INTERNATIONAL REVIEW PANEL REPORT FOR THE 2011 INTERNATIONAL FISHERIES STOCK ASSESSMENT WORKSHOP
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The Panel recognised the very high quality of the research presented at the 2011 International Fisheries Stock Assessment Review Workshop. This included research on hake, sardine, anchovy, horse mackerel and penguins. The work on (operational) management procedures (OMPs) continues to be world-leading, and modelling of the relationship between penguins and sardines is a world first. The Panel thanked the workshop participants for the hard work that went into preparing and presenting the workshop papers, and for the extra analyses undertaken during the workshop.

This report starts with observations from the Panel on some general issues and then focuses on the more detailed technical review and recommendations concerning each fishery. The Panel deliberations were guided by a set of key questions (see Appendix 1) and the text in square parentheses at the end of some of the recommendations pertains to these key questions. The Panel did not have the time to address all of the key questions. The recommendations are annotated by their priorities (H, M, L), while Panel observations and conclusions are indicated by asterisks (*). Appendix 2 contains a glossary of symbols and Appendices 3 and 4 contain some additional technical material.

General comments

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

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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.

A. Hake

A.1 Hake data

AA.1 (M). Further analyses of the survey catch-rate data should be conducted, with a view to estimating the impact of environmental (e.g. temperature) and other (e.g. time of day) factors. Revise the survey estimates of abundance if this is justified given the results of the analyses.

AA.2 (*). While changes in somatic growth rate over time are plausible, detection of these will require collection of additional age-length data.

AA.3 (H) In relation to the approach used to model the species split of the commercial catch for Namibia:

(a) the inferred catch by species and size in the commercial catch should be set to the survey catch by size multiplied by the commercial selectivity by size and divided by the survey selectivity by size,

(b) consider alternative models including that applied in South Africa, a GLMM with random effects for latitude x depth strata, and a GAM (or GAMM),

(c) avoid stochasticity in the assumed commercial and survey selectivity patterns or integrate out such stochasticity within the likelihood function, and
(d) investigate whether the estimation of time-trends in the species proportions is warranted. [*Suggestions for the approaches to be adopted for a joint assessment*]

AA.4 (H). Apply the approaches for splitting the historical catches developed for Namibia and South Africa to the data for each of Namibia and South Africa to evaluate the robustness of predictions to the method employed. Also, the methods could be evaluated using cross-validation, i.e., by fitting the models to a subset of the observed commercial sets and predicting the catch proportions for remaining observed commercial sets. [*Suggestions for the approaches to be adopted for a joint assessment*]

AA.5 (H). The use of predator-prey models requires data on diet composition (proportion of species / length eaten by predator length-class) and daily ration (by age and species). Sufficient diet composition data are available for the South African west coast to initiate modelling work, but further data collection (particularly off Namibia) is needed. The estimates of daily ration will impact model outcomes substantially, and efforts should be made to estimate daily ration for the two hake species directly, rather than relying only on results for similar species elsewhere.

AA.6 (M). Analyse existing observer length-frequency data to estimate plausible high-grade/ discard rates. As needed, improve the coverage of the observer program and the types of data collected by this program.

A.2 Stock structure

AB.1 (*). Genetic data have the potential to provide critical information on whether there are multiple stocks of each hake species and, if there are, how they mix in various areas. Existing data indicate that there are statistically significant differences in haplotype and allele frequencies among sampled regions for both *M. paradoxus* and *M. capensis*, which is indicative of there being multiple reproductively isolated units in the area sampled. The data, however, currently do not allow boundaries, overlaps or the relative proportions of these units in different regions to be inferred. Effective use of resources (financial and personnel) requires that:
(a) the objectives for any future genetics study should be clearly stated, and
(b) an appropriate sampling design selected.
The information provided to the Panel did not enable it to fully evaluate how each of these issues has been addressed, but it seems critical to follow these two steps formally to obtain maximum value from any genetics study. There would be value in attempting to sample where it may be possible to be sure that a 'pure' (i.e. non-mixed) stock is found (e.g. at the extremes of the distributions of each species, juveniles). [*Review of progress on genetic analyses and suggestions for future work*]

