Bayesian Pella-Tomlinson model for Indian Ocean bigeye tuna

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Details

To assess the impact of using an alternative, non age-structured assessment model for the Indian Ocean bigeye tuna catch and CPUE data, we implemented a Bayesian implementation of the Pella-Tomlinson production model, using the FLBayes package, found in the FLR software (Kell *et al.*, 2006). For this stock, we have increasing catches and an overall decreasing CPUE trend - this can be intrepretted as 'one way trip' catch and effort data. This causes serious problems in accurately estimating both the maximum growth rate, r, and the carrying capacity, K, together. To get round this, one can compute a value of r from biological data - stock-recruit behaviour, natural mortality, age at maturity - as defined in Myers *et al.* (1997). For our Bayesian implementation, we use this method to construct a sensible prior for r, which means we can then hopefully obtain more precise, non-degenerate estimates of the carrying capacity, K.

Our implementation can be described as follows:

- We use the total catch (in tonnes) and the Japanese LL CPUE series.

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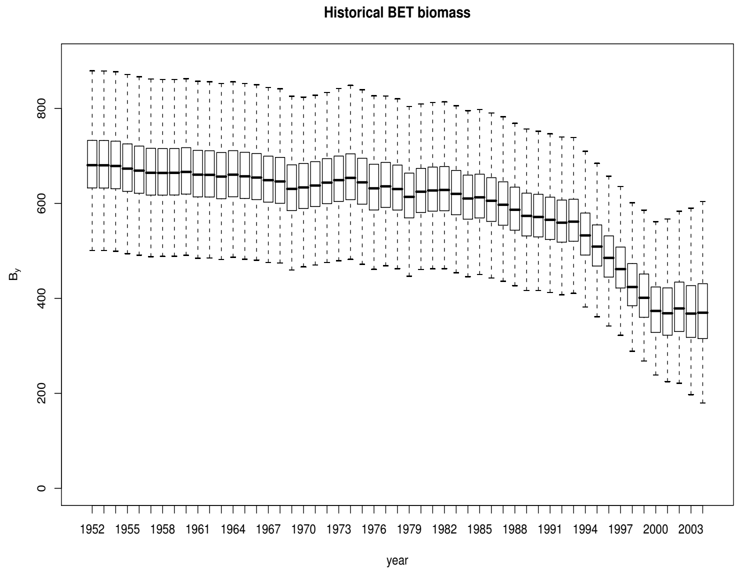

Figure 1: *Historical exploitable biomass for bigeye tuna, using the Pella-Tomlinson model. The central black line is the median; the box is the first interquartile range; the whiskers represents the 95% confidence interval.*

- We construct an informative prior for r, using biological data, as we have 'one way trip' data.
- The estimation scheme is Bayesian, using MCMC tehcniques, giving us uncertainty in both historical dynamics and MSY information.

Figure 1 shows the predicted historical (exploitable) biomass of bigeye tuna, and as we see it is decreases down to a level of around 380,000 tonnes in 2004 - around 55% of that seen at unfished equilibrium. Current harvest rates are predicted to be approximately equal to 0.32.

Figure 2 shows the distribution of the estimated value of C_{MSY}. As we see, the most probable value is 130,000 tonnes - the same as that predicted in the base case CASAL assessment of BET. When looking at the probabilities the biomass and harvest rates, with

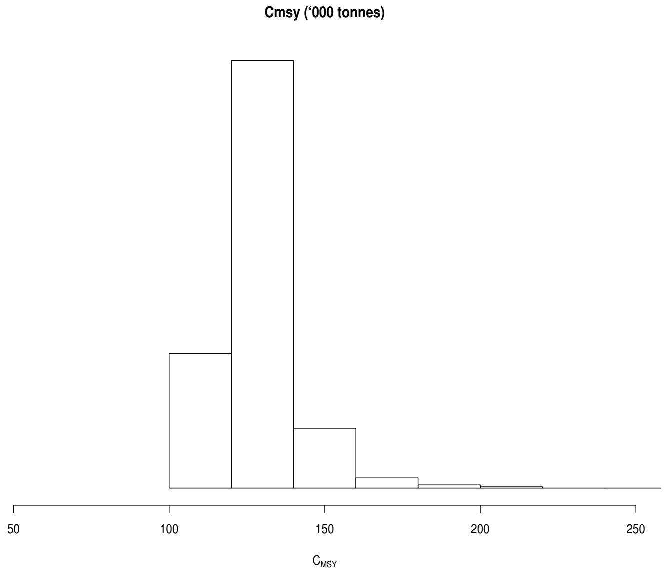

Figure 2: *Distribution of C_{MSY}, as predicted by the Bayesian estimation run, and the standard Pella-Tomlinson MSY equations.*

respect to being close to MSY, we have that $P(B_{2004} < B_{MSY}) = 0.29$, with $P(H_{2004} > H_{MSY}) = 0.352$. This would suggest that we are currently more likely to be above B_{MSY}, and below H_{MSY}.

