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FACTORS INFLUENCING GROWTH AND SURVIVAL OF STRIPED BASS JUVENILES IN CHEROKEE RESERVOIR, TENNESSEE

A Thesis
Presented for the
Master of Science Degree
The University of Tennessee, Knoxville

Henry G. Mealing, III
August 1989

ACKNOWLEDGEMENTS

Over the course of this study many people have given freely of their time and knowledge. Appreciation and gratitude are extended for their contributions toward the completion of this thesis.

My major professor, Dr. J. Larry Wilson, has earned a special thanks for his technical contributions, guidance, and patience. Appreciation is extended to my committee members, Drs. Thomas Hill and Richard Strange. Thanks are also extended to TWRA Biologist Douglas Peterson, who served as an adjunct member on my committee and contributed enormously throughout the project. TWRA Biologist Dave Bishop and Eagle Bend Hatchery Manager Mike Smith contributed valuable information and assistance during the project.

I would like to especially thank my fellow students who sacrificed countless hours for field collections and laboratory analyses: Jeff Durniak, Jim Habera, Mike Humphreys, Ben Nottingham, Janice Pelton, Pat Rakes, Dave Routledge, Doug Routledge, Bruce Saul, David Simms, Arnold Woodward, and LeeAnn Woodward.

Special thanks go to my wife Amy for her encouragement, patience, and endurance through this project. Thanks are also extended to my co-workers at Normandeau Associates, Southeast for their encouragement and assistance in the preparation of this thesis.

Deepest thanks are extended to Dr. Harvey L. Stirewalt of Augusta College, who encouraged my pursuit of a graduate degree. This thesis would not have been possible without his support.

ABSTRACT

Food habits, growth, and survival of two year classes of young-of-year striped bass (Morone saxatilis) stocked in Cherokee Reservoir were examined from July 1983 to June 1985. Of 82,022 striped bass stocked in 1983, 360 were recaptured. These exhibited excellent growth, reaching 27.4 cm by December of their first year. Of 118,216 striped bass stocked in 1984, 97 were recaptured. These exhibited poor growth, reaching 12.7 cm by December of their first year. Differences between the two years can be attributed to forage availability and abundance of competitiors. Also examined were four previous years of data. These data also indicated that forage availability and abundance of competitors are controlling factors in the production of strong year classes of young-of-year striped bass.

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CHAPTER I

INTRODUCTION

In 1941 the anadromous striped bass (*Morone saxatilis*) became land-locked in the Santee-Cooper River System, South Carolina. Scruggs (1955) reported that these fish could reproduce in the reservoir without contact with salt water, while Stevens (1967) determined that striped bass could thrive in fresh water, thereby creating a unique inland trophy fishery. Due to the successes achieved in South Carolina, biologists in Tennessee and other southern states have tried to establish similar striped bass fisheries.

It was soon realized that the success of this inland fishery depended upon annual introductions of striped bass fry and fingerlings (Bailey 1974). This was necessary due to limited natural reproduction of striped bass in reservoirs lacking suitable conditions necessary for egg incubation and fry survival.

Since 1964 the Tennessee Wildlife Resources Agency (TWRA) has maintained a striped bass stocking program for specified reservoirs throughout the state. The 10 reservoirs currently receiving fish are: Boone, Cherokee, Chickamauga, Kentucky, Melton Hill, Norris, Old Hickory, Percy Priest, Tims Ford, and Watts Bar. These reservoirs were chosen on the basis of (1) forage base (kg/ha), (2) available niche, (3) water quality, (4) fertility, and (5) size. The current management plan calls for the stocking of 13 striped bass fingerlings (5 to 8 cm total length) per surface hectare per year (TWRA 1982).

Since annual stockings are essential for the establishment of striped bass fisheries, study of young-of-year fish after introduction into the reservoir is necessary to provide data crucial for maximizing first year survival and growth. Previous studies in Tennessee have addressed this problem. Higginbotham's (1979) research on the growth, distribution, and food habits of young-of-year striped bass in Watts Bar Reservoir was the first of these. Similar studies have been conducted on Norris Reservoir by Richardson (1982) and on Cherokee Reservoir by Saul (1981) and Humphreys (1983). Saul's (1981) study reflected poor growth and survival of the 1979 and 1980 year classes of striped bass. In contrast, Humphreys' (1983) study reflected poor to average growth and survival of the 1981 year class followed by excellent growth and survival of the 1982 year class of striped bass.

The purpose of the present study was to continue observations of young-of-year striped bass in Cherokee Reservoir for an additional two years. It was hoped that with a total of six years of data on young-of-year striped bass, the factors that influence the establishment of strong year classes could be more completely understood. To characterize these influences and their effects, specific objectives were outlined. These were: (1) to determine growth and food habits of striped bass stocked in 1983 and 1984; (2) to examine abundance, growth, and food habits of native young-of-year predator fish that represented possible sources of competition; and (3) to assess the abundance and availability of fish and invertebrate forage species.

This study was sponsored by the Tennessee Wildlife Resources Agency with funds provided by Dingell-Johnson Project F-61. Dingell-Johnson funds are administered by the United States Fish and Wildlife Service.

CHAPTER II

LITERATURE REVIEW

The literature available on inland populations of striped bass is extensive. Much of this literature deals with the adult phase of striped bass, but a sizable portion has been devoted to the study of young-of-year. These studies have primarily dealt with growth and food habits. Other aspects addressed by some researchers have been survival of striped bass after reservoir introduction, competition of striped bass with other young-of-year predators, and effects of forage availability on striped bass.

First year growth of striped bass has been reported for several reservoirs throughout the southeast (Scruggs 1955; Stevens 1967; Ware 1970; Weaver 1975; England 1977; Higginbotham 1979; Saul 1981; Nifong 1982; Richardson 1982; Humphreys 1983). Growth rates from the Santee-Cooper Reservoir, South Carolina varied from 19.8 (Scruggs 1955) to 23.1 cm (Stevens 1967). Ware (1970) reported a first year growth of 28.2 cm for young-of-year striped bass in Florida, while England (1977) reported a first year growth of 30.2 cm in Lake Nottely, Georgia. Growth rates for young-of-year fish in Tennessee have ranged from a low of 18.2 cm in Watts Bar Reservoir (Higginbotham 1979) to a high of 30.6 cm in Cherokee

Reservoir (Humphreys 1983).

Food habits of inland young-of-year striped bass have been studied by several investigators (Huebach et al. 1963; Sandoz and Johnson 1965; Thomas 1967; Gomez 1970; Ware 1970; Humphries and Cummings 1973; Ager 1979; Axon 1979; Saul 1981; Richardson 1982; Humphreys 1983; Van Den Avyle et al. 1983). Most researchers have reported that striped bass feed on copepods and cladocerans when first introduced to the reservoir and as they grow switch to an insect and fish diet (Sandoz and Johnson 1965; Thomas 1967; Harper et al. 1968; Ware 1970; Ager 1979; Axon 1979; Richardson 1982; Humphreys 1983; Van Den Avyle et al. 1983). This has been contradicted by other investigators who have reported that fish were not important or not found in the diets of young-of-year striped bass (Huebach et al. 1963; Gomez 1970; Saul 1981).

The variations in growth, survival, and food selection from one reservoir to another and between years in the same reservoir have been attributed to one or more factors: competition with other young-of-year predators, forage availability, and size of striped bass at time of introduction (Otwell and Merriner 1975; Jenkins and Morais 1976; Ager 1979; Van Den Avyle and Higginbotham 1979; Humphreys 1983; Saul 1981; Saul et al. 1983; Van Den Avyle et al. 1983; Axon and Whitehurst 1985). Competition with white bass has been suspected in varition of growth, survival, and the creation of strong year classes of striped bass (Ager 1979; Nifong 1982; Saul 1981; Saul et al. 1983). This theory has been contradicted by Van Den Avyle and Higginbotham (1979). Prey availability has been shown to affect growth, survival, and forage selection (Axon 1979; Humphreys 1983; Saul et al. 1983). Humphreys (1983) reported that fluctuations in forage availability from year to year within the reservoir can affect striped bass. The size of fish stocked has also been a concern in relation to growth and survival of striped bass. It has been reported that striped bass exhibit better survival and growth when stocked at larger sizes (Otwell and Merriner 1975; Van Den Avyle and Higginbotham 1979; Van Den Avyle et al. 1983).

CHAPTER III

DESCRIPTION OF STUDY AREA

Cherokee Reservoir, constructed in 1941, is a multi-purpose storage impoundment created primarily for power generation and flood control. It is located approximately 96.5 km northeast of Knoxville on the mainstem of the Holston River in northeast Tennessee. It is the largest of five Tennessee Valley Authority (TVA) impoundments in the Holston River Basin (Young and Dennis 1983).

At full pool (327 meters above mean sea level) it is a 12,222 hectare reservoir with a maximum depth of 46 meters. At this level the reservoir extends 87 km upstream to John Sevier Steam Plant detention dam (Schaich and Coutant 1980). The reservior is subject to extreme water level fluctuations between summer and winter pool. Normal summer pool fluctuates between 321 to 327 m and normal minimum winter pool between 311 to 318 m (Waddle et al. 1980). During winter pool the upper section of the reservoir becomes riverine. Cherokee Reservoir has an average depth of 15 m and an average hydraulic retention time of 178 days (Young and Dennis 1983).

The drainage area for the reservoir is 8,879 km2. Watershed cover is approximately 50% forest, 26% pasture, 12% cropland, and 12% other uses. The Holston River, which drains a large part of northeast Tennessee and southwest Virginia, is the major inflow for the reservoir. Ground springs and small creeks drain the ridges surrounding the reservoir. The region is underlaid primarily by limestone, accompanied by the presence of shale and sandstone.

A heavy load of industrial, municipal, and domestic wastes are carried into Cherokee Reservoir by the Holston River (Schaich and Coutant 1980). Young and Dennis (1983) determined that 9,536 metric tons of biological oxygen demanding (BOD) material produced by aquatic macrophytes in the Holston River are carried into the reservoir annually. This amount is equal to 2.16 times the annual point source BOD loading of the basin. Cherokee has been categorized as eutrophic to hypereutrophic due to these high annual concentrations of nutrients (Heuer and Tomljanovich 1980). This eutrophic condition is especially apparent in the upper sections of the reservoir where heavy algal blooms have been observed (Schaich and Coutant 1980).

During the winter Cherokee Reservoir is generally isothermal with dissolved oxygen levels near saturation. As thermal stratification begins in March or April, dissolved oxygen levels become depleted in the hypolimnion. The use of hypolimnetic waters for power generation results in the reservoir becoming isothermal (24 C) by late summer (Young and Dennis 1983). Young and Dennis (1983) also reported that during this period dissolved oxygen concentrations below 5 to 10 m in depth are less than 1.0 mg/l. With the onset of fall turnover in late September, dissolved oxygen concentrations increase and water temperatures drop. Total water hardness in the main channel of Cherokee ranges from 95 to 125 mg/liter (Waddle et al. 1980).

CHAPTER IV

METHODS AND MATERIALS

Collection Period From July 1983 Through June 1984.

On 1 July 1983, approximately 37,100 Maryland-strain fingerling striped bass were stocked at the Quarryville access ramp, Holston River Mile (HRM) 91.5, by TWRA personnel (Table 1). Striped bass have, in previous years, experienced high survival and rapid growth when stocked at this location (Dave Bishop, TWRA, pers. commun.).

On 7 July 1983, a pre-stock evaluation to assess forage abundance and to identify potential predators and competitors was performed at five reservoir access areas to determine those best suited for additional striped bass stockings. Standard pre-stock sampling methods consisted of: (1) two quarter-hauls with a 1.2 X 6.1 m straight seine to determine forage fish present; (2) two Ekman dredge samples (232 cm^2 each) to determine benthos abundance; and (3) two 5 m horizontal tows with a 20 cm diameter plankton net (60 micra mesh) to determine zooplankton abundance. All pre-stock samples were collected after sundown.

As a result of the pre-stock analysis, approximately 45,000 Maryland-strain striped bass fingerlings were stocked at the Caney Creek access ramp (HRM 96.5)

Table 1. Fingerling and Fry Introductions into Cherokee Reservoir, 1983 - 1984.

Year	Species[1]	Date Stocked	Hatchery	Stocking Location[2]	Number Stocked	No/Kg
1983	SB (MS)	7-1	Morristown	2	37,065	174
	SB (MS)	7-15	Eagle Bend	1	44,957	95
	SH	5-26	Eagle Bend	2	30,591	245
	SH	5-31	Eagle Bend	2	41,968	277
	SH	6-22	Eagle Bend	2	27,842	341
1984	SB (CM)	7-18	Eagle Bend	2	92,664	259
	SB (MS)	8-9	Eagle Bend	3	25,552	83
	SH (Fry)	5-22	Eagle Bend	2	35,416	423
	SH	5-23	Eagle Bend	2	34,598	247
	SH (Fry)	5-24	Eagle Bend	2	23,913	500

[1]SB (MS) = striped bass Maryland-strain
SB (CM) = striped bass Cherokee/Maryland-strain
SH = *Stizostedion* hybrid

[2]1 = Caney Creek Access
2 = Quarryville Access
3 = County Line Access

on 15 July 1983. These Maryland-strain stocked fish were produced from Chesapeake Bay brood stock. Due to their demise in the Chesapeake Bay, these Maryland-strain fish have been stocked in Cherokee Reservoir by TWRA since 1981 in hopes of preserving the strain. In the event of their total disappearance from the Chesapeake Bay, a reserve of pure Maryland-strain fish would be available for reintroduction. TWRA was also interested in the effects of a completely freshwater environment on the buoyancy of the eggs produced by this strain. Due to the higher buoyancy of their egg, it was also thought that the chances of natural reproduction in Cherokee Reservoir might be increased (Dave Bishop, TWRA, pers. commun.).

Biweekly post-stock collections were begun on 7 July 1983 and continued through 17 October 1983. After this period, monthly sampling trips were undertaken from 16 November 1983 through 7 June 1984. Fish were collected from July through October with a 1.8 X 15.7 m straight seine having a mesh size of 9.5 mm. A minimum of two standard hauls at each of two to seven locations were made on each sampling trip. A standard seine haul, as described by Humphreys (1983), involved both seiners going out into water approximately 1.5 m deep. One of the seiners then walked parallel to the shore until the seine was pulled tight. At this point both seiners moved rapidly to the shore.

From 11 August 1983 through 7 June 1984, three to seven gill nets were set on each collection trip. The gill nets used were sinking nets 45.7 m long X 1.8 m deep with bar mesh sizes of 12.7, 19.1, 25.4, and 31.8 mm. These nets were anchored perpendicular to the shore and marked with buoys. A wide variety of different habitats were sampled on each trip ranging from shallow mud flats to steep rocky drop-offs. Depths sampled by gill nets ranged from 0.3 to 18.3 m deep.

Electrofishing with a boat-mounted, boom type, 230-VAC high cycle generating unit was conducted on all sampling trips. Electrofishing was primarily used in the collection of forage fishes, but striped and white bass were occasionally collected in this manner. Electrofishing for 30 minutes in a previously designated area, along with two paired quarter-hauls taken at the nearest access area, were combined to give total forage fish present.

On each collection trip at least one benthos and one zooplankton sample were taken. Collection methods were the same as previously described for pre-stock samples. All benthos and zooplankton samples were preserved in the field with 10% formalin and 50% isopropanol, respectively. All fish were preserved in the field in 10% formalin. Before preservation an incision was made through the body wall and into the gut cavity of all striped and white bass over 15 cm. This was done to aid in the preservation of stomach contents.

For post-stock collections the upper part of the reservoir, Holston River Miles (HRM) 67 to 100, was divided into five collection areas of approximately 6.5 km each. These sections were adjoining and centered around access areas located in this region of the reservoir. Access area locations were are as follows: Caney Creek (HRM 95, Section 1); Quarryville (HRM 91.5, Section 2); Fall Creek (HRM 80.7, Section 3); County Line (HRM 74.7, Section 4); and Oak Grove (HRM 70.3, Section 5) (Figure 1). Collection areas that were thought to yield the best sample of stocked fish were chosen for each sampling trip. The decisions of where to collect for each sampling trip were based on previous studies of young-of-year (YOY) striped bass in Cherokee by Saul (1981) and Humphreys (1983), personal communication with TWRA personnel, and from results of prior collection trips.

<u>Collection Period from July 1984 Through June 1985.</u>

On 18 July 1984, approximately 92,700 "Cherokee-Maryland" striped bass fingerlings (brood stock came from Maryland-strain fish stocked in Cherokee Reservoir) were stocked at the traditional stocking site of Quarryville access area by TWRA personnel. One month earlier (7 June) larval and fry shad were abundant in this area. On 17 July 1984, pre-stock collections were performed at

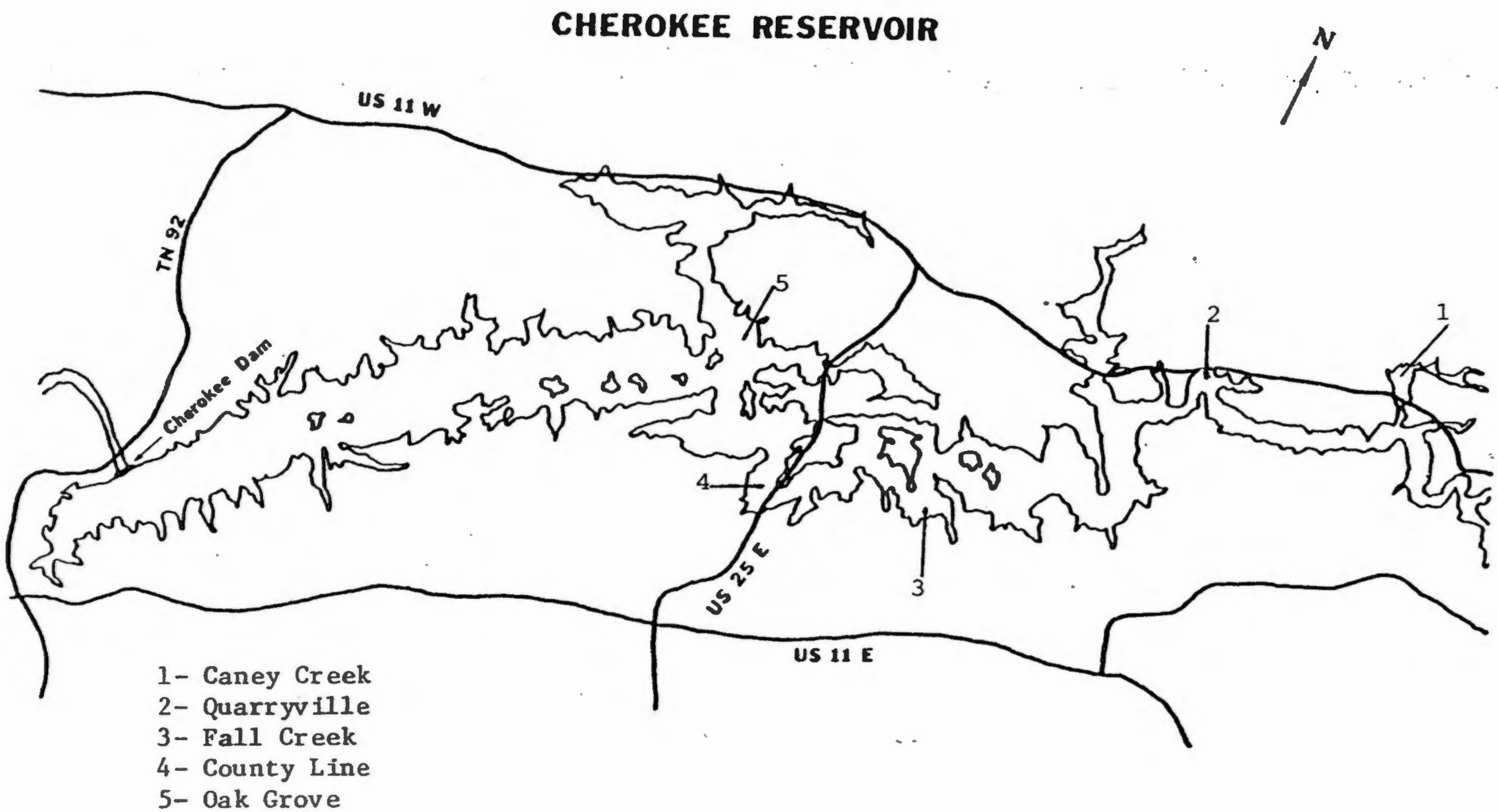


FIGURE 1. Stocking and sampling locations for striped bass and Stizostedion hybrids in Cherokee Reservoir, Tennessee.

four reservoir access areas. Pre-stock sampling was similar to the previous pre-stock collections with the addition of two standard hauls with the 15.7 m straight seine at each site. This was done to determine the abundance of competitors and predators at each site. Humphreys (1983) suggested that predation of stocked fingerling striped bass could be significant in areas with abundant predators. Due to the results of the pre-stock assessments, approximately 25,600 Maryland-strain fingerling striped bass were stocked at County Line access area on 9 August 1984.

