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First Year Growth and Survival of Walleyes in Power Plant Evaporation and Holding Reservoirs

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FIRST YEAR GROWTH AND SURVIVAL OF WALLEYES IN POWER

PLANT EVAPORATION AND HOLDING RESERVOIRS

By

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FIRST YEAR GROWTH AND SURVIVAL OF WALLEYES IN POWER PLANT EVAPORATION AND HOLDING RESERVOIRS

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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FIRST YEAR GROWTH AND SURVIVAL OF WALLEYES IN POWER PLANT EVAPORATION AND HOLDING RESERVOIRS

by

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Abstract

Walleyes (Stizostedion vitreum) were stocked at a rate of 88 fish/hectare in two South Dakota power plant reservoirs and their growth and survival were monitored for one year. Length, weight, and survival of walleyes were significantly ($P \leq 0.05$) different between the two reservoirs. The walleyes attained a mean length of 230 mm (range 192 - 265 mm) in the Evaporation Reservoir and 205 mm (range 177 - 250 mm) in the Holding Reservoir. Mean weights attained by the fish were 104 g (range 65 - 165 g) in the Evaporation Reservoir and 89 g (range 48 - 135 g) in the Holding Reservoir. The growth rates of walleyes in the two reservoirs were inversely related to survival and standing crops. Walleye survival in the Evaporation Reservoir was 1.5% (0.95 C.L., 0.9 - 2.8%) with a standing crop of 0.13 kg/hectare, whereas survival in the Holding Reservoir was 17.2% (0.95 C.L., 13.5 - 22.9%) with a standing crop of 1.33 kg/hectare. Walleye standing crop estimates, calculated in terms of weight of fish per volume of water beneath the ice, were similar in the two reservoirs; standing crops were 0.06 kg/1000 m^3 in the Evaporation Reservoir, and 0.08 kg/1000 m^3 in the Holding Reservoir. Estimated forage fish standing crops were 1.21 kg/hectare in the Evaporation Reservoir and 1.91 kg/hectare in the Holding Reservoir.

INTRODUCTION

The South Dakota Department of Game, Fish and Parks requires a reliable source of walleye (Stizostedion vitreum) brood stock for state hatcheries. In the past, wild brood stock have been used for propagation due to the difficulty in holding adult walleyes in hatcheries. The availability of brood fish in an area free from exploitation by fishermen, such as power plant reservoirs, could be suitable for rearing and holding brood fish.

Power plant reservoirs, aside from serving as areas to hold and recirculate cooling water, may also serve secondary functions (Metz 1977). One such function could be to rear and hold brood fish. This use may be valuable if adequate growth is exhibited by walleyes for sexual maturation and sufficient numbers of fish survive until sexual maturity.

Sexual maturity of walleyes is more dependent on size than on age. In Canada, male walleyes usually reach maturity at 279 mm or greater in length (age-classes II - IV) and females at 356 mm or greater in length (age-classes III - VI) (Scott and Crossman 1973). Grinstead (1971) reported sexual maturity in age-class I males ($\bar{x}$ length, 310 mm) and age-class II females ($\bar{x}$ length, 422 mm) in Canton Reservoir, Oklahoma, where high growth rates occurred. Other authors have found similar trends of early maturation in rapidly growing fish (Hile 1954; Forney 1965; Wolfert 1969).

The growth rate of walleyes is affected by temperature and forage abundance. The optimum temperature range for growth of juvenile walleye (84 - 87 mm in length) is from 19-25 C (Smith and Koenst 1975). As with most fishes, annual growth tends to increase with decreasing latitude due to the longer growing season. Growth can be inhibited, however, if water temperatures are too high. In Norris Reservoir, Tennessee, walleye growth rates slowed during August and September when water temperatures reached 28 C (Eschmeyer and Jones 1941). Forney (1965), Miller (1967), and Hofmann (1972) stated that abundant forage was the major reason for high growth rates in walleyes in Oneida Lake, New York and El Capitan Reservoir, California.

Walleyes are generally piscivorous, but invertebrates can become important food items until young-of-the-year forage fish become available (Colby et al. 1979). In areas where yellow perch (Perca flavescens) are available, they often become the dominant forage species (Eschmeyer 1950; Dobie 1966; Forney 1966; Swensen and Smith 1976). Ney (1978) stated that yellow perch as forage is a function of availability rather than preference. Walleyes in Lake Michigan were found to favor clupieds despite an abundance of small yellow perch (Wagner 1972). Other species, mostly cyprinids, catastomids, and centrarchids have been found to be important forage items in the absence of yellow perch (Colby et al. 1979). Yearling and younger walleyes have been shown to exhibit a size preference for prey consumed; this could possibly determine the predominant forage species in a body of water (Parsons 1971).

The present study was conducted to monitor the first year growth and survival of walleyes in two unheated power plant reservoirs, and to evaluate the feasibility of using these reservoirs for rearing and holding walleye brood stock. Forage fish populations were also monitored to determine the suitability of the forage base in the reservoirs.

STUDY AREA

The Big Stone Power Plant is a coal fired 440 MW steam electric generating facility located in Grant County, South Dakota. The power plant is jointly owned by Montana-Dakota Utilities Company, Northwestern Public Service Company, and Otter Tail Power Company.

The study reservoirs, an Evaporation Reservoir and a Holding Reservoir, are part of the water recycling system of the power plant and was completed and filled in March 1981. The Evaporation Reservoir concentrates dissolved salts in the water to a point where the power plant desalinator will work properly. Water from the Evaporation Reservoir is released into the Holding Reservoir and later pumped into the salt concentrator (Fig. 1). The non-heated reservoirs enable the power plant to reuse cooling water rather than relying totally on water from nearby Big Stone Lake. The physical characteristics of the study reservoirs are described in Table 1. Estimates of surface area and water volume at various elevations within these reservoirs can be derived from Figs. 2 and 3. Depth contours in the reservoirs are illustrated in Fig. 4.

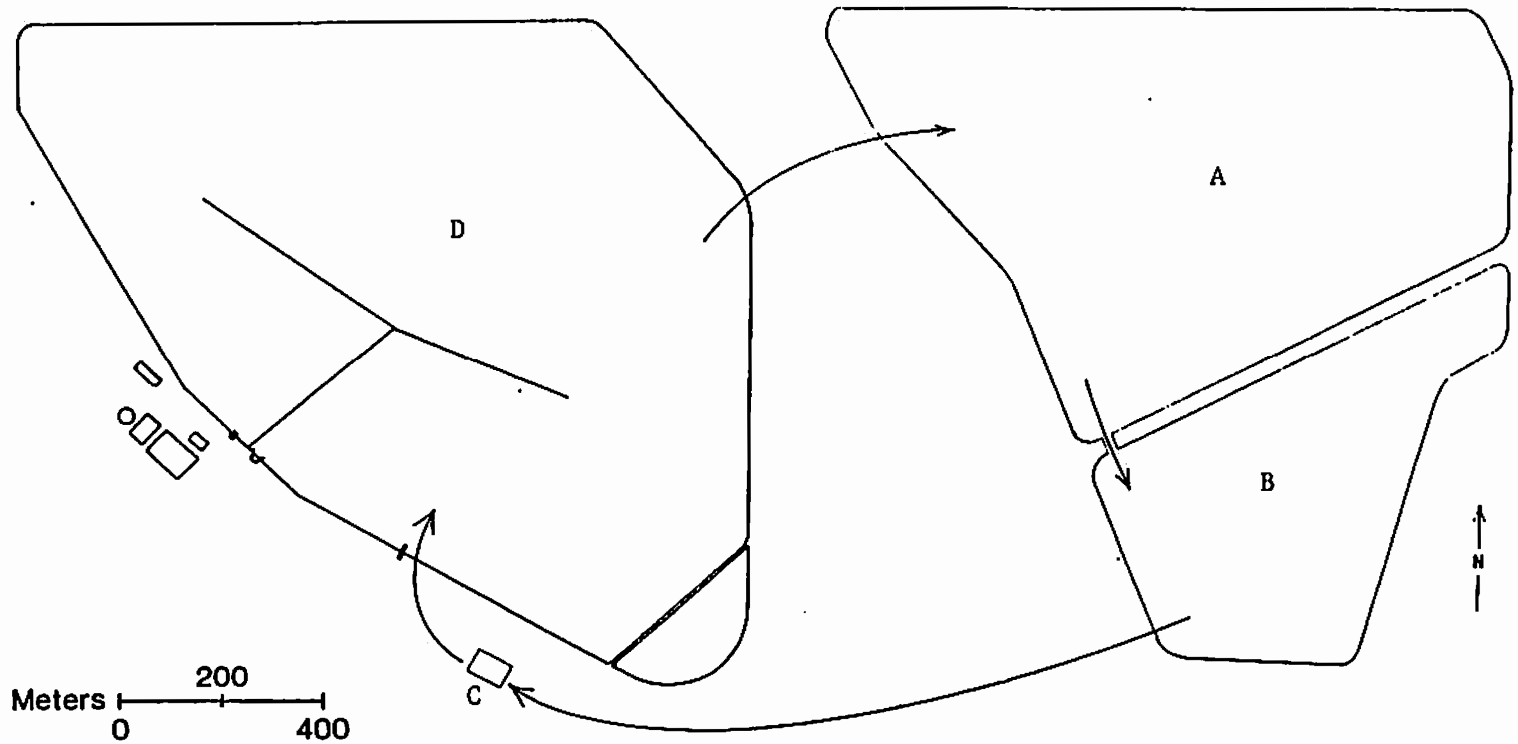

Figure 1. Direction of water flow in the water recycling system: A, Evaporation Reservoir; B, Holding Reservoir; C, desalinator; and D, Cooling Reservoir, Big Stone Power Plant, South Dakota, 1982.

Table 1. Physical characteristics of the Evaporation and Holding reservoirs, Big Stone Power Plant, South Dakota, 1982.

	Holding Reservoir	Evaporation Reservoir
Total surface area (hectares)	39.1	85.8
Bottom elevation (msl)	331.4	336.1
Maximum surface elevation (msl)	339.4	339.4
Maximum volume (m^3)	1,609,703.7	1,771,290.0

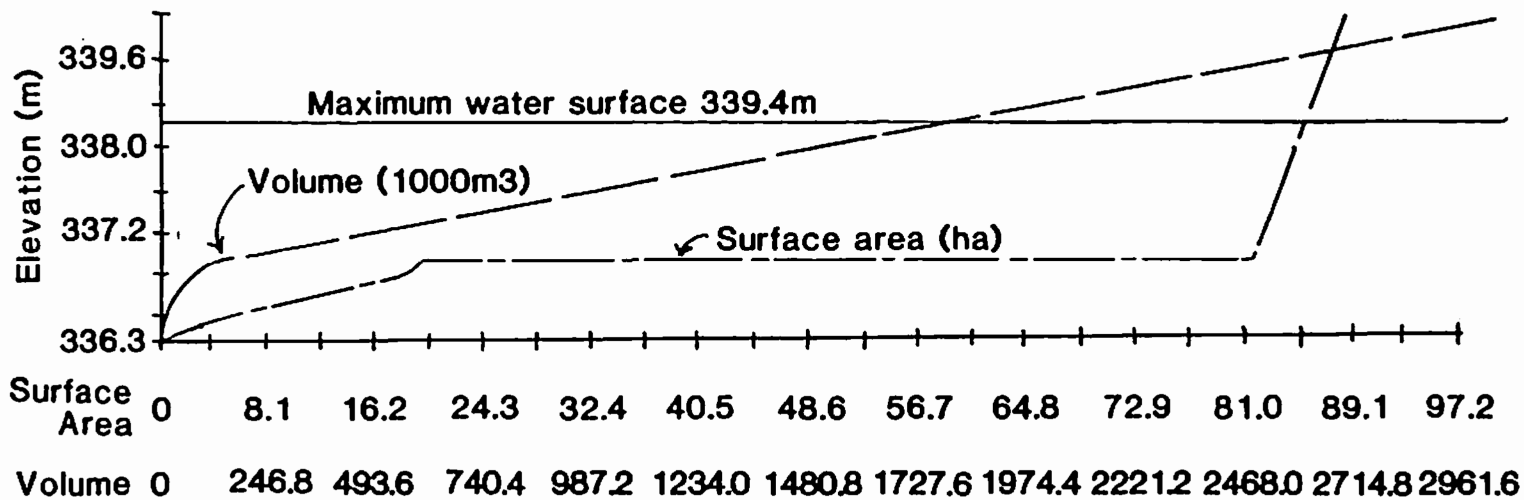

Figure 2. Surface elevation, surface area, and water volume of the Evaporation Reservoir, Big Stone Power Plant, South Dakota, 1982. (Data provided by the Big Stone Power Plant.)

