AN EXAMPLE OF A MANAGEMENT PROCEDURE BASED ON A BIOMASS DYNAMIC STOCK ASSESSMENT MODEL

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SUMMARY

We describe a Management Procedure based on a biomass dynamic stock assessment model, which is intended for used to evaluate harvest strategies as part of Management Strategy Evaluation.

RÉSUMÉ

Le présent document décrit une procédure de gestion basée sur un modèle dynamique d'évaluation des stocks de la biomasse qui est destinée à évaluer les stratégies de capture dans le cadre de l'évaluation de de la stratégie de gestion.

RESUMEN

En este documento se describe el procedimiento de ordenación basado en un modelo dinámico de evaluación de la biomasa del stock, que se puede utilizar para evaluar estrategias de captura como parte de una evaluación de estrategias de ordenación.

KEYWORDS

Albacore, Harvest Control Rule, FLR, R, Management Strategy Evaluation, Management procedure

1. Introduction

We describe a Management Procedure (MP) based on a biomass dynamic stock assessment model, which is intended to be used to evaluate harvest strategies as part of a process of Management Strategy Evaluation (MSE).

An MP is the combination of pre-defined data, together with an algorithm to which such data are input to provide a value for a total allowable catch (TAC) or effort control measure, e.g. a stock assessment method including the estimation of reference points for use in a harvest control rule (HCR). A main objective of an MSE is to show through simulation trials whether a proposed MP or harvest strategies is robust to uncertainty (Rademeyer, 2007). A HCR is set of well-defined rules used for determining a management action.

2. Material and Methods

2.1 Management Procedure

The MP is based on a biomass dynamic stock assessment, which assumes that the stock is homogenous with no immigration or emigration and that population processes are stationary.

Stock dynamics are modelled by the Pella-Tomlinson surplus production function (Pella and Tomlinson, 1969). An example of a HCR is shown in **Figure 1** as part of a phase plot. The orange line is the HCR where for a given stock biomass (x-axis) a harvest rate (y-axis) is set, i.e. management action is predetermined. The black line is the replacement line, i.e. for a given stock biomass any harvest rate above the black line will cause the stock to

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decline and any harvest rate below the line will cause the stock to increase. Therefore for the target harvest rate (the horizontal segment of the HCR) the target biomass is found at the intersection with the HCR. If the stock declines below the break point (i.e. a trigger biomass) then harvest rate is reduced progressively to the minimum harvest rate at a biomass level referred to as B_{lim}. B_{lim} is also referred to as a limit reference point (LRP).

2.2 Operating Model

To demonstrate the use of a HCR we first created an Operating Model (OM) which simulated a stock that initially was at virgin and then declined due to increasing levels of fishing until the stock was over exploited. Fishing then decline to a level below F_{MSY} after which the fishing level remained constant. **Figure 2** shows time series of harvest rate, stock biomass and yield and **Figure 3** is the corresponding Kobe phase plot of harvest rate relative to F_{MSY} and stock biomass relative to B_{MSY}.

We then sample from the OM to create data for use in the MP. Two data series are generated, catch by year and an index of abundance with two levels of CV (20 and 40%) see **Figure 4**. This gives 2 levels of precision in stock and reference point estimates.

2.3 Software

Software used was a biomass production model implemented as a package in R, this allows it to be used with a variety of other packages for plotting, summarizing results and to be simulation tested, e.g. as part of the FLR tools for management strategy evaluation (Kell *et al.*, 2007).

3. Results

In the first set of simulations we do not use the HCR to set catches; instead we conduct a retrospective analysis for every second year from year 60 to year 80. We then estimated stock status, reference points and stock status relative to reference points. We did this for each retrospective run and level of CPUE uncertainty. The estimates of F_{MSY}, B_{MSY}, F, stock biomass, F: F_{MSY} and B: B_{MSY} are shown in **Figure 5** which shows the inter-quartile ranges. Two main points can be seen from this analysis, i.e. that estimates obtained from an CPUE index with a CV of 20% are more precise than those based on a CV of 40% and that in the later retrospectives (i.e. those that use more data) estimates are again more precise.