Biweekly collections had been initiated on 31 July 1984 and alternated between the Quarryville area and the County Line area until 25 October 1984. From 13 November 1984 through 25 June 1985, monthly trips were conducted in areas thought to yield the highest number of stocked striped bass. Seining was utilized through November due to the small size of the striped bass. Gill nets were utilized from 28 August 1984 to 25 June 1985. Forage fish, zooplankton, and benthos were collected and preserved with the same methods used during the previous year; in addition, locations sampled corresponded to those sampled in 1983-84.

Food Habit Analysis

Food habits, growth, and condition of young-of-year and yearling striped bass were examined for each collection trip. When collection samples of young-of-year striped bass were above 30, a statified random subsample of 30 fish was examined. When collections were less than 30 individuals, all striped bass were examined; all yearling striped bass collected were also examined. Native white bass were also collected on these trips to determine if trends in growth and food habits were similar to those of striped bass and to detect if white bass were a possible source of competition for stocked striped bass. Of the white bass collected, a stratified random sample of 10 young-of-year fish per collection trip were examined. The age of all fishes examined for growth and food habits were verified by scale analysis.

The entire contents of the gastrointestinal (GI) tract of each fish was examined to determine food habits. All fish examined were measured to the nearest millimeter (TL) and weighed to the nearest tenth of a gram. The GI tract was severed at the esophagus and anus and removed intact from the body cavity. All attached organs and fat were removed from the exterior and the full GI tract was weighed to the nearest tenth of a gram. It was then cut open and the contents washed and scraped into a 9 X 9 cm gridded counting tray. The empty GI tract was blotted dry and reweighed. The empty weight of the GI tract was subtracted from the full weight to determine the wet weight of the contents. Gut contents were examined under a 40X dissecting microscope and food organisms were identified to the lowest practical taxon.

Total length of fishes found in the stomach contents were determined by two methods as in Humphreys' (1983) study. Fish in the early stages of digestion were measured directly. Total length of fish that were digested too much for direct measurement were estimated from measurements of the length of the veterbral column. Measurements were made from the posterior margin of the centrum of the basiocciptal bone to the anterior margin of the hypural plate. A total length by veterbral length regression line was calculated from 100 intact shad found in the stomachs. Since a majority of the fish in the stomachs were either threadfin or gizzard shad, length estimates were restricted to these two species. Using this equation, total lengths were estimated for the digested fish from their vertebral column length, and these total lengths used to calculate predator-prey length relationships (Popova 1967).

Fish and Invertebrate Forage Analysis

For benthos analysis Ekman samples were sifted through a column of standard brass Tyler sieves of 4, 8, and 16 mesh (holes per linear centimeter). All benthic organisms retained were enumerated and identified to the lowest practical taxon.

In zooplankton samples which contained few organisms (less than 1000), the entire sample was analyzed. In zooplankton samples which contained large numbers of organisms (more than 1000), subsamples were utilized for analysis. The sample was diluted to a known volume and 1 to 5 ml subsample volumes were removed with a Hensen-Stemple pipette while the diluted sample was stirred vigorously. Subsampling continued in this manner until 200 organisms had been removed and counted. The total number of organisms for the sample was then calculated from the number of organisms counted and the ratio of the volume sub-sampled to the total volume of the sample. Zooplankton and benthos samples were enumerated and identified to the lowest practical taxon using a gridded counting tray under a 40X dissecting microscope.

Forage fish samples obtained by electrofishing and seining were sorted by species and counted. All fish less than 10 cm were considered forage. The minimum and maximum sizes of each species were also recorded for each sample. TVA cove rotenone data were used to supplement forage and competitor sample data. Data from 1950 through 1984 usually consisted of 1 to 12 cove samples per year. Humphreys (1983) found that most of the coves sampled in 1981 and 1982 were located in the upper half of the reservoir. The 1983 and 1984 data were also representative of this area.

Data Analysis

Food habit and growth data were analyzed with the aid of the University of Tennessee Computing Center's Statistical Analysis Systems (SAS) 1979 software package. Graphs and other analyses were performed with an IBM-PC and the Lotus 1-2-3 software package.

The calculation of the percentages of each food item category in relation to the total numbers of food items in the diet and the frequency-of-occurrence of food items were used to examine trends in the food habit data. The percentage of each food item in relation to all food items reflected the relative abundance of each food item in the diet. The frequency-of-occurrence of food items calculated from all non-empty fish estimated the proportion of the feeding population that utilized each particular food item. In these two analyses fish were grouped by species, year class, month, length, and selected combinations of these variables. Analyses were performed on young-of-year and yearling fish separately. All fish collected before mid-May were considered to be young-of-year and after mid-May considered to be yearlings. Relative GI tract fullness, the total weight of the GI tract divided by the total weight of the fish, was also used to evaluate food habit trends.

The coefficient of condition (K) was calculated for each fish using Fulton's formula (Bagenal and Tesch 1978):

$$K = \frac{100(W)}{L^3}$$

where: W = weight in grams

L = total length in centimeters

Average condition factors were calculated for each year class of each species grouped by length class and month collected. Weight-length relationships (Ricker 1975) were calculated for each year class of each species grouped by young-of-year and yearling classification using the formula:

$$\log W = \log a + b \log L$$

where: W = weight in grams

L = total length in centimeters

a = y-intercept

b = slope

Predator-prey length relationships were calculated for striped and white bass. This was done by calculating the average total length of shad consumed by each 2.5 cm length class of predator species, and dividing by the midpoints of the corresponding predator length classes. Maximum and minimum total lengths of shad consumed by each predator length class was also recorded. The maximum prey size values were used to calculate the maximum size of shad that could be consumed by the average size predator during each month. The maximum size of shad consumed by month was then compared with the minimum size of shad from monthly forage collections of the corresponding months. The overlap of this comparison was interpreted as the range of sizes of shad that were potentially available to the average size young-of-year predator in the area sampled at the time of collection (Humphreys 1983).

Catch-per-unit-effort (CPUE) data were calculated for striped and white bass collected by three standardized methods. The units of effort were standard seine hauls, hours of electrofishing, and gill net hours. TVA cove rotenone data from 1979 through 1984 were utilized to assess the effects of forage and competitor abundance on the survival of young-of-year striped bass from year to year. T-tests were used to determine significance of differences in length, condition, and food habits between year classes, and among species of the same year class.

CHAPTER V

RESULTS AND DISCUSSION

Reservoir Conditions June 1983 Through May 1985

In 1983 TVA maintained Cherokee Reservoir water levels at higher than normal pool during the spring and summer. This inundated much shoreline vegetation, creating ideal nursery habitat for young-of-year fishes. In 1984 water levels were slightly higher than those experienced in 1983, again inundating much shoreline vegetation. The decline to normal winter pool levels was approximately the same in both years of this study.

Pre-stock Analyses

Pre-stock collections were conducted at five potential stocking locations on 7 July 1983. The results of these analyses indicated that the highest concentrations of zooplankton, benthic invertebrates, and small forage fish were present in the Caney Creek and Quarryville vicinities (Table 2). Of the two, the Quarryville area had consistently been shown to be an area of high productivity (Saul 1981; Saul and Wilson 1981; Humphreys 1983; Dave Bishop, TWRA, pers. comm.). Competitor abundance, also a factor considered in selecting a stocking location, was relatively low in both of these areas. Competitors were considered to be any young-of-year fish which might select the same food items as striped bass.

Table 2. Prestock Analyses of Zooplankton, Benthos, Forage Fish[1], and Potential Competitors[2] at Possible Stocking Sites.

Prestock Sites	Plankton per m^3	Benthos per m^2	Forage Fish per quarter-haul	Competitors per quarter-haul	Competitors per standard haul[3]
			7 July 1983		
Caney Creek	21,531	8,657	10.0	13.0	
Quarryville	13,201	3,962	13.5	7.5	
Fall Creek	3,466	2,756	1.5	34.0	
County Line	9,902	1,551	0.0	32.5	
Oak Grove	1,681	603	2.0	29.0	
			16 July 1984		
Caney Creek	182	1,292	1.5	16.5	126
Quarryville	15,985	24,248	4.5	49.5	58
Fall Creek	9,623	948	4.5	65.5	50
County Line	1,897	24,248	0.0	39.5	122

[1]All fish less than 2.5 cm

[2]All fish greater than 2.5 cm and less than 15 cm

[3]Large seine

Another factor considered was that there had been previous stockings of striped bass and Stizostedion hybrids at the Quarryville site. This investigator believed that dividing the striped bass stockings between two areas might increase survival by reducing intraspecific and interspecific competition with other stocked fishes. A decision to stock the additional striped bass in the Caney Creek area was made based on all of these factors. Therefore on 15 July approximately 45,000 striped bass were released at the Caney Creek site.

On 16 July 1984 intensive pre-stock analyses were performed at four potential stocking locations. Additional hauls with a larger seine were utilized to better assess competitor and predator abundance. The results indicated that the Quarryville site was the most suitable area, with relatively high concentrations of forage and low abundance of competitors. Shad spawning in this area had been detected earlier in the year on 16 May. Again this was verified by the presence of larval shad on 7 June. A lag time of 23 days ensued before striped bass were large enough to stock. Due to this lag period, the pre-stock analyses had lost much of their validity. The Quarryville area was ruled out since it had received previous stockings of striped bass and Stizostedion hybrids. The theory of dividing the stockings of striped between two areas to reduce intraspecific and interspecific competition was again employed; therefore the County Line site was selected. This area previously had high concentrations of benthic invertebrates and relatively low concentrations of competitors. It was also believed that the County Line area would be least affected by the reduction in water levels, which occurred during the lag period, and would still have abundant young-of-year forage. Thus approximately 25,600 striped bass were introduced at the County Line area on 9 August.

<u>Numbers Caught and Movements</u>

Of approximately 82,000 striped bass stocked in 1983, 356 were recaptured. In addition, 10 striped bass of the 1983 year class were collected during their second growing season. Most of the fish stocked in 1983 grew rapidly throughout the growing season. Gill netting was the most productive method of capture with a total of 250 fish (70%) collected in 675.1 gill net hours, yielding a relatively high catch rate of 0.37 fish per gill net hour (Table 3). Seining followed with 68 fish (19%) collected in 47 seine hauls, yielding a catch rate of 1.45 fish per seine haul. The most efficient method of collection was electrofishing with 38 fish (11%) collected in 7 hours of electrofishing yielding a catch rate of 5.43 fish per hour of electrofishing.

Of approximately 118,000 striped bass stocked in 1984, only 103 were recaptured. Individuals of the 1984 year class of striped bass grew slowly, remaining small and feeding close inshore throughout the year. This was supported by the fact that 93% of these fish were collected by shoreline electrofishing and seining. Electrofishing was the most effective method collecting 70 fish (68%) in 8.08 hours of electrofishing, producing the highest efficiency of capture with a catch rate of 8.66 fish per hour of electrofishing. Seining was second in effectiveness and efficiency with 26 striped bass (25%) collected in 84 seine hauls, yielding a catch rate of 0.31 fish per seine haul. Gill netting for 611.9 hours produced only 7 fish (7%) and a low catch rate of 0.01 fish per gill net hour. No striped bass were collected after December of 1984. Since the same collection techniques were used between years, it was believed that this decrease in catch indicated poor survival of striped bass through the winter months.

Dispersal rates of striped bass appeared to vary from year to year. Striped bass characteristically disperse rapidly after reservoir introduction (Higginbotham 1979; Richardson 1982; Saul 1981; Humphreys 1983). The 1983 striped bass fingerlings dispersed rapidly after stocking and exhibited a downstream movement throughout the year. This downstream movement was also documented by Humphreys (1983). The 1984 year class of striped bass did not disperse rapidly but tended to stay in the areas at which they had been stocked. This was shown by the capture of 76 striped bass (74% of the fish collected) on both the Quarryville and County Line ramps within 100 m of their original stocking location. Only a slight downstream movement was detected, and this was exhibited only by the larger fish. These observed differences could most probably be attributted to diet and growth. The downstream movement appears to be a response to downstream movements of shad (Humphreys 1983; Doug Peterson, TWRA, pers. commun.). As striped bass reach larger sizes and can more effectively utilize shad, it would be expected to observe this downstream movement. In years of limited striped bass fingerling growth, movements to follow shad would be expected to be minimal. These differences in growth and food habits between years will be discussed in greater detail in later sections.

Large numbers of white bass were collected in both years of the study, but an exceptionally strong year class of white bass was produced in 1984. This is supported by the higher catch and catch rates observed in 1984 (Table 3).

Condition

The mean condition factors (K) for the 1983 and 1984 year classes of striped and white bass separated by month and length class are presented in Tables 4 and 5, respectively. Although Stobo (1972) determined that preservation of fish alters their condition factor, comparisons

Table 3. Catch-Per-Unit-Effort (seining, electrofishing, and gill netting) of Striped and White Bass Grouped by Year-class and Age

Year-Class	Species[1]	Age[2]	Number Stocked	Number of Seine Hauls	Total Catch Seining	Catch/Seine Haul	Hours Electrofishing	Total Catch Electrofishing	Catch/Hour Electrofishing	Gill Net Hours	Total Catch Gill Nets	Catch/Gill Net Hour	Total Catch
1983	SB	Y-O-Y	82,022	47	68	1.45	7.0	38	5.43	675.1	250	.370	356
1983	SB	1+		87	0	0	8.58	0	0	644.6	10	.016	10
1984	SB	Y-O-Y	118,216	84	26	.31	8.08	70	8.66	611.9	7	.011	103
1983	WB	Y-O-Y		47	162	3.45	7.0	16	2.29	675.1	326	.483	504
1984	WB	Y-O-Y		84	784	9.33	8.08	207	25.62	611.9	602	.984	1593
	Total Effort			131			15.08			1287			

[1] SB = striped bass; WB = white bass

[2] Y-O-Y = young-of-year; 1+ = yearlings

Table 4. Mean Condition Factor (K), for Striped and White Bass in Each Month (July 1983-April 1985).

Year	Month	1983 Year Class Striped Bass		1984 Year Class Striped Bass		1983 Year Class White Bass		1984 Year Class White Bass	
		K	N	K	N	K	N	K	N
1983	Jul					1.24	20		
	Aug	1.10	22			1.33	20		
	Sep	1.08	20			1.34	20		
	Oct	1.10	59			1.36	20		
	Nov	1.06	11			1.20	10		
	Dec	1.18	30			1.36	10		
1984	Jan								
	Feb	1.09	25			1.33	10		
	Mar	0.96	30			1.31	10		
	Apr	1.01	9			1.17	10		
	May	0.94	5			1.02	6		
	Jun								
	Jul			0.88	5			1.19	10
	Aug			0.88	13			1.13	20
	Sep			0.86	39			1.19	20
	Oct	1.16	3	0.83	35			1.06	20
	Nov							1.02	8
	Dec			1.06	1			1.17	10
1985	Jan	1.31	1						
	Feb	1.50	3						
	Mar	1.40	1						
	Apr	1.14	2						

Table 5. Mean Condition Factors (K) for Striped and White Bass in Each Length Class Grouped by Year Class

Length Class[1]	1983 Year Class Striped Bass K	1983 Year Class Striped Bass N	1984 Year Class Striped Bass K	1984 Year Class Striped Bass N	1983 Year Class White Bass K	1983 Year Class White Bass N	1984 Year Class White Bass K	1984 Year Class White Bass N
1			0.87	22	1.24	15	1.02	5
2	1.02	6	0.81	59	1.23	9	1.05	14
3	0.98	5	1.01	5	1.29	8	1.19	12
4	1.05	26	1.07	1	1.38	9	1.15	20
5	1.14	23	1.06	2	1.37	14	1.09	14
6	1.11	32	1.01	3	1.31	32	1.14	14
7	1.08	63			1.27	33	1.20	7
8	1.04	55	1.11	1	1.30	15	1.29	2
9	1.10	35			1.42	1		
10	1.11	6						
11								
12								
13								
14								
15	1.23	1						
16	1.21	6						
17	1.50	3						

[1]Length classes (total length) are as follows:

1 = 5.1 to 7.5 cm	7 = 20.1 to 22.5 cm	13 = 35.1 to 37.5
2 = 7.6 to 10.0 cm	8 = 22.6 to 25.0 cm	14 = 37.6 to 40.0
3 = 10.1 to 12.5 cm	9 = 25.1 to 27.5 cm	15 = 40.1 to 42.5
4 = 12.6 to 15.0 cm	10 = 27.6 to 30.0 cm	16 = 42.6 to 45.0
5 = 15.1 to 17.5 cm	11 = 30.1 to 32.5 cm	17 = 45.1 to 47.5
6 = 17.6 to 20.0 cm	12 = 32.6 to 35.0 cm	

with previous studies on Cherokee Reservoir were considered valid since these fish were preserved in the same manner.

Comparisons between years were limited to 4 months and 6 length classes due to the low sample size of the 1984 year class collection. The mean condition factor of the 1983 year class of striped bass (1.08) was significantly greater ($P < 0.001$) than the mean condition factor of the 1984 year class (0.85). In all monthly comparisons (August, September, October, and December), the mean condition factors of the 1983 year class of striped bass (1.08 - 1.16) were significantly greater ($P < 0.001$) than those of the 1984 year class (0.83 - 1.06) (Table 4). When striped bass were separated by length classes, mean condition factors of length classes 2, 5, and 6 of the 1983 year class were significantly greater ($P < 0.001$) than those of the corresponding length classes of the 1984 year class. There were no significant differences detected in length classes 3 and 4 between the two years. In length class 8 the mean condition factor of the 1984 year class was significantly greater ($P < 0.001$) than that of the 1983 year class. This variation observed in the larger length classes can be attributed to small sample size of the 1984 year class (Table 5).

In comparisons with other studies of young-of-year striped bass in Cherokee Reservoir similarities can be seen. Humphreys reported mean condition factors of the 1982 year class ranging from 1.08 to 1.28. These are similar to mean condition factors observed in the 1983 year class of this study (0.94 - 1.18). Saul reported mean condition factors of the 1979 year class which ranged from 0.76 to 1.08. Humphreys also reported mean condition factors from the 1981 year class which ranged from 0.69 to 1.04. Both of these are comparable to the mean condition factors observed in the 1984 year class of this study (0.81 - 1.11) (Saul 1981; Humphreys 1983).

Upon examination, the differences between the year classes of striped bass was visually apparent. The 1983 year class appeared healthy and robust, usually having full rounded guts. The smaller length classes of the 1984 year class exhibited slightly emaciated bodies and appeared to be in poor condition. One point to note is that the few striped bass which attained larger sizes appeared to be in better condition, usually having full rounded guts. Laboratory examination of the gut cavity supported visual examinations. The 1983 year class had large deposits of visceral fat, whereas the 1984 year class only had discrete deposits of fat along the GI tract.

Similar differences in condition factors were observed between the 1983 and 1984 year classes of white bass. The mean condition factor of the 1983 year class (1.30) was significantly greater ($P < .001$) than that of the 1984 year class (1.13). In all monthly comparisons, except July, the mean condition factors of the 1983 year class were significantly greater ($P < 0.005$) than those of the 1984 year class. In the month of July, the condition factor of 1983 year class was significantly greater than the 1984 year class only at the 0.1 level. The mean condition factors of the 1983 year class steadily increased through December, but similar values for the 1984 year class tended to fluctuate from month to month (Table 4). All length class comparisons of mean conditions factors, with the exception of length classes 7 and 8, were significantly greater ($P < 0.05$) in the 1983 year class. Length class 7 of the 1983 year class was only significantly greater at the 0.1 level, and in length class 8 no significant difference between years was detected. The variations in the larger length classes can again be attributed to small sample size of the 1984 year class (Table 5).

