catch for shore fishermen (0.46 fish per hour) was below the rate for all fishermen (0.55 fish per hour).

Interviewed anglers came from 24 Missouri counties and 4 other states. Local anglers (Wayne County) provided 29 percent of the Missouri anglers, and St. Louis County furnished 30 percent. Out-of-state anglers (2 percent of those interviewed) were predominantly from Illinois.

DISCUSSION

Table Rock, Taneycomo and Clearwater tailwaters received 7, 10, and 16 times more fishing pressure, per acre, than their respective reservoirs. The total number of fishermen trips was greater on Taneycomo tailwater (320 acres) than on the reservoir (1,410 acres), and was nearly as great on Clearwater tailwater (80 acres) as on the reservoir (1,990 acres). Table Rock tailwater (320 acres) supported only a small fraction of the total fisherman trips compared to those on Table Rock Reservoir (43,100 acres). Considering these reservoirs and tailwaters together, about 10 percent of the fisherman trips were on the tailwaters, which comprise 1.5 percent of the combined areas.

Both Taneycomo and Clearwater tailwaters provided a greater weight of harvest than the respective reservoirs, and the Taneycomo tailwater also provided more fish numerically. In all three cases the rate of catch was lower on the tailwater than on the reservoir.

By coincidence the areas of Table Rock tailwater and Taneycomo tailwater were nearly equal. It is interesting to note that fishing pressure on the two areas was almost identical, though one is a trout fishery made possible by stocking and the other is a "natural" warmer water fishery. Rate of catch and percent of successful anglers was greater on Table Rock tailwater, resulting in a greater harvest of fish. Fish in Taneycomo tailwater averaged much larger, however, which resulted in a harvest there of more than twice the total weight of fish taken in Table Rock tailwater. Out-of-state anglers were attracted more to the trout fishery in Table Rock tailwater than to the warm water fishery of Taneycomo tailwater.

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FISH POPULATION DYNAMICS FOLLOWING A SELECTIVE SHAD KILL

By HERBERT N. WYATT and HOWARD D. ZELLER

ABSTRACT

Data is presented over a four-year period on population changes and dynamics in an 8,500-acre reservoir following rotenone treatment for selective shad reduction. Population data for four years prior to the shad kill is also discussed and analyzed.

An analysis of the operation including methods, techniques, and results is presented. Records of fish stocking, creel census, age and growth and population studies after treatment is discussed and evaluated.

Particular emphasis is directed toward two introduced species, white bass and threadfin shad. Data on the expansion and establishment of these introductions and the rapid growth rates encountered are presented. Year class dominance, reproduction, and fisherman success are compared, and the overall effect of selective shad kills on fish population changes is discussed and summarized.

INTRODUCTION

Selective shad kills have been generally accepted in the southern states as an effective reservoir management technique for reduction of gizzard shad populations. Various approaches as to the methods involved have been reported, and different techniques have been utilized with regard to the number of selective rotenone treatments; and species stocked following a shad kill.

Selective shad kills, in the broad sense of the term, refer to treatment of reservoirs with a dilute rotenone concentration which will be toxic to shad but generally non-toxic to game species. Following a shad reduction, fishing success will increase, and the void in the population will presumably stimulate game fish reproduction. Shad are not eliminated in selective kills, and the population will gradually return to its previous status in a matter of time.

For the selective shad kill on Lake Blackshear, it was intended to permanently alter the fish population by an introduction of white bass (*Roccus chrysops*) and threadfin shad (*Dorosoma petenense*) immediately following the selective kill. An introduction to the reservoir at this time could produce a permanent change in the fish population that would not otherwise be accomplished, and the change in species composition and establishment of additional species, would lessen the possibility of the reservoir returning to its original condition.

Threadfin shad are a desirable species for forage, and past research in other reservoirs in Georgia has indicated that threadfin shad exhibit a definite suppressive effect on gizzard shad. With increased forage for game species and an additional game fish such as white bass, an immediate change in the fishery was possible. Although these species could, in all probability, be established through normal introduction methods, the advantage of stocking after a shad kill was immediately apparent.

Lake Blackshear was constructed on the Flint River by the Crisp County Power Commission in 1930. The reservoir covers 8,515 acres and has an average depth of 9.1 feet. There are extensive areas of shallow water, and aquatic vegetation is a minor problem in late summer. The upper end of the reservoir, approximately 3,000 acres, is heavily wooded in standing timber from the original impoundment.