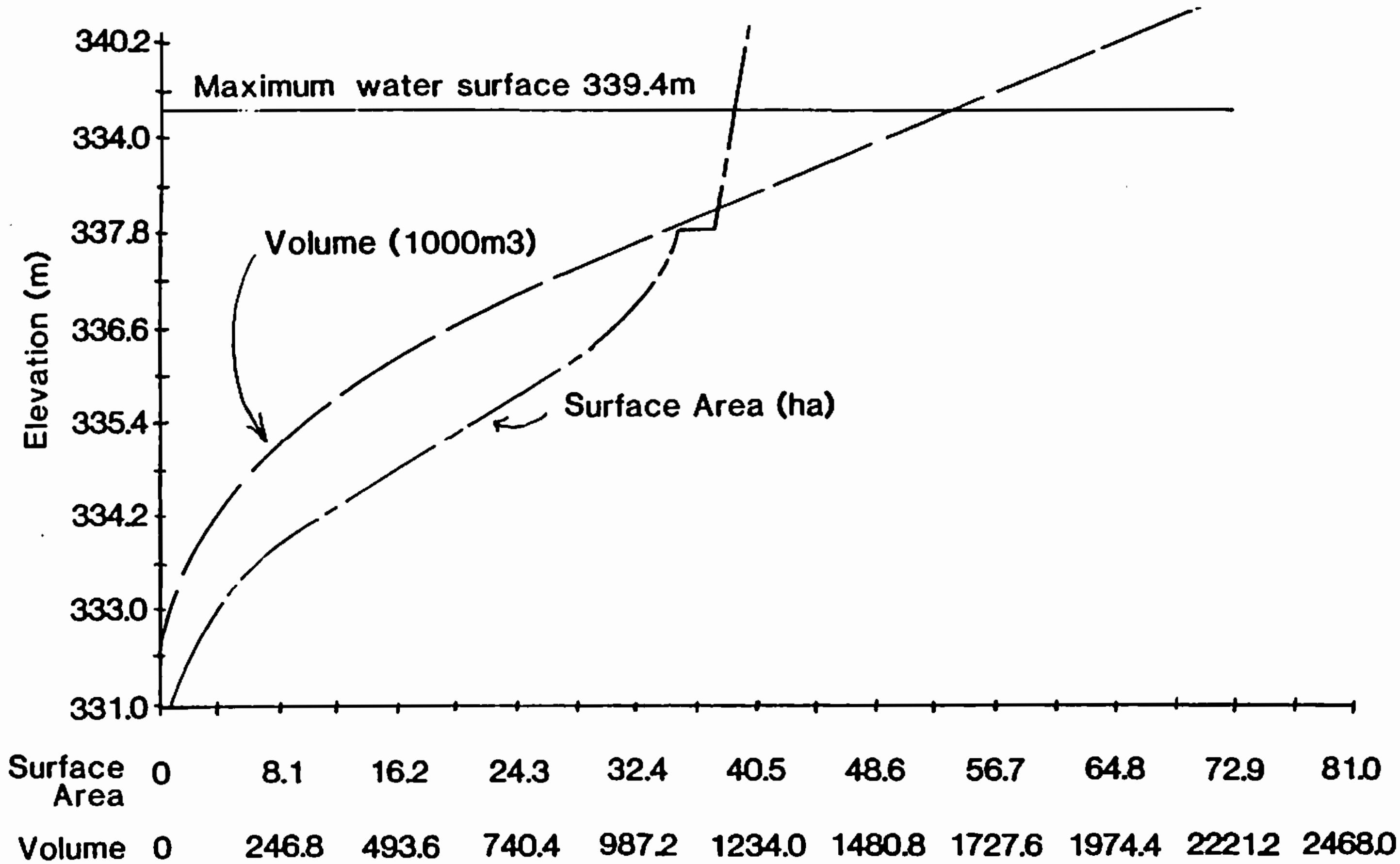

Figure 3. Surface elevation, surface area, and water volume of the Holding Reservoir, Big Stone Power Plant, South Dakota, 1982. (Data provided by the Big Stone Power Plant.)

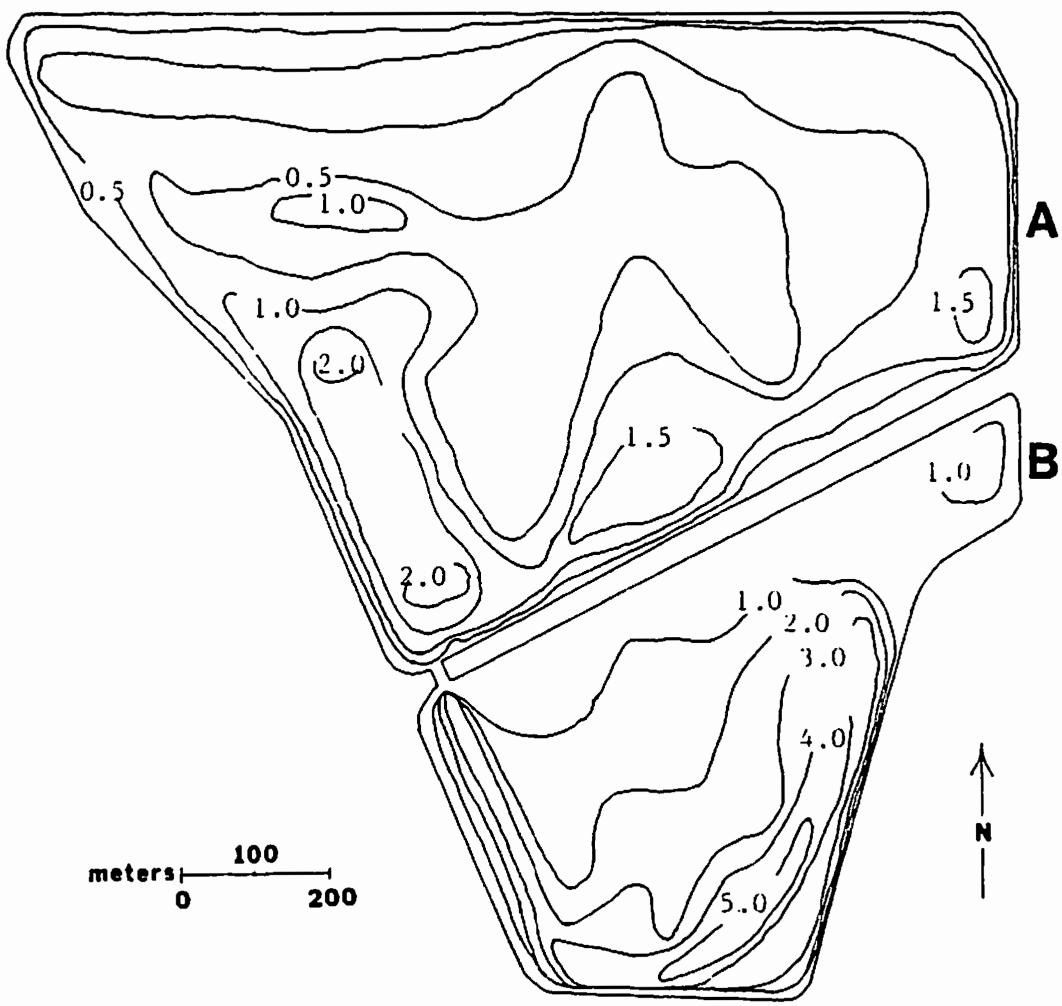

Figure 4. Bottom contours (m) at a surface elevation of 338.1 m above msl in the Evaporation Reservoir (A), and 339.4 m above msl in the Holding Reservoir (B), Big Stone Power Plant, South Dakota, 1982.

MATERIALS AND METHODS

Stocking of Fishes

In early May 1981, fathead minnows (*Pimephales promelas*) were stocked in the reservoirs at the rate of 2.6 gal/hectare to provide a forage base for the walleyes. The Evaporation Reservoir received 230 gal of fathead minnows; the Holding Reservoir received 105 gal. Walleye fingerlings (mean length, 33 mm; mean weight, 0.25 g) were obtained from Gavins Point National Fish Hatchery, South Dakota, and stocked in both reservoirs on 2 June 1981. Numbers of walleye fingerlings were estimated volumetrically and the fish were stocked at a density of 88 fish/hectare; 7,500 walleyes were stocked in the Evaporation Reservoir and 3,500 were stocked in the Holding Reservoir.

Determination of Physical and Chemical Factors

Temperature and dissolved oxygen profiles, and secchi disk visibility were monitored monthly in each reservoir for a one year period following the stocking of walleyes. A Kemmerer water bottle was used to sample at 1 m intervals. Water temperature was measured with a standard mercury thermometer and dissolved oxygen concentrations were measured by the azide modification of the Winkler titration method (Lind 1974). Data were examined for stratification and monthly means were calculated for each parameter measured.

During ice cover, ice depth was measured at 3 locations in each reservoir with a meter stick through a hole drilled with an ice auger.

Each reservoir was mapped from bottom contour transects (100 m apart) taken with a Lowrance chart depth recorder. The transects were from north to south and east to west. The amount of time required to complete each transect was recorded and partitioned into 15 second intervals. Each time interval represented an equal distance along the transect. For each transect segment, a depth was recorded on an outlined map of the reservoirs overlaid with the mapping transects. Contour lines were determined at 0.5 m intervals in the Evaporation Reservoir and 1.0 m intervals in the Holding Reservoir because they differed in depth.

Water level gauging stations were provided by the power plant for each reservoir, and monthly elevations were recorded from August 1981 through May 1982. Estimations of surface area and/or water volume could be determined at a given water level using data provided by the Big Stone Power Plant (Figs. 2 and 3).

Population Estimate of Fishes

A multiple census population estimate, based on collections taken from 19 May to 12 July, 1982, was made to determine first year walleye survival and the density of forage fish. Fish were captured with single-lead, South Dakota trap nets with 1.2 m^2 frames and 1.3 cm mesh. Attempts were also made to capture fish with a

240 volt A.C. electrofishing boat, angling, and experimental gill nets, but low catch rates precluded the use of these methods.

Six trap nets were placed in each reservoir and examined every 48 hours. Nets were randomly distributed around the reservoirs and rotated clockwise at 100 m intervals each week in order to distribute the fishing effort. Excluding fathead minnows, all captured fish were measured (total length), weighed, marked, and released near the center of the reservoirs to reduce bias in recaptures. Right pelvic fin clips were used to mark fish from the Evaporation Reservoir, and left pelvic fin clips were used to mark fish taken from the Holding Reservoir to determine if movement between the reservoirs occurred during water transfer. Pectoral spines of ictalurids and scales from other fish were taken from all marked fish for aging purposes (Sneed 1951; Lagler 1956).

Fish populations were estimated by using the modified Schnabel estimator. The equation used is as follows:

$$\hat{N} = \frac{\Sigma(C_t\ M_t)}{\Sigma R + 1} \qquad \text{(Ricker 1975)}$$

where:

$\hat{N}$ = estimate of population density,

C_t = total sample taken on day t,

M_t = total marked fish at large at the start of the t^{th} day,

R = recaptures.

Confidence limits were calculated for the population estimates by treating the number of recaptures as a Poisson variable. This results in a skewed distribution with the upper limits showing the greatest divergence from the mean. Confidence coefficients were calculated using the equation:

$$1 - P = 0.95 \quad R + 1.92 \pm 1.96\sqrt{R + 1.0} \qquad \text{(Ricker 1975).}$$

Confidence coefficients were substituted as recaptures in the modified Schnabel estimator to determine confidence limits. Statistical significance ($P \leq 0.05$) was tested by comparing confidence limits (i.e. if confidence limits did not overlap, a significant difference was assumed).

Systematic errors in multiple census population estimates can take complex forms, but those errors due to recruitment and mortality are of the greatest importance (Ricker 1975). Recruitment and mortality will be discussed separately for forage species and walleye.

Error due to growth recruitment can be minimized by making an allowance for fish growth during a multiple census and confining the calculation to a single age-class or otherwise restricted portion of the population (Ricker 1975). This was incorporated into forage fish abundance estimates by extending the sampling into mid-July and applying the estimates to age-class I and older fish. Walleye recruitment due to growth was minimized by extending the multiple census into mid-July and confining the estimate to age-class I walleyes.

Walleye recruitment in the Evaporation Reservoir due to pump-in was absent since the Big Stone Power Plant cooling reservoir was devoid of age-class I walleyes in 1982. Pump-in water was filtered through a 1.3 cm mesh trap net for 48 hours to estimate forage fish recruitment from the Cooling Reservoir into the Evaporation Reservoir during water transfer in May, 1982.

Marked fish removed by sampling mortality were accounted for by subtracting them from the number of marked fish at large, but no estimate of natural mortality was obtainable. In the absence of recruitment, a Schnabel estimate is generally less than the initial population size, but greater than the final population size (Ricker 1975).

