Development and diagnostics of the Beaufort assessment model applied to Spanish mackerel

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SEDAR28−RW04

Development and diagnostics of the Beaufort assessment model applied to Spanish mackerel

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1. Introduction

The BAM, a statistical catch-age formulation, was applied to Spanish mackerel as the primary stock assessment model. The model is detailed in SEDAR28-RW03, and results are documented in the assessment workshop report. This working paper describes development of the BAM's base run and related diagnostics that were not included elsewhere. Its primary purpose is to provide supplemental information for the RW panel.

2. Model development: weighting of model components

The BAM allows for each component of the likelihood to be weighted by user-supplied values. For data components, these weights were applied by either adjusting a scalar on the likelihood or adjusting effective sample sizes (multinomial components). In this application to Spanish mackerel, CVs of landings and discards (in arithmetic space) were assumed equal to 0.05, to achieve a close fit to these time series yet allow some imprecision. In practice, the small CVs are a matter of computational convenience, as they help achieve the desired result of close fits to the landings, while avoiding having to solve the Baranov equation iteratively (which is complex when there are multiple fisheries). Thus, weights on landings and discards were not adjusted. Weights on other data components (indices; age and length compositions) were adjusted iteratively, following the methods outlined by Chris Francis in his CIE review of SEDAR 24. These methods were expounded on by Francis (2011).

2.1. *Model run prior to iterative re-weighting*

Initial weights were set to 1 for all likelihood components.Using these initial weights, the BAM was fit to the data. In this model run, the spawner recruit curve was fit using a fixed steepness (h=0.75) andthe indices of abundance were fit fairly well (Figure 1). This model run was considered a sensitivity run in the assessment (Sensitivity Run S7 in the AW report).

2.2. Model run with iterative re-weighting

From that initial fit, we computed standard deviation of normalized residuals (SDNRs). Weights (w) were then calculated formultinomial components as $w=1/\text{SDNR}^2$, and approximated for lognormal components as$w=1/\text{SDNR}$. For multinomial components, these weights were applied as multipliers on the effective sample size (wN), and for lognormal components, as scalars on the likelihood component. The model was then re-fit using the new weights, and the procedure was continued until SDNRs were near 1.0. The target of SDNRs near 1.0 matches the assumption of standardized residuals, i.e., distributed N(0,1).

For indices, the normalized residual for year y was computed as, Following the above procedure, model components were iteratively re-weighted until SDNRs were near 1.0 (Table 1). Compared to the model without re-weighting, this modelwith iterative re-weightingshowed some small improvement in the fits to indices, but the MRFSS index still was underfit in the late 1990s and early 2000s (Figure 2).

3. Model diagnostics

3.1. *Standardized proportions at year*

Plots of standardized proportions at year (SPAY) can be useful for examining cohort patterns, as they show when abundance or catches are above or below normal. In terms of abundance, the proportion (*p*) of abundance (*N*) at age *a*in year *y* is computed as,

$$p_{a|y} = \frac{N_{ay}}{\sum_a N_{ay}}$$

Such proportions can be computed equally well from predicted or observed catch (*C*) rather than abundance. Whether in terms of *N* or *C*, the mean proportion at age is,

$$\bar{p}_{ay} = \frac{\sum_y p_{a|y}}{Y}$$

where*Y* is the number of years. The standardized proportion at age is then,

$$\acute{p}_{a|y} = \frac{p_{a|y} - \bar{p}_{a|y}}{Y^{-1} \sum_y \left(p_{a|y} - \bar{p}_{a|y}\right)^2}$$

The SPAY plots show how year classes pulse through the population over time (Figure 3). For example, strong year classes of Spanish mackerelwere predicted in 1994 and 2001 (Figure 3, predicted abundance panel and predicted catch panels).

3.2. *Likelihood profile*

A likelihood profile was computed for steepness to help determine an acceptable fixed value for the base model.The AW panel decided on 0.75 as it was the mean of the minimum range of the profile (0.6 – 0.9) (see Table 2 and Figure 4).

4. Literature cited

Francis, RICC. 2011. Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences 68:1124−1138.

Legault, CM, JE Powers, and VRRestrepo. 2001. Mixed Monte Carlo/bootstrap approach to assessing king and Spanish mackerel in the Atlantic and Gulf of Mexico: Its evolution and impact. American Fisheries Society Symposium 24:1−8.

Quinn, TJ II and RB Deriso.1999. Quantitative Fish Dynamics. Oxford University Press.

Table 1. SDNRs and weights computed in model fits.The component weights from the final iteration are bold.Data sources are as follows: age compositions from all the fisheries (handline, pound net, gill net, cast net and general recreational), the Florida handline index, the MRFSS index and the SEAMAP YOY index.

