Additional diagnostics of the CCSBT operating model for the 2017 assessment

2017 年の資源評価のためのオペレーティングモデルの追加診断

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Summary

In this document, additional diagnostics for the southern bluefin tuna (SBT) operating model (OM) are examined. From retrospective analysis, we concluded that the estimation of stock status as well as its trend did not bias substantially by a less availability of information for terminal year. Likelihood profile across the population scale parameter (log(B0)) showed that the catch-at-size (and catch-at-age) data had strong influence into the population scaling. There were found the non-converged issues, which would need further analysis.

要約

本文書では、ミナミマグロのオペレーティングモデル（OM）について実施した追加の診断の結果を説明する。レトロスペクティブ分析の結果、OM により推定された資源状態や資源トレンドには、最終年の情報によるバイアスは無いと結論付けられた。個体群スケールのパラメータに着目した尤度プロファイルからは、漁獲物サイズ（漁獲物年齢）の情報が個体群スケールの推定に大きく影響することが示された。モデルが収束しない問題があり、更なる分析が必要と考えられた。

Introduction

In many tuna-RFMOs, retrospective analysis and likelihood profiles focusing population scale are usually used as the diagnostic tools for their stock assessment model, whereas in CCSBT those analyses had not been conducted for Operating Model (OM) diagnostics. This document showed the results of those diagnostic analysis of the OM conditioning for the 2017 stock assessment.

Retrospective analysis was performed on the reference model via the subsequent removal of the terminal year of data. We evaluated seven years retrospective analysis to examine temporal trends in total biomass, biomass of age 10+ fish, and total reproductive output (TRO). Generally, a model without significant one-way bias would be considered as a positive diagnostic in this analysis.

Likelihood profile across the parameter addressing population scale was used to evaluate which data sources were providing information on the scale. In many tuna-RFMOs, their stock assessment was often conducted using integrated assessment model like Stock Synthesis (SS), in which the population scale estimate of ln(R0) was used for the analysis. In the OM for the southern bluefin tuna, the parameter of population scale is ln(B0), thus we tried to make a likelihood profile across the ln(B0). Generally, a model with population scale estimated that was consistent with the information provided by the primary tuning indices would be considered as a positive diagnostic. But the CCSBT has adopted "grid-approach" for their OM, thus we would not need to worry much about the consistency among the information.

Methods

Data and model

The version of program codes and data files used in this analysis is controlled by "GitHub". This is a web-based hosting service for software development projects, and CCSBT have a secure repository to manage, improve, and share the OM code. We used the program codes and data files which were uploaded on 3rd August 2017.

Reference set of current models

The diagnostic analysis was conducted using current reference set for the 2017 stock assessment (Hilary et al. 2017). Input data up to 2016 were used for the OM conditioning (the Aerial survey (AS) index extended over 2017). The grid specification which was agreed at the 8th OMMP meeting was used for this analysis (Table 1). The difference between the previous grid structure (for 2014 assessment) and new one (for 2017 assessment) is as follows;

(1) **Steepness**: values were changed to "0.6, 0.7, 0.8" from "0.55, 0.64, 0.73, 0.82, 0.90";

(2) **M10**: values were changed to "0.05, 0.085, 0.125" from "0.05, 0.075, 0.100, 0.125", and;

(3) **Psi**: a new axis of the reference set grid for a parameter of length specific weight and maturity relationships. Three values "1.50, 1.75, 2.00" were used with respective weights 0.25, 0.5, and 0.25.

Retrospective analysis

We removed one, two, …, seven years of data from end of time series for catch, catch-at-size, longline CPUE, aerial survey data, parent-offspring-pair (POP) and half-sibling-pair (HSP) of close-kin mark recapture (CKMR) data in "sbtdata2016.dat". Each data had different terminal year, thus we removed the data using following manner when we conducted the retrospective analysis of which terminal year was *t*;

a) Remove year *t* data from end of time series of catch, catch-at-size, longline CPUE;
b) Remove year *t+1* data from end of time series of aerial survey data;
c) Remove CKMR-POP data if the capture year of adult fish was *t* (automatically cohort of *t-1* year class for juvenile data was also removed), and;
d) Remove CKMR-HSP data if the younger cohort was *t* (automatically the data of elder cohort with *t-1* year class was also removed).

