

FILE

Report of Fisheries Investigations
Experimental Use of Copper Sulphate in Killing Undesirable
Fish Species

by

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June 1, 1959 - May 31, 1960

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A B S T R A C T

Five small lakes in eastern Texas were selected for field testing the use of copper sulphate as a selective fish toxicant. Water was hauled from each lake and bioassays were conducted in the laboratory to predetermine proper dosages for each lake. Copper sulphate in concentrations ranging from 1.3 to 1.61 parts per million proved to be selective under field conditions for bullhead catfish, gizzard shad, threadfin shad, chubsuckers, spotted suckers, bigmouth buffalo, carp, and golden shiners. Very few centrarchids were killed during the field tests..

Job Completion Report

State of TEXAS

Project No. F-3-R-7

Name: Fisheries Investigations and Surveys of
the Waters of Region 5-B

Job No. E-1, (Seg. 5)

Title: Experimental Use of Copper Sulphate in
Killing Undesirable Fish Species

Period Covered:

June 1, 1959 - May 31, 1960

OBJECTIVES

To continue the studies of the toxicity of copper sulphate on the fish in the waters of eastern Texas in the laboratory and to field test the findings that have resulted from laboratory work thus far.

It has been determined during previous segments that copper sulphate is a selective toxicant for black bullhead catfish (Ictalurus melas), yellow bullhead catfish (Ictalurus natalis), lake chubsuckers (Erimyzon sucetta), and golden shiners (Notemigonus crysoleucas) when used in waters of low alkalinity. Field tests have been planned for this segment, as well as experimental work in the laboratory, with certain additives to keep the copper in solution.

PROCEDURE

Laboratory procedure

Copper sulphate with a chelating agent added

Copper sulphate was used in five gallon jars in the laboratory with the addition of a chelating agent in an attempt to hold the copper ion in solution in waters of higher alkalinity. Bullhead catfish and bluegill sunfish (Lepomis macrochirus) were used as test animals.

Copper sulphate bioassays

Copper sulphate was field tested as a selective toxicant in five small lakes in eastern Texas. It was determined in previous segments that copper sulphate is selectively toxic to certain species. However, there are apparently many variables in different waters of the same area that make it difficult, if not impossible, to prescribe the proper dosage for any given body of water from available water analysis data. Therefore, it was deemed worthwhile to conduct bioassays in the laboratory using water from each body of water to determine the proper dosage. Water was hauled from each of the lakes to the laboratory and bioassays conducted. A selective dosage was determined from the data thus acquired. Bluegill sunfish and bullhead catfish were used as test animals.

