INTERNATIONAL REVIEW PANEL REPORT FOR THE 2022 INTERNATIONAL FISHERIES STOCK ASSESSMENT WORKSHOP
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Summary of general issues

The Panel recognised the high level of quantitative analysis presented to the 2022 International Fisheries Stock Assessment Workshop. This included work on the stocks of southern African hakes, sardine, west coast rock lobster, south coast sole and squid. There was also a general discussion related to Management Strategy Evaluation (MSE), the impact of climate change on assessment and management, as well as the estimation and communication of uncertainty.

This report starts with observations from the Panel on some general issues for the species and analysis programmes reviewed, and then focuses on answering questions posed to the Panel, providing a more detailed technical review where necessary, and finally recommending further work concerning each topic. The recommendations are annotated by their priorities (H, M, L), with Panel conclusions indicated by an asterisk (*). Much of this report reflects responses to the questions.

Hake

The Panel focussed on whether there is evidence for interference competition between the longline and trawl fishery sectors and if this might lead to CPUE changes of sufficient magnitude to have consequential impacts to Total Allowable Catch (TAC) recommendations. The Panel agreed that there is evidence that there is likely to be some spatial competition between the hake longline and trawl fisheries. However, the extent to which this will impact catch rates (nominal or standardized) will need to be analysed using appropriately structured generalized linear models.

The Panel also reviewed work to understand the implications of *M. Paradoxus* being shared (completely or partially) between South Africa and Namibia. The Panel recommends that models be developed that are intermediate between those that assume separate stocks between South Africa and Namibia and those that assume complete mixing over the range; such models might lead to qualitatively different estimates of overall stock status. Operating models that examine different degrees of mixing would be adequate for testing the robustness of the South African Operational Management Procedure (OMP) to alternative future catch scenarios and trends for the Namibian hake component. The Panel was very pleased to see that some data on historical Namibia hake catches, split by species, have been shared with South African scientists. Development of models that involve alternative hypotheses about mixing of hake from Namibia and South Africa will ideally require yet more data from Namibia, including species-disaggregated length compositions and further survey information. Accordingly, the Panel **strongly encourages** further data sharing and ideally collaborative development of assessments between Namibian and South African scientists.

Sardine

The Panel reviewed the conceptual model that has been developed for South African sardine given the genomic study results by Teske et al. 2022 (MARAM/IWS/2022/Sardine/P2), as well as the resulting demographic models and their results. Considerable work has been undertaken to develop a model structure that aims to capture the stock implications of the genetics study

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and to develop and implement this model structure. However, the Panel found that the conceptual model still contains assumptions that appear inconsistent with the conceptual understanding (e.g., that warm temperate sardine (WTS) and cool temperate sardine (CTS) spawn at the same time on the west coast but remain genetically distinguishable). Under the new hypothesis, there appears to be an inconsistency between the data on parasite prevalence and intensity on WTS, which imply that a large fraction of WTS must stay for a reasonably long period on the West coast, and the maintenance of genetic separation between CTS and WTS. Moreover, the preliminary modelling led to results that were inconsistent with the conceptual model, which required adding constraints the model fitting process by introducing penalties (e.g., by fixing the *R* parameter in MARAM/IWS/2022/Sardine/P4) when restructuring of the model might be more appropriate. The Panel concludes that further domestic discussion is needed to describe the stock hypothesis conceptually (e.g., where are stocks spatially during each month by life stage and to how the available data relate to model components) before models (simple or otherwise) are implemented. Hence, the Panel concludes that understanding of the new stock hypothesis is insufficient at present to form the basis for operating models for testing OMP variants. It therefore recommends additional work to refine the conceptual models before population models are developed and fitted, as well as additional data collection and analysis (in the longer-term). In the interim, the Panel recommends continuing with the previous approach to setting TACs so that maximal scientific effort can be directed to constructing conceptual models. Once further developed, these models can provide the basis for testing OMP variants.