In comparisons with other studies of young-of-year white bass in Cherokee reservoir, mean condition factors of Humphreys' 1982 year class are similar to the mean condition factors of the 1983 year class of this study. Mean condition factors of Saul's 1979 year class and Humphreys' 1981 year class are comparable to those observed in the 1984 year class of this study (Saul 1981; Humphreys 1983).

These differences between year classes of native white bass in Cherokee Reservoir reinforce Humphreys' (1983) conclusion that some environmental factors have an impact on success of white bass. It also reinforces his conclusions that there are factors other than size at stocking and time of stocking which influence differences between year classes of striped bass.

Growth

The mean monthly total lengths for the 1983 and 1984 year classes of striped bass are presented in Figure 2. The differences in growth between the two years is obvious. The monthly growth increments for the 1983 year class were relatively high through December with growth leveling off throughout the cooler months. This year class attained an average total length of 21.3 cm (N = 59) by October, and 27.9 cm (N = 9) by April. The highest monthly growth increments were observed between August and September (4.1 cm) and September and October (4.4 cm). These results were comparable but slightly lower than growth of the 1982 year class reported by Humphreys (1983). The 1983 year class growth was also similar to other young-of-year striped bass studies in the southeast (Scruggs 1955; Ware 1970; Weaver 1975; England 1977), leading to the conclusion that the 1983 year class exhibited typical growth rates.

In contrast the 1984 year class grew slowly through

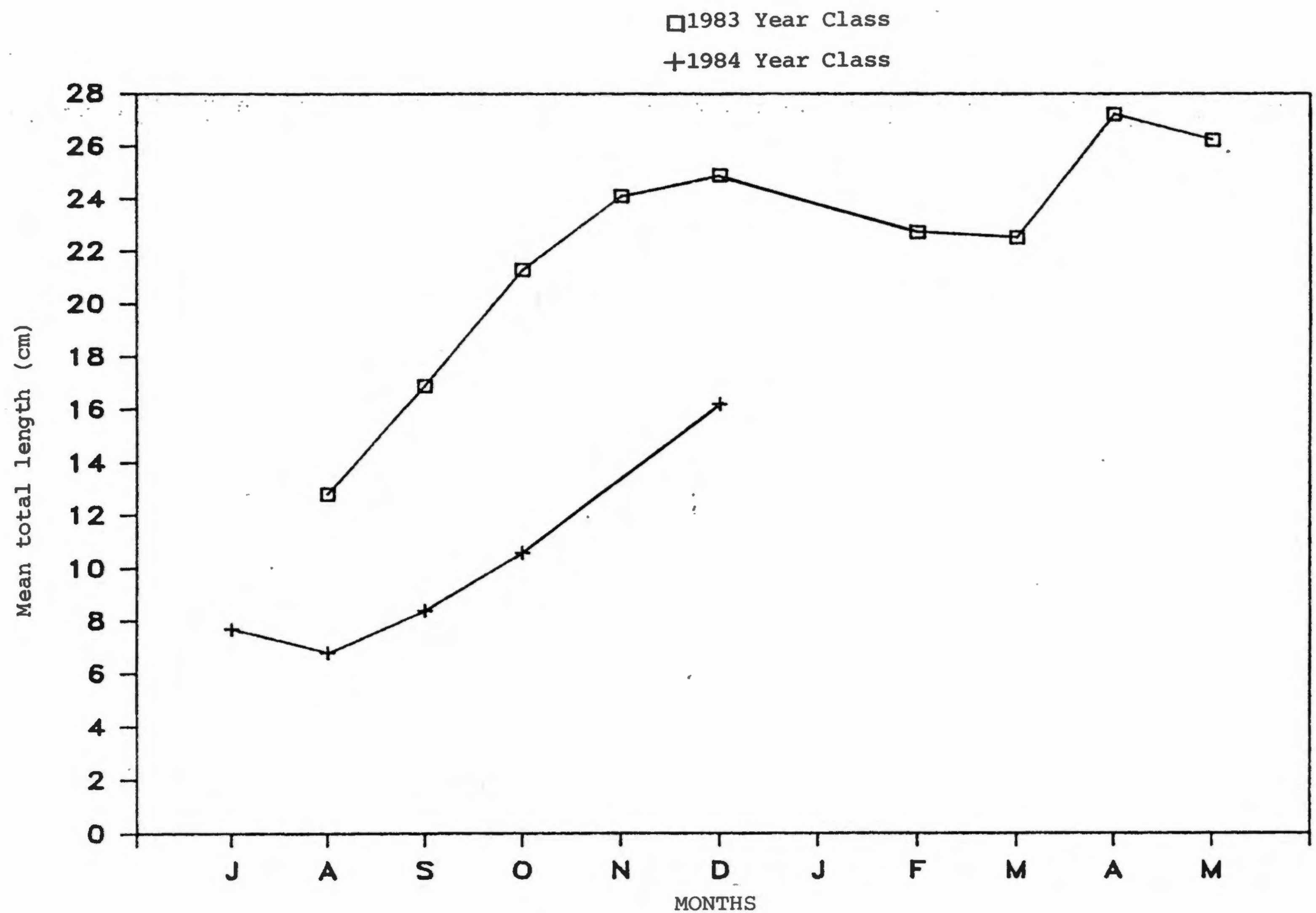


Figure 2. Mean total length of striped bass by month, 1983 and 1984 year classes.

December. These fish were stocked later and at a smaller size than the 1983 year class and remained small throughout the year. They attained an average total length of 10.6 cm (N = 35) by October and a maximum total length of 16.2 cm (N = 1) by December. This maximum size may not be representative of the entire year class due to the small sample size. These results compare closely with Humphreys' (1983) 1981 year class, which also exhibited poor growth.

T-tests revealed that the growth of the 1983 year class was significantly greater than that of the 1984 year class ($P < 0.001$). Also, in all monthly comparisons, the growth of the 1983 year class was significantly greater than that of the 1984 year class ($P < 0.001$).

Weight-length relationships calculated for the 1983 and 1984 year classes, respectively, were: $\log W = -4.62 + 3.029 \log L$ and $\log W = -5.152 + 3.178 \log L$. These relationships indicated that the 1984 year class put on more weight in proportion to length as they increased in size. This was contradictory to other results of this study, but could possibly be attributed to the small sample size of the 1984 year class. Also the larger fish collected in 1984 were not representative of the entire year class and further biased this relationship. These relationships also indicated that the 1984 fish were smaller in size. This was reflective of their small size at introduction and supported the observed growth differences between the two years.

Several studies have revealed the factors producing differences in growth between year classes of young-of-year striped bass. These factors are forage availability, size and time of stocking, and interspecific competition. Effects of low forage availability on reduced growth have also been documented (Axon 1979; Van Den Avyle 1979; Humphreys 1983). These studies reported that a reduction in forage availability could or did reduce growth rates. Van Den Avyle (1979) reported that survival and growth of young-of-year striped bass was dependent on their size at stocking and time of introduction. His recommendations were that striped bass should be stocked as large and as early as possible to minimize interspecific competion. Ager (1979) suggested that interspecific competition with white bass would reduce growth rates of striped bass in years of low forage availability. Variations in abundance of white bass would also result in years of higher interspecific competition. In the present study all three factors varied from year to year, producing the observed growth differences. A reduction in forage availability was noted from 1983 to 1984; in addition, the 1984 year class of striped bass were stocked at a smaller size and at a later date than the 1983 year class. Also observed was an increase in abundance of white bass from 1983 to 1984.

Mean monthly total lengths for the 1983 and 1984 year classes of white bass are presented in Figure 3. Growth differences between the two years were not as obvious as those observed in striped bass. The 1983 year class reached a size of 19.2 cm (N = 20) by October and 22.4 cm (N = 10) by April of the following year. These results were slightly less than lengths reported by Humphreys (1983) for the 1982 year class of young-of-year white bass. The 1984 year class was slightly smaller attaining a size of 15.3 cm (N = 20) by October and 20.3 cm (N = 10) by December. These results were similar to lengths observed in Humphreys' (1983) 1981 year class of young-of-year white bass. Both of these year classes were similar to white bass growth reported by other investigators (Forney and Taylor 1963; Yellayi and Kilambi 1975; James 1979; Saul 1981; Richardson 1982).

T-tests between years indicated that the mean length of the 1983 fish was significantly greater than that of the 1984 year class ($P < 0.001$). In monthly comparisons of September, October, and November, similar results were noted. In July the mean length of the 1984 year class was significantly greater than that of the 1983 year class ($P = 0.001$), in August no difference was detected, and in December the 1983 year class was only greater at $P < 0.1$. The greater fish growth observed in July of 1984 can be explained by the fact that July water levels in 1984 were higher than those found in July of 1983. This finding

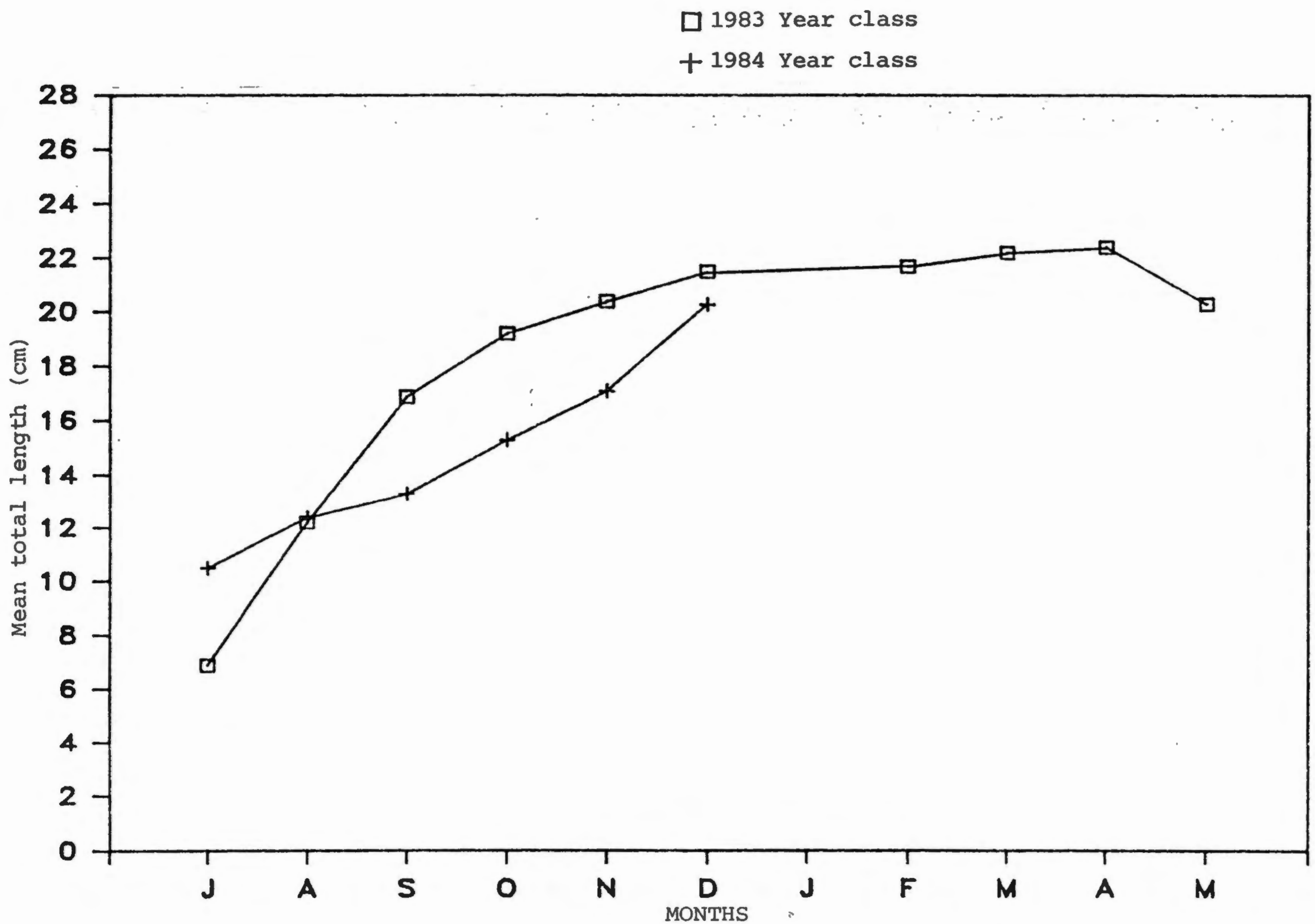


Figure 3. Mean total length of white bass by month, 1983 and 1984 year classes.

was supported by Bonn's (1952) study which reported that accelerated growth is associated with higher water levels.

Weight-length relationships calculated for the 1983 and 1984 year classes of white bass, respectively, were: $\log W = -4.429 + 3.029 \log L$ and $\log W = -4.791 + 3.115 \log L$. There was only a slight difference between the two and this could be attributed to the smaller sample size in 1984.

Variation in first year growth of white bass has been reported by other investigators (Webb and Moss 1967; Yellayi and Kilambi 1975). The reasons for these variations have been attributed to forage availabilty, intraspecific competition, and environmental factors. Reductions in availability of threadfin shad have been shown to cause reduced growth in white bass (Yellayi and Kilambi 1975; Humphreys 1983). Intraspecific competition due to year class abundance was shown to reduce growth in adult white bass by Forney and Taylor (1963). Martin (1981) reported that environmental factors such as high water levels during the spring would produce more abundant year classes of young-of-year. Yellayi and Kilambi (1975) determined that growth in the early stages of young-of-year white bass was highly vunerable to environmental changes. In this study, forage availability in 1984 was reduced, young-of-year white bass were more abundant, and higher water levels were experienced. It is probable that all three factors contributed to the reduced fish growth observed in 1984.

Food Habits

Two-hundred and twenty-two gastrointestinal tracts were examined from the 1983 year class of young-of-year striped bass and, of these, 29 were empty. Of the 10 yearling striped bass examined, only 6 contained food. Of the 92 guts examined for the 1984 year class, only 1 was empty.

The differences between the food habits of the two year classes of young-of-year striped bass were very apparent. The 1768 food items examined for the 1983 year class consisted of 32% fish, 51% insects, and 16% crustaceans. The 13,224 food items of the 1984 year class consisted of 0.3% fish, 30% insects, and 69% crustaceans (Table 6). T-tests indicated differences between years for all three major food categories. The 1983 year class ate significantly more fish ($P < 0.001$) than the 1984 year class, and the 1984 year class ate significantly more insects ($P < 0.001$) and crustaceans ($P < 0.001$) than the 1983 year class.

The fish consumed by the 1983 year class were primarily shad (96%), 81 (15%) of which could be identified as threadfin shad (*Dorosoma petenense*); the remainder (84%) were excessively digested and precluded

Table 6. Percent of Total Number of Food Items in Guts of 1983 and 1984 Year Class Young-of-Year (YOY) and Yearling (1+) Striped (SB) and White (WB) Bass.

	1983 Year Class			1984 Year Class	
Food Item Categories	YOY/SB	1+/SB	YOY/WB	YOY/SB	YOY/WB
Pisces	32.5	96.3	11.1	0.3	3.4
Dorosoma sp.	31.2	96.3	9.7	0.2	2.9
Dorosoma petenense	4.6	3.7	1.0	0.0	0.6
Dorosoma cepedianum	0.6	0.0	0.3	0.0	0.4
Unidentified *Dorosoma*	26.1	92.6	8.4	0.2	1.8
Cyprinidae	0.2	0.0	0.1	0.0	0.0
Other fish	0.1	0.0	0.2	0.0	0.0
Unidentified fish	1.0	0.0	1.0	0.1	0.5
Insecta	51.3	3.7	64.3	30.1	71.8
Diptera	50.5	0.0	63.0	29.5	70.6
Chironomidae	49.9	0.0	61.3	28.1	53.6
Chironomidae larvae	14.7	0.0	28.0	22.2	50.5
Chironomidae pupae	35.2	0.0	33.3	5.9	3.1
Chaoborus sp.	0.4	0.0	1.7	1.4	17.0
Adult Diptera	0.2	0.0	0.0	0.0	0.0
Ephemeroptera	0.6	3.7	1.0	0.2	0.6
Ephemeridae	0.5	3.7	0.8	0.1	0.5
Other Ephemeroptera	0.1	0.0	0.2	0.1	0.1
Trichoptera	0.0	0.0	0.0	0.4	0.3
Other insects	0.2	0.0	0.3	0.0	0.3
Crustacea	16.1	0.0	23.4	69.4	24.2
Cladocera	0.5	0.0	0.6	46.6	17.9
Ostracoda	0.2	0.0	0.0	0.2	0.0
Copepoda [1]	0.0	0.0	0.1	20.5	6.0
Argulus sp.	14.3	0.0	22.6	2.2	0.3
Amphipoda	1.1	0.0	0.1	0.0	0.0
Other invertebrates	0.1	0.0	1.1	0.0	0.5
Number of fish with food	222	6	122	92	77
Number of empty fish	29	4	14	1	11
Number of food items	1768	27	2023	13224	2785
Mean number of items/fish	8.0	4.5	16.6	143.7	36.2

[1]Exclusive of *Argulus* sp.

identification to species. The small number of fish consumed by the 1984 year class was primarily unidentified Dorosoma (67%). These percentages definitely indicated the importance of shad over other fish in the diets of both year classes.

The insects consumed by the 1983 year class were primarily Chironomidae (97%), most of which were pupae (70%) and larvae (29%). In contrast, the insects consumed by the 1984 year class also consisted primarily of Chironomidae (93%), with larvae (79%) being much more abundant than pupae (21%). Although the selection of chironomid pupae and larvae varied between the two years, it could be seen that Chironomidae were more important than other insects in the diets of both year classes.

Crustaceans consumed by the 1983 year class were dominated by the large parasitic copepod Argulus (89%), but some amphipods were also consumed (7%). The crustaceans ingested by the 1984 year class were primarily cladocerans (67%) and copepods (29%), but again some Argulus were found (3%). These results were variable and suggests that selection of crustaceans may have been dependent on their relative abundance in areas where striped bass were feeding.

From the mean number of food items per fish one can see that the 1984 year class of striped bass (143.7) consumed significantly more organisims ($P < 0.001$) than the 1983 year class. This would indicate that the 1984 year class had to eat more food items than the 1983 year class to maintain an adequate diet for proper growth. This also suggests that the 1983 year class striped bass were able to utilize larger prey than the 1984 year class and were able to feed less often. In the study of predator-prey relationships of the northern pike, Hart and Connellan (1984) reported low growth was associated with consumption of small "low-benefit" prey. They also stated that growth rates increased when "optimal size" prey were taken. This could have direct application to the observed condition and growth differences between the two year classes.

Food items consumed by the 1983 year class yearling striped bass consisted primarily of shad (96%). Of these shad only 4% were positively identified as threadfin shad; the remaining 96% were unidentified shad. Insects (3.7%) were represented in the diet by one Hexagenia which was found in the gut of one fish. These results indicated that the diet of yearling striped bass consisted primarily of shad.

Frequencies of occurrence of food items in the guts of fishes are presented in Table 7. Frequency of occurrence was used to ascertain percentages of utilization of each food category by the feeding population. With this analysis items that were consumed in low numbers but were utilized by large portions of the populations could be

Table 7. Frequency of Occurrence (%) of Food Items in Guts of 1983 and 1984 Year Class Young-of-Year (YOY) and Yearling (1+) Striped (SB) and White (WB) Bass.

