Proposed Operating Models to test decision rules for Zone F

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August 2015

Abstract

A set of nine age-structured Operating Models is proposed for simulation testing of revised Decision Rules for Zone F. These nine models reflect all combinations of pre-exploitation spawning biomass of 2 000, 3 000 and 4 500 tonnes, and annual average poaching estimates of 75, 160, 250 and 350 tonnes that are consistent with the data.

Introduction

Revised Decision Rules for setting catch limits in Zone F are needed to take into account that there are now more data available than when the present rules were developed. Possible new Decision Rules need to be tested by applying them to generated future data that are compatible with past data. These computer simulation tests are based on "Operating Models" (OMs) which reflect alternative possible true underlying dynamics of the resource to enable future data to be generated.

This document provides results for the conditioning of several Operating Models that reflect alternative possible values for the unexploited spawning biomass and for the annual average biomass poached since 2008. The OMs developed are Age-Structure Production Models (ASPMs) and are simpler versions of those used to assess abalone for Zones A-D.

Data

The following data have been used.

- GLMM standardised commercial CPUE from 1981 to 2014 (Brandão and Butterworth, 2015a).
- Commercial catches from 1981 to 2015 (for 2015 the TAC is used).
- Commercial catch-at-age data from 1986 to 2014.
- Poaching trend: values from analyses of policing effort and the number of confiscations for 2008 to 2015 (Brandão and Butterworth, 2015b) and a linear increase in poaching from zero in 1995 to the average of the 2008 and 2009 trend values in 2007.
- Poaching catch-at-age data from 1994 to 2015 (data are not available for all years).
- FIAS abundance indices from 1995 to 2014 (data are not available for all years).
- FIAS catch-at-age data from 1996 to 2014 (data are not available for all years).

Methodology

A simpler form of the spatial- and age-structured production model used for assessing abalone in Zones A-D (full details are provided in Brandão and Butterworth (2009) as well as in Plagányi and Butterworth (2010)) has been used. In this analysis, spatial structure in terms of inshore and offshore components have not been taken into account. The selectivity function for the FIAS sector has been assumed to be the same as that estimated for Zones A-D as no poaching catch-at-age proportions were available for the present modelling exercise.

Problems with obtaining realistic estimates of abundance of the resource when most model parameters were freed to be estimated led to the Basecase model presented in Brandão and Butterworth (2015c). Based on initial results presented in Brandão and Butterworth (2015c), a Task Group suggested several possible values for the unexploited spawning biomass (*K*) and for the average annual biomass poached since 2008. These define the Operating Models that will form the basis to generate future data in the simulation exercise of possible Decision Rules for Zone F. The values of 2 000, 3 000 and 4 500t for *K* and for the average annual biomass poached since 2008 of 75, 160, 250 and 350t were suggested by the Task Group. The range of values chosen for *K* were based on the relative of the potential abalone habitat areas (defined as rocky coastline length) around Robben Island and that of Zones A and B and roughly applying that ratio to estimated values of *K* for Zones A and B. The range of values for the average of poached biomass since 2008 were determined by taking into account results from research into the illegal abalone fishery in Hangberg (Hout Bay) (Raemaekers, 2013) and interviews revealed that most fishing is targeted around Robben Island (Zone F). Based on a conservative estimate of an average of 60 divers, each diving an average of 5 times a month, and assuming that each diver catches 80 kg of abalone (whole mass) per dive, an estimated 24 tons of abalone are dived by this group per month (Maharaj *et al*., 2013).

Results

Summary results for the Operating Models and the negative log-likelihood values are reported in Table 1. Table 2 shows the difference in in the negative log-likelihood values from the minimum value obtained. The best fit to the data is obtained by the Operating Model with a value of *K* of 4 500t and average annual poaching since 2008 of 350t. The worst fit occurs for the largest value of

K (4 500t) together with the lowest average in poaching since 2008 (i.e. 75t). Results for the conditioning of the best fitting Operating Model (i.e. *K* = 4 500t and average annual poaching since 2008 of 350t) are given in the Figures. Fits to CPUE for Zones F are shown in Figure 1, selectivity functions for the commercial, FIAS and poaching sectors in Figure 2, FIAS data in Figure 3, the spawning biomass trajectory in Figures 4, and annual poaching estimates (by number and biomass) in Figure 5. Legal and illegal catches as well as commercial exploitable biomass are shown in Figure 6. Fits to the catch-at-age proportions for the commercial sector are shown in Figure 7, for the FIAS surveys in Figure 8 and for the poaching sector in Figure 9. Bubble plots of the standardised residuals for these catch-at-age proportions are shown in Figure 10. Figure 11 compares spawning biomass trajectories for the three best fitting Operating Models, while Figure 12 shows this comparison for the annual poaching estimates. Figure 13 shows these values for the latter period only to enable readier comparison. Figure 14 shows a comparison of the fits of the CPUE indices by these three Operating Models; while the model with *K* = 3 000t and average annual poaching since 2008 of 250t provides the best fit to the CPUE data, the one with *K* = 4 500t and average annual poaching since 2008 of 350t provides a better fit to the age structure data and overall.

References

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Raemaekers, S. 2013. Extracts from recent student work related to illegal abalone fishing on the Cape Peninsula. FISHERIES/2013/AUG/SWG-AB/10.

Table 1. Summary results for the Operating Models for Zone F, including the values of the negative of the log-likelihood function (-*ln* L) for the various data sets to which the model is fitted. The best and the worst of these values are bolded. The Operating Models are distinguished by the notation "K – average poaching since 2008" (both in tonnes).

