To the Graduate Council:

I am submitting herewith a thesis written by William B. Kittrell, Jr., entitled "Reservoir Seeding Improves Abundance, Growth and Food of Young-of-Year Centrarchid Bass." I have examined the final 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.

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A

RESERVOIR SEEDING IMPROVES ABUNDANCE, GROWTH AND FOOD OF YOUNG-OF-YEAR CENTRARCHID BASS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

William B. Kittrell, Jr.

June 1982

DEDICATION

This thesis is dedicated to my mother and father, whose love and support have enabled me to come this far in life.

ACKNOWLEDGMENTS

Many individuals have contributed to the completion of this thesis. I sincerely appreciate the advice, understanding, and encouragement of my major professor, Dr. Richard J. Strange. Appreciation is also extended to my other committee members, Drs. J. Larry Wilson, Thomas K. Hill, and David A. Etnier, for all their help. Thanks are due Doug Powell, Tennessee Valley Authority biologist, who served as a committee member and donated much of his time to the project.

Special thanks are extended to my fellow students for their help in the field and in laboratory analyses: Glenn Thomas, Dave Turner, John Richardson, Mike Humphreys, Joy Keegan, Dave Routledge, and Jenny Vaughan.

Also, I want to thank Tim Broadbent, co-worker on the project, who was a good friend and companion throughout the entire study. Of course I would like to thank my wife, Suzanne, for her love and patience the past two years.

This project was sponsored by the Bass Research Foundation in full cooperation with the Tennessee Valley Authority and the Georgia Game and Fish Division.

ABSTRACT

Ten experimental sites on Lake Nottely, Georgia, seeded with field rye, and 10 corresponding control sites were sampled by night seining at two-week intervals from June through August 1981. Numbers of centrarchid bass collected from the seeded areas in June and July were significantly higher than those collected from control areas, though numbers in the seeded areas declined to control levels near the end of the summer. The decline in numbers of bass in seeded areas corresponded with falling water levels which reduced the amount of inundated grass. Dispersal, possibly coupled with increased predation due to loss of cover, was considered responsible for the decline. Mean condition factors (K) and weights of bass in seeded areas were significantly higher than control values at the first sampling period (June 16). This seemed related to the significantly higher invertebrate food supply available in seeded areas early in the summer. Aquatic insects remained significantly more abundant throughout the summer in seeded areas whereas zooplankton numbers sharply declined in both seeded and control areas. Young-of-year bass in seeded areas averaged 13% heavier and 8% longer than bass in control areas by the end of the summer sampling. This slight growth advantage was attributed to the early transition from an invertebrate diet to a piscivorous diet, which was prompted by a significantly greater abundance of young-of-year sunfish (*Lepomis* spp.) in seeded areas. Gut analyses of bass in control areas indicated a significant dependence on zooplankton and insects late into the summer, though numbers available for consumption were considered very low.

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CHAPTER I

INTRODUCTION

Water fluctuation regimes and the lack of cover for fish in many reservoirs pose severe problems for management of cover-dependent species of fish. Broad seasonal fluctuations and unfavorable soil conditions can preclude establishment of aquatic vegetation and consequently, the development of periphyton communities. Terrestrial vegetation, present in newly flooded areas, is soon lost as reservoirs age. This loss of cover is believed related to observed declines in standing crops of centrarchid species such as *Micropterus* spp. which are dependent on stable and sheltered shorelines. The lack of cover may result in reduced food availability and higher predation (Brouha and Geldern 1979). As is the case with many species of fishes, year-class strength of largemouth bass (*Micropterus salmoides*) is determined within the first month of life (Kramer and Smith 1962). This implies that the early days of young bass are the most crucial time in their lives.

The importance of vegetation in providing cover from predation and increased food availability has been well documented. Aggus and Elliot (1975) found a significant positive correlation between the amount and duration of flooded terrestrial vegetation during and after spawning and the density of young-of-year largemouth bass in fall rotenone samples. They believed that increased vegetative cover for small bass decreased predation. Vogele and Rainwater (1975) found that bass production increased in response to cover. Centrarchids were found to be significantly more abundant in years of flooded terrestrial vegetation (Wallburg 1977; Martin et al. 1981).

Although the availability of cover appears to influence early survival of young bass, the rate of growth during this period may be even more important to annual survival and determinations of year-class strengths (Aggus and Elliott 1975). Variation in growth among different year-classes has been well documented; however, growth variation within a single year-class has been discussed less frequently (Shelton et al. 1979). In West Point Reservoir, Alabama-Georgia, Shelton et al. (1979) found that one segment of a particular spring-spawned year-class of bass grew much more rapidly than another segment. Several reasons for the increased growth were given including the presence of inundated terrestrial vegetation in those areas of the lake. Aggus and Elliott (1975) found bimodal length distributions within years of flooded terrestrial vegetation indicating that some largemouth bass grew much faster than others. Varied growth rates over several years indicated that the fastest growing bass came from years when terrestrial vegetation had been inundated. These patterns of differential growth of young largemouth bass appeared directly related to differences in feeding (Aggus and Elliott 1975; Shelton et al. 1979).

Food available to bass in areas of flooded terrestrial vegetation seems to be of improved quality and quantity in comparison to food available in areas without flooded vegetation. Aggus and Elliott (1975) and Shirley and Andrews (1977) found that flooding of terrestrial vegetation can provide a nutrient source which increases primary productivity and the invertebrate supply for bass and forage fishes. Also, flooded terrestrial vegetation can provide a temporary immediate food supply of terrestrial invertebrates. Keith (1975) stated that areas of newly flooded vegetation stimulated the prolific spawning of other fishes, the young of which are important sources of food for young bass. Improved food quality and availability ultimately increase growth and survival (Kramer and Smith 1960).

The loss of important vegetation, which provided cover and food in reservoirs, has prompted many researchers to investigate new methods to insure survival and growth of young-of-year bass and subsequently provide strong year-classes to anglers. Keith (1975) found that water level manipulation can be used in managing fish populations. He concluded that increasing water levels produced heavy spawns of bass and provided sufficient food organisms for survival and growth of the bass. However, desirable water levels for management of bass and other related species may conflict with flood control projects, hydroelectric generating requirements, and other priorities (Heidinger 1976).

Several other options have been explored to achieve a more suitable habitat for certain species of fishes. These include installation of fish attractors made of brush and artificial reefs to provide cover (Vogele and Rainwater 1975; Pierce and Hooper 1979; Prince and Maughan 1979). Although these tactics have had positive effects on young-of-year and adult fish, they only provided cover for areas of restricted size. Several studies have used revegetation of fluctuation zones to improve wildlife habitat or soil conditions (Fowler and Maddox 1974;

Fowler and Hammer 1976). However, fewer studies have been done with direct application towards young-of-year fish. Keith (1967) renovated a small reservoir through revegetation, although the effects on resident fish populations were not evaluated. Brouha and Geldern (1979) revegetated reservoir fluctuation zones with several species of plants tolerant to periodic flooding. However, drought thwarted a fisheries evaluation.

The object of this research project was to seed the fluctuation zones of Lake Nottely with grass and evaluate the effects on young bass. The effects of flooded vegetation in fluctuation zones on growth and food for young fish have been shown to be positive (Aggus and Elliott 1975; Keith 1975). Most of the Tennessee Valley Authority reservoirs are already devoid of vegetation on the shorelines because of long-term fluctuations in water level. The revegetation effort (phase one of the overall project) was planned to coincide with the spring rise in water level following winter drawdown and ensure the presence of cover for spring-spawned bass.

Phase two of the project (June 1981 to June 1982) was the object of this thesis. This phase of the project evaluated the effects of vegetation on young-of-year largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*), and spotted bass (*Micropterus punctulatus*). The investigation determined abundance and growth for young-of-year bass in seeded and control areas. Food habits and the availability of food organisms utilized by young bass in these areas were also evaluated. In addition, several water quality characteristics were measured in both seeded and control areas. This data should give an index to the validity of seeding reservoir fluctuation zones as a habitat management technique for centrarchid bass species.

This study was a joint effort between two investigators, each responsible for certain objectives, even though much of the work was performed as a team. The seeding phase and the effects of cover on the abundance and food habits of competitors of centrarchid bass are reported by Broadbent (1982). He also investigated the validity of seeding fluctuation zones as a management technique to promote forage for young-of-year centrarchid bass and competitors.

