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IMPLEMENTATION OF A HARVEST CONTROL RULE FOR NORTHERN ATLANTIC ALBACORE

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SUMMARY

A Harvest Control Rule was developed for North Atlantic albacore during the 2013 assessment, this paper documents the procedure used.

RÉSUMÉ

Une norme de contrôle de la ponction a été élaborée pour le germon de l'Atlantique Nord pendant l'évaluation de 2013 ; le présent document décrit la procédure utilisée.

RESUMEN

Durante la evaluación de 2013, se desarrolló una norma de control de la captura para el atún blanco del Atlántico norte, en este documento se documenta el procedimiento utilizado.

KEYWORDS

Albacore, Harvest control rule, Management, Surplus Production model

1. Introduction

The ICCAT Commission [Rec. 11-04] asked the SCRS to develop a Limit Reference Point (LRP) for North Atlantic albacore that will trigger a rebuilding plan if biomass drops below it. The FAO Technical Consultation on the Precautionary Approach to Capture Fisheries (FAO, 1996) recommended the use of a harvest control rule (HCR) to specify in advance what actions should be taken when a LRP is reached. Therefore during the Albacore stock assessment working group a HCR was developed that was implemented as a Management Procedure (MP). Where a MP is the combination of pre-defined data, together with an algorithm to which such data are input to provide a value for a TAC or efiort 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. A HCR is set of well-defined rules used for determining a management action in the form of a TAC or allowable fishing effort. The MP uses an biomass dynamic model to derive population parameters and reference points from historical data (i.e. catch and efiort) and to projection the stock as part of a HCR.

2. Management Objectives

The main Management Objective of ICCAT is to maintain the populations of tuna and tuna-like fishes at levels which will permit the maximum sustainable catch. Originally interpreted as using MSY as a target. Whole the Precautionary Approach [?] requires stock status to be assessed relative to limits and targets, to predict outcomes of management alternatives for reaching targets and avoiding limits, and to characterise uncertainty. The Commission has therefore asked the SCRS to develop a Limit Reference Point for North Atlantic swordfish that will trigger a rebuilding plan if biomass drops below it.

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2.1 Precautionary Approach

The Precautionary Approach imposes specific needs for research, stock assessments, monitoring and management. A harvest control rule (HCR) is recommended to specify in advance what actions should be taken when limits are reached. Although HCRs may include precautionary elements, it does not mean that they will be precautionary in practice (Kirkwood and Smith 1996). If HCRs are not evaluated formally to determine whether they will actually achieve the goals for which they were designed, given the uncertainty inherent in the system being managed (Punt 2008). Therefore Management Strategy Evaluation (MSE) is increasingly been used to evaluate the impact of the main sources of uncertainty inherent in the system being managed (Cooke 1999). As well as reference points and HCRs, the minimum data and knowledge required for the assessment methods used for decision-making are evaluated. MSE allows uncertainty, beyond just the assessment process, to be considered. In this paper we detail a Management Procedure based on ASPIC that uses a HCR to set a total allowable catch (TAC)

2.2 Tuna RFMOs

Many of the tuna Regional Fisheries Management Organisations (tRFMOs) have been developing LRPs using MSE to evaluate them i.e.

- ICCAT is using MSE to develop LRPs for North Atlantic Albacore; about to embark on MSE for Bluefin tuna in order to develop long term management plans.
- WCPFC have evaluated reference points using MSE, without feedback and made recommendations on LRPs
- IOTC is starting to evaluate reference points using MSE with feedback, initially defined interim reference points for immediate use which will then be evaluated using MSE.
- CCSBT Have used MSE to develop a full Management Procedure
- IATTC are not using MSE, and are considering using the IOTC interim approach o define limit reference points based on percentages of B_{MSY} and F_{MSY}.

2.2.1 ICCAT

ICCAT is developing LRP for North Atlantic swordfish as well as albacore. i.e. In advance of the next assessment of Northern Atlantic Albacore, the SCRS shall develop a Limit Reference Point (LRP) for this stock. Future decisions on the management of this stock shall include a measure that would trigger a rebuilding plan, should the biomass decrease to a level approaching the defined LRP as established by the SCRS. [Rec. 11-04]
The principles of Decision Making [REC 11-13] require that if a stock is in the Red Quadrant of the Kobe phase plot that management should ensure a high probability of ending overfishing in as short a period as possible. A plan must also be adopted for rebuilding taking into account the biology of the stock and SCRS advice. However the risk levels, probabilities and time scales required to implement an appropriate management framework are not specified.

