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Evaluation of Walleye Introduction In Lake Cumberland

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by

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ABSTRACT

A Lake Cumberland walleye population was restored with annual fingerling stockings (1973-1980) of "northern-strain" walleye following the demise of the original population in the 1950's, presumably due to the newly created impoundment conditions. Walleye stocking was ceased from 1981-1983, during which natural reproduction from headwater spawning runs and/or in-lake spawning occurred in all 3 years. However, the 1981 year class was the only strong year class. Variations in both length and age structure between and among both stocking and non-stocking years indicated that walleye year-class strength was dependent on many other factors other than fish stocking. Lake Cumberland walleye exhibited average growth rates for southern reservoirs, with all year classes achieving legal-size (≥15 in) at age 2+. Walleye fed primarily on clupeids (gizzard and threadfin shad), with emphasis on the smaller-size threadfin shad. The walleye harvest objective of 1 lb/acre or an increase to the total yield by at least 10% was not met and was probably too optimistic considering the oligotrophic state of Lake Cumberland, the average depth (78 ft) of the lake, low exploitation of walleye (<20%), and possible competition with the striped bass. Walleye stockings will be continued at 7 fingerlings/acre, while efforts will be made to improve angler education on walleye fishing techniques.

INTRODUCTION

Walleye (*Stizostedion vitreum*) were native to the upper Cumberland River drainage (Everman 1918). Walleye were collected in stream studies in areas of the Cumberland River prior to impoundment by Wolf Creek dam (Lake Cumberland)(Bernie Carter personal communication). Following impoundment in 1952, a significant headwater walleye fishery developed during spawning runs in the Big South Fork of the Cumberland River, Cumberland River, and Rockcastle River. This fishery was regionally renowned for its trophy status walleye (>12 lb) and produced the state record walleye of 21 lb, 8 oz in 1958. The fishery rapidly declined in the late 1950's and early 1960's due to reportedly the following conditions: lack of suitable spawning sites due to inundation of major shoals by the reservoirs, over-harvest of adult walleye during the spawning season, and pollution by acid coal-mine runoff of the now limited spawning areas.

This same phenomenon of declining walleye fisheries in other portions of their range in the Tennessee, Cumberland, and Roanoke rivers occurred following the formation of impoundments (Hackney and Holbrook 1978). Walleye fisheries were only restored following stocking programs of "northern" stock walleye from New York (Cayuga Lake) or Ohio (Lake Erie). Hackney and Holbrook (1978) theorized these "southern" stocks of walleye were unable to sustain themselves in the lake-type environment.

Kentucky completed construction of its first major fish hatchery, Minor Clark Fish Hatchery, in 1972; one objective was to restore the walleye population in Lake Cumberland (Bernie Carter, personal communication). Walleye fingerling stockings commenced in 1973 and occurred annually through 1980, with numbers ranging from 2.2-26.2 walleye/acre (Table 1). Walleye fry were received from Senacaville National Fish Hatchery, Ohio or produced from broodstock reared from these original fry. All these walleye were the product of Lake Pymatuning broodstock (Lake Erie origin). In 1979 and 1980, some fry were produced by collecting "wild" broodstock from Lake Cumberland and later used to supplement other fingerling stockings.

A federal-aid (Dingell-Johnson) project (F-40: Sport Fisheries Research Subsection I: Sport Fish Investigation) was amended in 1980 to include investigations of the Lake Cumberland walleye population. The goal was to determine the success of previous stockings in developing a self-sustaining or put-grow-take fishery in Lake Cumberland. A harvest objective was later developed to increase the sport fishery yield by at least 10% or 1 lb/acre by the introduction of walleye.

MATERIALS AND METHODS

Three cove-rotenone studies were conducted annually from 1980-1985 with total acreage ranging from 8.3-9.7 acres. Sites were distributed throughout the lake in an attempt to sample at least 1 area in the upper-, mid-, and lower-lake sections (Figure 1). Cove sites in the extreme upper lake were non-existent; the Fishing Creek arm was utilized as the upper station. Locations of the two cove sites in the lower and mid-lake areas were unaltered beginning in 1981; the Fishing Creek site was moved downstream 4 miles in 1982 to a better location. Criteria for cove sites included: approximately 3 acres in surface area, maximum depth of 40 feet (depth of block net), presence of shoreline habitat, and mouth of the 3-acre cove site adjacent to open water. This last criterion was difficult to obtain due to variable summer pool levels; often, 3-acre sites adjacent to open water would exceed the maximum depth limitation of the block net.

Cove-rotenone procedures were similar throughout the study. The cove was blocked prior to 0800 hours on the first day with a 0.5-in mesh block net, and emulsified rotenone (2.5 or 5%) was dispersed via a boat venturi to obtain a rate of 1 ppm. Surfacing fish were dipped for 3 successive days and sorted to both species and inch-groups, with weights of fish gathered on the first day only. Data from the three studies were combined each year and presented as per acre values.

Gill netting was conducted annually in the fall (1980-1987) and spring of 1981 and 1985. Four experimental gill nets, 450-ft long by 8-ft deep and containing three 150 ft panels of 0.75, 1.25, and 1.75- in bar mesh, were fished at standard locations in October beginning in 1982-1987. These same nets were fished in 1980 (3 nets) and 1981 in an attempt to locate good sampling locations. This gear was utilized in conjunction with an ongoing striped bass study in Lake Cumberland; the effectiveness of this gear for walleye was diminished by floating these nets 4 ft from the surface. In 1985, the 150-ft section of 0.75-in mesh was removed from these experimental nets. Monofilament gill nets 75-ft long by 8-ft deep with uniform mesh sizes of 1.5- and 2.0-in, were fished in the spring of 1981 and 1985. One net of each mesh size (2 nets total) was fished for two nights along the rip-rap face of the dam in March 1981. Two nets of each mesh size (4 nets total) were fished for 1 night along the rip-rap of the dam and rocky points near the dam in March

1985. All nets were overnight sets with daily retrieval during the morning hours. All walleye were sexed (when possible), individually measured to the nearest 0.10 in, and weighed to the nearest 0.01 lb. Stomach contents were field identified when possible and enumerated by size range. Scale samples were removed for subsequent age and growth determinations.

Boat-mounted electrofishing gear was employed to sample walleye in headwater tributaries of the lake from 1980-1987. Initially (1980-1984), a 180 Hz, AC Chenault Booster box was used with a 230 volt, 5,000 watt, 3-phase Homelite generator. This equipment was replaced in 1985 with a Smith-Root 5.0 GPP electrofisher in which direct current was always utilized. All walleye collected were measured and weighed and scale samples were removed. Beginning in 1981, effort (time) was recorded and catch-per-unit-effort (CPUE) was described as walleye/hour. Survival estimates were derived by the Robson-Chapman method (Ricker 1975).

Walleye were tagged for a population estimate in 1980-1981 and for angler exploitation in 1980-1982. Legal-size (15 in) walleye were tagged with a Floy DF-68B anchor tag by inserting the "T" end of the tag into the musculature below the soft-rayed dorsal fin. Tags were returned via the mail-in survey data acquisition program (to be discussed). A $5.00 reward was offered for return tags in 1982. A modified Schnabel population estimate (Ricker 1975) was used in the Laurel River arm in 1980, but too few recaptures precluded a population estimate in the Big South Fork. In 1981, a Jolly-Seber analysis for an open population was applied to the Big South Fork walleye population. Computation of the Jolly-Seber analysis was facilitated by computer program (POPAN) by North Carolina State University - Institute of Statistics.

A non-uniform probability creel survey (Pfeiffer 1966) was conducted on the entire lake (1980-1983, 1987) and the lower lake, only (1986). The lake was divided in 1980 into 10 areas of approximately 5,000 acres each and probabilities were assigned based on 1979 aerial pressure counts by project personnel. Area probabilities were adjusted in the spring to reflect a greater percentage of fishing effort in the headwater areas of the lake. The number of areas was increased to 11 in 1981 and 1982, then reduced back to 10 areas in 1983. A description of the areas and their respective probabilities are presented in Table 2. In 1986, only the lower half of Lake Cumberland, encompassing four zones, was surveyed from 2 March 1986 through 28 February 1987. In 1987, the areas and probabilities were seasonally adjusted to better emphasize principal walleye fishing areas of the lake (Table 3).

Each survey week was stratified into 14 half-day periods, with the length of day figured monthly and the mid-day adjusted accordingly. A hired creel clerk sampled the lake on 5 of the possible 14 half-day periods each week, except for the survey in 1987 when two hired clerks worked on 5 days per week. An instantaneous count of anglers was made during a randomly selected 2-hour period during each half-day survey period; anglers were interviewed during the remaining portion of the period.

Prior to data expansion, daily creel information in 1980-1984 had to be summarized on a weekly basis to accommodate an existing Fortran IV computer program. Probabilities for each daily time period was multiplied by the survey area probability to arrive at a total daily probability. Daily probabilities were summed for a total weekly probability that was later utilized by the computer program to expand for monthly and yearly totals. Daily instantaneous pressure counts were averaged for a mean instantaneous count for the week. In 1986, a new statistical analysis system (SAS) program was developed that eliminated any hand calculations with a minor change in data expansion. Pressure values (man-hours) were derived by dividing the product of the instantaneous count and hours in the period by the product of time and area probabilities. Since our time probabilities expand to a weekly pressure value and the survey was conducted 5 days per week, five daily pressure values were then averaged to obtain a weekly pressure count. Weekly catch rates were then applied to this pressure to generate the various catch and harvest figures.

Headwater (only) creel surveys were conducted in 1980 and 1981 during the spring walleye spawning run. The 1980 survey was an access point survey conducted at the following three access sites: ramp at mouth of Laurel River (P = 0.30), Bee Rock ramp on Rockcastle River (P = 0.10), Alum Ford (P = 0.30), and Yamacraw (P = 0.30). Weekdays were assigned equal probabilities (p = 0.12) and each weekend day was assigned the probability of 0.20. A sampling schedule was formulated to include five of the 14 half-day periods each week from 3 February - 12 April. The 1981 survey was modified to a roving creel survey in which the clerk worked 3 half-day periods per week. Laurel River tailwater, Rockcastle River, and main Cumberland River were designated as one area (P = 0.33) and the Big South Fork was the second area (P = 0.66). The Big South Fork was sampled twice weekly and the other area once per week. The 1981 survey was scheduled for 15 February - 28 March.

A statewide voluntary mail-in survey was also used to monitor the relative contribution of annual walleye stockings to the Lake Cumberland walleye fishery. Boat docks, bait shops, country stores, and other establishments along with creel clerks and conservation officers were provided with self-addressed, postage-paid coin envelopes containing a questionnaire. Participating anglers who completed the questionnaire concerning the size, location of catch, method of fishing, etc., and who enclosed a scale sample from harvested walleye were mailed a clutch-back pin resembling a striped bass and a certificate (first fish only). A sub-sample of all walleye scales were read annually to assign a year class. Back-calculated lengths were not used due to variability among anglers in measuring their catch.

Larval tows were made in 1981 with half-meter nets to locate areas where walleye reproduction was occurring. Average walleye incubation time was coordinated with hatchery personnel and subsurface larval tows were attempted on April 7 and 17. Multiple tows were made in the Big South Fork (Alum Ford area), main Cumberland River (above Laurel River confluence), and along the riprap of Wolf Creek dam. River sampling was conducted in areas near the Lake Cumberland backwater and varying types of habitat, i.e. mid-river, inside bends, outside bends, and over previous shoal areas where walleye were collected.

DESCRIPTION OF THE AREA

Lake Cumberland is a 50,250-acre (summer pool) multi-purpose impoundment built on the upper Cumberland River in 1950 by the U.S. Army Corps of Engineers. The lake is also operated for hydroelectric power production and is equipped with six 45,000 KW electric power generators. Lake volumes between elevations

723-675 (msl) are allocated to power production, thus contributing to the annual 50-foot fluctuation. The average depth of 80 feet is the deepest average depth of all lakes in the state and accounts for the relatively high hydraulic residence time of approximately 215 days.

Lake Cumberland is a warm, monomictic lake which is stratified between April and November, but contains a well-oxygenated hypolmnion. Kentucky Division of Water (1984) rates Lake Cumberland in the upper end of the oligotrophic state using the Carlson Trophic State Index for chlorophyll-a. A water quality report by the U.S. Corps of Engineers (1976) found Lake Cumberland to have high water quality but to be phosphorus limited in regard to productivity.

The lower lake primarily lies in the Highland Rim physiographic region which is characterized by rolling hills, rough, precipitous terrain with wide bottoms bordering streams, while the upper lake enters the Cumberland plateau or Eastern Coal Field physiographic region which is characterized by dissected hills and low mountains. The lower lake contains large embayment-type habitat with considerably greater shoreline development than the upper lake, which is more riverine in appearance with very little inundated floodplain. Most of the watershed use is publically-owned forested land (55%) as opposed to only 21% that is in agricultural use.

RESULTS

A total of 2,038 walleye were collected from all methods of walleye sampling in 1980-1987 in which lengths were obtained. Walleye collected during the spring spawning season were externally sexed by genital palpation of the abdominal cavity for milt or eggs, while fall gill netted walleye were dissected for sex determinations. The overall sex ratio during the spring sampling was 14 males to every female walleye discounting an additional 38 walleye that could not be sexed due to immaturity. The average-size male walleye collected in the spring was 18.6 in (2.16 lb), while female walleye were significantly larger at 24.0 in (6.43 lb) (Figures 2 and 3). Male walleye were sexually mature by age 1+ or at a length within the 14-inch class. The smallest sexually mature female was 19.0 in (2.10 lb), which was age 3+; but, mature females were older and larger walleye. A pooled sample (N = 1572) of male and female walleye was used to develop the length-weight regression: $W = 0.361L - 4.395$. Male and female length-weight relationships were not statistically tested since the majority of walleye were collected during the spawning season, which influenced their weights due to gonadal development.

Growth data for Lake Cumberland walleye based on scale readings are presented in Table 4. Linear growth rates were rapid during the first few years of life, with walleye achieving the legal-size of 15 in at age 2+. Based on examination of 95 confidence limits for mean back-calculated growth of age, female walleye grew significantly faster than male walleye (Tables 5 and 6). Also, female walleye attained a larger maximum size than male walleye.

Population Dynamics

The original intention in 1980 was to obtain walleye population estimates in the major spawning tributaries of Lake Cumberland. Traditionally, native walleye had spawned in the Rockcastle, Big South Fork, and Cumberland rivers (see Figure 1) following impoundment of Lake Cumberland in the early 1950's. One year after walleye stockings were initiated in Lake Cumberland in 1973, Laurel River Lake was impounded in 1974. Only about 1 mile of backwater from Lake Cumberland was created in the Laurel River arm but the hydropower discharge from the dam apparently attracts walleye from the main Cumberland River during the spawning run. Successful walleye broodstock collections were made in this tributary in 1979 prior to this survey. Water temperatures were consistently <47°F in the Laurel River arm; during the spawning run whereas temperatures ranged from 44-55°F in the Big South Fork during the walleye spawning run at the same time.

Walleye sampling attempts in the Rockcastle River in 1980 and 1981 were unsuccessful. In 1980, electrofishing boats and gill nets were used on two occasions below the "narrows" and no walleye were collected. In 1981, an electrofishing run was initiated by traveling upstream from London Dock to free-flowing sections of the Rockcastle River (below the narrows). Several pool-riffle types of habitat were fished with sampling gear, with no walleye being observed. The Rockcastle River was then eliminated as a sample site despite some isolated reports of walleye being caught by anglers in areas near the "narrows" and many miles upstream near the Jackson County line.

In 1980, a walleye population estimate could only be generated in the Laurel River tributary. The Cumberland River remained high and muddy during the walleye spawning season that precluded any sampling attempts. A total of 166 legal-size walleye were tagged in the Big South Fork, but a population estimate could not be generated as only 4 walleye were recaptured despite 7 nights of a mark-recapture survey. A total of 186 walleye were tagged in the

Laurel River arm during March 18 to April 10; generally, walleye were most successfully sampled nocturnally immediately after hydropower generation ceased. A modified Schnabel population estimate (95% confidence limits) was calculated at 470 (348-632) walleye, with most of these fish being males (8.8:1; male:female ratio).

Mark-recapture in 1981 was limited to the Big South Fork. Only one walleye was successfully tagged in the Laurel River due to low use of this tributary by spawning walleye. Apparently, more favorable conditions of less turbid water than in 1980 existed in the Cumberland River to attract walleye and harvest reports received from the main Cumberland River confirmed this assumption. Only one electrofishing attempt was made in 1981 to sample walleye in the main Cumberland River. The swift, semi-turbid, deep-water conditions precluded any capture of walleye. A total of 314 walleye were tagged during 6 nights of electrofishing the Big South Fork in March 1981. The Jolly-Seber population model was used to allow for emigration (termed survival in this model) and immigration (termed births in this model) into the spawning area by sexually mature walleye. Sampling effort cannot appreciably be measured in the Big South Fork due to direct conflict with sport fishermen during the walleye spawning run; therefore, it is impractical to obtain a reliable population estimate. Table 7 is a summary of the mark-recapture history of the tagged walleye during the 6 nights of sampling. Data analysis is summarized in Table 8, which shows no population estimate for sampling nights 1 and 6 due to the lack of comparative marking information on those days. The population size increased to a size of 1,682 walleye on day 5, with a large standard error (897). The survival estimates were high, implying that few walleye were leaving the spawning grounds once they arrived. However, the birth estimates were also large, indicating a constant ingress of new potential spawners. In retrospect, our sampling ceased just as the population was peaking and valid estimates with low standard errors could only be achieved by increasing our effort on both individual days and numbers of days sampled (Dr. Ken Pollack, North Carolina State University, personal communication).