	2000-75	**2000-160**	**3000-75**	**3000-160**	**3000-250**	**4500-75**	**4500-160**	**4500-250**	**4500-350**
B_{2015}/K	0.677	0.446	0.787	0.606	0.458	0.859	0.742	0.613	0.487
P_{max} (MT)	172.6	278.4	166.9	358.5	425.4	159.3	367.8	561.6	647.2
-ln L(CPUE)	-8.057	-11.712	-6.476	-9.696	-11.863	-5.630	-7.410	-9.688	-11.663
-ln L(FIAS)	-3.620	-4.160	-3.367	-3.814	-4.112	-3.201	-3.519	-3.812	-4.048
-ln L(CAA_{com})	0.224	0.313	0.455	-0.179	-0.433	0.589	0.186	-0.249	-0.482
-ln L(CAA_{FIAS})	-2.117	-1.225	-2.395	-2.319	-1.623	-2.456	-2.628	-2.547	-1.986
-ln L(CAA_{poa})	3.610	4.982	3.489	3.778	4.728	3.439	3.546	3.774	4.362
-ln L(trend se)	0.337	0.451	0.155	0.520	0.520	0.068	0.280	0.532	0.512
-ln L(Total)	-9.623	-11.977	-8.138	-11.710	-12.783	**-7.191**	-9.545	-11.991	**-13.303**

Table 2. Differences in the values of the negative of the log-likelihood function (-*ln* L) from the minimum value obtained for the Operating Models for Zone F.

		Average poaching			
		75	**160**	**250**	**350**
K	**2 000**	-3.680	-1.326	—	—
	3 000	-5.165	-1.593	-0.520	—
	4 500	-6.112	-3.758	-1.312	0.000

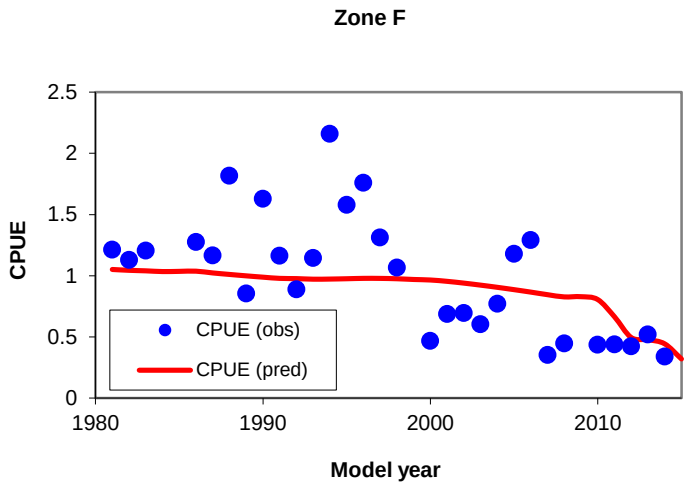

Figure 1. Comparisons between the standardised CPUE (obs) and model-predicted CPUE values for the best fitting Operating Model (K = 4 500t, average poaching since 2008 = 350t) for Zone F.

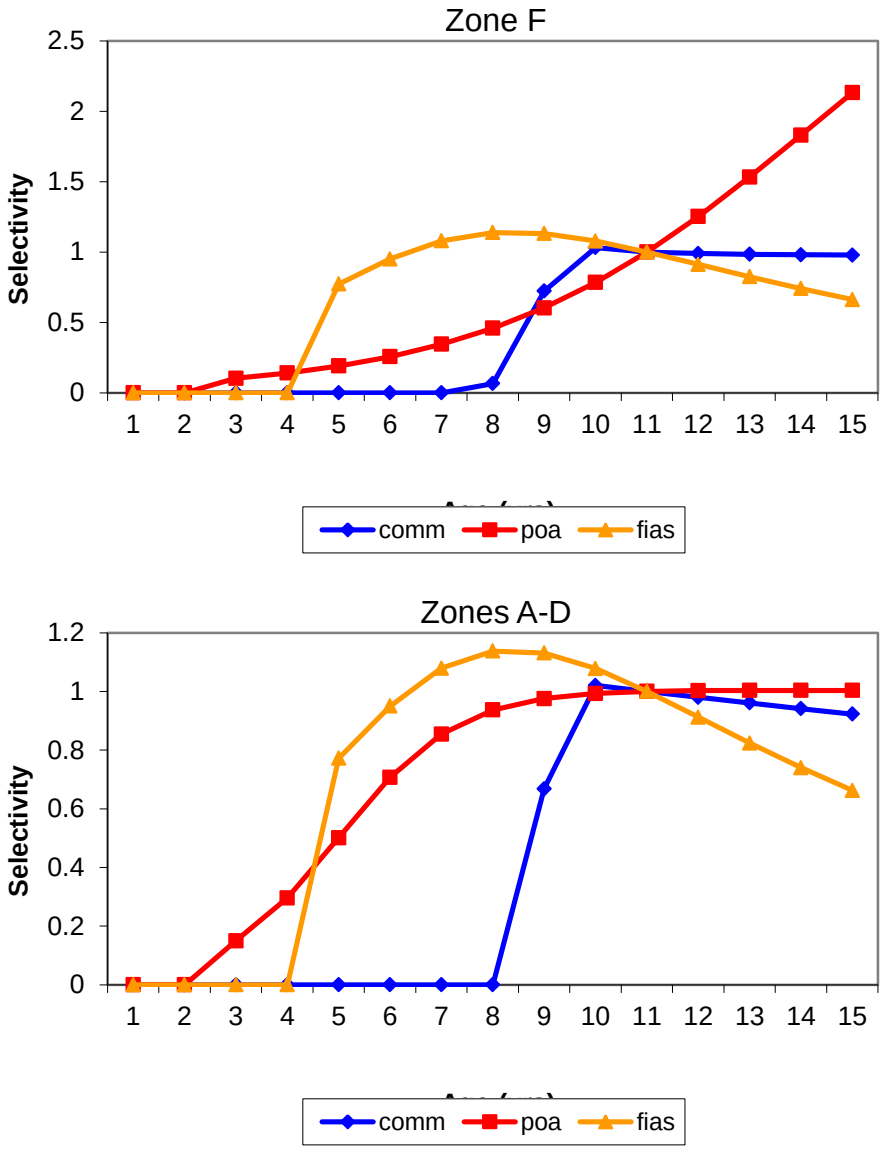

Figure 2. Plots of the best fitting Operating Model (K = 4 500t, average poaching since 2008 = 350t) for Zone F selectivity functions estimated for the commercial and poaching sectors, and the selectivity function for the FIAS sector fixed to be the same as that estimated for Zones A-D. For comparison the bottom plot shows the selectivity functions estimated for Zones A-D.

