Original: Fish Division ✓
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Institute for Fisheries Research
R. S. Marks
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ANN ARBOR, MICHIGAN

September 27, 1950

Report No. 1267

# Minnow Propagation Experiments for 1947



By

C. Troy Yoder[1]

## Abstract

Creek chub fry and common sucker fry can be produced economically by artificial methods.

The addition of fertilizer to certain ponds increased the production as compared to unfertilized ponds.

Production can be greatly increased by feeding artificial foods.

The greatest profit per acre of water was realized by feeding creek chub minnows in raceways with flowing water.

Many of the ponds yielded a large net profit, while others did not produce so well as desired. If conditions are ideal and the minnow producer is experienced, it is possible to raise minnows profitably for the bait market in Michigan. However, like any business, it is not a sure bet.

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[1] District Fisheries Biologist assigned to bait minnow problem April, 1947 to September, 1948. At present District Fisheries Supervisor, Plainwell, Michigan.

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## Abstract

Due to the existing shortage of bait minnows in Michigan, the Institute for Fisheries Research has undertaken a program of investigation to learn the feasibility of raising various species of bait minnows for commercial sale. This program was continued in 1947, with emphasis on feeding to attain maximum productions in small ponds and raceways.

In 1947, a total of 15 pounds and 12 raceways were utilized for minnow production. These waters had a combined surface area of 14.38 acres, and were located at the following fish hatcheries: Wolf Lake, Lydell, Drayton Plains, and Hastings State Hatcheries, and the Northville Federal Hatchery. All these hatcheries are in the southern portion of the state in Fisheries Region III.

Six species of "minnows" namely, white sucker (Catostomus commersonnii), creek chub (Semotilus atromaculatus), fathead minnow (Pimephales promelas), golden shiner (Notemigonus crysoleucas), redbelly dace (Chrosomus eos), and pearl dace (Margariscus margarita) were used in the experiments to study methods of propagation and production per unit area of water.

[1] District Fisheries Biologist assigned to bait minnow problem April, 1947 to September, 1948. At present District Fisheries Supervisor, Plainwell, Michigan.

In addition to the use of the above ponds and raceways, information was obtained by selling chub and sucker fry to individuals desiring to raise their own bait minnows. By this method, we have obtained data on chub and sucker production in 21 additional ponds of various types and located in different sections of the state.

For clarity, each species studied in these experiments is presented under a separate heading.

## Suckers

In 1947, five State Hatchery ponds were used exclusively for sucker experimentation and one pond was used in combination with creek chubs. In addition to the ponds, nine raceways were employed for sucker experimentation.

At the Wolf Lake Hatchery, three raceways were utilized for fertilization experiments, three for feeding experiments, and three served as controls. Pond 11 was stocked the same as in 1946 and fertilized in 1947 by Dr. R. C. Ball to check for any increase over the 1946 production when the pond was not fertilized. Adult suckers were released in one pond to spawn, thereby stocking the pond with fry.

At the Lydell Hatchery, one pond was stocked with adult suckers the same as the pond at Wolf Lake, two ponds were utilized for feeding experiments and one pond containing a mixture of chubs and suckers was also utilized in the feeding experiment.

One pond at the Northville Federal Hatchery was employed to obtain production figures in successive years when no artificial fertilizer or food was added.

### Propagation

As mentioned above, two ponds, one each at the Lydell Hatchery and Wolf Lake Hatchery were stocked with adult suckers. The Lydell pond No. 17 was

stocked with 17 pair of adults on April 30. Careful observation during the month of May did not disclose any fry in the pond. Consequently, early in June the pond was drained and the adult suckers recovered. There were no young suckers present.

Pond No. 2 at Wolf Lake was stocked with 12 female breeders, but only 4 males, as some difficulty was encountered in obtaining adult males. However, after the spawning season was nearly over 19 males were added. On June 5, many thousands of advanced fry were present in the shallow portions of the pond, indicating at least a fair amount of natural reproduction. This pond was drained early in July, but only approximately 4,000 small suckers were present, indicating a very large loss of fry during the month of June. There were no carnivorous fish present and no reason for the loss was evident.

On April 30, Mr. Claude Lydell and his crew started collecting fertile eggs from the shallow water of Silver Lake in Kent County. Approximately 90 quarts of green eggs were taken in this manner and transported to the Lydell Hatchery where they were cleaned and placed in standard hatching jars. In addition to these eggs, some adult suckers were seined from Silver Lake during the first week of May and held at the Hatchery for stripping. About 200 quarts of fertile eggs were obtained by the latter method, making a total of 290 quarts of green sucker eggs. The eggs numbered approximately 31,000 per quart, making nearly nine million green eggs. There was considerable loss during the early development due to injuries received when the eggs were picked up in the shoal areas and transported to the hatchery. Also, a shortage of males resulted in a failure to fertilize all the eggs while stripping. As a result, only approximately five and one-half million reached the eyed stage. One-hundred and eighty thousand of the eyed eggs were placed on cheesecloth trays in ponds to hatch, and the fry were then netted out for

distribution. The remainder of the eggs were allowed to hatch in the jars, requiring from 13 to 15 days at an average temperature of 52° F. After hatching, the fry were very light in color for several days, and only by very close observation could any movement be seen. To any but the careful observer they appeared to be dead, but later they became more golden in color and more active, followed by the development of dark pigmentation and loss of the yolk sac. From the time of hatching, six to ten days were required for the fry to absorb the yolk and become advanced to the stage where they would swim out of the jars and into the fry tank.

The original nine million green eggs developed into 5,088,500 advanced fry plus the 180,000 stocked as eyed eggs, giving approximately 59 percent survival from the green eggs.

