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Projections for East Atlantic Mediterranean Bluefin Tuna.

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SUMMARY

The management plan for East Atlantic and Mediterranean bluefin tuna is bsed on the Kobe II strategy matrix (K2SM), which indicates the probability of $SSB>B_{MSY}$ and $F<F_{MSY}$ for different levels of catch projections. In this paper we document the projections for Eastern Atlantic and Mediterranean bluefin tuna.

KEYWORDS: stock assessment; bluefin tuna

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1 Introduction

The management plan for East Atlantic and Mediterranean bluefin tuna is bsed on the Kobe II strategy matrix (K2SM), which indicates the probability of $SSB > B_{MSY}$ and $F < F_{MSY}$ for different levels of catch for a range of projection years. Resolution [11-14] summarised how the scientific information, modeling approaches and assumptions underpinning management advice should be presented in the SCRS annual reports and working group detailed reports. Since the projections were performed after the stock assessment working we do this in this document for East Atlantic and Mediterranean bluefin tuna.

2 Material and Methods

A full description of the stock assessment method, assumptions and data used can be found in the detailed report (SCRS, 2012). The longterm management plan is based on the Virtual Population Analysis (VPA) conducted in 2010 (SCRS, 2011). In 2010 four VPA scenarios were considered i.e. two levels of catch and two sets of catch per unit effort series. Catches used were either the reported or inflated scenario where the catches were raised to 50,000 tonnes from 1998 to 2006 and to 61,000 tonnes in 2007. The two sets of CPUE series considered differed by how the juvenile baitboat indices were included (i.e. by using either the nominal or standardised series). The reason for this was because management measures had affected these series making standardisation problematic. However as these were the only index for juvenile bluefin in the East Atlantic there inclusion was considered important.

In 2010 twenty four projection scenarios were run using Pro-2box to construct the K2SM. As well as the four VPA runs, there were three recruitment scenarios and two assummed future selection patterns. The three recruitment scenarios acknowledged that there was insufficient scientific information to determine precisely the productivity of the stock (i.e. the steepness of the stock-recruitment relationship) the projections had been conducted with three recruitment levels while taking into account for year-to-year variations. These levels correspond to the 'low' and 'high' scenarios as defined in the 2008 assessment plus a 'Medium' scenario that corresponds to the geometric mean of the recruitment over the 1950-2006 years. The two selection patterns corresponded to different assumptions about the effectiveness of management regulations in reducing catches of juveniles.

In 2012 only six projection scenarios (two catch and recruitement levels) were used to create the K2SM. A single index of juveniles had been constructed based on the Bay of Biscay baitboat fleet (SCRS/2012/xxx) and so only two VPA scenarios (i.e. reported and inflated catches) were considered when running the projections. The group also considered that it was now possible to estimate the changes in selection pattern and so only one selectivity scenario was used to create the K2SM. Three recruitment scenarios (low, medium and high) were considered as before. For comparison with the 2010 projections six scenarios were run with the selection pattern from 2010 where it had been assummed measures had been implemented perfectly. However, these were not used to construct the kobe matrix.

Projections were carried out using VPA Run 2, with both the reported and inflated catches (but no inflation of reported catch since 2008). When projecting it is necessary to specify, biological parameters, selection pattern (including any modifications due to technical measures that may be implemented), recruitment. Numbers-at-age are poorly estimated for the recent year classes by VPA. Therefore the first three ages in the initial population vector (i.e. for 2009, 2010, and 2011) were replaced with a random value from the stochastic recruitment specifications. These values were then projected forward in time accounting for the observed catches and the assumed natural mortality at age. This results in

changes to both the number at age in 2012 (i.e. the first projection year) and the fishing mortality and selectivity-at-age for the three year-classes replaced. The current estimated selectivity pattern was calculated as the geometric mean of the most recent three years i.e. 2009,2010 and 2011 in 2012, similar to the one used in the 2010 projections for calculating benchmarks. The plusgroup in the projections was age 10, to ensure consistency with the historic assessment. Weights-at-age in the projections were computed from the growth curve, this included using the average age of the plus-group to calculate the mean weight of individuals in the plusgroup.

