

Conditioning of the Reference Set of Operating Models for the toothfish resource in the Prince Edward Islands vicinity

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ABSTRACT

Conditioning results for the Reference Set of Operating Models identified at a Task Team meeting and described in Brandão *et al.* (2019) are given. The assumptions that show more marked differences in the conditioning results from those of the Base case OM01 are changes in natural mortality (OM02 and OM03), up-weighting all CPUE data by a factor of 10 (OM10), a change in recruitment residual standard deviation (OM11), alternative von Bertalanffy growth parameters (OM12) and large values of tag loss which are assumed to force good fits to the trotline CPUE (OM16 and OM17).

INTRODUCTION

This paper gives results for the conditioning of the Reference Set of Operating Models (OMs) that were identified in Table 1 of Brandão *et al.* (2019) and which form the main part of the suggested evaluation trials. Table 1 lists these OMs and gives details of the differences between the Base case OM (OM01) and each alternative OM.

RESULTS AND DISCUSSION

Table 2 gives some parameter estimates for the Reference Set OMs and Table 3 gives the contribution to the negative log-likelihood of the different data components fit by these models.

Spawning biomass trajectories for all OMs compared to the Base case OM (OM01), which is depicted by the thick red line, are shown in Figure 1, while Figure 2 shows the spawning biomass depletion trajectories. Estimated recruitment (Figure 3) and estimated recruitment residual (Figure 4) trajectories for all OMs are also given. Figures 5 and 6 show fits to the longline and trotline CPUE data respectively. Fits to the tag-recapture data are shown in Figure 7.

A positive definite Hessian matrix was obtained for all OMs except for OM02 for which natural mortality is assumed to be lower than for OM01.

The assumptions that show more marked differences in the conditioning results from those of OM01 are changes in natural mortality (OM02 and OM03), up-weighting all CPUE by a factor of 10 (OM10), change in recruitment residual standard deviation (OM11), alternative von Bertalanffy growth parameters (OM12) and large values of tag loss assumed to force good fits to the trotline CPUE (OM16 and OM17).

Although results are given here for OM11 (alternative recruitment residual standard deviation values), this OM forms part of the robustness set of trials as suggested in Brandão *et al.* (2019) rather than being a member of the Reference Set. It was included here because the OMs for which results are reported in this document were set up to represent the different options given in Table 1 of Brandão *et al.* (2019) and not necessarily the evaluation trials alone.

REFERENCE

Brandão, A., Butterworth, D.S. and Durholtz, D. 2019. Continuation of the development of an OMP for the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands region. DAFF Branch Fisheries document: FISHERIES/2019/MAR/SWG-DEM/02.

Table 1. List of the Reference Set OMs with details of the differences between the Base case OM (OM01) and each alternative OM.

Operating Model	Description	Base case values
OM01	Base case	
OM02	Natural mortality = 0.10	0.13
OM03	Natural mortality = 0.16	0.13
OM04	Steepness parameter $h = 0.6$	0.75
OM05	Steepness parameter $h = 0.9$	0.75
OM06	Cetacean predation (longlines) = +30%	+10%
OM07	Cetacean predation (trotlines) = 0%	+5%
OM08	Cetacean predation (trotlines) = +10%	+5%
OM09	Weight applied to all CPUE = 5	1
OM10	Weight applied to all CPUE = 10	1
OM11	$\sigma_R = 0.1$ (until 1997), 0.5 (after 1997)	0.5
OM12	$\ell_\infty = 174.5$ $\kappa = 0.0425$ $t_o = -1.4575$	$\ell_\infty = 152.0$ $\kappa = 0.067$ $t_o = -1.49$
OM13 [†]	$c = 4.09 \times 10^{-9}$ $d = 3.196$	$c = 2.54 \times 10^{-8}$ $d = 2.8$
OM14 [†]	$c = 4.17 \times 10^{-9}$ $d = 3.206$	$c = 2.54 \times 10^{-8}$ $d = 2.8$
OM15	Tag reporting rate = 0.8	1
OM16	Annual tag loss/mortality rate = 0.8	0
OM17	Annual tag loss/mortality rate = 0.5	0

[†] The weight at length conversion is given in terms of cm to tonnes.

Table 2. Some parameter estimates for the Reference Set OMs.