	SDNRs								Weights							
	HL agec	PN agec	GN agec	CN agec	Rec agec	FL HL index	MRFSS index	SMAP YOY index	HL agec	PN agec	GN agec	CN agec	Rec agec	FL HL index	MRFSS index	SMAP YOY index
Iteration 1	5.005	5.787	4.777	2.958	8.863	3.076	2.945	0.755	0.200	0.173	0.209	0.338	0.113	0.325	0.340	1.324
Iteration 2	2.002	2.386	1.961	1.728	3.063	1.097	0.994	1.029	0.100	0.072	0.107	0.196	0.037	0.296	0.342	1.286
Iteration 3	1.403	1.536	1.354	1.355	2.086	0.957	0.920	1.019	0.071	0.047	0.079	0.144	0.018	0.309	0.371	1.263
Iteration 4	1.191	1.271	1.159	1.221	1.418	0.951	0.945	1.020	0.060	0.037	0.068	0.118	0.012	0.325	0.393	1.238
Iteration 5	1.096	1.150	1.076	1.140	1.170	0.972	0.971	1.016	**0.054**	**0.032**	**0.063**	**0.104**	**0.011**	**0.335**	**0.404**	**1.219**
Iteration 6	1.049	1.090	1.038	1.088	1.073	0.985	0.986	1.009								

Table 2.Likelihood profile over steepness (h).lk indicates negative log-likelihood, U indicates indices, andagec indicates age compositions. Additional descriptors are SR=spawner recruit function, FL.HL=Florida handline, MRFSS=recreational index, SMAP.YOY=SEAMAP young of the year index, HL=commercial handline, PN=commercial pound net, GN=commercial gill net, CN=commercial cast net and Rec=recreational fishery.

steep	lk.total	lk.U.FL.HL	lk.U.MRFSS	lk.U.SMAP.YOY	lk.agec.HL	lk.agec.PN	lk.agec.GN	lk.agec.CN	lk.agec.Rec	lk.Srfit
0.25	7389449	109.3819	1656.089	129.4033	-6.55196	471.4631	13.80816	-7.33459	-2.33507	322.3875
0.35	-1023.18	41.71091	32.68249	9.014019	-12.3279	42.62869	-23.0352	-15.7989	-2.73598	11.03816
0.45	-1037.1	40.20803	31.82737	8.783664	-12.3705	42.52056	-23.375	-15.7343	-2.73843	6.88831
0.55	-1045.02	38.42963	31.14624	8.677013	-12.3852	42.44487	-23.548	-15.6698	-2.73685	4.286977
0.65	-1047.62	36.72911	31.75858	8.630141	-12.398	42.14631	-23.6236	-15.5873	-2.73341	2.981283
0.75	-1048.74	37.43064	31.28285	8.688411	-12.3932	42.51211	-23.6269	-15.6226	-2.73672	2.382879
0.85	-1048.92	37.42656	31.39963	8.706861	-12.3944	42.52355	-23.6289	-15.6282	-2.73676	2.196539
0.95	-1048.93	37.44162	31.46783	8.712068	-12.395	42.52727	-23.6285	-15.6326	-2.73679	2.159729

Figure 1.Estimated spawner-recruit curve and three indices from model run without iterative re-weighting.

