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I am submitting herewith a thesis written by Arnold G. Woodward entitled "Growth and food habits of introduced stizostedion hybrids in Cherokee Reservoir, Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

J. Larry Wilson, Major Professor

We have read this thesis and recommend its acceptance:

Richard Strange, David A. Entier, Douglas Peterson

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

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Date June 1987

GROWTH AND FOOD HABITS OF INTRODUCED <u>STIZOSTEDION</u> HYBRIDS IN CHEROKEE RESERVOIR, TENNESSEE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Arnold G. Woodward

June 1987

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ABSTRACT

Growth and food habits of young-of-year and yearling Stizostedion hybrids stocked in Cherokee Reservoir, Tennessee, were examined from July 1983 to December 1985. Growth was excellent throughout the study and hybrids averaged 296 and 442 mm at ages 1 and 2, respectively. Both young-of-year and yearling hybrids attained 90% of their annual growth by December. Condition factors (K) of hybrids increased with age (0.62-1.17), while relative weights (W_r) were within the acceptable range (95-105) for all but three months of the first two years following introduction. Both condition indices decreased sharply during the spring and summer. Reduced abundance of appropriate-sized shad following winter and sub-optimal temperature/dissolved oxygen characteristics may negatively affect hybrids during this period.

Hybrids began consuming fish immediately following stocking, with shad being the most important food item for both young-of-year and yearlings during each year of the study. Insects, primarily chironomids and Hexagenia nymphs, were consumed by hybrids during the spring and summer, but were a minor component of the total hybrid diet. Non-shad fishes were frequently collected in forage samples, but occurred rarely in the diets of hybrids. Results from prey-predator length relationships suggested that there was a decrease in the abundance of appropriate-sized shad during the late spring.

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Since the 1960's, the use of introduced sportfish hybrids has become a widely accepted technique in modern fisheries management. The success of the striped bass/white bass hybrid (*Morone saxatilis* x *M. chrysops*), the tiger muskie (*Esox lucius* x *E. masquinongy*), and numerous salmonid and centrachid hybrids has been instrumental in the continued research and utilization of sportfish hybrids in the United States and Canada. The success of these hybrids is attributed to heterosis, or "hybrid vigor", which is characterized by rapid growth, improved survival, aggressiveness, and improved tolerance of less than ideal environmental conditions. These traits make the hybrid suitable for situations where an "unoccupied" niche exists due to an abundance of underutilized prey, poor environmental conditions, and/or extirpation of native species.

As our aquatic resources are subject to continued environmental degradation and increased exploitation the potential for hybrids becomes evident. Most hybrids can be efficiently propagated when facilities and broodstock are available and often require equal or less time to produce than do parental types. These factors, in addition to increased survival when introduced, make the hybrid a cost-effective addition to many fishery management programs.

Both walleye (*Stizostedion vitreum*) and sauger (*S. canadense*) are native to Tennessee. In the mid-1900's, construction of dams created numerous reservoirs on the Tennessee and Cumberland river drainages which expanded the available habitat for these species. Sauger were found in the Holston River prior to closure of Cherokee Reservoir in 1941 (Smith and Miller 1942). Creel surveys, tagging studies, and cove rotenone data suggested that sauger developed a reproducing population in the reservoir following impoundment (Manges 1950, Netsch and Turner 1964). Information from Tennessee Game and Fish Commission fish rescue operations indicated that the abundance of sauger decreased dramatically from 1951 to 1963 with the last documented occurrence of sauger in a 1974 Tennessee Valley Authority (TVA) rotenone sample.

Walleye were not found in the Holston River prior to impoundment of Cherokee Reservoir; however, fingerling and sub-adult introductions from 1941 to 1957 established a limited population (Heuer and Tomljanovich 1980). Walleye were collected in the first TVA rotenone study on Cherokee Reservoir in 1949 and reported in the creel surveys from 1951 to 1954 (Netsch and Turner 1964). Occurrence of walleye in fish rescue operations indicated a cyclic abundance usually related to the previous year's fingerling introduction. Walleye demonstrated a precipitous decline after 1954 and were last documented in a 1963 TVA cove rotenone sample. Neither walleye nor sauger have appeared in creel surveys since 1972 (TWRA unpublished data).

The marked decline in abundance of sauger and walleye in Cherokee Reservoir coincided with the completion of the Fort Patrick Henry Dam on the Holston River in 1953, closure of the John Sevier Detention Dam at the headwaters of the reservoir in 1954, and increased degradation of water quality in the upper Holston River. The detention dam was constructed to provide adequate cooling water for the John Sevier Steam-Electric Plant and effectively blocked movement of fish out of the reservoir and into the upper Holston River. Following construction of the dam, only 16 kilometers of the Holston River at the headwaters of Cherokee Reservoir were suitable for sauger and/or walleye spawning, given normal reservoir level and flow conditions.

During 1977, TVA initiated a study to determine if sauger reproduction was possible in Cherokee Reservoir and the Holston River above John Sevier Detention Dam. A total of 975 sexually mature sauger were captured on spawning migrations below several mainstream Tennessee River reservoirs, marked with fin clips, and released in Cherokee Reservoir and the John Sevier Detention Reservoir. Only two of these fish were recovered and no reproduction was documented either above or below the detention dam. As a result of this study, a hypothesis describing the extirpation of walleye and sauger was proposed. Edrington et al. (1979) suggested that the cumulative effects of loss of spawning habitat, temperature and water level fluctuations resulting from operation of the John Sevier Steam-Electric Plant and other upstream impoundments, and inorganic and organic pollution from the upper Holston River resulted in poor reproductive success of sauger and walleye and eventual extirpation of both species. These investigators also suggested that introduction of adult fish would not re-establish the Stizostedion fishery in Cherokee Reservoir unless environmental conditions, both biotic and abiotic, approximated those prior to 1954. Recent investigations by the Tennessee Valley Authority (TVA 1986) have suggested that thermal releases from John Sevier Steam-Electric Plant would not interfere with reproductive success of sauger and, moreover, that water level fluctuations and turbidity have a more significant negative impact on spawning success.

In the mid-1970's, fisheries biologists with the Ohio Department of Natural Resources began introductions of the saugeye, a hybrid of the female walleye and male sauger, in selected reservoirs. Initial results indicated that this hybrid exhibited better growth and survival than introduced walleye in small eutrophic impoundments (Smith and Carline 1983). In 1982, the Tennessee Wildlife Resources Agency (TWRA) and the Tennessee Valley Authority began a cooperative effort to introduce Stizostedion hybrids in Cherokee Reservoir, Tennessee. These introductions marked the first use of this hybrid in Tennessee and in a large southeastern reservoir. The introduction of these hybrids in Cherokee Reservoir was designed as partial mitigation for the loss of the Stizostedion fishery and as an evaluation of the feasibility of hybrid introductions for maintaining a percid fishery.

The purpose of this study was to evaluate Stizostedion hybrid introductions in Cherokee Reservoir to provide pertinent information for future management of the hybrid in this and other Tennessee reservoirs. Specific objectives included (1) an assessment of growth of young-of-year and yearling hybrids, (2) comparisons of growth with hybrids and parental types in other reservoirs, (3) analyses of food habits of young-of-year and yearling hybrids, (4) comparisons of food habits with other reservoir predators, and (5) collection of other life history and habitat information that would be useful for management of this hybrid.

Primary funding for this research was provided by the University of Tennessee Agricultural Experiment Station. Additional support was made available from Dingell-Johnson Project F-61 administered through the United States Fish and Wildlife Service.

CHAPTER II

LITERATURE REVIEW

There exists a considerable volume of literature concerning the walleye and, to a lesser degree, the sauger. Much of this work is the result of investigations in the northern United States and Canada, while published works concerning southern populations of walleye and sauger are more limited in number.

The construction of several reservoirs in the Tennessee Valley region during the 1930's and 40's stimulated interest in both walleye and sauger as evidenced by several studies published during this period (Eschmeyer 1940; Dendy 1945, 1947; Eschmeyer and Haslbauer 1947; Stroud 1949). These investigators found that southern stocks of walleye and sauger grew faster and had shorter lifespans than their northern counterparts, utilized abundant shad (*Dorosoma* spp.) for food, and were limited by temperature and dissolved oxygen during certain times of the year. Studies by Hassler (1955, 1958), Muench (1966), Libbey (1969), and Scott (1976) supported these earlier findings while providing additional information on growth and fecundity of walleye and sauger in selected Tennessee reservoirs.

Growth of young-of-year walleye and sauger has been studied in detail by numerous investigators. Raney and Lachner (1942) and Forney (1966) investigated first year growth of walleye in Oneida Lake, New York, while Smith and Pycha (1960) found that spawning time influenced first year growth of walleye in The Red Lakes, Minnesota. Spykermann

(1974) reported that total length of walleye larvae increased threefold from May 13 to June 8 in Clear Lake, Iowa. Serns (1982) investigated the influence of various factors on growth of young-of-year walleye in Escanaba Lake, Wisconsin, from 1958 to 1980 and found a postitive relationship between growth and May-June water temperatures. Hassler (1955) found that both temperature and rainfall affected the first year growth of sauger in Norris Reservoir.

Food habits and feeding ecology of larvae, juvenile, and adult walleye and sauger have been examined by several investigators. Dendy (1947) studied food habits of walleye and sauger in Norris Reservoir,Tennessee, and reported shad to be the preferred food item for both sub-adults and adults. Smith and Pycha (1960), Houde (1967), Bulkey et al. (1976), and Mathias and Li (1982) found copepods and cladocerans to be the most important food items for larval and juvenile walleye less than 50 mm total length, while individuals in excess of this length preferred fish. Priegel (1963) compared food habits of walleye and sauger in Lake Winnebago, Wisconsin, and found that both species preferred fish, but would utilize insects, primarily chironomids, when fish were scarce. Parsons (1971) investigated food habits of the 1959 year class of walleye in western Lake Erie and found that prey length influenced selection and suggested that the abundance of desirable size prey may have a significant impact on year class strength. Range (1973) found that walleye growth increased following the introduction of threadfin shad in Dale Hollow Reservoir, Tennessee, while McGee et al. (1978) observed that sauger utilized cold-stressed threadfin shad in Watts Bar Reservoir, Tennessee. Paxton and Stevenson (1978) investigated food habits of young-of-year and yearling walleye in selected upground reservoirs in Ohio. These investigators found a high incidence of zooplankton and insects in the diet and related poor growth to low availability of forage fish. Wahl and Nielsen (1985) investigated the feeding ecology of sauger in the Ohio River and found that gizzard shad was the preferred food item, with emerald shiners of secondary importance.

Recent studies have emphasized the relationship of Stizostedion populations and their environment. Koenst and Smith (1976) studied the thermal requirements of the early life history of walleye and sauger while Hokanson (1977) discussed the adaptive behavior of walleye and sauger to seasonal temperature cycles. Kerr and Ryder (1977, 1978) proposed an application of niche theory to percid community structure and suggested that adult walleye occupy a species niche defined by the periodicity of feeding behavior. Leach et al. (1977) suggested that percids respond favorably to the initial stages of eutrophication; however, at some point in the trophic continuum, the reponse becomes negative. Momot et al. (1977) found that the temperature-oxygen regime resulting from eutrophication severely limited the walleye population of Hoover Reservoir, Ohio, by adversely affecting reproductive success, prey-predator relationships, and growth of adult fish. Hackney and Holbrook (1978) presented a synoptic review of walleye and sauger distribution in the southeastern United States. They suggested that abiotic factors may account for the large variability in year class strength of sauger in mainstream reservoirs, while walleye distribution appears to be limited by turbidity. Wrenn and Forsythe (1978) subjected juvenile walleye to varying temperature regimes in experimental channels and found a greater level of thermal tolerance than previously suggested. Schiavone (1981) detailed the decline of the walleye fishery in Black Lake, New York, and suggested the introduction of black crappie as a contributing factor.

Compared to the abundance of literature available concerning walleye and sauger, there is a scarcity of published work emphasizing the hybrid of the two species. Stroud (1948) first documented hybrids in Norris Reservoir, Tennessee, in 1943 and found growth to be intermediate to that of the parents, while Nelson and Walburg (1977) and Trautman (1981) made reference to the rare occurrence of these hybrids in natural situations. Nelson et al.(1965) and Nelson (1968) described artificial propagation techniques and larval characteristics, while Clayton et al. (1973) detailed the use of mitochondrial isozymes to differentiate hybrids from their parental types. Lynch et al. (1982) evaluated hybrids stocked in ponds and found these hybrids were exclusively piscivorous. Johnson (1981) investigated growth, food habits, survival, and habitat preference of hybrids in Pleasant Hill Reservoir, Ohio, while Humphreys (1984) examined growth and food habits of young-of-year hybrids in Cherokee Reservoir, Tennessee. Both investigators reported rapid first year growth and a predominance of shad in the diet. Hearn (1986) reported that hybrids were capable of producing viable F_2 offspring. Woodward et al. (1986) found growth of Cherokee Reservoir hybrids to be favorable when compared to that of its parental types in selected Tennessee reservoirs.

CHAPTER III

DESCRIPTION OF STUDY AREA

Cherokee Reservoir is a Tennessee Valley Authority (TVA) multipurpose impoundment located on the main stem of the Holston River in eastern Tennessee. The reservoir was impounded in 1941 following the completion of the Cherokee Dam at Holston River Mile (HRM) 52.3 and extends upstream to the John Sevier Detention Dam at HRM 106.3 during full pool. The reservoir is operated by TVA for flood control, hydroelectric power generation, and recreation.

The reservoir has a surface area of 12,222 hectares, a maximum depth of 46 m, and 745 km of shoreline at full pool (328 m above mean sea level). Reservoir level fluctuates greatly between summer and winter with normal summer elevations of 321 to 327 m and average winter elevations of 311 to 318 m (Waddle et al. 1980). Reservoir length varies from 87 km at summer pool to 48 km during winter when the upper reservoir becomes shallow and riverine.

The upper Holston River above Cherokee Reservoir drains an area of approximately 8,879 km^2 in northeastern Tennessee and southwestern Virginia. In addition, several smaller streams drain the surrounding ridges and flow directly into the reservoir. Geology of the drainage basin is characterized as predominantly limestone, with some shale and sandstone present. The watershed area is approximately 50% forest, 26% pasture, 12% cropland, and 12% other uses (Waddle et al. 1980).

The upper Holston River is characterized by large amounts of industrial, municipal, and domestic effluents which combined with seasonal contributions of decaying aquatic macrophytes create eutrophic conditions in Cherokee Reservoir (Young et al. 1983). Remote sensing (LANDSAT) techniques support observations that these conditions are especially evident in the upper areas of the reservoir (Schaich 1979, Iwanski et al. 1980).

Cherokee Reservoir has a diversity of physical features with sand and clay beaches, shallow mud flats, sheer rocky cliffs, and gravel shoals. The upper area of the reservoir is riverine and surrounded by steep ridges, while the forebay area is deep and broad with many islands and coves.

The reservoir begins to stratify in early spring and hypolimnetic anoxia is commonplace by summer. Epilimnetic temperatures remain above 25 C until early fall. Bottom discharge from the Cherokee Dam results in little thermal gradient from surface to bottom by late summer when dissolved oxygen concentrations are extremely low at depths of 5 to 10 m. These conditions have been suggested as a limiting factor of the striped bass population (Coutant 1978). After fall turnover and throughout the winter, the reservoir is generally isothermal with acceptable dissolved oxygen levels (>5 mg/l). Surface temperatures range from 4 C in the winter to 32 C during late summer. In extremely cold winters there is considerable ice cover in the lower areas of the reservoir. Thermal discharges from the John Sevier Steam-Electric Plant at the headwaters of the reservoir often result in above normal surface temperatures in the upper areas of the reservoir.

CHAPTER IV

METHODS

Collection Methods

During the period from 1982 to 1985, the Tennessee Wildlife Resources Agency (TWRA) introduced 410,000 fry and 365,000 fingerling *Stizostedion* hybrids (hereafter referred to as hybrids) into Cherokee Reservoir, Tennessee (Table 1). Both fry (10 days post-hatch) and fingerlings (25-50 mm total length) were produced at TWRA's Eagle Bend Hatchery using broodstock obtained from local reservoirs. All introductions were made in the upper area of the reservoir where pre-stock samples indicated an abundance of forage (Figure 1). The first introduction of these hybrids in 1982 consisted of approximately 31,500 fingerlings produced from the cross of the male sauger and female walleye stocked in the Quarryville area and 17,000 fingerlings produced from the reciprocal cross stocked in the County Line area. These two crosses could not be reliably distinguished on the basis of meristics (Bruce Saul, personal communication); therefore, no differences in growth or survival of the two crosses could be detected. The majority of hybrids stocked in 1983 and all hybrids stocked in years 1984 and 1985 were produced from the female walleye x male sauger cross. This pairing was preferred since the greater number of eggs found in larger walleye females increased hybrid production efficiency (Mike Smith, personal communication).

Table 1. *Stizostedion* hybrids stocked in Cherokee Reservoir, Tennessee, 1982-1985.

Year	Location	Fry	Fingerling
1982	HRM 75.0		17,100
	HRM 91.3		31,500
	Total		48,600
1983	HRM 71.0	30,000	
	HRM 91.3		101,400
	Total	30,000	101,400
1984	HRM 91.3	230,000	93,900
	HRM 101.3	150,000	
	Total	380,000	93,900
1985	HRM 81.5		60,400
	HRM 96.5		23,100
	Total		83,500
	Total	410,000	327,400
	Grand Total	737,400	

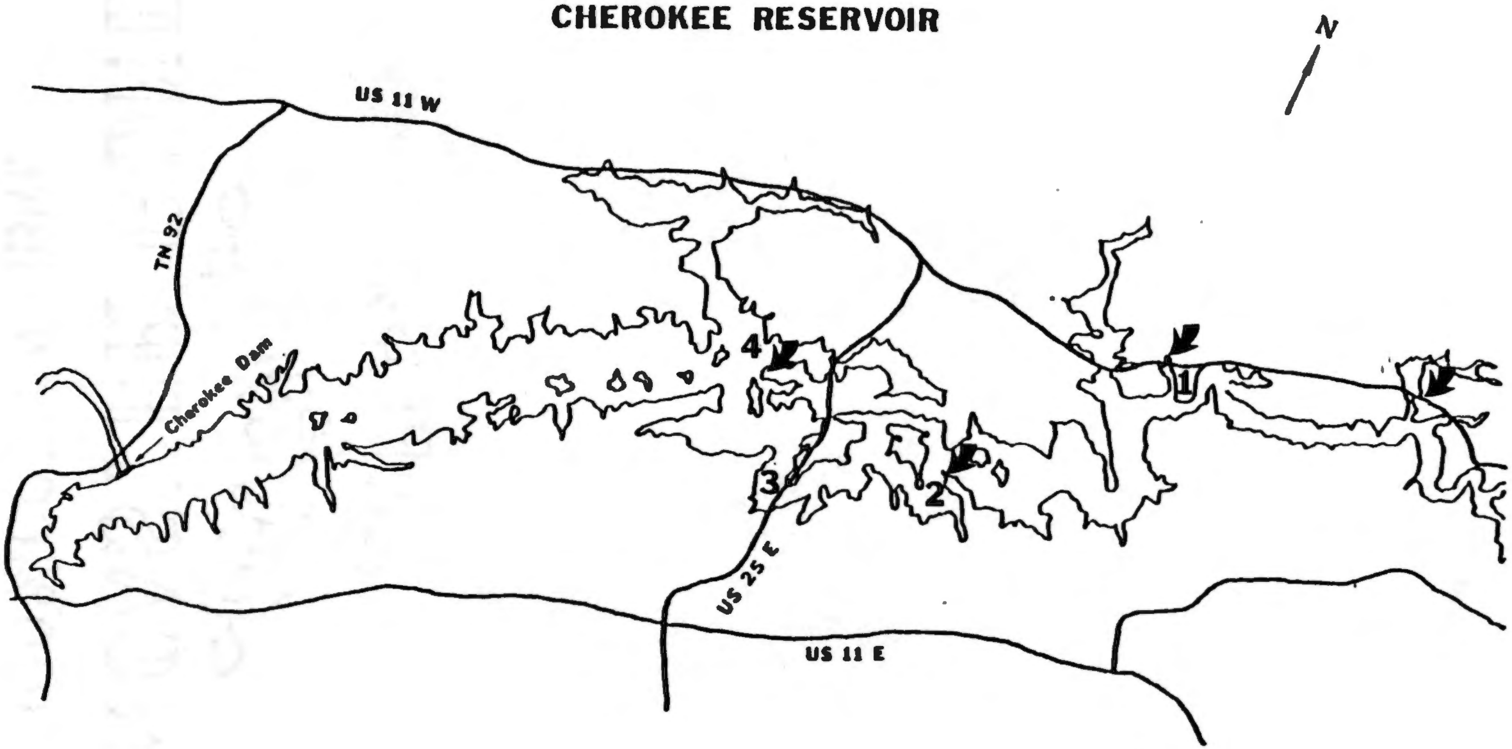

Figure 1. Stocking (arrow symbol) and sampling areas (1-4) for <u>Stizostedion</u> hybrids in Cherokee Reservoir, Tennessee (1-Quarryville; 2-Fall Creek; 3-County Line; 4-Oak Grove).

