Report of Jack mackerel stock assessment workshop

Valparaiso, Chile May 28-30th

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ACRONYMS

EM	Estimation Model
FL	Fork Length
F_{SPR}	The Fishing Intensity that results in an equilibrium Spawning Potential Ratio
HCR	Harvest Control Rule
LRP	Limit Reference Point
M	Natural Mortality
SSB	Spawning Stock Biomass
RSB	Relative Spawning Biomass
SC	Scientific Committee
SPR	Spawning Potential Ratio
SPRFMO	South Pacific Regional Fisheries Management Organization

HOW TO INTERPRET TERMINOLOGY CONTAINED IN THIS REPORT

This report has been written using the following terms and associated definitions so as to remove ambiguity surrounding how particular paragraphs should be interpreted.

Level 1: **RECOMMENDED**; **RECOMMENDATION** (formal); **REQUESTED** (informal): A conclusion for an action to be undertaken, by the Commission, a Contracting Party, a subsidiary (advisory) body of the Commission and/or the SPRFMO Secretariat. *Note*: Subsidiary (advisory) bodies of the Commission must have their Recommendations and Requests formally provided to the next level in the structure of the Commission for its consideration/endorsement (e.g. from an Advisory Board to the Commission). The intention is that the higher body will consider the action for endorsement under its own mandate, if the subsidiary body does not already have the required mandate. Ideally, this should be task-specific and contain a timeframe for completion.

Level 2: **AGREED**: Any point of discussion from a meeting, which the SPRFMO body considers to be an agreed course of action covered by its mandate, which has not already been dealt with under Level 1 above; a general point of agreement among delegations/participants of a meeting which does not need to be elevated in the Commission's reporting structure.

Level 3: **NOTED/NOTING**; **CONSIDERED**; **URGED**; **ACKNOWLEDGED**: General terms to be used for consistency. Any point of discussion from a meeting, which the workshop considers to be important enough to record in a meeting report for future reference. Any other term may be used to highlight to the reader of an SPRFMO report, the importance of the relevant paragraph. Other terms may be used but will be considered for explanatory/informational purposes only and shall have no higher rating within the reporting terminology hierarchy than Level 3.

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1 Opening, agenda adoption and meeting arrangements

The 6th SPRFMO Scientific Committee Working group (SCW6) was held in Valparaiso, Chile from May 28-30th, 2018. The list of participants is provided at Appendix I. The meeting was opened by the Chair, Dr Jim Ianelli who welcomed the participants.

NOTING that the core purpose of this assessment workshop is intended to build upon the results of the past workshops the working group (WG) **AGREED** that formal recommendations to the Commission would not be developed at the present meeting. Rather, these would be developed at SC-06 in September 2018. The Chair explained that an assessment will be conducted in September including the new data, whereas the purpose of the workshop was to agree on the assessment and advice methodology to be used in September.

The Chair reviewed the scientific priorities of the Commission for this meeting as presented in COMM6 Report Annex 3 (2018 workplan for the SC). Given these considerations, the WG **ADOPTED** the Agenda as provided at Appendix II. The documents provided to the WG are listed in Appendix III. Rapporteurs were nominated as the expert panel with assistance from member delegations.

2 Review of data

2.1 *A review of catch histories*

The Chair presented SCW6-Doc03 on behalf of the Secretariat. The WG noted that the new information from Ecuador included some relatively minor revisions of historical catches. The paper documented the ways in which fleets were organised and included box-plots of historical monthly catches including the first few months of 2018.

2.2 *CPUE and other abundance indices*

2.2.1 *Spatial-temporal aspects of fisheries*

Aquiles Sepúlveda presented a review of spatio-temporal patterns in the operation of the fleet off Central-South Chile, relating oceanographic features of this area to the distribution of fishing grounds of Jack mackerel (SCW6-Doc11). It is recognized that Jack mackerel distribution and migration patterns are influenced by interannual changes of ENSO (El Niño/La Niña). Based on the analysis of El Niño Southern Oscillation (ENSO) Indices and satellite information of sea surface temperature (SST) and sea level anomalies for the area of the South Pacific, the transition of a weak La Niña to a neutral condition was observed. In 2018, the purse seiner fleet of South-Central (S-C) Chile operated very close to the coast, maintaining the pattern of 2012. Fishing grounds in 2018 were concentrated close to coastal areas in operating between 35-43°S. Relative to 2017 and 2016, the 2018 fishery to date has reduced the level of fishing in the more northern zones (26-34°S). This was due to the fact that juveniles tend to favour warmer waters (often typical after El Niño events). In particular, the fishery tried to avoid fish below 26 cm FL due to size limit restrictions and market targets. Length compositions from January to May 2018 showed different modes between 20 to 60 cm FL. These data showed a main mode centred at 30 cm FL and a secondary mode at 42 cm FL. Fish below 26 cm FL and juveniles also appeared in the southern areas with warm water extensions and along frontal zones. Collaborative work with EU vessel-data showed a slightly narrower size range of jack mackerel from 30 to 52 cm FL with a mode centred at a length of 37 cm FL. The Central-South fleet catch as of mid-May was about 212 thousand tons which is about 76% of the annual TAC for this fleet. Aquiles noted that fishing strategies and fleet-specific decisions can influence CPUE and size compositions in the catch due to different patterns of fish distribution and changing oceanographic conditions. To the extent practical, it was **NOTED** that such factors should be considered in the CPUE standardisation and for evaluating selectivity estimates of the S-C Chilean fleet. It was also **NOTED** that a review of Chilean CPUE standardisation methods would be useful to better inform the use of their surveys in the assessment. The WG **REQUESTED** that analysts evaluate Chilean CPUE approach for SC-06 and Chile indicated it was willing to prepare a document.

2.2.2 Alternative offshore fleet CPUE standardization

Martin Pastoors and Niels Hintzen presented this analysis (SCW6-Doc05). The nominal CPUE of the offshore fleet fishing for Jack mackerel is currently being used as a tuning index for the assessment. The index consists of the nominal average catch per fishing day for the fleets of EU, Vanuatu and Korea (Fig. 1). China has been standardising their CPUE series separately since 2013, and this work aims to apply the Chinese approach to the offshore fleet. This working document describes the work to standardize the CPUE series of EU, Korea, Vanuatu, and Russia, based on the haul-by-haul data contained in the SPRFMO database. Permission to utilize that information was granted by the delegations of the EU, Korea, Vanuatu, and Russia, and the analysis was carried out by scientists from the EU delegation. The document consists of a description of the data available for the analysis and the methods towards model choice to select the optimal model configuration for CPUE standardization. The final GAM model consists of a number of discrete factors (year, vessel and month) and a smoothed interaction between latitude and longitude (Fig. 2). No significant relationships were found with El Niño indicators or sea surface temperatures. The final model configuration is presented in Table 1, together with the Chinese CPUE standardization. The new standardized CPUE series starts in 2006 as this is the first year for which haul by haul information was available to carry out this analysis, and differences with the previous nominal series are shown in Fig. 3. It was **NOTED** that this CPUE analysis was conducted up to 2016 and will be updated to 2017 by the SC meeting in September for use in the assessment. The WG acknowledged the Members that contributed their data.

