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Food Habits, Growth, and Production of Young-of-the-Year Walleyes, Stizostedion vitreum vitreum (Mitchell), in a South Dakota Pond

Ronne E. Walker

FOOD HABITS, GROWTH, AND PRODUCTION OF YOUNG-OF-THE-YEAR WALLEYES, *Stizostedion vitreum vitreum* (Mitchill), IN A SOUTH DAKOTA POND

BY

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REW

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IN A SOUTH DAKOTA POND

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.

FOOD HABITS, GROWTH, AND PRODUCTION OF YOUNG-OF-THE-YEAR WALLEYES, Stizostedion vitreum vitreum (Mitchill), IN A SOUTH DAKOTA POND

Abstract

RONNE E. WALKER

A 12.45 hectare South Dakota pond was stocked with 25,000 walleye, Stizostedion vitreum vitreum (Mitchill), fingerling on 13 June, 1973. Walleyes were monitored for growth rate and food habits until 13 September, 1973. Walleyes were removed from the pond using various methods in order to evaluate the efficiency of removal methods.

The average total length and average weight of walleyes in the pond increased from 43.5 mm and 0.50 g on 13 June to 167.1 mm and 41.25 g on 13 September. This was a gain of 123.6 mm and 40.75 g or an average daily increase of 1.34 mm and 0.44 g. The growing season was not complete at the time of the last sampling.

Stomachs of 177 young-of-the-year walleyes were examined during the study period. Diaptomus sp. was found in 49.7% of the stomachs (8.0% by volume). Fathead minnows (Pimephales promelas, Rafinesque) were found in 26.6% of the stomachs (69.2% by volume) and aquatic insects in 21.5% (17.6% by volume). Walleyes fed primarily on Diaptomus sp. until mid-July when they began feeding primarily on fathead minnows. Fathead minnow populations declined

and in mid-August walleyes sought an alternate food source. Aquatic insects, mostly chironomids, were the primary food at this time.

A total of 4,416 walleyes (17.7%) was removed from the pond. Of these, 2,347 were removed with seines, 1,937 with electrofishing gear, and 111 with trap nets. Seining yielded 287.3 fish per hour of operation, electrofishing yielded 221.4 fish per hour, and trap netting yielded 2.1 fish per hour. Electrofishing had the highest yield per effort of all methods used, yielding 75.2 walleyes per man-hour. Seining yielded 45.0 walleyes per man-hour and trap netting yielded 10.1 fish per man-hour.

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INTRODUCTION

Potholes and marshes are abundant in the glaciated portion of the northern Midwest. These wetlands are highly productive but, because they are subject to winterkill, they support no sportfish populations. These habitats provide areas where young fish may be stocked, left until they reach a desirable size, and restocked into larger bodies of water. Such a program provides a means of utilizing the high productivity of wetlands to produce a desirable-sized sportfish for stocking at a relatively low cost. The objectives of this study were to (a) evaluate Saarinen's Pond as a natural rearing area for young-of-the-year walleyes, *Stizostedion vitreum vitreum* (Mitchill), by following their growth rate and production in the pond; (b) study the food habits of the walleyes in the pond; and (c) evaluate methods of removing the walleyes from the pond near the end of the growing season.

STUDY AREA AND METHODS

Saarinen's Pond is a 12.45 hectare (30.76 acre) isolated embayment on the northwest side of Lake Poinsett in Hamlin County, South Dakota, elevation 503 meters (1,650 feet). The pond is rhomboid shaped with a uniform shoreline and no inlet or outlet. Shoreline development is 1.2. The pond has an average depth of 1.37 meters (4.5 feet) and a maximum depth of 1.83 meters (6.0 feet). The embayment is eutrophic and high in mineral content (specific conductance 1,680-2,000 micro-mhos/cm at 25C).

At the time of this study, emergent vegetation consisted of a stand of cattails on the east shore, and submergent vegetation was abundant throughout the pond. Ice generally covers the pond from November to March.

Saarinen's Pond was treated with NaCn (sodium cyanide) at a rate of 2.45 ppm on 22 September, 1972 to remove resident populations of fathead minnows, *Pimephales promelas* Rafinesque, carp, *Cyprinus carpio* Linneaus, and bigmouth buffalo, *Ictiobus cyprinellus* (Valenciennes); and stocked with 25,000 walleye fingerling (36 pounds) on 13 June, 1973. A complete kill of fathead minnows was not attained and a fathead minnow population remained in the pond at the time of this study. Walleyes and fathead minnows were sampled weekly from 19 June, 1973 to 13 September, 1973 with a 60.96 meter (200 foot) bag seine of 6.35 mm (1/4 inch) mesh. The standard seine haul was landed each time on the south shore where submergent vegetation was least abundant. Seine hauls were used as an index for relative abundance of fathead minnows. Fish samples were preserved in a 10% formalin solution for later analyses. Larger specimens were slit on the ventral side to allow adequate penetration of the preservative.

Walleyes were weighed and measured (total length) and stomach contents were identified using keys in Freshwater Biology (Edmondson, 1959) and counted. Contents with high numbers of *Diaptomus* spp. were diluted and subsampled to aid in counting. All other stomach contents were counted in entirety. Volumes of food items were measured by water displacement (Lagler, 1952).

Two zooplankton samples were collected each week with a metered Miller sampler (Miller, 1961) equipped with a No. 10 plankton net and preserved in 10% formalin. Zooplankters were identified to genus using keys in Freshwater Biology (Edmondson, 1959) and three 1 ml subsamples were counted in a circular counting chamber at 30X.

Food electivity for young-of-the-year walleyes for four categories of zooplankton was determined by an electivity index (Ivlev, 1961). The formula used to calculate the indices was:

$$E = \frac{r_i - P_i}{r_i + P_i}$$

where

E = electivity (selectivity)

r = percent occurrence of a food item in the stomach

p = percent occurrence of the item in the environment

Electivity values range from -1 to +1, indicating complete avoidance and complete selection, respectively. An index of zero indicates no selection or avoidance for the food item.

Various methods of seining, trap netting, and electrofishing to remove walleyes from Saarinen's Pond were evaluated. A 60.96 meter (200 foot) bag seine with 6.35 mm (1/4 inch) mesh and a 120.40 meter (395 foot) seine constructed from three smaller seines with 6.35 mm (1/4 inch) and 12.70 mm (1/2 inch) mesh were tested. Trap nets had mesh sizes of 6.35 mm (1/4 inch) and 19.05 mm (3/4 inch). A jon boat equipped with a variable ac-dc generator was used for electrofishing. The boat was powered by a 10 hp. outboard motor.

A portable water pump with an output of 208.18 liters per minute (55 gallons per minute) was used to produce an artificial current in the pond to attract walleyes on 1 August and 13 September. Trap nets were set in differing configurations across the current to capture walleyes (Figures 1 and 2).

Copper sulfate ($CuSO_4$) was applied to the pond to act as an irritant and increase walleye movement on 30 September. Copper sulfate was evenly distributed in the western 2/3 of the pond, and the eastern 1/3 of the pond was left untreated. Trap nets and a 120.40 meter (395 foot) seine were used to separate the two zones and to capture walleyes attempting to move from the treated to the untreated zone. Trap nets were checked and seine hauls were made before and after treatment to determine if copper sulfate increased walleye movement and harvest (Figure 3).

