A preliminary assessment of the South African east coast sole resource, *Austroglossus pectoralis*

D. S. Butterworth and J.P. Glazer

Introduction

Currently the Agulhas sole resource is managed by a Total Allowable Catch (TAC) which, for 2014, was set at 872 tons. Concern was expressed in the 2013 sole TAC recommendation regarding the fact that catches have, since 2002, been consistently below the TAC. In addition there has been a sharp decline in CPUE since 2009. As a result of the low catches and declining CPUE it was recommended that a task team be appointed to develop an effort limit programme for this particular fishery to be applied in conjunction with the existing TAC. This paper reports results from the application of a modified dynamic Schaefer production model fitted (coarsely) to the CPUE of sole specialists in six of the nine grid blocks which comprise the sole grounds in order to guide the effort limit-setting process.

The data

The annual catch series and CPUE index used in the Schaefer assessment model are reported in Table 1 and cover the period 2000-2013. The catches relate to the total sole catch made per annum, while the standardized CPUE index relates to that of Model C in Glazer *et al*. (2014), reflecting a CPUE index derived from data from seven sole specialist vessels in six of the nine grid blocks that comprise the sole grounds and which are further restricted to sole targeted fishing only.

The assessment model

The dynamic Schaefer model (adopted here for its simplicity) is of the form:

$$B_{y+1} = B_y + rB_y[1 - \frac{B_y}{K}] - C_y \qquad (1)$$

where

B_y is the biomass estimated in year *y*, with the starting biomass B_{2000} assumed to be at the MSY level $K/2$,

r is an estimable parameter (the intrinsic rate of population growth), which for realism was constrained to lie in the range [0.4; 0.7].

K is pristine biomass set at $800/(r/4)$, i.e. the MSY is assumed to be 800 tons (an amount landed regularly in the past), and

C_y is the annual catch.

The likelihood is calculated assuming that the abundance index (CPUE) is log-normally distributed about its expected values:

$$I_y = qB_y\varepsilon_y \qquad (2)$$

where I_y is the abundance index for year *y*, qB_y is the corresponding model estimate (*q* being the estimated catchability coefficient), and ε_y is the observation error, $\sim N\left(0,\sigma_i^2\right)$, in year *y*.

The contribution of the abundance index to the negative log-likelihood function (after the removal of constants) is given by:

$$-\ell nL = n\ell n\left(\hat{\sigma}_{cpue}\right) + \frac{n}{2} \tag{3}$$

The application of the Schaefer model above did not yield reasonable fits to the CPUE index, particularly for the period of declining CPUE since 2009. In order to better fit this recent decline in CPUE two plausible hypotheses were therefore considered:

- Hypothesis 1: assumes that catchability (now year-dependent, q_y) has decreased:
  - q_y was defined as qZ_y, where Z_y=1 for y≤2010, $Z_{2011} = 1 - \mu$, $Z_{2012} = 1 - 2\mu$, and $Z_{2013+} = 1 - 3\mu$. μ was assumed to be 0.2.
- Hypothesis 2: assumes that productivity has decreased (now both *r* and *K* are year-dependent):
  - r_y and K_y were defined as rU_y and KU_y, where U_y=1 for y≤2007, $U_{2008} = e^{-\delta}$, $U_{2009} = e^{-2\delta}$, $U_{2010} = e^{-3\delta}$, $U_{2011} = e^{-4\delta}$, $U_{2012} = e^{-5\delta}$and $U_{2013+} = e^{-6\delta}$. δ was assumed to be 0.3.

The model fits to the CPUE index and the resultant biomass indices for these two hypotheses are shown in Figure 1.

The fits conducted were not taken through to full minimisation – rather *r* values were estimated and times at which changes occurred were chosen that were considered realistic and provided a reasonable reflection of the main trends in the CPUE data. Thus, for example, the fact that the *r* value for the catchability change scenario was estimated on the constraint boundary of 0.4 has not immediately been taken further. The objective at this stage is simply to ensure that the model does capture the broad range of alternative explanations for the recent CPUE trend in the fishery.

