Report back on previous recommendations by the International Review Panel

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Extracts pertaining to South African pelagics in the reports by the International Review Panel of International Fisheries Stock Assessment Workshops in Decembers 2012, 2011 and 2010 are given below with responses provided by the authors in *red italics*.

December 2012

Key Issues : Survey-TAC Small Pelagics

News as of 23 November is that the *Africana* cannot complete the hydroacoustic survey, but that substitution of an industry vessel, the *Compass Challenger*, has just been approved

- Review of current rules applied if November survey does not take place
- What constitutes adequacy of the survey; to what extent is extrapolation admissible?
- Possible improvement of current rules for both November and May surveys
- Implications for 2013 mid-year TAC revisions if either or both of the current November and the May 2013 survey do not provide satisfactory estimates of abundance
- (Time permitting) advice on a comparable definition of risk for anchovy in finalising the small pelagics OMP in circumstances where best choices for both natural mortality and the form of the stock-recruitment curve have changed

Review Panel's Recommendations

Small pelagic surveys

In regard to the use of an industry vessel (*Compass Challenger*) to conduct the remainder of the November 2012 hydro-acoustic survey for small pelagic species, the Panel identified three potential sources of bias between *Africana* and *Compass Challenger* in estimation of resource abundance: (a) the position of the transducer, (b) the difference in noise levels between the vessels, and (c) whether sardine / anchovy will avoid the two vessels differently. Based on information provided by the DAFF scientists, the Panel does not consider it likely that any such bias for *Compass Challenger* relative to *Africana* will be large. Nevertheless, it supports the proposal to conduct a calibration exercise between *Africana a*nd *Compass Challenger* to confirm this.

> *This was attempted immediately after completion of the 2012 November survey in False Bay. Unfortunately, the exercise had to be aborted almost immediately after it started due to safety concerns. Whereas this intercalibration should still be attempted, the Africana has not yet been made available given maintenance, repair and registration issues.*

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The joint sardine-anchovy OMP relies on estimates of abundance from surveys. Rules have been agreed to handle situations in which such estimates of abundance are not available. These rules seem reasonable (although they have yet to be tested using simulations), and the Panel suggests they be applied in the event that the November 2012 survey cannot be completed sufficiently to yield acceptable estimates of sardine and anchovy abundance. A range of opinions were expressed during the workshop whether or not "Exceptional Circumstances" provisions should be implemented, and how the TAC from the OMP should be adjusted in the event a survey cannot be conducted.

Thankfully a pelagic hydroacoustic survey conducted on an industry vessel was completed in November 2012 to provide estimates of adult biomass for use in the OMP's Harvest Control Rules.

D. Surveys

D.1 Pelagic species

The new age-proportion data and the new and revised recruit and 1+ biomass indices for anchovy suggest that M=0.9yr^{-1} is not comparable with the assumption that catchability for the recruit survey is less than for November biomass survey (k_r/k_N). In addition, the Beverton-Holt stock-recruitment relationship now provides a better fit to the data than the hockey-stick stock-recruitment relationship[1]. There is also an increasing trend in k_r/k_N over the period 2006-2011. Moving from a reference case in which M=0.9yr^{-1} and the stock-recruitment relationship has the hockey-stick form to one in which M=1.2yr^{-1} and the stock-recruitment relationship has the Beverton-Holt form leads to higher risk for the same OMP. [*Advice on a comparable definition of risk for anchovy in finalising the small pelagics OMP in circumstances where best choices for both natural mortality and the form of the stock-recruitment curve have changed.*]

DA.1 (H) For anchovy, it is desirable to make different reference case specifications more comparable in terms of risk. The Panel recommends that "comparable risk" levels be defined as the result of applying a reference OMP (e.g., OMP-08) to an operating model based on the 2012 assessment but using data up to November 2006. It is, however, not necessary for risk for OMP-13 to be the same as for OMP-08 given that the relative probability associated with different assessment models has changed. Therefore, whether OMP-13 should be based on the same risk as OMP-08 should be evaluated taking into account the relative probability of the pertinent reference case models. [*Advice on a comparable definition of risk for anchovy in finalising the small pelagics OMP in circumstances where best choices for both natural mortality and the form of the stock-recruitment curve have changed.*]