Next three HCRs were run for a single realisation (a single time series) to demonstrate different options for use as part of an MSE. i.e. i) At Once the F based on harvest control is implemented as a TAC¸ ii) 10% F Bound the F each year is not allowed to vary by more than 10% a year. iii) 10% TAC Bound the TAC each year is not allowed to vary by more than 10% a year; and iv) Multi-annual the TAC is set for three years based on the average value TAC as predicted by the HCR. **Figures 6 and 7** show the time series and phase plots for the 4 HCRs. There is little difference between setting a TAC annually or for three year periods. However, there are large differences in the performance of the HCRs, when the inter-annual variability in TAC or F (i.e. capacity or effort) is restricted. This will have consequences both for the stock and the economic performance of fleets.

4. Discussion and Conclusions

The paper is intended to demonstrate how a MP can be modelling, despite the examples being simple some important points are worth noting i.e. Unsurprisingly reference points estimated by a stock assessment include uncertainty, the level of which depend upon the quality of the data and knowledge of stock and fleet dynamics.

For a given level of risk, e.g. of stock collapse, reference points used in a HCR will need to be based on the level of stock assessment uncertainty. This could be done by making reference points such as $B_{trigger}$ (a level of biomass that if the stock falls below results in a reduction in harvesting) a percentile of a probability distribution of a reference point such as B_{MSY} rather than a multiplier of a point estimate.

Different ways of estimating parameter uncertainty, e.g. normal approximations, bootstrapping and Bayesian approaches could be evaluated and their use as part of HCRs and MPs investigated.

In practice a HCR will have economic as well as biological consequences and these should be considered when designing a HCR.

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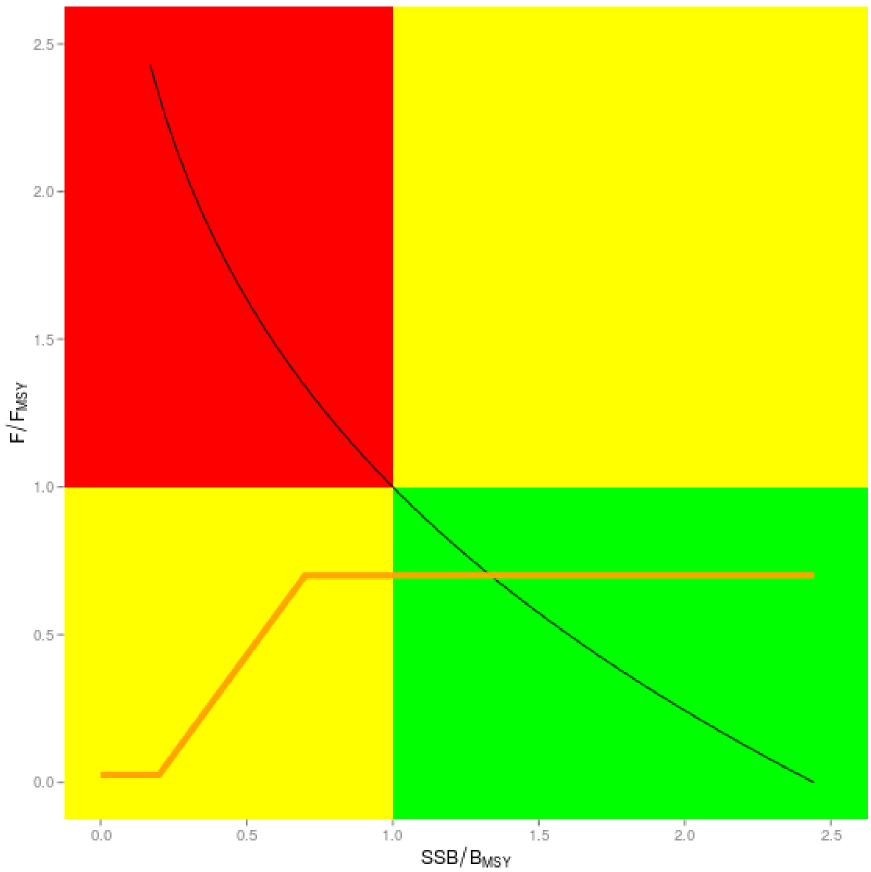

Figure 1. Example of a Harvest Control Rule (orange) plotted on a phase plot of harvest rate relative to F_{MSY} and stock biomass relative to B_{MSY}. The black line is the replacement line.

