KOBE II STRATEGY MATRICES FOR NORTH ATLANTIC SWORDFISH BASED ON CATCH, FISHING MORTALITY AND HARVEST CONTROL RULES

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SUMMARY

Scientific stock assessment advice given by the SCRS is presented in the form of the Kobe II Strategy Matrix (K2SM). Traditionally the K2SM shows the probabilities by year for different catches of achieving the management objective of ensuring that the stock biomass is greater than BMSY and fishing mortality less than FMSY. However, a K2SM can also be used, as in this paper, to help guide discussion about choice of reference points for use as part of a Harvest Control Rule.

RÉSUMÉ

L'avis formulé par le SCRS sur l'évaluation scientifique des stocks est présenté sous la forme de la matrice de stratégie de Kobe II (K2SM). Traditionnellement, la K2SM montre les probabilités par année pour différentes prises d'atteindre l'objectif de gestion de garantir que la biomasse du stock est supérieure à B_{PME} et que la mortalité par pêche est inférieure à $F_{PME.}$ Toutefois, une K2SM peut aussi être utilisée, comme dans le présent document, pour aider à orienter les discussions sur le choix des points de référence à utiliser dans le cadre d'une norme de contrôle de la ponction.

RESUMEN

El asesoramiento científico de las evaluaciones de stock facilitado por el SCRS se presenta en forma de matriz de estrategia de Kobe II (K2SM). Tradicionalmente, la K2SM muestra las probabilidades por año de las diferentes capturas de conseguir los objetivos de ordenación de garantizar que la biomasa del stock es mayor que la B_{RMS} y que la mortalidad por pesca es inferior a la B_{RMS}. Sin embargo, la K2SM puede utilizarse también, como en este documento, para orientar los debates sobre la elección de puntos de referencia para su utilización como parte de una norma de control de la captura.

KEYWORDS

Advice, ASPIC, Biomass Dynamic, Harvest Control Rule, Kobe II Strategy Matrix, Management, Projections, Stock Assessment

1. Introduction

Advice by the SCRS, in common with other tuna Regional Fisheries Management Organisations (tRFMOs), is presented in the form of the Kobe II Strategy Matrix (K2SM). The K2SM shows for different levels of total allowable catch (TAC) the probabilities by year the stock biomass is greater than BMSY and fishing mortality less than FMSY. I.e. of achieving the main management objective of ICCAT ensuring that high continuing catches.

The Commission has asked the SCRS to develop Limit Reference Points (LRPs) for North Atlantic swordfish (Rec. 11-02) that will trigger a rebuilding plan when biomass drops below the LRP. 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. This requires advice to be based not on a range of TACs but on a HCR, where choices have to be made about target fishing mortality, and other reference points, see **Figure 1** for the generic ICCAT HCR (ICCAT, 2012).

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Therefore in this paper we compare traditional K2SM advice based on TACs, to K2SMs based on target fishing mortalities and a HCR with a range of fishing mortality and biomass reference points based on Maximum Sustainable Yield (MSY) for North Atlantic swordfish based on the 2013 stock assessment. The K2SM in this paper are not those used in the North Atlantic Swordfish Executive Summary. They are simply intended to illustrate the difference between K2SMs conditioned on different types of projection.

2. Materials and methods

2.1 Harvest Control Rule

SCRS2013-150 summarised the rational used by the Albacore Group to propose an interim Limit Reference Point (iLRP) and its use as part of a HCR. The approach taken by the albacore group is based on that adopted by the IOTC. Where 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 reference points. IOTC will also assess through management strategy evaluation 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 scientific committee of the IOTC 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 taken by the albacore working group allowed advice to be provided in the Kobe framework consistent with the Commission’s decision making policy for development and application of conservation and management measures (Rec. 11-13).

In order to advance the Commission-SCRS dialogue, the Albacore WG provided information to the Commission on the basis of a range of interim HCR parameters, i.e. target fishing mortalities and biomass threshold (or buffer which if the stock fell below would result in fishing mortality being reduced).

The HCR meets the Commissions policy objectives based on the assessment outcomes, e.g.