Fishing pressure is principally local and stems from the surrounding rural area and small towns. Creel census records show that most Lake Blackshear fishermen prefer live bait, and that bluegill and black crappie are the main species sought by the local fishermen, with a high seasonal demand for largemouth bass and white bass. The climate is normally favorable for year around fishing.

SELECTIVE SHAD KILL

Although creel census records prior to 1959 are not available, local complaints on fishing success and inquiries to the Game and Fish Commission ultimately led to investigations on the reservoir. Population studies showed a high gizzard shad population, a low largemouth bass population, and a high weight percentage of bluegill. Increased interest for improvement of fishing in the lake prompted plans for the selective shad kill.

Actual treatment of the reservoir was accomplished on September 21, 1958. Emulsifiable 5% rotenone at a concentration of 0.13% was applied to the lake during a six-hour period. The upper end of the lake (3,000 acres) was treated aerially, since the dense stand of timber precluded any rapid boat movement.

The remaining area of the lake was sub-divided and treated with gravity flow of undiluted rotenone into the wake of the outboard motors. Power spray units were utilized for back waters and for areas heavy in aquatic vegetation. The entire lake was treated in the rotenone application. Although a higher kill of game fish would be accomplished in treating shoreline areas, it was hoped that a kill of bluegill would accomplish a population reduction of that species and stimulate growth of the remaining fish.

Sportsmen groups and civic clubs were contacted prior to the actual selective kill, as well as extensive news release coverage and explanation of the proposed management operation to the news media. The public was invited to attend and pick up any game fish killed in the operation so long as legal limits on possession were observed. News coverage of the fisheries operation was apparently good, since the state patrol estimated 45,000 people were present the day of the selective kill.

Estimates from shoreline areas the following day established the kill of game fish at 5 to 10%. Kill of game fish was apparently in proportion to their population density in the reservoir. Gizzard shad in all size groups were killed, indicating the selective kill for this species was a success. Although game fish were lost in the operation, public acceptance of the management program was generally good. This is attributed to an extensive public relation coverage of the anticipated results. Immediate fishing returns after the selective kill were only fair. Fall and winter fishing for crappie, and spring bream fishing were good as the later data on creel census will bear out.

INTRODUCTION OF FISH

The void left in the fish population following the selective kill provided an ideal situation for establishing new species. Threadfin Shad (*Dorosoma petenense*) and White Bass (*Roccus chrysops*) were stocked since these highly prolific species would fit well into the ecology of the lake and would rapidly establish under reduced competition from other species. An immediate build-up of Threadfin Shad was desirable to compete with Gizzard Shad and also to provide an abundant supply of desirable forage for the expanding fish population. White Bass were added to stimulate fishing by providing a new and easily harvested species which could also take advantage of an increased food supply such as Threadfin Shad with minimal competition toward existing game species.

Stocking of these two species was timed to provide the most favorable conditions for survival. This was accomplished by stocking Threadfin Shad as soon as possible after the selective kill, and when assured of a plentiful supply of forage fish for food, stocking with White Bass.

In March of 1959 10,000 Threadfin Shad were successfully stocked in Lake Blackshear. The fish were seined and transported in a hatchery tank truck equipped with bottled oxygen. Mortality was estimated at 40%

A population study three months after stocking failed to yield any Threadfin Shad. However, in October of 1959, a rotenone spot check in open water near the middle of the lake showed this species was established. Of the 1,200 shad recovered from the sample, one-third were Threadfin Shad. Many of these were in the one inch size group indicating a successful spawn 8 months after introduction.

Stocking of White Bass was initiated in March of 1960. Fish were seined at spring spawning concentration sites below an existing impoundment on the Chattahoochee River. Seining was done at night and the White Bass taken were held overnight in large live-boxes. The next morning the fish were transferred to 55-gallon drums equipped with agitators wired to run off the truck battery. From 25 to 30 fish were placed in each drum of water. The combination of seining at night, a short holding time, cool weather and three hours transportation made the stocking operation highly successful. In a two-week period, 475 White Bass ranging in size from one to four pounds were stocked in Lake Blackshear. Only sexually mature fish in a spawning condition were collected. Seining ceased when spent females were taken in the seine.