For stocks that are in the Green Quadrant, i.e. those that are not overfished and not subject to overfishing, management measures shall be designed to result in a high probability of maintaining the stock within the green quadrant.

2.2.2 WCPFC

WCPFC has asked SPC to provide advice on candidate reference points. To do this SPC used MSE (without feedback) based on Multifan. They subsequently recommended a three tier approach based on decreasing levels of information i.e.

- F_{MSY} and B_{MSY} but only when there are reliable and precise estimates of steepness
- F_{SPR} and $20\%_{SSB0}$ when steepness is uncertain but M, maturity, selectivity is well known
- $20\%_{SSB0}$ alone when key fishery and biological variables are uncertain

2.2.3 IOTC

IOTC resolution (RES-12/01) on the Implementation of the Precautionary Approach states that in applying the precautionary approach, the Commission shall adopt, after due consideration of the advice supplied by the Scientific Committee

- stock-specific reference points (including, but not necessarily limited to, target and limit reference points), relative to fishing mortality and biomass, and
- associated harvest control rules, that is, management actions to be taken as the reference points for stock status are approached or if they are breached
- Reference points and harvest control rules shall be determined so that, according to the best available science, the risk of a negative impact on the sustainability of Indian Ocean tuna and tuna-like species is minimized.

In the determination of appropriate reference points and harvest control rules, consideration must be given to major uncertainties, including the uncertainty about the status of the stocks relative to the reference points, uncertainty about biological, environmental and socio-economic events and the effects of fishing activities on on-target and associated or dependent species. Instruct the Scientific Committee to assess, through the management strategy evaluation process, the performance of reference points, including any interim reference points, and of potential harvest control rules to be applied as the status of the stocks approaches the reference points. The SC is therefore setting interim limit and target reference points for current use in defining limits and targets. MSE will then be used to evaluate the LRPs these as part of a HCR, The approach is the same as being undertaken by ICCAT for North Atlantic Albacore where a Simulation or Operating Model (OM) based on Multifan-CL will be used to test HCRs and the associated reference points and stock assessment methods.

3. Materials and Methods

3.1 Assessment

Advice for the meeting was based on a biomass dynamic stock assessment implemented as the ASPIC software package (Prager, 192). Seven scenarios were ran based on different combinations of catch per unit effort (CPUE) indices. All were assumed to be equally plausible ran, i.e. all equally weighted.

3.2 Harvest Control Rule

The HCR used is shown in **Figure 1** as part of a phase plot; the orange line sets the harvest rate (y-axis) Depending on the estimated stock biomass (x-axis). The black line is the replacement line, i.e. for a given stock biomass a harvest rate above the black line will cause the stock to decline and a harvest rate below the line will cause the stock to increase. For a given target harvest rate (i.e. the horizontal part of the HCR) the target biomass is given by the intersection of the two lines. If the stock declines below the break point (i.e. a trigger biomass or threshold biomass reference point) the harvest rate is reduced progressively to a minimum level of harvest rate at a biomass level equal to the LRP.

Uncertainty in the projections was based on the seven scenarios (equally weighted) and the bootstrapped ASPIC assessment, i.e. the initial conditions (F and biomass) for the HCR simulations were provided by the estimates from the 7 stock assessment scenario in the final year (i.e. 2011). Reference points used in the HCR were also by bootstrap, so that for every bootstrap realisation used in the HCR there were consistent current estimate of current stock size and harvest rate, Maximum Sustainable Yield (MSY) based reference points and stock parameters (i.e. r & K).

3.3 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).

4. Results

The Kobe framework requires assessment results to be reported as harvest rate and biomass relative to F_{MSY} and B_{MSY}. The estimated time series (medians and inter-quartiles) are shown in **Figure 2** and the kobe phase plots in **Figure 3**. The marginal densities are shown in **Figures 4** and **5** for biomass and **6** and **7** for harvest rate; by scenario and for all scenarios combined.

The Kobe II strategy matrix (K2SM) is plotted in **Figure 8.** Normally the K2SM summarises probabilities for a range of TACs. In this case the K2SM summarises probabilities for the Limit, target and threshold reference points. The probability of being in the green quadrant (i.e, $B > B_{MSY}$ and $F < F_{MSY}$), the stock being under fished ($B > B_{MSY}$) and under fishing occurring ($F < F_{MSY}$) for different target fishing mortality as a fraction of F_{MSY} (columns). Contours are the 0.9, 0.8, 0.7 and 0.6 probability levels. The sawtooth effect for $F_{Targets}$ close to F_{MSY} is because if F is close to F_{MSY} then due to uncertainty stock biomass will fluctuate around B_{MSY} causing the HCR to reduce then increase F.