1) For stocks in the green quadrant of the Kobe plot, management measures shall be designed to result in a high probability of maintaining the stock within this quadrant.
2) For stocks that are in the upper right yellow quadrant of the Kobe plot (overfishing), the Commission shall immediately adopt management measures designed to result in a high probability of ending overfishing in as short a period as possible.
3) For stocks in the red quadrant of the Kobe plot (overfishing and overfished), the Commission shall immediately adopt management measures, designed to result in a high probability of ending overfishing in as short a period as possible and the Commission shall adopt a plan to rebuild these stocks, and
4) For stocks in the lower left yellow quadrant of the Kobe plot (overfished but no overfishing), the Commission shall adopt management measures designed to rebuild these stocks in as short a period as possible.

2.2 Stock assessment

The data used are the results from Run 2 of the ASPIC assessment Prager *et al.* (1996) for the North Atlantic swordfish stock.

During the stock assessment meeting the ASPIC base model was projected to the year 2022 under constant TAC scenarios of 8 to 20 thousand tones. Catch in year 2012 was assumed to be the reported catch plus the average of the last three years (2009-11) for those CPCs that have not reported swordfish catches as of September 5, 2013 (i.e. 14,038 t)

2.3 Projections

Three sets of projections were conducted, i.e. based on a range of i) TACs, ii) target fishing mortalities and iii) target fishing mortalities and biomass thresholds as part of a HCR.

In the case of the HCR, the stock was projected for three years for the fishing mortality based on the assessed stock biomass, a TAC was then estimated by taking the average catch for the three projected years. Other algorithms for setting the TAC could be explored, see SCRS2013-33. This would require discussion and subsequent simulation testing.

2.4 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

Stock assessment results are shown in **Figures 2, 3 and 4**; **Figure 2** shows the time series of stock biomass relative to BMSY and harvest rate relative to FMSY. The corresponding Kobe phase plot, **Figure 3**, the historic median, boot strapped estimates and marginal densities for 2011 of stock biomass relative to BMSY and harvest rate relative to FMSY. The probabilities of being in the green, red and yellow zones of the Kobe phase plot are summarised as a pie chart in **Figure 4**. To help provide a consistent framework for presentation simulation of HCRs, the results are presented in a similar format as for North Atlantic albacore (SCRS2103-XXX). The Kobe II Strategy matrix, showing the joint probabilities of B > BMSY and F < FMSY is presented in **Table 1**. There are 5 types of projection i.e. 3 HCRs with different $B_{Thresholds}$, constant F and constant catch. In the case of the HCRs and the constant F projections the different F targets are shown by row. **Table 2** shows the probabilities of F < FMSY and **Table 3** for B > BMSY.

The associated catches, i.e. mean in next 3 years and cumulative for 5.10 and 15 years are summarised in **Table 4.**

4. Discussion

A K2SM constructed using TAC projections was compared with K2SMs based on constant F projections and the generic ICCAT HCR with a range of values for F_{Target} and $B_{Thresholds}$. Since the stock is in the green Kobe phase plot quadrant little difference was seen in the projected outcomes for TACs below BMSY and fishing mortalities below FMSY. The main difference was in at high fishing mortalities when the stock fell below the $B_{Threshold}$ and the HCR caused fishing mortality and hence catches to be reduced then increased in a three year cycle.

An objective of simulating a HCR was to help guide discussion and create a dialogue between the SCRS and the Commission not just on the level of TAC but on what is meant by high probability and as short as possible. For example if the stock falls below BMSY how quickly should F and catches be reduced in order to recover the stock. Also what should be the probability that the stock is greater than BMSY so that the recovery plan is successful.

While it is recognised that different assessment methods will provide alternative estimates of uncertainty it is still possible to provide information to the Commission on the basis of a range of interim HCR parameter values which would meet the Commissions policy based on assessment outcomes as done for North Atlantic albacore. Where a HCR was used to provide a range of time-frames and probability levels for achieving Commissions objectives (as established in Rec. 11-13).

The Precautionary Approach (PA, Garcia (1996)) recommends the use of a harvest control rule (HCR) to specify in advance what actions should be taken when limits are reached and requires stock status to be assessed relative to limits and targets. The proposed HCR is therefore consistent with the Precautionary Approach, which requires the prediction of outcomes of alternative management measures for reaching the targets and avoiding limits. In addition the PA requires a characterisation of uncertainty and imposes specific needs for research, stock assessments, monitoring and management. Particularly, since although HCRs may include several precautionary elements, it does not necessarily follow that they will be precautionary in practice Kirkwood and Smith (1995). 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).

