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Reservoir seeding for bass management and its effect on sunfish, white crappie, and yellow perch

Timothy Dale Broadbent

To the Graduate Council:

I am submitting herewith a thesis written by Timothy Dale Broadbent entitled "Reservoir seeding for bass management and its effect on sunfish, white crappie, and yellow perch." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Richard J. Strange, Major Professor

We have read this thesis and recommend its acceptance:

J. Larry Wilson, Dewey Bunting, Doug Powell

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

A

RESERVOIR SEEDING FOR BASS MANAGEMENT AND ITS EFFECT ON SUNFISH, WHITE CRAPPIE, AND YELLOW PERCH

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Timothy Dale Broadbent

June 1982

DEDICATION

This thesis is dedicated to my mother and father, for it was because of their love and encouragement that I have been able to achieve this goal.

ACKNOWLEDGMENTS

Deepest appreciation is extended to Dr. Richard Strange, who not only served as my major professor but has also been a close friend. His encouragement, guidance, and patience will always be remembered and appreciated. I would also like to thank the other members of my committee, Dr. J. Larry Wilson, Dr. Dewey Bunting, and Doug Powell. Their guidance, instruction, cooperation, and friendship attributed greatly to the completion of this thesis.

I especially would like to thank Doug Powell for his much appreciated advice and supervision at the study site. His ideas and understanding were very helpful in this project.

Special thanks are extended to my field partner, William B. Kittrell. His friendship and assistance were instrumental in the success of this project. Special thanks are also extended to Joy Keegan, John Richardson, Dave Routledge, Glenn Thomas, and Dave Turner for their unselfish assistance in the field. I would also like to thank Dr. Bruce H. Bauer and Dr. David A. Etnier for their laboratory assistance and advice.

Of course, I am especially thankful for the love, encouragement, understanding, and patience of my wife, Debbie.

ABSTRACT

Ten sections of the fluctuation zone of Lake Nottely, a 1692 ha tributary reservoir in northern Georgia, were seeded with four species of terrestrial grasses by the use of cyclone seeders. Sudan x sudan, sorghum x sudan, field rye, and fescue were the grasses utilized. Fertilized field rye, a winter species, exhibited the best growth attaining an average height of 79 cm with 43 stems per m^2. The failure of the sudan x sudan and sorghum x sudan to survive was attributed to the extremely dry summer.

The 10 seeded sections contained 270% more sunfish (*Lepomis* spp.) $\leq$ 40 mm when compared to the numbers of sunfish in the control areas. Young-of-the-year white crappie (*Pomoxis annularis*) and yellow perch (*Perca flavescens*) were more abundant in seeded areas by 120 and 240%, respectively. White crappie were the only species that exhibited better growth in the seeded areas at every sampling period.

When the total digestive tract of each species was examined, the sunfish $\leq$ 40 mm consistently exhibited fewer insects and zooplankton per stomach in the seeded areas. This trend was related to the significantly greater numbers of sunfish in the seeded areas. Yellow perch was the only species that had greater numbers of zooplankton and insects per gut in the seeded areas. The significant difference in these items at the first sampling period probably resulted in the better condition of yellow perch in the seeded areas during this time.

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CHAPTER I

GENERAL INTRODUCTION

The more than 1,300 large reservoirs of 200 or more hectares in the United States provide an estimated 60% of all freshwater angling (Prince et al. 1975). Many of these reservoirs experience annual fluctuations in water level which can be extreme, depending on the reservoir and its location. One major manipulation of the water level for the benefit of fisheries involves holding the water level constant until late summer or fall (Keith 1975). This timing results in significant reductions of the number of forage fish as a result of predation, and improves the condition and growth of major predators, such as bass (Keith 1975). The water level of the Tennessee Valley Authority (TVA) reservoirs begins to fall during mid-summer for purposes of power generation, navigation, water supply, and flood control. These are the primary purposes of these reservoirs and dictate the procedures for manipulating the water levels. This continual fluctuation promotes degradation of available cover in reservoirs (Vogele and Rainwater 1975), and the decrease in cover has been shown to be related to poor survival of juvenile centrarchid basses (Aggus and Elliot 1975; Vogele and Rainwater 1975; Shirley and Andrews 1977). Until a compromise of fishery management and water level manipulation can be found, other methods of improving cover and thus the fishery in fluctuating reservoirs must be utilized.

Efforts to replace this disappearing cover have been directed toward the use of brush shelters, tire reefs, and stake beds. These artificial structures have been very effective in the concentration of sportfish and in improving the fishing success of anglers (Vogele and Rainwater 1975; Brouha 1979; Prince and Maughan 1979; Wege and Anderson 1979). However, cover of this type provides a limited area of protection for the young-of-the-year centrarchid basses. If the area of vegetative cover were extended to include the entire fluctuation zone instead of only small sections, survival of young-of-the-year bass may increase and through increased survival, the year class strength of the bass would theoretically improve.

This project was a joint effort by two investigators, each responsible for certain objectives of the study. All water quality analysis and benthic and zooplankton evaluations were included in another report (Kittrell 1982), although all work was performed as a team. Also the effect of the terrestrial cover on the growth and food of juvenile centrarchid basses was evaluated (Kittrell 1982). The purpose of this study was to determine if seeding the fluctuation zone of a reservoir was effective as a management technique to promote forage for young-of-the-year largemouth (*Micropterus salmoides* Lacepede), spotted (*M. punctulatus* Rafinesque), and smallmouth (*M. dolomieui* Lacepede) basses. The effect of the cover on the abundance and food habits of sunfish (*Lepomis* spp.), white crappie (*Pomoxis annularis* Rafinesque), and yellow perceh (*Perca flavescens* Mitchell) was also considered.

CHAPTER II

SEEDING THE FLUCTUATION ZONE

I. INTRODUCTION

Efforts to replace disappearing terrestrial vegetation in reservoirs has been a primary concern of biologists during the past decade. These efforts have been directed toward the installation of brush and tire attractors, primarily in the fluctuation zone. A more recent method of cover manipulation involves planting terrestrial grasses in the fluctuation zone. This method is accomplished by distributing seed throughout the fluctuation zone during the summer and fall as the water level recedes. The seed sprouts and grows during the warm months. During the winter, the grass established an extensive root system and began growth again during the early spring before inundation.

Shoreline revegetation has been accomplished by several methods. Fowler and Maddox (1974) used a boat hydroseeder to establish Japanese millet, common buckwheat, and Italian ryegrass in the fluctuation zone of Cherokee Reservoir, Tennessee. They found these grasses did well until killed by frost. Also, the fertilized sections did better than the unfertilized sections. The effect of the grasses on the fisheries was mentioned, but their primary objective was to produce the vegetation for the benefit of wildlife. Fowler and Hammer (1976) tested three methods of distributing seed along the fluctuation zone of reservoirs in eastern Tennessee. These methods (air cushion vehicle, helicopter, aquaseeder) were not used because of the energy intensive tools used and the cost involved in attaining one of the above tools.

This project involved planting different species of grasses than used by Fowler and Maddox (1974). Also, a simpler method of distributing seed than used by Fowler (Fowler and Maddox 1974; Fowler and Hammer 1976) was tested. Seeds of four species of grasses were sown in the fluctuation zone of Lake Nottely, Georgia, by the use of two hand-cranked cyclone seeders. This chapter discusses the success of these grasses and techniques used.

II. METHODS AND MATERIALS

Description Of The Area

Lake Nottely is a Tennessee Valley Authority multi-purpose tributary impoundment on the Nottely River in Union County, Georgia (Figure 1). The lake was filled in 1942. The normal pool covers approximately 1692 ha with a shoreline of 171 km. The maximum depth is 51 mm at full pool. Normal pool elevation is 542 m with a average minimum pool elevation of 529 m. The storage volume is approximately 2.1×10^3 m^3.

Lake Nottely has a history of severe winter drawdowns. The lake has soft water (8 to 10 ppm total hardness) and nearly neutral pH. The Chattahoochee National Forest surrounds much of Lake Nottely. Due to the majority of the land being federally owned, the shoreline is relatively undeveloped with scattered summer homes and camping areas.

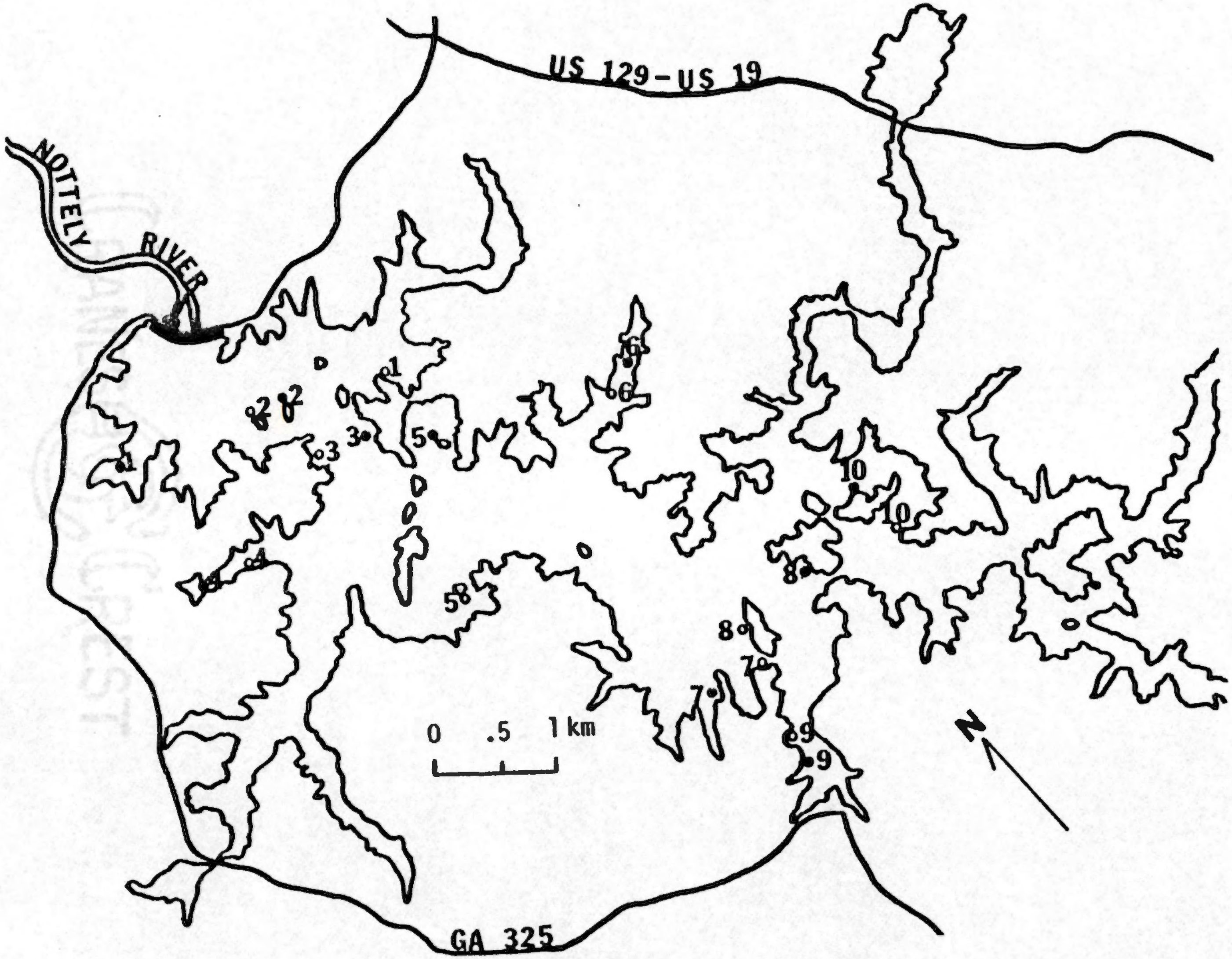

Figure 1. Lake Nottely showing the 10 seeded (●) and 10 control areas (○).

Seeding The Fluctuation Zone

In July 1980, 24 sites were chosen on which to establish terrestrial vegetation. These 24 sites were matched with 24 unseeded sites (control). The seeded and matching control sites were comparable in size, slope, and location on the lake. They were measured by the use of a 61 m tape and an optical rangefinder. Four species of terrestrial grasses were sown from July to September, 1980.

