To the Graduate Council:

I am submitting herewith a thesis written by Michael Humphreys entitled "Effects of Forage Variations on Young-of-Year Striped Bass and Other Young Predators in Cherokee Reservoir, Tennessee." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

J. Larry Wilson

J. Larry Wilson, Major Professor

We have read this thesis
and recommend its acceptance:

Richard J. Strange

Douglas C. Peterson

Thomas K. Hill

David A. Etnier

Accepted for the Council:

Cew Minkel

The Graduate School

EFFECTS OF FORAGE VARIATIONS ON YOUNG-OF-YEAR STRIPED BASS AND OTHER YOUNG PREDATORS IN CHEROKEE RESERVOIR, TENNESSEE

A Thesis

Presented for the

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ABSTRACT

Food habits and growth of young-of-year striped bass fingerlings stocked in 1981 and 1982 into Cherokee Reservoir, Tennessee, were examined. Food habits and growth of stocked Morone and Stizostedion hybrids and native white bass were also analyzed. Striped bass stocked in 1981 maintained relatively poor condition and grew slowly, reaching only 9.4 cm by December of their first year on a diet that consisted primarily of Chironomidae and Crustacea. Morone hybrids stocked the same year grew better than striped bass, reaching 24.7 cm by November on a diet that contained more shad.

Striped bass fingerlings stocked in 1982 began consuming small shad almost immediately and continued to utilize shad throughout their first growing season. These fish maintained good condition and grew rapidly to 27.1 cm by October of their first year and 31.8 cm by March of the following spring. White bass demonstrated similar year class differences which suggested that environmental factors accounted for at least part of the difference between striped bass year classes. The more rapid growth of striped and white bass in 1982 was attributed to a ten-fold increase in threadfin shad abundance between 1981 and 1982 which was the result of recovery from a severe winter-kill in 1976-77. Earlier stocking dates and high water conditions in 1982 may also have contributed to more rapid growth of the 1982 year class of striped bass.

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CHAPTER I

INTRODUCTION

The striped bass (*Morone saxatilis*) was originally an anadromous species that occurred along the Atlantic Coast from the St. Lawrence River in southern Quebec to the St. Johns River in northern Florida, and along the coast of the Gulf of Mexico from western Florida to Louisiana. In the late 1800's striped bass from New Jersey were transported to the coast of California, where a thriving population soon developed and expanded along the Pacific Coastline. Historical records have documented the value of this species to commercial and sport fisheries since colonial times.

Studies of the striped bass population isolated from the Atlantic Ocean by the impoundment of the Santee-Cooper Reservoir in South Carolina determined that this species could complete its life cycle in freshwater (Scruggs 1955). Stevens (1957) later reported that the diet of this thriving, land-locked population consisted primarily of clupeid fishes. These findings inspired many attempts at establishing reproducing populations in other freshwater impoundments. It was believed that these fish would help control over-abundant gizzard shad (*Dorosoma cepedianum*) and threadfin shad (*D. petenense*) populations by occupying the under-utilized niche of large pelagic predator. Successful striped bass introductions would also provide exciting new trophy sport fisheries.

After extremely limited success at establishing reproducing populations (Bailey 1974), it was realized that annual stocking of fingerlings would be required to maintain most inland striped bass fisheries. Concentrated efforts to improve spawning and fingerling culture techniques, and construction of larger, more efficient rearing facilities, have resulted in the establishment of successful fisheries in several states.

Tennessee Wildlife Resources Agency (TWRA) biologists have maintained a striped bass stocking program in the state's reservoirs since 1964. Since 1971 they have been able to spawn their own brood stock to produce fingerlings for stocking. With the completion of the Eagle Bend Hatchery in 1977, TWRA has been able to expand its striped bass stocking program to include nine reservoirs. The reservoirs that currently receive annual fingerling stockings are Boone, Cherokee, J. Percy Priest, Kentucky, Melton Hill, Norris, Old Hickory, Tims Ford, and Watts Bar. These reservoirs were chosen on the basis of (1) forage base, (2) available niche, (3) water quality, (4) fertility, and (5) size. The current managment plan calls for stocking these waters with five striped bass fingerlings per surface acre per year (TWRA 1981).

Several major research efforts have been directed toward learning more about striped bass in Tennessee. Some of these were concerned with growth, food habits, and/or movements of adult striped bass (Weaver 1975; Stooksbury 1977; Schaich 1979; Waddle et al. 1980; Nifong 1982). Higginbotham's (1979) research on the growth, distribution, and food habits of striped bass in Watts Bar Reservoir was the first major work on young-of-year striped bass in Tennessee. In 1979 The University of Tennessee was commissioned by TWRA to conduct two-year studies on growth and food habits of young-of-year striped bass in Norris and Cherokee reservoirs. These reservoir studies were conducted by Richardson (1982) and Saul (1981). The results of Saul's (1981) sampling efforts on Cherokee Reservoir suggested that survival and growth of both the 1979 and 1980 year classes were poor.

The purpose of the present study was to continue the young-of-year striped bass investigations on Cherokee Reservoir for two additional years to more clearly understand factors that influence first year growth and survival and the establishment of strong year classes. Specific objectives designed to characterize these influencing factors and their effects were: (1) to determine growth and food habits of striped bass stocked in 1981 and 1982; (2) to examine the growth and food habits of other stocked and native young-of-year predators that represented possible significant sources of competition; and (3) to assess the abundance and availability of fish and invertebrate forage species.

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CHAPTER II

LITERATURE REVIEW

The literature available on different aspects of the striped bass is extensive. Studies that include information on food habits and/or growth of young-of-year striped bass span from early, comprehensive life-history investigations of anadromous populations to recent coastal, reservoir, and hatchery pond research. Growth estimates and descriptions of food habits show a considerable amount of variation and demonstrate a degree of flexibility in habitat and food requirements.

First-year growth and food habit data are available for most of the major spawning and nursery areas along the Atlantic Coast (Merriman 1941; Rathjen and Miller 1957; Mansueti 1961; Trent 1962; Bason 1971; Boynton et al. 1981). Growth estimates from these areas are low, ranging from 7.6 cm in the lower Hudson River (Rathjen and Miller 1957) to 14.4 cm for fish from Chesapeake Bay (Mansueti 1961). These fingerlings remain in the mouths and estuaries of the large rivers where they were spawned, and rely heavily on invertebrate forage (Merriman 1941; Bason 1971; Boynton et al. 1981). Fish are of minor importance in the diet during the first year; however, some significant utilization of fish as food by larger young-of-year and yearlings was observed (Merriman 1971; Boynton et al. 1981).

Heubach et al. (1961) and Chadwick (1966) also found slow growth on the west coast in the delta of California's Sacramento-San Joaquin

River System. First-year growth estimates were 11.1 cm and 9.5 to 10.3 cm, respectively. These fish fed primarily on planktonic crustaceans and chironomid larvae. Again, fish were virtually absent from the diet.

Wigfall and Barkuloo (1975) examined growth and food habits of striped bass that were stocked into the lower Choctawhatchee River, which flows through western Florida and into the Gulf of Mexico. First year growth from these warmer waters, where the growing season is longer, was considerably higher. After 12 months striped bass averaged 18.6 cm on a diet consisting primarily of crustaceans, fish, and insects. This significant utilization of fish might also have contributed to the observed higher growth rate.

Many hatchery pond studies have been conducted since fingerling production has become an important part of striped bass stocking programs. Studies of food habits and growth of fingerlings under different conditions have been conducted in efforts to identify factors influencing growth and survival in culture pond environments. Most studies show that pond reared fingerlings consume copepods and cladocerans at smaller sizes, while insects become more important as the fish grow (Sandoz and Johnston 1965; Harper et al. 1968; Harper and Jarman 1971; Humphries and Cumming 1971, 1973). Enhanced growth has been associated with the addition of forage fish and/or artificial food to culture ponds (Sandoz and Johnston 1965; Logan 1967; Harper et al. 1968; Harper and Jarman 1971). Humphries and Cumming (1973) concluded that fingerlings retained in ponds through their first year grew rapidly and reached larger average sizes (17 cm) than striped bass from natural waters, even though the growing season was approximately the same. They attributed this difference to the increased food in the ponds resulting from artificial fertilization and supplemental feeding.

Results of first year growth and food habits studies of land-locked striped bass populations have been more variable. Some growth estimates from reservoir-stocked fish are much higher than those for coastal and hatchery pond juveniles. First year growth to total lengths of over 20 cm is common (Stevens 1957; Mensinger 1970; Ware 1970; Erickson et al. 1971; Weaver 1975; Axon 1979; Van Den Avyle and Higginbotham 1979; Moss and Lawson 1982; Nifong 1982); growth to over 30 cm in one year has been documented (Mensinger 1970; Ware 1970; Erickson et al. 1971; Axon 1979). This rapid growth is usually associated with a diet of shad (Stevens 1957; Ware 1970; Weaver 1975; Axon 1979; Van Den Avyle et al. 1983). Slower growth of young-of-year striped bass in reservoirs has been associated with a prolonged importance of invertebrates in the diet (Stevens 1957; Gomez 1970; Richardson 1982; Van Den Avyle et al. 1983). Saul (1981) found that young-of-year striped bass in Cherokee Reservoir consumed mostly Crustacea and Chironomidae through their first year. Fish became important in the diet during the second growing season. His first year growth estimate of 21.7 cm was based on measurement of three fish caught in June of their second year. This estimate may be somewhat high due to small sample size, apparent mortality of the smaller fish, and second year growth before June. Nifong (1982) investigated growth and food habits of adult striped bass in Cherokee Reservoir. Back-calculated first year growth estimates for six year classes ranged from 20.8 cm to 25.4 cm and averaged 23.1 cm. Again, back-calculated lengths may represent only the fastest growing individuals of a particular year class if mortality of the smaller fish is high.

CHAPTER III

DESCRIPTION OF THE STUDY AREA

Cherokee Reservoir is located on the main stem of the Holston River in Northeast Tennessee and is impounded by Cherokee Dam at Holston River Mile (HRM) 52.3. This multipurpose storage impoundment was completed in 1941 by the Tennessee Valley Authority (TVA) and was intended for power generation, flood control, and recreation.

The reservoir level fluctuates widely between summer- and winter-pool levels. The normal summer water elevation generally varies from 321 to 327 m above mean sea level, while winter levels vary from 311 to 318 m (Waddle et al. 1980). At full pool (328 m) the reservoir extends 87 km upstream to the John Sevier Steam Plant detention dam. At this level the surface area is 12,591 ha, the maximum depth is 46 m, and there are 745 km of shoreline (Schaich 1979). After the drawdown to normal minimum winter-pool levels the upper section of the reservoir becomes riverine and water is backed up only 48 km upstream from Cherokee Dam.

The watershed above the dam is 8,879 km^2 and extends north through northeastern Tennessee and into southwestern Virginia. Most of this area is drained by the Holston River which supplies the main input of water to the impoundment. Several small streams drain the surrounding hills and flow directly into the reservoir. The bedrock in this drainage basin is predominantly limestone, although some shale and sandstone are also present. Cover of the watershed is approximately 50% forest, 26% pasture, 12% cropland, and 12% other uses (Waddle et al. 1980).

The Holston River carries a heavy load of industrial, municipal, and domestic discharge. In 1973 Cherokee Reservoir received approximately 0.5 metric tons of phosphorus and 6.8 metric tons of nitrogen primarily from this source, which contributed to median total phosphorus and nitrogen concentrations of 0.05 and 1.27 mg/l, respectively (United States Environmental Protection Agency 1978). These relatively high concentrations of nutrients create eutrophic conditions which are especially apparent in the upper section of the reservoir where heavy algal blooms have been observed (Schaich 1979).

A wide range of physical features are found in Cherokee Reservoir. Cliffs, gravel shoals, sand and clay beaches, and shallow mud flats are found along the shoreline. The upper section of the reservoir is narrow and meanders through hilly terrain. There are many islands and coves in the deep, broad, lower portion of the reservoir.

Cherokee Reservoir is generally isothermal during the winter, with short periods of ice cover occurring only during the coldest winters. Dissolved oxygen concentrations during this period remain near saturation. Thermal stratification begins in March or April and continues into the summer. Dissolved oxygen becomes depleted in the cool hypolimnion as thermal stratification progresses. By early September most of the cool hypolimnetic water has been discharged through the turbines and there is little thermal gradient from top to bottom (Schaich 1979). At this time dissolved oxygen levels below

5.0 to 10.0 m are low. Dissolved oxygen concentrations rise and temperatures drop with fall turnover in late September. Thermal discharge from the John Sevier Steam Plant may elevate temperatures above normal. Total water hardness in the main channel generally ranges from 95 to 125 mg/liter (Waddle et al. 1980).

CHAPTER IV

METHODS AND MATERIALS

Collection Period From June 1981 Through May 1982

On 23 June 1981 TWRA personnel stocked approximately 16,700 white bass (*Morone chrysops*) (male) x striped bass (female) hybrids (hereafter referred to as *Morone* hybrids) at the Quarryville Access Ramp (HRM 91.5) (Table 1). Striped bass and *Morone* hybrids stocked at this location in the past have often experienced high survival rates and rapid growth (D. Bishop, pers. comm.). On 24 June 1981 an evaluation of available forage and potential competitors was conducted at five reservoir access areas to determine the area best suited to future introduction of striped bass fingerlings. Standard pre-stock sampling procedures consisted of: (1) two quarter-hauls with a 1.2 x 6.1 m straight seine with 3.2 mm mesh to determine fish present; (2) two 5 m horizontal tows with a 22.9 cm diameter plankton net (60 mesh) to determine zooplankton concentrations; and (3) two Ekman dredge samples (232.2 cm^2 each) to determine the abundance of benthic invertebrates. All pre-stock and post-stock samples were collected after sundown. After analyses of pre-stock samples, it was decided to stock striped bass at Quarryville. Approximately 44,000 striped bass fingerlings from three different hatchery ponds were stocked at the Quarryville access ramp on 14 July and 27 July 1981. All striped bass stocked into Cherokee Reservoir in 1981 and 1982 were spawned from Chesapeake Bay brood stock. It was hoped

TABLE 1. Stocking Data From Fingerling Introductions Into Cherokee Reservoir, 1981-1982

Year	Species[1]	Date stocked	Hatchery	Stocking location[2]	Number stocked	No./kg
1981	SB	7-14	Morristown	1	1,500	93
	SB	7-27	Eagle Bend	1	26,368	483
	SB	7-27	Eagle Bend	1	15,995	423
					43,863	
	MH	6-23	Morristown	1	16,700	551
		10-23	Eagle Bend	3	3,300	30
					20,000	
1982	SB	6-14	Morristown	1	22,000	679
	SB	7-2	Eagle Bend	2	6,700	265
					28,700	
	SH-S	5-24	Eagle Bend	1	31,584	1235
	SH-W	5-30	Eagle Bend	3	17,157	1257
					48,741	

[1]SB = striped bass.
MH = Morone hybrid.
SH-S = *Stizostedion* hybrid (sauger male x walleye female).
SH-W = *Stizostedion* hybrid (walleye male x sauger female).

[2]1 = Quarryville Access.
2 = Fall Creek Access
3 = County Line Access.

that this strain, which produces a larger, more buoyant egg, might have a better chance of reproducing naturally in Tennessee reservoirs.

One pond of Morone hybrids was retained at Eagle Bend Hatchery through the summer to determine the value of stocking these fish at a larger size. The entire right pectoral fin was removed from all 3,300 of these hybrids so that they could be distinguished from the hybrids stocked in June. These fish, ranging in size from 8.0 to 18.0 cm in total length, were stocked at County Line Access on 23 October.

Biweekly post-stock collections were initiated on 9 July and continued through October. Monthly sample trips continued from November 1981 through May 1982. Fish were sampled from July through February with a 1.8 x 15.7 m straight seine having 9.5 mm mesh. A minimum of two standard hauls at each of two to seven locations were made on each sample trip. A standard seine haul involved both seiners going out into water approximately 1.5 m in depth. One of the seiners then walked parallel to shore until the seine was pulled tight. Both seiners then rapidly headed to shore and dragged the seine up on the beach.

Three to nine gill nets were set on each trip from 3 September 1981 through 25 May 1982. Sinking nets 45.7 m long x 1.8 m deep with mesh sizes (bar mesh) of 12.7, 19.1, 25.4, and 31.8 mm were used. Nets were anchored perpendicular to shore and marked with labeled buoys. Efforts were made to sample a wide variety of different habitat types. Areas sampled with gill nets were up to 25 m deep and ranged from shallow mud flats to steep rocky dropoffs. Electrofishing with a boat-mounted, boom-type, 230-V generating unit (AC) was conducted on several occasions to sample Morone spp. and forage fishes. Paired quarter-hauls with the smaller pre-stock seine were completed at all shoreline seining locations to sample the smallest forage fish.

On each trip, at least one plankton and one benthos sample were collected. Methods of collection were the same as for pre-stock samples. All fish and benthos samples were preserved in the field in 10% formalin. Zooplankton was preserved in 70% isopropanol. Fish samples were later soaked in water at the laboratory and transferred to 40% isopropanol. Before fish over 15 cm were preserved, an incision was made through the body wall and into the gut cavity. This was done to facilitate preservation of stomach contents and internal organs.

Post-stock sampling locations were divided into four reservoir sections of approximately 7 km each. These sections were adjoining and were centered around four boat launch ramps on the upper half of the reservoir. These ramps were located at Quarryville (Section 1), Fall Creek (HRM 80.7, Section 2), County Line (HRM 74.7, Section 3), and Oak Grove (HRM 70.3, Section 4) (Figure 1). Sections were chosen for each sample trip that, it was believed, would yield the best sample of stocked fish. Decisions were based on results of previous sample trips, dispersal trends noticed by Saul (1981), and personal communication with TWRA personnel.

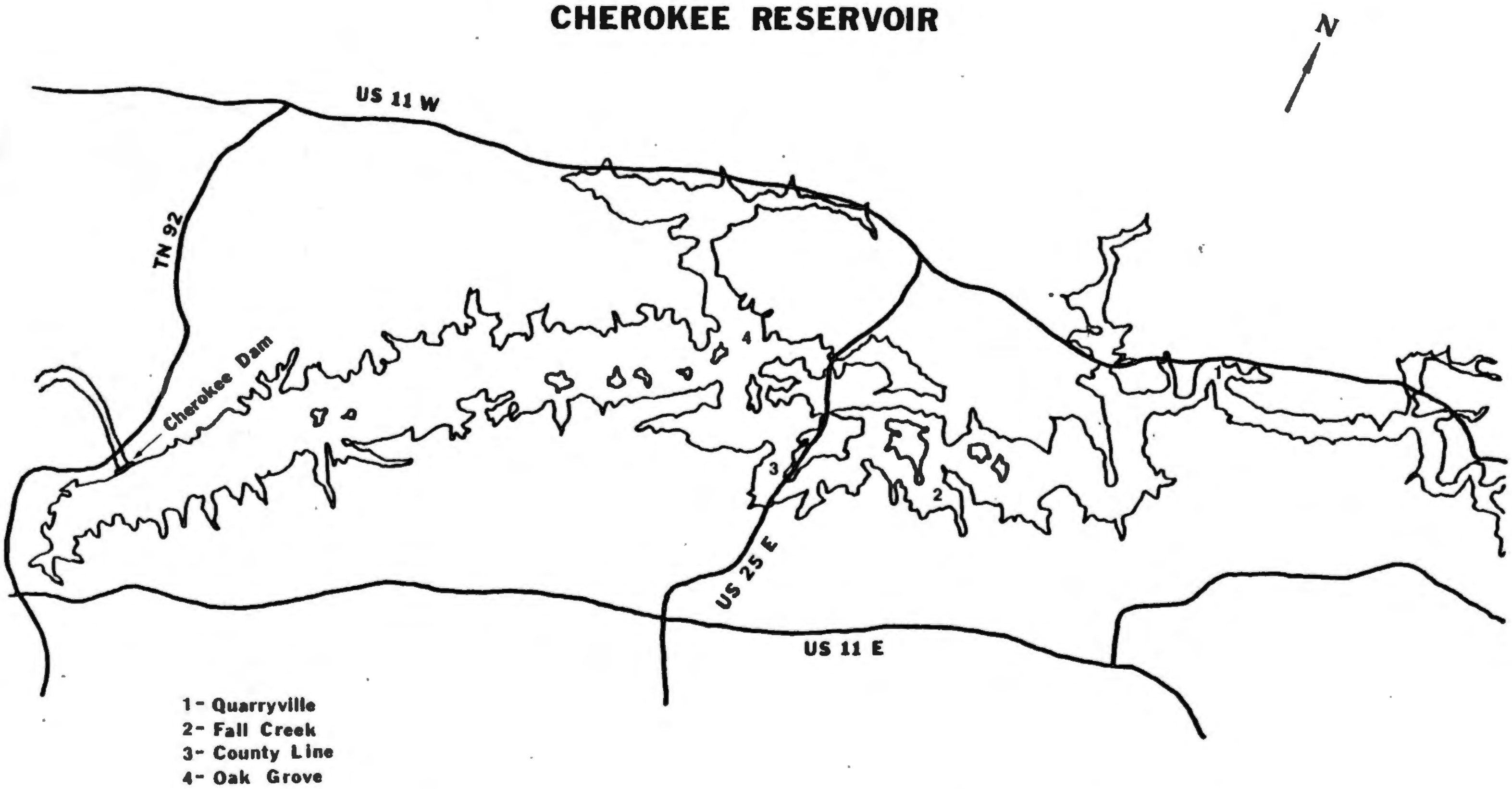

FIGURE 1. Stocking and sampling locations for striped bass, and Morone and Stizostedion hybrids in Cherokee Reservoir, Tennessee.

Collection Period From June 1982 Through April 1983

On 14 June 1982 approximately 22,000 striped bass fingerlings were stocked at the traditional stocking site, the Quarryville access ramp. The decision to stock here at this time was based on quarter-haul samples with a small-mesh seine which revealed large numbers of shad larvae and fry. Another predator, the hybrid of the sauger (*Stizostedion canadense*) male x walleye (*Stizostedion vitreum*) female, had been stocked earlier at this location. Approximately 31,500 of these fingerlings were stocked on 24 May 1982. Approximately 17,000 of the reciprocal cross were stocked at County Line 6 days later. These two hybrids could not be distinguished from each other and will be referred to as *Stizostedion* hybrids hereafter.

On 17 June post-stock samples were collected in the vicinity of the Quarryville stocking site. Post-stock sampling equipment and methods were similar to those used during the previous year. Seining was difficult due to high water levels which flooded the shoreline vegetation. On 1 July a combination pre-stock and post-stock sampling effort was conducted at four potential stocking locations to obtain a sample of the fish that had already been stocked and to determine the site best suited to the stocking of more fingerlings. In addition to previous pre-stock methods, two hauls were made at each location with the large post-stock seine. This was done to estimate the number of young predators present that might compete with young striped bass for the same resources. Predation was believed to be potentially significant after a striped bass fingerling was found in the stomach of a white bass that was collected on the previous sample trip. One gill net with 31.8 mm mesh was set at each potential stocking site to assess the abundance of large predators. After cursory examination of the results of the sample trip, it was recommended that the next stocking be at Fall Creek (Section 2). The following morning (2 July) 6,700 advanced striped bass fingerlings were stocked at the Fall Creek access area. Both stocking sites were sampled on the next two biweekly sample trips. Seining remained difficult because of the sustained high water level and flooded vegetation. Shoreline electrofishing was used more extensively to compensate for the difficulties encountered with seining. The next four biweekly sample trips alternated between the two stocking sites. Gill nets were also used during this period, as it became apparent that the striped bass were growing rapidly and moving offshore. Biweekly sample trips continued through October, followed by monthly trips from November through May 1983. Choices of reservoir sections to be sampled during this period were based on the same criteria used during the 1981-82 sample year. Forage fish, zooplankton, and benthos were sampled on each collection trip and preserved with the same methods used during the previous year.

Cove rotenone data collected by TVA biologists were used to supplement the forage sample data. Rotenone data from 1950 through 1982 were examined and usually consisted of 1 to 12 cove samples per year. Two coves were sampled from 28 July to 30 July 1981. These coves covered 0.40 and 0.33 ha and were located in the Quarryville area (Section 1) of the reservoir. In 1982 six coves were sampled from 20 July to 29 July. Five of these six coves were distributed in the upper half of the reservoir (Sections 1-4). The surface areas sampled ranged from 0.39 to 0.86 ha.

Food Habit Analysis

Food habits, growth, and condition of all young-of-year and yearling striped bass were examined. Other stocked and native predators were also examined to: (1) look for trends in growth and food habits similar to those observed for striped bass; (2) compare growth and survival of different types of stocked fish; and (3) evaluate possible sources of competition for young striped bass. Other young-of-year predators examined were *Morone* hybrids stocked in 1981, *Stizostedion* hybrids stocked in 1982, and native white bass produced in the reservoir in both years. It was believed that examination of these fish groups would be most useful since they occurred in large numbers in the reservoir, consumed foods similar to those consumed by striped bass, and were often caught in the same areas that striped bass were caught.

All young-of-year *Morone* and *Stizostedion* hybrids were examined. Random subsamples of 10 young-of-year white bass were examined from collecting trips on which more than 10 of these fish were caught. All young white bass were examined from sample trips on which 10 or fewer were caught. Scales from each fish were examined to verify age.