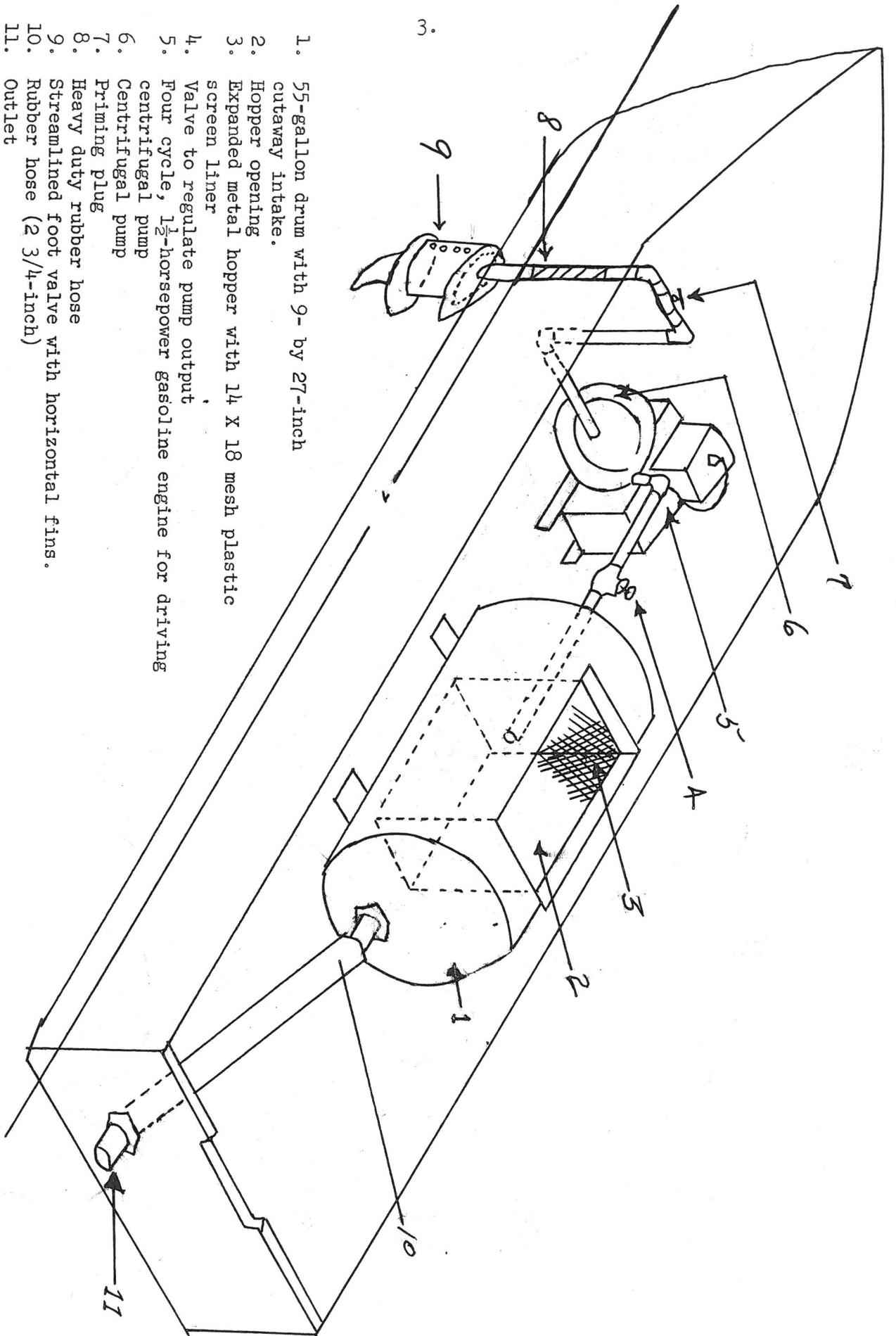
Nineteen five-gallon, wide-mouth jars equipped with one airstone each were used as test vessels. The volume of water used in each jar was sixteen liters. Nine of the test solutions were prepared over a wider range of concentrations (e.g. 1.0, 1.5, 2.0, 2.5, and 3.0 p.p.m.). If bullhead catfish were killed at 2.5 p.p.m. and not at 1.0 p.p.m. intermediates were set up within that range (e.g. 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, and 2.4 p.p.m.). Then from the intermediate tests a dosage was selected for field testing. The dosage selected was that which killed the maximum number of bullhead catfish and the minimum number of bluegill sunfish while leaving a broad enough margin in both directions to allow for reasonable error in field application. This margin or tolerance spread between the two species was found to be wide enough so that the dosage selected usually approached LD 100 for the bullheads and LD 00 for the bluegills.

Bluegill sunfish were selected as test animals because previous work proved them to have the lowest tolerance to copper sulphate than any of the centrarchids. Bullhead catfish were selected because they are one of the more problematic noxious species. Also, it has been determined by exploratory work that concentrations of copper sulphate that are lethal for bullhead catfish are also lethal for threadfin shad (Dorosoma petenense), gizzard shad (Dorosoma cepedianum), lake chubsuckers and possibly others.

Each series of bioassays was terminated after 96 hours. Two bluegill sunfish and two bullhead catfish were placed in each jar. One jar was used as a control. Water analyses included phenolphthalein and methyl-orange alkalinity, dissolved chlorides, dissolved carbon dioxide, and dissolved oxygen determinations. An attempt was made to keep the temperatures near the outside air temperatures. No attempt was made to control daily temperature fluctuations since it would be impossible to control them in the field.

Field Procedure

Each lake selected for a field test site was mapped and sounded to determine the water volume. Some of the lakes were sounded by means of a recording fathometer while others were sounded with a pole marked at one foot and one-fourth foot intervals. Lakes having large variations in depth were marked off in sections and volumes calculated for each section. After the proper dosage had been determined in the laboratory, concentrations were calculated for each section of the lake or in some instances for the entire lake. The copper sulphate was applied to the lakes in solution. The crystals were dissolved by pumping lake water through a hopper mounted inside a 55 gallon drum (Figure 1). The centrifugal pump delivers 50 gallons per minute into the hopper dissolving the crystals at the rate of approximately 1,600 pounds per hour. The hopper is built of expanded metal with a 14 by 18 mesh plastic screen liner and will hold 150 pounds of copper sulphate crystals. The solution leaves the drum by gravity flow through a 2 3/4 inch rubber hose connected to a pipe fitting which passes through the transom of the boat. The intake foot valve on the pump is streamlined and equipped with two horizontal fins that hold it under water while the boat is in motion. The two feet of intake line immediately above the foot valve is made of heavy duty rubber hose to allow the foot to deflect when struck by stumps or logs. Thus, the distribution of copper sulphate is an uninterrupted operation. The only stops required are to pick up additional copper sulphate. The stops can be minimized on larger lakes by the use of a supply boat to ferry copper sulphate to the distribution boat. Figures 2 and 3 show the distribution equipment in operation.



