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Food, Growth, and Reproduction of White Crappies (Pomixis Annularis) and Black Crappies (P. Nigromaculatus) in Lake Poinsett, South Dakota

Thomas R. Busiahn

FOOD, GROWTH, AND REPRODUCTION OF WHITE CRAPPIES (*POMOXIS ANNULARIS*) AND BLACK CRAPPIES (*P. NIGROMACULATUS*) IN LAKE POINSETT, SOUTH DAKOTA

BY

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TRB

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IN LAKE POINSETT, SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser — Date

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FOOD, GROWTH, AND REPRODUCTION OF WHITE CRAPPIES (POMOXIS ANNULARIS) AND BLACK CRAPPIES (P. NIGROMACULATUS) IN LAKE POINSETT, SOUTH DAKOTA

ABSTRACT

The food habits, food selectivity, growth, condition, and population structures of the white crappies (Pomoxis annularis) and black crappies (P. nigromaculatus) in Lake Poinsett, South Dakota, were studied from May, 1975, to May, 1976. The total food volume of 173 adult white crappies consisted of 59.0 % planktonic crustaceans, 25.2 % insects, 14.5 % fish, and 1.3 % miscellaneous organisms. The food volume of 39 adult black crappies consisted of 39.0 % planktonic crustaceans, 3.5 % insects, 57.8 % fish, and 0.7 % miscellaneous organisms. Both species selected Daphnia pulex over other zooplankton and probably contributed to its decline from 193.8/l on June 27 to 0.0/l on August 21. Both species preyed indiscriminately on forage fish. Growth rates were comparable to those found in similar temperate lakes. The growth rates of the crappies increased while their population densities declined. The population decline appeared to be due to a lack of spawning habitat caused by low water levels.

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INTRODUCTION

White crappies, Pomoxis annularis Rafinesque, and black crappies, P. nigromaculatus (Lesueur), are important sport fish in Lake Poinsett. A creel survey, July, 1971-June, 1972, indicated that about 31,456 kg of crappies were harvested, and that they contributed 57 % by weight (71 % by number) of the sport fish catch (Unkenholz 1973). The objectives of the present study were to determine if the crappies are capable of altering invertebrate populations by predation and to determine the crappie population structures.

The study of the food selectivity of fishes under natural conditions helps to determine the extent of utilization of food sources. The abundance of some forage items may be little affected by predation while others may be greatly reduced by selective predators.

The ability of fish predation to decimate a population of zooplankton has been demonstrated several times (Brooks and Dodson 1965, Applegate and Mullan 1969, Cramer and Marzolf 1970, Wells 1970, Hurlbert et al. 1972). Bigmouth buffalo (Ictiobus cyprinellus) in Lake Poinsett were found to be non-selective planktivores, but the structure of their gill rakers allowed them to filter out large plankters most efficiently (Starostka and Applegate 1970). The diets of black bullheads (Ictalurus melas) in Lake Poinsett were diverse, but they were shown to be selective for large zooplankters, especially Daphnia pulex and Leptodora kindtii (Repsys et al. 1976). Applegate et al. (1973) found that while the density of D. pulex in Lake Poinsett declined during late spring, its birth rate increased sevenfold, and its mortality rate fourfold. In other lakes white and black crappies have been found to be partially planktivorous and selective for D. pulex (Hall 1964, Unkenholz 1971).

Starrett and Fritz (1957) stated that crappie populations are often cyclic, with one year class dominating the population for several years. The crappies of Lake Poinsett are noted for fluctuations in abundance. The population structures of the crappies were studied to suggest causes for the fluctuations. Growth rates, condition, and fecundity were also investigated to form a more complete picture of the status of the crappies in Lake Poinsett.

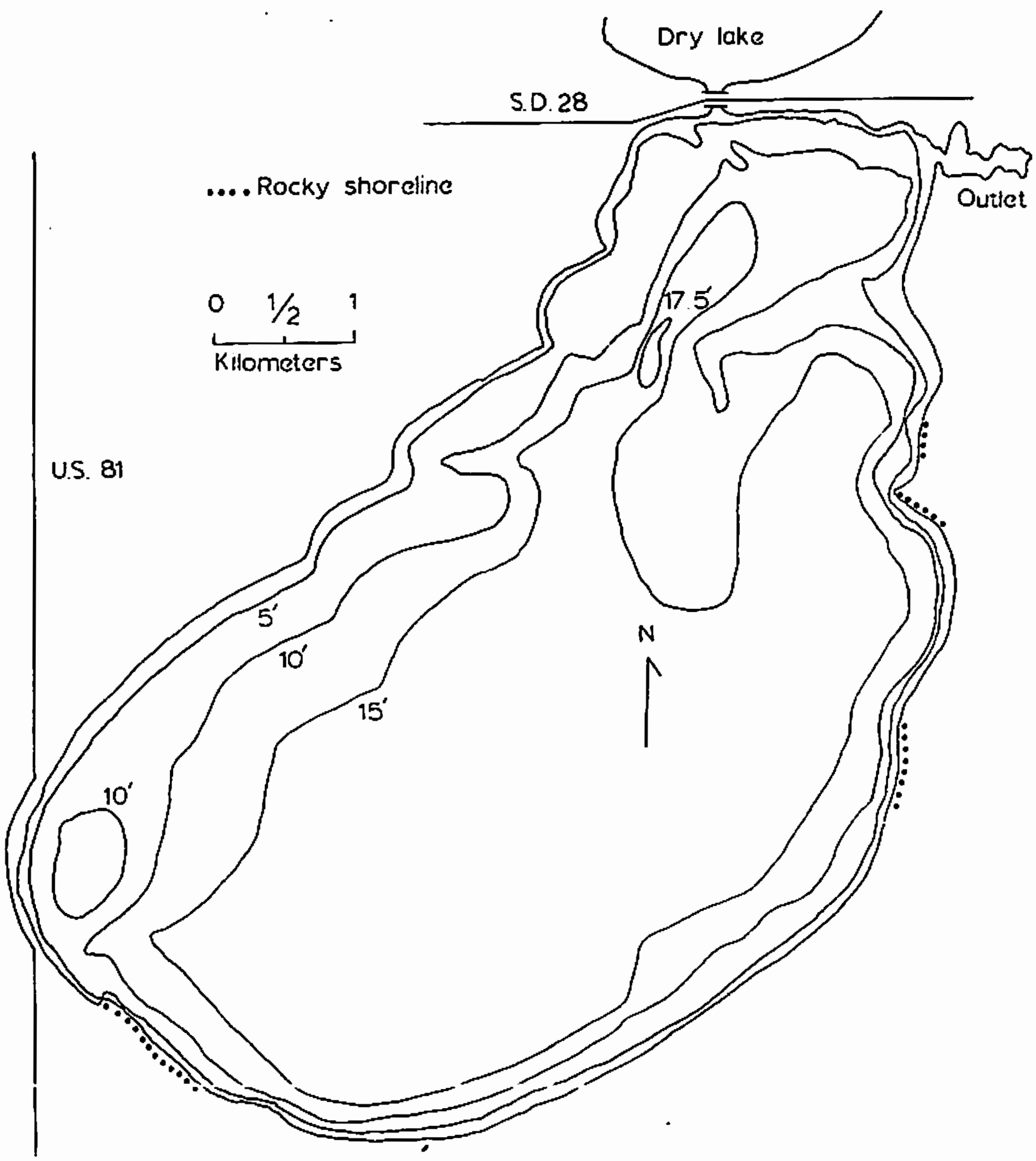

Figure 1. Contour map of Lake Poinsett, South Dakota, with water level at 503 m above mean sea level.

STUDY AREA

Lake Poinsett is the largest lake in the northeastern South Dakota glacial lake district. It has a surface area of 3157 ha, maximum depth of 4.6 m, average depth of 3.2 m, and shoreline development of 1.6. The lake level has fluctuated 6.4 m since 1936. The water level during this study declined to approximately 1.8 m below the modern high of 504 m above mean sea level (Barrari 1971). The shoreline consists of boulders, gravel, and sand, which intergrade to organically rich mud at about 2 m depth. Lake Poinsett is not known to stratify thermally and is under ice cover from November through March. It is bounded by rolling prairie which is cultivated and grazed.

Lake Poinsett is eutrophic and highly productive. Vascular aquatic vegetation is absent because the substrate is frequently shifted by wave action, but the filamentous alga *Cladophora* sp. forms dense mats on boulders and rubble. Unicellular phytoplankters are present in high numbers during early spring, and blue-green algae bloom in the summer (Applegate et al. 1973). Aquatic insects of the families Chironomidae and Corixidae are abundant. The fish population consists primarily of bigmouth buffalo, carp (*Cyprinus carpio*), white sucker (*Catostomus commersoni*), walleye (*Stizostedion vitreum*), yellow perch (*Perca flavescens*), spottail shiner (*Notropis hudsonius*), black bullhead, and white and black crappie.

METHODS

Attempts to capture adult crappies were made from May, 1975, through November, 1975, and from January, 1976, through May, 1976, at about 10-day intervals. Crappies were captured during open water with a semi-balloon otter trawl and trap nets. Trawl hauls were made parallel to shore for periods of 3 min. All trawling was done during daylight. Trap nets were set before sunset and were removed from the water at sunrise. The trap nets were made of five 1 m diameter steel hoops and two 1.2 m square aluminum frames with 1.3 cm bar mesh netting and a single lead 30 m long. During ice cover crappies were taken from seine hauls made by a commercial fisherman. Most of these fishes were frozen by the South Dakota Department of Game, Fish, and Parks Commercial Fishery Supervisor at Lake Poinsett, and their stomachs were later removed in the laboratory. Attempts to capture crappie fry and fingerlings were made with seines and meter nets during June and July of 1975 and 1976.

All crappies were weighed to the nearest gram and measured to the nearest millimeter (total length). Scale samples were taken from a random sample of fishes for ageing, and stomachs were preserved in 10 % formalin. The stomachs were grouped in the field according to the length groups of crappies.