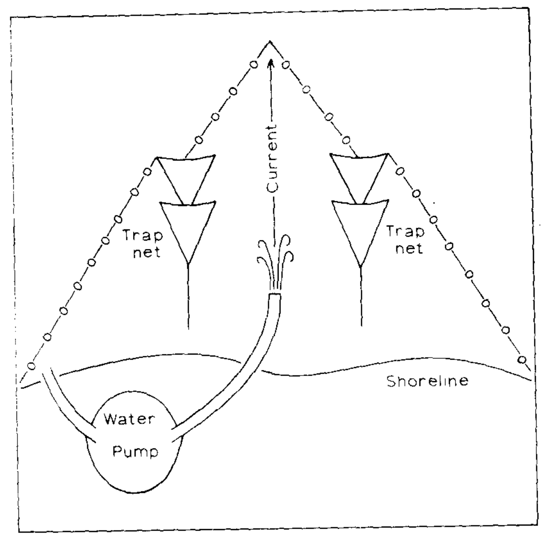

Figure 1. Arrangement of trap nets in an artificial water current to capture walleyes 1 August, 1973, Saarinen's Pond, South Dakota.

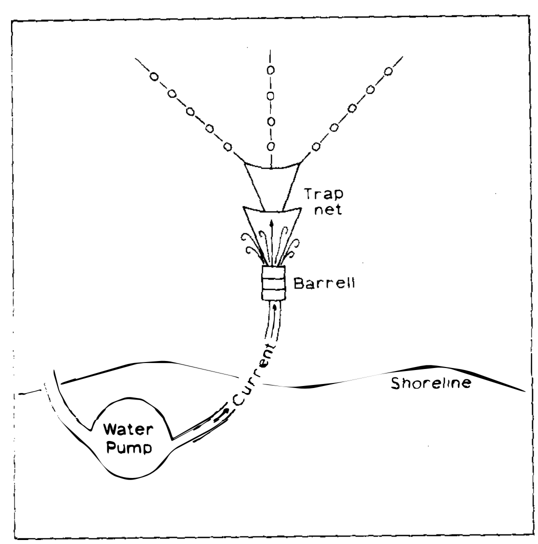

Figure 2. Arrangement of trap nets in an artificial water current to capture walleyes 13 September, 1973, Saarinen's Pond, South Dakota.

Artificial light was used to attract walleyes at night on 24 October. Three trap nets were set under floodlights powered by a gasoline generator. Another trap net was set on the same shore away from the lights. The time intervals both nets were in the water and their respective catches were compared (Figure 4).

A shelter was constructed by covering a trap net with a sheet of black plastic on 14 November. Another trap net was set on the same shore, but left uncovered. The time intervals both nets were in the water and their respective catches were compared (Figure 5).

Methods of walleye capture were compared on the basis of catch per hour of operation. Certain methods were also compared on a catch per man-hour basis to further clarify the cost and effort involved.

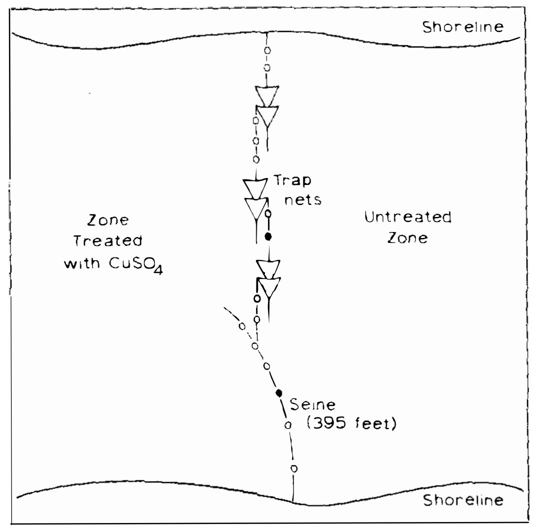

Figure 3. Trap nets and seine separating treated ($CuSO_4$) and untreated zones of Saarinen's Pond, South Dakota, 30 September, 1973.

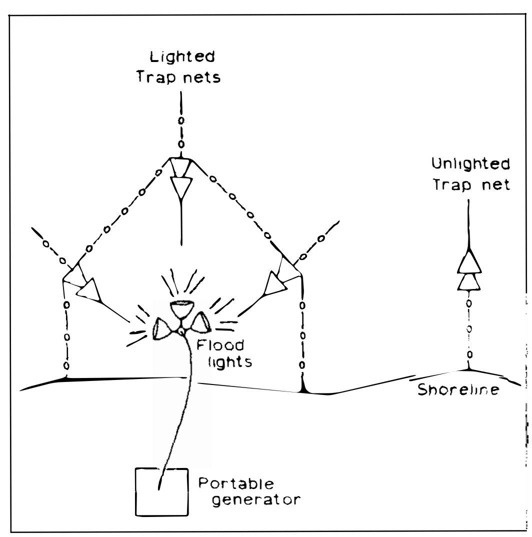

Figure 4. Lighted trap nets used to capture walleyes 24 October, 1973, Saarinen's Pond, South Dakota.

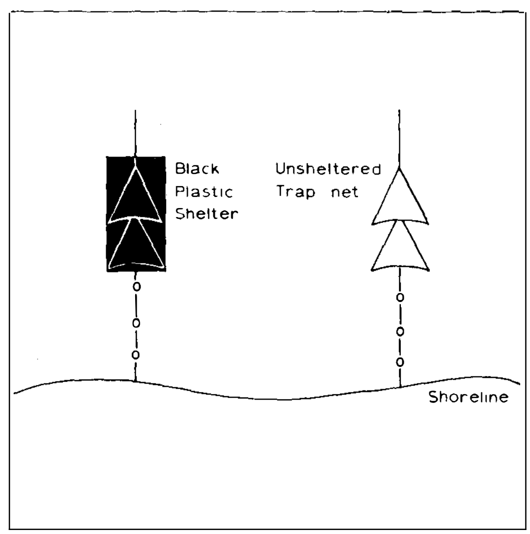

Figure 5. Dark shelter used to capture walleyes 14 November, 1973, Saarinen's Pond, South Dakota.

RESULTS AND DISCUSSION

Food habits of young-of-the-year walleyes in Saarinen's Pond

Stomachs of 177 young-of-the-year walleyes were examined during the study period. *Diaptomus* sp. was found in 49.7% of the stomachs (8.0% by volume). Fathead minnows were found in 26.6% of the stomachs (69.2% by volume); and various aquatic insects in 21.5% (17.6% by volume).

Diaptomus sp. was utilized most heavily by young walleyes early in the summer. Prior to and on 10 July, the percent occurrence of *Diaptomus* ranged from 70.6% to 95.0% (16.7% to 100% by volume) for the weekly samples. As summer progressed, walleyes fed less upon copepods and more upon fathead minnows and insects. *Diaptomus* declined in importance as a food after 10 July and was no longer utilized by walleyes after 7 August (Table 1, Figure 6).

