Report of Fisheries Investigations

Experimental Control of Undesirable Fish Species in Lake Diversion

by
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Dingell-Johnson Project F-7-R-4, Job E-2
June 1, 1956 - May 31, 1957

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SEGMENT REPORT

State of TEXAS

Project No. F7R4 Name: Fisheries Investigations and Surveys of the Waters of Region 1-B.

Job No. E-2 Title: Experimental Control of Undesirable Fish Species in Lake Diversion.

Period Covered: June 1, 1956 through May 31, 1957

ABSTRACT:

An estimated minimum of 185 tons of fish, mostly gizzard shad and drum, were removed from Lake Diversion by an experimental selective-kill treatment in March, 1957. Details of the treatment and a discussion of factors involved are given.

Inventory has been taken by gill net and seine collections before and after treatments in order to compile comparative data which may indicate possible effects of the treatment. A total of 1,288 fishes was collected by gill nets from which data concerning food habits, sexual development, spawning success, coefficient of condition and pathological conditions was recorded, and as far as possible, reduced to tabular form.

OBJECTIVES:

To determine the practical application and effectiveness of methods developed under Job E-1 (Experimental Control of Undesirable Fish Species).

TECHNIQUES:

Field work on this Job began in July, 1956. An attempt was made to collect sufficient data prior to experimental treatments that would be comparable to data that will be collected following treatments. Collections spaced approximately one month apart were attempted, but crowded work schedules, high winds and other adverse weather conditions prevented collections during the months of June, August and October, 1956, and January, 1957. Approximately 1200 feet of gill net, ranging in size from one inch to three inch (square mesh) were set on each visit. Each fish taken in these nets was measured, weighed, and the stage of gonadal development recorded. In addition, filled stomachs of predacious species were saved in formalin, as well as ripe ovaries, pathological tissues and parasites. Samples of forage fishes were obtained with the use of small-mesh seines, and the complete collections preserved in formalin. In the laboratory, formalin-preserved materials were identified, examined and the data recorded.

Physical data, including air temperature, water-surface temperature and turbidity were recorded at the lake. Samples of lake water were saved and the pH and dissolved solids present were determined. Ecological data pertaining to the lake were obtained in the usual ways and detailed notes were taken.

After ten months of inventory and study, Lake Diversion was treated for a selective-kill on shad and drum. Immediate effects of the treatment were observed and recorded, and a total-kill estimate was attempted. The next month following treatment, the study that is described above was continued to determine the long range effects and, possibly the need and feasibility of future treatments.

FINDINGS:

Lake Diversion, located in Archer and Baylor Counties, is 3,420 surface acres in size and contains 40,000 acre feet of water. Its greatest length is approximately 7 miles; its greatest width about 3 miles, and it has a shoreline of roughly 28 miles. The dam was construced in 1923. The lake is primarily a storage reservoir for water to irrigate the Big Wichita River Valley.

The source of Lake Diversion water is principally Lake Kemp, which is a much larger lake and whose dam is located eighteen miles, by river, to the westward of the Lake Diversion Dam. The water level of Lake Diversion is maintained at a desired level by regulated inflow from Lake Kemp.

An inventory of fish species present in Lake Diversion was made from June, 1953 to June, 1954. Results of this study are contained in the report, F-7-R-1, Job B-2. Lake Diversion was chosen as an experimental rough fish control lake as a result of this work.

FISH COLLECTIONS

A total of 1288 fishes was collected by gill nets from Lake Diversion during the segment period from June 1, 1956 to May 31, 1957. Percentage composition, sex ratios and average weights by sex of fishes collected by gill nets are given in Table 1. The total weight of all species collected by gill nets is 1,763.2 pounds. Percentage composition by weight and mean weights of fishes collected by gill nets is given in Table 2. Monthly totals of species collected by gill nets are given in Table 3.

A total of 1,395 forage fishes was taken from Lake Diversion during the segment with small mesh minnow seines. This information is given in Table 4. The total number of fishes taken by both gill nets and seines is given in Table 5.

WATER QUALITY

The water in Lake Diversion contains a very high concentration of salt. It is far too salty for municipal consumption, and the value of this water for irrigation has been questioned. Nevertheless, it is used to irrigate the valley of the Big Wichita River, and freshwater fishes thrive and reproduce in it.