Table 1. Formulation of the two standardized CPUE models used in the offshore fleet, terms in order of relevance

	Alternative offshore fleet CPUE model	**Chinese CPUE model**
Formula	Catch per week ~ year + vessel + month + s(longitude, latitude) + offset(effort per week)	Log(CPUE per hour+0.1) ~ year + month + vessel + ElNiño + s(longitude) + s(latitude) + s(sea surface temp) + s(sea surface chlorophyll-a concentration) + ElNiño3.4
Distribution	Negative binomial	Gaussian (log normal)
Temporal scale	Weekly	By fishing hour
Spatial scale	Average GPS position of haul	0.25 degree

Several members noted concerns about the suitability of the El Niño index used in the analysis. The El Niño metric used describes an area further north than where the offshore fleets operate. As such environmental factors more local to the fishing areas might be of more relevance.

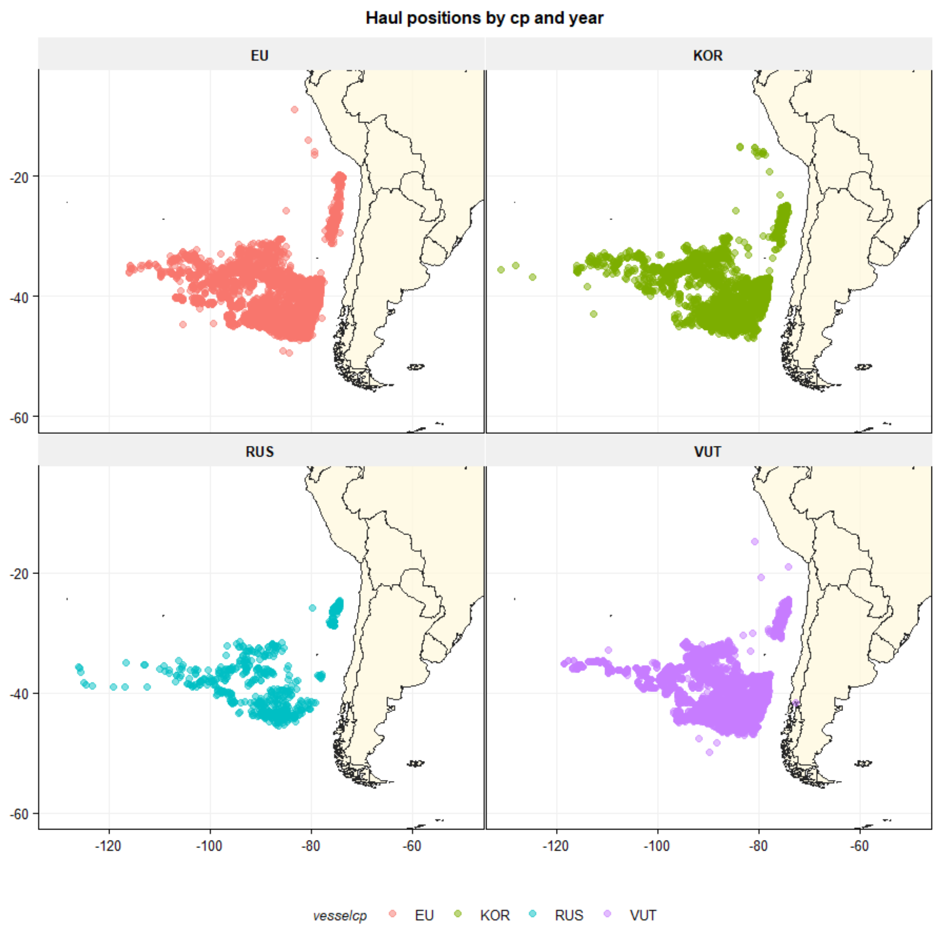


Figure 1. Spatial distribution of “offshore” fishery by fleet for the offshore CPUE analysis in all given years, combined.

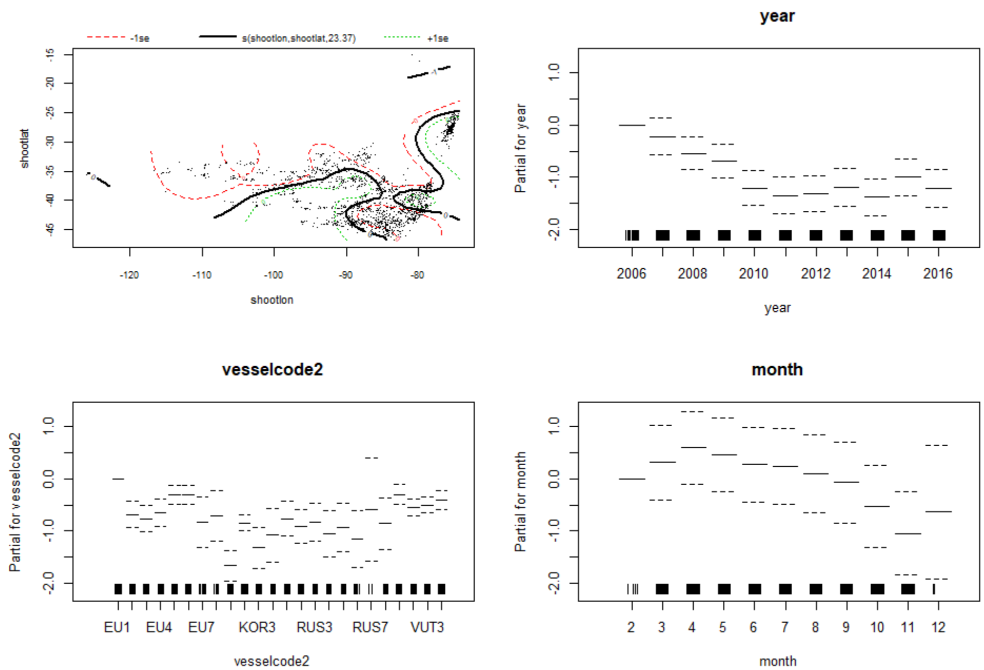


Figure 2. Illustration of response variables included in the offshore GAM CPUE standardization.

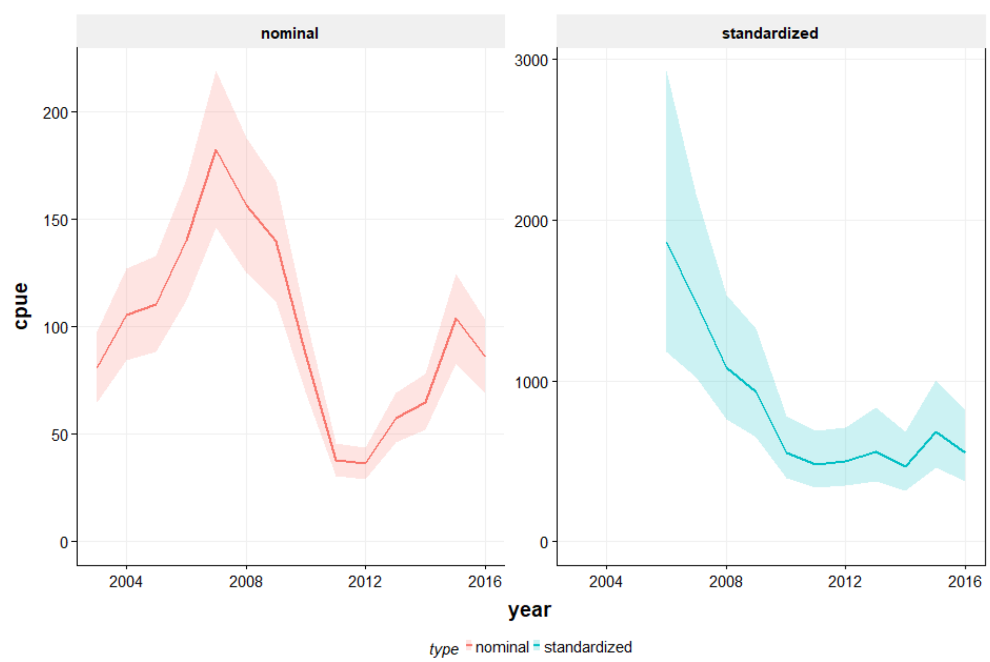


Figure 3. Comparisons of the nominal (used in the previous JJM assessments) and new standardized offshore CPUE developed at SCW6.