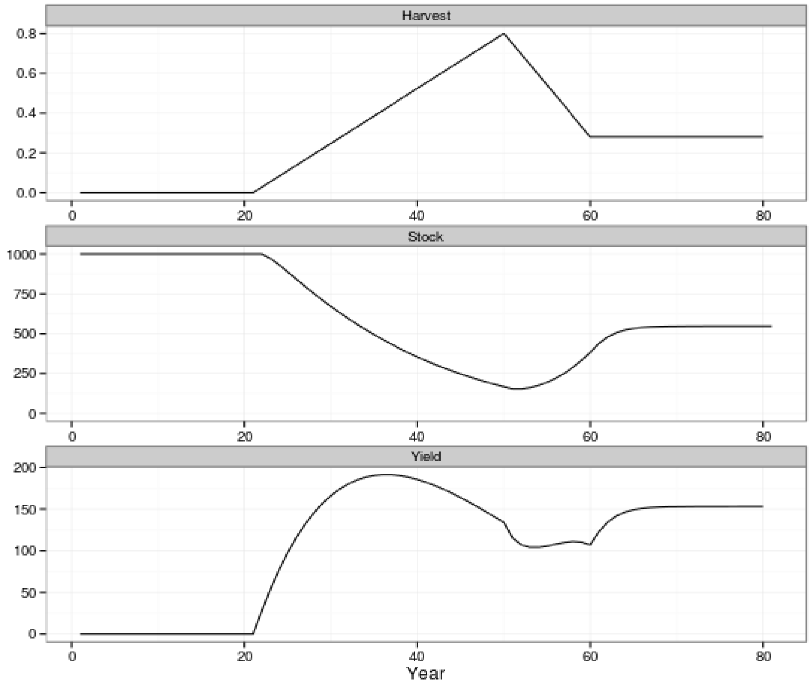

Figure 2. Simulated time series of harvest rate, stock biomass and yield.

