Results for the abalone spatial- and age-structured assessment model for Zones A, B, C and D in 2011

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Abstract

The 2009 assessment of abalone in Zones A-D is updated to take new data and a more reliable basis for estimation of poaching trends over the last four years into account. Sensitivity to a number of model assumptions and data input variations is checked, and generally appears to be slight. Viewed overall, the results do not suggest any major revisions to perceptions of resource status and future trends under current poaching levels to those from the 2009 assessment.

Introduction and Data

This document provides results from fitting the abalone spatial- and age-structured production model (ASPM) to Zones/Subareas A, B, CNP, CP and D in combination using updated data to 2011. (Note that throughout this document the convention is that, for example, the year 2008 refers to the Model-year running from October 2007 to September 2008.)

However information to update every data series customarily used to fit this model is not yet available. The series that have been updated compared to those used in Brandão and Butterworth (2009) for the analyses that follow are:

- CPUE: new values from updated GLM standardisation for Zones A and B only for 2010
- FIAS: new survey abundance indices for Zone A (2010 and 2011), Zone B (2009, 2010 and 2011), subarea CP (revised 2008, 2009 and 2010) and Zone D (2009 and 2010)
- Commercial catches for Zones A and B for 2010 and 2011 (TAC assumed taken in 2011)
- Poaching confiscations for all Zones (2009 updated, 2010 and 2011 extrapolated to a full Model-year)
- Commercial catch-at-age data: for Zones A and B for 2010
- FIAS catch-at-age data[1]: Zone A (2010 and 2011), Zone B (2009, 2010 and 2011), subarea CP (1997, 1998, 2002, 2008, 2009 and 2010) and Zone D (2009 and 2010)

[1] Instead of leaving out years in which too few sample were taken to obtain catch-at-age proportions, a new approach has been applied in which all data is used but data from years in which the samples

- Poaching catch-at-age data: Zone A (1996, 2009 and 2010), Zone B (1996, revised 2008 and 2009, and 2010), Zone C (1994, 1995, 2006, 2008, 2009 and 2010) and Zone D (1995, 1996, 2001, 2005 to 2010 with 2008 revised)

Methodological Changes

The full details of the spatial- and age-structured production model used for assessing abalone are provided in Brandão and Butterworth (2009) as well as in. Plagányi and Butterworth (2010).

The Reference case model described in those two documents is used here, but with some generally slight adjustments.

First, the ASPM model has also been re-coded and there have been some small changes made. These changes to the code lead to minor changes only to the results from the model.

Secondly, the method for calculating the CPUPE (catch per unit of policing effort) index, which serves as an index of the numbers of abalone poached in a Zone, has been changed for the most recent years. Previously the number of abalone confiscated (or abandoned) which were collected by all MCM/DAFF and other policing operations and which could be assigned to a Zone within Zones A-D was used (see Fig. 1). This annual value for each Zone was divided by an estimate of overall policing effort for that year (relative to previous years) as advised by a senior member of MCM/DAFF's compliance section, hence providing a CPUPE index time series for each Zone.

Continuation of this coarse approach to estimating policing effort trends was, however, undesirable in circumstances where the recovery plan adopted for abalone in 2010 specified an annual 15% reduction in the extent of poaching, which in turn begs the development of a more objectively based measure. This measure has been provided by an analysis of the detailed records on confiscations and policing effort maintained over recent years by DAFF's compliance section, and Brandão and Butterworth (2011) use these data for Zones A-D combined (see Fig. 2) to develop a new CPUPE index for the 2008-2011 period. This new index is used here in preference to the previous approach because of its more objective basis and the fact that the confiscations considered correspond exactly to the policing effort measures utilised. It is a partial concern that the trend in confiscations from the compliance section in Zones A-D is increasing over the last four years, whereas that from all policing operations (both DAFF and other agencies) country-wide is decreasing (see Fig. 2); however the latter trend needs to be adjusted by some measure of policing effort overall before these two sources of information on poaching levels could be contrasted on a comparable CPUPE basis. In implementing this change in the assessment model, the previous measure of CPUPE in each of Zones A-D has been used until 2007, and thereafter replaced by the new index from Brandão and Butterworth (2011, see Figure 1). This requires a calibration factor (k) for each Zone, as the two CPUPE indices have different units. For the Reference case model, this was fixed on input by dividing the sum of the CPUPE index for the Zone concerned for 2008 and 2009 under the old approach, by the sum of the corresponding values for the new approach. Note that this approach makes the tacit assumption that the distribution of abalone poached across Zones A-D has remained the same over the period from 2008.

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are small are penalised, where the penalty is linear from 0 (0 sample size) to 1 (sample size equal to a critical value) for sample sizes that fall below a critical value. This applies to all the catch-at-age data.

The final adjustment made to the assessment model was not to smooth the CPUPE index over three years as in the past when fitting the model to data. This was to avoid distortion of trends in poaching levels over the most recent years suggested by the analysis of Brandão and Butterworth (2011).

Results

Results have been obtained for the Reference case under this adjusted model and data update. These are reported in Tables 1-2 for some key statistics, and in terms of fits to CPUE and FIAS data for Zones A and B in Figs 3 and 4 respectively, spawning biomass with projections for all Zones in Figs 5-7, and annual poaching estimates (by number) for Zones A and B in Fig. 8.

