Extensive Culture of Walleye Fry in Ponds at the Wolf Lake Hatchery, 1975-1978

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EXTENSIVE CULTURE OF WALLEYE FRY IN PONDS AT THE WOLF LAKE HATCHERY, 1975-1978 [1]

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Abstract

Over a 4-year period extensive culture techniques were refined so that walleye fry stocked at the rate of 3.5 per cubic meter in naturally fertile ponds at Wolf Lake Hatchery could be raised in 6 to 7 weeks to a mean length of 50 mm with a survival of 90% or more. The principal food item for the walleyes during the entire rearing cycle, *Daphnia pulex*, was maintained best by weekly applications of horse or sheep manure (32 ppm) and torula or brewer's yeast (5.3 ppm). A recommended step-by-step procedure is presented.

[1] Contribution from Dingell-Johnson Project F-35-R, Michigan.

Introduction

In 1940, both Minnesota and Wisconsin began large-scale production of walleye fingerlings in rearing ponds (extensive culture). Both states now produce millions of walleyes annually for stocking into lakes and rivers. In Michigan, walleye fingerling production has been on a smaller, but increasing, scale (Peterson 1973; Buc 1975). The basic procedures for extensive culture of walleyes are well documented (Dobie 1957; Smith and Moyle 1945; Wistrom 1957; Laarman and Reynolds 1974). However, ponds often vary in production of walleyes because of differences in physical structure, basic fertility, water temperature, animal and plant communities, etc. Thus, cultural procedures often must be adjusted to individual ponds. Also, available sites for extensive rearing ponds, along with personnel and funds to operate them, usually are limited.

In the early 1970's, the Michigan Department of Natural Resources and other state, federal, and provincial agencies initiated attempts to culture walleye fry and fingerlings intensively on formulated food (Beyerle 1975). To date (Nickum 1978), significant progress has been made in intensive culture of small fingerlings to lengths of 100 mm and larger, but no agency has been successful in raising walleye fry intensively. Thus, the fingerlings used in intensive culture still have to be raised extensively from the fry stage in rearing ponds with natural foods.

At the Wolf Lake State Fish Hatchery in Michigan, walleye fry have been raised in ponds since 1972 to provide fingerlings of 25 to 50 mm for intensive culture to a larger size. By 1975 it was clear that healthy fingerlings 50 mm in length adapted better to intensive culture than smaller sizes. This report covers a series of four annual tests, beginning in 1975, by the Research Unit at the Wolf Lake Hatchery to improve extensive culture techniques. The goal was to produce predictable numbers of healthy walleyes of 50 mm mean length.

General procedures

The cultural procedures used in these tests closely matched the accepted methods for pond production of fingerling walleyes. Ponds were kept drained overwinter. In early spring, water from Wolf Lake was pumped into the ponds, organic fertilizer was added, and walleye fry were stocked. Periodically thereafter, various organic stimulants were applied to maintain plankton "blooms".

At weekly intervals, surface water temperatures were measured and vertical hauls with a 200-mm diameter "student" plankton net of 80-micron mesh were made at marked locations of known depth. Walleye fry were attracted to the pond valve boxes at night with a battery-powered floodlight and collected with a scap net. The samples of plankton and walleye fry were preserved in a solution of 50% ethyl alcohol and 10% glycerin. The contents of walleye stomachs were determined under a dissecting microscope. An estimate of the plankton in each water sample was made by counting the various plankters in three 1-ml subsamples, using a Sedgewick-Rafter counting cell and microscope.

Ponds were drained as soon as possible following an observed rapid decline in the plankton population.

Specific procedures, results, and discussion

1975

Procedures in 1975 closely approximated those used in previous years by hatchery personnel to raise walleye fry in ponds. The objective was to compare the growth and survival of walleyes with the periodic abundance of food items.

In mid-April, three ponds were filled with water and sheep manure was dumped at several locations in the shallow water of each pond at a rate of 336 kg per hectare (24 to 64 ppm). On April 30, walleyes were stocked at a rate of 96,330 fry per hectare (6.84 to 18.48 fry per cubic meter). Brewer's yeast, at a rate of 28 kg per hectare (2.0 to 5.3 ppm), was applied to pond 5 and pond 9 at weekly intervals beginning May 5. Since pond 8 received a continuous supply of nutrients (excess food and waste products) from an adjoining pond containing salmonids, it seemed unnecessary to add yeast to it.

Judging by the feeding activity of walleye fry stocked in aquaria, the first exogenous feeding by walleye fry stocked in the ponds occurred May 3-6. Plankton samples were collected at five marked locations in each pond starting May 5. Beginning May 8, walleye fry were collected from each pond once a week for three consecutive weeks.