Bi-weekly collection trips were made from June to October in 1983 and 1984. Monthly collections were made from November to May of those years and from June to December in 1985. All sampling from June 1983 to May 1985 was associated with ongoing striped bass studies, while sampling from June to December 1985 was specifically for hybrids. For sampling purposes, the upper half of the reservoir was separated into four areas which centered around public use boat ramps. These were as follows: Quarryville (Section 1, HRM 91.5); Fall Creek (Section 2, HRM 80.7); County Line (Section 3, HRM 74.7),and Oak Grove (Section 4, HRM 70.3) (Figure 1). During the June 1983 to May 1985 sampling period, efforts were oriented toward capture of striped bass and the selection of monthly sample sites was made accordingly. However, during the June to December 1985 sampling period, all efforts were centered around the Fall Creek area where the majority of the 1985 cohort of hybrids was introduced. During the entire study period all collections were made between sunset and sunrise.

Several methods were used to collect young-of-year and yearling hybrids following introduction. Hybrids were collected by shoreline seining using a 1.8 x 15.7 m straight seine with 9.5 mm mesh. Electrofishing utilizing a boat-mounted, boom type 230-V generating unit (AC) was also used to capture hybrids throughout the summer and into the early fall. Gill netting using sinking monofilament nets 45.7 m long x 1.8 m deep with mesh sizes (bar) of 12.7, 19.1, 25.4, and 31.8 mm was the most widely used technique for capturing hybrids during this study. Nets were set perpendicular to the shore, marked with identifying buoys, and left for periods of time ranging from 2-3 hours during summer and early fall to overnight sets in the winter and early spring. A variety of habitats were sampled using all methods varying from shallow mud flats to steep rocky dropoffs in excess of 25 m deep.

Timed electrofishing runs (30 minutes) and standard quarter hauls utilizing a 1.2 x 4.6 m straight seine with 3.2 mm mesh were used to sample forage fishes in the areas where hybrids were collected. Fish less than 100 mm (TL) were considered to be available forage. All fish samples were fixed in 10% formalin in the field and all hybrids greater than 150 mm (TL) had their gut cavities opened prior to immersion in formalin. After returning to the laboratory, all fish were soaked in freshwater for a period of 24 to 48 hours and transferred to 40% isopropanol until final analysis.

TVA fishery biologists conducted population studies in Cherokee Reservoir during each year of this study. Four coves averaging 0.58 hectares each were sampled with rotenone during the late summer in selected areas of the reservoir. Two of these coves were located in the upper area of the reservoir at HRM 81.5 and HRM 89.3. Some data from these collections were used to augment the forage sample data from this study.

Growth Analysis

Growth, condition factor, and relative weight of young-of-year and yearling hybrids were examined for each year of the study. All hybrids collected up to and during May were considered young-of-year, while individuals collected after May were classed as yearlings. Scale samples were removed from all hybrids to verify age. Fish samples were rehydrated in freshwater for a minimum of 24 hours prior to analysis. All hybrids were used in samples with less than 30 individuals, while a random sample of 30 individuals was analyzed for months when collections exceeded this number. Total length to the nearest millimeter and weight to the nearest gram were recorded for each hybrid.

Food Habits Analysis

Food habits were determined from examination of stomach contents of hybrids collected during each year of the study. Each fish was weighed to 0.1 gram and measured to the nearest millimeter (TL) prior to removal of the stomach. Stomachs were severed at the esophagus and the pylorus, removed intact, blotted dry, and weighed to the nearest 0.01 gram. Each stomach was split lengthwise and all contents scraped and washed into a 95 x 95 mm gridded counting tray. The empty stomach was then blotted dry and again weighed. The wet weight of the stomach contents was determined by subtraction of empty stomach weight from the full weight. All contents were examined under a 40X dissecting microscope and identified to the lowest practical taxon. A total of 20 hybrids were used for food habits analysis in each month. In months where more than this number were collected, a random sample of fish (n=20) was selected for analysis.

Total lengths of prey fish found in the stomachs of hybrids were determined by: 1) direct measurement of fish when in the early stages of digestion, or 2) estimates derived from a regression equation generated from measurements of intact fish. Since shad were the predominant item in the diet, this calculation was restricted to these species.

Measurements of the total lengths were regressed on the length of the vertebral column measured from the posterior margin of the centrum of the basioccipital bone to the anterior margin of the hypural plate for 100 gizzard and threadfin shad ranging from 55 to 160 mm (TL). The regression equation is as follows (H.G. Mealing, unpublished data):

$$TL = 5.984 + 1.457\ (VL)$$

where: TL = total length (mm)

VL = vertebral length (mm), and

$r^2 = 0.9245$.

Estimates of total lengths were obtained by entering the vertebral length into the regression equation. Sizes of shad in the stomachs of hybrids were used to develop prey-predator length relationships (Popova 1967).

Forage Analysis

Forage fishes collected by electrofishing and seining were sorted by species, counted, and maximum and minimum lengths recorded. All fish were stored in 40% isopropanol for future reference.

Data Analysis

Growth and food habits data were analyzed using Lotus 1-2-3 (Lotus Development Corporation, 1982) and PC-SAS (SAS Institute, 1986) software programs on a personal computer. Additional analyses utilized the Statistical Analysis System (SAS) through the University of Tennessee Computing Center. To provide descriptive information about the hybrid diets, both frequency of occurrence and percent composition by number were used. Frequency of occurrence was defined as the the number of fish in which one or more food items was found expressed as a percentage of fish stomachs with contents, while percent composition by number was based on the number of food items in each category expressed as a percentage of the total number of food items. Hybrids were grouped by month, length class, year class, and location prior to analysis of food habits.

A coefficient of condition (K) was computed using the Fulton formula (Bagenal and Tesch 1978):

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

where: W = weight in grams, and

L = total length in millimeters.

Mean condition factor was determined for hybrids on a monthly basis. Relative weight (W_r) (Wege and Anderson 1978) was calculated for hybrids utilizing a standard weight table developed by TVA (Ed Scott, unpublished data) for walleye in TVA tributary reservoirs and the following formula:

$$W_r = \frac{W \times (100)}{W_s}$$

where: W = weight of the fish in grams, and

W_s = standard weight.

This analysis was also used for assessing condition of these hybrids in Cherokee Reservoir. Length-weight relationships were determined for hybrids using the following formula (Ricker 1975):

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

where: W = weight in grams,

L = total length in millimeters,

a = y-intercept,

and b = slope.

Relationships were calculated for young-of-year (TL $\leq$ 300 mm), for yearlings (TL 301-445 mm), and both groups combined. Additional data from older hybrids collected outside of this study were included to generate another length-weight relationship for fish ranging from 90 to 635 mm (TL).

Monthly and length-class prey-predator length relationships were determined for young-of-year and yearling hybrids. All measured and estimated total lengths of shad ingested by hybrids for each month or length class were averaged, then subsequently divided by the mean length of hybrids which contained shad in their stomach for the corresponding month or length class. The range of sizes of shad eaten by hybrids in each month was also determined and the maximum value was considered the maximum size prey available to the average size hybrid for that month or length class . The monthly maximum prey size was compared to the minimum size shad available in the forage samples for the corresponding month. Any overlap in these values was considered to be the range of sizes of shad available to average size hybrids in the area sampled at that point in time.

Statistical methods used in this study were Student's T-test and a one-way analysis of variance (ANOVA). The REGWQ multiple range test was used to test for significant differences among means following ANOVA analyses.

CHAPTER V

RESULTS AND DISCUSSION

Lake Conditions from June 1983 Through December 1985

Water levels in Cherokee Reservoir fluctuated considerably during the course of this study. Reservoir levels followed the normal regime during the summer, fall, and early winter of 1983; however, heavy rainfall during the early months of 1984, resulted in reservoir levels which ranged from 2 to 5 m above normal for all but the latter months of that year. This high water flooded shoreline vegetation during the spring and summer creating ideal nursery habitat for benthic invertebrates and juvenile fishes. Total surface area for the reservoir averaged 10,882 hectares or 108% of normal from April to September 1984. In contrast to 1984, extremely low winter and spring precipitation in early 1985 resulted in drought conditions throughout most of the southeastern United States. This reduced the inflow into Cherokee Reservoir causing water levels to vary from 3 to 7 m below normal for most of that year. Total reservoir surface area averaged 7,645 hectares or 75% of normal from April through September 1985, resulting in reservoir conditions similar to winter pool for the entire year.

The effects of these varying reservoir conditions were most evident in the upper reservoir. Due to the basin morphometry of this area, locations which were lacustrine during the spring and summer of 1983 and 1984, became almost entirely riverine during 1985. All *Stizostedion* hybrids were stocked in the upper area of the reservoir and remained there throughout the first two years following introduction. Therefore, each year class was subject to widely varying environmental conditions, particularly during the spring and summer of the first year.

Growth

A total of 665 young-of-year and yearlings were used to evaluate hybrid growth from June 1983 to December 1985. Mean total lengths of hybrids collected during each month of this period are presented in Table 2. Hybrid fry (10 days post-hatch) were stocked during April, while fingerlings (25-50 mm TL) were introduced into the reservoir during late May of each year of this study. Growth was rapid throughout the summer and fall with hybrids from each year class averaging 279, 293, and 244 mm by December of 1983, 1984, and 1985, respectively. Although these lengths varied considerably for each year, they were not statistically different ($P>0.05$). Growth was nominal during the winter and spring with 1983 and 1984 year class hybrids reaching lengths of 281 and 317 mm, respectively, at age 1. Both year classes attained approximately 90% of the annual growth by December of the first year.

Fall growth of 1985 year class hybrids appeared to be somewhat less than that of hybrids during the same period of previous years. The majority of young-of-year hybrids collected during 1983 and 1984 were sampled using gill nets, while approximately 90% of the young-of-year hybrids collected during 1985 were obtained by electrofishing. It was felt that this method allowed for more efficient sampling of the entire population, and not just the larger individuals which were susceptible to capture in gill nets. Limited dispersal, restricted reservoir area,

Table 2. Mean total length (mm) of Stizostedion hybrids from each year class, collected monthly during the first two years following introduction, (July 1983-December 1985).

Month	1982 Length	1982 N	1983 Length	1983 N	1984 Length	1984 N	1985 Length	1985 N
Jun			171	1	95	30		
Jul			117	5	138	3	132	19
Aug			159	8			144	18
Sep			192	23	197	2	204	10
Oct			239	30	284	12	191	19
Nov			265	26	269	19	222	22
Dec			279	30	293	22	244	6
Jan					298	18		
Feb			274	10	297	24		
Mar			290	30	302	13		
Apr			284	30	292	4		
May			281	17	317	12		
Jun			295	7	336	23		
Jul					341	23		
Aug	380	3	363	1	361	8		
Sep	383	6	356	2	389	10		
Oct	458	11	400	4	415	3		
Nov	441	4	361	2	416	12		
Dec			401	27	409	3		
Jan			395	11				
Feb			406	13				
Mar	412	1	403	16				
Apr			383	9				
May			442	3				

and specific effort for hybrids also contributed to increased capture efficiency during this period. The reduction in mean length during the latter months of 1985 was more likely an artifact of collection methodology and not an indication of restrictive environmental conditions. Hybrids collected by TVA fishery biologists the following winter and spring had total lengths similar to those of the previous year, suggesting that hybrid growth was not impaired during 1985.

Yearling hybrids exhibited excellent growth during the summer and fall of the second year following introduction, with the 1983 and 1984 cohorts averaging 401 and 409 mm, respectively, by December of the second year. This rapid growth accounted for 90% of the total annual growth of the 1983 year class, which reached 442 mm (n=3) at age 2. The similarities in summer and fall growth of 1983 and 1984 yearling hybrids suggested the more restricted reservoir environment during 1985 had minimal, if any, deleterious effects on growth of yearlings from the 1984 year class.

A growth curve was developed by calculating the weighted mean length of hybrids during each month of the first two years following introduction (Figure 2). Examination of hybrid scale samples indicated that annulus deposition occurred sometime during the month of May. The mean total length attained by this month during each of the two years following introduction was considered to be the length at age 1 and 2. These values were used to compare growth of Cherokee Reservoir hybrids to that of hybrids and parental types in other areas (Table 3). Most of the published information concerning hybrid growth, with the exception of Stroud's (1948) early work, is from northern areas where the growing

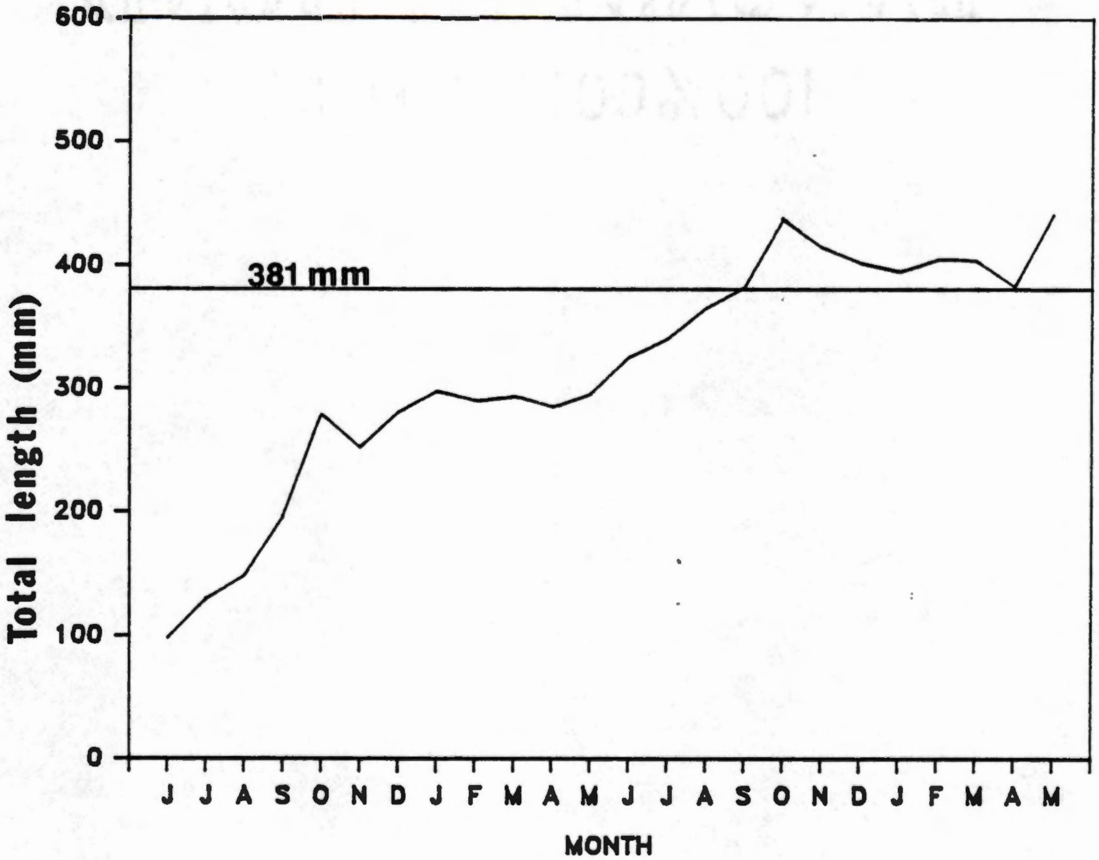

Figure 2. Weighted mean total lengths (mm) of <u>Stizostedion</u> hybrids from Cherokee Reservoir, Tennessee, July 1983-December 1985 (horizontal line indicates minimum legal harvestable size=381 mm).

Table 3. Published growth estimates of <u>Stizostedion</u> hybrids (H), walleye (W), and sauger (S) in selected reservoirs.

Author	Location	Total Length At Age (mm) 1	2
Present Study	Cherokee, TN (H)	296	442
Stroud (1948)	Norris, TN (H)	199	350
Lynch et al. (1982)	Delaware Ponds, OH (H)	205	284
Smith and Carline (1982)	Pleasant Hill, OH (H)	256	392
Smith and Carline (1983)	Pleasant Hill, OH (H)	236	380
Stroud (1949)	Norris, TN (W)	264	416
Scott (1976)	Center Hill, TN (W)	267	421
Woodward et al. (1986)	Center Hill, TN (W)	292	442
Libbey (1969)	Dale Hollow, TN (W)	264	409
Hassler (1957)	Norris, TN (S)	213	337
Fitz (1968)	Melton Hill, TN (S)	228	338
Woodward et al. (1986)	Watts Bar, TN (S)	269	359
Woodward et al. (1986)	Chickamauga, TN (S)	234	316

season is shorter than in Tennessee. Information detailing walleye and sauger growth is available for a wide variety of geographical areas; however, for the purposes of this study, only results from Tennessee investigations were used for direct comparison.

Cherokee Reservoir hybrids averaged 296 and 442 mm at ages 1 and 2, respectively, which compared favorably with data from Lynch et al. (1982) who reported lengths of 205 and 284 mm for hybrids of the same ages in ponds in Ohio. Johnson (1981) and Smith and Carline (1983) found that hybrids from the 1979 and 1980 year classes of Pleasant Hill Reservoir, Ohio, were 234 and 237 mm, respectively, by the first October following introduction. Two year classes of hybrids in Thunderbird Lake, Oklahoma, averaged 256 and 270 mm, respectively, by October of the first year following stocking (Leeds and Summers, unpublished data). The weighted mean length of three year classes of Cherokee Reservoir hybrids was 234 mm during that same month. Early growth of hybrids in Cherokee was similar to that of hybrids in Ohio reservoirs; however, Pleasant Hill hybrids ceased growth in October, whereas Cherokee hybrids continued to grow until December. This additional period of growth resulted in a greater length at age for Cherokee Reservoir hybrids. Growth of hybrids in Oklahoma appeared to exceed that of Tennessee hybrids; however until further information is available, any comparisons are inconclusive. Average length at age 1 in this study was larger than the value of 271 mm determined by Humphreys et al. (1984) for the first cohort of Cherokee Reservoir hybrids introduced in 1982.

