A SURVEY OF THE FISHERY RESOURCE OF PERCH LAKE MONROE COUNTY, WISCONSIN

A Thesis

Submitted to the Faculty

of

University of Wisconsin - La Crosse

La Crosse, Wisconsin 54601

by

Timothy E. Babros

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science in Biology

August 1985

UNIVERSITY OF WISCONSIN - LA CROSSE

La Crosse, Wisconsin 54601

COLLEGE OF ARTS, LETTERS, AND SCIENCES

Candidate: Timothy Edward Babros

We recommend acceptance of this thesis to the College of Arts, Letters, and Sciences in partial fulfillment of this candidate's requirements for the degree Master of Science in Biology. The candidate has completed his oral defense of the thesis.

Thesis approved:

Thesis Committee Chairperson	11 July 1985 Date
Fred P. Meyer Thesis Committee Member	July 8, 1985 Date
Thomas O. Claflin Thesis Committee Member	July 10, 1985 Date
John K. Schmidt Thesis Committee Member	July 11, 1985 Date
A. Vincent Weber Dean, College of Arts, Letters, and Sciences	July 11, 1985 Date
Howard C Rose Dean, Office of Graduate Studies	July 11, 1985 Date

ABSTRACT

An inventory of the fishery resource of Perch Lake, Monroe County, Wisconsin was conducted to determine the species present, species population structure, community structure and lake morphometry. Two laps of the shoreline were electrofished on four nights during a three week period in September 1983 and seine hauls were conducted prior to electrofishing to assess young-of-the-year and forage species abundance.

Analyses of the species population structure and condition showed that largemouth bass (*Micropterus salmoides*) and northern pike (*Esox lucius*) populations are growing favorably but these species are represented by young populations and very few large predators were observed. Assessment of the most abundant panfish species sampled revealed normal population structure for bluegill (*Lepomis macrochirus*) and pumpkinseed sunfish (*L. gibbosus*) and showed that these fishes were in average to good condition. In addition the growth rates of bluegill and pumpkinseeds were also found to be normal. The electrofishing sample mostly contained young-of-the-year black crappies (*Pomoxis nigromaculatus*) and an accurate assessment of population structure, growth rate and condition of that species was impossible. Two rough fish species that were observed in high abundance were white sucker (*Catostomus commersoni*) and common carp (*Cyprinus carpio*) and the sample contained many older individuals of both species. Assessments of the growth rates and condition indicated that common carp were approaching levels of overabundance; the high estimated number of white suckers suggested that this species may have been approaching overabundance as well.

Biomass measurements and an analysis of the community structure indicated a dominance of rough fish species in Perch Lake and it was concluded that their removal would enhance the overall community structure. Structural indices also showed that predator populations were young and were providing suboptimal quality sport fishing.

Results of the morphometric survey revealed that Perch Lake is characterized by a very uniform depth, narrow littoral zone, and minimal habitat for fish species. Predator populations are young and a direct result of stocking efforts. Although panfish populations are self-sustaining and presently provide quality fishing, rough fish removal would likely enhance community structure for sport fishing. Continued stocking of largemouth bass and northern pike will be necessary in the future unless adequate spawning habitat can be provided since the natural reproduction of these species is minimal. The recent installation of fish cribs in the lake will benefit all species present and the strong public interest observed in the locality suggests favorable cost/benefit ratios for management programs.

ACKNOWLEDGEMENTS

The author wishes to thank Dr. J. W. Held, Dr. F. P. Meyer, and Dr. T. O. Claflin for their advice throughout the project and for their careful review of the manuscript.

The author also wishes to thank the Wisconsin Department of Natural Resources for providing the electrofishing boat and manpower. Also much appreciated are the many fellow graduate students who volunteered to perform field investigations.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

FIGURE | PAGE

INTRODUCTION

This study was conducted to assess fish population and community structure and to develop a map of the existing lake morphometry in Perch Lake. Perch Lake is a 13.2 ha man-made impoundment of the La Crosse River located in Section 13, T17N, R4W, Monroe County, Wisconsin and located on the eastern edge of the City of Sparta. A pre-renovation survey of the lake was conducted in 1976 by the Wisconsin Department of Natural Resources (DNR) (Talley 1976). A brief paragraph summarizing the report follows.

The landscape is glacially formed and sandy soils dominate the river basin. This reach of the La Crosse River is characterized by a steady base flow and minimal flooding problems. Early settlers to the area recognized that these characteristics had good potential for power production. Sparta owes much of its early development to the large number of dams built in the area between 1850 and 1875. The Perch Lake dam is owned and maintained by the City of Sparta and is of the stop log type. Originally called the paper mill dam, the Perch Lake dam was first used as a grist mill and later to generate electrical power. In their 118 year history, both the dam and lake have been subject to considerable manipulation. The dam was rebuilt in 1901 and 1918, and received extensive repairs in 1960. The dam no longer performs any power-generated function but is maintained to provide recreation.

The recreational potential of Perch Lake is limited because of its small size and shallow depth ($\overline{d}$ = 2.1 m). The lake was partially excavated first in 1960 and most recently in 1980. The 1980 attempt proved to be unsuccessful because large amounts of sediment, which would normally have been trapped by an upstream impoundment (Angelo

Pond) reached Perch Lake. The Angelo Pond dam washed out in 1978 and was still under repair when the 1980 excavation efforts in Perch Lake were conducted. The Angelo impoundment is located about 4.8 Km upstream from Perch Lake and is larger but shallower than Perch Lake. Above Angelo Pond lies the headwater area of the La Crosse River which delivers a lot of sediment to the impoundment. This broad but shallow pool normally traps most of the incoming sediment and it is reasonably assumed that whatever sediment passes through Angelo Pond travels through Perch Lake as well (Talley 1976).

The 1976 DNR survey concluded that Perch Lake is subjected to siltation and the growth of aquatic macrophytes at nuisance levels. Both problems would be costly to rectify and any renovation would be temporary. The survey indicated that two submergent macrophytes dominated the plant community; coontail (Ceratophyllum demersum) and elodea (Anacharis canadensis). Both species were found to be very abundant at water depths up to 1.5 m. Other less abundant, but commonly found plants, included pondweed (Potamogeton diversifolius and Potamogeton zosteriformis), and duckweed (Lemna minor). Little emergent vegetation was observed.

In 1973, the DNR conducted a basic inventory of the fishery resource (Talley 1974). The survey noted that Perch Lake provided good to fair fishing throughout the year with public access described as sufficient. In addition to the public park and boat access, most of the south shoreline is a country club golf course where shoreline fishing is permitted.

The 1973 DNR survey indicated that the most abundant fishes were bluegills (Lepomis macrochirus), pumpkinseed sunfish (Lepomis gibbosus), black crappies (Pomoxis nigromaculatus), yellow bullheads (Ictalurus natalis), black bullheads (Ictalurus melas), and northern pike (Esox lucius). The survey listed white suckers (Catostomus commersoni) and carp (Cyprinus carpio) as being only present.

Presently, lake morphometry is unknown since excavation efforts in 1980 were unsuccessful and the lake has not been mapped since 1973. Following the 1980 renovation attempt, the DNR has stocked approximately 7,000 largemouth bass (Micropterus salmoides) and 300 northern pike in the lake between 1982 and 1983 (Table 1). The success of this stocking program is unknown as are fish population and community structure. However, biweekly visits to Perch Lake in July and August of 1983, on both week and weekend days, revealed very little to no fishing pressure and local disappointment in the lake as a fishery resource. Public opinion suggests that the lake is dominated by rough fishes and panfish with gamefish numbers declining.

Three characteristics of Perch Lake justify extensive research into the fishery as well as assigning a high management priority to the lake. These three characteristics are: (1) approximately 95% of the shoreline is accessable to public shore fishing, (2) adequate boating access and parking exist, and (3) the lake is located within the Sparta city limits, therefore decreasing angler travel expenses. These characteristics in combination with observed strong public interest suggest a high use potential and favorable cost/benefit ratios for management programs.

Table 1: Post dredging stocking program in Perch Lake, Monroe County, Wisconsin.

Species	Date	Age Class	Number Stocked
Northern pike	August 1982	Fingerlings	100
	July 1983	Fingerlings	250
Largemouth bass	September 1982	Fingerlings	2,000
	June 1983	Fingerlings	5,000

Taken from Wright (1983).

LITERATURE REVIEW

Man interacts with fish communities in three principle ways: (1) as a food source, (2) as source of economic benefit, and (3) as a source of recreational enjoyment (Hackney 1978). Sport fishing largely interacts with fish communities only as a source of recreational enjoyment. The management of sport fisheries should therefore emphasize and maximize recreational aspects. Anderson (1978) stated that a new philosophy in the management of recreational fisheries has promoted the concepts of quality and optimization. The application of this new management philosophy requires that management objectives include the optimization of fishing quality, including the relative abundance of quality size fishes in addition to traditional sustained yield objectives. This study intends to apply this philosophy to analyze the Perch Lake sport fishery.

Bennett (1970) pointed out the obvious first step in the application of a management strategy, i.e., a careful assessment of the fishery. Some of the most current and commonly used indices of fish population and community structure that will be employed in this survey include: (1) population estimates, (2) population age structure, (3) length-frequency distributions, (4) length-weight relationships, (5) condition indices, (6) catch per unit effort (CPUE), (7) proportional stock density (PSD), and (8) relative stock density (RSD). The following discussion serves only to briefly discuss the application of these indices to recreational fisheries because current literature discussing their theory and application can only be described as voluminous.

Measures of Abundance

Population estimation is a necessary part of fisheries management in order to understand population composition and number. One of the most common methods used to estimate fish numbers is the Schnabel (1938) modification of the Peterson estimate. Robson and Regier (1964) reported that if the product of the number of marked and released fish and the number of fish examined for marks is greater than four times the population estimate, the estimate is less than 2% biased. This criterion will be used to determine the population estimates performed in this study.

Biomass estimates can be used to determine relative abundance in much the same way as population estimates. The relative proportion that individual populations contribute to the total community biomass can be used as a measure of relative species abundance.

A third measure of abundance is catch per unit effort (CPUE) and is defined as the number of fish caught per unit of fishing effort. Quinn et al. (1982) stated that CPUE is a reliable index of population density when the assumptions regarding fishing gear and spatial distributions of fish and fishing efforts are satisfied. If species-specific gear selectivity is taken into consideration, then relative species CPUE's can be used to indicate relative species abundance within a particular fish community.

Structural Indices

The two most traditionally used indices of population structure are age determination (coupled with the back calculation of growth) and length-frequency distributions. Several methods are available for determining the age of fishes including the scale method, the cross-sectioning of fin rays, and the cross-sectioning of ossified structures such as otoliths and spines. Of these methodologies the use of scales is the most widely used and extensive literature exists explaining the technique and validity of the method (Adams 1931, Butler and Smith 1953, Campbell and Witt 1953, Carlander 1949, Dery 1983, Hile 1950). One important consideration of the scale method is the selection of scales from key regions of the fish's body (Hile 1970). These key regions vary amoung different species of fishes and have been identified as the areas that are least susceptable to natural scale loss and consequent regeneration (Ricker 1971). Back-calculated growth data, as outlined by Ricker (1971), are useful in determining if growth is occurring normally or if it is irregular relative to documented regional growth rates. Slower than normal regional growth rates imply suboptimal growth conditions usually due to some density dependent mechanism such as overabundance of a particular or several species.

Length-frequency distributions also provide a description of population structure. These distributions and changes in distributions with time can help in understanding the dynamics of populations and in identifing problems such as year class failures or low recruitment, slow growth or excessive annual mortality (Nielson and Johnson 1983).

Along with length measurements, individual weights can be used to establish a length-weight relationship for a particular population. In fishes the length-weight relationship can usually be adequately represented by the equation-$\log W = \log a + b \log TL$ (Ricker 1971), where W = weight, TL = total length, and a and b are fitted coefficients. Ricker (1971) adds that the coefficient b takes on a value most always between 2 and 4, and often close to 3. Length-weight relations describe structural characteristics of individuals within populations (Nielson and Johnson 1983) and the relationship can be compared to other documented length-weight relationships within a particular region as an index of condition.

Condition indices are derived from length-weight relationships (Nielson and Johnson 1983) and reflect the "plumpness" or well-being of the fish (Ricker 1971). The traditionally used index of condition is the ponderal index: $K = W/L^3$, where W = weight, L = total length, and K is defined as the condition factor (Ricker 1971). More recently a new index of condition, relative weight (W_r), has been adopted (Wege and Anderson 1978). This index is calculated by dividing the weight of a fish by a North American standard weight for its length and multipling by 100 (Anderson 1978). A distinct advantage of the W_r index is one set of standard weights can be used by biologists so that calculated W_r values can be compared among all users.

Two final structural indices to be discussed in this text are proportional stock density (PSD) and relative stock density (RSD). These indices have been recently developed along with W_r to involve the new recreational fishery concepts of quality and optimization (Anderson 1978). PSD is calculated by dividing the number of fish of quality size (36-41% of the world record) by the total number longer than minimum stock size (20-25% of the world record) and multipling the quotient by 100 (Anderson 1978). RSD measures the proportion of the stock comprised of "memorable" size, fish that are 59-74% of the world record length (Held 1983), and is calculated by dividing the number of "memorable" size fishes by the total number longer than minimum stock size and dividing the quotient by 100. Length ranges and proposed lengths for minimum stock, quality, preferred, memorable and trophy sizes calculated as percentages of world record lengths for several common freshwater fishes were tabulated by Gabelhouse (1981). The indices of PSD, RSD, and W_r conform to a concept of optimality in that a satisfactory or objective range can be established and calculated values much above or below optimal management objective ranges indicate that some adjustments of structure may be in order (Anderson 1978). The PSD index was originally developed to establish management objective ranges for bass/bluegill communities typical of midwestern farm ponds. A PSD tic-tac-toe diagram was designed by Anderson (1978) to assess the relationship between bass PSD's and bluegill PSD's, and he recommended a management objective range of 40-60% for bass and 20-40% for bluegill. More recently, Held (1983) and Goedde and Coble (1981) applied the index to larger more diverse communities by lumping together all predator species and all prey species to assess community structure. PSD ranges for a balanced community suggested by Goedde (1980) were 25-45% for prey and 35-60% for predators. Goedde and Coble (1981) stated that PSD seems to be useful for evaluating a fish community although it considers only relative abundance of quality size to stock size fish and if abundance of both increases or decreases, the change might not be evident in the PSD index. Held (1983) suggested that PSD be used as a tool in conjunction with other indices and determinations, and he anticipated that PSD's would offer clues to ecological responses of fishes to human influences and natural phenomena.

MATERIALS AND METHODS

Fish Sampling

Three seining trips were made in July and August 1983 in order to obtain qualitative samples of available forage and young-of-the-year fishes. A total of 30 seine hauls was made at intervals along the shore with a 3 x 1 m seine (0.3 cm^2 mesh).