Fathead utilization increased from 10 July to 24 July and 71.4% of the walleye stomachs examined on 24 July contained fathead minnows. During the period from 24 July to 7 August, 47.1% to 71.4% of the walleyes examined had eaten fathead minnows. Percent volume ranged from 97.0% to 98.7% during this period. Between 8 August and 21 August, consumption of fathead minnows decreased rapidly and the percent occurrence of fatheads dropped to 9.1% (25.0% by volume) on 21 August. Fathead minnows were not observed in stomachs after 21 August.

Table 1. Percent volume and percent occurrence (parentheses) of food items found in stomachs of young-of-the-year walleyes, 19 June to 13 September, 1973, Saarinen's Pond, South Dakota.

Date	*Diaptomus*	Fathead Minnows	Insecta	Amphipoda	Hirudinea
19 June	60.00 (88.24)	20.00 (11.76)	20.00 (5.88)		
26 June	100.00 (95.00)				
3 July	16.67 (70.59)	83.33 (29.41)			
10 July	54.84 (90.00)	29.03 (5.00)	3.23 (10.00)	3.23 (5.00)	9.68 (5.00)
18 July	25.00 (60.00)	75.00 (40.00)	T* (13.33)		
24 July	1.30 (35.71)	98.70 (71.43)	T (7.14)		
31 July	2.99 (25.00)	97.01 (70.00)			
7 Aug.	1.57 (29.41)	98.43 (47.06)			
21 Aug.		25.00 (9.09)	70.45 (81.82)	4.55 (18.18)	
28 Aug.			100.00 (100.00)		
13 Sept.			32.44 (75.00)	29.78 (41.67)	37.78 (16.67)
Total	8.01 (49.72)	69.18 (26.55)	17.55 (21.47)	2.29 (5.08)	2.97 (1.69)

*Trace (T) = less than 0.05 ml of stomach volume.

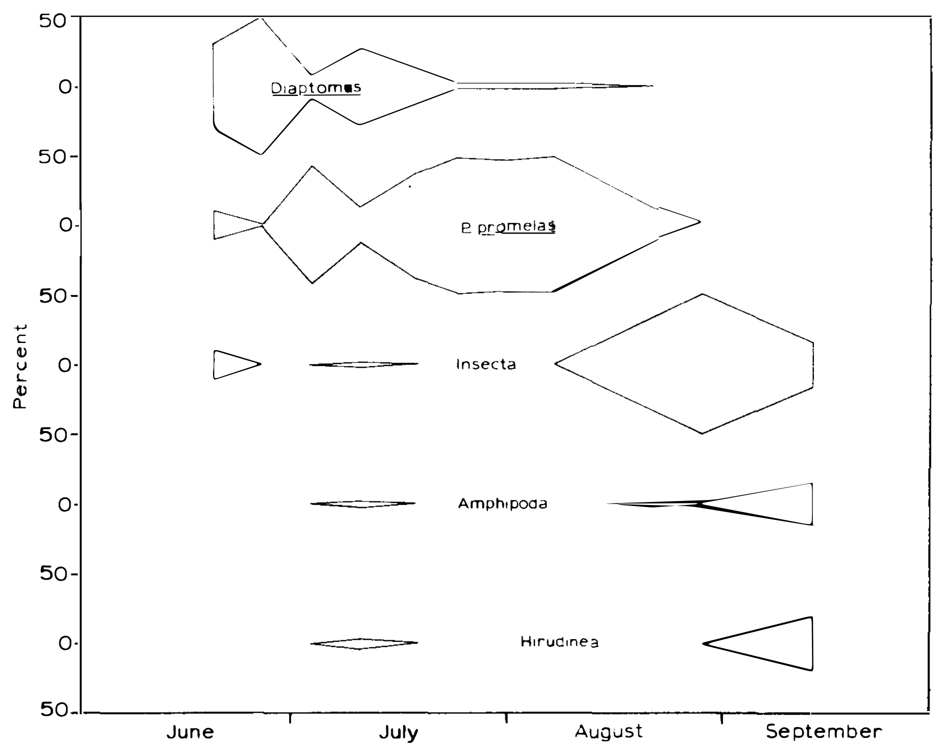

Figure 6. Percent volume of food items found in stomachs of young-of-the-year walleyes 19 June to 13 September, 1973, Saarinen's Pond, South Dakota.

Aquatic insects were the primary food of walleyes from 21 August to 13 September. Chironomidae (pupae and larvae) occurred in 84.4% of the stomachs during this period, Corixidae in 18.8%, Ephemeroptera in 15.6%, Odonata (Zygoptera) in 9.4%, and unidentifiable material occurred in 6.3% of the stomachs. Insects occurred in 100% of the walleyes examined on 28 August, and represented the entire food volume. Leeches (Hirundinea) and amphipods (Amphipoda) were of minor importance in July and August, but comprised 67.6% of the food volume on 13 September. Smith and Moyle (1945) reported that pond-reared walleyes in Minnesota fed on oligochaete worms, leeches, mollusks, and algae.

Walleyes between 48 mm and 100 mm total length fed primarily on Diaptomus sp.. No walleyes in Saarinen's Pond larger than 106 mm fed on Diaptomus while all walleyes smaller than 62 mm utilized this organism. The transition of the walleye diet from Diaptomus to fathead minnows appears to be related to the size of the walleye. The transition from fathead minnows to insects appears to be more closely related to the reduced levels of fathead minnows in Saarinen's Pond (Figure 7). Walleyes fed on fathead minnows until 7 August, after which only one fathead minnow was found in stomach samples.

Several authors have reported similar progressions of the walleye from an invertebrate to a vertebrate diet. Smith and Moyle (1945) found that walleyes in natural rearing ponds began feeding on rotifers; switched to copepods and cladocerans; then to an insect-crustacean diet; and finally to fish. According to Priegel (1969)