Forward Projections

Hypotheses 1 and 2 were projected deterministically 20 years into the future for the following two Scenarios:
<u>Scenario A</u>: project forward from the same levels as for $Z_y$or $U_y$as estimated for 2013
<u>Scenario B</u>: project forward, allowing $Z_y$for Hypothesis 1 and $U_y$for Hypothesis 2 to increase back to 1 by 2017

The two scenarios described above are depicted graphically in Figures 2 and 3 respectively.

Options for future effort levels (E_y) applied in the projections were as follows, reflecting a decrease in effort phased down steadily over three years:

$E_{2014} = E_{2013}$,
$E_{2015} = (1 - a)E_{2014}$,
$E_{2016} = (1 - 2a)E_{2014}$, and
$E_{2017+} = (1 - 3a)E_{2014}$

Values of a for which results are reported are 0, 0.2, and 0.3.

Results and Discussion

Results from the application of Scenarios A and B for Hypothesis 1 (related to catchability change) are shown in Figure 4 while those for Hypothesis 2 (related to productivity change) are shown in Figure 5 for the future effort level options which depend on the value of a used. A comparison across Hypothesis/Scenario combinations for the each of the a values used is shown in Figure 6.

Figure 4 indicates that if there was a catchability effect, and whether future levels remained low or increased, this would not be a cause for concern given that the projected biomass remains at high levels irrespective of the level of future effort applied.

Figure 5 indicates that assuming levels unchanged into the future from those for 2013 results in declining biomass, catches and CPUE over the projection period. However, for the scenario where U_y returns to 1 by 2017, the projected biomass shows an increasing trend for all future effort options shown, and both catches and CPUE increase even for the most pessimistic scenario of future effort.

Comparisons of the Hypothesis/Scenario combinations for each of the future effort levels tested (Figure 4) indicate that the Hypothesis I/Scenario A combination for future effort levels equivalent to that of 2013 results in a continued decline in projected biomass at the hypothesised decreased level of resource productivity. Across the "a" options, a=0.3 would be best for biomass stability, but this is at the expense of future catches, which would be very low. It is also to be noted that across the "a" scenarios maintaining effort at the 2013 level for 2015 (i.e. for $a = 0$) would not impact biomass appreciably if continued for a single further year only.

A choice amongst three options for a recommendation is therefore put to the Working Group:

a) maintain effort at its 2013 level for the next three years,
b) decrease effort by 20% for each of the next three years, or
c) maintain effort at its 2013 level for 2015, and then review the situation depending on the CPUE that eventuates for both 2014 and 2015 – note from Figure 6 that future CPUE levels do provide the possibility to distinguish amongst these different scenarios in the future.

References

Fairweather, T.P. 2014. Agulhas sole Data Document (Condensed for TAC purposes). Unpublished DAFF working Group Document: Fisheries/2014/JUL/SWG-DEM/24. 10pp.

Glazer, J.P., Fairweather, T.P. and Durholtz, M.D. 2014. Summary of Agulhas sole CPUE analyses. Unpublished DAFF working Group Document: Fisheries/2014/SEP/SWG-DEM/45. 13pp.

Table 1: Catch (tons) and standardized CPUE (kg/minute) used in the Schaefer assessment model. (Source: Catch -Total Landings in Table 2 of Fairweather (2014); CPUE – Model C of Glazer *et al*, 2014).