These Tables and Figures include comparisons with the results of the re-coded model using the same input data as the previous assessment of Brandão and Butterworth (2009), referenced as “Old data”. They also include results for the following five sensitivities to the Reference case:

Sen 1: Instead of fixing the CPUPE calibration factors for each Zone on input in the manner described above, they are each estimated in the model fitting procedure.

Sen 2: The new CPUE data point for 2010 is a possible influential outlier, being considerably larger in Zone B than that in the last year before commercial harvests were suspended (see Fig. 3). This sensitivity omits the CPUE data for 2010.

Sen 3: The residual standard deviations estimated for the CPUE data for the Reference case model fit are less than 10%, which is less than is generally the norm for fits to such data in fisheries assessments, suggesting that they are being overweighted in the fit. For this sensitivity they are fixed instead at 15%, thus effectively downweighting the CPUE index of population trend compared to that provided by FIAS.

Sen 4: An Allee effect is incorporated in the population model as follows: the stock-recruitment relationship follows the Beverton-Holt form, $BH\left(B^{sp}\right)$, for stock sizes above $0.4B_0^{sp}$, and $\max\left(0, BH\left(B^{sp}\right)\left(B^{sp}/B_0^{sp}-0.08\right)/\left(0.4-0.08\right)\right)$ for lower stock sizes (this is as recently recommended for such a test by an international assessment review panel).

Sen 5: There are wide confidence intervals associated with the estimates of increases in poaching provided by the analyses reported in Brandão and Butterworth (2011). To allow for the possibility that these are not as marked as suggested by the point estimates from those analyses, the extent of increase in each Zone for 2010 and 2011 from the average for 2008 and 2009 is halved.

Discussion

The Reference case results are similar to those from the previous assessment conducted in 2009 (Old data). Although Table 1 suggests that Zones A and B are less reduced than previously thought, inspection of Fig. 5 shows that this is more a consequence of a transient effect, and viewed more broadly there is little change. The greater differences are for Zones CNP and D, which are estimated to be less reduced than previously.

Fits to the CPUE data for Zones A and B (Fig. 3) are reasonable, including for all the sensitivities except *Sen 3* where down-weighting the CPUE data leads to a marked misfit for Zone A. If the 2010 CPUE data are omitted (*Sen 2*) the CPUE drop immediately before the commercial fishery was suspended is better fitted. Fits to the FIAS data (Fig. 4) are also reasonable, though with a lesser increase in poaching over the last two years (*Sen 5*), the model fails to reflect the drop in the FIAS index in the most recent survey.

Estimating the CPUPE calibration factor within the model fit (*Sen 1*) leads lower current levels but lesser future decreasing trends for Zones CNP and D (Fig. 6). Future trends are unsurprisingly more pessimistic under the Allee effect (*Sen 4*) and less pessimistic if the recent increase in poaching has been less (*Sen 5*), though the former does lead to a marked difference in the absolute abundance estimated for Zone CNP (Fig. 7).

Viewed overall, this assessment does not suggest any major revisions to perceptions of the resource status and future trends under current poaching levels to those that arose from the previous (2009) assessment.

REFERENCES

Brandão, A. and Butterworth, D.S. 2009. Results for the Reference-case abalone spatial- and age-structured assessment model for Zones A, B, C and in 2009. Marine and Coastal Management document: MCM/2009/OCT/SWG-AB/08.

Brandão, A. and Butterworth, D.S. 2011. Trends in policing effort and the number of confiscations for abalone. FISHERIES/2011/AUG/SWG-AB/08.

Plagányi, É.E. and Butterworth, D.S. 2010. A spatial- and age-structured assessment model to estimate the impact of illegal fishing and ecosystem change on the South African abalone *Haliotis midae* resource. African Journal of Marine Science, 32(2):207-236.

Table 1. Best fit estimates of the pre-exploitation spawning biomass B_0^{sp}, current depletion $\left(B_{2011}^{sp}/B_0^{sp}\right)$ and the depletion value at the end of the projection period $\left(B_{2031}^{sp}/B_0^{sp}\right)$ for the Reference case as well as for several sensitivity tests. Projections assume future poaching levels at their current estimated values (average of 2010 and 2011) .For comparison, results for the Reference case model fitted to the “Old data” of the previous assessment of Brandão and Butterworth (2009).are also given. Note that the end of the projection period for the “Old data” is 2029 and not 2031; the associated values are given in italics in the table to highlight this difference.

	B_0^{sp}					$\left(B_{2011}^{sp}/B_0^{sp}\right)$					$\left(B_{2031}^{sp}/B_0^{sp}\right)$				
Model	**A**	**B**	**CNP**	**CP**	**D**	**A**	**B**	**CNP**	**CP**	**D**	**A**	**B**	**CNP**	**CP**	**D**
Old data	9436	5904	2981	4478	7927	0.310	0.265	0.062	0.057	0.155	*0.155*	*0.193*	*0.014*	*0.007*	*0.036*
Reference case	9478	6364	3366	4812	10325	0.374	0.292	0.145	0.072	0.282	0.173	0.155	0.034	0.012	0.070
Sen1 - estimate *k*	9343	6072	2981	4699	8566	0.348	0.258	0.105	0.053	0.189	0.143	0.126	0.094	0.007	0.038
Sen 2 - omit 2010 CPUE	9220	5994	3021	4750	8465	0.330	0.245	0.098	0.064	0.257	0.147	0.129	0.023	0.009	0.059
Sen 3 - fix σ_{CPUE} = 0.15	7057	7315	2981	5157	20499	0.303	0.255	0.216	0.065	0.232	0.132	0.123	0.026	0.007	0.037
Sen 4 - Allee effect	8978	5933	7392	4771	8522	0.362	0.258	0.212	0.054	0.258	0.083	0.044	0.020	0.004	0.028
Sen 5 - half poaching increase	9041	6187	2981	4761	8609	0.359	0.278	0.079	0.052	0.242	0.217	0.223	0.019	0.008	0.115