3 Results

The selectivity pattern used in the projections are summarised in (figure 1); these show the medians (lines) and $\pm$ 1 sd (bars). These correspond to the reported and inflated catches and, for comparison purposes the *perfect implementation* selectivity pattern used in the 2010 projections and the current selectivity pattern. The current selectivity pattern was calculated independently for each bootstrap. For the calculation of benchmarks and projections based on the 2010 selectivity pattern, the 2012 selectivity pattern was modified by applying a vector (i.e. the ratio of the selectivities estimated in 2010 and 2012 based on their geometric means) to obtain the same selectivities as used in 2010.

Figure 2 shows the Kobe plot for stock relative to B_{MSY} and harvest rate relative to F_{MSY} as estimated in 2012, for the two selectivity patterns (rows), catch scenarios (columns) and recruitment scenarios (colors). The lines show the medians from 2008 to 2011 and the points the bootstraps in 2011. The green quadrant corresponds to the stock not being overfished and no overfishing occurring and the red quadrant to the stock being overfished and overfishing occurring.

The differences in the 2011 estimates of being in the kobe quadrants are summarised as a pie chart in (figure 3). These show the proportion of the VPA estimates in terminal year (2011) that are within the green quadrant of the Kobe plot chart (not overfished, no overfishing), the yellow quadrant (overfished or overfishing), and the red quadrant (overfished and overfishing). Split by catch scenario (reported and inflated) and benchmark (2010 and 2012).

The differences due to assuming benchmarks based upon 2010 or 2012 selectivities as summarised in figure 4.

The kobe matrices are summarised graphically in figure 5 and as tables in tables 1, 2 and 3. These indicate the probabilities of $F<F_{MSY}$, $B>B_{MSY}$ and $B>B_{MSY}$ and $F<F_{MSY}$ for quotas from 0 to 30000t for 2013 through 2022. Shading corresponds to the probabilities of being in he ranges of 50-59 %, 60- 69 %, 70-79 %, 80-89 % and greater or equal to 90 %.

4 Figures

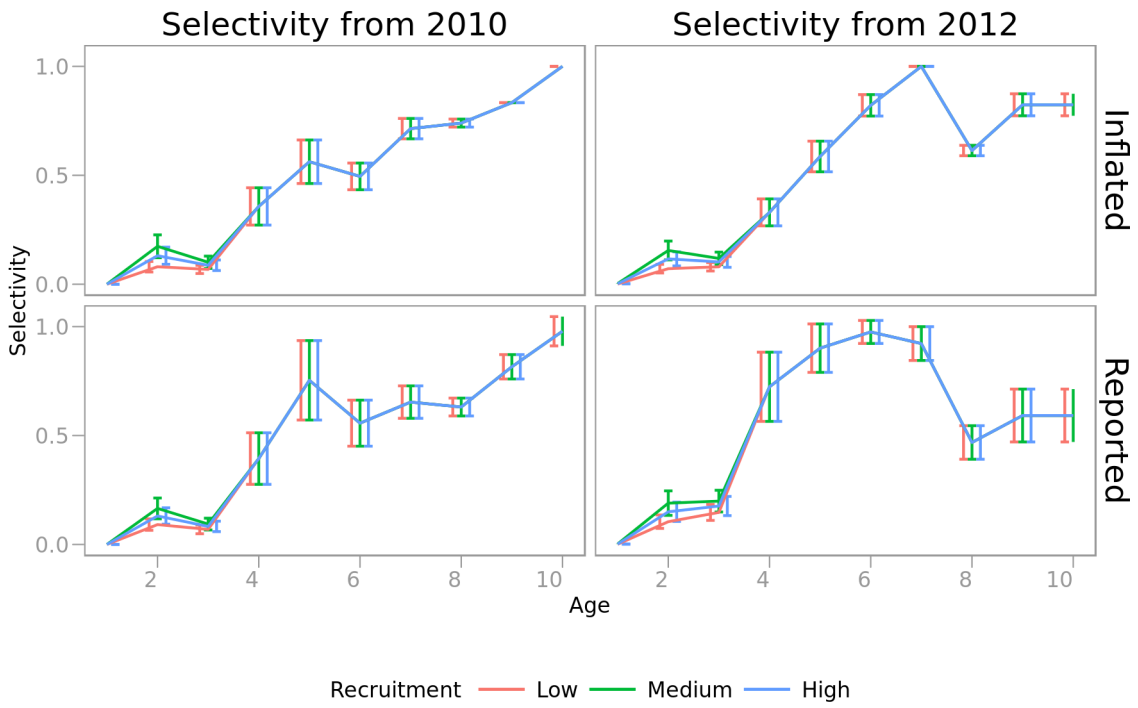

Figure 1: Vectors of selectivity-at-age used in the projections from the 2010 and 2012 assessments. The 2012 selectivities were obtained as the geometric mean of the fishing mortality at age for the last three years of each assessment, after applying the 3-year recruitment patch. The 2010 selectivity pattern was that used in the projections made in 2010 assessment

