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Evaluation of a Power Plant Reservoir As A Holding Area For Paddlefish Brood Stock

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EVALUATION OF A POWER PLANT RESERVOIR AS A HOLDING AREA FOR PADDLEFISH BROOD STOCK

BY

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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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EVALUATION OF A POWER PLANT RESERVOIR AS A

HOLDING AREA FOR PADDLEFISH BROOD STOCK

Abstract

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Twenty paddlefish (Polyodon spathula) released into the Big Stone Power Plant boiler make-up reservoir were monitored to determine growth, condition, and food habits. In addition, fish and zooplankton populations were sampled and chemical and physical parameters measured to determine the potential of the reservoir as a holding area for paddlefish brood stock.

Paddlefish captured during the first year after their release into the boiler make-up reservoir averaged 2.2 kg body weight increases and 59 mm eye-fork length increases. Condition factors of captured paddlefish also increased during this period from 1.26 to 1.49.

Paddlefish food in the reservoir consisted almost entirely of crustacean zooplankton. Cyclopoid copepods were the most abundant food item found in stomachs sampled, making up over 60% of the total food organisms consumed by numbers. Volumes of food in paddlefish stomachs sampled ranged from 0 to 90 ml. Feeding activity was greatest during April, May, and July. Feeding occurred at lower levels or ceased during June, August, September, October, and November.

Cyclopoid copepods had the highest mean selectivity index and Diaptomus spp. the lowest mean selectivity index. Mean selectivity values of other food items were all near 0, indicating that paddlefish had no preference for or against them.

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INTRODUCTION

The construction of a series of dams on the Missouri River in South Dakota transformed much of the river into a series of large reservoirs. Paddlefish (*Polyodon spathula*) require a swift current with a rock or gravel substrate to spawn successfully (Purkett 1961). Closure of dams and resultant reservoir formation eliminated habitat necessary for paddlefish reproduction in many areas of the Missouri River in South Dakota. Lake Francis Case and Lake Sharpe inundated the original river channel and no natural river habitat remains. Lack of suitable spawning habitat and the absence of young paddlefish have indicated that artificial propagation and stocking is necessary to maintain paddlefish populations in these areas (Friberg 1972). Artificial propagation of paddlefish in South Dakota began in 1972 by South Dakota Department of Game, Fish and Parks personnel. Production of fry and fingerlings was moderately successful by 1978 (Unkenholz 1979), but by 1981 brood fish were difficult to obtain and artificial propagation ceased.

The objective of the present study was to evaluate a power plant reservoir as an area to rear and maintain paddlefish brood stock so that artificial propagation may be continued in South Dakota.

Fifteen species of fish, excluding paddlefish, were sampled in the boiler make-up reservoir. Orangespotted sunfish (*Lepomis humilis*), black bullhead (*Ictalurus melas*), and yellow perch (*Perca flavescens*) were the most abundant species sampled (estimated standing crop, 45.2 kg/ha).

Zooplankton numbers were greatest during the spring and fall. Cyclopoid copepods, *Bosmina longirostris*, and *Diaptomus* spp. accounted for the majority of zooplankters throughout the year.

Monthly water temperatures were greatest during July (mean, 23.4 C). Dissolved oxygen levels were lowest during August (mean, 7.6 mg/l). Mean values for other parameters monitored were total hardness (349 mg/l), total alkalinity (129 mg/l), pH (8.4), and conductivity (835 μmhos/cm).

STUDY AREA

Big Stone Power Plant, located in northeastern South Dakota (Grant County), is owned jointly by Montana-Dakota Utilities Company, Northwestern Public Service Company, and Otter Tail Power Company. The Big Stone Power Plant, a coal-fired 440 MW steam electric generating facility, began operation in 1975.

The Big Stone Power Plant boiler make-up reservoir has a surface area of 3.4 ha, a maximum depth of 4 m, and a mean depth of 1.4 m at a water level of 341.8 m above mean sea level (msl) (Fig. 1). Water levels fluctuated throughout the study from 339.5 m above msl to 343 m above msl. Water was withdrawn from the reservoir by the power plant and additional water was pumped into the reservoir from Big Stone Lake on the South Dakota - Minnesota border; refilling of the reservoir occurred in spring and fall.

