Pauly, D. 1984. Recent developments in the methodology available for the assessment of exploited fish stocks of reservoirs, p. 321-326. In: J.M. Kapetzky and T. Petr (eds) Status of African Reservoir Fisheries. Committee for Island Fisheries of Africa, Technical Paper 10.

RECENT DEVELOPMENTS IN THE METHODOLOGY AVAILABLE FOR THE ASSESSMENT OF EXPLOITED FISH STOCKS OF RESERVOIRS

EVOLUTION RECENTE DE LA METHODOLOGIE UTILISEE POUR EVALUER LES STOCKS DE POISSON EXPLOITES DANS LES RESERVOIRS

by

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In J.M. Kapetzky and T. Petr (eds.) Status of African Reservoir Fisheries. CIFA Tech. Rep. No. 10, 326 p. 1984.

ABSTRACT

Recently developed fish stock assessment methods are briefly presented which could be used for the management of the fish stocks of African reservoirs. These methods include length-structured versions of Virtual Population Analysis which seem particularly suited to reservoirs because (a) they do not include any equilibrium assumption; and (b) they can be used in conjunction with such highly selective gears as gillnets.

RESUME

On trouvera résumé ci-après des méthodes d'évaluation des stocks de poisson qui viennent d'être élaborées et qui pourraient être utilisées pour aménager les stocks dans les réservoirs africains. Ces méthodes comportent divers types d'analyses de populations virtuelles, basées sur la longueur, qui semblent particulièrement adaptées aux réservoirs, car a) elles ne présupposent aucun équilibre; et b) elles peuvent être utilisées en même temps que des engins hautement sélectifs, par exemple les filets maillants.

1. INTRODUCTION

Reservoirs differ in a number of features from those water bodies (lakes, marine waters) where conventional methods for the assessment of fish stocks have been commonly applied. Among these features, the lack of stability of the various fish communities following impoundment has generally prevented the meaningful application of methods built around steady-state assumptions (e.g., surplus-yield models, yield per recruit models), while the presence of flooded tree stumps in most reservoirs has generally prevented the use of sampling gears other than the ubiquitous, but highly selective gillnets. While these constraints cannot be ignored, it is apparent that advances in the assessment and management of reservoir stocks will be made only if serious attempts are made to adapt to reservoir conditions at least a part of the stock assessment methodology that is presently in use in other aquatic systems. In the following, a brief review is given of methods used for the assessment of the fish stocks of African reservoirs, emphasis is given to methods recently developed which extract a maximum of reliable information from a minimum of data.

2. AVAILABLE METHODS

2.1 Growth Studies

The identification of annual rings on the scales or otoliths of African fishes has generally been achieved where it has been attempted (Matthes, 1973). In fishes with short life spans (e.g., in the clupeids Stolothrissa and Limnothrissa), the study of daily growth rings seems particularly indicated. The concept and methods are given in Panella (1971, 1974); Brothers (1980) gives an exhaustive bibliography.

Growth studies based on length-frequency data can be quite reliable when using the ELEFAN method of Pauly and David (1981); however, access to a microcomputer (at least) is required. The method allows, given length-frequency data, for the rapid estimation of the von Bertalanffy Growth Function (VBGF) L_∞ and K (and their standard errors) and of terms expressing the seasonality of growth occuring in African reservoirs, where marked summer-winter differences in temperature are common.

Tagging studies also are suitable for the estimation of L_∞ and K in reservoir fishes (besides allowing for the estimation of mortalities and biomass, see below); new methods for the estimation of growth parameters from length at tagging and length at recovery are given in Pauly and Ingles (1981) and Munro (1982).

2.2 Mortalities

Mortalities are defined in fishery biology as M (natural mortality), F (fishing mortality) and Z (total mortality) and Z = M + F. Gulland (1969) and Ricker (1975) give mathematical definitions of these parameters.

A variety of methods are available for estimating Z in fish stocks, such as:

(i) equation relating Z and mean length of the catch,

(ii) length-converted catch curves, i.e., relationships linking the relative numbers of large (old) fish to those of the small (young) fish in the catch or in scientific samples;

(iii) methods for analysis of mark and recapture data.

