Examination of the southern bluefin tuna (SBT) operating model and projections for the 2014 assessment

2014 年の資源評価のための

オペレーティングモデルの解析と将来予測

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Summary

The impacts of updates of the SBT operating Model (OM) and input data are examined. The stock status, historical trajectories of the biomass and recruitment, and future projection results based on the OM and Bali Procedure (MP3) are compared to the results from the previous stock assessment conducted in 2011. The analyses show that:

(1) for the new base case, there is a upward trend in the spawning stock of SBT, and the historical biomass trajectory is greater in absolute terms, compared to the previous stock assessment; but the stock status in 2014 remains low level ($B10+_{2013}/B10+_0$ =0.072);

(2) for the projection results for base case, the expected TAC under the MP is very similar to that for the previous results calculated in the MP evaluation in 2011, and the stock rebuilding probability is a little more optimistic ($P[B10+_{2035} > 20\%B10+_0]$=74.3%);

(3) due to the extremely high value of the most recent Aerial survey index, the OM estimates high recruitment for 2011;

(4) past unaccounted catch mortality (UAM) has a low impact on estimates of current stock status, but it has by far the strongest impact on the stock rebuilding projection under the current assumption among the sensitivity runs examined ($P[B10+_{2035} > 20\%B10+_0]$=49.6%);

(5) the sensitivity trials indicate no danger of the stock collapsing if managed under MP3, even for the pessimistic scenario (e.g. “AddedCatch” and “upq2008”) considered;

(6) these results suggest that the MP3 as currently specified can manage SBT stock adequately, so that there is no need for re-tuning at this time;

(7) further examination using more realistic UAM scenarios based on the best available research data would be required to understand the impact of the UAM on stock projections in more detail.

要約

オペレーティングモデル（OM）と入力データの更新の影響を検討した。OM とバリ方式に基づく資源状態、歴史的なバイオマスと加入量の変遷、および将来予測結果を、前回（2011 年）の資源評価結果と比較した。得られた結果は以下の通り：

(1) 新たなベースケースシナリオでは、前回の資源評価と比較して産卵親魚に増加傾向がみられ、全体的に高いバイオマスの絶対値が推定される。しかし、B0 に対する 2014 年の相対的な資源状態は未だ低い水準である　（$B10+_{2014}/B10+_{0}$=0.072）；

(2) ベースケースシナリオでの将来予測では、2011 年の MP 性能評価における将来予測結果に非常に類似した TAC の予測値が示される。また、資源回復確率はやや楽観的になる（$P[B10+_{2035} > 20\%B10+_{0}]$=74.3%）；

(3) 非常に高い最近年の航空目視調査指数により、OM は 2011 年に非常に高い加入量があったと推定する；

(4) 過去の考慮されていない死亡量について現在の仮定に基づき OM に含めると、資源回復確率が 49.6％へ減少する。ただし、現在の資源水準の推定値への影響は小さい；

(5) 感度試験の結果、たとえ悲観的なシナリオの下での評価（AddedCatch シナリオや upq2008 シナリオ）においても、管理方式での資源管理によって資源が崩壊する危険が無い事が示された；

(6) これらの結果は、現在のところバリ方式（MP3）を再チューニングせずに使用しても、ミナミマグロ資源を適切に管理できることを示唆している。

(7) 考慮されていない死亡量について、将来予測への影響を更に詳細に明らかにするためには、より現実的な死亡量の仮定を利用可能な調査データに基づいて設定し、更なる検討を進める必要があるだろう。

1. Introduction

The stock assessment of Southern bluefin tuna (SBT) scheduled in the CCSBT Extended Scientific Committee for the 19th Meeting of the Scientific Committee (ESC) is the first to be conducted after the implementation of the management procedure (MP) as the basis to recommend future TACs. One important task related to this assessment will be to check that continued management under the MP remains appropriate. This will require a comparison between the new assessment results and earlier simulated stock trajectories considered in the MP evaluations by ESC16 in 2011 (CCSBT 2011). If the assessment results fall substantially outside of these earlier simulations from the Operating Model (OM) used in testing and selecting this MP, the ESC will have to discuss whether “exceptional circumstances” apply under the “meta-rule” process.

The OM for stock assessment has been updated since the ESC16. In the 4th Operating Model and Management Procedure technical meeting (OMMP4) and ESC18, the inclusion of the Close-Kin (CK) data and changing the maturity schedule was agreed (CCSBT 2013a, 2013b). Then OMMP5 (CCSBT 2014) determined most of the final specifications for the model settings for the base case and some candidates for sensitivity runs of the OM to be used for the coming stock assessment. The meeting requested that members undertake work on the examination of the OM trials using these model settings.

In this document, we report on OM examination and projection results for the current base case and for some candidates for sensitivity trials to improve our understanding of the impact of the model settings and the input data. In particular, we focus on the most recent aerial survey data point and the influence of the inclusion of unaccounted catch mortality.

2. Methods

Updates of the data and the 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 repository to manage, improve and share the OM and projection program code[1]. We modified several program codes and data files which were downloaded from the GitHub repository in 16th July 2014.

Model specification

In this analysis, input data up to 2013 were used for OM conditioning (the Aerial survey (AS) index extended over 1993–2014). The projection period was the following 27 years (from 2014 to 2041),

[1] https://github.com/CCSBT-DM/sbtmod

although the TACs for the first 4 years were fixed to correspond to the TAC determination at the 12th annual Commission meeting (CCSBT 2013c): 12449t in 2014 and 14647t in 2015–2017 (TAC based on the MP). After 2018, TACs were simulated using the Bali procedure (MP3) every three years with a one year time lag. The control file for MP3 included the LL1 CPUE (1969–2013) and AS index (1993–2014) with the catchability ratio for AS vs CPUE = 877.42. Quota allocations by fleet were based on the "nominal allocations": LL1: 0.5414, LL2: 0.0712, Indonesia: 0.0507, Australia: 0.3367. The default grid specification which was agreed at the 18th ESC was used for this analysis (Table 1). The difference between the previous grid structure (Table 2) and new one is as follows:

(1) Steepness: using uniform weight to sample instead of the likelihood-based weight
(2) M0 (=M1): the high value "0.50" was added instead of the low value "0.30"
(3) M10: values were changed to "0.05, 0.075, 0.1, 0.125" from "0.07, 0.10, 0.13, 0.16".

Base case and sensitivity runs

We examined the base case run and some of the sensitivity trials which were specified at OMMP5 (CCSBT 2014). For the scenario related to the CK data, the scenario "CK-off" (excluding the close-kin data) was examined to understand the influence of the CK data, instead of the "UpWtCK" (change the CK data weighting) scenario which was requested by the OMMP5. In addition, we have examined three further scenarios ("GridTroll", "SbySCPUE", and "GAMCPUE") in this document: the "GridTroll" scenario includes an alternative "grid-type" trolling survey index (called GTI) which is specified in CCSBT-ESC/1409/34 (Itoh and Takahashi 2014). The "SbySCPUE" scenario uses a monitoring series CPUE based on shot by shot data instead of the base case CPUE. The "GAMCPUE" scenario also uses other monitoring series CPUE based on GAM. Details of the specifications of each run are summarized in Table 3.

Comparison with previous assessment results

The base case run was compared to the previous assessment results which are for the "base case" run for the MP tuning in 2011. Based on the "base.grid" specified at the 16th ESC, the "MP3_2035_3000_inc" scenario was re-run using the previous projection program (sbtprojv120) and the Bali procedure (MP3). The input file is the same as used for the MP evaluation in 2011 (catchability ratio AS vs CPUE = 838.2094).

3. Results and Discussion

"Base case"

Shade plots show that the middle M0 values (0.40 and 0.45) and lower M10 values are preferred in base case run (Fig. 1-a). When the steepness is weighted by the objective function (sensitivity scenario #17 "SteepnessWts"), the middle h values (0.64 and 0.73) are preferred (Fig. 1-b). In this case, the negative log-likelihood component of the data has the preference for somewhat higher steepness values, but a penalty term (stock-recruitment residuals) shows the opposite trend (Fig. 2), as was mentioned during the CCSBT- OMMP4 (CCSBT 2013a).

The current OM calculates an "index" of the spawning populations which involves weighting by the relative spawning contribution potential-at-age (CCSBT 2013a). We call this the "SSB" in the current OM outputs, but this is not an "absolute value" of the spawning stock biomass. Thus the OMMP4 meeting agreed to use age 10+ biomass (B10+) for reporting on stock status for consistency (CCSBT 2013b). Accordingly we show the trajectories of both age 10+ biomass and the SSB in this document for the base case. Compared to the age 10+ biomass, the SSB already indicates an upward trend in the most recent year, possibly due to the new maturity schedule (that now starts at age 7) which was used to calculate the SSB (Fig. 3).

-Comparison with the previous assessment in 2011:

In the base case analysis, the median value of the current age 10+ biomass is 83,289 t ($B10+_{2014}$), which is almost twice that of the previous assessment results ($B10+_{2011}$=45,400t –see Table 4 and 5). This higher biomass value is evident not only for recent years, but also for the whole historical trajectory for the age 10+ biomass (Fig.3-b). The stock status in 2014 remains low at 0.072 $B10+_0$, but this ratio is a little higher than that for previous assessment ($B10+_{2011}/B10+_0$=0.05)[2].

Figs 4, 5, and 6 show the historical estimates of MSY, Fmsy, and surplus production, which were calculated in a similar manner to that specified in the ESC16 report (CCSBT 2011). The estimated MSY value is 33,358 t in the base case, and this is close to the results from the previous assessment (34,500 t). However, the current replacement yield is much larger (44,605 t) than previously (27,200 t). $F_{current}/F_{msy}$ is 0.657. The base case projections using the Bali Procedure (MP3) indicate that the age 10+ biomass will reach the interim rebuilding target of 0.20 $B10+_0$ with 74.3% probability by 2035 (Fig. 7 and Table 5). Average catch from 2015 to 2035 (median) is 7% higher than that of previous assessment ($\bar{C}_{2015\text{-}2035}$ = 21,259t). The rebuilding probability is higher than for the previous assessment (tuning value 70%), which suggests that recent stock rebuilding has been faster than was expected.

Impact of the CK data (sensitivity #14 "CK-off")

For the "CKoff" scenario, for which we excluded the CK data from input data set, higher M10 values are preferred compared to the base case run (Appendix-Fig.1-#14). The median value of current age 10+ biomass and the stock status are lower than for the base case, which are 52,795 t ($B10+_{2014}$) and 0.058 $B10+_0$, respectively. The predicted rebuilding probability is 68.1% (Table 5).

[2] The stock status for 2014 ($B10+_{2014}/B10+_0$) which was predicted in the previous assessment was 0.06 $B10+_0$.

The historical trajectory for the stock biomass and the projection are very similar to the previous assessment (Fig. 8). This suggests that the higher biomass trajectory estimated in the base case is due to the influence of the CK data.

Impact of the aerial survey index (sensitivity #8 “HighAerialCV”, #9 “No2014Aerial”, and #18 “CorrHistRecDevs”)

The most recent value of the aerial survey index (for 2014) is extremely high. This high data point leads to the high recruitment estimate for 2011 in the base case OM. When the high process CV of the index was selected (#8 “HighAerialCV”) or the high data point (2014 value) was excluded (#9 “No2014Aerial”), the recruitment estimate for 2011 was moderated or reduced. Moreover, the lower values of replacement yield estimated for these scenarios compare closely with those for the base case scenario (Table 5). Lower stock rebuilding probabilities by 2035 are predicted for these scenarios (69.9% in “HighAerialCV” and 65.0% in “No2014Aerial”). When the projected recruitment deviates were correlated to historical estimates for the conditioning (#18 “CorrHistRecDevs”), the high recruitment estimate continued 2011 and led to a high stock rebuilding probability ($P[B10+_{2035} > 20\%B10+_0] = 87.7\%$), as mentioned during OMMP5 (Sakai and Takahashi 2014). These results suggest that the estimation of recruitment is affected strongly by the last data point for the aerial survey index and the specification of the extent of auto-correlation. This has a strong impact to the future projection of the stock biomass, but relatively little effect on the estimate of current stock status.

Impact of the additional unaccounted catch mortality (sensitivity #1 “AddedCatch”, #2 “SFOC20”, #3”SFOC40”, and #4 “SFOC00”)

The assumption of a continued 20% or 40% over-catch of the surface fishery (#2 “SFOC20” and #3 “SFOC40”) leads to lower stock rebuilding probability than for the base case ($P[B10+_{2035} > 20\%B10+_0] = 68.7\%$ and 67.0%, respectively). A lower rebuilding probability is also indicated when no over-catch in the surface fishery is assumed (#4 “SFOC00”), but this is probably the result of the higher M0 preference in the conditioning (Appendix-Fig.1-#4).

For the unaccounted catch mortality (UAM) scenario which was specified in OMMP5 (#1 “AddedCatch”), the lowest stock rebuilding probability among the sensitivity runs examined is predicted ($P[B10+_{2035} > 20\%B10+_0] = 49.6\%$). The future UAM rate which is assumed in this scenario (21.4% in fishery 1 and 43.8% in fishery 6 –see Table 3) is too large to allow the stock rebuilding target to be attained.

These scenarios show that the recent additional catch has a very strong impact on the future projection of the stock biomass (i.e. on achieving the rebuilding target), but relatively little effect on the estimate of current stock status (the median values of $B10+_{2014}/B10+_0$ are 0.070-0.073).

Impact of the CPUE series (sensitivity #12 “HighLatAggCPUE”, #13 “NoInteractCPUE”, #b ”SbySCPUE”, and #c “GAMCPUE”)

CCSBT has three monitoring series for longline CPUE (Reduced base, Base with shot by shot, and GAM CPUE) to check whether or not unexpected change(s) occur in the base case CPUE series. These data sets are available for the all members under the CCSBT data exchange. In addition, the CPUE index for whose high latitude areas were combined in GLM model was discussed in OMMP5. When these CPUE data are used instead of the base case CPUE in the assessment model, there is no great difference in the estimates of the historical stock biomass trajectories. However the current stock status is affected slightly (Table 5) —a lower value eventuates for the #13 “NoInteractCPUE” scenario ($B10+_{2014}$ = 0.067 $B10+_{0}$), while in contrast, the higher value occurs for the #c “GAMCPUE” scenario ($B10+_{2014}$ = 0.084 $B10+_{0}$).

The other sensitivities

We also examined the remaining eight sensitivity trials, most of which were specified at the OMMP5. Almost all these scenarios indicate similar distributions for the M0 and M10 values to those for the base case, but #7 “IndSelFlat20” scenario —changing the maximum age from 25 to 30 to start the flat selectivity in Indonesian LL fishery— has a preference for higher M10 values compared to the base case run. In this scenario, the past and future stock biomass trajectories are lower than that for the base case (Appendix-Fig2-#7), however the stock rebuilding probability is high (86.4%).

