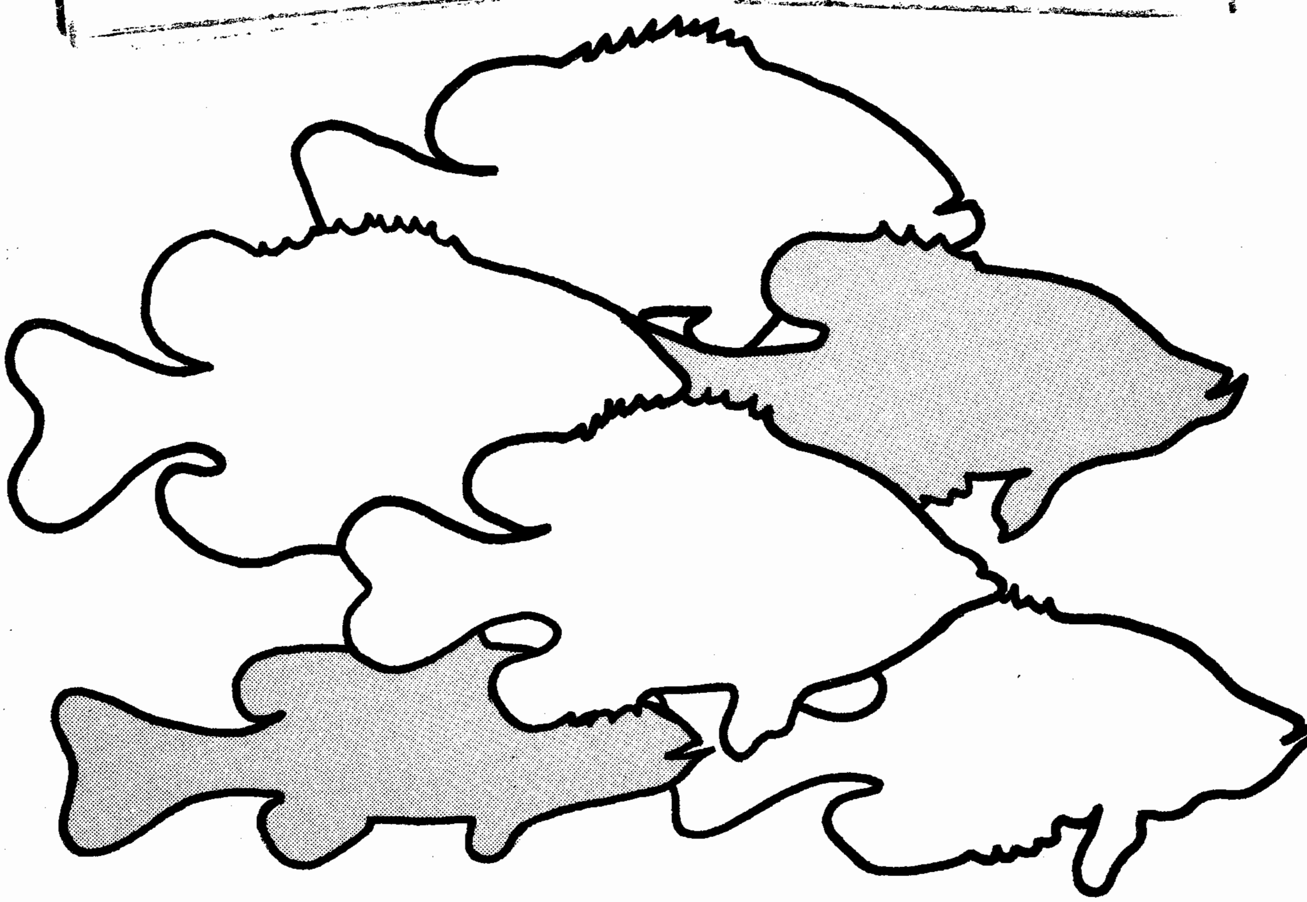
AMERICAN FISHERIES SOCIETY

PROCEEDINGS

ANNUAL MEETING
MISSISSIPPI CHAPTER



VOL. IV
February 14, 1980
Mississippi State
University

PROCEEDINGS
ANNUAL MEETING
AMERICAN FISHERIES SOCIETY
FEBRUARY 14, 1980
MISSISSIPPI STATE UNIVERSITY

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AMERICAN FISHERIES SOCIETY
MISSISSIPPI CHAPTER
1980 ANNUAL MEETING

Extension Auditorium, Mississippi State University
Mississippi State, Mississippi
February 14, 1980

AGENDA

8:30 - 9:30	Registration
9:30 - 11:30	Business Meeting
12:00 - 1:00	Lunch
1:30 - 1:50	Status of commercial catfish farming in Mississippi and the United States - Thomas L. Wellborn, Jr., Leader, Extension Wildlife & Fisheries Department, Mississippi State University
1:50 - 2:10	Benthic productivity in Mississippi lakes and reservoirs as compared with that of northern lakes - Charles M. Cooper, Ecologist, USDA Sedimentation Laboratory, Oxford, MS
2:10 - 2:30	The occurrence of mirex on aquatic animals collected in north east Mississippi - Jack Herring and Don Cotton
2:30 - 2:50	Break
2:50 - 3:10	Seasonality in trophic relationships of <u>Cynoscion arenarius</u> and <u>Cynoscion nothus</u> (Pisces: Sciaenidae) in the north central Gulf of Mexico - Steven M. Byers and Stephen T. Ross, University of Southern Mississippi, Hattiesburg, MS
3:10 - 3:30	Lake and pond management in national forests in Mississippi - Danny J. Ebert, U.S. Forest Service, Jackson, and Luther A. Knight, Biology Department, University of Mississippi, Oxford, MS
3:30 - 3:50	Formulating "Least Cost" catfish feeds - H. Randall Robinette, Department of Wildlife & Fisheries, Mississippi State University, Mississippi State, MS
3:50 - 5:00	Tour of fisheries facilities at Mississippi State University (optional) - Mississippi State University fisheries staff
5:00	Adjourn

STATUS OF FISH FARMING IN MISSISSIPPI - MARCH 1980

Dr. Thomas L. Wellborn, Jr., Leader
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Mississippi State University
Mississippi State, Mississippi 39762

Commercial fish farming in Mississippi, particularly catfish farming, continues to grow at a healthy rate. Mississippi remains the leader, by a wide margin, in the production of farm-raised channel catfish with a total of 27,370 acres, of which 24,464 acres are in food fish and 2,906 acres are in fingerlings (Table 1). There are now 1,674 acres in bait minnow production, thus giving Mississippi a total of 29,044 acres of water devoted to commercial fish farming (Table 1).

The growth of fish farming in Mississippi between May 1977 - March 1980 and between March 1979 - March 1980 is shown in Table 2. The acreage of food sized catfish increased by 1,923 acres (8.5%) from March 1979 to March 1980. I believe the growth would have been higher if excessive rains during the summer of 1979 had not slowed pond construction. The 33.9 percent increase in catfish fingerling acreage (735 acres) in my opinion reflects the great demand for catfish fingerlings.

Because of the availability of high quality water and the topography, 92.8 percent (25,407 acres) of all of the catfish acreage is located in the delta region of Mississippi (Fig. 1). The southern part of the state has 3.8 percent (1,035 acres) and the northeast region has 3.4 percent (928 acres) of the total catfish acreage (Fig. 1). This same relationship is true for bait minnow production with the delta having 69.7 percent (1,167 acres), the south 22.1 percent (369 acres), and the northeast 8.2 percent (138 acres) of the total bait minnow acreage (Fig. 1).

In catfish production the delta and northeast region showed a gain of 13.3 percent (2,973 acres) and 6.1 percent (53 acres) in acreage (Table 3), respectively. However, in the south there was a 26.2 percent (368 acres) loss in acreage devoted to catfish production (Table 3). This loss was primarily due to small farmers converting their ponds to pay lake operations or to producing catfish only for family and friends.

The delta had an increase of 20.9 percent (202 acres) and the south an increase of 11.5 percent (38 acres) in bait minnow acreage (Table 4). There was a loss in bait minnow acreage in the northeast region of 50.2 percent (139 acres) which is difficult to explain, although again most of the loss was in small farms (Table 4).

Average production and value figures, for the period from March 1979 to March 1980, used in Tables 5-6 are estimates which I made after consulting with a number of fish farmers in the state, and these figures are believed to represent an accurate view of commercial fish farming in Mississippi. However, since individual production levels and prices received vary so much these figures can not be applied to individual situation. In 1979, the estimated value of catfish farming in Mississippi, i.e., the amount of money catfish farmers received for their fish, was $57,127,040 (Table 5). The estimated value that bait minnow farmers received for their fish was $1,799,550 (Table 5) during the period from March 1979 to March 1980.

As part of the survey, each catfish farmer was asked if they planned to construct any new ponds during 1980, and if so, how many water acres. Also, several individuals who are not now involved in catfish farming indicated that they were planning to go into catfish farming and would construct ponds during 1980. The proposed new catfish acreage for Mississippi during 1980 is 4,845 acres with most of the new acreage (98.2%) to be constructed in the delta. This represents a growth of about 18 percent for catfish farming during 1980. However, I believe a more realistic figure would be about a 10 percent increase in catfish acreage during 1980. Table 7 shows what I think is a realistic projected acreage of catfish farms in 1981, 1983 and 1985.

