Center for Independent Experts (CIE) Independent Peer Review Report

STAR Panel Review of the 2020-2021 Pacific Sardine Stock Assessment

La Jolla, California. February 24-27, 2020

Dr. Noel Cadigan

Centre for Fisheries Ecosystems Research
Marine Institute of Memorial University of Newfoundland
St. John's, NL. Canada

Executive Summary

This Pacific Sardine Stock Assessment was sufficiently complete and the science reviewed is the best scientific information available.

The SS3 stock assessment model was competently applied. The selectivity models used in the proposed base model were appropriate, and the information content of the age composition data was appropriately accounted for in the assessment model.

Major axes of uncertainty involved

- The natural mortality rate (M), which is adequately accounted for in this assessment.
- The Southwest Fisheries Science Center (SWFSC) acoustic trawl (AT) survey catchability (Q) is poorly identified in the final base model. However, this model formulation has AT survey Q fixed and obviously does not account for uncertainty in Q. There does not seem to be external sources of information about the range of Q values that are appropriate for Pacific sardines. Hence, this seems to be an important source of uncertainty that cannot be objectively (i.e., data-based) accounted for.
- Mexican catches are more uncertain than those in the US. A large fraction of the northern sardine stock has recently been estimated to be caught in Mexican fisheries (via apportionment). These catches have an important consequence in the assessment, and I find that this is a source of uncertainty that has not been accounted for in the stock assessment.
- Steepness was also not estimable, and the STAT and Panel agreed that steepness would be fixed at 0.3 in the final base model. Since σ_R was fixed at 1.2 the assessment trends are not sensitive to reasonable values of steepness.

Important research recommendations are:

- The California Coastal Pelagic Species Survey (CCPSS) should be extended to cover more of the stock range and have reasonable biological sampling of schools detected to determine their species and size compositions. Some directed study of school detection probabilities is also required.
- AT and CCPSS survey information should be integrated using spatiotemporal modelling techniques before using this information in a stock assessment model.
- Cohorts do not seem to track well through the AT survey age compositions. Future research should be conducted to better understand this problem and hopefully provide better estimates of the length and age composition of sardines measured in the acoustic survey.
- Fishermen at the Review Panel meeting felt there were some sources of bias in the AT survey, notably surface dead zones and trawl sampling of vessel backwater. A collaborative research program between federal and state scientists and the fishing industry to examine the possibly important issues raised by fishermen seems warranted in the future.
- An SS3 with an internal growth model should be developed to utilize the length composition information from the Mexican catches and spring AT survey, which are currently not used in the Review Panel final base model.

Background

The Stock Assessment Review (STAR) of the Pacific sardine stock assessment was held in La Jolla, California during 24-27 February, 2020. The Pacific sardine stock is assessed regularly (currently, every year) by SWFSC scientists, and the Pacific Fishery Management Council (PFMC) uses the resulting biomass estimate to establish an annual harvest guideline (quota). The stock assessment data and model are formally reviewed by a STAR Panel once every three years, with a coastal pelagic species subcommittee of the Scientific and Statistical Committee (SSC) reviewing updates in interim years. Independent peer review is required by the PFMC review process.

The Review Panel (i.e., Panel) was composed of two independently appointed Center for Independent Experts (CIE) reviewers (Dr. N. Cadigan, Canada; Dr. José De Oliveira, UK), independent reviewers from the Pacific Fishery Management Council's (PFMC's) Scientific and Statistical Committee (SSC; Dr. Marisol García-Reyes and Dr. Melissa Haltuch) and an independent chair (Dr. André Punt) who is also a member of the PFMC SSC. The Panel was supported and assisted by Mr. Kerry Griffin (PFMC), CPSAS Advisor Ms. Diane Pleschner-Steele and CPSMT Advisor Mr. Alan Sarich. Assessment documents were prepared by stock assessment teams (STAT's) and presented by Dr. Peter Kuriyama and Dr. Juan Zwolinski (SWFSC) with assistance from Dr. Kevin Hill and Dr. Paul Crone (SWFSC). The support of all these scientists and staff to the STAR Review Panel process is gratefully acknowledged.

The CIE reviewers were equal members of the Panel. The CIE reviewers were required to have expertise as listed in the following descending order of importance:

- The CIE reviewer shall have expertise in the design and execution of fishery-independent surveys for use in stock assessments, preferably with coastal pelagic fishes.
- The CIE reviewer shall have expertise in the application of fish stock assessment methods, particularly, length/age-structured modeling approaches, e.g., 'forward-simulation' models (such as Stock Synthesis, SS) and it is desirable to have familiarity in 'backward-simulation' models (such as Virtual Population Analysis, VPA).
- The CIE reviewer shall have expertise in the life history strategies and population dynamics of coastal pelagic fishes.
- It is desirable for the CIE reviewer to be familiar with the design and application of fisheries underwater acoustic technology to estimate fish abundance for stock assessment.
- It is desirable for the CIE reviewer to be familiar with the design and application of aerial surveys to estimate fish abundance for stock assessment

The principal responsibilities of the Panel were to review stock assessment data inputs, analytical models, and to provide complete Review Panel reports. The Panel, including the CIE Reviewers, was responsible for determining if the Pacific sardine stock assessment or technical analysis was sufficiently complete. Assessment results based on model scenarios that had a flawed technical basis, or were questionable on other grounds, should be identified by the Panel and excluded from the set upon which management advice is to be developed. The Panel should comment on the degree to which the accepted model scenarios described and quantified the major sources of uncertainty.

Role of reviewer

All assessment documents and most supporting materials were made available to the Panel via an ftp server. The draft sardine stock assessment document was provided in a February 10, 2020 email. An aerial survey report and the proposed agenda were provided February 12. The 2019 ATM biomass report and the 2019 survey report were provided February 20. These documents are listed in Appendix 1. I reviewed the background documents I was provided and compiled a list of issues to get clarification at the Panel meeting.

I attended the entire STAR Panel review meeting in La Jolla, California during February 24-27, 2020. I reviewed presentations and reports (see Appendix 1) and participated in the discussion of these documents, in accordance with the SoW and ToRs (see Appendix 2). I drafted some text for the Panel report. After the meeting, I participated in email discussions finalizing with the Review Panel summary report.

This CIE report is structured according to my interpretation of the required format and content described in Appendix 2.1. However, unlike previous reviews I participated in, we did not evaluate specific ToRs in this Pacific sardine assessment review. The April 2019 PFMC ToRs for Groundfish and Coastal Pelagic Species was referred to, but the Panel focused on reviewing stock assessment data inputs, analytical models, and completing the Panel report, which were the principal responsibilities of the Panel. Hence, I provide a summary of findings for these three aspects of the review.

Summary of findings

The STAR Panel thanked the STAT for their hard work and willingness to respond to Panel requests.

ToR 1. Review stock assessment data inputs and assumptions.