1. 55-gallon drum with 9- by 27-inch cutaway intake.
2. Hopper opening
3. Expanded metal hopper with 14 X 18 mesh plastic screen liner
4. Valve to regulate pump output
5. Four cycle, 1½-horsepower gasoline engine for driving
6. Centrifugal pump
7. Priming plug
8. Heavy duty rubber hose
9. Streamlined foot valve with horizontal fins.
10. Rubber hose (2 3/4-inch)
11. Outlet

Figure 1. - Diagram of equipment for dissolving and distributing copper sulphate crystals

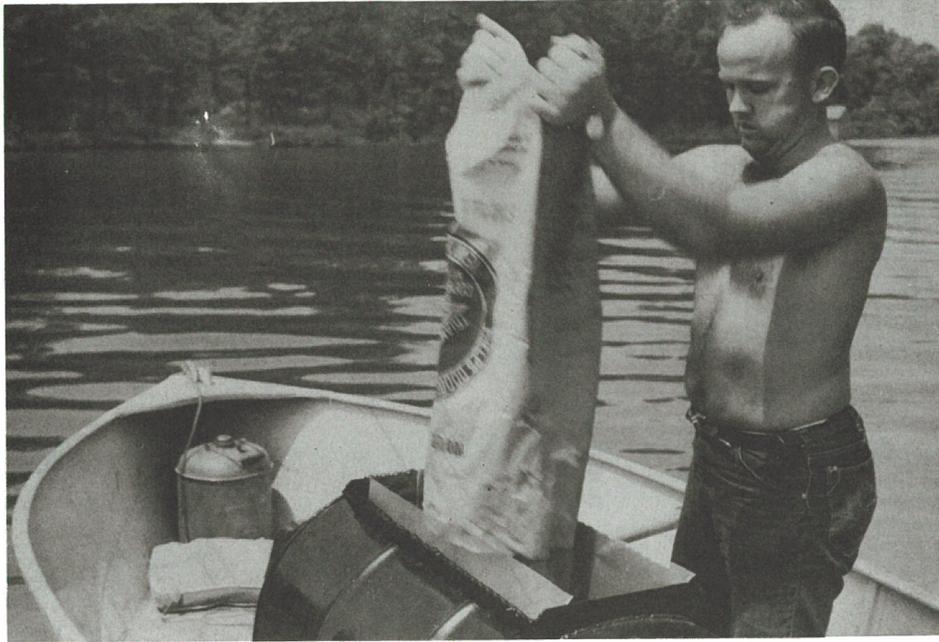


Figure 2. - Putting a 100 pound sack of copper sulphate into the hopper of the dissolving drum.