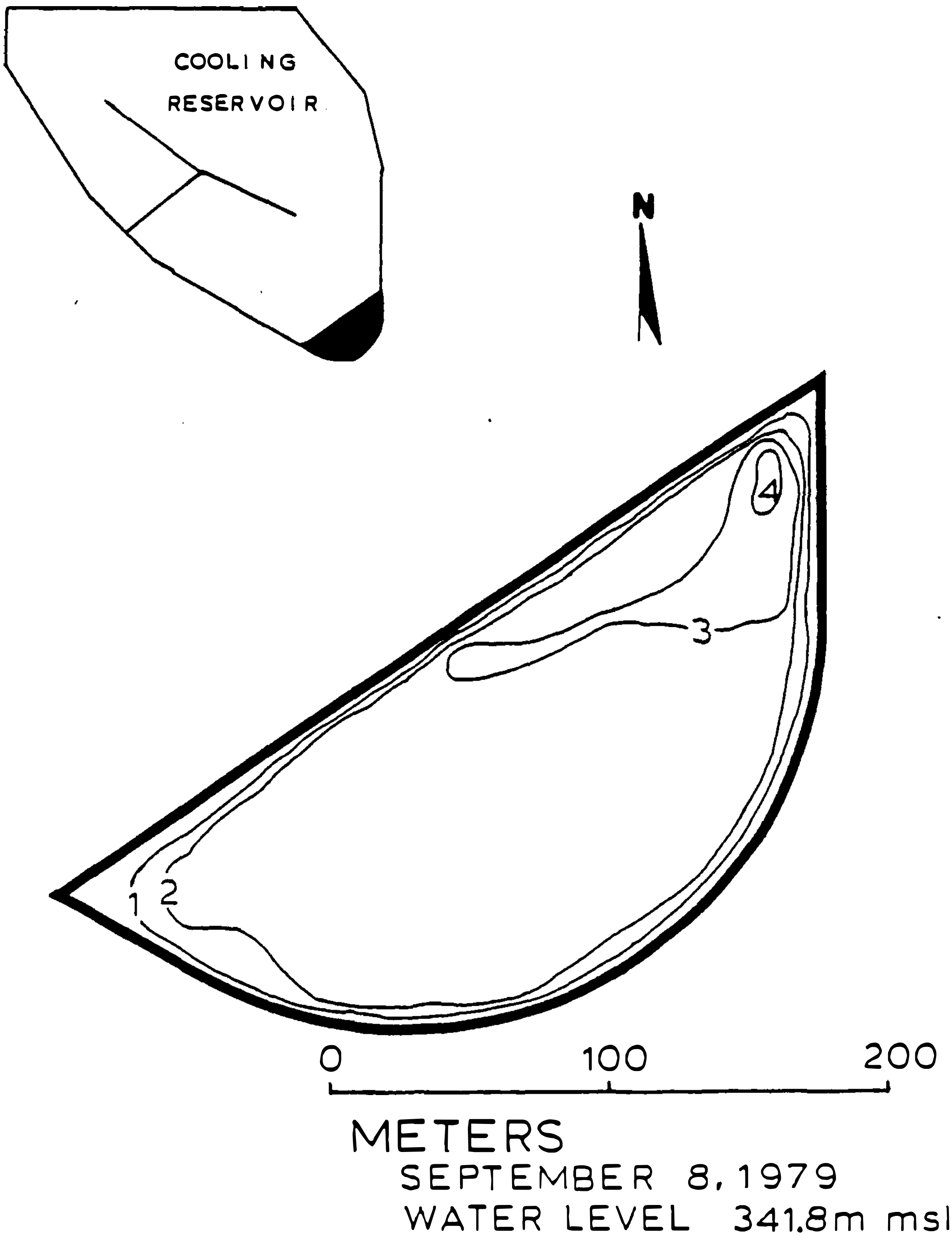

Figure 1. Big Stone Power Plant boiler make-up reservoir, South Dakota, 8 September 1979.

MATERIALS AND METHODS

Twenty paddlefish (540-840 mm eye-fork length, 2.0 - 7.6 kg) captured from the Missouri River below Gavins Point Dam, were individually marked and released in the Big Stone Power Plant boiler make-up reservoir on 15 December 1978. The paddlefish were recaptured from June 1979 to December 1980. Survival, growth, and condition factors were determined from fish collected from June 1979 through November 1979 and a food habits study was conducted from April 1980 through November 1980.

Paddlefish were captured with gill nets (7.6, 10.1, 12.7 cm mesh). Fish were chased into nets with a boat and immediately removed after entanglement. Weight was taken to the nearest 0.1 kg and length (distance from anterior orbit of the eye to the fork in the tail) measured to the nearest 1 mm. Organisms ingested by the fish were obtained by flushing the stomachs with a pulsed gastric lavage (Foster 1977). The fish were then treated with terramycin and returned to the reservoir. Stomach contents were later placed in a circular plankton counting chamber and analyzed under a multipower stereomicroscope; organisms were identified to species or genus. Volumetric measures of stomach contents were made by water displacement.

Zooplankton samples were taken weekly during periods of open water, by making oblique tows with a metered Miller sampler (Miller 1961) and every two weeks during ice cover, with a water core plankton sampler (Applegate et al. 1968). Both sampling devices were equipped with a No. 10 nylon net. Samples were preserved in Lugol's solution and diluted to fixed volumes. Three 1 ml subsamples from each sample were counted in a circular plankton counting chamber.

Selection by paddlefish for available food organisms was determined by use of a linear index of food selection (Strauss 1979). The linear index of food selection is calculated by the formula:

$$L = r_i - p_i$$

where L is the index of food selection, r_i is the relative abundance of prey item $_i$ in the gut (expressed as a percentage by number of total gut contents) and p_i the relative abundance of the same prey item in the environment (expressed as a percentage of total numbers of organisms in the environment). L values range from -1 to +1, with positive values indicating preference and negative values indicating avoidance of a particular prey item. Random feeding would result in a value of zero.

Condition factors (K) were determined from length and weight data by the formula:

$$K = \frac{W10^5}{L^3} \qquad \text{(Carlander 1977)}$$

where W is weight in grams, and L is length in millimeters.

A mark and recapture population estimate of existing fish other than paddlefish was conducted during an 8-day period (10 July - 17 July 1980). Fish were captured with single lead, South Dakota trap nets (2.54 cm stretched mesh) and a 240-volt alternating current (A.C.) eletrofishing boat.

Four trap nets were placed in the reservoir and examined every 24 hours. After four days the nets were moved to different areas to distribute fishing effort. Electrofishing was conducted every 24 hours along the entire shoreline. This process took 30 minutes each day. Age-group I and older fish were measured, marked by fin clipping the right pelvic fin, and released into the center of the reservoir. Weights were taken from various length-groups to estimate standing crop.

