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Individual CIE Report

STAR Panel Review of 2014-2015 Pacific Sardine Stock Assessment

Southwest Fisheries Science Center, La Jolla, California, 3-5 March 2014

Prepared for the Center for Independent Experts

By

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Executive Summary

A STAR Panel review of the 2014-2015 stock assessment of the northern subpopulation of Pacific sardine (*Sardinops sagax*) was held during 3-5 March 2014 in La Jolla, California. The review activities included reviewing the draft stock assessment and other pertinent information provided in advance of the review meeting, working with the STAT team to ensure input data and assessment models are reviewed as necessary, and recommending alternative methods and/or modifications to proposed methods, as appropriate. This report describes the material and methods provided for the review, and focuses on the review activities leading up to the selection of the final model for the 2014-2015 stock assessment, providing a summary of findings and recommendations. Review activities focussed primarily on alternative weighting for compositional data and found that, although abundance trends were generally well-determined by the available data, the absolute scale of the population was highly uncertain, with small changes to the model leading to large changes in scale. The assumption of catchability equal to 1 for both the ATM spring and summer surveys was key to reducing sensitivity to scale, although biomass estimates for the early years of the assessment remained volatile. The Panel could find no reason to disagree with the STAT's decision to omit the NWSS aerial survey from the assessment, and also supported the omission of the ATM conditional age-at-length data from the assessment, because the age-length keys that they relied on were inappropriately assembled, and model results were highly sensitive to alternative weightings for these data. The final model continued to show a high level of variation in terminal biomass (reflected by a strong retrospective pattern), but this has been seen in the past for this stock and will likely continue to be the case in future assessments. The Panel report provides results for the final model for both options for assigning catch to the northern subpopulation, the first using an environmentally-based method to remove southern subpopulation fish from the Mexican-southern Californian fleet data, and the second assuming all catches taken by the Mexican-southern Californian fleet belong to the northern subpopulation. The Panel concluded that the final model represented the best available science regarding the current status of the northern subpopulation of Pacific sardine. The CIE reviewer fully supports and endorses the Panel's findings and recommendations, as reflected in their report.

Background

The review concerns the 2014-2015 stock assessment for the northern subpopulation of Pacific sardine (*Sardinops sagax*). The majority of review material (including detailed output for two proposed models, and the draft assessment report) was made available through the FTP site (http://swfscftp.noaa.gov/) between 19-21 February 2014 – the review material made available before, during and after the STAR Panel review meeting is given in Annex 1. The actual STAR Panel review took place at the Southwest Fisheries Science Center in La Jolla, California over 3-5 March 2014. Details of this meeting, including Terms of Reference and Agenda, can be found in Annex 2 and its Appendices, and a list of participants in Annex 3.

The STAR Panel comprised four equal members, two of which were CIE reviewers (see Annex 3). The main responsibilities of the STAR Panel were as follows:

(a) Review stock assessment data inputs.
(b) Review the analytical models presented.
(c) Provide complete STAR Panel reports.

In particular, the STAR Panel are responsible for determining if a stock assessment or technical analysis is sufficiently complete, with any decision on this having to be made by Panel consensus.

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

1. Reviewing the draft stock assessment and other pertinent information (e.g. previous assessments and STAR Panel reports).
   This was done by reviewing material provided prior to and during the meeting (Annex 1).
2. Working with STAT Team to ensure assessments are reviewed as needed.
   A number of requests were made to explore model sensitivity to alternative parameterisations and data weighting scenarios, including the exclusion of some data (Annex 4).
3. Documenting meeting discussions.
   These are reflected in the STAR Panel report and below.
4. Reviewing summaries of stock status (prepared by STAT Team) for inclusion in the Stock Assessment and Fishery Evaluation (SAFE) document.
   These were provided during the meeting in the form of detailed model outputs for the final model (T-2_0.2; see Annex 5 for description), uploaded to the FTP site.
5. Recommending alternative methods and/or modifications of proposed methods, as appropriate, during the STAR Panel meeting.
   These were reflected in the number of requests the STAR Panel made to the STAT (Annex 4) as well as the research recommendations (see STAR Panel report and below).
6. The STAR Panel's terms of references 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 indeed kept to technical aspects of the stock assessment and its input data.

Following the meeting, a careful review of the STAR Panel report was conducted and suggestions made for improvements, making sure that all statements and conclusions were backed up and justified by model outputs and results. The STAT was requested to add key model outputs to the FTP site that were needed for the purposes of corroboration.

Review activities and findings

The Agenda for the meeting is given in Appendix 3 of Annex 2, and detailed descriptions with accompanying rationale and outcomes for all review requests provided in Annex 4. This section attempts to summarise these activities and their findings.