In 1981, our goal of estimating the total lake walleye population size by mark-recapture methods in the headwaters alone become unrealistic. On 11-12 March 1981, a total of 50 walleye (Table 9) were sampled near the dam during simultaneous spawning runs in the headwaters (100 miles upstream). Also, numerous reports were received of large schools of walleye feeding in mid-March in the warmwater power plant effluent entering the lake near Burnside (20+ miles from the headwaters). This was the first direct evidence that possible subpopulations of walleye exist in Lake Cumberland; there were both headwater (river) and lake spawning walleye. In summary, walleye population estimates in the headwaters were impossible to derive due to sampling conditions and conflicts with anglers; estimates could not be extrapolated for the whole lake due to extensive utilization of the reservoir by walleye.

Electrofishing was continued in the Big South Fork from 1982-1987 following the aborted population estimates in 1981 and 1982. Also, the Laurel River arm was only effectively sampled one more time in 1984 to collect broodstock (see Table 10 for Laurel River walleye length frequency). Length frequency for Big South Fork walleye from 1980-1987 is portrayed in Figure 4 and empirical data are listed in Table 11. The length distribution was generally unimodal, peaking in the 15-18 in range. The distribution was strongly influenced by size range of the male walleye since the male to female ratio for all years was approximately 14:1. The average-size male walleye varied from 17.5 in (1986) to 19.0 (1981) in. The average-size female walleye ranged from 22.0 in (1980) to 24.5 in (1982). Stock (10 in) to quality size (15 in) walleye were not available for capture during the spawning run; therefore, a proportional stock density (PSD) could not be calculated. However, a percentage of the walleye population between the minimum preferred size (20 in) and memorable size (25 in) was calculated for each year. There was a significant increase in the percentage of walleye in preferred-memorable size range (20-25 in) in 1981-1983 and a complimentary decrease in the quality-preferred size range (15-20 in) (Figures 5 and 6). This change in size structure corresponded to the 3 years (1981-1983) of non-stocking. However, a Kolmogoro-Smirnov test revealed no significant difference ($0.20 \leq p \leq 0.10$) between the size structures (percent by inch class) sampled in 1981 and 1985. The size structure in 1985 was used to reflect the size distribution following the 3 years of non-stocking (1981-1983) prior to recruitment of the 1984 (stocking year) year class.

The age distribution of walleye collected in the Big South Fork from 1981-1987 are graphically portrayed in Figure 7. Generally, age 3 and 4 walleye were dominant in the samples except for 1982 and 1986 when age 5 and age 2 walleye were dominant, respectively. The strength of the 1977 year class extended for 3 years (1981-1983) in this sampling period. The 1981 year class (non-stocking year) recruited into the fishery in 1983 and remained dominant from 1984-1985. The next strong year class did not appear until 1986 when the 1984 year class recruited. Stocking resumed in 1984; however, the contribution of the stocking cannot be separated from the impact of natural reproduction also occurring. Age distribution was further examined by percent of catch by age and CPUE by age through time in Figures 8 and 9, respectively. As a percent of the catch, the relative strength of the 1981 year class was superior to both the other non-stocking years of 1982 and 1983. Also, the strength of the 1984 year class is well expressed at both age 3 and 4, while the 1977 year class for both ages 3 and 4 was the dominant percentage through time. The CPUE data was the best data available for relative density of these age classes but these data were strongly dependent upon yearly sampling conditions; i.e. flow, turbidity, location of lake backwater, etc. Also, CPUE data was not available for 1980. CPUE data compliments percentage data for age 2 walleye but conflicts for age 3 and 4 walleye. The catch rates for the 1980 and 1984 year classes (stocking years) as age 3 fish exceeded the catch rate for year classes 1981-1983 (non-stocking years).

The relative strength of the 1980 year class displayed as age 3 fish did not continue for this year class as age 4 fish. Examination of age 4 CPUE data revealed the 1981 year class to be superior to all other year classes and the 1982 and 1983 year classes closely resembled the 1977 year class. This would indicate that the 1982 and 1983 year classes (non-stocking years) were equivalent to the 1977 year class (stocked year class) which had previously represented a higher percentage of the population in other comparisons. This discrepancy could be related to poor record keeping of electrofishing time in 1981 since automatic timers were not available with electrofishing booster boxes at that time. Also, at the end of the study, sampling efficiency vastly improved and electrofishing time in unproductive areas was minimized; thus catch rates would be affected by this dilution of effort.

Table 12 summarizes the CPUE data by year class and totals on a yearly basis. The best yearly catch rate (117 walleye/hour) was in 1986 and was a product of the strong 1984 year class (51 walleye/hour). Yearly catch rates were lowest in 1984 (28 walleye/hour) and 1982 (29 walleye/hour). The 1982 catch rate was most influenced by the poor year-class strength of both the 1978 and 1979 year classes and possibly the incomplete recruitment of the 1980 year class to the fishery. CPUE for 1984 could theoretically be impacted by the non-stocking years of 1981 and 1982, but the 1981 year class was strong when examined by other comparisons. Field notes revealed the sampling location utilized in 1984 was a deeper area that negatively influenced the overall catch rate of all year classes. Disregarding walleye ages and year of captures, the 1981 year class (93 walleye/hour) exhibited the best overall catch rate followed by 1984 (75 walleye/hour), 1980 (53 walleye/hour), 1977 (48 fish/hour) and 1982 (43 walleye/hour) year classes. Annual survival rates based on CPUE data for years 1984-1987 varied from 0.34 to 0.49.

Gill netting

Table 13 summarizes the CPUE for walleye from 1980-1988 from experimental gill netting. These nets were floated approximately 4 ft from the surface in conjunction with a striped bass study; however, the results can be used comparatively since the same locations were similar each year. Total CPUE displayed a downward trend from 1980-1985, although the catch of age 0+ walleye was negatively impacted by removal of the smaller mesh panel of the experimental nets in 1985. The 1977 year class dominated the CPUE followed by the 1981 and 1984 year classes. Netting sample sites were stratified into a lower lake and mid-lake zones. The lower lake netting sites consistently caught the most walleye except for 1984 when equal numbers were caught between the two zones. Catch was also affected by water temperatures; it was felt better results were obtained in late October following de-stratification of the lake.

In March 1985, gill netting for walleye broodstock along the dam and rocky points produced 46 walleye (Table 9). These nets were set at dark and pulled at 1:00 am, but they were bottom sets of 4 nets at 75 ft in length. This type of gear and set was superior to the October experimental gill netting, but similar results were produced with these nets when fished similarly in late October. Most (74%) of the walleye captured in March 1985 were representatives of the 1981 year class.

Exploitation

Exploitation was obtained from 1980-1982 based on angler returns of tagged walleye. In 1980 and 1981, walleye were tagged in conjunction with the mark-recapture population estimates, while the 1982 tagging was specific for estimating the exploitation rate. Size range for tagged walleye for years 1980-1982 are given in Figures 10 to 12. Exploitation rates were very similar in 1980 (9%) and 1981 (10.5%) but doubled to 20% in 1982. The results in 1982 were felt to be more realistic since this was the only year a monetary reward was offered. The average (range) number of days prior to harvest for each year (1980-1982) was as follows: 38.6 (1-140), 47.1 (4-233), and 42.1 (4-133), respectively. Many of the walleye were harvested in the headwaters, but there was a trend in downstream movement and harvest from April through June.

Food Habits

Stomach contents from walleye were examined primarily from fall gill netting captures, since spring walleye from spring electrofishing samples were not sacrificed. A total of 203 walleye stomachs were examined during the survey period, but too few stomachs were available to make annual comparisons. Data were pooled and stratified by age groups and presented as percent frequency of occurrence (Figure 13). The dominant food item that could be identified was consistently shad for all age groups. There was a gradual shift toward consuming larger shad as walleye became older. Fish that could be identified as threadfin shad were very important components of the diets of age 0+ and age 1+ walleye and more important if categories of other shad (not identified as to species) are combined with the threadfin shad group. Brook silverside and other minnows were occasionally identified in stomachs of most age groups of walleye. Interestingly, one 6-inch walleye was collected in an age 4 walleye stomach.

Sauger

A sauger population co-exists in Lake Cumberland and sauger were often encountered during spring walleye sampling. Anglers claimed that sauger migrated upstream prior to the walleye and their numbers were well diluted during the walleye spawning run. All sauger numbers and lengths were not actively recorded; however, available data are presented in Table 14. The modal length was the 13-inch class, with only two sauger exceeding 17 inches in length. Also, field notes revealed several walleye x sauger hybrids were sampled in 1980-1981, yet no hybrids were encountered during the last four years of the survey.

Fish Population Studies

The total fish standing crop at Lake Cumberland ranged from 100 to 275 lb/acre (Table 15); the mean standing crop was 181 lb/acre. Forage fish standing crop values ranged from 30-68% (40-128 lb/acre) of the total standing crop; therefore, change in forage fish populations primarily influenced the annual fluctuations in total standing crop. Forage species in Lake Cumberland were primarily gizzard and threadfin shad, with threadfin shad biomass comprising a maximum of 30 lb/acre (1981) and a minimum of 0.8 lb/acre (1984).

Cove-rotenone studies were relatively ineffective in sampling the fish population in Lake Cumberland since it is a very deep, clear lake. Adequate cove sites in which the block net could be set at or near the mouth of the cove were non-existent due to maximum depths generally exceeding 50 feet. Sonar-graph recording indicated that most of the forage fish were suspended near points at the mouth of coves - outside of the study sites. Therefore, the forage fish biomass estimates are not felt to be very reliable trend data. Schools of fish, i.e., white crappie and paddlefish (1980) and white bass (1985), also biased the total standing crop values for those years.

Black basses were comprised of largemouth, spotted, and smallmouth bass (Table 16). Smallmouth bass numbers and biomass were low since only 1 of 3 coves was located in the lower lake where smallmouth bass habitat is more abundant.

Good spawns of both largemouth and spotted bass were evident every year and 6-year averages were similar, 104 and 115 fingerlings/acre; respectively. There was no discernible relationship between yoy production and numbers of intermediate-size spotted or largemouth bass the following year. Although largemouth bass is the dominant black bass species, intermediate-size spotted bass numbers generally surpassed numbers of intermediate-size largemouth bass. This same phenomenon was seen in the 1986 creel survey in which a disproportionately large number of intermediate-size spotted bass compared to largemouth bass were caught and released below the size limit (12 in). Generally, one or less harvestable-size spotted bass per acre was sampled in the cove-rotenone studies. Average percent of the total black bass biomass for each species were as follows: largemouth bass (54.1%), spotted bass (35.7%), and smallmouth bass (10.1%).

Other principal game fishes collected in cove-rotenone studies were white bass, both black and white crappie, walleye, and an occasional fingerling or intermediate-size striped bass. Cove-rotenone sampling was also relatively ineffective in sampling these species and generally only yearling (0-4 in) and intermediate-size (5-14 in) walleye were collected in the coves. Based on cove rotenone data, the walleye standing crop was highest in 1981 (1.41 lb/acre) and lowest in 1983 (0.10 lb/acre). Walleye yearlings collected on a per acre basis from 1980-1985 were as follows: 4.5, 13.1, 0.33, 3.3, 5.7, 0.96. The largest number (13.1 fish/acre) of walleye fingerlings was collected in 1981, a non-stocking year; the lowest number (0.33 fish/acre) was a non-stocking (1982) year also. If cove-rotenone data is a good indicator of walleye yoy production, then in 1985 a total of 0.96 yoy walleye/acre should represent a poor walleye year class despite our stocking efforts.

The available prey-predator (AP/P) model (Jenkins and Morias 1977) was utilized to analyze cove-rotenone data for deficiencies in prey. Data were adjusted for open water based on the Douglas Lake rotenone study (Hayne et al 1967). Plots of the yearly data are presented in Figure 14. The straight diagonal line in the graph is the theoretical desirable ration of 1:1 in which there is sufficient available prey for every inch group of predators; therefore, all points lying above this line imply there is sufficient prey available for a given size predator.

Declines in the available prey, as indicated by the plots near or below the desirable diagonal line in 1983-1985, were primarily influenced by declines in numbers of intermediate-size gizzard shad. Numbers of intermediate-size gizzard shad are naturally influenced by spawning success the previous year. therefore, a plot of yearling gizzard shad numbers versus reservoir inflow values for May has been reported (Figure 15). These values had a high correlation coefficient (r=0.95) if 1981 data was omitted (r=0.32 with 1981 data), indicating spring water levels influenced the prey spawning success. Reasons for the non-conformity of the 1981 data cannot be explained except that averaging of monthly inflows possibly masked conditions during the peak spawning period. Low numbers of intermediate-size gizzard shad in 1983 can be explained by the low water conditions and poor spawn in 1982. An adequate gizzard shad spawn was observed in 1983; however, their survival was possibly influenced by the record duration of sub-freezing temperature and a partial freeze of Lake Cumberland in the winter of 1983-1984. Contrarily, there was a good spawn of gizzard shad in 1984 and a mild winter in 1984-1985, dismissing environmental factors as possible explanations for depressed numbers of intermediate-size gizzard shad in 1985.

Larval tows

Larval tows were only made between 5-7 April 1981, with no walleye larvae sampled. Tows were made in the Cumberland River and the Big South Fork in backwater sections of the lake where walleye were suspected to drift. Also, the riprap face of the dam was sampled on two occasions, to correlate tows with walleye hatching times based on water temperatures. This sampling was discontinued since time required for this type of labor-intensive sampling was not available.

Harvest

The estimated total fish harvest when the entire lake was surveyed from 1980-1983 and 1988 varied from 734,395 fish (17 fish/acre) in 1980 to 161,209 fish (3.7 fish/acre) in 1988 (Table 17). The total yield (lb) varied from 380,414 lb (8.9lb/acre) in 1980 to 105,655 lb (2.4 lb/acre) in 1981 but only varied from 4.0-5.1 lb/acre droping the last 4 years creeled. The year (1988) of low total harvest in number failed to correspond to the year (1981) of low yield in pounds due to the increased striped bass biomass harvested in 1988 and their large average weight. The mean annual harvest rate was 0.62 fish/hour and ranged from 0.26 fish/hour (1988) to 0.92 fish/hour (1981). Groups of fish dominating the harvest by weight were crappie (38.7%), black bass (18.2%), white bass (14.6%), striped bass (11.6%), sunfish (5.7%), and walleye (4.6%). Total pressure and harvest by weight and harvest of each of the major fish groups drastically declined from 1980 to 1981 but significantly increased again in 1982. Major fish groups shifted in their abundance in the creel; however, striped bass numbers consistently increased while crappie numbers have declined since 1982. The striped bass fishery has yielded a low of 0.02 lb/acre (1981) to 2.56 lb/acre in 1988. It should be noted the 1988 creel survey was confined to the main lake beginning in late May and major tributaries were not creeled. This survey was designed to maximum creel effort in areas of walleye harvest, which negatively impacted harvest data of some species, particularly crappie. However, disregarding the 1988 data, there has been a downward trend in the crappie harvest in Lake Cumberland.

Headwater creel surveys were conducted in 1980 and 1981 to estimate the walleye harvest during the spring spawning run. The estimated walleye harvest in 1980 and 1981 was 375 and 55, respectively (Tables 18 and 19). Other species dominant in the creel were crappie, sauger, and white bass. Walleye harvest was considered a drastic underestimate due mainly to survey design in both years.

Walleye harvest, harvest rate, and average size of fish creeled was the highest in 1980 among the years when the total lake was surveyed. The next best year for walleye harvest and harvest rate was in 1988 (Table 20). Fishing pressure for walleye remained low ($\leq$1 man-hour/acre) throughout the survey period. The 1988 creel survey was considered the best survey design for estimating walleye harvest and was the only year two creel clerks were also hired to survey the lake. However, the walleye harvest by weight (0.29 lb/acre) and % addition to the total fish yield (6.6%) failed to meet our harvest objectives of 1 lb/acre or $\geq$10% addition to the yield in 1988. May was the best fishing month (35.5%) for walleye and harvest from April through

July constituted 88% of yearly walleye harvest (Table 21). The age distribution of the catch in 1987-88 indicated the 1984 and 1985 year classes (Age 3 and 4) dominated the harvest (Table 22). Other important year classes in the limited creel survey years were 1983, 1980, and 1979, in that order. Age distribution information was not collected during the best walleye harvest year (1980); however, the average-size walleye (20.5 in) corresponded to the length range of age 3+ walleye or the 1977 year class. Since creel surveys were not conducted annually, year class strength of the walleye harvest cannot be equally compared among creel survey years. Overall, age 3+ walleye were the most frequently (48%) harvested age group of walleye and, collectively, age 2-4 walleye comprised 92% of the total walleye harvest. The mode of the length distribution for harvested walleye in 1988 was 17-18 inches in length and ranged in size from 15-30 inches (Figure 16). Only 1 walleye in the harvestable-size range was released in 1988.

Data from the 1988 creel survey was used to characterize miscellaneous characteristics of Lake Cumberland fishery. Most anglers are resident (85%) males (87%), who cast (47%) from a boat (86%). As previously stated, most of the walleye fishery is confined to a 4-month segment of the year. Walleye anglers in the headwaters will still fish with minnows, cast small jigs, or troll small deep-running crankbaits. Walleye anglers slowly troll (generally late evening) shoreline areas of the lake with deep running crankbaits or live nightcrawler rigs with baitwalkers. Jigs and crank baits were productive in catching walleye when fishing main-lake points. Most of the fishing activity occurs prior to thermal stratification; once the epiliminion warms, the walleye fishery shifts to night-time "under the lights". No estimate of the night-time fishery has been attempted; however, most are caught incidentally by white bass fishermen.