CHAPTER II

METHODS AND MATERIALS

Description of Study Area

Lake Nottely is a Tennessee Valley Authority (TVA) impoundment located on the Nottely River in Union County, Georgia (Figure 1). This multipurpose tributary reservoir lies 3.7 river kilometers (2.3 river miles) upstream from the Georgia-North Carolina state line in the southern reaches of the Appalachian Mountains. TVA manages this reservoir primarily for hydroelectric power generation, water storage, and flood control. The lake was filled in 1942.

At normal pool, Lake Nottely covers 1692 hectares (4180 acres) with a shoreline of 171 km (106 miles) and a maximum depth of 51 m (168 ft.). Normal pool elevation is 542 m (1779 ft.) and storage volume is approximately 2.1 x 10^8 m^3 (171,200 acre-feet). This reservoir is partially surrounded by the Chattahoochee National Forest, and the area is relatively undeveloped. Total drainage area above the dam is 344 km^2 (214 square miles). Nottely has a history of soft water (8-10 mg/l total hardness), nearly neutral pH, and a slightly turbid appearance (England 1977). Lake Nottely has three species of centrarchid bass (largemouth, smallmouth, and spotted), all of which were considered in this study.

Nottely is typical of many TVA tributary impoundments that have an extreme fluctuation in water level during the year. Evidence of this was displayed by a vertical drop of 6 m during the summer of 1980 that

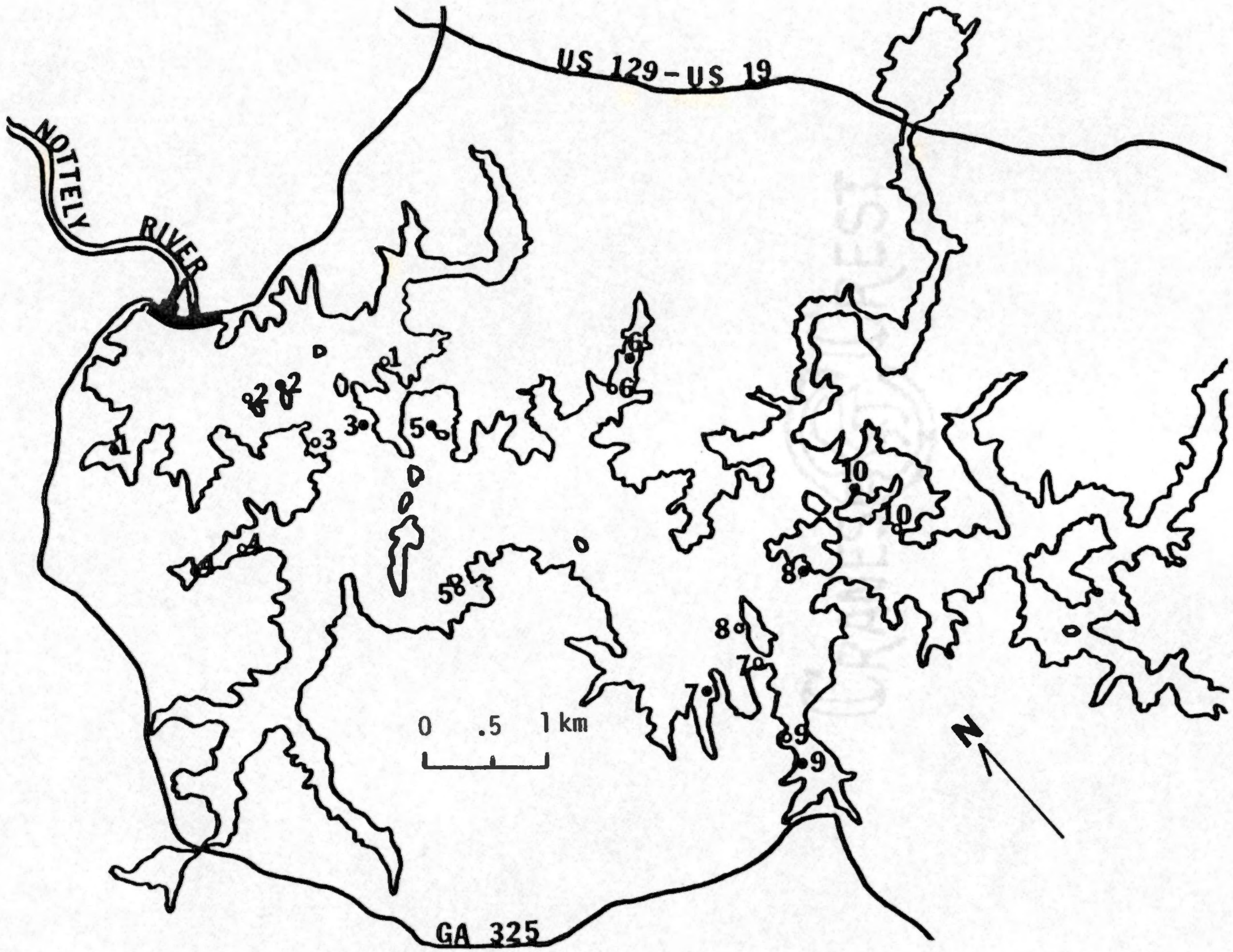

Figure 1. Nottely Reservoir, Union County, Georgia, showing the 10 seeded (•) and 10 control (o) areas.

exposed an average of 183 m of shoreline. This provided ample terrain for the seeding phase of the project.

The first phase of this project (summer and early fall, 1980) consisted of seeding grass in the fluctuation zones of Lake Nottely to provide food and cover for the young-of-year bass (Broadbent 1982). He chose twenty-four paired areas, ranging in size from 0.8 to 9.7 hectares, and randomly assigned them as either experimental or control. Several types of grass were seeded at different rates to determine the best grass to use. Approximately half of each seeded area was fertilized to enhance growth. Rye was the most successful grass with an average stem count/m^2 of 43 and an average height of 70 cm. Fescue was established to a lesser degree with approximately 32 stems/m^2 and an average height of 7 cm. Sparse natural vegetation was present in the experimental areas also. The unseeded and unfertilized control areas had only very sparse natural vegetation. The vegetation data was collected just prior to inundation.

Collection of Data

Beginning in early March 1981, the water level began to rise in the reservoir. At that time, 10 seeded areas with the best grass cover were chosen as experimental sites for the bass fishery evaluation. The corresponding paired areas were used as controls. Sampling was initiated on 6 June and terminated on 17 August. During the months of June, July, and August, each seeded and control site was sampled once every two weeks until the grass was no longer inundated. This resulted in five sampling periods. Seining was the primary technique used for capturing young-of-year bass. A series of standardized quarter hauls with a straight seine

(0.6 cm mesh, 1.2 x 9.1 m) were made two to eight times per site, depending on the size of the area. This resulted in a total of 45 seine hauls in each of the 10 seeded and control sites at each sampling period. All seining was done after sundown.

Boat electroshocking utilizing a boom-type, 230-V (500 watt) high cycle generating unit was also employed as a collection method. However, electrofishing failed to produce as many young-of-year bass as seining and was discontinued after several unsuccessful attempts.

As fish were collected, capture sites, species, lengths, and weights were recorded. Fish were measured (total length to the nearest mm) and weighed (to the nearest 0.1 g) on a triple beam balance. In order to have an adequate sample for the food habits portion of the project, it was necessary to keep virtually all centrarchid bass. These fish were cataloged and preserved in 10% formalin and were later transferred to 40% alcohol for future analyses.

During the biweekly sampling periods, plankton and benthic samples were also collected at each site. Three 5-meter plankton tows with a 22.9-cm diameter plankton net (60 mesh) were used to determine zooplankton concentrations. The three plankton tows were combined into a single sample. An Ekman dredge sample (232 cm^2) was taken at each site every two weeks to determine benthic invertebrates present. The benthic and zooplankton samples were preserved in 10% formalin for later analyses in the laboratory.

Several water quality characteristics were measured biweekly for comparisons between seeded and control sites. At each site temperature

(°C) and dissolved oxygen (mg/l) profiles were taken with a YSI (Model 51B) meter. Alkalinity (mg/l as $CaCO_3$) was measured with a standard Hach kit (Model AL-36B) and turbidity as Jackson Turbidity Units (JTU) was determined with a Hach (Model DR9137B) filter photometer.