Food habits were determined by examination of the contents of the entire gastrointestinal (GI) tract from mouth to anus. All fish examined for food habits were weighed to the nearest tenth of a gram and measured to the nearest millimeter (TL) before GI tracts were removed. The GI tracts were severed at the esophagus and anus and removed intact from the body cavity. The full GI tract was then blotted dry and weighed to the nearest hundredth of a gram. It was then cut open lengthwise and the entire contents were washed and scraped into a 9 x 9 cm gridded counting tray. The empty GI tract was then blotted dry and weighed again. The wet weight of the contents was determined by subtraction of the empty GI tract weight from the full weight. The contents were examined under a 40X dissecting microscope. All food organisms were identified to the lowest practical taxon.

Total lengths of fish found in stomachs were determined by two methods. Fish that were in the earliest stages of digestion were measured directly. With fish that were more digested, total length estimates were calculated from measurements of the length of the vertebral column. Measurements were made from the posterior margin of the centrum of the basioccipital bone to the anterior margin of the hypural plate. Since the vast majority of fish found in stomachs were threadfin and gizzard shad, length calculations were restricted to these two species. Measurement of the length of the vertebral column, as described above, was performed on 50 intact threadfin shad, 0.7 to 14.2 cm total length, and 50 gizzard shad, 1.5 to 16.0 cm total length. These length ranges encompassed the range of lengths of shad found in stomachs. Total lengths of these fish were also measured. Total length was regressed on vertebral column length for the two species separately and combined. Regression coefficients were 0.996 for threadfin shad and 0.997 for gizzard shad and for both species combined. Estimates of the total lengths of the shad consumed were then obtained from the measured vertebral column lengths by insertion into the appropriate regression equation. The equation for the two species combined was used for spinal column measurements obtained from unidentified shad remains. Measurements from identified shad were inserted into the appropriate equation for each species. The total length estimates thus obtained were used to calculate prey-predator length relationships (Popova 1967).

Fish and Invertebrate Forage Analysis

Benthos and zooplankton samples were analyzed to determine seasonal trends in abundance in each section of the upper reservoir. Benthos samples were sifted through standard brass substrate sieves of 10, 20, and 40 mesh (holes per linear inch). All organisms that were retained by the sieves were identified and counted.

Zooplankton samples which contained large numbers of organisms were subsampled before analysis. Subsamples were taken by diluting the sample to a measured volume, stirring the diluted sample vigorously, and removing 1 to 5 ml volumes with a Hensen-Stemple pipette until over 200 organisms had been removed and counted. The total number of organisms per sample was determined from the number counted and the precent of the total sample volume that was subsampled. Zooplankton samples which contained few organisms were not subsampled before counting. All zooplankton and benthos samples were identified and enumerated using a gridded counting tray under a 40X dissecting microscope.

Forage fish samples obtained by seining and electrofishing were sorted by species and counted. The maximum and minimum size of each species was determined for each sample. All fish less than 10 cm were included in forage analyses.

Data Analysis

All food habit and growth data were analyzed with the aid of The University of Tennessee Computing Center's Decsystem-10 computer and the Statistical Analysis Systems (SAS) 1979 software package. Several methods were used to determine trends in food habits. The numbers of food items in each category in the diet were expressed as percentages of total numbers of food items. This calculation estimates the relative abundance of each food item in the diet, and is referred to as the percentage composition by number. Another useful analysis method that was performed was calculation of the frequency of occurrence of food items. In frequency-of-occurrence calculations, the number of fish in which one or more of a given food item is found is expressed as a percentage of all non-empty fish examined. This calculated percentage is an estimate of the proportion of the population that feeds on that particular food item. To look for trends in food habits, fish were grouped by species, year classes, month, location, length, and combinations of these variables before frequency of occurrence and percentage composition by numbers were calculated. In all calculations, fish caught after April of their second growing season were considered to be yearlings. Fish caught before the end of April were considered to be young-of-year. Analyses were performed separately for these different age groups. To obtain relative estimates of GI tract fullness the total weight of the GI tract contents was expressed as a percentage of the total weight of the fish.

A 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 by month caught. Weight-length relationships (Ricker 1975) were calculated 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

Prey-predator length relationships were calculated by averaging all of the measured and estimated lengths of shad eaten by each 2.5 cm length class of each predator species, and dividing these averages by the midpoints of the corresponding length classes. Ranges of shad lengths were also recorded for each length class of predator. The maximum values of these ranges for striped bass were used as estimates of the maximum size of shad that could be preyed on by each striped bass length class. These estimates of maximum prey size were used to calculate the maximum size of shad that could be consumed by the average length striped bass during each month. These monthly maximum prey-size estimates were compared to minimum sizes of the two species of shad collected in forage samples during corresponding months. Overlap of these values was interpreted as the range of sizes of shad in the area sampled that were potentially available to the average size young-of-year striped bass at that time.

Catch-per-unit-effort was calculated for striped bass, white bass, and Morone hybrids collected by the three standardized methods of collection. The three standard units used were hours of electrofishing, gill net hours, and standard seine hauls.

T-tests were used to assess the significance of differences in length, condition, and food habits between year classes of the same species, and among species of the same year class.

CHAPTER V

RESULTS AND DISCUSSION

Reservoir Conditions June 1981 Through May 1983

TVA maintained the water level in Cherokee Reservoir at lower than normal elevations during the spring and summer of 1980 and 1981. These low water levels allowed the encroachment of thick growths of herbaceous terrestrial vegetation onto the reservoir fluctuation zone. In the spring of 1982 the reservoir reached normal summer-pool levels which flooded this dense vegetation and created ideal nursery habitat for many species of fish. The higher water levels in 1982 also provided more surface area for primary, secondary, and predator production. The winter water levels dropped to similar elevations during the two years of this study, which concentrated the fish present each winter in approximately the same reservoir volume.

Pre-Stock Analyses

Pre-stock analyses were conducted at five potential stocking locations on 24 June 1981. Results revealed relatively high concentrations of zooplankton, benthic invertebrates, and small forage-size fish at the traditional stocking site at Quarryville. Relatively few predators were collected at this location (Table 2). All of the striped bass and most of the *Morone* hybrids stocked into Cherokee Reservoir in 1981 were released at the Quarryville boat ramp. The

TABLE 2. Prestock Analyses of Predators[1], Zooplankton, Benthos, and Forage Fish[2] at Possible Stocking Sites

Prestock sites	Plankton per m^3	Benthos per m^2	Forage fish per quarter-haul	Predators per quarter-haul	Predators per standard haul[3]	Predators per gill net hour
			24 June 1981			
Caney Creek	13,553	1,613	14	7.5		
Quarryville	13,783	2,021	6	7.5		
Fall Creek	5,375	1,204	2.5	36.5		
County Line	8,728	1,140	1.5	25		
Oak Grove	12,367	2,000	3.5	6.5		
			1 July 1982			
Quarryville	1,893	2,366	8	1.5	26	5.6
Fall Creek	2,440	2,150	38	0.5	2	0.6
County Line	446	1,023	9	1.5	0.5	5.8
Kidwell's Ridge	1,542	1,505	9.5	0	0	1.9

[1]Predators include striped bass, white bass, *Morone* hybrids, *Stizostedion* hybrids, black bass, black crappie, blue catfish, and channel catfish.

[2]All fish less than 2.5 cm.

[3]Large seine.

Quarryville section of the reservoir has consistently been shown to be an area of high productivity in the spring and summer (Schaich 1979; Saul 1981; Bishop, pers. comm.). At normal spring and summer water levels, Quarryville is just below the area of transition from riverine to lacustrine reservoir conditions. Primary producers, and the rest of the organisms in the food chain, probably flourish here because of the rich nutrient inputs. Larvae and fry of fish that spawn in the headwaters also tend to accumulate here.

On 25 May 1982 a plankton sample containing 188 shad larvae and fry was collected at Quarryville with two 5 m tows of a 22.9 cm diameter plankton net. Approximately two weeks later TWRA biologists collected large numbers of shad fry at the same location with a small mesh seine. Approximately 22,000 striped bass fingerlings were subsequently stocked on 14 June 1982 at this location. It was hoped that these fingerlings would eat the abundant shad fry.

On 1 July 1982 an intensive pre-stock analysis was conducted at four locations to determine the site best suited to receiving an additional stocking of striped bass fingerlings. In addition to previous pre-stock methods, a gill net and a large seine were used at each location to assess the abundance of large predators. The data from these new pre-stock sample methods indicated that large concentrations of predators may go undetected by the methods that were previously used (Table 2). Large numbers of white bass and Morone hybrids were collected with a gill net and large seine in the immediate vicinity of the Quarryville boat launch ramp. Few predators and high concentrations of cyprinids less than 2.5 cm were present at the Fall Creek boat launch ramp.

These data, in addition to the fact that striped bass and Stizostedion hybrids had already been stocked at Quarryville, led this investigator to believe that the next group of striped bass would exhibit better growth and survival if stocked at Fall Creek. Thus, on 2 July, the final stocking of 6,700 striped bass fingerlings was released at the Fall Creek boat launch ramp.

Numbers Caught and Movements

Of approximately 44,000 striped bass stocked in 1981 only 64 were recaptured. Only four of these fish were collected during their second year of growth. Most of these fish, which were stocked late in the stocking season, remained small throughout the 1981 growing season. Seining was the most productive method of collecting this year class through December. Forty-six of these striped bass were collected from a total of 113 standard seine hauls, giving a catch rate of 0.41 fish per seine haul (Table 3). A total of 393.5 gill-net-hours of effort captured only two of these fish during their first year. This low catch rate of 0.005 fish per gill-net-hour indicated a low susceptibility of these small fish to capture with gill nets. The two young-of-year striped bass that were caught with gill nets were considerably larger than the others that were caught by electrofishing and seining. These two fish may have been part of the first group of 1,500 that were stocked at a much larger size 13 days earlier than the other striped bass (Table 1, page 12). These fish were not marked, however, and could not be positively

TABLE 3. Catch-Per-Unit-Effort (Seining, Electrofishing, and Gill Netting) of Striped, White, and Hybrid Bass Grouped by Year Class and Age

Year class, species[1], age[2]	No. stocked	No. of seine hauls	Total catch seining	Catch/seine haul	Hours electrofishing	Total catch electrofishing	Catch/hour electrofishing	Gill net hours	Total catch from gill nets	Catch/gill net hour	Total catch
1981, SB, Y-0-Y	43,823	113	46	0.41	7	12	1.7	393.5	2	0.005	60
1981, SB, 1+		30	0	0	14.6	0	0	735.3	4	0.005	4
1982, SB, Y-0-Y	28,700	30	18	0.60	13.3	24	1.8	644.4	103	0.16	145
1981, MH, Y-0-Y	16,700	123	96	0.78	7	8	1.1	393.5	67	0.17	171
1981, MH, 1+		30	2	0.07	14.6	0	0	735.3	68	0.09	70
1981, WB, Y-0-Y		123	1293	10.50	7	74	10.6	393.5	298	0.76	1665
1982, WB, Y-0-Y		30	82	2.70	13.3	186	14.0	644.4	713	1.11	981
Total effort		153			21.6			1128.8			

[1]SB = striped bass; MH = *Morone* hybrid; WB = white bass.

[2]Y-0-Y = young-of-year; 1+ = yearlings.

distinguished from the rest of the 1981 year class. Seven hours of shoreline electrofishing produced 12 of this year class of striped bass. This catch rate of 1.7 fish per hour is another indication that many of these fish remained small and close to shore during their first year. On November and December sampling trips, a total of 20 young-of-year striped bass were seined 27.5 km downstream from the stocking site (Table 4). This is a strong indication that this year class of fish moved downstream and was still fairly abundant at this time. The small size and poor condition of these fish (which will be discussed in later sections) and the low catch rate the following year (n = 4), however, indicated poor winter survival.

Of 16,700 Morone hybrids stocked in June 1981, 241 were recovered. Seventy of these were captured the following year during their second growing season. This high catch rate of yearlings indicated good survival of these fish through their first winter. Ninety-six young-of-year Morone hybrids were collected by seining, which gives a catch rate of 0.78 fish per standard seine haul. This is more than twice the catch rate for striped bass during the same time period, even though less than half as many Morone hybrids were stocked. Most of the hybrids recovered by seining were collected in the stocking vicinity in the first few months after stocking. These fish grew rapidly and were frequently captured in gill nets after July. Sixty-seven were caught with gill nets during their first year of growth. Other studies that have compared survival and growth of young striped bass and Morone hybrids in culture ponds (Bishop

TABLE 4. Numbers and Locations of Young-of-Year Striped Bass and Morone Hybrids Collected in Cherokee Reservoir on Each Sample Collection Date

	Sample Collection Date																													
						1981											1982												1983	
Section[1] Yr class/species[2]	7/9	7/23	8/5	8/20	9/3	9/17	10/1	10/15	11/6	12/9	1/8	2/5	3/17	4/18	5/25	6/17	7/1	7/12	7/26	8/12	8/18	9/23	9/29	10/21	10/28	11/23	12/20	1/28	2/25	3/10	4/20
Section 1																															
1981/SB		3	7	10	5		1							0																	
1981/MH	36	44	15	8	14		0							4																	
1982/SB																8	10	2	16	27		1									
Section 2																															
1981/SB					8	3		2					1		1																
1981/MH					3	15		4					14		16																
1982/SB																		0	0		0		29		4					4	3
Section 3																															
1981/SB									12	8		0																			
1981/MH									11	1		2																			
1982/SB																								32		3	0				
Section 4																															
1981/SB											0																				
1981/MH											0																				
1982/SB																												4	2		

[1]Section 1 = Quarryville; Section 2 = Fall Creek; Section 3 = County Line; Section 4 = Oak Grove.

[2]SB = striped bass; MH = Morone hybrid.

1967; Logan 1967; Ware 1974) and in reservoirs (Bishop 1967; Ware 1974; Saul 1981) have found *Morone* hybrids to be superior in both respects.

Only five of the 3,300 fin-clipped *Morone* hybrids that were stocked in October 1981 were recovered. They were collected by seining near the stocking site during the two months subsequent to stocking. At this time these fish were much smaller than the hybrids that had been growing in the reservoir since June. Assuming the mark remained detectable, none of these fin-clipped fish were recovered after the December sample trip. The small size and reduced fitness of these fish caused by removal of a pectoral fin may have contributed to high winter mortality rates. Due to the major differences between the two groups of *Morone* hybrids and the mark which allowed easy discrimination between them, the five fish from the October stocking were not included in tables and figures.

Of 28,700 striped bass stocked in June and July of 1982, 145 were recovered. These fish were collected consistently on five consecutive post-stock sample trips to the vicinity of the Quarryville stocking site (Table 4). Three sampling efforts were conducted in the vicinity of the Fall Creek stocking site within five weeks after the stocking of 6,700 striped bass fingerlings. No young-of-year striped bass were collected in this area on any of these trips.

Only 30 standard seine hauls were completed after the 1982 stockings. Most shoreline areas were covered with thick growths of flooded terrestrial vegetation which hampered seining efforts.

Seining on the gravel boat launch ramp at Quarryville, however, produced 18 striped bass fingerlings within the first 3 weeks after stocking. One 5.5 cm fingerling was lodged in the mouth and esophagus of an 18.2 cm yearling white bass. This fingerling was included in all calculations.

A total of 13.3 hours of electrofishing produced 24 striped bass fingerlings during this period. This catch rate of 1.8 fish per hour was similar to the 1.7 striped bass caught per hour in 1981, despite the fact that more fish were stocked in 1981.

The 1982 year class of striped bass grew rapidly and was effectively sampled with gill nets from mid-August through the end of the study. A total of 103 of these fish were collected with 644.4 gill-net-hours of effort. As in 1981, sampling success improved in the sections downstream from the stocking sites as the season progressed (Table 4). Downstream movement of striped bass fingerlings in Cherokee Reservoir was also observed by Saul (1981). As the reservoir was drawn down in the fall, the Quarryville area became shallower and more riverine. Benthic and planktonic invertebrates became less abundant, and schools of young-of-year shad moved downstream. The increased current and reduced abundance of food probably contributed to the observed downstream movement of striped bass.

Dispersal of striped bass fingerlings stocked at Quarryville appeared to be more rapid in 1981 than in 1982. Fewer fingerlings were collected in the immediate vicinity of the stocking site in 1981, even though more fish were stocked. Fingerlings stocked at Fall Creek in 1982 either dispersed rapidly or experienced poor survival, as none were caught on the three collecting trips to this area within five weeks after stocking. Other studies have documented rapid dispersal (Higginbotham 1979; Richardson 1981; Saul 1981; M. Smith, pers. comm.; J. Durniak, pers. comm.; H. Mealing, pers. comm.). D. Bishop (pers. comm.) observed that striped bass tended to remain in the stocking vicinity when food was abundant and moved out more quickly when food was less abundant. Bowles (1975) showed that presence of food reduced the area traveled by striped bass fingerlings held in circular tanks. These observations suggest that differences in dispersal rates observed in this study may have been due to differences in abundance of available food organisms. Forage abundance, food habits, and growth rates, which will be discussed later, also tend to support this hypothesis.

Strong year classes of white bass were produced during both 1981 and 1982. Large numbers of young-of-year white bass were collected during most sample trips. The number of young-of-year white bass caught per seine haul was considerably higher in 1981. Gill nets caught more young-of-year white bass per net-hour in 1982. These catch-per-unit-effort data reflect the more rapid growth rate, and earlier susceptibility to capture with gill nets, of the 1982 year class.

While sampling the 1982 year class of striped bass, a total of 217 stocked *Stizostedion* hybrids were collected. These fish were initially collected by seining and electrofishing in the vicinity of the Quarryville stocking site. It is probable that all of these smaller fish collected early in the summer were hybrids between walleye females and sauger males. This cross was stocked at Quarryville. The reciprocal cross was stocked approximately 26 km downstream at County Line. No characteristics for distinguishing between the two crosses have been determined, but it does not seem likely that the cross stocked at County Line would travel this distance upstream within several months after stocking. As these fish grew, they quickly became susceptible to capture with gill nets. Catch rates increased in sections of the reservoir below the Quarryville stocking site as the season progressed. This, again, indicated a downstream movement as water levels were lowered in the fall. Both crosses were probably present in later samples but could not be separated. In the spring of 1983 fishermen caught large numbers of these hybrids in the more riverine upper section of the reservoir (Bishop, pers. comm.). This suggests an upstream migration in the early spring.

Condition

Mean condition factors (k) separated by month and by length class are presented for each year class of striped, white, and hybrid bass in Tables 5 and 6, respectively. Condition factors may change after preservation (Stobo 1972), but since all fish in this study and in Saul's (1981) and Richardson's (1982) investigations were preserved similarly, and all measurements were made after preservation, comparisons should be valid. Mean condition of the 1982 year class of striped bass (1.08-1.28) was better than that of the

TABLE 5. Mean Condition Factors (K), for Striped, White, and Hybrid Bass in Each Month (June 1981-April 1983)

Year	Month	1981 year class striped bass K	N	1982 year class striped bass K	N	1981 year class white bass K	N	1982 year class white bass K	N	1981 year class *Morone* hybrids K	N
1981	Jul	0.77	3			1.06	20			1.03	80
	Aug	0.85	17			1.07	20			1.19	23
	Sep	0.84	16			1.04	20			1.12	32
	Oct	0.87	3			1.02	17			1.13	4
	Nov	0.69	12			1.18	10			1.33	11
	Dec	0.71	8			1.21	10			1.29	1
1982	Jan	--	0			1.24	10			--	0
	Feb	--	0			1.23	10			0.80	2
	Mar	0.91	1			1.14	10			1.11	14
	Apr	--	0			1.09	10			1.05	4
	May	1.04	1			1.19	10			1.25	16
	Jun	--	0	1.13	8	1.22	2	1.04	10	1.36	2
	Jul	--	0	1.10	28	1.19	10	1.17	30	1.30	11
	Aug	--	0	1.15	27			1.42	10	1.71	2
	Sep	1.39	2	1.12	30			1.23	20	1.49	22
	Oct	1.40	1	1.18	36			1.30	20	1.38	9
	Nov	--	0	1.14	3			1.32	10	1.59	5
	Dec	--	0	--	0			1.33	10	--	0
1983	Jan	--	0	1.22	4			1.36	10	--	0
	Feb	--	0	1.12	2			1.27	10	--	0
	Mar	--	0	1.16	4			1.28	10	1.61	3
	Apr	--	0	1.28	3			1.41	10	--	0

TABLE 6. Mean Condition Factors (K) for Striped, White, and Hybrid Bass in Each Length Class, Grouped by Year Class

Length class[1]	1981 year class striped bass K	N	1982 year class striped bass K	N	1981 year class white bass K	N	1982 year class white bass K	N	1981 year class Morone hybrids K	N
1	0.82	17	1.08	13	1.01	28	1.04	13	1.03	22
2	0.79	29	1.10	12	1.04	19	1.12	14	1.02	51
3	0.75	12	1.13	17	1.00	11	1.19	8	1.01	24
4			1.20	5	1.17	4	1.36	10	1.16	10
5	0.91	1	1.14	16	1.13	15	1.46	3	1.20	17
6			1.14	41	1.14	41	1.27	13	1.16	19
7	0.98	1	1.10	3	1.24	30	1.29	45	1.16	6
8			1.12	22			1.33	43	1.26	18
9			1.15	29			1.30	1	1.29	15
10	1.04	1	1.21	21					1.40	8
11			1.19	6					1.74	1
12			1.23	1					1.41	6
13	1.43	2							1.51	12
14									1.50	14
15	1.32	1							1.52	7
16										
17									1.48	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; 11 = 30.1 to 32.5 cm; 12 = 32.6 to 35.0 cm; 13 = 35.1 to 37.5 cm; 14 = 37.6 to 40.0 cm; 15 = 40.1 to 42.5 cm; 16 = 42.6 to 45.0 cm; 17 = 45.1 to 47.5 cm.

1981 year class young-of-year (0.69-0.91) in each length class and in each month. Differences were significant in length classes 1, 2, and 3 ($P<0.0001$), and in all months ($P=0.05$) in which fish from both year classes were caught. Saul (1981) calculated mean condition factors of 0.76 to 0.91 for young-of-year, 1979 year class striped bass from Cherokee Reservoir that ranged in length from 2.6 to 12.5 cm. These conditions are relatively poor and compare more closely to the values obtained for the 1981 year class in the present study. Richardson (1982) calculated condition factors for similar-sized young-of-year 1979 and 1980 year class striped bass from Norris Reservoir (0.73-0.81). These condition factors are also relatively low and compare closely to Saul's (1981) and those obtained for the first year of this study.

The differences among year classes observed in this study were obvious upon visual comparison. Most of the 1981 year class had emaciated bodies, and their heads were large when compared to the rest of the body. This was the case even with most of the fish collected in the months immediately following stocking. In contrast, most of the 1982 year class striped bass were thick and deep bodied. Greater gut content weight of the 1982 year class may have contributed to the differences in condition but this was not enough to completely account for these differences.

Comparison of condition factors of young-of-year 1981 and 1982 year class white bass revealed similar differences among year classes. The mean condition of the 1982 year class fish (1.27) was significantly better (P = 0.001) than that of the 1981 year class young-of-year (1.11). The 1982 year class means were higher in each length class and in each month.

The condition of white bass in Cherokee Reservoir in 1979 and 1980 (0.90-1.32) (Saul 1981) was lower than the condition of the 1982 year class in each 2.5 cm length class, and was similar to the condition of the 1981 year class. The condition factors that Richardson (1982) calculated for Norris Reservoir white bass (0.67-1.21) were also more similar to the conditions of the 1981 year class white bass in Cherokee. The differences in condition among year classes of native white bass in Cherokee Reservoir suggest that some difference in environmental conditions had a significant impact on this species. This further suggests that at least part of the difference between year classes of striped bass was due to environmental conditions that were independent of stocking size and date.

Comparisons of condition among striped, white, and hybrid bass were not considered to be valid, due to inherent differences in body depth and width. Mean condition of young-of-year Morone hybrids stocked in 1981, however, was fairly good. Mean condition in November (n = 11) was 1.33. This value compares favorably to the condition of young-of-year Morone hybrids in Cherokee Reservoir in 1979, which ranged from 0.9 to 1.2 (Saul 1981). Crandall (1978) calculated a condition factor of 1.38 for Morone hybrids in Texas. This condition factor, which was associated with rapid growth, is similar to the condition factors calculated in the present study. This apparent good condition of Morone hybrids, when striped and white bass were in relatively poor condition, may be explained by the earlier stocking date, the commonly observed superior vigor of these fish, and the more significant utilization of fish in the diet, which will be discussed later. An early competitive size advantage may also have enchanced the condition of these fish and contributed to the decreased condition of striped and white bass.

The mean condition of the five fin-clipped Morone hybrids that were recovered shortly after the October stocking was poor (0.77). When stocked these fish were smaller and appeared to be in worse condition than the Morone hybrids that had been growing in the reservoir since June. This later stocking did not allow much opportunity for first year growth. Since no Morone hybrids were stocked in 1982, year classes could not be compared. Mean condition factors of Stizostedion hybrids collected during each month ranged from 0.61 in June 1982 to 1.00 in May 1983 (Table 7). Again no Stizostedion hybrids were stocked in 1981 so year class comparisons could not be made.