Lake Diversion has but a small watershed of its own. Its water level is maintained at or slightly below spillway level with water from Lake Kemp, which is also salty. There is relatively little dilution of salts following rains due to the small watershed, and the water of Lake Diversion becomes extremely salty in periods of drought and heavy evaporation. Table 6 gives the chemical nature of the water at Lake Diversion from July, 1956 to May, 1957.

PHYSICAL CHARACTERISTICS

The surface of the open water at Lake Diversion reached temperatures as high as 80° F in summer and as low as 41°F in winter. During some cold snaps, a layer of ice formed along the shore of shallow, protected areas thick enough to prevent seining activities. Total salts ranged from 1272 to 2751 ppm during this study, and the flocculating effect of these salts resulted in relatively clear water. Maximum clarity is seldom obtained, however, because the lake is exposed to almost constant roiling action of winds. The lake

lies in semi-desert "mesquite country" with few cloudy days. As a result of abundant sunlight and water clarity, the plankton fauna is rich in species and individuals and the lake water is highly productive. Physical conditions of Lake Diversion water, at the time when fish samples were taken, are given in Table 7.

VEGETATION

By speciation, multicellular aquatic vegetation is not abundant in Lake Diversion. Pondweeds, mostly Potomogeton, appear in shallower waters of protected bays in the late spring and often form masses that are dense enough to impede boat traffic. Chara, although apparently abundant, seldom appears on the surface. Bottom samples obtained with an Eckman Dredge showed Chara to be present at or near all of the collection stations, and it is often snagged by deep-running trolling lures in the open waters. Emergent littoral vegetation is scarce and includes only a few small stands of cattail (Typha) and bullrush near the mouths of tributary creeks and along the river at the head of the lake.

FOOD HABITS

Food remains were found in stomachs of 37 specimens, 19 of which were white bass and 10 were channel catfish. Table 8 presents results of analysis made on food remains found in stomachs of all specimens that contained food. The bulk of the food items identified were insects and fish, mostly insects. Individual fish showed great selectivity in their feeding habits. Stomachs of those that were feeding on insects at the time of capture usually contained only insects and nothing else. The same was true of those feeding on fish at the time of capture. Mayflys were found in stomachs more frequently and in greater quantities than any other food item.

SEXUAL DEVELOPMENT AND SPAWNING SUCCESS

All fishes captured in gill nets were opened in the field and their gonads examined and the stage of development recorded. If the gonads were of medium-size or smaller, and were poorly developed, they were recorded as "immature". If they were large and well-developed, obviously approaching spawning condition, they were termed "ripe". In those instances where a fish was captured shortly after spawning, it was called "spent". The latter condition is difficult to determine in males, but easier in females.

Immature individuals of the larger fishes were taken in seine drags and measured and counted. In addition, notes were made of schools of fry seen, young fishes found in the stomachs of predacious fishes, etc.

When ovaries contained large eggs, nearly ready to be spawned, the two ovaries of such a fish were carefully removed, labeled and preserved in formalin. In the laboratory, the ovaries were carefully cleaned of excess tissues and weighed to the nearest one-tenth of a gram. Then a small quantity, roughly a gram, was snipped from one ovary and weighed on a chemical balance to the nearest one-one hundredth of a gram. The eggs in the small portion were then counted. An average of three counts was determined and the total number of eggs present in the two ovaries estimated (number of eggs counted times weight of both ovaries divided by the weight of the small section). Table 9 gives the total number of eggs found in ovaries of thirteen ripe females.

Lepisosteus osseus
(longnose gar)

Apparently, the major spawning period for this species is June. All specimens of both sexes captured in April and May were ripe, and one female was found to be spent on May 28, 1957. All specimens of both sexes were recorded as either spent or immature in July. No young gar were taken in seine hauls for forage fish at any time during the segment.

Lepisosteus platostomus
(shortnose gar)

Only three females were caught this segment. They were taken April 30, 1957, and were all ripe. Apparently, the spawning season of this species coincides with that of the longnose gar.

Dorosoma cepedianum
(gizzard shad)

All of the females taken in April and May were ripe, but the major spawn did not occur until June. Young of the year were common in seine hauls in July.

Ictiobus cyprinellus
(bigmouth buffalo)

Although known to be present in Lake Diversion, not a single specimen of this species was captured during this segment. Commercial fishermen have reported taking a few bigmouth buffalo along with several thousands of smallmouth buffalo. The reason for the apparent decrease and present rarity of this species is unknown at this time. Perhaps it is unable to compete with the large populations of smallmouth buffalo and carpsucker. A life history study of this most desirable of the rough fish species is greatly needed.