West Coast rock lobster

The Panel reviewed the basis for the estimates of poaching and the inability to fit the 60-74mm FIMS index for super-area A8+. Estimating poaching is often difficult, and the data in this case provide conflicting trends. The Panel notes the value of the TRAFFIC data when assessing poached catches, and supports continued work between TRAFFIC and industry to refine the estimates of illegally exported lobsters. The Panel concludes that while the TRAFFIC data may be in error to some extent, errors are unlikely to be substantial. There are more concerns with inferences on trends in poaching numbers based on the DFFE compliance data, and the Panel recommends that the index of poaching numbers be examined further. Such further examination would be aided by the compliance data being made available to more members of the associated DFFE scientific working group.

The inability of the model to fit the 60-74mm FIMS index for super-area A8+ was due to the result of FIM data suggesting that a strong cohort was spawned about 2007, but this cohort not being evident in the catch length-composition data for larger fish for subsequent years. This may simply be stochastic variation associated with a pre-recruit index (some of the 60-74mm FIMS index values are “outliers”), but the reason may also relate to changes in demographic parameters (e.g., somatic growth). The Panel recommends that the basic data related to growth be reviewed further. Additionally, the formulation of selectivity should be carefully considered when the FIMS survey is split to length classes because this splitting imposes artificial knife-edge selectivity.

Sole

The Panel reviewed the sole assessment (MARAM/IWS/2022/Sole/P2) and its results. The assessment postulated productivity changes to account for the recent CPUE decline (an earlier CPUE decline was assumed to be caused by a change in catchability) as a key issue. However, the Panel advised that basic commercial and survey data required closer examination before drawing firm conclusions in this regard (see section F2.1).

Squid

The Panel reviewed the key questions related to the proposed assessment revisions summarized in MARAM/IWS/2022/Squid/P2. While it agrees with several of the changes suggested, it also recommends alternative approaches. Moreover, the Panel recommends the collection of additional data (e.g., on fishery size-composition on a short [e.g., monthly] time-step) will be essential for the model to estimate the quantities needed to inform determination of the Total Allowable Effort (TAE), and advises that the alternative model formulation proposed in section E is sufficiently flexible to include such data. The Panel recommends continuing with the previous approach to setting TAEs while the new model is being developed.

General issues

Conceptual models and model building

Many of the models presented to the Panel were complex. The aim of modelling is to find model structures that are of the appropriate complexity, and for which it is not necessary to introduce constraints and penalties to ensure model results are consistent with conceptual understanding. Design of such models is facilitated by the availability of "conceptual models" that describe, for example in the sardine case, where putative stocks are to be found at different times of year, when spawning and fishing occur, etc. Such conceptual models could lead to "red face tests" that include checking (a) whether models are consistent with the data, and (b) that the results are consistent with biological expectations (for example that most of recruitment for WTS eventually spawn on the south coast). The next step is to write a set of model specifications that captures the conceptual model as closely as possible. There is then a need to identify whether data are available to estimate the associated parameters. At present, the step of designing the conceptual model has not been given sufficient attention, with the result that some proposed models were inconsistent with the data and led to implausible results unless constrained. The Panel recommends that more attention be given to the design of conceptual models when developing assessment models, as well as models that will be used on OMP testing.

Overarching problematic issues in fisheries assessment and management, including reference points

The Panel presented and received presentations about a variety of difficulties in fisheries stock assessment and management. These included: the treatment of non-stationarity; the interpretation and representation of uncertainty; as well as some of the problems in practice with addressing such issues within formal institutional structures (aka institutional inertia). The discussion highlighted the apparent loss of influence of fisheries science in the broader resource management community, and the need for fisheries science to address some of these issues to rebuild some of that credibility. While these issues may be of broad interest to the fisheries stock assessment community, many of the issues discussed were not highly relevant to the stock assessment and management of the stocks reviewed by the Panel. A summary of some of the broad and overarching problematic questions in management-related fisheries assessment practice globally that might provide appropriate topics for a high-level international workshop is provided in Section G.

Regime shifts

Regime shifts in productivity are real and will become more common in the future. There is a temptation to use changes of model parameters to explain unexpected changes in results (e.g., for south coast sole the lack of increase in CPUE given lower recent catches). In the case of sole, the Panel concludes that evidence to support a regime change (such as changes in environmental conditions, habitat, predator prey interactions etc.) needs to be examined in detail. More generally, the Panel recommends that a generic framework be developed to examine the evidence whether regime shifts have occurred, and hence provide consistency in this determination among stocks.