Quantitative zooplankton samples, surface temperatures, and Secchi disc readings were obtained on the same days as the crappies, except during ice cover, when they were obtained 1-3 times per month. Zooplankton samples were taken during open water with a metered Miller sampler equipped with a number 10 mesh net. During ice cover zooplankton samples were collected with a water core plankton sampler (Applegate et al. 1968) equipped with a number 10 mesh net. Samples were representative of all depth strata. Samples were concentrated to 150 ml and 5 ml of Lugol's solution were added to stain and preserve the specimens.

Stomach contents from each length group of crappies were combined. Volumes of the combined contents were measured by water displacement in graduated centrifuge tubes. Grouped stomach contents of less than 2 ml volume were counted at 15 X in a circular counting chamber. Grouped stomach contents of more than 2 ml volume were diluted to 10 times their volume, and three 1 ml subsamples were counted. Individual volumes of fish and other large food items were determined by water displacement. Zooplankters were identified to species and insects to family using keys in Edmondson (1959).

Three 1 ml subsamples from each plankton sample were counted at 15 X in a circular counting chamber. Volume measurements of _Leptodora kindtii_ were made by water displacement. Length measurements of zooplankters were made using a dissecting scope equipped with an ocular micrometer. Twenty individuals from each sample were measured, and the measurements were averaged. Body length measurements did not include spines, antennae, or setae.

Selectivity indices (Ivlev 1961) were calculated for zooplankton and forage fish to compare the ration content to the food available in the environment. The selectivity index (e) of a food item is calculated by the equation:

$$e = \frac{r_i - p_i}{r_i + p_i}$$

in which: r_i = the proportion of food item i in the ration

p_i = the proportion of food item i in the environment.

The value of e falls between +1 and -1. Positive values indicate selection for an item, and negative values indicate avoidance. Selectivity can best be estimated for food organisms that can be sampled non-selectively. Selectivity for different life forms (e.g. plankton and fish) cannot be compared. The zooplankton samples were used to calculate e for zooplankton species for each sampling date. During January, February, and March zooplankton samples were taken less often than samples of crappies. Only mean monthly selectivity indices were calculated for zooplankton species during these months. Records of forage fish caught by trawl, trap nets, and seines were used to calculate e for forage fish species.

Scale impressions were made on acetate strips, and the impressions were examined using a scale projector. Distances between annuli were measured to the nearest millimeter on the enlarged images of the scales. These measurements were converted to fish length using a direct proportion nomograph.

Coefficients of condition, K(TL), were calculated using the formula:

$$K(TL) = \frac{\text{weight}^3 \text{ (grams)}}{\text{total length (mm)} \times 100{,}000}.$$

Length-weight regression equations were determined by the least squares method.

Ovaries were preserved in 10 % formalin. Fecundity counts were made by measuring the volume of eggs by water displacement and then counting the eggs in 0.5 ml.

RESULTS AND DISCUSSION

Food and Food Selectivity

Stomachs were taken from 173 adult white crappies and 39 adult black crappies. No young-of-the-year crappies were captured. The food habits of all sizes of crappies studied were similar and are not differentiated.

Daphnia pulex was the most important food item for white crappies, making up 96.0 % of the food organisms by number and 58.3 % by volume (Table 1). No other microcrustacean was important in the diet, although *Leptodora kindtii*, the largest cladoceran in Lake Poinsett, was eaten when present.

Argulus sp., a mobile external parasite of fishes, was present in the white crappie diet during the summer. It is not known whether the parasite was eaten while free-swimming or while attached to a host. No external parasites were noted on fish captured during this study. Intraspecific and interspecific cleaning symbiosis by bluegills (*Lepomis macrochirus*) in nature has been observed by Sulak (1975) and may be a well-established behavioral pattern among centrarchids.

Chironomid larvae made up 14.3 % of the volume of white crappie stomach contents, while pupae made up 0.6 %. In this respect the diet of the white crappies contrasted that of black bullheads in Lake Poinsett, which ate more chironomid pupae than larvae (Repsys et al. 1976). Chironomids were eaten only during open water, but water boatmen (Corixidae) were eaten year-round and made up 10.3 % of the food volume.

Spottail shiners and young yellow perch together made up 14.5 % of

Table 1. Stomach contents of 173 adult white crappies (*Pomoxis annularis*) expressed as percentage number and (in parentheses) percentage volume, Lake Poinsett, South Dakota, 1975 and 1976. (T = <0.05).

Food item	1975 May	1975 June	1975 July	1975 Aug.	1976 Jan.	1976 Feb.	1976 March	1976 April	1976 May	Total
Cladocera										
Daphnia pulex	59.5 (31.8)	82.0 (42.2)	2.0 (0.5)	1.5 (T)	99.8 (99.0)	99.9 (99.4)	99.8 (95.0)	96.5 (55.2)	98.6 (62.5)	96.0 (58.3)
Diaphanosoma leuchtenbergianum		0.3 (0.1)	8.5 (1.0)	1.9 (T)						0.1 (0.1)
Leptodora kindtii		0.7 (2.1)	2.2 (3.2)	6.6 (1.0)						0.1 (0.6)
Copepoda										
Cyclops bicuspidatus thomasi		0.1 (T)			T (T)	T (T)	0.1 (T)		0.1 (T)	T (T)
Diaptomus clavipes		0.3 (T)		1.5 (T)	0.1 (T)			2.0 (0.2)		0.2 (T)
Diaptomus siciloides			0.6 (T)							T (T)
Branchiura										
Argulus sp.		0.1 (2.2)		0.4 (1.3)						T (0.6)
Decapoda				0.1 (1.9)						T (0.2)
Amphipoda										
Hyallela azteca				1.3 (1.2)			T (0.1)	T (0.3)	T (1.5)	T (0.3)
Hirudinea										
Illinobdella sp.									T (2.2)	T (0.2)
Chironomidae										
Larvae	39.8 (63.0)	10.5 (16.3)	70.3 (53.8)	55.3 (10.3)				0.9 (0.9)	0.8 (1.5)	2.8 (14.3)
Pupae		1.5 (2.1)	6.8 (4.7)	5.1 (0.4)					T (T)	0.1 (0.6)
Corixidae	0.7 (5.2)	4.5 (34.8)	9.6 (36.8)	25.7 (9.6)	0.1 (1.0)	0.1 (0.6)	0.2 (1.2)	0.5 (2.4)	0.4 (4.1)	0.6 (10.3)
Fish										
Spottail shiner				0.6 (66.8)			T (3.7)	T (22.3)	T (28.1)	T (12.2)
Yellow perch				0.1 (7.6)				T (18.6)		T (2.3)
No. white crappies examined	22	32	6	21	13	34	20	13	12	173
No. white crappies with food	12	26	5	18	13	34	20	13	12	153
Avg. food volume (ml) per stomach[1]	0.55	0.40	0.37	1.25	2.33	3.51	3.48	4.13	1.48	1.98
Avg. food number per stomach[1]	316.4	297.0	107.7	58.5	1787.0	2301.6	1934.3	1199.5	783.7	1060.7

[1] Includes empty stomachs

the white crappie food volume but less than 0.01 % of the food numbers. They were eaten during the spring, late summer, and fall.

D. pulex was also a major food item of black crappies. This cladoceran made up 95.5 % of the black crappie food by number and 37.1 % by volume (Table 2). L. kindtii was an important food item during July.

Chironomid larvae were eaten by black crappies more often than chironomid pupae, but neither was very important in the diet; larvae made up only 1.6 % of the total food volume. Most chironomids were eaten during the summer. Corixids made up 1.8 % of the total food volume but were important in the diet during the late spring.

Fish made up 57.8 % of the food of black crappies by volume and 0.05 % by number; however, there is evidence, to be discussed later, that the importance of fish in the diet of the crappies is overestimated due to a sampling bias.

The food habits of the two crappie species were similar. D. pulex was positively selected by both (Tables 3 and 4) and was the most important food item. White crappie stomachs contained an average of 1018.3 D. pulex; black crappie stomachs contained 805.5. Although white crappies had eaten a greater variety of microcrustaceans, this was probably a result of the larger white crappie sample. L. kindtii was positively selected by both species when present.

The percentages by number of insects in the diets of the two species were similar. The percentages by volume of insects was smaller in black crappies due to the greater volume of fish in the stomachs.

The greatest difference in the food habits of the crappies was the

Table 2. Stomach contents of 39 adult black crappies (*Pomoxis nigromaculatus*) expressed as percentage number and (in parentheses) percentage volume, Lake Poinsett, South Dakota, 1975 and 1976. (T = <0.05).