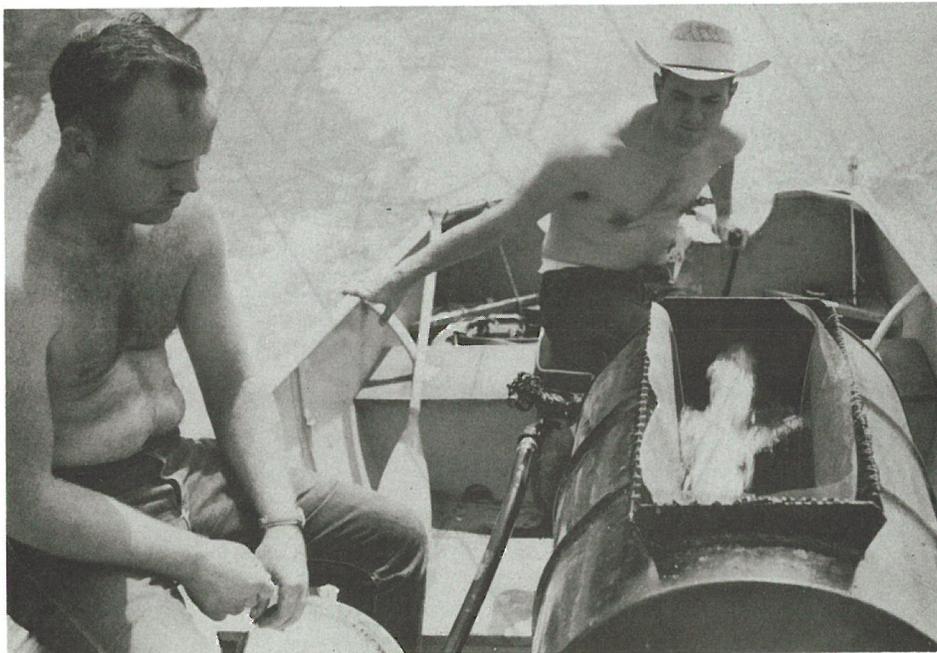


Figure 3. - Water is pumped over the copper sulphate crystals at the rate of 50 gallons per minute.

RESULTS

Laboratory resultsCopper sulphate with a chelating agent added

One of the factors limiting the use of copper sulphate as a fish toxicant is alkalinity. The calcium carbonate and bicarbonate react with the copper sulphate and precipitate as basic copper carbonate which is non-injurious to fish. This reaction is rather rapid and removes the copper ion before fish can acquire a lethal dose.

Versene, (tetrasodium salt of ethylenediaminetetraacetic acid) is a chelating agent manufactured by Dow Chemical Company. It was hoped that the Copper ions could be held in solution by making them a part of chelate ring compounds. While the Versene did hold the Copper in solution in waters of higher alkalinity, it greatly reduced the toxicity of copper sulphate to fish so this test was abandoned in the laboratory and was not field tested.

Field resultsLindale Club Lake

Lindale Club Lake is located three miles northeast of Lindale, Smith County, Texas. It is a man made lake, impounded by an earthen dam, and was built primarily for fishing. The lake covers 50 acres and contains 388 acre-feet of water. It was built in 1914 and rebuilt in 1946, after the spillway broke in 1944. A fishery survey was conducted in November 1958 by Charles R. Inman, Biologist for the Texas Game and Fish Commission. This survey revealed that the lake contained large numbers of yellow bullhead catfish (Ictalurus natalis), lake chubsuckers (Erimyzon sucetta), and large golden shiners (Notemigonus crysoleucas). These three species made up 71.26 percent of the total number and 61.2 percent of the total weight of the fish taken in 1,000 feet of gill net during that survey (Table 1).

On August 12, 1959, the lake was treated with 1,677 pounds of copper sulphate crystals which brought the concentration to 1.61 p.p.m. Application started at 10:00 a.m. and all of the chemical had been applied before noon. The only fish noted in distress on August 12th were a few madtoms (Schilbeodes gyrinus). Water temperatures reached 90° F. during the day.

On August 13th, dead and distressed golden shiners (Notemigonus crysoleucas), yellow bullhead catfish (Ictalurus natalis), madtoms (Schilbeodes gyrinus), and a few small bluegill sunfish (Lepomis macrochirus) began to appear. On August 18th, a good kill of golden shiners, bullheads, madtoms, and chubsuckers was evident. A very few bluegills and crappie were found dead. Also, two large flathead catfish (Pylodictus olivaris) and one large buffalo (Ictiobus bubalus) were found dead.

On September 9, 1959, a follow-up study was conducted to determine the effectiveness of the treatment as well as the effect, if any, the treatment had on the physical condition of the remaining fish (Tables 2 and 3).

Cost of chemical was \$0.73 per acre foot or a total of \$283.24 for the entire lake.

Table 1. - Netting results, Lindale Club Lake, November 11, 1958, before copper sulphate treatment, 1,000 feet of gill net

Species	Number	Percent of number	Weight	Percent of weight
Lake chubsucker	5	5.74	3.5	12.1
Golden shiner	53	60.92	11.8	40.8
Yellow bullhead	4	4.60	2.4	8.3
Largemouth bass	1	1.15	0.8	2.8
Warmouth	1	1.15	0.3	1.0
Bluegill sunfish	15	17.24	4.9	17.0
Yellowbelly sunfish	1	1.15	0.3	1.0
White crappie	1	1.15	0.9	3.1
Black crappie	6	6.90	4.0	13.9
Totals	87	100.00	28.9	100.0

Table 2. - Netting results, Lindale Club Lake, September 9, 1959, after copper sulphate treatment, 1,000 feet of gill net

