STREAM SURVEYS

OF THE

Guadalupe and San Antonio Rivers

BY

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SECTION I of this report deals with the survey conducted of the Guadalupe River

SECTION II of the report deals with the survey conducted of the San Antonio River

Division of Inland Fisheries
TEXAS GAME AND FISH COMMISSION
Austin, Texas
Marion Toole, *Director*

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Sincere thanks are tendered to William H. Brown, Aquatic Biologist, for the leadership and direction he provided and for his assistance in the preparation of these reports.

Lawrence S. Campbell served as survey partner in the Guadalupe River Survey from July 5 to August 29, 1951. Jack C. Ball was survey partner from September 12, 1951, until the termination of work on the Guadalupe River survey, October 17, 1952. He shared in gathering most of the information for the report, and in the formulation of many of the ideas included in the finished product.

Joe Watterson was field assistant and able participant in the San Antonio River survey project.

Appreciation is tendered to Dr. Clark Hubbs, University of Texas, who was most helpful in checking identification of seining collections and making reference materials available.

FOREWORD

This is the first of a series of surveys on lakes and streams in Texas. These surveys are being conducted by the Division of Inland Fisheries of the Texas Game and Fish Commission in order to determine the status of the state's fresh waters.

The series of surveys was begun in July 1951. The two surveys included in this report were financed by state funds. More recent surveys are being conducted under the provisions of the Dingell-Johnson Federal Aid Program. Under the provisions of this program the Federal Government contributes 75 percent of the overall cost of the project, and the State Game and Fish Commission contributes 25 percent of the total cost.

MARION TOOLE
Division of Inland Fisheries
TEXAS GAME & FISH COMMISSION

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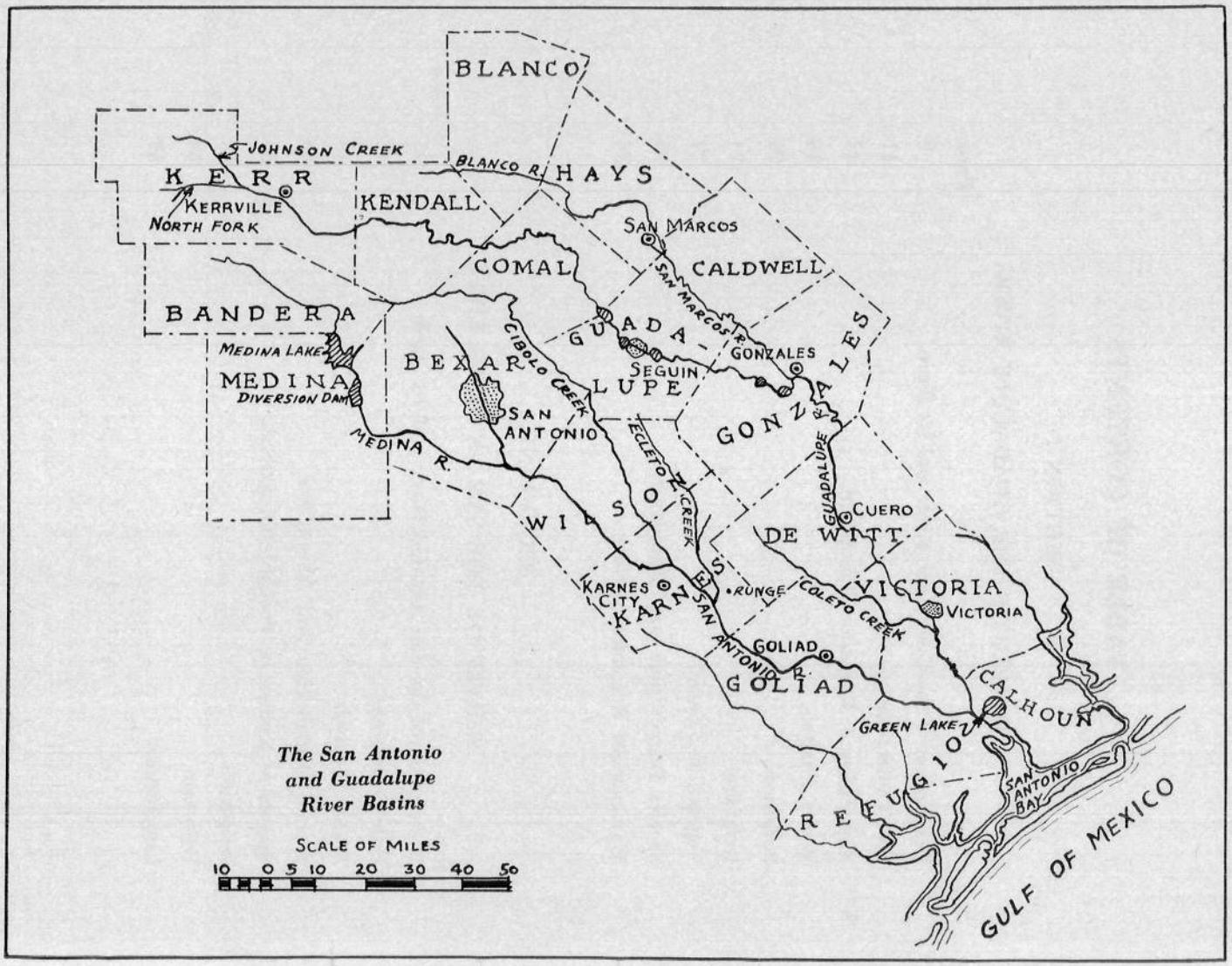
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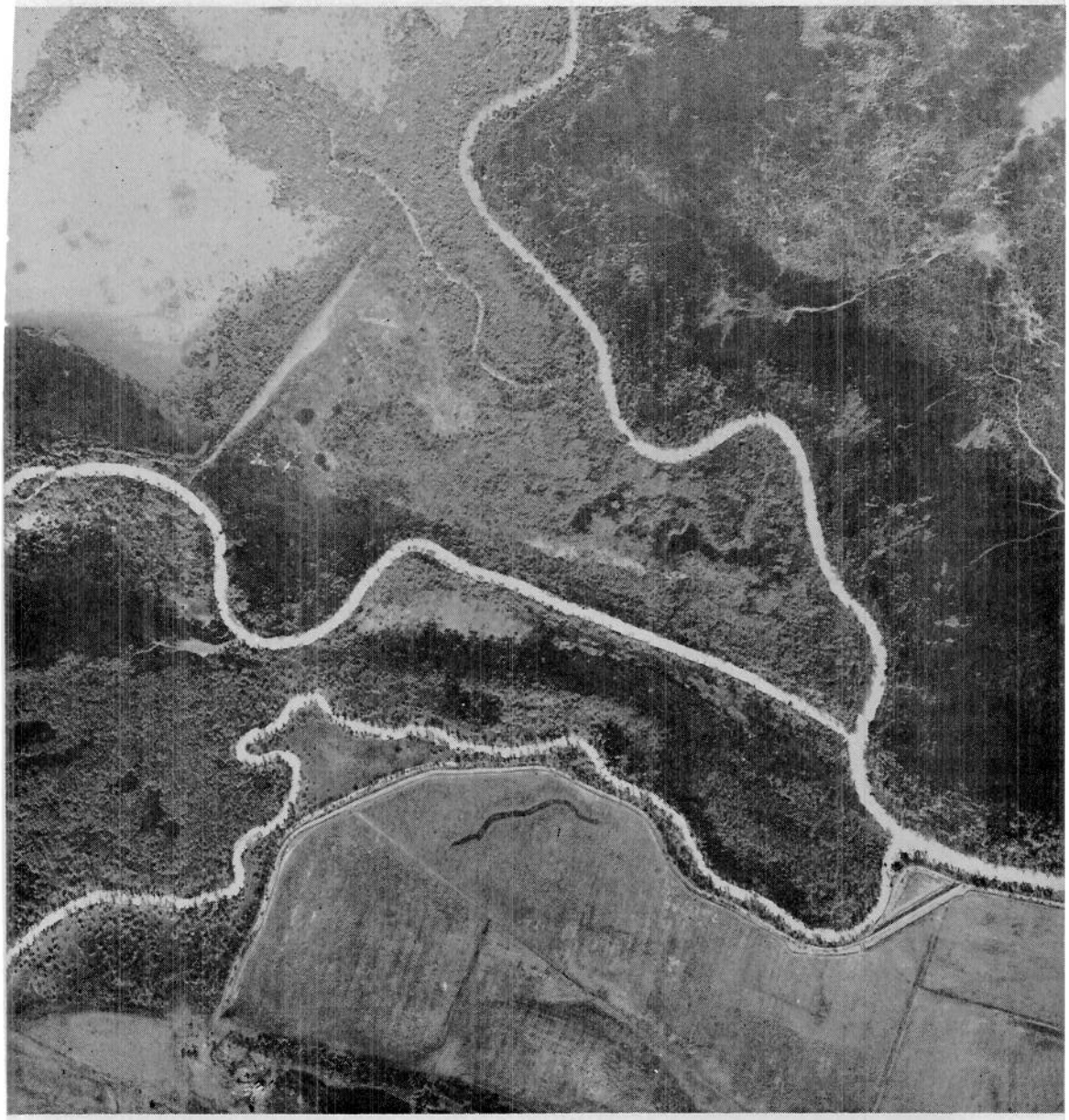


THE INTERSECTION OF THE GUADALUPE
AND SAN ANTONIO RIVERS

The above photograph shows clearly the meandering character of the San Antonio and Guadalupe Rivers just prior to their mergence. The Guadalupe River continues on into San Antonio Bay about eight miles to the east.

The headsprings of the North Fork. About 50 yards above this semi-circular area a small trickle of water disappears into a crevasse in the river bed and reappears as the stream pictured above. This section of the river forms the approximate south boundary of the Kerr Wildlife Area, which the Texas Game and Fish Department is using in wildlife experimentation.

East of the Balcones Fault Zone, near New Braunfels, the Guadalupe leaves the Edwards Plateau and enters the Blackland Prairie. From this point to the coast the river is characteriezd by a broad flat valley and meandering patterns.

Section I

STREAM SURVEY OF THE GUADALUPE RIVER

By
ROBERT A. KUEHNE
Aquatic Biologist

From July 5, 1951 to October 17, 1952 a survey of the fish populations of the Guadalupe River was conducted by the Inland Fisheries Division of the Texas Game and Fish Commission. Seining and gill net samples were taken throughout the length of the river as the primary means of determining the kinds and relative numbers of species present. The elimination of rough fish by the use of rotenone was evaluated in several experimental areas. Supplementary studies of water quality, pollution sources, general watershed conditions, and other factors were conducted to determine their effect on fish life. This report summarizes the findings of this survey and discusses several management practices designed to improve fishing in the Guadalupe watershed.

Description of Guadalupe River and Basin

The Guadalupe River rises in the Edwards Plateau west of Kerrville at an elevation of almost 2000 feet and flows southeastward into San Antonio Bay over 400 river miles away. The stream traverses five of the natural subdivisions of the state and itself assumes several distinct forms during its course.

In the Edwards Plateau the river is quite typical of the swift, shallow, and rocky streams of this hilly limestone region. Near its permanent spring sources the stream is extra clear, swift, and shallow. Various aquatic plants grow commonly in these upstream areas. Scattered stands of cypress appear along the banks near the headwaters and persist throughout the length of the stream. Sunfish, bass, catfish, minnows, and darters comprise the bulk of the fish population. Catches of fish are not large, partly due to the very limited water area and partly to the difficulty of capture in extremely clear water. 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. Sunfish and bass occur in diminished numbers and shad, suckers, and gar became the dominant fishes.

East of the Balcones Fault zone near New Braunfels 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 the Guadalupe receives a large and nearly constant water supply, which gives the stream the highest and most stable summertime flow of any Texas stream. Only minor areas of flowing water remain within the Blackland Prairie region since three power dams utilizing this stable water resource have converted the river into a series of long, channel filled lakes. These are Dunlap, McQueeney, and Placid. They are narrow, moderately deep, somewhat murky, and have heavy bottom deposits of mud. True aquatic plants occur only sporadically but cattails have invaded much shoreline area. Channel and flathead catfish and white crappie are caught in moderate numbers but bass and sunfish are not common. The Rio Grande cichlid is quite common in the uppermost of the lakes, where a fairly even temperature is maintained by the influence of the Comal River. Shad, suckers, buffalo, and gar are so abundant as to create a major rough fish problem.

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, gravelled riffles. Consolidated bedrock is found rarely. Lake Belmont and Lake Woods have converted much of this area into standing water and several smaller power dam lakes add to the impounded portion. Like those near Seguin these lakes are murky, partially silted, and invaded by cattails in many parts. Fishing in the open river is limited to catfish and spotted bass. The larger lakes furnish occasional strings of bass, redear sunfish, and bluegills in several sloughs, creek mouths, and oxbows and some fishing for catfish. The dominant fish remain gar, shad, suckers, and buffalo. Near Gonzales the Guadalupe receives the San Marcos River, which again increases the volume of flow in the lower Guadalupe 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 becomes wider and riffles fewer in number. 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, the shoreline trees disappear, and the river enters the bay in a large, open marsh. Several distributary channels carry water to the bay during flood times. The main game species of the river in the Coastal Prairie are again spotted bass and catfish. Best results in the area are had in the lower reaches in bayous and cutoffs, where both channel and blue catfish occur. Longnose, spotted, and alligator gar, shad, and buffalo dominate the population of the lower river.

In its course to the sea the Guadalupe receives many minor tributaries, most of which are extremely undependable in flow. The ma-

jority are restricted to standing pools during dry years. Strangely, the few constantly running tributaries are in the semiarid Edwards Plateau. They owe their existence to springs, which flow continuously regardless of fluctuations in rainfall. These streams in particular and all tributaries in general resemble the river headwaters in having fair populations of sunfish and bass and low numbers of the rough species constituting such a problem in most of the main stream.

Fish Collections

Seining results

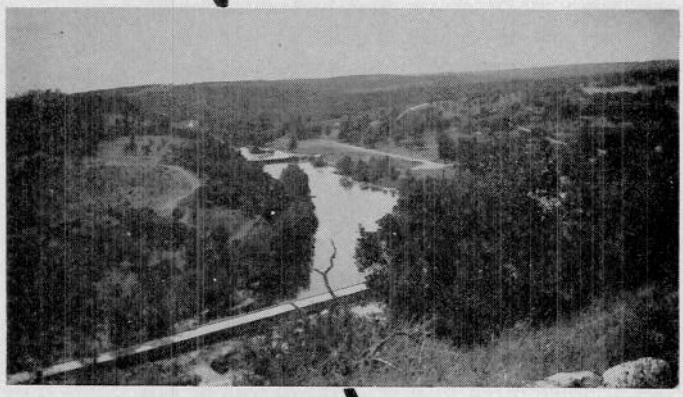
The most frequently used method of fish collecting was by seining. Fifty-two seining collections were made at varying intervals during the survey. Because of the ease of seining in the headwater areas, stations were inadvertently placed closer together than was later found practical in downstream areas. Thus, there is more seining data available for upstream portions of the river. Thirty foot regular and bag seines were used in accessible pools and ten, six, and four foot common sense minnow seines were employed in riffles and closely confined areas. All seining stations were made during daylight hours. Fifty-one species of fish were collected at one time or another by this method. In the lower portion of the river seining operations became increasingly difficult because of the greater depth and flow of the stream. Results generally showed a less complete picture than headwater collections. Shallow water inhabitants were usually caught but those species preferring deeper water were often missed. More frequent gill netting was necessary to help obtain more exact knowledge of fish populations in the lower Guadalupe.

Seining work was valuable in revealing the abundance of game fish in the upper reaches of the river and the decreasing frequency of their occurrence downstream. The range of distribution of many species was clearly defined by study of seining data. Habitat preferences and requirements of some fish could be ascertained by noting the area and water conditions at the time of capture. The relative numbers of rough fish could not be well determined by their frequency in seining hauls as they were never caught with consistency. However, it was soon found that large numbers of game fish indicated low numbers of rough fish, while few game fish indicated the presence of large concentrations of rough fish.

