Proposals for Issues to be Addressed in the Revision of the Pelagic OMP

C.L. Cunningham and D.S. Butterworth

Underlying (i.e. Operating) Models for Sardine and Anchovy

Broad Conceptual Issues:

- The present models all assume a single southern Benguela sardine stock. Is there sufficient evidence to consider as plausible an alternative that there could be two stocks, with one distributed more towards the east and of a size that is not trivially small compared to the "conventional" stock fished off the west coast? For a two-stock scenario, would the May recruit survey be regarded as indexing recruitment for the "west" stock only; further, need the model attempt to incorporate spatial distribution shifts over time for the two stocks (see Figure 1)?

Proposal: When two stocks are discussed, they will for the purposes of this document, be referred to as "west" and "east" stocks. A model including two sardine stocks will be developed. The "east" stock will not contribute to either recruits or older fish found on the west coast. The distributions of the two stocks will be without trend over time, so that the current apparent "eastward shift" of sardine will be taken to be the consequence of a recent increase in the "east" stock (unless the survey data prove to be inconsistent with such an assumption). For subsequent linkage to models for groups of penguin colonies, three areas along the coast need to be identified, with the model to output time series of abundances for both stocks in each of these areas. We suggest that this spatial disaggregation should be of the form of "western", "southern" and "eastern" areas, with the boundary between the "western" and "southern" areas at Cape Point, and that between the "southern" and "eastern" areas to be discussed (see Figure 2). For this two stock hypothesis, past catches will need to be split between the two stocks and this will require information on past catches disaggregated by the three areas; furthermore, assumptions about the future distributional pattern of fishing will need to be developed.

- The present models also assume only one anchovy stock. Need alternatives also be considered, as perhaps for sardine?

Proposal: Only one anchovy stock will be considered as in the past, with a distribution without trend over time. The model will output time series of abundances for the stock in each of the three areas identified in the response to the previous bullet point. The proportional distributional of anchovy by area will be taken to be time independent **unless the survey data prove to be inconsistent with such an assumption.**

- The present models assume that the proportions of the sardine and anchovy spawning stocks to the west of Port Alfred, as surveyed in the November cruises, have remained unchanged over time. Is distributional evidence from more recent surveys sufficient to suggest a systematic trend

that invalidates this assumption? If so, what alternative "standardisation" boundary should be considered; and how are estimates from some earlier surveys, which may not have been extended to such a limit, to be extrapolated?

Proposal: The biomass west of Port Alfred will be used, retaining the assumption that the proportion of sardine and anchovy west of Port Alfred has been unchanged over time. Only once in the past three years when the November cruises have extended east of Port Alfred was a substantial sardine biomass found east of Port Alfred (26% of total observed biomass in 2003, compared to <3% in 2004 and 2005). A model of a single sardine stock whose distribution changes over time will be considered. The model will output time series of abundances for the stock in each of the three areas identified in response to the first bullet point. The distributional shifts with time will be determined by fitting to available survey data disaggregated for these three areas. Hypotheses for alternative possible future distributional shifts will need to be developed by the PWG. For this single stock hypothesis, no information on the past or future distribution of the catch by area is required, as catches wherever taken have the same impact on the stock.

- The current models do not account for slippage. Should this be incorporated? (If so, in due course, alternative plausible levels and their trends over time will need to be specified.)

Proposal: Slippage will be accounted for in a sensitivity test to the chosen base case hypothesis (or, if necessary, some alternative hypotheses as well). An estimated fixed percentage of the anchovy and sardine slipped annually will be required in due course, or alternatively a fixed (or varying) annual tonnage slipped is required. The PWG will in due course be required to provide input into the proposed scenarios for possible slippage in the future.

- Explicit inclusion of predator-interaction effects in the models in an EAF context:

- Impacts of changes in the abundance of pelagics (total biomass or individual species?) on predators, such as penguins and gannets (and any others? – seals?). Which specific colonies are going to be considered, and what associated data are available, and will be collected in future?

Proposal: A dynamic model of the SA penguin populations (with colonies divided into three areas) is to be developed. Possible functional relationships between the model predicted estimates of sardine and anchovy abundance and the penguin demographic parameters (fledging rates, survival rates, etc.) will be explored. The penguin models will be incorporated into the testing of the OMP so that the risk of depletion of these penguin populations to undesirably low levels can be examined.

- There are currently no major areas modelled as closed to the pelagic fishery for predator conservation purposes. Should such possibilities be considered? Note that this would require spatial disaggregation of the model at a much finer scale.