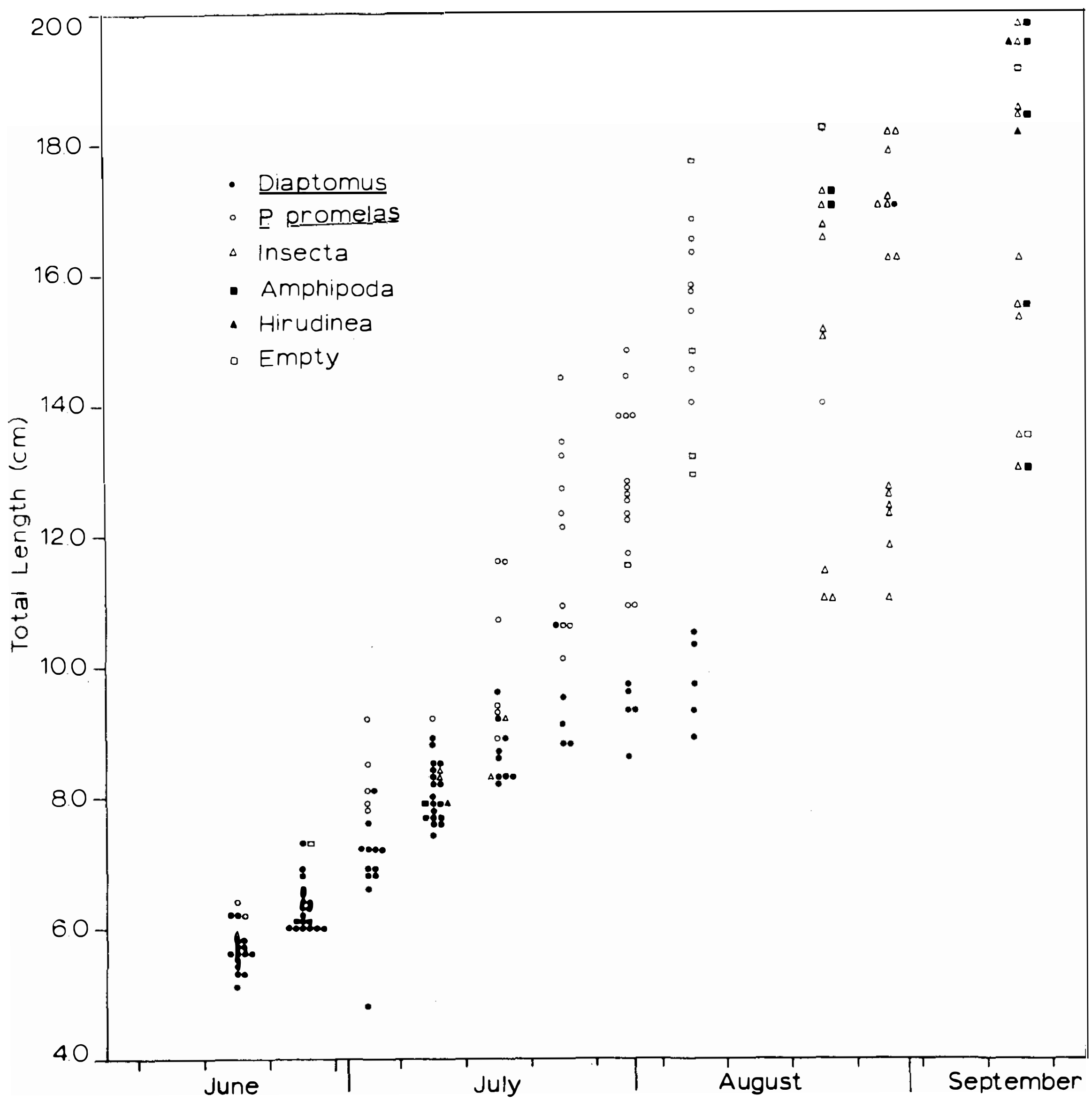

Figure 7. A comparison of food items ingested and total lengths of individual walleyes 19 June to 13 September, 1973, Saarinen's Pond, South Dakota.

walleyes smaller than 75 mm are generally considered plankton feeders, but beyond this length, they feed more heavily on forage fish, if this food source is extremely abundant. Whether walleye switch from zooplankton to insects or directly to fish and at what size depends primarily on the abundance of available food supplies.

The relative abundance of fathead minnows in Saarinen's Pond began to decrease when walleye fingerling became piscivorous. Fatheads existed only in small numbers on 7 August (Figure 8). The decrease in forage apparently forced the walleyes in the pond to seek alternate food, in this case aquatic insects. The diet became more varied after 7 August, an indication that adverse food conditions existed (Ivlev, 1961).

After fathead numbers in Saarinen's Pond had diminished, the numbers of Daphnia, Bosmina, and cyclopoid copepods increased (Figure 9). Fatheads were observed feeding on Daphnia, unidentified copepods, and insects (Ephemeroptera and Chironomidae). The decrease in predation from fathead minnows appears to be responsible, in part, for the increase in zooplankton numbers. Galbraith (1967) found that dramatic changes in the characteristics of Daphnia populations in Sporley Lake, Michigan coincided in time with the stocking of rainbow trout, Salmo gairdneri Richardson, the appearance of fathead minnows and smelt, Osmerus mordax (Mitchill), and the subsequent build up of large populations of fathead minnows and smelt. Higher numbers of larger zooplankters existed with lower levels of predation; as predation increased, larger zooplankters were selected by fishes and

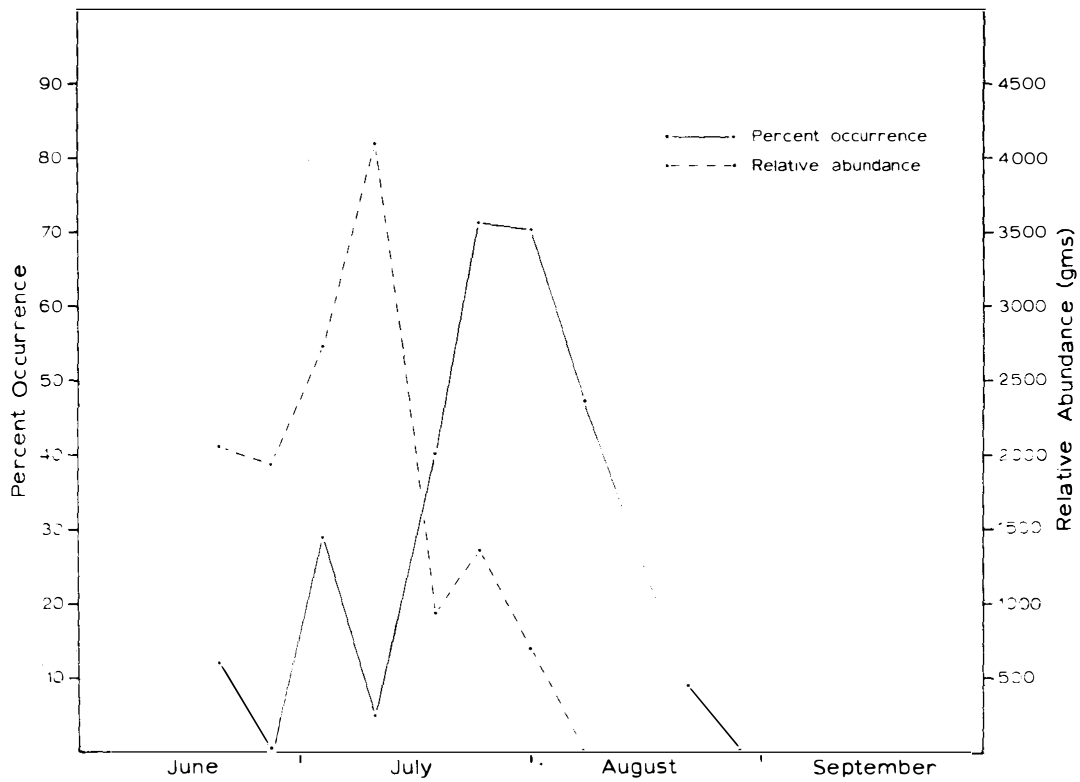

Figure 8. Comparison of percent occurrence of fathead minnows in stomachs of young-of-the-year walleyes and relative abundance of fathead minnows from standard 60.96 meter seine haul 19 June to 13 September, 1973, Saarinen's Pond, South Dakota.