It is therefore important to consider appropriate sources of uncertainty; traditional stock assessments mainly considers only uncertainty in observations and process (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. That is why it is better to consider Management Procedures (MP) or management strategies which are the combination of the available pseudo-data, the stock assessment used to derive estimates of stock status and the management model or Harvest Control Rule (HCR) that generates the management outcomes. Then to test these using Management Strategy Evaluation (MSE) to evaluate the impact of the main sources of uncertainty inherent in the system being managed (Cooke (1999), McAllister *et al.* (1999)).

For example SCRS2013-162 showed that there is considerable uncertainty about the indices of abundance used in the assessment for North Atlantic swordfish which is will have a greater impact on outcomes than the assumptions about process and measurement error. .

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Table 1. Kobe II Strategy matrix, showing joint probabilities of B > B_{MSY} and F < F_{MSY} for HCR with different $B_{Tresholds}$ by $F_{Targets}$, constant F and constant catch projections.

Harvest Control Rule	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Threshold 0.6 B_{MSY}	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
F_{MSY} times 0.75	88	92	95	96	99	99	99	99	100	100	100	100	100	100	100	100	100	100
0.80	88	92	95	96	97	99	99	99	99	100	100	100	100	100	100	100	100	100
0.85	88	92	94	95	96	97	99	99	99	99	99	100	100	100	100	100	100	100
0.90	88	92	94	95	96	96	96	99	99	99	99	99	99	99	100	100	100	100
0.95	88	92	93	94	95	95	96	96	96	97	99	99	99	99	99	99	99	99
1.00	88	92	92	0	92	92	0	92	92	0	92	92	0	92	92	0	92	92
Threshold 0.8 B_{MSY}	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
F_{MSY} times 0.75	88	92	95	96	99	99	99	99	100	100	100	100	100	100	100	100	100	100
0.80	88	92	95	96	97	99	99	99	99	100	100	100	100	100	100	100	100	100
0.85	88	92	94	95	96	97	99	99	99	99	99	100	100	100	100	100	100	100
0.90	88	92	94	95	96	96	96	99	99	99	99	99	99	99	100	100	100	100
0.95	88	92	93	94	95	95	96	96	96	97	99	99	99	99	99	99	99	99
1.00	88	92	92	0	92	92	0	92	92	0	92	92	0	92	92	0	92	92
Threshold 1.0 B_{MSY}	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
F_{MSY} times 0.75	88	92	95	97	99	99	100	100	100	100	100	100	100	100	100	100	100	100
0.80	88	92	95	97	99	99	100	100	100	100	100	100	100	100	100	100	100	100
0.85	88	92	95	96	99	99	99	100	100	100	100	100	100	100	100	100	100	100
0.90	88	92	94	96	99	99	99	100	100	100	100	100	100	100	100	100	100	100
0.95	88	92	93	95	98	99	99	99	100	100	100	100	100	100	100	100	100	100
1.00	88	92	92	0	94	96	5	99	99	2	100	100	1	100	100	0	100	100
Constant F																		
F times F_{MSY}	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0.75	88	92	95	96	99	99	99	99	100	100	100	100	100	100	100	100	100	100
0.80	88	92	95	96	97	99	99	99	99	100	100	100	100	100	100	100	100	100
0.85	88	92	94	96	96	98	99	99	99	99	99	100	100	100	100	100	100	100
0.90	88	92	94	95	96	96	97	99	99	99	99	99	99	99	100	100	100	100
0.95	88	92	93	94	95	95	96	96	96	97	99	99	99	99	99	99	99	99
1.00	88	5	1	0	0	1	0	0	0	1	1	1	1	2	1	1	1	0
Constant Catch																		
TAC	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
800	88	92	96	96	99	99	99	99	99	100	100	100	100	100	100	100	100	100
900	88	92	95	96	98	99	99	99	99	99	99	100	100	100	100	100	100	100
1000	88	92	95	96	96	97	99	99	99	99	99	99	99	99	99	99	99	99
1100	88	92	94	96	96	96	96	97	99	99	99	99	99	99	99	99	99	99
1200	88	92	93	94	95	95	96	96	96	96	97	97	97	97	97	97	98	98
1300	88	91	92	92	92	92	93	93	93	94	94	94	93	93	94	94	94	94
1400	88	84	82	80	79	77	75	74	72	69	67	65	62	60	57	56	54	51
1500	88	64	55	42	32	25	17	13	11	7	5	4	3	2	2	1	1	1
1600	88	31	17	10	4	2	0	0	0	0	0	0	0	0	0	0	0	0
1700	88	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1800	88	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1900	88	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. Kobe II Strategy matrix, showing probabilities of F < F_{MSY} for HCR with different $B_{Tresholds}$ by $F_{Targets}$, constant F and constant catch projections.