The total catch of forage fishes did not provide sufficient data to estimate the population size of age-classes within any species. Therefore, forage fish population estimates were applied to all sampled age-classes within a species. In addition, sufficient data was not collected to estimate the population size of all forage species found in the reservoirs. Abundance estimates were calculated for yellow perch, black bullheads (*Ictaluras melas*), and bluegills (*Lepomis macrochirus*) in the Evaporation Reservoir, whereas only bluegill abundance was estimated in the Holding Reservoir.

Walleye Growth

Walleye growth was monitored in the two reservoirs for a period of one year after stocking. Total length (mm) and weight (g) were measured from fish sampled during this time. Monthly means were calculated for length and weight in each reservoir, and growth curves drawn. The curves closely resembled logistic growth curves, so the nonlinear procedure (PROC NLIN) from SAS (Statistical Analysis System) was used to fit the data to logistics functions. The logistic function model:

$\hat{Y} = K/(1 + e^{(B-KPX)})$ (Goldstein et al. 1980)

was used to describe the growth curves. The parameters are defined as follows:

$\hat{Y}$ = estimated value of length or weight,

K = upper asymptote,

e = exponential,

B = a constant,

P = constant of proportionality,

X = the day when length or weight is to be calculated (i.e. for the 10^{th} day of growth, X = 10).

By using the logistic function and methods of calculus, determinations of maximum rate of growth, the day of maximum rate of growth, and the period of maximum rate of growth were calculated.

The maximum rate of increase (maximum rate of growth) occurs at the inflection point or when Y = K/2 (Fig. 5). By substituting K/2 for Y in the logistics function model and solving for X, the equation for the day at maximum rate of growth is determined. This is defined as X = B/KP.

The slope of the line tangent to the inflection point is the maximum rate of growth. This is defined by the first derivative of the logistics function. The equation defining the logistic first derivative is: $Y^1 = PY(K - Y)$ (Goldstein et al. 1980). Since the maximum rate of growth occurs when Y = K/2, K/2 may be substituted

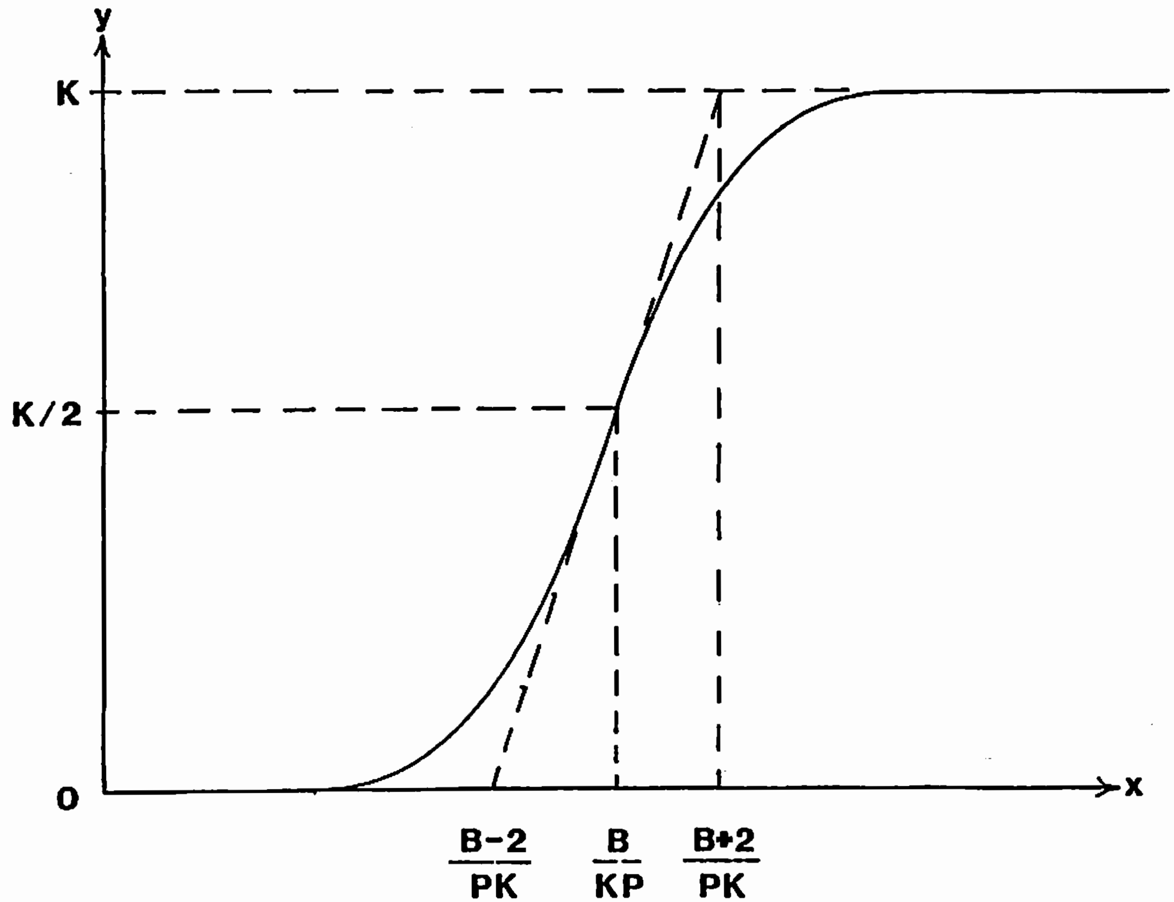

Figure 5. Hypothetical logistic growth curve showing specific values to be calculated.

for Y in the differential equation, and the slope of the tangent line or the maximum rate of growth is determined. This is denoted as:

$$Y^1 = \frac{PK^2}{4}$$ (Goldstein et al. 1980).

The equation for the tangent line was found using the point-slope form of a line:

$$Y - K/2 = PK^2/4\ (X - BKP)$$ (Swokowski 1975).

Solving this equation for Y, the equation takes the slope-intercept form of a line, $Y = PK^2/4\ X + K/4\ (2 - B)$ where $PK^2/4$ is the slope and $K/4\ (2 - B)$ is the Y intercept.

The period of optimum growth is defined as the difference between the X values where the line tangent to the inflection point crosses the upper and lower asymptotes. The lower X value for the period of optimum growth occurs when Y = 0 within the tangent line. By setting Y = 0 and solving for X, it is found that $X_L = B - 2/PK$. Likewise, the upper X value for the optimum growth period is found by setting Y = K and again solving for X. This upper X limit is defined as: $X_u = B + 2/PK$. Since X_u and X_L are the upper and lower limits of optimum growth, the amount of time in which optimum growth occurred can be defined as B + 2/PK - B - 2/PK or 4/PK.

The SAS program, PROC NLIN, calculated confidence limits for the upper asymptote of the logistic curve. Statistical significance was determined at the 0.05 level by comparing confidence limits (i.e. if confidence limits did not overlap, a significant difference was assumed).

Length Frequencies, Age Distribution, and Standing Crop Estimates of Fishes

Length frequencies were plotted at 10 mm intervals for each forage species used in the Schnabel estimate to determine the length and age structure of these fishes in the reservoirs. A subsample of fish were aged within length groups that indicated a separate age-class. Scale impressions from yellow perch and bluegills were made on acetate slides and magnified with an Eberbach scale reader. Thin sections were removed from black bullhead pectoral spines at the distal end of the basal groove. The sections were placed in water on a glass slide and read with the use of a stereo microscope. Annuli were counted on scales and spine cross sections to determine fish age.

A standing crop estimate was calculated for walleyes and each abundant forage species in both reservoirs. Mean weights were calculated for forage species by summing the individual weights of all captured fish of a species and dividing by the total number of captured fish of that species. Mean weights were then multiplied by their respective population estimate. Standing crop estimates were calculated by dividing these products by reservoir surface area.

Walleye standing crops were estimated in a different manner because curvelinear regression was used to model walleye growth. For each reservoir, mean weights for walleyes were calculated in the SAS nonlinear procedure (PROC NLIN). In the walleye growth (weight) model, K, or the upper asymptote, represents the mean weight of walleyes at the time the multiple census population estimates were started. Mean walleye weights were multiplied by their respective population estimates and these products represented the total biomass estimate of walleyes within each reservoir.

Two standing crop estimates for walleyes were calculated in each reservoir. The total biomass estimates were divided by their respective reservoir surface areas; this data was reported as kg walleyes/hectare of reservoir surface area. The total biomass estimates for each reservoir were also divided by the water volume beneath the ice in each reservoir; this data was reported as kg walleyes/1000 m^3 of water.

RESULTS AND DISCUSSION

Physical and Chemical Factors

Vertical water column profiles indicated no temperature or oxygen stratification in either reservoir during the one-year sampling period. All secchi disk visibility measurements were inclusive of the entire water column in both reservoirs due to low turbidity and high light penetration.

Mean water temperatures in the Evaporation Reservoir ranged from 1.0 C in January and February to 24.7 C in July; temperatures in the Holding Reservoir ranged from 0.5 C in March to 24.6 C in July. Dissolved oxygen concentrations in the Evaporation Reservoir ranged from 6.4 mg/l in January to 12.6 mg/l in March; oxygen concentrations in the Holding Reservoir ranged from 6.2 mg/l in January to 15.3 mg/l in February.

Smith and Koenst (1975) reported that 19-25 C was optimum for growth of juvenile walleyes. Mean water temperatures in both reservoirs were within this optimum range during July and August, and probably during parts of June and September 1981 (Table 2). Walleyes have been reported to tolerate oxygen levels as low as 2.0 mg/l in the laboratory (Scherer 1971), but they will attain highest population densities at dissolved oxygen concentrations of 3.0 mg/l or greater (Dendy 1948). Mean oxygen concentrations in the study reservoirs were never below 6.2 mg/l during the sampling period (Table 2).

Table 2. Mean[1] water column temperatures (C) and O_2 concentrations (mg/L) in the Evaporation and Holding reservoirs, Big Stone Power Plant, June 1981 to April 1982.

	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Evaporation Reservoir											
C	18.5	24.7	22.1	18.0	9.9	8.0	3.0	1.0	1.0	2.0	12.0
O_2	9.3	7.5	7.6	10.1	11.8	12.4	6.6	6.4	12.5	12.6	10.6
Holding Reservoir											
C	18.4	24.6	22.9	18.5	9.2	8.0	1.2	1.0	0.7	0.5	12.0
O_2	8.9	7.7	8.3	10.1	11.8	12.1	6.6	6.2	15.3	13.2	11.6

[1]Mean of samples taken at 1 m intervals at three stations in each reservoir.

From August 1981 to May 1982, maximum depth varied between 2.1 and 2.6 m in the Evaporation Reservoir and between 4.8 and 7.1 m in the Holding Reservoir (Appendix Table 1). Ice thickness in both reservoirs was 1 m from January through March, 1982. Ice caused reductions in surface area and water volume in both reservoirs (Fig. 6). The surface area beneath the ice in the Evaporation Reservoir was reduced by 64% and volume by 82%; the estimated water volume beneath the ice in the Evaporation Reservoir was 197,400 m^3. Ice caused a 22% decrease in water surface area in the Holding Reservoir; volume was reduced by 31% to 617,000 m^3. The reduction in capacity of the Evaporation Reservoir over winter probably had an impact on the survival potential of walleye in that reservoir.

Other physical factors such as substrate and bottom structure may limit walleye production in these reservoirs. Einhouse (1981) stated that walleyes prefer submerged points and bars with substrates consisting of small gravel or compacted sand. Substrates of this type were prevalent throughout both study reservoirs, but submerged points and bars were lacking in water of sufficient depth for walleye to avoid high light intensity. Ice cover, low turbidity and high light penetration could have caused crowding of walleyes in the deeper areas of the reservoirs and in turn increased the possibility of cannibalism.