Growth of young-of-year and yearling hybrids in Cherokee Reservoir equaled or exceeded all reported growth estimates of same age walleye in other Tennessee reservoirs. Woodward et al. (1986) found that back-calculated lengths of walleye at ages 1 (292 mm) and 2 (442 mm) collected in 1981 from Center Hill Reservoir, Tennessee, were almost identical to those observed for same age Cherokee Reservoir hybrids. First and second year growth of Cherokee Reservoir hybrids were consistently higher than that reported for sauger in Tennessee. Growth of both parental types is quite varied throughout Tennessee due to tremendous differences in reservoir environments where the two species are found. While growth of most hybrids, such as Morone hybrids, is usually intermediate to that of the parental types, young Stizostedion hybrids exhibit rapid growth similar to walleye. Although initial results are encouraging, further stocking of hybrids in other reservoirs will be necessary to fully assess the growth potential of these fish in Tennessee waters.

On March 1, 1984, the Tennessee Wildlife Resources Agency established a 381 mm minimum size limit (TL) for hybrids in Cherokee Reservoir to regulate exploitation of the stock. Information obtained during this study indicated that hybrids could reach this size as soon as 16 months following introduction.

Length-weight relationships calculated for young-of-year and yearling hybrids are as follows: $\log W = -5.437 + 3.15 \log L$ (r^2=0.980), and $\log W = -6.22 + 3.46 \log L$ (r^2=0.937), respectively. The slopes of these relationships were greater than 3.0 indicating that both young-of-year and yearling hybrids exhibited allometric growth (i.e., they became more rotund as they increased in length). The slopes of the two relationships were significantly different ($P<0.001$), suggesting that yearling hybrids gained more body weight per length increment than did young-of-year hybrids. An additional length-weight relationship was calculated using a total of 835 hybrids ranging from 90 to 635 mm in length: $\log W = -5.691 + 3.26 \log L$ (r^2=0.989).

Length-weight relationships for Cherokee Reservoir hybrids were compared to those of hybrids and parental types in other studies. Lynch et al. (1982) found a relationship of $\log W = -5.10 + 3.01 \log L$ for hybrids in Ohio ponds. Length-weight relationships established for hybrids from Ohio reservoirs had similar slopes (Deer Creek Lake, $\log W = -5.83 + 3.33 \log L$ (Ohio DNR 1981) and Pleasant Hill Reservoir, Ohio, $\log W = -5.55 + 3.19 \log L$ (Smith and Carline 1982)) to those for Cherokee Reservoir hybrids. Hassler (1957) determined a length-weight relationship of $\log W = -5.418 + 3.226 \log L$ for 3,145 sub-adult and adult sauger from Norris Lake, Tennessee, while Stroud (1949) reported a length-weight relationship of $\log W = -5.069 + 3.079 \log L$ for walleye from the same reservoir. Scott (1976) determined a length-weight relationship of $\log W = -5.11 + 3.03 \log L$ for 829 walleye from Center Hill Reservoir, Tennessee. The growth rate of Cherokee Reservoir hybrids is similar to growth rates reported for hybrids in other studies. However, the slopes of hybrid length-weight relationships were greater than those of length-weight relationships calculated for the parental types in most Tennessee reservoirs suggesting that these fish continue to grow rapidly at older ages.

Condition

Mean monthly coefficients of condition (K) calculated for young-of-year and yearling hybrids are presented in Table 4. First year condition factors ranged from a low of 0.62 in June 1984 to a high of 0.92 during February and March of 1983. Average first year condition factors were 0.81 and 0.80 for the 1983 and 1984 year classes of hybrids, respectively. An average condition factor of 0.82 was determined for the 1985 year class during the period from June through December 1985. These values were less than the average value of 0.90 determined by Humphreys et al. (1984) for the 1982 cohort of Cherokee Reservoir hybrids, but similar to the reported value of 0.80 for first year hybrids in Pleasant Hill Reservoir, Ohio (Smith and Carline 1983).

Average condition factors of yearling hybrids were significantly higher than those of young-of-year hybrids (T-test, $P \leq 0.05$). Average condition factor for yearlings of the 1982 year class was 1.03; however, this value was probably biased by the limited sample (n=25) of hybrids during that period. The 1983 year class of hybrids had an average condition factor of 0.92 for the second year following introduction, while an average value of 0.86 was determined for the 1984 year class during June through December of their second year. Hybrid condition tended to improve during the winter months, and the difference in average condition factors among yearlings of the 1983 and 1984 year class was likely a result of the lack of winter sampling of the 1984 cohort.

Mean monthly relative weights (W_r) of young-of-year and yearling hybrids are presented in Table 4. Wege and Anderson (1978) proposed the

Table 4. Mean condition factor (K) and mean relative weight (W_r) for each year class of Stizostedion hybrids collected monthly during the first two years following introduction (July 1983-December 1985).

Month	1982		1983		1984		1985	
	K	W_r	K	W_r	K	W_r	K	W_r
Jun					0.62	102	0.77	117
Jul			0.74	104	0.75	103	0.76	102
Aug			0.71	101			0.86	116
Sep			0.73	95	0.81	102	0.93	118
Oct			0.84	104	0.81	97	0.68	102
Nov			0.73	102	0.87	101	0.87	114
Dec			0.90	112	0.86	102	0.88	109
Jan					0.88	105		
Feb			0.92	109	0.89	109		
Mar			0.92	113	0.78	93		
Apr			0.80	97	0.73	86		
May			0.76	93	0.80	105		
Jun			0.73	88	0.78	92		
Jul					0.76	95		
Aug	0.87	98	0.90	104	0.86	100		
Sep	0.99	113	0.98	114	0.93	104		
Oct	1.04	116	0.94	107	0.96	108		
Nov	1.09	121	0.90	104	0.87	112		
Dec			0.94	105	0.88	126		
Jan			0.98	112				
Feb			1.05	116				
Mar	1.17	132	0.91	106				
Apr			0.86	105				
May			0.91	102				

relative weight index as a more sensitive method for detecting changes in condition of gamefishes. This index has been used in conjunction with other indices such as the Proportional Stock Density and Relative Stock Density to evaluate the status of naturally reproducing gamefish populations. In constrast to the coefficient of condition, relative weights are not affected by changes in the length-weight relationship as the fish matures. The relative weight is expressed as a percentage of the standard weight, with the acceptable range of values being between 95 to 105. Relative weights consistently below or above this range suggest that condition was extremely poor, extremely good, or the standard weight was not appropriate.

Recently, Tennessee Valley Authority (TVA) fishery biologists produced a standard weight table for selected sport and commercial fish species in the Tennessee Valley region. In this study, calculation of relative weights for Cherokee Reservoir hybrids was based on the standard weights of walleye found in TVA tributary reservoirs. The decision to use this standard was based on the observation that growth of walleye in these reservoirs was similar to that determined for hybrids in Cherokee Reservoir. Sample relative weights were generated using the standard weight table for sauger from TVA tributary reservoirs; however, actual hybrid weights at length were consistently higher than those of sauger, suggesting that these standard weights were inappropriate for use with hybrids.

Average first year relative weights were within the acceptable range for both the 1983 (W_r=103) and 1984 (W_r=100) year classes. The average relative weight calculated for the 1985 year class was 111, considerably higher than the values calculated for the 1983 and 1984 cohorts during the same period. Although these values were not significantly different (T-test, P>0.05), the greater relative weight determined for the 1985 year class suggested that the restrictive summer and fall reservoir environment may have had a positive effect on condition of young-of-year hybrids during that period.

Average relative weights of yearling hybrids were somewhat greater, although not significantly (T-test, P>0.05), than those of young-of-year hybrids from the same year class. An average relative weight of 116 was determined for 25 individuals of the 1982 year class. Values for yearlings of the 1983 and 1984 cohorts were 108 and 105, respectively. The slight differences among these years was likely influenced, as was condition factor, by the lack of winter samples for the 1984 year class. In general, relative weights of yearling hybrids indicated that environmental conditions were adequate for normal growth during each year of the study.

Condition of young-of-year hybrids improved as the fish grew older, with the greatest increase occurring during the winter months; however, both condition factors and relative weights of hybrids exhibited a precipitous decline during the late spring and early summer (Figures 3 and 4). These values remained low until late summer when condition quickly returned to acceptable levels. Food habits data indicated a decrease in the frequency of occurrence of fish in the diet of hybrids during the late spring and early summer, accompanied by an increase in the consumption of insects. Previous studies have determined that piscivorous fish forced to utilize zooplankton, insects, or other macro-

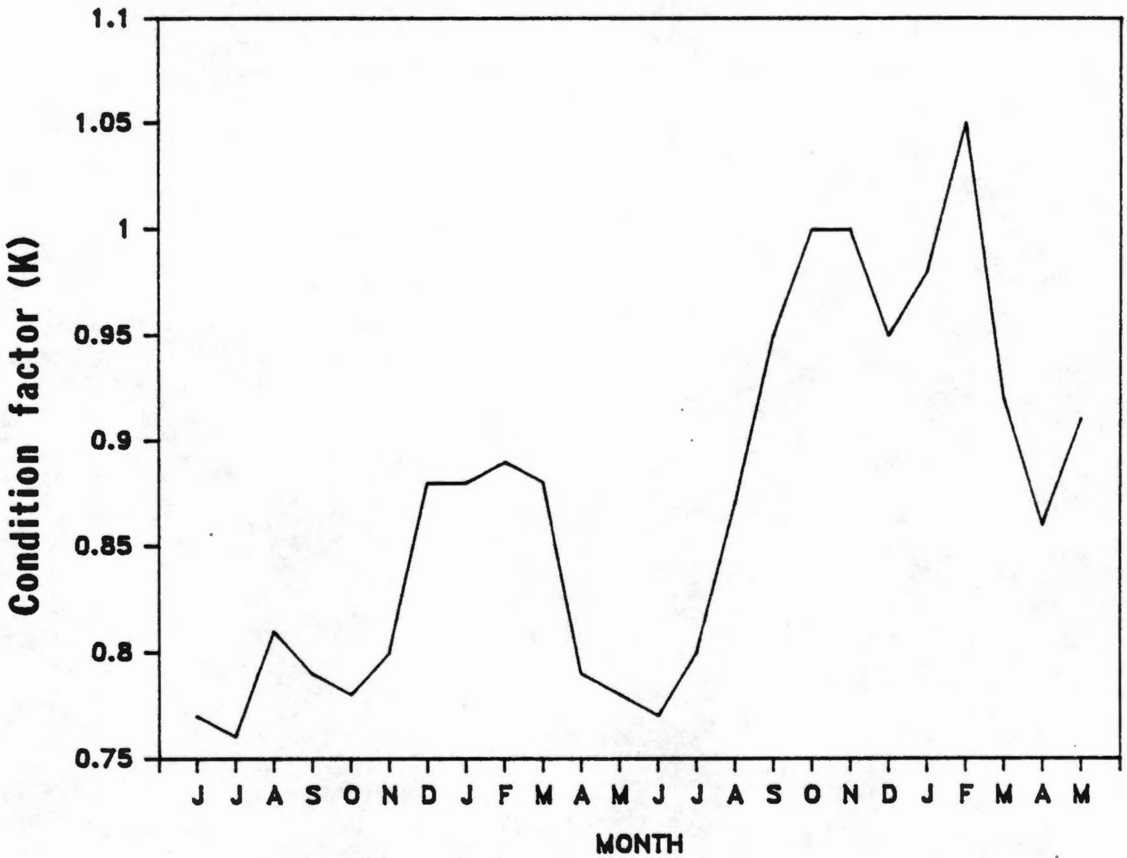

Figure 3. Weighted mean coefficient of condition (K) of <u>Stizostedion</u> hybrids from Cherokee Reservoir, Tennessee, July 1983-December 1985.

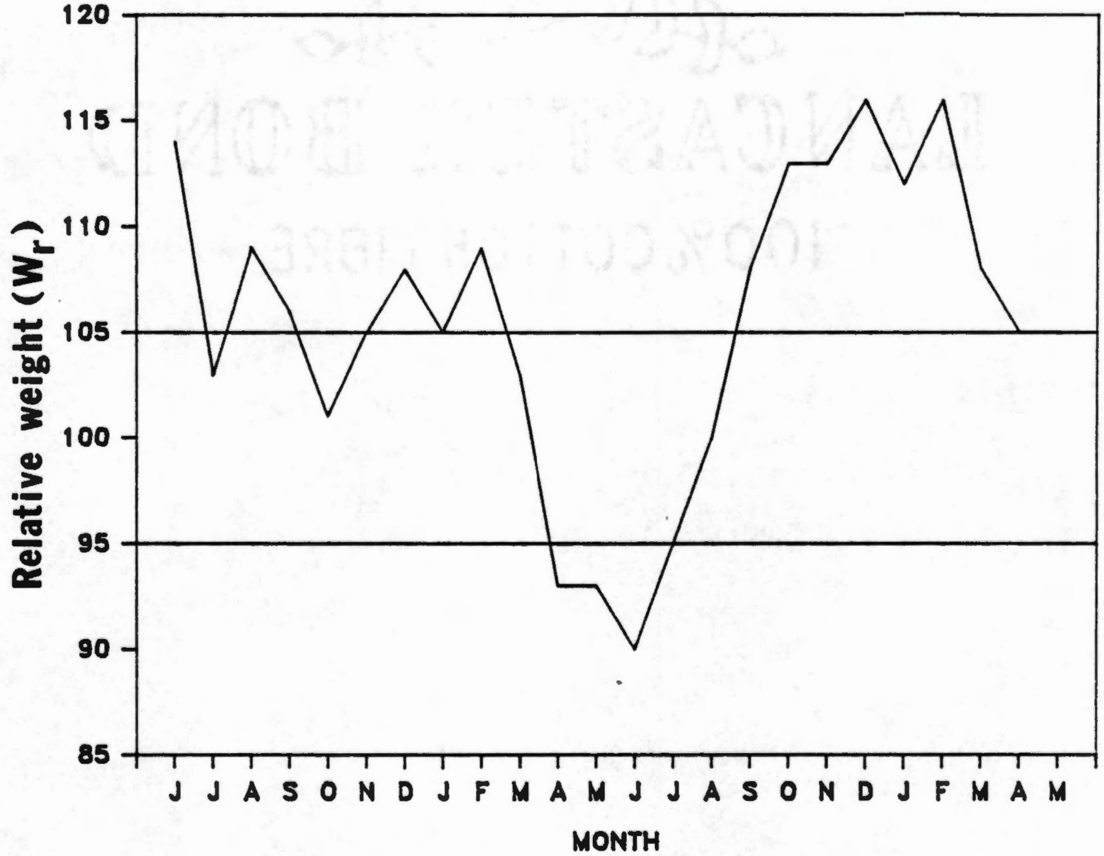

Figure 4. Weighted mean relative weight (W_r) of <u>Stizostedion</u> hybrids from Cherokee Reservoir, Tennessee, July 1983-December 1985 (horizontal lines indicate acceptable range of values).

invertebrates in the absence of fish, will exhibit reduced growth and condition (Saul 1981, Humphreys 1984). Once young-of-year shad are again available the overall condition of the hybrids rapidly improves.

Yearling hybrids of the 1983 year class experienced the same decline in condition during the spring of the second year. The magnitude of this decline in condition factor was somewhat larger than the decline in relative weight; however, the decrease in both indices was less severe in the older hybrids. Only a small number (n=5) of yearling hybrids was sexually mature during the winter and spring, with all of these being males. Therefore, loss of body weight as a result of spawning was not a likely cause for this decrease in condition.

Rapidly increasing water temperatures during the spring may indirectly affect hybrid condition. The thermal tolerance of both gizzard and threadfin shad is such that these species can readily inhabit areas of the reservoir that have temperature and dissolved oxygen characteristics which prohibit all but temporary occupation by mesothermal species such as walleye and sauger (Cox and Coutant 1976; Griffith 1978). Therefore, it is likely that prey-predator interaction may be negatively affected during this period. Momot et al. (1977) reported that reduced growth and fecundity of walleye in Hoover Reservoir, Ohio, resulted following eutrophication of that impoundment. These investigators suggested that prolonged exposure to sub-optimal temperatures and reduced ability to prey on shad negatively affected growth and fecundity of adult walleye, resulting in a population decline. Kelso (1972) found that walleye, which were forced to inhabit areas with temperatures at the upper limit of their range of tolerance and which exhibited daily migrations from cooler poorly oxygenated water to warmer waters in search of prey, characteristically had severely reduced food conversion efficiency, resulting in generally poorer condition. A situation similar to this may exist in Cherokee Reservoir during the late spring and summer, when hybrids are forced to occupy areas with above optimum temperatures in order to effectively utilize abundant prey such as shad. Summer epilimnetic temperatures can vary from 32 C on the surface to 24 C at the thermocline. These temperatures are well above the optimal temperature (22 C) for walleye and sauger, and approach the upper lethal limit for these species. During the summer and early fall, hypolimnetic anoxia forces hybrids to occupy areas where temperature and dissolved oxygen concentrations are marginal at best, so even when shad become abundant following the spring spawn, the temperature/dissolved oxygen characteristics of the reservoir can continue to adversely affect food conversion efficiency. Although rapid growth throughout the summer and the marked improvement in condition during the late summer suggests that hybrids may exhibit increased tolerance of these less than ideal environmental conditions, any such behavioral and physiological flexibility has not been documented in other studies at the present time. Small numbers of larger hybrids have been collected in spring-fed coves during the summer (TVA, unpublished data) and it is possible that older hybrids, like adult striped bass, seek out these areas as thermal refugia. The wide range of thermal tolerance exhibited by juvenile walleye and sauger has been well documented by Koenst and Smith (1975), Hokanson (1977), and Wrenn and Forsythe (1978), and may explain why recently introduced hybrids do not exhibit a decline, but an increase, in condition during the first summer. Further study of hybrids during the spring and summer is necessary to adequately describe the factors which affect condition of older fish.

Limiting environmental conditions appeared to have minimal effects on growth and condition of young-of-year and yearling hybrids during the first two years following introduction. Yearling hybrids continued to grow during the summer months at the expense of condition, but as prey abundance increased, condition rapidly improved. Reported summer die-offs of adult hybrids in Cherokee Reservoir suggest that these restrictive environmental conditions may ultimately have serious effects on the longevity of this hybrid.

<u>Food Habits</u>

A total of 563 young-of-year and yearling fish were used to evaluate hybrid food habits from July 1983 to December 1985. A total of 408 or 73% of these hybrids contained food items in their stomachs. Of 25 yearling hybrids from the 1982 year class examined for stomach contents, 17 individuals, or 68%, contained food. A total of 154 young-of-year and 69 yearling hybrids from the 1983 year class were examined, of which 116 (75%) and 49 (71%), respectively, contained food items. Of 128 young-of-year and 73 yearling hybrids from the 1984 year class examined for contents, 94 (73%) and 34 (47%), respectively, had stomachs with food items. Stomachs from 112 young-of-year hybrids from the 1985 year class were analyzed and a total of 98 (88%) contained food items.

Percentages of total numbers of food items ingested by young-of-year and yearling hybrids, by year class, are presented in Tables 5 and 6. Frequency-of-occurrence of items in young-of-year and yearling hybrid stomachs containing food are presented in Tables 7 and 8. These two methods of evaluating food habits give both a measure of numerical importance of particular items in the diet and an estimate of the percentage of the population which is utilizing these particular food items.