Distribution

With the exception of the one pond at Wolf Lake that was stocked with eggs, all suckers were transported as fry in the advanced stage in ten-gallon milk cans, both for experimental work elsewhere and to minnow dealers. Numbers ranging up to 50,000 were carried in each can for a period of three to four hours with no loss when the water temperatures remained below 60° F. Experimentally, 150,000 were carried in each ten-gallon can for three hours resulting in a loss estimated at 5 percent. On another occasion, 2,000 per can were carried 15 hours without aeration or change of water, and no loss was incurred.

The advanced fry were counted for distribution by four different methods, depending somewhat on the number of fry to be counted. (1) When it was necessary to count large numbers of fry, they were measured by dry volume in graduated cylinders. That is, they were moist, but not covered with water.

Several counts of a known volume of advanced fry gave an average of 2,416 fry per liquid ounce or 82 fry per cc. (2) A second method of counting, that of matching a known number, was found to work quite satisfactorily for smaller numbers of fry. The usual procedure was followed by counting a known number into one of two similar pans, and then adding a sufficient number to the second pan to give an impression of numbers similar to that of the first pan. (3) A third method was used successfully in the field. In this instance all the fry were put into one tub filled with water and stirred until a more or less homogeneous mixture was attained. By using a dipper, (one- to two-quart size) and counting the fry in several dippers of water, an average number per dipper was found. Using this figure, the fry could be rationed out by dippers. Several actual counts proved this method to be more reliable and accurate than might be expected. (4) The fourth method was to actually count the fry, obviously the most accurate but also the most laborious method. It was used only on comparatively small numbers.

Of the total number (5,088,500) of advanced sucker fry, 337,000 were sold to ten minnow propagators possessing suitable ponds for rearing suckers, 391,500 were utilized for experiments, and the remaining 4,360,000 served as forage fish in walleye and large- and smallmouth black bass rearing ponds at the Wolf Lake, Lydell, and Drayton Plains State Hatcheries, and the Northville Federal Hatchery.

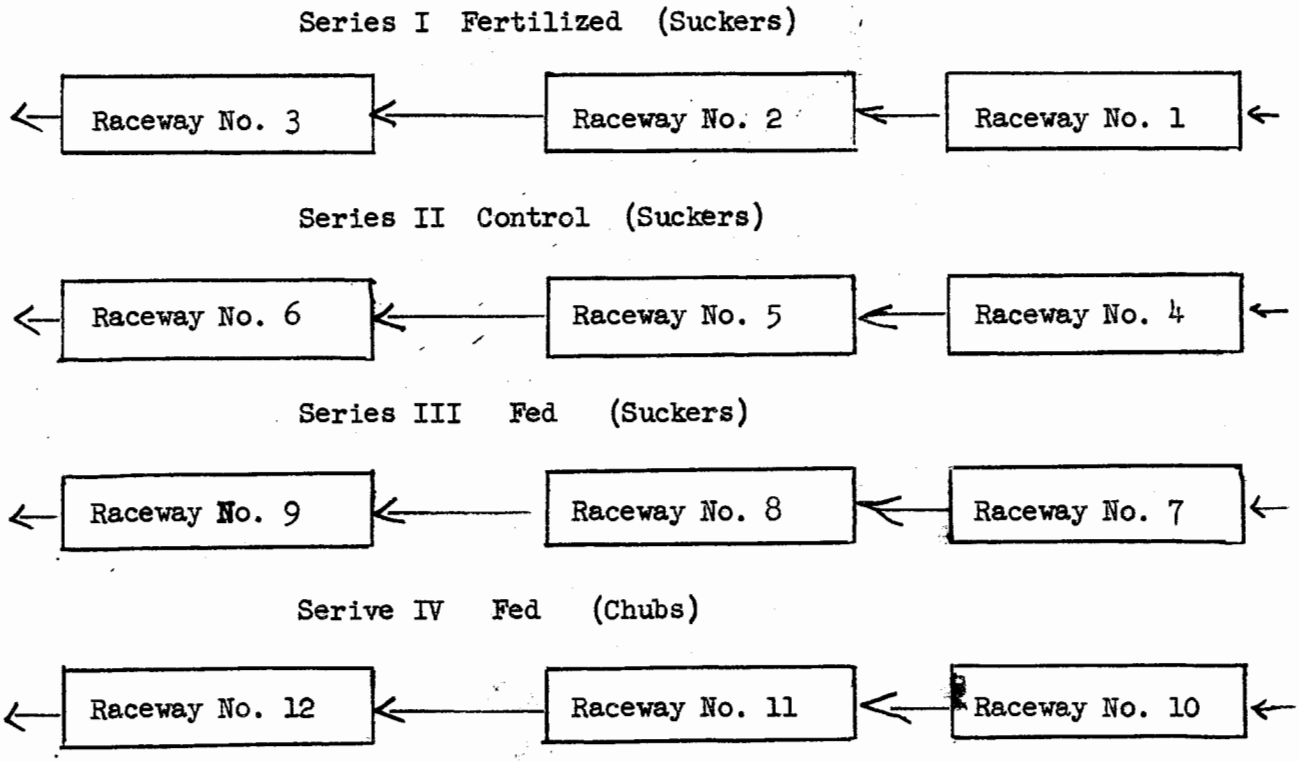
Production

Of the ten dealers purchasing the sucker fry, only two made any attempt to remove their suckers for sale during 1947 and these two individuals sold only a small portion of their stock. Consequently, the results obtained from the private sucker ponds will not be included here under production, but will be referred to later in the report.

At the Wolf Lake Hatchery, sucker experiments were conducted in nine similar raceways. Each raceway was approximately one-quarter acre in area, and varied from six inches of water at the upper end to 30 inches of water at the lower end. The nine raceways were arranged in three series of three, with the first raceway in each series fed from the overflow of hatchery pond No. 13.