On May 27-29, 38,800 walleye fingerlings (99.5% of the estimated number stocked), with a mean length of 29.0 mm, were collected when pond 5 was drained (Table 1). A total of 75,980 walleyes, with a mean length of 28.4 mm, were taken from pond 9 on May 29-30. Since only about 66,000 fry had been stocked in pond 9--fewer than recovered--there must have been an error in the stocking estimate, or some immigration from pond 8 via a water supply line. On June 13, 27,500 fingerlings, with a mean length of 45.0 mm, were collected from pond 8. Survival was 77.5%. These fish were relatively thin and emaciated compared with the walleyes from the other ponds. If these fingerlings had been harvested 10 days earlier, when the plankton population declined, they probably would have been in much better condition. Generally, optimal production of walleyes, in terms of both numbers and weight, seemed to be obtained when ponds were drained within 2-4 days after a rapid decline in the food supply.

A cladoceran, *Daphnia pulex*, was the predominant food found in the stomachs of walleyes in every collection from all three ponds (Tables 2, 3, and 4). Despite the abundance of copepods in plankton samples (Table 5), none was found in walleye stomachs. The copepods were usually smaller than *Daphnia*, but some were the same size as the *Daphnia* found in stomachs. Since walleyes begin exogenous feeding when they are 6 to 7 mm in length, it is interesting that on May 8 walleyes as small as 8 mm contained *Daphnia* as large as 1 mm in length. This strongly supports the contention that 6- to 7-mm walleyes were easily capable of ingesting the smallest *Daphnia* (0.2-0.4 mm) found in the plankton samples of May 5.

After May 8, some differences developed between pond 8 and ponds 5 and 9. The walleyes in ponds 5 and 9 were eating some of the largest Daphnia (2 mm) present but not the smallest (<0.5 mm). Selection for the larger, reproducing-size Daphnia continued in these ponds through May 20. Then the maximum size of Daphnia declined and the Daphnia population practically disappeared from pond 5 by May 27 and from pond 9 by May 29. By contrast, in pond 8 (a more naturally fertile pond) some Daphnia were as large as 2.9 mm on May 13, but the largest found in walleye stomachs were only 1.7 mm. This same relationship existed in samples taken a week later. On May 27, the pond contained some Daphnia more than 3 mm long. Thus, in pond 8 the largest of the reproducing-size Daphnia were not preyed on by the walleyes during mid-May. This may be the reason why Daphnia became twice as dense in pond 8 as in the other ponds by May 20, and why they persisted until June 10--2 weeks beyond Daphnia in pond 5 and pond 9.

In summary, the analysis of plankton samples and walleye stomach samples, plus the fact that the survival of walleyes was very high in all three ponds in 1975, are evidence that Daphnia was an acceptable food item for walleyes of every size from 6 to 45 mm. Walleyes in pond 8 attained a considerably larger size, 45 mm, because the Daphnia "bloom" lasted 2 weeks longer than in ponds 5 and 9. It was concluded that to produce fingerling walleyes of 50 mm mean length in these ponds, the stocking rate of fry would have to be reduced, or the rate or frequency of fertilization would have to be increased.

1976

In 1976, the stocking rate of fry was decreased, the rate of fertilization was increased, and sewage sludge was tested as a substitute for sheep manure and yeast.

On April 7, pond 8 was fertilized with sheep manure at 48 ppm. On April 22, weekly applications of brewer's yeast, at 5.3 ppm, were begun. Consistently below normal temperatures so inhibited plankton production that, beginning April 23, weekly applications of sheep manure at 32 ppm were made also.

At weekly intervals, beginning April 7, sewage sludge at 24 ppm was dumped into 1/8-inch mesh screen boxes at the water inlets of ponds 7 and 9. The sludge was forced through the mesh by spraying water from the inlet pipes.

On April 14, walleyes with conspicuous yolk sacs were stocked at rates of 1.64 to 4.51 fry per cubic meter. Samples of fry were collected on April 16, 18, and 21. Plankton samples were collected weekly, beginning April 16.

Pond 9 was drained on May 17 to provide walleye fingerlings for toxicity tests. Only 4,170 fingerling walleyes were recovered (26.3%) and their mean length was a disappointing 25.1 mm (Table 6). A small number of adult fathead minnows (*Pimephales promelas*) and brook sticklebacks (*Culaea inconstans*) were also taken, and it is assumed that they were partly responsible for the low survival of walleyes.

Ponds 7 and 8 were drained later, just after the cladocera bloom had ended. On June 2, 13,378 fingerlings (68.5% survival), 45.0 mm mean length, were recovered from pond 8. On June 4, pond 7 yielded 10,217 fingerlings (52.9% survival) with a mean length of 45.2 mm.