The Panel acknowledged the extensive efforts made to conduct and improve the California Current Ecosystem AT surveys, in particular, the increased density of acoustic transects, and the use of alternative survey platforms to provide data for the areas inshore of the regular AT survey area. In particular, I appreciated the extensive documentation on the AT surveys (e.g., Stierhoff et al., 2019, 2020), even if I did not understand all of the acoustic physics.

A substantial amount of time during the Review Panel was focused on more fully understanding the basic stock assessment model inputs and how to account for the sardine biomass inshore of the AT survey grid. However, the Panel also recognized that this was not a review of the methods on which the acoustic-trawl and aerial survey estimates of biomass were based. The draft assessment document did not include a detailed summary of the basic assessment data (and data gaps), such as plots of the locations of the catches, and how the catches varied seasonally, temporally and spatially. I found the assessment documentation was written tersely in some places, with frequent references to earlier documents for explanations.

The following requests during the Panel pertained to improved understanding of data inputs. These requests highlight the main information gaps in the draft assessment documentation.

Request 1: Provide a plot of the catches and age- and length-compositions for the non-directed fishery (NDF). Rationale: These data are included in a model sensitivity run, but are not shown in the document.

These plots were provided and they did not reveal anything that affected how these data were used in the assessment.

Request 2: Add sample sizes to the weight-at-age (W@A) plots for all fleets and surveys (or create a table). Rationale: The weight-at-age by cohort has odd behaviour at older ages in some years and fleets.

I agree with the panel that the odd behavior is because there are very few samples for ages beyond 4-5 because fish of these ages are not frequently observed in the MexCal S1 and S2 fleets. Hence, weights at these ages will not have much influence in the stock assessment. At first, I found the plots of W@A confusing because summer W@A tended to be less than spring W@A. However, I discovered during the review than this was due to terminology, and that spring samples occur after summer samples, so it then makes sense that W@A in the spring is greater than the summer. This is an unfortunate use of terminology that creates unnecessary confusion and should be avoided in the future.

I did not find a clear explanation about how age samples were selected for reading. Was it completely random or somehow stratified by length, region, etc.? I suspect sampling was not length-stratified, but this needs to be clarified. Also, length selectivity by the gears used for biological sampling may also result in over-estimation of population length and W@A for smaller fish (i.e., if selectivity is asymptotic). SS3 attempts to account for this when growth is estimated internally, but for Pacific sardine growth is estimated externally and I don't think selectivity effects were adjusted for.

There was some smoothing of growth data that was poorly described. Plots of the raw growth data should be presented, along with residuals from smoothing.

Request 3: Summarize how acoustic backscatter is converted to biomass estimates and how the variance for the estimates of biomass are calculated. Rationale: The Panel wished to fully understand the current methods, which were previously reviewed by the SSC.

Panel conclusion: The variance may still be underestimated owing to not accounting for uncertainty due to the locations of the trawls, but likely not by much.

I did not understand the details of the acoustic biomass estimation procedures, and I had to simply assume that the methodologies were appropriate and applied correctly, recognizing that this was not a review of the methods on which the acoustic-trawl and aerial survey estimates of biomass were based.

Request 4: Provide a table that shows the nearshore extent of each survey method (acoustic trawl, sail drone, commercial vessel, and aerial survey). Rationale: The Panel wished to better understand each survey region and the extent to which the area covered by each survey type overlaps.

Conclusion: I agree with the panel that the overlap was minimal because most sardine observations are in the most nearshore band of the CCPSS.

Request 6: Provide a table that summarizes changes in ageing methods and staff (by fleet). Also, provide a summary of ageing protocols by lab, which labs provide ages for which fleet, and any analyses of between-lab age reading comparisons. Rationale: The history of changes in ageing methods (readers and techniques) and which lab provides ages for which fleet is not clear. Ages are important in the model because the assessment pre-specifies weight-at-age.

Panel conclusion: Different labs are using different methods, Mexico in particular. Data from Mexico are not used in the assessment, and the model makes the assumption that the age data from California are representative of the Mexican catch.

In addition, this request made me better appreciate the rationale for the different standard deviations for age reader error used in the stock assessment.

Request 7: Plot the point set data for the aerial survey showing the observer estimates and landed catches. Rationale: The Panel wished to better understand how visual estimates from observers compare to captured biomass. What proportion of the visually estimated biomass is covered by the catch data?

I agree with the panel conclusions: Results confirmed good estimation of school size biomass up to about 100 mt. Additional information on the proportion of the visually estimated biomass that is covered by the point set data was necessary and is provided below (request 11).

Request 8: Provide the methods for estimating biomass and variance by stratum for the CCPSS. Provide the sum of the biomass estimated from each CCPSS stratum, along with the variance. Calculate the annual CV using the sum of variances rather than the sum of CVs. Rationale: The Panel wished to understand how the aerial survey estimates of inshore biomass were determined and to correct the CVs used in the draft document.

The panel recommended a better way to calculate biomass and variance, aggregated across the two strata (i.e., bands) for this survey. I conclude that the panel recommendations were the best for the information available. However, for the following reasons I suspect that the biomass may be underestimated and the variance may be overestimated, although I am very uncertain about the latter.

There are several sources of variation in the CCPSS that need to be considered. There is error in the aerial estimates of a school size that has been examined via point set purse seine sampling. A possibly larger source of uncertainty involves the detection probability of a school. This may be time (i.e., sea states, etc.) and location dependent and seems to currently be poorly understood. Nonetheless, the schools detected in a particular band seem likely to be a subset of the total

number of schools available; therefore, biomass estimates based on observed schools provide a stochastic lower bound on the total biomass in a band, with stochasticity arising from the measurement error and bias involved in aerial estimates of school biomass. That is, the CCPSS seems to under-estimate sardine biomass because of incomplete detection of all schools in a band. However, if there is species mis-identification, then there is a potential that biomass could be over-estimated, but no evidence was provided for this at the Review Panel meeting.

Repeat sampling may partially address the variability of school size detection, but in repeat sampling fish movement between bands will be an additional source of variation that will confound with the variability due to incomplete detection of schools. Repeat sampling may result in over-estimation of the latter source of variation.

I provide some additional perspectives on the CCPSS survey for Request 20 below.

Request 9: Provide a table on apportionment of southern and northern stock catches for the past few years. Rationale: The Panel wished to better understand the consequences of the change to the method used to assign catches to the two subpopulations.

I agree with the Panel in concluding that the apportionment of southern and northern stock catches seemed appropriate. The panel concluded that the Mexican catches are more uncertain than those in the US. A large fraction of the northern sardine stock is estimated to be caught in Mexican fisheries (via apportionment). These catches have an important consequence in the assessment, and I find that this is a source of uncertainty that has not been accounted for in the stock assessment. That is, the uncertainty in the estimation of the size of the Mexican catches was not presented to the Review Panel nor included in the assessment via a sensitivity analysis.

