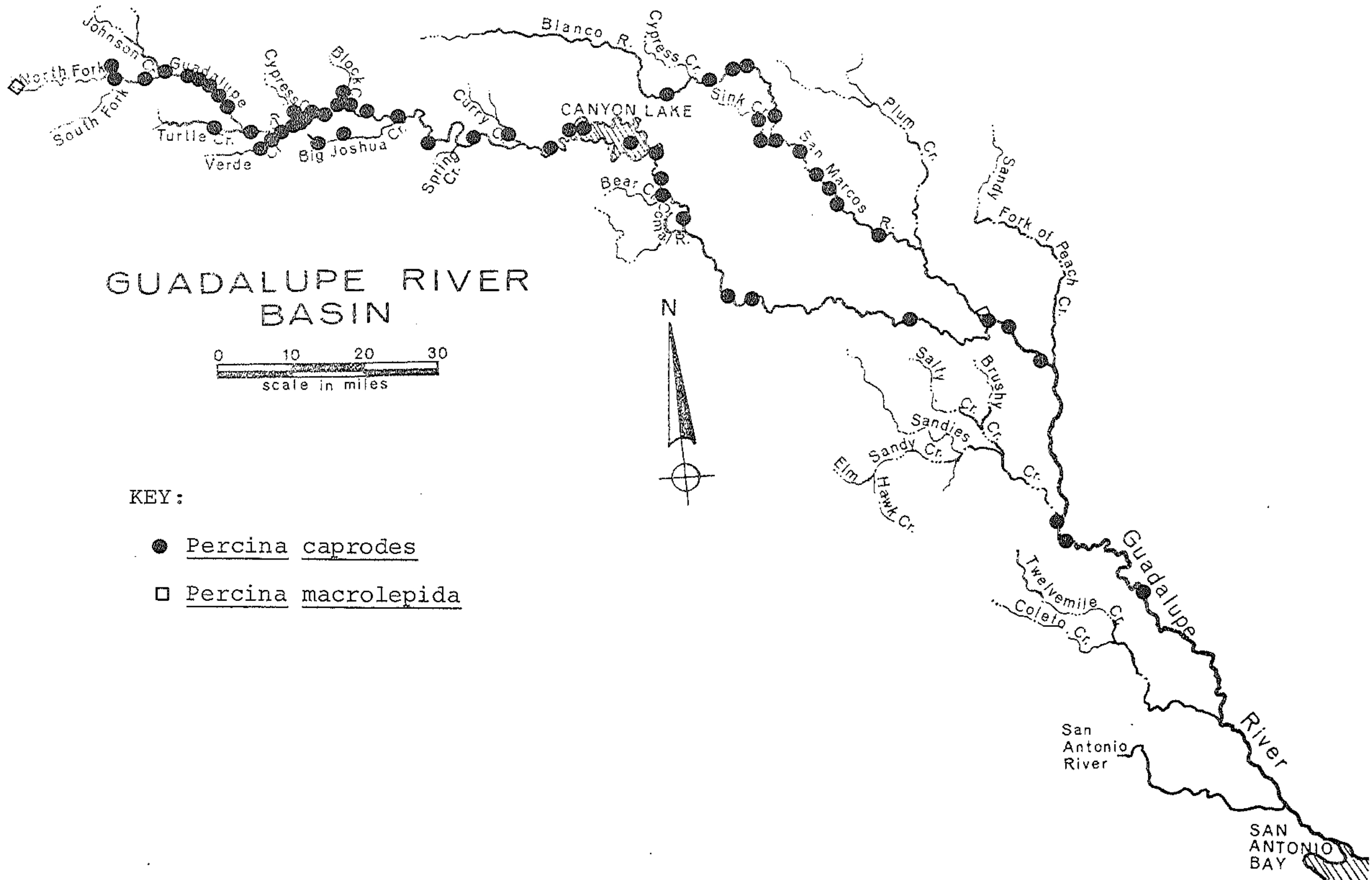

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
N
KEY:
Percina caprodes
Percina macrolepida
North Fork
Johnson Cr.
South Fork
Guadalupe
Turtle Cr.
Verde
Cypress
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
CANYON LAKE
Bear Cr.
Comal R.
Blanco R.
Cypress Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 38

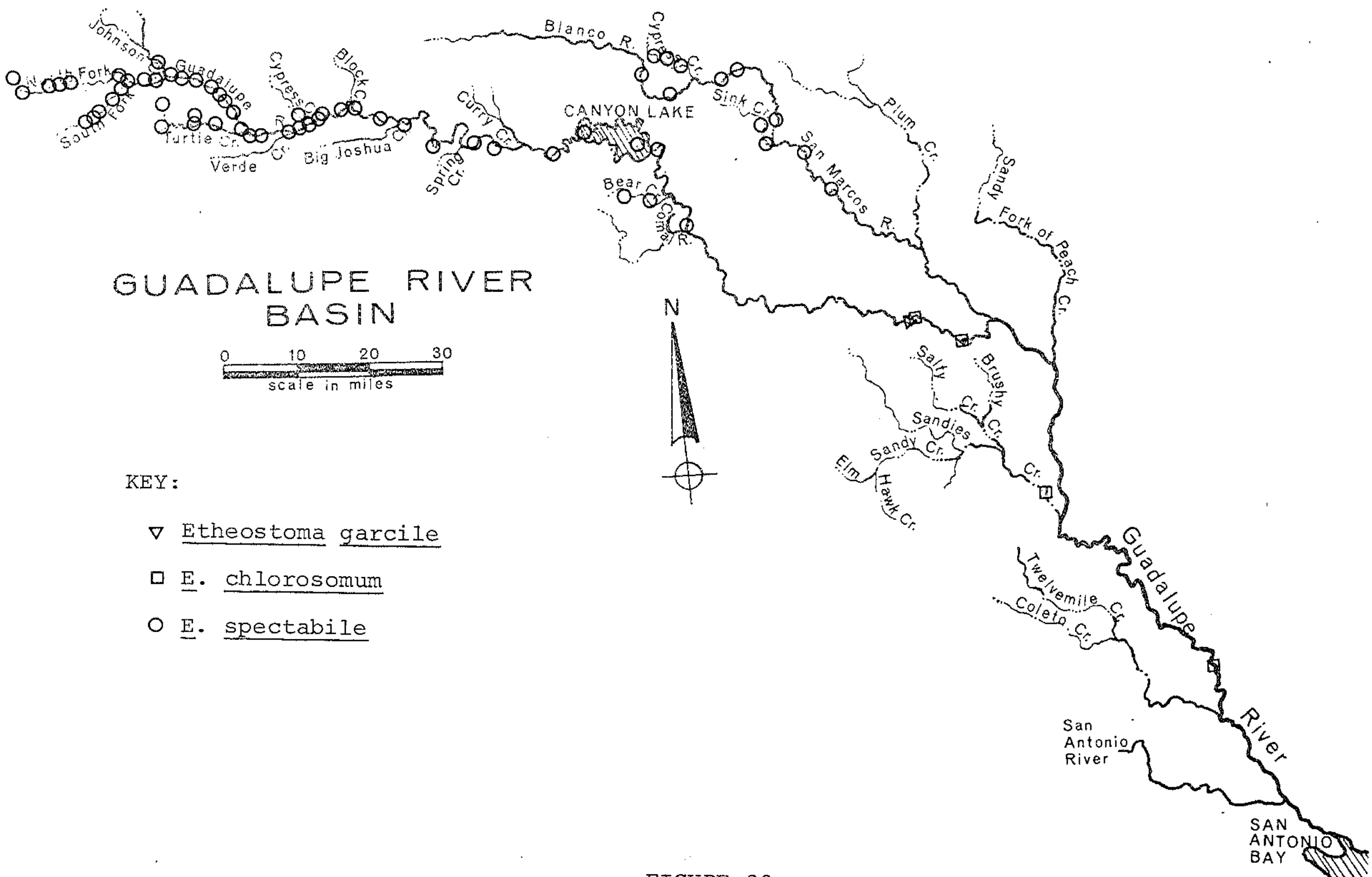

GUADALUPE RIVER
BASIN
0 10 20 30
scale in miles
KEY:
Etheostoma garcile
E. chlorosomum
E. spectabile
Johnson
North Fork
South Fork
Guadalupe
Turtle Cr.
Verde
Cypress Cr.
Block Cr.
Big Joshua
Curry Cr.
Spring Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Bear Cr.
Comal R.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy
Fork of Peach Cr.
N
Salty
Cr.
Brushy
Cr.
Sandies
Sandy Cr.
Elm
Hawk Cr.
Cr.
Guadalupe
River
Twelvemile Cr.
Coleto Cr.
San
Antonio
River
SAN
ANTONIO
BAY

FIGURE 39

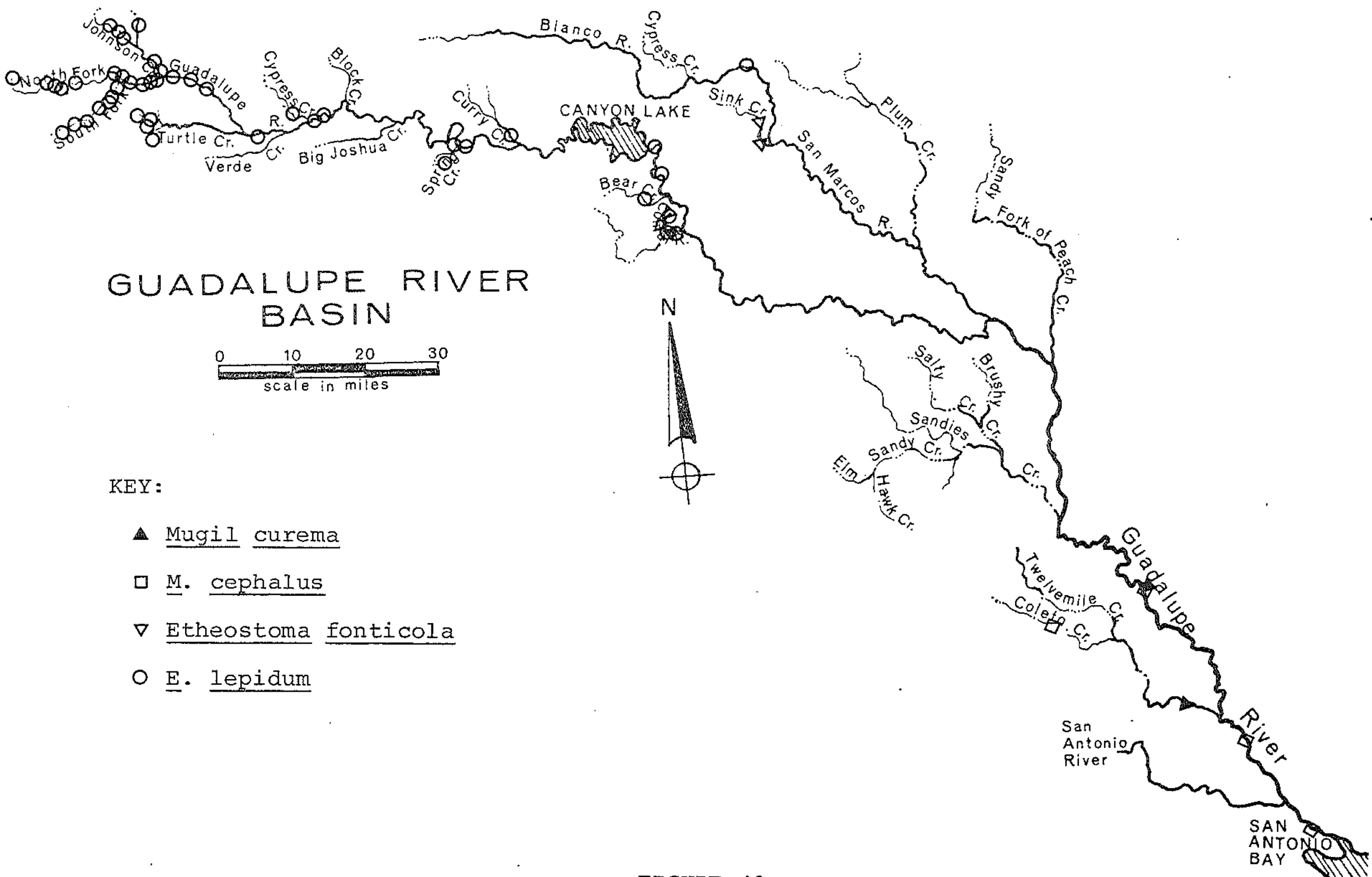

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
▲ Mugil curema
□ M. cephalus
▽ Etheostoma fonticola
○ E. lepidum
N
Johnson
North Fork
South Fork
Guadalupe R.
Cypress Cr.
Block Cr.
Turtle Cr.
Verde Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Bear Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 40

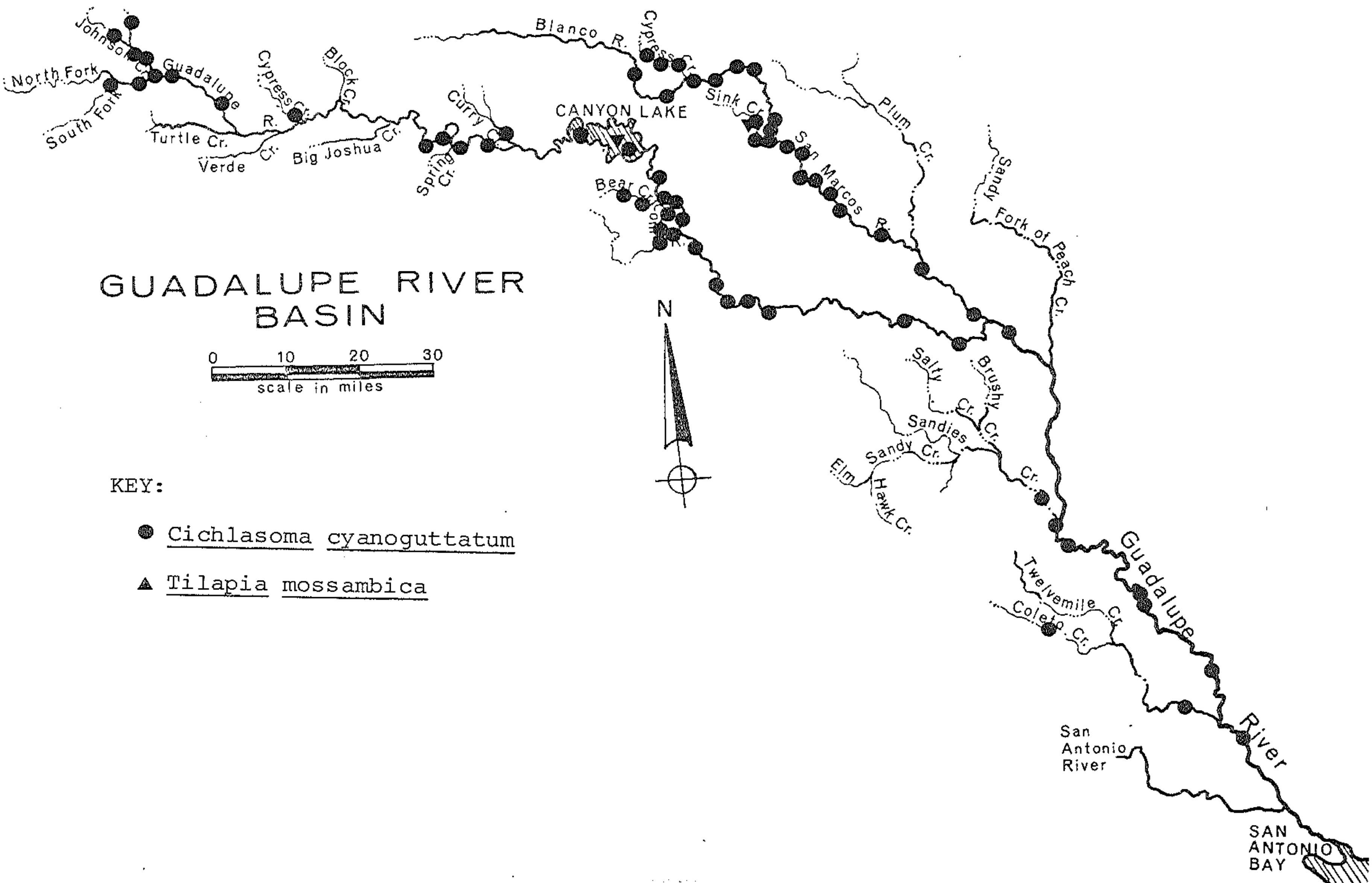

GUADALUPE RIVER BASIN
0 10 20 30
scale in miles
KEY:
Cichlasoma cyanoguttatum
Tilapia mossambica
N
North Fork
South Fork
Johnson Cr.
Guadalupe R.
Turtle Cr.
Verde Cr.
Cypress Cr.
Block Cr.
Big Joshua Cr.
Curry Cr.
Spring Cr.
Blanco R.
Cypress Cr.
CANYON LAKE
Bear Cr.
Sink Cr.
San Marcos R.
Plum Cr.
Sandy Fork of Peach Cr.
Salty Cr.
Brushy Cr.
Sandies Cr.
Sandy Cr.
Elm
Hawk Cr.
Guadalupe River
Twelvemile Cr.
Coleto Cr.
San Antonio River
SAN ANTONIO BAY

FIGURE 41

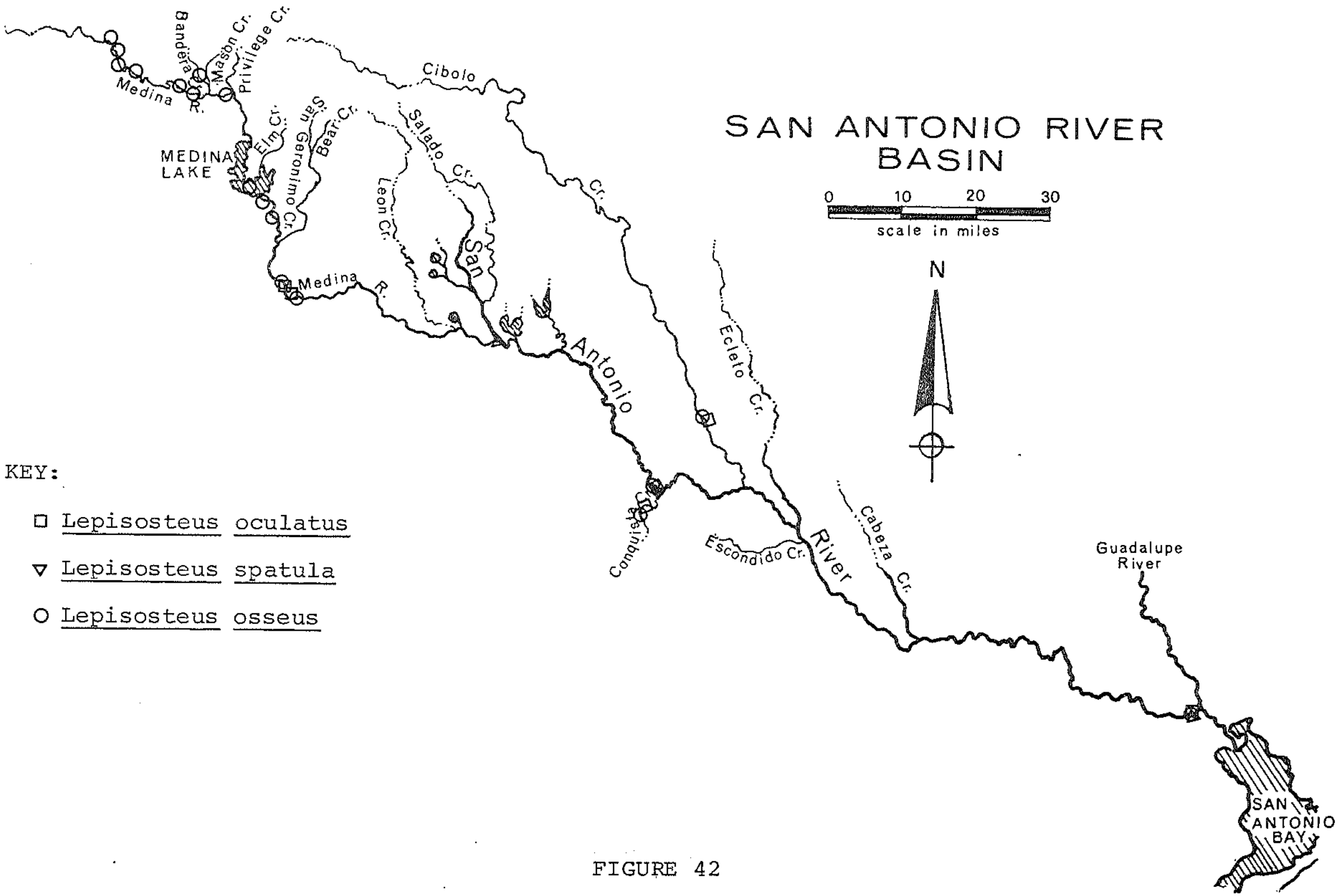

SAN ANTONIO RIVER BASIN
0 10 20 30
scale in miles
N
Medina R.
Bandera
Mason Cr.
Privilege Cr.
Cibolo Cr.
MEDINA LAKE
Elm Cr.
San Geronimo Cr.
Bear Cr.
Salado Cr.
Leon Cr.
San
Medina R.
Antonio
River
Ecleto Cr.
Cabeza Cr.
Escondido Cr.
Conquista
Guadalupe River
SAN ANTONIO BAY
KEY:
□ Lepisosteus oculatus
▽ Lepisosteus spatula
○ Lepisosteus osseus

FIGURE 42

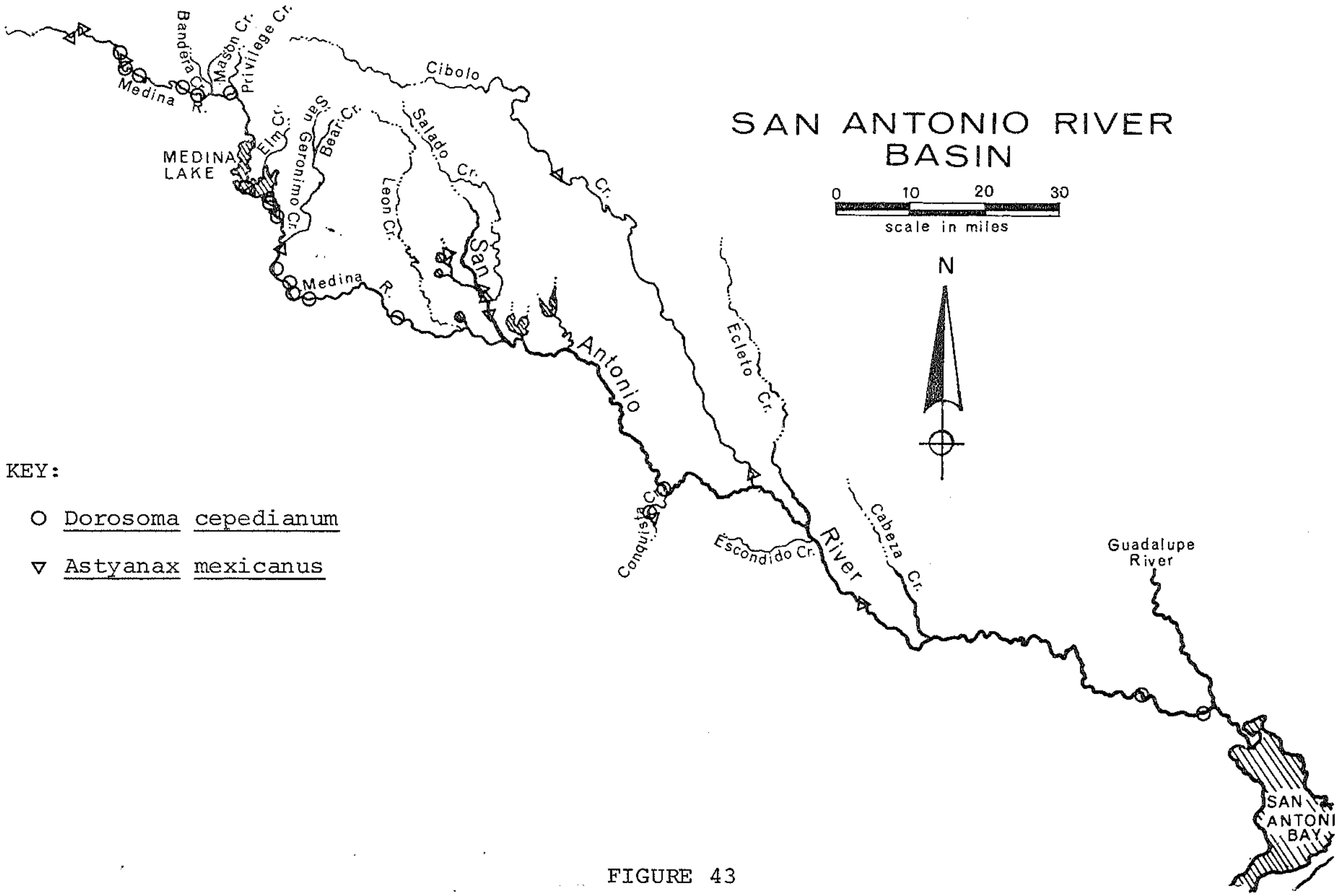
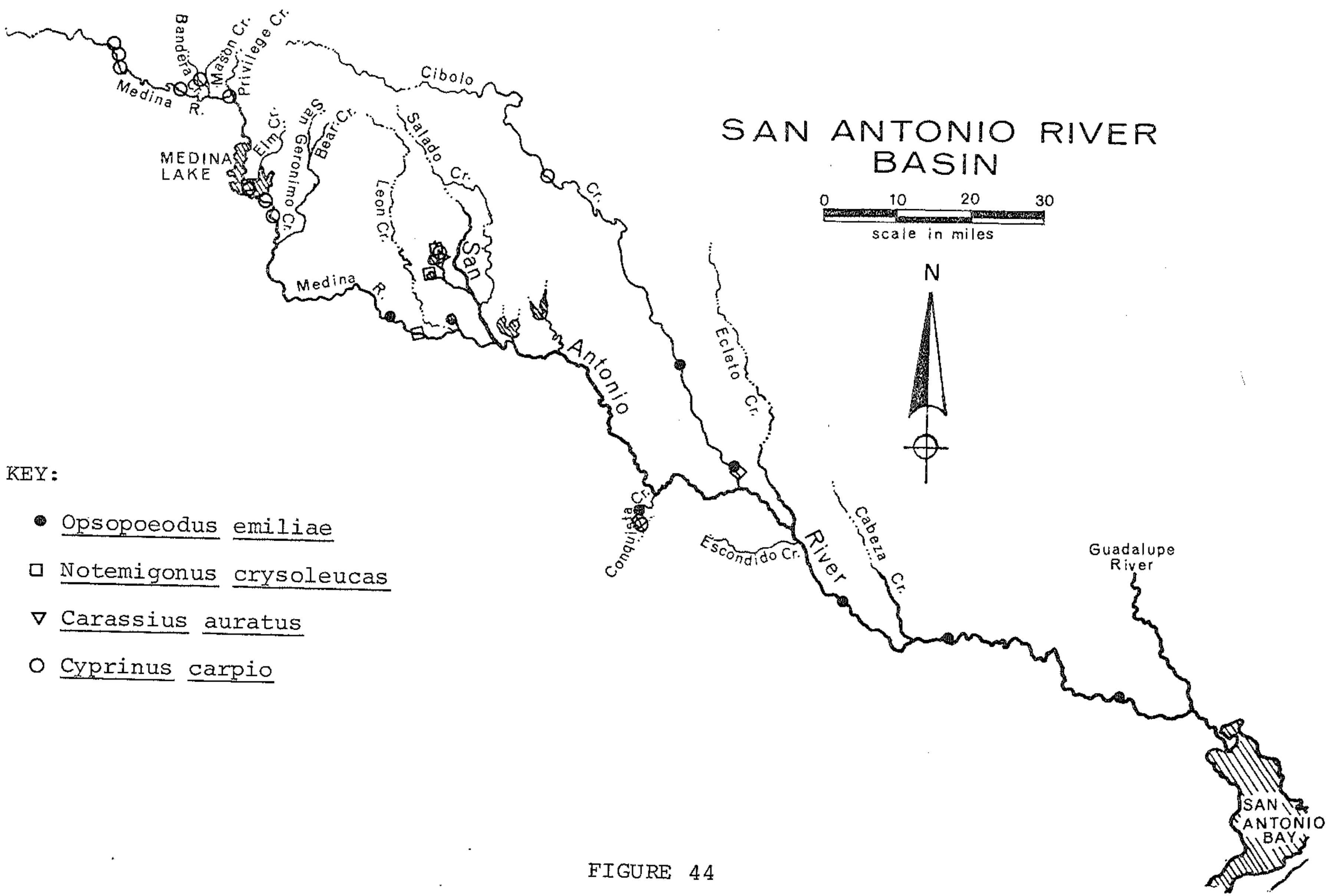

SAN ANTONIO RIVER
BASIN
0 10 20 30
scale in miles
N
KEY:
O Dorosoma cepedianum
▽ Astyanax mexicanus
Medina R.
Bandera Cr.
Mason Cr.
Privilege Cr.
MEDINA LAKE
Elm Cr.
San Geronimo Cr.
Bear Cr.
Leon Cr.
Salado Cr.
Cibolo Cr.
San Antonio River
Ecleto Cr.
Conquista Cr.
Escondido Cr.
Cabeza Cr.
Guadalupe River
SAN ANTONIO BAY

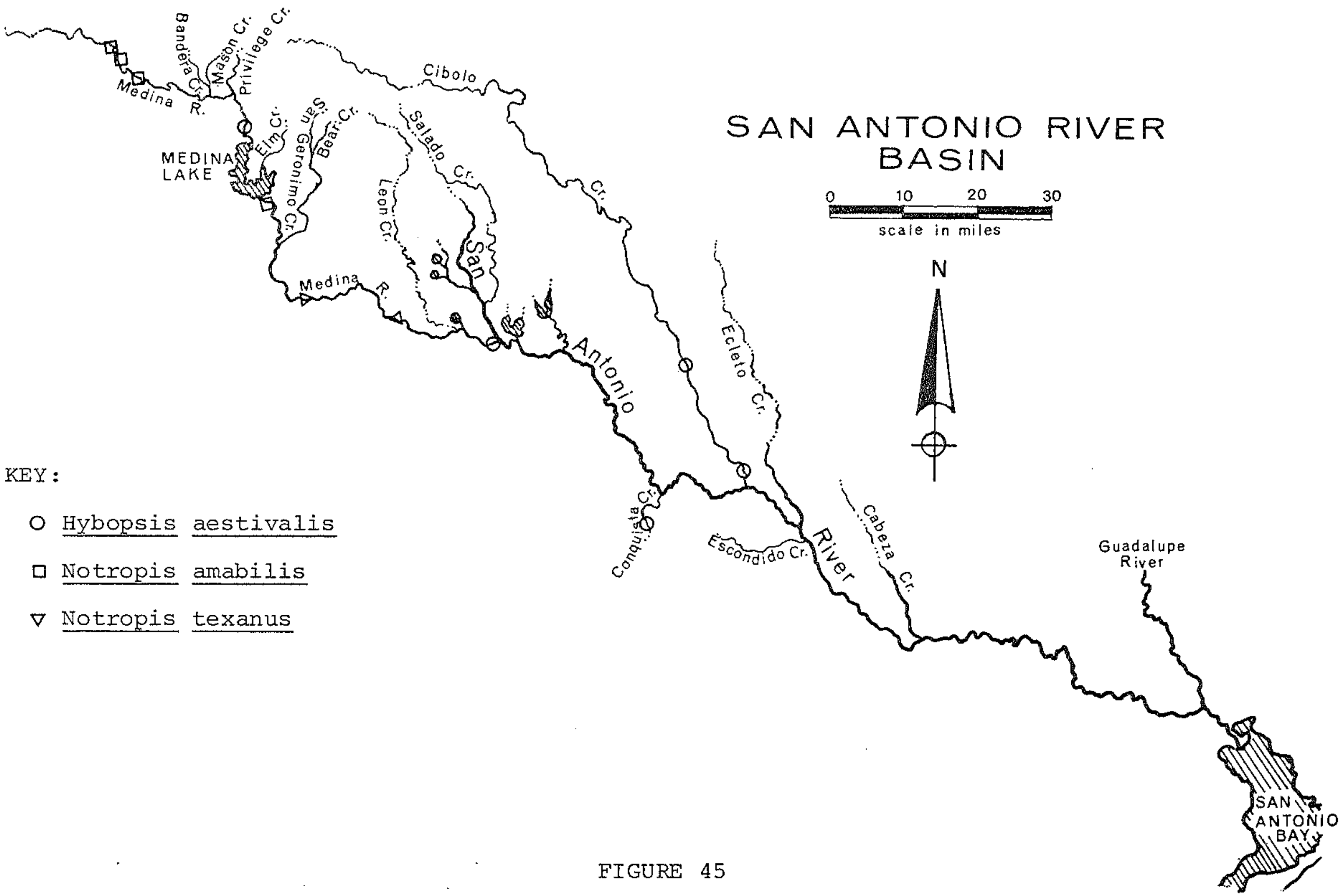
FIGURE 43



KEY:

- ● *Opsopoeodus emiliae*
- □ *Notemigonus crysoleucas*
- ▽ *Carassius auratus*
- ○ *Cyprinus carpio*

FIGURE 44



KEY:

- ○ *Hybopsis aestivalis*
- □ *Notropis amabilis*
- ▽ *Notropis texanus*

FIGURE 45

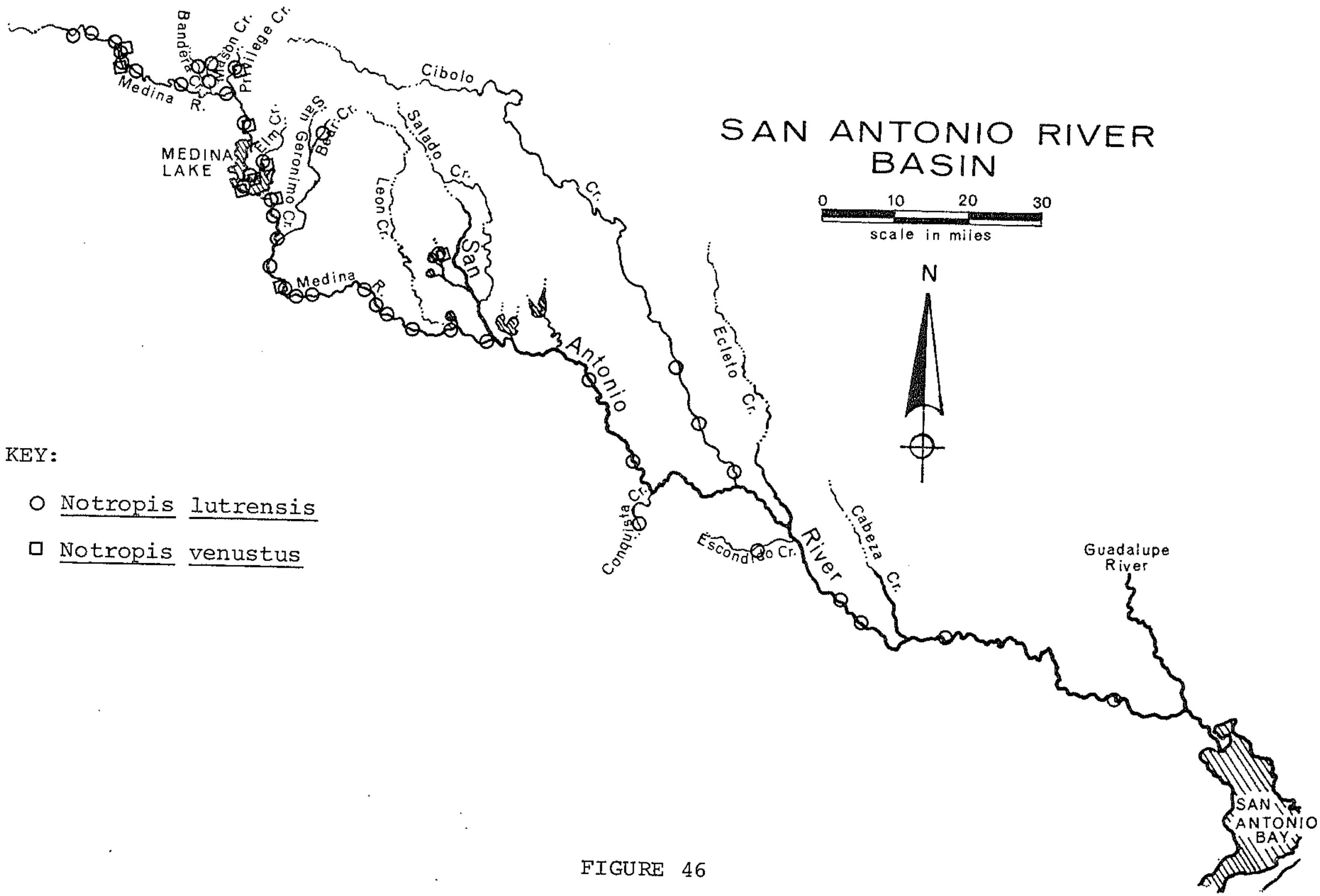

SAN ANTONIO RIVER
BASIN
0 10 20 30
scale in miles
N
Medina R.
Bandera Cr.
Mason Cr.
Privilege Cr.
Cibolo Cr.
MEDINA LAKE
Elm Cr.
San Geronimo Cr.
Bear Cr.
Salado Cr.
Leon Cr.
San Antonio River
Medina R.
Ecleto Cr.
Conquista Cr.
Escondido Cr.
Cabeza Cr.
Guadalupe River
SAN ANTONIO BAY
KEY:
Notropis lutrensis
Notropis venustus

FIGURE 46

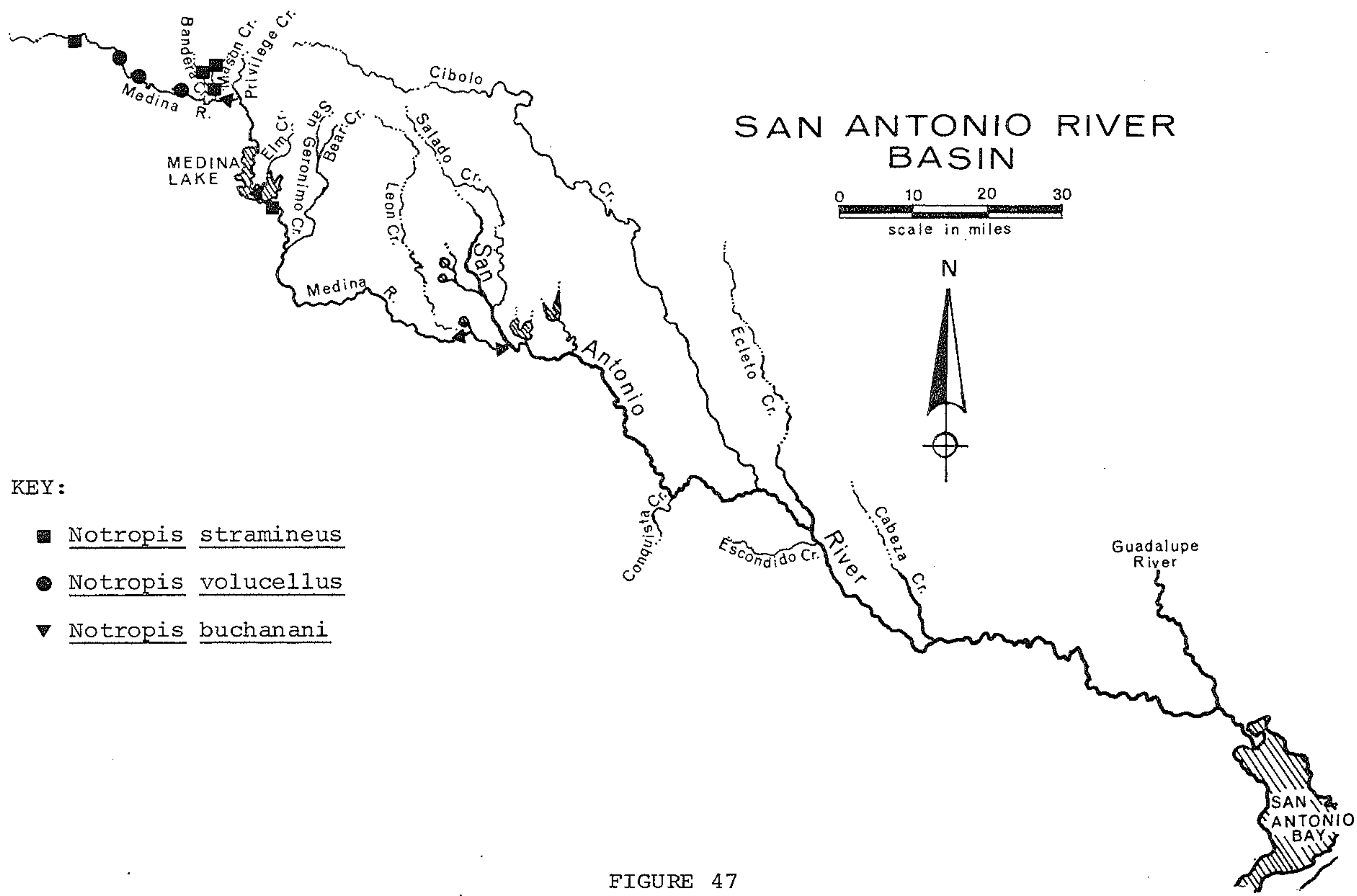

SAN ANTONIO RIVER
BASIN
0
10
20
30
scale in miles
N
Bandera Cr.
Mason Cr.
Privilege Cr.
Medina R.
MEDINA
LAKE
Elm Cr.
San Geronimo Cr.
Bear Cr.
Leon Cr.
Salado Cr.
Cibolo Cr.
San Antonio River
Medina R.
Ecleto Cr.
Conquista Cr.
Escondido Cr.
Cabeza Cr.
Guadalupe
River
SAN
ANTONIO
BAY
KEY:
Notropis stramineus
Notropis volucellus
Notropis buchanani

FIGURE 47

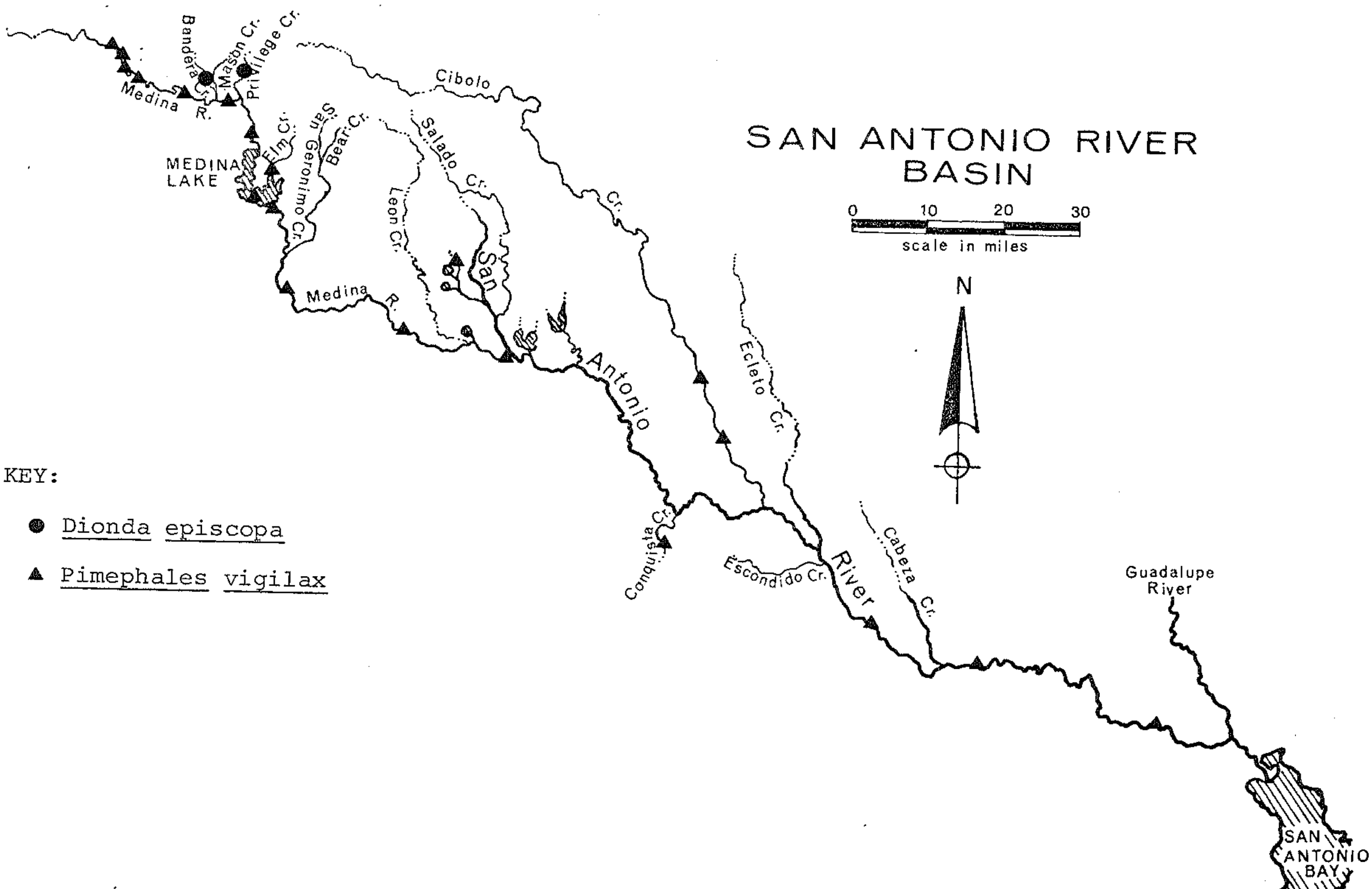
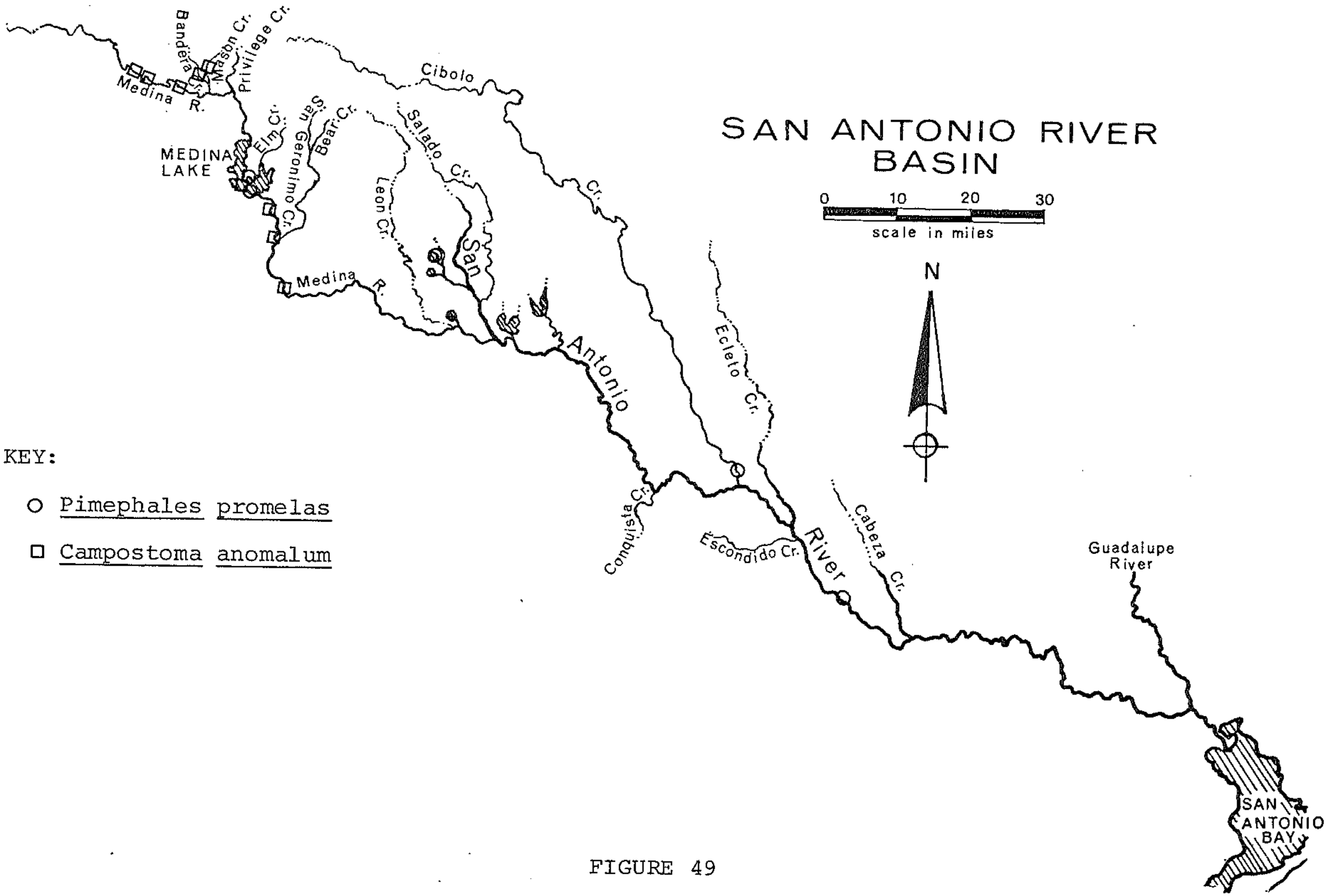

SAN ANTONIO RIVER
BASIN
0
10
20
30
scale in miles
N
KEY:
Dionda episcopa
Pimephales vigilax
Medina R.
Bandera Cr.
Mason Cr.
Privilege Cr.
MEDINA
LAKE
Elm Cr.
San Geronimo Cr.
Bear Cr.
Cibolo
Cr.
Salado Cr.
Leon Cr.
San
Medina R.
Antonio
River
Ecleto Cr.
Conquista Cr.
Escondido Cr.
Cabeza Cr.
Guadalupe
River
SAN
ANTONIO
BAY

FIGURE 48

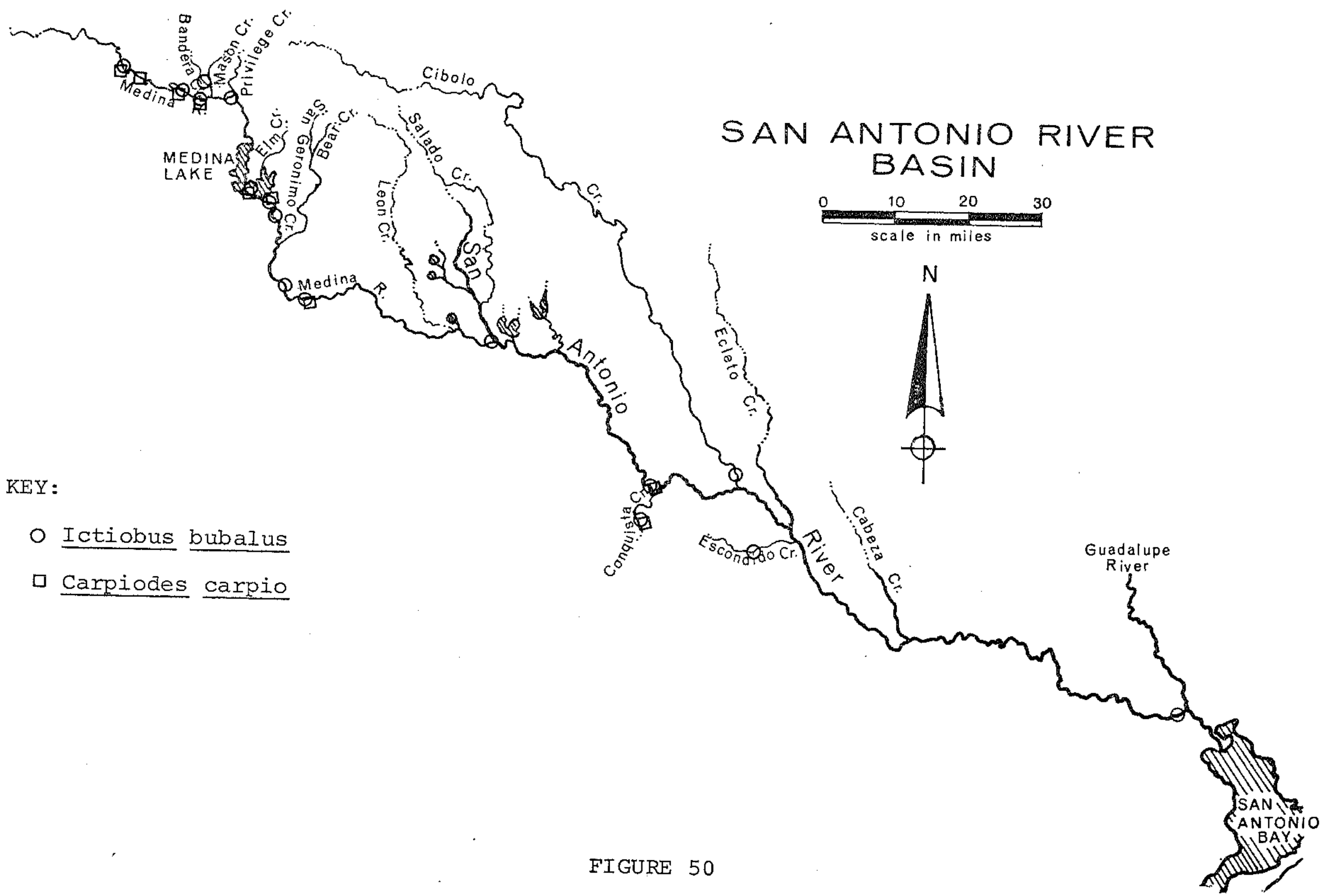


KEY:

○ Pimephales promelas

□ Campostoma anomalum

FIGURE 49



KEY:

○ Ictiobus bubalus

□ Carpiodes carpio

FIGURE 50

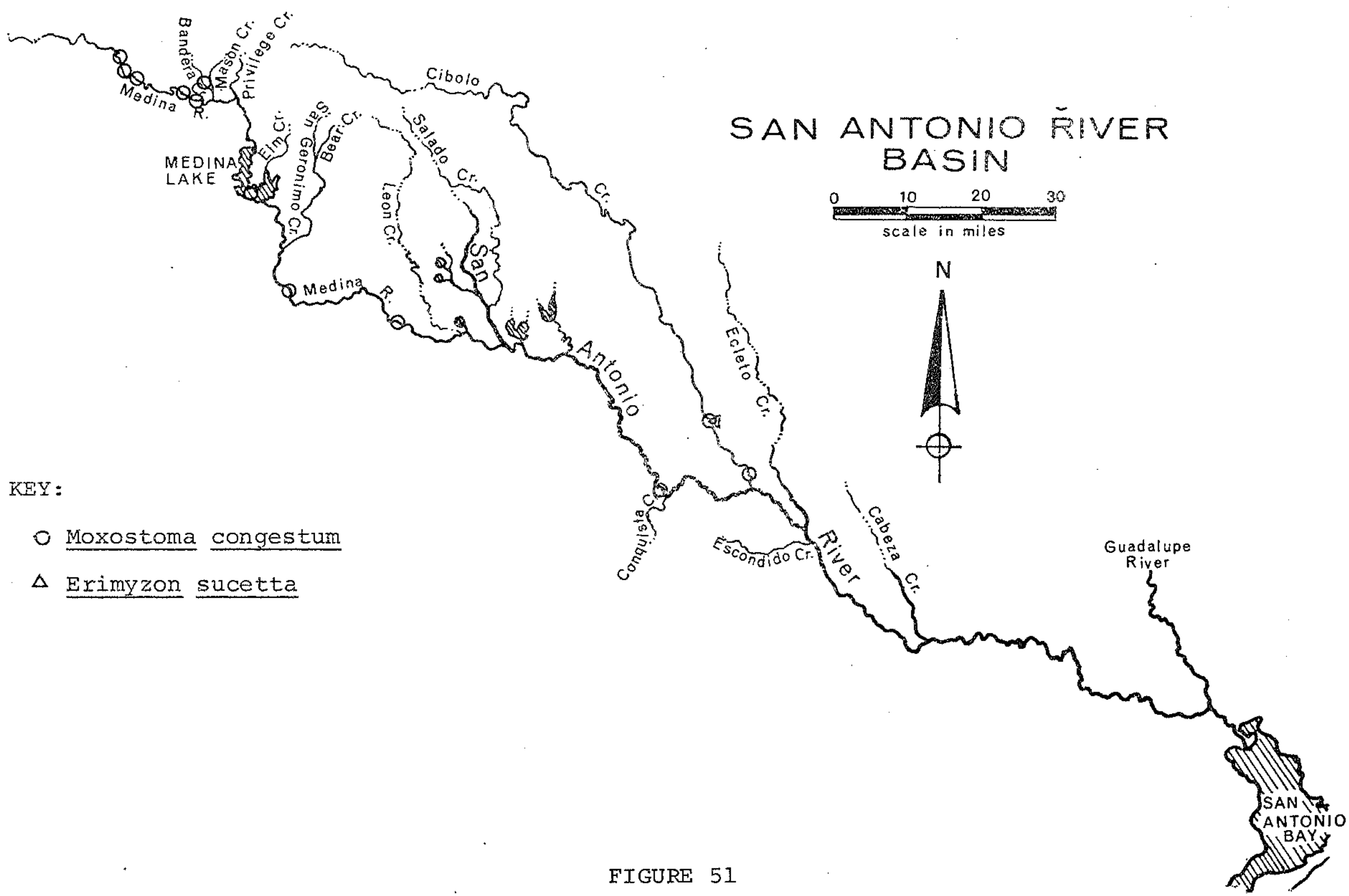

SAN ANTONIO ŘIVER
BASIN
0 10 20 30
scale in miles
N
Cibolo
Cr.
Salado Cr.
San
Antonio
River
Leon Cr.
Bear Cr.
San Geronimo Cr.
Elm Cr.
MEDINA
LAKE
Bandera
Mason Cr.
Privilege Cr.
Medina R.
Medina R.
Ecleto Cr.
Conquista Cr.
Escondido Cr.
Cabeza Cr.
Guadalupe
River
SAN
ANTONIO
BAY
KEY:
○ Moxostoma congestum
△ Erimyzon sucetta

FIGURE 51

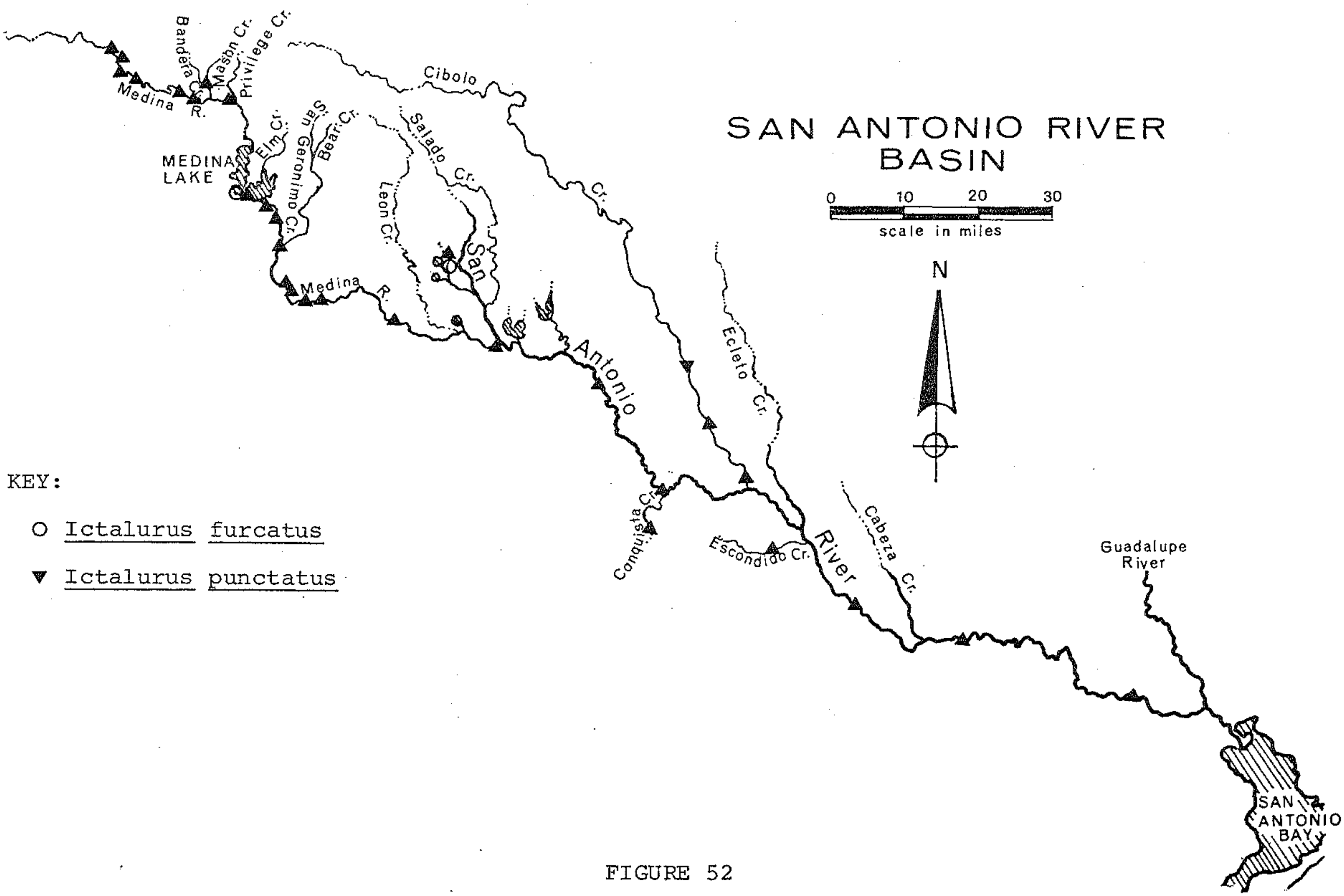

SAN ANTONIO RIVER
BASIN
0 10 20 30
scale in miles
N
KEY:
O Ictalurus furcatus
▼ Ictalurus punctatus
Medina R.
Bandera Cr.
Mason Cr.
Privilege Cr.
MEDINA LAKE
Elm Cr.
San Geronimo Cr.
Bear Cr.
Leon Cr.
Salado Cr.
Cibolo
Cr.
Medina R.
San
Antonio
River
Conquista Cr.
Escondido Cr.
Ecleto Cr.
Cabeza Cr.
Guadalupe River
SAN ANTONIO BAY

FIGURE 52

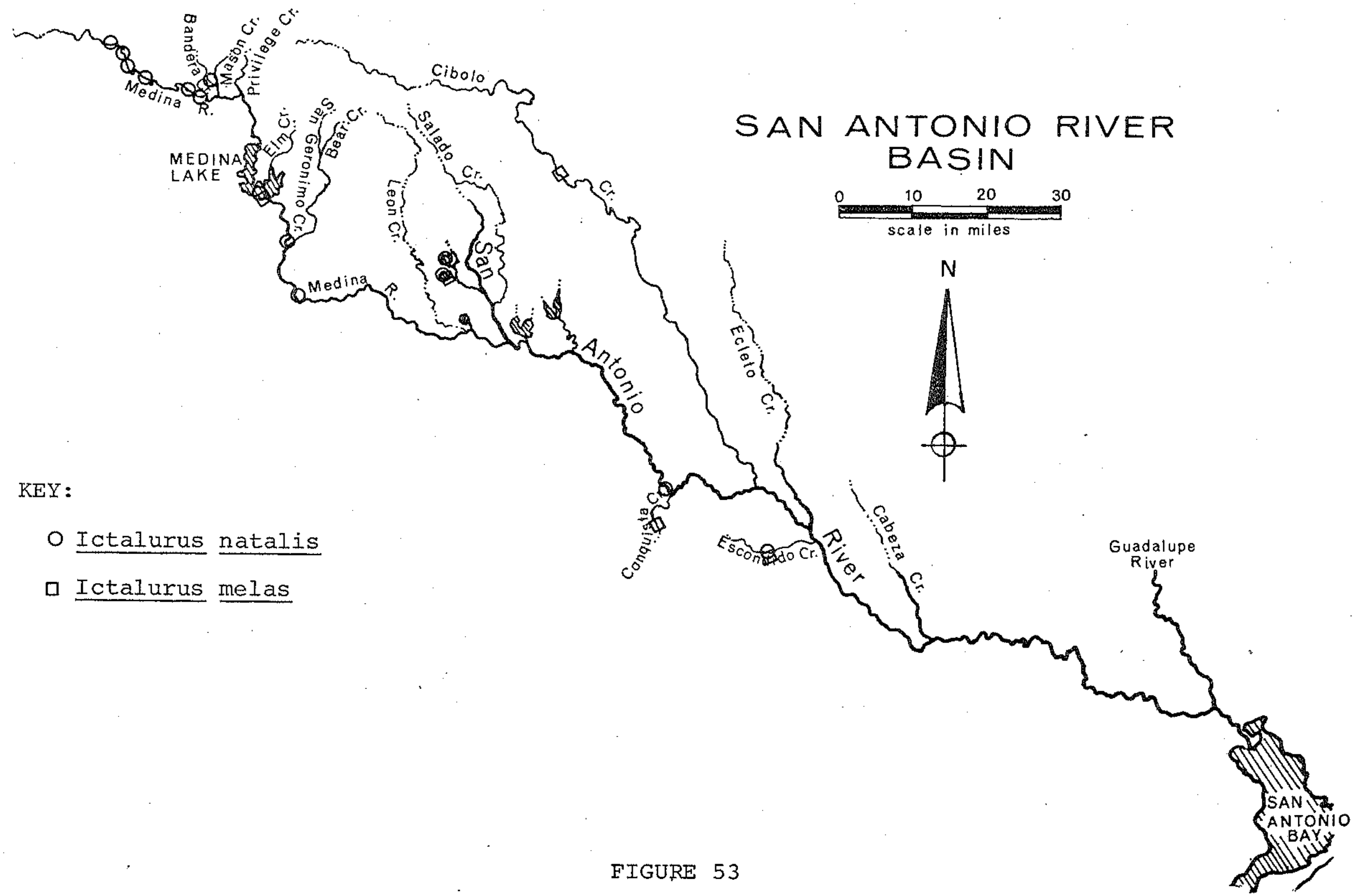
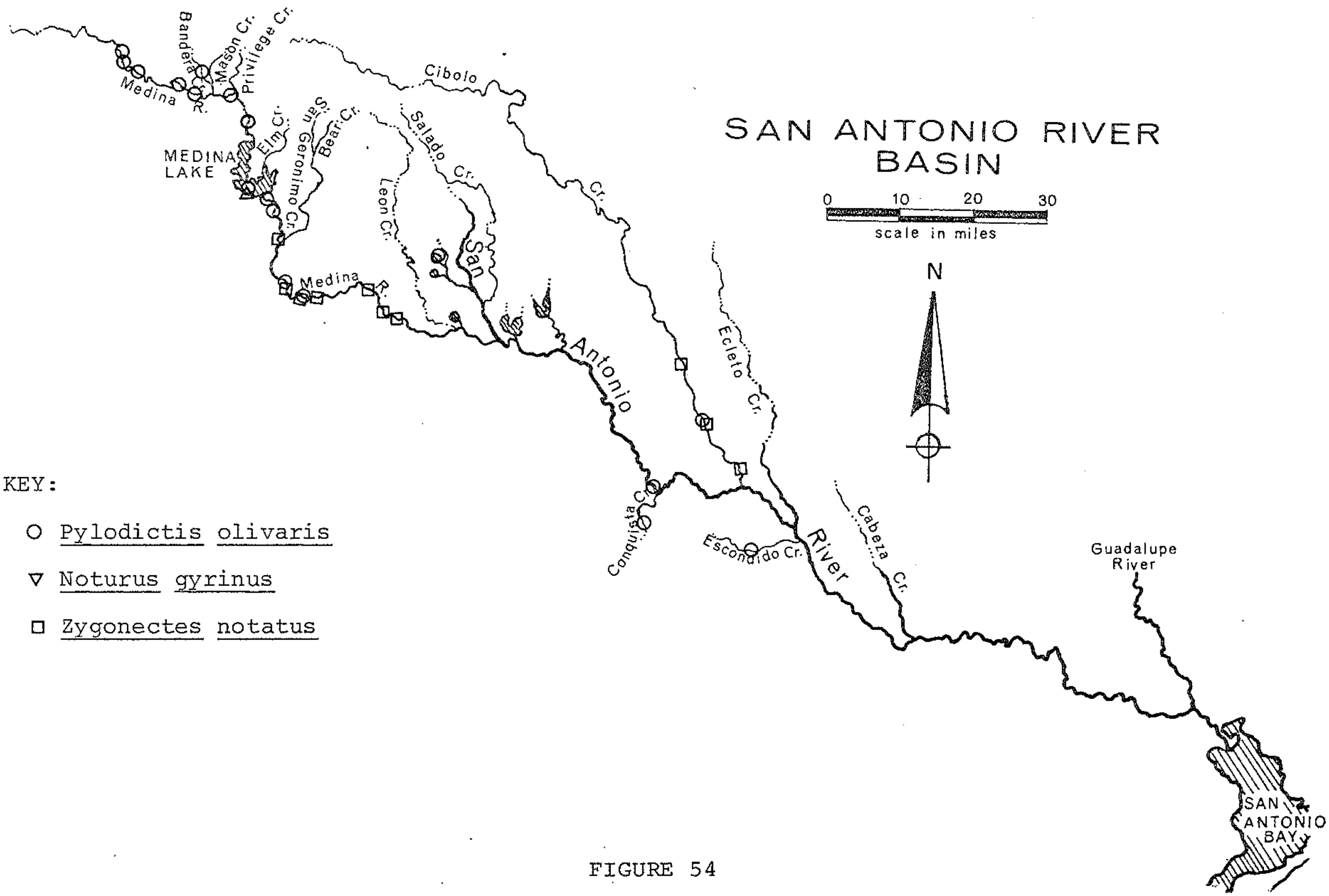

SAN ANTONIO RIVER
BASIN
0 10 20 30
scale in miles
N
KEY:
Ictalurus natalis
Ictalurus melas
Medina R.
Bandera
Mason Cr.
Privilege Cr.
Cibolo Cr.
MEDINA LAKE
Elm Cr.
San Geronimo Cr.
Bear Cr.
Salado Cr.
Leon Cr.
Medina R.
San Antonio River
Ecleto Cr.
Conquista Cr.
Escondido Cr.
Cabeza Cr.
Guadalupe River
SAN ANTONIO BAY

FIGURE 53



KEY:

○ Pylodictis olivaris

▽ Noturus gyrinus

□ Zygonectes notatus

FIGURE 54

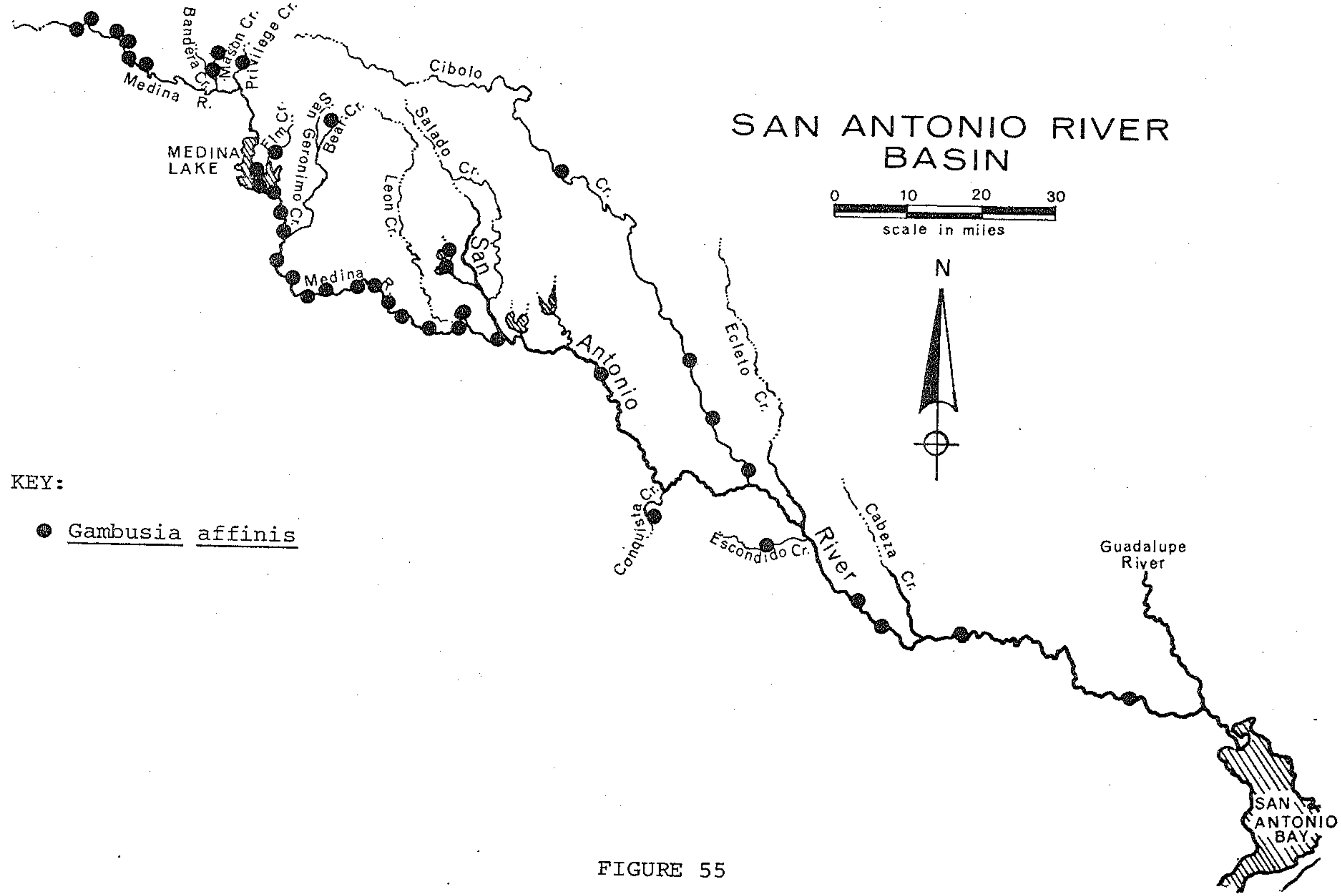

SAN ANTONIO RIVER
BASIN
0
10
20
30
scale in miles
N
Medina R.
Bandera Cr.
Mason Cr.
Privilege Cr.
MEDINA
LAKE
Elm Cr.
San Geronimo Cr.
Bear Cr.
Cibolo
Cr.
Salado
Cr.
Leon Cr.
San
Medina R.
Antonio
River
Ecleto
Cr.
Cabeza
Cr.
Conquista Cr.
Escondido Cr.
Guadalupe
River
SAN
ANTONIO
BAY
KEY:
Gambusia affinis

FIGURE 55

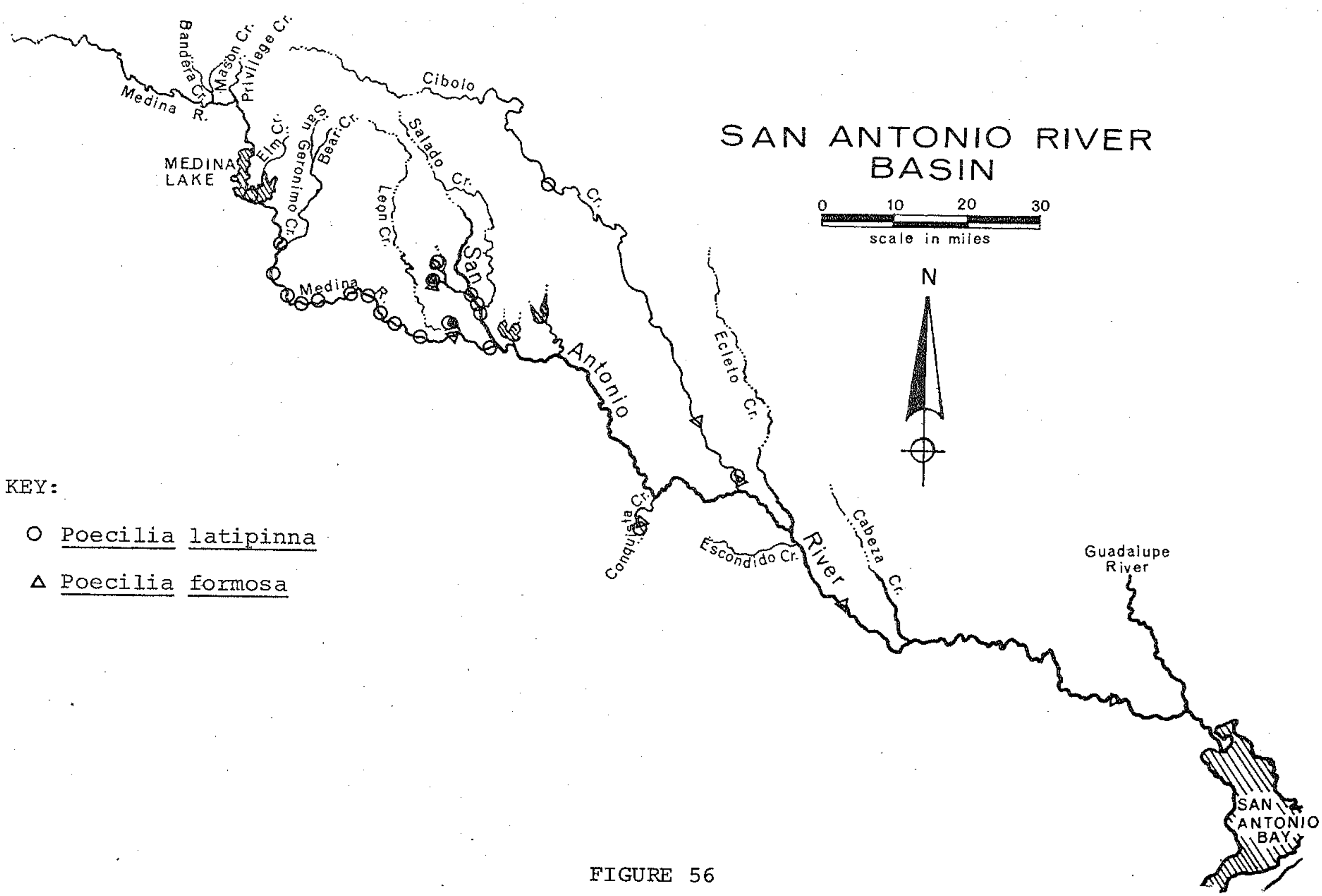

SAN ANTONIO RIVER
BASIN
0 10 20 30
scale in miles
N
KEY:
O Poecilia latipinna
Δ Poecilia formosa
Medina R.
Bandera Cr.
Mason Cr.
Privilege Cr.
MEDINA LAKE
Elm Cr.
San Geronimo Cr.
Bear Cr.
Leon Cr.
Salado Cr.
Cibolo Cr.
Medina R.
San
Antonio
River
Ecleto Cr.
Conquista Cr.
Escondido Cr.
Cabeza Cr.
Guadalupe River
SAN ANTONIO BAY

FIGURE 56

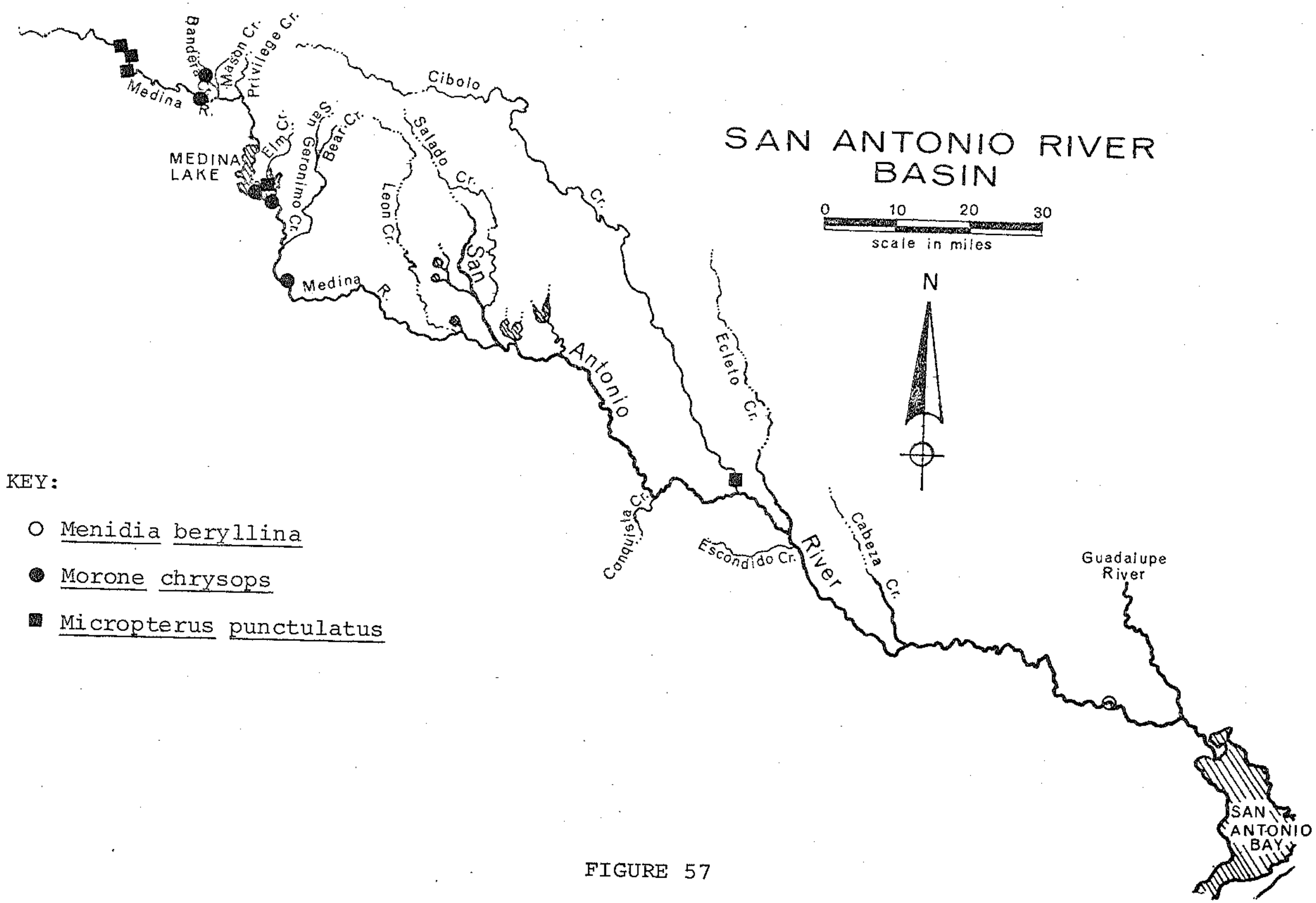
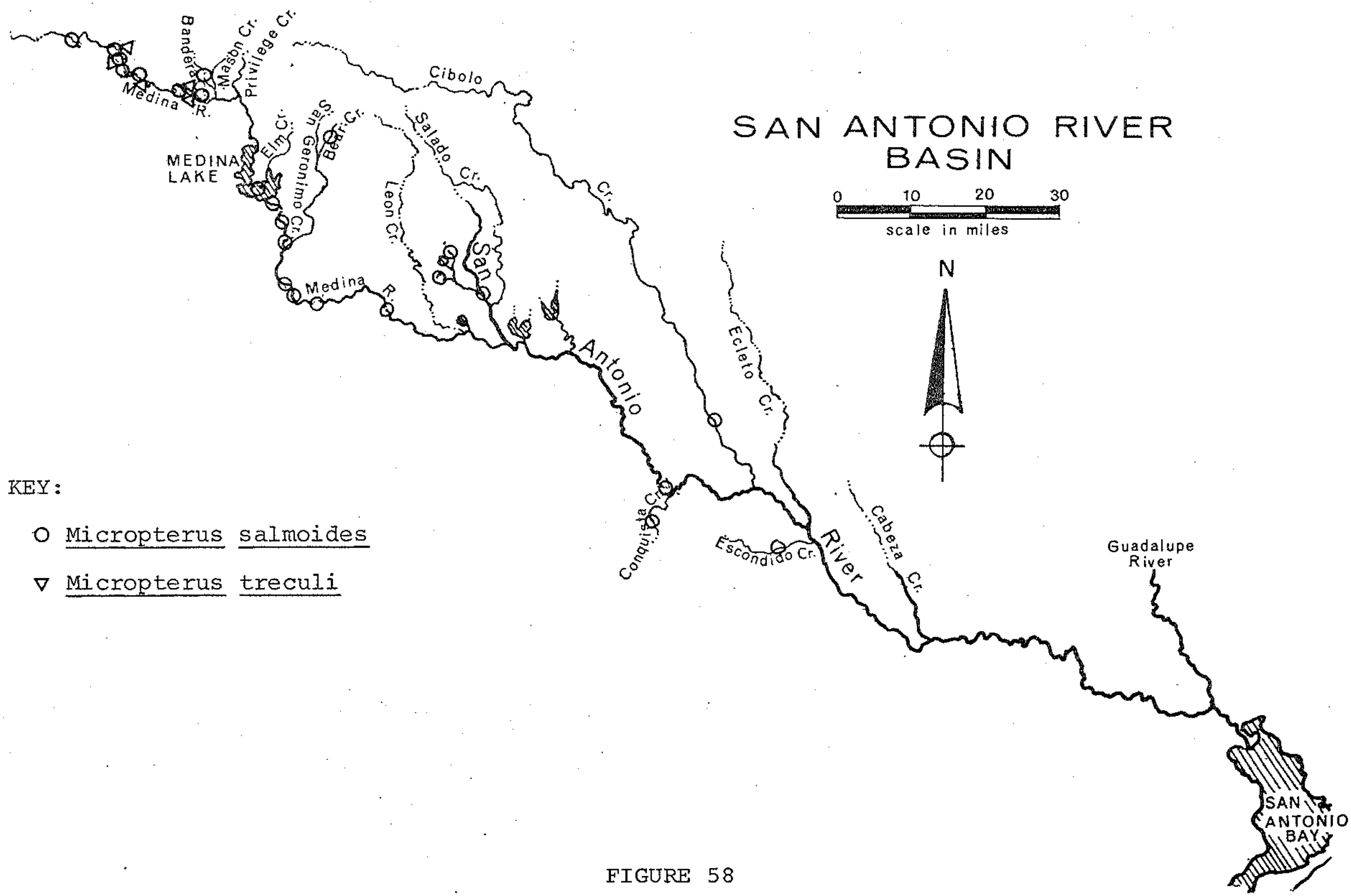

SAN ANTONIO RIVER
BASIN
0
10
20
30
scale in miles
N
KEY:
Menidia beryllina
Morone chrysops
Micropterus punctulatus
Bandera Cr.
Mason Cr.
Privilege Cr.
Medina R.
Cibolo
Cr.
Elm Cr.
San Geronimo Cr.
Bear Cr.
Salado Cr.
Leon Cr.
MEDINA
LAKE
Medina R.
San
Antonio
River
Ecleto Cr.
Conquista Cr.
Escondido Cr.
Cabeza Cr.
Guadalupe
River
SAN
ANTONIO
BAY

FIGURE 57

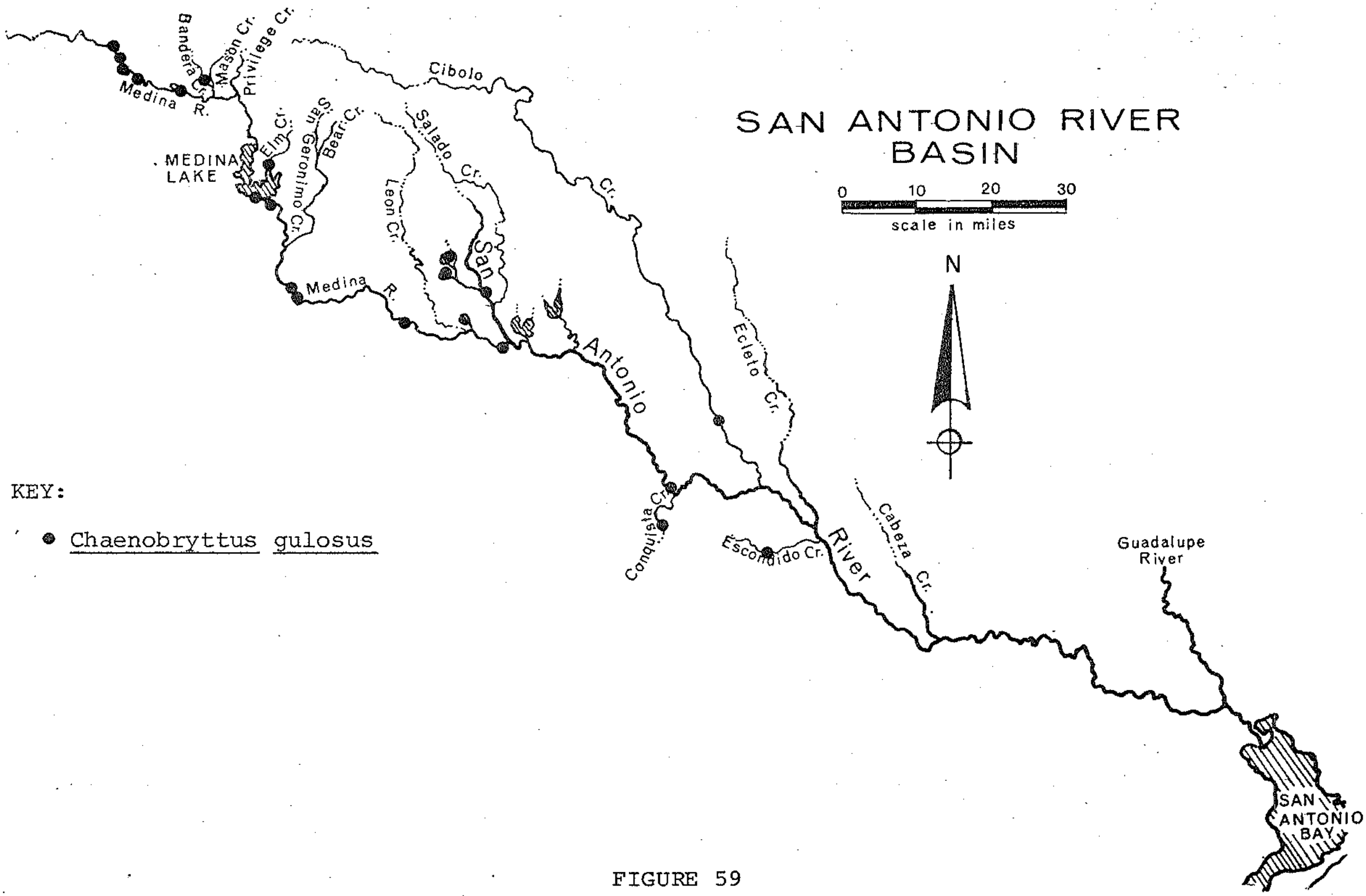


KEY:

