It is unfortunate that no comparative tests were made with other nets during this study. The catch per unit effort data herein reported for hobbled gill nets are among the highest listed for taking catfish in entanglement types of commercial gear. White (1959) reported catches of 13.3, 6.2 and 3.4 pounds of catfish (three species) per net day in 3.0-, 3.5- and 4.0-inch mesh whip set trammel nets respectively, while the same respective mesh sizes of regular trammel nets caught only 2.0, 2.0, and 1.9 pounds of catfish per net day. Starrett and Barnickol (1955) using 1.5-, 2.0- and 3.0-inch-mesh trammel nets on the Mississippi River stated "trammel net seems to be a very inefficient method for taking catfish." Houser (1957) listed a six-month commercial catch from Lake Texoma taken in flag or "shirt tail" type gill nets and regular gill nets (primarily 4.0-inch-mesh nets) which included over 23,500 pounds of catfish but did not list the catch per unit effort.

Care should be exercised in making comparisons between commercial fishing gears from different areas. Variations in fish populations and differences in personal techniques of the users can cause erroneous comparisons in different gears or the same type of gear. Although no comparative tests were made with other nets, it is believed that the hobbled gill net is an efficient modification over standard gill nets for certain purposes and may be more selective for large flathead catfish than other entanglement types of commercial gear.

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SOME EFFECTS OF LIME APPLICATIONS TO WARM-WATER HATCHERY PONDS

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ABSTRACT

The results of applying ground limestone ($CaCO_3$) and quicklime (CaO) to hatchery ponds used for the culture of bluegills (*Lepomis macrochirus*, Raf.) are described. Effects appeared to be beneficial in the sample of ponds treated. Quicklime was difficult to apply because of caustic effects to skin of personnel handling it.

Laboratory experiments indicated that hydrated lime ($Ca[OH]_2$) could be used to produce a pH as alkaline as that obtained from quicklime provided that an equivalent amount of calcium was used in the hydrated form.

INTRODUCTION

The use of lime in pondfish culture has been advocated for many years. Schaeperclaus (1933) devoted several pages of his "Textbook of Pond Culture" to a description of the advantages of using lime in both trout and carp ponds. While some of these advantages were somewhat hypothetical, the possibility of protecting the health of the fish stock and increasing fish production by creating more favorable biological conditions seems to provide an adequate justification for lime treatments. Neess (1949) in a review of pond fertilization in Europe, stated that lime was beneficial in reducing acidity which retarded decomposition of organic matter and the mineralization of nutrients, that the calcium in lime would displace other nutrients in organic collodial systems and that lime increased the ability of water to store carbon dioxide.

Limited use has been made in the United States of this work or the published information of other European workers on the addition of calcium to fish ponds which was summarized by Mortimer and Hickling (1954). Swingle and Smith (1938) recommended the addition of basic slag or ground limestone to the fertilizer mixture used in farm ponds where the source of nitrogen was ammonium sulfate. However, Swingle (1947) in a two-year fertilization experiment, obtained reduced production in every pond where ground limestone was used. The source of nitrogen was urea, various organic materials, ammonium sulfate, sodium nitrate and an unidentified nitrogen source in a commercially mixed inorganic fertilizer. He concluded that the calcium carbonate removed carbon dioxide as it was formed, thus depriving the plankton algae of this essential growth substance. He believed that while alga could utilize the half-bound CO_2 in the bicarbonates, the degree of utilization was affected making growth rates slower than if the free CO_2 were available.

Hasler, Brynildson and Helm (1951) used hydrated lime, $Ca(OH)_2$, to alkalize bog lakes in Wisconsin and concluded that the use of lime in this form improved conditions by clearing stained water thus allowing greater light penetration which resulted in more plant growth. Johnson and Hasler (1954) later reported that there was no apparent increase in fish production in the waters limed in this experiment. They indicated, however, that the treatments may have prevented winter kill by reducing the amount of oxygen-consuming organic matter.

Two acid bog lakes in northern Michigan were limed by Waters (1956) in an experiment to study the effects of applying lime to such waters. Using a summer and fall application of hydrated lime at a rate of 100 pounds per acre foot, he demonstrated that total phosphorus was greatly increased in one lake, a bloom of nannoplankton resulted in one lake and higher standing crops of net plankton occurred in both ponds the season following liming. Chemical data indicated that the nannoplankton was able to utilize carbon dioxide at a higher rate in the treated ponds than would have been possible without liming because of the presence of higher bicarbonate concentrations resulting from the lime applied.