Data Analyses

Throughout the summer of 1981, 151 centrarchid bass, which included largemouth, smallmouth, and spotted bass, were collected for food habit analyses. Total gut analyses were performed on these fish to determine all foods eaten. Gut analyses included the entire digestive tract from the esophagus to the anus. Each fish was analyzed in the same manner to ensure standardization. A shallow incision was made from the isthmus to the anus. At each end of this incision a perpendicular incision was made to facilitate easy removal of the gut. After removal of the gut, the entire length was opened to expose the ingested food items. These were categorized and quantified with the aid of a 40 X binocular dissecting scope (Richardson 1982). The food items were classified to the lowest practical taxa according to Pennak (1978).

Zooplankton samples were first diluted to a standard volume and then stirred vigorously. Before the suspension settled, subsamples were withdrawn with Hensen-Stempel pipets. When possible, 200 organisms were counted in each sample utilizing a 40 X binocular dissecting scope. From the ratio of percent volume counted to the total percent volume sampled, the total number of organisms per sample could be estimated (Saul 1981). Planktonic organisms were classified to the lowest practical taxa and calculated as organisms/m^3.

Benthic samples were strained through standard brass substrate sieves which are categorized by mesh size (holes per in^2). The sieves utilized in these analyses were sizes 10, 20, and 40. The residuals were also analyzed with a 40 X binocular dissecting scope. Usually all organisms in the sample were counted because of the low numbers present. Benthic organisms were classified to the lowest practical taxa and were expressed as organisms/m^2.

Analyses of most of the food habit and growth data were facilitated with the use of the UTCC Decsystem-10 and Statistical Analysis System (1979). Means were calculated for numbers of bass, lengths and weights of bass, food items, food items available, and condition factors (K) of bass in both seeded and control areas. Standard errors were computed for all means to express variance limits. Significant differences between means of seeded and control areas were determined with the t-test ($P < 0.10$). Fulton's Condition Factor (K) was calculated on all bass from:

$$K = \frac{10^5 W}{L^3}$$

where W and L are the observed total weight in grams and total length in millimeters, respectively (Bagenal and Tesch 1978).

CHAPTER III

RESULTS

Lake Conditions

The extremely dry weather during 1980 prevented Lake Nottely from attaining full pool (542 m) in the spring of 1981. Unfortunately, this resulted in the flooding of only half of the area (61 ha) originally seeded with terrestrial grass the previous summer by Broadbent (1982). The bass fishery evaluation began in June 1981 at a water lever elevation of 538 m or 4 m below normal pool for that time of year. Water levels continued to fall throughout the summer. By the last sampling period (August 14-16), the water elevation in Nottely was 536.6 m and the majority of vegetation was no longer inundated.

Dissolved oxygen, temperature, alkalinity and turbidity were measured biweekly throughout the summer of 1981 (Appendix A). No significant differences were found in these water quality characteristics between the seeded and control areas. Mean dissolved oxygen measurements ranged from 7.5 to 8.1 mg/l while mean temperatures ranged from 24.9 to 26.9°C throughout the summer. Mean alkalinity (mg/l as $CaCO_3$) values ranged from 7 to 14 mg/l and turbidity means ranged from < 1.0 to 8.4 JTU with individual measurements ranging from < 1.0 to 35.0 JTU.

Abundance and Growth

Throughout the summer of 1981, 185 young-of-year bass were captured. Of this total, 68% were largemouth bass, 23% were spotted bass, and 9% were smallmouth bass. All three species occurred in both the seeded and control areas. Of the 125 largemouth bass collected during the study, 75 (60%) came from seeded areas while 59 (40%) came from control areas. Numbers of spotted and smallmouth bass were very similar in seeded and control areas. The numbers of bass captured in the seeded areas were significantly higher (t-test, P = 0.02) at the second sampling period and consistently higher than numbers in the control areas until the fourth sampling period (Figure 2). At that time the numbers of bass in the seeded areas declined to control area levels. By the last sampling period, very low numbers were being captured in both seeded and control areas.

No statistical difference in mean lengths was evident between bass from seeded and control areas (Figure 3). However, bass in seeded areas were longer at three of the five sampling periods. By the end of the summer, bass in seeded areas averaged 8% longer than bass in control areas.

Trends in the weights of bass over the summer were similar to those of length. Bass in seeded areas at the initial sampling period were significantly heavier (t-test, P = 0.01) than bass in control areas and remained slightly heavier throughout most of the summer (Figure 4). Although control area bass were heavier at the fourth sampling period, bass from seeded areas averaged 13% heavier by the end of the summer.

Condition factors (K) of bass in seeded areas ranged from 1.0 to 2.0 while control K values ranged from 1.0 to 1.18 (Figure 5). The bass from seeded areas at the initial sampling period had a mean K value significantly (t-test, P = 0.01) higher (41%) than the control K value.

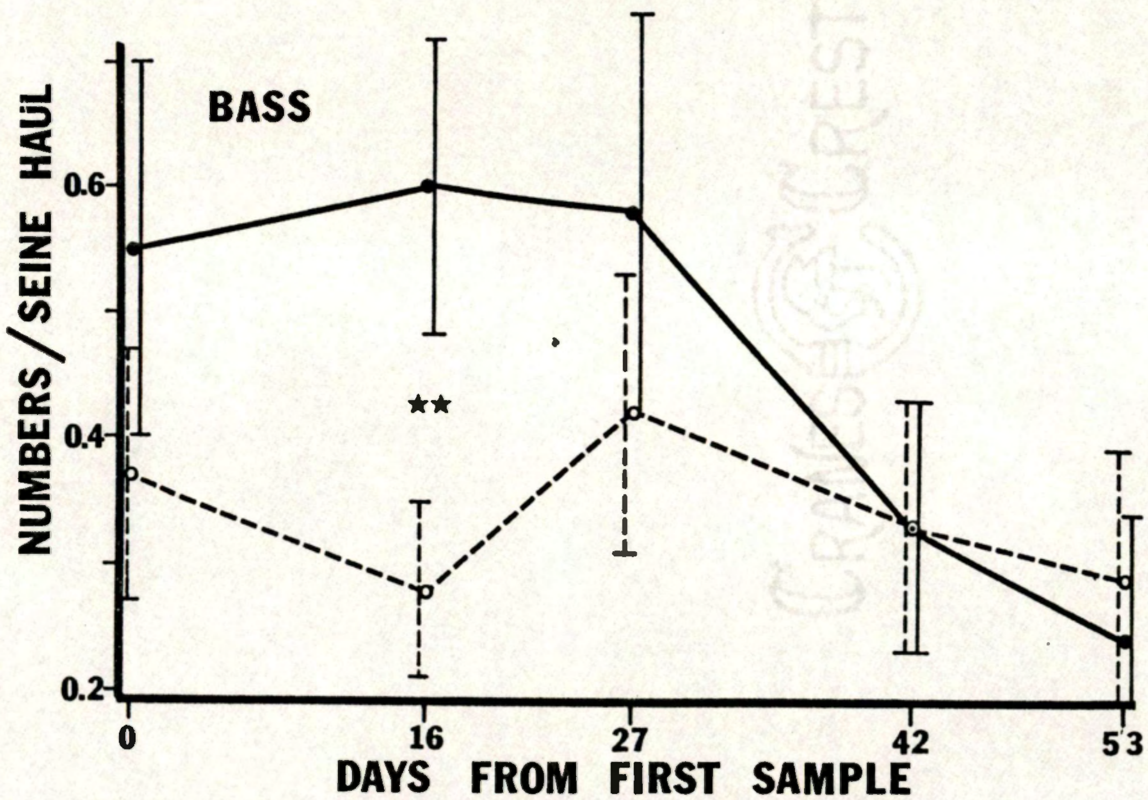

Figure 2. Mean numbers of bass per seine haul in seeded and control areas. Solid lines represent seeded areas, and broken lines represent control areas. Brackets indicate standard errors around the means. Stars indicate significance ($P < 0.05$).