O *Micropterus salmoides*

▽ *Micropterus treculi*

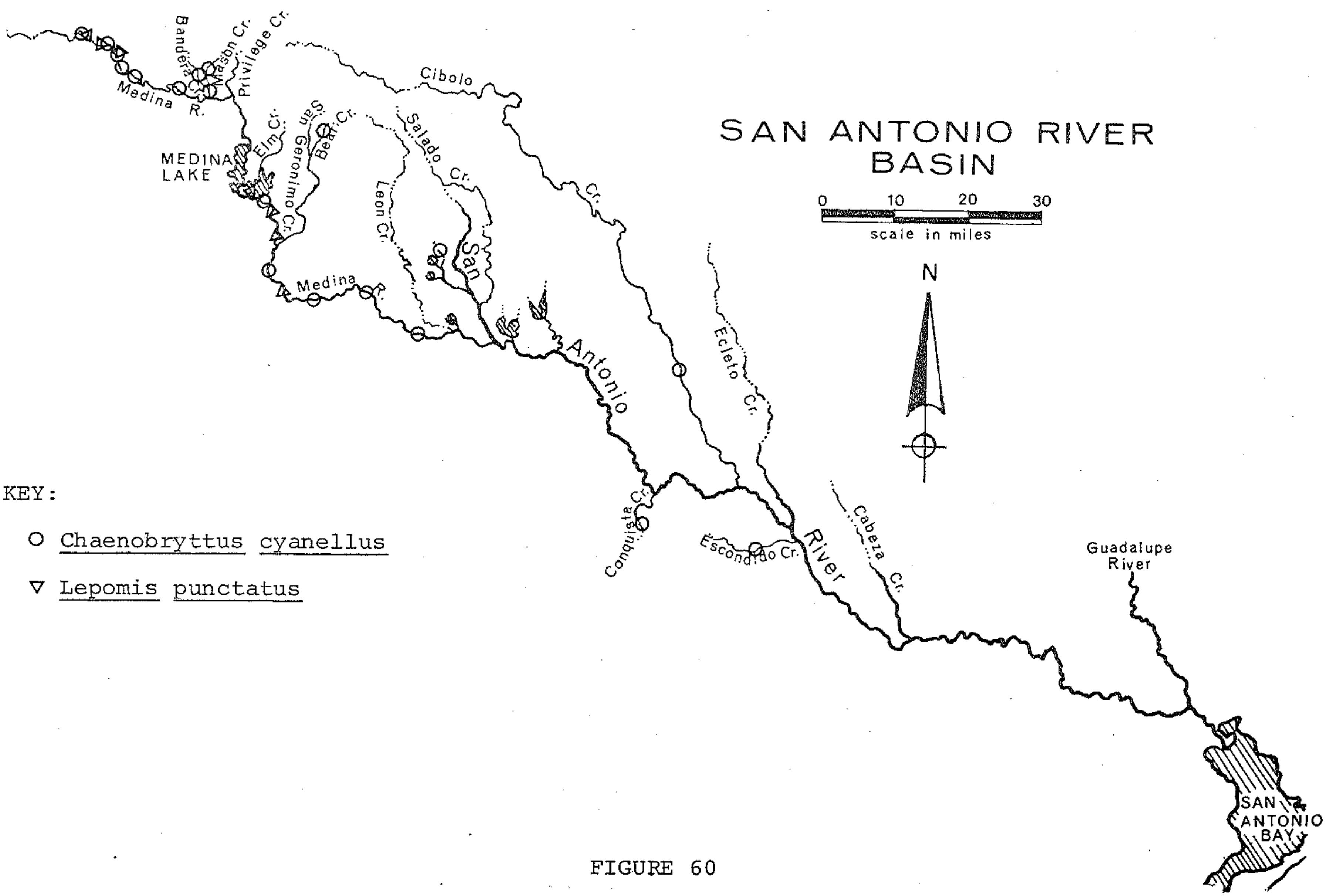
FIGURE 58



KEY:

● *Chaenobryttus gulosus*

FIGURE 59



KEY:

○ Chaenobryttus cyanellus

▽ Lepomis punctatus

FIGURE 60

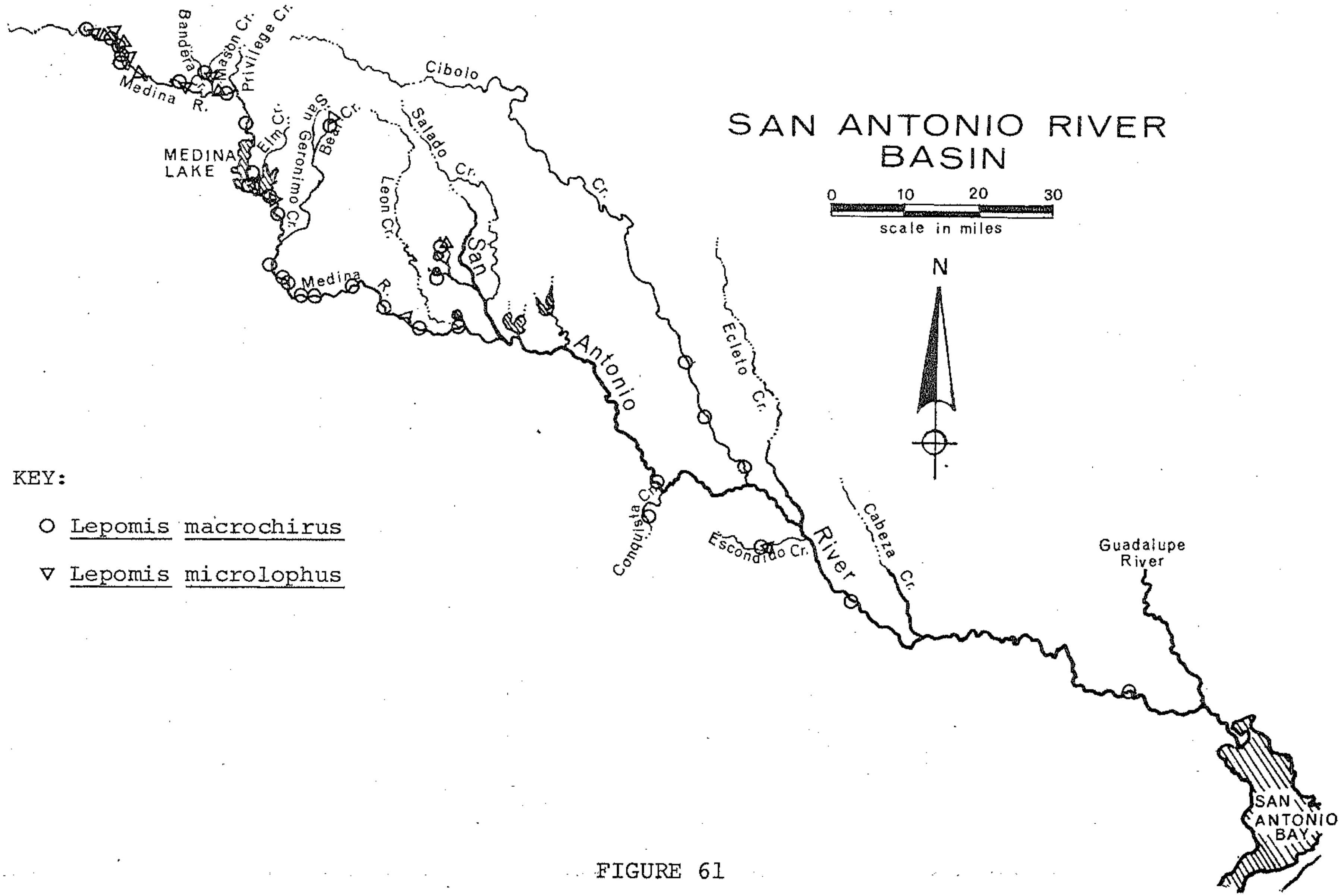

SAN ANTONIO RIVER
BASIN
0 10 20 30
scale in miles
N
KEY:
Lepomis macrochirus
Lepomis microlophus
Medina R.
Bandera Cr.
Mason Cr.
Privilege Cr.
Cibolo Cr.
MEDINA LAKE
Elm Cr.
San Geronimo Cr.
Bear Cr.
Salado Cr.
Leon Cr.
San Antonio River
Medina R.
Ecleto Cr.
Conquista Cr.
Escondido Cr.
Cabeza Cr.
Guadalupe River
SAN ANTONIO BAY

FIGURE 61

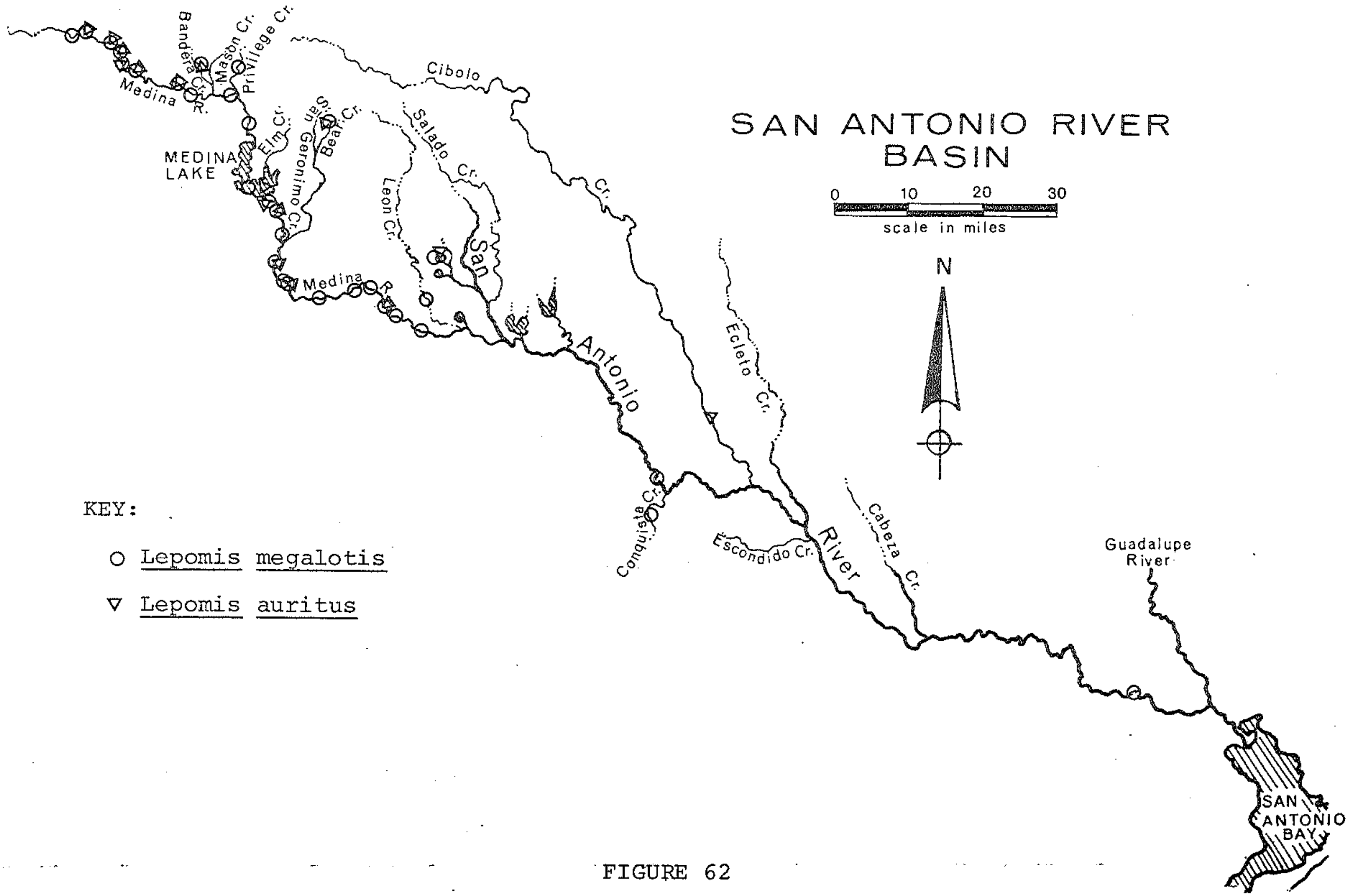
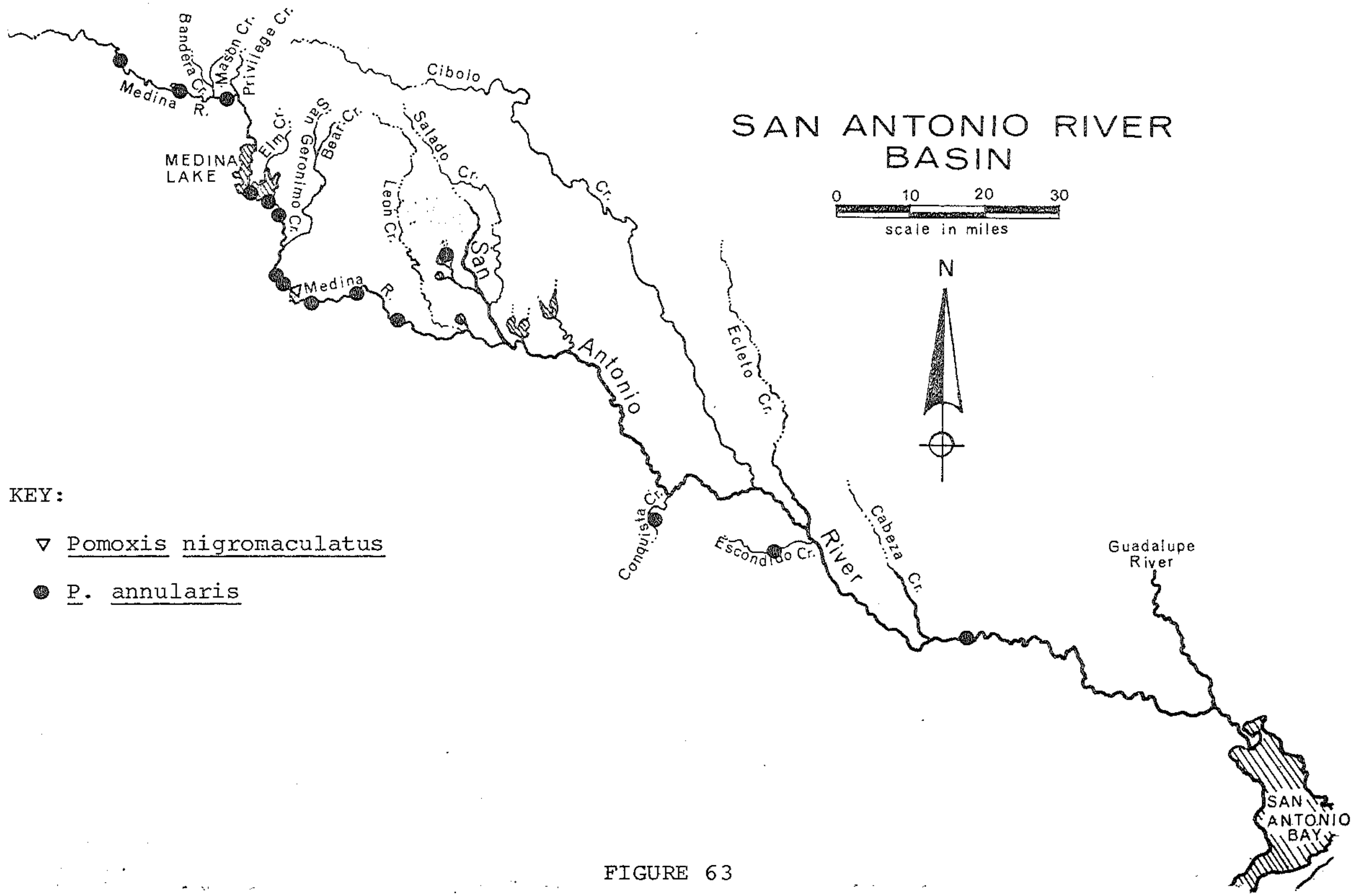

SAN ANTONIO RIVER
BASIN
0
10
20
30
scale in miles
N
KEY:
○ Lepomis megalotis
▽ Lepomis auritus
Medina R.
Bandera Cr.
Mason Cr.
Privilege Cr.
Cibolo
Cr.
Elm Cr.
San Geronimo Cr.
Bear Cr.
MEDINA
LAKE
Leon Cr.
Salado Cr.
San
Medina R.
Antonio
River
Conquista Cr.
Ecleto Cr.
Escondido Cr.
Cabeza Cr.
Guadalupe
River
SAN
ANTONIO
BAY

FIGURE 62



KEY:

▽ Pomoxis nigromaculatus

● P. annularis

FIGURE 63

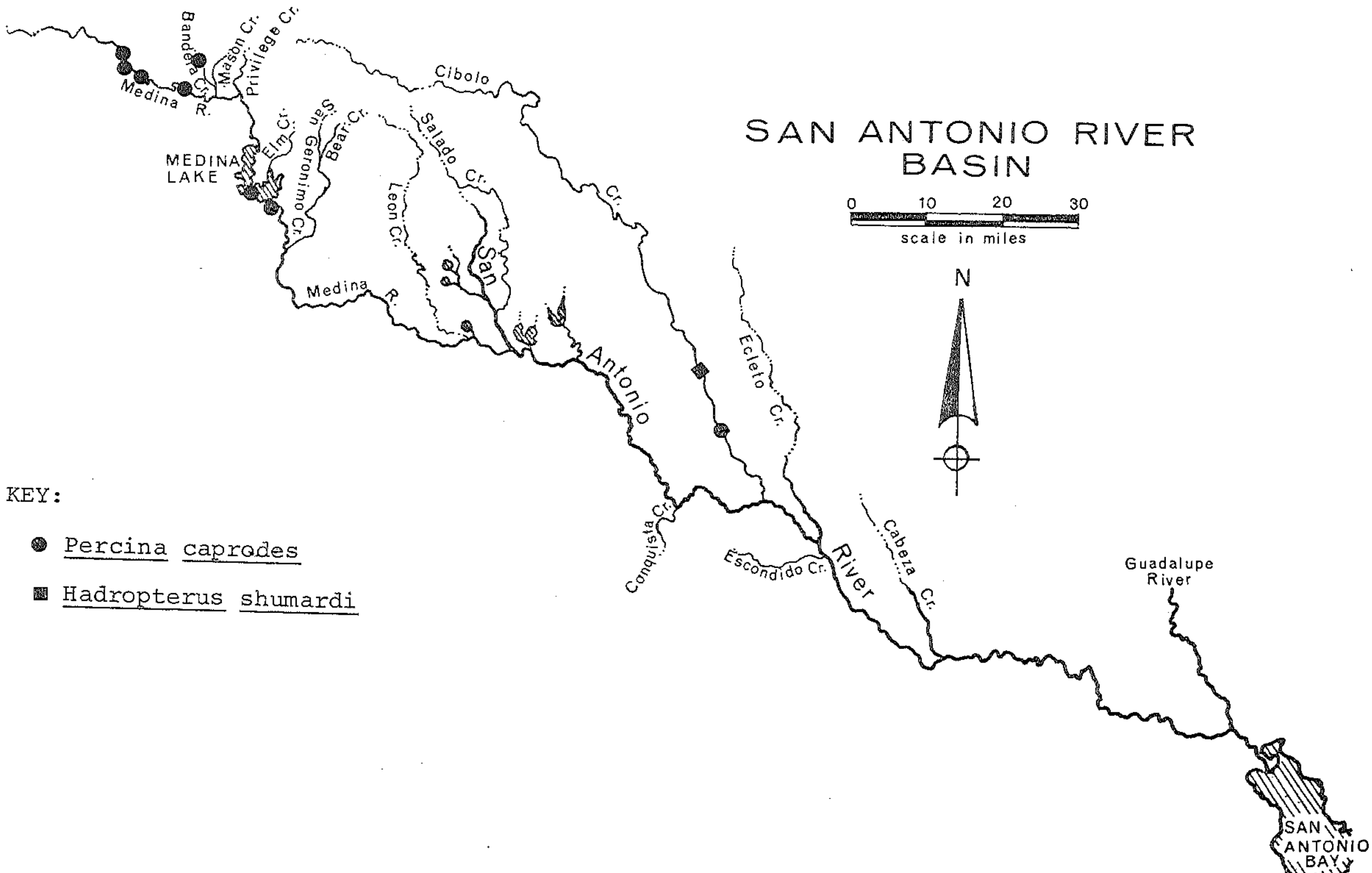
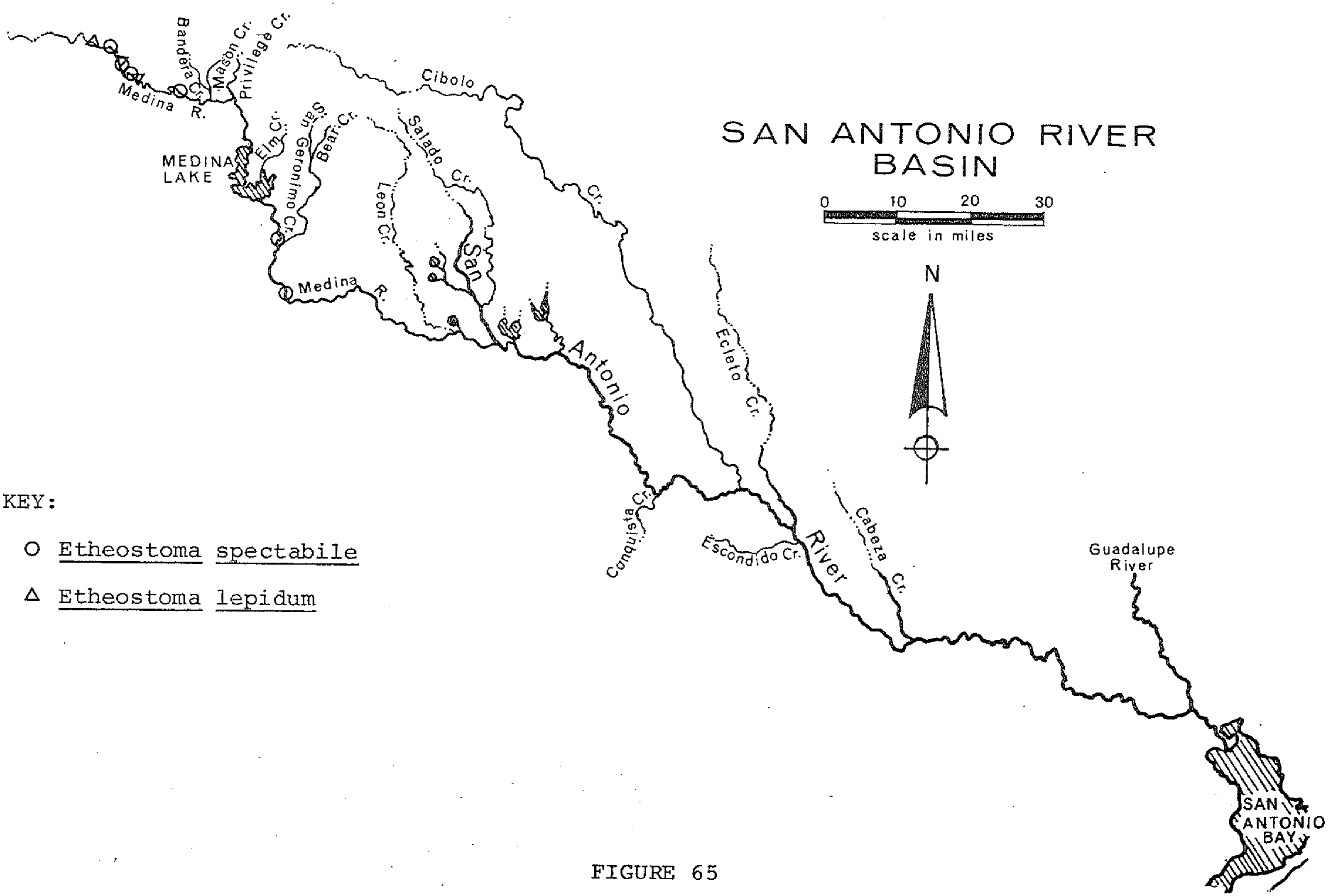

SAN ANTONIO RIVER BASIN
0 10 20 30
scale in miles
N
KEY:
Percina caprodes
Hadropterus shumardi
Medina R.
Bandera Cr.
Mason Cr.
Privilege Cr.
Cibolo Cr.
MEDINA LAKE
Elm Cr.
San Geronimo Cr.
Bear Cr.
Salado Cr.
Leon Cr.
San Antonio River
Medina R.
Ecleto Cr.
Conquista Cr.
Escondido Cr.
Cabeza Cr.
Guadalupe River
SAN ANTONIO BAY

FIGURE 64



KEY:

○ Etheostoma spectabile

△ Etheostoma lepidum

FIGURE 65

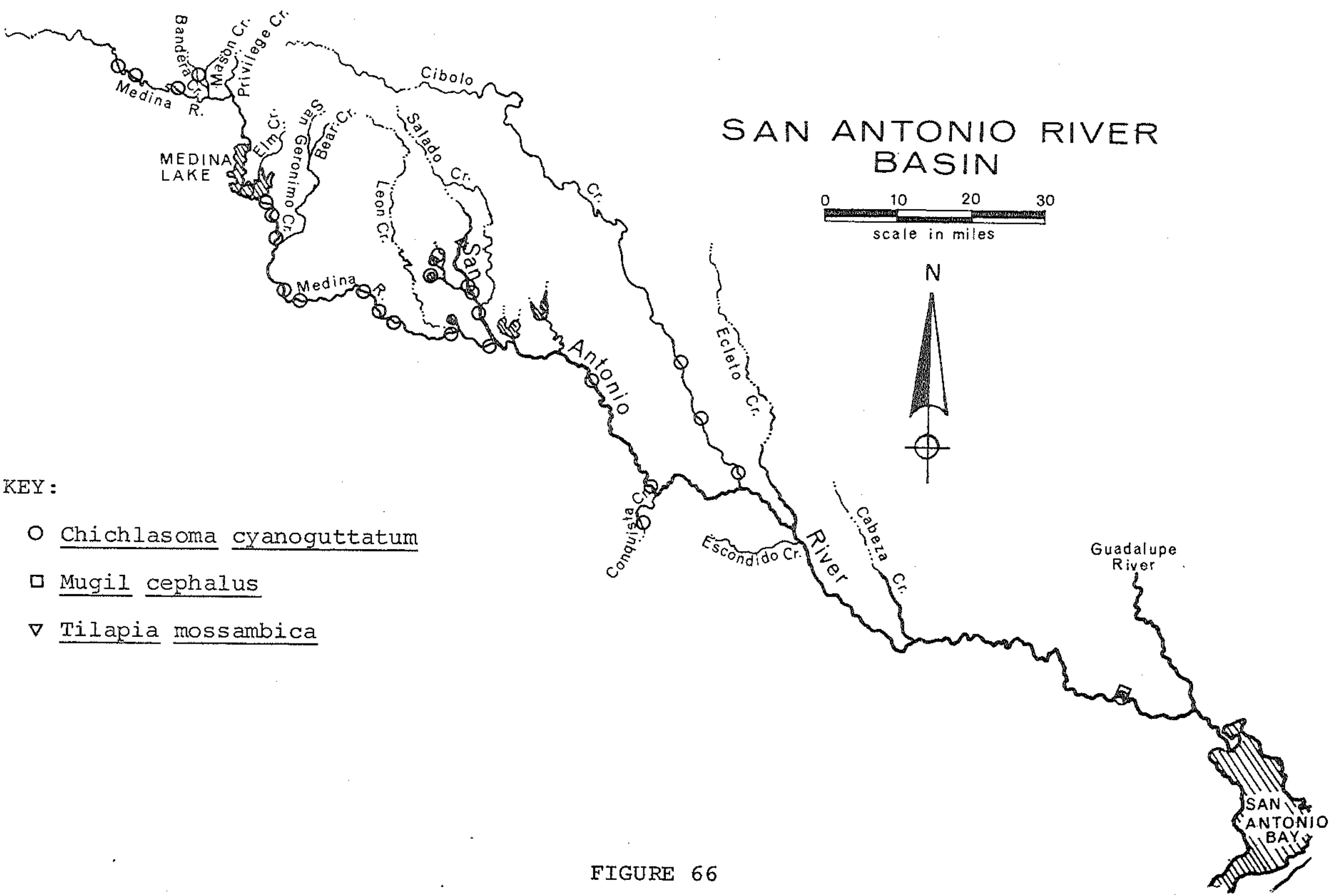

SAN ANTONIO RIVER
BASIN
0 10 20 30
scale in miles
N
Medina R.
Bandera Cr.
Mason Cr.
Privilege Cr.
Cibolo Cr.
MEDINA LAKE
Elm Cr.
San Geronimo Cr.
Bear Cr.
Salado Cr.
Leon Cr.
Medina R.
San Antonio River
Ecleto Cr.
Conquista Cr.
Escondido Cr.
Cabeza Cr.
Guadalupe River
SAN ANTONIO BAY
KEY:
○ Chichlasoma cyanoguttatum
□ Mugil cephalus
▽ Tilapia mossambica

FIGURE 66

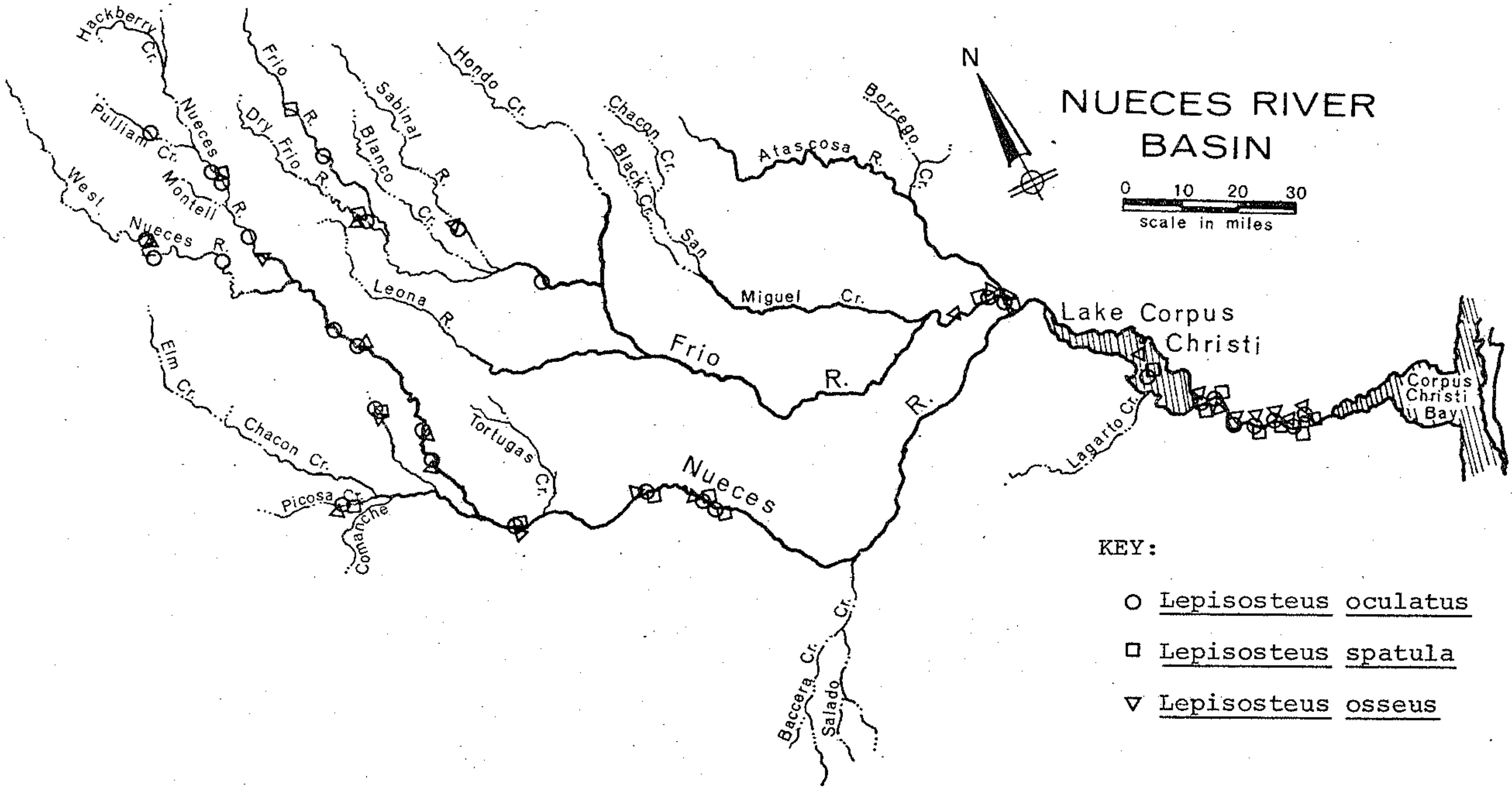

NUECES RIVER BASIN
N
0 10 20 30
scale in miles
KEY:
Lepisosteus oculatus
Lepisosteus spatula
Lepisosteus osseus
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell
West Nueces R.
Frio R.
Dry Frio R.
Blanco Cr.
Sabinal R.
Hondo Cr.
Leona R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Atascosa R.
Borrego Cr.
Frio R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Nueces R.
Baccera Cr.
Salado
Cr.
Lagarto Cr.
Lake Corpus Christi
Corpus Christi Bay

FIGURE 67

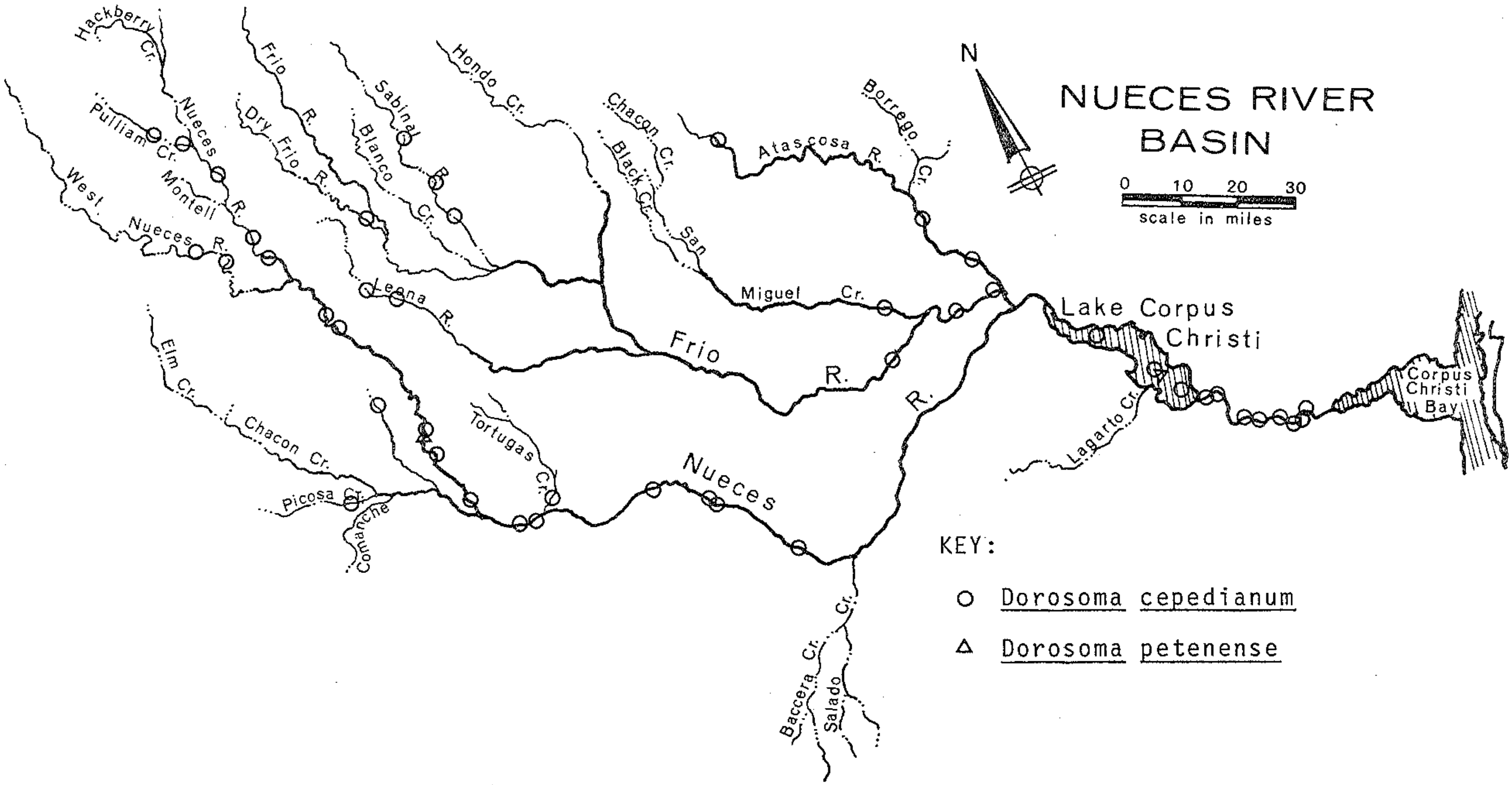

NUECES RIVER BASIN
N
0 10 20 30
scale in miles
KEY:
○ Dorosoma cepedianum
△ Dorosoma petenense
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Nueces R.
Frio R.
Atascosa R.
Borrego Cr.
San Miguel Cr.
Chacon Cr.
Black Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Nueces R.
Hackberry Cr.
Pulliam Cr.
Montell Cr.
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Baccera Cr.
Salado Cr.

Figure 68

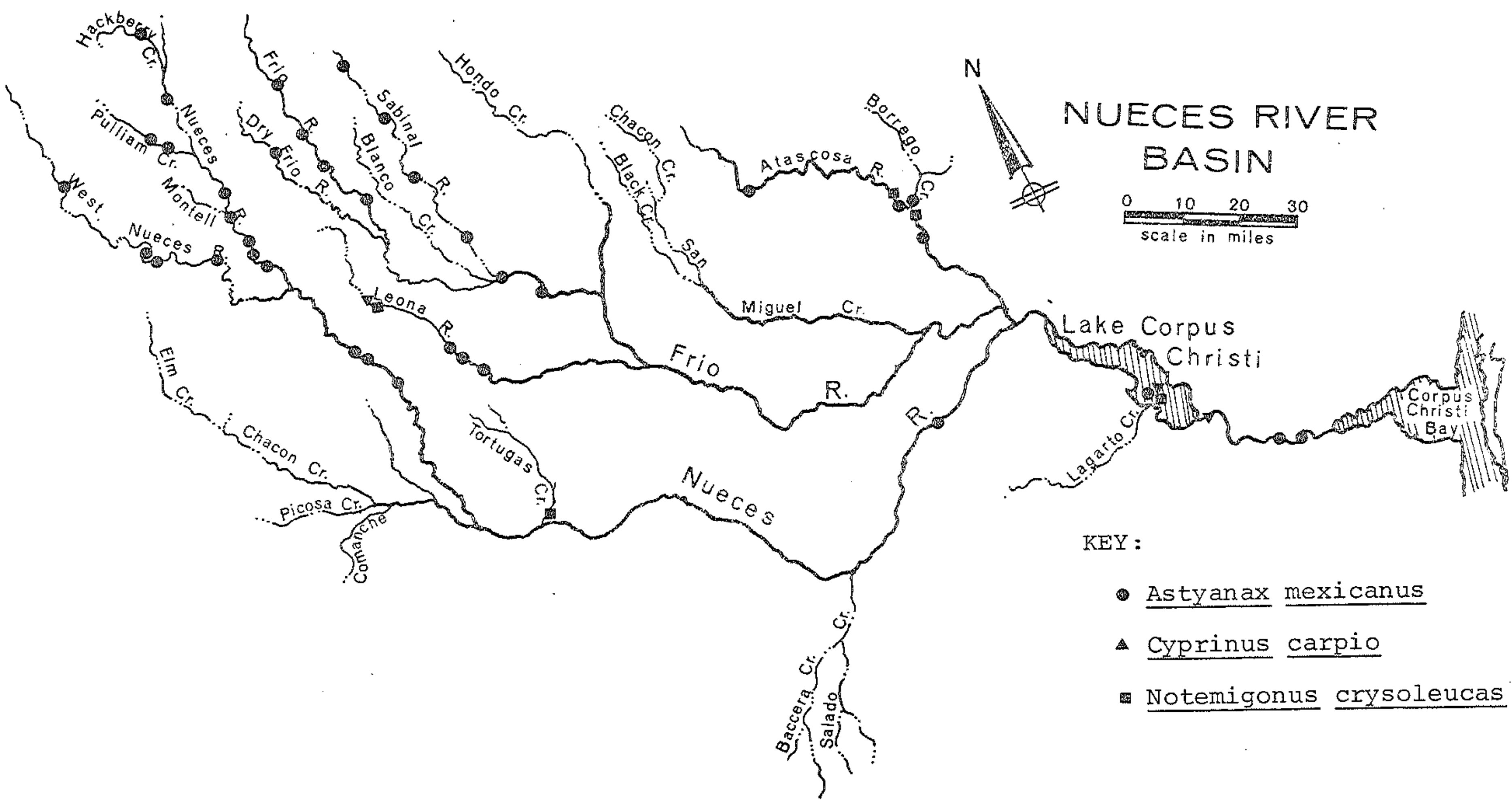

NUECES RIVER
BASIN
N
0 10 20 30
scale in miles
Hackberry Cr.
Nueces
Pulliam Cr.
Montell
R.
West
Nueces
R.
Frio
R.
Dry Frio R.
Sabinal
R.
Blanco
Cr.
Hondo Cr.
Leona
R.
Chacon Cr.
Black Cr.
San
Miguel Cr.
Atascosa R.
Borrego Cr.
Frio R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Nueces
R.
Cr.
Baccera Cr.
Salado
Lake Corpus Christi
Lagarto Cr.
Corpus Christi Bay
KEY:
Astyanax mexicanus
Cyprinus carpio
Notemigonus crysoleucas

FIGURE 69

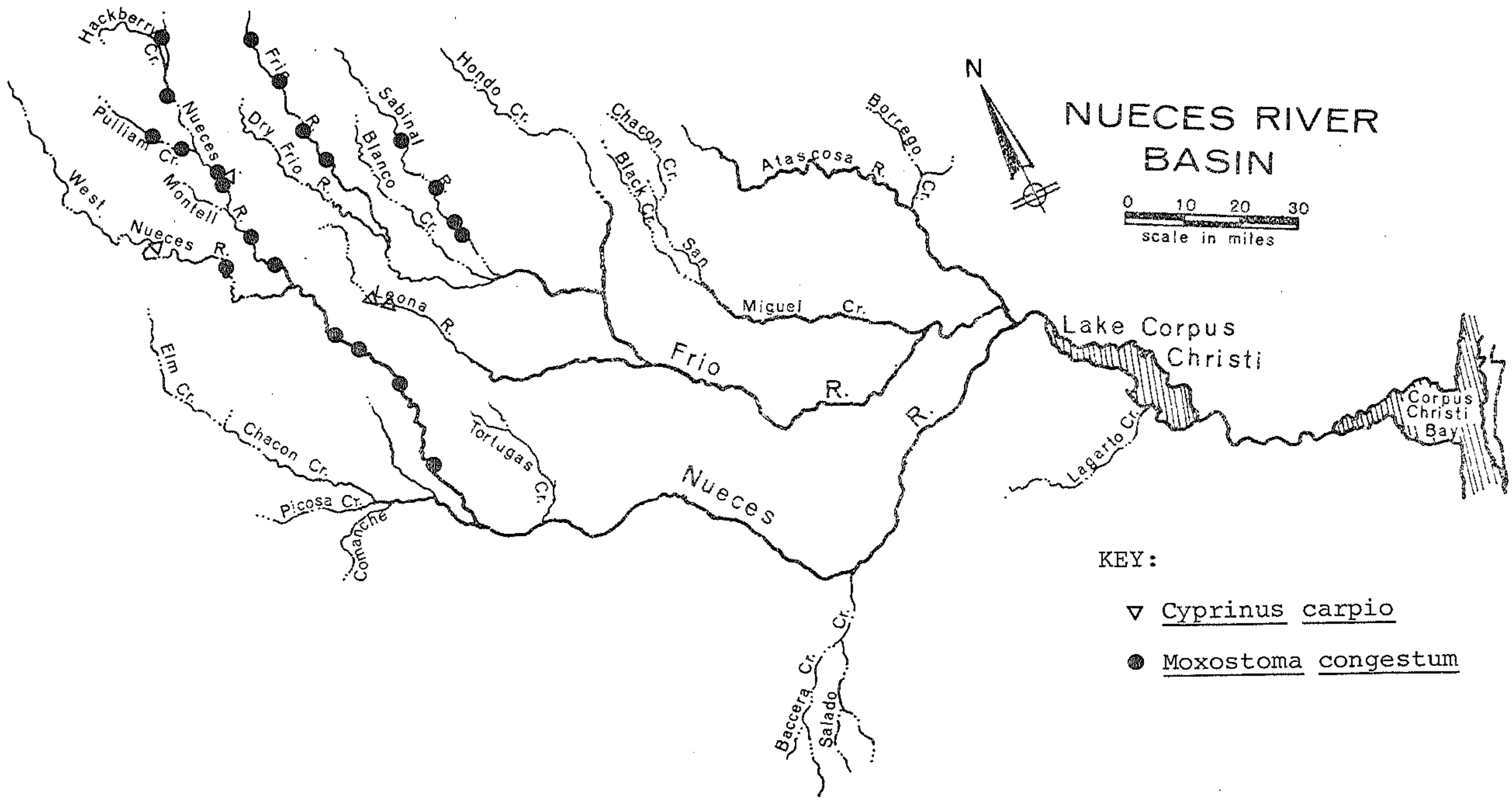
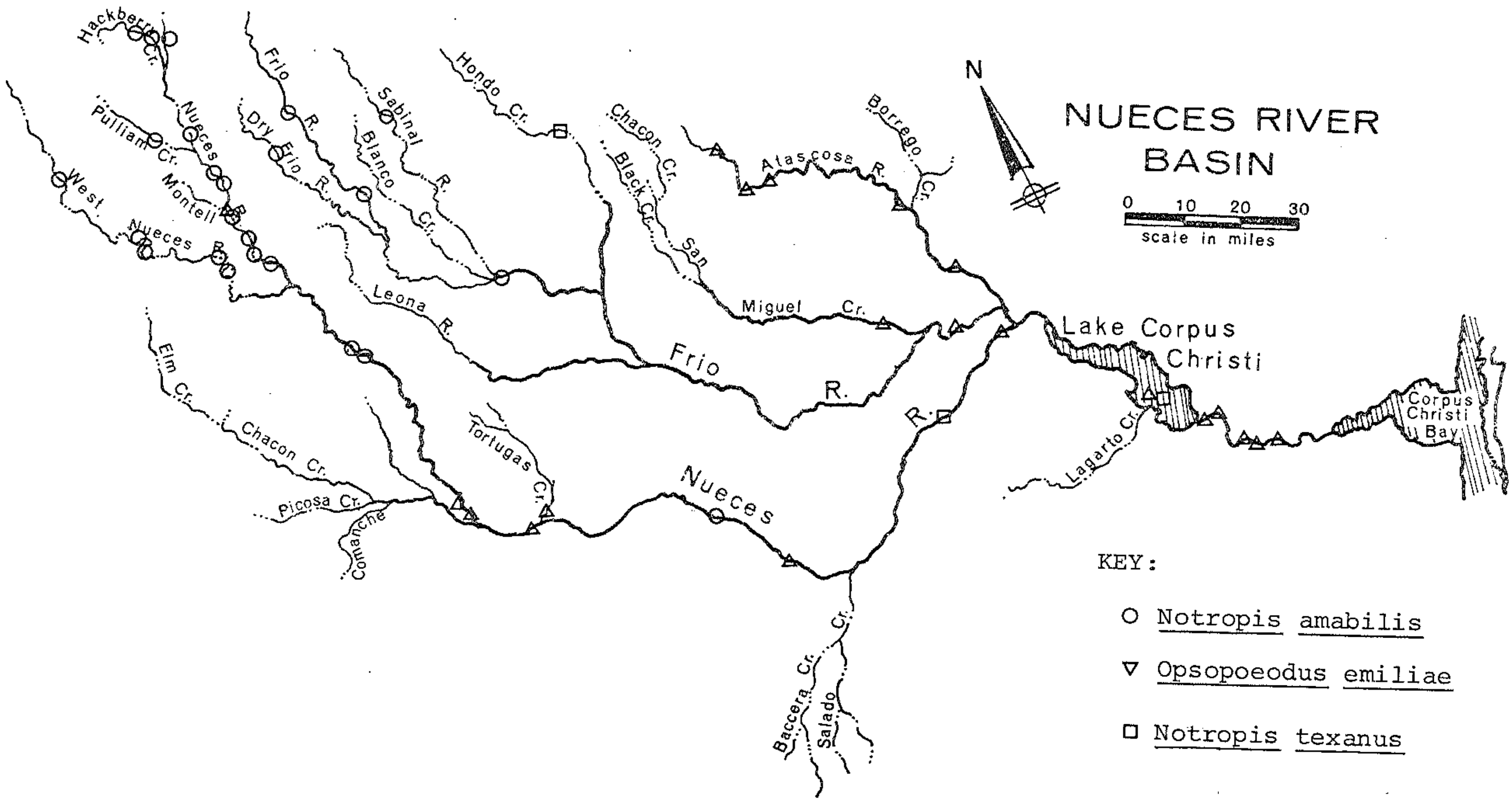

NUECES RIVER
BASIN
N
0 10 20 30
scale in miles
KEY:
Cyprinus carpio
Moxostoma congestum
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Atascosa R.
Borrego Cr.
Chacon Cr.
Black Cr.
San Miguel Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Nueces R.
Frio R.
Baccera Cr.
Salado
Cr.

FIGURE 70



NUECES RIVER BASIN
N
0 10 20 30
scale in miles
KEY:
Notropis amabilis
Opsopoeodus emiliae
Notropis texanus
Lake Corpus Christi
Corpus Christi Bay
Hackberry Cr.
Nueces R.
West Nueces R.
Pulliam Cr.
Montell
Frio R.
Dry Frio R.
Sabinal R.
Blanco Cr.
Hondo Cr.
Chacon Cr.
Black Cr.
San Miguel Cr.
Atascosa R.
Borrego Cr.
Leona R.
Frio R.
Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Lagarto Cr.
Baccera Cr.
Salado
Cr.

FIGURE 71

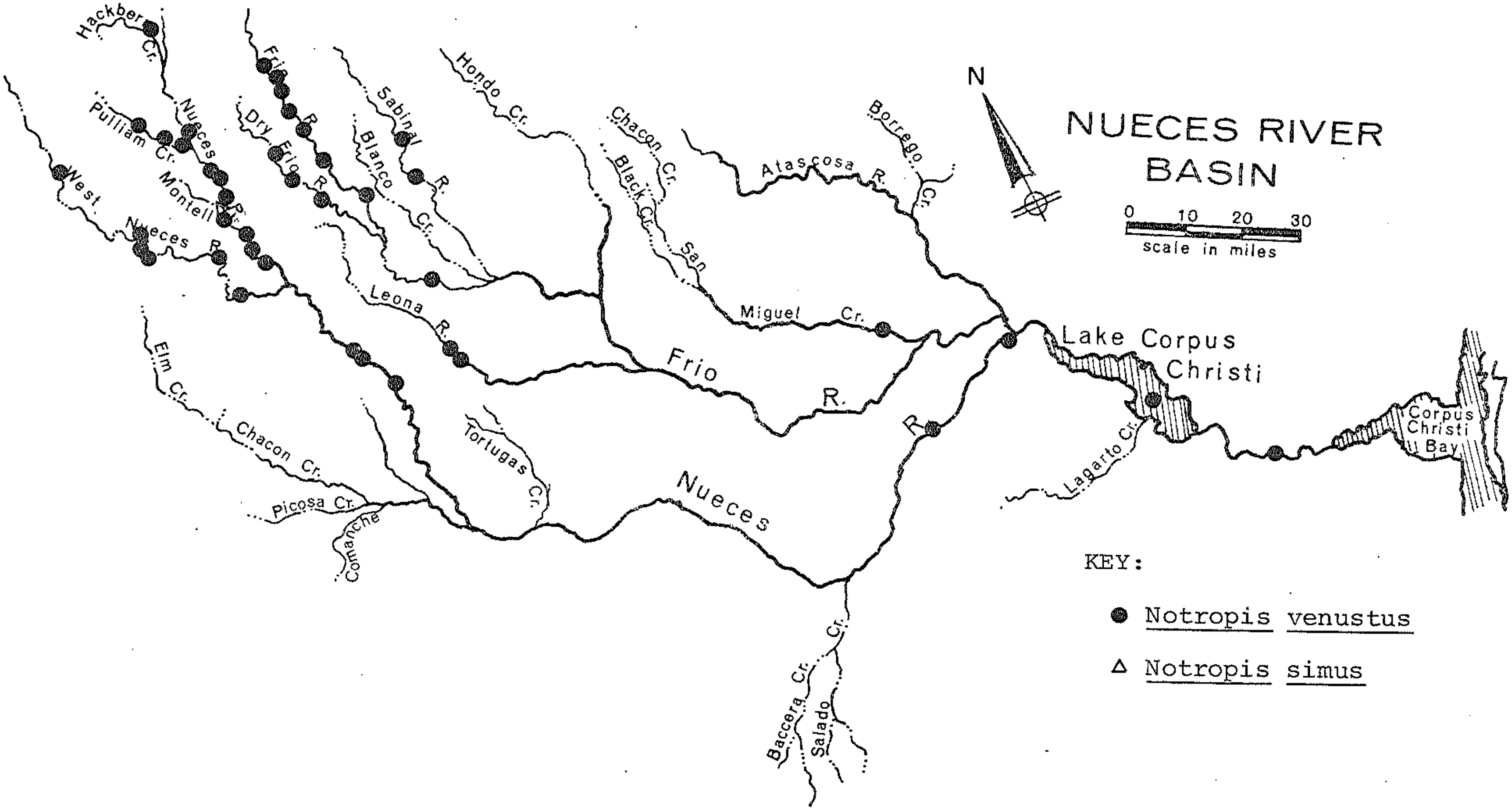

NUECES RIVER BASIN
N
0 10 20 30
scale in miles
KEY:
Notropis venustus
Notropis simus
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Borrego Cr.
Atascosa R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Nueces R.
Hackberry Cr.
Pulliam Cr.
Montell Cr.
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Nueces
Frio
R.
Baccera Cr.
Salado
Cr.

FIGURE 72

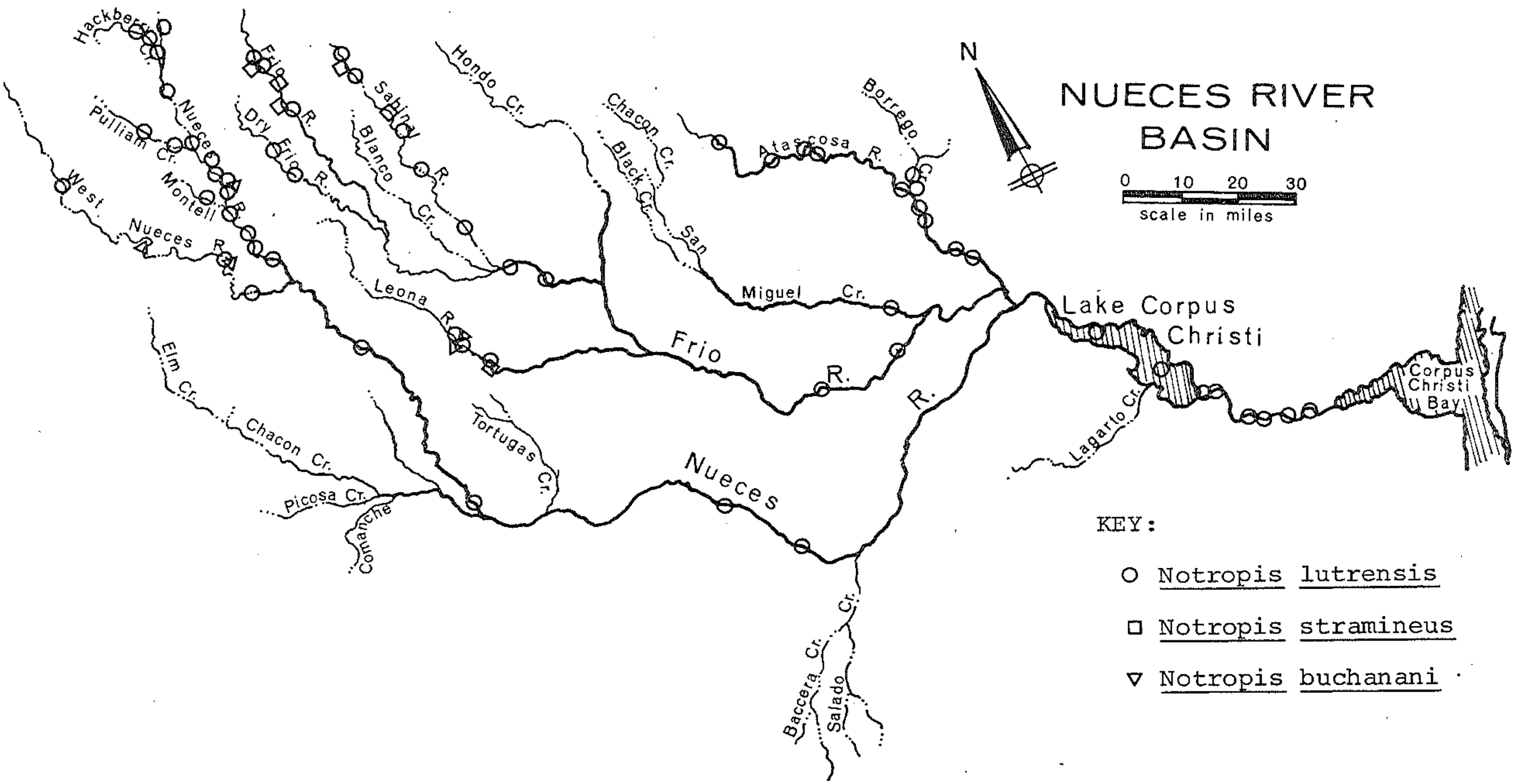

NUECES RIVER
BASIN
N
0 10 20 30
scale in miles
Lake Corpus Christi
Corpus Christi Bay
Hackberry Cr.
Nueces R.
Frio R.
Dry Frio R.
Sabinal R.
Blanco Cr.
Hondo Cr.
Chacon Cr.
Black Cr.
San Miguel Cr.
Atascosa R.
Borrego Cr.
Pulliam Cr.
Montell Cr.
West Nueces R.
Leona R.
Frio R.
Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Lagarto Cr.
Baccera Cr.
Salado
Cr.
KEY:
Notropis lutrensis
Notropis stramineus
Notropis buchanani

FIGURE 73

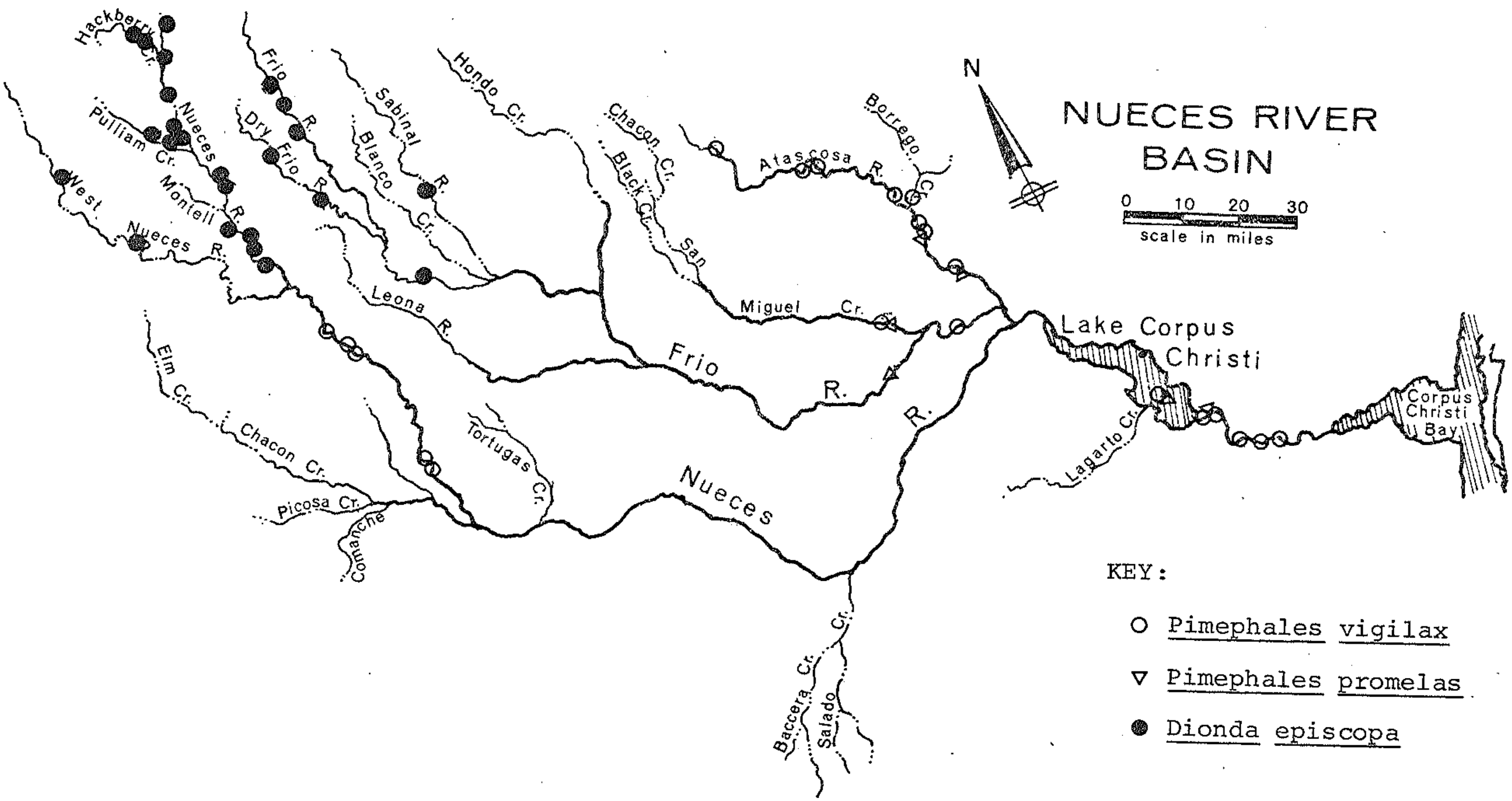

NUECES RIVER BASIN
0 10 20 30
scale in miles
N
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Atascosa R.
Borrego Cr.
Chacon Cr.
Black Cr.
San Miguel Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell Cr.
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Nueces R.
Baccera Cr.
Salado
Cr.
KEY:
Pimephales vigilax
Pimephales promelas
Dionda episcopa

FIGURE 74

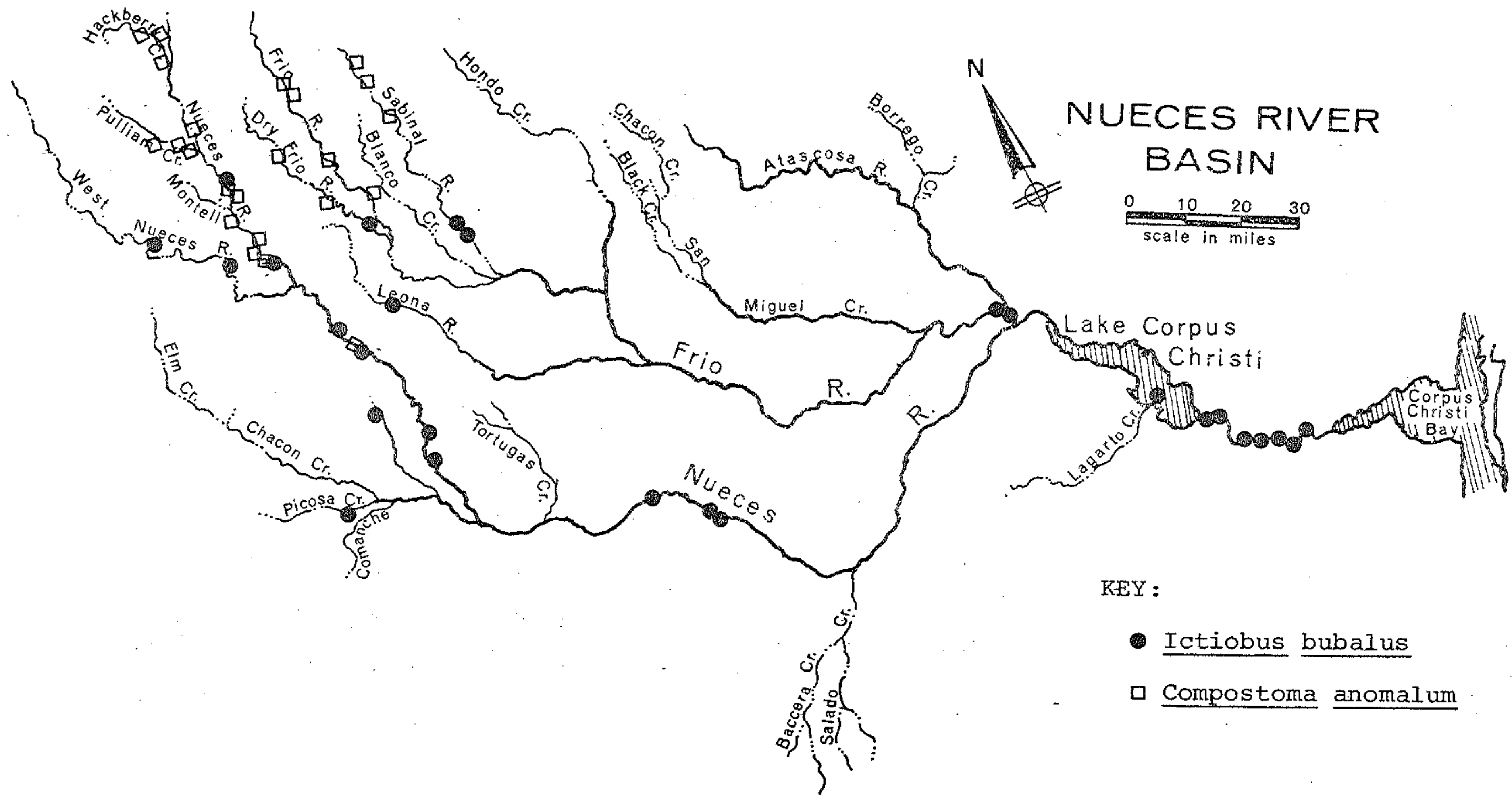

NUECES RIVER
BASIN
N
0 10 20 30
scale in miles
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Borrego Cr.
Atascosa R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Nueces R.
Hackberry Cr.
Pulliam Cr.
Montell
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Frio R.
Nueces R.
Baccera Cr.
Salado Cr.
KEY:
Ictiobus bubalus
Compostoma anomalum

FIGURE 75

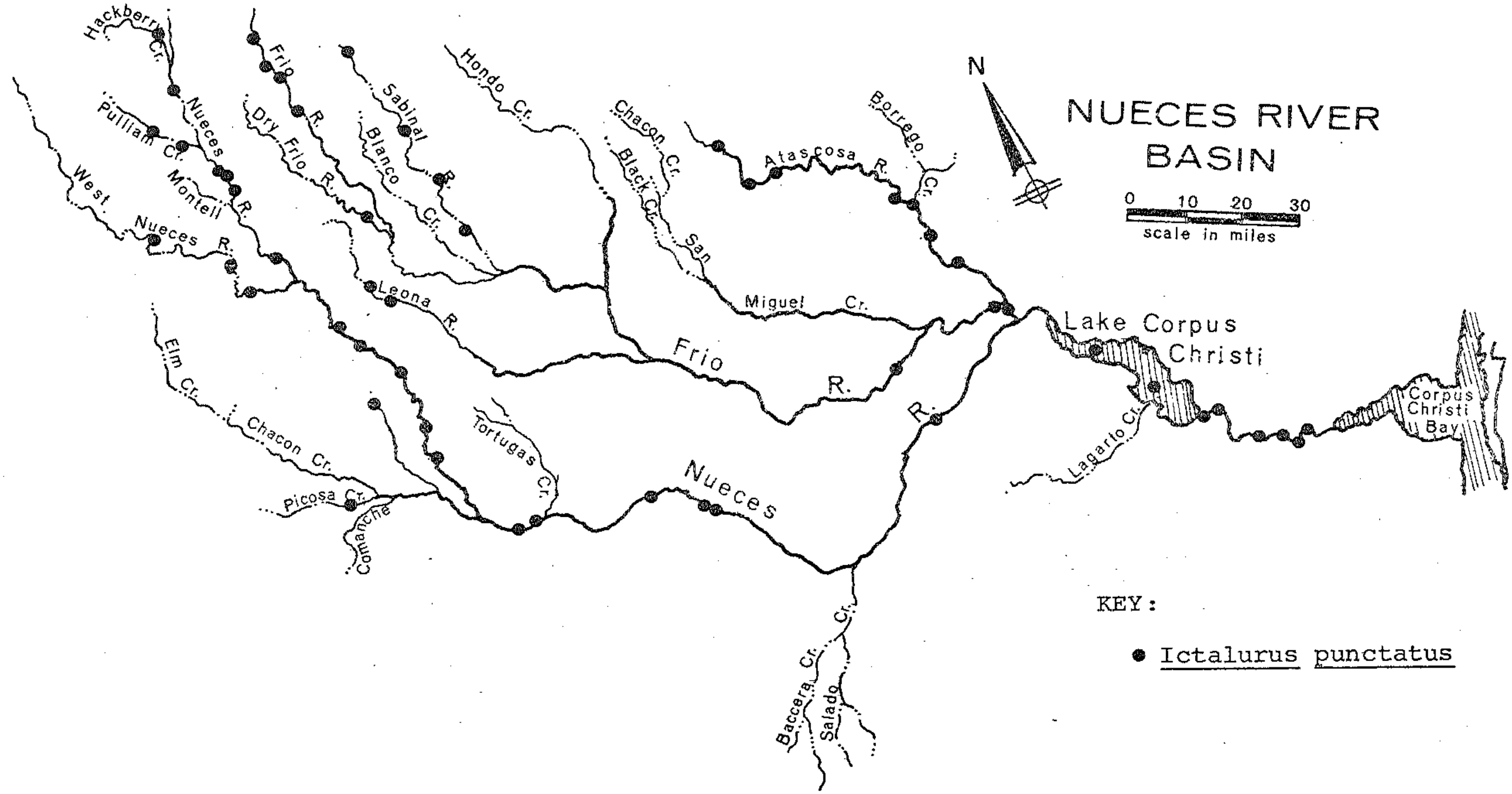

NUECES RIVER BASIN
N
0 10 20 30
scale in miles
KEY:
Ictalurus punctatus
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell
West Nueces R.
Frio R.
Dry Frio R.
Sabinal R.
Blanco Cr.
Hondo Cr.
Leona R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Nueces R.
Frio R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Atascosa R.
Borrego Cr.
Lake Corpus Christi
Lagarto Cr.
Corpus Christi Bay
Cr.
Baccera Cr.
Salado

FIGURE 76

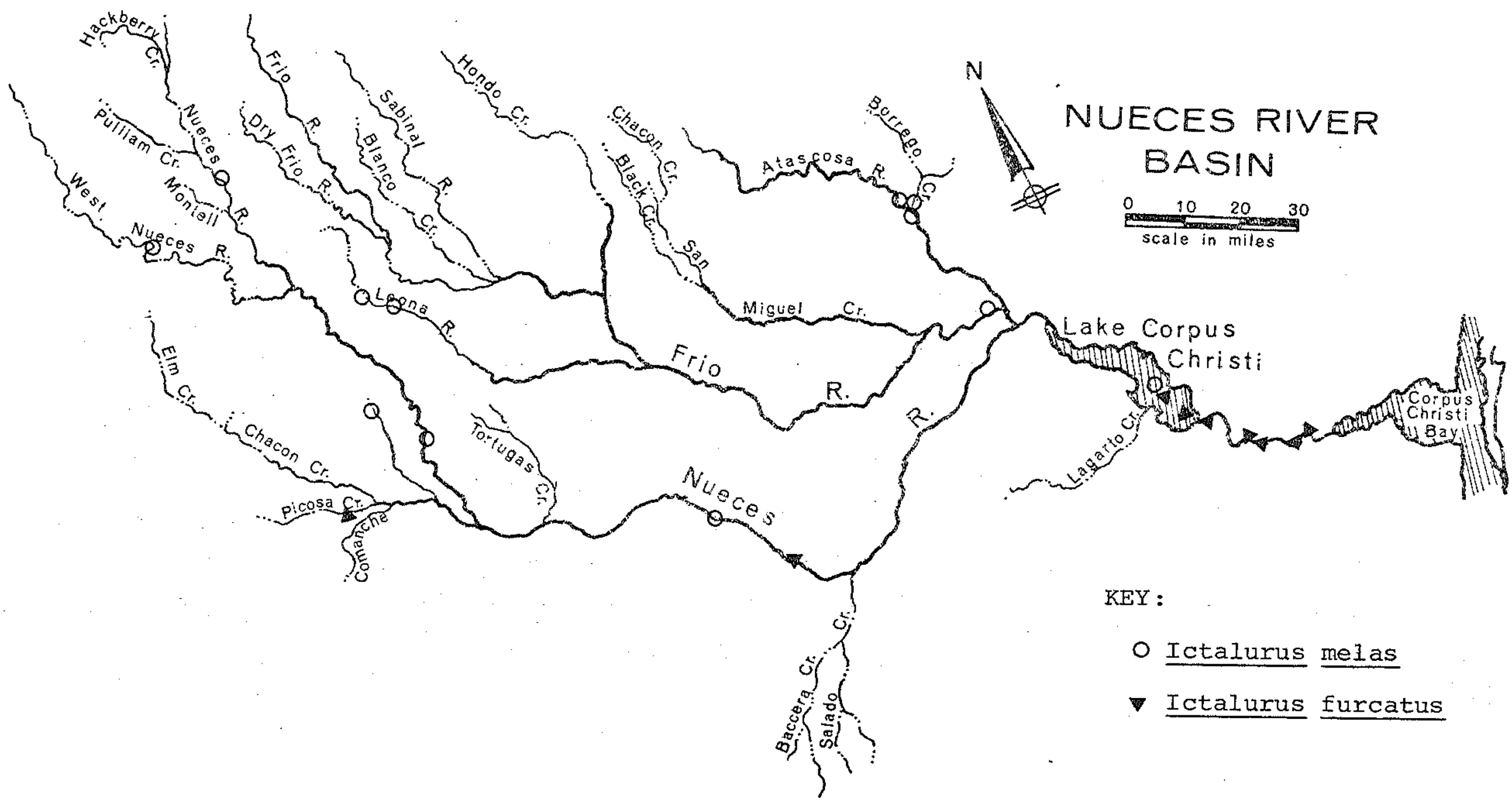

NUECES RIVER BASIN
N
0 10 20 30
scale in miles
Hackberry Cr.
Pulliam Cr.
Nueces R.
Moniell
West Nueces R.
Frio R.
Dry Frio R.
Sabinal R.
Blanco Cr.
Hondo Cr.
Leona R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Atascosa R.
Borrego Cr.
Frio R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Nueces R.
Baccera Cr.
Salado
Cr.
Lake Corpus Christi
Lagarto Cr.
Corpus Christi Bay
KEY:
Ictalurus melas
Ictalurus furcatus

FIGURE 77

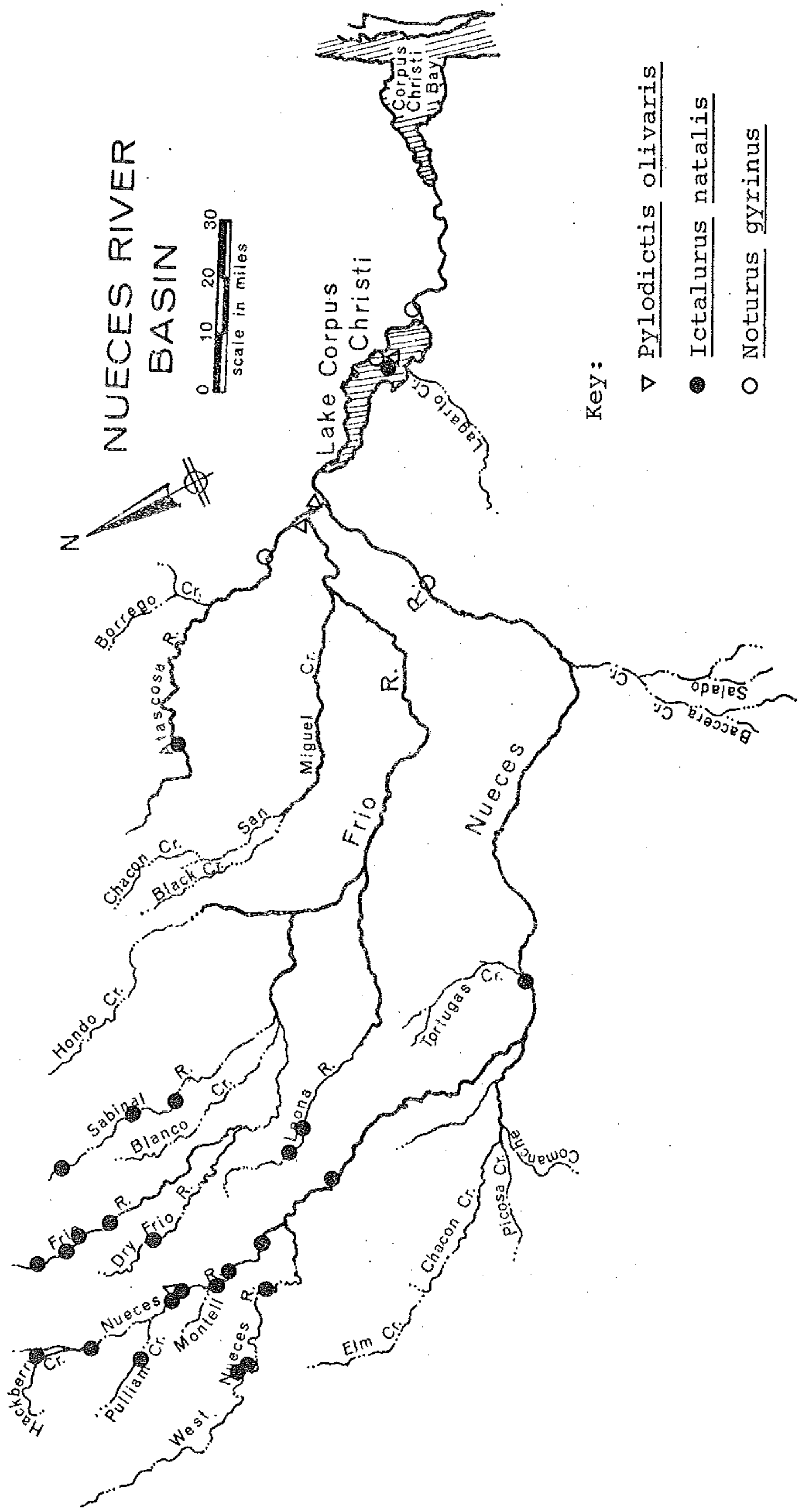

NUECES RIVER BASIN
0 10 20 30
scale in miles
N
Corpus Christi Bay
Lake Corpus Christi
Lagarto Cr.
Key:
Pylodictis olivaris
Ictalurus natalis
Noturus gyrinus
Borrego Cr.
Atascosa R.
San Miguel Cr.
Frio R.
Nueces R.
Salado Cr.
Baccera Cr.
Chacon Cr.
Black Cr.
Hondo Cr.
Tortugas Cr.
Sabinal R.
Blanco Cr.
Leona R.
Frio R.
Dry Frio R.
Comanche
Picosa Cr.
Chacon Cr.
Elm Cr.
Nueces R.
Montell Cr.
Pulliam Cr.
Hackberry Cr.
West Nueces R.