Mail-In Survey Returns

Walleye returns on the voluntary mail-in survey drastically decreased beginning in 1984 (Figure 17). This decrease cannot be solely related to a decline in harvest since there was a obvious decline in return numbers due to angler apathy. However this downward trend began following the 3-year lapse of no walleye stocking. Based on percent return by year class, the 1981-1983 year classes were the lowest overall returns except for 1985, which had not fully recruited to the fishery before the survey was terminated (Table 23). The dominant year class in the mail-in survey was 1977 followed by 1980 and 1979. Since this survey had higher returns during the first 4 years, these percentages were skewed toward the older year classes. Four years of returns were also examined for a monthly breakdown of harvest (Table 24). June (32.5%) was the best month overall for walleye harvest and followed by May and April. A total of 77% of the walleye harvest occurred between March-June. Finally, anglers were asked on the return questionnaire to list the area of the lake they harvested their walleye. Location specific information was difficult to obtain but some harvest patterns were learned. Approximately 40% of the returns were received from the headwater tributaries of the lake while another 22% were returned from the main lake approximately below Camp Earl Wallace. Beaver Creek (12%) was the only other major area of harvest that was delineated.

DISCUSSION

The objective of restoring a walleye population in Lake Cumberland was accomplished by multi-year stockings of "northern strain" walleye. All year classes were sampled by at least one of several methods and natural reproduction was documented in the 3-year lapse (1981-1983) of no stocking. Walleye spawning runs were made into the Big South Fork, Cumberland, and Laurel River arms of the lake; however, the contribution of natural reproduction in these tributaries was not measured. Circumstantial evidence indicated that walleye spawning may also be occurring on wind-swept rocky points and along the riprap of the dam.

Growth of Lake Cumberland walleye exceeded growth of walleye in northern reservoirs, and was slightly less than the average for southern reservoirs combined by Carlander (1989) (Table 25). Growth of Lake Cumberland was slower than Dale Hollow Lake and Lake Meredith, Texas walleye (age 1-3), but exceeded walleye growth for Summersville Reservoir, WV. By age 4, Lake Cumberland walleye growth was comparable to most of the selected water bodies. Growth differences from walleye in more southern waters are typical presumably due to a longer growing season. Also, the observed sexual dimorphism in growth rates is common throughout the walleye's range (Ney 1978). Also, the earlier maturity of male versus female walleye is common among walleye populations and differences in sexual maturity ages are related to water temperatures and available food (Colby et al 1979). Scott and Crossman (1973) reported male walleye generally mature at 2-4 years of age and females at 3-6 years of age which is comparable to Lake Cumberland walleye.

Growth of Lake Cumberland walleye was positively impacted by the presence of the clupeid forage base. Gizzard shad was the dominant food item in walleye stomachs in Canton Reservoir (Henderson 1971), and Caeser Lake, Ohio (Hurley and Austin 1988). Generally, good walleye populations in northern areas of their range feed on yellow perch, but most authors consider this to be related to availability and not preference. However, Hepworth and Gloss (1976) documented a dramatic shift from centrarchids to threadfin shad in the diet of walleye in Lake Powell following threadfin shad introduction. The pelagic nature of threadfin shad created more spatial overlap than existed with the more littoral-oriented centrachids. Threadfin shad numerically comprised 93% of the walleye diet in El Capitan Reservoir, California (Miller 1967) and was the dominant food item in Dale Hollow Lake walleye (Libbey 1969) and age 2+ walleye in Canyon Lake Arizona (Holanov and Tash 1977). The presence of threadfin shad in Lake Cumberland and other lakes with walleye populations probably prevents severe prey deficiencies late in the growing season. Tisa (1988) modeled the ingestibility limits and cohort production of gizzard shad and determined age 0 gizzard shad are largely invulnerable to first-year striped bass, walleye, and largemouth bass in Smith Mountain Lake. The presence of alewives in Smith Mountain lake, which spawn later and grow slower, ameliorated this prey deficiency during the first year of life for walleye. Age 1 walleye principally relied on energy reservoirs (fat deposits) prior to the gizzard shad and alewife spawn, the following year, since even same-age alewives outgrew the ingestability limits of the walleyes. This same analysis has not been performed on threadfin shad and walleye in Lake Cumberland; however, the maximum size of threadfin shad is generally considered smaller than alewives. Therefore, severe prey deficiencies based on morphological parameters probably do not occur for Lake Cumberland walleye, but the threadfin shad prey base remains vulnerable to a possible winter kill.

Also, this prey base is vitally important to many other major predators in Lake Cumberland, i.e. striped bass, black bass, white bass, crappie, etc.

Walleye population estimates on the headwaters were unsuccessful. Measurements of relative density were limited to electrofishing CPUE. Population levels encountered at the beginning of this survey were considered the product of the initial multi-year stocking (1973-1980). There was no statistical difference in the size structure in 1985 following a 3-year lapse of no stocking (1981-1983); however, there was a noticeable decrease in the percentage of walleye in the 15-20 inch length range. The overall catch rate in the Big South Fork was also lowest (28 walleye/hour) in 1984 following this lapse. The highest overall CPUE was observed in 1986 following the recruitment of the 1984 year class which was the second best overall year class based on CPUE. Stocking resumed in 1984 although the impact of natural reproduction could not be separated from the stocked walleye. The 1981 year class exhibited the best overall CPUE by year class, indicating that natural reproduction was also a significant contributor to the total walleye population. The highest stocking density occurred in 1980 (26 walleye/acre), but the CPUE for this year class was surpassed by the 1981 year class and nearly co-equaled by the 1977 (stocked at 7 walleye/acre) and 1982 year classes (non-stocking year).

This fluctuation in year class strength between stocking and non-stocking years demonstrated that recruitment is dictated by many other variables other than stocking density. Year class strength of walleye in 1978 and 1979 were relatively low and are possibly related to massive threadfin shad dieoffs in the winters of 1977 and 1978 in Lake Cumberland. The 1985 yoy survival was extremely low based on cove-rotenone data but was prominent in the 1988 creel harvest.

In general, poorer year classes of walleye were observed in 1980 (stocking year), 1982 (non-stocking year) and 1985 (stocking year) independent of stocking and/or stocking numbers. These years corresponded to years of low spring inflows and a concomitant poor spawn of gizzard shad. The role of threadfin shad and the early life history of walleye is not understood, but the timing of walleye stocking does not always match the walleye fingerlings conversion to a fish diet (Hurley and Austin 1984). Low flow years translate to a lower nutrient input (Aggus 1979), which impacts energy flow up the food chain, including the necessary zooplankton and other invertebrates necessary for walleye in this transitional period. Moser (1987) similarly reported the number of yoy walleye was not related to stocking density in small reservoirs in Kansas. Significant positive correlations were found between lake level and walleye year-class strength in three of four lakes in Voyagers National Park (Kallemeym 1987); Ney (1978) reported extreme fluctuations (10-50 fold) in natural percid populations. The independent variables of wind velocity, air temperature, and forage fish abundance accounted for 89% of the variation associated with walleye natural reproduction in Lake Sharp (Nelson and Walburg 1977). Other factors identified in the literature as influencing year-class strength include: low storage ratios (<1.0) and spillway loss during high discharges (Willis and Stephen 1987), (Jernejcic 1986), black bass predation (Hurley and Austin 1985), bluegill predation on eggs (Chevalier 1973), cannabilism (Forney 1974), timing of walleye stocking with gizzard shad spawn (Momot 1977), (Jester 1972) water-level fluctuations (Erickson and Stevenson 1972), and thermal and wind conditions during the spawning period (Koonce

1977).

The Lake Cumberland walleye population was re-established with fingerling (1-1.5 in) walleye stockings. However, many walleye populations have been established by initial-fry stockings and many others are maintained via fry stockings (Klingbriel 1969). Larrman (1978) recommended a maintenance stocking program in reservoirs where natural reproduction is low. Natural reproduction was documented in all 3 years of no stocking in Lake Cumberland; yet only one strong year class was produced. The questions remains if supplemental stocking would have impacted the year-class strength in the remaining 2 years. A total of 67% of the walleye year class strength was due to fingerling stockings versus natural reproduction in Claytor Lake when a genetic marker was utilized (Murphy et. al. 1983). Some states elect to stock only on alternate years (Puttman and Weber 1980) or every third year (Holanov and Tash 1977). Also, there is considerable disagreement regarding the merits of fry versus fingerling stockings. A review of walleye stocking among midwestern states revealed all states except Ohio (fry only) utilize a combination of fry and fingerling stockings to maintain walleye populations. All of these states have more walleye lakes than Kentucky and hatchery space and economics dictate limits to their walleye fingerling availability. Generally, most states will utilize fry stocking and revert to fingerling stockings if fry stockings fail, and use fingerlings in lakes that are given priority. A formal evaluation using genetic markers of simultaneous stockings of fry, 2-in, and 4-in fingerlings has been initiated in two Missouri reservoirs; results indicate the stocking of 2-inch walleye comprised the majority (69-78%) of the returned fish in subsequent sampling (Jeff Koppelman, personal communication MO Department of Conservation). Also, Illinois has conducted research with fin-clipped fingerlings and determined 20-60 times better survival of fingerling versus fry stockings in reservoirs (Jimmy Waddell, personal communication, Jimmy Waddell, Southern Illinois University).

Numbers of fingerling walleye stocked in Lake Cumberland from 1973-1980 (2.2-26.2 fingerlings/acre) were based primarily on availability. Following the 3-year lapse of non-stocking (1981-1983), the stocking rate was stabilized at 7 fingerlings/acre in 1984-1986. This rate was arbitrarily derived from the 1977 stocking rate (7 fingerlings/acre) that produced a very strong year class and created a substantial fishery in 1980. Numbers of fingerling stocked increased again in 1987-1989 (12.2-19.8 fingerlings/acre) due to hatchery surplus following all other lakes' stockings. Other state's policy on walleye fingerling stockings range from 10-100 fingerlings/acre with satisfactory results reported at 10 and 20 fingerlings/acre in Iowa and Nebraska, respectively (personal communication, North Central Division American Fisheries Society, Walleye Technical Committee). As previously mentioned, the highest stocking rate in Lake Cumberland (26 fingerlings/acre - 1980) failed to produce a strong year class.

The end point of any sport fish stocking program is the return in the creel. Walleye are highly-prized food fish and are not renowned for their sporting quality; therefore, catch and release of this species is less common than many other sport fish. In terms of yield (lb/acre), the highest walleye return occurred in 1980 (0.55 lb/acre), but failed to meet our harvest objective of 1 lb/acre or a 10% increase in the total yield. In 1988, walleye contributed a 6.6% increase to the yield. This objective may have been optimistic since the average annual yield of about 0.3 lb/acre was reported from selected southern reservoirs (Pritchard et. al. 1977). Also, the predicted harvest from Lake Cumberland was 0.35 lb/acre based on a multiple regression equation for predicting walleye harvest in cool and cold-water reservoirs in the United States (Aggus and Bruen 1982). This equation only incorporated the independent environmental variables of storage ratio, growing season, and shoreline development which only accounted from 32% of the variation in harvest observed in other reservoirs. However, high yields have been reported from some individual southern reservoirs: Lake Burton, Ga (2.19 lb/acre), Blue Ridge Lake, Ga (1.28 lb/acre) and Lake Watauga, Tn (5.99 lb/acre) (Weaver 1985). The harvest at Lake Cumberland may be much higher since the contribution of the night fishery has not been quantified. Beisser (1979) reported 42% of the total walleye harvest in lake Blue Ridge, Ga occurred at night. The harvest objective is probably more limited at Lake Cumberland by the low exploitation (<20%). The fishery is short-lived (approximately 4 months) in the spring and overlaps with many other major sport fisheries, i.e. black bass, crappie, other sunfish, and striped bass. Also, the biology of the walleye limits the harvest to the spring since telemetry studies in other lakes indicate the only extensive diurnal activity was in the spring after spawning (Summer 1979) and walleye generally avoid shallow water (Hall 1982). Also, the extremely clear-water conditions force walleye to rest in contact with the bottom (Fyder 1977) due to their negative phototaxis (Raney and Lachner 1942); deeper depths are difficult to attain with conventional fishing methods. In clear lakes, light is the most important variable determining depth distribution; walleye select depths above preferred temperature range which provide better shelter from light (Scott and Crossman 1973). The difficulty in harvesting walleye by inexperienced anglers was also a common problem for many state agencies with walleye programs (Prentice et. al. 1977).

Walleye stockings in Lake Cumberland must be balanced with the existing available habitat and other major predators in the lake. Lake Cumberland is rated an oligotrophic lake and contains large, high-quality summer coolwater habitat based on cool temperatures (70-72°F) available in the oxygenated hypolimnon. However, percid communities do best in mesotrophic conditions (Ryder and Kerr 1978) and yields were best in mesotrophic regions of a Minnesota lake with disparate environments (oligotrophic-eutrophic) (Ryder 1977). Peak abundance of walleye in Missouri River reservoirs occurred in sections of intermediate water - clarity and depth (Nelson and Walburg 1977). Also, in central European lakes, percids had the largest standing crops and larger proportions of total yield with morpho-edaphic indices (MEI) in the mesotrophic range of 18.0-21.9 (Entz 1977). The MEI for Lake Cumberland ranges from 4.4-8.8 which would be on the lower end of the oligotrophy scale (<18) developed for this data set. Walleye populations develop in larger lakes, especially oligotrophic lakes, since they are more likely to have mesotrophic conditions than smaller lakes (Johnson et. al. 1977). Lily and Beaver creeks are eutrophic and mesotrophic arms, respectively, in Lake Cumberland. Upper reaches of the lake (above mile point 487) have Carlson index levels (Carlson 1979) in the lower end of the mesotrophic range on several years. This translates to less than half of the total surface acreage of Lake Cumberland in the mesotrophic range. Also, the impounded areas of the upper reaches of the lake (above Burnside Island) are generally confined to the width of the river channels which does not create ideal walleye habitat, i.e. rocky points, submerged islands, and other abrupt changes in vertical relief.

Walleye probably have minimal overlap with black bass in Lake Cumberland based on summer-time habitat use documented in the literature (Schlagenhaff and Murphy 1985) (Dendy 1946). Also, Ney et. al. 1988 reported that trophic and habitat partitioning limits competition between native black basses and stocked walleye and striped bass. However, the striped bass population remains pelagic and occupies cool-water zones comparable to walleye at Lake Cumberland. This possible competition for space is compounded by their sharing of similar food source, gizzard and threadfin shad. Quantifying the impacts of this perceived competition is not feasible with existing fishery data and available fish sampling techniques in large, deep reservoirs. Based on bioenergetic stimulation and trophic level sharing of walleye and striped bass in Smith Mountain Lake, Ney et al. (1988) recommended that walleye and striped bass should be considered trophic equivalents for stocking purposes. The striped bass stocking rate for Lake Cumberland has been stabilized at 5 fingerlings/acre (Kinman 1988), while walleye stockings have fluctuated extremely. Since walleye are naturally reproducing and striped bass are not, there is no way to quantify the annual disparity in numbers of these yoy predators in the lake. Based on this limited information, it would be a prudent management decision to stabilize the walleye stocking rate in Lake Cumberland.

CONCLUSIONS

The objective of restoring a walleye population in Lake Cumberland has been achieved. This population is composed of multi-year classes that are exhibiting good growth rates; however, walleye in the 16-20 lb class (as seen in the 1950's) will probably be uncommon due to genetic differences in walleye stocks now utilized. Natural reproduction is occurring due to headwater spawning runs and/or in-lake spawning. The walleye harvest has not met the harvest objective, possibly due to unmeasured night-time harvest, total low exploitation, low density created by 2 of 3 (1982 and 1983) non-stocking years, lack of angler education of walleye fishing methods, competition by striped bass, inconsistent recruitment by stocked year classes due to other environmental variables, or a combination of all these factors. Expectations for walleye harvest may be too optimistic due to the basin morphemetry, i.e., mean depth, and the oligotrophic conditions of the lake, since walleye are more suited for mesotrophic lakes containing coolwater habitat. The literature and predicted yield for walleye indicate that a harvest of at least 0.3 lb/acre of walleye should be expected at Lake Cumberland and this yield was achieved in 1980 and 1988. Walleye stocking should be continued to augment natural reproduction. Walleye stockings in the lake have also created a secondary benefit, a significant tailwater fishery where their yield is second only to rainbow and brown trout.

RECOMMENDATIONS

Continue to stock walleye in Lake Cumberland, concentrating stockings in the Upper Cumberland River and the Big South Fork due to the homing tendency of walleye (Crowe 1962). The spring spawning run of walleye represents a major fishery in Lake Cumberland and maximum exploitation occurs during this time period.

Stabilize the walleye stocking rate at 7-10 fingerlings/acre. Changes in stocking rate should be balanced with striped bass stockings and will require public input to determine relative importance of these two fisheries.

Utilize late fall (post thermal stratification) gill netting as a long-term walleye sampling strategy. Experimental gill nets composed of three panels, 1.0, 1.5, and 2.0-inch bar mesh, fished on shallow rocky points should provide a relative measure of year class strength. Effort should be concentrated in the lower mid-lake on the main lake or near mouths of major tributary arms. Netting should be conducted following thermal destratification.

Develop a VHS video on walleye fishing techniques applicable to Kentucky reservoirs to improve the walleye harvest. This video should be shown locally to as many sport and civic groups as possible.

Consider closing a portion of the Big South Fork for night fishing for a period of 5-7 days near the third week of March for the purpose of walleye broodstock collections. This would minimize direct conflicts with anglers and provide superior fry to fingerlings survival in the hatchery for the annual maintenance stocking.