A.3 Models

AC.1 (H). In relation to the hake spatial model being developed, the work should start simple and increase in complexity as needed. This approach leads to the following recommendations:
(a) assume that there is one stock of each species across Namibia and South Africa,
(b) fit the model to catch-at-age and catch-at-length data rather than to catch-at-length and conditional age-at-length data,

(c) consider treating the annual fishing mortalities as parameters – this will facilitate eventual use of ADMB-RE to estimate process error variances,
(d) estimate the proportion of age-0 animals which recruit to each spatial cell,
(e) assume that *q* is the same for all depth zones for each species and survey,
(f) if the fits of the model suggest that carrying capacity has changed off Namibia, model this by multiplying the proportions recruiting to the Namibian cells at age-0 by an estimated constant which reflects the change in mean recruitment (effectively a decrease in age-0 survival) when the hypothesized change in carrying capacity occurred, and
(g) in order to reduce the number of movement parameters, form a group of biologists and modellers to (i) identify the combinations of areas by age-group between which it is implausible that animals move[5], and (ii) consider whether movement rates change smoothly (monotonically) with depth. Once the model has been fit, check that the proportions by age-group in each area are biologically realistic.

[*Suggestions for the approaches to de adopted for a joint assessment*]

AC.2 (H). In relation to the model which includes hake predation and cannibalism, the work should start simple and increase in complexity as needed. This approach leads to the following recommendations for initial work:
(a) model only hake predation off the South African west coast (extend to other species effecting appreciable predation mortality on hake and additional spatial strata only as needed),
(b) fit the model to catch-at-age, catch-at-length and diet data (see, for example, Kinzey and Punt, 2009), and
(c) ignore sex (because most data are not separated by sex).

Considering multiple feeding functional relationships is important, but the work to examine the implications of alternative relationships should wait until a model based on a simple (e.g. Holling Type II) feeding functional relationship is working. [*Suggestions for hake cannibalism and inter-species predation*]

AC.3 (M). The model on which the spatially-structured hake assessment is based should initially be developed as a standard errors-in-variable approach, i.e. treat deviations in recruitment and selectivity-at-age as estimable (fixed effects) parameters, a penalty related to variation in these deviations added to the objective function, and the variance of the deviations either pre-specified or estimated. Once the model is working, reformulate it so that parameters such as selectivity-at-age and the recruitment deviations are treated as random effects, and the associated process error variances estimated by maximizing the marginal likelihood over the process errors using, for example, ADMB-RE. Compare the results for the two implementations of the current assessments (standard errors-in-variables and full state-space) for the current formulation of the assessment as well as with an implementation based on the state-space stock assessment approach of MARAM IWS/DEC11/H/MODEL/P1. [*Suggestions for the approaches to de adopted for a joint assessment*]

B. Pelagic Fishery

B.1 Pelagic OMP

B.1.1 Review of updated assessments – sardine

[5] Considerable progress on this recommendation was made during the review.

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*]

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*]

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*]

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*]

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*]

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*]

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.

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*]

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.

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*]

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*]

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)*]

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.

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*]

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).

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*]

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.

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]*

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.

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).

B.2. Penguins (MARAM)

BE.1 (H). Consider additional robustness tests in which:

(a) there is immigration after 1999,
(b) the log-normal distribution for the variation about the penguin survival rate – sardine abundance relationship is replaced by an alternative (e.g. gamma),
(c) the relationships between sardine and anchovy abundance/density (temporal and spatially aspects) and population processes for penguins are based on alternatives selected by the penguin biologists (summarized in FISHERIES/2001/SWG-PEL/3).