The control parameters of OMP-08 were chosen based on projections of an operating model with M=0.9 and a hockey stick curve which was conditioned to data up to 2006. The risk to anchovy resource under OMP-08 but using an operating model with M=1.2 and a Beverton Holt stock recruitment curve (also conditioned to data up to 2006) was calculated to be more than double that used when tuning OMP-08. If the level of depletion under this operating model (M=1.2 and BH, but now conditioned to data up to 2011) was maintained, then OMP-13 could be tuned to a 35% chance of dropping below 10% of the historic average. This risk level was thought to be too high amongst some Small Pelagic Working Group members. A final compromise choice of risk level was not determined using the "objective" method of trying to maintain a similar level of depletion at low percentiles from one MP to the next. Rather a higher (than Interim OMP-13) risk level was used while increasing the threshold at which Exceptional Circumstances are declared (FISHERIES/2013/MAY/SWG-PEL/06).

DA.2 (H) Consider alternative (more general) stock-recruitment relationships for anchovy. [*Advice on a comparable definition of risk for anchovy in finalising the small pelagics OMP in circumstances*

[1] The form with a fixed inflection point.

where best choices for both natural mortality and the form of the stock-recruitment curve have changed.]

The LOWESS method was attempted to provide a non-parametric stock-recruitment curve, but no immediate benefits were evident and work was refocussed on other pressing issues.

DA.3 (H) The current rules for dealing with missing surveys are very complicated and cannot be simulation tested. As part of the process of developing OMP-13, develop simpler rules and test them using simulations in which some future surveys are missing. [*Review of current rules applied if November survey does not take place.*]

Not yet done.

December 2011

Key Issues : Pelagic OMP

- Review of updated assessments
  - i) Estimation of recruitment variability
  - ii) Acceptability of fits to age/length data
  - iii) Temporal variation in *M*
  - iv) Stock-recruitment relationship
  - v) Model(s) for multiple sardine stocks
  - vi) Key uncertainties requiring robustness tests

- Suggestions for projection specifications
  - i) Modeling future recruitment, including sequences of years of poor recruitment
  - ii) Taking account of implementation uncertainty (the undercatch of anchovy)

- Suggestions for performance statistics
  - i) Defining risk criteria, including in the case of a multiple sardine stock operating model
  - ii) Is there merit in developing a decision-analysis method for selecting amongst candidate OMPs

- Suggestions regarding management options and choices amongst them
  - i) How to assign relative plausibility to alternative hypotheses for constant vs time-varying M and for alternative stock structures
  - ii) Concerns about the current minimum TAC prescription with *F* increasing as biomass falls; does the Exceptional Circumstances fall back approach provide adequate safeguards, or does the TAC control rule require revision?

- Spatial management
  - i) Does the available evidence necessitate spatial management and at what scale?
  - ii) How might area-specific directed sardine TACs best be formulated (e.g. pro-rata to the proportion of survey biomass in the area)?

Review Panel's Recommendations

OMP development and testing can be considered as a specialised form of decision analysis. Being clear about management objectives is a pre-requisite to making good decisions, and the intended development of formal management plans by the Department responsible in South Africa will help clarify the broad objectives for each fishery. The performance statistics used to evaluate candidate OMPs are quantitative measures of the success in achieving these objectives, though some performance statistics play a secondary role in rather helping to understand aspects of performance

that are not directly related to key objectives. More specific and quantitative objectives tend to emerge in the process of OMP development and testing, as trade-offs and constraints in performance emerge in the analysis. There is a strong commitment in South Africa to achieving basic stock protection outcomes, with other key objectives relating to enhancing resource utilisation and industry performance, particularly stability, being met subject to achieving stock protection objectives. Broader ecosystem objectives are generally not well specified, and improved clarity in this area would assist management and decision making. The Panel recognised that one of the strengths of the OMP process is the explicit consideration of trade-offs in achieving conflicting management objectives. The Panel's experience is that the ability to highlight trade-offs is preferable to optimisation approaches that attempt to merge competing objectives into a single objective (utility) function, as is done in some forms of decision analysis.