Harvest Control Rule	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Threshold 0.6 B_{MSY}	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
F_{MSY} times 0.75	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.80	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.85	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.90	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.95	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1.00	88	92	92	8	92	92	8	92	92	8	92	92	8	92	92	8	92	92
Threshold 0.8 B_{MSY}	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
F_{MSY} times 0.75	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.80	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.85	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.90	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.95	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1.00	88	92	92	8	92	92	8	92	92	8	92	92	8	92	92	8	92	92
Threshold 1.0 B_{MSY}	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
F_{MSY} times 0.75	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.80	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.85	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.90	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.95	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1.00	88	99	99	8	100	100	8	100	100	2	100	100	1	100	100	0	100	100
Constant F																		
F times F_{MSY}	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0.75	93	92	95	96	99	99	99	99	100	100	100	100	100	100	100	100	100	100
0.80	93	92	95	96	97	99	99	99	99	100	100	100	100	100	100	100	100	100
0.85	93	92	94	96	96	98	99	99	99	99	99	100	100	100	100	100	100	100
0.90	93	92	94	95	96	96	97	99	99	99	99	99	99	99	100	100	100	100
0.95	93	92	93	94	95	95	96	96	96	97	99	99	99	99	99	99	99	99
1.00	93	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92
Constant Catch																		
TAC	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
800	93	92	96	96	99	99	99	99	99	100	100	100	100	100	100	100	100	100
900	93	92	95	96	98	99	99	99	99	99	99	100	100	100	100	100	100	100
1000	93	92	95	96	96	97	99	99	99	99	99	99	99	99	99	99	99	99
1100	93	92	94	96	96	96	96	97	99	99	99	99	99	99	99	99	99	99
1200	93	92	93	94	95	95	96	96	96	96	97	97	97	97	97	97	98	98
1300	93	92	92	93	93	93	93	93	93	94	94	94	94	94	94	94	94	94
1400	93	92	91	90	88	88	86	84	81	80	78	75	74	72	70	67	65	62
1500	93	92	90	85	80	72	61	49	37	27	19	13	9	7	5	4	3	2
1600	93	92	87	78	61	38	18	8	3	1	0	0	0	0	0	0	0	0
1700	93	92	84	63	31	9	2	0	0	0	0	0	0	0	0	0	0	0
1800	93	92	80	44	9	1	0	0	0	0	0	0	0	0	0	0	0	0
1900	93	92	75	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	93	92	67	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3. Kobe II Strategy matrix, showing probabilities of B > BMSY for HCR with different $B_{Tresholds}$ by FTargets, constant F and constant catch projections.

Harvest Control Rule

Threshold 0.6 B_{MSY}	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
F_{MSY} times 0.75	93	92	95	96	99	99	99	99	100	100	100	100	100	100	100	100	100	100
0.80	93	92	95	96	97	99	99	99	99	100	100	100	100	100	100	100	100	100
0.85	93	92	94	95	96	97	99	99	99	99	99	100	100	100	100	100	100	100
0.90	93	92	94	95	96	96	96	99	99	99	99	99	99	99	100	100	100	100
0.95	93	92	93	94	95	95	96	96	96	97	99	99	99	99	99	99	99	99
1.00	93	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92

Threshold 0.8 B_{MSY}	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
F_{MSY} times 0.75	93	92	95	96	99	99	99	99	100	100	100	100	100	100	100	100	100	100
0.80	93	92	95	96	99	99	99	99	100	100	100	100	100	100	100	100	100	100
0.85	93	92	95	96	99	99	99	99	100	100	100	100	100	100	100	100	100	100
0.90	93	92	95	96	99	99	99	99	100	100	100	100	100	100	100	100	100	100
0.95	93	92	95	96	99	99	99	99	100	100	100	100	100	100	100	100	100	100
1.00	93	92	95	96	99	99	99	99	100	100	100	100	100	100	100	100	100	100

