STANDING CROP OF FISHES AS AN ESTIMATE OF FISH PRODUCTION IN SMALL BODIES OF WATER

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ABSTRACT

Sampling of fish for the purpose of estimating standing crop, annual net production, and the degree of relationship between these two variables was carried out in four Oklahoma farm ponds in 1965. Fish populations were assumed to be at or near the upper asymptotic level, and fishing was almost nonexistent. Annual rate of turnover varied less from one population to another than did standing crop. Turnover rates for most species appeared high, but this may be the normal situation in older ponds whose fish populations are not being harvested.

Bartlett's three-group method for Model II regression was used to obtain the prediction equation: annual net production = 0.3465 + 0.6088 (standing crop). This equation showed by its positive slope that annual net production increased as standing crop increased. The coefficient of determination, r^2=0.92, indicated a strong relationship between standing crop and the annual net production of fishes.

INTRODUCTION

Production estimation is a demanding problem which has discouraged investigators in their research efforts toward increasing productivity of waters. As an alternative, many investigators have used standing crop estimation to identify factors limiting production. While the standing crop cannot be taken as a precise measure of production rate, since no information on the time required to produce the crop, or its turnover rate is considered, it is still an indicator of production. Providing that asymptotic levels have been reached and turnover rates are similar, population size probably indicates the amount of food required for its maintenance. Thus a large standing crop may suggest a high rate of production of organic material on which it feeds.

If the standing crop of fishes has accumulated over a period of time without being utilized, the crop should reach an upper asymptotic level in relation to existing environmental resistance factors. At this point, the population may approximate a steady state system. Natality, growth, and mortality essentially offset each other to maintain a fairly constant biomass. According to Carlander (1955), the annual rate of turnover probably varies less from one fish population to another than does standing crop. Since standing crop may be used as an estimate of the upper asymptotic level in older and underutilized waters, and since annual rate of turnover of fishes in these waters may be similar, standing crop data probably are a fairly good index of fish production. A large standing crop signifies a greater production than does a smaller standing crop. The same reasoning should apply to standing crops of fishes that have been subjected to a steady rate of utilization for an extended period of time.

In 1965 a detailed study of standing crops and fish production in four farm ponds was undertaken. Statistical relationship between these two variables is presented in this paper.

METHODS AND MATERIALS

In this study, annual net production is defined as the total annual growth in weight of fish including growth in the part of the population which dies before the year ends. Standing crop is regarded as the weight of a given species or complex of species of fishes present in a body of water at a specified time.

The farm ponds were located near Stillwater, Oklahoma, and were used principally for livestock watering. Fishing in these ponds was almost nonexistent. The watersheds of all ponds were mixed grass prairie. The ponds ranged in age from 16 to 35 years, averaging 23 years. The ponds varied in size from 0.32 to 4.91 surface acres, averaging 2.46 acres. Two ponds were muddy and two were clear (less than 25 Jackson turbidity units). For identification purposes, the ponds, according to their size and turbidity, are called Little Muddy, Big Muddy, Little Clear, and Big Clear. The muddy ponds contained few macrophytes as compared to the abundant quantity found in the clear ponds. Physical data for the four farm ponds are presented in Table 1.

Little Muddy was small enough that a 30-foot bag seine of ⅛ inch mesh size was the only gear needed for fish collections. Big Clear was sampled with 20 collapsible nylon fish traps of ⅝ inch mesh size, because extensive aquatic vegetation prevented use of the seine. Big Muddy and Little Clear were sampled by both the traps and the seine.

In analyzing the individual pond populations, the following estimates were made for each species present: population number, average weight, standing crop, average instantaneous mean growth rate, survival rate, and production rate. Chapman's (1954) modification of the Schnabel equation was used to obtain population estimates. The number of fish of each species was multiplied by the average species weight to obtain an estimate of the species standing crop. Growth data were obtained from fish scale and spine readings, and average instantaneous mean growth rate estimates were calculated by using Eipper's (1964) equations. Survival rate estimates were calculated using Robson and Chapman's (1961) equations. Annual net production estimates were calculated for all fishes in each pond for which adequate samples were available using Ricker's (1958) equations. A complete discussion of the above estimates is given by Whiteside (1967).

RESULTS AND DISCUSSION

Coefficient of variation values of 35 for annual turnover rates and 131 for standing crops show that the annual turnover rates varied less than did standing crops. These data were based on each species in each farm pond (Table 2). The turnover rates for most species seem high for old ponds where fish populations were underutilized and were assumed to have reached upper asymptotic levels. This may be due to sampling error associated with estimations of population, growth rate, and mortality rate, or to fishes in these ponds having a high natural mortality rate. High natural mortality rates may be normal in established fish populations. Gerking's (1962) investigation of an established bluegill population in Wyland Lake, Indiana supports this contention, since that population was subjected to low fishing pressure and had an annual turnover of 93 per cent.