Presentations

Presentations included a description of the seasonal distributions of the northern subpopulation, with associated fishing areas and modelled fleets; a description of the fishery data (landings and length and age compositions for the MexCal fleet by semester, and for the PacNW fleet by year); a description of the general survey areas for the spring and summer ATM surveys, the spring DEPM/TEP survey, and the summer NWSS aerial survey; a description of the survey time series available for each of these surveys, as well as the associated length and age compositions for the ATM surveys, and the length compositions for the NWSS aerial survey. In-depth presentations were made on methodology for the DEPM surveys and estimation procedure, and the ATM spring and summer surveys, including the environmental method used to differentiate between the northern and southern subpopulations of Pacific sardine. There was no specific presentation on the NWSS aerial survey, but a summary was provided by email and included in the Panel report. Key aspects of blended models G and H (results of which had been made available prior to the meeting on the FTP site and in the draft assessment document, along with a range of sensitivity analyses) were presented and compared with each other and with previous assessment results. The key difference between models G and H was that the former assumed length-specific selection by fitting to length-composition data, and estimated growth by fitting to conditional age-at-length data (which was down-weighting further relative to input weights), while the latter assumed age-specific selection by fitting the age-composition data and setting growth parameters to pre-specified values. The Stock Synthesis version used for the 2014-2015 assessment models was Version 3.24s. A presentation on issues affecting the use of composition data, including data weighting (a key concern for the Pacific sardine assessment) was given.

Exploring input data

Differentiating the northern subpopulation
A key concern for the assessment (and one highlighted by past Panels as a high research priority) was that catches should be appropriately allocated to the northern and southern subpopulations of Pacific sardine; to this end, an environmentally-based method was developed and used to exclude some of the data (catches and associated composition data) belonging to the southern subpopulation (taken in the San Pedro and Ensenada fisheries, the southern portion of the MexCal fleet) from the assessment. The Panel and STAT were in favour of this new approach, but foresaw difficulties for management related to setting catch levels for a portion of a population (the southern subpopulation) for which there is no assessment. A decision was therefore made to conduct all sensitivity analyses using the environmentally-based method for deriving the northern subpopulation fishery data, but then to present the final model as two versions, one where the environmentally-based method is

used to remove southern subpopulation fish from the MexCal fleet data, and the other assuming that all catches taken in the MexCal fleet belong to the northern subpopulation. Request C (Annex 4) found that the environmentally-based method was potentially sensitive to the threshold used to switch between whether an area was more suitable for the northern or for the southern subpopulation; if further analysis continues to find the method sensitive for plausible alternative threshold values, it may require further refinement.

DEPM survey
The Panel highlighted two minor issues with the DEPM estimation procedures that, although they may not lead to large changes in the estimates, nevertheless need to be corrected. These related to the appropriate area allocation for each point in each of two strata (high and low density), and appropriately accounting for transect-based sampling and correlated observations.

ATM surveys
During spring 2013, it was noticed that the ATM survey did not venture north of San Francisco, and concern was expressed that suitable habitat for sardine at the time may have been missed (Request D, Annex 4). However, an overlay of a habitat map with the survey results did not show evidence of this being the case, suggesting that the survey did indeed provide an adequate sample of the population. Furthermore, the ATM survey team considered the spring 2012 ATM survey length frequency as unreliable, and sensitivity tests explored the omission of this data (Request S, Annex 4) as well as the omission of the spring 2011 ATM survey length frequency data (Request U, Annex 4), since model fits to both these length frequencies were always poor. The latter request (U) helped in the selection of appropriate weighting for compositional data in the final model; however, the final model included both these length frequencies. The ATM survey team were also asked to investigate the apparent discrepancy between the biomass estimates from the ATM survey in the Oregon-Washington area during summer 2012 and the contemporaneous landings in the area (Request E, Annex 4); they found that point estimates from the survey comfortably exceeded the landings, and that assuming fish had migrated from the south, the landings were below the lower 95% confidence bound for combined survey estimate for the same period and area, and for the area to the north of it surveyed immediately afterwards.

Conditional age-at-length for the ATM surveys
When constructing ALKs for fish aged during ATM surveys, no weighting was used (aged fish were simply combined into a single ALK), despite possible differences between regions (e.g. separate ALKs were used for the MexCal and PacNW fleets). This treatment is not optimal, given the possibility for age- and size-specific distribution of sardine. This was one of the reasons the Panel supported the removal of conditional age-at-length data for the ATM surveys from the final model. Panel Request B (Annex 4) was intended to investigate this more closely, but was not pursued during the meeting because blended model H (age-based) was ignored; however, a research recommendation was raised.

NWSS aerial survey
Apart from a sensitivity analysis (Request G, Annex 4), the aerial survey was omitted from blended models G and H and all subsequent models developed during the meeting, including the final model. The Panel did not see evidence to disagree with the STAT's recommendation to omit the aerial survey.