[*Are further robustness tests required, including consideration of different hypotheses linking demographic parameters to food availability*]

BE.2 (H). Future projections showed a strong dependency on the value of $\tilde{\sigma}^2$, the parameter which determines variance of the random effects on natural mortaklity, *M*, decreasing for $\tilde{\sigma}$ =0.10 and increasing for $\tilde{\sigma}$ =0.05. This was attributed to the assumption of a lognormal distribution for the random effects on *M* resulting in lower average survival with increasing $\tilde{\sigma}$. Incorporate a log-normal bias-correction factor for *M* so that the expected value of *M* does not depend on the choice of $\tilde{\sigma}$ [6]. [*Is the estimation satisfactory, including the variability in the penguin survival rate-sardine biomass relationship?*]

[6] Initial implementation of this recommendation during the review indicated that it removed most of the dependency on $\tilde{\sigma}$.

BE.3 (H). Resolve the problem of systematic deviations in the residuals from the fits to the recaptures from marking in 1990 and 1992. First, check that the basic data are correct and investigate whether information exists about tagging success and other factors in those years. If this investigation does not highlight a problem, one technical solution which could be implemented within the model is to drop the data for these years and another solution is to estimate year-specific initial tag-loss / emigration rates. [*Is the estimation satisfactory, including the variability in the penguin survival rate-sardine biomass relationship?*]

BE.4 (H). Summarize the results of the projections of the penguin model in terms of (a) the probability of declining below current abundance, and (b) the difference in the change in penguin numbers with fishing to that without fishing, with particular focus on the next 5-10 years. [*What are appropriate performance statistics*]

BE.5 (H). Impose a uniform prior on $\tilde{\sigma}$, and alternatively an inverse gamma prior on $\tilde{\sigma}^2$. [*Is the estimation satisfactory, including the variability in the penguin survival rate-sardine biomass relationship?*]

BE.6 (H). Estimate a linear (constrained not to decrease) relationship between reproductive success and anchovy abundance rather than assuming there is no dependence of reproductive success on anchovy abundance, and hence develop a posterior distribution for this parameter based on MCMC sampling which could admit relatively low reproductive success at low anchovy biomasses. [*Is the estimation satisfactory, including the variability in the penguin survival rate-sardine biomass relationship?*]

BE.7 (H). The uncertainty in the biomass trajectories for sardine and anchovy should be accounted for when evaluating the relationships between penguin demographic parameters and sardine/anchovy abundances. This can be achieved by:

(a) selecting a small number (e.g. 10) of sardine and anchovy biomass trajectories from the posterior distributions estimated using the sardine and anchovy assessment models, and using these trajectories as input data to the penguin model, with application of the Markov Chain Monte Carlo (MCMC) algorithm conditioned on each of the trajectories,
(b) selecting a representative number of parameter vectors for the penguin model from each of the MCMC chains to construct the parameter vectors for the penguin model, and
(c) basing the inferences regarding the impact of alternative OMPs for anchovy and sardine on these parameter vectors.

[*Is the estimation satisfactory, including the variability in the penguin survival rate-sardine biomass relationship?*]

BE.8 (H). The credibility of the work will be considerably enhanced by further simulation testing which should:

(a) consider simulations in which there is an impact of sardine and anchovy on the dynamics of the penguin population via, for example, impacts on fledging success, participation in, and age-at-first breeding, juvenile survival and adult survival even if the current model suggests that there is no impact on some of these demographic parameters,
(b) allow for error when measuring the covariates related to sardine and anchovy abundance, and
(c) generate values for the random effects for survival and reproductive success.

BE.9 (H). As currently formulated, fledging success and juvenile survival are lumped in a single time-varying parameter. Develop a conceptual model of the penguin population and show how each parameter/process in the current model pertains to actual biological processes. Ideally, fledging success and juvenile survival should be modelled as separate processes, and the data on fledging success (initially as relative indices, but as absolute measures in sensitivity tests), on total nest counts, and on juvenile survival rates from tag-recapture data should be included in the likelihood function. [*Is the estimation satisfactory, including the variability in the penguin survival rate-sardine biomass relationship?*]

