Extract from the International Review Panel Report from the 2014 International Fisheries Stock Assessment Workshop

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The international review panel report from the 2014 International Fisheries Stock Assessment Workshop contains the following recommendations pertinent to sardine (Dunn et al. 2014). Some preliminary comments on the ability to incorporate these recommendations in both the short and long term are inserted in *italics* below.

C.1 (*) The alternative models (see MARAM/IWS/DEC14/Sardine/P2) should be implemented in the following priority order:

- Alternative D (Varied Adult Movement). Fits to the parasite data should be used to evaluate the plausibility of the sub-variants of this model variant.
- Alternative C (Varied Adult Distribution). Fits to the parasite data should be used to evaluate the plausibility of the sub-variants of this model variant.
- Alternative A (Effective Spawning Biomasses). An additional sub-variant in which the proportion of south SSB off the west coast exceeds 20% should be considered. Whether this sub-model is taken forward depends on whether auxiliary information suggests that it is plausible. See also recommendation C.4.
- Alternative B (Varied Recruit Distributions).

Alternative B is assigned lowest priority because the extent to which south stock recruits are assumed to be distributed west of Cape Infanta at the time of recruit survey is essentially arbitrary. Alternative A is given next lowest priority because it depends on the results of the linked biological-hydrodynamic model (MARAM/IWS/DEC14/Sardine/BG8), but those results are likely subject to considerable uncertainty owing to an inability to model the response of early life stages to environmental conditions.

> *Alternatives D and C require the greatest amount of additional coding to the sardine two stock modelling framework used previously. Further work will thus begin on these hypotheses, and*

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it is expected that modification to some fine details of the hypotheses might be required following initial results. (High priority)
The extension of the 2015 assessment model to incorporate hypotheses A and B will be dependent on time constraints. (Medium priority)

C.2 (H) The parasite data have the potential to evaluate the relative plausibility of the alternatives listed in MARAM/IWS/DEC14/Sardine/P2. These data should be included routinely in the likelihood maximized when fitting the model. The approach outlined in MARAM/IWS/DEC14/Sardine/P3 will need to be extended to allow predictions of prevalence and abundance of the parasite to be made. In particular, the prevalence of the parasite by age and over time needs to be tracked for the "South from west stock" animals. More complex models will be needed to implement alternative 'C' variants. For example, it will be necessary to keep track of 'South visited West" animals.

Extensions to the sardine two stock model framework to track multiple "components" of each stock is planned in the 2015 assessment. (High priority)

C.3 (H) Initial focus for model development should relate to including prevalence of the parasite, but the abundance (intensity) of the parasite may provide additional information and should be considered as a qualitative reality check if possible.

The 2015 sardine two stock assessment model is planned to be fit first to prevalence data for the period 2011-2014. Initial results will indicate whether parasite intensity might also be used directly in the likelihood. (High priority)

C.4 (H) Alternative B should be implemented accounting for the implications of south stock recruits being found throughout the west coast, and hence being subject to the fisheries there, and possibly being infected by the parasite.

This relates to a further modification to Alternative B as discussed during the workshop, in which the spawning products/recruits from the south stock are assumed to be transported up the west coast in a similar manner as the west stock spawning products/recruits, and then migrate back down the west coast and continue to the south coast. Under this hypothesis, some of these recruits would not have made the full migration to east of Cape Infanta by the

*time of the recruit survey. In addition, these south stock recruits would be subject to fishing on the west coast in the first half of the year. (Medium priority, **after** Alternatives D, C and A)*

C.5 (H) The alternative models should be evaluated in terms of their ability to fit the available data and to mimic more generic expectations for the dynamics of sardine populations. In particular, individual future projected trajectories of population size should exhibit the boom-and-bust dynamics typical of small pelagic fishes.

Model selection will be based on the ability of alternative hypotheses to fit the data, including the new source of parasite prevalence, and possible parasite intensity data which will be included in the likelihood. In addition, the increasing amount of evidence in support of a two stock hypothesis in comparison to a single stock hypothesis is noted (van der Lingen et al. 2015). (High priority)

C.6 (H) An attempt should be made to estimate the recruitment from winter spawning on the south coast. The two approaches in MARAM/IWS/DEC14/Sardine/P3 should be explored.