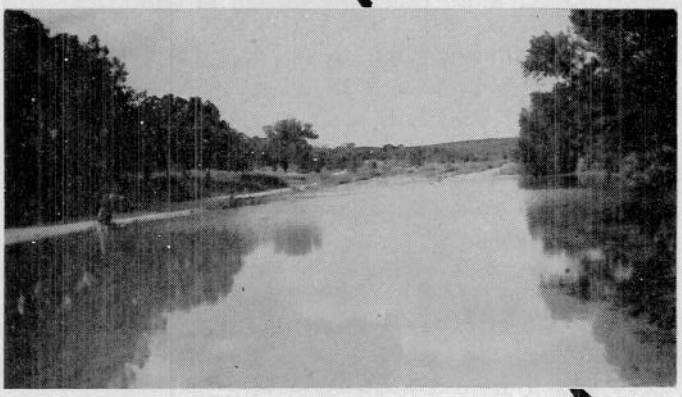
Gill netting results

During the survey forty-six individual gill net sets were made in various parts of the watershed as a means of determining fish populations, especially in relatively open water. Twenty-two species of fish were collected by this method, although many of these were also taken by seining. One hundred foot nylon and linen nets of one and a half, two, four, and experimental mesh sizes were used. All sets were made in the evening and run the next morning. Numbers, lengths, and weights of the various species collected were recorded for determining the relative abundance of game and rough fish.

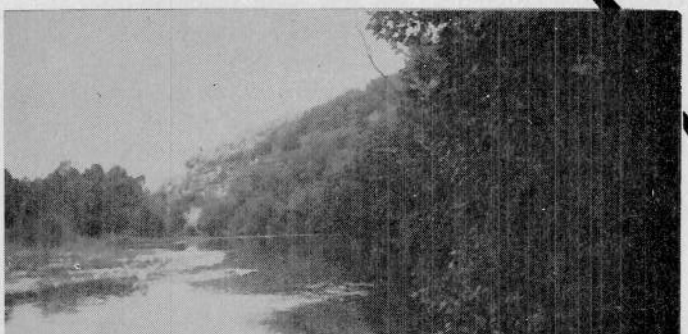
The junction of the North and South Forks to form the main river. The huge deposits of gravel have not yet killed the large cypress but small trees have been swept away. The South Fork enters from the left in a series of riffles.



Two low water dams at the Presbyterian Encampment far up the North Fork furnish a beautiful fishing and recreational area. Elevation of the river is just under 2000′. Elevation of the hill is about 2250′. Note the scattered areas where brush has been burned or cleared. The long ridge in the right background is the Edwards Formation from which the headsprings rise.



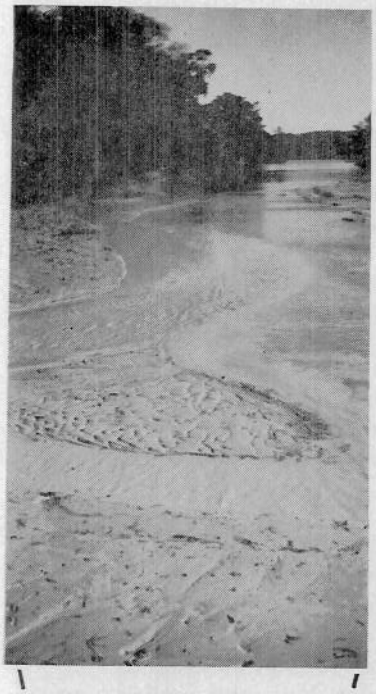
An extensive area of flat bedrock riffles on the North Fork. Spots such as this could be improved by construction of low water dams to create new habitat for game fish.



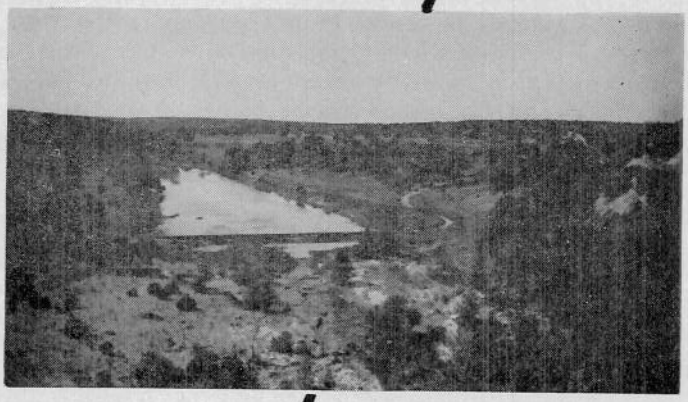
North Fork

The North Fork cuts sharply against a 150′ cliff. Fishermen frequenting this spot during the daytime experience

Johnson Creek above its springs stands in isolated pools in dry seasons. Notice the extensive flood gravels that have been left in the creek.

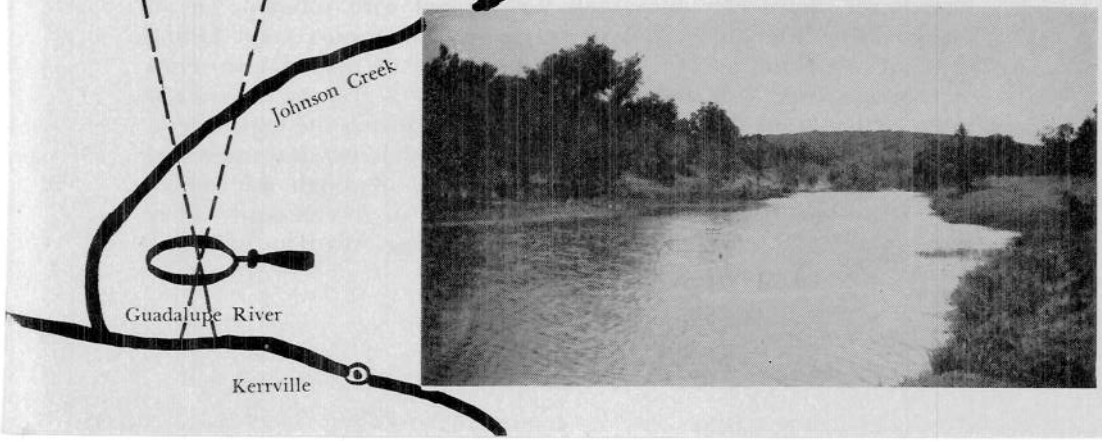


This striking example of stream pollution is just one mile west of Kerrville. Water used in washing sand and gravel is run directly into the stream. Seining in the pool below revealed no bass, very few sunfish, or minnows, but plenty of suckers.



Johnson Creek with the Heart of the Hills State Fish Hatchery in the distance. The low water dam has almost been filled in by gravel and boulders. A strip of land about 300 yards wide is virtually devoid of vegetation due to flood action.

A partially silted pool on the lower end of Johnson Creek. Shore line vegetation shows remarkable recovery from flood effects, but a long exposed gravel bar lies at the head of the pool. Flood crests of 20′ to 30′ are known in this area on some occasions.



Gill nets tend to catch more rough fish than game fish because of the greater activity of most rough species. This tendency explains why rough fish were dominant even in the sets made in the clear headwater portion of the river. However, these rough fish were usually shad and suckers and were accompanied by fair numbers of catfish, sunfish, and crappie. Gar became an increasingly large part of the population below Kerrville and except for catfish the percentage of game species became much reduced. This change occurred rather quickly and the new ratio remained fairly consistent from that point downstream.

At the end of each quarter during the survey a ratio of the rough and game fish collected in that period of time was made. The average of all these percentages is 89.6% in favor of the rough fish. Although this figure sounds extremely high, it is only slightly more than the actual ratios disclosed in the rotenone experiment near New Braunfels. The results of gill netting in the river strongly supported by actual evidence show that an extremely large rough fish population exists generally except in the clear headwaters.

Distribution of species

Table 1 shows the frequency with which the 66 species recorded by the survey were collected. The numbers are arranged so as to begin with headwater collections and run downstream. The table includes records of specimens taken by seining and gill netting. Many stations lying close together have been combined. It is interesting to note the more frequent records of minnows, darters, bass, and sunfish in the first 32 collections than in the remainder. Unfortunately, the chart does not reveal the fact that some entrys are based on one or two specimens and that others represent many individuals. For instance, some headwater records of largemouth black bass are based on dozens of individuals while other entries for this fish are based on very few specimens.

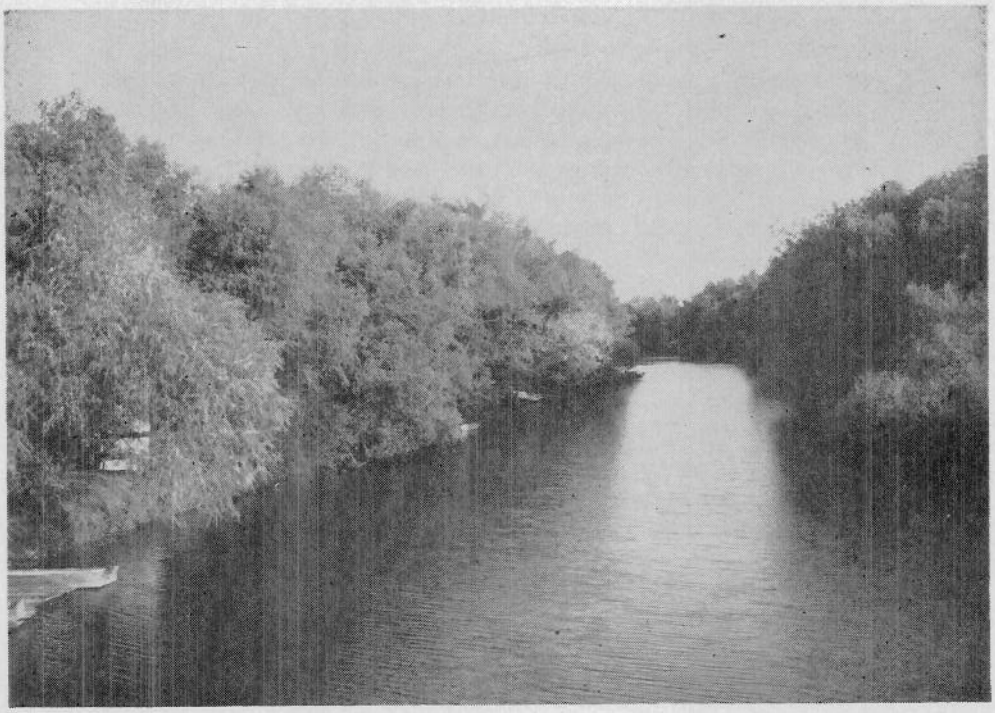
It can be seen that some species are of very wide and general distribution in the Guadalupe basin. Most notable of these are the redhorse shiner, mosquito fish, longear sunfish, and bluegill. Although not often taken in seining collections the longnose gar and gizzard shad should be included among the species of wide occurrence.

Experimental Rotenone Treatment

In September and October of 1951 a 20 mile stretch of the Guadalupe River above New Braunfels was treated with rotenone in an experimental attempt to control rough fish and restore good fishing through restocking. Although the final outcome of the work in terms of fishing success will not be fully known for a year or two, many interesting and helpful things were discovered during the experiment.

Several residents in and around New Braunfels became interested in testing the possibilities of rotenone control of rough fish, which they knew had become common in the river in recent years. They were organized by Game Warden Bill Sumbling. Warden Sumbling

The amount of flow of the Guadalupe increases after it receives the flow of the San Marcos River just southwest of Gonzales. This picture was taken at the bridge just south of Gonzales on U. S. Hwy. 183 after the Guadalupe has received the San Marcos River, and just before the river enters the Fayette Prairie.



Low banks are characteristic of the Guadalupe after it receives the San Antonio River near San Antonio Bay. Closer to the bay the trees disappear and the river enters the bay in a large open marsh.

also assisted in the operation which began with a single pool on the Dean Word Ranch. The small number of bass, sunfish, and catfish recovered and the preponderance of longnose gar, shad, suckers, and buffalo was convincing evidence that total poisoning in this portion of the river could do little harm and would eventually result in improved conditions. Low water conditions favored the controlled application of the chemical and the unusually warm temperatures increased its effectiveness. The entire area between Sattler and New Braunfels was treated to insure a sufficiently large test area. Public cooperation was exceptionally good and very few edible fish were wasted.

Results of application consistently showed that rough fish comprised over 80% of the total numbers of fish other than minnows, darters, and other small fish. In all pools the longnose gar was dominant, usually making up 60% to 70% of the population. Gizzard shad, Texas gray redhorse suckers, and smallmouth buffalo usually composed 10% to 20%, channel and flathead catfish about 10%, and largemouth black bass, Texas spotted bass, sunfish, and crappie always under 10% of the population.

Gill net collections in the Guadalupe below Kerrville had indicated that a large rough fish population was present but the experimental rotenone treatment gave concrete, visible evidence of the fact and convinced those people present of the seriousness of the condition. The experiment also showed the practicality of using rotenone as a corrective measure under certain water conditions. At present rotenone must be considered the most effective management aid that can be employed in rough fish control.

It was graphically illustrated that low game fish populations could not be blamed on overfishing. Several pools that were easily accessible to fishermen and fished by many visitors in the area showed no marked population differences from the most inaccessible pool treated. The so-called "fishing hotspots" were not encountered except for the presence of several pools containing a little better than average numbers of catfish. The stream displayed a remarkably consistent pattern in the relative abundance of various species. The concept of the adjustment of populations to the general capabilities of the habitat was well illustrated. The experiment pointed to the procedure necessary to successful future management: the elimination of rough fish followed by restocking to artificially swing the balance in favor of game fish, and the encouragement and promotion of proper land management techniques on the watershed to help restore the habitat conditions favoring the maintenance of game fish populations.

The upstream appearance of murky water and silted pools corresponds with the appearance of rough fish as a major problem. In the upper Guadalupe basin it is usually possible to predict the status of the fish ratios in a given area before seining or netting by studying the clarity of the water and bottom conditions. Siltation is the only factor found to rigidly control the suitability of habitat for most

Key to Collection Stations Listed in Table 1.