All 31 walleye fry collected from the three ponds on April 16 still had yolk sacs (Tables 7, 8, and 9). Seven of these fry contained at least one *D. pulex* (0.40-0.80 mm in length) and two fry contained 2-5 algae "balls" (0.15 mm in diameter). The stomachs of the remaining 22 fry were empty. These data indicate that the fry began active feeding well before their yolk sacs were completely absorbed, and that *D. pulex* was their first food.

In 1975, *D. pulex* was the only cladoceran found in the ponds. However in 1976, a new cladoceran, *Bosmina* sp., was identified in two ponds (Table 10). *Bosmina* was present in significant quantities in pond 9 on April 16, and made up 48% of the cladocera collected on May 7. Relatively insignificant numbers of *Bosmina* were found in pond 7 on May 21 and May 28, and no *Bosmina* were found in pond 8 on any date.

Merna (1977) found that walleye fry (8.7 to 10.4 mm long) in a borrow pit pond selected *Bosmina* (mean length 0.33 to 0.39 mm) over

D. pulex (mean length 0.80 to 1.00 mm). In the ponds at the Wolf Lake Hatchery, the walleye fry did not consume Bosmina (0.22 to 0.40 mm long) nor the smallest D. pulex, but selected D. pulex larger than 0.32 mm.

The survival and growth of fingerlings in 1976 was not better than in 1975. In pond 8, survival was 9% lower even though the fry stocking rate had been reduced 45% (Tables 1 and 6). As a result, less than half as many fingerlings were produced in 1976 as in 1975. Possibly because of the decrease in numbers of predators (walleyes), almost twice as many D. pulex were collected in plankton hauls in 1976 (38.8 per liter) as in 1975 (20.7 per liter). Yet, despite the relatively greater abundance of food in 1976, the mean length attained by the walleye fingerlings was no greater than in 1975. In addition, the growing period (day of stocking to end of plankton pulse) was 48 days in 1976, but only 35 days in 1975. It is suspected that these results were due to unusually cold weather from mid-April to early May (Table 10). The cold temperatures probably inhibited fry feeding and, to a lesser extent, the development of the Daphnia population, and likely caused a fairly high mortality of fry early in the test.

The application of sewage sludge to ponds 7 and 9 was a relatively tedious chore. The extremely heavy sludge had to be hand shoveled into coarse-wire screen boxes so that water from the inlet pipes could beat the sludge into small particles. Therefore the sludge could be applied to only one location in each pond. The sludge did not seem to be as effective as the manure-yeast combination in stimulating plankton production (Table 6). A combination of sludge plus yeast might prove to be equal in effectiveness to the manure-yeast mix, but the difficulties in application would make a sludge-yeast mix unfeasible.

1977

Since plant debris is a major constituent in the diet of Daphnia (Pennak 1953), a sediment-stirring technique was tested in 1977. The hypothesis was that if the availability of small plant particles could be increased, zooplankton production would be stimulated, and walleye production would be improved. Also, the technique involving weekly applications of manure and torula yeast was retested.

On April 4 and 5, four ponds were filled with water and fertilized with horse manure at a rate of 32 ppm (no local source of sheep manure could be found). On April 18, and at weekly intervals through May 10, additional manure (32 ppm) and torula yeast (5.3 ppm) were applied to three ponds (Nos. 7, 8, and 14) but only hay (32 ppm) was applied to pond 13. From April 20 through May 11, the sediments of pond 8 and pond 13 were thoroughly stirred three times per week using a water pump and hose mounted on a boat. Small particles were counted in water samples taken from these ponds immediately after stirring and 24 hours later. Comparison samples from ponds 7 and 14 were also analyzed.

On April 13, each pond was stocked with walleyes (3.5 fry per cubic meter). Fry were collected from each pond on April 19 and weekly plankton samples were collected off the outlet box of each pond beginning April 13.

By May 1, pond 13 had lost its turbidity. On May 10, many walleyes were observed swimming in groups near the perimeter of the pond (usually a sign of diminishing food supply) despite the fact that plankton samples from pond 13 still contained numerous Daphnia. Also about May 10, the turbidity rapidly disappeared from the remaining three ponds. All four ponds were drained and the walleyes were collected from May 16 through May 27.

Survival of walleyes in pond 13 was extremely high, but mean length was only 39.1 mm (Table 11). Mean length of walleyes in pond 14 was average, but survival was only mediocre. In pond 7 growth of walleyes was good, but survival was poor. As in past years, pond 8 produced the best combination of growth and survival. A comparison of overall survival and growth of walleyes in 1977 to earlier years leads to the conclusion that horse manure was as effective as sheep manure for fertilizing walleye ponds.