Fish samples were also collected on four electrofishing trips conducted at night during September 1983. Boccardy and Cooper (1963) stated that electrofishing is one of the least selective of all active fishing methods, and Reynolds and Simpson (1978) concluded that management sampling of fish communities in small impoundments should include seining during the summer to assess potential recruitment to stock, and electrofishing in the spring or fall to determine stock size structure. Reynolds and Simpson (1978) added that electrofishing can and should be used to assess stock structure in addition to documenting relative capture rates and proposed that one lap of shoreline apppears to be useful as a standard method. For purposes of this study, two complete laps of the shoreline were fished each sampling trip for a total fishing effort of 9.75 hours. Pulsed D.C. current (320 volts, 6-10 amps) was used, since Ricker (1971) described D.C. current as being particularly useful in turbid waters or in thick weeds and whenever it is important not to damage fish. Captured fishes were held in a 285 L tank until processed.

Processing

All fish were identified and counted. Large specimens (> 30 mm) were measured to the nearest millimeter (total length), weighed to the nearest gram, and released in the field. Small specimens (< 30 mm) were preserved in 10% formalin. They were later measured to the nearest millimeter (total length) and weighed to the nearest 0.01 gram in the laboratory. Scale samples were taken from all large specimens of species captured except white suckers. Because of the high frequency of white suckers between 380 and 420 mm, scale samples were taken from only about 1/3 of the white suckers in this size group. Scales were taken from spiney-rayed species in the area below the lateral line at the tip of the pectoral fin. For soft-rayed species, scales were collected above the lateral line below the insertion of the dorsal fin. Partial caudal fin clips were used to mark fish for mark-recapture population estimates.

Determinations and Indices

Three scales from each sample were pressed onto acetate using a roller press and ages were determined using a Eberbach 2700 projector. Increments of growth were measured by placing a paper tab along a transect extending from the focus to the anterior median margin of the scale according to the method of Carlander and Smith (1944). Back-calculations of growth were performed using the nomograph method of Ricker (1971) that assumes a linear relationship between scale length and total length of the fish. Scale length-fish length regressions were performed using data pairs of mean scale length and mean total length of 10 mm fish length intervals.

Length-frequency graphs were constructed for all abundant species. Abundant species were defined as those species with a sample size greater than 30. CPUE (fish/hr), percent of total catch numbers, and percent of total catch biomass were calculated for all species. PSD and RSD were calculated for abundant species using fish lengths proposed by Gabelhouse (1981) (Table 2). A weighted mean predator PSD and a weighted mean prey PSD were calculated using a formula given by Goedde (1980): $Pw = PW/\Sigma W$, where P_W is the weighted mean predator or prey PSD, P is the PSD for each predator or prey, and W is the weighting factor CPUE.

Length-weight regressions were performed using data pairs of mean weight and mean length at 10 mm length intervals for abundant species. The conditon factor K was calculated for abundant species and W_r was calculated for largemouth bass, black crappie and bluegill. W_r was not calculated for other species due to the lack of adequate standard length-regressions (Anderson 1985).

Population Statistics

Population estimates were calculated using the Schnabel (1938) modification of the multiple census Peterson estimate. The multiple census estimate is derived using the following formula:

$$N = \frac{\sum_{i=1}^{n} (M_i \; C_i)}{\left(\sum_{i=1}^{n} R_i\right) + 1}$$

where N is the population estimate, M is the number of marked fish, C is the number captured, R is the number of recaptured marked fish, and i is the sample number. A simplified equation to calculate 95% confidence limits given by Ricker (1958) is:

$$\sum_{i=1}^{n} R_i + 1.92 \pm 1.96 \sum_{i=i}^{n} \sqrt{R_i + 1}$$

Table 2: Minimum sizes (total length in mm) used to define stock, quality, and memorable sized fishes for purposes of calculating PSD and RSD values for species taken from Perch Lake, Monroe County, Wisconsin. (After Gabelhouse 1981).

Species	Stock-size (mm)	Quality-size (mm)	Memorable-size (mm)
Largemouth bass	200	300	510
Northern pike	350	530	810
Black crappie	130	200	300
Pumpkinseed	80	150	250
Bluegill	80	150	250
Yellow bullhead	150	230	380
Yellow perch	130	200	300
Green sunfish	80	150	250
White sucker	130	210	370
Common carp	280	410	660

where R is the number of recaptured fish. The equation replaces the denominator of the multiple census estimate formula shown above and the resultant values of N identify the lower and upper 95% confidence limits of the population estimate.

The four sample trips for this investigation were conducted over a three week period and were not less than three days apart. It was assumed that this sampling procedure minimized increases and decreases in stock numbers. It was also assumed that the minimum three-day interval between sampling trips allowed for random redistribution of marked fish. Observed mortalities due to sampling included five white suckers, three carp, and one northern pike.

Lake Mapping

An outline of the lake was drawn using an aerial photograph obtained from the U.S. Department of Agriculture, Monroe County ASCS office in Sparta, Wisconsin. The slide was projected onto a wall and, after making sure the projector was level, the shoreline was traced. Depth measurements were conducted through the ice and recorded using sonar equipment every 10 m along 16 predetermined transects. Transects were arranged in a criss-cross manner and defined by taking compass headings from strategic points that could be located on the aerial photograph. The map scale was calculated from measured transect lengths.

RESULTS

Species Composition

A total of 16 species were collected in Perch Lake during this investigation and for purposes of discussion were placed into four management catagories (Table 3). Seine hauls revealed several young-of-the-year largemouth bass, bluegills, and pumpkinseeds. Relative to these three species very few forage fishes were netted. Of the forage species observed, golden shiner, blackside darter, and johnny darter were most abundant. Two remaining species observed in seine hauls were bluntnose minnow and northern pike (two fingerlings).

Electrofishing revealed an abundance of largemouth bass, white suckers, and black crappies. The white sucker catch contained mostly adult fish (98%) and the black crappie catch was comprised primarily of young-of-the-year fish (98%). Other species that were abundant in electrofishing catches included northern pike, pumpkinseeds, bluegills, common carp, and northern brook lamprey. Species observed in low numbers included yellow bullheads, yellow perch, green sunfish, and freshwater drum.

Relative Abundance

Population estimates were calculated for the four species for which sufficient fishes were marked and recaptured to provide an estimate containing less than 2% bias as recommended for research purposes by Robson and Rieger (1964). The four species included: largemouth bass, northern pike, white sucker, and common carp and the estimates were 907, 142, 965, and 207, respectively (Table 4). These data show that white suckers and largemouth bass were the most abundant

Table 3: Species and number of fish taken by electrofishing and seining from Perch Lake, Monroe County, Wisconsin during September 1983.

Management catagory	Species	Number
Predators	Largemouth bass (Micropterus salmoides)	374
	Northern pike (Esox lucius)	47
Panfish	Black Crappie (Pomoxis nigromaculatus)	212
	Pumpkinseed (Lepomis gibbosus)	63
	Bluegill (Lepomis macrochirus)	39
	Yellow bullhead (Ictalurus natalis)	16
	Yellow perch (Perca flavescens)	1
	Green sunfish (Lepomis cyanellus)	1
Rough fish	White sucker (Catostomus commersoni)	307
	Common carp (Cyprinus carpio)	63
	Freshwater drum (Aplodinotus grunniens)	1
	Brook lamprey (Ichthyomyzon fossor)	NC*
Forage	Golden shiner (Notemigonus crysoleucas)	NC*
	Bluntnose minnow (Pimephales notatus)	NC*
	Blackside darter (Percina maculata)	NC*
	Johnny darter (Etheostoma nigrum)	NC*

* Species not counted. See text for discussion of relative abundance.

Table 4: Estimated and relative abundance data calculated for species taken by electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983.

Species	Population estimate	95% Confidence interval	Electrofishing CPUE (fish/hr.)
Largemouth bass	907	687-1,193	44.3
Northern pike	142	71-248	5.5
Black crappie	*	*	21.3
Pumpkinseed	*	*	6.6
Bluegill	*	*	4.0
Yellow bullhead	*	*	1.6
Yellow perch	*	*	0.1
Green sunfish	*	*	0.1
Freshwater drum	*	*	0.1
White sucker	965	732-1,296	38.7
Common carp	207	96-414	6.9

*Not calculated

species, with white suckers only slightly more abundant than largemouth bass. CPUE data (Table 4) also indicated a predominance of white suckers and largemouth bass in Perch Lake. The CPUE for black crappies (21.3 fish/hr) was approximately half that of largemouth bass (44.3 fish/hr) and white suckers (38.7 fish/hr), and nearly four times greater than values for pumpkinseeds (6.6 fish/hr), bluegills (4.0 fish/hr), common carp (6.9 fish/hr) and northern pike (5.5 fish/hr), all of which were nearly equal. The yellow bullhead CPUE was 1.6 fish/hr and CPUE values for all remaining species were 0.1 fish/hr.

Low CPUE values for certain species may reflect sampling gear selectivity, especially for yellow bullheads. Reynolds and Simpson (1978) found that electrofishing was inefficient for sampling bullheads and only moderately effective for sampling black crappies and green sunfish populations. Wright (1983) stated that electrofishing success is often low for northern pike and common carp due to their ability to detect and swim ahead of the electric field. It was apparent that several common carp were escaping capture during the field investigations of this study. However, as noted previously, an adequate sample was obtained to permit acceptable population estimates for both northern pike and common carp.

Total catch biomass and percent total catch compositon by number and biomass were calculated (Table 5). The percent numerical compositon of the catch related directly to CPUE data, but percent total catch composition by biomass data showed that 82.6% of the total biomass was attributable to common carp and white suckers. When all species were placed into the management catagories listed in Table 2, a nearly equal percentage of total catch for the number of

Table 5: Total catch and percent composition (by number and biomass) of species taken by electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983.

Species	No.	Total catch biomass (Kg)	% total catch no.	% total catch biomass
Largemouth bass	374	57.12	33.4	11.9
Northern pike	47	14.55	4.2	3.0
Black crappie	212	1.08	18.9	0.2
Pumpkinseed	63	3.46	5.6	0.7
Bluegill	39	1.53	3.5	0.3
Yellow bullhead	16	3.61	1.4	0.7
Yellow perch	1	0.15	0.1	0.03
Green sunfish	1	.04	0.1	0.01
Freshwater drum	1	1.38	0.1	0.3
White sucker	307	237.70	27.4	49.7
Common carp	59	157.35	5.3	32.9
Total	1,120	477.97	100%	100%

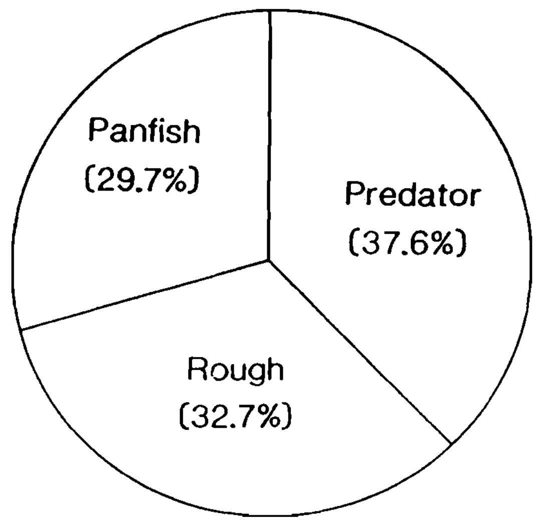
predators, panfish, and rough fish are observed. However the majority (82.6%) of the total catch biomass was attributable to rough fish and a very small percentage (2.5%) to panfish (Fig. 1).

Species Population Structure

Largemouth bass. The length-frequency distribution of largemouth bass revealed three peaks at approximately 100, 180, and 280 mm (Fig. 2). Scale analyses determined that the peaks corresponded to age 0, I+, and II+ fish with age I+ fish being most abundant in the catch (28.6%). The high frequency of age 0 and I+ fish most likely reflects the 1982-83 stocking program since largemouth bass spawning habitat appeared to be minimal in Perch Lake. However, the presence of age II+ and III+ fish in the catch suggests that either some natural reproduction is occurring or that largemouth bass are immigrating from Angelo Pond.

For purposes of back-calculating growth, a total of 356 scale samples was analyzed. The scale length-total length regression equation was : $TL = 18.99 + 1.47\ SL$ ($r^2 = .995$). Back-calculations of growth determined that the weighted mean total lengths attained at annuli I through IV were 68, 153, 233, and 306 mm respectively (Table 6), and that the 1982 year class (age I+) grew slightly slower than the 1979, 1980, and 1981 year classes. This may reflect the late stocking date in 1982 (September) or possibly shorter lengths at the time of stocking. Weighted mean calculated annual lengths compared with calculated annual lengths reported for largemouth bass from various locations in Wisconsin (Table 7) showed that the largemouth bass in Perch Lake are growing slower than the Wisconsin state average

% TOTAL CATCH NUMBERS



% TOTAL CATCH BIOMASS

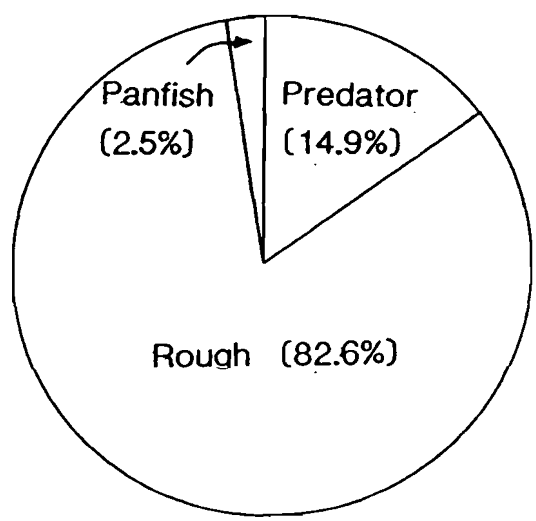


Fig. 1: Percent composition (by number and biomass) of predators, panfish, and rough fish taken by 9.75 hours of electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983.