Zeller and Montgomery (1957) added basic slag or ground limestone to 22 farm ponds in Georgia which had soft water supplies. They reported that plankton blooms were induced and pH and total hardness readings increased in every case. All ponds prior to lime treatment were considered to be problem ponds which did not produce satisfactory quantities of phytoplankton following applications of inorganic fertilizers.

Experiments in the use of several forms of calcium including quicklime, hydrated lime, ground agricultural limestone and basic slag have been conducted since 1953 at the U. S. Fish Cultural Station at Marion, Alabama.

A preliminary experiment was carried out in a 1.1-acre pond having a water supply with the following analysis: CO_2–35.2 p.p.m.; HCO_3–21.1 p.p.m.; pH–5.8; total hardness as $CaCO_3$–18.0 p.p.m. and calcium as $CaCO_3$–12.0 p.p.m. The previous year, water analysis of pond samples taken on ten dates over a four-month period showed an average total hardness of 28.9 p.p.m. as $CaCO_3$ and an average pH of 6.7. Plant growth was sparse although 8 applications of an 8-8-2 inorganic fertilizer at a rate of 100 pounds per acre plus 5 applications of 0-8-0 were used during the growing season. Aquatic vegetation was principally *Nitella sp.* and several forms of filamentous algae.

Chemical and biological conditions changed noticeably after the application of three tons of ground limestone per acre. The material was spread by hand over the dewatered pond bottom in the early spring and the pond then refilled with water. Total hardness increased to an average of 47.5 p.p.m. for 11 sampling dates. The pH averaged 8.7 and appeared to be influenced considerably by a moderate to heavy growth of *Pithophora* algae which was replaced in midsummer by a good bloom of phytoplankton. The year prior to liming, bluegill production per acre was 47,053 fish weighing 91.5 pounds. Following the lime application the yield was 101,980 fingerling fish that weighed 238.5 pounds. Production methods were similar except for the addition of ground limestone.

One of the beneficial results of using lime according to Schaeperclaus (op. cit.) is the elimination of fish parasites and other harmful organisms. He recommended the use of quicklime, CaO, for this purpose because of the heat and highly alkaline condition produced during its hydrolysis. Since fish parasites and diseases are a problem on some warm-water hatcheries the use of lime for the two-fold purpose of sterilizing the pond and later increasing fish production appeared to be a worthwhile subject for study.

Fish diseases have been a problem on the Marion Station for several years (Snow, 1955). The following experiment was conducted to explore the value of quicklime for sterilizing ponds prior to their use for the production of bluegill fingerlings. Five ponds that appeared to have a previous history of low or variable fish production were selected. Table I shows the previous production record of these ponds.

TABLE I

YIELDS OF BLUEGILL FINGERLINGS PER ACRE BEFORE AND AFTER ADDITION OF QUICKNESS

	Year											
	1950		*1951*		*1952*		*1953*		*1954*		*1955* *	
Pond	*No.*	*Wt. Lbs.*	*No.*	*Wt. Lbs.*	*No.*	*Wt. Lbs.*	*No.*	*Wt. Lbs.*	*No.*	*Wt. Lbs.*	*No.*	*Wt. Lbs.*
N	No bluegill production data available.						.....	...	.....	...	68,000	183
4†	113,100	90	114,200	183	10,900	74	2,300	26	49,000	205	62,300	194
8‡	41,700	106	8,900	148	15,800	22	33,600	222	–0–	–0–	800	1
44§	86,200	111	17,400	281	107,200	229	70,900	165	.....	...	109,000	235
50¶	.....	...	143,300	188	83,600	136	.....	...	.....	...	114,700	162

* Ponds N and 4 received 2,000 pounds of quicklime per acre, Ponds 44 and 50 received 1,000 pounds of quicklime per acre.

† *Fertilized with an 8-8-2 inorganic fertilizer two years and with phosphate alone two years prior to liming in 1955.*

‡ Fertilizer with an 8-8-2 inorganic fertilizer four out of the five years prior to liming.

§ Fertilized with an 8-8-2 inorganic fertilizer four years prior to liming.

¶ Fertilized with 8-8-2 one of the two years prior to liming.

While no bluegill production data were available for Pond N, this pond was judged to be a poor fish producer as indicated by samples of fish obtained from it during use as a bass brood stock holding pond. Outbreaks of disease had occurred previously in Ponds 44 and 50. While the ponds had not been treated the same way during the years for which yields are given, differences in treatment were not considered to be responsible for the wide degree of variation observed.