Table collection no.	Survey collection number	Location
1.	GS 6	Johnson Creek at Mountain Home, Kerr Co.
2.	GS 13	Fessenden Spring of Johnson Creek, Kerr Co.
3.	GS 5	Fessenden Spring Creek at State Fish Hatchery, Kerr Co.
4.	GN 7, 8	Johnson Creek at Roaring Rock Camp, Kerr Co.
5.	GS 4, 6 and GN 1	Johnson Creek, 4 mi. above mouth, Kerr Co.
6.	GS 3 and GN 9, 10	Johnson Creek, 2 mi. above mouth, Kerr Co.
7.	GS 2	Johnson Creek, 1 mi. above mouth, Kerr Co.
8.	GS 7	Springs, head N. Fork Guadalupe River, Kerr Co.
9.	GS 10	N. Fork Guadalupe R., 1.5 mi. below springs, Kerr Co.
10.	GS 15	N. Fork Guadalupe R., 6.5 mi. above Hunt, Kerr Co.
11.	GN 17, 18	N. Fork Guadalupe R., 2 mi. above Hunt, Kerr Co.
12.	GS 24	S. Fork Guadalupe R. at Lynx Haven Camp, Kerr Co.
13.	GS 8	S. Fork Guadalupe R., 7.6 mi. above Hunt, Kerr Co.
14.	GS 9	S. Fork Guadalupe R . 6.2 mi. above Hunt, Kerr Co.
15.	GS 14	S. Fork Guadalupe R., 4.5 mi. above Hunt, Kerr Co.
16.	GS 16	Junction N. and S. Forks Guadalupe R. at Hunt, Kerr Co.
17.	GS 12 and GN 6	Guadalupe R., 1 mi. above junction Johnson Creek, Kerr Co.
18.	GS 1 and GN 2, 3, 4, 5	Johnson Creek at mouth to 100 yds. above, Kerr Co.
19.	GS 17	Guadalupe R., 4 mi. E. Ingram, Goat Creek Road, Kerr Co.
20.	GS 18	Guadalupe R., 1 mi. W. Kerrville, Kerr Co.
21.	GS 21	Guadalupe R. at Kerrville State Park Road, Kerr Co.
22.	GS 22	Guadalupe R. at Center Point, Kerr Co.
23.	GN 13, 14, 15, 16	Guadalupe R., 200 yds. above junction Cypress Creek, Kendall Co.
24.	GS 20	Guadalupe R. at U. S. Hgwy. 87 Bridge, Kendall Co.
25.	GS 19 and GN 11, 12	Guadalupe R., Klemstein's Place, 4 mi. E. Comfort, Kendall Co.
26.	GS 25	Spring Creek, 1 mi. above entrance to Guadalupe R., Kendall Co.
27.	GS 27	Guadalupe R. at Crane's Mill Crossing, Comal Co.
28.	GS 28	Guadalupe R., E. edge T. C. McClure Ranch, Comal Co.
29.	GS 26	Bear Creek, below Bear Creek Road Crossing, Comal Co.
30.	RO 23	Guadalupe River, 1 mi. below Gruene, Comal Co.
31.	GS 30, 32	Comal River at head springs, Comal Co.
32.	GS 29, 31	Comal R. below swimming pool and at San Antonio St., New Braunfels
33.	GS 46 and GN 19, 20	Lake Dunlap, Guadalupe River, Guadalupe Co.
34.	GN 21	Lake McQueeney, Guadalupe River, Guadalupe Co.
35.	GN 22, 23	Lake Placid, Guadalupe River, Guadalupe Co.
36.	GS 47	Guadalupe R., ¼ mi. E. Tex. Hgwy. 123 near Seguin, Guadalupe Co.
37.	GS 36	Guadalupe R. below U. S. Hgwy. 80 Bridge, So. Belmont, Gonzales Co.
38.	RO 9 and GN 26, 27	Lake Belmont, Guadalupe River, Gonzales Co.
39.	GS 38	Guadalupe R. below power dam, Oak Forest, Gonzales Co.
40.	GN 24,25,28,29,30,31	Lake Wood, Guadalupe River, Gonzales Co.
41.	GN 34, 35	Backwaters Gonzales Power Dam, Guadalupe R., Gonzales Co.
42.	GS 34	Guadalupe R., ½ mi. S.E. U. S. Hgwy. 183 Bridge, Gonzales Co.
43.	GS 37 and GN 32, 33	Guadalupe R. at Abercrombe Ranch, Gonzales Co.
44.	GS 35	Peach Creek at Tex. Hgwy. 200 Bridge, Gonzales Co.
45.	GS 33	Guadalupe River at Dryer's Farm, Gonzales Co.
46.	GS 39	Guadalupe R., 1½ mi. So. U.S. Hgwy. 183 Bridge, Hochheim, DeWitt Co.
47.	GS 41	Fourth riffle above Cuero Lake, Guadalupe R., DeWitt Co.
48.	GN 36	Guadalupe R., ½ mi. from head Cuero Lake, DeWitt Co.
49.	GS 40	Sandies Creek at Tex. Farm Road 766, DeWitt Co.
50.	RO 10	Farm Pond, 2½ acres, Blackwell Ranch, DeWitt Co.
51.	RO 11	Pilgrim Lake, 6 acres, DuBois Ranch, N. of Westhoff, Gonzales Co.
52.	GS 44	Guadalupe River at U. S. Hgwy. 183 Bridge, So. Cuero, DeWitt Co.
53.	GS 42 and GN 37, 38	Guadalupe River at DeLeon, DeWitt Co.
54.	GS 45	Guadalupe R., ¼ mi. So. of bridge, 2 mi. W. Nursery, Victoria Co.
55.	GS 51 and GN 39, 40	Guadalupe River, Victoria City Park, Victoria Co.
56.	GS 50	Guadalupe River below DuPont Plant, Victoria Co.
57.	GS 43	Coleta Creek at U.S. Hgwy. Bridge 59, 10 mi. S.W. Victoria
58.	GN 41, 42	Old River Channel, Guadalupe River, W. Bloomington, Victoria Co.
59.	GS 49	Green Lake near Green Lake, Tex., Calhoun Co.
60.	GN 43, 44	Black's Bayou, ¼ mi. above Tex. Hgwy. 35, Calhoun Co.
61.	GN 45, 46	Guadalupe River, Tivoli Road, Calhoun Co.
62.	GS 48	San Antonio Bay, opposite mouth Guadalupe R., Long Mott, Calhoun Co.

species. Clear water is the preference of most game fish and the absolute requirement of some.

Water Analysis

Water analysis data were taken at 22 stations during the survey. Temperature, turbidity, and salinity were the only water properties tested for that were found to correlate at all with fish distribution. Dissolved oxygen counts often varied sharply between two stations from which identical or similar fish collections were taken, and the same situation was true for carbon dioxide and total alkalinity. Only in the broadest sense was fish distribution in the river affected by the chemical properties of the water.

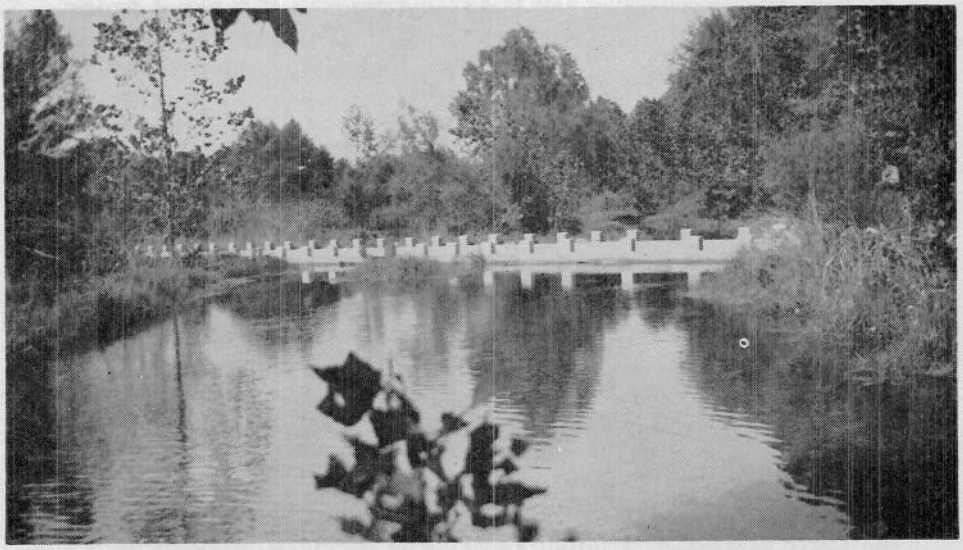
Temperature appears to be the primary if not the sole factor in controlling the distribution of the roundnose minnow, *Gambusia* sp., sailfin molly, fountain darter, Northern rock bass, and the Rio Grande perch. These fish are common only in or near spring areas, where a near constant temperature is maintained. The rock bass is unable to tolerate the warmer summer temperatures, while the sailfin molly and the Rio Grande perch are adversely affected by winter temperatures. The roundnose minnow, *Gambusia* sp., and the fountain darter are forms highly specialized for life in spring habitats.

Localized fish kills do occur due to the lack of dissolved oxygen but routine water analysis cannot reveal the fact that an area has undergone or will undergo such a kill. Under normal stream conditions it is safe to say that the Guadalupe River has a sufficient oxygen supply for the species now present. Summertime temperatures prevent high oxygen counts necessary for most northern species, notably trout, and introductions of these and similar fish have failed in the past and probably will continue to fail. Only one or two small areas around springs in the Kerr County region might support adult trout but the fish can be nothing more than an expensive novelty.

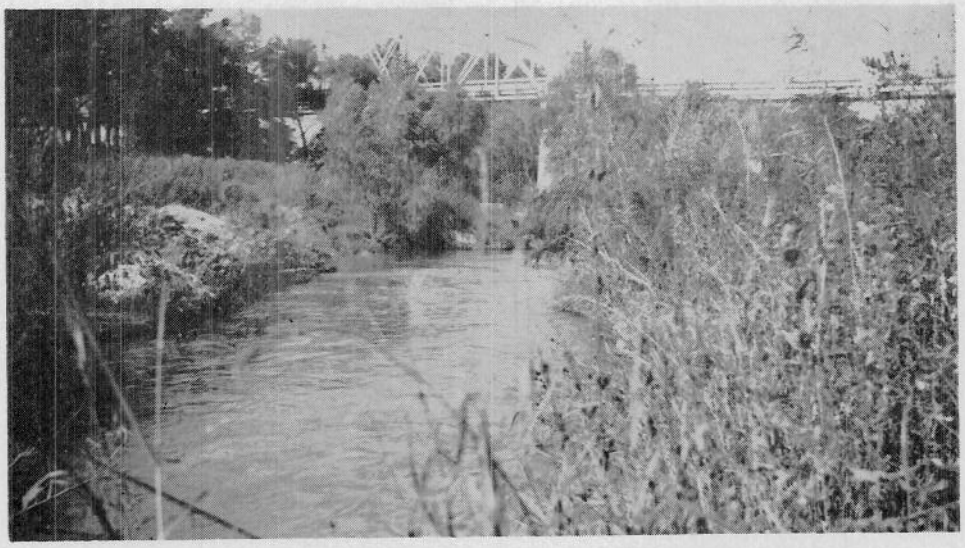
Free carbon dioxide varies from 30 parts per million at the main springs of the North Fork to nothing in collections made in warm, moving water. The presence and amount of carbon dioxide proved to vary greatly within short distances without affecting the fish population.

In one case the hydrogen ion concentration, pH, proved to be neutral but in all other samples the Guadalupe River waters were consistently basic in reaction. The lack of acid waters in the Guadalupe basin may restrict some species of fish common in East Texas from living in the watershed.

The total alkalinity of the stream is somewhat greater in the lower reaches than in the headwater areas but is consistently over 100 parts per million and contains sufficient calcium carbonate to stimulate high production of crustacea and aquatic insects, which furnish the basic food supply for most young game fish populations. High pro-



Large numbers of game fish were taken at this low water bridge on the South Fork. The main channel of the South Fork has been relatively undisturbed by floods in contrast to most of the river.



The Guadalupe River at the U. S. 87 bridge near Comfort. Above these riffles are a series of long pools. These pools contain virtually no game fish other than catfish. This condition is typical of the river below Kerr County.

duction of aquatic insects and smaller crustacea is still found in the extreme headwater areas and a few localized spots on the lower river, where normal turbidity is not too high. The high carbonate content of the river is due to the fact that most of the watershed is composed of limestone, shales, and marls from which calcium carbonate is leached by both meteoric and ground waters.

Normal chloride counts for the upper Guadalupe probably never exceed 30 parts per million and average between 10 and 20 parts per million. However, with the entrance of the San Marcos River the Guadalupe receives the effects of salt water pollution from the Luling and neighboring oil fields. At low water stages the chloride count of the Guadalupe at the Gonzales water works is usually about 250 parts per million and counts of over 1000 parts per million have been recorded several times. The small amount of dilution below this point causes these figures to hold fairly close for the entire stream below the entrance of the San Marcos.

At normal stream flow turbidity can hardly be measured in the clear headwaters of the Guadalupe, except for a slight murkiness on the lower portion of Johnson Creek. The stream is often turbid at Kerrville, where a gravel washing plant empties its waste water directly into the river. In the rest of the Edwards Plateau the stream has a slight murkiness but the bottom is visible in at least two feet of water except after rains. The larger lakes of the lower Guadalupe act as sediment traps and keep murkiness down considerably. Below Gonzales the river is always murky and the muddy water caused by floods clears very gradually.

Table 2 shows the results of the 22 water analysis stations made during the survey.

Pollution

Siltation

Siltation is the main form of pollution in the Guadalupe basin. Each new flood scours the stream bed and deposits a layer of silt over the bottom. In the Hill Country shoreline vegetation is stripped away as an additional bad effect. All evidence indicates that these floods are far more destructive than high water that occurred before 1900 and that they could be reduced in severity through proper land management practices.

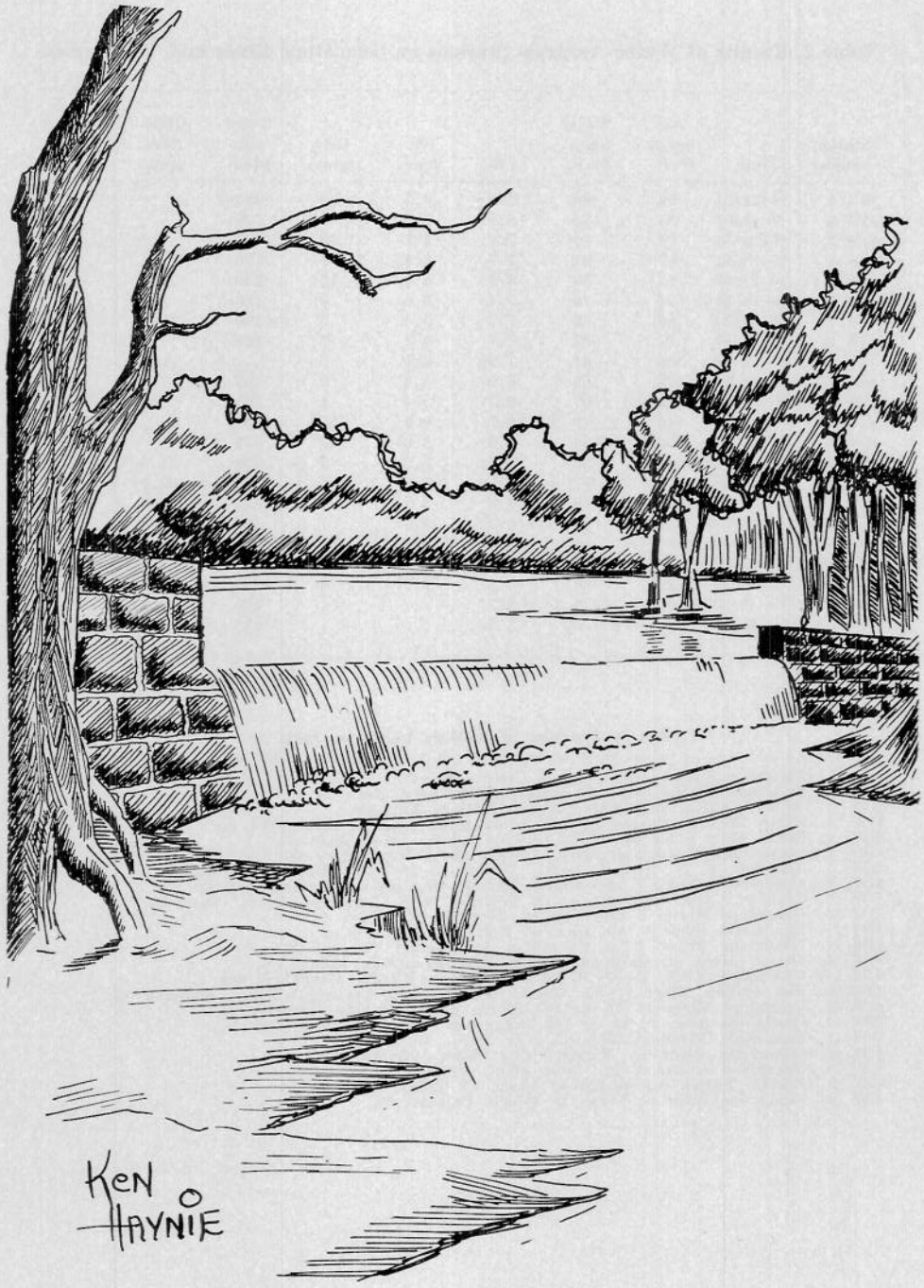
Information gathered by the late Henry Hahn indicates that the largest rise known on the Guadalupe River in Kerr County before 1900 was about six feet. A resident near New Braunfels stated that a log jammed against a cliff about five feet above normal river elevation had been washed out by the first major flood after the turn of the century. Flood crests of from 20 to 30 feet have been recorded several times in the upper Guadalupe in recent years. Many times as much damage can be done by a 20 foot rise as by a six foot rise and several times as much water is lost to the Gulf.

Table 2. Results of Water Analysis Stations on Guadalupe River and Tributaries.

Station number	Date	Air temp. 0° F.	Water temp. 0° F.	pH	O_2 ppm.	CO_2 ppm.	Total alk. ppm.	Chlorides ppm	Turb. ppm.
GW 1	7–21–51	92	69	7.2	4.5	22	185	....	...
GW 2	7– 9–51	95	84	8.4	6.6	0	179	....	...
GW 3	7–10–51	94	70	7.1	6.1	30	196	....	...
GW 4	7–18–51	97	91	7.7	8.4	0	190	....	...
GW 5	9–13–51	71	73	8.4	5.4	10	239	....	...
GW 6	9–13–51	74	76	8.4	6.6	0	169	....	...
GW 7	9–18–51	86	76	7.7	5.4	5	190	13.1	...
GW 8	7–25–51	87	82	7.7	4.2	5	108	....	...
GW 9	7– 6–51	84	81	7.5	4.1	5	...	....	...
GW 10	10–10–51	78	67	8.6	5.8	0	192	....	...
GW 11	10–10–51	78	67	8.3	5.4	1	201	....	...
GW 12	1–10–52	46	49	8.2	9.2	10	205	....	...
GW 13	1–12–52	73	74	7.0	3.6	18	235	....	...
GW 14	9–26–52	86	82	8.3	7.2	9	236	21.3	100
GW 15	9–26–52	87	77	8.5	6.5	5	230	92.1	100
GW 16	9–26–52	85	79	8.2	5.5	7	215	49.6	100
GW 17	9–26–52	80	79	8.2	4.0	7	217	53.0	130
GW 18	9–25–52	85	80	8.2	4.0	3	215	81.0	340
GW 19	10–16–52	..	71	8.6	...	..	225	106.4	...
GW 20	9–25–52	85	80	8.1	3.6	4	217	71.0	...
GW 21	10– 8–52	63	74	8.7	...	..	225	70.9	...
GW 22	10–15–52	65	74	8.8	...	..	249	88.6	...