	1975				1976					
Food item	May	June	July	Aug.	Jan.	Feb.	March	April	May	Total
Cladocera										
Daphnia pulex	92.5 (70.3)	94.0 (64.9)	74.7 (47.4)		100.0 (100.0)	99.9 (99.0)	98.7 (88.1)	99.1 (13.1)	98.0 (0.3)	95.8 (37.1)
Diaphanosoma leuchtenbergianum			0.5 (0.1)							0.2 (T)
Leptodora kindtii			19.8 (38.6)							0.7 (0.9)
Copepoda										
Diaptomus clavipes			1.5 (0.2)				1.1 (0.1)			0.3 (T)
Branchiura										
Argulus sp.			0.2 (4.4)							T (0.1)
Amphipoda										
Hyalella azteca								0.4 (4.5)		T (0.6)
Acari										
Arrhenurus sp.	2.7 (4.3)									0.1 (0.1)
Chironomidae										
Larvae	3.1 (7.0)	3.3 (6.7)	1.5 (3.9)	74.2 (7.0)				0.2 (0.1)		2.0 (1.6)
Pupae			0.7 (0.1)	10.7 (0.3)						0.2 (T)
Corixidae	1.6 (18.3)	2.8 (28.4)	1.1 (5.4)	14.4 (2.7)		0.1 (1.0)	0.1 (0.7)	0.1 (0.2)		0.7 (1.8)
Fish										
Spottail shiner				0.4 (58.2)			T (11.0)	0.1 (56.6)	2.0 (99.7)	T (48.7)
Yellow perch				0.3 (31.8)				0.1 (25.5)		T (9.1)
No. black crappies examined	4	4	3	4	4	7	6	2	5	39
No. black crappies with food	3	4	3	4	4	6	6	2	3	35
Avg. food volume (ml) per stomach[1]	0.30	0.81	1.00	5.50	1.48	2.74	2.88	8.80	7.38	3.24
Avg. food number per stomach[1]	368.5	766.8	374.3	165.5	770.0	1823.6	1433.6	883.0	50.4	840.8

[1] Includes empty stomachs

Table 3. **Mean number of crustaceans per liter in lake samples, (in parentheses) mean number per stomach in adult white crappies, and selectivity indices for crustaceans by white crappies from Lake Poinsett, South Dakota, 1975 and 1976.**

1975	May		June				July		August			
	27	30	4	19	23	27	29	30	6	12	21	27
Daphnia pulex	81.5	52.4	10.0	64.6	108.0	193.8	3.6	4.3	4.6	0.1		
	(101.6)	(578.8)	(134.0)	(107.6)	(189.4)	(1336.3)		(2.6)	(1.4)			
	+0.27	+0.22	+0.37	+0.66	+0.57	+0.75	-1.0	+0.97	+0.85	-1.0		
Diaphanosoma leuchtenbergianum				33.3	102.4	449.4	375.5	207.1	139.7	20.6	59.7	54.1
						(11.0)	(55.0)		(1.8)			
				-1.0	-1.0	-0.95	+0.42	-1.0	-0.34	-1.0	-1.0	-1.0
Leptodora kindtii				0.7	0.6	2.1	3.6	1.2	0.3	0.0	0.1	
				(2.2)		(12.0)	(4.0)	(2.0)	(6.0)	(3.0)		
				+0.79	-1.0	-0.41	+0.27	+0.99	+0.99	+1.0	-1.0	
Cyclops bicuspidatus thomasi	58.2	28.0	41.0	95.4	122.3	404.7	485.1	240.1	142.2	121.7	183.0	120.2
			(0.9)									
	-1.0	-1.0	-0.97	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
Diaptomus clavipes	0.7	0.3	1.1	39.9	13.1	59.6	25.2	18.5	15.8	5.3	12.4	8.7
				(1.1)	(0.9)	(3.0)				(4.0)	(3.5)	
	-1.0	-1.0	-1.0	-0.85	-0.74	-0.90	-1.0	-1.0	-1.0	+0.94	+0.92	-1.0
Diaptomus siciloides	1.7	0.9	1.7	36.4	22.4	119.3	34.1	19.1	13.1	5.9	14.3	10.8
							(4.0)					
	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	+0.27	-1.0	-1.0	-1.0	-1.0	-1.0

Table 3, continued.

1976	January	February	March	April 1	April 10	April 29	May 11	May 18	Weighted means of e
Daphnia pulex	0.1	0.6	0.6	16.8	35.9	79.8	120.0	140.6	
	(1782.5)	(2299.6)	(1930.1)	(2211.0)	(2303.0)	(774.2)	(824.4)	(513.5)	
	+0.96	+0.81	+0.89	+0.91	+0.86	+0.70	+0.39	+0.31	+0.64
Diaphanosoma leuchtenbergianum					1.2	3.7			
					-1.0	-1.0			-0.83
Leptodora kindtii									
									+0.45
Cyclops bicuspidatus thomasi	3.8	4.1	7.2	352.5	384.2	340.9	129.8	100.6	
	(0.8)	(0.4)	(1.1)					(3.5)	
	-0.99	-0.99	-0.99	-1.0	-1.0	-1.0	-1.0	-0.96	-0.99
Diaptomus clavipes	0.1	0.2	0.2	1.4	2.6	1.1	0.3	0.7	
	(1.4)			(22.0)		(3.3)			
	-0.92	-1.0	-1.0	+0.95	-1.0	+0.25	-1.0	-1.0	-0.83
Diaptomus siciloides	2.0	1.1	1.2	23.5	17.6	4.3	7.1	5.4	
	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-0.99

Table 4. Mean number of crustaceans per liter in lake samples, (in parentheses) mean number per stomach in adult black crappies, and selectivity indices for crustaceans by black crappies from Lake Poinsett, South Dakota, 1975 and 1976.

1975	May		June			July	August	
	27	30	4	19	27	2	12	27
<u>Daphnia</u> <u>pulex</u>	31.5	52.4	10.0	54.6	193.8	30.7	0.1	
	(213.2)	(727.0)	(478.5)	(2.0)	(1923.0)	(279.7)		
	+0.27	+0.22	+0.37	+0.67	+0.76	+0.90	-1.0	
<u>Diaphanosoma leuchtenbergianum</u>				33.3	449.4	465.6	20.6	54.1
						(2.0)		
				-1.0	-1.0	-0.98	-1.0	-1.0
<u>Leptodora</u> <u>kindtii</u>				0.7	2.1	4.8		
						(222.0)		
				-1.0	-1.0	+0.94		
<u>Diaptomus</u> <u>clavipes</u>	0.7	0.3	1.1	39.9	59.6	25.8	5.3	8.7
						(5.7)		
	-1.0	-1.0	-1.0	-1.0	-1.0	-0.36	-1.0	-1.0

Table 4, continued.

1976	January	February	March	April 21	April 29	May 11	Weighted means of e
<u>Daphnia pulex</u>	0.1	0.6	0.6	52.7	79.8	120.0	
	(770.0)	(1821.4)	(1415.8)	(68.0)	(1638.0)	(49.4)	
	+0.98	+0.81	+0.81	+0.76	+0.96	+0.39	+0.64
<u>Diaphanosoma leuchtenbergianum</u>				0.6	3.7		
				-1.0	-1.0		-0.99
<u>Leptodora kindtii</u>							
							+0.16
<u>Diaptomus clavipes</u>	0.1	0.2	0.2	1.7	1.1	0.3	
			(16.0)				
	-1.0	-1.0	-0.41	-1.0	-1.0	-1.0	-0.86

number and size of forage fish eaten. Fish made up 57.8 % of the black crappie food volume and 14.5 % of that of the white crappies. The individual fish eaten by black crappies averaged 20 % larger by volume than those eaten by white crappies. The mean length of black crappies captured was 282 mm, and that of white crappies was 256 mm. This size difference may have allowed black crappies to eat larger fish.

Seven attempts to capture crappies were made from September through November, 1975, but the number taken of either species was not sufficient to draw solid conclusions on their food habits. The stomachs of 2 white crappies and 1 black crappie captured during this period had an average food volume of 0.3 ml and contained only small numbers of insects and well-digested fish. The diversified diet of the summer probably continued into the fall due to the absence of preferred zooplankton species. Insects and fish probably comprised the bulk of the diet until November, when D. pulex reappeared. This highly selected species then probably became the major food item during the period of ice formation. It was heavily preyed upon during the winter months.

White crappies fed on 14 groups of organisms and black crappies on 11 groups. Leeches, crayfish, and mites were found only once. This indicates that they were not selected prey or that they were not normally encountered by crappies. A few negatively selected plankters may have been ingested accidentally. These include the copepods Cyclops bicuspidatus thomasi and Diaptomus siciloides, which did not occur in black crappie stomachs and which had mean electivity indices of -0.99 in the white crappie diet (Table 3). The amphipod Hyallela azteca and the branchiuran parasite Argulus sp. were not common in the diets, but were found several times, as were the zooplankton species Diaphanosoma leuchtenbergianum and Diaptomus clavipes.

The occurrence of fish in the stomachs of white and black crappies coincided remarkably with the use of trap nets to capture crappies. Trap nets were used on 5 of the 6 sampling dates on which fish were found in white crappie stomachs. For black crappies these numbers were 4 out of 5. This suggests that crappies ate small fish that were imprisoned with them in the trap net. The 1.3 cm bar mesh net held fish small enough to be eaten by crappies. Crappies may have been attracted into the net by the prey or may have encountered them there coincidentally. The presence of spottail shiners in the stomachs of crappies taken by seine during ice cover and the occaisional occurrence of fish bones in stomachs indicate that fish are a normal component of the crappie diets, although the figures presented here may be skewed due to the use of trap nets.

Another possible explanation for this coincidence is that the trap nets were set at night, but trawling and seining were done during daylight. If the crappies tend to eat fish at night, the results are as would be expected. Corroboration of this hypothesis was attempted by nighttime seining and daytime trap net sets, but these were not successful in taking crappies.

Some authors (Stevens 1959, Reid 1949, Ball and Kilambi 1973) have reported crappies to be primarily piscivorous. This could be said of black crappies in Lake Poinsett during early spring and late summer if it is assumed the trap nets had no effect on food selection. However the food volume of white crappies comprised only 14.5 % fish. The spottail shiner population of Lake Poinsett provides a large potential food supply for crappies, but did not appear to be effectively utilized. A possible reason for this is that the low transparency of the water prevented effective predation on fish while the ubiquitous plankton provided a ready food source. The average Secchi disc transparency during this study was 0.59 m.

Crappies were not selective for or against spottail shiners or young yellow perch (Table 5). These species were the only important forage fish present. The presence of young-of-the-year and yearling yellow perch in the diets is a reflection of the large year-class of yellow perch in 1975.

Chironomid larvae and pupae and corixids were important supplemental foods for both crappie species. The chironomids were most important during the summer when the Daphnia pulex population was declining, and they made up most of the food volume during some summer months.

Applegate (1974) stated that corixids are adapted to avoid fish predation while they remain in the littoral zone but are vulnerable if forced to move to the profundal zone by wave action or ice cover. Crappies ate water boatmen during all seasons. This may indicate that corixids are highly desirable food for crappies but that they are not effectively utilized because of their defenses against predation. The maximum numbers of corixids occurred in the diets during the summer, when the corixid population reaches a maximum (Applegate 1974). It appears that crappies were selective for corixids and ate them in numbers proportional to their abundance.