Proposal: Areas that some have proposed to be closed to the fishery include parts of Algoa Bay around St. Croix island (for the entire year) and the Cape Point to Cape Columbine region (during summer only).

These proposed areas are at a much finer scale than that to be considered in the assessment models. We propose that any analyses to evaluate the effectiveness of proposed closed areas of this nature be carried out on a separate basis to this OMP testing exercise, and include experimental design considerations.

- Need consideration be given to possible appreciable changes in the extent of fishing on red-eye in the near future, and consequently on the associated bycatch of adult sardine?

Proposal: The typical proportion of sardine bycatch with red-eye needs to be re-visited, given updated data. The proposed OMP will be tested under alternative scenarios of the amount of bycatch assumed caught with red-eye during the projection period. Note that the red-eye population will NOT for this OMP be included in the operating models in the same way as the sardine and anchovy populations (and the penguin populations are proposed to be). Two options will be pursued: i) red-eye catch remains at its recent average over the projection period and ii) the average red-eye catch doubles over the next 5 years and then remains at that level for the remainder of the projection period.

- Future recruitments are at present assumed to follow a hockey stick relationship for the base case model, with levels of variability as estimated from past data. Does a wider range of plausible scenarios need to be considered in an expanded set of base case models, e.g. a Beverton-Holt or Ricker model (given recent low recruitments at large spawning biomass); also perhaps regime shifts at decadal+ time scales (but on what basis are these to be specified?).

Proposal: Three hypotheses will be considered for the anchovy assessment (single stock) and each (single and two-stock) of the sardine assessments: the Hockey-stick, Beverton-Holt and Ricker stock recruitment models.

- The present models take no account of data from the pre-recruit survey or the SARP monitoring line? Should this be attempted (and such data perhaps also be used as input to the OMP formulae)?

Proposal: No, not as yet.

- The present models assume no within-year variation in the pattern of recruitment for either species (the 1 Nov birthday assumption). Thus no allowance is made for early or late recruitment (either in the model or the OMP). Does this variation need to be incorporated (for the first year of life only, in the interests of simplicity), and how best is such an effect to be matched to available data (e.g. perhaps a normal distribution for spawning each year, with random inter-annual peak shifts which themselves are drawn from another normal distribution?)

Proposal: We propose that the average birthday for recruits each year changes from being fixed at 1 Nov to being drawn from a distribution centred on 1 Nov. Mean weight of recruits at the time of the recruit survey will be required to fit the associated distribution parameter in the model.

Detailed Issues:

- The models currently assume equal selectivity over all ages in the survey for both sardine and anchovy. Recent selectivity of sardine in the commercial catch is assumed to remain unchanged when projecting into the future in testing candidate management procedures. This selectivity has in the past been estimated for each age from the ratio of the average fishing mortality over the most recent 5 years for that age to the maximum of the average fishing mortalities for each age over all the ages over the same period. But over recent years for sardine, selectivity has increased for 1-2 year olds compared to older fish. Is this pattern expected to continue into the future? What are the plausible alternative scenarios?

Proposal: The updated models will fit to catch-at-age data. Two commercial selectivity curves will be estimated i) for all years prior to November 2001 and ii) for all years from, and including, November 2001. The OMP will need to be tested under the assumption that future selectivity remains at ii), returns to i), or is governed by some relationship to sardine abundance.

- The models currently assume sardine mature at age 1. Should alternative hypotheses (maturity ogive, density dependence, changes over time), and/or an alternative base case be used for testing the next OMP?

Proposal: An annual maturity ogive derived along the lines of that in Cunningham and Butterworth (2005), using for example, annual length at maturity from Fairweather *et al*. (in press) and van der Lingen (in press) will be assumed. Past density-dependence will be incorporated explicitly (through the external specification of these maturity ogives for each year) or implicitly within the model; for the future the implied relationships of the ogive parameters to abundance will be assumed to continue. A sensitivity test to the selected base case hypothesis will assume all sardine mature at age 1 (to maintain a comparison with past work).

- The productivity-related factors are currently assumed not to change over time. Should changes in, e.g. growth and condition factor be taken into consideration (are adequate data available for this)?

Proposal: As the sardine assessment is an age-structured model, the direct use of, for example, condition factor or standardized gonad mass is not straightforward. However, if density-dependent growth has occurred, this should reflect in the age-length-keys used in the updated assessment. In the two-stock hypotheses, the same ALKs will be used for both stocks and thus both stocks will be assumed to be affected by density-dependence in a similar manner.