Summer species evaluated were improved hybrid varieties of sudan x sudan and sorghum x sudan (*Sorghum vulgare*). Winter species evaluated were fescue (*Festuca elatior*) and field rye (*Secale cereale*). The seed was distributed throughout the 24 sites with two hand-cranked cyclone seeders (27 cm spreading spinner). Approximately 1% of the total area was raked to determine if germination success was improved with a prepared seed bed.

Beginning in July and continuing into August 1980, 22 of the 24 experimental sites were sown with sudan x sudan hybrid (Table 1). Sorghum x sudan was sown on the two remaining sites. In late August and into early September, field rye was sown on 18 of the sites that received the sudan x sudan. Fourteen of these sites also received fescue. The logic of multiple grasses per site was to ensure growth of vegetation. Several seeded sites were also watered by the use of a Homelite pump and hoses as a further enhancement for growth. In late August and early September, half the area of each of 19 sites received approximately 97 Kg/ha of 5-10-15 fertilizer. The majority of the seed and fertilizer were sown on an unprepared substrate.

TABLE 1. Summary of grasses seeded on experimental areas.

Seed Type	Seed Species	Number of Sites Seeded	Kg of Seed	Area Seeded(ha)	Kg/ha
Summer	Sudan x Sudan	22	884	26	34
Summer	Sorghum x Sudan	2	437	12	35
Winter	Field Rye	18	1269	31	40
Winter	Fescue	14	694	16	30

A total of 3,400 Kg of seed (30 to 40 Kg/ha) was sown on 61 hectares of fluctuation zone, and 1,720 Kg of fertilizer (97 Kg/ha) was sown on 15 ha of the seeded sites. This resulted in over 5,000 Kg of seed and fertilizer broadcast on 61 ha.

On March 7, 1981, growth of the grasses during the fall and early winter was measured by randomly placing a square meter at different sites within each experimental plot. All live vegetation was counted, measured, and recorded on both the control and seeded sites (Table 2). A second measurement was obtained on May 23, 1981, to evaluate the spring growth of each of the grasses.

III. RESULTS

During 1980, the Tennessee Valley experienced its third driest summer since 1889. This unusually dry weather resulted in very poor survival of the summer grasses (Table 2). The efforts to water the seeded areas proved to be unsuccessful. Also, there were no differences in germination rates observed between the raked and unraked areas. The sudan x sudan did reach heights of 25 to 50 cm in isolated areas. The sorghum x sudan obtained heights of approximately 10 cm until killed by frost. Due to poor growth and survival, the summer grasses that did remain by March were of no significance in the study.

Due to the August and September rains and the fertilizer applied to these areas, the winter grasses demonstrated much better growth and survival. By March 7, both the fescue and rye had attained similar survival rates during the relatively dry winter (Table 2). By May 23,

TABLE 2. Growth (mean density and mean height ± standard error) measured on two dates of grasses seeded in the fluctuation zone of Nottely Reservoir.

	Seeded			Unseeded
	Unfertilized 3/7	Fertilized 3/7	Fertilized 5/23	Control 3/7
Rye				
stems/m^2	7	57 ± 8	43 ± 4	
height (cm)	6	9 ± 1	79 ± 4	--
N	1	10	10	
Fescue				
stems/m^2	--	55 ± 20	32 ± 9	
height (cm)		5 ± 1	7 ± 1	--
N		6	6	
Sudan				
stems/m^2	0	1 ± 1	0	
height (cm)	0	27 ± 5	0	--
N	1	10	10	
Natural				
stems/m^2	0	4 ± 1	5 ± 2	2 ± 1
height	0	18 ± 2	13 ± 2	15 ± 3
N	1	10	10	10

the field rye had gained an average height of 79 cm with 43 stems/m^2. The fescue did not do as well and was not included in the evaluation of the study. Unfortunately, only 10 of the original 24 seeded sites produced sufficient vegetative growth to be included in the fishery evaluation.

IV. DISCUSSION

It should be emphasized that only the fertilized sections of the seeded sites produced adequate growth. Soil samples taken from several sites proved that the fluctuation zone lacked all essential nutrients as evidenced by the poor growth of the unfertilized seeded sites. Apparently the continual water level fluctuation had leached valuable nutrients from the soil. It should also be noted that the greatest percentage of growth (80%) occurred between March and May. Lake Nottely normally reaches maximum pool during late April to mid-May. The rye average 36 cm in mid-April, which is the height the grass would have been flooded if Lake Nottely had demonstrated a normal water level year. Since Nottely did not reach full pool in 1981, the rye that was flooded was allowed an extra month of growth before inundation.

When Fowler and Maddox (1974) seeded the fluctuation zone of Cherokee Reservoir, Tennessee, with a boat hydroseeder, they concluded that the hydroseeding apparatus was not suitable for large-scale use in shoreline seeding because conventional hydroseeders are designed for use on land. Fowler and Hammer (1976) used three methods in which to establish vegetation at a rate of 23 Kg/ha. Each method (aquaseeder, air cushion vehicle, and helicopter) proved to be successful in establishing vegetation, but due to the specialized equipment and the cost of this equipment utilized, these methods were determined not to be applicable for this study.

The effort and cost required to seed the fluctuation zone with a cyclone seeder was not excessive. An individual worker could broadcast a single application of seed or fertilizer at a rate of 0.6 ha/hr. The total cost of materials for successful, fertilized rye treatment (40 Kg/ha seed and 97 Kg/ha fertilizer) was $38 per hectare. It took 170 man-hours to seed 61 ha with over 5,000 Kg of seed and fertilizer. Although the methods used by Fowler and Hammer (1976) could sow larger areas in a designated time period, other limitations such as terrain and maneuverability of the equipment would limit their use. The only limitations to cyclone seeding is the physical capacity of the worker.

In conclusion, field rye sown at 40 Kg/ha and fertilized at a rate of 97 Kg/ha produced satisfactory growth. The failure of the summer grasses to produce adequate growth was probably due to the lack of nutrients and the extremely dry weather. The unfertilized seeded area produced little growth, magnifying the importance of the fertilizer.

CHAPTER III

EFFECTS OF SEEDING ON FORAGE AND COMPETITORS OF BASS

I. INTRODUCTION

Fisheries workers and anglers have long recognized the importance of cover to fish. Aggus and Elliot (1975) found that the amount and duration of flooded shoreline vegetation strongly influenced the survival of young bass during the first summer of life. They reported that the numbers and growth were highest in years of extensive flooding following several years of low water level. Other researchers have also documented the importance of flooded vegetation to the year class strength of black bass (Zweiacher 1972; Shirley and Andrews 1977; Mirando 1981). The increase in vegetation may also provide more food, and food availability has been suggested as a factor that differentially affects growth and reinforces age caused size differences (Shelton et al. 1979). Holcomb and Wegener (1972) were able to demonstrate a 16% increase in the area of inundated terrestrial vegetation in Lake Tohopekaliga as a result of artificial drawdown followed by flooding. This resulted in an increase in the aquatic macroinvertebrate population levels (Wegener et al. 1974) and ultimately increased standing crops of sport and forage fish (Wegener and Williams 1974).

This natural cover, which helps stabilize the shoreline and provide spawning and nursery habitat for warmwater fishes, is lost as reservoirs age. Annual water level fluctuations accelerate the disappearance of cover at levels below full conservation pool. Also, water level fluctuations occur at a time that is most detrimental to the young-of-the-year basses. As the water level drops, the cover decreases, increasing predation on juvenile basses. This loss of cover may be related to observed declines in standing crops of centrarchid species, such as largemouth bass (Brouha 1979). Also, Smith and Crumpton (1976) noted that many lakes are losing vegetation due to rapid eutrophication. The initial effect of urban eutrophication is the reduction of aquatic plant communities which results in the decline of largemouth bass populations (Smith and Crumpton 1976).

In the absence of adequate natural cover, placement of artificial reefs was made in 1931 in a Michigan lake by C. L. Hubbs and L. Hubbs (Hubbs and Eschmeyer 1938). They collected 144 times more fish from brush shelters than from areas without brush. Since this initial endeavor, researchers have attempted to evaluate the attraction of fishes to various reef materials and locations (Petit 1972; Brouha 1974; Vogele and Rainwater 1975; Brouha 1979; Helfman 1979; Prince and Maughan 1979; Wege and Anderson 1979). Also, Vogele and Rainwater (1975) found bass production increases in response to brush shelters because cover provides a site for spawning and protection for the swim-up fry. But Helfman (1979) noted that prey fishes, especially sunfishes, were also attracted to these brush shelters. Since sunfish are predators on bass eggs, fry, and fingerlings, predation by sunfish could be severe of the young basses during the first two weeks of life. But the sunfish are also a food source for the young basses later in the summer. Thus, the brush attractors may concentrate and provide a greater abundance of sunfish as food for bass.

It is not practical or economically feasible to establish brush attractors at every point in the fluctuation zone. Seeding terrestrial grasses in reservoir fluctuation zones would increase flooded shoreline vegetation. When inundated, this type of vegetation could provide more cover and aid in promoting strong year classes of juvenile centrarchid basses.

Brush attractors have helped reestablish cover in reservoirs. But it is felt a larger area of cover is needed to improve the population of desirable fish populations. Establishing vegetation in the fluctuation zone may be a valuable tool to accomplish such a goal.

The objective of this study was to determine if reservoir seeding increased fish as forage for young-of-the-year centrarchid basses. The effect of the increased vegetation on abundance and food habits of sunfish, white crappie, and yellow perch was also determined.

II. METHODS AND MATERIALS

Fish Sampling

Field collections were made every two weeks from June 16 to August 17, 1981. A total of five samples were obtained from the 10 seeded and 10 control sites, ranging in size from 0.3 to 2.6 hectares. Each seeded and matching control site received equal numbers of quarter hauls with a 1.2 x 9.1 m x 0.6 cm bar mesh straight seine to determine fish abundance. The number of hauls ranged from two to eight depending on the area of the site. Plankton organisms were collected with a 22.9 cm diameter plankton net (60 mesh) to determine zooplankton abundance (Kittrell 1982). The benthic populations were sampled with an Ekman dredge as described by Kittrell (1982).

After each quarter haul, measurements were obtained from all centrarchid bass, crappie, yellow perch, channel catfish (Ictalurus punctatus), gizzard shad (Dorosoma cepadianum), and Lepomis spp. $\geq$ 41 mm that were captured. But due to the large numbers of Lepomis spp. $\leq$ 40 mm captured in the seine hauls, subsamples were taken of this size range. Each fish was weighed (nearest 0.1 g) with a triple beam balance and measured (total length in mm). All measured specimens were preserved for later stomach analysis in 10% formalin.

Food Habit Analysis

Due to the large numbers of specimens captured during sampling, gut analysis were performed on a subsample of each species captured during each sample period. The gut included the digestive tract from the esophagus to the anus. The Lepomis spp. were separated into two size categories, assuming all Lepomis spp. $\leq$ 40 mm were 0+ fish or young-of-the-year, and all Lepomis spp. $\geq$ 41 mm were 1+ or older. This was an artificial attempt to separate the sunfish captured into forage ($\leq$ 40 mm) and predators ($\geq$ 41 mm) of young-of-the-year centrarchid basses. The subsample of each species was randomly chosen by assigning each specimen a number. Numbers would be randomly picked until 10 fish of each species at each sampling period had been selected. If 10 specimens of a species were not collected during the sample period, then all fish of this species would be analyzed.

In all fish, a shallow incision was made between the two pelvic fins. Scissors were inserted into this shallow opening and an incision was made from the anus to the isthmus (Saul 1981). A vertical incision was made from the isthmus to the opercle and from the anus to the lateral line (Saul 1981). A horizontal cut was then made along the lateral line from the anus to the opercular. This final cut removed the flesh and muscle covering the digestive tract, exposing the total gut. The contents of the stomach were then placed into a petri dish and examined under a 40X binocular dissecting scope. Food items were counted and classified into the lowest practical taxa with the aid of Pennak (1978).

<u>Data Analysis</u>

Analysis of most food and abundance data were performed through the use of UTCC Decsystem -10 and SAS 1979. Means ($\bar{X}$) and standard errors were computed for abundance, preferred food items, and length for each species at each sampling period. The gut contents were combined into two major categories: zooplankton and insects. The insect category consisted of chironomid larvae and pupae, Helidae larvae, terrestrial and aquatic insects (Ephemeroptera, Odonata, Coleoptera, Hymenoptera, Thysanoptera) and Hydracarina. Zooplankton consisted of Copepoda, Cladocera, and Ostracoda.