Operating Model	K^{SP} (tonnes)	B_{1997}^{SP} / K^{SP}	B_{2018}^{SP} / K^{SP}	$MSYL_{Longline}^{SP} / K^{SP}$	$B_{2018}^{SP} / MSYL_{Longline}^{SP}$	$B_{2018}^{SP} / MSYL_{Trotline}^{SP}$	$MSY_{Longline}$ (tonnes)	MSY_{Pot} (tonnes)	$MSY_{Trotline}$ (tonnes)
OM01	28329	1.365	0.403	0.243	1.655	1.640	1134	1251	1188
OM02	35568	1.160	0.504	0.252	2.002	1.996	962	1122	1020
OM03	22982	1.678	0.348	0.236	1.479	1.463	1285	1352	1322
OM04	28919	1.313	0.383	0.305	1.254	1.245	903	1007	948
OM05	28009	1.399	0.416	0.166	2.508	2.481	1402	1529	1466
OM06	29032	1.359	0.403	0.243	1.654	1.640	1162	1283	1218
OM07	27726	1.371	0.398	0.243	1.638	1.624	1110	1225	1162
OM08	28929	1.359	0.406	0.243	1.671	1.656	1157	1278	1213
OM09	27235	1.493	0.396	0.242	1.634	1.625	1081	1195	1129
OM10	24461	1.756	0.425	0.241	1.762	1.756	961	1067	1003
OM11	52278	1.045	0.486	0.245	1.983	1.965	2100	2309	2173
OM12	32527	2.391	0.592	0.250	2.364	2.380	1117	1193	1154
OM13	30372	1.355	0.404	0.250	1.614	1.600	1074	1230	1144
OM14	30426	1.355	0.404	0.251	1.613	1.599	1073	1230	1143
OM15	25145	1.404	0.366	0.243	1.503	1.491	1007	1111	1054
OM16	11738	2.065	0.144	0.245	0.589	0.588	475	521	492
OM17	14646	1.828	0.217	0.244	0.888	0.885	590	648	613

Table 3. Contribution to the negative log-likelihood by different data components for the Reference Set of OMs. Those given in italics are not comparable across the OMs.

Operating Model	Total	Total relative to OM01	Catch at length			CPUE		Tagging		Recruit. residual
			Longline	Pot	Trotline	Longline	Trotline	Longline	Trotline	
OM01	-734.2	0	-492.5	-74.5	-363.3	-8.96	-7.79	41.4	158.6	12.956
OM02	-750.8	-16.6	-495.4	-78.8	-366.3	-8.10	-6.89	41.3	160.0	3.367
OM03	-702.5	31.7	-486.9	-65.8	-360.1	-9.63	-8.91	41.6	158.6	28.634
OM04	-736.1	-1.9	-492.8	-74.2	-363.4	-8.97	-7.75	41.4	158.5	11.074
OM05	-733.0	1.2	-492.4	-74.8	-363.3	-8.96	-7.83	41.3	158.8	14.189
OM06	-735.0	-0.8	-492.5	-74.6	-363.2	-10.07	-7.75	42.0	158.8	12.338
OM07	-733.6	0.6	-492.9	-74.6	-363.3	-9.09	-7.78	41.5	158.7	13.838
OM08	-734.7	-0.5	-492.1	-74.5	-363.3	-8.83	-7.80	41.3	158.5	12.126
OM09	<i>-806.1</i>	—	<i>-491.8</i>	<i>-78.1</i>	<i>-363.4</i>	<i>-49.47</i>	<i>-45.59</i>	<i>41.6</i>	<i>157.1</i>	<i>23.669</i>
OM10	<i>-906.9</i>	—	<i>-488.1</i>	<i>-81.3</i>	<i>-361.0</i>	<i>-104.70</i>	<i>-108.96</i>	<i>41.9</i>	<i>158.7</i>	<i>36.534</i>
OM11	-673.4	60.8	-411.3	-51.5	-379.3	-5.72	-7.20	38.6	174.5	-31.443
OM12	-555.4	178.8	-470.7	-73.9	-349.2	-4.19	-12.75	63.7	230.5	61.092
OM13	-733.9	0.3	-493.0	-74.5	-363.4	-8.97	-7.90	41.5	158.6	13.815
OM14	-733.9	0.3	-493.0	-74.5	-363.4	-8.97	-7.90	41.5	158.6	13.837
OM15	-733.1	1.1	-494.9	-74.6	-363.7	-9.68	-8.18	41.2	158.5	18.214
OM16	-702.0	32.2	-508.9	-74.5	-366.1	-8.52	-15.82	42.5	163.4	65.898
OM17	-718.6	15.6	-505.1	-75.0	-365.5	-10.21	-11.89	41.9	158.2	48.893