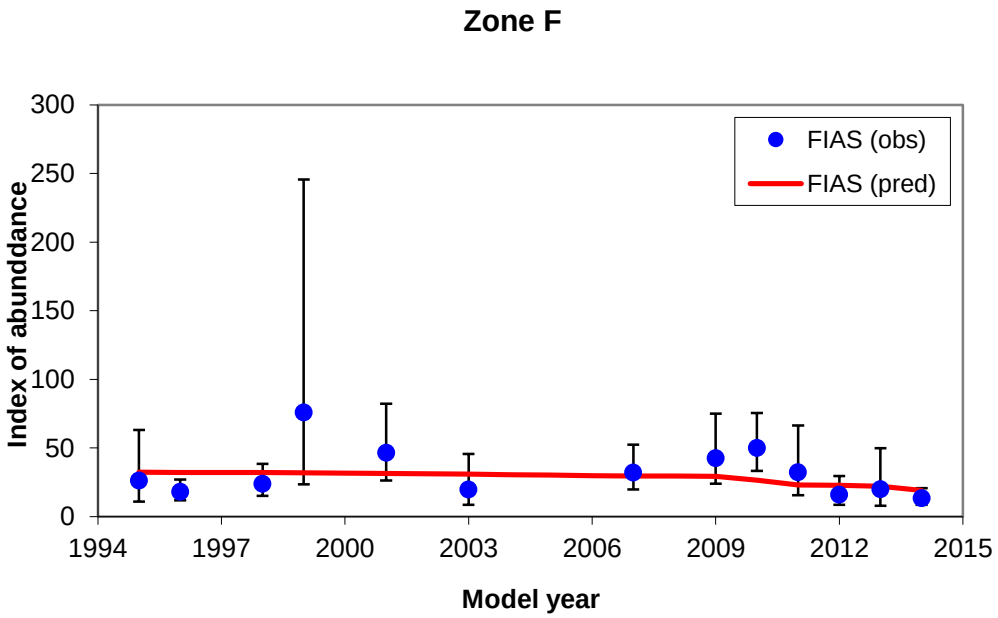

Figure 3. Comparison of observed and model-predicted FIAS values for the best fitting Operating Model (K = 4 500t, average poaching since 2008 = 350t) for Zone F. Note that the 95% confidence intervals shown have been computed as: estimate*exp(±1.96*CV).

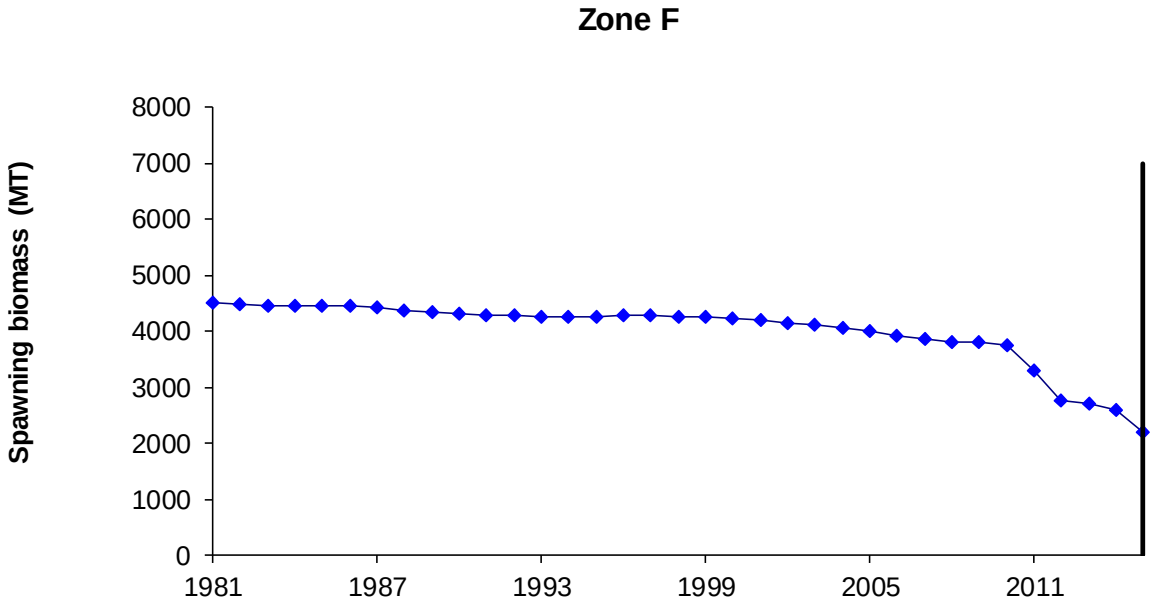

Figure 4. Spawning biomass trajectories shown for Zone F for the best fitting Operating Model (K = 4 500t, average poaching since 2008 = 350t).