Request 10 (extension from Request 5): Verify that ages are similar for Mexico and California catches by showing the length frequencies for each fleet. Rationale: This is important because there are no Mexican age data and this comparison serves as a test of the assumption that California ages are representative of Mexico.

Data show that Ensenada lengths are typically similar or larger than those from California. However, the data are variable, rather than being systematically different. It would be beneficial to get age data from Mexico in the future, which would require coordination of methods between ageing labs.

I conclude that the length composition information from the Mexican catches could also be included directly in an SS3 with an internal growth model. I realize this was attempted in the past and difficulties were encountered, but I recommend that additional research on this approach should be conducted in the future. It may be more valid to assume growth curves are the same between southern US and Mexican stock components rather than assuming age compositions are the same as was assumed in the model approved by the Panel.

Request 11 (extension from Request 8): Provide the sum of the biomasses for each CCPSS band. Compute the variance as documented in Appendix 4. Rationale: Correct the data.

The results were provided and calculations were verified by the Panel. The Panel discussed the need for multiple flights over the same band to provide variance estimates because the current method of basing variance on the difference in biomass between strata (i.e., bands) may not be appropriate because it was clear that there are differences in the distribution of fish between bands.

As I indicated for Request 8, repeat sampling may result in overestimation of the variance because of between-band movement of sardine schools between repeat samples. Nonetheless, future research should be conducted on how to estimate the variance of the CCPSS biomass estimates.

Request 13: Get and plot sardine data for the juvenile rockfish survey, including the index and composition data (if available). Rationale: The juvenile rockfish survey may provide information in recruitment not currently in the model.

The panel concluded that the data from the juvenile rockfish survey may be capable of detecting recent recruitment events, but this survey could not be included in the assessment because it has not been subject to a methodology review. I agree. We had very little information on the survey design (gear, etc.) and sources of error, and there seemed to be considerable regional differences in YOY Pacific sardine catch rates that need to be further analyzed.

ToR 2. Review analytical models, assumptions, estimates, and major sources of uncertainty.

The SS3 stock assessment model (version 3.30.14) was used for the Pacific sardine assessment. SS3 is a flexible stock assessment modelling framework that can integrate intermittent samples of length compositions, age compositions, and various types of abundance indices, although only age compositions for Pacific sardines were used to estimate the model, with external estimates of growth. Uncertainty in the estimates of weight-at-age were not provided to the Review Panel nor were they included in uncertainty quantification for biomass estimates. This uncertainty should be provided to future Review Panels who could then consider if it is large enough to justify modifying assessment procedures to account for the uncertainty.

The draft assessment report indicated that the iterative process for determining numerical solutions in the model was continued until the divergence between successive likelihood estimates was <0.00001. During the Panel we periodically checked on convergence for various runs and were assured by the STAT that this was not a problem. For several models, we checked that estimated parameter values were not hitting minimum or maximum bounds. The draft assessment report indicated that convergence was also evaluated through a jitter analysis, re-phasing parameter estimation, and inverting the hessian matrix, and the STAT did not find any problems. I conclude from the review meeting that the model was very competently applied. The skill of the STAT with SS3 has a strong merit. I continue to be impressed with the r4ss package and the HTML outputs that allowed the STAT to quickly produce relevant plots and other output based on requests for additional runs. This greatly improved the efficiency of the review.

The base model used time-varying selectivity for fishery age compositions and, as a result, these data were fit very well by the model. The Pacific sardine MexCal fishery select only young ages but no age sampling from the Mexican catches was available for the assessment, while the Pacific northwest fishery selects older ages. I conclude that the selectivity models used were

appropriate, and the information content of the age composition data were appropriately accounted for in the assessment model. Essentially, the MexCal catch was used in a VPA style, with no assumptions about selectivity, whereas the asymptotic selectivity assumption for older ages in the Pacific northwest fleet, which seemed to be better sampled, provided additional information about M (e.g., Figure 51 in the Kuriyama et al. 2020 draft assessment document).

Some preliminary analysis of using an auto-correlated stock-recruit model was presented to improve short-term forecasts which requires forecasting recruitment. This research seemed useful and I encourage the STAT to pursue this for future assessments.

The sizes of the Mexican catches of the northern Pacific sardine stock are uncertain but important in the stock assessment. These are currently the largest source of catch, by far. Uncertainty in the estimation of the magnitude of the Mexican catches was not provided to the Panel nor was this included in the quantification of uncertainty by the stock assessment model.

The following requests during the Panel pertained to ToR 2:

Request 5: Document the methods used to model the age-length keys. Show residual plots from the model fits (observed – expected) or metrics of goodness of fit. Rationale: Modelling methods have changed from using a multinomial to using a cumulative logistic. It is difficult to evaluate how well the model fits the data given the plots included in the draft report.

Conclusion: There are no obvious residual patterns.

I think it is unusual to model age-length keys before inputting this information to a stock assessment model or using the keys to derive age-based abundance as is the case for Pacific sardine AT survey ages. I was not completely satisfied with the rationale for this. How to account the uncertainty in this modelling aspect is also an issue that requires future consideration. It is opposite from the 'integrated assessment philosophy' of using the data in as raw a form as possible. There may be good reasons to model the age-length keys, but I was not convinced for this stock.

Request: 12: Provide methods and or justification for the Q prior in the proposed base model. Rationale: The Panel would like a better justification for how the Q prior was obtained.

The STAT described that log(Q) was estimated based on a normally distributed prior with a mean of 0 and a standard deviation of 0.1. The STAT reported that in sensitivity runs that determined that Q was poorly estimated and confounded with the level of M (i.e., not well identified) for the Pacific sardine data and stock assessment model. Therefore, they gave log(Q) a highly informative prior to stabilize model results. I agree with the Panel and the STAT that Q is poorly identified for this stock.

Request 14: Run a model without the R1 offset and with the R1 offset estimated but with no penalty on this parameter. Rationale: The Q profile has a likelihood component for the R1 offset (aka the "SR regime parameter"), but it was never the intention to impose a penalty / prior on this parameter – the STAT and Panel were unclear how this penalty was defined.

The Panel agreed that setting the lambda for the R1 offset to 0 is the best approach because it best matches the intent of how this parameter was to be treated in the 2017-2019 assessments. I

did not understand how the R1 offset was used in SS3 and therefore I deferred judgement to other panel members that have more experience with SS3.

Request 15: Provide a model run with corrected CCPSS data included into the model. Rationale: These data are incorrect in the proposed base model sensitivity.

I agree with the Panel that this could be part of the Panel proposed model.

Request 16: Evaluate whether the model without the R1 offset (see Request 14) can estimate steepness. If not, conduct a model run with steepness fixed at 0.3. Rationale: It is not clear which data are informing the estimate of steepness; the current base model appears to depend much on the R1 offset.