A variant of the sardine two stock model in which south stock sardine recruitment is modelled as occurring in two cohorts (November and May) will be simulated. As suggested in MARAM/IWS/DEC14/Sardine/P3, it is unclear at this stage whether time-varying proportions of recruitment in November v May could be estimated from the data available. (Medium-High priority)

The calculation of the proportion of age 0 sardine in the November survey biomass, using a method similar to that applied to anchovy by de Moor et al. (2013) will be attempted only after the changes to the model detailed above have been attempted, and if time allows. In addition, investigating methods by which the model separates out the juveniles by fitting directly to the total survey biomass and length frequency information would be preferable to methods which incorporate an additional step (with additional variance). (Medium-Low priority)

C.7 (H) The selectivity of the trawls used during the November survey is estimated to be domed-shaped. This was unexpected given the nature of an acoustic survey which should survey the entire biomass (uniform over all ages), and suggests that the trawls provide a biased view of the length-structure of the population. However, this will be inconsequential for assessment purposes if the trend in abundance is not sensitive to selectivity. The following ways should be explored to determine the extent to which this

selectivity could impact the results of sardine assessments: (a) compute length-frequencies based on biomass weighted length-frequencies stratified by survey stratum and broad size group, and (b) compute biomass estimates using length-frequencies where the abundance of the length classes assumed not to be fully selected are scaled up by the estimates of selectivity by length-class in Figure 6 of MARAM/IWS/DEC14/Sardine/BG6.

A new equal-weighting method for deriving survey weighted length frequencies was implemented in 2011. This method replaced the previous procedure in which the length frequency of each trawl sample had been weighted by the acoustic densities to which it had been assigned for biomass calculation. Additionally the new method made provision for downweighting trawls in which only a small number of fish had been caught. This new method effectively already provides a weighted length frequency by survey stratum [first request under (a) above]. (a) also requests the provision of a weighted length frequency stratified by broad size group – this may be attempted via an inshore/offshore stratification of trawls within each of the existing strata. (Low priority)

The sensitivity of biomass estimates to assumed selectivity as suggested in (b) is easier to check. Each trawl's length frequency will be scaled up the current estimates of selectivity by length-class to produce a new length frequency. This new length frequency will be used to derive new interval densities through the regular sardine TS/Length relationship. Biomass estimates obtained in this way will be compared to previous estimates. (High)

C.8 (M) Show "worm plots" of movement probabilities to evaluate whether the behaviour of, in particular, the MoveAutoC option results in realistic behaviour.

Some individual worm plots can easily be shown in addition to the median and upper/lower confidence intervals. (High priority)

C.9 (M) Age-0 animals should be included in the model predictions of the biomass available to the November survey.

The 2015 sardine assessment is planned to calculate November biomass (for fitting to the November survey estimate of total biomass) using weight-at-length, rather than weight-at-age, thereby allowing for small fish to contribute towards the surveyed biomass. (Using the weight-at-age method requires a weight of 0 for all 0-year-olds). (High priority)

C.10 (M) If computationally feasible, full account should be taken of the uncertainty associated with the parameters of the stock-recruitment relationship if this relationship is fitted outside of the process of fitting the population dynamics model.

It is intended that the 2015 assessment model will be tested with stock recruitment relationships estimated both within and external to the model. Should external estimation prove the more robust method to use, the most appropriate uncertainty surrounding that relationship will need to be investigated. (Medium priority)

C.11 (M) Consider an alternative model in which the effective spawning biomass is the spawning biomass off the south coast, under the assumption that all of the west coast recruitment originates from the south coast, as a sensitivity test.

This would be a further sub-hypothesis of the Alternative A hypotheses, and can be considered, if time permits, at the time when Alternative A hypotheses are modelled. We see this as an option to ***bound*** *the range of possibilities, rather than one which is of great plausibility in its own right. (Low priority)*

C.12 (M) Further examine whether an environmental variable exists that links environmental variables and recruitment / movement in the operating model (not necessarily the candidate OMPs). Although evaluations of the potential for environmental variables to explain movement and recruitment have been conducted in the past, substantially more data appear to be now available.

The PWG should discuss whether this merits investigation, and if so who would be the most appropriate choice to do so. Care would have to be taken concerning the procedures followed, i.e. a priori specification of hypotheses to be tested to avoid data dredging.

C.13 (L) The Panel continues to support its earlier recommendation that an alternative model be developed that assumes that recruitment is dependent on total west+south biomass and in which the proportion recruiting to the south and west is estimated.

This will be attempted if time allows. (Low priority)

References

de Moor, C.L., Butterworth, D.S. and Coetzee, J.C. 2013. Can anchovy age structure be estimated from length distribution data collected during surveys? *African Journal of Marine Science* 35:335-342.

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