Key to Location of Stations Listed in Table 2.

GW 1. Fessenden Spring, near Johnson Creek, Kerr Co.
GW 2. Fessenden Spring Creek at State Fish Hatchery, Kerr Co.
GW 3. Main Springs, North Fork Guadalupe River, Kerr Co.
GW 4. North Fork Guadalupe River, 1.5 mi. below main springs, Kerr Co.
GW 5. South Fork Guadalupe River, 7.6 mi. above Hunt, Kerr Co.
GW 6. South Fork Guadalupe River, 6.2 mi. above Hunt, Kerr Co.
GW 7. Junction of N. and S. Forks, Guadalupe River at Hunt, Kerr Co.
GW 8. Guadalupe River, 1 mi. above junction of Johnson Creek, Kerr Co.
GW 9. Johnson Creek, 0.1 mi. above junction with Guadalupe River, Kerr Co.
GW 10. Guadalupe River, 2 mi. west of Kerrville, Kerr Co.
GW 11. Guadalupe River, 1 mi. west of Kerrville, Kerr Co.
GW 12. Guadalupe River, U. S. 81 bridge, at Comfort, Kendall Co.
GW 13. Comal River at main springs in New Braunfels, Comal Co.
GW 14. Guadalupe River at U. S. 90 bridge near Seguin, Guadalupe Co.
GW 15. San Marcos River, 2 mi. above junction with Guadalupe River, Gonzales Co.
GW 16. Guadalupe River at U. S. 183 bridge near Gonzales, Gonzales Co.
GW 17. Guadalupe River at U. S. 183 bridge near Cuero, De Witt Co.
GW 18. Guadalupe River at Victoria City Park, Victoria Co.
GW 19. Guadalupe River at Victoria City Park, Victoria Co.
GW 20. Guadalupe River at Du Pont plant, Victoria Co.
GW 21. Black's Bayou, 0.3 mi. above Texas 35 bridge, Calhoun Co.
GW 22. Guadalupe River at Texas 35 bridge, Calhoun Co.



The construction of self-clearing low water dams such as that depicted above on the upper Guadalupe are desirable for increasing the amount of game fish habitat.

The Guadalupe receives many minor tributaries on its course to San Antonio Bay. Shown here is one of these minor tributaries, Coletto Creek, in the summer of 1954, when it was reduced to standing pools along its route. Heavy rains in the fall would again fill the banks of the creek to capacity.

The summertime flow of the river seems to have decreased markedly in recent years and many springs formerly considered permanent have become intermittant. The large spring at Landa Park, normally the second largest in the state, went dry in the summer of 1952. Rainfall has not been held on the watershed but has run off the land carrying topsoil with it and choking the river with silt.

The failure to maintain good cover on grazing areas and the improper management of much of the farming land of the watershed is directly responsible for the high degree of runoff and resulting floods. Silt deposits and murky water decrease the crustacea and aquatic insect populations on which young game fish are dependent and as a result the game fish are reduced in number. The extension of silt deposits over the bottoms of pools increases the feeding area of the sucker type, bottom feeders, which multiply because of the added habitat. Thus an entirely new ratio between rough and game fish can be effected and indeed has been in most of the Guadalupe River.

Industrial and municipal pollution

The various forms of industrial and municipal pollution, although important causes of trouble on many streams, hold a status of second-

ary importance on the Guadalupe River. As mentioned under the topic of salinity, the saltwater and sludge pollution from the Luling Oil Field is the primary source of industrial pollution in the watershed and enters the Guadalupe via the San Marcos River. Several injection wells have been drilled by the major producers but some operators still hold the brine in pits to be emptied at high stages of the river. When these pits break or overflow at low water stages the chloride count of the San Marcos jumps to dangerous levels. Perhaps of more damage than the brine is the occasional escape of heavy oil from slush pits. The combination of saltwater and sludge has nearly sterilized the lower San Marcos at least once. The Guadalupe quickly dillutes the effects of pollution from the San Marcos but some bad results must be felt since cattle often refuse to drink river water for several miles below the mouth of the San Marcos.

Minor pollution from a cedar cutting mill near New Braunfels, the Veterans Hospital at Legion, and the cotton mill at New Braunfels have been reported in recent years and the causes remedied. No major cities lie directly on the Guadalupe watershed and sewage disposal facilities of the smaller towns are adequate according to the State Health Department. The Du Pont plant at Bloomington discharges its wastes into solar evaporation lakes and has caused no pollution to the river as far as is known.

The practice of sand and gravel companies to discharge their wash water directly into the river must be considered industrial pollution. The A. Swartz Co. of Kerrville keeps two or three miles of river murky at most times and the result is that this section is inferior habitat for the game species that should be present. Gravel washes near Victoria tend to pollute the river similarly but normal murkiness of the water keeps the results from being so striking as at the Kerrville plant.

Irrigation

Irrigation on the upper Guadalupe has at times reduced stream flow to a dangerous point. Water users on Johnson Creek and the North Fork as well as the Mosty nursery, southeast of Kerrville, draw heavily on the river during its low summer stage. The granting of irrigation rights to any new users on the upper Guadalupe might result in the cessation of flow as shown by the drastically low stage in the summer of 1951. Wise water use and prevention of any waste should prevent the stream from drying.

Rice irrigation demands on the lower Guadalupe are very small and considerable expansion of rice farming would be necessary to cause any danger to the stream.

Vegetation Control

The overabundance of aquatic vegetation during the summer months in ponds and tanks of the watershed is a common cause of

worry to many landowners. Chemical control of these plants by the use of copper sulfate, sodium arsenite, and other herbicides is known but the concentration must be carefully watched or a fish kill may result. Pond vegetation, most often *Chara*, muskgrass, will not grow in deep water and the best way to assure open water is to construct the pond with some deep water or dredge out such an area. Raking the plants away from a few shoreline spots will assure some open water fishing from the banks. Some person trained in lake management work should be hired to do chemical treatment, if such is desired by the landowner.

In the larger pools of water for several miles west of Kerrville the Guadalupe has been invaded by *Nuphar advena*, a species of water lotus or spatterdock. This is a peculiar situation since the plant is most typical of sluggish, muddy, coastal streams. As recent floods have receded they have covered the rocky beds of these large pools with heavy layers of mud thus allowing the spread of this obnoxious plant. The choking of the pools and the spread of the tuberous root system have aided in further building up of the silt deposits. Large floods may strip away the leaves and stems and offer temporary relief but also bring in more silt through which the tuberous roots send new shoots. This plant can be controlled by chemical means. Where dense stands of the plant occur, 2,4-D or 2,4,5-T can be sprayed to obtain a fair kill but much of the chemical in the water is dangerous to fish, especially in shallow backwater areas, where high concentrations may be built up.

The safest way to control *Nuphar* is by cutting the leaves of the plant just below the water surface. A weed cutting device has been placed in one pool and does a good job of controlling the plant. Several landowners have cleared pools by manual cutting from a boat and the plant requires only minor attention each year. If the present high seeding capacity is decreased by cutting, the plant will respond more easily to control.

Cattails can be controlled by cutting or spraying with 2,4-D or 2,4,5-T but excess chemicals on the water surface should be avoided.

In many areas, that have excess vegetation, turtles are unusually common. Although they are not known to eat much besides vegetation and refuse, many people wish to get rid of them. They can be effectively reduced in numbers by using turtle traps. Information concerning the construction and use of turtle traps may be obtained from the Game Department.

Species Distribution and Abundance

Sixty-six species of fish were collected during the survey. Most of these represent true fresh water forms though some are more typical of brackish or salt water. It is highly probable that several species present somewhere in the watershed were missed but it is felt that

the more abundant species are represented in the survey collections.

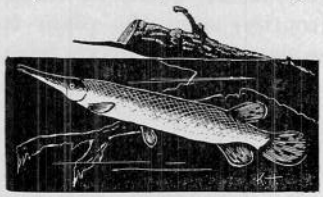
Some preserved specimens collected during the survey are deposited at the Game and Fish Laboratory in San Marcos. Many are deposited at the University of Texas Vertebrate Museum and others are being sent to the U. S. National Museum, Smithsonian Institution.

In the following list the species have been arranged by families and a short discussion accompanies each entry.

Family *Lepisosteidae*

Gars

Lepisosteus spatula: alligator gar. This species is the largest of the gars. It was collected as far upstream as Gonzales but is more abundant nearer the coast. Alligator gars were collected both in the main stream and lower bayous.



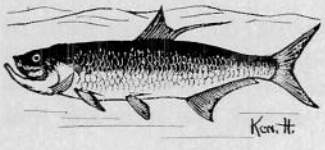
Lepisosteus productus: spotted gar. The spotted gar is primarily an inhabitant of shallows and backwaters from Gonzales County downstream, although it is sometimes found in the open river. It is the smallest of the gars in the basin, seldom getting larger than three or four pounds.

Lepisosteus osseus: long-nose gar. The long-nose is the most abundant of the gars in the Guadalupe and has the widest range, being common everywhere except in the spring headwaters. All of the gars seem to avoid very clear water and become more common as murkiness develops. The long-nose gar is an open water fish in that it is most common in large pools of the river as well as the larger lakes and absent in all but the major tributaries. This fish was found to comprise about 60% to 70% of the population of larger fish in the river near New Braunfels and this percentage is probably a reasonable one for most of the river below Kerr County. The long-nose acts as predator on the great numbers of small rough fish such as shad, buffalo, and suckers as well as minnows and occasionally sunfish or bass. Many gar indicate a high rough fish population.

Family *Elopidae*

Tarpon

Tarpon atlanticus: tarpon. One tarpon was netted in fresh water near San Antonio Bay. Tarpon are known to run into fresh waters, especially in the spring but cannot be considered to be of much importance to the permanent inhabitants of fresh water.

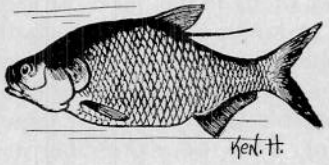


Family *Clupeidae*

Shad

Dorosoma petenensis: thread-fin shad. This species, which closely resembles the gizzard shad, is quite common in the river and larger tributaries on the Coastal Prairie. It is often found along with the gizzard shad in pools and backwaters. Three to six inches is the average size range of the species.

Dorosoma cepedianum: gizzard shad. The gizzard shad is found commonly, except in the extreme headwaters and small tributaries. It is a very prolific fish and its smaller members furnish a supply of food to gars, catfish, and bass. Although not particularly undesirable in themselves, shad usually indicate the presence of other less desirable fish. Specimens up to 15 inches in length were taken during the survey.



Family *Engraulidae*

Anchovies

Anchoa mitchilli: bay anchovy. The bay anchovy was taken only in brackish water areas near the mouth of the river and apparently does not enter fresh water.

Family *Catostomidae*

Suckers and Buffalo fishes

Ictiobus bubalus: small-mouth buffalo. This fish is common from the Edwards Plateau region to the mouth of the river and is most abundant in large pools and lakes. Buffalo have been taken commercially from several lakes on the river but not in sufficient numbers to severely reduce their numbers. They can be caught on dough balls, worms, and cut bait but few people fish for them. The buffalo is a bottom feeder that stirs the mud and helps maintain murky water conditions. Individual specimens may exceed 40 pounds in weight.

Carpiodes carpio: river carpsucker. This species was collected only in the main river in the Edwards Plateau, where it appears to replace the buffalo as a bottom feeder. It is rare or absent in the very clear headwaters. The carpsucker seldom exceeds three or four pounds in weight.

Moxostoma congestum: Texas gray redhorse sucker. The redhorse sucker is an open river form throughout its range in the river. It is not common in the extreme headwaters or near the mouth of the stream. This is one species of rough fish that has not been able to increase greatly in recent years. The creation of large lakes below the Edwards Plateau has cut down on its amount of

suitable habitat. The redhorse sucker is often found associated with good game fish populations near the headwaters and cannot be considered as being too undesirable.

Family *Cyprinidae*

Shiners and Minnows

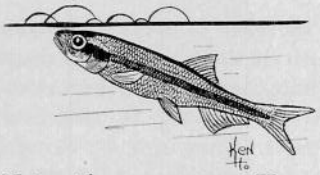
Cyprinus carpio: carp. The carp was introduced and propagated in Texas well before 1900 and was no doubt stocked in the Guadalupe River at various times. For some fortunate reason the carp has not become established in the river or its major lakes. It can be found quite commonly, however, in tanks, ponds, and small lakes on the lower half of the watershed. It often overpopulates these bodies of water and makes them too muddy for game fish.

Carassius auratus: goldfish. Two large goldfish were recovered from Landa Park during rotenone treatment. They were probably introduced by exotic fish fanciers from some local display pool. It is unlikely that they can become established among the high predator population in the lake.

Hybopsis aestivalis: speckled dace. This minnow is a common inhabitant of riffles in the main stream, except in the immediate headwaters. It is not a particularly valuable forage or bait minnow. Impoundments have greatly interrupted the distribution of the fish.

Opsopoeodus emiliae: pug-nose minnow. This minnow occurs in quieter waters below the Edwards Plateau. It was never found in abundance and is not likely to be an important forage species.

Notropis amabilis: Texas shiner. The Texas shiner occurs from the headwaters to the Coastal Prairie but is most typical of the Edwards Plateau. It is an excellent bait and forage minnow and can be found in moderate numbers locally.



Notropis venustus: Texas black-tail shiner. This species occurs throughout the Guadalupe drainage, although it is extremely rare below the Edwards Plateau. It reaches a larger size than any of the common native bait minnows and is abundant enough in the headwaters to be a very important forage fish. The blacktail prefers waters with a moderately strong current.

Notropis lutrensis: redhorse shiner. The redhorse shiner is the most abundant and widely distributed minnow in the Guadalupe drainage. It is found from the spring sources to brackish water and is common in the tributaries as well as the main stream. In flowing water it is found in or near the current. The redhorse is an excellent bait minnow and is the primary forage fish for game species.

Notropis amnis: pallid shiner. Limited in occurrence to the area below the Edwards Plateau, the pallid shiner is never abundant

enough to be an important forage species. It is typically found in the larger pools of the main river.

Notropis deliciosus: sand shiner. In the Guadalupe River the sand shiner is found only in clear headwater or tributary areas in the Edwards Plateau. It is most common in places where the stream flows over flat bedrock with little protection. This shiner lives inaccessible to most game fish.

Notropis volucellus: mimic shiner. In murky, silted pools of the river in the Edwards Plateau the mimic shiner is very common. It is a rather small minnow that lives as a bottom feeder. It is not a very desirable forage species.

Notropis buchanani: ghost mimic shiner. There is a sharply defined replacement of the mimic shiner by the ghost mimic shiner below the Edwards Plateau. This minnow is also a small, pool inhabiting shiner that is not too important as a forage or bait species. It is present in tributaries only near their mouths.

Dionda episcopa: round-nose minnow. This minnow is restricted to the immediate vicinity of springs in the Edwards Plateau area. It apparently has little tolerance of temperature changes and requires clear water. The round-nose is a large and desirable bait minnow but has only very local importance.

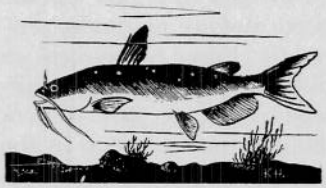
Pimephales vigilax: parrot minnow. This species is the most typical minnow of silted pools in the Guadalupe system. It is present throughout the basin, except in the clear headwaters and very small tributaries. The parrot minnow is of small importance as a forage species.

Campostoma anomalum: stoneroller. This large minnow is characteristic of the river and tributary headwaters. It is never abundant in the main river but may be of some importance as a forage minnow in small tributaries.

Family *Ameiuridae*

Freshwater Catfishes

Ictalurus punctatus: channel catfish. The channel catfish is the best distributed and most common game fish in the Guadalupe River. It can be found from the spring headwaters to San Antonio Bay and in many of the main tributaries. The channel catfish is also present in the larger lakes and has been stocked in many ponds and tanks in the basin. Experimental rotenone treatment near New Braunfels revealed that this species still comprised five to ten percent of the total population of fish in an area otherwise overrun with rough species. The channel catfish is one of the most highly prized and desirable fish from the fisherman's viewpoint and its propagation is one of the main undertakings of the state hatcheries.



