Abalone spatial- and age-structured assessment model and projections for Zones A, B, C and D

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Abstract

The 2013 assessment of abalone in Zones A-D is updated to take new data into account; these include results from the recent full population survey. Projections are shown for different scenarios for the future commercial and poaching catches in Zone A and Zone B. Current poaching levels (average of 2014 and 2015, estimated as 378t for Zone A, 293t for Zone B, 67t for Zone C and 139t for Zone D) if continued, would not be sustainable.

Introduction

This document provides results from fitting the spatial- and age-structured production model (ASPM) for abalone for Zones/Subareas A, B, CNP, CP and D in combination, using the new data that have become available since the previous assessment (Brandão and Butterworth, 2013). These new data include those from a repetition in 2015 of the full population survey carried out in 2002 to provide information on the recruitment for Zones B and C. The extra year of catch-at-age data has been included in the assessment model. As there are now two indices of abundance available from this full population survey, the assessment model has been modified to include these indices in the model fitting procedure.

Data

The series that have been updated, compared to those used in Brandão and Butterworth (2013), for the analyses that follow are (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):

- CPUE: new values from updated GLMM standardisation for Zones A and B only to include data until 2014 (Brandão and Butterworth, 2015a).
- Commercial catches for Zones A and B until 2014 (TAC assumed taken in 2015).

- Commercial catch-at-age data: data provided for Zones A and B to include data until 2014 (Maharaj and Mackenzie, 2015a).
- Poaching trend: new values from updated analyses of policing effort and the number of confiscations for 2008 to 2015 (Brandão and Butterworth, 2015b).
- Poaching catch-at-age data: Zones A to D (until 2014).
- FIAS abundance indices for 2013 in Zone C and 2014 for Zones B and D (Maharaj and Mackenzie, 2015b).
- FIAS catch-at-age data for 2013 in Zone C and 2014 for Zones B and D (Maharaj and Mackenzie, 2015b).
- Extractive survey indices for 2002 and 2015 (Maharaj and Mackenzie, 2015c).
- Extractive survey catch-at-age data for 2015.

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 Basecase model described in those two documents has been modified in some generally minor ways that are described in Brandão and Butterworth (2011). Brandão and Butterworth (2013) describes how the standard errors associated with the poaching indices are incorporated in the assessment model. In the assessment presented in this paper, the indices of abundance obtained from the full population surveys carried out in 2002 and 2015 are now also incorporated into the model fitting procedure.

Results

Results have been obtained for the new Basecase model for the updated data as well as for the case when an Allee effect is taken into account. Results for the new Basecase model are reported in Tables 1 and 2 for some key statistics. The model fits to various data are given in the Appendix A. Spawning biomass with projections for all Zones are shown in Figure 1 and annual poaching estimates (by number) for Zones A and B in Figure 2.

These Tables and Figures include comparisons with the results of the previous assessment of Brandão and Butterworth (2013), referenced as “Previous”.

Figure 3 plots the comparison of the depletion projections for new Basecase model and the model that takes an Allee effect into account.

Projections

Figure 4 shows spawning biomass projections for the new Basecase model for four scenarios for future commercial and poaching catches listed below. Figure 5 shows these projections when an Allee effect is taken into account.

- Poaching only (average of 2014 and 2015 levels)
- 25 ton commercial catch only for each of Zone A and B

- Both poaching and commercial catches at the above levels
- The poaching reduction necessary to keep the biomass at its current level.

Figure 6 shows the "intended" future poaching levels, which are assumed to remain at the current estimated level (average of 2014 and 2015), and the actual removals made by the model because of the model restriction that does not allow the fully selected fishing proportion to be greater than 95%. Thus the model builds in a factor to allow for the fact that as abundance declines, it would not be possible to sustain current poaching removals.

Discussion

The new Basecase results are similar to those from the previous assessment conducted in 2013 (Previous). Results show that the current estimates of the extent by which the abalone resource depletion in Zones A and B in 2013 are slightly less than was the case in the previous assessment, but also that the downward trend in abundance in these Zones as well as in Zones C and D has continued from 2013 to 2015 (Table 1 and Figure 1). These downward trends are projected to continue into the future under current poaching levels.

There has been an estimated increase in poaching levels from the 2013 season for both Zones A and B (Figure 2), though the estimate for the level of poaching in 2013 is now lower than estimated in the previous assessment. The current level of poaching (the average of 2014 and 2015, is estimated as 378t for Zone A, 293t for Zone B, 67t for Zone C and 139t for Zone D) (Table 2).

Future trends are unsurprisingly more pessimistic under the Allee effect, as might be expected (Figure 3).

Figures 4 and 5 show that the current level of poaching is NOT sustainable if maintained in the future.

The fits to the age structure from the full population surveys (Figure A.10) are not satisfactory, particularly for Zone C. This may in part reflect inaccuracies in the growth curve assumed for low ages, but also points to a need to re-examine the way the recruitment decrease arising from the lobster-urchin effect in Zone C is modelled. Nevertheless indications from Figure A.10 are that for both Zones B and C, recent recruitments are lower than the model is assuming.

References

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Maharaj, G. and Mackenzie, A. 2015a. Summary of commercial data updates for the abalone fishery in Zones A-D in 2015. FISHERIES/2015/AUG/SWG-AB/01.

Maharaj, G. and Mackenzie, A. 2015b. Progress with inshore FIAS density and catch-at-age data for Zones A to D. FISHERIES/2015/AUG/SWG-AB/03.

Maharaj, G. and Mackenzie, A. 2015c. Repeat joint industry-DAFF full population extractive survey of the abalone resource in 2015. FISHERIES/2015/AUG/SWG-AB/04.

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 for the pre-exploitation spawning biomass B_0^{sp}, current depletion and the depletion at the end of the projection period for the new Basecase. Projections assume future poaching levels at their current estimated values (average of 2014 and 2015). For comparison, results for the previous Basecase ("Previous") from the assessment of Brandão and Butterworth (2013) are also given.

	B_0^{sp}					$\left(B_y^{sp}/B_0^{sp}\right)$						$\left(B_y^{sp}/B_0^{sp}\right)$					
Model	**A**	**B**	**CNP**	**CP**	**D**	***y***	**A**	**B**	**CNP**	**CP**	**D**	***y***	**A**	**B**	**CNP**	**CP**	**D**
Previous	7590	5911	2633	4686	7313	2013	0.262	0.239	0.088	0.050	0.195	2033	0.121	0.136	0.025	0.009	0.082
New Basecase	7813	6030	2548	4734	7811	2013	0.271	0.256	0.107	0.070	0.210	2033	0.067	0.040	0.032	0.013	0.057
						2015	0.227	0.225	0.088	0.052	0.190	2035	0.058	0.030	0.029	0.011	0.052

Table 2. Estimates of the current (2015) 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 new Basecase. For comparison, results for the "Previous" 2013 assessment are also given (the poaching estimates given for that assessment are those estimated at that time for 2013). Note that all contributions from catch-at-age data to -*ln* L have been multiplied by 0.1 as an *ad hoc* adjustment to compensate for likely positive correlation in these data. The log-likelihood values are not comparable (because the data fitted previously differ from the current new Basecase) and are therefore shown in square brackets.