The raceways were stocked with advanced fry on May 22, and 23, 1947, with no apparent loss due to handling or transporting. The fry had a tendency to stay near the head of a raceway for about two weeks, and then distributed themselves over the entire raceway. They remained quite evenly distributed for the remainder of the 115-day growing season ending in September.

The following diagram gives the relative positions of the 9 sucker, and 3 chub raceways at Wolf Lake.



The water entered the first raceway in each series, flowed through the two lower raceways and overflowed into the waste ditch. By this arrangement, a fertilized raceway flowed into another fertilized raceway, and a control raceway flowed into another control raceway. No water from one series of three raceways could enter another series.

Table 1, shows the stocking rate and total production in the nine raceways.

Table 1

| Series | Race Number | Stocking rate per acre | Number of fry stocked | Number of suckers removed | Percent of survival | Average length of suckers (inches) | Weight of suckers (pounds) | Pounds per acre of suckers |
|---|---|---|---|---|---|---|---|---|
| Series I | 1 | 100,000 | 4,000 | 701 | 17.5 | 2.7 | 6.5 | 162.5 |
| Fertilized | 2 | 200,000 | 8,000 | 1,714 | 21.8 | 3.0 | 18 | 450 |
| | 3 | 300,000 | 12,000 | 1,750 | 14.6 | 2.9 | 17.5 | 437.5 |
| Series II | 4 | 100,000 | 4,000 | 684 | 17.1 | 3.4 | 10.5 | 262.5 |
| Control | 5 | 200,000 | 8,000 | 217 | 2.7 | 3.7 | 5 | 125 |
| | 6 | 300,000 | 12,000 | 119 | 1.0 | 4.3 | 4 | 100 |
| Series III | 7 | 200,000 | 8,000 | 1,404 | 17.6 | 3.4 | 29 | 725 |
| Fed | 8 | 400,000 | 16,000 | 2,657 | 16.6 | 3.4 | 51 | 1,275 |
| | 9 | 400,000 | 16,000 | 1,308 | 8.2 | 4.2 | 34 | 850 |

Series I was fertilized by Dr. R. C. Ball with a commercial inorganic fertilizer having a 10-6-4 ratio. Fertilization was started early in May and applications were made at the rate of 100 pounds per acre every three weeks until July 17, when the application was increased to 100 pounds per acre weekly. A total of 48 pounds of fertilizer was applied to each 1/25 acre raceway during the entire period. The flow of water into the fertilized series and the control series was reduced to an amount sufficient to maintain only the established water level, and no water was permitted to overflow from these raceways.

In the fertilized series, both raceways No. 2 and No. 3 produced approximately the same number of suckers of similar length and weight, but the number of fry stocked was not the same. This would indicate that stocking at the

lower rate (200,000 per acre) would be a sufficient number to produce the same results as a higher rate of stocking. Consequently, stocking 200,000 advanced sucker fry per acre of fertilized raceway should give a better financial return to the minnow propagator than a greater stocking rate.

In the third series of raceways where feeding was practiced, a very small flow of water was passed through the raceway when the fry were introduced and increased as the fry increased in size. However, this procedure had to be discontinued in late July, when the dense growth of algae made it necessary to reduce the flow of water considerably to prevent the screens from plugging during the night, as this would allow the suckers to escape in the water flowing over the screens.

Feeding was started on June 16 and continued until the experiments were completed in September. The suckers were fed a mixture of 35 percent finely ground beef liver and 65 percent "cereal" measured by weight. Water was added, and the mixture was then allowed to stand overnight to soften the harder ingredients in the cereal. The food was placed on barren gravel areas in several different sections of the raceways to made it readily accessible to the suckers. The amount of food placed on these feeding areas each day was determined by the amount left from the previous days feeding. An attempt was made to feed all the fish would eat in a 24-hour period without allowing an accumulation of decaying food. Five pounds per day were consumed in the three raceways at the beginning of the experiment and this amount was increased according to the demand until a maximum of 45 pounds daily was reached shortly before draining. The suckers were fed a total of 857 pounds of liver and 1,703 pounds of cereal, making a total of 2,560 pounds of food.

The "cereal" was composed of a formula used in the trout diet at the Wolf Lake Hatchery. It was a mixture of 20 percent dried milk, 35 percent meat scrap,

30 percent cotton seed meal, 9 percent low grade flour, and 6 percent of salt, and purchased from Little Brothers, Kalamazoo, Michigan for $8.50 per hundred pounds.

The liver was purchased for 12 cents per pound from the Armour Packing Company, Kalamazoo, Michigan, making the total cost of liver and cereal $247.00.

Raceway No. 7 was stocked with 8,000 fry and raceway No. 8 with 16,000 fry. These suckers were to be sorted and removed as soon as they reached the salable size of three inches in length or over. Starting August 1, and each two weeks following, an attempt was made to seine the suckers from the raceways to grade out the salable minnows. However, due to the intense algal growth, it was believed that only a small portion of the total numbers were removed by seining. In all, only 320 salable minnows were removed from raceway No. 7 and 657 from raceway No. 8 prior to the final draining. The size of the suckers present when the raceways were drained indicated there were many suckers over three inches in length that were missed with the seine during the earlier attempts to grade out the larger fish.

Raceway No. 9 was stocked with 16,000 fry, the same as No. 8, but it was not seined before final draining.

The results of the feeding experiments are compared with the fertilization experiments in Table I. It can be noted from this table that in general there was higher precentage of survival in the fertilized raceways than in either the unfertilized controls or the feeding experiment raceways. However, the total producation of the artifically fed raceways was considerably greater than either of the other series.