The workshop also discussed spatial management, with several Panel members providing perspectives on its use in other parts of the world. A distinction was drawn between aspects of spatial management that can be accommodated in an OMP (such as area-based TACs), and those at generally finer (sub-stock) spatial scales that are designed to address specific issues such as bycatch, habitat and certain trophic impacts. Further discussion of spatial management is provided under recommendation BC.1.

The Panel draws attention to the fact that the OMP approach can be used to explore other issues not directly related to core objectives. An example is the investment in different aspects of monitoring (abundance, age, length) to support stock assessment. Abundance surveys are fundamental to the management of most fishery resources in South Africa, but the relative value of data on length- and age-structure for assessments could be evaluated quantitatively. A different example concerns the form and complexity of the management rules underpinning some OMPs (e.g. sardine and anchovy), with a possible trade-off related to the extent of improvements in performance weighed against the understandability (and hence acceptability / buy-in) of the rules.

The Panel notes that ecosystem considerations are starting to emerge more strongly as management issues in some fisheries, but that there is something of a gulf presently existing between the local scientific communities that primarily focus on ecosystem modelling and on resource assessment. Both science and management advice would benefit from closer collaboration between these communities.

The Panel observes that assessments involve first conducting exploratory analyses of the basic data to identify appropriate model assumptions and sensitivity tests, and to determine how the data should best be used to parameterize a population dynamics model. Examination of all data components before they are used for fitting the model is therefore essential and should receive as much attention as the modelling itself. The Panel noted that not enough emphasis was given to this important phase of the analysis in the presentations. In one case (sardine), after examining the age-composition data, the workshop concluded that the data were not informative and recommended excluding them from the estimation (recommendation BA.1). More comprehensive diagnostic statistics and plots would help to identify data and model-misspecification issues (see, for example, recommendation BE.3).

While the diversity of species and issues considered led to a large number of interesting problems and results, the Panel was concerned that the amount of material presented precluded in-depth technical review of a number of the papers.

B.1 Pelagic OMP

B.1.1 Review of updated assessments – sardine

BA.1 (H). The fits to the sardine age data in MARAM IWS/DEC11/P/OMP/P8 remain poor even though considerable additional work has been undertaken to improve, in particular, the representativeness of the survey age data. Examination of the age data indicates that strong cohorts cannot be traced over time. This could be due to problems with ageing and/or problems with the construction of the survey length-frequency data. Future base models should therefore be based on:

(a) ignoring the survey and commercial age data,
(b) ignoring the survey length-frequency data, and assuming instead that survey selectivity is independent of age,
(c) fitting to commercial size composition data assuming length-based selectivity (possibly varying over time), and
(d) ignoring the possibility of time-varying natural mortality.

Consider fixing rather than estimating the parameters of the growth curve.
[*Review of updated assessments*]

> *The survey and commercial age data were removed from subsequent assessments of the sardine resource and the assessments were instead fit to survey and commercial length data. Survey selectivity-at-length is fixed to 1 for all length classes except the minus and plus length classes for which selectivity was estimated. The models assume time-invariant natural mortality, differing between juvenile and adult sardine. An improved fit to the data was obtained by estimating parameters of the growth curve, rather than fixing them to those estimated externally to the model, directly from ageing data (MARAM IWS/DEC13/Sardine/P1 and MARAM IWS/DEC13/Sardine/BG1).*

BA.2 (H). The ability of the model to fit the data in a broad sense should be assessed by plots of time-averaged observed values compared to averaged predicted length-frequencies. [*Review of updated assessments*]

> *Done, eg Figures 8 and 11 of MARAM IWS/DEC13/Sardine/P1 and Figures 7 and 10 of MARAM IWS/DEC13/Sardine/BG1.*

BA.3 (H). The "maximum likelihood" estimate of σ_{ad} [and σ_R] is zero, and the value of this parameter is consequently constrained. The ideal way to estimate σ_{ad} should be pursued: this is to treat the assessment as a random effects model and integrate the process errors out. Analytical integration is, however, difficult for models as complicated as the assessments for sardine and anchovy. An alternative approach is to include a prior on σ_{ad} in the estimation to keep the "maximum likelihood" estimate of σ_{ad} away from zero, and then to drop this prior when applying the MCMC algorithm. [*Review of updated assessments – estimation of recruitment variability*]