Data summaries

The Panel notes that its work (and that of the analysts) would have been easier had detailed summaries of the available data been available. This was most evident for sole where an apparent major discrepancy between the trend in CPUE was evident from the commercial fishery and the trawl survey, but detailed data summaries showed that the trend in relative survey biomass on the sole fishing grounds did not match that for the entire survey.

Meeting process

The Panel process was mostly effective: 1) the key questions were clear and specific and helped the Panel focus its deliberations and requests, 2) the many documents provided were informative and mostly sufficient to inform on the topics to be addressed by the Panel, 3) all participants were given a reasonable opportunity to express their opinions, and 4) the organizers and local scientists were quick to provide additional information required by the Panel. There were, however, some challenges to the process. Most specifically, the new sardine model relied on results of genomic analyses, but none of the Panel (and most of the other participants) had detailed knowledge of genomic techniques – the Panel should be selected to avoid being requested to comment on key results without the required technical expertise. The number of topics covered by the 2022 IWS included questions related to hake, sardine, sole, squid and rock lobster, as well as general issues. The Panel was able to provide comment on all of these topics, but the breadth of topics meant that there was little time for detailed discussion of technical matters and review of the models applied.

B. Hake

B.1. Questions to the Panel

B.1.1 Does the work in Bergh (2022b,c) adequately demonstrate that there is spatial competition between the longline and the hake trawl fisheries? If not, what further work is required?

The information (both quantitative and qualitative) provided to the Panel supports the claim that there is spatial competition between the longline and hake trawl fisheries, but no quantitative measure of the consequences of this for nominal and standardized CPUE was provided. The analyses in MARAM/IWS/2022/Hake/P4 should be expanded by allowing the effect of the number of sets on the number of hauls to be modelled as a random effect rather than as a fixed effect. The analyses should be restricted to those in which the relationship is log-linear, as the slope then has a common meaning among clusters, and an error structure (such as the negative binomial) that allows for zero trawls is assumed. It is important to explore the residuals of these models and to consider the potential effect of many of the observations being at the origin (i.e., zero longline and trawl effort).

B.1.2 What methods should be applied to estimate the extent to which the CPUE in the trawl fishery is reduced because of the presence of the longline fishery?

The Panel identified that a generalized linear model (GLM) could be used to assess the possible effects of longline fishing on the CPUE of the hake trawl fishery along the following lines:

- the analysis should be based on daily catch and effort data for recent years; and
- the GLM should include, as an (additional) factor, the number of sets on the day.

The analyses should consider various spatial scales for the spatial strata considered as well as the temporal scales. It should be recognized that the power to detect an effect of longlines on trawl CPUE may be low, and a power analysis may be valuable to conduct if no effect is detected. The Panel also notes that this type of analysis could be conducted to detect the effect of trawl effort on longline CPUE, but the use of trawl CPUE in the OMP means that understanding the effect of longlining on trawl CPUE is more important at present.

B.1.3 What plausible robustness tests of the joint SA-Namibia M. paradoxus assessment in DEM/03 and DEM/11 have a possibility of resulting in a worse estimated current stock status than that for the SA resource in isolation?

The Panel interpreted the term "assessment" in the context of model structures that could be included in the set of tests of a future OMP. Such model structures could also be used to assess stock status relative to reference points such as recent spawning stock biomass relative to the biomass at which maximum sustainable yield is achieved (B/B_{MSY}). The models in MARAM/IWS/2022/Hake/P7 and MARAM/IWS/2022/Hake/P8 are aimed to reflect bounding cases. Models that allow for source-sink dynamics (and make use of data from Namibia) may lead to qualitatively different results. In addition, models in which allowance is made for sub-stock structure within Namibia might be explored. The Panel noted that a key reason that the sensitivity tests in MARAM/IWS/2022/Hake/P7 (which incorporate catches of *M. paradoxus* off Namibia) are more optimistic than those for the reference case model for South Africa is the shape of the catch series for *M. paradoxus* off Namibia relative to that off South Africa. Changes to that shape are the most likely to lead to qualitatively different outcomes in terms of overall stock status. The Panel also noted that the survey trends off Namibia were very similar to those off South Africa.