2.2.3 Other CPUE indices

Peru has been using CPUE data from the industrial fleet in the stock assessment. However, this index may be problematic to describe jack mackerel over the last few years because the same fleet that targets jack mackerel also targets, with the same gears, mackerel (and sardine when available).
These vessels also change gear to target anchoveta. Mackerel and anchoveta have been more readily available in recent years (with anchoveta always being the principal target during their fishing season). Additionally, 2015, 2016 and 2017 have been characterized by the occurrence of two El Niño and one La Niña events, which affected the distribution and availability of species to the fishing fleet. Peruvian scientists are working on developing an abundance index from an artisanal fishery (which target jack mackerel more consistently) and hope to have something prepared for SC-06 in September 2018. Peru **ACKNOWLEDGED** a preference to include this index as a complementary dataset in the future 2-stock hypothesis assessment (for the northern stock), whereas they expect it not to have a strong impact on the results of the 1-stock hypothesis assessment.

China **INDICATED** that they will prepare an update of the Chinese CPUE for September, which would incorporate methodology recommendations from this meeting.

The WG **NOTED** a concern for weighting the Chinese CPUE index and that of the offshore fleet as presented in 2.2.2 in the assessment model, as there was a risk of artificially inflating information. The WG **AGREED** to conduct sensitivity tests excluding one series at a time from the assessment model. The WG **ENCOURAGED** investigations on developing ways to integrate their analysis with that of the offshore fleet, as both fleets operate in the same region during similar times.

2.2.4 Acoustic data from platforms of opportunity

François Gerlotto noted that the programme seems to be functioning and is now routinely implemented in Peru. The group **NOTED** that it was unlikely to have something available for the assessment update to occur in September 2018.

2.3 Age and growth of Jack mackerel

As agreed during SC-05 (Shanghai, China) in September 2017, Chile has been reviewing their age readings for jack mackerel caught off central-southern Chile (SCW6-Doc09). This was to establish a standardised protocol to correct past catch-at-age data and to apply to future age readings. Three approaches have been applied so far, including experiments to validate the periodicity of the microincrements (as daily rings) in the otoliths of juveniles, the validation of the first annual ring through analysis of microincrements (daily rings and modal progression analysis), and by age determination of older specimens through $C_{14.}$ Preliminary estimates tend to confirm that the growth rate of jack mackerel in central-southern Chile is slightly faster than initially estimated and used in current and past assessments (but the relationship between otolith and somatic growth is unconfirmed). Estimates of the preliminary corrected growth parameters in comparison to earlier estimates are shown in (Table 2), and the corresponding growth curves are displayed in Fig. 4.

Table 2. The von Bertalanffy (vB) growth model parameters estimated by IFOP for central Chile based on 2008 data, using old and new readings approaches.

	Old approach			
	Value	SE	UB	LB
Linf	72.670	1.312	70.099	75.246
K	0.074	0.002	0.069	0.079
t	-1.972	0.067	-2.103	-1.842
	Preliminary New approach			
	Value	SE	UB	LB
Linf	68.103	1.210	66.893	69.313
K	0.092	0.004	0.088	0.095
t	-2.964	0.104	-3.068	-2.860

It was recognized that Chile is making great efforts to review and correct available jack mackerel age readings for central-southern Chile. Final corrected vB growth model parameters based on new readings of 2008 otoliths will be available for SC-06 in September 2018, and so far, 56% of these otoliths have been read. The WG **ACKNOWLEDGED** that correcting the historical catch-age matrices with the new reading criteria is complex, and it is unlikely that it could be completed for the SC-06 meeting. As a way forward, it was **SUGGESTED** that an aging error matrix could be used to (determine the sensitivity of the assessment model to ageing errors and estimate weight-at-age based on allometric parameters based on 2008 data) eventually correct the catch-at-age data currently in use. This approach may require revising and correcting other data and estimates, such as catch-at-age, mean weight-at-age, selectivity, maturity, natural mortality.

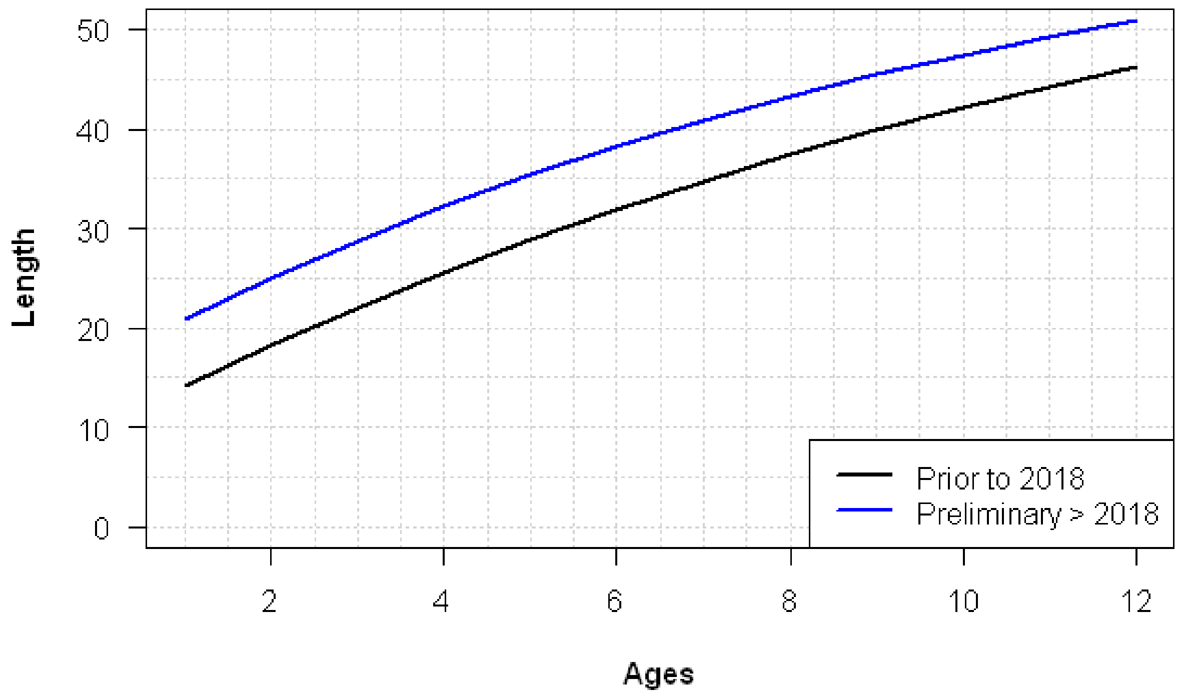


Figure 4. Age-length relationships according to the old and new preliminary growth curves.

