# Testing of abalone decision rules for Zone F

**A. Brandão and D.S. Butterworth**

Marine Resource Assessment and Management Group (MARAM)

Department of Mathematics and Applied Mathematics

University of Cape Town

Rondebosch 7701, Cape Town

*May 2016*

**Abstract**

This paper describes the simulation testing of three alternative decision rules (DRs) for setting catch limits for abalone in Zone F. Although there is very little change in the values of many of the performance statistics across all three DRs, it is clear from the results that continued poaching dominates future resource trends. However decision rule DR1 (which is similar to the existing decision rule) hardly responds to the overall downward trend in resource abundance, keeping the median legal TAC virtually unchanged. Hence it is suggested that a change to the existing decision rules be considered.

## Introduction

This document describes the methodology applied to test three decision rules for setting the TAC for abalone for Zone F and gives some results.

## Methodology

Three alternative decision rules for setting catch limits for abalone in Zone F are tested using computer simulation based on Operating Models (OMs) (the nine Operating Models proposed by Brandão and Butterworth (2015)) which reflect possible underlying dynamics of the resource to enable future data to be generated which are compatible with past data. These generated future data are then used by the decision rules to compute future catch limits.

The decision rules investigated assume that commercial CPUE and FIAS indices will continue to be available annually. These indices are generated using the population dynamics equations for these indices and adding observation error (so for example CPUE indices are generated by $I_y^{CPUE} = q^{CPUE} B_y^{\exp} e^{\varepsilon_y}$ where $\varepsilon_y$ is normally distributed with a mean zero and a standard deviation $\sigma^{CPUE}$ which is the estimate obtained when fitting the operating model as is *q*. The standard deviation for the FIAS indices is given the average of the sum of the historical sampling CVs and the estimated additional variance. Future poaching numbers are assumed to be the average of the estimated values for the last two years of observable data (i.e. 2014 and 2015) to which an error is applied, whose variance is given by the average of the lognormal variance from the CVs estimated from the GLM used to obtain these values. At the present time, for simplification, no error is applied to the numbers-at-age and no catch-at-age data are generated.

The decision rules considered are:

1) DR1: a simplified version of the current decision rules in which the trends in the recent (last 5 years) CPUE and FIAS indices are examined. If both trends in the indices are increasing/decreasing by more than 10%, then the TAC is increased/decreased by 10% provided no change in TAC occurred in the previous year, otherwise there is no change in the TAC.
2) DR2: The TAC is set using the formula:

   $TAC_{y+1} = TAC_y \left(1 - \lambda\left(\frac{J_y^{rec} - J^*}{J^*}\right)\right)$, where

   $\lambda$ and $J^*$ are tuning parameters (here set to 1 and 4 respectively), and

   $J_y^{rec}$ is a combined index of the CPUE and the FIAS indices given as $J_y^{rec} = w_1 J_y^{CPUE} + w_2 J_y^{FIAS}$, where $J_y^{CPUE}$ and $J_y^{FIAS}$ are the average of the most recent 5 years values of the corresponding indices, so for example $J_y^{CPUE} = \sum_{y'=y-5}^{y-1} I_{y'}^{CPUE} \Big/ 5$, and $w_1$ and $w_2$ are weights given to each index. The values for these weights are usually based on the inverse of the variance of the assessment model residuals for each index. However, since the residual variance of the FIAS indices is much greater than that of the CPUE indices, this would mean that very little weight was given to the FIAS indices. For the purposes of the results given here it was therefore decided to apply weights of 0.8 to the CPUE indices and 0.2 to the FIAS indices.

   The TAC is constrained to a maximum annual increase or decrease of 10%.
3) DR3: The TAC is set by the same formula as for DR2, except that equal weights are applied to the CPUE and FIAS indices and the tuning parameter $J^*$ is set to the value of 10.

**Summary Performance Statistics**

The performances of the different decision rules are considered in terms of future projections over a 20 year period, and in particular the following four statistics which were intended to capture key features of the trade-off choices to be made:

<u>Catches achieved</u>

Average annual catch: $\overline{C^s} = \frac{1}{20}\sum_{y=2016}^{2035} C_y^s$, where *s* represents simulation *s*.