<u>B.2. Other recommendations</u>

B.2.1 (H). The hake assessments in MARAM/IWS/2022/Hake/P7 and MARAM/IWS/2022/Hake/P8 were based on data from South Africa (except for the survey series for *M. paradoxus* for Namibia in MARAM/IWS/2022/Hake/P8). The Panel **strongly encourages** continued collaboration between scientists in South Africa and those in Namibia so that models that include hake in South Africa and Namibia incorporate data from both countries. In this respect, the Panel was pleased to see that data on the split of Namibian hake catches to species commencing in 1998 had recently been provided.

B.2.2 The following aspects of the models in MARAM/IWS/2022/Hake/P7 and MARAM/IWS/2022/Hake/P8 should ideally be explored in the construction of additional sensitivities that include *M. paradoxus* off both Namibia and South Africa.

- Construct models in which the component of *M. paradoxus* off Namibia that is shared with South Africa is only a fraction of that throughout its entire range off Namibia. The distributions of abundance plotted in Payne (1989) are helpful in this regard (H).
- Explore sensitivity to and ideally estimate selectivity patterns for surveys and fisheries off Namibia (which will require species-specific composition data for the surveys and fishery) (H).
- Include more data for Namibia. For example, there are length-composition (and perhaps age-composition) data for surveys and catches (but the extent to which they are available split by hake species remains unclear) (H).
- Consider including other index data for Namibia in a general model (e.g., early survey data and CPUE indices), if they are available by species (H).
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- Check whether the trends in abundance from the early (ICSEAF-period) CPUE series for Namibia match those for the South African series (M).
- Consider models in which Namibian *M. paradoxus* is a "sink" population, noting the lack of evidence for extensive spawning in Namibia (M).
- Construct a simulation model to examine the extent to which it is possible to estimate management quantities reliably using alternative model structures (e.g., how much bias [if any] in estimates of stock status is to be expected if a South Africa-only model is applied when there is mixing between the components off South Africa and Namibia) (M).
- Explore why the β parameter of the stock-recruitment relationship changes among models in MARAM/IWS/Hake/2022/P7 and consider models in which this parameter is pre-specified (L).

C. Sardine

C.1. Questions to the Panel

C.1.1 What are the most important features of the new sardine stock structure model to explore going forward?

As noted above, the Panel was concerned that the conceptual model is not fully fleshed out, together with the apparent inconsistencies between the new conceptual model for sardine, the available data, and the model results. It concludes that considerable extra work is needed before a three-region stock hypothesis (west coast, south coast, east coast) should be used to inform OMP selection. Specifically:

- The conceptual model should be consistent with expectations from demographic and ecological theory, such that a set of "red face tests" can be established. In this regard, the Panel could not see how the current conceptual model, which allows for spawning of WTS on the west coast at the same time as CTS is plausible conceptually, given the genomic results. Development of a conceptual model (or models) would ideally be achieved through an in-person meeting, perhaps continued over several days, with stakeholder participants.
- The conceptual model should be a key focus of future work (before any model results are explored). It should document where each age-class is located during each month (for example) for each stock, and where data are available at this resolution.
- None of the Panel members are experts in the genomic techniques used in MARAM/IWS/2022/Sardine/P2. There would be value in having the work reviewed by a genomic expert who is also aware of the likely use of the genomic results in stock assessment and OMP development. For example, the Panel was unsure of the consequences of basing the analyses on Single Nucleotide Polymorphisms (SNPs) that are selected for temperature, given that the resulting population units are related to temperature. Future review of the model would benefit from having an expert on the Panel who can provide a nuanced explanation of how to interpret genetics and genomics data for the purposes of defining stock structure, both within the context of stock assessment and in the evaluation of OMP variants.
- Collection and analysis of additional genomics data (particularly exome data) should be conducted to strengthen confidence in, and validate the robustness of, the evidence for the postulated complex stock structure in MARAM/IWS/2022/Sardine/P2, as well as whether the relative proportions of each population component in each spatial area vary over time.
- The current model that is being developed is an initial simple model that aims to broadly hold the existing information together. This initial model appears to have some undesirable properties associated with estimating the recruitment parameters, and

related to how the model seems not to include the length-composition for recruits in survey predictions when t_0 is positive.