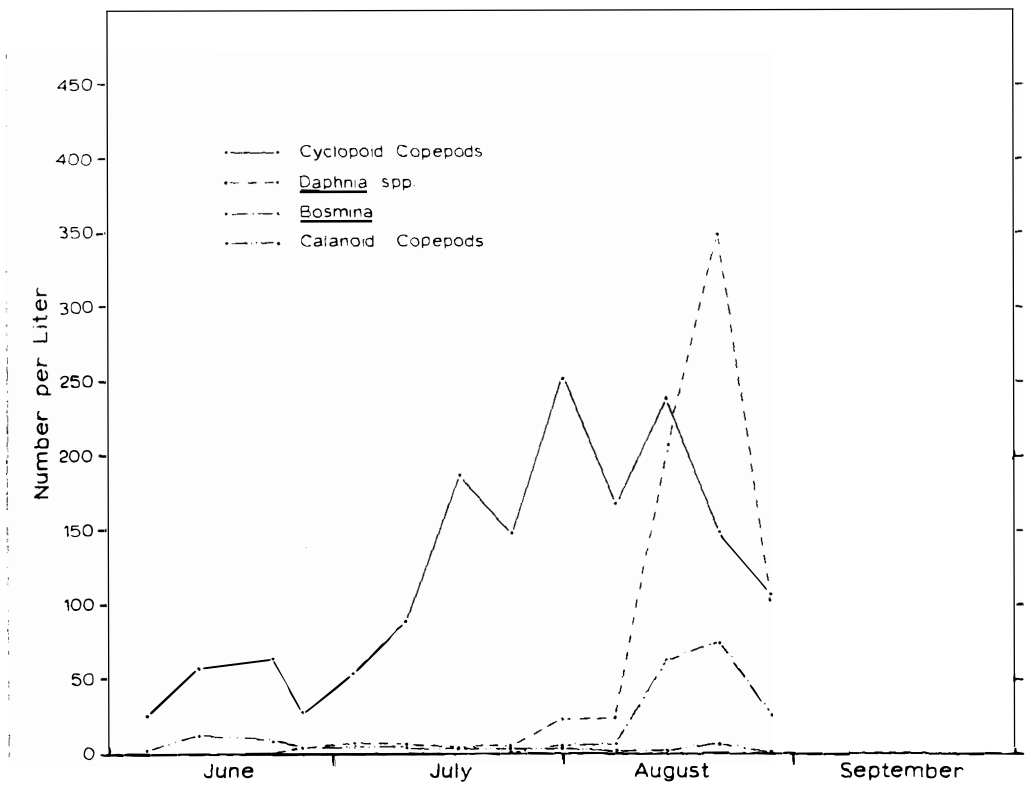

Figure 9. Numbers of major zooplankters per liter of pond water 17 April to 28 August, 1973, Saarinen's Pond, South Dakota.

their numbers decreased allowing smaller zooplankters (selected against) to increase in numbers. Gizzard shad, Dorosoma cepedianum (Lesueur), in Tuttle Creek Reservoir, Kansas had similar effects on zooplankton populations (Cramer and Marzolf, 1970).

Water clarity also increased in Saarinen's Pond after fathead minnows diminished in number. The turbidity of the pond water was, for the most part, caused by phytoplankton. Higher zooplankton numbers existed in Saarinen's Pond after fathead minnows diminished in number. A greater volume of water was filtered by the larger population of zooplankters in Saarinen's Pond, and water cleared noticeably between 21 and 28 August (Figure 10).

Zooplankters present at some time during the study period included two genera of Copepoda, Diaptomus and Cyclops; and three species of Cladocera, Daphnia parvula, D. galeata, and Bosmina longirostris. Cyclopoid copepods (Cyclops spp.) were the most abundant zooplankters until Daphnia spp. peaked in numbers on 21 August. Diaptomus was not relatively abundant at any time during the study, but their numbers were highest on 12 June (12.00 per liter) and 21 August (5.53 per liter). Bosmina was not observed in plankton samples until 24 July when its numbers began increasing to a peak of 74.28 per liter on 21 August (Table 2).

Young-of-the-year walleyes initially positively elected for Diaptomus. Positive electivity indices existed for this genus from 19 June to 7 August ranging from +0.73 to +1.00. The large size of Diaptomus (1.0 to 2.5 mm) might in part explain its initial utilization

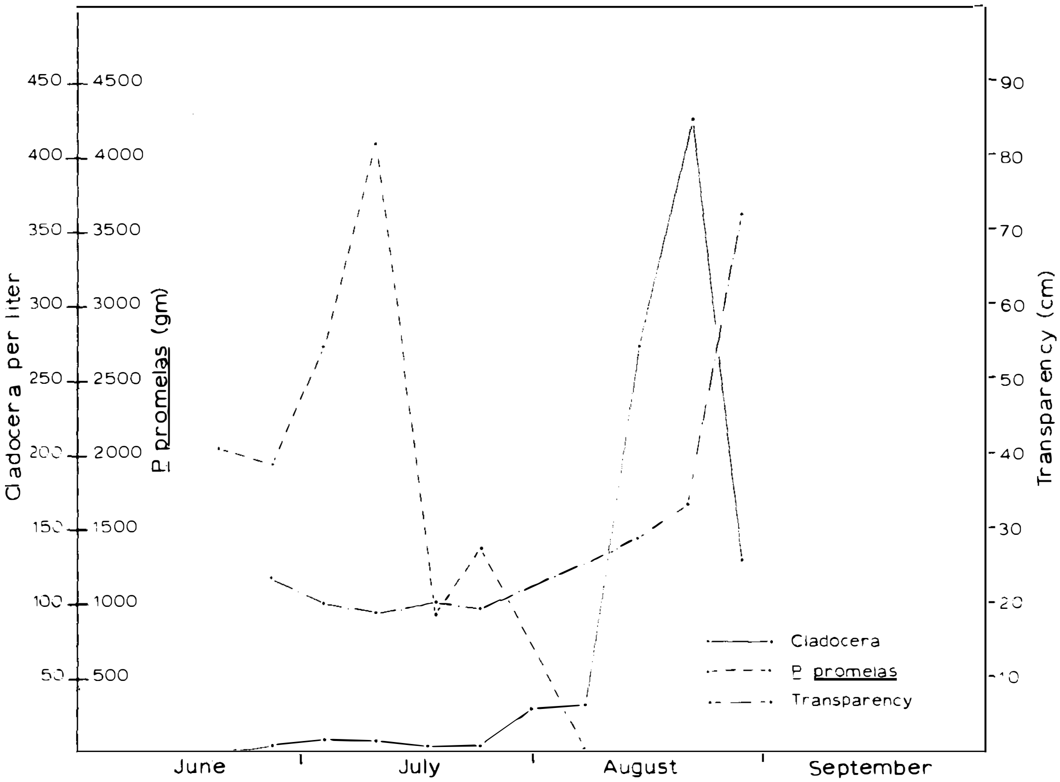

Figure 10. Comparison of the relative abundance of fathead minnows from standard 60.96 meter seine haul, the number of Cladocera per liter of pond water, and the transparency of the pond water 19 June to 28 August, 1973, Saarinen's Pond, South Dakota.

Table 2. Mean number per liter of zooplankters in weekly pond samples, 17 April to 28 August, 1973, Saarinen's Pond, South Dakota.

