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PARTIAL POISONING *of* OVERCROWDED FISH POPULATIONS

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MANY PONDS throughout the United States that have been stocked with the bluegill-bass combination and with other combinations have failed to yield satisfactory fishing because of overcrowding by one or more species, with resulting unbalance in the populations (*2, 4, 9*).

A number of remedies for such ponds have been suggested. Eschmeyer (*3*), Thompson and Bennett (*8*), and others have poisoned the entire population or drained the pond and started over. Beckman (*1*) reduced the population by poisoning a section of a lake. Weed control plus fertilization and thinning the population by fishing have been used successfully in certain cases (*7*). Thinning of overcrowded species by seining also has been used by the authors, but is too time-consuming for general usage.

Experiments begun in 1948 have resulted in the development of a method of correcting overcrowded pond fish populations by partial poisoning with rotenone and are reported in this circular.

PRELIMINARY EXPERIMENTS

Eight rectangular 1-acre experimental ponds were used in preliminary experiments with the use of rotenone for thinning overcrowded bluegills in bluegill-bass combinations.

The ponds each had a total volume between 4 and 5 acre-feet of water. Derris dust containing 5 per cent rotenone was used in all tests. The derris was mixed with water to form a thick paste and was applied June 21 as follows: (1) at one spot in the center of the pond (spot poisoning), (2) in one line down the center of the pond (center line poisoning), (3) over the entire shallower half of the pond (sectional poisoning), and (4) in a continuous line 15 to

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TABLE 1. FISH KILLS RESULTING FROM VARIOUS METHODS OF APPLICATION OF DERRIS

Method of application	Amount derris used	Volume of pond (approximate)	Number and weight of bluegills killed	
	Pounds	*Acre-feet*	*Number*	*Pounds*
Spot poisoning	0.5	5	0	0
Center line poisoning	3.0	4	0	0
Sectional poisoning	3.0	5	18,112	118.5
Marginal poisoning	3.0	5	46,765	195.0

25 feet from the bank around three sides of the pond (marginal poisoning). The applications and the results are given in Table 1.

Spot poisoning. In this method of application, 0.5 pound of derris was mixed with water to form a thin paste, placed in a bag and carried to the approximate center of the pond, where the water was 5 feet deep. The bag was held 2 feet under water and then broken, allowing the derris to fall to the bottom. The water was not stirred. Within 20 minutes, some golden shiners (*Notemigonus crysoleucas*) and bluegills (*Lepomis macrochirus*) rose to the surface and swam wildly about for a few minutes. One turtle came up and swam towards shore. No further effect was noted and no fish were killed.

Center line poisoning. In this case, 3 pounds of derris was mixed to form a stiff paste and applied in one line down the center of the pond from the shallow to the deep end. The paste was applied from a boat, by holding handfuls of the stiff paste several inches under water surface and moving the hand back and forth to form a continuous line of the poison, which gradually settled and diffused to each side. While a few fish became excited and swam rapidly away from the line, none were killed.

Sectional poisoning. Three pounds of derris was used over the shallow half of the pond; this was sufficient to give a concentration of 1 p.p.m derris powder in that area. It was mixed to form a thin paste and a poison line was first applied across the center, blocking off the shallow half of the pond. The remainder of the poison was then applied in parallel lines approximately 15 feet apart over the shallow half, and mixed by boat and motor. Fish began coming to the surface within 15 minutes and continued to surface for several hours. As many as possible were recovered during this period and the remainder was recovered after bloating and rising to the surface.

The total dead fish recovered was 18,112 intermediate and small bluegills weighing 118.5 pounds.

Marginal poisoning. The fourth method of application was similar to the second. A total of 3 pounds derris powder was used on the pond. The powder was first mixed to form a thick paste and was then applied by wading in the water about 20 feet from and parallel to the bank. Handfuls of the paste were held about 6 inches under water and a continuous line formed by moving the hand back and forth while wading in a straight line toward the opposite end of the pond. The poison was applied under the surface to prevent wide distribution by winds. Lines of poison were run parallel to two sides and the shallow end of the pond, using 1 pound of dry derris powder to 300 linear feet along the sides and 1 pound per 150 linear feet along the shallow end. Bluegills began to come to the surface within 10 minutes and continued to die for several hours. The total killed was 46,765 bluegills weighing 195 pounds, 5 largemouth bass (*Micropterus salmoides*) weighing 5.2 pounds, and 1 white crappie (*Pomoxis annularis*) weighing 0.5 pound.