The number of suckers in the artificially fed raceways was reduced considerably during the last week in July and throughout August. There was no large loss at any one time, but every day a few dead suckers were found. Examination of the dead suckers invariably disclosed a shortened or completely missing gill cover on

one or often on both sides. The "minnows" appeared to be in good physical condition except for this deformity, which may have been caused by improper diet.

Excessively high temperature may have been another factor in limiting production. During the entire month of August, the daytime temperature in the raceways was never below 80° F., and ranged from 85° to 88° F. for prolonged periods.

Predation by snakes and birds may have reduced the numbers considerably. Six snakes were killed in the raceways and both kingfishers and blue herons were occasionally observed preying on the minnows.

Also at the Wolf Lake Hatchery, as previously stated, Pond 11 (1.29 acres) was stocked May 13 with 12,900 eyed sucker eggs, and fertilized with 10-6-4 inorganic commercial fertilizer from early May until the completion of the experiment in September. A total of 700 pounds of fertilizer was applied during this period. For comparison with the 1946 production see Table 2.

Table 2

| Series | Stocking rate | Number removed | Percent survival | Average length (inches) | Weight (pounds) | Duration of experiment |
|---|---|---|---|---|---|---|
| 1946 Not fertilized | 12,900 eyed eggs | 370 | 2.9 | 7.0 | 44 | 150 days |
| 1947 Fertilized | 12,900 eyed eggs | 6,237 | 48.4 | 3.1 | 59.25 | 119 days |

The greater percent of survival, in the year when fertilizer was used, is in accord with the data of previous years which indicated a better survival of suckers in fertilized ponds. The average length was much less, suggesting that fertilization may not have had as significant an effect on the food supply of the larger suckers as that of the smaller fry.

At the Northville Federal Hatchery, Pond A (0.36 acre surface area) was stocked on May 26 with 7,500 advanced sucker fry to obtain the production per acre from the same pond over a period of years. The results are shown in Table 3.

Table 3

| Year | Number stocked | Number removed | Percent survival | Average length (inches) | Weight (pounds) | Duration of experiment |
|---|---|---|---|---|---|---|
| 1946 | 7,500 | 4,136 | 55.1 | 3.35 | 47.75 | 149 days |
| 1947 | 7,500 | 7,000 | 93.3 | 3.03 | 70 | 141 days |

No reason for the higher rate of survival is evident, and no reason for the wide variation in rate of survival for the two years was apparent. However, during both years when this pond was used for sucker production, the rate of survival was higher than in other experimental sucker ponds during respective years.

At the Lydell State Hatchery, Ponds 6 and 14 were used in an attempt to determine the maximum production possible by feeding suckers in small ponds.

Pond 11 at this hatchery was used to determine the practicability of raising chubs and suckers in the same pond and this experiment will be discussed later in the section on the combination of species.

The two ponds used in the feeding experiment were stocked May 26, 1947, at the rate of 300,000 advanced fry per acre. Pond 6 received 39,000 fry and Pond 14 received 120,000 fry.

The same two ponds had been used in 1946 for similar experiments but the suckers were not fed all the food they would consume. In 1947 they were fed all they could eat, and in the same manner as in the Wolf Lake raceways as previously described. The results of this experiment are shown in Table 4.

Table 4

| Experiment | Area in acres | Number of suckers removed | Average length (inches) | Weight (pounds) | Number per acre | Weight per acre (pounds) | Duration of Experiment |
|---|---|---|---|---|---|---|---|
| Pond 6 (1946) | 0.13 | 4,000 | 3.2 | 60 | 30,760 | 462 | 100 days |
| Pond 6 (1947) | 0.13 | 3,195 | 3.8 | 75 | 24,602 | 578 | 127 days |
| Pond 14 (1946) | 0.41 | 37,525 | 2.7 | 260 | 91,185 | 637 | 102 days |
| Pond 14 (1947) | 0.41 | 31,490 | 3.2 | 470 | 77,151 | 1,152 | 133 days |

Although the numbers of suckers, surviving until the pond was drained, was greater in 1946, the total length and the total production in pounds of suckers was considerably higher in 1947. This may have been influenced by the longer growing season in 1947. Pond 14 was fed 810 pounds of food in 1946 and 3,115 pounds in 1947. Pond 6 was fed 347 pounds in 1946 and 1,343 in 1947. In both instances, the ponds received nearly four times the amount of food in 1947 that they received in 1946, which undoubtedly increased production the second year. However, from an economic standpoint, the increase in production was not great enough to warrant feeding the larger amount of food. From the results of these two ponds, it appears safe to conclude that feeding all the food the fish will consume is not the most economical or practical method of growing suckers for bait. Also, feeding only a small amount will not increase the production greatly. Consequently, more experimentation will be necessary before a definite recommendation can be made on the amount of food to feed young suckers.

Table 5 shows an analysis of the food fed to the suckers in Ponds 6 and 14 described above, from June 12 to September 30, 1947.

Table 5

| Pond | Month: 1947 | Rowena chicken mash #2 | Dried clam meal | Powdered egg meal | Balto dog ration | Horse liver | Totals |
|---|---|---|---|---|---|---|---|
| Pond 6 | June | 29 | 21 | 3 | 21 | 0 | 74 |
| | July | 241 | 20 | 0 | 20 | 49 | 330 |
| | August | 424 | 0 | 0 | 0 | 86 | 510 |
| | September | 355 | 0 | 0 | 0 | 74 | 429 |
| | Total Pounds | 1,049 | 41 | 3 | 41 | 209 | 1,343 |
| Pond 14 | June | 47 | 39 | 6 | 42 | 0 | 134 |
| | July | 637 | 42 | 0 | 161 | 0 | 840 |
| | August | 1,020 | 0 | 0 | 204 | 0 | 1,224 |
| | September | 770 | 0 | 0 | 0 | 147 | 917 |
| | Total Pounds | 2,474 | 81 | 6 | 407 | 147 | 3,115 |

Throughout the month of August there was a mortality in Pond No. 6 similar to that described for the Wolf Lake raceways. However, the mortality was consistently higher in Pond 6, with practically every dead sucker having deformed gill covers. On several occasions the number of dead was between two and three hundred daily, but it was generally considerably lower. At the time of draining, 54 percent of the suckers had deformed gill covers and their average length was 3.3 inches, as compared with 4.4 inches average total length of the 46 percent possessing normal gill covers.