Year	Catch	CPUE
2000	1060	1.39
2001	850	1.40
2002	702	0.94
2003	754	0.98
2004	612	1.01
2005	485	0.90
2006	428	0.98
2007	331	0.88
2008	448	0.89
2009	568	1.35
2010	583	1.11
2011	442	1.07
2012	338	0.76
2013	127	0.36

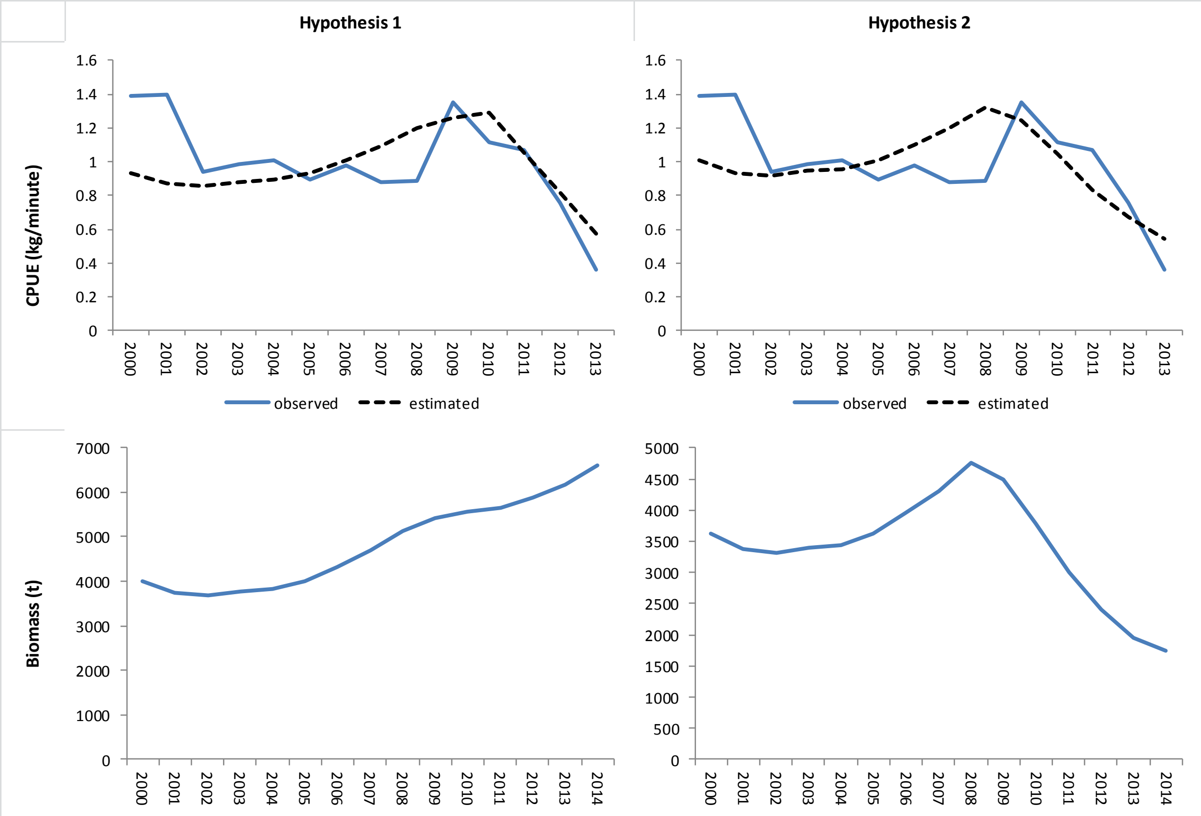

Figure 1: Fits to the CPUE data and the biomass trends for Hypothesis 1: catchability has decreased by 60% over 2010-2013 (r=0.4, μ=2) and Hypothesis2: productivity has dropped by 85% over 2008-2013 (r=0.441, δ=0.3).