FIGURE 78

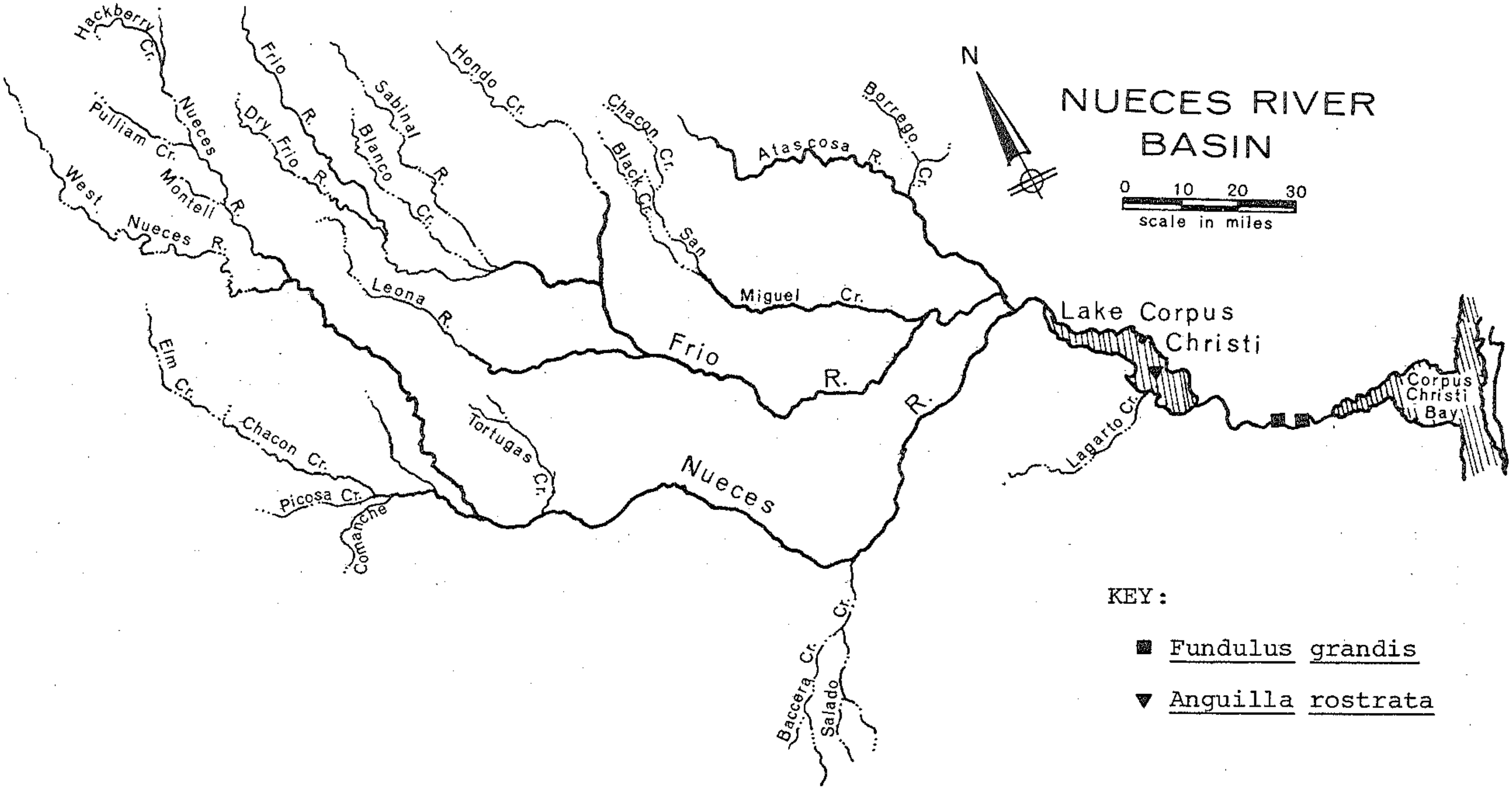

NUECES RIVER
BASIN
N
0 10 20 30
scale in miles
KEY:
Fundulus grandis
Anguilla rostrata
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Nueces R.
Frio R.
Atascosa R.
Borrego Cr.
Miguel Cr.
San
Chacon Cr.
Black Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell
West Nueces R.
Tortugas Cr.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Cr.
Baccera Cr.
Salado

FIGURE 79

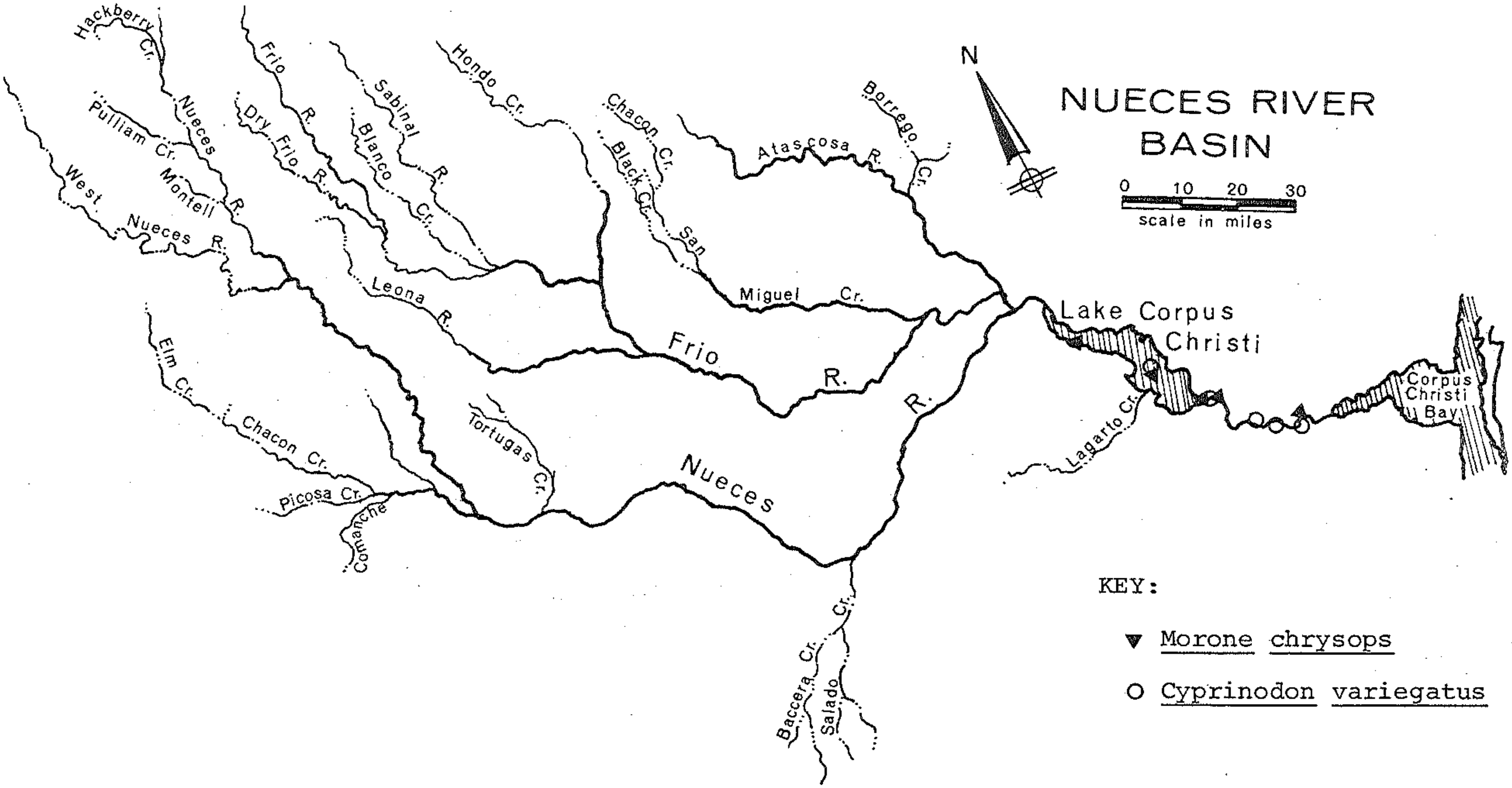

NUECES RIVER
BASIN
N
0 10 20 30
scale in miles
Lake Corpus Christi
Corpus Christi Bay
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell
West Nueces R.
Frio R.
Dry Frio R.
Sabinal R.
Blanco Cr.
Hondo Cr.
Leona R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Atascosa R.
Borrego Cr.
Frio R.
Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Lagarto Cr.
Baccera Cr.
Salado Cr.
KEY:
Morone chrysops
Cyprinodon variegatus

FIGURE 80

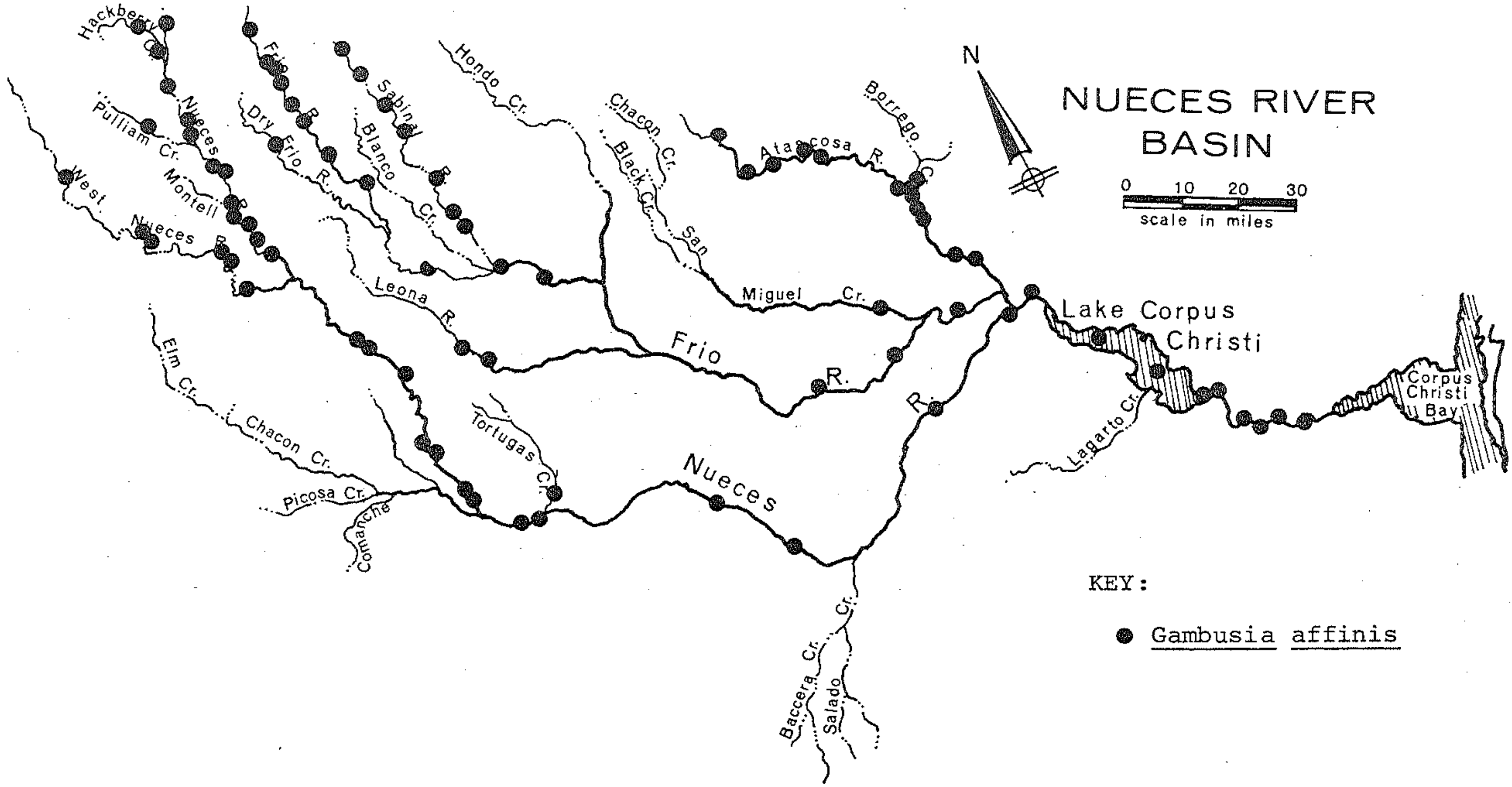

NUECES RIVER
BASIN
0 10 20 30
scale in miles
N
KEY:
Gambusia affinis
Lake Corpus
Christi
Corpus
Christi
Bay
Nueces
R.
Frio
R.
Atascosa R.
Borrego Cr.
Miguel Cr.
San
Chacon Cr.
Black Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Nueces R.
Hackberry Cr.
Pulliam Cr.
Montell
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Lagarto Cr.
Cr.
Baccera Cr.
Salado

FIGURE 81

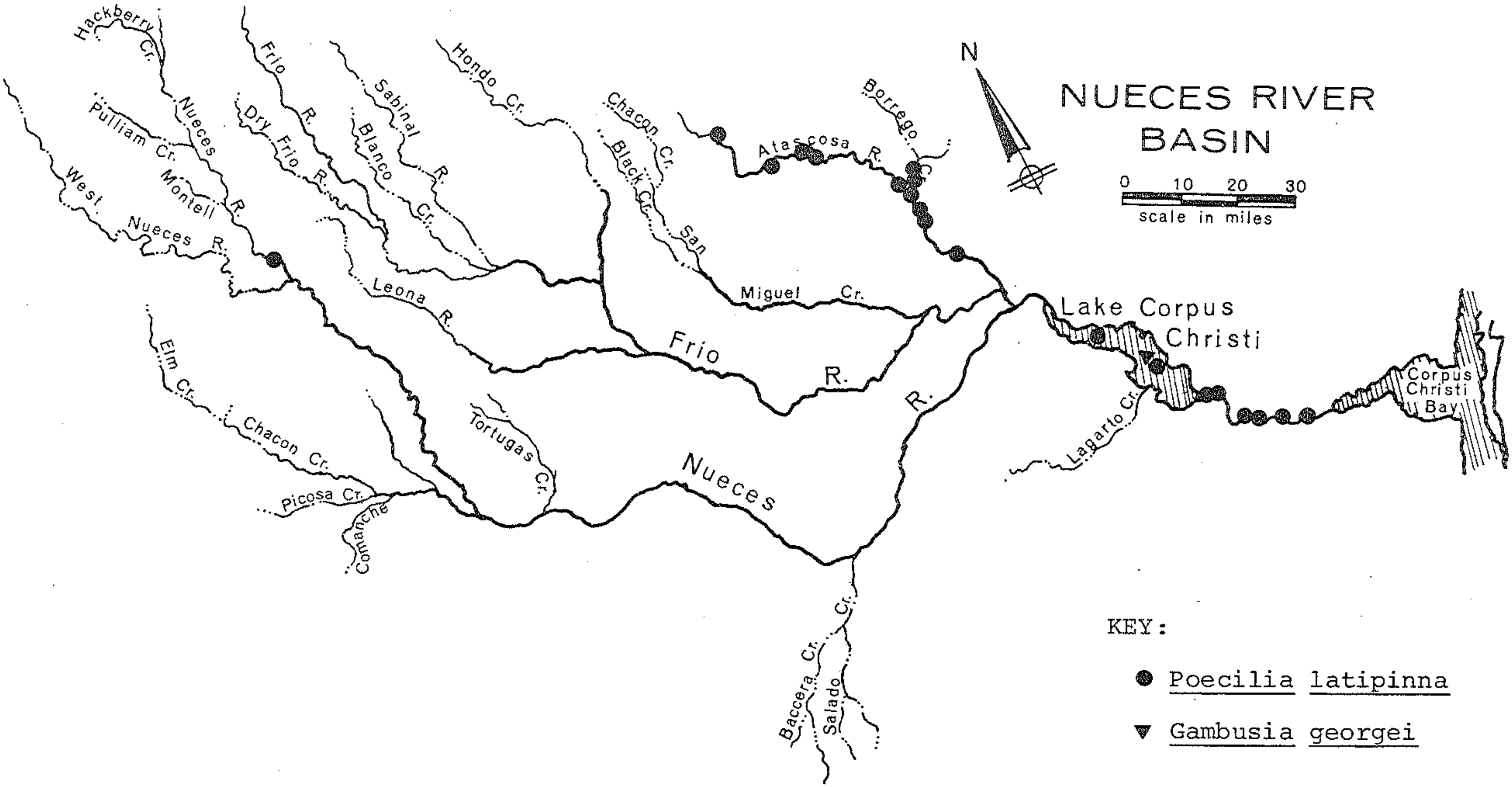

NUECES RIVER
BASIN
N
0 10 20 30
scale in miles
Lake Corpus
Christi
Corpus
Christi
Bay
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell
West Nueces R.
Frio R.
Dry Frio R.
Sabinal R.
Blanco Cr.
Leona R.
Hondo Cr.
Chacon Cr.
Black Cr.
San Miguel Cr.
Atascosa R.
Borrego Cr.
Frio R.
Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Lagarto Cr.
Cr.
Baccera Cr.
Salado
KEY:
Poecilia latipinna
Gambusia georgei

FIGURE 82

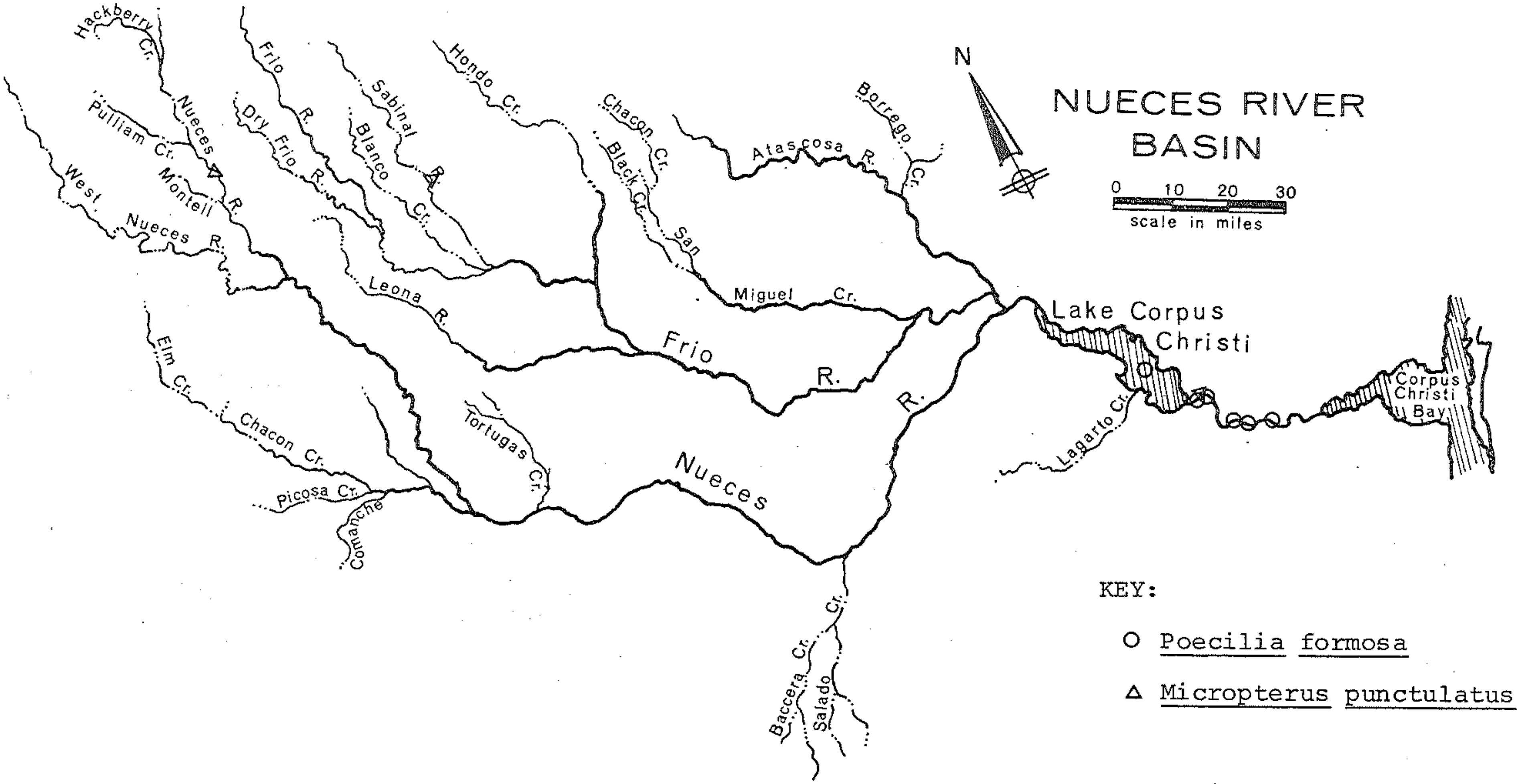
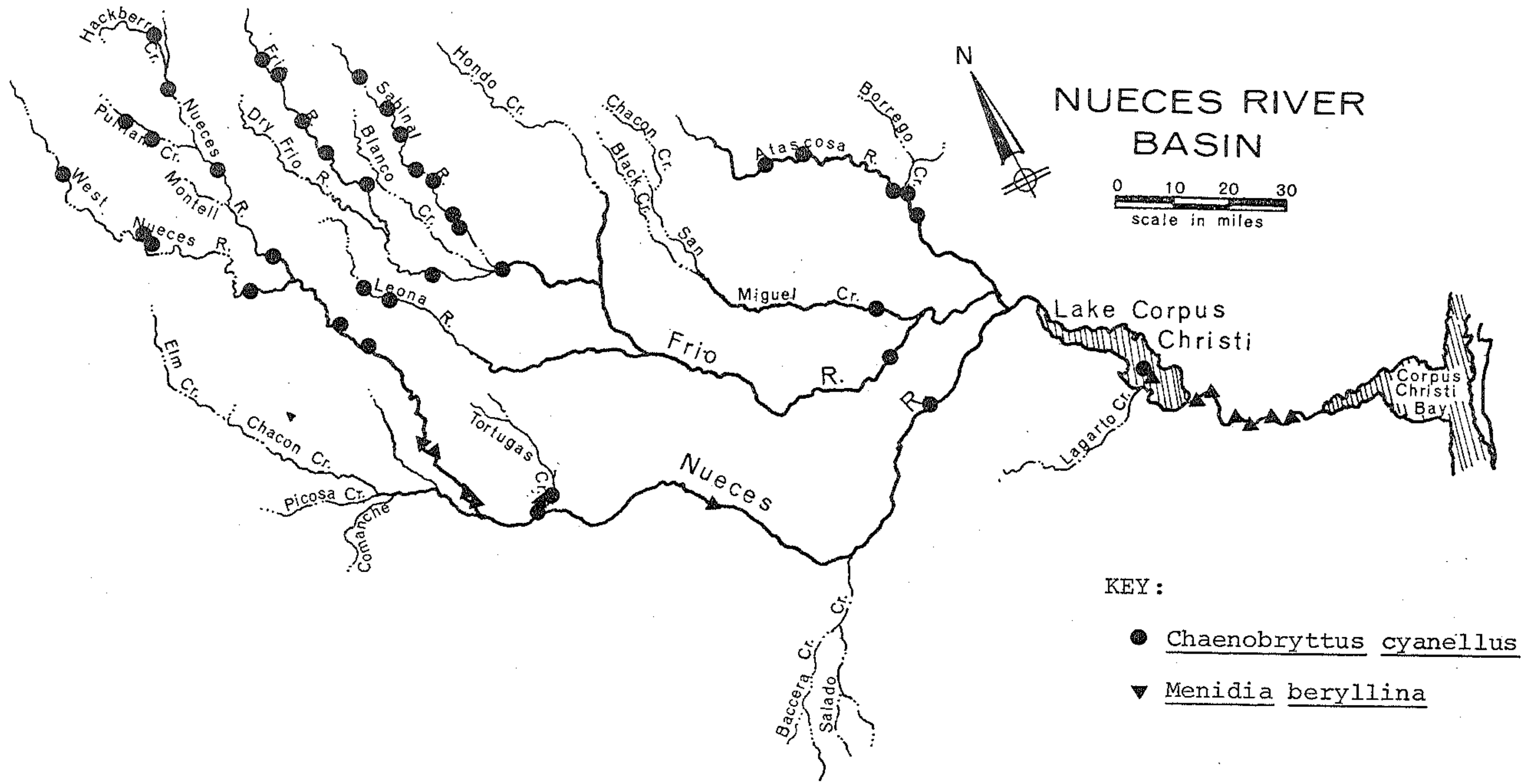

NUECES RIVER BASIN
0 10 20 30
scale in miles
N
KEY:
O Poecilia formosa
Δ Micropterus punctulatus
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Borrego Cr.
Atascosa R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Frio R.
Nueces R.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Baccera Cr.
Salado
Cr.

FIGURE 83



NUECES RIVER BASIN
N
0 10 20 30
scale in miles
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Borrego Cr.
Atascosa R.
Miguel Cr.
San
Chacon Cr.
Black Cr.
Hondo Cr.
Frio R.
Sabinal R.
Blanco Cr.
Dry Frio R.
Frio R.
Leona R.
Nueces R.
Hackberry Cr.
Pulliam Cr.
Montell
West Nueces R.
Nueces R.
Tortugas Cr.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Cr.
Baccera Cr.
Salado
KEY:
Chaenobryttus cyanellus
Menidia beryllina

FIGURE 84

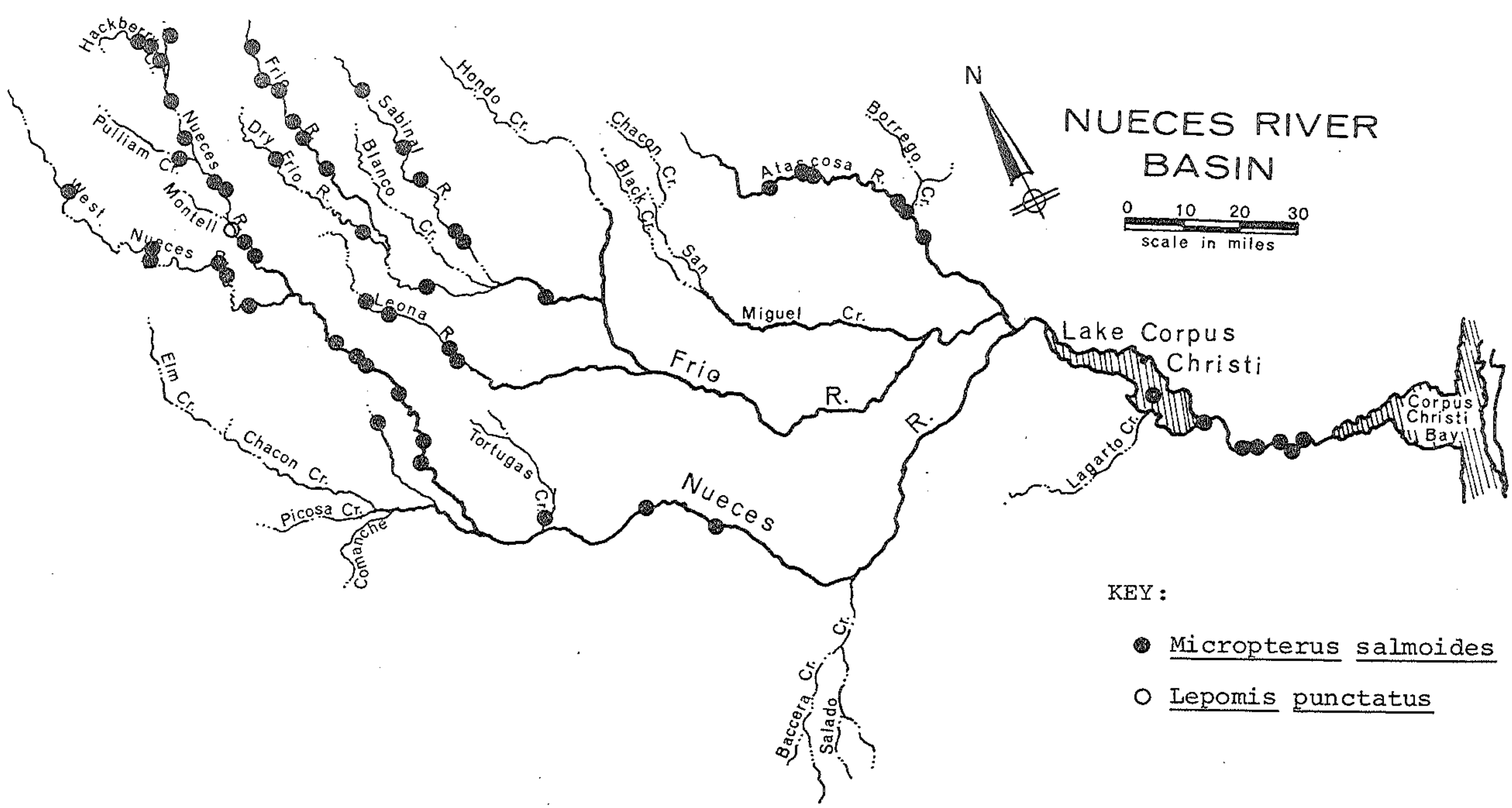

NUECES RIVER BASIN
N
0 10 20 30
scale in miles
KEY:
Micropterus salmoides
Lepomis punctatus
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Borrego Cr.
Atascosa R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell Cr.
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Nueces R.
Frio R.
Baccera Cr.
Salado Cr.

FIGURE 85

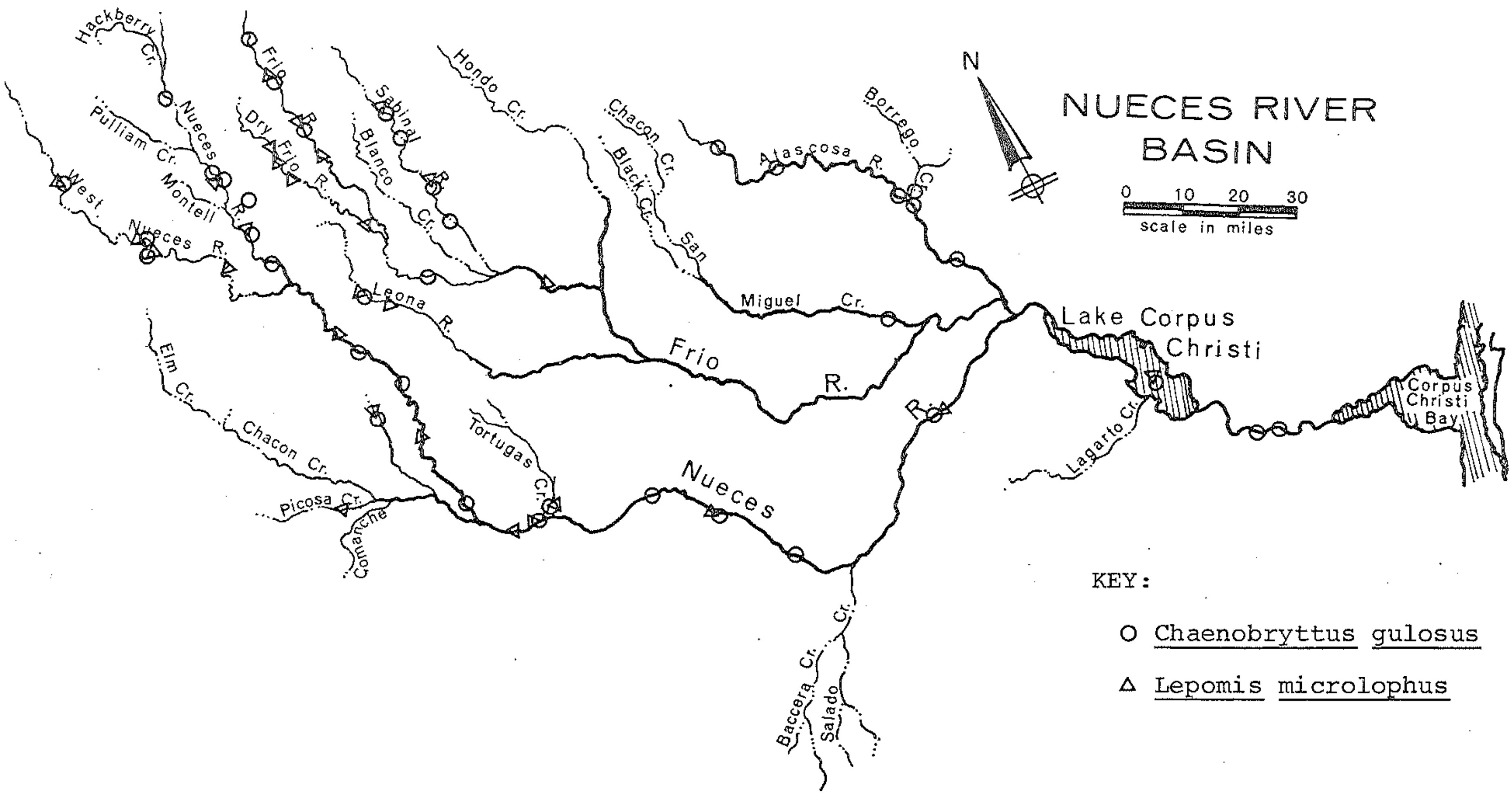

NUECES RIVER BASIN
N
0 10 20 30
scale in miles
Hackberry Cr.
Nueces
Pulliam Cr.
Montell
West Nueces R.
Frio
Dry Frio R.
Sabinal
Blanco Cr.
Hondo Cr.
Leona R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Atascosa R.
Borrego Cr.
Frio R.
Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Lake Corpus Christi
Lagarto Cr.
Corpus Christi Bay
Baccera Cr.
Salado Cr.
KEY:
O Chaenobryttus gulosus
Δ Lepomis microlophus

FIGURE 86

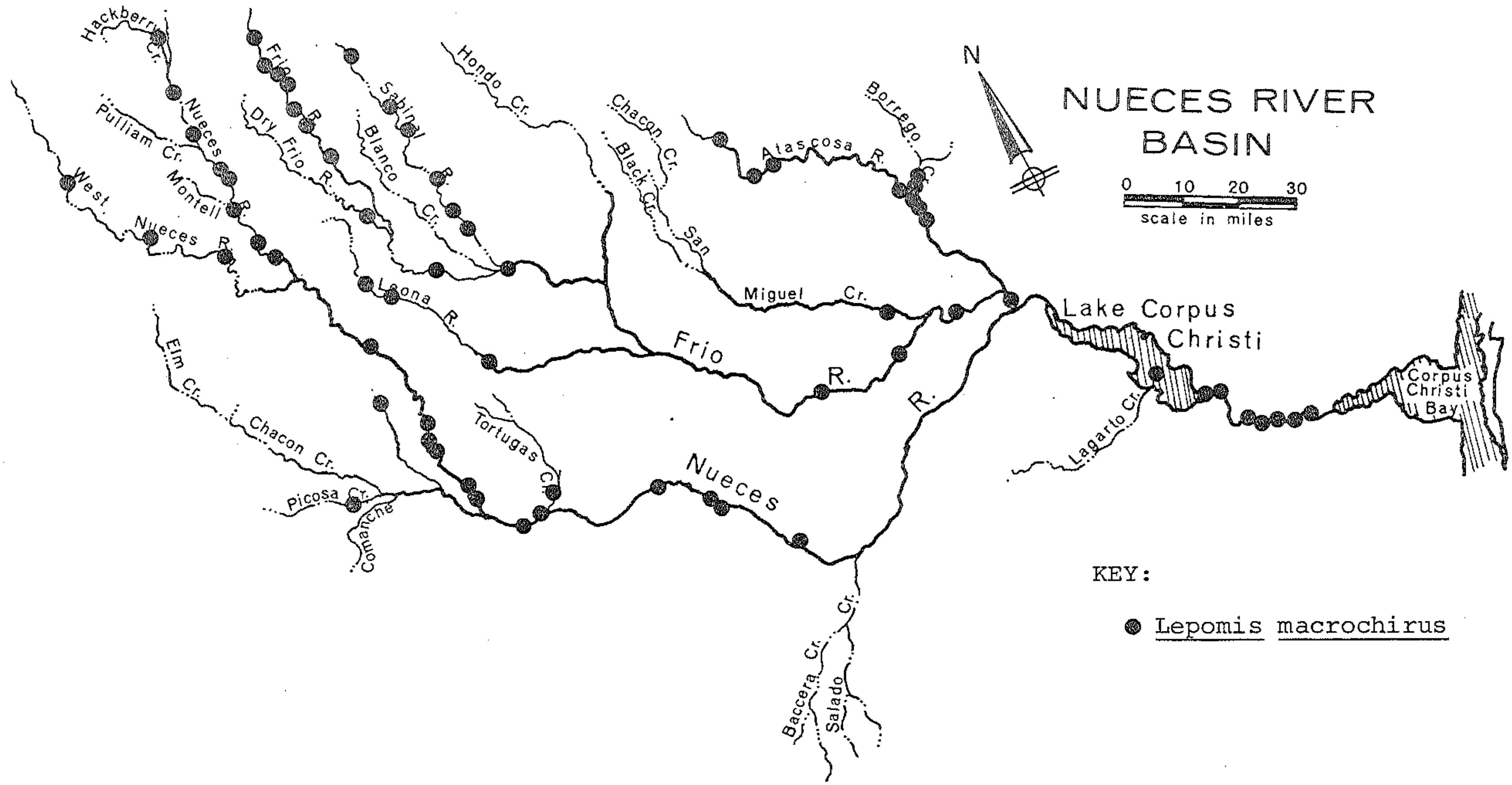

NUECES RIVER
BASIN
0 10 20 30
scale in miles
N
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Borrego Cr.
Atascosa R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Nueces R.
Baccera Cr.
Salado Cr.
KEY:
Lepomis macrochirus

FIGURE 87

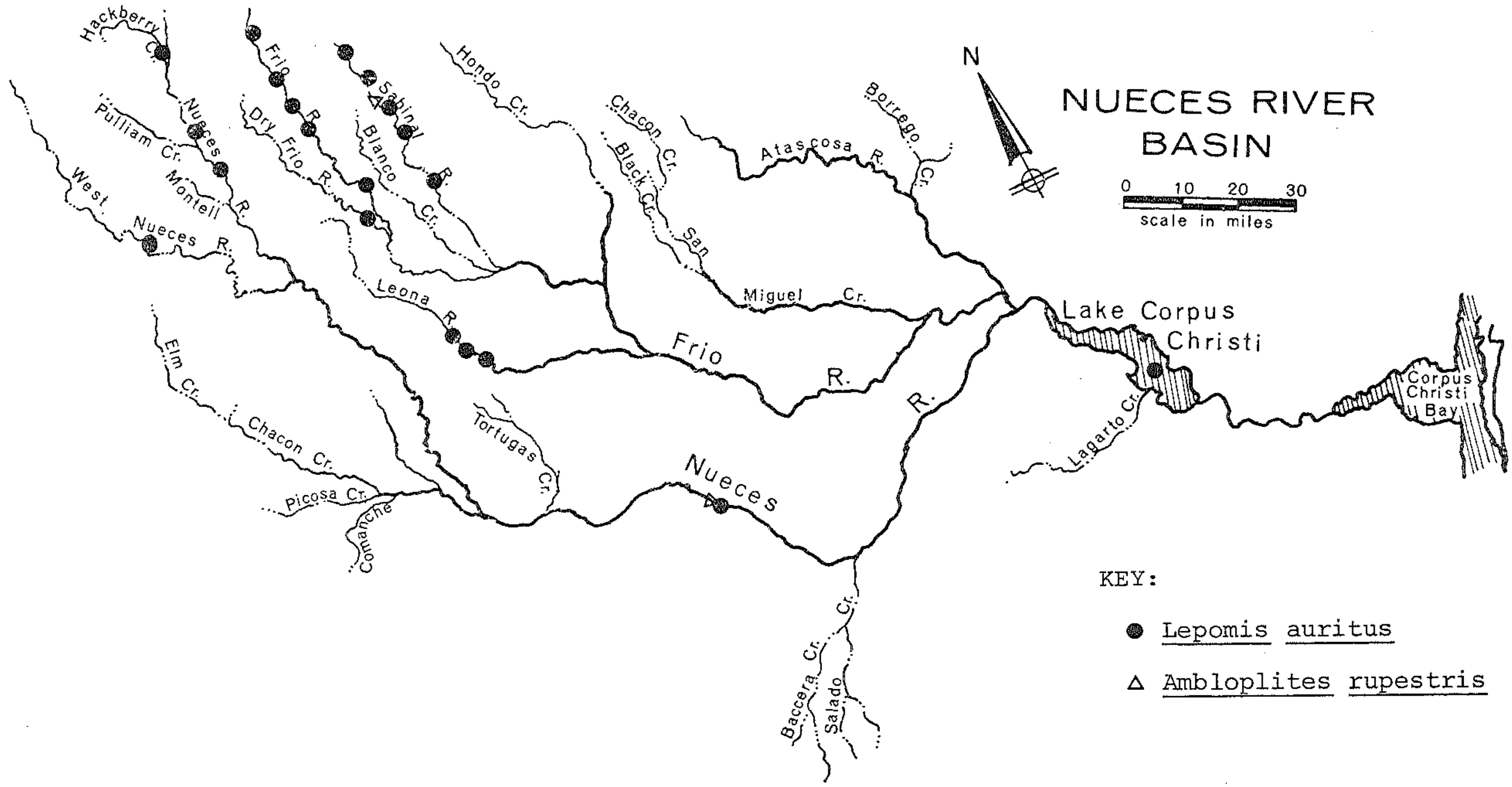

NUECES RIVER BASIN
N
0 10 20 30
scale in miles
KEY:
Lepomis auritus
Ambloplites rupestris
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Nueces R.
Frio R.
Atascosa R.
Borrego Cr.
Chacon Cr.
Black Cr.
San Miguel Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell Cr.
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Baccera Cr.
Salado Cr.

FIGURE 88

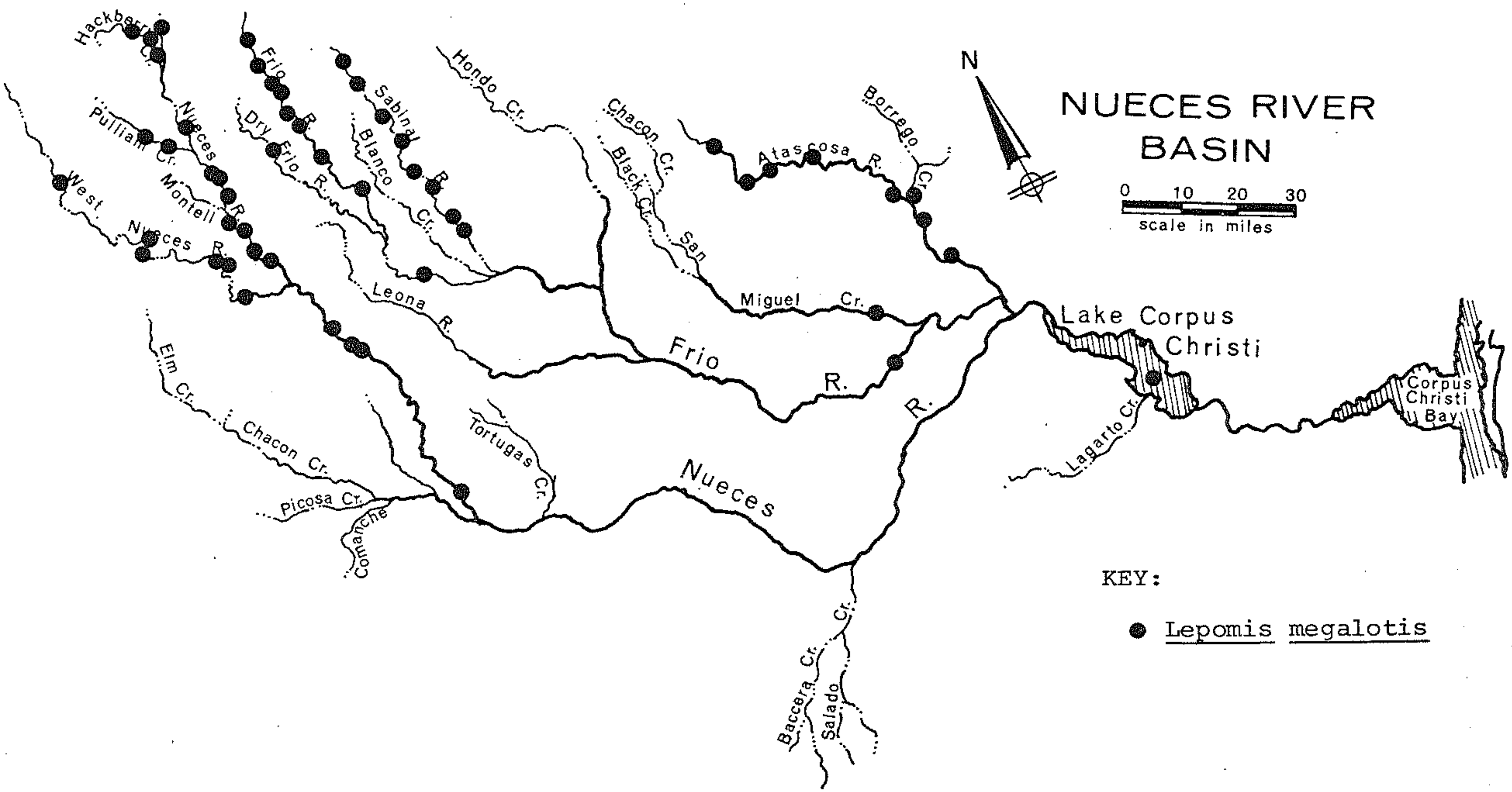

NUECES RIVER BASIN
N
0 10 20 30
scale in miles
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Borrego Cr.
Atascosa R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Nueces R.
Frio R.
Baccera Cr.
Salado Cr.
KEY:
Lepomis megalotis

FIGURE 89

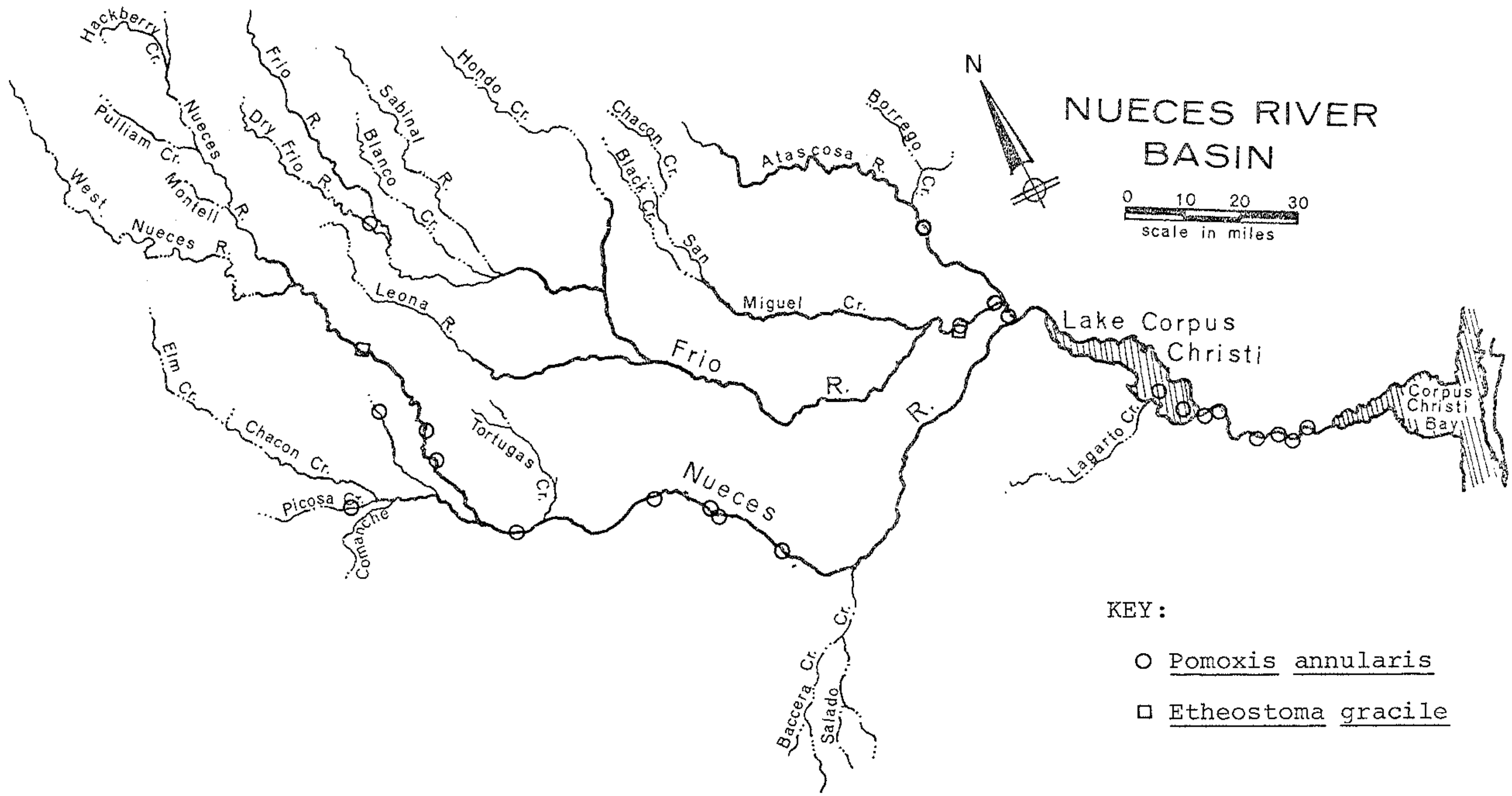

NUECES RIVER
BASIN
N
0 10 20 30
scale in miles
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Borrego Cr.
Atascosa R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Frio R.
Nueces R.
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Nueces R.
Baccera Cr.
Salado
Cr.
KEY:
Pomoxis annularis
Etheostoma gracile

FIGURE 90

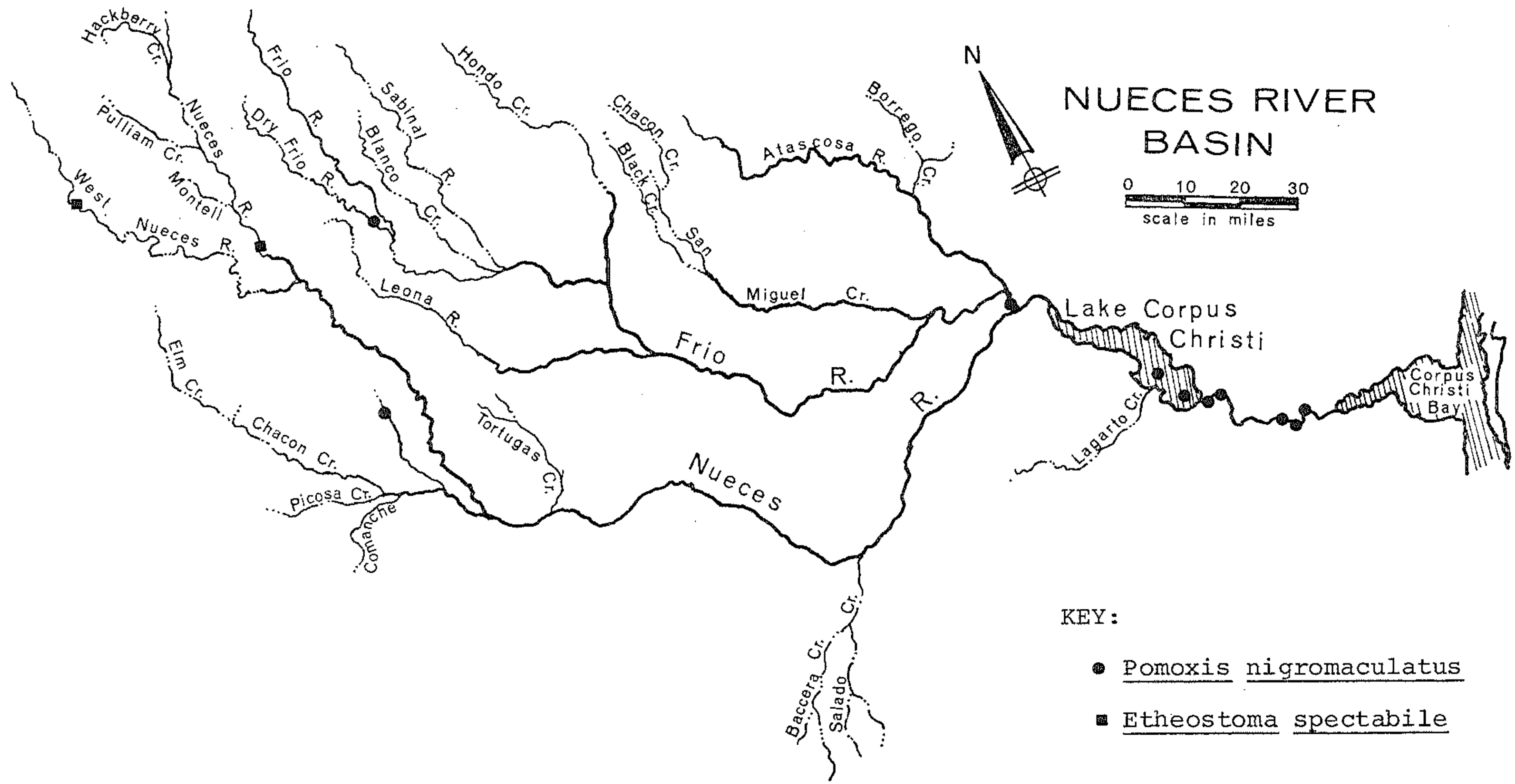

NUECES RIVER BASIN
N
0 10 20 30
scale in miles
Lake Corpus Christi
Corpus Christi Bay
Lagarto Cr.
Borrego Cr.
Atascosa R.
Chacon Cr.
Black Cr.
San Miguel Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Frio R.
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell Cr.
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Nueces R.
Baccera Cr.
Salado Cr.
KEY:
Pomoxis nigromaculatus
Etheostoma spectabile

FIGURE 91

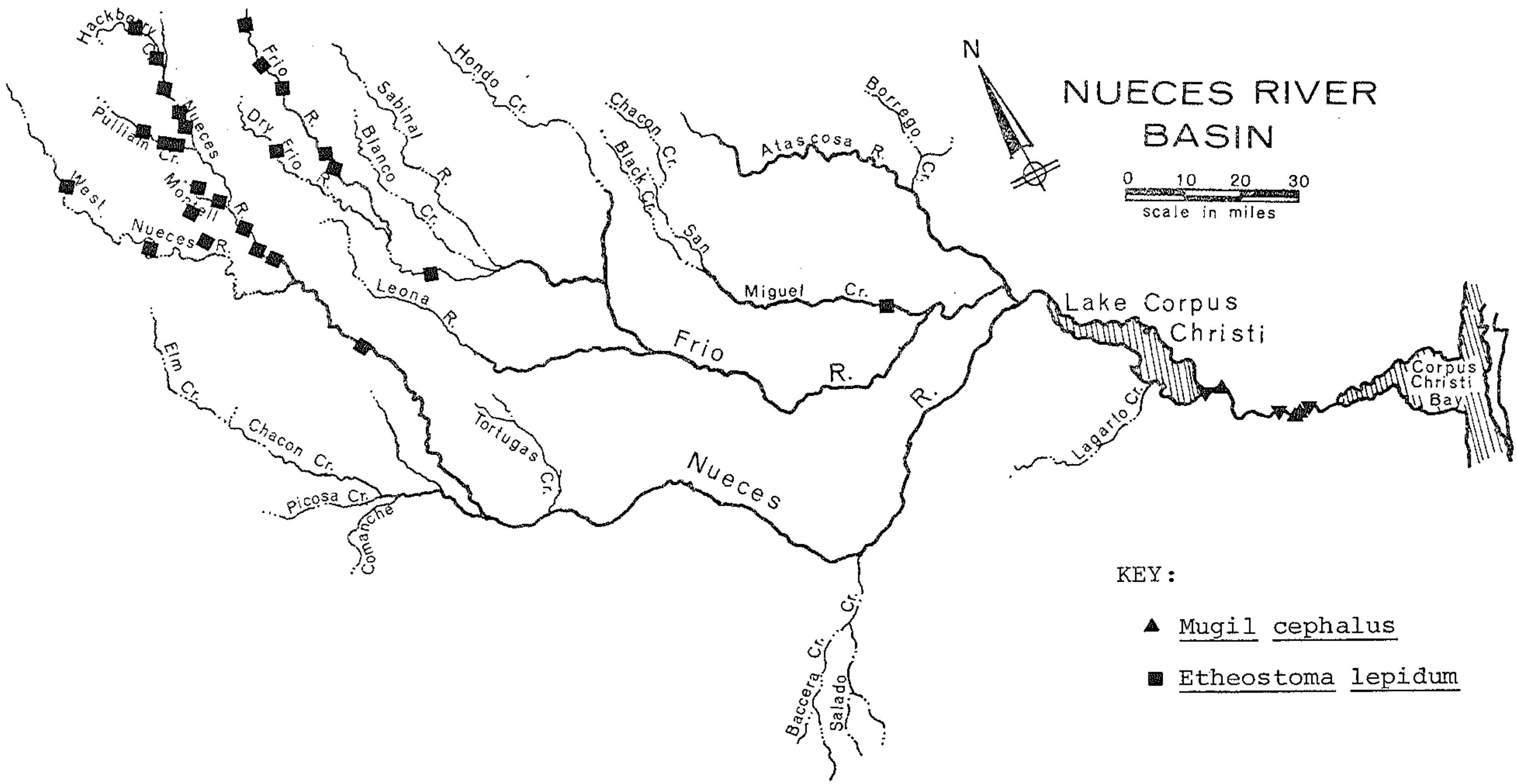

NUECES RIVER
BASIN
N
0 10 20 30
scale in miles
Lake Corpus
Christi
Corpus
Christi
Bay
Nueces R.
Frio R.
Atascosa R.
Borrego Cr.
Chacon Cr.
Black Cr.
San Miguel Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Dry Frio R.
Frio R.
Leona R.
Hackberry Cr.
Nueces R.
Pulliam Cr.
Montell
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Lagarto Cr.
Baccera Cr.
Salado Cr.
KEY:
Mugil cephalus
Etheostoma lepidum

FIGURE 92

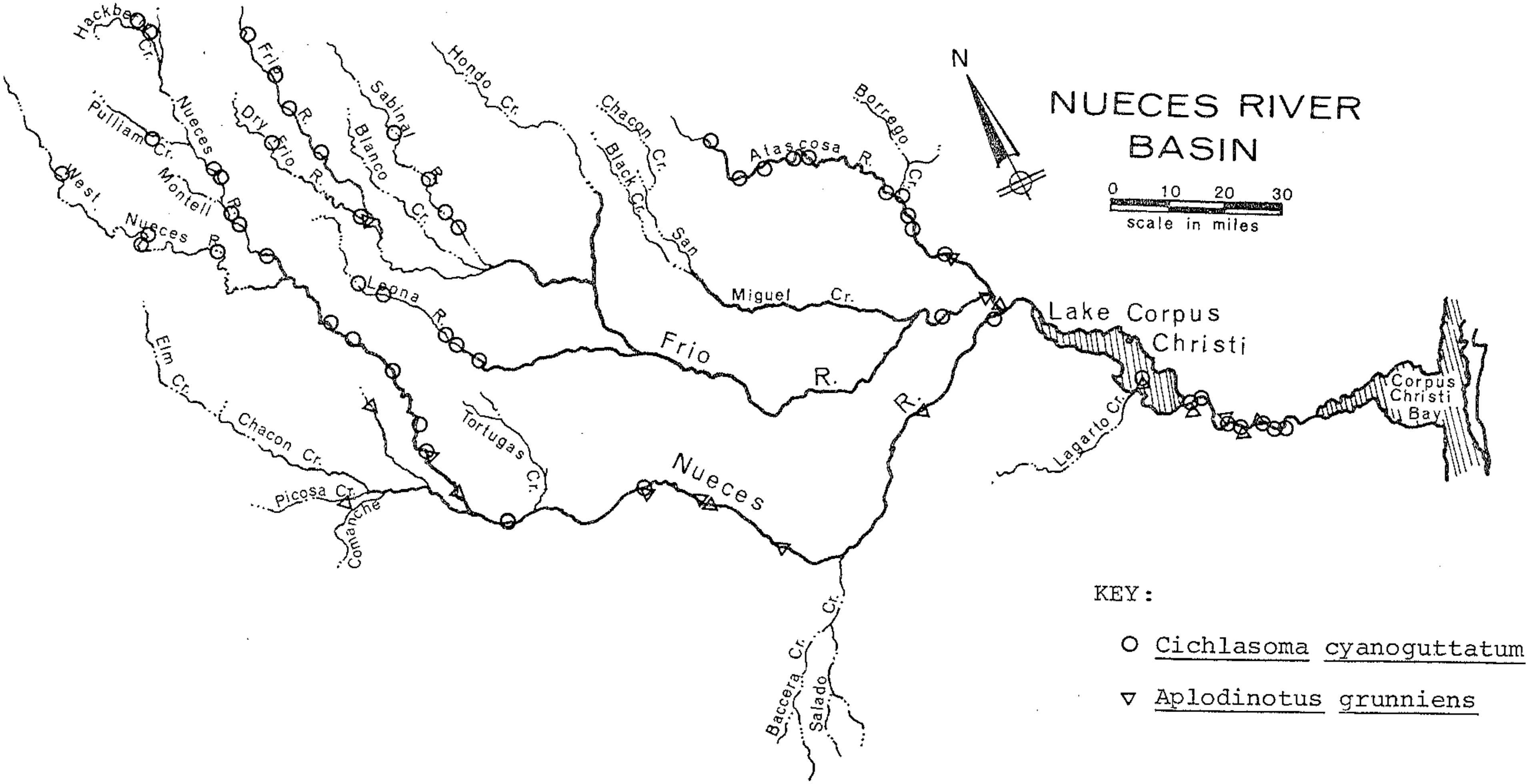

NUECES RIVER
BASIN
N
0 10 20 30
scale in miles
Lake Corpus Christi
Corpus Christi Bay
Nueces R.
Frio R.
Atascosa R.
Borrego Cr.
Miguel Cr.
San
Black Cr.
Chacon Cr.
Hondo Cr.
Sabinal R.
Blanco Cr.
Frio R.
Dry Frio R.
Leona R.
Nueces R.
Hackberry Cr.
Pulliam Cr.
Montell
West Nueces R.
Elm Cr.
Chacon Cr.
Picosa Cr.
Comanche
Tortugas Cr.
Lagarto Cr.
Cr.
Baccera Cr.
Salado
KEY:
Cichlasoma cyanoguttatum
Aplodinotus grunniens

FIGURE 93

from our checklists and distribution maps, since there are no firm records that indicate they occur there. The following discussion includes only those species that require further consideration to clarify their status in the river systems.

Hubbs (95) indicated that Ichthyomyzon gagei (southern brook lamprey) may occur in the Guadalupe River System, but Hubbs (83, 85) showed it occurs only in east Texas. Thus, it is assumed that this species does not occur in the Guadalupe River System.

Hubbs (95) indicated that Polyodon spatula (paddlefish) may occur in the Guadalupe River System. However, the Guadalupe River System is in the extreme south end of game area 4 which Hubbs (95) indicated is within the range of the paddlefish. Since Hubbs (85) gave its range as east Texas, it is assumed that this species does not occur in the study area.

Chaney (300) recorded one specimen of Lepisosteus platostomus from the Nueces River between the Calallen Dam and the Wesley Seale Dam. Hubbs (85, 95) reported its range in Texas as limited to north Texas. Thus, this record was probably a misidentification.

According to Hubbs (95) Amia calva (bowfin) might occur in any of the drainage basins in the study area, however, he indicated the study area is in the extreme southern end of the range. Hubbs (85) stated that this species was limited on the southwest by a line between Brazos and Matagorda counties. Thus, it is assumed that this species does not occur in the study area.

Texas Parks and Wildlife Department (245) recorded two specimens of *Elops saurus* from the lower Nueces River. Hubbs (95) listed it as a coastal form. Knapp (116) said it enters the lower parts of rivers, and Parker, Gallaway, and Moore (138) indicated it is a marine and estuarine form. Thus, this species may occur in the lower parts of all three river systems in the study area.

Although no collections of *Alosa chrysochloris* have been reported from the study area, Hubbs (95) indicated that it may occur in any of the three river systems in the study area. Knapp (116) stated that it occurred in the Gulf of Mexico and in adjacent streams in Texas. Parker, Gallaway, and Moore (138) reported it is an estuarine and freshwater form. Thus, it is possible that this species occurs in the study area.

Chaney (300) recorded many specimens of *Brevoortia patronus* from the lower Nueces River. Hubbs (95) did not list this species from freshwaters in Texas, however, Knapp (116) stated that the young may ascend streams. Parker, Gallaway, and Moore (138) listed it as a marine and estuarine form. Thus, this species probably occurs in the lower Nueces River.

No records of *Dorosoma petenense* in the San Antonio River System were found. However, Hubbs (85,95) and Knapp (116) showed its range included this river system. Since this species has been recorded from river systems adjacent to the San Antonio River System, it very likely occurs in the San Antonio River System and has probably been confused with the more common species, *D. cepedianum*.

Texas Parks and Wildlife Department (245) collected 212 specimens of _Anchoa hepsetus_ from the lower Nueces River. Parker, Gallaway, and Moore (138) listed this species as being marine and estuarine and Hubbs (95) listed it as a coastal form. Knapp (116) listed _A. mitchilli_ as the only species of anchovy which enters the Texas rivers where he found it in abundance in the mouths of rivers. Since Texas Parks and Wildlife Department (245) did not list _A. mitchilli_ in their collections, _Anchoa hepsetus_ may have been a misidentification.

No records could be found of releases of _Salmo gairdneri_ into Canyon Lake. However, one specimen was reported taken by gill nets in Canyon Lake by the Texas Parks and Wildlife Department in January 1966 (295). Since many releases of _S. gairdneri_ have been made into the Guadalupe River below Canyon Dam (see p. 166), it is possible that some were released into Canyon Lake also. However, there is no evidence that this is a self-reproducing population.

Hubbs (95) indicated that _Esox americanus_ (redfin pickerel) may occur in the Guadalupe River System. However, this would be the extreme southern end of the range given by Hubbs (95). Knapp (116) gave its range as east Texas and Hubbs (85) stated that it is limited on the southwest by a line between Brazos and Matagorda counties. Thus, it is assumed that this species does not occur in the study area.

Carassius auratus was collected from Woodlawn and Davis lakes in the San Antonio River System by the Texas Parks and

Wildlife Department (240, 247, 296). Within the Guadalupe River System, Whiteside (316) collected this species from the Blanco River, the Texas Parks and Wildlife Department (266, 295) collected it from Flat Rock Lake and Lake McQueeney, and Kuehne (119) collected it from the Comal River. No specimens of this species have been recorded from the Nueces River System. Since this species is an important bait and aquarium fish and is often released into streams and lakes as indicated by the above disjunct distribution, it likely also occurs in the Nueces River System.

We found no record of *Hybopsis aestivalis* from the Nueces River System, but it was collected from the San Antonio and the Guadalupe river systems. Hubbs (95) and Knapp (116) gave the entire state as within the range for *H. aestivalis*. Thus, this species probably occurs in the Nueces River System.

Rhinichthys cataractea (longnose dace) was not reported from the study area, although Hubbs (95) indicated that this species may occur in any of the river systems in the study area. Knapp (116) stated that this species occurs in tributaries of the Rio Grande and in the Pecos region of west Texas. Hubbs (83, 85) reported that the species is known only from the Rio Grande. Thus, it is assumed that this species does not occur in the study area.

No records were found of collections of *Phenacobius mirabilis* (suckermouth minnow) from the study area. While Hubbs (95) indicated that this species may occur in any of the river basins in the study area, Hubbs (85) gave the Texas range as limited chiefly to northeast Texas and the lower Colorado River System and Knapp (116) listed it as uncommon in Texas. Thus, it is assumed that this species does not occur in the study area.

Smith (309) reported one specimen of Notropis atherinoides from the Blanco River seven miles east of Wimberley and Mecham (304) reported this species from the San Marcos River at San Marcos. Hubbs (95) indicated that this species occurs in game areas 1, 2, and 4, all of which extend into the northeastern edge of the study area. However, Hubbs (85) indicated that this species occurs only in east Texas and although he stated (83), "Notropis atherinoides is not known southeast of the Trinity drainage", he apparently intended to say southwest instead of southeast. Thus, the occurrence of this species in the Blanco and San Marcos rivers is questionable.

The Texas Parks and Wildlife Department (269) recorded Notropis oxyrhynchus from Lake Dunlap. Hubbs (95) indicated that this species might occur in the study area. Hubbs (85) stated that this species is limited to the Texan Biotic Province (Fig. 94) which includes only the Guadalupe River System portion of the study area. However, Knapp (116) stated that this species is confined to the Brazos River System. Thus, the occurrence of this species in the study area is questionable.

No records of collections of Notropis fumeus (ribbon shiner) in the study area were found. Hubbs (85, 95) indicated that the extreme southwest part of its range may extend into the study

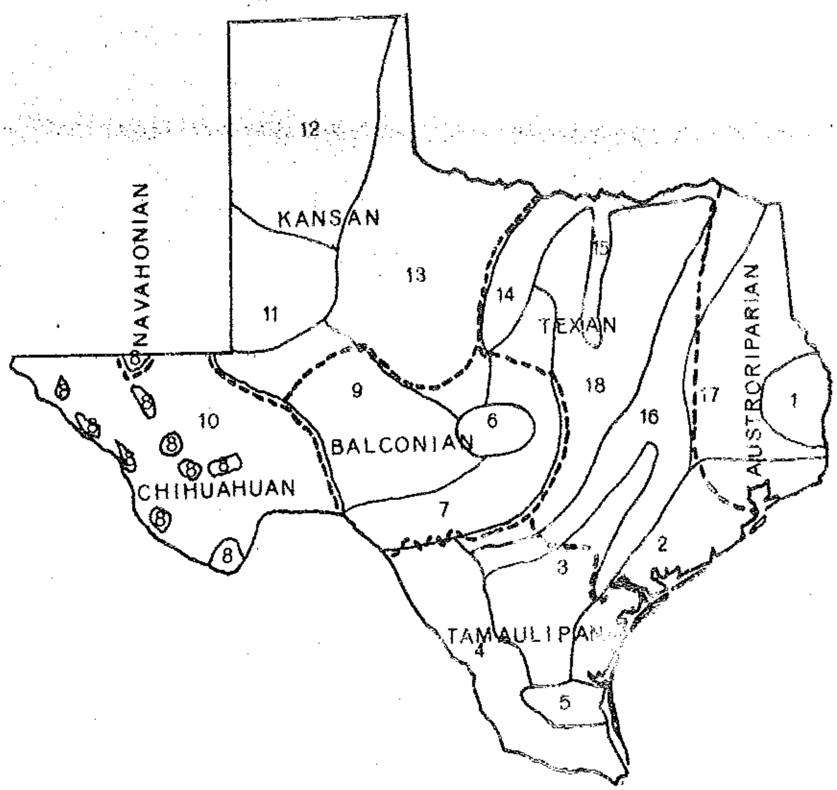


Figure 94. Taken from Hubbs (85). Heavy lines [illegible] show Biologic Provinces. Fine lines and number[illegible] Vegetation Regions. (1) Long-leaf Pine, (2) [illegible] Prairie, (3) Fayette Prairie and Transition [illegible] Mesquite-Chaparral, (5) Mainland Dunes, (6 [illegible] Mesquite of the Igneous Central Mineral Region [illegible] Juniper of Hilly Marginal Portion of Edwards P[illegible] [illegible]tane Forests and Oak-Savanna, (9) Liveoa[illegible] [illegible]anna, (10) Foothills and Mesa Region wes[illegible] [illegible]ver, (11) Sandy South Plains. (12) High [illegible] [illegible] Savanna, (14) Western Cross Timbers [illegible] [illegible] Cross Timbers, (16) Oak-Hickory, [illegible] [illegible]ak, (18) Blackland Prair[illegible]

area. However, Knapp (116) stated that this species occurs in the Red River and extends southward into Texas only as far as the Brazos River System. Thus, it is questionable if this species occurs as far southwest as the study area.

Reno (308) reported two specimens of Notropis shumardi from the Blanco River one mile east of Wimberley. Hubbs (85, 95) indicated that its range may extend into the study area. Knapp (116) listed the range of this species as "known only from the Brazos River system but possibly occurs in the lower parts of adjacent rivers in Texas." Hubbs (83) listed additional collection localities but none were in the study area. Thus, this species possibly occurs in at least the Guadalupe River System of the study area.

The Texas Parks and Wildlife Department (296) collected one specimen of Notropis chalybaeus from Cibolo Creek. Hubbs (85, 95) and Knapp (116) gave the range for this species as the eastern part of the state. Thus, it is likely that this specimen was misidentified and therefore this species does not occur in the study area.

The Texas Parks and Wildlife Department (297) collected six specimens of Notropis simus from the upper part of the Nueces River, two miles south of Montell. Knapp (116) and Hubbs (85, 95) gave its Texas range as the Rio Grande and its tributaries east to near Laredo. Since the collection site of this species is adjacent to the Rio Grande System, this may be a correct identification and an extension of its known range.

Caldwell (299) reported four specimens of _Notropis blennius_ from Woodlawn Lake, Bexar County. Hubbs (83, 85, 95) and Knapp (116) showed that it does not occur in Texas south of the Red River drainage. Thus, we assume this species does not occur in the study area.

No records were found of _Notropis potteri_ (chub shiner) being in the study area. Knapp (116) gave its range as the Brazos and Red River systems. However, Hubbs (95) indicated its range may include part of the study area. Since no records of this species in the study area were found, and since the exact range given by Hubbs (95) for this species cannot be pinpointed, it is likely that this species does not occur in the study area.

Records of collections of _Notropis amnis_ were found for both the Guadalupe and the San Antonio river systems. Hubbs (95) indicated that both of these river systems are within its range. However, Knapp (116) showed its range to include only the Guadalupe River System in the study area. Since Hubbs (95) is the more recent paper of the two, it is assumed that these were correct identifications of _N. amnis_, and that this species is found in both river systems.

The Texas Parks and Wildlife Department (296) collected one specimen of _Notropis proserpinus_ from the San Antonio River and one specimen from Cibolo Creek, Knapp (116) and Hubbs (85, 95) showed its Texas range to be the Rio Grande and its tributaries, including the Pecos River. It is assumed the two specimens were misidentified since this species is easily confused with the more common, closely related species N. lutrensis.

The Texas Parks and Wildlife Department (297) reported 38 specimens of Notropis atrocaudalis from Lake Corpus Christi. Knapp (116) stated the Texas range of this species is "East Texas west to Guadalupe system (rare) ...." Hubbs (83) stated, "There are no specimens in the Texas A. and M. collection from west of the Brazos River." Hubbs (85, 95) gave its range in Texas as the eastern part of the state. Thus, it is probable that these specimens were misidentified.

Collection records of Notropis volucellus were found for all three river systems in the study area. The only record from the Nueces River System was a collection of five specimens reported by the Texas Parks and Wildlife Department (231) from Hondo Creek, a tributary of the Frio River. Knapp (116) reported it as occurring throughout Texas and Hubbs (95) showed its range included all of Texas except the extreme western part of the state. However, Hubbs (85) stated that its range is discontinuous and that it is absent from the Nueces River System. N. volucellus may have been confused with a similar species, N. buchanani, which occurs in the Nueces River System. Thus, its occurrence in the Nueces River System is questionable.

Caldwell (299) recorded Notropis boops from the Guadalupe River five miles below Canyon Lake Dam. Hubbs (95) did not list this species in his checklist of Texas fishes. Knapp (116) and Moore (126) listed it from the Red River System between Texas and Oklahoma. Thus, it is assumed that this species does not occur in the study area.

No records were found to indicate *Hybognathus nuchalis* occurs in the study area. However, Hubbs (95) indicated its range may reach the Guadalupe River System and Knapp (116) stated its Texas range as being "in large silty rivers, oxbows and backwater areas in the central and eastern parts of Texas. Rather widespread in the state but nowhere common." According to these distribution descriptions, this species may occur in at least the Guadalupe River System in the study area.

No records were found of *Hybognathus placitus* being in the study area. However, Hubbs (95) and Knapp (116) indicated that its range may include any of the river systems in the study area. Thus, it is possible that this species occurs in the study area.

No records were found to indicate that *Cycleptus elongatus* occurs in the study area. The Academy of Sciences of Philadelphia (1) listed *Carpiodes elongatus* as being collected from the Guadalupe River near Victoria, however, it could not be determined if they were referring to *Cycleptus elongatus* or a subspecies of the river carpsucker, *Carpiodes carpio elongatus*. Hubbs (85, 95) and Knapp (116) indicated that *Cycleptus elongatus* may occur in small numbers throughout the study area. Thus, it is assumed that *Cycleptus elongatus* occurs in the study area.

The Texas Parks and Wildlife Department (269) recorded specimens of *Moxostoma erythrurum* from lakes Dunlap, Placid, Meadow, and H-4 on the Guadalupe River. However, Hubbs (83, 85, 95) and Knapp (116) showed that the nearest extension of the range of this species to the study area is the Red River System. Thus, it is assumed that these specimens were the closely related, commonly occurring *M. congestum*, and that *M. erythrurum* does not occur in the study area.

Fowler (56) listed *Moxostoma duquesnii* from the Colorado and Guadalupe rivers. Hubbs (83) stated, "Because this fish has not otherwise been recorded in Texas, it is presumed that the record is based on specimens of *M. congestum*, with which *M. duquesnii* has much in common."

Everman and Kendall (51) reported *Minytrema melanops* from the Guadalupe River near New Braunfels in 1894. Hubbs (95) reported it as introduced into game area 6 which includes the study area. Hubbs (85) stated that they are found north and east of a line from Fort Worth to Houston but not south and west of it. Knapp (116) gave the range for this species as "Widespread but not common; from Minnesota to Iowa to Pennsylvania on the north to northern Florida; southwest to the Rio Grande...." Hubbs (83) stated that "No recent collections are available west of the San Jacinto drainage." Since this species is not easily confused with other species of suckers, it is assumed that this 1894 record of *M. melanops* for the Guadalupe River was correct, but it is questionable if this species still occurs there.

Hubbs, Kuehne, and Ball (100) recorded *Erimyzon oblongus* from the headwaters of the Guadalupe River. However, Hubbs (85) stated that the above record was based on *E. sucetta*. Thus, this species is not known to occur in the study area.

Fowler (56) recorded *Ictalurus nebulosus* from the Nueces River, probably on the basis of his (1904) record from Hondo Creek. Hubbs (83) stated that Fowler's fish, on re-examination, proved to be *I. natalis*. Evermann and Kendall (51) listed *I. nebulosus* from San Marcos, Comal, and San Antonio springs and stated that this species was quite numerous at San Marcos and Comal springs. Hubbs (83) stated that *I. natalis* was the only species of the genus in these springs in 1954. Recently, Whiteside (313, 316, 317) collected both *I. natalis* and *I. melas* from the San Marcos River but only a few specimens were *I. melas*. Thus, it is assumed that the records of *I. nebulosus* were based on misidentified specimens of *I. natalis*.

Hubbs (94), Hubbs and Bailey (82), and Suttkus (162) reported that *Trogloglanis pattersoni* and *Satan eurystomus* have been taken only from deep artesian wells in the vicinity of San Antonio.

Noturus gyrinus was recorded from all three river systems in the study area. Hubbs (85) stated that this species is not found in the upper portions of these river systems which lie within the Balconian Biotic Province (Fig. 94) nor in those parts of the San Antonio or Nueces river systems which lie within the Tamaulipan Biotic Province (Fig. 94). However, there were records of this species from Medina Lake (187, 190, 201) which is in the Balconian Biotic Province and from several localities in the Nueces River System (174, 181, 237, 245, 297) which are in the Tamaulipan Biotic Province. The only species in the study area with which N. gyrinus is sometimes confused is young-of-the-year bullheads. Thus, the above records of N. gyrinus were probably correct.

Evermann and Kendall (51) stated that they obtained eight specimens of Noturus nocturnus from San Antonio Springs at San Antonio. Hubbs (85) stated that this species is found north and east of a line from Fort Worth to Houston but not south and west of it. Though Hubbs (95) later included the study area within the range of N. nocturnus, Knapp (116) stated that this species is not common in Texas. Thus, it is assumed that this record of N. nocturnus was a misidentification.

Anguilla rostrata was recorded from the Nueces and Guadalupe river systems, but no records of the species were found for the San Antonio River System. Hubbs (85, 95) and Knapp (116) stated that the range of this species includes the entire study area. Since this species is most frequently taken on hook and line or with traps, data which is usually not recorded or published, it is assumed that this species also occurs in the San Antonio River System, but has never been reported.

Evermann and Kendall (51) recorded Lucania parva from San Antonio Springs at San Antonio. Hubbs (95) indicated that the range of this species may include the San Antonio River System. Hubbs (85) stated that members of this species "occur abundantly in the saline waters of the Pecos but not in the nearby less saline habitats in Texas." Hubbs (85) also reported that they are often found in the Rio Grande above Falcon Dam and that perhaps they occupy most of the Tamaulipan Biotic Province (Fig. 94) which includes the San Antonio River System. Thus, the Evermann and Kendall (51) record may be correct.

The Texas Parks and Wildlife Department (245) recorded Fundulus grandis from the lower Nueces River. Hubbs (95) listed this species as coastal and Knapp (116) gave its range as "Gulf Coast from Florida to Mexico. A brackish water species ranging from salinities of 2 to 25 parts per thousand salt." Parker, Gallaway, and Moore (138) listed it as an estuarine and freshwater form. Thus, it is assumed that this species occurs in the lower Nueces River System.

Records of Zygonectes notatus were found for the Guadalupe and San Antonio river systems but not for the Nueces River System. Hubbs (85) indicated this species in Texas occurs in the Texan and Austroriparian biotic provinces. The Texan Biotic Province includes parts of the Guadalupe and San Antonio river systems but not the Nueces River System (Fig. 94). Knapp (116) said Z. notatus is typical of headwaters and fast streams in Texas. Hubbs (95) indicated that its range might extend south into the Nueces River System. It is assumed that Z. notatus occurs only in the Guadalupe and San Antonio river systems of the study area.

The only record of Zygonectes olivaceus from the study area was by Kuehne (119) from Lake Belmont (H-4 Lake) on the

Guadalupe River. Hubbs (95) indicated that the range of this species in Texas might include this area. However, Hubbs (85) stated that the western limit of this species corresponds with the western limit of the Mixed Pine-Oak Region in east Texas (Fig. 94). Kuehne (119) also collected Z. notatus from Lake Belmont and several other localities on the Guadalupe River, and stated that the specimens identified as Z. olivaceus may have been very aberrant Z. notatus. It is assumed that this was probably a misidentification and that Z. olivaceus does not occur in the study area.

Records of Cyprinodon variegatus were found for the Nueces and Guadalupe river systems but not for the San Antonio River System. Hubbs (95) indicated that this species may occur in the lower sections of any of the three river systems in the study area. Hubbs (85) stated that this species may occupy most of the Tamaulipan Biotic Province which includes parts of the San Antonio and Nueces river systems (Fig. 94). Knapp (116) gave its Texas range as "Very abundant on the Texas coast in salinities from 10 to 25 parts per thousand salt. Not uncommon in purely fresh waters of the coastal streams...." Thus, it is possible that C. variegatus may also occur in the San Antonio River System.

The only record of Gambusia gaigei from the study area was that of the Texas Parks and Wildlife Department (297) from the Dry Frio River. Hubbs (85, 95), Knapp (116), and Hubbs and Springer (104) stated that this species occurs only in the Big

Bend area of west Texas. Thus, this record of G. gaigei is assumed to be a misidentification.

Hubbs (85) stated that Poecilia formosa is restricted to the extreme southern tip of the state. Hubbs (95) also stated that it has been introduced into game area E6 which includes the upper portions of all three river systems in the study area. Drewry, Delco, and Hubbs (47) and Hubbs (91) stated that this species was introduced into the San Marcos River at San Marcos, and Whiteside (313, 315, 317) and Smith (307) have recorded this species from the San Marcos River. The Texas Parks and Wildlife Department recorded P. formosa from several localities in the San Antonio River System (237, 246, 247, 296) and from Lake Corpus Christi and the lower Nueces River (245, 246, 297). This species has either extended its range in recent years or there are several cases of misidentification.

Knapp (116) gave the range for Menidia audens as "now known to be widely scattered over most of the state." Hubbs (83) stated, "The records attributed to me are based on specimens of Menidia beryllina (Cope) misidentified by me. In Texas, M. audens is known only from the Red River and its tributaries (chiefly Caddo Lake)." No other records of this species in the study area were found except for Knapp (116), who stated that he collected it from the Medina River. It is assumed that M. audens does not occur in the study area.

The only record of Labidesthes sicculus in the study area was that of Mecham (304) from the San Marcos River at San Marcos.

Hubbs (85) stated that the Texas range for this species is north and east of a line from Fort Worth to Houston but not south and west of it. In recent years, we have collected extensively in the San Marcos River at San Marcos and have not taken this species. Thus, it is assumed that this record is incorrect.

Records of *Micropterus punctulatus* were found for the Guadalupe and San Antonio river systems and records of *M. treculi* were found for all three river systems in the study area. Knapp (116) considered these as two subspecies and Hubbs (83) considered them as distinct species. At best, they are difficult to separate, and many of the specimens reported may not be correctly identified. Our collections from the Guadalupe River System, made over the last six years, have yielded two specimens that might be identified as *M. treculi*. However, it remains questionable if *M. punctulatus* and *M. treculi* are distinct species.

Only one record of *Lepomis symmetricus* was recorded from the study area; a single specimen collected by the Texas Parks and Wildlife Department (296) from Medina Lake. Hubbs (92, 95) gave the Texas range of this species as the eastern part of Texas. Thus, it is assumed that the single specimen was misidentified.

Hubbs (95) indicated that the range of *Lepomis humulis* may extend into any of the three river systems in the study area, and Hubbs (85) indicated that its range may extend into the Guadalupe and San Antonio river systems. The only records for this species in the study area were from the Guadalupe River System and apparently this is the only river system in the study area in which *L. humulis* occurs.

The only reports that *Lepomis marginatus* occurs in the study area were made by the Texas Parks and Wildlife Department (269) on the basis of collections from lakes Dunlap, McQueeney, H-4, and H-5. Hubbs (85, 95) and Knapp (116) listed the Texas range of this species as east Texas. Thus, it is probable that these records are based on a misidentification of the common, closely related *L. megalotis*.

Callahan (278) reported three specimens of *Enneacanthus obesus* from Cibolo Creek. Hubbs (95) did not list this species in his checklist of Texas fishes. Moore (126) gave the range of this species as southeastern New Hampshire to Florida, in coastwise waters. Thus, we consider this record of *E. obesus* as a misidentification.

Several records of *Ambloplites rupestris* were found for both the Guadalupe and Nueces river systems but not for the San Antonio River System. Brown (27) stated that this species has been introduced extensively in the Edwards Plateau area. Thus, it is possible that this species also occurs in the San Antonio River System.

Records of *Hadropterus scierus* were found for only the Guadalupe River System in the study area. Knapp (116) stated that this species is generally widespread throughout Texas in suitable habitats and Hubbs (95) indicated that its range may extend into the other two river systems in the study area. However, Hubbs (85) stated that *H. scierus* is abundant in the

Guadalupe River System and northern streams, but absent from the Nueces. He considered the Guadalupe River System to include the San Antonio River System. Thus, it is possible that this species occurs in both the Guadalupe and San Antonio river systems.

The only records of Etheostoma fusiforme from the study area were reported by Evermann and Kendall (51) who gave the collection localities as, "Rio Seco and Rio Leona at Uvalde (as Boleosoma gracile types, Gilbert, 1859b), and (as Poecilichthyes gracilis, Synopsis)...." Hubbs (85) stated that E. fusiforme occurs in the Red River System east of Lake Texoma and is absent from the Sabine River and elsewhere in Texas. Thus, it is assumed that the above records were likely misidentifications of E. gracile, which occurs in the study area.

Records of Etheostoma spectabile were found for all three river systems in the study area. Hubbs (83, 85) and Strawn (158, 159) stated that this species is found in the Guadalupe and San Antonio river systems but is absent from the Nueces River System. The Texas Parks and Wildlife Department reported two specimens of E. spectabile from the upper Nueces River (240) and two specimens from the upper West Nueces River(244). It is questionable if the Nueces River System specimens indicated as E. spectabile were correctly identified. They may have been confused with E. lepidum which commonly occurs in that area.

The only record of Etheostoma grahami from the study area was that of Knapp (116) who gave its range as, "Nueces River in Texas south into the Rio Grande and streams of Chihuahua, west to the Pecos." However, Hubbs (83) stated, "This fish is not known in the Nueces River System, where it is replaced by E. lepidum." Also, Hubbs (95) and Strawn (158, 159) indicated its range does not include the study area. Thus, it is assumed that E. grahami does not occur in the study area.

Fowler (56) recorded Etheostoma microperca as Microperca punctulata, from Sabine, Trinity, Colorado, and Nueces rivers. However, Hubbs (83) stated that E. microperca does not occur in Texas and that he suspected that Fowler (56) based his statement of the range on misidentified specimens of E. gracile. Thus, it is assumed that E. microperca does not occur in the study area.

Hubbs (83, 85), Strawn (158, 159), and Hubbs, Kuehne, and Ball (100) stated that Etheostoma fonticola is endemic to the Comal and San Marcos springs and adjacent waters downstream, where it is found in dense vegetation in flowing water. In addition to these locality records, the Texas Parks and Wildlife Department (245) reported four specimens of this species from the lower Nueces River. It is assumed that the Nueces River specimens were misidentified since the Nueces River offers such a contrast in habitat when compared to those from which E. fonticola has been previously collected.

We found several records of collections of Aplodinotus grunniens from the Nueces River System and one report of a single specimen taken from the San Antonio River by the Texas Parks and Wildlife Department (296). No records of this species were found for the Guadalupe River System. Hubbs (95) and Knapp (116) indicated that the range of this species includes the entire study area. Thus, it is possible that this species also occurs in the Guadalupe River System.

Whiteside (317) collected several specimens of Tilapia mossambica from Canyon Lake on June 16, 1972 and August 29, 1972, which were the first records of this species collected in Canyon Lake. Hubbs (88) stated that established populations of this species now occur in the San Antonio and San Marcos springs. No other records were found for this species in the study area.

Records of Gobiomorus dormitator were found only for the Nueces River in the study area. However, Hubbs (95) indicated the range of this species may extend into any of the three river systems in the study area, so it is possible that this species occurs in the lower part of all three river systems in the study area.

Collections of Gobiosoma bosci were reported from the lower Nueces River by Chaney (300) and by the Texas Parks and Wildlife Department (245) as well as from Lake McQueeney (269). Hubbs (95) gave the range of this species as coastal. Parker, Gallaway, and Moore (138) gave its habitat as marine, estuarine, and freshwater. Thus, the Lake McQueeney record is questionable.

The species Gerres cinereus, Eucinostomus lefroyi, and Pomadasys crocro listed by Chaney (300) and Oligoplites saurus reported by the Texas Parks and Wildlife Department (245) were all recorded as collected from the lower Nueces River. However, Hubbs (95) did not include these species in his checklist of Texas freshwater fishes and Bailey, *et al*. (7) stated that all of these species occur in the Atlantic. Parker, Gallaway, and Moore (138) gave the habitat of *G. cinereus*, *E. lefroyi*, and *O. saurus* as marine and estuarine, and the habitat of *P. crocro* as only marine. While it is possible that these species enter into the lower parts of the Nueces River, the occurrence of *P. crocro* there is questionable.

The Academy of Natural Sciences of Philadelphia (1) listed *Achirus achirus* as collected from the Guadalupe River near Victoria. Hubbs (95), Parker, Gallaway, and Moore (138), and Bailey, *et al*. (7) do not list this species. Thus, it is assumed that the specimens recorded were misidentified or that the species name is a synonym for some other species.

Distribution Patterns of Fishes

The only major contribution to our knowledge of the distribution of fishes throughout the entire study area is that of Hubbs in 1957 (85). He discussed the distribution patterns of fishes in Texas in relation to terrestrial biotic areas (Fig. 94) and to stream systems.

The following discussion is based principally upon Hubbs' (85) conclusions concerning fish distributions related to the study area. These are supplemented by additional information that has come to light in this current survey.

Hubbs (85) stated that, "Distributional patterns of most freshwater fishes in Texas closely resemble those of terrestrial organisms, though there are three exceptional groups: (1) those limited by stream divides, (2) those of marine and freshwater forms meeting in fresh waters near the coast, and (3) certain species of northeastern Texas (Austroriparian) whose ranges include outliers or extensions into other biotic provinces." He concluded that the basic factors controlling distribution patterns of fishes are climatic and geological, these determining the properties of the water.

Species Limited Primarily By Stream Systems

Stream divides, obviously, can limit the geographic range of fishes and it is not surprising that in Texas the Rio Grande-Nueces River and Red River-Sabine River divides limit the largest number of species. The main streams are the most widely separated geographically and downstream flood connections are less likely to occur (85). Below is a discussion of fish species that are affected by stream divides in the study area.

Rio Grande-Nueces River Divide:

Hubbs (85) stated that, "*Notemigonus crysoleucas*, *Opsopoeodus emiliae*, *Ictalurus melas*, and *Etheostoma gracile* occur widely over Texas, especially in the lower Nueces River but are probably not native to the lower Rio Grande (*I. melas* has been recorded there, probably a result of introductions). Etheostoma grahami is found only in the Devil's River and adjacent San Felipe Creek in Texas.... Notropis proserpinus (also in Lower Pecos), Dionda diaboli (also in Las Moras Creek), and an undescribed species of Cyprinodon (only in Devil's River) also are limited to this region of Texas. Their boundaries may be considered to be correlated with either stream divides or biotic areas."

Two exceptions to the above quotation were found. E. grahami was recorded from one locality on the Nueces River (see p. 150), and N. proserpinus was recorded from the San Antonio River System (see p. 139). However, these records are believed to be based upon misidentified specimens.

Nueces River-Guadalupe River Divide:

Hubbs (85) stated that, "Notropis volucellus, Hadropterus scierus, Etheostoma spectabile, and Percina caprodes are abundant in the Guadalupe River System [which includes the San Antonio River System] and northern streams but absent from the Nueces. The Percina, however, also inhabits Rio Grande tributaries near the Devil's River. The cause of the range discontinuity is not known."

The only exceptions to the above quotation were two records of E. spectabile from the upper portion of the Nueces River System (see p. 150) and it was concluded that these were possibly misidentifications.

Guadalupe Disjunct Population:

Hubbs (85) stated that, "*Hadropterus shumardii* is known in Texas only from the Guadalupe system [which includes the San Antonio River System] east of the Balcones escarpment as well as east Texas. The cause of the range discontinuity is not known." We found no contradictions to the above statement.

Coastal Species

Hubbs (85) stated that, "Fish distributional data logically support a major coastal biologic area. Many salt water forms invade fresh waters for varying distances (Gunter, 1945), but many of these distances are similar. Probably the distance inland fluctuates directly with the amount of salt water. During the past several years of pronounced drought this area has been slightly narrower than Tharp's Coastal Prairie, and on the central coast corresponds rather closely with Campbell's outline of the range of the Karankawa Indians. The primarily marine species that occupy this area include *Elops saurus*, *Harengula pensacolae*, *Anchoa mitchilli*, *Bagre marinus*, *Galeichthys felis* [=*Arius felis*], *Adinia xenica*, *Fundulus similis*, *F. grandis*, *F. pulvereus*, *F. jenkinsi*, *Mugil curema*, *Membras martinica*, *Gobionellus shufeldti*, *Microgobius gulosus*, *Gobiosoma bosci*, *Trinectes maculatus*, and *Achirus lineatus*. Most of the primarily fresh-water fishes do not penetrate into this brackish water area. A few do enter the habitat and occur there with forms that are primarily marine. Other primarily marine forms may extend farther into fresh waters. Strongylura marina has been taken as far up the Colorado River as Bastrop. Cyprinodon variegatus, Menidia beryllina, and Lucania parva are often found in the Rio Grande above Falcon Dam. Perhaps they occupy most of the Tamaulipan Biotic Province. Lucania parva has also been taken in the Pecos River."

In Hubbs" (95) 1972 checklist of Texas freshwater fishes, he listed the Texas range of many species as being coastal. He stated that coastal fishes typically inhabit brackish or salt water and enter only the coastal streams. In addition to the coastal species given above by Hubbs (85), Hubbs (95) listed the following coastal species: Aprionodon isodon (finetooth shark), Carcharhinus leucas (bull shark), Pristis pectinata (smalltooth sawfish), Dasyatis sabina (Atlantic stingray), Megalops atlantica (tarpon), Brevoortia gunteri, Anchoa hepsetus, Syngnathus scovelli (gulf pipefish), Centropomus undecimalis (snook), Caranx hippos (crevalle jack), Eucinostomus argenteus, Bairdiella chrysura, Scianops ocellata, Leiostomus xanthurus, Micropogon undulatus, Pogonias cromis, Cynoscion arenarius (sand seatrout), C. nebulosus, Lagodon rhomboides, Archosargus probatocephalus, Agonostomus monticola (mountain mullet), Polydactylus octonemus (Atlantic threadfin), Gobiomorus dormitator, Eleotris pisonis (spinycheek sleeper), Dormitator maculatus (fat sleeper), Evorthodus lyricus (lyre goby), Gobinellus boleosoma (darter goby), G. hastatus (sharptail goby), Gobiosoma robustum (code goby), Gobioides broussonneti (violet goby), Citharichthys spilopterus (Bay whiff), Etropus crossotus (fringed flounder), Paralichthys lethostigma, Sphoeroides nephelus (Southern puffer). Four coastal fish species were also recorded (245, 300) from the lower Nueces River which were not listed in Hubbs (85) or Hubbs (95). These include Gerres cinereus, Eucinostomus lefroyi, Pomadasys crocro, and Oligoplites saurus (see p. 152). It is possible that any of the above mentioned coastal species might occur in the extreme lower portion of the river systems in the study area even though that species does not occur on the checklist (Table 1).

Species That Primarily Follow Terrestrial Biotic Areas

Hubbs (85) stated that in Texas, "The ranges of 79 fish species are entirely or in large part limited to the Biotic Areas based on the distribution of terrestrial organisms. Many of these fishes are common species the ranges of which are not likely to be modified by fishermen."

Below is a discussion of fish species that may be limited by Biotic Areas (Fig. 94) in the study area.

Oak-Hickory--Blackland Prairie Line:

Hubbs (85) stated that "Amia calva, Esox americanus, Notropis atrocaudalis, and Aphredoderus sayanus reach western limits near this line.... All are limited on the southwest by a line between Brazos and Matagorda counties. They therefore moderately transgress the Austroriparian.

"Notropis fumus and N. amnis have similar western limits, but toward the southwest extended to the northern edge of the Tamaulipan Biotic Province.

"The eastern limit of the range of Pimephales promelas coincides with this line north of San Antonio. This species is absent also in the Balconian Biotic Province (except for one specimen which was probably released as bait) and from the Rio Grande System of Texas (except in the Big Bend region)."

Two exceptions to the above quotation were found. First, N. atrocaudalis was reported from Lake Corpus Christi (see p. 140), however, this record was probably based on a misidentification. Second, several records of P. promelas were found from the Balconian Biotic Province (Figs. 15 and 49), these were probably due to bait releases since this species is an important bait minnow.

Eastern Cross Timbers and Edwards Plateau-Blackland Prairie Line:

Hubbs (85) stated that, "The western limit of Etheostoma chlorosomum, Opsopeodus emiliae, and Lepisosteus spatula approximates this line, which cuts through the Texan Province in north-central Texas.... On the south E. chlorosomum is absent in the Tamaulipan Biotic Province. Opsopoeodus emiliae occupies all but the Rio Grande drainage of the Tamaulipan in Texas. Lepisosteus spatula occurs throughout the Tamaulipan of Texas, and ranges farther.

"In Texas Campostoma anomalum and Etheostoma spectabile reach their eastern limits on this line. The former occupies the entire Balconian Biotic Province and parts of the Rio Grande System. The latter is excluded from the Nueces System. On the west both are excluded from the Kansan Biotic Province in Texas. The eastern limits of C. anomalum are slightly obscured by occasional eastern records, but that of E. spectabile is remarkable precise. West of the Balcones escarpment it is usually the most abundant riffle-inhabiting fish. No specimens are taken in extensive collections as little as 10 miles east (downstream)."

Three exceptions to the above quotation were found. First, records of L. spatula were reported for the Nueces River System in the Balconian Biotic Province (Fig. 67). If these records of L. spatula were not misidentifications, they represent a range extension of this species. Second, Jurgens (109) reported collecting C. anomulum from the San Marcos River (Fig. 16) for a short distance east of this line. Also, Hubbs (95) indicated that its range extends further east than this line. These records of C. anomulum may be included in the occasional eastern records mentioned by Hubbs (85). Third, Jurgens (109) recorded two specimens of E. spectabile from the San Marcos River, one at Martindale and one at Fentress. This is a slightly further eastern range extension than indicated by Hubbs (85).