Forage levels in Lake Cumberland should be examined for relative density. Monitoring of clupied spawning times may also be used to improve walleye stocking times.

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Table 1. Summary of walleye stockings in Lake Cumberland (50,250 acres).

Year	Number	No./acre	No./lb	Size range (in)
1989	968,777	19.8	1,000-2,070	1.3-2.0
1988	612,257	12.2	1,600-2,600	1.0-1.5
1987	883,179	17.8	1,987-2,141	1.0-1.3
1986	355,285	7.1	1,559-3,590	1.1-1.3
1985	355,570	7.1	1,609-3,075	1.1-1.3
1984	350,060	7.0	1,400-2,260	1.1-1.4
1980	1,314,475	26.2	1,958-2,495	1.1-1.8
	147,400	2.9		fry
1979	777,608	15.5	1,680-2,632	1.0-1.5
	503,050	10.0		fry
1978	205,625	4.1	1,000-2,282	1.0-1.5
1977	365,300	7.3	1,230-2,397	1.1-1.9
1976	284,682	5.7	1,400-3,300	1.0-1.5
1975	357,281	7.1	1,000-2,600	1.3-1.5
1974	233,500	4.6	600-1,752	13.-1.5
1973	109,000	2.2	300-	2.0-5.0

Table 2. Location of areas and probabilities used during creel surveys conducted on Lake Cumberland (1980-1986).

Area	Description	1980 (44,629 a) Apr	1980 (44,629 a) May-Oct	1981 (44,431 a) Apr	1981 (44,431 a) May-Oct	1982 (46,352 a) Mar-Apr	1982 (46,352 a) May-Oct	1983 (45,136 a) Mar-Apr	1983 (45,136 a) May-Jun 15	1983 (45,136 a) Jun 15-Oct	1986 (25,014 a) Mar 86 - Feb 87
1	Dam to mouth of Otter Creek, including Indian Creek	0.08	0.14	0.06	0.07	0.06	0.04	0.07	0.10	0.14	0.25
2	Otter and Beaver creeks	0.14	0.14	0.13	0.08	0.13	0.11	0.15	0.15	0.15	0.40
3	Mouth of Otter and Beaver creeks to Harmon Creek, including Lily and Greasy Creek										0.17
	Mouth of Otter and Beaver creeks to mouth of Wolf Creek	0.08	0.10	0.05	0.12	0.05	0.10	0.07	0.10	0.14	
4	Wolf and Caney creeks and tributaries	0.08	0.14	0.07	0.15	0.07	0.21	0.07	0.10	0.14	0.18
5	Mouth of Wolf Creek to below Camp Earl Wallace at Thomas Branch	0.05	0.06	0.05	0.07	0.05	0.05				
	Mouth of Wolf Creek to 4-H Camp							0.07	0.10	0.06	
6	Thomas Branch to bend below Conley Bottom	0.05	0.06	0.05	0.13	0.05	0.14				
	4-H Camp to mouth of Fishing Creek							0.07	0.12	0.14	
7	Conley Bottom to mouth of Fishing Creek, including Fishing Creek	0.08	0.14	0.07	0.13	0.07	0.13				
	Fishing Creek to Pitman Creek, inclusive							0.07	0.12	0.14	
8	Mouth of Fishing Creek to confluence of Buck Creek, including Buck Creek	0.08	0.10								
	Mouth of Fishing Creek to confluence of Buck Creek			0.04	0.05	0.04	0.04				
	Mouth of Pitman Creek to Buck creek, including Buck Creek							0.13	0.07	0.03	
9	Confluence of Buck Creek upstream in Cumberland River to first riffle	0.18	0.06								
	Cumberland River above Pitman Creek to first riffle			0.18	0.08	0.18	0.07	0.15	0.07	0.03	
10	South Fork Cumberland River to confluence of Little South Fork or first riffle, including area of Burnside Island	0.18	0.06	0.18	0.07	0.18	0.07	0.15	0.07	0.03	
11	Big Bend in Cumberland River to confluence of Buck Creek, including Buck Creek			0.12	0.05	0.12	0.04				

Table 3. Location of areas and probabilities used during the 1987 creel survey on Lake Cumberland (43,833 acres).

Area	Description	Probabilities March-May 15	Probabilities May 15-Oct 31
	CLERK 1		
1	Beaver and Otter creeks	0.08	0.02
2	Dam to mouth of Pumpkin Creek	0.08	0.20
3	Indian Creek	0.08	0.02
4	Greasy, Pumpkin, and Lily creeks	0.10	0.04
5	Wolf and Caney creeks	0.08	0.02
6	Mouth of Pumpkin Creek - Camp Earl Wallace including Difficulty and Harmon creeks	0.08	0.20
	CLERK 2		
7	Camp Earl Wallace - mouth of White Oak Creek including Fall and Cub creeks	0.04	0.20
8	Faubush and White Oak creeks	0.04	0.03
9	Fishing Creek	0.04	0.03
10	Mouth of White Oak Creek - Burnside including Pitman Creek	0.04	0.20
11	Big South Fork from Burnside to mouth of Little South Fork	0.02	0.01
12	Cumberland River from Burnside to mouth of Rockcastle River including first mile of Buck Creek	0.02	0.01
13	Big South Fork from mouth of Little South Fork to first riffle	0.15	0.01
14	Cumberland River from mouth of Rockcastle River to first riffle	0.15	0.01

Table 4. Backcalculated growth of walleye in Lake Cumberland from 1980-1987.

Year	No.	Age 1	2	3	4	5	6	7	8	9
1986	14	10.4	15.9							
1985	33	10.1	14.4	16.6						
1984	90	9.3	14.7	16.8	18.8					
1983	63	8.9	14.4	16.8	18.4	20.4				
1982	84	9.8	14.7	17.2	19.1	20.2	22.1			
1981	167	9.6	14.7	17.2	18.8	20.5	22.0			
1980	103	9.5	14.9	17.4	19.3	21.0	23.0	24.3		
1979	78	9.3	14.3	17.2	19.3	21.3	22.9	26.4	26.7	
1978	68	9.4	14.3	17.0	19.0	20.9	22.8	23.8	25.5	
1977	168	10.1	14.9	17.5	19.4	20.6	22.2	26.4	26.7	27.5
1976	76	10.3	15.3	18.1	19.9	21.4	22.7	25.0	27.5	27.8
1975	27	10.9	1.50	17.7	19.9	21.3	23.1	24.1	22.2	
1974	7	9.8	15.3	19.1	22.0	23.4	24.7	25.7		
Mean		9.7	14.8	17.3	19.3	21.0	22.8	24.7	26.1	27.7
No.	978	978	860	716	464	241	103	40	9	2
Smallest		4.0	9.7	1.21	14.0	18.0	19.3	21.0	22.0	27.5
Largest		13.7	19.3	23.8	26.0	27.8	29.5	30.8	32.0	27.8
Std error		0.04	0.05	0.05	0.07	0.11	0.20	0.40	1.10	
95% ConLo		9.6	14.7	17.3	19.2	20.8	22.4	23.9	23.6	
95% ConHi		9.8	14.9	17.4	19.4	21.2	23.1	25.6	28.6	

Table 5. Backcalculated growth of male walleye collected in Lake Cumberland from 1980-1987.

Year	No.	Age 1	2	3	4	5	6	7	8
1985	4	9.5	15.3						
1984	56	9.5	14.8	16.6					
1983	38	8.9	14.5	16.8	18.2				
1982	78	9.7	14.5	17.1	19.0	20.0			
1981	129	9.6	14.6	17.2	18.8	20.5	21.8		
1980	68	10.0	14.8	17.0	18.9	20.3	21.7	21.6	
1979	50	9.4	14.2	17.0	18.7	20.4	21.5	22.2	
1978	47	9.4	14.3	16.9	18.7	20.2	21.4	22.4	22.2
1977	111	10.2	14.9	17.3	19.1	20.3	21.5		
1976	33	10.2	14.8	17.3	18.8	20.0	21.1	22.0	
1975	11	10.9	14.6	16.6	18.3	19.4	20.3	21.5	22.2
Mean		9.7	14.7	17.1	18.8	20.2	21.4	22.2	22.2
No.	625	625	607	507	314	157	58	14	3
Smallest		5.5	9.7	12.1	14.0	18.0	19.3	21.0	22.0
Largest		13.7	17.8	20.4	21.7	22.7	24.1	25.2	22.4
Std error		0.05	0.05	0.05	0.06	0.07	0.12	0.31	0.12
95% ConLo		9.6	14.6	17.0	18.7	20.1	21.2	21.5	21.8
95% ConHi		9.8	14.7	17.2	18.9	20.4	21.7	22.8	22.6

Table 6. Backcalculated growth of female walleye collected in Lake Cumberland from 1980-1987.

Year	No.	Age 1	2	3	4	5	6	7	8	9	10
1984	2	7.8									
1983	5	9.5	14.8	18.5	19.5						
1982	4	10.5	16.7	20.0							
1981	9	10.2	15.7	18.1	19.8	21.1	22.9				
1980	11	10.3	15.7	18.9	20.9	23.5	25.0	25.7			
1979	9	10.1	14.5	17.9	20.8	22.6	23.9	25.6	26.6		
1978	8	9.9	15.0	19.0	21.4	24.1	25.6	27.3	32.0		
1977	19	10.3	15.3	18.5	21.0	22.7	25.3	26.4	26.7	27.5	
1976	26	10.6	16.3	19.4	21.5	23.7	24.9	26.9	27.5	27.8	
1975	16	10.9	15.3	18.5	21.0	22.6	24.0	25.8			
1974	4	10.5	16.2	19.7	22.1	23.4	24.7	25.6			
Mean		10.3	15.6	18.8	21.1	23.1	24.6	26.2	28.0	27.7	
No.	113	113	109	101	80	55	40	23	6	2	
Smallest		7.7	10.9	15.4	17.6	19.5	21.2	22.0	26.6	27.5	
Largest		13.5	19.3	23.8	26.0	27.8	29.5	30.8	32.0	27.8	
Std error		0.13	0.17	0.16	0.19	0.23	0.28	0.40	0.83		
95% ConLo		10.1	15.2	18.5	20.7	22.7	24.0	25.3	26.0		
95% ConHi		10.6	15.9	19.1	21.5	23.6	25.1	27.0	30.0		

Table 7. Capture history data on walleye from Big South Fork Cumberland River in March 1981.

Sampling date (I)	Sample size	Number marked in sample	Losses	Releases S(I)	R(I)[a]	A(I)[b]
1	29	0	0	29	8	0
2	51	2	0	51	19	6
3	48	5	0	48	9	20
4	62	14	0	62	7	15
5	98	9	0	98	7	13
6	79	20	0	79	0	0

[a]R(I) = number of recaptures out of S(I) seen at (I) and seen after (I).

[b]A(I) = number seen before I, after I, and not at I.

Table 8. Summary of Jolly-Seber population analysis for walleye in Big South Fork Cumberland River, April 1982.

Sampling dates	Number marked in population	Total population	S.E.[a] of population size estimate	Survival estimate	S.E. of survival estimate	"Birth" estimate	S.E. of "Birth" estimate
1	0	0	0	0.6	0.2	0	0
2	18	305	215	1.0	0.4	536	440
3	103	841	450	0.9	0.4	0	342
4	132	555	249	0.9	0.5	1,158	734
5	170	1,682	897	0.0	0.0	0	0
6	0	0	0	0.0	0.0	0	0

[a]S.E. - standard error.

Table 9. Length frequency of walleye captured near Wolf Creek dam of Lake Cumberland during 2 nights of gill netting and 1 night of electrofishing on 11-12 March 1981 and gill netting 20 March 1985.

	Inch class								
	15	16	17	18	19	20	21	22	Total
Gill netting (3-80)		1		5	21	11	5	1	44
Electrofishing (3-80)		1	1		1	2		1	6
Total (3-80)		2	1	5	22	13	5	2	50
Gill netting (3-85)	1	2	6	21	11	4	1		46

Table 10. Length frequency of walleye collected in the Laurel River arm of Lake Cumberland.

	Inch class															
Year	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total
1980	1	5	33	63	29	23	11	3	6	7	4	2				187
1982	2	2	1	4	5	1	1	1	1		1	3	2	1		25
1984		9	5	14	7	2	1	2		1	1		1		2	45
Total	3	16	39	81	41	26	13	6	7	8	6	5	3	1	2	257
%	1.2	6.2	15.2	31.5	16.0	10.1	5.1	2.3	2.7	3.1	2.3	1.9	1.2	0.4	0.8	

Table 11. Length frequency and CPUE for walleye collected by electrofishing the Big South Fork arm of Lake Cumberland, 1980-1987.

Year	Inch class 11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	32	Total	CPUE
1980				2	6	32	68	39	20	4		1	1	1								174	
1981			1		7	13	48	120	74	44	25	9	12	9	4	3	2	1		1		373	41.4
1982	4	1	1	8	29	18	24	20	31	22	19	6		2	1	2	1					189	29.1
1983				5	18	20	17	8	7	16	11	7	3	1		2						115	76.7
1984		1	2	1	9	14	26	17	4	5	2			1		2	1					85	28.2
1985					13	12	31	54	38	20	7	5	3	1	2	1	1	1	1			190	73.6
1986			2	18	48	65	22	37	39	20	10	11		3	3	4			1		1	284	117.4
1987				3	7	19	41	45	23	15	8	3	1	2		1	1					169	66.3
Total	4	2	6	37	137	193	277	340	236	146	82	42	20	20	10	15	6	2	2	1	1	1,579	
%	0.3	0.1	0.4	2.3	8.7	12.2	17.5	21.5	15.0	9.2	5.2	2.7	1.3	1.3	0.6	0.9	0.4	0.1	0.1	0.1	0.1		

[a]Additional walleye were collected during broodstock collections and omitted from these data.

Table 12. CPUE based on electrofishing for walleye by year class from 1981-1987 in Big South Fork of Lake Cumberland.

Year	1972	1975	1976	1977	1978	1979	1980	1981[c]	1982[c]	1983[c]	1984	1985	1986	Total	Annual survival (95% confidence limit)
1981	1.22	0.89	10.30	24.00	4.56	0.44								41.41	
1982	0.15	0.31	2.92	8.15	6.00	5.85	5.08	0.62						29.08	
1983		4.00	1.33	14.67	9.33	10.67	22.00	14.67						76.67	
1984			0.33	0.66	1.33	1.99	6.64	14.95	2.33					28.2	0.43[a](±0.19)
1985			0.78	0.78	2.33	5.43	11.24	43.41	9.30	0.39				73.66	0.34[b](±0.09)
1986					2.07	4.13	6.20	15.29	23.97	14.46	51.23			117.35	0.49[b](±0.11)
1987						0.39	1.78	4.31	11.37	23.53	23.92	1.57		66.87	0.40[b](±0.11)
Total	1.37	5.20	15.66	48.26	25.62	28.90	52.94	93.25	46.97	38.38	75.15	1.57			

[a] Survival estimates include ages 3-8.
[b] Survival estimates include ages 4-8.
[c] Non-stocking years.

Table 13. Catch per unit effort[a] by walleye year class derived from experimental gill netting[b] in Lake Cumberland from 1980-1985.

Year	Year class 1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Total
1980			1.56	3.22	0.56	0.67							6.01
1981	0.08		0.67	0.50	0.67	0.42	1.67	0.67					4.68
1982				0.45	0.27	0.27		1.45	0.36				2.80
1983						0.08	0.25	0.50	0.58	0.75			2.16
1984						0.08	0.17	0.17		0.25	2.17		2.84
1985[b]				0.08				0.08		0.42	0.50		1.08
Total	0.08		2.23	4.25	1.50	1.52	2.09	2.95	0.94	1.42	2.67		

[a] Catch per unit effort was defined by one net set for a 24-h period.

[b] Standard 3-panel experimental gill nets were modified by removing the 0.75-in mesh panel.

Table 14. Length frequency of sauger collected in the headwaters of Lake Cumberland.

Year	Inch class 8	9	10	11	12	13	14	15	16	17	18	19	20	21
1981	2		3		2	3	4	4	2	1			1	1
1984				1	1	2	1	1						
1985				1	2	2	2	1	4			2		
1986	3	5	2		2	3			1	1				
1987		1				2		1						
Total	5	6	5	2	7	12	7	7	7	2		2		

Table 15. Standing crop values (lb/acre) derived from cove rotenone samples collected in Lake Cumberland from 1980-1985.