> *Time-invariant natural mortality was assumed for the baseline (from recommendation BA.1d), so this was not further pursued for the standard deviation in the annual residuals about adult natural mortality, σ_{ad}. A sensitivity test assuming time varying natural mortality has not yet been run with the updated model.*

BA.4 (M). For the two-stock sardine model, consider imposing a prior on the annual movement rates. Treat all of the annual movement rates (even those for which no other data are available) as estimable parameters so that the MCMC sampling can reflect the uncertainty associated with historical movement rates. [*Review of updated assessments*]

> *The annual proportion of recruits moving was estimated using uninformative prior distributions for 1994-2011, in order that the estimated movement not be unduly biased by opinion. There was insufficient information to estimate movement prior to 1994 (initial results had a non positive definite Hessian) given this uninformative prior.*

B.1.2 Review of updated assessments – anchovy

BB.1 (H). Explore whether survey length cut-offs can be used to compute the age-1 proportions in the November survey for anchovy (rather than using a historical age-length key). [*Review of updated assessments – temporal variation in M*]

> *This method did not work, but another method of modelling the length distributions was pursued and used to develop a new time series of proportion-at-age 1 anchovy. See de Moor, Butterworth and Coetzee (2013) Can anchovy age structure be estimated from length distribution data collected during surveys? African Journal of Marine Science 35:335-342*

BB.2 (H). The introduction of time-varying adult natural mortality in the anchovy assessment improves the fit to the age-1 proportions in the November surveys. However, these proportions may be being overfit. Therefore (and once recommendation BB.1 has been effected):

(a) compute the sampling variances associated with these data, and
(b) explore the implications of a CV of 0.3 for the logits of the proportions.

In addition, consider a model formulation in which *M* is density-dependent rather than being governed by a correlated random walk.
[*Review of updated assessments – temporal variation in M*]

> *The analyses mentioned above also computed an effective sample size for each annual estimate of proportion-at-age 1, which was used as a measure of variance about these "data" points when fitting the assessment model. The updated base case anchovy assessment assumes time-invariant natural mortality, though sensitivity to time-varying natural mortality, a change in natural mortality at the turn of the century, and density dependent natural mortality were explored (FISHERIES/2012/SEP/SWG-PEL/47).*

BB.3 (H). Refine the ways in which survey and age-1 proportion biases are modelled for anchovy so that there are separate bias parameters (effectively selectivities) for ages 1 and 2+. The current approach of time-invariant total survey and age-1 proportion biases are inconsistent.

> *The authors are no longer sure to what this recommendation referred. Proportion-at-age 1 is not longer estimated with a bias parameter.*

BB.4 (M). Consider sensitivity tests in which *M* changes in 2000 as well as a robustness test for the OMP evaluation in which *M* changes in the future. [*Review of updated assessments*]

> *A sensitivity to a change in M in 2000 was tested (FISHERIES/2012/SEP/SWG-PEL/47). Future projections have not yet assumed a different M in future years to that assumed in the recent past.*

B.1.3 Stock structure and spatial management

BC.1 (*). There are many reasons for implementing spatial management arrangements, including management of target species, bycatch species, protected species, and benthic impacts. Within the small pelagics fishery, spatial management is being considered by:

(a) using the outputs from the penguin population dynamics model linked to the pelagic OMP as performance statistics – this addresses regional-scale issues,
(b) continuing to implement the experimental evaluation of the impact of fishing on the reproductive success of penguins – this addresses small-scale issues around colonies,
(c) considering operating models with west and south stocks – this addresses issues related to large-scale stock structure, and
(d) implementing short-term closures to avoid bycatch of, for example, horse mackerel.

The OMP evaluation process addresses a number of issues which may lead to spatial management arrangements (e.g. separate TACs for sardine east and west of Cape Agulhas). Additional spatial management arrangements may be needed due to other factors (e.g. bycatch of non-target species). These factors need to be dealt with outside of the OMP evaluation approach, particularly when the spatial scale of the management issue is finer than the scale of the stock assessment. This highlights the value of identifying objectives, including those related to the broader ecosystem, which will assist in evaluating the costs and benefits of spatial management.