Copepods were the main food item of walleyes in ponds 13 and 14 on April 19 (Table 12). This was the only instance in 4 years when Daphnia pulex was not the main food eaten by small walleyes in the Wolf Lake Hatchery ponds. Copepods were a minor constituent in the food ration of walleyes from ponds 7 and 8 on April 19. Evidently Daphnia pulex was in relatively short supply in all walleye ponds through April 21 and unusually dense populations of copepods developed in ponds 13 and 14 (Table 13). Although the walleyes ate more copepods than daphnids, a comparison of the relative abundance of Daphnia and copepods in plankton samples to that in walleye stomachs shows selection for Daphnia.

The stirring technique apparently was not successful in increasing the quantity of suspended plant particles nor the quantity of zooplankton (Tables 13 and 14). The fact that the two stirred ponds had the highest production of walleyes is attributed to their higher natural fertility, as shown in other years.

1978

In 1978, the objective was to evaluate sucrose as a substitute for manure-yeast in walleye fry culture. In New Mexico, weekly applications of sucrose at 1.5 to 2.0 ppm to ponds stimulated production of bacteria and crysophytes (both good food sources for zooplankton), and zooplankton dominance shifted from copepods to Daphnia (D. B. Jester, Jr., personal communication).

On April 18, four ponds were filled with water and fertilized with horse manure at 32 ppm. On April 25, a second application of manure was made to all ponds and, in addition, sucrose at 2 ppm was added to ponds 3 and 7, while torula yeast at 5.3 ppm was added to ponds 8 and 13. In succeeding weeks, additional manure and yeast were added to ponds 8 and 13. Sucrose was applied twice a week to pond 7 and at weekly intervals to pond 3.

On April 28, walleye fry were stocked in all four ponds at the rate of 3.5 fry per cubic meter. Weekly plankton samples were collected off the outlet box of each pond but fry were not sampled.

By May 19, the turbidity was gone from ponds 3 and 7 and by June 6, it was evident from visual inspection that Daphnia were no longer available. Pond 3 was drained on June 7 and pond 7 was drained on June 8. Pond 8 lost its turbidity on June 6, coincident with a buildup of filamentous algae. By June 12, no Daphnia were visible in pond 8 and the walleyes were swimming along the shoreline. Pond 8 was drained on June 13. Pond 13 was still moderately turbid when it was drained on June 15.

Unfortunately, the data sheets on survival and mean length of walleyes were inadvertently destroyed. It is known that the mean length of walleyes reached 54.6 mm in pond 13 and approximately 52 mm in pond 8. This was the first instance in which walleye fingerlings were raised on zooplankton to a mean length greater than 50 mm in the ponds at the Wolf Lake Hatchery. Mean length of walleyes from the sucrose ponds was less, approximately 44 mm. Survival of walleyes in the four ponds ranged from 60 to 90%.

Unusually cold temperatures from April 28 to May 5 inhibited Daphnia production in all ponds (Table 15). Steadily increasing pond temperatures from May 6 through May 19 were coincident with increased production of Daphnia. Evidently the twice-a-week applications of sucrose (pond 7) produced no more Daphnia than the weekly applications (pond 3). The Daphnia populations in ponds 8 and 13 were consistently larger and lasted about 1 week longer than those in the sucrose ponds.

Summary

In certain ponds at the Wolf Lake Hatchery, walleyes stocked in April at the rate of 3.5 fry per cubic meter grew in 6 to 7 weeks to a mean length of 50 mm, with survival rates as high as 90% or more. Daphnia pulex larger than 0.32 mm was the first food, and the main food, consumed by walleyes in these ponds. To achieve these rates of growth and survival, it was necessary to continually stimulate Daphnia production by weekly applications of sheep or horse manure at 32 ppm, plus torula or brewer's yeast at 5.3 ppm.

Several substitutes for the manure-yeast applications were tested: applications of hay followed by stirring the pond bottom to increase plant debris, applications of sewage sludge, and applications of sucrose. None of the substitutes produced the stimulus to the Daphnia populations provided by the manure-yeast combination (Table 16).

Periods of unusually cold weather tended to temporarily inhibit plankton production and, possibly, walleye growth. In 1 year a scarcity of Daphnia, because of cold weather immediately before fry stocking, may have drastically reduced survival.