Table 2. Estimates of the current (2011) poaching levels (in terms of biomass), the average of the last five years of the proportion of confiscations to estimated poaching numbers and the minimum values of the negative of the log-likelihood function (-*ln* L) for the Reference case as well as for several sensitivity tests. For comparison, results for the model fitted to the "Old data" of the 2009 assessment are also given. Note that all contributions from catch-at-age data have been multiplied by 0.1 as an *ad hoc* adjustment to compensate for likely positive correlation in these data, and log-likelihood values that are not comparable (because the model formulation and/or data fitted differs from those for the Reference case) are given within square brackets.

	Poaching (2011) MT					***Average proportion of confiscation to poaching over the last 5 years***					***-ln L***					
Model	**A**	**B**	**CNP**	**CP**	**D**	**A**	**B**	**CNP**	**CP**	**D**	**A**	**B**	**CNP**	**CP**	**D**	**Total**
Old data	460.5	247.5	30.6	52.7	95.7	18.4%	31.4%	8.3%		8.9%	[-64.42	-79.7	-50.6	-47.89	-55.65	**-298.3]**
Reference case	691.3	408.4	81.0	102.3	158.6	26.5%	40.0%	9.7%		12.8%	-77.17	-77.5	-52.3	-47.90	-52.76	**-307.6**
Sen1 - estimate *k*	885.0	492.6	15.2	86.8	433.1	24.9%	38.2%	12.5%		10.5%	-74.75	-81.4	-57.1	-51.16	-55.50	**-319.9**
Sen 2 - omit 2010 CPUE	817.8	466.0	81.9	127.9	156.5	22.6%	34.5%	8.7%		13.4%	[-73.37	-82.9	-55.9	-50.08	-53.63	**-315.9]**
Sen 3 - fix σ_{CPUE} = 0.15	568.0	551.8	81.7	122.3	597.8	33.7%	29.6%	11.4%		3.6%	[-58.30	-76.8	-52.3	-32.73	-60.61	**-280.7]**
Sen 4 - Allee effect	738.6	437.9	333.5	57.6	232.3	26.1%	39.5%	5.8%		8.6%	-75.13	-83.4	-42.8	-49.39	-53.05	**-303.8**
Sen 5 - half poaching increase	407.7	240.2	39.5	59.9	85.3	25.5%	37.8%	9.2%		13.1%	-72.28	-78.9	-57.0	-51.28	-55.08	**-314.5**

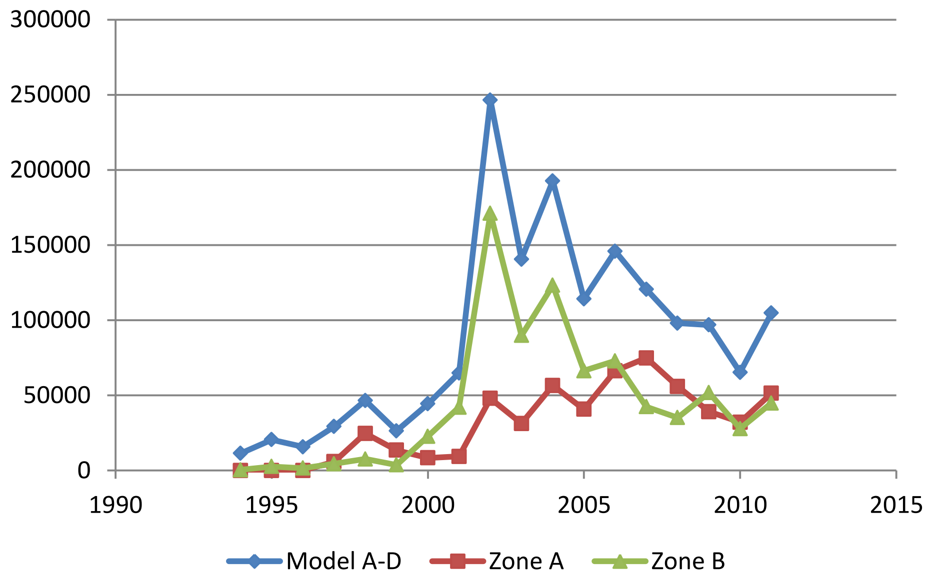

Figure 1. Known zone confiscations for Zones A-D from all (DAFF and other agencies) policing operations. These are as used previously by Plagányi and Butterworth (2010) in obtaining CPUPE index of poaching trend.