Results evaluated. The results from the first two methods appeared to indicate that fish moved away from poisoned areas and were killed only if they could not escape from these toxic waters. Marginal poisoning and sectional poisoning appeared to be two promising methods of partial poisoning for the reduction of overcrowded populations. Further tests were, therefore, confined to these two methods.

SECTIONAL POISONING

The sectional method was tried on a 60-acre lake overcrowded with bluegills. The upper third of the lake was blocked off with a poison line and treated with enough derris to give a concentration of 1 p.p.m. Large numbers of small and intermediate bluegills were killed. However, most of the large bass (approximately 1,000 pounds) in the pond were also killed because they were caught feeding in the poisoned area.

Because sectional poisoning is inclusive of relatively large areas, it can always be expected to kill many large bass and other large fishes along with the small overcrowded sunfishes. Consequently, this method for correcting overpopulation did not appear desirable

except under certain special circumstances. Where overcrowding is caused by bullheads or crappie, which normally are in the deeper waters, sectional poisoning may be necessary.

MARGINAL POISONING

Sampling in various areas of ponds indicated that there was a definite tendency for the smaller bluegills to be found in shallow water and the larger fish in the deeper areas. It therefore appeared possible that marginal poisoning might be used to eliminate small bluegills, while retaining most of the larger ones. It was also noted that largemouth bass did not usually feed in shallow waters during midday. Consequently it appeared possible that marginal poisoning might be used near midday to kill small bluegills without killing many of the large bass.

In order to determine if marginal poisoning could be used without killing large numbers of the harvestable fishes, tests were begun on a set of three 1-acre ponds that were in fishing experiments beginning March, 1948. When these ponds were seined in May and June, there was no recent hatch of bluegills and no hatch of bass, with many intermediate 1-inch and 3-inch bluegills. This indicated (5) that all three ponds contained unbalanced populations, which could not yield satisfactory annual crops of fish. The public that was fishing these ponds also came to the same conclusion and stopped fishing by June 15.

In the period March to June 15, the catches from the three ponds were as follows:

Pond	Composition of catch-numbers and weight of each species								
	Total catch	Largemouth bass		Bluegills		Shellcrackers		Green sunfish	
No.	*Lb.*	*No.*	*Lb.*	*No.*	*Lb.*	*No.*	*Lb.*	*No.*	*Lb.*
1	75.9	1	0.4	223	61.7	—	—	92	12.8
2	45.2	5	3.1	117	33.7	9	2.7	58	5.7
3	103.3	10	5.7	495	92.7	—	—	36	4.9

These ponds were partially poisoned at 1 p.m. on sunny days, using the technique for marginal poisoning. Pond No. 1 was treated June 21, Pond No. 2 on June 21 and 23, and Pond No. 3 on July 19. Each pond was drained the following October 26, to determine the effect upon the population.

Pond No. 1, Table 2, apparently contained at the time of poisoning 15 large bass, 5 of which were killed by the poison, and also 2 white

TABLE 2. RESULTS OF PARTIALLY POISONING POND NO. 1

Species and groups	Killed by partial poisoning June 21, 1948		Recovered on draining October 26, 1948	
	Number	*Pounds*	*Number*	*Pounds*
Largemouth bass, large	5	5.2	10	14.37
Largemouth bass, small[1]	1		22	0.5
White crappie, large	1	0.5	1	1.0
Bluegills, large			200	63.07
Bluegills, intermediate	46,765	195.0	1,859	81.53
Bluegills, small			4,284	84.72
TOTAL		205.7		245.19

[1] Restocked 100 bass fingerlings (3") June 28.

crappie, 1 of which was killed; none of the large bluegills were affected. The one poisoning eliminated 46,765 small and intermediate bluegills, leaving 1,859 intermediate and 4,284 small bluegills. These small bluegills apparently were present in deeper water at the time of poisoning, as repeated seining indicated that they were not hatched in the pond subsequent to poisoning.