Coefficients of Condition (Hile 1936)

$$K = \frac{10^5 \text{ x weight in grams}}{\text{total length}^3 \text{ in millimeters}}$$

were determined for yellow perch, white crappie, and the sunfishes (Table 3).

T-tests were calculated to determine significant differences between seeded and control areas for length, food items, abundance, and condition for the sunfish, white crappie, and yellow perch. A difference was considered significant when P was less than 0.10.

III. RESULTS

Lake Conditions

When the terrestrial vegetation was seeded on the experimental sites during the summer of 1980, seed was sown from the full pool elevation mark, 542 m, to an elevation of 535 m. When the fishery evaluation began in June 1981, the water level was at an elevation of 538 m, which was 4 m below normal pool for that time of year. This low water level resulted in inundation of only about one-half of the terrestrial vegetation sown the previous summer and reduced the number of days the vegetation was flooded.

From June to August, 1981, the water fell from 538 m to 536.6 m. Thus, little terrestrial vegetation was flooded during the last sampling period (August 14-16). The majority of the seed sown between the elevation of 535 m and 536 m had been washed away after distribution. The little vegetation that had grown was destroyed by wave action during the winter and during inundation.

TABLE 3. Mean condition factor (K) and standard errors (SE) for each species for seeded and control areas, and treatment.

Sampling Period	SEEDED			CONTROL		
	Sunfish K ± SE	White Crappie K ± SE	Yellow Perch K ± SE	Sunfish K ± SE	White Crappie K ± SE	Yellow Perch K ± SE
1	1.58 ± 0.15		1.55 ± 0.30	1.69 ± 0.28		1.02 ± 0.17
2	2.37 ± 0.50		0.88 ± 0.15	2.44 ± 0.51		0.76 ± 0.12
3	1.15 ± 0.20	0.96 ± 0.05	0.85 ± 0.07	1.12 ± 0.15	0.93 ± 0.09	0.87 ± 0.08
4	1.10 ± 0.13	0.99 ± 0.10	0.73 ± 0.06	1.05 ± 0.16	1.12 ± 0.17	0.83
5	0.91 ± 1.05	1.05 ± 0.48	0.82 ± 0.48	1.22 ± 0.14	1.48 ± 0.26	0.83

Fish Abundance and Growth

During the 10 week sampling period, white crappie, yellow perch, bluegill (*Lepomis macrochirus*), redear (*L. microlophus*), redbreast (*L. auritus*), and green sunfish (*L. cyanellus*) were the primary species captured during seining. These *Lepomis* spp. were lumped into one category (i.e., sunfish). Channel catfish and gizzard shad were also incidental captures in the seine hauls.

Sunfish, white crappie, and yellow perch were more abundant in the seeded areas than in the unseeded areas. Few sunfish $\leq$ 40 mm were captured during the first two sampling periods. The bluegill spawn became evident as the numbers per seine haul drastically increased during the third, fourth, and fifth sampling periods, with significant difference (t-test, P=0.04) in abundance between seeded and control areas at the fourth and fifth sampling periods (Figure 2). When the numbers of sunfish captured during each sampling period were totaled for seeded and unseeded areas, the seeded areas contained 270% more sunfish $\leq$ 40 mm. The sunfish $\geq$ 41 mm did not exhibit as great a difference in abundance between the seeded and control areas. However, 60% of these fish were captured in the seeded areas (Figure 3), with a significant difference at period five (t-test, P=0.03).

Unlike the sunfish, white crappie were not evident in the seine hauls until the third sampling period (Figure 4). When the total numbers of white crappie captured during the five sampling periods were totaled, white crappie were more abundant in the seeded areas by 120%. Yellow perch, like sunfish, were also more more abundant in

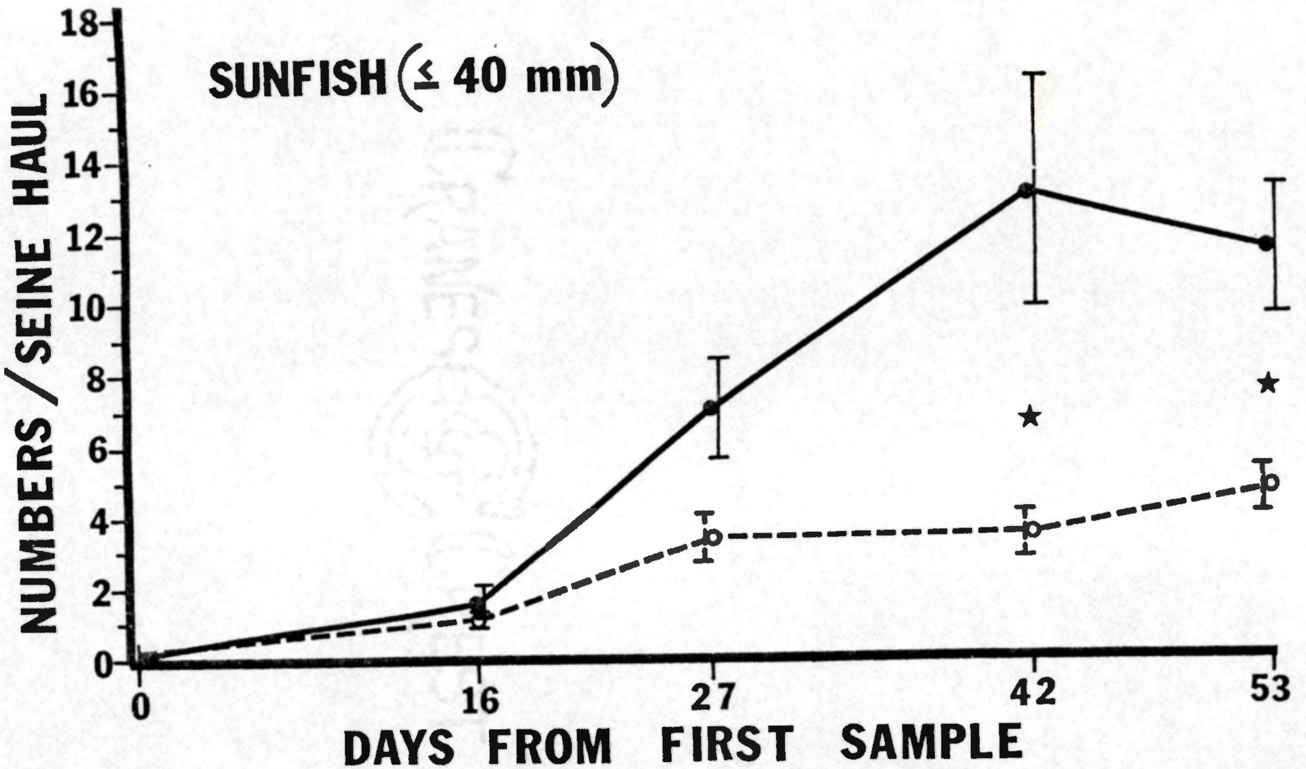

Figure 2. Numbers of sunfish ≤40 mm per seine haul at each period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas.

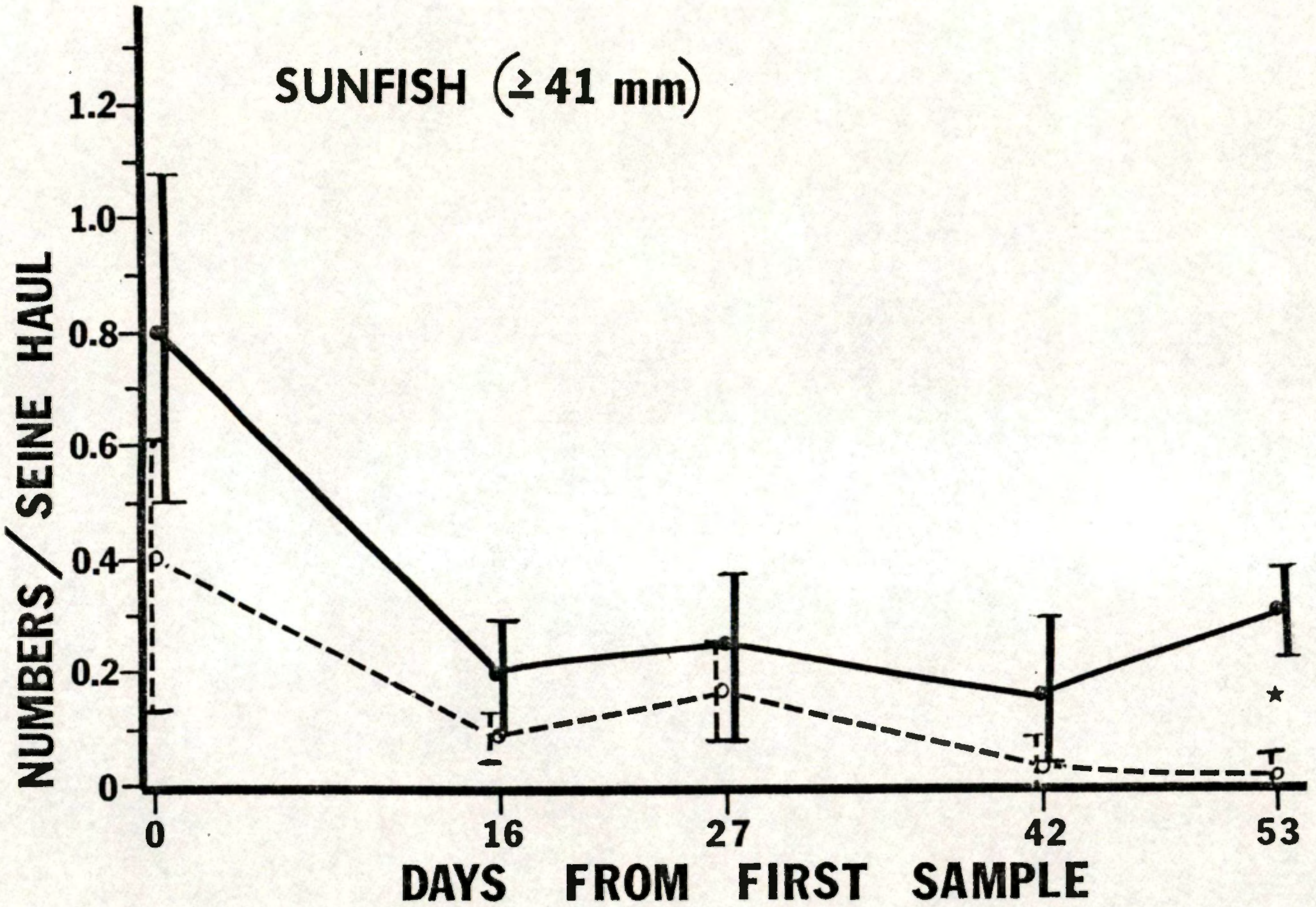

Figure 3. Numbers of sunfish ≥41 mm per seine haul at each period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas.