Growth

The average total lengths of the year classes of striped, white, and hybrid bass that were caught during each month are presented in Table 8. It is vividly apparent that monthly growth increments of the 1981 year class of striped bass were very small through December. Most of these fish were stocked late in July and remained small throughout their first growing season. They attained

TABLE 7. Mean Total Length (cm) and Condition of 1982 Year Class Stizostedion Hybrids Each Month (June 1982-May 1983)

Month	N	Total length (cm)	K
Jun	4	8.9	0.61
Jul	16	15.2	0.83
Aug	10	18.0	0.85
Sep	15	24.5	0.85
Oct	48	27.8	0.92
Nov	13	29.8	0.95
Dec	3	29.1	0.94
Jan	1	28.3	1.00
Feb	2	28.8	0.97
Mar	51	29.8	0.95
Apr	48	30.5	0.98
May	6	27.1	1.00

TABLE 8. Mean Total Length (cm) of Each Year Class of Striped, White, and Hybrid Bass Collected in Each Month (July 1981-April 1983)

Month	1981 year class striped bass Length	N	1982 year class striped bass Length	N	1981 year class white bass Length	N	1982 year class white bass Length	N	1981 year class *Morone* hybrids Length	N
Jul	10.4	3			7.2	20			8.7	80
Aug	7.2	17			8.8	20			13.5	23
Sep	9.1	16			11.3	20			16.9	32
Oct	13.0	3			16.1	17			18.1	4
Nov	9.4	12			18.5	10			24.7	11
Dec	9.4	8			20.0	10			23.8	1
Jan	--	0			19.3	10			--	0
Feb	--	0			19.2	10			12.3	2
Mar	17.2	1			19.5	10			20.4	14
Apr	--	0			18.1	10			21.4	4
May	29.5	1			20.3	10			24.7	16
Jun	--	0	6.4	8	19.0	2	6.7	10	17.6	2
Jul	--	0	10.0	28	23.1	10	9.6	30	25.8	11
Aug	--	0	17.0	27			15.9	10	32.8	2
Sep	37.7	2	24.5	30			20.3	20	37.7	22
Oct	36.5	1	27.1	36			22.9	20	37.4	9
Nov	--	0	26.8	3			24.1	10	38.1	5
Dec	--	0	--	0			22.6	10	--	0
Jan	--	0	27.3	4			22.8	10	--	0
Feb	--	0	27.1	2			23.2	10	--	0
Mar	--	0	31.8	4			21.6	10	41.7	3
Apr	--	0	30.6	3			22.4	10	--	0

an average length (n = 20) of only 9.4 cm by late fall. This figure was comparable to the lowest first year growth estimates found in the literature which were generally associated with diets of invertebrates. The three fish that were caught in July 1981 were from the 14 July stocking of only 1,500 large fingerlings. These fingerlings were a greater average length (10.4 cm) shortly after stocking than the 20 fish that were collected in November and December (9.4 cm). Some of this small number of fish that were stocked at a large size early in the season may have grown fairly well. One fish caught in a gill net in October stood out as being particularly large (20.4 cm). This fish and the five larger fish of this year class that were caught the following year may have been from the 14 July stocking. Again, these fish were not marked and could not be positively distinguished from the rest of the year class.

The average total lengths of 1982 year class striped bass caught during each month indicated a rapid growth rate. Growth increments between July and August and between August and September were 7.0 and 7.5 cm, respectively. These fish attained an average total length (n = 36) of 27.1 cm by October and 31.8 cm (n = 4) by March. These figures were comparable to the highest first year growth estimates found in the literature which were generally associated with diets of fish.

T-tests were used to compare mean total lengths of the two year classes in corresponding months of the two years. Differences in mean lengths in July were not significant (P = 0.1). Mean lengths of the 1982 year class were significantly greater ($P<0.0001$) in August, September, and November. The 1982 year class sample from October was significantly larger only at $P = 0.1$. This was due to small sample sizes and a high degree of variability contributed by the one uncharacteristically large 1981 year class striped bass caught in October 1981.

Weight-length relationships were calculated for both year classes. The relationships for the 1981 year class young-of-year and the 1982 year class, respectively, were: $\log W = -5.078 + 2.987 \log L$, and $\log W = -5.075 + 3.058 \log L$. A slope of 3.0 indicates isometric growth, thus the slope of less than 3.0 for the 1981 year class indicated that these fish put on less weight in proportion to length as they increased in size, and condition deteriorated. The slope of more than 3.0 for the 1982 year class indicated improved condition with increased size. The difference in initial condition of these two year classes accentuates the significance of the difference in weight-length relationships. The 1981 year class condition declined from an initially poor level. The initial condition of the 1982 year class was fairly good, and improved with increased size.

Other studies have sought explanations for differences in first year growth among year classes of striped bass within the same body of water. Van Den Avyle and Higginbotham (1979) demonstrated that survival and average lengths attained at ages I and II in Watts Bar Reservoir, Tennessee, were inversely related to stocking density and directly related to size at stocking. Since high stocking densities were accompanied by low average sizes of introduced fingerlings, the effects of the two variables could not be distinguished. The authors felt, however, that the size at stocking, rather than density-dependent mechanisms, were primarily responsible for the observed relationships. The findings of the present study are contradictory to those of Van Den Avyle and Higginbotham (1979). Most of the 1982 year class were stocked at a smaller average size (Table 1, page 12) but experienced much better growth and survival than fish stocked in 1981. The data suggests, however, that the larger fingerlings stocked in 1981 grew better than the smaller fingerlings stocked the same year. Van Den Avyle et al. (1983) later pointed out that growth was faster in one year class that contained higher percentages of fish in the diet, and suggested that variations in growth may have been due to differences in prey abundance. Similarly, Axon (1979) reported that first year growth and survival of one of five year classes of striped bass in Herrington Lake, Kentucky, was poor (13.2 cm) due to low standing crop of threadfin shad and forage-size gizzard shad that year. The faster growth of the 1982 year class in the present study was also related to utilization and abundance of forage-size shad. This will be discussed in more detail in later sections. The earlier stocking date in 1982 may also have contributed to the better growth of this year class.

Again, white bass showed differences among year classes similar to those observed for striped bass. Mean lengths of the 1982 year class were significantly greater ($P = 0.005$) in each month. The 1982 year class reached 24.1 cm (n = 10) by November. The 1981 year class only reached 18.5 cm (n = 10) by November of the previous year. Saul (1981) determined first year growth of white bass in Cherokee Reservoir in 1979 and 1980 to be only 14.0 cm. Richardson (1982) estimated first year growth of Norris Reservoir white bass to be 18.4 cm, which is similar to Cherokee white bass growth in 1981. Webb and Moss (1967) also found variation in first year growth of six year classes of white bass (18.8-24.7 cm) in Center Hill Reservoir, Tennessee. Their highest estimate, which was the greatest first year growth found in the literature, is very close to the lengths reached in November by 1982 year class Cherokee Reservoir white bass. Their lowest estimate is close to Cherokee white bass growth in 1981. Forney and Taylor (1963) attributed variation in growth of different year classes of white bass in Oneida Lake, New York, (12.2 cm-18.8 cm) to variation in intraspecific competition due to differences in year class abundance. Yellayi and Kilambi (1975) suggested that fluctuations in white bass growth in Beaver Reservoir, Arkansas, were due to winter-kill and subsequent recovery of threadfin shad populations. Bonn (1952) found that an increase in first year growth of white bass from 7.4 to 12.6 cm in Lake Texoma, Texas, was associated with unusually high water levels and a higher frequency of occurrence of gizzard shad in the diet. Differences in water level, *Morone* spp. abundance, threadfin shad abundance, and occurrence of shad in the diet were all observed in this study and probably interacted to produce the observed differences in white bass growth.

Weight-length relationships for the 1981 and 1982 year classes of white bass were: log W = -5.294 + 3.158 log L, and log W = -5.264 + 3.163 log L, respectively. Although both slopes are greater than 3.0 and condition improved with increased length in both years, the 1981 year class condition increased at a slightly slower rate from initially lower values.

Again, *Morone* hybrids did not fit the trend observed for striped and white bass. The hybrids that were stocked in June of 1981 grew fairly well and reached an average length of 24.7 cm (n = 11) by November. The slope in the weight-length relationship (log W = -5.674 + 3.328 log L) indicated a substantial increase in condition with increased size. Saul (1981) determined that 1980 year class *Morone* hybrids in Cherokee Reservoir grew to an average total length of only 21.5 cm by January 1981. Bishop (1967) reported that *Morone* hybrids may reach 35.8 cm in Cherokee Reservoir after one year of growth. This points out that although *Morone* hybrids grew better than striped and white bass in 1981, growth of the 1980 and 1981 year classes was much less than optimal for this body of water. *Morone* hybrids commonly exhibit higher initial growth rates than striped bass. Growth of striped bass in 1982, however, was better than growth of *Morone* hybrids in 1981 which, again, suggests differences in environmental conditions between the two years. The five fin-clipped *Morone* hybrids, recovered from the October 1981 stocking, were small (7.2 cm-8.3 cm) and not characteristic of the rest of the year class.

Stizostedion hybrids stocked in 1982 grew rapidly, attaining a mean total length (n = 13) of 29.8 cm by November (Table 7). This is much better first year growth than was observed by Stroud (1948) for four year classes of naturally produced *Stizostedion* hybrids in Norris Reservoir, Tennessee (22.1 cm). The fact that *Stizostedion* hybrids, as well as striped and white bass, grew remarkably well in 1982 suggests that inter- and intra-specific competition was minimal. The observation that competition was minimal, even though these young predators were all relatively abundant, further suggests that forage was abundant.

Food Habits

Of the 60 guts removed from 1981 year class young-of-year striped bass, only one was empty. The four yearlings of this year class that were caught in 1982 all contained food. Of 145 1982 year class young-of-year collected, one was empty. One was kept alive for behavioral observation and was not examined for food habits. All striped bass of the 1982 year class were collected from 17 June 1982 to 20 April 1983 and were considered to be young-of-year.

Feeding habits of the 1982 year class striped bass were markedly different from those of the 1981 year class. Of 2671 food items identified in the guts of the 1981 year class young-of-year striped bass (Table 9), 96.3% were invertebrates and only 1.2% were fish. Of 1169 food items consumed by the 1982 year class fish, only 31.2% were invertebrates and 67.3% were fish. T-tests showed that the mean number of fish consumed by the 1982 year class striped bass

TABLE 9. Percents of Total Numbers of Food Items in Guts of 1981 and 1982 Year Class Young-of-Year (YOY) and Yearling (1+) Striped (SB), White (WB), and Hybrid (MH) Bass

	1981 year class						1982 year class	
Food item categories	YOY/SB	1+/SB	YOY/MH	1+/MH	YOY/WB	1+/WB	YOY/SB	YOY/WB
Pisces	1.2	100.0	7.5	35.2	4.6	72.2	67.3	19.5
Dorosoma sp.	0.9	100.0	5.6	34.5	3.5	59.5	65.6	17.3
Dorosoma petenense	0.04	35.7	0.4	0.8	0.1	0.0	18.1	3.6
Dorosoma cepedianum	0.0	0.0	0.7	2.1	0.3	1.3	0.8	0.1
Unidentified *Dorosoma*	0.9	64.3	4.6	31.6	3.0	58.2	46.7	13.3
Cyprinidae	0.04	0.0	0.2	0.0	0.6	0.0	0.1	0.3
Other fish	0.0	0.0	0.1	0.0	0.0	1.3	0.3	0.2
Unidentified fish	0.3	0.0	1.6	0.7	0.6	11.4	1.4	1.6
Insecta	52.0	0.0	68.6	63.0	84.1	17.7	28.1	75.5
Diptera	50.0	0.0	64.1	58.3	79.6	17.7	21.6	72.6
Chironomidae	49.5	0.0	59.3	57.8	56.7	17.7	21.3	71.3
Chironomidae larvae	45.4	0.0	43.0	55.7	49.5	12.7	18.5	30.5
Chironomidae pupae	4.0	0.0	16.3	2.1	7.2	5.1	2.8	40.8
Chaoborus sp.	0.4	0.0	3.4	0.2	10.2	0.0	0.3	0.9
Adult Diptera	0.1	0.0	1.3	0.2	3.7	0.0	0.1	0.3
Ephemeroptera	1.7	0.0	3.4	3.7	0.0	0.0	6.3	2.8
Ephemeridae	0.1	0.0	0.1	3.3	2.0	0.0	6.2	0.5
Other Ephemeroptera	1.6	0.0	3.2	0.5	1.2	0.0	0.2	2.2
Trichoptera	0.1	0.0	0.2	0.2	0.7	0.0	0.0	0.1
Corixidae	0.1	0.0	0.6	0.0	0.5	0.0	0.0	0.0
Other insects	0.0	0.0	0.2	0.8	0.1	0.0	0.0	0.1
Unidentified insects	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Crustacea	44.1	0.0	16.5	1.3	10.1	6.3	3.0	4.0
Copepoda[1]	36.4	0.0	0.2	0.0	5.0	0.0	0.0	0.0
Argulus sp.	5.3	0.0	5.5	1.3	3.3	6.3	3.0	2.6
Cladocera[2]	2.4	0.0	10.4	0.0	1.8	0.0	0.0	0.7
Leptodora sp.	0.04	0.0	0.4	0.0	0.0	0.0	0.0	0.8
Other invertebrates	0.2	0.0	0.2	0.1	0.2	0.0	0.1	0.1
Miscellaneous	2.4	0.0	7.2	0.3	0.9	3.8	1.5	0.9
No. of fish with food	59	4	168	60	114	20	143	141
No. of food items	2671	28	3051	860	1764	79	1169	1516

[1]Exclusive of *Argulus* sp.

[2]Exclusive of *Leptodora* sp.

was significantly greater ($P<0.0001$) than the mean number consumed by the 1981 young-of-year. The 1981 year class consumed significantly more ($P=0.05$) insects and crustaceans, which were the most important invertebrate food groups during both years. Insects comprised 54% of the invertebrates consumed by the 1981 young-of-year and 90% of the invertebrates eaten by the 1982 year class. Chironomid larvae and pupae made up the majority of the insects consumed in 1981 (95%) and in 1982 (76%). Crustaceans comprised 46% and 10% of the invertebrates in 1981 and 1982, respectively. In 1982 *Argulus*, the large parasitic copepod, was the only crustacean consumed. In 1981 *Argulus*, other smaller copepods, and cladocerans were the most important crustaceans in the diet.

The majority of the fish that were eaten by both year classes were shad. Most shad found in the guts were partially digested and could not be identified to species. Of 32 fish consumed by the 1981 young-of-year, 24 (75%) were identified as *Dorosoma* sp. The 28 food items found in the guts of the four yearling fish of this year class were all shad. Ninety-seven percent of the fish found in the guts of the 1982 year class fish were identified as shad. These percentages may have been even higher, had it been possible to identify all fish remains found in the GI tracts.

Frequencies of occurrence of food items in the guts of fish that contained food are presented in Table 10. Frequency of occurrence analyses estimated the percentages of the populations that utilized each particular food category. These analyses pointed out

TABLE 10. Frequency of Occurrence (%) of Food Items in Guts of 1981 and 1982 Year Class Young-of-Year (YOY) and Yearling (1+) Striped (SB), White (WB), and Hybrid (MH) Bass That Contained Food

	1981 year class						1982 year class	
Food item categories	YOY/SB	1+/SB	YOY/MH	1+/MH	YOY/WB	1+/WB	YOY/SB	1+/SB
Pisces	36	100	70	88	46	95	97	84
Dorosoma sp.	27	100	54	85	33	55	92	67
Dorosoma petenense	2	25	7	7	2	0	34	23
Dorosoma cepedianum	0	0	11	18	5	5	5	1
Unidentified Dorosoma	25	100	47	75	27	50	88	60
Cyprinidae	2	0	4	0	6	0	1	2
Other fish	0	0	1	0	0	5	1	1
Unidentified fish	8	0	21	5	9	40	10	16
Insecta	88	0	71	23	75	20	27	50
Diptera	83	0	66	18	70	20	17	48
Chironomidae	83	0	65	15	68	20	16	46
Chironomidae larvae	76	0	58	8	61	10	10	33
Chironomidae pupae	44	0	40	12	44	15	11	30
Chaoborus sp.	17	0	11	3	18	0	1	3
Adult Diptera	5	0	4	2	8	0	1	2
Ephemeroptera	19	0	15	10	26	0	12	11
Ephemeridae	5	0	2	7	18	0	11	4
Other Ephemeroptera	15	0	14	5	10	0	1	8
Trichoptera	7	0	3	3	7	0	0	1
Corixidae	3	0	6	0	5	0	0	0
Other insects	0	0	4	5	1	0	0	1
Unidentified insects	3	0	2	0	1	0	1	0
Crustacea	37	0	22	7	18	5	8	16
Copepoda[1]	7	0	2	0	1	0	0	0
Argulus sp.	27	0	18	7	16	5	8	16
Cladocera[2]	10	0	6	0	4	0	0	1
Leptodora sp.	2	0	1	0	0	0	0	1
Other invertebrates	7	0	3	2	4	0	1	1
Miscellaneous	34	0	11	5	8	15	4	4
No. of fish with food	59	4	168	60	114	20	143	141

[1]Exclusive of Argulus sp.

[2]Exclusive of Leptodora sp.

the importance of food items that were consumed in low numbers but were utilized by significant portions of the populations. This table reveals that although fish only constituted 1.2% of the food items of the 1981 young-of-year, fish actually occurred in 36% of these striped bass guts that contained food. Thus, fish were more important in the first year diet of this year class than was indicated by the percent of total numbers data in Table 9. In terms of weight and volume, fish were probably even more important since they were the largest food items consumed. Insects and crustaceans remained important in terms of frequency of occurrence. They occurred in 88% and 33%, respectively, of the GI tracts that contained food.

The overwhelming importance of shad in the diet of the 1982 year class was again demonstrated by the fact that this food items was present in 92% of the guts that contained food. Insects and crustaceans were found in only 27 and 8%, respectively, of the GI tracts that contained food. Ephemeroptera (12%) were almost as important as Chironomidae (16%) in terms of frequency of occurrence.

The data in Tables 9 and 10 were grouped by month of capture, reservoir section, and 2.5 cm length class of fish to examine trends and changes in food habits associated with these variables. The percent-of-total-numbers and frequency-of-occurrence analyses for the 1981 year class, grouped by month of capture, are presented in Tables 11 and 12. These analyses indicate that fish occurred in the diet of the 1981 year class during each month. The three fingerlings from the 14 July 1981 stocking that were caught nine days after

TABLE 11. Percents of Total Numbers of Food Items in Guts of 1981 Year Class Striped Bass, Grouped by Month

Food item categories	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
	Month																				
Pisces	46.2	1.9	2.5	8.0	0.1	0.1			10.0		100.0				100.0	100.0					
Dorosoma sp.	15.4	1.5	2.2	8.0	0.0	0.1			10.0		100.0				100.0	100.0					
Dorosoma petenense	0.0	0.0	0.1	0.0	0.0	0.0			0.0		0.0				0.0	43.5					
Dorosoma cepedianum	0.0	0.0	0.0	0.0	0.0	0.0			0.0		0.0				0.0	0.0					
Unidentified *Dorosoma*	15.4	1.5	2.0	8.0	0.0	0.1			10.0		100.0				100.0	56.5					
Cyprinidae	0.0	0.0	0.1	0.0	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			0.0		0.0				0.0	0.0					
Unidentified fish	30.8	0.4	0.1	0.0	0.1	0.0			0.0		0.0				0.0	0.0					
Insecta	53.8	78.2	80.0	68.0	19.2	60.2			90.0		0.0				0.0	0.0					
Diptera	53.8	65.8	78.5	36.0	19.1	60.1			90.0		0.0				0.0	0.0					
Chironomidae	53.8	63.5	77.9	36.0	19.0	59.5			90.0		0.0				0.0	0.0					
Chironomidae larvae	53.8	58.3	73.8	8.0	14.5	58.6			0.0		0.0				0.0	0.0					
Chironomidae pupae	0.0	5.3	4.1	28.0	4.4	0.9			90.0		0.0				0.0	0.0					
Chaoborus sp.	0.0	1.1	0.6	0.0	0.1	0.6			0.0		0.0				0.0	0.0					
Adult Diptera	0.0	1.1	0.0	0.0	0.0	0.0			0.0		0.0				0.0	0.0					
Ephemeroptera	0.0	11.3	1.0	32.0	0.0	0.0			0.0		0.0				0.0	0.0					
Ephemeridae	0.0	0.8	0.1	0.0	0.0	0.0			0.0		0.0				0.0	0.0					
Other Ephemeroptera	0.0	10.5	0.9	32.0	0.0	0.0			0.0		0.0				0.0	0.0					
Trichoptera	0.0	0.8	0.3	0.0	0.0	0.0			0.0		0.0				0.0	0.0					
Corixidae	0.0	0.4	0.3	0.0	0.0	0.0			0.0		0.0				0.0	0.0					
Other insects	0.0	0.0	0.0	0.0	0.0	0.0			0.0		0.0				0.0	0.0					
Unidentified insects	0.0	0.0	0.0	0.0	0.1	0.1			0.0		0.0				0.0	0.0					
Crustacea	0.0	12.8	16.1	0.0	77.3	39.5			0.0		0.0				0.0	0.0					
Copepoda[1]	0.0	0.0	0.0	0.0	71.0	39.3			0.0		0.0				0.0	0.0					
Argulus sp.	0.0	6.8	16.1	0.0	1.2	0.1			0.0		0.0				0.0	0.0					
Cladocera[2]	0.0	5.6	0.0	0.0	5.1	0.0			0.0		0.0				0.0	0.0					
Leptodora sp.	0.0	0.4	0.0	0.0	0.0	0.0			0.0		0.0				0.0	0.0					
Other invertebrates	0.0	0.0	0.1	0.0	0.5	0.0			0.0		0.0				0.0	0.0					
Miscellaneous	0.0	7.1	1.2	24.0	2.9	0.1			0.0		0.0				0.0	0.0					
No. of fish with food	3	17	15	3	12	8	0	0	1	0	1	0	0	0	2	1	0	0	0	0	0
No. of food items	13	266	683	25	990	684			10		1				4	23					

[1]Exclusive of *Argulus* sp.

[2]Exclusive of *Leptodora* sp.

TABLE 12. Frequency of Occurrence (%) of Food Items in Guts of 1981 Year Class Striped Bass That Contained Food, Grouped by Month

Food item categories	Month J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
Pisces	100	18	67	67	8	13			100		100				100	100						
Dorosoma sp.	67	12	53	67	0	13			100		100				100	100						
Dorosoma petenense	0	0	7	0	0	0			0		0				0	100						
Dorosoma cepedianum	0	0	0	0	0	0			0		0				0	0						
Unidentified Dorosoma	67	12	47	67	0	13			100		100				100	100						
Cyprinidae	0	0	7	0	0	0			0		0				0	0						
Other fish	0	0	0	0	0	0			0		0				0	0						
Unidentified fish	67	6	7	0	8	0			0		0				0	0						
Insecta	67	94	87	67	92	88			100		0				0	0						
Diptera	67	82	87	33	92	88			100		0				0	0						
Chironomidae	67	82	87	33	92	88			100		0				0	0						
Chironomidae larvae	67	82	87	33	67	88			0		0				0	0						
Chironomidae pupae	0	47	33	33	67	38			100		0				0	0						
Chaoborus sp.	0	18	13	0	8	50			0		0				0	0						
Adult Diptera	0	18	0	0	0	0			0		0				0	0						
Ephemeroptera	0	29	27	67	0	0			0		0				0	0						
Ephemeridae	0	12	7	0	0	0			0		0				0	0						
Other Ephemeroptera	0	24	20	67	0	0			0		0				0	0						
Trichoptera	0	12	13	0	0	0			0		0				0	0						
Corixidae	0	6	7	0	0	0			0		0				0	0						
Other insects	0	0	0	0	0	0			0		0				0	0						
Unidentified insects	0	0	0	0	8	13			0		0				0	0						
Crustacea	0	47	33	0	58	25			0		0				0	0						
Copepoda[1]	0	0	0	0	25	13			0		0				0	0						
Argulus sp.	0	35	33	0	33	13			0		0				0	0						
Cladocera[2]	0	29	0	0	8	0			0		0				0	0						
Leptodora sp.	0	6	0	0	0	0			0		0				0	0						
Other invertebrates	0	0	7	0	25	0			0		0				0	0						
Miscellaneous	0	29	33	67	58	13			0		0				0	0						
No. of fish with food	3	17	15	3	12	8	0	0	1	0	1	0	0	0	2	1	0	0	0	0	0	0

[1]Exclusive of Argulus sp.

[2]Exclusive of Leptodora sp.

introduction into the reservoir, each had fish in their guts. Six of the 13 food items (46.2%) were fish. This significant utilization of fish shortly after stocking may have contributed to more rapid growth of this small part of the 1981 year class. The rest of the 1981 year class caught before the end of December 1981 utilized fish to a lesser degree. During this period, fish occurred in 8 to 67% of the young-of-year striped bass that contained food each month. Fish, however, only comprised 0.1 to 8.0% of the total food items. Insects and crustaceans remained important in terms of both frequency of occurrence and percent of total numbers of food items throughout this period. Saul (1981) also found that Chironomidae and Crustacea were the most important food items of the 1979 year class of striped bass in Cherokee Reservoir through their first year.

In the present study the miscellaneous category, which was composed of plant material, rocks, and fish scales, was also fairly important in terms of frequency of occurrence. This indicated fairly non-selective foraging at the substrate/water column interface. Emlen (1966), upon review of literature on feeding behavior, observed that animals will become more and more indiscriminate in their selection of foods as general food deprivation becomes more and more severe. He also suggested that the role of food in the population limitation of a predator species may be evaluated by examining the extent to which predators tend to pass by potential food items. The broad range of food items found in the young-of-year 1981 year class striped bass, including a high incidence of non-nutritious material, suggests that these fish passed by few potential food items, and that appropriate-sized food was scarce. This hypothesis was supported by growth and condition data that were discussed previously, and by data concerning forage abundance, and GI tract fullness which will be discussed later. Kerr (1971) used an equation system based upon the requirements of searching for prey, and the physiological properties of predators, to examine the hypothesis that growth efficiency of pelagic predators may be importantly determined by the metabolic cost of searching for prey. His equation system indicated that growth efficiency decreased when prey organisms became either rare or small in relation to the size of the predator. His system also indicated that sustained growth required increasingly large prey organisms even if they were increasingly rare. Prey available for the 1981 year class striped bass were apparently both rare and small. The poor condition, growth, and survival observed for these fish substantiate Kerr's (1971) observation that a prolonged diet of increasingly rare small invertebrates is not adequate to sustain growth and good condition.