Population estimates were derived using the modified Schnabel equation, which is a multiple census formula. The equation:

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

was used, where

$\hat{N}$ = estimate of population

C_t = total sample taken on day t

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

R = total recaptures during the experiment

Estimates derived from the equation are asymetrically distributed. Confidence limits were calculated by treating the number of recaptures as a Poisson variable. Confidence intervals were computed from:

$$\Sigma\ R + 1.92 \pm 1.96\sqrt{\Sigma\ R + 1.0} \qquad \text{(Ricker 1975)}$$

at the 0.95 level and substituted for the sum of recaptures in the modified Schnabel equation.

Water analysis was conducted every two weeks during the period of open water and once a month during ice cover. Water temperatures and conductivities were measured with a YSI model 33 S-C-T meter. Conductivity readings were standardized and reported at 25 C. Water samples were collected with a Van Dorn sampler at the water surface, bottom, and mid-depth. Dissolved oxygen was determined using the azide modification of the Winkler method. A Hellige glass comparator was used to obtain pH values. Total hardness, calcium hardness, alkalinity, and chloride were measured using a HACH water analysis kit. Nitrate (N), total Kjeldahl nitrogen, phosphate (ortho and total), sulfate, potassium, and sodium were determined every three months by procedures outlined by the American Public Health Association (1971). Secchi disc visibility was used to determine water transparency.

RESULTS AND DISCUSSION

Paddlefish Growth, Condition, and Food

Over the first year, 17 (85%) of the 20 paddlefish were recaptured. Recaptured paddlefish had increased an average of 2.2 kg in body weight and 59 mm in length (Table 1). Individual weight and length increases ranged from 1.2 to 3.9 kg and 0 to 122 mm, respectively. Smaller paddlefish (< 625 mm) increased more in length and had a greater percentage increase in body weight. One paddlefish, 585 mm and 2.5 kg, increased to 705 mm and 5.5 kg from 15 December 1978 to 1 November 1979. This represented a 20% increase in length and a 120% increase in body weight.

The average condition factor (K) for paddlefish increased from 1.26 to 1.49 from December 1978 to December 1979. Improved K values were observed for all paddlefish sampled. Increase in K values was a result of seasonal feeding activities. Rosen (1976) found paddlefish feeding activity at low levels during winter months and peak feeding in spring, early summer, and fall. Seasonal trends in feeding corresponded to seasonal K values in the study by Rosen (1976). Over 80% of weight gained by paddlefish in the present study was observed in fish captured prior to fall sampling. Paddlefish captured during the spring or summer and recaptured again during fall or early winter sampling increased their body weight by only 17%.

Table 1. Growth of recaptured paddlefish (*Polyodon spathula*), Big Stone Power Plant boiler make-up reservoir, South Dakota, December 1978 to December 1979.

December 1978		December 1979		Increase	
Length (mm)	Weight (kg)	Length (mm)	Weight (kg)	Length (mm)	Weight (kg)
540	2.0	635	3.3	95	1.3
585	2.5	705	5.5	120	3.0
590	2.7	641	4.2	51	1.5
595	2.6	717	5.3	122	2.7
610	2.9	724	5.0	114	2.1
625	3.0	660	4.6	35	1.6
680	3.7	737	5.8	57	2.1
720	5.3	775	7.4	55	2.1
725	4.4	725	5.6	0	1.2
750	5.5	768	8.2	18	2.7
750	5.4	800	7.4	50	2.0
775	6.3	813	7.8	38	1.5
800	6.2	846	8.2	46	2.0
800	6.2	832	8.9	32	2.7
810	6.7	857	9.1	47	2.4
840	7.2	902	10.2	62	3.0
840	7.6	902	11.5	62	3.9
			MEAN INCREASE	59	2.2

Rosen (1976) and Shields (1956) calculated average K values of 1.47 and 1.26, respectively, from paddlefish captured in the Missouri River. Meyer (1960) reported an average K value of 1.34 from Mississippi River paddlefish. Male and female paddlefish from the Osage River in Missouri had K values of 1.75 and 2.14, respectively (Russell 1972). The high K value for female paddlefish reported by Russell (1972) was a result of heavy egg masses.

Food of paddlefish in the boiler make-up reservoir consisted almost entirely of crustacean zooplankton. Cyclopoid copepods, *Bosmina longirostris*, and *Diaptomus* spp. made up 91.3% of the food injested by numbers. Cyclopoid copepods were the most abundant food item making up 60.3%, while *B. longirostris* and *Diaptomus* spp. made up 21.7% and 9.3%, respectively. *Diaphanosoma brachyurum*, *Daphnia pulex*, Chydorinae, *Macrothrix laticornis*, *Leptodora kindtii*, Ostracoda, Harpacticoda, Arachnida, and Chironomidae composed the remainder of food items.

The volume of food consumed by paddlefish ranged from 0 to 90 ml. Rosen and Hales (1981) reported volumes of material found in paddlefish stomachs from the Missouri River to range from 0 to 340 ml, however sand and detritus accounted for up to 78% of that volume. Stomach fullness of paddlefish captured on the same day were generally similar. When one stomach sample indicated little or no feeding, all stomachs sampled contained little or no food. Body weight of paddlefish did not necessarily dictate the amount of food its stomach contained, as smaller paddlefish occasionally contained a greater volume of food than larger paddlefish sampled on the same day. Rosen and Hales (1981) found stomach fullness for paddlefish sampled on the same day and in the same area to be similar.