BE.10 (H). Standard diagnostics for MCMC analyses (e.g. Gelman-Rubin R, Geweke statistic, trace plots for multiple chains, etc.) should be provided for the final reference case model(s). MCMC diagnostics should be provided for parameters and derived variables. [*Is the estimation satisfactory, including the variability in the penguin survival rate-sardine biomass relationship?*]

BE.11 (H). The sensitivity of the model results to different assumptions regarding the age-at-first-breeding, including ogives relating the probability of first breeding with age, should be examined in tests of sensitivity. Such assumptions should, at least initially, assume time independence, given the technical complexities of incorporating such possible dependence. Although many of these sensitivities have already been evaluated (MARAM IWS/DEC11/P/PENG/P1), this should be repeated for the final version of the model. [*Is the estimation satisfactory, including the variability in the penguin survival rate-sardine biomass relationship?*]

BE.12 (M). Compute the historical time-trajectory of moult numbers had there been no harvests of anchovy or sardine.

BE.13 (L). Data on time-trends in age-at-first breeding should be collated and analysed for incorporation in the model. Care needs to be taken when analysing these data to account for the probability of missing the first time an animal breeds. [*Is the estimation satisfactory, including the variability in the penguin survival rate-sardine biomass relationship?*]

BE.14 (L). A model which includes multiple Western Cape colonies should be developed. [*Is the estimation satisfactory, including the variability in the penguin survival rate-sardine biomass relationship?*]

B.3 Penguins (Other)

BF.1 (*). The Panel noted that the Penguin Pressure Model (MARAM IWS/DEC11/P/PENG/P2) was a work in progress. The absence of a detailed technical specification precluded formal review, but the Panel acknowledged some innovative features of the approach. While the exploratory nature of the modelling approach currently precludes its use in providing direct management advice, it appears to be a useful tool for synthesis of current information and understanding, and should assist in identifying and prioritising further research. In relation to identifying and prioritizing future research, the Panel supported the inclusion of factors in the model even when data are not currently available to parameterize the relationship between the factors and penguin population dynamics, provided that account is taken of the uncertainty associated with any such relationships.

C. Horse mackerel

C.1 (H). The assessment is probably the best possible at present. However, the fits to some abundance indices are poor (no fits to the catch-at-length information were presented in the documents to the review meeting). There is a need to consider a broad range of sensitivity tests when evaluating any management procedures for setting the PUCL (Precautionary Upper Catch Limit) for the pelagic fisheries and the TAC for the target fishery (midwater trawl with allowance for demersal trawl bycatch). The major foci for sensitivity tests should be:

(a) the survey q (and consequently the absolute size of the stock),
(b) σ_R, the extent of variation in recruitment,
(c) h, the steepness of the stock-recruitment relationship,
(d) M and its possible variation with age, and
(e) the extent to which the pelagic recruitment index reflects actual variation in recruitment or in availability.

[*Review of the horse mackerel assessment*]

C.2 (H). Data should be analysed to refine the (otherwise likely extremely broad) range of sensitivity tests. For example, data from the RAM II database could be used to inform steepness, results from assessments of other stocks could be used to inform σ_R, and analyses of concurrent trawl and acoustic surveys could be used to estimate the proportion of the stock not available to the demersal trawls (and hence q). [*Review of the horse mackerel assessment*]

C.3 (M). The indices from the November pelagic survey should be included in the likelihood function for the assessment if these data are to be used to provide an index of age-0 animals. This will lead to a reduced variance of the observation error (estimated from residuals) used to simulate future data. By altering the weight given to these data in the estimation one can develop scenarios that vary in the information content of this index (the least information corresponds to the scenarios presented at the meeting in which the pelagic survey index had been omitted when fitting). [*Review of the horse mackerel assessment*]

C.4 (H). Consider management procedures which specify a catch limit in terms of the average removal over several years rather than annual catch limits. [*Review of the suggestions for adaptive management procedure options and the testing thereof*]

C.5 (H). Examine whether catches in the pelagic fishery are related to the index of age-0 animals in the November survey. Use any relationship between these quantities to develop a model of the expected catch given the amount of recruitment, availability and the PUCL. [*Review of the suggestions for adaptive management procedure options and the testing thereof*]

C.6 (M). Consider including indices of recruitment from the May acoustic surveys in the assessment. [*Review of the horse mackerel assessment*]

Reference

Kinzey, D. and A.E. Punt. 2009. Multispecies and single-species age-structured models of fish population dynamics: Comparing parameter estimates. *Nat. Res. Mod.* 22: 67-204.