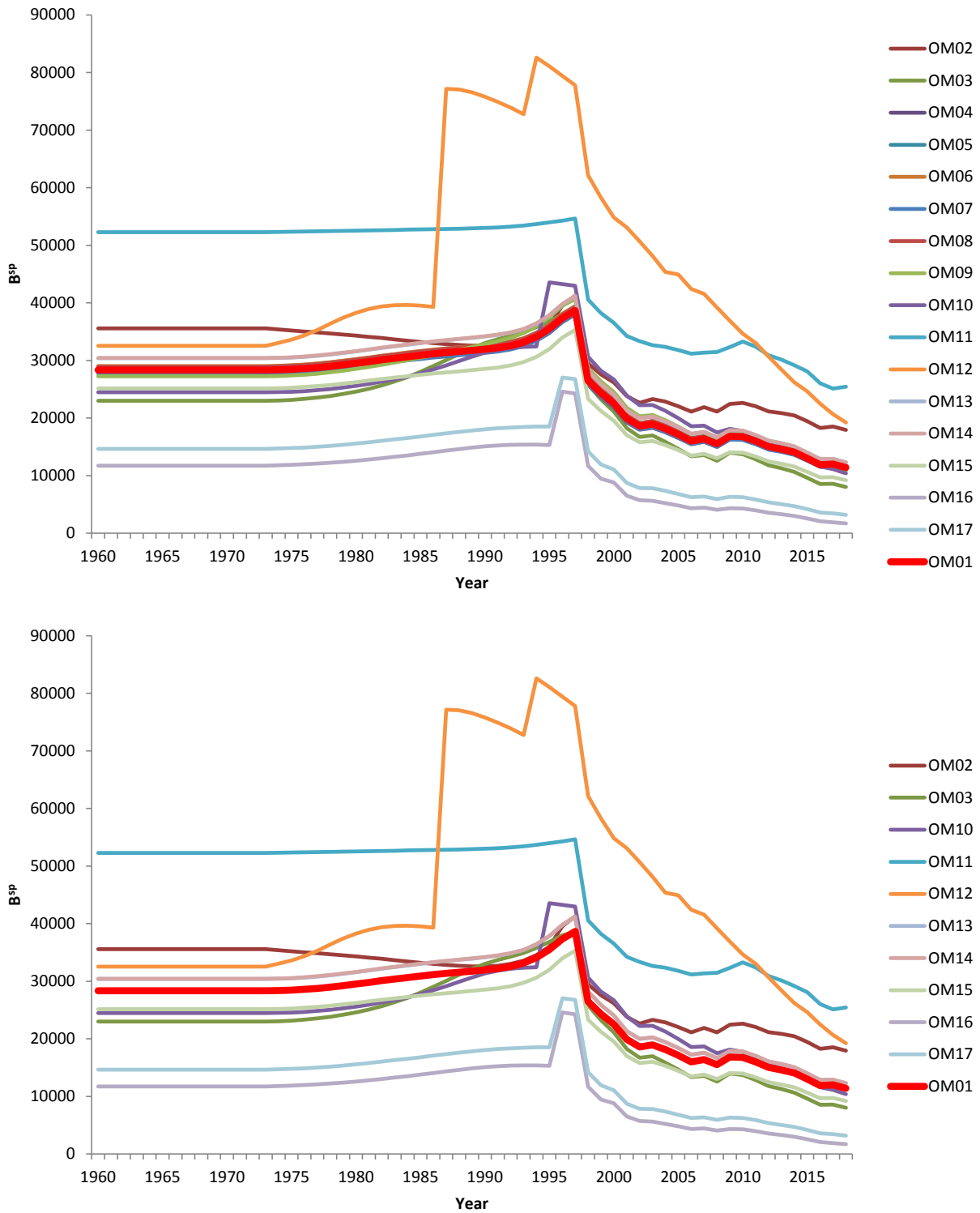


Figure 1. Spawning biomass trajectories for all OMs (above) and for only those OMs showing an appreciable difference in trajectory compared to the Base case OM (OM01) (below).