Seasonal fluctuations in feeding were evident. The quantity of food in stomachs indicated feeding activity was greatest during April, May, and July, and lowest during June, August, September, October, and November (Fig. 2). Maximum feeding was observed during May when volumes of food in stomachs averaged 34.1 ml. Rosen and Hales (1981) suggested water temperature and food supply as possible explanations for seasonal feeding trends in paddlefish. Rosen and Hales (1981) reported optimum feeding at water temperatures of 7 - 20 C, and peaks in feeding coinciding with peaks in the abundance of zooplankton. Average water temperatures in the present study during peak feeding months (April, May, and July) were 8.7, 14.4, and 21.8 C. Water temperatures in months when feeding occurred at lower levels (June and August) were 19.6 C. Water temperatures in September, October, and November when feeding had ceased (< 1 ml food/stomach) were 13.0, 9.4, and 3.2 C, respectively. Zooplankton numbers were most abundant during April, July (high feeding periods), and August (low feeding period); zooplankton numbers were low during May (high feeding period), June, September, October, and November (low feeding periods). Water levels in the present study may also provide some explanation for lack of feeding during the months of August and September. Water levels were lowered in the boiler make-up reservoir during August and September. During this period maximum water depth averaged 1 m and was < 1 m for a short period in September. The low water levels observed during this period may have caused paddlefish to cease feeding.

Cyclopoid copepods were the most preferred food item with a mean selectivity value of +0.21; Diaptomus spp. was least selected with a value of -0.21 (Fig. 3). Langord (1953) demonstrated that Diaptomus avoids capture by plankton pumps whereas cyclopoid copepods are positively selected. Starostka and Applegate (1970) found that feeding efficiency of the bigmouth buffalo to be similar to that of a plankton pump for capturing copepods and even though calanoid copepods (Diaptomus) may constitute a major portion of the plankton they may be of limited value as forage. The same occurrence may also hold true for paddlefish feeding. Other food items occurring in stomachs had mean selectivity values near zero, indicating no preference by paddlefish for or against them. Periods when food intake was highest (April, May, and July) food selection values were all near 0 (Table 2).

Three paddlefish were sacrificed to determine the efficiency of the pulsed gastric lavage. Two fish were sampled in July, when stomach samples indicated active feeding, and one in November when stomachs sampled contained little or no food. Over 90% of the stomach contents by volume were successfully removed from the fish in July, whereas 75% of the stomach contents were effectivly removed by the lavage in the November trial. Rosen (1976) found feeding paddlefish to have highly expanded, thin walled, and flaccid pyloric caeca and spiral valve intestines. Fish which had not fed recently or

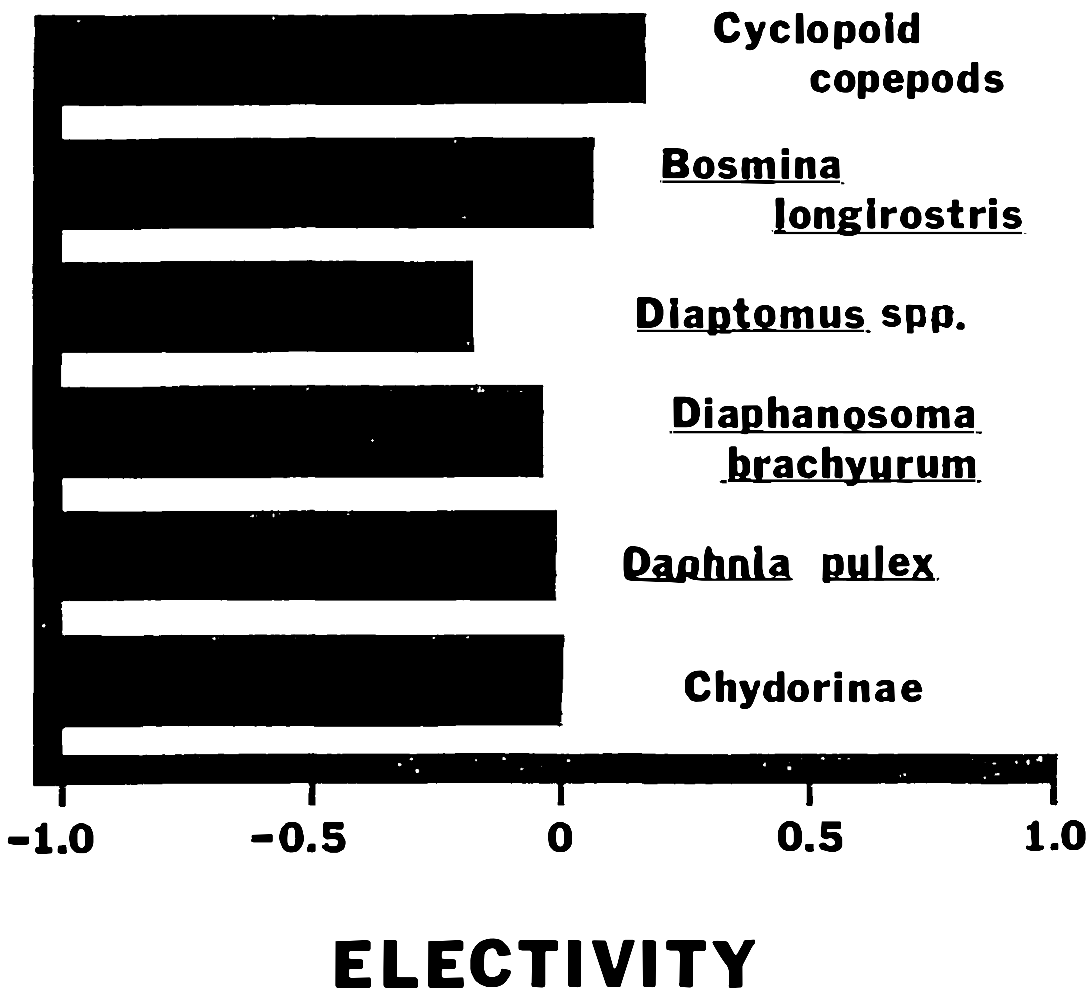

Figure 3. Mean selectivity indices of organisms consumed by paddlefish (*Polyodon spathula*), Big Stone Power Plant boiler make-up reservoir, South Dakota, 1980.