Species	Number	Percent of number	Weight	Percent of weight
Lake chubsuckers	0	--	--	--
Golden shiner	2	1.10	0.50	0.72
Yellow bullhead	12	6.59	7.37	10.65
Largemouth bass	2	1.10	0.75	1.09
Warmouth	5	2.75	1.50	2.17
Bluegill sunfish	138	75.82	40.31	58.27
Yellowbelly sunfish	1	0.56	0.50	0.72
White crappie	10	5.49	9.25	13.37
Black crappie	12	6.59	9.00	13.01
Totals	182	100.00	69.18	100.00

Table 3. - Lindale Club Lake coefficients of condition before and after copper sulphate treatment

Species	November 11, 1958			September 9, 1959		
	Number	Range	Average	Number	Range	Average
Yellow bullhead	4	1.65 - 1.88	1.74	7	1.99 - 2.67	2.22
Largemouth bass	1	1.95	1.95	2	2.19 - 2.21	2.20
Warmouth	1	3.43	3.43	5	3.60 - 4.16	3.86
Bluegill sunfish	15	3.36 - 4.85	4.12	25	3.51 - 5.01	4.27
White crappie	1	2.70	2.70	7	2.73 - 3.64	3.18
Black crappie	6	3.02 - 3.52	3.22	9	2.99 - 3.66	3.37

Pharris Lake

Pharris Lake is a 38 acre man-made lake located four or five miles south of Larue, Henderson County, Texas. It is impounded by an earthen dam and contains 238 acre-feet of water. A fishery survey was conducted in July 1957, at which time the lake was found to contain bullhead catfish and lake chubsuckers. In the spring of 1958, the lake was stocked with 400 threadfin shad (Dorosoma petenense). No shad were present in the survey collections of 1957.

On June 23, 1959, the lake was treated with copper sulphate crystals at the rate of 1.55 p.p.m. Water analysis values at the time of treatment were: methyl orange alkalinity - 18 p.p.m., pH - 7.2, dissolved chlorides - 21.28 p.p.m., and water temperature (surface) - 84° F.

Immediately after the copper sulphate was applied to the water, uncountable thousands of threadfin shad from $\frac{1}{2}$ - to 2-inches in length began to flounce on the surface and die. Several hours after treatment, golden shiners and chubsuckers began to come to the surface in distress. The next day, June 24, larger numbers of bullheads, golden shiners, and chubsuckers were observed dead or in distress. A few redear and bluegill sunfishes and crappie succumbed to the treatment. It was estimated that less than two percent of the fish killed were game species.

The cost of chemicals for treatment of Pharris Lake was \$0.71 per acre foot of water or a total of \$168.98 for the entire lake.

Tables 4 and 5 are the before and after treatment netting results. Table 6 is a comparison of condition coefficients before and after treatment. No threadfin shad were taken during the after-treatment netting although they had been previously stocked and many thousands were killed by the copper sulphate.

Table 4. - Netting results, Pharris' Lake, July 9, 1957, before copper sulphate treatment, 500 feet of gill net

Species	Number	Percent of number	Weight	Percent of weight
Lake chubsucker	1	0.55	0.56	0.82
Yellow bullhead catfish	17	9.39	10.94	16.03
Warmouth	15	8.29	2.31	3.38
Largemouth bass	2	1.10	5.00	7.33
Redear sunfish	24	13.26	8.31	12.18
Bluegill sunfish	97	53.59	26.13	38.29
White crappie	5	2.77	3.62	5.31
Black crappie	20	11.05	11.37	16.66
Totals	181	100.00	68.24	100.00

Table 5. - Netting results, Pharris' Lake, September 17, 1959, after copper sulphate treatment, 500 feet of gill net

Species	Number	Percent of number	Weight	Percent of weight
Lake chubsucker	1	1.53	0.37	1.32
Yellow bullhead catfish	11	16.93	5.00	17.94
Warmouth	2	3.07	0.25	0.90
Redear sunfish	5	7.70	1.50	5.38
Bluegill sunfish	31	47.68	7.50	26.91
White crappie	5	7.70	5.25	18.84
Black crappie	10	15.39	8.00	28.71
Totals	65	100.00	27.87	100.00

Table 6. - Pharris' Lake coefficients of condition three months after copper sulphate treatment

Species	Number	Range	Average
Yellow bullhead catfish	10	1.88 - 2.37	2.07
Warmouth	2	2.55 - 2.81	2.68
Redear sunfish	4	2.21 - 2.96	2.68
Bluegill sunfish	30	2.25 - 4.49	3.53
White crappie	5	2.10 - 3.16	2.54
Black crappie	10	2.15 - 3.02	2.73