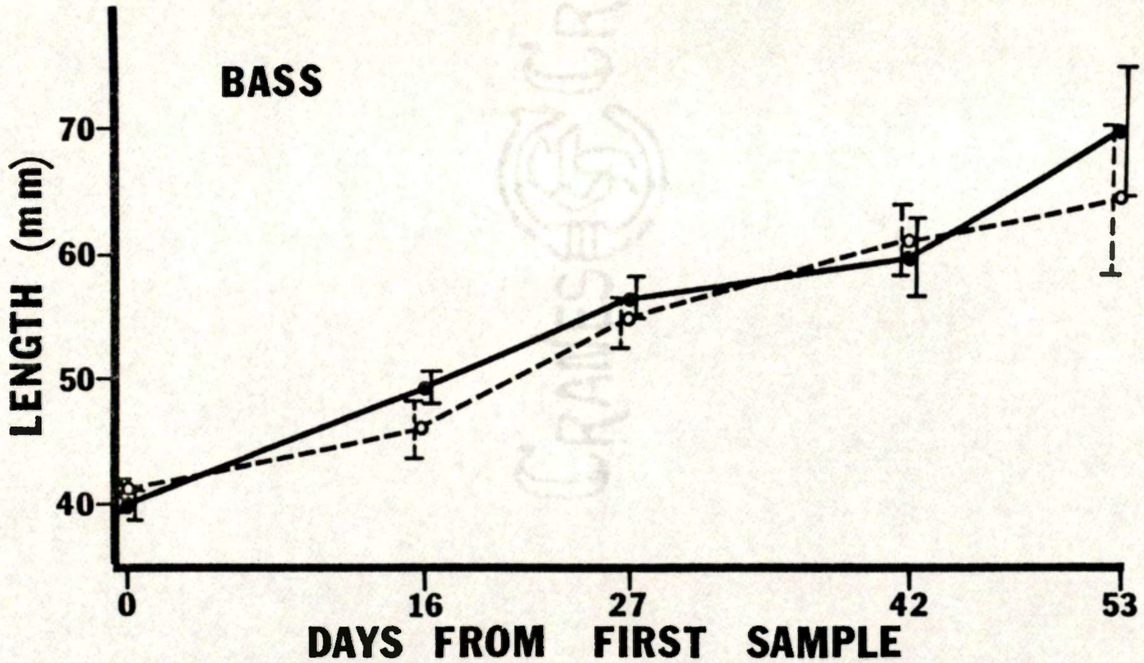

Figure 3. Mean total length of bass in seeded and control areas. Solid lines represent seeded areas, and broken lines represent control areas. Brackets indicate standard errors around the means. No significance detected ($P < 0.10$).

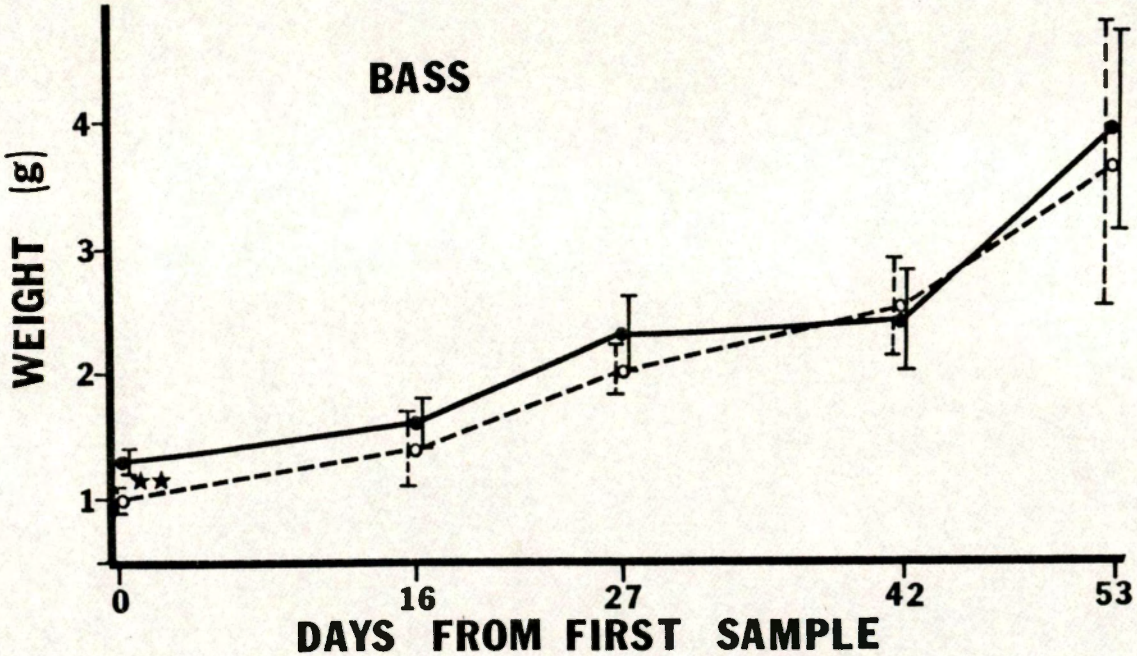

Figure 4. Mean weights of bass in seeded and control areas. Solid lines represent seeded areas, and broken lines represent control areas. Brackets indicate standard errors around the means. Stars indicate significance ($P < 0.05$).

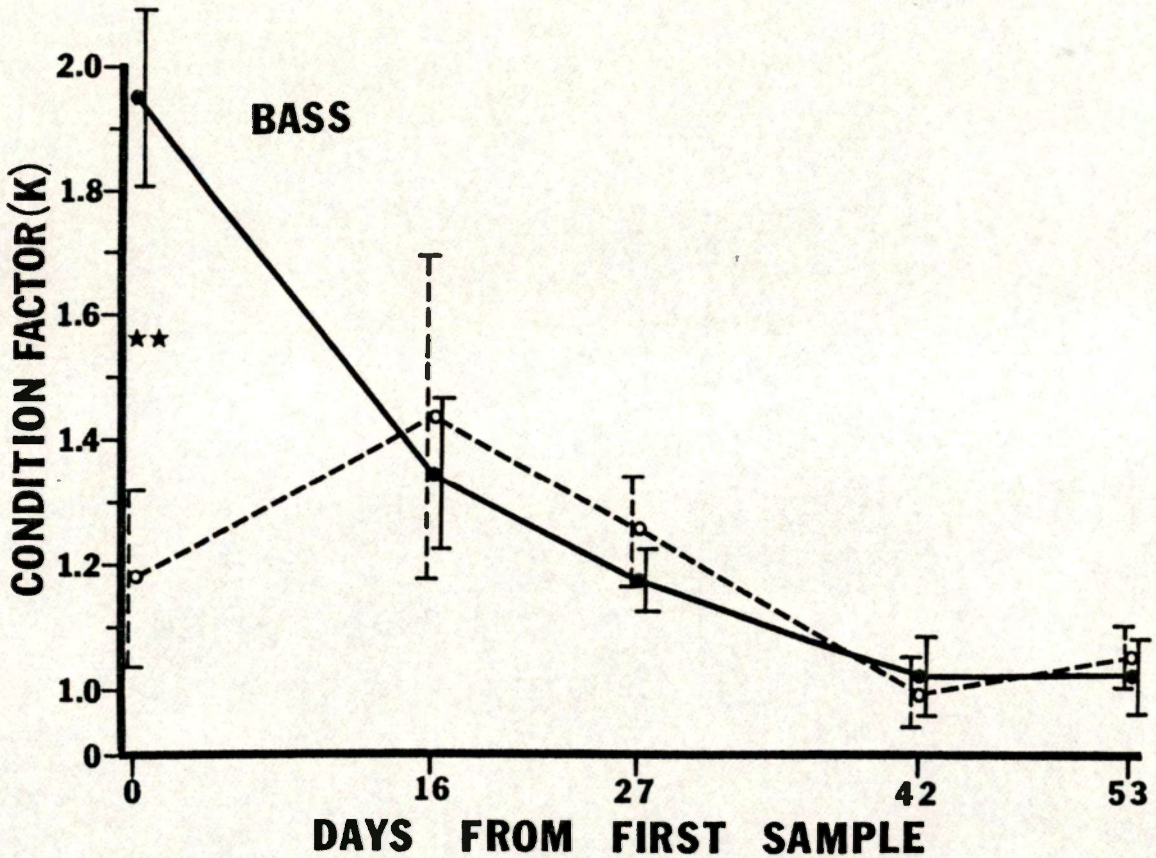

Figure 5. Mean Condition Factors (K) of bass in seeded and control areas. Solid lines represent seeded areas, and broken lines represent control areas. Brackets indicate standard errors around the means. Stars indicate significance ($P < 0.05$).

