USED OF DELAY-DIFFERENCE MODELS TO ASSESS THE INDIAN BIGEYE STOCK

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ABSTRACT

This document presents some exploratory runs of a spreadsheet implementation of the delay-difference model of Deriso applied to the Indian bigeye stock.

BACKGROUND

Indian bigeye stock has been assessed in the past using age-structured production model (ASPM) because the high uncertainties in the results of the traditional analytical methods. The ASPM can be defined as intermediate level between global and analytical models.

The delay-difference models could be classified as falling between an age-structured production model and a biomass-aggregated production model. These models explain the effect of fishing into the stock in terms of biomass changes but predicting the year's biomass from the last previous biomass and parameters for survival, growth and recruitment. Compared with the surplus production model the parameters used by these models to estimate biomass have more direct biological sense than the aggregate parameters of the surplus production models, but the quality of the delay-difference predictions is completely dependent on the process assumptions.

In general, the software available to fit this kind of models is not completely friendly so last year we prepared a spreadsheet implementation of the Delay-difference model of Deriso (1980) (see Quinn and Deriso 1999) to use in the assessment of the bigeye Atlantic stock data. The advantage of use this application is that it is easy and accessible to everybody the disadvantage is that the solver procedure used to estimate parameters is not robust enough to guaranty the goodness of fit. Nevertheless during the last SCRS meeting the model was also programmed in AD Model Builder (ADMB, Otter Research, 2001). This other implementation was made for validation purposes, and also because ADMB provides a better framework for estimating many parameters and for a fuller incorporation of uncertainty in the analyses.

This document present the results of some exploratory runs based in yield data and Japanese CPUE index used in the last bigeye stock assessment.

MODEL

DERISO'S MODEL

Equations mostly from Quinn and Deriso (1999) Quantitative Fish Dynamics.

Notation

α, β	Stock-recruitment parameters
r	Recruitment age
R	Number of recruits
B	Biomass
ρ	Ford growth parameter
ℓ	Annual survival from natural sources = e^{-M}
E	Fishing Effort
Y	Yield
U	CPUE = Y/E
S	Survival = (B-Y)
ε	Process error term for population
ω	Observation error for CPUE = $(\ln(U) - \ln(\hat{U}))$
q	Catchability

Dynamics

Recruitment $$R_t = \frac{\alpha B_{t-r}}{1+\beta B_{t-r}} e^{\varepsilon_t}$$

Biomass $$B_t = (1+\rho)\ell S_{t-1} - \frac{\rho \ell^2 S_{t-1} S_{t-2}}{B_{t-1}} + R_t$$

Virgin Biomass (equilibrium)
$$B_0 = \frac{\left((1-\rho\ell)(1-\ell) \right)}{\beta}$$

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Predicted yield: $\hat{Y}_t = (1 - e^{-qE_t})B_t$

Predicted CPUE $\hat{U}_t = \frac{\hat{Y}_t}{E_t}$

Estimation

Log-likelihood for observation errors

$$\lambda_O = -\frac{n_o}{2}\ln(\sum \omega^2)$$

Log-likelihood for process errors

$$\lambda_P = -\frac{n_P}{2}\ln(\sum \varepsilon^2)$$

Note: I think there should be as many process error terms as there are observations for effort.

Algorithm

- Fix ρ and ℓ based on external information. Parameters to estimate are α, β, q and all of the ε terms.

- Set $B_t = B_0$ for at least r years before the first observation; then use population dynamics equations

- Maximize $\lambda_O + \lambda_P$

Possible extension

In addition to an overall CPUE index, a second observation error series could be introduced with an index of recruitment abundance, *I*:

$$\xi_t = \ln(\kappa I_t) - \ln(R_t)$$

and the maximization would involve the additional log-likelihood $-\frac{n_I}{2}\ln(\sum \xi^2)$

In our runs we did not include observation errors.

PARAMETERS VALUES USED FOR BIGEYE

Growth (Stequert, in press)

L = 172.78 cm.

K= .3133 this value is used as initial guess, in the process it is indirectly estimated through ρ

t_o *= 0.326*

Length-weight parameters(): *a = 0.000027; b = 2.957*

Other Biological Parameters

l = .6 or M = .51

Age of Recruitment(r) = 1

“Knife edge” selection at age.

RESULTS

Figure 1 shows the fit to the CPUE data, the observed and predicted yield, the predicted fishing mortality, and the predicted recruitment and biomass series. The Delay Difference model fitted the data reasonably well. Nevertheless the dramatically increase in the catch and selectivity at the beginning of the nineties mainly due to the increase in the catch on floating objects by the purse seiners seems to be difficult to incorporate into the model. The increase in the recruitment shows by the model seems to be an artificial answer to the increase in the catch of juveniles.

Results also show a stock-recruitment relationship in which recruitment is independent of stock size. Because of this, the resulting equilibrium yield curves were flat-topped and therefore MSY-related quantities could not be estimated reliably. Nevertheless we present some results for comparing with previous assessment.