	1983 Year Class			1984 Year Class	
Food Item Categories	YOY/SB	1+/SB	YOY/WB	YOY/SB	YOY/WB
Pisces	83	83	66	26	66
Dorosoma sp.	81	83	62	13	51
Dorosoma petenense	20	17	12	1	15
Dorosoma cepedianum	4	0	5	4	14
Unidentified *Dorosoma*	74	83	54	11	40
Cyprinidae	1	0	2	2	0
Other fish	0	0	2	0	1
Unidentified fish	7	0	11	12	17
Insecta	37	17	64	93	57
Diptera	36	0	61	93	53
Chironomidae	34	0	60	93	51
Chironomidae larvae	24	0	50	91	44
Chironomidae pupae	21	0	43	83	42
Chaoborus sp.	2	0	7	19	18
Adult Diptera	1	0	0	3	1
Ephemeroptera	4	17	10	13	10
Ephemeridae	3	17	7	8	9
Other Ephemeroptera	1	0	2	5	1
Trichoptera	0	0	0	21	8
Other insects	1	0	3	3	4
Crustacea	4	0	16	85	23
Cladocera	1	0	3	72	14
Ostracoda	1	0	0	13	0
Copepoda [1]	0	0	1	64	14
Argulus sp.	4	0	13	21	6
Amphipoda	2	0	2	0	0
Other invertebrates	1	0	16	5	13
Number of fish with food	222	6	122	92	77
Number of empty fish	29	4	14	1	11

[1] Exclusive of *Argulus* sp.

detected. The data again indicated the importance of shad in the diet of the 1983 year class, with shad occurring in 81% of the striped bass that contained food. Even though numbers of chironomid pupae ingested were three times that of chironomid larvae, it can be seen that chironomid pupae (24%) and larvae (21%) were consumed by a similar number of striped bass in the 1983 year class. It was also observed that all striped bass that consumed crustaceans contained Argulus.

Although fish appeared to be of little importance to the 1984 year class, 26% of all striped bass containing food consumed fish, with 13% of striped bass consuming shad. This suggested that fish were more important to the 1984 year class than previously indicated by percent-of- total-number values. The presence of insects in 93% of the striped bass containing food also suggested that they were more important than indicated by percent-of-total-number data. For the most part frequencies of occurrence of crustaceans coincided with the results of percent-of-total-number. The exceptions were Argulus and ostracods, which were consumed in small numbers, but occurred in 21% and 13%, respectively, of the striped bass containing food.

Frequencies of occurrence for the yearling striped bass of the 1983 year class were reflective of the percent-of-total-number data. These data also pointed out the predominance of shad in the diet (83%). It should again be pointed out that the relatively high consumption value for insects (17%) was the result of one fish consuming one Hexagenia.

The data presented in Tables 6 and 7 were grouped by month of capture and by 2.5 cm length classes to examine trends in the food habits associated with season and fish size. The percent-of-total-number and frequency-of-occurrence analyses for the 1983 year class, grouped by month of capture, are presented in Tables 8 and 9. The analyses indicated that fish occurred as a food item in every month, and these fish were primarily shad. Of the shad that could be identified, threadfin were predominant. The percent of fish in the diet increased from introduction through December to 100%, but at that point began a slight decline (Table 8). Occurrence of shad in the diet was at least 83% through February, but then decreased more as time progressed (Table 9). This trend was most likely due to a reduction in availability of shad during the winter months.

Insects as food items occurred in 9 of the 10 months examined, with Chironomidae being the most abundant in all months. They slowly decreased by number and frequency through February and dramatically increased in March. The reduction in the fall and winter was probably due to the higher consumption of fish and also to decreasing chironomid abundance during this time. Due to the

Table 8. Percent of Total Numbers of Food Items in Guts of 1983 Year Class Young-of-Year Striped Bass, Grouped by Month.

Food Item Categories	Months J	A	S	O	N	D	J	F	M	A	M
Pisces		49.2	68.3	93.3	66.7	100.0		72.7	11.6	13.8	0.1
Dorosoma sp.		46.3	62.0	93.3	66.7	100.0		63.6	8.6	13.8	0.1
Dorosoma petenense		4.5	4.6	13.0	0.0	28.8		9.1	0.6	0.0	0.0
Dorosoma cepedianum		0.0	0.8	1.4	0.0	2.3		0.0	0.6	0.0	0.0
Unidentified *Dorosoma*		41.8	56.5	78.8	66.7	68.9		54.5	7.4	13.8	0.0
Cyprinidae		0.0	0.4	0.0	0.0	0.0		0.0	1.8	0.0	0.0
Other fish		0.0	0.0	0.4	0.0	0.0		0.0	0.0	0.0	0.0
Unidentified fish		3.0	5.5	0.0	0.0	0.0		9.1	1.2	0.0	0.0
Insecta		49.2	28.3	6.7	33.3	0.0		18.2	87.7	86.2	67.9
Diptera		40.3	26.6	6.2	33.3	0.0		18.2	87.7	86.2	67.7
Chironomidae		29.8	26.6	5.8	33.3	0.0		18.2	86.5	86.2	67.7
Chironomidae larvae		26.9	24.5	0.0	0.0	0.0		18.2	68.1	10.3	7.5
Chironomidae pupae		3.0	2.1	5.8	33.3	0.0		0.0	18.4	75.9	60.2
Chaoborus sp.		6.0	0.0	0.5	0.0	0.0		0.0	1.2	0.0	0.0
Adult Diptera		4.5	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Ephemeroptera		8.9	1.7	0.0	0.0	0.0		0.0	0.0	0.0	0.1
Ephemeridae		8.9	1.3	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Other Ephemeroptera		0.0	0.4	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Trichoptera		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Other insects		0.0	0.0	0.5	0.0	0.0		0.0	0.0	0.0	0.1
Crustacea		1.5	2.9	0.0	0.0	0.0		9.1	0.0	0.0	31.9
Cladocera		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.1
Ostracoda		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.5
Copepoda [1]		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Argulus sp.		1.5	2.9	0.0	0.0	0.0		9.1	0.0	0.0	28.1
Amphipoda		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	2.3
Other invertebrates		0.0	0.4	0.0	0.0	0.0		0.0	0.6	0.0	0.0
Number of fish with food		21	57	56	9	30		6	29	9	5
Number of empty fish		1	3	3	2	0		19	1	0	0
Number of food items		67	237	208	27	132		11	163	58	864
Mean number of items/fish		3.2	4.1	3.7	3.0	4.4		1.8	5.6	6.4	173.0

[1]Exclusive of *Argulus* sp.

Table 9. Frequency of Occurrence (%) of Food Items in Guts of 1983 Year Class Young-of-Year Striped Bass, Grouped by Month.

	Months										
Food Item Categories	J	A	S	O	N	D	J	F	M	A	M
Pisces		90	95	89	100	100		83	38	55	20
<u>Dorosoma</u> sp.		86	91	89	100	100		67	31	55	20
<u>Dorosoma petenense</u>		14	16	30	0	47		17	3	0	0
<u>Dorosoma cepedianum</u>		0	3	5	0	10		0	3	0	20
Unidentified <u>Dorosoma</u>		81	82	87	10	90		51	28	55	0
Cyprinidae		0	2	0	0	0		0	7	0	0
Other fish		0	2	0	0	0		0	0	0	0
Unidentified fish		9	8	0	0	0		17	7	0	0
Insecta		57	28	16	55	0		17	90	100	100
Diptera		48	26	14	55	0		17	90	100	100
Chironomidae		38	26	12	55	0		17	90	100	100
Chironomidae larvae		28	24	0	0	0		17	83	44	80
Chironomidae pupae		9	7	12	55	0		0	48	100	100
<u>Chaoborus</u> sp.		9	0	2	0	0		0	7	0	0
Adult Diptera		9	0	0	0	0		0	0	0	0
Ephemeroptera		19	5	0	0	0		0	0	0	20
Ephemeridae		19	5	0	0	0		0	0	0	0
Other Ephemeroptera		0	2	0	0	0		0	0	0	20
Trichoptera		0	0	0	0	0		0	0	0	0
Other insects		0	0	2	0	0		0	0	0	20
Crustacea		5	5	0	0	0		17	0	0	80
Cladocera		0	0	0	0	0		0	0	0	60
Ostracoda		0	0	0	0	0		0	0	0	40
Copepoda [1]		0	0	0	0	0		0	0	0	0
<u>Argulus</u> sp.		5	5	0	0	0		17	0	0	80
Amphipoda		0	0	0	0	0		0	0	0	80
Other invertebrates		0	2	0	0	0		0	3	0	0
Number of fish with food		21	57	56	9	30		6	29	9	5
Number of empty fish		1	3	3	2	0		19	1	0	0

[1]Exclusive of <u>Argulus</u> sp.

reduction of shad available as forage in the winter and spring, the striped bass were obviously forced to switch back to available insects as their primary forage.

Crustaceans occurred in guts in only 4 of the 10 months examined and were primarily Argulus in all months except May. Crustaceans were consumed at low levels throughout most of the year, but increased dramatically in May. This no doubt was also due to forage availabilty. With the onset of warmer temperatures and rising water levels, crustaceans became more abundant. This abundance, coupled with the reduction of shad availability, resulted in the observed increases of crustaceans in the diet.

The mean number of items per fish remained below 7 through April, but suddenly increased to 173 in May. This was due to the diet of insects and crustaceans during May. As previously discussed the striped bass were forced to eat a larger quantity of food items to maintain an adequate diet. In May there was also a reduction in growth rate and condition. This reduction in growth rate could be attributed to the presence of low-benefit prey in the diet. Striped bass were obviously feeding on prey below the optimal size resulting in the reduced growth rates observed. Adams (1982) suggested that to survive through the spring stress period of low prey abundance, predators must find adequately sized prey or must use their energy reserves. Since adequately sized prey were obviously not available, striped bass had to use their stored fat causing the reduction in condition factor.

Percent-of-total-number and frequency-of-occurrence analyses for the food habits of the 1984 year class, grouped by month of capture, are presented in Tables 10 and 11. The data indicated that fish occurred in the diet of the 1984 year class in all months examined. Fish occurred in low numbers and frequencies through November, but increased dramatically in December. The data for December came from one exceptionally large striped bass that contained one shad. Shad entered the diet in September and were present through December. Of the shad that could be identified, gizzard shad were predominant. This seemed contradictory since gizzard shad grow faster than threadfin and the 1984 year class of striped bass were small in size. This contradiction was explained by the fact that a second spawn of gizzard shad occurred in August, thus making them more available than threadfin due to their smaller size. No consistent patterns in the food habits like those of the 1983 year class were detected. This was attributed to the fact that the data collected did not include any samples beyond December.

Insects occurred in the food items consumed during all months examined, with Chironomidae again being the most abundant by number and frequency. Insects were

Table 10. Percent of Total Numbers of Food Items in Guts of 1984 Year Class Young-of-Year Striped Bass, Grouped by Month.

Food Item Categories	Months J	A	S	O	N	D
Pisces	0.5	0.2	0.3	0.4		33.3
Dorosoma sp.	0.0	0.0	0.1	0.4		33.3
Dorosoma petenense	0.0	0.0	0.0	0.0		0.0
Dorosoma cepedianum	0.0	0.0	0.1	0.0		0.0
Unidentified Dorosoma	0.0	0.0	0.1	0.3		33.3
Cyprinidae	0.0	0.0	0.0	0.0		0.0
Other fish	0.0	0.0	0.0	0.0		0.0
Unidentified fish	0.5	0.2	0.1	0.0		0.0
Insecta	15.6	55.4	22.9	32.9		33.3
Diptera	14.8	55.0	22.1	32.6		33.3
Chironomidae	9.9	50.0	20.9	32.4		33.3
Chironomidae larvae	8.4	45.9	17.1	22.4		0.0
Chironomidae pupae	1.5	4.0	3.8	10.0		33.3
Chaoborus sp.	4.9	5.0	1.2	0.1		0.0
Adult Diptera	0.0	0.0	0.0	0.1		0.0
Ephemeroptera	0.7	0.3	0.2	0.1		0.0
Ephemeridae	0.7	0.3	0.1	0.0		0.0
Other Ephemeroptera	0.0	0.0	0.2	0.1		0.0
Trichoptera	0.0	0.1	0.6	0.2		0.0
Other insects	0.0	0.0	0.0	0.0		0.0
Crustacea	83.9	44.3	76.7	66.6		0.0
Cladocera	5.7	1.8	55.2	53.7		0.0
Ostracoda	0.0	0.0	0.2	0.3		0.0
Copepoda [1]	22.5	40.2	20.9	12.6		0.0
Argulus sp.	55.7	2.2	0.4	0.1		0.0
Amphipoda	0.0	0.0	0.0	0.0		0.0
Other invertebrates	0.0	0.1	0.0	0.0		33.3
Number of fish with food	5	13	39	34		1
Number of empty fish	0	0	0	1		0
Number of food items	404	1629	6651	4537		3
Mean number of items/fish	80.8	125.3	170.5	133.4		3.0

[1]Exclusive of Argulus sp.

Table 11. Frequency of Occurrence (%) of Food Items in Guts of 1984 Year Class Young-of-Year Striped Bass, Grouped by Month.

Food Item Categories	Months J	A	S	O	N	D
Pisces	20	23	28	23		100
Dorosoma sp.	0	0	10	21		100
Dorosoma petenense	0	0	0	3		0
Dorosoma cepedianum	0	0	8	3		0
Unidentified *Dorosoma*	0	0	8	18		100
Cyprinidae	0	0	5	0		0
Other fish	0	0	0	0		0
Unidentified fish	20	23	15	3		0
Insecta	100	100	95	88		100
Diptera	100	100	95	88		100
Chironomidae	100	100	95	88		100
Chironomidae larvae	100	100	92	88		0
Chironomidae pupae	60	85	87	79		100
Chaoborus sp.	40	38	18	12		0
Adult Diptera	0	0	0	9		0
Ephemeroptera	60	23	8	9		0
Ephemeridae	60	23	3	0		0
Other Ephemeroptera	0	0	5	9		0
Trichoptera	0	15	20	26		0
Other insects	0	3	0	6		0
Crustacea	60	85	87	88		0
Cladocera	60	8	82	88		0
Ostracoda	0	8	20	12		0
Copepoda [1]	20	54	64	76		0
Argulus sp.	60	54	15	9		0
Amphipoda	0	0	0	0		0
Other invertebrates	0	8	5	3		100
Number of fish with food	5	13	39	34		1
Number of empty fish	0	0	0	1		0

[1]Exclusive of *Argulus* sp.

ingested in relatively low numbers, but occurred in at least 88 % of the striped bass each month. This indicated that they were very important to the diet. Crustaceans consisting primarily of cladocerans, copepods, and Argulus occurred in all months except December. Although consumed in large numbers, the highest frequency-of-occurrence of crustaceans was only 88%.

The mean number of items per fish remained high in all months except December. The majority of the 1984 year class of striped bass was forced to consume large quantities of low-benefit prey items throughout the year which resulted in the low growth rates and condition factors. The one exception in the 1984 year class was a striped bass collected in December which exhibited good growth and condition. This was the result of a piscivorous diet that included optimal size prey.

Analyses of percent-of-total-number and frequency-of-occurrence data for the 1983 year class of striped bass, grouped by length class, are presented in Tables 12 and 13. Since fish size was a function of time, trends in food habits by length class were similar to monthly analyses of food habits. The data indicated that at length class 4 (12.6 to 15.0 cm) fish became more important (in number) in the diet than insects and crustaceans. Also at length class 4, the frequency of striped bass that selected fish was twice that of striped bass that selected insects. It was at this size that striped

Table 12. Percent of Total Numbers of Food Items in Guts of 1983 Year Class Young-of-Year Striped Bass, Grouped by Length Class.

Food Item Categories	Length Classes[1] 1	2	3	4	5	6	7	8	9	10
Pisces		33.3	26.7	52.7	71.1	95.8	71.3	50.3	8.4	25.0
Dorosoma sp.		23.8	20.0	44.5	66.1	93.7	69.8	50.3	8.4	25.0
Dorosoma petenense		0.0	6.7	2.7	4.9	14.7	5.7	12.7	2.2	0.0
Dorosoma cepedianum		0.0	0.0	0.0	0.8	0.0	1.4	1.6	0.2	5.0
Unidentified Dorosoma		23.8	13.3	41.8	60.3	78.9	62.7	35.9	6.0	20.0
Cyprinidae		9.5	6.7	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Other fish		0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Unidentified fish		0.0	0.0	8.2	4.9	0.0	1.4	0.0	0.0	0.0
Insecta		61.9	40.0	44.5	28.1	4.2	28.7	49.2	63.8	75.0
Diptera		61.9	33.3	40.0	24.8	3.1	28.2	49.2	63.6	75.0
Chironomidae		52.4	33.3	35.4	24.8	3.1	27.7	48.1	63.6	75.0
Chironomidae larvae		47.6	20.0	34.5	21.5	3.1	15.8	36.5	8.1	0.0
Chironomidae pupae		4.8	13.3	0.9	3.3	0.0	12.0	11.6	55.5	75.0
Chaoborus sp.		0.0	0.0	3.6	0.0	0.0	0.5	1.1	0.0	0.0
Adult Diptera		9.5	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Ephemeroptera		0.0	6.7	3.6	3.3	1.0	0.0	0.0	0.1	0.0
Ephemeridae		0.0	6.7	2.7	3.3	1.0	0.0	0.0	0.0	0.0
Other Ephemeroptera		0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.1	0.0
Trichoptera		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other insects		0.0	0.0	0.9	0.0	0.0	0.5	0.0	0.1	0.0
Crustacea		4.8	26.7	1.8	0.8	0.0	0.0	0.5	27.7	0.0
Cladocera		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0
Ostracoda		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Copepoda [2]		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Argulus sp.		4.8	26.7	1.8	0.8	0.0	0.0	0.5	24.4	0.0
Amphipoda		0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
Other invertebrates		0.0	6.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Number of fish with food		6	5	25	23	30	53	42	33	5
Number of empty fish		0	0	1	0	2	10	13	2	1
Number of food items		21	15	110	121	95	209	181	996	20
Mean number of items/fish		3.5	3.0	4.4	5.3	3.2	3.9	3.5	30.2	4.0

[1]Length classes (total length) are as follows:

1 = 5.1 to 7.5 cm	4 = 12.6 to 15.0 cm	7 = 20.1 to 22.5 cm
2 = 7.6 to 10.0 cm	5 = 15.1 to 17.5 cm	8 = 22.6 to 25.0 cm
3 = 10.1 to 12.5 cm	6 = 17.6 to 20.0 cm	9 = 25.1 to 27.5 cm
		10 = 27.6 to 30.0 cm

[2]Exclusive of Argulus sp.

Table 13. Frequency of Occurrence (%) of Food Items in Guts of 1983 Year Class Young-of-Year Striped Bass, Grouped by Length Class.

Food Item Categories	Length Classes[1]									
	1	2	3	4	5	6	7	8	9	10
Pisces		67	80	96	96	97	79	76	72	60
Dorosoma sp.		50	60	88	91	97	77	76	73	60
Dorosoma petenense		0	20	8	26	27	17	24	27	0
Dorosoma cepedianum		0	0	0	4	0	6	7	6	20
Unidentified *Dorosoma*		50	40	88	83	93	74	67	67	40
Cyprinidae		17	20	0	0	3	0	0	0	0
Other fish		0	0	0	0	3	0	0	0	0
Unidentified fish		0	0	32	17	0	6	0	0	0
Insecta		67	80	44	39	10	34	38	39	100
Diptera		67	80	44	30	7	32	38	39	100
Chironomidae		50	80	40	30	7	30	38	39	100
Chironomidae larvae		33	40	36	30	7	13	31	33	0
Chironomidae pupae		17	40	4	13	0	24	24	33	100
Chaoborus sp.		0	0	8	0	0	2	5	0	0
Adult Diptera		17	0	4	0	0	0	0	0	0
Ephemeroptera		0	20	8	13	3	0	0	3	0
Ephemeridae		0	20	8	13	3	0	0	0	0
Other Ephemeroptera		0	0	4	0	0	0	0	3	0
Trichoptera		0	0	0	0	0	0	0	0	0
Other insects		0	0	0	0	0	0	0	3	0
Crustacea		17	20	4	4	0	0	2	12	0
Cladocera		0	0	0	0	0	0	0	9	0
Ostracoda		0	0	0	0	0	0	0	6	0
Copepoda[2]		0	0	0	0	0	0	0	0	0
Argulus sp.		17	20	4	4	0	0	2	12	0
Amphipoda		0	0	0	0	0	0	0	12	0
Other invertebrates		0	20	4	0	0	0	0	0	0
Number of fish with food		6	5	25	23	30	53	42	33	5
Number of empty fish		0	0	1	0	2	10	13	2	1

[1]Length classes (total length) are as follows:

1 = 5.1 to 7.5 cm; 2 = 7.6 to 10.0 cm; 3 = 10.1 to 12.5 cm; 4 = 12.6 to 15.0 cm; 5 = 15.1 to 17.5 cm; 6 = 17.6 to 20.0 cm; 7 = 20.1 to 22.5 cm; 8 = 22.6 to 25.0 cm; 9 = 25.1 to 27.5 cm; 10 = 27.6 to 30.0 cm

[2]Exclusive of *Argulus* sp.

bass appeared to switch primarily to shad. This compared closely with Humphreys' (1983) findings. The mean number of food items per fish remained relatively low (less than 5.3) in all length classes except length class 9 (30.2). Condition factors of length class 9 were relatively high (1.11) even though the striped bass consumed less than optimal size prey.