Therefore, the removals of CKMR-POP and CKMR-HSP data were started from 3 years retrospective analysis and 5 years retrospective analysis, respectively (Table 2). We didn't change any of parameter settings to run the OM, except for the removal of yearly data. The grid sampling was conducted by the usual method.

Likelihood profile across the population scale parameter

Best fitting grid cell of reference set (scenario 2312321; Hillary et al. 2017) was focused for likelihood profile analysis. Firstly, we changed the setting in "base.file" to run the "best fitting grid cell (2312321)", then fixed the parameter of population scale which is estimated in the OM (i.e. a parameter "ln_B0"), by setting initial value of ln_B0 in INITIALIZATION_SECTION of "sbtmod.tpl". In order to fix it (i.e. not to estimate), the phase of estimation was changed to -1 from 1 in PARAMETER_SECTION of "sbtmod.tpl" (from "ln_B0(1)" to "ln_B0(-1)"). During the analysis, a boundary issue for the M30 parameter estimation was found, therefore we conducted this analysis using the model of which the upper bound of M30 was extended (from 0.50 to 0.70).

Results and Discussion

Retrospective analysis

The retrospective analysis showed no substantial tendency of estimation in the total biomass, biomass of age 10+ fish, and TRO for recent 8 terminal years (Figure 1). There is a bit of variation in the estimated value of total biomass in terminal year, probably reflecting the deference of the estimation of recruitment. According to the level plots of retrospective runs, there were not substantial difference of the sampling for M0 and M10 values among the retrospective runs (Figure 2). Therefore, it was considered that the information from recent terminal years had consistency for the preference of M0

and M10 values. In this analysis, we would be able to conclude that the estimation of stock status as well as its trend did not bias substantially by a less availability of information for terminal year. This would be positive sign of the performance of OM.

Likelihood profile across the population scale parameter

Profiles of total and component likelihoods over fixed log(B0) for the best fitting grid cell (2312321) are shown in Figure 3. The main data components which strongly influence the population scaling of log(B0) were the catch-at-size (and catch-at-age) data. All of catch-at-size (age) data showed a similar trend among them except Indonesian fisheries data. The influence of catch-at-age for Indonesian fisheries to log(B0) scaling was on high side, while the others of catch-at-size (age) affected low side. Among the abundance indices data, longline CPUE and aerial survey index had opposite preference for the population scale.

We tried to make likelihood profile at 0.005 intervals of log(B0) between 16.100 and 16.200, but the model was not converged when the log(B0) was fixed lower than 16.135. This value is very close to the Maximum Likelihood Estimate (MLE) of log(B0) when the log(B0) was not fixed (16.137). Thus, it was suspected that the model still has boundary issue like M30 (Table 3 and 4, e.g "initial_sel_prms", "sigma_cpue", etc.), but currently exact reason(s) for it is still unkown. Further analysis would be needed in order to address this issue.

Reference

Hillary, R.M., A,L,Preece, C.R.Davies, N.Takahashi, O.Sakai, and T.Itoh. 2017. Reconditioning of the CCSBT Operating Model in 2017. CCSBT-ESC/1708/14.

Table 1. The default grid structure specified at the 8th OMMP meeting.

	Levels	Cumulate Number	Values	Prior	Simulation weight
Steepness (h)	3	3	0.6, 0.7, 0.8	Uniform	Prior
M_1	4	12	0.35, 0.40, 0.45, 0.50	Uniform	Posterior
M_{10}	3	36	0.050, 0.085, 0.120	Uniform	Posterior
Omega	1	36	1	NA	NA
CPUE series	2	72	w0.5, w0.8	Uniform	Prior
q-age-range	2	144	4-18, 8-12	0.67, 0.33	Prior
Psi	3	432	1.50, 1.75, 2.00	0.25, 0.5, 0.25	Prior
Sample size	1	432	Sqrt	NA	NA

Table 2. Summary of the range of each data set using retrospective analysis.