The food selectivity of fishes is determined by the needs, prefer-

Table 5. Selectivity indices for forage fishes in diets of white crappies and black crappies and (in parentheses) relative abundance of forage fishes, Lake Poinsett, South Dakota, 1975 and 1976.

	Young-of-the-year and yearling yellow perch (16.3 %)	Spottail shiner (82.9 %)	Fathead minnow (0.8 %)
White crappie	-0.03	+0.01	-1.0
Black crappie	+0.10	-0.02	-1.0

ences, and habits of the predator and by characteristics of the prey, such as size, speed, and protective coloration (Ivlev 1961). Of the zooplankton species in Lake Poinsett, only Daphnia pulex provided a substantial and sustained food source for adult crappies. It was the only species positively selected during much of the year (Tables 3 and 4).

A combination of characteristics of the crappies, of D. pulex, and of the environment made this large cladoceran an important food. Crappies feed by sight and select those food organisms that provide the greatest amount of energy but require the least expenditure of energy to capture. In the rather opaque water of Lake Poinsett, the vision of the crappies is restricted, and large, mobile organisms are not often encountered. Zooplankton, on the other hand, is always present in the vicinity, and the fishes may easily select the largest and/or slowest of these organisms. D. pulex is larger than all but the uncommon and transient Leptodora kindtii, and is the slowest swimmer among the common zooplankton species in Lake Poinsett (Repsys 1972). This makes it an ideal prey.

D. pulex normally reaches a high population level during the spring in Lake Poinsett (Starostka and Applegate 1970, Applegate et al. 1973, Repsys et al. 1976). By late summer it decreases to a very low density. Applegate et al. (1973) reported that the birth rate of D. pulex in Lake Poinsett increased sevenfold while the mortality rate increased fourfold during the spring. The dominance of D. pulex in the crappie diets during the spring indicates that predation by crappies may be partially responsible for the decline.

A comparison of the average length of D. pulex in the population to the average length of *D. pulex* in crappie stomachs indicates that crappies selected the larger individuals at all times (Figure 2). They appear to have been less size-selective during the late spring and early summer than during the winter.

Gailbraith (1967) suggested that predation on mature and immature plankton reduces the population level of the plankton faster than predation on mature individuals only. During the winter and spring, when the *D. pulex* population in Lake Poinsett was stable or growing, crappies selected the large mature *D. pulex*. In the summer, when *D. pulex* was declining, crappies ate both mature and immature individuals (Figure 2).

The average density of *D. pulex* in the lake water and the average number of *D. pulex* in white crappie stomachs followed similar trends during the summer months (Figure 3), indicating that, though *D. pulex* was always positively selected, white crappies readily switched to other foods when *D. pulex* declined in abundance.

The trends were quite different during the winter (Figure 3). Because of their slow digestive rates and low food requirements during the winter, the crappies were very selective in their feeding, in regard to both species and size of prey. During the winter the diets of crappies consisted almost solely of *D. pulex*. The population of *D. pulex* remained at a low level throughtout the winter, but was stable, indicating that *D. pulex* reproduction kept pace with the predation by crappies and other fishes. During the spring the increased digestive rates and the availability of other foods caused a decline in the number of *D. pulex* present in a crappie stomach at any particular time,

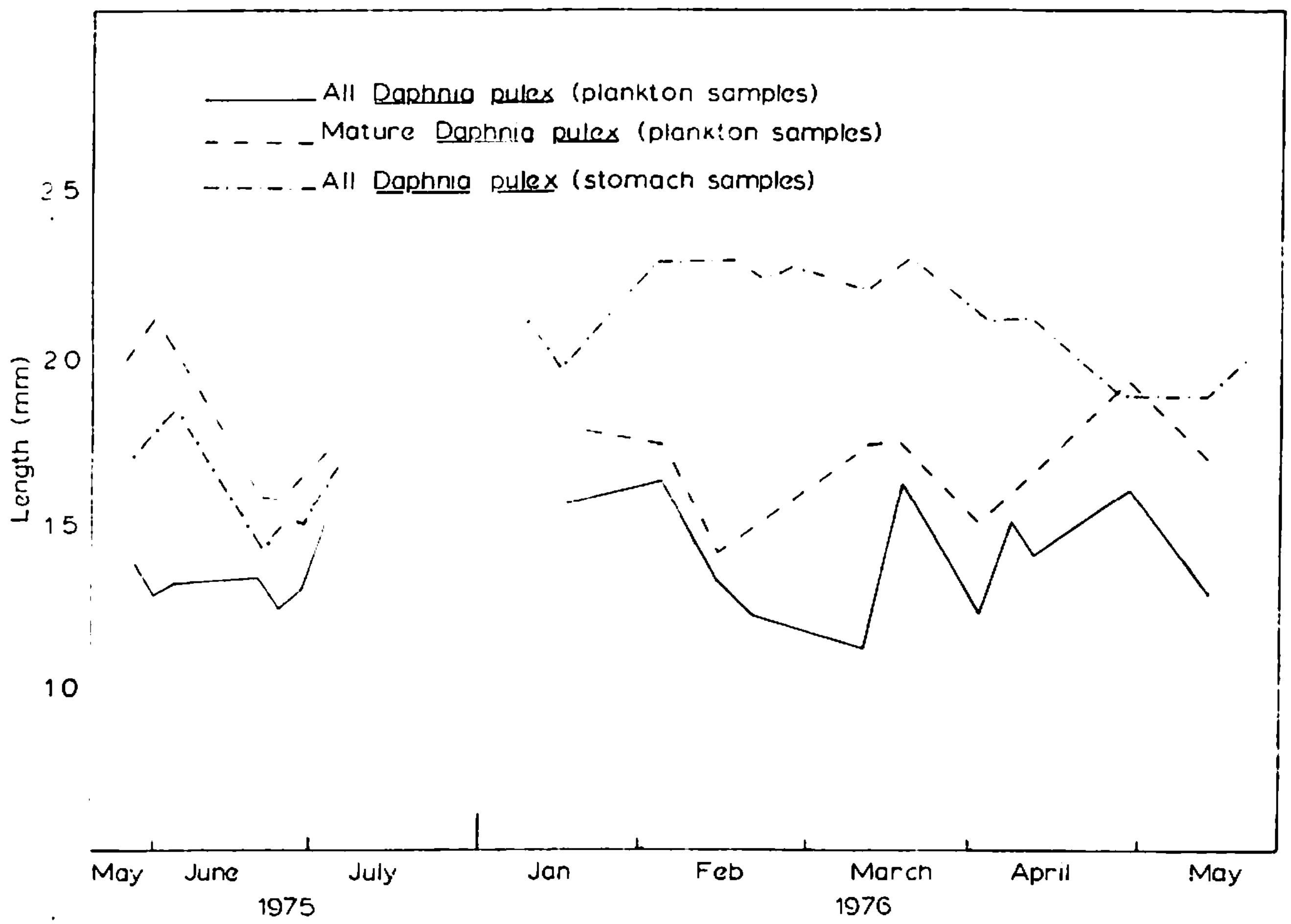

Figure 2. Mean lengths of Daphnia pulex from plankton samples and from stomachs of adult white crappies (Pomoxis annularis) and adult black crappies (P. nigromaculatus), Lake Poinsett, South Dakota, 1975 and 1976

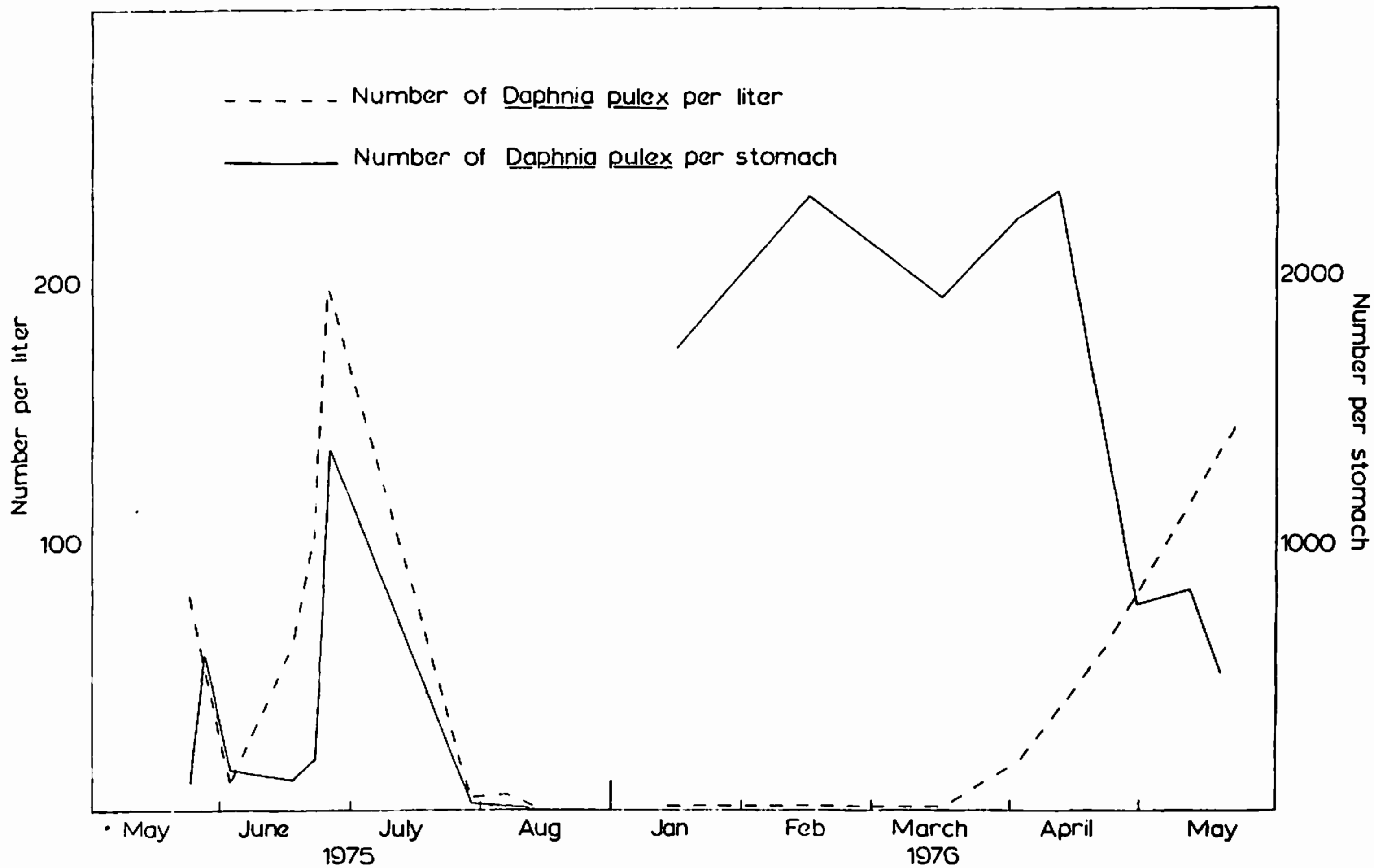

Figure 3. Mean numbers of *Daphnia pulex* per liter of lake water and per white crappie stomach, Lake Poinsett, South Dakota, 1975 and 1976.