Analyses of percent-of-total-number and frequency-of-occurrence for the 1984 year class of striped bass, grouped by length class, are presented in Tables 14 and 15. Trends in the food habits of the 1984 year class were more apparent when the data were grouped by length class. The data for the 1984 year class also indicated that shad became more important in the diet by number at length class 4. The frequency-of-occurrence values indicated a stronger tendency for selection of shad at length class 3 (10.1 to 12.5 cm). This switch to fish at approximately 10 cm compared closely with Ager's (1979) findings. It can also be seen that the smaller fish of length classes 1 and 2 consumed primarily insects and crustaceans while fish of length classes 3 through 6 consumed primarily fish and insects. The mean numbers of food items per fish was very high in length classes 1 and 2, 159.6 and 163.5, respectively. This would explain the low condition factors observed for these two groups. The mean numbers of food items per fish in length classes 3

Table 14. Percent of Total Numbers of Food Items in Guts of 1984 Year Class Young-of-Year Striped Bass, Grouped by Length Class.

	Length Classes[1]							
Food Item Categories	1	2	3	4	5	6	7	8
Pisces	0.1	0.1	27.5	100.0	66.7	100.0		
Dorosoma sp.	0.0	0.0	17.5	100.0	66.7	100.0		
Dorosoma petenense	0.0	0.0	0.0	0.0	0.0	8.3		
Dorosoma cepedianum	0.0	0.0	7.5	50.0	0.0	0.0		
Unidentified *Dorosoma*	0.0	0.0	10.0	50.0	66.7	91.7		
Cyprinidae	0.0	0.0	0.0	0.0	0.0	0.0		
Other fish	0.0	0.0	0.0	0.0	0.0	0.0		
Unidentified fish	0.1	0.1	10.0	0.0	0.0	0.0		
Insecta	36.0	28.0	55.0	0.0	16.7	0.0		
Diptera	35.6	27.3	55.0	0.0	16.7	0.0		
Chironomidae	32.6	26.4	55.0	0.0	16.7	0.0		
Chironomidae larvae	28.6	19.8	35.0	0.0	0.0	0.0		
Chironomidae pupae	4.0	6.6	20.0	0.0	16.7	0.0		
Chaoborus sp.	3.0	0.8	0.0	0.0	0.0	0.0		
Adult Diptera	0.0	0.0	0.0	0.0	0.0	0.0		
Ephemeroptera	0.1	0.2	0.0	0.0	0.0	0.0		
Ephemeridae	0.1	0.0	0.0	0.0	0.0	0.0		
Other Ephemeroptera	0.0	0.2	0.0	0.0	0.0	0.0		
Trichoptera	0.3	0.5	0.0	0.0	0.0	0.0		
Other insects	0.0	0.0	0.0	0.0	0.0	0.0		
Crustacea	63.8	72.0	17.5	0.0	0.0	0.0		
Cladocera	33.4	51.6	15.0	0.0	0.0	0.0		
Ostracoda	0.1	0.2	0.0	0.0	0.0	0.0		
Copepoda [2]	28.9	17.6	0.0	0.0	0.0	0.0		
Argulus sp.	1.4	2.5	2.5	0.0	0.0	0.0		
Amphipoda	0.0	0.0	0.0	0.0	0.0	0.0		
Other invertebrates	0.1	0.0	0.0	0.0	16.7	0.0		
Number of fish with food	22	59	5	1	2	3		0
Number of empty fish	0	0	0	0	0	0		1
Number of food items	3512	9650	40	4	6	12		0
Mean number of items/fish	159.6	163.5	8.0	4.0	3.0	4.0		0.0

[1]Length classes (total length) are as follows:

1 = 5.1 to 7.5 cm　4 = 12.6 to 15.0 cm　7 = 20.1 to 22.5 cm

2 = 7.6 to 10.0 cm　5 = 15.1 to 17.5 cm　8 = 22.6 to 25.0 cm

3 = 10.1 to 12.5 cm　6 = 17.6 to 20.0 cm

[2]Exclusive of *Argulus* sp.

Table 15. Frequency of Occurrence (%) of Food Items in Guts of 1984 Year Class Young-of-Year Striped Bass, Grouped by Length Class.

Food Item Categories	Length Classes[1] 1	2	3	4	5	6	7	8
Pisces	14	17	100	100	100	100		
Dorosoma sp.	0	4	80	100	100	100		
Dorosoma petenense	0	0	0	0	0	33		
Dorosoma cepedianum	0	0	60	100	0	0		
Unidentified *Dorosoma*	0	3	40	100	100	100		
Cyprinidae	0	3	0	0	0	0		
Other fish	0	0	0	0	0	0		
Unidentified fish	14	10	40	0	0	0		
Insecta	100	100	80	0	50	0		
Diptera	100	100	80	0	50	0		
Chironomidae	100	100	80	0	50	0		
Chironomidae larvae	100	100	60	0	0	0		
Chironomidae pupae	86	88	80	0	50	0		
Chaoborus sp.	41	15	0	0	0	0		
Adult Diptera	0	5	0	0	0	0		
Ephemeroptera	18	13	0	0	0	0		
Ephemeridae	18	5	0	0	0	0		
Other Ephemeroptera	0	8	0	0	0	0		
Trichoptera	23	24	0	0	0	0		
Other insects	0	2	0	0	0	0		
Crustacea	91	95	40	0	0	0		
Cladocera	45	93	20	0	0	0		
Ostracoda	18	15	0	0	0	0		
Copepoda [2]	64	76	0	0	0	0		
Argulus sp.	36	17	20	0	0	0		
Amphipoda	0	0	0	0	0	0		
Other invertebrates	9	3	0	0	50	0		
Number of fish with food	22	59	5	1	2	3		0
Number of empty fish	0	0	0	0	0	0		1

[1]Length classes (total length) are as follows:

1 = 5.1 to 7.5 cm   4 = 12.6 to 15.0 cm   7 = 20.1 to 22.5 cm
2 = 7.6 to 10.0 cm   5 = 15.1 to 17.5 cm   8 = 22.6 to 25.0 cm
3 = 10.1 to 12.5 cm   6 = 17.6 to 20.0 cm

[2]Exclusive of *Argulus* sp.

through 6 were much lower (< 8.0). Again this would explain the higher condition factors exhibited by these groups. These larger fish were apparently able to consume more suitable prey of the optimal size.

The total wet weight of the gut content was expressed as a percentage of the total weight of the fish to obtain relative gut content fullness. The mean percentages for the 1983 and 1984 year classes of non-empty young-of-year striped bass were 3.61 and 3.73, respectively. No significant difference was detected between the means of the two year classes. The percent weights of gut contents, grouped by month, are presented in Table 16. Gut content weight of the 1983 year class was significantly greater ($P < 0.05$) than that of the 1984 year class only in the month of October. The 1984 weights were significantly greater ($P < 0.05$) than the 1983 weights in the months of August and December. There were no significant differences detected between years in the month of September. Reasons for these spurious results were that most of the 1983 year class striped bass were collected with gill nets and were prone to regurgitation. This would tend to lower the percentage wet weight results. Conversely, most of the 1984 year class striped bass were collected by electrofishing and seining and were not as subject to regurgitation. Also the 1984 year class were smaller and in poorer condition. This would tend to inflate the percentage wet weight calculations.

Table 16. Mean Wet Weights of GI Tract Contents of Non-empty 1983 and 1984 Year Class Striped(SB) and White (WB) Bass Expressed as Percentages of Total Weights of Fish.

Month	1983 / SB		1984 / SB		1983 / WB		1984 / WB	
	%	N	%	N	%	N	%	N
Jul			3.78	5	6.47	20	6.79	10
Aug	3.05	21	3.65	13	6.05	20	6.25	19
Sep	4.48	57	3.92	39	3.31	16	5.70	20
Oct	4.64	56	3.50	34	2.73	17	2.88	15
Nov	1.82	9			0.87	9	1.68	6
Dec	3.79	30	5.10	1	1.38	10	1.58	7
Jan								
Feb	3.58	6			0.85	4		
Mar	1.61	29			0.40	10		
Apr	1.25	9			0.90	10		
May	2.45	5			1.11	6		

It was believed that these two factors influenced the results by bringing the means of the two years closer together and thus reducing detectable differences between the two year classes.

Analyses of white bass food habits indicated trends somewhat similar to those detected in striped bass. No significant differences between numbers of fish or insects consumed were detected between the two years. The number of crustaceans consumed by the 1984 year class was significantly greater ($P < 0.025$) than the number consumed by the 1983 year class. The GI tract fullness of the 1984 year class was significantly greater than the 1983 year class ($P < 0.025$). In the months of July and September gutfullness in the 1984 year class was significantly greater than the 1983 year class ($P < 0.1$ and $P < 0.01$, respectively). Percent-of-total-number and frequency-of-occurrence for both year classes, grouped by month and length class, are presented in Appendixes A through H. White bass made the transition to fish at approximately the same size, 12.6 to 15 cm, during both years. The same trends of invertebrates regaining importance in the diet by late winter and early spring were also observed. One difference in forage utilzed between years was the higher occurrence of gizzard shad in the diets of the 1984 fish. This was a result of a second spawn of gizzard shad in late summer.

Forage Abundance and Availability

The number of benthic organisms by month are presented in Figure 4; prestock data are also included for both years. The trend of high densities in summer followed by a decrease in fall and winter and again peaking in spring was observed in 1983 and 1984. These same trends for Cherokee Reservoir were reported by Humphreys (1983). The deviations from this pattern observed in the 1984 data were probably more related to site specific anomalies rather than a direct result of environmental changes. The declines in abundance during the winter months can be attributed primarily to winter draw-down. This reduction in benthic abundance, especially in chironomids, has been documented previously by Benson and Hudson (1975). Benthos was dominated by chironomids (83%) which explains their high occurrence in the food habits of young-of-year striped and white bass. Zooplankton abundance was depicted by similar trends with peaks during the spring months followed by declines throughout the winter (Figure 5). Zooplankton was dominated by the presence of copepods and cladocerans (95%). Overall, the number of benthos and zooplankton were similar over both years and are comparable to previous studies on Cherokee Reservoir (Humphreys 1983). The decline in benthos and zooplankton abundance during the fall and winter months contributed to the observed

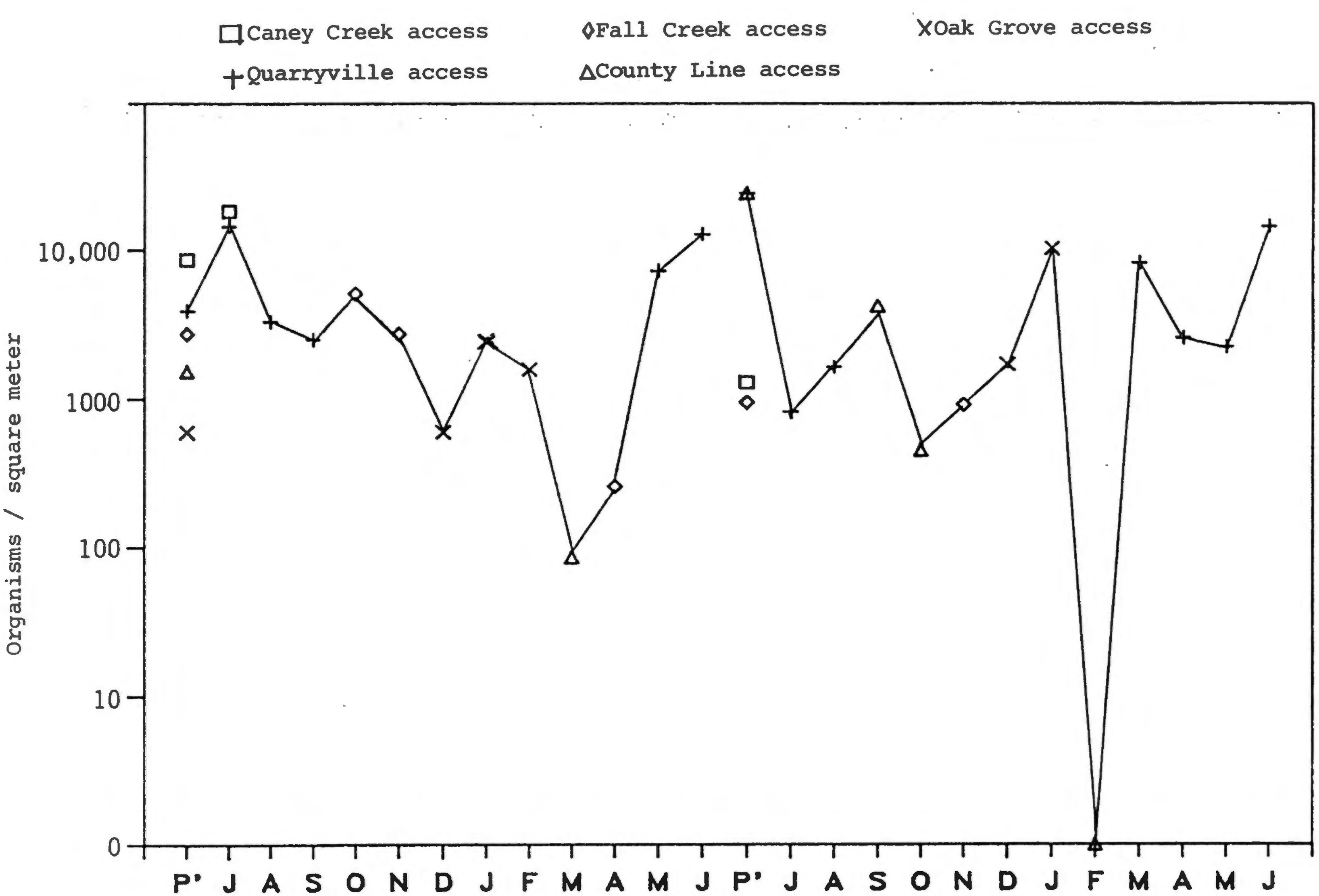


Figure 4. Benthos abundance in Cherokee Reservoir, July 1983 - January 1985 (prestock collections also displayed).

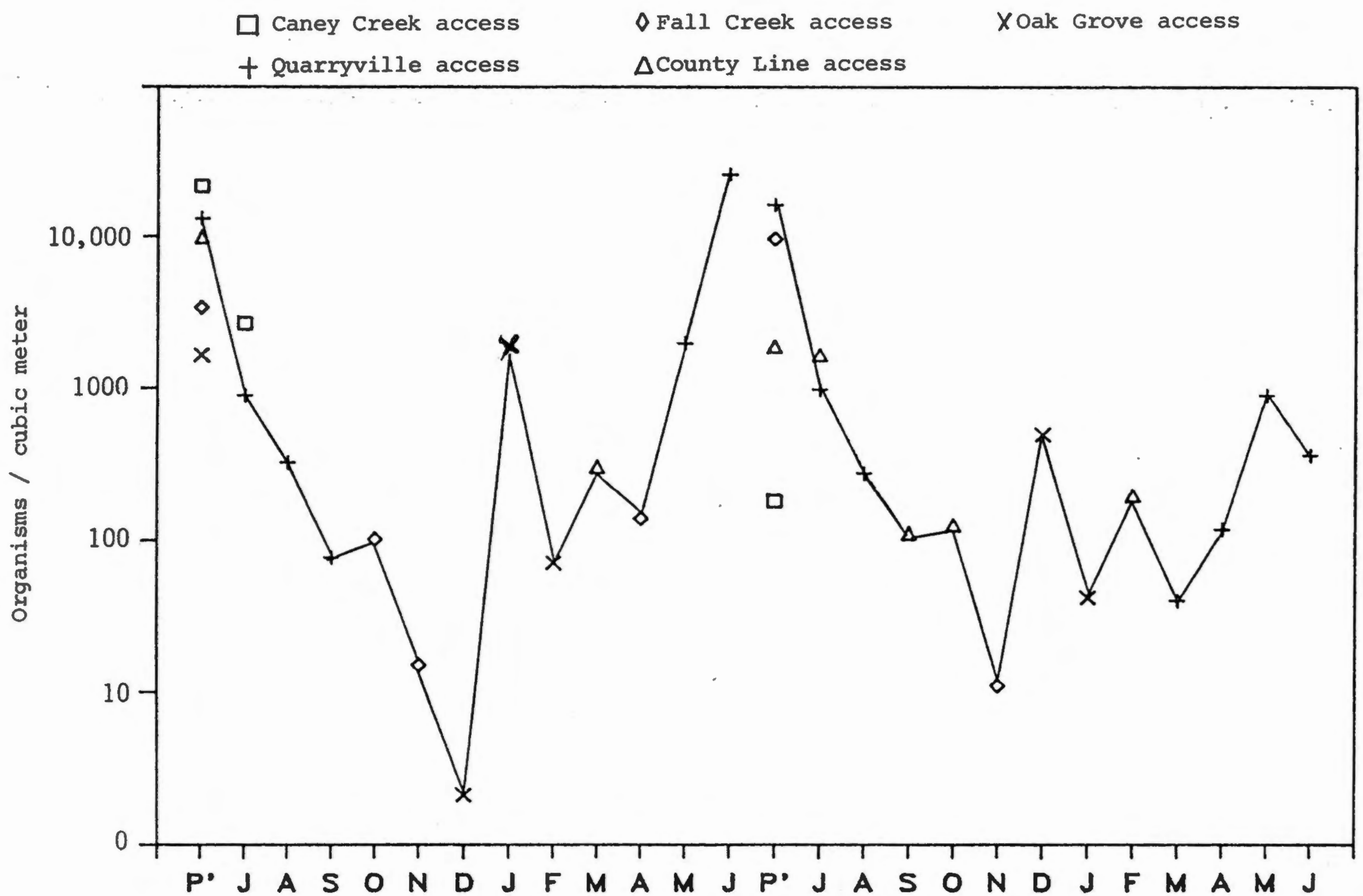


Figure 5. Zooplankton abundance in Cherokee Reservoir, July 1983 - January 1984. (prestock collections also displayed).

reduced growth and possibly survival of the 1984 year class of striped bass due to their non-piscivorous diet and heavy dependence upon these groups.

Relative abundance of forage fish based on TVA cove rotenone data is presented in Figure 6. Due to winter kills during 1976-77, threadfin shad virtually disappeared in Cherokee. They did not appear again in cove rotenone data until 1980 and continued to be present throughout the present study. The population expanded rapidly from 1980, peaking in 1983 and decining in 1984.