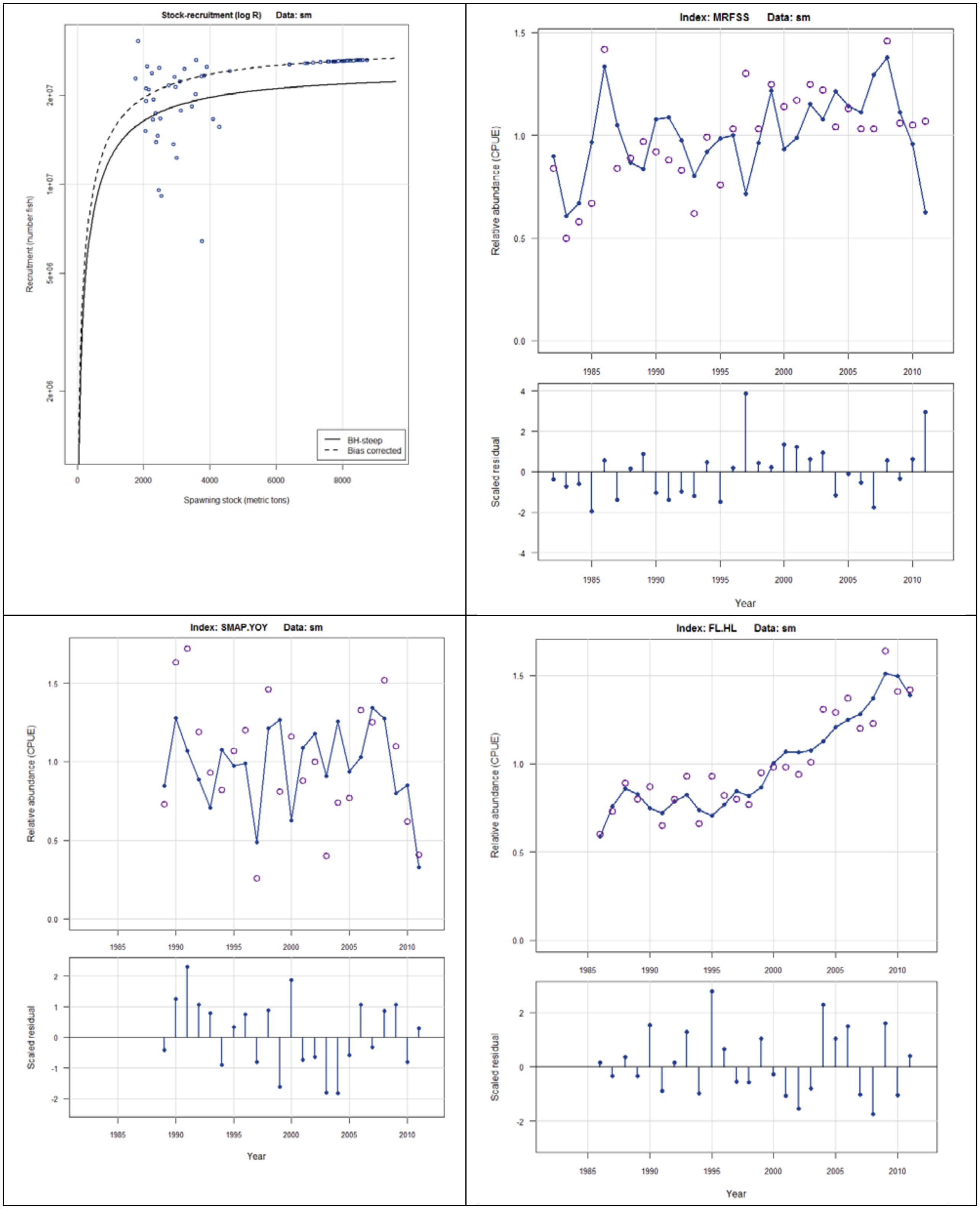


Figure 2.Estimated spawner-recruit curve and three from model run with all indices and composition data iteratively re-weighted. Weights shown in Table 1.

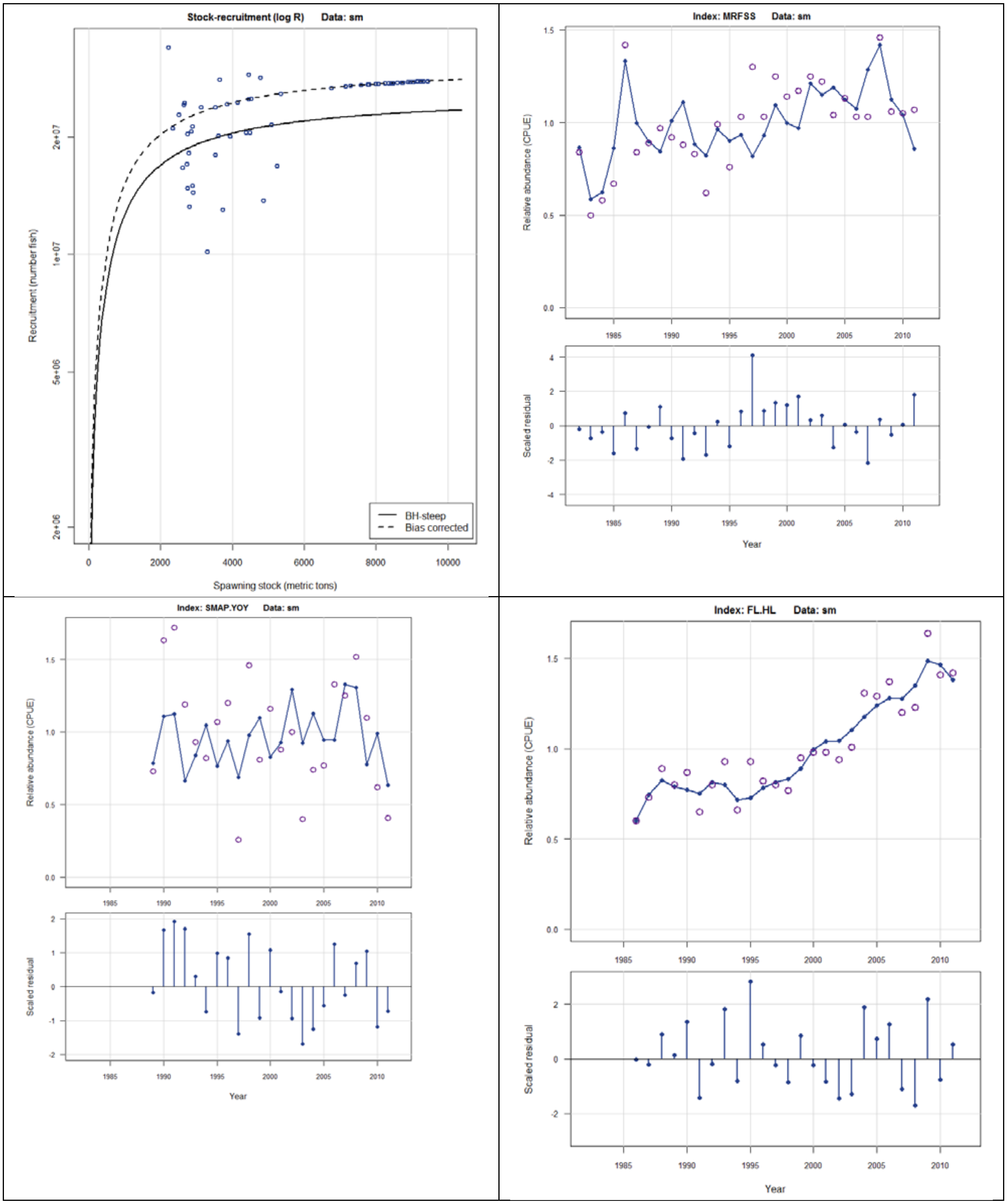


Figure 3.Standardized proportions at year (SPAY) plots. Light gray indicates above average proportion at age, black indicates below average proportion at age. The size of bubbles within each data set is scaled to the largest values. As indicated above the panels, spay plots are shown for predicted abundance, as well as for observed and predicted catches from fleets with suitably long time series of catch at age. MRIP is the Recreational catch.