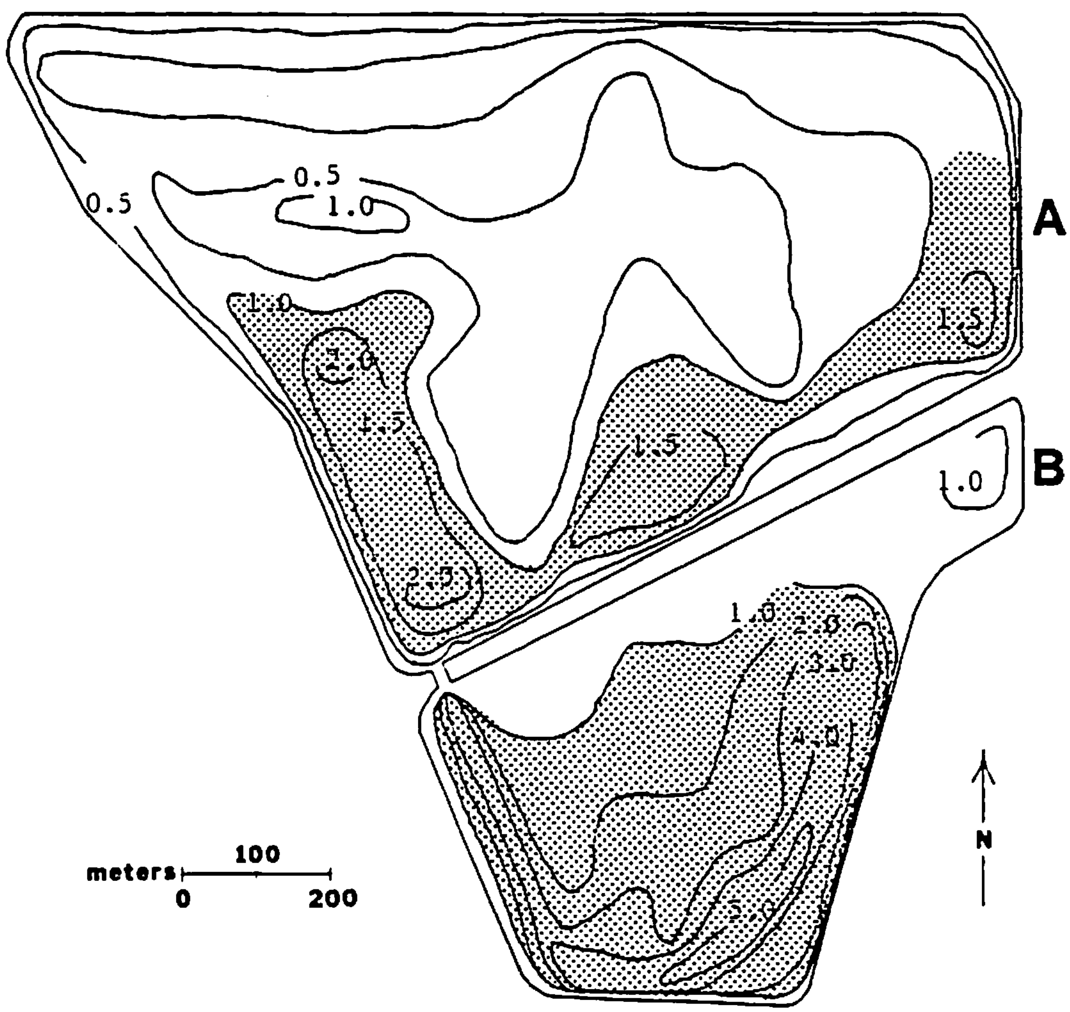

Figure 6. Bottom contour map of the Evaporation Reservoir (A), and the Holding Reservoir (B), indicating areas of unfrozen water (shaded) beneath the ice, Big Stone Power Plant, South Dakota, January, 1982.

Population and Standing Crop Estimates of Forage Fishes

This study indicated the presence of three major forage species other than fathead minnows in the Evaporation and Holding reservoirs: yellow perch, black bullheads, and bluegills. All three species were common in the Evaporation Reservoir, but only bluegills were common in the Holding Reservoir. Eleven additional species were captured in the two reservoirs (Table 3), but no population estimates were calculated for these species because sample sizes were insufficient.

Parsons (1971) found that as juvenile walleyes in Lake Erie increased in length, their size preference for forage species increased also. Generally, walleyes prefer forage less than 45% of their body length (Colby et al. 1979). Stocked walleyes in the study reservoirs initially would have been restricted to larval fish and invertebrates for forage. Other small fishes such as cyprinids and darters would have become available forage as the walleyes grew to the appropriate size. It is assumed that from the forage fish abundance estimates in 1982, only age-class 1 yellow perch, black bullheads, and bluegills were available as forage to walleyes during the growing season of 1981.

Yellow perch was the most abundant forage species captured in the Evaporation Reservoir. The final population estimate for this species was 1,352 (0.95 C.L. 783 - 2,276) (Appendix Table 4); the mean weight of marked yellow perch was 48 g. The majority of these fish (98.8%) were age-class I, and ranged from 111 to 160 mm in length (Fig. 7).

Table 3. Forage fishes present in the Evaporation and Holding reservoirs, Big Stone Power Plant, South Dakota, 1982.

Scientific Name	Common Name
Cyprinus carpio	Carp
Notropis cornutus	Common shiner
Notropis hudsonius	Spottail shiner
Pimephales promelas	Fathead minnow
Catostomus commersoni	White sucker
Ictalurus melas	Black bullhead
Noturus gyrinus	Tadpole madtom
Culaea inconstans	Brook stickleback
Lepomis macrochirus	Bluegill
Lepomis humilis	Orangespotted sunfish
Lepomis gibbosus	Pumpkinseed
Poxomis annularis	White crappie
Perca flavescens	Yellow perch
Etheostoma nigrum	Johnny darter

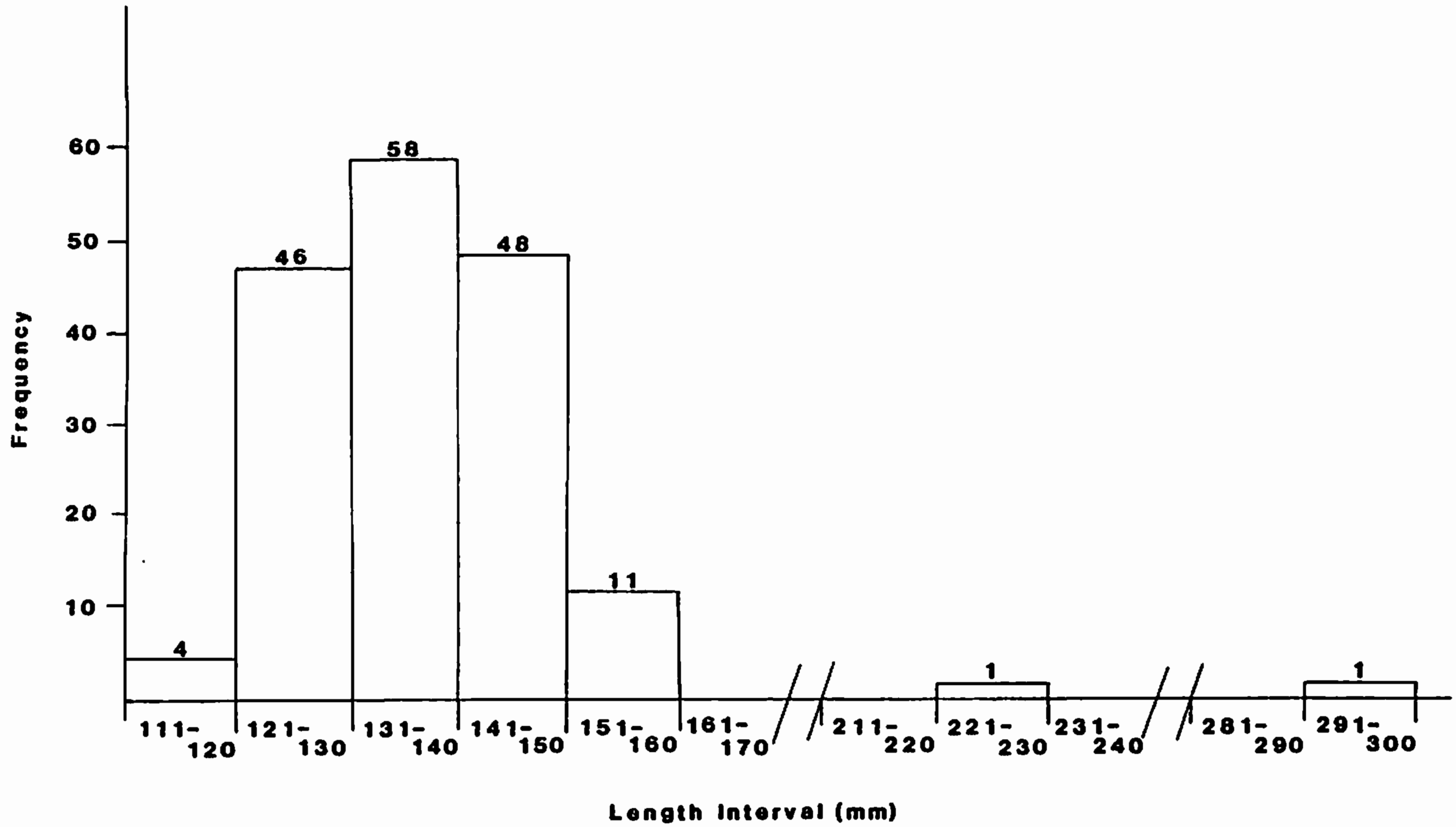

Figure 7. Length frequencies of marked yellow perch (*Perca flavescens*) in the Evaporation Reservoir, Big Stone Power Plant, South Dakota, 1982.

Black bullhead was the second most abundant forage species in the Evaporation Reservoir. The final population estimate for black bullhead was 290 (0.95 C.L. 212 - 399) (Appendix Table 5); the mean weight for this species was 115 g. Age-class I black bullheads ranged from 71 to 150 mm (Fig. 8) and comprised 73.2% of the marked individuals.

Bluegill was also a common forage species in the Evaporation Reservoir, but the least abundant of those measured. The final population estimate for this species was 103 (0.95 C.L. 75 - 144) (Appendix Table 6); the mean weight of marked bluegills was 25 g. Age-class I bluegills in the Evaporation Reservoir ranged from 51 to 110 mm (Fig. 9) and comprised 65.2% of all marked bluegills.

The final population estimate for bluegills in the Holding Reservoir was 7,312 (0.95 C.L. 4,601 - 13,487) (Appendix Table 7); the mean weight of bluegills in this reservoir was 10 g. Of all marked bluegills in the holding reservoir, 98.4% were age-class I fish, and their lengths ranged from 41 to 80 mm (Fig. 10).

Little difference was noted in the total estimated standing crops of forage fishes between the two reservoirs (Table 4). However, the population sizes of the other eleven species in the two reservoirs were not estimated, and could have contributed greatly to the total standing crop estimates. In particular, fathead minnows were frequently observed along the shorelines throughout the study, and were undoubtedly the most abundant fish in the two reservoirs. Fathead minnows could have as much as doubled the estimated standing crop of forage fishes in these reservoirs, but no abundance estimates

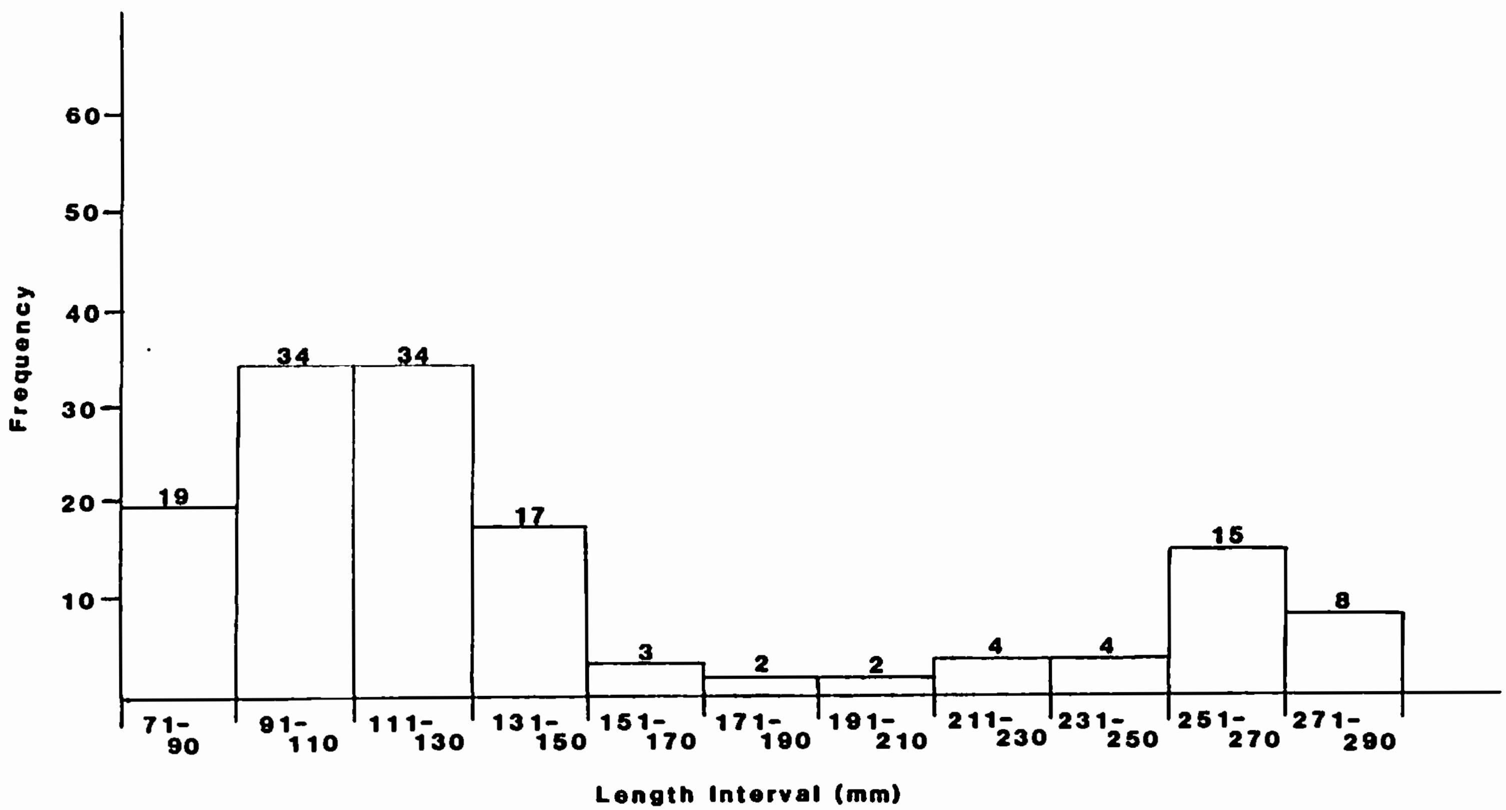

Figure 8. Length frequencies of marked black bullheads (Ictaluras melas) in the Evaporation Reservoir, Big Stone Power Plant, South Dakota, 1982.

