Exploratory assessment models for Indian Ocean Yellowfin Tuna using a Bayesian two-age delay-difference model

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1 Details

This document presents some exploratory runs of a Bayesian two-age delay-difference model which was first applied to this stock in IOTC-WPTT-2005. It has a stock-recruit relationship relating the mature adult stock biomass to the recruiting juvenile fish, as well as catches split on this rough basis. It does not in this case estimate recruitment variations, given the previous conversations that have taken place at this meeting with respect to recruitment information for this stock. it is basically an assessment model that is half-way between the more basic production model applied in IOTC-WPTT-2007-27, and the more complex age/length-structured integrated assessment models such as SS2 or CASAL.

Our implementation can be described as follows:

- We use the total catch (in numbers; from 1950 to 2006) split essentially by the two modes seen in the total length frequency data into juvenile and adult catches, and the Japanese LL CPUE (tropical) series, from 1960 and 1968 to 2005, respectively,

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and a weighted combination of the Taiwanese and Japanese long-line CPUE series from 1968 to 2005.

- We fix the steepness parameter at $h = 0.8$, but estimate the virgin spawning/adult stock biomass, S_0 - maturity is knife-edge with juveniles fully immature and adults fully mature.

- The estimation scheme is Bayesian, using MCMC techniques, giving us uncertainty in both historical dynamics and MSY information.

1.1 Defining the priors

Our three estimated parameters are the catchability coefficient, q, the variance in the (logarithmic) observed-minus-predicted index residuals, σ_s^2, and the virgin spawning stock biomass, S_0. The prior for q is actually set on $\ln(q)$ and is defined to be normal, with a very wide variance, so as to be largely uninformative and the prior for σ_s^2 is set to be a non-informative inverse-gamma distribution. With respect to the prior for S_0, a lognormal prior was assumed with a CV of 1, and mean so that that the lower 95% confidence bound of the prior for S_0 is twice the maximum catch biomass observed on the adult/mature stock. In all cases, the posterior for all parameters strongly updates the prior, so we do not have any obvious problems with prior forcing in the results.

1.2 Results

As with document IOTC-WPTT-07-27, we look at comparative trends between the two CPUE series we tune to in the model. Figures 1 & 2 show the SSB-to-B_{msy} ratio and harvest rate-to-H_{msy} ratio for both the CPUE cases, respectively. As we can see

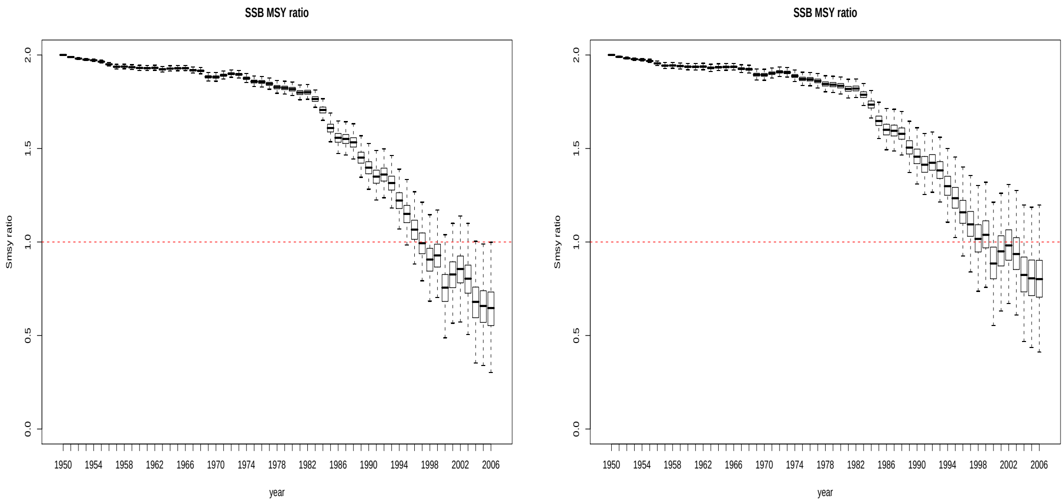

Figure 1: *Ratio of SSB to the estimated distribution of* B_{msy}*, for the longer (left) and shortened (right) Japanese CPUE series.*

1.3 Combining the Japanese and Taiwanese series

To combine the two series a selection of possible weighting schemes were considered, so that given the two cpue series, $I_{f,y}$, where f represents the relevant fleet, we can derive a weighting factor, $\omega_{f,y}$, so that we derive a combined index $\widehat{I_y}$, where

$$\widehat{I_y} = \sum_f \omega_{f,y} I_{f,y}, \tag{1}$$

where

$$\sum_f \omega_{f,y} = 1. \tag{2}$$

One method we used to combine the two series was to use the number of 5 by 5 squares visited by both fisheries, in the years 1968 to 2005. Figure 3 shows the two separate and the conbined series, using this weighting scheme.