However, condition factors of bass in both seeded and control areas attained similar values and generally declined throughout the remainder of the summer.

Food Availability

The planktonic organisms captured with the plankton tows were almost entirely zooplankton (over 99% in both seeded and control areas). Therefore, all planktonic organisms were combined and considered as the single category of zooplankton. Cladocerans and Copepoda comprised 99% of the zooplankton group with a percent composition of 71% and 28%, respectively. No differences were found in the percentage composition between seeded and control areas (Figure 6). Numbers of zooplankton in both the seeded and control areas declined throughout the summer although there were significantly (t-test, $P = 0.05$) more present in the seeded areas at the initial sampling period. The most dramatic decline (80%) came between the second and third sampling periods.

Aquatic oligochaetes and nematodes comprised a large percentage of the total benthos collected with the Ekman grabs (34% in seeded areas and 48% in control areas). Since neither group was found in any of the bass guts analyzed, they were not graphed as available invertebrate food. Likewise, zooplankton occurring in small percentages was not graphed because the plankton tows were a better index to the crustacea available for bass consumption. The remainder consisted entirely of aquatic insects as shown in Figure 7. Chironomidae larvae and pupae and Heleidae larvae comprised approximately 98% of the aquatic insect group throughout the summer in both seeded and control areas. Chironomid larvae

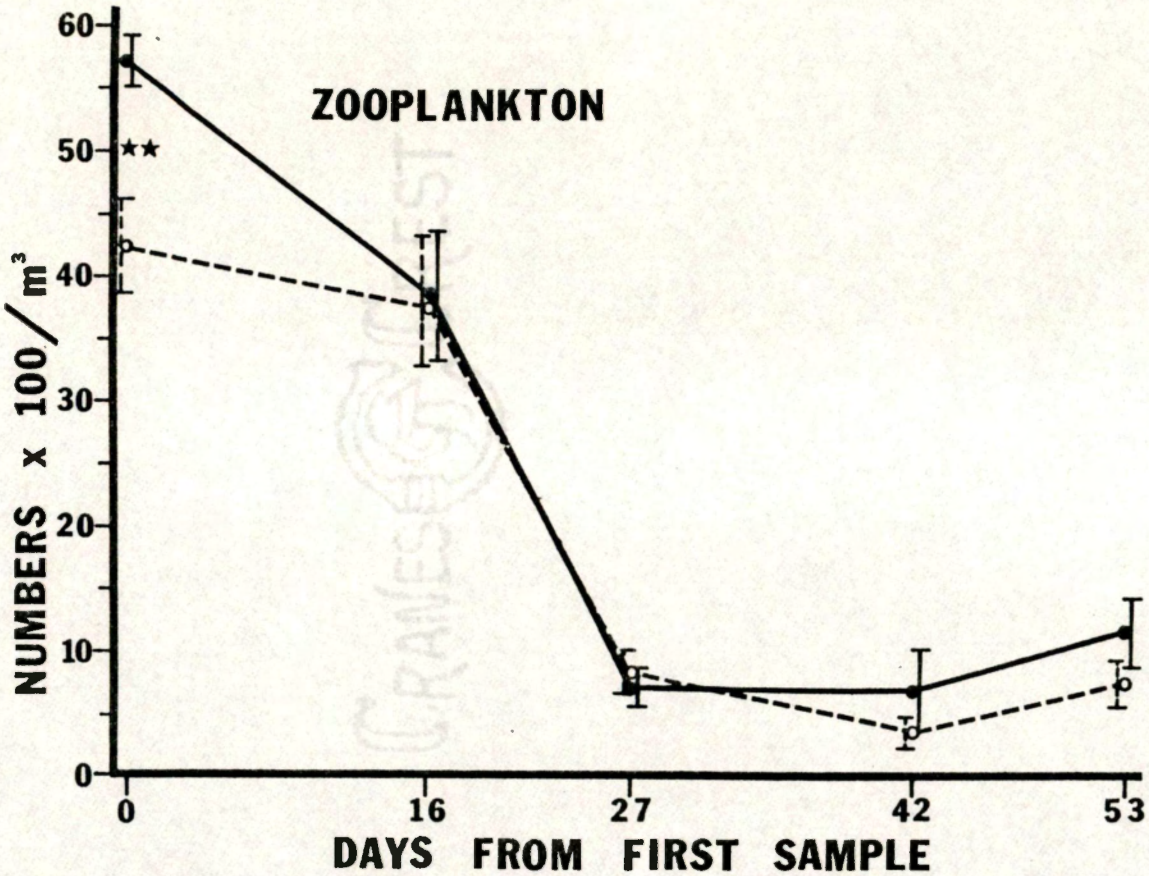

Figure 6. Mean numbers of zooplankton per cubic meter in seeded and control areas. Solid lines represent seeded areas, and broken lines represent control areas. Brackets indicate standard errors around the means. Stars indicate significance ($P < 0.05$).

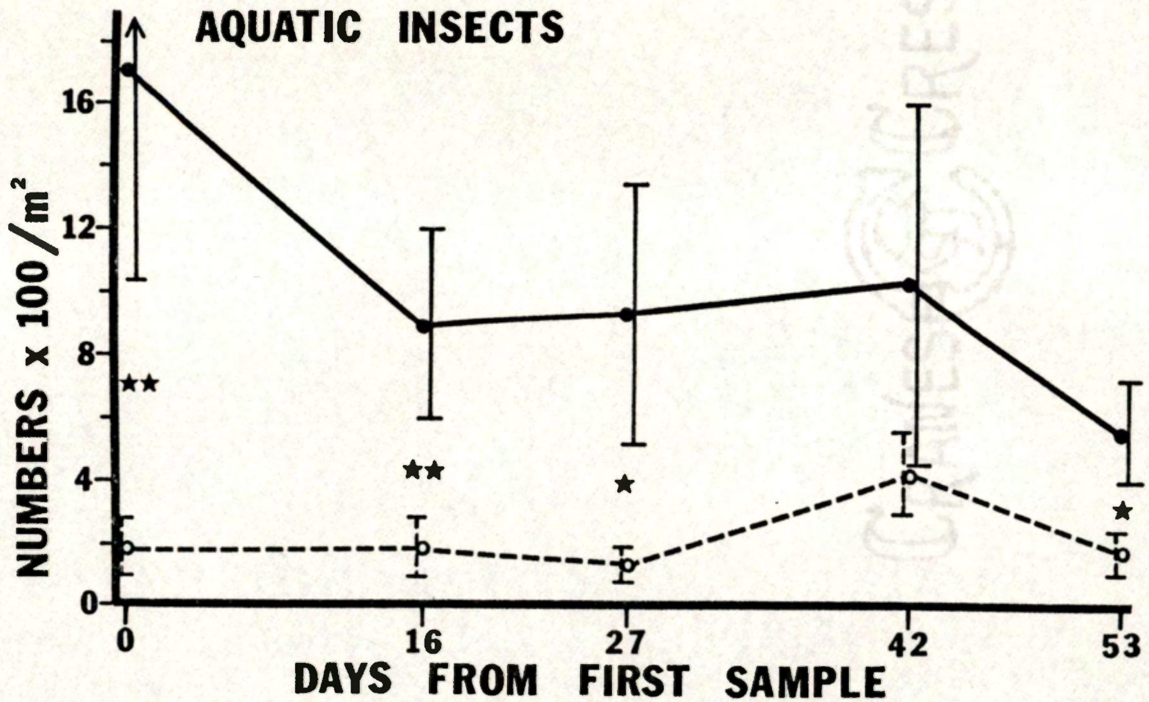

Figure 7. Mean numbers of aquatic insects per square meter in seeded and control areas. Solid lines represent seeded areas, and broken lines represent control areas. Brackets indicate standard errors around the means. Stars indicate significance (one star = $P < 0.10$ and two stars = $P < 0.05$).

averaged 88% of the total in seeded areas and 74% of the total in control areas. Numbers of aquatic insects present in seeded areas were significantly higher (t-test, $P = 0.05$) during four of the five sampling periods and averaged 75% higher than numbers in control areas throughout the summer.

Food Habits

Of 185 bass captured, total gut analyses were performed on 151, all of which contained food items (Appendix B). The food items present in the guts were combined into the three broad categories of zooplankton, insects, and fish.