It is expected that final results from the Chilean review will become available prior to SC-07 in 2019. In the interim, the WG **REQUESTED** that the model be enhanced to allow sensitivity testing of the new growth curve. As such, a conversion matrix was constructed during the workshop that converted the old catch proportions-at-age and weight-at-age matrices according to the preliminary new growth curve. This was applied to South-Central Chile, North Chile and Offshore data. The WG **ACKNOWLEDGED** that, based on this approach, there was a need to correct stock mean weight-at-age, maturity and natural mortality (originally derived from both Chilean and Peruvian growth functions; SC-04 Report Annex 7, the Hague, Kingdom of the Netherlands) as well.

The WG **NOTED** that the way that model 1.14 (see Table 3, below) is specified, the growth curve used to fit the length frequency data for the far north fleet differs from what is used in the other models.

3 Jack mackerel stock assessment modelling

3.1 Alternative assessment models

All alternative assessment model runs and their respective files can be found on the SPRFMO JJM Github page.

3.1.1 SAM Model

A State-Space Assessment (SAM; Nielson and Berg 2014) was prepared by Niels Hintzen to assess the Jack Mackerel stock excluding the Far North Fleet, essentially assessing the southern stock under the two-stock hypothesis (SCW6-Doc04). The assessment used identical data inputs as the model that is currently used for advisory purposes (Joint Jack Mackerel; JJM) but differed in the underlying dynamics that are simulated in the assessment framework. Within the assessment evaluation, a data exploration was executed as well.

It was **NOTED** that the existing survey indices with age-composition data show limited cohort-tracking capabilities. The Northern Chile catch-at-age data has limited cohort-tracking capabilities as well, while the South-Central and Offshore fleet catch-at-age data show higher internal consistency.

The results from the SAM assessment reflect these internal consistencies and as such fit South-Central and Offshore data well, together with the standardized Chinese CPUE. Many datasets were downweighted by the assessment, suggesting noisy data sources. It was suggested that this might have been due to changes in catchability or selectivity from year to year, which is managed for in the JJM model by estimating separate selectivity patterns for the surveys in several year-blocks. SAM was used to evaluate if such a change in selection was justified. This does not seem to be the case, particularly for the DEPM survey. Furthermore, a difference in SSB estimation in recent years was investigated. Two processes contribute to a discrepancy between the JJM and the SAM assessment:

1) expected recruitment in recent years. JJM estimates a large incoming recruitment in 2016 while SAM down weights the data source indicating that.
2) selection of fish at older ages. JJM assumes substantial selection of older ages in the most recent years, thereby estimating higher stock numbers at ages 7-12 in recent years, while SAM assumes lower selection and therefore lower stock numbers as well. If the selectivity is assumed lower, theoretically the corresponding stock will be larger to get the same amount of catch. For example, with high selection at age 8-12 stock numbers would need to be higher to actually realize some catches at age 12 (otherwise they would have been killed off already at age 9-11). So, if there is a consistent high selection at older ages for a number of years in a row, this would inflate stock numbers.

It was **AGREED** during the meeting to run sensitivities investigate the points highlighted by Hintzen in the comparison between JJM and SAM. It was also **NOTED** that some prior standardisation of survey results should be attempted.

3.1.2 Stock Synthesis

Chile presented developments of an application (under the single stock hypothesis) for Stock Synthesis (SS3; Version 3.3, Methot and Wetzel 2013), starting from a template originally prepared by C. Fernandez. They configured the model using an approximation of weight-at-age, calculated internally by SS3 from weight-at-length and growth models that could be modified to test alternative growth relationships. It was noted that the resultant (time-invariant) weights-at-age were higher than the empirical ones used by the JJM model for most fleets, though more similar to those used for the Far North fleet. Although there had been some issues with convergence, there was a general concordance with previous JJM results.

The Chair presented a draft SS3 implementation on behalf of a Peruvian scientist who was unable to attend the workshop (SCW6-Doc06). A main difference between the Chilean implementation and the Peruvian implementation of the model was in their treatment of growth. Whereas the Chilean version approximated a von Bertalanffy growth curve, the Peruvian version used empirical weight-at-age data, similar to that of JJM.

The SS3 assessment conducted by the Peruvian scientist was under the single-stock hypothesis and largely aimed to replicate the current JJM assessment. The Chair ran the SS3 model and gave a short presentation for information. A comparison of the results with JJM outputs showed general agreement with the JJM specification. The Chair noted that several aspects were still under development in the SS3 implementation and that this should not be interpreted in any way as "final" results. It was noted that all fleets' and indices' selectivity patterns had been modelled as logistic, i.e. no doming allowed. The suitability of this assumption should be reconsidered in future iterations of this work. Despite this asymptotic selectivity assumption, results did not appear to be hugely different from those from the JJM model. Peru indicated that SS3 work may be developed for the September meeting for the north stock only.

3.1.3 Surplus production

A surplus production in "continuous time" (SPICT; SCW6-Doc15) model was developed by Niels Hintzen and applied to the Far North Fleet as a complement to the SAM model presented above (applied to the southern stock under the two-stock hypothesis). Results were sensitive to including both indices (an acoustic survey index and a fishery CPUE series).

High positive correlations between the catchability parameters of the Peruvian acoustic survey and Peruvian CPUE index were observed in the SPICT model, which was not identified in JJM. Peru noted that the Peruvian CPUE was affected by changes in regulations. They also noted that Peruvian surveys from earlier years were targeted at anchoveta, and hence may not have captured trends in jack mackerel abundance. For comparison purposes with SPICT outputs, it was agreed to run the JJM 2-stock model for the north stock leaving out the Peruvian commercial CPUE data. Outside of the workshop, a comparison between the JJM results with and without the CPUE data was made, which showed similar results, contrary to the SPICT analyses that gave markedly different outcomes. It was acknowledged that the results of this model alternative were not to be relied upon for management advice. Rather, they were to be used to examine the quality of data on the northern stock.

3.2 Joint jack mackerel model

3.2.1 Code development

During the workshop some features were added to accommodate requests for sensitivities. This included:

- Adding weight-length capabilities by adapting the growth curve specification (and facilitating ability to evaluate alternative growth assumptions).
- Errors in the jjmR package were corrected, including plotting function issues
- Francis data-weighting was added to the output

3.2.2 Model sensitivities

It was noted that in the 2016 agreed assessment, selectivity changes in the Chile acoustic N survey were applied in 2015 and 2016, because the survey was showing a very high recruitment in 2016, which the SC felt uncertain about for various reasons. For example, the strong year class seen in the survey could have been driven by changes in availability. Furthermore, the strong recruitment observed in the survey in 2015 was not followed by a high abundance index in the survey at age 2 in 2016. The 2017 assessment does not include these selectivity changes in the survey, so it was decided to start the runs from mod1.18 of 2016 but including the new data available for the assessment in 2017 (i.e. with selectivity change in acoustic N in 2015 and 2016).

As noted on the Github site, the following set of sensitivities were presented and discussed (Table 3).

Table 3. List of model sensitivities run during SCW6.