	Poaching MT					***Average proportion of confiscation to poaching over the last 5 years***				***-ln L***					
Model	**A**	**B**	**CNP**	**CP**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**CNP**	**CP**	**D**	**Total**
Previous (for 2013)	420.1	291.0	48.1	72.0	117.6	18.3%	32.4%	5.6%	6.8%	[-78.1	-81.3	-56.2	-50.2	-55.3	**-317.5]**
New Basecase (for 2015)	395.8	288.8	44.4	73.5	132.2	19.5%	35.0%	5.7%	3.7%	-85.4	-86.2	-56.2	-48.2	-51.5	**-322.8**

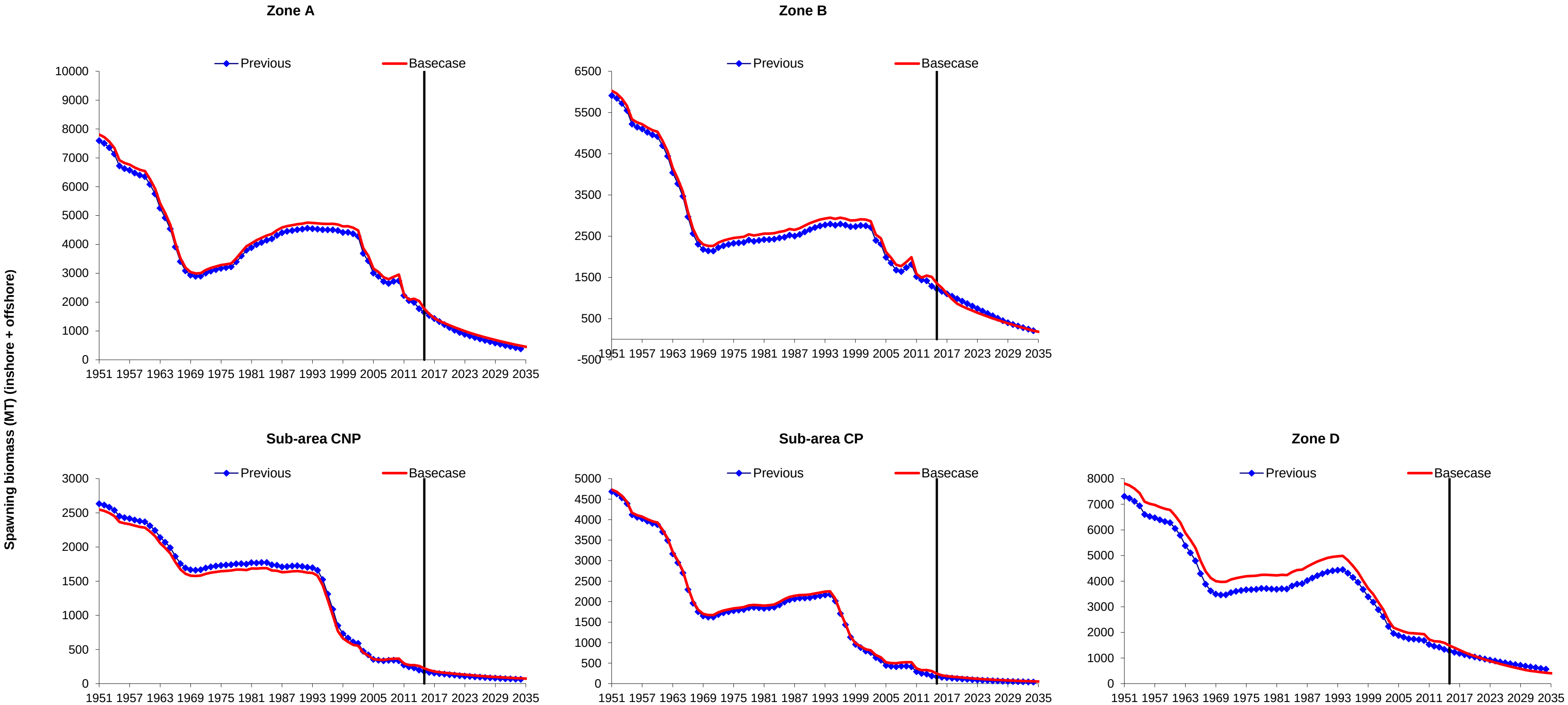


Figure 1. Total (inshore + offshore) spawning biomass trajectories shown for Zones A to D for the new Basecase model compared to the "Previous" results obtained in the 2013 assessment. Note that the 20-yr projections shown (after the vertical bar) represent scenarios under which future poaching levels are assumed to remain at the "current" estimated level (average of 2012 and 2013 for the "Previous" model and the average of 2014 and 2015 for the "Basecase") and future commercial catches are set to 50 tons for the "Previous" model and 25 tons for the "Basecase"s in each of Zones A and B only.

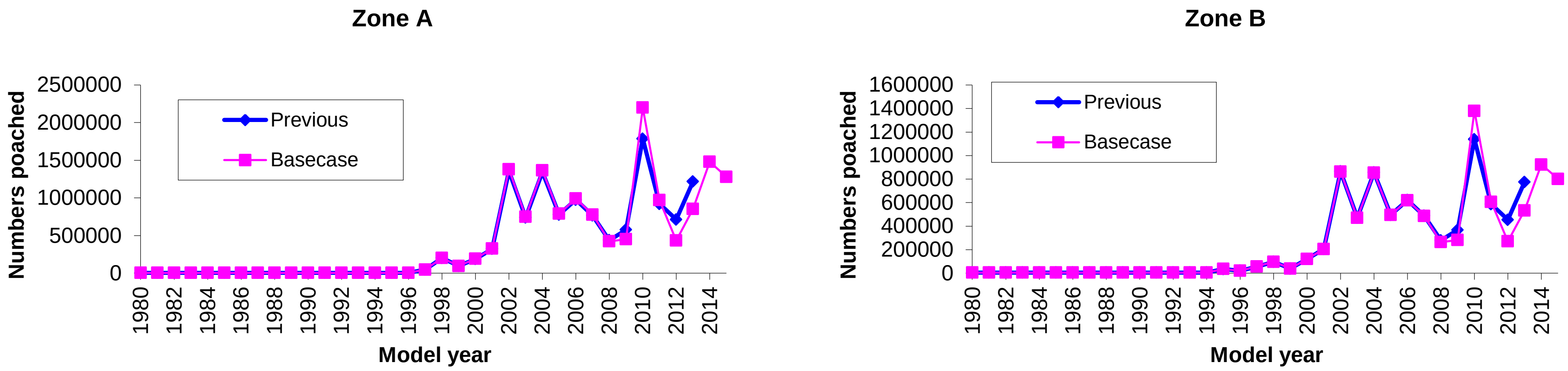


Figure 2. Comparison of model-predicted numbers of abalone poached for Zones A and B for the new Basecase model and those obtained in the 2013 assessment ("Previous").

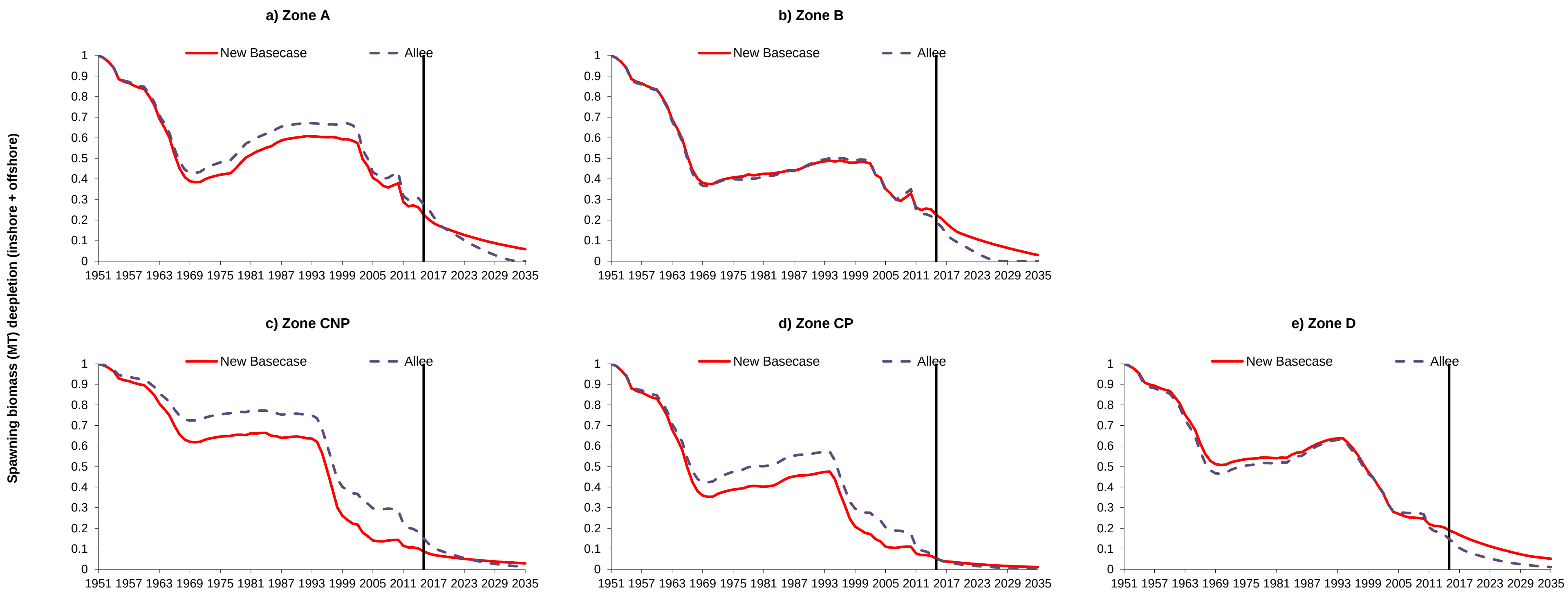


Figure 3. Total (inshore + offshore) depletion trajectories shown for Zones A to D for the new Basecase model compared to sensitivity test 3 (Allee effect). Note that the 20-yr projections shown (after the vertical bar) represent scenarios under which future poaching levels are assumed to remain at the current estimated level (average of 2014 and 2015) and future commercial catches are set to 25 tons in each of Zones A and B only.