Table 1. Acres of commercial fish farms in Mississippi in May, 1977, March 1979 and March 1980.

	May 1977	March 1979	March 1980
Channel Catfish			
Food	15,182	22,541	24,464
Fingerlings	1,969	2,171	2,906
Subtotal	17,151	24,712	27,370
Bait Minnows	1,327	1,573	1,674
Total Acres	18,478	26,285	29,044

Table 2. Increase in acres of commercial fish farms in Mississippi between May 1977 - March 1980 and March 1979 - March 1980

	May 1977-Mar. 1980		Mar. 1979-Mar. 1980	
	Increase in acres	Percent increase	Increase in acres	Percent increase
Channel Catfish				
Food	9,282	61.1	1,923	8.5
Fingerlings	937	47.6	735	33.9
Subtotal	10,219	59.6	2,658	10.8
Bait Minnows	347	26.1	101	6.4
Total	10,566	57.2	2,759	10.5

Table 3. Change in catfish acreage in three regions of Mississippi between March 1979 and March 1980

	1979	1980	Change in acres	Percent change
Delta				
Food	20,519	22,840	+2,321	+11.3
Fingerlings	1,915	2,567	+652	+34.1
	22,434	25,407	+2,973	+13.3
Northeast				
Food	774	713	-61	-7.9
Fingerlings	101	215	+114	+112.9
	875	928	+53	+6.1
South				
Food	1,248	911	-337	-27.0
Fingerlings	155	124	-31	-20.0
	1,403	1,035	-368	-26.2
Total	24,712	27,370	+2,658	+10.8

Table 4. Change in bait minnow acreage in three regions of Mississippi between March 1979 and March 1980

	1979	1980	Change in acres	Percent change
Delta	965	1,167	+202	+20.9
Northeast	277	138	-139	-50.2
South	331	369	+38	+11.5
Total	1,573	1,674	+101	+6.4

Table 5. Estimated value of farm-raised catfish in Mississippi - March 1980

Food Fish	
Average production	3,000 lbs./acre
Average value per lb. in 1979	.62¢
	$1,860/acre
24,464 acres X $1,860.00/acre = $45,503,040.00	
Fingerlings	
Average production	80,000/acre
Average price per inch in 1979	1¼¢ 1 inch
Average length	4 inches
	$4,000/acre
2,906 acres X $4,000.00/acre = $11,624,000.00	
Food Fish	$45,503,040.00
Fingerlings	11,624,000.00
	$57,127,040.00

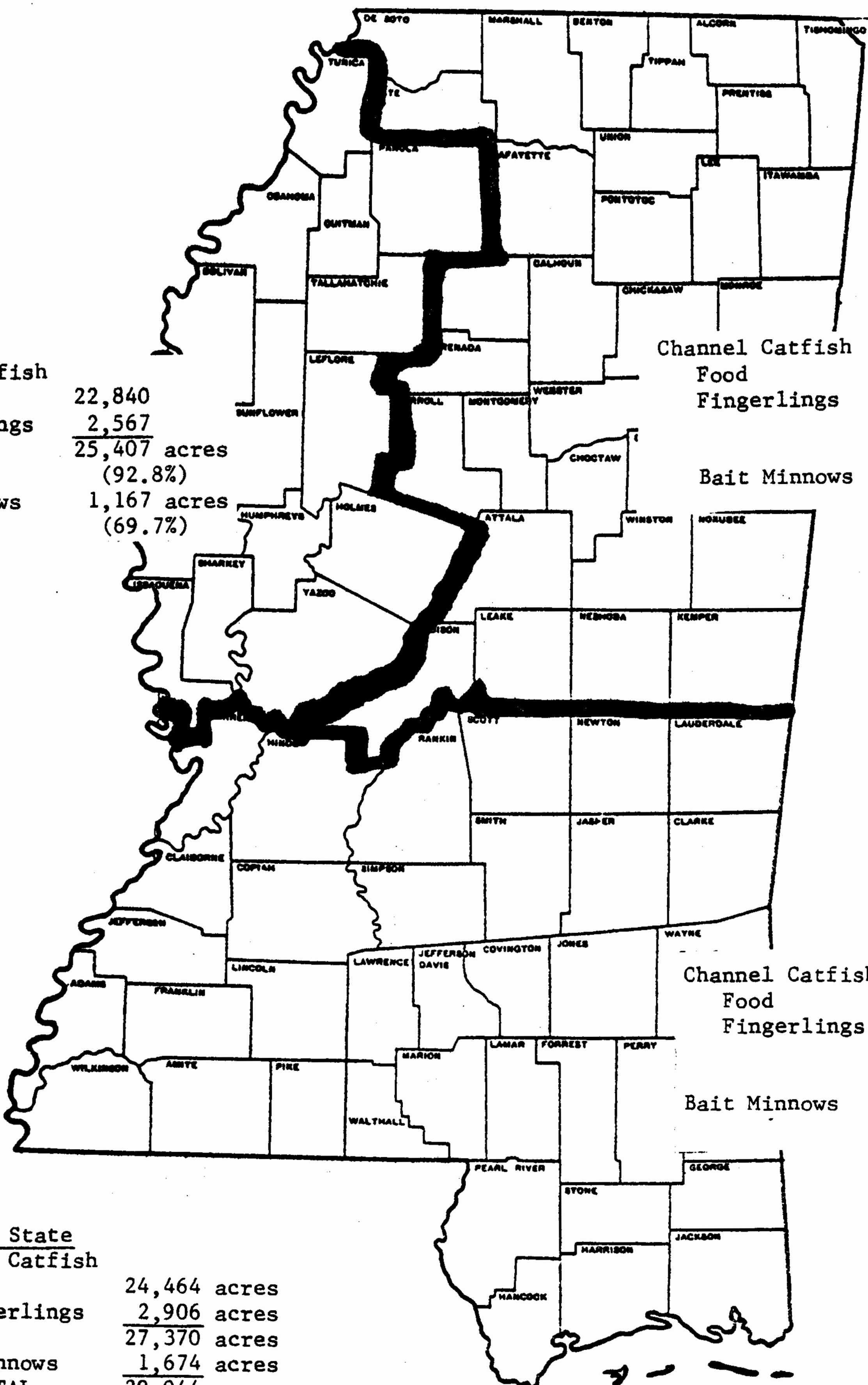
Table 6. Estimated value of bait minnows raised in Mississippi - March 1980

Bait Minnows	
Average production	500 lbs./acre
Average price per pound in 1979	$2.15
Average value	$1,075.00/acre
1,674 acres X $1,075.00/acre = $1,799,550.00	

Table 7. Projected acreage for the commercial catfish farming industry in Mississippi in 1981, 1983 and 1985 by region.

Delta	27,948	33,817	40,919
Northeast	947	985	1,025
South	1,045	1,066	1,088
Total	29,940	35,868	43,032

Figure 1. Commercial Fish Farming Acreage in Mississippi by region - March 1980



Channel Catfish	
Food	22,840
Fingerlings	2,567
	25,407 acres
	(92.8%)
Bait Minnows	1,167 acres
	(69.7%)

Channel Catfish	
Food	713
Fingerlings	215
	928 acres
	(3.4%)
Bait Minnows	138 acres
	(8.2%)

Channel Catfish	
Food	911
Fingerlings	124
	1,035 acres
	(3.8%)
Bait Minnows	369 acres
	(22.1%)

Totals for State

Channel Catfish	
Food	24,464 acres
Fingerlings	2,906 acres
	27,370 acres
Bait Minnows	1,674 acres
TOTAL	29,044 acres

BENTHIC PRODUCTIVITY IN MISSISSIPPI LAKES AND RESERVOIRS

AS COMPARED WITH THAT OF NORTHERN LAKES[1/]

C. M. Cooper[2/]

ABSTRACT

The benthic macrofauna in several flood control reservoirs and oxbow lakes in Mississippi was studied and compared with results of similar investigations in northern lakes. The Mississippi lakes contained fewer species and numbers of organisms than were reported for the northern lakes reviewed, although both groups of waters had many of the same genera. The largest number of species recorded in Mississippi lakes was 29 while northern counterparts commonly report 50 or more species. Similarly, the highest secondary production recorded was 10.4 g/m^2 in Mississippi but commonly exceeded 50 g/m^2 in Northern lakes. The lower level of production found in the Mississippi lakes was associated with differences in both littoral and profundal zones. Littoral areas, normally the most productive regions in northern lakes, yielded fewer benthos in Mississippi lakes mainly because of water level fluctuations and lack of available habitat.

INTRODUCTION

Freshwater benthos, like many other aquatic communities, has been studied very little in the southern United States. In the south stable glacial lakes are non-existent. Though some natural lakes exist, most bodies of standing water in the South are man-made and have sizable water level fluctuations, creating barren shorelines, increasing turbidity, and giving an appearance quite different from that of northern natural lakes. The purpose of this study was to compare species diversity and production of the benthos in flood-control reservoirs and natural oxbows in Mississippi with those of northern lakes.