5. Discussion

Although harvest control rules may include several precautionary elements, it does not necessarily follow that they will be precautionary in practice (Kirkwood and Smith 1996). Since many harvest control rules are not evaluated formally to determine the extent to which they achieve the goals for which they were designed, given the uncertainty inherent in the system being managed (Punt 2008). When providing advice it is important to ensure it is robust to the main sources of uncertainty. Traditional stock assessments mainly consider observation and process error (e.g. recruitment). However, uncertainty about the actual dynamics (i.e. model uncertainty) has a larger impact on achieving management objectives (Punt 2008). Therefore when providing management advice it is important to consider appropriate sources of uncertainty.

Therefore Management Strategy Evaluation (MSE) based on simulation modelling has increasingly been used to evaluate the impact of the main sources of uncertainty inherent in the system being managed (Kirkwood and Smith 1996).

Therefore the LRP must be evaluated as part of a HCR using MSE. SCRS/2013/035 detailed the approaches that can be used. The choice of scenarios for use in the evaluation trials will be critical. The choice of trials should reflect uncertainty about population and fishery dynamics and the potential impacts on the risks of not achieving management objectives.

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Table 1. Fleet definitions

CPUE Group	Fleets
1	Composite surface cpue only
2	China Taiwan old and new LL only (2 qs)
3	CT LL as one only
4	Japanese old and new LL only (2 qs)
5	5 fisheries (surface comp, Jap old and new LL, Ch Tai old and new LL
6	Idem 5 but No Ch Tai LL
7	Idem 5 but No Jap LL