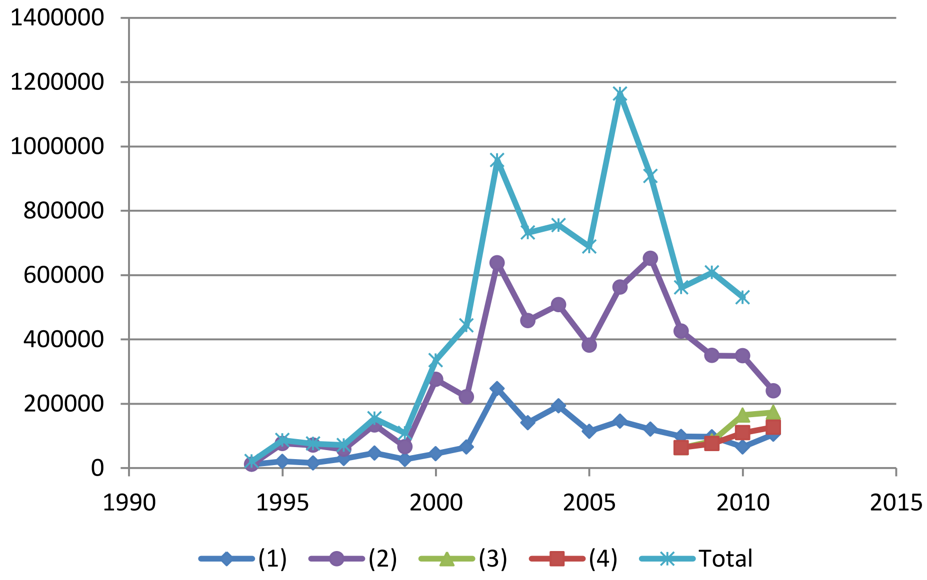

Figure 2. Confiscations for Zones A-D from all (DAFF and other agencies) policing operations: (1) where the specific Zone within A-D is known and (2) including cases where the specific Zone is not known. Further plots show confiscations[2] by the compliance section only: (3) for all of the South coast and (4) for Zones A-D only. The total number of confiscations throughout South Africa are also shown, though those results refer to calendar rather than Model-year.

[2] Only partial year's data are available for 2008 and 2011. Confiscations for these two years have been scaled to full Model-year concerned using monthly proportions estimated from the averages for 2009 and 2010.