Documents considered during the Workshop can be found on the website
http://www.mth.uct.ac.za/maram/workshops.php .

Appendix 1

Key Issues to be discussed at International Fisheries Stock Assessment Review Workshop, 28 Nov – 2 Dec, 2011

Hake

Note that a broad underlying objective is the development of a joint Namibian-South African hake assessment through Work Package 1 of the ECOFISH programme (a joint Benguela Current Commission – European Union initiative).

Note that the issue of the data to be used for the assessments will be discussed during (and in parallel with) the workshop, but Panel input on technical issues associated with the data is unlikely to be sought.

Species split

- Review of the approaches currently employed in Namibia and SA
- Suggestions for the approach(es?) to be adopted for a joint assessment

Stock structure

- Review of the progress on genetic analyses and suggestions for future work
- Review of the results from the Nansen trans-boundary surveys and suggestions for future work
- Initial suggestions for alternative stock structure hypotheses to be considered

Models

- Review of the stock assessment approaches currently employed in Namibia and SA, as well as the Danish SAM
- Suggestions for the approach(es?) to be adopted for a joint assessment, to cover:
    - i) Spatial and temporal stratification
    - ii) Explicit modelling of movement
    - iii) Disaggregation by species and (?) by sex
    - iv) Selectivity modelling including length *vs* age basis
    - v) Fitting criteria

- Suggestions for hake cannibalism and inter-species predation
    - i) Spatial and temporal stratification
    - ii) Inclusion of additional species?
    - iii) Feeding functional relationships
    - iv) Daily ration estimation
    - v) Data and fitting

Pelagic Fishery

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)?

Penguins

- Review of updated penguin model
    i) Is the estimation satisfactory, including of the variability in the penguin survival rate-sardine biomass relationship?
    ii) Are further robustness tests required, including consideration of different hypotheses linking demographic parameters to food availability?

- Review of Penguin Pressure model
    i) What further work would be needed to make this model operational?

- Linking the penguin model to the pelagic OMP
    i) What are appropriate performance statistics?
    ii) How best to balance “future benefit to penguins” vs “future decreased catches”?

Horse mackerel

- Review of the horse mackerel assessment
- Review of the suggestions for adaptive management procedure options and the testing thereof

MSC LTLF[7]

- Summary presentations of Smith *et al*. paper and MSC requirements arising therefrom
- Summary outline of ecosystem model approaches (EwE, OSMOSE, Atlantis)

- Scientific issues raised by PSWG
    i) Norms for acceptability of models for management purposes- single species *vs* ecosystem
    ii) Modelling recruitment fluctuations of forage fish in ecosystem models
    iii) Criteria for acceptable levels of impact on predator populations
    iv) Operational considerations related to estimation and comparability

- Process issues raised by PSWG
- Suggestions for key focus areas for future research and evaluation

[7] Though discussions on these topics did take place, they were external to those on which the Panel was asked to report.

Appendix 2
Glossary of Symbols and Abbreviations

Symbols

q	the catchability coefficient
h	the steepness of the stock-recruitment relationship
M	the instantaneous rate of natural mortality
σ_{ad}	the standard deviation of the fluctuations in natural mortality for anchovy and sardine
σ_R	the standard deviation of the fluctuations about the stock-recruitment relationship
$\tilde{\sigma}$	a parameter which determines the variability in the relationship between natural mortality for penguins and prey abundance (also, a prominent element of Appendix 5).