Sensitivity analyses

[Note, in an attempt to follow a narrative (grouping similar areas of investigation together), the order that requests are discussed below is not necessarily chronological or the same as followed in the Panel report.]

It was decided early on to focus on blended model G (length-based) because blended model H (age-based) was not as fully tested, and because the fishery age composition data ignored the length compositions for the fisheries at the extremes of the northern subpopulation distribution (i.e. in Canada and Mexico), thereby implicitly assuming that these length compositions were the same as those from adjacent fisheries (i.e. Oregon-Washington and southern California respectively). The first two of the Panel requests (Requests A and B, Annex 4) were therefore not considered, and instead put forward as research recommendations. This issue (assuming length compositions at the extremes are the same as adjacent areas for the purpose of compiling age data) remains a concern for the conditional age-at-length data used in the final model, although the additional weighting (λ=0.2) in the final model does further down-weight this data (see Annex 5).

The primary concern for the review was that appropriate weights were established and justified for the compositional data, particularly given the high sensitivity of stock assessment results to alternative weighting of the conditional age-at-length data. Sensitivity analyses focussed primarily on this aspect, but also looked at sensitivity to combining/splitting the spring and summer ATM survey *q*s (catchability) and selectivities, estimating/fixing the ATM survey *q*s, and omitting certain ATM spring survey length frequencies. Sensitivity to an alternative stock-recruit formulation (Request I, Annex 4) and to an alternative value for M (Request J, Annex 4) was also checked, but results were found to be either relatively insensitive (former) or predictable (latter).

Applications of "Francis weights" to compositional data

Blended model G applied rather arbitrary weights to the compositional data (λ=1 for all length composition data, and λ=0.5 for all conditional age-at-length data; Table A4.2, Annex 4). These weights were in addition to the input weights which accounted for effective sample sizes (note: when referring to weighting below, it is always in this context – i.e. in addition to input weights). One of the first tasks related to the stock assessment model itself was to investigate the effect of applying one of the weighting methods proposed by Francis (2011; method TA1.8) to the compositional data, referred to here and in the Panel report as "Francis weights". In order to derive these Francis weights, the STAT team first developed model K by setting all weights to 1 (λ=1 for all compositional data), then estimated the Francis weights using model K. The Panel supported this approach. Compared to model G, model K, which gave more weight to the conditional age-at-length data, substantially lowered estimates of biomass, and changed the spring ATM selection to be less knife-edge and more like the summer ATM selection pattern.

Francis weights derived from model K (and implemented as changes to λ) were applied to all compositional data (model F) which resulted in a severe down-weighting of all length composition data and up-weighting of all conditional age-at-length data apart from that for the PacNW fleet. However, some of the weights were poorly determined (e.g. for the ATM summer survey), so the Panel requested pooling of similar data sources (the summer and spring ATM surveys were pooled, and the first and second semester MexCal fleets were pooled), which led to improved estimates for weights (model L). Models F and L showed similar behaviour to each other; however, compared to G they gave substantially lower estimates of biomass (like K), and substantially different selection patterns for the two MexCal fleets (whereas K had shown changed selection for the spring ATM survey). These results led to further requests in order to isolate what was causing the differences.

In order to investigate whether it was the length composition data or the conditional age-at-length data that were most influential, model M assigned Francis weights only to the length composition data, while model N assigned Francis weights only to the conditional age-at-length data; in both cases, the compositional data that were not assigned Francis weights were allocated λ=1. Although biomass estimates for the earlier years for model M were affected, the scale and trend in biomass in recent years were relatively insensitive, whereas biomass estimates for model N were markedly lower throughout the times series, leading to the conclusion that weighting of the conditional age-at-length caused the most sensitivity. When allocating Francis weights to conditional age-at-length data for models F, L and N, it was noticed that weights greater than 1 were allocated to all but the PacNW fleet (λ well below 1), so model O was the same as model N but forced λ=1 for the conditional age-at-length data of the PacNW fleet. Results for model O were almost identical to model N.

Although they did not apply Francis weights, models U and W looked further into the question of which of the different sources of conditional age-at-length data were most influential. Considering the weighting for conditional age-at-length data only and compared to model G (for which λ=0.5 was used throughout for these data), model U kept λ=0.5 for the ATM survey but down-weighted all the fishery data (λ=0.01), while model W set λ=0 for the ATM survey (i.e. omitted the ATM survey conditional age-at-length data) but kept λ=0.5 for all the fishery data (see Annex 4, Table A4.2). The contrast between models U and W was quite marked, with U leading to much lower biomass levels than model G (and consequently unrealistically high estimates of survey q), and W much higher ones. Given these results and the Panel's unease with the way in which the conditional age-at-length data were constructed for the ATM surveys (see "Exploring input data" above), some of the later sensitivity tests and the final model ignored the conditional age-at-length data from the ATM surveys.