Table 2. Mean number of organisms per liter in environment, mean percent number in stomach (in parentheses), and selectivity indices for organisms consumed by paddlefish (*Polyodon spathula*) from Big Stone Power Plant boiler make-up reservoir, South Dakota, 1980.

Food Item	April	May	June	July	August	September	October	November
Cyclopoid copepods	34.1	33.1	12.3	20.4	17.7	3.4	0.2	0.3
	(89.5)	(90.3)	(41.7)	(43.7)	(17.8)	(0.0)	(44.0)	(95.1)
	- .01	+ .03	+ .02	+ .12	- .01	a	+ .42	+ .88
Bosmina longirostris	-	0.1	5.2	23.9	52.2	6.7	3.2	1.0
		(0.1)	(40.8)	(41.1)	(78.6)	(0.0)	(26.9)	(0.5)
		0.0	+ .25	+ .05	+ .22	a	- .12	- .16
Diaptomus spp.	1.5	4.3	9.3	11.7	18.6	0.3	6.4	4.2
	(6.9)	(7.2)	(8.1)	(10.3)	(2.9)	(0.0)	(27.5)	(2.4)
	+ .03	- .04	- .21	- .08	- .18	a	- .28	- .73
Diaphanosoma brachyurum	0.1	-	4.3	7.3	2.0	-	0.2	-
	(0.0)		(6.3)	(1.0)	(T)[1]		(0.6)	
	0.0		- .06	- .10	- .02[1]		- .02	
Daphnia pulex	0.9	T	0.6	2.3	0.8	-	-	-
	(0.35)	(T)[2]	(0.8)	(2.4)	(T)			
	- .02	0.0	- .01	- .01	- .01			
Chydorinae	0.5	0.3	0.2	-	-	-	T	T
	(2.5)	(0.4)	(0.6)				(0.3)	(1.4)
	+ .01	0.0	0.0				0.0	+ .01
Macrothrix laticornis	T	T	-	-	-	-	-	T
	(T)	(T)						(T)
	0.0	0.0						0.0
Harpacticoda	T	T	-	-	-	T	0.0	T
	(0.1)	(T)				(0.0)	(T)	(0.0)
	0.0	0.0				a	0.0	0.0
Leptodora kindtii	-	-	-	T	T	-	-	-
				(0.0)	(T)			
				0.0	0.0			
Ostracoda	T	T	T	T	T	T	T	-
	(0.4)	(1.3)	(1.2)	(1.0)	(2.3)	(0.0)	(T)	
	0.0	0.0	0.0	0.0	0.0	a	0.0	
Chironomidae	-	0.0	0.0	0.0	0.0	-	-	-
		(T)	(0.3)	(0.2)	(0.3)			
		b	b	b	b			
Arachnida	-	0.0						
		(T)						
		b						
No. paddlefish examined	5	6	6	5	6	2	6	1
Average food volume (ml)/stomach	24.9	34.1	1.7	28.3	3.1	< 1.0	< 1.0	< 1.0
Average no. zooplankton/liter	37.1	37.8	31.9	65.6	91.3	10.5	10.0	5.6

[1] Less than 0.1 %

[2] Less than 0.1/liter

[a] No calculated selectiveity index (no food in stomachs sampled)

[b] No calculated selectvity index (benthic organisms)

fed very little had tightly contracted and thick walled pyloric caeca and spiral valve intestines. In the present study the pyloric caeca and spiral valve intestine of paddlefish sampled in July were expanded and thin walled, while the paddlefish sampled in November possessed contracted and thick walled pyloric caeca and sprial valve intestine.

Mortality of paddlefish due to the pulsed gastric lavage appeared very low. Of 17 paddlefish sampled from October 1979 to October 1980, 5 were captured only once. The remaining 12 were recaptured and their stomachs pumped from two to six times. Foster (1977) found a 90% survival rate in fish which were subject to pulsed gastric lavage.

Other Fish Species

There were 15 species of fishes other than paddlefish in the boiler make-up reservoir (Table 3). Population estimates were conducted on the three major species. Orangespotted sunfish (*Lepomis humilis*) made 80.8% of these species, black bullhead (*Ictalurus melas*) 10.1%, and yellow perch (*Perca flavescens*) 9.1% (Table 4). The estimated standing crop of these species was 45.2 kg/ha (Table 5). The population estimate of orangespotted sunfish was 8,110 (5,950 - 11,029 95% C.I.). The estimated standing crop was 15.2 kg/ha. The population estimate for black bullheads was 1,013 (903 - 1,136 95% C.I.). The standing crop for black bullhead was estimated at 18.3 kg/ha. Population and standing crop estimates for yellow perch were 917 (773 - 1,076 95% C.I.) and 11.7 kg/ha, respectively.

Table 3. Fishes in Big Stone Power Plant boiler make-up reservoir, South Dakota, 1980.

Common name	Scientific name
Carp	Cyprinus carpio
Emerald shiner	Notropis atherinoides
Fathead minnow	Pimephales promelas
White sucker	Catostomus commersoni
Black bullhead	Ictalurus melas
Yellow bullhead	I. natalis
Tadpole madtom	Noturus gyrinus
Rock bass	Ambloplites rupestris
Orangespotted sunfish	Lepomis humilis
Bluegill	L. macrochirus
Black crappie	Etheostoma exile
Iowa darter	E. nigrum
Johnny darter	Etheostoma nigrum
Yellow perch	Perca flavescens
Freshwater drum	Aplodinotus grunniens

Table 4. Population estimates of three major fish species in Big Stone Power Plant boiler make-up reservoir, South Dakota, July 1980.