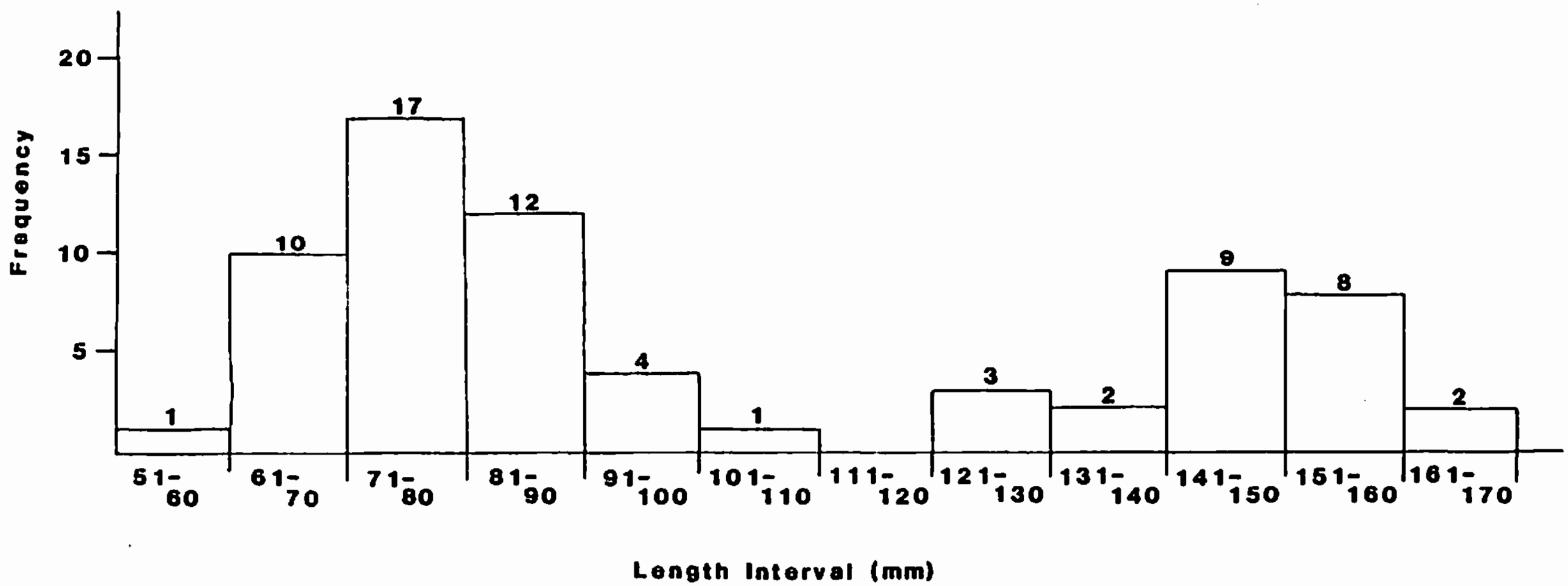

Figure 9. Length frequencies of marked bluegills (*Lepomis macrochirus*) in the Evaporation Reservoir, Big Stone Power Plant, South Dakota, 1982.

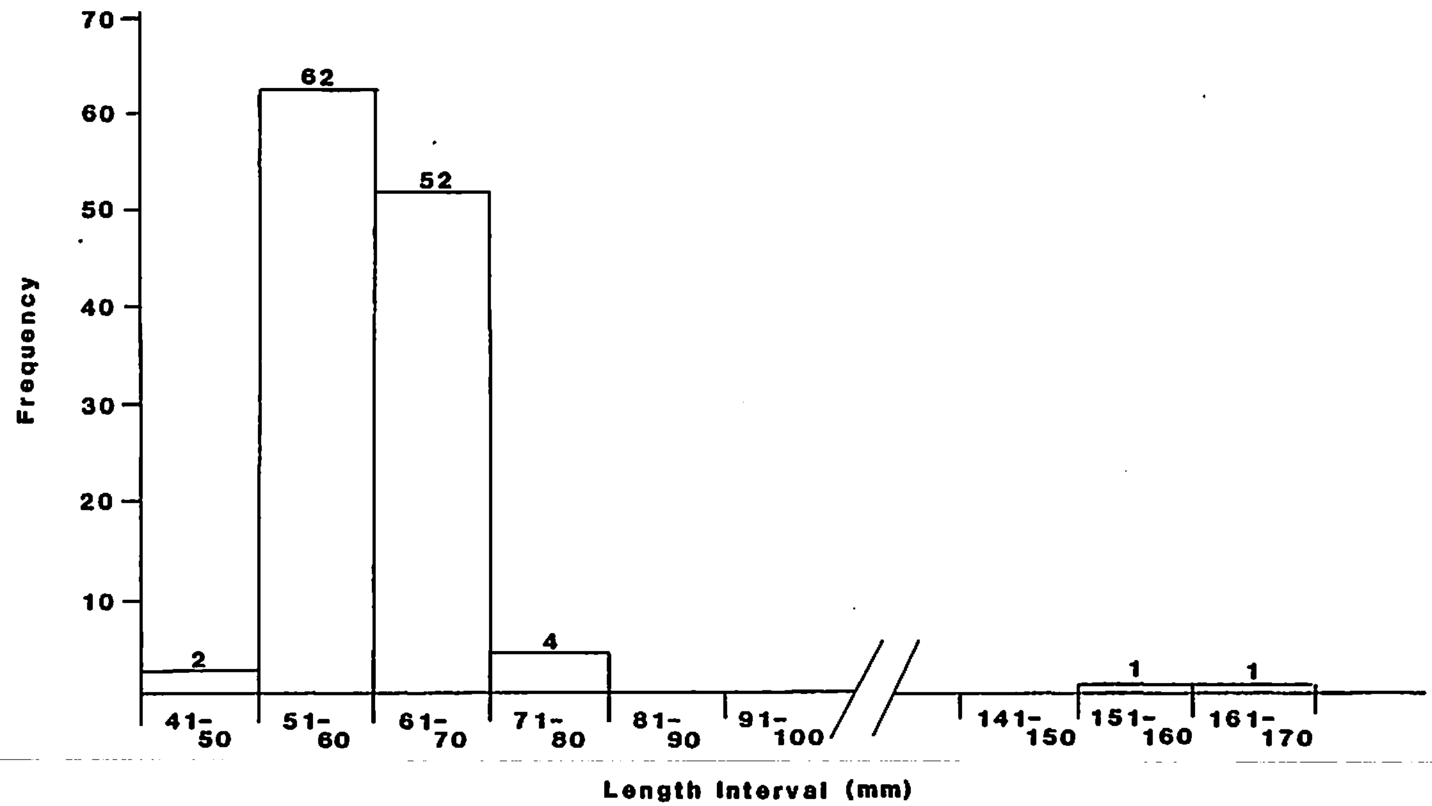

Figure 10. Length frequencies of marked bluegills (<u>Lepomis macrochirus</u>) in the Holding Reservoir, Big Stone Power Plant, South Dakota, 1982.

Table 4. Standing crop estimates of forage fishes in the Evaporation and Holding reservoirs, Big Stone Power Plant, South Dakota, 1982.

	Estimate	.95 C.L.
Evaporation Reservoir		
Yellow Perch	0.79 kg/hectare	0.44 - 1.28 kg/hectare
Black Bullheads	0.39 kg/hectare	0.29 - 0.54 kg/hectare
Bluegills	0.03 kg/hectare	0.02 - 0.05 kg/hectare
Total	1.21 kg/hectare	0.75 - 1.87 kg/hectare
Holding Reservoir		
Bluegills	1.91 kg/hectare	1.15 - 3.11 kg/hectare
Total	1.91 kg/hectare	1.15 - 3.11 kg/hectare

were attempted because the traps would not capture a representative sample of this species. The additional ten species of fish found in the two reservoirs were rarely observed, and probably added little to the total standing crop.

The estimated standing crops of forage fishes in the reservoirs were relatively low compared to average standing crops of the same species in other areas (Table 5). This was due primarily to the low numbers of adults that entered the reservoirs when filled for the first time in March 1981, only two months before this study began. One year-class had been recruited from these adults when the forage abundance estimates were made so no population structure had developed. This year-class was available to the juvenile walleyes (stocked at 33 mm in length) as forage during their first growing season.

Dobie (1966) found that juvenile walleyes become piscivorous at 30 mm in length. Numerous authors have found that yellow perch are important forage for walleyes (Eschmeyer 1950; Maloney and Johnson 1957; Swensen and Smith 1976). In addition, Maloney and Johnson (1957) stated that size and abundance of yellow perch was an important factor in determining year-class strength of walleyes. Other species, mostly cyprinids, centrarchids, and clupeids, become important food items when yellow perch are not available (Colby et al. 1979). Cyprinids and centrachids were common in both study reservoirs, but clupeids were never observed.

The timing of forage availability between the two reservoirs could have affected the growth rate of walleyes. Young-of-the-year

Table 5. Estimated standing crops of forage fishes in the Evaporation and Holding reservoirs, Big Stone Power Plant, South Dakota, 1982, and average standing crops of those species reported by Carlander (1955).

	Evaporation Reservoir	Holding Reservoir	Carlander (1955)
Yellow Perch	0.79 kg/hectare	-	10.2 kg/hectare
Black Bullhead	0.39 kg/hectare	-	67.6 kg/hectare
Bluegill	0.03 kg/hectare	1.91 kg/hectare	47.5 kg/hectare

yellow perch were available to juvenile walleyes in the Evaporation Reservoir as forage early in the growing season of 1981. However, young-of-the-year bluegills were not available to juvenile walleyes in the Holding Reservoir until late in the growing season of 1981. Hence, walleyes in the Holding Reservoir would have had slower growth than those in the Evaporation Reservoir.

For 6 days in early May 1982, the power plant pumped water from the cooling reservoir into the Evaporation Reservoir and subsequently opened the sluiceway to allow water to pass into the Holding Reservoir. Exchange of fish between the Cooling and Evaportion reservoirs was probably low; only one orangespotted sunfish (Lepomis humilis) was captured in a 48 hour entrainment sample at a pump outflow from the cooling reservoir. Several johnny darters (Etheostoma nigrum), spottail shiners (Notropis hudsonius), and fathead minnows were observed in the outflow, but these fishes were small enough to pass through the mesh of the trap net. Wahl (1980) found that impingement of the larger fishes on the water intake screens at the Big Stone Power Plant cooling reservoir was prevalent only in the winter months when the fishes were closer to shore. The lack of large numbers of adult fish in the pump-in water suggested that this form of recruitment was negligible. No evidence was found in the recovery of marked fish to indicate fish movement between the Evaporation and Holding Reservoirs during water transfer.

Natural mortality from predation by other fish and birds probably had the greatest effect on the accuracy of the forage fish population estimates. Double-crested cormorants (Phalacrocorax auritus) were regularly observed in the Evaporation and Holding Reservoirs. The daily ration of an adult cormorant consists of approximately 700 g of fish (Nikolsky 1963). Cormorants also injure many fish that may die later. It is assumed that natural mortality was greater than recruitment during the multiple census causing the final estimate to be greater than the final population size.

Growth, Survival, and Standing Crop Estimates of Walleye

Walleyes in the Evaporation Reservoir grew significantly ($P \leq 0.05$) larger than those in the Holding Reservoir. The mean length of walleyes in the Evaporation Reservoir after one year of growth was 230 mm (0.95 C.L. 227 - 232 mm); mean length of walleyes in the Holding Reservoir was 205 mm (0.95 C.L. 203 - 208 mm). The mean weight of walleyes in the Evaporation Reservoir was 104 g (0.95 C.L. 100 - 107 g), and walleyes in the Holding Reservoir averaged 89 g (0.95 C.L. 87 - 92 g).