Since shad, primarily threadfin, have been shown to be the primary prey of young-of-year striped bass by Humphreys (1983) and the present study, predator-prey relationships between young-of-year striped bass and shad were developed. These length relationships were used in conjunction with monthly forage data to develop prey availability relationships for shad. Predator-prey relationships for the 1983 and 1984 year classes of young-of-year striped bass were combined and are presented in Figure 7. To develop this relationship, the maximum, minimum, and average total lengths of shad found in the gastrointestinal tracts were calculated for each 2.5 cm length class of striped bass. Also presented are the mean predator-prey length ratios for each length class. These ratios are similar to trends presented by Humphreys (1983) and follow closely with expected values determined by Popova (1967). Mean prey lengths were initially 40%

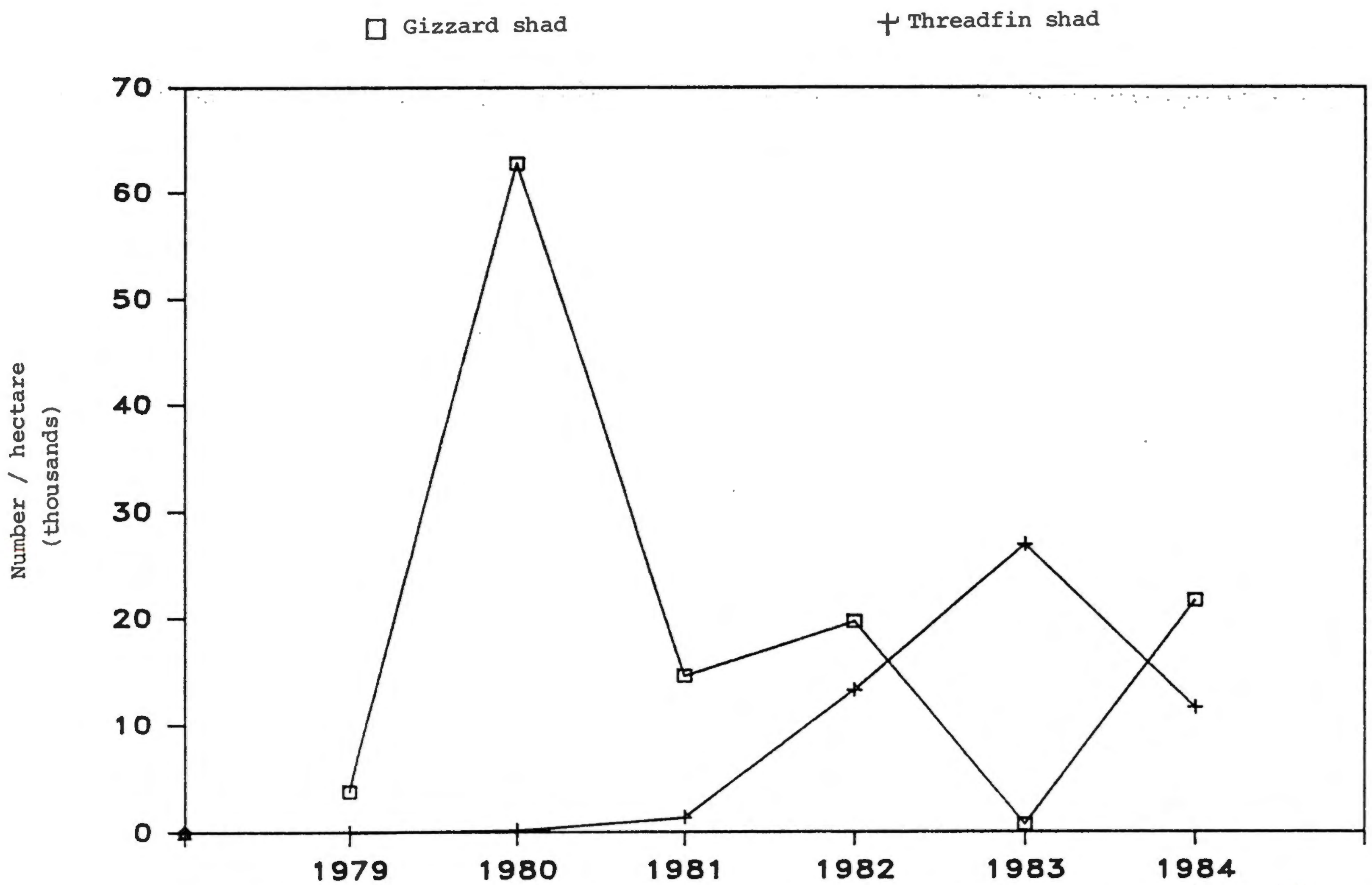
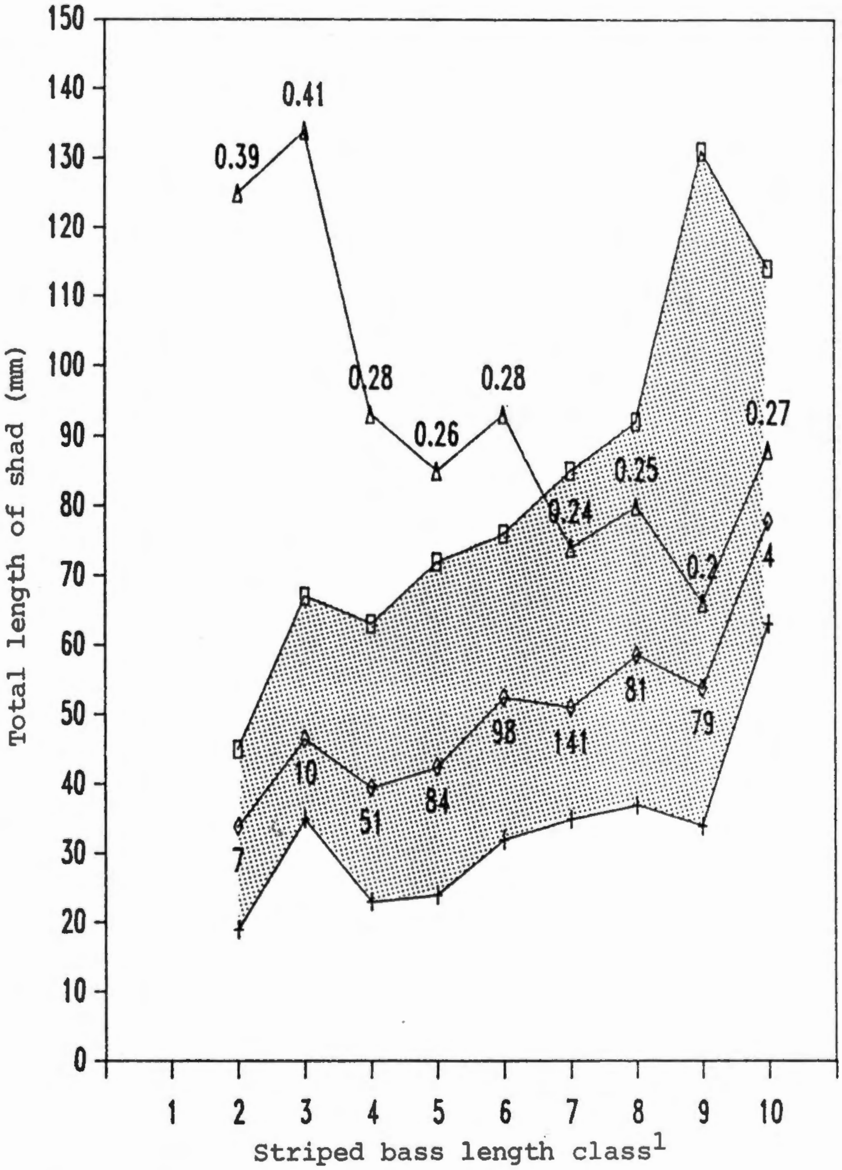


Figure 6. Estimates of numbers of gizzard and threadfin shad per hectare (from TVA cove-rotenone data) in Cherokee Reservoir, 1979 - 1984.



□ Maximum total lengths of shad
+ Minumum total lengths of shad
◊ Average total length of shad (and number measured)
Δ Relative length of shad

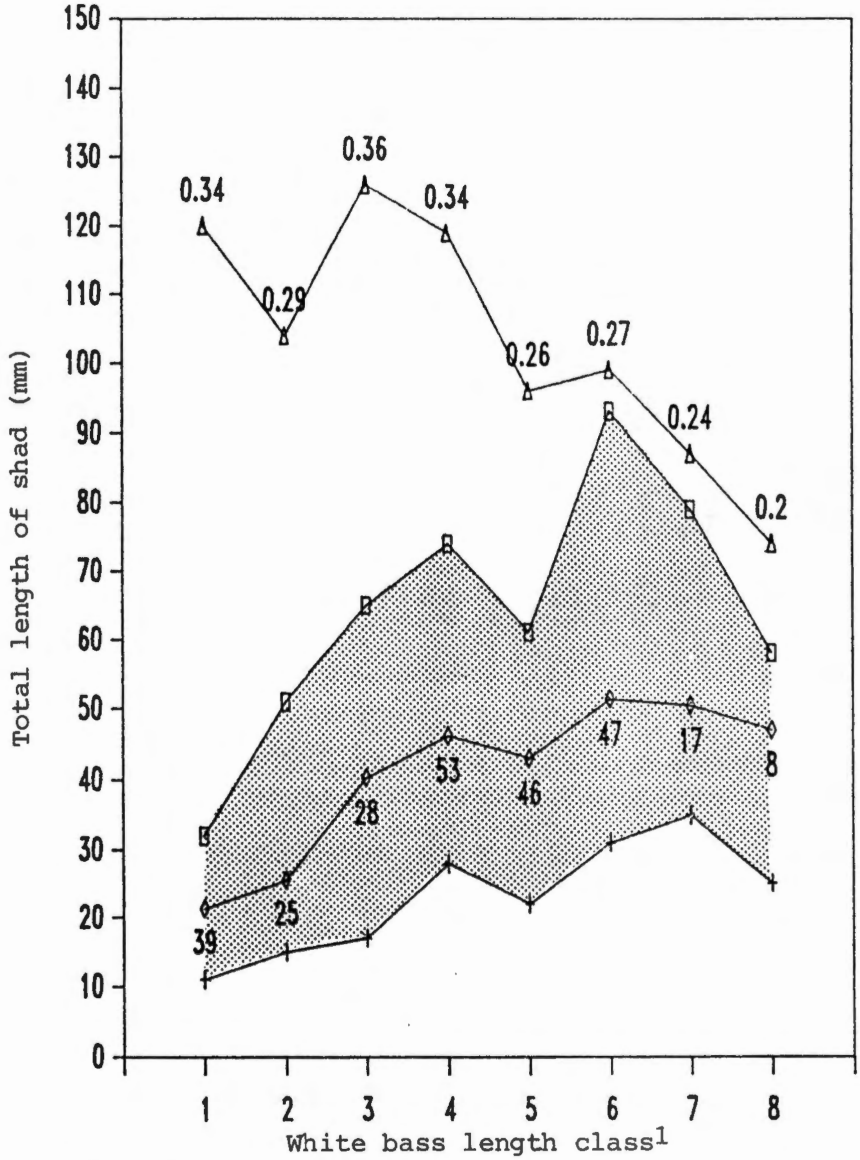
Figure 7. Predator-prey length relationships for young-of-year striped bass and shad.

[1]Length classes (total length) are as follows:

1= 2.5 to 5.0 cm	2= 5.1 to 7.5 cm	3= 7.6 to 10.0 cm
4=10.1 to12.5 cm	5=12.6 to15.0 cm	6=15.1 to 17.5 cm
7=17.6 to20.0 cm	8=20.1 to22.5 cm	9=22.6 to 25.0 cm
10=25.1 to27.5 cm.		

of the smaller predator lengths and decreased to about 20% of the larger predator lengths. Analysis of white bass yielded similar results and are presented in Figure 8. Mean predator-prey lengths for smaller predators were 30% and decreased to 20% for the larger predators.

To establish forage availability differences between years, the maximum size prey consumed by the average size young-of-year striped bass and the smallest size threadfin and gizzard shad collected in forage samples was plotted on a monthly basis and is presented in Figure 9. The shaded portion represents the forage potentially available for each year class, respectively. The differences between years is obvious, with significantly more prey avaialable in 1983 than 1984. This further explains the observed differences in food habits between the two years with 1983 young-of-year striped bass consuming fish much more frequently than in 1984. Important to note is that forage sizes on the whole for both threadfin and gizzard shad were smaller in 1984 than 1983, due in part to the second spawning of gizzard shad late in the summer. This again emphasizes the point that due to their small size and late stocking, the 1984 year class were exclusively restricted to a benthos and zooplankton diet. This inability to shift to a piscivorous diet would account for the reduced growth and survival observed. This phenomenon was also observed in



□ Maximum total lengths of shad
+ Minimum total lengths of shad
◇ Average total length of shad (and number measured)
△ Relative length of shad

Figure 8. Predator-prey length relationships for young-of-year white bass and shad.

[1]Length classes (total length) are as follows:
1= 2.5 to 5.0 cm 2= 5.1 to 7.5 cm 3= 7.6 to 10.0 cm
4=10.1 to 12.5 cm 5=12.6 to 15.0 cm 6=15.1 to 17.5 cm
7=17.5 to 20.0 cm 8=20.1 to 22.5 cm.

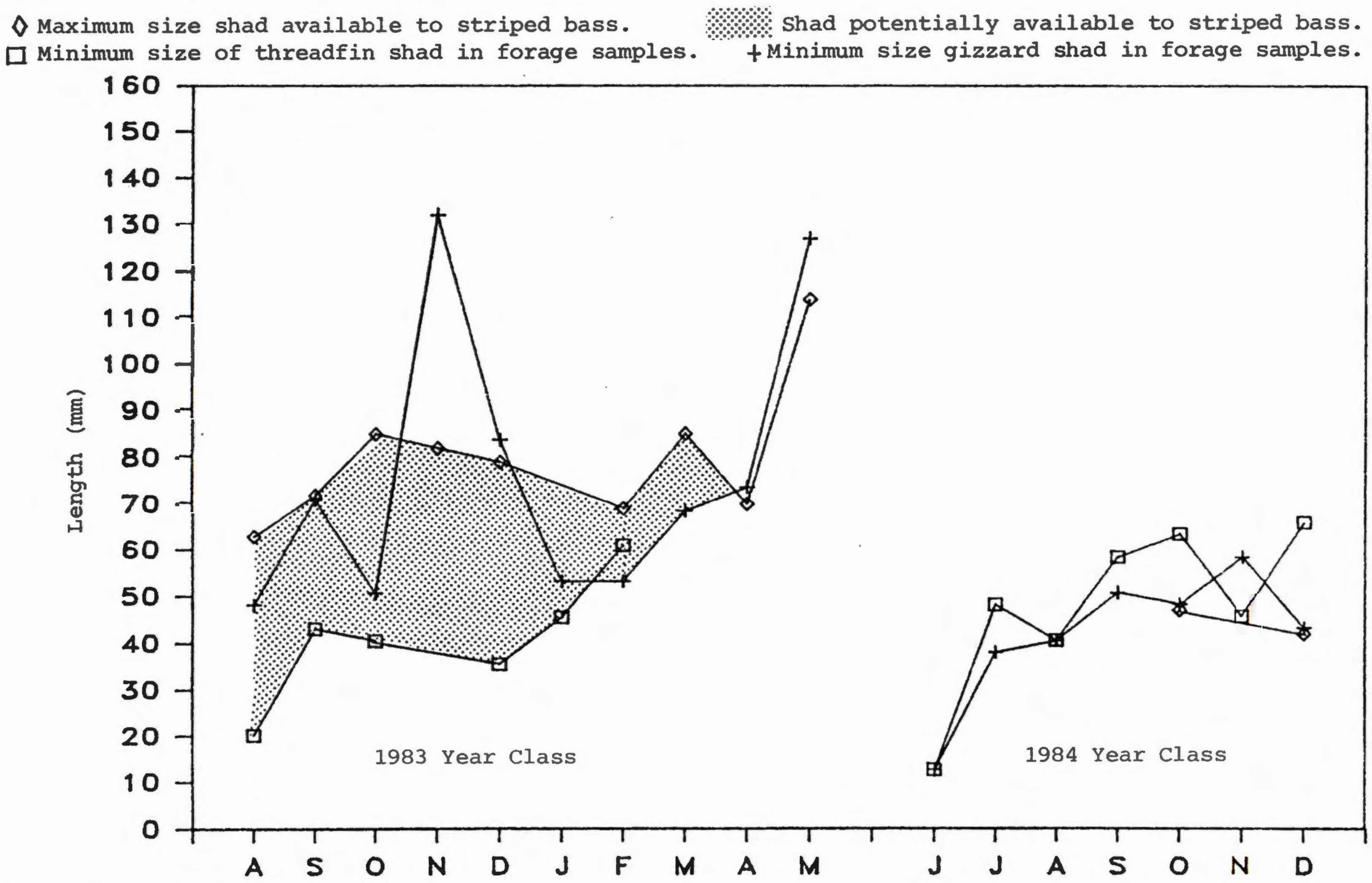


Figure 9. Potential availability of threadfin and gizzard shad from forage samples to average length young-of-year striped bass each month for the 1983 and 1984 year classes.

Humphreys'(1983) 1981 year class (1983) and in Saul's 1979 and 1980 year classes.

Analysis of forage availability for young-of-year white bass is presented in Figure 10. It can be seen that forage availability for white bass between the two years was similar. This would explain the similar food habits and growth exhibited by the 1983 and 1984 year classes.

To better understand the factors controlling production of strong year classes of young-of-year striped bass, all six years of data for Cherokee Reservoir (1979 - 1984) were analyzed for trends based on forage availability, white bass competition, and size at stocking.

So that trends for the entire six years of the study could be observed, TVA cove rotenone data were utilized. To justify these comparisons, CPUE data for electrofishing and seining were converted to fish collected per hectare. Due to the similarity of collection technique and areas sampled, these conversions were limited to the collection years of 1981 through 1984. Comparisons between converted data and cove rotenone data were then made for young-of-year white bass and threadfin shad and are presented in Figures 11 and 12. Based on the similarity of these patterns indicating relative abundance between years, cove rotenone data were felt to be reflective of collection data. Since cove rotenone data are standardized between years, the data for 1979 to

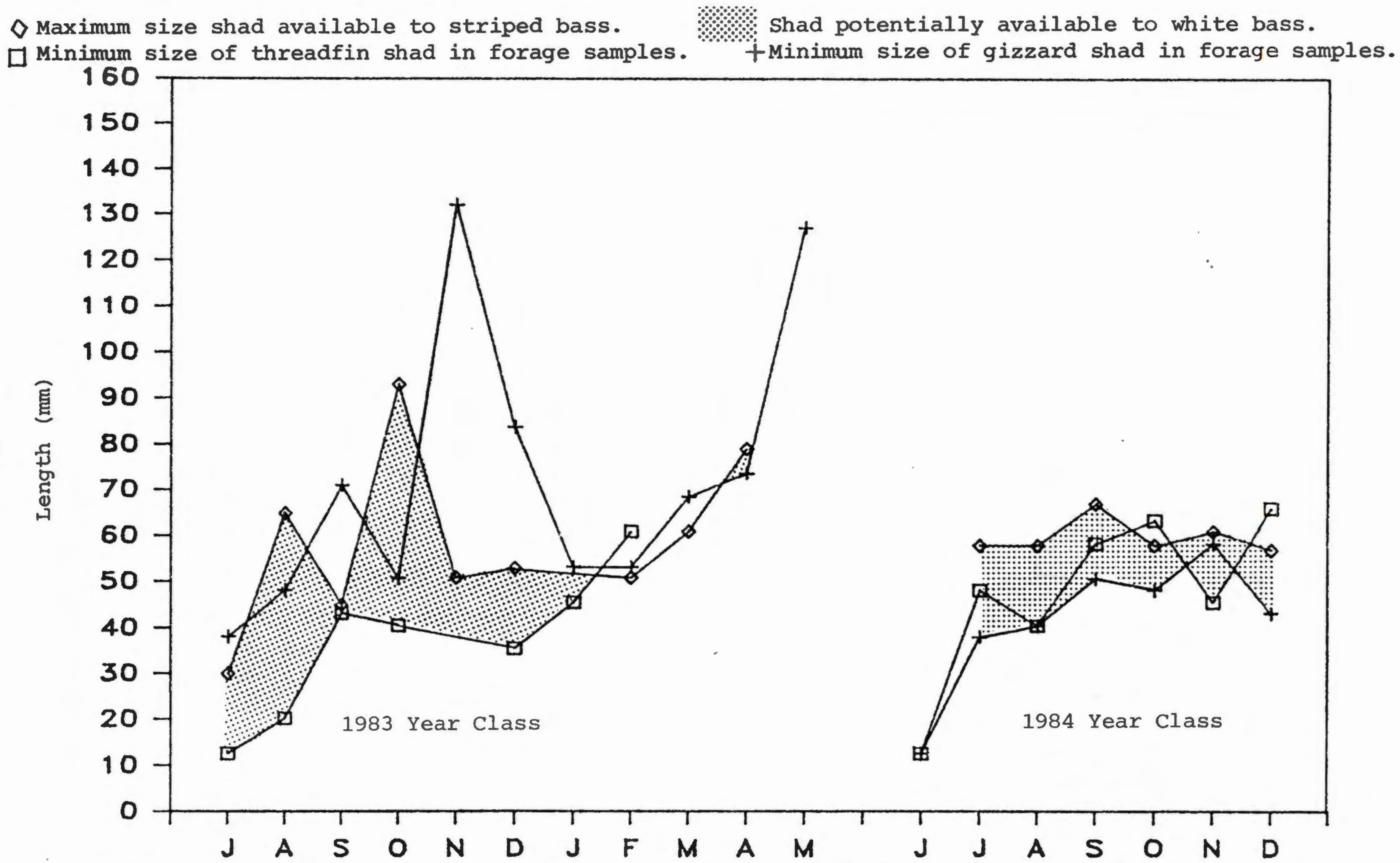


Figure 10. Potential availability of threadfin and gizzard shad from forage samples to average length young-of-year white bass each month for the 1983 and 1984 year classes.