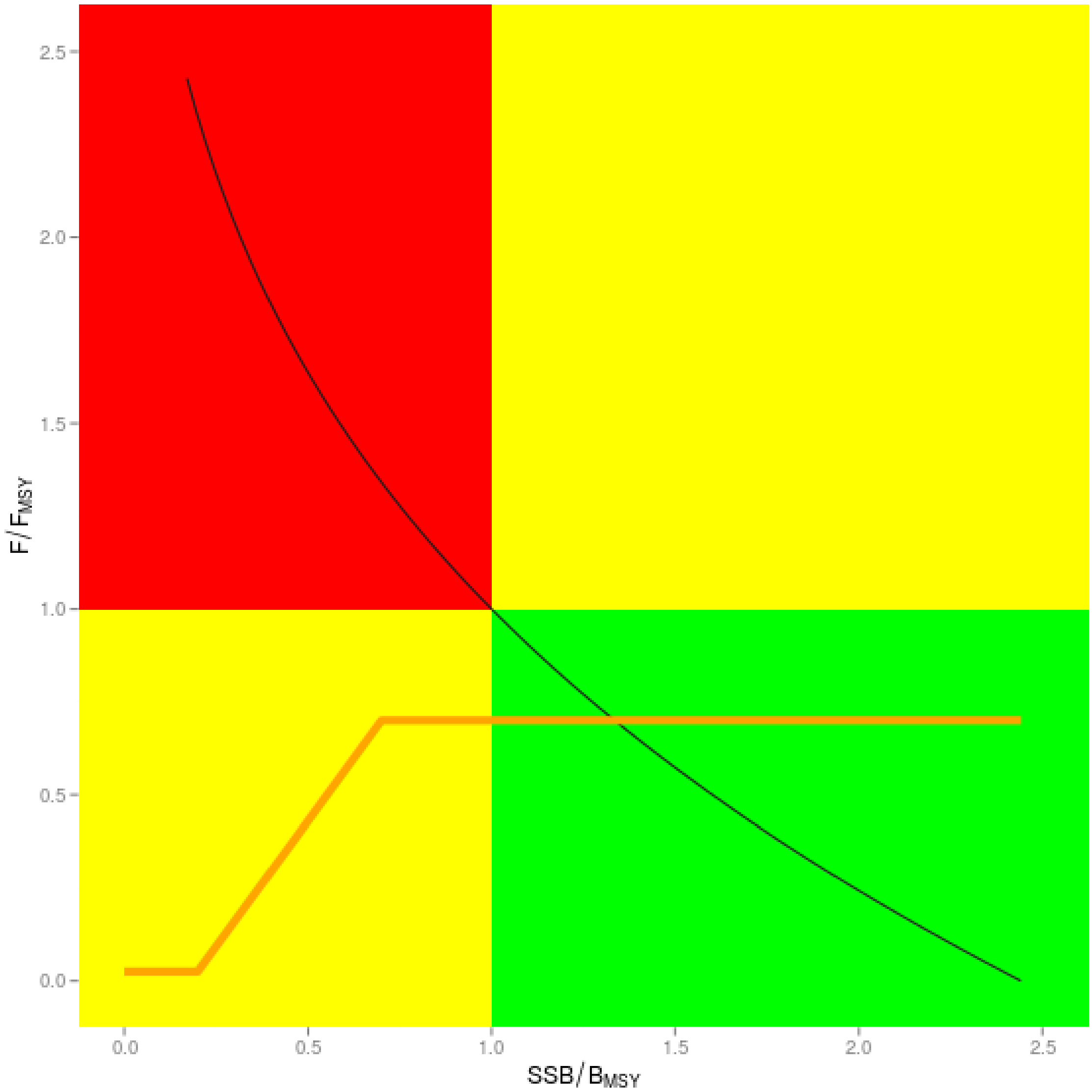

Figure 1. Example of a Harvest Control Rule (orange) plotted on a phase plot of harvest rate relative to FMSY and stock biomass relative to BMSY. The black line is the replacement line.