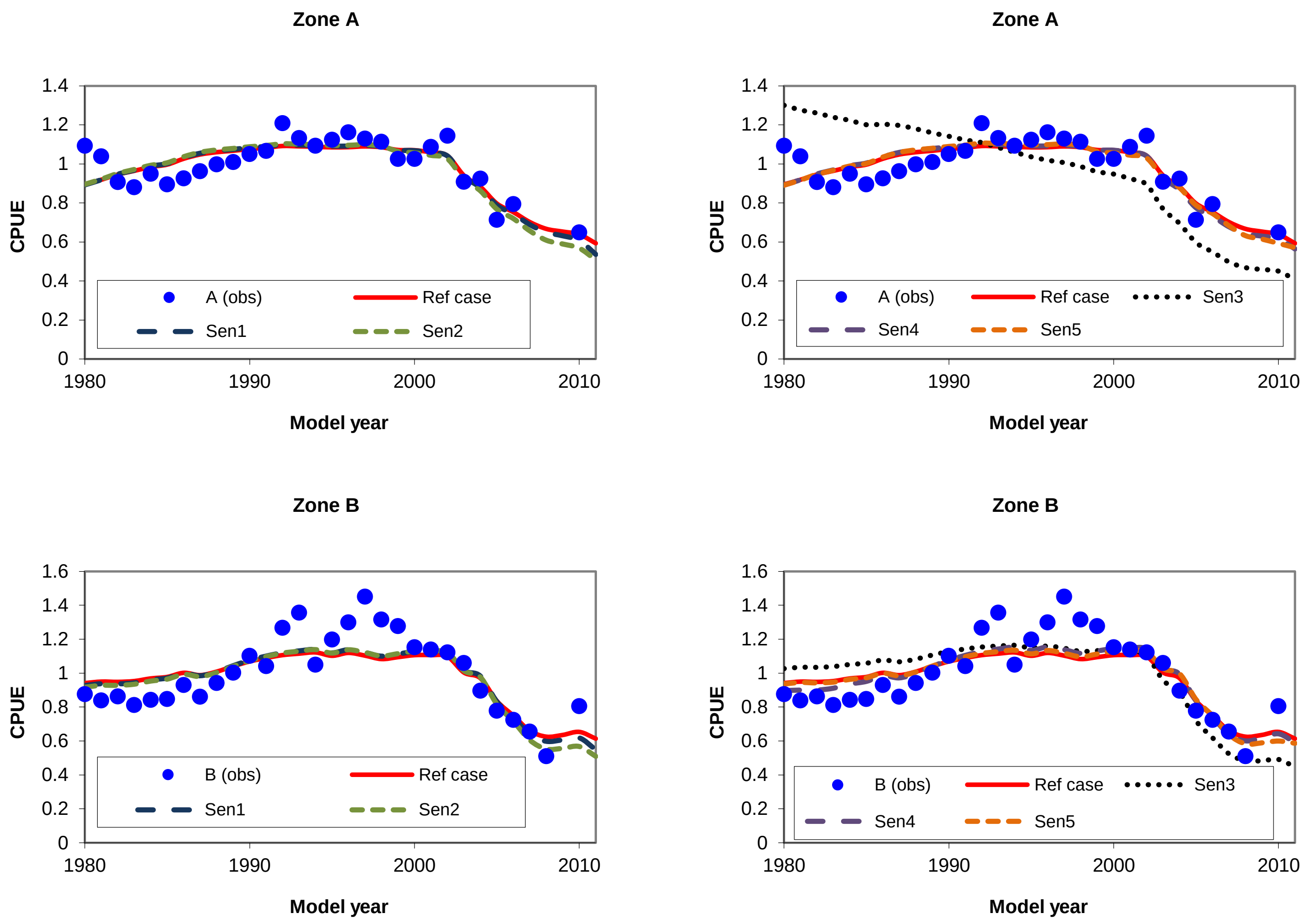

Figure 3. Comparisons between the standardised CPUE (obs) and model-predicted CPUE values for the Reference case and several sensitivity tests for Zones A and B. The sensitivity tests are Sen 1: estimate *k*, Sen 2: omit 2010 CPUE, Sen 3: fix $\sigma_{CPUE} = 0.15$, Sen 4: Allee effect and Sen 5: half poaching increase.

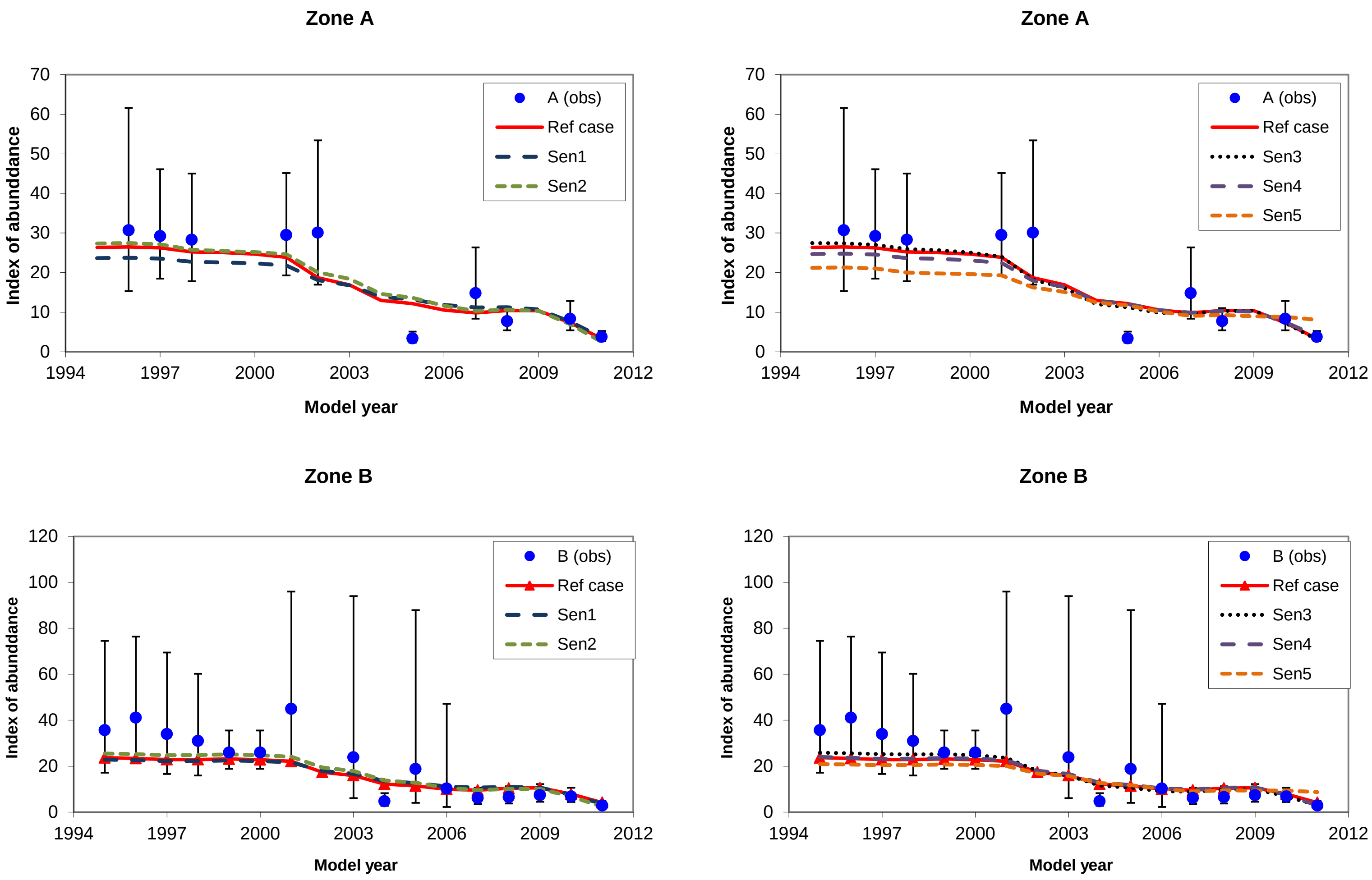

Figure 4. Comparison of observed FIAS and model-predicted trends for the Reference case and several sensitivity tests for Zones A and B. Note that 95% confidence intervals have been computed as estimate*exp(±1.96*CV). The sensitivity tests are Sen 1: estimate *k*, Sen 2: omit 2010 CPUE, Sen 3: fix $\sigma_{CPUE} = 0.15$, Sen 4: Allee effect and Sen 5: half poaching increase.