although mortality of D. pulex due to fish predation probably increased.

Leptodora kindtii was positively selected (Tables 3 and 4) for the same reasons as D. pulex. It was not a major food because it was never abundant and was present in the plankton for a relatively short time. The crappies appeared to size-selective when eating L. kindtii. On June 27 the average L. kindtii in the plankton had a volume of 2.67 µl, while those from white crappie stomachs averaged 7.69 µl. Black bullheads in Lake Poinsett also positively selected L. kindtii (Repsys et al. 1976). The abundance of this cladoceran may be limited by a paucity of prey during the colder months and by fish predation during the summer.

The "size-efficiency hypothesis" of Brooks and Dodson (1965) appears to hold true for the zooplankton in Lake Poinsett. During early spring, when piscine predation is low, and the food supply for planktonic herbivores is at a maximum, D. pulex, the largest of these herbivores, reaches a maximum density due to its ability to outcompete smaller plankters. D. pulex does not long maintain its dominant position among the zooplankton when young-of-the-year fishes begin to feed and the food requirements of larger planktivorous fishes approach summer maxima. The populations of smaller zooplankton species may be limited only be the food supply and by competition with D. pulex.

Brooks and Dodson (1965) and Wells (1970) reported on the tendency of alewife (Alosa pseudoharengus) to modify zooplankton composition by reducing or eliminating large plankters. As long as they were present the alewife kept the large plankters at low densities. The study of Hurlbert et al. (1972) demonstrated the ability of mosquitofish

(*Gambusia affinis*) to eliminate a zooplankton species in an artificial ecosystem. Lake Poinsett is a more complex system in which several species acting in concert (e.g. white crappie, black crappie, black bullhead) affect the zooplankton composition by predation, resulting in a well-defined annual cycle.

Age, Growth, and Condition

The scales of 121 white crappies and 30 black crappies were examined to age the fish and to calculate fish length at each at each annulus (Tables 6 and 7).

The youngest white crappies captured were spawned in 1973 and the youngest black crappies in 1972. The oldest fish captured of each species were spawned in 1969. The normal life span of crappies is 4-7 years (Bennett 1971).

The growth of both species of crappies was greater in 1974 and 1975 than in previous years. This acceleration of growth occurred despite the decreasing water volume and surface area of Lake Poinsett. The water level has fallen over a period of 4 years, with the effect of concentrating long-lived organisms, while having little or no effect on the densities of short-lived invertebrate prey species. However the crappie populations in Lake Poinsett have been declining in numbers as evidenced by the absence of young fish (Figures 4 and 5). The decline in numbers probably brought about a decline in intraspecific and intrageneric competition, compensating for the crowding effect and increasing the growth rates of the crappies.

Lee's phenomonon is probably another factor in the apparent increase in the crappie growth rates. Size-selective cropping by

Table 6. Average calculated lengths of white crappies at annulus formation, Lake Poinsett, South Dakota, 1975 and 1976.

No. of fish	Year-class	Average length at capture	I	II	III	IV	V	VI
2	1973	190.00 mm	38.00	134.50				
84	1972	247.47	43.31	152.57	222.80			
18	1971	275.67	38.67	133.06	209.78	251.56		
8	1970	302.75	36.12	129.12	196.62	238.25	276.62	
9	1969	288.67	28.77	107.44	171.55	211.11	236.89	260.66
121		Mean:	36.97	131.34	200.19	233.68	256.76	260.66

Table 7. Average calculated lengths of black crappies at annulus formation, Lake Poinsett, South Dakota, 1975 and 1976.

No. of fish	Year-class	Average length at capture	I	II	III	IV	V	VI
5	1972	240.60 mm	48.00	152.40	222.60			
6	1971	285.17	59.50	142.83	207.50	258.50		
16	1970	287.62	43.19	125.57	179.82	223.01	267.57	
3	1969	295.33	30.33	112.67	157.00	210.33	247.33	292.67
30		Mean:	45.26	133.37	191.73	230.61	257.45	292.67

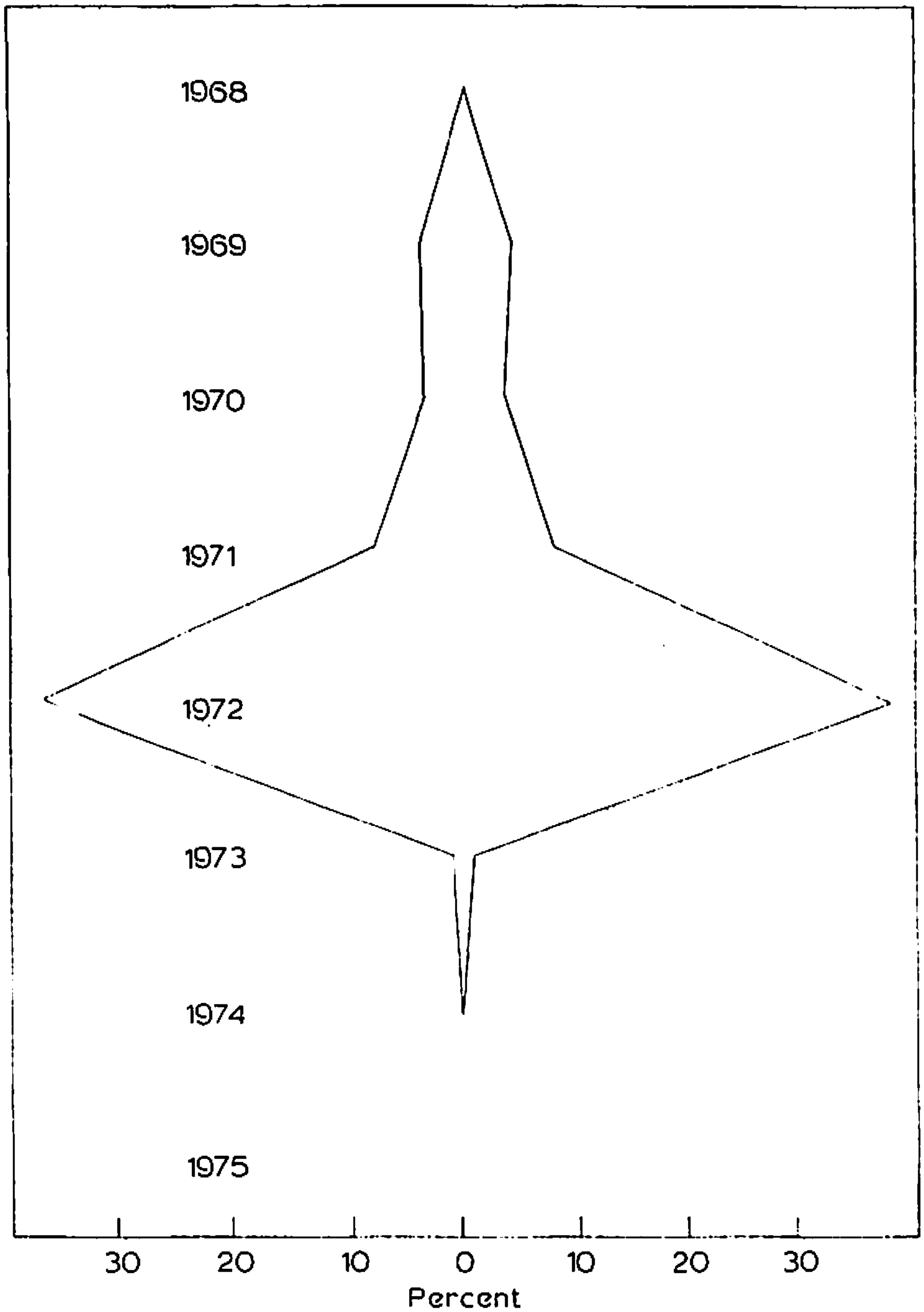

Figure 4. Relative abundance of year-classes by percent of 121 white crappies, Lake Poinsett, South Dakota, 1975 and 1976.