The suckers in Pond 14 did not die in appreciable numbers during August, and there was no evidence of the deformity at the time of draining.

Suckers in Pond No.6 and the suckers at Wolf Lake were both fed a considerable amount of fresh horse liver during July, August, and September, while the suckers in Pond 14 received fresh meat for only two weeks prior to the conclusion of the experiment. It is possible that the horse liver failed to supply some of the needed elements that were provided the suckers in Pond 14 on the Balto formula.

Table 10 gives a complete summary of all the sucker experiments for 1947.

## CREEK CHUBS

In 1947, three raceways were devoted to creek chub (Semotilus atromaculatus) experimentation. Also one pond contained a spawning race, two ponds held brood fish for another season, and one pond was stocked with a combination of chubs and suckers.

At the Wolf Lake Hatchery, three raceways similar to those used for sucker experimentation were employed in an attempt to find the maximum production of creek chubs by artificial feeding in raceways.

At the Drayton Plains Hatchery, Pond No. 2 was used to carry over last years brood stock, and Pond No. 6 contained a brood stock that would be two years old in the spring of 1948. Pond No. 5, as in previous years, was modified to serve as a spawning race for the brood fish.

### Propagation

In 1946, an artificial spawning raceway was constructed in Pond No. 5 at the Drayton Plains Hatchery, and in 1947 this same raceway was repaired and put into operation again. The raceway can best be described as a ditch 295 feet long and six feet wide, starting at the inlet to the pond and angling toward the deeper portion. At intervals of 15 to 25 feet along the raceway, offset pits five feet long and two and one-half feet wide were constructed and covered with tar-paper as protective devices for the adult fish during spawning activities. Also at each offset pit, a splash board was set to create a deeper pool above the board and a riffle area below each board.

The entire bottom of the raceway was covered with four to six inches of gravel varying from one-fourth to three-fourths inches in diameter.

To provide protection from predaceous birds, the entire raceway was covered with netting suspended from stakes driven along each bank.

The inlet valve to the raceway was regulated to create a constant flow of approximately one and one-fourth cubic feet per second through the raceway, and

splash boards were installed at the outlet to maintain the pond level so that the water was backed just to the lower end of the raceway.

On May 5, 1947, the water temperature in the raceway reached 54° F, and 800 female and 400 male three-year-old breeders were introduced into the pond below the raceway. The average total length of the females was 5.8 inches, and the average total length of the males was 6.4 inches.

On May 8, three days after introduction, the males started constructing redds, and on May 10, there were 60 redds present, with eggs deposited in 10. The number of redds increased daily until the peak number of 160 active redds was reached on May 14.

The redds were located throughout the entire length of the raceway, but 48 percent of the redds were constructed in the lower one-third of the raceway. Consequently, as the males worked progressively downstream with their redds, there was considerable overlapping in the congested areas, and it was decided to remove the eggs from the redds in these areas and incubate them in hatchery jars.

The eggs were removed from the gravel by raising the gravel and egg mixture in front of a screen box. The water current was sufficient to carry the eggs back into the screen box, while the heavier gravel dropped to the bottom in front of the box. After a little practice, this could be accomplished with a very small loss of eggs. Approximately 20 percent of the eggs were carried past the screen box by the current, or were crushed in the gravel.

Several counts of these eggs gave an average of 69 eggs per cubic centimeter, both while green and in the eyed stage. Several counts of the eggs in the redds of the raceway gave an average of 2,308 eggs per running foot of redd.

The eggs picked from the gravel were allowed to develop to the eyed stage in standard hatchery jars, and then placed on screen trays in troughs to hatch. Approximately 72 percent of the green eggs reached the sac fry stage, and very

little loss occurred during the sac fry stage in the troughs. At an average temperature of 56° F., approximately eleven days were required for development to sac fry, and approximately 18 more days were required before the free swimming or advanced fry stage was reached.

On June 4, 27 days after the first spawning activity, free swimming fry were emerging from the gravel in the raceway, and it was necessary to remove the brood stock to prevent cannibalism although a few breeders were still spawning. Three-hundred and eight females and 74 males were recovered, giving a loss of 62 percent of the females and 81 percent of the males during the spawning season. The males were constantly fighting to hold a specific spawning area during the entire spawning period. They were constantly at war with their neighboring males, and at times a female would suffer the attack of a rampaging male. As the season progressed, an increasing number of males showed signs of battle fatigue, and fungus was evident in the wounds of a large percentage of them. Undoubtedly the high mortality rate was the result of the continual fighting.

On June 10, the temperature in the raceway reached 85°, and, as a result, all the sac fry still in the redds were lost. Examinations of several redds did not disclose a single living fry. This loss probably represented over one-half of the potential fry production.

When the brood stock was introduced to the raceway, 12 females taken at random were preserved for ovary counts. The 12 ovaries contained an average of approximately 2,087 eggs. Since 800 female breeders were used, the total potential production was 1,699,600 eggs. Of this potential, 329,700 or 19 percent reached the advanced fry stage.

The advanced fry that had drifted down into the pond previous to the high raceway temperature were not harmed, and they were used to supplement the fry hatched in the jars.