Two ponds, numbers 44 and 50, were treated with quicklime at a rate of 1,000 pounds per surface acre, Ponds N and 4 received 2,000 pounds per acre and Pond 8 was untreated. The lime was spread by hand in the late winter. One pond in each rate of treatment contained no water at the time of liming, while the other was full. About five weeks after treatment, all ponds were stocked with 150 brood fish per acre from a common source. No fertilizer was used in any of the ponds, but vegetation was controlled with copper sulfate, sodium arsenite and Delrad 50-S. There was no indication that vegetation control with these chemicals caused any damage to the fish crop.

The pH of water samples indicated that fish could have been safely stocked 10 days after the lime treatment. At this time samples from three of the four ponds showed pH values of 9.0, 9.1 and 10.2. After an initial increase following treatment, there was no appreciable difference in total hardness and pH between the treated and untreated ponds. The ponds treated with 2,000 pounds of quicklime were quite similar in these respects to those receiving 1,000 pounds per acre.

Ponds in the experiment were drained in the late fall and the yields determined. Data on production are shown in the 1955 column of Table I.

Since the previous production records indicated that ponds 44 and 50 were more productive than Number 4 and the presumed low production of Pond N, the yields after the lime treatments suggest that there was no benefit gained from the additional 1,000 pounds of quicklime. The data are not extensive enough to indicate that production of bluegill fingerlings was increased by the lime treatment, but the consistent pattern of both the numerical and weight yields strongly suggests that the treatments were of value. Such consistency in yields is not shown in these ponds prior to treatment and has not been observed in other bluegill experiments conducted in ponds of a similar type at this location.

The yields obtained were within the range of those normally occurring in fertilized ponds at Marion. Since no fertilizer was used in the ponds the year of this experiment, such production may have been caused by the release of fixed nutrients from previous fertilization such as phosphorus as was demonstrated by Waters (op. cit.).

The failure of Pond 8 to produce bluegills cannot be explained with information obtained from observation of the experiment. Periodic seining checks showed that successful reproduction failed to occur but the reason for this was not determined.

The application of the quicklime in the experiment described above indicated that this form of lime was disagreeable to handle because of its caustic effects. except for the heat released during the initial change from calcium oxide to the hydroxide form, there appeared no reason why hydrated lime ($Ca[OH]_2$) would not be just as effective in sterilizing a pond as would quicklime. An experiment in the laboratory was conducted to test the feasibility of this hypothesis.

LABORATORY EXPERIMENTS

The degree of change of pH induced by adding definite amounts of three forms of lime to known quantities of water which contain various concentrations of dissolved substances was tested by laboratory methods. The amounts of lime used in this series of tests were calculated to simulate the application of 1,000 pounds of quicklime (CaO) to a one-acre pond with an average depth of two and one-half feet. Tests were made with quicklime, hydrated lime ($Ca[OH]_2$) and to a lesser extent with calcium carbonate.

For the latter two chemicals the quantity was adjusted so that the lime added to each liter of water would contain the same weight of calcium. On this basis the amounts applied to each liter of water was: quicklime, 148 milligrams; hydrated lime, 196 milligrams; and calcium carbonate, 264 milligrams.

The amounts were weighed and added to measured liters of the various waters after they had been analyzed for total hardness using the method of Diehl, Goetz and Hach (1950) ; total alkalinity as calculated from carbonate-bicarbonate determinations and pH which was obtained using a Beckman glass electrode pH meter. The samples were kept in glass vessels, exposed to air, but protected from dust. pH determinations were made one hour after adding the lime and at various intervals thereafter. When the lime was added it was thoroughly mixed with the water, but thereafter the samples were not stirred. Small portions were decanted to make the pH determinations and then gently poured back into the containers. Results of the tests are shown in Table II.

The hydroxyl ion concentration of samples taken from containers receiving hydrated lime was equal to or slightly greater than that from those receiving quicklime in every case. Changes of pH caused by addition of calcium carbonate were slower as would be expected, and of markedly lesser magnitude, since the ionization of an hydroxide was not involved.