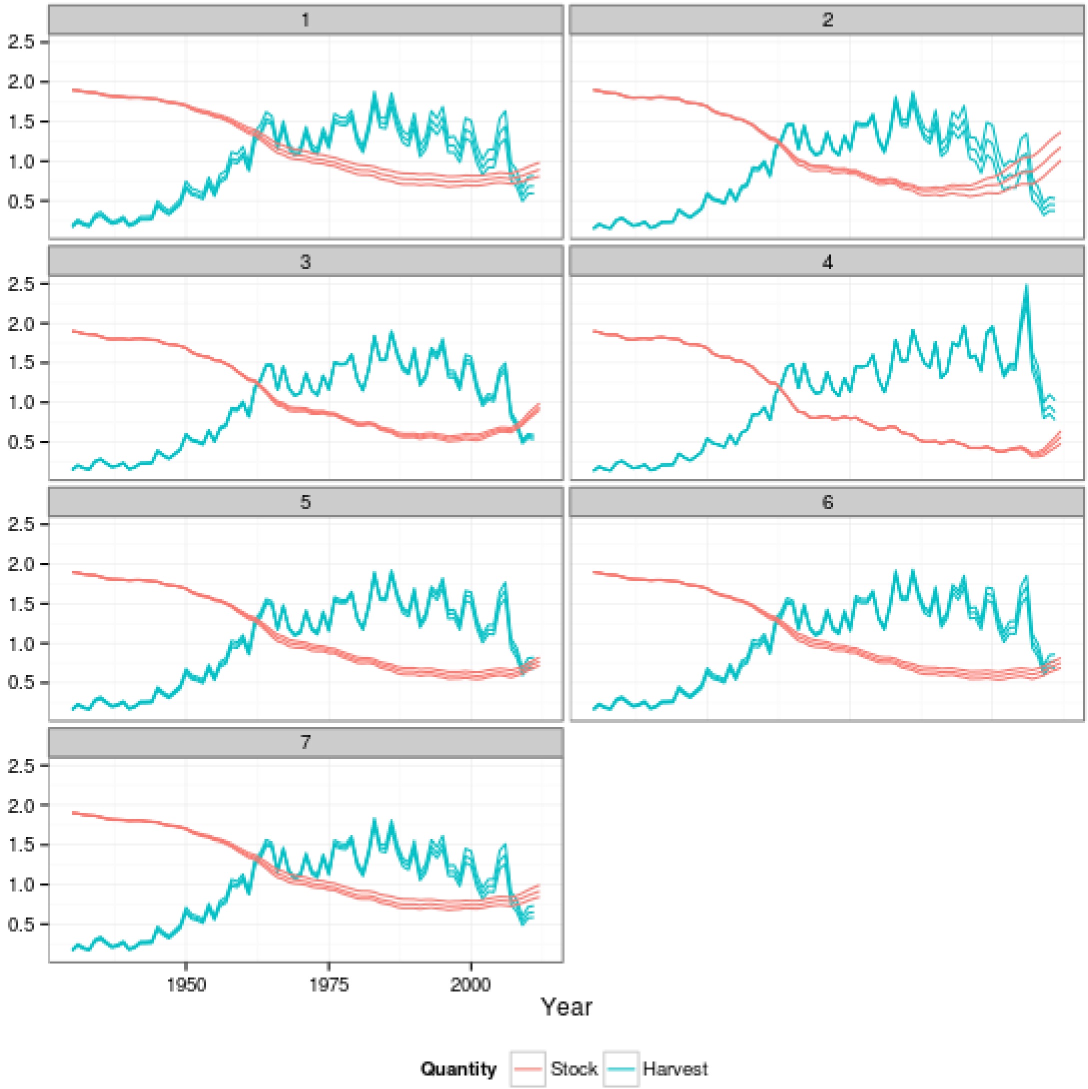

Figure 2. Time series of harvest rate, stock biomass harvest relative to FMSY and BMSY by scenario; lines correspond to medians and inter-quartiles.

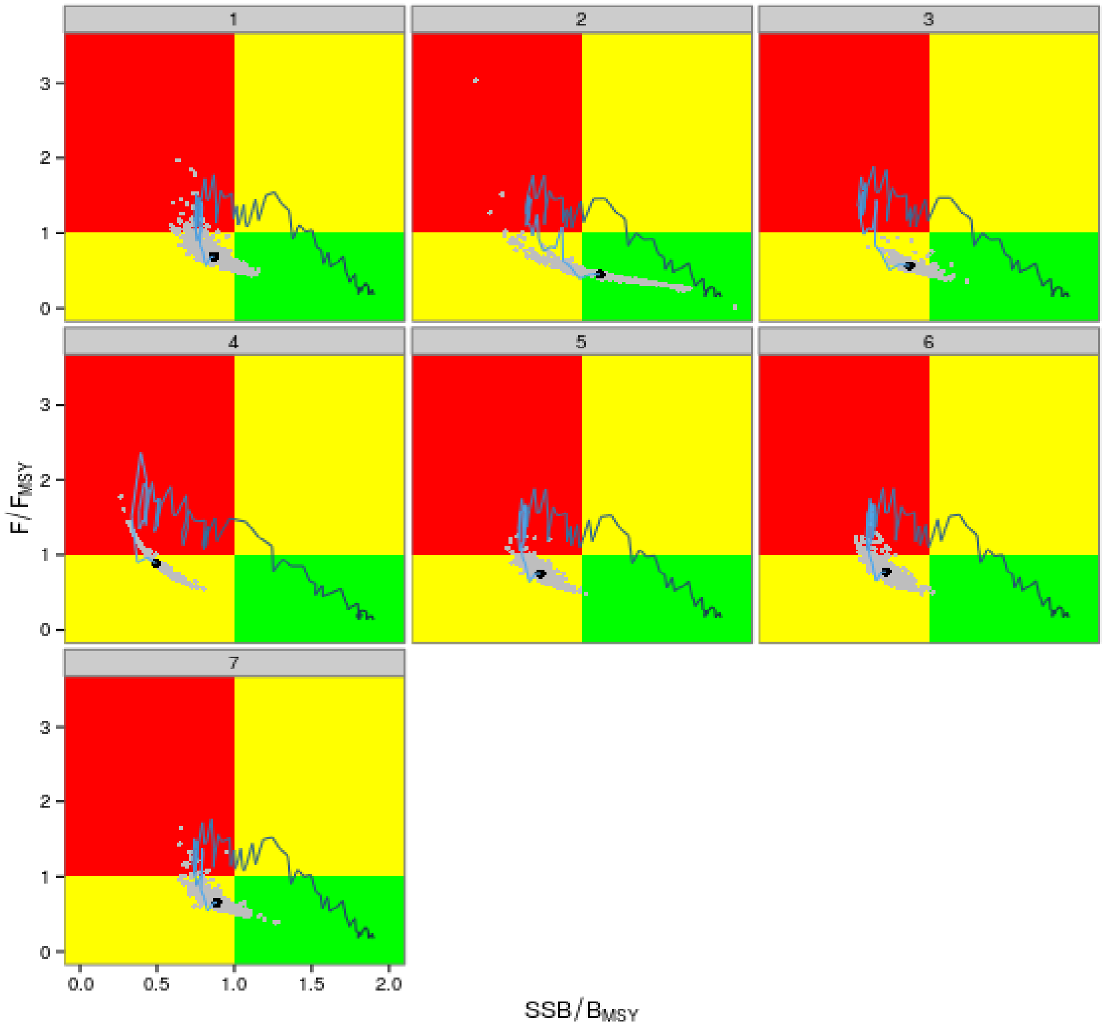

Figure 3. Phase plot of harvest rate relative to FMSY and stock biomass relative to BMSY by scenario.