STUDY AREA

Arkabutla, Sardis, Enid, and Grenada reservoirs were constructed as a part of the U. S. Corps of Engineers Yazoo River Basin flood control plan during the 1940's and 1950's. All four reservoirs have earth-fill dams with concrete spillways and adjustable spillway gates that were constructed across major rivers (Fig. 1). The basins of these impoundments consist of alluvial valleys which before impoundment were farmland, forestland, or lowlands. These basins are surrounded by highly erosive sandy-loess Mississippi hill-lands. Although all four reservoirs have common structural features, they also have many differences.

1/ Contribution of the USDA Sedimentation Laboratory, SEA, AR, U. S. Department of Agriculture.

2/ Ecologist, Sedimentation Labortory, Oxford, Mississippi.

Arkabutla has the smallest holding capacity, a water residence time of less than one-half year, and a 20.6 km^2 conservation pool and a 135 km^2 flood control pool. Enid Reservoir has a similar surface area with a 24.7 km^2 conservation pool and 113 km^2 flood pool but, due to its increased depth, has a longer residence time (0.88 year). Grenada Reservoir with its Y-shape has a much larger surface area of 39.7 km^2 in the conservation pool and 261 km^2 for the flood pool. Sardis Reservoir has the largest holding capacity, a 39.7 km^2 conservation pool, and a 237 km^2 flood pool area. Both Sardis and Grenada reservoirs have water residence times similar to that of Enid. Ross Barnett Reservoir, in central Mississippi, was filled in 1965 and has a surface area of 125 km^2. Since its purpose is water supply and recreation, its water level does not fluctuate greatly. Mossy Lake, an old river oxbow (7,000 years old), is representative of many of the natural river runs and oxbows in the Mississippi River delta. It has a surface area of .9 km^2 and has a maximum depth of 4 m, much shallower than the flood control reservoirs.

Bottom associations in natural lakes have traditionally been divided into three zones: littoral, sublittoral, and profundal. Littoral zones are characterized by greater species diversity (Adamstone, 1924; Sublette, 1957). However, in many water bodies these zones are not always stable. Flood-control and hydroelectric reservoirs are subject to extreme fluctuations in water level. These constantly changing water levels cause environmental stress not found in more stable lentic environments like those in the north and prevent the establishment of a classically-defined littoral zone. Many oxbow lakes in Mississippi have a morphometry such that sides are steep and little littoral zone exists.

MATERIALS AND METHODS

From 1973-1975, I sampled bottom deposits (0.28 m^2/sample) monthly in Grenada Reservoir (Fig. 1) and quarterly in Enid, Arkabutla, and Sardis reservoirs with a 15.2 x 15.2 cm Ekman dredge. Mossy Lake and Ross Barnett were sampled during 1978 and 1979, respectively. Bottom materials were washed in a bucket wth a U. S. No. 30 sieve (0.589 mm) bottom. In the lab organisms were floated off, using a sugar solution, counted, preserved, and a wet weight determination was done.

RESULTS AND DISCUSSION

Bottom zones were influenced greatly by changing water levels in the 4 north Mississippi reservoirs and were less stable environmentally than those found in natural lakes. Littoral zones in the reservoirs shifted as water levels changed and were composed of areas of sand-gravel cenosis and hard pan clay produced by shallow-water wave action and periods of drying and baking. The ecotone (sublittoral zone), separating the littoral and profundal zones had a gumbo clay substrate produced because this zone was out of water one to two months each year but was not subjected to extensive shallow-water wave action or drying. The profundal zone with its mud-muck substrate was never dry.

These impoundments contrast greatly with northern lakes, many of which have stable shorelines where water levels usually fluctuate less than one meter, and bays and coastlines may have vegetation extending out from shore for several meters and a thick organic muck layer deposited over centuries covering much of the bottom.

Water level fluctuations in the reservoirs were the results of their basic purpose, to hold excess water which they gradually release to reduce flooding. Thus, water levels might rise six m in one week and recede six m in two months. Profundal zones 20-m deep in May might be only eight m deep in November. Drawdown procedures also normally limited periods of thermal stratification, water column stability, and hypolimnional stagnation because water removed from the hypolimnion.

Drawdown procedures resulted in profundal areas being more productive than littoral zones. Profundal regions of Grenada Reservoir produced 62, 70, and 77 percent of benthic biomass from 1973 to 1975, respectively. The benthic fauna of two adjacent sampling stations only 100 m apart showed that the productivity of the profundal zone (Fig. 2) was much higher than that of the littoral zone (Cooper, 1977). Observations of the littoral zone station revealed a gravelly-sand cenosis on hardpan clay with no decomposing vegetation or mud substrate. These conditions are unsuitable for macroinvertebrate life.

The absence of littoral flora and the decomposing layer beneath it reduced faunal diversity. Miller (1941) found that of 50 species in Costello Lake, Ontario, 43 were in the epilimnion. Krecker and Lancaster (1933) found that the 45.7 cm deep area was the most highly populated area along Lake Erie shoreline. Ball (1948) showed that the reduction of flora of a natural lake resulted in a reduced fauna.

The absence of flora and accompanying fauna in bays and other littoral areas of the reservoirs was directly associated with changes in water level and wave action. The fluctuating water level left areas of aquatic plants and the associated fauna without water for two to four months each year. Although some animals migrated into deeper water, many were trapped and died. These dry periods and the grinding action of shallow water waves in these areas effectively prevented the development of any aquatic plant communities in the littoral zones.

The lack of production in the littoral zone due to habitat destruction was further substantiated. During the 1972-73 life-cycle period, abnormally high rainfall increased water levels until drawdown could not be completed. Thus, littoral habitats were preserved that year, and littoral macrofauna production in Grenada Reservoir was 43 percent greater than that of the following year when more normal drawdown occurred.

Littoral production in Grenada Reservoir averaged 4.4 $g/m^2/yr$, and profundal production averaged 10.4 $g/m^2/yr$. Benthic production in Sardis Reservoir never exceeded 6.4 g/m^2 in profundal zones. Sublette (1957) found Lake Texoma, a large reservoir in Texas and Oklahoma, to have a mean standing crop of 2.3 g/m^2 in littoral regions and 10.3 g/m^2 in the profundal zone.

Ross Barnett Reservoir near Jackson has much less water level fluctuation than the flood control reservoirs, and, thus, should be more productive. Though I found the proper taxa of benthos in Ross Barnett for greater potential production, actual profundal production in 1979 was 7.3 g/m^2. Bottom material were indicative of a young lake and were evidently not supportive of larger populations of benthos.

Benthic production on Mossy Lake, a natural oxbow in the Mississippi River delta was low, averaging $gm/m^2/yr$. Because of its shallow basin, no hypolimnional oxygen stagnation occurred during the study in Mossy Lake. However, deposited sediments were quite deep and the top 0.10 m consisted of a loose fluff which was unsuitable for many benthic invertebrates.

The richness of benthos production in natural lakes far exceeds that of the Mississippi lakes (Table I). Ball (1948) found that Third Sister Lake in Michigan produced from 13.4 to 26.9 $g/m^2/yr$ of benthos. Anderson and Hooper (1956) collected 10.1 g/m^2 of littoral fauna in Sugarloaf Lake, Michigan. Townes (1938), however, suggested that a natural lake yielding 30 $g/m^2/yr$ of bottom fauna would be normally rich. This value agreed with Juday's findings (1922). Productivity values vary according to methods and time of sampling; some oligotrophic northern lakes had even less biomass than southern reservoirs. Most sources (Table I), however, indicated that northern lakes have greater productivity, especially in the littoral zones.

Differences also occurred in species diversity. The largest number of species recorded from the Mississippi lakes was 29, and those were mainly from the profundal zone. Many northern studies reported at least 50 species, mainly from shallow plant-covered bays. Reservoir benthic genera were also reported in the northern lakes, and the same three phyla were predominant: Arthropoda, Mollusca, and Annelida. Though Chaoborus (Diptera) and chironomids (Diptera) were abundant, mayflies and oligochaete worms were not nearly as common in Mississippi as in the northern lakes. The low number of mayflies (0 to $150/m^2$) in the Mississippi lakes suggested poor habitat conditions whereas low numbers of worms may be linked to the reducing conditions of muds. Though naiads of Hexagenia bilineata (Ephemeroptera) inhabitated profundal zones of all reservoirs at some time during the study, no populations were maintained in the 4 flood control reservoirs because of periodic hypolimnional stagnation since areas normally having sufficient oxygen were occasionally oxygen deficient due to stagnation. Caenis sp. (Ephemeroptera) attempted yearly habitation of littoral zones in spring, but, as water levels declined, they did not migrate to a different habitat. Ross Barnett did resemble the northern lakes where more stable water levels resulted in lower mortality rates of benthic taxa.

Emergence of benthos in southern lakes was not as impressive as that in northern waters, partly because of smaller numbers of animals and partly because of warmer winter water. First major emergences of aquatic insects in northern Mississippi occurred in March, while many northern lakes still had ice; final emergences occurred in mid-September, making emergence more gradual. Scattered emergence occurred during all winter months in Mississippi lakes. Diptera which have three life cycles per year in northern lakes as recorded by Curry (1962) have up to six cycles per year in Mississippi. This higher reproductive rate increased the rate of production of some species of aquatic Diptera by 50 percent over their northern counterparts.

Summer epilimnional temperatures in the Mississippi lakes varied from 20^{o} to 32^{o} C. When present, hypolimnional waters varied from 10^{o} to 14^{o} C. Midwinter low temperatures for all reservoirs ranged from 8^{o} to 10^{o} C in open water areas with occasional ice formation in shallow bays.