Detailed description of the methods in (i) and (ii) are given in Pauly (1980); for use in reservoirs, it is important to use data from time periods during which the assumption of equilibrium condition is at least approximately met. Some of the methods also have to be adapted when the sampling gears are gillnets, i.e., the establishment of selection curves and the subsequent debiasing of data are imperative. Gulland (1969) gives methods to deal with this and also with estimation of Z using the methods in (iii). Another approach is to estimate Z from the maximum age (t_{max}) in years in the catch (Hoenig, 1982; Hoenig and Lawing, 1982) which can be done, e.g., using the relationship

$$\log_e Z = 1.44 - 0.984 \log_e t_{max} \quad (1)$$

Separating Z into its constituent parts M and F is generally quite difficult and the use of the following expression is suggested for obtaining first estimates of M from the growth parameters and mean environmental temperature of a stock:

$$\log_{10} M = -0.0066 - 0.279 \log_{10} L_\infty + 0.6543 \log_{10} K + 0.4634 \log_{10} T \qquad (2)$$

where T is the annual mean water temperature (in ^{o}C) of that part of the reservoir inhabited by the stock in question, K is expressed on a yearly basis and L_∞ is the total length in cm (Pauly, 1980a).

2.3 Estimation of Biomass

Estimating the standing stock of fish in reservoirs by species or groups of species of the same ecotype is extremely useful, both to manage the stocks in practice and to reach an understanding of the working of a given ecosystem.

In reservoirs, standing stocks can be estimated from mark-recapture studies, through Virtual Population Analysis (VPA, see below), sampling, and the DeLury method. Catch in weight (Y), fishing mortality (F) and biomass (B) are related by

$$Y = F.B \qquad (3)$$

which offers the possibility, if F can be estimated by subtraction, using equation (1) and (2) above, to estimate biomass through

$$B = Y/F \qquad (4)$$

Thus, there are situations where it is possible to estimate biomass (at least roughly) without sampling more than the catch of a fishery (as is also possible using VPA, see below).

An interesting aspect of biomass estimates is that they can be used in conjunction with equations, such as (3) and (4), to construct ecosystem (trophic) models by linking the biomasses of given taxa (or group of them) through arrows expressing food consumed (Q) by a predatory species and quantified, in analogy to (3) by

$$Q = M.B \qquad (5)$$

where M and B apply to a prey species. Trophic models of this type (which are discussed in detail in Pauly, 1982) are relatively easy to construct, and offer a concise way of summarizing what is known of a given fishery and of the ecosystem that supports it. Moreover, such trophic models have built-in checks, for example, the amount consumed daily by the animals of a given taxon should be in the vicinity of 3-5 percent of their own weight, or that their gross food conversion efficiency (Z.B)/food consumed) should be somewhere between 0 and 20 percent (Jones, 1982). It is thus possible to infer, if such a trophic model does not balance, that either important groups have not been accounted for or that the values of some of the parameters are incorrect.

2.4 Simultaneous Estimation of Fishing Mortality, Standing Stock and Recruitment

Virtual Population Analysis (VPA) and its related methods (cohort analysis, length cohort analysis; see Jones, 1981) seem not to have been applied to any reservoir stocks, and certainly not to any African stock. The principle of the method is that, in an exploited stock, the population of fish that must have been in the water to generate, over time, a given succession of catches can be reconstructed, using only the catches themselves and an estimate of M. The important features of VPA-based methods in connection with their potential use in reservoir fisheries are:

- VPA does not require unselective gears, nor debiasing of catch samples for the effect of selection. Thus, catch data even from a fishery using strongly selective gears can be used;
- No estimates of effort are needed;
- No assumptions of equilibrium are involved.

As commonly used (e.g., in Northern Europe), VPA requires data on catch-at-age; however, various modifications have been proposed which require only catch-at-length data, along with estimates of L_∞ and K of the VBGF (Jones, 1981). Recently, a version of VPA has been developed which, while still being based on catch-at-length data, performs an analysis similar to an age-based VPA, with the result that estimates of F, standing stock and recruitment can be obtained in real time, e.g., on a monthly basis (Pope *et al.*, MS).

This method, which was developed for application of stocks of short-lived fishes, e.g., Peruvian anchoveta, could very profitably be applied in an African reservoir context, especially to the stocks of pelagic clupeids which have dynamics similar to those of the Peruvian anchovy-with quantity of river inflow replacing upwelling intensity (Marshall et al., 1982).

The author will be glad, within the framework of ICLARM's Network of Tropical Fisheries Scientists (Munro and Pauly, 1982), to assist any reader in the implementation of the methodology outlined above, as well as to provide copies of the papers listed in the references (with the exception of Ricker's and Gulland's books).

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