Steepness was not estimable, and the STAT and Panel agreed that steepness would be fixed at 0.3 in the final base model. Since σ_R is fixed at 1.2, I felt that the assessment trends should not be sensitive to reasonable values of steepness.

Request 17: Examine the sensitivity to removing the spring AT age data. Rationale: The spring AT age data are based on a pooled age-length key, which is not appropriate because the estimates of age-frequency will be biased as no account is taken of varying cohort strengths.

I agree with the STAT, and Panel agreed that the spring AT age data would be excluded from the final base model. However, similar to Request 10 above, I recommend that future age-based catch-at-length assessment formulations be explored in which case the spring AT length compositions could be used.

Request 18: Run a model with all day 2 changes, i.e.: (1) turn off the likelihood component for the R1 offset parameter by setting the 'lambda' to zero, (2) fix steepness to 0.3, and (3) remove the spring AT age data. Rationale: These model changes were agreed based on the day 2 requests.

I agree with the Panel conclusion that the estimate of the fishing mortality rate for 2020 is unrealistically high and is related to pre-specifying the catches (particularly for MexCal S2) from the 2019-2 model year onwards.

Request 19: Remove earlier years of AT age-composition data and/or include these compositions as a separate fleet because they do not appear to be representative of the biomass observed by the acoustics. Rationale: The early AT age compositions were not well sampled (based on few clusters) and likely not representative of the population surveyed using the acoustics.

The Panel wondered if poor fitting to the AT age-composition data could be the reason for the unrealistically high F's (see Request 18); however, this was not the case. These data are further considered in Request 22 below.

The Panel suggested that the forecast F option be used in the forecast for 2020 rather than setting catches after the 2019-1 model year to the observed catches for the 2018-2 and 2019-1 model years. This suggestion formed part of the final base model. I felt that this was the best available option. Whether one forecasts with a fixed F or a fixed catch will involve additional uncertainty

the model does not account for, because neither the F or a fixed catch value will likely be right as will be discovered in future assessments (e.g., Wetzel and Hamel, 2019). This is an additional source of uncertainty that is likely important for Pacific sardines. Methods should be investigated, perhaps based on retrospective analysis of forecasted F's, to account for this additional uncertainty.

Request 20: Conduct a model run that allows for a time change in AT Q in 2015 (Q=1 before 2015 and Q equal to the ratio of the AT estimate of biomass for 2019 [33,632t] to the sum of the CCPSS estimate of biomass for 2019 [12,280t] and the AT estimate of biomass for 2019 [33,632t]. Rationale: There is evidence that the proportion of the stock shoreward of the acoustic trawl survey area has increased since at least 2015 onwards.

The Panel decided that this was a reasonable approach to account for sardines that are suspected to be shoreward of the acoustic trawl survey area has increased since at least 2015 onwards. The results of this run looked reasonable.

I think this is an interim way to address this problem. It does not account for uncertainty in either the AT or CCPSS estimates of biomass, nor potential differences in the selectivity of these two surveys for the stock as a whole. The amount of biomass inshore of the AT survey may vary from year to year, and the solution above does not account for this either. The Pacific sardine assessment is in the difficult situation where there is some evidence of a shoreward change in the spatial distribution of the stock in recent years, and this reduces the Q of the AT survey for recent years. However, the magnitude of the change in Q is uncertain because we do not have a survey of the entire stock area shoreward of the AT survey. Also, the CCPSS on the whole may only provide a minimum estimate of biomass shoreward of the AT survey and in the areas covered by the CCPSS because not all schools are detected during these aerial surveys. Although the estimates of school biomass obtained in these aerial surveys have measurement error, as indicated by the point set data for the aerial survey comparing the observer estimates and landed catches, so that there is some potential that total biomass could be over-estimated for all of the schools detected, I conclude that the lack of detection of some schools, as indicated by fishermen involved with point set sampling, means that the CCPSS biomass will under-estimate the biomass in the area surveyed. There is also biomass in regions not covered by the aerial surveys. However, the magnitude of the under-estimation cannot be quantified with the information presented to the Panel. Hence, the recent decrease in AT survey Q may be greater than the value (0.733) assumed in the final model. For example, if the biomass inshore of the AT survey in 2019 was actually twice as large as the estimate from the CCPSS, then the AT Q for 2019 derived in the manner of Request 20 would be 0.578, assuming the AT survey has Q=1 for offshore sardines. However, this is completely hypothetical, and I mention this only to indicate the potential impact of under-estimation of biomass shoreward of the AT survey.

Request 21: Run a model with all agreed changes to the proposed base model: (a) the changes in request 18, (b) the changes to acoustic Q from request 20, (c) basing removals off Mexico from the 2020-1 model year on the estimates of fishing for the 2018-2 and 2019-1 model years (i.e., the catches for model years 2020-1 and 2020-2 are based on the F's estimated for model years 2019-1 and 2018-2) [the catch for model year 2019-2 is unchanged from that in the proposed base model, but see the research recommendations for an alternative approach] , and (d) use the selectivity pattern for the AT survey from the proposed base model. Rationale: This was a possible new base model.

This run was provided, and derived outputs were largely the same as previous model runs. I agree that this model could be a new base model formulation, pending the outcomes of sensitivity analyses.

However, this model formulation has AT survey Q fixed and obviously does not account for uncertainty in Q. The assessment model seems largely uninformative about this Q and there does not seem to be external sources of information about the range of Q values that are appropriate for Pacific sardines. Hence, this seems to be an important source of uncertainty that cannot be objectively (i.e., data-based) accounted for.

Sensitivities

The following requests during the Panel pertained to sensitivity analyses:

Request 22: Run the following sensitivities:

- consider a time-invariant dome-shaped selectivity pattern for the AT age data (treated as a separate fleet);
- consider a dome-shaped selectivity pattern for the AT age data (treated as a separate fleet) with the ascending limb time-varying;
- set the 2019 and 2020 Mexican catches to the average of the those for 2016-2018; and
- change the year in which the time change in Q for the AT survey occurs.

Rationale: These sensitivity analyses reflect some of the major sources of unresolved uncertainty.

The improvement in fit to the age composition information from the AT survey was improved only a little with dome-shaped selectivity. Cohorts do not seem to track well through the AT survey age compositions, and I think these data are hard to fit well with a stock assessment model unless a time-varying selectivity model is used which I don't think is a good idea. However, it is a concern to me that the AT survey sardine sampling does not seem to adequately estimate the size and age distribution of the stock very well. I am not sure why, but I recommend that future research be conducted to better understand this problem and hopefully provide better estimates of the length and age composition of sardines measured in the acoustic survey.

I agree with the Panel that model results were not sensitive to changing the year in which Q changes.