<u>Risk to resource</u>

Final resource size: $B_{2035}^{sp(s)} / K^{sp(s)}$

<u>Industrial stability</u>

Average annual catch variation: $$AAV^s = \frac{1}{20}\sum_{y=2016}^{2035}\frac{\left|C_y^s - C_{y-1}^s\right|}{C_{y-1}^s}$$

<u>Economic viability</u>

CPUE relative to recent level: $$\frac{CPUE_{2035}^s}{\frac{1}{3}\sum_{y=2012}^{2014} CPUE_y^s}.$$

Over the simulations *s* there is a distribution for each of these statistics, and performance is reported in terms of statistics of those distributions (typically the median and 90% probability interval, with the probability that the last of the four is below 1 also reported here).

## Results

Table 1 shows the performance of the three decision rules under the reference set OMs and these are plotted in Figure 1. Figure 2 shows some projections for decision rule DR2 under the best fitting OM (*K* = 4 500t, average poaching since 2008 = 350t). Figure 3 shows projections of annual commercial catches under the three decision rules.

## Discussion

It is clear from Figure 2 that continued poaching clearly dominates future resource trends. The legal TAC is so much smaller than the poaching that changing this hardly impacts the overall abundance trend. Thus the simpler DR1 outperforms the more complex DR2 and DR 3 by giving TACs that vary much less from year to year. A concern with DR1 however, is that it hardly responds to the overall downward trend in resource abundance, keeping the median legal TAC virtually unchanged. There is very little change in the values of many of the performance statistics across all three DRs, and particularly between DR2 and DR3.

The concern mentioned suggests that consideration be given to changing the existing decision rule.

## Reference

Brandão, A. and Butterworth, D.S. 2015. Proposed Operating Models to test decision rules for Zone F. FISHERIES/2015/JUL/SWG-AB/07.

**Table 1.** Projected median average annual commercial catches of abalone for the period 2016 to 2035, the median spawning biomass depletion at the start of the year 2035, the average annual variation (AAV) in the catch and the median CPUE index in 2035 as a proportion of the average of the 2012 to 2014 CPUE indices, for the nine reference set OMs and three decision rules. The lower 5% and upper 95% percentiles are also shown. The probability of the CPUE index in 2035 being less than that of the average of the 2012 to 2014 values is also given.

