List of the key focus questions for the panel regarding sardine (and anchovy), together with brief summaries of the documents provided

These questions focus on work which has been undertaken to feed into a new Management Strategy Evaluation (MSE) to develop a joint sardine-anchovy Management Procedure. As part of this work, a sardine-only 'scoping' MSE was developed and is used for some of the projections reported for this workshop.

Key questions relating to sardine (and anchovy) are:
1) How should future stock-specific recruitment be generated for sardine for the upcoming MSE?
2) Should the future recruitments generated from a parametric stock recruitment relationship include a bias correction?
   - Butterworth comments (does the panel concur?): When recruitment deviations about a stock recruitment curve are modelled in the assessment process as log-normally distributed, standard local practice has been not to correct the resultant estimates of that curve for bias (related to the mean – median difference). The reason is that it is the effect of catches on the **average** future biomass (reflecting the combination of a number of year-classes) that determines their sustainability. In future projections, that is what is reflected by generating future recruitments from log-normal distributions about the estimated stock-recruitment relationship **without** any bias correction.
3) Is there likely to be bias in estimates of recruitment process error variance for sardine? If so, is it necessary to correct for this for MSE purposes?
4) Should the upcoming MSE assume a time-invariant stock-recruitment relationship or should a relationship corresponding to more recent years (for which productivity was lower) be used?
   - A time-invariant stock-recruitment relationship, fitting to all years in the time series, has historically been used for South African anchovy, including in MSEs. Robustness tests have historically investigated the idea of a less productive 'regime' prior to ~2000 and a more productive 'regime' post ~2000, and possibly a 'middle regime' after ~2010. However, three consecutive years of poor recruitment, two of which are at the end of the most recent time series of data, have prompted local scientists to reconsider if a time-invariant stock-recruitment relationship remains the best choice for the upcoming MSE.
5) What is the best approach to follow when there is an indication of more than one local minimum?
6) What is the best approach to follow when the inverse of the Hessian shows some parameters are highly correlated?
7) Is there a problem if the deterministic joint posterior mode of the mean of recruitment estimates falls outside the range of values from a sample of the posterior distribution, and if so how should this be addressed.

The documents provided are listed below. *A brief description of each document is provided in red italics.*

<u>Primary papers</u>

IWS/2025/Sardine/P1: List of key focus questions for the panel regarding sardine, together with brief summaries of the documents provided.

IWS/2025/Sardine/P2: de Moor CL. 2025. Stock recruitment relationships for South African anchovy

A range of alternative stock-recruitment relationships are considered in the assessment of South African anchovy. This document relates to Q4 above.

IWS/2025/Sardine/P3: de Moor CL. 2025. Projections of the sardine population using an operating model which does not estimate stock-recruitment relationships during conditioning.

The operating model for the projections (IWS/2025/Sardine/BG5) is based on an assessment which estimated historical recruitment independent of any stock-recruitment relationship (IWS/2025/Sardine/BG3, IWS/2025/Sardine/BG4). This document relates to Q1 above, showing an assumption of future recruitment being

set at the historical median (for comparative/understanding purposes only) and Hockey-Stick 'like' relationships with fixed hinge points. Results for the later are shown with and without a bias correction to inform Q2.

IWS/2025/Sardine/P4: de Moor CL. 2025. Projections of the sardine population using an operating model with parametric stock-recruitment relationships estimated during conditioning.

The operating model for the projections (IWS/2025/Sardine/BG5) is based on an assessment which estimated a Beverton Holt stock-recruitment relationship for CTS and a Hockey-Stick stock recruitment relationship for WTS during conditioning (IWS/2025/Sardine/BG3, IWS/2025/Sardine/BG4). This document relates to Q1 and Q2 above.

IWS/2025/Sardine/P5: Bergh M. 2025. Correcting the recruitment process error variance for bias due to recruitment estimation error.

Estimates of the recruitment process error variance σ_R^2 are likely to be positively biassed. A bias correction, subtracting the estimation error variance from the value of σ_R^2, is proposed. This document relates to Q3 above.