Pond No. 2, Table 3, received two partial poisonings. Of the 27 large bass present, only 6 were killed. None of the 215 large bluegills and shellcrackers (*Lepomis microlophus*) were killed, while 40,000 small and intermediate bluegills and shellcrackers were eliminated. Subsequent to this marginal poisoning, overcrowding was corrected to a point where heavy reproduction by bluegills and shellcrackers occurred August 23, and 43,603 young were present upon draining.

In Pond No. 3, Table 4, none of the 11 large bass and the 348 large bluegills and shellcrackers present were killed by poisoning,

TABLE 3. RESULTS OF PARTIALLY POISONING POND NO. 2

Species groups	Killed by partial poisoning June 21		June 23		Recovered on draining October 26, 1948	
	No.	*Lb.*	*No.*	*Lb.*	*No.*	*Lb.*
Largemouth bass, large			6	6.3	21	30.12
Largemouth bass, small[1]					28	4.06
Bluegills, large					182	58.69
Bluegills, intermediate					173	9.50
Shellcracker, large					33	14.81
Bluegills — shellcrackers, small	18,112	118.5	21,888	144.0	43,603	28.56
Golden shiners					11	0.75
TOTAL		118.5		150.3		146.49

[1] Restocked 100 bass fingerlings (3") June 28.

TABLE 4. FISH RECOVERED ON DRAINING POND NO. 3, OCTOBER 26, FOLLOWING PARTIAL POISONING,[1] JULY 19

Species and groups	Number	Pounds
Largemouth bass, large	11	19.75
Largemouth bass, small[2]	50	0.94
Bluegills, large	56	15.37
Bluegills, intermediate	275	18.76
Bluegills, small	11,559	158.45
Shellcrackers, large	73	20.37
Shellcrackers, intermediate	154	12.05
Shellcrackers, small	661	12.38
Golden shiners	1,202	50.27
TOTAL		308.34

[1] Large numbers of intermediate and small sunfishes killed, but no records kept.
[2] Restocked August 5, with 100 largemouth fingerlings (3").

while large numbers of small and intermediate sunfishes were eliminated.

Marginal poisoning, therefore, appeared to be a tool that could be used to eliminate large numbers of small and intermediate fishes, while sparing most of the fishes of harvestable size.

Preliminary results had indicated that principally those bluegills caught between the poison line and the bank were killed, and those beyond the line moved away from the poison. To test just how far the toxicity extended, a line of derris was placed 20 feet from and parallel to one pond side, using 1 pound derris per 300 linear feet. Bluegills were placed in cages on the pond bottom 10, 20, and 30 feet from the line and toward the center of the pond. Approximately 50 per cent of those caged nearest the line were killed, while none died in cages 20 and 30 feet away.

In this connection, however, another experiment with this method must be considered. Following a week of cloudy and rainy weather, 3 pounds of cube powder was applied by the marginal poisoning technique around the edges of a 1-acre pond approximately 150 × 300 feet. The poison was applied during a heavy rain and followed by a high wind. This resulted in a complete kill of all fish in the pond. It appeared probable that the long continued cloudy weather had greatly reduced the oxygen content of the pond water and that the high wind distributed the poison sufficiently to kill all fish under this condition. Consequently, further use of this technique was confined to clear days with bright sunshine, and no similar trouble was experienced.

Rates of application. The amounts of derris and cube powder containing 5 per cent rotenone used in ponds were varied from 1 to 3

pounds per each 300 linear feet. The difference in the number of fish killed was insignificant; consequently, in all subsequent work between 1 and 2 pounds per 300 linear feet were used. For shallow, narrow ponds, the lower rate is recommended and for large, deep ponds the larger amount may be used. The higher amount is especially desirable if bullheads are present in the marginal waters.

Number of applications of poison. Marginal poisoning will kill principally the fish between the poison line and the bank. In balanced populations, these shallow areas contain the majority of the small- and intermediate-sized fishes. In unbalanced populations, which usually lack adequate numbers of predatory fishes, the small and intermediate fishes are able to venture into deeper water and large numbers are found farther from the margin. Consequently, in badly overcrowded populations, one poisoning was usually insufficient to correct this unbalanced condition.

In Pond No. 1, Table 2, and Pond No. 3, Table 4, one marginal poisoning failed to bring these populations into balance, while in Pond No. 2, Table 3, two marginal poisonings resulted in balance. The population values *(5,6)* are given in Table 5.