Percent-of-total-numbers and frequency-of-occurrence analyses of the 1982 year class food habits data, grouped by month of capture, are presented in Tables 13 and 14. These analyses show that this year class began consuming small shad soon after stocking, as was anticipated, and continued to rely heavily on fish throughout the rest of their first year. Fish were found in 100% of the GI tracts that contained food during 8 of the 10 months in which striped bass from this year class were caught. The majority of the fish that were

TABLE 13. Percents of Total Numbers of Food Items in Guts of 1982 Year Class Striped Bass, Grouped by Month

Food item categories	Month J	J	A	S	O	N	D	J	F	M	A
Pisces	79.2	42.5	65.0	99.4	98.6	100.0		100.0	57.1	2.4	100.0
Dorosoma sp.	41.7	38.6	65.0	98.3	98.0	100.0		75.0	57.1	2.4	100.0
Dorosoma petenense	0.0	7.8	3.0	20.2	43.9	0.0		0.0	21.4	0.0	0.0
Dorosoma cepedianum	0.0	0.0	0.0	0.0	2.0	0.0		0.0	0.0	0.9	0.0
Unidentified *Dorosoma*	41.7	30.7	62.1	78.0	52.1	100.0		75.0	35.7	1.4	100.0
Cyprinidae	0.0	0.7	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Other fish	8.3	0.0	0.0	0.6	0.0	0.0		0.0	0.0	0.0	0.0
Unidentified fish	29.2	3.3	0.0	0.6	0.6	0.0		25.0	0.0	0.0	0.0
Insecta	20.8	28.1	30.5	0.6	1.4	0.0		0.0	42.9	97.6	0.0
Diptera	20.8	19.6	1.0	0.0	1.1	0.0		0.0	42.9	97.6	0.0
Chironomidae	20.8	17.6	1.0	0.0	0.8	0.0		0.0	42.9	97.6	0.0
Chironomidae larvae	16.7	8.5	0.5	0.0	0.0	0.0		0.0	21.4	92.4	0.0
Chironomidae pupae	4.2	9.2	0.5	0.0	0.8	0.0		0.0	21.4	5.2	0.0
Chaoborus sp.	0.0	2.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Adult Diptera	0.0	0.0	0.0	0.0	0.3	0.0		0.0	0.0	0.0	0.0
Ephemeroptera	0.0	8.5	29.6	0.0	0.3	0.0		0.0	0.0	0.0	0.0
Ephemeridae	0.0	8.5	29.1	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Other Ephemeroptera	0.0	0.0	0.5	0.0	0.3	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	0.0
Corixidae	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Other insects	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Unidentified insects	0.0	0.0	0.0	0.6	0.0	0.0		0.0	0.0	0.0	0.0
Crustacea	0.0	17.0	4.4	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Copepoda[1]	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Argulus sp.	0.0	17.0	4.4	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Cladocera[2]	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Leptodora sp.	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Other invertebrates	0.0	0.7	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Miscellaneous	0.0	11.8	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
No. of fish with food	8	28	27	30	36	3	0	3	2	4	2
No. of food items	24	153	203	173	355	20		4	14	211	12

[1]Exclusive of *Argulus* sp.

[2]Exclusive of *Leptodora* sp.

TABLE 14. Frequency of Occurrence (%) of Food Items in Guts of 1982 Year Class Striped Bass That Contained Food, Grouped by Month

Food item categories	Month J	J	A	S	O	N	D	J	F	M	A
Pisces	100	93	100	100	100	100		100	100	50	100
Dorosoma sp.	63	93	100	97	94	100		67	100	50	100
Dorosoma petenense	0	25	11	40	67	0		0	100	0	0
Dorosoma cepedianum	0	0	0	0	17	0		0	0	25	0
Unidentified *Dorosoma*	63	82	100	97	89	100		67	50	50	100
Cyprinidae	0	4	0	0	0	0		0	0	0	0
Other fish	13	0	0	3	0	0		0	0	0	0
Unidentified fish	63	18	0	3	6	0		33	0	0	0
Insecta	38	61	41	3	8	0		0	50	75	0
Diptera	38	46	7	0	6	0		0	50	75	0
Chironomidae	38	46	7	0	3	0		0	50	75	0
Chironomidae larvae	25	25	4	0	0	0		0	50	75	0
Chironomidae pupae	13	32	4	0	3	0		0	50	75	0
Chaoborus sp.	0	7	0	0	0	0		0	0	0	0
Adult Diptera	0	0	0	0	3	0		0	0	0	0
Ephemeroptera	0	18	41	0	3	0		0	0	0	0
Ephemeridae	0	18	37	0	0	0		0	0	0	0
Other Ephemeroptera	0	0	4	0	3	0		0	0	0	0
Trichoptera	0	0	0	0	0	0		0	0	0	0
Corixidae	0	0	0	0	0	0		0	0	0	0
Other insects	0	0	0	0	0	0		0	0	0	0
Unidentified insects	0	0	0	3	0	0		0	0	0	0
Crustacea	0	29	15	0	0	0		0	0	0	0
Copepoda[1]	0	0	0	0	0	0		0	0	0	0
Argulus sp.	0	29	15	0	0	0		0	0	0	0
Cladocera[2]	0	0	0	0	0	0		0	0	0	0
Leptodora sp.	0	0	0	0	0	0		0	0	0	0
Other invertebrates	0	4	0	0	0	0		0	0	0	0
Miscellaneous	0	21	0	0	0	0		0	0	0	0
No. of fish with food	8	28	27	30	36	3	0	3	2	4	2

[1]Exclusive of *Argulus* sp.

[2]Exclusive of *Leptodora* sp.

consumed each month were shad and most of those that were identified to species were threadfin shad. Insects were moderately important during the first three months after stocking. They made up 20.8 to 30.5% of the total numbers of food items, and were present in 38 to 61% of the fish that contained food during these months. Chironomidae and Ephemeridae were the most prevalent insect families in the diet. All of the ephemerids that could be identified to genus were Hexagenia sp., with many of these being emerging subimagoes. In August, when these mayflies were most important in the diet, many subimagoes were attracted to lights that were used while sampling. These large burrowing mayflies are probably most vulnerable to predation as they leave the sediments and migrate to the surface to emerge. Stevens (1957) also found seasonal importance of mayflies in the diet of striped bass in the Santee-Cooper Reservoir. The only crustacean that assumed importance in the diet of these fish was Argulus, which was eaten in July and August.

Four of the six large young-of-year fish collected in February and March contained Chironomidae. This switch back to utilization of chironomids after acquiring predominantly piscivorous feeding habits demonstrated a degree of feeding flexibility. This change in diet may have been due to reduced activity in the colder water or reduced abundance of forage-size shad in the area sampled.

T-tests comparing food habits of the young-of-year of both year classes caught in corresponding months of each year revealed that significantly more fish (P = 0.05) were consumed by the 1982 year class in August, September, and October. Mean numbers of insects and crustaceans in the GI tracts of the 1981 year class young-of-year were greater in most months, but these differences were not significant.

The young-of-year 1981 year class food habits data, grouped by 2.5 cm length class of fish, are present in Tables 15 and 16. The majority of these fish were in the first three length classes (5.1-12.5 cm), and showed only slight variation in food habits among length classes. There was a slight trend toward increased utilization of fish and miscellaneous food items and decreased use of insects and crustaceans with increasing size. The two young-of-year fish that fell into larger length classes both contained shad in their guts. One also contained chironomid pupae. This indicated that the largest of these young-of-year fish, although primarily piscivorous, still consumed some insects.

The food habits data for the 1982 year class grouped by 2.5 cm length class, are presented in Tables 17 and 18. Fish made up the largest percentage of total food items and occurred more frequently than other food categories in most length classes. Insects and <u>Argulus</u> were fairly important in length classes 1 through 6 (5.0-20.0 cm). These invertebrate food sources were utilized to a lesser degree in length classes 7 through 10 (20.1-30.0 cm). Four of the six largest young-of-year consumed Chironomidae. This was the result of the late winter change in food habits discussed previously. Of the shad that were identified to species, threadfin shad occurred

TABLE 15. Percents of Total Numbers of Food Items in Guts of Young-of-Year 1981 Year Class Striped Bass, Grouped by Length Class

Food item categories	Length class[1] 1	2	3	4	5	6	7
Pisces	1.5	0.7	14.1		10.0		100.0
Dorosoma sp.	1.0	0.5	12.7		10.0		100.0
Dorosoma petenense	0.0	0.1	0.0		0.0		0.0
Dorosoma cepedianum	0.0	0.0	0.0		0.0		0.0
Unidentified Dorosoma	1.0	0.4	12.7		10.0		100.0
Cyprinidae	0.3	0.0	0.0		0.0		0.0
Other fish	0.0	0.0	0.0		0.0		0.0
Unidentified fish	0.3	0.2	1.4		0.0		0.0
Insecta	65.4	49.5	52.1		90.0		0.0
Diptera	56.3	48.8	46.5		90.0		0.0
Chironomidae	54.0	48.6	45.1		90.0		0.0
Chironomidae larvae	44.9	46.6	19.7		0.0		0.0
Chironomidae pupae	9.1	2.1	25.4		90.0		0.0
Chaoborus sp.	1.8	0.2	0.0		0.0		0.0
Adult Diptera	0.5	0.0	1.4		0.0		0.0
Ephemeroptera	8.3	0.4	4.2		0.0		0.0
Ephemeridae	0.3	0.1	0.0		0.0		0.0
Other Ephemeroptera	8.1	0.3	4.2		0.0		0.0
Trichoptera	0.5	0.1	1.4		0.0		0.0
Corixidae	0.3	0.1	0.0		0.0		0.0
Other insects	0.0	0.0	0.0		0.0		0.0
Unidentified insects	0.0	0.1	0.0		0.0		0.0
Crustacea	29.5	47.9	15.5		0.0		0.0
Copepoda[2]	21.2	40.5	0.0		0.0		0.0
Argulus sp.	4.3	5.2	15.5		0.0		0.0
Cladocera[3]	3.8	2.3	0.0		0.0		0.0
Leptodora sp.	0.3	0.0	0.0		0.0		0.0
Other invertebrates	0.0	0.3	0.0		0.0		0.0
Miscellaneous	3.5	1.6	18.3		0.0		0.0
No. of fish with food	17	29	11	0	1	0	1
No. of food items	396	2193	71		10		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.

[2]Exclusive of Argulus sp.

[3]Exclusive of Leptodora sp.

TABLE 16. Frequency of Occurrence (%) of Food Items in Guts of Young-of-Year 1981 Year Class Striped Bass That Contained Food, Grouped by Length Class

Food item categories	Length class[1] 1	2	3	4	5	6	7
Pisces	24	31	55		100		100
Dorosoma sp.	12	24	45		100		100
Dorosoma petenense	0	3	0		0		0
Dorosoma cepedianum	0	0	0		0		0
Unidentified *Dorosoma*	12	21	45		100		100
Cyprinidae	6	0	0		0		0
Other fish	0	0	0		0		0
Unidentified fish	6	10	9		0		0
Insecta	94	90	82		100		0
Diptera	88	83	82		100		0
Chironomidae	88	83	82		100		0
Chironomidae larvae	88	79	64		0		0
Chironomidae pupae	53	41	36		100		0
Chaoborus sp.	29	17	0		0		0
Adult Diptera	12	0	9		0		0
Ephemeroptera	29	17	9		0		0
Ephemeridae	6	7	0		0		0
Other Ephemeroptera	29	10	9		0		0
Trichoptera	12	3	9		0		0
Corixidae	6	3	0		0		0
Other insects	0	0	0		0		0
Unidentified insects	0	7	0		0		0
Crustacea	47	37	27		0		0
Copepoda[2]	6	10	0		0		0
Argulus sp.	29	28	27		0		0
Cladocera[3]	29	3	0		0		0
Leptodora sp.	6	0	0		0		0
Other invertebrates	0	14	0		0		0
Miscellaneous	24	38	45		0		0
No. of fish with food	17	29	11	0	1	0	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.

[2]Exclusive of *Argulus* sp.

[3]Exclusive of *Leptodora* sp.

TABLE 17. Percents of Total Numbers of Food Items in Guts of Young-of-Year 1982 Year Class Striped Bass, Grouped by Length Class

Food item categories	Length class[1] 1	2	3	4	5	6	7	8	9	10	11	12
Pisces	57.1	34.6	45.2	80.0	59.8	71.1	100.0	99.2	98.3	99.5	43.1	0.0
Dorosoma sp.	36.7	30.8	45.2	70.0	59.8	71.1	100.0	99.2	97.0	98.4	43.1	0.0
Dorosoma petenense	6.1	10.3	0.0	5.0	1.8	4.4	36.8	19.8	41.8	34.2	4.9	0.0
Dorosoma cepedianum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.9	2.1	4.9	0.0
Unidentified *Dorosoma*	30.6	20.5	45.2	65.0	58.0	66.7	63.2	78.5	54.3	62.0	34.1	0.0
Cyprinidae	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other fish	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Unidentified fish	16.3	2.6	0.0	10.0	0.0	0.0	0.0	0.0	0.9	1.1	0.0	0.0
Insecta	24.5	24.4	41.9	20.0	35.7	24.4	0.0	0.8	1.7	0.5	56.1	100.0
Diptera	24.5	19.2	16.1	15.0	0.9	1.1	0.0	0.0	1.7	0.0	56.1	100.0
Chironomidae	22.4	16.7	16.1	15.0	0.9	1.1	0.0	0.0	1.3	0.0	56.1	100.0
Chironomidae larvae	8.2	7.7	12.9	15.0	0.9	0.0	0.0	0.0	0.0	0.0	24.4	99.5
Chironomidae pupae	14.3	9.0	3.2	0.0	0.0	1.1	0.0	0.0	1.3	0.0	31.7	0.5
Chaoborus sp.	2.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Diptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Ephemeroptera	0.0	5.1	25.8	5.0	34.8	23.3	0.0	0.0	0.0	0.5	0.0	0.0
Ephemeridae	0.0	5.1	25.8	5.0	33.9	23.3	0.0	0.0	0.0	0.0	0.0	0.0
Other Ephemeroptera	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.5	.0.0	0.0
Trichoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corixidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other insects	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified insects	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Crustacea	18.4	20.5	3.2	0.0	4.5	4.4	0.0	0.0	0.0	0.0	0.0	0.0
Copepoda[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Argulus sp.	18.4	20.5	3.2	0.0	4.5	4.4	0.0	0.0	0.0	0.0	0.0	0.0
Cladocera[3]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leptodora sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other invertebrates	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous	0.0	19.2	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
No. of fish with food	13	12	7	5	16	10	3	21	29	21	5	1
No. of food items	49	78	31	20	112	90	19	121	232	187	41	189

[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; 11 = 30.1 to 32.5 cm; 12 = 32.6 to 35.0 cm.

[2]Exclusive of *Argulus* sp.

[3]Exclusive of *Leptodora* sp.

TABLE 18. Frequency of Occurrence (%) of Food Items in Guts of Young-of-Year 1982 Year Class Striped Bass That Contained Food, Grouped by Length Class

Food item categories	Length class[1] 1	2	3	4	5	6	7	8	9	10	11	12
Pisces	100	92	86	100	100	100	100	100	100	100	80	0
Dorosoma sp.	77	92	86	100	100	100	100	100	93	90	80	0
Dorosoma petenense	23	25	0	20	6	20	67	33	62	48	20	0
Dorosoma cepedianum	0	0	0	0	0	0	0	5	3	19	20	0
Unidentified *Dorosoma*	69	75	86	100	100	100	100	100	90	86	50	0
Cyprinidae	0	8	0	0	0	0	0	0	0	0	0	0
Other fish	8	0	0	0	0	0	0	0	3	0	0	0
Unidentified fish	46	17	0	40	0	0	0	0	7	10	0	0
Insecta	46	58	71	40	50	30	0	5	7	5	60	100
Diptera	46	42	57	20	6	10	0	0	7	0	60	100
Chironomidae	46	42	57	20	6	10	0	0	3	0	60	100
Chironomidae larvae	15	17	57	20	6	0	0	0	0	0	60	100
Chironomidae pupae	31	42	14	0	0	10	0	0	3	0	60	100
Chaoborus sp.	8	8	0	0	0	0	0	0	0	0	0	0
Adult Diptera	0	0	0	0	0	0	0	0	3	0	0	0
Ephemeroptera	0	17	29	20	50	30	0	0	0	5	0	0
Ephemeridae	0	17	29	20	44	30	0	0	0	0	0	0
Other Ephemeroptera	0	0	0	0	6	0	0	0	0	5	0	0
Trichoptera	0	0	0	0	0	0	0	0	0	0	0	0
Corixidae	0	0	0	0	0	0	0	0	0	0	0	0
Other insects	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified insects	0	0	0	0	0	0	0	5	0	0	0	0
Crustacea	15	42	14	0	13	20	0	0	0	0	0	0
Copepoda[2]	0	0	0	0	0	0	0	0	0	0	0	0
Argulus sp.	15	42	14	0	13	20	0	0	0	0	0	0
Cladocera[3]	0	0	0	0	0	0	0	0	0	0	0	0
Leptodora sp.	0	0	0	0	0	0	0	0	0	0	0	0
Other invertebrates	0	8	0	0	0	0	0	0	0	0	0	0
Miscellaneous	0	42	14	0	0	0	0	0	0	0	0	0
No. of fish with food	13	12	7	5	16	10	3	21	29	21	5	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; 11 = 30.1 to 32.5 cm; 12 = 32.6 to 35.0 cm.

[2]Exclusive of *Argulus* sp.

[3]Exclusive of *Leptodora* sp.

most frequently in all size classes but one (length class 11). The somewhat larger gizzard shad increased in importance in the larger length classes. This trend indicated that most gizzard shad may have been too large to be readily consumed by the smaller length classes of striped bass.

T-test results indicated that significantly more (P=0.1) fish were consumed by the 1982 year class than by the 1981 young-of-year, in each length class except length class 7. In length classes 1 and 2, the differences were significant at P=0.005. The mean number of insects consumed was greater for each length class of the 1981 year class. Differences were significant (P=.05) for length classes 1 and 2. The mean numbers of crustaceans in the guts of the 1981 young-of-year were higher for the first three length classes, but differences were not significant.

The food habits data, grouped by the sections of the reservoir in which the fish were collected, are presented in Tables 19 and 20. It was apparent that a wider variety of insects were consumed by both year classes of both Morone species and the Morone hybrid in the two upper sections of the reservoir (Quarryville and Fall Creek). Trichoptera and Corixidae were only consumed in these two areas. Ephemeroptera were consumed frequently here and were rarely eaten in other areas. This may indicate higher concentrations of these organisms in the upper end of the reservoir. These observations could also be the result of seasonal changes in the abundance or vulnerability of these insects, or changes in feeding habits of the young-of-year fish.

TABLE 19. Percents of Total Numbers of Food Items in Guts of Young-of-Year 1981 and 1982 Year Class Striped (SB), White (WB), and Hybrid (MH) Bass, Grouped by Reservoir Section

Food item categories	1981/SB			1982/SB				1981/WB				1982/WB				1981/MH		
Section[1]:	1	2	3	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Pisces	1.7	7.3	0.1	58.0	48.8	99.7	66.7	3.2	5.2	64.0	41.7	15.5	10.9	100.0	75.7	5.8	14.3	77.3
Dorosoma sp.	0.9	6.9	0.06	54.2	48.3	99.1	61.1	2.3	4.1	48.0	33.3	12.8	10.2	95.5	56.8	4.0	12.4	72.7
Dorosoma petenense	0.0	0.4	0.0	4.6	10.0	43.1	16.7	0.1	0.0	0.0	8.3	2.2	2.5	18.2	16.2	0.4	0.2	0.0
Dorosoma cepedianum	0.0	0.0	0.0	0.0	0.5	2.0	0.0	0.1	0.0	16.0	0.0	0.2	0.0	0.0	0.0	0.5	1.4	4.5
Unidentified *Dorosoma*	0.9	6.5	0.06	49.6	37.8	54.0	44.4	2.1	4.1	32.0	25.3	10.5	7.7	77.3	40.5	3.1	10.8	68.2
Cyprinidae	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.5	0.4	8.0	0.0	0.3	0.3	0.0	0.0	0.2	0.7	0.0
Other fish	0.0	0.0	0.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.04	0.2	0.0
Unidentified fish	0.7	0.4	0.06	3.1	0.2	0.6	5.6	0.3	0.7	8.0	8.3	1.8	0.4	4.5	18.9	1.7	0.9	4.5
Insecta	89.5	47.2	36.0	28.2	51.2	0.3	33.3	83.6	93.7	28.0	58.3	74.2	87.4	0.0	24.3	74.0	38.2	18.2
Diptera	83.2	45.1	35.8	9.4	51.0	0.3	33.3	78.5	91.8	28.0	50.0	67.0	87.1	0.0	24.3	69.6	33.5	9.1
Chironomidae	82.4	43.5	35.5	8.7	51.0	0.0	33.3	59.6	45.1	16.0	50.0	64.2	86.9	0.0	24.3	64.6	29.5	9.1
Chironomidae larvae	80.2	26.8	32.6	4.6	47.6	0.0	16.7	52.9	35.1	8.0	41.7	57.5	14.0	0.0	18.9	47.0	20.8	0.0
Chironomidae pupae	2.3	16.7	3.0	4.1	3.4	0.0	16.7	6.6	10.1	8.0	8.3	6.7	72.8	0.0	5.4	17.6	8.7	9.1
Chaoborus sp.	0.4	1.6	0.3	0.8	0.0	0.0	0.0	14.5	46.6	12.0	0.0	2.3	0.0	0.0	0.0	4.0	0.0	0.0
Adult Diptera	0.4	0.0	0.0	0.0	0.0	0.3	0.0	4.5	0.0	0.0	0.0	0.5	0.3	0.0	0.0	0.9	4.0	0.0
Ephemeroptera	5.5	1.6	0.0	18.6	0.2	0.0	0.0	3.5	1.5	0.0	8.3	6.8	0.1	0.0	0.0	3.3	3.7	9.1
Ephemeridae	0.4	0.0	0.0	18.3	0.0	0.0	0.0	2.4	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.1	0.2	0.0
Other Ephemeroptera	5.1	1.6	0.0	0.3	0.2	0.0	0.0	1.1	1.5	0.0	8.3	5.5	0.1	0.0	0.0	3.2	3.5	9.1
Trichoptera	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.8	0.4	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.7	0.0
Corixidae	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
Other insects	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.2	0.2	0.0
Unidentified insects	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Crustacea	4.7	44.3	61.8	8.9	0.0	0.0	0.0	12.2	0.4	0.0	0.0	9.5	0.5	0.0	0.0	17.0	14.1	0.0
Copepoda[2]	0.0	0.0	58.1	0.0	0.0	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Argulus sp.	2.5	44.3	0.8	8.9	0.0	0.0	0.0	4.0	0.4	0.0	0.0	5.8	0.5	0.0	0.0	4.2	14.1	0.0
Cladocera[3]	2.0	0.0	3.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	1.7	0.0	0.0	0.0	12.2	0.0	0.0
Leptodora sp.	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.5	0.0	0.0
Other invertebrates	0.0	0.4	0.3	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.7	4.5
Miscellaneous	4.1	0.8	1.8	4.6	0.0	0.0	0.0	0.8	0.7	8.0	0.0	0.5	1.3	0.0	0.0	3.0	32.8	0.0
No. of fish with food	26	13	20	64	39	35	5	65	24	18	7	50	47	28	16	120	36	12
No. of food items	751	246	1674	393	410	348	18	1459	268	25	12	600	791	88	37	2602	427	22

[1]Reservoir sections are as follows: 1 = Quarryville; 2 = Fall Creek; 3 = County Line; 4 = Oak Grove.

[2]Exclusive of *Argulus* sp.

[3]Exclusive of *Leptodora* sp.