Juday (1942) noted that at Lake Mendota, Wisconsin, winter to summer temperature ranged between 1^{o} to 25^{o} C. Jacobsen (1966) found summer epilimnional temperatures between 16.3^{o} and 21.6^{o} C. in Oneida Lake, New York. Although the temperatures of some northern lakes may approach those of Mississippi lakes in summer, the extremely low winter temperatures of the northern lakes cause life-cycle differences in several taxa of benthic macroinvertebrates.

SUMMARY

As compared with reported data for northern lakes, Mississippi lakes were less productive in benthic biomass, had less species diversity, and had similar species composition. Because of the habitat destruction from fluctuating water levels and drawdown, macrobenthos production in littoral areas of reservoirs was less than in profundal zones. Ross Barnett was less productive because of the oligotrophic state of bottom muds while Mossy Lake was unproductive because of a loose fluffy sediment.

ACKNOWLEDGMENTS

This paper is a contribution of the Sedimentation Laboratory, AR, SEA, U. S. Department of Agriculture, in cooperation with the University of Mississippi. Work done at the University of Mississippi was partially supported by the Biology Department, The Graduate School, and the Mississippi Water Resources Institute. Jerry Hollis, Stratford Kay, John Steen, and John Burris helped with the field work, and Peggy Hamilton and Winfred Cook helped prepare the manuscript.

LITERATURE CITED

1. Adamstone, F. B. 1924. The bottom fauna of Lake Nipigon. Publ. Ontario Fish Res. Lab. 19:45-70.

2. Anderson, R. O., and F. F. Hooper. 1956. Seasonal abundance and production of littoral bottom fauna in a southern Michigan lake. Trans. Am. Micros. Soc. 65:259-270.

3. Ball, Robert C. 1948. Relationship between available fish foods, feeding habits of fish, and total fish production in a Michigan lake. Mich. St. Coll. Agr. Exp. State. Tech. Bull. 206:1-59.

4. Cooper, C. M. 1976. Dynamics of benthic fauna of Grenada Reservoir. Ph.D. dissertation. University of Mississippi. 152 pp.

5. Cooper, C. M. 1977. Abundance and production of littoral and profundal benthic fauna in a flood control reservoir. Miss. Chap. Amer. Fish. Soc. Proc. 1977: pp. 25-33.

6. Curry, L. L. 1962. A study of the ecology and taxonomy of fresh-water midges (Diptera: Tendipedidae) of Michigan with Special Reference to their role in the "turnover" of radioactive substances in the hydrosol. National Institute of Health Contract RG-6429, Terminal Rept. (2) 149 pp.

7. Jacobsen, T. V. 1966. Trends in abundance of the mayfly (Hexagenia limbata) and chironomids in Oneida Lake. N. Y. Fish and Game J. 13:168-175.

8. Juday, Chancey. 1922. Quantitative studies of the bottom fauna in the deeper waters of Lake Mendota. Trans. Wisc. Acad. Sci., Arts, Lett. 20:461-493.

9. Juday, C. 1924. The productivity of Green Lake, Wisconsin. Verh. Int. Ver. Limnol. 2:357-360.

10. Juday, Chancey. 1942. The summer standing crop of plants and animals in four Wisconsin lakes. Trans. Wisc. Acad. Sci., Arts. Lett. 34:103-135.

11. Krecker, Frederick H., and L. V. Lancaster. 1933. Bottom shorefauna of western Lake Erie: A population study to a depth of six feet. Ecol. 14:79-93.

12. Miller, R. B. 1941. A contribution to the ecology of the Chironomidae of Costello Lake, Algonquin Park, Ontario. Univ. Toronto Stud., Biol. Serv. 49:1-6.

13. Millican, Troy. 1971. Dynamics of benthic fauna in waters of northern Mississippi. Ph.D. dissertation. University of Mississippi.

14. Sublette, J. E. 1957. The ecology of the macroscopic bottom fauna in Lake Texoma (Denison Resevoir), Oklahoma and Texas. Am. Midl. Nat. 57:371-402.

15. Rawson, D. S. 1955. Morphometry as a dominant factor in the productivity of large lakes. Verh. Int. Ver. Limnol. 12:164-175.

16. Townes, Henry K. 1938. Studies on the food organisms of fish. A biological survey of the Allegheny and Chemung watersheds. Suppl. to 27th Ann. Rept. 1937. N.Y. Conserv. Dept. Biol. Surv. No. 12, pp. 162-173.

17. Welch, Paul S. 1952. Limnology. McGraw Hill, New York. 510 pp.

Table I. Comparison of biomass of benthic macroinvertebrates of some North American lakes and reservoirs as reported in the literature.

Lake		Wet weight g/m^2	Source
Sardis Reservoir, MS		6.4	Millican (1971)
Grenada Reservoir, MS			Cooper (1976)
1973	Littoral	6.1	
	Profundal	10.0	
1974	Littoral	3.5	
	Profundal	8.3	
1975	Littoral	3.7	
	Profundal	12.8	
Ross Barnett Reservoir, MS			
1979	Profundal	7.3	
Mossy Lake, MS			
1978	Profundal	4.0	
Lake Texoma, TX			Sublette (1957)
	Littoral	2.3	
	Profundal	10.3	
Green Lake, WI			Juday (1924)
	0-10 m	8.2	
	10-20 m	16.6	
	20-40 m	17.1	
	40-66 m	15.0	
Sugarloaf Lake, MI			Anderson and Hooper (1956)
	Littoral	10.1	
Lake Mendota, WI			Juday (1942)
	0-7 m	43.4	
	>20 m	69.7	
Third Sister Lake, MI			Ball (1948)
	Littoral	13.4	
Great Slave Lake, NWT		2.0	Rawson (1955)

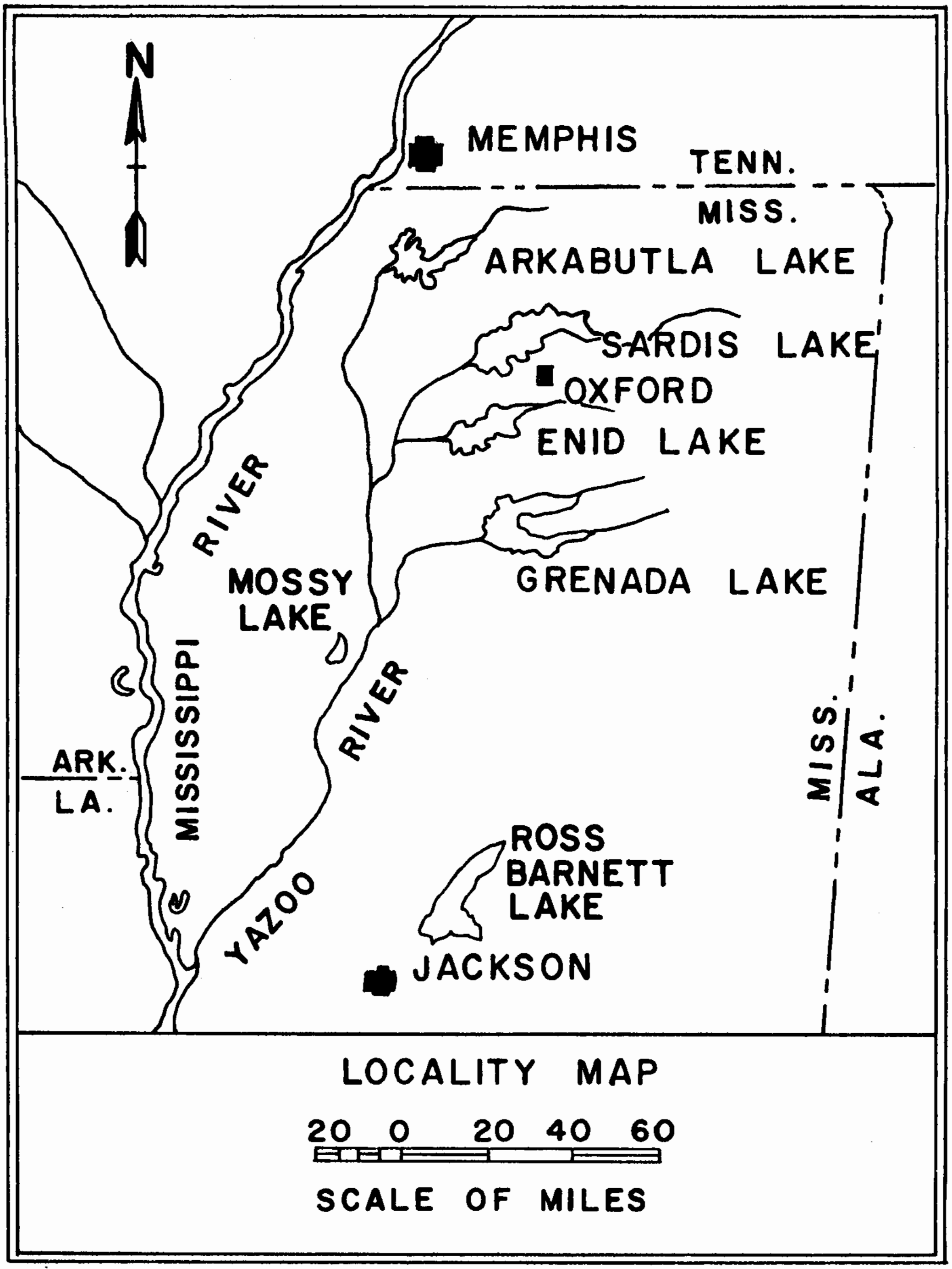


Fig. 1. Map of northern Mississippi, including the 6 lakes sampled.