| Decision rule | Reference set | Average catch | | | Final Bsp/Ksp | | | AAV | | | CPUE2035/CPUE2012-2014 | | | Prob (CPUE2035/CPUE 2012-14) < 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Median | lower | upper | Median | lower | upper | Median | lower | upper | Median | lower | upper | |
| DR1 | K2000 av75 | 16.8 | 14.5 | 20.1 | 0.261 | 0.191 | 0.392 | 0.035 | 0.030 | 0.045 | 0.245 | 0.077 | 0.879 | 0.97 |
| | K2000 av160 | 15.4 | 13.2 | 18.3 | 0.131 | 0.123 | 0.161 | 0.035 | 0.025 | 0.040 | 0.029 | 0.013 | 0.089 | 1.00 |
| | K3000 av75 | 16.7 | 14.5 | 20.0 | 0.407 | 0.254 | 0.572 | 0.035 | 0.025 | 0.045 | 0.735 | 0.232 | 1.845 | 0.73 |
| | K3000 av160 | 16.8 | 14.0 | 20.1 | 0.208 | 0.158 | 0.295 | 0.040 | 0.030 | 0.045 | 0.146 | 0.047 | 0.477 | 0.99 |
| | K3000 av250 | 15.2 | 13.2 | 18.5 | 0.128 | 0.119 | 0.162 | 0.035 | 0.025 | 0.040 | 0.031 | 0.015 | 0.093 | 1.00 |
| | K4500 av75 | 16.9 | 14.5 | 20.2 | 0.567 | 0.372 | 0.698 | 0.035 | 0.025 | 0.045 | 1.279 | 0.395 | 2.829 | 0.32 |
| | K4500 av160 | 16.8 | 14.6 | 20.3 | 0.310 | 0.214 | 0.468 | 0.035 | 0.030 | 0.045 | 0.401 | 0.151 | 1.184 | 0.88 |
| | K4500 av250 | 16.8 | 14.0 | 20.0 | 0.213 | 0.163 | 0.304 | 0.035 | 0.030 | 0.045 | 0.159 | 0.063 | 0.518 | 0.99 |
| | K4500 av350 | 15.3 | 12.8 | 18.3 | 0.137 | 0.120 | 0.179 | 0.035 | 0.025 | 0.040 | 0.048 | 0.018 | 0.146 | 1.00 |
| DR2 | K2000 av75 | 16.9 | 9.1 | 10.6 | 0.249 | 0.062 | 0.133 | 0.086 | 0.013 | 0.009 | 0.165 | 0.124 | 0.398 | 0.97 |
| | K2000 av160 | 7.0 | 7.0 | 9.0 | 0.139 | 0.129 | 0.174 | 0.095 | 0.088 | 0.095 | 0.058 | 0.027 | 0.135 | 1.00 |
| | K3000 av75 | 25.4 | 9.3 | 39.8 | 0.366 | 0.237 | 0.526 | 0.085 | 0.072 | 0.095 | 0.551 | 0.122 | 1.613 | 0.78 |
| | K3000 av160 | 11.1 | 7.0 | 22.8 | 0.202 | 0.157 | 0.287 | 0.089 | 0.077 | 0.095 | 0.160 | 0.046 | 0.492 | 1.00 |
| | K3000 av250 | 7.0 | 7.0 | 9.3 | 0.136 | 0.126 | 0.171 | 0.095 | 0.088 | 0.095 | 0.059 | 0.028 | 0.136 | 1.00 |
| | K4500 av75 | 33.6 | 15.8 | 45.4 | 0.510 | 0.284 | 0.643 | 0.084 | 0.068 | 0.095 | 1.144 | 0.275 | 2.476 | 0.44 |
| | K4500 av160 | 18.9 | 8.0 | 33.5 | 0.294 | 0.207 | 0.450 | 0.085 | 0.072 | 0.094 | 0.366 | 0.090 | 1.236 | 0.88 |
| | K4500 av250 | 11.0 | 7.0 | 22.6 | 0.203 | 0.161 | 0.285 | 0.089 | 0.077 | 0.095 | 0.166 | 0.052 | 0.500 | 1.00 |
| | K4500 av350 | 7.3 | 7.0 | 11.5 | 0.142 | 0.122 | 0.175 | 0.093 | 0.085 | 0.095 | 0.072 | 0.029 | 0.168 | 1.00 |
| DR3 | K2000 av75 | 14.0 | 7.0 | 26.2 | 0.260 | 0.190 | 0.401 | 0.087 | 0.069 | 0.095 | 0.284 | 0.066 | 0.990 | 0.95 |
| | K2000 av160 | 7.0 | 7.0 | 8.1 | 0.139 | 0.129 | 0.174 | 0.095 | 0.089 | 0.095 | 0.058 | 0.027 | 0.135 | 1.00 |
| | K3000 av75 | 21.2 | 7.5 | 33.8 | 0.367 | 0.241 | 0.543 | 0.084 | 0.067 | 0.093 | 0.608 | 0.158 | 1.755 | 0.70 |
| | K3000 av160 | 9.5 | 7.0 | 19.1 | 0.203 | 0.158 | 0.290 | 0.089 | 0.074 | 0.095 | 0.170 | 0.047 | 0.519 | 1.00 |
| | K3000 av250 | 7.0 | 7.0 | 8.5 | 0.137 | 0.126 | 0.171 | 0.095 | 0.089 | 0.095 | 0.060 | 0.028 | 0.136 | 1.00 |
| | K4500 av75 | 27.7 | 11.3 | 41.0 | 0.525 | 0.289 | 0.665 | 0.083 | 0.067 | 0.095 | 1.177 | 0.300 | 2.613 | 0.42 |
| | K4500 av160 | 14.9 | 7.1 | 27.6 | 0.297 | 0.208 | 0.455 | 0.086 | 0.070 | 0.095 | 0.384 | 0.092 | 1.279 | 0.87 |
| | K4500 av250 | 9.3 | 7.0 | 18.7 | 0.203 | 0.162 | 0.287 | 0.090 | 0.075 | 0.095 | 0.167 | 0.056 | 0.507 | 1.00 |
| | K4500 av350 | 7.0 | 7.0 | 10.8 | 0.142 | 0.122 | 0.175 | 0.095 | 0.086 | 0.095 | 0.072 | 0.029 | 0.168 | 1.00 |