Food habits of young-of-year hybrids were similar for each year of the study. In terms of total number, insects were of major importance for the 1983 year class accounting for 59% of the 386 food items eaten; however, these results are likely biased since 203 chironomid larvae and pupae were found in stomachs of 7 hybrids during May 1984. This figure accounted for 89% of the total number of insects consumed by hybrids for the entire year. Fish, while less important in number, occurred in 90% of hybrid stomachs containing food during that year. In contrast, fish accounted for 97 and 99% of the total number of food items consumed and occurred in 96 and 100% of stomachs containing food during 1984 and 1985, respectively. Insects comprised only 3 and 1%, respectively, of the total number of food items consumed during those same years. Since insects were a seasonal component of the diet for hybrids; their occurrence in the diets of 1985 year class hybrids was probably influenced by the limited sampling of this cohort.

Shad comprised the majority of fish consumed by young-of-year hybrids in all years of this study. Threadfin and gizzard shad were found in hybrid stomachs; however, many shad were almost completely

Table 5. Percents of total numbers of food items in stomachs of Stizostedion hybrids (YOY), grouped by year class.

FOOD ITEM	1983	1984	1985
Pisces	41	97	99
Dorosoma spp.	71	77	53
D. petenense	4	1	1
D. cepedianum	18	29	4
Unidentified	78	70	95
Cyprinidae	1	1	9
Centrachidae	0	0	1
Atherinidae	3	0	1
Ictaluridae	0	0	1
Unidentified	25	22	35
Insecta	59	3	1
Chironomidae	97	80	100
larvae	1	100	0
pupae	99	0	100
Diptera (adult)	1	0	0
Ephemeridae	2	20	0
Hexagenia spp.	100	100	0
No. fish with food	116	94	98
No. of food items	386	154	122

Table 6. Percents of total numbers of food items in stomachs of Stizostedion hybrids (1+), grouped by year class.

FOOD ITEM	1982	1983	1984
Pisces	100	82	98
Dorosoma spp.	41	83	62
D. petenense	11	23	0
D. cepedianum	33	30	36
Unidentified	56	47	64
Cyprinidae	0	0	0
Centrachidae	0	3	5
Atherinidae	0	0	0
Ictaluridae	0	2	0
Unidentified	59	12	33
Insecta	0	18	2
Chironomidae	0	53	0
larvae	0	10	0
pupae	0	90	0
Diptera (adult)	0	0	0
Ephemeridae	0	47	100
Hexagenia spp.	0	100	100
No. fish with food	17	49	34
No. of food items	22	108	46

Table 7. Frequency of occurrence (%) of food items in stomachs of *Stizostedion* hybrids (YOY) that contained food, grouped by year class.

FOOD ITEM	1983	1984	1985
Pisces	90	96	100
Dorosoma spp.	51	63	82
D. petenense	10	19	2
D. cepedianum	5	1	3
Unidentified	45	49	54
Cyprinidae	2	2	6
Centrachidae	0	0	1
Atherinidae	1	0	1
Ictaluridae	0	0	1
Unidentified	35	34	43
Insecta	14	4	1
Chironomidae	12	3	1
larvae	2	3	1
pupae	11	0	1
Diptera (adult)	1	0	0
Ephemeridae	4	1	0
Hexagenia spp.	4	1	0
No. fish with food	116	94	98

Table 8. Frequency of occurrence (%) of food items in stomachs of *Stizostedion* hybrids (1+) that contained food, grouped by year class.

FOOD ITEM	1982	1983	1984
Pisces	100	96	100
Dorosoma spp.	41	65	59
D. petenense	6	8	0
D. cepedianum	18	25	21
Unidentified	21	41	47
Cyprinidae	0	0	0
Centrachidae	0	6	6
Atherinidae	0	0	0
Ictaluridae	0	2	0
Unidentified	65	22	44
Insecta	0	6	3
Chironomidae	0	4	0
larvae	0	2	0
pupae	0	4	0
Diptera (adult)	0	0	0
Ephemeridae	0	2	3
Hexagenia spp.	0	2	3
No. fish with food	17	49	34

digested making identification to species very difficult. Although, it was impossible to accurately determine any preference for either species in the diet, threadfin shad were found most often in the stomachs of young-of-year hybrids. A total of 158 fish were eaten by hybrids of the 1983 year class, of which 112 (71%) were shad. Of 149 fish consumed by young-of-year hybrids of the 1984 year class, a total of 115 (77%) were shad. Shad were also important to the 1985 year class of hybrids, accounting for 53% (64) of the 121 fish eaten during the first six months following stocking. Of the other fish consumed by young-of-year hybrids, small cyprinids, atherinids, centrachids, and ictalurids were the only groups identified. These fish frequently occurred in great numbers during forage sampling, but infrequently in the diet, indicating that they were relatively unimportant as food items. This topic will be discussed in more detail in later sections.

Chironomid larvae and pupae were the most important insects found in the diet, accounting for over 80% of the insects consumed by hybrids during each year of this study. The nymph of Hexagenia sp., a burrowing mayfly, was the other important insect found in hybrid stomachs. The only other insect found in a hybrid stomach during the course of this study was one adult dipteran which was found in the stomach of a 1983 year class young-of-year hybrid collected in May 1984. Insects were the only invertebrates found in the stomachs of young-of-year hybrids and represented only a minor portion of the total hybrid diet.

Food habits of yearlings were similar to those of young-of-year hybrids with fish being the most important item in both numbers and frequency of occurrence. Fish accounted for 100% of the total number of contents and occurred in 100% of stomachs containing food from yearlings of the 1982 year class. Yearlings of the 1983 and 1984 year classes exhibited slighty more diversity in feeding, with insects and non-shad fish occurring in the diet. Fish accounted for 82% of the total number of contents and occurred in 96% of stomachs containing food from 1983 yearling hybrids. Similarly, fish composed 98% of the contents and occurred in 100% of stomachs from 1984 yearlings.

Gizzard and threadfin shad were the most abundant fish species identified in stomachs of older hybrids, accounting for 41, 83, and 62% of the total number of fish consumed by yearling hybrids of the 1982, 1983, and 1984 year classes, respectively. Unidentified fish remains were the second most abundant food item group found in yearling hybrid stomachs. Gizzard shad were more abundant than threadfin shad in the stomachs of yearling hybrids. The rare occurrence of small cyprinids, atherinids, centrachids, and ictalurids in the diets of yearling hybrids suggested a slight opportunistic trait in feeding. However, the abundance of these species in the reservoir environment compared with their rare occurrence in the diet demonstrates the absence of any selective preference.

Insects were of minor importance to yearling hybrids from both the 1983 and 1984 year classes, occurring in only 6 and 3% of the stomachs from both of these years, respectively. Chironomids (larvae and pupae) and nymphs of <u>Hexagenia</u> sp. were the only invertebrates found in yearling hybrid stomachs. The limited collections of 1982 and 1984 yearlings could account for the reduced occurrence of insects in diet of hybrids from these year classes.

Food habits of young-of-year and yearling hybrids from Cherokee Reservoir observed during this investigation were consistent with those reported for hybrids in other studies. Johnson (1981) and Smith and Carline (1983) found that young-of-year hybrids in Pleasant Hill Reservoir, Ohio, consumed zooplankton immediately after stocking, but were eating fish, primarily gizzard shad, within one week. These hybrids also utilized insects, primarily chironomids and Hexagenia sp. nymphs, throughout the summer and during the late spring of the following year. Although gizzard shad was the most important fish in the diet, other species such as white crappie, yellow perch, logperch, and brown bullheads were also utilized to a lesser extent. Lynch et al. (1982) reported that hybrids stocked in small ponds consumed only fish, primarily fathead minnows, golden shiners, bluegill, and green sunfish. Humphreys (1984) investigated first year food habits of young-of-year hybrids in Cherokee Reservoir, Tennesee, and found that shad was the most important food item in terms of both percent-of-total-number and frequency-of-occurrence. He also reported that insects, primarily chironomid larvae/pupae and Hexagenia sp., were of some importance during the first summer following introduction. Hybrids were recently introduced into Thunderbird Lake, Oklahoma, and were reported to use introduced inland silversides (Menidia beryllina) as primary forage, with gizzard shad of secondary importance, during the first six months following stocking (Leeds and Summers, unpublished data).

Frequency-of-occurrence of major food item groups found in stomachs of 1983 and 1984 year class young-of-year hybrids was compared to those of striped bass and white bass collected during the same years in

Figures 5 and 6. This comparison was made to assess any dietary overlap among these predators. All three species utilized fish and insects for food during 1983 and 1984. While the occurrence of fish and insects in hybrid and white bass stomachs was virtually unchanged in both years, a greater number of striped bass utilized insects and not fish during 1984. This difference in striped bass food habits between years has been attributed to the later stocking time of the 1984 year class (H.G. Mealing, personal communication). Hybrids and striped bass have both been stocked in the upper area of Cherokee Reservoir where white bass are abundant, and, since these species utilize the same food items at one time or another, it is possible that the current stocking practices may actually increase the potential for competition between these predators during years of limited forage abundance. Humphreys (1984) found that introduced striped bass were particularly susceptible to forage variations in terms of both size and abundance of prey. Since hybrids appeared to be only slightly influenced by variations in forage conditions, they may provide an alternative predator for stocking in years where low forage fish abundance is anticipated.

In order to assess any temporal and spatial changes in hybrid diets, food habits data were analyzed by month of capture and collection area. Food habits of young-of-year and yearling hybrids grouped in 25 mm length classes were used to evaluate any changes associated with growth of hybrids.

The results of percent-of-total-numbers and frequency-of-occurrence analyses of young-of-year hybrid food habits, grouped by month of capture, are presented in Appendix A. Fish were the dominant food item

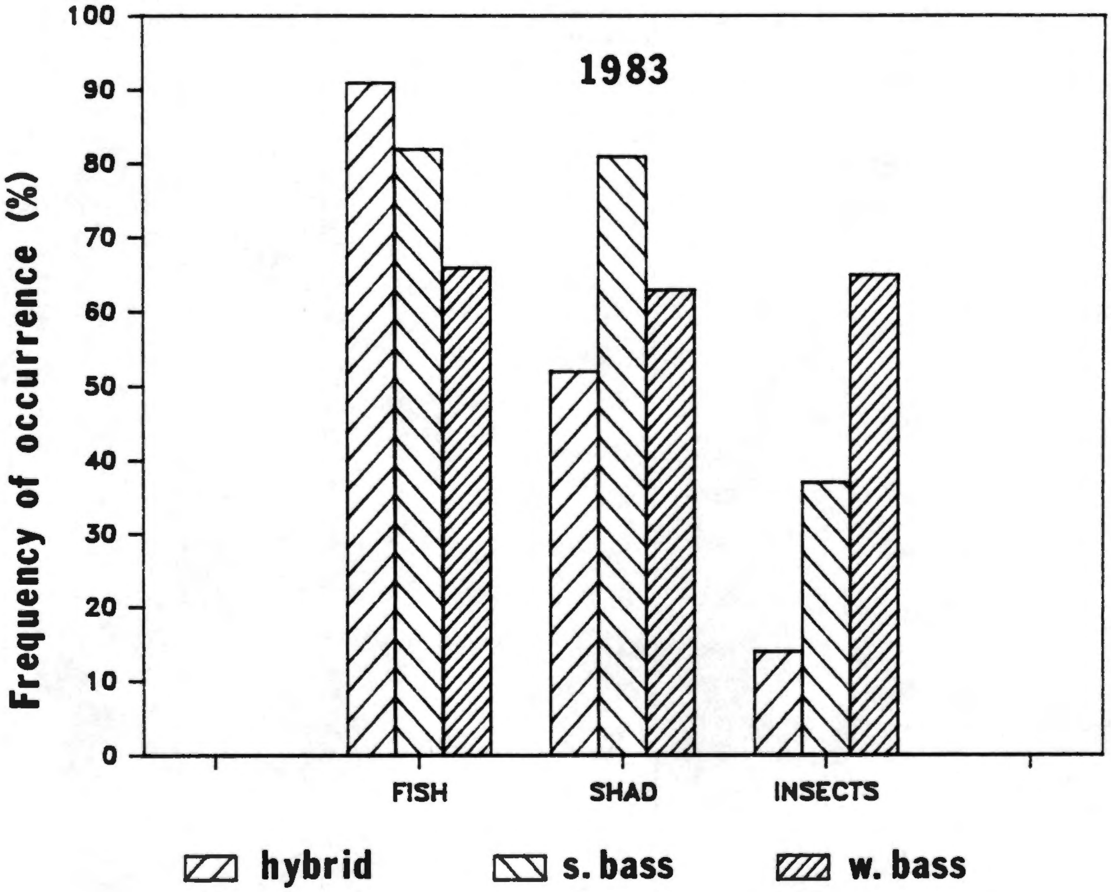

Figure 5. Frequency of occurrence of fish, shad, and insects in guts of 1983 year class Stizostedion hybrids, striped bass, and white bass from Cherokee Reservoir, Tennessee.

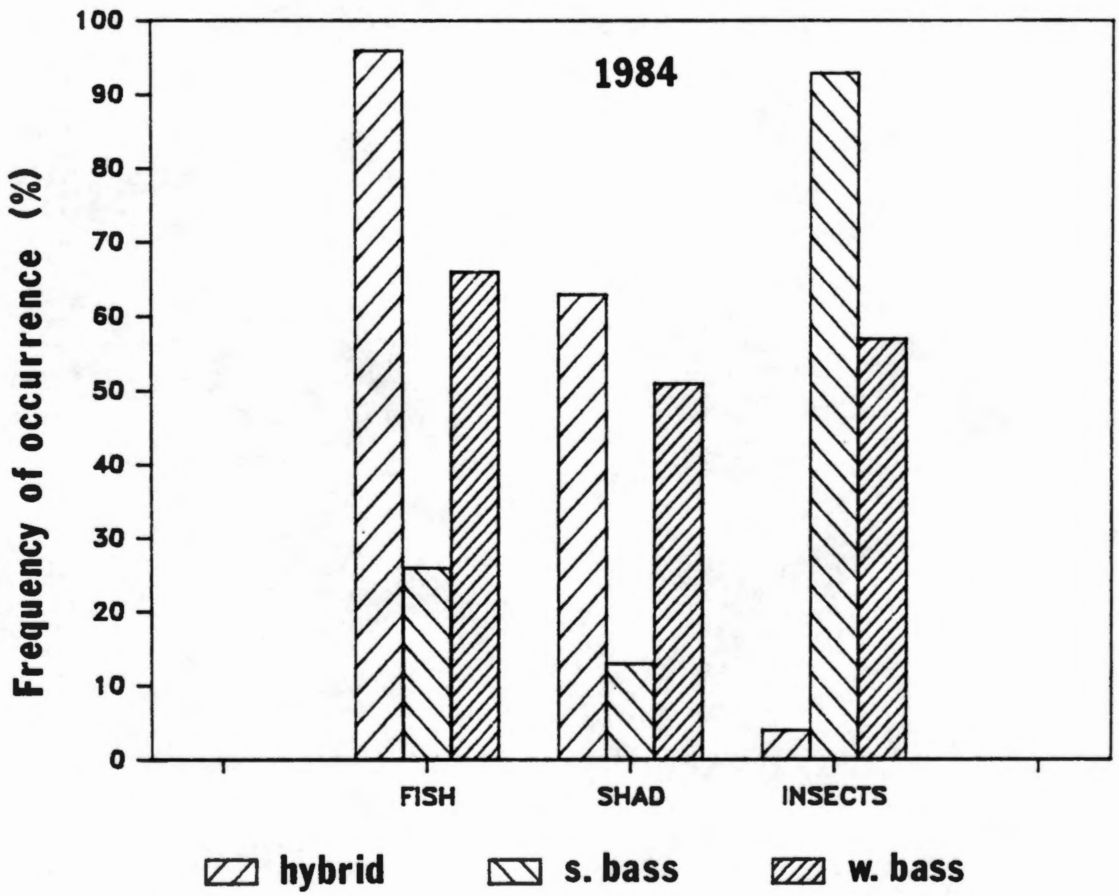

Figure 6. Frequency of occurrence of fish, shad, and insects in guts of 1984 year class Stizostedion hybrids, striped bass, and white bass from Cherokee Reservoir, Tennessee.

in terms of number and frequency of occurrence throughout most of the first year. Insects were of limited importance during the months immediately following stocking, and in spring of the following year.

The majority of fish consumed by young-of-year hybrids during all months but one (February 1984) was shad, with threadfin shad being the dominant species in both number and frequency-of-occurrence. Fish other than shad were consumed rarely by young-of-year hybrids of the 1983 and 1984 year classes; however, non-shad fish were of some importance to the 1985 year class hybrids during summer and early fall of that year. Reduced water levels may have forced littoral species such as cyprinids and atherinids into closer proximity with hybrids, accounting for this increased occurrence in the diet.

Young-of-year hybrids of the 1983 year class consumed greater numbers of chironomids and Hexagenia sp. nymphs than did hybrids of the 1984 and 1985 year classes, with approximately 90% of these insects being eaten during April and May 1984. A limited number of insects were also found in the stomachs of 1984 year class hybrids immediately following stocking during June and July 1984 and in March 1985. Insects were of minimal importance to hybrids of the 1985 year class during the first month following introduction. No other insects were eaten in the following months indicating that insects were relatively unimportant in diets of 1985 young-of-year hybrids during the first summer and fall following introduction.

The results of percent-of-total-numbers and frequency-of-occurrence analyses of yearling hybrid food habits, grouped by month of capture, are presented in Appendix B. Food habits of yearlings were similar to those of young-of-year hybrids when evaluated on a monthly basis. With the exception of June 1984 and March 1985, fish were the most important food item in terms of both number (>90%) and frequency of of occurrence (100%) for yearling hybrids during each month sampled. Insects became less important as a component of the hybrid diet during the second year following introduction.

Shad were found in more stomachs of yearling hybrids than were any other identified fish species and accounted for the greatest number of fish found in hybrid stomachs during each month sampled. Gizzard shad were more abundant than threadfin shad in the stomachs of yearling hybrids during most of the months examined. Stomachs from yearling hybrids of the 1982 year class contained only shad and unidentified fish remains, while yearlings of the 1983 year class consumed small cyprinids, atherinids, centrachids, and ictalurids in addition to shad. These species were consumed during the winter of 1985, even when shad were abundant in the diet. However, the frequency of occurrence of these species in the diet ($\leq$ 20%) suggested that they were incidental prey, likely consumed while hybrids were actively preying on shad. A small number of centrachids (n=3) was consumed by 1984 year class hybrids during July and December of the second year following introduction; however, shad was the major component of the hybrid diet during those same months.

No insects were eaten by yearling hybrids of the 1982 year class. Small numbers of chironomid pupae and nymphs of Hexagenia sp. were consumed by 1983 year class hybrids during June 1984 and again in March

1985. One Hexagenia nymph was found in the stomach of a yearling hybrid of the 1984 year class collected July 1985.

Percent-of-total-numbers and frequency-of-occurrence analyses of food habits of young-of-year hybrids, grouped by collection site, are presented in Appendix C. Fish were consumed in the greatest numbers (70 to 100% of the total number of contents) and by the majority (80 to 100%) of 1983 year class hybrids collected in the Quarryville, County Line, and Oak Grove areas. Fish were the most important food item of young-of-year hybrids from the 1984 year class collected in all four areas, in both percent-of-total-number (77 to 100%) and frequency-of-occurrence (80 to 100%). Hybrids from the 1983 year class consumed insects at both the Quarryville and Fall Creek areas, with these insects constituting the majority of food items (79%) eaten at the Quarryville area. Young-of-year hybrids from the 1984 year class ingested insects in only the Quarryville area. Since all young-of-year hybrids from the 1985 year class were collected in the same reservoir area (Fall Creek), no comparisons were made for this year class.