CONDITION OF THE FISH POPULATION

There were four population studies made prior to the selective kill and five studies made after. Composite data from all population studies are compared in Figure 1 as percentages of total number of fish, and in Figure 2 as percentages of total weight of fish for all population data before the selective kill and all data collected after the selective kill. The species listed include the major game species in the lake. Threadfin Shad and White Bass, having been recently introduced made only a small amount of the total, and the information could not be adequately presented in these graphs.

GIZZARD SHAD

The decline in numbers of Gizzard Shad immediately indicates the effectiveness of the selective kill. The stability of the percent by weight, however, indicates attainment of larger size by fewer individuals. It appears that although expansion in numbers of Gizzard Shad was limited by competition with Threadfin Shad, their potential capacity in the lake was realized in terms of weight.

The decrease in numbers of fish is further illustrated in Table I. These two studies are typical of Gizzard Shad population changes since the selective kill. The drastic reduction of Gizzard Shad plus intense competition for the limited numbers of offspring will, we feel, hold this population in check for some years.

TABLE I

LENGTH FREQUENCY COMPARISON OF GIZZARD SHAD TAKEN FROM POPULATION STUDIES BEFORE AND AFTER THE SELECTIVE KILL

Inch Groups	1	2	3	4	5	6	7	8	9	10	11	12	13
Aug. 1958			4606	14									
Sept. 1962				629	17	14	7			5	3	5	1

LARGEMOUTH BASS

The slight increase in Largemouth Bass (*Micropterus salmoides*) shown in Figures 1 and 2 do not adequately describe the reaction of this species to the selective kill. Each year since the selective kill there have been very heavy spawns of largemouth bass, with a subsequent increase in the intermediate and harvestable groups. This is demonstrated by the data in Table II.

TABLE II

COMPARISON OF SIZE GROUPS OF LARGEMOUTH BASS TAKEN IN POPULATION STUDIES BEFORE AND AFTER THE SELECTIVE KILL

Inch Groups	1	2	3	4	5	6	7	8	9	10	11	12	13	14	18	24
Aug. 1958	16	80	19		1		1									
Sept. 1962		429	38	5	8	6	8	3	2	3	2	3	1	5	1	1

It should be pointed out that these population studies were selected for comparison because they were taken from the same cove at the same time of year. Any bias in sampling would be in favor of the 1958 study since a block-off net was used in the 1962 sample, limiting the number of fish recovered.

Preliminary age and growth studies indicate that the extremely heavy spawn

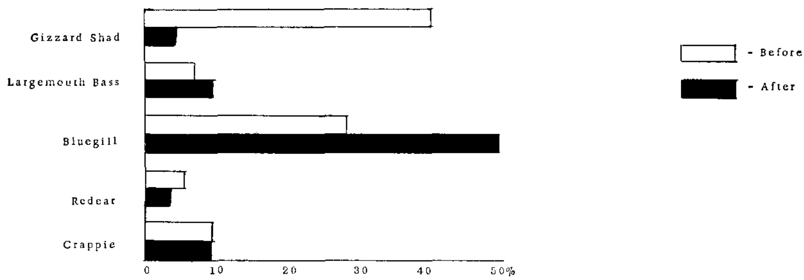

Figure 1. Percent of total number of fish from population studies before and after the selective kill.

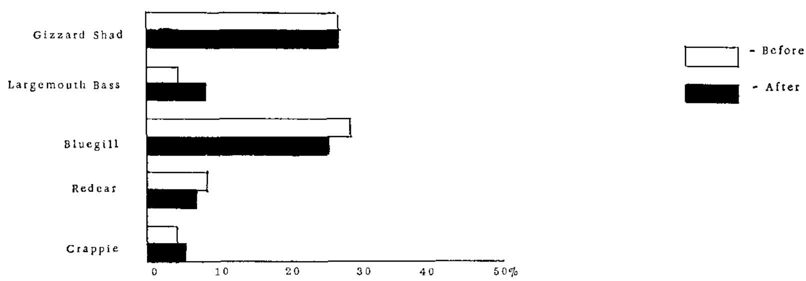

Figure 2. Percent of total weight of fish from population studies before and after the selective kill.

of bass in 1960 is represented by the 14-inch group shown here. These fish average 20 ounces in weight.