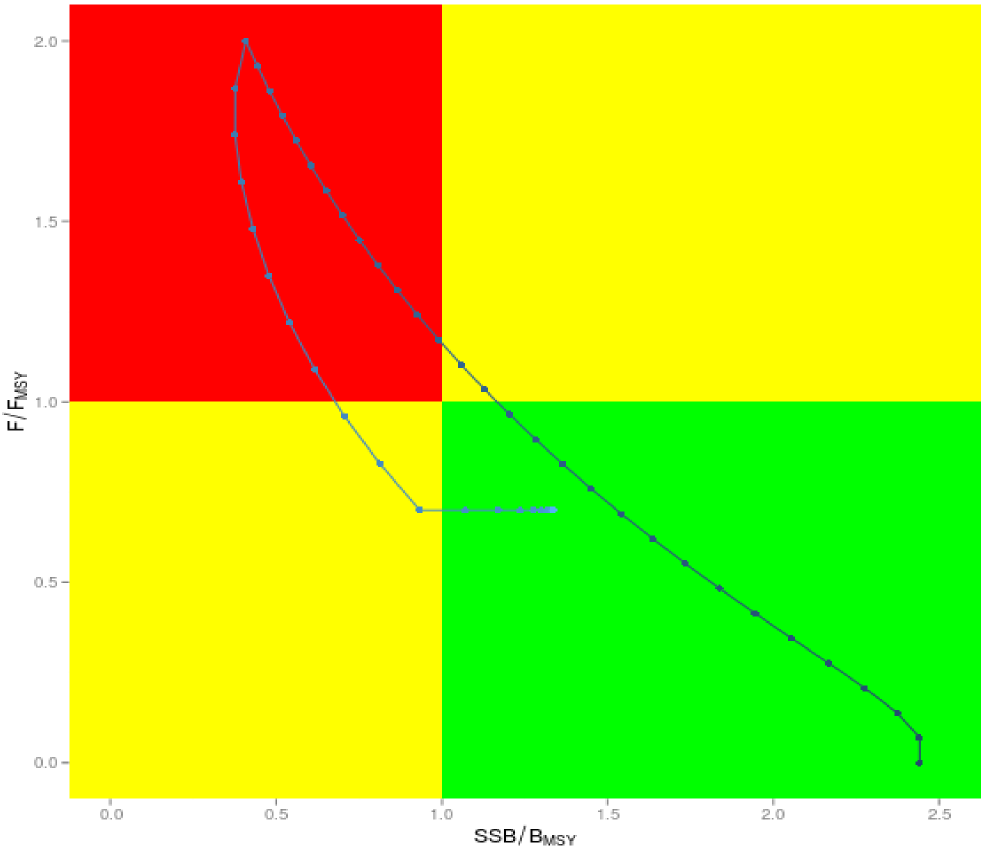

Figure 3. Phase plot of harvest rate relative to F_{MSY} and stock biomass relative to B_{MSY}.

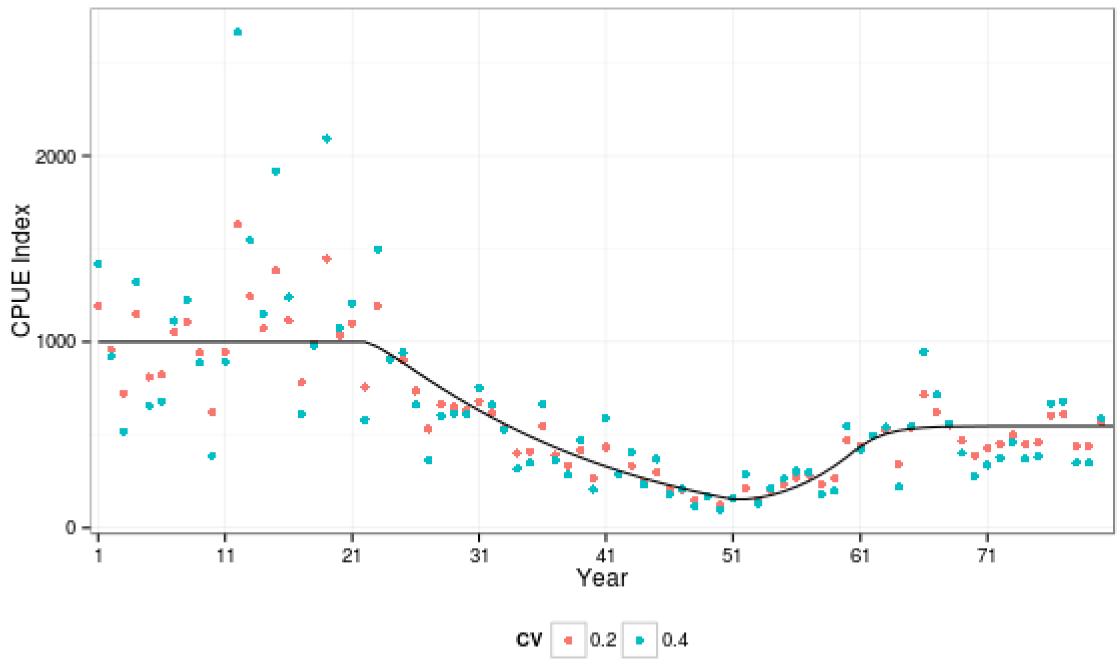

Figure 4. Simulated time series of index of abundance, assuming a measurement error with CVs of 20 and 40%.