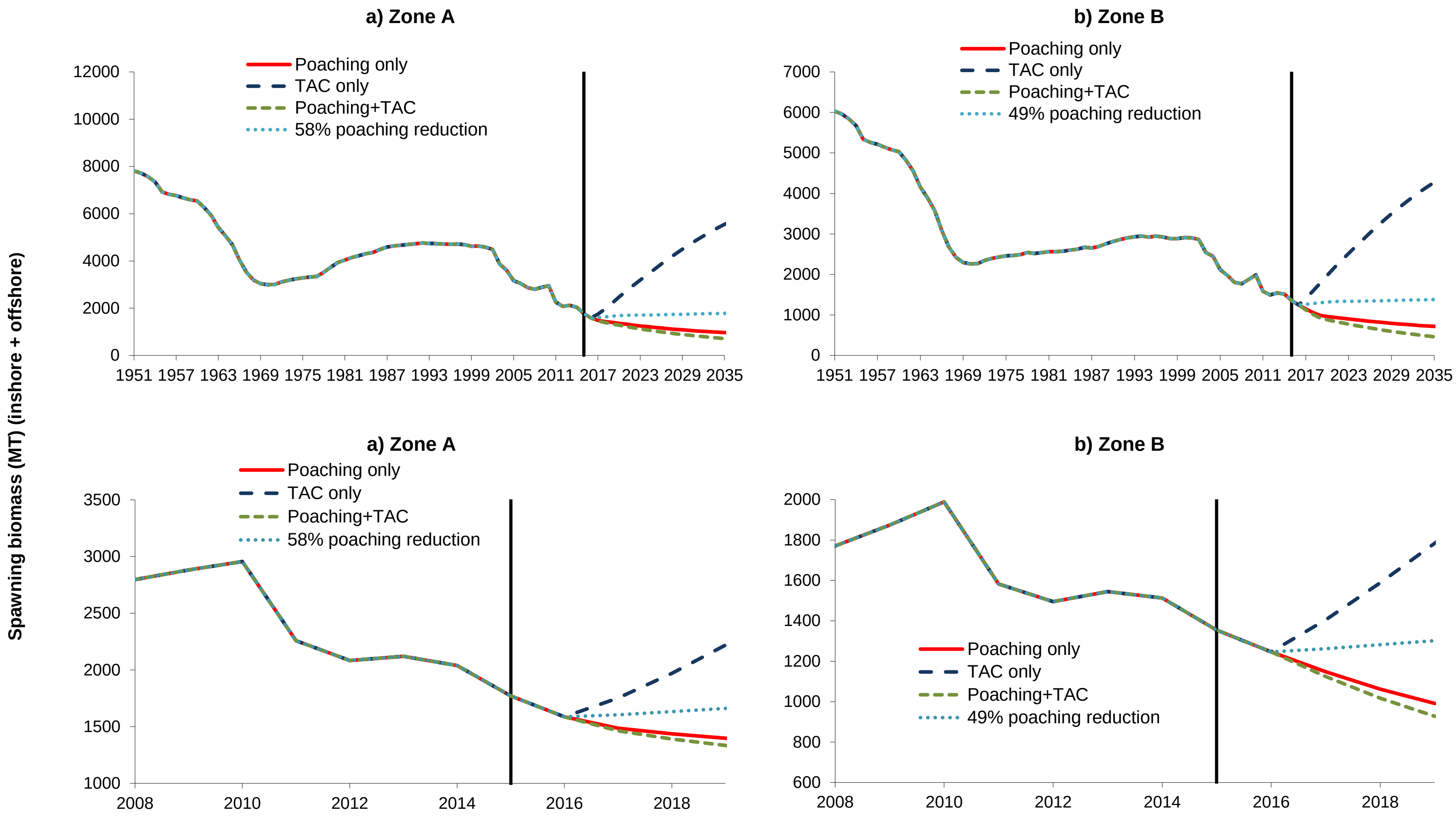


Figure 4. Total (inshore + offshore) spawning biomass trajectories shown for Zones A and B for the new Basecase model. The 20-yr projections shown (after the vertical bar) represent four different scenarios for future commercial and poaching catches. Unless a zero amount is assigned, future poaching levels are assumed to remain at the current estimated level (average of 2014 and 2015) and future commercial catches in each of these two Zones are set to the current TAC of 25 tons. The bottom plots zoom in on a shorter period to be able to distinguish the curves more clearly. In each plot, the required reduction in poaching necessary to keep the resource stable at its present level under the current TAC is also shown, with the required reduction indicated in the legend.

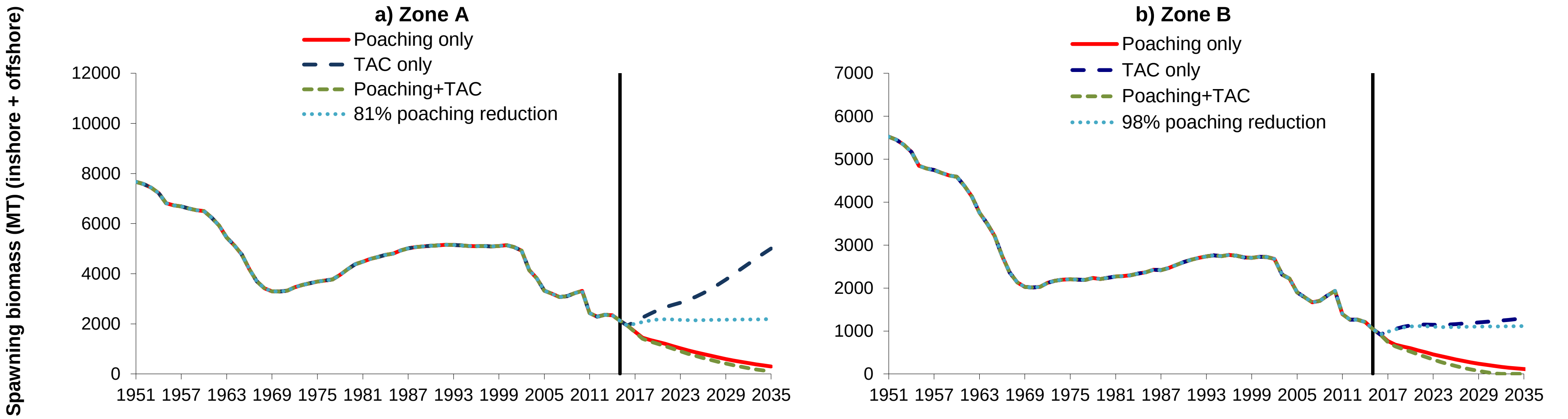


Figure 5. Total (inshore + offshore) spawning biomass trajectories shown for Zones A and B for the new Basecase model taking an Allee effect into account. The 20-yr projections shown (after the vertical bar) represent four different scenarios for future commercial and poaching catches. Unless a zero amount is assigned, future poaching levels are assumed to remain at the current estimated level (average of 2014 and 2015) and future commercial catches are set to the current TAC of 25 tons. In each plot, the required reduction in poaching necessary to keep the resource stable at its present level under the current TAC is also shown, with the required reduction indicated in the legend.