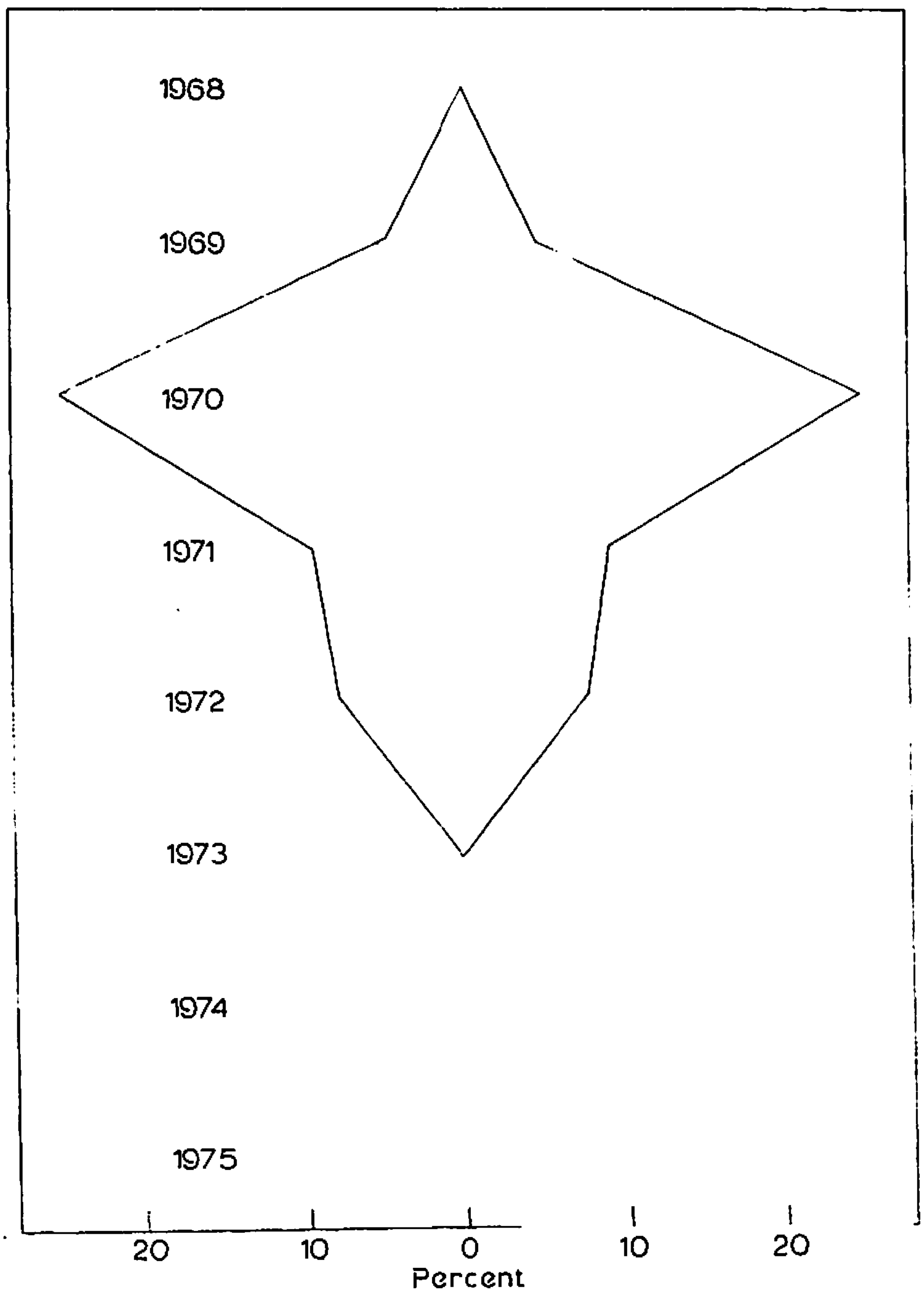

Figure 5. Relative abundance of year-classes by percent of 30 black crappies, Lake Poinsett, South Dakota, 1975 and 1976.

sport fishermen or proportionately greater mortality among fast-growing individuals could have increased the relative abundance of slow-growing fishes in the older year classes.

The white and black crappies of Lake Poinsett reached a usable size of 200 mm in about 3 years. The growth rate in Lake Poinsett is approximately the same as in comparably-sized Oklahoma reservoirs (Hall et al. 1954). White crappies averaged 208 mm and black crappies 228 mm after 3 years growth in those reservoirs. This is also comparable to the growth rates of white and black crappies in Iowa lakes ecologically similar to Lake Poinsett (Mayhew 1965).

The lengths and weights of 209 white crappies and 46 black crappies were used to regress weight on length (Figures 6 and 7). The differences in the regression equations reflect the difference in the form of the two species; black crappies were heavier for their length than white crappies.

White crappies had an average coefficient of condition, K(TL), of 1.38 and black crappies 1.66. This difference is also an indication of the differing body forms of the crappie species.

A seasonal cycle in the average monthly coefficients of condition is evident for both species (Figure 8). The crappies reached peak condition in mid-winter and were in their lowest condition soon after the major spawning period was finished, in June and July. These cycles are identical to those reported by Hansen (1951) in mature white crappies in Illinois. All the crappies captured during the present study were mature.

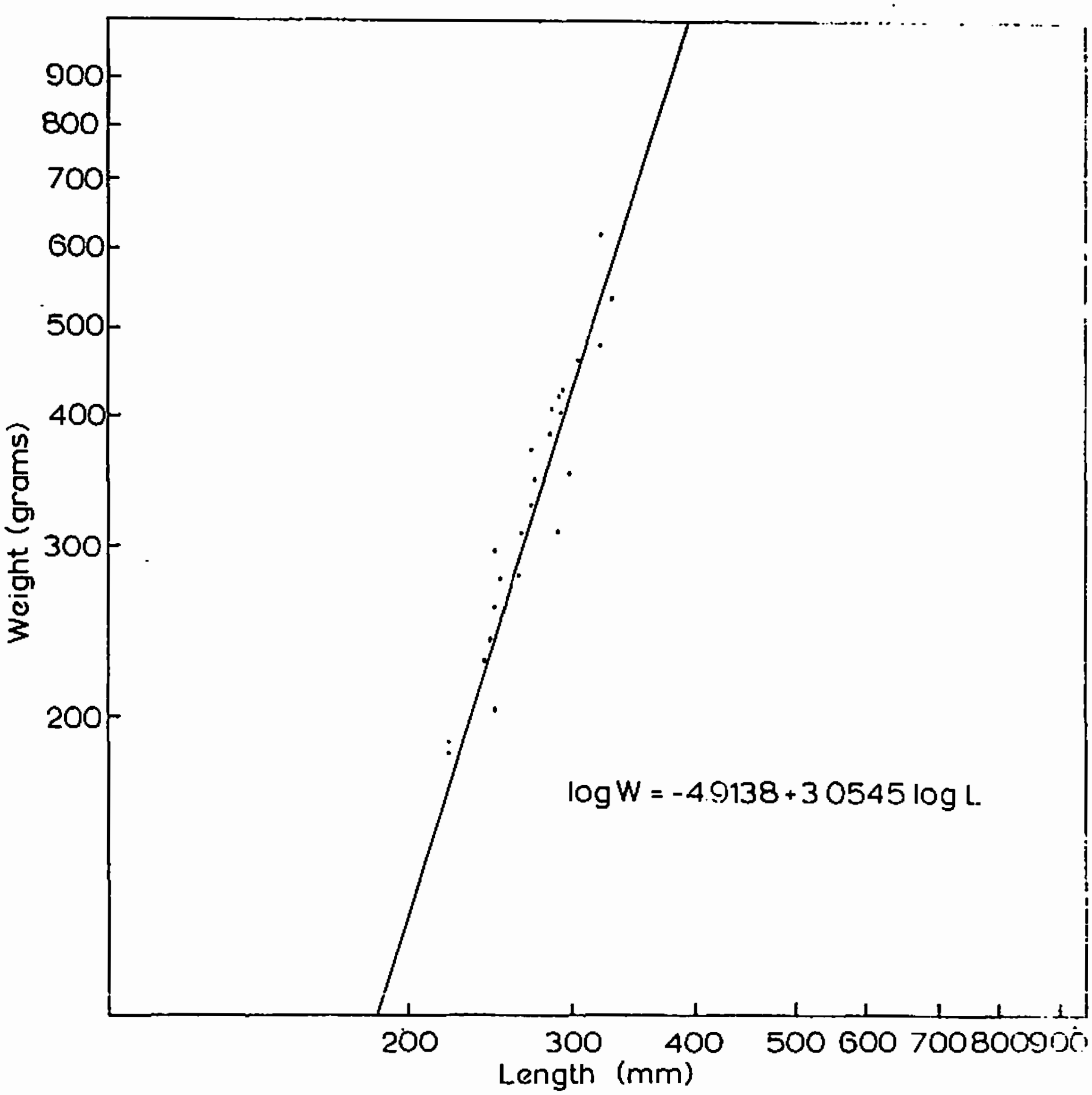

Figure 6. Length-weight relationship of adult white crappies, Lake Poinsett, South Dakota, 1975 and 1976.