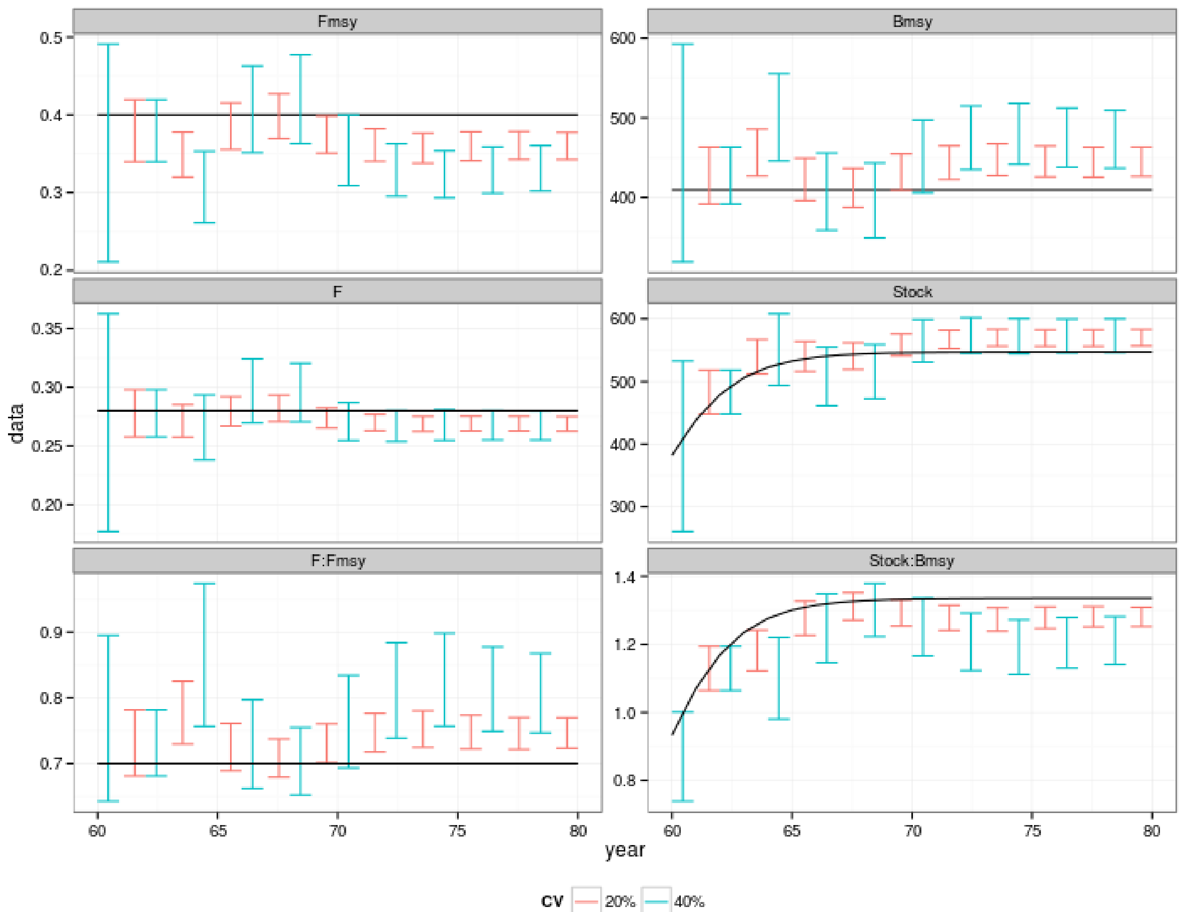

Figure 5. A comparison of the interquartile range with the true values (lines) for two levels of CPUE CV. Bars are derived from a retrospective analysis, i.e. the values estimated in the last year.

