Progress on recommendations from the 2017 review panel report

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The international review panel report (Cox *et al.* 2017) 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 27 November to 1 December 2017.

Comments on these recommendations are inserted in italics.

B.1. Have we an adequate Reference Set of operating models for sardine? How do we best report performance statistics for this set?

The Panel recommends that the stock-recruitment relationship be estimated outside of the stock assessment (i.e. option (i) in item B.2.2b from the 2016 Panel report) as this is both an acceptable approach and should speed the OMP revision process.

The Reference Set should include alternative values for *p* as well as the MoveR option. It is desirable to explore another model of west to east movement. However, the evidence for the current alternative (0.5MoveR) is not sufficiently strong to include it in the Reference Set.

Weighting of factors within the Reference Set to provide weighted outcomes should make the selection of an OMP easier (e.g. narrow the ranges of candidate MPs). However, the selection process must also involve examining the results for each individual trial in detail. The Panel lacked a basis for commenting on the factor weights presented in Table 1.

A robustness trial should be developed in which the November biomass on the south coast in 2016 is forced to be low, consistent with the associated survey estimate.

> *The new joint sardine-anchovy OMP (OMP-18) is being developed using a sardine Operating Model with the stock recruitment relationship estimated after conditioning. Two movement hypotheses have been considered, MoveR, and MoveD. The latter assumes a density-dependent relationship with west component biomass (de Moor et al. 2018), and has recently been agreed to form part of the baseline OM. While results have been shown under the range of OMs and weighted reference sets of OMs, it has recently been agreed that OMP-18 will be finalised using p=0.08, with the remaining OMs forming robustness tests.*

B.2. How do we best choose risk threshold biomass for sardine and anchovy?

There is much less consistency worldwide in the choice of the threshold biomass level for small pelagic species such as sardine and anchovy than for longer-lived species such as cods and hakes. In addition, there is considerable variation in the basis for the threshold biomass among jurisdictions; these include impacts on average catches and on the broader ecosystem. The Panel recommends that the threshold biomass for defining risk be set to the lowest level of spawning biomass provided that recruitment near this biomass was 'reasonable' (e.g. recruitment at half the asymptotic level for the Beverton-Holt or Hockey Stick stock-recruitment relationship). This approach reflects that there is no basis to infer that recruitment will be adequate at levels of spawning biomass lower than lowest spawning biomass ever observed. Alternatively, a higher level of spawning biomass could be selected so that recruitment at that biomass would be expected to be 'reasonable'.

The Panel notes that the risk identified relates to spawning biomass falling below a pre-specified risk threshold. Given the natural variability of the sardine stock, the extent of precaution of the candidate MPs rests on how the harvest control rules reduce fishery catch. Therefore, it is critical that the OMP actually implement what is likely to actually occur in practice when biomass is below the harvest control rule biomass threshold.

> *The risk threshold for sardine and anchovy are now both defined as the lowest historical (effective) spawning biomass level. This level is 1996 for anchovy, and 2007[1] for sardine.*
> *Changes to the developing OMP this year have included constraints (e.g. an overall minimum TAC and restrictions on inter-annual changes in the TAC during years of low survey estimates of biomass) introduced to capture the concerns expected to apply in reality.*

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[1] 2007 is lowest historical level of effective spawning biomass for the sardine OM with p=0.08, but not for higher p values.

B.3 (*). How do we best select the acceptable probability of dropping below a risk threshold?

There are two ways to define an acceptable probability of dropping below a risk criterion: (a) by analogy with such probabilities accepted previously, which could potentially maintain consistency in risk tolerance over time, and (b) by examining the trade-off between risk and other performance statistics. Option (a) will be difficult to implement at present, given the very marked changes in the structure of the operating model. For option (b), the Panel suggested examining the additional risk imposed by the directed fishery compared to the case with zero directed fishery, which is compatible with Working Group proposals in ICES for similar stocks (ICES WKGMSE 2013). The following algorithm could be used to define such an acceptable probability:

- Identify a "tuning trial" – the Panel suggests the trial with p=0.08 and MoveR as a trial for which risk should be non-zero but not too high, and thus provides contrast in results for different candidate management procedures.
- Identify a management procedure that has a tuning parameter such that increasing values for the tuning parameter lead to higher catch limits for the same stock size (such as OMP-14).
- Conduct a zero future catch scenario.
- Conduct simulations for a range of values for the tuning parameter that is sufficiently wide that the median long-term (years 11-20) catch stops increasing if the tuning parameter is increased any further.
- Plot (minimally) the median and lower 5th percentile of short-term (years 3-5 given pre-specified catches for 2016 and 2017) and long-term (years 11-20) catch against the probability of biomass dropping below the threshold level (the "risk" – computed via method (i) or (ii) as define below).
- Select a risk level (R_*) given the trade-off among the various summary statistics
- Compute ΔR_1 as the ratio of R_* to the risk for zero catch (R_0), and ΔR_2 as the difference between R_* and R_0.