Texan Biotic Province:

Hubbs (85) stated that, "Three fishes, Notropis oxyrhynchus, N. brazosensis [=N. shumardi], and N. potteri are limited to this area. These species were originally thought to be limited entirely or almost entirely to the Brazos River System (Carl L. Hubbs and Bonham, 1951), but have since been taken in adjacent systems (Jurgens, 1954). Notropis buccula is also found only here, but is absent in the Red River System, where it is replaced by N. bairdi, with which it may be conspecific.

"Three species, Schilbeodes gyrinus [=Noturus gyrinus], Fundulus notatus [=Zygonectes notatus], and Micropterus punctulatus occupy both the Austroriparian and Texan in Texas.

"Four species, Lepisosteus productus [=L. oculatus], Signalosa petenensis [=Dorosoma petenense], Etheostoma gracile, and Mugil cephalus occupy the Texan, Austroriparian, and Tamaulipan biotic provinces in Texas. Etheostoma gracile is absent in the Rio Grande drainage of the Tamaulipan. Mugil cephalus is primarily marine but its freshwater records closely approximate the listed geographic area.

"Notropis venustus, Ictalurus natalis, and Lepomis punctatus occupy the Texan, Austroriparian, and Balconian biotic provinces in Texas. In Texas Notropis volucellus has the same limit, except that it is absent in the Nueces River Drainage. Hadropterus scierus also occupies the three biotic provinces but is absent in the Nueces System and on the coastal part of the Texan."

Eight exceptions to the above quotation were found. First, Noturus gyrinus was reported from Medina Lake (see p. 144) in the Balconian Biotic Province and from the lower Nueces River System (see p. 144) in the Tamaulipan Biotic Province. This represents a range extension for N. gyrinus unless these records were based on young-of-the-year bullheads which are sometimes confused with madtoms. Second, Zygonectes notatus was reported from several localities in the Guadalupe River System in the Balconian Biotic Province (Fig. 22) and from several localities in the San Antonio River System in the Tamaulipan Biotic Province (Fig. 54). This probably represents a range extension for Z. notatus. Third, Micropterus punctulatus was recorded from several localities in the San Antonio (Fig. 57) and Guadalupe (Fig. 26) river systems in the Balconian Biotic Province. If these were not misidentifications (see p. 148) this represents a range extension for M. punctulatus. Fourth, Lepisosteus oculatus was recorded from several localities in upper portions of the Nueces (Fig. 67), the San Antonio (Fig. 42), and the Guadalupe (Fig. 5) river systems which are in the Balconian Biotic Province. This is probably a range extension for this species. Fifth, Dorosoma petenense was recorded from Canyon Lake and the lower portion of the Blanco River which is in the Balconian Biotic Province. This represents a range extension for D. petenense; probably a result of introductions of this species as a forage fish. Sixth, Notropis venustus was recorded from several localities in the lower Nueces (Fig. 72) and San

Antonio (Fig. 46) river systems in the Tamaulipan Biotic Province. This probably represents a range extension for *N. venustus*. Seventh, *Ictalurus natalis* was recorded from several localities in the Nueces (Fig. 78) and San Antonio (Fig. 53) river systems in the Tamaulipan Biotic Province. This range extension of *I. natalis* is probably due to introductions of this species. Eighth, *Notropis volucellus* was reported from Hondo Creek in the Nueces River System (231). However, it is questionable if the Hondo Creek records were correct identifications (see p. 140).

Balconian Biotic Province:

Hubbs (85) stated that, "A number of fishes are entirely or chiefly limited to this Biotic Province, which is limited on the south and east by the Balcones Escarpment. The range of *Etheostoma lepidum* nearly coincides, if *Etheostoma grahami* is specifically distinct. If *E. grahami* and *lepidum* are conspecific, the Texas range of *E. lepidum* equals the Balconian. *Notropis amabilis* in Texas is limited to the Balconian. Established populations of the introduced *Lepomis auritus* are chiefly limited to this area, though some are found elsewhere, especially in farm ponds. A disjunct part of the range of *Notropis deliciosus* [=*N. stramineus*] corresponds with the Balconian; other specimens are from northern Mexico and the Red River and northern drainages in the United States. *Notropis lepidus* [=*N. lutrensis*] and *Micropterus treculi* occupy the southern and northern halves of the Balconian, respectively.

Both are essentially allopatric to closely related species (lutrensis and punctulatus).

"Moxostoma congestum in Texas is chiefly limited to the Balconian, but does extend into the Chihuahuan and Texan to Coastal Prairie and Brazos-Trinity divide."

Four exceptions to the above quotation were found. First, Notropis amabilis was recorded from the Nueces River in the Tamaulipan Biotic Province (Fig. 71) and from the San Marcos and Guadalupe rivers (Fig. 10) in the Texas Biotic Province for a short distance downstream from the Balconian Biotic Province. If these specimens were correctly identified, this represents a range extension for N. amabilis. Second, Notropis stramineus was recorded from the Leona River a short distance downstream from the Balconian Biotic Province in the Tamaulipan Biotic Province (Fig. 73). If this was a correct identification, it represents a slight range extension for N. stramineus. Third, Micropterus treculi was recorded from the West Nueces River in the southeast part of the Balconian Biotic Province (244) and from the Guadalupe River System in the Texan Biotic Province (Fig. 28). If these records were not incorrectly based on specimens of M. punctulatus (see p. 148), this represents a range extension for M. treculi. Fourth, Moxostoma congestum was recorded from the San Antonio (Fig. 51) and Nueces (Fig. 70) river systems in the Tamaulipan Biotic Province. Thus, if these are correctly identified specimens, they represent a range extension for M. congestum.

Tamaulipan Biotic Province:

Hubbs (85) stated that, "Three fishes, Cichlasoma cyanoguttatum, Mollienisia latipinna [=Poecilia latipinna], and M. formosa [=Poecilia formosa] are essentially limited to the Tamaulipan. M. formosa is restricted to the extreme southern tip of the state. Mollienisia latipinna also occupies the coastal plain and has been introduced elsewhere (Brown, 1953).

"The native range of Astyanax faciatus [=A. mexicanus] in Texas is essentially limited to the Tamaulipan and Chihuahuan. It has been widely introduced elsewhere by bait release (Miller, 1952, Brown, 1953, and Riggs, 1954)."

Two exceptions to the above quotation were found. First, Cichlasoma cyanoguttatum was recorded from many localities in the Balconian and Texan biotic provinces (Figs. 41, 66, 93), which probably represent a range extension. Second, Poecilia formosa was recorded from several localities throughout the study area (see p. 147) and represents a range extension for this species.

Local Endemics

Four species in the study area have extremely small ranges. They can be considered restricted to stream systems or biotic areas (85).

Hubbs (85) states that "Satan eurystomus and Trogloglanis pattersoni are blind catfishes known only from artesian wells near San Antonio .... [see p. 143].

"Etheostoma fonticola and Gambusia geiseri naturally occur in Comal and San Marcos springs and adjacent waters downstream.

Those are the two largest springs along the Balcones Escarpment. The former fish has not been collected elsewhere. The latter has been found elsewhere probably as a result of mosquito control introductions (Clark Hubbs and Springer, 1957)."

The only exception to the above quotation was four specimens of _E_. _fonticola_ recorded from the lower Nueces River (245). These specimens were assumed to be misidentifications (see p. 151).

In addition to the above mentioned local endemic species, Hubbs and Peden (103) reported a new species, _Gambusia georgei_, which is a localized endemic inhabiting thermally consistent shallow water over muddy bottom with sparse aquatic vegetation in the San Marcos River.

Introduced Fishes

Baughman (11) stated that _Alosa sapidissima_ (American shad), _Oncorhynchus tshawytscha_ (chinook salmon), _Salmo trutta_ (brown trout), _Salmo gairdneri_, _Salvelinus fontinalis_ (brook trout), _Perca flavescens_ (yellow perch), and _Stizostedion vitreum_ (walleye) have been introduced into various streams or lakes in Texas but he did not give the localities of the introductions. He also stated that as far as he knew all attempts to establish populations of these fish were unsuccessful.

The Texas Parks and Wildlife Department (253, 257, 260, 261, 267) stated that the Texas Parks and Wildlife Department stocked 32,000 _Salmo gairdneri_ into the Guadalupe River below Canyon Lake Dam during the period from April 1966 to May 1968. These fish were furnished by the Lone Star Brewery. Since March 1969 the Texas Parks and Wildlife Department has stocked an additional 36,000 S. gairdneri, furnished by the Bureau of Sports Fisheries and Wildlife, in the same area. There are no records that show this species reproduces in the Guadalupe River.

Mr. James Bilbro, Chairman of the Fish Committee, Guadalupe Chapter of Trout Unlimited (personal communication), stated that on April 7, 1972, 16,000 fingerling Salmo trutta and 1,200 fingerling S. aguabonita (golden trout) were stocked in the Guadalupe River from immediately below Canyon Lake Dam to about 6 miles downstream. On November 2, 1972, an additional 6,000 S. trutta were stocked in the same area. He stated that some S. trutta caught recently measured about 8 inches in total length. It is not known whether or not these fish will establish themselves as reproducing populations.

Brown (27) stated that Mr. C. H. Brunstein and a San Antonio fisherman were probably responsible for the introduction of Astyanax mexicanus into the San Antonio River in 1908. He also stated that Mr. Shiner of San Antonio and Mr. Lucious Parish of the U. S. Fish Culture Station at San Marcos introduced this species into the San Marcos River in 1928-1930. Hubbs (95) listed it as introduced in game areas W1, W2, and W4, which include parts of the Guadalupe and San Antonio river systems.

Barron (10) stated that Plecostomus plecostomus (armored catfish) and Belonesox belizanus (pike killifish) have been introduced into the San Antonio River by accidental releases of aquarium fishes.

Brown (27) stated that Poecilia latipinna was probably introduced into the San Antonio, Comal, and San Marcos rivers during the period from 1932 to 1944.

Hubbs stated that Poecilia formosa was introduced into the San Marcos River prior to 1958 (47), probably in 1955 from the Brownsville Population (91). It is now found in several localities in the study area (see p. 147).

Hubbs and Peden (102) stated that on October 6, 1966, 1,500 Micropterus dolomieui were released into the upper San Marcos River by Richard White, Texas Parks and Wildlife Biologist. There is no evidence that a reproducing population was established.

Hubbs (85) stated that the introduced species Lepomis auritus, which is abundant in the study area, has established populations chiefly limited to the Balconian Biotic Province, though some are found elsewhere, especially in farm ponds.

Brown (27) stated that it seems apparent that Ambloplites rupestris was first introduced into Texas in 1897 by the U. S. Fish Cultural Station at San Marcos, Texas. Hubbs (95) said this species was introduced into game area 6 which includes the headwater areas of all three river systems in the study area.

Texas Parks and Wildlife Department (250, 262) stated that 1,150,000 Stizostedion vitreum fry were stocked in Canyon Lake on May 10, 1965, and that no specimens have been recovered.

Brown (27) and the Texas Parks and Wildlife Department (183) stated that *Cichlasoma cyanoguttatum* was first introduced into the Guadalupe and San Antonio river systems in 1928 by the U. S. Fish Cultural Station at San Marcos, Texas.

Hubbs (88) stated that *Tilapia mossambica* has been introduced into San Antonio and San Marcos springs and Whiteside (317) reported it has been introduced into Canyon Lake. There are established populations of this species in San Antonio and San Marcos springs, but it is not known if the Canyon Lake population will become an established population.

Many other sport and bait fishes such as *Micropterus salmoides*, *Lepomis macrochirus*, *L. microlophus*, *L. cyanellus*, *Pomoxis annularis*, *P. nigromaculatus*, *Ictalurus punctatus*, *I. furcatus*, *Morone chrysops*, *Cyprinus carpio*, and *Pimephales promelas* have been introduced into many streams and lakes in the study area.

Rare Fish Species

The following annotated list of rare fish species in the study area was compiled by Hubbs (96) and Miller (123). Rare is defined as not under immediate threat of extinction, but occurring in such small numbers and/or in such a restricted or specialized habitat that it could quickly disappear. These species require careful watching. The factor common to all threatened species is not deterioration of status, but vulnerability to extinction in the foreseeable future.

Satan eurystomus -- a blind catfish which has been obtained only from deep artesian wells in the vicinity of San Antonio, Texas.

Trogloglanis pattersoni -- a blind catfish which has been obtained only from deep artesian wells in the vicinity of San Antonio, Texas.

Gambusia georgei -- a localized endemic inhabiting thermally consistent shallow water over muddy bottom with sparse aquatic vegetation in the San Marcos River.

Poecilia formosa -- a gynogenetic molly which was introduced into the study area (San Marcos River at San Marcos) in 1955 (47, 91). The Texas Parks and Wildlife Department has recently reported collecting this species from several localities in the San Antonio River System, from Lake Corpus Christi, and from several localities in the lower Nueces River (see p.147). If the Texas Parks and Wildlife Department records are correct identifications, then it might be possible to remove this species from the rare list.

Etheostoma fonticola -- a darter which is endemic to the Comal and San Marcos springs and adjacent waters downstream.

Quantitative Analysis of Fishery Resources

Of primary concern to water development organizations is the ability to appraise the effects of changes of any kind resulting from man's activities on water resources. Observing the response of fish populations to changes in their environment is one way to make this appraisal. However, quantitative determinations of fish populations are necessary, and these are difficult to obtain. For any one fishing method the catch is not a reliable criterion of actual abundance of all species. Sampling methods are selective with respect to species, size, and sex of individuals; therefore, representativeness of these sampling methods depend on the care and thoroughness used in sampling.

The bulk of fishery data on the Guadalupe, San Antonio, and Nueces river basins are a result of Texas Parks and Wildlife field surveys. Some of the data came from research supported by private organizations and educational institutions. In all of these studies, personnel made only limited use of poisons. The difficulties encountered in sampling with poisons in streams and the serious public repercussions that could have occurred with their use prevented wide utilization of this sampling method. Some of the data were obtained by hoop nets, fyke nets, barrel traps, and rod-and-reel fishing. However, the largest part of the data was collected by gill nets and seines. Gill nets were usually experimental; that is, nets had webbing of different mesh size. The mesh sizes most often employed were: 1-, 1 1/2-, 2-, 2 1/2-, and 3-inch square measure. Occasionally gill nets of one mesh size were used in sampling. The mesh sizes employed for these nets were either 2- or 3-inch square measure. Bag seines and common sense minnow seines were the main types of seines utilized. Bag seines were usually about 30 ft long by 6 ft deep with a mesh size of 1/4-inch square measure. Common sense minnow seines ranged from 4 to 10 ft long by 4 ft deep and had a mesh size of 1/8-inch square measure.

According to Bennett (14) gill nets are selective for pelagic fishes, and therefore, do not yield completely representative samples. However, the potential for a representative sample taken from a fish population does exist with use of experimental gill nets because of the different mesh sizes utilized. But such factors as non-random distribution of fish, movement of fish, presence or absence of spines on fish, mesh size of nets, time of day, season, and others will add to the selectivity of gill nets. Seines are somewhat less selective than most other types of gear (14). However, seines can be used efficiently only in waters no deeper than the depth of the seine and where the bottom is devoid of snags. Certain fishes can be expected to escape from seines by jumping over the cork line at the top and by going under the lead line at the bottom. All of the above factors, as well as others not defined, add to the selectivity of the respective gears and cause enough experimental error in sampling to require that the results be cautiously interpreted.

A large number of personnel (fishery technicians and biologists) were utilized in the fish sampling programs conducted on the three river basins. A problem causing concern is that these people varied in competence in the fisheries profession and they followed no standardized sampling procedure. The sampling programs differed according to gear used and fishing effort. Attempting to derive concrete conclusions based on data collected in such a manner is impossible. This is a difficulty faced when inappropriate experimental designs are used; that is, statistical confounding is unavoidable under these circumstances. At best, then, only rough approximations to quantitative accuracy of fish populations are possible. In other words, further study is needed with an experimental design that will provide unambiguous results.

Number of species was one statistic used to evaluate fisheries resources and water quality of the three river basins. If Gause's Principle (134) of no more than one species per ecological niche holds, then the number of species is an indication of the number of filled niches. Probably the more niches filled, the greater the production for that type of habitat. However, one should be cautious in this approach since many fishes may have a wide tolerance of habitat type and feeding habits and, therefore, niches may be poorly separated.

One species, then, might have the ability to produce as much as several species together. Number of species may also be an index to environmental disturbance. According to Patrick (139, 140) "healthy" streams contain a great many species representing various taxonomic groups. However, interpretation of results on this basis must be handled carefully. There are polluted streams that have many fish species (110). On the other hand, there are unpolluted streams that have few fish species; for example, trout streams have few species because of their cold waters. But in specific instances number of species is a useful index to the environmental conditions of a stream. For example, the presence of some fish above a point of entry of a waste and their paucity or absence below the point of entry suggests that the waste is detrimental to the fish. Of course, number of species as an index to environmental quality will take on more meaning as other kinds of information are used in conjunction with it. For example, data on kinds of fishes and their standing crops are needed to help in the appraisal of the effects of changes resulting from pollutants or from measures taken for stream improvement. All aquatic organisms are more or less sensitive to environmental changes, and the fate of any of them can be instructive concerning the nature and magnitude of these changes. Data on abundance of the different age classes for non-migratory fish species as well as average growth rates is significant. Numerous representatives of different age classes whose growth rates are average suggest no environmental anomalies which are restrictive to these fishes have occurred in recent times.

According to Ramsey (142) many fishes in the minnow family (Cyprinidae) are good indicators of "clean" water. In this study Notropis spp. (shiners), which belong to the minnow family, were used as a biological indicator of undisturbed environmental conditions because they were widespread in the river systems. There appeared to be no distributional or ecologic limitation problem for these minnows. However, it should be pointed out that no real knowledge of the specific factors which limit the distribution and abundance of the Notropis spp. is known. That is, before these minnows will be of much value as indicator organisms it must be determined if their absence at a locality is due to pollutional damage or to natural habitat limitation.

The percentage of sport fish, rough fish, and minnows taken per sample were used with corresponding information on total number of species and number of Notropis spp. to formulate some idea of the environmental status of the river basins' water resources. Sport fish were arbitrarily defined as small insectivorous fish (bluegills, crappies, other sunfishes, etc.), and secondary predators (largemouth bass, trout, blue catfish, etc.). Rough fish were considered as species with relatively short food chains (gizzard shad, buffalo, carp, suckers, etc.). Minnows were mainly fishes belonging to the family Cyprinidae (carp excluded). See Table 5 for specific separation of fishes to sport, rough, and minnow groups. The status of a fish population may indicate suitable or unsuitable environmental conditions. But it should be pointed out that the water quality requirements of most fish have never been adequately investigated, so there is no real information of environmental factors which limit fish distribution and abundance; that is, the value of fish as indicators of water conditions for uses other than fishing has not been shown.

The data on number of species, rough fish, sport fish, and minnows are summarized according to river basin and habitat (Tables 6-9). The data represent 23 years of field investigations; therefore, any changes that may have occurred in a habitat during this period is obscured. So, caution should be exercised in evaluating significance of any results. Two of the habitat classifications are mainstream and deep storage impoundments. The mainstream impoundments are arbitrarily defined as bodies of water less than 3,000 acres, and the deep storage impoundments are defined as bodies of water greater than 3,000 acres. Other habitat designations are minor, major, and principal streams. Minor streams are defined as intermittent streams (148); i.e., streams which receive their waters mostly from runoff, and because the runoff is seasonal, stream flow occurs only during wet periods. Major streams are permanent streams (148), i.e., streams which receive their waters mostly through seepage and springs from subsurface water and are tributaries

Table 5. An arbitrary separation of fishes for the Guadalupe, San Antonio, and Nueces river basins into sport, rough, and minnow classifications (Common names obtained from Bailey, et al. (7))

Sport Fishes	Rough Fishes	Minnows
Rainbow trout	Alligator gar	Mexican tetra
Channel catfish	Spotted gar	Golden shiner
Blue catfish	Longnose gar	Pugnose minnow
Flathead catfish	Threadfin shad	Speckled chub
American eel	Gizzard shad	Texas shiner
White bass	Carp	Silverband shiner
Spotted bass	Goldfish	Weed shiner
Guadalupe bass	Blue sucker	Pallid shiner
Largemouth bass	Smallmouth buffalo	Blacktail shiner
Warmouth	River carpsucker	Red shiner
Green sunfish	Grey redhorse	Sand shiner
Spotted sunfish	Spotted sucker	Mimic shiner
Redear sunfish	Lake chubsucker	Ghost shiner
Bluegill	Black bullhead	Roundnose minnow
Orangespotted sunfish	Yellow bullhead	Bullhead minnow
Redbreast sunfish	Freshwater drum	Fathead minnow
Longear sunfish	Mozambique tilapia	Stoneroller
Rock bass		Tadpole madtom
White crappie		Rainwater killifish
Black crappie		Gulf killifish
Rio Grande perch		Blackstripe topminnow
Smallmouth bass		Sheepshead minnow
		Largespring gambusia
		Mosquito fish
		San Marcos gambusia
		Sailfin molly
		Amazon molly
		Tidewater silverside
		Dusky darter
		River darter
		Logperch
		Big scale logperch
		Bluntnose darter
		Slough darter
		Orangethroat darter
		Greenthroat darter
		Fountain darter

Table 6. A comparison of the average number of fish species taken by seines from the Guadalupe, Nueces, and San Antonio river basins (1950-1972).

		Average Number of Fish Species				
		Impoundments		Streams		
River Basins	Sources of Data	Mainstream[1]	Deep Storage[2]	Minor[3]	Major[4]	Principal[5]
Guadalupe:	109, 182, 192, 193, 199, 210, 213, 223, 236, 243, 266, 269, 285, 295.	10	13	4	12	14
Nueces:	174, 181, 183, 184, 186, 191, 197, 207, 217, 222, 229, 237, 240, 245, 246, 251, 263, 268, 296, 297.	7	12	7	7	11
San Antonio:	168, 170, 171, 177, 190, 194, 201, 223, 232, 233, 236, 240, 247, 268, 278, 296.	9	14	6	8	4
Weighted Mean		10	13	5	9	7

1 Impoundments arbitrarily defined as bodies of water less than 3,000 acres.
2 Impoundments arbitrarily defined as bodies of water greater than 3,000 acres.
3 Intermittent streams (148).
4 Permanent streams that are tributaries to principal streams (148).
5 The permanent stream from which the river basin gets its name.

Table 7. A comparison of the average number of fish species taken by gill nets from the Guadalupe, Nueces, and San Antonio river basins (1950-1972).

River Basins	Sources of Data	Average Number of Fish Species: Impoundments		Streams		
		Mainstream[1]	Deep Storage[2]	Minor[3]	Major[4]	Principal[5]
Guadalupe:	109, 182, 192, 193, 199, 210, 213, 223, 236, 243, 266, 269, 285, 295.	11	27	--	8	9
Nueces:	174, 181, 183, 184, 186, 191, 197, 207, 217, 222, 229, 237, 240, 245, 246, 251, 263, 268, 296, 297.	9	14	10	8	9
San Antonio:	168, 170, 171, 177, 190, 194, 201, 223, 232, 233, 236, 240, 247, 268, 278, 296.	9	15	6	6	8
Weighted mean		10	21	9	7	8

1 Impoundments arbitrarily defined as bodies of water less than 3,000 acres.
2 Impoundments arbitrarily defined as bodies of water greater than 3,000 acres.
3 Intermittent streams (148).
4 Permanent streams that are tributaries to principal streams (148).
5 The permanent stream from which the river basin gets its name.

Table 8. A comparison of the percentage of rough fish, sport fish, and minnows taken by seine from the Guadalupe, Nueces, and San Antonio river basins (1950-1972).

River Basins	Sources of Data	Rough Fish (%)			Sport Fish (%)			Minnows (%)		
		Main-stream[1]	Deep Storage[2]	Streams[3]	Main stream[1]	Deep Storage[2]	Streams[3]	Main stream[1]	Deep Storage[2]	Streams[3]
Guadalupe:	109, 182, 192 193, 199, 210, 213, 223, 236, 243, 266, 269, 285, 295.	15	45	1	41	17	17	44	38	82
Nueces:	174, 181, 183, 184, 186, 191, 197, 207, 217, 222, 229, 237, 240, 245, 246, 251, 263, 268, 296, 297.	0	31	3	19	4	15	81	65	82
San Antonio:	168, 170, 171, 177, 190, 194, 201, 223, 232, 233, 236, 240, 247, 268, 278, 296.	5	6	1	34	35	14	61	59	85
Weighted Percentages		8	29	2	36	11	15	56	60	83

1 Impoundments arbitrarily defined as bodies of water less than 3,000 acres.
2 Impoundments arbitrarily defined as bodies of water greater than 3,000 acres.
3 Intermittent and permanent streams combined.

Table 9. A comparison of the percentage of rough fish, sport fish, and minnows taken by gill nets from the Guadalupe, Nueces, and San Antonio river basins (1950-1972).

River Basins	Sources of Data	Rough Fish (%)			Sport Fish (%)			Minnows (%)		
		Main-stream[1]	Deep Storage[2]	Streams[3]	Main stream[1]	Deep Storage[2]	Streams[3]	Main stream[1]	Deep Storage[2]	Streams[3]
Guadalupe:	109, 182, 192 193, 199, 210, 213, 223, 236, 243, 266, 269, 285, 295.	59	63	78	39	37	22	2	0	0
Nueces:	174, 181, 183, 184, 186, 191, 197, 207, 217, 222, 229, 237, 240, 245, 246, 251, 263, 268, 296, 297.	71	58	78	29	42	22	0	0	0
San Antonio:	168, 170, 171, 177, 190, 194, 201, 223, 232, 233, 236, 240, 247, 268, 278, 296.	54	64	78	44	36	22	2	0	0
Weighted Percentages		61	61	78	37	39	22	2	0	0

1 Impoundments arbitrarily defined as bodies of water less than 3,000 acres.
2 Impoundments arbitrarily defined as bodies of water greater than 3,000 acres.
3 Intermittent and permanent streams combined.

to principal streams. A principal stream is a permanent stream from which the river basin gets its name. Admittedly, this classification of habitats is broad.

A comparison of the average number of fish species for the Guadalupe, Nueces, and San Antonio river basins are given in Table 6 (seine data) and Table 7 (gillnet data). The weighted means given for each habitat type represent the average number of species for all three river basins combined. The largest weighted mean was associated with deep storage impoundments. This value may indicate a more diverse habitat for deep storage impoundments than for mainstream impoundments and streams. Mainstream impoundments had a larger weighted mean than did streams, but the difference probably is not significant since these impoundments are river-like in nature. Comparisons between stream habitats gave varied results. In Table 6, minor streams had a smaller weighted mean than did the major or principal streams, but the reverse situation was seen in Table 7. In Tables 6 and 7 no appreciable difference between the average number of fish species for each river basin within any of the habitat groups was noted. However, the Guadalupe River Basin did have a greater, or at least an equivalent, average for each habitat classification than did the other two river basins except in the case of minor streams. This river basin probably has a greater diversity of habitat as compared to the other basins because it extends farther onto the Edwards Plateau.

Comparison of the percentage of rough fish, sport fish, and minnows are given by Table 8 (seine data) and Table 9 (gillnet data). Percentages are given for mainstream and deep storage impoundments, and streams. The various kinds of streams (defined in this report as minor, major, and principal) were combined to facilitate presentation of the data. Obviously, the results may change with the subdivision of the stream category to minor, major, and principal streams. But hopefully, a representative picture of the population structure for impoundments and stream habitats is obtained from the habitat classification used in Tables 8 and 9. The weighted percentages listed for each habitat represent the percentage of rough fish, sport fish, and minnows respectively for the three river basins combined.

In Table 8 the weighted percentages indicated that rough fish populations were larger in impoundments than in streams, sport fish populations were greater in stream-like habitats (mainstream impoundments and streams) than in deep storage impoundments, and streams had more minnows in their fish populations than did impoundments. Most of the rough fish taken by seines were young-of-the-year gizzard shad that happened to be in shallow water at the time of sampling. The sport fish were mainly small sunfish.

In Table 9 the weighted percentages indicated a larger rough fish population for streams than for impoundments, and more sport fish for impoundments than for streams. The results for the rough fish data were opposite to those shown by seining data in Table 8. No definite reasons that would explain these conflicting results are readily apparent. But the rough fish as well as the sport fish gillnet data represented a wider size and species range than did seining data. Therefore, the gillnet data may be more representative of the true population structure than was the seining data. Gill nets rarely caught minnows, but occasionally large golden shiners were taken. When these minnows were caught they came from impoundment habitats in either the Guadalupe or San Antonio river basins.

Comparisons between the three river basins showed variable results for the percentages of rough fish, sport fish, and minnows in mainstream and deep storage impoundments (Tables 8 and 9). However, in streams the percentages were similar; that is, streams of the three river basins appeared to have similar population structures.

The fisheries data on number of species, percent rough fish, sport fish, and minnows have been summarized by figures for the Guadalupe (Figs. 95 to 111), San Antonio (Figs. 112 to 123), and Nueces (Figs.124 to 149) river basins. It is intended that the figures be used only as a source of information to gain some insight to the status of the fisheries of the three river basins. However, interpretation of the figures will be left to the discretion of the user. The point is that the use of the information presented by the figures to evaluate environmental conditions is too risky at this stage. Fish are potentially useful indicators of the environmental status of an aquatic habitat. But before they can be used to reliably reflect

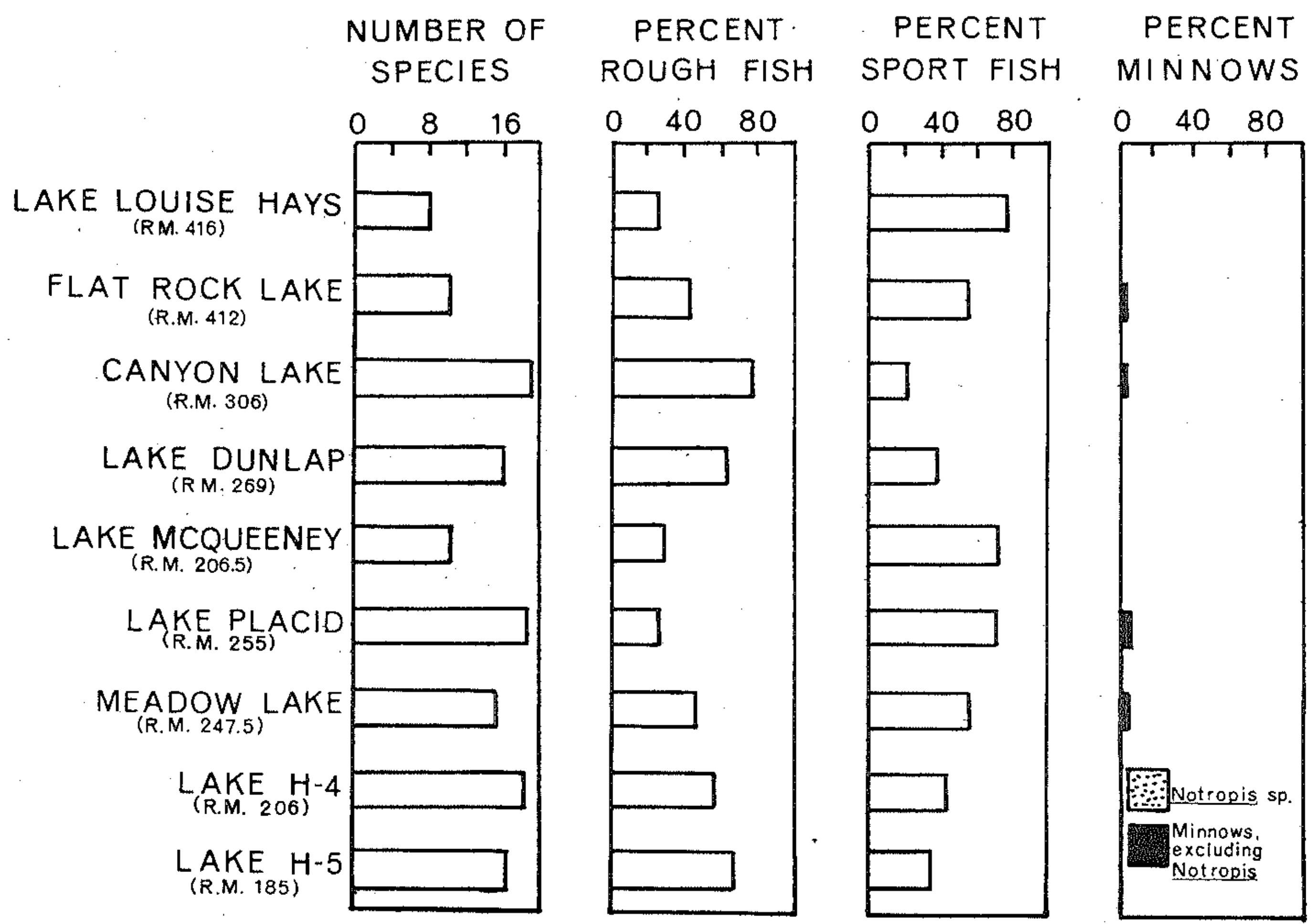


Figure 95. Number of fish species and percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife gillnet data for 1969-70, Guadalupe River Basin lakes (266, 269, 295).

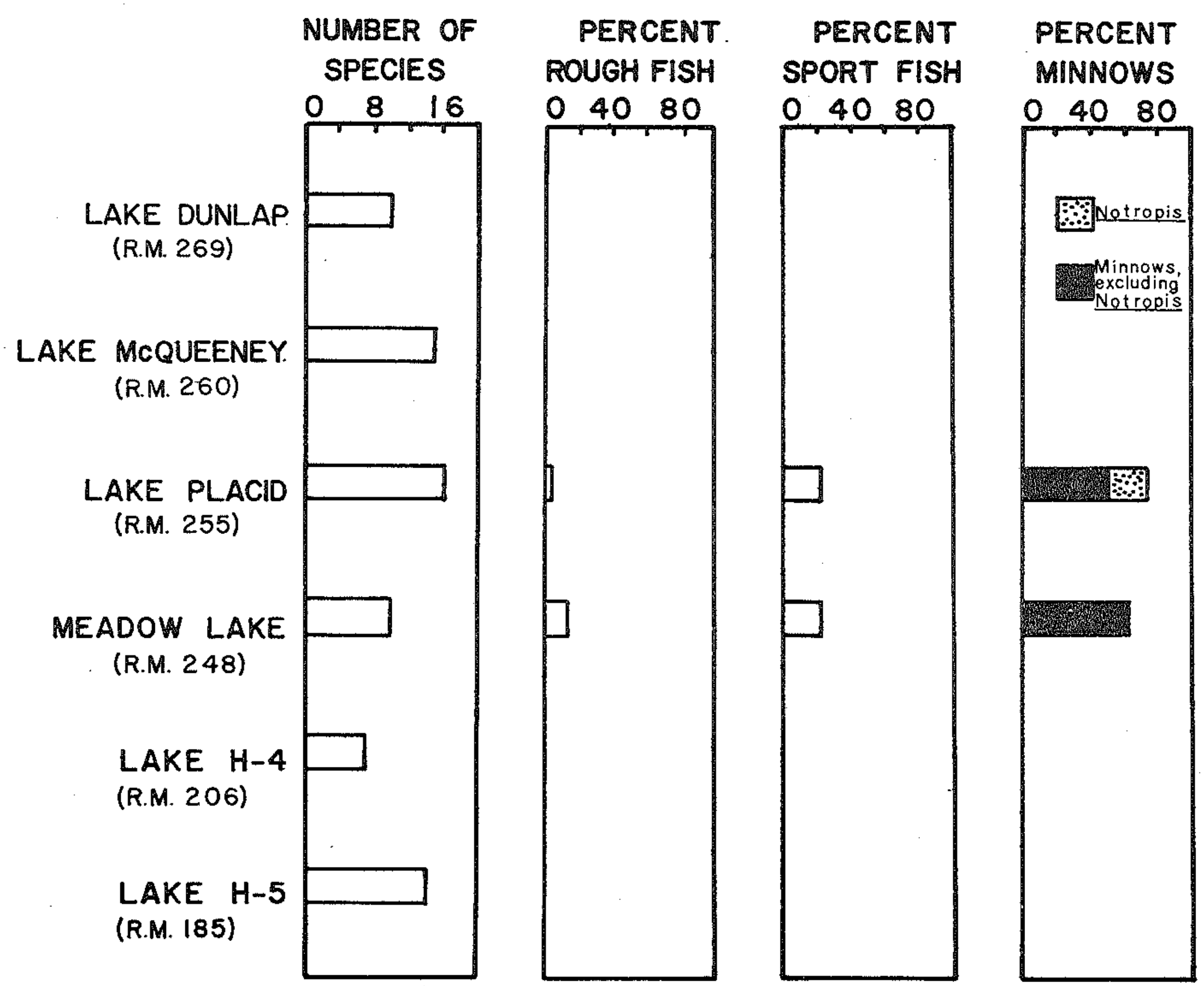


Figure 96. Number of fish species and percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data for 1969-70, Guadalupe River Basin lakes (266, 269).

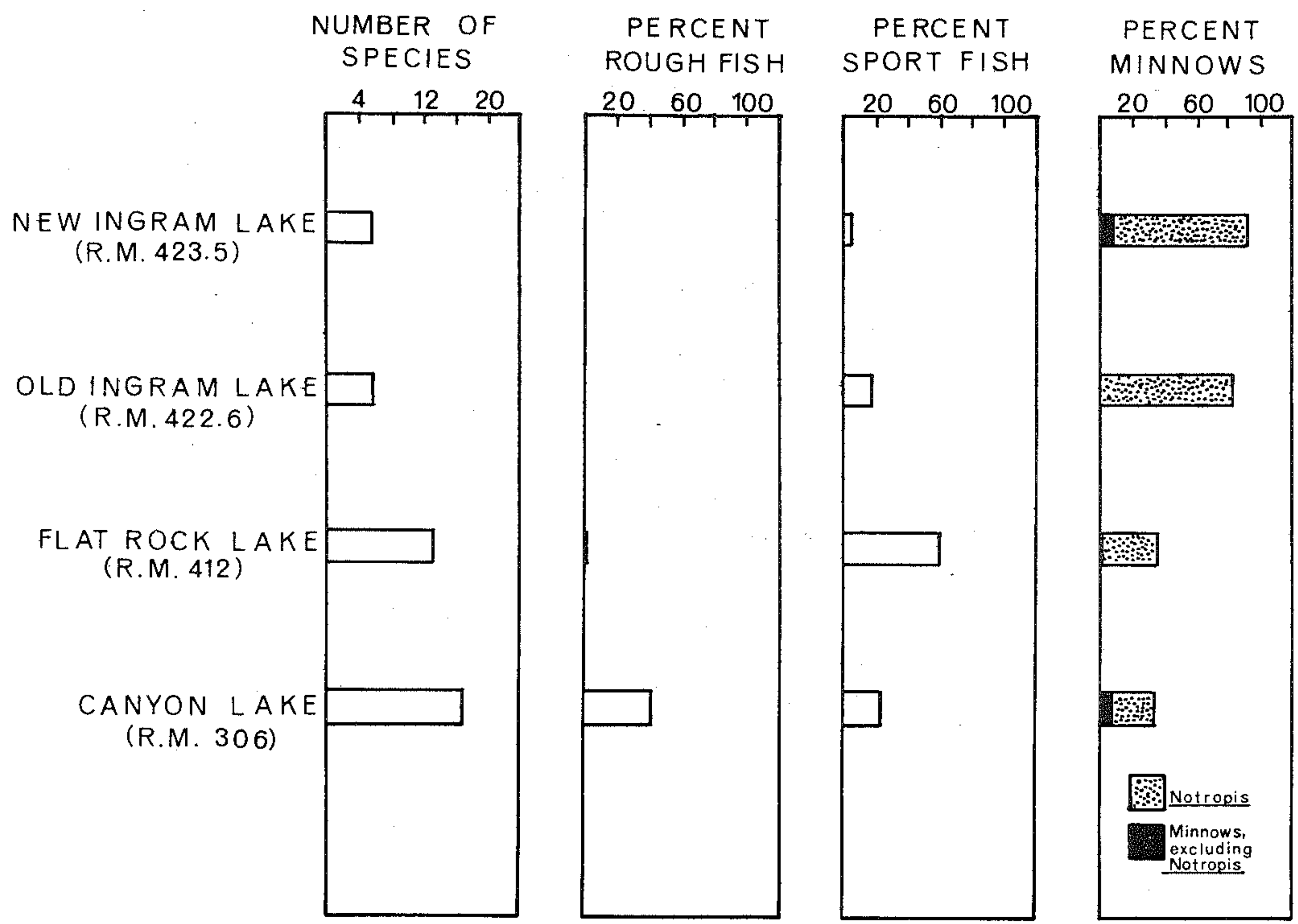


Figure 97. Number of fish species and percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data for 1967-68, Guadalupe River Basin lakes (295).

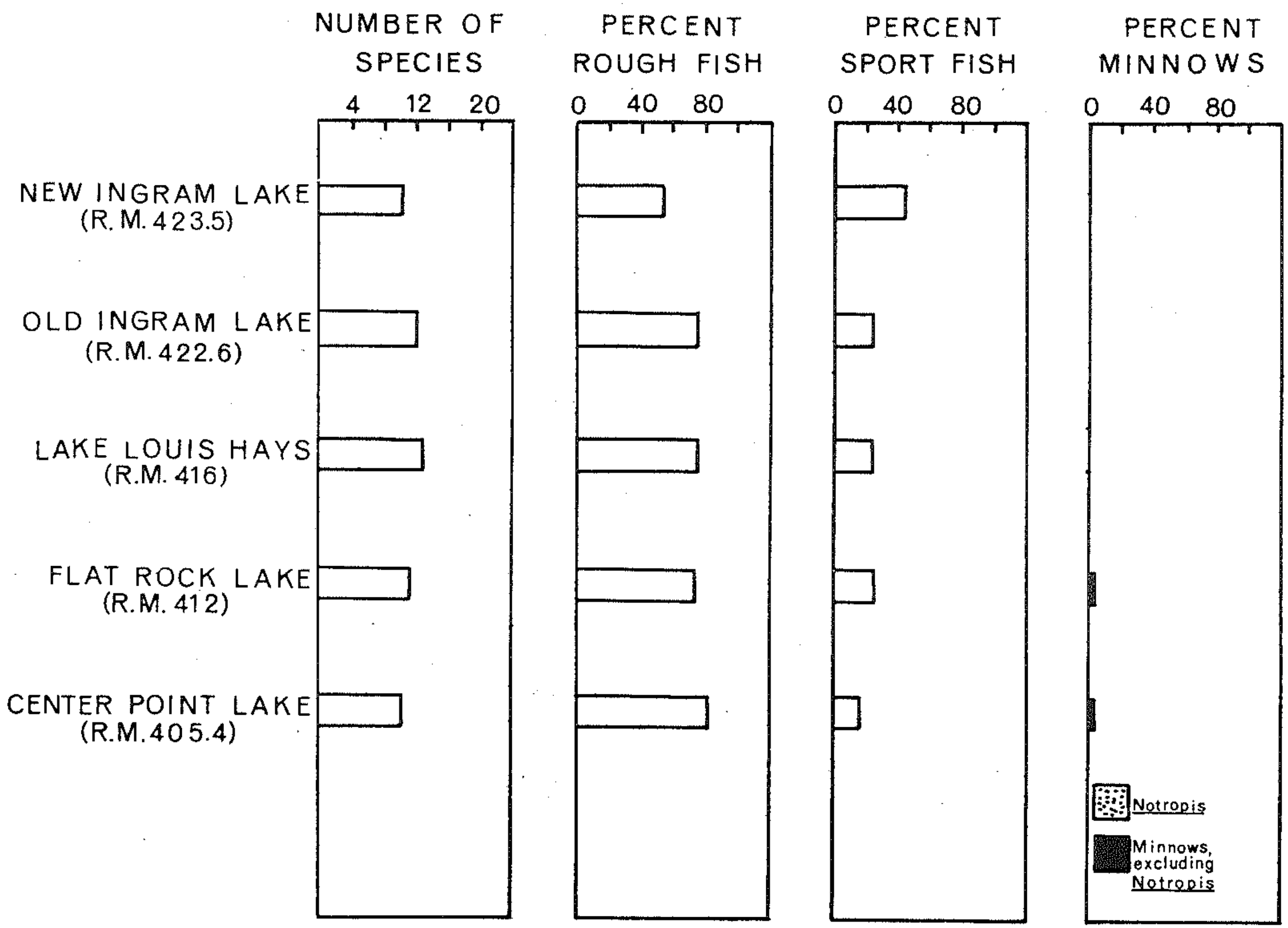


Figure 98. Number of fish species and percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife gillnet data for 1960, Guadalupe River Basin lakes (213, 295).

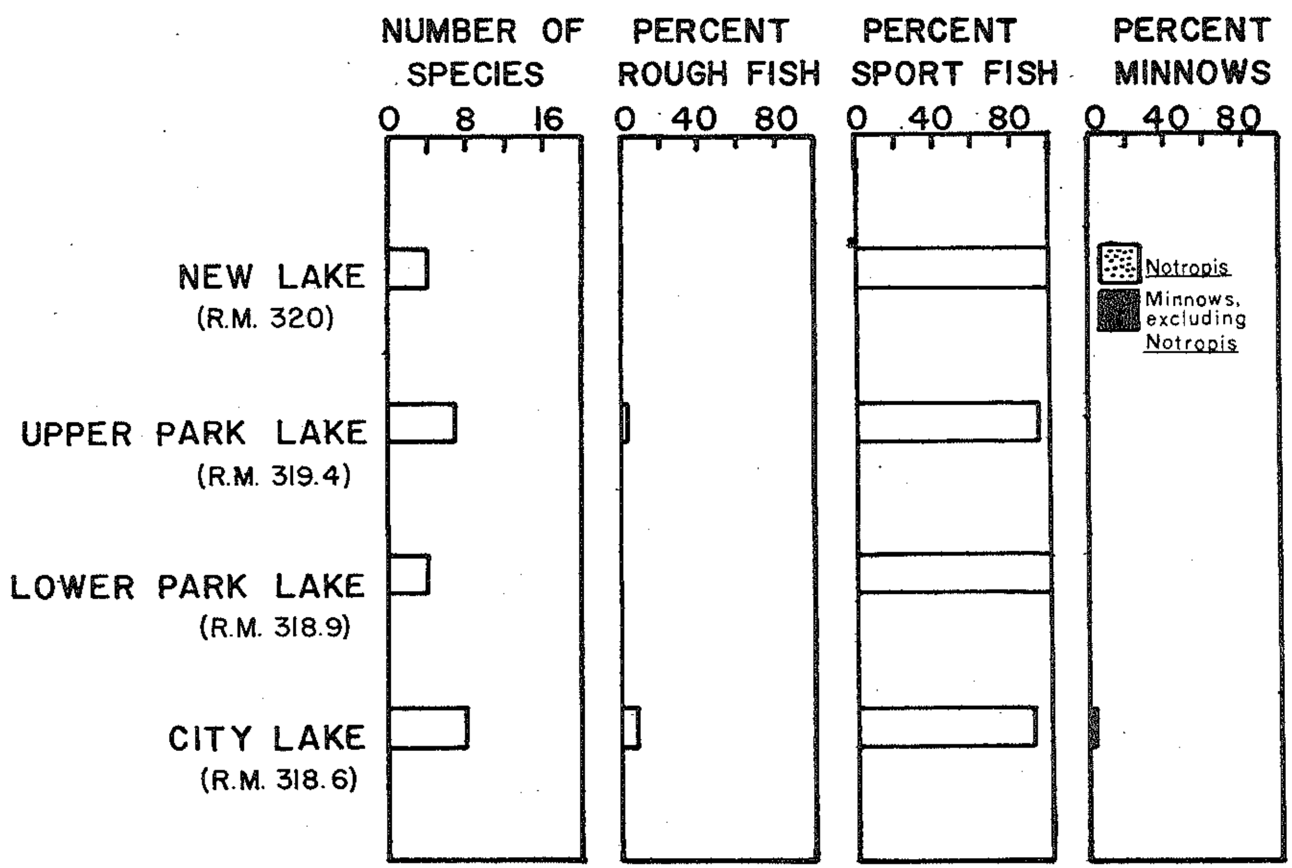


Figure 99. Number of fish species and percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife gillnet data for 1960, Guadalupe River Basin lakes (220).

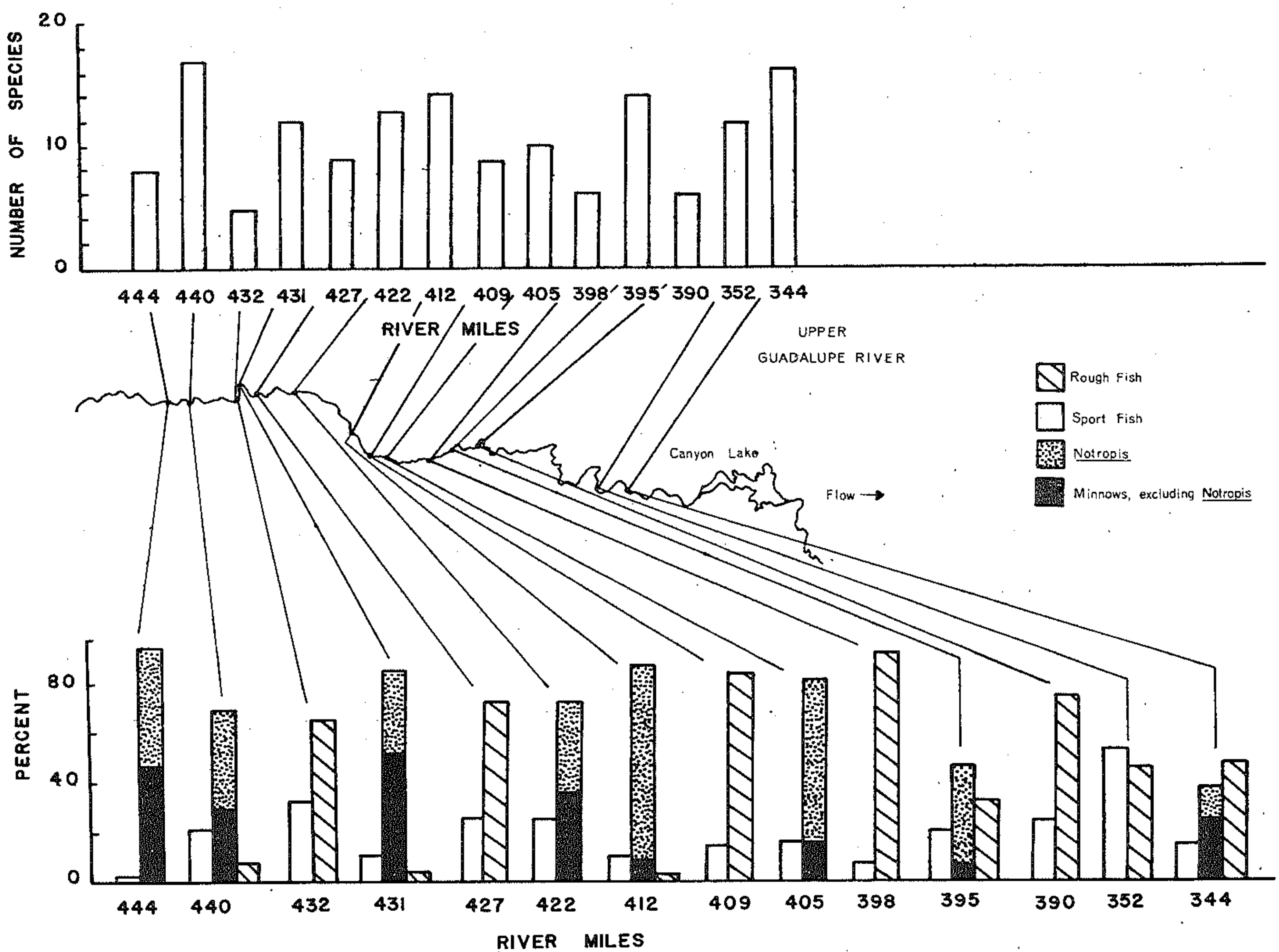


Figure 100. Number of fish species (top) and percent number of sport fish, rough fish, and minnows (bottom), Texas Parks and Wildlife combined seining and gillnet data for 1961, upper Guadalupe River, Guadalupe River Basin (223).

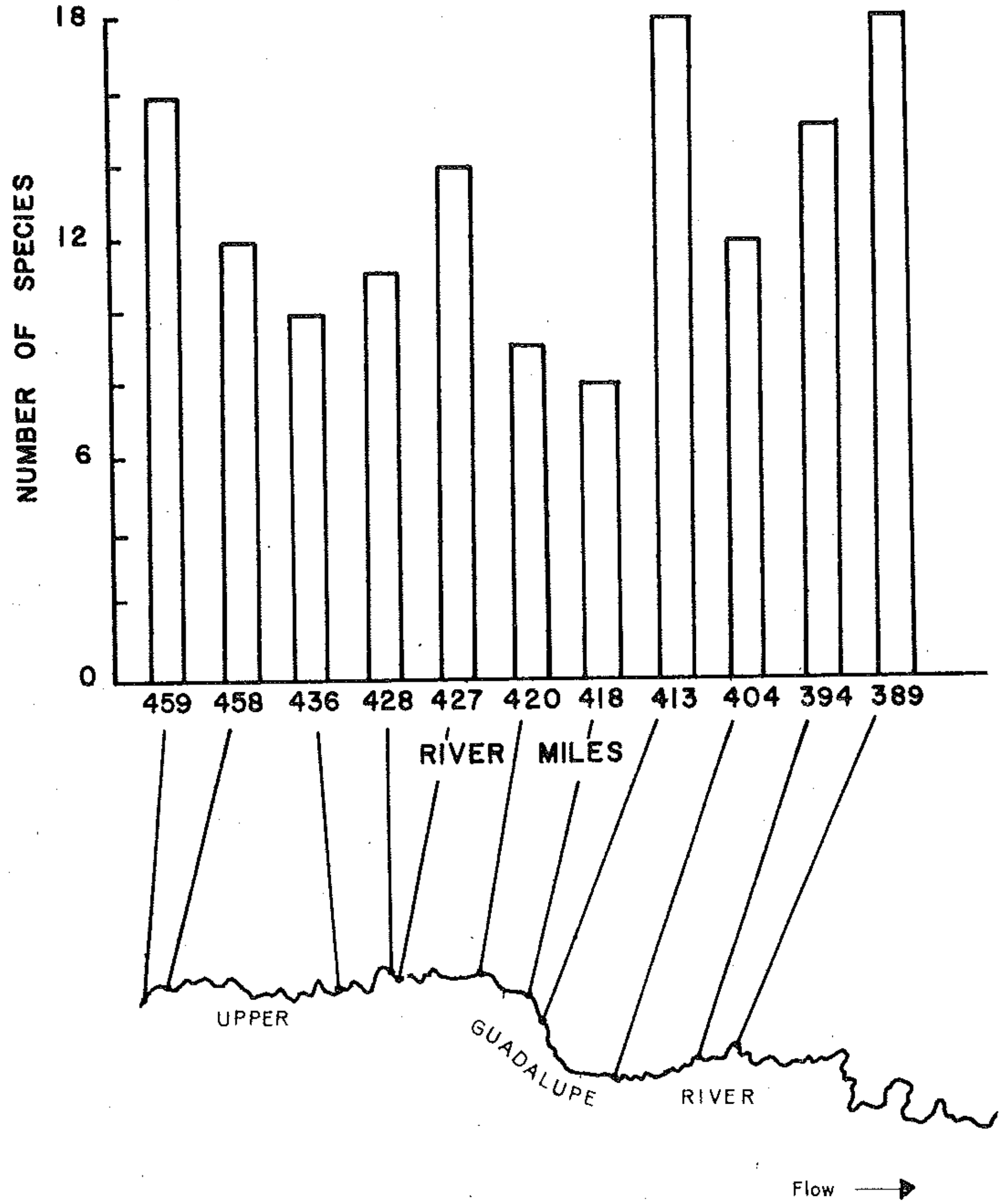


Figure 101. Number of fish species, Texas Parks and Wildlife combined seining and gillnet data for 1952-53, upper Guadalupe River, Guadalupe River Basin (119).

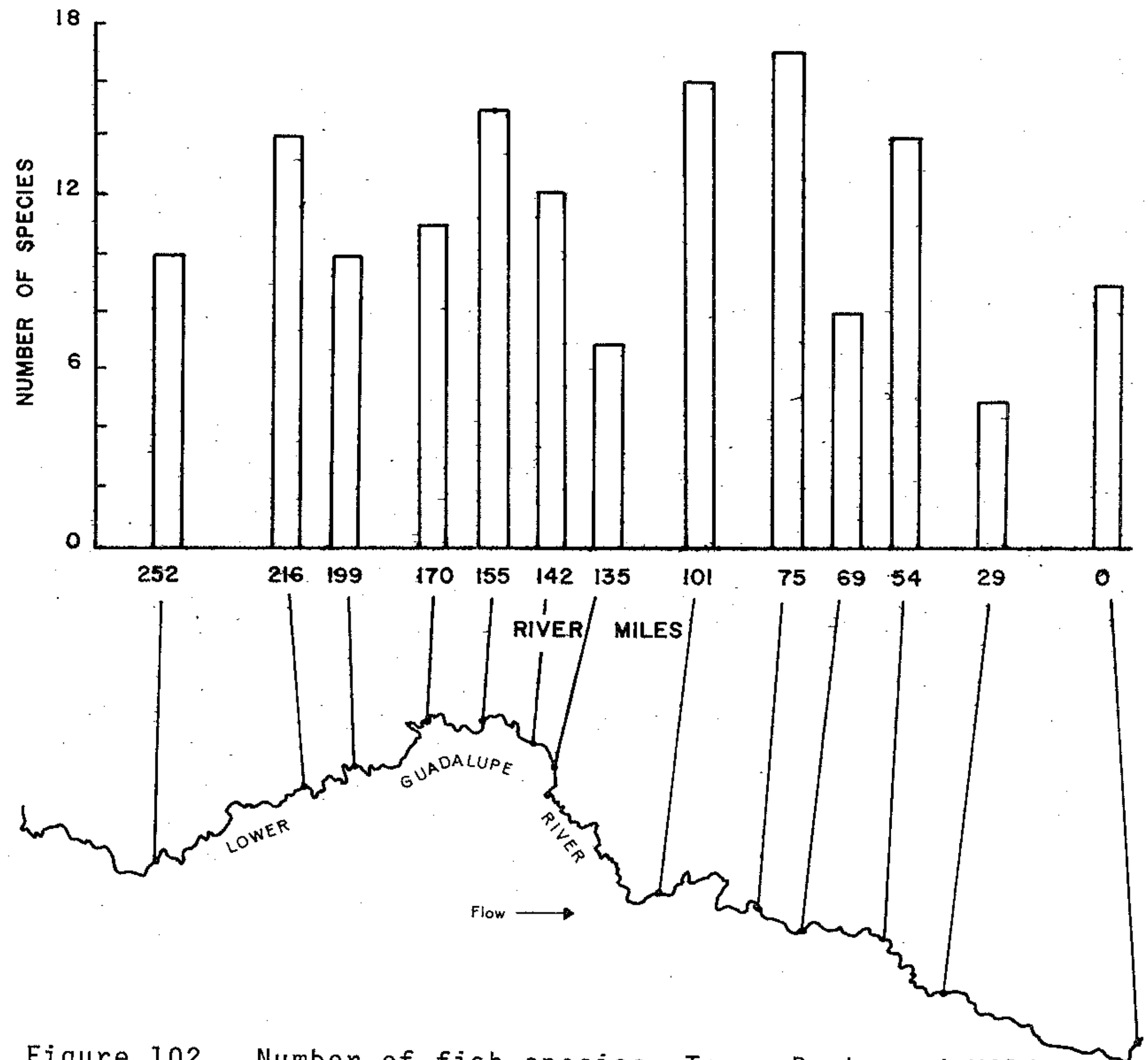


Figure 102. Number of fish species, Texas Parks and Wildlife combined seining and gillnet data for 1952-53, lower Guadalupe River, Guadalupe River Basin (119).

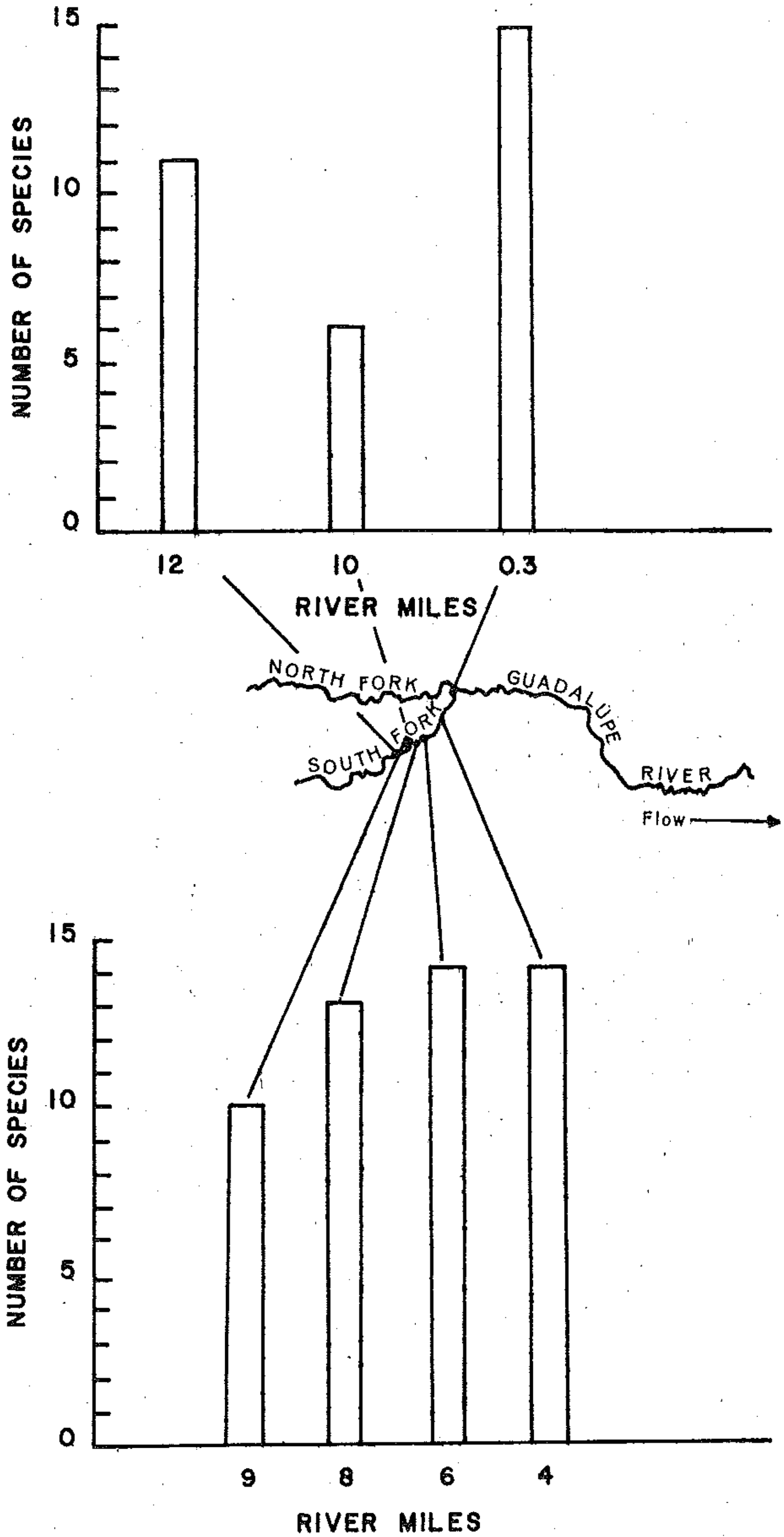


Figure 103. Number of fish species, Texas Parks and Wildlife combined seining and gillnet data for 1961 (top) and 1951-52 (bottom), South Fork of Guadalupe River, Guadalupe River Basin (119, 223).

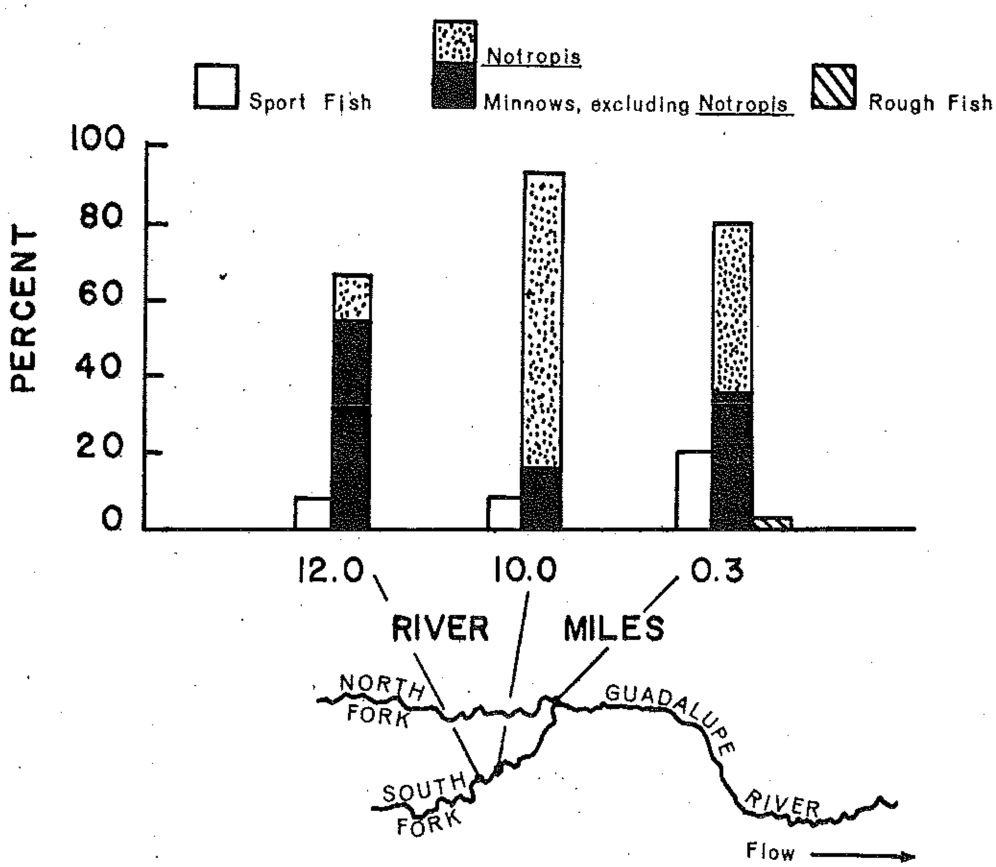


Figure 104. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife combined seining and gillnet data for 1961, South Fork of the Guadalupe River, Guadalupe River Basin (223).

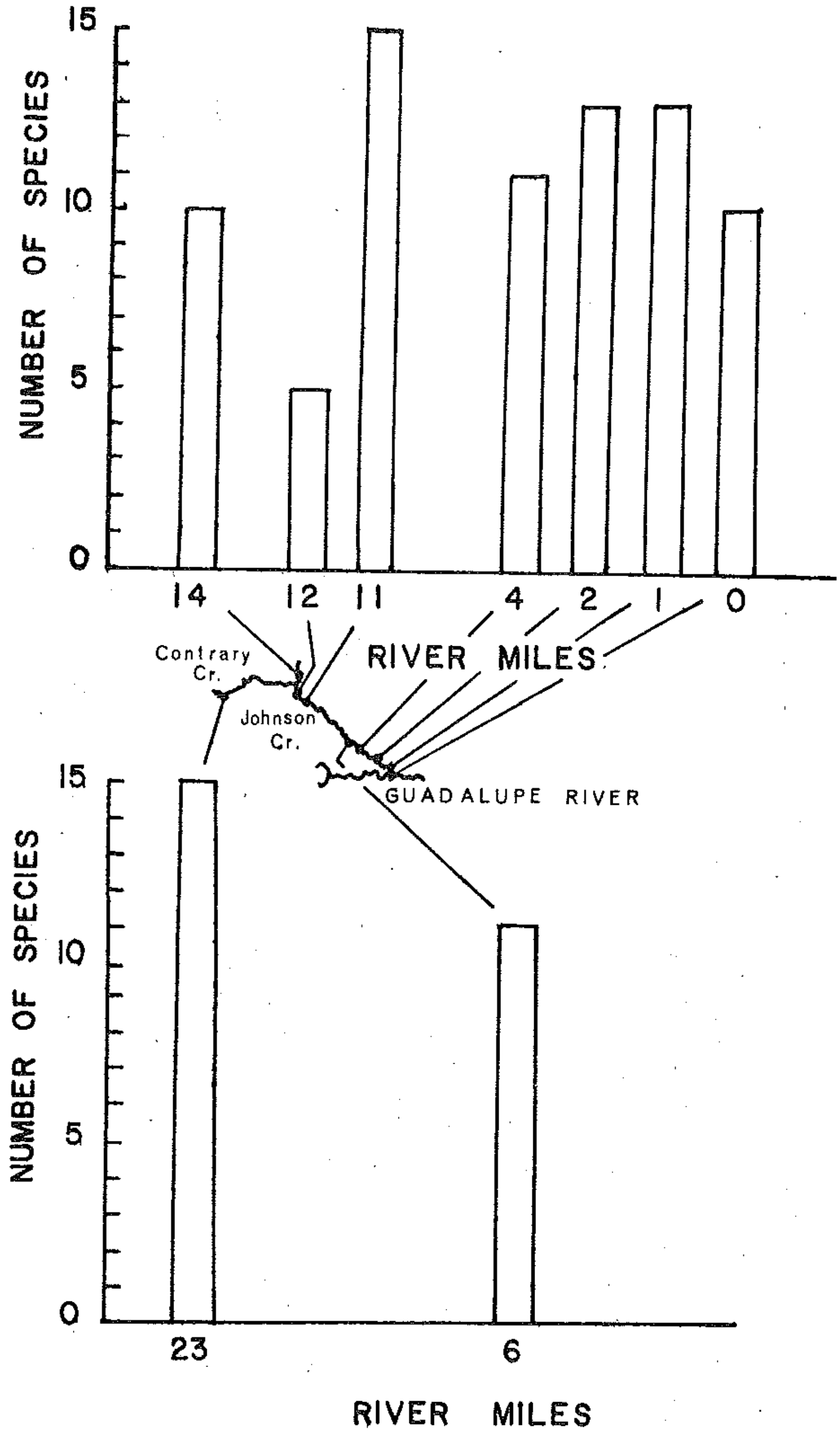


Figure 105. Number of fish species, Texas Parks and Wildlife combined seining and gillnet data for 1951-52 (top) and 1961 (bottom), Johnson Creek, Guadalupe River Basin (119, 223).

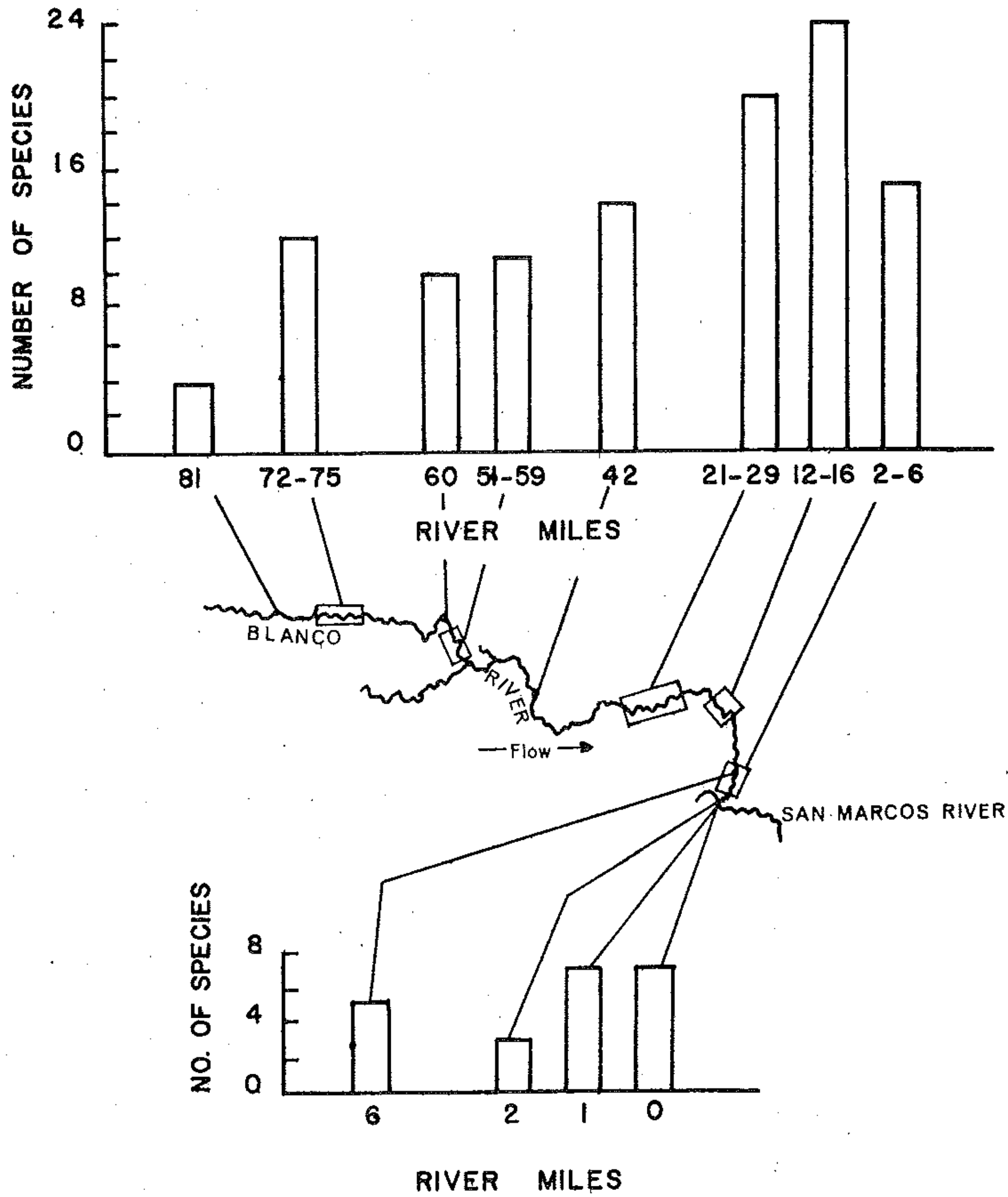


Figure 106. Number of fish species, Texas Parks and Wildlife seining data (top), and gillnet data (bottom) for 1955-56, Blanco River, Guadalupe River Basin (182).

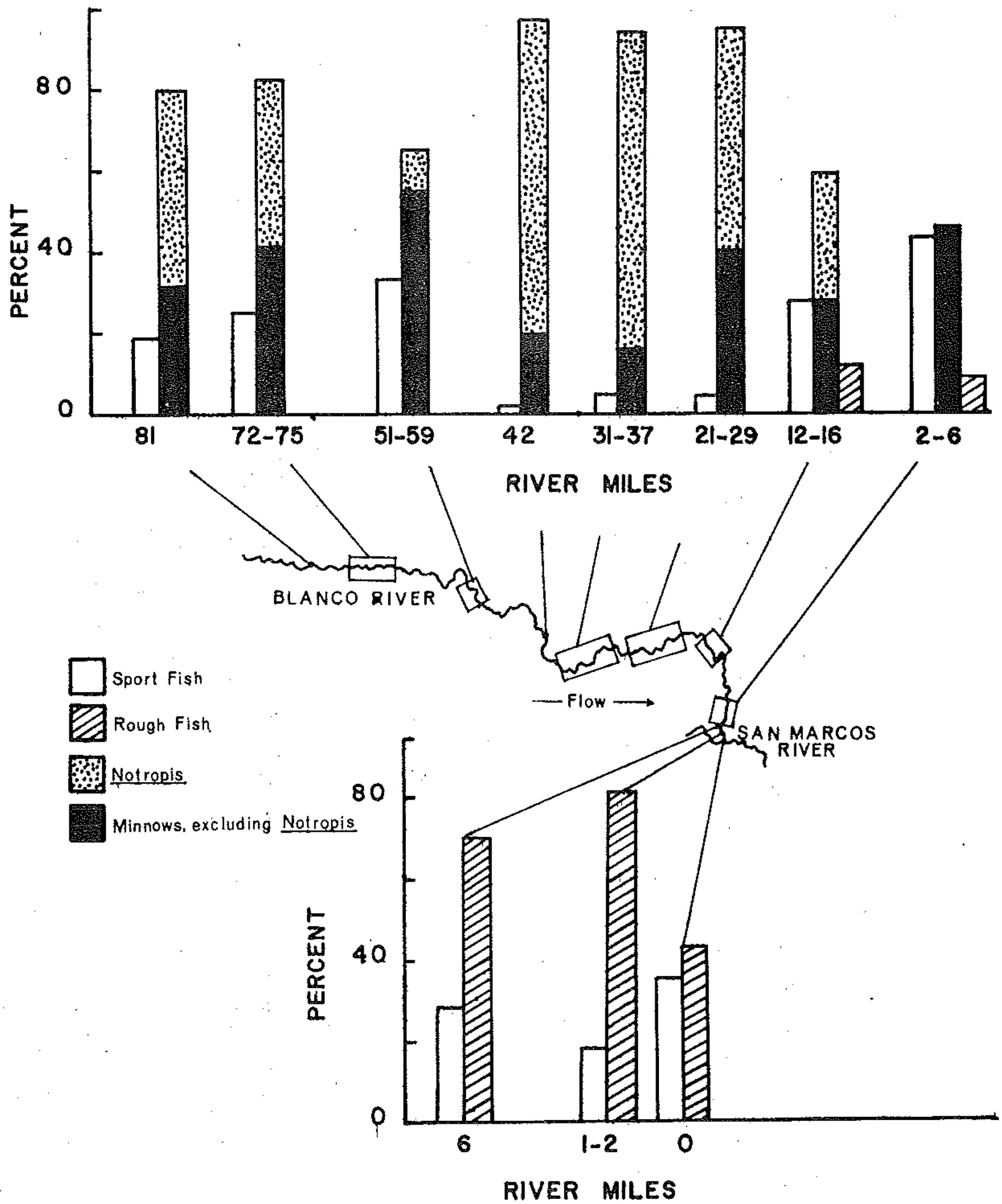


Figure 107. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data (top) and gillnet data (bottom) for 1955-56, Blanco River, Guadalupe River Basin (182).

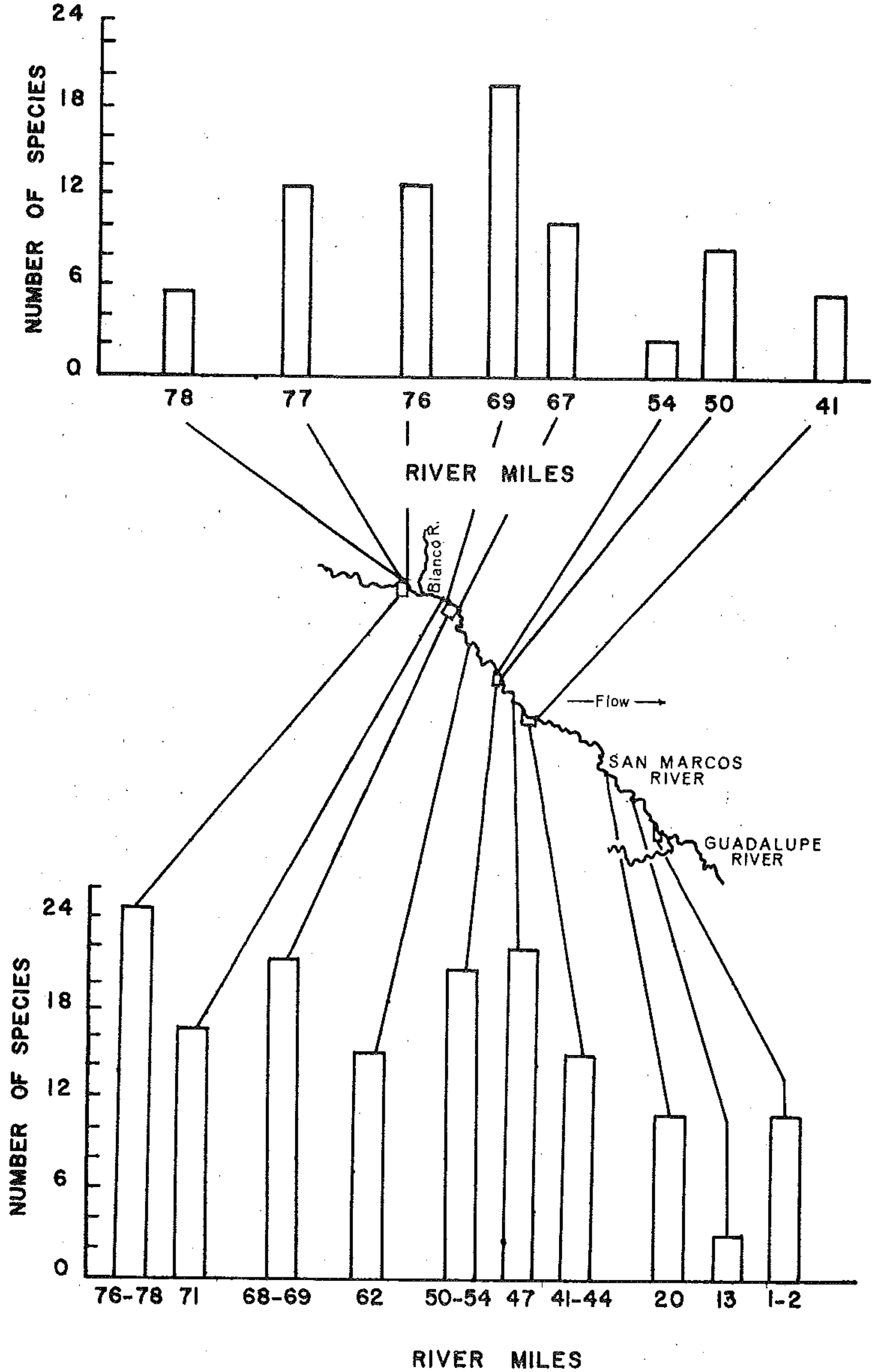


Figure 108. Number of fish species, Texas Parks and Wildlife seining data for 1957-58 (top), and University of Texas seining data for 1951 (bottom), San Marcos River, Guadalupe River Basin (109, 192).

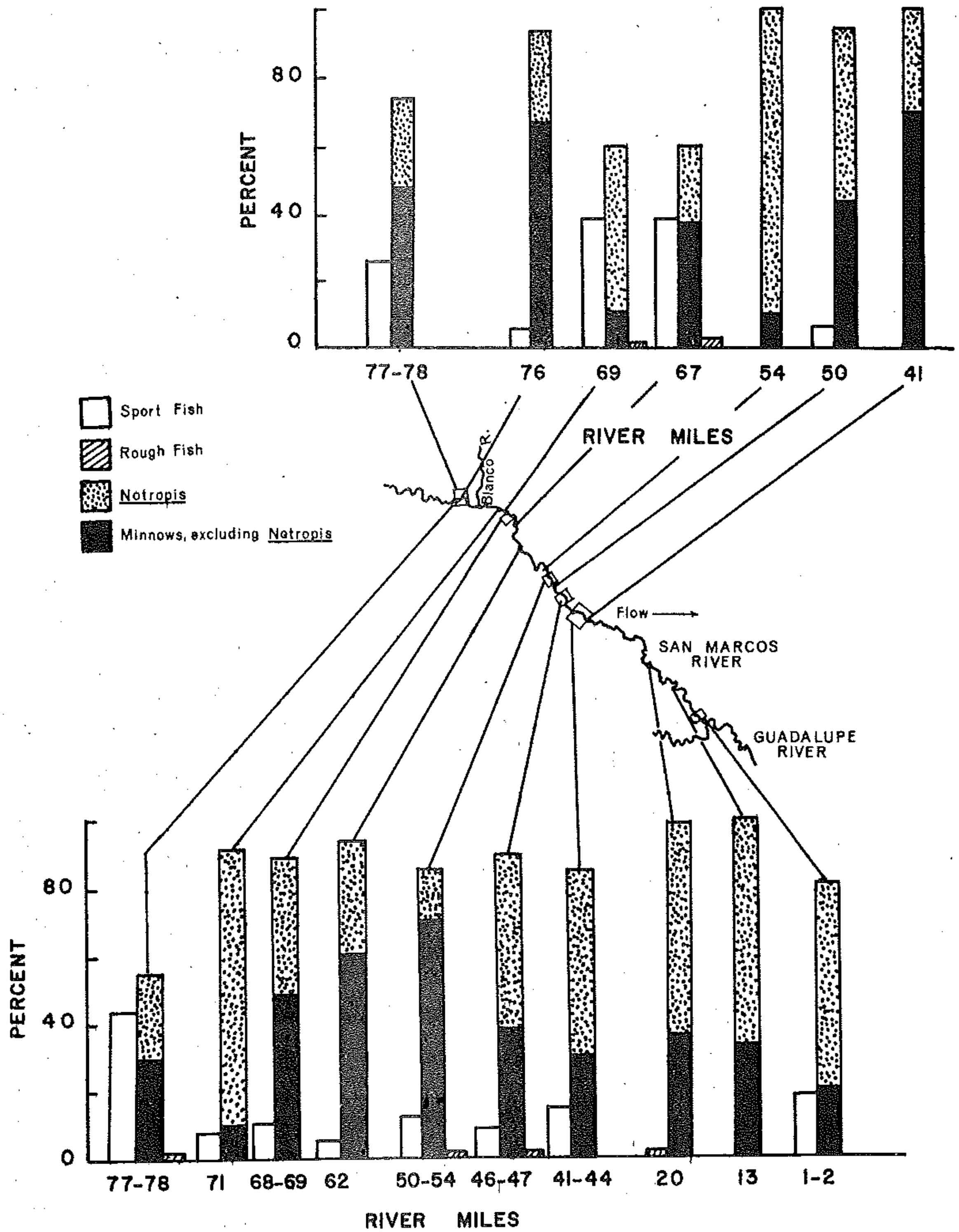


Figure 109. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data for 1957-58 (top), and University of Texas seining data for 1951 (bottom), San Marcos River, Guadalupe River Basin (109, 192).

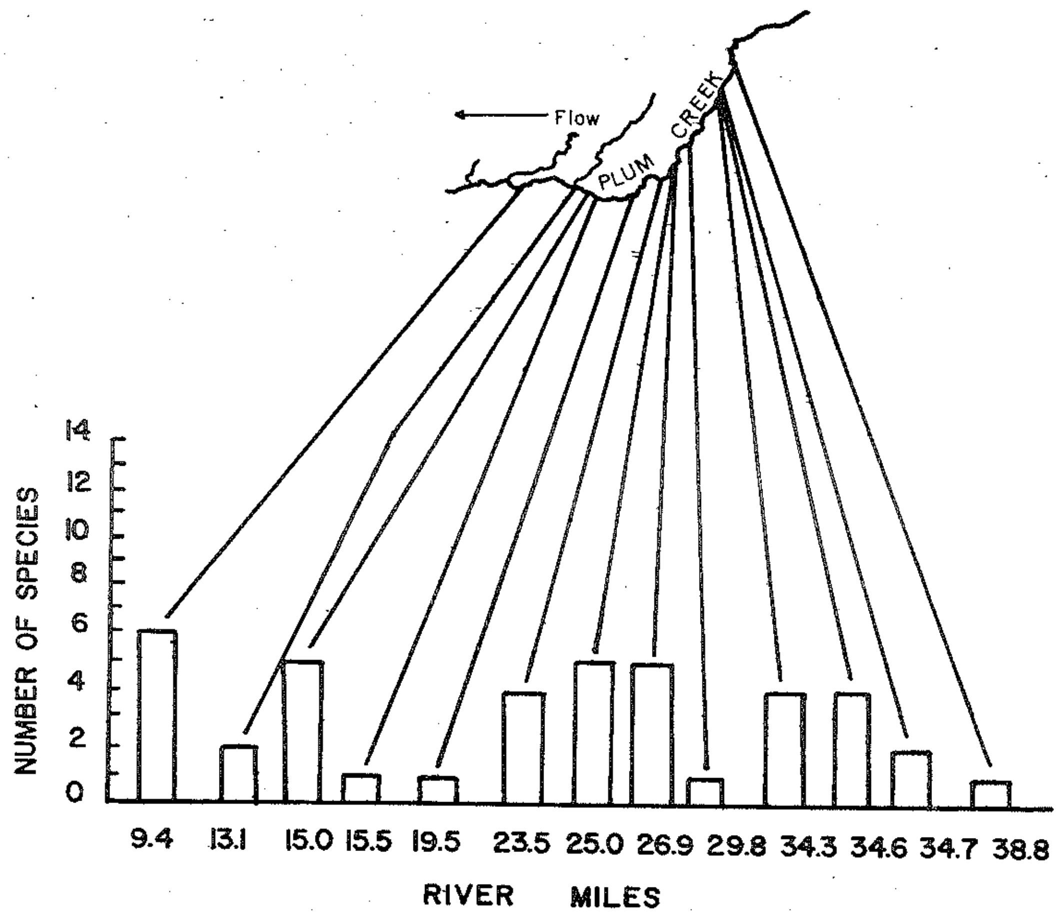


Figure 110. Number of fish species, Southwest Texas State University Aquatic Station seining data for 1968, Plum Creek, Guadalupe River Basin (285).