Request 23: Provide a joint likelihood profile across M and Q. Add standard profiles on M, steepness and Q. Also show how derived parameters change across the likelihood surface (e.g., 2020 season 1 biomass and stock depletion), where appropriate. Rationale: M and Q are likely influencing the poor fits, a joint likelihood profile across M and Q would be helpful.

The joint profile on M and Q, using a single fixed parameter for Q, showed the correlation between these two parameters. How the derived parameters changed across the likelihood surface (e.g., 2020 season 1 biomass and stock depletion), was not available when I wrote this report. I conclude that this analysis did not indicate a need to change the new base model formulation.

Request 24: Conduct additional sensitivity tests in which (a) the AT age data are down-weighted by 50%, (b) the PNW age data are down-weighted by 50%, (c) the AT age data are restricted to 2017 onwards, and (d) an additional variance parameter is estimated for the AT survey. Rationale: The Panel wished to explore the sensitivity of the results of the weighting of the data.

I agree with the Panel that the time-trajectories of biomass (both long-term and recent) are robust to these changes. I conclude that this analysis did not indicate a need to change the new base model formulation.

Hence, I conclude that the new base model formulation briefly described in Request 21 is the best available.

ToR 3. Determine whether the stock assessment or technical analysis is sufficiently complete. Specify whether or not the science reviewed is the best scientific information available.

The stock assessment was sufficiently complete, and the science reviewed is the best scientific information available.

ToR 4. When possible, provide specific suggestions for future improvements in any relevant aspects of data collection and treatment, modeling approaches and technical issues, differentiating between the short-term and longer-term time frame.

Most of my recommendations on future research that may improve the stock assessment of Pacific sardine were incorporated into the Panel Research Recommendations. I expand on two of these recommendations in this section. I presented some other research recommendations under ToRs 1-2, and these will be summarized below.

An important assessment issue involves biological sampling of fish species detected in the acoustic surveys (i.e., species and size compositions). Bias in the estimation of species and size compositions could directly affect AT survey estimates of Pacific sardine biomass. I appreciate that the high mobility of the pelagic species makes biological sampling difficult. My expertise is more about how to estimate stock assessment models and I have little expertise on how to conduct acoustic surveys for pelagic species. However, fishermen at the Panel indicated that they felt there were various sources of bias in the AT survey trawl samples, and some directed studies to examine these issues seem warranted in the future. For example, some directed purse seine sampling using industry vessels of schools detected during the AT survey might provide some insight about the efficacy of AT trawl samples collected later at night. Discrimination between sardines and anchovy in acoustic sampling seems like an issue, although it is not clear to me that purse seine samples will help with this if the seiners have low selectivity for anchovy. I wonder if EDNA samples from acoustic aggregations could provide some quantification of species composition.

Another important assessment issue involves the fraction of the stock that is shoreward of the AT survey. The CCPSS aerial survey seems like a practically useful survey for this purpose; however, this survey needs to cover more of the stock range and have reasonable biological

sampling of schools detected to determine their species and size compositions. Some directed study of school detection probabilities is also required. I agree with the Panel recommendation that increased collaboration between SWFSC and CDFW scientists should lead to better integration of the CCPSS survey information into the stock assessment. In particular, I emphasize the Panel recommendation that it is likely better if the AT and CCPSS survey information is integrated using spatiotemporal modelling techniques before using this information in a stock assessment model. It is better to provide a more spatially complete index of total stock abundance at length and/or age rather than letting a stock assessment model determine what fraction of stock size is available to spatially disparate surveys.

Conclusions and Recommendations

Recommendations are provided under Tor 4.

ToR 1. Review stock assessment data inputs and assumptions.

The Panel acknowledged the extensive efforts by the SWFSC to conduct and improve the California Current Ecosystem AT surveys; in particular, the increased density of acoustic transects, and the use of alternative survey platforms to provide data for the areas inshore of the regular AT survey area. In particular, I appreciated the extensive documentation on the AT surveys.

The CCPSS aerial survey needs to cover more of the stock range and have reasonable biological sampling of schools detected to determine their species and size compositions. Some directed study of school detection probabilities is also required.

I suspect that nearshore sardine biomass may be underestimated by the CCPSS survey, and the variance may be overestimated, although I am very uncertain about the latter. I suspect under-estimation of biomass because not all schools are detected in areas surveyed in CCPSS, and there is also biomass in regions not covered by the aerial surveys. However, the magnitude of the under-estimation cannot be quantified with the information presented to the Panel.

The Panel discussed the need for multiple flights over the same band to provide variance estimates because the current method of basing variance on the difference in biomass between strata (i.e., bands) may not be appropriate because it was clear that there are differences in the distribution of fish between bands. However, repeat sampling may result in over-estimation of the variance because of between-band movement of sardine schools between repeat samples.

Mexican catches are more uncertain than those in the US. A large fraction of the northern sardine stock has recently been estimated to be caught in Mexican fisheries (via apportionment). These catches have an important consequence in the assessment, and I find that this is a source of uncertainty that has not been accounted for in the stock assessment.

There was some smoothing of growth data that was poorly described.

The draft assessment document did not include a detailed summary of the basic assessment data (and data gaps), such as plots of the locations of the catches, and how the catches varied seasonally, temporally and spatially. I found that the assessment documentation was written

tersely in some places, with frequent references to earlier documents for explanations. Some terminology (e.g., spring and summer surveys, where summer precedes spring) created unnecessary confusion. I did not find a clear explanation about how age samples were selected for reading. It was more challenging than usual to understand the data inputs and assumptions for this assessment.

ToR 2. Review analytical models, assumptions, estimates, and major sources of uncertainty.

I conclude from the review meeting that the SS3 model was very competently applied. The selectivity models used in the proposed base model were appropriate, and the information content of the age composition data were appropriately accounted for in the assessment model.

AT survey Q is poorly identified in the final base model for this stock. However, this model formulation has AT survey Q fixed and obviously does not account for uncertainty in Q. There does not seem to be external sources of information about the range of Q values that are appropriate for Pacific sardines. Hence, this seems to be an important source of uncertainty that cannot be objectively (i.e., data-based) accounted for.

Steepness was also not estimable, and the STAT and Panel agreed that steepness would be fixed at 0.3 in the final base model. Since σ_R was fixed at 1.2, the assessment trends are not sensitive to reasonable values of steepness.

Uncertainty in the estimates of weight-at-age were not provided to the Review Panel nor were they included in uncertainty quantification for biomass estimates. This uncertainty should be provided to future Review Panels who could then consider if it is large enough to justify modifying assessment procedures to account for the uncertainty.

ToR 3. Determine whether the stock assessment or technical analysis is sufficiently complete. Specify whether or not the science reviewed is the best scientific information available.

The stock assessment was sufficiently complete, and the science reviewed is the best scientific information available.

ToR 4. When possible, provide specific suggestions for future improvements in any relevant aspects of data collection and treatment, modeling approaches and technical issues, differentiating between the short-term and longer-term time frame.