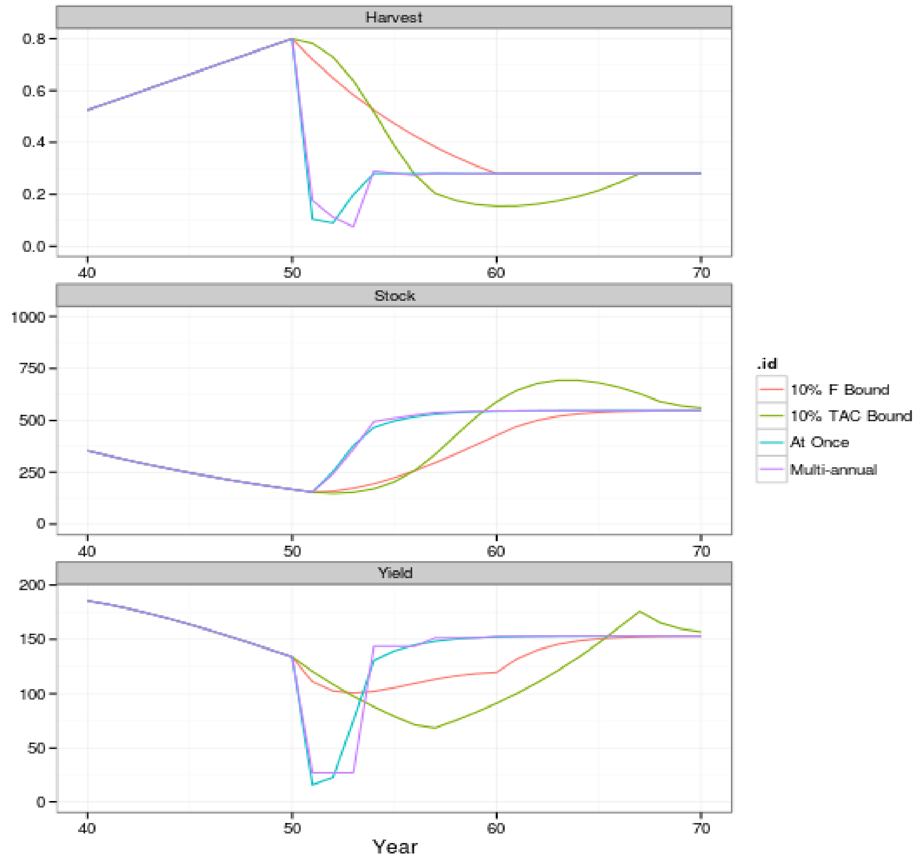

Figure 6. Time series of harvest rate, stock biomass and yield for the four HCRs.

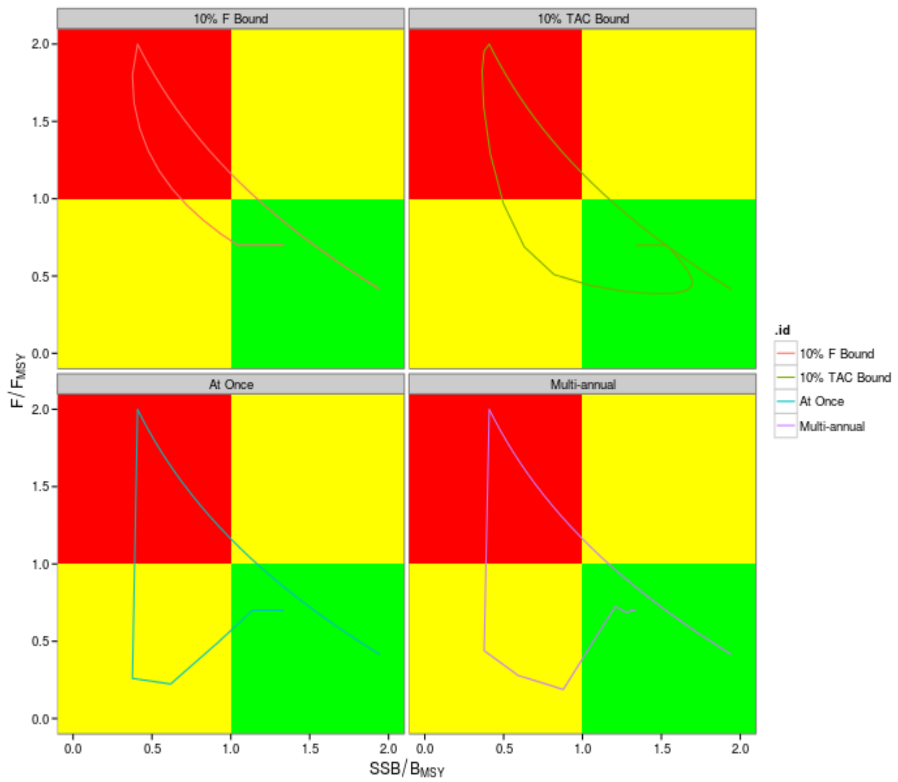

Figure 7. Phase plots of harvest rate relative to F_{MSY} and stock biomass relative to B_{MSY} for the four HCRs.