D. West Coast Rock Lobster

D.1. Questions to the Panel

D.1.1. How might the "marriage" algorithm set out in WCRL/P1 to combine the conflicting data sources available be improved?

Estimating poaching catches is a very difficult problem. The "marriage" approach (MARAM/IWS/2022/WCRL/P1) attempts to estimate the total poached catch by integrating three data sets that are acknowledged to be in mutual conflict: compliance indices for the north and south and TRAFFIC estimates of exported unreported catch. This approach estimates additional "local" poached catches to construct a time series of total poached catches that is assumed to be proportional to the compliance indices. These "local" catches represent all poached catches that are not represented in the TRAFFIC estimates (the TRAFFIC estimates pertain only to exported lobsters), which may reflect more than those consumed locally.

The Panel had several concerns about approach in MARAM/IWS/2022/WCRL/P1. It appears to place undue weight on constraints compared to data, and consequently hardly fits the index data (Fig. 1) and has the undesirable property of resulting in some negative "local" poaching estimates despite including a constraint that seeks to avoid this. Negative values of local poaching would mean that legally caught lobsters are entering the illegal market, which seems unlikely. Lastly, the effectiveness of enforcement actions may have changed over time.

The Panel had several additional observations and suggestions:

1) The assumptions of the approach in MARAM/IWS/2022/WCRL/P1should be clearly stated and the relative strengths of the data sources should be checked against those assumptions. Assumptions of the approach in MARAM/IWS/2022/WCRL/P1 include:
   a. all data sets are accurate (the Panel is most concerned with the trends from the DFFE compliance data, while the TRAFFIC data set appears to be largely robust following extensive review, including by industry);
   b. enforcement effectiveness is constant over time;
   c. the proportion of TRAFFIC catches for the two regions (70:30) is known and unchanged over time; and
   d. the local catch in the last year is known.
2) Develop scenarios using alternative approaches that do not require a model that integrates the compliance and TRAFFIC data to estimate of total poaching. Possibilities include:
   a. poaching is a constant fraction of reported catch over some time frame;
   b. poaching is a constant amount over some time frame;
   c. add all known (TRAFFIC and confiscations) illegal catches to develop minimum levels of poaching;
   d. use fishery CPUE together with plausible levels of poaching effort; and
   e. apply a state-space assessment model to estimate unreported catches (e.g., Cadigan, 2016; Perretti et al., 2020) (longer term aim).

D.1.2 How might any information becoming available about local sales of poached lobster be incorporated in the calculations of the total amount poached?

Any new estimates of local sales of poached lobsters should be included in the approach for estimating scenarios about the total amount of poaching. However, including new local poaching estimates should be conducted in a consistent and parsimonious manner. For example, if an estimate of local sales of poached lobsters is developed, it could be added to the TRAFFIC estimates for each year, assuming a constant amount of local sales over that period. Missing catch in an assessment model has important implications for the accuracy of estimates.

If the average amount of poaching over time can be estimated, then the assessment results should be more accurate (Perretti et al., 2020).

Several approaches might be useful to estimate either the total amount of poaching or the total amount of local catches (which would be added to the TRAFFIC estimates). The three main ones would be:

1. Use fishery CPUE and plausible levels of effort to generate a potential poached catch time series. This approach would estimate total poached catch (both local and exported).
2. Use confiscation data and estimates of the area and time covered by policing to generate estimates of poached catches. For example, if 28 tons of lobster was confiscated and 10% of the landing sites were monitored on 10% of the days, then the estimated total harvest would be 28 tons/(0.1*0.1) = 28/0.01 = 2,800 tons. The confiscation data to use for such an analysis should probably be limited to the boat and slipway confiscations because they are more likely associated with a single trip, whereas the truck confiscations may be more likely to aggregate lobsters from multiple trips. This approach would estimate total poached catch (both local and exported).
3. Survey groups who catch, sell, and/or eat lobsters about the amount and source of their lobsters. Survey approaches have been developed to estimate illegal activities such as poaching. One such method is Randomized Response Techniques (e.g., St. John et al., 2010). This type of approach asks a survey respondent to answer the question truthfully based on a random event such as a flip of a coin. This means that it is not possible to determine if an individual participated in an illegal activity, but the aggregate results can be used to estimate the "inappropriate" behaviour. If this kind of survey were conducted on harvesters, it would provide an estimate of total unreported catch. If it were carried out for restaurants and other end users, it would provide an estimate of the local unreported catch.