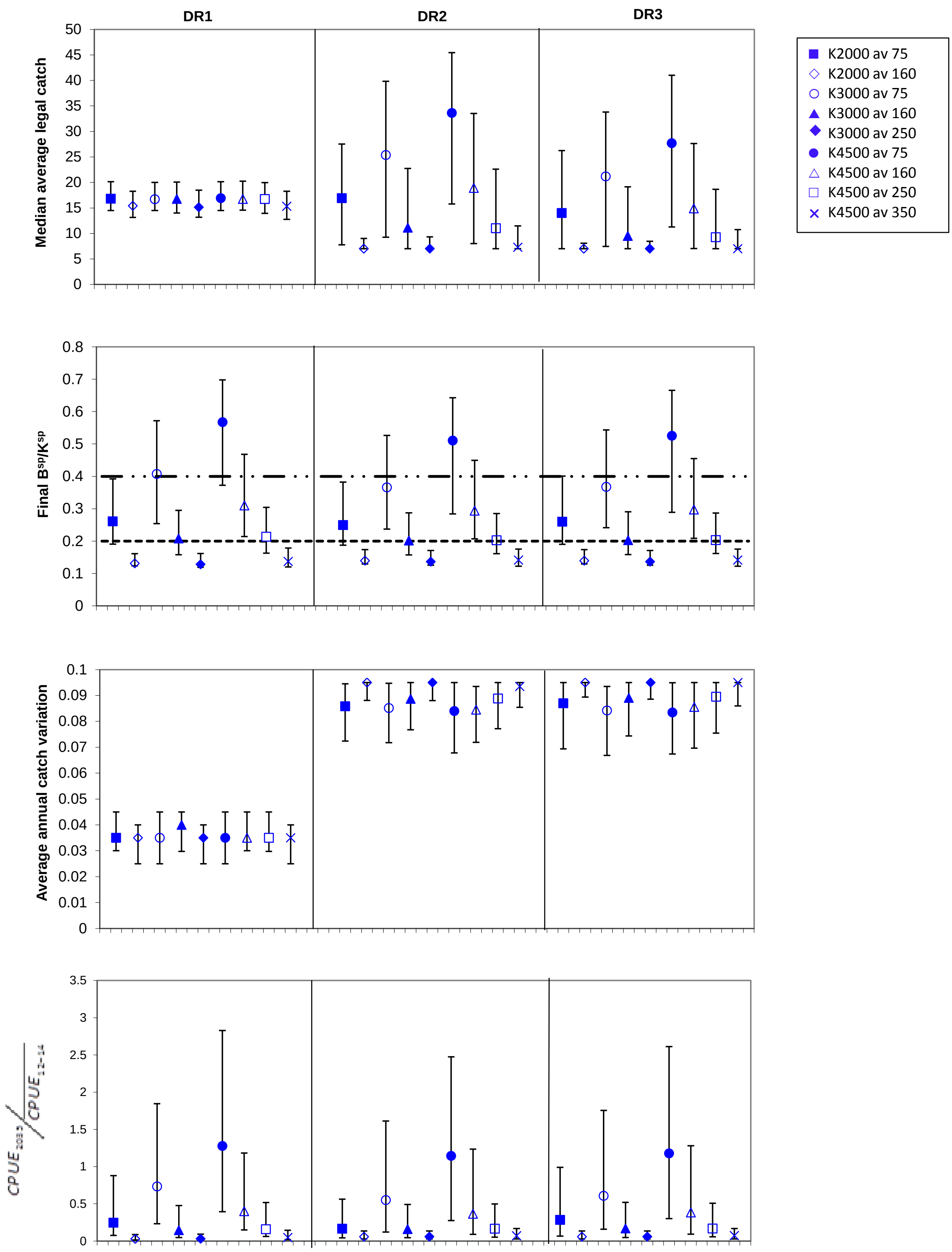


**Figure 1.** Projected median (and 90% percentiles) of the average annual legal commercial catches of abalone for the period 2016 to 2035, the spawning biomass depletion at the start of 2035, the average annual variation in catch and the CPUE index in 2035 as a proportion of the average of the 2012 to 2014 CPUE indices, for the nine OMs and three decision rules.