Model	Description
1.0	same as 0.7 in 2017, selectivity change in Chile N acoustic in 2015 and 2016
1.1	same as 1.0, but constant selectivity for Chile N Acoustic all years
1.2	same as 1.1, but constant selectivity for S-C Chile acoustic all years
1.3	same as 1.2, but constant selectivity for DEPM all years (was changed in 2003)
1.4	same as 0.7 in 2017, selectivity change in Chile N acoustic in 2012 and 2016
1.5	same as 1.4, but replace offshore CPUE w/ new version CV=0.2; dropping Russian nominal index
1.5_r	As 1.5, retros to evaluate if Francis weights are stable.
1.6	same as 1.5, but without Chinese CPUE
1.7	same as 1.5, but without Offshore (and Russian) CPUE
1.8	same as 1.5, but only Offshore CPUE included (all other indices downweighted)
1.9	same as 1.5, but only Chinese CPUE included (all other indices downweighted)
1.10	same as 1.5, but without the Acoustic N data
1.11	same as 1.5, but allow fishery selectivity to change up until age 11 and reduce penalty on dome shapedness
1.12	same as 1.5, but constant average weight at age w/in fleets and surveys (no time varying)
1.13	as 1.5 but rescale sample size using Francis T1.8 method (one iteration)
1.14	same as 1.12, but use ageing error consistent growth relationship (w/ aL^b for wt-age) and supply Maturity at length to get conversion
1.15	same as 1.5, but change catchability in 2012 for Chilean CPUE
1.16	same as 1.14, but look at alternative values for M, = 0.28…

Results for each individual run can be found on the Github site. The impact of some of these sensitivities on the stock assessment is shown in figures below. Changing the selection patterns in Acoustic surveys had little impact on the overall outcome (Fig. 5).

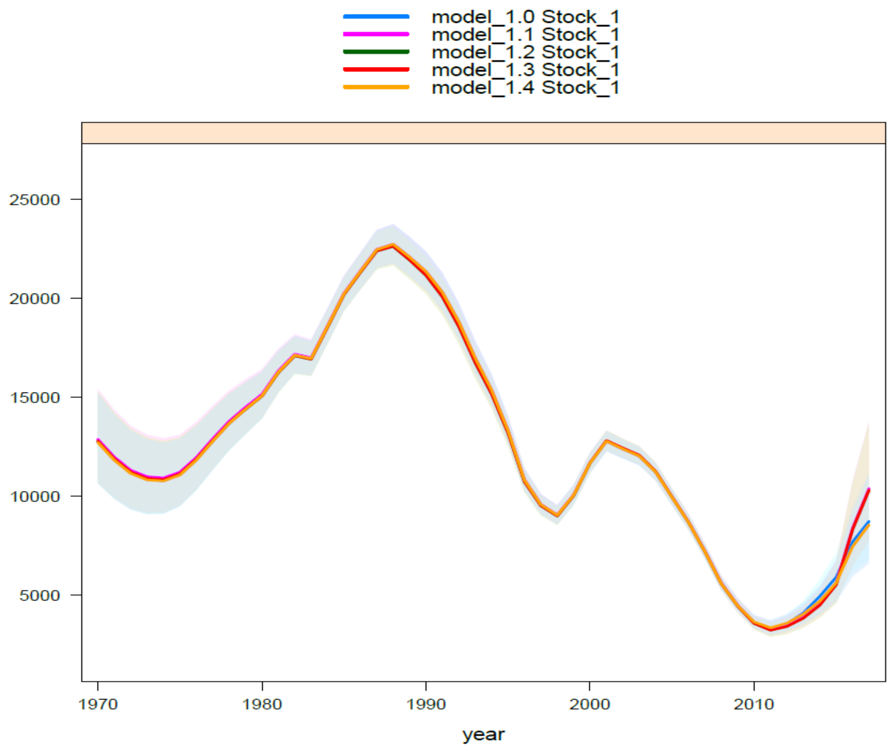


Figure 5. Comparison of SSB over time for the base model (model 1.0) and the models in which catchability / selectivity changes were removed.

Figure 6 shows the impact on the fitted CPUE time-series of the offshore fleet under the old (left) nominal calculation and under the (right) standardized calculation. The standardized CPUE includes data from Vanuatu, Russia, Korea and the EU. The standardized data fit the assessment markedly better but have only a limited effect (downward SSB revision) on the overall outcome.

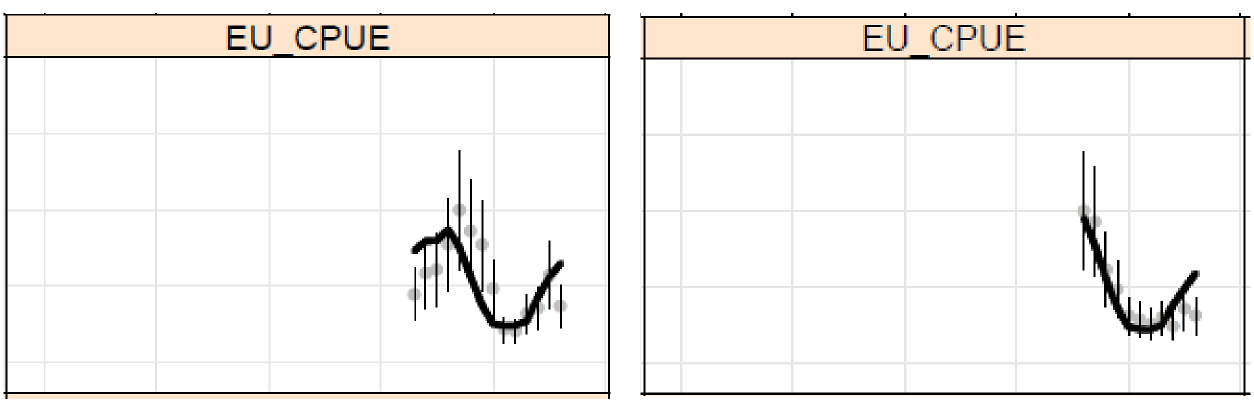


Figure 6. Left: Fitted nominal CPUE (grey dots) and fitted stock trends (black line). Right: Fitted standardized CPUE (grey dots).

In the model sensitivity runs where selection at older ages was allowed to be estimated (not fixed to age 9 as in the base model), the JJM model estimated high selection on older ages. This coincided with higher estimation of older age groups, while catch data was missing to support this estimation. The WG **AGREED** to look further into this behavior intersessionally for presentation at the SC-06 meeting (Fig. 7).