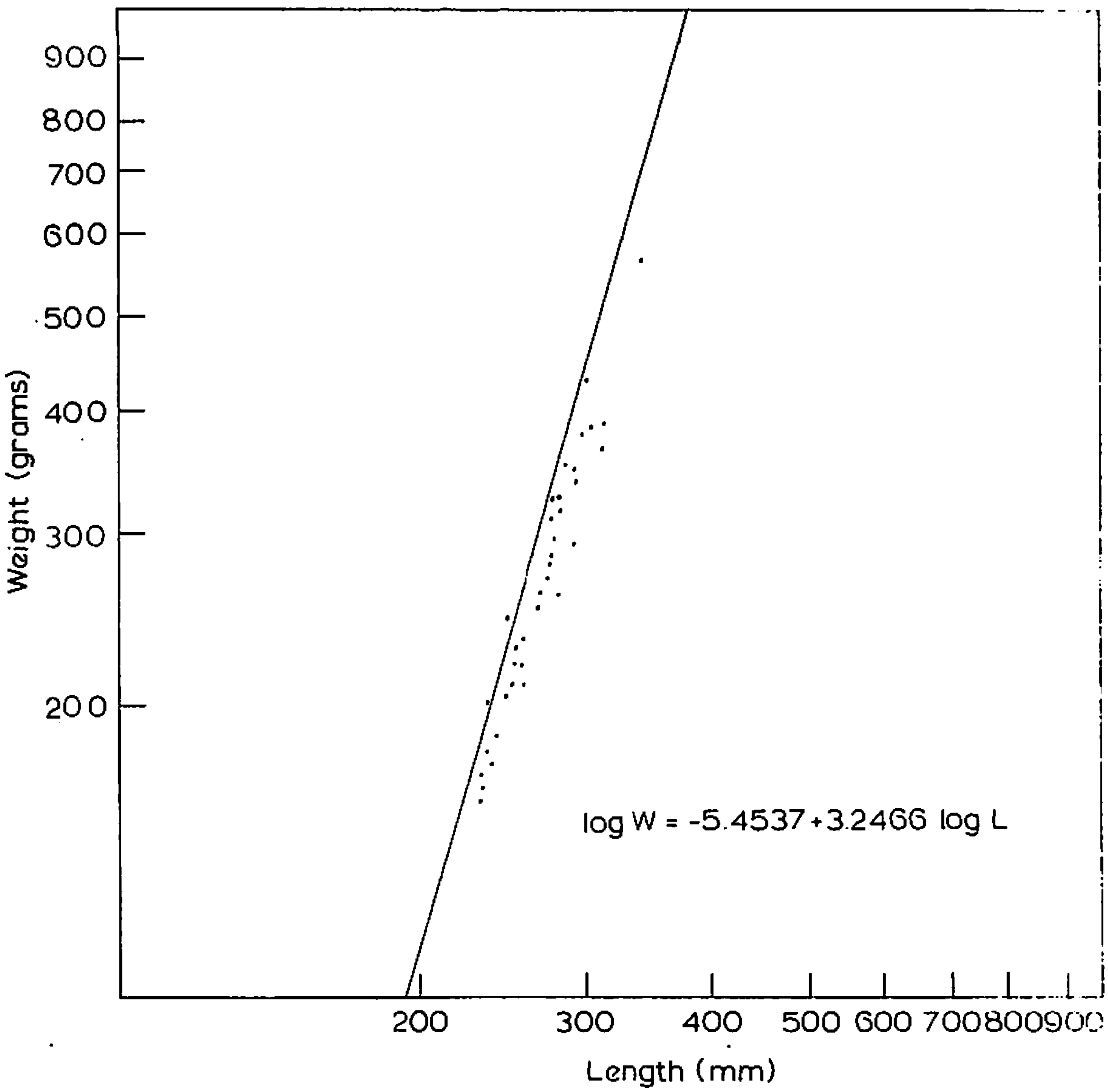

Figure 7. Length-weight relationship of adult black crappies, Lake Poinsett, South Dakota, 1975 and 1976.

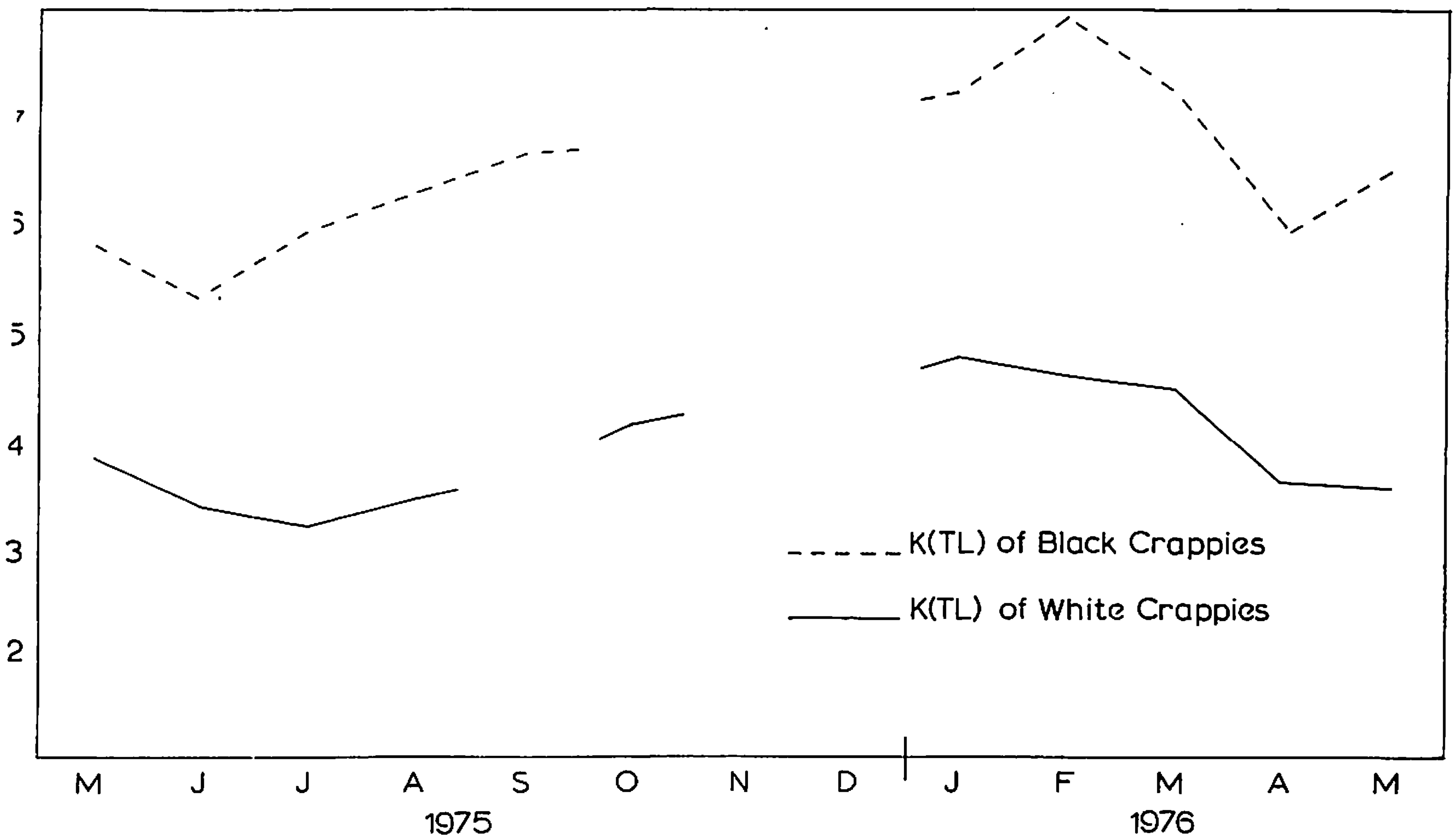

Figure 8. Average monthly coefficients of condition, K(TL), of adult white crappies and adult black crappies, Lake Poinsett, South Dakota, 1975 and 1976.

Hansen was unable to give a satisfactory explanation of the condition cycles of the Illinois white crappies. Their condition decreased approximately 15 % by mid-summer, but eggs of gravid females comprised no more than 5 % of the body weight. White crappies in Lake Poinsett decreased in condition 10.7 % and black crappies by 14.2 % during the spring. The fullness of the crappie stomachs during the winter (Tables 1 and 2) certainly increased the condition of the crappies at that time. The full stomachs, together with the expulsion of eggs and sperm during the spring, may account for the decrease in the coefficients of condition.

Reproduction

The youngest white crappies captured were from the 1973 year-class. The youngest black crappies were spawned in 1972. Complaints by fishermen that "the crappies do not bite like they used to" were very common in 1975 and 1976. Records of the commercial fishery catch, kept by the South Dakota Department of Game, Fish, and Parks, show that the catch of white and black crappies in Lake Poinsett has been declining since 1972 (Figure 9). (Crappies and other sport fish are not sold commercially, but are returned to the water.) These facts, in addition to the difficulty encountered in catching crappies for this study, indicate that the abundance of crappies in Lake Poinsett is declining and is presently at a comparatively low level.

The decline appears to be a result of very poor spawning success during the years 1973-1976. The poor spawning success may be related to the declining water level in Lake Poinsett (Figure 10), which has left former spawning areas above the water line.

