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.

LITERATURE CITED

Jenkins, Robert. 1957. "Growth of White Bass in Oklahoma". Fisheries Research Laboratory, Report No. 60, Norman, Oklahoma.

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 production. Zeller and Montgomery (1957) found that calcium was a limiting factor in phytoplankton production. Thomaston and Zeller (1961) in a six-year investigation, further substantiated these findings and established the rates at which lime must be added to obtain phytoplankton production.

The latter workers found that in addition to an adequate fertilization program, lime must be added at the rate of one ton of agricultural lime, or one hundred pounds per acre of hydrated lime to obtain satisfactory phytoplankton production.

Although it has been demonstrated that lime additions to farm ponds increase phytoplankton production, it has not been established whether the increased phytoplankton production is passed on the food chain, resulting in an ultimate increase in fish production. The purpose of this study is to determine if lime additions result in increased benthic production.

METHODS AND PROCEDURE

A total of eight farm ponds was originally selected for this study. Four ponds were located in the lower Piedmont Province on clay watersheds and four were selected in the upper Coastal Plains Province of Georgia on sandy watersheds.

The ponds in each area were as nearly similar as possible with regard to size, depth, and past history of stocking, fertilization, and fishing. All ponds had been fertilized previously, and fertilization was continued during the course of the study.

Two ponds in each of the areas were used as control ponds and two were treated with agricultural lime ($CaCo_3$), at the rate of one ton per acre.

The ponds were sampled for six months prior to the lime addition and for twelve months after lime added at the rate of one ton per acre. Monthly water and soil analysis were made and benthic organisms were collected and measured volumetrically each month.

Water analyses consisted of total hardness and pH measurements. Secchi disc measurements were also taken monthly.

Five soil samples were collected from each pond bottom at depths of two, three, four, five, and six feet at permanently marked sampling stations. The samples from each pond were combined and packaged in special soil sample bags and returned to the University of Georgia soil testing laboratory where measurements of calcium, phosphorus, potassium, soluble salts, and soil pH were made.

Benthos samples were taken from the same stations as the soil samples and screened through ten and thirty mesh screens. The material remaining on the screens was preserved and returned to the laboratory where the benthic organisms were separated and measured volumetrically.

Samples of the fish population were made with fifty- and fifteen-foot seines in an effort to determine the condition of the fish population and their state of balance. All ponds contained largemouth bass (*Micropterus salmoides*), and bluegill bream (*Lepomis macrochirus*), and one pond contained brown bullhead (*Ictalurus nebulosus*). The ponds were all found to be in a good state of balance except one. The pond which was out of balance and the pond which contained catfish were dropped from the study, leaving a total of six experimental ponds.

For comparative purposes, the results of the first six months sampling and the last six months sampling, after the addition of lime, are included in Table I. The months of October, December, January, February, March, and April, 1960-1961, are compared with the same months of 1961-1962.

In comparing the average results from all data collected before and after lime treatment, the one significant chemical change is an increase in total hardness. This increase was immediately apparent after liming and persisted throughout the course of the investigation.

Bottom soil nutrients including phosphorus, potassium, calcium, and soluble salts, varied between control and experimental ponds. The only apparent correlation between increased production of benthos was found in the ponds with a high total hardness. In general, the level of total water hardness in all ponds was directly proportionate to the production of benthos organisms.

TABLE I

AVERAGE RESULTS OF SOIL, WATER, AND BENTHIC ORGANISM SAMPLING FOR SIX MONTHS BEFORE AND AFTER LIME TREATMENT

	Soil Analyses					Water Analyses		
Ponds	*pH*	*Phos-phorus*	*Potas-sium*	*Calcium*	*Soluble Salts*	*pH*	*Total Hard-ness*	*Benthos * (mi./ 180 sq. in.)*
SANDY AREA:	1-Before 2-After							
Brown †	1-5.5	17.7	32.2	603.5	52.7	6.4	7	6.0
	2-5.3	9.3	14.7	125.5	16.3	6.6	7	2.7
Park †	1-5.5	20.5	38.0	496.3	67.5	6.5	9.2	15.4
	2-5.3	15.7	33.8	289.2	53.8	6.8	10.5	11.2
Clarke	1-5.6	24.3	70.5	786.7	70.8	6.9	8.7	6.9
	2-5.8	21.0	53.3	579.2	81.8	7.1	17.2	9.1
CLAY AREA:								
Sanders †	1-5.2	10.7	54.0	740.5	136.8	7.5	21.8	17.1
	2-4.9	23.0	56.2	340.8	172.0	7.1	14.5	26.7
Jordan	1-5.5	14.7	37.3	273.3	46.7	6.6	12.0	6.4
	2-6.0	13.7	41.8	511.7	69.8	7.4	19.0	24.7
Peed	1-5.2	8.3	45.5	330.5	104.8	6.8	12.0	6.9
	2-5.1	6.3	47.5	227.5	136.2	7.4	20.2	9.7