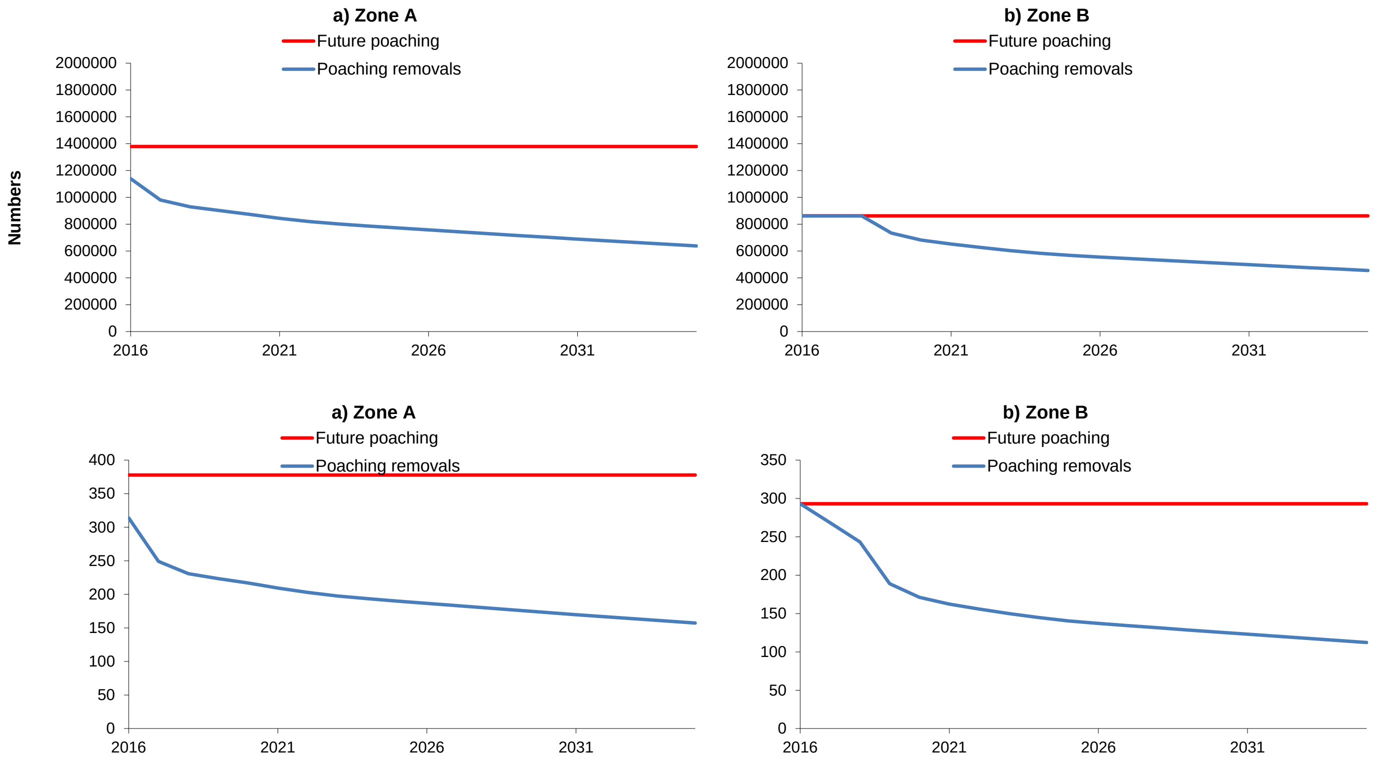


Figure 6. Future poaching levels (in terms of numbers (top) and biomass (bottom)), as assumed to remain at the current estimated level (average of 2014 and 2015), and the actual removals made by the model because of the model restriction that does not allow the fully selected fishing proportion to be greater than 95%. Thus the model builds in a factor to allow for the fact that as abundance declines, it would not be possible to sustain current poaching removals. Results shown are for the new Basecase.

Appendix A

Diagnostic plots and others for the ASPM model for Zones A to D

Legal and illegal catches as well as the commercial exploitable biomass are shown in Figure A1. Diagnostic plots for CPUE for Zones A and B are shown in Figure A2, selectivity functions for the commercial, recreational, poaching, FIAS, “old” surveys and full population surveys in Figure A3, FIAS data in Figure A4, and full population survey indices in Figure A5. The fits to the CPUE data for Zones A and B (Figure A2), fits to the FIAS data (Figure A3) and fits to the full population survey indices (Figure A4) are reasonable.

Fits to the catch-at-age proportions are shown in Figures A6 to A11 for the various components of available data. The fits to the catch-at-age proportions are good with the exception of the full population survey (Figure A10). For Zone B the high proportion of 4 year olds is not fitted well and a higher proportion of 2 year olds is estimated for 2015 than observed. For Zone C a higher proportion of younger and lower proportion of older abalone are estimated than observed.

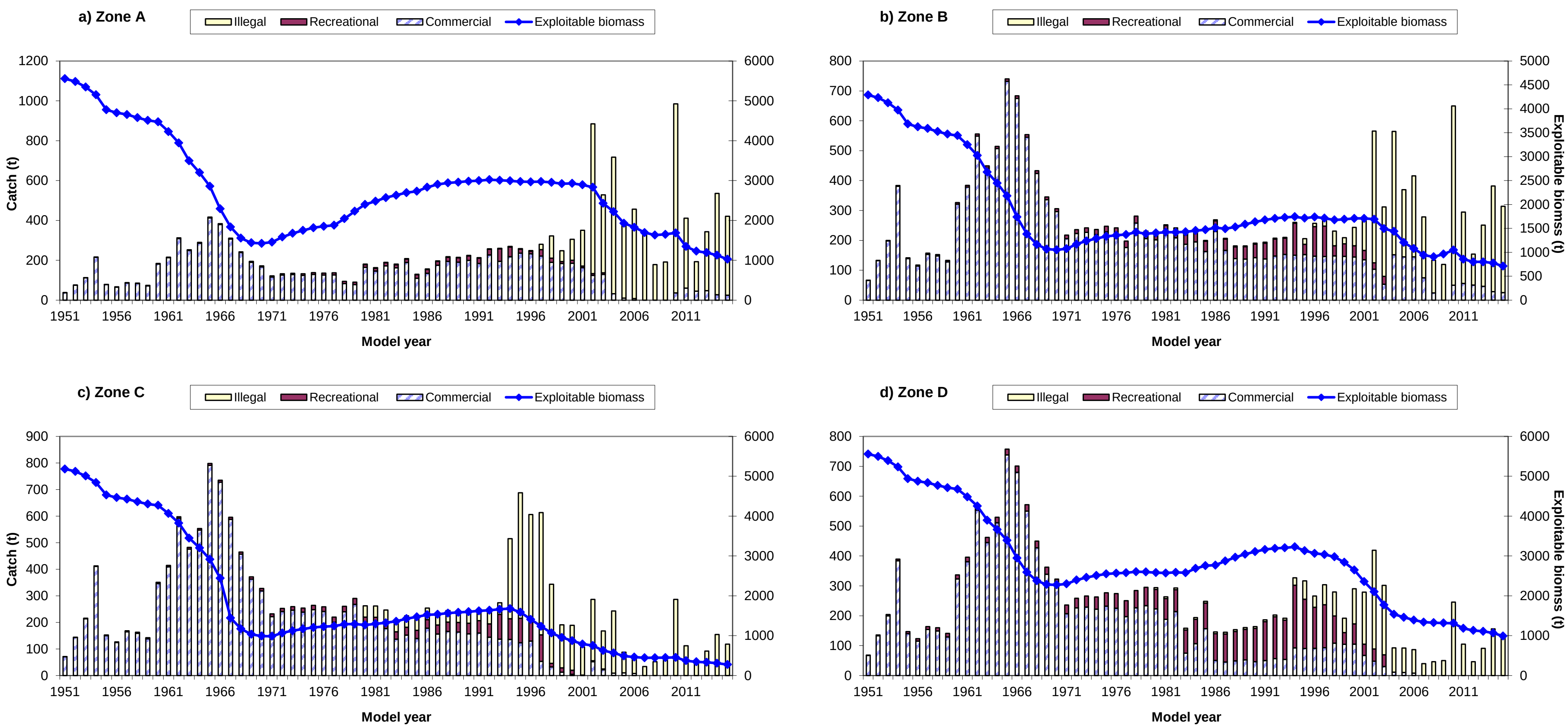


Figure A1. Estimated commercial exploitable biomass for the new Basecase model for Zones A to D (right hand axis) in tons and total catches (commercial + recreational + estimated illegal) for the Zones (left hand axis).