Numbers of zooplankton in the guts of bass from seeded areas sharply declined after the second sampling period (Figure 8). However, bass in control areas were relying significantly (t-test, $P = 0.01$) more on zooplankton near the end of the summer. The sharp decline in numbers present in the guts of bass in seeded areas corresponded with the decline seen in the water column (Figure 6). The zooplankton category consisted of Cladocera, Copepoda, and Ostracoda. Cladocerans and copepods comprised the largest percentage of this group (98% in seeded areas and 96% in control areas). Throughout the summer bass ate twice as many cladocerans as copepods in both seeded and control areas.

Numbers of insects present in guts from seeded and control areas fluctuated between 13 and 30 organisms per bass with the development of no definite trend (Figure 9). Chironomid larvae and pupae were the predominant components of the aquatic insect diet throughout the study (79% in seeded areas and 69% in control areas), while Hymenoptera was the

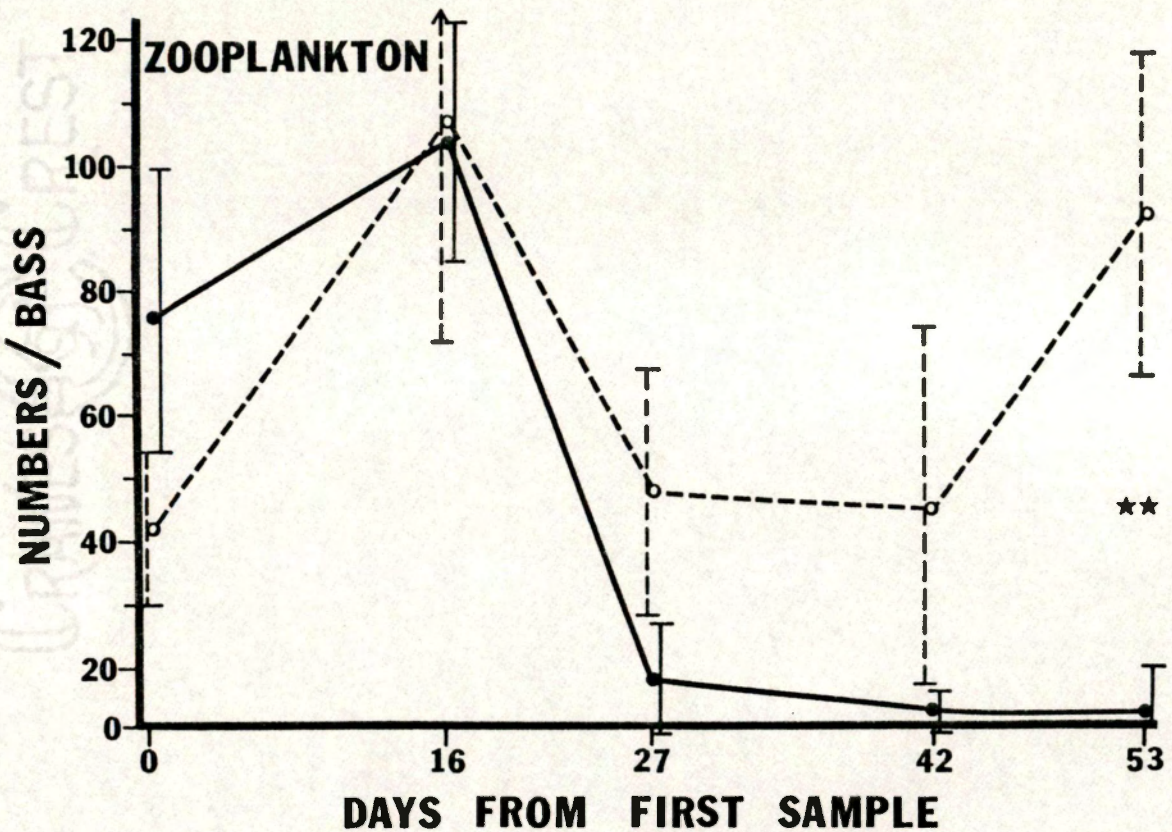

Figure 8. Mean numbers of zooplankton per bass gut in seeded and control areas. Solid lines represent seeded areas, and broken lines represent control areas. Brackets indicate standard errors around the means. Stars indicate significance ($P < 0.05$).

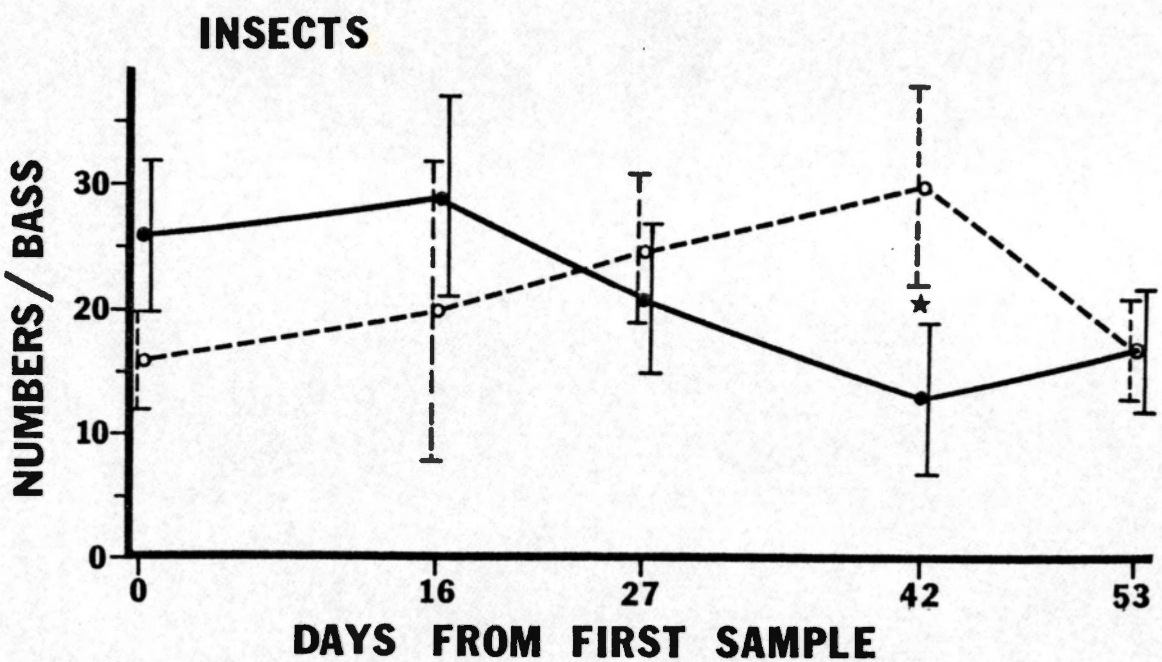

Figure 9. Mean numbers of insects per bass gut in seeded and control areas. Solid lines represent seeded areas, and broken lines represent control areas. Brackets indicate standard errors around the means. The star indicates significance ($P < 0.10$).

predominant order of terrestrial insects. Both Hymenoptera and Thysanoptera were being utilized by the bass near the end of the summer. One bass collected in a control area at the fourth sampling period contained well over a hundred Heleidae pupae which exaggerated the data (Figure 9) and resulted in a significant difference in means (t-test, $P = 0.10$).

By the third sampling period, numbers of fish present in guts from seeded areas were significantly higher (t-test, $P = 0.10$) and remained consistently higher (52%) than those in control area bass throughout most of the summer (Figure 10). Their increase in a piscivorous diet coincides with the sharp decline in zooplankton consumption and the general decline in insect consumption (Figures 8 and 9). The numbers of fish eaten by control area bass follow a rather flat graphic trend at a lower level. The fish category consisted entirely of *Lepomis* spp. and unidentifiable fish.