- It is assumed at present that adult sardine natural mortality is constant over time at $M = 0.4$ year^{-1} and juvenile $M = 1$ year^{-1} (estimates based weakly on maximum likelihood considerations for past assessments, and also on plausible proportions of recruits available to the May survey . Is there reason to suspect temporal changes, and if so how are alternative possibilities to be plausibly

quantified? Do 1 and/or 2 year olds have a natural mortality closer to that of juveniles than adults?

Proposal: Alternative combinations of adult and juvenile natural mortality, constant over time, will be tested. Bayesian posterior mode and plausible proportions of recruits available to the May survey will be taken into consideration in determining a suitable choice of *M*. Juvenile natural mortality will apply to the recruits only.

- It is assumed at present that adult and juvenile anchovy natural mortality is constant over time at $M = 0.9$ year^{-1} (estimates again based weakly on past maximum likelihood considerations, 'biologically probable' cases of juvenile M being greater than or equal to adult M, and also on plausible proportions of recruits available to the May survey). Is there reason to suspect temporal changes, and if so how are alternative possibilities to be plausibly quantified?

Proposal: Alternative combinations of adult and juvenile natural mortality, constant over time, will be tested. Bayesian posterior mode and plausible proportions of recruits available to the May survey will be taken into consideration in determining a suitable choice of *M*. Juvenile natural mortality will apply to the recruits only.

- Somatic growth rate is assumed constant over time at present. What are plausible scenarios for recent changes over time, and how might these continue into the future?

Proposal: As mentioned above, if density-dependent growth has occurred, this should reflect in the age-length-keys used in the updated age-structured assessment models. In the two-stock hypotheses, the same ALKs will be used for both stocks and thus both stocks will be assumed to be affected by density-dependent growth in a similar manner.

- The only age data used in the anchovy assessment model are age length keys (ALKs) derived by Prosch (unpublished data, MCM) for the 1992-1995 November surveys. A combined 1992-1995 Prosch key was applied to raised length frequencies from the November surveys for all other years to obtain mean masses. The proportions of 1-year-olds in the November survey were obtained using this Prosch key. The alternative is to use a cut-off length (10cm, 10.5cm, or 11cm) for the raised length frequencies from the surveys. Are there any new data available to improve on the current assumption?

Proposal: No new data are available. Sensitivity tests to the selected base case anchovy assessment will consider these alternative cut-off lengths for the raised length frequencies.

Very detailed issues

- The model currently assumes sardine live to age 5 and then die. Should a plus group be modelled? (Note, inclusion of plus group will probably require retesting of assumed fixed *M*.)

Proposal: Yes.

- The model currently assumes anchovy live to age 4 and then die. Should a plus group be modelled? (Note, inclusion of plus group will probably require retesting of assumed fixed *M*.)

Proposal: Yes.

- Sardine catch is approximated as taken 6 months after birthdate = 1 May. Should catch rather be modelled to be taken on a quarterly basis?

Proposal: No. Catch will continue to be modelled on an annual basis, as it seems likely that the further complexity that this would introduce would be analytically burdensome without providing commensurate improvement to the model's predictive capabilities.

- Juvenile sardine catch taken prior to the survey is currently assumed to be taken halfway from 1 Jan to the start of survey. Should this rather be halfway from 1 Nov to the start of the survey?

Proposal: Sardine recruit catch in November and December is generally low in comparison to that from January to May, though recent years (2001-2004) have seen high recruit landings during November and December. We propose that no change be made to this assumption, given that the highest sardine recruit landings generally occur in April and May.

- It is currently assumed that adult anchovy (1 year olds only) caught from 1 Nov – 31 March are approximated as taken on 1 Feb. Is this approximation adequate?

Proposal: Probably yes, but the catch data will be examined to reconfirm this.

- In OMP testing, 30% of normal season anchovy catch is assumed to be taken between Jan and March, and to comprise. 1 year olds. Is this an adequate approximation?

Proposal: Probably yes, but the catch data will be examined to reconfirm this

- It is currently assumed that juvenile anchovy caught from 1 April – 31 Oct can be approximated as taken on 1 June (7 months after birthdate). Should this rather be split between halfway through the normal season and halfway through the additional season, or should another date, e.g. 1 May, be used?

Proposal: Past data will be examined to check this.

Important Changes in Data available to Condition new Operating Models:

- New series of acoustic survey estimates (and associated variances-covariances) of spawner biomass in November and recruitment in May following capping calibration analyses.
- The May recruit numbers will be updated from previous assessments to allow for annual revision of the cut-off length for recruits.