An attempt was made to determine the reasons why a high percent of the males should prefer one section of the stream for spawning, but no physical differences could be discovered that might influence their selection of the congested spawning areas when other areas were available.

Distribution

All the chub fry were transported in the advanced stage under conditions similar to those previously described for sucker fry, and again no loss was encountered in handling or transporting. Also, the chub fry were counted by the same methods described for counting sucker fry.

Of the 329,700 advanced fry produced, 275,000 were sold to 13 minnow propagators, and 54,700 were used for feeding experiments at the Wolf Lake and Lydell State Hatcheries.

Production

The results of the fry sold to private propagators will be discussed later in this report.

Fourteen thousand seven hundred of the fry used in the experiments were in combination with suckers and will also be discussed later.

The remaining 40,000 advanced fry were stocked in three raceways at the Wolf Lake Hatchery. The one-quarter acre raceways were stocked on June 13, and the chubs removed October 9, giving a 118-day growing season. The stocking rates and production are shown in Table 6.

Table 6

| Race number | Stocking rate per acre | Number of fry stocked | Number of chubs removed | Percent of survival | Average length of chubs (inches) | Weight of chubs (pounds) | Pounds per acre of chubs |
|---|---|---|---|---|---|---|---|
| 10 | 200,000 | 8,000 | 7,137 | 89.2 | 2.6 | 39. | 975 |
| 11 | 400,000 | 16,000 | 5,382 | 33.6 | 2.9 | 46. | 1,150 |
| 12 | 400,000 | 16,000 | 14,165 | 88.5 | 2.5 | 66.5 | 1,662.5 |

The chubs were fed a mixture of 65 percent ground fresh meat and 35 percent cereal. The ingredients in the cereal and the cost of the cereal and meat were the same as for the suckers in the Wolf Lake raceways. Artificial feeding was started on June 16, but the chubs did not start eating until about July 1, and then they would eat only the sinking particles as the food was scattered over the surface of the raceway. It was not until the latter part of July, when they were about one and one-half inches in length, that the chubs began picking up food that had settled to the bottom.

During the hot weather in August when the water temperature was over 80° F., the chubs would eat only at night or early morning when the water was cooler. Consequently, the feeding schedule was arranged so they could be fed early in the morning.

Table 10 gives more complete data on the total production and the cost of producing the chubs.

## COMBINATIONS OF SPECIES

Pond No. 11 (0.49 acre) at the Lydell Hatchery was stocked with suckers at the same rate as Pond 6 and Pond 14 at the same hatchery (300,000 advanced fry per acre). In addition, an estimated 14,700 chub fry were introduced.

This pond was fed the same food as the sucker ponds, and at the same rate. Table 7 gives a comparison of the results in the three ponds.

Table 7

| Pond number | Number of suckers removed per acre | Number of chubs removed per acre | Weight of suckers per acre | Weight of chubs per acre | Combined weight per acre | Pounds of food per acre | Pounds of food per pound of fish produced |
|---|---|---|---|---|---|---|---|
| 6 | 24,602 | ... | 578 | ... | 578 | 10,331 | 17.9 |
| 11 | 74,322 | 34,286 | 567 | 245 | 812 | 4,955 | 6.1 |
| 14 | 77,151 | ... | 1,152 | ... | 1,152 | 7,598 | 6.6 |

From Table 7 it becomes apparent that although the combination pond was not fed so much food as the sucker ponds, the pounds of food required to produce

a pound of minnows was nearly as much as for Pond No. 14. However, in terms of value to a minnow retailer, the combination pond yielded a considerably greater net profit than either of the sucker ponds (Table 10).

## FATHEAD MINNOW

Two ponds at the Wolf Lake State Fish Hatchery were utilized for the propagation of fathead minnows. On June 6, Pond No. 4 (one acre) was stocked with 590 fatheads and Pond No. 5 (1.2 acres) was stocked with 699 fatheads ranging in size from one to three inches.

Previous to the introduction of the brood stock, the ponds had been drained and shingles had been driven into the banks and bottom to provide spawning facilities in the otherwise barren sandy ponds. Pond No. 4 received 338 shingles and Pond No. 5 received 406 shingles set in depths of water varying from six inches to three feet.

Pond No. 4 was fertilized with inorganic 10-6-4 fertilizer at the rate of 100 pounds every three weeks from April 2 to August 6. Pond No. 5 served as a control, receiving no fertilizer.

Spawning was first observed in Pond No. 4 on June 19, when egg masses were found on the lower surfaces of several shingles, and fry were observed on June 26. Table 8 shows the sizes of egg masses in Pond No. 4 on shingles placed at various depths.

Table 8

| Depth of water in inches | Size of egg mass in square inches |
|---|---|
| 8 | 6 |
| 8 | 4 |
| 9 | 12 |
| 9 | 12 |
| 10 | 5 |
| 11 | 9 |
| 12 | 10 |
| 18 | 6 |
| 20 | 12 |

No males could be seen guarding nests, and no fry were visible in Pond No. 5 by July 15. Also, several large fish had been seen in this pond, and consequently gill nets were utilized to remove nine suckers, three eight-inch perch and three eight- to ten-inch smallmouth black bass. Undoubtedly the perch and bass eliminated a sizable portion of the brood stock before spawning could take place. Consequently the comparative results are not conclusive. The results of this experiment are shown in Table 9.

Table 9

| Pond number | Area (acres) | Number of breeders | Number of fatheads removed | Average length (inches) | Weight of fatheads (pounds) | Weight per acre (pounds) |
|---|---|---|---|---|---|---|
| 4 (fertilized) | 1.0 | 590 | 69,464 | 2.3 | 152 | 152 |
| 5 (unfertilized) | 1.2 | 699 | 27,356 | 1.7 | 42 | 35 |

Ninety of the large fathead breeders in Pond No. 4 were marked by removing the dorsal fin at the time of stocking, and twenty-five of these were recovered at the time of draining. This indicates that possibly all fathead breeders do not die after spawning, but more experimentation is necessary to determine if fatheads will live through several spawning seasons.