Fishermen at the Review Panel meeting felt there were some sources of bias in the AT survey trawl samples, notably surface dead zones and trawl sampling of vessel backwater. A collaborative research program between federal and state scientists and the fishing industry to examine the possibly important issues raised by fishermen seems warranted in the future.

Extend the CCPSS aerial survey to cover more of the stock range and have reasonable biological sampling of schools detected to determine their species and size compositions. Directed studies of school detection probabilities should also be conducted.

AT and CCPSS survey information should be integrated using spatiotemporal modelling techniques before using this information in a stock assessment model. It is better to provide a more spatially complete index of total stock abundance at length and/or age rather than letting a stock assessment model attempt to determine what fraction of stock size is available to spatially disparate surveys.

The length composition information from the Mexican catches and spring AT survey were not utilized in the age-based base model formulation recommended by the Panel. These length data could be included directly in an SS3 with an internal growth model. I realize this was attempted in the past and difficulties were encountered, but I recommend that additional research on this approach should be conducted in the future. It may be more valid to assume growth curves are the same between southern US and Mexican stock components rather than assuming age compositions are the same as was assumed in the model approved by the Panel.

Cohorts do not seem to track well through the AT survey age compositions. Future research should be conducted to better understand this problem and hopefully provide better estimates of the length and age composition of sardines measured in the acoustic survey.

Future research should be conducted on how to estimate the variance of the CCPSS biomass estimates.

Plots of the raw growth data should be presented, along with residuals from smoothing.

Some preliminary analysis of using an auto-correlated stock-recruit model was presented to improve short-term forecasts which requires forecasting recruitment. This research seemed useful and I encourage the STAT to pursue this for future assessments.

Whether one forecasts with a fixed F or a fixed catch will involve additional uncertainty the model does not account for, because neither the F nor a fixed catch value will likely be right as will be discovered in future assessments. Methods should be investigated, perhaps based on retrospective analysis of forecasted F's, to account for this additional uncertainty.

Critique of the NMFS review process, including suggestions for improvements of both process and products

Overall, I find the NMFS review process to be rigorous and at a high standard. However, we always strive to improve and I have a couple of suggestions for this.

I was somewhat misled by the documentation I was provided before the meeting, and I accept partial responsibility for not reading the documents provided before the review carefully enough. In previous assessment documents and in the 2020 draft assessment document I found text similar to 'the survey-based assessment remains the STAT's preferred approach for advising management regarding Pacific sardine abundance in the future'. I got the impression that the AT survey estimation of total stock size was very reliable. I did not understand that there was a change in Q issue or that biological sampling during the survey was a concern to some. The

clues are there in the documents in hindsight, but I did not get a good sense of these issues from my initial review of the documents. An issues list would have helped me key in on the important issues while I was reviewing the documents before the review meeting.

The Panel Chair had a lot of experience with this stock and SS3 and really drove the review at a rapid pace. Some of the SS3 options used in the draft and final base models were not described clearly enough for me. For example, I did not understand the R1 offset issue that was addressed during the review. While it is reasonable to expect reviewers to have expertise in the application of fish stock assessment methods (e.g., length/age-structured modeling approaches), the NMFS review process should recognize that SS3 is not commonly used in some assessment fora and some stock assessment experts, such as myself, will not understand the intricacies of SS3. It will be helpful to provide descriptions of assessment models and estimation methods that are clear for non-SS3 experts. However, I appreciate that we would have run out of time during the Review Panel meeting if much description of SS3 model formulation and estimation has been given. In the past I have read documents about SS3 but it is hard, if not impossible, to remember all that is going on in that software.

Appendix 1: Bibliography of materials provided for review

Meeting Materials:

Proposed Agenda. Pacific Sardine Stock Assessment Review.

Terms of Reference for the Groundfish and Coastal Pelagic Species Stock Assessment and Review Process for 2019-2020. Pacific Fishery Management Council. APRIL 2019.

Peter T. Kuriyama, Juan P. Zwolinski, Kevin T. Hill, Paul R. Crone. Assessment of the Pacific sardine resource in 2020. Presentation.

Juan P. Zwolinski, Kevin L. Stierhoff, David A. Demer, and many others. Distribution, biomass, and demography of coastal pelagic fishes in the California Current Ecosystem during summer 2019 based on acoustic-trawl sampling. Presentation.

Kirk Lynn, Dianna Porzio, Trung Nguyen. California Coastal Pelagic Species Survey Results from Summer 2017 and 2019 for Pacific Sardine (*Sardinops sagax*).

Draft Stock Assessment Documents

Kuriyama, P.T., Zwolinski J.P., Hill, K.T., and Crone, P.R. Assessment of the Pacific sardine resource in 2020 for U.S. management in 2020-2021. Pacific Fishery Management Council, Portland, OR. Available from https://www.pcouncil.org/coastal-pelagic-species/stock-assessment-and-fishery-evaluation-safe-documents/

Background Materials

Past assessments and review documents

Hill, K.T., P.R. Crone, J.P. Zwolinski. 2017. Assessment of the Pacific sardine resource in 2017 for U.S. management in 2017-18. Pacific Fishery Management Council, April 2017 Briefing Book, Agenda Item G.5.a, Portland, Oregon. 146 p.

Hill, K.T., Crone, P.R., and Zwolinski, J.P. 2019. Assessment of the Pacific sardine resource in 2019 for U.S. management in 2019-20. Supplemental REVISED Attachment 1 (Full version electronic only) April 2019.

Pacific Fishery Management Council (PFMC). 2017. Pacific Sardine STAR Panel Meeting Report.

Pacific Fishery Management Council (PFMC). 2017. Scientific and Statistical Committee Report and Final Action and Sardine Assessment, Specifications, and Management Measures.

Pacific Fishery Management Council (PFMC). 2019. DRAFT SUMMARY MINUTES Scientific and Statistical Committee.

Pacific Fishery Management Council (PFMC). 2019. Scientific and Statistical Committee Report on Pacific Sardine Assessment, Harvest Specifications, and Management Measures – Final Action.

Methodology reviews
Pacific Fishery Management Council (PFMC). 2017. Southern California Coastal Pelagic Species Aerial Survey Methodology Review.

Pacific Fishery Management Council (PFMC). 2018. Methodology Review Panel Report: Acoustic Trawl Methodology Review For Use in Coastal Pelagic Species Stock Assessments.

ATM and aerial surveys

Juan P. Zwolinski, Kevin L. Stierhoff, and David A. Demer. 2019. Distribution, biomass, and demography of coastal pelagic fishes in the California Current Ecosystem during summer 2017 based on acoustic-trawl sampling. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-610.

Kevin L. Stierhoff, Juan P. Zwolinski, and David A. Demer. 2019. Distribution, biomass, and demography of coastal pelagic fishes in the California Current Ecosystem during summer 2018 based on acoustic-trawl sampling. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-613.