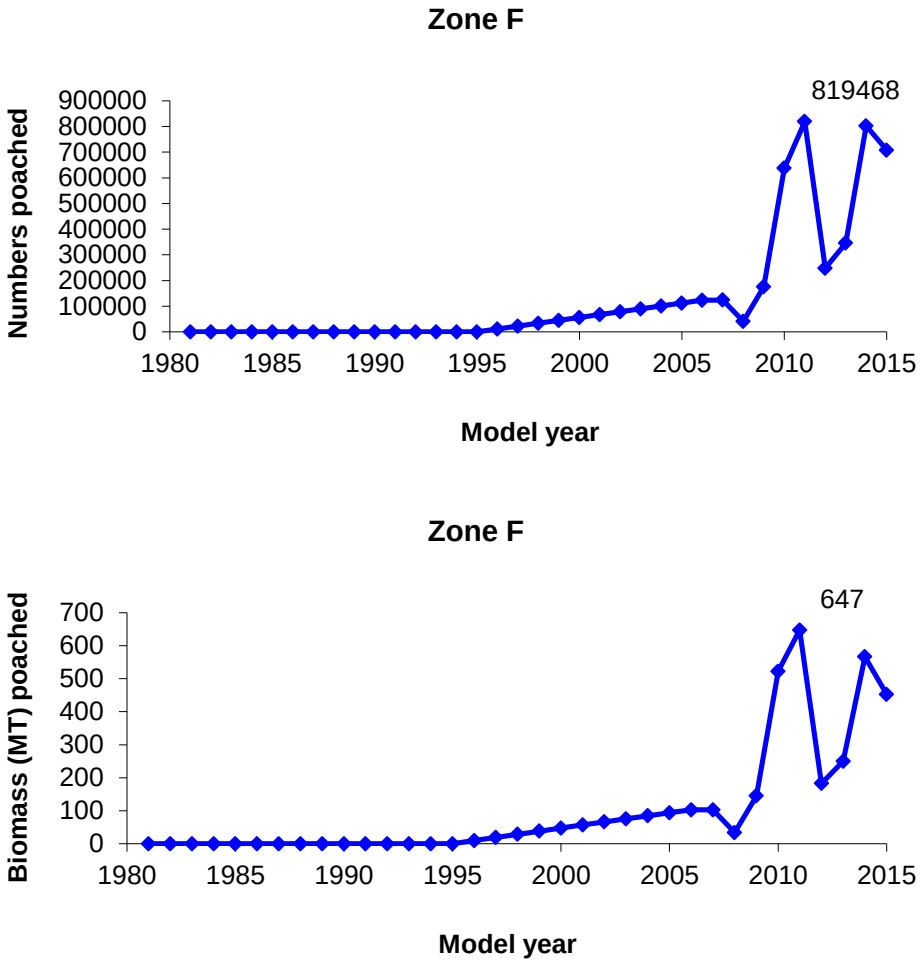

Figure 5. Model-predicted numbers (top) and biomass (bottom) of abalone poached for Zone F for the best fitting Operating Model (K = 4 500t, average poaching since 2008 = 350t).

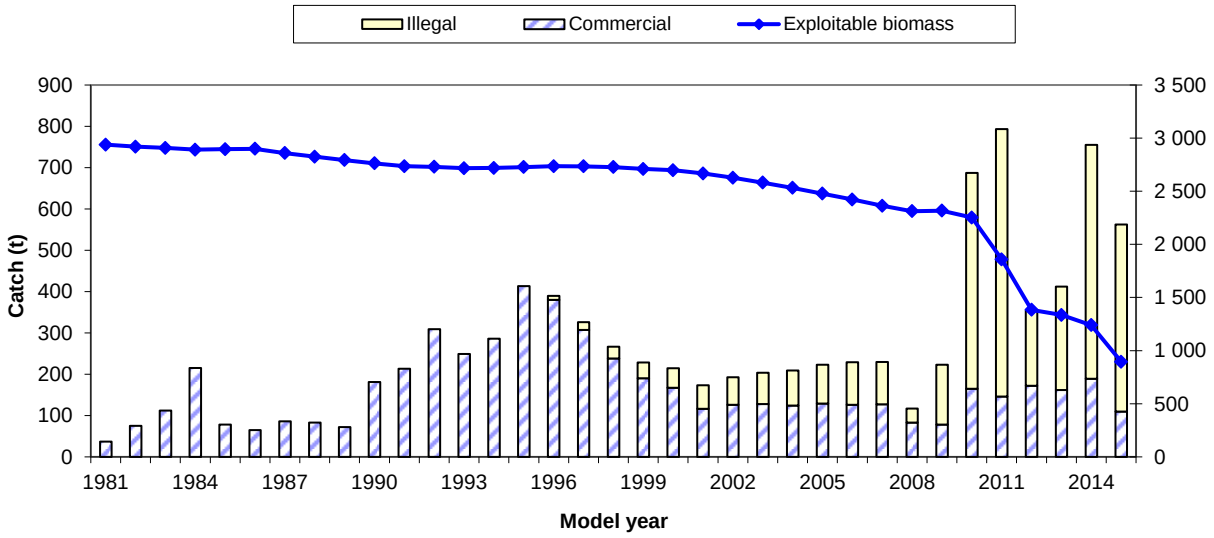

Figure 6. Estimated commercial exploitable biomass for the best fitting Operating Model (K = 4 500t, average poaching since 2008 = 350t) for Zone F (right hand axis) in tonnes and total catches (commercial + estimated illegal) for the Zone (left hand axis).

