in lakes where stocking is adequate and adult shortnose gar have been controlled they will not be a problem. However, the presence of shortnose gars reduces the number of legal largemouth bass.

A drastic revision of our stocking standards may be necessary since the total number of largemouth black bass taken per acre did not approach the number stocked, by up to one-third. The interesting fact is that the number of largemouth bass per acre was so similar in the various lakes.

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# GONAD MEASUREMENTS AND EGG COUNTS OF BROWN TROUT (*SALMO TRUTTA*) FROM THE MADISON RIVER, MONTANA[1]

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## Abstract

Gonad studies were made on 41 female and 15 male brown trout, *Salmo trutta*, from the Madison River, Montana. The left ovary, with some exceptions, was found to be longer and heavier and to produce more eggs than the right. The average numbers of eggs produced by the right and left ovaries were 589 and 680, respectively (38 fish), and the average of all eggs per female for fish that were weighed was 1,285 (37 fish). There seemed to be little or no correlation between the length, weight, condition, or age of these females and the number of eggs produced. The gonads comprised 1.7 per cent of the body weights of the males. The weight of the testes did not show any correlation with the length, weight, age, or condition of the fish.

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## Introduction

During November and December of 1936, while engaged in a study of the incidence of furunculosis in fishes of the Madison River, Montana, the writers had an opportunity to secure about one hundred brown trout spawners for studies of the gonads. Most of these fish came from the traps of the former U. S. Bureau of Fisheries in the Meadow Lake region, Madison County, but a few were taken from the traps of the Montana State Fish and Game Commission above Hebgen Reservoir, Gallatin County, Montana.

Collections were made at random from the traps soon after the fish had entered. Special effort was made to avoid any selection in order that the sample might be representative of the run. However, only those fish were saved for study, which, after examination, showed the egg sacs to be intact or the testes to be firm. Fish in this stage of maturity are termed "green" in hatchery parlance. Fifteen males and 41 females were retained for study.

The standard and total lengths of each fish were measured to the nearest ⅛ inch and the weight was recorded to the nearest 2 ounces. Actual counts were made of all eggs. Egg measurements were made with a vernier caliper to the nearest 0.1 millimeter. Our figures represent an average of 15 eggs taken at random from both ovaries. Gonad weights were taken by means of a torsion balance to the nearest 0.1 gram. All measurements were made while the fish were in a fresh condition, usually within 2 or 3 hours after the fish were captured.

[1]Contribution from the Michigan Institute for Fisheries Research and the Zoology Department, Montana State College.

The age of each fish was determined by the usual method of counting the annuli on the scales and the condition factor ($K$) was calculated from the formula adopted by the Fisheries Board for Scotland (Nall, 1930).

## Measurements of Ovaries

A comparison was made between the right and left ovaries of eight individuals as to their length, weight and number of eggs. As shown in Table 1, the left ovary is generally longer and heavier than the

*Table 1.—Comparison between the length, weight, and number of eggs for the right and left ovaries*

[Averages are given in the bottom row]

| Standard length of fish (inches) | Weight of fish (ounces) | Right ovary | | | Left ovary | | |
|---|---|---|---|---|---|---|---|
| | | Length (millimeters) | Weight (grams) | Number of eggs | Length (millimeters) | Weight (grams) | Number of eggs |
| 12.25 | 16 | 128 | 29.7 | 443 | 153 | 36.2 | 550 |
| 13.25 | 18 | 133 | 42.3 | 580 | 174 | 47.4 | 658 |
| 13.75 | 22 | 156 | 44.9 | 600 | 187 | 43.9 | 574 |
| 14.25 | 24 | 148 | 44.9 | 567 | 175 | 56.7 | 721 |
| 14.50 | 24 | 125 | 28.7 | 400 | 188 | 61.7 | 856 |
| 15.00 | 24 | 151 | 27.6 | 368 | 179 | 35.0 | 503 |
| 15.12 | 20 | 94 | 17.3 | 228 | 150 | 31.5 | 431 |
| 15.50 | 24 | 132 | 23.7 | 297 | 150 | 28.5 | 370 |
| 14.20 | 22 | 133 | 32.4 | 435 | 169.5 | 42.6 | 583 |

right. It also usually contains more eggs. This difference is due primarily to the anatomical arrangement of the organs in the coelomic cavity. In the brown trout, the posterior portion of the intestine usually bends strongly to the right, thus crowding the right ovary at its caudal end. The length of the ovary is inversely proportional to the degree of crowding. However, the left ovary is not always the longer. One fish was observed to have a longer right ovary and it was interesting to note that this specimen had an intestine which bent to the left instead of the right. In one or two fish the ovaries were of approximately equal length, with the intestine bending neither to the right nor the left.