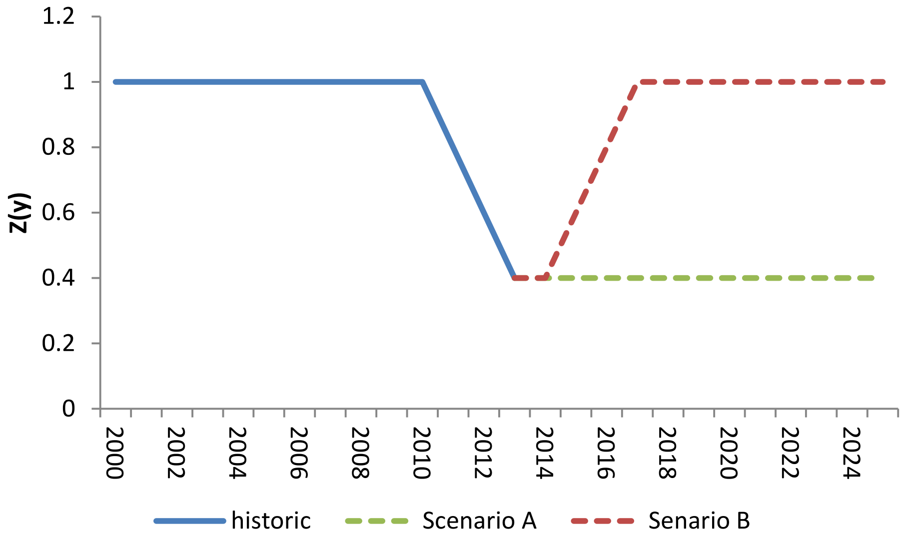

Figure 2: Scenarios A and B for projections related to Hypothesis I: catchability has decreased by 60% over 2010-2013.

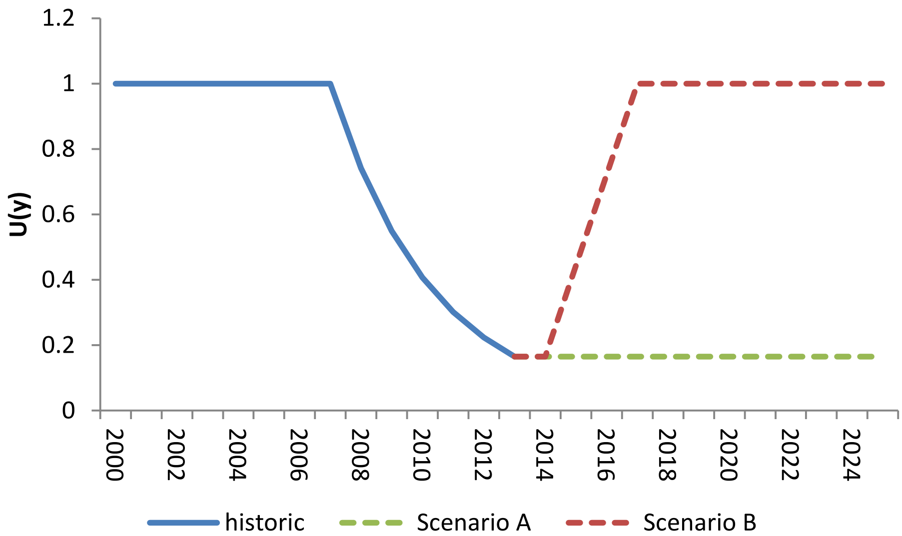

Figure 3: Scenarios A and B for projections related to Hypothesis II: productivity has dropped by 85% over 2008-2013.