	Catch and Catch-at-size(age) data	Long-line CPUE (LL1)	Aerial survey	Close-Kin Mark-Recapture (CKMR) Parents-Offspring-Pair (POP)	Close-Kin Mark-Recapture (CKMR) Half-Sibling-Pair (HSP)
Base	~2016	~2016	1993~2000, 2005~2014, 2016~2017	Cohort: 2002~2012 Capture year: 2006~2014	Cohort1: 2003~2011 Cohort2: 2004~2012
Retro 1	**~2015**	**~2015**	1993~2000, 2005~2014, **2016**	Cohort: 2002~2012 Capture year: 2006~2014	Cohort1: 2003~2011 Cohort2: 2004~2012
Retro 2	**~2014**	**~2014**	1993~2000, 2005~**2014**	Cohort: 2002~2012 Capture year: 2006~2014	Cohort1: 2003~2011 Cohort2: 2004~2012
Retro 3	**~2013**	**~2013**	1993~2000, 2005~**2014**	Cohort: 2002~2012 Capture year: 2006~**2013**	Cohort1: 2003~2011 Cohort2: 2004~2012
Retro 4	**~2012**	**~2012**	1993~2000, 2005~**2013**	Cohort: 2002~**2011** Capture year: 2006~**2012**	Cohort1: 2003~2011 Cohort2: 2004~2012
Retro 5	**~2011**	**~2011**	1993~2000, 2005~**2012**	Cohort: 2002~**2010** Capture year: 2006~**2011**	Cohort1: 2003~**2010** Cohort2: 2004~**2011**
Retro 6	**~2010**	**~2010**	1993~2000, 2005~**2011**	Cohort: 2002~**2009** Capture year: 2006~**2010**	Cohort1: 2003~**2009** Cohort2: 2004~**2010**
Retro 7	**~2009**	**~2009**	1993~2000, 2005~**2010**	Cohort: 2002~**2008** Capture year: 2006~**2009**	Cohort1: 2003~**2008** Cohort2: 2004~**2009**

Table 3. Summary of likelihood and penalty over fixed log(B0) for the best fitting cell (scenario 2312321) of reference set.

	Scale parameter			lnlike										Penalty			
	Ln_B0	B0	ObjF	LL1	LL2	LL3	LL4	Indo	Aus	CPUE	Tags	Aerial	POP	HSP	sel.change	sel.smooth	rec	Penalty (total)
Estimate using sbtmod ver.20170803	16.137	10193934	3117.73	169.928	27.732	34.6376	36.8929	67.3846	44.7429	-67.4171	173.96	1.28253	1122.64	1439.17	58.2912	24.5403	-23.4658	66.77569024
fixed lnB0	16.100	9820671	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0	0	1.8166	-43.9309	-40.41046307
	16.105	9869897	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0	0	0.0407414	-43.931	-42.18940206
	16.110	9919370	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0	0	1.18E-05	-43.931	-42.23068823
	16.115	9969091	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0	0	0.0008097	-43.931	-42.22989009
	16.120	10019062	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0	0	0.244486	-43.931	-41.9861001
	16.125	10069282	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0	0	3.91E-08	-43.931	-42.23069996
	16.130	10119755	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0	0	91801.6	-24.1942	97829.1258
	16.135	10170480	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0	0	3.91E-08	-43.931	-42.23069996
	16.140	10221460	3117.73	169.932	27.7322	34.642	36.899	67.3818	44.7439	-67.4164	173.965	1.27764	1122.64	1439.17	58.2961	24.5394	-23.4805	66.76469024
	16.145	10272695	3117.74	169.938	27.7327	34.6503	36.9102	67.3765	44.7459	-67.415	173.974	1.26858	1122.64	1439.17	58.3052	24.5376	-23.5061	66.74584024
	16.150	10324187	3117.74	169.944	27.7331	34.6585	36.9214	67.3713	44.7479	-67.4136	173.982	1.25956	1122.64	1439.17	58.3144	24.5359	-23.5298	66.72910023
	16.155	10375938	3117.74	169.951	27.7335	34.6666	36.9326	67.3661	44.7499	-67.4121	173.991	1.25056	1122.63	1439.17	58.3236	24.5341	-23.5513	66.71445023
	16.160	10427947	3117.76	169.957	27.7339	34.6748	36.9438	67.3609	44.7519	-67.4106	174	1.24159	1122.63	1439.17	58.3329	24.5324	-23.5709	66.70190023
	16.165	10480218	3117.77	169.963	27.7344	34.683	36.955	67.3557	44.754	-67.4091	174.009	1.23264	1122.63	1439.17	58.3422	24.5307	-23.5884	66.69146022
	16.170	10532750	3117.78	169.97	27.7348	34.6912	36.9662	67.3506	44.756	-67.4076	174.019	1.22373	1122.62	1439.17	58.3516	24.529	-23.6039	66.68311022
	16.175	10585546	3117.80	169.976	27.7352	34.6994	36.9775	67.3454	44.758	-67.4061	174.028	1.21484	1122.62	1439.17	58.3611	24.5273	-23.6173	66.67697022
	16.180	10638606	3117.82	169.983	27.7357	34.7075	36.9887	67.3403	44.7601	-67.4046	174.037	1.20598	1122.62	1439.17	58.3706	24.5256	-23.6287	66.67282021
	16.185	10691932	3117.84	169.989	27.7361	34.7157	36.9999	67.3351	44.7621	-67.403	174.046	1.19714	1122.62	1439.17	58.3801	24.5239	-23.6381	66.67068021
	16.190	10745526	3117.85	169.996	27.7365	34.7238	37.0112	67.33	44.7642	-67.4014	174.055	1.18833	1122.61	1439.17	58.3897	24.5223	-23.6455	66.67073021
	16.195	10799388	3117.88	170.002	27.737	34.732	37.0224	67.3249	44.7663	-67.3998	174.064	1.17954	1122.61	1439.17	58.3994	24.5206	-23.6509	66.6727902
	16.200	10853520	3117.91	170.009	27.7374	34.7401	37.0336	67.3198	44.7683	-67.3982	174.074	1.17079	1122.61	1439.17	58.4091	24.519	-23.6543	66.6769502