The number of marginal poisonings necessary appears to depend upon two factors – the average size of the overcrowded fish and the width of the pond in relation to its perimeter or marginal areas. No method has yet been developed to enable the technician to know exactly how many partial poisonings must be used to achieve balance; this knowledge results only from experience.

TABLE 5. POPULATION VALUES RESULTING FROM MARGINAL POISONING OF UNBALANCED FISH POPULATIONS

Pond	Date of marginal poisoning	Killed Fish	Population values when drained on October 26					
			F/C[1]	Y/C[2]	A_T[3]	A_F[4]	I_F[5]	S_F[6]
No.		*Pounds*						
1	June 21	205.7	14.4	5.3	32.0	27.5	35.6	36.9
2	June 21	118.5						
	June 23	150.3	3.3	0.9	92.2	65.4	8.4	26.1
3	July 19	Many	13.9	10.7	18.0	12.4	10.7	76.9

[1] $F/C = \frac{\text{Pounds forage species}}{\text{Pounds piscivorous species}}$

[2] $Y/C = \frac{\text{Pounds small forage fish available as food}}{\text{Pounds of piscivorous species}}$

[3] A_T = Percentage of total weight of fish that are of harvestable size.

[4] A_F = Percentage of weight of forage fishes that are of harvestable size.

[5] I_F = Percentage of weight of forage species of intermediate size.

[6] S_F = Percentage of weight of forage species composed of small fishes available as food for predatory species.

As a partial guide, the results from poisoning several large ponds are given.

A 22-acre pond was stocked in June 1947 with 1,000 bluegills plus 50 largemouth bass per acre. It contained an unbalanced population in 1948 and in 1949. This was evidenced both by pond analysis techniques and the results of fishing experiments. It was marginally poisoned using 1 pound cube, containing 5 per cent rotenone, for each 300 linear feet at 1 p.m., June 1, 1949.

Fish began to die within 30 minutes and continued to die for several hours. By the following morning, the toxicity was dissipated and fish had moved back into the poisoned area. The total kill was as follows:

Number		*Pounds*
65	largemouth bass, large	98
206	largemouth bass, small	26
64	chain pickerel	80
1,443	large bluegills	241
36,410	small and intermediate bluegills	1,820
28	yellow bullheads	28
	TOTAL	2,293

The pond was subsequently restocked with 150 fingerling largemouth bass per acre on June 8.

In this case approximately 20 pounds of the harvestable-sized fish and 83 pounds small and intermediate bluegills were killed per acre. This treatment killed a total of 80 pounds large chain pickerel, which was 50 per cent of all those present. These fish apparently moved into the poisoned area to feed on the dying bluegills. While approximately 104 pounds fish per acre was killed in this 22-acre pond, balance did not result. Bluegills did not spawn until September 22, and the intermediates were still too crowded to grow to a harvestable size.

A 26-acre pond was found to contain an unbalanced population in 1949. There were so many intermediate bluegills that bass and bluegills were both unable to spawn and fishing became very poor. This pond was treated June 17 by marginal poisoning with 1 pound cube per 300 linear feet with the following kill:

Number		*Pounds*
94,400	small and intermediate bluegills	1,968
215	large bluegills and shellcrackers	43
27	large largemouth bass	16
1	yellow bullhead	1
	TOTAL	2,028

Marginal poisoning was repeated at the same rate on June 24 with the following kill:

Number		*Pounds*
17,245	small and intermediate bluegills	129.3
9	large bluegills and shellcrackers	2.0
1	largemouth bass	0.5
	TOTAL	131.8

These two poisonings eliminated an average of 0.6 pounds harvestable-sized bass and 1.7 pounds harvestable sunfishes per acre, along with approximately 80 pounds small and intermediate bluegills. While the second poisoning did not kill large poundages, it must be remembered that in partial poisoning it is also important to reduce the **number** of fish. The second poisoning killed approximately 664 small and intermediate bluegills per acre, and thus effectively reduced the competition for food.

The pond was restocked with 150 largemouth bass fingerlings per acre and a moderate hatch of bluegills occurred July 27, with a subsequent heavy hatch on September 22. Consequently the pond came into a good balance and yielded good fishing the remainder of 1949 and in 1950.