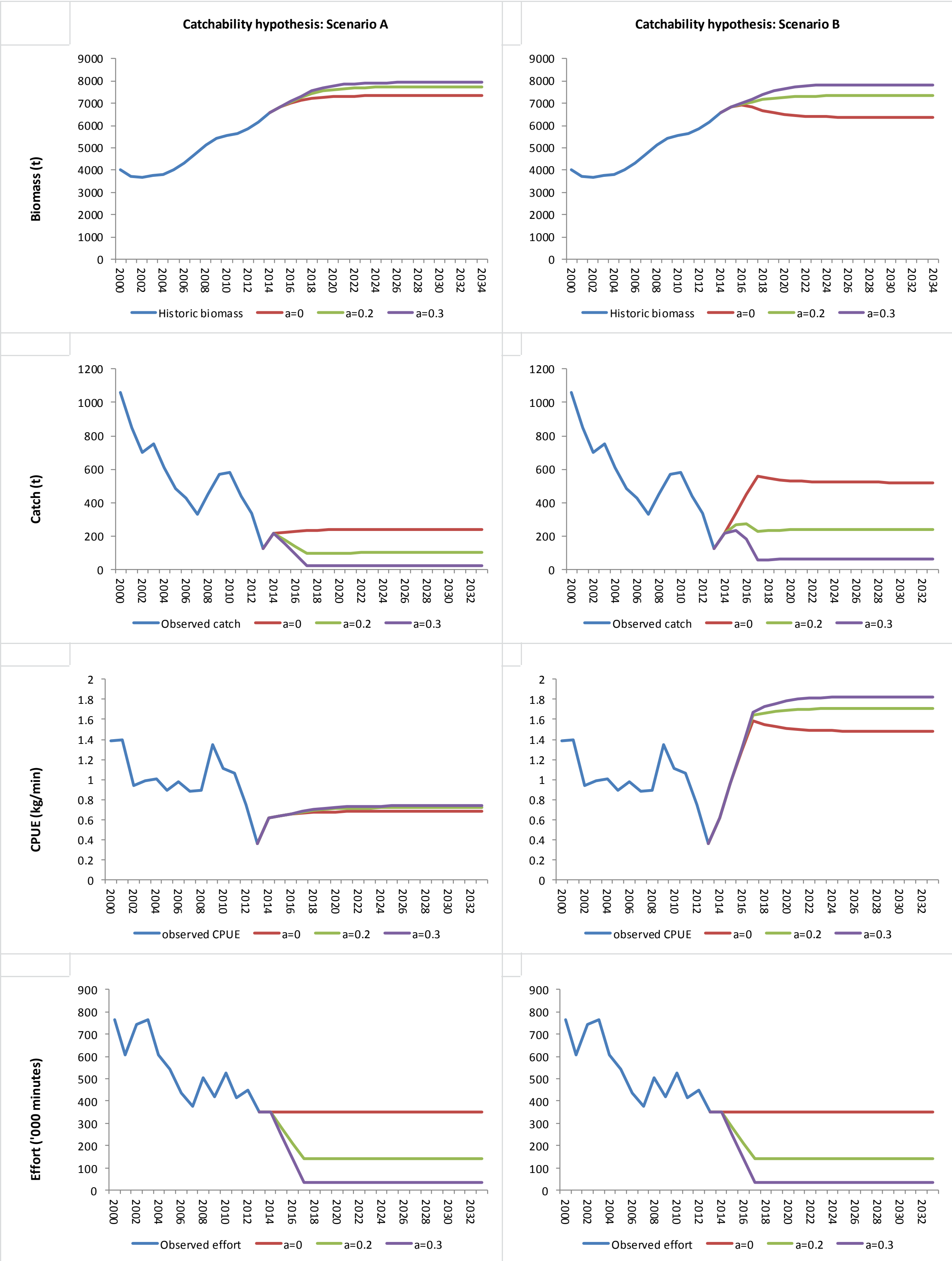

Figure 4: Projected biomass, catch and effort for Hypothesis 1: catchability has decreased by 60% over 2010-2013 for Scenario A (no change – left side plots) and Scenario B (back to normal – right side plots) for different future effort reduction levels.