Species	Total fish marked	Population estimate ($\hat{N}$)	95% Confidence limits
Orangespotted sunfish (*Lepomis humilis*)	832	8,110	5,950 - 11,029
Black bullhead (*Ictalurus melas*)	627	1,013	930 - 1,136
Yellow perch (*Perca flavescens*)	477	917	773 - 1,076

Table 5. Standing crop of three major fish species in Big Stone Power Plant boiler make-up reservoir, South Dakota, July 1980.

	Standing crop			
Species	Fish/ha	95% Confidence limits	kg/ha	95% Confidence limits
Orangespotted sunfish (*Lepomis humilis*)	2,414	1,771 - 3,282	15.2	11.1 - 20.7
Black bullhead (*Ictalurus melas*)	301	269 - 338	18.3	16.4 - 20.6
Yellow perch (*Perca flavescens*)	273	230 - 320	11.7	9.9 - 13.7
TOTAL	2,988	2,270 - 3,940	45.2	37.4 - 55.0

Zooplankton

Cyclopoid copepods (include copepidids), Bosmina longirostris, and Diaptomus spp. made up 73% of the total zooplankton sampled from October 1979 to October 1980. Cyclopoid copepods were the most abundant, making up 38% (18.1/1) of the total zooplankters sampled. Bosmina longirostris and Diaptomus spp. made up 20% (9.3/1) and 15% (6.9/1), respectively. Zooplankters occurring at lower levels of abundance were Diaphanosoma brachyurum, Daphnia pulex, Chydorinae, Macrothrix laticornis, Harpacticoda, Leptodora kindtii, and Ostracoda.

Two seasonal peaks were observed in zooplankton numbers (Fig. 4). The first peak occurred from mid-March through April and was almost entirely the result of cyclopoid copepods. Total zooplankton were estimated at 79/1 at the peak of this pulse. The second peak during July and August resulted from cyclopoid copepods, Diaptomus spp., and Bosmina longirostris. Zooplankton numbers were estimated at 100/1 during this peak. Zooplankton levels were lowest from October through February as numbers averaged 11/1.

Chemical and Physical Characteristics

Chemical and physical parameters of the boiler make-up reservoir were monitored from October 1979 to October 1980 (Table 6). Average monthly water temperatures ranged from 0.6 C in February to 23.4 C in July. The maximum water temperature recorded was 28 C on 9 July 1980. Ice cover formed in December and remained until mid-April. Maximum ice thickness was 61 cm, however a small portion of the reservoir near

