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Reviewing the weighting factors used in the Jack mackerel stock assessment

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1. Background

Weights of the different pieces of information used in the assessment are often determining factors in the scale and diagnosis of the population, especially in the presence of inconsistent and contradictory information. Excluding the catches series of the four fleets, 16 sets of different data are considered in the jack mackerel stock assessment in which the standard error (or coefficient of variation) used to model the 9 abundance indices has not been analyzed formally, while in the case of the sample size used to model the series (7) of proportions of age/size of catches/cruises, the McAllister & Ianelli (1997) estimator has only been considered referentially and it does not prevent the correlation effects recorded in the residuals of the model fit (Francis, 2011).

The last analysis or estimation of sample sizes in the jack mackerel stock assessment was recorded in 2011. Since then, these measures have maintained constant although significant changes in the configuration of the model have been introduced, such as the inclusion of the annual variability of the selectivity patterns, compositions of catches of the Peruvian fleet, and age compositions of the hydroacoustic survey of the northern area of Chile.

Estimations of the data weighting factors used in the jack mackerel stock assessment are reviewed in this document to suggest a weighting with regard to the measure of the observation error estimated by the model.

2. Materials y methods

Data weighting factors for 16 pieces of information used in the jack mackerel stock assessment were calculated. Current measures (a priori) regarding a posteriori estimations of the coefficients of variation and simple sizes on the basis of two estimators were compared. It was considered, for all purposes, that catch per fleet shows a coefficient of variation of 5%.

2.1. Coefficients of variation

Coefficients of variation (cv) of the abundance indices were estimated *a posteriori* and compared with the value assigned *a priori* (hyper-prior). The estimator of the cv for each index (I) corresponds to:

$$\widehat{cv} = \frac{1}{n}\sqrt{\sum_i (logI_y - log\hat{I}_y)^2}$$

where $\hat{I}$ is the annual value (y) of the index predicted by the model.

2.2. Effective simple size

Sample sizes of each age or size composition used in the assessment were compared through the McAllister & Ianelli (1997) and Francis (2011) methods (**Table 1**). In each case an iterative process for reaching certain stability in the final estimations is required.

Table 1.

Sample size estimators used in the analysis

Source	Estimator
McAllister & Ianelli (1997). p_a is the proportion at-age in the catch	$\dfrac{\sum_a \hat{p}_{y,a}(1 - \hat{p}_{y,a})}{\sum_a (p_{y,a} - \hat{p}_{y,a})^2}$
Francis (2011) n_1 is the inital simple size, O y E correspond to mean age (a) observed and expected, respectively	$n_1 \, var \left[\dfrac{(\bar{O}_y - \bar{E}_y)}{\sqrt{\left(\dfrac{\sum_a a^2 \hat{p}_{y,a} - \bar{E}_y^{\,2}}{n_1}\right)}} \right]^{-1}$

3. Results

The results show that, in general, there are very few abundance indices whose coefficient of variation a posteriori that display similarity to the initial assumptions, and that the general increase in these terms were to be an average of 73%. If considered as reference that an observation error (coefficient of variation) of any indices higher than 50% may indicate few information regarding population trends, several assumptions of the indices used in the assessment may be relaxed in the model with no greater impact in the populations estimations (Gavaris & Ianelli, 2002). This last scenario may be the case of all the signals of the surveys from Chile and Peru along with the CPUE of the former USSR (**Table 2**).

Regarding the sample sizes, the MacAllister & Ianelli estimator (1997) indicates that the values currently used should show a 21% average decrease, while the Francis (2011) estimator suggests that, in order to reproduce at least the average age or size variability of catches, this decrease in the weighting should reach a 64% (**Table 3**). It is important to note that this last method has the advantage of reducing the correlation level in the fit residuals of the traditional model (Francis, 2011).

Ultimately, however these significant changes in the weighting scale used so far, the quality of the model fit to the data did not have a greater impact (**Figure 1, 2**).

Table 2.

Coefficients of variation of abundance indices used in the evaluation of the stock of horse mackerel. The value is estimated retrospectively after the model fit to the data.

Index	N	cv prior	cv posterior	% var
1: Surv Chile CSouth	13	0.20	0.45	125%
2: Surv Chile North	16	0.50	0.94	88%
3: Chile_CPUE	33	0.15	0.15	0%
4: Chile_MDPH	9	0.50	0.82	64%
5: Surv_Peru	27	0.20	0.60	200%
6: Peru_CPUE	13	0.20	0.33	65%
7: China_CPUE	14	0.20	0.23	15%
8: EU_CPUE	10	0.20	0.29	45%
9: USSR_CPUE.	8	0.40	0.61	53%

Table 3.

Effective sample sizes for age/length compositions used in jack mackerel stock assessment. The estimator value of McAllister & Ianelli (M & I) corresponds to the geometric mean. Variability (%) is based on prior value.