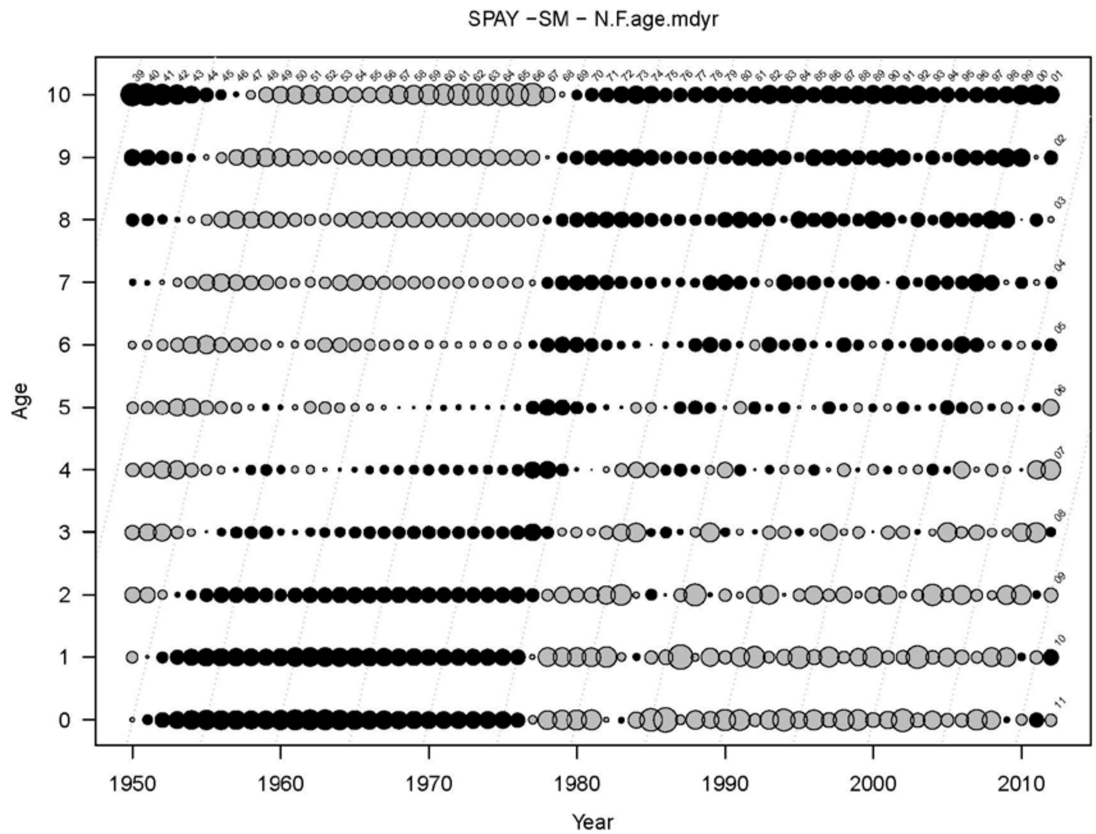
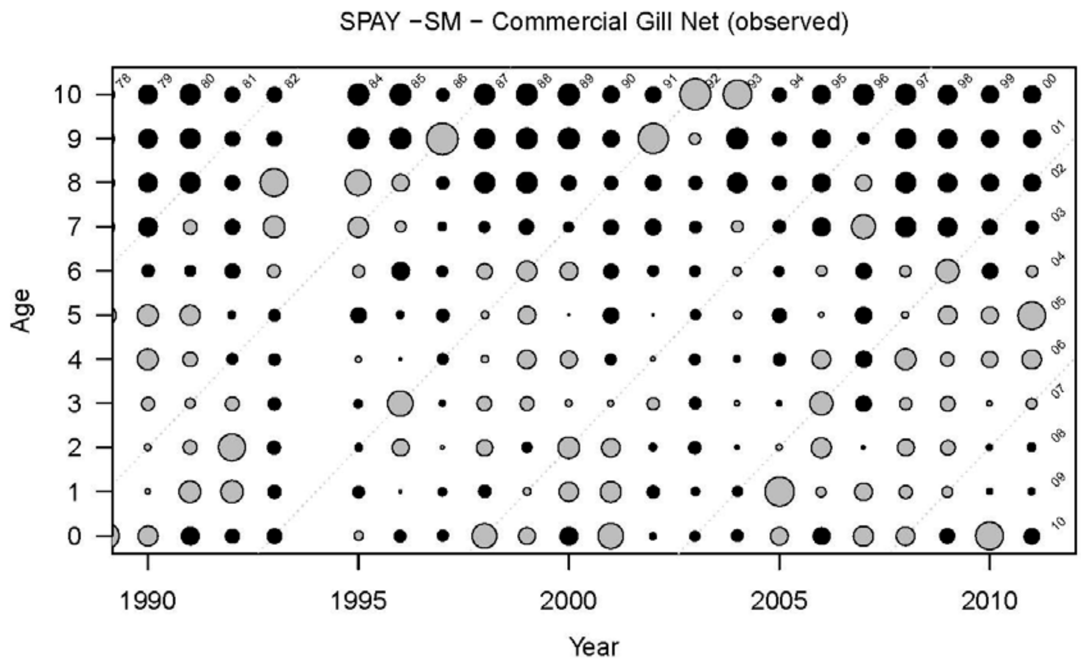
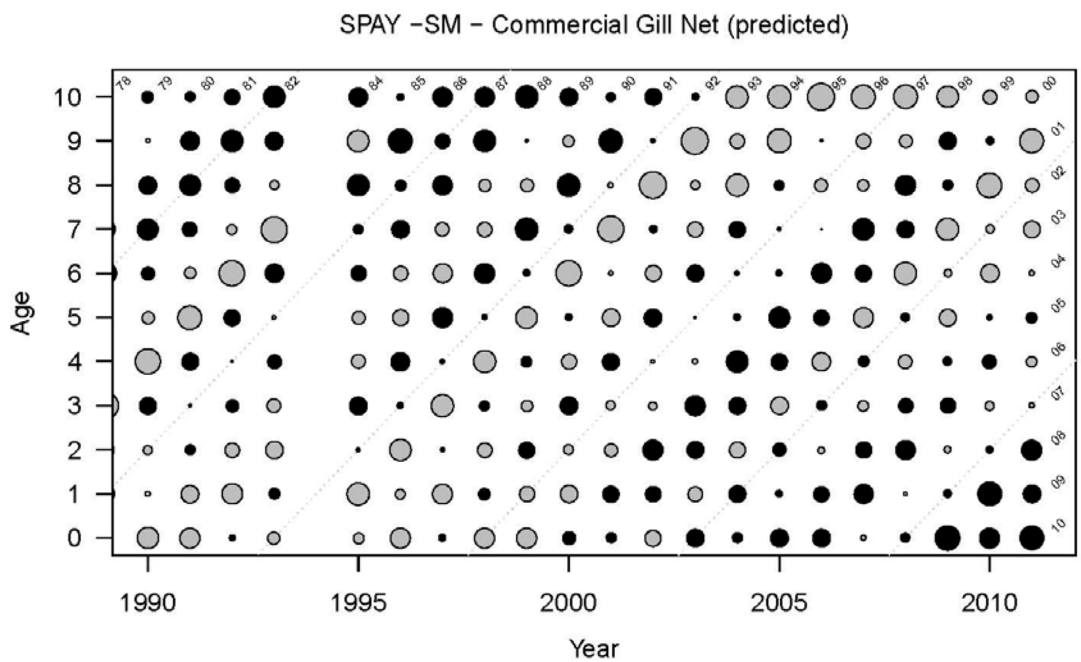