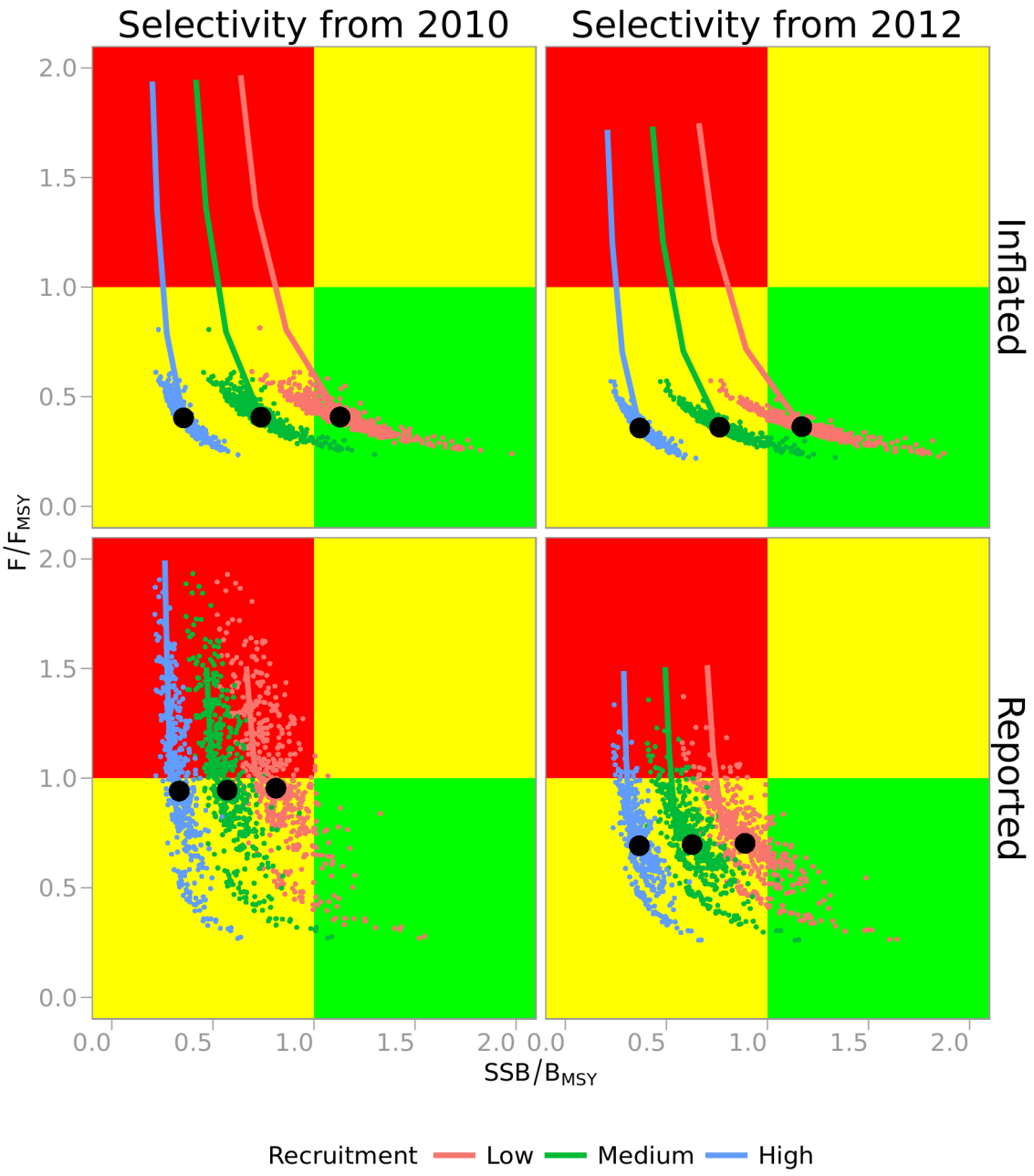

Figure 2: Figure 6.1.9. Kobe plot for 2011 stock status, individual realisations starting in 2008 with median for the two selectivity patterns (rows) and the catch scenarios (reported or inflated; column) and for the three recruitment scenarios (colors).