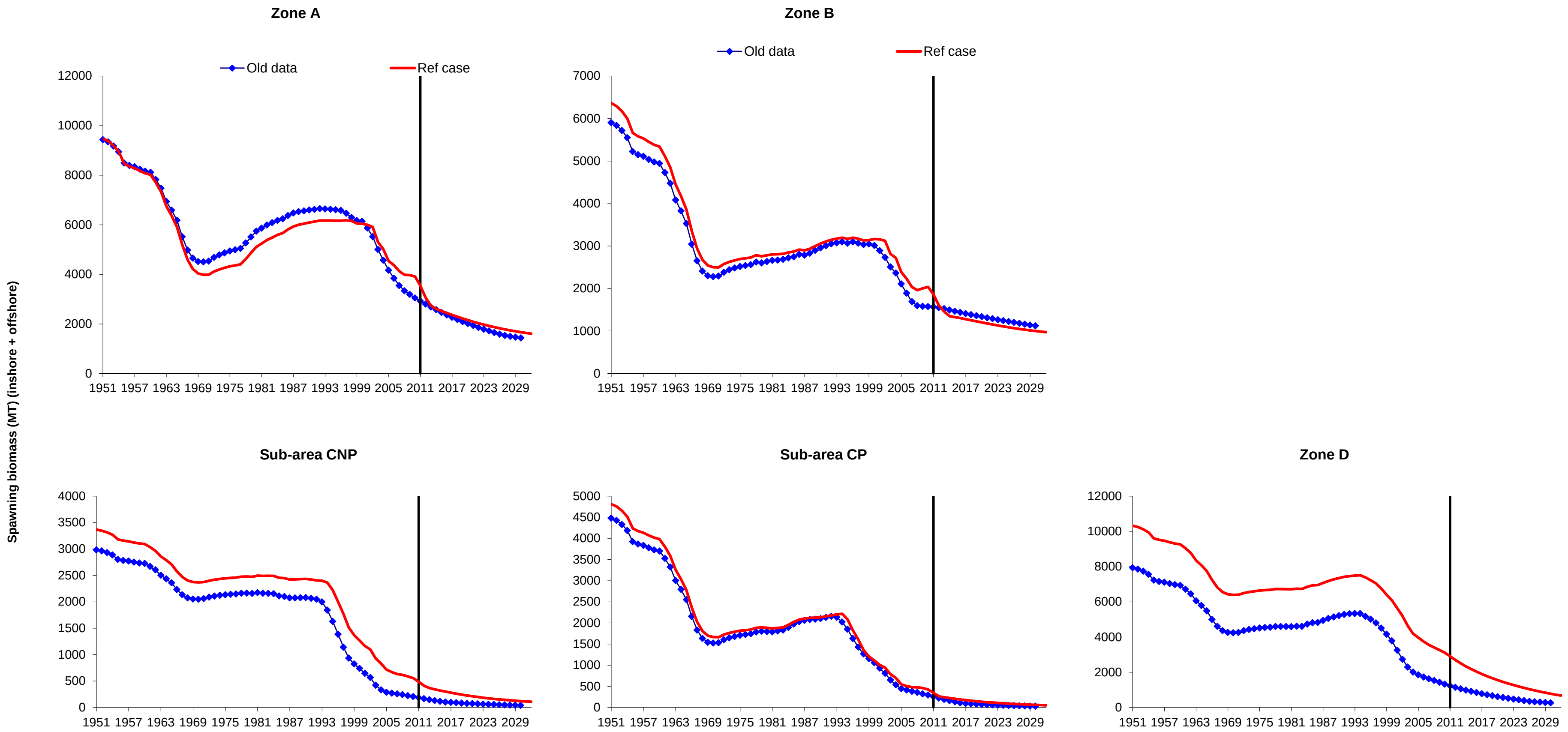

Figure 5. Total (inshore + offshore) spawning biomass trajectories shown for Zones A to D for the Reference case model compared to the model fitted to the "Old data" of the 2009 assessment. Note that the 20-yr projections shown (after the vertical bar) represent scenarios under which future poaching levels are assumed to remain at the current estimated level (average of 2010 and 2011) and future commercial catches are set to zero.