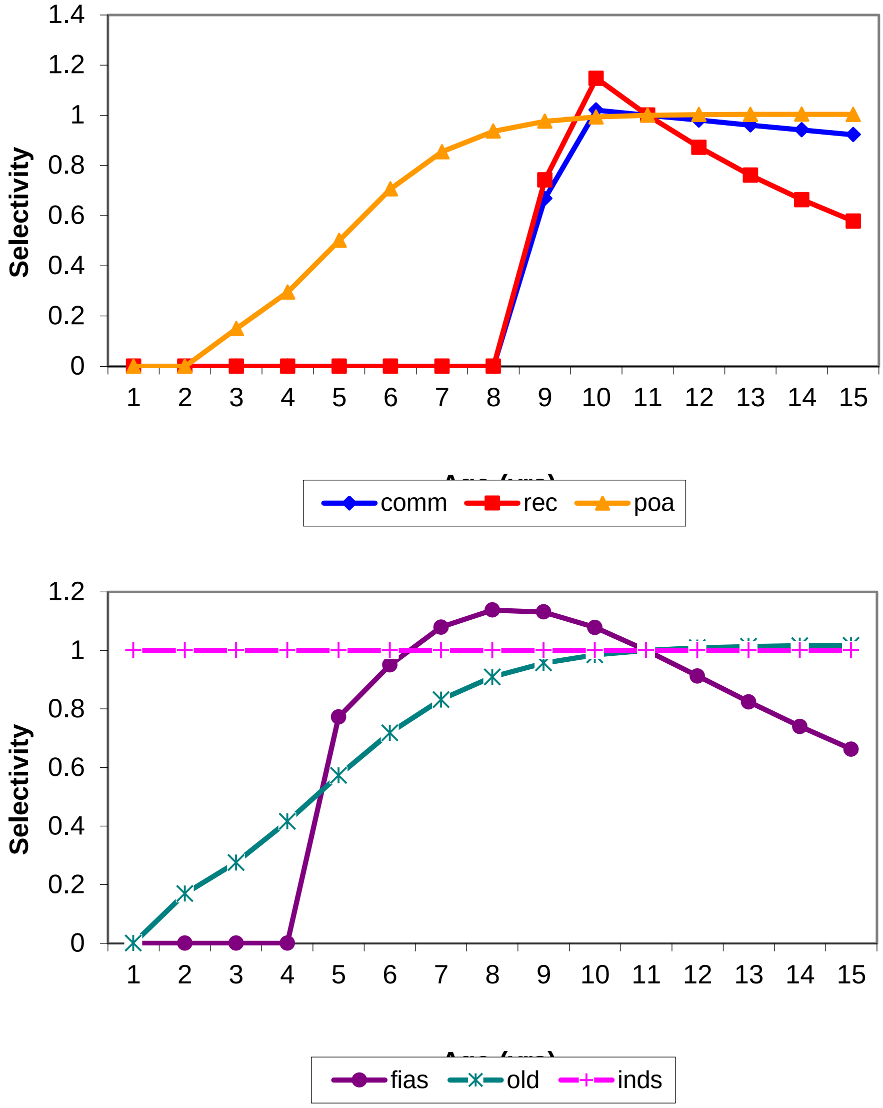
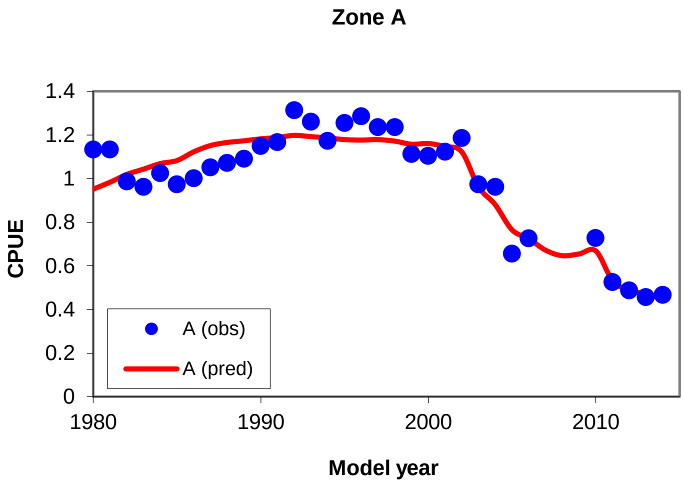


Figure A2. Plots of the new Basecase model selectivity functions estimated for the commercial (comm), recreational (rec) and poaching (poa) fishery sectors, and for FIAS (fias) and the old 1980's surveys (old). A uniform value is assumed for the full population surveys (inds) because of the extractive nature of the sampling methodology used.



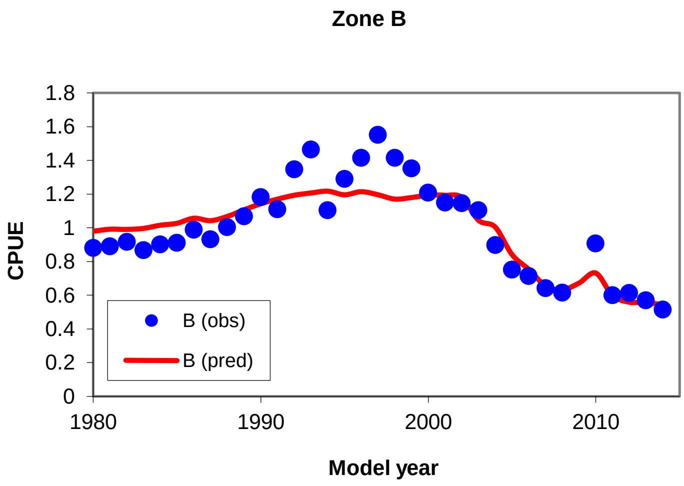


Figure A3. Comparisons between the standardised CPUE (obs) and model-predicted CPUE values for the new Basecase for Zones A and B.

