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THE IMPLICIT NORTH ATLANTIC ALBACORE MANAGEMENT PROCEDURE

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SUMMARY

Management Strategy Evaluation is used to simulation test a Management Procedure using an Operating Model. Where the Operating Model is a simulation model used to describe the actual resource dynamics in simulation trials and to generate resource monitoring data when projecting forward. The Management Procedure is the combination of pre-defined data, together with an algorithm (e.g. a stock assessment procedure) to which such data are input to provide a value for a management control measure. The intention is to demonstrate, through simulation trials, robust performance of the Management Procedure in the presence of uncertainties. This requires identifying candidate management strategies and coding these as an MP and then to identify the MP that robustly meet management objectives. In this paper we describe an implicit Management Procedure for North Atlantic albacore based on the Kobe Advice Framework. An implicit Management Procedure is a procedure that contains all the elements of a Management Procedure, but has not yet been evaluated through simulation trials.

RÉSUMÉ

Une évaluation de la stratégie de gestion est utilisée pour réaliser un test de simulation d'une procédure de gestion employant un modèle opérationnel, où le modèle opérationnel est un modèle de simulation utilisé pour décrire les dynamiques réelles de la ressource dans des essais de simulation et pour générer des données de suivi de la ressource en réalisant une projection vers l'avant. La procédure de gestion est une combinaison de données prédéfinies, conjointement avec un algorithme (p. ex. une procédure d'évaluation des stocks) dans lequel ces données sont saisies afin de fournir une valeur pour une mesure de contrôle de la gestion. Le but consiste à démontrer, par le biais d'essais de simulation, le rendement efficace de la procédure de gestion en présence d'incertitudes. Ceci implique l'identification des stratégies de gestion concourantes et leur codage en procédure de gestion avant d'identifier la procédure de gestion qui remplit efficacement les objectifs de gestion. Le présent document décrit une procédure de gestion implicites pour le germon du Nord fondée sur la cadre de l'avis de Kobe. Une procédure de gestion implicite est une procédure qui contient tous les éléments d'une procédure de gestion, mais qui n'a pas encore été évaluée au moyen d'essais de simulation.

RESUMEN

La evaluación de estrategias de ordenación se utiliza para realizar una prueba de simulación de un procedimiento de ordenación utilizando un modelo operativo. Donde el modelo operativo es un modelo de simulación utilizado para describir la dinámica real del recurso en pruebas de simulación y para generar datos de seguimiento del recurso al realizar proyecciones hacia adelante. El procedimiento de ordenación es la combinación de datos predefinidos junto con un algoritmo (por ejemplo, un procedimiento de evaluación de stock, en el que se introducen dichos datos para obtener un valor para una medida de control de ordenación. La intención es demostrar, mediante pruebas de simulación, el rendimiento robusto del procedimiento de ordenación en presencia de incertidumbres. Esto requiere la identificación de posibles estrategias de ordenación y su codificación como un MP y después la identificación del MP que alcance de un modo robusto los objetivos de ordenación. En este documento, se describe un procedimiento de ordenación implícito para el atún blanco del Atlántico norte basado en el

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marco de asesoramiento de Kobe. Un procedimiento de ordenación implícito es un procedimiento que contiene todos los elementos de un procedimiento de ordenación, pero que no ha sido evaluado todavía mediante pruebas de simulación.

KEYWORDS

Albacore, Biomass Dynamic; Management Strategy Evaluation; Management Procedure; Stock Assessment;

Introduction

When conducting a Management Strategy Evaluation (MSE) it is necessary to identifying candidate management strategies and code these up as Management Procedure (MP). Where an MP is the combination of pre-defined data, together with an algorithm, e.g. to estimate stock status and reference points from the data to set management (e.g. TAC). An Operating Model (OM) is then projected forward using the MP as a feedback controller in order to simulate the long-term impact of management. The performance of alternative MPs are evaluated by comparing performance with respect to management objectives. Even if the implicit MP is never run on autopilot MSE can also be used to evaluate the current advice framework as an implicit MP (e.g. Kell *et al*., 2005). Evaluating an implicit MP can help identify short comings of current procedures.

In the case of North Atlantic albacore and swordfish (see Kell *et al.*, 2013b, 2012) advice is provided in the form of a Kobe II Phase Plot (K2SM) using a Harvest Control Rule (HCR). MSE has not been used to simulation test an MP in either case. The elements of an MP do exist, however, and could be to conduct an MSE once an OM is agreed to demonstrate, or otherwise, through simulation the robust performance of the current implicit MP. For North Atlantic albacore an OM based on Multifan-CL has been agreed (Kell *et al*., 2013a).

To model the MP we use the mpb R package. First we validate biodyn by comparing estimates of stock status to assessments made by ASPIC for North Atlantic albacore, South Atlantic albacore, yellowfin, bigeye, North Atlantic swordfish and South Atlantic swordfish. We then conduct a cross test (Deroba *et al*., 2015) using the Multifan-CL OM developed for North Atlantic Albacore.

