Progress on recommendations from the 2018 review panel report

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The international review panel report (Cox *et al.* 2018) contains the following recommendations pertinent to sardine in response to key questions put to them at the annual stock assessment review meeting held at UCT from 26-30 November 2018.

Comments are provided on the recommendations of the November 2018 international review panel of the annual international stock assessment review meeting.

The Panel evaluated several supporting analyses for the sardine OMP-18 revision, including methods for projecting recruitment, for approximating assessment model estimation uncertainty and for establishing risk equivalence across old and new sardine operating models. Overall, the Panel supported the intent to project recruitment with a similar distribution to that observed historically, and made recommendations to further refine how recruitment is generated for projections. The Panel supported methods proposed by the sardine analysts to evaluate risk to the stock, noting that risk measures will vary among Operating Models and trials (previous OMP evaluations for sardine had few trials so this was less of an issue in the past), and recommended a consistent approach to risk metrics. Other Panel recommendations related to sardines apply in general to all assessed species. In general, the Panel considered it reasonable to use the simplified approach to approximating estimation uncertainty from the assessment using a multivariate normal approximation centred on the variance-covariance matrix from an inverted Hessian. The Panel offered a structured approach based on this idea to streamline evaluation of estimation uncertainty when MCMC sampling is not possible given time constraints.

C.1 (*) Is the method followed to estimate a fixed σ_R's to apply in sardine projections for OMP testing appropriate?

The analysts provided an approach (MARAM/IWS/2018/Sardine/P3) aimed mainly to address the issue of how to mimic the observed distribution of recruitments. There are several ways to address this issue. The Panel recommends that the following empirical approach be adopted (for each replicate):

1. Calculate the log-deviations, ε_y, about the fitted stock-recruitment relationship.
2. Convert these to residuals by adjusting them for auto-correlation (with the extent of auto-correlation, ρ, replicate–specific, unless this leads to difficulties), $\eta_y = (\varepsilon_y - \rho\varepsilon_{y-1}) / \sqrt{1-\rho^2}$.
3. In future, project the log-deviations forward by sampling a residual, η_y^*, from step #2 and then computing the future log-deviation, i.e.: $\varepsilon_y = \rho\varepsilon_{y-1} + \sqrt{1-\rho^2}\,\eta_y^*$.

This method is intended for use in future OMP simulations if a stock-recruitment relationship is to be used. (The simulation methodology for OMP-18 wasn't changed as that OMP needed to be finalised very shortly after the Cox et al. 2018 report became available.) The projections described by de Moor and Coetzee (2019) generated recruitment in the immediate future from that estimated for the most recent 5 years because their focus was on the short-term only.

C.2. How might one best check whether use of the variance-covariance matrix from the Hessian to reflect stock assessment uncertainty is an acceptable alternative to the Bayesian sampling approach to develop joint-distributions for parameters in question for OMP testing.

Some of the models used for South African assessments are very complicated; this can make conducting many applications of the MCMC algorithm computationally prohibitive. Thus, it is desirable have an approximation to MCMC sampling available. One such approach would involve:

- Re-parameterizing the model so that, for example, all parameters that have to be positive are estimated in log-space, and all parameters that have lower and upper bounds are estimated in logit-space.

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- Selecting a threshold difference from the maximum posterior density (MPD – the PD is the product of the likelihood and any priors) that determines when the predictions from a parameter vector are unrealistic. One such threshold would be based on the 1st percentile of a chi-square distribution with degrees of freedom equal to the number of parameters.
- Generating parameter vectors from a multivariate normal (or t) distribution centered on the MPD estimates with the variance-covariance matrix set to that based on inverting the Hessian matrix. Any parameter vectors for which the objective function differs from that corresponding to the MPD by more than the threshold difference would be rejected in this procedure.

One way to use this procedure would be to: (a) construct a posterior using the MCMC algorithm for the reference case model, and an (approximate) posterior using the simpler approach, (b) compare the biomass and mortality trajectories from the two posterior distributions, (c) compare the performance metrics for a small number of OMP variants based on the two posterior distributions, and (d) conduct robustness tests based on the simpler approach and compare the results with those for the reference case operating model based on the simpler approach.