A suggested procedure for extensive culture of walleyes to a length of 50 mm in ponds, with *Daphnia pulex* as the dominant zooplankter, is as follows:

1. Utilize the most naturally fertile ponds available.
2. Keep ponds dry overwinter.
3. Approximately 10 days before walleye fry are stocked, fill ponds with water and fertilize with manure at 32 ppm. Avoid introduction of other fishes.
4. At weekly intervals thereafter, apply additional manure at the same rate and torula or brewer's yeast at 5.3 ppm.
5. Stock walleyes at a density of 3.5 fry per cubic meter.
6. Keep pond levels as high as possible without overflow.
7. Periodically monitor the *Daphnia* populations by collecting and examining plankton samples. A sudden decrease in pond turbidity is usually associated with a decline in the population of *Daphnia*.
8. For maximum production of healthy walleyes, drain each pond within 4 days following a rapid decline in the *Daphnia* population.

Table 1.--Summary of walleye fry stocked and fingerlings recovered from Wolf Lake Hatchery ponds in 1975.

Pond No. and volume (m^3)	Fry stocked Number per m^3	Fry stocked Number per pond	Fingerlings recovered Number per m^3	Fingerlings recovered Number per pond	Fingerlings recovered Weight g/m^3	Fingerlings recovered Mean length (mm)	Fingerlings recovered Percent survival	Days in pond
Pond 5								
2110	18.48	39,000	18.39	38,800	3.60	29.0	99.5	29
Pond 8								
4333	8.19	35,500	6.35	27,500	4.24	45.0	77.5	43
Pond 9								
9656	6.84	66,000	7.87	75,980	1.54	28.4	115.1[a]	30

[a] Number of fry stocked was probably underestimated.

Table 2.--Size of walleyes, size of *Daphnia*, in walleye stomachs, and size of *Daphnia* in plankton samples, Wolf Lake Hatchery Pond 5, 1975.

Date	Walleye fry			*Daphnia* in stomachs			*Daphnia* in plankton		
	Number	Length (mm) Mean	Length (mm) Range	Number per stomach	Length (mm) Mean	Length (mm) Range	Number measured	Length (mm) Mean	Length (mm) Range
May 5	--	--	--	--	--	--	185	0.80	0.35-1.82
May 8	6	8.7	8-10	3.0	0.51	0.34-1.10	--	--	--
May 13	--	--	--	--	--	--	204	0.70	0.25-2.22
May 14	7	13.6	11-15	9.0	0.82	0.45-2.02	--	--	--
May 20	--	--	--	--	--	--	130	1.00	0.25-1.78
May 21	5	22.0	21-24	21.2	1.08	0.60-2.08	--	--	--

Table 3.--Size of walleyes, size of Daphnia in walleye stomachs, and size of Daphnia in plankton samples, Wolf Lake Hatchery Pond 8, 1975.

Date	Walleye fry			Daphnia in stomachs			Daphnia in plankton		
	Number	Length (mm) Mean	Length (mm) Range	Number per stomach	Length (mm) Mean	Length (mm) Range	Number measured	Length (mm) Mean	Length (mm) Range
May 5	--	--	--	--	--	--	202	0.97	0.45-2.35
May 8	7	9.1	8-10	12.4	0.61	0.35-1.02	--	--	--
May 13	--	--	--	--	--	--	241	0.90	0.28-2.90
May 14	8	13.4	12-15	8.8	1.08	0.55-1.75	--	--	--
May 20	--	--	--	--	--	--	463	0.76	0.28-2.70
May 21	5	19.8	19-20	8.0	1.02	0.60-1.68	--	--	--
May 27	--	--	--	--	--	--	343	1.01	0.28-3.18
June 3	--	--	--	--	--	--	254	1.20	0.35-2.22
June 10	--	--	--	--	--	--	16	0.80	0.35-1.42

Table 4.--Size of walleyes, size of Daphnia in walleye stomachs, and size of Daphnia in plankton samples, Wolf Lake Hatchery Pond 9, 1975.

Date	Walleye fry			Daphnia in stomachs			Daphnia in plankton		
	Number	Length (mm) Mean	Length (mm) Range	Number per stomach	Length (mm) Mean	Length (mm) Range	Number measured	Length (mm) Mean	Length (mm) Range
May 5	--	--	--	--	--	--	230	0.76	0.22-1.45
May 8	13	8.5	7-9	3.9	0.47	0.32-1.04	--	--	--
May 13	--	--	--	--	--	--	157	0.82	0.30-2.22
May 14	10	14.7	13-16	7.1	1.18	0.52-2.10	--	--	--
May 20	--	--	--	--	--	--	245	0.94	0.35-1.92
May 21	5	22.0	21-23	8.0	1.15	0.68-1.78	--	--	--
May 27	--	--	--	--	--	--	15	0.87	0.42-1.50

Table 5.--Water temperature (°C) and mean number of zooplankters per liter in three walleye rearing ponds at Wolf Lake Hatchery, May 5-June 10, 1975.