Ictiobus bubalus
(smallmouth buffalo)

This species is an early spawner, mostly in late March and early April. All of the seven females taken April 30, 1957, and all of the sixteen females taken May 28, 1957, were spent. Ripe males were taken throughout the year, especially following periods of rainfall.

Carpiodes carpio
(river carpsucker)

Spawning of this species is very successful in Lake Diversion. All of the larger females were ripe in March. Spawning began in April and continued through May and June, and was completed, for the most part, by July. A few ripe males were found throughout the year. No young of the year were taken in any of the seine drags nor in stomachs of any predacious fishes. A life history study of this species is also greatly needed.

Cyprinus carpio
(carp)

Carp are not numerous and do not constitute a problem in Lake Diversion. No

xplanation is given for this at the present time. Large numbers of spawning carp ıve been observed on numerous occasions, and live eggs of this species have been collected from Lake Diversion for laboratory study. Ripe females have been taken practically every month of the year. The major spawn occurs from early May through June. Ripe males are taken throughout the year, especially following rainfall.

Ictalurus punctatus
(channel catfish)

Ripe females were taken in April, but spawning was deferred until May. No regular spawning pattern was followed by this species during this segment.

Pylodictus olivaris
(flathead catfish)

Only two female flatheads were taken, both of which were in a spent condition on April 30, 1957.

Roccus chrysops
(white bass)

Very little was learned about spawning of this species during the study. Apparently, their spawning depends on such conditions as wind, rainfall and the operation of flood gates at Lake Kemp Dam. Young of the year (1 to $1\frac{1}{2}$ inches) were taken in seine drags in July.

Micropterus salmoides
(black bass)

Ripe females were found in April. Young of the year were taken in seine hauls in July.

Pomoxis annularis
(white crappie)

Ripe females were taken in April, and young of the year were taken in May.

Aplodinotus grunniens
(drum)

Although previous studies at Lake Diversion have shown drum to be quite numerous, only nine were taken in gill nets. None of those taken were in spawning condition. The selective-kill proved drum to be very abundant.

COEFFICIENT OF CONDITION

"K" factors were worked out for all of the larger fishes taken in gill nets. Distribution of "K" factors for fishes in Lake Diversion is given in Table 10. In the report for the following segment, an attempt will be made to utilize monthly variations in "K" factor distribution as an indication of the effects of selective-kill treatments and other rough fish control methods.

EXPERIMENTAL SELECTIVE-KILL TREATMENT:

Following ten months of inventory and study, Lake Diversion was treated in March, 1957, for an experimental selective-kill on shad and drum. A concentration of .3 pounds of 5% rotenone to the acre-foot of water (.10 ppm) was distributed when the temperature of the lake was 55°F. A total of 10,320 pounds of rotenone was distributed over the entire surface of the lake. High winds and hard, driving rain during the time of treatment caused many difficulties and increased the time required for treatment. In spite of adverse weather conditions, however, the work was carried out as planned.

Within an hour following the treatment, large numbers of both shad and drum began to work the surface in a moribund condition. After death, except for those that were washed ashore by wind and wave action, both shad and drum sank to the bottom. Later, most of the drum bloated and floated, whereas shad remained on the bottom in the cold water where they decomposed without rising to the surface. This was expected, however, because during laboratory experiments with water temperatures below 60°F both shad and drum sink to the bottom of the vats. Shad remain there until removed, whereas drum begin to surface after the fifth day.

Since most of the fish that were to be killed by the treatment were not expected to float and make possible a total-kill estimate, wire baskets containing live shad were placed at various depths in the lake. They were spaced at five foot vertical intervals in the thirty foot depth water near the dam, and at four foot intervals in the eighteen foot water in the river channel near Rock Island. High winds prevented checking these live baskets until six days after the treatment. Two of the baskets had been torn loose from their moorings by wind and high waves, but all others remained in place. All shad in each basket were found to be dead and quite decomposed. Whether the test shad were killed by rotenone, weather conditions or some other cause, is a matter of speculation. The badly decomposed condition of shad in the baskets indicates that they were killed shortly after the treatment, however.