Tomlin Lake

Tomlin Lake is located two miles northwest of Lindale, Smith County, Texas. It is impounded by an earthen dam on Duck Creek which flows north to the Sabine River. The lake covers 24.29 acres and contains 98.17 acre-feet of water at spillway level. It was built in 1934. A fishery survey was conducted in January 1959, by Charles R. Inman, Biologist for the Texas Game and Fish Commission. During that survey, gill netting produced large numbers of gizzard shad (Dorosoma cepedianum), spotted suckers (Minytrema melanops), lake chubsuckers (Erimyzon sucetta), and a lesser number of river carpsuckers (Carpiodes carpio), carp (Cyprinus carpio), golden shiners (Notemigonus crysoleucas), black bullheads (Ictalurus melas), and yellow bullheads (Ictalurus natalis) (Table 7).

On June 10, 1959, the lake was treated with 345 pounds of copper sulphate crystals, or a concentration of 1.3 p.p.m. Late in the day eight carp averaging 4 pounds each had died. On June 11, 1959, due to the lack of distressed and dead fish, it was suspected that the lake had been under treated and an additional 55 pounds of copper sulphate were applied to the lake. The total amount of copper sulphate applied would have brought the lake to 1.5 p.p.m. concentration. However, it is believed that a large amount of the copper sulphate that was applied the first day had precipitated in non-toxic forms before the second dosage was applied. The copper residual in the water two days after treatment was 0.1 p.p.m.

Water analysis values at the time of treatment were: water temperature - 82° F, pH - 7.0, methyl orange alkalinity - 18 p.p.m., chlorides - 21.28 p.p.m., turbidity - 30 inches secchi disc.

Cost of chemical for this treatment was \$0.69 per acre foot of water or \$67.74 for the entire lake.

Table 8 contains the results of after-treatment netting and Table 9 is the before and after treatment comparison of condition.

Table 7. - Netting results, Tomlin Lake, January 29, 1959, before copper sulphate treatment, 950 feet of gill net

Species	Number	Percent of number	Weight	Percent of weight
Spotted gar	4	1.31	7.5	3.7
Gizzard shad	66	21.64	18.0	8.9
Spotted sucker	77	25.24	89.8	44.4
Lake chubsucker	93	30.49	52.4	25.9
Bigmouth buffalo	2	0.66	3.9	1.9
River carpsucker	1	0.33	5.5	2.7
Carp	1	0.33	4.1	2.0
Golden shiner	10	3.27	1.8	0.9
Channel catfish	1	0.33	0.6	0.3
Black bullhead	4	1.31	3.7	1.8
Yellow bullhead	10	3.28	6.1	3.0
Bluegill sunfish	7	2.30	0.7	0.4
Redear sunfish	7	2.29	1.9	0.9
Longear sunfish	1	0.33	0.3	0.2
White crappie	21	6.89	6.0	3.0
Totals	305	100.00	202.3	100.0

Table 8. - Netting results, Tomlin Lake, August 13, 1959, after copper sulphate treatment, 950 feet of gill net

Species	Number	Percent of number	Weight	Percent of weight
Spotted gar	4	10.00	8.00	28.36
Gizzard shad	3	7.50	0.88	3.12
Bigmouth buffalo	2	5.00	5.44	19.30
Spotted sucker	12	30.00	11.25	39.89
Black bullhead	1	2.50	---	---
Yellow bullhead	3	7.50	0.88	3.12
Redear sunfish	1	2.50	0.25	0.89
Bluegill sunfish	9	22.50	0.69	2.44
White crappie	3	7.50	0.31	1.10
Black crappie	2	5.00	0.50	1.78
Totals	40	100.00	28.20	100.00

Table 9. - Tomlin Lake coefficients of condition before and after copper sulphate treatment

Species	January 29, 1959			August 13, 1959		
	Number	Range	Average	Number	Range	Average
Spotted gar	4	0.51 - 0.87	0.65	-	-	--
Gizzard shad	15	1.84 - 2.09	1.96	-	-	--
Spotted sucker	15	1.73 - 2.60	2.25	-	-	--
Lake chubsucker	15	2.32 - 2.93	2.25	-	-	--
Bigmouth buffalo	2	3.84 - 3.86	3.85	-	-	--
River carpsucker	1	3.27	3.27	-	-	--
Carp	1	3.38	3.38	-	-	--
Golden shiner	10	1.95 - 2.31	2.09	-	-	--
Channel catfish	1	1.31	1.31	-	-	--
Black bullhead	4	2.44 - 3.98	2.90	1	2.06	2.06
Yellow bullhead	10	2.00 - 2.66	2.15	3	1.98 - 2.44	2.15
Bluegill sunfish	7	3.85 - 5.15	4.39	9	3.18 - 4.24	3.70
Redear sunfish	9	3.42 - 4.12	3.75	1	2.78	2.78
Longear sunfish	1	4.01	4.01	-	-	--
White crappie	15	2.35 - 4.16	3.05	3	2.38 - 2.67	2.50
Black crappie	-	-	--	2	2.55 - 2.60	2.57