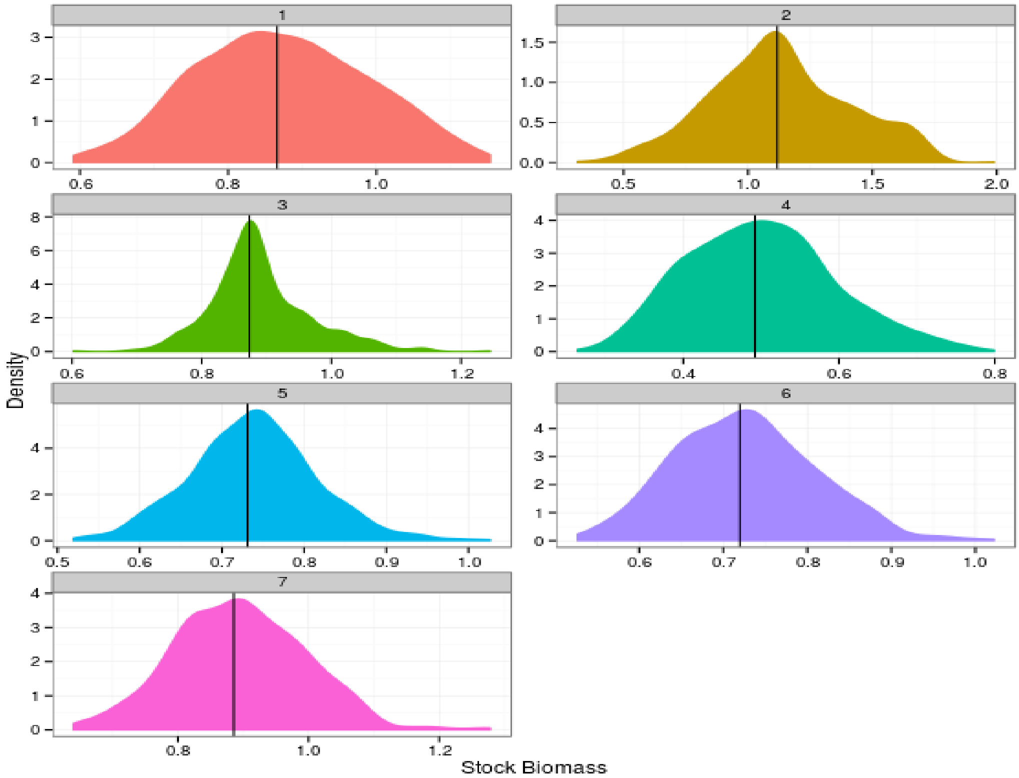

Figure 4. Marginal distributions of B: BMSY in the last assessment year (2011) by scenario.

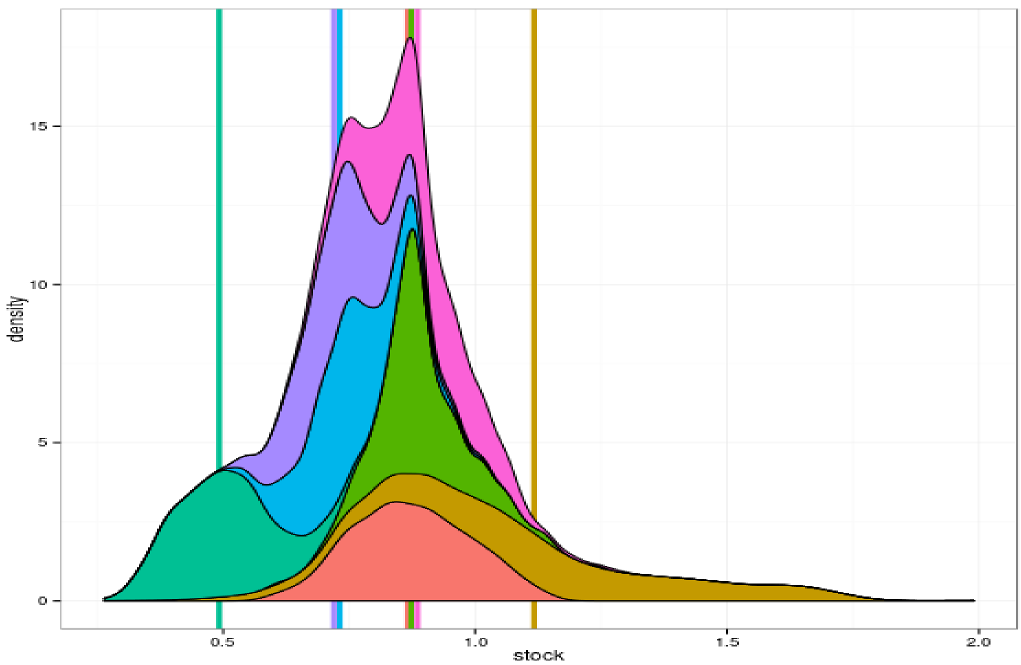

Figure 5. Marginal distributions of B: BMSY in the last assessment year (2011); densities are stacked.