- The CVs for the recruit estimates will be updated from previous assessments to reflect the CV of recruits only, rather than that of adults and recruits.
- ALKs for sardine from November surveys for 2000 onwards.
- ALKs for sardine commercial catches for selected months from 2000 onwards.

Management Procedure

Broad Conceptual Issues:

- Thresholds for invoking Exceptional Circumstances currently depend on the individual biomass of sardine and anchovy. Should a combined threshold biomass (sardine + anchovy + redeye) also be considered (e.g. w.r.t. EAF / predator risk)?

Proposal: Separate thresholds will remain for sardine and anchovy. If possible, the question of providing an Exceptional Circumstance threshold based on penguin numbers will be examined.

- Does the current OMP protect sardine too much at the expense of anchovy catches? Is the current sardine-anchovy trade-off to be re-considered (but what are the implications for current rights allocations)?

Proposal: As a default the current directed sardine-anchovy trade-off will be used.

- The current risk definitions are:

  $risk_S$ - the probability that adult sardine biomass falls below the average adult sardine biomass over November 1991 and November 1994 at least once during the projection period of 20 years.

  $risk_A$ - the probability that adult anchovy biomass falls below 10% of the average adult anchovy biomass between November 1984 and November 1999 at least once during the projection period of 20 years.

  Need these be redefined?

Proposal: These should be re-checked for appropriateness.

- The present OMP uses essentially only abundance estimates from the May and November surveys. Should further input data also be considered, e.g. age or length information, measures of early/late recruitment, pre-recruit surveys, etc.

Proposal: The calculation of the TACs in the absence of exceptional circumstances will remain dependent on these survey observations. If Exceptional Circumstance thresholds are developed based on penguin numbers, these thresholds and the rules to be followed in the event that Exceptional Circumstances are invoked will incorporate data relating to the penguin population abundance.

- Provision needs to be made for deviation from the OMP when the conditions encountered fall outside that used in the initial design of the OMP.

Proposal: Follow the metarule process as outlined in Butterworth (2006).

Detailed Issues:

- Should the constraints on inter-annual change in the TACs be readdressed? (Industry to comment.)

Proposal: Not at this stage, although input from the industry will be required in due course.

- Should the thresholds and rules for Exceptional Circumstances be reconsidered?

Proposal: Threshold levels and rules for sardine and anchovy will remain unchanged unless evaluations based upon the updated operating models indicate a need for substantial revision. A threshold level for penguin abundance may be proposed and accompanying exceptional circumstance rules developed.

Acknowledgements

Our thanks go, in particular, to Awie Badenhorst, Janet Coetzee, Rob Crawford and Carl van der Lingen for their comments and suggestions following the circulation of an initial list of considerations.

References

Butterworth, D.S. 2006. Proposed Procedures for Deviating from the Hake OMP Output for the Recommendation for a TAC, and for Initiating an OMP Review. MCM Document WG/07/06/D:H:22.

Cunningham, C.L. and Butterworth, D.S. 2005. Further Robustness Tests for the South African Anchovy and Sardine Resources, Including Maturity-at-Age. MCM Document WG/MAY2005/PEL/07.

Fairweather et al. In press.

van der Lingen, C. In press.

Table 1. Proposed Hypotheses and Robustness Tests for the Update to the Sardine Assessment. (Blank cells refer to no change from the above cell). In addition, two options for each hypothesis will be used when testing the OMP; one assuming the red-eye catch, and consequently the sardine bycatch associated with red-eye, remains at its recent average level over the projection period and one assuming the average red-eye catch will double over the next 5 years.

Hypotheses / Robustness Test	Number of Stocks	Stock-Recruitment Model	Distributional Shift Over Time	Maturity Assumptions	Future Selectivity Assumptions
H1a	One	Hockey Stick	Option 1	Annual Maturity Ogives	Same as that prior to 2001
H1b			Eg. Option 2		
H1c			E.g. Option 3		
H2a-c		Beverton Holt	Options 1-3		
H3a-c		Ricker	Options 1-3		
H4	Two	Hockey Stick	N/A		
H5		Beverton Holt	N/A		
H6		Ricker	N/A		
H7a-c	One	Hockey Stick	Options 1-3		Same as that after 2001
H8a-c		Beverton Holt	Options 1-3		
H9a-c		Ricker	Options 1-3		
H10	Two	Hockey Stick	N/A		
H11		Beverton Holt	N/A		
H12		Ricker	N/A		
R1	Applied to selected one or two of above hypotheses			Maturity at Age 1	Depending on above hypotheses chosen

Table 2. Proposed Hypotheses and Robustness Tests for the Update to the Anchovy Assessment. (Blank cells indicate no change from the above cell.)