Table II

Changes of pH Caused by Adding CaO, $Ca(OH)_2$ and $CaCO_3$ to Several Types of Water

	Data Before Adding Lime				pH of Water After Indicated Time Lapse					
Water Source	*Form of Lime*	*Total Alkalinity**	*Total Hardness**	*pH*	*1 Hr.*	*24 Hrs.*	*48 Hrs.*	*4 Days*	*5 Days*	*7 Days*
Spring	CaO	35	18	5.7	10.9	10.6	...	...	..	..
Spring	$Ca(OH)_2$	35	18	5.7	11.0	10.8	...	...	..	..
Well No. 8	CaO	149	68	6.8	9.2	9.9	...	...	..	8.8
Well No. 8	$Ca(OH)_2$	149	68	6.8	10.5	10.5	...	...	..	8.7
Well No. 5	CaO	163	79	7.1	10.1	10.6	...	...	..	..
Well No. 5	$Ca(OH)_2$	163	79	7.1	10.0	10.6	...	...	..	..
Well No. 4	CaO	197	98	7.6	9.9	10.0	...	...	..	8.7
Well No. 4	$Ca(OH)_2$	197	98	7.6	10.4	10.4	...	...	..	8.7
Well No. 10	CaO	218	110	7.4	10.2	10.6	...	10.9	..	..
Well No. 10	$Ca(OH)_2$	218	110	7.4	10.4	11.0	...	10.9	..	..
Distilled Water Boiled and Cooled	CaO	...	..	6.7	11.0	10.7	10.9	...	8.7	..
Distilled Water Boiled and Cooled	$Ca(OH)_2$	...	..	5.3	11.0	11.0	11.0	...	8.7	..
Distilled Water Boiled and Cooled	$CaCO_3$	...	..	6.2	6.3	8.9†	9.2‡	...	..	..
Distilled Water Sat. w/CO_2	CaO	...	..	5.3	10.4	10.4	10.7	...	8.7	..
Distilled Water Sat. w/CO_2	$Ca(OH)_2$	...	..	6.0	11.0	11.0	10.6	...	8.7	..
Distilled Water Sat. w/CO_2	$CaCO_3$	...	..	4.0	5.0	5.5	5.7§	...	..	..
Well No. 2	$CaCO_3$	106	80	7.3	7.3	7.4†	7.6‡	...	..	..

* p.p.m. as $CaCO_3$
† After 21 hours instead of 24.
‡ After 53 hours instead of 48.
§ After 56 hours instead of 48.

Additional tests of quicklime and hydrated lime were made using the same amounts of lime but in a combination of mud and water. The ratio of mud to water was approximately one to nine.

Mud was obtained from the bottoms of three ponds, Nos. 5, 13 and 35, by scooping the top one-half inch from the wet (recently drained) pond bottom.

The mud collected was thoroughly mixed, allowed to stand for one hour and the pH determined. Three equal portions were then measured from each sample by completely filling 100 milliliter beakers and shearing off the top with a straightedge. The actual volume of mud in each case was 112 milliliters. One such portion from each sample was used to determine the dry weight of the mud. The other two portions from each pond were used in tests with quicklime and hydrated lime. The mud samples were transferred to one liter graduated cylinders and the volume made up to one liter with distilled water. Water and mud were shaken together. After standing for one hour pH determinations were made on the supernatant fluid. One cylinder of each pair received 148 milligrams of CaO and 196 milligrams of $Ca(OH)_2$. The lime was added at the surface of the water and was not stirred in. pH determinations were made one hour after adding the lime and at various intervals thereafter until the experiment was terminated after twelve days. At the time of termination each sample was shaken and the pH again determined after standing for one hour. Results of the analyses are shown in Table III. Only in the samples containing mud from Pond 5 was a relatively high pH obtained. No explanation can be offered for the differences displayed, but it is noteworthy that the pH changes produced by calcium oxide and calcium hydroxide are approximately the same in each pair of samples.

TABLE III

EFFECT OF QUICKLIME AND HYDRATED LIME ON pH OF BOTTOM MUD*

Data Before Adding Lime						*pH of Supernatant Liquid at Intervals After Adding Lime*							
Source of Mud	*Dry Wt. of Mud in Sample Grams*	*Form of Lime*	*pH of Mud*	*pH of Distilled Water*	*Supernatant after Standing pH*	*1 Hour*	*24 Hours*	*48 Hours*	*96 Hours*	*6 Days*	*7 Days*	*12 Days*	*After Shaking and Settling 1 Hour*
Pond	33.2	CaO	6.9	5.8	7.2	10.6	10.3	. .	9.8	9.1	9.0	7.9	7.5
No. 5	. . .	$Ca(OH)_2$	6.9	5.8	7.2	10.5	10.4	. .	9.7	9.5	9.4	8.0	7.7
Pond	45.6	CaO	6.7	6.0	6.6	9.4	8.2	. .	7.3	7.3	7.3	7.2	7.3
No. 13	. . .	$Ca(OH)_2$	6.7	6.0	6.5	10.0	8.4	. .	7.5	7.5	7.5	7.5	7.4
Pond	61.4	CaO	7.3	5.6	7.4	8.9	8.2	8.1	. .	. .	7.6	. .	7.8
No. 35	. . .	$Ca(OH)_2$	7.3	5.6	7.5	8.7	8.5	8.3	. .	. .	7.5	. .	7.9

* Combination of one part pond bottom mud and nine parts of distilled water. Total volume one liter.