TABLE 20. Frequency of Occurrence (%) of Food Items in Guts of Young-of-Year 1981 and 1982 Year Class Striped (SB), White (WB), and Hybrid (MH) Bass That Contained Food, Grouped By Reservoir Section

Food item categories	1981/SB			1982/SB				1981/WB				1982/WB				1981/MH		
Section[1]:	1	2	3	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Pisces	31	85	10	97	95	100	100	35	42	83	71	88	74	100	75	64	86	92
Dorosoma sp.	19	77	5	92	92	94	80	25	29	61	57	68	64	86	38	46	69	83
Dorosoma petenense	0	8	0	16	36	63	40	2	0	0	14	16	26	36	19	8	3	0
Dorosoma cepedianum	0	0	0	0	3	17	0	3	0	22	0	2	0	0	0	10	14	8
Unidentified *Dorosoma*	19	69	5	88	92	89	60	22	29	39	43	60	60	79	31	38	67	75
Cyprinidae	4	0	0	2	0	0	0	6	4	11	0	2	4	0	0	3	8	0
Other fish	0	0	0	2	3	0	0	0	0	0	0	4	0	0	0	1	3	0
Unidentified fish	12	8	5	16	3	6	20	8	8	11	14	20	6	14	38	25	11	8
Insecta	92	77	90	50	13	3	20	92	71	22	71	80	53	0	31	83	44	33
Diptera	81	77	90	28	10	3	20	85	71	22	57	76	51	0	31	79	39	17
Chironomidae	81	77	90	28	10	0	20	82	71	22	57	74	49	0	31	78	39	17
Chironomidae larvae	81	69	75	16	8	0	20	78	54	11	43	58	30	0	25	75	22	0
Chironomidae pupae	38	38	55	17	10	0	20	55	46	11	14	44	40	0	13	44	36	17
Chaoborus sp.	12	15	25	3	0	0	0	22	21	6	0	8	0	0	0	15	0	0
Adult Diptera	12	0	0	0	0	3	0	14	0	0	0	4	2	0	0	4	6	0
Ephemeroptera	35	15	0	25	3	0	0	40	13	0	14	28	2	0	0	14	19	17
Ephemeridae	12	0	0	23	0	0	0	32	0	0	0	10	0	0	0	3	3	0
Other Ephemeroptera	27	15	0	2	3	0	0	11	13	0	14	20	2	0	0	13	19	17
Trichoptera	12	8	0	0	0	0	0	11	4	0	0	2	0	0	0	3	3	0
Corixidae	8	0	0	0	0	0	0	9	0	0	0	0	0	0	0	8	0	0
Other insects	0	0	0	0	0	0	0	2	0	0	0	2	2	0	0	5	3	0
Unidentified insects	0	0	10	2	0	0	0	2	0	0	0	0	0	0	0	3	0	0
Crustacea	35	31	45	19	0	0	0	31	4	0	0	40	6	0	0	28	11	0
Copepoda[2]	0	0	20	0	0	0	0	2	0	0	0	0	0	0	0	3	0	0
Argulus sp.	27	31	25	19	0	0	0	26	4	0	0	38	6	0	0	22	11	0
Cladocera[3]	19	0	5	0	0	0	0	6	0	0	0	2	0	0	0	8	0	0
Leptodora sp.	4	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0
Other invertebrates	0	8	15	2	0	0	0	6	0	0	0	2	0	0	0	3	3	8
Miscellaneous	38	15	40	9	0	0	0	9	8	6	0	4	6	0	0	13	11	0
No. of fish with food	26	13	20	64	39	35	5	65	24	18	7	50	47	28	16	120	36	12

[1]Reservoir sections are as follows: 1 = Quarryville; 2 = Fall Creek; 3 = County Line; 4 = Oak Grove.

[2]Exclusive of *Argulus* sp.

[3]Exclusive of *Leptodora* sp.

Preliminary examination of the amounts of food in the GI tracts of striped bass suggested seasonal and year class differences. To obtain relative estimates of GI tract fullness the total wet weight of the gut contents was expressed as a percentage of the total weight of the fish. The mean percentages for 1981 and 1982 year class young-of-year striped bass were 2.4 and 4.0, respectively. This difference in means was significant at $P<0.0001$. The average total numbers of food items in the GI tracts of the 1981 and 1982 year class young-of-year were 45 and 8, respectively. This difference was significant at $P=0.01$. These analyses support the contention that the 1981 year class fed less efficiently. They consumed larger numbers of food items than the 1982 year class but contained less food. Several uncontrollable variables may have influenced these data. Fish caught in gillnets may regurgitate some food and digestion may continue for several hours after entanglement in the nets. Fish in poor condition would tend to give higher percent weights of gut contents. These variables, however, would tend to reduce, not accentuate, the observed significant differences, since many more of the 1982 year class were caught in gill nets, and condition factors of the 1981 year class were less.

In Table 21, the percent weights of gut contents, grouped by month of capture, are given. The mean percent weights of GI tract contents of the 1982 year class were higher in all corresponding months of the two years, except in March. This difference in means was significant ($P=0.05$) in August and October. Relative weight of stomach contents appeared to be somewhat reduced in the winter and

TABLE 21. Mean Wet Weights of GI Tract Contents of 1981 and 1982 Year Class Striped (SB), White (WB), and Hybrid (MH) Bass Expressed as Percentages of Total Weights of Fish

Month	1981/SB %	1981/SB N	1982/SB %	1982/SB N	1981/WB %	1981/WB N	1982/WB %	1982/WB N	1981/MH %	1981/MH N
Jul	3.10	3			2.83	20			2.53	80
Aug	1.71	17			2.40	20			4.45	23
Sep	3.49	15			1.62	20			3.96	25
Oct	1.81	3			0.99	17			4.55	4
Nov	1.66	12			2.06	10			1.67	11
Dec	2.72	8			1.28	10			2.07	1
Jan	--	0			1.49	10			--	0
Feb	--	0			0.05	10			0.40	2
Mar	1.45	1			1.16	10			2.38	14
Apr	--	0			1.22	10			0.52	4
May	1.29	1			1.54	10			1.89	16
Jun	--	0	3.46	8	1.84	2	2.97	10	2.10	2
Jul	--	0	4.55	28	0.83	10	3.80	30	2.29	11
Aug	--	0	3.78	27			4.01	10	1.15	2
Sep	1.22	2	3.63	30			1.96	20	1.94	22
Oct	8.55	1	5.14	36			1.46	20	3.31	1
Nov	--	0	2.78	3			1.62	10	2.49	5
Dec	--	0	--	0			0.96	10	--	0
Jan	--	0	0.73	3			0.46	10	--	0
Feb	--	0	3.33	2			1.02	10	--	0
Mar	--	0	1.27	4			0.46	10	1.16	3
Apr	--	0	1.47	3			0.92	10	--	0

early spring months. This reduced food content, combined with slower digestion rates in the colder water, indicated diminished feeding during this period.

Food habits of other predator species and hybrids examined were generally similar to those of striped bass. The same food item categories were generally present; however, differences in the degree of utilization of each category were apparent (Table 9, page 48; Table 10, page 50). The June stocking of Morone hybrids that demonstrated better condition and growth than striped bass in 1981 also consumed more fish ($P<0.0001$) and had relatively fuller GI tracts ($P=0.1$). A broad range of insects and crustaceans was also consumed. In terms of both frequency of occurrence and percent of total numbers, fish increased in importance in the diet of Morone hybrids in successive months and with increased size (Appendixes A-D). These trends were paralleled by a decrease in the importance of insects. The five fin-clipped Morone hybrids from the October stocking consumed 192 insects, two copepods, and only one fish. The food habits of these small fin-clipped fish were not characteristic of the food habits of the fish that were stocked in June.

Analysis of white bass food habits revealed trends similar to those observed for striped bass. The 1982 year class, which grew more rapidly than the 1981 year class, also consumed significantly more fish ($P<0.0001$) and had fuller GI tracts ($P=0.1$). The majority of fish consumed both years were shad. Threadfin shad made up the majority of those that were identified to species in 1982. Differences between year classes, however, were of less magnitude than those observed between year classes of striped bass. Percent-of-total-numbers and frequency-of-occurrence data for both year classes of white bass, separated by month of capture and length class, are presented in Appendixes E through L. Both year classes of white bass were primarily piscivorous by the end of their first growing season. The 1982 year class, however, made the transition from invertebrates to fish at a much earlier age and smaller size. As with the 1982 year class of striped bass, invertebrates regained importance in the diets of both year classes in late winter and early spring.

Shad occurred most frequently in the GI tracts of yearling striped, white, and hybrid bass (Table 10, page 50). Chironomids, however, were also important in the diet of yearling _Morone_ hybrids in terms of the percent of total numbers of food items consumed.

Of the 217 1982 year class _Stizostedion_ hybrid stomachs examined, 34 (16%) were empty. This percentage would have been smaller had intestinal contents also been examined. Appendixes M through R present percent-of-total-numbers, and frequency-of-occurrence analyses of _Stizostedion_ hybrid food habits data. The food habits of these fish were very similar to those of the 1982 year class striped bass. Fish were the most important food items in terms of frequency-of-occurrence and percent-of-total-numbers for all length classes, in all months, and at all locations. The vast majority of these fish were shad, most of which could not be identified to species. The larger gizzard shad were consumed more frequently late in the year by larger sized _Stizostedion_ hybrids. Insects (exclusively Chironomidae and Ephemeridae) were of moderate importance to small fish early in the season in the upper section of the reservoir; no crustaceans were consumed.

Forage Abundance and Availability

Data on abundance of forage fish and benthic and planktonic invertebrates were collected and analyzed. It was believed that these data might help to explain the observed trends in growth and food habits.

Benthos and zooplankton. The numbers of benthic organisms/m^2 in Ekman dredge samples from the four designated sections of the reservoir are presented in Figure 2. It was apparent that the highest concentrations of organisms at three locations were present in the spring and summer, with Quarryville having the densest concentrations during both years. Nematodes and oligochaetes occurred frequently in benthic samples. These organisms were not graphed as available invertebrate food because they were never found in fish stomachs, and probably remained unavailable to piscine predators. Chironomidae comprised 95.2% of the rest of the benthic organisms. This fact explains the predominance of chironomids in the guts of insectivorous fish. Winter benthos densities were several orders of magnitude lower than densities in spring and summer. This may have been due to inherent seasonal population fluctuations, colder water temperatures, predation, and/or reduced habitat after drawdown to winter-pool levels. Benson and Hudson (1975) demonstrated that

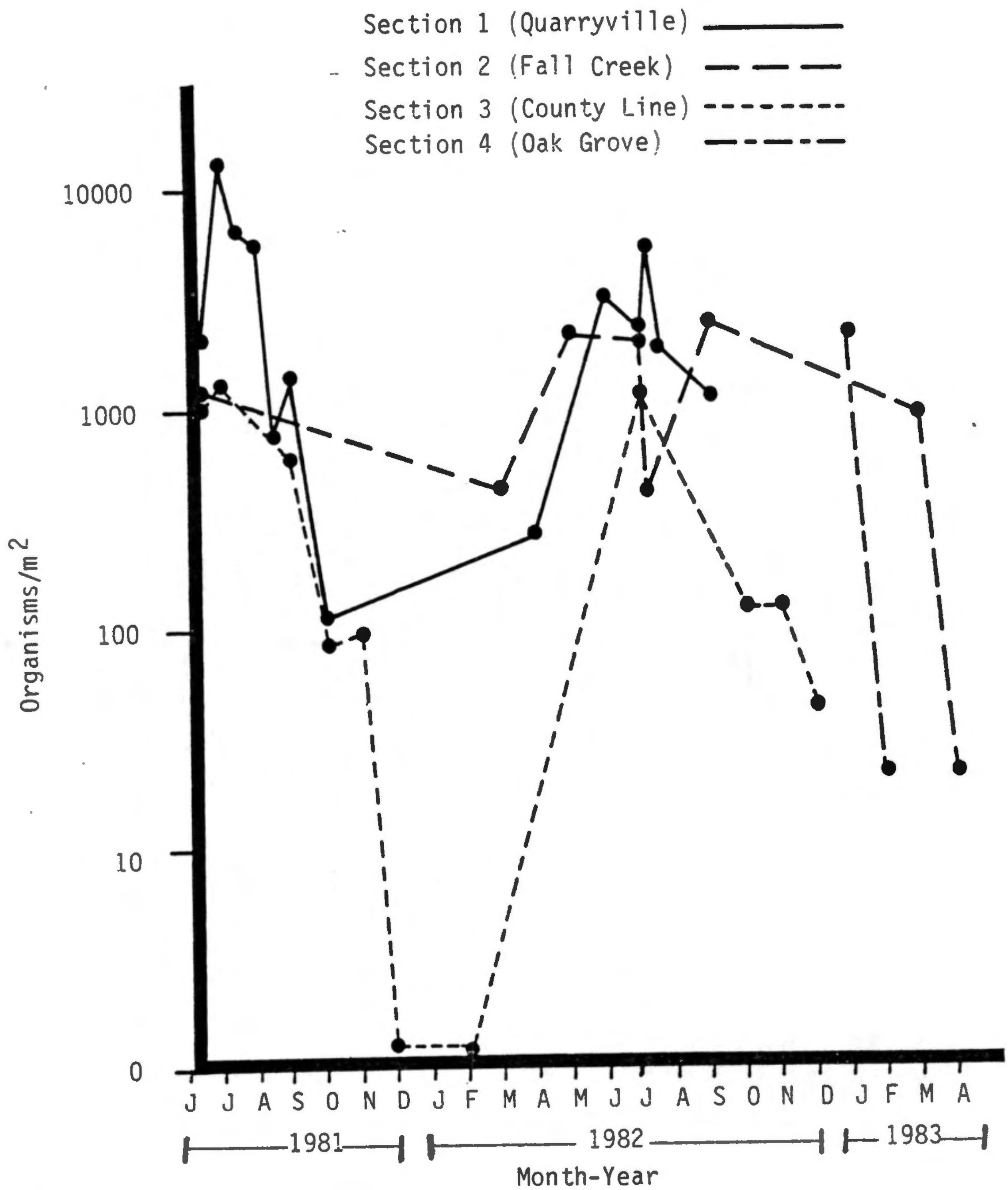

FIGURE 2. Benthos abundance in four sections of Cherokee Reservoir, June 1981-April 1983.

winter drawdown of Lake Francis Case, South Dakota, was responsible for reduced abundance of chironomids, Hexagenia, oligochaetes, and other benthic invertebrates during the following spring.

Zooplankton abundance showed seasonal trends similar to those observed for benthic organisms (Figure 3). Plankton was densest in spring and early summer, and became scarce in fall and winter. Copepods and cladocerans comprised 70.7% of the planktonic organisms in the samples. This helps to account for the importance of these crustacean groups in the diets of some of the smaller fish. Argulus was present in several plankton samples in 1981 and 1982 but was never collected in large numbers. Its importance in the diets of some fish indicates that these fish probably selected the Argulus because of its larger size. Plankton concentrations appeared to drop earlier in the summer in the Quarryville section of the reservoir. This could have been due to heavier predation by shad, young-of-year predators, and other planktivores concentrated in this area, or may have been due to the increasingly riverine conditions at this location as water levels began to drop. Martin et al. (1981) suggested that decreases in standing crop of larger zooplankton in Lake Francis Case were due to predation by age 0 fish. Reduced concentrations of benthic and planktonic organisms in fall and winter may have contributed to the apparent starved condition of small, relatively non-piscivorous striped bass at this time.

Forage fish. The percent composition of fish less than 10 cm (N = 13,031), that were collected by shoreline seining and electrofishing,

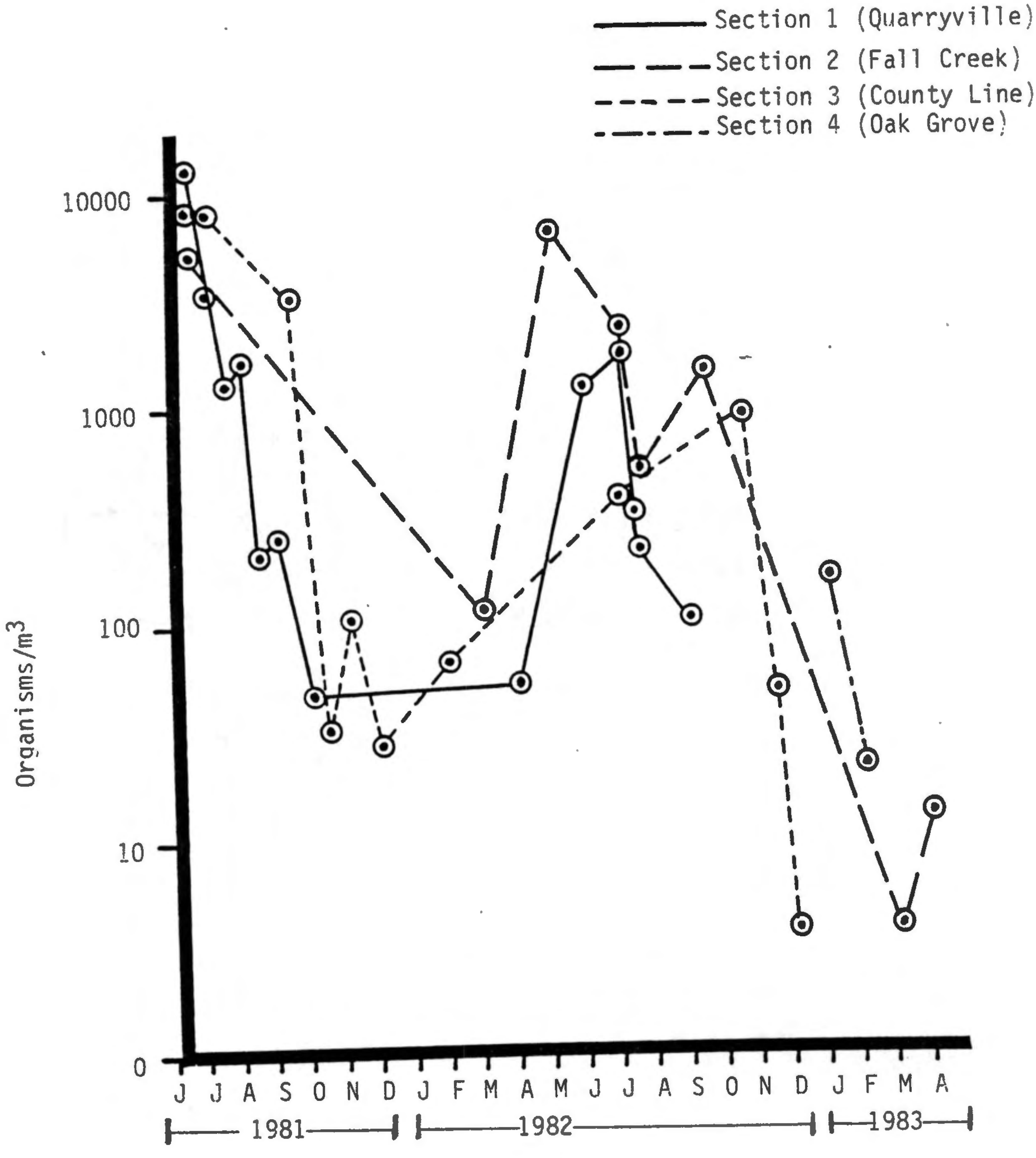

FIGURE 3. Zooplankton abundance in four sections of Cherokee Reservoir, June 1981-April 1983.

is presented in Table 22. Also included in this table are the percent compositions of identifiable fish that were found in the young-of-year predators examined. Only 50.1% of the small fish collected in forage samples were shad, yet 99.5% of the 790 fish identified in striped bass stomachs were shad. Abundant small cyprinid species, brook silversides, and other species were virtually unutilized. Most of these small fish are shore oriented. Shoreline sampling may have underestimated the relative numbers of shad present. These data do, however, indicate that the piscivorous young-of-year striped bass fed in open water on pelagic schools of shad and seldom ventured close to shore in pursuit of other forage species.

The food habits, growth, and condition data presented and the literature cited overwhelmingly support the conclusion that occurrence of fish in the diet of young-of-year striped bass is positively correlated with first-year growth and condition. Threadfin and gizzard shad are the most important forage species for most landlocked striped bass populations, including the population in Cherokee Reservoir. Because of their smaller average size, threadfin shad are often the most important of these two species in the diet of young-of-year fish. This appeared to be the case in Cherokee in 1982. It was believed that analysis of numbers and sizes of shad in the reservoir, as well as calculation of prey-predator length relationships (Popova 1967) for striped bass and shad, might shed light on factors affecting the first year utilization of shad.

Estimates of numbers of threadfin and gizzard shad per hectare (from TVA cove-rotenone samples) in Cherokee Reservoir, from 1950

TABLE 22. Percent Composition of Forage Fish In Seining and Electrofishing Samples, and in GI Tracts of Young-of-Year Striped and White Bass and *Morone* and *Stizostedion* Hybrids

Forage Fish[1]	Seining and electrofishing	Striped bass	*Morone* hybrids	White bass	*Stizostedion* hybrids
	(N=13031)	(N=790)	(N=181)	(N=340)	(N=314)
Dorosoma spp.	50.1	99.5	95.0	95.3	94.2
Cyprinidae[2]	18.9	0.1	3.9	3.8	1.0
Other[3]	31.0	0.4	1.1	0.9	4.8

[1]All fish less than 10 cm in total length in seining and electrofishing samples were considered to be forage fish.

[2]Cyprinidae includes: *Notropis* spp., *Pimephales* spp., river chubs (*Nocomis micropogon*), carp (*Cyprinus carpio*), and goldfish (*Carassius auratus*).

[3]Others includes: Centrarchids, brook silversides (*Labidesthes sicculus*), channel catfish (*Ictalurus punctatus*) mosquitofish (*Gambusia affinis*), log perch (*Percina caprodes*), freshwater drum (*Aplodinotus grunniens*), northern hogsuckers (*Hypentelium nigricans*), *Moxostoma* sp., *Morone* spp., *Carpiodes* spp., and *Stizostedion* hybrids.

through 1982, are illustrated in Figure 4. One of the most striking observations revealed by this figure is the virtual disappearance of threadfin shad from the reservoir in the winter of 1976-77. This particular winter was unusually cold and severe. The mean air temperature in Knoxville in January of 1977 was -2.7°C, which was 7.4°C colder than the 20-year average, and was the coldest January in 37 years (National Oceanic and Atmospheric Administration). At this time concern was expressed to TVA personnel about maintaining a steady flow of heated discharge water from the John Sevier Steam Plant located at the upper end of the reservoir. It was hoped that this would reduce the magnitude of the winter die-off of the cold-sensitive threadfin shad (Barr, pers. comm.). This apparently was not successful. McGee et al. (1977) monitored the threadfin shad population below the Kingston Steam Plant in Watts Bar Reservoir, Tennessee, during the same winter and discovered that threadfins were almost completely eliminated by the low temperatures in December and January. Griffith (1978) determined that no threadfin shad survived laboratory exposure to 4°C water temperatures. Feeding and schooling behavior were affected at 9°C.

It was not until 1980 that threadfin shad were again collected in Cherokee Reservoir cove rotenone samples. The population increased exponentially during the next two years, and by 1982 reached previous high levels. The occurrence of shad in the diet of young-of-year striped bass from 1979 through 1982, as determined by Saul (1981) and by the present study, paralleled the population increase of

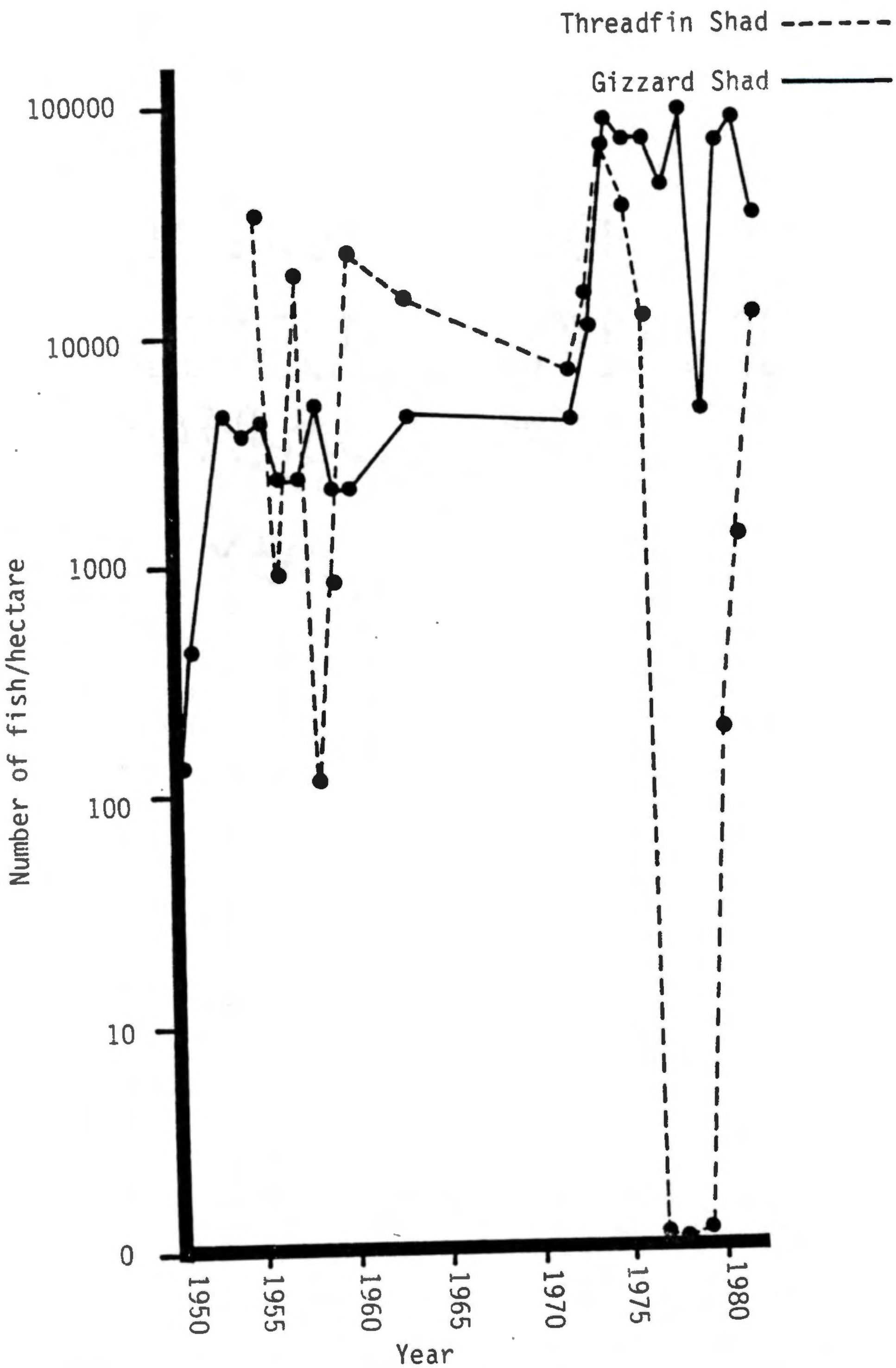

FIGURE 4. Estimates of numbers of threadfin and gizzard shad per hectare (from TVA cove-rotenone data) in Cherokee Reservoir, 1950-1982.

threadfin shad during this period. Saul (1981) found that shad constituted 3.4% of the total food items and occurred in 6.9% of the striped bass guts in 1979. These numbers would have been negligible if the food habits of several one- and two-year-old fish had not been included in these calculations. TVA collected no threadfin shad in 1979. In 1980 Saul (1981) collected no young-of-year striped bass. In 1981 shad constituted 0.9% of the total food items and occurred in 27% of the stomachs of young-of-year striped bass. Threadfin shad concentrations were over 1,000 fish per hectare at this time. In 1982 the occurrence of shad in the GI tracts of young-of-year striped bass increased dramatically. Shad (mostly threadfin shad) made up 65.6% of the total food items and occurred in 92% of the fish examined. Threadfin shad abundance in the reservoir in 1982 had increased by a factor of 10, over the previous year's abundance, to over 10,000 fish per hectare.