The increased numbers of Largemouth Bass, and the good size distribution is evidence of a vigorous expanding population. Apparently the population is continuing to expand as further evidenced by an increase in the creel each year following the shad kill. Also, during the past summer Largemouth Bass were caught schooling after Threadfin Shad. This is the first time Largemouth Bass have been caught in this manner in Lake Blackshear and further substantiates an increase in the population.

BLUEGILL SUNFISH

The Bluegill (*Lepomis macrochirus*) reacted to the selective kill with a significant increase in numbers, particularly in the smaller size groups. The slight loss of weight as indicated in Figure 2 is understandable in view of the large increase in numbers of fish. The data given in Table III is typical of the conditions found in spring population samples following the selective kill. These data indicate that the harvestable sized Bluegill have increased, but not substantially. It does point out, however, that predation and/or other mortality of the small Bluegill is high enough to maintain the Bluegill fishery at its former level.

TABLE III

LENGTH FREQUENCY COMPARISON OF BLUEGILL RECOVERED IN POPULATION STUDIES BEFORE AND AFTER THE SELECTIVE KILL

Inch Groups	1	2	3	4	5	6	7	8	9
Aug. 1958	160	92	216	96	97	21	4	2	1
Sept. 1962	5	16,958	998	391	110	58	4	4	1

The table shows an increase in the number of large intermediates and harvestable-sized Bluegill. The loss of weight indicated in Figure 2 is due to the tremendous number of 2- and 3-inch Bluegill not previously found in the reservoir. The situation described here may be similar to that observed in farm ponds when there is a natural die-off or partial kill of Bluegill. In this case however, reduction of the small Bluegill is sufficient to prevent stunting and allows growth to a harvestable-size fish. Observation on creel census further bear this out.

REDEAR SUNFISH

Data given in Figures 1 and 2 indicate the Redear (*Lepomis microlophus*) was reduced in both weight and numbers by the selective kill. We feel that the slow return of this species within the population is due to increased competition from the Bluegill.

CRAPPIE

The identical percentage of both numbers and weight of Crappie before and after the shad kill is probably due to their rapid re-establishment following rotenone treatment of the reservoir. The slight increase in weight is probably due to an increased food supply in the form of Threadfin Shad. It would appear from the above data that the carrying capacity of Lake Blackshear with regards to Crappie is fairly stable. Crappie are a prolific species, and as such, they have reached carrying capacity in the four years following the slective kill. Present data from the reservoir indicates that this game species is also stable in the censused catch.

THREADFIN SHAD

The rapid development of Threadfin Shad in the fishery is illustrated in Figure 3. Through comparison of the numbers of Gizzard Shad to Threadfin Shad from year to year as determined by population studies, it is readily apparent that Threadfin Shad make up an increasingly larger percent of the total shad population. Since a large number of Gizzard Shad undoubtedly survived the selective kill, it is assumed that the failure of this species to re-establish itself in the fishery is due to the influence of Threadfin Shad. Including all population studies made since the selective kill, Threadfin Shad have made up 67 percent of the total number and 4 percent of the weight of the Gizzard Shad-Threadfin Shad combination. The high weight percentage of Gizzard Shad is maintained by a few large individuals in the population.

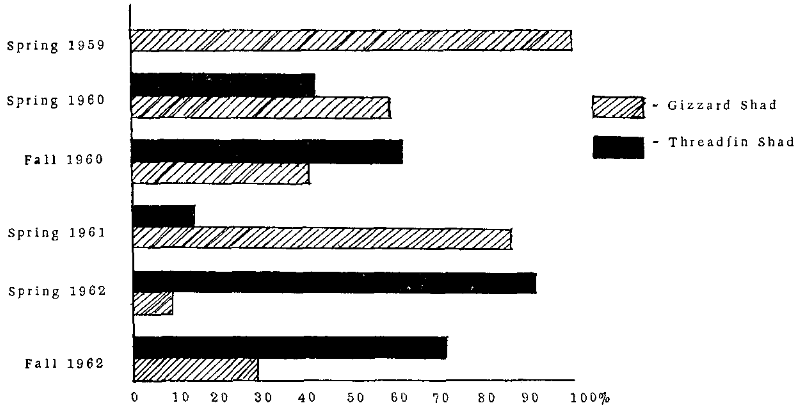

Figure 3. Percent by number of Threadfin Shad and Gizzard Shad from population studies following the selective kill.