The most optimistic scenario is #a “GridTroll” which has highest rebuilding probability ($P[B10+_{2035} > 20\%B10+_{0}]$ = 89.1%). This scenario incorporates the alternative troll survey index, and shows higher recruitment estimates for 2010-2012 (Appendix-Fig2-#a). When the usual troll index is incorporated, a higher recruitment is estimated for 2010 (Appendix-Fig2-#16). These results show some differences for the high recruitment years compared to the base case. In contrast, #10 “Upq2008” scenario is a pessimistic scenario —this assumes a step-function increase in catchability of 0.25 from 2008 onwards. This scenario leads to a low stock status (B_{2013}/B_{0} = 0.066), and its rebuilding probability is lower than the target ($P[B10+_{2035} > 20\%B10+_{0}]$ =59.8%). But even if this pessimistic scenario is used, no potential danger of the stock collapsing under the MP3 management is indicated.

4. Conclusion

The current base case shows more optimistic results than that of the previous assessment. All of sensitivity trials indicate that the MP3 provides a robust basis to manage the SBT stock; there is no danger of the stock collapsing under every sensitivity scenario examined when projecting using MP3.

In addition, almost all the scenarios show that the stock can achieve the rebuilding target or close to that in 2035. These results suggest that the MP3 as currently specified will be able to manage SBT stock adequately, so that there is no need for re-tuning at this time.

The most pessimistic result occurs under the "AddedCatch" scenario for the projections in this examination. The UAM values in this scenario are just a tentatively assumed scenario. Further examination using more realistic UAM scenarios based on the best available research data would be desirable. This would enable a more detailed evaluation of the impact on the stock in future under UAM.

Reference

CCSBT (2011) Report of the Sixteenth Meeting of the Scientific Committee. 19-28 September 2011. Bali, Indonesia.

CCSBT (2013a) Report of the Fourth Operating Model and Management Procedure Technical Meeting. 23-26 July 2013. Portland, Maine, USA.

CCSBT (2013b) Report of the Eighteenth Meeting of the Scientific Committee. 7 September 2013. Canbera, Australia.

CCSBT (2013c) Report of the Twentieth Annual Meeting of Commission. 14-17 October 2013. Adelaide, Australia.

CCSBT (2014) Report of the Fifth Operating Model and Management Procedure Technical Meeting. 24-27 June 2014. Seattle, Washington, USA.

Itoh T. and Takahashi N. (2014a) Update of the core vessel data and CPUE for southern bluefin tuna in 2014. CCSBT-OMMP/1406/13 17p.

Itoh T. and Takahashi N. (2014b) Trolling indices for age-1 southern bluefin tuna update of the piston line index and preliminary analysis of the grid type trolling index. CCSBT-ESC/1409/34 43p.

Sakai O. and Takahashi N. (2014) Impact of updated data in the southern bluefin tuna (SBT) operating model and projections for the 2014 assessment. CCSBT-ESC/1409/Info5 10p.

Table 1. The default grid structure specified at the 18th ESC.

	Levels	Cumulate Number	Values	Prior	Simulation weight
Steepness	5	5	0.55, 0.64, 0.73, 0.82, 0.90	Uniform	Prior
M_1	4	20	0.35, 0.40, 0.45, 0.50	Uniform	Likelihood
M_{10}	4	80	0.050, 0.075, 0.100, 0.125	Uniform	Likelihood
Omega	1	80	1	NA	NA
CPUE series	2	160	w0.5, w0.8	Uniform	Prior
q-age-range	2	320	4-18, 8-12	0.67, 0.33	Prior
Sample size	1	320	Sqrt	NA	NA

Table 2. The old grid structure used for the previous stock assessment (16th ESC). The shading indicates specifications which are not included in the new default.

	Levels	Cumulate Number	Values	Prior	Simulation weight
Steepness	5	5	0.55, 0.64, 0.73, 0.82, 0.90	Uniform	**Likelihood**
M_1	4	20	**0.30**, 0.35, 0.40, 0.45	Uniform	Likelihood
M_{10}	4	80	**0.070**, 0.100, **0.130**, **0.160**	Uniform	Likelihood
Omega	1	80	1	NA	NA
CPUE series	2	160	w0.5, w0.8	Uniform	Prior
q-age-range	2	320	4-18, 8-12	0.67, 0.33	Prior
Sample size	1	320	Sqrt	NA	NA

Table 3. The list of base case and sensitivity run specifications

Scenario	Description	Priority
#0 [Base_case]	➢ Base case setting was agreed in 5th OMMP. ➢ Including the Close-Kin (CK) data and new maturity schedule and fecundity assumption (CCSBT 2013). ➢ Free Indonesian selectivity for 2013 (in addition to 2012) to accommodate the observed sharp increase in smaller/younger fish in the catch (age 7+). ➢ Tag over-dispersion parameter is 1.82 (changed from 2.35), and the process error for the aerial survey is 0.22 (changed from 0.18). ➢ Projected recruitment deviates are unlinked to historical estimates.	-

#1 [AddedCatch]	➢ Inclusion of the unaccounted catch mortalities (UAM) in conditioning.	High

- Catch increasing from 0 t in 1990 to 1,000 t in 2013, both for smaller fish (assigned to fishery 6) and larger fish (assigned to fishery 1). Those values are added to the sbtdata2013.dat (Lines 747-770).

Table: Assumed UAM from 1990-2013 (unit: t)

Fishery	1	2	3	4	5	6
Year	LL1	LL2	LL3	LL4	Indo	Aus
1990	0.00	0.00	0.00	0.00	0.00	0.00
1991	43.48	0.00	0.00	0.00	0.00	43.48
1992	86.96	0.00	0.00	0.00	0.00	86.96
1993	130.43	0.00	0.00	0.00	0.00	130.43
1994	173.91	0.00	0.00	0.00	0.00	173.91
1995	217.39	0.00	0.00	0.00	0.00	217.39
1996	260.87	0.00	0.00	0.00	0.00	260.87
1997	304.35	0.00	0.00	0.00	0.00	304.35
1998	347.83	0.00	0.00	0.00	0.00	347.83
1999	391.30	0.00	0.00	0.00	0.00	391.30
2000	434.78	0.00	0.00	0.00	0.00	434.78
2001	478.26	0.00	0.00	0.00	0.00	478.26
2002	521.74	0.00	0.00	0.00	0.00	521.74
2003	565.22	0.00	0.00	0.00	0.00	565.22
2004	608.70	0.00	0.00	0.00	0.00	608.70
2005	652.17	0.00	0.00	0.00	0.00	652.17
2006	695.65	0.00	0.00	0.00	0.00	695.65
2007	739.13	0.00	0.00	0.00	0.00	739.13
2008	782.61	0.00	0.00	0.00	0.00	782.61
2009	826.09	0.00	0.00	0.00	0.00	826.09
2010	869.57	0.00	0.00	0.00	0.00	869.57
2011	913.04	0.00	0.00	0.00	0.00	913.04
2012	956.52	0.00	0.00	0.00	0.00	956.52
2013	1000.00	0.00	0.00	0.00	0.00	1000.00

➢ Assuming that the additional catch remains at the same proportion as in 2013 in the projection. The surface fishery is additionally increased by 20% as the SCFO20 sensitivity scenario.

- The multipliers for LL1(fishery 1) and Aus (fishery 6) are calculated using following information;

The catch amount of 2013 (from the input file of OM) (unit: t)

Year	LL1	LL2	LL3	LL4	Indo	Aus
2013	4676.04	1014.91	17.95	0.00	1080.30	4198.28

The UAM rate for Fishery 1 is: 1000/4676.04 =**0.2139**

The UAM rate for Fishery 6 is: 1000/4198.28 +0.20 = **0.4382**

- The following multipliers are inputted in mycontrol.dat line 38;

Fishery 1: 1+0.2139 = **1.2139**

Fishery 6: 1+0.4382 = **1.4382**

#2 [SFOC20]	➢ Continued 20% overcatch by Australian surface fishery in projections. - Set “1.2” as the UAM option of Australian surface fishery in mycontrol.dat file using the base case grid in projection phase.	High
#3 [SFOC40]	➢ Apply 40% overcatch by the Australian surface fishery: ramps up from 1% in 1992 to 40% by 1999 and onwards to 2014. ➢ Adjust the age composition as was done for the 20% method. ➢ Continued 40% overcatch in projection. - Set “1.4” as the UAM option of Australian surface fishery in mycontrol.dat file using the base case grid in the projection phase.	High
#4 [SFOC00]	➢ No historical nor future additional catch in surface fishery. - Select “0” scenario option for the “surface scenario” in base.dat file line 23. - Set “0.0” as the UAM option of Australian surface fishery in mycontrol.dat file using the base case grid in the projection phase.	High
#5 [S00CPUE]	➢ Past longline overcatch had no impact on LL1 CPUE. - Select “0” scenario option for the “cpue_case” in base.dat file line 20.	High
#6 [S50CPUE]	➢ 50% of lonline overcatch associated with reported effort for LL1 CPUE - Select “2” scenario option for the “cpue_case” in base.dat file line 20.	High
#7 [IndSelFlat20]	➢ Change of the maximum age from 25 to 20 to start flat selectivity in Indonesian LL fishery. - Replace fifth “max age (I35)” value from “25” to “20” in sqrt.dat file line 90.	Med
#8 [HighAerialCV]	➢ Set the process CV of the Aerial Survey Index to 0.4 for the conditioning phase. - Replace “tau aerial survey” value from “0.22” to “0.40” in sqrt.dat file line 52.	Low
#9 [No2014Aerial]	➢ Remove the 2014 aerial survey data point from the conditioning (keep for MP) - Replace 2014 value of aerial survey data from sbtdata2013.dat file line 334 and modify the “Number of aerial survey indices” from “18” to “17” in line 315.	High

<table>
<tr><td>#10
[upq2008]</td><td>➢ Assume an increase in catchability of 0.25, using a step function, from 2008 onwards.
- A 25% increase in “catchability parameters (I16)” at 2008 in sqrt.dat file line36.</td><td>Med</td></tr>
<tr><td>#11
[Omega75]</td><td>➢ Relationship between biomass and CPUE with power=0.75.
- Replace “Omega (I19) of CPUE parameter” from “1.0” to “0.75” in sqrt.dat file line 44.
- Replace “omega value” from “1.0” to “0.75” in base.dat file line 15.</td><td>Med</td></tr>
<tr><td>#12
[HighLatAggCPUE]</td><td>➢ Combine Lat 45S and 40S in the GLM standardization of LL1 CPUE
➢ This CPUE series were distributed by Japan on 25/July/2014.
- Added following series to the OM input file as the cpue 8 and 9.
CPUE of combined 45S
(values of 1969-1985 were the same as base model)
<table>
<tr><td>Series</td><td>1986</td><td>1987</td><td>1988</td><td>1989</td><td>1990</td><td>1991</td><td>1992</td></tr>
<tr><td>W08</td><td>0.6189</td><td>0.6287</td><td>0.5387</td><td>0.5214</td><td>0.5176</td><td>0.4737</td><td>0.5492</td></tr>
<tr><td>W05</td><td>0.6486</td><td>0.6455</td><td>0.5511</td><td>0.536</td><td>0.4941</td><td>0.4741</td><td>0.5395</td></tr>
<tr><td>1993</td><td>1994</td><td>1995</td><td>1996</td><td>1997</td><td>1998</td><td>1999</td><td>2000</td></tr>
<tr><td>0.7299</td><td>0.6795</td><td>0.7825</td><td>0.5702</td><td>0.5085</td><td>0.5587</td><td>0.5783</td><td>0.5639</td></tr>
<tr><td>0.6655</td><td>0.5672</td><td>0.6926</td><td>0.5243</td><td>0.4555</td><td>0.5444</td><td>0.5554</td><td>0.4997</td></tr>
<tr><td>2001</td><td>2002</td><td>2003</td><td>2004</td><td>2005</td><td>2006</td><td>2007</td><td>2008</td></tr>
<tr><td>0.6011</td><td>0.8974</td><td>0.695</td><td>0.6183</td><td>0.49</td><td>0.3678</td><td>0.2818</td><td>0.5811</td></tr>
<tr><td>0.5618</td><td>0.7458</td><td>0.5882</td><td>0.5701</td><td>0.4684</td><td>0.3311</td><td>0.2391</td><td>0.4448</td></tr>
<tr><td>2009</td><td>2010</td><td>2011</td><td>2012</td><td>2013</td><td></td><td></td><td></td></tr>
<tr><td>0.7442</td><td>0.9265</td><td>0.8765</td><td>1.011</td><td>0.845</td><td></td><td></td><td></td></tr>
<tr><td>0.5725</td><td>0.6646</td><td>0.6442</td><td>0.753</td><td>0.6172</td><td></td><td></td><td></td></tr>
</table>
- Replace “cpue” from “2” and “3” to “8” and “9” in base.dat file line 9 and16.</td><td>High</td></tr>
<tr><td>#13
[NoInteractCPUE]</td><td>➢ Use CPUE trend from GLM without interactions year x area & year x latitude. This is the “reduced base case model” which uses the monitoring CPUE series 1 (CCSBT-OMMP/1406/13).
- Replace “cpue” from “2” and “3” to “4” and “5” in base.dat file line 9 and16.</td><td>High</td></tr>
<tr><td>#14
[CKoff]
Instead of [UpWtCK]</td><td>➢ Exclude the CK data.
- Replace “ck_sw” from “1” to “0” in sqrt.dat file line 60.</td><td>Low</td></tr>
<tr><td>#15
[TagFmixing]</td><td>➢ Increase the fishing mortality of tagged SBT by 50% relative to the F applied to the whole population.
➢ Account for incomplete mixing of the tagged fish.
- Replace “tag_H_factor” from “1.00” to “1.50” in sqrt.dat file line 58 (second value).</td><td>Med</td></tr>
</table>

#16 [TrollSurv]	➢ Include the piston-line troll survey index. - Replace "troll_sw" from "0" to "1", and "phase_tautroll" from "0" to "1" in sqrt.dat file line 62 and 64, respectively.	Med
#17 [SteepnessWts]	➢ For continuity with previous assessment, weight steepness h by the objective function. - Replace "no of fixed axis" from "4" to "3" in line 3, and remove "1" in line 36 for base.dat file.	High
#18 [CorrHistRecDevs]	➢ Projected recruitment deviates are correlated to the historical estimates from the conditioned model. - Replace "noAC_switch" from "1" to "0" for the second value in line 50 for mycontrol.dat file.	Low

Additional scenario;

#a [GridTroll]

➢ Including the alternative troll survey index specified in CCSBT-ESC/1409/34.