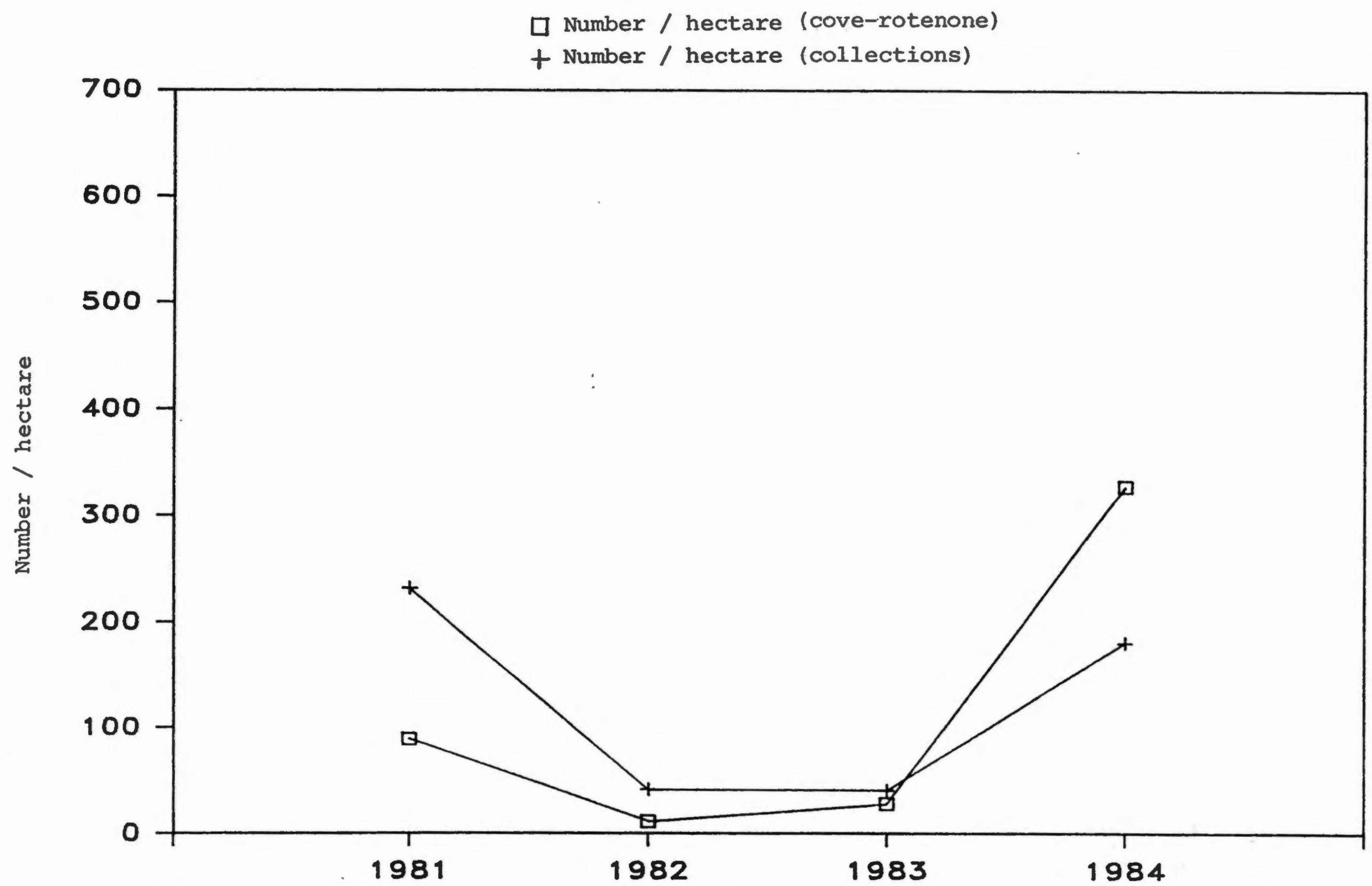


Figure 11. Comparison of TVA cove-rotenone data with collection data for white bass in Cherokee Reservoir, 1981 - 1984.

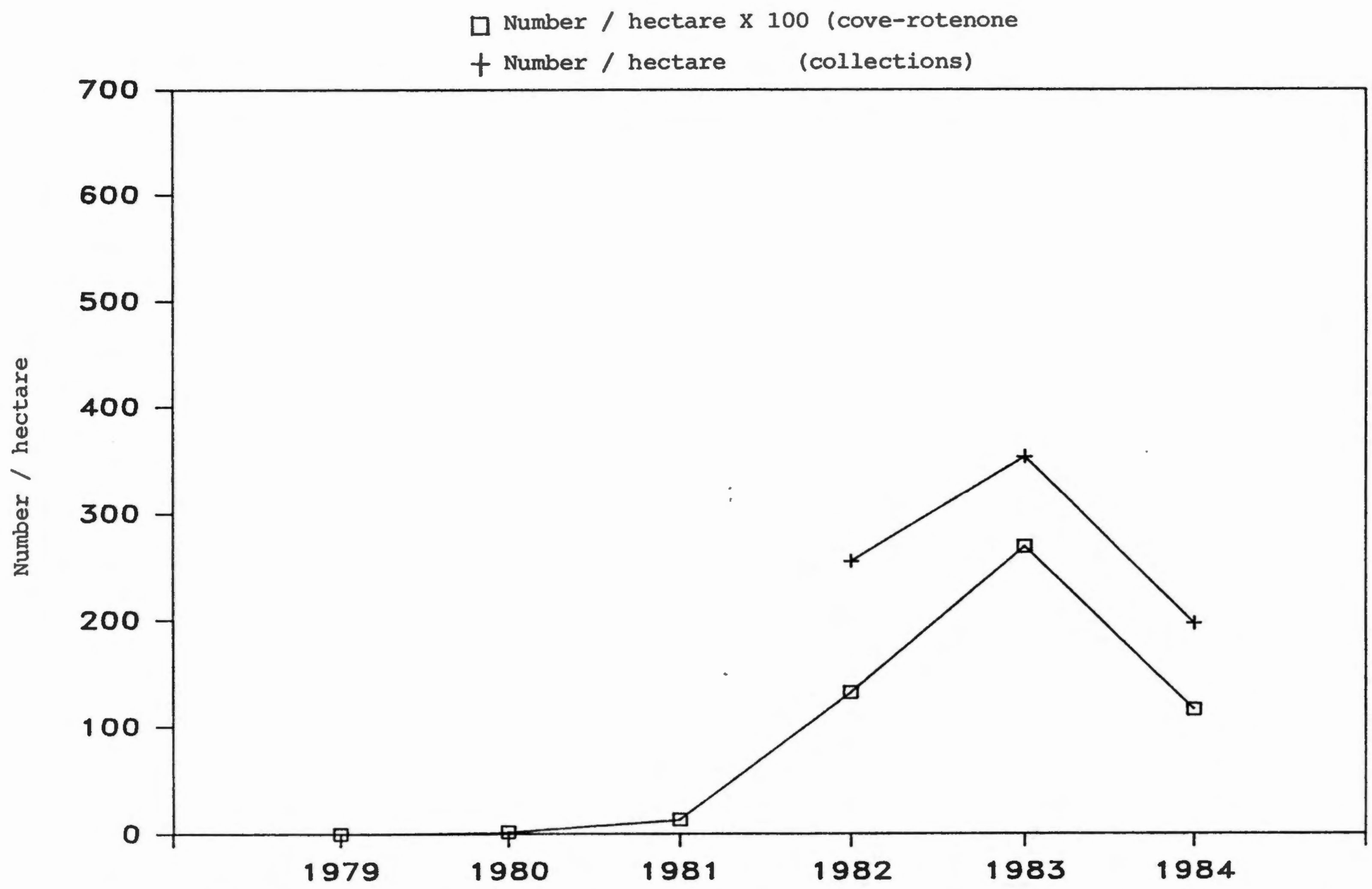


Figure 12. Comparison of TVA cove-rotenone data with collection data for threadfin shad in Cherokee Reservoir, 1979 -1984.

1984 could be used for baseline comparisons on abundance of threadfin shad and young-of-year white bass between years. Since young-of-year striped bass sampled by cove rotenone are sporadic between years and yield spurious results (Dave Bishop, TWRA, pers. commun.), striped bass percent recapture was used to indicate relative abundance and survival between years for the six year period. This recapture percentage is the total number of young-of-year striped bass collected by all techniques divided by the total number of striped bass stocked for that year. Cove rotenone data for threadfin shad and white bass were then plotted against the percent recapture rate of striped bass for each corresponding year and are presented in Figure 13. These patterns indicate that the abundance of competitors and prey directly affect the recapture of striped bass, and this in turn indicates that survival of striped bass increases with fewer competitors and more prey as observed in 1981 through 1983. These indications coincide with previous conclusions of other investigators (Ager 1979; Humphreys 1983). Other comparisons between time of stocking and size at stocking and their effects on striped bass recapture were made but were not conclusive. Size at stocking and early introduction should give young-of-year striped an advantage for survival over years of small stocking size or late introduction. Although these factors are important, the trends observed

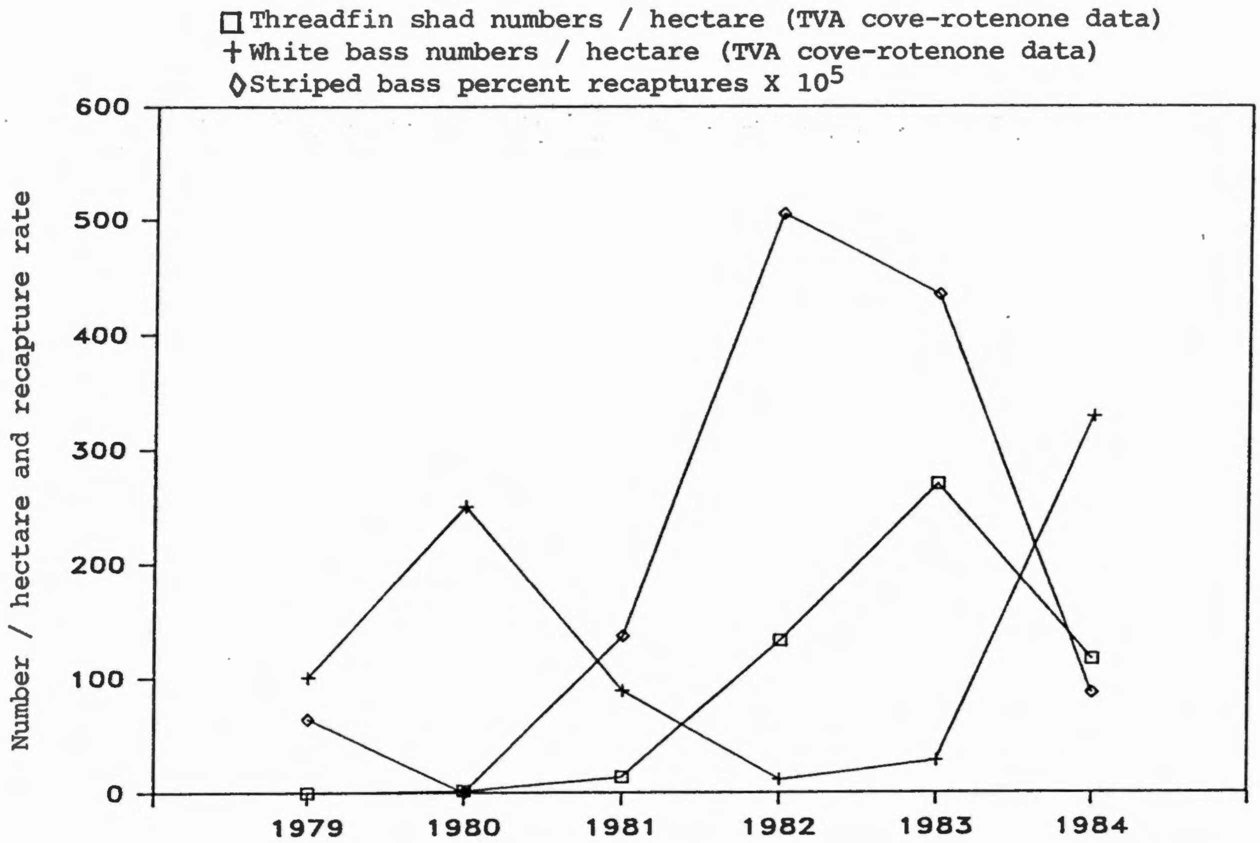


Figure 13. Influence of Threadfin shad and white bass abundance (TVA cove-rotenone data 1979-1984) on striped bass recaptures.

indicate that abundance of young-of-year competitors and forage are the main factors influencing survival of young-of-year striped bass and production of strong year classes.

CHAPTER VI

RECOMMENDATIONS

As concluded by Humphreys (1983), success of striped bass year classes is linked with the success of shad spawns. Therefore shad stocks should be monitored closely to determine when and where stocking should be initiated. Modifications of pre-stock assessments should be incorporated to achieve this. Additional collections of larval shad prior to stockings combined with additional collections of competitor and predator collections should be made to determine ideal areas for stockings. Dividing the stocking sites into two or more areas to reduce intraspecific and interspecific competion should become a standard practice. Better utilization of cove rotenone data to predict high and low forage years is essential to ensure higher survival of stocked fish.

The development of early spawning techniques would be an ideal way to maximize stocking survival. The procurement of brood stock earlier in the season and inducing spawning would create a situation highly beneficial for young-of-year striped bass. Earlier stocking of fry would almost ensure higher survival rates by reducing the advantages of naturally occurring young-of-year competitors.

CHAPTER VII

SUMMARY

1. In 1983, a total of 88,022 striped bass fingerlings were stocked in Cherokee Reservoir. Of these fish, 356 were recaptured as young-of-year and 10 were recaptured as yearlings. This indicated good survival throughout the year. In 1984, 118,216 striped bass fingerlings were stocked and only 103 of these were recaptured as young-of-year. No fish were collected after December of 1984 indicating poor survival through the winter months.

2. White bass numbers were very different between years with much higher abundance in 1984 by almost two to one.

3. Overall, the mean condition factor of the 1983 striped bass (1.08) was significantly greater ($P < .001$) than that of the 1984 year class of striped bass (0.85). In all monthly and most length class comparisons this significance was also present.

4. Growth of the 1983 year class of striped bass grew to 21.3 cm by October and reached 27.9 cm by April of 1984. The 1984 year class grew much slower reaching 10.6 cm by October with a maximum length of 16.2 in December. T- tests revealed that the 1983 year class

grew significantly larger ($P < .001$) than the 1984 year class of striped bass.

5. Growth rates of young-of-year white bass between the two years was comparable, with slightly better growth exhibited by the 1983 year class. The 1983 year class attained a length of 19.2 cm by October and 22.4 cm by April of 1984. The 1984 year class averaged 15.3 cm in length by October and reached 20.3 cm by December. This suggests that there were environmental factors that differed between years that produced all growth differences observed.

6. Food habits varied greatly between year classes of striped bass. The 1983 year class consumed shad at a higher frequency than the 1984 year class; the 1984 year class diet was dominated primarily by chironomids and crustaceans. The differences in condition and growth between the two years can be attributed to these differences in diets. The 1983 year class was able to utilize optimal sized prey and was therefore able to feed more efficiently.

7. White bass food habits remained comparable between years, but indicated that the 1983 year class utilized more fish in their diets than the 1984 year class. This compared closely with the forage availabilities for both years.

8. Benthos and zooplankton abundance was comparable

between years, with high levels in the spring and decreasing dramatically during the winter months. Cove rotenone data indicated that abundance of threadfin shad dropped in 1984 from the levels observed in 1983. Gizzard shad abundance increased from 1983 to 1984. Since gizzard shad spawned twice in 1984, more of this species were available as prey for young-of-year.

9. Predator-prey length ratios for striped bass ranged from 40% for the smaller length clases to 20% for the larger length classes. Comparisons of prey availability between years indicated that shad were utilized to a greater degree by the 1983 year class of striped bass even though prey sizes appeared to be smaller during 1984. This must be attributed to the small size and late introduction of the 1984 striped bass stocking and to the probable increased competition with white bass young-of-year.

10. Predator-prey length ratios for white bass were similar ranging from 30% for the smaller length classes to 20% for the larger length classes. Prey availability between years was also similar, indicating that white bass were able to take advantage of the available prey even though there was increased competition.

11. Collection data from 1981-1984 converted to fish/hectare, compared closely with trends in cove rote-

none abundance of young-of-year threadfin shad and white bass. Using this fact, six years (1979 - 1984) of cove rotenone data were used to relate abundance of prey and competitors to sucess of striped bass year classes. Success of a striped bass year class was measured by the percentage of recaptures in relation to the total number of fish stocked. When these were compared to abundances of threadfin shad and white bass over the six years, certain trends were observed. The data indicated that in years of abundant white bass competitors, striped bass success was limited. Also abundance or absence of threadfin shad further accentuated these successes or failures. This suggested that although size and early stocking time were important for striped bass young-of-year, competition with white bass and prey availability appeared to be more important to the production of strong year classes of striped bass.

12. It appears that striped bass stockings under the conditions of high white bass young-of-year competition and low prey availability have a low success rate and should be discouraged. The concept of earlier stockings should be utilized to overcome these limiting factors.

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APPENDIXES

APPENDIX A

Table 17. Percent of Total Numbers of Food Items in Guts of 1983 Year Class Young-of-Year White Bass, Grouped by Month.