Table 4. Summary of likelihood and penalty over fixed log(B0) for the best fitting cell (scenario 2312321) of reference set with extending M30 upper bound for the estimation.

	Scale parameter			lnlike												Penalty			
	Ln_B0	B0	ObjF	LL1	LL2	LL3	LL4	Indo	Aus	CPUE	Tags	Aerial	POP	HSP		sel.change	sel.smooth	rec	Penalty (total)
Estimate using sbtmod extending M30 upper bound	16.137	10192166	3117.738	169.922	27.7316	34.638	36.8907	67.3874	44.7418	-67.421	173.964	1.28132	1122.65	1439.17		58.2984	24.5375	-23.4641	66.78174
fixed lnB0	16.100	9820671	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0		0	1.8166	-43.9309	-40.41046
	16.105	9869897	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0		0	0.0407414	-43.931	-42.1894
	16.110	9919370	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0		0	1.18E-05	-43.931	-42.23069
	16.115	9969091	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0		0	0.0008097	-43.931	-42.22989
	16.120	10019062	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0		0	0.244486	-43.931	-41.9861
	16.125	10069282	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0		0	3.91E-08	-43.931	-42.2307
	16.130	10119755	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0		0	91801.6	-24.1942	97829.126
	16.135	10170480	**Not converged**	nan	nan	nan	nan	nan	nan	nan	nan	nan	0	0		0	1.11E+01	-43.9304	-30.5017
	16.140	10221460	3117.730	169.926	27.7318	34.6427	36.8972	67.3843	44.7429	-67.4201	173.969	1.27613	1122.64	1439.17		58.3035	24.5365	-23.4798	66.76982
	16.145	10272695	3117.735	169.932	27.7323	34.6509	36.9084	67.379	44.7449	-67.4186	173.978	1.26713	1122.64	1439.17		58.3124	24.5348	-23.5053	66.75098
	16.150	10324187	3117.743	169.939	27.7327	34.6591	36.9197	67.3736	44.747	-67.417	173.987	1.25815	1122.64	1439.17		58.3214	24.5331	-23.5289	66.73413
	16.155	10375938	3117.743	169.945	27.7331	34.6673	36.931	67.3683	44.749	-67.4155	173.996	1.24919	1122.63	1439.17		58.3304	24.5315	-23.5504	66.71949
	16.160	10427947	3117.755	169.952	27.7336	34.6754	36.9422	67.363	44.751	-67.4139	174.004	1.24026	1122.63	1439.17		58.3395	24.5299	-23.5699	66.70694
	16.165	10480218	3117.768	169.958	27.734	34.6836	36.9535	67.3577	44.7531	-67.4123	174.013	1.23136	1122.63	1439.17		58.3486	24.5282	-23.5873	66.6964
	16.170	10532750	3117.785	169.965	27.7345	34.6917	36.9647	67.3524	44.7551	-67.4107	174.022	1.22249	1122.63	1439.17		58.3578	24.5266	-23.6028	66.68795
	16.175	10585546	3117.794	169.971	27.7349	34.6999	36.976	67.3472	44.7572	-67.409	174.031	1.21364	1122.62	1439.17		58.3671	24.525	-23.6162	66.68171
	16.180	10638606	3117.815	169.978	27.7353	34.708	36.9873	67.3419	44.7593	-67.4074	174.04	1.20482	1122.62	1439.17		58.3764	24.5234	-23.6276	66.67747
	16.185	10691932	3117.838	169.985	27.7358	34.7162	36.9985	67.3367	44.7613	-67.4057	174.049	1.19602	1122.62	1439.17		58.3858	24.5218	-23.6369	66.67543
	16.190	10745526	3117.853	169.991	27.7362	34.7243	37.0098	67.3314	44.7634	-67.404	174.058	1.18725	1122.61	1439.17		58.3952	24.5202	-23.6443	66.67529
	16.195	10799388	3117.881	169.998	27.7367	34.7324	37.0211	67.3262	44.7655	-67.4023	174.068	1.1785	1122.61	1439.17		58.4047	24.5186	-23.6496	66.67734
	16.200	10853520	3117.911	170.005	27.7371	34.7405	37.0323	67.3211	44.7676	-67.4006	174.077	1.16979	1122.61	1439.17		58.4142	24.5171	-23.653	66.6814