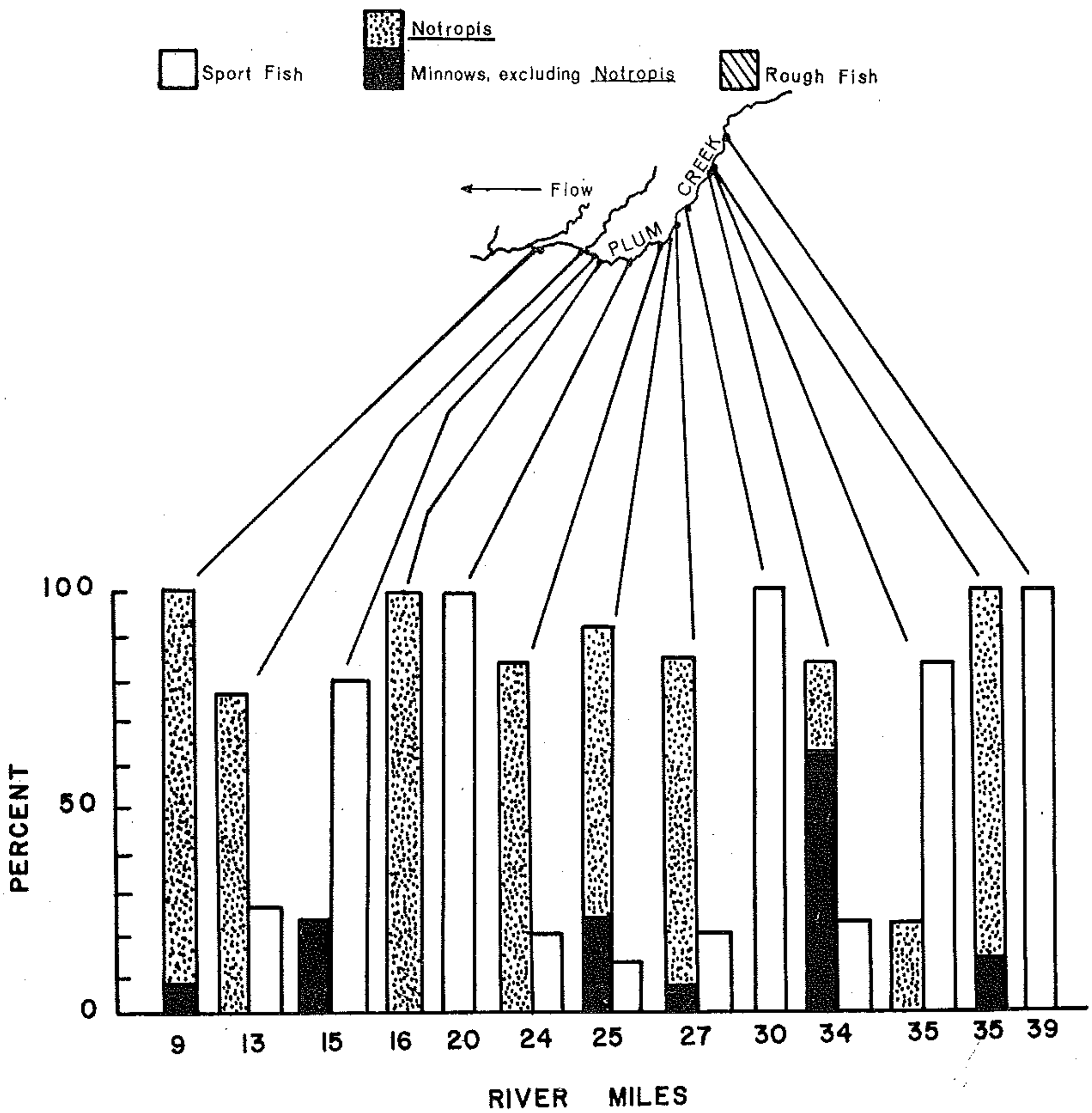


Figure 111. Percent number of sport fish, rough fish, and minnows, Southwest Texas State University Aquatic Station seining data for 1968, Plum Creek, Guadalupe River Basin (285).

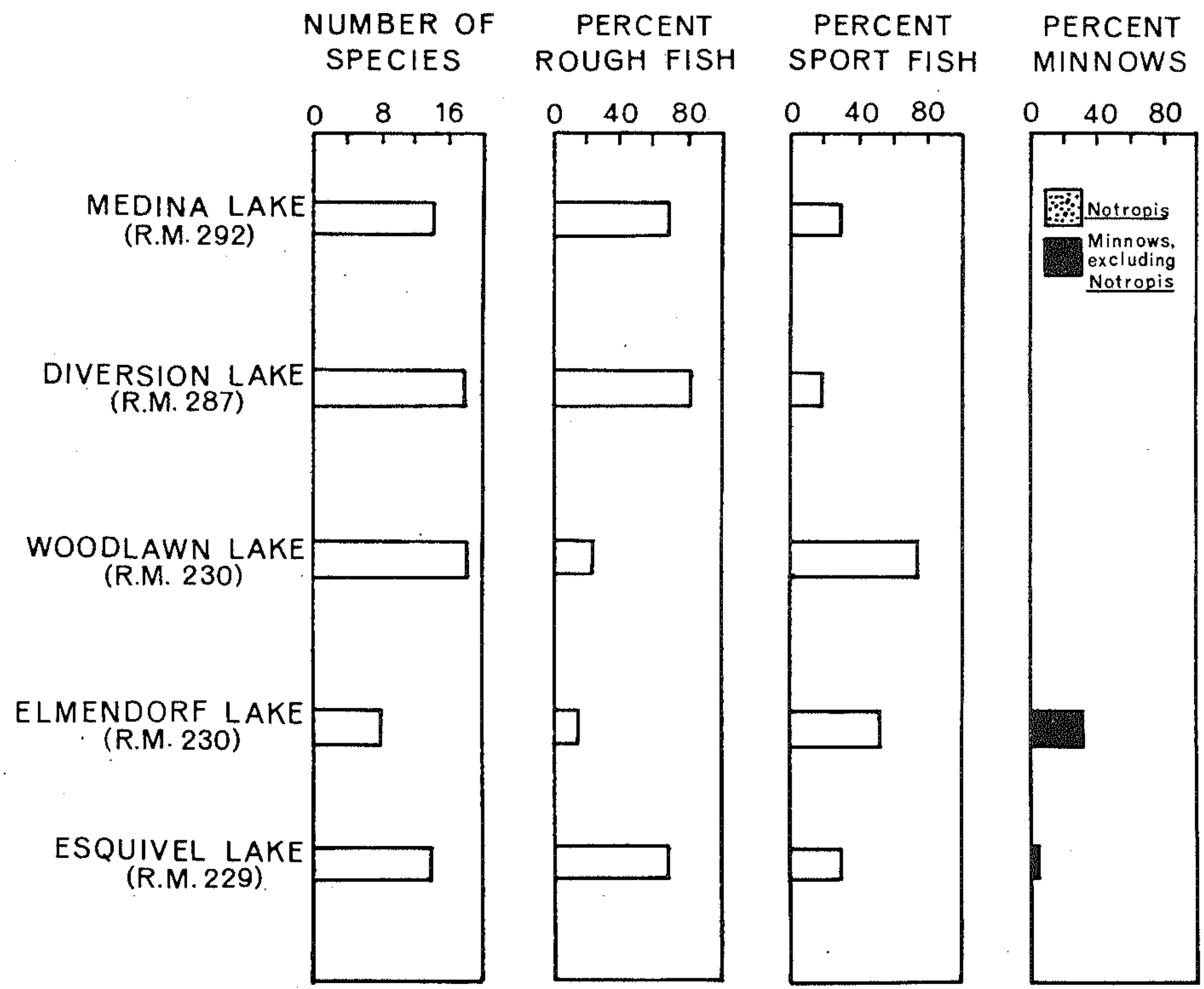


Figure 112. Number of species and percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife gillnet data for 1963-64, San Antonio River Basin lakes (232, 233, 240, 247, 248).

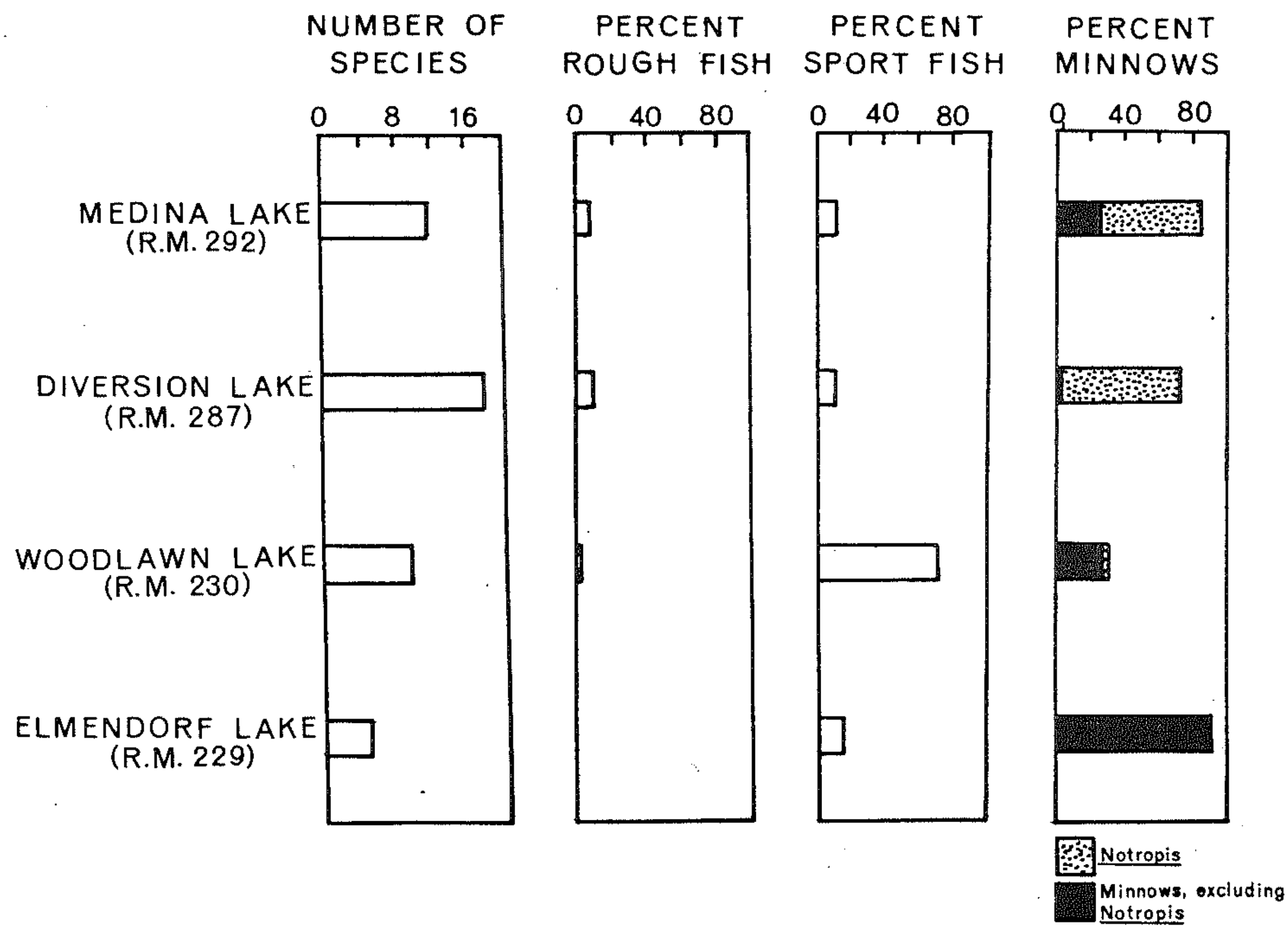


Figure 113. Number of fish species and percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data for 1962-63, San Antonio River Basin lakes (232, 233, 240, 247, 248).

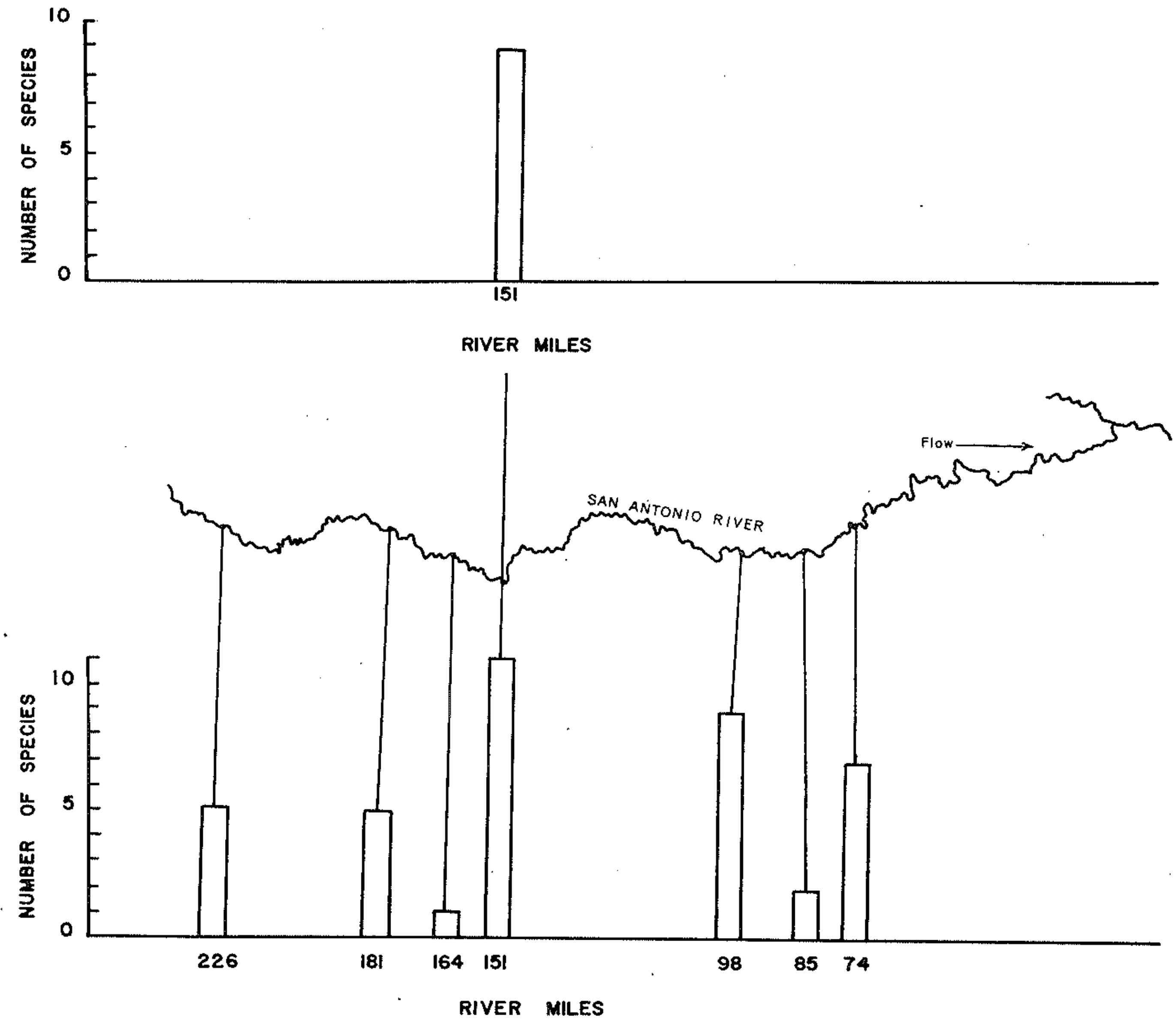


Figure 114. Number of fish species, Texas Parks and Wildlife seining data for 1958-64 (bottom) and 1968-70 (top), San Antonio River, San Antonio River Basin (240, 247, 263, 268, 296).

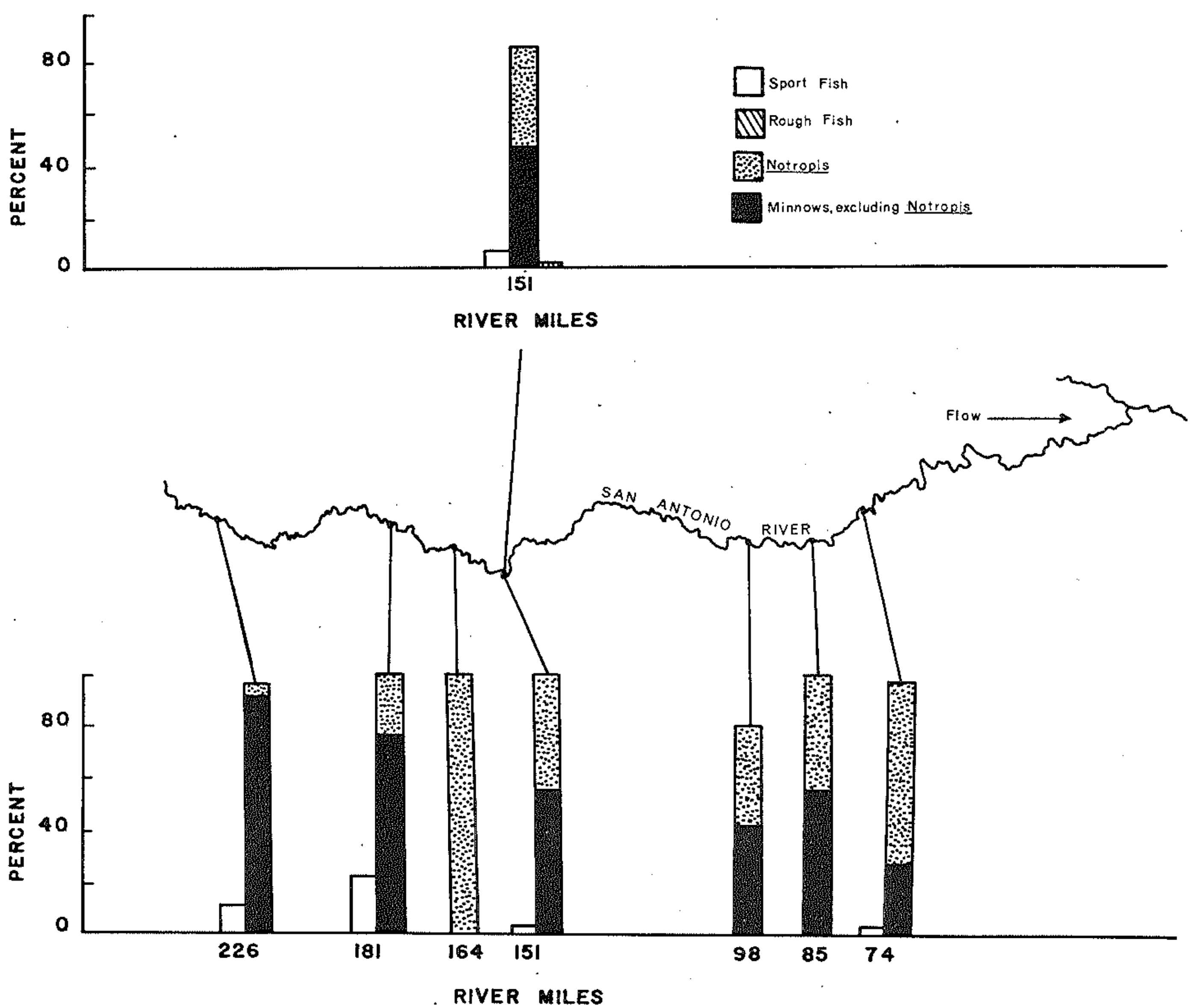


Figure 115. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data for 1958-64 (bottom) and 1968-70 (top), San Antonio River, San Antonio River Basin (240, 247, 263, 268, 296).

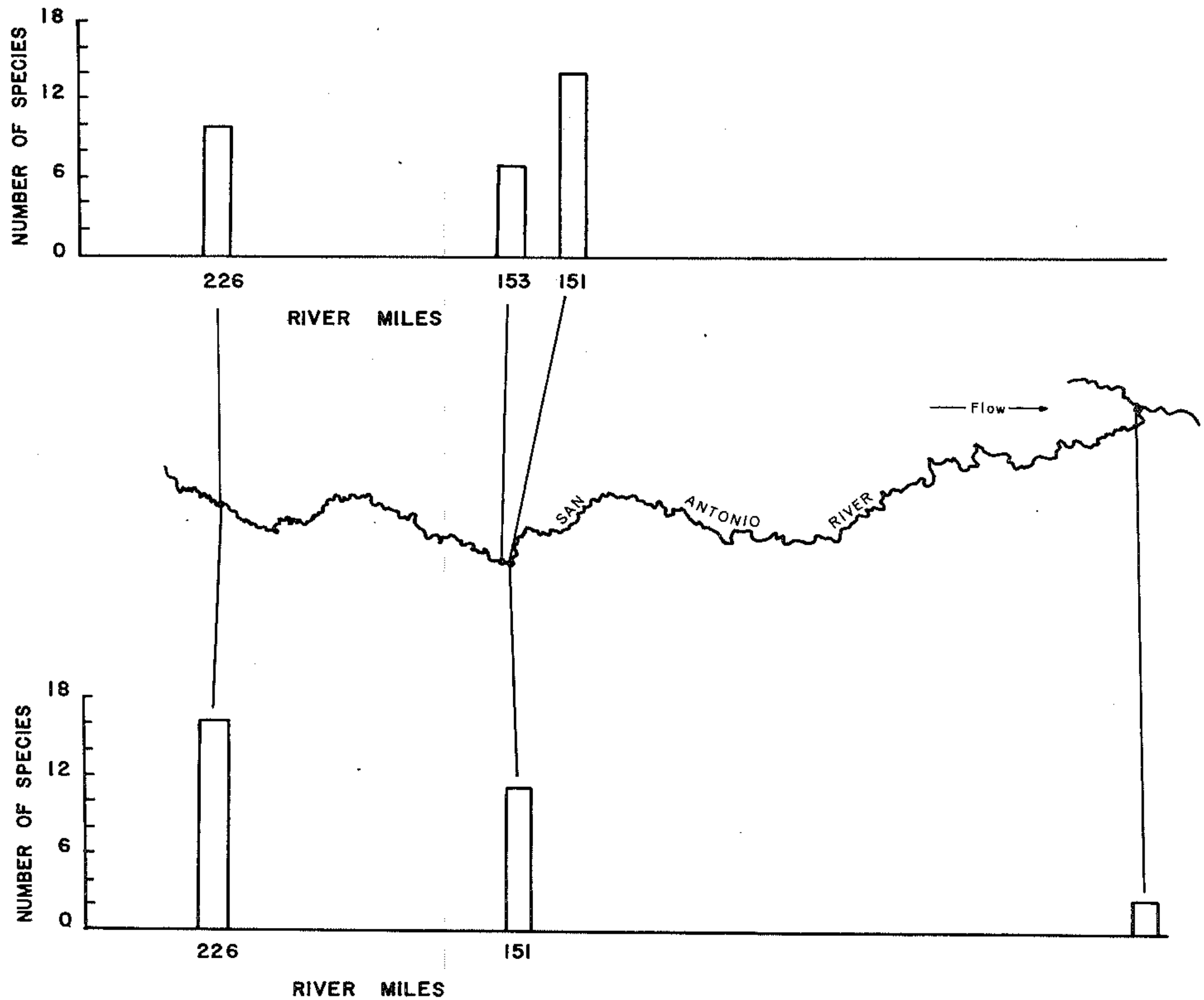


Figure 116. Number of fish species, Texas Parks and Wildlife gillnet data for 1958-64 (bottom) and 1968-70 (top), San Antonio River, San Antonio River Basin (240, 247, 263, 268, 296).

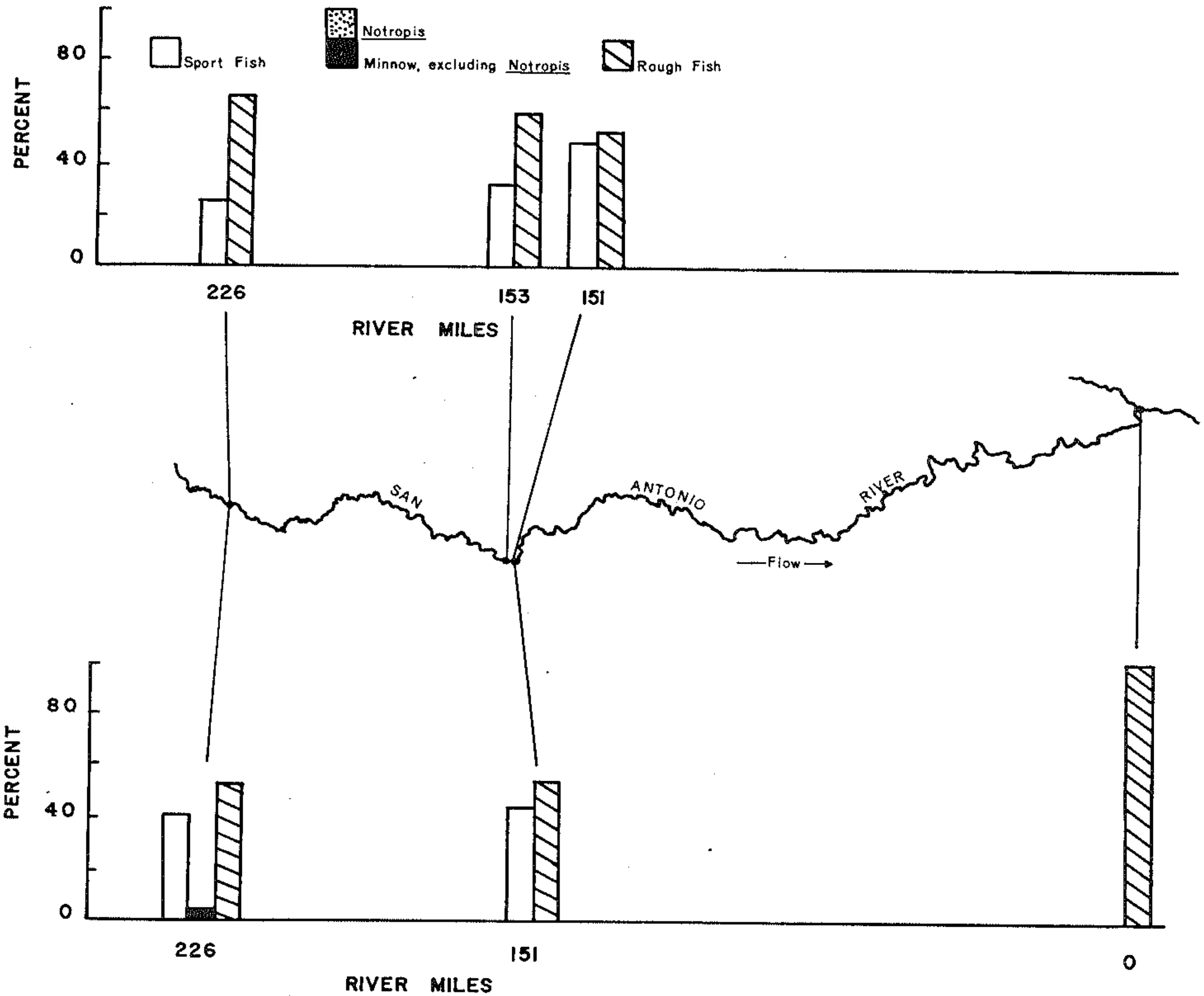


Figure 117. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife gillnet data for 1958-64 (bottom) and 1968-70 (top), San Antonio River, San Antonio River Basin (240, 247, 263, 268, 296).

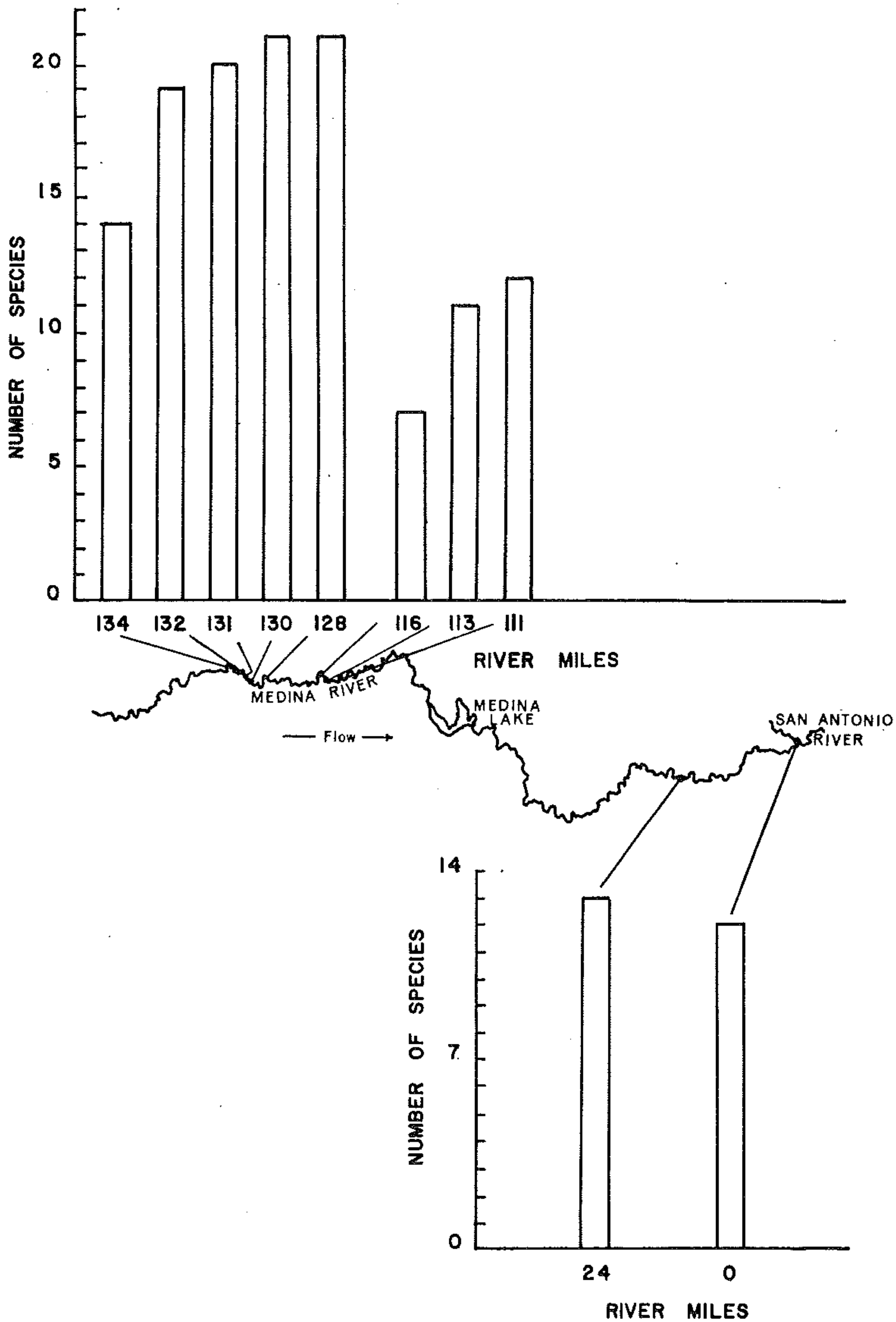


Figure 118. Number of fish species, Texas Parks and Wildlife rotenone data (top) and combined seining and gillnet data (bottom) for 1953-54, Medina River, San Antonio River Basin (170).

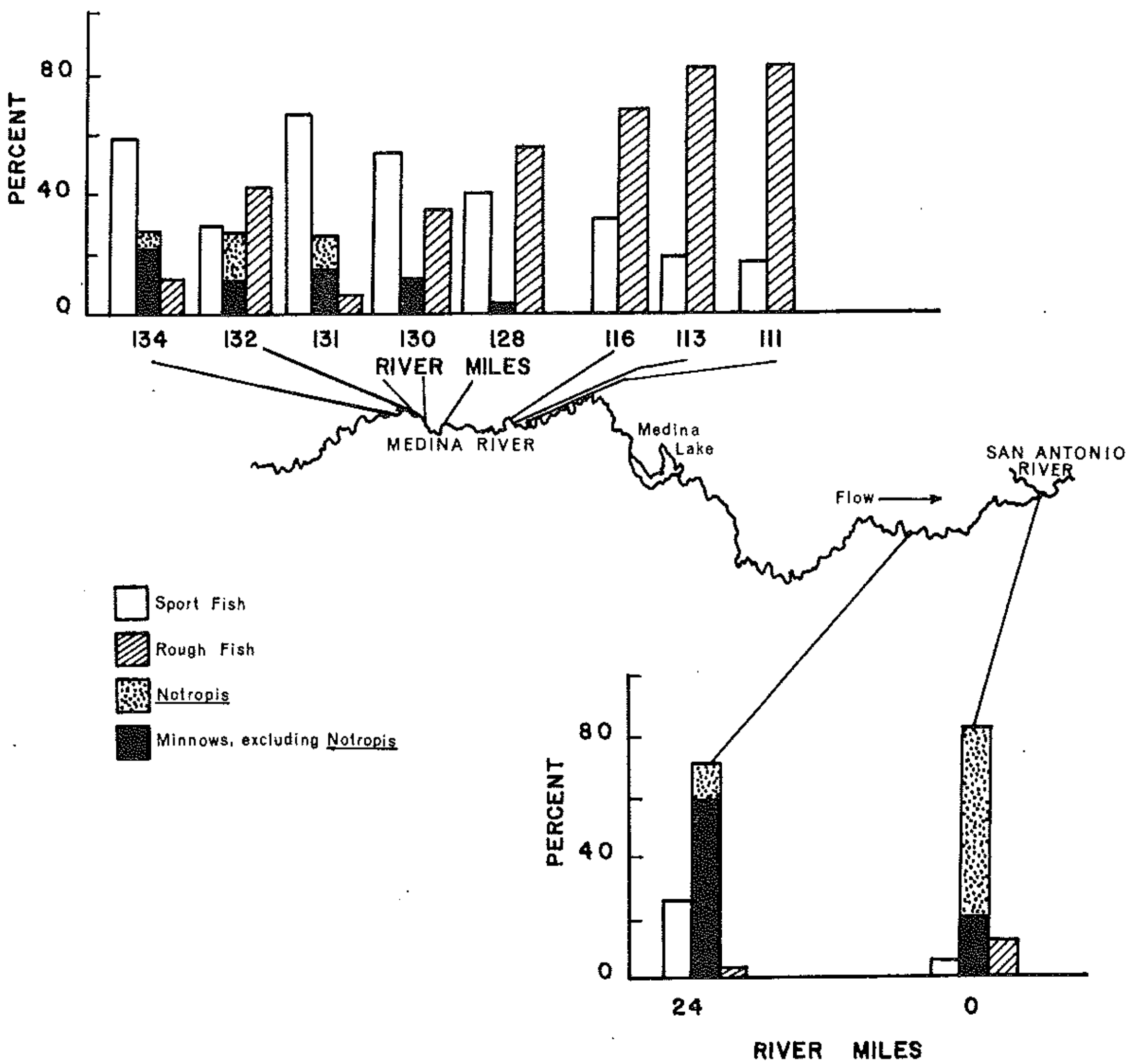


Figure 119. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife rotenone data (top) and combined seining and gillnet data (bottom) for 1953-54, Medina River, San Antonio River Basin (170).

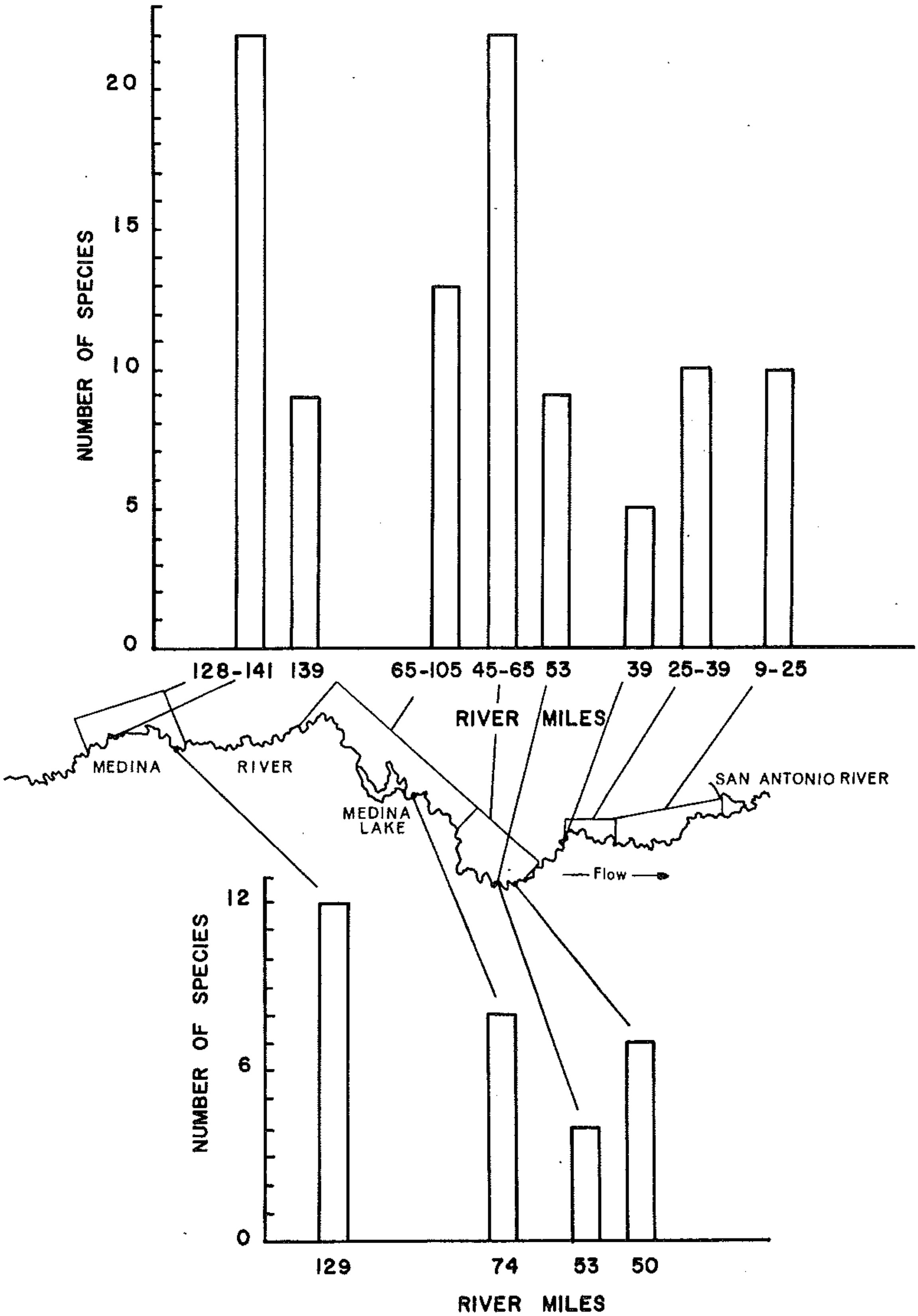


Figure 120. Number of fish species, Texas Parks and Wildlife seining data (top) and gillnet data (bottom) for 1953-54, Medina River, San Antonio River Basin (170).

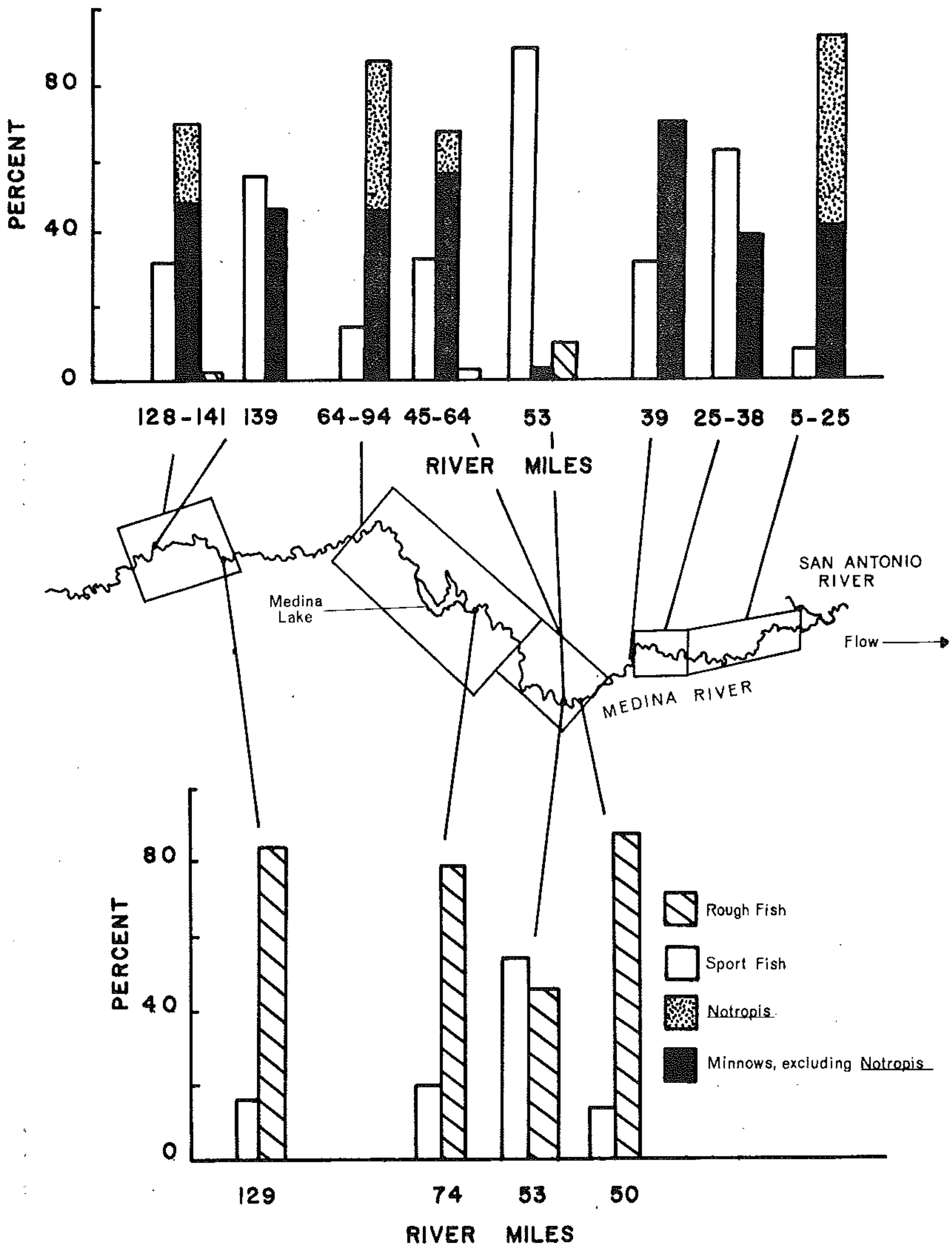


Figure 121. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data (top) and gillnet data (bottom) for 1953-54, Medina River, San Antonio River Basin (170).

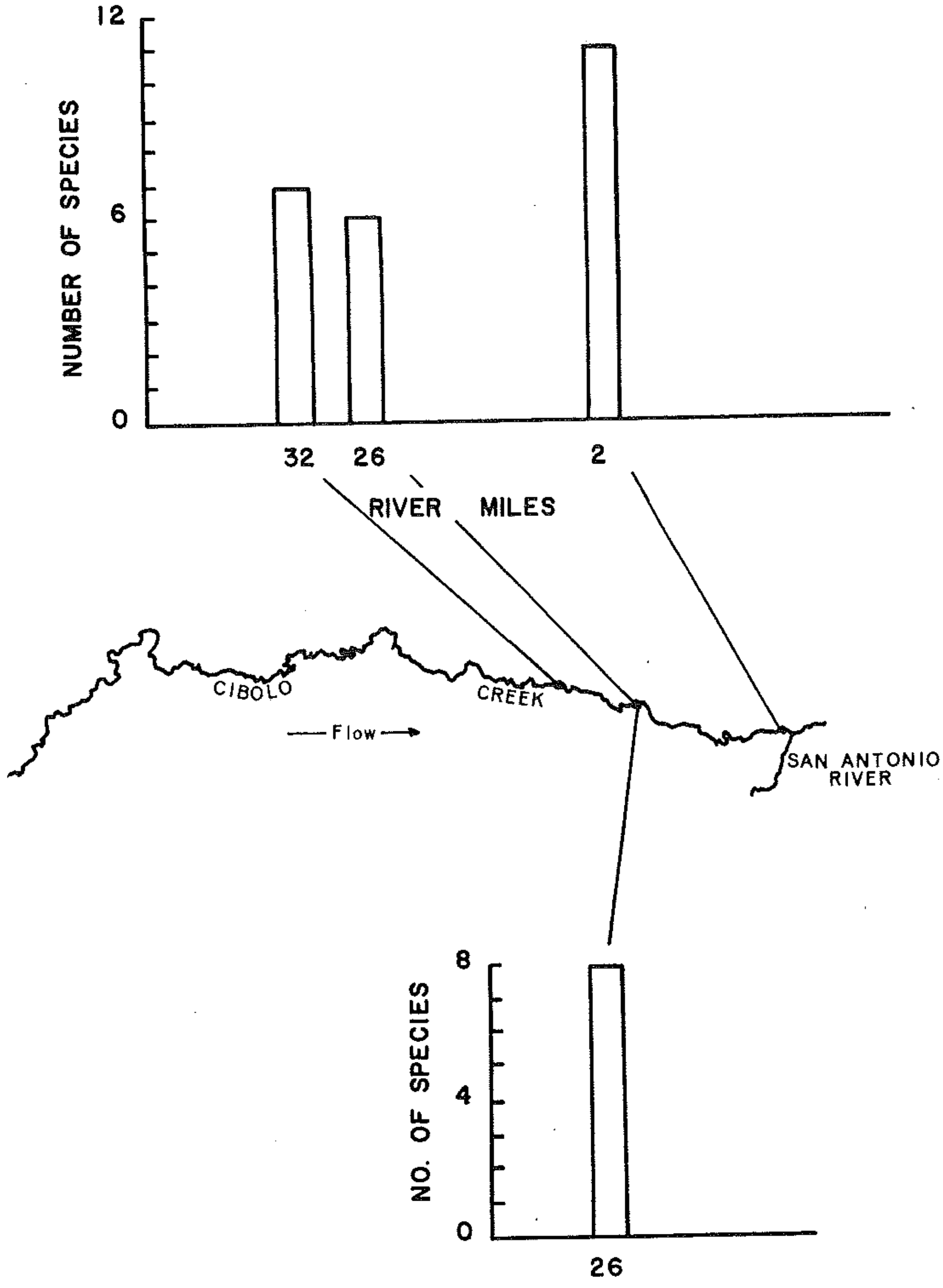


Figure 122. Number of fish species, Texas Parks and Wildlife seining data (top) and gillnet data (bottom) for 1962-64, Cibolo Creek, San Antonio River Basin (296).

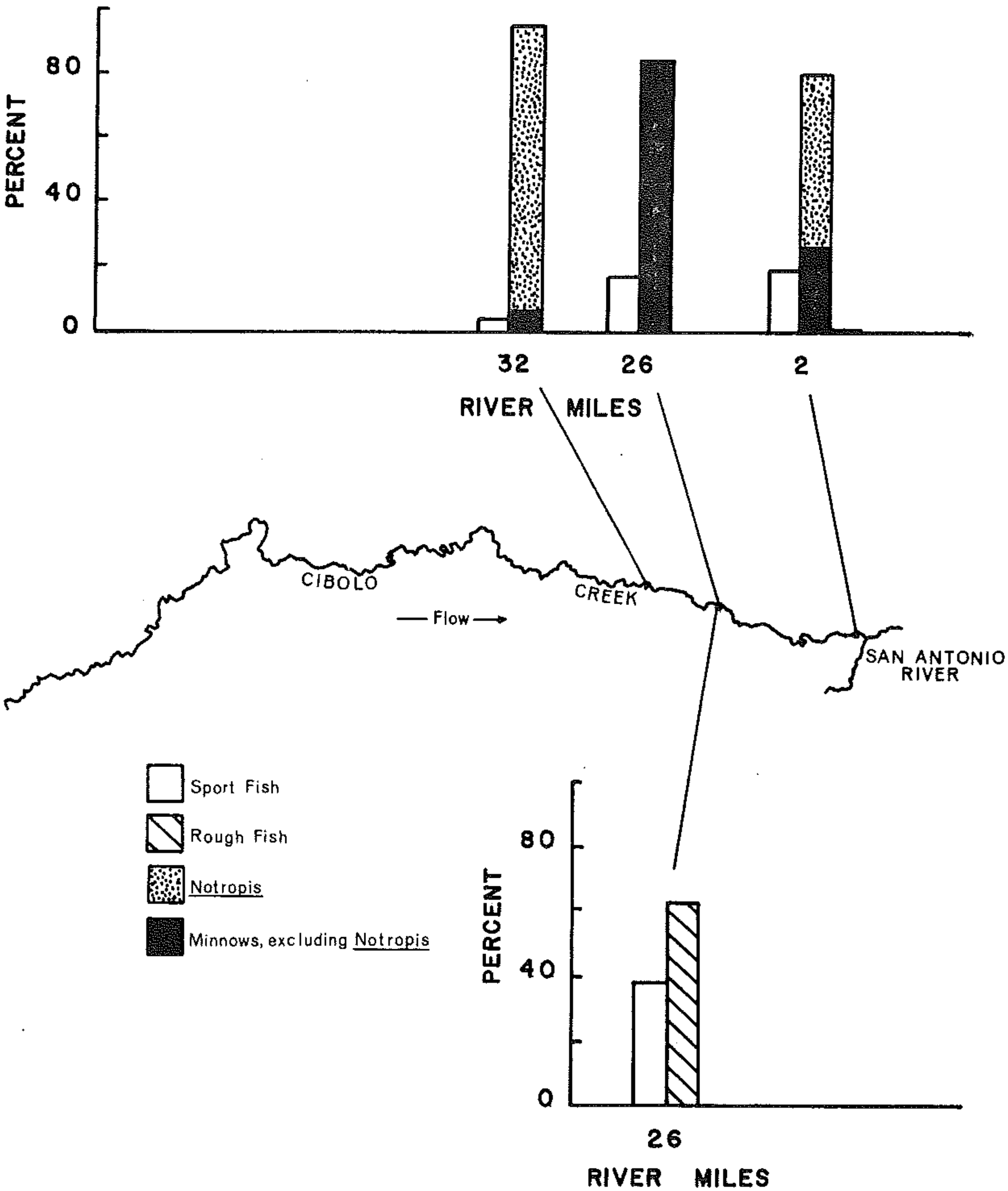


Figure 123. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data (top), and gillnet data (bottom) for 1962-64, Cibolo Creek, San Antonio River Basin (296).

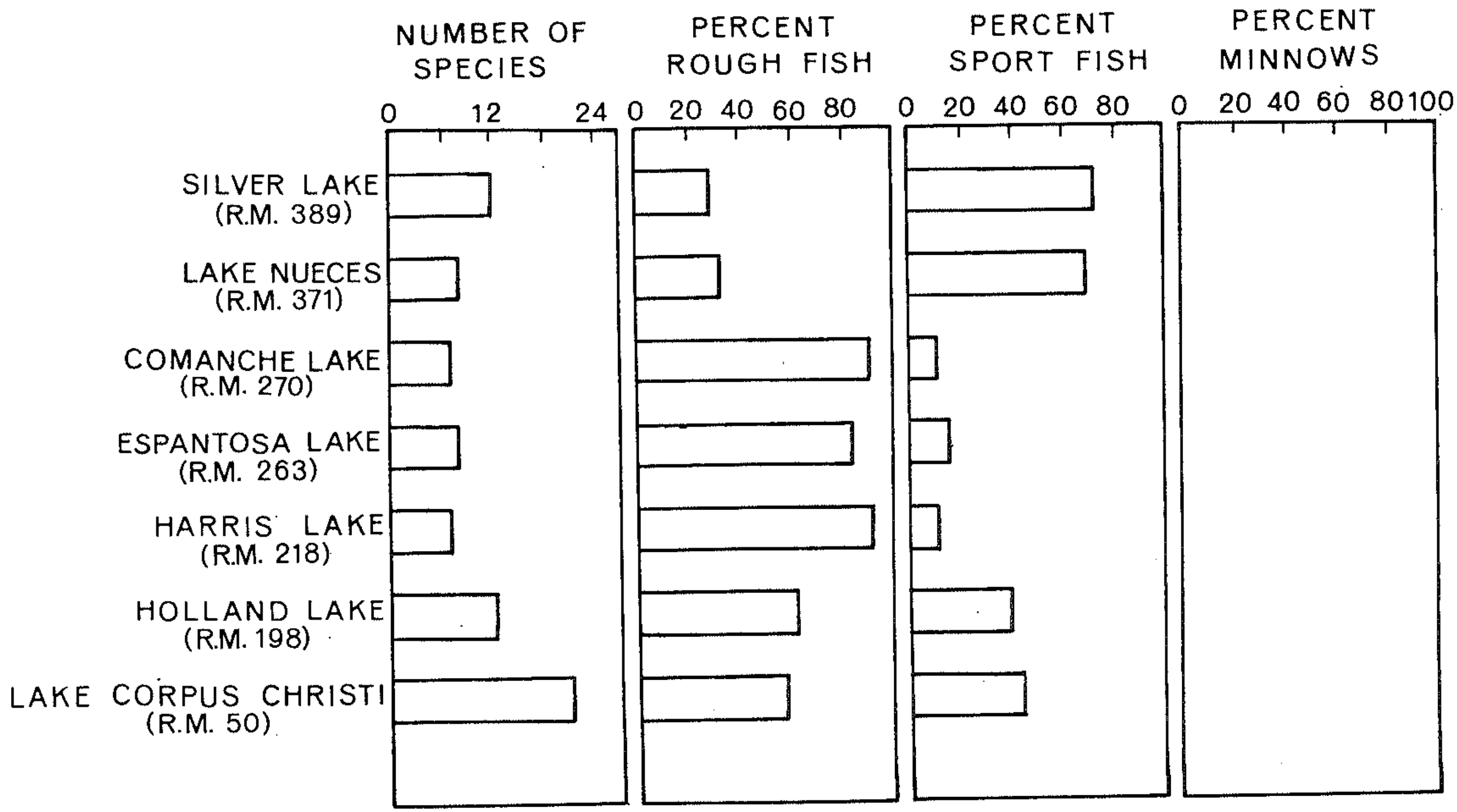


Figure 124. Number of fish species and percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife gillnet data for 1960-64, Nueces River Basin lakes (217, 222, 229, 237, 240, 246, 296, 297).

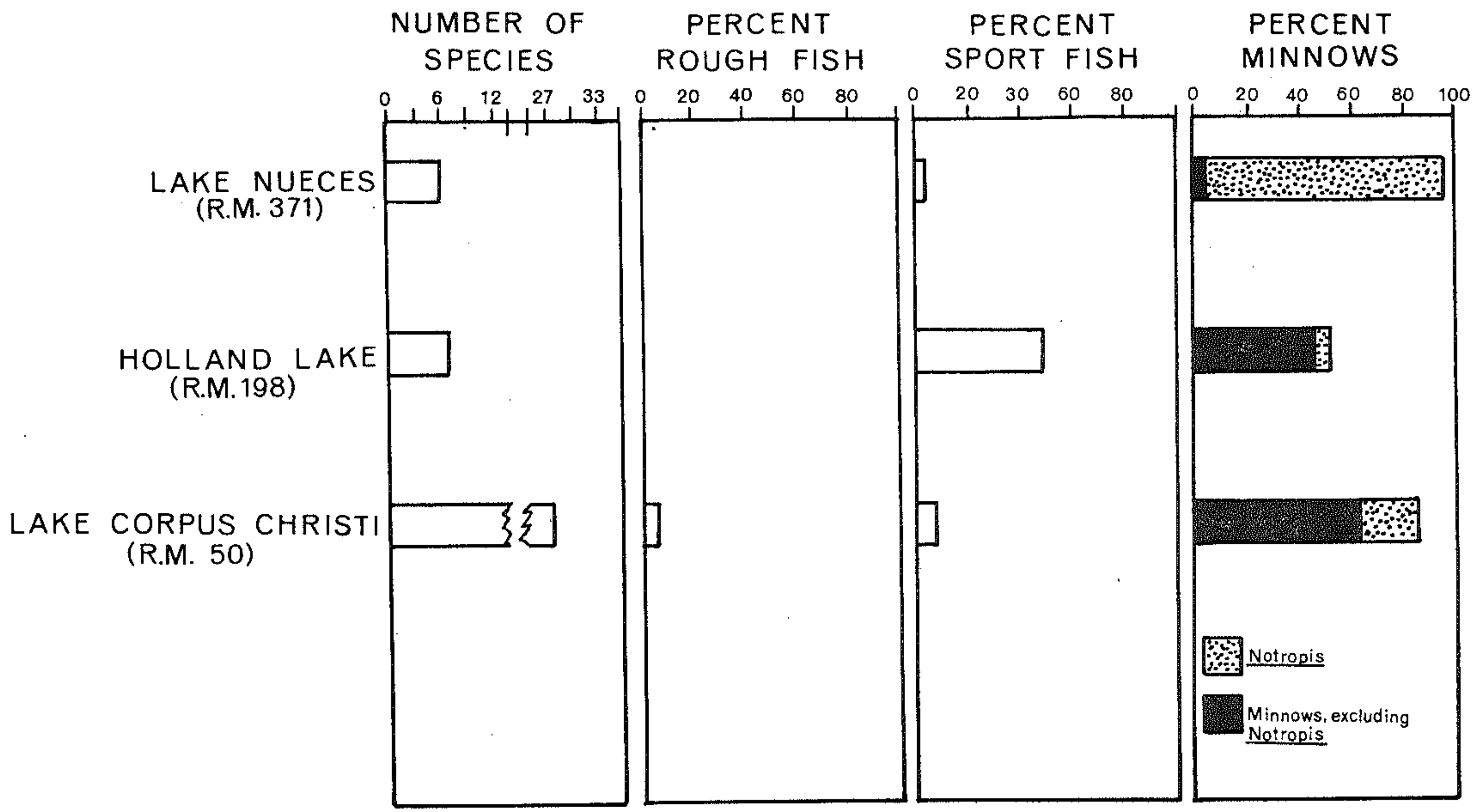


Figure 125. Number of fish species and percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data for 1960-64, Nueces River Basin lakes (229, 237, 240, 246, 297).

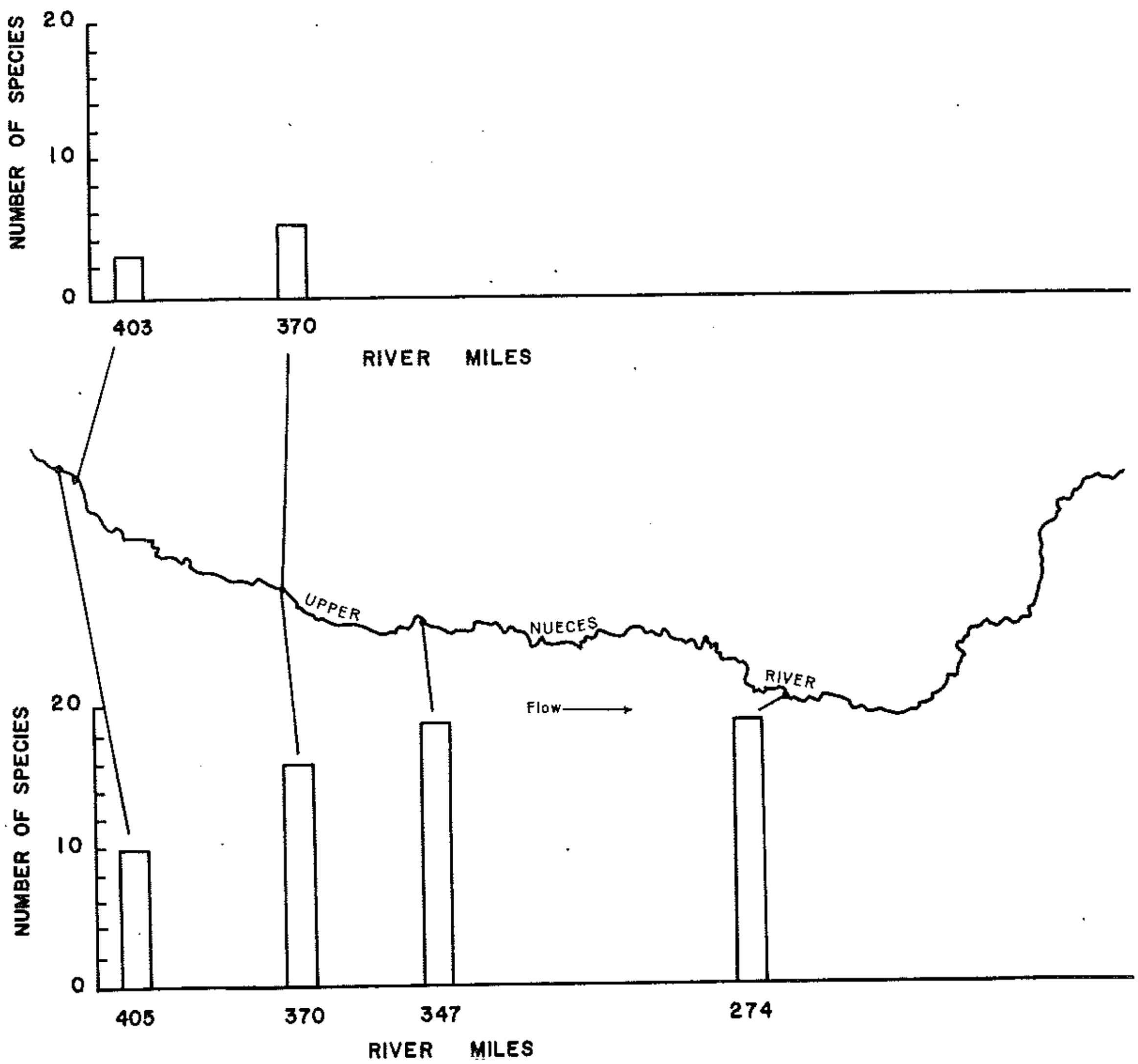


Figure 126. Number of fish species, Texas Parks and Wildlife combined seining and gillnet data for 1955 (top) and 1959-61 (bottom), upper Nueces River, Nueces River Basin (181, 183, 197, 217, 245, 297).

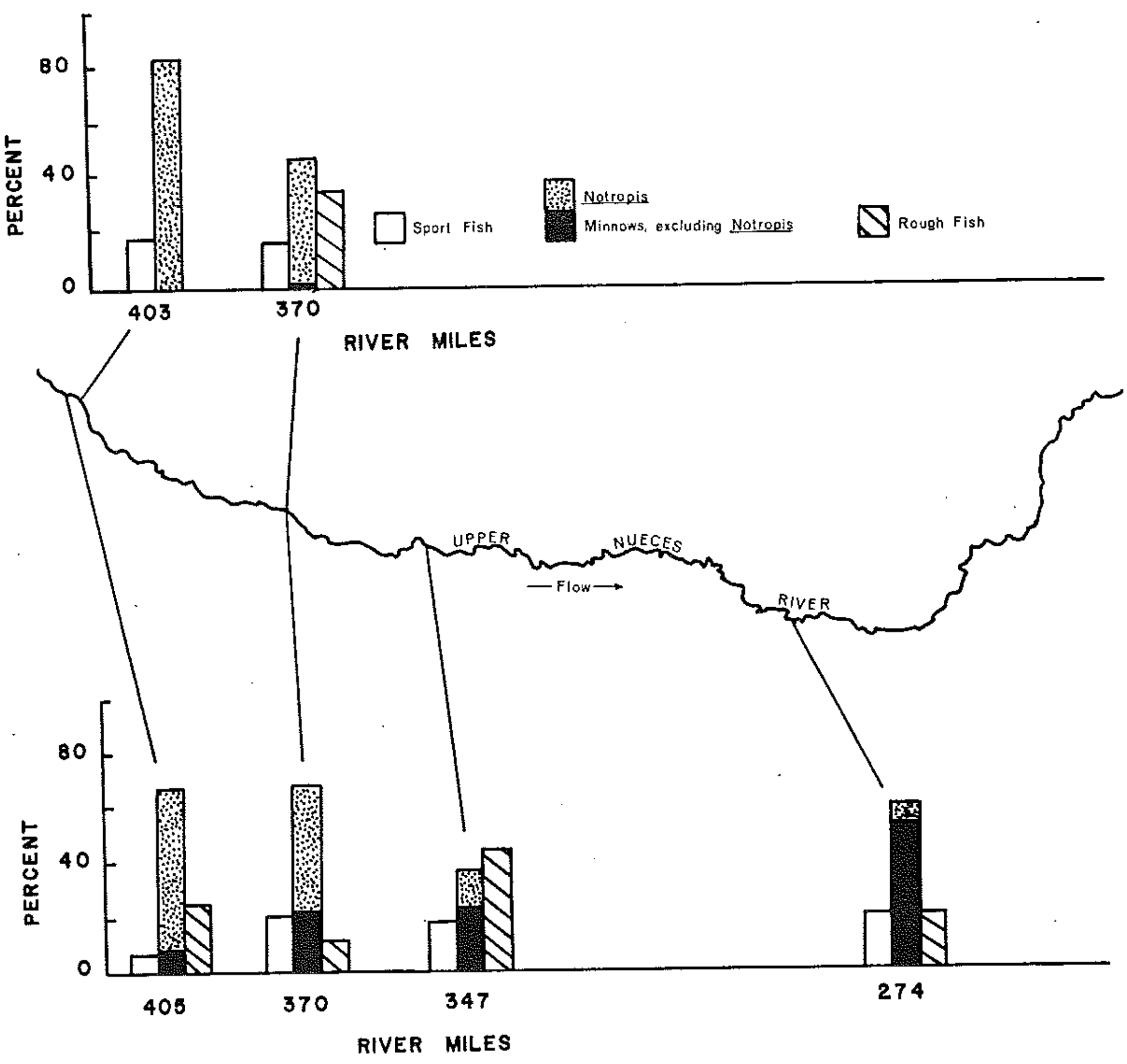


Figure 127. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife combined seining and gillnet data for 1955 (top) and 1959-61 (bottom), upper Nueces River, Nueces River Basin (181, 183, 197, 217, 245, 297).

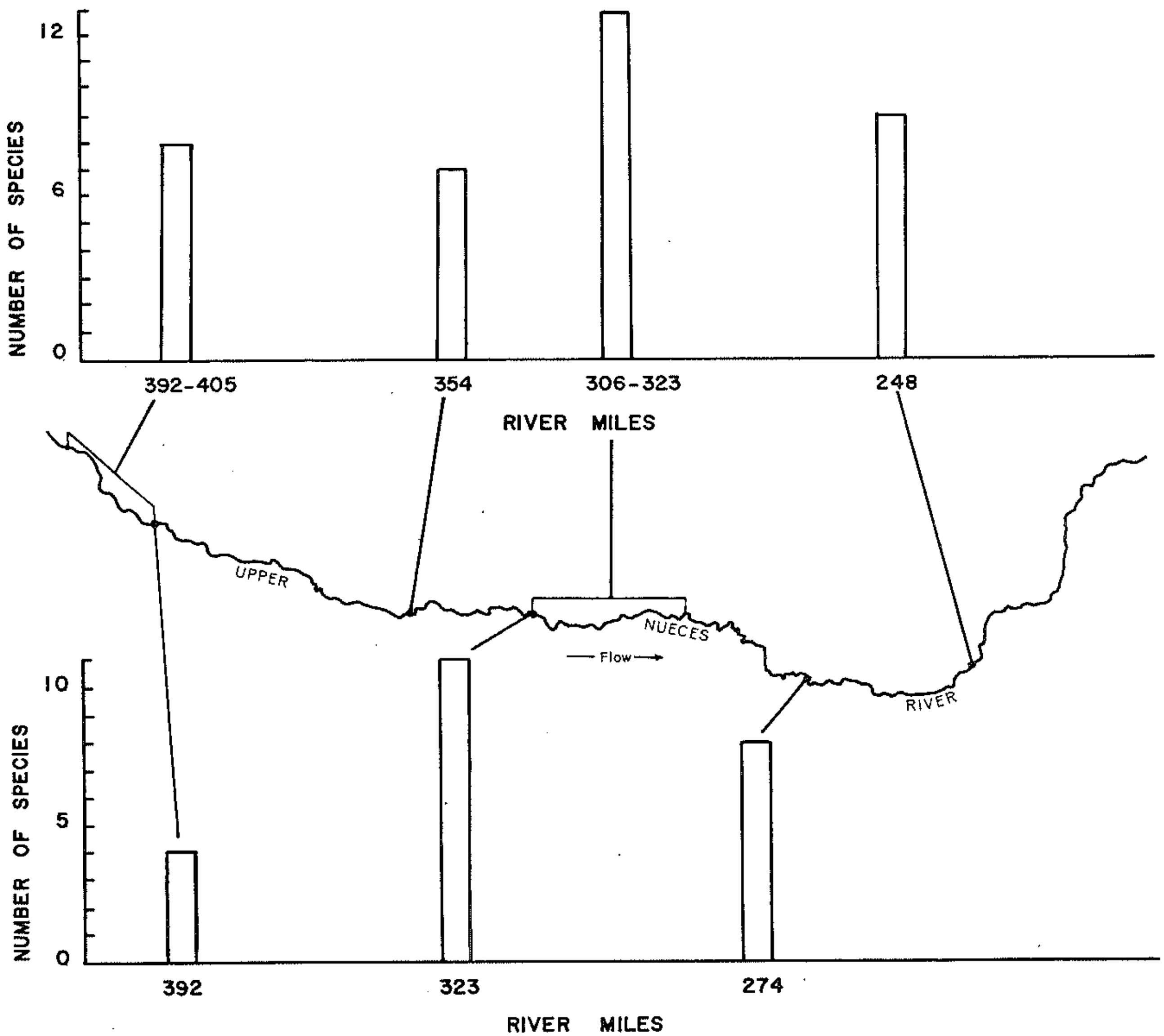


Figure 128. Number of fish species, Texas Parks and Wildlife gillnet data for 1952-56 (top) and 1957-72 (bottom), upper Nueces River, Nueces River Basin (181, 183, 197, 217, 245, 297).

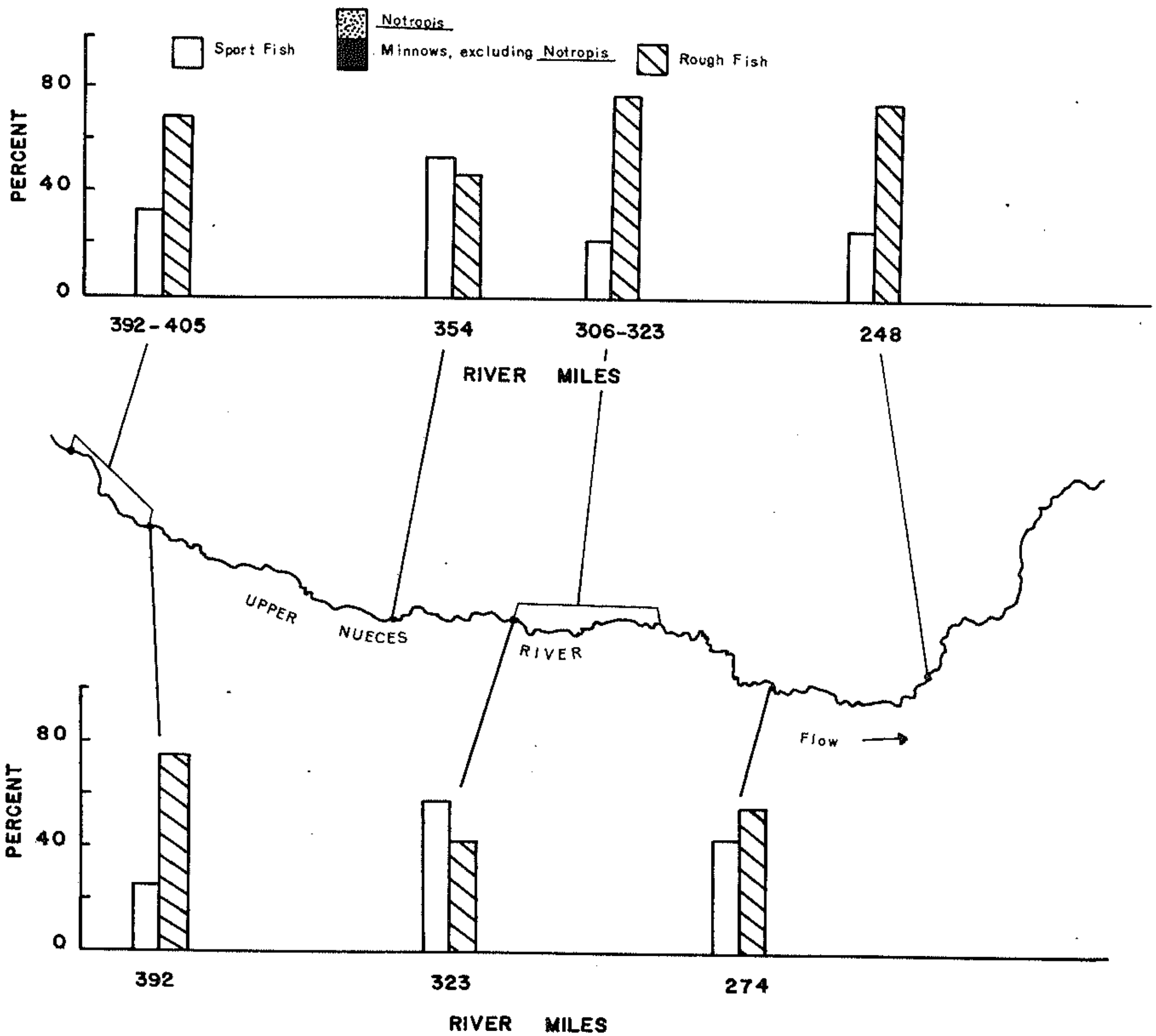


Figure 129. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife gillnet data for 1952-56 (top) and 1957-72 (bottom), upper Nueces River, Nueces River Basin (181, 183, 197, 217, 245, 297).

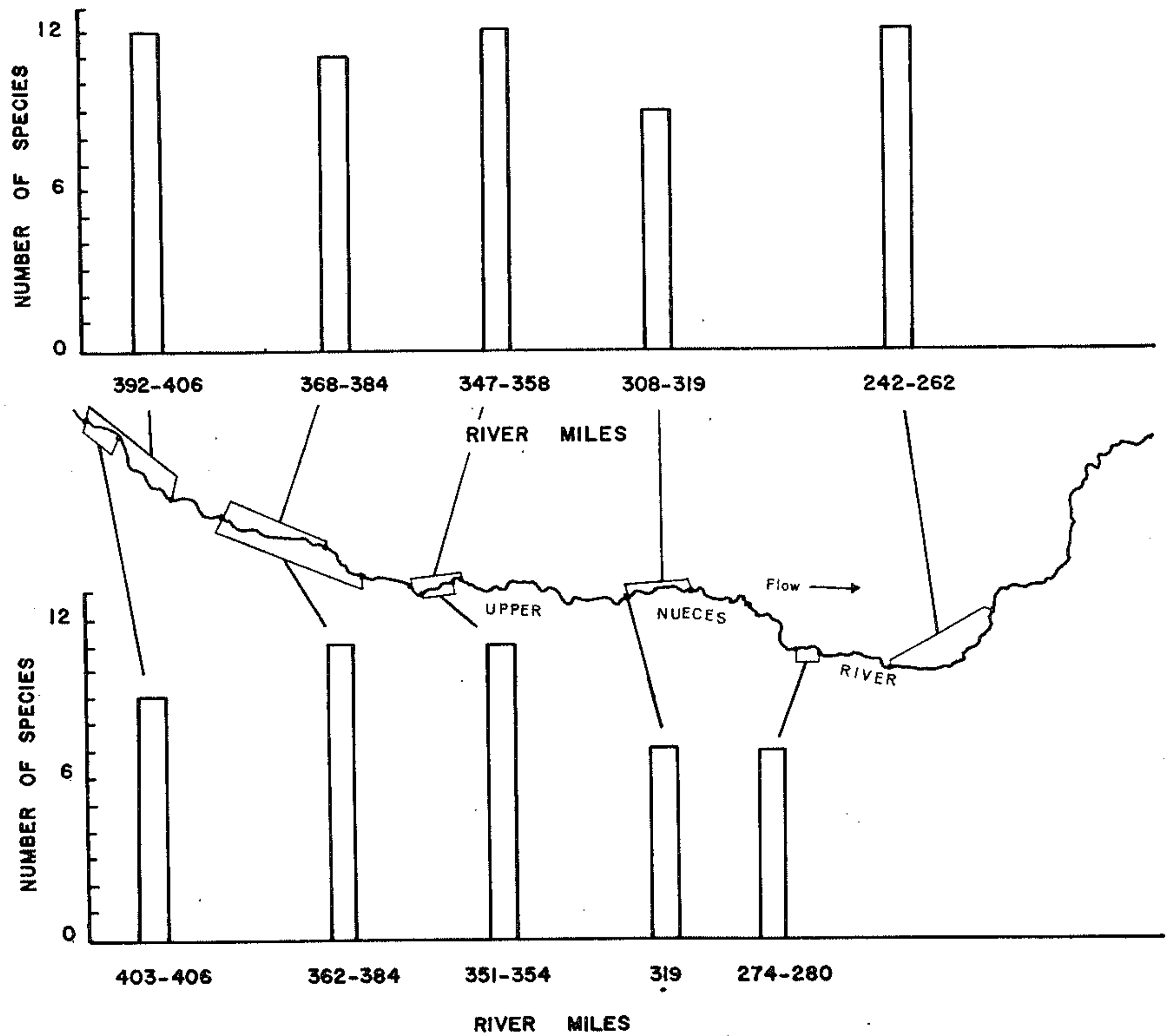


Figure 130. Number of fish species, Texas Parks and Wildlife seining data for 1953-56 (top) and 1957-72 (bottom), upper Nueces River, Nueces River Basin (181, 183, 197, 217, 245, 297).

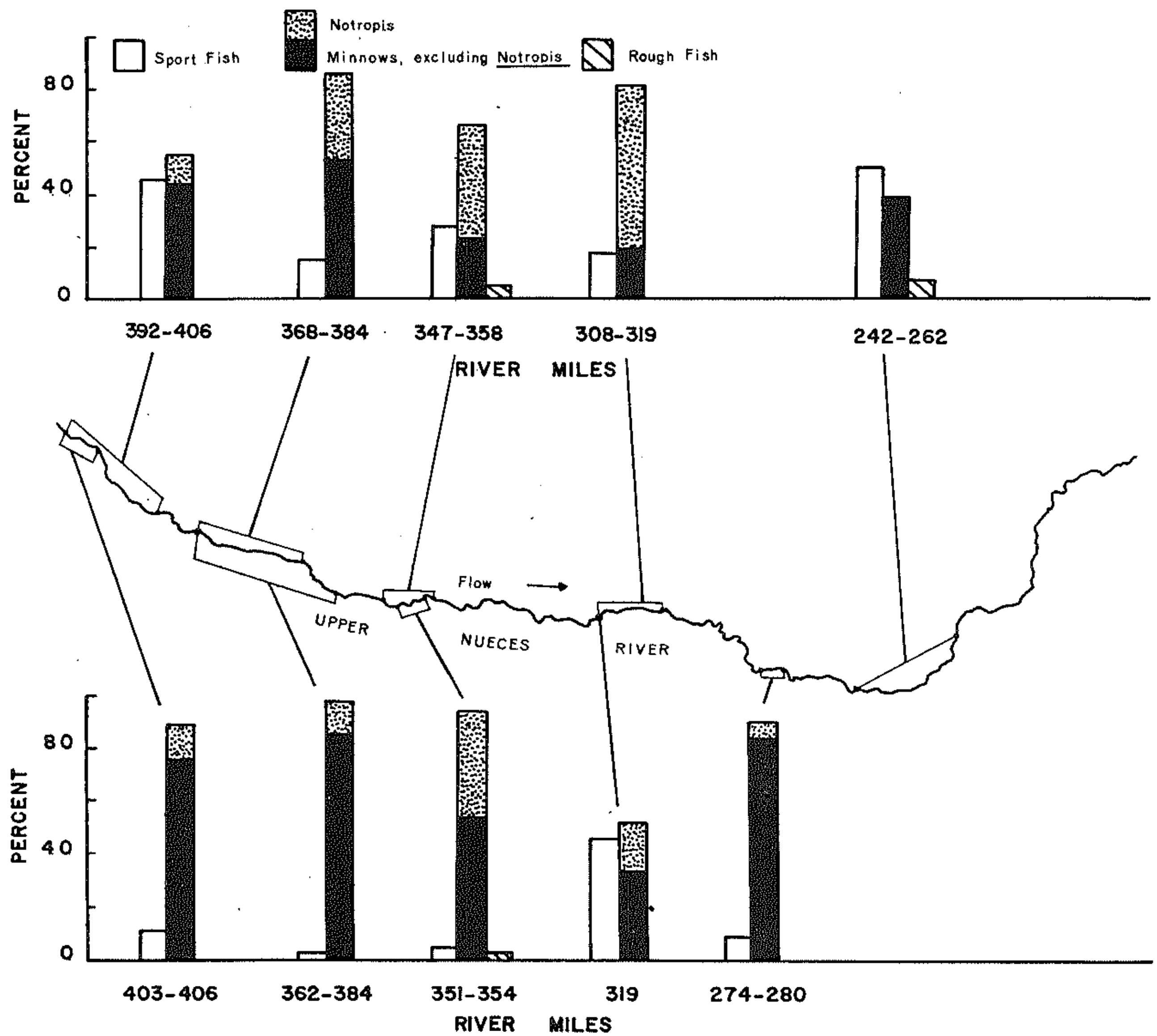


Figure 131. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data for 1953-56 (top) and 1957-72 (bottom), upper Nueces River, Nueces River Basin (181, 183, 197, 217, 245, 297).

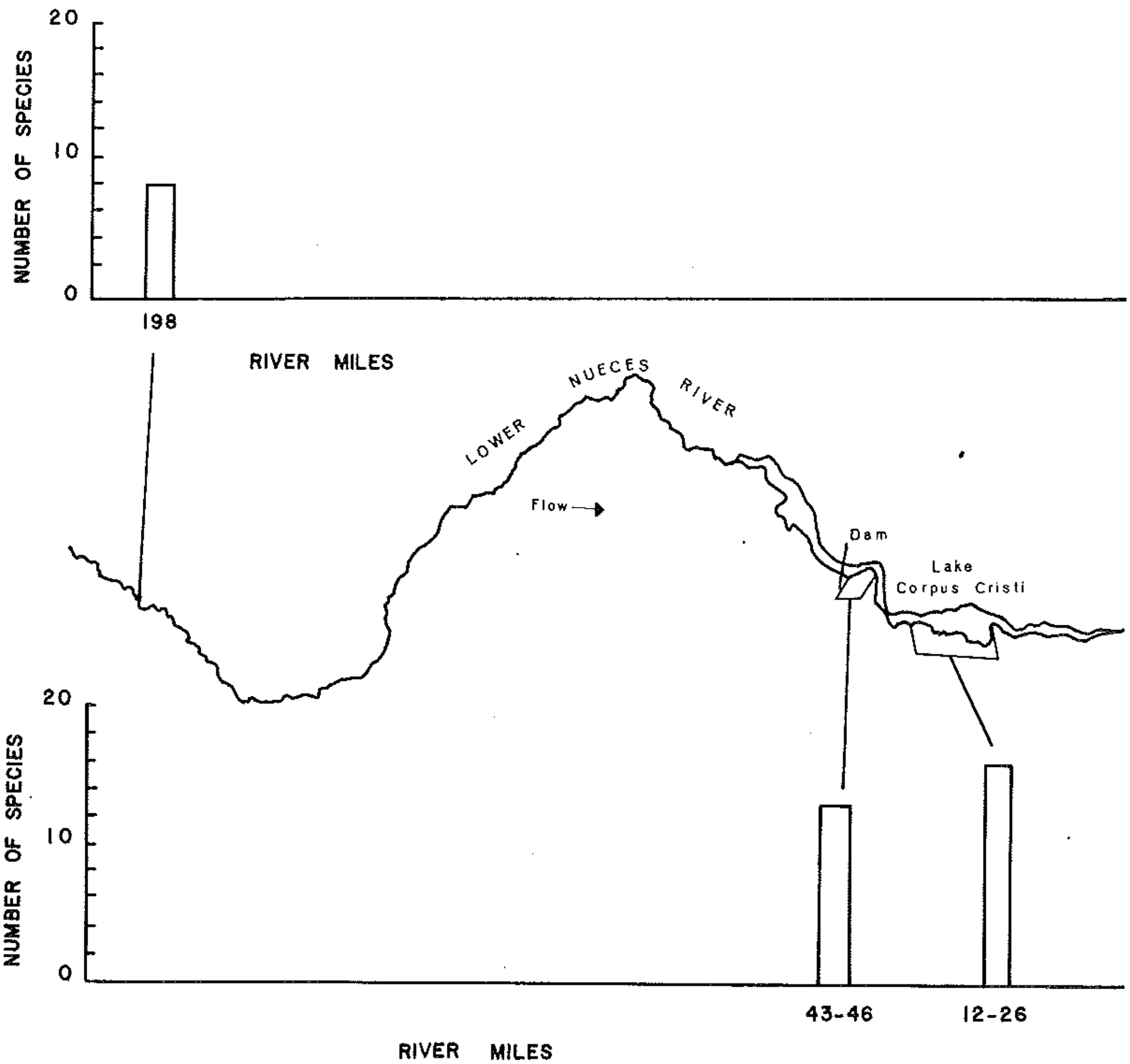


Figure 132. Number of fish species, Texas Parks and Wildlife gillnet data for 1952-56 (top) and 1957-72 (bottom), lower Nueces River, Nueces River Basin (181, 183, 197, 217, 245, 297).

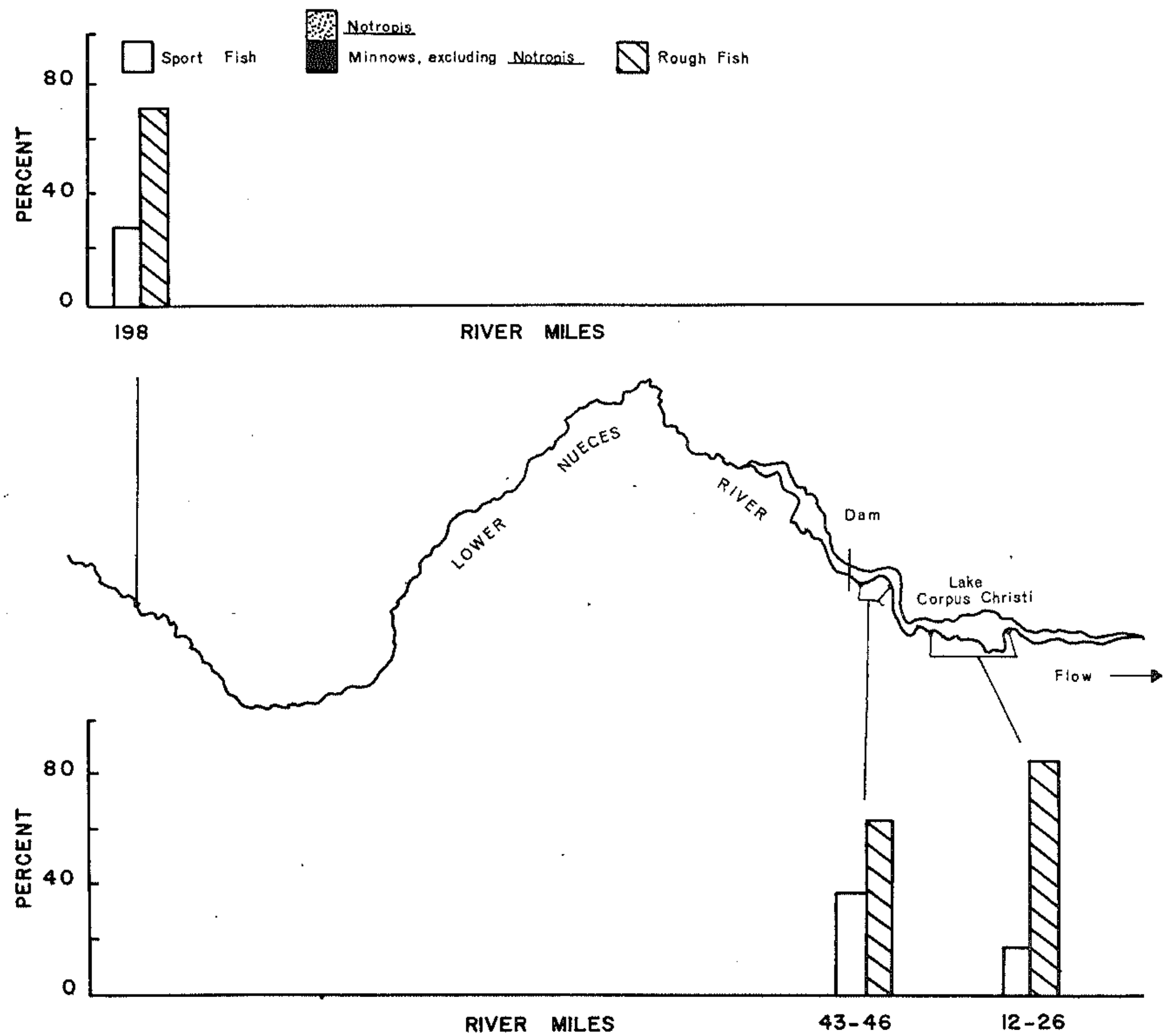


Figure 133. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife gillnet data for 1952-56 (top) and 1957-72 (bottom), lower Nueces River, Nueces River Basin (181, 183, 197, 217, 245, 297).

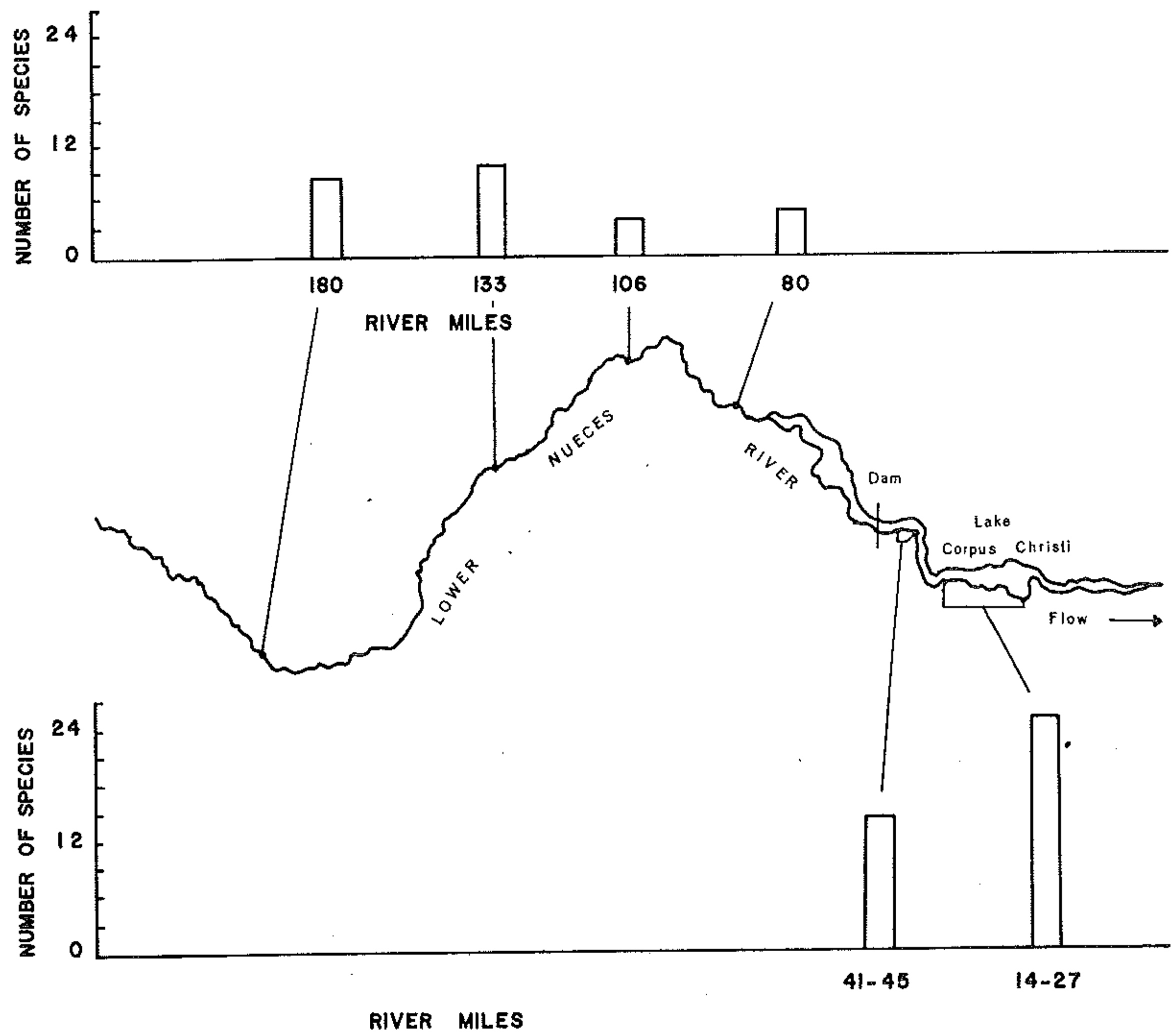


Figure 134. Number of fish species, Texas Parks and Wildlife seining data for 1953-56 (top) and 1957-72 (bottom), lower Nueces River, Nueces River Basin (181, 183, 197, 217, 245, 297).