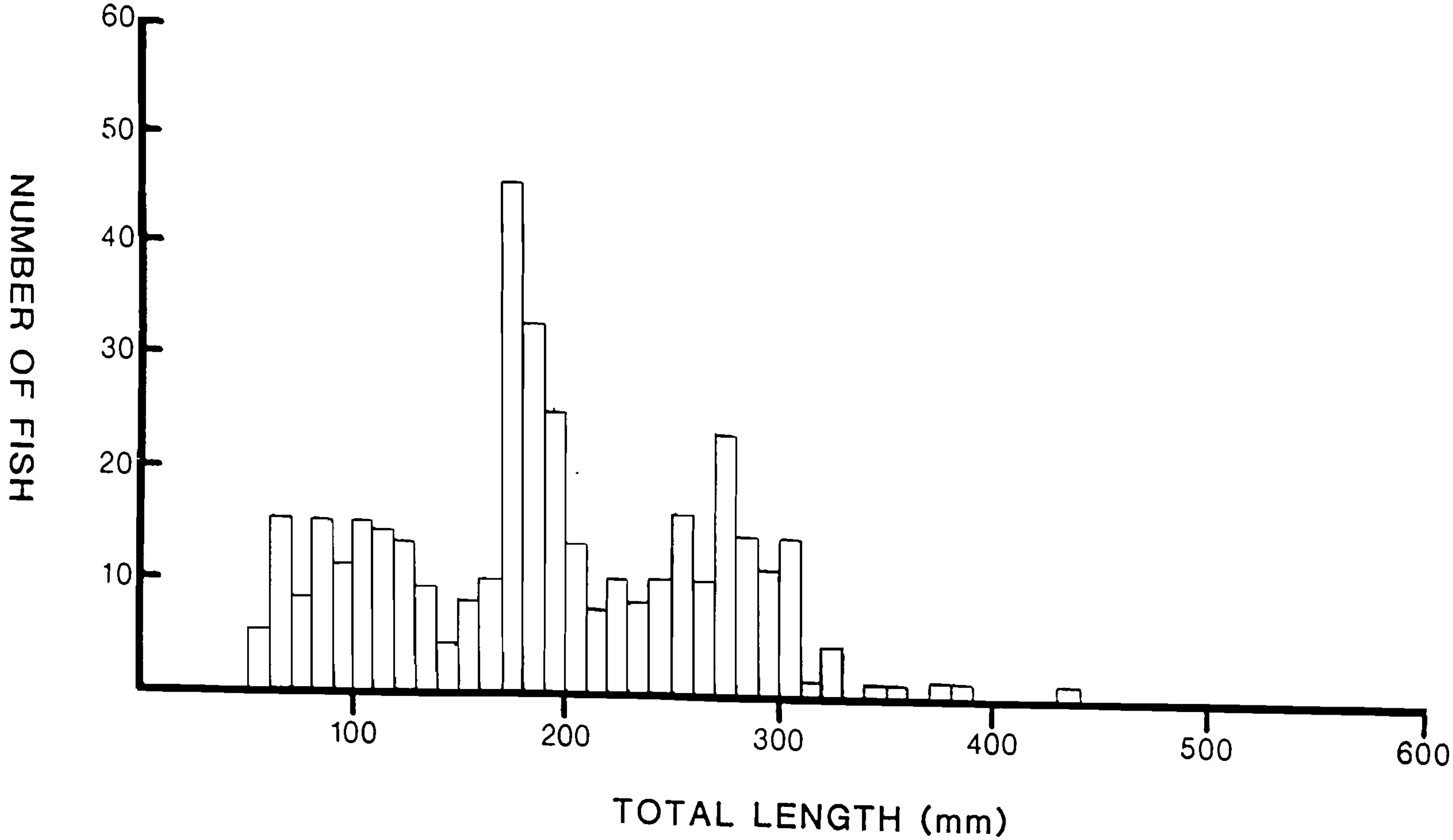


Fig. 2: Length-frequency distribution of largemouth bass taken by electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983.

Table 6: Back-calculated growth of largemouth bass taken in September 1983 from Perch Lake, Monroe County, Wisconsin.

Age	Number of Fish	Mean length at capture (mm)	Calculated mean length (mm) at each annulus			
			I	II	III	IV
0	105	94				
I+	107	184	64			
II+	79	259	73	153		
III+	33	301	76	152	232	
IV+	2	355	75	189	257	306
Column means			72	165	244	306
Standard deviation			5.5	21.0	17.7	0
Increment			72	93	79	62
Weighted means			68	153	233	306
Standard deviation			4.9	4.8	5.9	0
Increment			68	85	80	73

Table 7: Comparative calculated total lengths of largemouth bass from various locations in Wisconsin.

Location	Author	Average annual total length (mm)			
		I	II	III	IV
Perch Lake, Monroe County, Wisconsin-1983	Present study	68	153	233	306
State of Wisconsin (average)	Bennett (1937)	84	188	267	318
Punch Lake, Wisconsin (stunted population)	Marz et al. (1961)	56	137	193	236
Southern Wisconsin	Kmiotek & Cline (1952)	53	135	206	259
Northern Wisconsin	Bennett (1937)	71	165	246	297
Murphy Flowage, Wisconsin	Dunham (1956)	130	208	259	340

calculated by Bennett (1937), but faster than an average compiled from southern Wisconsin by Kmiotek and Cline (1952). Annual lengths compared closely to averages compiled from northern Wisconsin by Bennett (1937).

The length-weight relationship calculated for largemouth bass was log W = -4.719 + 2.9616 log TL (r^2 = .999) and the K value was determined to be 1.57 (Table 8). The slope of the length-weight regression and the K factor compare favorably with other populations from various locations in the Midwest (Table 8). W_r was calculated by comparing mean weights of 10 mm length intervals to North American standard weights described by the equation log W_s = 5.316 + 3.191 log TL (Wege and Anderson 1978). The grand mean W_r for largemouth bass in Perch Lake was determined to be 110.1% (Table 9). This value is above the 95-100% range of good condition proposed by Anderson (1978) for largemouth bass in late summer and fall.

Determinations of growth and condition indicate that largemouth bass were growing favorably in Perch Lake. However the length-frequency distribution of the catch indicates a young population. The calculated PSD and RSD values of 14.6 and 0%, respectively (Table 9) also typify a young population. The proportion of quality size fish to stock size fish was very low and the consequent PSD value (14.6%) falls far short of the management objective range of 40-60% proposed for largemouth bass by Anderson (1978). No "memorable" size largemouth bass were captured, thus an RSD value of 0% resulted.

Table 8: Comparative length-weight relationships and K-values for largemouth bass from various locations in the Midwest.

Location	Author	Length-weight equation	K
Perch Lake, Monroe County, Wisconsin-1983	Present study	Log W = -4.719 + 2.9616 Log TL	1.57
Lake Onalaska, Pool 7, Mississippi River, 1982	Held (1983)	Log W = -5.1993 + 3.1587 Log TL	1.53
Red Haw Lake, Iowa	Mitzner (1974)	Log W = -5.448 + 3.244 Log TL	1.39
Clear Lake, Iowa	Thompson (1965)	Log W = -4.99 + 3.091 Log TL	1.62
Big Creek Reservoir, Iowa	Paragamian (1974a)	Log W = -5.58 + 3.32 Log TL	1.61
Flora Lake, Wisconsin	Parker (1958)	Log W = -11.765 + 3.084 Log TL	--
State of Michigan (average)	Beckman (1948)		1.28
North American (average)	Carlander (1977)		1.39

Table 9: Population structure data calculated for species taken by electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983.

Species	PSD (%)	RSD (%)	K	W_r (%)
Largemouth bass	14.6	0	1.57	110.1
Northern pike	4.0	0	0.54	--
Black crappie	50.0	0	1.47	92.1
Pumpkinseed	27.5	0	2.24	--
Bluegill	0	0	2.13	114.1
Yellow bullhead	50	6.2	1.54	--
Yellow perch	100	0	--	--
Green sunfish	0	0	--	--
Freshwater drum	100	0	--	--
White sucker	100	93.7	1.10	--
Common carp	96.7	7.9	1.44	--

Northern pike. The northern pike length-frequency distribution revealed distinct peaks at 270 and 380 mm (Fig. 3), corresponding to age 0 and I+ fish. The relative high frequencies of age 0 and I+ fish probably reflects 1982-83 stockings since northern pike spawning habitat is minimal in Perch Lake. The presence of older fish, specifically ages II+ and III+, suggests immigration of northern pike from Angelo Pond. The relatively low numbers of fish in ages II+ and older could be attributable to three causes: biased sampling, low recruitment, or migrations. As discussed previously, northern pike are difficult to capture by electrofishing and it is therefore possible that the catch was biased towards younger individuals. However, the fact that a large enough sample was taken to permit calculation of an accurate population estimate suggests that the population was adequately sampled. The two most likely causes for the absence of age II+ and older fish are low recruitment and emmigration. Immigration from Angelo Pond which contains a large number of northern pike (Wright 1985), and extensive marsh areas for spawning may be a source of natural recruitment of northern pike to Perch Lake. Emmigration from Perch Lake is probably not as significant a factor as low natural reproduction. However Anderson (1985) stated that northern pike tend to emmigrate from small reservoirs, especially during spawning seasons in search of more desirable habitat. Fishes generally migrate upstream in search of spawning habitat. However the relatively short reach of the La Crosse River betwen Perch Lake and Angelo Pond offers only minimal spawning habitat so it is more likely that northern pike would seek spawing habitat downstream.

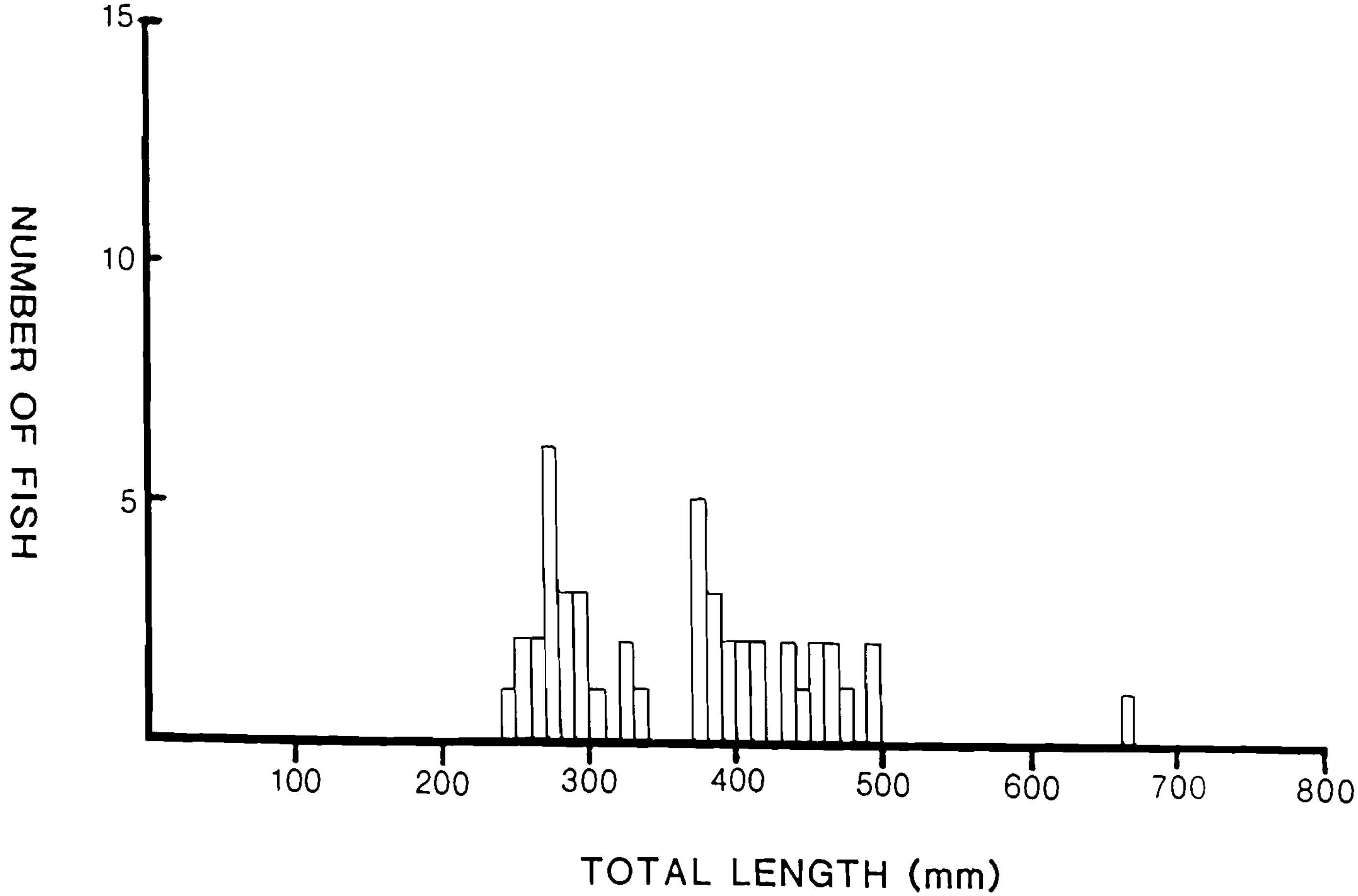


Fig. 3: Length-frequency distribution of northern pike taken by electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983. (N = 47).

A total of 47 scale samples was analyzed for back-calculating growth. The scale length-total length regression equation was: TL = 116.94 + 1.97 SL (r^2 = .962). Back-calculations of growth determined that the weighted mean total lengths attained at annuli I through III were 216, 355, and 509 mm, respectively (Table 10). First-year growth varied among year classes. Annual calculated mean lengths of the 1980 and 1981 year classes were much shorter than calculated annual lengths reported from most other locations in the Midwest (Table 11).

The length-weight relationship calculated for northern pike was log W = -6.066 + 3.3097 log TL (r^2 = .996) and K was determined to be 0.54 (Table 12). The slope value of the regression indicates better growth rate of northern pike in Perch Lake in comparison to length-weight regressions calculated from various locations in the Midwest (Table 12). Back-calculated mean annual lengths indicate that the northern pike growth rate in Perch lake is slower than in other regional waters. This conflict in the data is attributable to the high number of age 0 and I+ fish in the Perch Lake sample. Length-weight regressions calculated for juvenile northern pike tend to contain a relatively high slope value, whereas slope values of length-weight regressions calculated for older and larger northern pike tend to be relatively low, usually below 2.9 (Anderson 1985). Anderson (1985) also noted that the trend toward decreasing slope values in length-weight regressions as northern pike become older has hindered the development of a good North Anerican standard length-weight regression equation to calculate standard weights for W_r analyses.

Table 10: Back-calculated growth of northern pike taken in September 1983 from Perch Lake, Monroe County, Wisconsin.

Age	Number of Fish	Mean length at capture (mm)	Calculated mean length (mm) at each annulus		
			I	II	III
0	22	284			
I+	19	404	232		
II+	5	476	158	357	
III+	1	660	193	342	509
Column means			194	349	509
Standard deviation			37.0	10.6	0
Increment			194	155	160
Weighted means			216	355	509
Standard deviation			30.4	6.1	0
Increment			216	139	154

Table 11: Comparative calculated total lengths of northern pike from various locations in the Midwest.