Management Framework

For North Atlantic albacore (see Kell *et al*., 2013, 2012) advice is provided in the form of a Kobe II Strategy Matrix (K2SM). In the last assessment a Harvest Control Rule (HCR) was used for projection to generate the K2SM using a biomass dynamic model. MSE has not been used to simulation test an MP. Therefore two of the elements of an MP exist, the assessment algorithm and the HCR. Work has already been conducted on a preliminary MSE to evaluate the robustness of the current implicit MP. An OM based on Multifan-CL has been agreed and run (Kell, in press a), an Observation Error Model (OEM) to simulate resource monitoring data described (Kell, in press b) and the assessment algorithm tested (Kell, in press c, Kell, in press d). In this paper we describe the remaining step; the HCR.

Management Objectives

Management objectives for the northern albacore stock are given in Rec-15-04 and are

- to maintain the stock in the green zone of the Kobe plot, with at least a 60% probability, while maximizing long-term yield from the fishery, and

- where the spawning stock biomass (SSB) has been assessed by the SCRS as below the level capable of producing MSY (SSB_{MSY}), to rebuild SSB to or above SSB_{MSY}, with at least a 60% probability, and within as short time as possible, by 2020 at the latest, while maximizing average catch and minimizing inter-annual fluctuations in TAC levels.

Harvest Control Rule

The elements of a HCR are also specified in Rec. 15-04, i.e.

- If the average spawning stock biomass (SSB) level is less than SSB_{LIM} (i.e., $SSB<SSB_{LIM}$), the Commission shall adopt severe management actions immediately to reduce the fishing mortality rate, including measures that suspend the fishery and initiate a scientific monitoring quota to be able to evaluate stock status. This scientific monitoring quota shall be set at the lowest possible level to be effective. The Commission shall not consider reopening the fishery until the average SSB level exceeds SSB_{LIM} with a high probability. Further, before reopening the fishery, the Commission shall develop a rebuilding program in order to ensure that the stock returns to the green zone of the Kobe plot.

- If the average SSB level is equal to or less than $SSB_{THRESHOLD}$ and equal to or above SSB_{LIM} (i.e., $SSB_{LIM} \leq SSB \leq SSB_{THRESHOLD}$) and F is above the level specified in the HCR, the Commission shall take steps to reduce F as specified in the HCR to ensure F is at a level that will rebuild SSB to SSB_{MSY} or above that level.

- If the average SSB is above $SSB_{THRESHOLD}$ but F exceeds F_{TARGET} (i.e., $SSB>SSB_{THRESHOLD}$ and $F>F_{TARGET}$), the Commission shall immediately take steps to reduce F to F_{TARGET}

- Once the average SSB level reaches or exceeds $SSB_{THRESHOLD}$ and F is less or equal than F_{TARGET} (i.e., $SSB> SSB_{THRESHOLD}$ and $F\leq F_{TARGET}$), the Commission shall assure that applied management measures will maintain F at or below F_{TARGET}.

Coding

The tasks of the SCRS are to evaluate the HCRs that come up as different combinations of reference points, i.e. $SSB_{THRESHOLD}$, SSB_{LIM} and F_{TARGET}. The SCRS has already described a hockey stick HCR, where if the stock is above $SSB_{THRESHOLD}$ the TAC is set equivalent to a fishing mortality of F_{TARGET}. If the stock falls below $SSB_{THRESHOLD}$ then F is linearly decreased until SSB_{LIM} is reached, at which point the fisheries would be closed. It is seldom possible to prevent all fishing on a stock, e.g. due to bycatch and so it is assumed that even after closure of the fisheries there will still be some fishing mortality (i.e. F_{LIM}).

Important elements that need to be agreed as part of the HCR are the time scales, and how quickly TACs and effort should be reduced or allowed to increase. As an illustration, a HCR is simulated for single choices of reference points. In practice when conducting an MSE a variety of choices for the reference points would be evaluated and the HCR chosen that best meets management objectives. A process called tuning, (similar to making adjustments to a musical instrument) is carried out until the best performance is achieved.

Results

Figure 1 presents an example of the "one off" application of a harvest control rule. The stock is originally overexploited, then in year 30 a HCR is applied and the stock fished at the level determined by such HCR until ar 47. Fishing mortality is initially above F_{TARGET} so is reduced by application of the HCR. This results in an initial decline in yield, followed by an increase as the stock recovers.

Next the same HCR is simulated showing the effect of 5% bounds on inter-annual changes in F (or effort) and catches. This is purely an example and not proposed as a management option. The stock, harvest rate and yield trajectories are shown relative to B_{MSY}, F_{MSY} and MSY respectively in **Figure 2, 3 and 4.** The grey lines are $B_{THRESHOLD}$ and F_{TARGET} and the red lines are B_{lim} and F_{min}. The HCR is shown in the corresponding Kobe Phase Plot (K2PP) **in Figure 5.** The F set by the HCR is less than F_{TARGET} since when the HCR was applied B was less than $B_{THRESHOLD}$.

The harvest control rule was applied in year 30 but then reapplied every three years; **Figures 6, 7 and 8** show stock, harvest rate and yield trajectories relative to B_{MSY}, F_{MSY} and MSY and **Figure 9** the K2PP. The application of the TAC bound results in oscillations in biomass and yield.