Threshold 1.0 B_{MSY}	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
F_{MSY} times 0.75	93	92	95	97	99	99	100	100	100	100	100	100	100	100	100	100	100	100
0.80	93	92	95	97	99	99	100	100	100	100	100	100	100	100	100	100	100	100
0.85	93	92	95	97	99	99	100	100	100	100	100	100	100	100	100	100	100	100
0.90	93	92	95	97	99	99	100	100	100	100	100	100	100	100	100	100	100	100
0.95	93	92	95	97	99	99	100	100	100	100	100	100	100	100	100	100	100	100
1.00	93	92	95	97	99	99	100	100	100	100	100	100	100	100	100	100	100	100

Constant F

F times F_{MSY}	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
0.75	93	92	95	96	99	99	99	99	100	100	100	100	100	100	100	100	100	100
0.80	93	92	95	96	97	99	99	99	99	100	100	100	100	100	100	100	100	100
0.85	93	92	94	96	96	98	99	99	99	99	99	100	100	100	100	100	100	100
0.90	93	92	94	95	96	96	97	99	99	99	99	99	99	99	100	100	100	100
0.95	93	92	93	94	95	95	96	96	96	97	99	99	99	99	99	99	99	99
1.00	93	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92

Constant Catch

TAC	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
800	93	92	96	96	99	99	99	99	99	100	100	100	100	100	100	100	100	100
900	93	92	95	96	98	99	99	99	99	99	99	100	100	100	100	100	100	100
1000	93	92	95	96	96	97	99	99	99	99	99	99	99	99	99	99	99	99
1100	93	92	94	96	96	96	96	97	99	99	99	99	99	99	99	99	99	99
1200	93	92	93	94	95	95	96	96	96	96	97	97	97	97	97	97	98	98
1300	93	92	92	93	93	93	93	93	93	94	94	94	94	94	94	94	94	94
1400	93	92	91	90	88	88	86	84	81	80	78	75	74	72	70	67	65	62
1500	93	92	90	85	80	72	61	49	37	27	19	13	9	7	5	4	3	2
1600	93	92	87	78	61	38	18	8	3	1	0	0	0	0	0	0	0	0
1700	93	92	84	63	31	9	2	0	0	0	0	0	0	0	0	0	0	0
1800	93	92	80	44	9	1	0	0	0	0	0	0	0	0	0	0	0	0
1900	93	92	75	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	93	92	67	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4. Catches, i.e. mean in next 3 years and cumulative for 5,10 and 15 years, for HCR with different $B_{Tresholds}$ by $F_{Targets}$, constant F and constant catch projections.

		Mean	Cumulative		
Harvest Control Rule	F times F_{MSY}	2014 – 2016	2014 – 2016	2014 – 2016	2014 – 2016
Threshold 0.6 B_{MSY}	0.75	12	60	122	186
	0.80	12	63	127	192
	0.85	13	65	132	198
	0.90	14	68	136	203
	0.95	14	71	139	207
	1.00	15	73	143	211
Threshold 0.8 B_{MSY}	0.75	12	60	122	186
	0.80	12	63	127	192
	0.85	13	65	132	198
	0.90	14	68	136	203
	0.95	14	71	139	207
	1.00	15	73	143	211
Threshold 1.0 B_{MSY}	0.75	12	60	122	186
	0.80	12	62	127	192
	0.85	13	65	131	198
	0.90	14	68	135	203
	0.95	14	70	139	207
	1.00	15	73	142	211

		Mean	Cumulative		
Constant F	F times F_{MSY}	2014 – 2016	2014 – 2016	2014 – 2016	2014 – 2016
	0.75	12	60	122	186
	0.80	12	63	127	192
	0.85	13	65	132	198
	0.90	14	68	136	203
	0.95	14	71	139	207
	1.00	15	73	143	211