Location	Author	Average annual total length (mm) I	II	III
Perch Lake, Monroe County, Wisconsin-1983	Present study	216	355	509
State of Wisconsin	Van Engel (1940)	257	465	584
Clear Lake, Iowa	Ridenhour (1957)	307	421	518
Mississippi River (backwaters in Minnesota)	Christenson (1957)	226	399	528
Lake Vermilion, Minnesota	Carlander & Hiner (1943)	193	325	427
North American (average)	Karvelis (1952)	251	396	533

Table 12: Comparative length-weight relationships and K-values for northern pike from various locations in the Midwest.

Location	Author	Length-weight equation	K
Perch Lake, Monroe County, Wisconsin-1983	Present study	Log W = -6.066 + 3.3097 Log TL	0.54
Clear Lake, Iowa	Ridenhour (1957)	Log W = 5.552 + 3.122 Log TL	0.63
Lake Erie, Ohio (males)		Log W = 4.826 + 2.902 Log TL	--
(females)	Carlander (1977)	Log W = 4.579 + 2.779 Log TL	--
Lake George, Minnesota	Franklin & Smith (1963)	Log W = 5.179 + 2.996 Log TL	--
State of Michigan	Beckman (1948)		0.5-0.63
State of Minnesota	Carlander (1977)		0.61
State of Ohio	Roach (1948a)		0.69

The K value calculated in this study is slightly lower than values calculated from other midwestern waters (Table 12) and is probably also influenced by the high percentage of juveniles in the sample. The K value calculated for age II+ and III+ fish was 0.62; this compares favorably with K values reported from regional waters.

Determinations of growth and condition indicate that older northern pike in Perch Lake attain shorter annual lengths than those reported from comparable waters. The length-weight equation and K value are typical of a young population and the back-calculated mean length at annulus I of age I+ fish was greater than calculated lengths at annulus I for age II+ and III+ fish. Assuming that age 0 and I+ fish represent the 1982 and 83 stockings, the young stocked northern pike appear to be growing normally but older individuals are growing slower than northern pike from comparable waters.

The calculated PSD and RSD values of 4.0 and 0% respectively are indicative of a relativity high proportion of small fish in the population. The low PSD value indicates a young population and supports the argument that natural recruitment of northern pike in Perch Lake is low and suggests that the majority of the northern pike present are a result of stocking efforts.

Black crappie. The black crappie length-frequency was skewed to the left indicating that the sample contained mostly young-of-the-year fish (Fig. 4). Scale analyses showed only five adults among 212 black crappie captured. This may be a result of high mortality of older fish (natural or fishing), sampling gear selectivity, or spatial distribution biases. Electrofishing samples taken from Lake Onalaska, Pool 7 of the Mississippi River by Held (1983) in August of 1976, 1977,

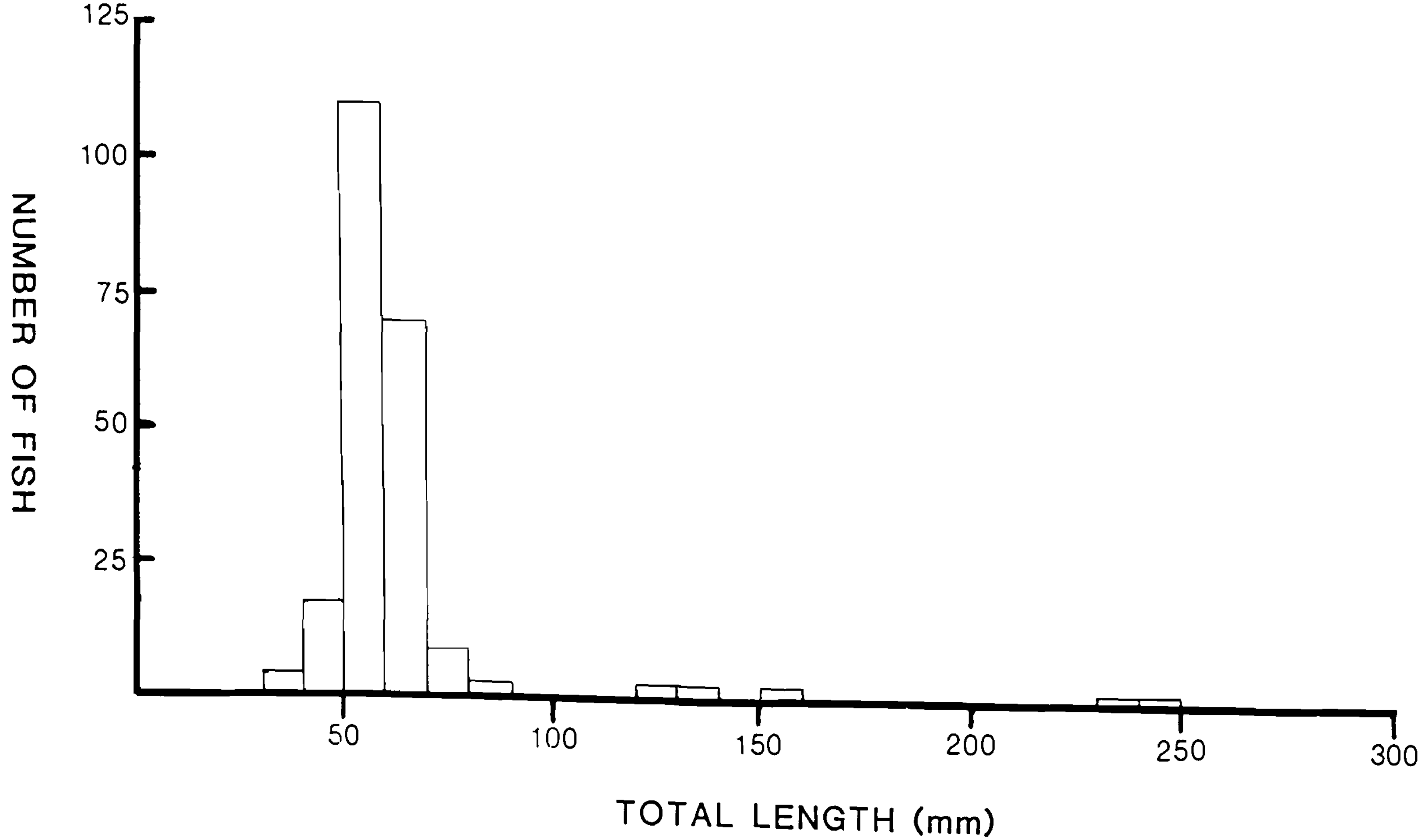


Fig. 4: Length-frequency distribution of black crappie taken by electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983.

and 1982 also showed a high abundance of young-of-the-year black crappies and relatively few adults. As noted earlier, Reynolds and Simpson (1978) found electrofishing to be only moderately effective for sampling black crappie, however Cooper (1952) and McFadden (1961) reported a higher rate of capture of larger fishes by electrofishing than of smaller fishes. The electrofishing catch of black crappie taken for this study was primarily comprised of young-of-the-year fish. Therefore, the low number of adult black crappie captured may indicate a low abundance of adult fish in Perch Lake, but more likely indicates that adults inhabit deeper water and consequently are inaccessable to electrofishing gear.

An inadequate number of scale samples was obtained from adult black crappies to permit back-calculations of annual lengths. Therefore, the reader should keep in mind that the following results are essentially determinations based on young-of-the-year black crappies.

The length-weight relationship calculated for black crappies was: $\log W = -4.947 + 3.0568 \log TL$ ($r^2 = .998$) and the slope compares well with the slopes of length-weight relationships calculated for black crappies from various other locations in the Midwest (Table 13). It also agrees with Carlander's (1977) average slope of 3.126 for 26 North American black crappie populations. The K value was determined to be 1.47 and is slightly lower than most values reported from comparable waters. However, the value still falls within the North American standard of average conditon calculated by Carlander (1977).

Table 13: Comparative length-weight relationships and K-values for black crappies from various locations in the Midwest.

Location	Author	Length-weight equation	K
Perch Lake, Monroe County, Wisconsin-1983	Present study	Log W = -4.947 + 3.0568 Log TL	1.47
lake Onalaska, Pool 7, Mississippi River, 1982	Held (1983)	Log W = -4.676 + 3.096 Log TL	1.58
Spirit lake, Iowa	Jennings (1969)	Log W = -4.928 + 3.066 Log TL	1.66
Red Rock Lake, Iowa	Paragamian (1974b)	Log W = -4.990 + 3.080 Log TL	1.71
Lewis and Clark Lake, South Dakota	Vanderpuye & Carlander (1971)	Log W = -5.019 + 3.075 Log TL	1.42
Chetek Lake, Wisconsin	Elliot (1948)		1.68
State of Minnesota standards (poor)			<1.05
(average)	Carlander		1.22-1.50
(excellent)	(1977)		>1.88

The moderately high CPUE value for black crappies compared to CPUE values calculated for other species in Perch Lake indicates a relatively moderate abundance of black crappies. The PSD of 50% (Table 9) may be high due to the small sample of adult black crappies. Of the four adults captured, half were larger than 200 mm (quality-size) resulting in the PSD value of 50%. The W_r value of 92.1% (Table 8) is lower than the minimum management objective of 95%. As noted earlier, Anderson (1985) warned that standard weights calculated from the North American standard length-weight equation, $\log W_s = -4.914 + 3.052 \log TL$ for small black crappies are high because the length-weight relationship is not linear, and therefore results in low W_r values for smaller fish.

The large number of young-of-the-year fish in the sample does not provide for an accurate assessment of the black crappie population in Perch Lake but does suggest favorable reproductive success. The CPUE value may give some indication of relative abundance; however, the length-weight equation and indices of condition serve only to assess the status of young-of-the-year individuals.

Pumpkinseed sunfish. The length-frequency distribution of pumpkinseeds revealed peaks at 45, 75, and 145 mm (Fig. 5), with the majority of the fish occurring in the third peak. Scale analyses determined that the first and second peaks are comprised of age 0 and I+ fish. The first half of the third peak largely represents age II+ fish; the second half of the peak represents age III+ fish, and the trailing edge of the peak represents age IV+ pumpkinseeds.

For purposes of back-calculating growth, a total of 63 scale samples was analyzed. The scale length-total length regression

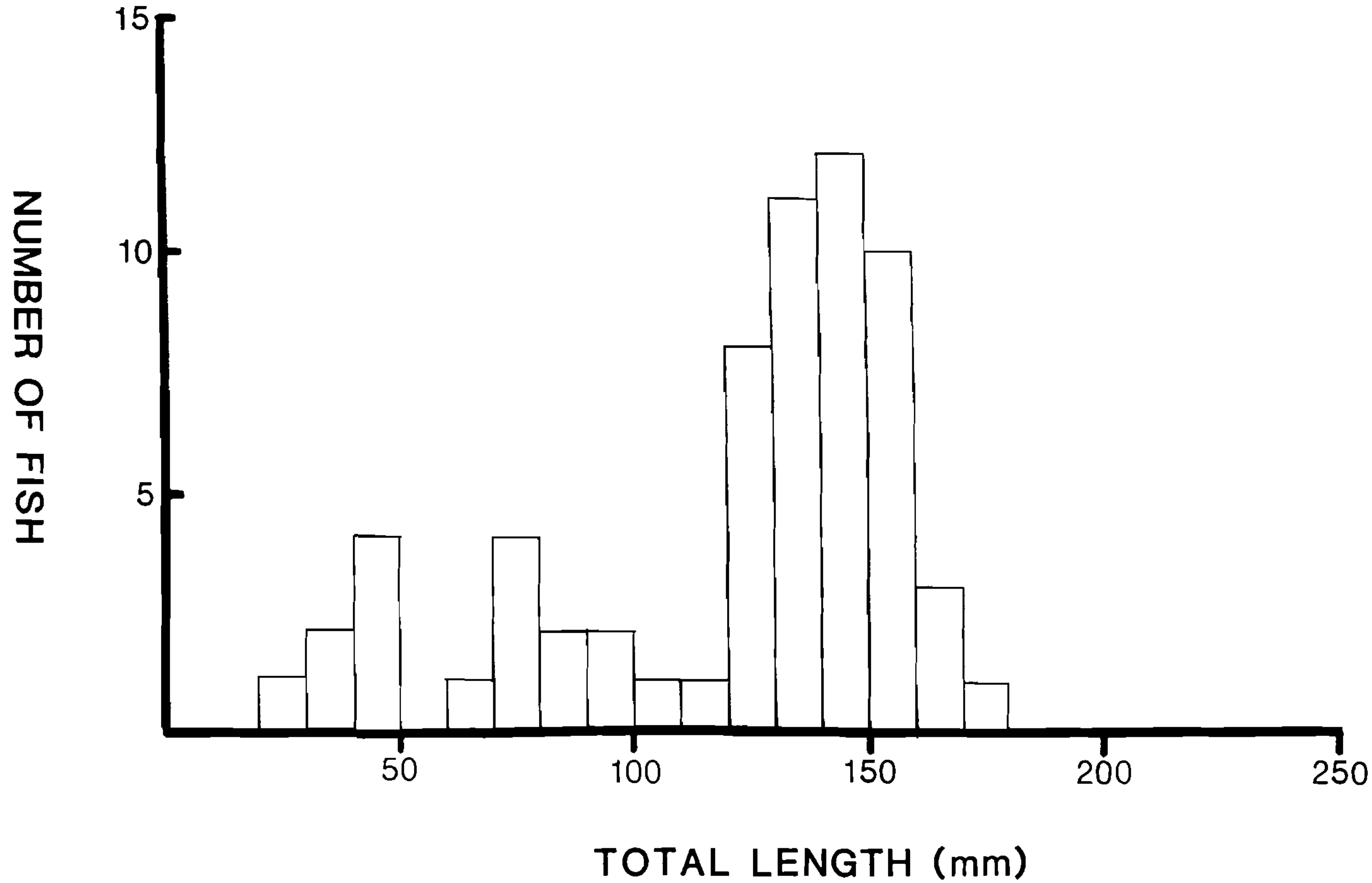


Fig. 5: Length-frequency distribution of pumpkinseed sunfish taken by electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983.

equation was: $TL = 4.37 + 0.93\ SL$ ($r^2 = .952$). Back-calculations of growth determined that weighted mean total lengths attained at annuli I through IV were 25, 65, 106, and 140 mm, respectively (Table 14). These data indicate that pumpkinseed growth is slow the first year, increases during the next two years, and then declines. Weighted mean calculated annual lengths attained at annuli III and IV compare closely with age III and IV calculated annual lengths from various other locations in the Midwest (Table 15). A comparison of the calculated length at ages I and II on the other hand, shows that pumpkinseeds in Perch Lake attain shorter lengths than those in populations in other midwestern waters.