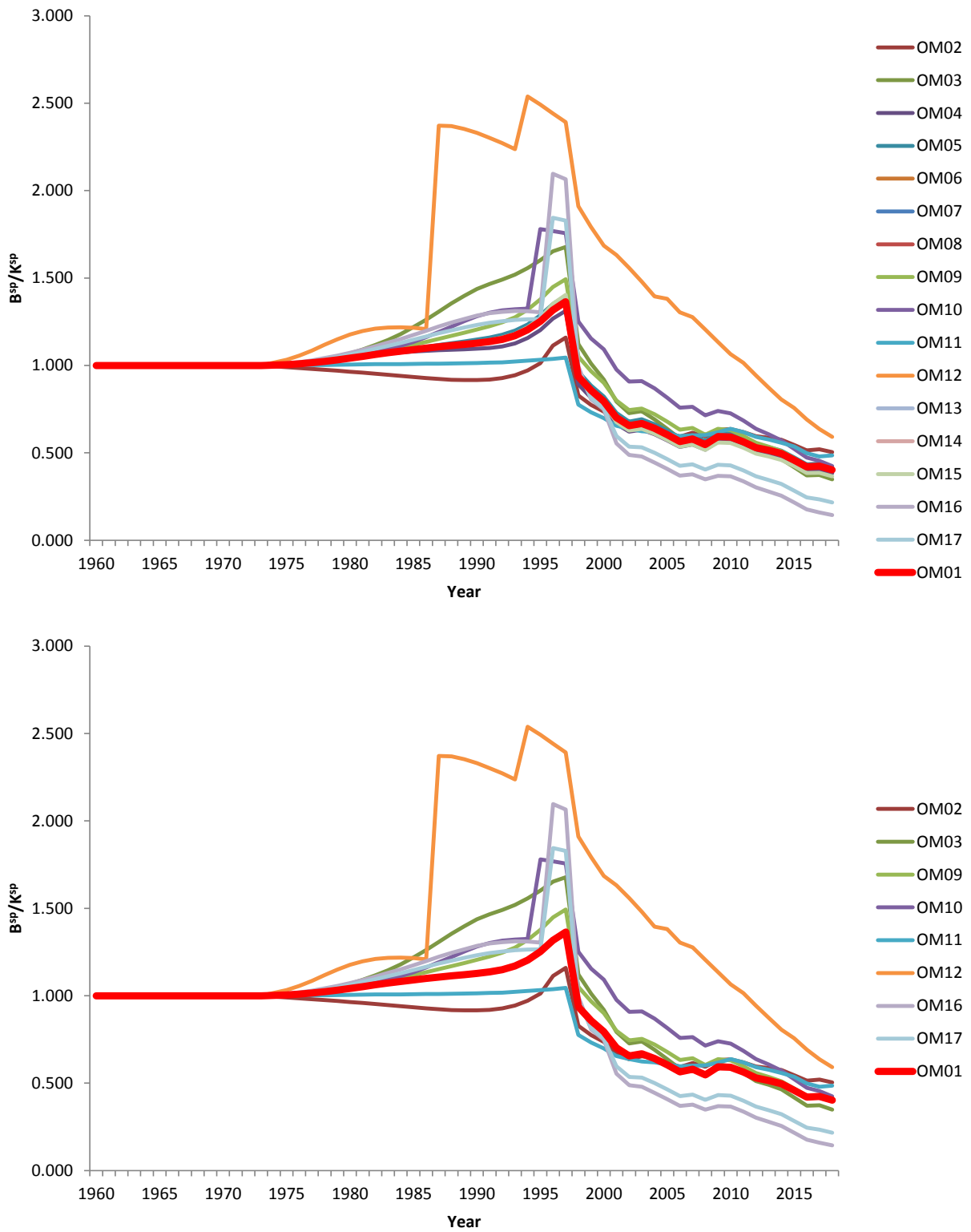


Figure 2. Spawning biomass depletion trajectories for all OMs (above) and for only those OMs showing an appreciable difference in trajectory compared to the Base case OM (OM01) (below).