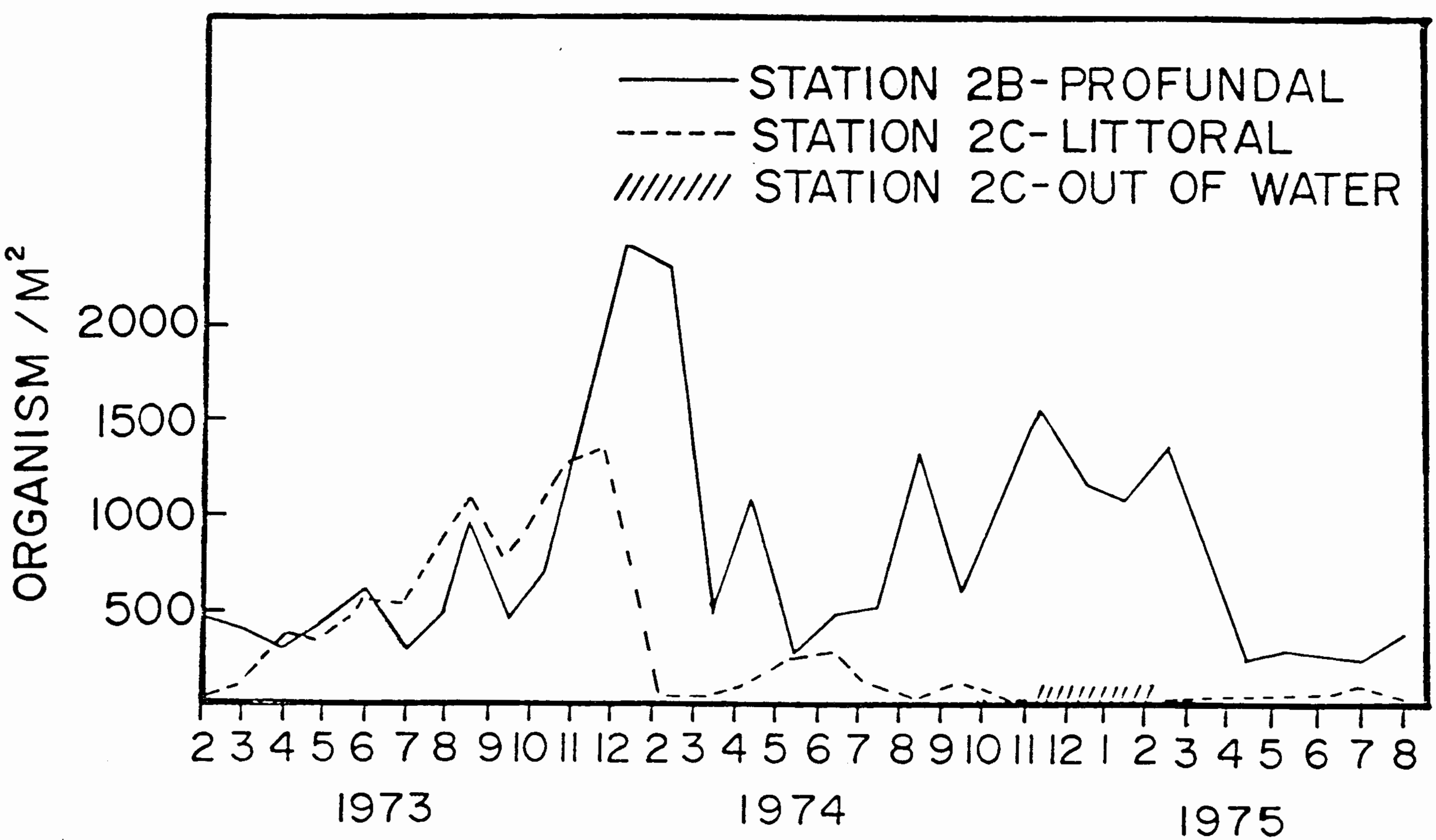


Fig. 2. Comparison on littoral and profundal habitats 100 m apart in Grenada Reservoir.

THE OCCURRENCE OF MIREX IN AQUATIC ANIMALS COLLECTED IN NORTHEAST MISSISSIPPI

by

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ABSTRACT

Two areas in northeast Mississippi were surveyed for mirex residues. The areas had received from 1 1/4 to 6 1/4 pounds per acre of mirex fire ant bait.

Largemouth bass, bluegill, channel catfish, crayfish, clams and pond muds were analyzed for mirex residues.

Residues as high as 0.47 ppm were found. Continued use of mirex could be harmful to all fisheries, particularly, the commercial catfish industry.

Introduction

The USDA launched a fire ant eradication program utilizing the insecticide heptachlor in 1957. Because of the adverse effects on the environment, the USDA abandoned the use of heptachlor during 1963 and substituted the use of mirex bait (decachloro octahydro-1,3,4-metheno-2H-cyclobuta/cd/pentanlene) placed on ground corn cob grits, along with soybean oil which serves as an attractant. This bait was then applied to infested areas at the rate of 1.25 pounds per acre.

The original fire ant eradication program called for treating 120 million acres in nine southeastern states three times with 1.25 pounds of mirex bait per acre. Such a program would have utilized 450 million pounds of mirex bait. Applications of the mirex bait would be spread on every field, pond, woodlot, and stream in the major portions of the nine southeastern states. Each square foot of land and water would receive approximately 50 of the poison corn cob grit baits after the three successive treatments. The cost of this proposed program was 200 million dollars with Federal funds to be matched with State funds on a two for one basis.

The Committee on the Imported Fire Ant (1967) concluded: after considering all available information, the Committee feels that an eradication of the imported fire ant is not now biologically and technically feasible.

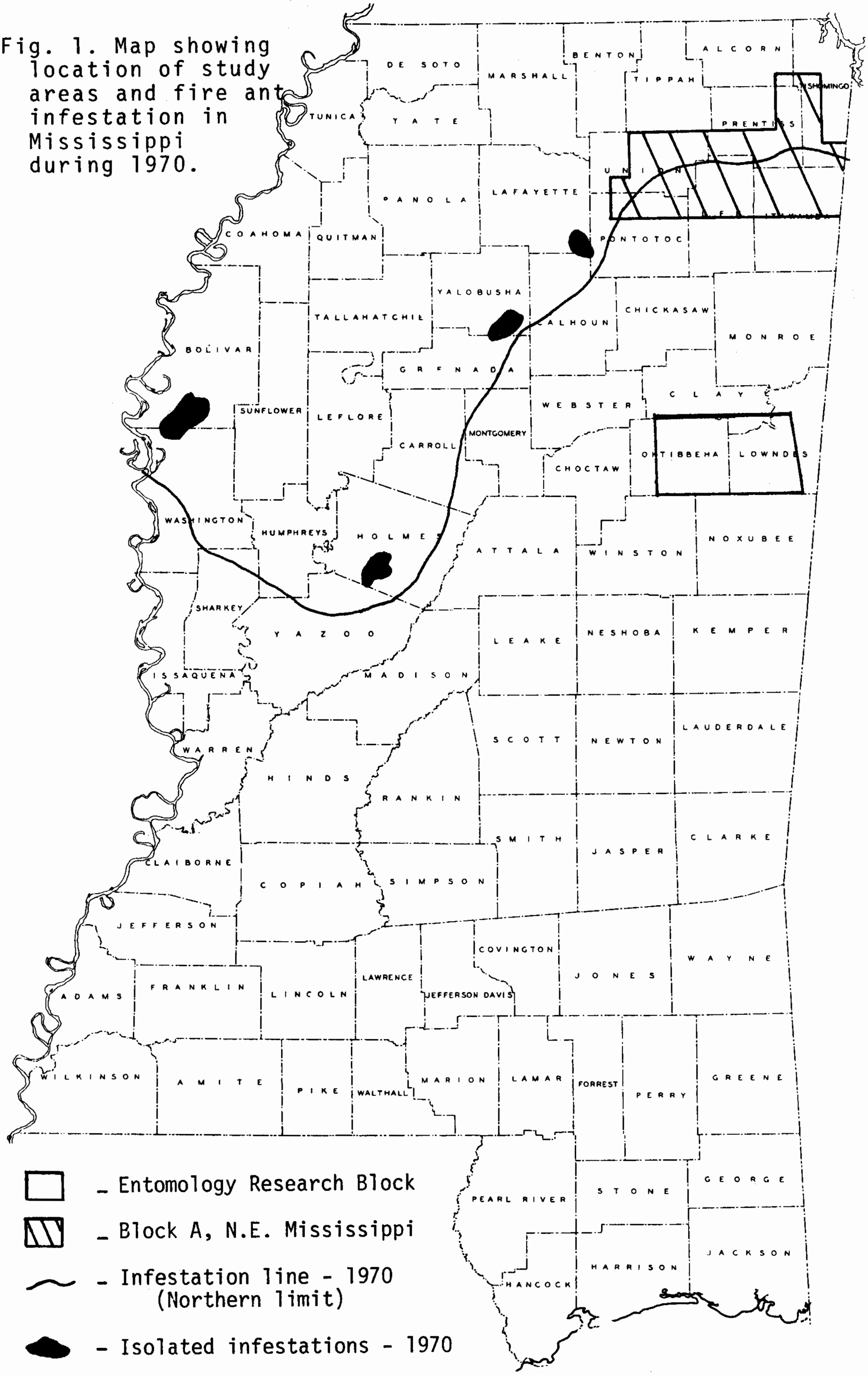
The U. S. Department of the Interior, during the 1970 deliberations of the working group of the Subcommittee on Pesticides of the President's Cabinet Committee on the Environment, objected to USDA's program for control of the fire ant involving the large-scale applications of mirex.