The assessment model was fitted to the combined CPUE data, and the MSY ratio plots can be seen in Figure 4. As we can see, in comparison with the stock status-to-

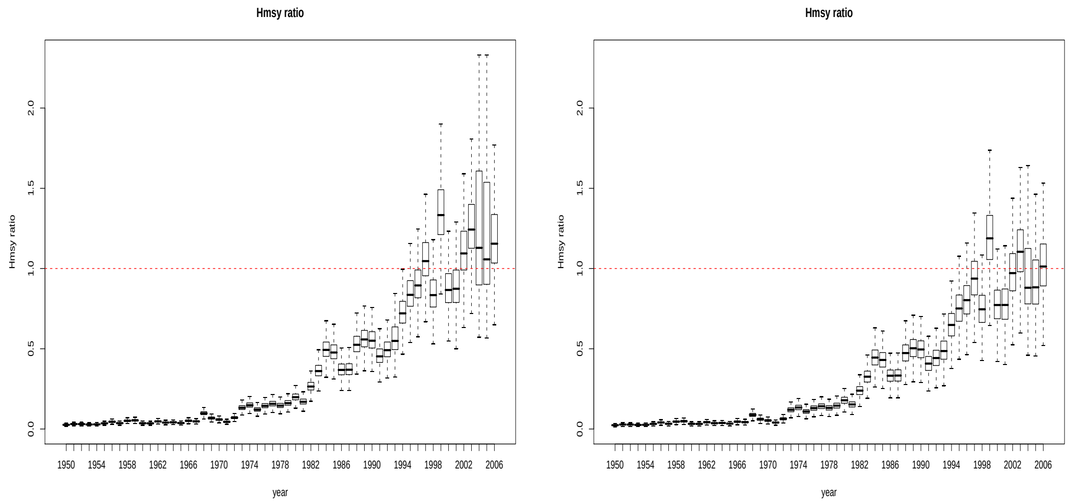

Figure 2: *Ratio of harvest rate to the estimated distribution of* H_{msy}*, for the longer (left) and shortened (right) Japanese CPUE series.*

MSY scenarios for the model fitted to the Japanese CPUE (1968-2005) alone, seen in Figures 1 & 2, when using the combined series, the picture is a little more optomistic - the stock is slightly above and below B_{msy} and H_{msy}, respectively. This is not hard to understand if we see the slightly more optomistic trend seen in the combined series, in comparison with the Japanese series - see Figure 3. The model fits to both data these data sets (Japanese 1968-2005 and combined series 1968-2005) can bee seen in Figure 5, and it is clear that both fit to the data poorly, capturing only the general downward trend in CPUE and ignoring the early high CPUE to a large degree, but fit to the data in a very similar fashion. Another trend to observe is the stronger downard trend in predicted CPUE (and, hence, stock abundance) seen when tuning to the Japanese dat alone (Figure 5 left).

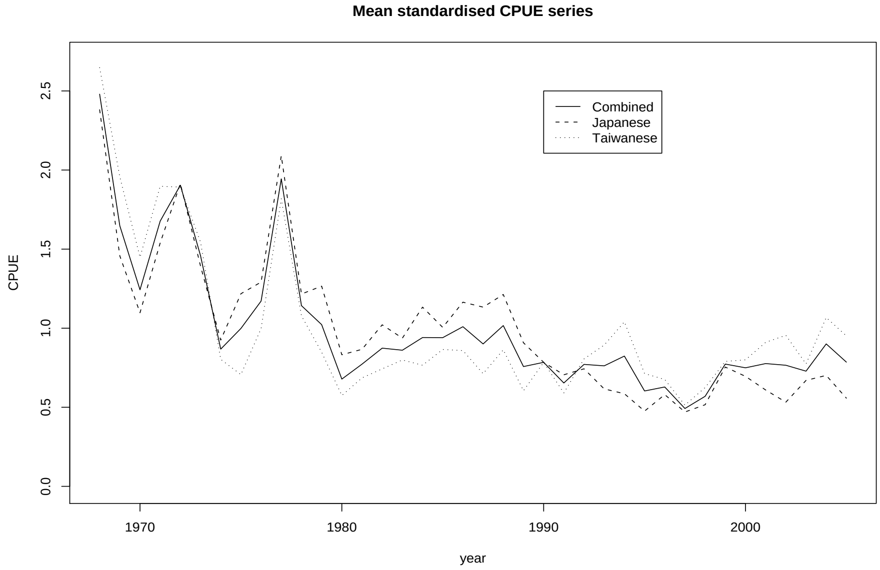

Figure 3: *Weighted combined CPUE series (full line), and the two separate Japanese and Taiwanese long-line CPUE series, from 1968 to 2005.*