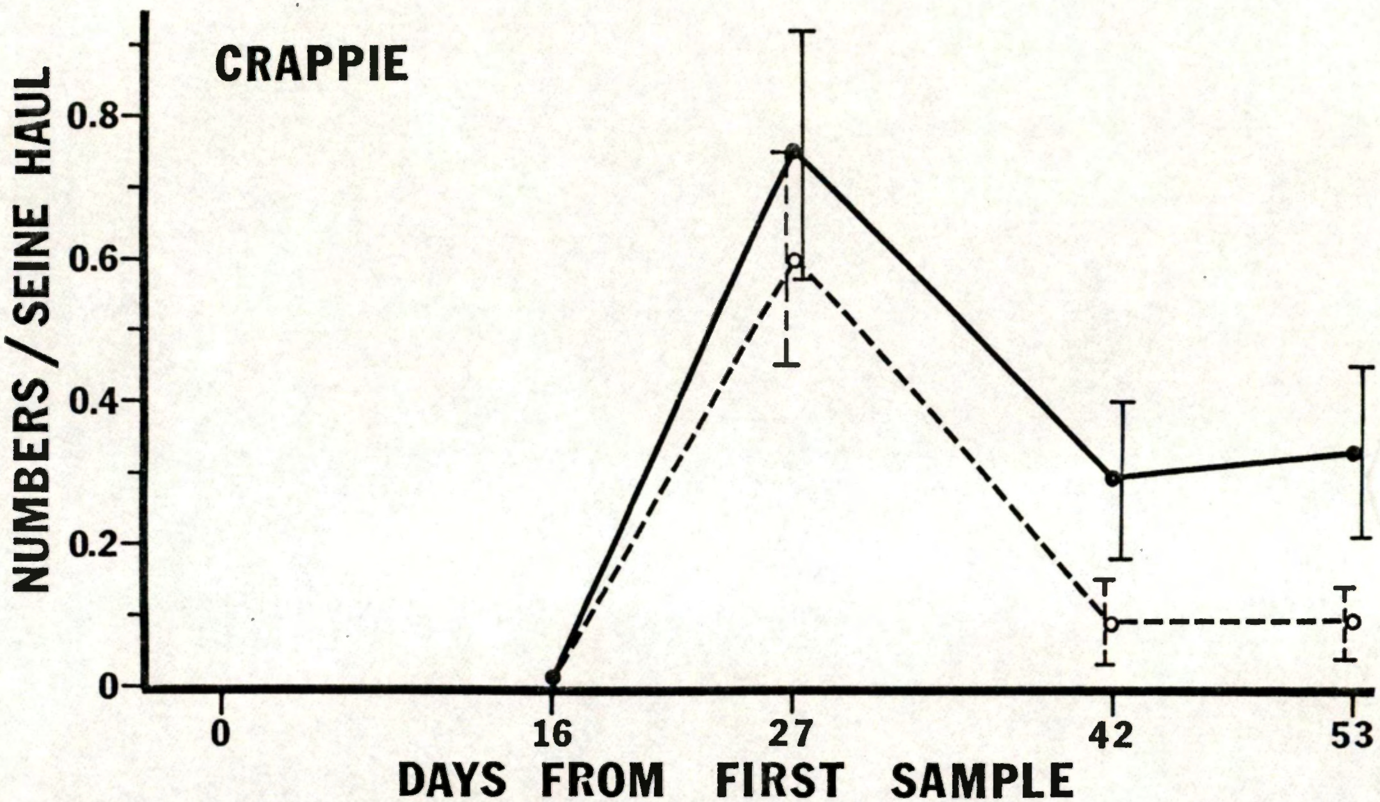

Figure 4. Numbers of white crappie per seine haul at each period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas.

the seeded areas. When the total numbers of yellow perch were examined for the seeded and control areas, 240% more were captured at the seeded sites. Only one fish was captured in each of the last two sampling periods at the unseeded sites (Figure 5).

The mean lengths varied for each species captured during the study. Sunfish lengths were not determined because sunfish are multiple spawners during the summer and with new recruitment of sunfish at each sampling period, the mean lengths would not reflect growth. The white crappie were the only species that demonstrated a greater mean length in the seeded areas at every sampling period (Figure 6), with the difference significant at the fifth sampling period (t-test, P=0.05). The yellow perch exhibited a significant difference (t-test, P=0.06) in mean length during the first sampling period in the seeded areas, but the yellow perch of the control areas showed better growth during the remainder of the study (Figure 7), although no significant difference was detected. Condition factors for each species were also calculated at each sampling period. The only species that showed a significant difference in condition was yellow perch, which exhibited the better condition at the first sample period.

Food Habits

A total of 16 different organisms were found in the guts of the fish captured during seining (Appendices A, B, C, and D). These 16 items were grouped into two categories (i.e., zooplankton and insects).

When observing the food habits of sunfish, white crappie, and

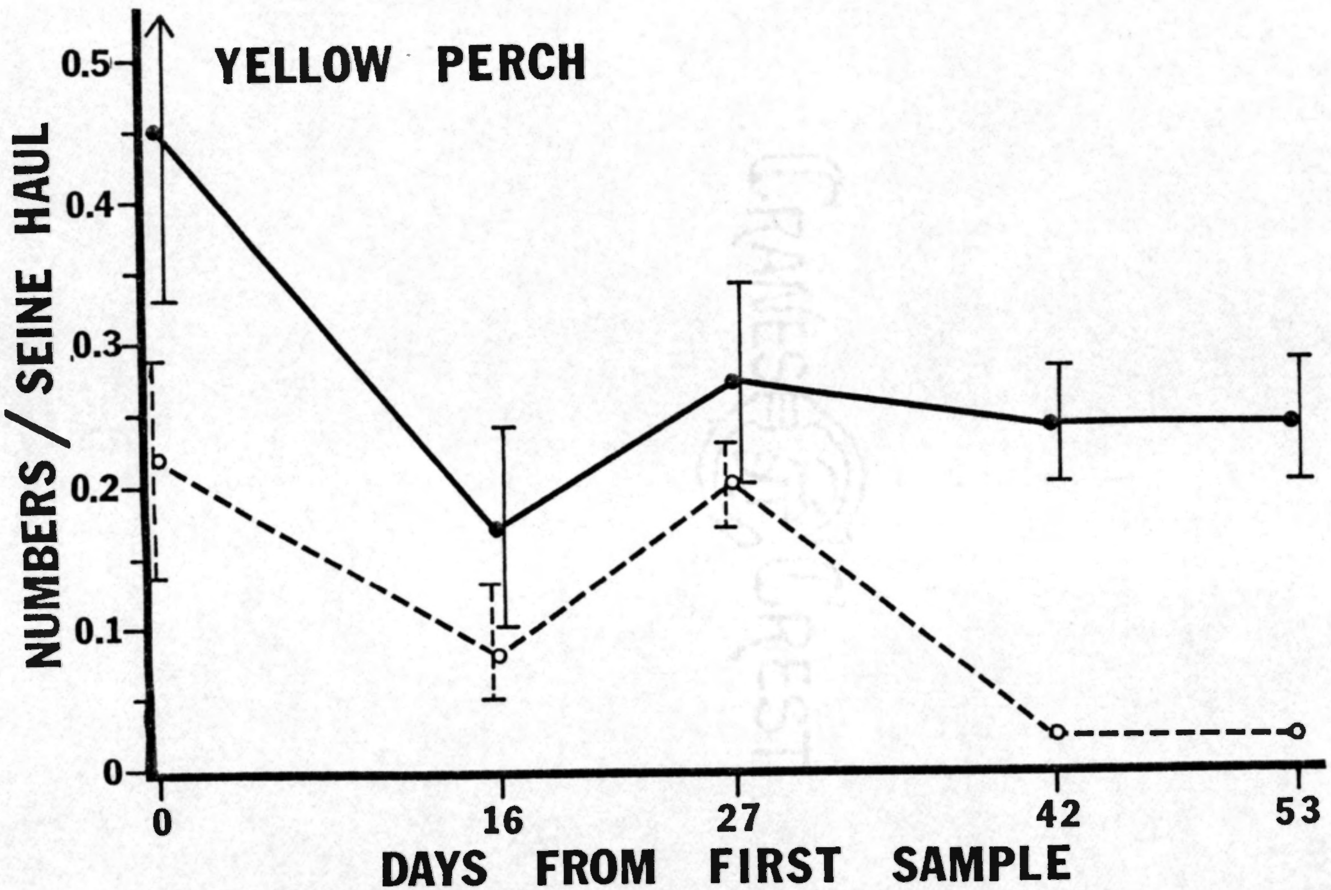

Figure 5. Numbers of yellow perch per seine haul at each period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas.

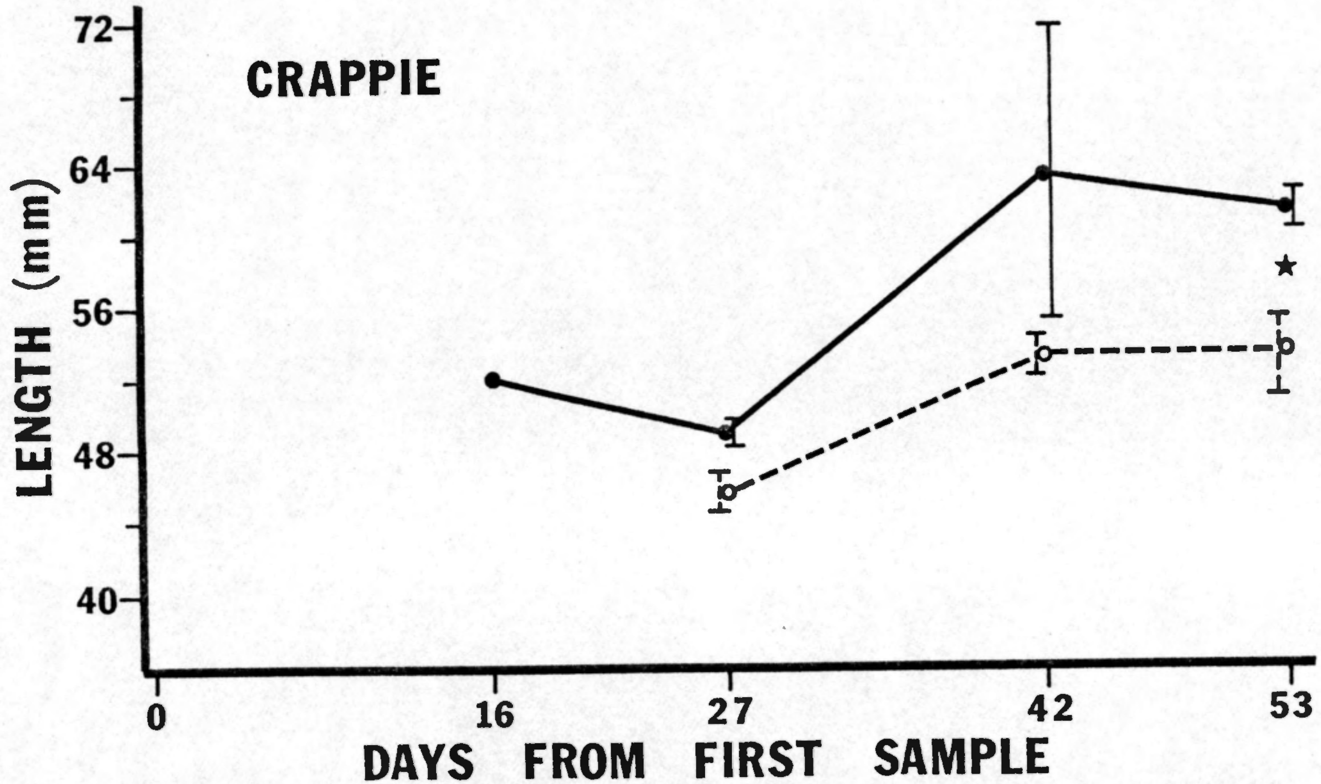

Figure 6. Mean length of white crappie at each sample period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas.