Ictalurus furcatus: blue catfish. The blue catfish is reportedly found throughout the basin but those reported from the upper Guadalupe are actually channel catfish. The blue catfish was collected near the mouth of the river and verified catches have been made at least as far upstream as Cuero. It is a highly desirable game fish since it sometimes attains sizes far greater than the channel catfish.

Ameiurus melas: black bullhead. This small catfish was collected at but one station near Gonzales but probably occurs throughout the lower basin, especially in tributaries and tanks. It was not reported to have overpopulated any ponds or tanks as it often does in many parts of the state.

Ameiurus natalis: yellow bullhead. Yellow bullheads are most common near the Guadalupe headwaters and become less abundant downstream, almost disappearing below the Edwards Plateau. Its small size prevents it from being an important game fish.

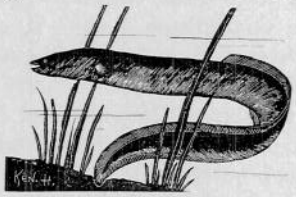
Pilodictis olivaris: flathead catfish. This fish goes under many names depending on the appearance of the water from which it was taken. On the Guadalupe it is often called yellow catfish, speckled catfish, mud cat, and shovelhead catfish. The flathead catfish is well distributed in the river and larger lakes from eastern Kerr County downstream and some specimens are taken even in the headwaters. In the rotenone treated area it comprised two or three percent of the population and many specimens weighed over 30 pounds. Large flatheads are always a desirable catch and all trotline and throwline fishermen hope to hook one sooner or later.

Schilbeodes mollis: tadpole madtom. This very small catfish occurs in minor tributaries and ponds below the Edwards Plateau. Most fishermen are never aware of their presence. Madtoms are of little importance to the fisheries picture.

Family *Anguillidae*

Eels

Anguilla rostrata: American eel. Eels were collected in a lake on the Coastal Prairie and are no doubt present in all of the lower Guadalupe as attested to by their common occurrence in the tributary San Marcos River. Although once common in the upper Guadalupe, no reports of eels have been known for several years. This situation has probably been caused by the construction of so many small power dams above the entrance of the San Marcos. No one of these dams is a formidable barrier to eel migration but the great number of obstacles seems to have effectively shut the species out of part of its former range. Eels are well thought of for food and sport on the San Marcos.



Family *Cyprinodontidae*

Killifishes and Topminnows

Fundulus confluentis: bayou killifish. This species was taken in brackish water just below the mouth of the Guadalupe and probably never enters the stream.

Fundulus notatus: black-band topminnow. This topminnow is common in sloughs, backwaters, and quiet pools below the Edwards Plateau. It is primarily a near shore surface feeder and is not too important as a forage species.

Fundulus olivaceus: Southern black-band topminnow. A large collection taken near Gonzales contained several specimens, which were either this species or very aberrant *Fundulus notatus*. The habits of the two species are very similar.

Cyprinodon variegatus: sea pupfish. This normally brackish water fish is often found in backwaters and tributaries of the Guadalupe on the Coastal Prairie. It is not desirable for bait or as a forage fish.

Family *Poeciliidae*

Mosquitofishes

Gambusia affinis: mosquitofish. The common mosquitofish is found throughout the Guadalupe basin wherever a little quiet water is present. The fish is very valuable in helping control mosquitoes and similar aquatic insects but is of minor importance as forage for game species.

Gambusia sp. An undescribed mosquitofish is known to inhabit the main springs of the Comal and San Marcos Rivers and was collected during the survey. The form lives in swifter water than the common mosquitofish but is otherwise quite similar.

Mollienesia latipinna: sailfin molly. This topminnow is native along the Texas coast and has been introduced into such places as the Comal Springs and River, where it is now present in large numbers. Small populations may be encountered almost anywhere in the lower Guadalupe. It is sometimes used for bait and may be of some local importance as a forage fish.

Family *Serranidae*

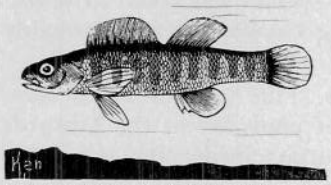
Sea Basses

Morone chrysops: white bass. The white bass has been introduced into the larger lakes between New Braunfels and Gonzales but has failed to become very well established. This area is very far south for the species and water temperatures may remain too warm all year long. Other environmental conditions appear to favor the fish and its predation on young shad would be a welcome thing in these lakes.

Family *Percidae*

Perches and Darters

Hadropterus scierus: dusky darter. This large darter is present in deeper riffles from the appearance of murky water in eastern Kerr County to the entrance of the San Marcos. The species, like most darters, lives and feeds in swift water and furnishes little or no food to game species.



Hadropterus shumardi: channel darter. This somewhat smaller darter replaces the dusky darter in the riffles below the junction of the San Marcos River. Its habits and importance are similar to the dusky darter.

Percina caprodes: log perch. The large log perch is present in riffles and sometimes pools from the first appearance of murky water to the mouth of the river. It is probably never taken as food by game fish but has no detrimental habits.

Boleosoma chlorosomum: blunt-nose darter. This lesser darter is found in sloughs, backwaters, and cutoffs below the Edwards Plateau but is of rather spotty occurrence. It is of very little importance.

Etheostoma spectabile: orange-throat darter. This small darter lives in the riffle areas of the stream in the Edwards Plateau, except in the immediate vicinity of springs.

Etheostoma lepidum: green-throat darter. This darter almost replaces the orange-throat darter in and near springs in the plateau area. It is most common in vegetated riffles.

Etheostoma gracile: western swamp darter. This small darter was collected one time in a backwater area near Gonzales. It no doubt occurs in other shallow backwaters but is not particularly important.

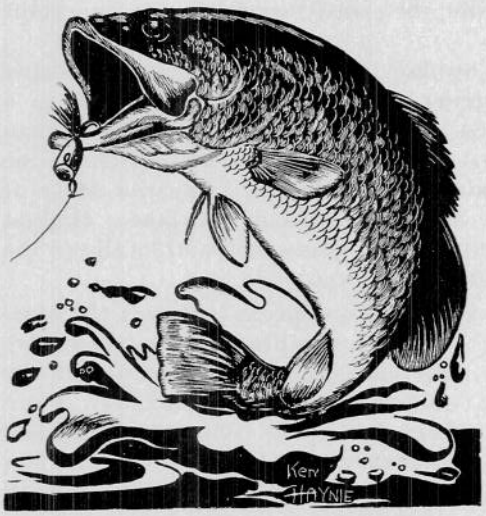
Etheostoma fonticola: fountain darter. This little darter is endemic to the springs of the Comal and San Marcos Rivers.

Family *Centrarchidae*

Bass, Sunfish, Crappie

Micropterus treculi: Texas spotted bass. This rather small member of the basses is restricted to the Colorado and Guadalupe drainages. It is common in and around moving water from Kerrville to the coast. Rotenone work near New Braunfels showed that most of the bass remaining in the river were this species rather than the largemouth black bass. Few specimens of this fish exceed one pound in weight. It is usually caught in riffles or where a current enters a pool with small plugs, flies, or minnows. Larger lakes do not furnish habitat for this bass and it was never collected in these areas. Although this fish is not so large as the black bass, it is a valuable game species because of its ability to live in shallow and swift water not well suited to its bigger kin.

Micropterus salmoides: largemouth black bass. Of all the freshwater fish in Texas the largemouth black bass is the most highly prized for sport purposes and its propagation is the primary concern of the state hatcheries. It is present throughout the Guadalupe basin but shows great extremes in abundance. In the clear headwaters west of Kerrville the largemouth bass is very common, being taken in numbers at almost every seining station during the survey. There is a rapid decrease in numbers with the appearance of murky water. Good bass fishing can be found in some small lakes, ponds, and tanks in the basin but not in the lower river or its larger lakes. Near New Braunfels the actual percentage of largemouth black bass was less than one percent in all the pools that were treated. The presence of a few very large individuals with hardly any specimens of intermediate size indicates that either spawning is seldom successful or that survival of small bass is very low. Both conditions are probably contributing to the poor showing of the species. Floods and siltation do heavy damage to bass habitat and encourage rough species. The abundance of bass in headwaters, ponds, and tanks is correlated with low siltation rate. Cases in which overfishing can be blamed for poor bass population are rare and limited to small areas receiving exceptional fishing pressure.



Chaenobryttus coronarius: warmouth bass. The warmouth bass is one of the most desirable members of the sunfish group. Natural and stocked populations occur throughout the drainage basin. The fish is more abundant in the clear headwater area and in farm ponds than elsewhere within the basin. It has little tendency to overpopulate and individuals reach much larger size than most sunfish.

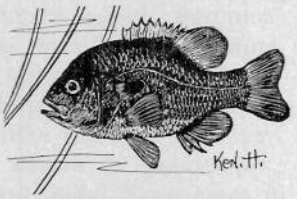
Lepomis cyanellus: green sunfish. The green sunfish is a common inhabitant of the headwaters, small tributaries, and ponds throughout the watershed. It lives in some little streams that would otherwise produce limited sport fishing but shows a strong tendency to overpopulate its habitat. Large numbers of green sunfish can compete badly with young bass and cause poor bass fishing to result.

Lepomis punctatus: spotted sunfish. This small sunfish is very com-

mon in the clear headwaters but rare elsewhere in the river drainage. Because of its small size, the spotted sunfish is not important as a game fish.

Lepomis microlophus: redear sunfish. The redear sunfish is probably the most desirable occurring in the Guadalupe basin. It is a native species well adapted to most habitat conditions other than muddy water. It attains exceptionally good size and is little prone to overpopulate. Its moderate reproductive capacities make it ideally suited for pond and tank stocking purposes. Highest numbers of redear are found in the headwaters and locally in the lakes between New Braunfels and Gonzales.

Lepomis auritus: yellowbelly sunfish. This species possesses the same desirable qualities of the redear sunfish and has been introduced into the Guadalupe through hatchery plantings. It is fairly common in the clear headwaters but evidently cannot adapt itself to the murkier waters of most of the river.



Lepomis megalotis: longear sunfish. This is the sunfish best adapted to the open river conditions of the Guadalupe River. It is common from source to mouth, except in the larger lakes. Only rarely does the longear attain much size and it is not too important a game fish.

Lepomis macrochirus: bluegill. Although not so plentiful as the longear sunfish in the open river, the bluegill has wide distribution the length of the stream. It is fairly common in the lakes between New Braunfels and Gonzales and some specimens attain nice size. In farm ponds and tanks the bluegill usually becomes a problem because of its frequent spawning. Many ponds become overrun with stunted bluegills, which consume the food productivity of the waters but offer no fishing.

Ambloplites rupestris: rock bass. The northern rock bass has been introduced into the upper Guadalupe drainage and has become established in Comal Springs and a spring fed lake on the Johnson Creek watershed. It survives only where spring waters hold down the summer temperatures. The rock bass is a large, excellent game fish.

Pomoxis annularis: white crappie. White crappie are locally common in the lakes between New Braunfels and Gonzales and occur sporadically in larger pools in the Edwards Plateau. They furnish good fishing in the very early spring before most game fish become active.

Pomoxis nigromaculatus: black crappie. Black crappie have been introduced into the upper Guadalupe and do well in a few large pools. The limited amount of habitat prevents it from being an important game species within the basin.

Family *Syngnathidae*

Pipefishes

Syngnathus scovelli: Scovell's pipefish. One specimen of this species was taken in Green Lake, a normally brackish water coastal lake near the mouth of the Guadalupe.

Family *Atherinidae*

Silversides

Menidia beryllina: tide-water silverside. This species was collected in Green Lake and near the mouth of the river. It is definitely limited to coastal areas.

Family *Mugilidae*

Mullet

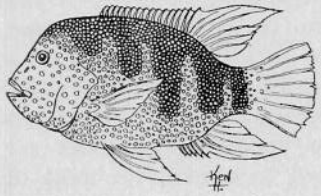
Mugil cephalus: striped mullet. Specimens of this mullet were netted in Black's Bayou, a flood time tributary of the Guadalupe. They often run upstream for miles.

Mugil curema: white mullet. This mullet was seined in the river below Cuero. Both species of mullet can probably be collected as far upstream as the power dam at Cuero, which blocks their further movement. Mullet are characteristic of the Guadalupe River on the Coastal Prairie.

Family *Cichlidae*

Cichlids

Cichlasoma cyanoguttata: Rio Grande perch. The Rio Grande perch well illustrates the hazard of introducing fish as well as other animals into entirely new ranges. A very large and desirable fish in Mexico, it was introduced into Landa Park Lake and probably elsewhere to improve the variety of fish. The sportsmen who made the introductions soon discovered that the species was crowding out all other fish from the lake. "Rio Grandes" have spread through the lower river basin and into the Edwards Plateau, where springs allow survival of brood stock during winter months. Occasional severe winters control the population in most of the basin. Landa Park Lake was recently treated with rotenone to reduce the millions of stunted Rio Grande perch that had taken over the lake and river in the last ten to twenty years. This temporary relief does not brighten the picture very much since ample brood stock survived in the springs to repeat the process of overpopulation in a matter of time. Meanwhile, the lake should produce some of the excellent bass fishing for which it was once known.



Family *Gobiidae*

Gobies

Gobiosoma bosci: naked goby. One specimen of this fish was taken in San Antonio Bay, opposite the mouth of the Guadalupe River. It does not likely enter fresh water.

Family *Carangidae*

Jacks

Oligoplites saurus: leatherjack. One specimen of this brackish water fish was collected in Green Lake.

Hybrid crosses

Three hybrid crosses were encountered during the survey. In the area around Kerrville, where the change from clear to murky water is most notable, *Notropis venustus* and *N. lutrensis* hybridize quite readily. Several hybrids of these species were collected elsewhere in the Edwards Plateau. One cross between *Lepomis megalotis* and *L. auritus* was found in an upstream collection. A cross of *Lepomis cyanellus* and *L. punctatus* came from Spring Creek in the Edwards Plateau.

Management Recommendations

The Guadalupe River Survey has made the basic disclosure that the majority of the stream contains a preponderance of rough fish. This condition has been revealed by gill netting, rotenone treatment, and the reports of generally poor luck by fishermen on the stream. Old time residents along the Guadalupe, especially its upper portion, claim that fishing used to be good and has reached its present state well within their memories. There is little doubt that this consensus of opinion is correct and that optimum or at least good game fish populations must have been present to furnish the described sport. The one primary cause for the degeneration of game fish populations and their replacement by rough fish is the change in the river brought by the scouring and siltation of major floods. These floods are the direct result of faulty land management so evident in most of the basin.

Thus the recommendations for improvement of the Guadalupe River must center about the removal of rough fish and the restoration of conditions which permanently favor the basic requirements of game fish. In the following discussion attention is first given to the various methods which can and should be employed to eliminate rough fish and then to the land practices deemed most favorable to optimum stream conditions.

Rough fish control:

Rotenone treatment: The most promising of the various means of rough fish removal known at the present time is treatment with rotenone. Since it kills all fish regardless of kind, it must only be used in areas that are known to be badly infested with rough fish.

From the eastern border of Kerr County to the mouth of the river rough fish almost completely dominate the population and the main restriction to rotenone use is not applicable.

With the present capacity of the state fish hatcheries and limited trained personnel it would be impossible to treat the entire river in one season and restock it adequately. In Guadalupe County strong opposition to the idea of rotenone treatment would offer another obstacle to complete coverage of the river. Immediate public cooperation can be secured in Comal County and probably in Kerr and Kendall Counties as well. The large lakes near Gonzales and at Cuero would make good individual projects. The majority of public sentiment would be in favor of such projects in the lower basin.

The treatment of large lakes or long sections of the river entails considerable advance planning. Summer or early fall is the best time for the work, since stream flow is small and water temperatures are high. Adequate chemical, personnel, and equipment for the work must be on hand. The reasons for chemical treatment must be explained to the public and their cooperation solicited in the recovery of fish. Hatcheries must be prepared for the undertaking to insure proper stocking in the fall and following spring. Although such projects offer quite a test of organizational ability, the successful treatment of several lakes, as well as the river work near New Braunfels, prove the feasibility of rotenone use.

Many owners of small lakes and ponds now desire to have them treated with rotenone in order to get rid of rough fish or destroy a stunted game fish population. Game Department personnel will advise interested parties on the use of the chemical and state hatcheries will restock such lakes but the work and expense of treatment cannot be the Department's responsibility.