One week following the treatment, when most of the dead fish that bloated and floated had been blown to the shore, an attempt was made to estimate the numbers of fish killed. Shifting wind had formed windrows of dead fish along the shoreline of the lake and islands. Due to their badly decomposed condition, average weights could not be determined; therefore, it was necessary to determine their average length and compute average weight from "K" factor data collected immediately preceding the kill. Estimates were made by shoreline counts at random in 100 foot strips. Only representative areas were considered-not coves where there were many, nor points and protected areas where there were few. Total shoreline to be considered was determined by measuring the shoreline (including islands) on the most recent SCS aerial photograph of Lake Diversion. The resulting estimate was a minimum figure which did not include the following:

1. Fish picked up by fishermen and spectators during and following the treatment.

2. Fish eaten by other fish, pelicans, gulls, raccoons, etc.

3. Fish, especially shad, that sunk to bottom and did not float.

The estimated total-kill according to the shoreline count as described above is as follows:

DRUM

Average number per foot shoreline - 2.7
Average weight per drum - .5 lb.
Total drum killed - 399,168
Total weight - 199,584.0 lbs. or 99.8 tons.

The inventory of species in Lake Diversion during 1953 and 1954 showed the drum population to be 780,589. The shoreline count of dead drum following the kill was only 399,168, or approximately one-half the estimated total population of drum. Since 1200 feet of gill net in the lake produced only two drum in four days after the kill, the shoreline count is probably an underestimate.

CARP

Average number per 138 feet of shoreline - 1
Average weight per carp - 3.5 lb.
Total carp killed - 1072
Total weight - 3,752 lbs. or 1.8 tons.

CARPSUCKER

Average number per 100 feet of shoreline - 2.6
Average weight per carpsucker - 1.8 lbs.
Total killed - 3,843.8
Total weight - 6,918.8 lbs. or approximately 3.5 tons

BUFFALO

No buffalo observed in the count areas. They were seen elsewhere, however, and reports indicate many were picked up following the kill.

GAR

No gar in the count areas, but they too were occasionally observed elsewhere in very small numbers.

WHITE BASS

Average number per 100 feet of shoreline - .7
Average weight per white bass - .5 lb.
Total white bass killed - 1035
Total weight - 518 lbs.

CRAPPIE

Average number per 100 feet of shoreline - .2
Average weight per crappie - .1 lb.
Total crappie killed - 296
Total weight - 30 lbs.

BLACK BASS

No black bass observed anywhere

CHANNEL CAT

No channel cat in count areas - very few reported elsewhere.

SHAD

Impossible to count becasue they sunk immediately after death and did not float up to time of estimate. It is considered safe, however, to assume that at least as many shad were killed as drum.

Approximately 400,000 shad killed.
Approximate weight per shad - .4 lb.
Total weight killed - 160,000 lbs. or 80 tons.

	NUMBER	POUNDS	TONS	NO./ACRE	LBS./ACRE
ROUGH FISH SPECIES					
Shad	400,000	160,000	80	116.9	46.8
Drum	399,168	199,584	99.8	116.7	58.4
Carp	1,072	3,752	1.9	.3	1.1
Carpsucker	3,844	6,919	3.5	1.1	2.0
	804,084	370,255	185.2		
GAME FISH SPECIES					
White Bass	1,035	518		.3	0.2
Crappie	296	30		.0	0.0
	1,331	548			
	.16% total kill		.21% total wt.	235.3	108.5

On March 22, two days after the treatment, gill nets were set in Lake Diversion to obtain additional data concerning effects of the treatment. A total of 1200 feet of experimental gill nets (1 inch mesh to 3 inch mesh), 200 feet of which were 16 feet deep, was set in the middle and lower sections of the lake. They were set below the surface to prevent catching dead fish that may be drifting on the surface. High winds and adverse weather conditions prevented crews from checking the nets until March 25, three days later. No shad and only 2 drum were found in the nets. Tabulated results of these nets sets are as follows:

Carpsucker	192	69.81%
Buffalo	47	17.09%
Carp	8	2.90%
Drum	2	.72%
White bass	5	1.81%
Channel Cat	9	3.27%
Crappie	12	4.36%
	275	99.96%

DISCUSSION:

The treatment of Lake Diversion brought to mind several problems, the solutions to which are unanswered at the time of this writing. Accuracy of the total-kill estimate is very questionable in spite of the fact that the most applicable techniques known at the time of the treatment were employed. Much time, continuous study, and reports of fishing success from Lake Diversion sportsmen are necessary before the feasibility and benefits of the treatment can be ascertained.