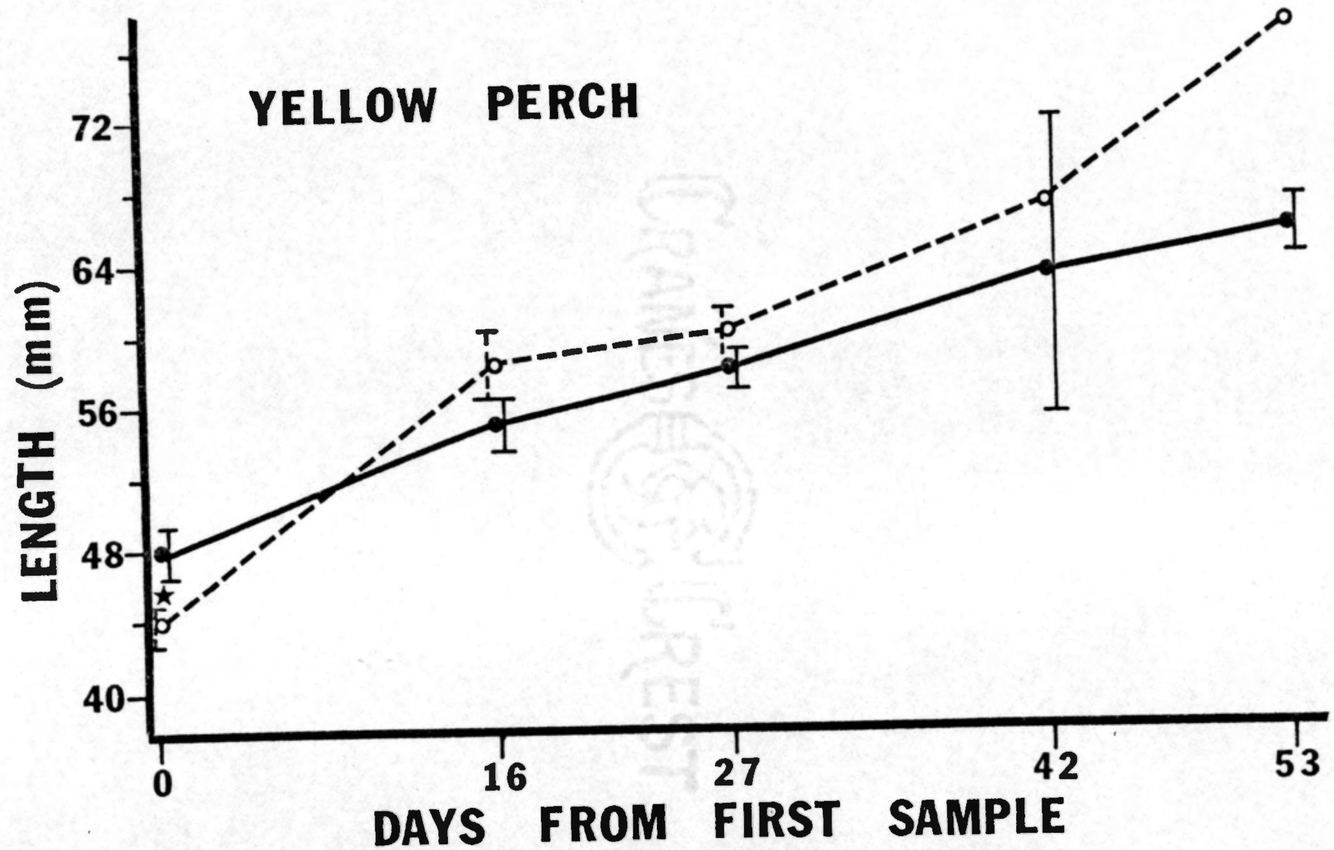

Figure 7. Mean length for yellow perch at each sample period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas.

yellow perch from the seeded and unseeded areas, the sunfish ≤ 40 mm of the control areas contained greater numbers of zooplankton and insects when compared to the sunfish ≤ 40 mm captured in the seeded areas (Figure 8 and 9). These differences were significant (t-test, P=0.01) at the third sampling period for both insects and zooplankton and for insects at the fifth sampling period. But the sunfish ≥ 41 mm showed no significant difference for food items between seeded and unseeded sites.

The guts of white crappie had greater number of zooplankton in the control areas (Figure 10), but the white crappie of the seeded sites contained more insects (Figure 11), although no significant difference was detected at any of the sampling periods. In contrast, both zooplankton and insects showed a significant difference (t-test, P=0.01) in yellow perch in the seeded areas during the first sampling period (Figure 12 and 13).

IV. DISCUSSION

Many investigators have documented the attraction of fish to cover (Vogele and Rainwater 1975; Pierce and Hooper 1979; Wege and Anderson 1979), but most of the work has dealt with brush attractors and their use by adult fish. Only a few researchers have documented the effect of flooded terrestrial cover on young-of-the-year sunfish, white crappie, yellow perch (Martin et al. 1981), and how their abundance affects the young-of-the-year basses.

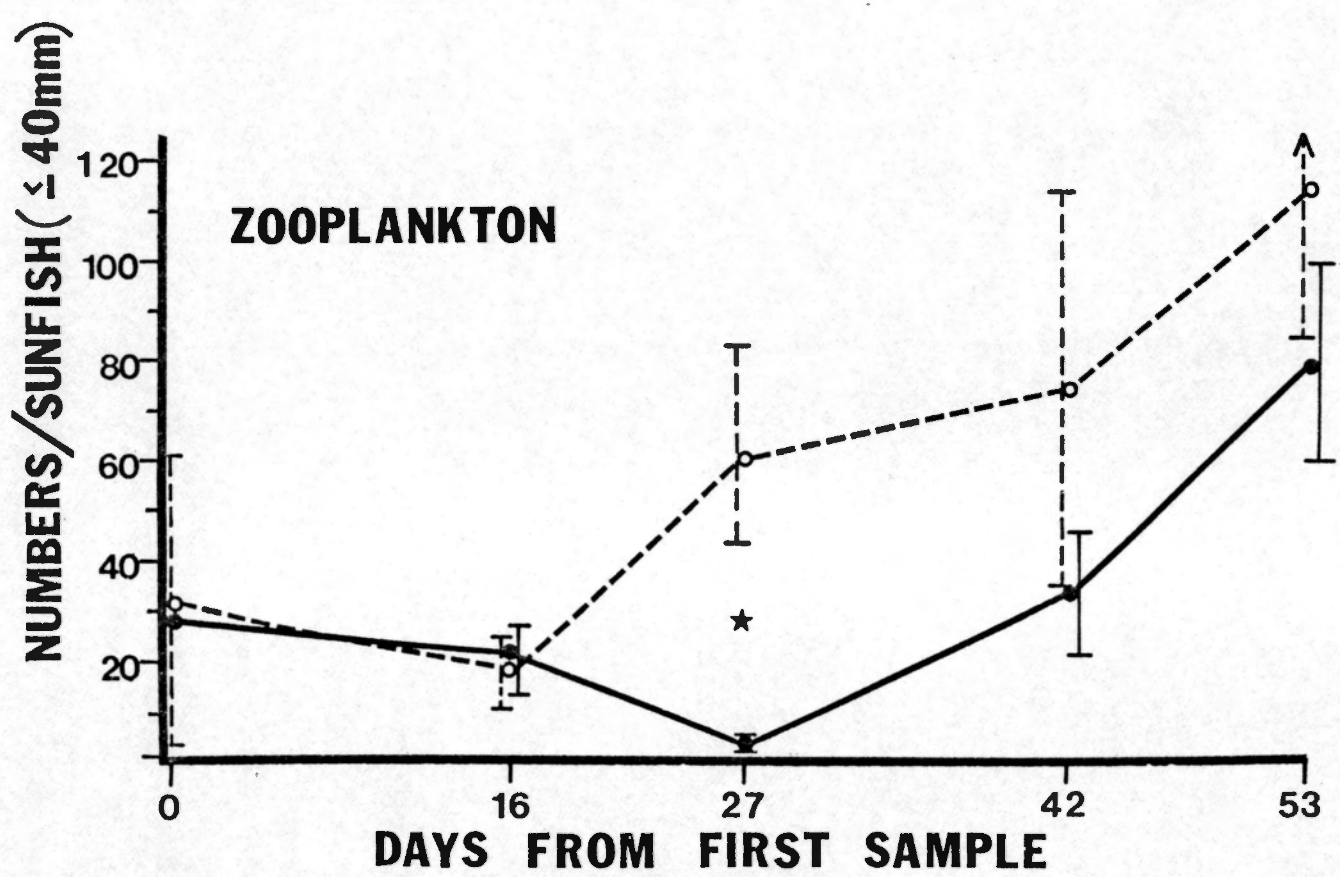

Figure 8. Mean numbers of zooplankton per sunfish ≤ 40 mm at each sample period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas.

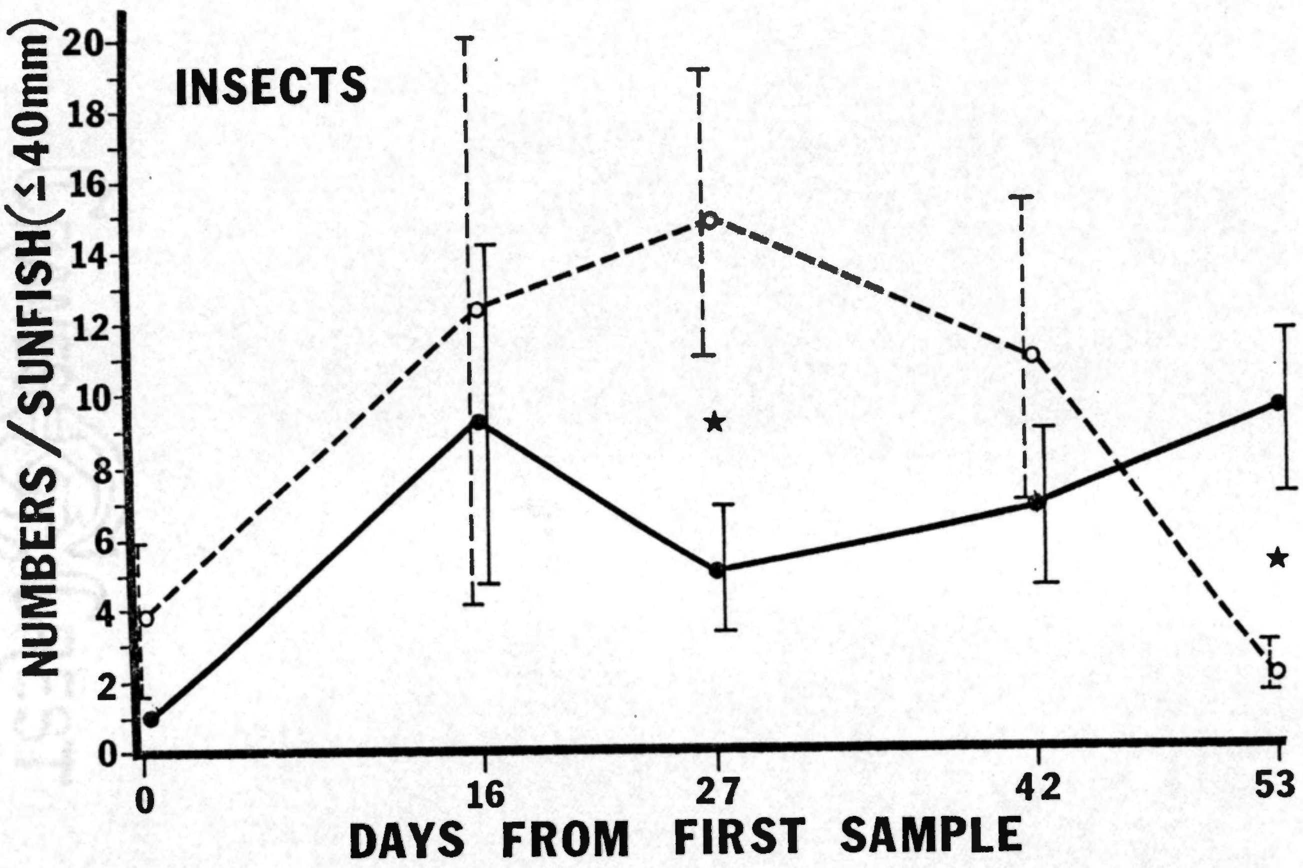

Figure 9. Mean numbers of insects per sunfish ≤ 40 mm at each sample period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas.