		Mean	Cumulative		
Constant Catch	TAC	2014 – 2016	2014 – 2016	2014 – 2016	2014 – 2016
	800	8	40	80	120
	900	9	45	90	135
	1000	10	50	100	150
	1100	11	55	110	165
	1200	12	60	120	180
	1300	13	65	130	195
	1400	14	70	140	210
	1500	15	75	150	-
	1600	16	80	160	-
	1700	17	85	-	-
	1800	18	90	-	-
	1900	19	95	-	-
	2000	20	100	-	-

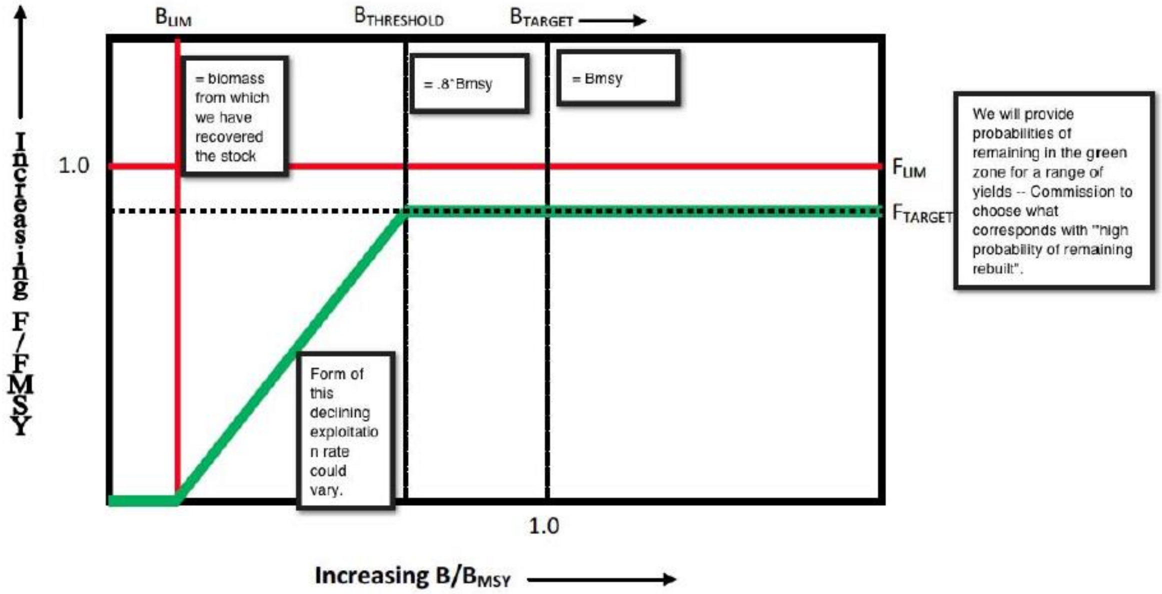

Figure 1. Harvest Control Rule and Limit Reference Points for North Atlantic swordfish that uses the template developed by the Stock Assessment Methods Working Group.