> *The Small Pelagic Working Group now has an agreed set of objectives for use in developing OMP-13 (FISHERIES/FEB/2012/SWG-PEL/03rev2).*

BC.2 (*). There are three primary stock structure hypotheses for sardine: (a) panmixia (one perfectly mixed stock), (b) two separate unrelated stocks, and (c) two stocks, but with mixing between them. Care needs to be taken when interpreting data which informs stock structure not to confuse the impact of environmental factors on population processes and parameters from the impact of stock structure. The hypothesis of separate unrelated stocks is not supported by the data (e.g. MARAM IWS/DEC11/P/OMP/P7), while the data on, for example, parasites, gill-raker gaps and vertebral counts, and length-at-maturity are not consistent with a single-stock in which biological parameters are spatially-invariant. Given the available information, the Panel consequently considers the hypothesis of two stocks which are linked through some form of mixing as the most likely. [*How to assign relative plausibility to alternative hypotheses for alternative stock structures*]

A single stock hypothesis (a) has been maintained to enable some continuity in comparisons of the new OMP with the previous OMP and a two mixing stock hypothesis (c) has been developed (MARAM IWS/DEC13/Sardine/P1 and MARAM IWS/DEC13/Sardine/BG1).

BC.3 (*). There are three ways in which two putative stocks of sardine could be linked through mixing:

(a) a common spawning biomass determining density-dependence on total recruitment,
(b) movement of age-1 animals (animals spawned the previous November), and
(c) movement of 2+ animals.

The spatial discontinuity in the spawning aggregations and information from the Individual Based Model on egg and larval behaviour are inconsistent with option (a), while the differences in parasite loads and the presence of large differences in the length-at-50%-maturity between the south and the west coasts suggests that any movement of 2+ animals (option c) is likely low. The Panel therefore supports using the stock structure hypothesis (b) with movement of age-1 animals as the initial basis for allowing the two putative stocks of sardine to be linked. [*How to assign relative plausibility to alternative hypotheses for alternative stock structures*]

The two mixing stock hypothesis is based on option (b) above (MARAM IWS/DEC13/Sardine/P1).

BC.4 (H). Develop a model of the proportion of the sardine catch and bycatch on the west and south coasts for the case in which there is a single TAC/TAB, but two stocks of sardine. Consider as covariates the proportion of the sardine biomass on the west and south coasts, as well as possible time-lags or thresholds below which fishing in an area would be unprofitable. Include constraints on the relative fishing mortalities on the west and south coasts to prevent unrealistic fishing patterns. Consult with industry about the future impact of the recent changes in the main location of the fishing fleet. [*Taking account of implementation uncertainty (the undercatch of anchovy)*]

A relationship between the proportion of catch on the west coast ("west" stock) and the ratio of the single area TAC to the survey estimate of 1+ biomass west of Cape Agulhas was used (MARAM IWS/DEC13/Sardine/BG3).

BC.5 (H). For the scenarios in which there are two sardine stocks, the boundary between the west and south stocks should ideally be selected to best separate where catches take place and spawning biomass aggregations are found.

It was agreed that Cape Agulhas was the best position for the boundary (FISHERIES/2012/SWG-PEL/06).

B.1.4 Projection, OMPs and performance statistics

BD.1 (H). In relation to robustness tests for evaluating candidate OMPs for the pelagic fishery:

(a) model future "poor recruitment" by sampling low recruitment deviations for the first five years of the projection period (see recommendation BD.6 below for one use of this robustness test),
(b) include a robustness test based on the pre-2000 stock-recruitment relationship,
(c) eliminate the robustness tests related to time-varying natural mortality for sardine,
(d) project future deviations in natural mortality for anchovy based on an AR(1) process,
(e) eliminate the robustness tests in which there a single sardine stock, but different selectivities-at-age west and east of Cape Agulhas, and
(f) examine sensitivity to different algorithms for the split of the catch / bycatch west and south when there are two stocks, and the OMP sets a single TAC / TAB.