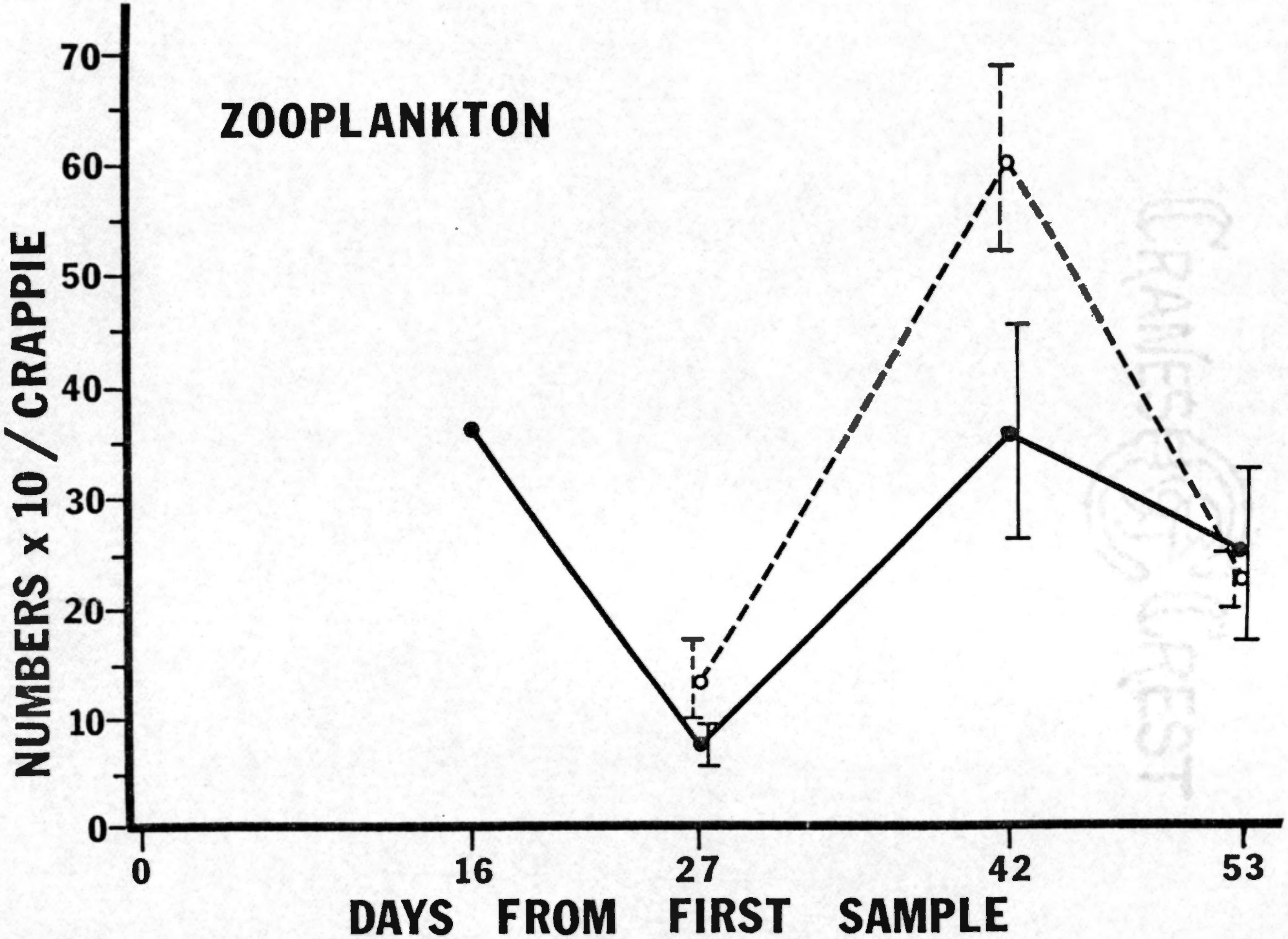

Figure 10. Mean numbers of zooplankton per white crappie at each sample period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas.

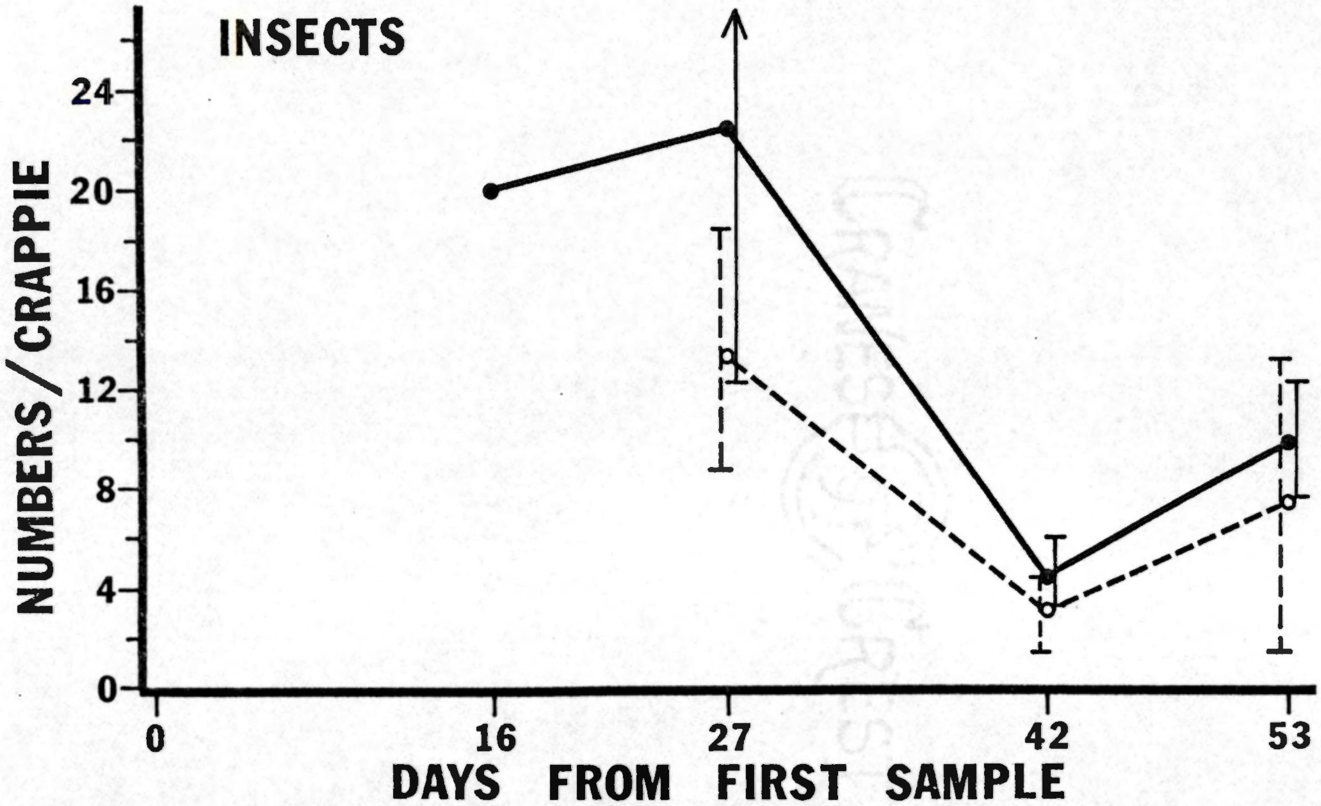

Figure 11. Mean numbers of insects per white crappie at each sample period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas.

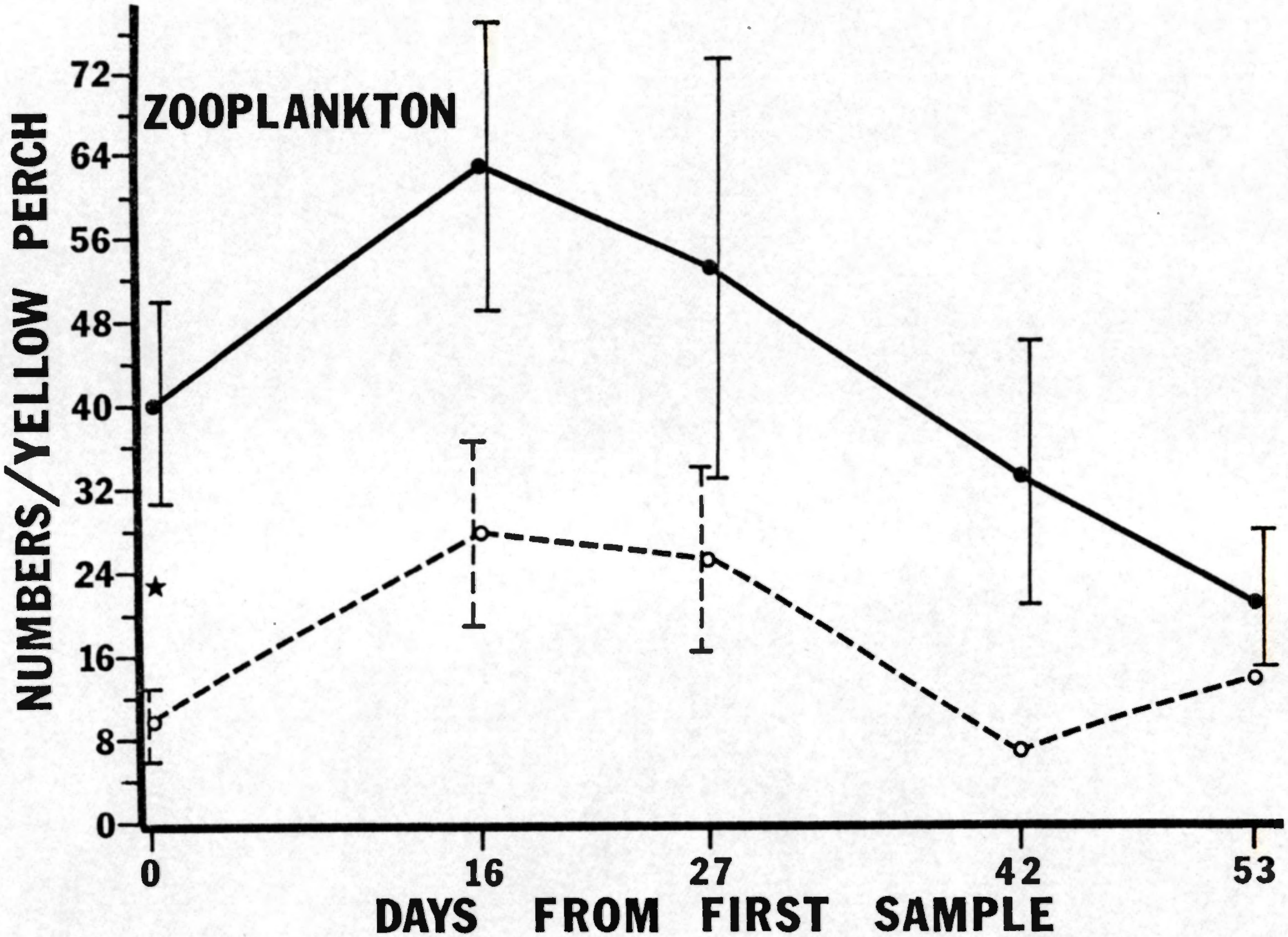

Figure 12. Mean numbers of zooplankton per yellow perch at each sample period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas.

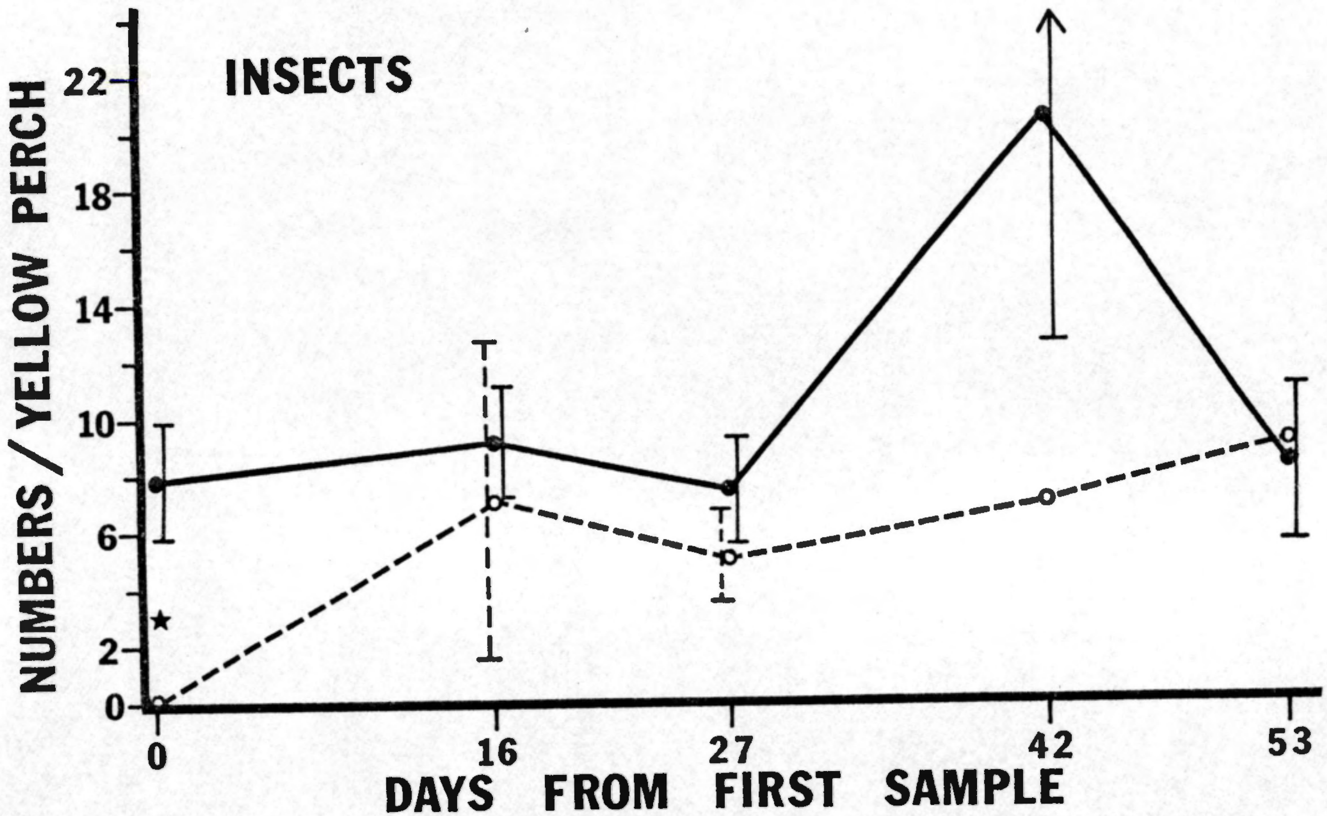

Figure 13. Mean numbers of insects per yellow perch at each sample period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas.