There has been no progress as yet with using this method for small pelagics, given other priorities arising from the Exceptional Circumstances situation that arose from sardine abundance having dropped very low as indicated by the November 2018 survey.

C.3 (*) Is the general approach used in (MARAM/IWS/2018/Sardine/P4) appropriate for attempting to determine the reasons underlying different operating models (for sardine) indicating different levels of harvest intensity to correspond to the same level of risk (as expressed by leftward shift)? How would one best apply the approach further to uncover the underlying mechanism(s) causing such differences?

The general approach in MARAM/IWS/2018/Sardine/P4 is appropriate, and suggests that it is some aspect related to the sample of parameter values from the posterior distribution that is leading to the effect observed. This can be investigated further by studying how risk changes with different hinge points for the stock-recruitment relationship.

This investigation also highlighted that risk measures will vary among Operating Models (OMs)/trials (previous OMP evaluations for sardine had few trials so this was less of an issue in the past) and leads to several recommendations:

- The risk measure should be based on biomass values for "the current regime". Care should be taken to apply objective methods for defining "the current regime".
- The value for the β parameter should be calculated for one OM (as recommended by IWS 2017) or over a weighted set of OMs, but naturally this requires that the set of OMs and their weights be selected.
- Final selection of an OMP should consider all the performance statistics (and not, for example, just average catch).
- The values for risk measures should be considered in the context of the risk under zero catch.
- The approach should be based on setting the specifications for computing the "leftward shift" for OMP-14 in terms of the biomass component measure available from the application of the OM in use at that time that most closely corresponds to that appropriate for the current OMs (e.g. basing it on changes to the distribution for spawning rather than total biomass).
- It is better to consider absolute rather than relative changes in risk (i.e. 0.005 to 0.1 is an increase of 0.095 rather than an increase by a factor of 20), as the latter is very sensitive to the initial risk chosen.

OMP-18 was finalised using a risk threshold of the 2007 (historically lowest year for the baseline OM) west component effective spawning biomass. The "leftward shift" under OMP-18 was tuned to match that of the total spawning biomass (and no longer the total biomass) "leftward shift" under OMP-14 (de Moor 2019). No weighting between alternative OMs was agreed and OMP-18 was instead tuned to a baseline OM assuming density-dependent movement and 8% of the south component spawning biomass contributing to west component effective spawning biomass (de Moor 2018a,b).

C.4 (*) When risk is to be related to wishing to avoid dropping below a certain level of abundance, how is that risk best measured in a way that is readily interpreted, and also shows appreciable differences when the management controls are changed substantially?

Appendix 2 outlines the thresholds used in management of other small pelagic species.

MARAM/IWS/Sardine/P5 presented results for four variants of OMP CMP3 for three trials. The variants differ in terms of how the OMP reacts to values for the proportion of the TAC taken on west coast. The performances of the variants differ in terms of catch variability, but minimally in terms of the probability of west component biomass falling below 150 000t for the base case trial. The differences in the risk measure for CMP3 among all the trials are very small (maximum 1 percentage point) and the Panel would consider such differences insufficiently large that they should be the focus for much attention. Sensitivity of risk measures to changes in management controls depends on the structure of the dynamic models and stochastic processes. Lack of sensitivity should be investigated to better understand possible hidden feedbacks within the closed-loop simulation that offset impacts of the control. Further, it should be confirmed that the closed-loop simulation model structure adequately represents the risk (e.g. that deviations from the OMP have appropriate structure to impact outcomes if warranted). The Panel also recommends that:

- Correlation in the residuals about the relationship between the proportion of the TAC taken from the west coast and the ratio of the west component biomass to the total TAC should be examined. If this is found to be statistically significant, it should be included in trials (although analyses presented to the Panel suggest that this is not the case (Figure 1)), Following that, robustness trials in which there is correlation in the residuals should be developed to better capture the observed behaviour of the industry and therefore the consequences of the industry not allocating their effort spatially as in the past.
- A performance metric that is the proportion of consecutive x years that the spawning biomass of the west component is less than, say, the 2007 level may better quantify the impact of short-term changes to the total TAC on the west coast component.

There was insufficient time to consider these recommendations prior to finalising OMP-18, but they will be considered during the development of the next OMP.

References

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