Optimum length gain of walleyes in both reservoirs occurred in June, July, and August, whereas optimum weight gain occurred in August, September, and October. Respective optimum growth rates for length and weight in the Evaporation Reservoir were 1.48 mm/day and 0.86 g/day. Optimum growth rates for length and weight in the deeper Holding Reservoir were 1.31 mm/day and 0.27 g/day. Walleyes grew faster in the Evaporation Reservoir than in the Holding Reservoir;

this was probably due to the availability of young-of-the-year yellow perch as forage.

First year walleye growth rates gradually increase in spring and early summer, become constant in early and mid-summer, and gradually decrease in late summer and early fall (Smith and Pycha 1960; Grinstead 1971). Usually little or no growth occurs over winter (Stroud 1949a; Kelso and Ward 1972). During the present study, walleye growth in both reservoirs tended to follow these trends (Figs. 11, 12, 13, and 14) (Appendix Tables 2 and 3). Comparison of first year walleye growth in the Big Stone Power Plant reservoirs to those of walleyes in four midwestern lakes indicated that walleyes in this study had a good growth rate (Table 6). Numerous authors have reported that abundant forage promoted high growth rates in walleyes (Stroud 1949a, 1949b; Rose 1951; Forney 1965; Miller 1967; Hofmann 1972). Although total adult forage fish standing crops were low in the Evaporation and Holding reservoirs as compared to other midwestern lakes, fathead minnows and high percentages of juvenile forage fish apparently provided an adequate food supply for good walleye growth.

Forney (1966) noted a slight increase in growth for juvenile walleyes from fall to the following spring. He attributed this to winter mortality of the smaller individuals. Small sample sizes of walleyes after ice-out in 1982 prevented a determination of winter growth. Forney (1966) suggested that by late summer, young perch may grow beyond the vulnerable size to be forage for juvenile walleyes; only the larger juveniles can feed on perch after September. For

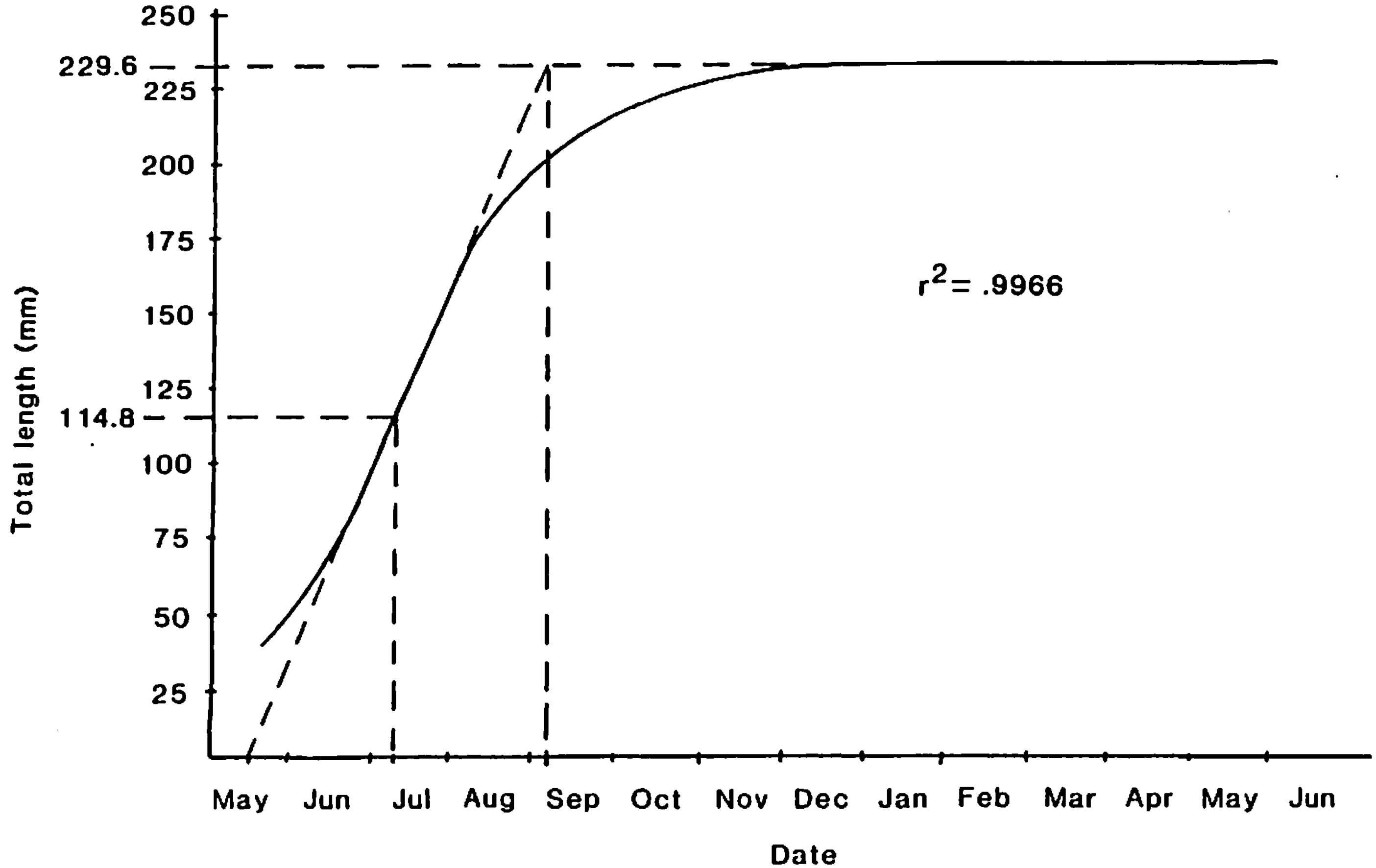

Figure 11. First year growth curve (length) for walleyes (*Stizostedion vitreum*) in the Evaporation Reservoir, Big Stone Power Plant, South Dakota, 1981-1982.

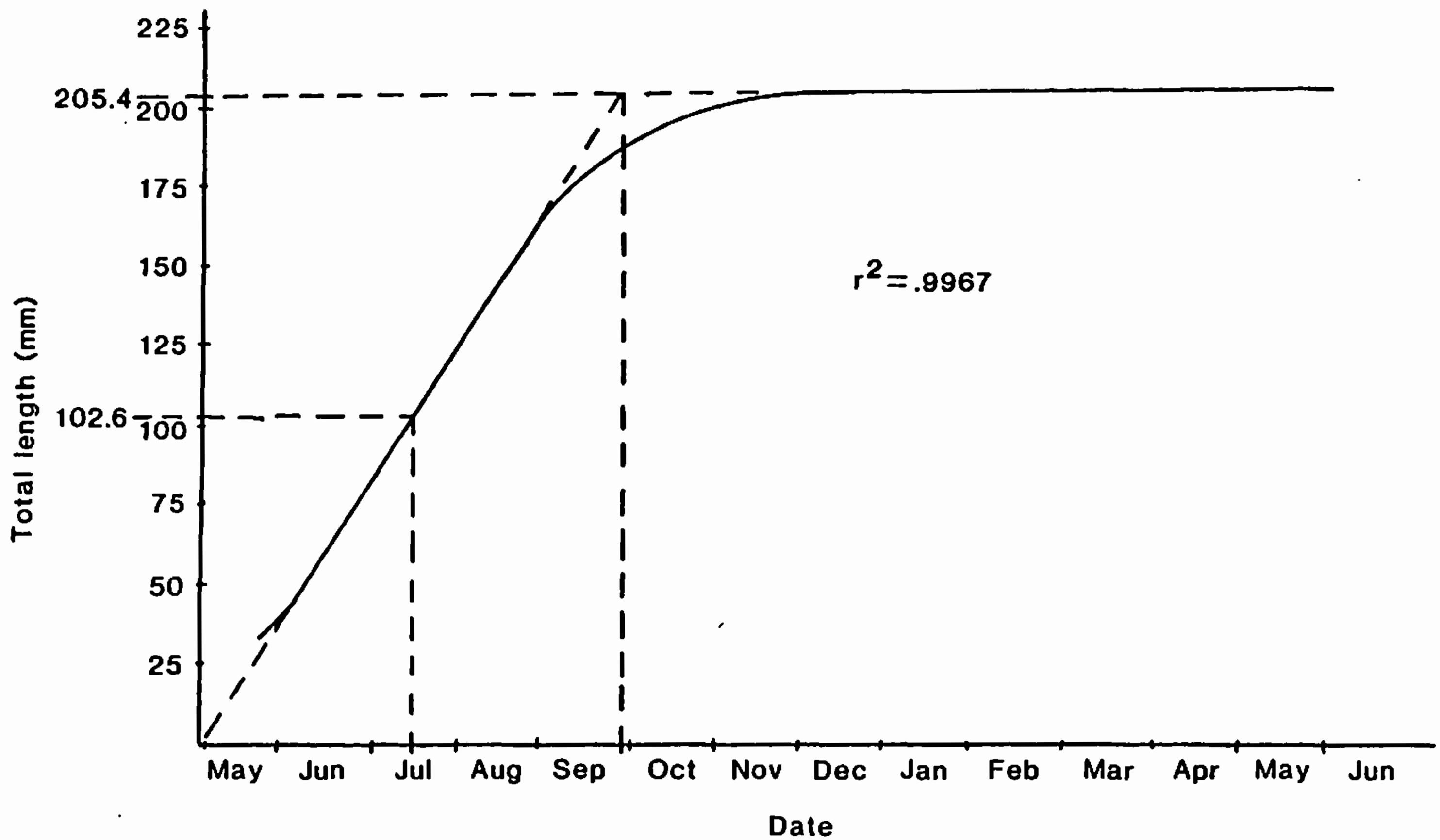

Figure 12. First year growth curve (length) for walleyes (*Stizostedion vitreum*) in the Holding Reservoir, Big Stone Power Plant, South Dakota, 1981-1982.

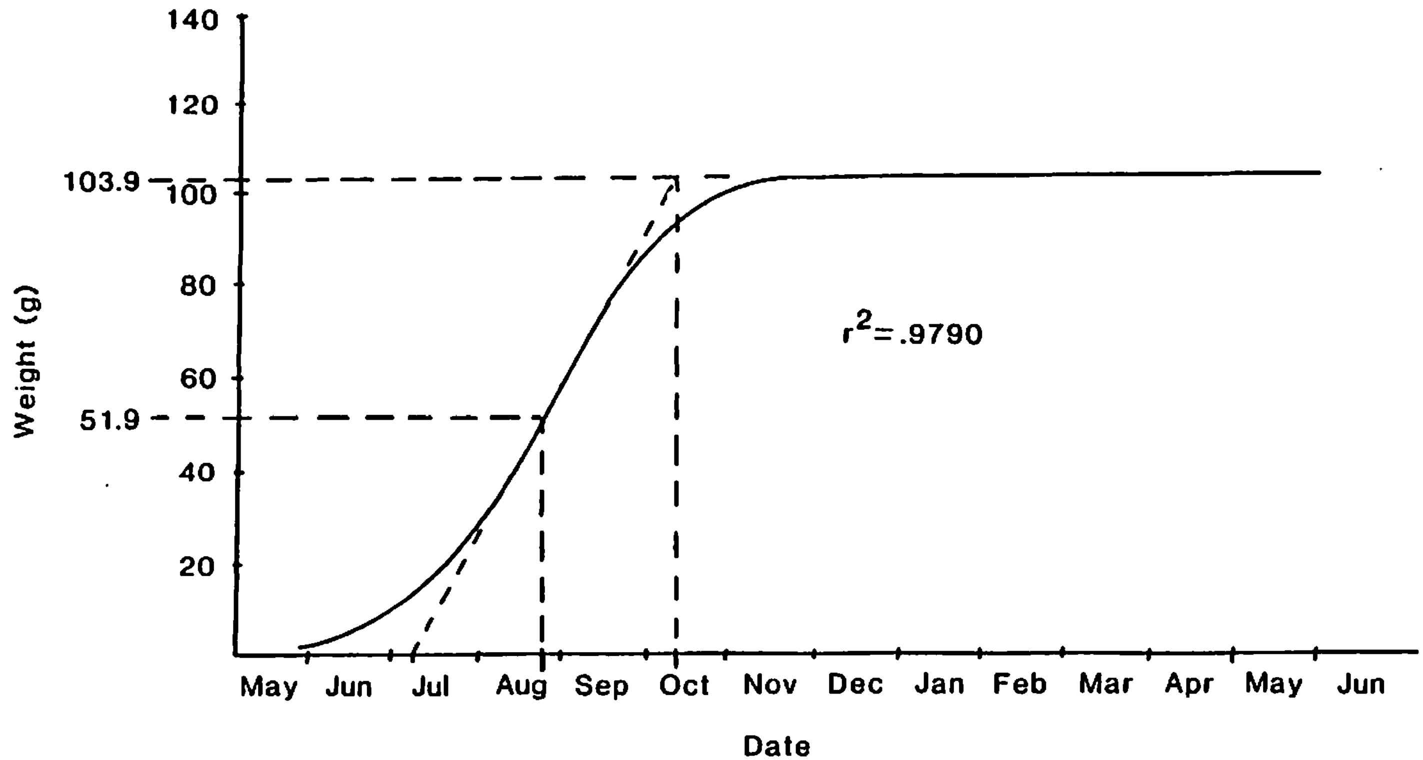

Figure 13. First year growth curve (weight) for walleyes (Stizostedion vitreum) in the Evaporation Reservoir, Big Stone Power Plant, South Dakota, 1981-1982.