Kittrell (1982) found that planted terrestrial vegetation in Lake Nottely supported a larger population of young-of-the-year centrarchid basses than the control areas (non-vegetated sites). He also found insect populations of the seeded areas were significantly higher during four of the five sampling periods, but the numbers of zooplankton were significantly greater only in the first sample period. Thereafter, the zooplankton populations dropped to control levels with a drastic decrease at the third sample period (Figure 14). This decrease in zooplankton populations resulted in similar populations of zooplankton in the control and seeded areas during the remainder of the study (Kittrell 1982).

The young-of-the-year populations of sunfish $\leq$ 40 mm were greater in the seeded areas by 270%. Since young-of-the-year sunfish feed primarily on zooplankton (Huish 1957; Siefert 1972; Taylor 1977), the greater numbers of sunfish in the seeded area would appear to explain the fewer number of zooplankton per gut of these fish. For example, the 87% increase in numbers of sunfish at the third sample period resulted in significantly fewer zooplankton per gut, and contributed to the drastic decrease in the littoral zooplankton population between the second and third periods. Since numbers of small sunfish were less in the control areas, and the zooplankton population was the same as seeded areas, more zooplankton were available per sunfish in the control areas. Despite the decrease of zooplankton per sunfish $\leq$ 40 mm at period three for both seeded and control fish, the zooplankton per gut increased for both areas during the fourth and fifth sampling periods.

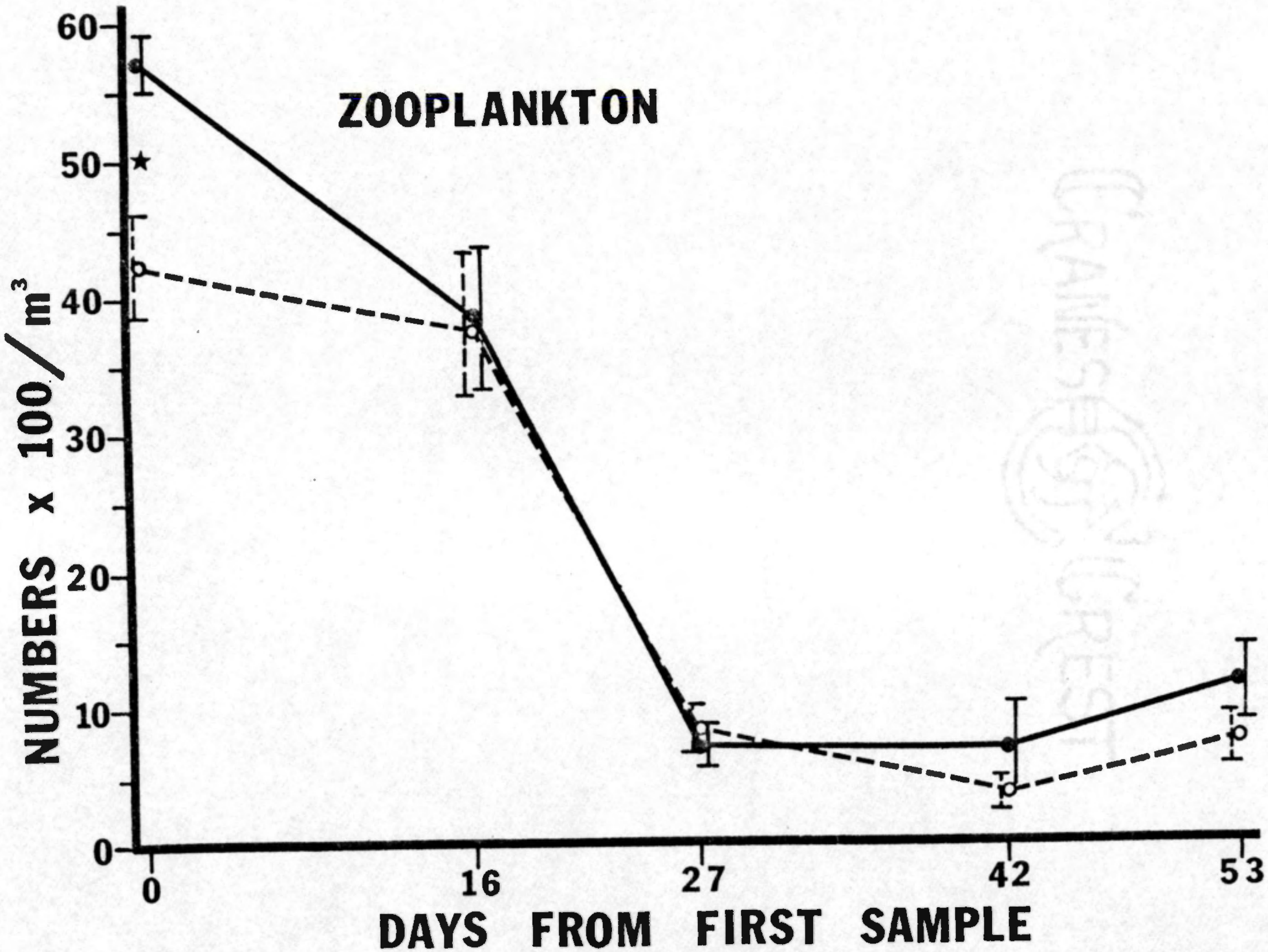

Figure 14. Mean numbers of littoral zooplankton for each sample period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas (Kittrell 1982).

However, the control sunfish ≤ 40 mm contained more zooplankton during the remainder of the study. The decrease of zooplankton at period three may be due to a cyclic fluctuation in the population, but the greater numbers of fish may also have contributed to this decrease. Insects were also more abundant in the guts of the control sunfish ≤ 40 mm, but the insect population was greater in the seeded areas (Figure 15). This inconsistency could be due to the ability of the insects to escape predation by taking refuge in the vegetation.

The data shows that sunfish ≥ 41 mm were consistently more abundant in the seeded areas and fed nearly equally on insects and zooplankton. Etnier (1971) documented that bluegill between 60 and 170 mm standard length ate a wide variety of small aquatic organisms and zooplankton. The larger sunfish could compete with young-of-the-year bass during the early summer for zooplankton and later in the summer for insects. Sunfish are also predators of centrarchid bass eggs and fry (Bennet 1948; Applegate et al. 1966). Mullan and Applegate (1967) found that the diet of sunfish > 100 mm contained 36 to 41% bass larvae in May. The sunfish > 63 mm preyed most heavily on fish eggs, although very little fish as food was used. The more abundant numbers of large sunfish may be detrimental to the young-of-the-year basses during spawning, but the increase in cover may allow the juvenile bass to escape predation.

The spawning temperature of most adult sunfish is about 24°C (Durham 1957). Lake Nottely reached this temperature in late May in the areas near the dam, but very few small sunfish were captured during the first two sampling periods (0 to 2 per seine haul). Werner (1967, 1969) found that the young-of-the-year bluegill move to littoral vegetation

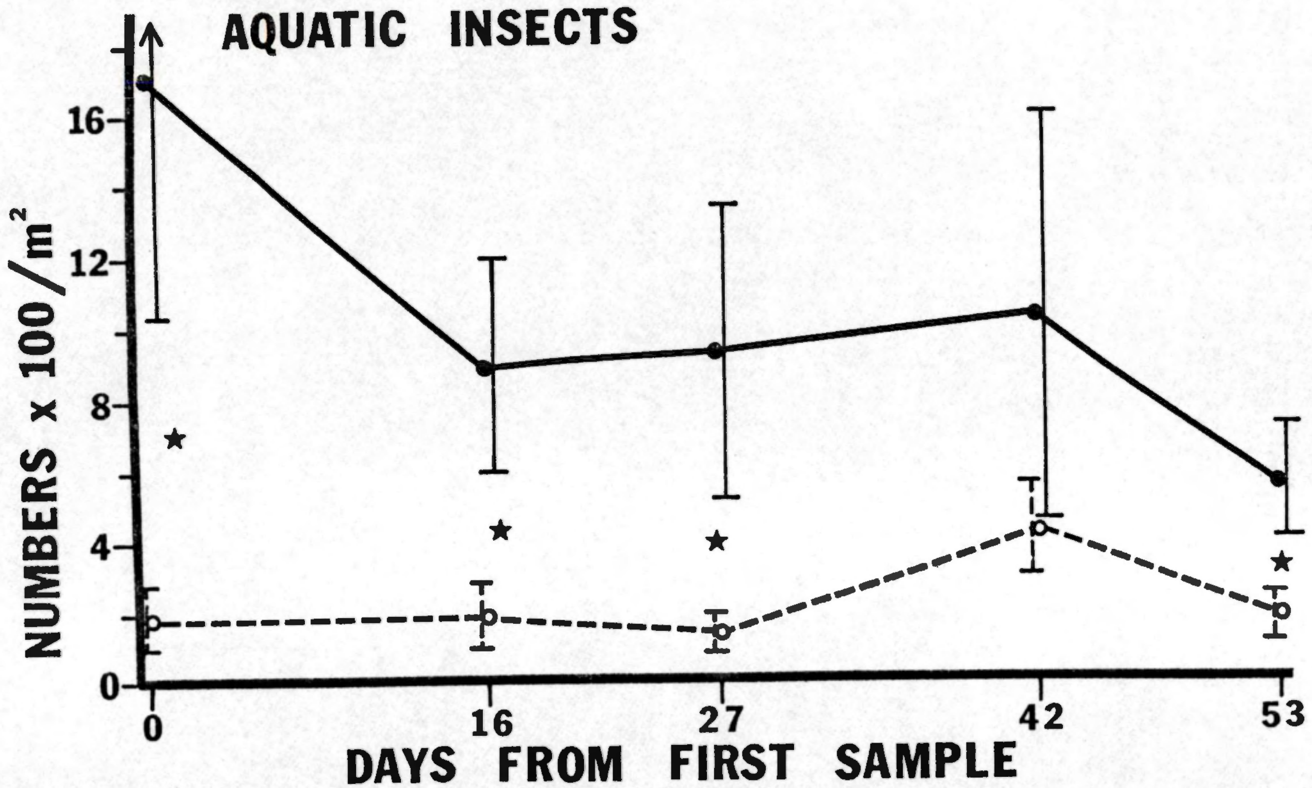

Figure 15. Mean numbers of aquatic insects for each sample period for seeded and control areas. Star denotes significance at $P < 0.10$. Solid circles represent seeded areas and open circles represent control areas (Kittrell 1982).

after absorbing the yolk-sac. At 10 to 12 mm, the young sunfish move to the limnetic zone for six to seven weeks. They return to the littoral zone at 22 to 25 mm (Werner 1967), which is the length at which we first began capturing sunfish in the seine hauls.

Numerous investigations have shown that bass prefer food items such as crayfish, fathead minnows, shad, or goldfish over young-of-the-year sunfish (Lewis et al. 1961; Snow 1961; Lewis and Helms 1964). But McGammon et al. (1964) stated that while preference may play a role in determining food habits of young bass, size and availability of forage were more important factors. Largemouth bass will eat small crappie (Tucker 1973) and have better growth rates when shad is used as forage (Applegate and Mullan 1967). The crappie and gizzard shad of Lake Nottely had mean lengths of 48 and 65 mm, respectively, during the third sample period. Since the juvenile bass were only 58 mm (Kittrell 1982), utilization of these species would be unlikely.