The main differences in the age-structured and non age-structured models is in the biomass and harvest rate current-to-MSY ratios. The CASAL model predicts that the stock is currently further above biomass MSY levels, and further below MSY exploitation rates, and this difference is clearly a result of the strong differences in complexity between the two approaches. They do, however, agree quite closely on the predicted level of C_{MSY}, both estimating $C_{MSY} \approx 130,000$ tonnes.

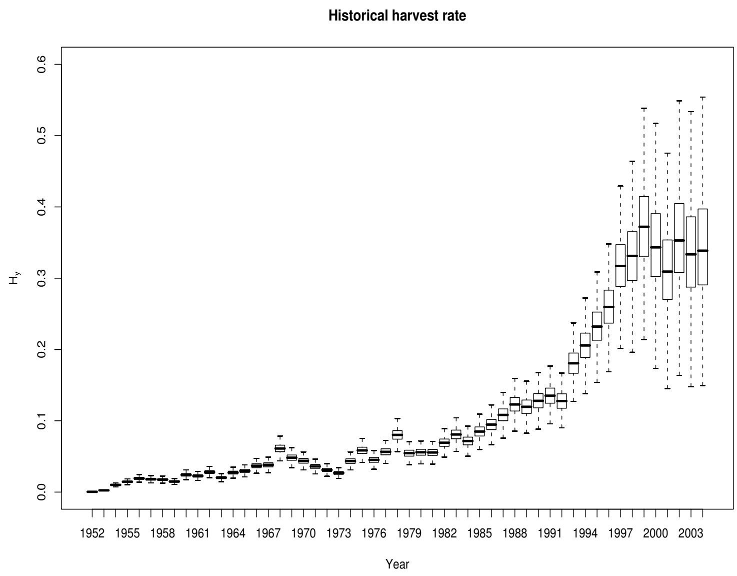

Figure 3: *Historical harvest rate.*

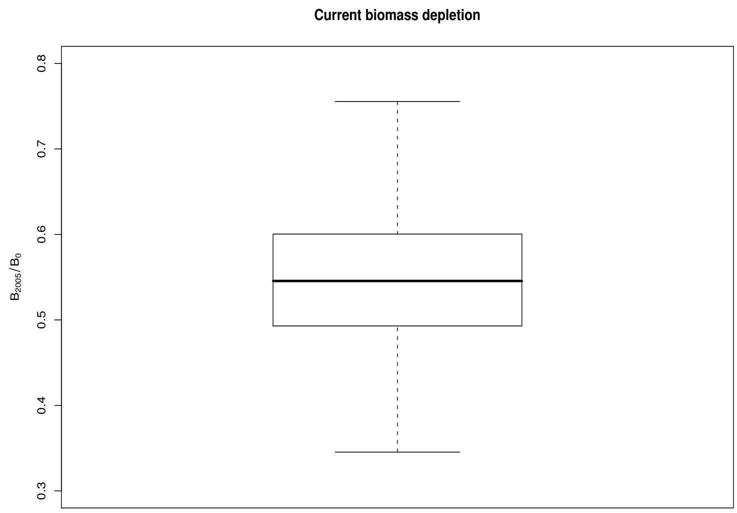

Figure 4: *Disitribution of current biomass depletion:* B_{2004}/B_0.