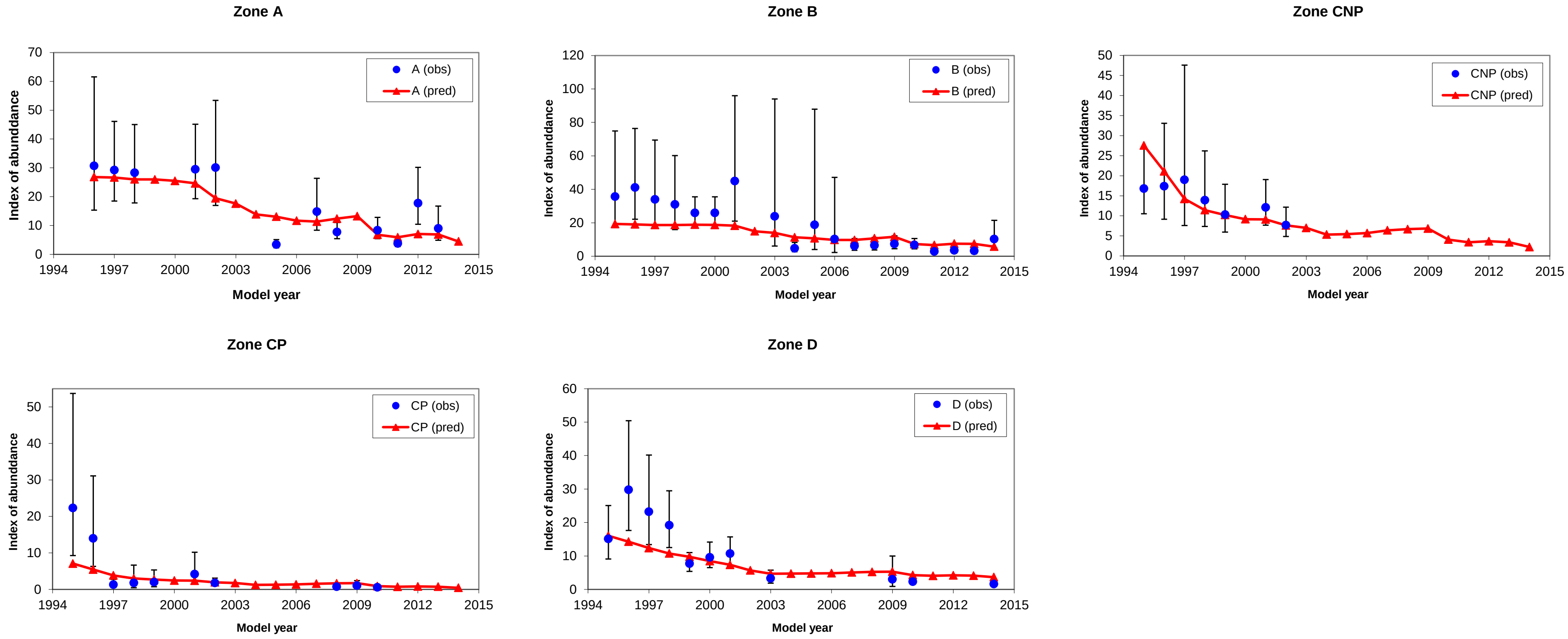


Figure A4. Comparison of observed FIAS and model-predicted trends for the new Basecase model for Zones A to D. Note that the 95% confidence intervals shown have been computed as: estimate*exp(±1.96*CV).

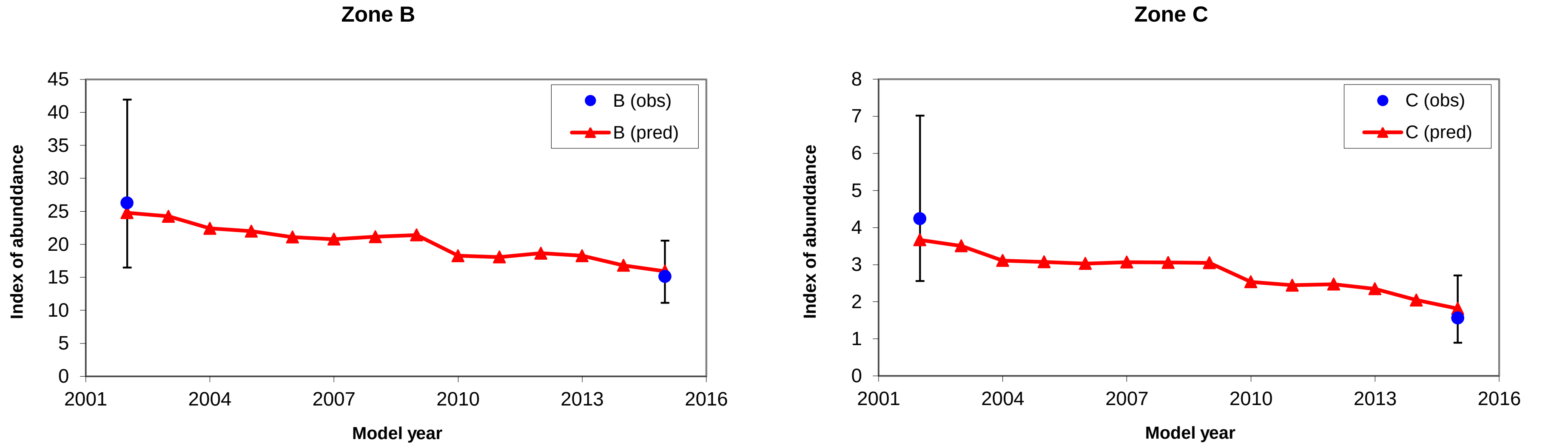


Figure A5. Comparison of observed extractive survey and model-predicted values and trends for the new Basecase model for Zones B and C. Note that the 95% confidence intervals shown have been computed as: estimate*exp(±1.96*CV).

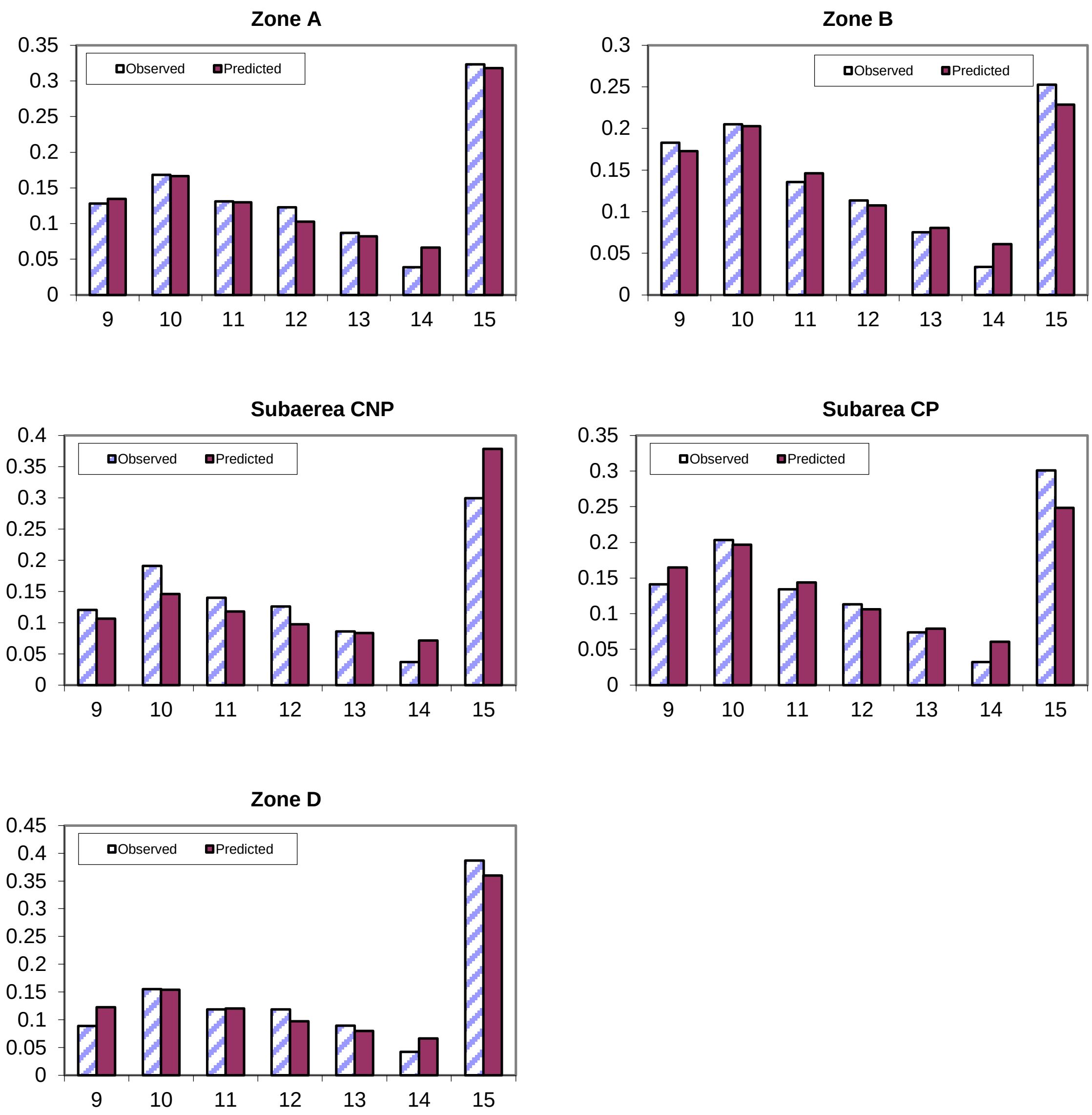


Figure A6. Comparison for the average over all the years between observed and model predicted catch-at-age proportions for the commercial sector for Zones A to D for the new Basecase model.