Kirk Lynn, Dianna Porzio, Trung Nguyen. 2020. California Coastal Pelagic Species Survey Results from Summer 2017 and 2019 for Pacific Sardine (*Sardinops sagax*).

Stierhoff, K.L., Zwolinski, J.P., Renfree, J.S. and Demer, D.A., 2017. Report on the Collection of Data During the Acoustic-Trawl and Daily Egg Production Methods Survey of Coastal Pelagic Fish Species and Krill (1504sh) Within the California Current Ecosystem, 28 March to 1 May 2015, Conducted Aboard Fisheries Survey Vessel Bell M. Shimada. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-580.

Stierhoff, Kevin L., Juan P. Zwolinski, Josiah S. Renfree, Gabriel E. Johnson, Scott A. Mau, David W. Murfin, Thomas S. Sessions, and David A. Demer. 2020. Report on the Summer 2019 California Current Ecosystem Survey (1907RL), 13 June to 9 September 2019, conducted aboard NOAA Ship Reuben Lasker, fishing vessels Lisa Marie and Long Beach Carnage, and three unmanned sailboats. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-625.

Stierhoff, Kevin L., Juan P. Zwolinski, and David A. Demer. 2020. Distribution, biomass, and demography of coastal pelagic fishes in the California Current Ecosystem during summer 2019 based on acoustic-trawl sampling. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-626. https://doi.org/10.25923/nghv-7c40.

Sigma re-evaluation

Kristin M. Privitera-Johnson and André E. Punt. 2019. Estimating among-assessment variation in overfishing limits.

Kristin M. Privitera-Johnson and André E. Punt. 2019. Addendum – Estimating among-assessment variation in overfishing limits.

Chantel R.Wetzel and Owen Hamel. 2019. Accounting for increased uncertainty in setting precautionary harvest limits from past assessments.

Appendix 2: CIE Statement of Work

Performance Work Statement

National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)
Center for Independent Experts (CIE) Program
External Independent Peer Review

STAR Panel Review of the 2020-2021 Pacific Sardine Stock Assessment

February 24-27, 2020

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards. (http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf). Further information on the CIE program may be obtained from www.ciereviews.org.

Scope

The CIE reviewers will serve on a Stock Assessment Review (STAR) Panel and will be expected to participate in the review of Pacific sardine stock assessment. The Pacific sardine stock is assessed regularly (currently, every year) by SWFSC scientists, and the Pacific Fishery Management Council (PFMC) uses the resulting biomass estimate to establish an annual harvest guideline (quota). The stock assessment data and model are formally reviewed by a Stock Assessment Review (STAR) Panel once every three years, with a coastal pelagic species subcommittee of the Scientific and Statistical Committee (SSC) reviewing updates in interim years. Independent peer review is required by the PFMC review process. The STAR Panel will

review draft stock assessment documents and any other pertinent information for Pacific sardine, work with the stock assessment teams to make necessary revisions, and produce a STAR Panel report for use by the PFMC and other interested persons for developing management recommendations for the fishery. The PFMC's Terms of Reference (ToRs) for the STAR Panel review are attached in Appendix 1. The tentative agenda of the Panel review meeting is attached in Appendix 2. Finally, a Panel summary report template is attached as Appendix 3.

Requirements

Two CIE reviewers shall participate during a panel review meeting in La Jolla, California during 24-27 February, and shall conduct an impartial and independent peer review accordance with this Performance Work Statement (PWS) and ToRs herein. The CIE reviewers shall have the expertise as listed in the following descending order of importance:

- The CIE reviewer shall have expertise in the design and execution of fishery-independent surveys for use in stock assessments, preferably with coastal pelagic fishes.
- The CIE reviewer shall have expertise in the application of fish stock assessment methods, particularly, length/age-structured modeling approaches, e.g., 'forward-simulation' models (such as Stock Synthesis, SS) and it is desirable to have familiarity in 'backward-simulation' models (such as Virtual Population Analysis, VPA).
- The CIE reviewer shall have expertise in the life history strategies and population dynamics of coastal pelagic fishes.
- It is desirable for the CIE reviewer to be familiar with the design and application of fisheries underwater acoustic technology to estimate fish abundance for stock assessment.
- It is desirable for the CIE reviewer to be familiar with the design and application of aerial surveys to estimate fish abundance for stock assessment.

The CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review process.

Tasks for reviewers

- Review the following background materials and reports prior to the review meeting: *Two weeks before the peer review, the NMFS Project Contact will send by electronic mail or make available at an FTP site to the CIE reviewers all necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE on where to send documents. The CIE reviewers shall read all documents in preparation for the peer review, for example:*

    - *Recent stock assessment documents since 2013;*
    - *STAR Panel- and SSC-related documents pertaining to reviews of past assessments;*

- *CIE-related summary reports pertaining to past assessments; and*
- *Miscellaneous documents, such as the PWS, logistical considerations.*

Pre-review documents will be provided up to two weeks before the peer review. Any delays in submission of pre-review documents for the CIE peer review will result in delays with the CIE peer review process, including a PWS modification to the schedule of milestones and deliverables. Furthermore, the CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the PWS scheduled deadlines specified herein.

- Attend and participate in the panel review meeting
  - The meeting will consist of presentations by NOAA and other scientists, stock assessment authors and others to facilitate the review, to provide any additional information required by the reviewers, and to answer any questions from reviewers
- After the review meeting, reviewers shall conduct an independent peer review in accordance with the requirements specified in this PWS, OMB guidelines, and TORs, in adherence with the required formatting and content guidelines; reviewers are not required to reach a consensus
- Each reviewer may assist the Chair of the meeting with contributions to the summary report, if required by the TORs
- Deliver their reports to the Government according to the specified milestone dates

Foreign National Security Clearance

When reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/ and http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance

The place of performance shall be at the contractor's facilities, and at the NMFS Southwest Fisheries Science Center in La Jolla, California.

Period of Performance

The period of performance shall be from the time of award through April 30, 2020. Each reviewer's duties shall not exceed 14 days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

Schedule	Milestones and Deliverables
January 27, 2020	CIE sends reviewers contact information to the COTR, who then sends this to the NMFS Project Contact
No later than February 10, 2020	NMFS Project Contact sends the CIE Reviewers the pre-review documents
February 24-27, 2020	The reviewers participate and conduct an independent peer review during the panel review meeting
Within two weeks after review	Contractor receives draft reports and summary report
Within two weeks of receiving draft reports	Contractor submits final reports to the Government

Applicable Performance Standards
The acceptance of the contract deliverables shall be based on three performance standards: (1) The reports shall be completed in accordance with the required formatting and content (2) The reports shall address each TOR as specified (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel
All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790). International travel is authorized for this contract.

Restricted or Limited Use of Data
The contractors may be required to sign and adhere to a non-disclosure agreement.