Pond No. and species	Sampling date					
	May				June	
	5	13	20	27	3	10
<u>Pond 5</u>						
Water temperature	(13)	(18)	(26)			
Daphnia pulex	19.0	20.7	14.4	--	--	--
Copepoda	0.7	21.4	62.0	--	--	--
Ostracoda	44.1	6.6	16.2	--	--	--
Rotifera	12.3	0.6	0.0	--	--	--
<u>Pond 8</u>						
Water temperature	(14)	(20)	(23)	(23)	(17)	(19)
Daphnia pulex	19.9	19.4	37.8	26.6	19.0	1.2
Copepoda	0.7	12.1	46.1	44.8	14.9	0.7
Ostracoda	1.1	2.2	10.4	14.0	17.8	8.3
Rotifera	33.8	60.4	20.3	1.7	0.0	0.7
<u>Pond 9</u>						
Water temperature	(13)	(20)	(23)	(25)		
Daphnia pulex	19.1	12.7	18.9	1.2	--	--
Copepoda	19.1	12.4	18.0	14.6	--	--
Ostracoda	4.2	4.6	6.1	9.3	--	--
Rotifera	19.2	2.6	1.5	4.1	--	--

Table 6.--Summary of walleye fry stocked and fingerlings recovered from Wolf Lake Hatchery ponds in 1976.

Pond No. and volume (m^3)	Fry stocked Number per m^3	Fry stocked Number per pond	Fingerlings recovered Number per m^3	Fingerlings recovered Number per pond	Weight g/m^3	Mean length (mm)	Percent survival	Days in pond
Pond 7[a]								
5692	3.40	19,330	1.80	10,217	1.14	45.2	52.9	51
Pond 8								
4333	4.51	19,525	3.07	13,378	1.86	45.0	68.5	49
Pond 9[a]								
9656	1.64	15,850	0.43	4,170	0.06	25.1	26.3	34

[a] Fertilized periodically with sewage sludge instead of manure and yeast.

Table 7.--Size of walleyes, size of Daphnia in walleye stomachs, and size of Daphnia in plankton samples, Wolf Lake Hatchery Pond 7, 1976.

Date	Walleye fry			Daphnia in stomachs			Daphnia in plankton		
	Number	Length (mm) Mean	Length (mm) Range	Number per stomach	Length (mm) Mean	Length (mm) Range	Number measured	Length (mm) Mean	Length (mm) Range
April 16	2	6.0	6.0	1.0	0.48	0.40-0.55	147	0.82	0.40-1.22
April 21	4	10.6	9.3-11.9	9.2	0.88	0.50-1.47	447	--	--
April 23	--	--	--	--	--	--	304	0.51	0.28-3.55[a]
April 30	--	--	--	--	--	--	419	0.60	0.25-1.95
May 7	--	--	--	--	--	--	1276	0.88	0.32-1.28
May 14	--	--	--	--	--	--	147	1.11	0.38-3.08
May 21	--	--	--	--	--	--	447	1.34	0.32-2.60
May 28	--	--	--	--	--	--	59	1.18	0.32-2.10

[a] The 3.55 daphnid may have been Daphnia magna.

Table 8.--Size of walleyes, size of *Daphnia* in walleye stomachs, and size of *Daphnia* in plankton samples, Wolf Lake Hatchery Pond 8, 1976.

Date	Walleye fry			*Daphnia* in stomachs			*Daphnia* in plankton		
	Number	Length (mm) Mean	Length (mm) Range	Number per stomach	Length (mm) Mean	Length (mm) Range	Number measured	Length (mm) Mean	Length (mm) Range
April 16	23	7.6	5.5-9.4	0.35	0.62	0.42-0.80	12	0.59	0.22-0.98
April 18	9	9.4	8.5-10.7	8.4	0.71	0.45-1.12	--	--	--
April 21	5	10.7	10.0-11.4	17.4	0.75	0.48-1.25	--	--	--
April 23	--	--	--	--	--	--	499	0.98	0.32-3.20
April 30	--	--	--	--	--	--	395	0.67	0.25-2.42
May 7	--	--	--	--	--	--	601	1.14	0.28-3.10
May 14	--	--	--	--	--	--	124	0.58	0.25-1.78
May 21	--	--	--	--	--	--	771	0.92	0.28-2.55
May 28	--	--	--	--	--	--	885	0.44	0.25-0.87

Table 9.--Size of walleyes, size of *Daphnia* in walleye stomachs, and size of cladocera (*Daphnia* and *Bosmina*) in plankton samples, Wolf Lake Hatchery Pond 9, 1976.