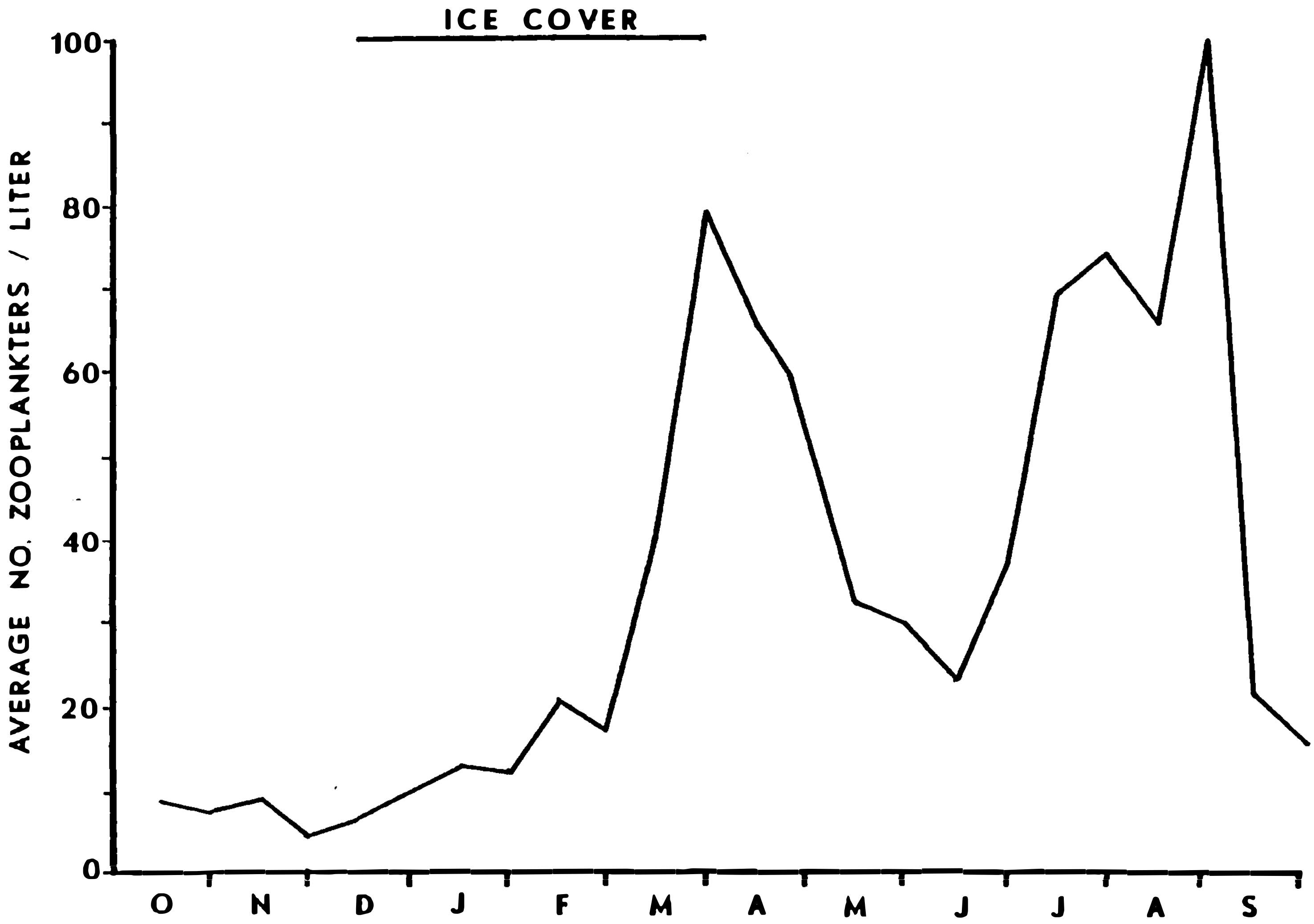

Figure 4. Zooplankton abundance in Big Stone Power Plant boiler make-up reservoir, South Dakota, October 1979 to October 1980.

Table 6. Mean chemical and physical parameters for Big Stone Power Plant boiler make-up reservoir, South Dakota, October 1979 to October 1980.

Parameter	October	November	December	January	February	March	April	May	June	July	August	September	Mean
Dissolved oxygen (mg/l)	15.2	13.4	-	11.7	14.1	14.1	11.7	9.4	8.7	8.4	7.6	9.6	11.2
Temperature (C)	8.8	2.3	-	1.0	0.6	1.8	8.3	11.9	20.3	23.4	20.6	13.6	10.2
Specific conductance (µmhos/cm at 25 C)	754.0	896.0	-	850.0	944.0	975.0	763.0	797.0	813.0	826.0	722.0	843.0	835.0
pH (units)	9.4	9.0	8.4	8.4	8.4	8.3	8.4	8.4	8.4	8.7	8.8	8.8	8.4
Total hardness (mg/l as $CaCO_3$)	327.0	340.0	387.0	406.0	436.0	448.0	252.0	384.0	347.0	300.0	287.0	268.0	349.0
Calcium hardness (mg/l as $CaCO_3$)	133.0	159.0	209.0	213.0	234.0	226.0	120.0	201.0	172.0	129.0	134.0	138.0	172.0
Total alkalinity (mg/l as $CaCO_3$)	101.0	121.0	156.0	167.0	172.0	176.0	98.0	157.0	134.0	101.0	88.0	80.0	129.0
Phenolphthalein alkalinity (mg/l as $CaCO_3$)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	11.0	10.0	12.0	3.0
Chloride (mg/l as $CaCO_3$)	19.0	17.0	21.0	20.0	21.0	21.0	10.0	18.0	17.0	18.0	20.0	18.0	18.0
Sulfate (mg/l)	-	222.0	-	-	275.0	-	-	260.0	-	-	252.0	-	252.0
Potassium (mg/l)	-	8.0	-	-	9.0	-	-	8.0	-	-	9.0	-	8.0
Sodium (mg/l)	-	33.0	-	-	35.0	-	-	32.0	-	-	32.0	-	33.0
Nitrate (mg/l as N)	-	0.16	-	-	0.06	-	-	0.04	-	-	0.04	-	0.07
Total Kjeldahl nitrogen (mg/l)	-	1.07	-	-	1.07	-	-	0.93	-	-	2.01	-	1.27
Ortho-phosphate (mg/l)	-	0.010	-	-	0.005	-	-	0.10	-	-	0.020	-	0.01
Phosphate (total) (mg/l)	-	0.020	-	-	0.035	-	-	0.035	-	-	0.140	-	0.06
Visibility (cm)	78.0	102.0	150.0	191.0	149.0	-	99.0	62.0	42.0	35.0	22.0	23.0	87.0

the intake structure remained open water year around as a result of mechanical aeration. Average dissolved oxygen levels were lowest during August (7.6 mg/l) and highest during October (15.2 mg/l). The lowest dissolved oxygen level observed was 6.3 mg/l on 20 August 1980. Water visibility ranged from 22 cm in August to 191 cm in January.

Sampling indicated average values for specific conductance, 835 μmhos/cm at 25 C, total hardness, 349 mg/l (of which calcium hardness accounted for 172 mg/l), and total alkalinity, 129 mg/l. Total and ortho-phosphate averaged 0.06 mg/l and 0.01 mg/l, respectively. Mean values for nitrate nitrogen and total Kjeldahl nitrogen were 0.07 mg/l and 1.27 mg/l, respectively. Average values for other parameters monitored were chloride, 18 mg/l; sulfate, 252 mg/l; potassium, 8 mg/l; and sodium, 33 mg/l.

In September 1980 Big Stone Power Plant began operation of a brine concentration unit. The brine concentrator reduces the salt levels in the boiler make-up reservoir prior to pumping water into the power plant boilers. Water monitoring to detect changes induced by the brine concentrator was conducted in January 1981. Results indicated a change in specific conductance from 835 μmhos/cm (mean value from October 1979 to October 1980) to 199 μmhos/cm in January 1981. Total hardness changed from 351 mg/l (mean value October 1979 to October 1980) to 122 mg/l in January 1981 (Fig. 5). The level to which the brine concentration unit will reduce salt levels is uncertain, but removal of salts from water in the boiler make-up reservoir may pose a threat to its productivity and ultimately its ability to support aquatic life.