It was apparent, upon examination of Figure 4, that shad (particularly gizzard shad) may be abundant but not utilized by young striped bass. This appeared to be the case in 1981. It was believed that most of these shad may have been too large to be available to young striped bass. To examine this hypothesis the prey-predator length relationship for young striped bass and shad was characterized. This length relationship was examined, in conjunction with data collected on lengths of shad present in the reservoir each month, to assess the potential availability of these shad.

The minimum, maximum, and average total lengths of shad found in the GI tracts of each 2.5 cm length class of striped bass are presented in Figure 5. Data for the 1981 and 1982 year classes (including yearlings) were combined. The mean prey/predator length ratios for each length class of striped bass are also given. It was apparent that the maximum, minimum, and mean prey lengths increased with increased predator length. The ratio of mean prey length to predator length, however, decreased. Popova (1967) stated that these general trends are commonly observed in prey-predator relationships of other species. Mean prey lengths initially were approximately 30% of the predator lengths, and decreased to about 20%, over the range of striped bass lengths examined. Analyses of white bass and Morone and Stizostedion hybrid prey-predator length relationships showed similar trends (Appendix S-U).

Maximum prey-predator length ratios ranged from 0.56 for the smallest striped bass length class to 0.31 for larger length classes. These maximum values were assumed to be close to the maximum size limits of shad that could be consumed by each length class. These limitations are probably imposed by gape size of striped bass. Jenkins and Morais (1977) derived formulas for calculating maximum prey size for various predator and prey species. These formulas were based on measurement of gape size of predators and body depth of prey. Maximum prey-predator length ratios were calculated for shad and striped bass for each length class by substitution into the appropriate formula. Values obtained ranged from 0.52 for the smallest length class to 0.32 for larger lengths. These values compare closely to those obtained from actual measurements recorded

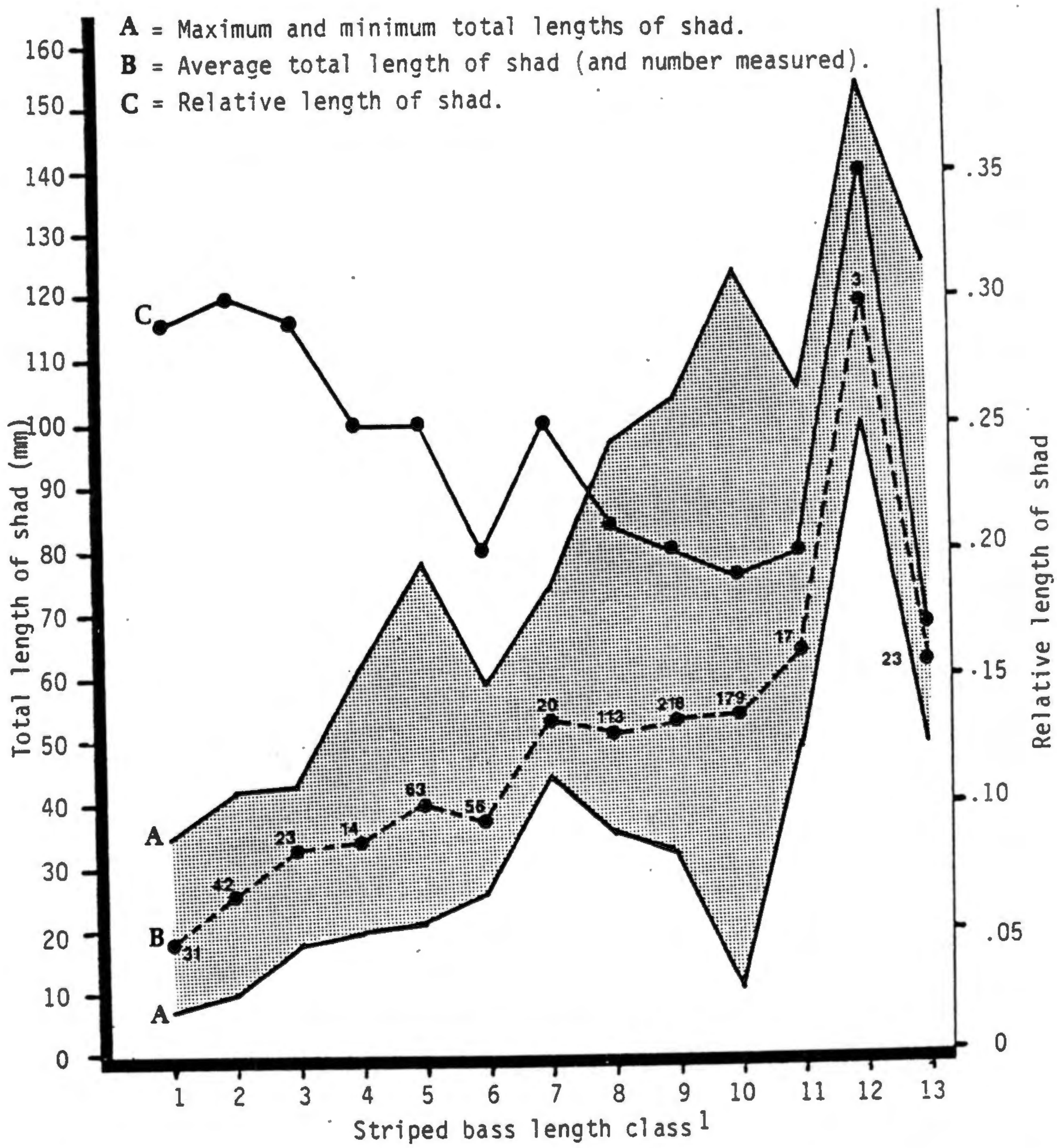

FIGURE 5. Prey-predator length relationship for young striped bass and shad.

[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; 11 = 30.1 to 32.5 cm; 12 = 32.6 to 35.0 cm; 13 = 35.1 to 37.5 cm.

in this study. Maximum prey sizes for 6 of 13 length classes were slightly higher in the present study which indicates that the estimates of Jenkins and Morais (1977) were somewhat low.

The maximum prey size estimates obtained in the present study were used to determine the maximum size of shad that could be consumed by the average length young-of-year striped bass during each month. In Figure 6 these prey size limits for each month were compared to the smallest threadfin and gizzard shad collected in forage samples each month. The overlaps of these values were considered to be the ranges of sizes of shad that were potentially available as prey. The smallest gizzard shad were considerably larger than the smallest threadfin shad collected in most months. The 1981 year class striped bass were too small to utilize most of the shad present in monthly samples. This helped explain the relatively minor importance of shad in the diet of these fish, even though gizzard shad were abundant. In contrast, the larger sizes of the 1982 year class striped bass coupled with the smaller sizes of threadfin shad created a situation in which a broad range of shad sizes were potentially available as prey. As the striped bass grew, some gizzard shad fell within the range of available prey sizes and were utilized. Some of the smallest gizzard shad found in both years were collected in late fall and winter samples. These fish may have been concentrated in areas other than those that were sampled during the first part of each year, or may have been the result of a late gizzard shad spawn. In either case these smaller gizzard shad were

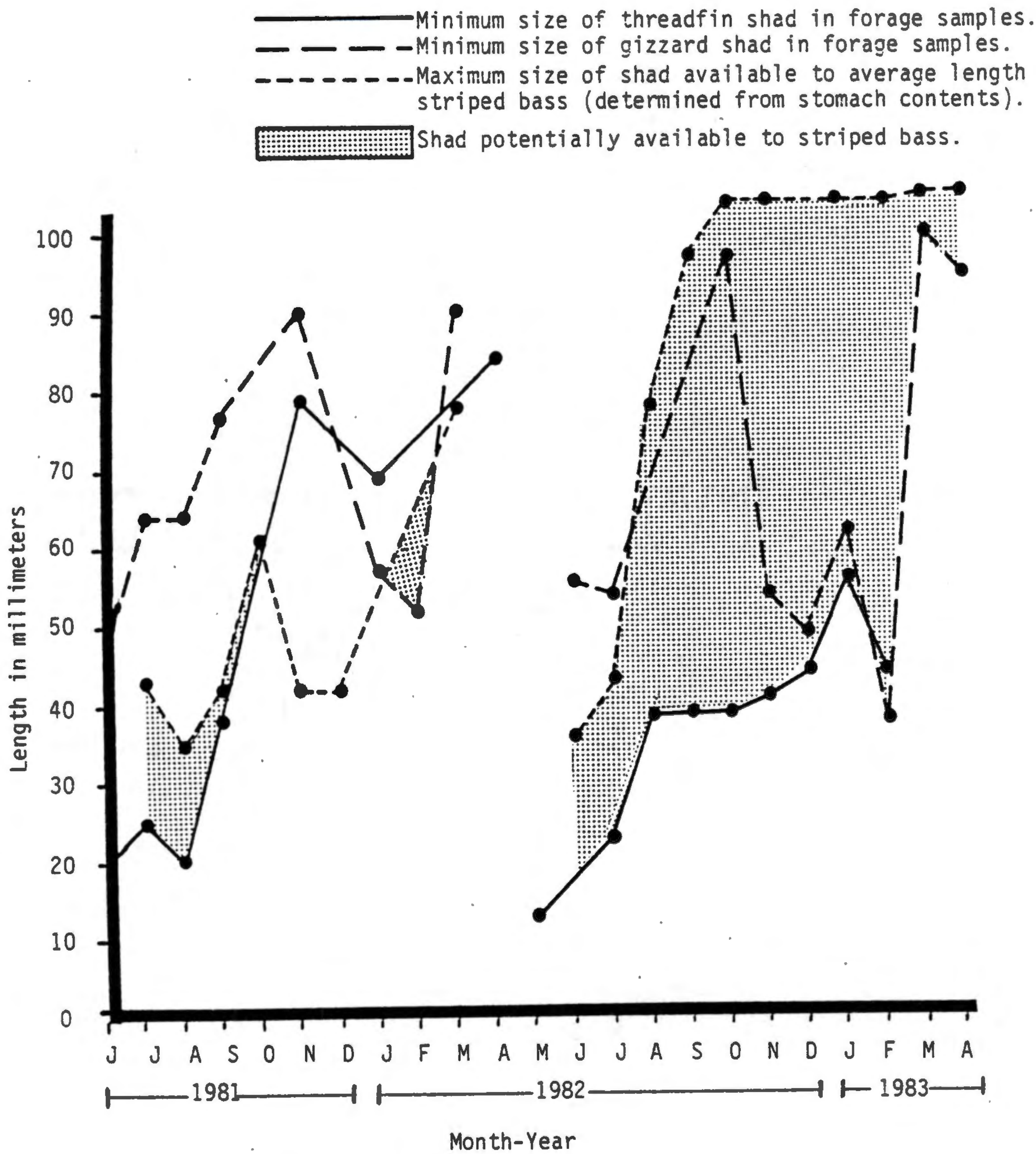

FIGURE 6. Potential availability of threadfin and gizzard shad from forage samples to average length young-of-year striped bass each month, June 1981-April 1983.

collected infrequently and in low numbers and did not contribute significantly to striped bass diets. Most of the gizzard shad that occurred in the diets of the larger 1982 year class fish were relatively large (>75 mm). TVA cove rotenone samples, collected at the end of July, also contained low numbers of small gizzard shad. Estimates of numbers of gizzard shad per hectare that were less than 5.0 cm in total length were 9 and 30 in 1981 and 1982, respectively. Numbers of threadfin shad in this size range in rotenone samples were 50 and 1267 in 1981 and 1982, respectively.

These prey-predator analyses, combined with predator growth, condition, and food habits data, vividly demonstrate that abundance of appropriate-size shad was not adequate to support all small predators in 1981, and probably also in 1979 and 1980. Similarly, Jenkins and Morais (1977) determined from cove rotenone data that available prey were deficient for predators less than 24.0 cm total length in Cherokee Reservoir in 1972 and 1973. They suggested that stocking success in these years would be limited. Competition among fish with similar food habits was probably more severe in these years of low forage abundance, and relative size of young-of-year predators may have been more important. Native white bass and hearty <u>Morone</u> hybrids may also have had an innate advantage over striped bass. This would help explain the relatively poor growth and survival, the invertebrate diet, and the apparent starved condition of the 1979 and 1981 year classes of striped bass. In 1982 when forage was abundant, competition appeared to be minimal and all young-of-year predators grew well.

CHAPTER VI

RECOMMENDATIONS

Since early piscivory appears to be of major importance to first year growth and winter survival of striped bass, and shad are the preferred forage species, success of shad spawns should be monitored closely. Stocking sizes and rates should be adjusted to maximize the utilization of shad. In years of low abundance of small shad it is probably more important to stock larger fingerlings earlier in the year to offset the effects of competition with white bass. To accomplish this, ripe brood fish should be obtained as early as possible in the spring. New fingerling feeding techniques at Eagle Bend Hatchery also appear to enhance the production of larger fingerlings earlier in the year. It may be beneficial to increase feeding rates or reduce hatchery pond stocking densities to maximum growth during years when brook fish are obtained late in the season, or when young-of-year shad are scarce in some reservoirs. Stocking of more competitive <u>Morone</u> hybrids in conjunction with striped bass in years of low forage abundance does not seem advisable. Stocking only <u>Morone</u> hybrids at these times might be considered. During years when small shad are abundant, stocking rates might be increased to maximize their utilization and establish strong year classes. The shad population present in 1982 could probably have supported many more stocked fish. Other types of fish with similar food habits, such as *Stizostedion* hybrids, might also be stocked only during abundant forage years. The growth rate of *Stizostedion* hybrids in years when small shad are scarce remains to be seen. Growth and survival may be superior to that of striped bass during low forage years. *Stizostedion* hybrids can be stocked one to two months earlier in the spring which may give them a size advantage over other young-of-year predators. They may also be less dependent on shad and may utilize other forage species more readily when small shad are scarce. Hybridization may also confer heterosis to these fish. Stocking of *Stizostedion* hybrids exclusively during years when forage for small predators is deficient might also be considered.

Prestock sampling and stocking results have consistently shown Quarryville to be an area of high productivity. The highest densities of shad larvae and fry in late spring appear to be in this area. This area should continue to be given strong consideration when planning future stockings. The access area at Caney Creek, which is located 8 km upstream from Quarryville, might also be considered during high water years when lacustrine conditions extend further upstream.

Since cove rotenone samples are not taken until the end of July after most fish have been stocked, it would be beneficial to sample young-of-year shad populations with other methods earlier in the year. Kilch (1976) effectively sampled larval shad in Center Hill Reservoir, Tennessee, with 5 minute, night-time, mid-channel surface tows with a 0.196 m^2 conical plankton net. He determined that shad (both threadfin and gizzard shad) spawned from late April to mid-June, with peak abundance of larval shad occurring in mid-June in the upper part of the reservoir at water temperatures of 27.0-28.5°C. Similar standardized sampling in the Quarryville and Caney Creek areas at peak shad spawning temperatures would provide an indication of young-of-year shad abundance. Night-time electrofishing later in the season would provide a more qualitative estimate of young shad abundance and distribution. Examination of lengths of striped bass in hatchery ponds and lengths of shad in reservoirs to be stocked should permit rough calculation of shad/striped bass length ratios. Ratios of 0.3 or less should indicate that healthy fingerlings will utilize shad quickly if these small shad are abundant. Examination of cove rotenone data from previous years would elucidate trends in forage abundance, such as winter-kills and recoveries of threadfin shad populations. Species, numbers, sizes to be stocked, and dates and locations of stocking could then be adjusted to suit the forage conditions.

CHAPTER VII

SUMMARY

1. Of 44,000 striped bass fingerlings stocked into Cherokee Reservoir in July 1981, 64 were recaptured. Only four of these fish were recaptured during their second year of life. Of 16,700 Morone hybrids stocked in June of 1981, 241 were recovered. Seventy of these were recovered after they had reached age 1. These data indicated much better first year survival of the Morone hybrids. However, only 5 of 3,300 fin-clipped Morone hybrids that were stocked in October 1981 were recovered. None of this late stocking of relatively small fish were recovered after December, and it was assumed that they experienced poor survival through the winter. Of 28,700 striped bass stocked in June and July of 1982, 145 were recovered. These fish were collected consistently through the winter and spring following stocking, which indicated relatively good survival to age 1.

2. Mean condition of the 1982 year class young-of-year striped bass (1.08-1.28) was better than that of the 1981 year class (0.69-0.91) in each 2.5 cm length class and in corresponding months of the two years of the study.

3. Fingerling striped bass stocked in July 1981 reached only 9.4 cm total length by December 1981. This was relatively poor first year growth compared to other reservoir growth estimates. Morone hybrids demonstrated better growing during the same growing season,

reaching 24.7 cm by November. Striped bass stocked in June and July 1982 demonstrated better growth than both striped bass and *Morone* hybrids stocked in 1981, reaching 27.1 cm by October 1982, and 31.8 cm by March 1983. This is comparable to the highest first year growth estimates found in the literature.

4. Native young-of-year white bass produced in 1982 grew to larger sizes and were in better condition than white bass produced in 1981. This suggested that environmental conditions were more conducive to rapid growth in 1982, and that at least part of the difference in young-of-year striped bass growth between years was due to environmental differences that were independent of stocking size and date.

5. Growth and survival of 48,700 *Stizostedion* hybrids stocked in May 1982 were also remarkably good, again indicating that conditions for growth of young predators were near optimal during the 1982 growing season, and that competition was probably minimal.

6. Food habit analyses performed on striped and white bass and *Morone* and *Stizostedion* hybrids indicated that more rapid first year growth and higher condition factors were associated with more shad in the diet. Slower growth was associated with a prolonged importance of invertebrates (primarily Chironomidae and Crustacea). These findings were supported by growth and food habits studies reported in the literature. Piscivorous striped, white, and hybrid bass appeared to feed more efficiently than individuals that contained invertebrates, consuming fewer and larger prey items and maintaining fuller GI tracts.

7. The decrease in abundance of zooplankton and benthos in fall and winter probably contributed to the apparent starved condition and higher winter mortality of small, relatively non-piscivorous striped bass in 1981.

8. The increase in abundance of threadfin shad by a factor of 10 between 1981 and 1982 was the result of recovery from a severe winter-kill during the winter of 1976-77. This dramatic increase in abundance of forage-size shad contributed to the differences in condition, growth, and food habits between year classes of striped and white bass.

9. The earlier striped bass stocking dates in 1982 along with the ideal nursery habitat created by high water levels and flooded shoreline vegetation may also have contributed to better growth and survival of the 1982 year class.

10. Mean prey/predator length ratios for striped bass decreased from about 0.3 for the smallest striped bass length classes to about 0.2 for larger length classes. Maximum prey length decreased from 56% of the striped bass length for the smallest length class (5.1-7.5 cm) to 31% for larger length classes. Comparison of maximum prey size limits with actual sizes of shad in the reservoir showed that most shad present in 1981 were too large to be available to young-of-year striped bass. In 1982, however, a wide range of shad sizes were available. This explained the minor importance of shad in the diet of the 1981 year class striped bass even though gizzard shad were abundant.

11. Since early piscivory appeared to be of major importance to first year growth and winter survival of striped bass, and shad were the most utilized forage species, it was recommended that shad populations be carefully examined when planning future stockings. Shad/striped bass length ratios of 0.3 or less should indicate that healthy striped bass fingerlings will begin consuming shad quickly if these small shad are abundant. In years when small shad are scarce, stocking reduced numbers of larger fingerlings might help offset competition with white bass. In years when small shad are abundant, numbers stocked might be increased to establish strong year classes. Other predators with similar food habits, such as Morone and Stizostedion hybrids, might be stocked in addition to striped bass to diversify the fishery when small shad are abundant and competition is minimal.

12. Prestock sampling and stocking results have consistently shown Quarryville to be an area of high productivity. This area should continue to be given strong consideration when planning future stockings.

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APPENDIXES

APPENDIX A

TABLE 23. Percents of Total Numbers of Food Items in Guts of 1981 Year Class *Morone* Hybrids, Grouped by Month

	Month																					
Food item categories	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
Pisces	5.0	15.7	39.6	1.7	88.2	50.0		33.3	18.6	0.0	55.9	64.7	91.0	10.3	90.1	100.0	96.0				0.8	
Dorosoma sp.	2.6	14.8	35.8	1.7	88.2	50.0		0.0	14.3	0.0	55.9	35.3	91.0	10.3	88.9	100.0	96.0				0.8	
Dorosoma petenense	0.2	2.6	1.3	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	2.0				0.0	
Dorosoma cepedianum	0.3	2.6	1.9	0.3	5.9	0.0		0.0	4.3	0.0	11.8	0.0	0.6	0.0	11.1	0.0	8.0				0.0	
Unidentified *Dorosoma*	2.1	9.6	32.7	1.4	82.4	50.0		0.0	10.0	0.0	44.1	35.3	86.5	10.3	77.8	100.0	86.0				0.8	
Cyprinidae	0.2	0.0	1.3	0.0	0.0	0.0		0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.0	
Other fish	0.0	0.4	0.6	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.0	
Unidentified fish	2.2	0.4	1.9	0.0	0.0	0.0		33.3	1.4	0.0	0.0	29.4	0.0	0.0	1.2	0.0	0.0				0.0	
Insecta	75.4	67.4	50.9	31.1	11.8	50.0		33.3	77.1	72.7	44.1	23.5	2.6	89.7	8.6	0.0	0.0				99.2	
Diptera	72.7	43.9	44.7	30.1	5.9	50.0		0.0	57.1	71.5	26.5	11.8	1.3	3.4	2.5	0.0	0.0				99.0	
Chironomidae	66.7	42.6	42.7	24.9	5.9	50.0		0.0	57.1	69.0	26.5	5.9	0.6	3.4	0.0	0.0	0.0				99.0	
Chironomidae larvae	45.1	37.4	32.7	24.2	0.0	0.0		0.0	22.9	61.3	2.9	5.9	0.6	0.0	0.0	0.0	0.0				97.1	
Chironomidae pupae	21.6	5.2	10.1	0.7	5.9	50.0		0.0	34.3	7.7	23.5	0.0	0.0	3.4	0.0	0.0	0.0				1.8	
Chaoborus sp.	5.3	0.9	0.6	0.0	0.0	0.0		0.0	0.0	0.0	0.0	5.9	0.6	0.0	0.0	0.0	0.0				0.0	
Adult Diptera	0.7	0.4	1.3	5.2	0.0	0.0		0.0	0.0	2.5	0.0	0.0	0.0	0.0	2.5	0.0	0.0				0.0	
Ephemeroptera	1.7	20.9	3.8	0.0	5.9	0.0		33.3	18.6	0.6	11.8	11.8	0.0	86.2	0.0	0.0	0.0				0.2	
Ephemeridae	0.0	0.4	1.3	0.0	0.0	0.0		0.0	1.4	0.0	8.8	0.0	0.0	86.2	0.0	0.0	0.0				0.0	
Other Ephemeroptera	1.7	20.4	2.5	0.0	5.9	0.0		33.3	17.1	0.6	2.9	11.8	0.0	0.0	0.0	0.0	0.0				0.2	
Trichoptera	0.1	0.4	0.0	1.0	0.0	0.0		0.0	0.0	0.6	2.9	0.0	0.6	0.0	0.0	0.0	0.0				0.0	
Corixidae	0.7	1.7	0.6	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.0	
Other insects	0.3	0.0	0.6	0.0	0.0	0.0		0.0	1.4	0.0	2.9	0.0	0.6	0.0	6.2	0.0	0.0				0.0	
Unidentified insects	0.0	0.4	1.3	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.0	
Crustacea	19.2	1.7	4.4	18.7	0.0	0.0		0.0	4.3	18.2	0.0	5.9	6.4	0.0	0.0	0.0	0.0				0.0	
Copepoda[1]	0.3	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.0	
Argulus sp.	2.0	1.7	1.9	18.7	0.0	0.0		0.0	4.3	18.2	0.0	5.9	6.4	0.0	0.0	0.0	0.0				0.0	
Cladocera[2]	16.3	0.0	2.5	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.0	
Leptodora sp.	0.6	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.0	
Other invertebrates	0.1	0.4	0.0	1.0	0.0	0.0		33.3	0.0	0.3	0.0	5.9	0.0	0.0	0.0	0.0	0.0				0.0	
Miscellaneous	0.4	14.8	5.0	47.0	0.0	0.0		0.0	0.0	8.8	0.0	0.0	0.0	0.0	1.2	0.0	4.0				0.0	
No. of fish with food	80	23	32	4	11	1	0	2	14	4	16	2	11	2	22	1	5	0	0	0	3	0
No. of food items	1919	230	159	289	17	2		3	70	362	34	17	156	29	81	3	20				490	

[1]Exclusive of *Argulus* sp.