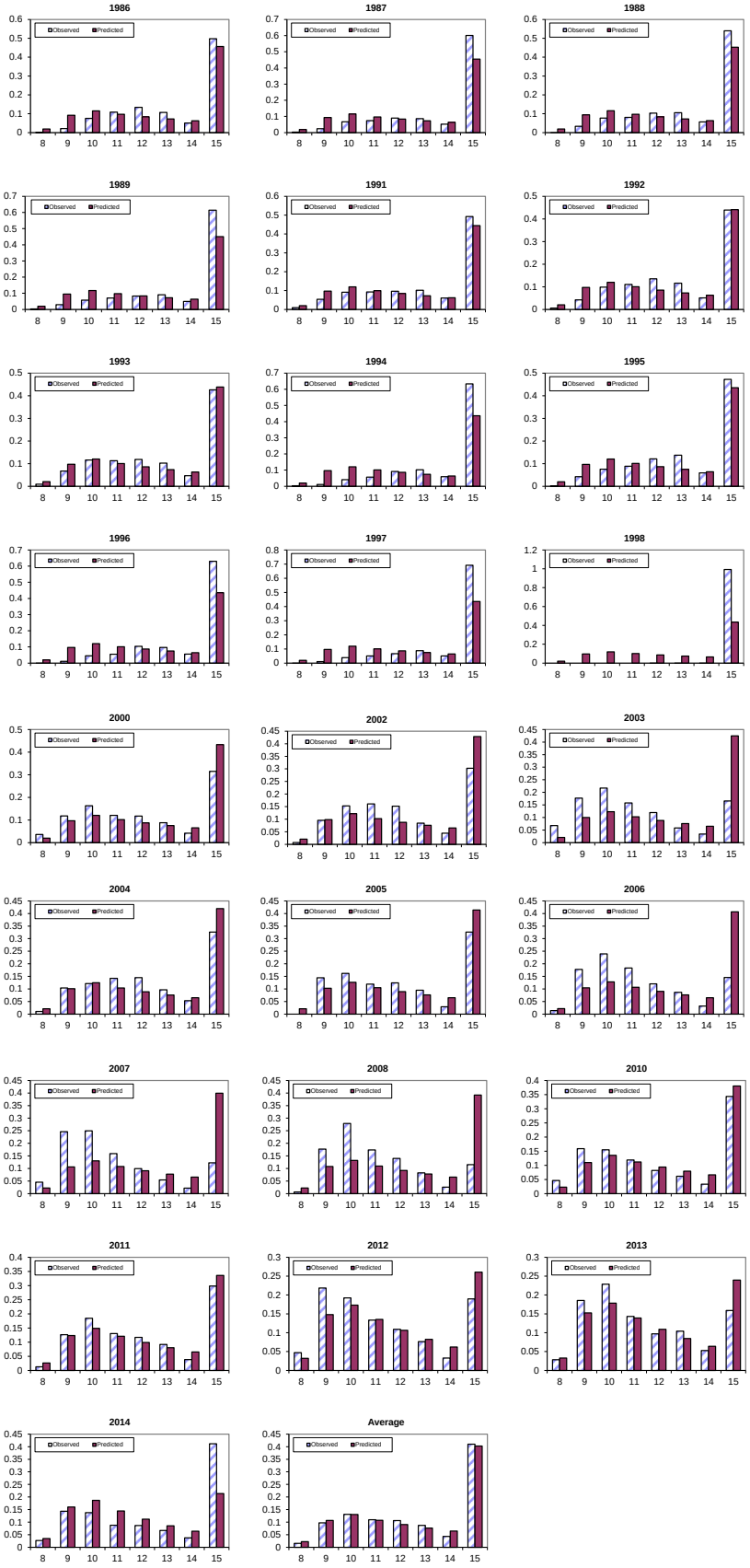

Figure 7. Comparison between observed and model predicted catch-at-age proportions for the commercial sector for Zone F for the best fitting Operating Model (K = 4 500t, average poaching since 2008 = 350t). The last plot shows the comparison for the average over all the years.