	Copepoda		Cladocera	
Date	Calanoid	Cyclopoid	*Daphnia*	*Bosmina*
17 April	9.82	77.08	3.30	
27 April		566.30		
3 May		34.36		
10 May	0.28	96.10		
15 May	0.44	149.16	0.72	
24 May		70.32		
30 May		93.80		
5 June	0.96	24.16		
12 June	12.00	57.00		
22 June	8.21	64.34		
26 June	4.84	26.66	1.70	
3 July	4.43	54.70	6.52	
10 July	4.73	88.92	5.72	
17 July	4.24	186.73	3.74	
24 July	3.21	146.38	4.82	4.73
7 Aug.	0.60	167.94	24.88	6.07
14 Aug.	0.60	239.30	207.40	62.48
21 Aug.	5.53	149.80	346.78	74.28
28 Aug.		105.45	102.98	24.66

by walleyes. Both size and abundance are factors involved in food selection (Houde, 1967). Diaptomus was no longer observed in walleye stomachs after 7 August, and the electivity indices for 21 and 28 August were -1.00 (Table 3). Priegel (1970) and Houde (1967) found that Diaptomus was negatively elected on all sampling dates in Lake Winnebago, Wisconsin and Oneida Lake, New York, respectively, but the larger sizes of Leptodora in Lake Winnebago and Epischura in Lake Oneida might have made them the more attractive prey items. Leach (1927) suggested that Diaptomus was perhaps unpalatable to walleye fingerling or possessed some defense mechanism that rendered it unavailable because hatchery reared walleyes refused to eat this organism. Diaptomus was the largest available zooplankter in Saarinen's Pond and was the major planktonic food organism.

Daphnia spp. were positively elected by walleyes on only one sampling date (+0.41 on 7 August). They were negatively elected (-1.00) on all other sampling dates except 19 June when they were not found in the environment. Neither cyclopoid copepods nor Bosmina was positively elected at any time during the study. The indices for Cyclops remained at -1.00 throughout the study; and the indices for Bosmina were -1.00 on all sampling dates when Bosmina was present in the environment.

Smith and Moyle (1945) found that Bosmina was taken by walleye fry in rearing ponds but ignored by fingerling able to ingest larger food items. Bosmina was not abundant in Saarinen's Pond until after walleyes were large enough to feed on fish and the fathead minnow

Table 3. Food electivity indices for zooplankton by young-of-the-year walleyes, 19 June to 28 August, 1973, Saarinen's Pond, South Dakota.

Date	Diaptomus	Daphnia	Cyclopoid Copepods	Bosmina
19 June	+0.78	--	-1.00	--
26 June	+0.73	-1.00	-1.00	--
3 July	+0.82	-1.00	-1.00	--
10 July	+0.89	-1.00	-1.00	--
18 July	+0.93	-1.00	-1.00	--
24 July	+0.89	-1.00	-1.00	--
31 July	-0.85	-1.00	-1.00	-1.00
7 Aug.	+1.00	+0.41	-1.00	-1.00
21 Aug.	-1.00	-1.00	-1.00	-1.00
28 Aug.	-1.00	-1.00	-1.00	-1.00

population had declined. This might explain why *Bosmina* was never found in the diet of walleyes examined.

No evidence of cannibalism was observed in walleyes examined. Eschmeyer (1950) reported older walleyes preying on young-of-the-year in Lake Gogebic. Forney, as reported by Regier *et al.* (1969), stated evidence of adult walleyes preying on young in the first winter of life when both age groups occupied a similar environment. Only one year-class of walleyes was present in Saarinen's Pond and although the size range might have permitted cannibalism late in the summer, none was observed.

According to Smith and Moyle (1945) the walleye is carnivorous; and toward the middle of the first season of growth, fish enter the diet in quantity. Beyond this the diet of the walleye is dependent on what foods are available. Regier *et al.* (1969) define the walleye as a generalized predator upon organisms occupying all habitats within its common environment.

Growth of young-of-the-year walleyes in Saarinen's Pond

The average total length and average weight of walleyes in Saarinen's Pond increased from 43.5 mm and 0.50 g on 13 June to 167.1 mm and 41.25 g on 13 September. This was a gain of 123.6 mm and 40.75 g or an average daily increase of 1.34 mm and 0.44 g. The growing season was not complete at the time of the last sampling (Table 4, Figure 11).

Table 4. Growth of young-of-the-year walleyes, 13 June to 13 September, 1973, Saarinen's Pond, South Dakota.

	Weight*			Total Length**		
Date	Average	Increase	I_w/D***	Average	Increase	I_l/D***
13 June	0.50			4.35		
19 June	1.50	1.00	0.167	5.69	1.34	0.223
26 June	2.40	0.90	0.129	6.40	0.71	0.101
3 July	4.00	1.60	0.229	7.69	1.29	0.184
10 July	5.19	1.19	0.170	8.47	0.78	0.111
18 July	8.33	3.14	0.393	9.32	0.85	0.106
24 July	15.57	7.24	1.210	11.28	1.96	0.327
31 July	14.50	-1.07	-0.153	11.93	0.65	0.093
7 Aug.	27.70	13.20	1.850	13.39	1.46	0.209
21 Aug.	33.50	5.80	0.414	14.82	1.43	0.102
28 Aug.	35.80	2.30	0.329	14.99	0.17	0.024
13 Sept.	41.25	5.45	0.007	16.71	1.72	0.108
Total		40.75	4.745		12.36	1.588
Mean		3.70	0.431		1.12	0.144