Date	Walleye fry			*Daphnia* in stomachs			Cladocera in plankton		
	Number	Length (mm) Mean	Length (mm) Range	Number per stomach	Length (mm) Mean	Length (mm) Range	Number measured	Length (mm) Mean	Length (mm) Range
April 16	6	7.9	7.1-8.5	0.0	--	--	18	0.58	0.28-1.25
April 21	3	11.1	10.7-11.5	7.3	0.79	0.48-1.25	--	--	--
April 23	--	--	--	--	--	--	307	0.71	0.25-1.92
April 30	--	--	--	--	--	--	201	0.57	0.22-1.65
May 7	--	--	--	--	--	--	172	0.64	0.22-2.28
May 14	--	--	--	--	--	--	124	0.90	0.22-1.98

Table 10.--Water temperature (°C) and mean number of *Daphnia pulex* and *Bosmina* per liter in three walleye rearing ponds, April 16-May 28, 1976.

Pond No. and species	April 16	April 23	April 30	May 7	May 14	May 21	May 28
Pond 7							
Water temperature	(20)	(17)	(13)	(12)	(21)	(19)	(19)
Daphnia pulex	1.0	16.8	22.2	97.6[a]	8.9	36.8	3.2
Bosmina	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Pond 8							
Water temperature	(19)	(17)	(14)	(13)	(21)	(20)	(19)
Daphnia pulex	1.7	46.5	31.9	59.9	10.2	68.2	51.3
Bosmina	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pond 9							
Water temperature	(18)	(17)	(14)	(11)	(20)		
Daphnia pulex	0.9	15.6	8.5	4.9	5.8		
Bosmina	0.3	1.5	2.7	4.7	1.1		

[a] Probably not representative because one haul contained 22,680 cladocera. The mean of the other four hauls was 16.7 daphnids per liter.

Table 11. --Summary of walleye fry stocked and fingerlings recovered from Wolf Lake Hatchery ponds in 1977.

Pond No. and volume (m^3)	Fry stocked Number per m^3	Fry stocked Number per pond	Fingerlings recovered Number per m^3	Fingerlings recovered Number per pond	Weight g/m^3	Mean length (mm)	Percent survival	Days in pond
Pond 7								
5692	3.53	20,100	1.4	8,004	1.1	49.5	39.8	43
Pond 8 [a]								
4333	3.53 [b]	15,300 [b]	3.9	17,130	2.9	48.3	112.0 [b]	44
Pond 13 [c]								
14,329	3.53	50,600	3.4	48,975	1.4	39.1	96.8	37
Pond 14								
11,327	3.53	40,000	1.9	22,137	1.1	43.4	55.3	34

[a] Pond bottom was stirred.

[b] For pond 8 the number of walleyes stocked was estimated by measuring the volume of fry rather than the volume of eggs (just prior to hatching), as was done for the other ponds. Obviously, the number stocked in pond 8 was underestimated.

[c] Fertilized periodically with hay rather than manure and yeast; bottom stirred.

Table 12.--Stomach contents of walleyes collected from rearing ponds on April 19, 1977.

Pond No.	Walleyes sampled		Stomach contents		
	Number	Mean length (mm)	Item	Mean number of individuals per stomach	Size range (mm)
7	9	10.5	Daphnia	23.7	0.38-1.32
			Copepoda	1.0	0.52-1.15
8	8	10.2	Daphnia	18.0	0.27-1.16
			Copepoda	3.2	0.36-1.07
			Ostracoda	0.1	0.58
13	8	11.8	Daphnia	3.9	0.39-1.22
			Copepoda	19.5	0.38-1.09
14	8	11.3	Daphnia	3.4	0.32-1.52
			Bosmina	0.1	0.39
			Copepoda	27.8	0.37-1.17
			Ostracoda	0.4	0.32-0.41

Table 13.--Water temperature (°C) and mean number of Daphnia pulex, Bosmina, and Copepoda per liter in four walleye rearing ponds, April 13-May 19, 1977.