[*Modelling future recruitment, including sequences of years of poor recruitment*]

Recommendation a) was used when testing some alternative OMP constraints and rules (FISHERIES/2013/MAY/SWG-PEL/10). Robustness test b) was run, though the OMP has not yet been simulated under this alternative OM. Recommendations c) and e) were done. Recommendation d) not attempted. Recommendation f) has recently been explored (FISHERIES/2013/NOV/SWG-PEL/33).

BD.2 (H). Consider OMP formulations which (a) have separate Exceptional Circumstances for the west and south areas, and (b) compute total TACs and allocate them to the west and south coasts based on the proportion of the biomass off the west and south coasts (perhaps by way of shrinking to averages over recent years to reduction variation).

Initial projections of a 2-area sardine MP have been undertaken with as few changes as possible from the single area sardine MP (MARAM IWS/DEC13/Sardine/P3), where the TAC by area is dependent on the survey estimate of 1+ biomass in each area. Further work on a 2-area sardine MP will continue next year and different Exceptional Circumstances thresholds for "west" and "south" areas will be tested.

BD.3 (H). Conduct simulations of an OMP which does not include a minimum TAC to determine the impact of the minimum TAC, and hence the associated increased fishing mortality when the stock size drops before the Exceptional Circumstances level is reached. [*Concerns about the current minimum TAC prescription with F increasing as biomass falls*]

Not yet attempted.

BD.4 (H). In relation to the performance statistics:
(a) Divide the performance statistics into "decision" and "reporting". "Decision" performance statistics are those which will form the primary basis for selecting among candidate OMP variants.
(b) Consider outputs of the total biomass of anchovy and sardine relative to a reference level. The reference level could be a lower percentile of the total biomass historically. This could be formulated as a performance measure if there is evidence that the probability of dropping below the reference level is non-negligible. One solution to a high probability of dropping below the reference level would be to modify the OMP to include an Exceptional Circumstances clause based on the total biomass of anchovy and sardine.

A list of "non-negotiable", "core" and "trade-off" objectives were each linked to appropriate performance statistics (FISHERIES/FEB/2012/SWG-PEL/03rev2). Performance statistics have been added to report the proportion of times future combined sardine and anchovy biomass drops below a proportion of the historic average, as well as one third of the historic maximum.

BD.5 (H). "Tune" the OMPs by matching the 20% percentile of the distribution for the change in risk with and without fishing. Care should be taken to ensure that the behaviour of this distribution is

sensible for other percentiles. This "tuning" procedure needs to be applied separately to the west and south coasts. [*Defining risk criteria, including the case of a multiple sardine stock operating model]*

Done for sardine. The final choice of risk for anchovy was a trade-off decision, rather than based on the above method. Under a sardine two-stock scenario, the risk to the "west" stock has been of primary concern, but the OMP has not yet been tuned to this.

BD.6 (M). Conduct simulations in which there are successive years of poor recruitment and, if conservation performance is poor for these simulations, consider OMP formulations in which fishing mortality is reduced as a function of the numbers of consecutive years of poor recruitment. This recommendation relates to whether it is necessary to modify the OMP to deal specifically with consecutive years of poor recruitment.

Changes to the HCRs based on consecutive years of poor recruitment have not been attempted. Changes to OMP rules and constraints have been simulated against 5 consecutive years of good or poor anchovy and/or sardine recruitment to more adequately inform on trade-offs between constraints (FISHERIES/2013/MAY/SWG-PEL/10).

BD.7 (L). The following modifications to the OMP formulation are desirable, but should be implemented only if time is available:

(a) allowing for flexibility in the extent to which the west-south split of the TAC is achieved,
(b) changing the 2-tier TAC variation approach, and
(c) discounting the biomasses on which the Exceptional Circumstances clauses are triggered by their sampling standard deviations (to check if this is a useful approach, initially assume the sampling CV is correct).

Not attempted.

December 2010

Key Issues : Sardine-anchovy OMP revision

- How do we best model recruitment and its variability in the future for both sardine and anchovy?
- How do we best account for implementation uncertainty in the OMP, particularly as regards likely undercatch of anchovy?
- How do we best calculate the TAC if abundance estimates from the most recent hydroacoustic survey, upon which computations are highly dependent, are unavailable (e.g. because of a survey vessel breakdown)?
- How do we best calculate the risk to the resources, which is used to tune the OMP?
- How do we best determine relative plausibility for alternative sardine stock structure hypotheses?