Discussion

Simulating a HCR also allows important details to be fine-tuned, e.g. how fast to reduce catches or effort. It also allows behaviour that may not have been expected, to be seen, e.g. the oscillation of catches by applying a bound on inter-annual variation in catches.

The software used in this example can be used to simulate an MP as using the OM described in Kell (in press a) and Kell (in press b). However, outstanding issues are the data to use in the MP and the choices made when running stock assessment algorithm. Kell (in press d) showed that the current procedure used to select data and to estimate parameters when running the biomass dynamic model was problematic. Kell (in press c) performed a cross-test to evaluate the robustness of those procedures and Kell (in press e) proposed a procedure to help ensure that future assessments are reliable.

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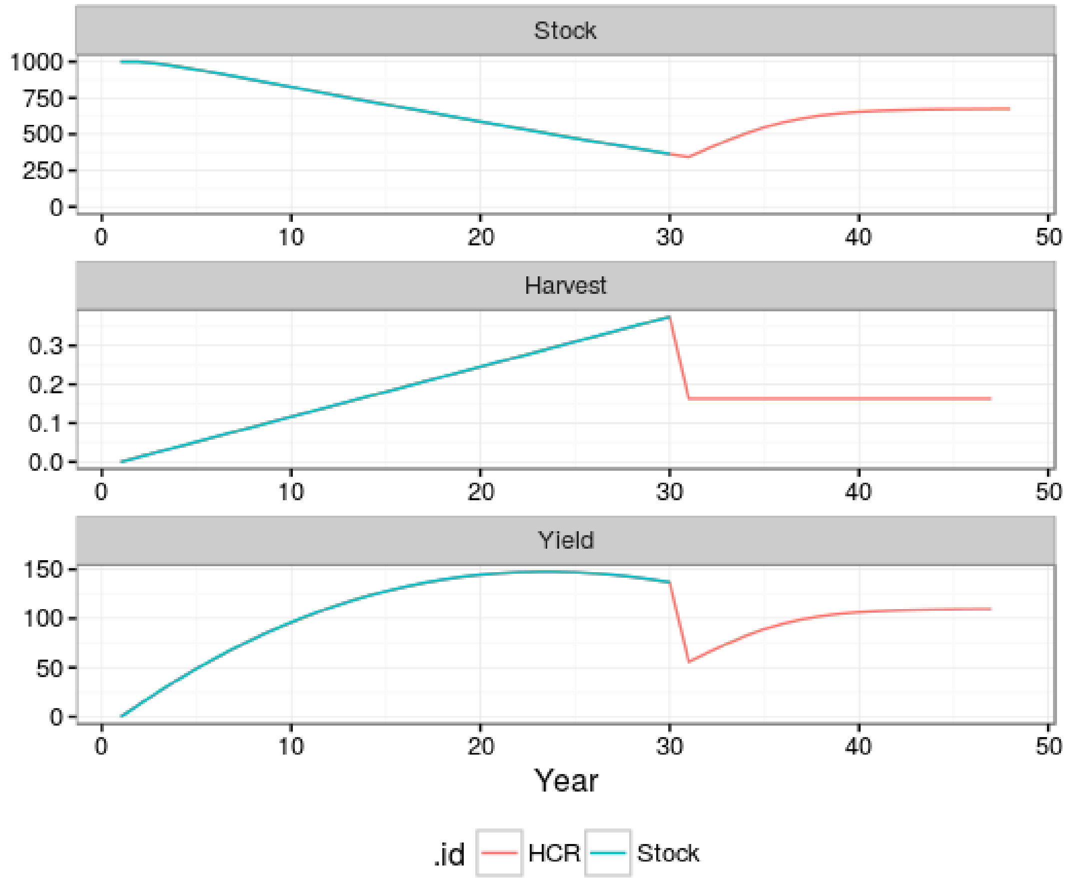

Figure 1. Example of the one off application of a harvest control rule, stock is originally overexploited, then in year 30 a HCR is applied.