A 60-acre fertilized pond was originally stocked with a total of 500 largemouth bass and 5,000 bluegills. As a result, an unbalanced population was obtained and it remained unbalanced for several years prior to 1949. The pond was sectionally poisoned with cube in July, 1949. No bass were restocked and a hatch of bluegills subsequently occurred. As a result, the young bluegills grew for a short time and then became part of an overcrowded population. Since partial poisoning is normally required in populations containing too few bass and all small bass in the pond edges are killed, marginal or sectional poisoning in the spring or summer is detrimental unless followed by restocking of bass.

This pond was treated by marginal poisoning using emulsifiable rotenone at the rate of 1 pint per 300 linear feet on May 7 and again on May 15, 1950. It was then restocked with 100 bass fingerlings per acre June 1. The pond subsequently came into balance, yielding good fishing in the fall of 1950 and during 1951.

A 25-acre pond was stocked in a hap-hazard manner in 1946-47 with adult fishes and with fingerlings. It produced poor fishing in 1948, and was operated as a public fishing lake in 1949. Since few fish could be caught, this venture was a financial failure; therefore, the pond was sold. Under an agreement with the new owner, the

pond was marginally poisoned using 1 pound cube per 300 linear feet; at this time, the average size of the bluegills was 2 to 3 inches. In 1949 the first poisoning was made September 13; subsequent marginal poisonings were made on September 21, and October 7.

These poisonings killed uncounted thousands of intermediate bluegills, several hundred small bass, plus approximately 12 harvestable bluegills and 1 harvestable bass. Reproduction by bluegills occurred in late September and the October poisoning killed thousands of bluegill fry. It was necessary that these fry be killed since no largemouth fingerlings were available for restocking at that time; if they had not been eliminated they would have grown too large by the following spring for predation by the time bass fry or fingerlings were available.

After each marginal poisoning, the pond was sampled by seining with a half-inch-mesh seine 50 feet long and 6 feet deep to gain a rough quantitative idea of the abundance of the remaining sunfish. It was seined again in March, 1950, and the intermediate bluegills were found to have grown to sizes between 3 and 6 inches. Also there were considerable numbers of very small bluegills that had hatched the previous fall and survived the October poisoning.

Since there appeared to be too many intermediate bluegills still present and it was desirable to eliminate the fall hatch, the pond was again marginally poisoned on March 16, when the water temperature was 56° F. One pound of cube (5 per cent rotenone) was used per each 300 linear feet; a total of 34 pounds was used for the entire pond. This killed thousands of the very small bluegills, a moderate number of intermediates, and 10 bass and 400 bluegills of harvestable size.

Also, the pond was fertilized, beginning February 1 and making three applications at 2-week intervals, followed by an application every 3 to 4 weeks as needed to maintain a good plankton growth. As a result of the partial poisoning and fertilization, bass had reproduced adequately by March 22; consequently restocking was unnecessary. Bluegills began spawning in May and continued to spawn the remainder of the summer. By August, the larger bluegills had grown to a size of 4 ounces and could be caught readily; bluegill fishing became excellent during the fall and winter.

Following the 1949 poisoning, bass fishing became good in the fall and winter and was excellent during the following year.

Four partial poisonings, therefore, using a total of 144 pounds cube costing $43.20, transformed this unproductive pond into a balanced, highly productive one, without the necessity for completely poisoning or draining and restocking it.

SUMMARY of PROCEDURE for MARGINAL POISONING

When to poison. Use marginal poisoning when seining for pond analysis indicates unbalance due to overcrowded sunfish and where the majority of these stunted fish taken in a half-inch-mesh seine are from 3 to 5 inches in length. If overcrowding is caused principally by sunfishes less than 3 inches in length, total poisoning or draining should be used.

Material to use. Small Ponds: Derris or cube powders containing 5 per cent rotenone.
Large Ponds: Derris or cube powders containing 5 per cent rotenone, or emulsifiable rotenone containing 5 per cent rotenone.

Amount to use. For small ponds use 1 pound derris or cube, or 1 pint emulsifiable rotenone for each 300 linear feet of the area to be poisoned. In large ponds twice the above amounts should be used if bullheads are present.

Time of year to poison. Poison only during the period in the spring or early summer when largemouth bass can be obtained from hatcheries for restocking, or late enough in the summer that bluegills will not spawn before the following spring. In each case, the pond should be restocked with bass before bluegills resume reproduction, unless adequate natural reproduction by bass has occurred.