	1980	1981	1982	1983	1984	1985
GAME FISHES						
White bass	2.05	4.23	0.79	1.31	2.49	12.39
Striped bass	0.45	0.18	0.04		0.12	0.01
Sauger		0.04	0.08	0.24	0.73	
Walleye	0.84	1.41	0.46	0.10	0.53	0.63
Largemouth bass	3.06	4.70	2.62	2.31	8.31	1.71
Smallmouth bass	0.34	1.68	1.09	0.57	0.39	0.24
Spotted bass	2.10	4.95	1.39	1.97	2.34	1.86
Black crappie	0.28	0.09	0.01	0.55	0.10	0.39
White crappie	34.88	6.74	1.55	11.95	12.51	7.21
Total	44.00	24.02	8.02	19.00	27.91	24.44
FOOD FISHES						
Blue catfish				0.03		0.02
Channel catfish	4.21	1.80	1.60	3.25	6.52	1.29
Flathead catfish	1.29	2.14	4.82	6.91	1.80	4.61
Total	5.49	3.94	6.42	10.19	8.32	5.92
PREDATORY FISHES						
Mooneye	0.30	2.34	0.81	0.47	0.89	4.66
Longnose gar	0.96	0.03	0.01	2.55	1.03	0.85
Total	1.26	2.37	0.82	3.03	1.93	5.50
PISCIVOROUS TOTAL	50.75	30.33	15.26	32.22	38.16	35.86
PANFISHES						
Bluegill	10.18	12.57	6.33	11.02	10.21	4.66
Hybrid sunfish		0.01				
Longear sunfish	6.02	6.76	4.94	6.83	6.46	4.89
Green sunfish			t	0.11	0.04	0.01
Warmouth	0.19	0.38	0.30	0.83	1.20	0.28
Rock bass			t		t	
Total	16.39	19.72	11.57	18.78	17.91	9.84
COMMERCIAL FISHES						
Paddlefish	50.84					
Carpsuckers	2.86				0.13	0.14
Hogsuckers	0.30	0.11	0.03	0.22	0.04	0.17
Redhorses	12.31	7.40	3.25	11.89	11.08	3.81
Carp	4.59	8.41	2.04	4.14	14.12	2.53
Buffalofishes		0.54		3.96	0.16	0.95
Bullhead		0.03		0.01		
Drum	9.64	7.71	4.50	11.67	11.61	10.72
White sucker	0.02					
Total	80.55	24.21	9.82	31.89	37.13	18.32
FORAGE FISHES						
Gizzard shad	125.07	127.39	61.80	130.24	36.73	49.39
Threadfin shad	1.53	30.17	1.61	8.00	0.84	11.19
Shiners	0.06	0.01	0.01	0.03	1.57	3.16
Misc. cyprinids	0.12	0.02	t	0.22	0.22	0.22
Madtom	0.01	0.02	0.04	0.01	0.01	0.01
Topminnows		0.01			t	0.01
Darters	0.77	0.41	0.20	0.37	0.42	0.47
Brook silverside	0.03	0.03	t	0.01	0.01	0.04
Total	127.58	158.05	63.66	138.88	39.80	64.49
NON-PISCIVOROUS TOTAL	224.52	201.97	85.05	189.55	94.85	92.65
GRAND TOTAL	275.28	232.30	100.32	221.77	133.01	128.51

t 0.01 lb/acre.

Table 16. Number and pounds per acre by size group derived from cove-rotenone studies of the three species of black bass in Lake Cumberland.

		Year													
		1980		1981		1982		1983		1984		1985		$\bar{x}$	
Species	Size group[a]	No.	Lb(%)	No.	Lb(%)	No.	Lb(%)	No.	Lb(%)	No.	Lb(%)	No.	Lb(%)	No.	Lb(%)
Largemouth bass	Fingerling	84	0.35	342	1.98	78	0.30	51	0.57	41	0.32	29	0.17	104	0.62
	Intermediate	6	0.89	6	0.93	6	1.49	3	0.85	15	5.19	2	0.69	6	1.67
	Harvestable	2	1.82	1	1.78	1	0.83	1	0.89	2	2.80	1	0.85	1	1.50
	Total	92	3.06	349	4.70	85	2.62	55	2.31	58	8.31	32	1.71	111	3.79
			(55.6)		(41.2)		(51.4)		(47.7)		(72.3)		(44.9)		(54.1)
Spotted bass	Fingerling	55	0.48	193	1.12	127	0.44	93	0.51	80	0.59	142	0.46	115	0.60
	Intermediate	8	1.13	10	2.94	4	0.65	7	1.06	11	2.15	9	1.22	8	1.52
	Harvestable	1	0.50	1	0.88	t	0.29	0	0.41	t	0.10	t	0.18	t	0.38
	Total	64	2.11	204	4.95	131	1.39	100	1.97	91	2.84	151	1.86	123	2.50
			(38.4)		(43.7)		(27.3)		(40.7)		(24.7)		(48.8)		(35.7)
Smallmouth bass	Fingerling	4	0.03	17	0.34	8	0.05	8	0.08	t	t	18	0.11	9	0.10
	Intermediate	1	0.15	2	0.82	3	0.50	2	0.40	1	0.25	t	0.06	2	0.36
	Harvestable	t	0.15	t	0.52	1	0.54	t	0.08	t	0.13	t	0.07	t	0.25
	Total	5	0.33	19	1.68	12	1.09	10	0.56	1	0.38	18	0.24	11	0.71
			(6.10)		(13.0)		(21.4)		(11.6)		(3.3)		(1.8)		(10.1)

[a]Fingerling = 1-4 inch group, intermediate = 5-11 inch group, and harvestable ≥ 12 inch class.

Table 17. Sport fish harvest, and fishing pressure (man-h/acre) for principal species in Lake Cumberland from 1980-1984 and 1986 and 1988 (values in parentheses are per acre values).

	Black bass	White bass	Striped bass	Walleye	Sauger	Crappie	Sunfish	Catfish	Drum	Carp	Trout	Total
1980												
No.	40,708	56,147	658	8,076	1,833	447,926	158,186	14,460	6,403			734,395
	(0.91)	(1.30)	(0.02)	(0.19)	(0.04)	(10.37)	(3.66)	(0.34)	(0.15)			(17.01)
%	5.5	7.6	t	1.1	0.2	60.9	21.5	2.0	0.9			
Lb	60,458	57,784	9,093	23,912	1,396	165,219	29,721	27,139	5,691			380,414
	(1.35)	(1.34)	(0.21)	(0.55)	(0.03)	(3.83)	(0.69)	(0.63)	(0.13)			(8.91)
%	15.9	15.2	2.4	6.3	0.4	43.4	7.8	7.1	1.5			
Pressure	4.78	1.24	0.21	1.01		11.38	1.18					20
1981												
No.	10,977	14,590	98	1,763	318	156,263	34,060	4,506	5,491	29		228,095
	(0.25)	(0.33)	(t)	(0.04)	(0.01)	(3.50)	(0.76)	(0.11)	(0.12)	(t)		(5.13)
%	4.8	6.4	t	0.7	0.1	68.5	14.9	2.0	2.4	t		
Lb	18,844	17,305	855	4,470	198	45,486	4,832	9,829	3,548	287		105,655
	(0.42)	(0.39)	(0.02)	(0.10)	(t)	(1.02)	(0.11)	(0.23)	(0.18)	(t)		(2.38)
%	17.8	16.4	0.8	4.2	0.2	43.1	4.6	9.3	3.4	0.3		
Pressure	1.61	0.52	0.11	0.35		2.8	0.09	0.05	0.02			5.6
1982												
No.	30,421	50,107	1,076	2,225	686	291,434	87,673	3,494	5,202	233	730	473,142
	(0.66)	(1.08)	(0.02)	(0.05)	(0.02)	(6.30)	(1.90)	(0.07)	(0.11)	(t)	(0.02)	(10.2)
%	6.4	10.6	0.2	0.5	0.1	61.7	18.5	0.7	1.1		0.2	
Lb	36,087	56,775	4,858	5,468	935	126,303	11,095	4,693	5,119	1,757	505	253,622
	(0.79)	(1.20)	(0.10)	(0.12)	(0.02)	(2.70)	(0.24)	(0.10)	(0.11)	(0.04)	(0.01)	(5.50)
%	14.2	22.4	1.9	2.2	0.4	49.8	4.4	1.9	2.0	0.7	0.2	
Pressure	3.1	1.0	0.2	0.4	t	3.0	0.2	t			t	14.1
1983												
No.	40,364	22,374	735	2,340	224	211,751	96,480	5,985	13,719		1,469	395,441
	(0.89)	(0.50)	(0.02)	(0.05)	(t)	(4.20)	(2.10)	(0.13)	(0.30)		(0.03)	(8.8)
%	10.2	5.7	0.2	0.6	t	53.5	24.4	1.5	3.5		0.4	
Lb	50,689	14,515	4,160	4,974	201	82,449	8,383	6,491	6,699		1,070	179,627
	(1.10)	(0.32)	(0.09)	(0.11)	(t)	(1.83)	(0.19)	(0.15)	(0.15)		(0.02)	(4.0)
%	28.0	8.0	2.3	2.8	0.1	45.9	4.7	3.6	3.8		0.6	
Pressure	3.9	0.4	0.4	0.6		3.6	0.6		0.06		0.06	12.7
1986 (lower lake only)												
No.	21,599	9,239	5,406	2,014		30,708	50,804	4,423	1,938	71	543	127,499
	(0.9)	(0.4)	(0.2)	(0.08)		(1.2)	(2.0)	(0.18)	(0.08)	(t)	(0.02)	(5.1)
%	16.9	7.2	4.2	1.6		24.1	39.8	3.5	1.5	0.1	0.4	
Lb	26,051	5,870	41,846	3,165		8,742	6,797	6,532	1,938	761	403	102,608
	(1.0)	(0.2)	(1.7)	(0.1)		(0.4)	(0.3)	(0.3)	(0.08)	(t)	(t)	(4.1)
%	25.4	5.7	40.8	3.1		8.5	6.6	6.4	1.9	0.7	0.4	
Pressure	5.9	0.4	2.3	0.5		1.8	1.3	0.6	0.02	t	0.08	13.8

Table 17 continued.

	Black bass	White bass	Striped bass	Walleye	Sauger	Crappie	Sunfish	Catfish	Drum	Carp	Trout	Total
1988												
No.	43,411	25,849	12,671	6,136	2,015	28,111	39,768	1,872	634	308	270	161,209
	(1.00)	(0.60)	(0.29)	(0.14)	(0.50)	(0.65)	(0.92)	(0.04)	(0.01)	(0.01)	(0.01)	(3.72)
%	27.0	16.1	7.9	3.8	1.3	17.5	24.7	1.1	0.4	0.2	0.2	
Lb	38,571	17,130	111,135	12,487	916	14,457	3,459	2,820	930	1,322		203,305
	(0.89)	(0.40)	(2.56)	(0.29)	(0.02)	(0.34)	(0.08)	(0.06)	(0.02)	(0.02)		(4.69)
%	19.0	8.4	54.7	6.1	0.5	7.1	1.7	1.4	0.5	0.7		
Pressure	4.36	0.25	1.94	0.63	0.02	2.08	0.16	0.01			0.01	14.08

t < 0.1%, 0.01 lb, 0.01 m-h/acre.

Table 18. Expanded creel survey results from the access point creel survey in Lake Cumberland headwater streams, 03 February - 12 April 1980.

	White Bass		Crappie		Channel catfish		Sauger		Walleye		Drum		Sunfish		Number of anglers	Man-h.
	no	lb	no	lb	no	lb	no	lb	no	lb	no	lb	no	lb		
Laurel River	629	467	5,738	801	194	199	1,326	74	24	45	139	114	-	-	4,245	18,141
South Fork Cumberland River	293	282	56	12	251	115	306	152	351	648	-	-	-	-	4,320	19,077
Rockcastle River	-	-	2,500	1,008	-	-	-	-	-	-	125	114	1,375	210	5,750	14,531
Total	922	749	8,294	1,821	445	314	1,632	226	375	693	264	228	1,375	210	14,315	51,749

Table 19. Sport fish harvest at Lake Cumberland headwater areas (combined) during 22 February through 28 March 1981.

	Walleye	Channel catfish	Sunfish	Sauger	Crappie	White bass	Totals
Number harvested	55	77	26	384	3,271	178	3,991
% of total harvest	1.4	1.9	0.7	9.6	81.9	4.5	100
Pounds harvested	216	106	1	173	1,216	220	1,933
% of total lb harvested	11.1	5.5	t	8.9	62.9	11.4	100
Mean length (in)	22.0	16.0	4.0	14.0	9.4	14.0	-
Mean weight (lb)	3.93	1.38	0.04	0.45	0.37	1.24	-
Number of fishing trips for that species	1,937	0	0	283.8	1,221	204	3,671
% of all trips	53.0	0	0	7.7	33.3	5.6	-
Hrs fished for that species	4,015	0	0	579	2,600	421	-
No. caught fishing for that species	55	0	0	78	3,114	178	-
Lb caught fishing for that species	216	0	0	42	1,118	220	-
No./hr caught fishing for that species	0.05	0	0	0.13	1.20	0.42	-
% success fishing for that species	2.9	0	0	18.3	45.3	37.4	-

Table 20. Walleye harvest data from Lake Cumberland derived from daytime creel surveys.

Year	No. harvested	Lb harvested	Lb/acre	Harvest rate No./hour	Average size (in)	Average size (lb)
1980	8,076	23,912	0.55	0.14	20.5	2.96
1981	1,763	4,470	0.10	0.11	19.2	2.54
1982	2,225	5,468	0.12	0.06	18.6	2.46
1983	2,340	4,974	0.11	0.05	18.2	2.13
1986*	2,014	3,165	0.10	0.10	17.0	1.55
1988	6,136	12,487	0.29	0.16	18.3	2.04

*Only lower half of lake surveyed.

Table 21. Monthly daytime harvest of walleye derived from creel surveys conducted on Lake Cumberland.

	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	DEC	TOTAL
1980		382	1,639	2,217	3,557		282			8,077
1981			925	132	60	33	478	136		1,764
1982	291	232	839	710	39		48	41		2,200
1983	74	260	140	739	274	343	390	121		2,341
1986 (lower lake only)		860	587	281	119		53		115	2,014
1988	195	857	3,879	1,126	27	40		12		6,136
Total	560	2,591	8,009	5,205	4,076	416	1,251	310	115	22,532
%	2.5	11.5	35.5	23.1	18.1	1.8	5.6	1.4	0.5	

Table 22. Year class (age) distribution of daytime walleye harvest in Lake Cumberland.

	75	76	77	78	79	80	81	82	83	84	85	86	Total
1981	91		124	992	557								1,764
	(6+)		(4+)	(3+)	(2+)								
1983	37		111	37	715	1,369	72						2,341
	(8+)		(6+)	(5+)	(4+)	(3+)	(2+)						
1986							28	219	1,216	551			2,014
							(5+)	(4+)	(3+)	(2+)			
1988							51	253	406	2,181	2,333	913	6,136
							(7+)	(6+)	(5+)	(4+)	(3+)	(2+)	
Total	128		235	1,029	1,272	1,369	151	472	1,622	2,732	2,333	913	12,255

Table 23. Harvest by year class (age) derived from walleye mail-in survey returns.

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1980		4	5	43	142	26								
1981	2	3	16	37	46	48	27	1						
1982[b]		9	18	49	36	55	75							
1983[b]		5	12	16	28	15	67	172	5					
1984[b]		1			1	6	11	14	35	18	3			
1985[b]				1	1	6	2	4	10	20	7			
1986[c]					2	2	3	3	7	22	41	91		
1987[c]					2	1	3	3	3	4	6	16	14	
Total	2	22	51	146	258	159	188	197	60	64	57	107	14	
%	0.2	1.7	3.8	11.0	19.5	12.0	14.2	14.9	4.5	4.8	4.3	8.1	1.1	

[a] All fish from mail-in survey could not be aged or scale samples were not included in questionnaire envelope.

[b] Numbers were generated by aging a subsample of the total number of fish submitted.

[c] Year classes were assigned based on growth from walleye collected during other sampling.

Table 24. Monthly mail-in survey returns of walleye from Lake Cumberland, 1982-1985.

Month	Year 1982	1983	1984	1985	Total	%
Jan		2	4		6	0.8
Feb	3	3	2		8	1.0
Mar	23	31	20	15	89	11.3
Apr	67	31	7	19	124	15.7
May	68	51	11	9	139	17.6
Jun	46	136	32	43	257	32.5
Jul	31	19	3	20	73	9.2
Aug	11	12	4	4	31	3.9
Sep	9	17	3		29	3.6
Oct	6	7	3		16	2.0
Nov	4	9			13	1.6
Dec	3	2			5	0.6
Total	271	320	89	110		

Table 25. Comparisons of walleye growth in selected water bodies.

	Sex	Age 1	2	3	4	5	6	7	8
Northern reservoirs (Carlander 1989)	M	6.6	10.9	14.1	16.7	18.9	21.0	22.6	
	F	6.8	11.1	14.8	18.0	21.0	22.8	25.2	25.3
Western reservoirs (Carlander 1989)	M	9.9	15.1	16.7	17.7	18.0	18.8		
	F	10.5	16.0	16.4	18.6	20.8	21.9		
Southern reservoirs (Carlander 1989)	M	10.0	15.5	18.0	19.1	19.7	20.9	21.2	
	F	10.8	17.0	19.7	21.5	23.1	23.7	26.8	28.1
Center Hills Reservoir, Tennessee (Woodward and Wills 1985)	M	11.6	17.1	19.5					
	F	11.6	17.8	21.4	23.7	27.4			
Dale Hollow Reservoir, Tennessee (Libbey 1969)	C[a]	10.4	16.1	19.2	21.5				
Lake Meredith, Texas (Kraai and Prentice 1974)	M	13.5	16.0	17.2	17.9	18.3	18.7		
Summersville Reservoir, WV (Heartwell 1970)		7.7	11.7	14.3	15.1	15.7	16.4		
Lake Cumberland	M	9.7	14.7	17.1	18.8	20.2	21.4	22.2	
	F	10.3	15.6	18.8	21.1	23.1	24.6	26.2	28.0
	C	9.7	14.8	17.3	19.3	21.0	22.8	24.7	
Lake Burton, GA (Rabern 1989)	M	9.5	14.7	17.1	18.2	19.6			
	F	10.0	15.6	18.3	20.0	21.1	22.0	23.1	24.1

[a]Combined sexes.