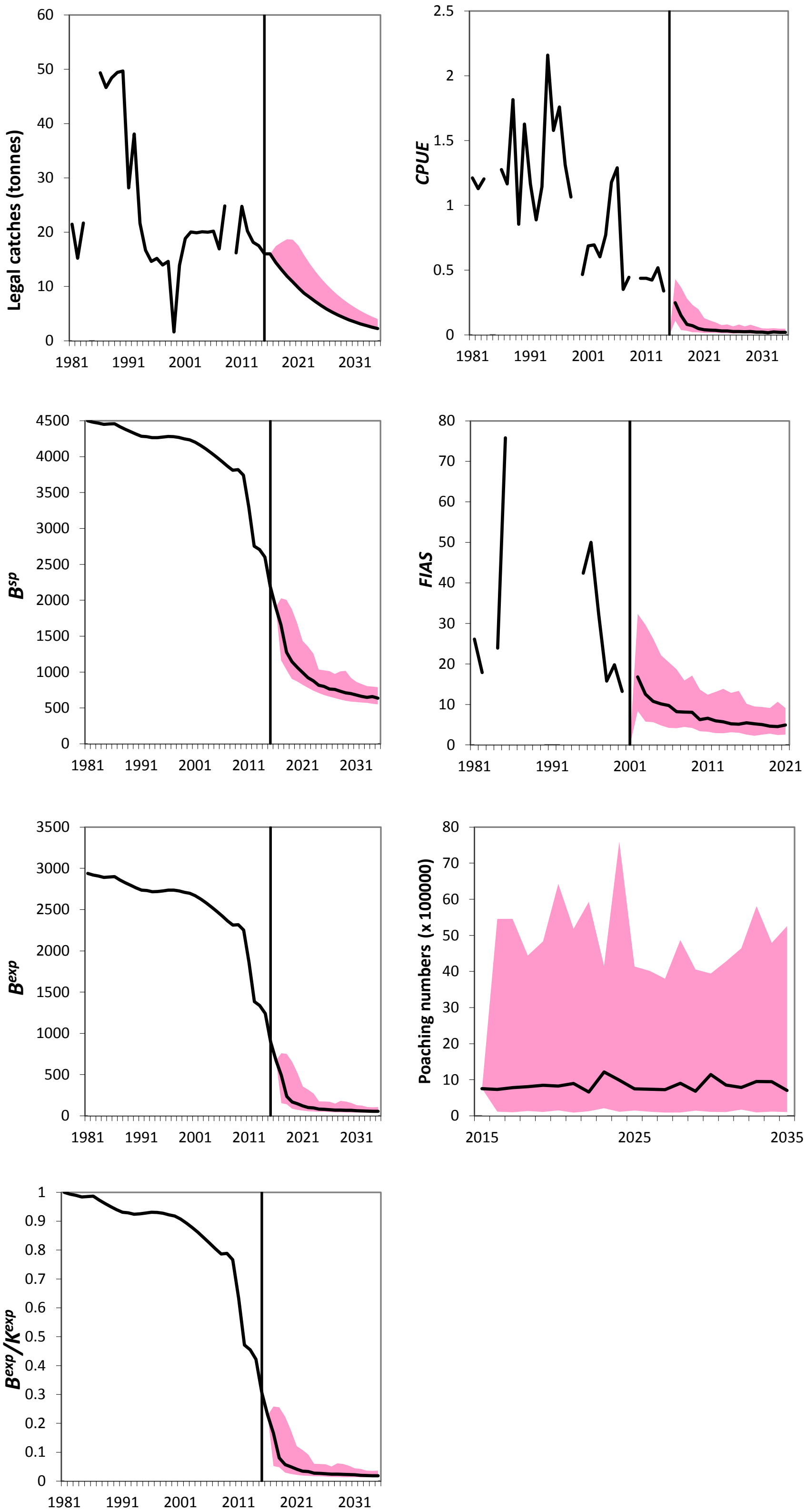


**Figure 2.** Median trajectories of legal annual commercial catches, spawning biomass, exploitable biomass, exploitable biomass depletion, CPUE and FIAS trends and poaching numbers under the decision rule DR2 for the K 4500 av 350 Operating Model. Projections (medians) commence to the right of the vertical lines and the shaded areas represent 90% probability envelopes.