Commercial fishing: Commercial fishing is looked upon unfavorably by most residents in the Guadalupe basin. Netting has been restricted or made illegal in many counties along the river. Game Wardens feel that they cannot properly supervise many small operators, who might feel tempted to keep the game fish they catch. It is true that the commercial fishing interests now working the area are insufficient to do noticeable good and may actually be detrimental. However, large scale operations for buffalo patterned after those at Lake Texoma and the Wichita Falls area take rough fish in sufficient numbers to remove population pressures on game species. These large undertakings are easily checked by wardens and the public. Any large operator wishing to get started in some of the larger river lakes, especially where rotenone treatment is opposed, should be strongly encouraged to do so.

In the headwater areas of the river, where moderate numbers of shad, suckers, and gar exist along with game fish, the use of gill nets can be of much benefit in bringing about better conditions. Unfortunately, there is insufficient economic incentive to interest a commercial fisherman unless he were given an added fee by the camp and

river front owners wanting to improve fishing conditions for their summertime trade or sport. The present Kerr County restrictions against netting would require a special permit for such an operator. Some mild form of rough fish control is needed on the large pools between Hunt and Kerrville and the lower half of Johnson Creek.

Special controls: A special situation exists in Landa Park Lake, where an overpopulation of stunted Rio Grande perch was treated with rotenone to allow restocking with bass, sunfish, and catfish. The numerous springs washed the chemical away from certain areas; however, and prevented a complete kill from being effected. To prevent the rapid re-establishment of the "Rio Grandes" to their former abundance some form of control must be devised. Gill nets would not be very effective in this swift, clear, heavily vegetated lake. Baited traps or umbrella nets might offer a means of catching enough of the fish to curb their numbers and would be well worth trying. Since the city of New Braunfels employs a permanent crew in the park, the periodic running of such traps and nets would not be much added expense and might be helpful in answering this perplexing problem.

Land management practices:

As stated before, the primary cause for the present situation of fishing in the Guadalupe River is improper use of the land resources of the basin. Lack of cover causes floods which scour the creeks and river bed and leave deposits of silt on the bottoms of pools. These floods greatly reduce the numbers of small crustacea and insect larvae on which small game fish depend for food. The organisms living in silt deposits are of no use to game fish but offer ideal food to the sucker type fish now so common in the river. Gar multiply to prey on the new supply of rough fish and the transition from clear water game fish habitat to murky water rough fish habitat is complete. In all probability the Guadalupe River below the Edwards Plateau has always tended to be slightly murky due to the lack of a solid rock bed in most places. This tendency surely has been multiplied many times by the washing of thousands of tons of silt into the channel every year. With the ever-increasing demands on our land resources ignorance of the natural laws governing proper usage of these land and water resources is inexcusable. Agencies of the Departments of Agriculture and Interior are always willing to help farmers and ranchers to increase productivity and conserve soil and water through the use of terraces, fertilizers, brush removal, water storage, etc. While this is contrary to the management for some game species, these restoration practices are also those most essential to the maintenance of permanently good fishing conditions in the basin. There are no conflicts between wise land utilization and game fish management.

The primary use of land in the Edwards Plateau is for grazing and the main problem of the area is the elimination of excess brush and the restoration of soil cover in the form of grass. Virtually the entire area suffers from excessive overgrazing at this time. Sheep and goats

keep some pastures almost bare and eat the leaves of canopy vegetation to a height of three or four feet. Such land has little or no value even for deer and represents the worst type of land abuse. Some pastures are badly invaded by cedar, various scrubby oaks, and different types of brush and others are relatively free from brush but have been grazed to a short grass and weed stage. Only small areas west of Kerrville and the old Schrenier place south of Kerrville display the native midgrass association of little bluestem, Indian grass, sideoats grama, and related grasses, which maintain the highest economy of soil and water for the Edwards Plateau. As it has taken many years to destroy the vegetative balance, so it will take many years to rebuild it but the task should be started now.

The Blackland Prairie belt is mainly devoted to the farming of cotton, corn, grain sorghums, and other row crops. Some farm land has been abandoned due to low fertility or excessive erosion and is now devoted to pasture or Johnson grass meadows. Commercial fertilizers seem to offer the only solution to the problem of low soil productivity in the area with legumes, cover crops, and crop rotation as auxiliary measures. Terraces, grassed waterways, and ponds offer means of curbing erosion. That portion of the region now in pasture is in a sad state of overgrazing resulting in washing and invasion of mesquite, desert willow, and other brushy plants. This pasture land lacks sufficient stocks of grass for natural reseeding and should be sowed to the more desirable imported grasses or to native species.

The Post Oak region originally supported rather open stands of oaks with many included prairies. Much of the area has been farmed at one time or another but most uplands are now being used as pasture. Bottom land is usually cultivated. Desirable farming practices are the same as those for the Blacklands. Much of the former oak forest has been cut over several times and is now overgrown with scrubby oaks. The original prairie areas are badly invaded by mesquite but many have surprisingly good cover of moderately desirable grasses. Brush clearing or spraying followed by a period of carefully controlled grazing could produce rapid recovery of these mesquite pastures.

The Coastal Prairie portion of the Guadalupe basin contains both farming areas and some of the largest and most productive ranches in the state. Erosion is very localized since most of the land is very flat. Soil fertility is high on the tighter, dark, clay soils but fertilizers will no doubt become necessary in future years. The grazing land is badly invaded by mesquite and huisache but many clearing programs have already been undertaken with very marked success. The resources of the Coastal Prairie are not only the greatest but the most easily managed of the entire basin.

Additional recommendations: The above discussions cover the basic points for the restoration and maintenance of desirable game fish in the Guadalupe watershed but several other points also come to mind.

Dams: The construction of the self-clearing type low water dams as started by Kerr County and individuals in that area are desirable for increasing the amount of game fish habitat. This value is greatest when such lakes are built to back water over long reaches of shallow, exposed bedrock that at present provide no habitat for larger fish. Below Kerr County low water dams are less effective because of reduced exposures of bedrock and increased flood damage. Small dams on minor creeks and draws throughout the watershed are beneficial, if they do not receive too much silt from their water supply. These small lakes often furnish a great deal of sport fishing.

The U. S. Engineers have three proposed dams on the watershed. One on the Guadalupe above Gonzales and one on the San Marcos just above its junction with the Guadalupe have been strongly attacked on the basis that they will cover too much valuable land. In my opinion these arguments are correct and the money could be more wisely spent on watershed improvements. Although large lakes do furnish a new habitat for game fish, the present land condition of the basins would doom such waters to a short period of productivity before siltation resulted in the familiar rough fish problem. The proposed Canyon Reservoir west of Sattler in Comal County offers few of the objections raised to the other dams. Several good sites for a relatively short, high dam are present and little first class land would be inundated. The life and productivity of the lake should be similar to the "highland lakes" on the Colorado River and the lack of heavy water demands should allow a fairly permanent water level to be maintained. This lake, if constructed, should be a valuable addition to the fishery resources of the basin.

Section II

STREAM SURVEY OF THE SAN ANTONIO RIVER

By

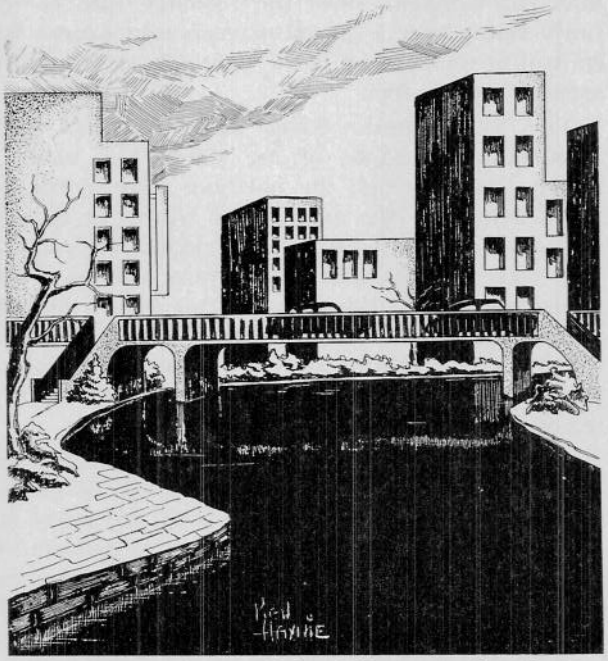
ROBERT A. KUEHNE
Aquatic Biologist

The field studies of the San Antonio River basin were conducted during the period from June 24, 1953 through August 14, 1953 to determine the kinds of fish present in the river and to gain information on the relationship of game and rough species.

Standard water analyses were run at most test stations. Attention was given to the problem of pollution, general watershed conditions, irrigation, and other factors that might influence fisheries management in the basin. Recommendations for the maintenance or improvement of fishing conditions are included in this report.

Description of the San Antonio River and Basin

The San Antonio River rises in the city of San Antonio and flows southeastward about 100 miles before joining the Guadalupe River only a few miles from San Antonio Bay. The two main tributaries are the Medina River, which enters in southern Bexar County, and Cibolo Creek, entering the main stream near Karnes City.



Depicted above is one of the bridges spanning the San Antonio River in the heart of San Antonio.

The rainfall is typical of the subhumid region of Texas, ranging from about 27 inches in the western portion of the basin to 32 inches near the mouth of the river.

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 within 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, a period of no flow being recorded as early as 1897. The average discharge, however, was comparable to that of the Comal Springs. San Pedro Creek was a respectable spring fed tributary of the river and rose from similarly faulted and fractured limestones. There were no early records of San Pedro Springs ever having gone dry.

These big springs are now virtually extinct. Since 1930 they have been dry most of the time 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 increments the stream somewhat.

The reason for the spring's cessation is simply that the water demands of San Antonio and surrounding irrigated land have drawn the reservoir level below that of the spring openings and artesian flow has stopped. Since the recharge rate of the water supply is fairly stable over a period of years and cannot be increased, careful control of water usage is the only answer to maintenance of the city's artesian well system.

The San Antonio River basin transects several of the major physiographic regions of the state. The main river rises in and largely 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. Cibolo Creek and the Medina River rise in the Edwards Plateau before flowing onto the coastal plains. The Cibolo actually flows through the southwestward edge of the Blackland Prairie and Post Oak Belt before entering the river. Before joining the Guadalupe the river enters the flat Coastal Prairie region.

The valley of the San Antonio is very narrow and the channel not deeply developed above the junction of the Medina River. Very small pools and riffles alternate and the fairly clear water contains aquatic plants such as *Potomogeton, Sagittaria, Myriophyllum,* and *Euchornia.* These conditions are interrupted in downtown San Antonio as the river is led through artificial, walled channels. Below the junction of the Medina the valley broadens noticeably and the main channel is more deeply entrenched. Rocky riffles and aquatic plants are no longer found. 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

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	2
1. Lepisosteus osseus					X		X																		X				
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7. Anchoa mitchilli																							X		X				
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10. Moxostoma congestum				X	X	X			X		X						X	X	X	X	X		X	X	X	X			
11. Cyprinus carpio																							X	X	X	X			
12. Carassius auratus																													
13. Hybopsis aestivalis																					X	X		X	X		X	X	
14. Opsopoeodus emiliae																													
15. Notropis amabilis								X				X	X			X				X		X			X			X	
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17. Notropis buchanani																													
18. Notropis deliciosus	X		X					X	X			X	X	X															X
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20. Notropis venustus	X		X		X	X	X	X		X		X				X	X	X	X		X	X			X		X	X	X
21. Notropis volucellus																					X	X		X	X				
22. Dionda episcopa		X	X					X																			X	X	
23. Pimephales vigilax					X		X													X	X	X			X		X	X	
24. Campostoma anomalum	X		X					X				X			X	X	X				X	X							X
25. Ictalurus furcatus																										X			
26. Ictalurus punctatus				X					X		X						X	X	X					X	X		X		
27. Ameiurus melas																													
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31. Anguilla rostrata																													
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48. Micropterus treculi										X				X	X										X				
49. Micropterus salmoides	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X			X	X	X			X
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51. Lepomis cyanellus	X		X				X	X	X	X			X	X	X	X	X	X			X			X		X	X		
52. Lepomis punctatus	X		X		X	X	X	X				X	X	X	X			X			X			X		X		X	X
53. Lepomis microlophus		X	X		X	X	X	X	X	X				X	X		X		X						X			X
54. Lepomis auritus	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X		X	X	X			X					
55. Lapomis megalotis	X		X		X	X	X	X	X	X		X	X	X	X	X	X	X		X	X	X		X	X	X	X	X	X
56. Lepomis macrochirus	X		X	X	X	X	X					X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	
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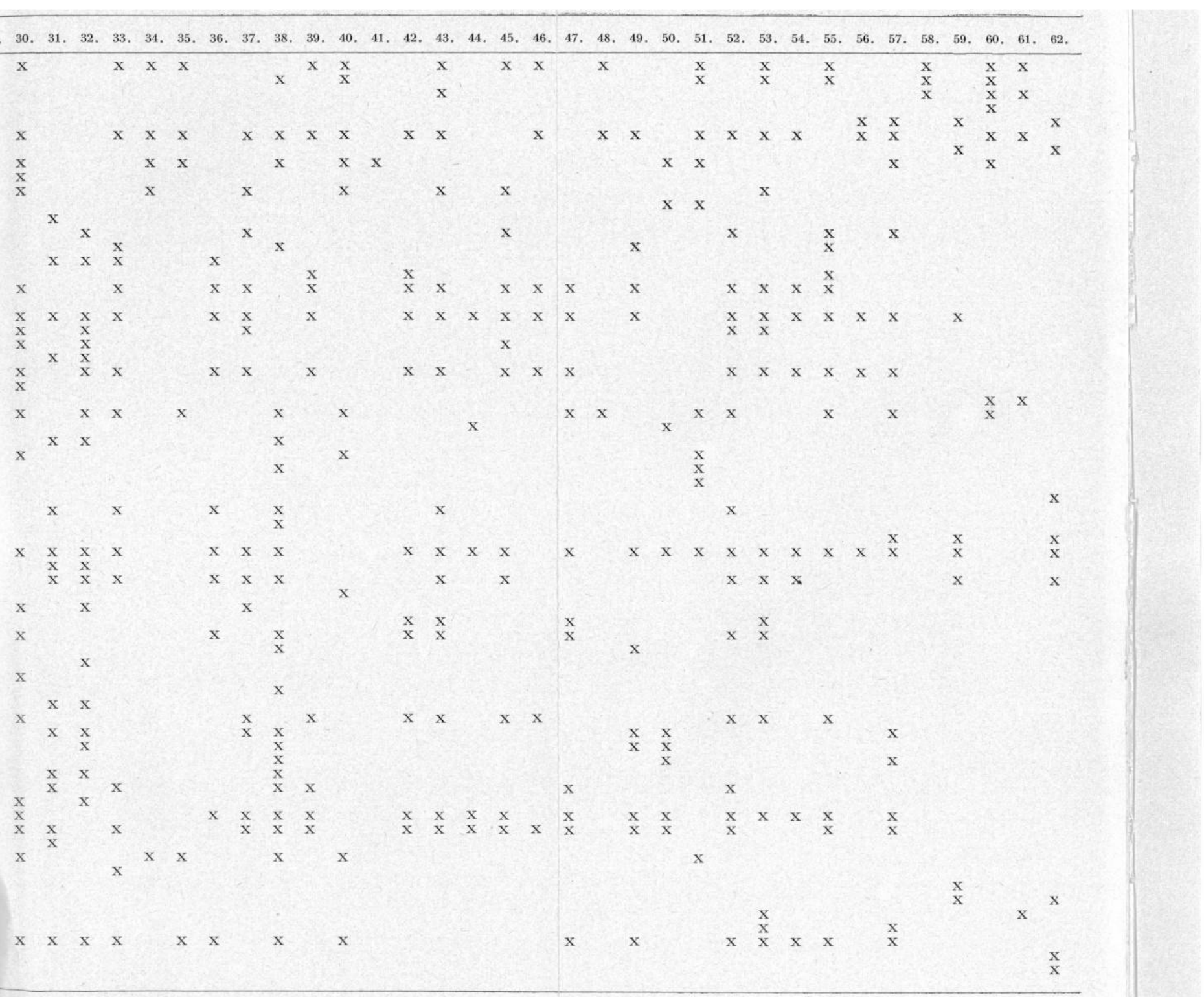
61. Menidia beryllina																													
62. Mugil cephalus																													
63. Mugil curema																													
64. Cichlasoma cyanoguttatus			X			X															X						X	X	X
65. Gobiosoma bosci																													
66. Oligoplites saurus																													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SAN ANTONIO RIVER SURVEY