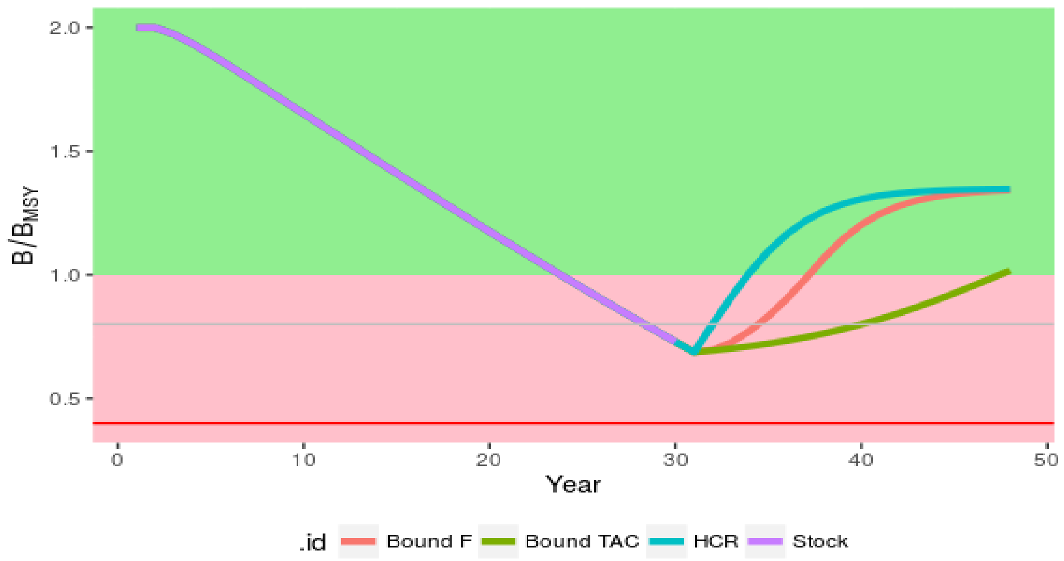

Figure 2. Stock relative to B_{MSY} for the one off application of a harvest control, grey line is the $B_{Threshold}$ and red the B_{Lim}

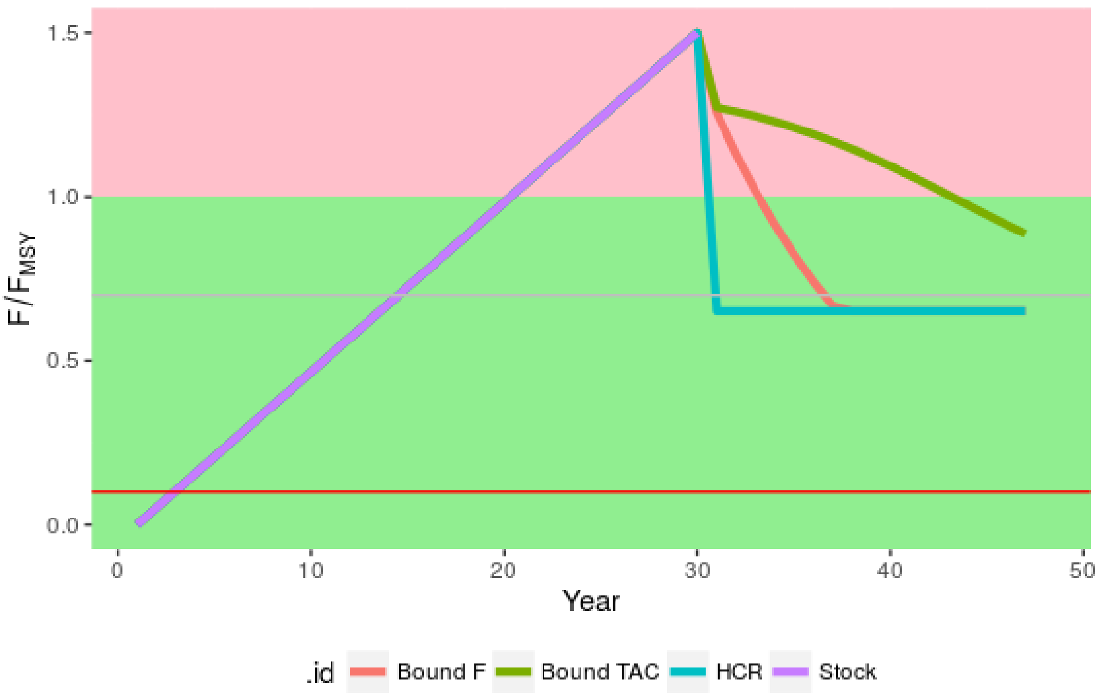

Figure 3. Harvest rate relative to F_{MSY} for the one off application of a harvest control, grey line is the F_{Target} and red the F_{min}.