## GOLDEN SHINERS

At the Hastings State Hatchery, Pond No. 4 (0.70 acre) was stocked with 400 three-to four-inch golden shiners on May 8, 1947.

On July 2, fry were numerous in schools on the surface, and an attempt was made to seine and transfer the fry to other ponds. However, the golden shiner fry were too delicate to handle in this manner, resulting in a very heavy loss. It was concluded that golden shiner ponds would have to be stocked with adults rather than fry.

The pond was drained on October 2, and yielded 41,500 fish weighing 51 pounds. The average length was one and one-half inches. This pond was not fertilized.

## NORTHERN PEARL DACE

On May 17, eight pairs of adult pearl dace were put in Pond No. 5 at the Lydell State Hatchery. There was no noticeable attempt at spawning, and no young were produced.

It was planned to leave these adults another year to determine if they would spawn in a small pond.

## NORTHERN REDBELLY DACE

Thirty-five pair of adult redbelly dace were stocked in Pond No. 20 (0.47 acre) at the Lydell State Hatchery on May 17. Several attempts were made during the summer to find eggs or fry, but neither was discovered. The pond was drained November 10, and sixteen females and three males were recovered. There was no evidence that any young were produced.

## SALE OF FRY

As previously mentioned, chub and sucker fry were sold to private individuals having suitable ponds for raising these minnows for the commercial bait market. A total of 21 ponds were used for suckers, chubs, or a combination of the two.

A total of 275,000 chubs were sold to thirteen individuals. In only one instance were any of these minnows removed for sale during the summer and then only a very few were sold.

From personal observation and reports from the purchasers, there was a very good survival in all ponds, but the chubs did not attain a size suitable for bass or pike bait during the season when such bait is scarce. Consequently, most of the chubs were being held until bait became scarce the following summer.

A similar condition existed in the case of the 337,000 sucker fry sold to ten individuals. Only two sold any of the suckers, and they sold only a small percent of the total number. Several propagators expressed the belief that they had poor survival of the suckers, but this may be due to the fact that as the suckers became larger they tend to remain in the deeper portions of the pond

where they were not observed as readily as the chubs.

There is a tendency, among those who raised both chubs and suckers, to favor the chubs. This may be due to the better survival of the chubs, or to the fact that the chubs can be easily seen by tossing food on the surface. Certainly, the psychological factor of being able to see the fish will offer encouragement to some minnow raisers.

Many bait raisers believe they will profit by keeping the minnows until they are large enough to bring high prices, rather than disposing of them while they are smaller although greater in number.

Many of the dealers who purchased fry in 1947, are constructing more ponds to expand their productive capacity, as a few small ponds of minnows in reserve will tide them over the periods of extreme minnow shortages.

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Typed by M. E. Keyser

| Pond | Location | Area (acres) | Species propagated | Date stocked | Number stocked | Pounds of fertilizer |
|---|---|---|---|---|---|---|
| Raceway No. 1 | Wolf Lake | .04 | Suckers | May 22 | 4,000 fry | 48 |
| Raceway No. 2 | Wolf Lake | .04 | Suckers | May 22 | 8,000 fry | 48 |
| Raceway No. 3 | Wolf Lake | .04 | Suckers | May 22 | 12,000 fry | 48 |
| Raceway No. 4 | Wolf Lake | .04 | Suckers | May 22 | 4,000 fry | ... |
| Raceway No. 5 | Wolf Lake | .04 | Suckers | May 22 | 8,000 fry | ... |
| Raceway No. 6 | Wolf Lake | .04 | Suckers | May 22 | 12,000 fry | ... |
| Raceway No. 7 | Wolf Lake | .04 | Suckers | May 23 | 8,000 fry | ... |
| Raceway No. 8 | Wolf Lake | .04 | Suckers | May 23 | 16,000 fry | ... |
| Raceway No. 9 | Wolf Lake | .04 | Suckers | May 23 | 16,000 fry | ... |
| Pond No. 2 | Wolf Lake | .47 | Suckers | May 1 | 16 adult | ... |
| Pond No. 11 | Wolf Lake | 1.29 | Suckers | May 13 | 12,900 eggs | 700 |
| Pond No. 6 | Lydell | .13 | Suckers | May 26 | 39,000 fry | ... |
| Pond No. 14 | Lydell | .41 | Suckers | May 26 | 120,000 fry | ... |
| Pond No. 17 | Lydell | .66 | Suckers | April 30 | 34 adult | ... |
| Pond No. A | Northville | .36 | Suckers | May 26 | 7,500 fry | ... |
| Pond No. 11 | Lydell | .49 | Suckers | May 26 | 147,000 fry | ... |
| | | | Chubs | June 20 | ... | ... |
| Raceway No. 10 | Wolf Lake | .04 | Chubs | June 13 | 8,000 fry | ... |
| Raceway No. 11 | Wolf Lake | .04 | Chubs | June 13 | 16,000 fry | ... |
| Raceway No. 12 | Wolf Lake | .04 | Chubs | June 13 | 16,000 fry | ... |
| Pond No. 4 | Wolf Lake | 1.00 | Fathead | June 6 | 590 adult | 700 |
| Pond No. 5 | Wolf Lake | 1.20 | Fathead | June 6 | 699 adult | ... |
| Pond No. 4 | Hastings | .70 | Golden shiner | May 8 | 400 adult | ... |

* Based on weights and counts of representative samples.
** Based on average current retail prices.
*** Does not include labor or the original cost of the pond.