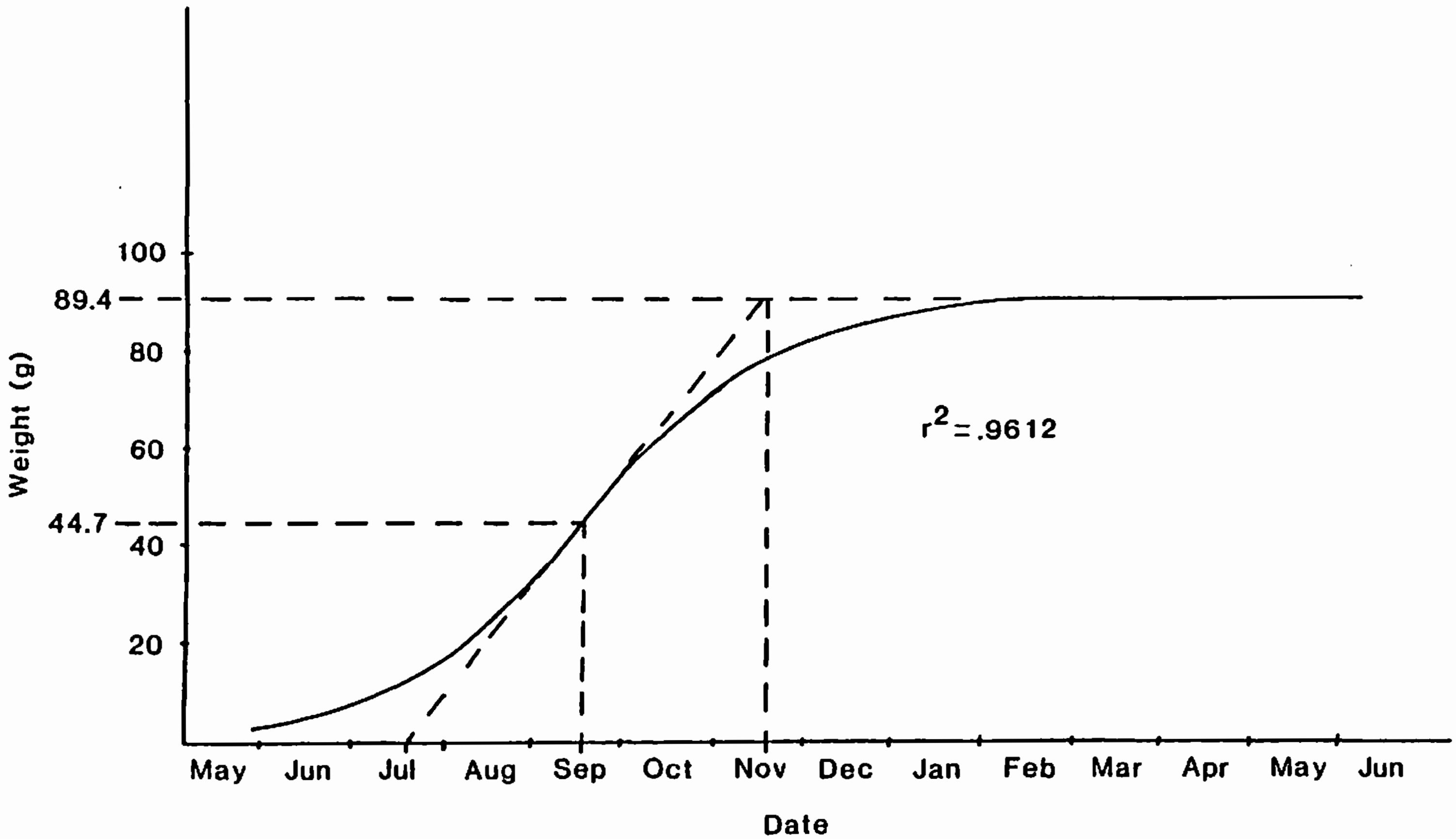

Figure 14. First year growth curve (weight) for walleyes (*Stizostedion vitreum*) in the Holding Reservoir, Big Stone Power Plant, South Dakota, 1981-1982.

Table 6. Comparable first year walleye (*Stizostedion vitreum*) growth (mm) in the Evaporation and Holding reservoirs, Big Stone Power Plant, South Dakota, 1982, and selected midwestern lakes.

Location	Walleye length
Evaporation Reservoir, South Dakota	229.6 mm
Holding Reservoir, South Dakota	205.4 mm
Clear Lake, Iowa (Carlander and Whitney 1961)	178.0 mm
Spirit Lake, Iowa (Rose 1951)	183.0 mm
Kirwin Reservoir, Kansas (Schreyer 1967)	259.0 mm
Council Grove Reservoir, Kansas (Cole and Jones 1969)	221.0 mm

this reason, Forney (1966) suggested that year-classes which grow rapidly their first year should experience lower mortality over winter than slower growing year-classes. The Evaporation Reservoir had a better walleye growth rate than in the Holding Reservoir, but also had the higher walleye mortality rate.

The final population estimate of walleyes in the Evaporation Reservoir was 110 (0.95 C.L. 70 - 214), and in the Holding Reservoir it was 569 (0.95 C.L. 445 - 754) (Appendix Tables 8 and 9). Walleye survival in the two reservoirs was 1.5% (0.95 C.L. 0.09 - 2.8%), and 17.2% (0.95 C.L. 13.5 - 22.9%), respectively. A significant difference ($P \leq 0.05$) was found in walleye survival between the two reservoirs because the confidence limits did not overlap.

Schneider (1969) found about 10% survival from walleye fingerlings (<90 mm in length) stocked at densities ranging from 37 to 408 fish/hectare. Laarman (1981) reported survival rates of 26% for walleyes stocked at lengths of 110 to 170 mm. However, Laarman (1978) also indicated that walleye stocking success was more dependent on biological and environmental conditions of individual water bodies than on size or number of fish stocked. Perhaps the most important biological conditions affecting juvenile walleye stocking success are predation and the availability of sufficient forage. Likewise, suitable habitat and water conditions would be physical factors that limit success.

The survival of stocked fish is a major problem in fisheries. Beyerle (1978) reported that poor survival of northern pike (*Esox lucius*) and walleye fingerlings was due to low forage density in some small Michigan lakes. Predator density was attributed to poor survival of tiger muskellunge (F_1 hybrid of female muskellunge (Esox masquinongy) X male northern pike) in a small Ohio pond (Stein et al. 1981). Stocked saugeye (F_1 hybrid of female walleye X male sauger (Stizostedion canadense)) in four Ohio ponds exhibited 0% survival in two ponds with predators, whereas ponds, without predators had survival rates of 31 and 81% (Lynch et al. 1982). Piscivorous birds such as gulls and cormorants can also affect fish survival. Ruggerone (1986) reported that piscivorous birds consumed as many as 562 juvenile salmonids/h below a Columbia River hydroelectric dam in Washington state. The Big Stone Power Plant reservoirs had small populations of predatory fish in addition to a nearby rookery of double-crested cormorants.

The surface area standing crop estimate of walleyes in the Evaporation Reservoir was 0.13 kg/hectare; in the Holding Reservoir it was 1.30 kg/hectare. The Evaporation Reservoir volumetric standing crop estimate was 0.05 kg/1,000 m^3; the Holding Reservoir estimate was 0.08 kg/1,000 m^3 (Table 7). A 10-fold difference was found in surface area standing crop estimates of walleyes between the two reservoirs, but little difference was detected in volumetric standing crop estimates. These data suggest that a winter carrying capacity could have limited walleye production in these reservoirs.

Walleye population density and growth were inversely related in the two reservoirs. Other authors have noted similar relationships (Carlander 1948; Dobie 1956; Carlander and Whitney 1961; Beeton 1966; Dobie 1969). Colby et al. (1979) stated that high walleye densities

Table 7. Standing crop estimates of walleyes (*Stizostedion vitreum*) in the Evaporation and Holding reservoirs, Big Stone Power Plant, South Dakota, 1982.

	Standard Standing Crop		Volumetric Standing Crop	
	Estimate	.95 C.L.	Estimate	.95 C.L.
Evaporation Reservoir	0.13 kg/hectare	0.08 - 0.22 kg/hectare	0.06 kg/1000m^3	0.04 - 0.09 kg/1000m^3
Holding Reservoir	0.33 kg/hectare	1.02 - 1.72 kg/hectare	0.08 kg/1000m^3	0.06 - 0.11 kg/1000m^3

and poor growth are indicative of a scarcity of forage, whereas lower densities and good growth are normally associated with adequate food for the entire population. The Evaporation and Holding reservoirs both seemed to have sufficient forage since walleye growth was good, but population densities, survival, and surface area standing crop estimates were very different.

The most noticable difference in environmental conditions between the two reservoirs was the difference in maximum depth and the resulting water volume beneath the ice. The slight difference in volumetric standing crops between the reservoirs suggests that water volume beneath the ice may have affected walleye population regulation in the two reservoirs. However, Colby et al. (1979) stated that ice cover was not a limiting factor in walleye populations unless winterkill conditions exist, but no data were presented to defend his statement. The effect of winter water volumes on walleye densities needs to be further investigated.

CONCLUSION

The Holding Reservoir showed the greatest potential as a rearing and holding area for walleye brood stock. Although walleye growth rates were highest in the Evaporation Reservoir, the Holding Reservoir had the largest number of potential brood fish. Also, forage abundance will increase as subsequent forage fish year-classes are recruited into the reservoir.

Winterkill can be a major threat to fisheries in the prairie pothole region. The shallower Evaporation Reservoir would likely be affected by this phenomenon as fish populations increase with reservoir age. For this reason, I believe the Evaporation Reservoir would not be a suitable area to rear and hold walleye brood stock. The deeper Holding Reservoir might be excluded from winterkill due to its depth and large water volume beneath the ice, and therefore shows potential for a brood stock rearing area.

Future management suggestions for the Big Stone Power Plant reservoirs would be to; (1) plant yearly maintenance walleye stocks into the reservoirs, (2) establish a larger population of yellow perch in the holding reservoir to serve as forage, (3) harvest fingerling walleyes from the Evaporation Reservoir each fall for stocking in recreational lakes to prevent loss due to winterkill, and (4) determine the maximum standing crop possible of egg producing walleyes so the state will know what to expect for egg production from these lakes.

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APPENDIX

Appendix Table 1. Maximum depth (m) of the Evaporation and Holding reservoirs, Big Stone Power Plant, South Dakota, August 1981 to May 1982.

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Evaporation Reservoir	2.5	2.4	2.3	2.1	2.1	2.1	2.1	2.6	2.6	2.5
Holding Reservoir	4.8	4.8	5.9	5.8	5.8	5.8	5.8	7.1	7.1	7.0

Appendix Table 2. Walleye (Stizostedion vitreum) growth data, ranges, and sample sizes for daily catches in the Evaporation Reservoir, Big Stone Power Plant, South Dakota, 3 July 1981 to 27 May 1982.

Date	$\bar{x}$ (mm)	Range (mm)	$\bar{x}$ (g)	Range (g)	N
3 July	94	---	8	---	1
7 July	106	89 - 114	11	10 - 15	10
10 July	113	99 - 127	14	10 - 20	27
13 July	122	118 - 124	16	14 - 19	6
16 July	122	112 - 133	17	12 - 24	14
19 July	125	111 - 145	19	10 - 25	22
22 July	128	89 - 155	18	9 - 30	25
25 July	133	121 - 160	20	14 - 38	10
28 July	143	137 - 147	30	18 - 23	4
31 July	141	133 - 145	25	20 - 30	6
31 August	199	184 - 212	61	50 - 79	9
5 October	221	209 - 244	93	79 - 122	26
2 November	224	215 - 246	94	77 - 130	37
19 May	228	222 - 233	109	94 - 130	4
21 May	228	220 - 235	103	95 - 110	2
25 May	235	---	110	---	1
27 May	231	192 - 252	107	60 - 138	4
				Total	207

Appendix Table 3. Walleye (Stizostedion vitreum) growth data, ranges, and sample sizes for daily catches in the Holding Reservoir, Big Stone Power Plant, South Dakota, 3 August 1981 to 29 May 1982.