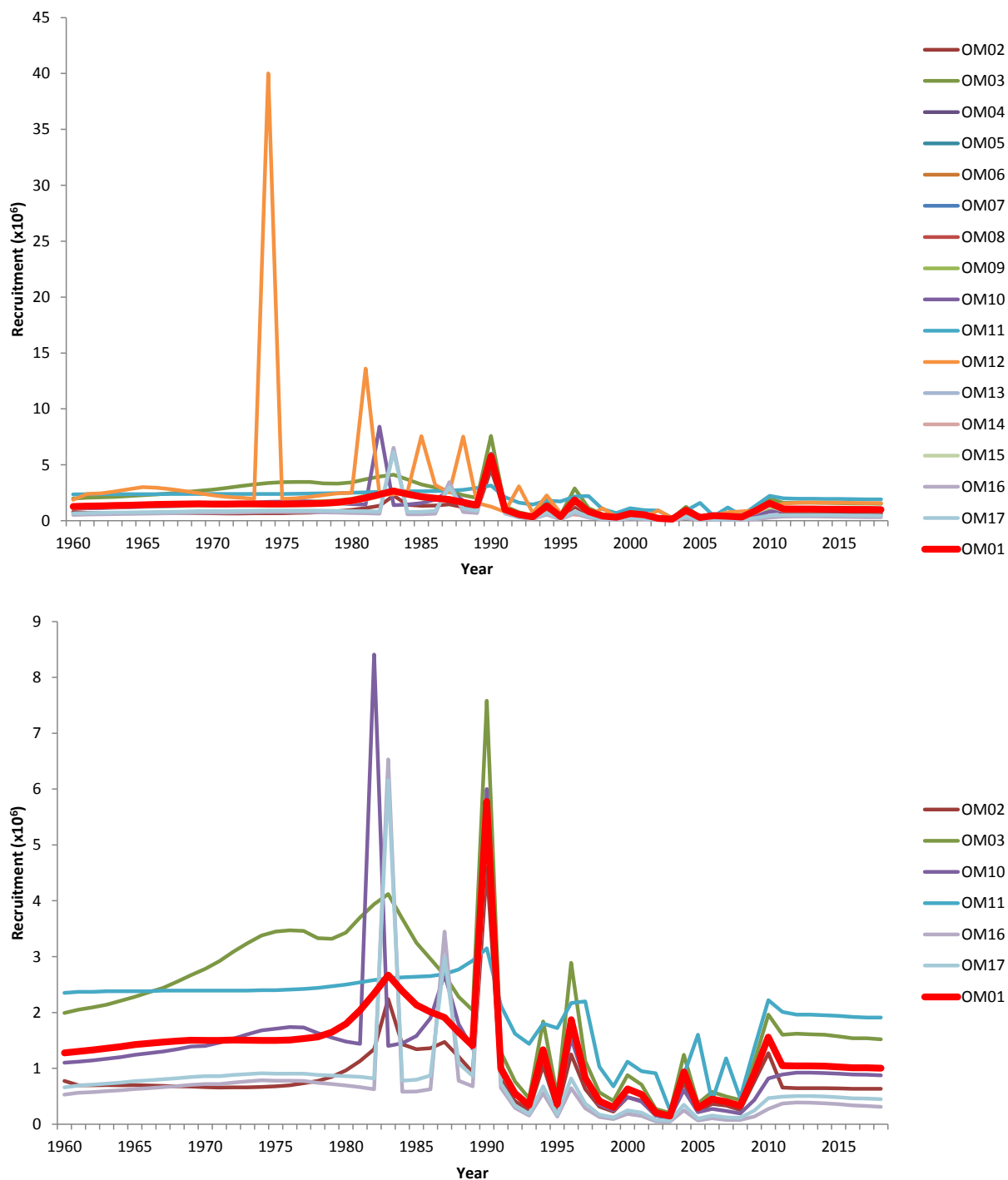


Figure 3. Estimated recruitment trajectories for all OMs (above), and for only OMs showing an appreciable difference in trajectory compared to the Base case OM (OM01) together with OM12 removed to enable a better distinction between trajectories (below).

