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Comments and Suggestions regarding the Parameters

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COMMENTS AND SUGGESTIONS REGARDING THE PARAMETERS AND THE AGE-STRUCTURED MODEL CURRENTLY USED FOR THE ASSESSMENT OF JACK MACKEREL IN THE SPRFMO

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The model currently used by the SPRFMO for the assessment of jack mackerel (known as the Joint Jack Mackerel model, JJM) is a "catch-at-age" model which incorporates different information sources for the calibration. The penalized negative of the log-likelihood is minimized using ADMB (Fournier et al. 2012) and several libraries for the analysis have been developed using R programming language (R Core Team, 2012).

A key step in applying this or any stock assessment model for fisheries management purposes is to define the spatial population structure and the stock or stocks to which the model would be applied. In discussing this issue of the jack mackerel stock structure, in 2008 the SPRFMO identified four alternative working hypotheses which could best explain the spatial population structure of the jack mackerel in the South Pacific, recommending that these be used to guide the future SPRFMO stock assessment work. These four hypotheses can be summarized as follows:

- Hypothesis 1.- Jack mackerel caught off the coasts of Peru and Chile each constitute separate stocks which straddle the high seas;
- Hypothesis 2.- Jack mackerel caught off the coasts of Peru and Chile constitute a single shared stock which straddles the high seas;
- Hypothesis 3.- Jack mackerel caught off the Chilean area constitute a single straddling stock extending from the coast out to about 120°W; and,
- Hypothesis 4.- Jack mackerel caught off the Chilean area constitute separate straddling and high seas stocks.

These 4 hypotheses, where actually hypotheses 3 and 4 represent possible subsets of 1 and 2, were supposed to be investigated further and be used to guide the SWG-SPRFMO stock assessment work in the area. However, as applied during the last SWG meeting, the JJM model assumed that all the jack mackerel in the South Pacific belongs to a single homogeneous "unit stock", with the whole population being equally and uniformly vulnerable to the four distinct fisheries operating in different and somewhat far apart areas of the South Pacific. Or namely, that the far North fishery off Peru and Ecuador, the Northern Chilean fishery, the Central-southern Chilean fishery, and the high seas fishery (by EU, Australia, New Zealand, and China among others) have all a similar impact on the same stock unit, commensurate only to the volume and the size frequency composition of their catches. So that by entering these four distinct fisheries as separate fleets in the JJM model, the SWG opted for only one of the four possible combinations of the 2+2 hypotheses listed above. That is, the combination of hypothesis 2 and 3. So far, only one of the four original hypotheses (or of their possible four combinations) have been considered in the stock assessment work of the SPRFMO, and this can be misleading and worst, can lead to erroneous assessments and poor fisheries management advice.

In trying to justify this approach, it has been said that setting quotas for the jack mackerel with the above mentioned JMM model while ignoring the possible population structure - and lumping together what could otherwise be separate fish stocks - may lead to a more precautionary management approach. The main argument being that if one of the main stocks has been overexploited or depleted, the simultaneous reduction of fishing quotas for all, including a particular healthier stock, causes no danger while the lumping of what might be separate stocks could simplify the assessments and management advice.

This, however, besides being wrong and purposely ignoring a wealth of scientific evidence indicating that there is some differentiation and separation between stocks, may cause unnecessary harm to what otherwise might be a healthier fishery, in addition to magnifying the risks associated with the assessment and management of fish stocks at a too rough, large and aggregated scale. Some real case scenarios and fish population dynamics simulations have shown that assessing and managing fish populations at a too large and aggregated scale (i.e. such as lumping stocks or sub-stocks) could fail to detect overexploitation, could mask or lead to local depletions, and could fail to detect and distinguish the effects of overexploitation and those from regime shifts (see, for instance, Sinclair, 1988; Wilson et al, 1999; Laurence et al, 2009; Ying et al, 2011). Therefore, a safer and more realistic approach would be to apply a modified version of the JJM model which more explicitly considers the four hypotheses (or combinations of hypotheses) mentioned above, at least until the jack mackerel stock structure issue is resolved.

A recent study by Gerlotto et al (2010) proposed that the concept of metapopulation was the most appropriate model to explain the population structure of jack mackerel in the south Pacific and their findings have been confirmed by a more recent follow-up study by Gerlotto et al (2012), who ratify that the metapopulation is likely to better describe the stock structure of the jack mackerel in the South Pacific. They also analyzed the possible consequences of each population structure for fisheries management concluding that the metapopulation hypothesis represents a safer definition as far as stock assessment (…and management) is concerned. In this respect, it is noted that this more complex metapopulation hypothesis is not entirely incompatible with some of the hypotheses (or combination of hypotheses) listed above.

When working under the hypothesis that there are two or more distinct stock units or under the more complex metapopulation hypothesis, with two or more sub-populations or sub-stocks that can remain independent during long periods of time with some limited and occasional interaction and genetic mixing (Gerlotto et al 2012), one can account for stocks or sub-stocks in different regions experimenting different recruitments and different abundances. Additionally, some other important local differences can be considered in the modeling efforts, such as differences in growth and natural mortality, as well as other differences that may be a consequence of local adaptations to different environmental conditions and local ecological relationships.