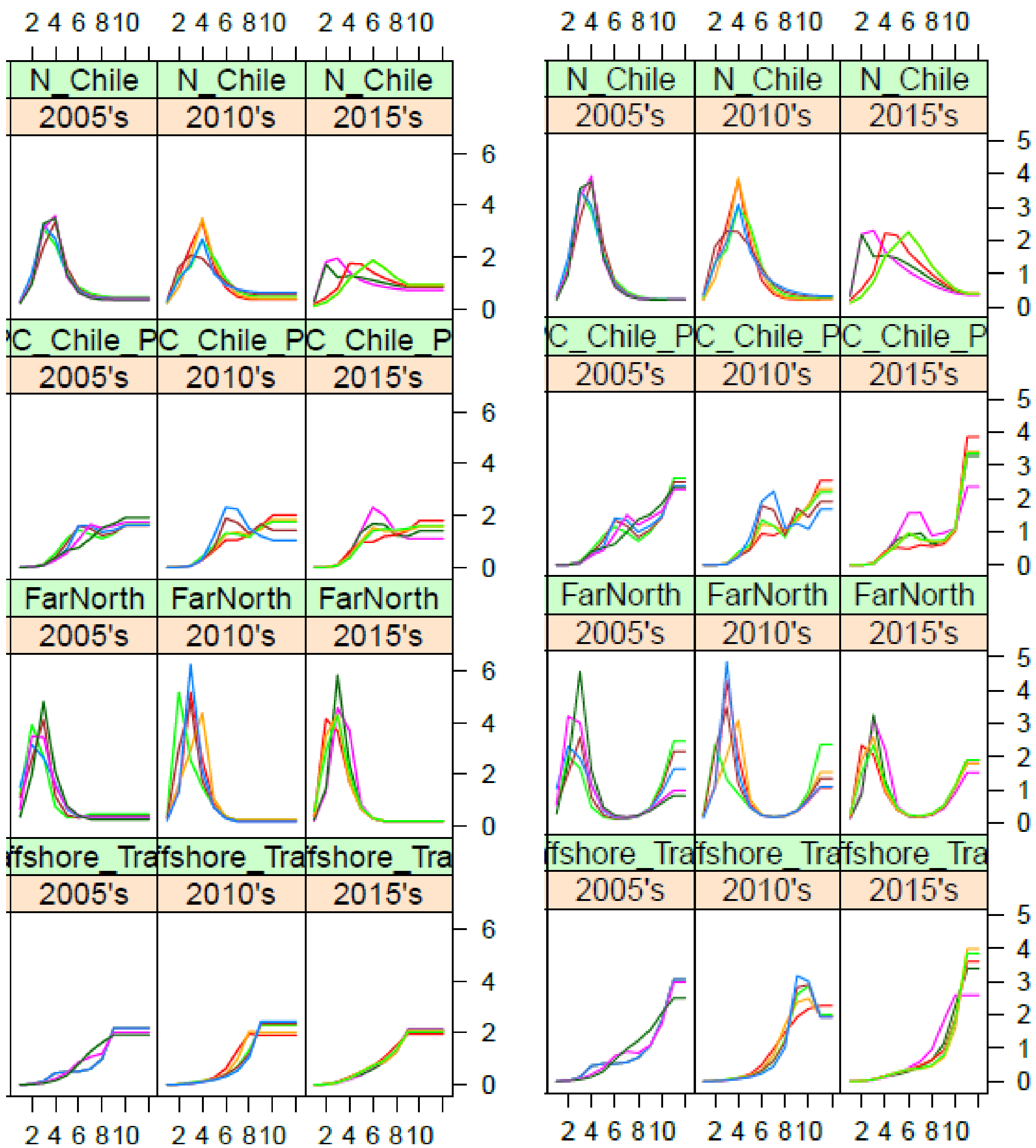


Figure 7. Left: selection patterns of Northern Chile, South-Central Chile, Far North and Offshore fleet under the base 1.0 model. Right: Selection under the 1.11 model configuration.

The impact of new growth data from Chile on the assessment was evaluated in models 1.12 and 1.14. Model 1.12 assumed time-invariant weight, following previously estimated weight-at-age, while model 1.14 revised weight-at-age according to the latest information on growth. Figure 8 shows the marked impact this has on total biomass, although trends seem to be similar (but scaled) to previous perceptions of the stock.

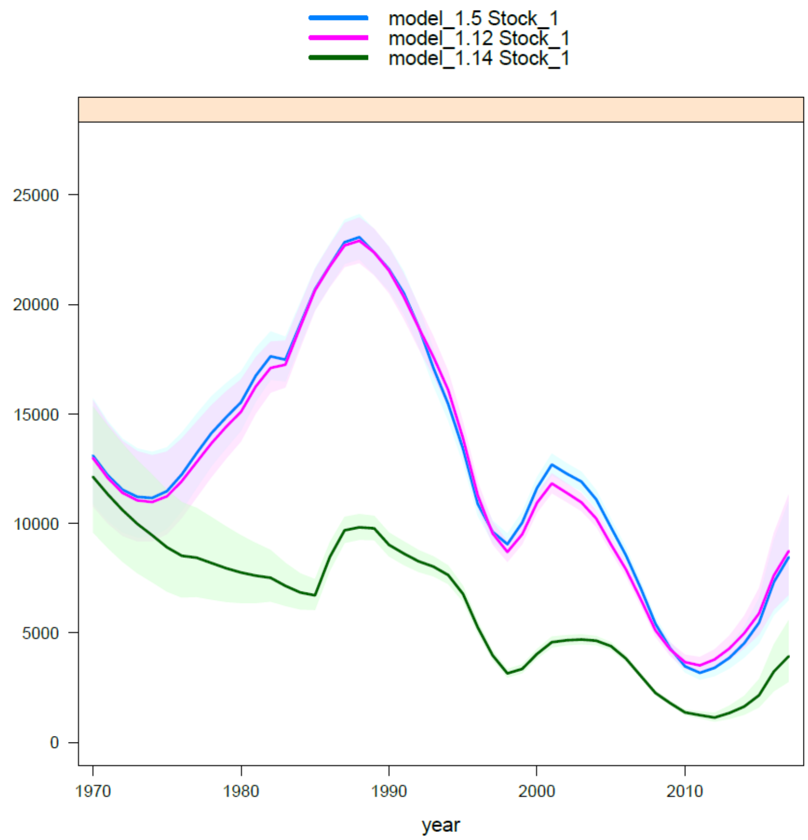


Figure 8. SSB over time under the default model (1.5, including updated data), the model with time-invariant weight-at-age based on previous information (1.12) and time-invariant weight but using the latest information on growth rate in Chile (1.14).

Finally, an alternative method to weighting age composition data (Francis 2011) was applied and resulted in a revision in perception of recruitment, especially the 2016 recruiting year-class. The down-weighting of age composition data of the Northern Chilean Acoustic survey resulted in a reduced estimation of the 2016 recruiting year class (Fig. 9). The model fits to the indices were similar to that of the base case, as were estimated spawning biomass (Fig. 10).

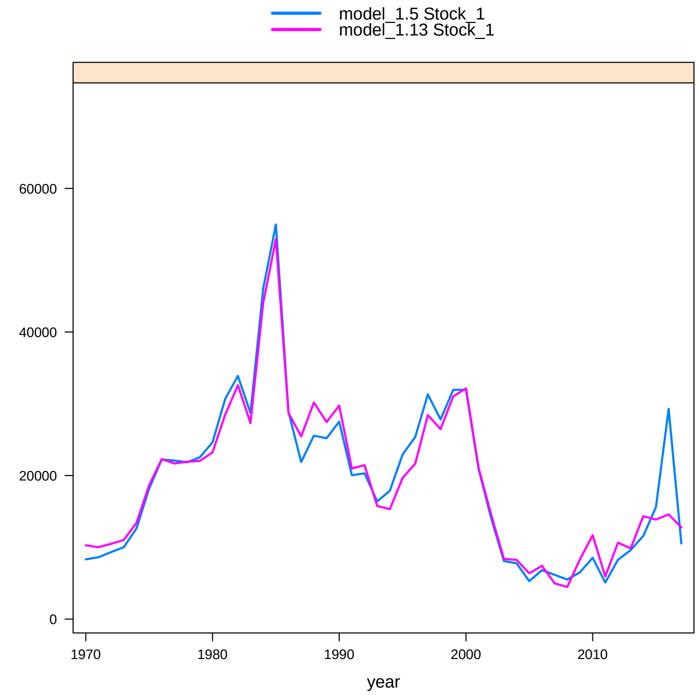


Figure 9. Recruitment over time under the base model (1.5, with updated data) and the model applying a modified weighting factor on the age composition datasets (1.13).