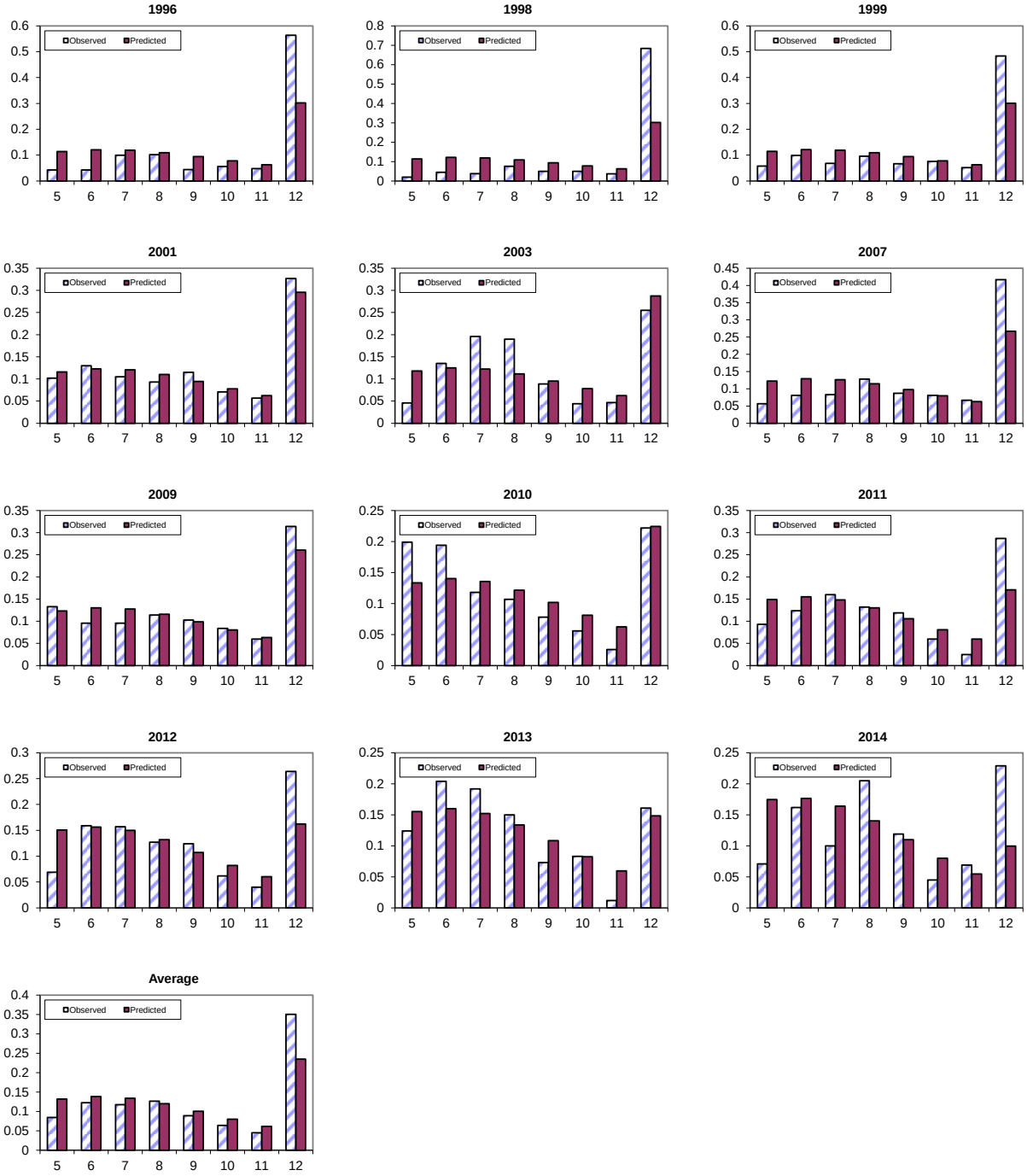

Figure 8. Comparison between observed and model predicted catch-at-age proportions for the FIAS survey data for Zone F for the best fitting Operating Model (K = 4 500t, average poaching since 2008 = 350t). The last plot shows the comparison for the average over all the years.

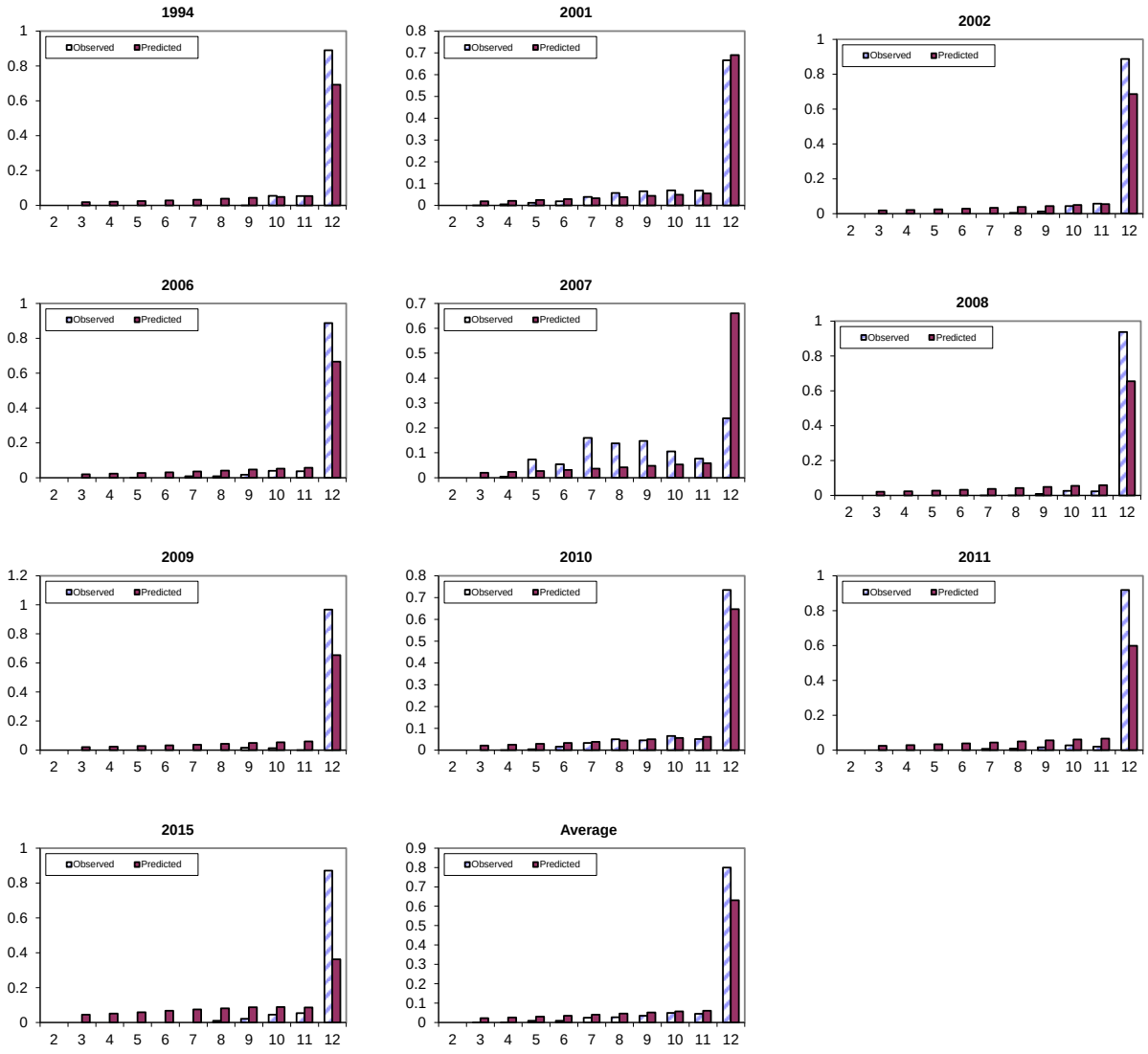

Figure 9. Comparison between observed and model predicted catch-at-age proportions for the poaching sector for Zone F for the best fitting Operating Model (K = 4 500t, average poaching since 2008 = 350t). The last plot shows the comparison for the average over all the years.