The average numbers of eggs in the right and left ovaries from 38 females were 589 and 680, respectively, showing that the shorter ovary as a rule contained fewer eggs.

Gonad weights and egg counts were made for four females collected above Hebgen Reservoir, approximately 1 month before spawning began, and these data were compared with those for five other fish taken at the same place during the spawning season. Table 2 shows that the ovaries of the brown trout collected before the spawning season averaged 3.4 grams as compared to 73.5 grams for those collected during spawning.



*Table 2.—Comparison of the weights of the ovaries and of the numbers of eggs for brown trout collected above Hebgen Reservoir one month before spawning began and during the spawning season*

[Averages are given in the bottom row of both the upper and lower portion of the table]

| Age (number) of annuli) | Standard length (inches) | Weight of fish (ounces) | Weight of ovaries (grams) | Total number of eggs | Number of old eggs |
|---|---|---|---|---|---|
| Females taken one month before spawning began—October 9, 1936 | | | | | |
| 3 | 14.50 | 16 | 4.4 | 862 | 3 |
| 4 | 15.00 | 20 | 2.7 | 2,070 | 1 |
| 4 | 15.00 | 24 | 3.2 | 1,776 | 2 |
| 4 | 16.00 | 24 | 3.6 | 1,425 | 28 |
| 3.8 | 15.12 | 21 | 3.5 | 1,533 | 8.5 |
| Females taken during spawning period—November 18, 1936 | | | | | |
| 4 | 14.25 | 24 | 101.6 | 1,288 | 0 |
| 4 | 15.00 | 24 | 62.9 | 871 | 4 |
| 4 | 15.12 | 20 | 48.8 | 659 | 6 |
| 4 | 15.50 | 24 | 52.2 | 667 | 1 |
| 5 | 15.50 | 28 | 102.0 | 1,073 | 10 |
| 4.2 | 15.07 | 24 | 73.5 | 912 | 4.2 |

If this sample is representative, the weight of the ovaries increases about 20 times during the month prior to spawning. The number of eggs in those females taken early averaged 1,533 as compared to 912 for those taken during the spawning run, while the weights of the females in the latter group averaged 3 ounces greater than the weights of those taken earlier.

Day (1887) reported that early-spawning trout have smaller eggs than those from the latter part of the run and that the size of eggs increases with age and probably with condition of the parent. Our collections did not include specimens from the early and late run and therefore throw no light on this point.

## Egg Counts

Actual numbers of eggs for each of 37 females are given in Table 3 (we omitted 4 fish for which we had no weights). The average number of eggs produced was 1,285 for these fish which had an average total length of 15.3 inches and an average weight of 21.4 ounces. This value is very near the number reported by Vladykov and Legendre (1940) for a native brook trout of comparable size. The largest number of eggs was from a fish with a total length of 16½ inches and a weight of 26 ounces, and the smallest number from a 17¼-inch fish which weighed 20 ounces.

Hayford and Embody (1930), in selection experiments with hatchery brook trout, found that selected females produced an average of 1,164 eggs per female their first spawning year as compared to an average of 272 for like females of the general hatchery stock. At the second spawning the selected fish produced an average of 1,916 eggs (fish 16 to 16½ inches, total length). They discovered much variation, however, within the group studied. Some of the larger females produced the smaller numbers of eggs. Nevertheless, they concluded

that, in general, the fast-growing, larger females produce the most eggs.

In our sample there was no marked correlation between the size and weight of the fish and the number of eggs produced. As shown in Table 3, the fish with the greatest length produced 667 eggs, only about one half of the average; on the other hand a specimen almost as large had the highest egg count. Several of the smaller females had counts above the average. Fish with a standard length between 12 and 13 inches averaged 1,364 eggs; between 13 and 14 inches, 1,300 eggs; between 14 and 15 inches, 1,300 eggs; and between 15 and 16 inches, 1,131 eggs.

The conditon of the fish seems to have no relationship to egg production. At least, our sample shows no correlation between condition and the number of eggs. The specimen with the highest *K* value, however, did produce the largest number of eggs.