A minimum estimate of poaching could be determined by noting that the confiscation data are probably the most reliable of all the unreported harvest data because these represent verified amounts of illegal lobster catches. Therefore, the confiscations should serve as minimum estimates of poached catch. Confiscations could be added to the TRAFFIC estimates to provide a minimum estimate of total unreported catch.

The approach of MARAM/IWS/2022/WCRL/P1 allows for negative "local consumption" given the constraints imposed on the estimates of local consumption and the change in total poaching numbers. Some of these estimates are substantial (>100t). The analysts should report the average local consumption estimated over the period analysed, and consideration should be given to projecting forward based on the average numbers poached over time.

D.1.3 How best to select an appropriate weighting for the split FIMS data in the likelihood?
D.1.4 Any suggestions for other adjustments to the model to provide a better fit to these FIMS data?

There appears to be a fundamental conflict between the 60-74 FIMS index and the CPUE indices (which relate to animals selected by the legal fishery) for super-area A8. It was not possible to identify the reasons for the conflict between the indices during the workshop. However, the trend in the 60-74 FIMS index for super area A8+ (Fig. 1 of MARAM/IWS/2022/WCRL/P2) suggests that there was a pulse of recruitment (around 2007) that was not seen subsequently in the fishery. While it is not unusual for pulses of recruitment seen in pre-recruit surveys not to appear in the subsequent fishery, and the FIMS index is quite noisy (with two large outliers), better understanding of the reason(s) for the conflict could be obtained by:

- estimating more recruitments (or weakening the penalty on 2010 and subsequent recruitment); and
- exploring the basic demographic data (such as for somatic growth) which might be suggestive of (additional) lack of growth.

D.2 Other recommendations
D.2.1 (H) The model of MARAM/IWS/2022/WCRL/P1 fits the compliance index very poorly (Fig. 1). The Panel notes that the basic data on which this index is based are very noisy, questioning the assumption of a negative binomial distribution. Examination of the residuals of the fit of the model to the two data sources may suggest an alternative model. In addition, the effect of outlying observations should be examined and the possibility of non-linear relationships between confiscations and illegal catch considered.

D.2.2 (M) The fit to the size-composition for the FIMS index is very poor with large residuals at the 75mm bin (e.g., Fig. 3b of MARAM/IWS/2022/WCRL/P2). It may be possible to resolve this problem by replacing the current formulation for FIMS selectivity by a dome-shaped pattern (e.g., a double normal formulation), but without pre-specified break points at which selectivity changes from one functional form to another.

E. Squid

E.1. Questions to the Panel
E.1.1 Provide comments relating to improvements, corrections and extensions to the suggestions made for the new squid assessment model. The Panel has the following suggestions for shorter-term model development (H):

- Base the assessment on a population dynamics model in which monthly cohorts are modelled by sex.
- Growth should be modelled using a (time-invariant) sex-specific growth curve (based on the results of previous age and growth studies for squid). Thus, the aggregate growth and mortality parameter *g* should be dropped and growth and (time-invariant) natural mortality should be modelled separately.
- The catch and CPUE data should be disaggregated to month, the catches removed by month (thereby allowing explicitly for the spawning period closure), and the CPUE fitted by month. In-season trends in CPUE can, in principle, allow for better estimation of annual recruitments.
- In the absence of in-season size-composition data, which would be needed to estimate seasonal patterns in recruitment and be able to track within-season cohorts over time, industry information should be used to develop an informative prior for the recruitment pattern or alternative scenarios on when dominant recruitment pulses occur.

E.2. Other recommendations
E.2.1 (*) The Panel noted that the proposed model (MARAM/IWS/2022/Squid/P1) is based on the data currently available. However, models for short-lived species such as squid are essentially depletion estimators with little or no carry-over of animals from one year to the next. As such, collection of additional data would be beneficial. In particular, the Panel highlights the value of monthly size-composition data, ideally by sex. The model structure proposed above would be able to make use of such data, which would provide information on growth, selectivity and the recruitment pattern.