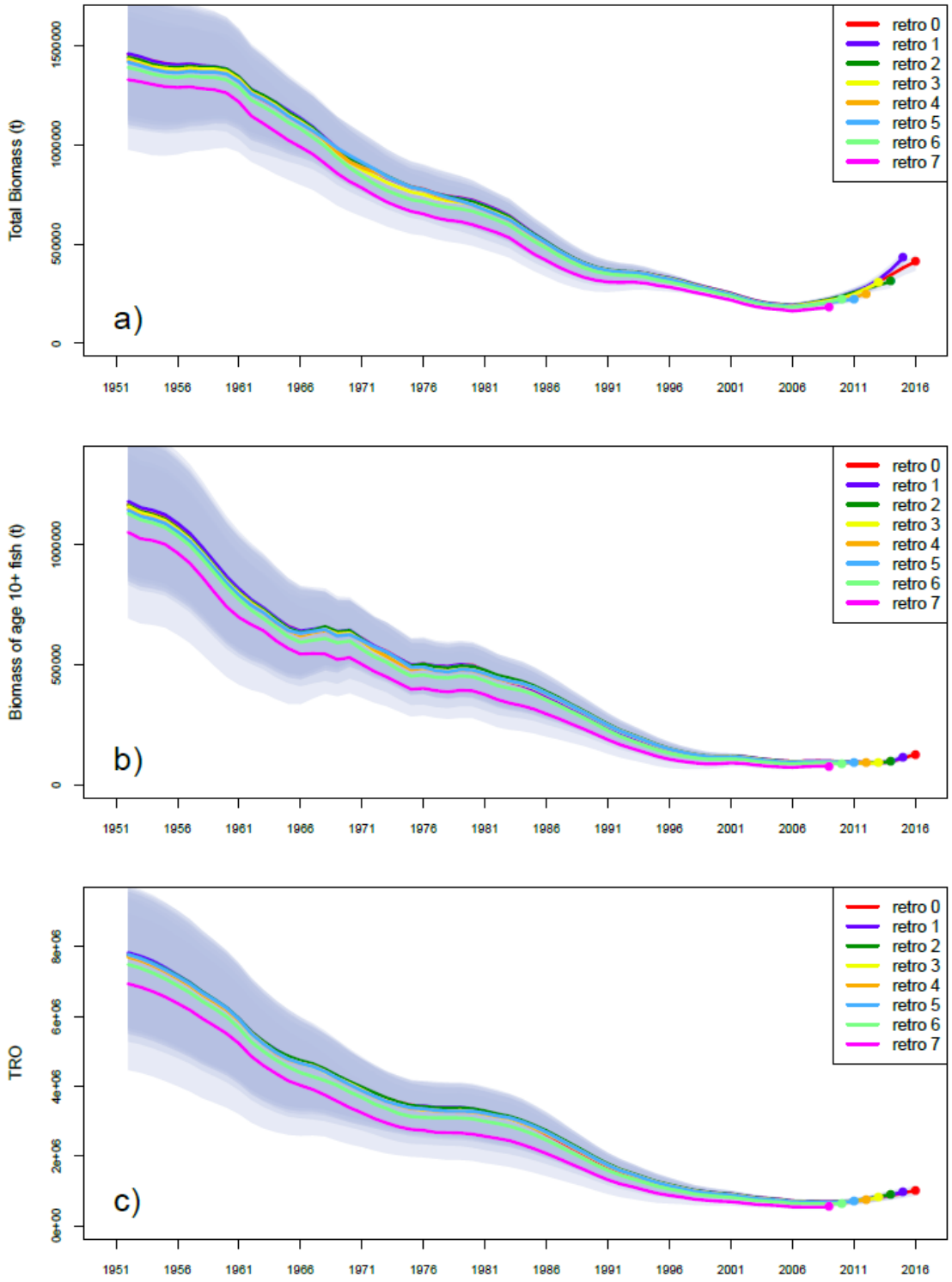
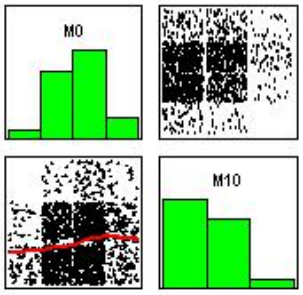
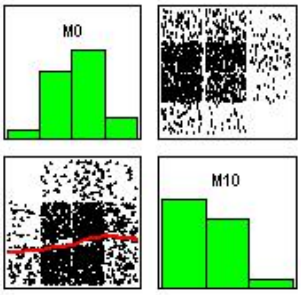