Rainbow Lake

Rainbow Lake is located approximately 15 miles southeast of Athens, Henderson County, Texas. The area of the lake at the time of treatment was 65 acres with an average depth of 4.25 feet and contained 276.9 acre-feet of water. A fishery survey conducted in October 1959, revealed that the lake contained a rather large population of gizzard shad (Dorosoma cepedianum) and a good number of black bullhead catfish (Ictalurus melas) and yellow bullhead catfish (Ictalurus natalis) (Table 10). On March 11, 1960, the lake was treated with 1,196 pounds of copper sulphate crystals, which was a calculated concentration of 1.6 p.p.m. Water conditions at the time of treatment were: temperature - 53° F., methyl orange alkalinity - 15 p.p.m., pH - 6.2, turbidity - 11 inches (secchi disc). The sky was clear with a wind 10 - 15 m.p.h. The air temperature was 45° F.

On March 15, 1960, a trip was made to the lake to observe results. Thousands of gizzard shad from eight to twelve inches in length were found dead and floating. Good numbers of bullhead catfish and chubsuckers were also found dead and floating. Many shad, chubsuckers, and bullheads could be seen on the bottom in shallow water, apparently held there by bottom muck.

On April 26, 1960, a follow-up netting sample was taken from the lake (Table 11). Table 12 is a comparison of coefficients of condition before and after treatment.

Table 10. - Netting results, Rainbow Lake, October 20, 1959, before copper sulphate treatment, 750 feet of gill net

Species	Number	Percent of number	Weight	Percent of weight
Spotted gar	9	4.36	18.25	13.11
Bowfin	7	3.40	33.19	23.86
Gizzard shad	66	32.04	24.25	17.43
Lake chubsucker	2	0.97	1.50	1.08
Black bullhead	14	6.80	14.50	10.42
Yellow bullhead	15	7.28	10.88	7.82
Largemouth bass	1	0.48	0.81	0.58
Redear sunfish	4	1.95	1.00	0.72
Bluegill sunfish	10	4.85	2.13	1.53
White crappie	34	16.51	2.31	1.66
Black crappie	44	21.36	30.31	21.79
Totals	206	100.00	139.13	100.00

Table 11. - Netting results, Rainbow Lake, April 26, 1960, after copper sulphate treatment, 750 feet of gill net.

Species	Number	Percent of number	Weight	Percent of weight
Spotted gar	17	11.04	48.37	31.21
Bowfin	7	4.54	31.43	20.29
Gizzard shad	22	14.29	5.56	3.59
Lake chubsucker	0	---	---	---
Black bullheads	3	1.95	4.25	2.74
Yellow bullheads	24	15.58	18.75	12.10
Largemouth bass	5	3.24	10.25	6.61
Warmouth	4	2.60	1.37	0.88
Redear sunfish	17	11.04	5.75	3.71
Bluegill sunfish	22	14.29	5.12	3.30
White crappie	11	7.14	10.19	6.58
Black crappie	22	14.29	13.94	8.99
Totals	154	100.00	154.98	100.00

Table 12. - Rainbow Lake coefficients of condition before and after copper sulphate treatment

Species	October 20, 1959			April 26, 1960		
	Number	Range	Average	Number	Range	Average
Largemouth bass	1	2.46	2.46	4	2.14 - 2.68	2.37
Redear sunfish	3	3.45 - 4.04	3.70	5	3.35 - 4.00	3.63
Bluegill sunfish	3	4.24 - 4.46	4.34	5	4.00 - 4.91	4.40
White crappie	10	2.51 - 3.26	2.86	5	2.36 - 3.46	3.06
Black crappie	10	2.37 - 3.88	3.30	5	2.96 - 3.49	3.26

Roundhouse Lake

Roundhouse Lake is located one mile south of Commerce, Hunt County, Texas. It covers 10.4 acres and contains 63.49 acre-feet of water. The lake was netted in February and was found to contain large numbers of black bullhead catfish (Ictalurus melas) and a few golden shiners (Notemigonus crysoleucas) (Table 13).