- Modify the troll index as follows;

Alternative "Grid Troll" Index (CCSBT-ESC/1409/34)

1996	1997	1998	1999	2000	2001	2002	2003	2005
0.625	0.885	0.787	1.279	0.340	0.285	0.133	0.510	0.597
2006	2007	2008	2009	2010	2011	2012	2013	2014
1.392	1.820	1.789	1.119	1.328	1.686	0.841	1.504	0.978

- Replace "troll_sw" from "0" to "1", and "phase_tautroll" from "0" to "1" in sqrt.dat file line 62 and 64, respectively.

#b [SbyS CPUE]

➢ Use CPUE based on the shot-by-shot daily level. This is the "Base with SxS model" which uses the monitoring CPUE series 2 (CCSBT-OMMP/1406/13).

- Replace "cpue" from "2" and "3" to "6" and "7" in base.dat file line 9 and16.

#c [GAM CPUE]

➢ Use the monitoring "GAM CPUE" series provided from Australia under the 2014 CCSBT data exchange.

"GAM CPUE" series;

1969	1970	1971	1972	1973	1974	1975	1976	1977
2.505	2.167	1.8811	2.050	1.669	1.864	1.375	1.617	1.712
1978	1979	1980	1981	1982	1983	1984	1985	1986
1.375	1.332	1.367	1.251	0.971	1.033	0.943	0.764	0.551
1987	1988	1989	1990	1991	1992	1993	1994	1995
0.596	0.550	0.486	0.548	0.568	0.648	0.812	0.827	0.793
1996	1997	1998	1999	2000	2001	2002	2003	2004
0.689	0.644	0.641	0.590	0.620	0.695	0.769	0.709	0.664
2005	2006	2007	2008	2009	2010	2011	2012	2013
0.644	0.498	0.481	0.631	0.830	0.892	0.9117	0.887	0.929

Table 4. Summary of conditioning and projection results under the Bali Procedure (which was tuned at the 2011 ESC) in previous assessment.

	Relative biomass of age 10+ B10+(2011)/B10+(0)			MSY	Replacement Yield	B10+ (2011)	SSB2011/ SSBmsy	F2010/ Fmsy	$\bar{C}_{2015-2035}$	Probability of reaching the target by 2035
Scenario	10%ile	Median	90%ile	Median	Median	Median	Median	Median	Median	P[B10+(2035) > 20%B10+(0)]
Previous assessment (2011 assess)	0.04	0.05	0.07	34,500	27,200	45,400	0.229	0.76	19,958	70.3%

Table 5. Summary of conditioning and projection results under the Bali Procedure (which was tuned at the 2011 ESC) for the base case and sensitivity trials. $\bar{C}_{2015-2035}$ is an average catch expected from 2015 to 2035, not TAC.

		Relative spawning stock index SSB(2014)/SSB(0)			Relative biomass of age 10+ B10+(2014)/B10+(0)			MSY	Replacement Yield	B10+ (2014)	SSB2014/ SSBmsy	F2013/ Fmsy	$\bar{C}_{2015-2035}$	Probability of reaching the target by 2035
#	Scenario	10%ile	Median	90%ile	10%ile	Median	90%ile	Median	Median	Median	Median	Median	Median	P[B10+(2035) > 20%B10+(0)]
0	Base case	0.077	0.093	0.116	0.061	0.072	0.087	33,358	44,605	83,289	0.378	0.657	21,259	74.3%
1	Added Catch	0.076	0.091	0.113	0.059	0.070	0.086	33,648	45,495	80,655	0.367	0.769	24,830	49.6%
2	SFOC20	0.077	0.093	0.116	0.061	0.072	0.087	33,358	44,605	83,289	0.378	0.657	22,175	68.7%
3	SFOC40	0.079	0.096	0.120	0.062	0.073	0.090	34,257	46,216	82,412	0.398	0.719	23,535	67.0%
4	SFOC00	0.075	0.090	0.110	0.059	0.071	0.086	32,304	42,775	86,452	0.361	0.604	20,884	69.5%
5	S00CPUE	0.081	0.101	0.132	0.064	0.078	0.096	34,087	47,386	85,847	0.414	0.596	21,430	81.7%
6	S50CPUE	0.075	0.090	0.110	0.060	0.070	0.085	32,903	42,979	81,387	0.362	0.701	21,138	68.9%
7	IndSelFlat20	0.094	0.122	0.152	0.069	0.087	0.108	34,195	47,123	67,363	0.480	0.568	21,933	86.4%
8	HighAerialCV	0.077	0.095	0.121	0.061	0.073	0.091	32,818	31,568	85,049	0.382	0.715	20,256	69.9%
9	No2014Aerial	0.075	0.092	0.117	0.061	0.072	0.089	31,839	21,205	83,744	0.375	0.796	18,846	65.0%
10	upq2008	0.070	0.086	0.106	0.056	0.066	0.080	32,987	42,518	76,770	0.343	0.728	21,639	59.8%
11	Omega75	0.067	0.082	0.104	0.052	0.063	0.077	34,160	44,777	73,936	0.333	0.694	20,258	70.1%
12	HighLatAggCPUE	0.078	0.093	0.116	0.062	0.072	0.087	33,349	44,490	83,669	0.378	0.663	21,220	73.7%
13	NoInteractCPUE	0.072	0.088	0.107	0.058	0.067	0.082	32,907	42,451	78,028	0.347	0.737	20,425	67.2%
14	CKoff	0.066	0.082	0.102	0.045	0.058	0.078	34,339	41,752	52,795	0.327	0.708	21,671	68.1%
15	TagFmixing	0.080	0.096	0.119	0.064	0.075	0.090	33,465	45,654	84,288	0.390	0.633	21,272	76.0%
16	TrollSurv	0.086	0.103	0.132	0.063	0.076	0.094	33,274	37,775	84,196	0.430	0.560	21,524	85.5%
17	SteepnessWts	0.073	0.089	0.111	0.058	0.070	0.084	33,078	43,102	83,882	0.345	0.702	20,852	72.3%
18	CorrHistRecDevs	0.077	0.093	0.116	0.061	0.072	0.087	33,358	44,605	83,289	0.378	0.657	23,106	87.7%
a.	GridTroll	0.091	0.111	0.141	0.066	0.078	0.096	33,098	34,812	84,510	0.456	0.530	21,795	89.1%
b.	SbySCPUE	0.077	0.094	0.117	0.061	0.073	0.088	33,419	44,977	83,753	0.378	0.651	21,372	75.5%
c.	GAMCPUE	0.089	0.104	0.128	0.074	0.084	0.099	33,280	45,016	98,709	0.4	0.620	22,205	79.3%

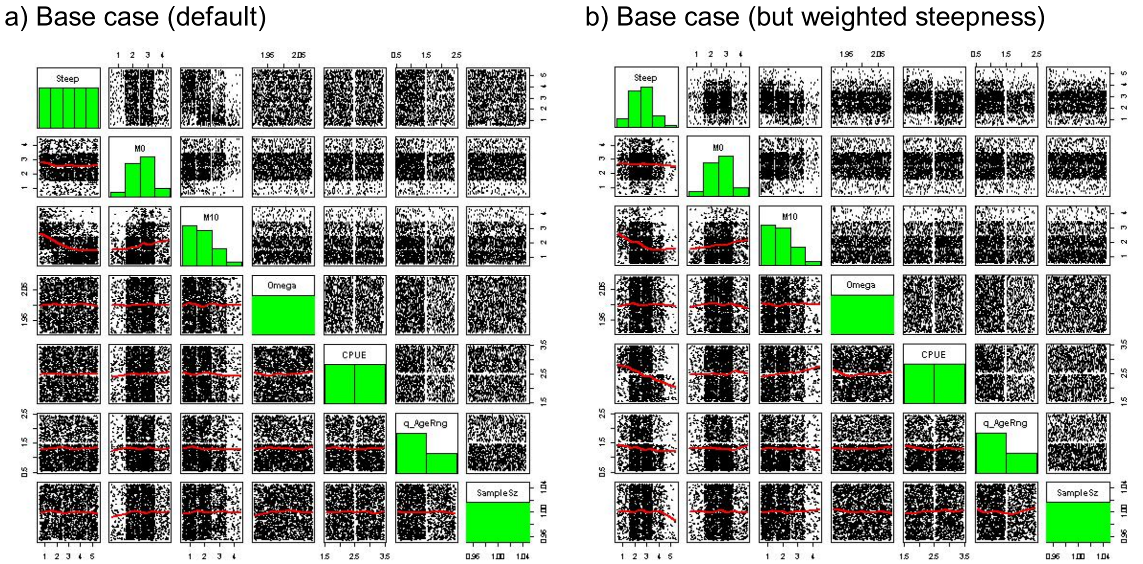


Fig. 1. Shad plots for the "Base case" and "Steepness Wt" run.

The grid structure was examined using the default setting (left) and the weighted h sensitivity setting (right).

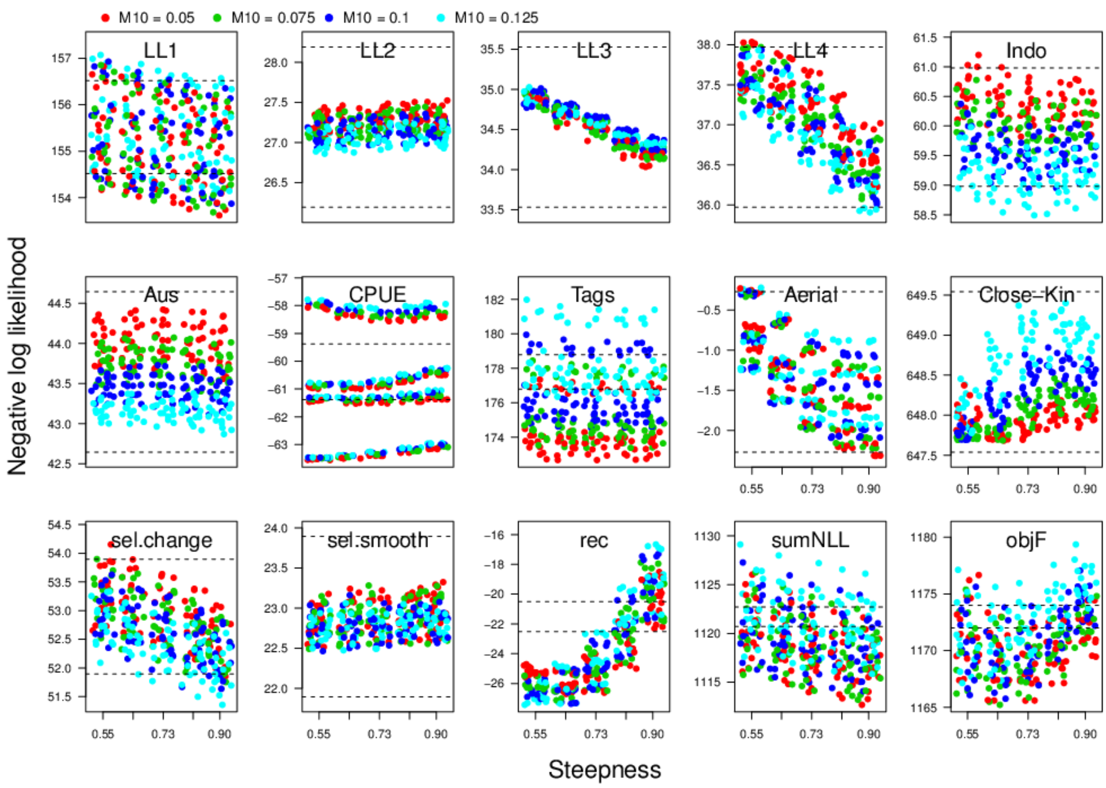


Fig. 2. Negative log-likelihood and penalty profiles for the steepness (base case).

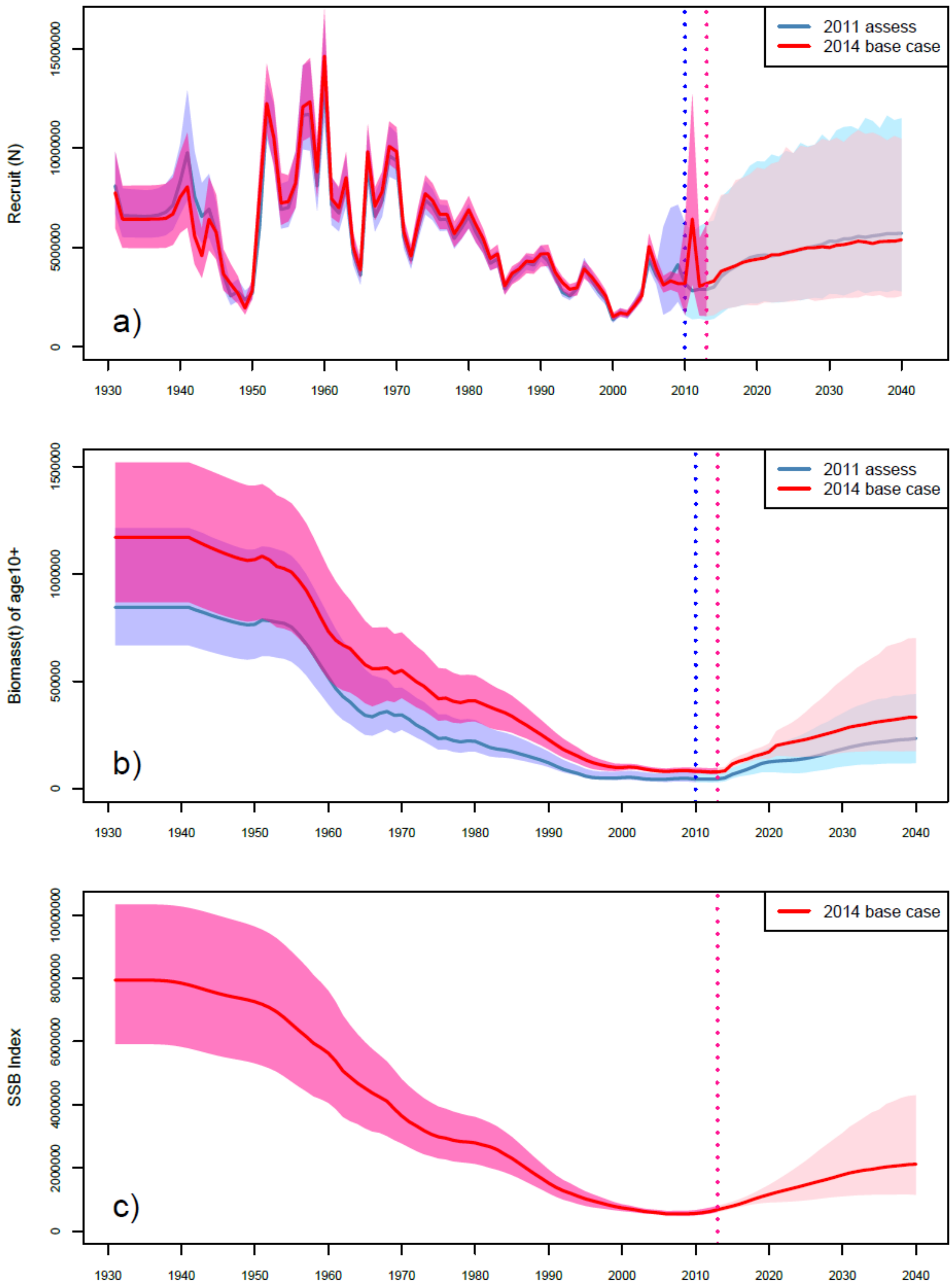


Fig. 3. Base case trajectories for a) recruitment, b) biomass of age 10+ fish, and c) "SSB index".