The results from food habits analysis by reservoir section in this study were almost identical to those reported for 1982 year class hybrids by Humphreys (1984). The greater numbers of insects in diets of hybrids collected in the Quarryville and Fall Creek areas can be attributed to seasonal changes in the diets of hybrids. The majority of hybrids collected in these areas of the reservoir were sampled during the spring and summer months when insects became a more important component of the diet. Hybrids were collected in the County Line and Oak Grove areas during the late fall and winter months, which was a period when hybrids consumed large numbers of shad and few insects. Although hybrids dispersed throughout the upper reservoir, it was unlikely that the spatial distribution of hybrids within the reservoir strongly influenced food habits during the first year following introduction.

Due to limited sampling of yearling hybrids from each year class in the four reservoir sections, comparisons of food habits between collection areas were not made. Yearling hybrids demonstrated less diversity in feeding than did young-of-year hybrids, and it is probable that food habits of yearlings were more strongly influenced by seasonal and not spatial factors.

The results of percent-of-total-number and frequency-of-occurrence analyses of young-of-year hybrid food habits, grouped by 25 mm length classes are presented in Appendix D. Hybrids from each year class consumed fish in all length classes, with shad being the most abundant fish found in length classes 3 through 12 (101-350 mm). Length class 2 (76-100 mm) hybrids from both the 1983 and 1985 year classes ingested non-shad fish, primarily small cyprinids and atherinids. Hybrids from the 1983 year class began to consume more gizzard shad in length classes 9 through 12 (251-350 mm). This increase was not observed in young-of-year hybrids from the 1984 and 1985 year classes.

Insects were most abundant in length classes 2 through 5 (76-175 mm) and length classes 8 through 11 (226-325 mm). Hybrids from 1983 year class consumed more insects in these length classes than did young-of-year hybrids from either the 1984 or 1985 year classes.

It is likely that seasonal changes in the abundance of insects and forage fish influenced length class food habits. The ranges of lengths at which hybrids utilized insects were the same as those observed for hybrids during the summer following introduction and the spring of the following year. There appeared to be no major shifts in food habits associated with changes in length during the first year following introduction. Instead, seasonal changes in prey abundance probably had a stronger influence of food habits than did growth.

Results of percent-of-total-numbers and frequency-of-occurrence analyses of yearling hybrid food habits, grouped by 25 mm length classes, are presented in Appendix E. Food habits of yearling hybrids exhibited very little change as these fish grew. Fish were found in stomachs of 85% or more of the hybrids in each of the length classes 10 through 17 (276-475 mm) with the exception of two 1983 year class hybrids from length class 10 (276-300 mm) which consumed only insects. Gizzard and threadfin shad were the most commonly identifed fish species found in yearling hybrid stomachs in each length class during each year of this study. Gizzard shad were most abundant in the diet of larger yearlings (351-450 mm) from the 1982 and 1983 year classes, while 1984 year class hybrids consumed more gizzard shad in length classes 11 through 16 (301-450 mm). The use of larger shad as a primary food item suggests that as hybrids grow, they will be able to utilize the larger gizzard shad.

The results of food habits analysis by length class were similar to those reported by Humphreys (1984) for young-of-year Cherokee Reservoir hybrids from the 1982 year class. He reported that hybrids utilized shad in all length classes examined, with insects of minor importance to hybrids in length classes 2, 5, 6, and 11. These hybrids also exhibited a shift to gizzard shad in length classes 8-11, which was similar to that observed in young-of-year hybrids from the 1983 year class.

Forage Availability

Insects, especially chironomids, are usually abundant in the upper reaches of Cherokee Reservoir during the entire year and there is probably little, if any, competition for this resource among fish species (Saul 1981; Humphreys 1984). Numbers of benthic invertebrates were consistently high during the spring and summer of each year (H. G. Mealing, personal communication) and this increased abundance may have positively influenced the occurrence of insects in the diets of young-of-year and yearling hybrids during that period. Winter drawdown of reservoirs has been documented to reduce the abundance of benthic invertebrates, particularly chironomids and mayflies, during the following spring (Benson and Hudson 1975). Extremely low water levels during spring and summer of 1985 probably had a continued negative effect on the abundance of benthic invertebrates by reducing the habitat available for colonization. This possible reduction in numbers, combined with the change in physical characteristics of the reservoir, may have also minimized the habitat overlap between hybrids and benthic invertebrates in Cherokee Reservoir. Johnson (1981) found that hybrids in Pleasant Hill Reservoir, Ohio, consumed large numbers of insects during the first May following introduction, while several other investigators have reported that walleye and sauger will consume greater numbers of invertebrates in the absence of forage fish (Priegel 1963; Forney 1966; Schupp 1978; Paxton and Stevenson 1978). It is likely that the seasonal increase of invertebrates in the diet of hybrids was influenced by both the abundance of these invertebrates in the reservoir and the absence of appropriate-size forage fish.

All fish collected by electrofishing and seining which were less than 100 mm (TL) were considered to be available forage for hybrids. Percentage composition of forage fish in electrofishing and seining samples and in stomachs of hybrids is presented in Table 21. Numerous fish species were found in forage samples but not in stomachs of young-of-year and yearling hybrids. Small cyprinids, atherinids, and centrachids were abundant throughout the year, but were eaten very rarely by hybrids. Lyons (1984) reported that walleye will readily utilize littoral fish species in the absence of primary prey. Hybrids frequented shoreline areas for at least six months following stocking, but apparently utilized littoral species only as secondary prey. Once hybrids begin utilizing pelagic shad as primary prey, they did not move inshore to feed on abundant littoral fish species even when shad numbers were low.

Gizzard and threadfin shad are the most important forage fish species for walleye and sauger in Tennessee and many other southeastern reservoirs (Dendy 1947; Libbey 1969; Scott 1976; Fitz and Holbrook 1978). The rapid growth and excellent condition of hybrids observed during this study appeared to be related to the abundance of shad in the diet. An analysis of predator-prey length relationships (Popova 1967) was used to provide further insight into the interaction between hybrids and shad and to evaluate any potential limitations for future introductions of hybrids.

Table 9. Percent composition of forage fish in seining and electrofishing samples, and in stomachs of *Stizostedion* hybrids.

Forage Fish[a]	Forage Samples	*Stizostedion* Hybrids
	(N=10,002)	(N=431)
Clupeidae	43.4	93.3
Cyprinidae	22.7	3.3
Atherinidae	17.0	1.4
Centrachidae	13.9	1.4
Ictaluridae	0.4	0.6
Other[b]	2.6	0

[a]All fish less than 100 mm in total length in seining and electrofishing samples were considered to be forage fish.

[b]Others include: *Morone* spp., northern hogsucker (*Hypentelium nigricans*), log perch (*Percina caprodes*), mosquitofish (*Gambusia affinis*), *Carpiodes* spp., *Etheostoma* spp., and *Lepisosteus* spp.

Shad were collected in forage sampling; however, it is likely that the abundance of these species during any given month may have been underestimated. TVA fishery biologists sampled four coves with rotenone in the late summer of each year of this study and information obtained from these surveys indicated that both species were abundant in the upper area of the reservoir. Gizzard shad averaged 58,517 fish per hectare and threadfin shad 20,736 fish per hectare during the three years of this study. Although gizzard shad were more abundant, a significant portion of the population was composed of adults, which were too large to be ingested by young-of-year and yearling hybrids. It was likely that a greater percentage of the threadfin shad population would be available as prey for young hybrids for a longer period of time.

The minimum, maximum, and average total lengths of shad found in stomachs of each 25 mm length class of hybrids are presented in Figure 7. Since the sizes of shad ingested by hybrids were similar during each year of this study, data for all year classes were combined during the calculation of these values. While the minimum, maximum, and average sizes of shad found in hybrid stomachs increased as hybrids grew, the larger hybrids continued to utilize the smaller shad. As many as 8 individual shad were found in the stomach of a single hybrid, and many hybrids had in excess of 5 shad in their stomachs during the winter months. This was likely a result of hybrids gorging themselves on cold-stressed threadfin shad; a mechanism by which percids compensate for reduced food conversion efficiency (Swenson 1977). Mean prey lengths were approximately 0.31 of predator lengths in length classes 3 through 7, and decreased to an average of 0.24 in length classes 8 through 16.

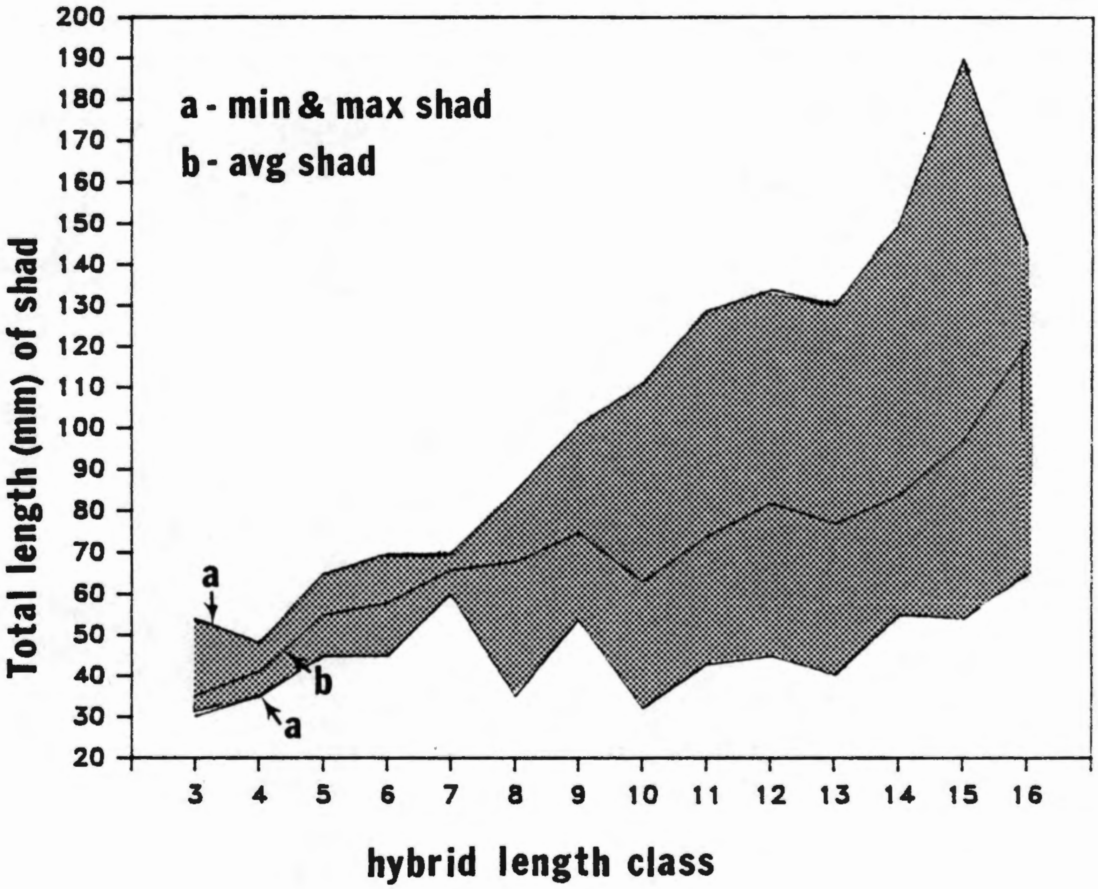

Figure 7. Prey-predator length relationships for young Stizostedion hybrids and shad.

In Figure 8, the maximum and average size shad found in hybrid stomachs during each month are compared to the minimum size shad found in forage samples during the corresponding month. The overlap in these values was considered to be the size range of shad that were potentially available as prey to average size hybrids at that point in time. Data from all years of the study were complied to develop this relationship. Relative lengths and numbers of shad found in hybrid stomachs during each month are presented in Table 22. Hybrids were somewhat restricted to a narrow size range of shad during the first few months following stocking, but as these hybrids grew rapidly, a wider length range of shad became available as prey. This trend continued until spring of the following year, when again the range of shad lengths became more confined. By May the minimum length of shad in the forage and the maximum length of shad found in the stomach of hybrids were almost identical. During the summer months the range of shad available increased rapidly as young-of-year shad were recruited as forage. The potential availability of shad continued to increase as older hybrids began to utilize larger gizzard shad and no restriction in forage availability was observed during the spring of the second year.

Food habits data support the results of this evaluation as shad were consumed in very small numbers by few hybrids during the late spring of the first year. The percentage of hybrids with empty stomachs also increased slightly during this period. McGee et al. (1977) found that, by November, threadfin shad averaged 80 mm (TL) in Watts Bar Reservoir, Tennessee, and few sauger less than 300 mm (TL) contained any of this species. The rapid growth of these shad, combined with high

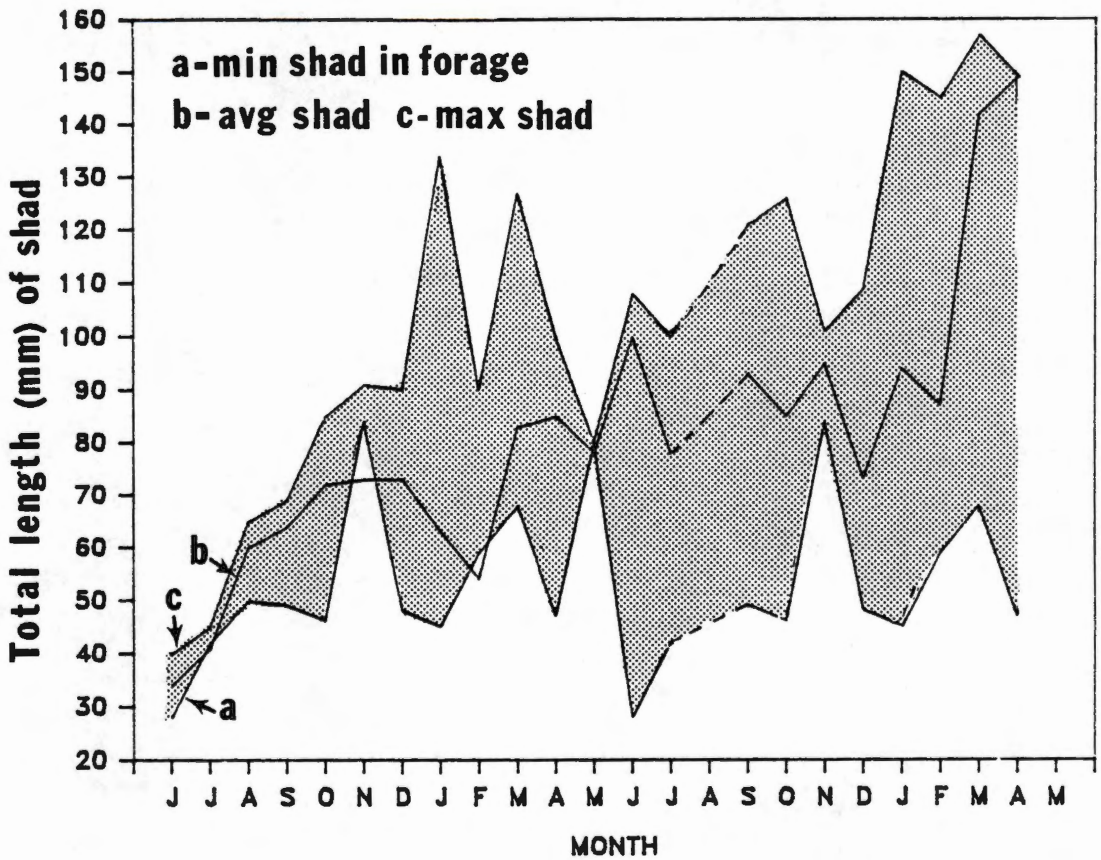

Figure 8. Potential availability of shad from forage samples to average size Stizostedion hybrids during each month of the first two years following stocking (a=minimum-size shad found in forage samples, b=average-size shad found in hybrid stomachs, and c=maximum-size shad found in hybrid stomachs).

Table 10. Relative lengths (R) and numbers (N) of shad measured in stomachs of Stizostedion hybrids, grouped by month.

Month	1982 R	1982 N	1983 R	1983 N	1984 R	1984 N	1985 R	1985 N
Jun							0.32	4
Jul			0.27	1	0.35	2	0.31	10
Aug							0.36	5
Sep			0.30	3			0.30	6
Oct			0.32	11	0.22	3	0.32	8
Nov			0.32	21	0.26	18	0.30	9
Dec			0.20	34	0.21	14	0.27	5
Jan					0.21	18		
Feb			0.35	3	0.20	15		
Mar			0.27	16				
Apr			0.25	2	0.39	1		
May					0.25	4		
Jun			0.35	2	0.29	3		
Jul					0.24	2		
Aug								
Sep			0.35	1	0.24	5		
Oct	0.19	1	0.19	4	0.30	1		
Nov	0.10	2	0.24	3	0.29	5		
Dec			0.16	10	0.26	3		
Jan			0.24	13				
Feb			0.21	11				
Mar	0.29	2	0.40	2				
Apr			0.37	1				
May								

winter mortality, eliminated them as prey for sauger by early spring, when alternate prey such as logperch, bluegill, and Hexagenia nymphs were eaten. Johnson (1981) reported similar findings in Pleasant Hill Reservoir, Ohio, where the frequency of occurrence of shad in the diets of Stizostedion hybrids approached zero during late spring. A similar, but less extreme situation, may exist in Cherokee Reservoir. The maximum size shad ingested by 300 mm hybrids in this reservoir was over 100 mm in length, suggesting that although there was probably a reduction in appropriate-size shad following winter, it is likely that other factors are affecting the prey-predator relationship.

Temperatures in the upper area of Cherokee Reservoir can change rapidly due to the influence of heated effluents from John Sevier Steam-Electric Plant (i.e., water temperatures in the Quarryville area exceeded 30 C during March 1985). These fluctuating temperatures may force the hybrids into areas where forage abundance is limited as shad move to the warmer waters and, until pelagic young-of-year shad become abundant, these predators utilize insects as alternative prey.

The relative ineffectiveness of the forage collection methods for adequately sampling shad can be seen in Figure 8. In November and February of the first year, the average length of shad found in the stomachs of hybrids fell below the minimum size shad found in the forage samples for those sampling dates. This is a clear indication that the forage collection techniques were somewhat limited for sampling the shad which were available to hybrids. Although it is likely that this factor may have influenced the results of this comparison, the extensive data used in developing this relationship may have minimized any bias. As further study is needed to fully elucidate the relationship between hybrids and their prey, a more efficient, less biased method for accurately assessing shad abundance must be sought for future investigations.

Many reservoir stocking programs have failed because of a basic lack of knowledge concerning prey-predator relationships in reservoir systems (Kohler et al. 1986). Both a knowledge of predator population dynamics and a understanding of the complex trophic relationships between predator and prey are essential for effective management of predators in reservoir systems. Since young hybrids appeared to be susceptible to seasonal variations in shad abundance, it is apparent that even in a system as productive as Cherokee Reservoir, aggressive predators can be negatively affected by a lack of appropriate prey.

The results from growth, condition, and food habits analyses indicated that Stizostedion hybrids have the capacity to adapt to large reservoir conditions with little difficulty. Although physical conditions in Cherokee Reservoir were considerably different throughout the course of this study, hybrid growth and condition were consistently good. The findings from the prey-predator relationships indicate that there are seasonal periods during which hybrids appear to be limited by shad abundance, as well as other possible abiotic factors. However, these limitations had very little, if any, negative effect on the overall growth and well-being of these hybrids during the first two years following introduction.