ATM survey q and selection

In order to investigate whether assessment data supported a single q for ATM surveys, one of the first assessment model requests (Request H, Annex 4) was to force q to be the same for the ATM spring and summer surveys, and instead of estimating the single q, scanning over a range of values for it (0.7 to 1.1 was run in steps of 0.1). From a likelihood point of view, there was no support for separate qs; furthermore, the biomass trajectory re-scales with changing q, and the selection pattern for the ATM spring survey flips from being almost knife-edged to being closer to the ATM summer survey selection as q increases. The lack of these changes occurring in a systematic way (as pointed out in the Panel report) is likely to do with the model not having obtained a global minimum in some cases. This behaviour (ATM spring survey selection markedly changing) was also noted for model K when conditional age-at-length data were up-weighted (λ changed from 0.5 to 1).

These results led to further requests (Requests P, Q and V, Annex 4) to investigate whether there was any support for treating the ATM spring and summer surveys as a single survey time series (i.e. with a common q and selection pattern for both spring and summer surveys). For model P the ATM spring and summer survey q and selection were forced the same, and when compared to model G resulted in a poorer fit to the ATM survey length frequency data, lower biomass estimates and consequently an unrealistically high survey q. Furthermore, for fish lengths below ~15cm and above ~20cm, the single ATM survey selection was respectively above and well below both the ATM spring and summer selection curves estimated under model G – the use of a single ATM selection curve with only two parameters to estimate for model P means there is less flexibility to deal with differences in the length frequencies (after accounting for growth and mortality) in the spring and summer surveys, and so a "compromise" selection curve is obtained, with the inevitable poorer fits to some length frequency data. Model Q was the same as P, but gave a much higher weighting (λ=20) to the ATM survey length frequency data in an attempt to improve the fits to these data. Although there were some improvements, the model was still unable to fit all the length frequencies adequately. Model V was an attempt to improve the fit to the ATM length frequencies by removing one of the ATM survey length frequencies (spring survey held in 2012) that the ATM survey team considered unreliable; the model (same as model Q but with the 2012 ATM spring survey compositional data omitted) was still unable to fit the remaining ATM survey length frequencies adequately.

Models R, S and T were an attempt to further understand the trade-offs involved depending on how the estimation of the ATM survey *q*s and selectivities were treated; in all these cases, the conditional age-at-length data for the ATM surveys were ignored (λ=0) for the reasons explained in the final paragraph of "Applications of 'Francis weights' to compositional data" above, and in the section "Exploring input data" also above. Models R and S assume the same *q* and selection pattern for the ATM spring and summer surveys, but the former estimates the single *q* while the latter sets it to 1; both cases result in higher estimates of biomass than model G (S being more optimistic than R). Model T sets the single *q* to 1, but estimates separate selectivities for the ATM spring and summer surveys; this results in lower estimates of biomass than model G and contrasts with model W (described earlier), which estimates separate ATM spring and summer *q*s (this is the only difference to model T) that results in even higher biomass estimates than model S. Given the difficulties encountered when assuming a single selection pattern for the ATM spring and summer surveys (previous paragraph), the Panel was leaning towards estimating separate selection patterns for the ATM spring and summer surveys.

Profiling over weights for the conditional age-at-length data

The Panel continued to have difficulty with the *ad-hoc* weighting assumed for the conditional age-at-length data (λ=0.5). Further requests therefore focussed on profiling over the λ weights for these data for a selection of models in order to better justify a value for λ. The models were: G (the base model), W (estimating separate ATM spring and summer survey *q*s) and T (a single ATM survey *q* fixed at 1), and the profiling models were labelled G-2, W-2 and T-2 respectively. A further version of model W was considered, where Francis weights were used for the length composition data, pooled for the MexCal fishery and for the ATM surveys (as was done for these data in model L), and this was labelled W-3. All these models estimated separate ATM spring and summer survey selection patterns. The initial approach, particularly for G-2, W-2 and W-3, was to specify a λ value that would result in the average of the ATM spring and summer survey *q*s being around 1. This was achieved for $\lambda\approx0.7$ for G-2 and for $\lambda\approx0.035$ for W-2, but was not achievable for W-3, the latter resulting in unrealistically low values for *q* for all λ values tried. Inclusion of the ATM survey conditional age-at-length data, and increasing λ on these data had the tendency of reducing biomass estimates (e.g. models G and K), so omission of these data led to higher biomass estimates (model W) which then required a much lower value of λ in order to reduce these biomass estimates to achieve an average ATM survey *q* of 1.