The red line with the pink region shows the median and 90% intervals of the current base case. The blue line with the light-blue region shows those for the previous assessment which was calculated in 2011. The dotted line shows the boundaries of the conditioning and projections.

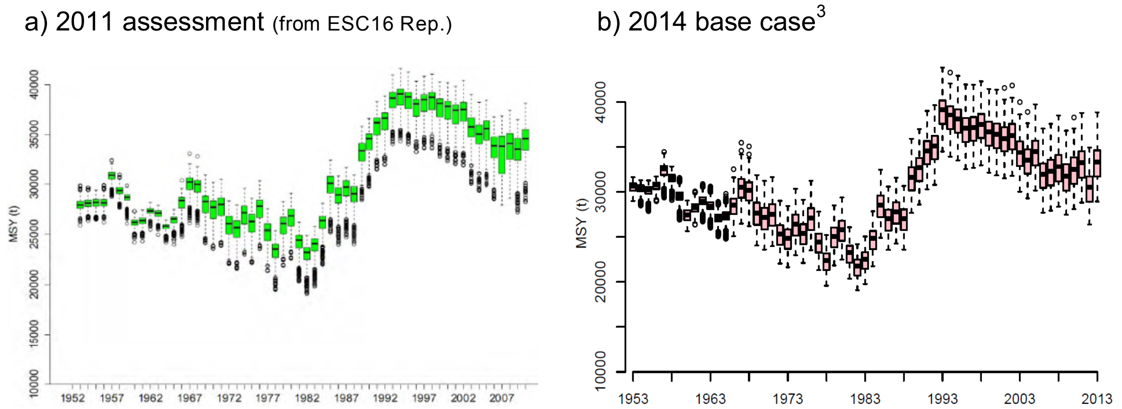


Fig. 4. Estimated MSY based on annual age-specific mean weight and selectivity as estimated using the base case of the OM; a) the result of previous assessment and b) current base case.

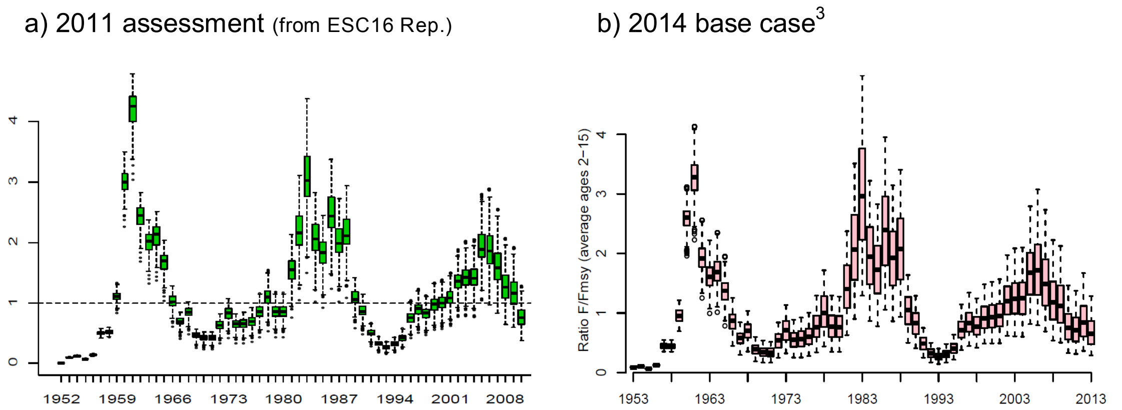


Fig. 5. Boxplot of the fishing mortality over the Fmsy (for ages 2-15) as estimated using the base case of the OM; a) the result of previous assessment and b) current base case.

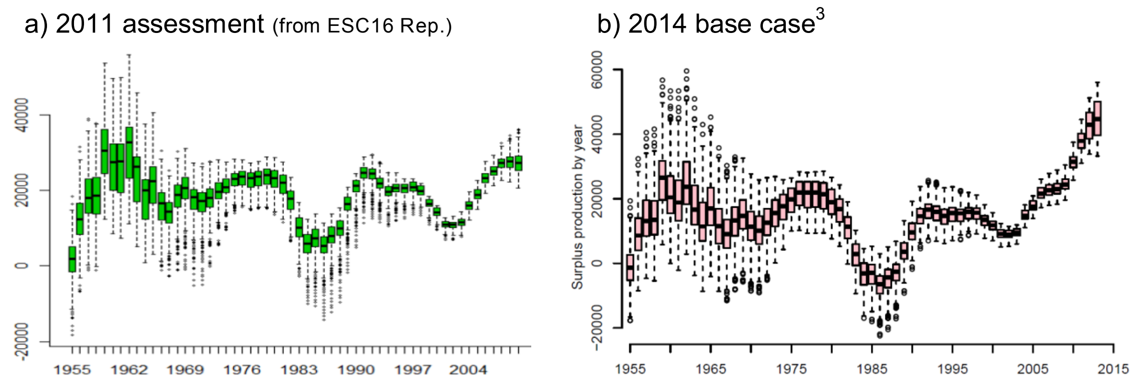


Fig. 6. Boxplot of the surplus production (catch in year t + biomass difference in year t from year t-1) as estimated using the base case of the OM ; a) the result of previous assessment and b) current base case.

[3] Current base case result is based on the 2000 sampled cells from 320 models.

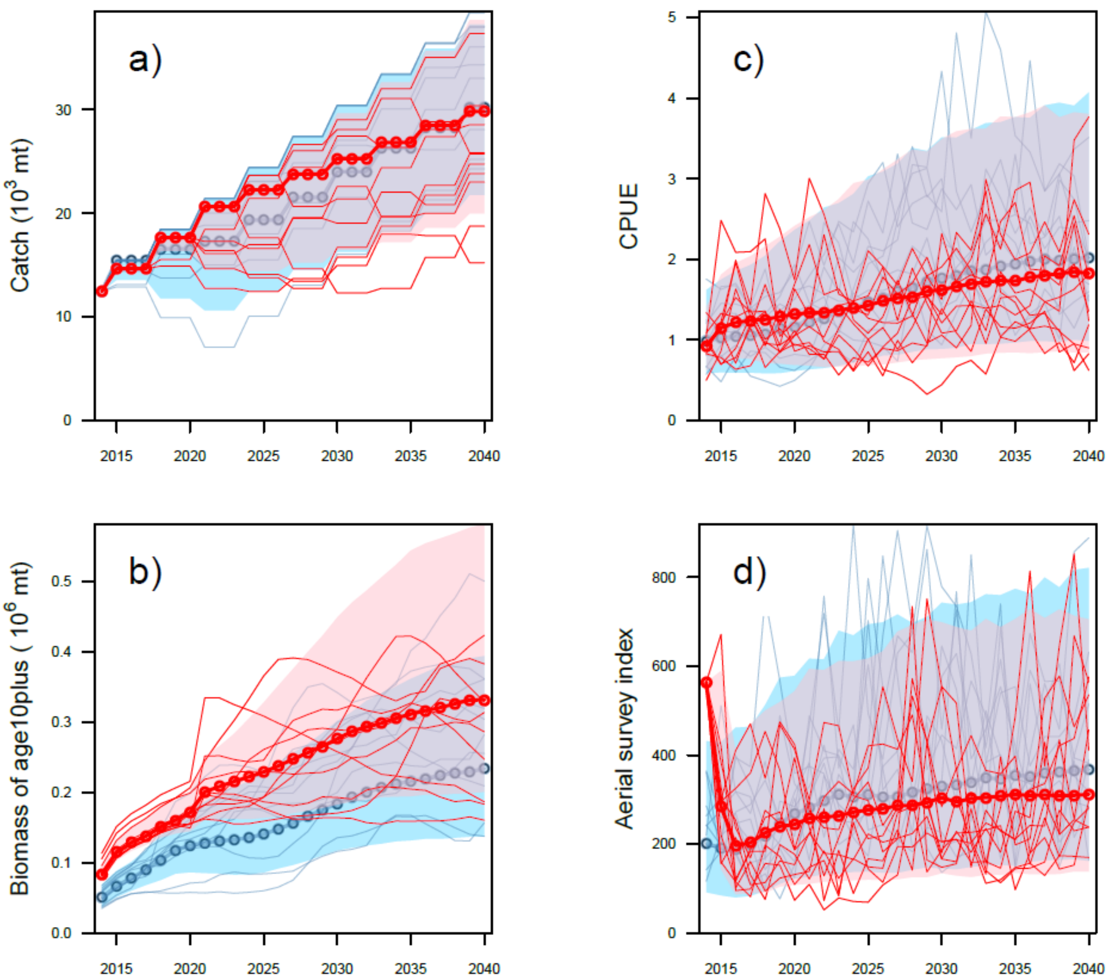


Fig. 7. Predicted values under the Bali Procedure; a) catch (10^3 tonnes), b) biomass of age 10+ fish (10^6 tonnes), c) CPUE of LL1, and d) Aerial survey index.

The red points with the pink regions show the median and 90% intervals of the current base case. The blue points with the light-blue regions show those for the previous assessment which was calculated in 2011.

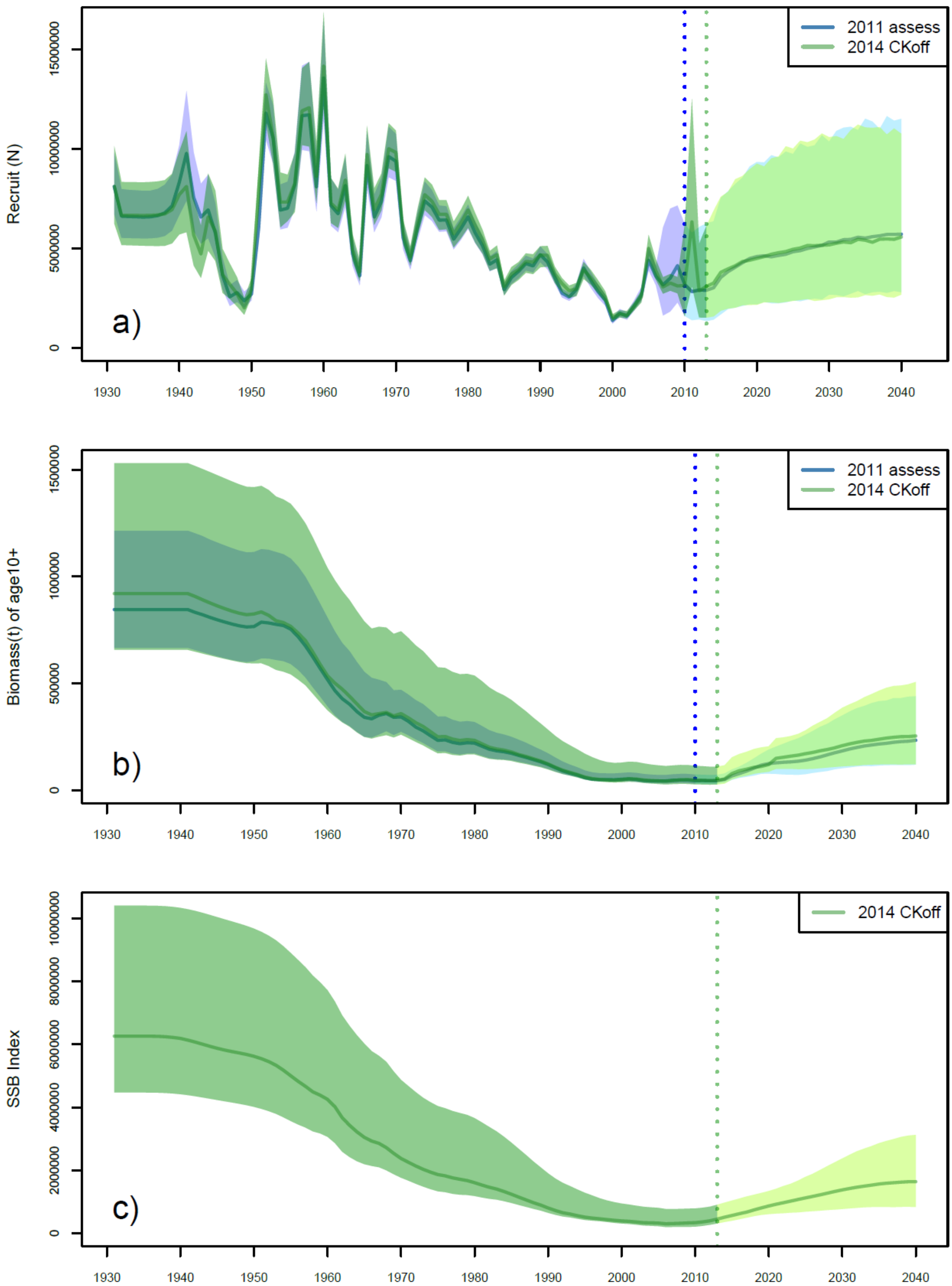


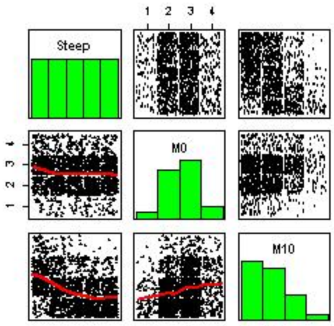
Fig. 8. Results of "CKoff"; a) recruitment, b) biomass of age 10+ fish, and c) "SSB index".

The green line and region shows the median and 90% intervals of the "CKoff" scenario. The blue line with the light-blue region shows those for the previous assessment which was calculated in 2011. The dotted line shows the boundaries of the conditioning and projections.