* The dominant benthic organisms were the bloodworms (*Tendipes* and *Pentaneura*) in all cases except one, Peed's pond, in which Oligocheata was the dominant form.

† Indicates control pond, no lime added.

DISCUSSION

During the course of this study, the writer has found that various factors affect the production of benthic organisms. The rate of fertilization has a great effect on benthos production. Ball (1949) found that fertilization increased benthic production by forty-two percent and plankton production by three hundred percent, thereby linking plankton production with benthic production. Lime additions to Georgia farm ponds greatly increase plankton production and should result in an increased benthic production. Howell (1941) found a correlation between plankton production and benthos production.

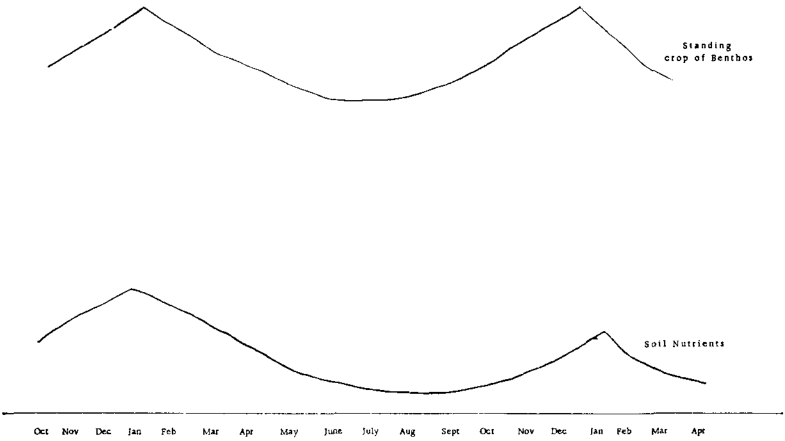
The fish population in a pond influences the standing crop of benthos a great deal. Dendy (1956) found that ponds with no fish and with a bass-only fish population had a much larger standing crop of benthic organisms than ponds with a bass-bluegill population or an over-crowded bluegill population. Borutzky (1939) found that a balance between fish and benthic organisms must exist to have a high benthic population. This in turn affects fish production. Moehean (1936) found that when the weight of benthic organisms increased from five to nine grams per square meter, bass production more than doubled. Bass and Hayne (1953) discovered that the removal of fish brought about a two-fold increase in numbers and volume of benthic organisms.

The texture and organic content of bottom soils seems to influence benthic production. Were (1939) found that benthic production was higher in clay soil than sandy soil, and that production was higher in soils with high organic content. Barnichol (1941) found more organisms in soft ooze than in any other bottom type. Eggelton (1930) found more bottom organisms on muddy bottoms than on sandy bottoms. Ruttner (1953) reports that benthic organisms are ooze eaters, and must pass great quantities through their gut.

Soil pH apparently does not influence benthic production. In this study there was no evidence of soil pH influencing benthic production, nor any evidence of correlation between calcium content and soil pH.

The season of the year appears to exert the greatest influence on the standing crop of benthic organisms. Benthic production is greater in the winter than any other time. During this study in every instance except one (Jordan's pond). December and January were periods of peak production. Borutzky

Figure 1 Showing General Monthly Levels of Benthos and Soil Nutrients In Ponds Included In This Study



(1939) found that the winter was the most productive season for benthos, and that fishes remove almost all organisms during the spring. Eggelton (1930) found that production was highest in January and February in Michigan. Howell (1941) discovered more organisms in late fall and early winter in Alabama ponds.