At this point the STAT and Panel agreed that selecting a weighting factor in order to achieve some average value of a survey q (in this case 1) was not a robust and sensible way to provide management advice, so focus shifted instead to model T-2, which explicitly assumed q=1 for both ATM surveys. Setting q=1 also helped reduce model sensitivity to weighting. Although profiling over the λ applied to the fishery conditional age-at-length data showed model T-2 to be quite sensitive to changes in this λ for the early years of the biomass trajectory, it was fairly robust for recent years; nevertheless, biomass trajectories for recent years fell into two groups, one where λ was 0.1, 0.2 and 0.4, and the other where it was 0.3, 0.5 and higher, which seemed to depend on which sort of data the model "latched onto" (similar "flipping" behaviour was described earlier under "ATM survey q and selection"; as before, the lack of this happening in a systematic way is likely due to the model not reaching its global minimum in some cases). This led the Panel to explore a means for selecting which group was most appropriate, so the λ values at the midpoint of each group were selected for further exploration, leading to models T-2_0.2 and T-2_0.7 (the numbers after the underscore reflecting the midpoint λ values).

Two approaches were used to try to isolate which of models T-2_0.2 and T-2_0.7 was the most appropriate to serve as a final model. The first approach (Request U, Annex 4) refitted each model without two ATM spring survey length frequencies (2011 and 2012), assuming that the observed "flipping" behaviour was due to trying to fit these two length frequencies (which were always poorly fitted); furthermore, the 2012 ATM spring survey length frequency was considered unreliable by the ATM survey team. The models using the first approach were re-labelled T-2_0.2a and T-2_0.7a respectively. The second approach (Request V, Annex 4) conducted a retrospective analysis (comparing the models with and without the most recent four years of data). The second approach did not provide a decisive means to distinguish between the two candidates (both models changing markedly), but the first approach did: models T-2_0.2a and T-2_0.7a both fell into the same group as T-2_0.2, indicating that the grouping behaviour discussed in the preceding paragraph was at least partially being caused by conflicts when fitting the two ATM survey length frequencies. Model T-2_0.2 was selected as the final model because it showed less sensitivity to the omission of 2011 and 2012 ATM spring survey length frequencies (but note that the final model did include these length frequencies). The specifications of the final model are provided in Annex 5.

Additional STAT runs
The STAT presented additional model runs on the final day that included time-varying selectivity (models X and X-1 in Table A4.2 of Annex 4), but there wasn't sufficient time to fully evaluate these models. However the Panel agreed that they would be valuable options to consider for future assessments.

Conclusions and recommendations

The STAT, with input from the Panel during the review, conducted a thorough investigation of input data and model settings leading up to selection of the final model (T-2_0.2) to be used for the 2014-2015 Pacific sardine stock assessment (Annex 5). These investigations focussed particularly on alternative weighting for compositional data. Although the trend in abundance is generally well determined by the available data, the absolute scale of the population continues to be uncertain (as found in previous years), with small changes to the model (e.g. relative weights assigned to compositional data) leading to large changes in model results (including population scale). The assumptions of q=1 for both ATM surveys was important to reduce model sensitivity, particularly to scale, but despite this, the scale of early years continued to be relatively sensitive. Previous assessments had investigated setting q=1 for the DEPM survey, but found that this lead to unrealistic qs for the ATM surveys.

The Panel could not find reason to disagree with the STAT's view that the NWSS aerial survey should be omitted from the assessment, so the final model excludes this data source. The final model also excludes the ATM spring and summer conditional age-at-length data because it was felt that the ALKs used were not appropriately assembled and because model results were particularly sensitive to alternative weights assigned to these data. In contrast, model results were relatively insensitive to alternative weights assigned to the length composition data (compare the following models: K to M, N to F, and P to Q and V). However, this conclusion (relative insensitivity to alternative weights for length composition data) only held while the ATM conditional age-at-length data were included (Figure 1). As soon as ATM conditional age-at-length data were omitted, model results became very sensitive to alternative weights assigned to the length composition data (compare W-2_0.3 and W-3_0.3 in Figure 1, where the "_0.3" refers to the value for λ assigned to the fishery conditional age-at-length data; this λ value was used because it was the only common value for which results were available on the FTP site for both models W-2 and W-3). This result supports the choice of q=1 for the ATM surveys in the final model (because it acts to stabilise the scale), but also raises the possibility that it may be worth including once again in future assessments the conditional age-at-length data for ATM surveys once the ALKs on which they are based have been appropriately assembled.