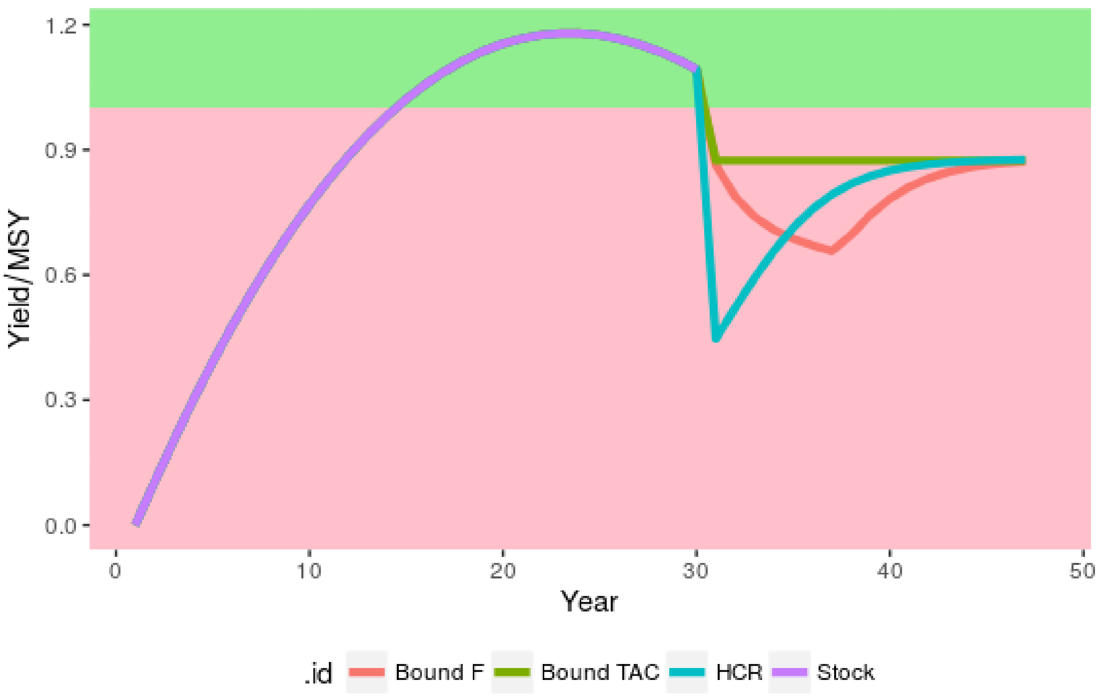

Figure 4. Yield relative to MSY for the one off application of a harvest control.

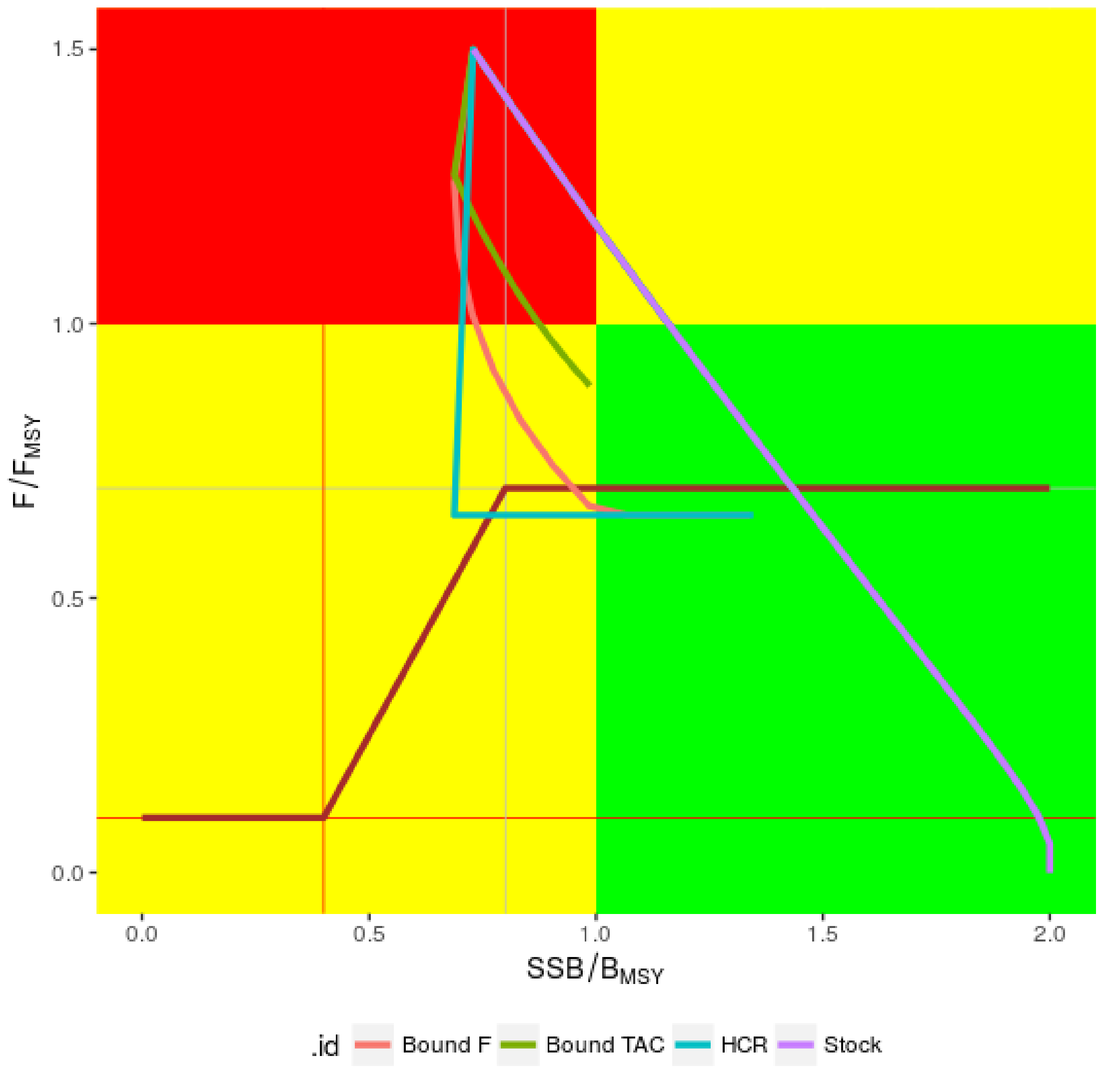

Figure 5. Kobe phase plot for the one off application of a harvest control, vertical grey line is the $B_{Threshold}$ and red the B_{Lim}, horizontal grey line is the F_{Target} and red the F_{min}.

