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USE OF A SURPLUS-PRODUCTION MODEL TO ANALYZE THE STANDARD ICCAT AGE-STRUCTURED SIMULATED DATA SETS

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SUMMARY

This document describes the application of a non-equilibrium surplus-production model (ASPIC) to four standard ICCAT simulated data sets as distributed by Dr. V. Restrepo. Each data set is 15 yr. old and characterized by either high data contrast (population increase and then decrease) or low contrast (only a decline during the series) and by either clear length modes or blurred length modes in the catch data. The acronyms HCCM, HCBM, LCCM, LCBM are used here for the data sets.

RESUME

Un modèle de production excédentaire non structuré par âge a été ajusté à des données simulées représentant des échantillons d'une population simulée structurée par âge. Dans tous les cas, les estimations du modèle concernant l'abondance globale présentaient une forte relation avec les séries "réelles" d'abondance ; il n'a cependant pas été possible d'obtenir des estimations paramétriques fiables pour les données peu contrastées.

RESUMEN

Se ajustó un modelo de producción excedente no estructurado por edad, a datos simulados que representaban muestras de una población simulada estructurada por edad. En todos los casos, las estimaciones de la abundancia global realizadas por el modelo estaban muy relacionadas con las "auténticas" series de abundancia; sin embargo, no fue posible obtener estimaciones fiables del parámetro para los datos de bajo.

Introduction

This document describes the application of a non-equilibrium surplus-production model (ASPIC) to four standard ICCAT simulated data sets as distributed by Restrepo. Each data set is 15 yr long and characterized by either high data contrast (population increase and then decrease) or low contrast (only a decline during the series) and by either clear length modes or blurred length modes in the catch data. The acronyms HCCM, HCBM, LCCM, LCBM are used here for the data sets.

Data Processing and Fitting

For each data set, time series of fishing effort and yield in weight were constructed from the simulated data. For fishing effort, the supplied F values were used. To compile catch in weight, the average weight at size was computed from the equation $W = 10^5 \times L^3$ and each catch at length was multiplied by weight at length. The total yield in weight was the sum of yields at each length interval.

To compare the population estimates to the true underlying biomass, a "true" population biomass series was computed. The supplied growth equation was used to compute length at each age; this was converted to weight at each age; and the total stock biomass for each year was then computed as the product of numbers at age (as given) times weight at age, summed across ages.

In fitting the production model, estimates were made conditional on yield (rather than effort). In this case, both yield and a measure of F were known exactly; however, the correspondence of the given F to the effective F in weight units was not expected to be exact. By conditioning on yield, error in this relationship is correctly handled, assuming lognormal error in catchability q.

Results

For both the HCCM and HCBM data, correlation between true and estimated biomasses was greater than 0.95 (Fig. 1, 2). Production models often provide inaccurate estimates of absolute biomass levels (Prager 1994), and here the biomass estimates were lower than the true values. Presentation of absolute biomass estimates from simple production models is generally not advised, and is done here for illustration only. Use of such estimates for management purposes or for judging the appropriateness of the model would be incorrect.

Estimates of management benchmarks for the high-contrast series were made without computational difficulty. For the HCCM and HCBM series, they were: MSY = (17,100; 14,700); f_{MSY} = (0.11; 0.11); B_{15}/B_{MSY} = (0.10; 0.12); and F_{15}/F_{MSY} = (3.6; 3.4).

Models of both low-contrast data sets produced good correlation with the true biomass ($r > 0.99$), but no unique solutions of MSY and related benchmarks. Most runs ended with parameter estimates at a constraint, indicating an invalid estimate. The data series exhibited no patterns other than linear declines in abundance; such series are not sufficiently informative for estimation of management benchmarks (Hilborn and Walters 1992).

Discussion

The estimates from the high-contrast data appear fairly reliable. Nonetheless, caution would be appropriate in a real fishery, because the relative biomass was estimated always to have been substantially lower than its optimum value. (The highest estimated ratio of $\hat{B}/\hat{B}_{MSY}$ was 0.31 for HCCM and 0.38 for HCBM.) Estimation of an optimum value in general must be considered tentative if the system for which it is estimated has not been observed near that optimum. Still, there is no reason to discount the corresponding estimates of biomass trend, which show a stock increase and then a marked decline.

Trajectory estimates from the low-contrast series clearly show strong stock declines. The inability of the data to allow estimation of optimum values illustrates the modeling paradigm that goodness of fit, in itself, is not a measure of a model's suitability.

Fitting age-structured simulated data with a production model is interesting, but interpretation of the results is not trivial. Production models rely on unspecified form(s) of compensation in the stock. We know that compensation does exist, or unfished stocks would fill the ocean and fished stocks would crash. Compensation in simulated data is usually in the stock–recruitment function; what forms of compensation exist in particular stocks is usually unknown. Among the types possible are compensation in spawning success (recruitment), natural mortality, growth in length, growth in weight (condition factor), and fecundity. Failure of a production model when evaluated on simulated data may reflect model insufficiency, but may also reflect the failure of the simulated data to be sufficiently representative of a natural stock. Age-structured models in general do not attempt to model population persistence, so their evaluation on simulated data is more straightforward.

References Cited

Hilborn, R., and C.J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics, and uncertainty. Chapman and Hall, NY. 570 p.

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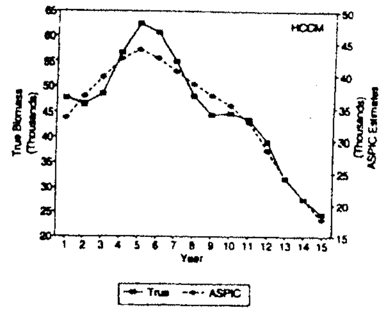

Figure 1. Fit to HCCM data.

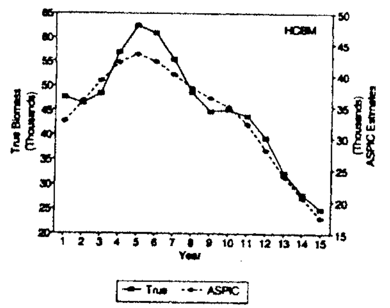

Figure 2. Fit to HCBM data.