The estimate of shad killed is nothing more than a guess because it is not possible to count fish that are not visible. Although drum, as well as other species, were present along the shoreline to make possible a minimum estimation, it was not possible to include those fishes that remained on the bottom, those netted by spectating fishermen, and those eaten by surviving fish and other fish-eating predators. Observations of the bottoms of shallow, protected coves, as well as seining activities in the river above Lake Diversion, revealed great numbers of decomposed remains of both shad and drum which were not included in the count. Stomachs of all catfish removed from gill nets five days after the treatment were gorged with remains of shad and drum. (Interesting to note is that no species other than shad and drum were represented in stomachs of catfish at that time, not even minnows).

There are many discrepancies in sampling methods used at the present time. Gill nets of variable sized meshes are being employed to obtain relative abundance data before and after treatment. Although this method serves as an indication of the fish population, spot treatments with rotenone have proved gill net sampling to be greatly in error. Sampling with gill nets will be continued, however, in order to obtain comparative data from which to determine effects of the selective-kill treatment.

It was interesting to note that although no shad were caught in gill nets set continuously in the lake for three days following the treatment, they began to reappear in greatly reduced numbers in gill net samplings in April and May. Only nine were caught in April and three in May (see Table 3). Several explanations are offered for their re-occurrence. Even if the treatment had killed all the shad, which is highly improbable, reinfestation was eminent from the upper river and tributary streams which could not be treated. Lake Kemp is another possible source of contamination. After the Lake Diversion treatment, it was necessary to reduce the water level of Lake Kemp, which empties into the Big Wichita River above Lake Diversion. Two flood gates at Lake Kemp were opened to discharge 1,400,000 gallons per minute for twenty-seven days. If shad or any other species of fish can tolerate the sudden change of pressure from the bottom of Lake Kemp to the atmosphere below the dam, Lake Kemp is certainly a source of contamination for Lake Diversion. This possibility will be checked in the spring of 1958.

Lake Diversion is an excellent body of water for experimental control of undesirable species. Its fish population includes all game and rough fish species native to waters in the Wichita Valley. Complete control of its water level can be exercised by draining either through irrigation canals or through the dam, and refilling at any time by opening flood gates at Lake Kemp. Thus, off-season migrations of rough fish species can be caused at any time by flooding the river above the lake. This will be very advantageous in future studies and experimental control of the river carpsucker. Authorization has been approved to continue this work until at least May 31, 1958.

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Approved by: Marion Toole
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Date: April 14, 1958

TABLE NO. 1 PERCENTAGE COMPOSITION, SEX RATIOS AND AVERAGE WEIGHTS BY SEX OF FISHES COLLECTED BY GILL NETS FROM LAKE DIVERSION, 1956 - 1957

Species	Number Taken	% of Total	% Males	Ave.Male Weight	% Females	Ave.Female Weight
Lepisosteus osseus	37	2.9	54.0	2.9	46.0	6.4
Lepisosteus platostomus	4	.3	25.0	2.8	75.0	3.7
Lepisosteus productus	0	.00		0		0
Dorosoma cepedianum	472	36.6	42.6	.65	57.4	.75
Ictiobus bubalus	175	13.6	64.0	2.22	36.0	3.54
Carpiodes carpio	369	28.6	54.2	1.27	45.8	1.33
Cyprinus carpio	31	2.40	48.4	3.82	51.6	4.47
Ictalurus punctatus	38	3.0	55.3	1.58	44.7	1.68
Roccus chrysops	76	5.90	47.4	.72	52.6	.72
Micropterus salmoides	7	.5	28.6	.74	71.4	1.80
Pomoxis annularis	68	5.3	47.0	.34	53.0	.53
Aplodinotus grunniens	9	.7	55.5	.80	44.5	.92
Pylodictus olivaris	2	.2	0		100.0	1.40
Total	1288	100.00				

TABLE NO. 2 PERCENTAGE COMPOSITION BY WEIGHT AND MEAN WEIGHTS OF FISHES COLLECTED BY GILL NETS FROM LAKE DIVERSION, 1956 - 1957

Species	Weight (lbs)	%of Total Weight	Mean Weight
Lepisosteus osseus	166.1	9.4	4.5
Lepisosteus platostomus	13.8	.8	3.45
Lepisosteus productus	0	0	0
Dorosoma cepedianum	335.4	19.0	.71
Ictiobus bubalus	472.0	26.8	2.7
Carpiodes carpio	479.5	27.2	1.3
Cyprinus carpio	128.7	7.3	4.15
Ictalurus punctatus	61.7	3.5	1.6
Roccus chrysops	54.5	3.1	.72
Micropterus salmoides	10.5	.6	1.50
Pomoxis annularis	30.0	1.7	.44
Aplodinotus grunniens	7.7	.4	.85
Pylodictus olivaris	2.8	.2	1.4
Total	1,763.2	100.0	-

TABLE NO. 3 MONTHLY TOTALS OF SPECIES COLLECTED BY GILL NETS, 1956 - 1957.