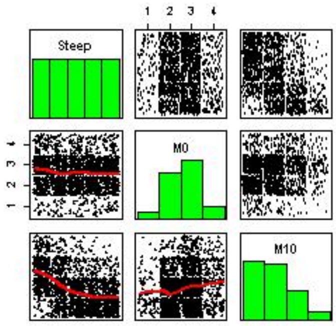
Appendix

#0 Base case,

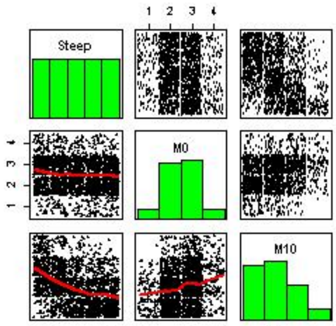
(#2 SFOC20 and #18 CorrHistRecDevs)



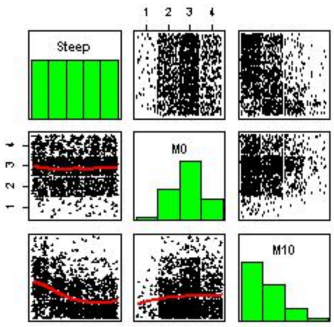
#1 Added Catch



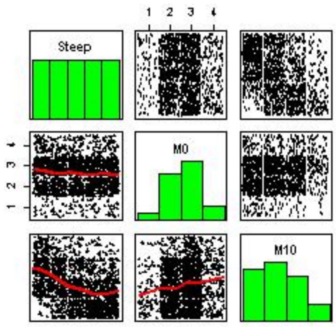
#3 SFOC40



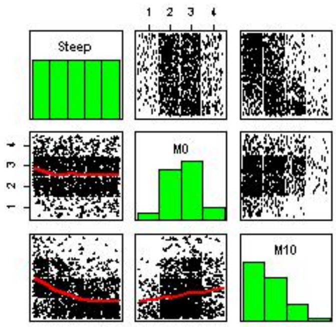
#4 SFOC00



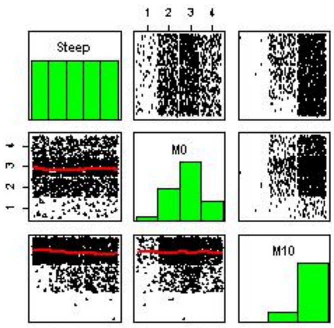
#5 S00CPUE



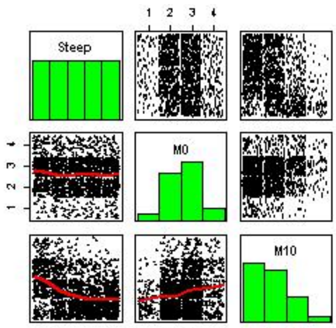
#6 S50CPUE



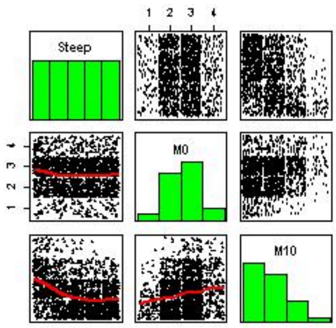
#7 IndSelFlat20



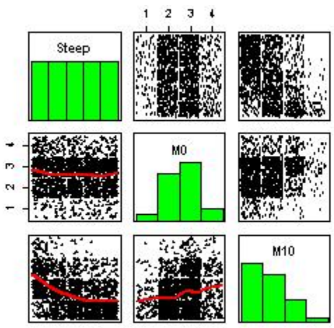
#8 HighAerialCV



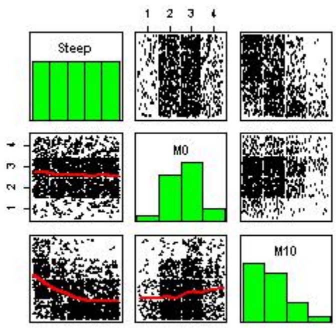
#9 No2014Aerial



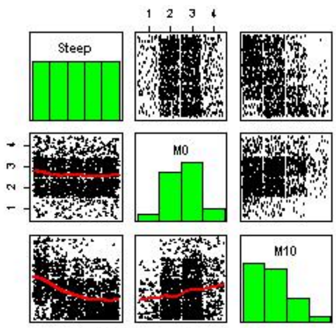
#10 upq2008



#11 Omega75

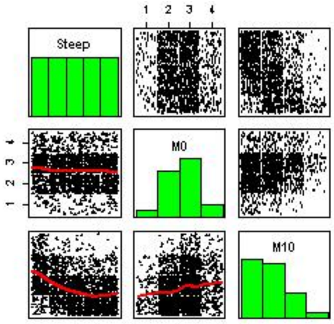


#12 HighLatAggCPUE

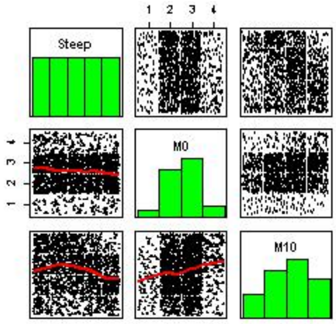


Appendix-Fig.1. Shaded plots of Steepness, M0, and M10 for the all runs.

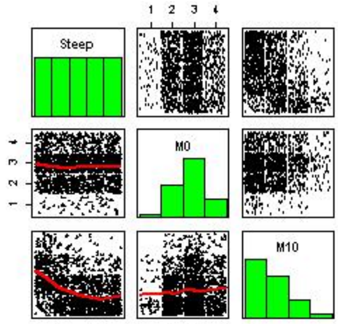
#13 NoInteractCPUE



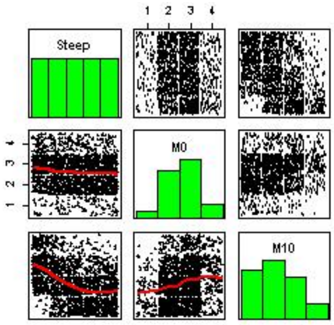
#14 CKoff



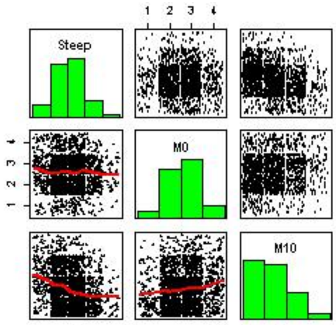
#15 TagFmixing



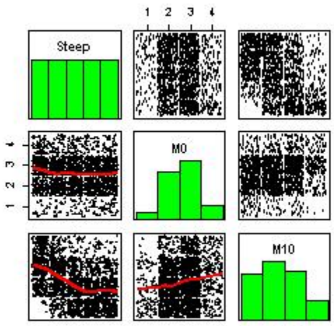
#16 TrollSurv



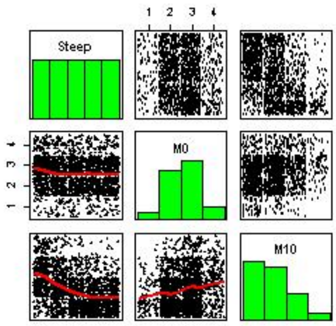
#17 SteepnessWts



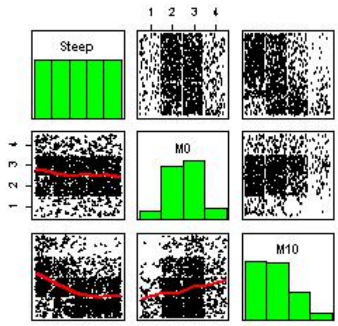
#a GridTroll



#b SbySCPUE

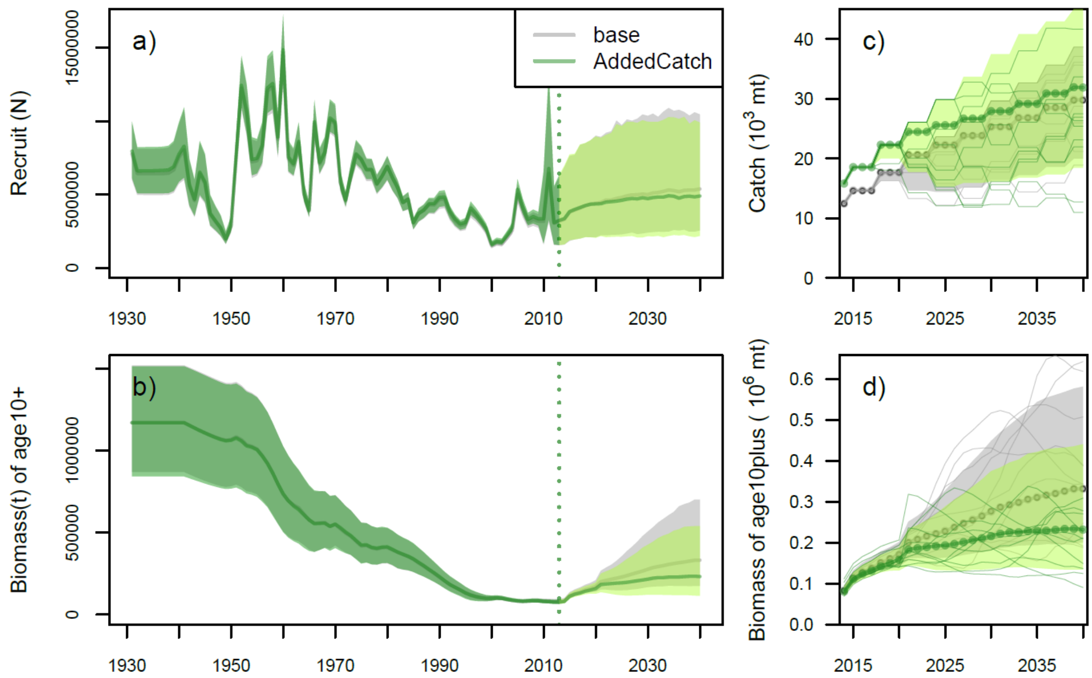


#c GAMCPUE

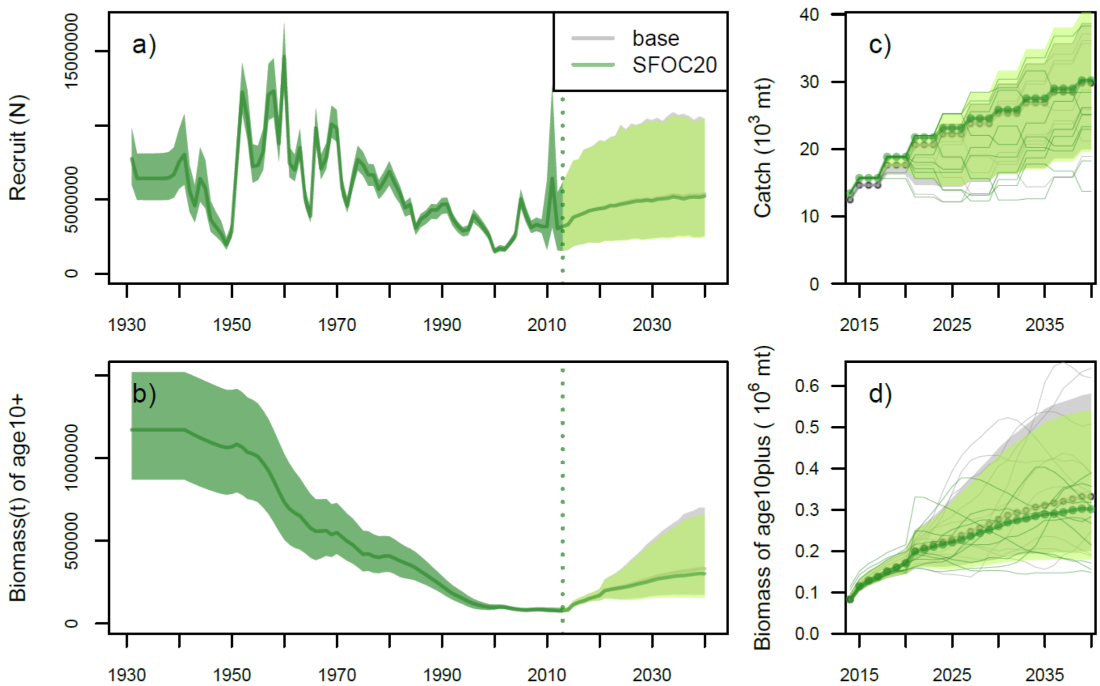


Appendix-Fig.1. cont.