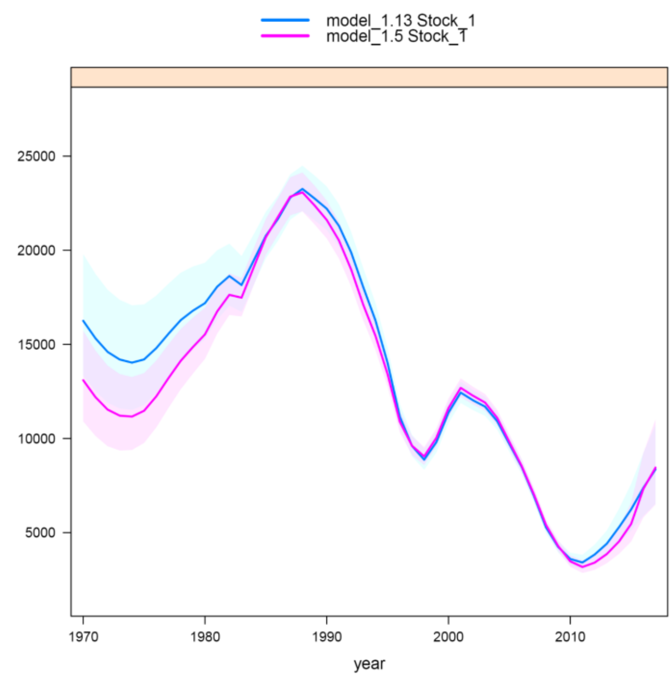
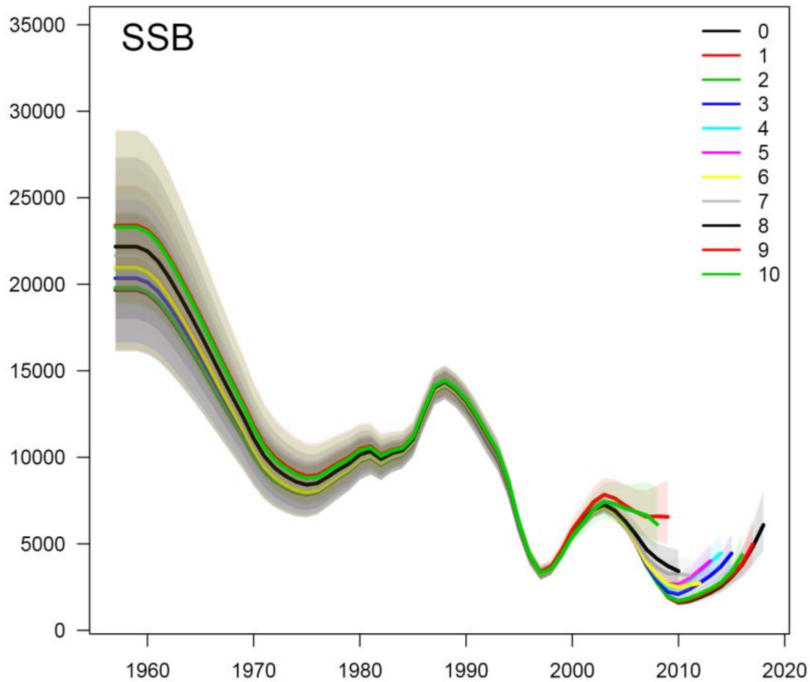


Figure 10. Spawning stock biomass (SSB; thousands of tons) over time under the base model (1.5, with updated data) and the model applying a modified weighting factor on the age composition datasets (1.13).

Retrospective analyses were conducted on models 1.5 and 1.13 and the WG noted that 1.13 was slightly improved over the pattern observed in 1.5, even though both mostly had a slight tendency to be biased high in recent years (Fig. 11).

Goodness of fits via likelihood tables and Francis weights diagnostics were examined in addition to residual patterns and goodness of fit measures over all sensitivities and model alternatives drawn up. Based on the evaluation of these sensitivities, including retrospective plots, new Francis weights, and likelihood tables, the WG **AGREED** that Model 1.13 was preferred for the basis of advice for the coming SC-06 meeting. This preferred model will be run with updated data for the single stock hypothesis and for the northern and southern stocks under the two-stock hypothesis during the upcoming SC-06 meeting in Puerto Varas, Chile from 9 to 14 September 2018.

Model 1.5



Model 1.13

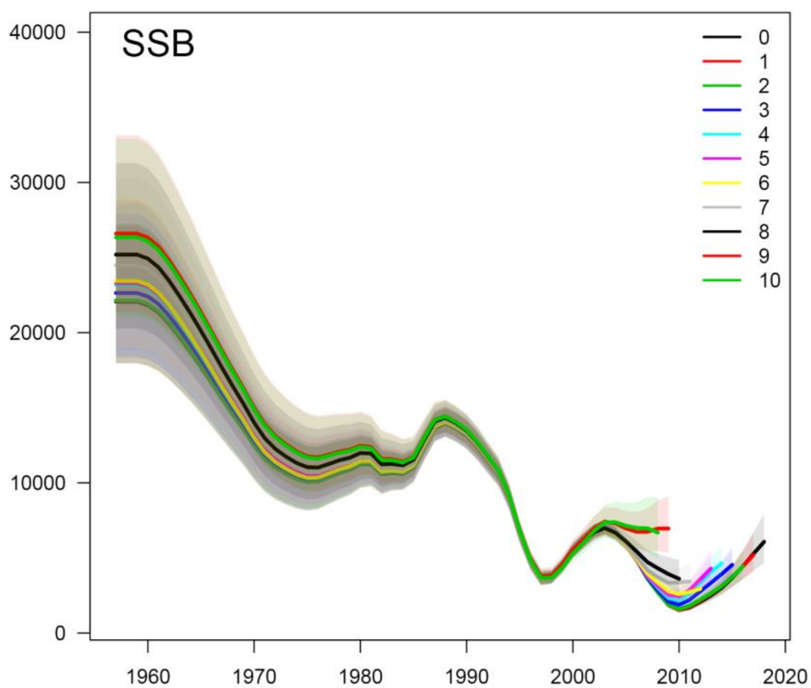


Figure 11. Retrospective patterns in spawning biomass (SSB) for Models 1.5 (top) and 1.13 (bottom).

3.3 Projections/rebuilding target

The group discussed the existing rebuilding plan and **NOTED** that there are discontinuities that should be considered in providing annual TAC advice.

In recent years, 5.5 million t has been taken as a provisional B_{MSY} value and recent recruitment has been used for projections to provide catch advice. The use of recent recruitment in projections was motivated by the fact that this was lower recruitment than the average of the entire time series.

It was also noted that the HCR in the current rebuilding plan has discontinuities in the F to be applied to provide advice at the boundaries 0.8B_{MSY} and B_{MSY} for SSB. This means that the catch advice for the stock can be highly variable between years when the SSB is estimated to be close to these boundaries. An alternative HCR could consist of a continuous line for F throughout the entire SSB range, with a diagonal line linking the F values to be used when SSB<0.8B_{MSY} and when SSB>B_{MSY} (Fig. 12). This could be used when the SSB is estimated to be between 0.8B_{MSY} and B_{MSY} with the intent to reduce the variability of the catch advice at these SSB boundaries.