Abbreviations

ADMB-RE	Ad Model Builder with random effects
GAM	Generalized Additive Model
GAMM	Generalized Additive Mixed Model
GLMM	Generalized Linear Mixed Model
OMP	Operational management procedure
PUCL	Precautionary Upper Catch Limit
TAB	Total Allowable Bycatch
TAC	Total Allowable Catch

Appendix 3

As document MARAM IWS/DEC11/P/HM/P1 [equations (A.17) and (A.19)] correctly points out, if a random variable exp(ε) follows a log-normal distribution with coefficient of variation CV, then ε has a Normal distribution with variance $\sigma^2 = \ln(1+ CV^2)$. This follows because if ε has a Normal distribution with mean=μ and variance=σ^2, then exp(ε) has a Log-Normal distribution with mean=$\exp(\mu+\sigma^2/2)$ and coefficient of variation CV=$\{\exp(\sigma^2)-1\}^{1/2}$. Therefore, the standard deviation of the Log-Normal distribution is StDev=mean*CV= $\exp(\mu+\sigma^2/2)\ \{\exp(\sigma^2)-1\}^{1/2}$.

Equations (7) and (8) of MARAM IWS/DEC11/P/PENG/P1 aim that the standard deviation of M_y would be constant. However:

$$\mathrm{StDev}[M_y] = f_S(B_{S,y})\ \mathrm{StDev}[\exp(X_y)] = f_S(B_{S,y})\ \exp(\sigma_y^2/2)\ \{\exp(\sigma_y^2)-1\}^{1/2},$$

which is not the same for all M_y given the definition of σ_y in equation (8). The same value of StDev[M_y] for all M_y would be achieved by solving the equation:

$$\mathrm{StDev}[M_y] = f_S(B_{S,y})\ \exp(\sigma_y^2/2)\ \{\exp(\sigma_y^2)-1\}^{1/2} = c,$$

for σ_y. The solution is:

$$\sigma_y = [\ \ln(1 + \{1+4\ [c/f_S(B_{S,y})]^2\}^{1/2}) - \ln(2)\ ]^{1/2}.$$

The same issue arises for Equation (App.II.10) of MARAM IWS/DEC11/H/MODEL/BG1; from equation (App.II.10), the standard deviation of length-at-age a is:

$$\mathrm{StDev}[l_a]= l_\infty\ [1-\exp\{-\kappa(a-t_0)\}]\ \exp(\sigma_a^2/2)\ \{\exp(\sigma_a^2)-1\}^{1/2},$$

where

$$\sigma_a = \theta_a\ /\ (\ l_\infty\ [1-\exp\{-\kappa(a-t_0)\}]\ ).$$

Hence, StDev[l_a] is not equal to θ_a. In order to obtain StDev[l_a]= θ_a, the standard deviation currently used in equation (App.II.10) should be replaced by the value of σ_a that fulfils:

$$\mathrm{StDev}[l_a]= l_\infty\ [1-\exp\{-\kappa(a-t_0)\}]\ \exp(\sigma_a^2/2)\ \{\exp(\sigma_a^2)-1\}^{1/2}= \theta_a.$$

The solution is:

$$\sigma_a = [\ \ln(1 + \{1+4\ [\theta_a\ /(\ l_\infty\ [1-\exp\{-\kappa(a-t_0)\}]\ )]^2\}^{1/2}) - \ln(2)\ ]^{1/2}.$$

Another technical comment in relation to document MARAM IWS/DEC11/H/MODEL/BG1 is the definition of the probability that a fish in length class l is read as having age a (for fitting of age-length keys). This probability is the second factor on the right-hand side of Equation (App.II.42). In principle, the probability that a fish in length class l has age a' should simply be:

$$N_{ya'}\ P_{a',l}\ /\ (\textstyle\sum_a N_{ya}\ P_{a,l}),$$

where N_{ya} is the number of fish of age a and $P_{a,l}$ is the probability that a fish of age a is in length class l. Age reading errors can be incorporated through a matrix $P(a',a)$, which denotes the probability that a fish whose true age is a' is classified as having age a. In this case, the probability that a fish in length class l is read as having age a is equal to:

$$(\textstyle\sum_{a'} P(a',a)\ N_{ya'}\ P_{a',l})/\ (\sum_{a'} N_{ya'}\ P_{a',l}).$$

It is unclear how this expression relates to the second factor in equation (App.II.42), so the latter equation should be checked or clarified.