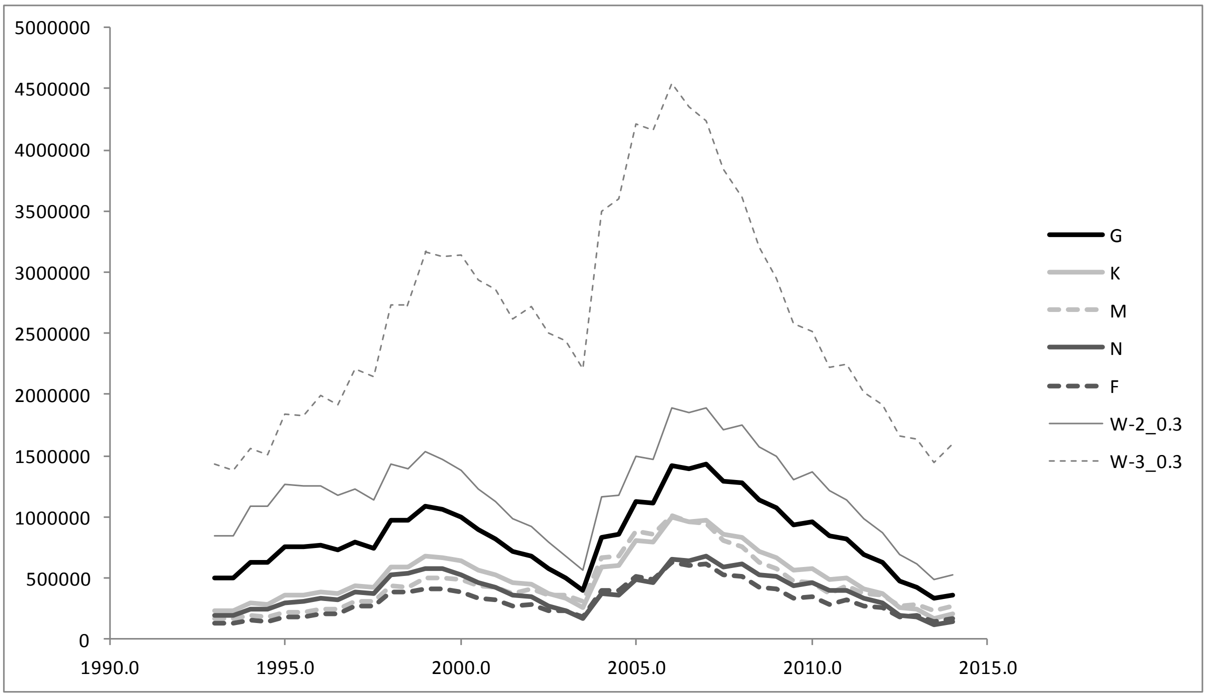

Figure 1. A comparison of models that assign Francis weights to the length composition data (broken lines), given a particular model configuration (solid line in the same colour). Model G is included for comparison. For a description of model differences, see Table A4.2 in Annex 4.

The final model uses separate selection patterns for the ATM spring and summer surveys, given the additional difficulties encountered when forcing these patterns to be the same (poorer fits to survey length frequency data and unrealistically high survey qs). The Panel concluded that the final model represented the best available science regarding the current status of the northern subpopulation of Pacific sardine, and that the level of variation in terminal biomass, reflected by a strong retrospective pattern, was both expected and seen in previous assessments, and will likely occur again in future assessments. The Panel report provides results for the final model for both options for assigning catch to the northern subpopulation, the first using the environmentally-based method to remove southern subpopulation fish from the MexCal fleet data, and the second assuming all catches taken in the MexCal fleet belong to the northern subpopulation.

A number of recommendations arose from the review, and these were classified as high (H), medium (M) or low (L) priority. Most of them were "rolled over" from previous STAR Panel reviews and related to the benefits of greater international cooperation (H), needed changes to the Stock Synthesis package (H), the need to consider models with a longer period of data for a broader context of changes in productivity (H), exploring additional fishery-independent data sources (H), exploring reasons for discrepancies in the observed and expected proportions of older fish in length and age compositions (M), continued support for the expansion of coast-wide sampling of adult fish (M), the need to consider spatial models in order to better capture regional variations in population dynamics (M), the need to explicitly consider sex-structure in models (despite the lack of sexual dimorphism in length-at-age samples demonstrated during this review) because of sensitivity to this seen in the past (M), the need to model fleets separately (Mexico, California, Oregon-Washington, Canada) (M), continued investigation of the pros and cons of age-based models rather than age-length ones given evidence for time- and spatially-varying growth (despite being presented as an option, age-based models were not really given any attention during this review) (M), further exploration of methods to reduce between-reader ageing bias (M), and developing a relationship between egg production and fish age that accounts for processes by age (e.g. duration of spawning and batch fecundity) (L).