Since the fish population has such a great influence on benthic production, two ponds were necessarily dropped from this study. One of the ponds became overcrowded with bluegill and infested with warmouth perch (*Chaenobrythera gulosus*). The other pond deleted from the study became overcrowded with bluegill and infested with catfish. After these two ponds were dropped from the study, there remained a total of six ponds, three in each soil type area. The sandy soil area then had two control ponds and one experimental pond, and the clay soil area had two experimental and one control pond.

The control ponds in the sandy soil showed a *decrease* in benthic porduction, while the experimental pond experienced an *increase* in benthic production for the months compared before and after lime additions. The fall, winter, and spring months of October, December, January, February, March, and April before and after lime additions were chosen because peak production occurs during this time, and fish do not remove many organisms during this time.

Brown's pond, a control pond, experienced a fifty percent decrease in benthos production, and Park's pond, the other control pond, suffered a thirty percent decrease in benthos production for the months compared in this study. On the other hand, Clarke's pond, which was limed, showed an increase of twenty-four percent in benthic production. Although catch records were not kept, the owner felt that bluegill fishing improved after liming and that the fish were of larger-than-average size, thus making the lime addition economically justifiable to the owner, even if the effect was psychological.

Soil sample analysis showed no distinct trends. All ponds in the sandy area had a lower soil nutrient level after lime treatment. Nutrient levels were very low during the summer months. Calcium and phosphorus were especially low, indicating that additions of these elements might be beneficial to benthos production. The writer believes that plant growth, plankton and aquatic weeds, removes nutrients from the water and bottom soils of the pond during the summer months, and that this accounts for the low nutrient levels at that time.

The standing crop of benthos was very low in all ponds during the summer. This was due to predation by fishes and the organisms changing from larvae to adults and swarming. Borutzky (1939) reports that there is one generation per year and swarming is affected by water temperature. Emergence of adult forms and swarming occurred in the ponds studied in early April. The reduction in benthic organisms prior to April is presumed due to feeding activities of fishes.

Ponds in the clay soil area reacted slightly different from the ponds in sandy soil. The general differences noted included higher benthic production, less leaching of soil nutrients, and in one instance, the peak standing crop of benthos occurred at a different time.

Benthic production increased thirty-five percent in Sander's pond during the period compared with the interval after lime additions to the other ponds. This pond was a control area in clay soil, but it is very productive with a high total hardness while the experimental ponds were not particularly productive before liming.

Jordan's pond reacted differently from the other experimental ponds in clay soil since benthic production occurred in December after liming. This is not unusual, however, the December peak was preceded by a tremendous increase in October which did not occur in the other ponds. This unusual increase in benthic production during October was preceded by a dense plankton bloom in June and July. The plankton bloom is at least partially responsible for the increase in benthic production at an earlier date. Plankton blooms of this nature were not recorded for other ponds during midsummer.

Jordan's pond experienced a four-fold increase in benthic production after lime additions. This was the highest level of benthos recorded from all ponds. Soil nutrients in Jordan's pond dropped during the summer, but increased the following fall and winter to a higher level than the year before. This would indicate that additions of calcium, phosphorus, and potassium exceeded the amounts lost through leaching. Jordan's is the only pond in which optimum conditions of soil type, fertilization, and lime treatment were found. Although lime was added at the same rate of one ton per acre in other ponds, optimum conditions for benthos productivity were not present.

Peed's pond in the clay soil area was limed but not fertilized. The owner agreed to fertilize the pond prior to the study but failed to do so. Data was nevertheless taken in an attempt to evaluate the effect of lime on benthic production. Benthic production did increase thirty percent after liming, however, this is not necessarily significant sincethe control pond in this area increased thirty-five percent without lime additions. In all probabality, Peed's pond would have had a significant increase in benthic production had it been fertilized at a normal rate. It it interesting to note that this pond was the only pond in which Oligochaeta was the dominant benthic organism found (Table I).

CONCLUSION

Although the results of this study are not necessarily conclusive, certain general trends are apparent in the overall production of benthos.

Lime (calcium carbonate) added to ponds at the rate of one ton per acre in conjunction with recommended fertilization is beneficial to plankton and benthos production. Agricultural lime increases benthic production, but does not affect qualitative organisms production. Lime added at the rate of one ton per acre without fertilization does not significantly increase benthic production, although its addition may release nutrients bound in pond bottom and cause a temporary increase in productivity.

Soil pH has no apparent influence on benthic production at a pH range of 4.5 to 6.0.