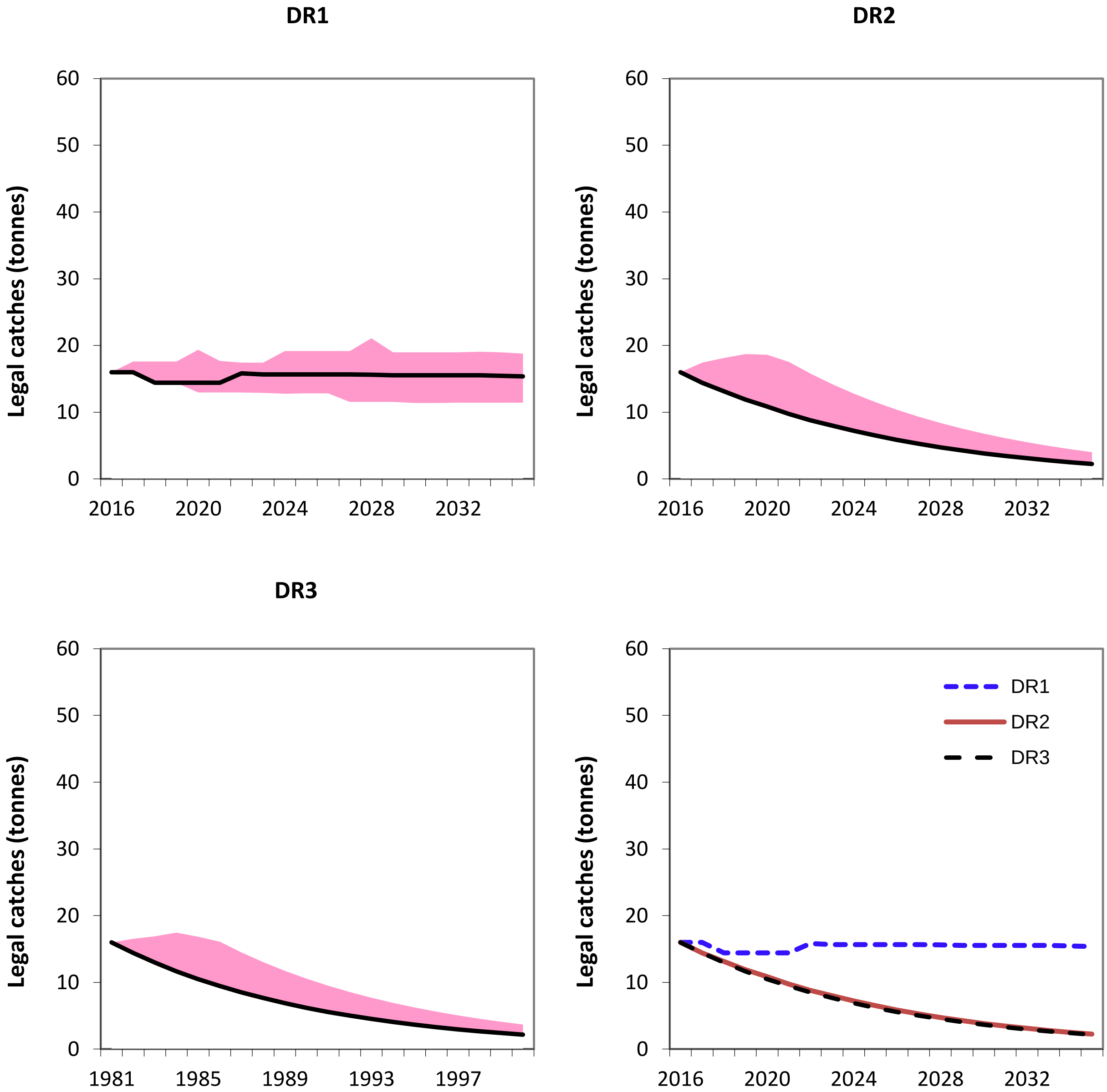


**Figure 3.** Median projections of legal annual commercial catches under the decision rules DR1, DR2 and DR3 for the K 4500 av 350 Operating Model. The shaded areas represent 90% probability envelopes. The bottom right hand plot shows the comparison of the median annual catches under the three decision rules.