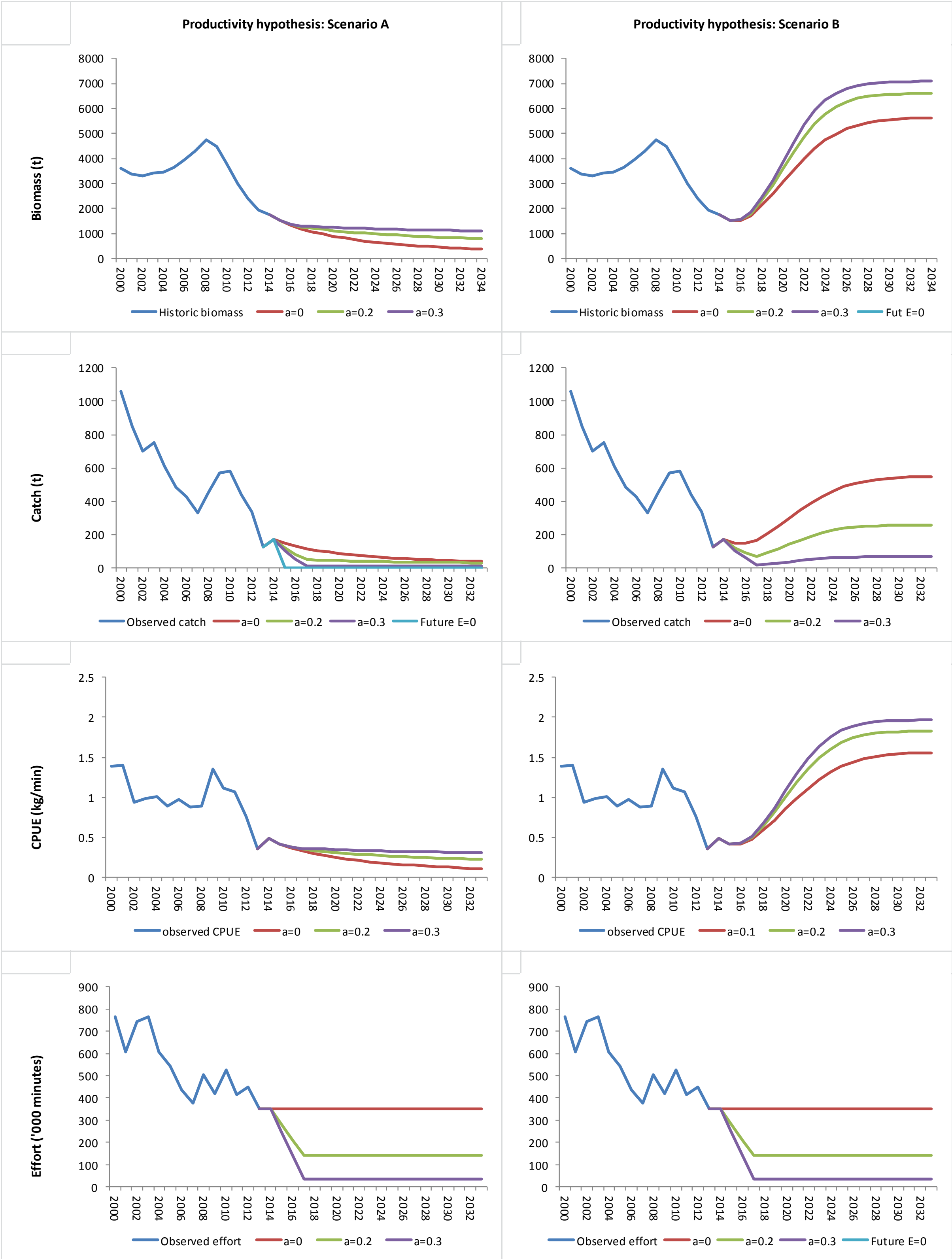

Figure 5: Projected biomass, catch and effort for Hypothesis 2: productivity has dropped by 85% over 2008-2013 for Scenario A (no change – left side plots) and Scenario B (back to normal – right side plots) for different future effort levels.