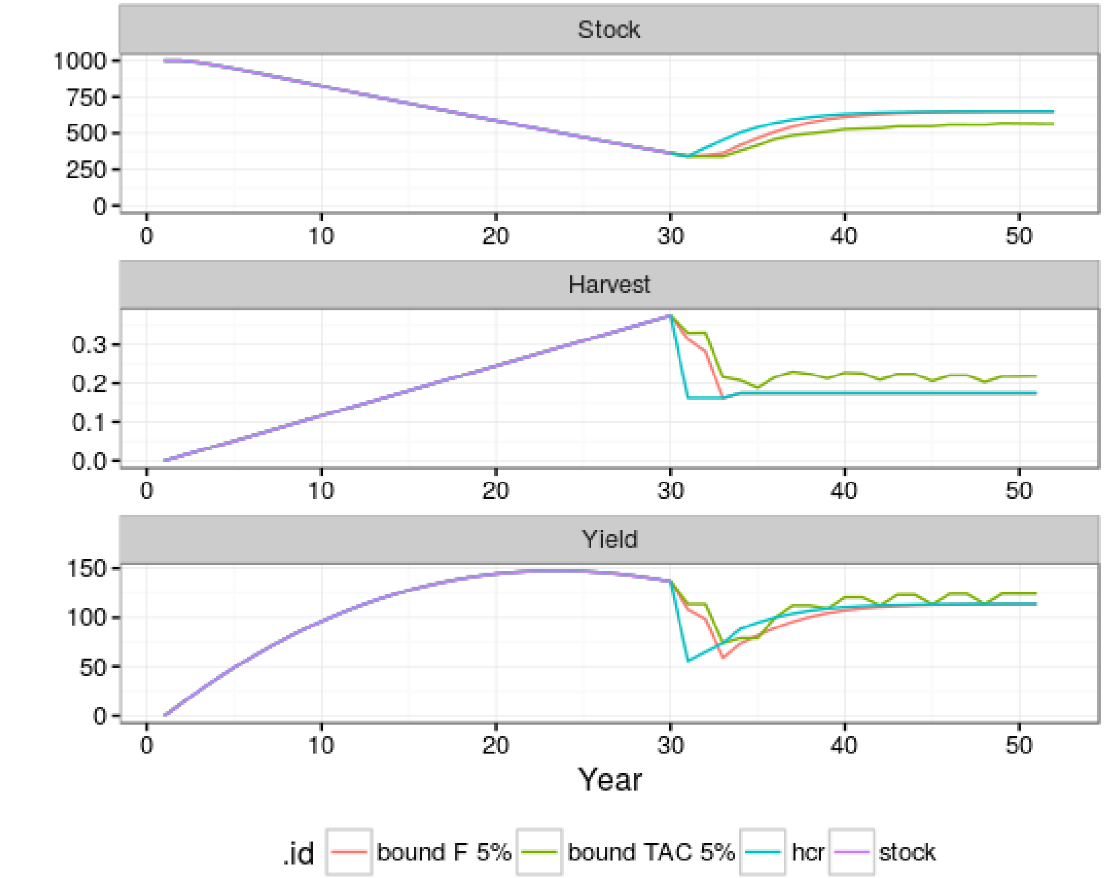

Figure 6. Example of a harvest control rule every three years, stock is originally overexploited, then in year 30 a HCR is applied.