CREEL CENSUS

Creel census was initially conducted on Lake Blackshear from March through September of 1959. Beginning in March of 1960 the census was renewed and has operated until the present time. There was no creel census on Lake Blackshear prior to the selective kill, hence a comparison of fishing success is not possible. Figures 4, 5, and 6 show comparative catch data for selected species

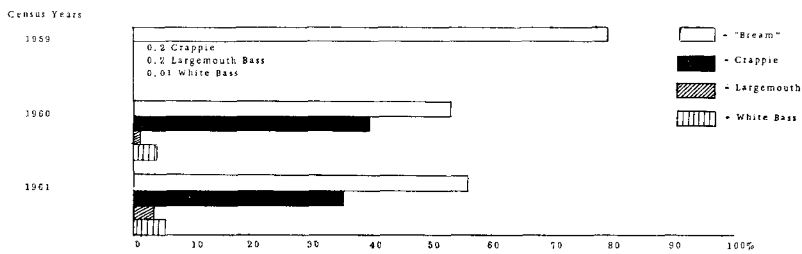

Figure 4. Percent by number of censused catch for four species following the selective kill.

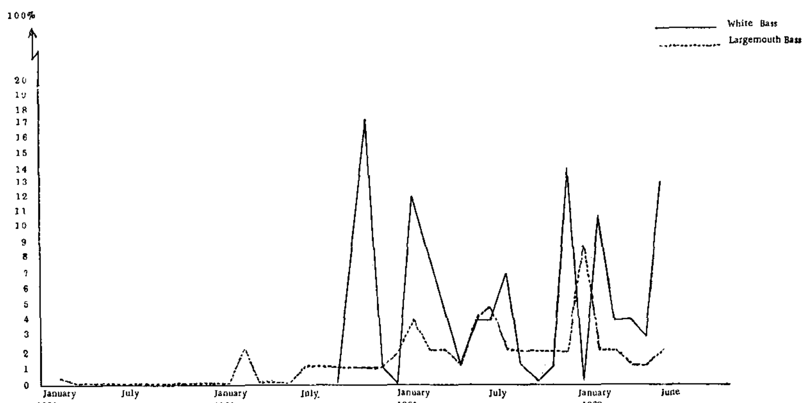

Figure 5. Monthly variation and percent of censused catch for Largemouth Bass and White Bass 1959 - 1962 in Lake Blackshear.

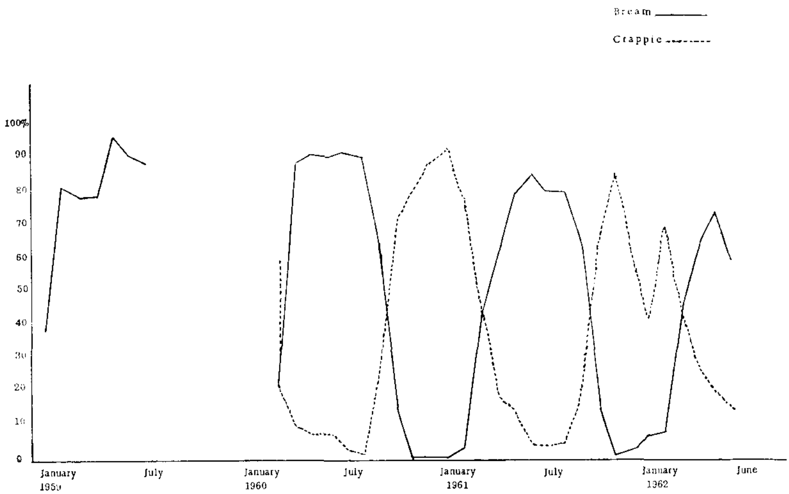

Figure 6. Monthly variations and percent of censused catch for Bream and Crappie in Lake Blackshear 1959-1962

as percent by number of the yearly censused catch. The data for 1959 includes only the spring and summer months and consequently shows a prejudiced high percentage of bream and a low percentage of other species.

BREAM

The term bream as referred to in the following discussion includes Bluegill, Redear, Redbreast (*Lepomis auritus*), and Warmouth (*Chaenobrytus gulosis*). This grouping is made since all species are taken by similar methods during the same time of the year, and a breakdown by species would be unnecessary for discussion purposes. Species were separated in the creel census, however.