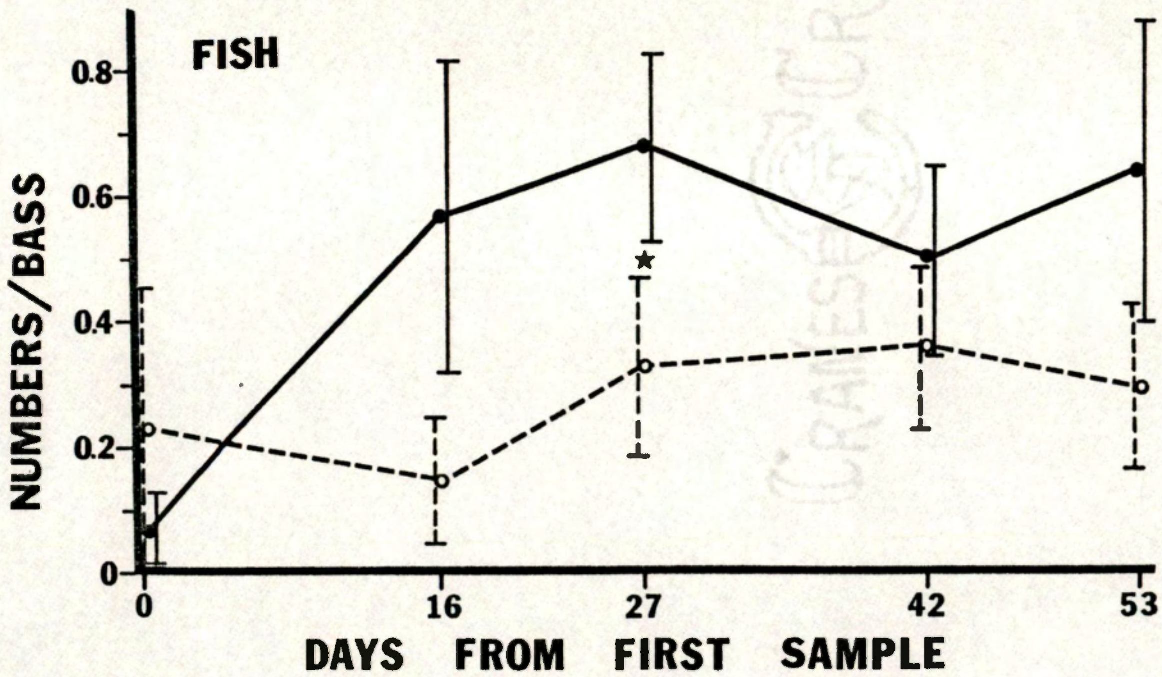

Figure 10. Mean numbers of fish per bass gut in seeded and control areas. Solid lines represent seeded areas, and broken lines represent control areas. Brackets indicate standard errors around the means. The star indicates significance ($P < 0.10$).

CHAPTER IV

DISCUSSION

Shoreline fluctuation zones on Nottely Reservoir seeded by Broadbent (1982) with terrestrial grasses during the summer and early fall of 1980 were inundated by the spring rise in water level in 1981. Unfortunately, only about half of the seeded areas were flooded due to the extremely dry weather of 1980. There were, however, differences in the success of young-of-year bass in the seeded versus control areas. Bass were more abundant in seeded areas than in control areas throughout the first part of the summer of 1981. Bass were significantly more abundant in seeded areas at the second sampling period; however, numbers declined to control area levels near the end of the summer. This decline in numbers in seeded areas coincided with the receding of the water from much of the vegetation.

Reduction in numbers of bass in an area may be due to either emigration or predation. Kramer and Smith (1962) observed a general emigration of bass fingerlings from shoreline areas by the end of August in Lake George, Minnesota. The food supply for bass in seeded areas in our study seemed to be quite adequate throughout the summer. Numbers of aquatic insects and sunfish $\leq$ 40 mm TL (forage) were still significantly higher in seeded areas than in control areas by the end of the summer. Therefore, food availability should not have encouraged emigration. Reduced numbers of bass in seeded areas during the last sampling periods were probably due to a natural tendency to disperse, despite plentiful food, perhaps coupled with increased predation caused by reduced cover.

The efficiency of fish sampling was greater in control areas than in seeded areas. Control areas were devoid of vegetation, and seines could be drawn through unobstructed waters to a bare beach. In seeded areas, seines were drawn through moderately thick vegetation which decreased sampling efficiency. Young-of-year bass observed in the vegetation in seeded areas were not necessarily captured. Therefore, the same sampling effort probably caught a lower percentage of bass in seeded areas than it did in control areas. The between-treatment difference in sampling efficiency must be considered when catches are compared. This problem in sampling was also described by Martin et al. (1981).

Largemouth bass was the predominant bass species occurring in the experimental areas. Of the 125 largemouth bass obtained (from a total of 185 centrarchid bass) during the study, 75 (60%) came from seeded areas while 59 (40%) came from control areas. Numbers of spotted bass and smallmouth bass were very similar in seeded and control areas throughout the summer. Therefore, the increased vegetation seemed more advantageous to the survival of largemouth bass than to either spotted or smallmouth bass.

Growth curves for bass were very similar in seeded and control areas, although mean lengths and weights were slightly higher from bass in seeded areas throughout much of the summer. Bass in the seeded areas were 8% longer and 13% heavier by the end of the summer. Several researchers have found increased growth rates of young-of-year bass in areas of flooded vegetation (Zweiacker et al. 1972; Aggus and Elliot 1975; Shelton et al. 1979). Condition factors (K) for bass in the seeded areas at the beginning of our sampling (mid-June) were significantly higher than control K values. This corresponded to the significantly higher numbers of zooplankton and aquatic insects available for consumption at the initial sampling period in seeded areas. Mean weights were also significantly higher at that time. However, as numbers of zooplankton and aquatic insects in the seeded areas declined, mean K values did also. Bennett (1962) reported that largemouth bass may have sudden changes of condition associated with the availability of desirable food organisms. The decline in K values for seeded area bass may also have been related to the maturity of the bass. Tucker (1973) found that mean K values were highest (1.7) from ponds near the beginning of the summer and declined (1.3) near the end of the summer.

Zooplankton concentrations in the water column were very similar in the seeded and control areas throughout the summer, although zooplankton numbers were significantly higher in seeded areas at the initial sampling period. This was not totally unexpected. Long-term studies on Lake Francis Case have indicated that annual fluctuations of zooplankton populations are closely related to water temperature and occur with yearly regularity (Martin and Novotny 1977). I believe the flooded vegetation in seeded areas had very little effect on zooplankton abundance. Peak numbers of zooplankton in seeded and control areas were recorded in June and declined throughout the summer, perhaps a result of young-of-year fish predation. Martin et al. (1981) found similar population trends. Numbers of zooplankton in the guts of bass in seeded and control areas peaked at the second sampling period (early July). However, bass in seeded areas reduced zooplankton consumption sharply from that point to the end of the summer. Control area bass were still very dependent on zooplankton by the end of the summer even though numbers available were low.

The sharp decline in zooplankton predation by seeded area bass coincided with an increased piscivorous diet. Numbers of sunfish of a suitable size for consumption by bass were higher in the seeded areas than in control areas when they were most needed by bass as Figure 11 illustrates (Broadbent 1982). We found seeded area bass were utilizing fish as a major part of the diet earlier (second sampling period) than control area bass, probably because of increased availability. McGammon et al. (1964) working on Clear Lake, California, found that young-of-year largemouth bass will switch to a fish diet at a length of less than 75 mm if forage fishes of appropriate sizes are available. This seemed to be the case with bass in the seeded areas. Martin et al. (1981) concluded an increased abundance of young fish (forage) is beneficial to the growth and survival of predatory fishes during the first growing season. We found bass in the seeded areas did have a slight advantage (though not significant) in growth by the end of the summer (8% longer and 13% heavier).