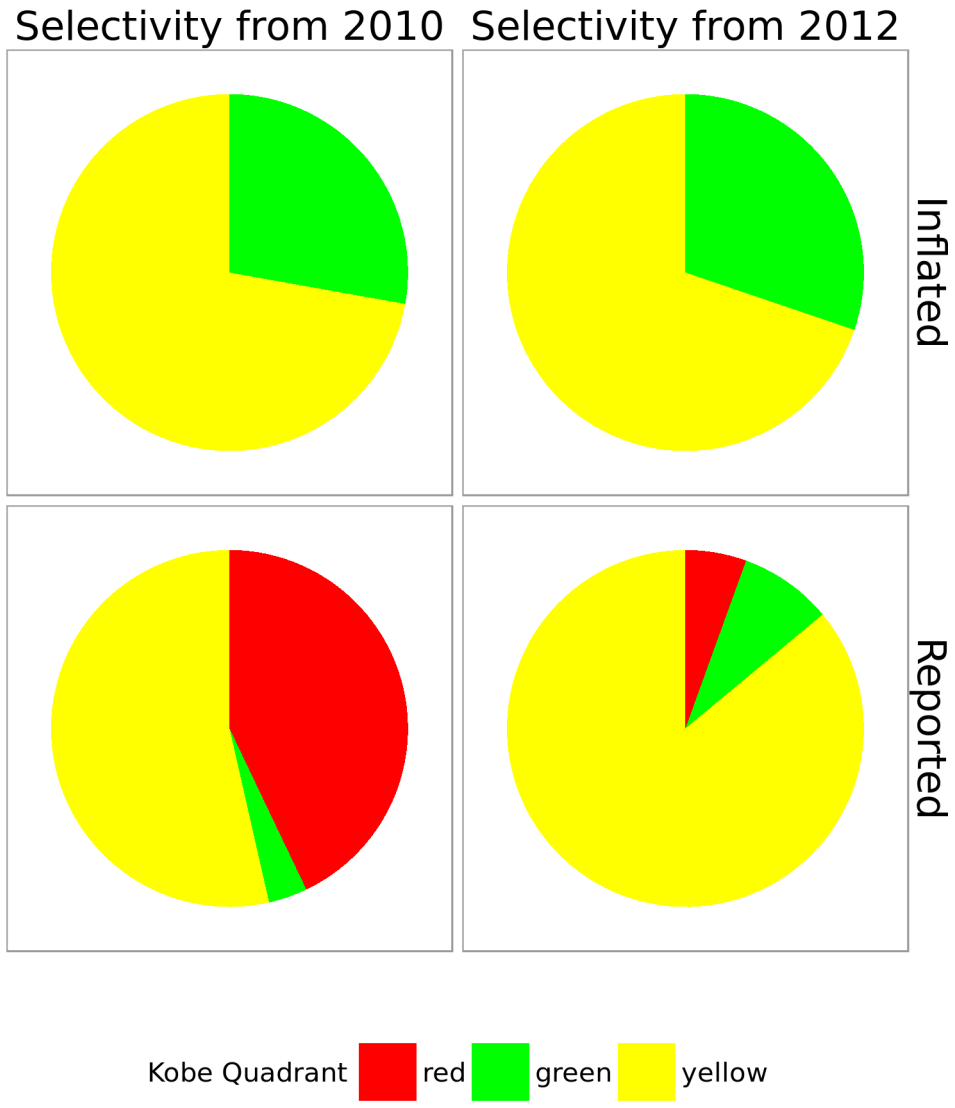

Figure 3: Figure 7.1.2 Pie chart showing the proportion of the VPA continuity run results for the terminal year (2011) that are within the green quadrant of the Kobe plot chart (not overfished, no overfishing), the yellow quadrant (overfished or overfishing), and the red quadrant (overfished and overfishing). Split by catch scenario (reported and inflated) and benchmark (2010 and 2012).