The general morphology of Lake Blackshear is conducive to high populations of bottom feeding fishes. The extensive shallow areas, and aquatic weed growth in the summer and fall combine to provide excellent spawning grounds and cover for smaller fish. Bream spawning activity usually begins in April and continues into September. Spawning areas are extensive, often an acre in size and are fished heavily. The seasonal distribution of the catch of Bream is shown in Figure 6.

The relative stability of the catch of Bream indicates the harvestable population is fairly constant and recruitment is satisfactory despite the tremendous numbers of small Bluegill.

CRAPPIE

The percent of catch for Crappie also seems to be constant over the census period. As shown in Figure 6, fishing for Crappie increases rapidly when Bream fishing drops off in the fall. This fortunate combination of seasonal fishing pressure assures a year-round harvest and fisherman success.

WHITE BASS

There was a population explosion of White Bass in Lake Blackshear the first year they were stocked in the reservoir. The harvest of the 1960 year class started in July of 1960, approximately four months after the initial stocking. The catch was mostly young-of-the-year varying from 4 to 6 inches in length. Harvest gradually increased throughout the mild autumn and peaked in November of this same year when 1,596 White Bass were checked by the creel census clerk. This included an estimated 25% of the total fishermen on the lake during this month.

Preliminary age and growth studies on the White Bass in Lake Blackshear have shown that the average weight for the 1960 year class creeled in November was 12 ounces and the average length was 10.7 inches. This rate of growth exceeds the first year's growth reported for this species to date (Jenkins, 1957). The rapid growth was without doubt a result of the selective kill which gave adequate living space combined with an abundant supply of threadfin shad for food. This permitted White Bass, although small in numbers, to expand with the population and bring the 1960 year class to a position of prominence in the sport fishery within an amazingly short time.

White Bass changed the fishing habits of thousands of fishermen in the area and were accepted as valued addition to the creel.

SUMMARY AND CONCLUSIONS

The selective kill on Lake Blackshear was successful in reducing the Gizzard Shad population, and the fish population was altered through the establishment of two new species in the reservoir. Immediate establishment of White Bass and Threadfin Shad was possible due to the void created in the population. Increased reproduction of all game species and an increase in harvestable sizes of Largemouth Bass indicate that the fish population is still expanding.

Threadfin Shad have apparently suppressed the Gizzard Shad population in the reservoir. Assuming the Threadfin Shad population continues its present rate of increase, the Gizzard Shad population will be further reduced.

Bluegill increased in number following the fish kill; however, their total weight in the fish population decreased. This was caused by heavy reproduction each year after the kill. Redear Sunfish were reduced by both weight and number of fish after the chad kill.

The most outstanding contribution to fishing success following the management operation was made by White Bass. This species appeared in the creel shortly after stocking, and although the catch is seasonal, at certain months of the year White Bass have accounted for as high as 17% of the censused catch. The overall contribution to the fishery and popularity of this introduced game fish with local fishermen was instrumental in the success of the program.

In general, the selective shad kill described was considered successful in terms of overall results achieved.

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THE EFFECTS OF LIME TREATMENT ON BENTHOS PRODUCTION IN GEORGIA FARM PONDS

By Michael L. Bowling

ABSTRACT

Past research by the Georgia Game and Fish Commission on lime treatment of farm ponds has indicated a definite improvement in fertilization results following lime application. Management recommendations for problem areas has been one ton of agricultural lime per acre.

This study was initiated to determine the effects of lime treatment on the qualitative and quantitative production of benthic organisms in upper coastal plain and piedmont ponds.

Lime added at the rates indicated above will significantly increase production of benthic fish food organisms. This increase of bottom food organisms was accompanied by changes in soil and water pH and an increase in plankton production and total hardness of the water. In some instances it is believed that the addition of lime at the rate of one ton per acre is not sufficient to attain maximum benthos production.

INTRODUCTION

Past research in soft-water farm ponds in Georgia has demonstrated that certain ponds will not produce phytoplankton when fertilized at the rate recommended by Swingle and Smith (1947). It has been further shown that lime additions to these ponds must be made to obtain necessary phytoplankton pro-