Appendix 4

Some inconsistencies were encountered in the equations used to predict catch at age when selectivity is a function of length in MARAM IWS/DEC11/H/Model/BG1 and MARAM IWS/DEC11/H/Model/P3.

Let:

S_l : Selectivity at length

S_a : Selectivity at age

$P_{l|a}$: Distribution of length at age

w_l : Weight of fish of length *l*

W_a^c : Average weight of fish of age *a* in the catch

W_a : Average weight of fish of age *a* in the population

N_a : Abundance at age at the time fishing pulse occurs

F : Fishing mortality multiplier

C_a : Catch at age in numbers

C_a^w : Catch at age in mass

Selectivity at age is given by:

$$S_a = \sum_l S_l \, P_{l|a}$$

Catch at age in numbers is:

$$C_a = S_a \, F \, N_a \tag{1}$$

Catch at age by mass is:

$$C_a^w = F \, N_a \sum_l w_l \, S_l \, P_{l|a} \quad = \quad C_a \, W_a^c \qquad \text{where} \quad W_a^c = \frac{\sum_l w_l \, S_l \, P_{l|a}}{\sum_l S_l \, P_{l|a}} \tag{2}$$

In paper H/MODEL/P3 catch at age by mass is equivalently expressed as:

$$C_a^w = W_a \, F \, N_a \, \tilde{S}_a \qquad \text{where} \qquad \tilde{S}_a = \frac{\sum_l w_l \, S_l \, P_{l|a}}{\sum_l w_l \, P_{l|a}} = \frac{\sum_l w_l \, S_l \, P_{l|a}}{W_a}$$

This expression is equal to (2). The inconsistency is in the equation for catch in numbers, which is calculated as a function of $\tilde{S}_a$ instead of S_a as in (1).

The error introduced in the calculation of catch in numbers is equal to W_a^c / W_a so the catch of younger partially selected age classes will be overestimated as $W_a^c > W_a$, and the opposite is true for older ages in the case of dome-shaped selectivity. The overall effect is likely small, but should be evaluated.

Appendix 5

Sigma Tilde
By The Panelbeaten

(Sung to the tune of the Australian national anthem - 'Waltzing Matilda')

Once a shoal of stock assessors
Gathered for a workshop
Under the shade
Of Table Mountain,
And they smiled as they thunk
And started mathematicing
Who'll integrate $\tilde{\sigma}$ with me?
$\rho\,\tilde{\sigma}$, $\rho\,\tilde{\sigma}$
Who'll integrate $\tilde{\sigma}$ with me?
And they smiled as they thunk
And started mathematicing
Who'll integrate $\tilde{\sigma}$ with me?

They modelled the pelagic fish
And looked at all the likelihoods
Under exceptional
Circumstances,
And they looked for the bias
In all of the analyses,
Who'll integrate $\tilde{\sigma}$ with me?
$\rho\,\tilde{\sigma}$, $\rho\,\tilde{\sigma}$
Who'll integrate $\tilde{\sigma}$ with me?
And they looked for the bias
In all of the analyses,
Who'll integrate $\tilde{\sigma}$ with me?

They thought of the risks
Under constant F and variable M
And how these affect
The residuals,
And they wrote their report
Long before the week began,
Who'll integrate $\tilde{\sigma}$ with me?
$\rho\,\tilde{\sigma}$, $\rho\,\tilde{\sigma}$
Who'll integrate $\tilde{\sigma}$ with me?
And they wrote their report
Long before the week began,
Who'll integrate $\tilde{\sigma}$ with me?