The length-weight relationship and K value calculated for pumpkinseeds were: $\log W = -4.984 + 3.1699 \log TL$ ($r^2 = .999$) and 2.24, respectively. The slope of the length-weight equation is similar to the slope of the length-weight equation calculated for pumpkinseeds from Flora Lake, Wisconsin in 1952 but is much less than the slope value calculated in 1956 by Parker (1958) (Table 16). The K value calculated for pumpkinseeds taken from Perch Lake falls within the range of average K values calculated by Beckman (1948) for the state of Michigan, but falls well short of the upper limit of the standard calculated by Carlander (1977). This indicates poor condition (Table 16) in the specimens from Perch Lake.

Determinations of growth and condition indicate that the growth of Perch Lake pumpkinseeds is slow in their initial years and then accelerates to more normal growth rates at age III. However, the overall condition of the fish is less than desirable.

Table 14: Back-calculated growth of pumpkinseed sunfish taken in September 1983 from Perch Lake, Monroe County, Wisconsin.

Age	Number of Fish	Mean length at capture (mm)	Calculated mean length (mm) at each annulus			
			I	II	III	IV
0	7	38				
I+	9	79	24			
II+	17	128	31	73		
III+	27	148	23	60	106	
IV+	3	163	21	58	105	140
Column means			25	64	106	140
Standard deviation			4.3	8.1	0.7	0
Increment			25	39	42	34
Weighted means			25	65	106	140
Standard deviation			3.7	6.4	0.3	0
Increment			25	40	41	34

Table 15: Comparative calculated total lengths of pumpkinseed sunfish from various locations in the Midwest.

Location	Author	Average annual total length (mm)			
		I	II	III	IV
Perch Lake, Monroe County, Wisconsin-1983	Present study	25	65	106	140
Flora Lake, Wisconsin	Parker (1958)	53	79	104	127
Murphy Flowage, Wisconsin	Dunham (1956)	99	142	168	183
Houghton Lake, Michigan	Creaser (1926)	38	75	119	166
State of Minnesota	Kuehn (1949)	43	79	109	140
Crystal Lake, Michigan	Hubbs (1933)	31	54	---	---

Table 16: Comparative length-weight relationships and K-values for pumpkinseed sunfish from various locations in the Midwest.

Location	Author	Length-weight equation	K
Perch Lake, Monroe County, Wisconsin-1983	Present study	Log W = -4.984 + 3.1699 Log TL	2.24
Flora Lake, Wisconsin-1952	Parker (1958)	Log W = -4.990 + 3.123 Log TL	--
Flora Lake, Wisconsin-1956	Parker (1958)	Log W = -10.878 + 5.912 Log TL	--
State of Michigan (average)	Beckman (1948)		1.64-2.44
Clear Lake, Iowa	Di Costanzo (1957)		2.23
State of Minnesota Standards (poor)			<3.1
(average)	Carlander (1977)		3.6-4.5
(excellent)			>5.0

The PSD and RSD values calculated for the Perch Lake pumpkinseed population were 27.5 and 0%, respectively. The PSD value falls midway between the objective management range of 20-40% suggested by Novinger and Legler (1978) for bluegills. From the standpoint of optimizing fishing quality, structural indices show that the pumpkinseeds population structure of Perch Lake is nearly optimal. However, the relatively poor condition of individuals in the population may indicate the presence of some interspecific or intraspecific density dependent mechanisms such as competition for food that are not evident in structural index calculations.

Bluegill. The length-frequency distribution of bluegills revealed three peaks (Fig. 6). Scale analyses showed that the first two peaks correspond to age 0 and I+ fish, respectively, and the third, broader peak is comprised of both age III+ and IV+ fish. It is believed that this length-frequency distribution indicates no sampling bias and accurately depicts a normal bluegill population structure in Perch Lake.

An inadequate number of scale samples was obtained from bluegills to permit back-calculations of annual lengths. However, total lengths of bluegills at capture compared very closely with total lengths of comparable aged fish from various locations in the Midwest as reported by Carlander (1977). The length-weight relationship calculated for bluegills was log W = -4.887 + 3.1071 log TL (r^2 =.999), and the slope is similar to the slopes of length-weight equations calculated for bluegills from various midwestern waters (Table 17). The K value was determined to be 2.13 and is slightly less

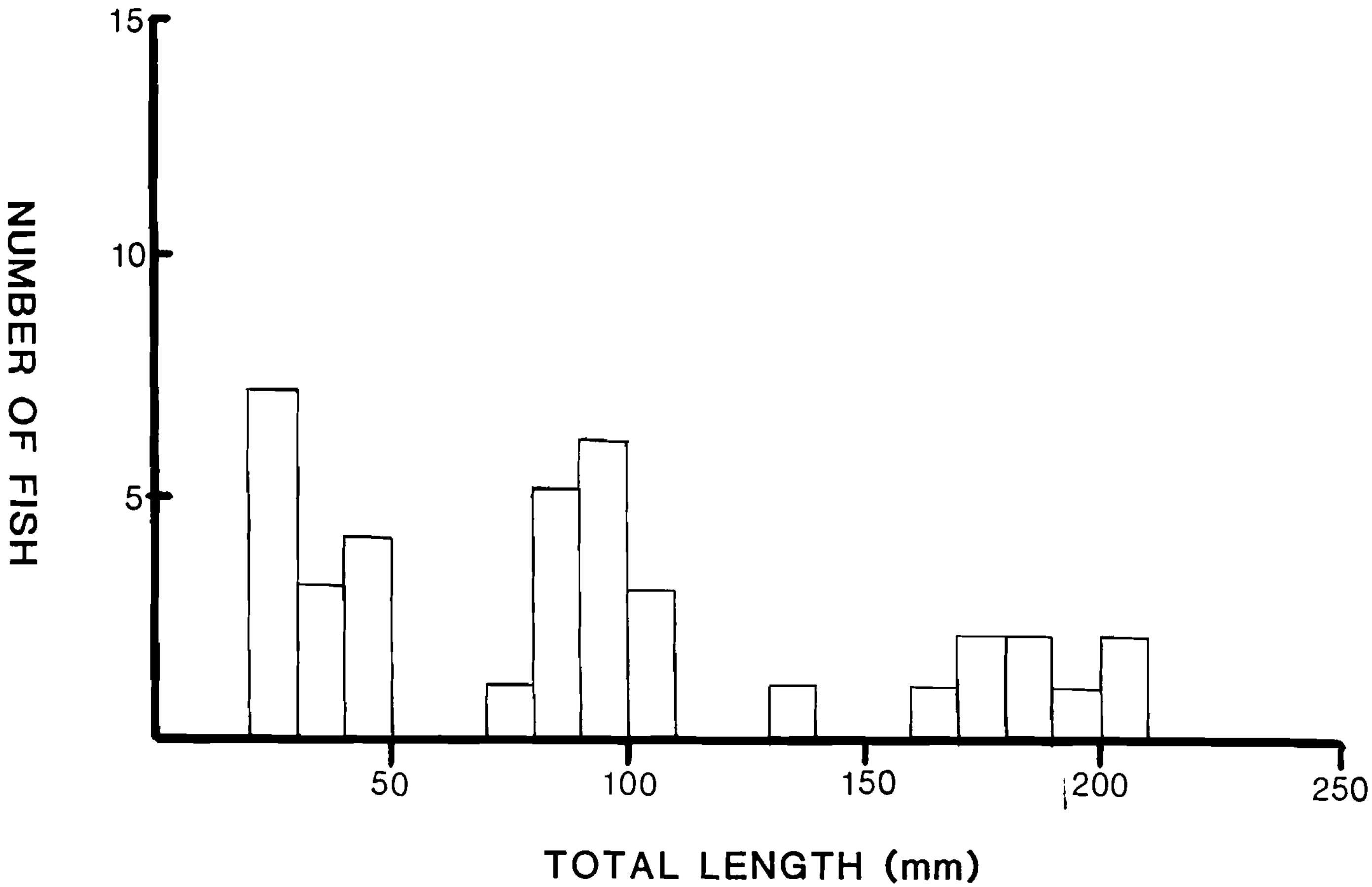


Fig. 6: Length-frequency distribution of bluegills taken by electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983.

Table 17: Comparative length-weight relationships and K-values for bluegills from various locations in the Midwest.

Location	Author	Length-weight equation	K
Perch Lake, Monroe County, Wisconsin-1983	Present study	Log W = -4.887 + 3.1071 Log TL	2.13
Lake Onalaska, Pool 7, Mississippi River-1982	Held (1983)	Log W = -5.31 + 3.30 Log TL	2.27
Pool 8 Mississippi River	Wynes (1976)	Log W = -4.93 + 3.17 Log TL	2.87
Pool 9 Mississippi River	Ferkin (1981)	Log W = -5.64 + 3.15 Log TL	2.52
Flora Lake, Wisconsin-1956	Parker (1958)	Log W = -5.236 + 3.183 Log TL	--
State of Minnesota Standards (poor)			<1.66
(average)	Carlander		1.83-2.24
(excellent)	(1977)		>2.52

than K values reported from other locations in the Midwest. It falls in the upper 25% of the range of average condition values for bluegills as reported by Carlander (1977). The grand mean W_r value calculated for bluegills in Perch Lake of 114.1% (Table 9) is above the minimum management goal of 95% and indicates good condition. The high W_r value indicates that Perch Lake bluegills weigh more than North American standard weights calculated from the equation $\log W_s = -5.374 + 3.316 \log TL$ proposed by Anderson (1980).

PSD and RSD values for the Perch Lake bluegill sample were determined to be 33.4 and 0%, respectively (Table 9). The PSD value falls within the management objective of 20 to 40% proposed by Novinger and Legler (1978) and indicates an optimal bluegill population structure for quality sport fishing.

Assessment of growth and conditon indicates that the growth rate of the bluegill population in Perch Lake is normal and that the fish are in average to good condition. Length-frequency distributions and population structure indices suggest that an optimum exists for maximizing quality sport fishing.

White sucker. The white sucker length-frequency was highly skewed to the right indicating that the sample contained mostly older fish (Fig. 7). Scale analyses showed that two age groups, ages III+ and IV+, dominated the catch. Ages II+ and V+ white suckers were moderately represented in samples collected by electrofishing and age 0 and I+ fish were slightly represented. Speculations as to the reasons for the high number (98%) of large fish in the sample reveal no definite explanations. Campbell (1971) found that white sucker

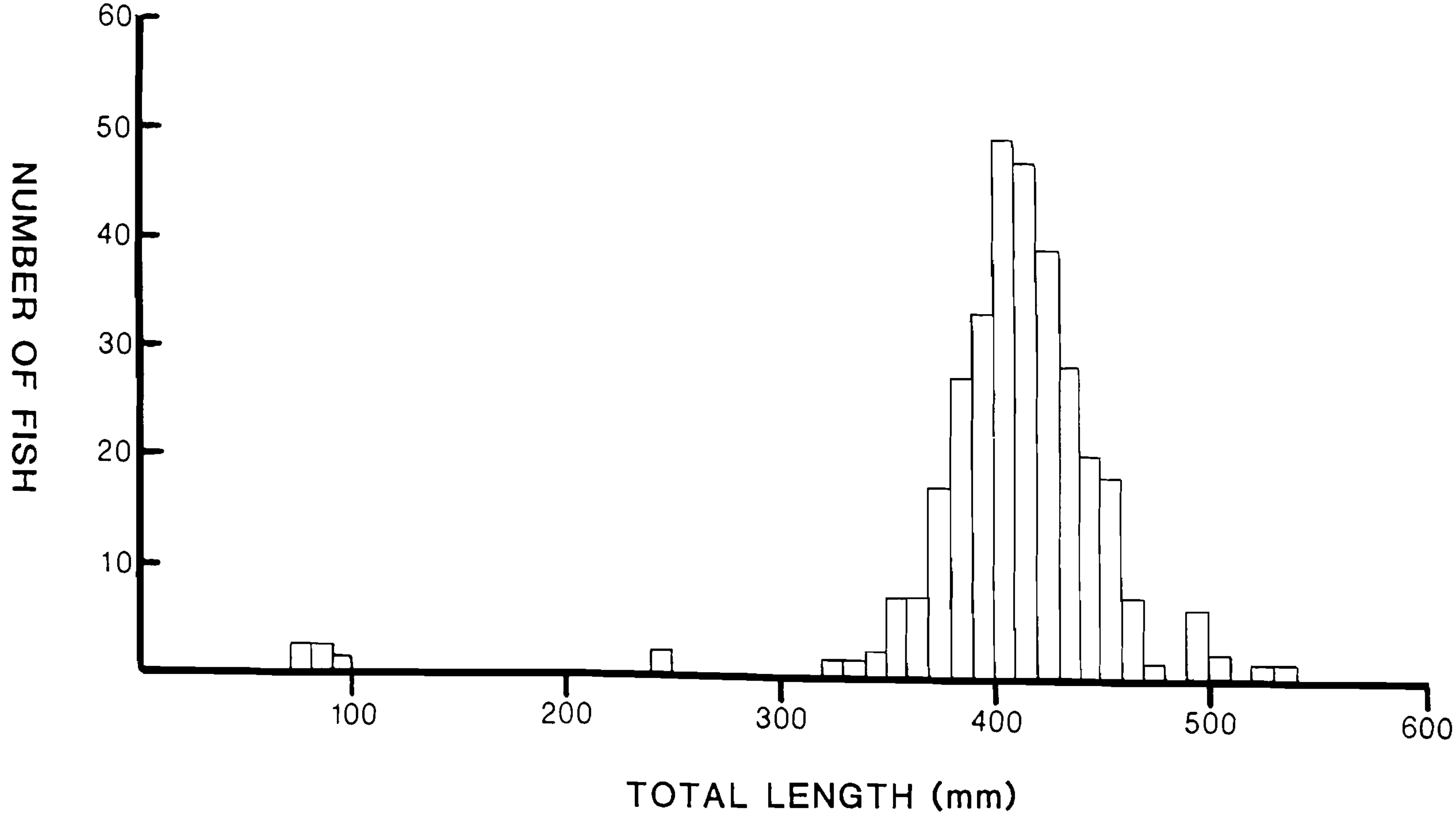


Fig. 7: Length-frequency distribution of white suckers taken by electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983.

activity increases in the late afternoon and early evening and also observed an inshore movement toward feeding areas during these times. If true, this phenomena would reduce sampling biases due to effects of spatial distributions. Furthermore, the fact that an adequate sample of white suckers was taken to calculate an appropriate population estimate indicates that electrofishing was effective for capturing white suckers in Perch Lake. The sample may represent a high proportion of older white suckers, possibly due to high predation rates of younger fish by predator fishes stocked in Perch Lake in recent years. Of the two predator species present, largemouth bass and northern pike, only the latter might prey heavily on white suckers. However, Wagner (1972) and Hunt (1965) both reported that northern pike did not prey heavily on white suckers. In fact, Wagner (1972) reported that northern pike showed a higher incidence of cannablism than consumption of white suckers.