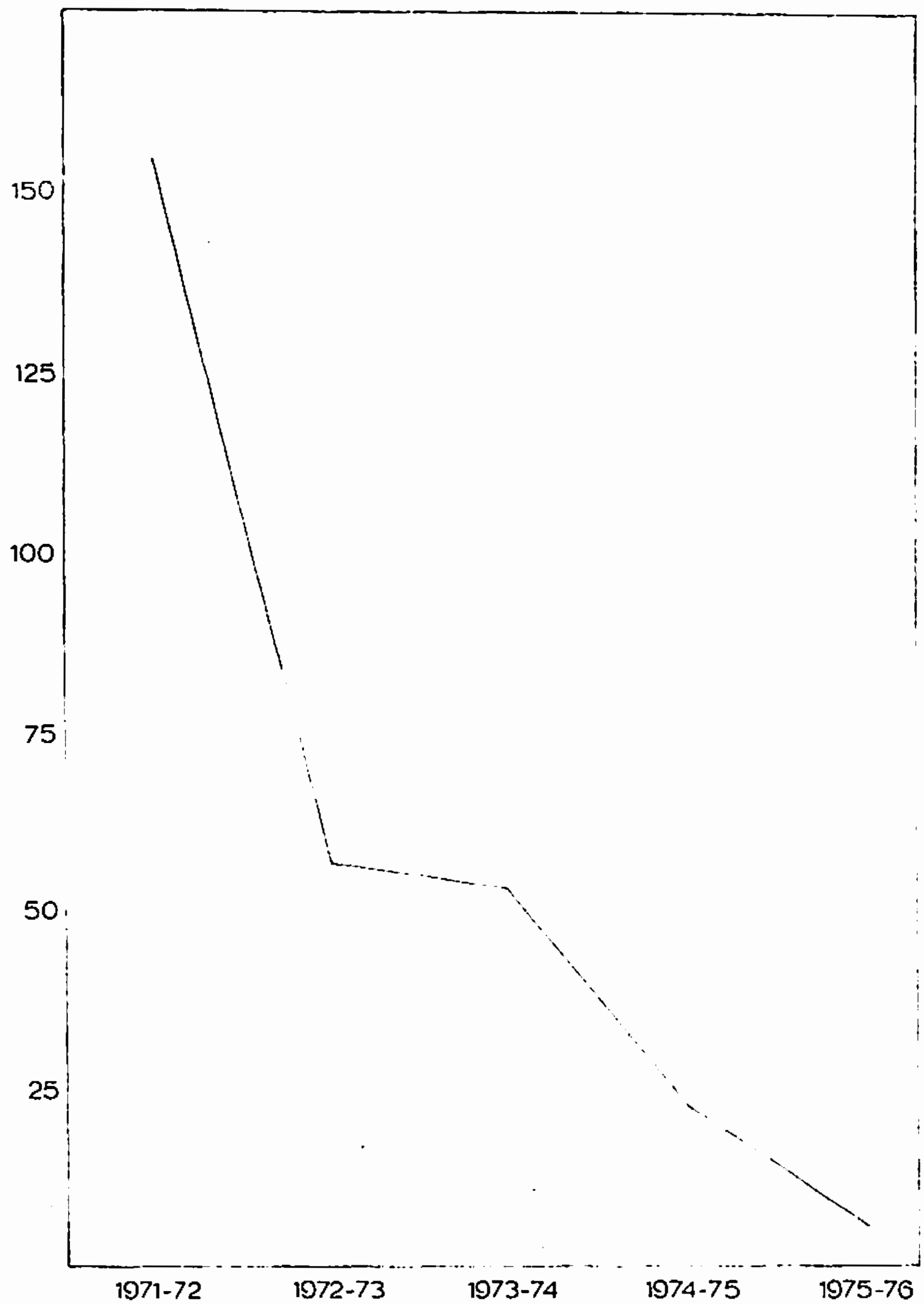

Figure 9. Mean number of crappies captured per seine haul by commercial fishermen during winter, Lake Poinsett, South Dakota. From records of South Dakota Department of Game, Fish, and Parks.

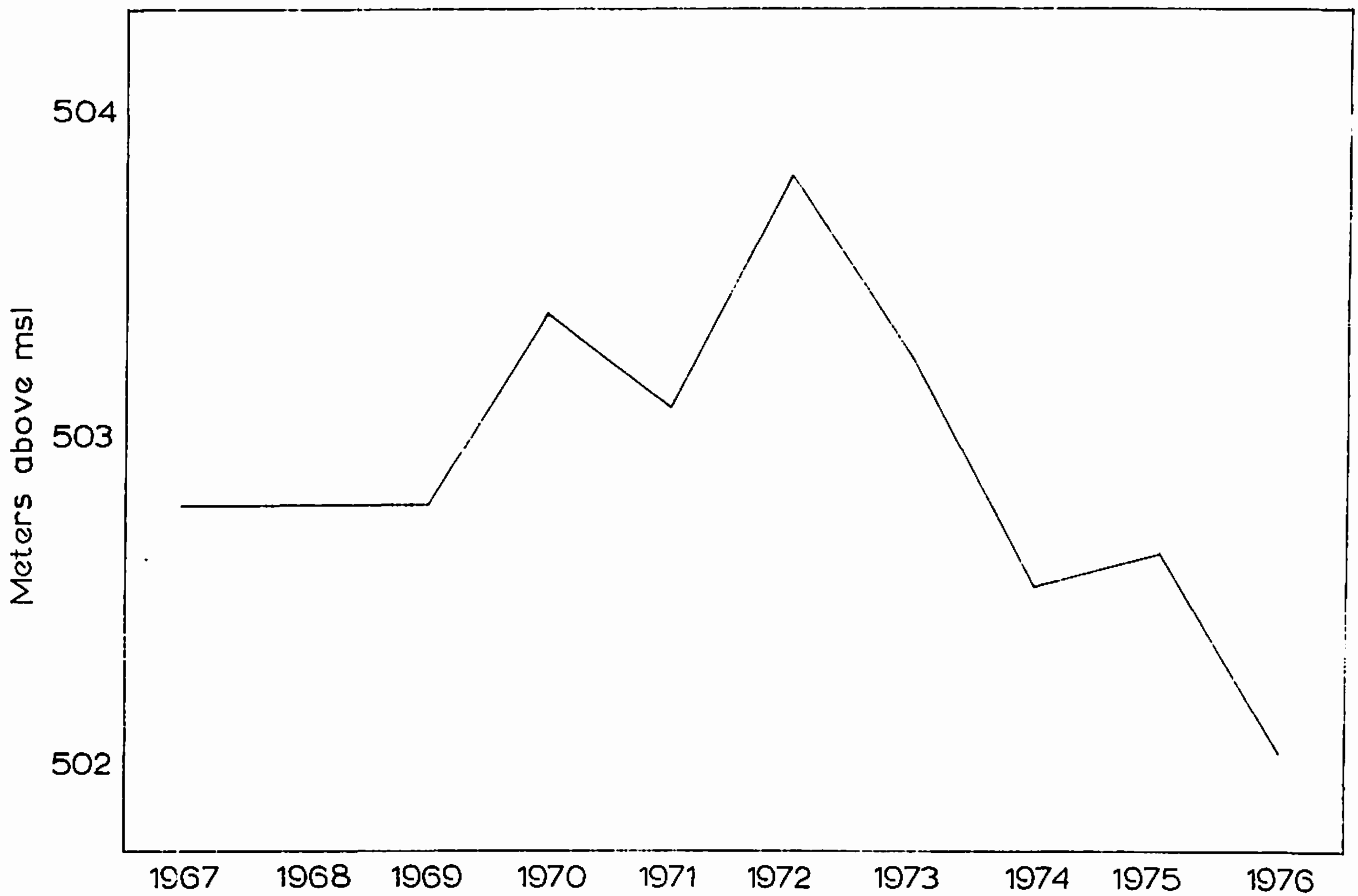

Figure 10. Annual low water level (meters above mean sea level), Lake Poinsett, South Dakota.

The lake is roughly oval in shape and at a low level has no sheltered, vegetated bays, which would be ideal spawning habitat for white and black crappies. Crappies are nest-builders and may use a variety of substrates, ranging from gravel to mud (Hansen 1951, Goodson 1966). The shallow areas of Lake Poinsett have substrate suitable for crappie spawning, but wave action frequently shifts the sand and gravel, possibly destroying nests and eggs. The outlet channel in the northeast corner of the lake (Figure 1) is approximately 2 m deep during periods of high water, at which stage the channel supports vascular aquatic vegetation, and may be good crappie spawning habitat. The channel contained water about 0.5 m deep during the summer of 1975 and dried up completely during the summer of 1976.

Hansen (1951) stated that the eggs of white crappies are often attached to vegetation. During their spawning period in Lake Poinsett, white and black crappies congregated near rocky shoreline areas (Figure 1), possibly to take advantage of dense stands of Cladophora sp. growing on the boulders and rubble. This filamentous alga may be an adequate substitute for vascular vegetation during crappie spawning if wave action is light, but this is rarely the case for any length of time in Lake Poinsett. In fact Cladophora sp. is primarily adapted to growing on rocks in turbulent water. Although the crappies chose the rocky areas as the most suitable for spawning, they were not capable of reproducing successfully there, probably due to wave action. The problem is aggravated by the emergence of much of the rocky shoreline during low water.

Starrett and Fritz (1957) stated that the year-class strength of crappies in Illinois lakes varies greatly. They also reported that white and black crappies may shift dominance between themselves and that when crappie populations are low, another species, such as bluegills, may be at an unusually high level. Factors other than water level, such as predation on young crappies or competition with other species may also be important in affecting the abundance of crappies in Lake Poinsett. Yellow perch produced strong year-classes in 1975 and 1976 and may be outcompeting the crappies.

Egg counts, performed on several crappies during the spawning period in 1975 (Table 8), fall within the ranges given in the literature (Breder and Rosen 1966, Hansen 1951). Fecundity of both species increased with age.

Ripe females of both species were captured from late May through early August, 1975, although the incidence of ripe crappies declined through the summer. Eggs were found in all female crappies dissected during the study. This indicates that not all eggs were shed during spawning. Hansen (1951) stated that white crappies often reabsorb many of their eggs. It may be that a lack of suitable spawning areas inhibited the shedding of eggs and increased the number reabsorbed.

Sexual dimorphism occurs in white crappies in Illinois (Hansen 1951). During the spawning period male white crappies become very dark, while females retain their normal light color. This condition was found in the white crappies of Lake Poinsett from May through late August, 1975, although the proportion of dark males declined through the summer. The change in color was first noted again in mid-March, 1976,

Table 8. Fecundity of white crappies and black crappies, Lake Poinsett, South Dakota, 1975.

	Age of fish	No. of fish	Mean no. of eggs	Range
White crappies	2 years	1	15,199	—
	3	10	42,405	17,567-94,813
	4	3	68,272	33,333-94,043
		Total: 14	Mean: 46,005	
Black crappies	3	1	20,653	—
	4	2	59,220	46,360-72,080
		Total: 3	Mean: 46,364	

approximately 60 days before the beginning of the spawning period. The condition appears to be reliable for sexual differentiation of white crappies only during the height of spawning activity during late May and early June. No change of color was noted in black crappies.

The white and black crappies of Lake Poinsett were primarily planktivorous and piscivorous. They were highly selective for *Daphnia pulex* over other zooplankton species but did not show a preference for any particular species of forage fish. Their growth rates were comparable to those in similar temperate lakes and increased in recent years in conjunction with a decline in their numbers. The decline appears to be due to a lack of spawning habitat caused by the declining water level of Lake Poinsett.

Future studies on the food of yellow perch and spottail shiners in Lake Poinsett would be useful in clarifying the trophic interrelationships there. During the next period of high water, spot checks should be made to corroborate the hypothesis that low water levels prevent crappie reproduction in Lake Poinsett.

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