Pond No. and species	Sampling date						
	April				May		
	13	19	21	28	5	12	19
Pond 7							
Water temperature	(18)	(19)	(--)	(12)	(18)	(18)	(19)
Daphnia pulex	1.1	9.4	5.9	79.0	59.0	127.0	38.0
Bosmina	0.0	0.0	0.0	1.0	0.6	8.6	1.6
Copepoda	0.4	20.0	22.0	7.2	101.0	34.0	26.0
Pond 8							
Water temperature	(17)	(19)	(--)	(14)	(18)	(18)	(27)
Daphnia pulex	0.5	5.4	3.3	38.0	21.0	147.0	18.0
Bosmina	0.0	0.0	0.0	0.0	0.5	0.0	0.4
Copepoda	1.0	8.1	5.7	5.5	12.0	4.0	18.0
Pond 13							
Water temperature	(17)	(19)	(--)	(13)	(18)	(18)	(--)
Daphnia pulex	0.7	5.8	12.0	29.0	41.0	43.0	
Bosmina	0.0	0.0	0.4	0.0	0.0	0.4	
Copepoda	87.0	362.0	153.0	88.0	113.0	105.0	
Pond 14							
Water temperature	(18)	(19)	(--)	(12)	(18)	(18)	(--)
Daphnia pulex	0.7	0.4	0.6	3.3	136.0	196.0	
Bosmina	0.0	0.4	0.0	0.0	1.1	0.6	
Copepoda	10.0	150.0	83.0	281.0	347.0	472.0	

Table 14.--Mean number of small plant particles per milliliter of water in four walleye ponds, two of which (ponds 8 and 13) were stirred three times per week (see text). Samples taken immediately after are marked with an asterisk.

Collection date	Size range of particles [a] (mm)	Mean number of plant particles			
		Pond 7	Pond 8	Pond 13	Pond 14
4-27-77	0.1-0.5	54	30*	91*	48
4-28-77	0.1-0.5	--	62	54	--
5-4-77	0.1-0.75	35	47*	46*	37
5-5-77	0.1-0.75	--	66	53	--
5-11-77	0.1-1.0	78	88*	61*	59
5-12-77	0.1-1.0	--	63	69	--

[a] Only particles that theoretically could be ingested by Daphnia were counted.

Table 15.--Water temperature (°C) and mean number of Daphnia pulex, Bosmina, and Copepoda per liter in four walleye rearing ponds, April 28-June 2, 1978.

Pond No. and species	Sampling date April 28	May 5	12	19	26	June 2
Pond 3 [a]						
Water temperature	(16)	(11)	(14)	(20)	(23)	(24)
Daphnia pulex	1.4	1.2	1.5	21.0	53.4	12.8
Bosmina	0.0	0.0	0.0	0.0	0.5	0.0
Copepoda	1.4	0.0	5.6	38.1	75.8	13.1
Pond 7 [a]						
Water temperature	(16)	(10)	(15)	(21)	(24)	(25)
Daphnia pulex	0.7	3.8	16.1	28.1	20.0	2.9
Bosmina	0.3	0.0	3.7	3.4	2.0	0.7
Copepoda	3.4	8.7	8.7	144.3	171.2	121.7
Pond 8 [b]						
Water temperature	(17)	(11)	(14)	(20)	(24)	(23)
Daphnia pulex	0.5	5.0	36.2	26.8	63.0	142.3
Bosmina	0.0	0.0	0.0	0.6	0.4	0.5
Copepoda	0.5	1.7	13.3	73.9	72.4	34.7
Pond 13 [b]						
Water temperature	(16)	(9)	(15)	(22)	(24)	(24)
Daphnia pulex	5.2	9.0	30.6	59.1	204.8	34.0
Bosmina	0.0	0.0	2.6	14.4	15.3	2.0
Copepoda	7.0	58.3	180.1	339.2	195.8	112.7

[a] Fertilized with sucrose.

[b] Fertilized with manure and yeast.

Table 16.--Comparison between stimulants applied (I = initial, P = periodic applications), fry stocking rate (per cubic meter), and fingerling production, Wolf Lake Hatchery walleye ponds, 1975 through 1978.

Year	Stimulants applied	Pond No.	Stocking rate of fry	Fingerlings produced	
				Weight (g/m^3)	Mean length (mm)
1975	Sheep manure (I) and yeast (P)	5	8.0	1.6	29
		8	8.2	4.2	45
		9	6.8	1.5	28
1976	Sheep manure (P) and yeast (P)	8	4.5	1.9	45
	Sewage sludge (P)	7	3.4	1.1	45
		9	1.6	0.1	25
1977	Horse manure (P) and yeast (P)	7	3.5	1.1	50
		14	3.5	1.1	43
	Horse manure (P) and ;yeast (P), stirred (P)	8	3.5	2.9	48
	Horse manure (I) and hay (P), stirred (P)	13	3.5	1.4	39
1978	Horse manure (P) and yeast (P)	8	3.5	no data	52
		13	3.5	no data	55
	Horse manure (I) and sucrose (P)	3	3.5	no data	44
		7	3.5	no data	44

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