The predomanince of older fish might be due to recruitment failure, sampling gear selectivity, or both. If recruitment is occurring in the Perch Lake system, young white suckers should have been present at the time of sampling because Geen et al. (1966) documented the peak downstream movement of white sucker fry one month after spawning in a British Columbia reservoir. Further, if successful reproduction had occurred in the past three years, young white suckers would have appeared in larger numbers in the catch regardless of sample bias. The low numbers of white suckers in Perch Lake seems to be due to a succession of recent year class failures that may be dependent or independent of density.

A total of 112 scale samples was analyzed. The scale length-total length regression equation was TL = 41.60 + 1.75 SL (r^2 = .987). Back-calculations of growth determined that weighted mean total lengths attained at annuli I through IV were 132, 241, 336, 394, and 455 mm, respectively (Table 18). These data indicate that growth rates decline from age I to age V. Weighted mean calculated annual lengths compared favorably with back-calculated annual lengths from various locations in the Midwest (Table 19) and were comparable to values reported from Flora Lake, Wisconsin after the population had been thinned (Parker 1958).

The length-weight relationship for white suckers was determined to be: log W = -5.011 + 3.0209 log TL (r^2 = .999) (Table 20). The slope of the regression compares closely to slope values calculated from various locations of the northern United States. The K value was determined to be 1.10 (Table 20) and falls approximately in the middle of the Minnesota standard average conditon range of 1.02-1.27 reported by Carlander (1977).

Determinations of growth and condition indicate that the growth rate of the white sucker population in Perch Lake is slightly above normal and that the fish are in good conditon. These data, in combination with the high number of white suckers observed suggest that density dependent growth-limiting mechanisms are exerting mininal effects. The white sucker PSD value of 100% (Table 9) also reflects the high proportion of large white suckers in the sample. Most of the white suckers captured were longer than 209 mm (quality size); this resulted in the PSD value of 100%. This value likely represents the true population structure of white suckers in Perch Lake if succession

Table 18: Back-calculated growth of white suckers taken in September 1983 from Perch Lake, Monroe County, Wisconsin.

Age	Number of Fish	Mean length at capture (mm)	Calculated mean length (mm) at each annulus				
			I	II	III	IV	V
0	5	82					
I+	4	286	145				
II+	14	359	164	279			
III+	35	387	143	248	340		
IV+	34	419	121	232	334	393	
V+	11	500	145	246	334	413	455
Column means			144	251	336	403	455
Standard deviation			15.3	19.8	3.5	14.1	0
Increment			144	107	85	67	52
Weighted means			132	241	336	394	455
Standard deviation			13.4	7.0	2.8	4.8	0
Increment			132	109	95	58	61

Table 19: Comparative calculated total lengths of white suckers from various locations in the Midwest.

Location	Author	Average annual total length (mm)				
		I	II	III	IV	V
Perch Lake, Monroe County, Wisconsin-1983	Present study	132	241	336	394	455
Flora Lake, Wisconsin (before thinning)	Parker (1958)	147	224	290	366	401
(after thinning)	Parker (1958)	160	257	338	399	429
State of Minnesota	Smith and Moe (1944)	109	206	295	351	401
Muskellunge Lake, Wisconsin	Spoor (1938)	71	117	163	203	231
State of Ohio	Roach (1948b)	64	229	318	384	432

Table 20: Comparative length-weight relationships and K-values for white suckers from various regions of the northern United States.

Location	Author	Length-weight equation	K
Perch Lake, Monroe County, Wisconsin-1983	Present study	Log W = -5.011 + 3.0209 Log TL	1.10
Skaneateles Lake, New York (male)	Raney and Webster (1942)	Log W = 3.885 + 2.5914 Log TL	- -
(female)	Raney and Webster (1942)	Log W = 3.671 + 2.5070 Log TL	- -
Shadow Mt. Lake, Colorado	Hayes (1956)	Log W = -5.395 + 3.223 Log TL	- -
Flora Lake, Wisconsin	Parker (1958)	Log W = -5.051 + 3.040 Log TL	- -
Fort Randall Reservoir, South Dakota	Sprague (1961)		1.13
State of Illinois	Carlander (1977)		1.14
State of Minnesota Standards (poor)	Carlander (1977)		<1.02
(excellent)	Carlander (1977)		>1.27

if succession of recent year class failure is the reason for the observed skewed length-frequency.

Common carp. The length-frequency distribution of carp revealed one broad peak that ranged from 440 to 670 mm (Fig. 8). Scale analyses determined that the peak contains four age groups: III+, IV+, V+ and VI+ with age IV+ and V+ fish being the most abundant in the catch.

A total of 59 scale samples were analyzed for purposes of back-calculating growth. The scale length-total length regression equation was: $TL = 2.27 + 1.73\ SL$ ($r^2 = .992$). Back-calculations of growth determined that weighted mean total lengths attained at annuli I through IX were 150, 310, 447, 514, 559, 619, 673, 714, and 732 mm, respectively (Table 21). These data show that growth rates of common carp in Perch Lake decline rapidly at age III and then decline more gradually until age VIII, at which time, they apparently reach assymptotic lengths. The data also show that the 1982, 1980, and 1979 year classes attained much shorter lengths than the 1978 and older year classes at comparable ages (Table 21). This indicates that common carp are growing much slower now than they were four years ago and suggests the presence of growth limiting, density dependent mechanisms.

Weighted mean calculated annual lengths compare favorably with back-calculated annual lengths from various other locations in the Midwest, except for annual lengths reported by Held (1983) for fish age VII and VIII from Lake Onalaska, Wisconsin (Table 22). Growth rates of common carp in Perch Lake are much greater than those reported by Landis et al. (1984) from Lake Neshonoc, the only impoundment of the La Crosse River downstream from Perch Lake.

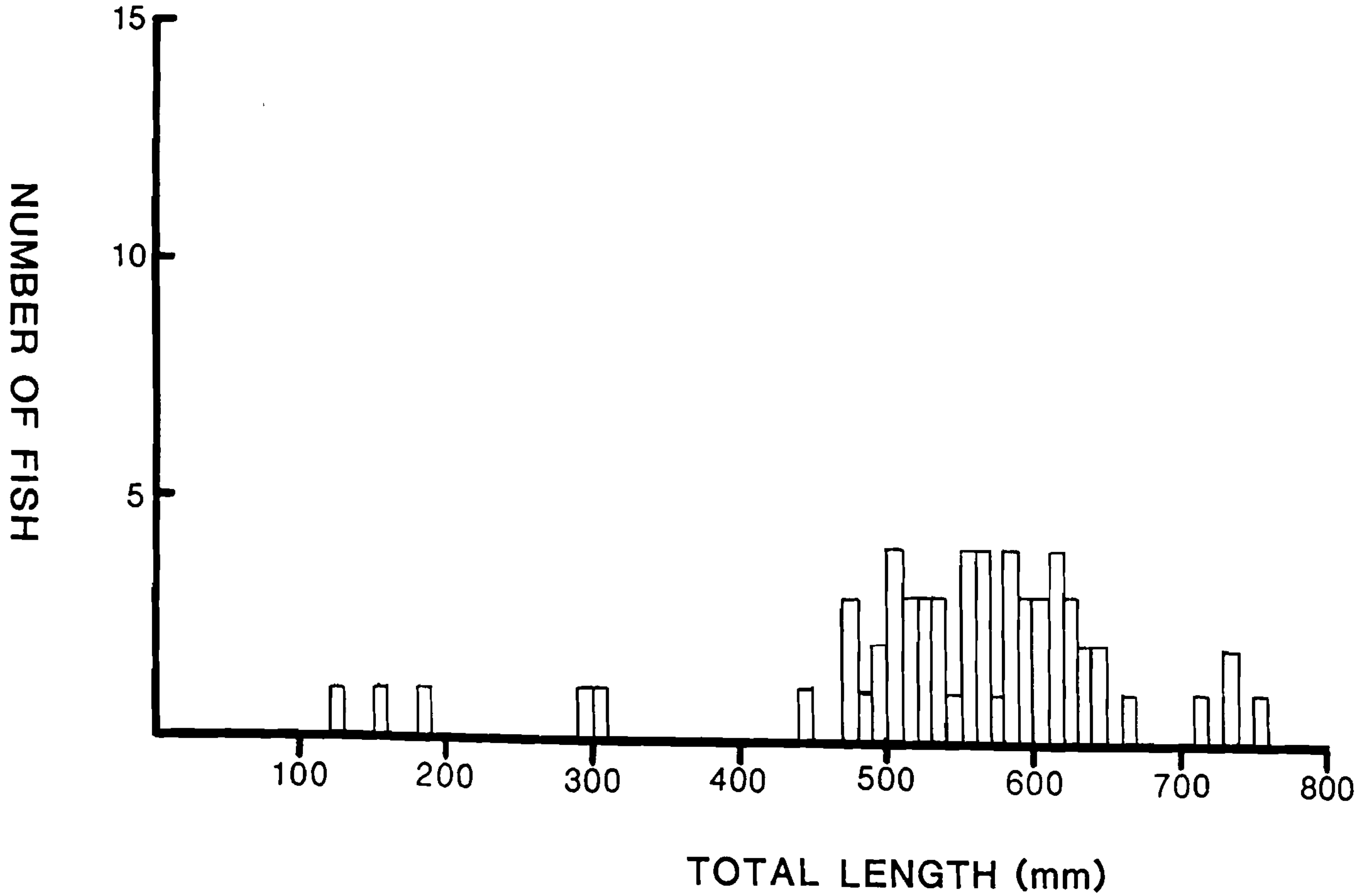


Fig. 8: Length-frequency distribution of common carp taken by electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983.

Table 21: Back-calculated growth of common carp taken in September 1983 from Perch Lake, Monroe County, Wisconsin.

Age	Number of fish	Mean length at capture (mm)	Calculated mean length (mm) at each annulus								
			I	II	III	IV	V	VI	VII	VIII	IX
0											
I+	2	300	118								
II+											
III+	9	484	138	288	424						
IV+	14	527	136	285	435	494					
V+	26	594	160	318	453	520	556				
VI+	4	660	177	339	475	529	568	613			
VII+											
VIII+	3	739	128	368	480	525	578	624	673	718	
IX+	1	758	192	387	468	526	556	624	674	700	732
Column means			150	331	456	519	564	620	674	709	732
Standard deviation			27.2	41.7	22.6	14.2	10.6	6.3	0.7	12.7	0
Increment			150	181	125	63	45	56	54	35	23
Weighted means			150	310	447	514	559	619	673	714	732
Standard deviation			15.9	24.7	16.1	12.9	7.1	5.9	0.5	9.0	0
Increment			150	160	137	67	45	60	54	41	18

Table 22: Comparative calculated total lengths of common carp from various locations in Wisconsin.

Location	Author	Average annual total length (mm)								
		I	II	III	IV	V	VI	VII	VIII	IX
Perch Lake, Monroe County, Wisconsin 1983	Present Study	150	310	447	514	559	619	673	714	732
Lake Neshonoc, La Crosse County, Wisconsin	Landis et al. (1984)	87	166	236	286	333	371	418	434	484
Lake Onalaska, Pool 7 Mississippi River	Held (1983)	119	274	426	497	558	629	714	802	-
Lake Wingra, Wisconsin	Frey (1940)	152	409	513	549	572	610	630	643	-
Lake Kegonsa, Wisconsin	Frey (1940)	122	338	462	500	544	632	660	696	-
Lake Monona, Wisconsin	Frey (1940)	117	348	450	495	544	635	658	724	-

The length-weight relationship and K value for common carp were determined to be: Log W = -4.565 + 2.8958 log TL (r^2 = .998) and 1.44, respectively (Table 23). The slope of the regression equation compares favorably with the slope values of length-weight regressions calculated from various locations in the Midwest (Table 23), as does the K value.

Determinations of growth and condition indicate that the growth rates and condition of common carp in Perch Lake are normal for this latitude. These determinations, however, are influenced by the large number of age IV+ and V+ fish in the catch. The sample largely represents older fish that show normal growth rates and weighted mean calculated annual lengths do not reflect declining growth rates of the younger fish in the population. The declining growth rates of the younger fish suggest overabundance. Recruitment of common carp to quality size (410 mm) occurs at age III and the high PSD value of 96.7% (Table 9) reflects the relative large proportion of age IV+ and V+ fish in the sample. The RSD value was determined to be 7.9% (Table 9) and indicates the presence of a few very large common carp ($\geq$ 660 mm) in the sample.

Other species. Inadequate samples of yellow bullheads, yellow perch, green sunfish, and freshwater drum were taken to permit determinations of growth and condition (Table 5). PSD and RSD values (Table 9) have little significance for these species and were calculated only to include these species in the assessment of community structure. Yellow bullhead was the only species, besides common carp and white sucker for which an RSD value greater than 0% was calculated. This suggests that the effect of growth limiting density dependent

Table 23: Comparative length-weight relationships and K-values for common carp from various locations of the Midwest.

Location	Author	Length-weight equatition	K
Perch Lake, Monroe Country Wisconsin-1983	Present Study	Log W = -4.565 + 2.8958 Log TL	1.44
Lake Neshonic, La Crosse County, Wisconsin	Landis et al. (1984)	Log W = -3.678 + 2.5178 Log TL	1.44
Lake Onalaska, Pool 7, Mississippi River 1982	Held (1983)	Log W = -1.970 + 2.953 Log TL	1.50
Clear Lake, Iowa (males)	English (1952)	Log W = -4.224 + 2.746 Log TL	1.33
(females)	English (1952)	Log W = -4.182 + 2.746 Log TL	1.33
Izaak Walton Lake, Indiana	Youn (1962)	Log W = -3.982 + 2.664 Log TL	1.39

mechanisms is low and that yellow bullheads in Perch Lake are in low abundance and are growing well.

Community Structure.

A tic-tac-toe diagram was designed by Anderson (1978) to assess the relationship between a predator (largemouth bass) PSD and a prey (bluegill) PSD and recommended optimal management ranges of 40-60% for largemouth bass and 20-40% for bluegills. An expanded version of this theory as described by Goedde (1980) and Held (1983) was used in this study. Goedde (1980) and Held (1983) expanded this assessment of predator/prey relationships by lumping all predator species together and all prey species together, and plotting the weighted mean predator PSD and prey PSD on a tic-tac-toe diagram. The optimal management PSD ranges for balanced community structure proposed by Goedde (1980) are 35-60% for predator species and 25-45% for prey species. The weighted mean predator and prey PSD's for this study were calculated to be 13.5 and 73.8%, respectively (Table 24). When rough fish species were excluded from the analysis to assess the effects of their removal, the weighted mean prey PSD was 39.1% (Table 24). Plotting these values on a tic-tac-toe diagram illustrates that the predator PSD falls well short of the management objective range (Fig. 9) needed to provide a quality fishery. The weighted mean prey PSD calculated for all species falls above the objective management range, but the prey PSD calculated after excluding rough fish species falls within the objective range for prey species (Fig. 9). The data indicated that removal of rough fish would enhance community structure for sport fishing in Perch Lake.