Figure 1. Retrospective analysis for a) total biomass, b) biomass of age 10+ fish, and c) total reproductive output (TRO) for recent 7 years. Each line shows the median trajectory, and gray region is the overwriting of the 90% intervals of the all retrospective runs.

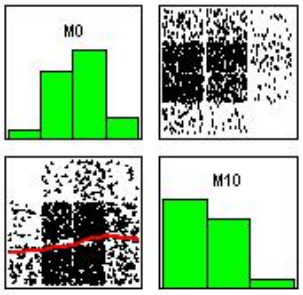
a) Reference set (retro 0)



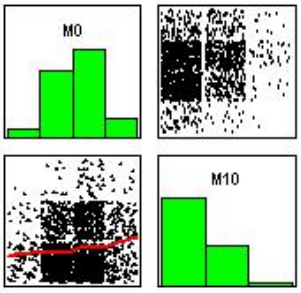
b) retro 1



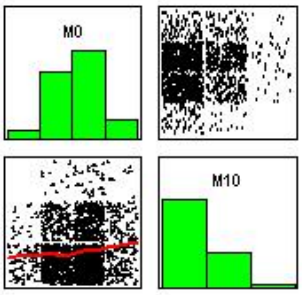
c) retro 2



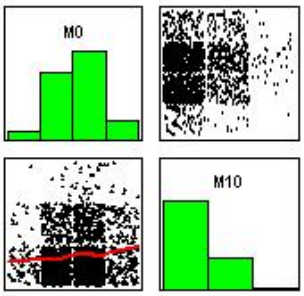
d) retro 3



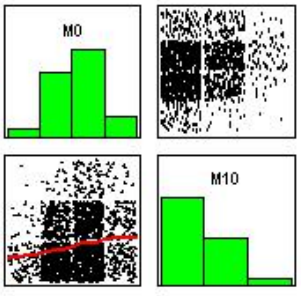
e) retro 4



f) retro 5



g) retro 6



h) retro 7