In October, 1968, and again in April, 1969, USDA spread mirex bait over a large area near Starkville and Columbus, Mississippi. One year after the second treatment, Mississippi State University scientists sampled various animals from the treated area via gas chromatography and found mirex residues. This area was part of an entomology research block sprayed in 1968-1969. In February, 1971, five sampling sites were located in this entomology research block as one of the areas to be surveyed for mirex residues (Fig. 1).

The other area in Mississippi in which mirex residues were surveyed in 1971 was in the northeast corner of Mississippi (Fig. 1). This area was to receive three applications of the mirex bait. Due to public pressure, the State Department of Agriculture's plans were altered and the proposed eradication program took on a whole new approach. Only one aerial application of mirex bait was applied to this area. This treatment was made during the fall of 1970. Spot checks were made within the treated area and mound to mound treatments were made on the surviving ant hills. Borders were treated to keep the fire ants from the untreated or infested area from migrating into the treated area.

The application of mirex to the environment in such a manner where it enters lakes, ponds and streams should be prevented where possible for it concentrates readily in aquatic species.

Fig. 1. Map showing location of study areas and fire ant infestation in Mississippi during 1970.



Hyde et al. (1974) found channel catfish and green sunfish to have reduced growth following three applications of 1.4 kg/ha (1.25 lb./acre) of mirex bait. Van Valin et al. (1968) likewise found mirex to reduce growth of bluegill. Mirex residues were found in soil samples from Mississippi and Louisiana after only one application (Spence and Marken 1974).

Ludke et al. (1971) found a common prey species of crayfish, *Procambarus blandingi*, to be extremely sensitive to mirex. Further evidence that mirex may alter the normal predator-prey relationship of aquatic animals was shown by Tagatz (1976). Thus, a close look at mirex and its effect upon the aquatic ecosystem is warranted.

Materials and Methods

Sample sites were randomly selected from two different areas in Mississippi. Sampling sites 1 - 5 were selected from an area used as an entomology research test area in 1968-1969 (Fig. 1). The other area used was Block A of the proposed Fire Ant Eradication Program which began in 1970. This area was sprayed with mirex bait in the fall of 1970. Sites 7 - 10 were located within this area (Fig. 1). Site 6 was located outside the sprayed area by mistake. The error was discovered after the first sampling period. It was decided to continue sampling at site 6 and use it as a control site. Collections were made at each site four times during the project year. Wildlife and aquatic type samples were collected at each site. Collections were made within a five mile radius of the sampling area. The aquatic type samples collected were channel catfish (*Ictalurus* punctatus), bluegill (Lepomis macrochirus), freshwater clams (Unionidae), largemouth bass (Micropterus salmoides), crayfish (Procambarus sp), and pond bottom mud. In order to assure a representative sample, when possible, a composite sample of at least 5 fish, clams, crayfish and dredges of pond mud were collected at each site. Fish samples were collected from ponds within the sampling areas by seining. A 75 foot, 1 inch mesh bag seine, was used in collecting bass, bluegill and catfish. Crayfish and clams were collected with a 30 foot, 1/4 inch mesh, seine and a long handle dip net. Crayfish and clams were difficult to collect and were not collected at all sites on all sampling dates. Individual samples of each type were pooled, put on ice in the field and frozen after arriving at the laboratory. Samples were kept frozen until beginning of the laboratory analysis. Pond mud was collected with an Eckman dredge. The top 1/2 inch of mud was scooped off and put in a hexane washed one half gallon jar. An average of five dredges were made at each sampling site.

Extraction procedures for all samples are outlined in Herring and Cotton (1972). All samples were analyzed with a Micro-Tek 220 chromatograph, equipped with Ni^{63} electron-capture detectors.

Results

Aquatic types selected for analysis were largemouth bass, bluegill, channel catfish, crayfish, clams and pond mud.

Clams were seldom found and crayfish were not found during the fall collection. Clams and pond mud did not contain measurable amounts of mirex (Table 1 & 2). Aquatic species from all areas contained similar levels of mirex. Samples from the northeast Mississippi area (Table 2) had received only 1 1/4 lb./acre of mirex bait, yet they contained similar levels to those from the entomology research block (Table 1) which received 2 1/2 to 6 1/4 lb./acre mirex bait in 1968-1969. It is apparent that mirex accumulates rapidly in the aquatic environment.

Bass and bluegill flesh from both areas contained approximately five times the Food and Drug Administration tolerance of 0.01 ppm (Milunas 1971) in effect at that time. Channel catfish from the entomology research block (Table 1) contained over six times the allowed tolerance level.

Currently, January, 1980, there is no official Food and Drug Administration tolerance level but there is an administrative guide line for edible fish tissue of 0.1 ppm (Per. comm. -Tom Wellborn). No species collected during 1971 averaged over the current guide line, yet individual collections often were in excess of current limits.

Presently, the future of mirex remains uncertain. It had been removed from the market but pressure remains strong for its use to control fire ants. Our fisheries in general, and particularly the commercial catfish industry, stand to lose if mirex is allowed registration.

Table 1. Range and average of mirex residues in aquatic samples for sites 1 - 5, located in entomology research block sprayed in 1968-1969. Sites were sprayed 2 to 3 times and mirex applied varied from from 2 1/2 to 6 1/4 lb./acre.

Type	Number Analyzed	Sites	Average	Range
Largemouth bass	86	1-5	0.062	0.0-0.237
Bluegill	169	1-5	0.049	0.0-0.190
Channel catfish	56	1-5	0.065	0.0-0.388
Crayfish	377	1-5	0.020	0.0-0.080
Clams	21	1-5	0.000	0.0-0.000
Pond mud	12	1-5	0.000	0.0-0.000

Table 2. Range and average of mirex residues in ppm in aquatic samples for sites 7-10 located in Block A, N.E. Miss. sprayed in fall of 1970 using 1 1/4 lb./acre mirex bait.

Type	Number Analyzed	Sites	Average	Range
Largemouth bass	86	7-10	0.054	0.0-0.133
Bluegill	151	7-10	0.052	0.0-0.191
Channel catfish	62	7-1-	0.006	0.0-0.053
Crayfish	384	7-10	0.133	0.0-0.470
Pond mud	11	7-10	0.000	0.0-0.000

LITERATURE CITED

Committee on the Imported Fire Ant. 1967. Report to the Administrator, Agriculture Research Service, USDA. National Research Council, National Academy of Engineering.

Herring, Jack and Dan Cotton. 1972. A survey of mirex residues in fish and wildlife from two areas in Mississippi. Completion Report, FW-8-1. Mississippi Game and Fish Comm., Jackson, Ms. 39205.

Hyde, Kenneth M., Sammy Stokes, James F. Fowler, Jerry B. Graves and Frances L. Bonner. 1974. The effect of mirex on channel catfish production. Trans. Am. Fish. Soc. 103:366-369.

Ludke, J., M. T. Finley and Christina Lusk. 1971. Toxicity of mirex to crayfish, *Procambarus blandingi*. Bull. of Environmental Contamination & Toxicology. 6:89-96.

Milunas, J. 1971. Minutes of mirex meeting held on April 27, 1971, Jackson, Mississippi.

Spence, J. H. and G. P. Macken. 1974. Mirex residues in the physical environment following a single bait application. Pest. Monit. Jour. 8:135-139.

Tagatz, Marlin E. 1976. Effect of mirex on predator-prey interaction in an experimental estuarine ecosystem. Trans. Am. Fish. Soc. 105:546-549.

Van Valin, Charles C., Austin K. Andrews and LaFayette L. Eller. 1968. Some effects of mirex on two warm-water fishes. Trans. Am. Fish. Soc. 97:185-196.

Seasonality in trophic relationships of
Cynoscion arenarius and *Cynoscion nothus* (Pisces: Sciaenidae)
in the north central Gulf of Mexico

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Cynoscion arenarius and *C. nothus* showed spatial overlap in inshore and offshore waters of the northern Gulf of Mexico. The fishes were collected by trawl in Mississippi Sound and the Gulf of Mexico off Mississippi during 1978-1979. Overall, 58% of the trawl hauls captured both species; co-occurrence was 38% in Mississippi Sound and 83% offshore.

Fish and crustacean prey dominated the diets of both species and each fed on fish and crustacean prey with approximately equal frequency. However, fish material contributed 75% of the total prey volume for *C. arenarius* and 88% of the total volume for *C. nothus*, with the remaining volume consisting primarily of crustacean material. The major fish prey for both species were engraulids and the major crustacean prey were natantia for *C. arenarius* and mysids, copepods and natantia for *C. nothus*.