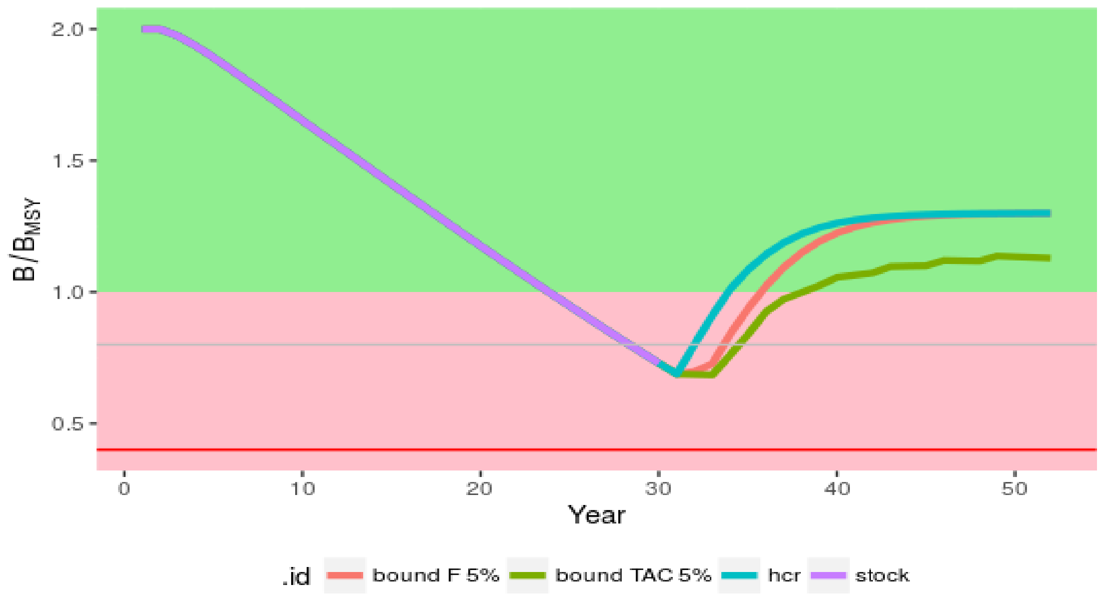

Figure 7. Stock relative to B_{MSY} for a harvest control applied every three years, grey line is the $B_{Threshold}$ and red the B_{Lim}.

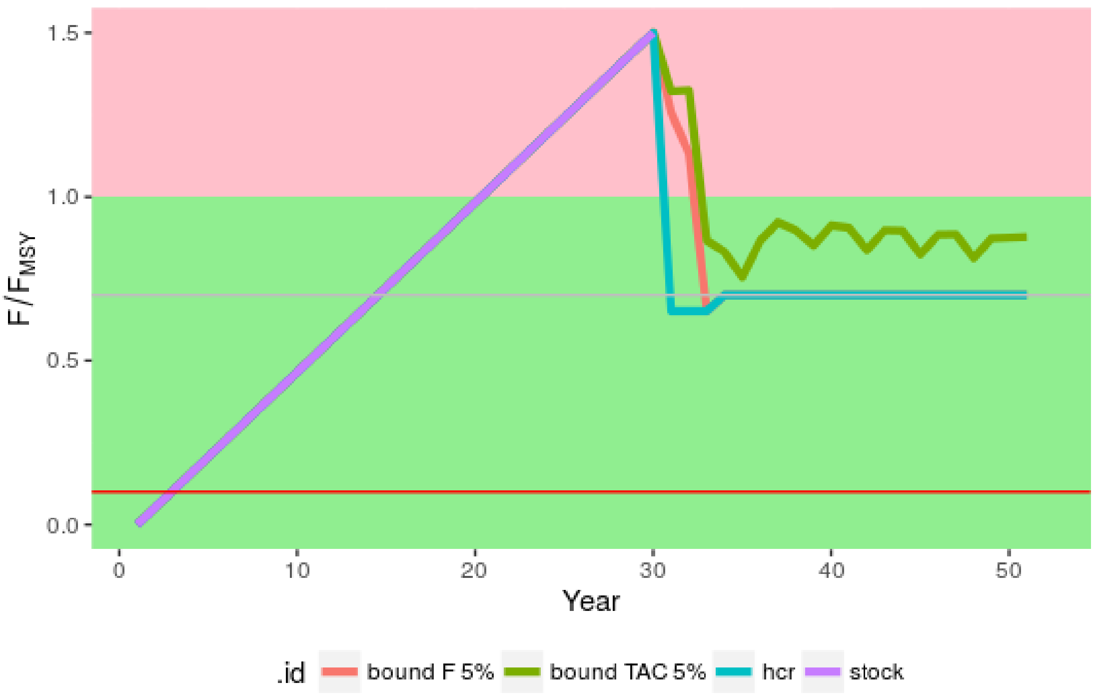

Figure 8. Harvest rate relative to F_{MSY} for a harvest control applied every three years, grey line is the F_{Target} and red the F_{min}.