These kinds of differences and sources of variability cannot be handled by introducing different parameterization scenarios in a global model under the single stock unit hypothesis, as done in the last SWG meeting. It should be noted that in the case of neighboring stocks or sub-stocks showing independent recruitments, separate spawning areas and spatial variability in length frequency distributions and population parameters, the uncertainties related to the temporal variability of these and other features and parameters can only be poorly addressed by a global model under the assumption of a stock unity. It has been shown that in the case of a metapopulation, the setting of a global precautionary quota for both a critical “source” stock and healthier “sink” stocks could lead to collapse of the whole metapopulation in the mid-term, despite the optimistic projections given by a global stock assessment model. As correctly pointed out by Gerlotto et al (2012) “a single population requires a unique global management, while separate populations, either independent or linked by exchange of individuals (as in a metapopulation), may require separate management policies adapted to each sub-population”. This obviously required separate assessments as well. It is therefore important that other modeling approaches be considered to handle all the stock structure hypotheses and be able to set real precautionary quotas for jack mackerel based on our most up to date knowledge.

Also, reproductive activity is strongly influenced by environmental conditions. Thus, environmental changes could drive to the success of failure of a recruitment batch. The relationship between spawners and recruits can be highly uncertain and the lack of consideration of the environmental effects could be responsible for part of such uncertainty. Even considering statistical deviations in the recruitment, calculations based in the expectation can be over optimistic, particularly in the long term, leading to a failure in the recovery objectives for the jack mackerel. On the other hand, pessimistic predictions and quotas based on such predictions could derive in lessen credibility in the stock assessment work and increased distrust on the management decisions, particularly when management measures fail to yield noticeable results and/or when these impose tight short-term constrains and socio-economic impacts. Identifying and choosing a good and reliable environmental predictor for the forcing of a population dynamics model can be difficult, but research efforts has to be done in that direction in order to distinguish signs of a real stock recovery from those of local blooms of the population, and thus avoid misunderstandings and distrust from the community and all the related negative socio-economic impacts.

Additionally, when considering long term recovery goals (like the projected state of biomass in ten years) to set fishing quotas, the predictive strength of the model has to be assessed in a reliable way. Even if rigorous statistical validations are not usual in stock assessments, several techniques are available and should be used (cross validation, calibration/validation of data sets, etc.). In this context, the consideration and integration of results and outputs from different models (especially models based on different or independent assumptions and/or sources of data) would help to better understand the dynamics of jack mackerel and gain confidence in the assessments, as well as in their results and management recommended.

Concluding remarks and recommendations

i. Apply a modified version of the JJM model or alternative models which more explicitly consider the four hypotheses (or combinations of hypotheses) on the jack mackerel stock structure, including the one on a metapopulation;

ii. Make available for the SWG spatial data and other information needed to apply other modeling approaches consistent with all the population structure hypotheses;

iii. Investigate possible environment predictors and improve efforts to include and assess different environmental indexes in the proposed models and assessments;

iv. Calculate ecological risk measures for the projected biomass including spatial considerations and environmental variability; and,

v. Consider the use of alternative stock assessment models and methods (especially those based on independent assumptions and/or sources of data) whose results and outputs could be integrated to improve understanding the dynamics of jack mackerel and gain confidence in the assessment results; Develop a protocol for the statistical validation of the jack mackerel assessment models.

References

Fournier D.A., H.J. Skaug, J. Ancheta, J. Ianelli, A. Magnusson, M.N. Maunder, A. Nielsen and J. Sibert, 2011. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models, Optimization Methods and Software, DOI:10.1080/10556788.2011.597854

Gerlotto, F., M. Gutierrez and A. Bertrand, 2010. The distribution of jack mackerel *Trachurus murphyi* in the South Pacific Ocean: a metapopulation hypothesis. FAST-ICES-WG annual meeting. SWNFS, NOAA, San Diego, April 2010.

Gerlotto F., A. Bertrand and M. Gutierrez, 2012. Insights on population structure of the Chilean jack mackerel (*Trachurus murphyi*). Aquatic Living Resources. (In press).

Kell, L.T., Dickey-Collas, M., Hintzen, N.T., Nash, R.D.M., Pilling, G.M., and Roel, B.A., 2009. Lumpers or splitters? Evaluating recovery and management plans for metapopulations of herring. ICES Journal of Marine Science, 66: 1776–1783

R Core Team, 2012. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL: http://www.R-project.org/

Sinclair, M., 1988. Marine Populations. An essay on population, regulation and speciation. University of Washington Press: 251p

Wilson, J., B. Low, R. Costanza and E. Ostrom. 1999. Scale misperceptions and the spatial dynamics of a social-ecological system. Ecological Economics 31: 243-258.

Ying, Y., Y. Chen, L. Lin and T. Gao, 2011. Risks of ignoring fish population spatial structure in fisheries management. Can. J. Fish. Aquat. Sci. 68(12): 2101-2120