To further understand the behaviour of the present HCR and of the potential alternative, further analysis and simulation work would be necessary. However, the WG **NOTED** that substantial work on HCRs was already conducted by the SC in a previous meeting (SC-02, Honolulu, USA), and that it may be sufficient to read and reconsider the conclusions from that meeting. In addition, the WG found out that the present HCR originally contained a 15% constraint in interannual TAC variability, although it is unclear if this constraint appears in all relevant documentation.

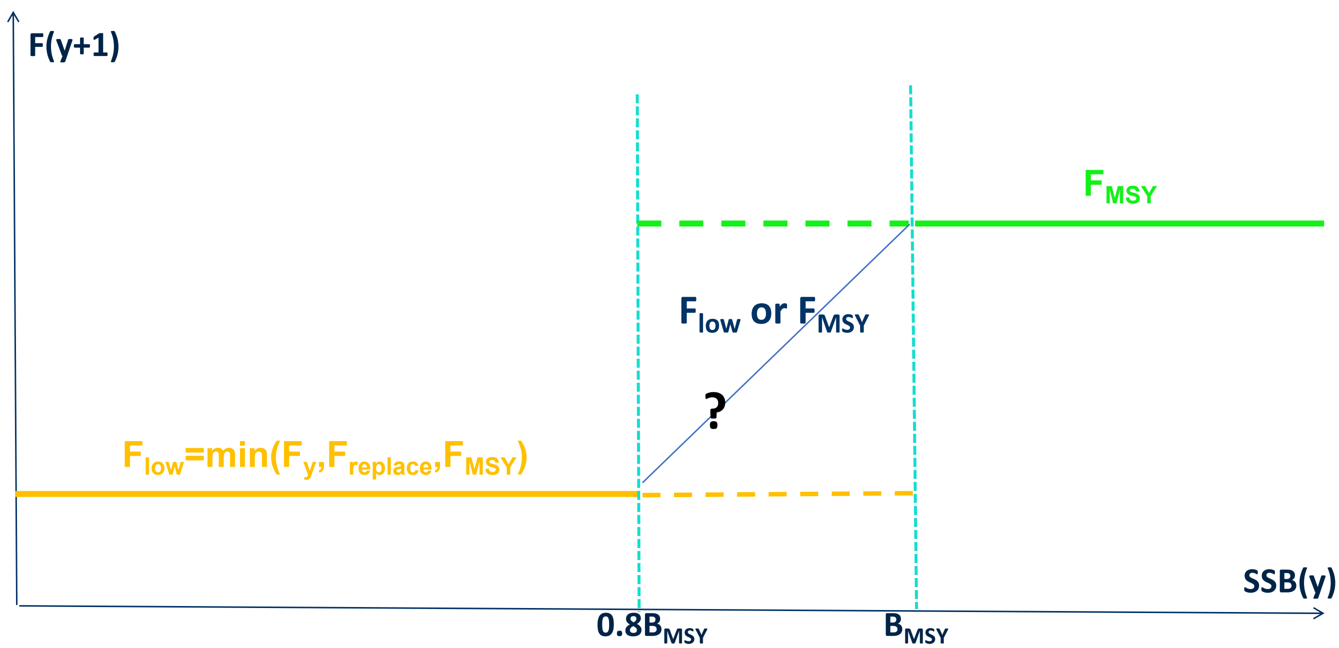


Figure 12. Plot showing schematic of fishing mortality rate relative to spawning biomass as part of the rebuilding plan. Note that the actual value of F_{low} will change from year to year, so the distance between F_{low} and F_{MSY} may be larger or smaller depending on the year. Note also that from SC02 an TAC overarching maximum change of 15% was established for biomass > 0.8Bmsy.

4 Other items

4.1 Developments for capacity building

Assessment technology continues to evolve as noted with the 4 separate model approaches covered during the workshop. One aspect of this includes approaches to make the assessment as transparent as possible. Arni Magnusson, invited expert from the International Council for the Exploration of the Sea (ICES), provided methods for approaches being undertaken by their organisation (SCW6-Doc13).

4.2 Preparation towards SC06

Prior to the close of the meeting, the Vice Chair (Hintzen) requested members to discuss the expected products for SC-06. These included

- Further refinements of a stock synthesis application by Peru
- An analysis of CPUE data of artisanal fisheries from Peru
- EU will present comparison between observer and self-sampling programmes
- Juan-Carlos Quiroz indicated potentially some work on acoustic survey standardisation

It was noted that a web meeting in late July will be needed to follow through on these and any other commitments so that SC-06 will be able to compile updated advice to the Commission regarding Jack mackerel catch advice and stock status.

4.3 Report adoption

The report of the WG was **ADOPTED** on May 30th, 2018 at 1700 with the understanding that edits will be conducted via correspondence to be completed no later than by June 15, 2018.

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APPENDIX I
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APPENDIX II
AGENDA FOR THE 2018 JACK MACKEREL STOCK ASSESSMENT WORKSHOP

1. Welcome and Introduction

This Assessment workshop builds upon the results of previous Jack mackerel workshops (Port Vila-2015 and The Hague-2016)

- *1.1 Administrative Arrangements*
- *1.2 Adoption of Agenda*
- *1.3 Nomination of Rapporteurs*

2. Data Coordination

- *2.1 Review of submitted papers*
- *2.2 Review of data submission*
- *2.3 Treatment of industry acoustic and self-sampling data*
- *2.4 Standardization of CPUE time-series*
- *2.5 Review available data on life history parameters*

3. Jack mackerel assessment

- *3.1 JJM software and recent developments*
- *3.2 Review model diagnostics*
- *3.3 Age determination error*
- *3.4 Model fits to age in numbers instead of biomass*
- *3.5 Alternative growth parameters*
- *3.6 Review projection methods and rebuilding plan*
- *3.7 Update reference points for Jack mackerel*

4. Recommendations to SC06

- *4.1 Model alternatives*
- *4.2 Advice approach including rebuilding status*
- *4.3 Key uncertainties and data requirements*

5. Report writing

APPENDIX III
LIST OF DOCUMENTS FOR THE 2018 JACK MACKEREL STOCK ASSESSMENT WORKSHOP

Document	**Title**
SCW6-Doc01	Provisional agenda
SCW6-Doc02	March 2018 web meeting
SCW6-Doc03	Jack mackerel historic catch data
SCW6-Doc04	Applying the SAM Framework to Jack mackerel in the SPRFMO Area
SCW6-Doc05	CPUE Standardization for the offshore fleet fishing for Jack mackerel in the SPRFMO Area
SCW6-Doc06	JM model implemented on SS3
SCW6-Doc07	SAM for CJM
SCW6-Doc08	SPICT for CJM
SCW6-Doc09	Current Status of Age Research
SCW6-Doc10	Data Updates for CJM
SCW6-Doc11	Spatio-temporal aspects of South Central Chile Fishery
SCW6-Doc12	Microincrements Study JM
SCW6-Doc13	ICES-TAF
SCW6-Doc14	Results of the Assessment runs
SCW6-Doc15	Applying the SPICT Framework to Jack mackerel in the SPRFMO Area