CHAPTER VI

SUMMARY AND RECOMMENDATIONS

Summary

1. A total of 665 young-of-year and yearlings were used to assess growth and condition of Cherokee Reservoir Stizostedion hybrids from July 1983 to December 1985. A sample of 563 young-of-year and yearlings were used to evaluate hybrid food habits during the same period.

2. Despite varying reservoir conditions, hybrid growth was consistently good throughout the course of this study. Hybrid growth was rapid during the summer, fall, and early winter, with minimal increase throughout the late winter and spring. Hybrids averaged 296 and 442 mm (TL) at ages 1 and 2, respectively. This growth equaled or exceeded all published growth estimates for hybrids in other areas, as well as, that of sauger and walleye in Tennessee.

3. Condition factors of young hybrids improved as these fish grew, with the exception of the late spring and summer when condition declined sharply. Relative weights exhibited the same decline during the late spring and summer, but were within or above the acceptable range (95-105) during the remainder of the year.

4. Low shad abundance following winter combined with undesirable temperature and dissolved oxygen characteristics may negatively affect hybrid condition during the spring and summer.

5. Shad were the primary food of both young-of-year and yearling hybrids during each year of this study. Non-shad fish such as cyprinids,

atherinids, and centrachids occurred frequently and in great numbers in forage samples but were rare in stomachs of hybrids. Insects, primarily chironomids and Hexagenia nymphs, were a seasonal component of the hybrid diet, being of limited importance during spring and summer. Young-of-year hybrids consumed greater numbers of insects and non-shad fish than did yearling hybrids.

6. Food habits of young hybrids were similar to those of young introduced striped bass and native white bass. All three species utilized fish and insects as food during 1983 and 1984. Since there is considerable dietary overlap, current stocking practices may increase the potential for competitive interaction among these species, particularly during periods of low forage abundance.

7. Mean prey/predator length ratios for shad and hybrids decreased from 0.31 in length classes 3 through 7 to 0.24 in length classes 8 through 16. Comparisons of monthly mean prey/predator length ratios with the minimum size shad collected in forage samples indicated a reduction in appropriate-size shad during late spring.

8. Although young hybrids appeared to be affected by seasonal changes in forage abundance and temperature/dissolved oxygen characteristics, these fluctuations had minimal negative effects on the overall growth and well-being of these fish in Cherokee Reservoir.

Recommendations

1. Since hybrids are stocked during periods of optimal forage abundance (i.e., immediately following the spring shad spawn), it is likely that survival and growth is directly related to early piscivory.

In 1984, large numbers of hybrid fry were stocked in addition to fingerlings; however, there was no evidence of differential growth among that year class. This suggests that fry stocking may be an alternative to the more costly fingerling stocking program. Further research should be designed to address the feasibility of such a program and provide more detailed information concerning post-stocking survival.

2. The rapid growth of hybrids during summer and fall, a period when temperature/dissolved oxygen characteristics are sub-optimal for percids, suggests that these hybrids may have an increased tolerance of less than ideal environmental conditions. If these hybrids do display heterosis, such as that observed in Morone hybrids, it is likely that they may be used to establish percid fisheries in waters previously deemed undesirable. Detailed laboratory experimentation is necessary to establish the behavioral and physiological limitations of these hybrids.

3. Unlike many fish hybrids, Stizostedion hybrids are capable of producing viable offspring by back-crossing with parental types or by forming F_2 hybrids. Numerous sexually mature hybrids have been collected in Cherokee Reservoir; however, there appears to be no natural reproduction at this time. Environmental conditions have precluded walleye/sauger reproductive success in the past and it is unlikely that hybrids will be able to successfully spawn in this reservoir. However, the reproductive limitations of hybrids in nature remain undetermined. Since fishery managers are becoming more aware of the genetic implications of stocking programs, the possible contamination of existing walleye and/or sauger stocks following introduction of hybrids remains a serious consideration.

LIST OF REFERENCES

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BENSON, N. G., and P. L. HUDSON. 1975. Effects of reduced fall drawdown on benthos abundance in Lake Francis Case. Transactions of the American Fisheries Society 104:526-528.

BAGENAL, T. B., and F. W. TESCH. 1978. Age and Growth. Pages 101-136 in T. Bagenal, editor. Methods of Assessment of Fish Production in Fresh Waters, IBP Handbook No. 3. Blackwell Scientific Publications, Oxford.

BULKEY, R. V., V. L. SPYKERMANN, and L. E. INMAN. 1976. Food of the pelagic young of walleye and five cohabiting fish species in Clear Lake, Iowa. Transactions of the American Fisheries Society 105:77-83.

CLAYTON, J. W., R. E. K. HARRIS, and D. N. TRETIAK. 1973. Identification of supernatant and mitochondrial isozymes of malate dehydrogenase on electropherograms applied to taxonomic discrimination of walleye (Stizostedion vitreum vitreum), sauger (S. canadense), and suspected interspecific hybrid fishes. Journal of the Fisheries Research Board of Canada 30:927-938.

COUTANT, C. C. 1978. A working hypothesis to explain mortalities of striped bass, Morone saxatilis, in Cherokee Reservoir. Environmental Sciences Division. Publicaton No. 1240. Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830.

COX, D. K., and C. C. COUTANT. 1976. Acute cold-shock resistance of gizzard shad. Pages 159-161 in Thermal ecology II. ERDA Symposium Series, CONF-750425.

DENDY, J. S. 1945. Predicting depth distribution of fish in three TVA storage type reservoirs. Transactions of the American Fisheries Society 75:65-71.

DENDY, J. S. 1947. Foods of several species of fish in Norris Reservoir, Tennessee. Journal of the Tennessee Academy of Science 2:105-127.

ESCHMEYER, R. W. 1940. Growth of fishes in Norris Lake, Tennessee. Journal of the Tennessee Academy of Science 15:329-341.

ESCHMEYER, R. W., and O. F. HASLBAUER. 1947. Utilization of the sauger crop in Norris Reservoir, Tennessee. Journal of the Tennessee Academy of Science 21:72-75.

EDRINGTON, C. J. , L. B. STARNES, and P. A. HACKNEY. 1979. Suitability of Cherokee Reservoir and the upper Holston River for sauger and walleye. Division of Water Resources, Tennessee Valley Authority, Norris, Tennessee 37828.

FITZ, R. B. 1968. Fish habitat and population changes resulting from impoundment of Clinch River by Melton Hill Dam. Journal of the Tennessee Academy of Science 43:7-15.

FITZ, R. B., and J. A. HOLBROOK II. 1978. Sauger and walleye in Norris Reservoir, Tennessee. American Fisheries Society Special Publication 11:82-88.

FORNEY, J. L. 1966. Factors affecting first-year growth of walleyes in Oneida Lake, New York. New York Fish and Game Journal 13:146-167.

GRIFFITH, J. S. 1978. Effects of low temperature on the survival and behavior of threadfin shad, Dorosoma petenense. Transactions of the American Fisheries Society 107:63-70.

HACKNEY, P. A., and J. A. HOLBROOK II. 1978. Sauger, walleye, and yellow perch in the southeastern United States. American Fisheries Society Special Publication 11:74-81.

HASSLER, W. M. 1955. The influence of certain environmental factors on the growth of Norris Reservoir sauger, Stizostedion canadense canadense (Smith). Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 9:111-119.

HASSLER, W. M. 1957. Age and growth of sauger, Stizostedion canadense, in Norris Reservoir, Tennessee. Journal of the Tennessee Academy of Science 32:55-76.

HASSLER, W. M. 1958. The fecundity, sex ratio, and maturity of the sauger, Stizostedion canadense canadense (Smith) in Norris Reservoir, Tennessee. Journal of the Tennessee Academy of Science 33:32-38.

HEARN, M. 1986. Reproductive viability of sauger-walleye hybrids. Progressive Fish-Culturist 48:149-150.

HEUER, J. H., and D. A. TOMLJANOVICH. 1980. A synopsis of fisheries investigations on Cherokee Reservoir: 1941-1979. Technical Report No. WR-40-1-80.1. Tennessee Valley Authority, Division of Water Resources, Office of Natural Resources.

HOKANSON, K. E. F. 1977. Temperature requirements of some percids and adaptations to the seasonal temperature cycle. Journal of the Fisheries Research Board of Canada 34:1515-1523.

HOUDE, E. D. 1967. Food of the pelagic young of the walleye, Stizostedion vitreum vitreum. Transactions of the American Fisheries Society 96:17-24.

HUMPHREYS, M. 1984. Effects of forage variations on young-of-year striped bass and other young predators in Cherokee Reservoir, Tennessee. Master's thesis. University of Tennessee, Knoxville, Tennessee.

IWANSKI, M. L., J. M. HIGGINS, B. R. KIM, and R. C. YOUNG. 1980. Factors affecting water quality in Cherokee Reservoir. Division of Water Resources, Tennessee Valley Authority, Chattanooga, Tennessee 37401.

JOHNSON, B. L. 1981. First year growth, survival, habitat preference, and food habits of stocked walleye and walleye X sauger hybrids in Pleasant Hill Reservoir, Ohio. Masters thesis, Ohio State University, Columbus, Ohio.

KELSO, J. R. M. 1972. Conversion, maintenance, and assimilation for walleye, Stizostedion vitreum vitreum (Mitchill), as affected by size, diet, and temperature. Journal of the Fisheries Research Board of Canada 29:1181-1192.

KERR, S. R., and R. A. RYDER. 1977. Niche theory and percid community structure. Journal of the Fisheries Research Board of Canada 34:1952-1958.

KERR, S. R., and R. A. RYDER. 1978. The adult walleye in the percid community - a niche definition based on feeding behavior and food specificity. American Fisheries Society Special Publication 11:39-51.

KOENST, W. M., and L. L. SMITH Jr. 1976. Thermal requirements of the early life history stages of walleye, Stizostedion vitreum vitreum and sauger, Stizostedion canadense. Journal of the Fisheries Research Board of Canada 33:1130-1138.

KOHLER, C. C., J. J. NEY, and W. E. KELSO. 1986. Filling the void: development of a pelagic fishery and its consequences to littoral fishes in a Virginia mainstream reservoir. pages 166-177 in G. E. Hall and M. J. Van Den Avyle, editors. Reservoir Fisheries Management: Strategies for the 80's. Reservoir Committee, Southern Division American Fisheries Society, Bethesda, Maryland, USA.

LEACH, J. H., M. G. JOHNSON, J. R. M. KELSO, J. HARTMANN, W. NUMANN, and B. ENTZ. 1977. Responses of percid fishes and their habitats to eutrophication. Journal of the Fisheries Research Board of Canada 34:1964-1971.

LIBBEY, J. E. 1969. Certain aspects of the life history of the walleye, Stizostedion vitreum vitreum (Mitchill), in Dale Hollow Reservoir, Tennessee and Kentucky, with emphasis on spawning. Master's thesis, Tennessee Technological University, Cookeville, Tennessee.

LOTUS DEVELOPMENT CORPORATION. 1983. Lotus User's Manual. Lotus Development Corporation Inc., Cambridge, Massachusetts., USA.

LYNCH, W. E., D. L. JOHNSON, and S. A. SCHELL. 1982. Survival, growth, and food habits of walleye X sauger hybrids (saugeye) in ponds. North American Journal of Fisheries Management 4:381-387.

LYONS, J. 1984. Walleye predation, yellow perch abundance, and the population structure of littoral zone fishes in a small Wisconsin lake. Bulletin of the Ecological Society of America 65:187.

MANGES, D. E. 1950. Fish tagging studies in TVA storage reservoirs, 1947-1949. Journal of the Tennessee Academy of Science 25:126-140.

MATHIAS, J. A., and S. LI. 1982. Feeding habits of walleye larvae and juveniles: comparative laboratory and field studies. Transactions of the American Fisheries Society 111:722-735.

McGEE, M. V., J. S. GRIFFITH, and R. B. McCLEAN. 1977. Prey selection by sauger in Watts Bar Reservoir, Tennessee, as affected by cold-induced mortality of threadfin shad. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 31:404-411.

MOMOT, W. T., J. ERICKSON, and F. STEVENSON. 1977. Maintenance of a walleye (Stizostedion vitreum vitreum) fishery in a eutrophic reservoir. Journal of the Fisheries Research Board of Canada 34:1725-1733.

MUENCH, K. A. 1966. Certain aspects of the life history of the walleye, Stizostedion vitreum vitreum (Mitchill), in Center Hill Reservoir, Tennessee. Master's thesis, Tennessee Technological Universtiy, Cookeville, Tennessee.

NELSON, W. R., M. R. HINES, and L. G. BECKMAN. 1965. Artificial propagation of saugers and hybridization with walleyes. Progressive Fish-Culturist 27:216-218.

NELSON, W. R. 1968. Embryo and larval characteristics of sauger, walleye, and their reciprocal hybrids. Transactions of the American Fisheries Society 97:167-174.

NELSON, W. R., and C. H. WALBURG. 1977. Population dynamics of yellow perch (Perca flavescens), sauger (Stizostedion canadense), and walleye (S. vitreum vitreum) in four main stem Missouri River reservoirs. Journal of the Fisheries Research Board of Canada 34:1748-1763.

NETSCH, N. F., and W. L. TURNER. 1964. Tennessee Game and Fish Commission, final report July 1, 1951, to December 31, 1954. F-2-R. Table 22.

OHIO DEPARTMENT OF NATURAL RESOURCES. 1981. Deer Creek Lake annual report. Federal Aid Project F-53-R-9, Ohio Division of Wildlife, Columbus, Ohio.

PARSONS, J. W. 1971. Selective food preferences of walleyes of the 1959 year class in Lake Erie. Transactions of the American Fisheries Society 100:474-485.

PAXTON, K. O., and F. STEVENSON. 1978. Food, growth, and exploitation of percids in Ohio's upground reservoirs. American Fisheries Society Special Publication 11:270-277.

POPOVA, O. A. 1967. The "predator-prey" relationship among fishes (a survey of Soviet papers). Pages 359-376 in S. D. Gerking, editor. The Biological Basis of Freshwater Fish Production. Blackwell Scientific Publications, Oxford.

PRIEGEL, G. R. 1963. Food of the walleye and sauger in Lake Winnebago, Wisconsin. Transactions of the American Fisheries Society 92:312-313.

RANEY, E. C., and E. A. LACHNER. 1942. Studies of the summer food, growth, and movements of young yellow pike-perch, Stizostedion v. vitreum, in Oneida Lake, New York. Journal of Wildlife Management 6:1-16.

RANGE, J. D. 1973. Growth of five species of game fishes before and after introduction of the threadfin shad into Dale Hollow Reservoir, Tennessee. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 26:510-518.

RICKER, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

SAS INSTITUTE. 1985. SAS/STAT guide for personal computers, version 6 edition. SAS Institute Inc., Cary, North Carolina., USA.

SAUL, B. M. 1981. Food habits and growth of young-of-year striped bass in Cherokee Reservoir, Tennessee. Master's thesis. The University of Tennessee, Knoxville, Tennessee.

SCHAICH, B. A. 1979. A biotelemetry study of spring and summer habitat selection by striped bass in Cherokee Reservoir, Tennessee. 1978. Master's thesis. The University of Tennessee, Knoxville, Tennessee.

SCHIAVONE, A., Jr. 1981. Decline of the walleye population in Black Lake, New York. New York Fish and Game Journal 28:68-72.

SCHUPP, D. H. 1978. Walleye abundance, growth, movement, and yield in disparate environments within a Minnesota lake. American Fisheries Society Special Publication 11:58-65.

SCOTT, E. M., Jr. 1976. Dynamics of the Center Hill walleye population. Tennessee Wildlife Resources Agency Technical Report No. 76-55, Nashville, Tennessee.

SERNS, S. L. 1982. Influence of various factors on density and growth of age-0 walleyes in Escanaba Lake, Wisconsin, 1958-1980. Transactions of the American Fisheries Society 111:299-306.

SMITH, D. L., and R. F. CARLINE. 1982. Evaluation of saugeye stocking in selected Ohio lakes. Ohio Federal Aid Project F-57-R-4, Ohio Division of Wildlife, Columbus, Ohio.

SMITH, D. L., and R. F. CARLINE. 1983. Evaluation of saugeye stocking in selected Ohio lakes. Ohio Federal Aid Project F-57-R-4, Ohio Division of Wildlife, Columbus, Ohio.

SMITH, C. G., and L. F. MILLER. 1942. A comparison of hoop-net catch on several waters in the Tennessee Valley before and after impoundment. Transactions of the American Fisheries Society 72:212-219.

SMITH, L. L., and R. L. PYCHA. 1960. First-year growth of the walleye, Stizostedion vitreum, and associated factors in the Red Lakes, Minnesota. Limnology and Oceanography 5:281-290.

SPYKERMANN, V. L. 1974. Food habits, growth, and distribution of larval walleye, Stizostedion vitreum vitreum (Mitchill), in Clear Lake, Iowa. Proceedings of the Iowa Academy of Science 81:143-149.

STROUD, R. H. 1948. Notes on growth of hybrids between the sauger and the walleye (Stizostedion canadense canadense x S. vitreum vitreum) in Norris Reservoir, Tennessee. Copeia 1948:297-298.

STROUD, R. H. 1949. Rate of growth and condition of game and pan fish in Cherokee and Douglas Reservoirs, Tennessee, and Hiwassee Reservoir, North Carolina. Journal of the Tennessee Academy of Science. 24:61-74.

SWENSON, W. A. 1977. Food consumption of walleye (Stizostedion vitreum vitreum) and sauger (S. canadense) in relation to food availability and physical conditions in Lake of the Woods, Minnesota, Shagawa Lake, and western Lake Superior. Journal of the Fisheries Research Board of Canada 34:1643-1654,

TRAUTMAN, M. B. 1981. The fishes of Ohio. The Ohio State University Press, Columbus, Ohio, USA.

TENNESSEE VALLEY AUTHORITY. 1986. John Sevier Fossil Plant:hydrothermal, water quality, and biological assessments of thermal impacts. Technical Report WR28-1-41-108. Division of Air and Water Resources, Norris, Tennessee.

WADDLE, H. R., C. C. COUTANT, and J. L. WILSON. 1980. Summer habitat selection by striped bass, Morone saxatilis, in Cherokee Reservoir, Tennessee, 1977. Oak Ridge National Laboratory, ORNL/TM-6927, Oak Ridge, Tennessee.

WAHL, D. H., and L. A. NIELSEN. 1985. Feeding ecology of the sauger (Stizostedion canadense) in a large river. Canadian Journal of Fisheries and Aquatic Sciences 42:120-128.

WEGE, G. J., and R. O. ANDERSON. 1978. Relative weight (W_r): a new index of condition for largemouth bass. American Fisheries Society Special Publication 5:79-91.

WRENN, W. B., and T. D. FORSYTHE. 1978. Effects of temperature on production and yield of juvenile walleye in experimental ecosystems. American Fisheries Society Special Publication 11:66-73.

WOODWARD, A. G., J. L. WILSON, and J. D. LITTLE. 1986. Growth characteristics of walleye, sauger, and their hybrids in selected Tennessee reservoirs. Journal of the Tennessee Academy of Science (Abstract).

YOUNG, R. C., and W. M. DENNIS. 1983. Productivity of the aquatic macrophyte community of the Holston River: implications to hypolimnetic oxygen depletions of Cherokee Reservoir. Division of Air and Water Resources, Tennessee Valley Authority, Muscle Shoals, Alabama, 35660.