Water Analysis Data

Station	Time	Temp. Fahrenheit air	Temp. Fahrenheit H_2O	Turb.[1] ppm	pH	O_2 ppm	CO_2 ppm	Tot. Alk. ppm	Cl[2] ppm
SAS 1[3]	3:30 PM	95	88	–25[4]	8.6	3.2	tr.[5]	230	53
SAS 2	9:30 AM	89	86	45	8.1	4.1	0.0	205	35
SAS 1[6]	3:00 PM	97	89	–25	8.6	4.0	5.0	234	75.5
SAS 5	2:30 PM	95	89	aprx 25[7]	8.8	4.8	0.0	235	81.6
SAS 6	9:30 AM	91	82	–25	8.4	4.5	0.0	216	21.2
SAS 7	12:00 AM	89	85	55	9.2	6.7	0.0	245	99.3
SAS 8	1:00 PM	91	84	50	9.5	7.3	0.0	245	99.0
SAG 2	4:00 PM	92	89	–25	8.8	3.5	0.0	248	92.6
SAS 13	4:00 PM	93	90	–25	9.0	6.0	0.0	252	125.9
SAS 15	6:00 PM	89	89	–25	8.9	4.8	0.0	200	134.7
SAS 16	3:30 PM	100	92	–25	8.8	5.1	0.0	210	168.4
SAS 18	10:00 AM	90	87	–25	8.8	5.6	0.0	245	141.8
SAS 19	2:00 PM	102	90	aprx 25	8.8	7.2	0.0	223	195.0
SAS 20	10:00 AM	94	86	aprx 25	8.9	5.8	0.0	225	187.0
SAS 21	2:30 PM	102	90	50	8.8	7.2	0.0	253	197.9
SAS 22	2:30 PM	98	90	65	8.8	5.8	0.0	246	173.7
SAS 9	12:00 AM	92	82	–25	8.2	5.2	0.0	195	92.2
SAS 17	2:00 PM	98	90	–25	8.5	4.2	0.0	198	567.2
SAS 10	2:00 PM	99	90	30	8.8	6.2	tr.	180	106.5
SAS 11	3:30 PM	98	90	–25	8.4	5.1	0.0	196	115.2
SAS 14	10:00 AM	93	84	–25	8.8	6.1	0.0	173	131.2
SAS 23	3:00 PM	86	84	aprx 25	8.6	7.0	0.0	251	19.5

[1]Turb.—Jackson Turbidimeter
[2]Cl—Chlorides
[3]SAS—Seining station
[4]"–"—Less than 25
[5]tr.—Trace
[6]SAG—Gill net station
[7]aprx—Closely approaching 25

Key to Water Analysis Stations

SAS 1 Bexar Co.; June 25, 1953; San Antonio River at Mission San Juan de Capistrano.
SAS 2 Bexar Co.; July 3, 1953; San Antonio River just above entrance of San Pedro Creek.
SAG 1 Bexar Co.; July 7, 1953; San Antonio River 1.7 miles southwest of Southton.
SAS 5 Wilson Co.; July 8, 1953; San Antonio River 3 miles below Saspamco.
SAS 6 Bexar Co.; July 9, 1953; San Antonio River at source in Brackenridge Park.
SAS 7 Wilson Co.; July 14, 1953; San Antonio River at State Highway 97 crossing.
SAS 8 Wilson Co.; July 15, 1953; San Antonio River at Farm Road 541 crossing.
SAG 2 Karnes Co.; July 29, 1953; San Antonio River at Farm Road 791 crossing.
SAS 13 Karnes Co.; July 27, 1953; San Antonio River at State Highway 123 crossing.
SAS 15 Karnes Co.; July 28, 1953; San Antonio River at crossing 6 miles northeast of Kenedy.
SAS 16 Goliad Co.; August 3, 1953; San Antonio River at State Highway 239 crossing.
SAS 18 Karnes Co.; August 5, 1953; San Antonio River at State Highway 72 crossing.
SAS 19 Goliad Co.; August 6, 1953; San Antonio River at crossing marked Riverdale, 9 miles west-northwest of Goliad.
SAS 20 Goliad Co.; August 7, 1953; San Antonio River at US Highway 183 crossing.
SAS 21 Refugio Co.; August 10, 1953; San Antonio River at US Highway 77 crossing.
SAS 22 Goliad Co.; August 14, 1953; San Antonio River at crossing on O'Connor Ranch, 7.5 miles south of Fannin.
SAS 9 Bexar Co.; August 17, 1953; Salado Creek at US Highway 181 crossing.
SAS 17 Karnes Co.; August 4, 1953; Ecleto Creek at crossiing 2.5 miles west-northwest of Runge.
SAS 10 Wilson Co.; July 17, 1953; Cibolo Creek at Farm Road 541 crossing.
SAS 11 Wilson Co.; July 20, 1953; Cibolo Creek at Farm Road 775 crossing.
SAS 14 Karnes Co.; July 28, 1953; Cibolo Creek at unmarked crossing 2 miles northwest of Panna Maria.
SAS 23 Bexar Co.; August 19, 1953; Cibolo Creek at Bulverde Road 1.2 miles east of US Highway 281.

30 years and has become fairly well established in the river headwaters where artesian well flow keeps local temperatures above the critical point for the species. Spread of the tetra into the lower basin is not likely since its tolerance to low temperatures is so limited.

Family *Catostomidae*

Suckers and Buffalo Fishes

Ictiobus bubalus: Small-mouth buffalo. The buffalo was taken in the middle and lower portion of the main river, where it probably is the dominant bottom feeding forage fish. It was not taken in tributary collections or the clear headwater collections. Though considered a good food fish by many people, the buffalo is bad about stirring bottom muds and helping maintain murkiness.

Carpiodes carpio: River carpsucker. The river carpsucker was taken once in a gill net collection in the upper part of the river. Crowded out downstream by the buffalo, the carpsucker occurs in moderate numbers in murky waters of the upper basin.

Moxostoma congestum: Texas gray redhorse sucker. This is the smallest of the suckers in the San Antonio system and is virtually limited to the upper half of the river and Cibolo Creek. Though common within its range it shows little tendency to overpopulate.

Family *Cyprinidae*

Shiners and Minnows

Hybopsis aestivalis: Speckled dace. The speckled dace is of general distribution in riffles except in the clear headwater areas. It occurs in Cibolo Creek also but not in the smaller tributaries. This species is probably of limited importance as a forage minnow for larger fish because of the restricted amount of suitable habitat.

Opsopoeodus emiliae: Pugnose minnow. The pugnose minnow is found commonly as an inhabitant of quiet pools in all but the smallest tributaries. Though never very abundant, it must be considered as a desirable forage species.

Notemigonus crysoleucas: Golden shiner. The golden shiner was collected in Cibolo and Salado Creeks and probably can be found in other places within the basin. This species has been stocked by State Hatcheries in an effort to maintain and spread its natural range. The golden shiner is the most desirable native bait minnow and does well in fairly clear streams, lakes, and ponds, often reaching 6 inches in length.

Notropis lutrensis: Redhorse shiner. As is the case in the Guadalupe basin the redhorse shiner is the best distributed and most abundant minnow in the San Antonio basin. It shows little preference as to river or stream, clear or murky water. It must be con-

of San Antonio and a natural pool near Falls City, the river averages about 20 feet wide and 3 feet deep with a sandy bottom in the main current and deep, soft muds toward the banks. Even before the junction of the Medina the stream begins to develop murkiness, a condition which becomes more pronounced as the river flows toward the Gulf.

Below the junction of Cibolo Creek, which has a broad, flat, well developed valley, the San Antonio valley broadens further and a tendency to form large pools develops. Only rarely along narrow outcrops of resistant rock do true riffles appear but shallow, swift areas with sandy bottoms commonly separate the pools. The average channel width is from 35 to 50 feet and pools are from 3 to 7 feet deep. The tendency toward murkiness becomes stronger but the channel is usually not so badly choked with muds and log jams as above the union of the river and the Cibolo.

Fish Collection

Twenty-four seining collections spaced at convenient crossings throughout the basin form most of the material on which this report is based. Of these collections 17 are on the main river, 5 on Cibolo Creek, 1 on Salado Creek, and 1 on Ecleto Creek. Studies of the Medina River are being made by Aquatic Biologist Elgin Dietz, and that stream is not covered in this report. Some stations were worked with a 30-foot, ¼-inch mesh seine and 10 and 4-foot common sense minnow seines. Other places were unsuited to the larger seine and only the smaller sizes were used. When possible both pools and riffles were seined. Fish were preserved in 2-quart jars containing 10% formaldehyde.

Three gill net sets were made during the survey and all were located on the main river. Nylon nets 125 feet long, 8 feet deep, and of 2-inch and experimental mesh sizes were used. Suitable water for netting was very difficult to find in the river due to restricted width and submerged brush. Game fish were weighed, measured, and sexed while rough fish were only counted and recorded.

The location of stations was based on county maps prepared by the Texas State Highway Department and these maps were found excellent for planning operations.

Water Analysis

Standard water analysis was run at 22 localities on the river and tributaries in conjunction with seining or netting stations. Results were fairly uniform in all tests. The waters of the basin are all alkaline and the pH is consistently high. Turbidity, alkalinity, pH, and chlorides all show a tendency to increase downstream. Water temperatures were uniformly high but not so high as to preclude a sufficient oxygen supply.

The table shown opposite this page and the accompanying key give the results of water analysis by stations. It should be mentioned that though turbidity was not high at most stations the slightest disturbance of the bottom caused the water to muddy badly. After seining an area the turbidity was commonly about 500 ppm.

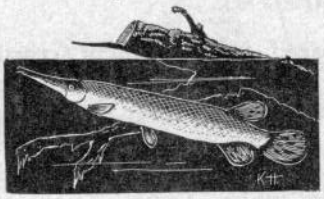
Species Distribution and Abundance

Most species of fish collected during the survey showed a definite distribution pattern or else displayed a strong preference for certain habitats. The following notes try to describe briefly the area occupied and abundance of the various fishes collected. The arrangement is phylogenetic.

Family *Lepisosteidae*

Gars

Lepisosteus spatula: Alligator gar. One specimen of the alligator gar was collected near the mouth of the San Antonio. This largest species of the gars is thought to be of general occurrence in the lower portion of the main river as is the case in the Guadalupe. The lack of many large pools may prevent this predator from becoming very numerous.

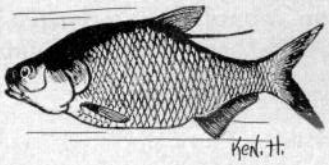


Lepisosteus osseus: Longnose gar. The longnose gar was collected several times from the area just south of San Antonio to the river mouth. This species is the dominant predator in the murky waters of the river. It is rare or absent in the smaller tributaries of the basin.

Family *Clupeidae*

Shad

Dorosoma cepedianum: Gizzard shad. Spotty distribution characterized the distribution of the gizzard shad. It was missed in the upper portion of the river but was caught downstream and in upper Cibolo Creek. Lack of extensive suitable habitat and the establishment of gars and catfish as efficient predators probably keep the shad population small.



Family *Characidae*

Tetras

Astyanax fasciatus: Rio Grande tetra. The Rio Grande tetra was introduced into the basin from the Rio Grande within the last

sidered the primary food supply for bass and a very important item for all other game species. The redhorse is a very desirable stream form but does not do nearly so well as the golden shiner in farm and ranch ponds.

Notropis amnis: Pallid shiner. The pallid shiner was collected but twice in lower Cibolo Creek and is unimportant as a forage species because of its rareness.

Notropis volucellus: Mimic shiner. The mimic shiner is fairly typical of quiet backwaters in the upper part of the San Antonio basin but does not occur very far down the river system and is limited to the river and Cibolo Creek.

Notropis buchanani: Ghost mimic shiner. The ghost mimic shiner replaces *Notropis volucellus* in the lower part of the basin and is generally more abundant. It is also restricted to the larger streams and is of some importance as a forage species.

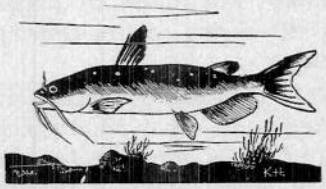
Pimephales vigilax: Parrot minnow. The parrot minnow is typical of muddy bottomed, backwater conditions throughout the basin. After the redhorse shiner it is the most common minnow collected and probably is used to some extent as a forage species.

Pimephales promelas: Fathead minnow. The fathead was collected only in Brackenridge Park and is not important in the overall picture. It is a very hardy but somewhat inferior bait minnow.

Campostoma anomalum: Stoneroller. The stoneroller was collected only at the headwaters of the San Antonio River and is of limited occurrence and importance in headwater areas.

Family *Ameiuridae*
Freshwater Catfish

Ictalurus punctatus: Channel catfish. The channel catfish is of common occurrence in the upper half of the basin and becomes abundant in the lower half of the river except around the mouth. Cibolo Creek displays a similar pattern of abundance. Great numbers of small and medium sized channel catfish were seined, indicating good numbers of adults and successful spawning for at least the last two years. This is the game fish of importance in the basin as it tolerates murky as well as clear water and does not give way in the presence of large rough fish populations. Channel catfish make up the bulk of fish caught from the river.



Ictalurus furcatus: Blue catfish. Blue catfish began appearing in collections from Goliad County and downstream almost replaced the channel catfish. The blue catfish has preferences and habits similar to the channel catfish but gets much larger. Though fairly distinct, the two species are constantly confused by fishermen. The vague term "blue channel" is used by many people trying to use color as a guide. All other criteria aside the blue

catfish has 30 anal rays or more while the channel catfish has less than 30.

Ameiurus natalis: Yellow bullhead. The yellow bullhead occurs in limited numbers in the upper part of the basin. It was never found to be abundant and seldom reaches edible size.

Pilodictis olivaris: Flathead catfish. The flathead can be found throughout the larger streams of the basin except in the extreme headwaters. It is an efficient predator and is the big prize sought by trotline fishermen. Specimens from 40 to 60 pounds are occasionally reported from the river.

Schilbeodes mollis: Tadpole madtom. This little catfish with the sharp sting to its spines occurs in shoreline vegetation in the lower part of the river. It is of no economic importance.

Family *Cyprinodontidae*

Killifishes and Topminnows

Fundulus notatus: Black-band topminnow. This topminnow is liable to be found in any quiet water below the Edwards Plateau. It is of little value except as a mosquito and insect feeder.

Family *Poeciliidae*

Mosquito Fishes

Gambusia affinis: Mosquitofish. This is the common topwater species in the basin and only requires still backwater to thrive. It feeds on small aquatic insects or larvae and is an excellent control for many noxious forms.

Gambusia sp.: Large spring mosquitofish. As at the San Marcos and New Braunfels springs this mosquitofish was found in limited numbers. It is the only characteristically spring species collected at the head of the San Antonio River.

Mollienesia latipinna: Sailfin molly. This colorful livebearer was introduced into the San Antonio River as an ornamental species and has multiplied in the headwater areas until it far outnumbers all other species combined in many places. It becomes more uncommon below the junction of the Medina and disappears altogether for a long stretch before reappearing on the the Coastal Prairie region where it is thought to be native. That the molly has any merits in the headwaters is very doubtful.

Family *Percidae*

Perches and Darter

Hadropterus shumardi: Channel darter. The channel darter is limited to the few riffles of lower Cibolo Creek and the lower river. It is a species of little importance in the economy of the stream system.

Percina caprodes: Log perch. Also of limited occurrence and little importance is this larger darter of the river and Cibolo Creek.

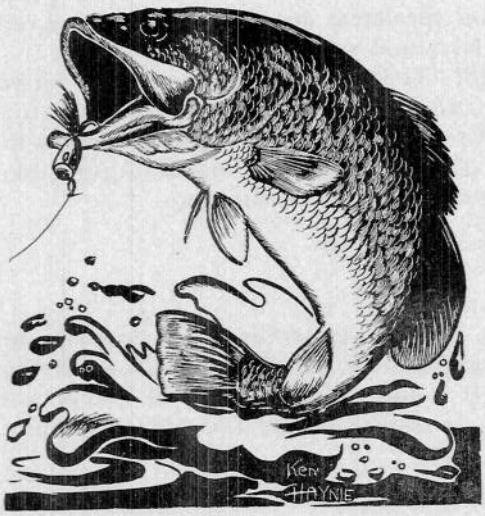
Etheostoma chlorosomum: Blunt-nose darter. This small darter occurs in sandy bottomed tributaries of the lower basin but is not common.

Etheostoma gracile: Western swamp darter. Collected from the lower river and tributaries in sandy areas the western swamp darter was nowhere found to be abundant.