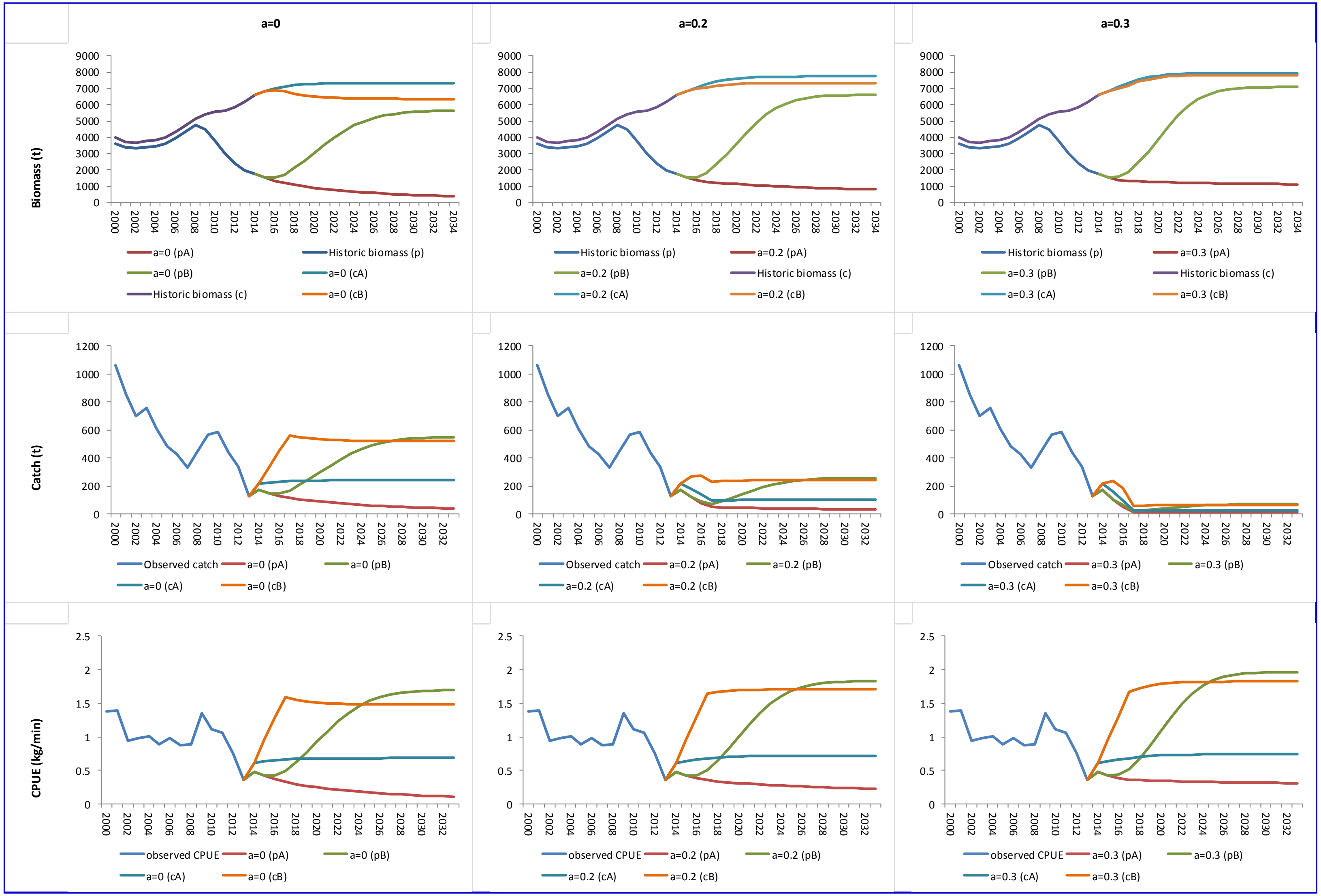

Figure 6: Comparisons across a=0, a=0.2, and a=0.3 (different future effort levels) for the two hypotheses. "pA" and "cA" refer to the productivity and catchability hypotheses respectively where for the future projections levels remain at those of 2013. "pB" and "cB" refer to the productivity and catchability hypotheses respectively where for the future projections Z(y) and U(y) return to 1 by 2017.