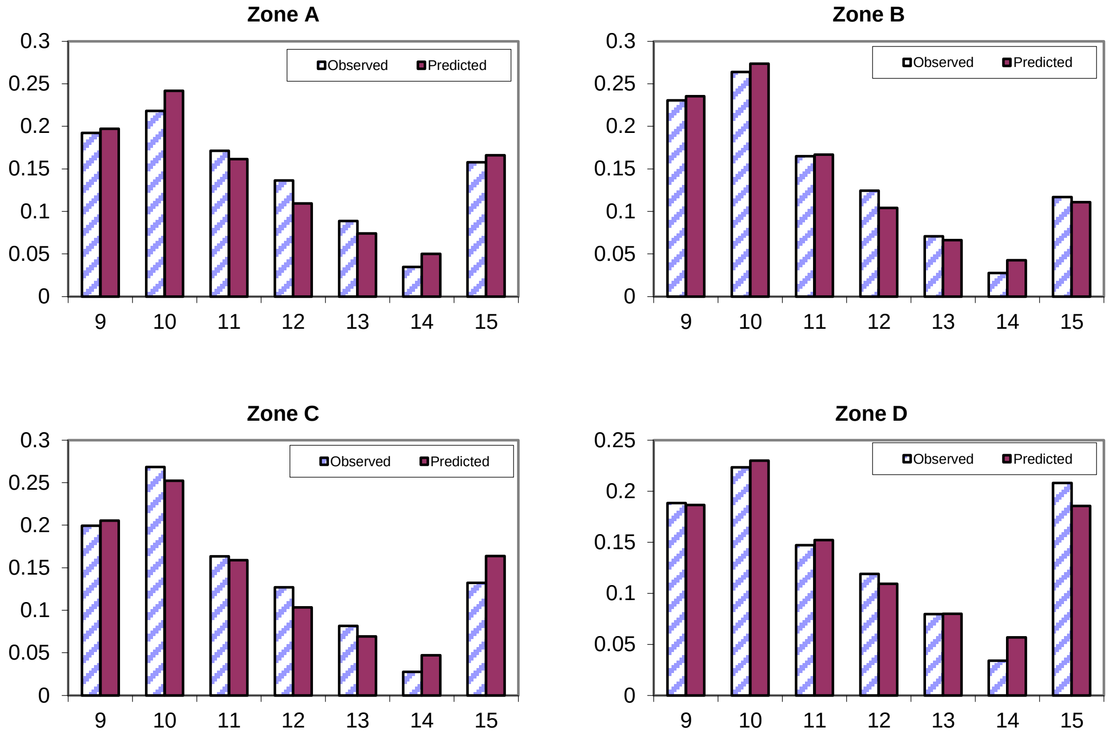


Figure A7. Comparison for the average over all the years between observed and model predicted catch-at-age proportions for the recreational sector for Zones A to D for the new Basecase model.

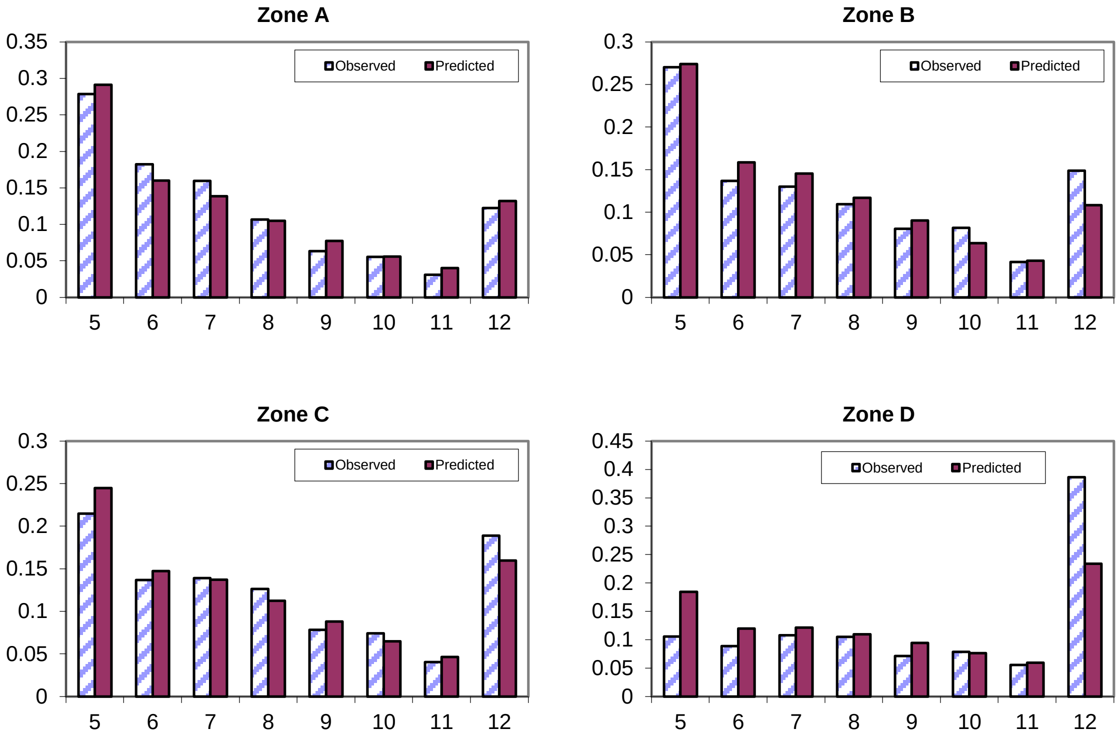


Figure A8. Comparison for the average over all the years between observed and model predicted catch-at-age proportions for the poaching sector for Zones A to D for the new Basecase model.

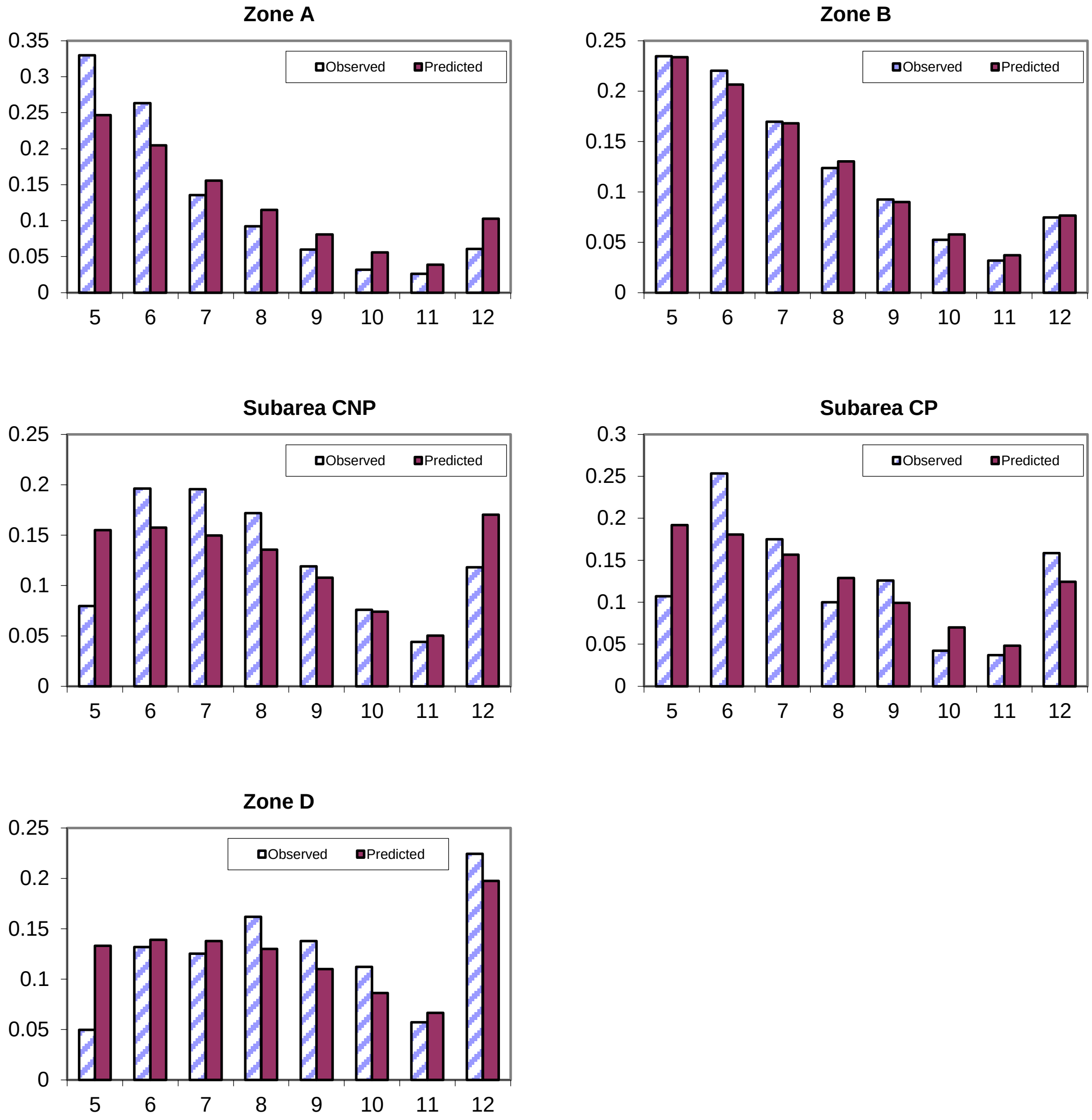


Figure A9. Comparison for the average over all the years between observed and model predicted catch-at-age proportions for the FIAS inshore survey data for Zones A to D for the new Basecase model.