Table 10

Summary of 1947 Minnow Propagation Experiments
(All numbers of fish are estimated) */

| Pounds of artificial food | Duration of experiment (days) | Percent survival | Number of bait minnows recovered | Average length (inches) | Weight of minnows recovered (pounds) | Weight of crayfish and tadpoles (pounds) | Production of all organisms (pounds) |
|---|---|---|---|---|---|---|---|
| ... | 115 | 17.5 | 701 | 2.7 | 6.5 | 1.0 | 7.5 |
| ... | 115 | 21.8 | 1,714 | 3.0 | 18.0 | 1.5 | 19.5 |
| ... | 115 | 14.6 | 1,750 | 2.9 | 17.5 | 11.0 | 28.5 |
| ... | 115 | 17.1 | 684 | 3.4 | 10.5 | ... | 10.5 |
| ... | 115 | 2.7 | 217 | 3.7 | 5.0 | ... | 5.0 |
| ... | 115 | 1.0 | 119 | 4.3 | 4.0 | ... | 4.0 |
| 512 | 115 | 17.6 | 1,404 | 3.4 | 29.0 | 1.8 | 30.8 |
| 1,024 | 115 | 16.6 | 2,657 | 3.4 | 51.0 | 11.0 | 62.0 |
| 1,024 | 115 | 8.2 | 1,308 | 4.2 | 34.0 | 25.0 | 59.0 |
| ... | 72 | ... | 4,000 | 1.5 | ... | ... | ... |
| ... | 119 | 48.4 | 6,237 | 3.1 | 59.3 | 182.0 | 241.3 |
| 1,343 | 127 | 8.2 | 3,195 | 3.8 | 75.0 | 20.0 | 95.0 |
| 3,115 | 133 | 26.2 | 31,490 | 3.2 | 470.0 | 30.0 | 500.0 |
| ... | 43 | ... | ... | ... | ... | ... | ... |
| ... | 141 | 93.3 | 7,000 | 3.0 | 70.0 | ... | ... |
| 2,428 | 138 | 24.7 | 36,418 | 3.0 | 278.0 | 100.0 | 498.0 |
| ... | 112 | ... | 16,800 | 2.8 | 120.0 | | |
| 285 | 118 | 89.2 | 7,137 | 2.6 | 39.0 | 5.0 | 43.0 |
| 570 | 118 | 33.6 | 5,382 | 2.9 | 46.0 | 7.0 | 53.0 |
| 570 | 118 | 88.5 | 14,165 | 2.5 | 66.5 | 22.0 | 88.5 |
| ... | 138 | ... | 69,464 | 2.3 | 152.0 | 140.0 | 292.0 |
| ... | 139 | ... | 27,356 | 1.7 | 42.0 | 100.0 | 142.0 |
| ... | 147 | ... | 41,500 | 1.5 | 51.0 | 213.0 | 264.0 |

| Number of fish per acre | Weight of fish per acre (pounds) | Weight of all organisms per acre (pounds) | Cost of food and fertilizer per acre | Cost of fry or brood stock per acre | Retail value of bait per acre ** | Net profit per acre *** |
|---|---|---|---|---|---|---|
| 17,525 | 162.5 | 187.5 | $ 49.80 | $ 150.00 | $ 630.90 | $ 431.10 |
| 42,850 | 450.0 | 487.5 | 49.80 | 300.00 | 1,928.25 | 1,578.45 |
| 43,750 | 437.5 | 712.5 | 49.80 | 450.00 | 1,749.99 | 1,250.19 |
| 17,100 | 262.5 | 262.5 | 0.00 | 150.00 | 852.00 | 702.00 |
| 5,425 | 125.0 | 125.0 | 0.00 | 300.00 | 219.00 | 81.00 |
| 2,975 | 100.0 | 100.0 | 0.00 | 450.00 | 179.00 | 270.50 |
| 35,100 | 725.0 | 770.0 | 1,235.00 | 300.00 | 1,956.00 | 421.00 |
| 66,425 | 1,275.0 | 1,550.0 | 2,470.00 | 600.00 | 3,487.32 | 417.32 |
| 32,700 | 850.0 | 1,475.0 | 2,470.00 | 600.00 | 2,223.60 | 846.40 |
| 8,511 | ... | ... | ... | ... | 255.53 | 255.33 |
| 4,835 | 45.9 | 187.0 | 24.40 | 10.00 | 241.74 | 207.34 |
| 24,602 | 578.0 | 730.8 | 965.08 | 450.00 | 1,476.12 | 61.04 |
| 77,151 | 1,152.0 | 1,200.0 | 657.77 | 450.00 | 3,471.75 | 2,363.98 |
| ... | ... | ... | ... | ... | ... | 0.00 |
| 19,600 | 196.0 | ... | ... | 31.25 | 970.02 | 938.77 |
| 108,608 | 812.0 | 997.0 | 429.56 | 540.00 | 4,279.80 | 3,310.24 |
| | | | | | | |
| 178,425 | 975.0 | 1,075.0 | 772.75 | 500.00 | 6,423.00 | 5,150.25 |
| 134,550 | 1,150.0 | 1,325.0 | 1,545.50 | 1,000.00 | 5,382.00 | 2,836.50 |
| 354,125 | 1,662.5 | 2,212.5 | 1,545.50 | 1,000.00 | 10,623.75 | 8,078.25 |
| 69,464 | 152.0 | 292.0 | 29.05 | 17.70 | 2,083.92 | 2,037.17 |
| 22,979 | 35.0 | 119.3 | ... | 21.00 | 689.37 | 668.37 |
| 59,286 | 73.0 | 377.0 | ... | 24.00 | 296.43 | 272.43 |