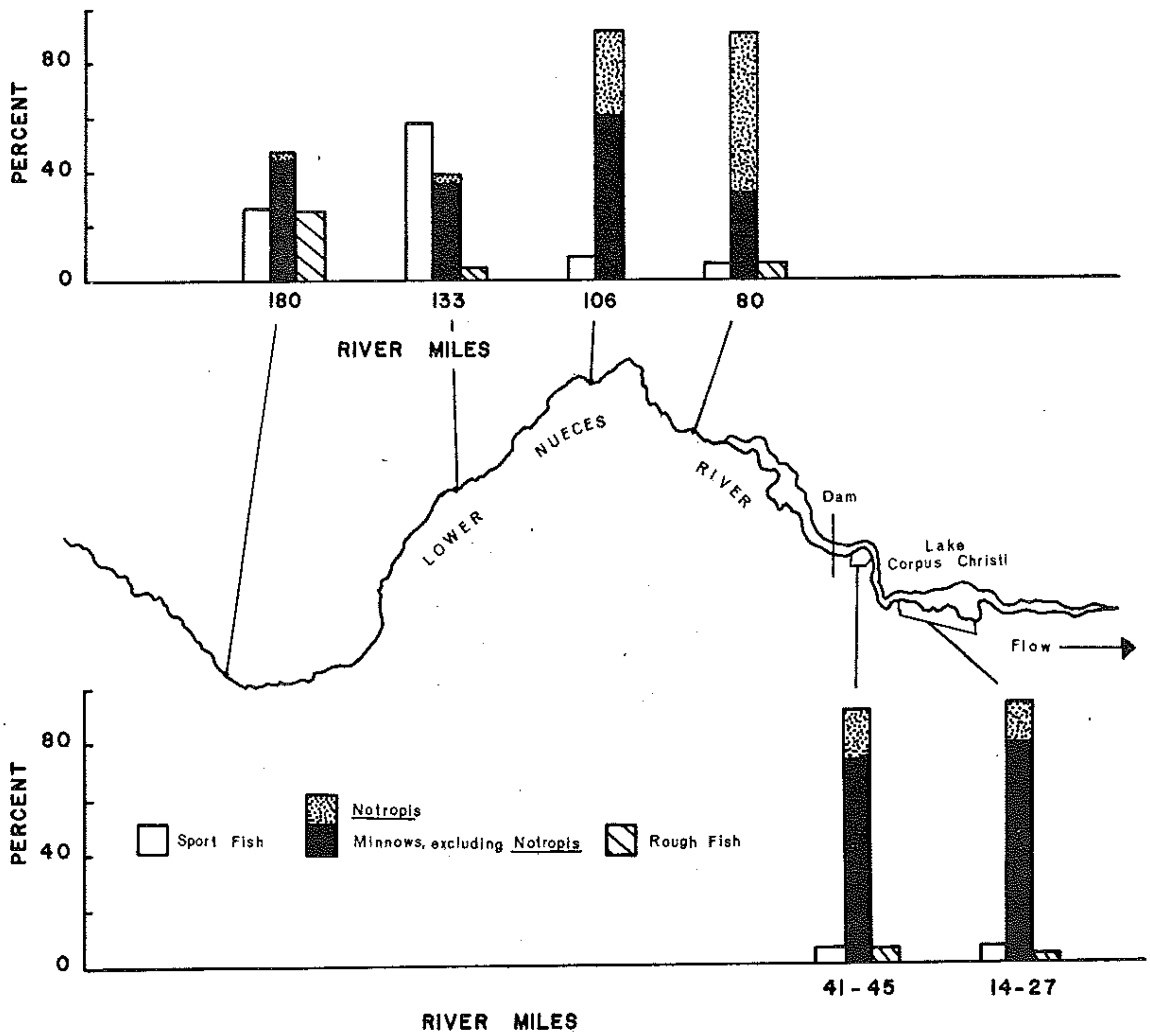


Figure 135. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data for 1953-56 (top) and 1957-72 (bottom), lower Nueces River, Nueces River Basin (181, 183, 197, 217, 245, 297).

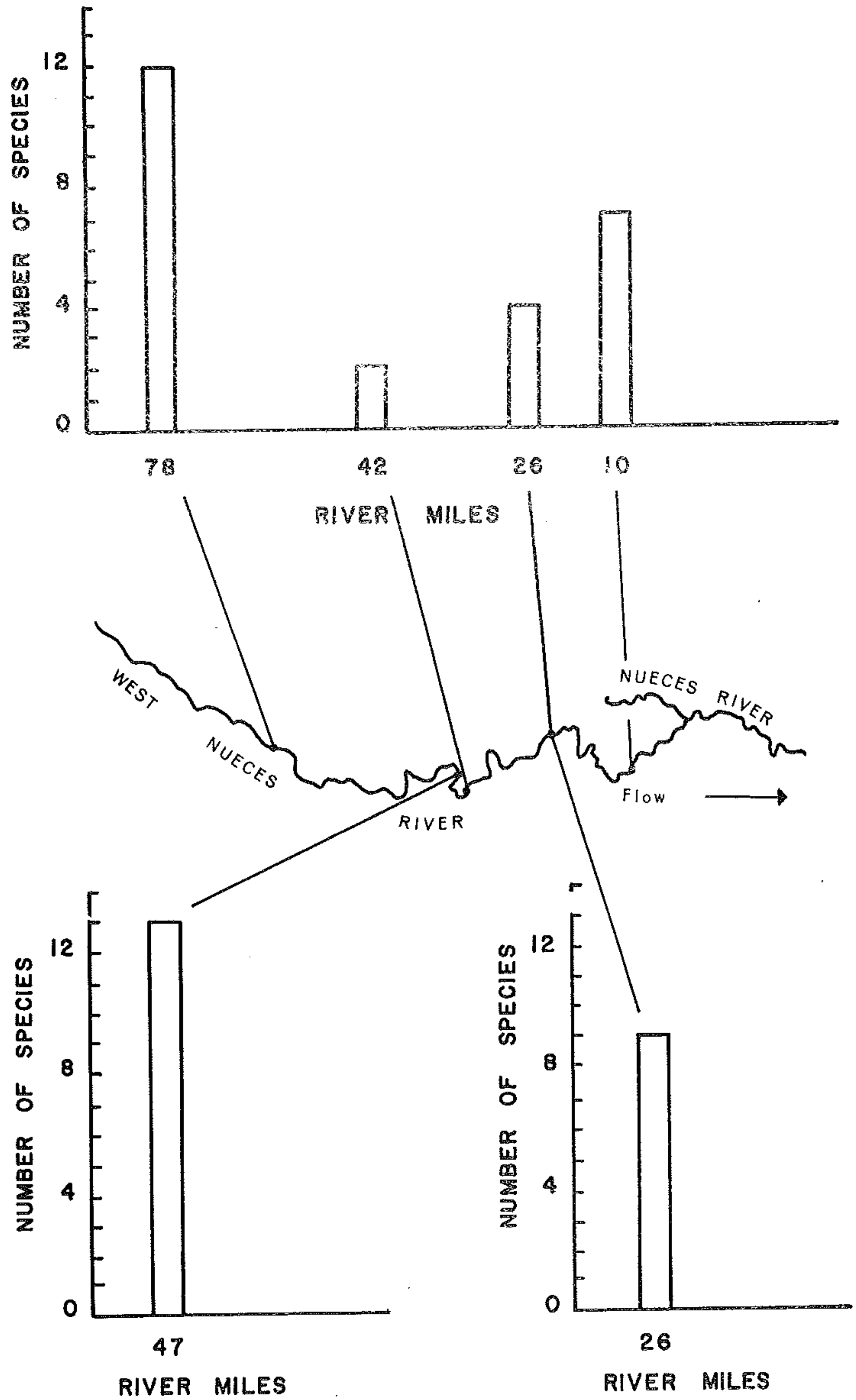


Figure 136. Number of fish species, Texas Parks and Wildlife seining data (top), combined seining and gillnet data (bottom left), and gillnet data (bottom right) for 1955-64, West Nueces River, Nueces River Basin (183, 297).

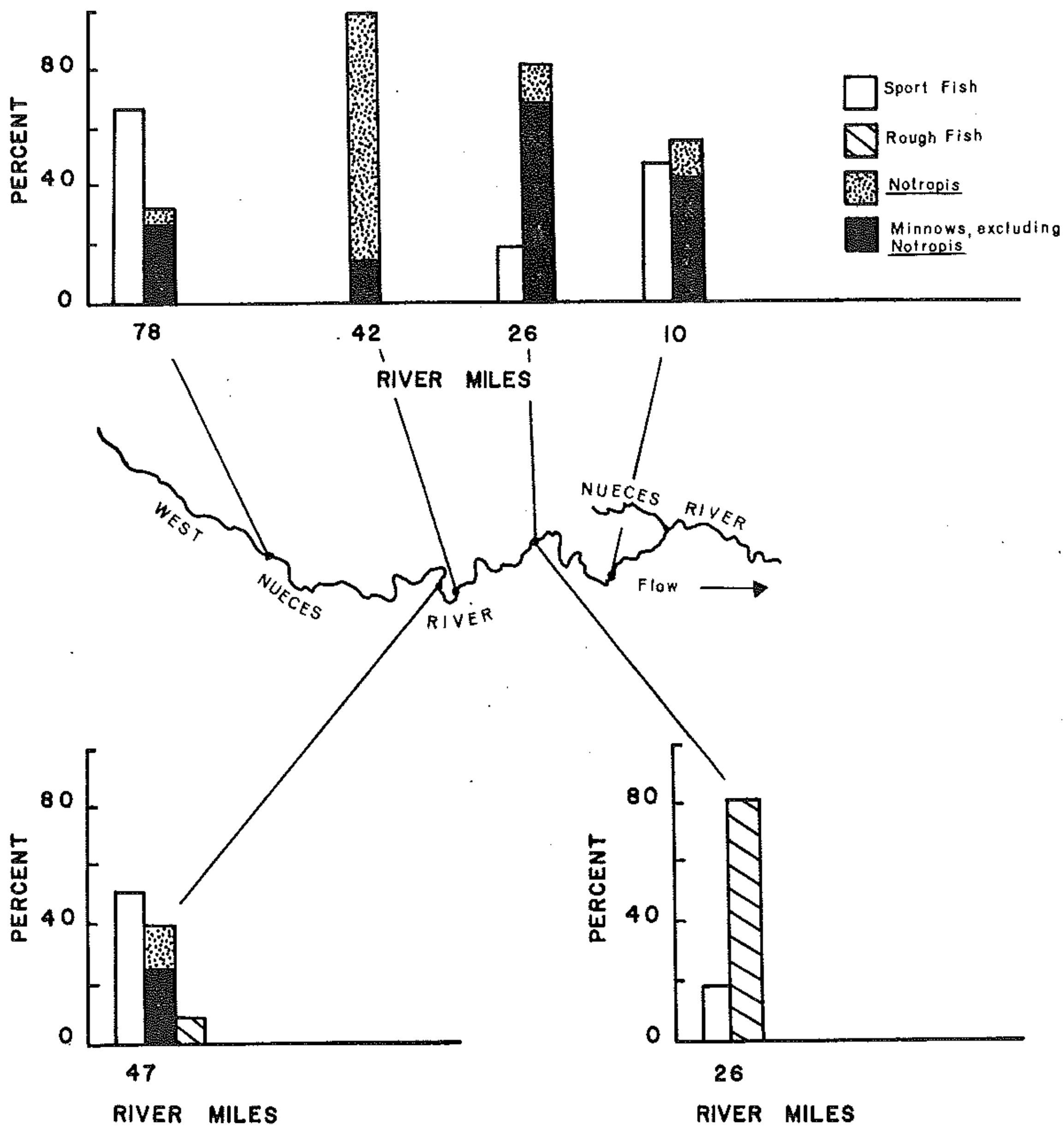


Figure 137. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data (top), combined seining and gillnet data (bottom left), and gillnet data (bottom right) for 1955-64, West Nueces River, Nueces River Basin (183, 297).

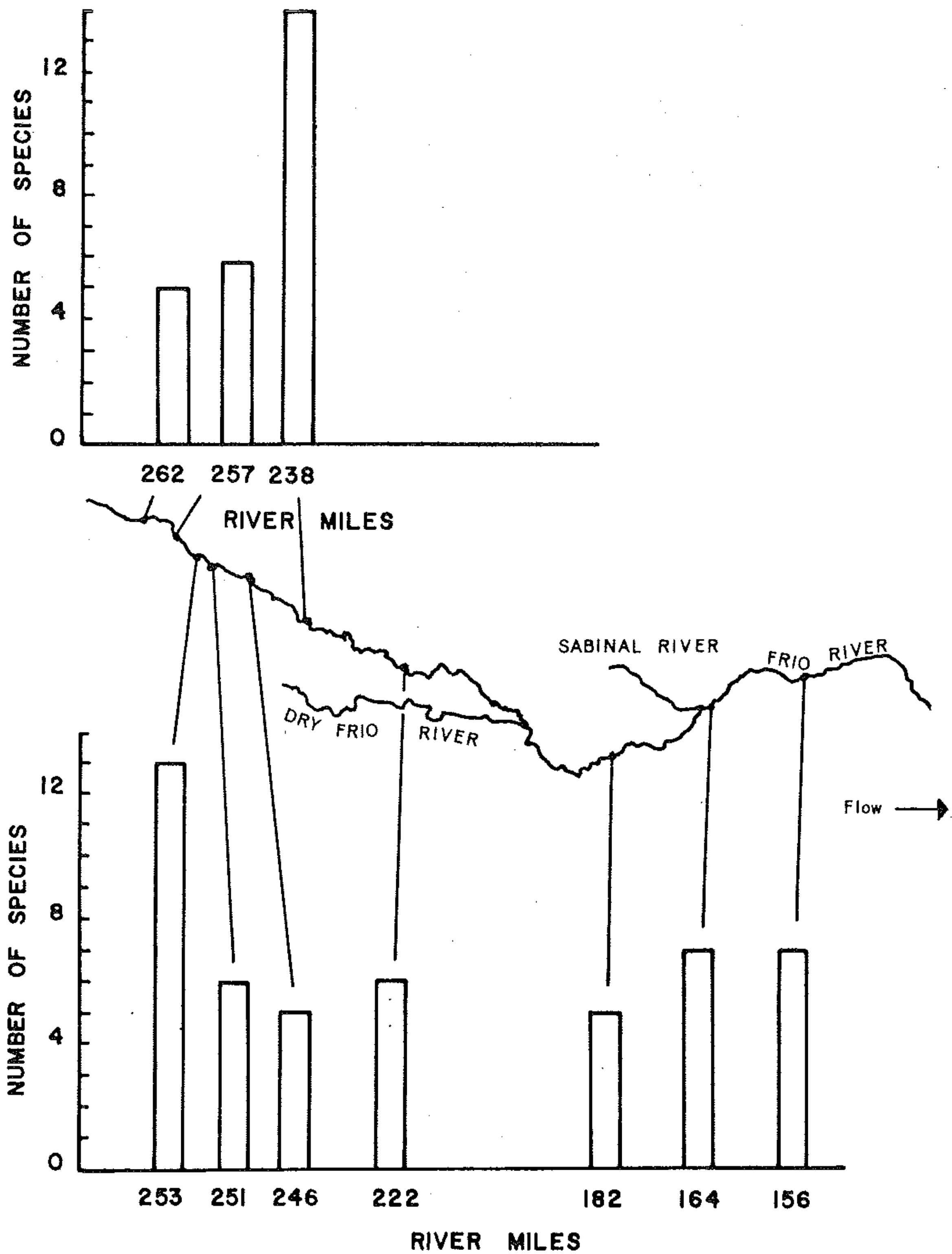


Figure 138. Number of fish species, Texas Parks and Wildlife combined seining and gillnet data (top) and seining data (bottom) for 1961, Frio River, Nueces River Basin (297).

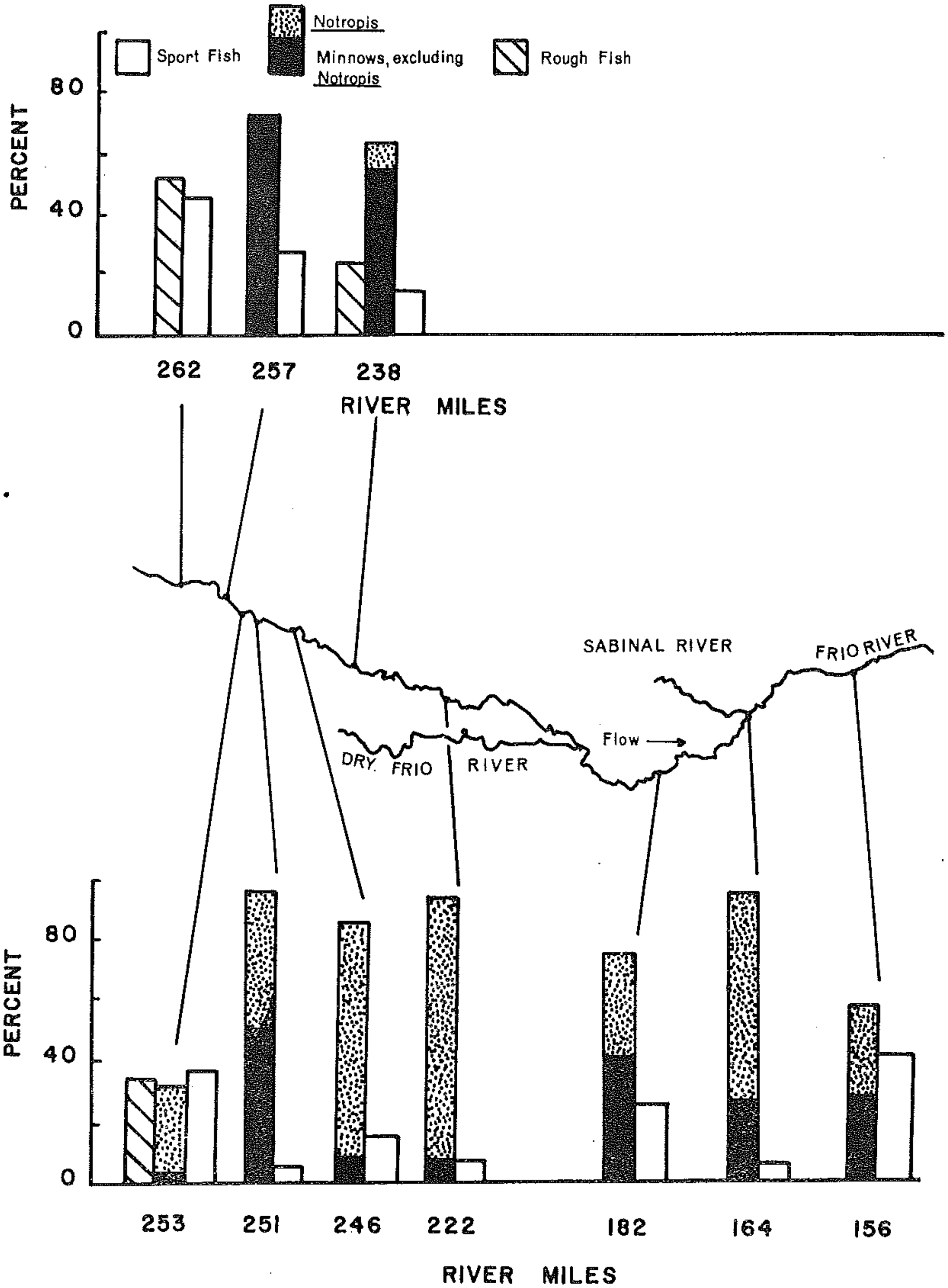


Figure 139. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife combined seining and gillnet data (top) and seining data (bottom) for 1961, Frio River, Nueces River Basin (297).

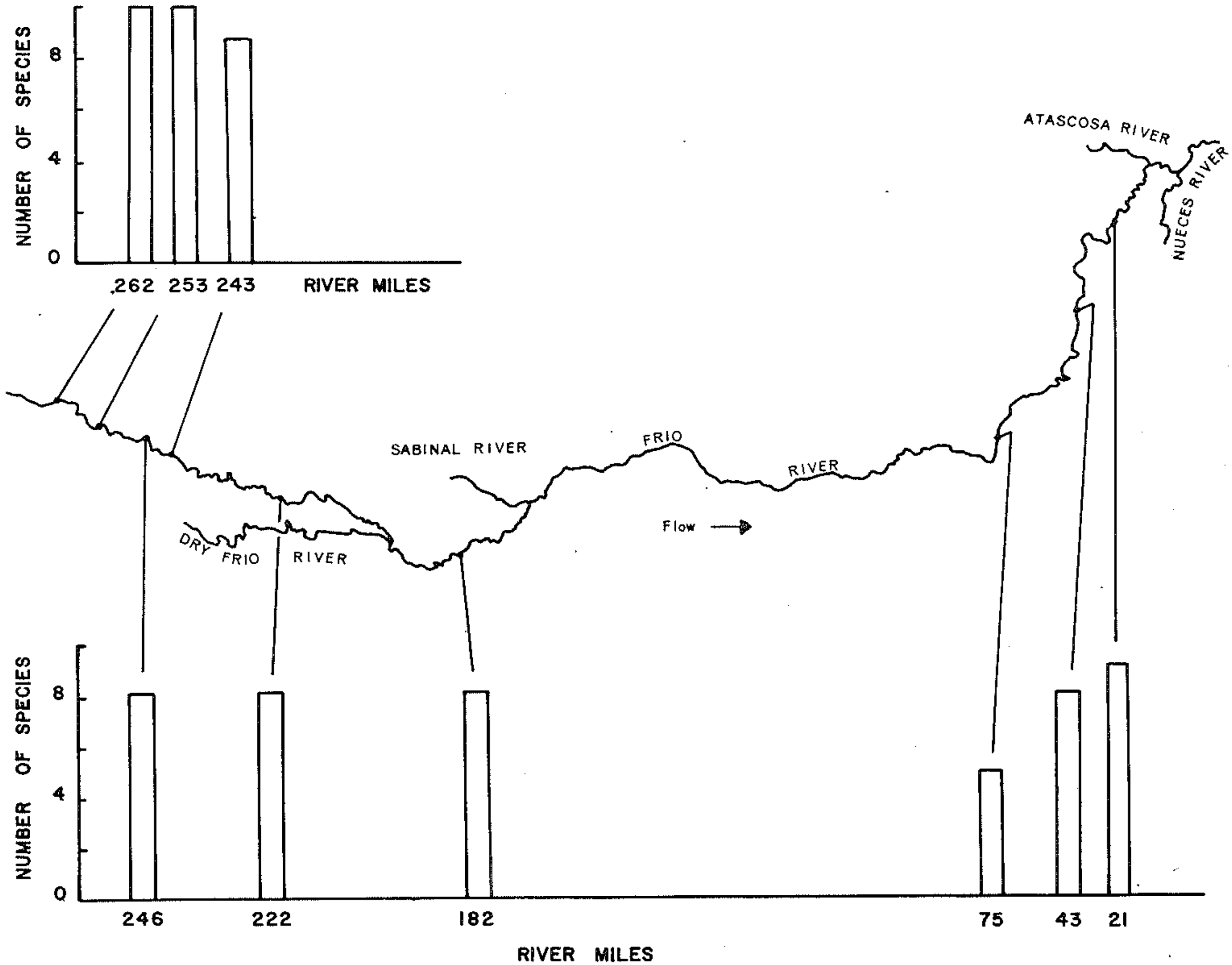


Figure 140. Number of fish species, Texas Parks and Wildlife combined seining and gillnet data (top) and seining data (bottom) for 1952-55, Frio River, Nueces River Basin (181, 184, 297).

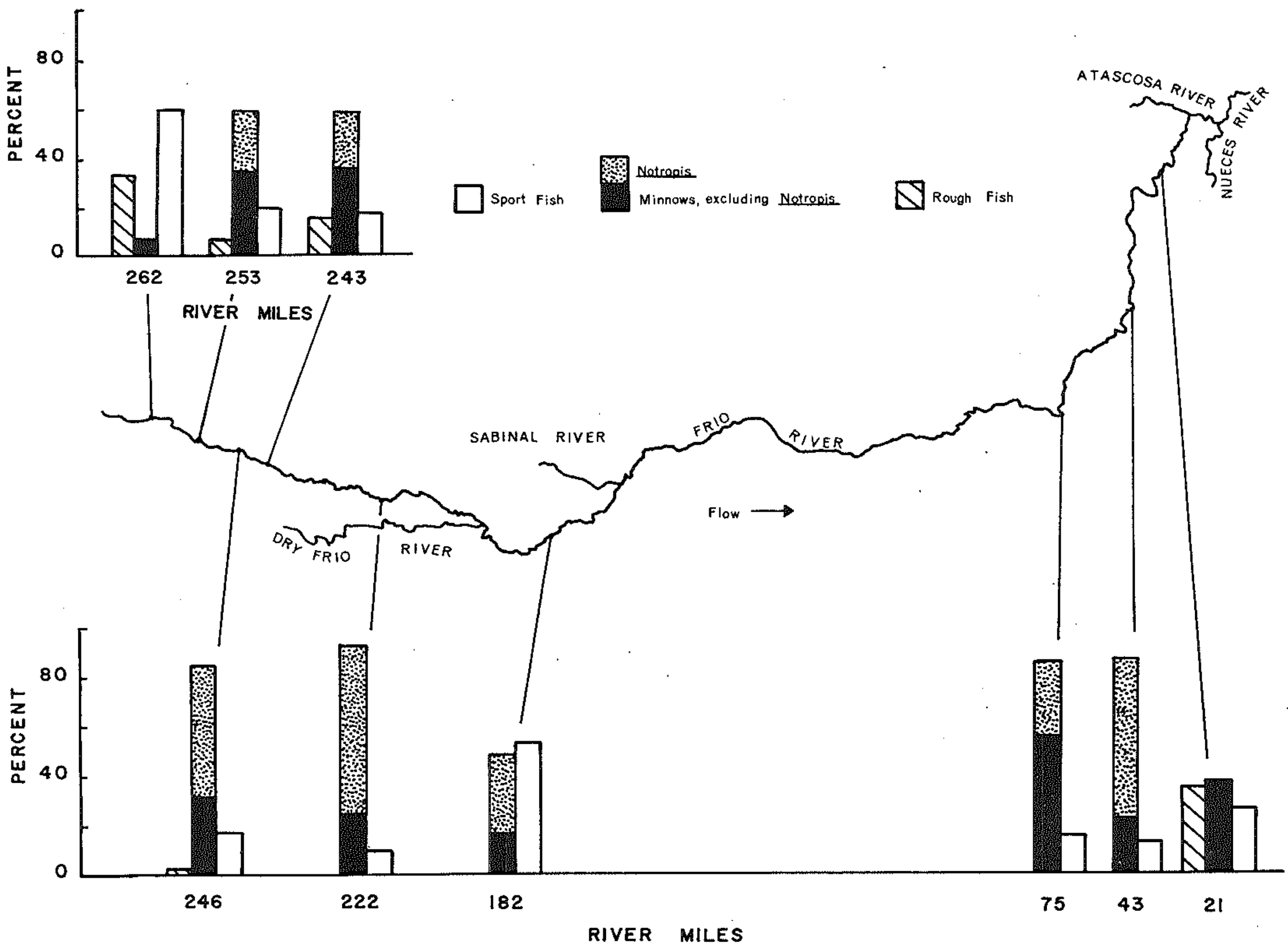


Figure 141. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife combined seining and gillnet data (bottom) and seining data (top) for 1952-55, Frio River, Nueces River Basin (181, 184, 297).

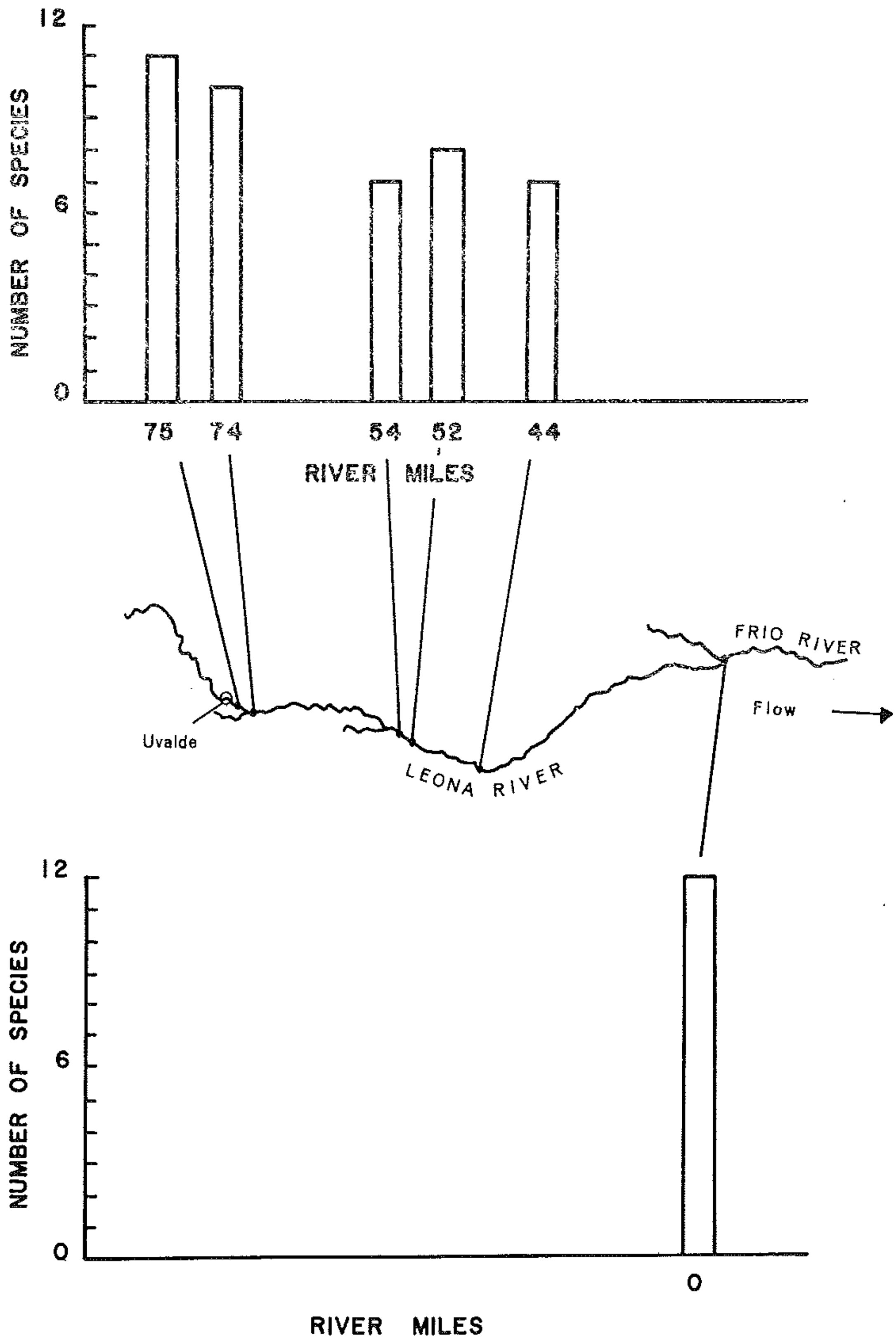


Figure 142. Number of fish species, Texas Parks and Wildlife combined seining and gillnet data (top) and gillnet data (bottom) for 1962-63, Leona River, Nueces River Basin (232, 240).

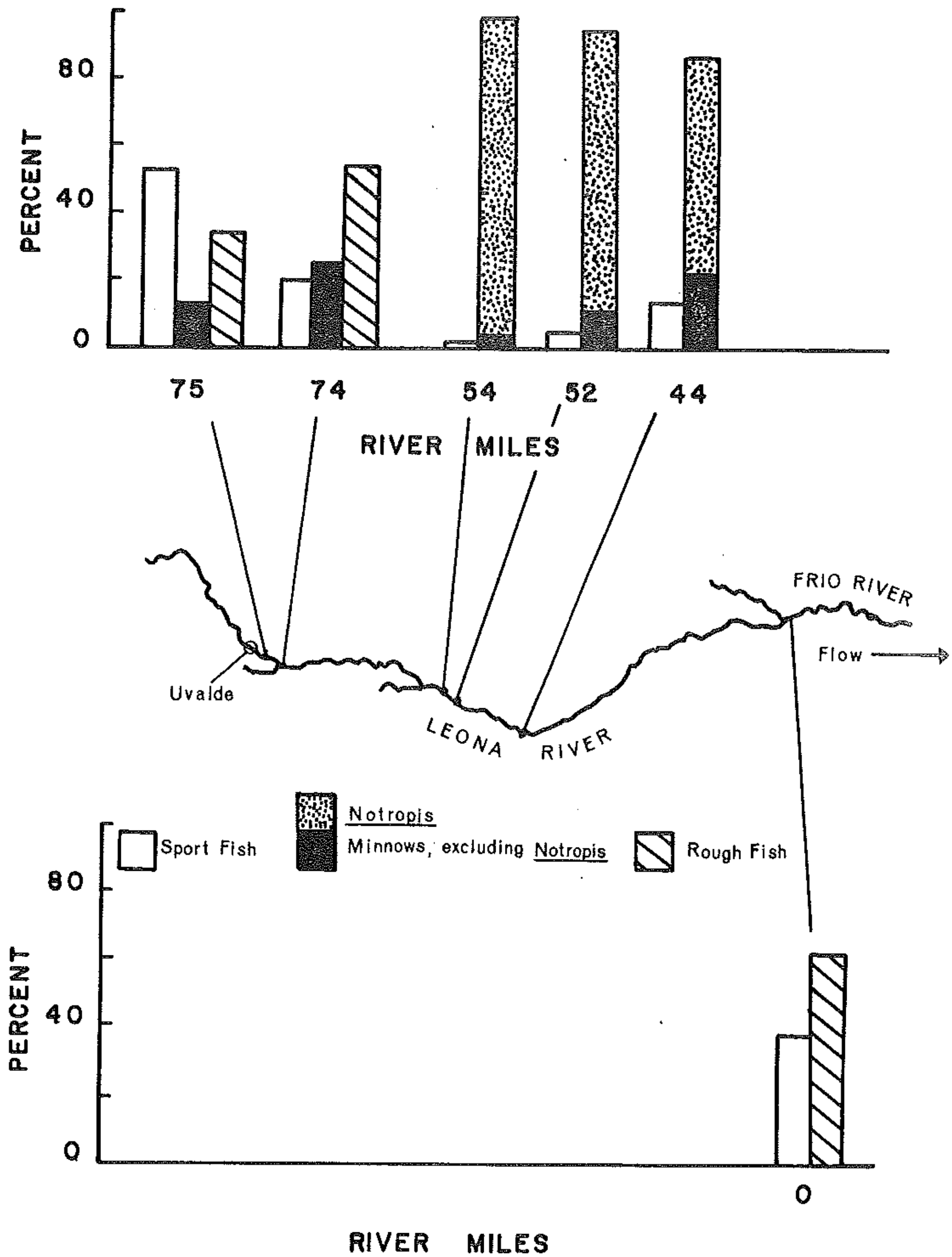


Figure 143. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife combined seining and gillnet data (top) and gillnet data (bottom) for 1962-63, Leona River, Nueces River Basin (232, 240).

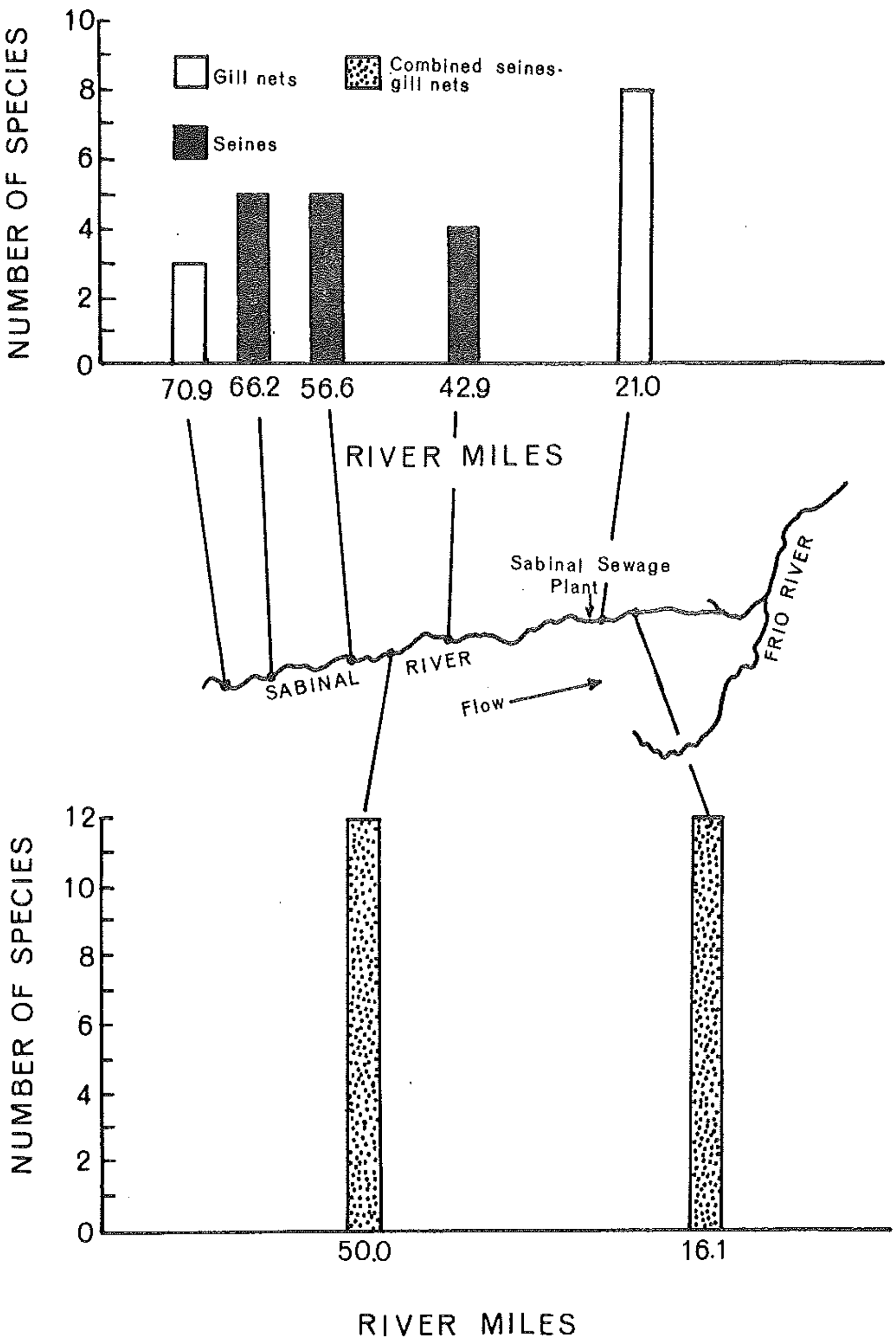


Figure 144. Number of fish species, Texas Parks and Wildlife seining and gillnet data (top) and combined seining and gillnet data (bottom) for 1961, Sabinal River, Nueces River Basin (297).

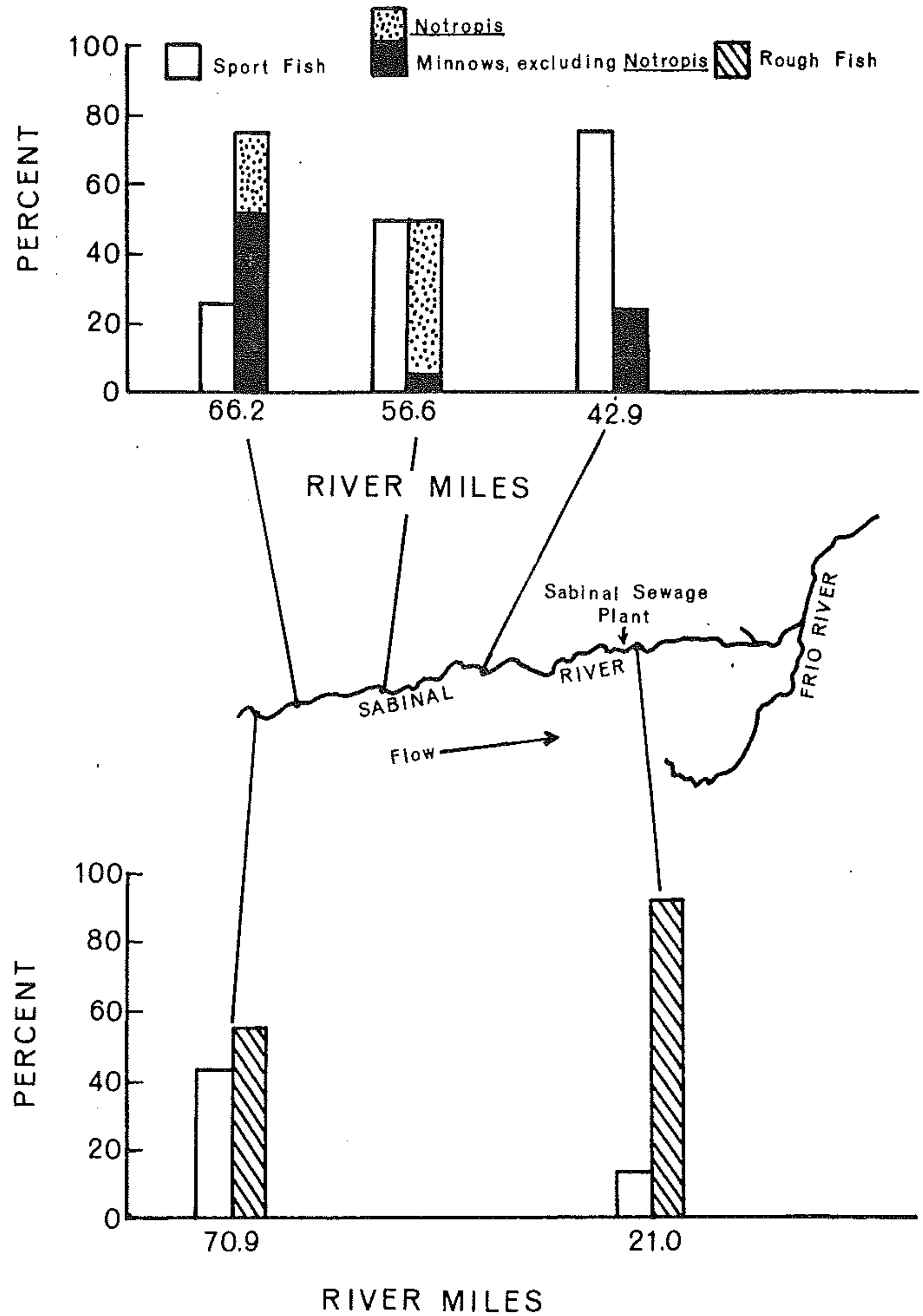


Figure 145. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data (top) and gill-net data (bottom) for 1961, Sabinal River, Nueces River Basin (297).

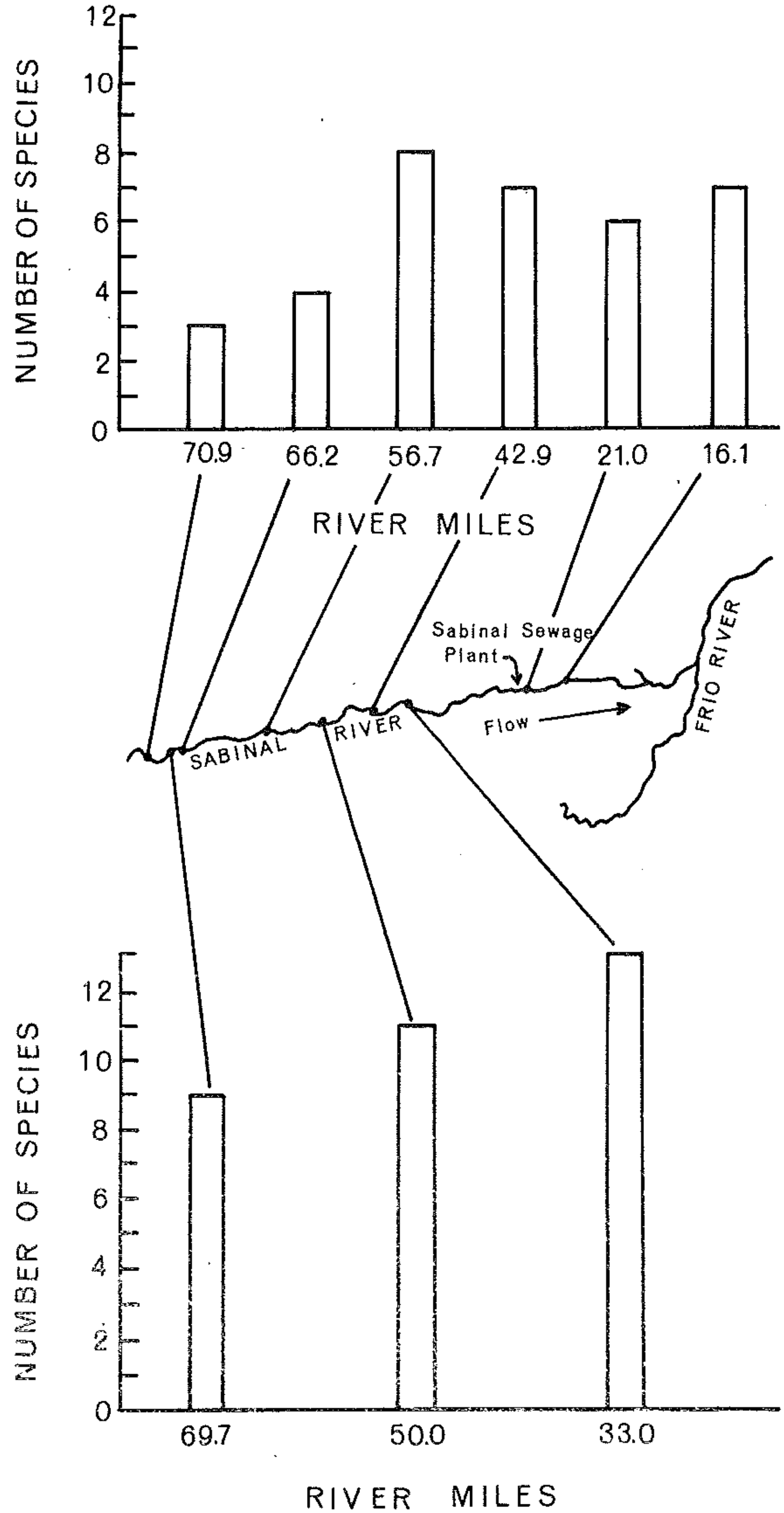


Figure 146. Number of fish species, Texas Parks and Wildlife seining data (top) and combined seining and gillnet data (bottom) for 1955, Sabinal River, Nueces River Basin (186).

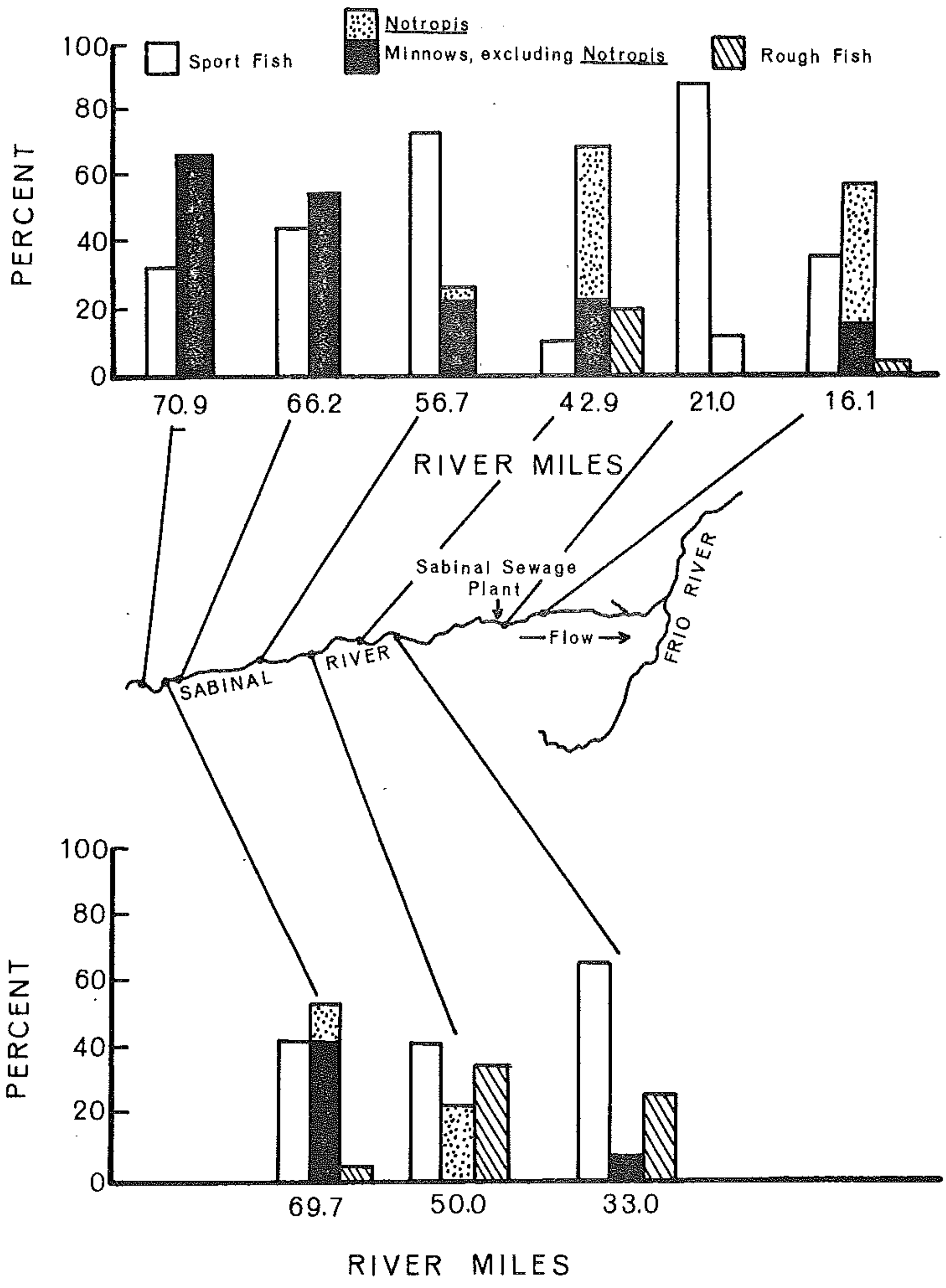


Figure 147. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data (top) and combined seining and gillnet data (bottom) for 1955, Sabinal River, Nueces River Basin (186).

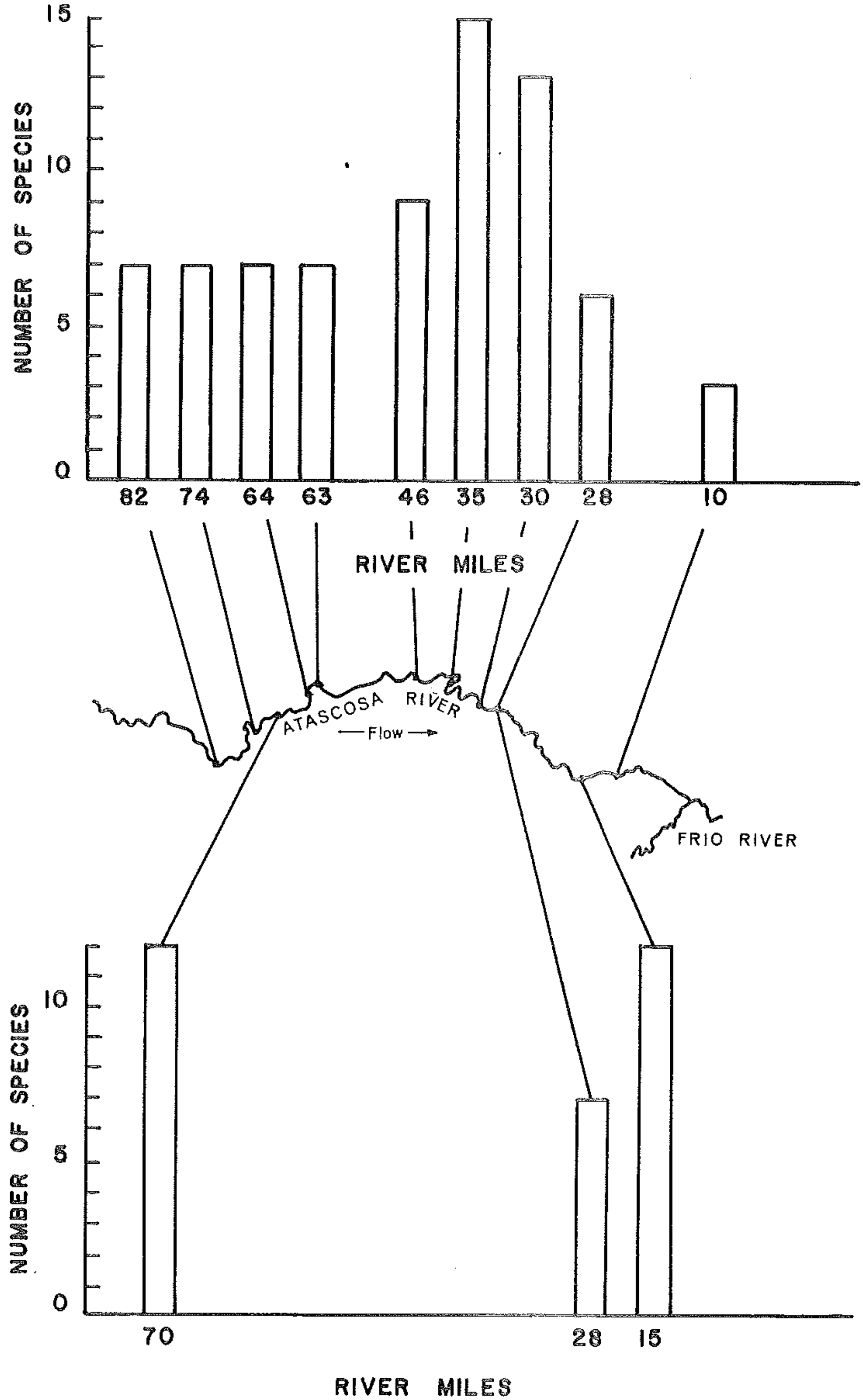


Figure 148. Number of fish species, Texas Parks and Wildlife seining data (top) and combined seining and gillnet data (bottom) for 1953-56, Atascosa River, Nueces River Basin (181).

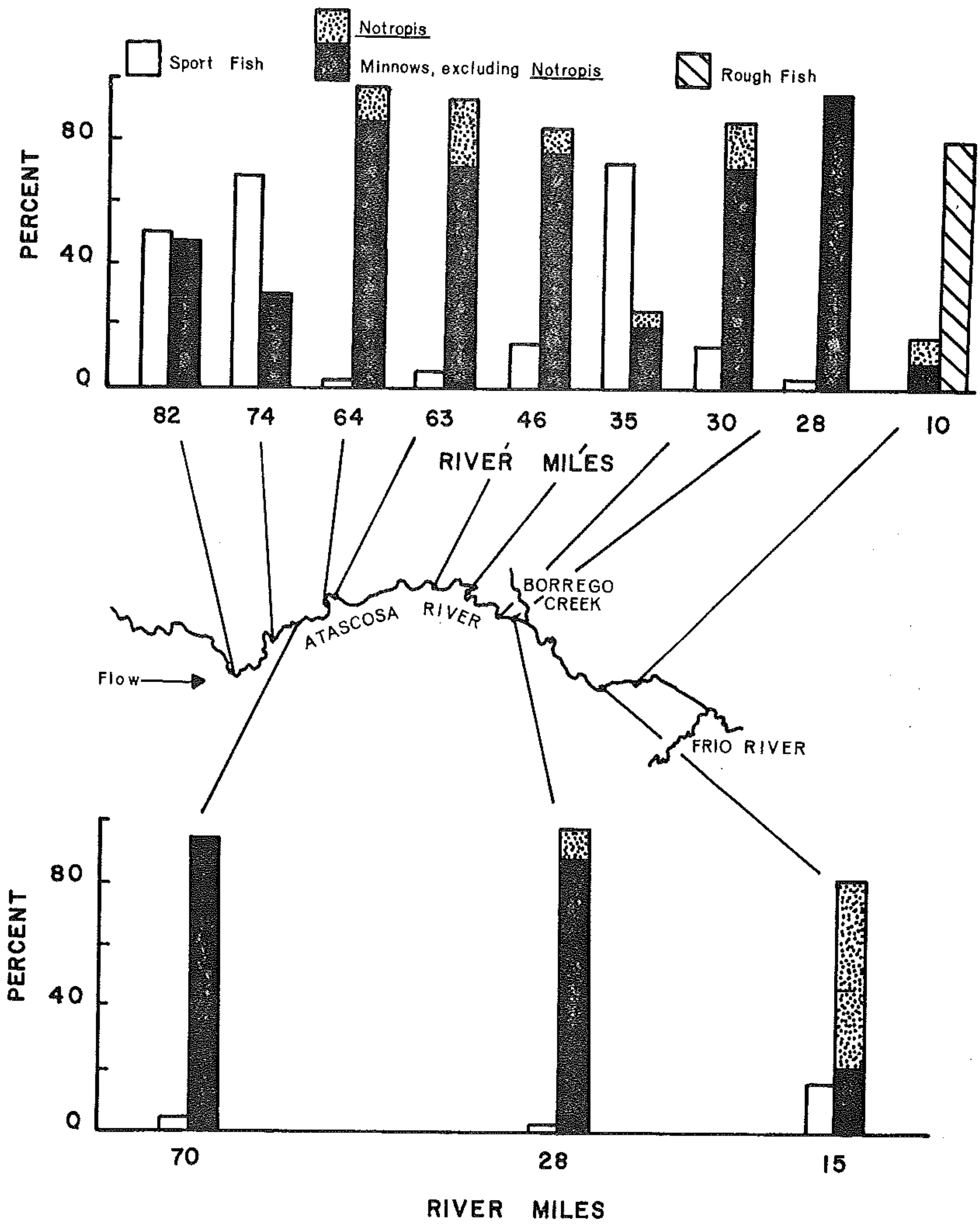


Figure 149. Percent number of sport fish, rough fish, and minnows, Texas Parks and Wildlife seining data (top) and combined seining and gillnet data (bottom) for 1953-56, Atascosa River, Nueces River Basin (181).

the suitability or unsuitability of the environment the fish species present, their relative abundance, condition, number of year classes, growth of the different year classes, and reproductive success must be shown to be an index of something tangible. In other words, the habitat preferences, natural food, water quality requirements, etc. for the various species of fish must be known. To begin to answer these questions a good sampling procedure must be used to get a representative picture of the fish population. A sampling design is needed that will adjust for gear selectivity and allow for maximal gear efficiency relative to the habits of the fishes. Such a design, then, will necessitate the use of chemicals or a combination of sampling methods based on the probable distribution of fishes by habitat. Unfortunately, fishery data taken by such a carefully planned sampling method are not available for analysis at present.

AQUATIC INVERTEBRATES

The aquatic invertebrates have received little attention in Texas. The limited information about aquatic invertebrates in published papers, theses, and state reports bears this out. The available information has been found after a diligent search of records. It is apparent that in the limited duration of this study a complete list of all records pertaining to aquatic invertebrates could not be compiled, since many scattered collection records of various groups exist in museums outside the state. Much of our knowledge of invertebrates in the study area comes from reviews (59, 60, 61, 62, 63, 64, 65, 66) of the work of early collectors who deposited their collections in museums.

The discussion of the aquatic invertebrates in each of the three river basins will follow a systematic approach with a brief discussion of each major taxon in each river basin. When the number of organisms discussed or the number of collectors is large, lists of members of each taxon will be given in tables along with a reference to collectors and a number code to locations where the group occurs. Maps of the river basins are utilized to show,by code numbers, the collection sites recorded in sufficient detail that they can be located on maps. Records that list localities only by county or stream will be noted in the tables.

Aquatic Invertebrates of the Guadalupe River Basin

Locations of invertebrate collection sites in the Guadalupe River Basin are given in Figure 150.

Porifera:

Records of sponges in the study area are rare. The ANSP (2) listed two species, *Trochospongilla horrida* from site 22 and *Trochospongilla leidyi* from site 4 (Fig. 150). Undetermined

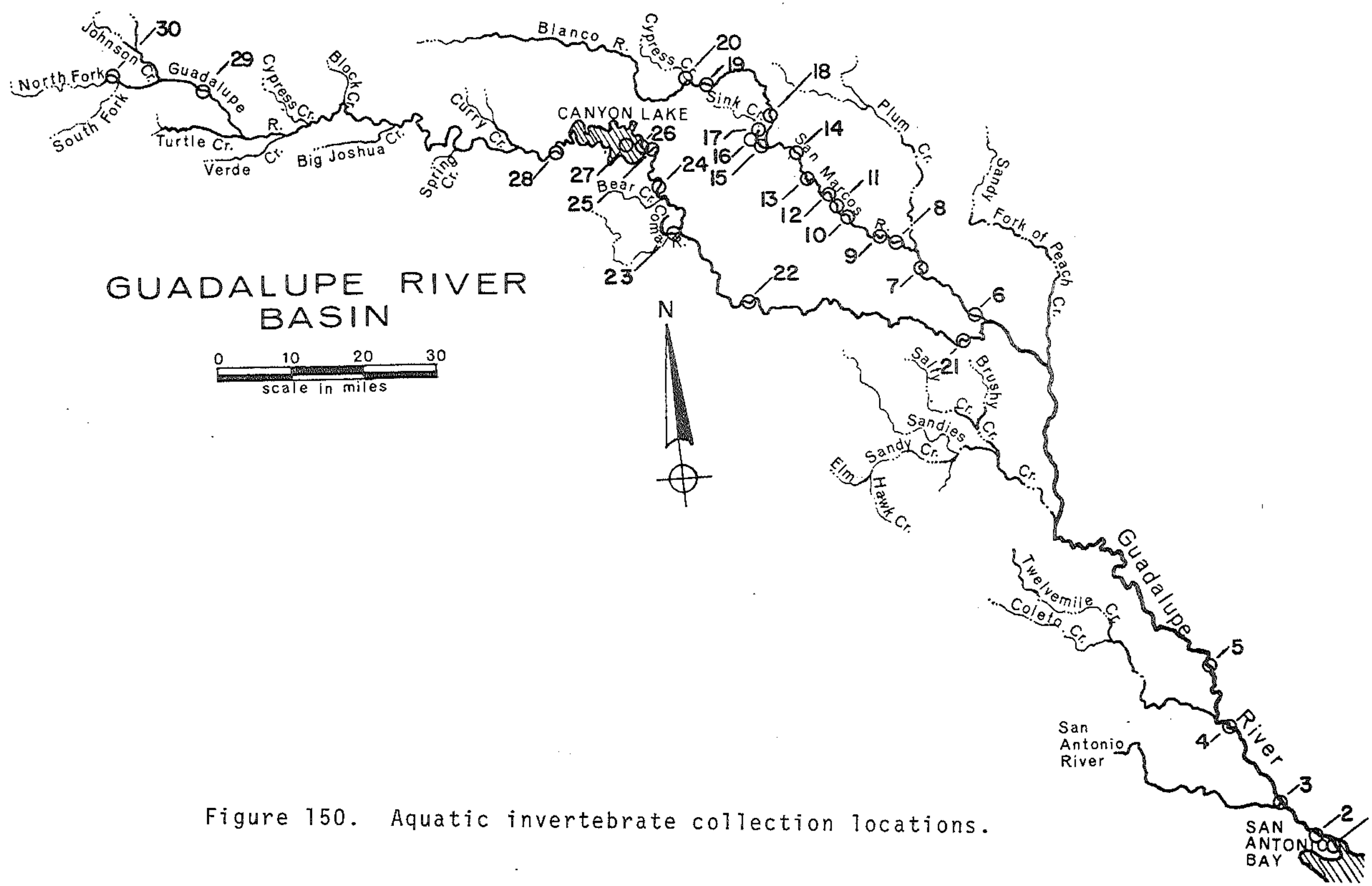


Figure 150. Aquatic invertebrate collection locations.

Table 10. Aquatic Protozoa in the Guadalupe River Basin

Taxonomic unit	Reference	Location
Mastigophora		
Chrysomonadina		
Chromulinidae		
Chromulina sp.	2	4
Cryptomonadina		
Cryptomonadidae		
Cryptomonas sp.	2	4
Cryptomonas erosa	1,2	4,22
Cryptomonas ovata var. curvata	2	4
Chilomonas paramecium	2	4
Nephroselmidae		
Nephroselmis olivacea	1	4
Phytomonadina		
Chlamydomonadidae		
Chlamydomonas globosa	2	4,22
C. gracilis	2	4,22
C. monadina	2	4
Sphaerillopsis fluviatilis	2	4
Scourfieldia complanta	2	4,22
Thorakomonas sabulosa	2	4
Carteriidae		
Carteria ellipsoidalis	1,2	4
C. cardiformis	1	4
Phacotidae		
Phacotus lenticularis	2	4,22
Pteroymonas angulosa	2	4
Volvocidae		
Gonium pectorale	2	4,22
G. sociale	2	4,22
Pandorina morum	2	4,22
Eudorina elegans	2	4,22
Euglenoidina		
Euglenidae		
Euglena deses	2	4,22
E. gracilis	2	22
E. haematodes	2	22
E. minima	2	4,22
E. mutabilis	2	4
E. oxyuris	2	4,22
E. pisciformis	1,2	4,22
E. viridis	1,2	4,22
E. sp.	1	4
Phacus pleuronectes	2	4,22
P. pyrium	2	22

Table 10. Continued

Taxonomic unit	Reference	Location
Lepocynclis lenticularis	2	4
Trachelomonas caudata	2	4
T. hispida	2	4,22
T. horrida	2	4
T. volgensis	2	4
T. volvocina	2	4,22
Cryptoglena pigra	2	4
Astasiidae		
Astasia klebsii	1,2	4,22
Petalomonas medicanellata	2	4,22
Scytomonas pusilla	2	22
Anisonemidae		
Anisoma acinus	2	4,22
A. emarginatum	2	4
Peranema trichophorum	1,2	4,22
Heteronema spirale	2	22
H. tremulum	2	22
Entosiphon sulcatum	2	4,22
Notosolenus apocamtus	2	4,22
Dinoflagellata		
Cystodiniidae		
Glenodinium neglectum	2	22
Rhyomastigina		
Mastigamoebidae		
Mastigamoeba auriculata	2	22
Protomonadina		
Monadidae		
Monas guttula	2	4,22
Anthophyse vegetans	2	22
Bodonidae		
Bodo amoebinus	2	4,22
B. caudatus	1,2	4,22
B. minimus	2	4
B. obovatus	2	4,22
B. saltans	2	4,22
B. cruzi	1	4
B. sp.	2	4
B. alexeieffi	1	22
B. sp. 1	1	22
B. sp. 2	1	22

Table 10. Continued

Taxonomic unit	Reference	Location
Sarcodina		
Amoebina		
Amoebidae		
Amoeba cochliopodium bilumbosum	129	17
A. guffula	129	17
A. limicola	1,2	4,22
A. proteus	1,2	22
A. radiosa	1,2,129	4,17,22
A. spumosa	2	4,22
A. villosa	1	4
A. verrucosa	1	22
A. sp.	36	16
Vahlkampfia limax	1,2	4,22
Acanthamoeba hyalina	2	4
Testacea		
Gromiidae		
Lecythium hyalinium	2	4
Difflugidae		
Difflugia lobostoma	2,36	16,22
D. acuminata	1	4,16
D. urceolata	36	16
D. globulus (?)	1	22
D. oblonga	2	22
D. sp.	15	17
Centropyxis aculeata	36	16
Arcellidae		
Arcella vulgaris	36	16
Heliozoa		
Actinophryidae		
Actinophrys sol	1,2	4,22
Actinosphaerium eichornii	2	4
Lithocollidae		
Lithocolla globusa	2	4
Acanthocystidae		
Acanthocystis aculeata	2	4
Clathrulinidae		
Clathrulina elegans	2	4

Table 10. Continued

Taxonomic unit	Reference	Location
Ciliata		
Holotricha		
Didiniidae		
Didinium balbianii	2	22
Mesodinium pulex	2	4
Colepidae		
Coleps hirtus	2	22
Holophryidae		
Holophrya simplex	2	4,22
Urotricha farcata	2	4,22
Prorodon discolor	2	4,22
Prorodon sp.	1	22
Pseudoprorodon farcatus	2	4,22
Lacrymaria oloe	2	22
L. sp.	2,15	22
Amphileptidae		
Amphileptus claparedi	2	4,22
Lionotus fasciola	2	4,22
L. trichocystis	1	22
L. sp.	1	4
Bryophyllum vorax	2	4
Trachelidae		
Trachelius ovum	2	4
Dileptus anser	2	4
Loxodidae		
Loxodes vorax	1,2	4,22
Actinobolinidae		
Dactylochlamys sp.	1	22
Nassulidae		
Nassula aurea	2	22
Nassula ornata	1	4
Trochilia palustris	2	22
Trochiloides recta	2	4,22
Chlamydodontidae		
Chilodonella caudata	2	4
C. cucullula	2,15	4,17
C. fluviatilis	2	4,22
C. uncinata	1	4
C. sp.	1	4
Paramacidae		
Paramecium putrenium	2	22
P. trichium	2	4,22
P. aurelia	1,2	4,22
P. sp.	15	17

Table 10. Continued

Taxonomic unit	Reference	Location
Frontoniidae		
Frontonia leucas	2	4,22
Tetrahymena pyriformis	2	22
Glaucoma scintillans	2	4,22
Saprophilus muscarum	2	22
Cinetochilum margaritaceum	2	4
Cyrtolophosis centralis	2	22
Urocentrum turbo	1,2	22
Pleuronematidae		
Pleuronema sp.	2	22
Cyclidium litomesum	2	4,22
Cristigeria phoenix	2	4
Spirotricha		
Bursariidae		
Bursaridium difficile	2	22
Spirostomidae		
Spirostomum ambiguum	2	4
S. teres	2	4,22
Halteriidae		
Halteria grandinella	2	4,22
Strombidium viride	2	4
Strobilidiidae		
Strobilidium gyrans	2	4,22
Myelstomidae		
Myelostoma bipartitum	2	4
Oxytrichidae		
Oxytricha fallax	2	4,22
O. setigera	2	4,22
O. ludibunda	1	22
Urosoma caudata	2	4,22
Kahlia acrobates	2	4
Uroleptus limnetis	2	4,22
U. longicaudatus	2	4
U. dispar	1	4
Stichotricha secunda	2	4
Holosticha vernalis	2	4
Stylonychia mytilis	2	4
S. putrina	2	22
Euplotidae		
Euplotes aediculatus	2	4
E. eurystomus	2	4,22
E. patella	2	22
Aspidiscidae		
Aspidisca costata	2	4,22

Table 10. Continued

Taxonomic unit	Reference	Location
Peritricha		
Vorticellidae		
Vorticella mayeri	2	4
V. microstoma	1,2	4,22
V. montilata	2	22
V. convallaria	1,2	4,22
V. picta	2	4
V. sp.	15	17
Vaginicolidae		
Cothurina annulata	2	4
C. flocularia	2	4
Urceolariidae		
Urceolaria sp.	2	4

species have also been recorded on several instances from sites 16 and 18 by Aquatic Biology classes of S.W.T.S.U. The occurrence of sponges usually denotes water low in silt, since silt clogs the filter system of sponges. Another paper which listed Texas sponges (34) did not include records for the study area, but it likely included the sponges that occur in this river basin.

Coelenterata:

Several members of this phylum have been reported in this river basin: *Chlorohydra* sp. by Beyers (15) at site 17; *Hydra* sp. by Kent (113) at sites 24 and 26; *Cordylophora lacustris* by ANSP (2) at site 22; and *Craspedacusta sowerbyi*, a fresh water medusa, by Aquatic Biology classes from S.W.T.S.U. at site 27 in Canyon Lake (Fig. 150).

Platyhelminthes:

The flatworm *Dugesia tigrina* has been noted by Kent (113) at locations 24, 25, and 28, and by ANSP (2) at location 22 (Fig. 150). It should be noted that no flatworms were collected by ANSP on the lower end of the Guadalupe. Kenk (111) published an excellent identification guide which listed several species from Texas but he did not specify river basins.

Rotifera:

Thirty-four species have been recorded from this river basin. Table 11 shows the species collected and the collection localities. Three sources of information; ANSP (1), Colbert (36), and Wilton (287) were used for compiling this list of species. Wilton (287) examined rotifers in preserved plankton samples taken over a three year period in Canyon Reservoir. The study was very limited, however, since sampling was restricted to monthly surface samples taken at two locations in the reservoir. Keratella sp. and Polyarthra sp. occurred in the greatest numbers and maximum total numbers of approximately 1,000 rotifers/liter occurred in the spring or early summer each year at the upper end of the reservoir.

Nematomorpha:

The only report of Nematomorpha was that of ANSP (2) which listed Gordius sp. at location 4 near Victoria (Fig. 150).

Endoprocta:

This group is represented by Urnatella gracilis collected by ANSP (2) just upriver from the Dupont disposal outfall, location 4 in Figure 150.

Table 11. Rotifers in the Guadalupe River Basin, Texas

Taxonomic unit	Reference	Location
Digonta		
Bdelloidea		
Philodinidae		
Philodina citrina	1	4,22
Monogononta		
Ploima		
Notommatidae		
Cephalodella auriculata	1	22
C. forficula	1	4,22
C. gibba	1	4
C. sp. 1	1	22
C. sp. 2	1	4
Notommata sp.	1	4
Synchaetidae		
Polyarthra vulgaris	36	16
P. sp.	1,287	22,26,27
Synchaeta sp.	1,287	4,26,27
Trichocercidae		
Trichocerca rattus	1	22
T. multicrinus	36	16
T. sp.	36,287	16,26,27
Euchlanidae		
Euchlanis parva	1	22
Tripeuchlanis plicata	1	22
Lecane luna	36	16
L. luna presumpta	1	22
L. stichaea	1	22
L. depressa	36	16
L. hastata	1	4
Monostyla cornuta	1	22
M. hamata	1	22
M. lunaris	1	22
M. pyriformis	1	22
M. quadridentata	36	16
M. bulla	36	16
Colurella sp.	1	4
Brachionidae		
Brachionus furculatus	36	16
B. sp.	1	4
Keratella cochlearis	36	16
K. quadrata	36	16
K. sp.	38,287	2,26,27
Trichotria sp.	36	16
Platyias patulus	36	16

Table 11. Continued

Taxonomic unit	Reference	Location
Gastropodidae		
Gastropus sp.	36	16
Ascomorpha sp.	287	26,27
Asplanchidae		
Asplanchna priodonta	36	16
A. sp.	287	26,27
Flosculariacea		
Testudinellidae		
Testudinella sp.	36	16
Sinantherina sp.	287	26,27
Filiniidae		
Filinia longiseta	36	16
Conochilidae		
Conochiloides sp.	287	26,27

Mollusca:

As a group, the mollusks have been collected more than any other invertebrate group in this river basin. Table 12 shows the forms reported from this basin and lists collection locations (Fig. 150). Useful references include Reid (144), Branson (23), and Burch (30), which, although they did not refer to records in the study area, listed forms which possibly occur there.

Annelida:

Few annelids have been collected in this river basin. ANSP (2) and Kent (113) are the two most complete studies reported Annelida in their collections of macroinvertebrates (Table 13). Leffingwell (120) utilized the leech, *Placobdella catenigera*, from the San Marcos River in a physiological study. Klemms' (115) leech identification manual also listed several leeches found in Texas with no specific locations so it is likely that some of the species occur in this river basin. Table 13 lists the annelids recorded for this river basin.

Hydracarina:

Young (291) listed 35 species of water mites from the Spring Lake at the headwaters of the San Marcos River (Table 14), location 17 in Figure 150.

Table 12. Aquatic Mollusca in the Guadalupe River Basin, Texas.

Taxonomic unit	Reference	Location
Gastropoda		
Basommatophora		
Physidae		
Physa virgata	33	Statewide
P. anatina	32	Kendall Co.
P. forsbeyi	32	Kendall Co.
P. integra	1	22
P. halei	2,51,154,161	4,15,17,23, Hays Co., Comal Co.
P. amygdalus	161	"Texas"
P. sp.	15,113	17,24,25
Lymnaeidae		
Lymnaea (=*Fossaria*) *humilis*	33,130	Statewide
L. bulimoides	32,33	Kendall Co., Statewide
L. desidosa	51,154	15,17
Pseudosuccinea columella	1,33,54	22,Statewide
P. columella chalybea	161	Victoria Co.
Galba (=*Fossaria*) *cubensis*	130,161	Garcitas Cr.
G. bulimoides techella	161	San Marcos R., New Braunfels
G. drussa	161	23
Planorbidae		
Gyraulus parvus	33	Statewide
G. sp.	113	24,25
Helisoma anceps (=*Planorbis bicarinatus*)	1,130,154	22, Guadalupe R., Comal Co., San Marcos R., Hays Co.
H. trivolvis lentum (=P. lentus)	2,33,161	22,Statewide
Promenetus exacuous	33	Statewide
Tropicorbis obstructus	33	Statewide
T. liebmanni	32	Kendall Co.
Planorbis parvas (=*Gyraulus*)	130,154	Guadalupe R., New Braunfels
P. antrosus	161	15
P. carus	161	Sinking Springs, Hays Co., Guadalupe R., Comal Co.
P. dilatatus	154,161	Guadalupe R., Comal Co., Victoria Co.

Table 12. Continued

Taxonomic unit	Reference	Location
P. liebmanni	51,154	23, Guadalupe R., Comal Co.
P. trivolvis	125,161	Blanco R., Hays Co.
Segmetina ammigira	154	Comal R.,New Braunfels
S. havanensis	154	"Collected by Roemer"
S. obstructa	154	"Abundant north to Austin"
Ancylidae		
Ferrissa excentrica (=*Ancylus*)	51,130,154,161	23
F. kirklandi	161	Guadalupe R., Victoria Co.
F. sp.	33	Central and south Texas
Mesogastropoda		
Vivaparidae		
Viviparus sp.	33	Central and south Texas
Campeloma sp.	33	Central and south Texas
Valvatidae =Bulimidae		
Valvata tricarinata	33	Central and south Texas
Amnicolidae		
Amnicola peracuta	51,154	Guadalupe R., Comal Co., 23
A. limosa	1	22
A. comalensis	161	23,Guadalupe R., New Braunfels
A. sp.	2,33,51	22,23,central and south Texas
Tryonia cheatumi	33	Central and south Texas
Littordina sp.	113	24,25
Potomopyragus spinosa	154,161	23
P. coronatus	2	22
Pyragula spinosa	51	23
Hydrobia texana	51,154	23
Cochliopa texana	33	Central and south Texas
Horatia micra	161	Guadalupe R., New Braunfels
H. micra nugax	161	Guadalupe R., New Braunfels

Table 12. Continued

Taxonomic unit	Reference	Location
Pleurocercidae		
Goniobasis comalensis	51,154	Type locality-23, Guadalupe R., New Braunfels,San Marcos R., Hays Co.
G. pleuristriata	51,154	23,Guadalupe R., Comal Co.
G. comalensis fontinalis	161	23
G. sp.	15	17
Ampullaridae (Not native)		
Ampullaria sp.	33	Central and south Texas
Thiaridae (Not native)		
Thiara sp.	33	Central and south Texas
Pelecypoda		
Eulamellibranchia		
Unionidae		
Unio multiplicans	125,154	Guadalupe R., Victoria Co.
U. pauciplicatus	154	Gonzales Co.
U. undulatus	125	Guadalupe R., Victoria Co.
U. anodontoides	125	Guadalupe R., Victoria Co.
U. tuberculatus	125,154	San Marcos R., Guadalupe R., Victoria Co.
U. berlandieri	125,154	23
U. berlandieri var.	125	Guadalupe R.
U. aureus	125	San Marcos R., Guadalupe R.
U. aureus var.	125	Guadalupe R.
U. reeveianus	154	23
U. rowelli	154	23
U. hydianus	125	(Lakes)Victoria Co.
U. manubius	125	(Lakes)Victoria Co.
U. mitchelli	125	(Lakes)Victoria Co.
U. perplicatus	125	(Lakes)Victoria Co.
U. rotundatus	125	(Lakes)Victoria Co.
U. rutersvillensis	125	(Lakes)Victoria Co.
U. speciosus	125	Coleto Cr., Victoria Co.
U. tampecoensis	125	(Lakes)Victoria Co.
U. texasensis	125	Lakes and Coleto Cr., Victoria Co.

Taxonomic unit	Reference	Location
Unidentified unionid	113	27,28
Amblema plicata perplicata	2	22
=*A. costata*	2	4,22
Quadrula quadrula apiculata	1,2	22
Q. aurea	1,2	4,22
Q. petrina	1	22
Q. quincunnina	1	22
Proptera purpurata	1,2	22
Lampsilis anodontoides	1,2	22
L. fasciata hydriana	1,2	22
L. tampecoensis	2	22
Carunculina parva texasensis	1,2	4,22
Anodonta imbicillus	2	22
A. leonensis	125,154	(Lakes)Victoria Co.
A. stewartiana	125	(Lakes)Victoria Co.
A. grandis	2	22
Tritigonia verrucosa	2	4,22
Sphaeridae		
Eupera singleyi	2	22
Sphaerium singleyi	51	23 in Guadalupe R.
Sphaerium sp.	1,2,51	22,23
Pisidium compressum	51,154	23
P. sp.	113	24,25

Table 13. Annelida from the Guadalupe River Basin, Texas.

Taxonomic unit	References	Location
Oligochaeta		
Opisthopora		
Lumbriculidae		
Lumbriculus sp.	113	24,25,28
Sutroa sp.	15	17
Plesiopora		
Tubificidae		
Branchiura sowerbyi	2,113	4,22,24,25, 26,27,28
Aeolosomatidae		
Aeolosoma sp.	113	27
Naididae		
undet. sp.	2	4
Hirudinea		
Glossiphonidae		
Helobdella sp.	113	44,28
Helobdella stagnalis	2	22
Placobdella catenigera	120	15

Table 14. The Hydracarina (water mites) of Spring Lake, San Marcos River (Young, 291).

Taxonomic unit
Arthropoda
Chelicerata
Arachnida
Hydracarina
Lebertiidae
Lebertia (4 sp.)
Oxidae
Oxus intermedius
O. gnaphiscoides
O. connatus
Limnesiidae
Limnesia undulata
L. paucispina
Pionidae
Forelia liliaceae
Piona exilis
Piona inconstans
Krendowskiidae
Krendowskia similis
Geayia ovata
Arrenuridae
Arrenurus bicaudatus
A. infundibularis
A. cardiacus
A. panguisomus
A. crennullatus
A. manubriator
A. bartonensis
A. reflexus
A. marshallae
A. intermedius
A. megalurus
A. falcicornis
A. fabellifer
A. sp.
Hygrobatidae
Atractides sp.
Hygrobates longipalpis
Unionicolidae
Koenikea marshallae
Neumania distincta
Neumania papillator
Neumania semicircularis

Table 14. Continued

Taxonomic unit
Mideopsidae
Mideopsis orbicularis
Axonopsidae
Axonopsis cullasaja
A. pallida
Torrenticolidae
Torrenticola sp.

Crustacea:

Table 15 shows the crustaceans that have been recorded from this river basin and Fig. 150 shows collection locations. All species are surface water forms. Cave forms will be mentioned later. *Macrobrachium* sp., the river shrimps, have been more widely investigated than any other crustaceans (58, 71, 78, 79). These large freshwater shrimps were used as food by early settlers (58) and attempts are now being made in some parts of the country to raise them commercially for food (39). In an early paper, Geiser (58) indicated that these shrimp occurred in rivers in east Texas and in spring-fed rivers associated with the Balcones Fault in central Texas. Evidence indicates these shrimp reproduce in estuaries and migrate upriver to live as adults. Research on the life cycles of *Macrobrachium acanthurus* is currently being carried out by the Biology Department of Southwest Texas State University (Horne, Pers. Comm.). If the river shrimp populations depend upon continual migration from estuaries to maintain the population, the addition of large dams will eliminate these shrimp from the upper part of this river basin. Since *M. carcinus* presently inhabits San Marcos Springs and the San Marcos River, they are apparently able to migrate around or over small dams, but large dams would likely be a barrier to their movement.

Farber (52) gave a list of the Crustacea in the San Marcos area and Becker (12) and Becker and Sissom (113) listed the

Table 15. Aquatic Crustacea of the Guadalupe River Basin, Texas

Taxonomic unit	Reference	Location
Branchiopoda		
Notostraca		
(No family names)		
Triops (=*Apus*) *aequalis*	52	(Pond)Hays Co.
Conchostraca		
Limnadiidae		
Leptestheria compleximanus	52	16
Cladocera		
Sididae		
Sida crystallina	12,38	16
Diaphanosoma brachyurum	12,38	1,2,3,Hays Co.
D. leutchtenbergianum	36,38	1,2,3,16
Latonopsis occidentalis	12	Hays Co.
Daphnidae		
Daphnia ambigua	12	Hays Co.
D. laevis	12	Hays Co.
D. parvala	12	Hays Co.
D. pulex	12	Hays Co.
D. schodleri	12	Hays Co.
D. longispina	52	17,14
D. middendorffiana	38	3
Simocephalus serrulatus	12,38,52	1,2,15,Hays Co.
Scapholoberis kingi	12	Hays Co.
Ceriodaphnia rigaudi	12	Hays Co.
C. reticulata	38	1,2
C. lacustris	12	Hays Co.
C. pulchella	12	Hays Co.
C. quadrangula	12,36	16,Hays Co.
Moinidae		
Moina micrura	12	Hays Co.
M. macrocopa	38	1,2
Bosminidae		
Bosmina longirostris	12,36	16,Hays Co.
B. coregoni	12	Hays Co.
Macrothricidae		
Ilyocryptus spinifer	12	Hays Co.
I. sordidus	12	Hays Co.
Macrothrix laticornis	12,38	1,2,3,Hays Co.
M. rosea	12,38	2,3,Hays Co.

Table 15. Continued

Taxonomic unit	Reference	Location
Chydoridae		
Camptocercus rectirostris	12	Hays Co.
Acroperus harpae	12,52	12,14,Hays Co.
Kurzia latissima	12	Hays Co.
Leydigia quadrangularis	12,38	1,2,3,Hays Co.
L. acanthocercoides	38	1,2,3
Alona karau	12,36	16,Hays Co.
A. costata	12	Hays Co.
A. rectangula	12	Hays Co.
Pleuroxus denticulatus	12,36	16,Hays Co.
P. hamulatus	12,36	16,Hays Co.
Dunhevedia crassa	12	Hays Co.
D. serrata	12	Hays Co.
Chydorus barroisi	52	17
C. globosus	52	17
C. sphaericus	12,36	16,Hays Co.
Graptoleberis testudinaria	52	15
Ostracoda		
Podocopa		
Cypridae		
Cypridopsis vidua	52	Hays Co.
Candona acuminata	52	14,17
Eucaryis fuscatus	52	17
Typhlocypris peirci	52	14
Copepoda		
Calanoida		
Diaptomidae		
Diaptomus pallidus	36	16
D. dorsalis	38	1,2,3
Temoridae		
Eurytemora affinis	38	1
Cyclopoda		
Cyclopoidae		
Cyclops varicans rubellus	36	16
C. vernalis	36,38	1,2,3,16
C. scutifer	38	1,2,3
C. bicuspidatus	38,52	2,3,14,17
Tropocyclops prasinus	38	1
T. prasinus mexicanus	36	16
Halicyclops magniceps	38	1
Mesocyclops edax	36	16

Table 15. Continued

Taxonomic unit	Reference	Location
Eucyclops serrulatus	52	17
E. agilis	36	16
Macrocyclops albidus	52	17
Harpacticoda		
Canthocamptidae		
Bryocamptus hiemalis	38	1,2,3
Branchiura		
Arguloida		
Argulus japonicus	38	1,2,3
Lernacopodidae		
Salminicola sp.	52	San Marcos
Malacostraca		
Decapoda		
Palaemodiidae		
Macrobrachium carcinus (=*jamaicense*)	58,79,150, 52, SWTSU Coll.	1,14,23 15
M. ohione	38, SWTSU Coll.	1,2,3
M. offersii	SWTSU Coll.	1
M. acanthurus	SWTSU Coll.	1
Palaemonetes exilipes	52	17
P. pugio	38	1,2,3
P. vulgaris	2	4
P. sp.	4	22
Paenieidae		
Paeneus sp.	1	22
Astacidae		
Cambarus bartonii	52	15
C. diogenes	52	15
Orconectes palmeri longimanus	141	Guadalupe R.
O. palmeri	113	24,28
Procambarus clarkii	2,141	22,Guadalupe R.
Portunidae		
Calinectes sapidus acutidens	1,2	4
Potamobiidae		
unid. sp.	1	22
Amphipoda		
Gammaridae		
unid. sp.	52	15
Talitridae		
Hyallela azteca	38,113	2,25,27

Table 15. Continued

Taxonomic unit	Reference	Location
Mysidacea		
Neomysis mercedis	38	2,3
Mysidopsis almyra	38	2

Cladocera found in Hays County. Two publications (80, 141) on the distribution of crayfish of Texas listed four species in this river basin. Cooper (38) listed 36 crustacean taxa collected from eight sampling stations in the lower end of the Guadalupe River. Colbert (36) listed thirteen taxa of crustaceans in hatchery ponds at the Aquatic Station, Southwest Texas State University which continually drain into the San Marcos River.