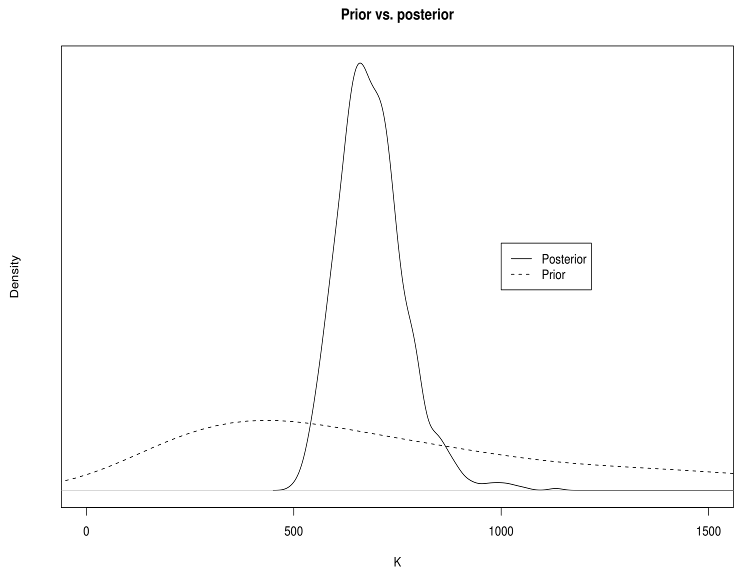

Figure 5: *Prior versus posterior for K, as we clearly, there posterior strongly updates the prior, and the data contain information on this parameter.*

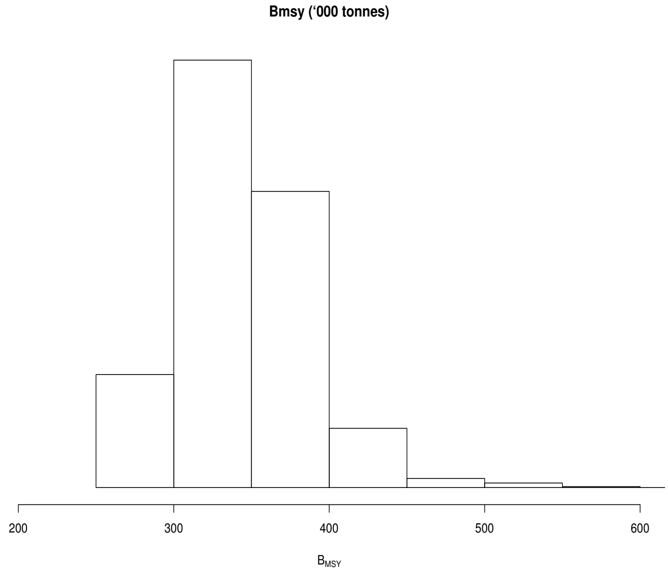

Figure 6: *Distribution of* B_{MSY}.

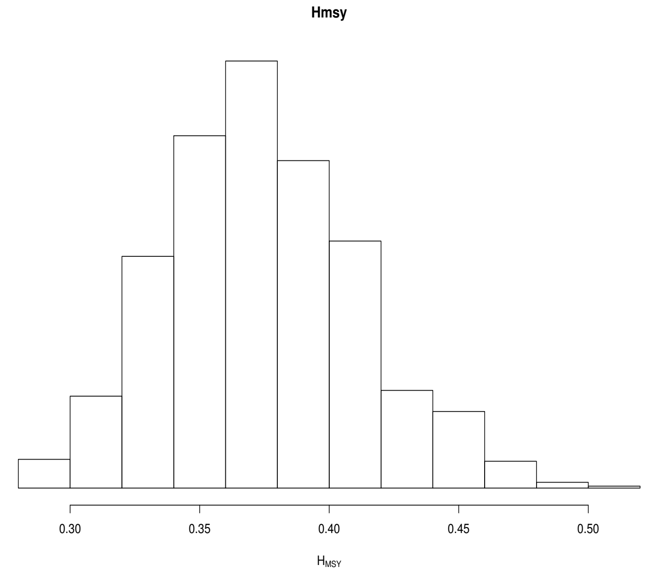

Figure 7: *Distribution of* H_{MSY}.

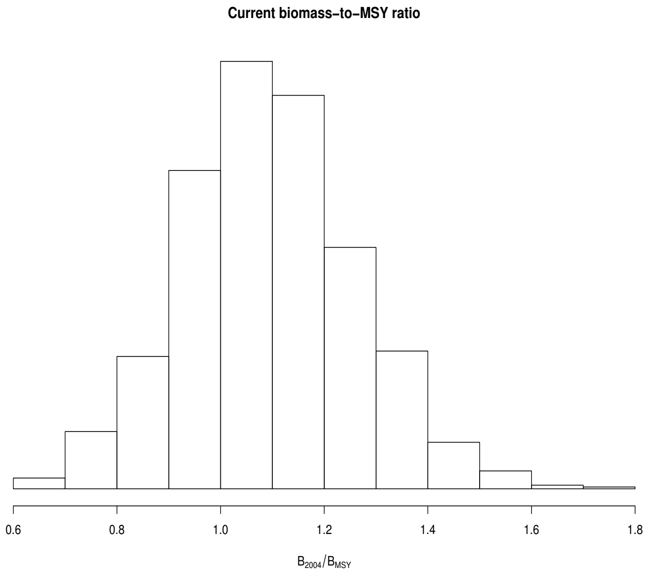

Figure 8: *Distribution of* B_{2004}/B_{MSY}.

