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THE FOOD YIELD OF ONE ACRE OF WATER

Under date of January 19, 1933 the Institute received a request from Mr. F. A. Westerman of the Fish Division, Department of Conservation, for information regarding yield of food per acre of water. The information which we have gathered on this subject is given in this report.

I. Yield of Fish

Since fish are the principal crop of waters, often the only utilized food resource, information on yield of fish should be more useful than figures dealing with aquatic plants, mammals or other crops.

Obviously, no one figure established for one particular body of water could be taken as a standard figure for all one-acre units. The yield is subject to modification by numerous factors. These concern both physical and biological features, differing from one body of water to another. Since plant life is the basis of animal production, conditions for plant growth will modify the fish yield. The basic fertility of the water and bottom, light-penetration conditions, and temperature conditions are very important. A fertile, shallow, warm body of water would be expected to have a greater productivity than an infertile, deep, cold one.

For our purposes, it is necessary to differentiate between total production and fishery yield. The figure for total fish production, as in a pond that is drained of all fish, will be much higher than the figure for fishery yield, where only a fraction of the total amount of desirable fish is removed and poundage of

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undesirable fish is not included.

(1). Total annual yield of fish per acre.

(a). Ponds heavily fertilized, shallow, and warm. Experiments at the U. S. Bureau of Fisheries Station at Fairport, Iowa, on the rearing of fish on natural food in fertilized ponds, gave figures as high as 10,000 fingerling bass per acre. Black crappie and bluegill production was over 20,000 fingerlings per acre. Reduced to poundage, the best yield was at the rate of 260 pounds per acre (Higgins 1931, p. 496).

A record of a yield of bluegill sunfish at the rate of 272 pounds per acre (Fairport, Iowa) is given by Radcliffe (a. 1928, p. 22). He cites that carp ponds in Germany have produced as high as 150 pounds to the acre.

Viosca (1929, p. 210) gives a figure of 800 pounds of fish (bass and other warm-water species) per acre for the annual production of fish ponds at the Lake St. John hatchery, Louisiana. This figure was estimated from samples of the population and not by weighing the total number of fish produced in one year.

(b). Flowing waters. Embury (1926, p. 25) reports trout production, under experimental conditions, at the rate of 300 pounds under rich food conditions and at 75 pounds per acre under less rich conditions. The experiment was carried on at the Experimental Hatching Station of Cornell University in races.

(2). Census of unit areas. By counting all fish within a measured unit area it is possible to calculate how many fish are present per acre. Such a census figure cannot be greater than the figure for total annual yield but may be smaller, since no count is taken of any fish removed before the census is made.

Counts of 100 foot sections have been made by the Institute in several

Michigan trout streams. As many as 5,000 trout (predominantly of fingerling size) per acre have been obtained. Reduced to pounds per acre, such a figure would be slightly over 10 pounds per acre.

Embrey (1928, p. 23-24) obtained a figure of 45 pounds per acre (70 percent minnows and suckers, and 30 percent trout) in one census of 1000 feet of trout stream in New York state.

(3). Fishery yield. Perhaps the most useful figures, bearing on annual yield, are those gathered from records of fish catch. Knut Dahl (as quoted by Hewitt, 1931) reports that certain Norwegian lakes produced 1.78 to 2.67 pounds of trout per acre in a year. Loch Leven, in Scotland, is recorded as producing from 7.7 to 10 pounds of trout per acre. Hewitt (1931, p. 81) concludes that a yield of 10 pounds per acre per year is exceptional for trout streams or lakes and that 5 to 8 pounds is nearer the general average.

Yields of trout for European trout streams is given by Walter (1912, p. 65) at 10 to 500 kilograms per kilometer, per year. Unfortunately, widths of stream are not given, and yields per acre cannot be calculated from the figures, which range, for the mile of stream, from 35 to 1770 pounds per year. A stream $8 \frac{1}{4}$ feet wide averages one acre per mile. Since this is a very small fishing stream, it is probable that Walter's figures are for streams that average several acres to the mile.

Huitfeldt-Kaas (1917, p. 212) gives the production of a Norwegian Lake (Mjosen) at 3.5 kilograms per hectare (3.11 pounds per acre).

Alm (1927, p. 33) cites a figure of 2.9 kilograms per hectare (2.58 pounds per acre) for a Swedish Lake (Mälarsee).

Production of trout is given at 3 kilograms per hectare (2.67 pounds per acre) by Dahl (1930, p. 29) for a Norwegian lake (Skurdalsfjord). An extremely productive lake, the Haugatjern, he gives at 200 kilograms of fish (mainly a species of whitefish) per hectare. This is at the rate of 178 pounds per acre

per year.

Radcliffe (a. 1928, p. 5) states that the commercial fish catch around Cape Cod is about 122 pounds per acre. The great lakes, he gives at 2 pounds per acre (evidently an average for all of the lakes). Elsewhere (b. 1928, p. 22) he gives other figures as follows: North Sea fishing grounds 17 pounds per acre, Lake Pepin, Mississippi River 145 pounds, and Lake Erie 10 pounds.

Lake Erie is, by far, the most productive one of the great lakes. Figured from statistics of total fish catch, annual production has varied from 4.6 to 11.9 pounds per acre. The latest figure, 1930 catch, is given as 42,220, 241 pounds (Fiedler, 1931 p. 389). This is 6.6 pounds per acre.

(4). Total calculated fish yield, based on quantitative studies of fish food.

A number of quantitative studies of bottom organisms, plankton, and aquatic vegetation have been made. Where the amount of fish food per acre of water has been determined, calculations have often been made, of the amount of fish life that could be supported by the known amount of food. Using a 5 to 1 ratio (5 pounds of food being considered equivalent to 1 pound of fish flesh) Locke (1930, p. 681) gives calculated fish productions ranging from 93 to 2,726 pounds per acre.

II. Comparison of Water and Land Yields

According to Leopold (1932, p. 12) the maximum density of quail population is one bird per acre. He also gives this figure for pheasants and Hungarian part^aridges.

Experience of hunters and fishermen, in general, is that a much larger area of land must be covered to provide a satisfactory day's hunting, than must be covered to provide a comparably satisfactory day's fishing. The general statement, that the fish population is more dense per acre, than the game population, appears to be warranted.

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