The process for selecting OMP-18 would then involve comparing the performance statistics for alternative candidate MPs such that risk does not exceed the maximum possible risk, which is defined for any given trial either as the risk when catch is zero plus ΔR_2 or this risk multiplied by ΔR_1. These performance statistics would include short- and long-term catches, the probability of a severely reduced fishery, and a measure of annual variation in catch.

The first four steps of the algorithm above should be applied to the base case trial on which OMP-14 was based to allow the trade-off among the various summary statistics on which OMP-14 was based to be determined.

The Panel was presented with three methods to compute the probability of biomass dropping below the risk threshold: (i) the proportion of simulation trials in which biomass drops below the risk threshold at least once over the projection time period; (ii) the average probability of biomass being below the threshold over all projection years; and (iii) the probability of biomass being below the threshold in the final year of the projection. Of these alternatives, the Panel eliminated method (i) because it lacks discriminatory power for species such as sardine that exhibit high natural variability. The approach suggested above therefore could use either method (ii) or (iii).

> *Risk is measured as the average probability of spawner biomass being below the risk threshold over the full projection period (Option ii above).*
> *To determine the acceptable level of risk, Option (b) was attempted for sardine, but there was no agreement at which lower percentile risk should be measured in order to select a risk level R*. A version of option (a) has been used thus far, but the difficulty encountered is that the "leftward shift" which compares the 20%ile of the distribution of total (west+south) sardine biomass at the end of the projection period under a catch scenario to the 20%ile from the corresponding distribution assuming no future catch, is calculated in terms of total biomass, while the sardine "Risk" is calculated in terms of west component effective spawning biomass.*

B.4. Can one dispense with risk and simply consider catch over the medium-to-long term as sufficient to incorporate any negative consequences of undue depletion of the population?

This approach to evaluating management procedures should be considered for use in future OMP evaluations, and may be more appropriate for long-lived species that are not as heavily subject to large process error variation. The Panel does not though recommend using this approach for the current OMP revision both because of local inexperience with interpreting results in this form and because this approach depends heavily on having a stock-recruitment relationship that is reliable at low biomass (at minimum sensitivity to alternative assumptions for that relationship, including ones involving depensation, would need to be checked). An alternative to explicitly evaluating the risk of undue depletion would be to report how often fishery catches are unduly low, which may be more robust to the uncertainty associated with the stock-recruitment relationship at low biomass. Furthermore, choosing to focus on average yield over the medium-to-long term only would lose information on the proportion of years with a severely reduced fishery. If a small probability of a very low TAC is considered a potential management objective, then one cannot dispense with analysing this risk.

> *A new performance statistic on the proportion of times directed sardine catches are simulated to be below 20 000t is now included in CMP output.*

B.5. What would be the best way to simulation test the impact of a single area directed sardine TAC in a situation of two spatially distinct sardine population components?

The approach in MARAM/IWS/2017/Sardine/P4 is an appropriate way to model the impact of a single area directed sardine TAC. Uncertainty in the relationship between the proportion of the catch west of Cape Agulhas and the ratio of the biomass off the west coast to the TAC should be taken into account by fitting this relationship to each draw from the posterior.

Done (de Moor 2018a).

B.6. The 2016 panel recommended OMP variants that include spatial management be considered (recommendation B.1.3). Is spatial management of the sardine TAC necessary? If we consider explicit spatial management to be necessary during "concerning periods" only, how do we best determine the "flags" for switching such spatial management on and off?

The approaches outlined MARAM/IWS/2017/Sardine/P7 are sensible ways to include spatial management considerations in an OMP. These options should be explored if the calculations to determine whether or not there is a need for spatial management confirm that the risk criterion cannot be satisfied without some spatial management (or that TACs need to be very low in the absence of explicit spatial management).

The methods of including "preventative" and "penalty" red flags in the OMP as initially outlined by MARAM/IWS/2017/Sardine/P7 have advanced, with the 'conservative action' once flags are raised including options other than explicit spatial management (de Moor 2018b,c).

B.7. How might one best specify the November survey estimate of abundance below which the directed sardine fishery should be closed?

The Panel response to this question is framed in the context of a short-term (December 2017) management decision rather than in the context of a threshold biomass in an OMP harvest control rule. The latter should be based on the values for performance statistics from simulation trials, some of which will depend on the choice of risk threshold biomass. In relation to the short-term need, the Panel recommends that the approach outlined for item B.2 be adopted, except that the lowest level of estimated spawning biomass at which estimated recruitment was 'reasonable' be converted into survey biomass. In addition, it may be appropriate to increase the value so computed to account for the impacts of observation error – the latter is not relevant to item 2 as the threshold biomass there is computed using the operating model rather than an actual estimate of biomass from a survey.

The lowest historical sardine west component spawner biomass, corresponding to 2007, was considered 'reasonable' (de Moor 2017). This spawning biomass threshold corresponded to a survey estimate of biomass of approximately 80 – 150 000t. The total sardine in 2007 corresponded to a survey estimate of biomass of more than 520 000t. No further increase in these threshold to account for the impact of observation error was considered (de Moor 2017). No action was taken.

References

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