APPENDIXES

APPENDIX A

FOOD HABITS OF YOUNG-OF-YEAR HYBRIDS GROUPED BY MONTH

Table 11. Percents of total numbers of food items in stomachs of 1983 year class Stizostedion hybrids (YOY), grouped by month.

	1983/84											
FOOD ITEM	J	J	A	S	O	N	D	J	F	M	A	M
Pisces		20	100	92	94	97	100		100	100	50	2
Dorosoma spp.		50	57	23	67	79	91		28	89	33	0
D. petenense		100	25	100	0	13	28		0	4	0	0
D. cepedianum		0	0	0	0	13	0		0	8	0	0
Unidentified		0	75	0	100	74	72		100	88	100	0
Cyprinidae		50	0	0	0	0	0		7	0	0	0
Centrachidae		0	0	0	0	0	0		0	0	0	0
Atherinidae		0	0	0	0	0	0		29	0	0	0
Ictaluridae		0	0	0	0	0	0		0	0	0	0
Unidentified		0	43	69	27	21	9		36	11	67	100
Insecta		80	0	8	6	3	0		0	0	50	98
Chironomidae		100	0	0	0	100	0		0	0	100	98
larvae		0	0	0	0	0	0		0	0	17	1
pupae		100	0	0	0	100	0		0	0	83	99
Diptera (adult)		0	0	0	0	0	0		0	0	0	1
Ephemeridae		0	0	100	100	0	0		0	0	0	1
Hexagenia spp.		0	0	100	100	0	0		0	0	0	100
No. fish with food	0	4	7	13	13	17	18	0	8	17	9	10
No. of food items	0	10	7	13	18	29	44	0	14	28	12	217

Table 12. Frequency of occurrence (%) of food items in stomachs of 1983 year class Stizostedion hybrids (YOY) that contained food, grouped by month.

	1983/84											
FOOD ITEM	J	J	A	S	O	N	D	J	F	M	A	M
Pisces		50	100	92	100	100	100		100	100	67	50
Dorosoma spp.		25	57	23	62	77	78		50	82	22	0
D. petenense		25	14	23	0	12	22		0	6	0	0
D. cepedianum		0	0	0	0	18	0		0	12	0	0
Unidentified		0	43	0	62	65	67		50	77	22	0
Cyprinidae		25	0	0	0	0	0		13	0	0	0
Centrachidae		0	0	0	0	0	0		0	0	0	0
Atherinidae		0	0	0	0	0	0		13	0	0	0
Ictaluridae		0	0	0	0	0	0		0	0	0	0
Unidentified		0	43	69	39	24	22		63	18	44	50
Insecta		50	0	8	8	6	0		0	0	44	70
Chironomidae		50	0	0	0	6	0		0	0	44	70
larvae		0	0	0	0	0	0		0	0	11	10
pupae		50	0	0	0	6	0		0	0	33	70
Diptera (adult)		0	0	0	0	0	0		0	0	0	10
Ephemeridae		0	0	8	8	0	0		0	0	0	30
Hexagenia spp.		0	0	8	8	0	0		0	0	0	30
No. fish with food	0	4	7	13	13	17	18	0	8	17	9	10

Table 13. Percents of total numbers of food items in stomachs of 1984 year class Stizostedion hybrids (YOY), grouped by month.

FOOD ITEM	J	J	A	S	O	N (1984/85)	D	J	F	M	A	M
Pisces	0	67		100	100	100	100	100	100	50	100	100
Dorosoma spp.	0	100		0	50	79	64	88	87	50	33	63
D. petenense	0	50		0	50	47	67	19	8	0	0	0
D. cepedianum	0	50		0	0	0	0	0	0	0	0	0
Unidentified	0	0		0	50	53	33	81	92	100	100	100
Cyprinidae	0	0		0	0	8	0	0	0	0	0	0
Centrachidae	0	0		0	0	0	0	0	0	0	0	0
Atherinidae	0	0		0	0	0	0	0	0	0	0	0
Ictaluridae	0	0		0	0	0	0	0	0	0	0	0
Unidentified	0	0		100	50	13	36	12	13	50	67	37
Insecta	100	33		0	0	0	0	0	0	50	0	0
Chironomidae	100	100		0	0	0	0	0	0	50	0	0
larvae	0	0		0	0	0	0	0	0	100	0	0
pupae	100	100		0	0	0	0	0	0	0	0	0
Diptera (adult)	0	0		0	0	0	0	0	0	0	0	0
Ephemeridae	0	0		0	0	0	0	0	0	50	0	0
Hexagenia spp.	0	0		0	0	0	0	0	0	100	0	0
No. fish with food	1	3	0	2	8	14	20	16	16	4	3	7
No. of food items	2	3	0	2	8	24	28	42	30	4	3	8

Table 14. Frequency of occurrence (%) of food items in stomachs of 1984 year class Stizostedion hybrids (YOY) that contained food, grouped by month.

	1984/85											
FOOD ITEM	J	J	A	S	O	N	D	J	F	M	A	M
Pisces	0	67		100	100	100	100	100	100	50	100	100
Dorosoma spp.	0	67		0	50	71	52	94	75	25	33	57
D. petenense	0	33		0	25	36	24	19	13	0	0	0
D. cepedianum	0	34		0	0	0	0	0	0	0	0	0
Unidentified	0	0		0	25	50	28	88	69	25	33	57
Cyprinidae	0	0		0	0	14	0	0	0	0	0	0
Centrachidae	0	0		0	0	0	0	0	0	0	0	0
Atherinidae	0	0		0	0	0	0	0	0	0	0	0
Ictaluridae	0	0		0	0	0	0	0	0	0	0	0
Unidentified	0	0		100	50	21	48	18	25	25	67	43
Insecta	100	33		0	0	0	0	0	0	50	0	0
Chironomidae	100	33		0	0	0	0	0	0	25	0	0
larvae	0	0		0	0	0	0	0	0	25	0	0
pupae	100	33		0	0	0	0	0	0	0	0	0
Diptera (adult)	0	0		0	0	0	0	0	0	0	0	0
Ephemeridae	0	0		0	0	0	0	0	0	25	0	0
Hexagenia spp.	0	0		0	0	0	0	0	0	25	0	0
No. fish with food	1	3	0	2	8	14	20	16	16	4	3	7

Table 15. Percents of total numbers of food items in stomachs of 1985 year class Stizostedion hybrids (YOY), grouped by month.

FOOD ITEM	J	J	A	1985 S	O	N	D
Pisces	96	100	100	100	100	100	100
Dorosoma spp.	52	57	39	40	56	61	71
D. petenense	0	0	0	0	8	0	0
D. cepedianum	0	0	0	0	0	0	40
Unidentified	100	100	100	100	92	100	60
Cyprinidae	20	4	8	10	9	0	0
Centrachidae	0	0	8	0	0	0	0
Atherinidae	0	4	0	0	0	0	0
Ictaluridae	4	0	0	0	0	0	0
Unidentified	24	35	45	50	35	39	29
Insecta	4	0	0	0	0	0	0
Chironomidae	100	0	0	0	0	0	0
larvae	0	0	0	0	0	0	0
pupae	100	0	0	0	0	0	0
Diptera (adult)	0	0	0	0	0	0	0
Ephemeridae	0	0	0	0	0	0	0
Hexagenia spp.	0	0	0	0	0	0	0
No. fish with food	19	18	13	9	18	16	5
No. of food items	26	23	13	12	23	18	7

Table 16. Frequency of occurrence (%) of food items in stomachs of 1985 year class Stizostedion hybrids (YOY) that contained food, grouped by month.

FOOD ITEM	1985 J	J	A	S	O	N	D
Pisces	100	100	100	100	100	100	100
Dorosoma spp.	63	50	39	40	67	63	80
D. petenense	0	0	0	0	6	0	0
D. cepedianum	0	0	0	0	0	0	20
Unidentified	63	50	39	40	61	63	60
Cyprinidae	5	6	8	10	11	0	0
Centrachidae	0	0	8	0	0	0	0
Atherinidae	0	6	0	0	0	0	0
Ictaluridae	5	0	0	0	0	0	0
Unidentified	26	44	45	50	39	44	40
Insecta	5	0	0	0	0	0	0
Chironomidae	5	0	0	0	0	0	0
larvae	0	0	0	0	0	0	0
pupae	5	0	0	0	0	0	0
Diptera (adult)	0	0	0	0	0	0	0
Ephemeridae	0	0	0	0	0	0	0
Hexagenia spp.	0	0	0	0	0	0	0
No. fish with food	19	18	13	9	18	16	5

APPENDIX B

FOOD HABITS OF YEARLING HYBRIDS GROUPED BY MONTH

Table 17. Percents of total numbers of food items in stomachs of 1982 year class Stizostedion hybrids (1+), grouped by month.

						1983/84						
FOOD ITEM	J	J	A	S	O	N	D	J	F	M	A	M
Pisces			100	100	100	100				100		
Dorosoma spp.			0	33	57	40				40		
D. petenense			0	0	0	50				0		
D. cepedianum			0	0	50	50				0		
Unidentified			0	100	50	0				100		
Cyprinidae			0	0	0	0				0		
Centrachidae			0	0	0	0				0		
Atherinidae			0	0	0	0				0		
Ictaluridae			0	0	0	0				0		
Unidentified			0	67	43	60				60		
Insecta			0	0	0	0				0		
Chironomidae			0	0	0	0				0		
larvae			0	0	0	0				0		
pupae			0	0	0	0				0		
Diptera (adult)			0	0	0	0				0		
Ephemeridae			0	0	0	0				0		
Hexagenia spp.			0	0	0	0				0		
No. fish with food	0	0	2	3	7	4	0	0	0	1	0	0
No. of food items	0	0	2	3	7	5	0	0	0	5	0	0

Table 18. Frequency of occurrence (%) of food items in stomachs of 1982 year class *Stizostedion* hybrids (1+) that contained food, grouped by month.

						1983/84						
FOOD ITEM	J	J	A	S	O	N	D	J	F	M	A	M
Pisces			100	100	100	100				100		
Dorosoma spp.			0	33	57	25				100		
D. petenense			0	0	0	25				0		
D. cepedianum			0	0	29	25				0		
Unidentified			0	33	29	0				100		
Cyprinidae			0	0	0	0				0		
Centrachidae			0	0	0	0				0		
Atherinidae			0	0	0	0				0		
Ictaluridae			0	0	0	0				0		
Unidentified			0	67	43	75				100		
Insecta			0	0	0	0				0		
Chironomidae			0	0	0	0				0		
larvae			0	0	0	0				0		
pupae			0	0	0	0				0		
Diptera (adult)			0	0	0	0				0		
Ephemeridae			0	0	0	0				0		
Hexagenia spp.			0	0	0	0				0		
No. fish with food	0	0	2	3	7	4	0	0	0	1	0	0

Table 19. Percents of total numbers of food items in stomachs of 1983 year class *Stizostedion* hybrids (1+), grouped by month.

FOOD ITEM	J	J	A	S	O	N	D	J	F	M	A	M
						1984/85						
Pisces	11			100	100	100	100	100	100	67	100	
Dorosoma spp.	100			50	75	80	83	93	79	50	100	
D. petenense	0			0	0	0	70	8	9	0	0	
D. cepedianum	0			0	67	0	0	23	73	100	50	
Unidentified	100			100	33	100	30	69	18	0	50	
Cyprinidae	0			0	0	0	0	0	7	0	0	
Centrachidae	0			0	0	0	4	7	0	0	0	
Atherinidae	0			0	0	0	0	0	29	0	0	
Ictaluridae	0			0	0	0	0	0	0	25	0	
Unidentified	0			50	25	20	13	0	36	25	0	
Insecta	89			0	0	0	0	0	0	33	0	
Chironomidae	47			0	0	0	0	0	0	100	0	
larvae	0			0	0	0	0	0	0	0	0	
pupae	100			0	0	0	0	0	0	100	0	
Diptera (adult)	0			0	0	0	0	0	0	0	0	
Ephemeridae	53			0	0	0	0	0	0	0	0	
Hexagenia spp.	100			0	0	0	0	0	0	0	0	
No. fish with food	4	0	0	2	5	3	11	10	7	5	2	0
No. of food items	19	0	0	2	8	5	24	28	14	6	2	0

Table 20. Frequency of occurrence (%) of food items in stomachs of 1983 year class *Stizostedion* hybrids (1+) that contained food, grouped by month.

	1984/85											
FOOD ITEM	J	J	A	S	O	N	D	J	F	M	A	M
Pisces	50			100	100	100	100	100	100	80	100	
Dorosoma spp.	50			50	60	67	73	80	57	40	100	
D. petenense	0			0	0	0	18	10	14	0	0	
D. cepedianum	0			50	40	0	0	40	29	40	50	
Unidentified	50			0	20	67	55	60	29	0	50	
Cyprinidae	0			0	0	0	0	0	0	0	0	
Centrachidae	0			0	0	0	9	20	0	0	0	
Atherinidae	0			0	0	0	0	0	0	0	0	
Ictaluridae	0			0	0	0	0	0	0	20	0	
Unidentified	0			50	40	33	27	0	43	20	0	
Insecta	50			0	0	0	0	0	0	20	0	
Chironomidae	25			0	0	0	0	0	0	20	0	
larvae	25			0	0	0	0	0	0	20	0	
pupae	25			0	0	0	0	0	0	0	0	
Diptera (adult)	0			0	0	0	0	0	0	0	0	
Ephemeridae	25			0	0	0	0	0	0	0	0	
Hexagenia spp.	25			0	0	0	0	0	0	0	0	
No. fish with food	4	0	0	2	5	3	11	10	7	5	2	0

Table 21. Percents of total numbers of food items in stomachs of 1984 year class Stizostedion hybrids (1+), grouped by month.

	1985						
FOOD ITEM	J	J	A	S	O	N	D
Pisces	100	90	100	100	100	100	100
Dorosoma spp.	43	60	50	88	50	55	67
D. petenense	0	0	0	0	0	0	0
D. cepedianum	0	0	0	57	0	67	33
Unidentified	100	100	100	43	100	33	67
Cyprinidae	0	0	0	0	0	0	0
Centrachidae	0	10	0	0	0	0	33
Atherinidae	0	0	0	0	0	0	0
Ictaluridae	0	0	0	0	0	0	0
Unidentified	57	30	50	12	50	45	33
Insecta	0	10	0	0	0	0	0
Chironomidae	0	0	0	0	0	0	0
larvae	0	0	0	0	0	0	0
pupae	0	0	0	0	0	0	0
Diptera (adult)	0	0	0	0	0	0	0
Ephemeridae	0	100	0	0	0	0	0
Hexagenia spp.	0	100	0	0	0	0	0
No. fish with food	7	9	2	4	1	8	3
No. of food items	7	10	2	8	2	11	6

Table 22. Frequency of occurrence (%) of food items in stomachs of 1984 year class Stizostedion hybrids (1+) that contained food, grouped by month.

				1985			
FOOD ITEM	J	J	A	S	O	N	D
Pisces	100	100	100	100	100	100	100
Dorosoma spp.	43	67	50	75	100	50	67
D. petenense	0	0	0	0	0	0	0
D. cepedianum	0	0	0	50	0	38	33
Unidentified	43	67	50	50	100	25	67
Cyprinidae	0	0	0	0	0	0	0
Centrachidae	0	11	0	0	0	0	33
Atherinidae	0	0	0	0	0	0	0
Ictaluridae	0	0	0	0	0	0	0
Unidentified	57	22	50	25	100	21	33
Insecta	0	11	0	0	0	0	0
Chironomidae	0	0	0	0	0	0	0
larvae	0	0	0	0	0	0	0
pupae	0	0	0	0	0	0	0
Diptera (adult)	0	0	0	0	0	0	0
Ephemeridae	0	11	0	0	0	0	0
Hexagenia spp.	0	11	0	0	0	0	0
No. fish with food	7	9	2	4	1	8	3

APPENDIX C

FOOD HABITS OF YOUNG-OF-YEAR HYBRIDS GROUPED BY COLLECTION SITE

Table 23. Percents of total numbers of food items in stomachs of 1983 year class Stizostedion hybrids (YOY), grouped by collection site.

FOOD ITEM	Quarryville	Fall Creek	1983/84 County Line	Oak Grove
Pisces	70	21	100	100
Dorosoma spp.	38	63	89	75
D. petenense	63	8	4	28
D. cepedianum	0	8	8	0
Unidentified	37	84	88	72
Cyprinidae	5	0	0	2
Centrachidae	0	0	0	0
Atherinidae	0	0	0	8
Ictaluridae	0	0	0	0
Unidentified	57	37	11	15
Insecta	30	79	0	0
Chironomidae	89	97	0	0
larvae	0	1	0	0
pupae	100	99	0	0
Diptera (adult)	0	1	0	0
Ephemeridae	11	2	0	0
Hexagenia spp.	100	100	0	0
No. fish with food	24	49	17	26
No. of food items	30	275	28	52

Table 24. Frequency of occurrence (%) of food items in stomachs of 1983 year class *Stizostedion* hybrids (YOY) that contained food, grouped by collection site.

FOOD ITEM	Quarryville	Fall Creek	1983/84 County Line	Oak Grove
Pisces	87	86	100	100
Dorosoma spp.	38	47	82	69
D. petenense	21	4	6	15
D. cepedianum	0	4	12	0
Unidentified	13	43	77	62
Cyprinidae	4	0	0	4
Centrachidae	0	0	0	0
Atherinidae	0	0	0	4
Ictaluridae	0	0	0	0
Unidentified	50	39	18	35
Insecta	13	27	0	0
Chironomidae	8	27	0	0
larvae	0	4	0	0
pupae	8	22	0	0
Diptera (adult)	0	2	0	0
Ephemeridae	13	8	0	0
Hexagenia spp.	13	8	0	0
No. fish with food	24	49	17	26

Table 25. Percents of total numbers of food items in stomachs of 1984 year class Stizostedion hybrids (YOY), grouped by collection site.

FOOD ITEM	Quarryville	Fall Creek	1984/85 County Line	Oak Grove
Pisces	77	100	100	100
Dorosoma spp.	53	79	79	78
D. petenense	11	47	13	35
D. cepedianum	11	0	0	0
Unidentified	78	53	87	65
Cyprinidae	0	8	0	0
Centrachidae	0	0	0	0
Atherinidae	0	0	0	0
Ictaluridae	0	0	0	0
Unidentified	47	13	21	22
Insecta	23	0	0	0
Chironomidae	80	0	0	0
larvae	100	0	0	0
pupae	0	0	0	0
Diptera (adult)	0	0	0	0
Ephemeridae	20	0	0	0
Hexagenia spp.	100	0	0	0
No. fish with food	20	14	24	36
No. of food items	22	24	39	69

Table 26. Frequency of occurrence (%) of food items in stomachs of 1984 year class Stizostedion hybrids (YOY) that contained food, grouped by collection site.