As discussed earlier, the numbers of sunfish in the seeded areas increased between the second and third sampling periods. The result of this increase in numbers may have attributed to the decrease of zooplankton in the water column (Kittrell 1982). This decrease probably accounts for the decrease of zooplankton in yellow perch and crappie guts. The zooplankton population in the water column remained low for both the seeded and control areas during the remainder of the study (Kittrell 1982). Either the cyclic phenomonon of zooplankton, or the increase in numbers of fish, or a combination of both probably attributed to this decrease. The numbers of zooplankton in the guts of bass of seeded areas also remained low (Kittrell 1982). But bass of the seeded areas increased their fish as food earlier (second sampling period) and maintained more fish per gut when compared to the control bass (Kittrell 1982). Swingle and Swingle (1967) found for rapid growth largemouth bass must feed on larger animals such as fish or crayfish. It is felt that the slightly better growth exhibited by the seeded area bass was due to the greater availability of sunfish as forage.

White crappie were also more abundant in the seeded areas. Black crappie (Pomoxis nigromaculatus) were not captured during the study, although England (1980) documents their existence in Lake Nottely. The white crappie were not captured in the seine hauls in abundant numbers until the third sample period. Swingle and Swingle (1967) and Siefert (1969) note that juvenile crappie migrate to the limnetic zone before bass begin feeding. This would result in no competition between crappie and bass during the first two sampling periods. The one specimen of white crappie captured in the seeded area at sample period two contained high numbers of both insects and zooplankton. But the zooplankton numbers in the stomachs of crappie decreased at the third sample period. The predation of littoral zooplankton population by both crappie and sunfish and the decrease in littoral zooplankton populations may have forced crappie to switch to insects. Bennet (1948) noted that if two species of fish compete slightly for food under favorable conditions that they may, under crowded conditions, be forced to change their normal feeding habits and become slightly competitive.

Tucker (1973) suggested that when crappie are too large to be eaten by bass, and there is not forage available, competition for food will result. Goodson (1961) also stated that crappie are considered predators which compete with largemouth and smallmouth basses. Since zooplankton is an important food item for white crappie (Marcy 1954; Nelson et al. 1967; Siefert 1969; Mathur 1972), crappie may compete for this food item with late spawing bass. The white crappie of Nottely may also compete with bass for insects as suggested by Tucker (1973). Competition between bass and crappie for small sunfish has also been documented (Tucker 1973). Three crappie of the seeded areas contained fish remains during the time bass were feeding on fish. This fact, plus the greater numbers of insects in the stomachs would account for the better growth rate of the seeded area crappie.

The increase in vegetation would provide spawning areas for yellow perch. Beckman and Elrod (1977) showed that yellow perch prefer inundated brush for deposition of egg skeins.

Noble (1975) found that annual variations in growth of juvenile perch was dependent on annual variations in the density of Daphnia. Ney and Smith (1975) also found that yellow perch that fed primarily on zooplankton during the early summer exhibited better growth rates. After attaining a length of 30 mm, yellow perch switch to large zooplankton or benthic larvae, whichever is more abundant. The yellow perch of Lake Nottely fed on insects and zooplankton at the same time these food items were eaten by bass. The number of insects in yellow perch guts at period five may have decreased because more sunfish and bass were seeking insects as a food item in the seeded areas. Finally yellow perch exhibited a significantly better condition in the seeded areas at the first sample period. This was attributed to the greater number of insects and zooplankton in the guts of the seeded area yellow perch at this time.

CHAPTER IV

GENERAL CONCLUSIONS

The terrestrial vegetation established in the fluctuation zone of Lake Nottely was sown using cyclone seeders. Other researchers have documented the successful use of more energy intensive techniques to distribute seed. However, the expense of operation and actual cost of the tools prevented our utilization of those tools.

Field rye sown at 40 kg/ha and fertilized at 97 kg/ha provided adequate growth to be included in the study. The fertilized rye attained measurements of 79 cm with 43 stems/m^2. The continual water level fluctuations had apparently leached nutrients required for growth from the soil, as evidenced by the poor growth of the unfertilized field rye. Fertilized fescue attained only a height of 7 cm, so was not included in the evaluation of the study. The sudan x sudan and sorghum x sudan (summer species) had poor survival with minimal growth. We suspect the failure of the summer grasses to be due to the lack of nutrients and the extremely dry summer.

Bimonthly samples of the 10 seeded and 10 control sites began on June 16 and ended August 17, 1981. Collections were made by night seining.

Sunfish, white crappie, and yellow perch were more abundant in the vegetated areas when compared to the control areas. Sunfish $\leq$ 40 mm and sunfish $\geq$ 41 mm were consistently more abundant in the seeded areas during the entire study. There was a significant difference in numbers at the fourth and fifth sampling periods for sunfish ≤ 40 mm and for sunfish ≥ 41 mm at the fifth sampling period. The sunfish ≥ 41 mm fed on zooplankton and insects during the summer, with no significant difference detected between the seeded and control areas. The sunfish ≤ 40 mm of the seeded areas contained fewer zooplankton per fish than the control areas. Since sunfish ≤ 40 mm were more abundant in the seeded areas by 270%, and the littoral zooplankton populations were similar in both seeded and control areas, fewer zooplankton were available per sunfish in the seeded areas. Zooplankton populations decreased at the third sampling period in both seeded and control areas. But numbers of zooplankton were more abundant in the gut of the control fish ≤ 40 mm. Thus the decrease in numbers of zooplankton per gut of seeded sunfish ≤ 40 mm was probably due to the greater numbers of sunfish ≤ 40 mm in the seeded areas. The insect population was greater in the seeded areas, but the sunfish ≤ 40 mm of the control areas contained more insects per gut. Vegetation may have provided cover for the insects, inhibiting the ability of the sunfish ≤ 40 mm to prey on them.

White crappie were not evident in the seine hauls until the third sampling period. Crappie have been described as competitors of centrarchid basses for food. When the crappie were captured in the seine hauls, bass were feeding primarily on insects and fish (Kittrell 1982). The numbers of zooplankton per crappie were low at the third sampling period for both seeded and control areas, which coincided with the decrease of the littoral zone zooplankton population. However, the numbers of insects per crappie were higher at this time. The decreased zooplankton population may have caused the crappie to consume more insects, which would put them in competition with bass.

Yellow perch were more abundant in the seeded areas by 240%. The food items, zooplankton and insects, were also consistently more abundant in yellow perch of the seeded areas. When the yellow perch switched from zooplankton to insects at the fourth sampling period, competition may have resulted with bass at this time.

Since sunfish, white crappie, and yellow perch were more abundant in the seeded areas, competition for food may have resulted with bass at certain periods during the study. For example, at the third sampling period, all species of fish were preying upon the insect population of the seeded areas. This predation on insects may result in direct competition for the insect population. But sunfish may play a role in the survival of juvenile basses. Numerous investigators have shown that the earlier a young-of-the-year bass begins feeding on fish as food, the better the growth. For a young-of-the-year bass to take advantage of this growth, the forage must be available. In this study, the forage was more available in the seeded areas in the form of sunfish fry.

Since numerous researchers have documented the importance of fish as forage as a factor in gaining a competitive advantage over other species, the author feels this project warrants serious consideration. The increase in vegetation did increase the availability of young-of-the-year sunfish as forage. If greater numbers of forage are available, the juvenile bass may utilize this population earlier and more extensively, increasing their chances of surviving the harsh winter.

The following recommendations are presented:

1. Plant a winter species of terrestrial grass and fertilize (field rye fertilized with 5-10-15 was successful in this study). Contact the county extension agent to determine the best grass for the geographical area.
2. Utilize a volunteer work force to reduce costs.
3. For a more complete study, I recommend that at least one year of preliminary fish sampling should be conducted before seeding.
4. An attempt should be made to determine if the increase in vegetation increases the survival of young-of-the-year bass into the second year.

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APPENDICES

APPENDIX A

TABLE 4. Mean number of food items per stomach for sunfish ≤ 40 mm (*Lepomis* spp.) by sample period and treatment.

Food Organisms Consumed	SAMPLE PERIOD Seeded (S) and Control (C) Areas									
	1		2		3		4		5	
	S	C	S	C	S	C	S	C	S	C
Chironomid larvae			1.8	0.7	0.3	2.0	2.0	1.4	1.0	0.9
Chironomid pupae	1.0	2.3	6.3	10.8	2.5	9.3	3.6	1.7	7.5	1.2
Helidae larve		0.3				0.1		0.7	0.2	0.5
Copepoda		0.7	16.3	5.3	1.9	9.2	4.3	11.7	9.6	8.5
Cladocera	12.0	28.0	3.1	6.0	1.2	46.0	30.2	59.8	68.7	105.9
Hydracarina		1.0	1.0	0.5	1.2	3.1	0.8	7.0	0.5	0.5
Ostracoda	16.0	0.3	0.1	6.8		1.1			1.5	
Insects					1.0		0.1	0.2		
Miscellaneous			0.1			0.3	0.1			
Leptodoridae		3.3	0.6			5.9	0.1	2.6		0.6
Odonata									0.1	
Ephemeroptera										

APPENDIX B

TABLE 5. Mean number of food items per stomach for sunfish $\geq$ 41 mm (*Lepomis* spp.) by sample period and treatment.

Food Organisms Consumed	SAMPLE PERIOD Seeded (S) and Control (C) Areas									
	1		2		3		4		5	
	S	C	S	C	S	C	S	C	S	C
Chironomid larvae		0.5	6.4	6.0	4.4	3.7	7.1	1.1	3.1	1.7
Chironomid pupae	40.6	18.0	56.8	18.8	15.0	26.2	11.2	6.4	52.5	27.7
Helidae larvae		2.6		3.6	0.1	0.4	0.4	1.4	1.8	
Copepoda		1.2	54.7	79.5	22.5	21.4	20.5	9.2	9.0	7.6
Cladocera	7.6	57.3	20.6	2.9	54.4	63.3	62.9	113.0	63.7	48.9
Hydracarina	0.4	0.2	1.4	1.5	2.6	2.4	1.7			0.1
Ostracoda	71.0	5.0	8.4	14.8	11.9	6.2	8.4	1.2	7.6	7.9
Insects	0.3	0.5	0.2	12.8	0.7	0.3	6.2	9.8	1.0	2.1
Miscellaneous	0.4	0.8		1.9	1.4	1.0		0.1	4.3	
Leptodoridae	0.1	1.3	0.4	2.3	0.7	0.4	4.1			
Odonata										
Ephemeroptera									0.4	

APPENDIX C

TABLE 6. Mean number of food items per stomach for white crappie by sample period and treatment.

Food Organisms Consumed	SAMPLE PERIOD Seeded (S) and Control (C) Areas									
	1		2		3		4		5	
	S	C	S	C	S	C	S	C	S	C
Chironomid larvae			17.0		5.9	5.5	1.7	1.8	6.2	5.5
Chironomid pupae			3.0		5.5	2.8	2.0	1.3	2.0	1.8
Helidae larvae					0.1	0.5	0.8		0.2	
Copepoda			363.0		77.5	120.6	114.1	135.0	98.5	72.8
Cladocera					0.7	8.4	241.3	468.0	152.2	154.5
Hydracarina					0.3	4.6				
Ostracoda										
Insects					6.6					
Miscellaneous					4.2					
Leptodoridae					1.4	4.4				
Odonata										
Ephemeroptera									1.4	

APPENDIX D

TABLE 7. Mean number of food items per stomach for yellow perch by sample period and treatment.

Food Organisms Consumed	SAMPLE PERIOD Seeded (S) and Control (C) Areas									
	1		2		3		4		5	
	S	C	S	C	S	C	S	C	S	C
Chironomid larvae	4.7		5.0	4.3	3.4	2.6	5.0		0.9	
Chironomid pupae	2.9		3.8	1.5	2.9	1.8	15.0	5.0	6.2	7.0
Helidae larvae	0.1									
Copepoda	33.4	5.4	53.3	27.3	50.3	23.5	22.3	3.0	10.3	14.0
Cladocera	5.8	3.8	9.0	0.5	0.1	0.9	10.8		11.1	
Hydracarina	0.1		0.3	1.3	0.8	0.5		2.0	0.8	2.0
Ostracoda	0.3		0.4	0.5	0.5	0.5	0.2	4.0	0.3	
Insects						0.1	0.2		0.1	
Miscellaneous			0.1		0.5	0.1	0.3		0.2	
Leptodoridae	0.5		0.6		2.9	0.5				
Odonata	0.1									
Ephemeroptera										

VITA

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