Figure 3 (cont.)





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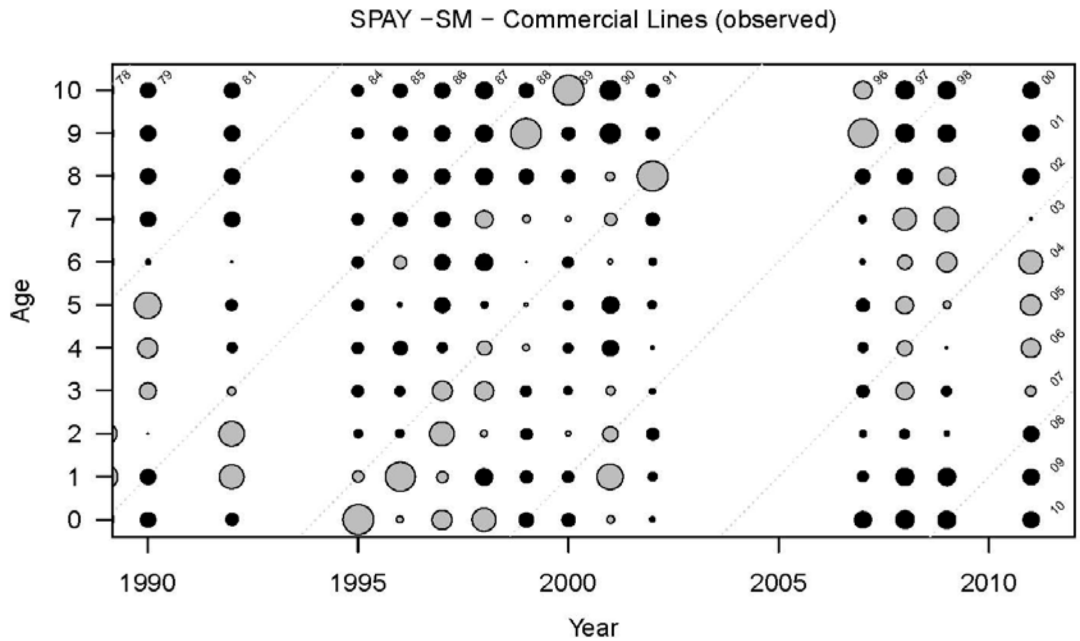