Recommendations that specifically arose from this review were the following:

- Investigate the sensitivity of the assessment model to the threshold used in the environmentally-based method to delineate the northern and southern subpopulations of Pacific sardine. An initial investigation conducted during the review did not consider changing the threshold itself (this would require more time than available), but instead used a rough proxy for this and found that proportion allocated to each subpopulation was potentially sensitive to the threshold used. [H]
- Carry out validation of the environmentally-based method used to split catches between the northern and southern subpopulation of Pacific sardine. The development of simple discriminant factors from areas where mixing doesn't occur (e.g. morphometrics, otolith morphology and microstructure, latest developments in genetics) to be applied where mixing does occur or to areas close to the separation boundary was suggested. [H]
- Compute age compositions for the ATM surveys by applying weighted length frequencies to appropriately derived ALKs (i.e. taking into account where sampling occurred). This was one of the main reasons for ignoring the conditional age-at-length information for the ATM surveys. [H]
- Investigate alternative ways to deal with the most recent estimates of those that tend to be among the most uncertain and have a large impact on the estimation of 1+ biomass used for management. In the absence of information, the most recent recruitment estimates rely heavily on stock-recruit assumptions. The Panel report highlights several options for

dealing with these estimates of recruitment, including: a prediction model based solely on recent recruitment and observed autocorrelation; a recruitment prediction index developed outside the assessment model, such as proposed by Zwolinski and Demer (in press), and then combined with the assessment model estimate of recruitment in the form of a weighted mean, with weights derived by, for example, the method proposed by Shepherd (1997); direct inclusion of environmental indices within the assessment model that are informative about recruitment. The Panel report also highlights the challenges involved when investigating environmental drivers to explain recruitment – in particular that assessment uncertainty should not be ignored when using stock-recruit pairs, and that the degrees of freedom effect (leading to over-fitting data) should also not be ignored when considering a range of environmental indices (see e.g. De Oliveira and Butterworth 2005). [H]

- For the MexCal data, compare annual length compositions from Ensenada to those from California, and for the PacNW data, compare annual length compositions from British Columbia with those from Oregon-Washington. The length compositions from Ensenada and British Columbia were ignored in the age-based model (blended model H), because no age data was made available for these regions, and age compositions for adjacent areas were assumed to apply to these regions (i.e. implicitly assuming length compositions were the same as in adjacent areas). This recommendation is seen as important if age-based models are pursued in future, but it is also important because conditional age-at-length data (used in the age-length models presented for review) will have the same problem. [M]
- For the DEPM estimation methodology, change the method used to allocate area for each point included in each stratum, and apply a method that better accounts for transect-based sampling and correlated observations. These suggested changes have a potentially minor effect on estimates, but are nevertheless regarded as more appropriate. [M]
- Consider future research on natural mortality. The assessment models currently assume a time- and age-invariant value of 0.4. [M]

Comments on Terms of Reference

The terms of reference are given in "Background" above and in Appendix 2 of Annex 2. As a CIE reviewer, I participated fully in the activities of the STAR Panel, and provide full support to, and endorse the Panel's findings and recommendations, as reflected in their report. Comments on the individual terms of reference are already provided in italics in the "Background" section.

Comments on NMFS review process

The review process was thorough, but also fast-moving. Although understanding of the difficulty of doing it (lack of time and personnel, and volume of material), the one thing I did find frustrating was that model results produced during the meeting were not automatically made fully available on the FTP site, either during the meeting or afterwards (apart from those specifically requested for corroboration of report statements). I found that this did hamper slightly the review process for me, particularly when compiling this report (as I wanted to give careful consideration to all the model results covered during the meeting). If the volume of material was a concern, then even just making available the Report.sso files for all model runs would have been helpful. As a caveat to this, I must add that when I did ask for information, it was always provided. Apart from this, I found the review to be well-run, professionally handled and very informative, and I was appreciative of the efforts of the STAT to provide everything needed for the review, and of the organisers for their background work to ensure a smoothly run meeting.

References

De Oliveira, J.A.A. and D.S. Butterworth. 2005. Limits to the use of environmental indices to reduce risk and/or increase yield in the South African anchovy fishery. African Journal of Marine Science 2005, 27: 191–203.

Francis, R.I.C.C. 2011. Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences 68: 1124–1138.

Shepherd, J.G. 1997. Prediction of year-class strength by calibration regression analysis of multiple recruit index series. ICES Journal of Marine Science 54: 741–752.

Zwolinski, J.P. and D.A. Demer. In press. Environmental and parental control of Pacific sardine (*Sardinops sagax*) recruitment. ICES Journal of Marine Science. doi: 10.1093/icesjms/fst173.

Annex 1

Bibliography of materials provided for review

Background literature

Butler, J.L., Smith, P.E. and N. Chyan-Hueilo. 1993. The effect of natural variability of life-history parameters on anchovy and sardine population growth. CalCOFl Rep. 34: 104-111.

CPSMT. 2014. Coastal Pelagic Species Management Team report on sardine harvest parameters changes. Agenda item I.1.c, CPSMT Report, March 2014: 14pp.

Demer, D.A. and J.P. Zwolinski. 2014. Corroboration and refinement of a method for differentiating landings from two stocks of Pacific sardine (*Sardinops sagax*) in the California Current. ICES Journal of Marine Science, 71: 328–335.