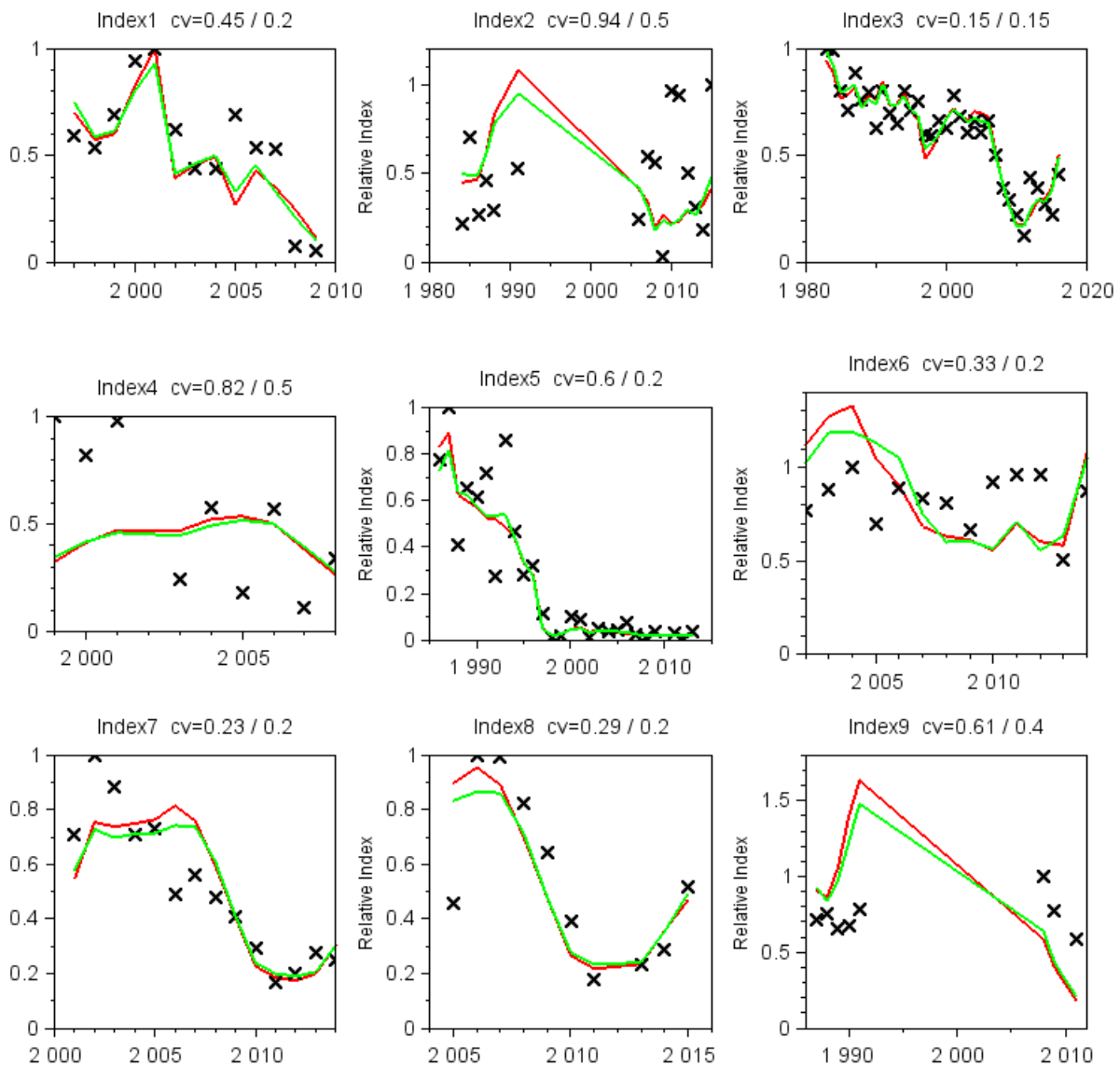| Composition/source	N (yrs)	n prior	n (M & I)	n (Francis)	% var
F1: Chile North	41	20	17.6	17.2	-14%
F2: Chile CSouth	41	50	69.3	20.9	-58%
F3: Perú	35	50	24.4	6.8	-86%
F4: Offshore	27	30	30.1	9.8	-67%
S1: Surv Chile CSouth	13	30	11.0	3.1	-90%
S2: Surv Chile North	10	30	5.7	2.9	-90%
S3: DEPM	6	20	23.7	21.3	7%