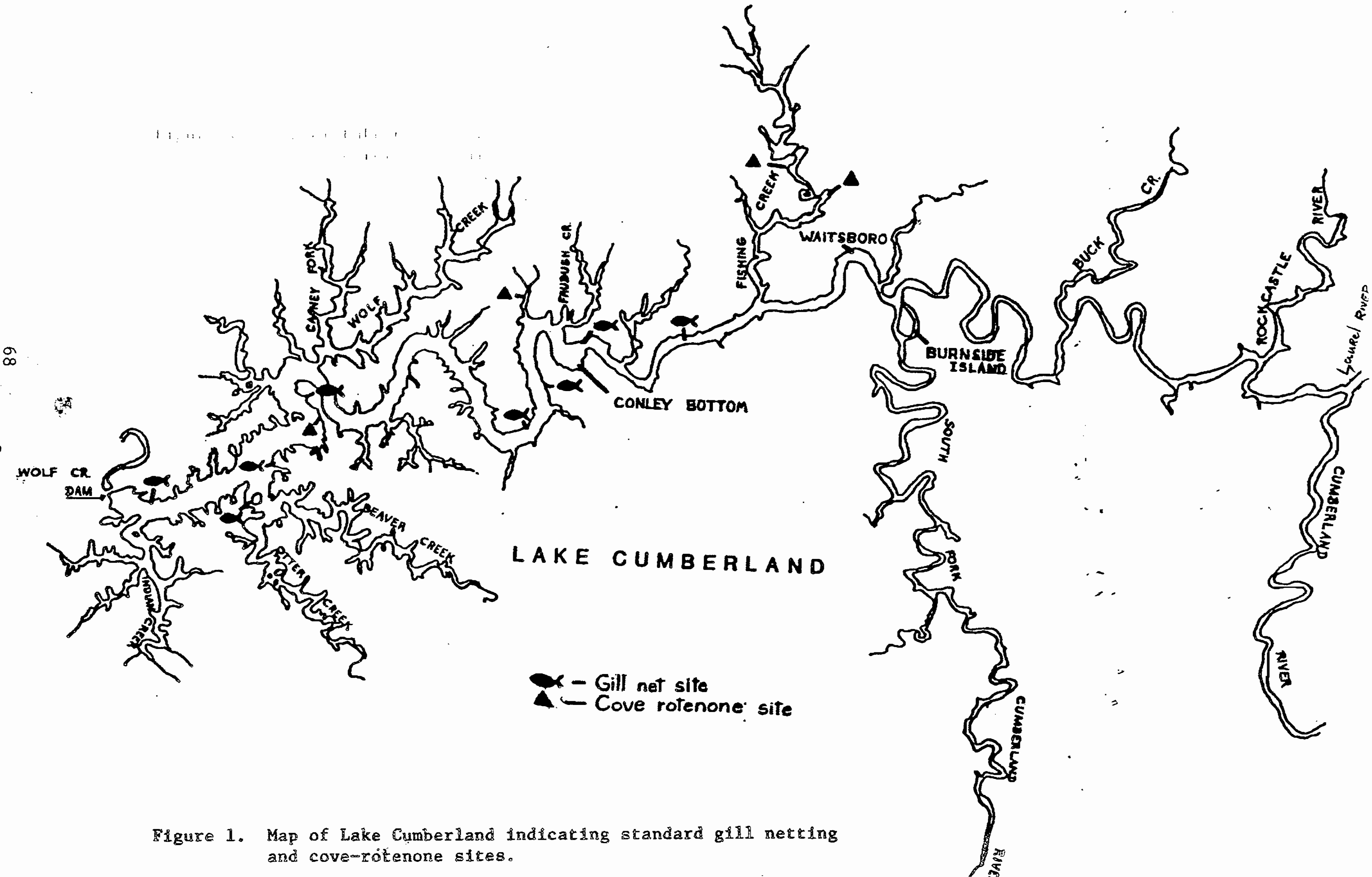


Figure 1. Map of Lake Cumberland indicating standard gill netting and cove-rotenone sites.

Figure 2. Length-frequency of a pooled sample of male walleye collected in Lake Cumberland from 1980-1987.

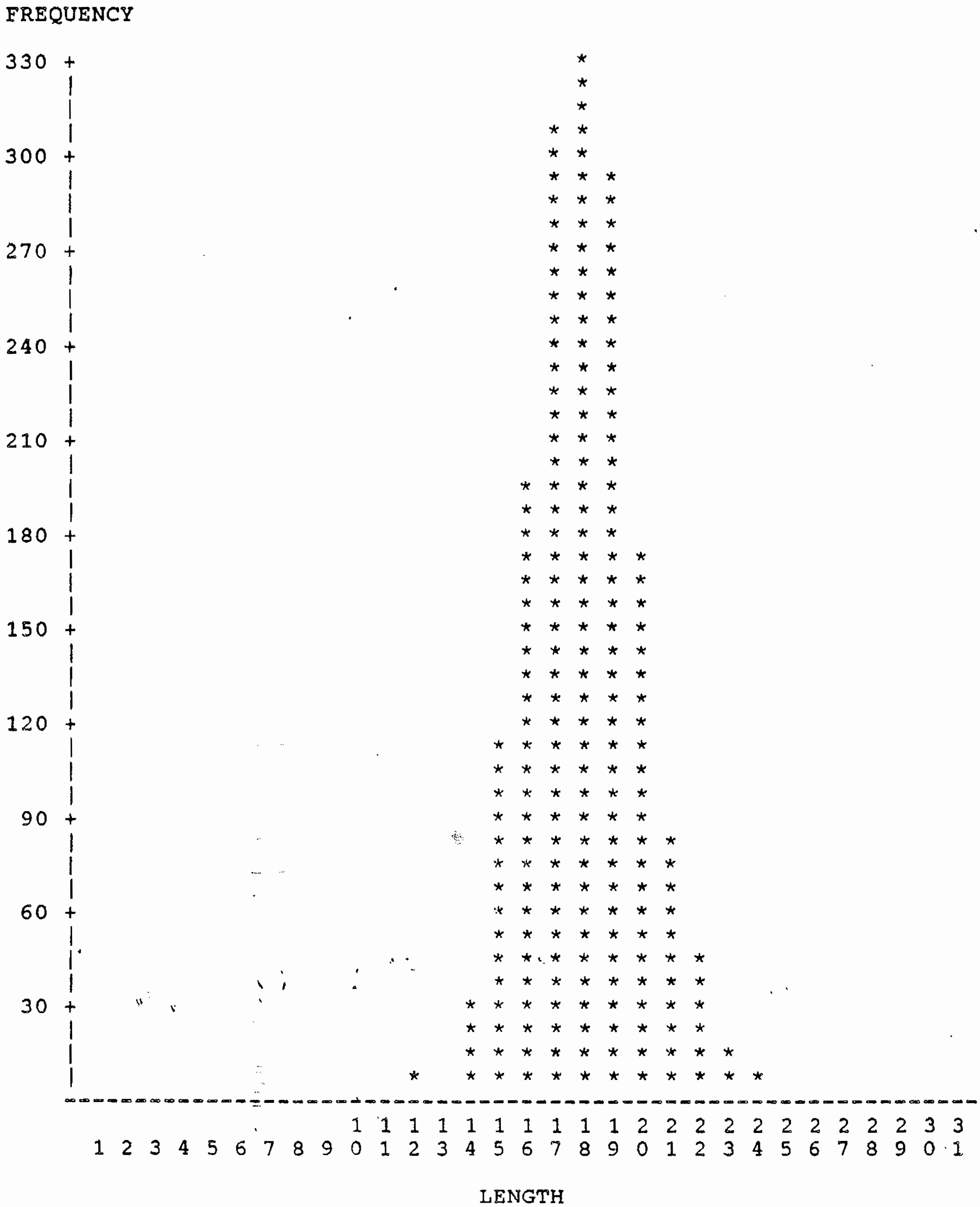
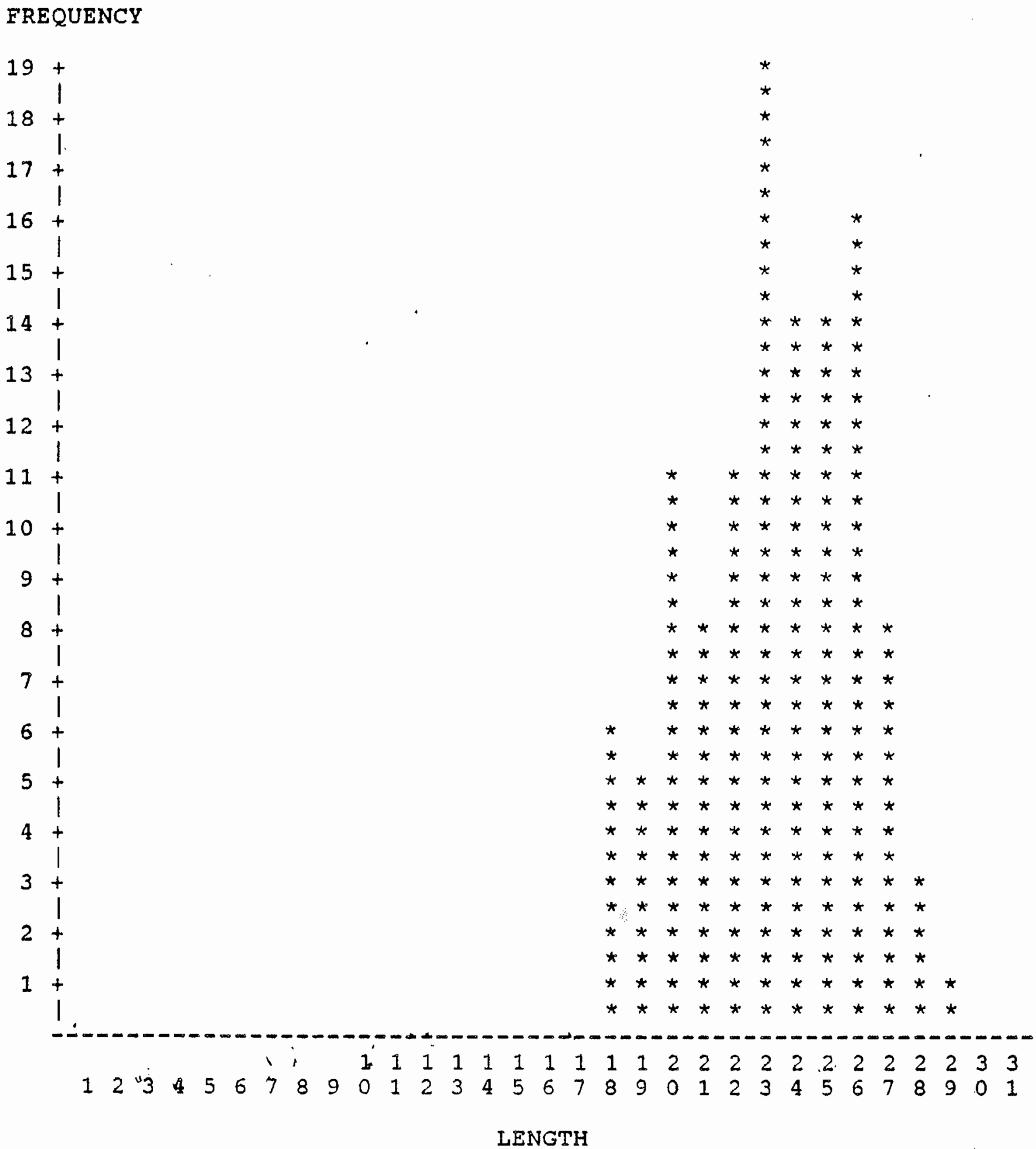


Figure 3. Length-frequency of a pooled sample of female walleye collected in Lake Cumberland from 1980-1987.



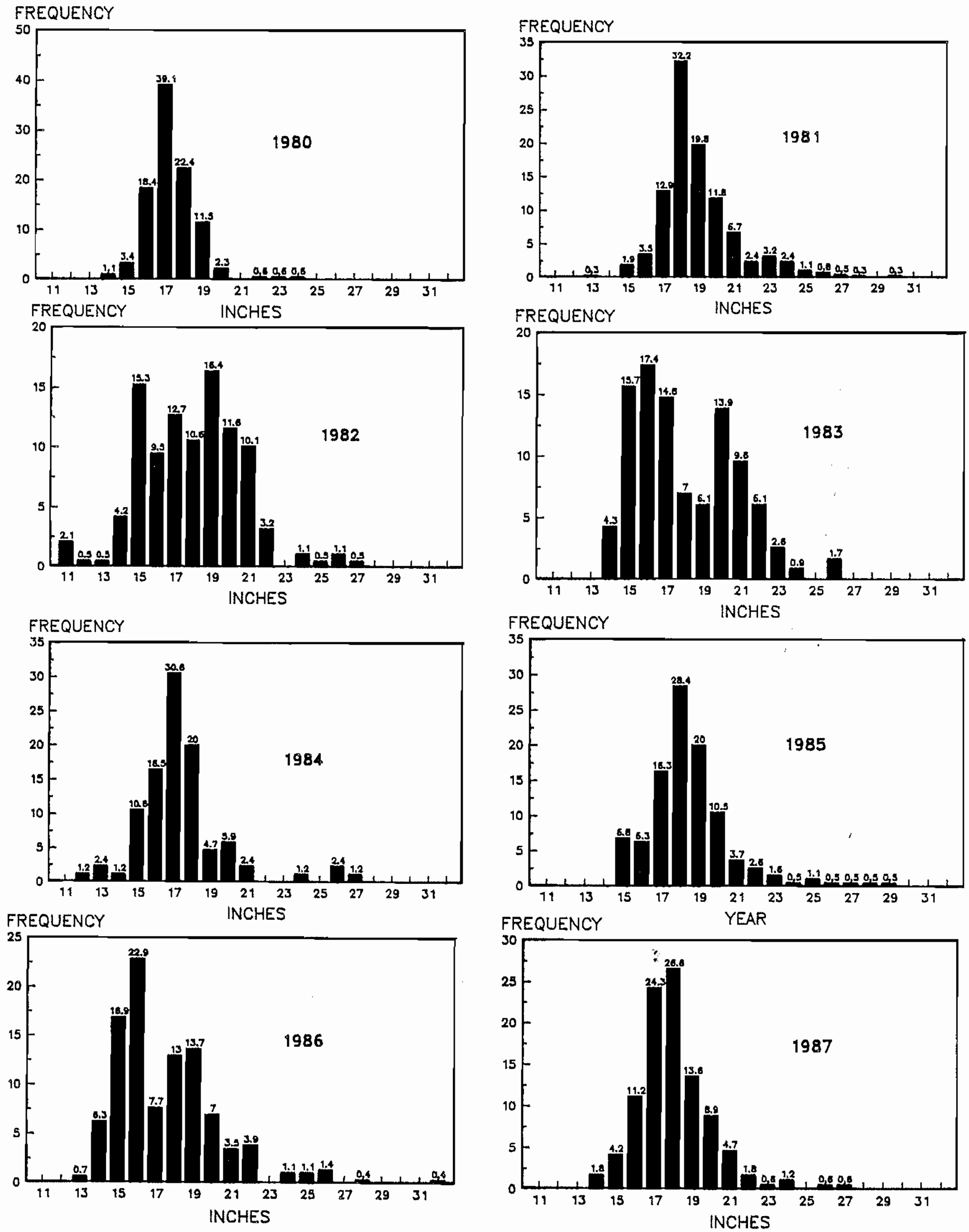


Figure 4. Length frequency of walleye sampled in the headwaters of Lake Cumberland, 1980-1987.

Figure 5. Percent of walleye collected in the Big South Fork in quality (15 in) to preferred (20 in) size range.

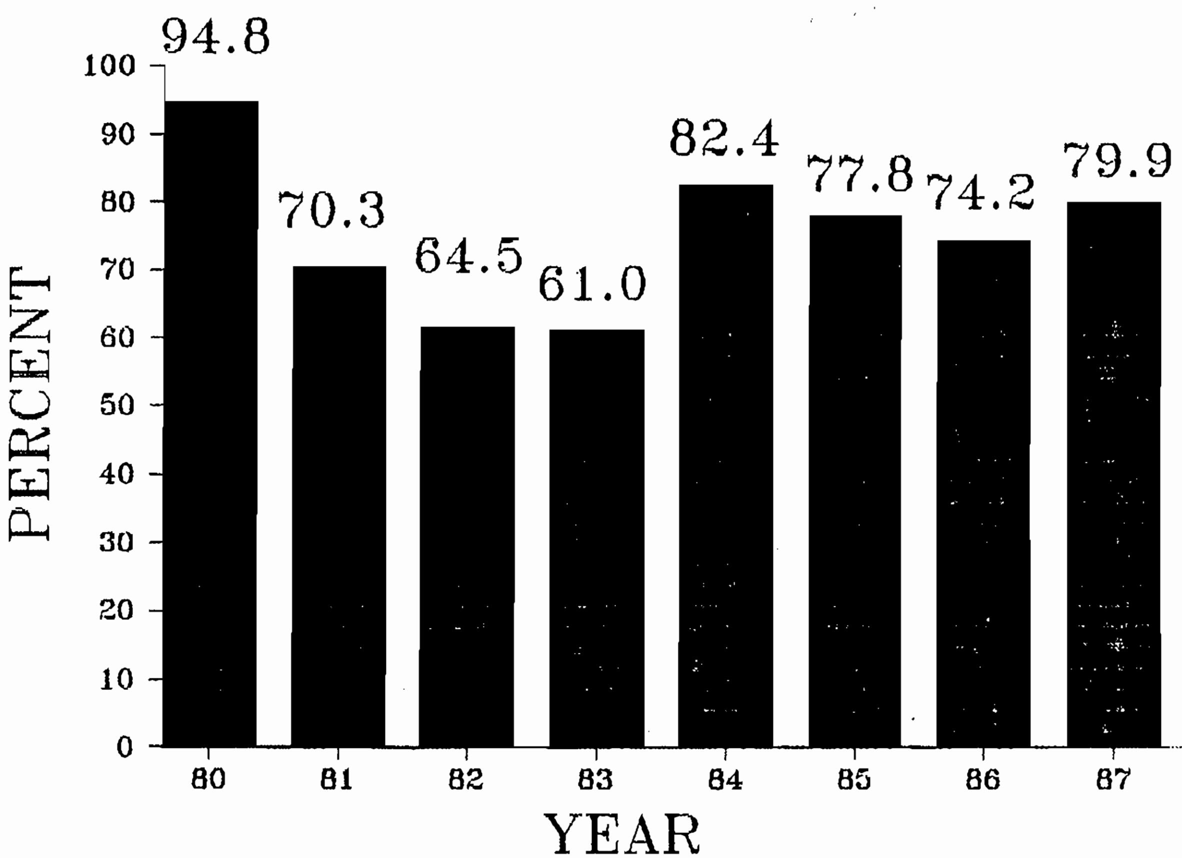


Figure 6. Percent of walleye collected in the Big South Fork in preferred (20 in) to memorable (25 in) size range.