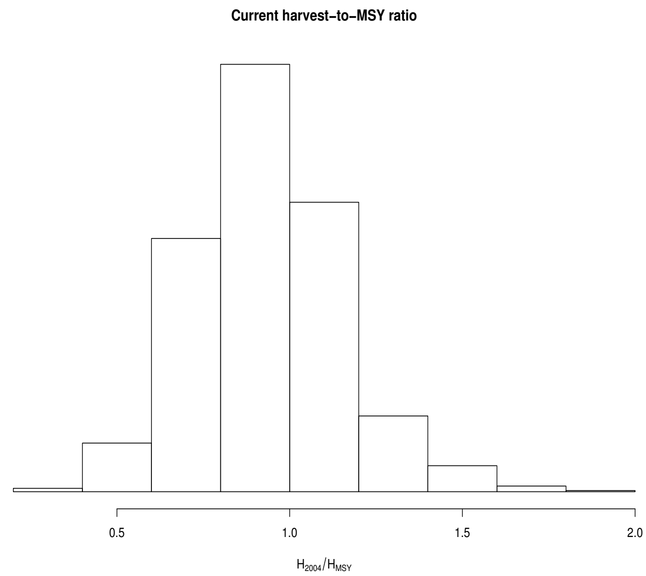

Figure 9: *Distribution of* H_{2004}/H_{MSY}.

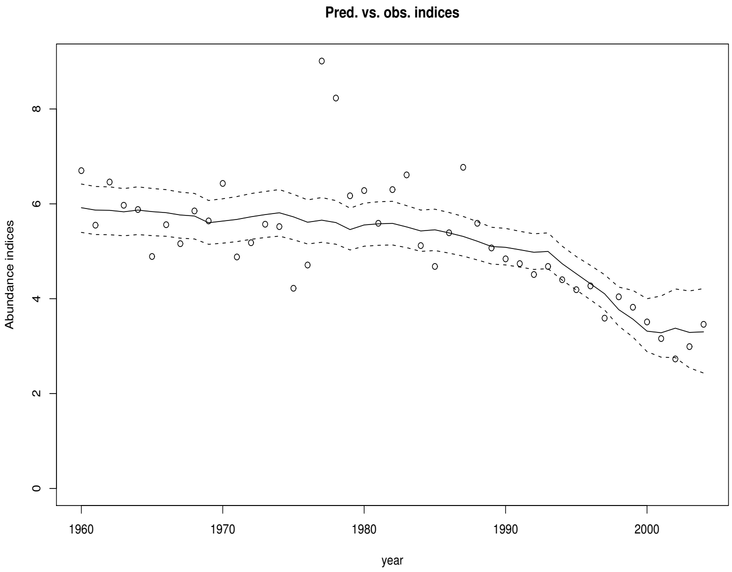

Figure 10: *Fit of the model to the CPUE data. Points are the observed points, full line is the median, with the dotted lines the 95% credible interval.*

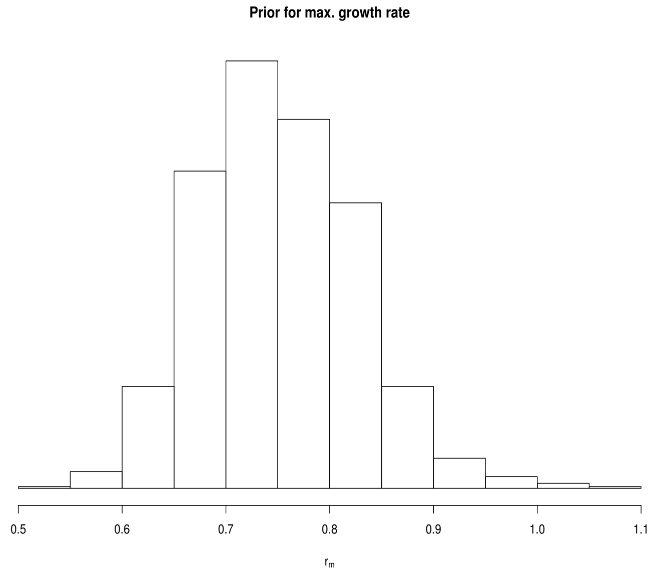

Figure 11: *Prior distribution estimated for r.*

References

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