IWS/2025/Sardine/P6: Bergh M. 2025. Some issues and questions regarding sardine model fits and associated Markov chains.

The negative log-likelihood surface of the sardine stock assessment model developed independently shows evidence of more than one local minimum, some near perfect correlations between a small number of parameters, and a mode which lies outside the range of an n=60 sample of the reported converged Markov chain. This document relates to Q5, Q6 and Q7.

IWS/2025/Sardine/P7: de Moor CL. 2025. Projections of the sardine population using an operating model which does not estimate stock-recruitment relationships during conditioning and uses the 'binning approach' for generating future recruitment.

The operating model for the projections (IWS/2025/Sardine/BG5) is based on an assessment which estimated historical recruitment independent of any stock-recruitment relationship (IWS/2025/Sardine/BG3, IWS/2025/Sardine/BG4). This document relates to Q1 above, showing an assumption of future recruitment being generated from the historical estimates, according to which 'bin' the year's spawner biomass corresponds.

Background documents

IWS/2025/Sardine/BG1: Coetzee JC and de Moor CL. 2024. A summary of the South African sardine fishery.

This is a summary document providing an overview of the sardine resource and fishery, and a brief description of the data available, together with past assessments and management of the fishery. It has not been updated since December 2024.

IWS/2025/Sardine/BG2: de Moor CL, Merkle D, Coetzee J and van der Lingen CD. 2025. The data used in the 2024 sardine assessment.

This document describes the data to which the sardine model is fit. See also Appendix A of IWS/2025/Sardine/BG4.

IWS/2025/Sardine/BG3: de Moor. 2025. Revisions to the updated assessment model for the revised sardine stock structure hypothesis.

This details the stock assessment model of South African sardine. The sardine are modelled to consist of two stocks which mix, (i) Cold Temperate Sardine (CTS) which spawn off the west coast and are seldom found off the south coast, but some do (permanently) move via the south coast to take part in the Sardine Run off the east coast, and (ii) Warm Temperate Sardine (WTS) which spawn off both the south and (south-)west coasts and

which may spend some part of their early life off the west coast before returning to the south coast. This two-area model distinguishes the area west of Cape Agulhas (west coast) from that between Cape Agulhas and Port Alfred (south coast). Growth is no longer stock-dependent and is now only coast-dependent and modelled using a mean length-at-age which accounts for movement from the west to the south coast instead of keeping track of the age at which WTS moved from the west to the south coast. The results presented at this workshop assume catch by stock off the west coast is removed in proportion to the numbers of exploitable fish by stock available. The model does, however, allow for alternative proportions of CTS and WTS to be removed for the region to the north of Cape Point and between Cape Point and Cape Agulhas, but these alternatives are now considered a lower priority.

IWS/2025/Sardine/BG4: de Moor. 2025. Results for the updated assessment of the revised sardine stock structure hypothesis.

This document shows the model fits to the data for the two alternative models considered at this workshop (detailed in IWS/2025/Sardine/BG3): (i) where historical recruitment is estimated independently and (ii) where parametric stock-recruitment relationships are estimated during conditioning. For the latter, a Beverton Holt stock recruitment relationship is estimated for CTS and a Hockey Stick stock recruitment relationship is estimated for WTS.

IWS/2025/Sardine/BG5: de Moor. 2025. Scoping MSE for South African sardine.

The operating model (OM) for the sardine-only 'scoping' Management Strategy Evaluation (MSE) is detailed. This OM is used for sardine projections shown during this workshop. A very simple candidate management procedure, is also detailed and used for sardine projections shown during this workshop.

IWS/2025/Sardine/BG6: de Moor CL, Merkle D and Coetzee J. 2025. The data used in the 2024 anchovy assessment.

This document describes the data to which the anchovy model is fit. See also Appendix A of IWS/2025/Sardine/BG6.

IWS/2025/Sardine/BG7: de Moor CL. 2025. Assessment of the South African anchovy resource using data up to 2024.

This document details the stock assessment model for South African anchovy and gives some deterministic results.