Several researchers have found that flooded terrestrial vegetation can increase the aquatic and terrestrial insect food supply for

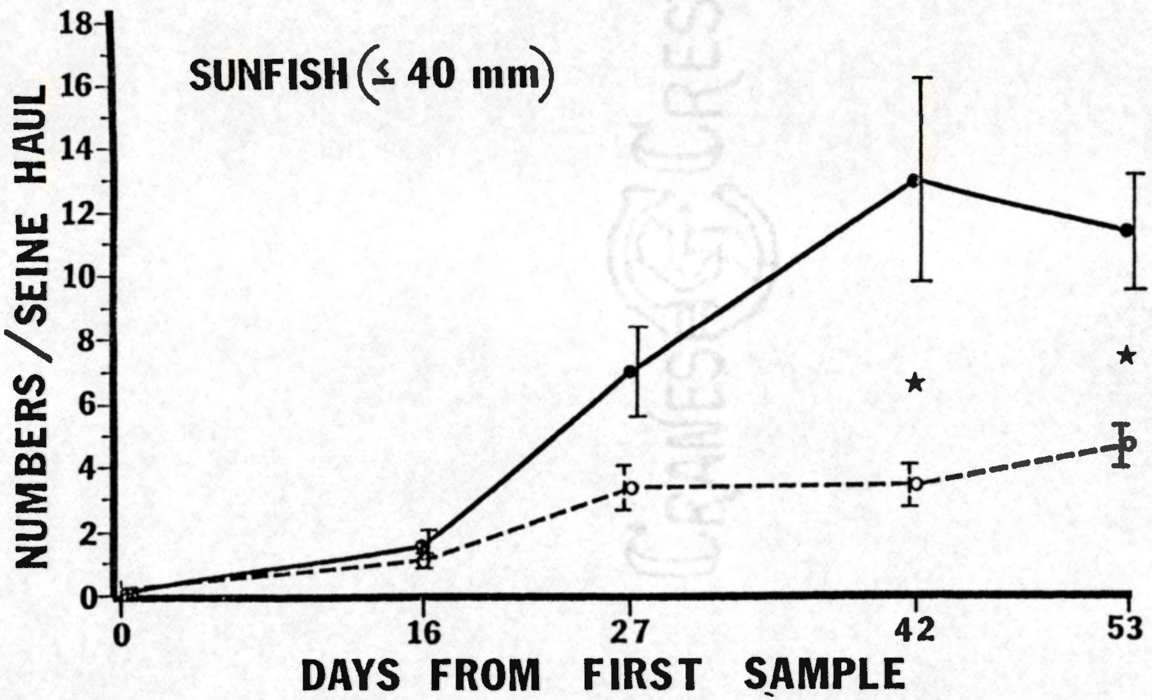

Figure 11. Mean numbers of sunfish (*Lepomis* spp.) ≤ 40 mm (TL) per seine haul in seeded and control areas. Solid lines represent seeded areas, and broken lines represent control areas. Brackets indicate standard errors around the means. Stars indicate ($P < 0.10$), (Broadbent 1982).

young-of-year bass and forage fishes (Aggus and Elliott 1975; Keith 1975; Shirley and Andrews 1977). Our results supported their conclusions. Numbers of aquatic insects were significantly higher in seeded areas throughout most of the summer; however, bass in these areas did not utilize them significantly more than control area bass. Insects (aquatic and terrestrial) seemed to be primarily a transition food from zooplankton to fish. Applegate and Mullan (1967) found midge larvae "bridged the gap" from zooplankton to a diet of fish in Beaver Reservoir, Arkansas. Bass in control areas utilized higher numbers of insects and zooplankton near the end of the summer than did seeded area bass even though numbers available to them were lower. This indicated a desirable food (forage fish) was unavailable; therefore, they consumed significantly more insects and zooplankton. Kramer and Smith (1962) found this to be the case in a study at Lake George, Minnesota. They concluded that bass appeared to eat food organisms in relation to their abundance.

The results of this study indicated a slightly greater abundance of bass in seeded areas than in control areas throughout much of the summer. As the summer progressed, numbers of bass in seeded areas declined to control levels. This was probably the result of a natural tendency for bass to disperse, perhaps coupled with predation. Growth data indicated mean K values and weights were significantly higher at the initial sampling period in seeded areas. The increased food availability (zooplankton and insects) may explain their early increase in growth. Bass in seeded areas switched from an invertebrate diet to a piscivorous diet sooner and to a greater degree than did control area bass. The significantly higher numbers of sunfish available for consumption in seeded areas was likely the primary reason for the early switch. Bass at the last sampling period were 8% longer and 13% heavier, perhaps reflecting a diet higher in fish. This growth advantage of seeded area bass, which may be due to the early transition to a piscivorous diet, will possibly increase survival chances over a longer period of time.

Increased success of young-of-year bass is the ultimate goal of a reservoir revegetation program, and increased success means better recruitment and an improved bass fishery available for anglers. Results of this study have shown positive effects of a revegetation project on abundance of juvenile bass early in the summer and to a lesser degree on growth. There was also evidence that the aquatic insect supply and fish food availability were enhanced by the seeding project. All of these factors benefit the success of young bass. Bearing in mind the influence of a low-water year like 1980 and the small total area of seeded sites which prevented more conclusive results, I believe that seeding reservoir fluctuation zones has the potential to be a useful bass management tool to the fisheries biologist.

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APPENDIXES

APPENDIX A

Table A-1. Mean Dissolved Oxygen, Temperature, Alkalinity, Turbidity, and Pool Elevations by Sample Period and Treatment

Water Quality Characteristic		Sample Period Seeded (S) and Control (C) Areas									
		1		2		3		4		5	
		S	C	S	C	S	C	S	C	S	C
Temperature (°C)	Surface	26.5	26.2	25.2	24.9	27.0	26.2	26.0	26.2	25.6	25.6
	Bottom	26.9	26.8	25.5	25.2	27.3	26.6	26.4	26.5	26.1	26.1
Dissolved Oxygen (mg/l)	Surface	8.0	8.1	8.0	8.1	7.6	7.7	7.9	8.0	7.9	7.9
	Bottom	7.4	7.5	7.5	7.7	7.1	7.2	7.6	7.6	7.6	7.7
Alkalinity (mg/l as $CaCO_3$)		7-14	7-14	7-14	7-14	7-14	7-14	7-14	7-14	7-14	7-14
Turbidity (JTU)		0.3	4.3	8.4	4.7	4.4	6.5	4.2	7.7	6.0	5.3
Pool Elevation (1981) (meters)		538.0		537.8		537.5		537.4		536.6	

APPENDIX B

Table B-1. Mean Numbers of Food Items Per Gut for Centrarchid Bass 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
Cladocera	24.0	23.0	44.7	20.5	8.9	33.0	11.5	37.4	12.2	91.3
Copepoda	52.0	14.6	48.3	80.4	8.7	13.2	1.3	7.7	0.1	
Leptodoridae	0.5	4.3	10.6	6.3	0.1	1.8				0.4
Ostracoda	0.1	0.1	0.5			0.5			0.2	0.6
Chironomidae larvae	14.9	8.7	17.5	14.8	8.0	14.0	2.3	1.6	6.0	3.7
Chironomidae pupae	11.8	6.0	10.3	3.9	6.1	5.7	6.8	7.2	1.5	5.3
Heleidae larvae	0.1		0.4	0.5	0.9	0.2		0.1	0.1	0.2
Heleidae pupae					0.4	0.8		12.1		
Diptera adults	0.4	0.5			0.8	0.2	0.3	0.4	0.1	0.5
Diptera pupae					0.2	0.7	0.5	0.6	1.3	1.3
Hymenoptera		0.1			2.8	1.7	2.4	7.1	2.3	1.9
Araneidae					0.2	0.2		0.2	0.1	0.1
Thysanoptera						0.3	0.7	0.2	2.5	1.5
Collembolla	0.1		0.2				0.3			
Coleoptera			0.1	0.1	0.3	0.2			0.8	0.2
Hydracarina	0.1				0.1			0.1	0.5	0.5
*Miscellaneous	0.3	0.5	0.3	0.5	1.3	1.3	0.1	0.6	2.2	
Lepomis spp.			0.2		0.1		0.3	0.2	0.5	0.2
Unidentified fish	0.1	0.2	0.3	0.2	0.6	0.3	0.3	0.1	0.2	0.2

*Miscellaneous includes extremely low numbers of Ephemeroptera, Tricoptera, Odonata, Hemiptera, *Chaoborus* larvae, Decapoda and unidentified invertebrates.

VITA

William B. Kittrell, Jr., was born in Centerville, Tennessee, on October 8, 1958. He attended the public schools in that city and graduated from Hickman County High School in May 1976. The following September he entered David Lipscomb College in Nashville, Tennessee, and graduated June 1980 with a Bachelor of Science degree in Biology. From July 1980 to June 1982, Bill attended The University of Tennessee, Knoxville, and while serving as a graduate research assistant, obtained a Master of Science degree in Wildlife and Fisheries Science with an emphasis in fisheries. The author is a member of Gamma Sigma Delta, The American Fisheries Society, The Wildlife Society, and the American Institute of Biological Sciences. Bill was married to the former Betty Suzanne Hill of Knoxville, Tennessee, on June 26, 1982.