Hypotheses / Robustness Test	Number of Stocks	Stock-Recruitment Model	Ageing Assumptions
H1	One	Hockey Stick	Prosch ALK
H2	One	Beverton Holt	Prosch ALK
H3	One	Ricker	Prosch ALK
R1	One	Applied to one of the above hypotheses	10cm cut-off in RLFs
R2	One	Applied to one of the above hypotheses	10.5cm cut-off in RLFs
R3	One	Applied to one of the above hypotheses	11cm cut-off in RLFs

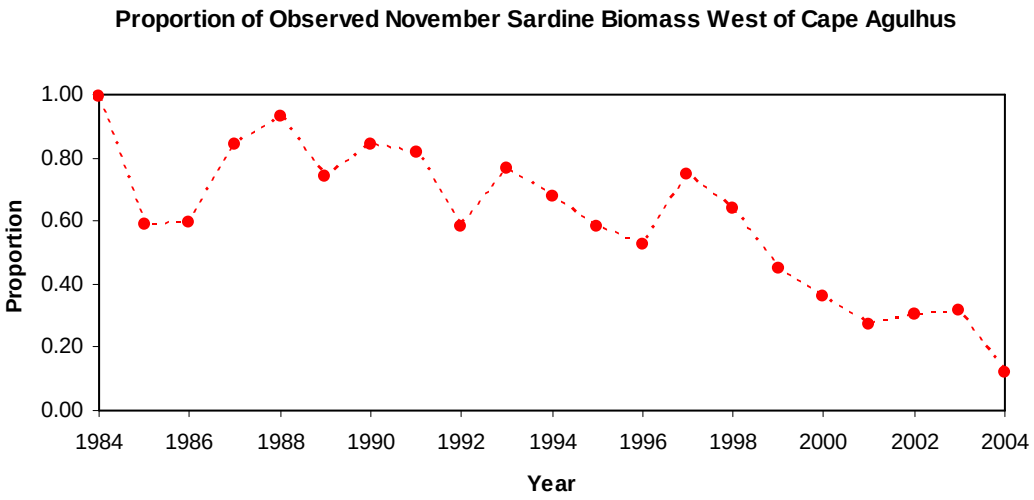

Figure 1. Proportion of observed uncapped (new target strength) November sardine biomass west of Cape Agulhas over time.

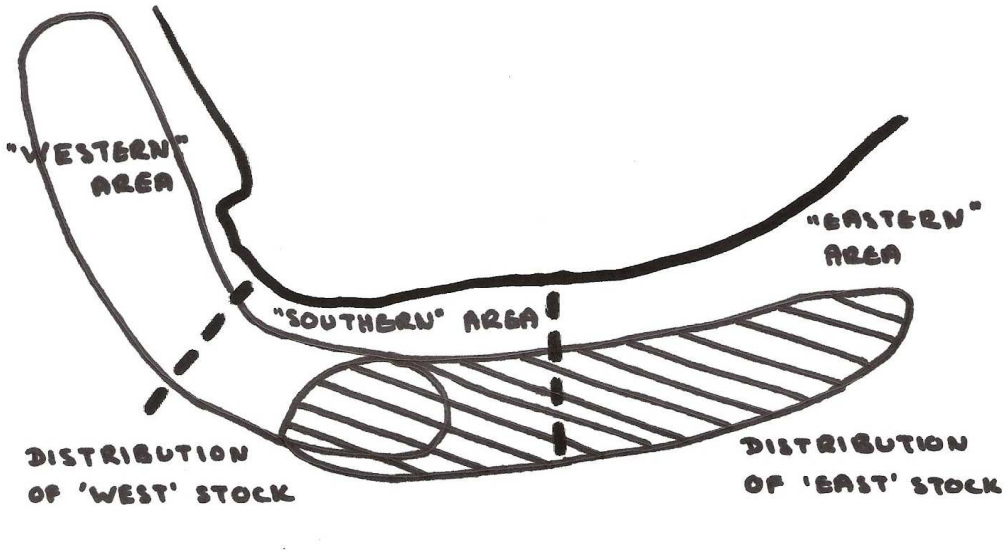

Figure 2. Schematic diagram indicating the single and two-stock sardine hypotheses, with the proposed "western", "southern" and "eastern" areas for spatial disaggregation. Boundaries between these areas need to be discussed. Given that the areas will be chosen in relation to penguin distribution, the "west" stock might also overlap into the "eastern" area.