The time of year has a great influence on the standing crop of benthic organisms with fall and winter months being the time of greatest abundance.

Ponds located on a clay soil watershed are generally more productive than ponds located on sandy soil watershed, since a greater amount of leaching of soil nutrients occurs in sandy soil. Lime added at the rate of one ton per acre may not be sufficient for ponds in sandy soil areas.

Table II

Benthic Organisms Found and the Months of their Occurrence

Organism	*Oct.* '60	*Nov.* '60	*Dec.* '60	*Jan.* '61	*Feb.* '61	*Mar.* '61	*Apr.* '61	*May* '61	*June* '61	*July* '61	*Aug.* '61	*Sept.* '61	*Oct.* '61	*Dec.* '61	*Jan.* '62	*Feb.* '62	*Mar.* '62	*Apr.* '62
Chaoborus	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Tendipes	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pentaneura	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Oxyethira	x	x							x							x		
Palpomyia	x	x	x	x	x	x	x		x	x	x		x	x	x	x	x	
Taeniogaster															x			x
Caenis							x		x						x			
Nematoda	x	x	x									x				x		
Oligochaeta	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x

LITERATURE CITED

Ball, Robert C. "Experimental Use of Fertilizer in Production of Fish Food Organisms and Fish." Tech. Bulletin 210, Mich. State College, 1949.

———— and Don W. Hayne. "Effects of the Removal of the Fish Population on the Fish Food Organisms of the Lake." Ecology, 33(1)41-48, 1953.

Barnickol, P. G. "An Investigation of the Bottom Fauna, Lake of the Ozarks, Missouri." M.S. Thesis, University of Missouri, 1941.

Borutzky, E. V. "The Dynamics of the Biomass of Chironomous Plumocus in the Deep Waters of Lake Beloie." Proc. Kossino Limnological Station Hydrometeorological Service, U. S. S. R. #22, 1939.

Dendy, Jack S. "Bottom Fauna in Ponds with Largemouth Bass Only and With a Combination of Largemouth Bass Plus Bluegill." Journal Tennessee Academy Science, 31:3, July 1956.

Eggelton, Frank E. "A Limnological Study of the Profundal Bottom Fauna of Certain Freshwater Lakes." Doctoral Thesis, University of Michigan, 1930.

Howell, Henry H. "Bottom Organisms in Fertilized and Unfertilized Fish Ponds." M.S. Thesis, Alabama Polytechnic Institute, 1941.

Mohean, Lloyd O. "Some Factors Controlling Largemouth Bass Production." Prog. Fish Culture, 16, 1-6.

Ruttner, Franz. "Fundamentals of Limnology." University of Toronto Press, 1953, 242 pp.

Swingle, H. S. and E. V. Smith. "Management of Farm Ponds." Alabama Polytechnic Institute, Agricultural Experiment Station Bulletin, 254, 30 pp., 1947.

Thomaston, W. W. and H. D. Zeller. "Results of a Six-Year Investigation of Soil and Water Analysis and Lime Treatment in Georgia Farm Ponds." Proceedings 15th American Conference Southeastern Association Game and Fish Commissioners, 1961.

Were, George P. "Soil as an Ecological Factor in the Abundance of Aquatic Midge (*Chironomid*) Larvae." M.S. Thesis, Ohio State University, 1939.

Zeller, H. D. and A. B. Montgomery. "Preliminary Investigation of Chemical Soil and Water Relationships and Lime Treatment of Soft Water in Georgia Farm Ponds." Proceedings 11th Annual Conference Southeastern Association Game and Fish Commissioners, 1957.

A TAGGING EXPERIMENT ON SPOTTED AND LARGEMOUTH BASS USING AN ELECTRIC SHOCKER AND THE PETERSEN DISC TAG

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ABSTRACT

An electro-fishing unit developed for use on large impoundments was tested for efficiency in capturing Largemouth and Spotted Bass during the winter months for a tagging program.

Experiments were conducted to determine mortality rate of fish captured under actual field conditions for the electro-fishing units described.

Two body locations on Largemouth and Spotted Bass were tested for their ability to retain the Petersen Tag. Tagging mortality for one of the locations is given.

INTRODUCTION

The inability to obtain adequate numbers of game fish, particularly bass, from large impoundments has seriously hampered research on this species in the past. With the advent of electro-fishing gear facilitating capture of this species, many of these problems can and are being solved.