In inshore waters, fish are the dominant prey by volume for both species except during the colder months when *C. nothus* switches substantially to crustacean prey while *C. arenarius* continues to feed heavily on fish. Offshore, there is also a change during the colder months; *C. arenarius* increases the volume of crustacean prey while engraulids dominate the diet of *C. nothus*.

Total diet comparison by the Spearman Rank Correlation Coefficient indicates that the diets are significantly different. Though the same prey categories are utilized, the degree of utilization of these categories is quite different between the two species. It appears that these two similar sciaenids may be segregating trophically in areas where sympatry occurs.

LAKE AND POND MANAGEMENT IN NATIONAL FORESTS IN MISSISSIPPI

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ABSTRACT

During the past two decades the U.S. Forest Service has either constructed or permitted the construction of a number of flood retarding lakes under PL 566 in the National Forests of Mississippi. A number of these, and the small streams which were impounded, are potential fishery resources. The majority lack suitable cover for spawning, shelter and concentration of forage species, but may have value in the recruitment of game species. Efforts by the U.S. Forest Service have recently been directed at improvement of the lakes by installation of structures to provide shelter and concentrate food organisms and to control weeds. In 1978 and 1979 fourteen such lakes were provided with at least one of several types of structures, among which were brushtop shelters, slat structures, tire pyramids, artificial weed beds, gravel spawning beds and bank stabilization structures. Seven of the lakes renovated in 1978 and 1979 and an additional 12 lakes will be surveyed in 1980 and appropriate management activities implemented. As a part of the preliminary survey of the lakes water quality factors were measured concurrent with the fish studies.

INTRODUCTION

During the past several years it has become increasingly more evident that more areas suitable for fishing by the general public must be made available. Many of the better known public lakes and reservoirs are fast becoming over-crowded while fishing pressure has increased tenfold during the past decade. Not only must existing waters be made available to the occasional angler, but areas not previously considered suitable for fishing must be re-evaluated and improved where needs exist if fisheries adequate to meet public demands are to be assured.

There are approximately 1.14 million acres of National Forest lands within Mississippi and in these forests are numerous watersheds. Since the 1950's the U.S. Forest Service has either constructed or permitted the construction of flood retarding structures under PL 566 in the National Forests. The purpose of these structures was to control flooding and erosion, but several areas where larger reservoirs were built have been further developed as recreation facilities. The reservoirs and streams on which they were constructed may be useful not only for production of game species, but also equally valuable as recruitment areas for game species.

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The lakes range from 0.4 to 100 hectares surface area and all are relatively shallow. Although a few contain standing timber which may offer some shelter, the majority lack cover of any sort. Much of the timber and other vegetation was removed prior to construction of the dams. Additionally, stretches of several of the creeks were channeled both above and below the lakes.

MATERIALS AND METHODS

The U.S. Forest Service began surveys of a number of drainage systems in the National Forests to ascertain fish species composition and to determine if fish structures were needed. Samples of fish were collected by seining, electrofishing and poisoning with rotenone. Fish were preserved in the field in 10% formalin and later transferred to 70% propanol. Population studies were conducted by blocking off an area with a block net and killing the fishes within the enclosure with rotenone. Specimens were picked up on each of the first three or four days; weights, lengths and numbers were recorded. Selected physico-chemical parameters were measured concurrent with fish collections. Physico-chemical data are not included in this report, but were used in the evaluation of habitats.

Surveys of existing cover in promising locations were made to determine if additional cover and fish structures were needed. Methods for design and placement of structures were taken from a number of sources including White and Brynildson (1967) and Prince et al. (1976).

DISCUSSION

The importance of fish structure as a fisheries management technique is not new. As early as 1930, Hubbs recognized the potential of structures as fish concentrators. More recently, Petit (1972), Wilbur (1978) and Brouha and Prince (1974) have advocated use of structures and reefs in fishery management practices. Even in areas of lush vegetation natural cover may be insufficient for maximum production. Lagler (1952) emphasized that shelter other than aquatic weeds is seldom too abundant in natural waters.

Many warmwater fishes require cover of some sort for spawning and often their young continue living in the cover during the first year of life. Loss of cover is believed to be related to the decline in standing crops of species such as largemouth bass (Micropterus salmoides) (Arner et al. 1975). Recently, Reeves et al. (1977) indicated success in concentrating game species using mid-water structures. Fish were observed over the structures 18 days following installation. More recently, fishery biologists of the Mississippi Department of Wildlife Conservation initiated a program in small impoundments of constructing gravel spawning beds and placement of brushtop shelters. These techniques were successful in concentrating forage species and other food organisms and subsequently, game fishes (Jack Herring, personal communication).

The lakes examined in our work varied in several aspects, among which were size, fish populations, location and water quality. Lake Chewalla and Cox Lake represent two extremes among the impoundments. Lake Chewalla, the largest of the PL 566 lakes in the Holly Springs National Forest Ranger District is a 100 hectare lake built in 1965 by the Soil Conservation Service as a part of the Tippah River drainage flood prevention plan. The lake was later improved for recreation opportunities. Cox Lake, also in the Holly Springs District is much smaller at 12 hectares and unlike Lake Chewalla has received little attention.

Table 1 shows ratios and percentages (Swingle 1950) used in evaluation of fish populations in the lakes. These values indicate that Lake Chewalla is in balance although the A_t value of 58.3% is low (normal range is 60 to 85%). The lake appears to be somewhat overcrowded with forage species. On the other hand, Cox Lake data showing an A_t = 3.9, F/C = 288.8 and Y/C = 215.5 indicate that this lake is seriously out of balance. The remainder of the lakes fall between these extremes.

Table 1. Fish population data for Lake Chewalla and Cox Lake, Mississippi.

Lake	Date	A_t	F/C	Y/C
Lake Chewalla	5/14/79	58.3	3.9	1.7
Cox Lake	10/21/78	3.9	288.8	215.5

normal values: A_t = 60 to 85%, F/C = 3 to 6, Y/C = 1 to 3

During 1978 and 1979, 14 lakes from five Ranger Districts were selected for at least one type of fish cover (Table 2). Unbalanced lakes in the original survey were restocked and one (Choctaw) received selective killing treatment to remove gizzard shad and to bring it into balance (Table 3).

Seven of the lakes surveyed during the first two years are scheduled for additional treatment in 1980. Gator, Pow and Ashley Ponds contained insufficient numbers of largemouth bass and will be restocked. Fish samples will be taken from Brents, Mt. Olive, Turkey Fork and Davis Lakes. Another 12 impoundments will be sampled for possible restocking (Table 4).

A majority of the lakes were lacking adequate cover to support game fish populations and to attract food organisms. In a number of the lakes (e.g., Cox Lake) there was an excessive number of small forage fishes and imbalance was extreme. In others (e.g., Lake Chewalla) there was balance although the numbers of predator species were minimal. Under these circumstances restocking was warranted.

Table 2. Lakes in National Forests in Mississippi in which management techniques were used in 1978 and 1979. 1 = brushtop shelters, 2 = slat structures, 3 = tire pyramids, 4 = artificial weed beds, 5 = gravel spawning beds, 6 = dam renovations, 7 = fishing piers, 8 = bank stabilization.

Lake	Ranger District	Surface Area (hectares)	Type of Structure
Lake Chewalla	Holly Springs	100.0	1,2,3,4
Puskus Lake	Holly Springs	24.0	1,2,3,4,8
Cox Lake	Holly Springs	12.0	1,2,3
Cypress Lake	Holly Springs	12.4	1,2,3,5
Friendship Lake	Holly Springs	8.0	1,3
Curtis Creek Lake	Holly Springs	14.0	1,2,3
Mt. Olive Lake	Holly Springs	16.0	1,2,3
Brents Lake	Holly Springs	18.0	1,2,3
Turkey Fork Lake	Chickasawhay	80.0	1,2,3,5
Gator Pond	Chickasawhay	4.0	1,2,3,5,6,7,8
Autrey Lake	Holly Springs	10.0	1,2,8
Davis Lake	Tombigbee	40.0	1,3
Pow Pond	Biloxi	6.0	1,3
Ashley Pond	Black Creek	2.0	1

Table 3. Completed fish samples and stocking per district, 1978 and 1979.