On November 10, 1959, the lake was treated with 274 pounds of copper sulphate, which is a calculated concentration of 1.6 p.p.m. Due to a depletion of standard solution, an alkalinity determination was not accomplished at the time of treatment. However, on February 11, 1960, the methyl orange alkalinity was 100 p.p.m. and the pH was 7.6. On the day that the lake was treated, the water temperature was 53° F. and the air temperature was 62° F. Observations of November 12 and 13, 1960, indicated that very few fish had succumbed to the treatment. However, the owner of the lake reported that an undetermined number of bullhead catfish and golden shiners died as much as two weeks after the treatment.

On July 20, 1960, a netting and seining sample was taken from the lake (Table 14). The seining sample revealed that a very heavy population of golden shiners still existed in the lake. Table 15 is a comparison of coefficients of condition before and after treatment.

Cost of the chemical for treating Roundhouse Lake was \$0.73 per acre-foot or \$46.34 for the entire lake.

Table 13. - Netting results, Roundhouse Lake, February 20, 1959, before copper sulphate treatment, 500 feet of gill net

Species	Number	Percent of number	Weight	Percent of weight
Bigmouth buffalo	1	2.23	4.50	16.67
Golden shiners	2	4.44	0.30	1.11
Black bullhead catfish	26	57.77	4.27	15.81
Channel catfish	1	2.23	3.50	12.96
Largemouth bass	5	11.11	8.21	30.41
Bluegill sunfish	2	4.44	0.12	0.45
White crappie	8	17.78	6.10	22.59
Totals	45	100.00	27.00	100.00

Table 14. - Netting results, Roundhouse Lake, July 20, 1960, after copper sulphate treatment, 500 feet of gill net

Species	Number	Percent of number	Weight	Percent of weight
Bigmouth buffalo	0	---	---	---
Black bullhead	1	5.26	0.56	4.38
Channel catfish	2	10.53	1.94	15.21
Largemouth bass	2	10.53	4.94	38.71
Green sunfish	1	5.26	0.13	1.02
Bluegill sunfish	2	10.53	0.31	2.43
White crappie	5	26.32	1.44	11.29
Black crappie	6	31.57	3.44	26.96
Totals	19	100.00	12.76	100.00

Table 15. - Roundhouse Lake coefficients of condition before and after copper sulphate treatment

Species	February 20, 1959			July 20, 1960		
	Number	Range	Average	Number	Range	Average
Channel catfish	1	1.86	--	2	1.59 - 1.63	1.61
Black bullhead	26	1.78 - 2.47	2.10	1	2.61	--
Largemouth bass	5	1.89 - 3.19	2.79	2	2.95 - 3.03	2.99
Bluegill sunfish	2	3.00 - 3.00	3.00	2	3.81 - 4.70	4.25
White crappie	8	3.32 - 3.97	3.88	5	2.29 - 3.20	2.74

CONCLUSIONS

The before and after treatment netting results do not, in all cases, show a great reduction of undesirable species. However, the writer feels that a single netting effort is not enough to give a good picture of the relative number of fish in the lakes treated. The fact that large numbers of dead bullhead catfish, chubsuckers, carp, carpsuckers, golden shiners, and shad were observed after treatment is irrefutable evidence that these species were reduced to some extent. Also, the fact that few desirable fish were found dead after treatment is good testimony that the undesirable species were reduced selectively.

The carbonates and bicarbonates in waters of higher alkalinity precipitate the copper very rapidly as copper carbonate which is non-toxic to fish. Exploratory work indicates that the critical alkalinity for successful use of this technique is somewhere between 60 and 100 p.p.m. Further tests are necessary to more accurately locate the critical alkalinity.

The present work did not include studies to determine the effect of copper sulphate on fish food organisms. However, coefficients of condition were compared on samples of fish taken before and after treatment. The comparison revealed that very little change in condition had occurred that could be attributed to the copper sulphate. Condition factor averages for some fish species had even increased following the treatment.

The field tests conducted during this segment clearly indicate that selective control of rough species with copper sulphate can be an effective management technique with certain limitations. Rotenone treatment, while cheaper than copper sulphate treatment, does not selectively control species such as bullhead catfish and golden shiners. However, copper sulphate treatment is limited to waters of lower alkalinity. Also, the cost of treating large reservoirs may be prohibitive at present.

RECOMMENDATIONS

This study should be continued to improve techniques and to acquire information as to long range effects and possible adaptation of the treatment to waters of higher alkalinity.

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