The model estimated depletion (B_{1998}/B_{1950}) of 0.38. The estimate of the relative proxy, F_{2001}/F_{msy} was .52. Figure 2 shows the equilibrium yield and the observed catches. The estimated MSY is 109,998 t., about 29% below the average yield for 1997-1999. Those results are intermediate between the two options (pessimistic and optimistic) considered in the last bigeye assessment using the ASPM. As in that assessment the current catches are a 30% higher than the MSY level and could not be sustainable although the current fishing mortality seems to be much lower than the F corresponding to MSY.

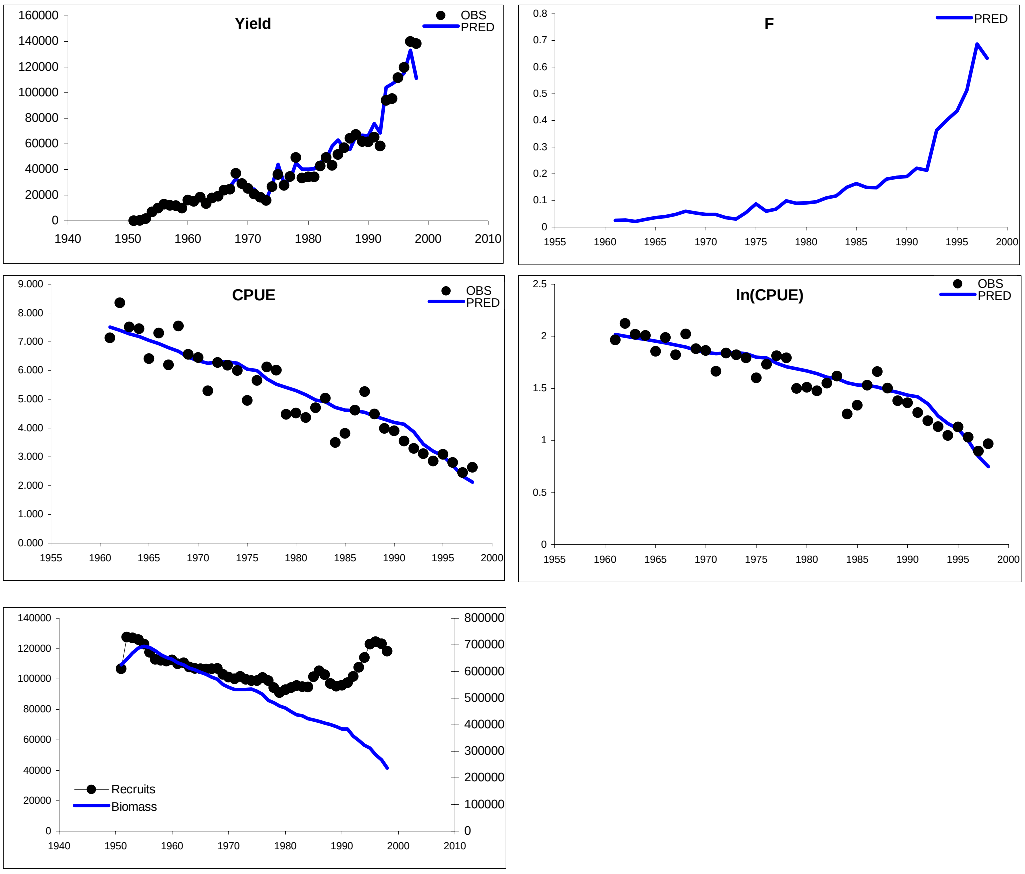

Figure 1.- Yield, biomass, CPUE observed and predicted values. Fishing mortality, biomass and recruitment estimations.

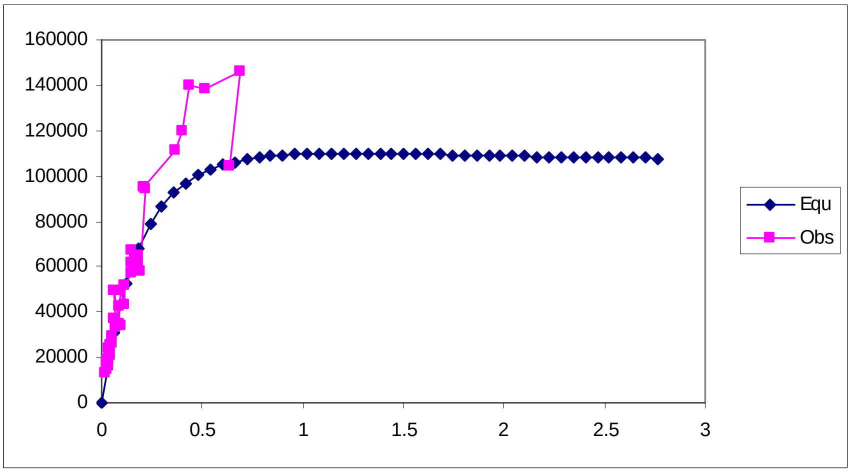

Figure 2.- Observed and equilibrium yield.