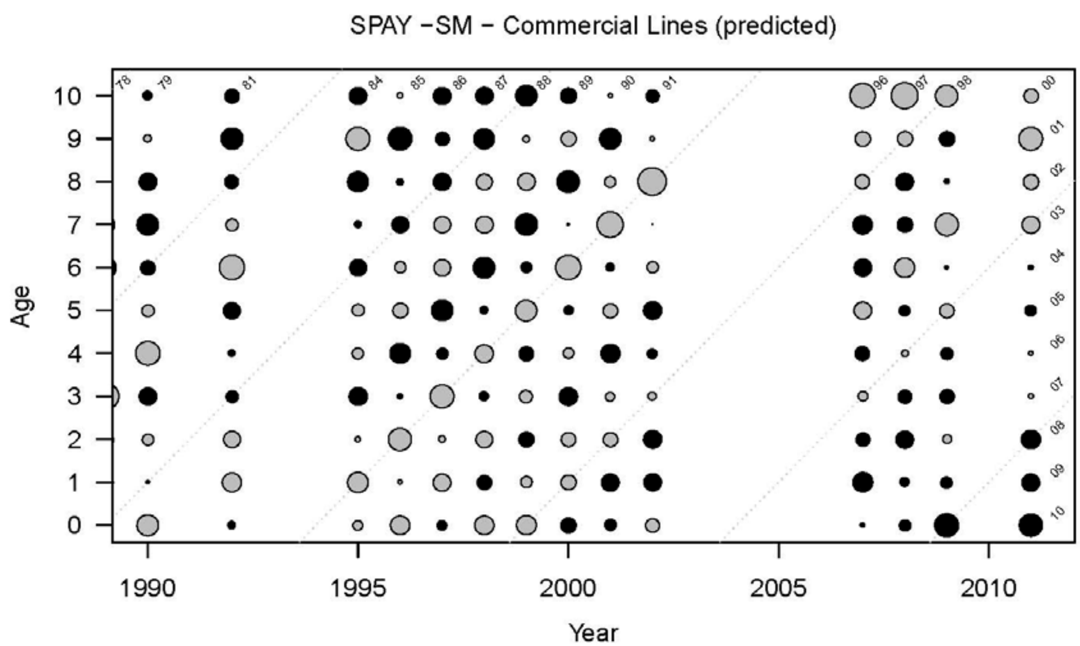

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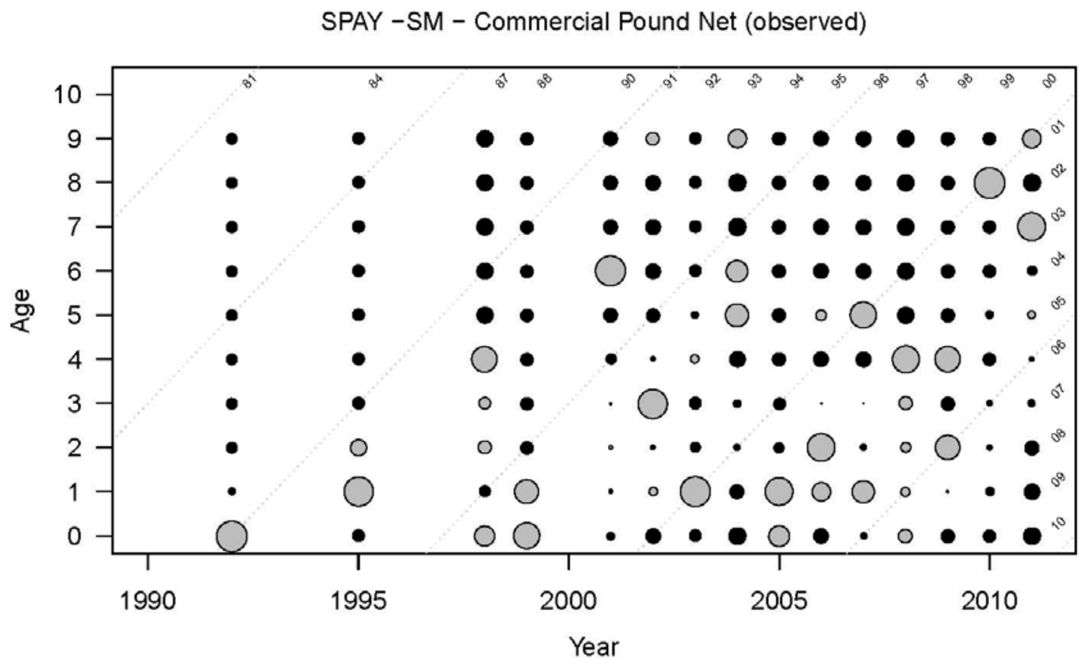