		1984/85		
FOOD ITEM	Quarryville	Fall Creek	County Line	Oak Grove
Pisces	80	100	100	100
Dorosoma spp.	40	71	67	72
D. petenense	5	36	17	22
D. cepedianum	5	0	0	0
Unidentified	30	50	54	56
Cyprinidae	0	14	0	0
Centrachidae	0	0	0	0
Atherinidae	0	0	0	4
Ictaluridae	0	0	0	0
Unidentified	40	21	33	36
Insecta	20	0	0	0
Chironomidae	15	0	0	0
larvae	15	0	0	0
pupae	0	0	0	0
Diptera (adult)	0	0	0	0
Ephemeridae	5	0	0	0
Hexagenia spp.	5	0	0	0
No. fish with food	20	14	24	36

APPENDIX D

FOOD HABITS OF YOUNG-OF-YEAR HYBRIDS GROUPED BY LENGTH CLASS

Table 27. Percents of total numbers of food items in stomachs of Stizostedion hybrids (YOY) from the 1983 year class, grouped by length class.[a]

	1983/84										
FOOD ITEM	2	3	4	5	6	7	8	9	10	11	12
Pisces	100	17	33	100	100	100	95	17	70	89	100
Dorosoma spp.	0	100	50	50	50	17	71	83	71	81	100
D. petenense	0	100	0	50	67	100	0	14	18	24	0
D. cepedianum	0	0	0	0	0	0	0	9	3	0	33
Unidentified	0	0	100	50	33	0	100	77	79	76	67
Cyprinidae	100	0	0	0	0	0	0	0	2	0	0
Centrachidae	0	0	0	0	0	0	0	0	0	0	0
Atherinidae	0	0	0	0	0	0	0	0	8	0	0
Ictaluridae	0	0	0	0	0	0	0	0	0	0	0
Unidentified	0	0	50	50	50	83	29	17	19	19	0
Insecta	0	83	67	0	0	0	5	83	30	11	0
Chironomidae	0	100	75	0	0	0	0	98	100	100	0
larvae	0	0	0	0	0	0	0	1	5	0	0
pupae	0	100	100	0	0	0	0	99	95	100	0
Diptera (adult)	0	0	0	0	0	0	0	0.5	0	0	0
Ephemeridae	0	0	25	0	0	0	100	1.5	0	0	0
Hexagenia spp.	0	0	100	0	0	0	100	100	0	0	0
No. fish with food	1	2	4	4	6	6	15	34	29	14	1
No. of food items	1	6	6	4	6	6	22	236	69	28	3

[a] Length classes (total length in millimeters) are as follows: 2=76-100; 3=101-125; 4=126-150; 5=151-175; 6=176-200; 7=201-225; 8=226-250; 9=251-275; 10=276-300; 11=301-325; 12=326-350.

Table 28. Frequency of occurrence (%) of food items in stomachs of 1983 year class Stizostedion hybrids (YOY) that contained food, grouped by length class.[a]

FOOD ITEM	1983/84										
	2	3	4	5	6	7	8	9	10	11	12
Pisces	100	50	50	100	100	100	100	88	86	100	100
Dorosoma spp.	0	50	25	50	50	17	60	56	55	71	100
D. petenense	0	50	0	25	33	17	0	9	7	14	0
D. cepedianum	0	0	0	0	0	0	0	9	3	0	100
Unidentified	0	0	25	25	17	0	60	50	48	64	100
Cyprinidae	100	0	0	0	0	0	0	0	3	0	0
Centrachidae	0	0	0	0	0	0	0	0	0	0	0
Atherinidae	0	0	0	0	0	0	0	0	3	0	0
Ictaluridae	0	0	0	0	0	0	0	0	0	0	0
Unidentified	0	0	25	50	50	83	40	29	31	29	0
Insecta	0	50	50	0	0	0	7	21	14	7	0
Chironomidae	0	50	25	0	0	0	0	21	14	7	0
larvae	0	0	0	0	0	0	0	3	3	0	0
pupae	0	50	25	0	0	0	0	21	10	7	0
Diptera (adult)	0	0	0	0	0	0	0	3	0	0	0
Ephemeridae	0	0	25	0	0	0	7	9	0	0	0
Hexagenia spp.	0	0	25	0	0	0	7	9	0	0	0
No. fish with food	1	2	4	4	6	6	15	34	29	14	1

[a] Length classes (total length in millimeters) are as follows: 2=76-100; 3=101-125; 4=126-150; 5=151-175; 6=176-200; 7=201-225; 8=226-250; 9=251-275; 10=276-300; 11=301-325; 12=326-350.

Table 29. Percents of total numbers of food items in stomachs of *Stizostedion* hybrids (YOY) from the 1984 year class, grouped by length class.[a]

FOOD ITEM	2	3	4	5	1984/85 6	7	8	9	10	11	12
Pisces			50	33	100	100	100	97	100	98	100
Dorosoma spp.			100	100	0	0	100	65	78	76	91
D. petenense			100	0	0	0	50	53	32	10	20
D. cepedianum			0	100	0	0	0	0	0	0	0
Unidentified			0	0	0	0	50	47	68	90	80
Cyprinidae			0	0	0	0	0	7	0	0	0
Centrachidae			0	0	0	0	0	0	0	0	0
Atherinidae			0	0	0	0	0	0	0	0	0
Ictaluridae			0	0	0	0	0	0	0	0	0
Unidentified			0	0	100	100	0	28	22	24	9
Insecta			50	67	0	0	0	3	0	2	0
Chironomidae			100	100	0	0	0	0	0	100	0
larvae			100	100	0	0	0	0	0	100	0
pupae			0	0	0	0	0	0	0	0	0
Diptera (adult)			0	0	0	0	0	0	0	0	0
Ephemeridae			0	0	0	0	0	100	0	0	0
Hexagenia spp.			0	0	0	0	0	100	0	0	0
No. fish with food	0	0	2	2	1	1	1	20	38	25	4
No. of food items	0	0	2	3	1	1	2	30	62	42	11

[a] Length classes (total length in millimeters) are as follows: 2=76-100; 3=101-125; 4=126-150; 5=151-175; 6=176-200; 7=201-225; 8=226-250; 9=251-275; 10=276-300; 11=301-325; 12=326-350.

Table 30. Frequency of occurrence (%) of food items in stomachs of 1984 year class *Stizostedion* hybrids (YOY) that contained food, grouped by length class.[a]

FOOD ITEM	2	3	4	5	6	7	8	9	10	11	12
					1984/85						
Pisces			50	50	100	100	100	95	100	96	100
Dorosoma spp.			50	50	0	0	100	50	71	68	75
D. petenense			50	0	0	0	100	30	24	4	25
D. cepedianum			0	50	0	0	0	0	0	0	0
Unidentified			0	0	0	0	100	25	55	64	75
Cyprinidae			0	0	0	0	0	10	0	0	0
Centrachidae			0	0	0	0	0	0	0	0	0
Atherinidae			0	0	0	0	0	0	0	0	0
Ictaluridae			0	0	0	0	0	0	0	0	0
Unidentified			0	0	100	100	0	40	34	32	25
Insecta			50	50	0	0	0	5	0	4	0
Chironomidae			50	50	0	0	0	0	0	4	0
larvae			50	50	0	0	0	0	0	4	0
pupae			0	0	0	0	0	0	0	0	0
Diptera (adult)			0	0	0	0	0	0	0	0	0
Ephemeridae			0	0	0	0	0	5	0	0	0
Hexagenia spp.			0	0	0	0	0	5	0	0	0
No. fish with food			2	2	1	1	1	20	38	25	4

[a] Length classes (total length in millimeters) are as follows: 2=76-100; 3=101-125; 4=126-150; 5=151-175; 6=176-200; 7=201-225; 8=226-250; 9=251-275; 10=276-300; 11=301-325; 12=326-350.

Table 31. Percents of total numbers of food items in stomachs of *Stizostedion* hybrids (YOY) from the 1985 year class, grouped by length class.[a]

					1985						
FOOD ITEM	2	3	4	5	6	7	8	9	10	11	12
Pisces	100	96	100	100	100	100	100	100	100	100	
Dorosoma spp.	13	58	50	54	60	50	75	67	50	100	
D. petenense	0	0	0	0	0	0	0	0	0	0	
D. cepedianum	0	0	0	8	0	0	0	0	0	100	
Unidentified	100	100	100	92	100	100	100	100	100	0	
Cyprinidae	63	4	5	13	0	10	0	0	0	0	
Centrachidae	0	4	0	0	0	0	0	0	0	0	
Atherinidae	13	0	5	0	0	0	0	0	0	0	
Ictaluridae	13	0	0	0	0	0	0	0	0	0	
Unidentified	0	34	40	33	40	40	25	33	50	0	
Insecta	0	4	0	0	0	0	0	0	0	0	
Chironomidae	0	100	0	0	0	0	0	0	0	0	
larvae	0	0	0	0	0	0	0	0	0	0	
pupae	0	100	0	0	0	0	0	0	0	0	
Diptera (adult)	0	0	0	0	0	0	0	0	0	0	
Ephemeridae	0	0	0	0	0	0	0	0	0	0	
Hexagenia spp.	0	0	0	0	0	0	0	0	0	0	
No. fish with food	4	25	17	18	13	8	4	6	2	1	0
No. of food items	8	27	24	24	15	10	4	6	2	2	0

[a] Length classes (total length in millimeters) are as follows: 2=76-100; 3=101-125; 4=126-150; 5=151-175; 6=176-200; 7=201-225; 8=226-250; 9=251-275; 10=276-300; 11=301-325; 12=326-350.

Table 32. Frequency of occurrence (%) of food items in stomachs of 1985 year class Stizostedion hybrids (YOY) that contained food, grouped by length class.[a]

	1985										
FOOD ITEM	2	3	4	5	6	7	8	9	10	11	12
Pisces	100	100	100	100	100	100	100	100	100	100	
Dorosoma spp.	25	56	44	61	69	50	75	67	50	100	
D. petenense	0	0	0	0	0	0	0	0	0	0	
D. cepedianum	0	0	0	6	0	0	0	0	0	100	
Unidentified	25	56	44	56	69	50	75	67	50	0	
Cyprinidae	25	4	6	6	0	13	0	0	0	0	
Centrachidae	0	4	0	0	0	0	0	0	0	0	
Atherinidae	25	0	6	0	0	0	0	0	0	0	
Ictaluridae	25	0	0	0	0	0	0	0	0	0	
Unidentified	0	36	50	44	46	50	25	33	50	0	
Insecta	0	4	0	0	0	0	0	0	0	0	
Chironomidae	0	4	0	0	0	0	0	0	0	0	
larvae	0	0	0	0	0	0	0	0	0	0	
pupae	0	4	0	0	0	0	0	0	0	0	
Diptera (adult)	0	0	0	0	0	0	0	0	0	0	
Ephemeridae	0	0	0	0	0	0	0	0	0	0	
Hexagenia spp.	0	0	0	0	0	0	0	0	0	0	
No. fish with food	4	25	17	18	13	8	4	6	2	1	0

[a] Length classes (total length in millimeters) are as follows: 2=76-100; 3=101-125; 4=126-150; 5=151-175; 6=176-200; 7=201-225; 8=226-250; 9=251-275; 10=276-300; 11=301-325; 12=326-350.

APPENDIX E

FOOD HABITS OF YEARLING HYBRIDS GROUPED BY LENGTH CLASS

Table 33. Percents of total numbers of food items in stomachs of *Stizostedion* hybrids (1+) from the 1982 year class, grouped by length class.[a]

FOOD ITEM	10	11	12	1983/84 13	14	15	16	17
Pisces				100	100	100	100	100
Dorosoma spp.				33	0	57	0	0
D. petenense				100	0	13	0	0
D. cepedianum				0	0	38	0	0
Unidentified				0	0	59	0	0
Cyprinidae				0	0	0	0	0
Centrachidae				0	0	0	0	0
Atherinidae				0	0	0	0	0
Ictaluridae				0	0	0	0	0
Unidentified				67	100	43	100	100
Insecta				0	0	0	0	0
Chironomidae				0	0	0	0	0
larvae				0	0	0	0	0
pupae				0	0	0	0	0
Diptera (adult)				0	0	0	0	0
Ephemeridae				0	0	0	0	0
Hexagenia spp.				0	0	0	0	0
No. fish with food	0	0	0	3	2	9	1	2
No. of food items	0	0	0	3	2	14	1	2

[a] Length classes (total length in millimeters) are as follows: 10=276-300; 11=301-325; 12=326-350; 13=351-375; 14=376-400; 15=401-425; 16=426-450; 17=451-475.

Table 34. Frequency of occurrence (%) of food items in stomachs of 1982 year class Stizostedion hybrids (1+) that contained food, grouped by length class.[a]

FOOD ITEM	10	11	12	1983/84 13	14	15	16	17
Pisces				100	100	100	100	100
Dorosoma spp.				33	0	67	0	0
D. petenense				33	0	11	0	0
D. cepedianum				0	0	33	0	0
Unidentified				0	0	33	0	0
Cyprinidae				0	0	0	0	0
Centrachidae				0	0	0	0	0
Atherinidae				0	0	0	0	0
Ictaluridae				0	0	0	0	0
Unidentified				67	100	44	100	100
Insecta				0	0	0	0	0
Chironomidae				0	0	0	0	0
larvae				0	0	0	0	0
pupae				0	0	0	0	0
Diptera (adult)				0	0	0	0	0
Ephemeridae				0	0	0	0	0
Hexagenia spp.				0	0	0	0	0
No. fish with food	0	0	0	3	2	9	1	2

[a] Length classes (total length in millimeters) are as follows: 10=276-300; 11=301-325; 12=326-350; 13=351-375; 14=376-400; 15=401-425; 16=426-450; 17=451-475.

Table 35. Percents of total numbers of food items in stomachs of *Stizostedion* hybrids (1+) from the 1983 year class, grouped by length class.[a]

FOOD ITEM	10	11	12	1984/85 13	14	15	16	17
Pisces	0	100	100	85	100	100	100	
Dorosoma spp.	0	100	71	92	80	83	86	
D. petenense	0	0	0	17	3	74	0	
D. cepedianum	0	0	0	16	48	15	50	
Unidentified	0	100	100	67	49	11	50	
Cyprinidae	0	0	0	0	0	0	0	
Centrachidae	0	0	0	0	6	4	0	
Atherinidae	0	0	0	0	0	0	0	
Ictaluridae	0	0	0	0	3	0	0	
Unidentified	0	0	29	8	11	13	14	
Insecta	100	0	0	15	0	0	0	
Chironomidae	47	0	0	100	0	0	0	
larvae	13	0	0	0	0	0	0	
pupae	87	0	0	100	0	0	0	
Diptera (adult)	0	0	0	0	0	0	0	
Ephemeridae	53	0	0	0	0	0	0	
Hexagenia spp.	100	0	0	0	0	0	0	
No. fish with food	2	1	5	8	19	11	3	0
No. of food items	17	1	7	17	36	23	7	0

[a] Length classes (total length in millimeters) are as follows: 10=276-300; 11=301-325; 12=326-350; 13=351-375; 14=376-400; 15=401-425; 16=426-450; 17=451-475.

Table 36. Frequency of occurrence (%) of food items in stomachs of 1983 year class Stizostedion hybrids (1+) that contained food, grouped by length class.[a]

	1984/85							
FOOD ITEM	10	11	12	13	14	15	16	17
Pisces	0	100	100	88	100	100	100	
Dorosoma spp.	0	100	60	75	61	64	100	
D. petenense	0	0	0	13	6	18	0	
D. cepedianum	0	0	0	25	28	27	67	
Unidentified	0	100	60	38	44	18	67	
Cyprinidae	0	0	0	0	0	0	0	
Centrachidae	0	0	0	0	11	9	0	
Atherinidae	0	0	0	0	0	0	0	
Ictaluridae	0	0	0	0	6	0	0	
Unidentified	0	0	40	13	22	27	33	
Insecta	100	0	0	12	0	0	0	
Chironomidae	50	0	0	12	0	0	0	
larvae	50	0	0	0	0	0	0	
pupae	50	0	0	12	0	0	0	
Diptera (adult)	0	0	0	0	0	0	0	
Ephemeridae	50	0	0	0	0	0	0	
Hexagenia spp.	50	0	0	0	0	0	0	
No. fish with food	2	1	5	8	19	11	3	0

[a] Length classes (total length in millimeters) are as follows: 10=276-300; 11=301-325; 12=326-350; 13=351-375; 14=376-400; 15=401-425; 16=426-450; 17=451-475.

Table 37. Percents of total numbers of food items in stomachs of *Stizostedion* hybrids (1+) from the 1984 year class, grouped by length class.[a]

				1985				
FOOD ITEM	10	11	12	13	14	15	16	17
Pisces	100	100	100	100	87	100	100	100
Dorosoma spp.	100	67	72	25	43	62	72	0
D. petenense	0	0	0	0	0	0	0	0
D. cepedianum	0	75	11	100	33	40	60	0
Unidentified	100	25	89	0	67	60	40	0
Cyprinidae	0	0	0	0	0	0	0	0
Centrachidae	0	0	0	0	14	0	14	0
Atherinidae	0	0	0	0	0	0	0	0
Ictaluridae	0	0	0	0	0	0	0	0
Unidentified	0	33	18	75	43	38	14	100
Insecta	0	0	0	0	13	0	0	0
Chironomidae	0	0	0	0	0	0	0	0
larvae	0	0	0	0	0	0	0	0
pupae	0	0	0	0	0	0	0	0
Diptera (adult)	0	0	0	0	0	0	0	0
Ephemeridae	0	0	0	0	100	0	0	0
Hexagenia spp.	0	0	0	0	100	0	0	0
No. fish with food	1	4	10	4	5	5	4	1
No. of food items	1	6	11	4	8	8	7	1

[a] Length classes (total length in millimeters) are as follows: 10=276-300; 11=301-325; 12=326-350; 13=351-375; 14=376-400; 15=401-425; 16=426-450; 17=451-475.

Table 38. Frequency of occurrence (%) of food items in stomachs of 1984 year class Stizostedion hybrids (1+) that contained food, grouped by length class.[a]

FOOD ITEM	10	11	12	1985 13	14	15	16	17
Pisces	100	100	100	100	100	100	100	100
Dorosoma spp.	100	50	80	25	20	80	75	0
D. petenense	0	0	0	0	0	0	0	0
D. cepedianum	0	25	10	25	20	40	50	0
Unidentified	100	25	80	0	20	40	50	0
Cyprinidae	0	0	0	0	0	0	0	0
Centrachidae	0	0	0	0	20	0	25	0
Atherinidae	0	0	0	0	0	0	0	0
Ictaluridae	0	0	0	0	0	0	0	0
Unidentified	0	50	20	75	60	60	25	100
Insecta	0	0	0	0	25	0	0	0
Chironomidae	0	0	0	0	0	0	0	0
larvae	0	0	0	0	0	0	0	0
pupae	0	0	0	0	0	0	0	0
Diptera (adult)	0	0	0	0	0	0	0	0
Ephemeridae	0	0	0	0	25	0	0	0
Hexagenia spp.	0	0	0	0	25	0	0	0
No. fish with food	1	4	10	4	5	5	4	1

[a] Length classes (total length in millimeters) are as follows: 10=276-300; 11=301-325; 12=326-350; 13=351-375; 14=376-400; 15=401-425; 16=426-450; 17=451-475.

VITA

Arnold Gene Woodward was born in Augusta, Georgia, on December 11, 1957. He attended elementary school in that city and graduated from the Academy of Richmond County in June 1975. In June 1980, he received the Bachelor of Science degree from Augusta College, Augusta, Georgia. Mr. Woodward was employed by the Game and Fish Division of the Georgia Department of Natural Resources from June 1981 to September 1984. From October 1984 to June 1987, he attended the University of Tennessee, Knoxville, serving as a graduate research assistant. In June 1987, he received the Master of Science degree in Wildlife and Fisheries Science with major emphasis in fisheries management.

The author is a member of the American Fisheries Society, Beta Beta Beta, Gamma Sigma Delta, the Wildlife Society, the Tennessee Academy of Science, and the North American Benthological Society.

Following graduation, Mr. Woodward was employed by the Tennessee Valley Authority.