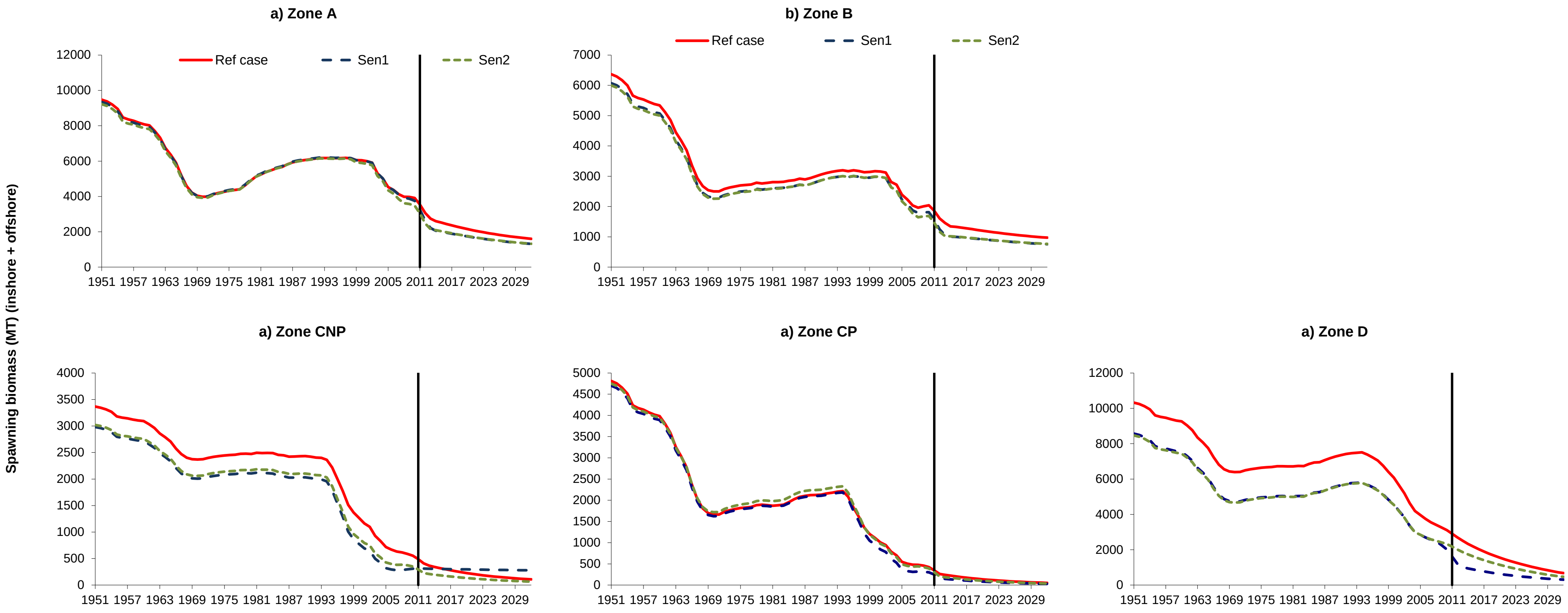

Figure 6. Total (inshore + offshore) spawning biomass trajectories shown for Zones A to D for the Reference case model and two sensitivity tests. The sensitivity tests are Sen 1: estimate *k* and Sen 2: omit 2010 CPUE. Note that the 20-yr projections shown (after the vertical bar) represent scenarios under which future poaching levels are assumed to remain at the current estimated level (average of 2010 and 2011) and future commercial catches are set to zero.