*gm

**cm

***I/D = increase / number of days between sampling dates.

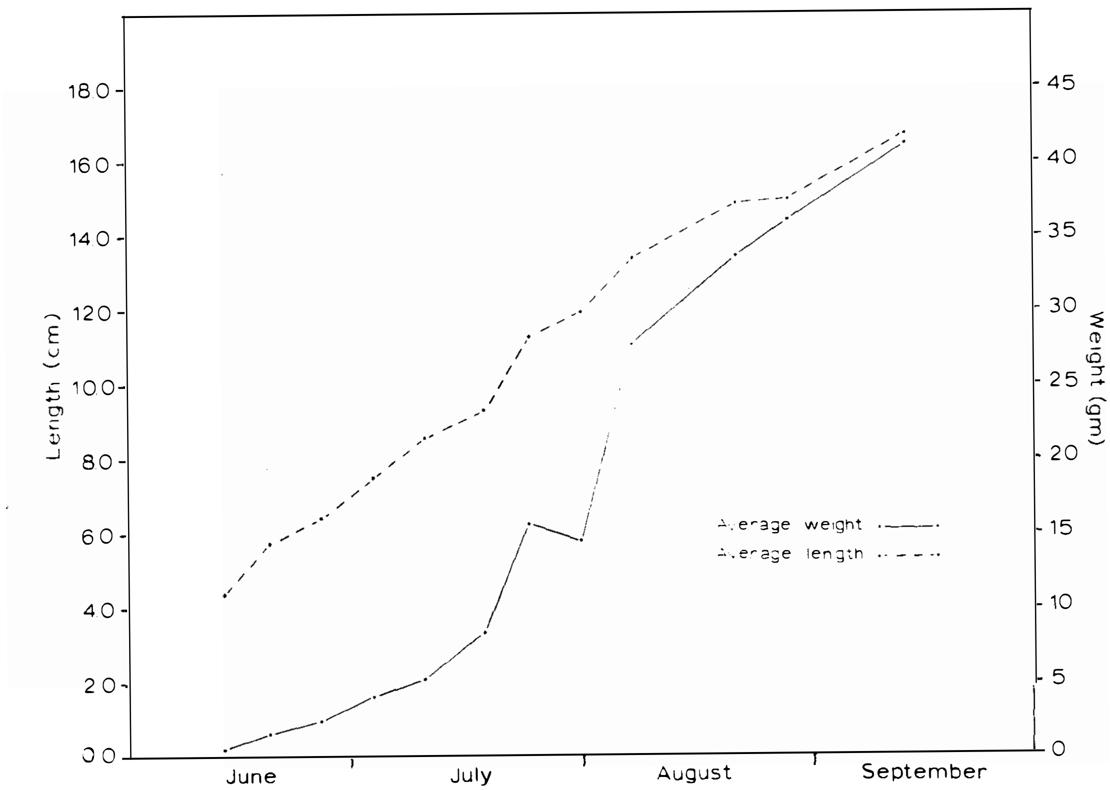

Figure 11. Comparison of average weight (gm) and average total length (cm) of weekly samples of young-of-the-year walleyes 13 June to 13 September, 1973, Saarinen's Pond, South Dakota.

Similar first year growth rates have been reported in various northern lakes. The following total lengths have been reported as being attained in the first season of growth; 119 to 165 mm in Oneida Lake, New York (Forney, 1966); 130 to 175 mm in Lake Winnebago, Wisconsin (Priegel, 1970); 137 mm in Red Lakes, Minnesota (Smith and Pycha, 1960); and 109 mm in Lac LaRonge, Saskatchewan (Rawson, 1957). Higher growth rates have been reported for walleyes in Canton Reservoir, Oklahoma (Grinstead, 1971) and Norris Reservoir, Tennessee (Stroud, 1949), where young-of-the-year fish attained lengths of 310 mm and 262 mm, respectively.

One factor responsible for various growth rates from different regions is the length of the growing season. Walleyes from Canton Reservoir had completed only 91% of their first year growth by November (Grinstead, 1971); while those from Norris Reservoir had completed their entire first year growth by November (Stroud, 1949). In comparison, Forney (1966), Priegel (1970), and Rawson (1957) reported that very little first year growth took place after 1 October in their respective lakes; and Smith and Pycha (1960) observed 86 to 91% of the first year growth being completed by 30 August in Red Lakes. The growing season in Saarinen's Pond is shorter than that found in Canton or Norris Reservoirs. The growth rate of walleyes in Saarinen's Pond is similar to the growth rates recorded for other northern lakes with relatively short growing seasons.

According to Grinstead (1971), the fact that Canton Reservoir walleyes attained a length of 310 mm in an 8 month growing season while walleyes in the northern lakes attained total lengths of 109 mm to 175 mm in a 5 to 6 month growing season suggests that first year growth is not a linear function of growing season. Smith and Pycha (1960) reported that factors such as temperature, food availability, time of spawning, abundance of older fish, and abundance of other small competing or forage species, affect the growth rate of walleyes.

Temperature influences the metabolic rate of poikilothermic organisms. In addition, spring temperatures govern time of spawning and time-of-hatch for the walleye. The increase in average total length of walleyes in Saarinen's Pond from one sampling date to the next was calculated and divided by the number of days in each sampling period, thus yielding a growth index expressed as average length (mm) increased per day. This index was correlated with air and water temperatures recorded on each sampling day for Saarinen's Pond, but no values were significant. Since only one year-class of hatchery fish was monitored in the pond, time of spawning and time of hatch would not have been expressed in the correlations.

Forney (1966) found that Oneida Lake temperatures determined growth in early summer; however growth may have been a reflection of early or late hatching which would be influenced by temperatures in early May. Smith and Pycha (1960) compared air-degree-days above 7.2°C (45°F) and 10°C (50°F) for Red Lakes with total lengths of walleyes at the end of 17 growing seasons, 1940 to 1956. All summations of degree days showed positive correlations with first year growth, but none were significant below the 15% level. Early spring temperatures in Saarinen's Pond had no influence on walleye growth rate since walleyes were not stocked until 13 June.

The only vertebrate found in the diet of walleyes in Saarinen's Pond was the fathead minnow. Growth increment (in total length) per day for each sampling period was correlated with the percent occurrence of fathead minnows, Diaptomus, and insects for each sampling period. The correlation between the percent occurrence of fathead minnows in the walleye diet and the daily growth increment was the only correlation that was positive, but none of the correlations were significant (Table 5).

Walleyes in Lake Winnebago grew fastest in years when forage fish were frequently found in walleye stomachs (Priegel, 1969). August and September growth increments were lowest for walleyes in Oneida Lake in years when invertebrates were common in the diet, and highest when fish were consumed (Forney, 1966). Morsell (1970) found that the highest fish consumption occurred when walleye growth was the fastest in Escanaba Lake, Wisconsin; and the lowest fish consumption occurred when growth was slowest. Smith and Pycha (1960) found that first year growth of walleyes in Red Lakes was not determined by the extent of fish consumption.

Growth seemed to vary greatly for individual walleyes in Saarinen's Pond. Walleyes taken on 13 September ranged from 131 mm to

Table 5. Comparison of daily growth rates with percent volume and percent occurrence (parentheses) of vertebrates and invertebrates in the walleye diet, 19 June to 13 September, 1973, Saarinen's Pond, South Dakota.

Date	Vertebrates	Invertebrates	I_l/D*	I_w/D**
19 June	20.00 (11.76)	80.00 (94.12)	0.223	0.167
26 June		100.00 (95.00)	0.101	0.129
3 July	83.33 (29.41)	16.67 (70.59)	0.184	0.229
10 July	20.03 (5.00)	70.97 (95.00)	0.111	0.170
18 July	75.00 (40.00)	25.00 (60.00)	0.106	0.393
24 July	98.70 (71.43)	1.30 (35.71)	0.327	1.210
31 July	97.01 (70.00)	2.99 (25.00)	0.093	-0.153
7 Aug.	98.43 (47.06)	1.57 (29.41)	0.209	1.850
21 Aug.	25.00 (9.09)	75.00 (81.82)	0.102	0.414
28 Aug.		100.00 (100.00)	0.024	0.329
13 Sept.		100.00 (83.33)	0.108	0.007

*Increase in length / number of days between sampling dates.

**Increase in weight / number of days between sampling dates.

211 mm in total length. This was the greatest range in length of all samples. The range in total length generally increased for each successive sample throughout the summer (Figure 12).

Similar variation in growth among individual walleyes was reported by Eddy and Carlander (1939), Stroud (1949), Raney and Lachner (1942), Rawson (1957), and Eschmeyer (1950). Growth variation of walleyes from Norris Reservoir was due to sexual differences (Stroud, 1949). Eschmeyer (1950) also indicated that variation in first year growth as well as variation in later life was due to sexual differences.

Removal of young-of-the-year walleyes from Saarinen's Pond

A total of 4,416 walleyes (17.7%) was removed from Saarinen's Pond during the study period. Of these, 2,347 were removed with seines, 1,937 with electrofishing gear, and 111 with trap nets. Seining was the most efficient of the methods used, yielding 287.3 fish per hour of operation; electrofishing yielded 221.4; and trap netting yielded 2.1 fish per hour of operation. Hours of operation did not include the time needed to transport or assemble the equipment (Table 6).