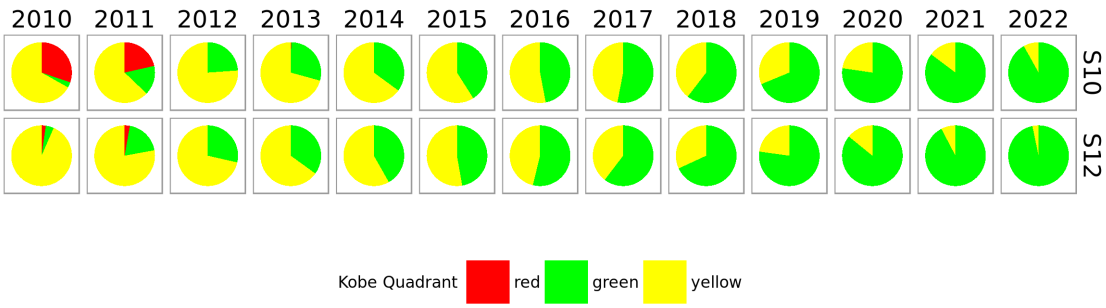

Figure 4: Figure 7.1.3: Pie chart showing the proportion of the VPA continuity run results for the terminal year (2011) that are within the green quadrant of the Kobe plot chart (not overfished, no overfishing), the yellow quadrant (overfished or overfishing), and the red quadrant (overfished and overfishing). Split by benchmark (i.e. as estimated in 2010 and 2012) and integrating over the 3 recruitment (low, medium and high) and two catch scenarios (reported and inflated).