Appendix 2.1: Peer Review Report Requirements

1. The report must be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether or not the science reviewed is the best scientific information available.

2. The report must contain a background section, description of the individual reviewers' roles in the review activities, summary of findings for each TOR in which the weaknesses and strengths are described, and conclusions and recommendations in accordance with the TORs.

   a. Reviewers must describe in their own words the review activities completed during the panel review meeting, including a brief summary of findings, of the science, conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each TOR even if these were consistent with those of other panelists, but especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the summary report that they believe might require further clarification.

   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The report shall represent the peer review of each TOR, and shall not simply repeat the contents of the summary report.

3. The report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of this Statement of Work
   Appendix 3: Panel membership or other pertinent information from the panel review meeting.

Appendix 2.2: Terms of Reference for the Peer Review of the Pacific sardine stock assessment

The CIE reviewers are one of the four equal members of the STAR panel. The principal responsibilities of the STAR Panel are to review stock assessment data inputs, analytical models, and to provide complete STAR Panel reports.

Along with the entire STAR Panel, the CIE Reviewer's duties include:

1. Reviewing draft stock assessment and other pertinent information (e.g.; previous assessments and STAR Panel reports);
2. Working with Stock Assessment Team (STAT) Teams to ensure assessments are reviewed as needed;
3. Documenting meeting discussions;
4. Reviewing summaries of stock status (prepared by STAT Teams) for inclusion in the Stock Assessment and Fishery Evaluation (SAFE) document;
5. Recommending alternative methods and/or modifications of proposed methods, as appropriate during the STAR Panel meeting, and;
6. The STAR Panel's terms of reference concern technical aspects of stock assessment work. The STAR Panel should strive for a risk neutral approach in its reports and deliberations.

The STAR Panel, including the CIE Reviewers, are responsible for determining if a stock assessment or technical analysis is sufficiently complete. It is their responsibility to identify assessments that cannot be reviewed or completed for any reason. The decision that an assessment is complete should be made by Panel consensus. If agreement cannot be reached, then the nature of the disagreement must be described in the Panels' and CIE Reviewer's reports.

The review solely concerns technical aspects of stock assessment. It is therefore important that the Panel strive for a risk neutral perspective in its reports and deliberations. Assessment results based on model scenarios that have a flawed technical basis, or are questionable on other grounds, should be identified by the Panel and excluded from the set upon which management advice is to be developed. The STAR Panel should comment on the degree to which the accepted model scenarios describe and quantify the major sources of uncertainty Confidence intervals of indices and model outputs, as well as other measures of uncertainty that could affect management decisions, should be provided in completed stock assessments and the reports prepared by STAR Panels.

Recommendations and requests to the STAT Team for additional or revised analyses must be clear, explicit, and in writing. A written summary of discussion on significant technical points and lists of all STAR Panel recommendations and requests to the STAT Team are required in the STAR Panel's report. This should be completed (at least in draft form) prior to the end of the meeting. It is the chair and Panel's responsibility to carry out any follow-up review of work that is required.

Appendix 2.3: DRAFT AGENDA: 2020 PACIFIC SARDINE STAR PANEL

Monday, 24 February		
08h30	Call to Order and Administrative Matters	
	Introductions	Punt
	Facilities, e-mail, network, etc.	Sweetnam
	Work plan and Terms of Reference	Griffin
	Report Outline and Appointment of Rapporteurs	Punt
09h00	Pacific Sardine survey-based assessment presentation	Kuriyama/Hill/Crone
10h00	Break	
10h30	Pacific Sardine model-based assessment presentation	Kuriyama/Hill/Crone
11h30	Acoustic and trawl survey	Zwolinski, ATM group
12h00	Lunch	
13h30	Pacific Sardine assessment presentation (continue)	Kuriyama/Hill/Crone
14h30	Panel discussion and analysis requests	Panel
15h00	Break	
15h30	Public comments and general issues	
17h00	Adjourn	

Tuesday, 25 February	
08h00. Assessment Team Responses	Kuriyama/Hill/Crone
10h30 Break	
11h00. Discussion and STAR Panel requests	Panel
12h30 Lunch	
13h30 Report drafting	Panel
15h00 Break	
15h30 Assessment Team Responses	Kuriyama/Hill/Crone
16h30 Discussion and STAR Panel requests	
17h00 Adjourn	

Wednesday, 26 February	
08h00. Assessment Team Responses	Kuriyama/Hill/Crone
10h30 Break	
11h00. Discussion and STAR Panel requests	Panel
12h30 Lunch	
13h30 Report drafting	Panel
15h00 Break	
15h30 Assessment Team Responses	Kuriyama/Hill/Crone
16h30 Discussion and STAR Panel requests	
17h00 Adjourn	

Thursday, 27 February	
08h00. Assessment Team Responses	Kuriyama/Hill/Crone
10h30 Break	
11h00. Discussion and STAR Panel requests	Panel
12h30 Lunch	
13h30 Finalize STAR Panel Report	Panel
15h00 Break	
15h30 Finalize STAR Panel Report	Panel
17h00 Adjourn	

Appendix 2.4: STAR Panel Summary Report (Template)

- Names and affiliations of STAR Panel members
- List of analyses requested by the STAR Panel, the rationale for each request, and a brief summary the STAT responses to each request
- Comments on the technical merits and/or deficiencies in the assessment and recommendations for remedies
- Explanation of areas of disagreement regarding STAR Panel recommendations
  - Among STAR Panel members (including concerns raised by the CPSMT and CPSAS representatives)
  - Between the STAR Panel and STAT Team
- Unresolved problems and major uncertainties, e.g., any special issues that complicate scientific assessment, questions about the best model scenario, etc.
- Management, data or fishery issues raised by the public and CPSMT and CPSAS representatives during the STAR Panel
- Prioritized recommendations for future research and data collection

Appendix 3: Panel membership or other pertinent information from the panel review meeting

STAR Panel Members:

André Punt (Chair), Scientific and Statistical Committee (SSC), Univ. of Washington
Marisol García-Reyes, Scientific and Statistical Committee (SSC), Farallon Institute
Melissa Haltuch, Scientific and Statistical Committee (SSC), NOAA/NWFSC
Noel Cadigan, Center of Independent Experts (CIE)
José De Oliveira, Center of Independent Experts (CIE)

Pacific Fishery Management Council (Council) Representatives:

Kerry Griffin, Council Staff
Diane Pleschner-Steele, CPSAS Advisor to STAR Panel
Alan Sarich, CPSMT Advisor to STAR Panel

Pacific Sardine Stock Assessment Team:

Peter Kuriyama, NOAA / SWFSC
Kevin Hill, NOAA / SWFSC
Paul Crone, NOAA / SWFSC
Juan Zwolinski, Univ. California Santa Cruz, affiliated to NOAA/ SWFSC