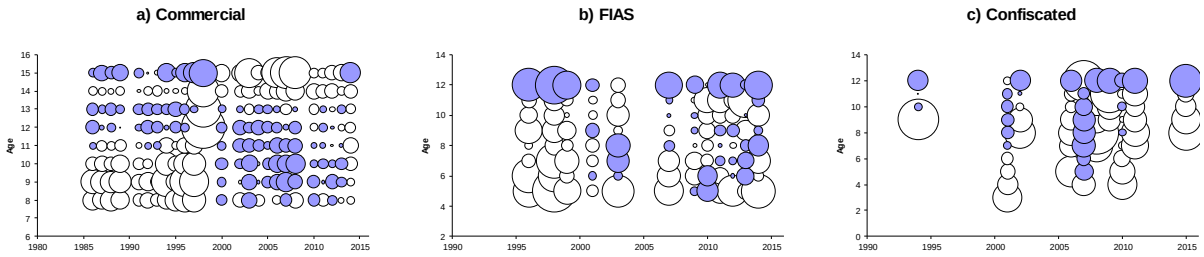

Figure 10. Catch-at-age residuals for Zone F for a) the commercial data, b) the FIAS data and c) the poaching data for the best fitting Operating Model (K = 4 500t, average poaching since 2008 = 350t). The size (radius) of the "bubble" in the plots is proportional to the corresponding standardized residual ((ln(obs)-ln(pred))/(sigma/sqrt(pred))). White bubbles represent negative residuals and grey bubbles represent positive residuals.

Figure 11. Comparison of spawning biomass trajectories for Zone F for the three best fitting Operating Models.

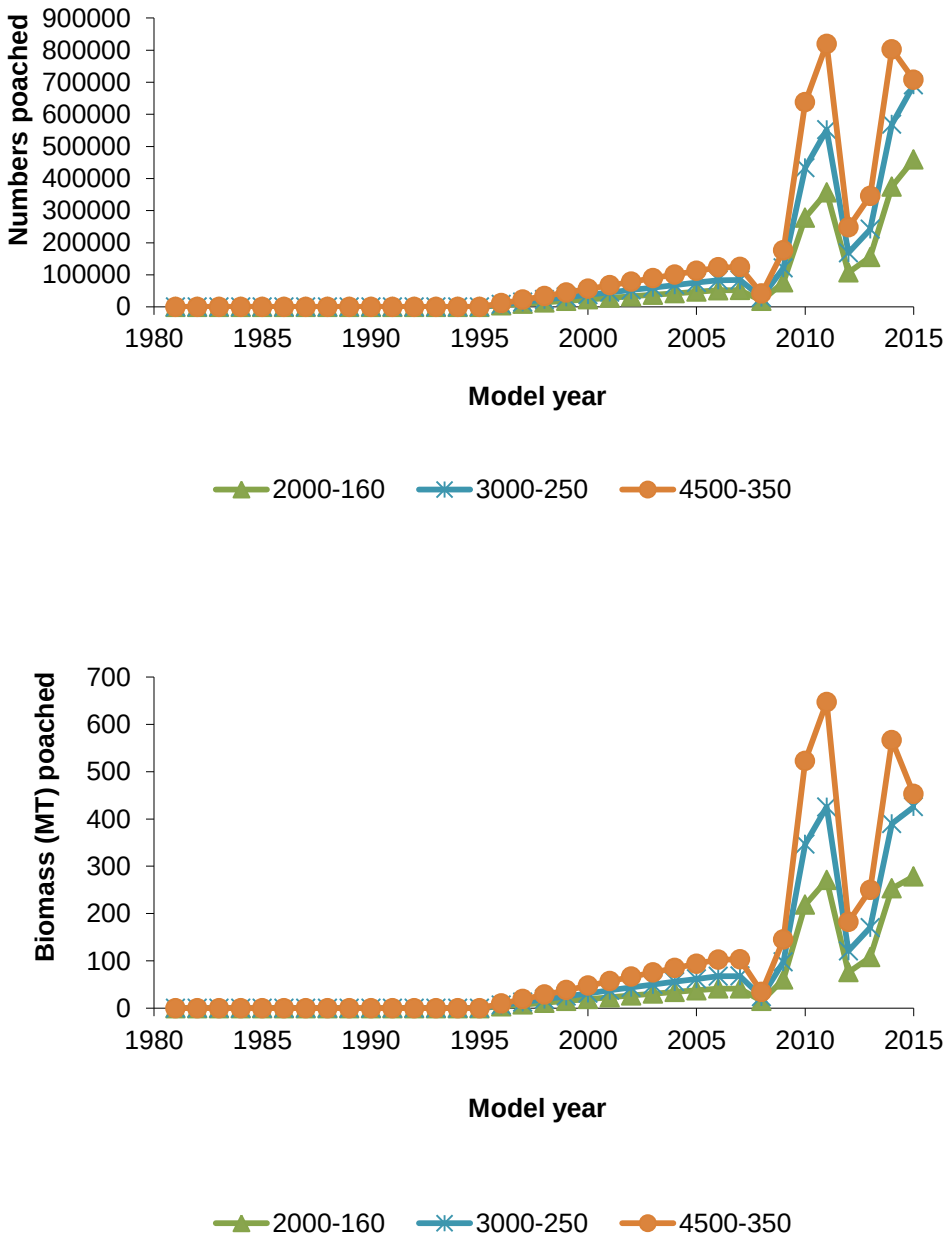

Figure 12. Comparison of model-predicted numbers (top) and biomass (bottom) of abalone poached for Zone F for the three of the best fitting Operating Models.