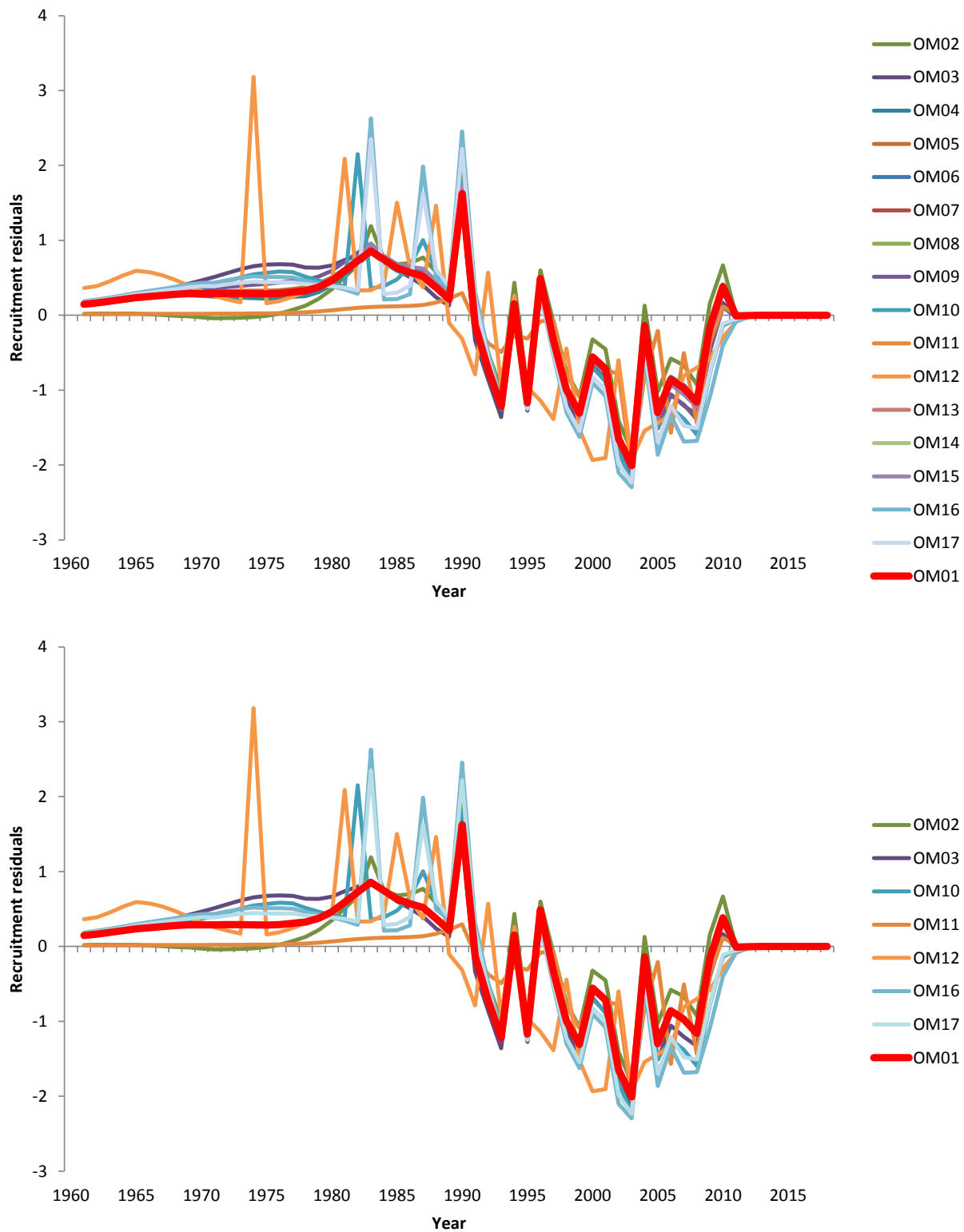


Figure 4. Estimated recruitment residual trajectories for all OMs (above), and for only OMs showing an appreciable difference in trajectory compared to the Base case OM (OM01) together with OM12 removed to enable a better distinction between trajectories (below).