E.2.2 (*) In relation to the acoustic survey, the Panel notes that even in the best case that the uncertainty regarding the species composition of the acoustic signal can be resolved, the estimates can be considered only as an estimate of biomass at a given point in time when the population is dominated by spawning (and dying) squid. Moreover, the uncertainty regarding the species composition of "B" and "C" signals means that it will be difficult to use the results of the acoustic surveys as measures of absolute abundance. Hence, the Panel supports continued work to understand the species composition of "B" and "C" signals better.

E.2.3 (*) The current model can continue to be used to provide management advice while the new model is being developed.

F. Sole

F.1. Questions to the Panel

F.1.1 What parsimonious revisions to the assumptions underlying the current sole model do you suggest for further investigation?

There initially appeared to be a large conflict between the 2021 autumn survey index and the 2021 commercial CPUE. While the latter had declined in 2021, the survey index had remained at approximately the same level as it had been in 2019. The Panel received a plot of abundance estimates for the autumn area (0-500m) covered by the survey and the sole fishing grounds (see Fig. 2). Only the index corresponding to the sole fishing grounds showed a similar decline to the commercial CPUE. The model should be modified once further analyses of the abundance survey and fishery data based on spatio-temporal models are undertaken.

The Panel notes that assessing south coast sole is a very difficult problem due to the "one-way trip" nature of the catch and abundance index time series. Based on the preliminary exploration conducted during the workshop, the Panel considers that the survey provides a more reliable index of the population biomass than the CPUE index, which pertains to the component of the population on the sole fishing grounds.

F.2 Other recommendations

F.2.1 (*) The fact that the (apparent) conflict between the survey and CPUE indices was resolved by examining detailed data plots emphasizes the need to review maps of the data by time and size class.

F.2.2 (H) The sole assessment (and others) would benefit from a detailed description of the fishery that includes the history of targeting and the regulatory context in the fishery. Such a description would assist readers with understanding potential spatial effort dynamics relevant for interpreting CPUE data.

F.2.3 (H) The range of estimated values the r parameter between the early and late periods in MARAM/IWS/2022/Sole/P2 is substantial. There is value in developing and applying a framework to evaluate the weight of evidence for persistent trends or a regime-shift change in a parameter value, for example, based on the approach of Klaer et al. (2015), and using evidence such as changes in environmental conditions, habitat, range distribution changes, or ecological interactions to justify modelling regime shifts.

F.2.4 (H) The next review of the sole assessment should include a document that outlines why catches have consistently been lower than TACs.

G. Overarching problematic issues in fisheries assessment and management, including reference points

The Panel participated in a general discussion, including with several experts from outside of South Africa (Michael Sissenwine [Marine Science Consulting], Manuel Barange [FAO] and Mark Dickey-Collas [ICES]), on overarching problematic issues in fisheries assessment and management that might provide appropriate topics for a high-level international workshop. Based on those discussions, the Panel identifies the following issues:

- How can the problem of non-stationarity be acknowledged/highlighted, and how is it exacerbated by climate change in stock assessments?
- How can the consequences of non-stationarity be acknowledged/highlighted to a) institutional frameworks, b) assessment and management processes, c) fishing and processing operations, as well as d) markets and eventually consumer behaviour?
- How can a shift from a best-assessment paradigm to MSE to test performance of management procedures against operating models with non-stationary dynamics be promoted?
- How are possible climate-change impacts best quantified and incorporated in operating models including: a) distributional changes (affecting relative abundance), b) differential productivity changes (affecting productivity functions), c) seasonality patterns (affecting relative abundance and productivity functions) and d) marine heat waves (the only one of the four that would be non-linear in its consequences)?
- How can Harvest Control Rules be designed and applied to avoid discontinuities?
- What new technologies are now available for resource surveys and assessment?
- Should timely detection and response to changes in productivity be emphasised, rather than prediction?
- Given that the signal-to-noise ratio in trying to parameterize climate-change/non-stationarity impacts is very low, what are the best statistical approaches to estimate these impacts? How well do these approaches work?
- How can broader stock assessment and management systems best be reviewed to ensure that they are working?