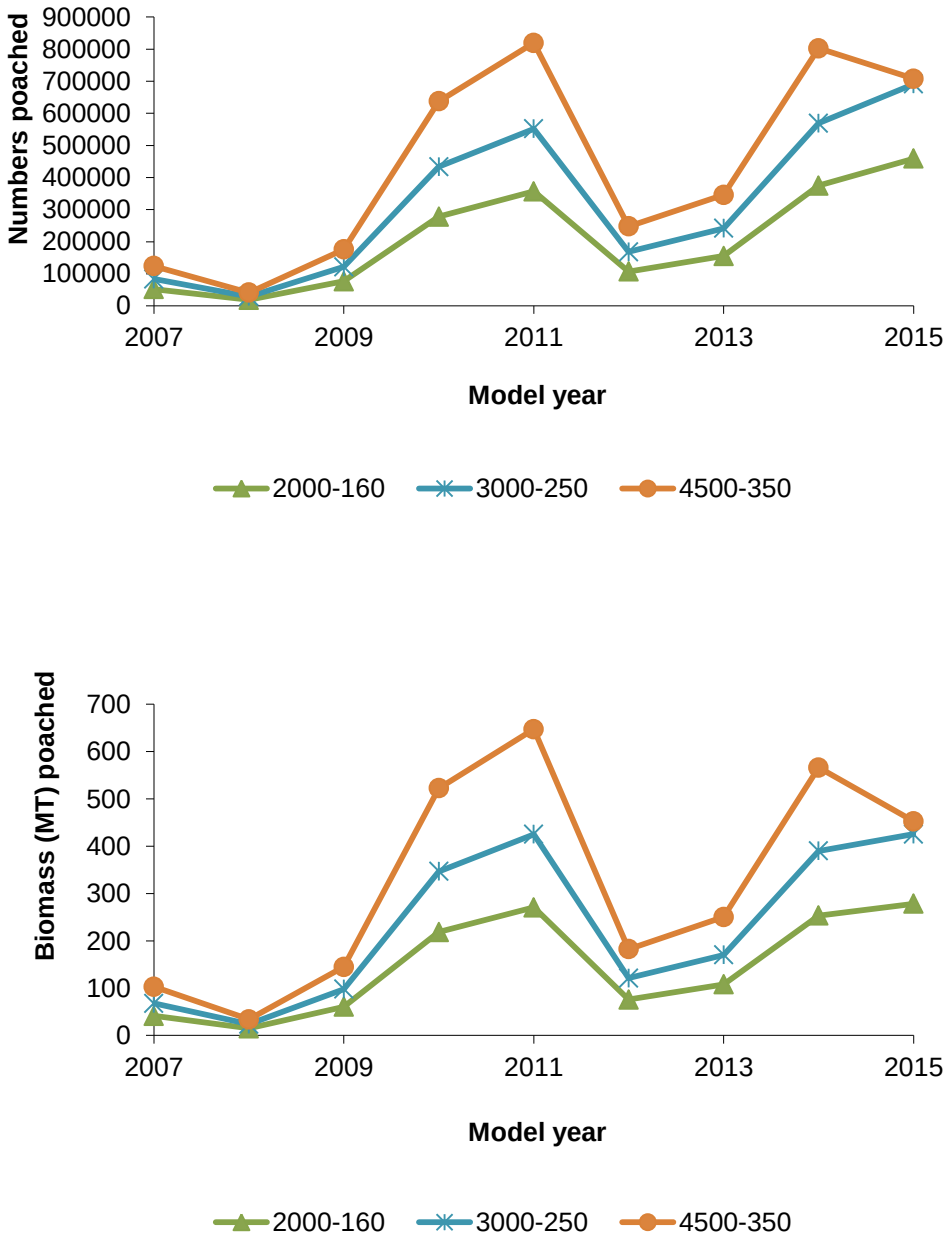

Figure 13. Zoomed comparison of model-predicted numbers (top) and biomass (bottom) of abalone poached for Zone F for the three best fitting Operating Models.

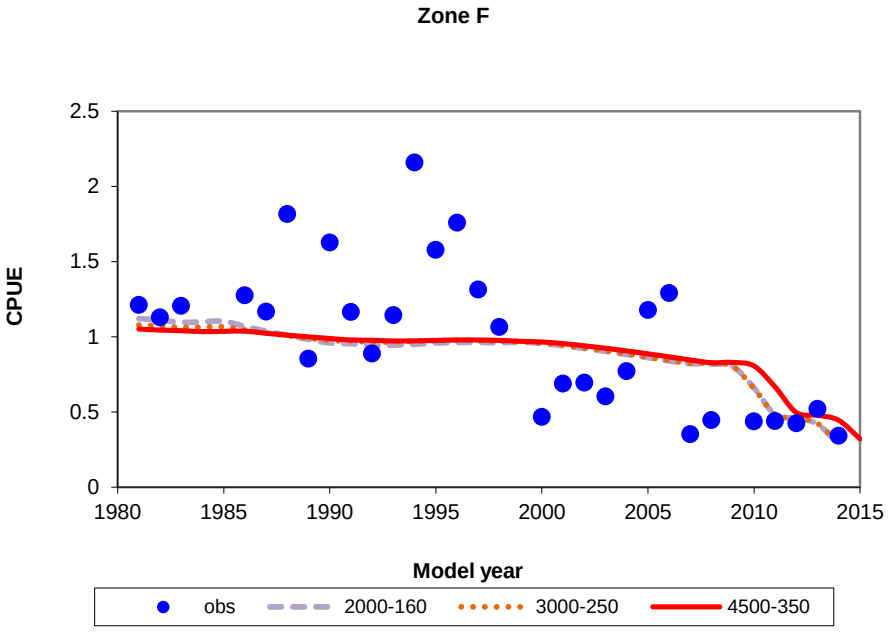

Figure 14. Comparisons between the standardised CPUE (obs) and model-predicted CPUE values for the three best fitting Operating Models for Zone F.