Insecta:

A review of the literature pertaining to aquatic orders of insects in Texas shows that little taxonomic work has been done statewide and virtually none has been done in the Guadalupe River Basin. Most knowledge of this group has been derived from surveys of macroinvertebrate populations or species diversity studies.

The most notable work done to date is a series of reports to E. I. du Pont de Nemours and Company prepared by the Academy of Natural Sciences of Philadelphia (1, 2, 4). These reports covered a period of 17 years beginning in 1949 with a report on the conditions at four sites on the river. These four sites were sampled again in 1962 and in 1966.

Kent (113) studied the effects of Canyon Reservoir on the species diversity of the benthic macroinvertebrate community of five stations located above, in, and below the reservoir. He concluded that the reservoir caused a considerable reduction in species diversity of the benthic macroinvertebrates immediately downstream from the dam, apparently because of reduced water temperatures and high concentrations of hydrogen sulfide during the summer. However, the effect dissipated quickly downstream, so that the species diversity 14.7 miles below the dam was as high as that of a similar community upstream from the reservoir, though it had a different species composition.

A Texas Parks and Wildlife Department study of Canyon Dam tailwater bottom samples from May 1967 to February 1968 indicated that Ephemeroptera (mayflies) were the most abundant forms, with Diptera (flies) and snails also being very abundant (253). The greatest volume of fish food species of invertebrates occurred in May and August while the smallest volume occurred in January and February. This was expected since photosynthetic productivity of the river decreased during the winter. The study was done to determine the availability of food for the newly established trout fishery in the Guadalupe River immediately below Canyon Dam.

A small species diversity study was carried out on two stations in the Blanco River in the summer of 1972 by Whiteside (S.W.T.S.U., unpublished). At the upper station, located approximately 0.5 miles above the outfall to the old San Marcos sewage treatment plant, the average $\bar{d}$ for May, June, and July was 2.8. At the lower station, located approximately 0.5 miles below the old sewage treatment plant outfall, the average $\bar{d}$ value was 2.1.

In addition to these survey studies, records of the aquatic insects of the Guadalupe River Basin are scattered through various taxonomic and physiological papers. In only a few instances are these comprehensive or complete. Table 16 gives all species of aquatic insects for which records were found. Location sites given are shown in Figure 150.

Ephemeroptera:

The mayflies have not been collected extensively in this basin. The most significant work has been done by the ANSP (1, 2, 4).

Odonata:

The dragonflies and damselflies have been studied more intensely in Texas than other orders with aquatic stages. Ferguson (53) included a good bibliography listing the older works done on odonates in Texas.

Plecoptera:

The stoneflies are a minor group in this river basin since they are primarily found in colder waters. The stoneflies as a group are intolerant of pollution and their presence should indicate favorable conditions in the few habitats in which they occur in this river basin.

Table 16. Aquatic Insecta in the Guadalupe River Basin, Texas

Taxonomic unit	Reference	Location
Ephemeroptera		
Ephemeridae		
Hexagenia bilineata	1	4,22
H. limbata	2	4
H. spp.	38,113	1,2,3,24,27
Pentagenia vittegara	1,2	4,22
Brachycercus sp. n.	113	28
Caenis spp.	1,2,113	4,22,24,27,28
Heptageniidae		
Stenonema tripunctatum	127	15,20
S. spp.	1,2,113	4,24,28
Baetidae		
Centroptilum album	127	15
C. (?) sp.	1	4
Baetis flavistriga	2	4
B. intercalaris	2	4
B. spp.	1,2,113	4,27,28
Callibaetis sp.	2	22
Pseudocloen sp.	113	24,25
Campsurus sp.	2	22
Leptophlebiidae		
Traverella presidiana (?)	1	4
T. sp.	113,127	15,24,28
Thraulodes spp.	113,127	15,24,28
Siphlonuridae		
Isonychia aurea	127	15,20
I. sp.	113	24,28
Tricorythidae		
Tricorythodes spp.	1,2,113,127	4,15,22,24,25, 28, Comal Co.
Leptohyphes spp.	2,113	4,28
Polymitarcidae		
Tortopus sp.	1	22
Odonata		
Zygoptera		
Calopterygidae		
Calopteryx sp.	1	4
Hetaerina sp.	1,113	22,24
H. titia	1	4
H. americana	53,286	Black's Bayou

Table 16. Continued

Taxonomic unit	Reference	Location
Agrionidae		
Argia apicalis	2,286	4,22,Black's Bayou
A. moesta	1,2	4,22
A. sedula	1,2,286	22
A. translata	1,2	22
A. vivida plana	1	4
A. tibialis	286	Black's Bayou
A. apicalis	286	Black's Bayou
Argia near *sedula*	1	4
A. sp.	1,113	4,22,25,28
Nehalennia sp.	113	24
Neoneura aaroni	1	22
Enallagma basidens	2	4,22
E. signatum	2	4,22
E. verperum	2	22
Ischnura ramburi	1	4
Anisoptera		
Gomphidae		
Progomphus obscurus	1,2,112	4,Coleto Cr.
Erpetogomphus sp.	113	24,28
E. designatus	2	4
Gomphus (=*Gomphurus*) sp.	2	4
G. (*stylurus*) *laurae*	2	4
G. externus	1	4,22
G. olivaceous	1	4,22
G. notatus	1	4,22
G. militaris (?)	1	22
G. exilis	1	22
G. (=*Arigomphus*) *supapicalis* or *submedianus*	112	Coleto Cr.
G. (=*Stylurus*) *plagiatus*	112	Coleto Cr.
G. sp.	2	22
Gomphoides sp.	2	22
Dromogomphus spoliatus	112	Coleto Cr.
Aeshnidae		
Anax junius	1	4
Macromiidae		
Macromia sp.	1	4,22
Didymops transversa	1	22
Lestidae		
Lestes alacer	53	Black's Bayou
L. sigma	53	Black's Bayou

Table 16. Continued

Taxonomic unit	Reference	Location
Libellulidae		
Epicordulia princeps	1,2	4,22
Neurocordulia molesta	2	4
Tetragoneuria sp.	1	4
Dythemis velox or *nigrescens*	1,2	22
Erythrodiplax sp.	113	24
Leucorrhinia sp.	113	24
Orthemis ferruginea	1	4
Paltothemis sp.	113	28
Plecoptera		
Unid. sp.	38	2,3
Perlidae		
Neoperla clymene	1,2	4
N. sp.	113	28
Perlesta sp.	113	25
Hemiptera		
Hydrometridae		
Hydrometra martini	124	Hays, Kerr, and Comal Cos.
Veliidae		
Limnogonus hesione	124	Hays Co. (San Marcos), Comal Co.
Gerris remigis	124	Hays, Kerr, and Comal Co.
Metrobates artus	2	4,22
M. hesperus	124	Hays Co. (San Marcos), Comal Co. (New Braunfels)
Trepobates inermis	1,2	22
Rhagovelia choreutes	1,2	4,22
R. armata	124	Kerr Co.
Velia brachialis	124	Hays, Kerr, and Comal Cos.
Gelastocoridae		
Gelastocoris oculatus	2	4
G. cucullatus	124	Hays, Kerr, Comal, and Kendall Cos.
G. rotundatus	124	Kerr Co.

Table 16. Continued

Taxonomic unit	Reference	Location
Nepidae		
Ranatra prob. *australis*	1,2	4,22
Belostoma fluminea	2	4
B. bakeri	1	4
Curicta howardi	124	
Naucoridae		
Cryphocricos sp.	113	28
Ambrysus near *variegatus*	124	Hays, Kerr, and Comal Cos.
A. hungerfordi	124	Kendall and Comal Cos.
Pelocoris sp.	124	Hays Co. (San Marcos)
P. femoratus	2	4
Notonectidae		
Notonecta undulata	124	Kerr Co.
Trichocorixa prob. *calva*	1	4
T. kansa	2	4
Morphocorixa compacta	124	Kerr Co.
Neuroptera		
Megaloptera = Sialodea		
Corydalidae (Dobsonflies)		
Corydalus sp.	2,113	4,25,28
Planipennia (Spongilla-flies)		
Sisyridae		
Climacia chapini	137	Seguin
Coleoptera		
Adephaga		
Gyrinidae		
Gyrinus poss. *parcus*	1	22
Gyretes sinuatus	1,2	4
unid. sp.		
Dineutus assimilis	1,38	3,4
D. hernii	1	4
D. emarginatus	2	4
D. augustus	2	4
D. analis	2	4
D. carolinus	2	4

Table 16. Continued

Taxonomic unit	Reference	Location
Haliplidae		
Peltodytes (*Chemidotus*) *muticus*	1	22
P. festivus	2	4,22
P. tortulosus	2	4
P. sp.	2	4
Noteridae		
Hydrocanthus iricolor	2	4
Dyticidae		
Bidessus fuscatus	2	4
Laccophilus proximus	2	4
Coptotomus obscurus	2	4
Polyphaga		
Hydrophilidae		
Hydrochus subcupreus	2	4
Tropisternus lateralis	1,2	4,22
T. glaber	2	4
T. striolatus	2	4
Berosus peregrinus	2	4
B. sp.	2	4
Hydrobius tersellatus	2	4
Elmidae		
Helichus (*Dryops*) *fastigiatus*	1	4
H. lithophilus	2	4
H. sp.	113	24,28
Dryops sp.	113	24,25
Lara sp.	113	24
Ordobrevia sp.	11	28
Stenelmis sp.	1,2	4,22
S. crenata	1	4
S. beameri	1	4
S. sp.	113	24,25,28
Heterelmis vulnerata ?	31	Balconian,and Texas Biotic province
Microcylloepus pusillus?	31	Balconian biotic province
Hexacylloepus ferrugineus	31	Balconian biotic province
H. sp.	113	28
Rhizelmis sp.	113	28
Dubiraphia sp.	31,113	24,29
Promoresia sp.	38	1,2,3

Table 16. Continued

Taxonomic unit	Reference	Location
Limnichidae		
Lutrochus sp.	113	24,28
Hetercercidae		
Heterocercus tristis	2	4
Trichoptera		
Psychomyiidae		
unid. sp.	1,2,113	4,22,27
Neureclipsis crepuscularis	1,49	4,7,8,13,17,22
Polycentropus cinereus	49,70	15,17
Cyrnellus marginalis	40	7
Lype sp.	113	28
Cernotina calcea	49	9
Hydropsychidae		
Hydropsyche orris	2,49	4,7
H. sp.	1,113	4,24
Cheumatopsyche analis	49	17
C. (=*Sordida*) *comis*	6,49,70	15,17,20
C. lasia	49	8,9,17
C. sp.	113	28
Smicridea fasciatella	49	7,12,13,15,17
Rhyacophilidae		
Atopsyche erigia	49	15,17
Glossosomatidae		
Protoptila (=*Glossosoma*) *arca*	49,70	15
P. parce	49	10,13
P. maculata	49	15,17
P. alexanderi	49	7,17
Hydroptilidae		
Leucotrichia sarita	49	9,15,17
Ochotrichia tarsialis	49	9,10,11,12,13,15,17
O. americana	49	7
Hydroptila consimilis	49	9,13,15,17
H. sp.	113	24,27,28
Metrichia nigritta	49	15
Oxyethira florida	49	10,15,17
O. sp.	2	22
Mayatrichia ayana	49	13

Table 16. Continued

Taxonomic unit	Reference	Location
Limnephilidae		
Neophylax sp.	113	25
Helicopsychidae		
Helicopsyche piroa	49	7,8
H. borealis	70	23
H. sp.	113	24,25
Leptoceridae		
unid. sp.	1	22
unid. case	2	4
Leptocella diarina	49	7
L. exquisita	49	9,13
L. pavida	49	7
L. sp.	2	4
Triaenodes injusta	49	15
Athripsodes flavus	49	7
A. transversus	49	7
Oecetis avara	49	7,11,12,13,17
O. cinerascens	49	7,15,17
O. inconspicua	49	7,8,15
O. sp.	113	24
Philopotamidae		
Chimarra betteni	6,49	15,17
C. obscura	49,113	7,11,17,28
C. aterrima	49	7,17
Beraeidae		
Beraea sp.	113	27
Calamoceratidae		
Notiomyia ornata	6,49	19
Xiphocentridae		
Xiphocentron mexico	49	19
Lepidoptera		
Heterocerca		
Pyralidae		
Cataclysta (=*Elophila*) sp.	113	25
Nymphula sp.	1	22
Diptera		
Nematocera		
Tipulidae		
Tipula sp.	113	25
Culicidae		
Chaoborus sp.	38,113	3,25,26,27

Table 16. Continued

Taxonomic unit	Reference	Location
Aedes sollicitans	42	5
A. gonimus	42	29
A. mitchellae	42	5
A. taeniorhynchus	42	5
A. zoosophus	42	29
A. triseriatus	42	5
Culex erraticus	42	5
C. stigmatosoma	42	29
Orthopodomyia signifera	42	29
Heleidae		
Palpomyia sp.	2	4
Unid. sp.	38,113	27
Tendipedidae (Chironomidae)		
unid. Tendipedinae sp.	1,113	4,22,24,25,27,28
unid. Pelopiinae sp.	113	27
Procladius adumbratus	2	22
Pelopia sp.	2	4
Pentaneura monilis	2	4
P. sp.	113	26,27,28
Clinotanypus sp.	2	22
Coelotanypus sp.	113	27
Dasyhelia sp.	113	24
Calopsectra querla	2	4,22
C. dissimilis	2	4,22
Tanytarsus (E) *nigracans*	2	4
Tendipes (L) poss. *modestus*	2	4,22
T. (L) *fumidus*	2	22
T. (T) *attenuatus*	2	22
Chironomus tentans	38	1,2,3
C. sp.	113	26,27
Hydrobaenus dorenus	2	4
Cryptochironomus argus	2	4
Xenochironomus xenolabis	2	4
Polypedilum illinoense (?)	2	22
P. illinoense var.	2	4
P. poss. *scalaenum*	2	4
Simuliidae		
Simulium solarii	288	Hays Co.
Simulium sp.	113	24,25,28
Cyclorrhapha		
Tabanidae		
Tabanus sp.	113	25,28
Dolichopodidae		
unid. sp.	113	25

Hemiptera:

Many families of aquatic and semiaquatic Hemiptera are found in the Guadalupe River Basin. Four papers were used as the basis for the list of Hemiptera from this river basin. The most useful reference is Millspaugh (124), who presented a complete bibliography of work done in Texas prior to 1939.

Neuroptera:

This order is represented by at least three species in this river basin. The stoneroller, *Corydalus* sp., is common in the San Marcos and Blanco rivers (personal observation). The spongilla-fly, *Climacia* sp., has been noted in the Blanco River near San Marcos (Aquatic Station collection, S.W.T.S.U.). This form is rarely observed since it is usually found with certain species of freshwater sponge. Paratypes of *Climacia chapini* have been recorded from Seguin and Victoria on the Guadalupe River (137). *Sisyra vicaria* has only been recorded in association with the freshwater sponge *Spongilla fragilis*.

Coleoptera:

Coleoptera are well represented in the river basin. Though they are poorly known, 43 species have been recorded.

Trichoptera:

Fifty-one species of caddisflies have been reported from this river basin. The most extensive study of this order was done by Edwards (49) on the San Marcos River. In his study he noted several rare species and described three new species: *Protoptila arca*, *Protoptila parce*, and *Cheumatopsyche comis*. The first is found only in the headwaters of the San Marcos River, the other two are found in the lower San Marcos River. A laboratory study of oxygen consumption by caddisfly larvae (133) determined metabolic rates for three species of San Marcos caddisflies. Edwards (48) described a rare species, *Xiphocentron mexico*, previously unknown from the United States, from Fern Bank Spring on the Blanco River (location 19, Fig. 150).

Lepidoptera:

Two studies (1, 113) listed aquatic moths of the family Pyralidae in this river basin. The two forms found are *Cataclysta* (=*Elophila*) sp. and *Nymphula* sp.

Diptera:

The Diptera are represented by many diverse families. Many of these have highly specialized breathing structures which allow them to live in waters with little or no dissolved oxygen. This factor allows them to occur in great numbers where organic (non-toxic) wastes are concentrated. Several publications (24, 25, 157) that referred to dipterans in Texas but did not give exact locations should be considered in studies of that group.

In summary, the aquatic invertebrate fauna of the Guadalupe River Basin has probably been investigated both ecologically and taxonomically as thoroughly as that of any basin in the state; still our knowledge of the invertebrate fauna is extremely limited. Before a river basin model can be set up for this or any other basin, it will be necessary to have more detailed information about the aquatic fauna present. The Texas Water Quality Board has recently started a macroinvertebrate sampling program (Pers. comm. Dick Respess, T.W.Q.B., Austin) for use in determining the species diversity of various points on major streams in the state. They will encounter tremendous difficulty in the identification of a poorly described aquatic fauna. What is most needed at present is a thorough survey of the aquatic macroinvertebrates in this river basin. Unidentified and undescribed taxa should be sent to qualified taxonomists with interests in each particular group for identification. Sites that are representative of the different ecosystems in the streams should be selected for investigation through the use of species diversity indices of macroinvertebrates in order to establish clearly the current condition of the river in those areas. Species diversity indices would be extremely useful in determining the quality of the environment of a river where many complicating factors can lead to incorrect assumptions when studied by investigations of the physicochemical factors alone. A biological community is a continuum and any alterations in the environment, even subtle changes that are difficult to discern, will result in changes in the biota. Examples of short term changes that might be detected by studies of macroinvertebrate communities but not by routine chemical analysis include: periodic releases of organic matter, the occurrence of toxic wastes such as heavy metals or pesticides, or occasional releases of salt from brine holding tanks in oil fields.

The cave invertebrates were not discussed or listed in the previous discussion though many of them are aquatic. Reddel (145, 146) listed several endemic forms that occur in caves throughout this river basin. The most notable forms occur in Ezell's Cave located in the underground Purgatory Creek system in San Marcos (121, 145).

Aquatic Invertebrates of the San Antonio River Basin

Very little work has been done on the aquatic invertebrates, other than cave forms, in the San Antonio River Basin. Locations of invertebrate collection sites in this basin are given in Figure 151.

Mollusca:

Several publications (32, 51, 160, 161) listed mollusks that occur in this river basin. In addition, Murray and Roy (130) gave a checklist that included 88 clams and 96 freshwater snails from Texas, but they did not give distribution information and the report contained some apparent inaccuracies as to which snails are aquatic and which are terrestrial. The most valuable contribution of the paper was a good bibliography of the Mollusca

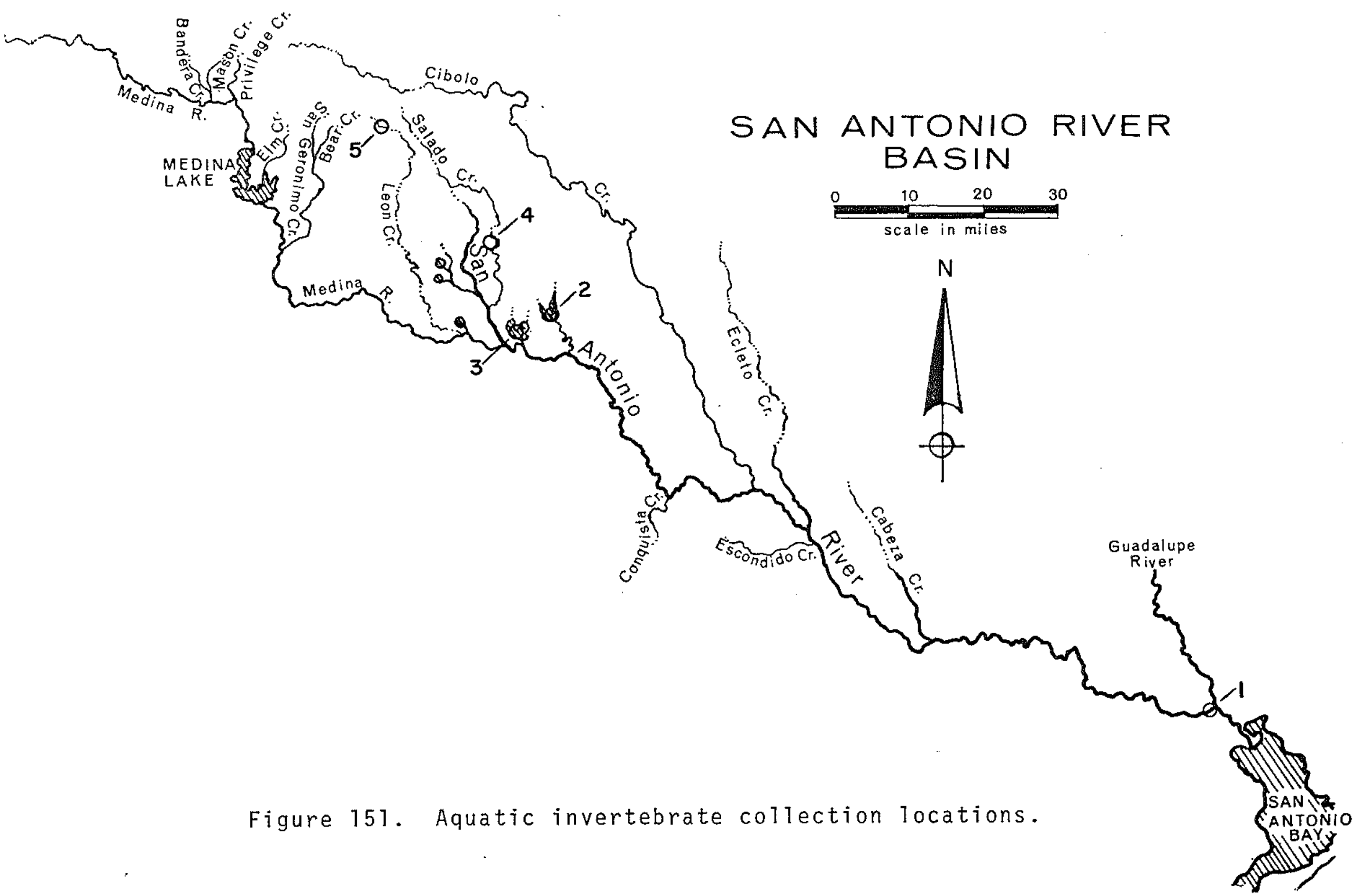


Figure 151. Aquatic invertebrate collection locations.

literature of Texas. A list of Mollusca recorded from this basin is given in Table 17.

Annelida:

Giesler (67) reported oligochaete worms in bottom samples from Braunig and Calaveras lakes, but he did not identify them further.

Crustacea:

Publications on the Crustacea gave only fragmentary reports of the forms found in the San Antonio River Basin (38, 58, 79, 141) and these are summarized in Table 18. Of interest are reports (58, 79) that Macrobrachium spp. were once found in San Pedro Springs in San Antonio. Since they have not been reported in recent years, they have apparently been eliminated from the headwaters of the San Antonio River by some environmental condition.

Insecta:

Very little is known of the aquatic insects of this basin. The San Antonio River Authority (SARA) plans to begin taking stream bottom macroinvertebrate samples at their collecting stations in the fall of 1972 (Ken Cave, SARA, personal communication). The lack of records of insects in this basin

Table 17. Aquatic mollusca reported from the San Antonio River Basin, Texas

Taxonomic unit	Reference	Location
Gastropoda		
Basommatophora		
Physidae		
Physa virgata	33	Statewide
P. humerosa	32	Bexar Co.
P. halei	51,154,161	Bexar Co.
P. amygdalus	161	Type Locality- "Texas"
Lymnaeidae		
Lymnaea (=*Fossaria*) *humilis*	33,130	Statewide
L. bulimoides techella	33	Statewide
L. desidosa	51,154	Leon Cr., Bexar Co.
Pseudosuccinea columella	33,154	Statewide
Galba bulimoides techella	161	San Antonio R., Bexar Co.
G. drussa	161	Leon Cr.,Bexar Co.
Planorbidae		
Gyraulus parvus	33	Statewide
Helisoma trivolvis lentum	33	Statewide
H. tenue	32	Bexar Co.
Promenetus exacuous	33	Statewide
Tropicorbis obstructus	33	Statewide
T. liebmanni	32	Bexar Co.
Planorbis bicarinatus (=*Helisoma anceps*)	130,154	San Antonio R., Bexar Co.
P. antrosus	161	San Antonio R., Bexar Co.
P. lentus	161	"Common in all streams"
P. liebmanni	51,154	Leon Cr.,Bexar Co.
P. trivolvis	125,161	(Creek), San Antonio Bexar Co.
Segmetina ammigira	154	Leon Cr.,Bexar Co.
S. havanensis	154	(Collected by Roemer)
S. obstructa	154	"Abundant north to Austin"
Ancylidae		
Ferrissa sp.	33	Central and south Texas

Table 17. Continued

Taxonomic unit	Reference	Location
Mesogastropoda		
Vivaparidae		
Viviparus sp.	33	Central and south Texas
Campeloma sp.	33	Central and south Texas
Valvatidae = Bulimidae		
Valvata tricarinata	33	Central and south Texas
Amnicolidae		
Amnicola sp.	33,51	Central and south Texas
Cochliopa texana	33	Central and south Texas
Pleurocercidae		
Goniobasis comalensis	51,154	Helotes Cr., Bexar Co.
Ampullaridae (Not native)		
Ampullaria sp.	33	Central and south Texas
Thiaridae (imported)		
Thiara sp.	33	Central and south Texas
Pelecypoda		
Eulamellibranchia		
Unionidae		
Unio laticostatus	154	San Antonio R., Goliad Co.,Medina R Bexar Co.
U. aureau	125,154	San Antonio R.
U. hurmanii	154	Medina R.
U. luteolus	154	San Antonio R.
U. undulatus	154	Guadalupe R., Comal Co.
U. pauciplicatus	154	Guadalupe R., Gonzales Co.
U. multiplicatus	154	Guadalupe R.

Table 18. Aquatic Crustacea reported from the San Antonio River Basin, Texas

Taxonomic unit	Reference	Location
Malacostraca		
Decapoda		
Astacidae		
Procambarus clarkii	141	Bexar Co.
Paeneidae		
Macrobrachium carcinus	58,79	San Antonio

will certainly hamper this effort, but this type of sampling must be done before a complete evaluation of the ecosystem in the river is possible.

The aquatic insects that have been reported from the San Antonio River Basin are presented in Table 19 along with collectors and collection sites. Locations of collecting sites are given in Figure 151.

Ephemeroptera:

The only specific reference to collections of Ephemoroptera in this river basin was by Moore (127) who listed seven species collected in Bexar County.

Odonata:

Ferguson (54) listed four species of Odonata from Bexar County. A report by the Texas Parks and Wildlife Department (168) indicated that odonates are a common food item of large-mouth bass and channel catfish in Medina Lake. Since odonates are usually larger than most aquatic insects, they would be expected to be a significant part of the food of insectivorous fish.

Neuroptera:

The spongilla-fly, *Sisyra vicaria* was noted by Parfin and Gurney (137) as occurring in San Antonio.

Table 19. Aquatic Insecta reported from the San Antonio River Basin, Texas

Taxonomic unit	Reference	Location
Ephemeroptera		
Ephemeridae		
Caenis sp.	127	Bexar Co.
Heptageniidae		
Stenonema majus	127	Bexar Co.
S. frontale	127	Bexar Co.
Baetidae		
Baetis vigans	127	Bexar Co.
_B._ sp.	127	Bexar Co.
Leptophlebiidae		
Thraulodes sp.	127	Bexar Co.
Tricorythidae		
Tricorythodes sp.	127	Bexar Co.
Odonata		
Calopterygidae		
Hetaerina americana	54	Bexar Co.
Agrionidae		
Argia sedula	54	Bexar Co.
Libellulidae		
Libellula luctosa	54	Bexar Co.
Erythemis (=Mesothemis) simplicicollis	54	Bexar Co.
Neuroptera		
Planipennia		
Sisyridae		
Sisyra vicaria	137	San Antonio
Climacia chapini	137	Boerne
Coleoptera		
Polyphaga		
Elmidae		
Heterelmis (_vulnerata_ ?)	31	Balconian, Texan Biotic province
H. obscura	31	San Antonio
Microcylloepus (_pusillus_ ?)	31	Balconian Biotic Province
Hexacylloepus ferrugineus	31	Balconian Biotic Province
Dubiraphia sp.	31	Medina R., Bandera Co.

Table 19. Continued

Taxonomic unit	Reference	Location
Trichoptera		
Psychomyiidae		
Polypectropus charlesi or *santiago*	55	(Stream) near Bandera (Possibly Medina R.)
Glossosomatidae		
Protoptila alexanderi	149	San Antonio R., San Antonio
Diptera		
Nematocera		
Culicidae		
Psorophora signipennis	42	San Antonio
Aedes trivittatus	42	5
A. aegypti	42	San Antonio
A. inhabitor	42	San Antonio
Simuliidae		
Simulium virgatum	288	Helotes Cr.

Coleoptera:

The only known records of Coleoptera taken in this basin are five species of riffle beetles reported by Burke (31).

Trichoptera:

Two species of Trichoptera have been described from localities in the San Antonio River Basin: Protoptila alexanderi by Ross (149) from the San Antonio River, and a new form, "Genus C", by Flint (55) from a stream near Bandera. Flint (personal communication) now considers this new form to be either Polyplectropus charlesi or P. santiago.

Diptera:

Cushing (42) reported four species of mosquitos from this basin. Wiseman and Eads (288) made extensive collections of blackflies (Simuliidae) in central and south Texas, however the only record in the San Antonio River Basin was of Simulium virgatum in Helotes Creek in Bexar County. Blackflies can cause considerable annoyance to humans by swarming and their bites are painful, causing pronounced welts in a short time.

Callahan and Fishburn (278) have the only in-depth report on benthic invertebrates in this basin. Their report was a study to determine the effect of waste effluent from Randolph Air Force Base on Cibolo Creek. They had two upstream and four downstream stations where they sampled numerous physicochemical parameters, along with biological data. They collected macro-invertebrates at six stations with Ponar dredges and identified major taxa. Chironomids were the most numerous taxon above the outfall but their numbers decreased downstream. Other groups noted above the outfall were oligochaetes, roundworms, crustaceans, gastropods, coleopterans, and dipterans. The first station below the outfall showed only four groups; chironomids, oligochaetes, one roundworm, and one snail. Zooplankton, also sampled at the six stations, occurred in higher numbers above the outfall. This report presented only raw data with no discussion of materials and methods, so the information is of limited value.

Aquatic Invertebrates of the Nueces River Basin

Members of only a few phyla of aquatic invertebrates have been recorded from the Nueces River Basin and the few collected are very poorly known. Locations of invertebrate collection sites in the Nueces River Basin are given in Figure 152.

Mollusca:

More records (32, 33, 51, 161) occur for the mollusks than any other invertebrate group in the Nueces River Basin. A list of Mollusca occurring in this basin is given in Table 20. A

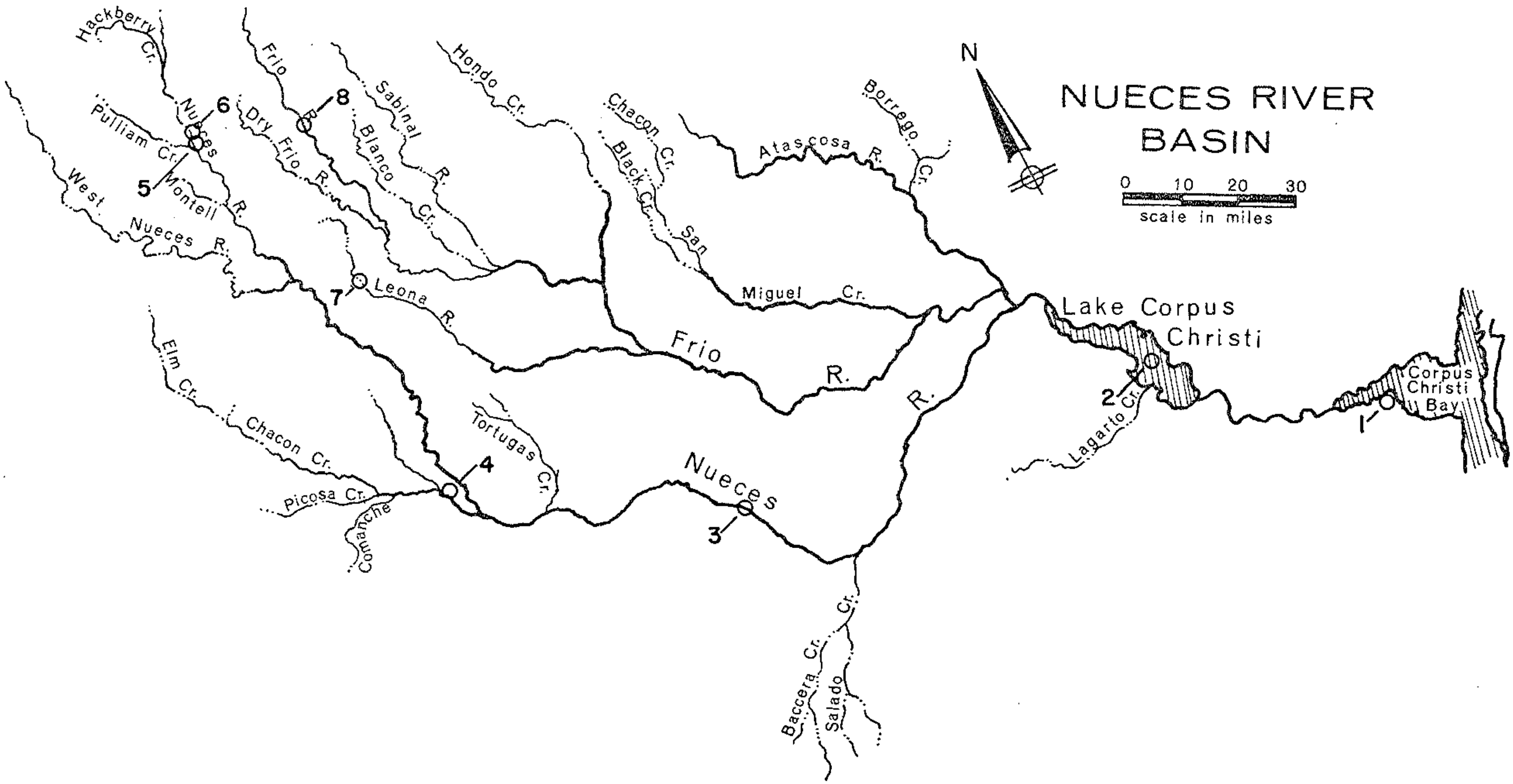


Figure 152. Aquatic invertebrate collection locations.

Table 20. Aquatic Mollusca reported from the Nueces River Basin, Texas

Taxonomic unit	Reference	Location
Basommatophora		
Physidae		
Physa virgata	33	Statewide
P. anatina	32	Nueces Co.
P. forsbeyi	32	Nueces Co.
P. amygdalus	161	Type locality-Texas
Lymnaeidae		
Lymnaea (=Fossaria) humilis	33	Statewide
L. bulimoides techella	33	Statewide
Pseudosucinnea columella	33,154	Statewide
Galba parva	161	Nueces R.
Planorbidae		
Gyraulus parvus	33	Statewide
Helisoma trivolvis lentum	33	Statewide
H. tenue	32	Nueces Co.
Promenetus exacuous	33	Statewide
Tropicorbis obstructus	33	Statewide
Planorbis antrosus	161	Nueces R.
P. carus	161	Nueces R.
P. dilatatus	154	Nueces R.
P. lentus	161	Common in all explored streams
Segmetina obstructa	154	Abundant north to Austin; Nueces R.
Ancylidae		
Ferrissa sp.	33	Central, and south Texas
Mesogastropoda		
Vivaparidae		
Viviparus sp.	33	Central, and south Texas
Campeloma sp.	33	Central, and south Texas
Valvatidae (=Bulimidae)		
Valvata tricarinata	33	Central, and south Texas
Amnicolidae		
Amnicola sp.	33,51	Central, and south Texas
Tryonia cheatumi	33	Central, and south Texas

Table 20. Continued

Taxonomic unit	Reference	Location
Paludestrina seemanni	161	Nueces R.
P. protea	161	Nueces R.
Cochliopa texana	33	Central, and south Texas
C. riograndensis	161	Nueces R.
Ampullaridae (Not native)		
Ampullaria sp.	33	Central, and south Texas
Thiaridae		
Thiara sp. (Introduced)	33	Central, and south Texas

Texas Parks and Wildlife Department study (174) noted that three undesignated species of large freshwater mussels were found in large numbers on silt bottoms in 3 to 6 ft of water in Lake Corpus Christi and reported that channel catfish and blue catfish, especially the smaller ones, often had their stomachs and intestines filled with shells of small mussels. This indicates their importance in the food chain of that lake.

Annelida:

The only available record of annelids in the Nueces River Basin was of leeches noted on gars and blue catfish of Lake Corpus Christi (174).

Crustacea:

A list of species of crustaceans found in this river basin is given in Table 21. A Texas Parks and Wildlife Department report (174) indicated that the small freshwater shrimp, *Paleomonetes* sp., was probably the most important food item for fish in Lake Corpus Christi, since large numbers of these were taken by seining, especially during the summer months. This same report indicated that during a seining operation 90 *Macrobrachium acanthurus* and one *M. carcinus* (large freshwater shrimps = prawns) were taken by a hoop net with lead seine set for three nights in the state park slough. They also mentioned

Table 21. Aquatic Crustacea reported from the Nueces River Basin, Texas

Taxonomic Unit	Reference	Location
Malacostraca		
Decapoda		
Palaemoniidae		
Macrobrachium carcinus	174	2
Macrobrachium acanthurus	174	2
Paleomonetes sp.	174	2
Astacidae		
Procambarus blandingii acutus	141	Edwards, Nueces Counties
P. clarkii	141	Nueces R.
P. simulans simulans	141	Zavala Co.

that crayfish (species not given) were found commonly on water hyacinth roots. The crustacean fish louse, _Argulus_ sp., was noticed on the heads and gill covers of almost all large alligator gars examined. Hedgpeth (79) listed _Macrobrachium carcinus_ as common in Lake Corpus Christi. Penn and Hobbs (141) reviewed the older literature and listed five species of crayfish from the Nueces River Basin with _Procambarus clarkii_ being the most common.

Insecta:

This group has received the least attention of all animal groups studied in this river basin. A summary of the insects reported, including taxa names and collection sites, is given in Table 22.

Ephemeroptera:

The only reference to this order was a Texas Parks and Wildlife Department report (174) which indicated that catfish in Lake Corpus Christi fed heavily on mayflies of an undetermined species.

Odonata:

A Texas Parks and Wildlife report (174) indicated odonates were common in Lake Corpus Christi where they were frequently eaten by catfish and crappie.

Table 22. Aquatic Insecta reported from the Nueces River Basin, Texas

Taxonomic unit	Reference	Location
Hemiptera		
Notonectidae		
Arctocorisa (=_Arctocorixa_) _compacta_	124	Uvalde Co.
Salididae		
Pentacora _signoreti_	124	Corpus Christi
Coleoptera		
Polyphaga		
Elmidae		
Heterelmis (_vulnerata_ ?)	31	Balconian, Texan Biotic Provinces
Microcylloepus (_pusillus_ ?)	31	Balconian Biotic Province
Neoelmis _caesa_	31	6, (4 mi. east of 4)
Hexacylloepus _ferrugineus_	31	Balconian Biotic Province
Dubiraphia sp.	31	Frio R., Rio Frio
Diptera		
Nematocera		
Culicidae		
Aedes _sollicitans_	42	1
Culex _quinquifasciatus_	42	1
Simuliidae		
Simulium _argus_	288	Hondo Cr., Medina Co., Sabinal R., Uvalde Co.
_S._ _meridionale_	288	Corpus Christi State Park
_S._ _trivittatum_	288	Sabinal R., Leona R., Nueces R., Uvalde Co., Pulliam Cr., Edwards Co.
_S._ _mediovittatum_	288	4; Hondo R., Medina Co.; Nueces R., Nueces Co., Leona R., Uvalde Co.

Table 22. Continued

Taxonomic unit	Reference	Location
S. virgatum	288	Nueces R.,Nueces Co.;Sabinal R., and Frio R., Uvalde Co.; Nueces R.,Zavala Co.
S. vittatum	288	7,Hondo Cr., Medina Co.;Leona R. and Nueces R., Uvalde Co.

Hemiptera:

Millspaugh (124) recorded three water bugs as having been collected in this river basin.

Coleoptera:

The only known reference to water beetles in this basin is that of Burke (31) who listed five species of elmid beetles from the area.

Diptera:

The only records of dipterans in the basin were two species of mosquitoes listed by Cushing (42), and six species of black-flies reported by Wiseman and Eads (288).

AQUATIC VERTEBRATES OTHER THAN FISHES

Vertebrates, other than fishes, have rarely been studied in the study area. Reports are available for only a few groups, particularly the salamanders.

It should be noted that a number of the more complete studies of vertebrates in these river basins have been included in the surveys of cave faunas. While a number of these cave studies have been conducted in the study area, a complete discussion is beyond the scope of this study. Reference will be made to a number of strictly aquatic cave forms and a general summary of the vertebrates of Texas caves is available in Reddell (147).

Aquatic Vertebrates of the Guadalupe River Basin

The vertebrates, other than fishes, which have been studied most extensively in the Guadalupe River Basin are the neotenic salamanders of the genus *Eurycea*. These plethodontid forms are limited to certain springs and subterranean water courses along the eroded Balcones Escarpment and adjacent areas on the Edwards Plateau (9, 17, 37, 46, 68, 279). Hamilton (71) is currently preparing a review of the distribution and taxonomy of this group. The most unique of these salamanders is *Eurycea* (=*Typhlomolge*) *rathbuni*, the Texas blind salamander found only in the Purgatory Creek underground system at San Marcos. Uhlenhuth (277) described the environment and habits of this extremely rare form which has been collected only from two wells and two caves in the San Marcos area. Another interesting form is *Eurycea nana*, the San Marcos dwarf salamander, which is restricted to the headwaters spring area of the San Marcos River, apparently by its very narrow range of tolerance for temperature (46). The distribution and restricted ranges of the species of *Eurycea* along the Balcones Escarpment offer an interesting study in evolution.

Only two other specific references could be found to aquatic vertebrates other than fishes in this river basin. Raun (143) described the vertebrates of Palmetto State Park on the San Marcos River and Muenzler (128) discussed the distribution of amphibians of Gonzales County, Texas.

The existing records indicate that the salamanders found in springs along the Balcones Escarpment are limited to clean water with generally constant environmental conditions. If the springs at San Marcos cease to flow, the endemic forms that live there will, in all probability, become extinct. The Texas Water Development Board (273) and the Guadalupe-Blanco River Authority (69) have estimated the perennial yield of the Balcones Fault Zone to the Edwards Aquifer to be in the order of 400,000 acre-ft per year within the Guadalupe, San Antonio, and Nueces river basins. If the projected annual pumpage of approximately 400,000 acre-ft within these basins is accomplished, flow from Comal and San Marcos springs will cease, at least part of the time (69, 273). If pumpage predictions are met, it is estimated (69) that these two springs will not flow at all for two out of every 26 years and that flow will occur throughout the entire year only one half of the remaining 24 years. To insure that some spring flow is maintained at all times, the Texas Water Development Board (273) recommended that pumpage from the aquifer be held somewhat below 400,000 acre-ft annually, while the Guadalupe-Blanco River Authority (69) indicated that pumpage should be held below 300,000 acre-ft. The 1960 ground water use was 197,550 acre-ft and the projected use of ground water by 1990 is 367,600 acre-ft (69). It is impossible to predict what effect changing water levels within the Edwards Aquifer will have on the subterranean life there, but it is likely to be extremely detrimental.

Aquatic Vertebrates of the San Antonio River Basin

The only aquatic vertebrates other than fishes reported from the San Antonio River Basin are salamanders. Baker (9) and Bogart (17) described the salamanders of the genus *Eurycea* from localities in this basin and reviewed previous publications on the group. All collections reported from this basin have been made north of the Balcones Escarpment. *Eurycea latitans* has been collected from Cascade Caverns stream system at Boerne; *Eurycea tridentifera* from Honey Creek Cave stream, seven miles northwest of Bulverde, Comal County; and the type locality for *Eurycea neotenes* is Culebra Creek, Bexar County. *E. neotenes* has also been reported in this basin from Helotes Creek, five miles north of Helotes. It has the widest distribution of any of the *Eurycea* in Texas, being reported from several springs on the Edwards Plateau.

Aquatic Vertebrates of the Nueces River Basin

Flury (174) discussed the aquatic vertebrates of Lake Corpus Christi. Among turtles he termed common were the slider

(*Pseudemys scripta*) and the soft shell (*Amyda ferox*). The most common frog around the lake was the tree frog (*Hyla cinera*), with leopard frogs (*Rana pipiens*), and cricket frogs (*Acris crepitans*) also being common. He noted that alligators (*Alligator mississippiensis*) occurred in the lake.

Baker (9) and Bogart (17) listed localities for the different salamanders of the genus *Eurycea* in the basin. *Eurycea neotenes* was reported from springs on the Edwards Plateau, while *Eurycea troglodytes* is endemic to its type locality, Valdina Farms Sinkhole, Valdina Farms, Medina County. Bogart (17) described what he considered to be a population of *Eurycea nana* in the Sabinal River, 5.5 miles north of Vanderpool, Bandera County, though no other authors concur.

Additional collections of neotenic *Eurycea* have been reported by Baker (9) from the following localities in this basin. Bandera County: Five miles northeast of Vanderpool, collector unknown; 8 miles northeast of Utopia, C. Hubbs and K. Strawn; 8 miles north of Vanderpool, collector unknown; 7 miles east of Vanderpool, K. Strawn. Edwards County: Four miles northwest of Pulliam Creek, Barksdale, collector unknown. Real County: Seven miles east and 4 miles south of Leakey, C. Hubbs and K. Strawn; 10 miles northeast of Leakey, East Frio River, C. Hubbs and K. Strawn; 10 miles northeast of Leakey, Cypress Creek, H. Lindsay and K. Strawn; 15 miles north of Leakey, Moffit Ranch, J. K. Baker. Uvalde County; Montell Springs at Montell, C. Hubbs; Montell Creek, Miller and Wells.

WATERFOWL

Though little has been published concerning waterfowl in the study area, statewide reports, a few localized reports, and interviews with game management personnel leave no doubt as to the importance of these river basins to the waterfowl of Texas.

Robert West, Waterfowl Biologist for Texas Parks and Wildlife Department, supplied much of the available waterfowl information in a personal interview. He stated that he knew of no studies of inland waterfowl conducted by federal or state agencies in the study area.

Mr. West supplied the following information and rough waterfowl population estimates on various localities within the study area. Kerr County is the main nesting area for wood ducks in the river basin. If their habitat there is destroyed, the wood duck population will vanish from this part of Texas. This would not have a significant effect on the overall population of wood ducks in the state, however, since the main nesting area for these ducks is in east Texas.

He further stated that the Guadalupe River Delta is the main feeding and resting area for 10,000 snow geese, 2,000 lesser Canada geese, and some white-fronted geese. Around 8,000 to 10,000 ducks (pintail, mottled, green-winged teal, blue-winged teal, mallards) overwinter in this area. Also, around 2,000 white pelicans occur there and some egret and heron rookeries are established in the area.

Nueces Bay serves as a resting place for 5,000 to 10,000 snow geese and blue geese and 1,000 Canada geese. A moderate number of ducks, representing all species found along the Texas coast, rest there. During spring migration, shoveler ducks number 12,000 to 15,000.

According to West, San Antonio Bay offers little suitable habitat for waterfowl due to the lack of shallow water and the heavy silt load carried into the bay by the Guadalupe River. These conditions prevent growth of vegetation essential for good waterfowl habitat.

He also reported that the Lake Corpus Christi area in the Nueces River Basin has the largest nesting colony of black-bellied tree ducks in the United States.

Flury (174) indicated that large flocks of ducks and geese winter on Lake Corpus Christi, mostly in upper Coffin Bay. Other water birds common in the lake area during the winter were Mexican cormorants, anhingas, coots, great blue herons, American and snowy egrets, green and night herons, white and wood ibis, white pelicans, sea gulls, and terns.

The most comprehensive source of information about waterfowl along the Texas Coast is a Texas Parks and Wildlife Department report (152) on waterfowl population trends, food habits, mortality from hunter-kill, migrations, and wintering conditions on the Texas coast from 1947 to 1952. Population estimates were made by monthly aerial inventories from October through February each year. The study indicated a definite correlation between the occurrence of waterfowl species and habitat type. Mallards are limited almost exclusively to the deep marsh and rice belt, while the redheads inhabit shallow bays of the southern coast. Waterfowl kill varied from 1.8 to 3.2 per hunter-day with redheads and pintails bagged most frequently in the study area. Age ratios were 44.5% adults to 54.5% juveniles. Mortality, other than hunter-kill, was related to pollution, lead poisoning, and disease. The report also indicated that the breeding potential of the mottled duck, _Anas fulvigula maculosa_, the most important resident of the Texas Coast, could be increased through proper management. Reduction of overgrazing which causes unfavorable nesting conditions was the most important consideration.

A Bureau of Sport Fisheries and Wildlife (281) assessment of the fish and wildlife resources of the Guadalupe-San Antonio River Subbasin indicated there are about 373,000 acres of waterfowl habitat in the subbasin. Of this there are 35,000 acres of high value; 55,000 acres of moderate value; and 283,000 acres of low value habitat for waterfowl. The habitats consist of ponds, lakes, reservoirs, bays, rice fields, seasonally flooded stream bottoms, shallow fresh marshes, salt flats, and salt marshes. About 56% of the waterfowl habitat occurs on bays and 16% on rice fields. Approximately 87% of the waterfowl habitat lies in Calhoun County and adjacent bays. About 165,000 waterfowl use the Guadalupe River Basin in their migratory flights to and from the coast. Species include pintail, mallard, blue-winged and green-winged teal, baldpate, shoveler, gadwall, lesser scaup, redhead, Canada goose, snow goose, white-fronted goose, and coot.

Nesting species include the wood duck on streams in the central part of the subbasin and fulvous tree duck and mottled duck on the coastal prairie. In addition, though the wintering habitat of the rare whooping crane is located on the Aransas National Refuge in the Mission River Subbasin, they also utilize the Matagorda Island area in Calhoun County in the Guadalupe-San Antonio Subbasin. The report also stated that numerous other water birds are found along the coast, particularly pelicans, gulls, terns, herons, cranes, roseatte spoonbills, and ibises.

The report stated that the Crossley Survey indicated that in 1955 there was a subbasinwide demand for 109,600 man-days of waterfowl hunting annually but only 40,000 man-days were estimated to be available. By the year 2010, the demand is expected to increase to 325,000 man-days annually. Except for a limited amount of hunting on farm tanks, waterfowl hunting opportunities are almost entirely confined to bays and coastal areas.

The report (281) further stated that the construction of one or more reservoirs on the middle or lower reaches of the Guadalupe and San Antonio rivers would be of considerable value to waterfowl. However, provisions should be made for the adequate flow of fresh water into estuarine areas so as to preserve valuable waterfowl habitat.

Singleton (153) discussed the influence of waterfowl habitat management on the waterfowl of Texas. He stated the first objective of waterfowl management is to increase nesting success through the regulation of nesting and rearing cover, supply of fresh surface water, food supply, predators, and breeding population. Food supply is largely dependent upon aquatic plant production which is influenced by fertility of land, turbidity of the water, and water quality. The best growth of food plants occurs in waters less than 3 ft deep, thus impoundments with broad zones of shallow water are highly productive. Ideally, the impoundment should be drawn down in the spring or early summer to expose shallow water areas and allow root growth and seed germination. Adequate water supply must be available to raise water levels at the proper time to realize the full value of the controlled drawdown.

The Bureau of Reclamation (282) cited substantial gains in waterfowl habitat as one aspect of the environmental impact of the proposed Cibolo Dam Project being considered for construction on Cibolo Creek in the San Antonio River Basin.

Bolen (19) conducted a life history study of the black-bellied tree duck, Dendrocygna autumnalis, in the Lake Corpus Christi area from 1962 to 1966. He determined that black-bellied tree ducks arrive in the Lake Corpus Christi area irregularly each spring around March 25. Band returns located the wintering ground in northeastern Mexico, especially Tamaulipas. They nest primarily in tree cavities, mostly in savannahs where underbrush is minimal, but some ground nests occur in areas of heavy cover. Hatching takes place late June to early September. Cultivated plants provide the bulk of the diet of the adults in south Texas. These ducks will be adversely affected by loss of their native habitat if reservoirs are constructed in their nesting or feeding grounds.

In summary, no studies were located that considered inland waterfowl communities in depth. This aspect of waterfowl management will need to be developed before a reasonable understanding of the biota of these river basins is accomplished.

BACTERIA

The Texas State Health Department has an established sampling network which tests water quality parameters that are essential to determining the suitability of water for human or domestic consumption or for recreation. Many of these sampling stations are scattered throughout the Guadalupe-San Antonio-Nueces river basins. Most stations are sampled only once or twice a year; thus knowledge of the bacterial density on a seasonal basis is very limited. Heavily utilized areas are sampled more extensively, monthly or bimonthly in most instances.

Several standard bacteriological methods are used to assess water quality. The most commonly utilized analysis is the Total Coliform (MPN) Test. Until recently the Texas State Health Department has used the multiple fermentation tube procedure to determine total coliform. In the last year they have switched to the membrane filter technique of analysis. Coliform population counts give an indication of the sanitary condition of a stream, since the presence of coliform bacteria indicates fecal pollution. Two other analyses used to locate sources of contamination are fecal coliform and fecal streptococcus tests.

Since the mid 1960's, the Texas State Health Department has developed a computerized storage and retrieval program for their raw data. These data (294) were utilized to determine the general condition of the three river basins as indicated by bacterial populations. For the purpose of determining trends in the bacteriological quality of water in the three river basins the computerized data taken prior to 1970 is compared to that taken from 1970 to 1972.

Bacteria of the Guadalupe River Basin

According to Texas State Health Department data (294) the water with the poorest bacteriological quality of any sampling station within the Guadalupe River Basin occurred at the Palmetto State Park swimming area near Ottine on the San Marcos River (R.M. 20). Overall, the quality of the water in this basin has improved during the last three years.

Two watershed surveys carried out on the lower and middle Guadalupe River Basin by Menzies in 1970 (271, 272) described in detail the soil types, river utilization, pollution potentials, current pollution control practices, and gave chemical and bacteriological sampling data. He concluded that the central Guadalupe River was generally in very good condition, but no longer "pristine pure", and further that the regions of lowest bacterial quality in streams of the lower Guadalupe River Basin would generally not meet water quality guidelines for contact recreation activities.

Bacteria of the San Antonio River Basin

In the San Antonio River Basin, the highest coliform bacteria numbers have consistently occurred in and near the San Antonio metropolitan area (294). This area has by far the lowest bacteriological water quality occurring in the study area. The bacterial water quality was particularly poor prior to 1970, with numerous samples exceeding one million total coliform (MPN) and a few exceeding ten million total coliform (MPN). The last three years have witnessed a decrease in total coliform by a factor of approximately ten throughout the basin. In spite of this reduction, however, the bacterial quality of water in that region is still the poorest in the study area (294).

Currently, a controversy over the potential detrimental effect of San Antonio Ranch New Town development north of San Antonio has led to investigations of bacteria in runoff and ground water in that area. Fruh, in a report to San Antonio Ranch New Town (57), stated that samples of natural runoff obtained at the San Antonio Ranch and Colonies North Basin would not meet U. S. Public Health Service Drinking Water Standards. The ratio of fecal coliforms to fecal streptococci there indicated that animals at present are the prime source of wastes.

Preliminary estimates were made of potential aquifer pollution at this site. In another report to the San Antonio Ranch Water Quality Advisory Review Board (276), Turk and Fruh reported analysis of water samples taken on twelve dates between March 13, 1972 and May 23, 1972 for total coliforms, fecal coliforms, and fecal streptococci. Their calculations, based on gross assumptions about the field data, indicated that there is only a remote chance that indicators of bacterial pollution would reach the aquifer under assumed future urban runoff conditions. This conclusion is difficult to accept since the investigators also reported that there are fractures and solution cavities in some areas of San Antonio Ranch. It seems likely that ground water could percolate at a relatively high rate through such formations.

Bacteria of the Nueces River Basin

Bacteriological data (294) for the Nueces River Basin did not indicate total coliform (MPN) counts exceeding 10,000 in any sample taken during the last three years. Based on the raw data from this basin, the quality of water is apparently quite good. A comparison of the bacteriological data for the years preceding 1970 with that for the years 1970-72 showed there has been an apparent improvement in bacteriological quality throughout the basin in the last three years.

Menzies (270), in a 1969 watershed survey of Lake Corpus

Christi, indicated that pollution control measures practiced in the immediate watershed at that time were excellent and surveillance was adequate. He termed the chemical and bacteriological quality of water in Lake Corpus Christi excellent.

It should be noted that the City of Corpus Christi operates an extensive sampling program around and below Lake Corpus Christi and at several sites in the upper watershed. They sample alkalinity, pH, chlorides, hardness, settleable solids, and total coliform bacteria. In March 1972, the total coliform bacteria in the Atascosa River at Whitsett (R.M. 15) were too numerous to count. This was the only report from any sampling site in the basin between September 1970 and June 1972 (293) that had total coliform (MPN) of over 10,000.

ALGAE

Studies of algae in these river basins have been very limited. Scientific explorations in early Texas were described in several papers by Geiser (59, 60, 62, 64, 65, and 66). Some of the early explorers kept diaries, later published, in which they often noted flora and fauna as they traveled in Texas. For example, McClintock (122) made observations of spring areas along the Balcones Escarpment. Several German immigrants who settled in Texas in the mid-1800's were highly educated scientists trained in natural history. They often collected specimens, some of which were sent to the Smithsonian Institute, European collectors, or museums at various eastern universities. References are very sketchy and it is usually difficult to determine whether or not the botanists included aquatic species in their collections. Most references clearly indicated that collections were of terrestrial species, often only economically or horticulturally important species. In this century, references to collections of algae have often been in the form of brief notes on individual species or genera collected in restricted localities for use in taxonomic or physiological studies.

In a study of the vegetation of San Marcos Springs, Watkins (283) included a partial list of algae. This was the first known study which listed aquatic species in the study area. A very limited study by Munson (129) listed a few taxa of algae occurring in Spring Lake at the headwaters of the San Marcos River. In collecting materials for a laboratory study of microcosms Beyers (15) listed the algae present in his collections from Spring Lake. A list of the common epilithic algae was given by Hannan and Dorris (74) in a study of community succession in the San Marcos River. A study of Stigeoclonium by Cox and Bold noted various species of this epiphyte from San Marcos and New Braunfels (41). Bischoff, 1965 (16), described a new species of red algae from Comal Springs in New Braunfels. A study of the effect of phosphate reduction on algal ecology in Mitchell Lake near San Antonio was made by Painter (135). In a macroinvertebrate study of the Guadalupe River below Canyon Reservoir, the alga Cladophora was noted by Kent (113). King (114) in a study of palmelloid green algae and Tupa (275) in a study of chaetophoralean algae listed forms found in the San Marcos River. In a 1969-70 study by Kubota (118) on Braunig and Canyon lakes, phytoplankton population changes were compared with changes in the chemical make-up of the waters. Bovie (22) investigated planktonic algae in Canyon Lake from July 1967 to June 1970 and made counts of the eight most prevalent genera.

The most comprehensive study of algae in the study area was conducted on the Guadalupe River by the Academy of Natural Sciences of Philadelphia (ANSP). This study, done for the E. I. du Pont de Nemours and Company located at Victoria, has been conducted periodically since 1949, with reports submitted in 1949 (1), 1963 (2), and 1966 (4). These reports were cursory stream surveys utilizing four stations on the Guadalupe River. The upper station was located 3/4 mile south of Seguin (R.M. 253). The other three stations were in the lower reach of the river; one just above the Victoria du Pont plant outfall (R.M. 28), one just below the du Pont outfall (R.M. 27), and one approximately 3 miles downstream from the plant outfall (R.M. 24.8).

A tenth year progress report (3) was also submitted to du Pont by the Academy of Natural Sciences of Philadelphia in 1964 on Catherwood diatometer readings which were taken on a regular basis from August 1954 to July 1964. This report described changes in number of individuals versus number of species at two stations on the Guadalupe River. The upper station was 1 mile above the Victoria plant outfall (R.M. 29) and the lower station was approximately 2 miles below the plant outfall (R.M. 26). Readings were taken monthly from two diatometers located at each station. The report stated that August 1963 readings showed evidence of a decrease in pollution other than organic and/or thermal pollution when compared to average readings of the previous fall. Data indicated that pollution other than organic and/or thermal pollution increased for the remainder of the report period at the lower station except during November, December, January, and February 1963. The report did not indicate what other types of pollution were involved.

Colbert (36) conducted a plankton study from February 1971 to March 1972 on two man-made ponds in San Marcos, Texas. Fifty-seven taxa of plankton (21 phytoplankters and 36 zooplankters), taken in weekly samples, were identified and their seasonal population changes analyzed. Dinobryon divergens was the only true "bloom" phytoplankter and Tribonema minus was the second most abundant phytoplankter in both ponds. The patterns of periodicity proved to be quite different from the general pattern of plankton periodicity that occurs in northern lakes.

A study conducted from June 1969 to March 1970 made comparisons between the phytoplankton composition and chemical characteristics of Braunig and Canyon reservoirs (118). A list of the common genera and the time of year when they were most abundant is given in Table 23. The data indicated that

Table 23. Dominant algal genera and month of highest populations in Canyon and Braunig reservoirs, 1969-1970. X indicates the month the highest population of a genus occurred in Canyon Reservoir. O indicates the month the highest population of a genus occurred in Braunig Reservoir

Genus	Month							
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.-- Mar.
Agmenellum		X		O				
Anacystis			O			X		
Lyngbya					X			
Anabaena	O	X						
Schizothrix			O					
Fragilaria				X				
Nitzschia				X	O			
Melosira							O	
Dinobryon	X							
Coelastrum								X
Pediastrum	X							
Scenedesmus		X			O			
Staurastrum				X				O
Peridinium		X						
Ceratium			O			X		

blue-green algae and diatoms were more abundant in Braunig Reservoir and green algae and yellow-brown algae were more abundant in Canyon Reservoir (Fig. 153) though there was no evident relationship between concentrations of nutrients in the two reservoirs and changes in genera or in numbers of algae. Young (292), in a study of Canyon Reservoir at about the same time, measured planktonic chlorophyll a concentrations in different areas of the reservoir (Fig. 154). He concluded from N:P ratios, that nitrogen was limiting to phytoplankton production within Canyon Reservoir and became a limiting factor in the river upstream from the reservoir during periods of increased autotrophic productivity and decreased runoff. Bovie (22) made algal collections at two sites on Canyon Reservoir once or twice a month from July 1967 to June 1970. Surface samples were collected at Canyon Dam (location 9, Fig. 155) and near Cranes Mill Park (location 11, Fig. 155). She used two genera from each of four divisions of planktonic algae to show seasonal fluctuations.

Chlorophyll a concentrations have been used by a number of investigators as an indication of phytoplankton population levels in various regions of the study area. Woerner (289), in a study of a 95 mile segment of the Guadalupe River, found that sampling stations located above dams on the Guadalupe River yielded higher levels of chlorophyll a and substantially lower concentrations of dissolved oxygen than samples taken at either

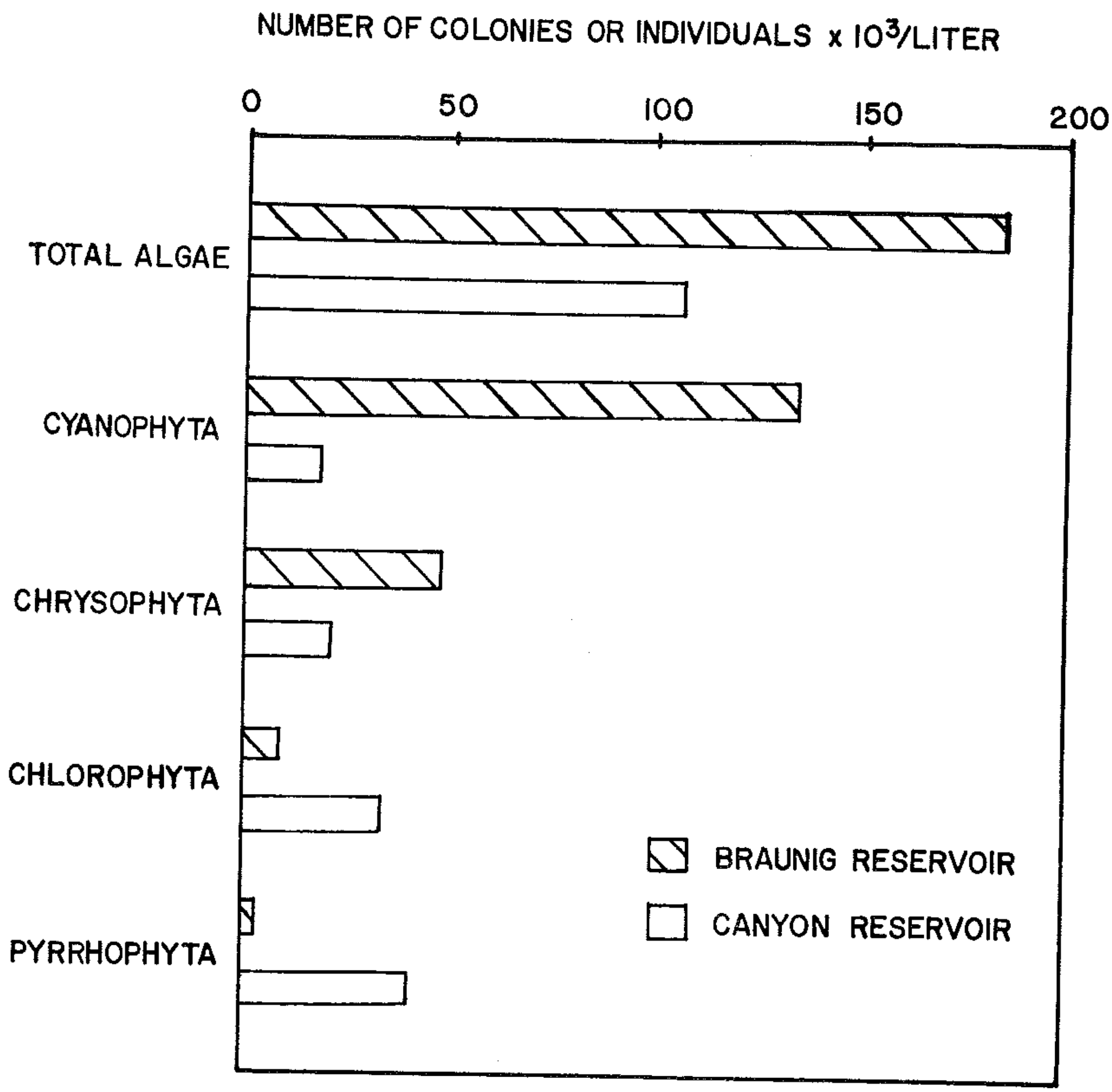


Figure 153. Relative abundance of four groups of algae in Braunig and Canyon reservoirs, 1969-1970 (118).

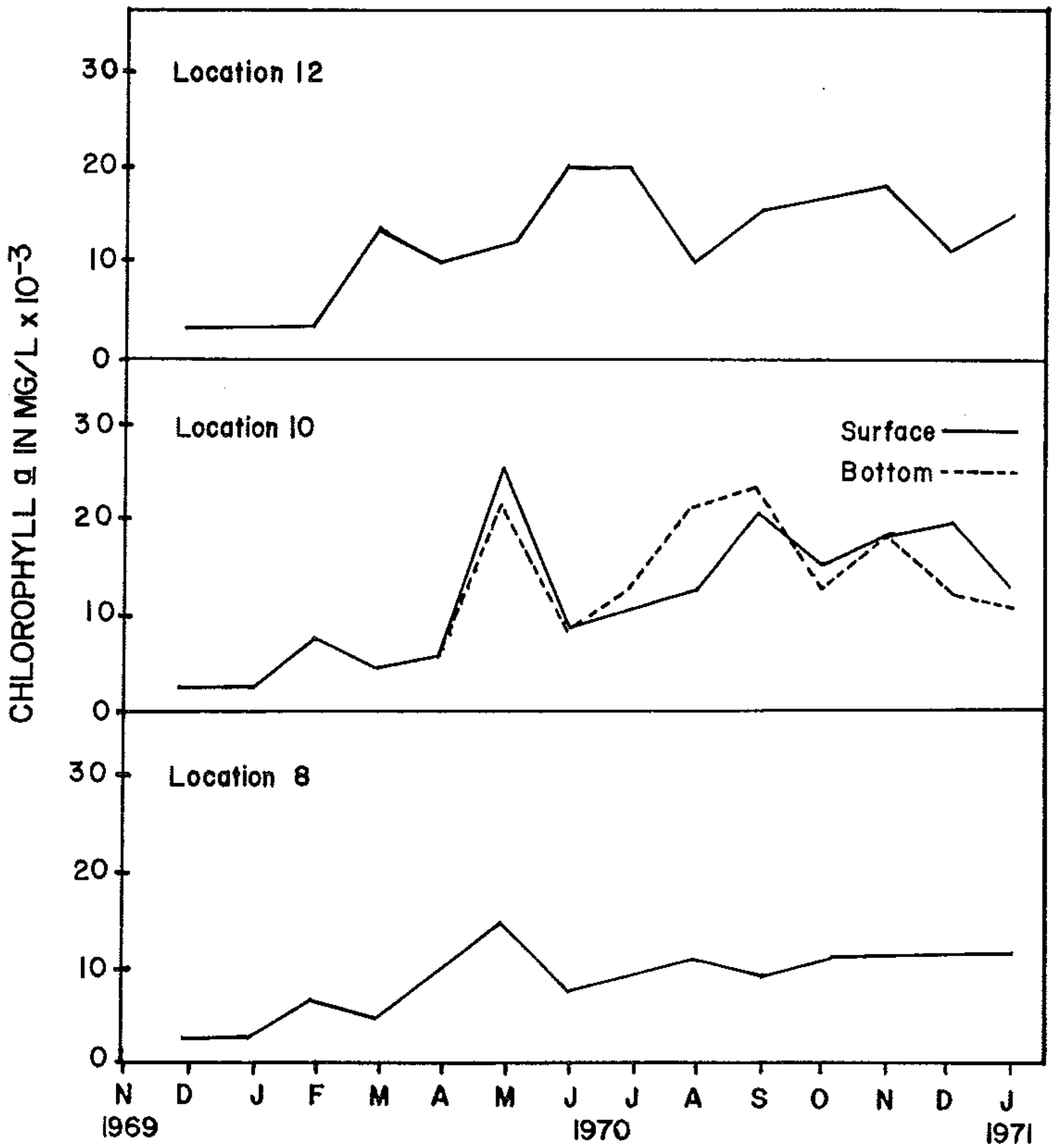


Figure 154. Planktonic chlorophyll a above, in, and below Canyon Reservoir (75). Locations are shown in Figure 155.

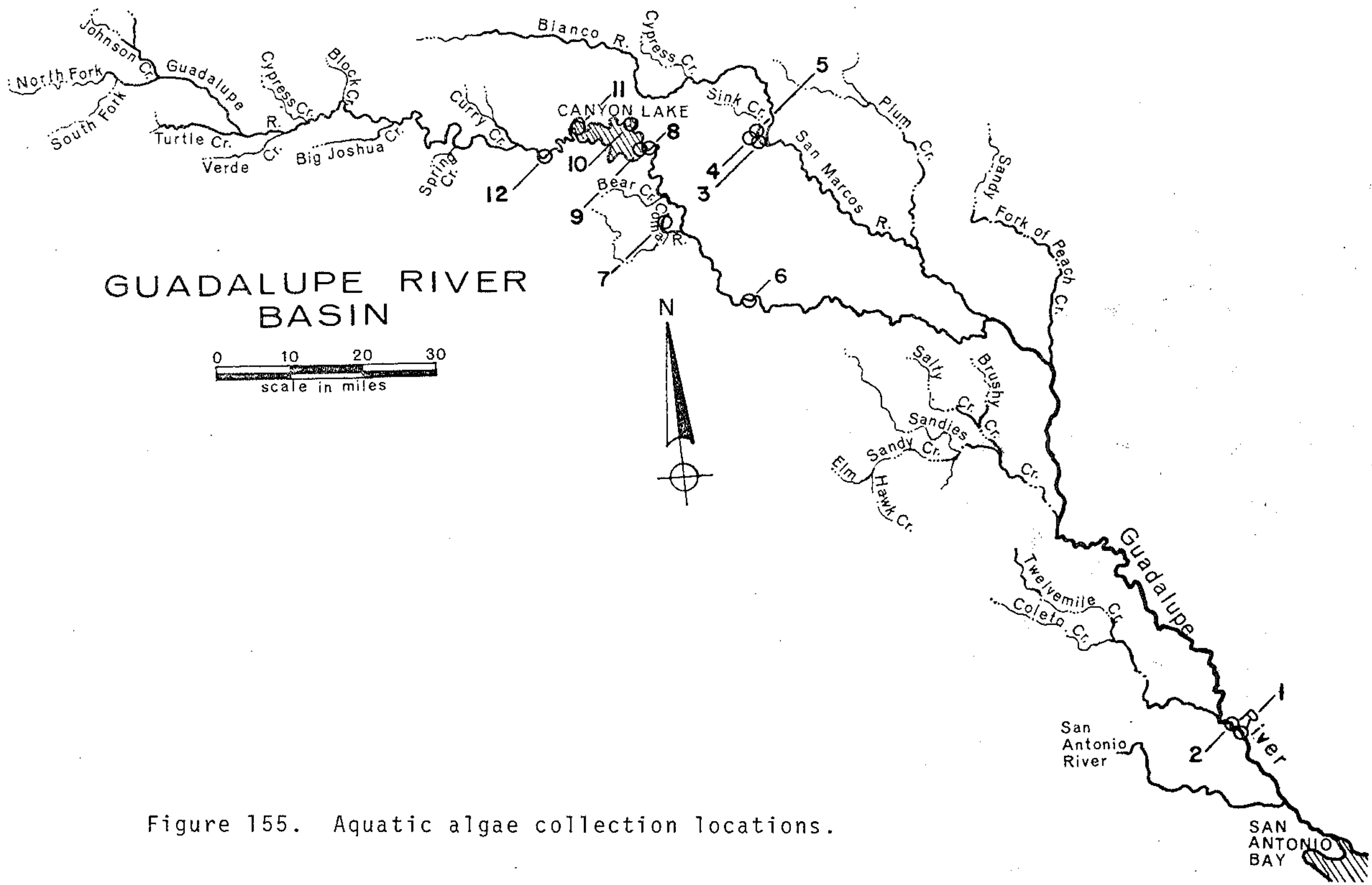


Figure 155. Aquatic algae collection locations.

lake-entrance or below-dam sampling stations. He concluded that nutrient enrichment apparently played a significant role in causing high chlorophyll a levels (i.e., high plankton populations) in lakes Dunlap, McQueeney, Meadow, and Gonzales on the Guadalupe River. Hannan and Young (292), in a report on the influence of Canyon Reservoir on the water quality of the Guadalupe River, showed planktonic chlorophyll a varied from a minimum of 0.013 mg/l (June 17, 1970) to a maximum of 0.054 mg/l (January 20, 1971) in the reservoir and that, in general, chlorophyll a concentrations throughout the year were higher in the riverine portion of the reservoir than in the open water portions. Similar values for chlorophyll a have been given by other authors as indicating an oligotrophic or slightly mesotrophic condition. Hannan, et al. (76), in a study of three impoundments on the Guadalupe between New Braunfels and Gonzales, found that chlorophyll a ranged from slightly more than 0.01 mg/l to slightly more than 0.1 mg/l throughout the year. By calculating phosphorus and nitrogen budgets they determined that these impoundments served as nutrient traps. Based on N:P ratios, it was postulated that nitrogen was the nutrient which limited algal growth in all three impoundments (76). In studies (75, 290) involving 15 sampling stations in the Guadalupe River between river miles 184 and 279, surface chlorophyll a concentrations ranged from a minimum of 0.009 mg/l to a maximum of 0.153 mg/l. These chlorophyll _a_ concentrations were most influenced by changes in flow rates and to a lesser extent by temperature changes throughout the year.

It is interesting that two algae usually considered to be marine forms, or halophiles, have been reported from the Guadalupe River at Seguin, Texas. The forms listed are: _Entophysalis rivularis_ (2), _Lyngbya aestuarii_ (1, 4). It is probable that a collection was mislabeled or that species were misidentified.

Table 24 is a summary list of the algae recorded from the Guadalupe River Basin. Locations of collections are shown in Figure 155. This table can best be utilized by comparing the list of taxa at a given location to the list of pollution tolerant forms in Tables 25 and 26. This will give an indication of the ecological condition of a particular location. If, for example, there is a predominance of pollution tolerant forms at a location, the area is probably polluted.

The San Antonio River Basin has had few studies that involved algae and none are known from the Nueces River Basin. Studies in the San Antonio River Basin that included algae have been done on Mitchell Lake (135), Braunig Lake (118), Cibolo Creek (278), and Leon Creek (279), all near San Antonio. None of these studies listed species, but included only total algal counts or chlorophyll concentrations.

Since little is known about the algae of the San Antonio and Nueces river basins, some reconnaissance level sampling

Table 24. Algae reported from the Guadalupe River Basin

Taxonomic unit	Reference	Location
Chlorophyta		
Chlorophyceae		
Volvocales		
Volvocaceae		
Volvox sp.	36	4
Eudorina sp.	36	4
Chlamydomonadaceae		
Chlamydomonas sp.	15	5
Tetrasporales		
Palmellaceae		
Gloeocystis sp.	15	5
Ulotrichales (Cladophorales)		
Cladophoraceae		
Cladophora glomerata	1	6
C. sp.	1,15,72,74,283	3,5,6
Pithophora oedogonia	4	1
P. sp.	2	6
Rhizoclonium hieroglyphicum	1,2,74	6
Ulotrichaceae		
Stichococcus sp.	129	5
Chaetophorales		
Chaetophoraceae		
Chaetophora attenuata	283	5
Gongrosira papuasica	275	4,5,7
Pseudendoclonium basiliense brandii	275	4,5
P. akinetum	275	5
P. prostratum	275	3,4
Aphanochaete magna	275	3
A. elegans	275	3,4,5
Stigeoclonium tenue	41	3
S. pasheri	41	7
S. variabile	41	3
S. farctum	41	3,7
S. sp.	72,74	3
Microthamnion sp.	72,74	3,5

Table 24. Continued

Taxonomic unit	Reference	Location
Oedogoniales		
Oedogoniaceae		
Oedogonium sp.	1,2,4,15	1,2,5,6
Chlorococcales		
Hydrodictyaceae		
Hydrodictyon reticulatum	283	5
Pediastrum simplex duodenarium	36	4
P. duplex	36	4
P. sp.	22	9,11
Coelastraceae		
Coelastrum sp.	22	9,11
Oocystaceae		
Ankistrodesmus sp.	15	5
Chlorella sp.	129	5
Zygnematales		
Zygnemataceae		
Spirogyra sp.	1,2,4,72,74,283	1,2,3,4,5,6
Zygnema sp.	36,283	4,5
Mougeotia sp.	36	4
Desmidiaceae		
Closterium moniliferum	283	5
Cosmarium sp.	36	4
Staurastrum crenulatum	129	5
Charophyta		
Charophyceae		
Charales		
Characeae		
Chara sp.	2,15	5,6
Nitella sp.	(Pers. obs.)	4
Euglenophyta		
Euglenophyceae		
Euglenales		
Euglenaceae		
Euglena sp. (These are included in Protozoa)		
Pyrrhophyta		
Dinophyceae		
Peridiniales		
Peridiniceae		
Perididinium sp.	22,36	4,9,11
Ceratiaceae		
Ceratium hirundinella	22,36	4,9,11

Table 24. Continued

Taxonomic unit	Reference	Location
Chrysophyta		
Xanthophyceae		
Heterotrichales		
Heterotrichaceae		
Tribonema minus	36	4
Heterosiphonales		
Vaucheriaceae		
Vaucheria geminata	283	5
V. sp.	1,2,4	6
Chrysophyceae		
Chrysomonadales		
Ochromonadaceae		
Dinobryon divergens	36	4
D. sp.	22	9,11
Bacillariophyceae		
Centrales		
Coscinodiscaceae		
Cyclotella menghiniana	2,283	1,2,5,6
C. comta	1	2
C. comta bipunctata	1	2
C. striata bipunctata	1	1
C. atomus	2	1,2
C. pseudostelligera	2	1,2
C. stelligera	2	1,2
C. striata	2	1,2,6
C. sp.	4	1,2
Coscinodiscus pygmaeus	2	1,2
Melosira varians	2	1
Stephanodiscus astraea minutula	2	1,2
Biddulphiaceae		
Biddulphia laevis	2	1
B. sp.	1	2
Anaulaceae		
Terpsinoe sp.	72,74	3,5
Pennales		
Diatomaceae		
Diatoma vulgare	2	2,1
Fragilaria sp.	22,36	4,9,11
Synedra acus	1	6
S. ulna	1,2,283	5,6
S. ulna domica	1	6
S. rumpens scotia	2	1
S. capita	283	5
S. sp.	36	4

Table 24. Continued

Taxonomic unit	Reference	Location
Achnanthaceae		
Achnanthes exigua heterovalvata	2	1
A. minutissima	2	1,6
A. affinis	1	6
A. exigua	1	6
A. sp.	15	5
Cocconeis placentula	283	5
C. placentula euglypta	2	1,2,6
Rhoicosphenia curvata	129	5
Naviculaceae		
Amphipleura pellucida	2,4	6
Anomoeoneis exilis	1,2	6
A. pellucida	1	6
A. sp.	1	6
Caloneis bacillum	2	1,6
C. schumanniana	2	6
C. silicula truncatula	2	6
Diploneis ovalis	1,2	1,6
D. sp.	1	1
D. pseudovalis	2	6
D. puella	2	1,6
Pleurosigma delicatulum	1	1,2
Gyrosigma sp.	4,36	4,6
G. kuetzingii	1,2	1,2,6
G. scalproides	2	6
G. spenceri modifera	1	1,6
G. attenuatum	2	6
Navicula sp.	4,36	4,6
N. cryptocephala pumila	1	6
N. gregaria	1	1,2,6
N. grimmei	1	6
N. kotschyi	1	6
N. pupula	1	6
N. radiosa	1	6
N. radiosa tenella	1	6
N. symmetrica	1,2	1,2,6
N. gracilis schizonemoides	1,2	1,2,6
N. rhynchocephala	1	2
N. gracilis neglectum	1	1
N. arvensis	2	1,2
N. canalis	2	1,2,6
N. cincta	2	1,2,6
N. confervaceae	2,4	1,6
N. cryptocephala	2	2

Table 24. Continued

Taxonomic unit	Reference	Location
N. cryptocephala veneta	2	6
N. cuspidata	2	1,2
N. cuspidata ambigua	2	1,2,6
N. gastrum	2	1
N. germainii	2	1,2,6
N. halophila	2	1,6
N. hungarica	2	1
N. lanceolata	2	1,6
N. minima	2	6
N. mutica cohnii	2	1
N. pupula capitata	2	6
N. pupula rectangularis	2,4	1,2,6
N. ruttneri rostrata	2	1,6
N. sanctae crucis	2	1,2,6
N. savannahiana	2	6
N. seminulum	2	6
N. tripunctata schizonemoides	4	6
Pinnularia acrosphaeria	2	1
P. braunii amphicephala	2	1
P. gibba subundulata	2	1,2,6
P. interrupta	2	1
P. sp.	15	5
Stauroneis sp.	36	4
Gomphonemataceae		
Gomphonema sp.	36	4
G. acuminatum	283	5
G. parvulum	1,2,283	1,2,5,6
G. intricatum vibrio	1	6
G. lanceolata	1	6
G. affinis	2,4	1,6
G. sphaerophorum	2	1,2,6
Cymbellaceae (=Gomphocymbellaceae)		
Amphora sp.	1,2	1,6
A. ovalis	2	1,2,6
A. ovalis pediculus	2	1,6
A. cymbelloides	4	6
Cymbella tumida	283	5
C. affinis	1,2,4	6
C. cessatii	1	6
C. hybridiformis	1	6
C. microcephala	1,2	6
C. ventricosa	1,2	6
C. sp.	1	6
C. pusilla	2	6
C. sinuata	2	1
C. turgida	2	6

Table 24. Continued

Taxonomic unit	Reference	Location
Nitzschiaceae		
Bacillaria paradoxa	2	1
Nitzschia amphibia	1,2,4	1,2,6
N. frustulum tenella	1	6
N. palea	1,2,4,	1,2,6
N. calida	1	1,2
N. closterium	1	2
N. hungarica	1,2	1,2,6
N. palea debilis	1	2
N. sp.	1,2	1,2
N. panduriformis continua	1	1
N. acicularis	2	1,2,6
N. accomoda	2	2
N. bacata	2	1,2,6
N. capitellata	2	1
N. confinis	2	2,6
N. filiformis	2	1,2
N. fonticola	2	1,2
N. frustulum	2	1,2,6
N. frustulum subsalina	2	6
N. gracile	2	1,2,6
N. kutzingiana	2,4	1,2,6
N. linearis	2	1,2
N. microcephala	2	1,2
N. obtusa scalpelliformis	2,4	1,2,6
N. sigma	2	6
N. tryblionella debilis	2	1,2,6
N. tryblionella levidensis	2	1,2,6
N. tryblionella victoriae	2	1
N. clausii	4	6
N. paleaformis	4	6
Surirellaceae		
Surirella sp.	36	4
S. ovata	1	1,2
S. brightwellii	2	1
S. ovata pinnata	2	1
S. robusta	2	6
S. robusta splendida	2	1
Cyanophyta		
Myxophyceae		
Chroococcales		
Chroococcaceae		
Anacystis cyanea	36	4
A. sp.	22	9,11
Gomphosphaeria sp.	15	5
Agmenellum (=*Merismopedia*) sp.	15	5

Table 24. Continued

Taxonomic unit	Reference	Location
Chamaesiphonales		
Chamaesiphonaceae		
Entophysalis rivularis	2	6
Hormogonales		
Oscillatoriaceae		
Lyngbya sp.	22	9,11
L. aestuarii	1,4	6
L. putealis	1,2	1,2,6
Microcoleus vaginatus fuscus	8	7
M. calcicola discreta	8	7
M. chthonoplastes	2	2,6
M. lyngbyaceus	4	2,6
Oscillatoria sp.	72,74,283	3,5
O. limnosa	129	5
O. prolifica	129	5
O. princeps	1,2,4	1,2,6
O. splendida	1,4	2,6
O. tenuis	1,2	1,2,6
O. chalybea	2,4	6
O. retzii	4	1
O. lutea	4	1
Phormidium sp.	1	1
Porphyrosiphon notarisii	4	1
Schizothrix calcicola	2,4	1,2,6
S. rubella	4	6
S. arenaria	4	1,2,6
S. mexicana	4	6
Spirulina princeps	36	4
S. major	2	2
Symploca atlantica	2	1
S. muscorum	4	2,6
Nostocaceae		
Anabaena sp.	2,4,15,72,74,283	1,2,3,5
Cylindrospermum sp.	1	2,6
Rivulariaceae		
Calothrix parietina	2	6
Rhodophyta		
Rhodophyceae		
Protoflorideae (= Bangoioideae)		
Bangiales		
Erythrotrichaceae		
Compsopogon coeruleus	2	6

Table 24. Continued

Taxonomic unit	Reference	Location
Florideae		
Nemalionales		
Batrachospermaceae		
Batrachospermum (= *Chantransia*) sp.	1,2,4,283	1,2,5,6
Thoreaceae		
Thorea riekei	16	7

Table 25. Pollution tolerant genera of algae (136)

List of 22 Most Tolerant Genera
In Order of Decreasing Emphasis by 110 Authorities

	Genera	Group	No. of Authors	Total* Points
1.	Euglena	F	62	110
2.	Oscillatoria	B	61	105
3.	Chlamydomonas	F	42	70
4.	Scenedesmus	G	40	65
5.	Chlorella	G	36	63
6.	Nitzschia	D	38	63
7.	Navicula	D	35	55
8.	Stigeoclonium	G	34	50
9.	Phormidium	B	30	45
10.	Synedra	D	25	33
11.	Phacus	F	23	32
12.	Ankistrodesmus	G	19	31
13.	Gomphonema	D	20	30
14.	Spirogyra	G	19	29
15.	Cyclotella	D	22	29
16.	Pandorina	F	18	25
17.	Closterium	G	19	25
18.	Lepocinclis	F	14	24
19.	Melosira	D	18	24
20.	Chlorogonium	F	14	23
21.	Anabaena	B	17	23
22.	Ulothrix	G	17	23

*Tolerance by author: "Very High", 2 points; "High", 1 point.

Table 26. Pollution tolerant species of algae (136)

List of the 20 Most Tolerant Species
In Order of Decreasing Emphasis by 110 Authorities

	Species	Group	No. of Authors	Total* Points
1.	Euglena viridis	F	34	63
2.	Nitzschia palea	D	30	46
3.	Stigeoclonium tenue	G	17	26
4.	Oscillatoria tenuis	B	17	25
5.	Oscillatoria limosa	B	14	21
6.	Scenedesmus quadricauda	G	12	18
7.	Chlorella vulgaris	G	11	17
8.	Pandorina morum	F	12	17
9.	Arthrospira jenneri	B	9	16
10.	Ankistrodesmus falcatus	G	11	16
11.	Cyclotella meneghiniana	D	12	16
12.	Chlorella pyrenoidosa	G	8	15
13.	Gomphonema parvulum	D	8	15
14.	Euglena gracilis	F	9	15
15.	Oscillatoria chalybea	B	10	15
16.	Synedra ulna	D	12	15
17.	Oscillatoria chlorina	B	9	14
18.	Nitzschia acicularis	D	10	14
19.	Oscillatoria formosa	B	10	14
20.	Oscillatoria princeps	B	10	14

*Tolerance by author: "Very High", 2 points; "High", 1 point.

should be done to determine what is currently there. This type of information would be necessary if a river ecological model is to be utilized. In addition to qualitative sampling of algae in a river basin, it will be necessary to know the seasonal patterns of dominance of various forms. Forms that dominate should be studied physiologically to determine their role in energy flow and their position in the food chain relative to consumer organisms.