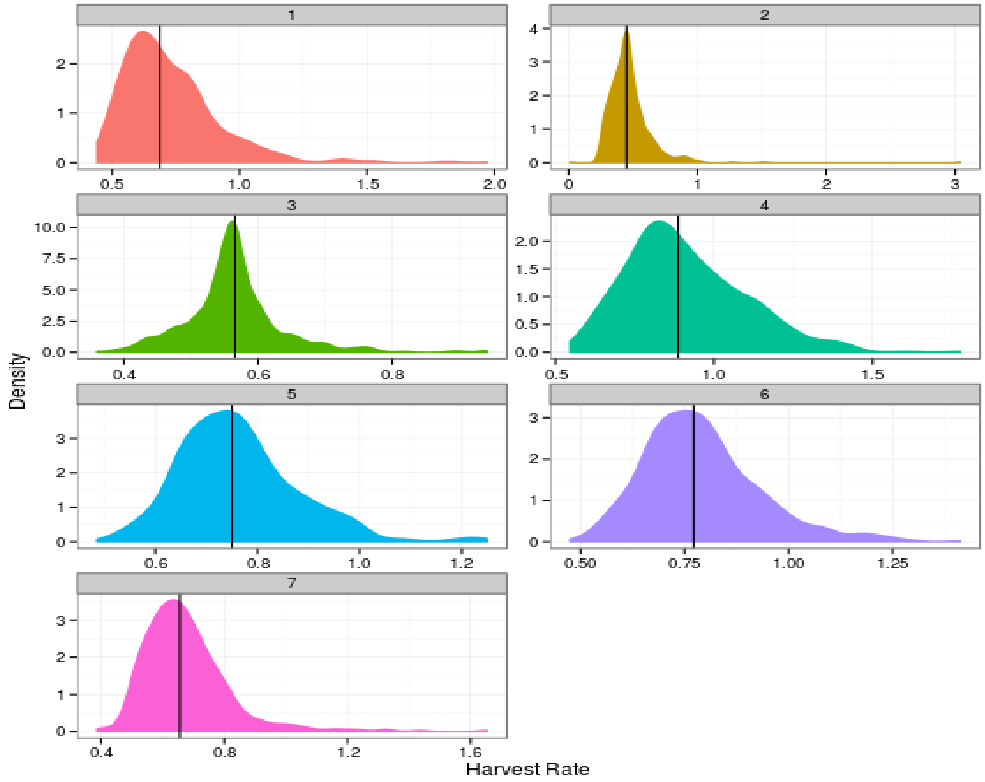

Figure 6. Marginal distributions of F: FMSY in the last assessment year (2011) by scenario.