Lake	Ranger District	Action	Result
Lake Chewa-la	Holly Springs	Fish Sample	Balance
Curtis Creek Lake	Holly Springs	Fish Sample	Balance
Puskus Lake	Holly Springs	Fish Sample	Balance
Mt. Olive Lake	Holly Springs	Fish Sample	Balance
Brents Lake	Holly Spring	Restocked	2 Yrs. Post.
DJs Pond	Holly Springs	Restocked	In Process
West Cypress Lake	Holly Springs	Restocked	In Process
Turkey Fork Lake	Chickasawhay	Fish Sample	Balance
Gator Pond	Chickasawhay	Restocked	In Process
Ashley Pond	Black Creek	Restocked	Imbalance
Choctaw Lake	Tombigbee	Selective Kill	Balance
Cox Lake	Holly Springs	Fish Sample	Imbalance

Table 4. Planned lake and pond renovation per district for 1980

Lake	Ranger District	Surface Area (hectares)	Action
Turkey Fork Lake	Chickasawhay	80.0	Fish Sample
Gator Pond	Chick awhay	4.0	Restock
Pow Pond	Biloxi	4.0	Restock
Duck Pond	Biloxi	4.0	Restock
Airey Lake	Biloxi	3.2	Fish Sample
Ashley Pond	Black Creek	2.0	Restock
Leaf Pond	Black Creek	0.8	Fish Sample
Ashe Lake	Black Creek	6.0	Fish Sample
Raworth Pond	Bienville	1.2	Restock
Davis Lake	Tombigbee	40.0	Fish Sample
Clear Spring Lake	Bude	4.0	Fish Sample
Marathon Lake	Strong River	10.0	Fish Sample
Pipes Lake	Homochitto	4.0	Fish Sample
Shongelo Lake	Strong River	4.0	Fish Sample
Blue Lake	Delta	4.0	Fish Sample
Lost Lake	Delta	4.0	Fish Sample
Brents Lake	Holly Springs	12.0	Fish Sample
Mt. Olive Lake	Holly Springs	14.2	Fish Sample
Denmark Lake	Holly Springs	8.0	Fish Sample

Sufficient time has not elapsed for complete evaluation of the effectiveness of the structures and restocking program, but casual observations, preliminary samples and apparent fisherman success have suggested that the management program will be reasonably successful in attracting game species.

CONCLUSIONS

Although the purpose of PL 566 impoundments in the National Forests in Mississippi was to control flooding and erosion, these reservoirs have potential as fishery resources. Fourteen lakes were surveyed initially with additional ones included in 1980. Fish populations were examined to ascertain if there was balance according to Swingle's ratios (1950), and where warranted fish attractors, cover and spawning beds were developed. Early data indicate success of these structures as concentrators of bait and food organisms for game species of fishes.

LITERATURE CITED

Arner, D. H., H. R. Robinette, J. E. Frasier and M. Gray. 1975. Effects of channel modification on the Luxapalila River. Symposium of Stream Channel Modification Proc. Aug. 15-17, 1975. Harrisonburg, VA.

Brouha, P., and E. D. Prince. 1974. How to build a freshwater artificial reef. Virginia Polytechnic Institute and State Univ., Blacksburg, VA. Sea Grant Publ. VPI-SG-73-03. 14 p.

Hubbs, C. L. 1930. Fishery research in Michigan. Trans. Amer. Fish. Soc. 30:182-185.

Lagler. K. 1952. Freshwater fishery biology. W. C. Brown Co., Dubuque, IO. 421 p.

Petit, G. D. 1972. Stake beds as crappie concentrators. Proc. Annual Conf. Southeast. Assoc. Game and Fish Comm. 26:401-406.

Prince, E. D., O.E. Maughan and P. Brouha. 1977. How to build a freshwater reef. Virginia Polytechnic Institute and State Univ., Blacksburg, VA. Sea Grant Publ. VPI-SG-77-02. 14 p.

Reeves, W. C., G. R. Hooper and B. W. Smith. 1977. Preliminary observations of fish attraction to artificial midwater structures in freshwater. Proc. Annual Conf. Southeast. Assoc. Game and Fish Comm. 31:471-476.

Swingle, H. S. 1950. Relationships and dynamics of balanced and unbalanced fish populations. Alabama Polytechnic Institute. Bull. 274. 74 p.

White, R. J., and O. M. Brynildson. 1967. Guidelines for management of trout stream habitat in Wisconsin. Wisconsin Dept. Nat. Res. Tech. Bull. No. 39. 64 p.

Wilbur, R. L. 1978. Two types of fish attractors compared in Lake Tohopekaliga, Florida. Trans. Amer. Fish. Soc. 107:689-695.

Formulating 'Least Cost' Catfish Feeds

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ABSTRACT

Least cost formulation requires a knowledge of 1) the nutritional requirements of the animal and 2) the digestibilities of the feedstuffs for the animal. From this information a set of nutritional restrictions can be developed and a programmed computer utilized to select ingredients in proper proportion to meet the restrictions. The least cost approach is being used to formulate experimental feeds utilizing available nutritional information. Current experiments are designed to investigate various energy to protein ratios. Results indicate that catfish may perform much better on low energy diets than originally thought when equivalent energy - nutrient levels are maintained as occur in high energy diets.

FORMULATING 'LEAST COST' CATFISH FEEDS

Channel catfish require a fairly high level of protein in their feed, i.e. 32-36% crude protein. Traditionally, fish meal has been the irreplaceable protein source. This created few problems as long as fish meal was abundant and inexpensive. In the past few years, market factors have caused fish meal to be a rather expensive feedstuff. Thus, researchers have been looking at ways to formulate more efficient and less expensive feeds. Since fish feeds represent the number one production cost, sizeable savings can be gained for the $45 million plus industry.

I feel that the 'least cost' approach to formulation represents the best approach to minimizing feed cost. This is in contrast to the concept of "fixed" formulations, i.e. the feed formula is fixed and is not changed to take advantage of fluctuating ingredient prices. So called 'least cost' feeds are feeds whose formulations are made up by utilizing the least cost or least expensive feedstuffs which satisfy the nutritional requirements. To use this approach, one must know 1) the nutritional requirements of the animal and 2) the digestibility of the feedstuffs or ingredients (Table 1). Once this information is in hand, then a set of nutritional restrictions can be developed (Table 2). A programmed computer selects ingredients in proper proportions to meet the set of restrictions (Table 3).

Our least cost formulation research was initiated soon after the Peruvian fish meal shortage of 1973 which drove feed prices sky high. Since we didn't know much about the catfish's nutritional requirements

Table 1. Percent digestibility of several feedstuffs for channel catfish compared with swine.

	Percent Digestibility	
Feedstuff	Channel Catfish	Swine
Feather meal	66.6	53.2
Fish meal	84.5	70.0
Raw corn	26.1	95.9
Cooked corn	58.5	--
Wheat	60.4	87.1

Table 2. An example of several least cost catfish feed restrictions.

Restriction	Minimum (%)	Equ (%)	Maximum (%)
Fat			6
Fiber			10
Calcium		1.09	
Phosphorus		0.78	
Energy	1000 (kcal/lb)		
Lysine	1.58		
Methionine	.49		
Methionine + cys.	.89		
Yellow corn			10
SBOM	10		
CS mean			10
Masonex		2.5	

Table 3. An example of a least cost catfish feed formulation.

Amount (lbs)	Ingredient	Cost (cwt)	Shadow Price
171.8	Rice Mill Feed	2.00	
49.7	Dical 22-18.5	10.25	
12.2	Limestone	1.00	
2.9	Methionine (MHA)	120.00	
1046.4	SBOM 49	11.20	
50.0	Menhaden	19.50	
612.0	Rice bran	4.00	
50.0	Masonex	6.55	
5.0	Vitamen premix	240.00	
	Yellow corn	4.90	2.40
	Corn gluten feed	8.15	4.38
	Fat	22.50	5.60
	Soft wheat	6.30	3.69

nor much about feedstuff digestibilities at that time, we guessed at some and used poultry values on others. We have gained much in the way of nutritional requirements and feedstuff digestibilities in the past few years and have modified our set of restrictions as the data became available.

Our first attempt was to look at all plant protein feeds. These feeds were cheaper than animal protein supplemented feeds, but were not economical because they had 12 to 25 % higher conversion values.

The relationship between energy and protein is quite important. If energy is too high, then it appears that fish won't eat enough for maximum gains. If energy is too low, then protein is used for metabolic needs instead of growth. We looked at several energy-to-protein ratios suggested in the literature and found that similar ratios gave different results. Upon further examination, it was determined that although energy and total protein were similar, certain critical amino acid levels were quite different compared to the available energy.

Thus, in the past few years, we have formulated our experimental feeds on a megacalorie percent basis with the amino acids lysine, methionine and methionine + cystine, i.e. equivalent energy and nutrient ratios were maintained as occurred in the control feed (Producers Feed Co.).

In 1978 and 1979 experimental feeds containing 1000 and 1075 kcal/lb along with a control feed (1150 kcal/lb) were fed to channel catfish in 0.1 acre ponds (TAble 4). Significant differences ($P \leq 0.1$) were detected for weight gain between fish in the 1978 trials. Fish gained less weight when fed1075 kcal/lb compared to 1000 kcal/lb. There were no significant differences between treatments for feed conversion, survival or net return/acre.

Table 4. A comparison of average weight gain, feed conversion and survival of channel catfish fed experimental feeds containing 1000, 1075 and 1150 kcal/lb in 1978 and 1979.

Ration	Year	Avg. Wt. Gain (lb)	Conversion (lb feed/lb gain)	Survival (%)
1000 kcal/lb	1978	.94	2.04	97
	1979	.84	1.81	92
1075 kcal/lb	1978	.79	2.39	95
	1979	.77	1.77	94
1150 kcal/lb	1978	.90	2.06	93
	1979	.90	1.45	96

Feed conversion and net return/acre were significantly better in 1979 for treatment 1 (1150 kcal/lb) compared to treatments 2 and 3 (1075 and 1000 kcal/lb). There were no significant differences between average weight gain and survival for the three groups of fish. When 1978 and 1979 data were pooled, only average weight gain was statistically different ($P \leq 0.05$) between the three treatments. Fish fed the 1075 kcal/lb feed gained significantly less than fish fed either the 1150 or 1000 kcal/lb feed.