Table 24: Weighted mean predator and prey PSD's calculated for all species excluding rough fish, captured by electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983.

Species	Ecological role	Weighted mean PSD (%)
Largemouth bass Northern pike	Predators	13.5
Black crappie Pumpkinseed Bluegill Yellow bullhead Yellow perch Green sunfish Freshwater drum White sucker Common carp	Prey	73.8
Black crappie Pumpkinseed Bluegill Yellow bullhead Yellow perch Green sunfish Freshwater drun	Prey	39.1

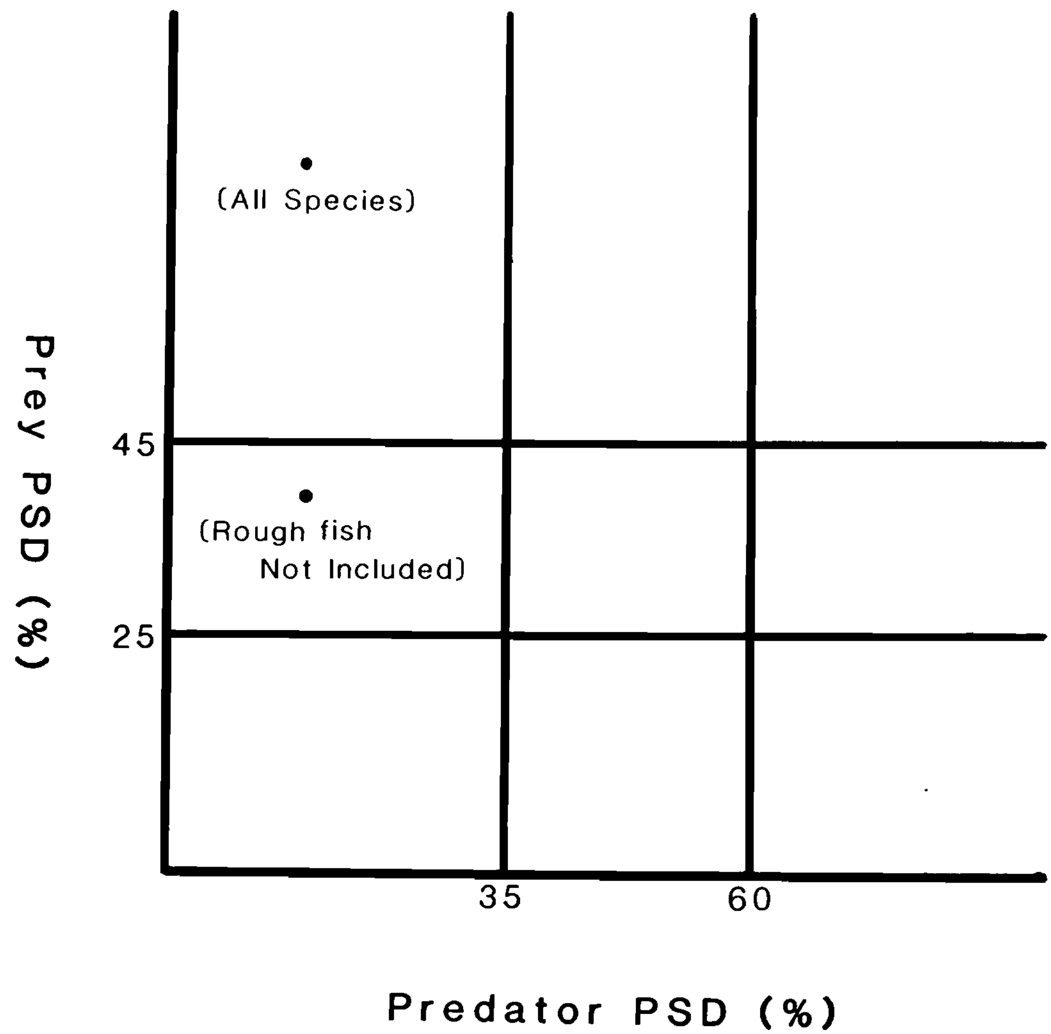


Fig. 9: Concurrent predator and prey weighted mean PSD's calculated for all species captured and for all species captured excluding rough fish taken by electrofishing from Perch Lake, Monroe County, Wisconsin during September 1983.

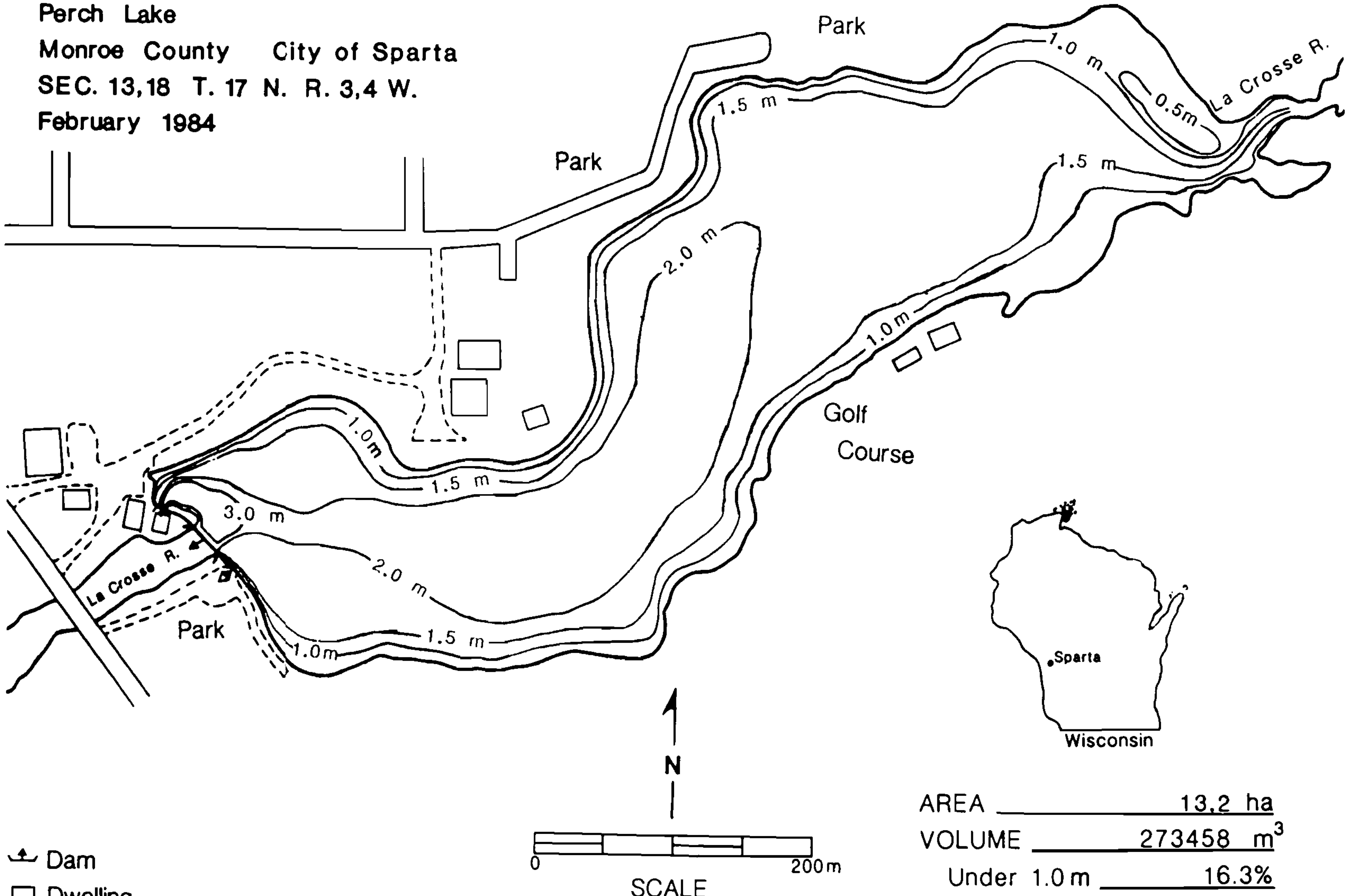
Lake Morphometry

Lake contours determined from sonar readings (Fig. 10) illustrate that Perch Lake is a relatively long and narrow reservoir of uniform depth. The lake has a surface area of 13.2 ha and a volume of 273,458 m^3. Shoreline reliefs are steep and only 16.3% of the total surface area has a depth less than 1.0 m deep. The majority of the lake is 1.5-2.0 m deep; the maximum depth of 3.0 m observed was in a small area adjacent to the dam. The small percentage of the lake surface area less than 1.0 m deep explains the paucity of emergent aquatic plants. The littoral zone is narrow and consequently shoreline depths are suboptimal for establishment of emergent plant species. Submergent aquatic plants were abundant around the entire shoreline to depths of 1.5 m and covered 16.3% of the total area.

The La Crosse River flows through Perch Lake from east to west and the inflow area is extremely dynamic. A large sand bar located in this area changes dramatically with fluctuating discharge levels of the La Crosse River.

Fig. 10: Lake morphometry map, Perch Lake, Monroe County, Wisconsin Feburary 1984.

Perch Lake
Monroe County City of Sparta
SEC. 13,18 T. 17 N. R. 3,4 W.
February 1984



AREA	13.2 ha
VOLUME	273458 m^3
Under 1.0 m	16.3%
MAX. DEPTH	3.0 m
SHORELINE	3.9 km

Dam
Dwelling
Boat Livery

Fig. 10:

DISCUSSION

Predator Species

The survey found an abundance of largemouth bass in Perch Lake and a relatively low population of northern pike. Structural indices indicate that both predator populations are young and age determinations correlate strongly with recent stocking efforts. These observations, combined with the observed lack of sufficient spawning habitat in Perch Lake, suggest that the present predator populations are largely a direct result of the stocking program.

The growth rate and condition of largemouth bass in Perch lake are better than average and suggest that if recruitment can be maintained through stocking or by providing adequate spawning habitat, a self-sustaining population of largemouth bass could be established. The extreme interest exhibited by local bass fishing clubs suggests that management objectives should consider optimizing quality-sized fish. Such a goal might possibly be achieved through the installation of a slot size limit that would protect individuals of a selected range and allow them to reach a larger size. A slot size limit of 200 to 300 mm would protect stock-sized fishes from removal by anglers.

The growth rate and condition of northern pike in Perch Lake appear to be average, but results of this survey suggest that if recruitment is not maintained through management programs, the population is not likely to sustain itself. Anderson (1985) warned that in systems such as Perch Lake, it is very difficult to keep northern pike "at home" because they tend to emmigrate in search of more desirable habitat. It is conceivable that largemouth bass would behave in much the same manner. However, the recent placement of nine fish cribs in Perch Lake could help to offset this phenomenon. Other techniques of habitat development, such as the establishment of emergent vegetation, submerged logs, and artificial spawning structures, would also benefit these predator populations. Local interest in the fishery suggests that cost/benefit ratios of such management programs might be favorable.

Panfish Species

The survey found that the three most abundant species of panfish in Perch Lake are black crappies, bluegills, and pumpkinseeds. All other observed panfish species were present in low abundance.

Assessments of growth and condition indicate that the bluegills in Perch Lake are in average to good condition and are growing at normal rates. The growth rate of pumpkinseeds is slow at first but accelerates to a more normal rate. The overall condition of pumpkinseeds is low and suggests the presence of some growth limiting density-dependent mechanisms. Interspecific and intraspecific competition for food may be largely responsible for the observed poor condition. Troutman (1957) stated that pumpkinseeds require large dense masses of aquatic vegetation for good growth and that they grow poorly in open deeper waters containing sparse vegetation. Perch Lake offers dense submerged masses of vegetation but they are limited due to the narrow littoral zone. Interspecific and intraspecific competition for available habitat may also be stressing the pumpkinseed population.

Assessment of the black crappie population in Perch Lake was very difficult due to the very high number of young-of-the-year fish in the sample. It is apparent that black crappies are fairly abundant but the lack of submerged habitat in Perch Lake may indicate that the lake is suboptimal for black crappie production. Calhoun (1966) found that black crappies depend on an abundance of aquatic vegetation and/or submerged brush for maximum growth and propagation.

Habitat development in Perch Lake would be beneficial for all panfish species. Calhoun (1966) stated that large black crappies will compete for available forage with largemouth bass due to their piscivorous feeding behavior. At present, Perch Lake supports a healthy bluegill population and the introduction of fish cribs may help to improve the condition of pumpkinseeds. For these reasons, it may be beneficial to maintain submerged brush and vegetation at levels that are suboptimal for black crappies since those same levels are adequate for optimal bluegill and pumpkinseed growth and condition. This might allow bluegills and pumpkinseeds to slightly out-compete black crappies and help ensure that the numbers of black crappie would not reach a point where interspecific competition between black crappies and largemouth bass would be significant. Suboptimal black crappie habitat would also help to provide a balance in relative abundance among the three panfish species that would lead to more diverse and stable predator/prey relationships.

Rough Fish Species

The white sucker and common carp samples both showed a high proportion of older fish in the populations. Condition indices demonstrated that white suckers are in average conditon and that common carp are in good condition. Back-calculations of growth indicated that the growth rate of recent year classes of common carp have declined in comparison to early life growth rates of older year classes. This suggests that density-dependent mechanisms are limiting growth of common carp and suggests possible overabundance of this species. Carlander (1977) noted that population density seems to be the most significant factor controlling growth of common carp even when food is available in excess quantities.

Determinations of growth and condition do not indicate any serious problem of an overabundance of white suckers. However, the large population estimate calculated for this species illustrates high numbers and suggests that overabundance could occur in the future. The percent total catch composition by biomass and the weighted mean prey PSD calculations also indicate a dominance of rough fish species in Perch Lake. As noted earlier, it is apparent from the PSD tic-tac-toe diagram (Fig. 9) that the removal of rough fish species might significantly enhance community structure for sport fishing.

The abundance of rough fishes in Perch Lake results in reduced habitat availability to other desirable game fish species in a system where habitat is limiting. Total eradication of rough fishes can rarely be achieved, especially in an open system such as Perch Lake. However, rough fish removal would temporarily decrease competition for available habitat, could result in increased growth rates, and possibly increase recruitment of game fish species. The optimum solution would be to eliminate the rough fish species in such a manner that desirable species would not be harmed. At present, the only removal method that will selectively harvest fishes is mechanical harvesting and this is usually ineffective. Recent attempts by the DNR to chemically drive common carp from Perch Lake through the use of sub-lethal levels of rotenone were unsuccessful (Wright 1984). However, the theory seems applicable and further investigations into such methods may produce more desirable results.