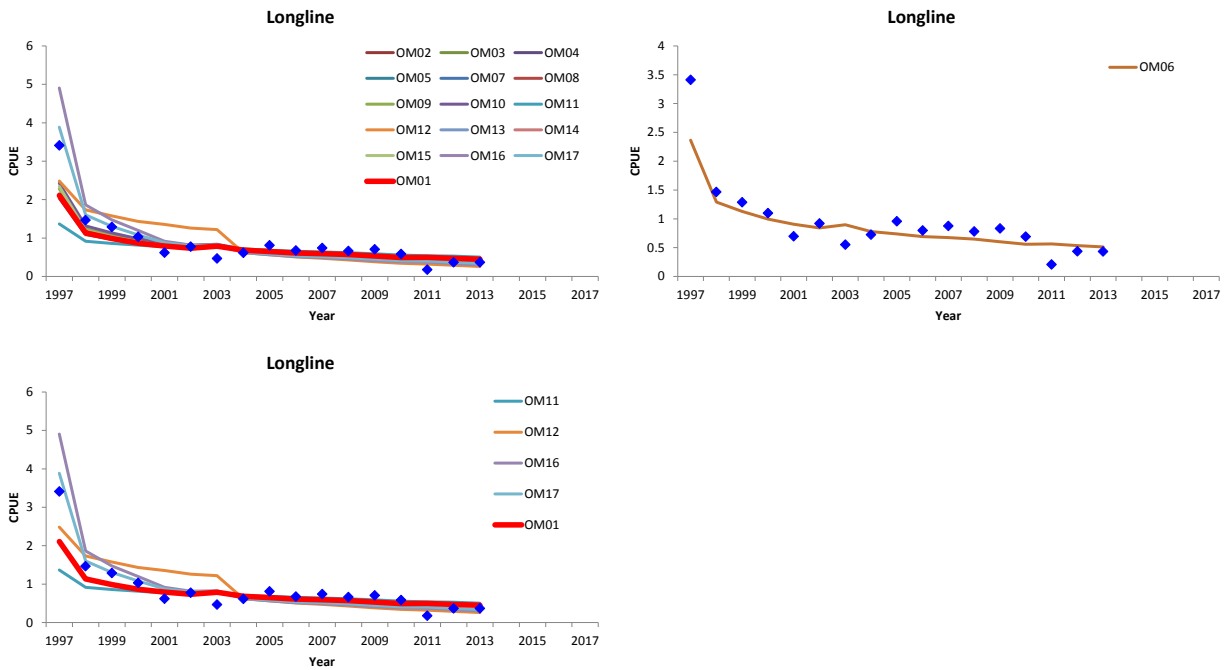


Figure 5. Exploitable biomass and the GLM-standardised CPUE indices for **longlines** to which the OMs are fit (divided by the estimated catchability q to express them in biomass units) for all OMs (above left) and for only OMs showing an appreciable difference in trajectory compared to the Base case OM (OM01) (below left). The fit to the CPUE data for OM06 is shown separately (above right) because the assumed cetacean predation on longlines differs for this Operating Model.