#1 Added Catch



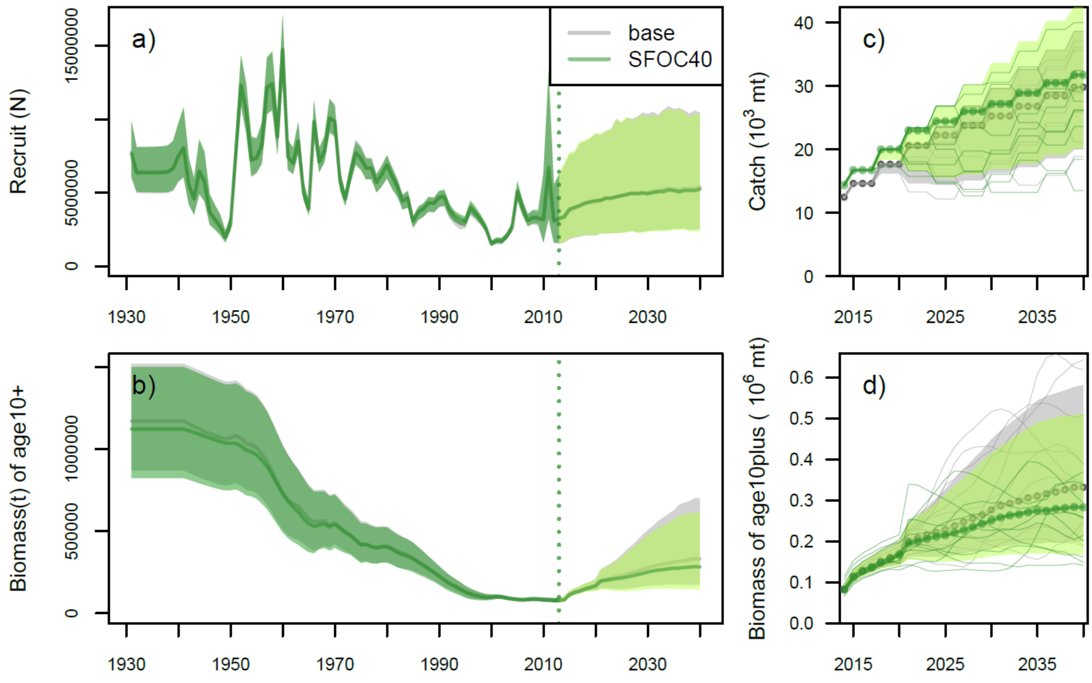
#2 SFOC20



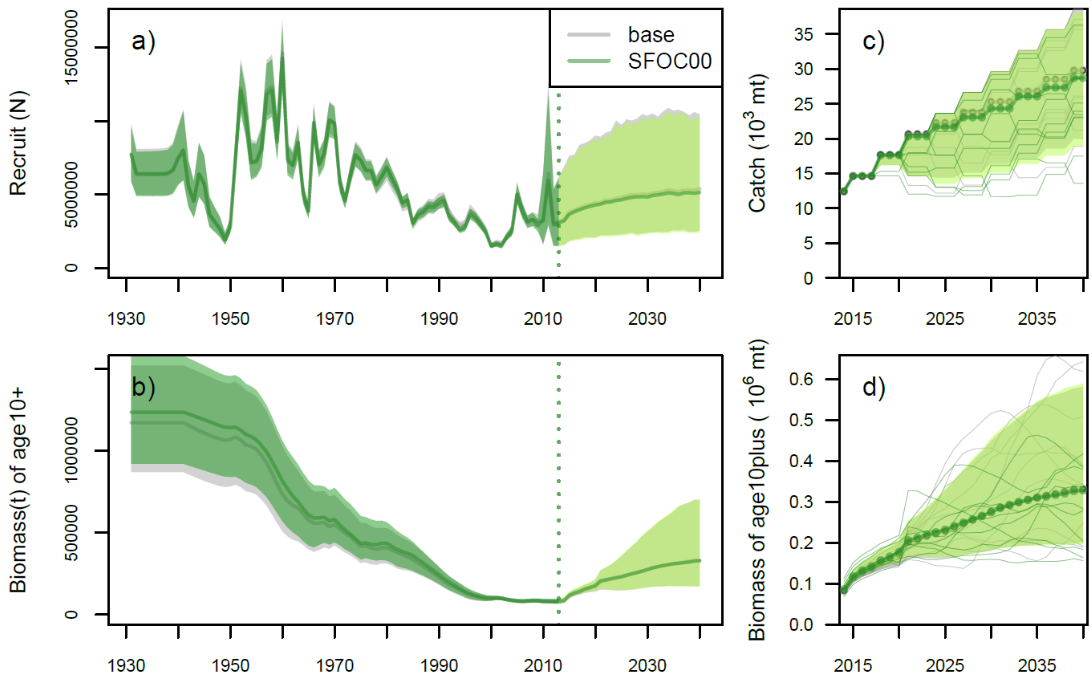
Appendix-Fig.2. Trajectories of a) recruitment, b) biomass of age 10+ fish, c) predicted TAC, and d) biomass for the sensitivity trials.

The green line with the greenish yellow region shows the median and 90% intervals of each scenario. The grey line and region shows the base case result.

#3 SFOC40

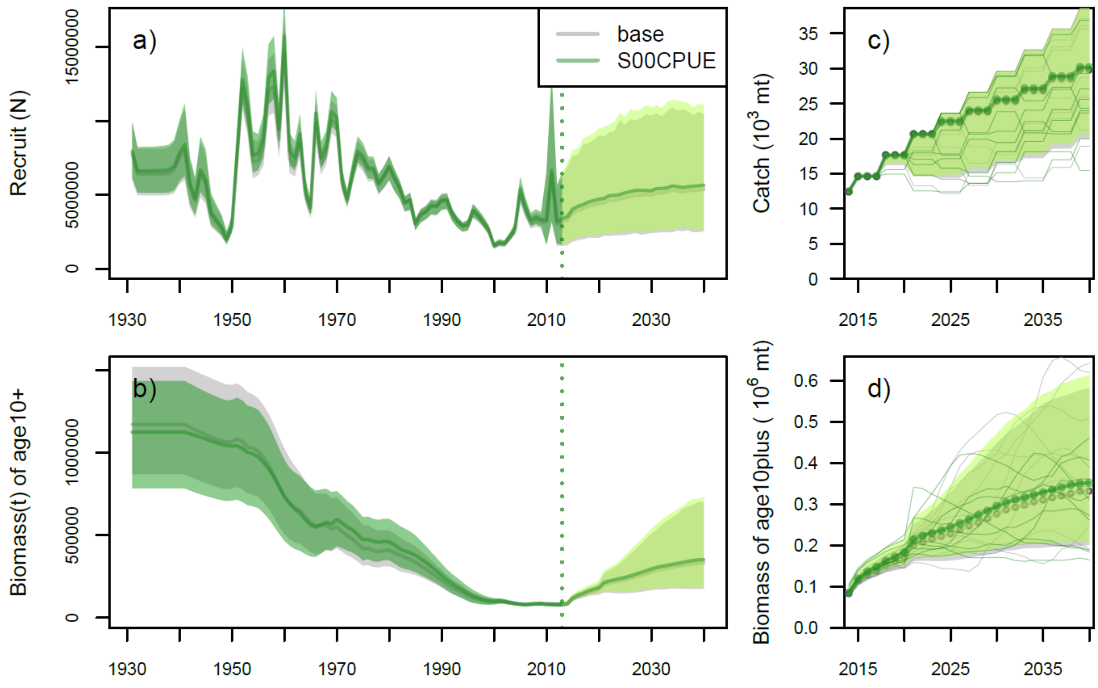


#4 SFOC00

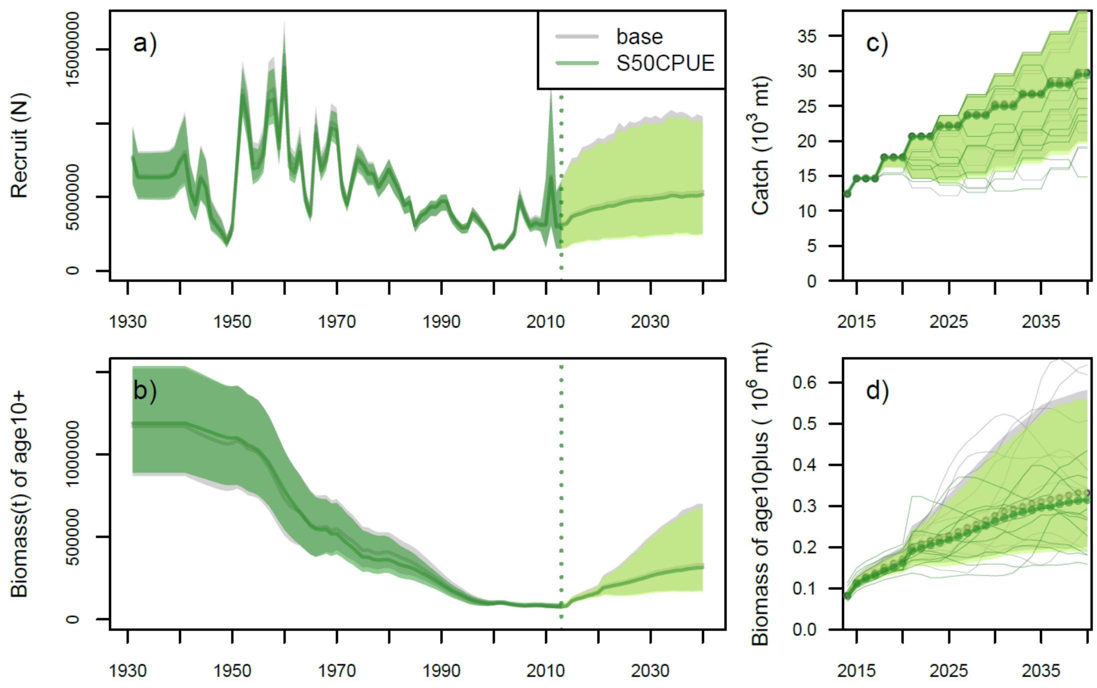


Appendix-Fig.2. conts.

#5 S00CPUE

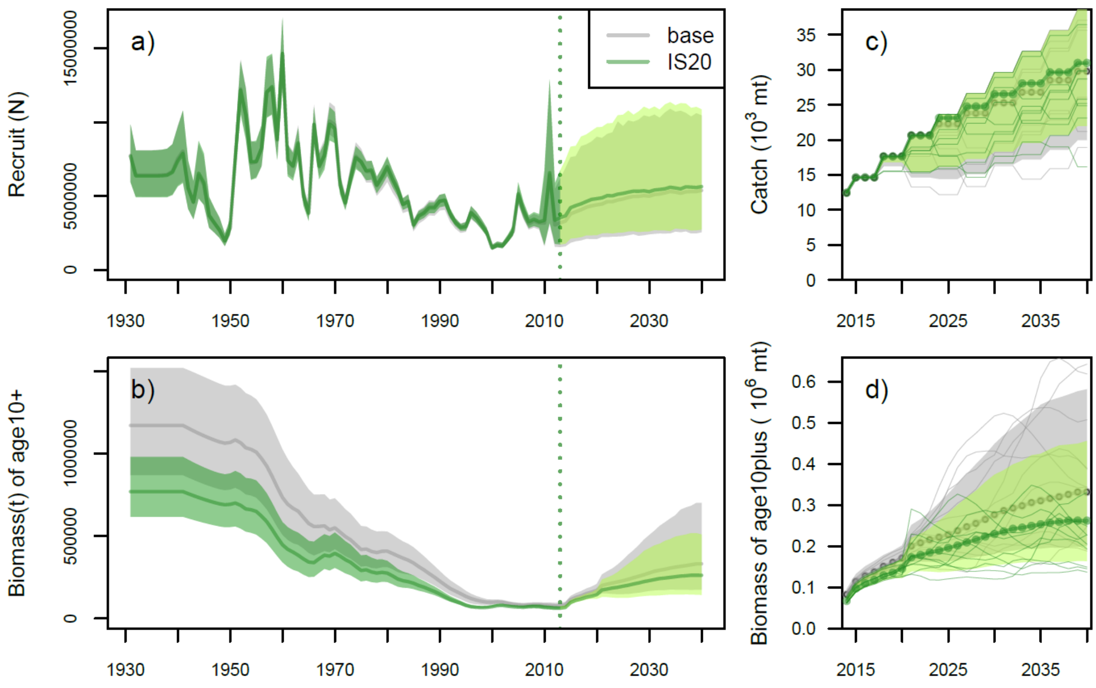


#6 S50CPUE

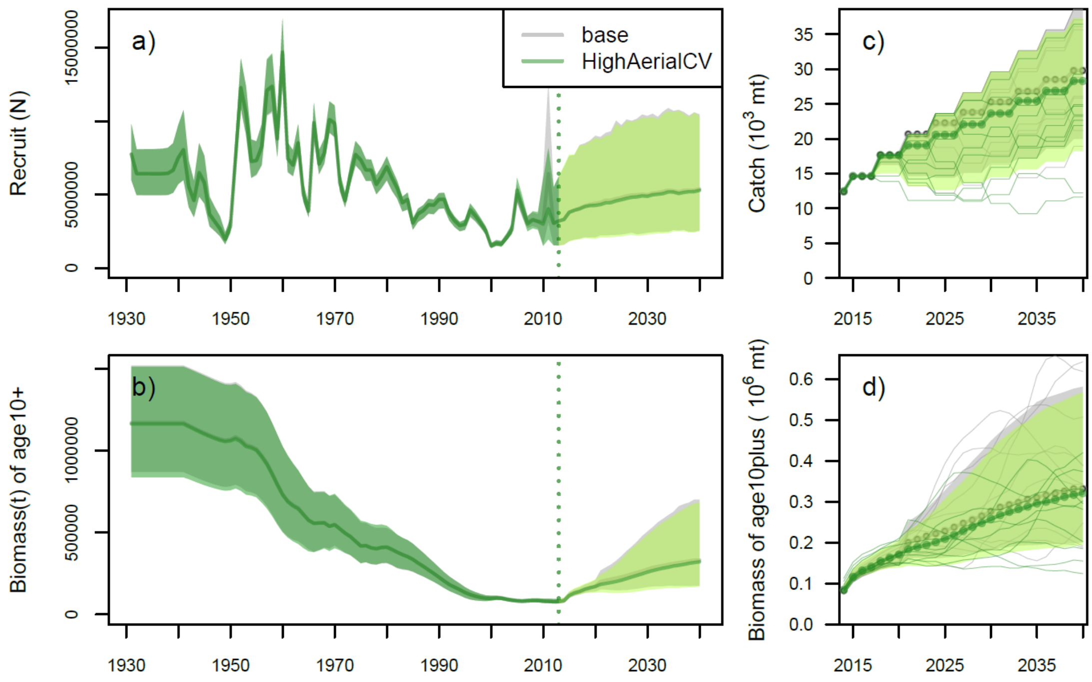


Appendix-Fig.2. conts.