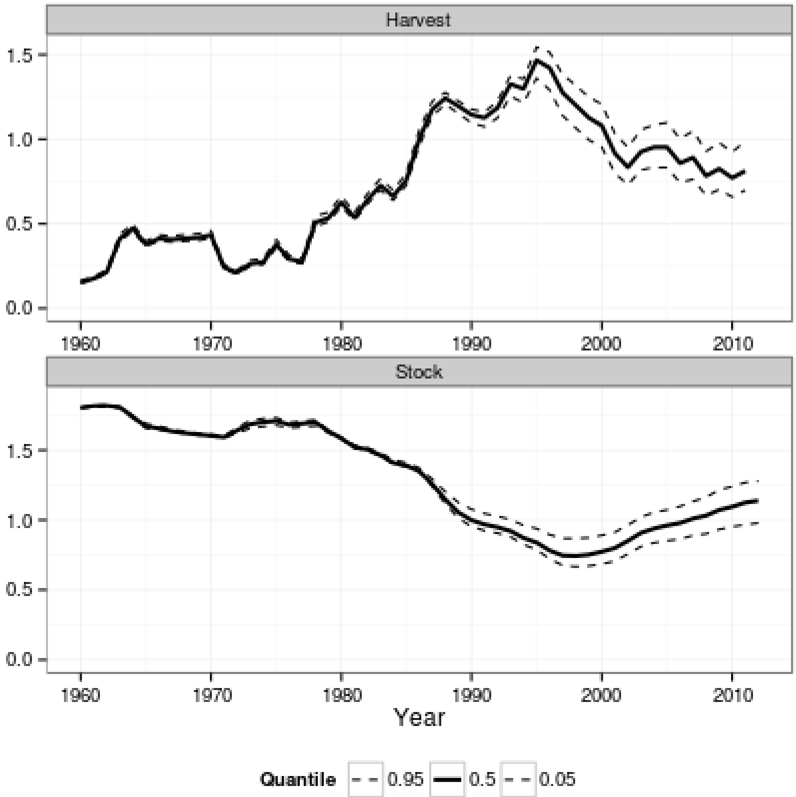

Figure 2. Estimates of stock biomass relative to BMSY and harvest rate relative to FMSY.

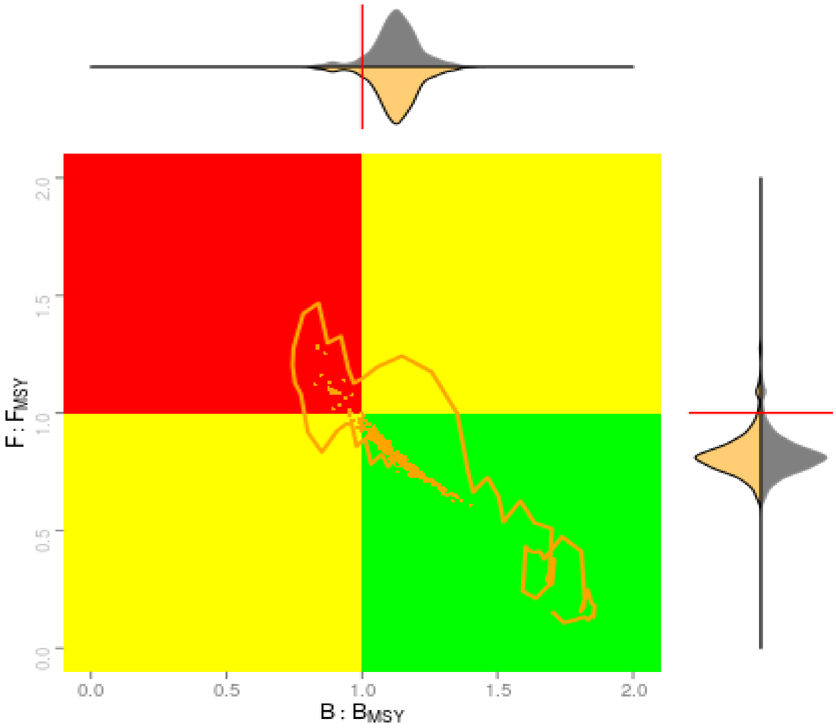

Figure 3. Kobe phase plot showing historic median (line), boot strapped (points) estimates and marginal densities of stock biomass relative to BMSY and harvest rate relative to FMSY.

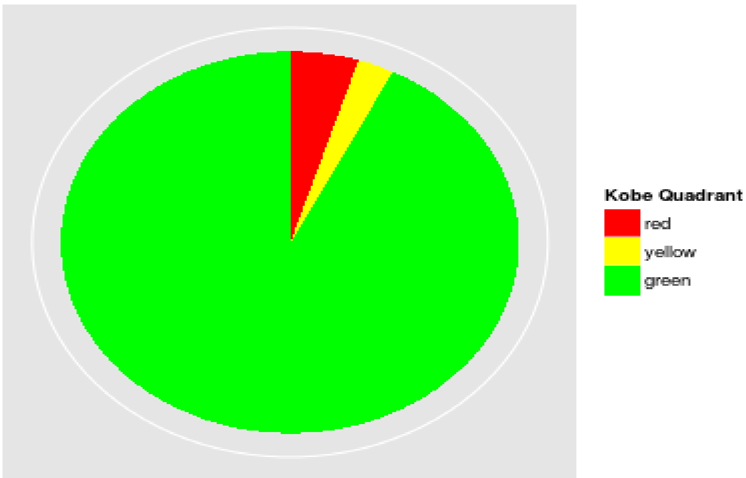

Figure 4. Pie chart show the probabilities of being in the green, red and yellow zones of the Kobe phase plot.