Species	July No.	%	Sept. No.	%	Nov. No.	%	Dec. No.	%	Feb. No.	%	March No.	%	April No.	%	May No.	%	Total No.	% of Total
Longnose gar	5	7.3	7	4.1	10	4.3	1	.5					8	5.5	6	4.7	37	2.8
Shortnose gar			1	.6									3	2.1			4	.3
Gizzard shad	19	27.9	81	47.1	129	55.1	66	35.3	105	46.7	55	45.4	9	6.2	3	2.4	467	36.4
Samllmouth buffalo	16	23.5	29	16.8	14	6.0	23	12.3	11	4.9	29	24.0	18	12.5	31	24.4	171	14.1
River carpsucker	3	4.4	17	9.9	37	15.8	59	31.6	69	30.7	18	14.9	89	61.8	78	61.4	370	28.9
Carp	2	2.9									1	.8	4	2.8	4	3.1	31	2.4
Channel Cat	11	17.6	2	1.1	7	3.0	5	2.7	4	1.8	3	2.5	3	2.1	1	.8	36	2.8
White Bass	7	10.2	7	4.1	15	6.4	12	6.4	29	12.9	6	4.9					76	5.9
Black Bass					1	.4			5	2.2			1	.7			7	.5
White Crappie	4	5.8	7	4.1	20	8.5	16	8.5	2	..8	9	7.4	6	4.1	4	3.1	68	5.3
Drum	1	1.4	1	.6	1	.4	5	2.7					1	.7			9	.8
Flathead catfish													2	1.4			2	.1
Totals	68	101.0	172	99.9	234	99.8	187	100.0	225	100.0	121	99.9	144	99.9	127	99.9	1278	100.3

TABLE NO. 4 TOTAL NUMBER OF FORAGE FISHES TAKEN FROM LAKE DIVERSION, 1956 - 1957

Species	Total
Dorosoma	13
Cyprinus	1
N. percobromus	27
N. lutrensis	870
N. deliciosus	19
N. buchanani	11
P. vigilax	343
Cyprinodon	8
Gambusia	16
Roccus chrysops	4
Micropterus	8
L. cyanellus	6
L. microlophus	16
L. macrochirus	36
L. humilis	8
L. megalotis	9
Total	1395

TABLE NO. 5 TOTAL NUMBER OF FISHES TAKEN FROM LAKE DIVERSION, 1956 - 1957

Species	Total
Lepisosteus platostomus	4
Lepisosteus osseus	37
Dorosoma	485
Ictiobus bubalus	175
Carpiodes	369
Cyprinus	32
N. percobromus	27
N. lutrensis	870
N. deliciosus	19
N. buchanani	11
P. vigilax	343
Ictalurus punctatus	38
Pylodictus olivaris	2
Cyprinodon	8
Gambusia	16
Roccus chrysops	80
Micropterus	15
L. cyanellus	6
L. microlophus	16
L. macrochirus	36
L. humilis	8
L. megalotis	9
Pomoxis annularis	68
Aplodinotus grunniens	9
Total	2683

TABLE NO. 6 CHEMICAL NATURE OF THE WATER AT LAKE DIVERSION

Date	Calcium	Sodium	Chloride	Sulfate	Carbonates	Bicarbonates	Total Salts	pH
7/27/56	482	420	804	878	6	73	2663	-
11/2/56	316	552	799	749	0	102	2518	7.85
12/10/56	306	539	880	629	0	55	2409	7.9
1/7/57	310	552	892	595	0	122	2471	8.2
2/5/57	386	564	888	811	12	90	2751	8.0
3/8/57	280	504	809	614	12	55	2274	8.12
4/30/57	278	510	755	567	12	168	2290	-
5/27/57	182	264	490	240	12	84	1272	8.13

TABLE NO. 7 PHYSICAL CONDITIONS OF LAKE DIVERSION WATER, 1956 - 1957.