#7 IndSelFlat20

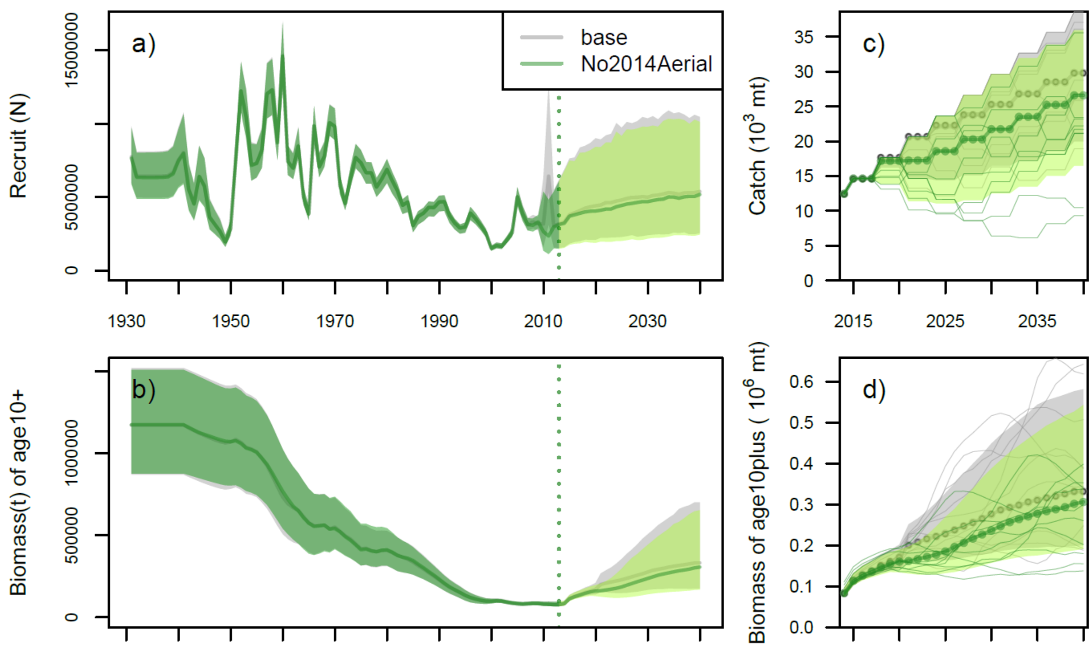


#8 HighAerialCV

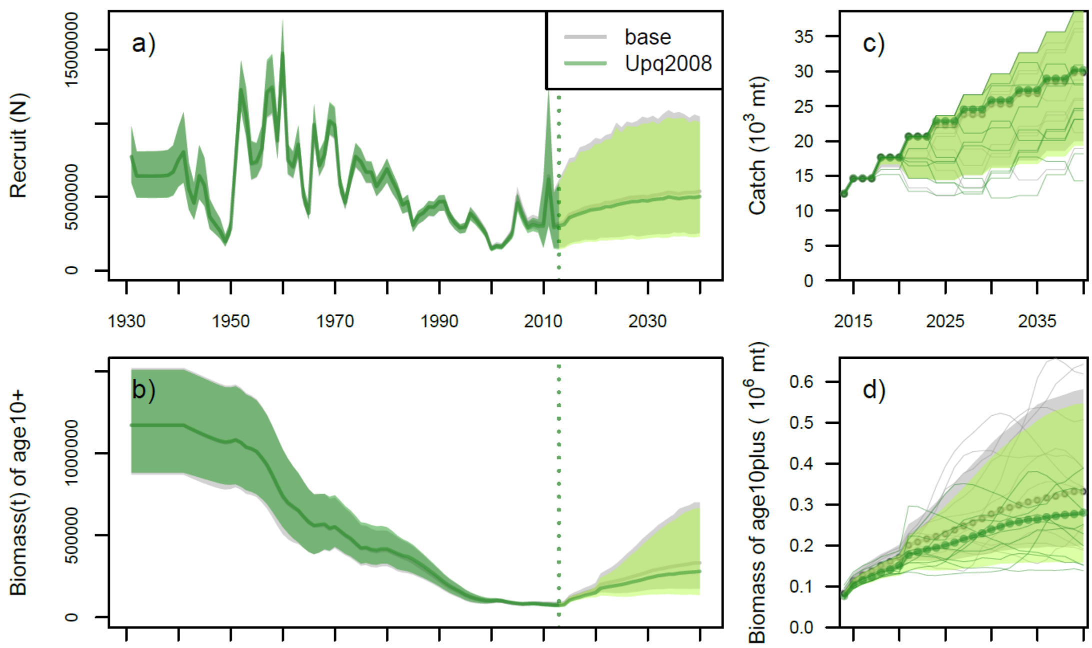


Appendix-Fig.2. conts.

#9 No2014Aerial

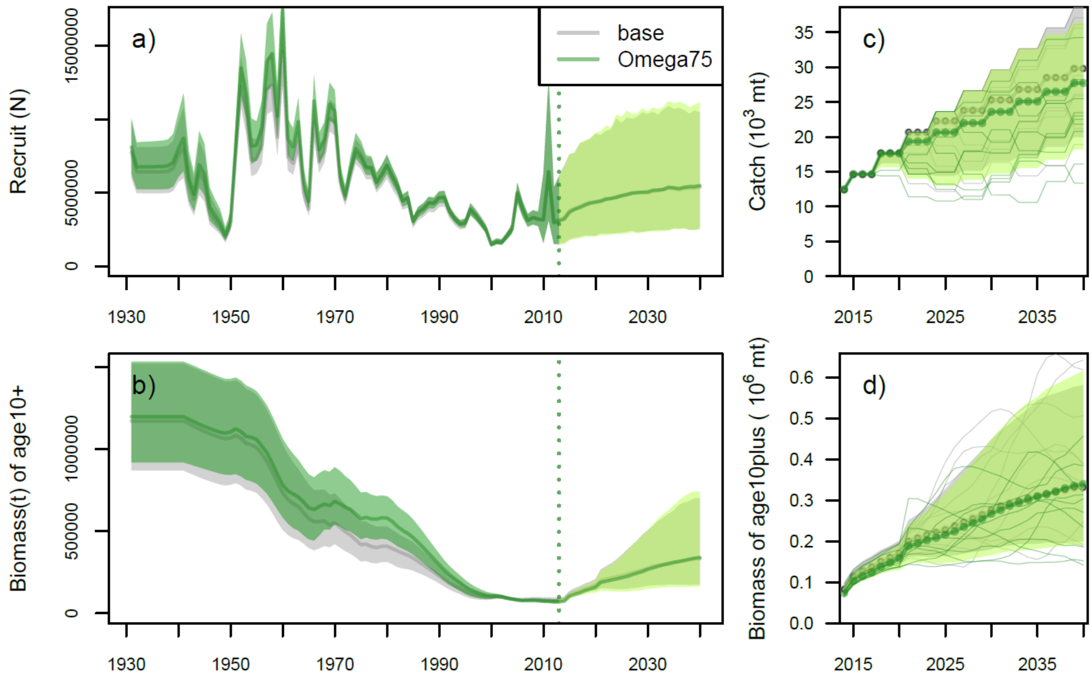


#10 Upq2008

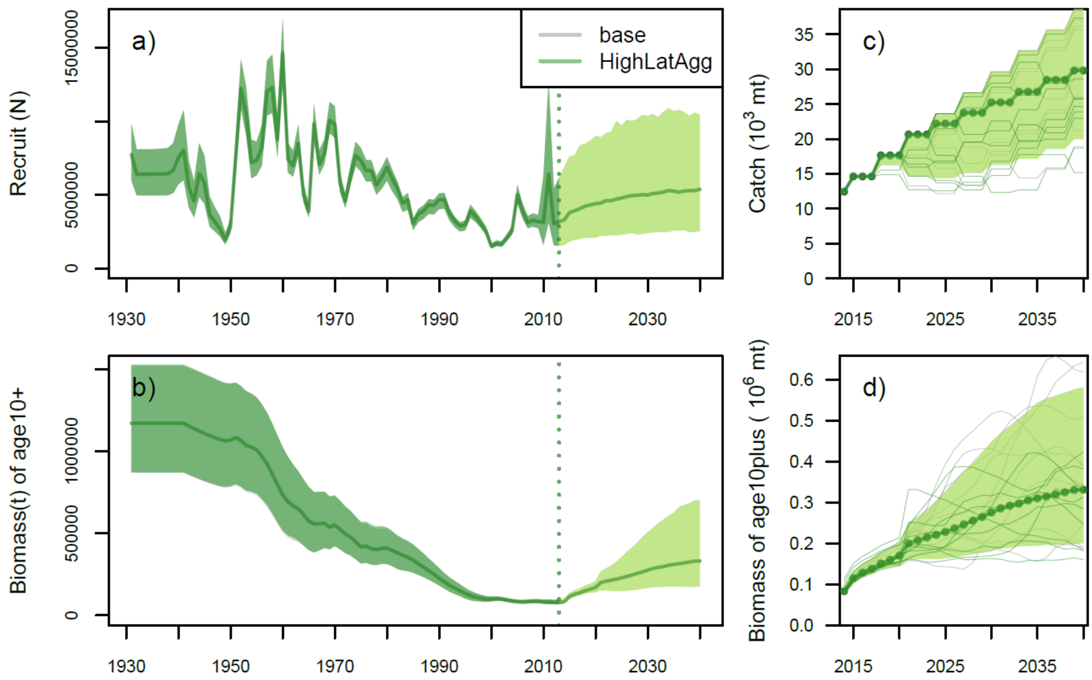


Appendix-Fig.2. conts.

#11 Omega75

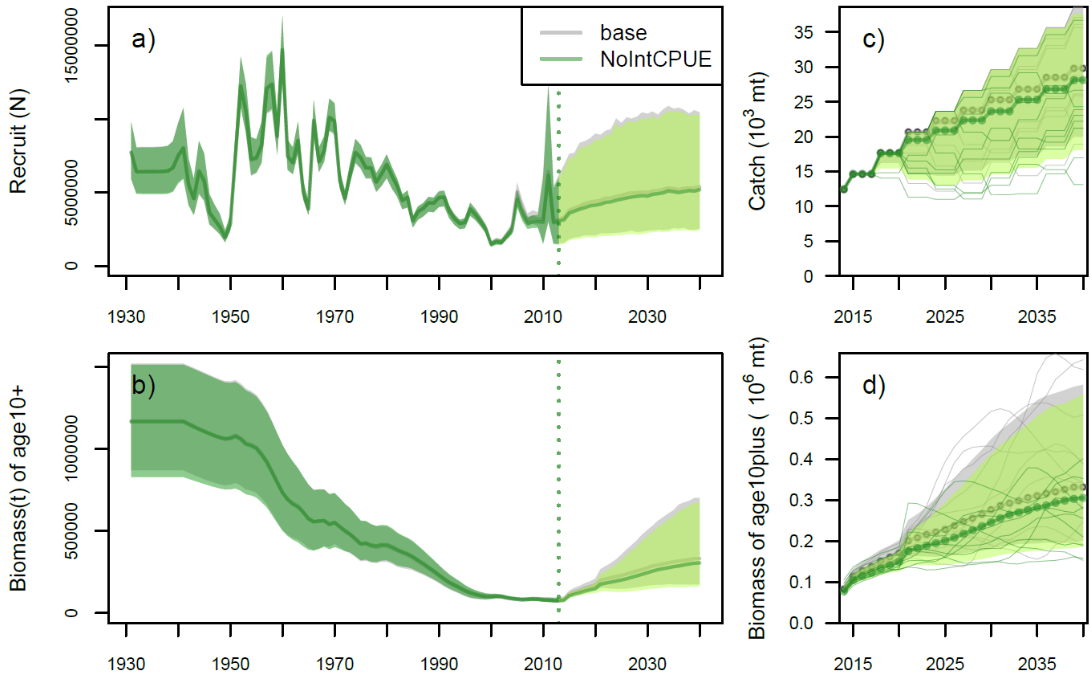


#12 HighLatAggCPUE

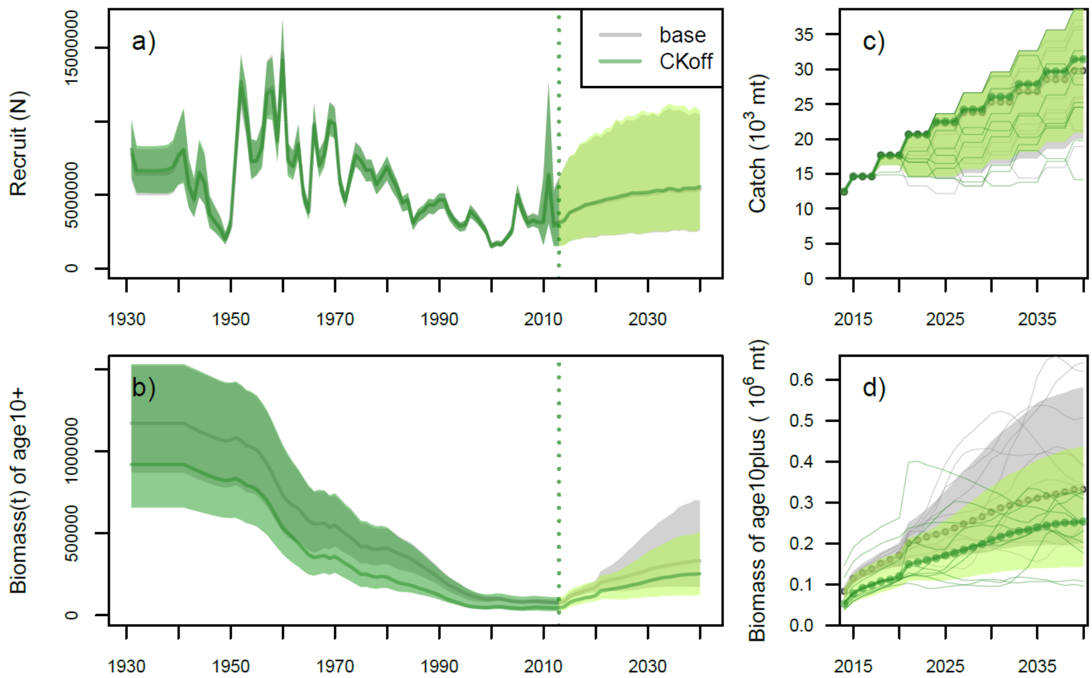


Appendix-Fig.2. conts.