Family *Centrarchidae*

Bass, Sunfish, Crappie

Micropterus salmoides: Largemouth black bass. Though it is Texas' most prized game fish and is frequently stocked in the basin, the largemouth black bass is uncommon except in smaller tributaries and clear headwater areas. Murky water and silted bottoms seem to virtually exclude this fish and its most successful propagation appears to be found in small lakes and farm and ranch ponds. Only watershed improvement practices can increase bass populations in the natural streams. The lower river has probably always been sufficiently murky to preclude good bass fishing but the fish was no doubt much more common in the upper part of the basin than it is today.



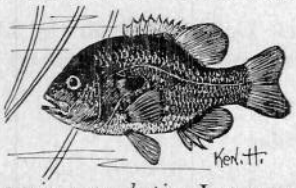
Chaenobryttus coronarius: Warmouth bass. The warmouth bass favors the clear water areas inhabited by largemouth bass and was usually taken with the latter species. This sunfish reaches a large size and is excellent for pond and tank stocking. Its habitat in natural streams of the basin is very limited.

Lepomis cyanellus: Green sunfish. The green sunfish is typical of all headwater and small stream habitats of the basin. It seldom becomes large and furnishes only minor sporting pleasure. Ponds, tanks, and small lakes often become overpopulated with this prolific species.

Lepomis punctatus: Western spotted sunfish. This small sunfish prefers heavily vegetated waters and was collected only at Brackenridge Park.

Lepomis microlophus: Redear sunfish. This large, desirable sunfish was collected only in the clear headwater area. It is often stocked in lakes and ponds, where it usually reaches good size and does not overpopulate.

Lepomis auritus: Yellowbelly sunfish. This species possess the same desirable qualities of the redear sunfish. This introduced sunfish was collected in Brackenridge Park. Where established it is similar to the redear in size and general desirability.



Lepomis megalotis: Longear sunfish. Longear sunfish occur throughout the stream system of the basin and in most cases are the most abundant sunfish. They are capable of attaining good size but most murky water specimens are rather small. Longear are of inferior value in lakes and ponds.

Lepomis macrochirus: Bluegill. The well known bluegill is fairly common in tributaries and somewhat less numerous in the main river and Cibolo Creek. Unlike the longear it does very well in standing bodies of water but sometimes multiplies too fast and brings about overcrowding and stunting.

Family *Mugilidae*

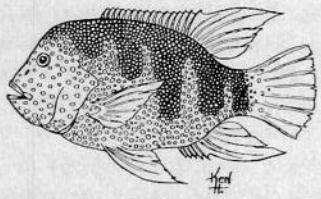
Mullet

Mugil curema: White mullet. Mullet were collected in numbers on Ecleto Creek and are probably of general occurrence in the lower half of the basin. It is interesting to note the abundance of mullet at the station recording by far the highest salinity count of the survey.

Family *Cichlidae*

Cichlids

Cichlasoma cyanoguttatus: Rio Grande perch. Since its rather recent introduction into the river at San Antonio, the Rio Grande perch has spread throughout the entire river and several of the tributaries. Cold water during severe winters controls the numbers in downstream areas but near the regulated waters of the river source the fish has almost crowded out sunfish and bass by sheer weight of numbers. It is a careful guardian of its young and very pugnacious toward bass and sunfish. Though it is a fairly game fish and edible, it usually overcrowds its habitat and few large fish can be found. The control or elimination of this species now presents a considerable problem in many parts of South Texas.



Of the species of fish known to be in the basin but not collected by the survey the most important is the carp, which occurs in the Medina River not covered in this study. The carp was introduced into Texas before 1900 and has locally become a rough fish to reckon with. This is the case in the Medina River where carp make up a good percentage of the population. This species may also occur in scattered parts of the survey area.

The white bass, *Morone chrysops,* is recorded from the Medina watershed and might possibly enter the survey area.

Also known to occur near San Antonio are the rare blind catfish *Trogloglanis pattersoni* and *Satan eurystomus.*

Of probable rare occurrence in the lower river and Cibolo Creek is the Texas spotted bass, *Micropterus punctulatus treculi,* which is common in most streams between the Colorado and Rio Grande. The eel, *Anguilla rostrata,* may enter the San Antonio system since no large dams are present to discourage upstream movement. The spotted gar, *Lepisosteus productus,* is likely to be present in the lower portion of the basin but was missed by the survey. The black bullhead, *Ameiurus melas,* is likely to be found in creeks and ponds of the lower basin.

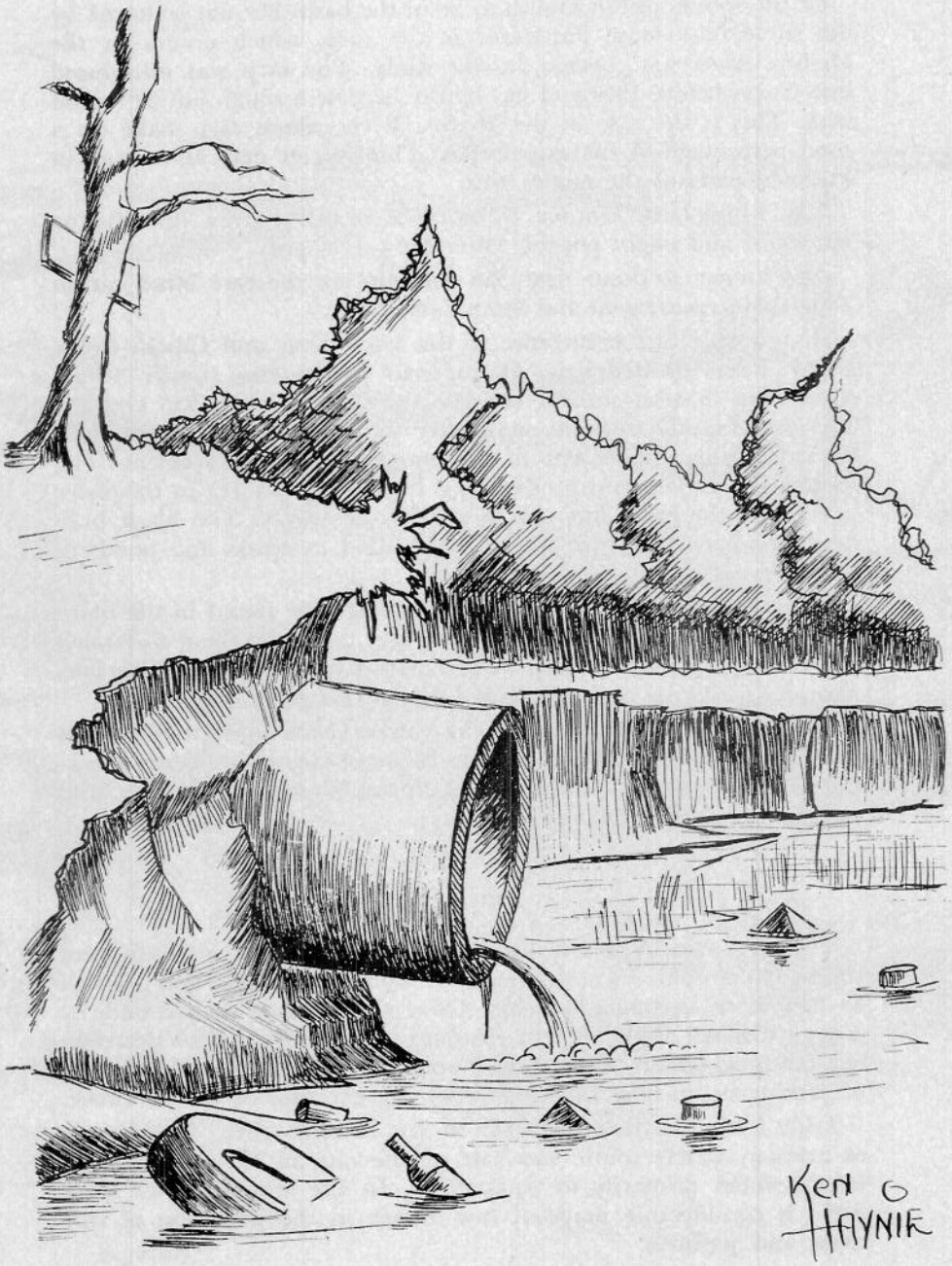
Many typically brackish water species might be found in the basin near the mouth of the river. These include: thread-fin shad, *Dorosoma petenensis;* sea pupfish, *Cyprinodon variegatus;* tidewater silverside, *Menidia beryllina;* and the striped mullet, *Mugil cephalus.*

Minnows of possible occurrence in Cibolo Creek above the Balcones Escarpment are: the Texas shiner, *Notropis amabilis;* Texas blacktail shiner, *Notropis venustus;* sand shiner, *Notropis deliciosus;* and roundnose minnow, *Dionda episcopa.*

Irrigation

There is some irrigation directly from the river for some distance below San Antonio. Water is pumped from the channel and allowed to flow over bottomland fields. Once the stream is increased by sewage disposal water at San Antonio its volume of flow decreases constantly as far downstream as Floresville. After that it shows signs of picking up in flow, especially after the entrance of Cibolo Creek.

Aside from the huge demands of San Antonio there is some use of artesian waters south and east of the city in the irrigation of land devoted primarily to truck crops. In the area south of town there is considerable usage of raw sewage in the irrigation of row crops and pastures.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Pollution

There are many minor sources for possible industrial and municipal pollution within the city limits of San Antonio but no contamination was observed during the survey. Indiscriminate pollution can hardly be tolerated by the city since the river flows directly through town and fish kills would create sanitary problems.

Just below the city limits the sewage disposal plant for San Antonio empties treated water back into the river. A collection made a short distance downstream from the plant gave no indication of recent pollution since many fish of several species were taken. It is known, however, that past pollution has seriously contaminated the river. The very restricted flow of the river makes it imperative that no untreated sewage be allowed to enter the stream or the recovery that has been made by fish populations will be lost.

There is an exceptional amount of very fine mud over the banks and bottom of the river for many miles below San Antonio. It is not known whether or not these are composed of sewage sludge or soil particles but low flow in the river allows them to coat the bed in many places and render the stream unsuitable for many species of fish.

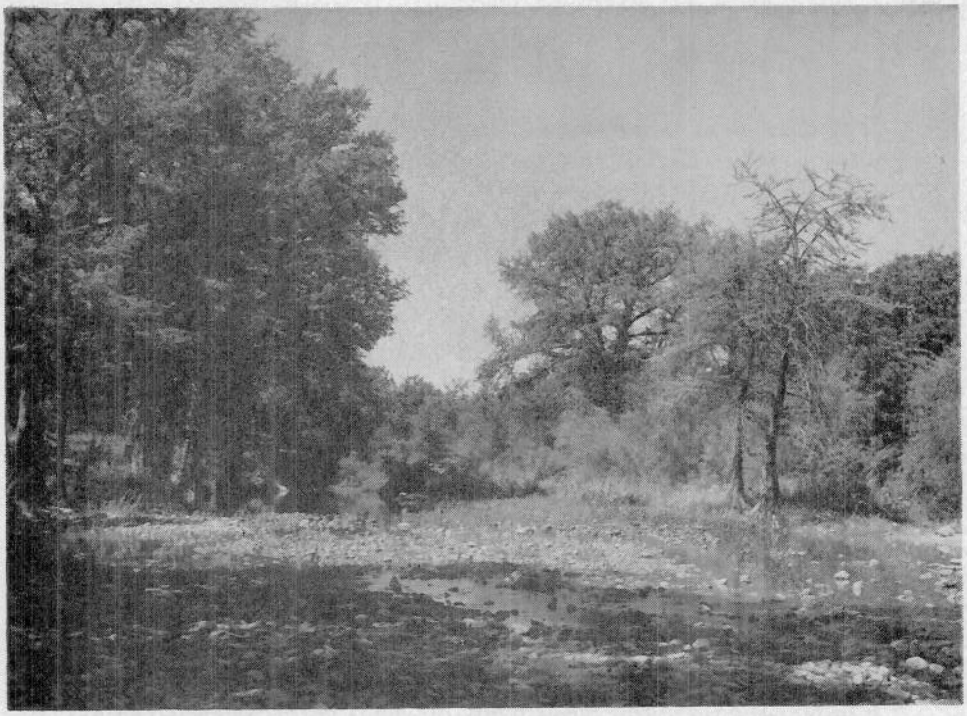
Throughout the lower basin many oil fields are a potential pollution source. Oil slicks were never seen on waters of the river or its tributaries and chloride counts, though moderate, were never found to be dangerously high. One serious case of salt water pollution from an abandoned oil field is known at Canvasback Lake south of San Antonio so chloride pollution is not an impossibility in the basin.

Soil pollution is the major reason for decreased production of game fish in the basin. Only the flat Coastal Prairie is relatively free from the excessive erosion that brings muds and silt into the stream. Much farmland in the lower basin is either too hilly for successful farming or is in need of terracing. Grassed waterways are almost unknown as a means of retarding erosion. The ranchland is almost always overgrazed and usually badly invaded by mesquite, huisache and other thorny brush. In the Edwards Plateau the brush plants are cedar and various oaks.

The siltation of a stream bed results in the elimination of insects and small crustaceans eaten by young bass and sunfish and promotes the growth of burrowing forms eaten by sucker type fishes. The transformation has probably been gradual over many years until now only the river headwaters and small tributaries have many game fish other than catfish.

Conclusions

Of the rivers in this state the San Antonio offers a peculiar situation. Rising within the limits of Texas' third largest city and



The Medina River near its headwaters just west of Bandera. The Medina is one of the main tributaries of the San Antonio River. The other is Cibolo Creek that enters the San Antonio River near Karnes City.

Bandera Falls on the Medina River just north of Medina Lake and about 55 miles north of

flowing a relatively short distance to the Gulf, any aspect of fishery management must take into account the municipal demands of that city. Once a large spring fed stream, its very existence is now controlled by a headwater pump, surplus water from downtown artesian wells, and treated sewage water. The channel for miles below the city is badly silted. A sizeable upper tributary, the Medina River, is so heavily used for irrigation that it seldom contributes much water to the river.

The picture is further complicated by the introduction of the exotic carp, Rio Grande perch, sailfin molly, and Rio Grande tetra, which have crowded some native species into a minor role in the upper basin.

Below the mouth of Cibolo Creek the situation begins to change. Water flow is somewhat increased, the channel is not so silted and the exotic species are no longer a big problem. Murkiness prevents bass and sunfish from being dominant but channel catfish, flathead catfish, and blue catfish, all much more tolerant to murky water, are found to be surprisingly abundant.

In headwater areas in the Edwards Plateau the construction of small dams would create quite a bit of fish habitat where none exists now. Cibolo Creek and its branches are dried into small pools during most of the year and dam construction could greatly increase the amount of permanent water. Similarly, tributaries of the upper Medina River could be made to produce good fishing.

Rotenone treatment or the use of fish poisons in and around San Antonio would probably be objectionable to residents and considered a possible health hazard. Only a limited amount of fishing water would be affected since the stream is very small in this area. Except for one small dam, the river is uniformly narrow, deep, and steady flowing for many miles below San Antonio and rotenone treatment would be very economical. Channel and flathead catfish would be the species benefited most after restocking but moderate numbers of these fish already live in this portion of the river and there would be considerable loss in the initial treatment. Also, the rapid re-establishment of rough fish and the Rio Grande perch would be a certainty, unless the stream were treated from San Antonio clear to the entrance of Cibolo Creek. Though no guarantee of great success can be positively predicted, I believe this area offers an excellent chance to test the long-range benefits of large scale fish removal in flowing water at a minimum of expense to the Department.

The good populations of catfish in much of the lower basin would prevent fish poisoning from doing much to improve the situation below the entrance of Cibolo Creek. Only the develepment of selective fish poisons could prevent the loss of this sizeable catfish population.

The further expansion of irrigation rights below San Antonio could easily create drastic results in the river. Summertime flow

has a guaranteed minimum below San Antonio but the actual volume of water moving down the channel is only a few thousand gallons per minute. The use of artesian water for irrigation will no doubt be carefully restricted in the future as San Antonio's demands on the underground reservoir increase.

As was discovered in the Guadalupe basin, fishery management techniques are much restricted and handicapped where floods and excessive siltation are of regular occurrence. Dams, rough fish removal, and stocking have their effectiveness greatly reduced and the use of stream improvement devices in use in some northern states are completely impractical. The gradual spread of soil and water conservation practices assure fishery management an easier time in future years. At present the promotion of these practices are the main hope for stream management. In the meantime the construction of feasible headwater dams, strategic rough fish removal and restocking, abatement of pollution and excessive irrigation demands, and encouragement of commercial fishing for rough species are the techniques available to give the Texas fisherman a better chance in the public streams of the State.