Food Item Categories	Months J	A	S	O	N	D	J	F	M	A	M
Pisces	20.1	59.3	36.8	70.4	36.8	71.4		20.0	1.0	2.4	0.0
Dorosoma sp.	15.5	56.6	35.1	59.1	36.8	71.4		20.0	1.0	0.6	0.0
Dorosoma petenense	0.4	11.5	1.7	4.5	0.0	14.3		0.0	0.0	0.0	0.0
Dorosoma cepedianum	0.4	0.0	0.9	9.1	0.0	0.0		0.0	0.0	0.0	0.0
Unidentified Dorosoma	14.8	45.1	32.4	45.4	36.8	57.1		20.0	1.0	0.6	0.0
Cyprinidae	0.4	1.8	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Other fish	1.1	0.0	0.9	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Unidentified fish	3.0	0.9	0.9	11.4	0.0	0.0		0.0	0.0	1.5	0.0
Insecta	76.5	35.4	57.0	22.7	47.4	23.8		0.0	99.0	94.1	55.2
Diptera	73.5	31.0	51.7	20.4	47.4	23.8		0.0	99.0	93.8	54.7
Chironomidae	67.4	30.1	51.7	20.4	42.1	23.8		0.0	99.0	93.8	53.0
Chironomidae larvae	40.5	24.8	49.1	2.3	42.1	23.8		0.0	54.6	47.9	14.6
Chironomidae pupae	26.9	5.3	2.6	18.2	0.0	0.0		0.0	44.3	45.8	38.4
Chaoborus sp.	6.1	0.9	0.0	0.0	5.3	0.0		0.0	0.0	0.0	1.7
Adult Diptera	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Ephemeroptera	2.7	4.4	3.5	2.3	0.0	0.0		0.0	0.0	0.3	0.2
Ephemeridae	2.3	4.4	3.5	0.0	0.0	0.0		0.0	0.0	0.3	0.1
Other Ephemeroptera	0.4	0.0	0.0	2.3	0.0	0.0		0.0	0.0	0.0	0.1
Trichoptera	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Other insects	0.4	0.0	1.7	0.0	0.0	0.0		0.0	0.0	0.0	0.4
Crustacea	3.0	2.6	1.7	4.5	5.3	0.0		0.0	0.0	2.4	44.5
Cladocera	1.5	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.9
Ostracoda	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Copepoda [1]	0.4	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Argulus sp.	0.7	2.6	1.7	4.5	0.0	0.0		0.0	0.0	2.4	43.6
Amphipoda	0.4	0.0	0.0	0.0	5.3	0.0		0.0	0.0	0.0	0.0
Other invertebrates	0.4	2.6	4.4	2.3	10.5	4.8		80.0	0.0	1.2	0.2
Number of fish with food	20	20	16	17	9	10		4	10	10	6
Number of empty fish	0	0	4	3	1	0		6	0	0	0
Number of food items	264	113	114	44	19	21		5	97	338	1008
Mean number of items/fish	13.2	5.6	7.1	2.6	2.1	2.1		1.2	9.7	33.8	168.0

[1]Exclusive of Argulus sp.

APPENDIX B

Table 18. Frequency of Occurrence (%) of Food Items in Guts of 1983 Year Class Young-of-Year White Bass, Grouped by Month.

Food Item Categories	Months J	A	S	O	N	D	J	F	M	A	M
Pisces	75	95	69	82	67	80		25	10	30	0
Dorosoma sp.	65	90	62	76	66	80		25	10	20	0
Dorosoma petenense	5	45	12	6	0	20		0	0	0	0
Dorosoma cepedianum	5	0	25	0	0	0		0	0	0	0
Unidentified *Dorosoma*	65	70	62	65	67	80		25	10	20	0
Cyprinidae	5	5	0	0	0	0		0	0	0	0
Other fish	5	0	6	0	0	0		0	0	10	0
Unidentified fish	25	5	6	23	0	0		0	0	30	0
Insecta	90	75	37	35	33	30		10	100	100	100
Diptera	90	70	25	29	33	30		0	100	100	100
Chironomidae	85	70	25	29	33	30		0	100	100	100
Chironomidae larvae	75	55	12	6	33	30		0	100	100	100
Chironomidae pupae	70	25	19	23	0	0		0	100	100	100
Chaoborus sp.	20	5	0	0	11	0		0	0	0	33
Adult Diptera	0	0	0	0	0	0		0	0	0	0
Ephemeroptera	10	15	19	6	0	0		0	0	10	33
Ephemeridae	5	15	19	0	0	0		0	0	10	17
Other Ephemeroptera	5	0	0	6	0	0		0	0	0	17
Trichoptera	0	0	0	0	0	0		0	0	0	0
Other insects	5	0	6	0	0	0		0	0	0	33
Crustacea	15	15	6	12	11	0		0	0	30	100
Cladocera	5	0	0	0	0	0		0	0	0	50
Ostracoda	0	0	0	0	0	0		0	0	0	0
Copepoda [1]	5	0	0	0	0	0		0	0	0	0
Argulus sp.	5	15	6	12	0	0		0	0	30	100
Amphipoda	5	0	0	0	11	0		0	0	0	0
Other invertebrates	5	15	12	6	22	10		100	0	40	33
Number of fish with food	20	20	16	17	9	10		4	10	10	6
Number of empty fish	0	0	4	3	1	0		6	0	0	0

[1]Exclusive of *Argulus* sp.

APPENDIX C

Table 19. Percent of Total Numbers of Food Items in Guts of 1983 Year Class Young-of-Year White Bass, Grouped by Length Class.

	Length Classes[1]								
Food Item Categories	1	2	3	4	5	6	7	8	9
Pisces	23.6	27.9	13.5	80.5	81.8	5.6	2.9	7.1	0.0
<u>Dorosoma</u> sp.	18.5	27.9	11.4	75.0	79.5	4.8	2.7	4.4	0.0
<u>Dorosoma petenense</u>	0.5	2.3	4.2	13.9	6.8	0.4	0.3	0.5	0.0
<u>Dorosoma cepedianum</u>	0.5	0.0	0.0	0.0	2.3	0.3	0.3	0.0	0.0
Unidentified <u>Dorosoma</u>	17.6	25.6	7.3	61.1	70.4	4.1	2.0	3.8	0.0
Cyprinidae	0.5	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0
Other fish	1.4	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0
Unidentified fish	3.2	0.0	2.1	0.0	2.3	0.7	0.0	2.7	0.0
Insecta	73.1	68.6	80.2	16.7	9.1	52.4	71.9	89.1	100.0
Diptera	69.9	61.6	78.1	13.9	9.1	51.3	71.4	89.1	100.0
Chironomidae	62.5	61.6	78.1	11.1	9.1	49.3	70.9	89.1	100.0
Chironomidae larvae	43.0	30.2	70.8	8.3	2.3	14.5	27.4	53.0	53.8
Chironomidae pupae	19.4	31.4	7.3	2.8	6.8	34.8	43.6	36.1	46.2
<u>Chaoborus</u> sp.	7.4	0.0	0.0	2.8	0.0	2.0	0.5	0.0	0.0
Adult Diptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ephemeroptera	2.8	7.0	2.1	2.8	0.0	0.2	0.5	0.0	0.0
Ephemeridae	2.8	5.8	2.1	2.8	0.0	0.1	0.3	0.0	0.0
Other Ephemeroptera	0.0	1.2	0.0	0.0	0.0	0.1	0.2	0.0	0.0
Trichoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other insects	0.5	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0
Crustacea	3.2	3.5	1.0	0.0	4.5	41.5	24.3	1.1	0.0
Cladocera	1.8	0.0	0.0	0.0	0.0	1.0	0.2	0.0	0.0
Ostracoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Copepoda [2]	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<u>Argulus</u> sp.	0.5	3.5	1.0	0.0	4.5	40.5	24.0	1.1	0.0
Amphipoda	0.5	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Other invertebrates	0.0	0.0	5.2	2.8	4.5	0.5	0.8	2.7	0.0
Number of fish with food	15	8	9	9	12	26	28	14	1
Number of empty fish	0	0	0	0	2	6	5	1	0
Number of food items	216	86	96	36	44	756	592	183	13
Mean number of items/fish	14.4	10.7	10.7	4.0	3.7	29.1	21.1	13.1	13.0

[1]Length classes (total length) are as follows:

1 = 5.1 to 7.5 cm	4 = 12.6 to 15.0 cm	7 = 20.1 to 22.5 cm
2 = 7.6 to 10.0 cm	5 = 15.1 to 17.5 cm	8 = 22.6 to 25.0 cm
3 = 10.1 to 12.5 cm	6 = 17.6 to 20.0 cm	9 = 25.1 to 27.5 cm

[2]Exclusive of <u>Argulus</u> sp.

APPENDIX D

Table 20. Frequency of Occurrence (%) of Food Items in Guts of 1983 Year Class Young-of-Year White Bass, Grouped by Length Class.

Food Item Categories	Length Classes[1] 1	2	3	4	5	6	7	8	9
Pisces	80	62	78	100	92	69	39	36	0
Dorosoma sp.	73	62	67	89	83	65	36	36	0
Dorosoma petenense	7	2	33	33	17	8	3	7	0
Dorosoma cepedianum	7	0	0	0	8	8	7	0	0
Unidentified *Dorosoma*	73	62	33	78	83	61	32	36	0
Cyprinidae	7	0	0	11	0	0	0	0	0
Other fish	7	0	0	0	0	4	3	0	0
Unidentified fish	27	0	22	0	8	15	0	21	0
Insecta	93	87	89	44	33	38	71	64	100
Diptera	93	75	89	44	33	31	68	64	100
Chironomidae	87	75	89	44	33	31	68	64	100
Chironomidae larvae	73	62	89	33	33	19	64	64	100
Chironomidae pupae	80	37	33	11	25	23	57	50	100
Chaoborus sp.	27	0	0	11	0	8	3	0	0
Adult Diptera	0	0	0	0	0	0	0	0	0
Ephemeroptera	7	37	22	11	0	8	11	0	0
Ephemeridae	7	25	22	11	0	4	7	0	0
Other Ephemeroptera	0	12	0	0	0	4	3	0	0
Trichoptera	0	0	0	0	0	0	0	0	0
Other insects	7	0	0	0	0	12	0	0	0
Crustacea	20	25	11	0	8	19	21	7	0
Cladocera	7	0	0	0	0	8	3	0	0
Ostracoda	0	0	0	0	0	0	0	0	0
Copepoda[2]	7	0	0	0	0	0	0	0	0
Argulus sp.	7	25	11	0	8	19	18	7	0
Amphipoda	7	0	0	0	0	0	0	3	0
Other invertebrates	0	12	11	11	17	15	14	36	0
Number of fish with food	15	8	9	9	12	26	28	14	1
Number of empty fish	0	0	0	0	2	6	5	1	0

[1]Length classes (total length) are as follows:

1 = 5.1 to 7.5 cm	4 = 12.6 to 15.0 cm	7 = 20.1 to 22.5 cm
2 = 7.6 to 10.0 cm	5 = 15.1 to 17.5 cm	8 = 22.6 to 25.0 cm
3 = 10.1 to 12.5 cm	6 = 17.6 to 20.0 cm	9 = 25.1 to 27.5 cm

[2]Exclusive of *Argulus* sp.

APPENDIX E

Table 21. Percent of Total Numbers of Food Items in Guts of 1984 Year Class Young-of-Year White Bass, Grouped by Month.

Food Item Categories	Months J	A	S	O	N	D
Pisces	1.5	13.2	2.5	9.1	9.1	66.7
Dorosoma sp.	1.0	11.9	2.4	1.7	6.1	16.7
Dorosoma petenense	0.0	2.3	0.6	0.6	0.0	0.0
Dorosoma cepedianum	0.6	2.3	0.3	0.0	0.0	0.0
Unidentified *Dorosoma*	0.4	7.3	1.5	1.2	6.1	16.7
Cyprinidae	0.0	0.0	0.0	0.0	0.0	0.0
Other fish	0.0	0.0	0.1	0.0	0.0	0.0
Unidentified fish	0.4	1.4	0.0	0.4	3.0	50.0
Insecta	94.2	82.6	80.4	18.9	90.9	33.3
Diptera	94.0	82.2	80.0	17.1	87.9	33.3
Chironomidae	5.1	75.3	78.0	15.0	87.9	25.0
Chironomidae larvae	2.4	68.5	76.5	11.7	27.3	25.0
Chironomidae pupae	2.8	6.8	1.5	3.3	60.6	0.0
Chaoborus sp.	88.6	6.8	2.1	2.1	0.0	8.3
Adult Diptera	0.2	0.0	0.0	0.0	0.0	0.0
Ephemeroptera	0.2	0.0	0.0	0.0	3.0	0.0
Ephemeridae	0.2	0.0	0.0	0.0	0.0	0.0
Other Ephemeroptera	0.0	0.0	0.0	0.0	3.0	0.0
Trichoptera	0.0	0.4	0.4	0.4	0.0	0.0
Other insects	0.0	0.0	0.0	1.4	0.0	0.0
Crustacea	2.8	1.4	16.9	78.6	0.0	0.0
Cladocera	0.0	1.4	12.7	59.1	0.0	0.0
Ostracoda	0.0	0.0	0.0	0.0	0.0	0.0
Copepoda [1]	1.3	0.0	4.1	19.3	0.0	0.0
Argulus sp.	1.5	0.0	0.1	0.2	0.0	0.0
Amphipoda	0.0	0.0	0.0	0.0	0.0	0.0
Other invertebrates	1.1	2.7	0.1	0.4	0.0	0.0
Number of fish with food	10	19	20	15	6	7
Number of empty fish	0	1	0	5	2	3
Number of food items	466	219	1498	514	33	12
Mean number of items/fish	46.6	11.5	74.9	34.2	5.5	1.7

[1]Exclusive of *Argulus* sp.

APPENDIX F

Table 22. Frequency of Occurrence (%) of Food Items in Guts of 1984 Year Class Young-of-Year White Bass, Grouped by Month.

Food Item Categories	Months J	A	S	O	N	D
Pisces	70	79	65	53	50	71
Dorosoma sp.	50	74	60	40	33	14
Dorosoma petenense	0	16	30	20	0	0
Dorosoma cepedianum	30	26	15	0	0	0
Unidentified *Dorosoma*	20	53	60	27	33	14
Cyprinidae	0	0	0	0	0	0
Other fish	0	0	5	0	0	0
Unidentified fish	20	16	0	13	16	71
Insecta	70	53	45	53	83	57
Diptera	70	37	45	47	83	57
Chironomidae	70	37	40	47	83	43
Chironomidae larvae	70	37	35	40	67	43
Chironomidae pupae	70	37	40	40	67	0
Chaoborus sp.	20	21	15	27	0	14
Adult Diptera	10	0	0	0	0	0
Ephemeroptera	10	32	0	0	17	0
Ephemeridae	10	32	0	0	0	0
Other Ephemeroptera	0	0	0	0	17	0
Trichoptera	0	5	20	7	0	0
Other insects	0	5	0	13	0	0
Crustacea	30	5	40	40	0	0
Cladocera	0	5	30	27	0	0
Ostracoda	0	0	0	0	0	0
Copepoda [1]	10	0	30	27	0	0
Argulus sp.	30	0	5	7	0	0
Amphipoda	0	0	0	0	0	0
Other invertebrates	20	21	10	13	0	0
Number of fish with food	10	19	20	15	6	7
Number of empty fish	0	1	0	5	2	3

[1]Exclusive of *Argulus* sp.

APPENDIX G

Table 23. Percent of Total Numbers of Food Items in Guts of 1984 Year Class Young-of-Year White Bass, Grouped by Length Class.

	Length Classes[1]							
Food Item Categories	1	2	3	4	5	6	7	8
Pisces	0.1	0.1	38.3	48.4	36.4	55.2	72.7	75.0
Dorosoma sp.	0.1	0.1	34.0	40.7	31.8	51.7	36.4	50.0
Dorosoma petenense	0.0	0.0	6.4	14.1	6.8	6.9	0.0	0.0
Dorosoma cepedianum	0.0	0.1	10.6	7.8	2.3	0.0	0.0	0.0
Unidentified Dorosoma	0.1	0.1	17.0	18.8	22.7	44.8	36.4	50.0
Cyprinidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other fish	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0
Unidentified fish	0.0	0.0	4.3	7.8	2.3	3.4	36.4	25.0
Insecta	88.9	64.2	55.2	42.2	61.4	41.4	18.2	25.0
Diptera	88.8	63.1	51.0	32.8	54.5	31.0	18.2	25.0
Chironomidae	85.8	35.8	40.4	29.7	52.3	27.5	18.2	25.0
Chironomidae larvae	84.5	33.8	23.4	6.3	22.7	3.4	18.2	25.0
Chironomidae pupae	1.3	1.9	17.0	23.4	29.5	24.1	0.0	0.0
Chaoborus sp.	3.0	27.3	10.6	1.6	2.3	3.4	0.0	0.0
Adult Diptera	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0
Ephemeroptera	0.0	0.6	2.1	3.1	6.8	0.0	0.0	0.0
Ephemeridae	0.0	0.6	2.1	1.6	6.8	0.0	0.0	0.0
Other Ephemeroptera	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0
Trichoptera	0.1	0.4	2.1	0.0	0.0	0.0	0.0	0.0
Other insects	0.0	0.1	0.0	6.3	0.0	10.3	0.0	0.0
Crustacea	10.9	35.2	2.1	4.7	0.0	0.0	9.1	0.0
Cladocera	6.3	27.2	0.0	1.6	0.0	0.0	9.1	0.0
Ostracoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Copepoda[2]	4.5	7.6	0.0	1.5	0.0	0.0	0.0	0.0
Argulus sp.	0.0	0.4	2.1	1.6	0.0	0.0	0.0	0.0
Amphipoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other invertebrates	0.1	0.4	4.3	4.7	2.3	3.4	0.0	0.0
Number of fish with food	5	14	12	18	11	8	7	2
Number of empty fish	0	0	0	2	3	6	0	0
Number of food items	990	1596	47	64	44	29	11	4
Mean number of items/fish	198.0	114.0	3.9	3.5	4.0	3.6	1.6	2.0

[1]Length classes (total length) are as follows:

1 = 5.1 to 7.5 cm	4 = 12.6 to 15.0 cm	7 = 20.1 to 22.5 cm
2 = 7.6 to 10.0 cm	5 = 15.1 to 17.5 cm	8 = 22.6 to 25.0 cm
3 = 10.1 to 12.5 cm	6 = 17.6 to 20.0 cm	

[2]Exclusive of Argulus sp.

APPENDIX H

Table 24. Frequency of Occurrence (%) of Food Items in Guts of 1984 Year Class Young-of-Year White Bass, Grouped by Length Class.

	Length Classes[1]							
Food Item Categories	1	2	3	4	5	6	7	8
Pisces	20	14	92	89	73	62	100	50
Dorosoma sp.	20	14	83	67	64	50	57	50
Dorosoma petenense	0	0	17	33	18	25	0	0
Dorosoma cepedianum	0	7	42	22	9	0	0	0
Unidentified Dorosoma	20	7	50	44	54	50	57	50
Cyprinidae	0	0	0	0	0	0	0	0
Other fish	0	0	0	0	9	0	0	0
Unidentified fish	0	0	17	28	9	12	43	50
Insecta	100	93	58	28	54	37	29	50
Diptera	100	93	50	28	54	37	29	50
Chironomidae	100	93	50	22	54	25	29	50
Chironomidae larvae	100	93	42	11	45	12	29	50
Chironomidae pupae	80	93	42	22	45	12	0	0
Chaoborus sp.	40	50	17	5	9	12	0	0
Adult Diptera	0	0	0	5	0	0	0	0
Ephemeroptera	0	29	8	11	9	0	0	0
Ephemeridae	0	29	8	6	9	0	0	0
Other Ephemeroptera	0	0	0	5	0	0	0	0
Trichoptera	20	29	8	0	0	0	0	0
Other insects	0	7	0	5	0	12	0	0
Crustacea	60	71	8	17	0	0	14	0
Cladocera	40	50	0	5	0	0	14	0
Ostracoda	0	0	0	0	0	0	0	0
Copepoda[2]	60	50	0	5	0	0	0	0
Argulus sp.	0	21	8	5	0	0	0	0
Amphipoda	0	0	0	0	0	0	0	0
Other invertebrates	20	14	17	17	9	12	0	0
Number of fish with food	5	14	12	18	11	8	7	2
Number of empty fish	0	0	0	2	3	6	0	0

[1]Length classes (total length) are as follows:

1 = 5.1 to 7.5 cm	4 = 12.6 to 15.0 cm	7 = 20.1 to 22.5 cm
2 = 7.6 to 10.0 cm	5 = 15.1 to 17.5 cm	8 = 22.6 to 25.0 cm
3 = 10.1 to 12.5 cm	6 = 17.6 to 20.0 cm	

[2]Exclusive of Argulus sp.

VITA

Henry G. Mealing, III was born in Augusta, Georgia on June 3, 1958. He attended elementary schools in North Augusta, South Carolina and graduated from North Aususta Senior High School in June of 1976. In June of 1981, he received his Bachelor of Science degree from Augusta College, Augusta, Georgia. In August of 1989, he received his Masters degree in Wildlife and Fisheries Science from the University of Tennessee, Knoxville.

Henry was married to the former Amy L. Spivey of Augusta, Georgia, on August 27, 1983. Henry and Amy have two children, Daniel and Samantha.