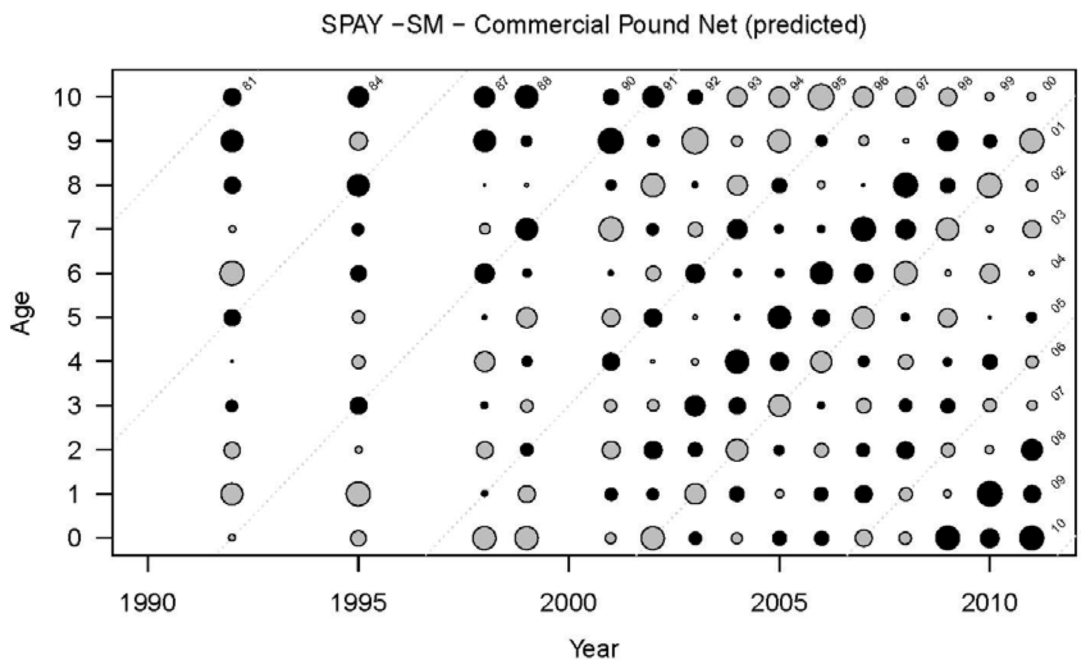
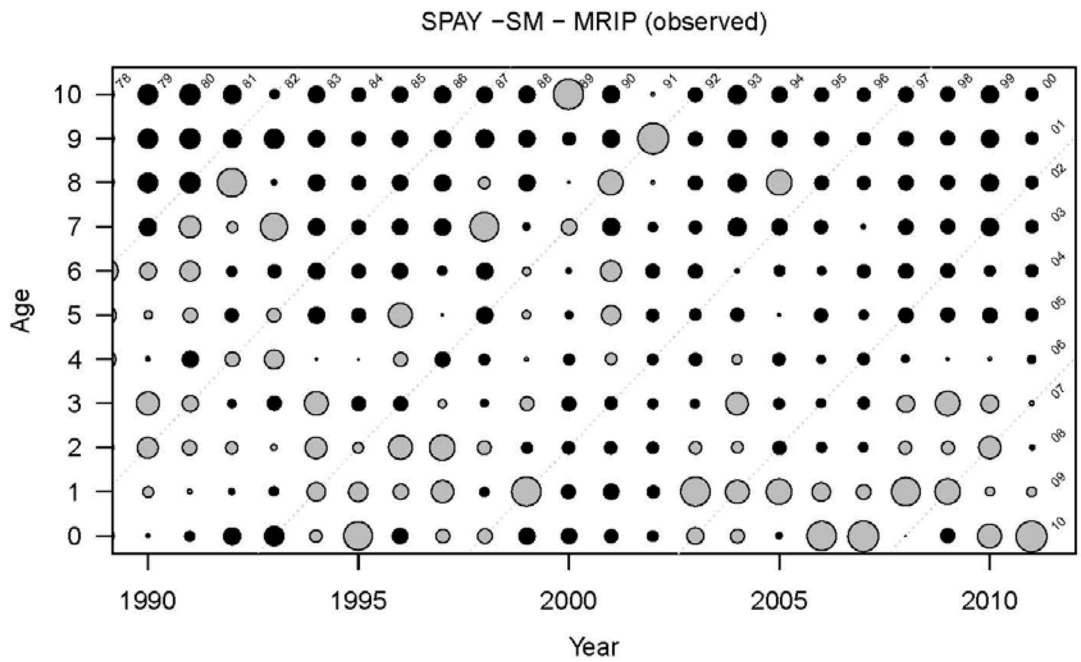


Figure 3 (cont.)