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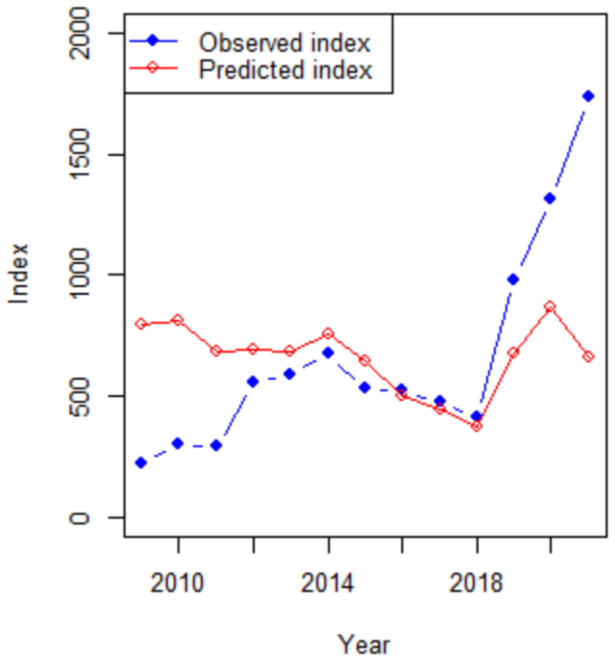

Fig. 1. Fit of the model of MARAM/IWS/2022/WCRL/P1 to the index data based on the compliance data (2021 local poaching catch of 850t).

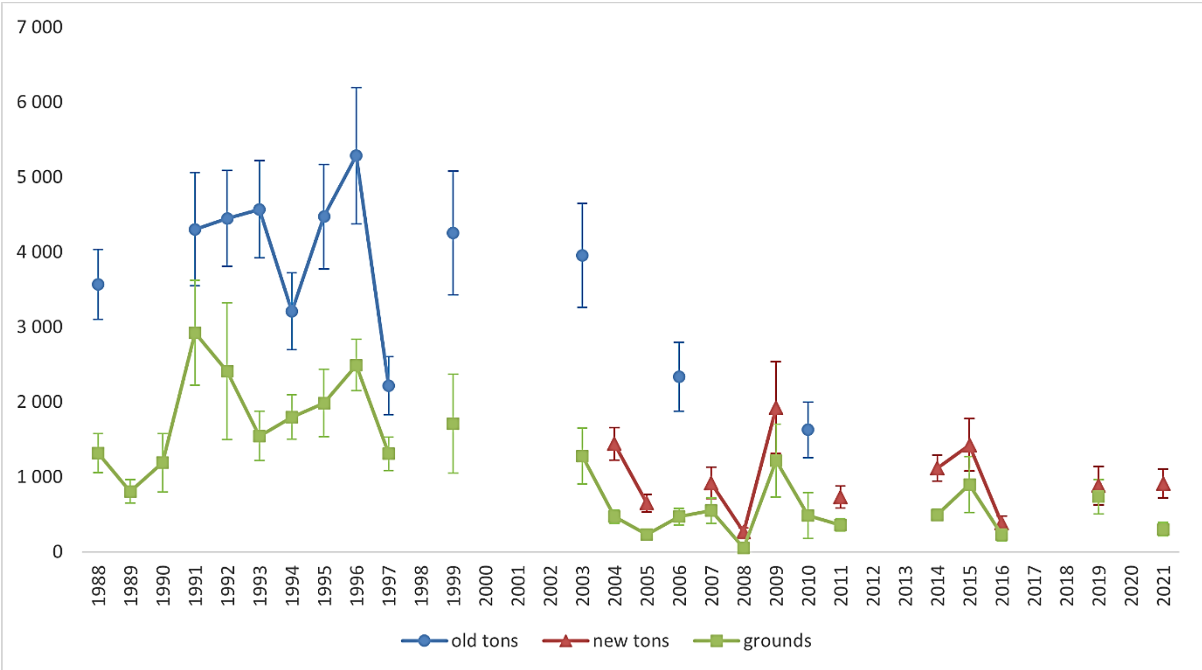

Figure 2. Abundance estimates from autumn surveys for the old/new gear for the entire survey area (0-500m) and the sole fishing grounds as defined for the CPUE time series.