[2]Exclusive of *Leptodora* sp.

APPENDIX B

TABLE 24. Frequency of Occurrence (%) of Food Items in Guts of 1981 Year Class *Morone* Hybrids That Contained Food, Grouped by Month

	Month																					
Food item categories	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
Pisces	64	74	87	75	100	100		50	71	0	79	100	91	100	95	100	100				33	
Dorosoma sp.	39	70	71	75	100	100		0	57	0	79	50	91	100	91	100	100				33	
Dorosoma petenense	4	26	6	0	0	0		0	0	0	0	0	27	0	0	0	20				0	
Dorosoma cepedianum	6	26	10	25	11	0		0	14	0	29	0	9	0	23	0	20				0	
Unidentified *Dorosoma*	33	57	68	75	89	100		0	50	0	57	50	82	100	82	100	100				33	
Cyprinidae	3	0	6	0	0	0		0	14	0	0	0	0	0	0	0	0				0	
Other fish	0	4	3	0	0	0		0	0	0	0	0	0	0	0	0	0				0	
Unidentified fish	36	4	10	0	0	0		50	7	0	0	100	0	0	5	0	0				0	
Insecta	96	52	39	25	22	100		50	71	100	29	100	18	100	5	0	0				100	
Diptera	94	52	26	25	11	100		0	64	100	21	50	18	50	5	0	0				100	
Chironomidae	91	52	26	25	11	100		0	64	100	21	50	9	50	0	0	0				100	
Chironomidae larvae	89	48	19	25	0	0		0	36	100	7	50	9	0	0	0	0				67	
Chironomidae pupae	51	26	16	25	11	100		0	64	100	21	0	0	50	0	0	0				100	
Chaoborus sp.	19	9	3	0	0	0		0	0	0	0	50	9	0	0	0	0				0	
Adult Diptera	4	4	3	25	0	0		0	0	25	0	0	0	0	5	0	0				0	
Ephemeroptera	9	26	13	0	11	0		50	36	50	14	50	0	100	0	0	0				33	
Ephemeridae	0	4	6	0	0	0		0	7	0	14	0	0	100	0	0	0				0	
Other Ephemeroptera	9	22	10	0	11	0		50	36	50	7	50	0	0	0	0	0				33	
Trichoptera	1	4	0	25	0	0		0	0	50	7	0	9	0	0	0	0				0	
Corixidae	10	4	3	0	0	0		0	0	0	0	0	0	0	0	0	0				0	
Other insects	6	0	3	0	0	0		0	7	0	7	0	9	0	5	0	0				0	
Unidentified insects	0	4	6	0	0	0		0	0	0	0	0	0	0	0	0	0				0	
Crustacea	30	17	6	25	0	0		0	14	100	0	50	27	0	0	0	0				0	
Copepoda[1]	4	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0				0	
Argulus sp.	23	17	3	25	0	0		0	14	100	0	50	27	0	0	0	0				0	
Cladocera[2]	11	0	3	0	0	0		0	0	0	0	0	0	0	0	0	0				0	
Leptodora sp.	1	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0				0	
Other invertebrates	1	4	0	25	0	0		50	0	25	0	50	0	0	0	0	0				0	
Miscellaneous	3	35	19	25	0	0		0	0	50	0	0	0	0	5	0	40				0	
No. of fish with food	80	23	31	4	9	1	0	2	3	4	14	2	11	2	22	1	5	0	0	0	3	0

[1]Exclusive of *Argulus* sp.

[2]Exclusive of *Leptodora* sp.

APPENDIX C

TABLE 25. Percents of Total Numbers of Food Items in Guts of Young-of-Year 1981 Year Class *Morone* Hybrids, Grouped by Length Class

Food item categories	Length class[1] 1	2	3	4	5	6	7	8	9	10
Pisces	0.9	6.4	6.4	30.4	59.6	8.6	22.4	35.7	85.7	16.7
Dorosoma sp.	0.3	3.2	3.9	23.2	57.4	8.3	20.0	35.7	85.7	16.7
Dorosoma petenense	0.0	0.3	0.0	7.1	4.3	0.3	1.2	0.0	0.0	0.0
Dorosoma cepedianum	0.1	0.1	1.0	3.6	8.5	0.3	2.4	7.1	0.0	0.0
Unidentified *Dorosoma*	0.2	2.8	2.9	12.5	44.7	7.7	16.5	28.6	85.7	16.7
Cyprinidae	0.1	0.3	0.0	3.6	0.0	0.3	0.0	0.0	0.0	0.0
Other fish	0.0	0.1	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified fish	0.5	2.7	2.5	1.8	2.1	0.0	2.4	0.0	0.0	0.0
Insecta	67.1	85.5	49.9	53.6	36.2	78.3	36.5	23.2	14.3	83.3
Diptera	65.6	77.0	46.4	51.8	27.7	75.3	29.4	21.4	7.1	50.0
Chironomidae	56.3	74.7	42.3	48.2	27.7	72.6	29.4	21.4	7.1	50.0
Chironomidae larvae	29.1	58.5	39.0	44.6	8.5	65.5	16.5	3.6	0.0	16.7
Chironomidae pupae	27.2	16.3	3.3	3.6	19.1	7.1	12.9	17.9	7.1	33.3
Chaoborus sp.	8.8	1.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Diptera	0.5	0.9	2.9	3.6	0.0	2.7	0.0	0.0	0.0	0.0
Ephemeroptera	1.3	6.9	1.0	0.0	6.4	2.1	7.1	0.0	7.1	33.3
Ephemeridae	0.0	0.0	0.2	0.0	4.3	0.0	1.2	0.0	0.0	0.0
Other Ephemeroptera	1.3	6.9	0.8	0.0	2.1	2.1	5.9	0.0	7.1	33.3
Trichoptera	0.0	0.1	0.8	0.0	0.0	0.3	0.0	1.8	0.0	0.0
Corixidae	0.1	1.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other insects	0.0	0.3	0.6	0.0	2.1	0.0	0.0	0.0	0.0	0.0
Unidentified insects	0.0	0.0	0.0	1.8	0.0	0.6	0.0	0.0	0.0	0.0
Crustacea	31.1	5.9	13.2	7.1	2.1	12.8	7.1	35.7	0.0	0.0
Copepoda[2]	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Argulus sp.	0.3	3.2	11.7	7.1	2.1	12.8	7.1	35.7	0.0	0.0
Cladocera[3]	29.1	2.5	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leptodora sp.	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other invertebrates	0.0	0.1	1.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Miscellaneous	0.9	2.1	29.5	8.9	2.1	0.0	34.1	5.4	0.0	0.0
No. of fish with food	22	50	24	10	16	17	12	9	6	2
No. of food items	978	958	515	56	47	336	85	56	14	6

[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.

[3]Exclusive of *Leptodora* sp.

APPENDIX D

TABLE 26. Frequency of Occurrence (%) of Food Items in Guts of Young-of-Year 1981 Year Class *Morone* Hybrids that Contained Food, Grouped by Length Class

	Length class[1]									
Food item categories	1	2	3	4	5	6	7	8	9	10
Pisces	23	66	79	90	94	82	75	89	100	50
Dorosoma sp.	9	34	58	70	88	82	58	89	100	50
Dorosoma petenense	0	6	0	40	13	6	8	0	0	0
Dorosoma cepedianum	5	2	17	20	25	6	17	33	0	0
Unidentified *Dorosoma*	5	30	46	60	81	76	50	78	100	50
Cyprinidae	5	4	0	20	0	6	0	0	0	0
Other fish	0	2	0	10	0	0	0	0	0	0
Unidentified fish	14	36	42	10	6	0	17	0	0	0
Insecta	100	94	92	50	38	53	33	22	33	50
Diptera	100	90	83	50	25	41	33	22	17	50
Chironomidae	95	90	79	50	25	41	33	22	17	50
Chironomidae larvae	91	90	75	40	13	29	17	11	0	50
Chironomidae pupae	73	48	38	10	25	35	33	22	17	50
Chaoborus sp.	27	18	13	0	0	0	0	0	0	0
Adult Diptera	5	6	4	10	0	6	0	0	0	0
Ephemeroptera	9	18	17	0	19	24	17	0	17	50
Ephemeridae	0	0	4	0	13	0	8	0	0	0
Other Ephemeroptera	9	18	17	0	6	24	17	0	17	50
Trichoptera	0	2	8	0	0	6	0	11	0	0
Corixidae	4	14	8	0	0	0	0	0	0	0
Other insects	0	6	13	0	6	0	0	0	0	0
Unidentified insects	0	0	0	10	0	12	0	0	0	0
Crustacea	32	28	29	20	6	18	17	11	0	0
Copepoda[2]	9	2	0	0	0	0	0	0	0	0
Argulus sp.	14	26	21	20	6	18	17	11	0	0
Cladocera[3]	18	8	8	0	0.	0	0	0	0	0
Leptodora sp.	4	0	0	0	0	0	0	0	0	0
Other invertebrates	0	2	13	0	0	6	0	0	0	0
Miscellaneous	4	12	21	40	6	0	8	11	0	0
No. of fish with food	22	50	24	10	16	17	12	9	6	2

[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.

[3]Exclusive of *Leptodora* sp.

APPENDIX E

TABLE 27. Percents of Total Numbers of Food Items in Guts of 1981 Year Class White Bass, Grouped by Month

Food item categories	Month J	A	S	O	N	D	J	F	M	A	M	J	J
Pisces	3.4	5.4	1.4	15.1	61.5	100.0	41.7	0.0	23.5	0.6	90.0	21.4	81.8
Dorosoma sp.	3.0	3.5	0.9	7.6	46.2	75.0	33.3	0.0	20.6	0.3	30.0	0.0	80.0
Dorosoma petenense	0.1	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0
Dorosoma cepedianum	0.1	0.0	0.0	0.0	15.4	25.0	0.0	0.0	0.0	0.3	10.0	0.0	0.0
Unidentified Dorosoma	2.7	3.5	0.9	7.6	30.8	50.0	25.0	0.0	20.6	0.0	20.0	0.0	80.0
Cyprinidae	0.1	1.2	0.6	5.7	15.4	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0
Unidentified fish	0.3	0.8	0.0	1.9	0.0	25.0	8.3	0.0	2.9	0.3	60.0	14.3	1.8
Insecta	92.0	50.6	96.9	83.0	23.1	0.0	58.3	100.0	70.6	86.5	0.0	76.6	5.5
Diptera	91.2	42.4	92.6	50.9	23.1	0.0	50.0	100.0	58.8	81.7	0.0	78.6	5.5
Chironomidae	68.0	39.7	43.8	50.9	23.1	0.0	50.0	25.0	58.8	63.6	0.0	78.6	5.5
Chironomidae larvae	63.4	34.2	38.6	43.4	7.7	0.0	41.7	25.0	26.5	50.2	0.0	64.3	1.8
Chironomidae pupae	4.7	5.4	5.1	7.6	15.4	0.0	8.3	0.0	32.4	13.5	0.0	14.3	3.6
Chaoborus sp.	22.4	1.9	48.6	0.0	0.0	0.0	0.0	75.0	0.0	0.6	0.0	0.0	0.0
Adult Diptera	0.7	0.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	17.4	0.0	0.0	0.0
Ephemeroptera	0.6	5.8	3.1	20.8	0.0	0.0	8.3	0.0	11.8	3.1	0.0	0.0	0.0
Ephemeridae	0.3	5.8	2.0	17.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
Other Ephemeroptera	0.3	0.0	1.1	3.8	0.0	0.0	8.3	0.0	11.8	2.4	0.0	0.0	0.0
Trichoptera	0.0	0.8	0.3	11.3	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0
Corixidae	0.3	1.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Other insects	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
Unidentified insects	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crustacea	4.3	42.8	0.6	0.0	0.0	0.0	0.0	0.0	2.9	11.0	0.0	0.0	9.1
Copepoda[1]	0.0	34.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Argulus sp.	2.7	0.4	0.6	0.0	0.0	0.0	0.0	0.0	2.9	11.0	0.0	0.0	9.1
Cladocera[2]	1.6	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leptodora sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other invertebrates	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0
Miscellaneous	0.1	1.2	1.1	1.9	15.4	0.0	0.0	0.0	2.9	0.9	10.0	0.0	3.6
No. of fish with food	20	20	18	13	9	7	7	2	8	10	9	2	9
No. of food items	704	257	352	53	13	8	12	4	34	327	10	14	55

[1]Exclusive of Argulus sp.

[2]Exclusive of Leptodora sp.

APPENDIX F

TABLE 28. Frequency of Occurrence (%) of Food Items in Guts of 1981 Year Class White Bass That Contained Food, Grouped by Month

Food item categories	Month J	A	S	O	N	D	J	F	M	A	M	J	J
Pisces	45	40	22	54	88	100	71	0	50	10	89	100	100
Dorosoma sp.	35	25	17	31	67	71	57	0	38	10	33	0	89
Dorosoma petenense	5	0	0	0	0	0	0	0	0	0	0	0	0
Dorosoma cepedianum	5	0	0	0	22	29	0	0	0	10	11	0	0
Unidentified *Dorosoma*	30	25	17	31	44	43	43	0	38	0	22	0	89
Cyprinidae	5	5	6	15	22	0	0	0	0	0	0	0	0
Other fish	0	0	0	0	0	0	0	0	0	0	0	50	0
Unidentified fish	10	10	0	8	0	29	14	0	13	10	56	100	11
Insecta	100	90	89	46	33	0	71	50	88	100	0	50	33
Diptera	100	75	83	38	33	0	57	50	88	100	0	50	33
Chironomidae	95	70	83	38	33	0	57	50	88	100	0	50	33
Chironomidae larvae	95	65	72	23	11	0	43	50	75	100	0	50	11
Chironomidae pupae	80	35	56	15	22	0	14	0	50	80	0	50	22
Chaoborus sp.	55	5	33	0	0	0	0	50	0	10	0	0	0
Adult Diptera	25	10	6	0	0	0	0	0	0	10	0	0	0
Ephemeroptera	20	40	39	23	0	0	14	0	38	40	0	0	0
Ephemeridae	10	40	33	23	0	0	0	0	0	20	0	0	0
Other Ephemeroptera	10	0	6	15	0	0	14	0	38	20	0	0	0
Trichoptera	0	10	6	23	0	0	0	0	0	20	0	0	0
Corixidae	10	10	6	0	0	0	0	0	0	10	0	0	0
Other insects	0	0	0	0	0	0	0	0	0	10	0	0	0
Unidentified insects	0	5	0	0	0	0	0	0	0	0	0	0	0
Crustacea	45	15	11	0	0	0	0	0	13	60	0	0	11
Copepoda[1]	0	5	0	0	0	0	0	0	0	0	0	0	0
Argulus sp.	40	5	11	0	0	0	0	0	13	60	0	0	11
Cladocera[2]	10	10	0	0	0	0	0	0	0	0	0	0	0
Leptodora sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Other invertebrates	5	0	0	0	0	0	0	50	0	30	0	0	0
Miscellaneous	5	10	11	8	11	0	0	0	13	10	11	0	22
No. of fish with food	20	20	18	13	9	7	7	2	8	10	9	2	9

[1]Exclusive of *Argulus* sp.

[2]Exclusive of *Leptodora* sp.

APPENDIX G

TABLE 29. Percents of Total Numbers of Food Items in Guts of Young-of-Year 1981 Year Class White Bass, Grouped by Length Class

Food item categories	Length class[1] 1	2	3	4	5	6	7	8
Pisces	1.0	3.3	27.0	30.0	24.3	6.2	9.2	100.0
Dorosoma sp.	0.6	2.0	23.0	20.0	24.3	4.0	6.9	100.0
Dorosoma petenense	0.0	0.0	1.4	0.0	0.0	0.4	0.0	0.0
Dorosoma cepedianum	0.0	0.0	1.4	0.0	2.7	1.3	0.8	0.0
Unidentified *Dorosoma*	0.6	2.0	20.3	20.0	21.6	2.2	6.1	100.0
Cyprinidae	0.3	1.0	2.7	0.0	0.0	0.9	0.0	0.0
Other fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified fish	0.1	0.3	1.4	10.0	0.0	1.3	2.3	0.0
Insecta	85.5	89.8	59.5	60.0	67.6	78.8	88.5	0.0
Diptera	83.6	82.7	43.2	40.0	54.1	77.0	79.4	0.0
Chironomidae	57.4	55.5	43.2	30.0	49.9	76.1	35.9	0.0
Chironomidae larvae	52.9	51.1	36.5	20.0	35.1	54.0	28.2	0.0
Chironomidae pupae	4.5	4.3	6.8	10.0	10.8	22.1	7.6	0.0
Chaoborus sp.	25.8	26.5	0.0	0.0	8.1	0.9	0.0	0.0
Adult Diptera	0.4	0.8	0.0	10.0	0.0	0.0	43.5	0.0
Ephemeroptera	1.1	5.1	12.2	20.0	13.5	0.9	6.1	0.0
Ephemeridae	0.6	4.8	9.5	20.0	2.7	0.4	0.0	0.0
Other Ephemeroptera	0.6	0.3	2.7	0.0	10.8	0.4	6.1	0.0
Trichoptera	0.1	1.3	4.1	0.0	0.0	0.4	1.5	0.0
Corixidae	0.6	0.8	0.0	0.0	0.0	0.4	0.0	0.0
Other insects	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0
Unidentified insects	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crustacea	13.1	5.3	4.1	10.0	8.1	14.2	1.5	0.0
Copepoda[2]	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Argulus sp.	0.4	3.6	4.1	10.0	8.1	14.2	1.5	0.0
Cladocera[3]	2.7	1.8	0.0	0.0	0.0	0.0	0.0	0.0
Leptodora sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other invertebrates	0.1	0.0	1.4	0.0	0.0	0.4	0.8	0.0
Miscellaneous	0.2	1.5	8.1	0.0	0.0	0.4	0.0	0.0
No. of fish with food	28	19	10	3	13	25	14	2
No. of food items	891	393	74	10	37	226	131	2

[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.

[2]Exclusive of *Argulus* sp.

[3]Exclusive of *Leptodora* sp.

APPENDIX H

TABLE 30. Frequency of Occurrence (%) of Food Items in Guts of Young-of-Year 1981 Year Class White Bass that Contained Food, Grouped by Length Class

Food item categories	Length class[1] 1	2	3	4	5	6	7	8
Pisces	21	47	50	67	62	44	71	100
Dorosoma sp.	14	26	40	33	62	28	50	100
Dorosoma petenense	0	0	10	0	0	4	0	0
Dorosoma cepedianum	0	0	10	0	8	12	7	0
Unidentified Dorosoma	14	26	30	33	54	12	43	100
Cyprinidae	4	16	10	0	0	8	0	0
Other fish	0	0	0	0	0	0	0	0
Unidentified fish	4	5	10	33	0	12	21	0
Insecta	100	100	70	67	46	68	50	0
Diptera	96	95	50	33	46	68	43	0
Chironomidae	96	84	50	33	46	68	43	0
Chironomidae larvae	96	73	50	33	38	52	29	0
Chironomidae pupae	68	47	20	33	23	52	21	0
Chaoborus sp.	39	37	0	0	8	4	0	0
Adult Diptera	14	16	0	33	0	0	7	0
Ephemeroptera	25	42	50	66	31	8	14	0
Ephemeridae	18	42	40	66	8	4	0	0
Other Ephemeroptera	7	5	20	0	23	4	14	0
Trichoptera	4	21	10	0	0	4	7	0
Corixidae	14	5	0	0	0	4	0	0
Other insects	0	0	0	0	0	0	7	0
Unidentified insects	4	0	0	0	0	0	0	0
Crustacea	21	26	20	33	15	16	7	0
Copepoda[2]	4	0	0	0	0	0	0	0
Argulus sp.	11	26	20	33	15	16	7	0
Cladocera[3]	11	5	0	0	0	0	0	0
Leptodora sp.	0	0	0	0	0	0	0	0
Other invertebrates	4	0	10	0	0	4	7	0
Miscellaneous	7	16	30	0	0	4	0	0
No. of fish with food	28	19	10	3	13	25	14	2

[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.

[2]Exclusive of Argulus sp.

[3]Exclusive of Leptodora sp.

APPENDIX I

TABLE 31. Percents of Total Numbers of Food Items in Guts of 1982 Year Class White Bass, Grouped by Month

Food item categories	J	J	A	S	Month O	N	D	J	F	M	A
Pisces	38.6	10.7	90.0	72.1	92.2	100.0	100.0	87.5	72.4	2.4	0.9
Dorosoma sp.	34.1	8.8	78.6	65.6	90.1	97.0	87.5	50.5	58.6	0.8	0.5
Dorosoma petenense	2.3	2.3	21.4	16.4	17.2	12.1	12.5	12.5	17.2	0.0	0.0
Dorosoma cepedianum	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified *Dorosoma*	31.8	6.5	57.1	47.6	73.4	84.8	75.0	37.5	41.4	0.8	0.5
Cyprinidae	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Other fish	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified fish	4.5	0.9	2.4	6.6	1.6	3.0	12.5	37.5	13.8	1.6	0.0
Insecta	54.5	78.0	11.9	24.6	7.8	0.0	0.0	12.5	27.6	97.6	97.5
Diptera	50.0	71.4	11.9	13.1	7.8	0.0	0.0	12.5	27.6	96.8	97.5
Chironomidae	50.0	68.1	11.9	9.8	7.8	0.0	0.0	12.5	27.6	96.8	97.5
Chironomidae larvae	43.0	62.2	4.8	0.0	1.6	0.0	0.0	0.0	24.1	75.0	2.6
Chironomidae pupae	6.8	5.9	7.1	9.8	6.3	0.0	0.0	12.5	3.4	21.8	94.9
Chaoborus sp.	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adult Diptera	0.0	6.6	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ephemeroptera	4.5	6.5	0.0	8.2	0.0	0.0	0.0	0.0	0.0	0.8	0.0
Ephemeridae	0.0	0.6	0.0	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Ephemeroptera	4.5	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0
Trichoptera	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corixidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other insects	0.0	0.2	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified insects	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crustacea	6.8	10.3	4.8	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Copepoda[1]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Argulus sp.	6.8	6.1	4.8	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cladocera[2]	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leptodora sp.	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other invertebrates	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous	0.0	0.6	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6
No. of fish with food	10	30	10	19	20	10	8	7	9	9	9
No. of food items	44	524	42	61	64	33	16	8	29	124	571

[1]Exclusive of *Argulus* sp.

[2]Exclusive of *Leptodora* sp.

APPENDIX J

TABLE 32. Frequency of Occurrence (%) of Food Items in Guts of 1982 Year Class White Bass That Contained Food, Grouped by Month

	Month										
Food item categories	J	J	A	S	O	N	D	J	F	M	A
Pisces	90	87	100	84	100	100	100	86	67	33	56
Dorosoma sp.	80	67	90	68	95	90	75	43	33	11	33
Dorosoma petenense	10	23	60	26	30	30	25	14	22	0	0
Dorosoma cepedianum	0	0	0	5	0	0	0	0	0	0	0
Unidentified *Dorosoma*	80	53	80	63	95	90	50	29	33	11	33
Cyprinidae	0	3	0	0	0	0	0	0	0	0	22
Other fish	0	7	0	0	0	0	0	0	0	0	0
Unidentified fish	20	17	10	16	5	10	25	43	33	22	0
Insecta	90	87	40	37	10	0	0	14	44	89	100
Diptera	90	87	40	21	10	0	0	14	44	89	100
Chironomidae	90	83	40	16	10	0	0	14	44	89	100
Chironomidae larvae	90	67	10	0	5	0	0	0	44	78	56
Chironomidae pupae	30	53	30	16	10	0	0	14	11	67	89
Chaoborus sp.	0	13	0	0	0	0	0	0	0	0	0
Adult Diptera	0	7	0	5	0	0	0	0	0	0	0
Ephemeroptera	20	33	0	11	0	0	0	0	0	11	0
Ephemeridae	0	10	0	11	0	0	0	0	0	0	0
Other Ephemeroptera	20	27	0	0	0	0	0	0	0	11	0
Trichoptera	0	0	0	5	0	0	0	0	0	0	0
Corixidae	0	0	0	0	0	0	0	0	0	0	0
Other insects	0	3	0	5	0	0	0	0	0	0	0
Unidentified insects	0	0	0	0	0	0	0	0	0	0	0
Crustacea	30	57	20	5	0	0	0	0	0	0	0
Copepoda[1]	0	0	0	0	0	0	0	0	0	0	0
Argulus sp.	30	53	20	5	0	0	0	0	0	0	0
Cladocera[2]	0	3	0	0	0	0	0	0	0	0	0
Leptodora sp.	0	3	0	0	0	0	0	0	0	0	0
Other invertebrates	0	3	0	0	0	0	0	0	0	0	0
Miscellaneous	0	7	10	0	0	0	0	0	0	0	22
No. of fish with food	10	30	10	19	20	10	8	7	9	9	9

[1]Exclusive of *Argulus* sp.

[2]Exclusive of *Leptodora* sp.