Date	Air Temp.	Water Temp.	Turbidity (mm.)
7/27/56	84	80	395
9/11/56	92	79	470
11/2/56	64	63	460
12/4/56	62	53	860
12/18/56	55	45	730
2/5/57	45	41	1000 plus
3/8/57	61	52	790
4/30/57	67	64	790
5/27/57	79	73	890

TABLE NO. 8 FOOD REMAINS FOUND IN STOMACHS OF 37 SPECIMENS FROM LAKE DIVERSION.

Food Item	Frequency of Occurrence	Total Number Identified
White Bass		
Shad (*Dorosoma*)	5	5
Fish remains	6	10
Mayfly (*Hexagenia*)	11	601 +
Terrestrial plant seed	2	2
Black Bass		
Crappie (*Pomoxis*)	1	1
Sunfish (*Lepomis*)	1	1
Fish remains	3	4
Plant remains	1	1
Crappie		
Shad (*Dorosoma*)	1	1
Mayfly (*Hexagenia*)	2	395 +
Channel Cat		
Fish remains	1	1
Crayfish	1	1
Mayfly (*Hexagenia*)	8	1 3/4 + lbs.
Flathead Catfish		
Fish remains	1	8

TABLE NO. 9 REPRODUCTIVE POTENTIAL

Date Collected	Length of Fish	Weight of Fish		Total Number of Eggs
		Lepisosteus platostomus		
4/30/57	665 mm	1730 g		18,671
		Lepisosteus osseus		
4/30/57	900 mm	2800 g		23,144
4/30/57	1180 mm	8165 g		66,528
4/30/57	955 mm	3000 g		19,656
		Dorosoma cepedianum		
3/28/57	300 mm	690 g	1.52	340,636
		Carpiodes carpio		
3/8/57	310 mm	875 g		139,481
3/8/57	288 mm	760 g		152,760
		Ictiobus bubalus	lb.	
3/8/57	325 mm	1115 g	2.45	69,495
3/8/57	400 mm	2160 g	4.76	212,968
4/30/57	395 mm	2110 g	4.64	141,212
4/30/57	320 mm	1175 g	2.59	81,516
		Cyprinus carpio		
3/28/57	470 mm	2975 g	6.55	563,018
		Ictalurus punctatus		
4/30/57	395 mm	1120 g		12,284

TABLE NO. 10 DISTRIBUTION OF "K" FACTORS FOR LAKE DIVERSION
1956 - 1957

Lepisosteus platostomus

Factor	.5	.6
Males	1	
Females	1	2

Lepisosteus osseus

Factor	.3	.4	.5
Males	4	15	
Females	3	13	1

Dorosoma cepedianum

Factor	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
Males	2	-	1	2	17	30	38	52	40	13	5	-	1
Females	-	1	-	10	22	47	55	59	42	19	12	2	1

Carpiodes carpio

Factor	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6
Males	2	1	5	13	17	31	34	27	35	15	9	6	2	1			
Females	-	-	5	7	23	25	21	23	20	16	14	7	5	1	2		

Ictiobus bubalus

Factor	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.2
Males	1	3	8	12	14	13	18	14	10	11	4	3					
Females	-	-	8	9	3	8	10	6	4	8	2	3	1	-	-	-	1

Cyprinus carpio

Factor	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9
Males	-	-	1	2	1	4	3	2	-	1	1
Females	1	-	-	-	1	3	1	4	1	4	1

Ictalurus punctatus

Factor	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1
Males	-	-	-	-	5	6	5	2	2	-	1
Females	1	-	1	3	2	4	3	3	-	-	-

Pylodictus olivaris

Factor	1.4	1.5	1.6
Males	-	-	-
Females	1	-	1

TABLE NO. 10 DISTRIBUTION OF "K" FACTORS FOR LAKE DIVERSION (continued)

Roccus chrysops

Factor	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4
Males	1	1	-	1	7	8	7	3	4	2	-	1	-	-	-	1
Females	1	-	1	1	1	6	11	6	4	5	3	1	-	-	-	-