Water temperature. Poison, if possible, when the water temperature in the surface 6 inches is higher than 80° F. At higher temperatures the poison acts more rapidly and remains toxic for shorter periods of time. At 90° F., for example, the poison begins to kill fish in 15 minutes and the poisoned water loses its toxicity within 24 hours. Marginal poisoning, however, has been done successfully in water having a temperature of 56° F.

Time of day to poison. Poisoning for partial reduction of a fish population should be done just before or just after noon. At this time a minimum number of large fish will be found in the shallow water and the water temperature will be near its peak during the poisoning. Do not poison on a cloudy day if there was little or no sunshine the preceding day. Avoid periods when strong winds are causing rapid water movement.

Mixing the poison. Powdered derris or cube should be mixed with water to form a stiff paste. Emulsifiable rotenone should be mixed with twice its volume of water.

Applying the poison. Poison should be applied in one continuous line parallel to, and 15 to 30 feet from the bank. This is done either from a boat or by wading. Successive handfuls of the poison paste are used to form a continuous line of poison about 6 inches under water. The poison is placed under water to minimize its spread by surface water movement. The emulsifiable rotenone is poured in a continuous line on the surface. The normal application is at the rate of 1 pound dry powdered poison or 1 pint emulsifiable rotenone per each 300 linear feet.

Action of the poison. The poison settles downward through the water and diffuses slowly to each side of the line. All of the fish between the line of poison and the bank are killed, while most of those outside the line move away and are not killed. Thus, it is possible to kill most of the small fish in shallow water without injury to many of the larger fish. Some large bass and other piscivorous fish will be killed if they move into the poisoned area to feed on the struggling bluegills, or if they are caught between the poison line and the bank.

Repoisoning. It is usually necessary to repoison once or twice at weekly intervals, and as many as four partial poisonings may be necessary if the bluegills are extremely crowded and small. If the population has been adequately thinned by partial poisoning in the spring or summer, newly-hatched bluegills should be found within 4 to 6 weeks. If no hatch occurs within this time, the pond should be repoisoned.

Restocking. If poisoning is done when the water temperature is above 80° F. the water loses its toxicity in 24 hours. A pond marginally poisoned in the spring or summer may be restocked with bass 7 to 10 days after poisoning or restocking may be delayed until newly-hatched bluegills can be found. Fertilized ponds should be restocked with from 150 to 200 largemouth bass fingerlings per acre. Ponds marginally poisoned in the fall, need to be restocked with bass the following spring unless natural reproduction by this species occurs at that time.

LITERATURE

(1) BECKMAN, WILLIAM C. Increased Growth Rate of Rock Bass, *Ambloplites rupestris* (Rafinesque), Following Reduction in the Density of the Population. Trans. Amer. Fisheries Soc. 70 (1940): 143-148. 1941.

(2) BENNETT, GEORGE W. Management of Small Artificial Lakes. Ill. Nat. Hist. Survey 22 (3): 357-376. 1943.

(3) ESCHMEYER, R. W. Some Characteristics of a Population of Stunted Perch. Mich. Acad. Sci. Arts and Letters Paper XXII (1936): 613-627. 1937.

(4) KRUMHOLZ, LOUIS A. Indiana Ponds, Their Construction and Management for Fishing. Lake and Stream Survey of the Indiana Department of Conservation, Division of Fish and Game and Indiana University. 35 pp. 1950.

(5) SWINGLE, H. S. Improvement of Fishing in Old Ponds. Trans. N. Amer. Wildlife Conf. 10: 299-308. 1945.

(6) ——————. Relationships and Dynamics of Balanced and Unbalanced Fish Populations. Ala. Agr. Expt. Sta. Bull. 274: 73 pp. 1950.

(7) —————— and SMITH, E. V. The Management of Ponds with Stunted Fish Populations. Trans. Amer. Fisheries Soc. 71: 102-105. 1942.

(8) THOMPSON, DAVID H., and BENNETT, GEORGE W. Lake Management Reports. 2. Fork Lake Near Mount Zion, Illinois. Ill. Nat. Hist. Survey Biol. Notes. 9: 1-14. 1939.

(9) TOOLE, MARION. Utilizing Stock Tanks and Farm Ponds for Fish. Texas Game, Fish and Oyster Commission Bul. 24: 53 pp. 1950.