Possible mechanical methods of removing rough fishes include commercial fishing. Area bass clubs have expressed an interest in obtaining the necessary permits required to gill net common carp and indicated a willingness to conduct the work. It may be possible to remove white suckers by trapping them during spawning migrations in the La Crosse River. White suckers exhibit short, distinct spawning migrations and large numbers could be effectively netted during peak migration times.

CONCLUSIONS AND MANAGEMENT CONSIDERATIONS

Perch Lake is a small, long, and narrow reservoir of uniform depth. Emergent vegetation and submergent brush are scarce and submergent vegetation is abundant in the littoral zone. Because this zone is so narrow throughout most of the lake, however, submergent vegetation provides only limited habitat for fishes. The recent placement of fish cribs in the lake should enhance habitat availability.

The fish species present in Perch Lake appear to be doing well. It is apparent that the predator populations are a result of stocking efforts by the DNR. It is also evident that the absence of spawning habitat for predator species will require management authorities to continue stocking unless adequate spawning habitat, natural or artificial, can be provided. Adequate spawning habitat exists in Perch Lake for panfish species. Panfish populations will benefit from the installation of fish cribs because the cribs will offer additional refuge from predators and provide a source for invertebrate production. Rough fish species appear to be reaching levels of overabundance and it seems inevitable that some type of removal will be necessary in the near future. The removal of these species would decrease competition for available habitat and the community structure indices suggest that rough fish removal would optimize quality fishing for prey species. If a quality community structure for prey species can be developed, it is apparent that the growth of predator species coupled with possible slot-size harvest limits, especially for largemouth bass, would result in an optimal community structure for maximizing quality fishing in Perch Lake.

LITERATURE CITED

Adams, L. A. 1931. Determination of age in fishes. Trans. Illinois State Acad. Sci. 23:218-226.

Anderson, R. O. 1978. New approaches to recreational fishery management. Pages 73-78 In G. D. Novinger and J. G. Dillard, eds., New approaches to the management of small impoundments. Spec. Publ. N. 5, N. Cent. Div. Am. Fish. Soc.

Anderson, R. O. 1985. Personnel communication. University of Missouri, Columbia, Missouri.

Beckman, W. C. C. 1948. The length-weight relationship factors for conversion between standard and total lengths, and coefficients of conditon for seven Michigan fishes. Trans. Am. Fish. Soc. 75:237-256.

Bennett, G. W. 1937. The growth of the large-mouthed black bass, Huro salmoides (Lacepede), in the waters of Wisconsin. Copeia 1937(2):104-118.

Bennett, G. W. 1970. Management of lakes and ponds. Van Nostrand Reinhold Company, Litten Educational Publishing, Inc., New York, New York. Pp. 182-184.

Boccardy, J. A., and E. L. Cooper. 1963. The use of rotenone and electrofishing in surveying small streams. Trans. Am. fish. Soc. 92:307-310.

Butler, R. L., and L. L. Smith, Jr. 1953. A method for cellulose acetate impressions of fish scales with a measurement of its reliability. Prog. Fish-Cult. 15:175-178.

Calhoun, A., ed. 1966. Inland fisheries management. California Dept. Fish and Game. 546 pp.

Campbell, P. K. 1971. Influence of light and dark periods on spatial distribution and activity of white sucker, Catostomus commersoni. Trans. Am. Fish. Soc. 100:353-355.

Campbell, R. S., and A. W. Witt, Jr. 1953. Impressions of fish scales in plastic. J. Wildl. Mgmt. 17:218-219.

Carlander, K. D. 1949. Some consideration in the use of fish growth data based upon scale studies. Trans. Am. Fish. Soc. 79:187-194.

Carlander, K. D. 1977. Handbook of freshwater fishery biology. Vol. II. Iowa State University Press, Ames, Iowa. 431 pp.

Carlander, K. D., and L. E. Hines. 1943. Fisheries investigations and management report for Lake Vermilion, St. Louis couty. Minnesota Bur. Fish. Res. Invest. Rep. 54:1-175.

Carlander, K. D., and L. L. Smith. 1944. Some uses of nomographs in fish studies. Copeia 3:157-162.

Christenson, L. M. 1957. Some charateristics of the fish populations in backwater areas of the Upper Mississippi River. MS thesis, Univ. Minnesota. 125 pp.

Cooper, E. L. 1952. Rate of exploitation of wild eastern brook trout and brown trout populations in the Pigeon River, Ostego County, Michiugan. Trans. Am. Fish. Soc. 81:224-234.

Creaser, C. W. 1926. The structure and growth of the scales of fishes in relation to the interpretation of their life history, with special reference to the sunfish, Eupomatis gibbosus. Mus. Zool. Univ. Michigan, Misc. Publ. No. 17.

Dery, L. M. 1983. Use of laminated plastic to impress fish scales. Prog. Fish-Cult. 45:88-89.

Di Costanzo, C. J. 1957. Growth of bluegill, Lepomis macrochirus, and pumpkinseed L. gibbosus, of Clear Lake, Iowa. Iowa State J. Sci. 32(1):19-34.

Dunham, D. K. 1956. How old is that fish? Wisconsin Conserv. Bull. 21(7):11-13.

Elliot, J. M. 1948. The age and rate of growth of the black crappie, Poxomis nigro-maculatus (Le sueur), and the white crappie Poxomis annularis (Rafinesque), in the Koon Kreek Club Lakes, Texas. MS thesis, N. Texas St. Teachers Coll. 56 pp.

English, T. S. 1952. Method of sectioning carp spines for growth studies. Prog. Fish-Cult. 14:36.

Ferkin, G. F. 1981. Growth rates and diets of three game fish in Pool 9 of the Mississippi River. Unpubl. manuscript, Luther College, Decorah, Iowa. 50 pp.

Franklin, D. R., and L. L. Smith, Jr. 1963. Early life history of the northern pike Esox lucius L., with special reference to the factors influencing the numerical strength of year classes. Trans. Am. Fish. Soc. 92:91-110.

Frey, D. G. 1940. Growth and ecology of the carp Cyprinus carpio Linnaeus in four lakes of the Madison Region, Wisconsin. Ph.D. thesis, Univ. Wisconsin. 248 pp.

Gabelhouse, D. 1981. Proposed lengths for stock, quality, preferred, memorable, and trophy-sized fishes. Tabulated data, mimeo Kansas Fish and Game Comm. Emporia 2 pp.

Geen, G. H., T. G. Northcote, G. F. Hartman, and C. C. Lindsey. 1966. Life histories of two species of Catostomid fishes in Sixteenmile Lake, British Columbia, with particular reference to inlet stream spawning. J. Fish. Res. Bd. Canada 23:1761-1788.

Goedde, L. E. 1980. Effects of angling on a previously fished and an unfished warm water fish community in two small lakes in central Wisconsin. MS thesis, Univ. Wisconsin-Stevens Point 143 pp.

Goedde, L. E., and D. W. Coble. 1981. Effects of angling on a previously fished and an unfished warm water fish community in two small lakes in central Wisconsin. Trans. Am. Fish. Soc. 110:594-603.

Hackney, P. A. 1978. Fish community biomass relationships. Pages 25-36 In G. D. Novinger and J. G. Dillard, eds., New approaches to the management of small impoundments. Spec. Publ. No. 5, N. Cent. Div. Am. Fish. Soc.

Hayes, M. L. 1956. Life history studies of suckers in Shadow Mountain Reservoir, Grand County, Colorado. MS thesis, Colorado A.M. college 126 pp.

Held, J. W. 1983. The populations and community structure of fishes of Lake Onalaska, 1976-1982, Contract No. 14-16-0003-83-013. Submitted to U.S. Fish and Wildlife Service, Fort Snelling, Twin Cities, Minnesota 150 pp.

Hile, R. 1970. Body-scale relation and calculation of growth in fishes. Trans. Am. Fish. Soc. 99:468-469.

Hile, R. 1950. A nomograph for the computation of the growth of fish from scale measurements. Trans. Am. Fish. soc. 78:156-162.

Hubbs, C. L. 1933. The increased growth, predominant maleness and apparent infertility of hybrid sunfishes. Michigan Acad. Sci. Arts Lett. Paper 17:613-641.

Hunt, R. L. 1965. Food of northern pike in a Wisconsin trout stream. Trans. Am. Fish. Soc. 94:95-97.

Jennings, T. 1969. Age and growth of black crappie in Spirit lake, Iowa. Iowa Q. Biol. Rep. 21(4):60-64

Karvelis, E. G. 1952. The true pikes. Fish. Leafl. 569, Washington, D.C. 11 pp.

Kmiotek, S., and C. L. Cline. 1952. Growth of southern Wisconsin largemouth bass with creel census results from lakes with liberalized regulations. Wisconsin Conserv. Dept. Fish. Invest. Rep. 670. 11 pp.

Kuehn, J. H. 1949. Statewide average total length in inches at each year. Minnesota Res. Lab. Suppl. Invest. Rep. 51 (2nd rev.).

Landis, P., P. Ritter, and M. Steingraeber. 1984. Age and growth of carp *Cyprinuis carpio* (Linnaeus) in Lake Neshonoc, La Crosse County, Wisconsin. Unpubl. rept., Univ. Wisconsin-La Crosse. 17 pp.

Marz, D., S. Kmiotek, and L. Frankenberger. 1961. The largemouth bass: Its life history, ecology and management. Wisconsin Conserv. Dept. Publ. 232:13.

McFadden, J. T. 1961. A population study of the brook trout, *Salvelinus fontinalis*. Wildlife Monographs, No. 7. 73 pp.

Mitzner, L. 1974. Life history and dynamics of largemouth bass in man-made lakes. Iowa conserv. Comm. Fed. Aid Proj. F-88-R-1, Study No. 503-1:26.

Nielson, L. A., and D. L. Johnson, eds. 1983. Fisheries techniques. Southern Printing Company, Inc., Blacksburg, Virginia. 468 pp.

Novinger, G. D., and R. E. Leger. 1978. Bluegill population structure and dynamics. Pages 37-49 *In* G. D. Novinger and J. G. Dillard, eds., New approaches to the management of small impoundments. Spec. Publ. No. 5, N. Cent. Div. Am. Fish. Soc.

Paragamian. V. L. 1974a. Evaluation of the 14-inch size limit on largemouth bass at Big Creek Reservoir. Iowa Conserv. Comm. Fed. Aid Proj. F-88-R-1, Study No. 601-1:28 pp.

Paragamian, V. L. 1974b. Vital statistics of fish populations in Red Rock Reservoir and Rathbum Reservoir following initial impoundment. Iowa Conserv. Comm. Fed. Aid Proj. F-88-R-1, Study No. 702-703:1-46.

Parker, R. A. 1958. Some effects of thinning on a population of fishes. Ecology 39:304-317.

Quinn, T. J., II, S. H. Hoag, and G. M. Southward. 1982. Comparison of two methods of combining catch-per-unit-effort from geographical regons. Can. J. Fish. Aquat. Sci. 39:837-846.

Raney, E. C., and D. A. Webster. 1942. The spring migration of the common white sucker, Catostomus c. commerson (La cepede), in Skaveateles Lake Inlet, New York. Copeia 1:139-148.

Reynolds, J. B., and D. E. Simpson. 1978. Evaluation of fish sampling methods and rotenone census. Pages 11-24 In G. D. Novinger and J. G. Dillard, eds., New approaches to the management of small impoundments. Spec. Publ. No. 5, N. Cent. Div. Am. Fish. Soc.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Fish. Res. Bd. of Canada, Bull. 119. 300 pp.

Ricker, W. E. 1971. Methods for assessment of fish production in fresh waters. Blackwell Scientific Publications, Oxford, England. 348 pp.

Ridenhour, R. L. 1957. Northern pike, Esox lucius L., population of Clear Lake, Iowa. Iowa State J. Sci. 32(1):1-18.

Roach, L. S. 1948a. In fishing circles. Ohio Conserv. Bull. 12(6): 12-13.

Roach, L. S. 1948b. Common sucker. Ohio Conserv. Bull. 12(5):13.

Robson, D. S., and H. A. Rieger. 1964. Sample size in Peterson mark-recapture experiments. Trans. Am. Fish. Soc. 93:215-226.

Schnabel, Z. E. 1938. The estimation of the total fish population of a lake. Amer. Math. Mon. 45:348-352.

Smith. L. L., Jr., and N. L. Moe. 1944. Minnesota fish facts. Minnesota Dept. Conser. Bull. 7:1-31.

Spoor, W. A. 1938. Age and growth of the sucker, Catostomus commersonnii (Lacepede), in Muskellunge Lake, Vilas county, Wisconsin. Trans. Wisconsin Acad. Sci. Arts Lett. 31:457-505.

Sprague, J. W. 1961. Report of fisheries investigations during the seventh year of impoundment of Fort Randall Reservoir, South Dakota, 1959. south Dakota Dept. Game Fish Parks Dingell-Johnson Prog. F-1-R-9. 49 pp.

Talley, J. G. 1976. Perch Lake management alternatives. Intra-department Memorandum, Wisconsin Department of Natural Resources, Black River Falls, Wisconsin. 17 pp.

Thompson, J. D. 1965. Age and growth of largemouth bass in Clear Lake, Iowa. Proc. Iowa Acad. Sci. 71:252-258.

Troutman, M. B. 1957. The fishes of Ohio. Ohio State University Press, Ames, Iowa. 683 pp.

Vanderpuye, C. J., and K. D. Carlander. 1971. Age, growth and condition of black crappie Poxomis nigromaculatus (Le Sueur) in Lewis and Clark Lake, South Dakota, 1954-1967. Iowa State J. Sci. 45:541-555.

Van Engel, W. A. 1940. The rate of growth of the northern pike, *Esox lucius* Linnaeus, in Wisconsin waters. Copeia 1940(3):177-188.

Wagner, W. C. 1972. Utiliztion of alewives by inshore piscivorous fishes in Lake Michigan. Trans. Am. Fish. Soc. 101:55-63.

Wege, G. L., and R. O. Anderson. 1978. Relative weight (W_r): A new index of conditon for largemouth bass. Pages 79-91 *In* G. D. Novinger, and J. G. Dillard, eds., New approaches to the management of small impoundments. Spec. Publ. No. 5, N. Cent. Div. Am. Fish. Soc.

Wright, K. 1983. Perch Lake fish stocking record. Department records, Wisconsin Department of Natural Resources, La Crosse, Wisconsin. 1 pp.

Wright, K. 1983. Personnel Communication. Wisconsin Department of Natural Resources, La Crosse, Wisconsin.

Wright, K. 1984. Personnel communication. Wisconsin Department of Natural Resources, La Crosse, Wisconsin.

Wynes, D. L. 1976. Age, growth and food habits of the Centrarchidae in Pool 8 of the Upper Mississippi River, MS thesis, Univ. Wisconsin-La Crosse 170 pp.

Youn, P. M. D. 1962. Comparisons of some carp populations. MS thesis, Iowa State Univ., Ames, Iowa 48 pp.