Weekly bag seine hauls removed 1,174 walleyes from the pond. The catch rate of the individual bag seine hauls ranged from 48 fish per hour on 21 August to 669 fish per hour on 7 August with a mean of 320.2 fish per hour. The catches for the 395 foot seine were 395

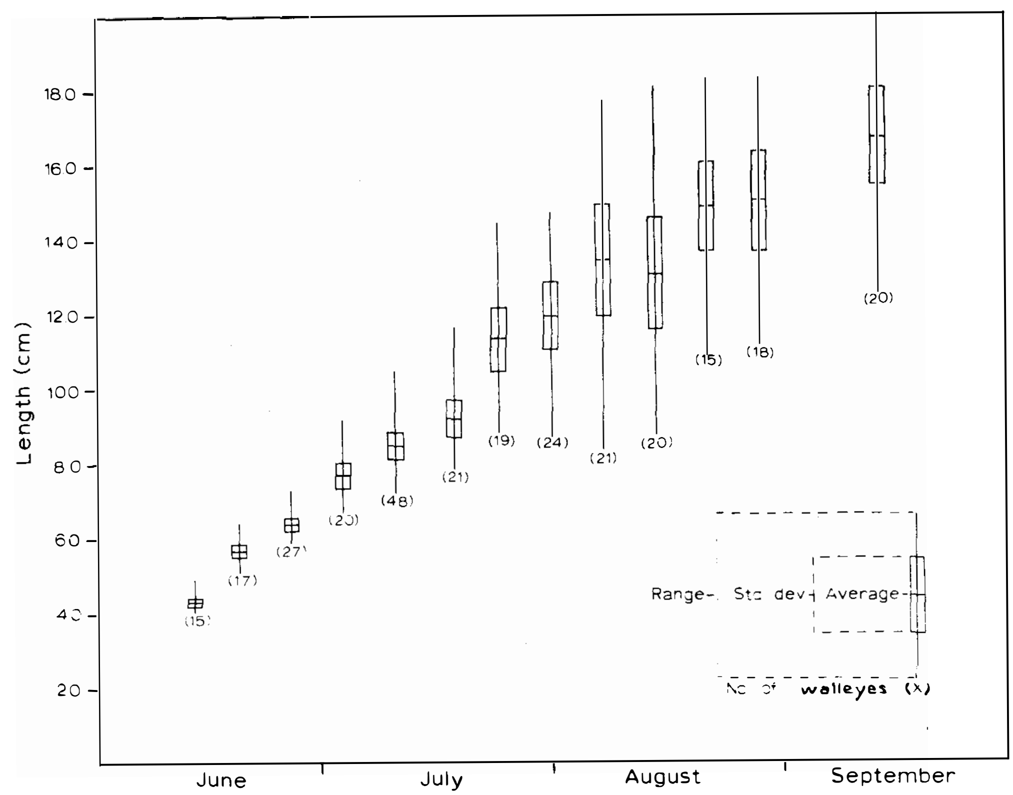

Figure 12. Average total length (cm), range in total length (cm), and standard deviation of weekly samples of young-of-the-year walleyes 13 June to 13 September, 1973, Saarinen's Pond, South Dakota.

Table 6. Numbers and percentages (parentheses) of young-of-the-year walleyes captured by various removal methods, 19 June to 14 November, 1973, Saarinen's Pond, South Dakota.

Date	Seine	Trap Net	Water Pump	Shocker	Total
19 June	17 (0.38)				17 (0.38)
26 June	63 (1.43)				63 (1.43)
3 July	68 (1.54)				68 (1.54)
10 July	64 (1.45)				64 (1.45)
18 July	211 (4.78)				211 (4.78)
24 July	89 (2.02)				89 (2.02)
1 Aug.	214 (4.85)	51 (1.15)	5 (0.11)		270 (6.11)
7 Aug.	223 (5.05)				223 (5.05)
14 Aug.	188 (4.26)				188 (4.26)
15 Aug.				264 (5.98)	264 (5.98)
21 Aug.	17 (0.38)			974 (22.06)	991 (22.44)
28 Aug.	20 (0.45)				20 (0.45)
13 Sept.			16 (0.36)	699 (15.83)	715 (16.19)
30 Sept.	1,173* (26.56)	60* (1.36)			1,233 (27.92)
24 Oct.		0.0**			0.0
14 Nov.		0.0***			0.0
Total	2,347 (53.15)	111 (2.51)	21 (0.48)	1,937 (43.86)	4,416
Fish/hr.	287.3	2.1****	1.5	221.4	
Fish/man-hr.	45.0	10.1	1.9	75.2	

*395 fish caught in long seine before application of $CuSO_4$, 778 caught after application. 0 fish caught in trap nets before, 60 caught after.

**Includes lighted and unlighted trap nets.

***Includes trap net covered with black shelter, and net without shelter.

****2.1 fish/hr. does not account for number of trap nets, 1.3 fish were caught/trap-hr.

walleyes in one haul prior to copper sulfate application and 466, 209, and 103 walleyes, respectively, in three seine hauls following application. The trap net catches prior to and following copper sulfate application were 0 walleyes and 60 walleyes, respectively. Walleye movement was apparently increased by the application of copper sulfate. Increased walleye activity could have been as much the result of the action of boats and people required to distribute the chemical as the chemical itself. The long seine was less efficient than the weekly seine hauls in terms of man-hours. While the long seine yielded 260.7 fish per hour of operation, it yielded only 26.1 fish per man-hour. The weekly seine haul averaged 320.2 fish per hour and 160.1 fish per man-hour.

Electrofishing had the most potential of the methods used. Catches per hour with electrofishing gear ranged from 34 fish per hour of operation (17 fish per man-hour) to 802 fish per hour (267.3 fish per man-hour) with a mean of 221.4 fish per hour (75.2 fish per man-hour). The lowest catch rate occurred on a sunny day with a 5 mph breeze. Night shocking was more successful than daytime shocking, yielding 85.5 fish per man-hour as opposed to 42.8 in the daytime.

Trap netting yielded 2.1 walleyes per hour and was the least successful of the removal methods. This yield also includes trap nets used in conjunction with copper sulfate, artificial light, and a shelter. Neither artificial light nor the shelter attracted walleyes and no fish were captured with either method. Artificial light did attract large numbers of microcrustacea, mostly *Gammarus.* Trap nets aided by copper sulfate yielded 13.3 walleyes per hour.

Water circulation was of little advantage in attracting walleyes in Saarinen's Pond, and yielded only 1.5 fish per hour of operation. Some success has been reported using an artificially produced water current to attract northern pike, *Esox lucius,* Linneaus, in Minnesota lakes; but the technique was used under ice cover when dissolved oxygen concentrations were low (Hanson, 1958).

A natural rearing area similar to Saarinen's Pond could be the basis for a low cost rearing program if an efficient method of removal were found. Good growth rates were observed for walleyes in Saarinen's Pond and the walleyes attained a size ideal for stocking. The major problem encountered in the study was that of removing the young walleyes from the pond.

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