According to Nall (1930), female sea trout produce 700 to 800 eggs

*Table 3.—Size, age, condition, and number of eggs for 37 Madison River brown trout*

[Averages are given in the bottom row]

| Standard length (inches) | Total length (inches) | Weight of fish (ounces) | *K* | Age (number of annuli) | Weight of ovaries (grams) | Number of eggs | Number of old eggs |
|---|---|---|---|---|---|---|---|
| 12.25 | 13.75 | 16 | 0.901 | 3 | 65.9 | 993 | 0 |
| 12.25 | 14.00 | 14 | 0.747 | 3 | 73.2 | 1,045 | 2 |
| 12.50 | 13.75 | 18 | 1.014 | 3 | 87.0 | 1,884 | 3 |
| 12.75 | 14.37 | 18 | 0.888 | 3 | 89.4 | 1,532 | 1 |
| 13.25 | 14.62 | 18 | 0.843 | 2 | 89.7 | 1,238 | 1 |
| 13.25 | 14.75 | 22 | 1.003 | 3 | 113.6 | 1,435 | 8 |
| 13.25 | 14.87 | 18 | 0.801 | 3 | 92.9 | 1,310 | 6 |
| 13.25 | 14.87 | 20 | 0.890 | 4 | 98.2 | 1,410 | 0 |
| 13.25 | 15.00 | 16 | 0.694 | 3 | 77.0 | 1,077 | 0 |
| 13.25 | 15.00 | 20 | 0.867 | 3 | 89.2 | 994 | 1 |
| 13.37 | 14.87 | 20 | 0.890 | 3 | 105.5 | 1,299 | 8 |
| 13.50 | 14.87 | 18 | 0.801 | 3 | 93.1 | 1,454 | 0 |
| 13.75 | 15.25 | 20 | 0.825 | 3 | 79.9 | 1,503 | 3 |
| 13.75 | 15.25 | 22 | 0.908 | 4 | 88.8 | 1,174 | 0 |
| 13.75 | 15.50 | 20 | 0.786 | 3 | 94.1 | 1,328 | 2 |
| 13.75 | 15.50 | 20 | 0.786 | 3 | 85.2 | 1,374 | 0 |
| 14.00 | 15.62 | 22 | 0.845 | 3 | 117.1 | 1,688 | 0 |
| 14.00 | 15.75 | 20 | 0.749 | 3 | 108.2 | 1,794 | 1 |
| 14.00 | 16.00 | 20 | 0.715 | 5 | 76.8 | 1,196 | 0 |
| 14.12 | 16.00 | 20 | 0.715 | 3 | 78.7 | 1,337 | 1 |
| 14.25 | 15.50 | 24 | 0.944 | 4 | 101.6 | 1,288 | 0 |
| 14.25 | 16.00 | 20 | 0.715 | 3 | 69.1 | 1,166 | 51 |
| 14.25 | 16.12 | 22 | 0.769 | 4 | 90.2 | 1,174 | 0 |
| 14.50 | 16.12 | 24 | 0.839 | 4 | 100.0 | 1,377 | 0 |
| 14.50 | 16.12 | 24 | 0.839 | 4 | 80.9 | 839 | 0 |
| 14.50 | 16.25 | 24 | 0.819 | 4 | 90.4 | 1,256 | 0 |
| 14.50 | 16.25 | 24 | 0.819 | 5 | 124.3 | 1,744 | 0 |
| 14.50 | 16.50 | 22 | 0.717 | 4 | 97.4 | 1,067 | 8 |
| 14.75 | 16.50 | 28 | 0.912 | 4 | 106.0 | 2,352 | 0 |
| 14.75 | 16.62 | 24 | 0.765 | 4 | 80.2 | 865 | 3 |
| 15.00 | 17.00 | 24 | 0.715 | 4 | 62.6 | 871 | 4 |
| 15.00 | 17.00 | 26 | 0.796 | 3 | 106.1 | 1,682 | 0 |
| 15.12 | 17.25 | 20 | 0.570 | 4 | 48.8 | 659 | 6 |
| 15.25 | 17.25 | 24 | 0.685 | 5 | 95.6 | 1,104 | 0 |
| 15.50 | 17.25 | 26 | 0.682 | 4 | 141.2 | 1,299 | 71 |
| 15.50 | 17.25 | 28 | 0.799 | 5 | 102.0 | 1,073 | 10 |
| 15.50 | 17.50 | 24 | 0.700 | 4 | 52.2 | 667 | 0 |
| 14.02 | 15.73 | 21.4 | 0.784 | 3.6 | 90.5 | 1,285 | 5.1 |



per pound of fish, but he recognized a great deal of variation from this figure. He observed that the smaller fish have more eggs per pound of fish but that the eggs are smaller.

Dahl (1917) reported that the weight of the roe per pound of fish is less in young than in old females but that the number of eggs decreases as the age and weight of females increase, *i.e.*, young trout are more prolific but produce smaller ova.

The females of our collection showed from 2 to 5 annuli on their scales but egg counts did not seem to show significant variation between the different age groups, although Needham (1938) reported that in brook trout, "The number of eggs depends naturally upon the age of the fish." In our sample one 2-year-old brown trout had 1,238 eggs; 18 three-year-olds averaged 1,383 eggs; 17 four-year-olds, 1,155 eggs; and 4 five-year-olds, 1,279 eggs.