Figure 1.   Model fit (lines) to abundance indexes (crosses). The first number in the title of each figure corresponds to posteriori estimation (green lines) of cv while the second one are the priori (red lines). The indices were listed considering the sequence: 1: Surv_ChileCS, 2: Surv_ChileN, 3: Chile_CPUE, 4: Surv_DEPM, 5: Acus_Peru, 6: Peru_CPUE, 7: Chinna_CPUE, 8:EU_CPUE, 9: USSR_CPUE.
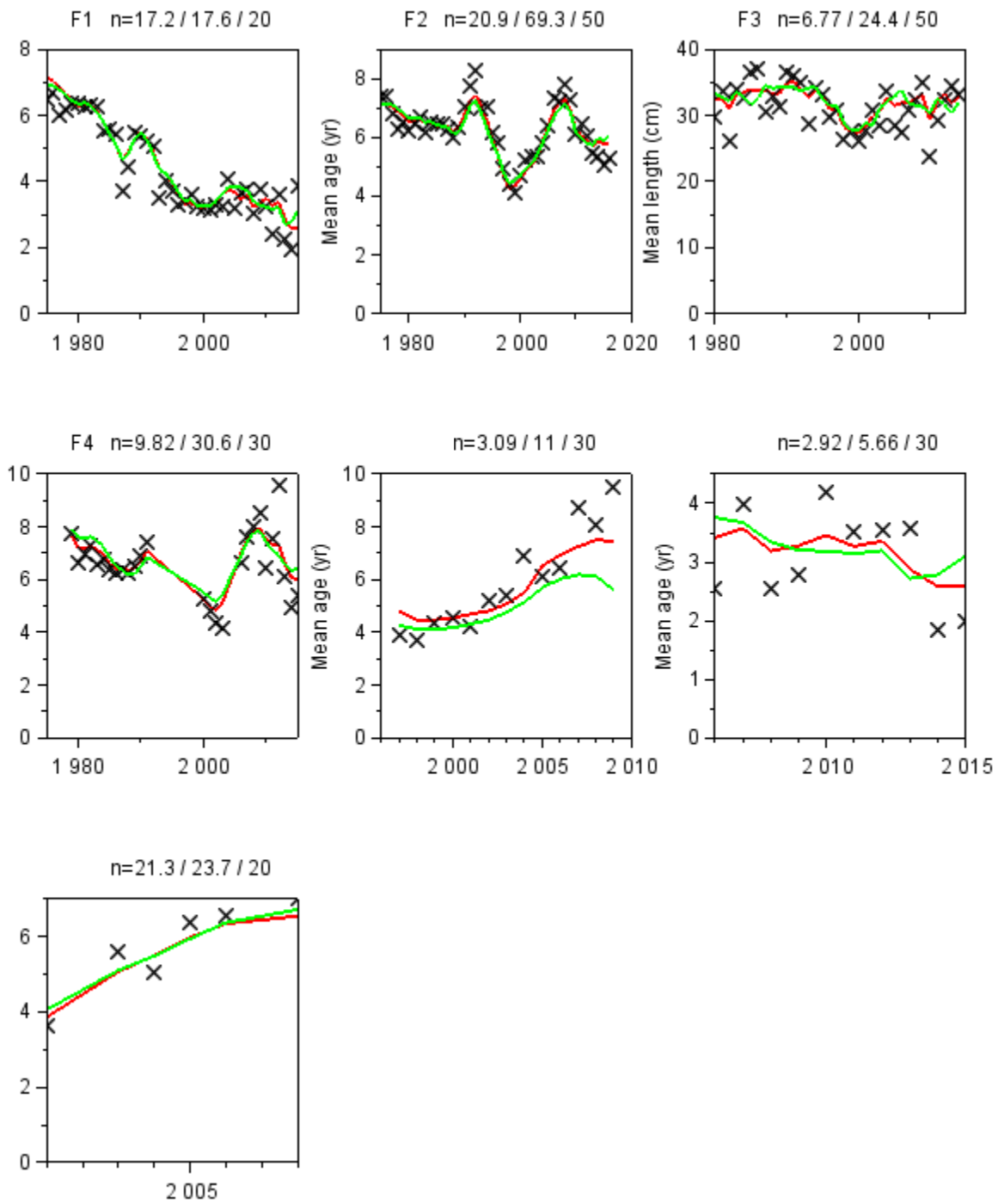
Figure 2. Model fit (lines) to the average age/length in the catches (crosses). The numbers in the title of each figure corresponds, respectively to estimator of: Francis (green lines), McAllister & Ianelli and the priori values (red lines). F represents the fleet and S the surveys. (S1: Acus_ChileCS, S2: Acus_ChileN, S3: DEPM)

4. Discussion

The results on the review of the data weighting factors in the jack mackerel assessment model showed that, in general, the value of these weights should be relaxed. The best quality in the fit of the CPUE indices in respect of the surveys is reflected in its lowest estimated coefficient of variation. This would be mainly to the use of variable selectivity patterns by years in the fleets. This situation also affects directly in the best performance of the model fit to the age/size compositions of catches.

In addition, the Francis estimator (2011) suggests reducing the influence of age/size compositions of catches in the stock assessment due to the high correlation observed in the residuals, giving at the same time, higher relative importance to the signal of the abundance levels. It is important to mention that a similar result is obtained taking into account the annual variability on the selectivity patterns as it is currently done in spite of the significant increase in the number of the model parameters (parsimony problem). However, modeling the processing error this way, whether through changes in the catchability or in the selectivity, is also a way of excluding such information source from the analysis.

Based on the previous result and from a statistical view given the significant difference in respect of the initial weights, it is recommended to modify the statistical weight currently given to the different pieces of information in order to generate a better balance in the use of data to stock assessment.

5. References

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