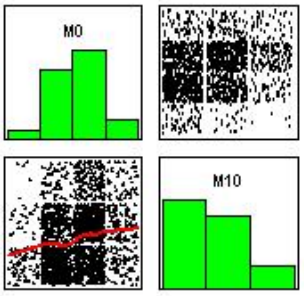
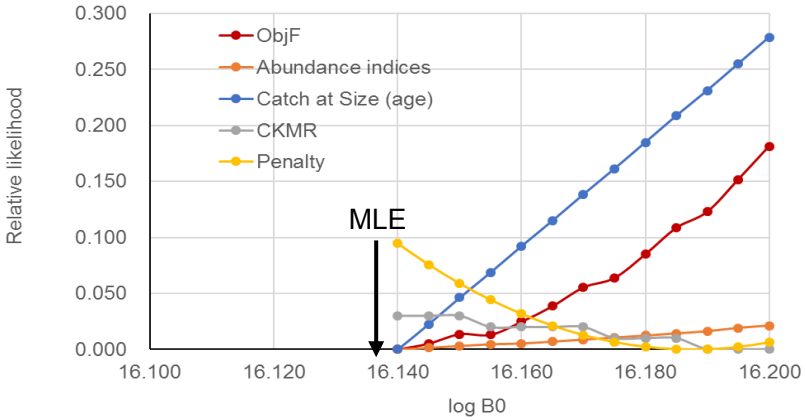
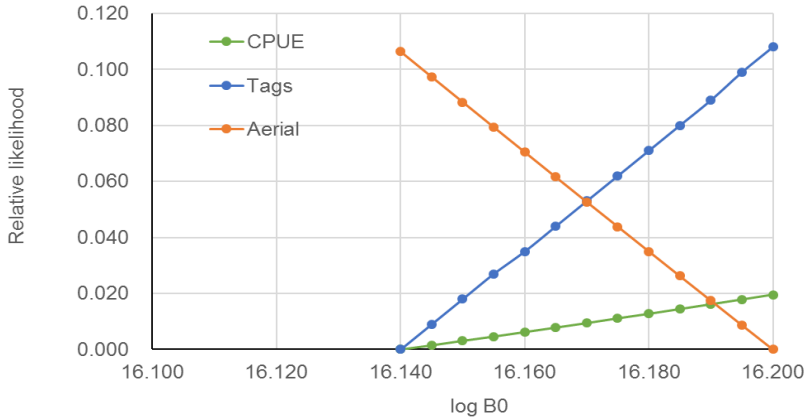


Figure 2. Level plots for the grid parameters which were sampled by posterior (M1 and M10) in the retrospective analysis.

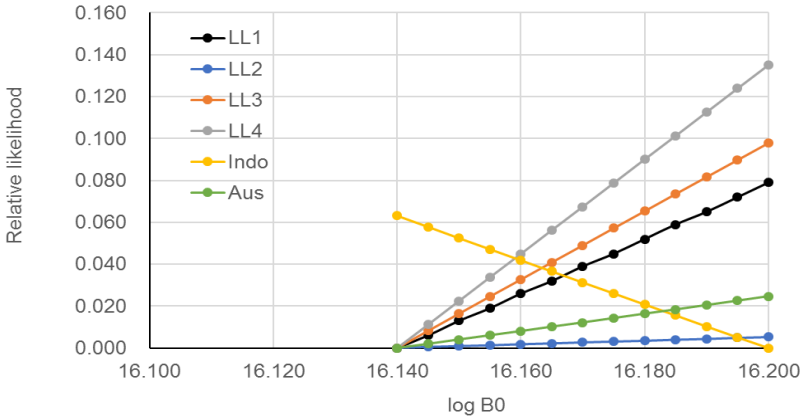
a) Total



b) Abundance indices



c) Catch at Size (Age)



d) CKMR

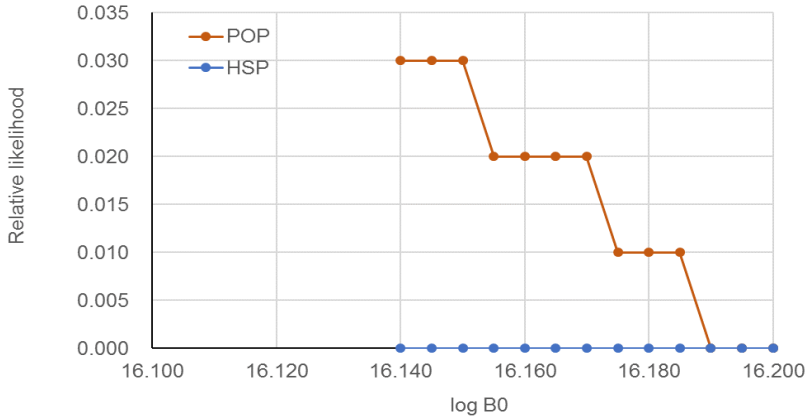


Figure 3. Profiles of a) total and component likelihoods (b-d) over fixed log(B0) for the best fitting cell (scenario 2312321) of reference set with extended upper bound for M30 parameter estimation.