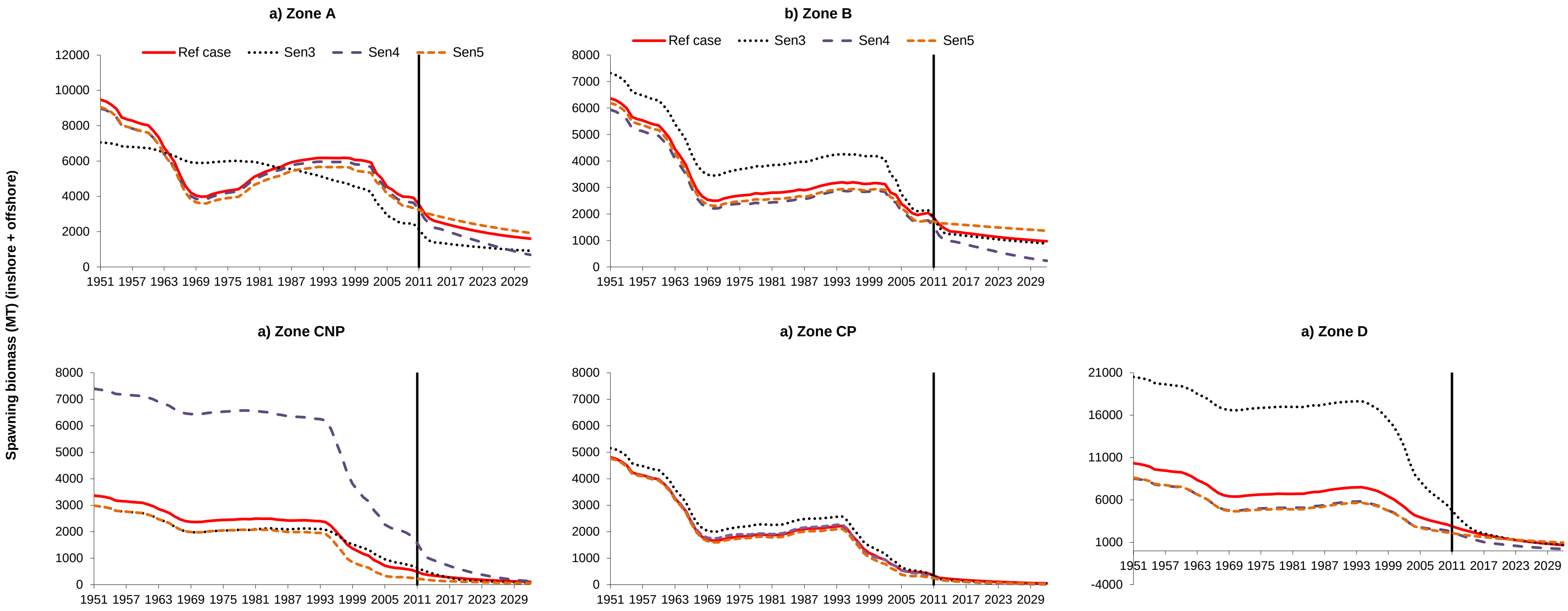

Figure 7. Total (inshore + offshore) spawning biomass trajectories shown for Zones A to D for the Reference case model and three sensitivity tests. The sensitivity tests are Sen 3: fix $\sigma_{CPUE} = 0.15$, Sen 4: Allee effect and Sen 5: half poaching increase. Note that the 20-yr projections shown (after the vertical bar) represent scenarios under which future poaching levels are assumed to remain at the current estimated level (average of 2010 and 2011) and future commercial catches are set to zero.

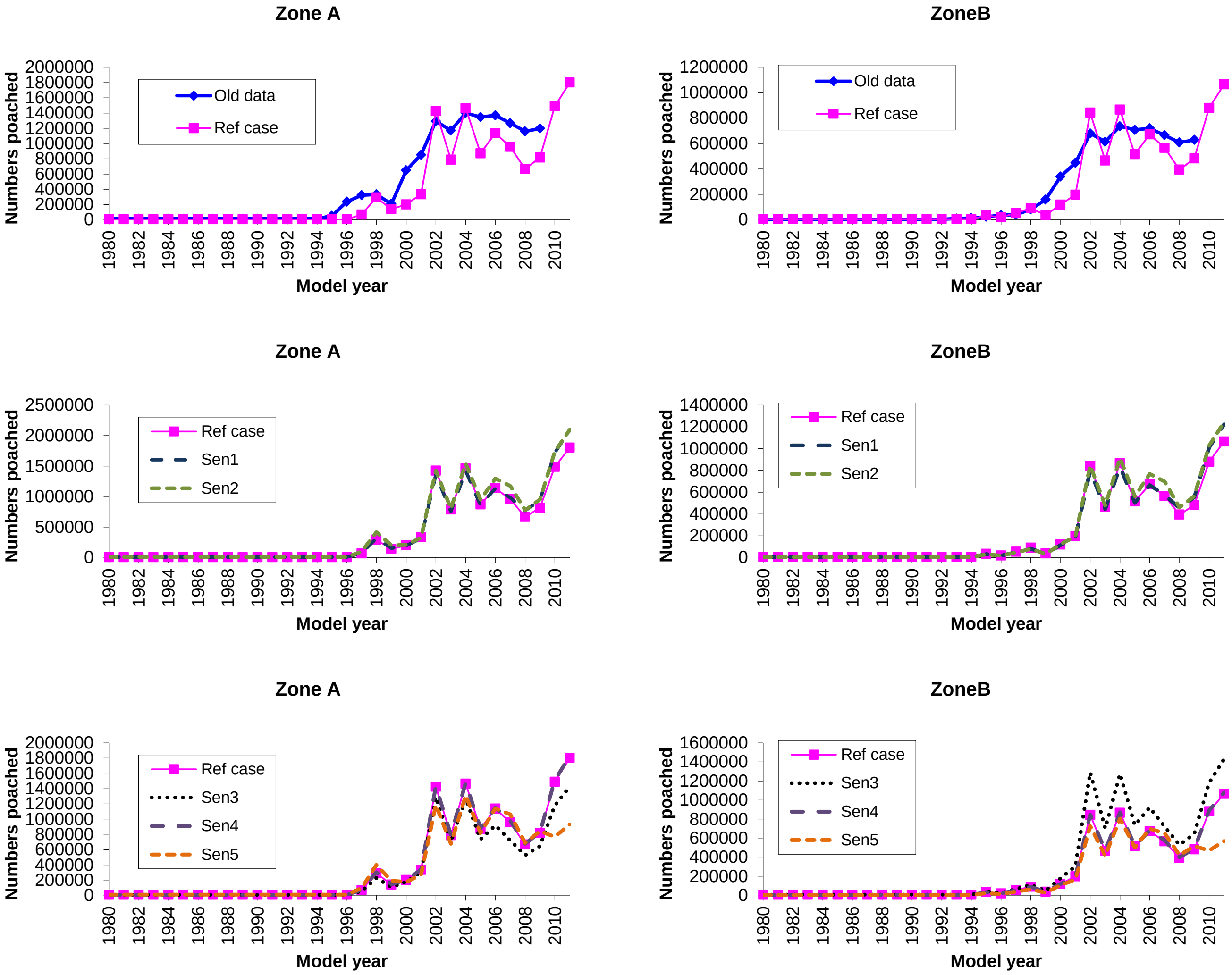

Figure 8. Comparison of model-predicted total numbers of abalone poached for Zones A and B for the Reference case model and several sensitivity tests. The sensitivity tests are Sen 1: estimate *k*, Sen 2: omit 2010 CPUE, Sen 3:fix $\sigma_{CPUE} = 0.15$, Sen 4: Allee effect and Sen 5: half poaching increase. The Reference case is also compared to the model fitted to the "Old data" of 2009 assessment.