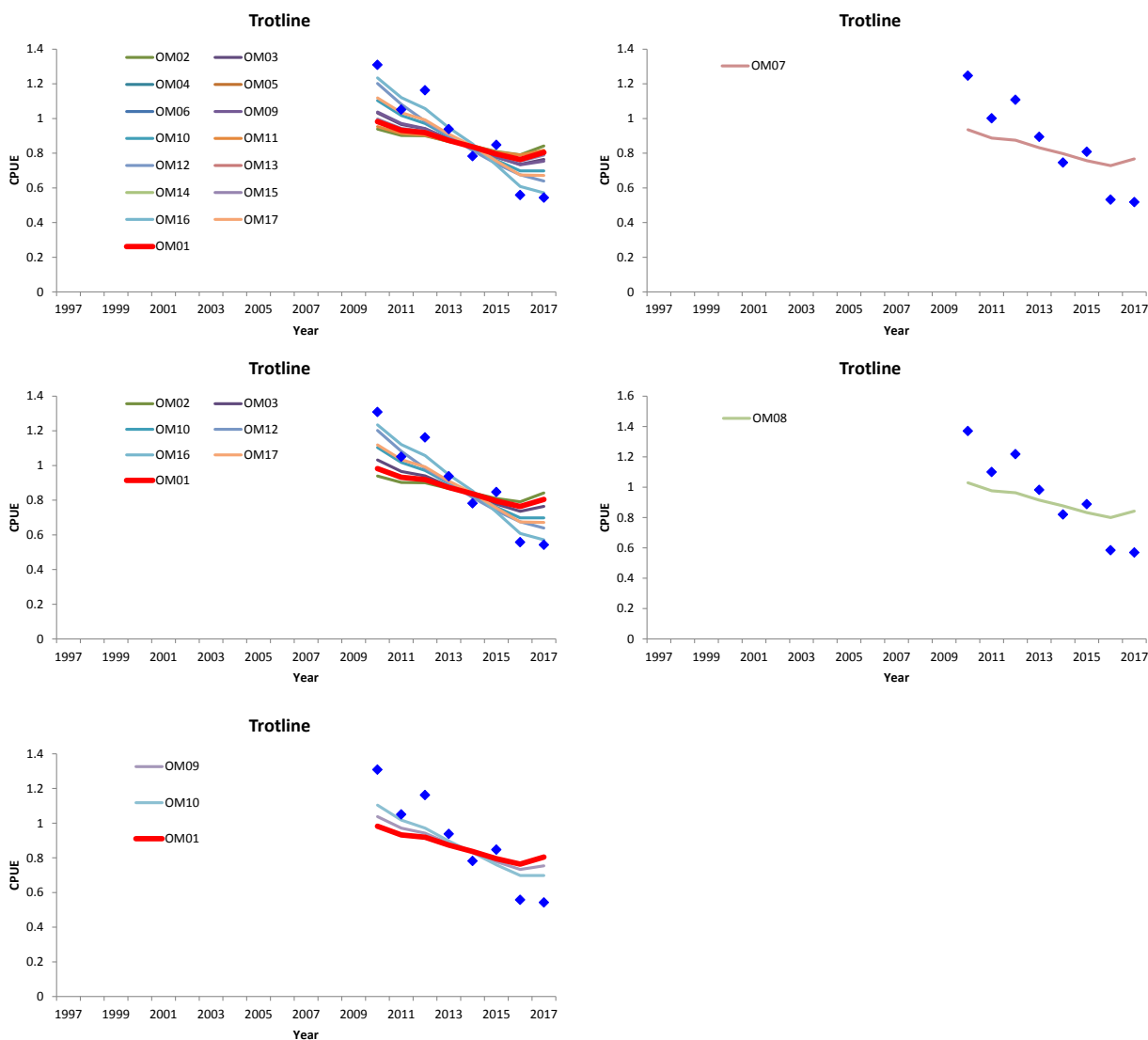


Figure 6. Exploitable biomass and the GLM-standardised CPUE indices for **trotlines** to which the OMs are fit (divided by the estimated catchability q to express them in biomass units) for all OMs (above left) and for only OMs showing an appreciable difference in trajectory compared to the Base case OM (OM01) (middle left). The fits to the CPUE data for OM07 and OM08 are shown separately (above right and middle right) because the assumed cetacean predation on trotlines differs for these Operating Models. The comparison between the fits to CPUE for the Base case OM and the OMs that up-weight all CPUE data (OM09 and OM10) are also shown (below left).

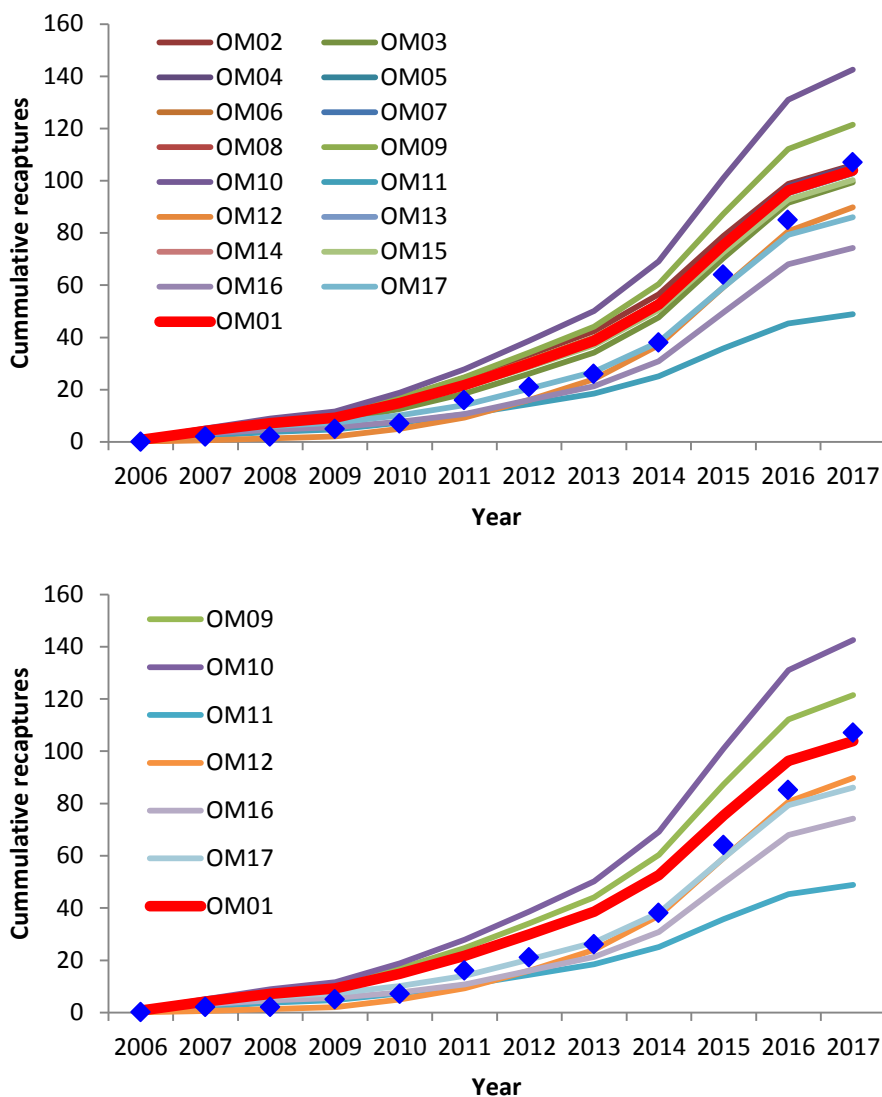


Figure 7. Observed (diamonds) and model predicted (continuous lines) cumulative recapture numbers of toothfish for all OMs (above) and for only OMs showing an appreciable difference in trajectory compared to the Base case OM (OM01) (below), and combining recaptures by longlines and trotlines.