AQUATIC MACROPHYTES

The aquatic macrophytes in the study area are not well known since they are often ignored in biological surveys. As a general rule, they are noted only when they reach nuisance proportions, thus their importance in the ecosystem is often overlooked. Studies within the study area which discuss their role in the ecosystem are few in number. Hannan (74) discussed their role in the productivity of the San Marcos River. Several reports (174, 198) mention their role in providing cover for fish. Singleton (153) pointed out that aquatic and shore plants are a major source of food for waterfowl on the Texas coast. He indicated that waterfowl in the Texas Coast region feed upon some 125 species of plants, with smartweed (Polygonum sp.), wild duck millet (Echinochloa sp.), and pondweed (Polygonum sp.) playing a dominant role. There is a distinct need for more studies investigating the role of aquatic macrophytes in the streams and lakes of this region.

Though much of the taxonomic work done in the study area is questionable and the major studies have been done in highly restricted areas, a survey of the available literature indicates a general pattern. The clear headwaters of streams and spring areas have a rich flora. As the stream becomes more turbid downstream, the submerged vegetation disappears and nuisance growths of floating and emergent plants are common.

Aquatic Macrophytes of the Guadalupe River Basin

Information on the aquatic macrophytic vegetation of the Guadalupe River Drainage Basin is scattered throughout reports on nuisance plants for the most part. The only concerted efforts to identify the entire aquatic plant community of the Guadalupe River (132) have centered in the headwaters regions of the stream while the only extensive work done on the vegetation of tributaries has been in the headwaters of the San Marcos River (29, 44, 192, 283).

The headwaters of the Guadalupe River, in the vicinity of Kerrville, have a diverse aquatic plant community as reported by Newman (132). He listed 24 shoreline plants, 10 rooted-emergents, 2 floating-leaved plants, 6 rooted-submerged plants, and 2 non-rooted submerged macrophytes (Table 27). He reported that the most abundant growths occurred in the headwaters upstream from Kerrville. Clear waters, conducive to plant growth, prevail in that stretch of the Guadalupe River.

Table 27. Aquatic Macrophytes of the Guadalupe River in the Vicinity of Kerrville, Texas (132).

SHORELINE PLANTS:

Common Name	Scientific Name
River Walnut	*Juglans rupestris*
Black Willow	*Salix nigra*
Cypress	*Taxodium destichum*
Sycamore	*Plantanus occidentalis*
Desert Willow	*Chilopsis linearis*
Horsetail	*Equisetum hyemale*
Bloodweed	*Ambrosia apter*
Spikerush	*Eleocharis caribara*
Frog Fruit	*Lippia lanceolata*
Peppermint	*Mentha piperita*
Button Bush	*Cephalanthus occidentalis*
Smartweed	*Polygonum persicariodes*
Pennywort	*Hydrocotyle verticillata*
Water Primrose	*Jussiaea* sp.
Vine Mesquite	*Panicum obtusum*
Bullrush	*Scirpus validus*
Lake Nettle	*Boehmerra cylindrica*
Chufa	*Cyperus* spp.
Sedge	*Carex* spp.
Venus-hair Fern	*Adiantum capillus*
White Umbrella Grass	*Dichromera nivea*

Table 27. Continued

Common Name	Scientific Name
Spike Rush	*Eleocharis cellulosa*
Mealy Sedge	*Salvia farinacea*
Saw Grass	*Cladium jamaecenses*
Woodbine	*Cissus amelopsis*
ROOTED EMERGENT PLANTS:	
Water Willow	*Dianthera americana*
Smartweed	*Polygonum lepathifolum*
Parrot's Feather	*Myriophyllum heterophyllum*
Water Primrose	*Jussiaea diffusa*
Cat-tail	*Typha augustifolia*
Water Cress	*Rorippa nasturtium-aquaticum*
Alligator Weed	*Alternanthera philoxeroides*
Water Hyssop	*Bacopa monnieria*
Duck Potato	*Sagittaria platyphylla*
Pickeral Weed	*Pontederia cordata*
ROOTED PLANTS WITH FLOATING LEAVES:	
Spatterdock	*Nuphar* (=*Nymphaea*) *advena*
Yellow Water Lily	*Nuphar* (=*Nymphaea*) *mexicana*

Table 27. Continued

ROOTED PLANTS WITH SUBMERGED LEAVES:

Common Name	Scientific Name
Pondweed	*Potamogetan lucens*
Sago Pondweed	*Potamogetan pectinatus*
Fishgrass	*Najas guadalupensis*
Coontail	*Ceratophyllum demersum*
Muskgrass	*Tolypella* sp.
Muskgrass	*Chara* sp.
Scale Moss	*Pellia* sp.

NON-ROOTED SUBMERGED PLANTS:

Bladderwort	*Utricularia subulata*
Bladderwort	*Utricularia macrorhiza*
Algae	*Spirogyra* sp.

Overabundance of aquatic vegetation has been cited as a problem in the Kerrville vicinity (119, 212). Spatterdock (Nuphar advena) was a widespread nuisance in that vicinity in 1955 after silting of the headwaters occurred during heavy floods (119). Chemical treatment by spraying with 2,4-D or 2,4,5-T or by cutting leaves below the surface was proposed at that time. By 1960, spatterdock was reported to be virtually eliminated in the Kerrville region in areas treated with Kuron at 1 gallon per acre (205, 211, 212, 215).

The Guadalupe River between Center Point (R.M. 405) and New Braunfels (R.M. 276) has experienced no nuisance plant growths that have been recorded. Reports indicate that Canyon Reservoir (R.M. 306) has considerable amounts of Najas guadalupensis, Potamogetan pectinatus, Potamogetan natans, and Chara vulgaris (113, 252, 292). Also, there are reports of stands of Typha latifolia, Potamogetan illinoensis, Potamogetan pectinatus, Myriophyllum heterophyllum, Nuphar sp., Nasturtium sp., Zizaniopsis milacea, Chara vulgaris, Jussiaea sp., Najas guadalupensis, and Cyperus sp. in the reach just below Canyon Dam (113, 253). However, aquatic vegetation in this reach is reported as sparse and posing no problems (249). Willow (Salix sp.), bald cypress (Taxodium distichum), oak (Quercus sp.), sycamore (Platanus occidentalis), pecan (Carya illinoensis), and cottonwood (Populus sp.) are the common trees in the river bottoms (253).

The Guadalupe River between New Braunfels and Gonzales, Texas has several stretches where reduced stream flow, due to impoundment, has created ideal habitats for certain aquatic plants. Texas Parks and Wildlife Department project reports called attention to existing or potential problems with aquatic vegetation in lakes in that region as early at 1958 and 1959 (193, 200). Spatterdock (Nuphar sp.), saw grass (Zizaniopsis milacea), cattails (Typha sp.), bulrushes (Scirpus sp.), and water hyacinths (Eichornia crassipes) were listed as undesirable aquatic plants present in amounts that warranted treatment, particularly in Lake McQueeney. Some success was had in eliminating sawgrass and cattails from Lake H-4 (R.M. 205) in 1959 and 1962 by treatment with Dowpon (206, 211, 216, 226). The severity of the problem of overabundance of plants was reiterated in 1960 (211) and 1962 (223) however, and it was predicted that this problem would worsen when Canyon Dam was completed and flooding and scouring which had held plant populations in check would cease. Eradication of the potential nuisance plants was recommended.

In 1965, the situation was reviewed (249). Lake Dunlap had growths of giant cutgrass (Zizaniopsis milacea), spatterdock (Nuphar advena), and water hyacinths (Eichornia crassipes) in amounts that were severe only in small localities. Lake McQueeney had several acres of spatterdock, particularly in the Treasure Island region of the lake. Submerged vegetation, mostly filamentous algae and water planchon (Elodea sp.), had caused complaints also. Lake Placid, which had experienced a serious water hyacinth problem in 1963, prior to chemical treatment, had troublesome stands of water hyacinth, but they posed no serious problem. This was the only lake where American lotus (Nelumbo sp.) was reported, but it created no problem. Meadow Lake had approximately one acre of elephant ear mixed with cutgrass. Some spatterdock was present but plants did not interfere with fishing or boating. Lake H-4 was experiencing a severe overabundance of vegetation; primarily water hyacinths with troublesome stands of cattail, spatterdock, and giant cutgrass. Lake H-5 had no major plant problems.

Concern over extensive plant growths in the New Braunfels-Gonzales stretch of the Guadalupe River, attributed to cultural eutrophication, resulted in a complete limnological survey of that region by Hannan and Young (75) in 1969-70. This study showed that the impoundment of water in the small, riverine reservoirs resulted in their functioning as nutrient traps and caused dense aquatic plant growths. The report also indicated that the situation was aggravated by the reduction in flow in that region that accompanied the establishment of Canyon Reservoir. A recommendation was made that flooding of the small impoundments be allowed to occur when feasible, thus flushing out nutrients and vegetation as had occurred periodically prior to filling Canyon Reservoir (75).

In 1970 (266) and 1971 (269, 280) nuisance plants persisted in approximately the same amounts reported in 1965, possibly a little worse. They were termed a potential nuisance that would require control measures if the situation deteriorated further. The overall detrimental effect of impoundments appears certain, since no difficulties with excessive vegetation has been reported in unimpounded stretches of the Guadalupe River in this area. The impact of Canyon Reservoir upon nuisance vegetation of this reach cannot be accurately assessed at present, but indications are that it is a cause for concern.

Few macrophytes, other than nuisance plants, have been reported from the New Braunfels-Gonzales region. Ludwigia sp. occurs in Lake Dunlap (75) and sweet flag (Acorus sp.) and stonewort (Chara gymnopus) have been reported from the upper end of Meadow Lake (1, 2).

In the delta region of the lower Guadalupe River, large stands of cattails dominate the broad plains and water hyacinths have virtually blocked the main stream, bayous, and ditches in recent years (209, 249). It was speculated that the loss of flushing which was expected to accompany the filling of Canyon Reservoir would adversely affect the vegetation problem (249). However, no reassessment of the problem has been reported since Canyon Reservoir was filled.

The only tributary of the Guadalupe River in which the vegetation is well known is the San Marcos River. Due to the unique character of the flora of the San Marcos Springs and the headwaters of the river, several plant surveys have been made (29, 44, 192, 283). Watkins (283) pointed out that the spring is situated on a dividing line between two plant formations described by Tharp (274): Quercus-Juniperus-Prosopais to the west and Andropogon-Stipa-Aristida to the east. This fact, coupled with the unique physical and chemical properties of the spring, results in a diverse aquatic plant community.

Table 28 lists the plants reported in five studies (29, 44, 74, 192, 283) carried out in the headwaters of the San Marcos River from San Marcos Spring (R.M. 79) to the junction with the Blanco River (R.M. 74). Since none of the lists appears complete, the list is a compilation of plants reported in the five studies. Though the list likely contains some synonyms and misidentifications, the aquatic flora is shown to be extremely diverse; likely more diverse than that of any comparable area in this region.

Based upon the assumption that most identifications in the reports are correct and that at least the major species were recorded, there have been significant changes in the vegetation since 1930. Particularly noticeable are reports of Eichornia crassipes, Cabomba caroliniana, Elodea (=Egeria) densa, Limnophilia sessiliflora, Ceratopteris thalictroides, Vallisneria americana, and Heteranthera dubia in more recent lists of strictly aquatic vegetation, but not in 1930. Since these are large, distinctive plants that are now common in the spring and stream, it is doubtful they were missed in earlier surveys.

Table 28. Aquatic macrophytes of the headwaters of the San Marcos River. X ? sp. indicates that plants in this genus were not identified to species in that collection. It is assumed they belong to the species indicated, since this is the common species in other collections. Sources of data are given in parenthesis.

Plants	Collectors				
	Watkins 1930 (283)	Deval 1940 (44)	P. & W. 1958 (192)	Hannan 1969 (74)	Bruchmiller 1972 (29)
MARGINAL OR SHALLOW-WATER PLANTS:					
Typha latifolia	X	X	X		X
Typha domingensis					X
Salix nigra	X				X
Populus deltoides	X				
Zizaniopsis miliacea	X	X			
Echinochlea walteri	X				
Leersia oryzoides (=*Homalocenchrus oryzoides*)	X				
Andropogon glomeratus	X				
Eleocharis arenicola	X				
Eleocharis montevidensis					X
Eleocharis sp.			X		
Mikana scandens (=*Willugbaeya scandens*)	X				X
Bidens laevis	X				
Helenium microcephalum	X				
Pluchea comphorata	X				

Table 28. Continued

Plants	Collectors Watkins 1930 (283)	 Deval 1940 (44)	 P. & W. 1958 (192)	 Hannan 1969 (74)	 Bruchmiller 1972 (29)
MARGINAL OR SHALLOW-WATER PLANTS:					
Pluchea purpurascens					X
Samolus cuneatus	X				
Samolus parviflorus					X
Rumex crispus	X				X
Hydrocotyle umbellata	X		X		
Hydrocotyle verticilatta					X
Paspalum dilatatum	X				
Mentha spicata	X				
Eclipta alba	X				X
Hicoria pecan	X				
Rulac texana	X				
Celtis mississippiensis	X				
Melia azedarach	X				
Carex crus-corvi	X				
Carex alata					X
Rubus trivialis	X				
Monniera monniera	X				
Poa annus	X				
Stachus agraria	X				

Table 28. Continued

Plants	Collectors				
	Watkins 1930 (283)	Deval 1940 (44)	P. & W. 1958 (192)	Hannan 1969 (74)	Bruchmiller 1972 (29)
MARGINAL OR SHALLOW-WATER PLANTS:					
Veronica peregrina	X				
Scirpus validus					X
Scirpus lacustris	X				
Scirpus etuberculatus			X		
Scirpus americana			X		
Cyperus odoratus					X
Cyperus acuminatus					X
Cyperus sp.			X		
Fuirena simplex			X		X
Alisma subcardatum		X			
Dianthera americana		X			
Lophotocarpus calycinus		X			
Pontederia cordata		X			
Echinodorus rostratus					X
Amaranthus albus					X
Calocasia antiquorum					X
Sambucus canadensis					X
Ambrosia psilotachya					X
Ambrosia trifida					X

Table 28. Continued

Plants	Collectors				
	Watkins 1930 (283)	Deval 1940 (44)	P. & W. 1958 (192)	Hannan 1969 (74)	Bruchmiller 1972 (29)
MARGINAL OR SHALLOW-WATER PLANTS:					
Aster subulatus					X
Eupatorium coelestinum					X
Solidago altissima					X
Vernonia baldwinii					X
Ipomoea trichocorpa					X
Juncus texanus					X
Teucrium canadenae					X
Oenothera speciosa					X
Plantago major					X
Galium aparine					X
Bacopa monnieri					X
Phyla incisa					X
Verbena scabra					X
STRICTLY AQUATIC PLANTS:					
Myriophyllum heterophyllum	X	X	X	X	X
Myriophyllum brasiliense				X	X
Ceratophyllum demersum	X	X	X	X	X
Zanichellia palustris	X	X	X	X	
Najas guadalupensis	X	X	X ? sp.	X	X

Table 28. Continued

Plants	Collectors				
	Watkins 1930 (283)	Deval 1940 (44)	P. & W. 1958 (192)	Hannan 1969 (74)	Bruchmiller 1972 (29)
STRICTLY AQUATIC PLANTS:					
Sagittaria platyphylla	X	X		X	X
Sagittaria latifolia			X		
Jussiaea diffusa (prob. *Ludwigia natans*)	X	X			
Jussiaea suffruticosa	X				X
Ludwigia natans		X	X ? sp.		X
Ludwigia palustris				X	
Polygonum punctatum					X
Polygonum opelousana (=*Persicaria opelousana*)	X				
Zizania aquatica	X				
Zizania texana		X			
Potamogetan americanus	X				
Potamogetan nodus				X	
Potamogetan illinoisensis				X	X
Potamogetan pectinatus		X		X	
Potamogetan crispus		X		X	X
Potamogetan natans		X			
Potamogetan pusillus		X			
Potamogetan sp.			X		
Nuphar advena	X	X	X		X

Table 28. Continued

Plants	Watkins 1930 (283)	Deval 1940 (44)	P. & W. 1958 (192)	Hannan 1969 (74)	Bruchmiller 1972 (29)
	Collectors				
STRICTLY AQUATIC PLANTS:					
Pistia stratiotes	X	X	X ? sp.		
Rorippa nasturtium (=*Nasturtium officinale*)	X	X	X		
Utricularia sublata	X			X	
Utricularia gibba					X
Utricularia sp.			X		
Lemna minor	X	X			X
Wolffia papulifera	X				X
Wolffia columbiana		X			
Azolla caroliniana	X	X	X		X
Wolffiella floridana	X				
Egeria densa (=*Elodea densa*)			X ? sp.	X	X
Elodea canadensis		X			
Heteranthera dubia				X	
Vallisneria americana			X	X	X
Vallisneria spiralis		X			
Chara vulgaris			X		
Fontinalis sp.			X		
Eichornia crassipes		X	X		X
Spirodela polyrrhiza		X			X

Table 28. Continued

Plants	Watkins 1930 (283)	Deval 1940 (44)	P. & W. 1958 (192)	Hannan 1969 (74)	Bruchmiller 1972 (29)
	Collectors				
STRICTLY AQUATIC PLANTS:					
Ceratopteris thalictroides					X
Limnophilia sessiliflora					X
Amblystegium riparium (=*Leptodictyum riparium*)	X			X	X
Riccia fluitans	X		X		X

Some of these are known to be introduced species, but the only known published record of an introduction is that of *Ceratopteris thalictroides* (73).

There are also numerous differences in the lists of marginal or shallow-water plants. Some of these differences can be attributed to errors in sampling and to differences in emphasis on the part of the researchers. However, since about 80% of the marginal plants listed by Bruchmiller (29) in 1972 are different from those reported by Watkins (283) in 1930, there has certainly been a major change in this type of vegetation. The obvious cause of this change has been the increased urbanization and commercial development of the headwaters region in the last 40 years, resulting in the elimination of many plants, introduction of new plants, and changes in habitat.

The headwaters of the San Marcos River is the habitat for one endemic plant species, *Zizania texana* (wild rice). Emery (50) stated that the population of wild rice, described in 1933 and reported as abundant at that time (151), is rapidly declining. He credited floating debris released by mowing, bottom plowing, intensive plant collecting, and pollution as the factors responsible for its decline and threatened extinction.

The San Marcos River, and the Edwards Plateau region in general, has a unique flora of bryophytes (284). San Marcos is recorded as the site locality for several species of mosses. Since many of these occur in or near streams, they warrant consideration in future alterations to be made on aquatic habitats in that area.

Hannan (74) carried out an extensive study of the relationship of community metabolism to community structure in the San Marcos River during a period of autotrophic succession following dredging which is done periodically in the headwaters. He found a general increase in species and biomass of plants as succession developed in the ecosystem, and that community metabolism fluctuated significantly in the immature community which developed in the disturbed area, whereas ecological stability increased as succession progressed. In addition to important basic concepts of community metabolism and community structure, the study gives good insight into the influence of disruption of plant communities on the ecosystem.

Numerous other studies involving plants and fauna associated with plants have been conducted in the headwaters of the San Marcos River (12, 40, 46, 73, 117, 131). The value of this unique plant association to biological research should not be overlooked in future considerations of the fate of the headwaters of this river.

A second unique ecosystem in the San Marcos River Basin is a series of six small marshes, or bogs, that occur just north of Ottine, Texas (adjacent R.M. 24). This marsh area has vegetation unlike any in Texas (18, 143). The terrestrial and aquatic vegetation of the bogs resembles that of east Texas, but is isolated on all sides by ecological barriers. Though most of the unique vegetation reported is terrestrial, the wet sandy flats have stands of Monniera, Hydrocotyle, Sagittaria *falcata*, *Typha latifolia*, and *Andropogon glomeratus* according to Bogusch (18). Raun (143) later mentioned water hyacinth (which he identified as *Iris hexagona*) in that area. This is the type of specialized habitat that should be preserved in its natural condition whenever feasible.

The Blanco River has been reported as having heavy growths of aquatic vegetation (182). In shallow riffle areas, pondweeds (*Potamogetan* spp.) and muskgrass (*Chara vulgaris*) abound, and in deeper, still pools, dense growths of spatterdock (*Nuphar advena*), cattails (*Typha latifolia*), spikerushes (*Eleocharis* spp.), sedges (*Cyperus* spp.) and pondweeds occur. Willows (*Salix* sp.), cottonwoods (*Populus* sp.), and cypress (*Taxodium* sp.) are common along banks. Spatterdock is mentioned as the plant most likely to become a problem in the river (182). Muskweed (*Chara vulgaris*) and bushy pondweed (*Najas guadalupensis*) have been reported as a minor problem in Blanco State Park (220).

A checklist of aquatic plants reported from the Blanco River and its tributaries within Kendall, Blanco, and Hays counties is given in Table 29.

Aquatic Macrophytes of the San Antonio River Basin

Aquatic vegetation is either absent or very sparse throughout most of the San Antonio River Basin. High turbidity, the absence of riffles, and the occurrence of unstable substrates are not conducive to aquatic plant growth. Since these conditions

Table 29. The aquatic macrophytes of the Blanco River and its tributaries within Kendall, Blanco, and Hays counties (37, 182, 220).

Common Name	Scientific Name
Cattail	*Typha latifolia*
Coontail	*Cerotophyllum demersum*
Pondweeds	*Potamogetan* spp.
Bulrush	*Scirpus etuberculatus*
Spikerush	*Eleocharis* sp.
Muskgrass	*Chara vulgaris*
Spatterdock	*Nuphar advena*
Sedges	*Cyperus* spp.
Water Pennywort	*Hydrocotyle umbellata*
Duck potato	*Sagittaria latifolia*
Bushy Pondweed	*Najas guadalupensis*
Water cress	*Nasturtium officinale*
False loosestrife	*Ludwigia* sp.
Water milfoil	*Myriophyllum heterophyllum*
Hedge nettle	*Stachys* sp.
Bladderwort	*Utricularia* sp.
Green algae	*Rhizoclonium* sp.
Red algae	*Batrachospermum* sp.

persist in the lower reaches of the San Antonio River in Wilson, Karnes, and Goliad counties, aquatic vegetation in that reach is not a problem, nor is it likely to become one (228). Kuehne (119) reported no macrophytic aquatic vegetation occurred in the San Antonio River below its junction with the Medina River (R.M. 214) in 1955, though some water pennywort (Hydrocotyle) was reported along banks and duckweed (Lemna sp.) in backwaters in 1961 (228).

In the upper reaches of the San Antonio River, fairly clear water and alterwating pools and riffles offer more favorable habitats for aquatic plants. Potamogetan, Sagittaria, Myriophyllum, and Eichornia occur there and have recently reached nuisance proportions (119, 234). This led to chemical treatment of water hyacinths (Eichornia) and submerged vegetation in several stretches of the river and its tributaries in the downtown San Antonio area in 1963 and 1964 (234, 242).

Woodlawn Lake, on Alazan Creek in the headwaters region of the San Antonio River, has experienced overabundance of vegetation on several occasions. The lake had no submerged plants in 1954, but troublesome stands of cattail (Typha latifolia) and bulrushes (Scirpus etuberculatus) along shores and severe clogging by lotus (Nelumbo pentapetala) during the summer (171). These were treated with 2,4-D in 1955 (179). Bushy pondweed (Najas guadalupensis) then became the most troublesome species and was eliminated, along with other submergents, in 1963 by treatment with sodium aresenite (233, 234).

The Medina River, the major tributary of the San Antonio River, is a spring-fed, shallow stream with a limestone substrate throughout most of its course (167). As a result of these favorable conditions for plant growth, it has a diverse flora typical of spring-fed streams, as shown by the list of aquatic vegetation occurring there (Table 30). Spatterdock is common throughout the river basin and is a nuisance in many areas of Bandera and Medina counties (178).

Medina Lake has little aquatic vegetation in the main body of the lake, apparently due to fluctuations in water levels and high phytoplankton populations. Pondweed (*Potamogetan* sp.), mixed with green algae (*Spirogyra* sp.) and blue green algae, occurs in small patches in spring areas, in shallow sloughs, and around the edges of the lake. Muskgrass (*Chara* sp.) is present in the spring of the year. There are no emergent plants, but desert willow (*Baccharis* sp.) quickly invades areas exposed as waters recede (45, 168, 177).

Cibolo Creek, a smaller tributary, has scattered stands of spatterdock, water pennywort, and arrowhead, along with various algae, but none are considered undesirable since they offer some cover for fish and invertebrate faunas. It is likely that winter kills of aquatic plants control the vegetation (228).

Aquatic Macrophytes of the Nueces River Basin

The Nueces River and its tributaries are clear, spring-fed streams that possess a varied aquatic flora. In the upper

Table 30. The aquatic macrophytes of the Medina River (167, 259)

Common Name	Scientific Name
Spatterdock	Nuphar advena
Cattail	Typha latifolia
Bulrush	Scirpus etuberculatus
Sedges	Eleocharis sp.
Sedges	Cyperus sp.
Water Plantain	Alisma sp.
Water Pennywort	Hydrocotyle umbellata
Water Milfoil	Myriophyllum sp.
Coontail	Ceratophyllum sp.
Muskgrass	Chara vulgaris
Bladderwort	Utricularia sp.
Pondweed	Potamogetan sp.
Wild Celery	Vallisneria sp.

Nueces and the upper tributaries, aquatic plants are seldom abundant except in pools backed up by dams (183, 297). The lower Nueces River, on the other hand, has a history of severe overabundance of aquatic vegetation. It appears that more effort has been expended to control aquatic vegetation in the Lake Corpus Christi region than in any comparable area in the state.

In the headwaters and tributaries, plants generally occur in amounts sufficient to provide sparse cover for fish. Washouts during floods, choking by silt, turbid waters, winter kills, and cropping by fish apparently hold plant populations in check (180, 297, 183). The most common plants are coontail (Ceratophyllum demersum), muskgrass (Chara vulgaris), and water milfoil (Myriophyllum heterophyllum). Cattails (Typha latifolia) occur occasionally along banks, spatterdock (Nuphar advena) is found in still, shallow waters, and water cress (Nasturtium officinale) is common in spring areas (183, 297).

The checklist in Table 31 shows the plants reported from the Nueces River and its major tributaries.

While the upper reaches of the Nueces River Basin have rarely experienced excessive plant populations, the South Plains and Gulf Prairies regions from Calallen (R.M. 13) to 20 miles above Corpus Christi Lake (R.M. 67), have experienced severe overabundance of aquatic plants, particularly water hyacinths (Eichornia crassipes). This has been an area of extensive aquatic plant eradication for the last ten years and the program has, apparently, been successful (280).

Table 31. Aquatic macrophytes of the Nueces, Frio, and Sabinal rivers (173, 180, 183, 184, 185, 186, 198, 221, 229, 245, 297).

Plants		Rivers		
Common Name	Scientific Name	Nueces	Frio	Sabinal
Cattail	*Typha latifolia*	X	X	X
Spikerush	*Eleocharis* sp.		X	X
Bulrush	*Scirpus etuberculatus*	X	X	X
Great Bulrush	*Scirpus validus*	X		
Sedges	*Cyperus* sp.	X	X	X
Sedges	*Eleocharis* sp.	X	X	X
Spatterdock	*Nuphar advena*	X	X	X
White Water Lily	*Nymphaea odorata*	X		
Pondweed	*Potamogetan* sp.	X	X	X
Pondweed	*Potamogetan nodus*	X		
Pondweed	*Potamogetan pectinatus*	X		
Bushy Pondweed	*Najas guadalupensis*	X		
Water Cress	*Nasturtium officinale*	X	X	X
Water Milfoil	*Myriophyllum heterophyllum*	X	X	X
False Loosestrife	*Ludwigia* sp.	X	X	X
Coontail	*Ceratophyllum demersum*	X	X	X
Muskgrass	*Chara vulgaris*	X	X	X
Umbrella Grass	*Fuirena simplex*	X	X	
Water Pennywort	*Hydrocotyle umbellata*	X	X	
Arrowhead	*Sagittaria* sp.	X	X	
Water Hyacinth	*Eichornia crassipes*	X		

Table 31. Continued

Plants		Rivers		
Common Name	Scientific Name	Nueces	Frio	Sabinal
Water Star Grass	*Heteranthera* sp.	X		
Horned Pondweed	*Zanichellia palustris*		X	
Duckweed	*Lemna* sp.	X		
Water Fern	*Azolla caroliniana*	X		

It was determined in 1953 that 2,4-D at about 4 lbs. acid equivalent per acre would kill water hyacinths (163). Early attempts to spray the chemicals from aircraft proved impractical (164), so techniques of spraying from boats were developed. The major problem encountered was the inability to penetrate mats of water hyacinths with boats (172). A technique was developed whereby a man utilizing two floats "walked" out onto the mats by alternately moving floats. He then sprayed a 150 ft circle with a power spray (188, 189). In this way, paths were cut into mats. Difficulty was encountered because water hyacinths quickly repopulated a cleared area, mainly by being washed in from upstream (189, 257). Also, mats in trees left standing in the lake proved impossible to treat so simultaneous treatment of the whole water hyacinth mass from the air was again recommended (204, 225, 230, 235). Aerial application proved less effective than anticipated, however (238), so techniques using boats were further refined.

Success in the eradication of water hyacinths is difficult to assess from reports. A total of 700 acres was reported on Lake Corpus Christi in 1955 (173). After over 200 acres were washed out by flooding and 200 acres destroyed chemically in 1957, 144 acres remained (196). Following a 200 acre kill in 1960, 1,100 acres remained (214), while 1,000 acres were reported to exist in 1962 after 990 acres were destroyed (225). Considerable progress was reported in 1963 when 2,500 acres were killed and the water hyacinths were termed under control (235). In 1964, 2,000 acres were destroyed and continued treatment was recommended (241). Despite the overly optimistic reports of the water hyacinths being under control, 8,000 acres were reported in the vicinity of Lake Corpus Christi in 1970. By 1971, however, this had been reduced to 200 acres, and it appears the overabundance of water hyacinths is under control (280).

Lake Corpus Christi does not usually have sufficient submerged aquatic vegetation to supply fish cover. High turbidity, silting, and a fluctuating water level are credited with eliminating underwater plants (175, 176, 229). Scattered stands of pondweeds (Potamogetan sp.) and bulrush (Scirpus sp.) furnish some cover and water hyacinths afford some protection (174). Of these, bulrush was determined to offer the best cover for small fish. Limited attempts to plant bulrushes (176, 258) showed promise if planted close enough together. An attempt to propagate cover vegetation by planting giant bulrush (Scirpus validus) seedlings, coontail (Ceratophyllum demersum) seeds, and tubers and leaves of white water lilies (Nymphaea odorata) was made in the Peritas Creek arm of the lake (198), but the degree of success was not reported.

Only rarely has any type of submerged vegetation in Lake Corpus Christi caused complaints. Pondweed (Potamogetan sp.) becomes sufficiently abundant in some areas to cause complaints but only local treatment has been recommended (218, 222). Water stargrass (Heteranthera sp.) has been a problem on occasion around docks and channels (229).

Cattail (*Typha latifolia*) is the only emergent cited as causing a problem. At times thick stands have made up to 30% of the shoreline inaccessible for bank fishing (222).

These problems caused by aquatic vegetation apparently result from the impoundment of water in Lake Corpus Christi. While water hyacinths would likely cause minor problems in an open stream, it is likely that flooding would prevent the build-up of nuisance populations. It is obvious that excessive vegetation is one serious consequence to be expected when impoundments are constructed and control measures need to be perfected.

RECOMMENDATIONS FOR FUTURE STUDIES

It is obvious from this report that our knowledge of the ecosystems of the Guadalupe, San Antonio, and Nueces river basins is so meager that it is not possible to formulate any firm conclusions concerning the ecosystems of any region within the study area. Data are not sufficient to gauge the impact on the biota of any event that occurred in the past, to make any predictions of expected future changes, nor even to be able to detect modifications in ecosystems that will occur in the future. We badly need these capabilities in planning future developments in these river basins but since this report considers all of the known biological data and finds it to be inadequate, the only feasible approach is to initiate new studies to develop these capabilities for the future. We therefore propose the following investigations be carried out.

The most obvious need at present is that of survey studies of the aquatic flora and fauna of the study area. Only on the fishes is there sufficient information on the species present and their distributions to warrant any conclusions. For all other major groups of organisms there should be intensive collection and identification of the organisms present. This is basic to all other investigations to be proposed, with the exception of some investigations on fishes. Survey work is very time consuming and involves much travel, both of which cause it to be expensive. During the last year, all Federal agencies which fund biological research were approached personally through their regional or main offices concerning funds to conduct survey work in this region. In every instance they indicated that no funds are available for such studies. So these studies must be funded locally or the data must accumulate from small studies over an extended period of time as researchers in academic institutions find time to devote to survey work.

Survey studies can be approached in several ways. One approach is to study a given group of organisms throughout an entire area and relate the distributions of species to ecological factors. A range of tolerance to different factors might then be established by determining the range in which they exist in nature.

A second approach is to study typical habitats in given reaches of a stream system and determine the inhabitants of each reach. This type of survey considers the entire communities of each of the different types of habitats. A logical approach to such a survey in the study area would be to select a stretch of each major river in the area near the headwaters on the Edwards Plateau, a second stretch just below the escarpment, and a third stretch in the coastal plain and survey all typical communities in each stretch. Community types would be riffle, pool, deep water, mud bottom, etc. to insure a representative sampling of each stretch.

A third approach is to center surveys in regions where some predictable change will occur and study the impact of the change by surveying typical communities in the area of impact prior to and following a change. Typical examples would be surveys of an area before and after the construction of a dam to determine the influence of impoundment on community structure or before and after the construction of a waste treatment plant to determine the impact of waste discharges.

The above approaches may be utilized separately or in combination to gain the knowledge needed. Also, they should be accompanied by studies of the physicochemical characters of the stream in the various stretches so that the influence of different physicochemical parameters can be determined. Within the study area, careful planning could eliminate the need for much of this physicochemical sampling since permanent physicochemical sampling stations are operated at various points throughout the drainage systems by the Texas Water Development Board - U. S. Geological Survey Program, Texas Water Quality Board, San Antonio River Authority, Guadalupe-Blanco River Authority, and the City of Corpus Christi. By situating study regions to coincide with these sampling stations much repetition in sampling could be avoided.

Though it is feasible to conduct surveys of only one part of a community, it would be more meaningful to survey the entire community. The sampling of such community components as benthic macroinvertebrates, plankton, bacteria, algae, macrophytes, and vertebrates (including fish and waterfowl) require several teams of researchers equipped and trained for specific types of sampling.

Coupled with the survey studies, there should be quantitative studies of all ecosystem components that will show differences in community structure in different regions and under various conditions. Investigations of species diversity, standing crops, and seasonal changes in community structure are obvious quantitative studies that should be made. These are among the best methods known at present for discerning differences between communities. These studies conducted in different regions of the study area where physicochemical characteristics are being monitered simultaneously would give valuable information about the influence of physicochemical factors on communities. In addition, community structure is the best tool available for determining the influence of water quality changes through time.

Community structure, as a whole, is much more responsive to subtle changes in environmental factors than is the presence or absence of "indicator species". Thus, the best criterion for determining what changes are occurring as conditions change in these river basins is to observe alterations in community structure. As changes in the hydrologic regime and water quality occur in these river basins it will be necessary to implement additional means of monitoring ecological changes. The most likely addition to current programs will be the periodic monitoring of macroinvertebrate populations at specified collecting stations. The San Antonio River Authority is presently preparing to initiate such a monitoring program.

The most critical of all considerations in conducting any of these survey or quantitative studies would be the choice of study areas. While it is beyond the scope of the present study to pinpoint where study sites should be, several points should be emphasized. Obviously, headwaters of the streams must be included since they offer the most undisturbed communities available. Special attention should be directed at the headwaters region of the Nueces River since it is unique in that isolation of communities is more likely there, due to the pattern of interrupted flow that results when the streams go underground.

Particular attention should also be directed to springs and spring runs in the study area. These harbor unique communities because of their ecological isolation. As previously pointed out, the larger of these springs are in danger of extinction. Studies that will give information about their influence on the biota are needed before watershed planners can evaluate expected benefits of future development that might reduce their flow as opposed to the benefits of alternative plans that would have less impact on spring flow.

In addition to general surveys of organisms, there are numerous other studies that should be conducted in the future. For example, though the general distribution of several species of fish based on their occurrence in a given biotic province or stream system has been reported by Hubbs (85), it would be beneficial to know the degree of influence exercised by such factors as riffles, pools, impoundments, springs, headwaters, aquatic vegetation, concentrations of various chemicals, etc. on the distribution of fish. If habitat preferences and limitations could be established for various fish species it would be of considerable value to water management personnel in making water management decisions. Such information would have predictive value in determining what beneficial or detrimental effects such events as decreasing the flow of springs, channelization of streams, construction of dams, presence of pollutants, etc. would have on fish populations. Such information could be obtained by careful sampling in various habitat types.

Quantitative determinations of fish populations are also needed, though difficult to obtain because of gear selectivity. Through investigations of species present, number of species in a given area, standing crops of fishes in an area, and growth rates for selected fish species, information could be gained that would be applicable in determining the effect of pollutants, soil types, impoundment of water, amount of protective cover, measures taken for stream improvements, etc. on fish populations. These quantitative determinations would require a sampling design that eliminates gear selectivity and allows for maximal gear efficiency relative to the habits of the fishes. Such a design would necessitate the use of a shocker and chemicals in combination with more conventional methods of sampling.

As indicated above, the range of tolerance of an organism can be determined to some extent by observing habitat preferences in nature. In addition, it is desirable to know the range of tolerance of some of the common forms for specific limiting factors in order to be able to predict the effect altered regimens will have on these organisms. Therefore, laboratory studies should be conducted to establish ranges of tolerance to such commonly occurring limiting factors as oxygen concentrations, temperature, salinity, pesticides, herbicides, metal ion concentrations, turbidity, etc. These ranges should be established for certain "key" species in various phyla. In selecting these "key" species it will be necessary to know the general distribution of species throughout the study area. The most useful information can be gained from species that have wide geographical distributions within the area but have disjunct distribution patterns. Care should also be taken to choose organisms that are readily dispersed but which form communities that are relatively immobile. Benthic macroinvertebrate species are best adapted for this type of study. The disjunct distribution of such organisms indicates that they are limited by ecological conditions and that their ranges of tolerance are of a magnitude that is commonly surpassed in nature. Any man-caused alterations in the environment would likely adversely affect such organisms at once. By establishing, through laboratory studies, the tolerance ranges of such organisms, biologists could provide criteria for estimating changes in biota that would result from proposed developments that would cause changes in the ecosystem and, even more important, be able to determine when stresses are being placed upon an ecosystem by observing the disappearance of those "key" forms.

Life histories of certain species in the study area should also be investigated, since it is necessary to know the requirements for all stages of the life cycle of an organism before the full impact of environmental changes can be predicted. A prime example in the study area is the river prawn, Macrobrachium spp. If a life history study indicates that breeding occurs only in bays, as is now believed, then the construction of dams with no provisions for upstream migrations will eliminate the river prawn from the rivers where they now are quite common. Other examples are life history studies to determine the dependence of certain insect species on substrate types during larval stages and the dependence of water-mites upon the occurrence of certain host insects which they parasitize as nymphs. Since these organisms are major food items in the food web, an understanding of their life cycles is essential to a full understanding of the ecosystem.

There is a distinct need for more knowledge of the movement of energy through the different trophic levels of ecosystems. The physiology of producer organisms, particularly the algae, should be investigated to determine the effect of cultural eutrophication on their productivity. Further, the flow of energy through the various consumer levels should be determined. This will require tedious studies of the feeding habits of many organisms, from herbivorous invertebrates through the carnivorous fishes. Admittedly, we are far from any complete understanding of energy flow through the ecosystems in the study area, but in the overall research program in these basins it should be kept in mind that this is an ultimate goal to be pursued and the research projects should be designed to contribute to this end when possible.

It is obvious from the small amount of concrete information included in the waterfowl section of this report that there is a real need for studies of waterfowl in inland areas. There is not sufficient information available to form even tentative conclusions on the effect that impoundments have on waterfowl, though it is logical they play a role in providing resting areas. Studies of the inland waterfowl in the study area would be difficult to do, but are badly needed.

These proposed research problems are beyond the capabilities of any one agency or institution. They are discussed in hopes that they will be included in an overall research effort in these river basins in the near future. This research effort needs to be coordinated in a well planned program to prevent repetition and to insure that sufficient information be derived to permit conclusions about the current status of ecosystems in the area. It is hoped that the Texas Water Development Board will continue research in these basins through an extensive, well coordinated program utilizing other state agencies and educational institutions.

LITERATURE CITED

1. Acad. of Nat. Sci. of Philadelphia. 1949. A biological survey of the Guadalupe River at Victoria and San Antonio Bay, Texas. A report to E. I. du Pont de Nemours and Co. by Acad. Nat. Sci. Phila. 49 p.

2. Acad. of Nat. Sci. of Philadelphia. 1963. Guadalupe River, Texas, stream survey report. Report to E. I. du Pont de Nemours and Co. by Limnol. Dept., Acad. Nat. Sci. Phila. 67 p.

3. Acad. of Nat. Sci. of Philadelphia. 1964. Catherwood diatometer readings, Guadalupe River, Texas. Tenth year progress report for E. I. du Pont de Nemours and Co. by Limnol. Dept., Acad. Nat. Sci. of Phila. 16 p.

4. Acad. of Nat. Sci. of Philadelphia. 1967. Cursory stream survey report of the Guadalupe River. Report to E. I. du Pont de Nemours and Co. by Limnol. Dept., Acad. Nat. Sci. Phila. 21 p.

5. Alexander, W. H., B. N. Myers, and O. C. Dale. 1964. Reconnaissance investigation of the ground-water resources of the Guadalupe, San Antonio, and Nueces river basins, Texas. Tex. Water Comm. Bull. 6409. 106 p.

6. Arnold, C. R. 1962. Oxygen consumption as a factor in the distribution of certain Trichoptera larvae. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 30 p.

7. Bailey, R. M., et al. 1970. A list of common and scientific names of fishes from the United States and Canada (Third ed.). Am. Fish. Soc., Spec. Publ. 6:1-149.

8. Baker, A. F. 1969. Taxonomic studies in the Oscillatoriaceae. Unpubl. Ph.D. Diss., Univ. Tex., Austin, Tex. 150 p.

9. Baker, J. K. 1961. Distribution of and key to the neotenic Eurycea of Texas. Southwest. Nat. 6:27-32.

10. Barron, J. C. 1964. Reproduction and apparent overwinter survival of the suckermouth armored catfish, Plecostomus sp., in the headwaters of the San Antonio River. Tex. J. Sci. 16:449-450.

11. Baughman, J. L. 1950. Random notes on Texas fishes. Part I. Tex. J. Sci. 2:117-138.

12. Becker, P. R. 1969. The systematics and seasonal distribution of the Cladocera of Hays County. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 95 p.

13. Becker, P. R., and S. Sissom. 1971. A summary of the cladoceran fauna of Texas. Tex. J. Sci. 22:424-425.

14. Bennett, G. W. 1962. Management of artificial lakes and ponds. Reinhold Publ. Corp., New York. 283 p.

15. Beyers, R. J. 1962. The metabolism of twelve aquatic laboratory microecosystems. Unpubl. Ph.D. Diss., Univ. Tex., Austin, Tex. 189 p.

16. Bischoff, H. W. 1965. Thorea riekei sp. nov. and related species. J. Phycol. 1:111-117.

17. Bogart, J. P. 1967. Life history and chromosomes of some of the neotenic salamanders of the Edwards Plateau. Unpubl. M.A. Thesis, Univ. Tex., Austin, Tex. 79 p.

18. Bogusch, E. R. 1928. Composition and seasonal aspects of the Gonzales County marsh associates. Unpubl. M.A. Thesis, Univ. Tex., Austin, Tex. 49 p.

19. Bolen, E. G. 1967. The ecology of the black-bellied tree duck in southern Texas. Unpubl. Ph.D. Diss., Utah State Univ., Logan, Utah. 138 p.

20. Bonham, K. 1939. Report of stream survey of Guadalupe River in Kerr County, Texas. Unpubl. manuscript. Tex. A. and M. Univ., College Station, Tex. 8 p.

21. Bonham, K. 1941. Food of gars in Texas. Trans. Amer. Fish. Soc. 70:356-362.

22. Bovie, I. W. 1972. Quantitative study of eight genera of planktonic algae in Canyon Lake over a three-year period. Unpubl. M.S. Thesis, Trinity Univ., San Antonio, Tex. 36 p.

23. Branson, B. A. 1960. Gastropoda of the Rob and Bessie Welder Wildlife Foundation Refuge, San Patricio County, Texas. Southwest. Natur. 5:143-159.

24. Breland, O. P. 1952. Keys to the larvae of Texas mosquitoes with notes on recent synonomy I. Key to genera and the species of the genus Aedes. Tex. J. Sci. 4:65-72.

25. Breland, O. P. 1953. Keys to the larvae of Texas mosquitoes with notes on recent synonymy II. The genus Culex Linnaeus. Tex. J. Sci. 5:114-119.

26. Brooks, E. G. 1950. Observations on fish subjected to various salt concentrations. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 29 p.

27. Brown, W. H. 1953. Introduced fish species of the Guadalupe River Basin. Tex. J. Sci. 5:245-251.

28. Brown, W. H. 1955. Egg production of the fish Hadropterus scierus apristis in San Marcos River, Texas. Copeia 2:149-150.

29. Bruchmiller, J. P. 1973. A key to the aquatic macrophytes of Spring Lake (excluding algae). Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. (In preparation).

30. Burch, J. B. 1972. Freshwater sphaeriacean clams (Mollusca: Pelecypoda) of North America. Water Poll. Contr. Res. Ser. Biota of Freshwater Ecosystems Ident. Man. No. 3. Environ. Prot. Ag., Wash., D. C. 31 p.

31. Burke, H. B. 1963. Notes on Texas riffle beetles (Coleoptera, Elmidae). Southwest. Nat. 8:111-114.

32. Cheatum, E. P. 1939. An annotated list of snails from Texas and northern Mexico collected by C. D. Orchard. Field and Laboratory 7:10-16.

33. Cheatum, E. P., and R. W. Fullington. 1971. Keys to the families of the recent land and fresh-water snails of Texas. The aquatic and land mollusca of Texas. Bull. 1 suppl., Dallas Mus. Nat. Hist. 18 p.

34. Cheatum, E. P., and J. P. Harris, Jr. 1953. Ecological observations upon the freshwater sponges in Dallas County, Texas. Field and Laboratory 21:97-103.

35. City of Corpus Christi Water Division. 1971. Annual statistical report on the Corpus Christi water works for fiscal year ending July 31, 1971. 69 p.

36. Colbert, B. K. 1973. Plankton periodicity in two man-made ponds in central Texas. Unpubl. M.S. Thesis, Southwest Tex. State Univ., San Marcos, Tex. (In preparation).

37. Conrads, L. M. 1969. Demography and ecology of the Fern Bank salamander, Eurycea pterophila. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 38 p.

38. Cooper, D. C. 1967. Ecological parameters concerning the zooplankton community of the San Antonio estuarine system. Unpubl. M.A. Thesis, Univ. Tex., Austin, Tex. 124 p.

39. Costello, T. J. 1971. Freshwater prawn culture techniques developed. Amer. Fish Farmer 2:8-10, 27.

40. Cox, E. R. 1966. Taxonomic, morphological, and physiological studies on the algal genus Stigeoclonium. Unpubl. M.A. Thesis, Univ. Tex., Austin, Tex. 331 p.

41. Cox, E. R., and H. C. Bold. 1966. Phycological studies VII. Taxonomic investigations of Stigeoclonium. Univ. Tex. Pub. 6618, Univ. Tex., Austin, Tex. 167 p.

42. Cushing, E. C. 1936. Mosquitoes of Brazos County, Texas. Trans. Tex. Acad. Sci. 19:5-9.

43. Davis, O. S., Jr. 1969. Effects of DDT and 2,4-D (sodium salts) on various enzymes of Micropterus salmoides. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 55 p.

44. Devall, L. L. 1940. A comparative study of plant dominance in a spring-fed lake. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 49 p.

45. Dietz, E. M., and K. C. Jurgens. 1963. An evaluation of selective shad control at Medina Lake, Texas. Tex. Parks and Wildl. Dept. 32 p.

46. Dowden, D. L. 1968. Population dynamics of the San Marcos salamander, Eurycea nana. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 44 p.

47. Drewry, G. E., E. A. Delco, Jr., and Clark Hubbs. 1958. Occurrence of the amazon molly, Mollienesia formosa, at San Marcos, Texas. Tex. J. Sci. 10:489-490.

48. Edwards, S. W. 1961. The immature stages of Xiphocentron mexico (Trichoptera). Tex. J. Sci. 13:51-56.

49. Edwards, S. W., and C. R. Arnold. 1961. The caddis flies of the San Marcos River. Tex. J. Sci. 13:398-415.

50. Emery, Wm. H. P. 1967. The decline and threatened extinction of Texas wild rice (Zizania texana Hitch.). Southwest. Nat. 12:203-204.

51. Evermann, B. W., and W. C. Kendall. 1894. Fishes of Texas and the Rio Grande Basin, considered chiefly with reference to their geographic distribution. Bull. U.S. Fish Comm. for 1892. p. 57-126.

52. Farber, W. E., Jr. 1950. An annotated list of the crustacea of the San Marcos area. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 43 p.

53. Ferguson, A. 1940. A preliminary list of the Odonata of Dallas County, Texas. Field and Laboratory 8:1-10.

54. Ferguson, A. 1942. Scattered records of Texas and Louisiana Odonata with additional notes on the Odonata of Dallas County. Field and Laboratory 10:145-149.

55. Flint, O. S., Jr. 1964. Notes on some Nearctic Psychomyiidae with special reference to their larvae (Trichoptera). Proc. U.S. Nat. Mus. 115:467-481.

56. Fowler, H. W. 1945. A study of the fishes of the southern piedmont and coastal plain. Monographs Acad. Nat. Sci. Phila. 7:480.

57. Fruh, E. G. 1972. Virus and bacteria analysis. Water quality report for San Antonio Ranch New Town. 6 p.

58. Geiser, S. W. 1934. Notes on Texas Crustacea. Field and Laboratory 2:59-60.

59. Geiser, S. W. 1936. A century of scientific exploration in Texas, Part 1:1820-1880. Field and Laboratory 4:41-55.

60. Geiser, S. W. 1939. A century of scientific exploration in Texas, Part 1b:1820-1880. Field and Laboratory 7:29-52.

61. Geiser, S. W. 1947. Notes on some workers in Texas entomology, 1838-1880. Field and Laboratory 15:35-41.

62. Geiser, S. W. 1958. Men of science in Texas, 1820-1880. Field and Laboratory 26:86-139.

63. Geiser, S. W. 1959. Men of science in Texas, 1820-1880:II. Field and Laboratory 27:20-48.

64. Geiser, S. W. 1959. Men of science in Texas, 1820-1880:III. Field and Laboratory 27:81-96.

65. Geiser, S. W. 1959. Men of science in Texas, 1820-1880:IV. Field and Laboratory 27:111-160.

66. Geiser, S. W. 1959. Men of science in Texas, 1820-1880:V (conclusion). Field and Laboratory 27:163-256.

67. Giesler, R. S. 1972. A comparison of the macroinvertebrates of Calaveras and Braunig lakes. Unpubl. M.S. Thesis, Trinity Univ., San Antonio, Tex. 18 p.

68. Grandy, P. A. 1960. A comparative study of the oxygen consumption of neotenic salamanders under varying conditions. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 42 p.

69. Guadalupe-Blanco River Authority. 1970. Water quality management study, Guadalupe River Basin. Report No. 1 to Texas Water Qual. Bd.: Survey of existing water quality. 114 p.

70. Hall, C. C., Jr. 1950. The Trichoptera or caddisflies of Dallas County, Texas. Field and Laboratory 18:165-177.

71. Hamilton, A. 1973. Some taxonomic aspects of certain paedgenetic Eurycea of the Blanco River drainage system in Hays and Blanco counties, Texas. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. (In preparation).

72. Hannan, H. H. 1967. Macrophyte standing crop and metabolism in a constant temperature river. Unpubl. Ph.D. Diss., Okla. State Univ., Oklahoma City, Okla. 47 p.

73. Hannan, H. H. 1969. The introduction and establishment of Ceratopteris in Texas. Amer. Fern J. 59 p.

74. Hannan, H. H. 1970. Succession of a macrophyte community in a constant temperature river. Limnol. and Oceanog. 15:442-453.

75. Hannan, H. H., and W. C. Young. 1970. Physicochemical limnology of the Guadalupe River, Texas. Final report to Tex. Water Qual. Bd. for IAC(68-69)-373. 152 p.

76. Hannan, H. H., W. C. Young, and J. J. Mayhew. 1972. Nitrogen and phosphorous dynamics in three central Texas impoundments. Hydrobiologia 40:121-129.

77. Hannan, H. H., W. C. Young, and J. J. Mayhew. 1973. Nitrogen and phosphorus in a stretch of the Guadalupe River, Texas, with five mainstream impoundments. Hydrobiologia (In press).

78. Hedgpeth, J. W. 1947. Fresh water shrimp. Tex. Game and Fish 5:14-15.

79. Hedgpeth, J. W. 1949. The North American species of Macrobrachium. Tex. J. Sci. 1:28-38.

80. Hobbs, H. H., Jr. 1972. Crayfishes (Astacidae) of North and Middle America. Water Poll. Contr. Res. Ser. Biota of Freshwater Ecosystems Ident. Man. No. 9. Environ. Prot. Ag., Washington, D. C. 173 p.

81. Hubbs, Carl L. 1954. A new Texas subspecies, apristis, of the darter Hadropterus scierus, with a discussion of variation within the species. Amer. Midl. Natur. 52:211-220.

82. Hubbs, Carl L., and R. M. Bailey. 1947. Blind catfishes from artesian waters of Texas. Occas. Papers Mus. Zool., Univ. Mich., Ann Arbor, Mich., No. 499. 15 p.

83. Hubbs, Clark. 1954. Corrected distributional records for Texas fresh-water fishes. Tex. J. Sci. 6:277-291.

84. Hubbs, Clark. 1956. Relative variability of hybrids between the minnows, Notropis lepidus and N. proserpinus. Tex. J. Sci. 8:463-469.

85. Hubbs, Clark. 1957. Distributional patterns of Texas fresh-water fishes. Southwest. Nat. 2:89-104.

86. Hubbs, Clark. 1958. Geographic variations in egg complement of Percina caprodes and Etheostoma spectabile. Copeia 2:102-105.

87. Hubbs, Clark. 1960. Duration of sperm function in the percid fishes Etheostoma lepidum and E. spectabile, associated with sympatry of the parental populations. Copeia 1:1-8.

88. Hubbs, Clark. 1961. A checklist of Texas fresh-water fishes. Tex. Game and Fish Comm. IF Ser. No. 3. 14 p.

89. Hubbs, Clark. 1961. Differences in the incubation period of two populations of Etheostoma lepidum. Copeia 2:198-200.

90. Hubbs, Clark. 1964. Effects of thermal fluctuations on the relative survival of greenthroat darter young from stenothermal and eurythermal waters. Ecology 45:376-379.

91. Hubbs, Clark. 1964. Interaction between a bisexual fish species and its gynogenetic sexual parasite. Bull. Tex. Mem. Mus. 8:1-72.

92. Hubbs, Clark. 1970. Teleost hybridization studies. Proc. Calif. Acad. Sci., Fourth Ser. 38:289-298.

93. Hubbs, Clark. 1971. Survival of intergroup percid hybrids. Jap. J. Ichthyol. 18:65-75.

94. Hubbs, Clark. 1971. Texas cave fishes, p. 91-93. In E. L. Lundelius and B. H. Slaughter, Natural history of Texas caves. Gulf Nat. Hist., Dallas, Tex.

95. Hubbs, Clark. 1972. A checklist of Texas freshwater fishes. Tex. Parks and Wildl. Dept., Tech. Ser. No. 11. 12 p.

96. Hubbs, Clark. ND. List of rare and endangered minnows. Univ. Tex., Austin, Tex. Unpubl. mimeo. 1 p.

97. Hubbs, Clark, and N. E. Armstrong. 1962. Developmental temperature tolerance of Texas and Arkansas-Missouri *Etheostoma spectabile* (Percidae, Osteichthyes). Ecology 43:742-744.

98. Hubbs, Clark, and E. A. Delco, Jr. 1962. Courtship preferences of *Gambusia affinis* associated with the sympatry of the parental populations. Copeia 2:396-400.

99. Hubbs, Clark, and M. V. Johnson. 1961. Differences in the egg complement of *Hadropterus scierus* from Austin and San Marcos. Southwest. Nat. 6:9-12.

100. Hubbs, Clark, R. A. Kuehne, and J. C. Ball. 1953. The fishes of the upper Guadalupe River, Texas. Tex. J. Sci. 5:216-244.

101. Hubbs, Clark, and C. M. Laritz. 1961. Occurrence of a natural intergeneric etheostomatine fish hybrid. Copeia 2:231-232.

102. Hubbs, Clark, and A. E. Peden. 1968. Notes on the distribution of blackbass (*Micropterus*) in the San Marcos River, Hays County, Texas. Tex. J. Sci. 20:193-194.

103. Hubbs, Clark, and A. E. Peden. 1969. *Gambusia georgei* sp. nov. from San Marcos, Texas. Copeia 2:357-364.

104. Hubbs, Clark, and V. G. Springer. 1957. A revision of *Gambusia nobilis* species group, with descriptions of three new species, and notes on their variation, ecology, and evolution. Tex. J. Sci. 9:279-327.

105. Hubbs, Clark, and K. Strawn. 1956. Interfertility between two sympatric fishes, *Notropis lutrensis* and *Notropis venustus*. Evolution 10:341-344.

106. Hubbs, Clark, and K. Strawn. 1957. Survival of F_1 hybrids between fishes of the subfamily Etheostominae. J. Exper. Zool. 134:33-61.

107. Hubbs, Clark, and K. Strawn. 1957. The effects of light and temperature on the fecundity of the greenthroat darter, Etheostoma lepidum. Ecology 38:596-602.

108. Hubbs, Clark, and K. Strawn. 1963. Differences in the developmental temperature tolerance of central Texas and more northern stocks of Percina caprodes (Percidae, Osteichthyes). Southwest. Nat. 8:43-45.

109. Jurgens, K. C. 1951. The distribution and ecology of the fishes of the San Marcos River. Unpubl. M.A. Thesis, Univ. Tex., Austin, Tex. 32 p.

110. Katz, M., and A. R. Gaufin. 1953. The effects of sewage pollution on the fish populations of a Mid-western stream. Trans. Amer. Fish. Soc. 82:156-165.

111. Kenk, R. 1972. Freshwater planarians (Turbellaria) of North America. Water Poll. Contr. Res. Ser. Biota of Freshwater Ecosystems Ident. Man. No. 1. Environ. Prot. Ag., Washington, D. C. 81 p.

112. Kennedy, C. H. 1921. Some interesting dragon-fly naiads from Texas. Proc. U.S. Nat. Mus. 59:595-598.

113. Kent, D. H. 1971. The effects of a deep-storage reservoir on the benthic macroinvertebrate community of the Guadalupe River, Texas. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 75 p.

114. King, J. M. 1971. Comparative studies of some palmelloid green algae. Unpubl. Ph.D. Diss., Univ. Tex., Austin, Tex.

115. Klemm, D. J. 1972. Freshwater leeches (Annelida: Hirudinea) of North America. Water Poll. Contr. Res. Ser. Biota of Freshwater Ecosystems Ident. Man. No. 8. Environ. Prot. Ag., Washington, D. C. 53 p.

116. Knapp, F. T. 1953. Fishes found in the freshwaters of Texas. Ragland Studio and Litho Print. Co., Brunswick, Georgia. 166 p.

117. Kronkosky, D. A. 1968. Characterization of chloroplast quinones and steridines in Limnophilia sessiliflora. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 36 p.

118. Kubota, S. 1970. Some limnological aspects of two reservoirs, Braunig Lake and Canyon Lake, with emphasis on some algal and chemical comparisons. Unpubl. M.S. Thesis, Trinity Univ., San Antonio, Tex. 25 p.

119. Kuehne, R. A. 1955. Stream surveys of the Guadalupe and San Antonio rivers. Tex. Game and Fish Comm. IF Rep. Ser. No. 1. 56 p.

120. Leffingwell, T. 1949. Embryology of the developing leech egg, Placobdella catenigera. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 23 p.

121. Maguire, B., Jr. 1964. Crustacea: a primitive Mediterranean group also occurs in North America. Science 146:931-932.

122. McClintock, W. A. 1930. Diary. Southwest Hist. Quart. 34:20-27, 141-158, 231-256.

123. Miller, R. R. 1972. Threatened freshwater fishes of the United States. Trans. Amer. Fish. Soc. 101:239-252.

124. Millspaugh, D. D. 1939. Bionomics of the aquatic and semi-aquatic Hemiptera of Dallas County, Texas. Field and Laboratory 7:67-87.

125. Mitchell, J. D. 1895. List of Texas Mollusca, land and freshwater. Nat. Sci. News 1:40.

126. Moore, G. A. 1968. Fishes, p. 22-165. In: W. F. Blair, et al., Vertebrates of the United States (Second ed.). Mc-Graw-Hill Book Co., New York.

127. Moore, L. E., Jr. 1950. Distribution of mayfly nymphs (Ephemeroptera) in streams of Dallas County, Texas. Field and Laboratory 18:103-112.

128. Muenzler, L. B. 1957. An ecological study of the distribution of amphibians and reptiles of Gonzales County, Texas. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 72 p.

129. Munson, J. W. 1946. The distribution of plankton in the San Marcos River. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 97 p.

130. Murray, H. D., and E. C. Roy, Jr. 1968. Checklist of fresh-water and land mollusks of Texas. Sterkeriana 30:25-42.

131. Nelson, E. J. 1944. A study of the water hyacinth and the animal life closely associated with it. Unpubl. Res. Paper, Southwest Tex. State Univ., San Marcos, Tex. 22 p.

132. Newman, C. 1939. Aquatic vegetation in the vicinity of Kerrville. Unpubl. manuscript, Tex. A. & M. Univ., College Station, Tex. 12 p.

133. Norris, W. E., Jr., C. R. Arnold, and S. W. Edwards. 1964. Oxygen consumption by caddisfly larvae. Tex. J. Sci. 16:72-79.

134. Odum, E. P. 1959. Fundamentals of ecology (Second ed.). W. B. Saunders Co., Philadelphia, Penn. 546 p.

135. Painter, D. E. 1968. Algal ecology related to phosphate reduction in Mitchell Lake. Unpubl. M.S. Thesis, Trinity Univ., San Antonio, Tex. 55 p.

136. Palmer, C. M. 1968. Algae, p. E1 - E27. In F. K. Parrish (ed.), Keys to water quality indicative organisms of the southeastern United States. Fed. Water Poll. Contr. Admin., U.S. Dept. Int.

137. Parfin, S. I., and A. B. Gurney. 1956. The spongilla-flies, with special reference to those of the Western Hemisphere (Sisyridae, Neuroptera). Proc. U.S. Nat. Mus. 105:421-529.

138. Parker, J. C., B. J. Gallaway, and D. Moore. 1971. Provisional keys to the marine fishes of Texas. Tex. A. & M. Univ., College Station, Tex. Unpubl. mimeo. 111 p.

139. Patrick, R. 1949. A proposed biological measure of stream conditions, based on a survey of the Conestoga Basin, Lancaster County, Pennsylvania. Proc. Acad. Sci. Phila. 101:277-341.

140. Patrick, R. 1950. Biological measure of stream conditions. Sew. and Ind. Wastes 22:926-938.

141. Penn, G. H., and H. H. Hobbs, Jr. 1958. A contribution toward a knowledge of the crawfishes of Texas (Decapoda, Astacidae). Tex. J. Sci. 10:452-483.

142. Ramsey, J. S. 1968. Freshwater fishes, p. Y1 - Y15. In F. K. Parrish (ed.), Keys to water quality indicative organisms of the southeastern United States. Fed. Water Poll. Contr. Admin., U.S. Dept. Int.

143. Raun, G. G. 1958. Vertebrates of a moist relict area in Texas. Unpubl. M.A. Thesis, Univ. Tex., Austin, Tex. 92 p.

144. Read, L. B. 1954. The Pelecypoda of Dallas County, Texas. Field and Laboratory 22:35-52.

145. Reddell, J. R. 1965. A checklist of the cave fauna of Texas. I. The Invertebrata (exclusive of Insecta). Tex. J. Sci. 17:143-187.

146. Reddell, J. R. 1966. A checklist of the cave fauna of Texas. II. Insecta. Tex. J. Sci. 18:25-56.

147. Reddell, J. R. 1967. A checklist of the cave fauna of Texas. III. Vertebrata. Tex. J. Sci. 19:184-226.

148. Reid, G. K. 1961. Ecology of inland waters and estuaries. Reinhold Publ. Corp., New York. 375 p.

149. Ross, H. H. 1941. Descriptions and records of North American Trichoptera. Trans. Amer. Ent. Soc. 67:35-126.

150. Shaw, E. G. 1948. The Macrobrachium carcinus of the San Marcos River. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 29 p.

151. Silveus, W. A. 1933. Texas grasses. Publ. by W. A. Silveus, San Antonio, Tex. 782 p.

152. Singleton, J. R. 1953. Texas Coastal waterfowl survey. FA Rep. Ser. No. 11. Tex. Game and Fish Comm. 127 p.

153. Singleton, J. R. 1971. Waterfowl habitat management in Texas. Tex. Parks and Wildl. Dept. Bull. 47. 65 p.

154. Singley, J. A. 1893. Texas Mollusca. Geol. Surv. Tex. 10:297-343.

155. Smith, G. M. 1950. The fresh-water algae of the United States. McGraw-Hill Book Co., Inc., New York. 719 p.

156. Stevenson, M. M. 1971. Percina macrolepida (Pisces, Percidae, Etheostomatinea), a new percid fish of the subgenus Percina from Texas. Southwest. Nat. 16:65-83.

157. Stojanovich, C. J. 1960. Illustrated key to common mosquitoes of southeastern United States. Publ. by C. J. Stojanovich, Atlanta, Georgia. 36 p.

158. Strawn, K. 1955. The method of breeding and raising three Texas darters, Part I. Aquarium J. 26:408-412.

159. Strawn, K. 1961. A comparison of meristic means and variances of wild and laboratory-raised samples of the fishes, Etheostoma grahami and E. lepidum (Percidae). Tex. J. Sci. 8:127-159.

160. Strecker, J. K., Jr. 1931. The distribution of the Naiades or pearly freshwater mussels of Texas. Baylor Univ. Mus. Spec. Bull. No. 2. 69 p.

161. Strecker, J. K., Jr. 1935. Land and freshwater snails of Texas. Trans. Tex. Acad. Sci. 17:4-45.

162. Suttkus, R. D. 1961. Additional information about blind catfishes from Texas. Southwest. Nat. 6:55-64.

163. Texas Parks and Wildlife Dept. 1953. Experimental spraying of water hyacinths with 2,4-D. Proj. No. F-6-R-1, Job E-1. 3 p.

164. Texas Parks and Wildlife Dept. 1954. Lake Corpus Christi water hyacinth control project. Proj. No. F-1-D-1. 2 p.

165. Texas Parks and Wildlife Dept. 1954. Inventory of fish species present in Lake Corpus Christi. Proj. No. F-6-R-1, Job B-3. 3 p.

166. Texas Parks and Wildlife Dept. 1954. Creel census and check of commercial catch of rough fish from Lake Corpus Christi. Proj. No. F-6-R-1, Job B-6. 9 p.

167. Texas Parks and Wildlife Dept. 1954. Basic survey of those portions of the Medina River, excluding Medina Lake, which lie within Medina, Bandera, and Bexar counties, Texas. Proj. No. F-9-R-1, Job A-2. 7 p.

168. Texas Parks and Wildlife Dept. 1954. Inventory of species present in Medina Lake, Bandera and Medina counties, Texas. Proj. No. F-9-R-1, Job B-1. 26 p.

169. Texas Parks and Wildlife Dept. 1954. Creel census of Medina Lake, Medina and Bandera counties, Texas. Proj. No. F-9-R-1, Job B-2. 6 p.

170. Texas Parks and Wildlife Dept. 1954. Inventory of species present and their distribution in those portions of the Medina River, exclusive of Medina, Bandera, and Bexar counties, Texas. Proj. No. F-9-R-1, Job B-3. 24 p.

171. Texas Parks and Wildlife Dept. 1954. Inventory of species present in Woodlawn Lake, San Antonio, Texas. Proj. No. F-9-R-1, Job B-7. 10 p.

172. Texas Parks and Wildlife Dept. 1955. Lake Corpus Christi water hyacinth control project. Proj. No. F-1-D-2. 2 p.

173. Texas Parks and Wildlife Dept. 1955. Basic survey of Lake Corpus Christi. Proj. No. F-6-R-1 & 2, Job A-3. 23 p.

174. Texas Parks and Wildlife Dept. 1955. Inventory of species present in Lake Corpus Christi. Proj. No. F-6-R-1 & 2, Job B-3. 32 p.

175. Texas Parks and Wildlife Dept. 1955. Fisheries problems determination. Proj. No. F-6-R-1 & 2, Job D-1. 2 p.

176. Texas Parks and Wildlife Dept. 1955. Experimental provisions of cover for game fish. Proj. No. F-6-R-2, Job E-2. 3 p.

177. Texas Parks and Wildlife Dept. 1955. Inventory of species present in Medina Lake, Bandera and Medina counties, Texas. Proj. No. F-9-R-2, Job B-1. 5 p.

178. Texas Parks and Wildlife Dept. 1955. Creel census of Medina Lake, Medina and Bandera counties, Texas. Proj. No. F-9-R-2, Job B-2. 4 p.

179. Texas Parks and Wildlife Dept. 1955. Fisheries problem determination. Proj. No. F-9-R-2, Job D-1. 4 p.

180. Texas Parks and Wildlife Dept. 1956. Basic survey of the Nueces, Frio, and Atascosa rivers. Proj. No. F-6-R-3, Job A-1. 12 p.

181. Texas Parks and Wildlife Dept. 1956. Inventory of the fish species in the Nueces, Frio, and Atascosa rivers. Proj. No. F-6-R-3, Job B-1. 6 p.

182. Texas Parks and Wildlife Dept. 1956. Basic survey and inventory of fish species present, as well as their distribution in the Blanco River, its tributaries and watershed lying within Blanco, Kendall, and Hays counties, Texas. Proj. No. F-9-R-3, Job B-10. 29 p.

183. Texas Parks and Wildlife Dept. 1956. Basic survey and inventory of fish species present, as well as their distribution in the Nueces River, its tributaries and watershed, lying within Edwards, Real, Uvalde, and Kinney counties, Texas. Proj. No. F-9-R-3, Job B-12. 23 p.

184. Texas Parks and Wildlife Dept. 1956. Basic survey and inventory of fish species present, as well as their distribution in the Frio River, its tributaries and watershed, lying within Real and Uvalde counties, Texas. Proj. No. F-9-R-3, Job B-13. 24 p.

185. Texas Parks and Wildlife Dept. 1956. Basic survey and inventory of fish species present, as well as their distribution in the Frio River, its tributaries and watershed, lying within Real and Uvalde counties, Texas. Proj. No. F-9-R-3, Job B-13. 24 p.

186. Texas Parks and Wildlife Dept. 1956. Basic survey and inventory of fish species present, as well as their distribution in the Sabinal River, its tributaries and watershed, lying within Bandera, Medina, and Uvalde counties, Texas. Proj. No. F-9-R-3, Job B-14. 15 p.

187. Texas Parks and Wildlife Dept. 1956. Rotenone fish population sampling of Medina Lake, Medina and Bandera counties, Texas. Proj. No. F-9-R-3, Job No. B-17. 9 p.

188. Texas Parks and Wildlife Dept. 1957. A search for a means of spraying the large mats of water hyacinths on Lake Corpus Christi with 2,4-D. Proj. No. F-6-R-3, Job E-3. 2 p.

189. Texas Parks and Wildlife Dept. 1957. A search for a means of spraying the large mats of water hyacinths on Lake Corpus Christi with 2,4-D. Proj. No. F-6-R-4, Job E-3. 4 p.

190. Texas Parks and Wildlife Dept. 1957. Influence of selective rotenone killing of rough fish (gizzard shad and European carp) on sport fishing and the standing fish populations of Medina Lake, Medina and Bandera counties, Texas. Proj. No. F-9-R-4, Job E-1. 35 p.

191. Texas Parks and Wildlife Dept. 1958. Resurvey of waters of Region 8-B. Proj. No. F-6-R-5, Job B-11. 25 p.

192. Texas Parks and Wildlife Dept. 1958. Basic survey and inventory of fish species present, as well as their distribution in the San Marcos River, its tributaries and watershed lying within Hays, Caldwell, Guadalupe, and Gonzales counties, Texas. Proj. No. F-9-R-5, Job B-18. 15 p.

193. Texas Parks and Wildlife Dept. 1958. Resurvey of the waters of Region 7-B. Proj. No. F-9-R-5, Job B-19. 3 p.

194. Texas Parks and Wildlife Dept. 1958. Influence of selective rotenone killing of rough fish (gizzard shad and European carp) on sport fishing and the standing fish populations of Medina Lake, Medina and Bandera counties, Texas. Proj. No. F-9-R-5, Job E-1. 33 p.

195. Texas Parks and Wildlife Dept. 1958. Experimental selective rotenone killing of undesirable fish species in flowing streams. (Continuation of Job E-3, Proj. F-9-R-3). Proj. No. F-9-R-5, Job E-3. 7 p.

196. Texas Parks and Wildlife Dept. 1959. Lake Corpus Christi water hyacinth control. Proj. No. F-1-D-3. 7 p.

197. Texas Parks and Wildlife Dept. 1959. Basic survey and fish inventory of four small lakes of the middle Nueces River. Proj. No. F-6-R-7, Job B-16. 10 p.

198. Texas Parks and Wildlife Dept. 1959. Supervision of regional development work. Proj. No. F-6-R-7, Job S-1. 3 p.

199. Texas Parks and Wildlife Dept. 1959. Resurvey of the waters of Region 7-B. Proj. No. F-9-R-6, Job B-19. 8 p.

200. Texas Parks and Wildlife Dept. 1959. Fisheries problem determination. Proj. No. F-9-R-6, Job D-1. 5 p.

201. Texas Parks and Wildlife Dept. 1959. Influence of selective rotenone killing of rough fish (gizzard shad and European carp) on sport fishing and the standing fish population of Medina Lake, Medina and Bandera counties, Texas. Proj. No. F-9-R-6, Job E-1. 33 p.

202. Texas Parks and Wildlife Dept. 1959. Experimental selective rotenone killing of undesirable fish species in flowing streams. Proj. No. F-9-R-6, Job E-3. 5 p.

203. Texas Parks and Wildlife Dept. 1959. Report of fisheries investigations, experimental control of sunfish and bullhead catfish with flathead and blue catfish. Proj. No. F-9-R-6, Job E-4. 7 p.

204. Texas Parks and Wildlife Dept. 1959. Lake Corpus Christi water hyacinth control. Proj. No. F-15-D-1, Job 15a-4. 2 p.

205. Texas Parks and Wildlife Dept. 1959. Control of spatterdock (Nuphar advena) on public lakes and stream areas on the Guadalupe River near Kerrville, Texas (Kerr County). Proj. No. F-15-D-1, Job 15a-5. 2 p.

206. Texas Parks and Wildlife Dept. 1959. Control of sawgrass (Zizaniopsis miliacea) and cattails (Typha latifolia) at Belmont Lake, Gonzales County, Texas. Proj. No. F-15-D-1, Job 15a-6. 2 p.

207. Texas Parks and Wildlife Dept. 1960. Resurvey of the waters of Region 8-B. Proj. No. F-6-R-6, Job B-11. 23 p.

208. Texas Parks and Wildlife Dept. 1960. Basic survey and inventory of fish species in the Escondido Creek watershed. Proj. No. F-6-R-6, Job B-14. 10 p.

209. Texas Parks and Wildlife Dept. 1960. Resurvey of waters of Region 8-B. Proj. No. F-6-R-8, Job B-11. 22 p.

210. Texas Parks and Wildlife Dept. 1960. Resurvey of the waters of Region 7-B. Proj. No. F-9-R-7, Job B-19. 11 p.

211. Texas Parks and Wildlife Dept. 1960. Fisheries problem determination. Proj. No. F-9-R-7, Job D-1. 3 p.

212. Texas Parks and Wildlife Dept. 1960. Fisheries problem determination. Proj. No. F-9-R-8, Job D-1. 4 p.

213. Texas Parks and Wildlife Dept. 1960. Selective control of gizzard shad and/or other undesirable fish species in five small lakes on the Guadalupe River in the Kerrville area, Kerr County, Texas. Proj. No. F-14-D-4, Job 16a-21. 10 p.

214. Texas Parks and Wildlife Dept. 1960. Lake Corpus Christi water hyacinth control. Proj. No. F-15-D-2, Job 15a-4. 2 p.

215. Texas Parks and Wildlife Dept. 1960. Control of spatterdock on public lakes and stream areas of the Guadalupe River near Kerrville, Kerr County, Texas. Proj. No. F-15-D-2, Job 15a-5. 2 p.

216. Texas Parks and Wildlife Dept. 1960. Chemical control of sawgrass and cattails on Belmont Lake, Gonzales County, Texas. Proj. No. F-15-D-2, Job 15a-6. 2 p.

217. Texas Parks and Wildlife Dept. 1961. Basic survey and fish inventory of four small lakes of the middle Nueces River. Proj. No. F-6-R-8, Job B-16. 11 p.

218. Texas Parks and Wildlife Dept. 1961. Fisheries problems determination. Proj. No. F-6-R-8, Job D-1. 2 p.

219. Texas Parks and Wildlife Dept. 1961. Fisheries investigations and surveys of the waters of Region 8-B; basic survey and fish inventory of the San Antonio River in Region 8-B. Proj. No. F-6-R-9, Job B-18. 2 p.

220. Texas Parks and Wildlife Dept. 1961. Fisheries reconnaissance. Proj. No. F-9-R-8, Job B-22. 7 p.

221. Texas Parks and Wildlife Dept. 1962. Fisheries reconnaissance. Proj. No. F-6-R-9, Job B-20. 29 p.

222. Texas Parks and Wildlife Dept. 1962. Resurvey of Lake Corpus Christi. Proj. No. F-6-R-9, Job B-21. 23 p.

223. Texas Parks and Wildlife Dept. 1962. Fisheries reconnaissance. Proj. No. F-9-R-9, Job B-22. 34 p.

224. Texas Parks and Wildlife Dept. 1962. Selective control of gizzard shad in Lake Dunlap. Proj. No. F-14-D-5, Job 16a-31. 9 p.

225. Texas Parks and Wildlife Dept. 1962. Lake Corpus Christi water hyacinth control. Proj. No. F-15-D-3, Job 15a-4. 3 p.

226. Texas Parks and Wildlife Dept. 1962. Control of sawgrass and cattails on Belmont Lake, Gonzales County, Texas. Proj. No. F-15-D-3, Job 15a-6. 2 p.

227. Texas Parks and Wildlife Dept. 1963. Fisheries reconnaissance. Proj. No. F-2-R-10, Job B-22. 22 p.

228. Texas Parks and Wildlife Dept. 1963. Basic survey and inventory of the fish species present in the San Antonio River. Proj. No. F-6-R-10, Job B-18. 12 p.

229. Texas Parks and Wildlife Dept. 1963. Fisheries reconnaissance. Proj. No. F-6-R-10, Job B-20. 25 p.

230. Texas Parks and Wildlife Dept. 1963. Experimental aerial herbicide spraying of water hyacinths. Proj. No. F-6-R-11, Job D-2. 4 p.

231. Texas Parks and Wildlife Dept. 1963. Basic survey and inventory of fish species present, as well as their distribution in the Sabinal River, its tributaries and watershed, lying within Bandera, Medina, and Uvalde counties, Texas. Proj. No. F-9-R-3, Job B-14. 15 p.

232. Texas Parks and Wildlife Dept. 1963. Fisheries reconnaissance. Proj. No. F-9-R-10, Job B-22. 13 p.

233. Texas Parks and Wildlife Dept. 1963. Fisheries problems determination. Proj. No. F-9-R-10, Job D-1. 8 p.

234. Texas Parks and Wildlife Dept. 1963. Supervision of regional developmental work. Proj. No. F-9-R-10, Job S-1. 3 p.

235. Texas Parks and Wildlife Dept. 1963. Lake Corpus Christi water hyacinth control. Proj. No. F-15-D-4, Job 15a-4. 4 p.

236. Texas Parks and Wildlife Dept. 1964. Fisheries reconnaissance. Proj. No. F-2-R-11, Job B-22. 18 p.

237. Texas Parks and Wildlife Dept. 1964. Fisheries reconnaissance. Proj. No. F-6-R-11, Job B-20. 33 p.

238. Texas Parks and Wildlife Dept. 1964. Fisheries problems determination. Proj. No. F-6-R-11, Job D-1. 2 p.

239. Texas Parks and Wildlife Dept. 1964. Experimental stocking of largemouth bass and threadfin shad in ponds in south Texas. Proj. No. F-6-R-11, Job E-6. 10 p.

240. Texas Parks and Wildlife Dept. 1964. Fisheries investigations and surveys of the waters of Region 5-A. Proj. No. F-9-R-11, Job B-22. 32 p.

241. Texas Parks and Wildlife Dept. 1964. Lake Corpus Christi water hyacinth control. Proj. No. F-15-D-5, Job 15a-4. 5 p.

242. Texas Parks and Wildlife Dept. 1964. Chemical control of water hyacinths (Eichornia crassipes) on the San Antonio River and its tributaries in Bexar and Wilson counties, Texas. Proj. No. F-15-D-5, Job 15a-16. 4 p.

243. Texas Parks and Wildlife Dept. 1965. Fisheries reconnaissance. Proj. No. F-2-R-12, Job B-22. 24 p.

244. Texas Parks and Wildlife Dept. 1965. Fish harvest regulations. Proj. No. F-5-R-12, Job B-28. 27 p.

245. Texas Parks and Wildlife Dept. 1965. Basic survey and inventory of fish present in the lower Nueces River. Proj. No. F-6-R-11, Job B-23. 10 p.

246. Texas Parks and Wildlife Dept. 1965. Fisheries reconnaissance. Proj. No. F-6-R-12, Job B-20. 24 p.

247. Texas Parks and Wildlife Dept. 1965. Fisheries reconnaissance. Proj. No. F-9-R-12, Job B-22. 19 p.

248. Texas Parks and Wildlife Dept. 1965. The K factor index, KI: a qualitative measure of fish populations. Proj. No. F-9-R-12, Job B-25. 24 p.

249. Texas Parks and Wildlife Dept. 1965. Vegetation survey of the Guadalupe River. Proj. No. F-12-R-10, Job B-11. 21 p.

250. Texas Parks and Wildlife Dept. 1965. Statewide rough fish control, walleye stocking in lakes Meredith and Canyon. Proj. No. F-14-D-8, Job 18a-22. 3 p.

251. Texas Parks and Wildlife Dept. 1966. Appraisal of various mesh sizes in taking fishes at Lake Corpus Christi, Texas. Proj. No. F-6-R-13, Job D-3. 4 p.

252. Texas Parks and Wildlife Dept. 1968. Experimental control of submerged vegetation in clear water lakes. Proj. No. F-2-R-15, Job E-7. 8 p.

253. Texas Parks and Wildlife Dept. 1968. Evaluation of catchable rainbow trout fishery. Proj. No. F-2-R-15, Job E-9. 24 p.

254. Texas Parks and Wildlife Dept. 1968. Appraisal of various mesh sizes in taking fishes. Proj. No. F-6-R-15, Job D-3. 9 p.

255. Texas Parks and Wildlife Dept. 1968. Stocking recommendations - Region 5-A. Proj. No. F-9-R-15, Job B-27. 2 p.

256. Texas Parks and Wildlife Dept. 1969. Stocking recommendations. Proj. No. F-6-R-16, Job B-25. 3 p.

257. Texas Parks and Wildlife Dept. 1969. Evaluation of catchable trout fishery. Proj. No. F-2-R-16, Job E-9. 18 p.

258. Texas Parks and Wildlife Dept. 1969. Fish toxicant studies. Proj. No. F-2-R-16, Job E-10. 6 p.

259. Texas Parks and Wildlife Dept. 1969. Life history study of the flathead catfish (*Pylodictus olivaris*). Proj. No. F-9-R-16, Job B-28. 6 p.

260. Texas Parks and Wildlife Dept. 1970. Evaluation of catchable rainbow trout fishery. Proj. No. F-2-R-15, Job E-9. 23 p.

261. Texas Parks and Wildlife Dept. 1970. Evaluation of catchable trout fishery. Proj. No. F-2-R-17, Job E-9. 8 p.

262. Texas Parks and Wildlife Dept. 1970. Fishery management recommendations. Proj. No. F-2-R-17, Job 26. 9 p.

263. Texas Parks and Wildlife Dept. 1970. Fisheries investigations - Region 5-B. Proj. No. F-6-R-17. Job II. 15 p.

264. Texas Parks and Wildlife Dept. 1970. Trotline study. Proj. No. F-6-R-17, Job III. 3 p.

265. Texas Parks and Wildlife Dept. 1970. Life history study of the flathead catfish (*Pylodictus olivaris*). Proj. No. F-9-R-17, Job IV. 27 p.

266. Texas Parks and Wildlife Dept. 1970. Pollution studies. Proj. No. F-12-R-15, Job 2-A. 22 p.

267. Texas Parks and Wildlife Dept. 1971. Evaluation of catchable rainbow trout fishery. Proj. No. F-2-R-15, Job E-9. 24 p.

268. Texas Parks and Wildlife Dept. 1971. Fisheries investigations - Region 5-B. Proj. No. F-6-R-18, Job II. 12 p.

269. Texas Parks and Wildlife Dept. 1971. Management recommendations. Proj. No. F-12-R-16, Job 10-A. 21 p.

270. Texas State Dept. of Health. 1969. Watershed survey of Lake Corpus Christi. 26 p.

271. Texas State Dept. of Health. 1970. Watershed survey of the central Guadalupe River Basin. 29 p.

272. Texas State Dept. of Health. 1970. Watershed survey of the lower Guadalupe River. 44 p.

273. Texas Water Development Board. 1968. The Texas water plan. Tex. Water Dev. Bd., Austin, Tex. 213 p.

274. Tharp, B. C. 1925. Structure of Texas vegetation east of the 98th meridian. Univ. Tex. Bull. No. 2606.

275. Tupa, D. L. 1972. An investigation of certain chaetophoralean algae. Unpubl. Ph.D. Diss., Univ. Tex., Austin, Tex. 280 p.

276. Turk, L. J., and E. G. Fruh. 1972. Summary report to the San Antonio Ranch Quality Advisory Review Board. 112 p.

277. Uhlenhuth, E. 1921. Observations on the distribution of the blind Texan cave salamander, Typhlomolge rathbuni. Bio. Bull. 15:73-104.

278. U.S. Air Force. 1971. Environmental pollution survey - Randoph AFB. Interim Data - Special Proj. 71-26. 49 p.

279. U.S. Air Force. 1971. Kelly AFB industrial waste treatment plant evaluation and the ecological effects of discharges. Rep. EHL(K) 71-33. 210 p.

280. U.S. Army Corps of Engineers. 1971. Aquatic plant control program, State of Texas. U.S. Army Eng. Dist., Galveston, Tex. 12 p.

281. U.S. Dept. of the Interior. 1960. Fish and wildlife resources of the Guadalupe-San Antonio Rivers Subbasin, Texas. Fish and Wildl. Serv., Bur. of Sport Fish. and Wildl. Albuquerque, N.M. 18 p.

282. U.S. Dept. of Interior. 1972. Environmental statement, Cibolo Project, Texas. Dept. of Int. Rep. DES 72-45. 39 p.

283. Watkins, Gustav M. 1930. Vegetation of San Marcos Springs. Unpubl. M.A. Thesis, Univ. Texas, Austin, Tex. 53 p.

284. Whitehouse, Eula. 1952. Bryology in Texas - mosses (Musci). Field and Laboratory 20:9-17.

285. Whiteside, B.G. 1972. Fish species diversity in relation to stream order and physicochemical conditions in the Plum Creek Drainage Creek. Amer. Midl. Nat. 88:90-101.

286. Williamson, E. B. 1914. Gomphus pallidus and two new related species (Odonata). Ent. News 25:49-58.

287. Wilton, J. R. 1971. A quantitative study of rotifers in Canyon Lake over a period of three years. Unpubl. M.A. Thesis, Trinity Univ., San Antonio, Tex. 22 p.

288. Wiseman, J. S., and R. B. Eads. 1960. Texas blackfly records (Diptera: Simuliidae). Mosquito News 20:45-49.

289. Woerner, H. A. 1971. Multiple regression analysis of nineteen variables influencing eutrophication in a 153-kilometer stretch of the Guadalupe River, Texas. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 80 p.

290. Young, W. C., H. H. Hannan, and J. W. Tatum. 1972. The physiochemical limnology of a stretch of the Guadalupe River, Texas, with five mainstream impoundments. Hydrobiologia 40:297-319.

291. Young, Willard. 1973. The Hydracarina of San Marcos Springs. (In preparation).

292. Young, W. J. 1971. The influence of impoundment and thermal stratification in Canyon Reservoir on the physicochemical limnology and chlorophyll a of the Guadalupe River, Texas. Unpubl. M.A. Thesis, Southwest Tex. State Univ., San Marcos, Tex. 85 p.

Raw Data

293. City of Corpus Christi. 1970-1972. Raw data. Water analysis upper Nueces River to George West. 37 p.

294. Texas Dept. of Health. 1967-1972. Raw data. Codes and data, bacteriological water quality.

295. Texas Parks and Wildlife Dept. Raw data. Guadalupe River Basin.

296. Texas Parks and Wildlife Dept. Raw data. San Antonio River Basin.

297. Texas Parks and Wildlife Dept. Raw data. Nueces River Basin.

Texas Parks and Wildlife Scientific Collecting Permits

298. Baldauf, R. J. 1965. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 204.

299. Caldwell, R. D. 1971. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 250.

300. Chaney, A. H. 1971. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 11.

301. Grant, R. R., Jr. 1966. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 234.

302. James, S. N. 1971. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 251.

303. Kennedy, H. D. 1971. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 266.

304. Mecham, J. S. 1967. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 82.

305. Ossian, C. R. 1970. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 312.

306. Ossian, C. R. 1971. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 12.

307. Ossian, C. R. 1972. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 85.

308. Reno, H. W. 1969. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 95.

309. Smith, P. W. 1965. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 196.

310. Suttkus, R. D. 1967. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 139.

311. Suttkus, R. D. 1968. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 155.

312. Whiteside, B. G. 1967. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 222.

313. Whiteside, B. G. 1968. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 222.

314. Whiteside, B. G. 1969. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 238.

315. Whiteside, B. G. 1970. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 76.

316. Whiteside, B. G. 1971. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 258.

317. Whiteside, B. G. 1972. Texas Parks and Wildlife Dept. Scientific Collection Permit No. 153.