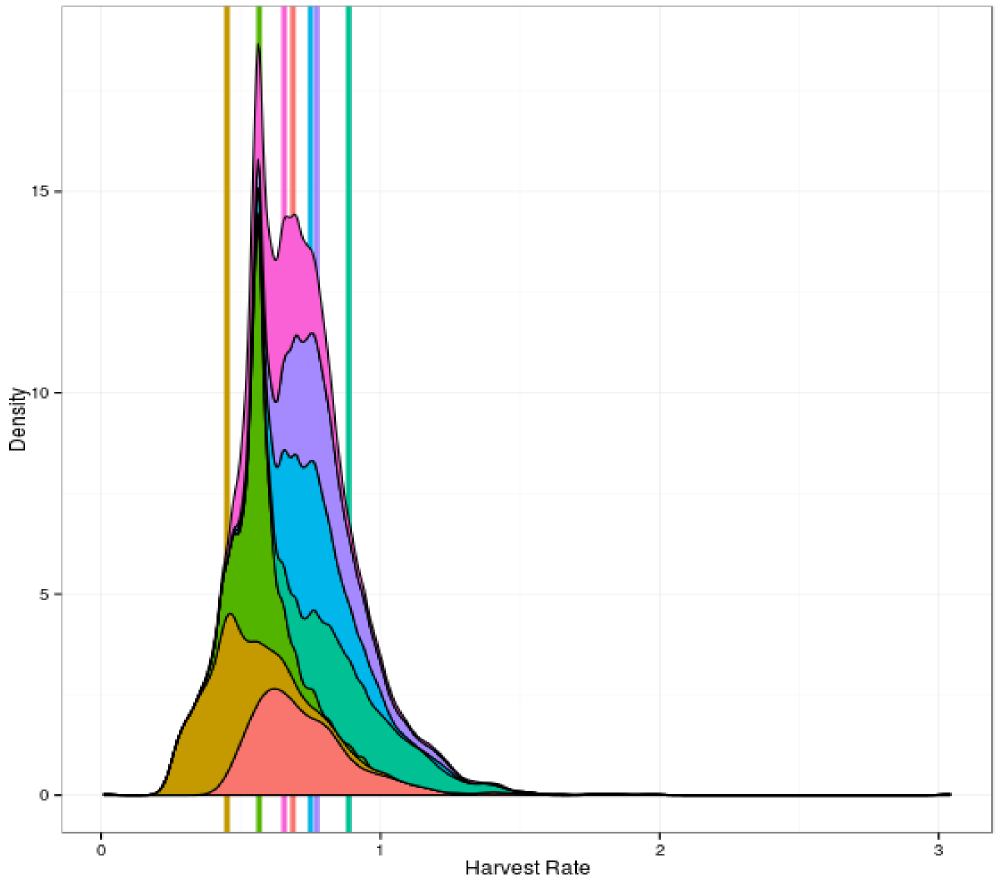

Figure 7. Marginal distributions of F: FMSY in the last assessment year (2011); densities are stacked.

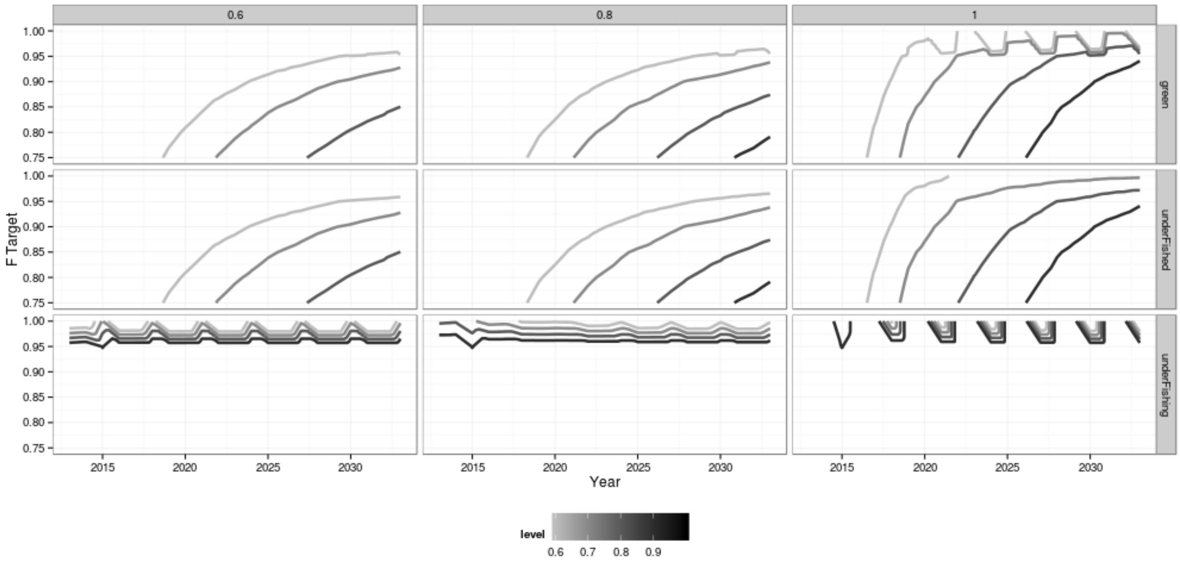

Figure 8. Kobe II strategy matrix (K2SM) showing (by row) the probability of being in the green quadrant (i.e, $B > B_{MSY}$ and $F < F_{MSY}$), the stock being underfished ($B > B_{MSY}$) and under fishing occurring ($F < F_{MSY}$) for different target fishing mortalities as a fraction of F_{MSY} (columns). Contours are the 0.9, 0.8, 0.7 and 0.6 probability levels.