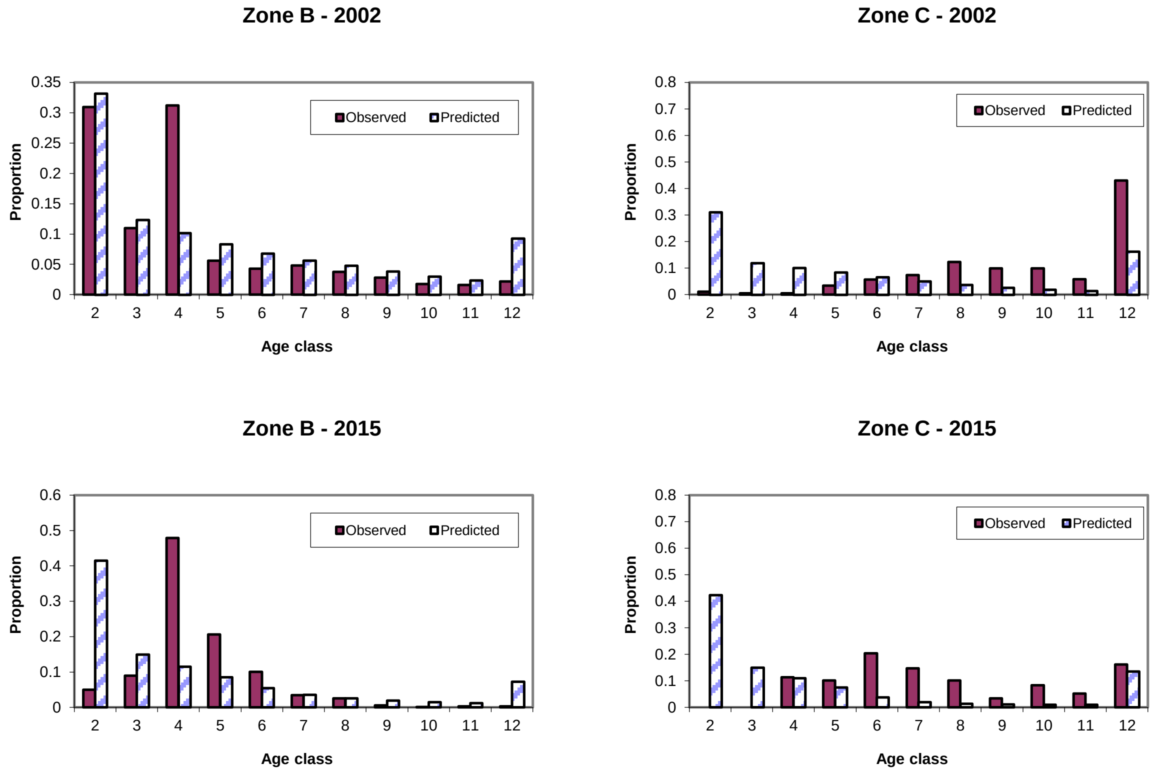


Figure A10. Comparison between observed and model predicted catch-at-age proportions for the full population survey data for Zones B and C for the new Basecase model.

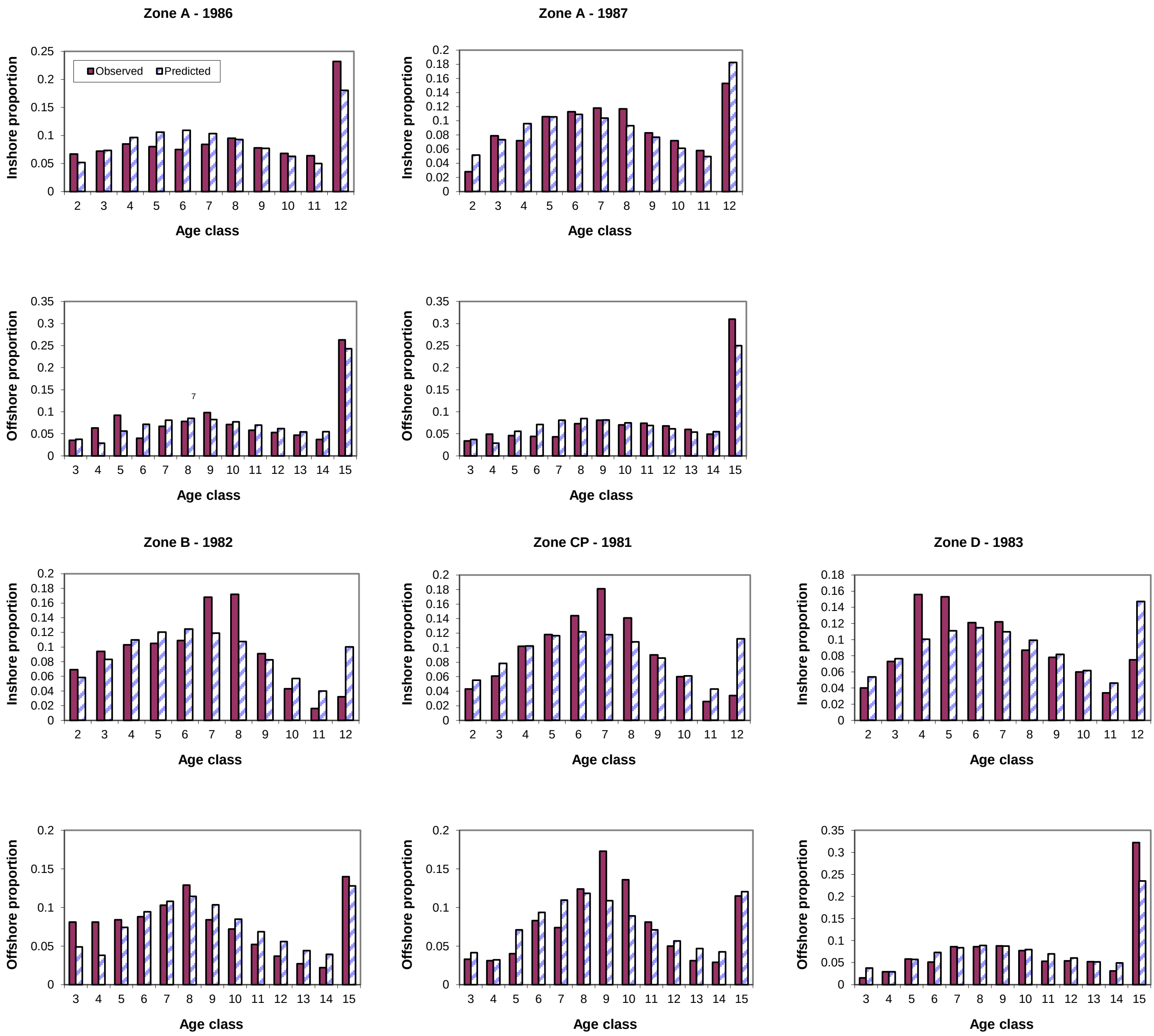


Figure A11. Comparison between observed and model predicted catch-at-age proportions for the “old” inshore and offshore survey data for Zones A to D for the new Basecase model.