Linear regression analysis was used for the purpose of obtaining a prediction equation of annual net production in terms of standing crop, and to explain some of the variation of annual net production by standing crop. Since the variates of the independent variable standing crop were not controlled, the Bartlett's three-group method for Model II regression was used instead of Model I regression (Sokal and Rohlf, 1969). The following calculations were based on data for each species in each farm pond (Table 2). The linear equation, annual net production = 0.3465 + 0.6088 (standing crop), showed by its positive slope that annual net production increases as standing crop increases. The coefficient of linear correlation, r = 0.96, demonstrated a highly significant association between the two variables at the 0.01 probability level. According to Remington and Schork (1970) the real strength of a relationship between two variables is best shown by the coefficient of determination, r^2, the proportion of the variance of the dependent variable "explained" by linear regression on the independent variable. For this analysis r^2 is equal to 0.92 which indicates a near perfect linear relationship for standing crops of fishes and their annual net production.

Production may be affected by environmental factors that set the limits on the upper asymptotic level. A study of the relationships between various environmental factors and standing crops is one way of determining these factors. Experimental studies where all environmental factors but one are kept constant while the one is varied according to experimental design would be the ideal way to determine the effect of the various factors. However, since such experiments are not possible in natural conditions, an analysis of the available field data by regression methods should give clues as to the important limiting factors and may permit a more accurate prediction of production and of upper asymptotic levels as knowledge increases.

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LITERATURE CITED

American Fisheries Society. 1970. A list of common and scientific names of fishes from the United States and Canada. Amer. Fish. Soc., Spec. Publ. No. 6. 102 p.

Carlander, Kenneth D. 1955. The standing crop of fish in lakes. J. Fish. Res. Bd. Can., 12(4):543-570.

Chapman, D. G. 1954. The estimation of biological populations. Ann. Math. Statist., 25(1):1-15.

Eipper, Alfred W. 1964. Growth, mortality rates, and standing crops of trout in New York farm ponds. Cornell Univ. Agr. Exp. Sta., Ithaca, N. Y., Mem. 388. 67 p.

Gerking, Shelly D. 1962. Production and food utilization in a population of bluegill sunfish. Ecol. Monogr., 32:32-78.

Remington, Richard D. and M. Anthony Schork. 1970. Statistics with applications to the biological and health sciences. Prentice-Hall, Inc., New Jersey. 418 p.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Fish. Res. Bd. Can., Bull. 119. 300 p.

Robson, D. S. and D. G. Chapman. 1961. Catch curves and mortality rates. Trans. Amer. Fish. Soc., 90(2):181-189.

Sokal, Robert R., and F. James Rohlf. 1969. Biometry the principles and practice of statistics in biological research. W. H. Freeman & Co., San Francisco. 776 p.

Whiteside, B. G. 1967. Population dynamics of fishes in farm ponds in Payne County, Oklahoma. Unpublished Ph.D. thesis. Stillwater, Okla., Libr., Okla. State Univ.

Table 1. Physical data of four farm ponds studied to determine the standing crop and production of fish, 1965.

Name of pond	Date of fish collections	Area (acres)	Mean annual turbidity (turbidity units)	Age of pond (years)
Little Muddy	June-July	0.32	247	18
Big Muddy	Feb-July	4.91	107	35
Little Clear	April-May	0.70	21	23
Big Clear	April-May	3.92	23	16

Table 2. The estimated standing crop, annual net production, and annual per cent turnover in four farm ponds.

Pond	Species[1]	Standing Crop (lbs/acre)	Annual Net Production (lbs/acre)	Annual Per cent Turnover
Little Muddy	Green sunfish	88.69	63.01	71
	Black bullhead	68.74	41.72	61
Big Muddy	Green sunfish	0.39	0.20	51
	White crappie	104.34	45.08	48
	Largemouth bass	5.27	6.40	121
	Orangespotted sunfish	2.62	1.40	53
	Bluegill	7.53	3.91	52
	Redear sunfish	4.68	1.95	42
	Channel catfish	0.75	0.67	89
	Golden shiner	0.39	0.13	33
Little Clear	Green sunfish	65.47	40.48	62
Big Clear	Green sunfish	33.36	29.56	89
	Largemouth bass	11.77	9.75	83
	Black bullhead	2.92	2.22	76

[1]Common names obtained from Amer. Fish. Soc., Spec. Publ. No. 6.