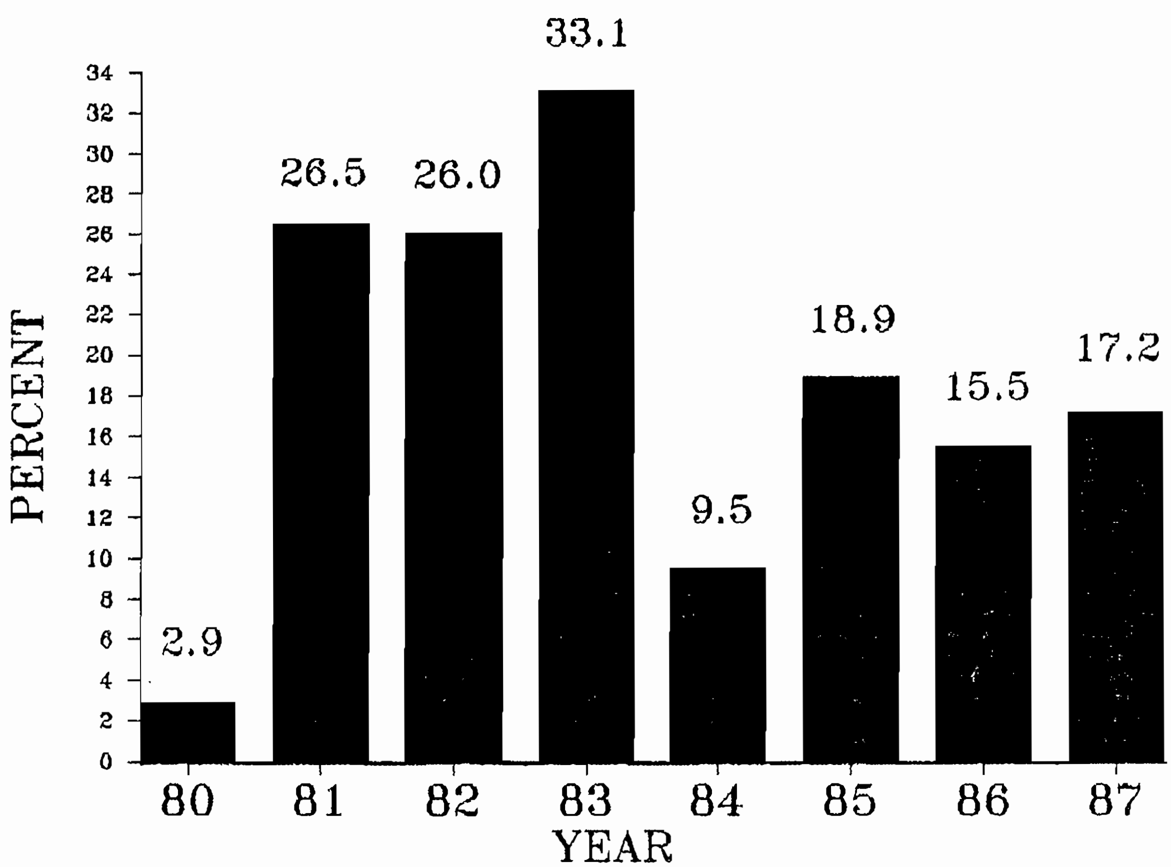


Figure 7. Percent by year class for each year walleye collected in the Big South Fork, 1981-1987.

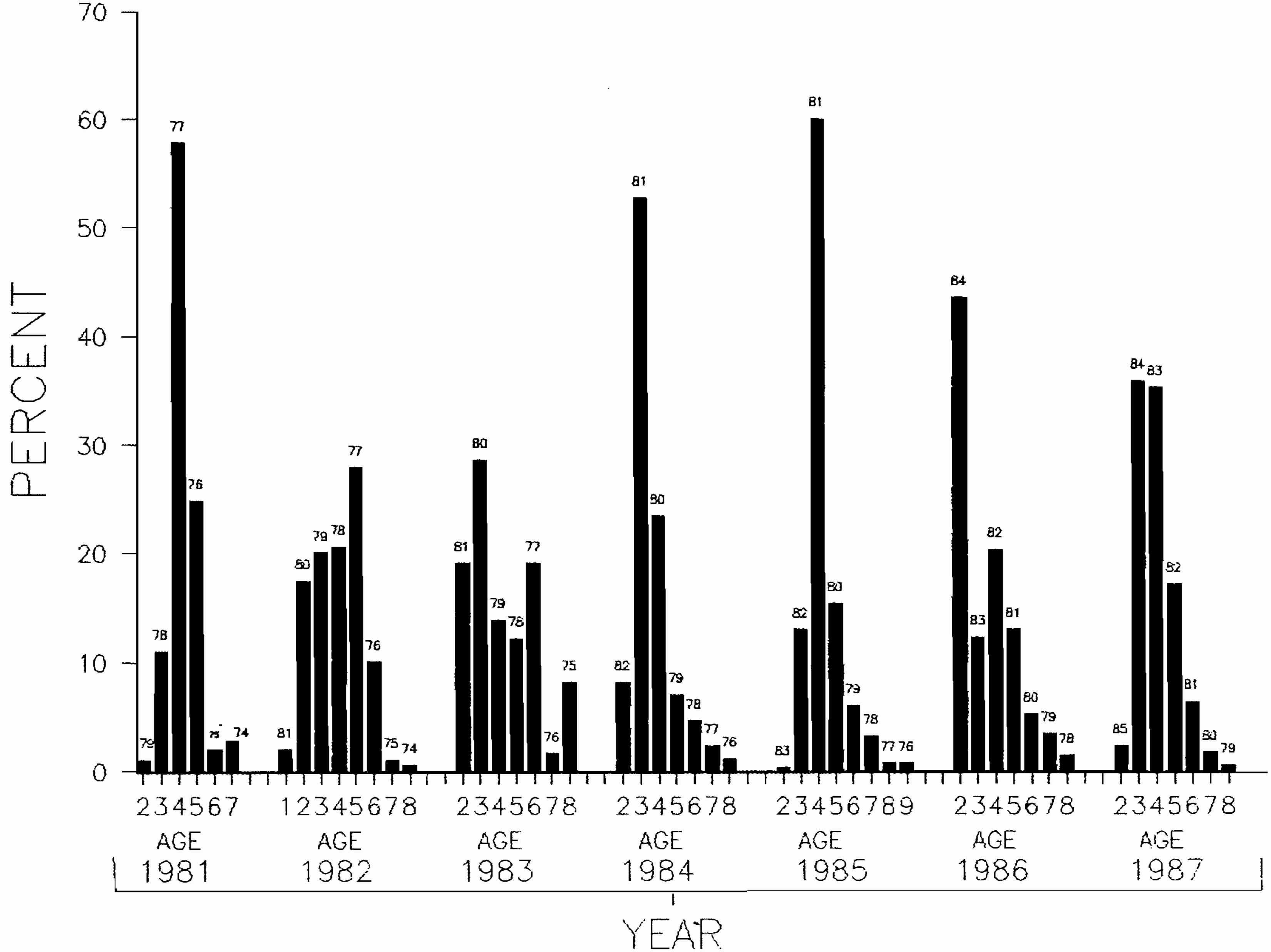


Figure 8. Percent of walleye catch in the Big South Fork by year class for years 1980-1987.

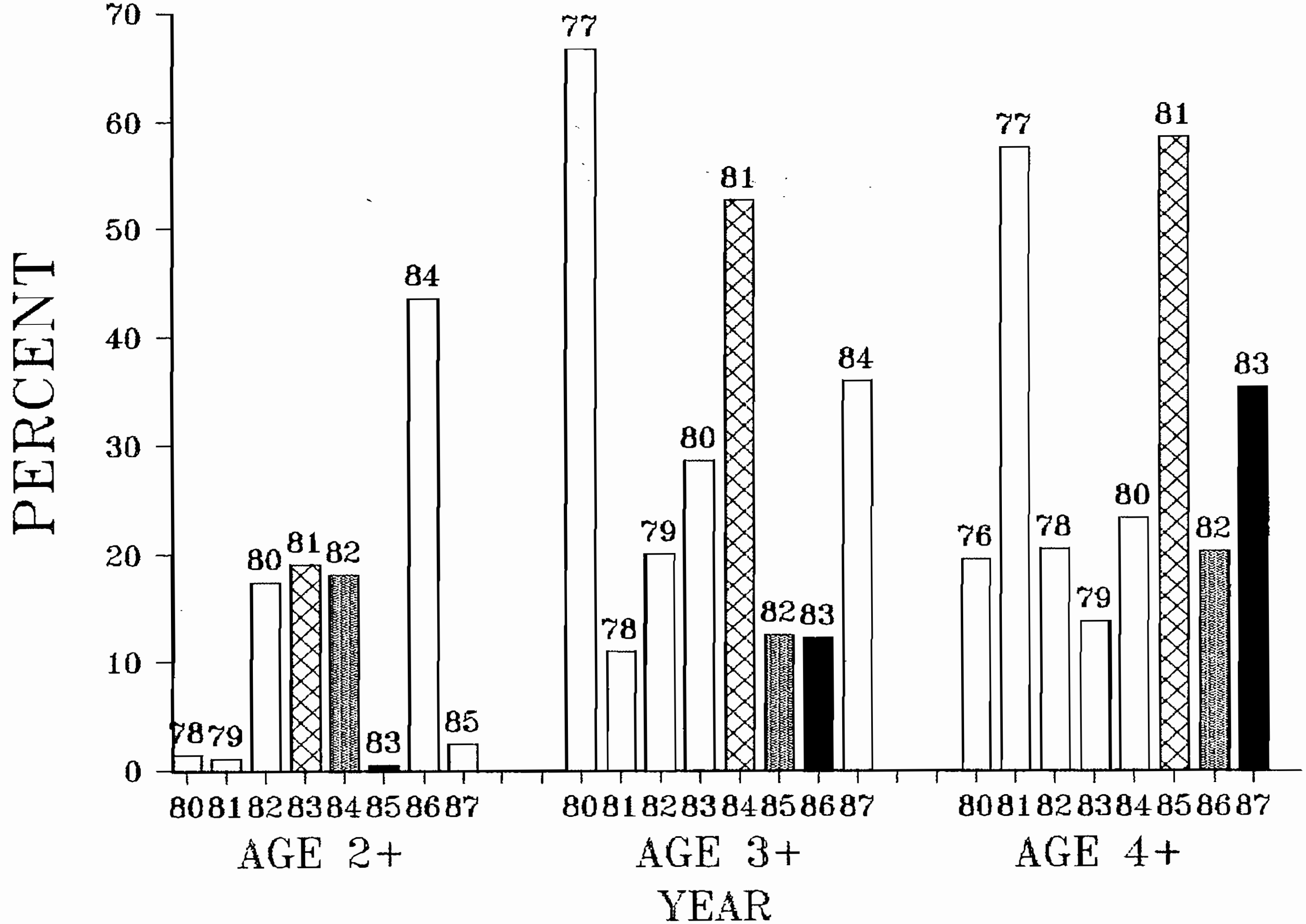
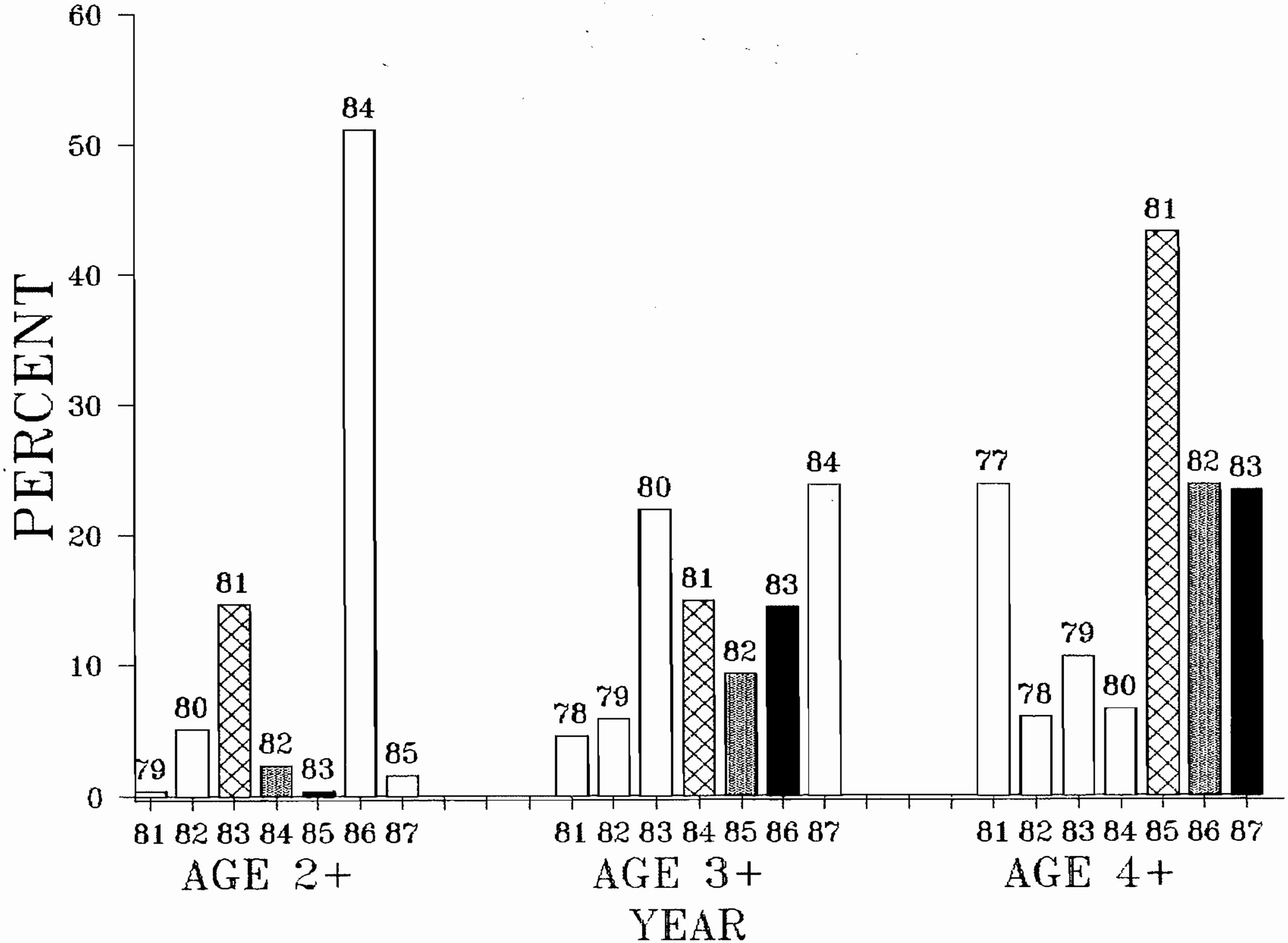


Figure 9. CPU by walleye year class in the Big South Fork for years 1981-1987.



LENGTH		FREQ	CUM FREQ	PERCENT	CUM PERCENT
1		0	0	0.00	0.00
2		0	0	0.00	0.00
3		0	0	0.00	0.00
4		0	0	0.00	0.00
5		0	0	0.00	0.00
6		0	0	0.00	0.00
7		0	0	0.00	0.00
8		0	0	0.00	0.00
9		0	0	0.00	0.00
10		0	0	0.00	0.00
11		0	0	0.00	0.00
12		0	0	0.00	0.00
13		0	0	0.00	0.00
14		0	0	0.00	0.00
15	**	8	8	2.29	2.29
16	*********	44	52	12.57	14.86
17	*************************	127	179	36.29	51.14
18	*****************	84	263	24.00	75.14
19	********	42	305	12.00	87.14
20	***	17	322	4.86	92.00
21	*	6	328	1.71	93.71
22	*	6	334	1.71	95.43
23	*	7	341	2.00	97.43
24	*	6	347	1.71	99.14
25	*	3	350	0.86	100.00
26		0	350	0.00	100.00
27		0	350	0.00	100.00
28		0	350	0.00	100.00
29		0	350	0.00	100.00
30		0	350	0.00	100.00
31		0	350	0.00	100.00

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       40      80     120
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FREQUENCY

Figure 10. Length frequency of walleye tagged in 1980 in the headwaters of Lake Cumberland.