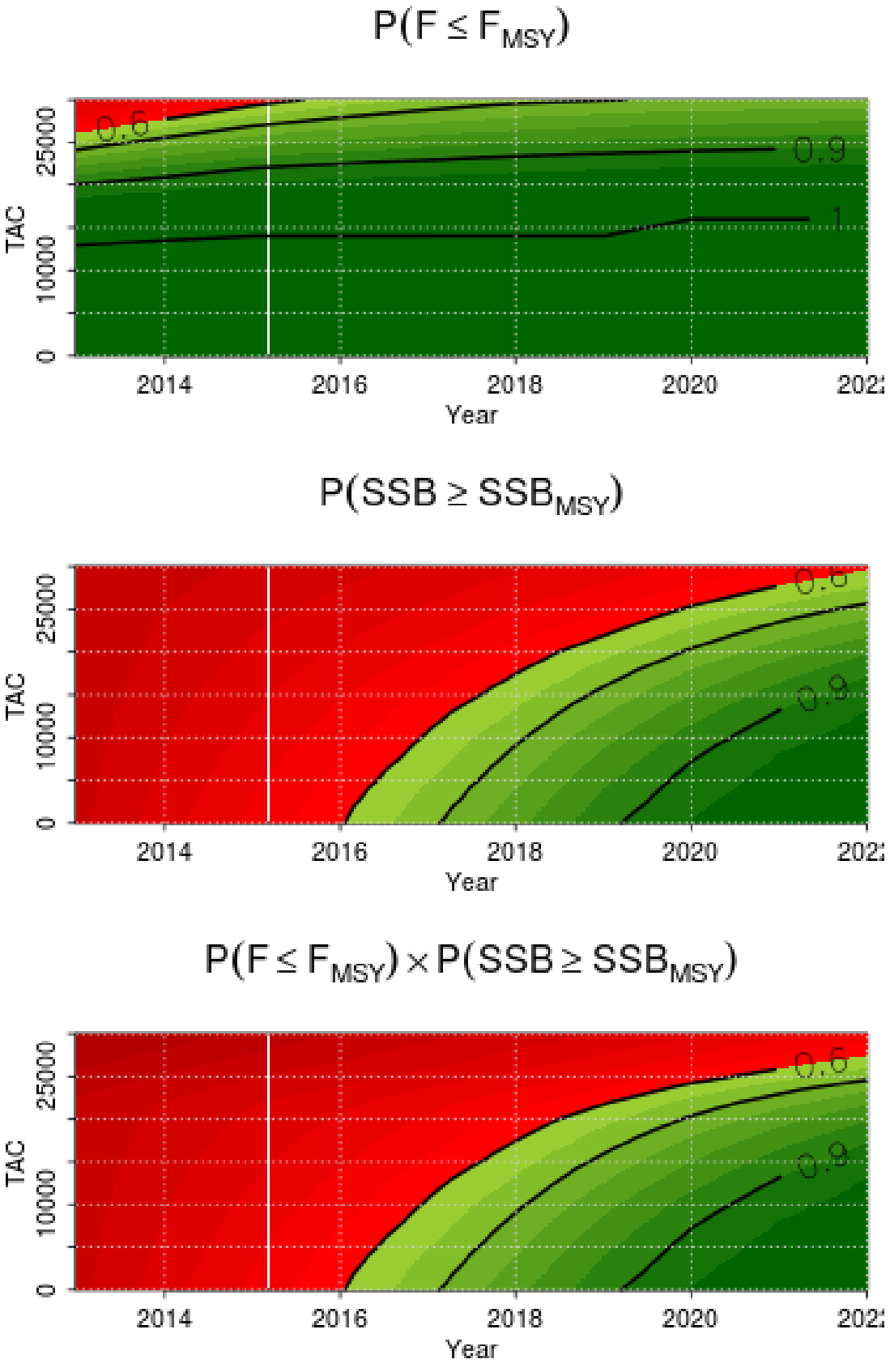

Figure 5: Kobe II strategy matrices, indicating the probabilities of $F<F_{MSY}$, $B>B_{MSY}$ and $B>B_{MSY}$ and $F<F_{MSY}$ for quotas from 0 to 30000t for 2013 through 2022.

Table 1: Kobe II Strategy Matrix, $P(F \leq F_{MSY})$.

TAC	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
0	100	100	100	100	100	100	100	100	100	100
2000	100	100	100	100	100	100	100	100	100	100
4000	100	100	100	100	100	100	100	100	100	100
6000	100	100	100	100	100	100	100	100	100	100
8000	100	100	100	100	100	100	100	100	100	100
10000	100	100	100	100	100	100	100	100	100	100
12000	100	100	100	100	100	100	100	100	100	100
12900	100	100	100	100	100	100	100	100	100	100
13500	100	100	100	100	100	100	100	100	100	100
14000	100	100	100	100	100	100	100	100	100	100
16000	99	100	100	100	100	100	100	100	100	100
18000	97	98	99	99	100	100	100	100	100	100
20000	93	95	97	97	98	98	98	99	99	99
22000	86	89	92	93	94	94	94	95	95	95
24000	77	81	85	86	88	89	89	90	90	90
26000	68	73	78	80	81	82	83	83	84	84
28000	59	65	70	73	74	76	76	77	77	78
30000	51	57	62	66	68	70	70	71	71	71

Table 2: Kobe II Strategy Matrix, $P(SSB \geq B_{MSY})$).

TAC	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
0	36	46	54	63	72	82	92	97	100	100
2000	36	45	54	62	70	81	90	97	99	100
4000	36	45	53	61	69	79	89	96	99	100
6000	36	44	52	59	67	77	87	94	98	100
8000	36	43	51	58	66	75	85	92	97	99
10000	35	43	50	56	64	73	83	91	96	99
12000	35	42	48	55	63	70	80	88	95	98
12900	35	42	48	55	62	69	79	87	93	98
13500	35	42	48	54	61	69	78	87	93	97
14000	35	42	47	54	60	68	77	86	92	97
16000	35	41	46	52	58	66	74	83	90	94
18000	34	40	45	51	56	63	71	79	86	92
20000	34	39	44	49	54	60	68	75	83	88
22000	34	39	43	47	52	57	63	71	77	83
24000	34	38	42	46	50	55	60	67	73	78
26000	34	37	41	44	48	52	57	62	67	73
28000	33	36	40	43	45	49	53	58	63	66
30000	33	36	38	41	43	46	50	54	58	62

Table 3: Kobe II Strategy Matrix, $P(F \leq F_{MSY})$ and $P(SSB \geq B_{MSY})$.

TAC	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
0	36	46	54	63	72	82	92	97	100	100
2000	36	45	54	62	70	81	90	97	99	100
4000	36	45	53	61	69	79	89	96	99	100
6000	36	44	52	59	67	77	87	94	98	100
8000	36	43	51	58	66	75	85	92	97	99
10000	35	43	50	56	64	73	83	91	96	99
12000	35	42	48	55	63	70	80	88	95	98
12900	35	42	48	55	62	69	79	87	93	98
13500	35	42	48	54	61	69	78	87	93	97
14000	35	42	47	54	60	68	77	86	92	97
16000	35	41	46	52	58	66	74	83	90	94
18000	34	40	45	51	56	63	71	79	86	92
20000	34	39	44	49	54	60	68	75	83	88
22000	33	37	42	46	51	56	63	70	76	83
24000	30	34	38	41	46	51	56	63	69	74
26000	28	31	34	37	41	45	50	57	62	67
28000	25	27	31	34	38	41	46	51	56	60
30000	23	25	28	31	34	38	41	46	50	54