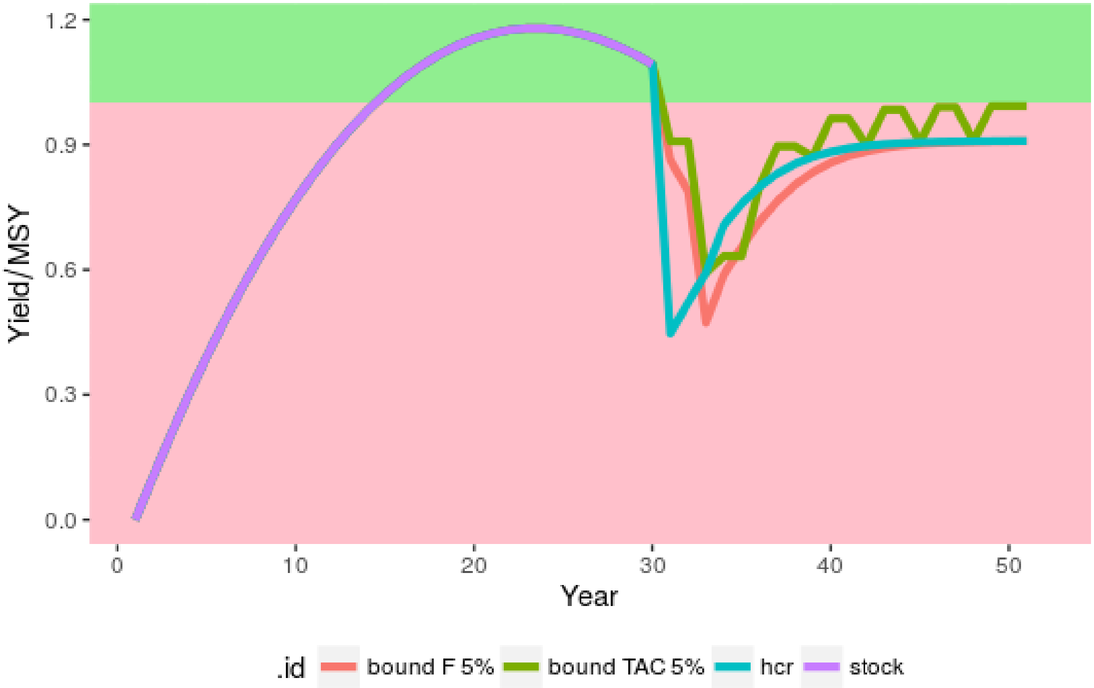

Figure 9. Yield relative to MSY for a harvest control applied every three years.

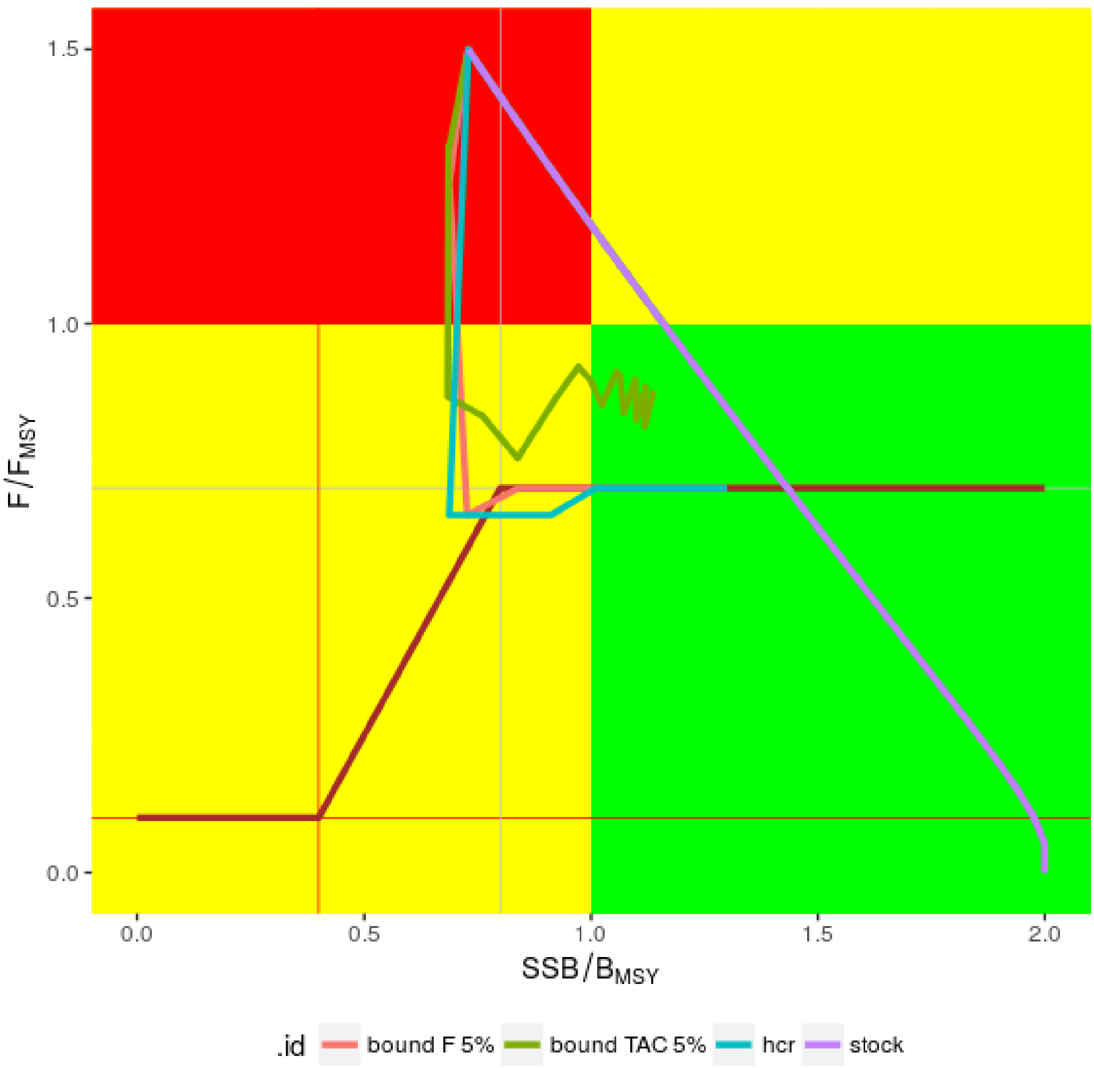

Figure 10. Kobe phase plot for a harvest control applied every three years, vertical grey line is the $B_{Threshold}$ and red the B_{Lim}, horizontal grey line is the F_{Target} and red the F_{Lim}.