#13 NoInteractCPUE

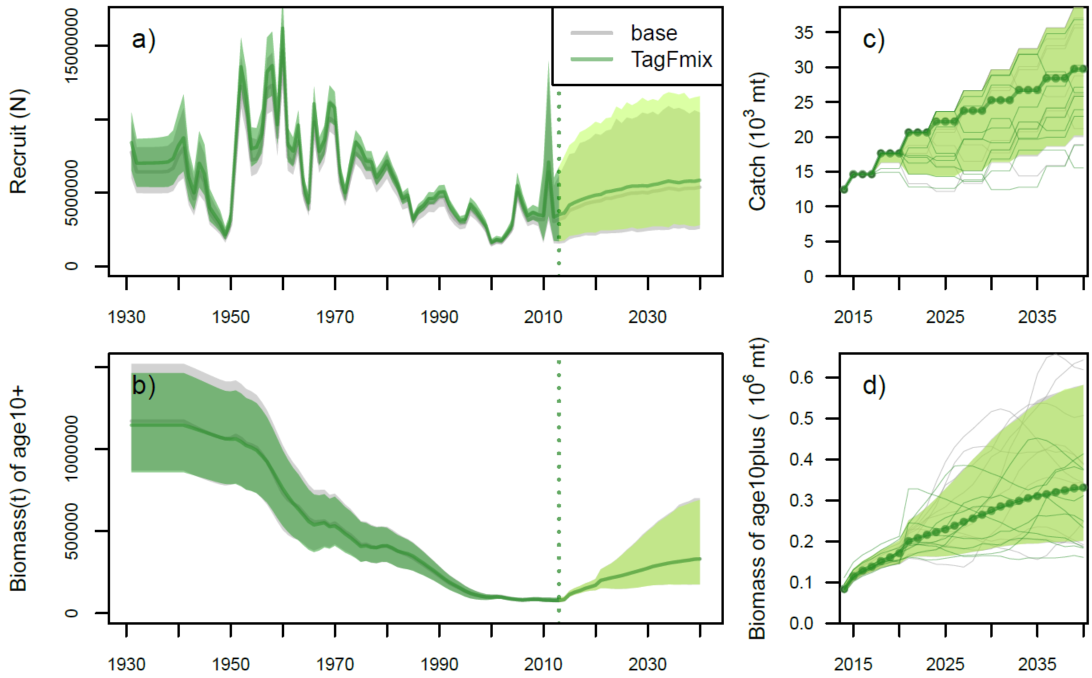


#14 CKoff

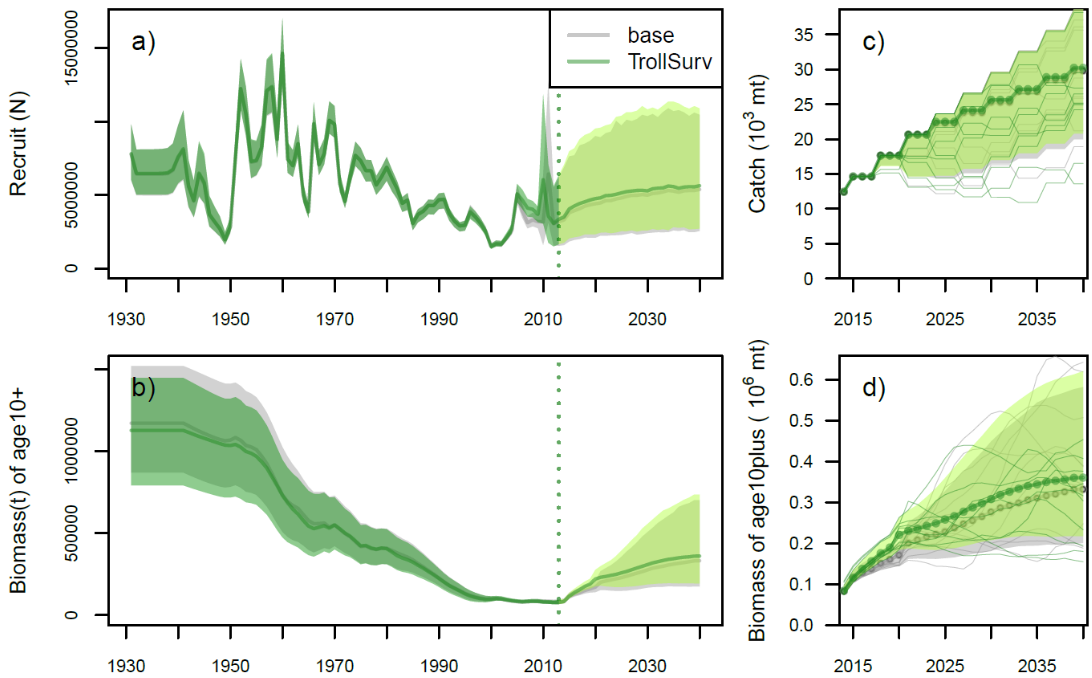


Appendix-Fig.2. conts.

#15 TagFmixing

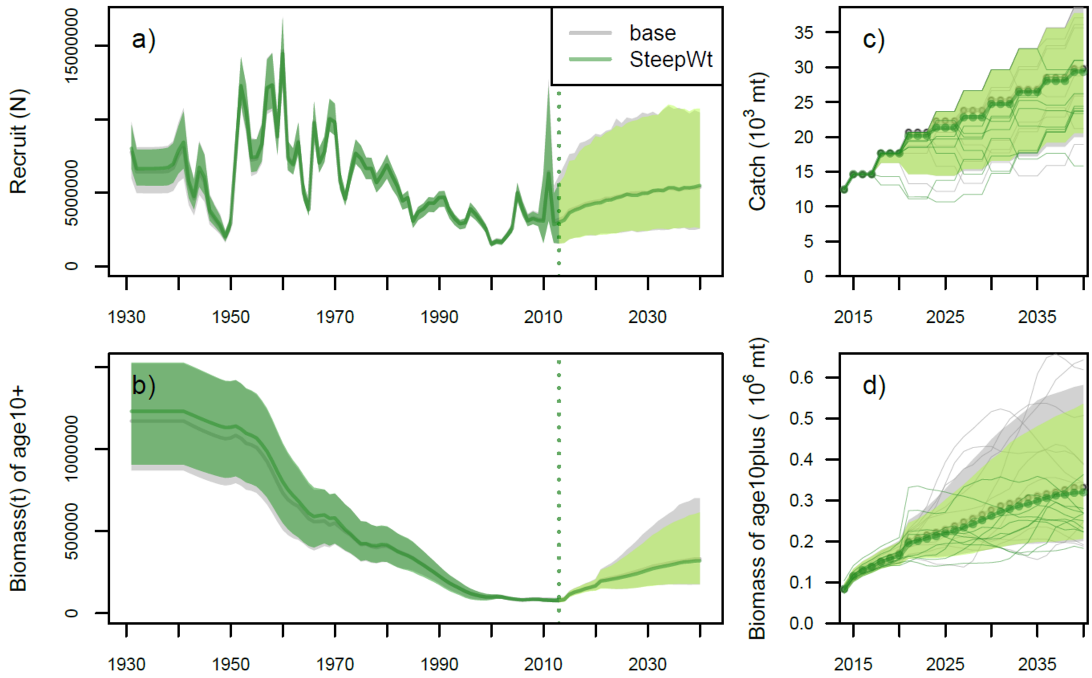


#16 TrollSurv

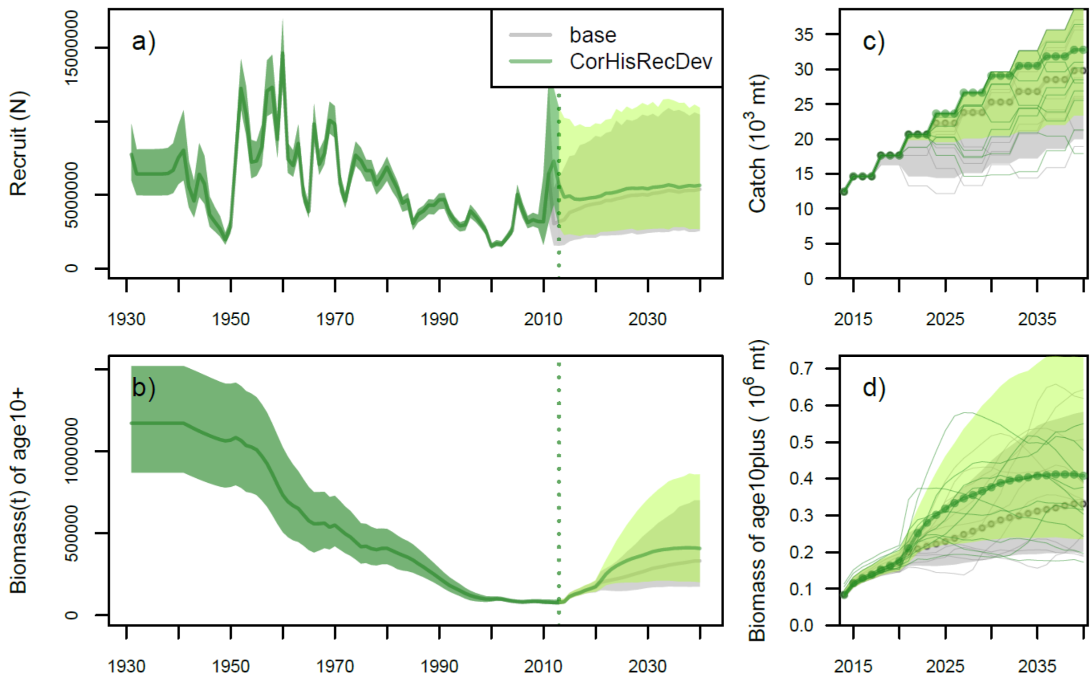


Appendix-Fig.2. conts.

#17 SteepnessWts

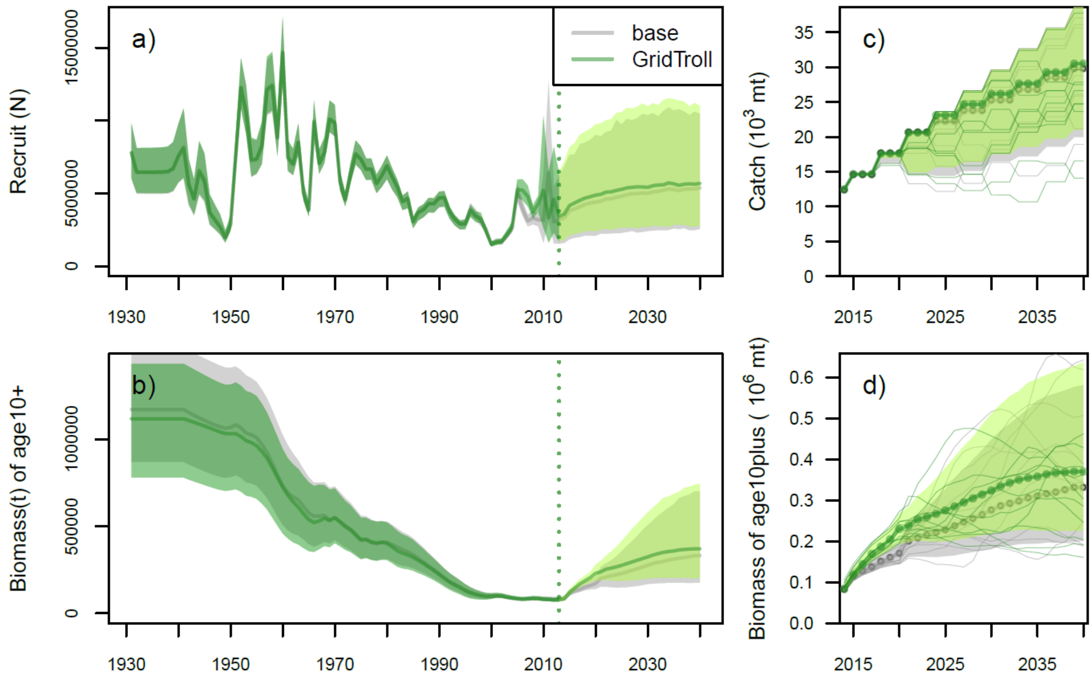


#18 CorrHistRecDevs

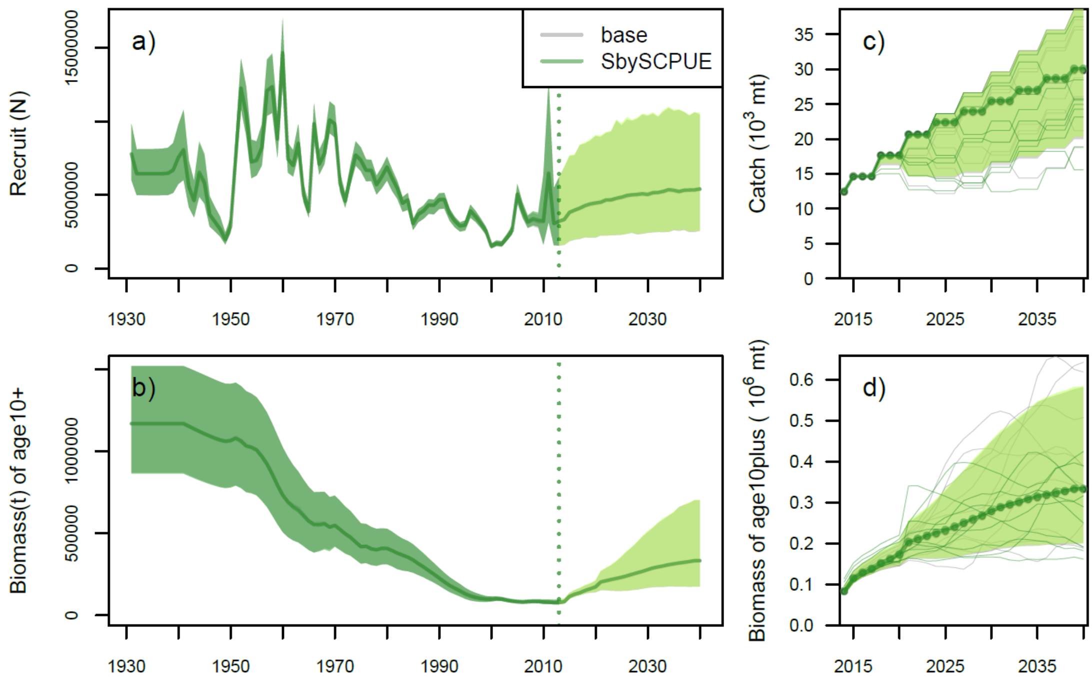


Appendix-Fig.2. conts.

#a. GridTroll

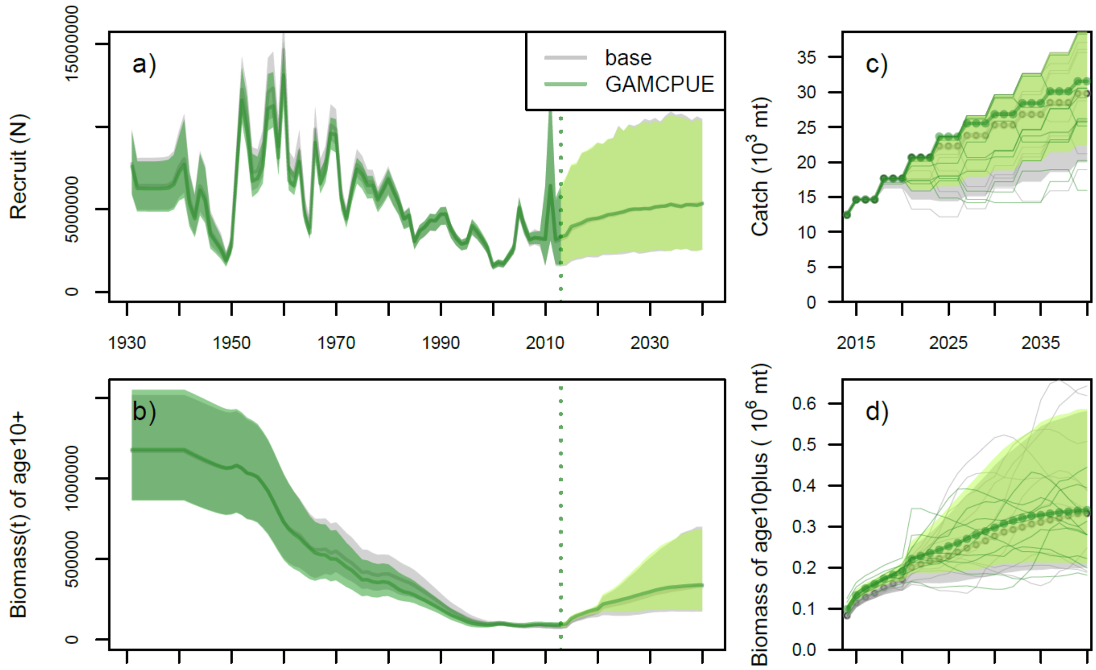


#b. SbySCPUE



Appendix-Fig.2. conts.

#c. GAMCPUE



Appendix-Fig.2. conts.