D. Sardine-Anchovy OMP Revision

D.1 (*) The approach outlined in MARAM IWS/DEC10/S/P1 is an appropriate way to handle situations in which future survey data are not available. This approach is similar to that applied in other jurisdictions (e.g. historically for capelin off Iceland). [*How do we best calculate the TAC if abundance estimates from the most recent hydroacoustic survey, upon which computations are highly dependent, are unavailable (e.g. because of a survey vessel breakdown)?*]

No further work has been undertaken on developing a simpler rule to use should there be no hydro-acoustic survey, so this method remains our "fall-back" method for now.

D.2 (*) The management procedures for the 2011 sardine-anchovy OMP should be tuned to risk measures in a similar manner to OMP-2008. However, the tuning should be based on an integral from a percentile of 0.05 to the median because this should be a more robust approach. [*How do we best calculate the risk to the resources, which is used to tune the OMP?*]

This has not yet been quantitatively attempted. As before the 10th, 20th, 30th, 40th and 50th percentiles have been considered, with the greatest focus on the 20th percentile (e.g. FISHERIES/2012/NOV/SWG-PEL/61 and FISHERIES/2013/APR/SWG-PEL/04).

D.3 (H). The operating models on which the 2011 sardine-anchovy OMP revision will be based should include one set in which it is assumed that there is a single stock off South Africa and another set in which it is assumed that there are two stocks (east and west). This is because there is sufficient biological evidence (separate spawning sites and morphometrics) to justify consideration of a two-stock operating model. [*How do we best determine relative plausibility for alternative sardine stock structure hypotheses?*]

This has been done (eg FISHERIES/2013/OCT/SWG-PEL/31).

D.4 (H). The results for the single- and two-stock operating models should not be pooled, but rather examined separately because the results of these two classes of operating model may be qualitatively different. [*How do we best determine relative plausibility for alternative sardine stock structure hypotheses?*]

This has been done (e.g. FISHERIES/2013/OCT/SWG-PEL/27 and FISHERIES/2013/OCT/SWG-PEL/31)

D.5 (H). Management procedures which treat the entire South Africa sardine population as a single management unit should be considered as well as management procedures incorporating spatial structure which explicitly allow for two stocks (even if there is only one stock in the operating model). Comparison of the results from these two sets of management procedures could be used to estimate the value of resolving uncertainty regarding stock-structure.

This is currently being pursued (e.g. FISHERIES/2013/OCT/SWG-PEL/31).

D.6 (H). The approach used previously to generate future sardine recruitment (i.e. a stock-recruitment relationship with the estimates for 2000-2004 ignored) should be used to develop the 2011 sardine-anchovy OMP. The stock-recruitment relationship for anchovy should be based on fitting a curve to all of the available data points because there is relatively weak support for the possibility of a regime-shift change in the stock-recruitment relationship. [*How do we best model recruitment and its variability in the future for both sardine and anchovy?*]

This has been done (e.g. FISHERIES/2012/SEP/SWG-PEL/47, FISHERIES/2012/SEP/SWG-PEL/48, and FISHERIES/2013/AUG/SWG-PEL/20).

D.7 (M). The performance of management procedures which treat the entire South African sardine population as a single management unit until data collected during monitoring (e.g. survey estimates and age data) suggest that there are two stocks should be examined.

This has been done (e.g. FISHERIES/2013/OCT/SWG-PEL/31).

D.8 (M). Migration rates between the two putative stocks, and the life stages at which migration occurs, should be estimated. Otolith microchemistry is probably the most feasible way to obtain these estimates. [*How do we best determine relative plausibility for alternative sardine stock structure hypotheses?*]

Otolith microchemistry not yet pursued.

D.9 (M) Management procedures in which a greater proportion of the anchovy TAC is allocated for the first part of the season should be examined as this may provide a means to reduce undercatch of anchovy. The trade-off between anchovy and sardine catch should be quantified to evaluate the impact of trying to reduce this undercatch. [*How do we best account for implementation uncertainty in the OMP, particularly as regards likely undercatch of anchovy?*]

Some such computations have been done, but this matter awaits further consideration by the PWG.