LENGTH		FREQ	CUM FREQ	PERCENT	CUM PERCENT
1		0	0	0.00	0.00
2		0	0	0.00	0.00
3		0	0	0.00	0.00
4		0	0	0.00	0.00
5		0	0	0.00	0.00
6		0	0	0.00	0.00
7		0	0	0.00	0.00
8		0	0	0.00	0.00
9		0	0	0.00	0.00
10		0	0	0.00	0.00
11		0	0	0.00	0.00
12		0	0	0.00	0.00
13		0	0	0.00	0.00
14		1	1	0.31	0.31
15	**	4	5	1.24	1.55
16	**	6	11	1.86	3.42
17	************	30	41	9.32	12.73
18	******************************	75	116	23.29	36.02
19	************************************	91	207	28.26	64.29
20	*******************	48	255	14.91	79.19
21	*********	22	277	6.83	86.02
22	*****	12	289	3.73	89.75
23	*****	12	301	3.73	93.48
24	**	6	307	1.86	95.34
25	**	4	311	1.24	96.58
26	**	6	317	1.86	98.45
27	*	3	320	0.93	99.38
28		1	321	0.31	99.69
29		0	321	0.00	99.69
30		0	321	0.00	99.69
31		1	322	0.31	100.00

10 20 30 40 50 60 70 80 90

FREQUENCY

Figure 11. Length frequency of walleye tagged in 1981 in the headwaters of Lake Cumberland.

LENGTH		FREQ	CUM FREQ	PERCENT	CUM PERCENT
1		0	0	0.00	0.00
2		0	0	0.00	0.00
3		0	0	0.00	0.00
4		0	0	0.00	0.00
5		0	0	0.00	0.00
6		0	0	0.00	0.00
7		0	0	0.00	0.00
8		0	0	0.00	0.00
9		0	0	0.00	0.00
10		0	0	0.00	0.00
11		0	0	0.00	0.00
12		0	0	0.00	0.00
13		0	0	0.00	0.00
14		0	0	0.00	0.00
15	******************	18	18	9.73	9.73
16	**********************	22	40	11.89	21.62
17	*********************	21	61	11.35	32.97
18	****************************	28	89	15.14	48.11
19	*************************	25	114	13.51	61.62
20	**************************	26	140	14.05	75.68
21	***********************	23	163	12.43	88.11
22	*******	7	170	3.78	91.89
23	**	2	172	1.08	92.97
24		0	172	0.00	92.97
25	*****	5	177	2.70	95.68
26	******	6	183	3.24	98.92
27	**	2	185	1.08	100.00
28		0	185	0.00	100.00
29		0	185	0.00	100.00
30		0	185	0.00	100.00
31		0	185	0.00	100.00

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5 10 15 20 25

FREQUENCY

Figure 12. Length frequency of walleye tagged in 1982 in the headwaters of Lake Cumberland.

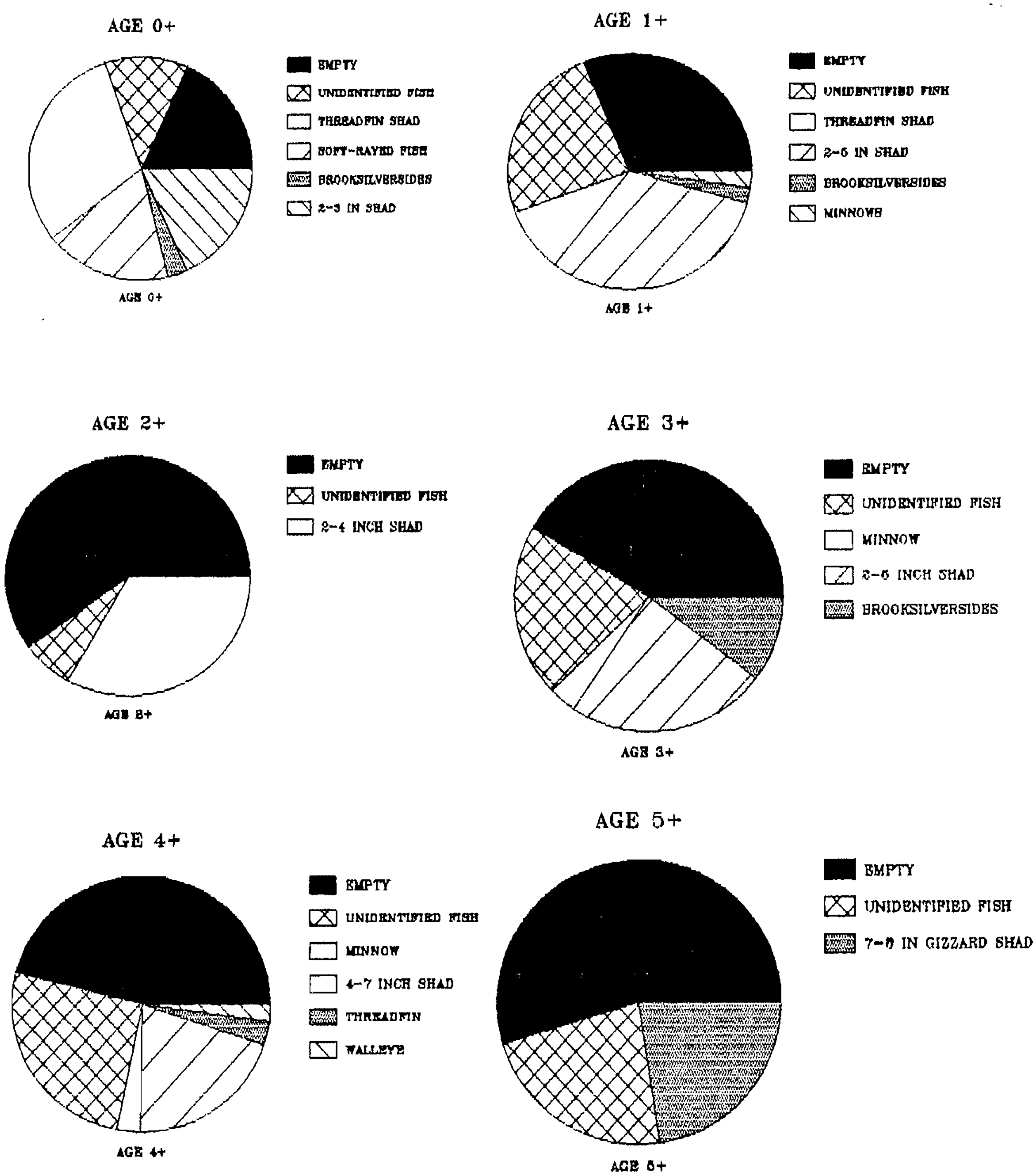

Figure 13. Percent frequency of occurrence of food items by walleye age group.

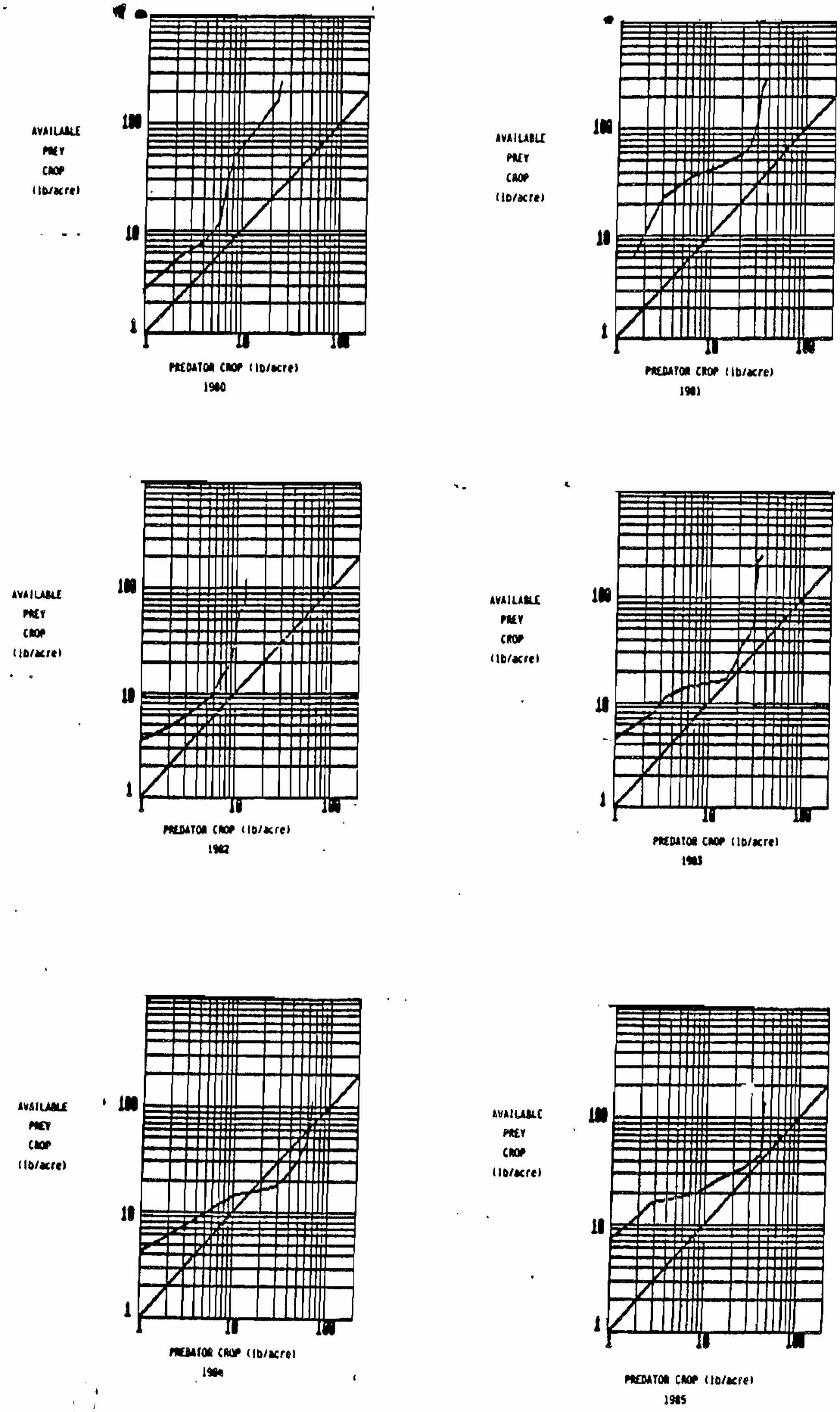

Figure 14. Available prey/predator (AP/P) plots by year of cove-rotenone studies conducted in Lake Cumberland (1980-1985).

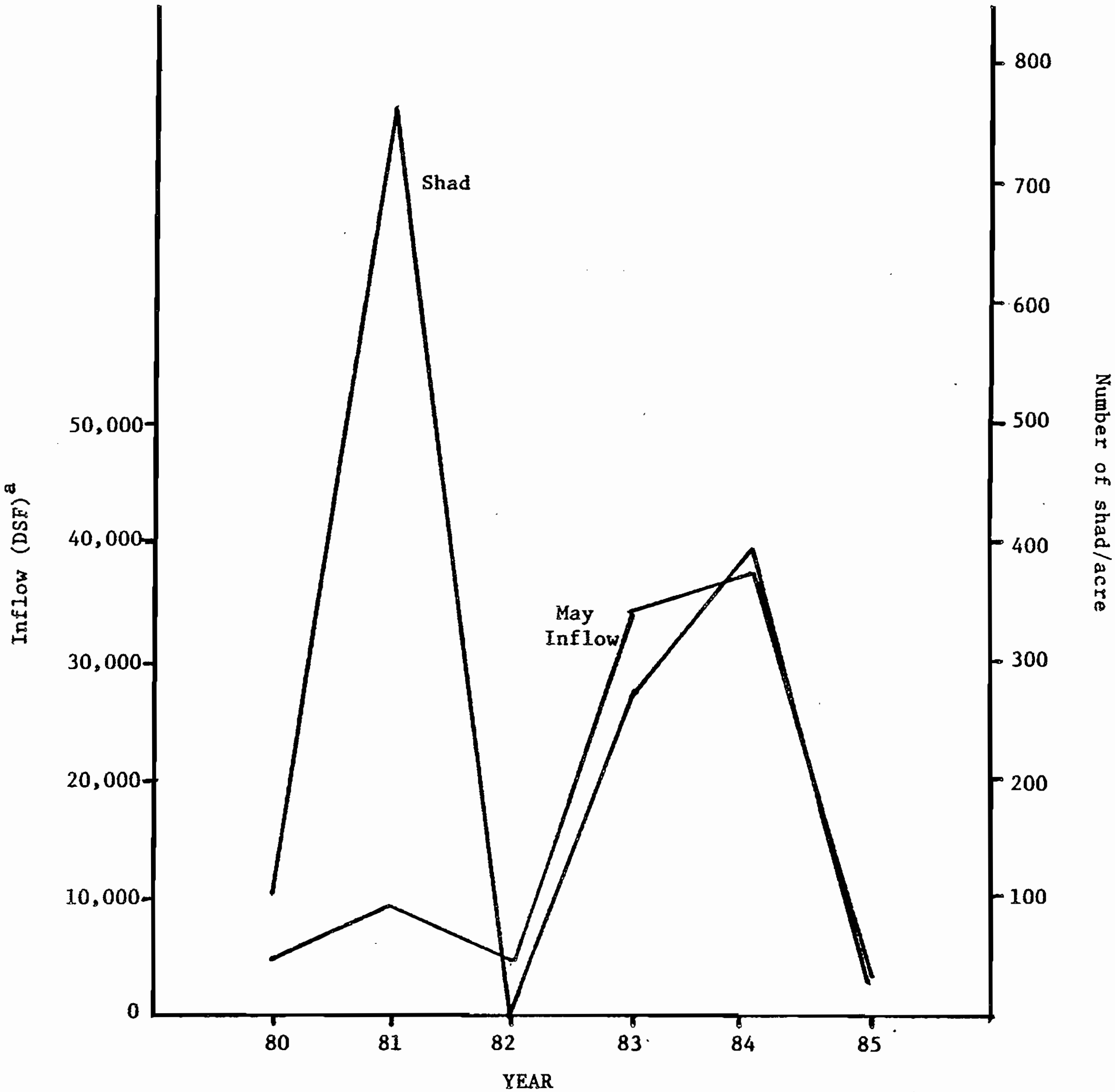

Figure 15. Relationship between May lake inflow and young-of-year gizzard shad. [a]DSF= day second feet

Figure 16. Length distribution of walleye harvested in the 1988 creel survey on Lake Cumberland.

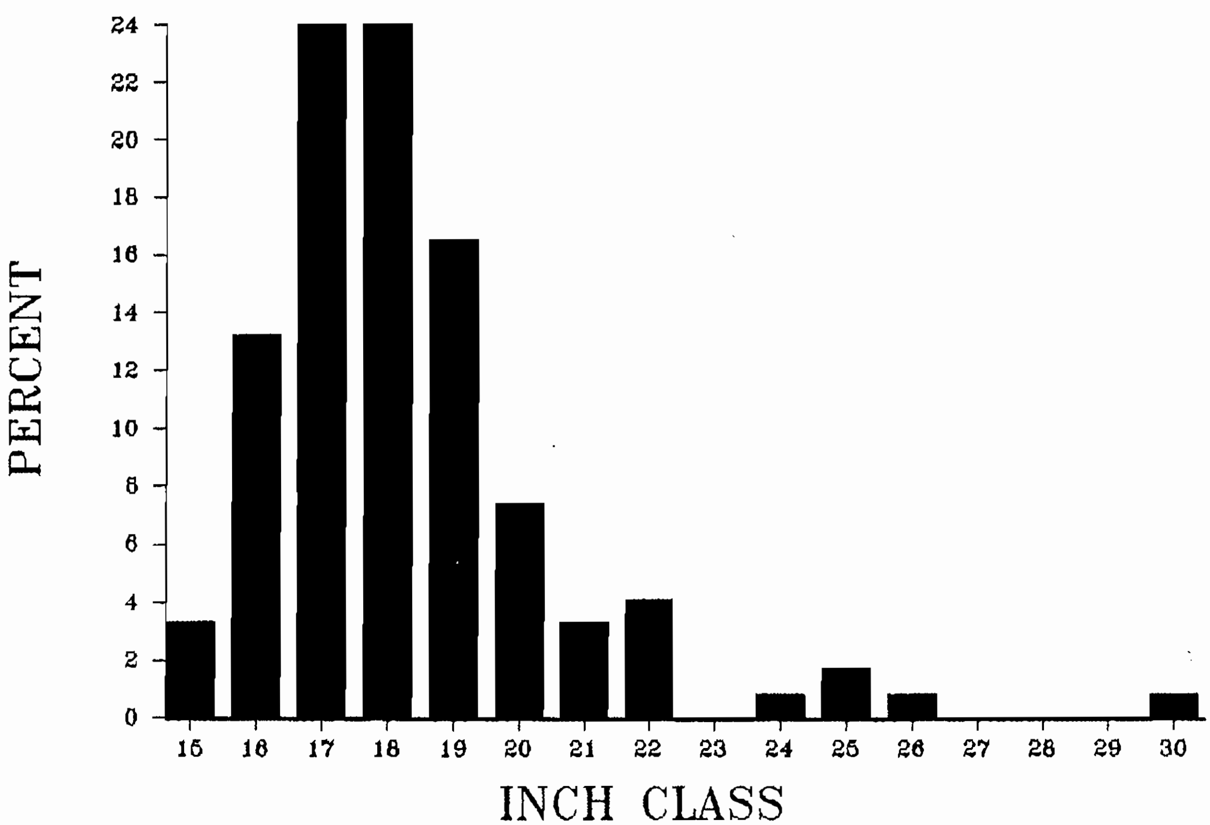

Figure 17. Numbers of walleye mail-in survey returns from Lake Cumberland (1980-1987).