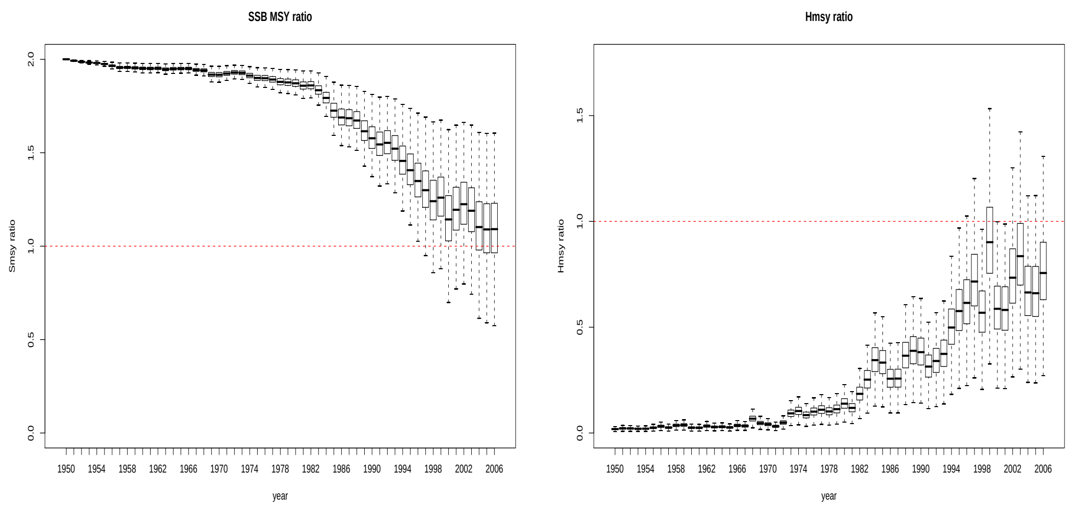

Figure 4: *MSY ratios, SSB-to-B_{msy} on the left and harvest rate-to-H_{msy} on the right, when fitting the assessment model to the combined CPUE series.*

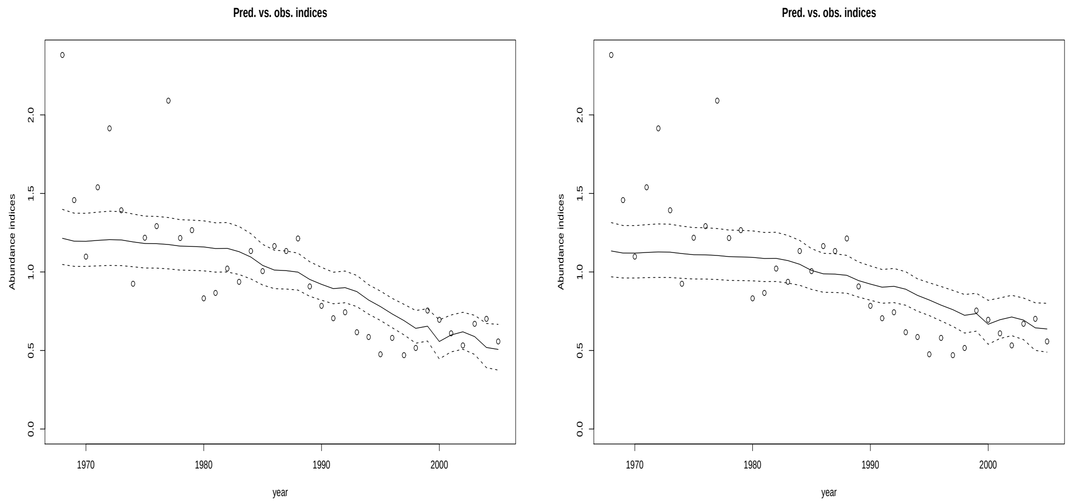

Figure 5: *Fits (full line median and dotted lines 95% probability interval) to the two CPUE tuning series (Japanese CPUE, left; Combined CPUE, right).*

1.4 Summary & implications

There are obvious shortcomings in this model - probably the strongest is the assumption of a constant catchability coefficient over all the years. One advantage is that, given we are using MCMC methods, the uncertainty in this assumption is expressed in the uncertainty in the estimated stock indices. We make no strong conclusions as to what sort of management advice may be given, based on the modelling done in this paper. One general conclusion would be that, depending on the CPUE series used to fit the model(s) to, the stock of Yellowfin tuna is probably at, or somewhat below, B_{msy} with exploitation rates likely to be at or higher than the estimated optimum rates.