Old eggs, or eggs apparently held over from the previous year, were present in 50 per cent of the females studied. The numbers ranged from a single egg to 71 per female, with an average of approximately 5 old eggs per fish.

Measurements of diameter were made of eggs obtained from 31 females. The average diameter was 4.94 millimeters. The size of the eggs in this sample could not be correlated with the size or age of the fish or the number of eggs produced.

*Table 4.—Size, weight, age, condition, and weight of the gonads of 15 Madison River male brown trout*

[Averages are given in the bottom row]

| Age (number of annuli) | Standard length (inches) | Total length (inches) | Weight (ounces) | *K* | Weight of testes (grams) |
|---|---|---|---|---|---|
| 4 | 11.75 | 13.25 | 10 | 0.629 | 8.6 |
| 2 | 12.00 | 13.50 | 16 | 0.952 | 13.5 |
| 4 | 12.25 | 13.50 | 14 | 0.833 | 5.2 |
| 3 | 12.50 | 14.25 | 16 | 0.810 | 8.9 |
| 4 | 12.75 | 14.25 | 18 | 0.911 | 8.9 |
| 4 | 12.75 | 14.75 | 16 | 0.810 | 4.9 |
| 5 | 13.25 | 15.50 | 20 | 0.786 | 6.1 |
| 4 | 13.50 | 15.00 | 20 | 0.867 | 8.0 |
| 4 | 13.75 | 15.25 | 20 | 0.825 | 8.1 |
| 4 | 13.75 | 15.50 | 20 | 0.786 | 13.0 |
| 5 | 14.00 | 16.25 | 22 | 0.750 | 13.1 |
| 3 | 14.25 | 16.25 | 20 | 0.682 | 7.4 |
| 3 | 14.50 | 16.00 | 20 | 0.715 | 7.5 |
| 4 | 14.75 | 16.50 | 24 | 0.782 | 14.3 |
| 5 | 15.38 | 17.12 | 28 | 0.817 | 16.0 |
| 3.9 | 13.41 | 15.10 | 19 | 0.797 | 9.6 |

## Measurements of Testes

Only 15 males were studied. Their body weights and lengths and gonad weights are given in Table 4. This small sample shows no correlation between the size or condition of the fish and the weight of the testes. The testes averaged 9.9 grams, or 1.7 per cent of the body weight. The lack of correlation may be due to the inadequate sample or to the different degrees of "ripeness." There is no reason to be-

lieve from this sample that the age of the fish has any bearing on the weight of the testes.

A summary of this paper may be found in the abstract.

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# FISH POPULATIONS IN THE BACKWATERS OF WHEELER RESERVOIR AND SUGGESTIONS FOR THEIR MANAGEMENT[1]

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## Abstract

During the past 3 years, several methods have been used in an effort to determine the standing crop of fish and the relative abundance of the different species in the fish population of Wheeler Reservoir. In addition to a census of sport and commercial fishing, gillnets, set lines, seines, fyke nets, and rotenone have been used to sample the fish population. Among the methods used, poisoning with rotenone has proven to be the most effective. When sampling the fish population by this method, areas of the reservoir which were suitable for study were shut off by means of a barrier seine before the rotenone was applied. This procedure made it possible to determine the total fish population and the relative numbers and weights of each species without allowing the poison to spread or fish to migrate to or from the area. Three plots having a combined area of 12 acres were treated in this way.

It was found that of the total weight of fish taken in the three areas, game fish comprised from 2 to 4 per cent; panfish 7 to 19 per cent; food fish 3 to 6 per cent; and coarse fish 73 to 85 per cent. Coarse fish, such as carp, buffalo, and shad, were dominant in the population of all areas. It is concluded that the desirable species, such as black bass, must be encouraged in all possible ways and the coarse species controlled by all means at hand, if game fishing is to be maintained. As an experiment, it is planned to screen off an area having a narrow connection with the main reservoir so that all fish can be removed by the use of rotenone and the area restocked with desirable species. It is blieved that by removing the coarse species which now comprise about 73 to 85 per cent of the total weight of fish present, the total productive capacity of the water will be used in the production of desirable species and the yield of these species will be greatly increased, which will greatly benefit sport fishing.

## Introduction

The formation of a chain of multiple-purpose reservoirs along the Tennessee River and its tributaries, by the Tennessee Valley Authority, has created extensive areas of new fishing water and has produced new problems for the fishery manager. Investigations conducted by the Biological Readjustment Division of the Authority indicate that each reservoir and its fish population pass through a cycle of development during the first few years of impoundment, and that one of the most important problems in the sustaining of sport and commercial fishing in the lower run-of-the-river reservoirs is the maintanance of a desirable balance among the different species comprising the total population. There are indications that the species composition of the fish population changes from year to year and that the trend is toward a

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