In addition to the trials with water and with mud and distilled water as described above, an attempt was made to determine the approximate maximum pH which might be encountered when using quicklime or hydrated lime spread over wet pond bottoms at the rate of 1,000 pounds of quicklime per acre or its calcium equivalent when using hydrated lime, i. e., 1,321 pounds per acre.

At this rate of application, assuming uniform distribution of the lime, each square meter of bottom would receive 0.247 pounds, or 112.05 grams of quicklime. Assuming, also, that the top two millimeters of bottom mud would be in intimate contact with the lime and that the specific gravity of this surface layer would approximate unity, a calculation of the weight ratio of lime to mud was made. The weight ratios determined in this manner were 5.6 grams of quicklime or 7.4 grams of hydrated lime for each 100 grams of mud.

A pond bottom sample was taken using scrapings not deeper than five millimeters. The pond bottom was quite wet at the time the sample was taken giving a semi-fluid mud to which no water was added.

The quicklime and mud were weighed and mixed after which the mixture was allowed to stand for one hour. The beaker became warm, but not hot. Near the end of the hour bubble formation was observed. The pH at the end of one hour was 13.6.

The same procedure was followed using 7.4 grams of hydrated lime. Unfortunately the glass electrode became polarized and was not in proper working order again in time to obtain a comparable reading. The experiment was repeated with mud from a drier pond bottom. In order to obtain workable samples each 100 grams of mud was mixed with 20 milliliters of freshly boiled and cooled distilled water. The pH of this mixture before adding lime was 5.7 Three samples were used. One had 5.6 grams of quicklime stirred into it, another was mixed with 7.4 grams of hydrated lime and the third was untreated. Each lime treated sample had pH of 12.4 after standing for one hour. At that time the temperature of the untreated sample was 22.4, the hydrated lime sample 22.5 and the quicklime sample 23.5 degrees centigrade.

The results of these laboratory tests show that hydrated lime can produce a concentration of hydroxyl ions just as high as that produced by an equivalent amount of quicklime.

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EXPERIMENTAL USE OF SILVEX AND OTHER AQUATIC HERBICIDES IN GEORGIA FARM PONDS[1]

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ABSTRACT

The results of two years experimental weed control in Georgia Farm Ponds using silvex,[2] propylene glycol butyl ether ester, dalapon, sodium salt of 2,2-dichloropropionic acid; 2,4-D granules of iso-octyl ester of 2,4-dichlorophenoxy acetic acid. Residual control and overall effectiveness is evaluated over a two-year period on acquatic weeds in approximately 100 ponds. Preliminary screening of Inverton, an invert emulsion of 2,4,5-trichlorophenoxy acetic acid; Garlon, a solution of dalapon and silvex; and simazine, 2-chloro-4, 6 bis-(ethylamino)-S-trizaine are presented.

Different concentrations were used and observations made during 1958 and 1959. Results are presented for different herbicides and evaluation made for their effectiveness on specific aquatic weeds.

Silvex appears to have the widest range of control for underwater and emergent aquatic weeds. Preliminary results indicate this chemical is as effective as sodium arsenite in many situations. Dalapon has given some degree of control for grasses and satisfactory control for cattails. Granular 2,4-D has given satisfactory control for water lilies and parrots feather (*Myriophyllum brasiliense*). Garlon and Inverton look promising for the control of some aquatic weeds. Simazine has not been generally effective for control or eradication of higher aquatic plants in the concentrations listed.

INTRODUCTION

One of the major problems in Georgia Farm Pond Management is aquatic weeds. Their detriment to fish production has long been recognized by fishery

1 This work was undertaken with Federal Aid to Fish Restoration funds under Dingell-Johnson Project F-6-R-5, "Evaluation of Pond Management Practices".

2 Common name for 2(2, 4-5 trichlorphenoxy) propionic acid.