Micropterus salmoides

Factor	2.2	2.3	2.4	2.5	2.6	2.7
Males	1	-	-	1	-	-
Females	1	1	-	2	1	-

Pomoxis annularis

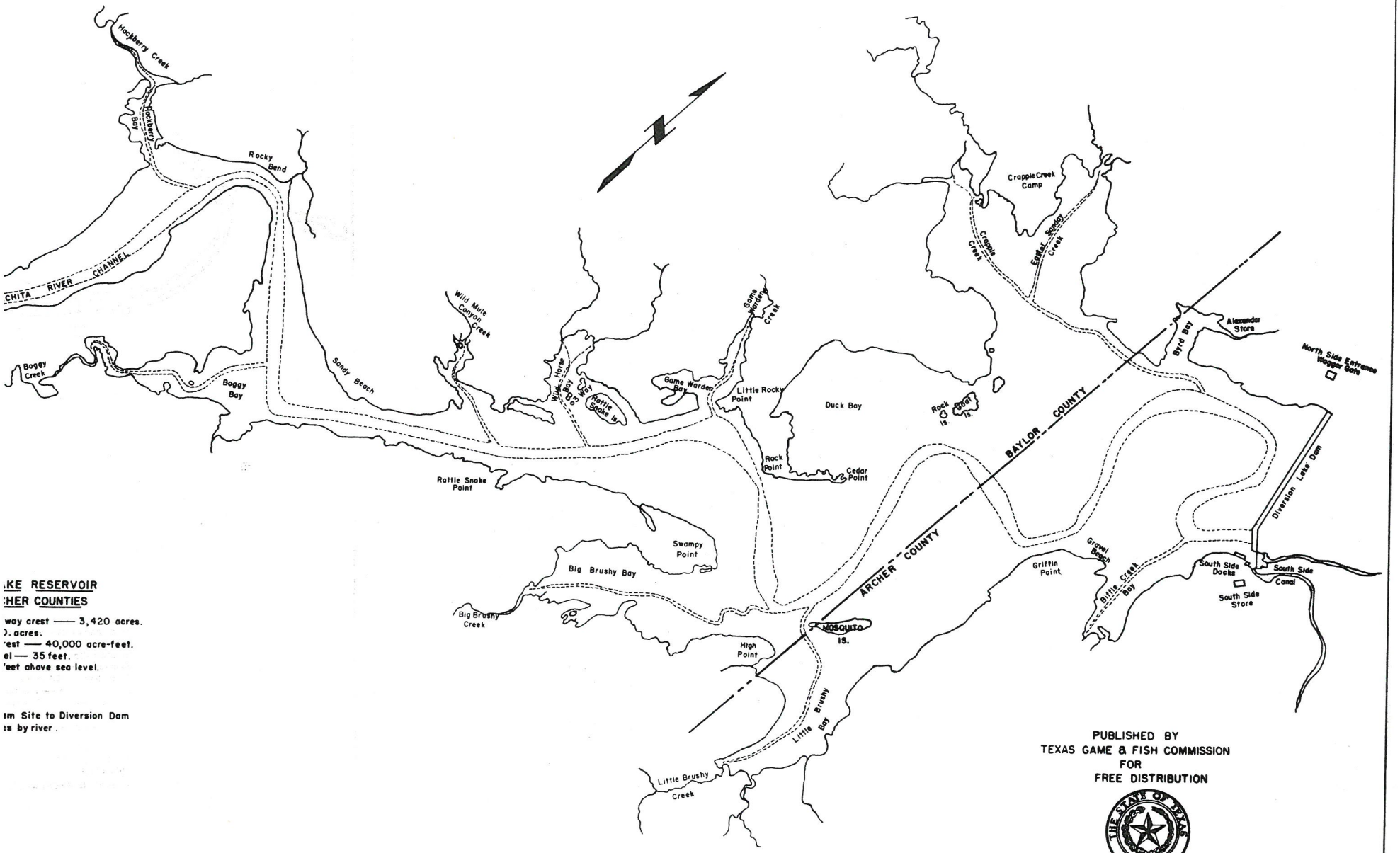
Factor	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
Males	-	-	-	-	-	1	6	4	3	4	4	4	2	1	1	1	1
Females	1	-	-	-	-	3	2	4	5	9	3	5	2	-	-	-	2

Aplodinotus grunniens

Factor	2.0	2.1	2.2	2.3	2.4	2.5
Males	1	-	2	1	1	-
Females	1	-	2	-	-	1

Rear View of Rotenone Mixing and Dispensing Barge While Treating Lake Diversion

Side View of Rotenone Mixing and Dispensing Barge While Treating Lake Diversion



KE RESERVOIR
HER COUNTIES

way crest —— 3,420 acres.
). acres.
rest —— 40,000 acre-feet.
el — 35 feet.
feet above sea level.

im Site to Diversion Dam
s by river.

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LAKE DIVERSION