APPENDIX K

TABLE 33. Percents of Total Numbers of Food Items in Guts of Young-of-Year 1982 Year Class White Bass, Grouped by Length Class

Food item categories	Length class[1] 1	2	3	4	5	6	7	8	9
Pisces	9.3	14.2	10.5	53.4	91.7	35.1	15.3	22.7	100.0
Dorosoma sp.	8.1	11.6	8.6	51.7	91.7	28.4	12.6	21.8	100.0
Dorosoma petenense	0.6	2.7	1.3	20.7	8.3	8.1	3.0	2.6	66.7
Dorosoma cepedianum	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Unidentified *Dorosoma*	7.5	8.9	7.2	31.0	83.3	20.3	9.4	19.2	33.3
Cyprinidae	0.0	0.9	0.0	0.0	0.0	0.0	0.2	0.2	0.0
Other fish	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified fish	1.2	0.4	2.0	1.7	0.0	6.8	2.5	0.7	0.0
Insecta	68.9	76.0	86.2	41.4	8.3	64.9	84.0	75.4	0.0
Diptera	55.3	72.0	82.2	41.4	8.3	62.2	82.5	75.4	0.0
Chironomidae	49.1	70.2	81.6	37.9	8.3	62.2	82.0	75.4	0.0
Chironomidae larvae	37.3	67.1	77.6	31.0	0.0	47.3	17.5	2.4	0.0
Chironomidae pupae	11.8	3.1	3.9	6.9	8.3	14.9	64.5	73.0	0.0
Chaoborus sp.	6.2	1.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Adult Diptera	0.0	0.4	0.0	3.4	0.0	0.0	0.5	0.0	0.0
Ephemeroptera	13.7	4.0	3.3	0.0	0.0	1.4	1.2	0.0	0.0
Ephemeridae	0.0	0.4	1.3	0.0	0.0	1.4	1.0	0.0	0.0
Other Ephemeroptera	13.7	3.6	2.0	0.0	0.0	0.0	0.2	0.0	0.0
Trichoptera	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0
Corixidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other insects	0.0	0.0	0.7	0.0	0.0	0.0	0.2	0.0	0.0
Unidentified insects	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crustacea	20.5	9.8	1.3	3.4	0.0	0.0	0.5	0.0	0.0
Copepoda[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Argulus sp.	6.8	9.8	1.3	3.4	0.0	0.0	0.5	0.0	0.0
Cladocera[3]	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leptodora sp.	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other invertebrates	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous	0.0	0.0	2.0	1.7	0.0	0.0	0.3	1.9	0.0
No. of fish with food	13	14	8	10	3	13	41	38	1
No. of food items	161	225	152	58	12	74	406	422	6

[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.

[2]Exclusive of *Argulus* sp.

[3]Exclusive of *Leptodora* sp.

APPENDIX L

TABLE 34. Frequency of Occurrence (%) of Food Items in Guts of Young-of-Year 1982 Year Class White Bass That Contained Food, Grouped by Length Class

Food item categories	Length class[1] 1	2	3	4	5	6	7	8	9
Pisces	77	93	88	100	100	85	73	89	100
Dorosoma sp.	69	71	63	90	100	54	49	79	100
Dorosoma petenense	8	14	25	80	33	15	20	21	100
Dorosoma cepedianum	0	0	0	0	0	0	2	0	0
Unidentified Dorosoma	69	57	50	70	100	54	41	76	100
Cyprinidae	0	7	0	0	0	0	2	3	0
Other fish	0	14	0	0	0	0	0	0	0
Unidentified fish	15	7	38	10	0	31	22	8	0
Insecta	92	86	88	70	33	38	41	24	0
Diptera	92	86	88	70	33	31	37	24	0
Chironomidae	92	79	88	70	33	31	34	24	0
Chironomidae larvae	92	64	63	40	0	8	27	13	0
Chironomidae pupae	62	36	50	40	33	31	29	13	0
Chaoborus sp.	8	14	13	0	0	0	0	0	0
Adult Diptera	0	7	0	10	0	0	2	0	0
Ephemeroptera	23	43	38	0	0	8	5	0	0
Ephemeridae	0	7	25	0	0	8	2	0	0
Other Ephemeroptera	23	36	25	0	0	0	2	0	0
Trichoptera	0	0	0	0	0	8	0	0	0
Corixidae	0	0	0	0	0	0	0	0	0
Other insects	0	0	13	0	0	0	2	0	0
Unidentified insects	0	0	0	0	0	0	0	0	0
Crustacea	62	71	25	20	0	0	2	0	0
Copepoda[2]	0	0	0	0	0	0	0	0	0
Argulus sp.	54	71	25	20	0	0	2	0	0
Cladocera[3]	8	0	0	0	0	0	0	0	0
Leptodora sp.	8	0	0	0	0	0	0	0	0
Other invertebrates	8	0	0	0	0	0	0	0	0
Miscellaneous	0	0	25	10	0	0	7	3	0
No. of fish with food	13	14	8	10	3	13	41	38	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.

[2]Exclusive of Argulus sp.

[3]Exclusive of Leptodora sp.

APPENDIX M

TABLE 35. Percents of Total Numbers of Food Items in Stomachs of 1982 Year Class *Stizostedion* Hybrids, Grouped by Month

Food item categories	Month J	J	A	S	O	N	D	J	F	M	A	M
Pisces	80.0	89.5	47.4	100.0	100.0	100.0	100.0	100.0	100.0	97.7	100.0	100.0
Dorosoma sp.	20.0	84.2	42.1	92.0	97.6	100.0	90.9	100.0	33.3	72.7	87.7	85.7
Dorosoma petenense	0.0	47.4	10.5	8.0	6.4	7.7	18.2	0.0	0.0	2.3	0.0	14.3
Dorosoma cepedianum	0.0	0.0	0.0	24.0	6.4	0.0	0.0	0.0	0.0	36.4	8.8	0.0
Unidentified *Dorosoma*	20.0	36.8	31.6	60.0	84.8	92.3	72.7	100.0	33.3	34.1	78.9	71.4
Cyprinidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	14.3
Other fish	0.0	0.0	0.0	0.0	1.6	0.0	9.1	0.0	66.7	13.6	7.0	0.0
Unidentified fish	60.0	5.3	5.3	8.0	0.8	0.0	0.0	0.0	0.0	6.8	5.3	0.0
Insecta	20.0	10.5	52.6	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
Chironomidae	20.0	0.0	10.5	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
Chironomidae larvae	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chironomidae pupae	0.0	0.0	10.5	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
Ephemeridae	0.0	10.5	42.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
No. of fish with food	4	15	8	14	46	12	3	1	2	35	39	5
No. of food items	5	19	19	25	125	26	11	1	3	44	57	7

APPENDIX N

TABLE 36. Frequency of Occurrence (%) of Food Items in Stomachs of 1982 Year Class Stizostedion Hybrids That Contained Food, Grouped by Month

	Month											
Food item categories	J	J	A	S	O	N	D	J	F	M	A	M
Pisces	75	100	75	100	100	100	100	100	100	97	100	80
Dorosoma sp.	25	93	75	86	96	100	100	100	50	77	85	60
Dorosoma petenense	0	47	25	7	9	17	33	0	0	3	0	20
Dorosoma cepedianum	0	0	0	43	15	0	0	0	0	46	13	0
Unidentified Dorosoma	25	47	50	50	89	100	100	100	50	43	77	60
Cyprinidae	0	0	0	0	0	0	0	0	0	6	0	20
Other fish	0	0	0	0	4	0	33	0	50	17	10	0
Unidentified fish	50	7	13	14	2	0	0	0	0	9	8	0
Insecta	25	7	38	0	0	0	0	0	0	3	0	0
Chironomidae	25	0	13	0	0	0	0	0	0	3	0	0
Chironomidae larvae	25	0	0	0	0	0	0	0	0	0	0	0
Chironomidae pupae	0	0	13	0	0	0	0	0	0	3	0	0
Ephemeridae	0	7	25	0	0	0	0	0	0	0	0	0
No. of fish with food	4	15	8	14	46	12	3	1	2	35	39	5

APPENDIX O

TABLE 37. Percents of Total Numbers of Food Items in Stomachs of 1982 Year Class *Stizostedion* Hybrids, Grouped by Length Class

Food item categories	Length class[1] 1	2	3	4	5	6	7	8	9	10	11	12
Pisces		83.3		100.0	58.8	66.7	100.0	100.0	100.0	100.0	98.7	100.0
Dorosoma sp.		33.3		83.3	52.9	66.7	75.0	90.0	89.8	91.9	91.0	0.0
Dorosoma petenense		16.7		33.3	29.4	20.0	0.0	13.3	12.2	2.9	2.6	0.0
Dorosoma cepedianum		0.0		0.0	0.0	0.0	0.0	10.0	8.2	13.2	12.8	0.0
Unidentified *Dorosoma*		16.7		50.0	23.5	46.7	75.0	66.7	69.4	75.7	75.6	0.0
Cyprinidae		0.0		0.0	0.0	0.0	0.0	3.3	2.0	0.7	0.0	0.0
Other fish		0.0		0.0	0.0	0.0	0.0	3.3	6.1	5.1	3.8	100.0
Unidentified fish		50.0		16.7	5.9	0.0	25.0	3.3	2.0	2.2	3.8	0.0
Insecta		16.7		0.0	41.2	33.3	0.0	0.0	0.0	0.0	1.3	0.0
Chironomidae		16.7		0.0	11.8	0.0	0.0	0.0	0.0	0.0	1.3	0.0
Chironomidae larvae		16.7		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chironomidae pupae		0.0		0.0	11.8	0.0	0.0	0.0	0.0	0.0	1.3	0.0
Ephemeridae		0.0		0.0	29.4	33.3	0.0	0.0	0.0	0.0	0.0	0.0
No. of fish with food	0	5	0	6	8	9	2	13	20	69	51	1
No. of food items		6		6	17	15	4	30	49	136	78	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; 11 = 30.1 to 32.5 cm; 12 = 32.6 to 35.0 cm.

APPENDIX P

TABLE 38. Frequency of Occurrence (%) of Food Items in Stomachs of 1982 Year Class *Stizostedion* Hybrids That Contained Food, Grouped by Length Class

Food item categories	Length class[1] 1	2	3	4	5	6	7	8	9	10	11	12
Pisces		80		100	88	89	100	100	100	100	96	100
Dorosoma sp.		40		83	88	89	50	92	85	88	86	0
Dorosoma petenense		20		33	38	33	0	23	15	4	2	0
Dorosoma cepedianum		0		0	0	0	0	23	20	25	20	0
Unidentified *Dorosoma*		20		50	50	56	50	62	65	78	71	0
Cyprinidae		0		0	0	0	0	8	5	1	0	0
Other fish		0		0	0	0	0	8	10	10	6	100
Unidentified fish		40		17	13	0	50	8	5	4	6	0
Insecta		20		0	25	22	0	0	0	0	2	0
Chironomidae		20		0	13	0	0	0	0	0	2	0
Chironomidae larvae		20		0	0	0	0	0	0	0	0	0
Chironomidae pupae		0		0	13	0	0	0	0	0	2	0
Ephemeridae		0		0	13	22	0	0	0	0	0	0
No. of fish with food	0	5	0	6	8	9	2	13	20	69	51	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; 11 = 30.1 to 32.5 cm; 12 = 32.6 to 35.0 cm.

APPENDIX Q

TABLE 39. Percents of Total Numbers of Food Items in Stomachs of 1982 Year Class *Stizostedion* Hybrids, Grouped by Reservoir Section

	Section[1]			
Food item categories	1	2	3	4
Pisces	77.1	98.7	100.0	100.0
Dorosoma sp.	62.5	88.9	98.4	50.0
Dorosoma petenense	22.9	2.7	15.6	0.0
Dorosoma cepedianum	2.1	14.6	1.6	0.0
Unidentified *Dorosoma*	37.5	71.7	81.3	50.0
Cyprinidae	2.1	0.9	0.0	0.0
Other fish	0.0	5.3	1.6	50.0
Unidentified fish	12.5	3.5	0.0	0.0
Insecta	22.9	1.3	0.0	0.0
Chironomidae	2.1	1.3	0.0	0.0
Chironomidae larvae	2.1	0.0	0.0	0.0
Chironomidae pupae	0.0	1.3	0.0	0.0
Ephemeridae	20.8	0.0	0.0	0.0
No. of fish with food	33	124	24	3
No. of food items	48	226	64	4

[1]Reservoir sections are as follows: 1 = Quarryville; 2 = Fall Creek; 3 = County Line; 4 = Oak Grove.

APPENDIX R

TABLE 40. Frequency of Occurrence (%) of Food Items in Stomachs of 1982 Year Class *Stizostedion* Hybrids That Contained Food, Grouped by Reservoir Section

Food item categories	Section[1] 1	2	3	4
Pisces	88	99	100	100
Dorosoma sp.	70	87	100	67
Dorosoma petenense	27	3	25	0
Dorosoma cepedianum	3	26	4	0
Unidentified *Dorosoma*	42	70	92	67
Cyprinidae	3	2	0	0
Other fish	0	10	4	33
Unidentified fish	15	6	0	0
Insecta	12	2	0	0
Chironomidae	3	2	0	0
Chironomidae larvae	3	0	0	0
Chironomidae pupae	0	2	0	0
Ephemeridae	9	0	0	0
No. of fish with food	33	124	24	3

[1]Reservoir sections are as follows: 1 = Quarryville; 2 = Fall Creek; 3 = County Line; 4 = Oak Grove.

APPENDIX S

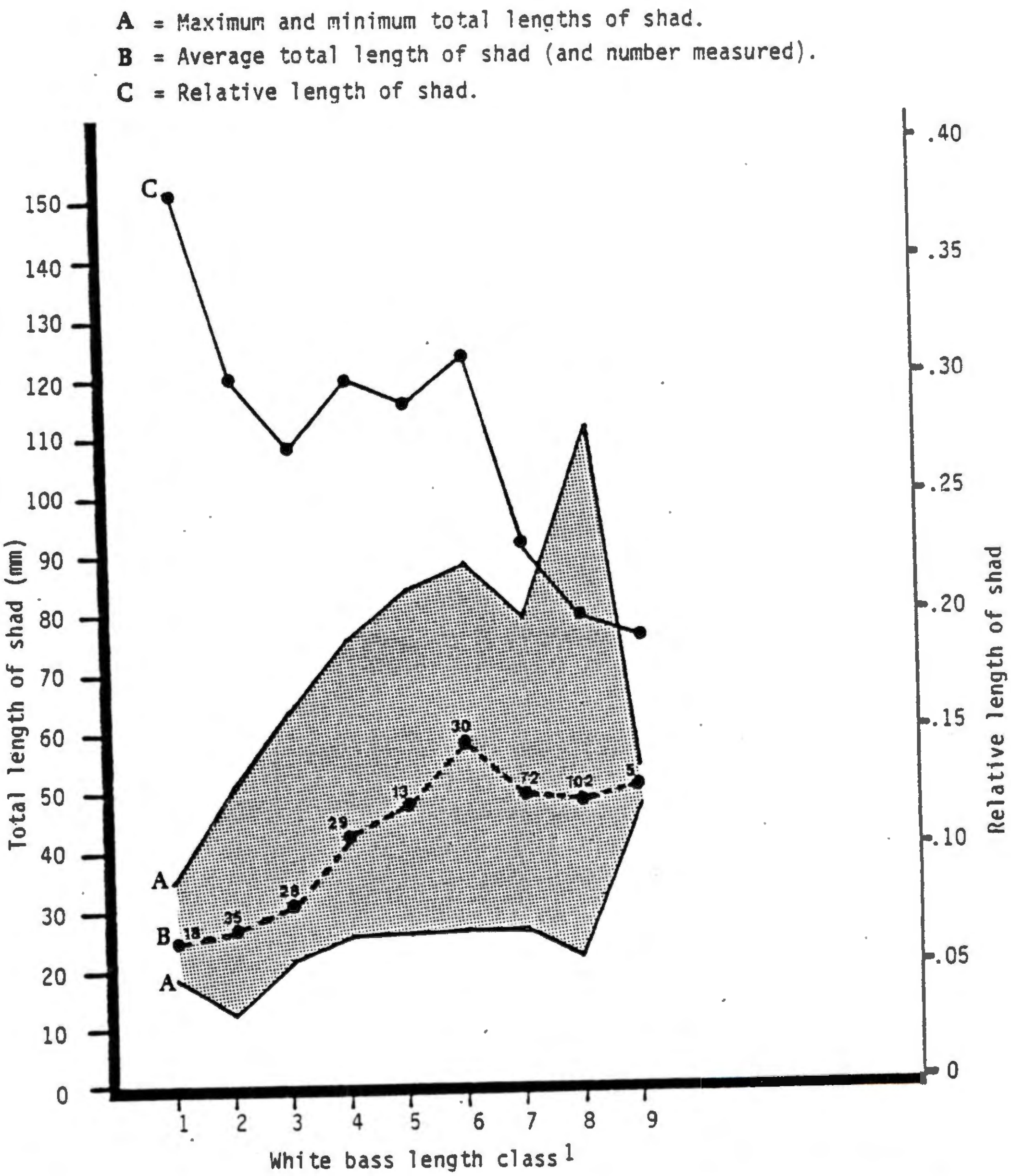

FIGURE 7. Prey-predator length relationship for young white bass and shad.

[1]Length class (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.

APPENDIX T

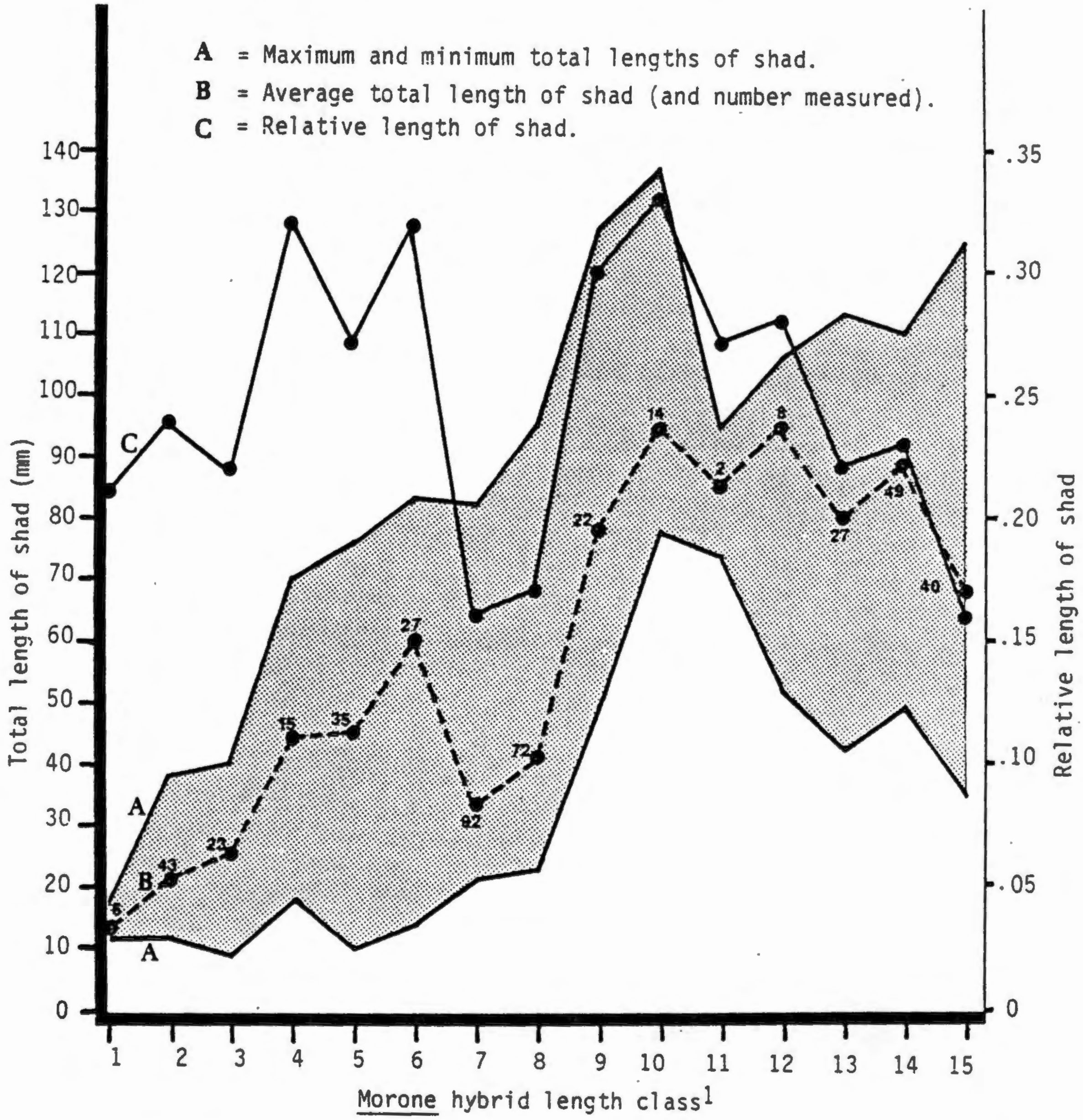

FIGURE 8. Prey-predator length relationship for young Morone hybrids and shad.

[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; 11 = 30.1 to 32.5 cm; 12 = 32.6 to 35.0 cm; 13 = 35.1 to 37.5 cm; 14 = 37.6 to 40.0 cm; 15 = 40.1 to 42.5 cm;

APPENDIX U

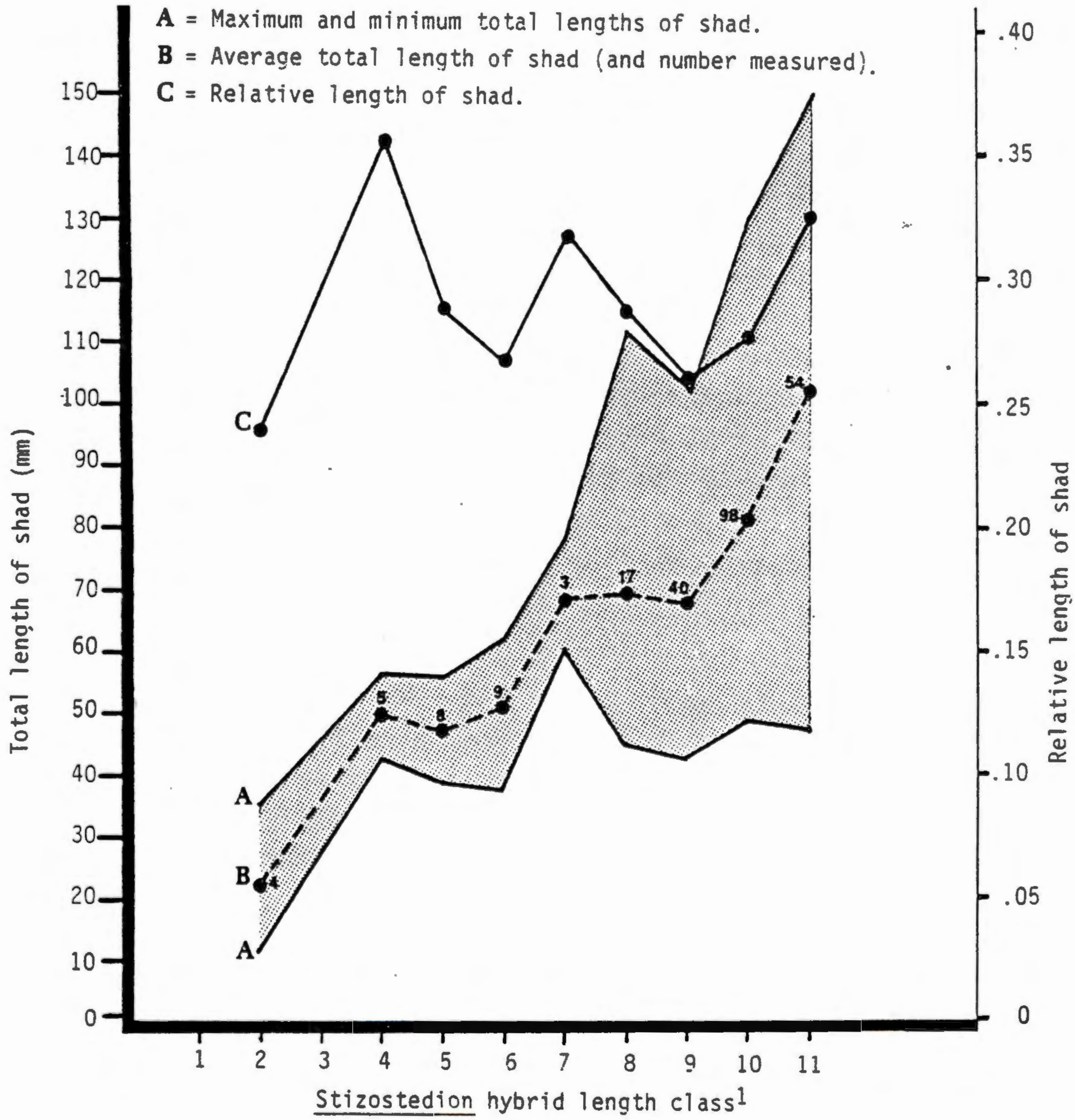

FIGURE 9. Prey-predator length relationship for young Stizostedion hybrids and shad.

[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; 11 = 30.1 to 32.5 cm.

VITA

Michael Humphreys was born in New Milford, Connecticut on September 7, 1957. He attended elementary school in Sherman, Connecticut and graduated from New Milford High School in June 1975. In June 1980, he received his Bachelor of Science Degree in Biology from Hobart College, Geneva, New York. In the spring of 1981 he accepted a graduate research assistantship with the Department of Forestry, Wildlife, and Fisheries at The University of Tennessee, Knoxville. The Master's degree was awarded in December 1983.