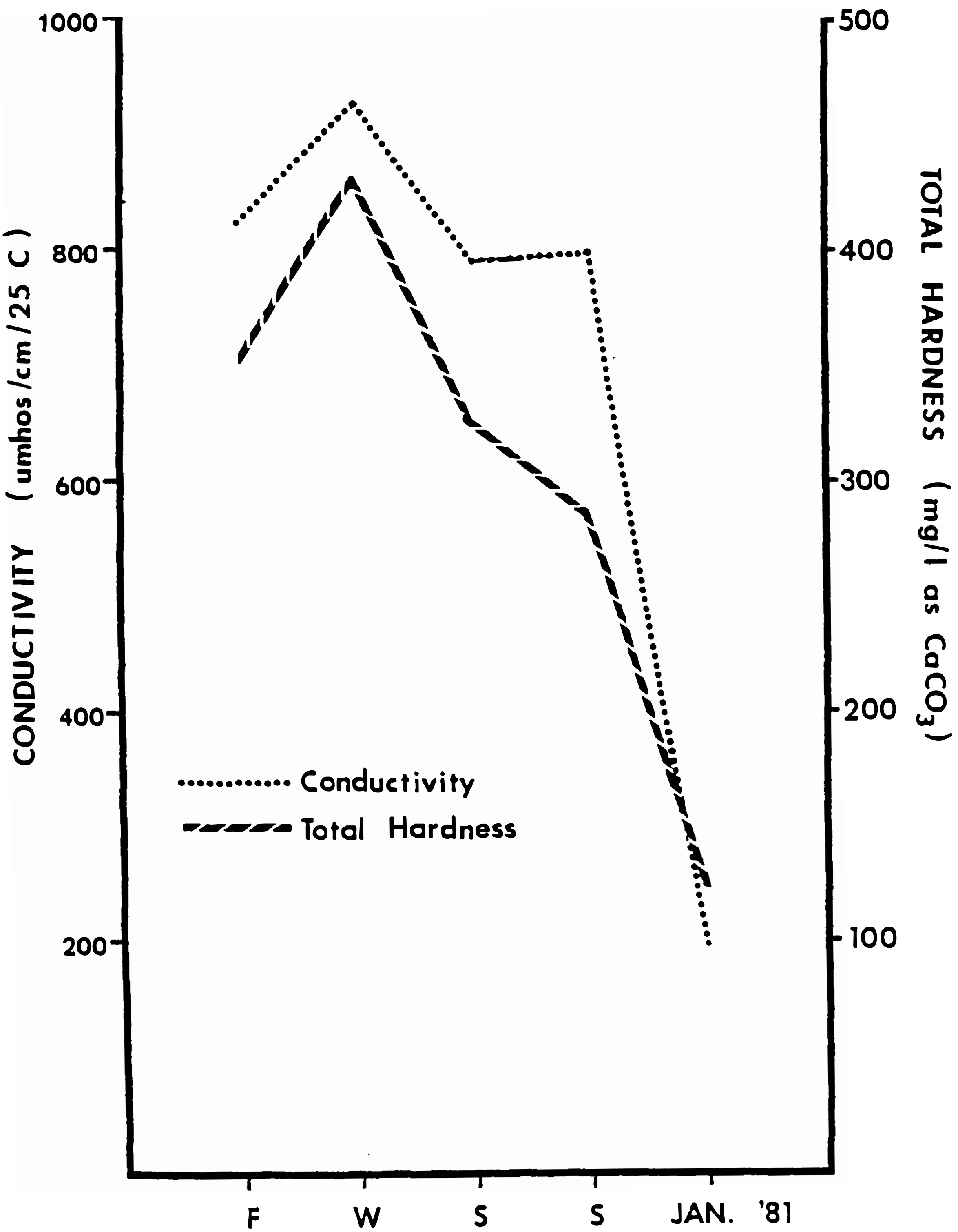

Figure 5. Conductivity and total hardness mean values over four sampling seasons, and after initial operation of brine concentration unit, Big Stone Power Plant boiler make-up reservoir, South Dakota, October 1979 to January 1981.

CONCLUSION

Data collected during the present study indicated that Big Stone Power Plant boiler make-up reservoir provided a suitable area for paddlefish, as determined by growth, condition factors, and food utilization of paddlefish in the reservoir. Other parameters monitored also indicated conditions favorable for aquatic life. Future consideration must be given to the impact the brine concentration unit may have on the reservoir. Based on these findings, I conclude that Big Stone Power Plant boiler make-up reservoir has potential as a holding area for paddlefish brood stock.

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APPENDIX

Appendix Table 1. Tagging, recapture, and present location of paddlefish (Polyodon spathula) at Big Stone Power Plant, South Dakota.

Tag #	December 1978 Length (mm)	December 1978 Weight (kg)	Date last recaptured	Length (mm)	Weight (kg)	Location
2108	585	2.5	08/80	749	6.6	Boiler make-up reservoir
1834	840	7.6	08/80	902	11.1	"
2055	800	6.2	07/80	832	9.4	"
2560	725	4.4	07/79	711	5.6	"
203	750	5.4	05/80	787	6.8	"
3009	720	5.3	04/80	781	7.3	"
12	648	3.5	05/80	724	5.7	"
59	540	2.0	07/80	654	3.3	"
2064	595	2.6	11/80	760	6.4	Cooling reservoir
2005	810	6.7	11/80	889	8.4	"
3182	680	3.7	11/80	760	6.3	"
3588	775	6.3	11/80	820	7.1	"
3921	840	7.2	09/80	908	10.1	"
3563	590	2.7	09/80	711	4.2	"
3528	610	2.9	09/80	737	4.8	"