Date	$\bar{x}$ (mm)	Range (mm)	$\bar{x}$ (g)	Range (g)	N
3 August	138	128 - 147	19	14 - 24	31
4 August	139	133 - 143	21	19 - 24	3
6 August	142	132 - 155	21	17 - 30	23
9 August	148	135 - 157	23	18 - 26	12
12 August	148	135 - 158	22	18 - 26	9
15 August	151	139 - 165	24	18 - 34	53
18 August	155	140 - 168	26	19 - 42	49
20 August	160	158 - 161	31	30 - 32	2
31 August	178	160 - 200	38	30 - 52	8
5 October	195	---	50	---	1
11 October	207	203 - 213	68	65 - 70	3
2 November	197	189 - 206	43	40 - 50	7
6 May	216	196 - 232	79	65 - 100	5
19 May	207	203 - 210	85	80 - 90	2
23 May	209	---	79	---	1
25 May	207	184 - 246	86	55 - 135	13
27 May	208	195 - 245	87	70 - 130	6
29 May	201	182 - 230	98	80 - 130	20
				Total	248

Appendix Table 4. Mark and recapture data, population estimates, and confidence limits for yellow perch (<u>Perca flavescens</u>) in the Big Stone Power Plant Evaporation Reservoir, South Dakota, 19 May to 12 July 1982.

Date	Total Caught (Ct)	Recaptures (R)	Marked fish at large (Mt)	Ct Mt	Population estimate (N)	.95 C.L.
5/19/82	4	-	-	-	-	
5/21/82	4	0	4	16	-	
5/23/82	2	0	8	16	-	
5/25/82	3	0	10	30	-	
5/27/82	7	0	13	91	-	
5/29/82	12	0	20	240	-	
5/31/82	0	0	32	0	-	
6/02/82	13	0	32	416	-	
6/04/82	33	0	45	1,485	-	
6/06/82	0	0	78	0	-	
6/08/82	2	0	78	156	-	
6/10/82	8	0	79	632	-	
6/12/82	2	0	83	166	-	
6/14/82	10	0	85	850	-	
6/15/82	5	1	89	445	2,271	678 - 4,130
6/16/82	8	0	94	752	2,647	790 - 4,814
6/17/82	5	0	99	495	2,895	864 - 5,264
6/19/82	6	0	104	624	3,207	957 - 5,831
6/21/82	2	1	110	220	2,211	799 - 4,422

Appendix Table 4. (continued)

Date	Total Caught (Ct)	Recaptures (R)	Marked fish at large (Mt)	Ct Mt	Population estimate (N)	.95 C.L.
6/23/82	6	1	111	666	1,825	745 - 3,650
6/25/82	11	1	116	1,276	1,715	759 - 3,430
6/28/82	16	2	126	2,016	1,513	751 - 2,863
6/30/82	11	0	133	1,463	1,722	855 - 3,258
7/02/82	17	2	144	2,448	1,611	863 - 2,901
7/07/82	0	0	155	0	1,611	863 - 2,901
7/09/82	5	2	155	755	1,389	787 - 2,387
7/12/82	6	1	158	948	1,352	784 - 2,285

Appendix Table 5. Mark and recapture data, population estimates, and confidence limits for black bullheads (*Ictalurus melas*) in the Big Stone Power Plant Evaporation Reservoir, South Dakota, 19 May to 12 July 1982.

Date	Total Caught (Ct)	Recaptures (R)	Marked fish at large (Mt)	Ct Mt	Population estimate (N)	.95 C.L.
5/19/82	2	-	-	-	-	
5/21/82	2	0	2	4	-	
5/23/82	4	0	4	16	-	
5/25/82	1	0	8	8	-	
5/27/82	3	0	9	27	-	
5/29/82	4	1	12	48	51	15 - 94
5/31/82	0	0	15	0	51	15 - 94
6/02/82	7	3	15	105	42	18 - 83
6/04/82	6	2	19	114	46	23 - 87
6/06/82	0	0	23	0	46	23 - 87
6/08/82	1	1	23	23	43	22 - 78
6/10/82	4	3	23	92	40	22 - 68
6/12/82	5	2	24	120	43	25 - 71
6/14/82	8	0	27	216	59	35 - 99
6/15/82	3	0	36	108	68	40 - 113
6/16/82	7	4	39	273	68	44 - 107
6/17/82	3	0	42	126	75	49 - 118
6/19/82	3	0	45	135	83	54 - 113
6/21/82	2	0	48	96	89	58 - 140

Appendix Table 5. (continued)

Date	Total Caught (Ct)	Recaptures (R)	Marked fish at large (Mt)	Ct Mt	Population estimate (N)	.95 C.L.
6/23/82	6	2	50	300	95	61 - 146
6/25/82	8	3	54	432	102	68 - 152
6/28/82	15	4	59	885	120	82 - 175
6/30/82	8	1	67	536	136	94 - 196
7/02/82	10	3	74	740	147	103 - 208
7/07/82	4	1	81	324	152	108 - 215
7/09/82	26	2	84	2,184	209	150 - 292
7/12/82	36	4	107	3,852	291	212 - 399

Appendix Table 6. Mark and recapture data, population estimates, and confidence limits for bluegills (*Lepomis macrochirus*) in the Big Stone Power Plant Evaporation Reservoir, South Dakota, 19 May to 12 July 1982.

Date	Total Caught (Ct)	Recaptures (R)	Marked fish at large (Mt)	Ct Mt	Population estimate (N)	.95 C.L.
5/19/82	4	-	-	-	-	
5/21/82	1	0	4	4	-	
5/23/82	4	1	5	20	12	4 - 22
5/25/82	7	1	8	56	27	10 - 53
5/27/82	1	0	14	14	31	11 - 63
5/29/82	9	0	15	135	76	27 - 153
5/31/82	0	0	24	0	76	27 - 153
6/02/82	9	2	24	216	89	39 - 178
6/04/82	7	6	31	217	60	34 - 103
6/06/82	0	0	32	0	60	34 - 103
6/08/82	1	1	32	32	58	33 - 98
6/10/82	1	1	32	32	56	33 - 93
6/12/82	10	4	32	320	61	40 - 97
6/14/82	11	2	38	418	77	50 - 118
6/15/82	1	0	47	47	79	51 - 122
6/16/82	1	1	48	48	78	51 - 118
6/17/82	1	1	48	48	76	50 - 116
6/19/82	3	1	48	144	79	53 - 119
6/21/82	8	5	50	400	80	55 - 115

Appendix Table 6. (continued)

Date	Total Caught (Ct)	Recaptures (R)	Marked fish at large (Mt)	Ct Mt	Population estimate (N)	.95 C.L.
6/23/82	10	2	53	530	92	65 - 131
6/25/82	2	1	58	116	93	66 - 132
6/28/82	5	2	59	295	100	71 - 140
6/30/82	0	0	62	0	100	71 - 140
7/02/82	3	0	62	186	106	75 - 149
7/07/82	1	0	65	65	108	76 - 152
7/09/82	0	0	66	0	108	76 - 152
7/12/82	1	1	66	66	106	78 - 155

Appendix Table 7. Mark and recapture data, population estimates, and confidence limits for bluegills (Lepomis macrochirus) in the Big Stone Power Plant Holding Reservoir, South Dakota, 6 May to 12 July 1982.

Date	Total Caught (Ct)	Recaptures (R)	Marked fish at large (Mt)	Ct Mt	Population estimate (N)	.95 C.L.
5/06/82	0	-	-	-		
5/19/82	1	0	0	0	-	
5/21/82	0	0	1	0	-	
5/23/82	0	0	1	0	-	
5/25/82	2	0	1	2	-	
5/27/82	4	0	3	12	-	
5/29/82	2	0	7	14	-	
5/31/82	0	0	9	0	-	
6/02/82	0	0	9	0	-	
6/04/82	7	0	9	63	-	
6/06/82	2	0	16	32	-	
6/08/82	3	0	16	48	-	
6/10/82	8	0	19	152	-	
6/12/82	98	0	27	2,646	-	
6/14/82	26	0	124	3,224	-	
6/15/82	5	2	150	750	2,314	846 - 5,785
6/16/82	132	4	153	20,196	3,877	1,926 - 7,335
6/17/82	33	2	279	9,207	4,038	2,163 - 7,269

Appendix Table 7. (continued)

Date	Total Caught (Ct)	Recaptures (R)	Marked fish at large (Mt)	Ct Mt	Population estimate (N)	.95 C.L.
6/19/82	3	0	310	930	4,141	2,219 - 7,455
6/21/82	1	0	313	313	4,176	2,237 - 8,542
6/23/82	21	1	313	6,573	4,416	2,439 - 7,748
6/25/82	2	0	332	664	4,483	2,477 - 7,864
6/28/82	143	3	333	47,619	7,111	4,217 - 11,672
6/30/82	5	0	471	2,355	7,292	4,325 - 11,970
7/02/82	0	0	473	0	7,292	4,325 - 11,970
7/07/82	16	1	473	7,568	7,312	4,412 - 11,903
7/09/82	0	0	488	0	7,312	4,412 - 11,903
7/12/82	0	0	488	0	7,312	4,412 - 11,903

Appendix Table 8. Mark and recapture data, population estimates, and confidence limits for walleyes (<u>Stizostedion vitreum</u>) in the Big Stone Power Plant Evaporation Reservoir, South Dakota, 19 May to 12 July 1982.

Date	Total Caught (Ct)	Recaptures (R)	Marked fish at large (Mt)	Ct Mt	Population estimate (N)	.95 C.L.
5/19/82	4	-	-	-	-	
5/21/82	2	0	4	8	-	
5/23/82	0	0	6	0	-	
5/25/82	1	0	6	6	-	
5/27/82	3	0	7	21	-	
5/29/82	1	0	10	10	-	
5/31/82	0	0	11	0	-	
6/02/82	6	1	11	66	55	16 - 101
6/04/82	5	0	16	80	95	28 - 174
6/06/82	1	1	21	21	71	25 - 141
6/08/82	0	0	22	0	71	25 - 141
6/10/82	4	0	22	88	100	36 - 200
6/12/82	4	1	23	92	98	40 - 196
6/14/82	3	1	26	78	94	41 - 188
6/15/82	0	0	27	0	94	41 - 188
6/16/82	0	0	27	0	94	41 - 188
6/17/82	2	1	27	54	87	41 - 169
6/19/82	2	0	28	56	97	46 - 187
6/21/82	1	0	30	30	102	48 - 197

Appendix Table 8. (continued)

Date	Total Caught (Ct)	Recaptures (R)	Marked fish at large (Mt)	Ct Mt	Population estimate (N)	.95 C.L.
6/23/82	1	0	31	31	107	50 - 207
6/25/82	1	1	32	32	96	48 - 182
6/28/82	3	1	33	99	96	50 - 175
6/30/82	4	1	34	136	101	54 - 182
7/02/82	8	3	37	296	100	58 - 169
7/07/82	3	0	42	126	111	64 - 187
7/09/82	1	0	45	45	114	66 - 194
7/12/82	6	3	46	276	110	67 - 177

Appendix Table 9. Mark and recapture data, population estimates, and confidence limits for walleyes (*Stizostedion vitreum*) in the Big Stone Power Plant Holding Reservoir, South Dakota, 6 May to 12 July 1982.

Date	Total Caught (Ct)	Recaptures (R)	Marked fish at large (Mt)	Ct Mt	Population estimate (N)	.95 C.L.
5/06/82	5	-	-	-	-	
5/19/82	2	0	5	10	-	
5/21/82	0	0	7	0	-	
5/23/82	1	0	7	7	-	
5/25/82	13	0	7	91	-	
5/27/82	6	1	20	120	-	
5/29/82	20	1	24	480	-	
5/31/82	18	2	43	774	296	131 - 593
6/02/82	57	6	59	4,161	513	291 - 882
6/04/82	40	10	108	4,320	474	312 - 717
6/06/82	9	5	136	1,224	430	295 - 625
6/08/82	12	2	137	1,644	458	318 - 665
6/10/82	27	4	147	3,969	525	373 - 737
6/12/82	2	0	149	596	544	386 - 763
6/14/82	6	2	151	906	538	387 - 747
6/15/82	1	0	154	154	543	390 - 753
6/16/82	0	0	154	0	543	390 - 753
6/17/82	2	0	154	308	552	397 - 766
6/19/82	0	0	156	0	552	397 - 766

Appendix Table 9. (continued)

Date	Total Caught (Ct)	Recaptures (R)	Marked fish at large (Mt)	Ct Mt	Population estimate (N)	.95 C.L.
6/21/82	5	1	156	780	558	401 - 775
6/23/82	8	4	159	1,272	534	391 - 725
6/25/82	2	1	163	326	528	389 - 717
6/28/82	11	1	163	1,793	559	413 - 754
6/30/82	2	1	173	346	554	411 - 746
7/02/82	5	1	174	870	562	418 - 752
7/07/82	1	0	178	178	566	421 - 758
7/09/82	11	4	179	1,969	559	421 - 741
7/12/82	30	8	186	5,580	580	446 - 752