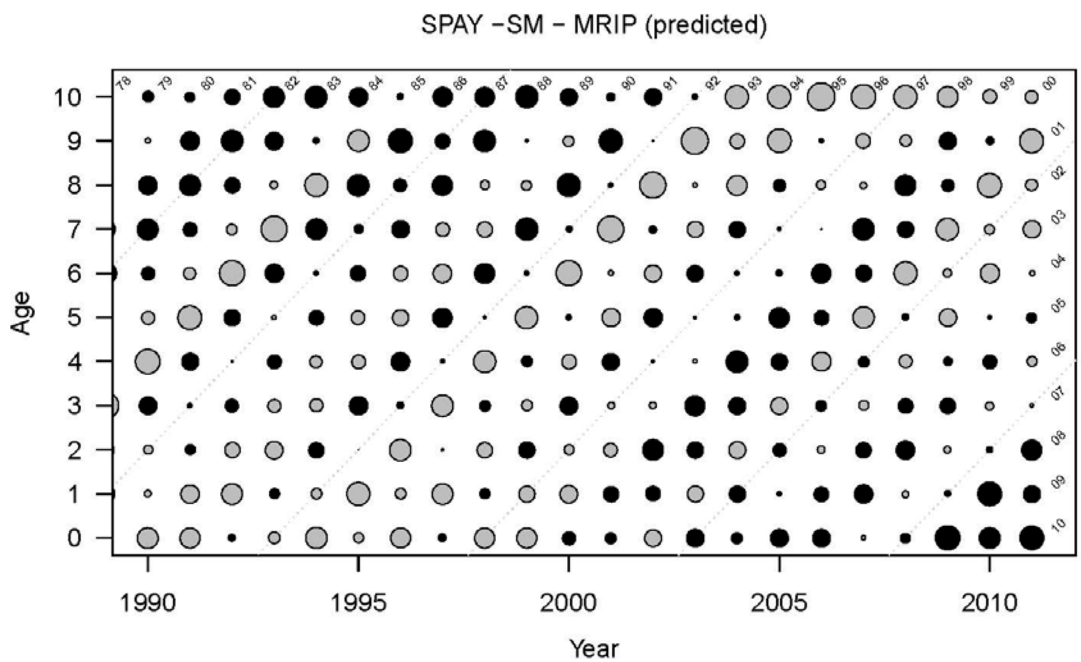
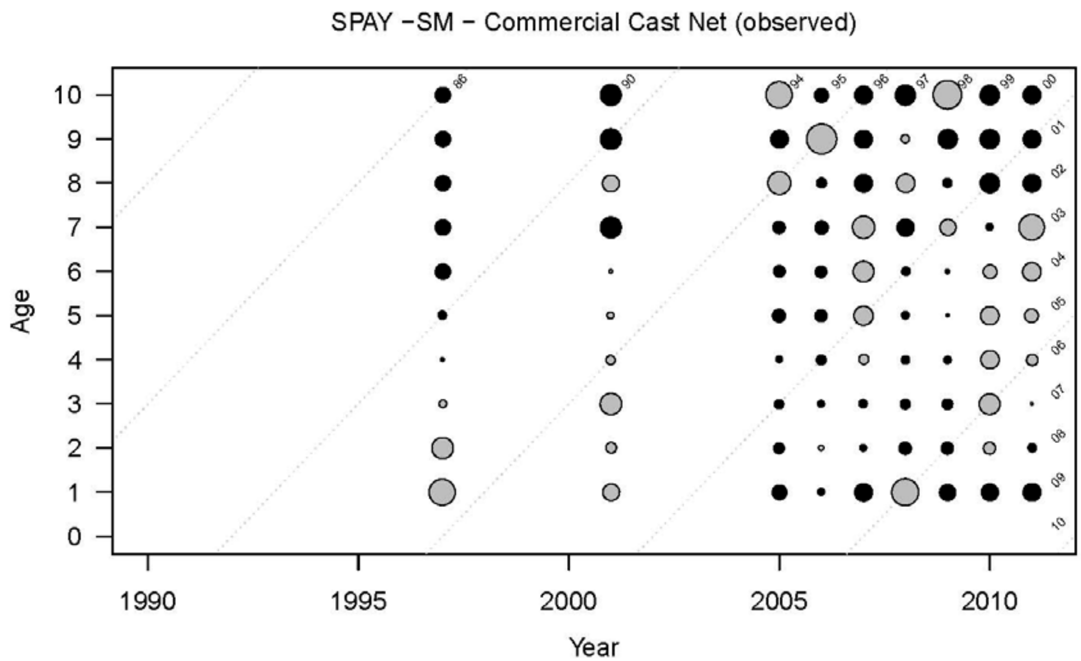


Figure 3 (cont.)



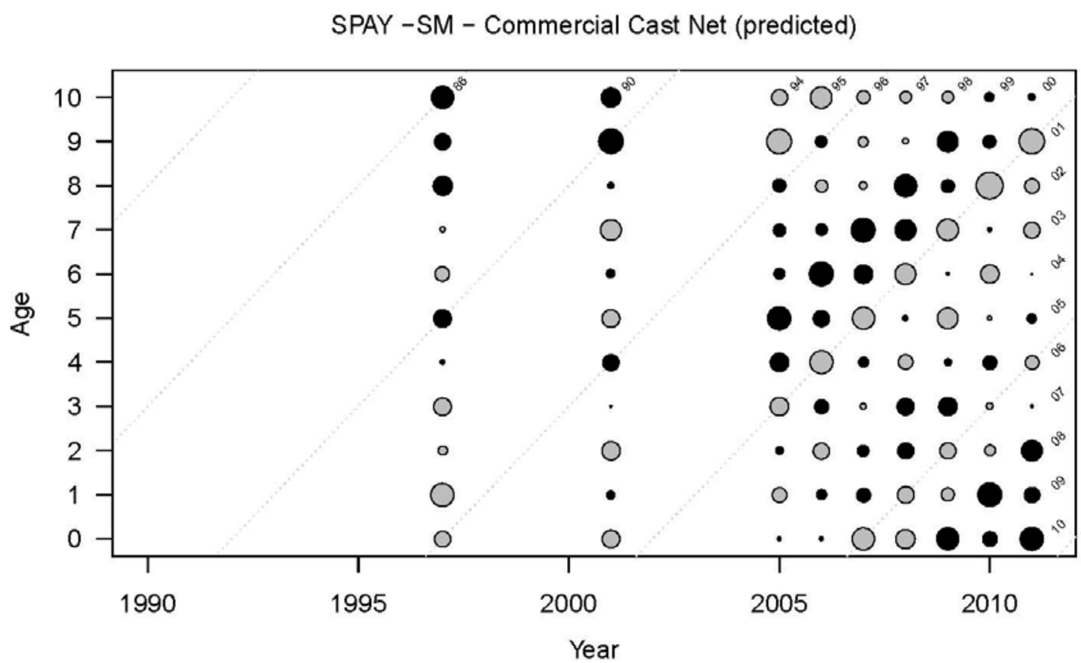


Figure 4.Likelihood profile on steepness.