Demer, D.A., Zwolinski, J.P., Cutter, G.R. Jr, Byers, K.A., Macewicz, B.J. and K.T. Hill. In press. Sampling selectivity in acoustic-trawl surveys of Pacific sardine (*Sardinops sagax*) biomass and length distribution. ICES Journal of Marine Science, doi.10.1093/icesjms/fst116.

Dorval, E., McDaniel, J.D., Porzio, D.L., Hodes, V., Felix-Uraga, R. and S. Rosenfield. 2013. Computing and selecting ageing errors to include in stock assessment models of Pacific sardine (*Sardinops sagax*). CalCOFI Rep. 54: 1-13.

Félix-Uraga, R., Gómez-Muñoz, V.M., Quiñónez-Velázquez, C. , Neri Melo-Barrera, F. and W. García-Franco. 2004. On the existence of Pacific sardine groups off the west coast of Baja California and Southern California. CalCOFI Rep. 45: 146-151.

Félix-Uraga, R., Gómez-Muñoz, V.M., Quiñónez-Velázquez, C., Neri Melo-Barrera, F., Hill, K.T. and W. García-Franco. 2005. Pacific sardine stock discrimination off the west coast of Baja California and southern California using otolith morphometry. CalCOFI Rep. 46: 113-121.

Garcia-Morales, R., Shirasago-German, B., Felix-Uraga, R. and E.L. Perez-Lezama. 2012. Conceptual models of Pacific sardine distribution in the California Current system. Current Develop. Oceangr. 5(1): 23-47.

Hurtado-Ferro, F. and A.E. Punt. 2014. Revised analyses related to Pacific sardine harvest parameters. School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA. PFMC March 2014 Briefing Book. Agenda Item I.1.b. 40 p.

Javor, B.J. 2013. Do shifts in otolith morphology of young Pacific sardine (*Sardinops sagax*) reflect changing recruitment contributions from northern and southern stocks? CalCOFI Rep. 54: 1-12.

MacCall, A.D. 1979. Population estimates for the waning years of the Pacific sardine fishery. CalCOFI Rep. 20: 72-82.

Murphy, G.I. 1966. Population biology of the Pacific sardine (*Sardinops caerulea*). Proc. Calif. Acad. Sci. Vol. 34 (1): 1-84.

Myers, R.A., Bowen, K.G., and N.J. Barrowman. 1999. Maximum reproductive rate of fish at low population sizes. Canadian Journal of Fisheries and Aquatic Sciences 56: 2404-2419.

Smith, P.E. 2005. A history of proposals for subpopulation structure in the Pacific sardine (*Sardinops sagax*) population off western North America. CalCOFI Rep. 46: 75-82.

Zwolinski, J.P. and D.A. Demer. 2013. Measurements of natural mortality for Pacific sardine (*Sardinops sagax*). ICES Journal of Marine Science 70: 1408-1415.

Zwolinski, J.P. and D.A. Demer. In press. Environmental and parental control of Pacific sardine (*Sardinops sagax*) recruitment. ICES Journal of Marine Science. doi:10.1093/icesjms/fst173.

Zwolinski, J.P., Emmett, R.L. and D.A. Demer. 2011. Predicting habitat to optimize sampling of Pacific sardine (*Sardinops sagax*). ICES Journal of Marine Science, 68: 867–879.

Stock Synthesis documentation

Methot, R.D. Jr. 2013. User manual for Stock Synthesis. Model Version 3.24s. Updated November 21, 2013: 152pp.

Methot, R.D. Jr. and C.R. Wetzel. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research 142: 86–99

Previous assessment reports and reviews

Hill, K.T. 2013. Pacific sardine biomass projection in 2013 for U.S. management during the first half of 2014 (Executive Summary). Agenda item E.5.b, Supplemental Attachment 2, November 2013: 7pp.

Hill, K.T., Crone, P.R., Lo, N.C.H., Macewicz, B.J., Dorval, E., McDaniel, J.D. and Y. Gu. 2011. Assessment of the Pacific sardine resource in 2011 for U.S. management in 2012. November 2011. NOAA-TM-NMFS-SWFSC-487: 264pp.

Hill, K.T., Crone, P.R., Lo, N.C.H., Demer, D.A., Zwolinski, J.P., and B.J. Macewicz. 2011. Assessment of the Pacific sardine resource in 2012 for U.S. management in 2013. December 2012. NOAA-TM-NMFS-SWFSC-501: 162pp.

Jagielo, T., Howe, R. and M. Mikesell. 2012. Northwest aerial sardine survey sampling results in 2012. Agenda item G.3.a, Attachment 6, November 2012: 82pp.

SSC. 2011. Scientific and Statistical Committee report on Pacific sardine assessment and coastal pelagic species management measures for 2012. Agenda item F.2.c, Supplemental SSC Report, November 2011: 2pp.

SSC. 2012. Scientific and Statistical Committee report on the Pacific sardine stock assessment and management for 2013, including preliminary EFP proposals and tribal set-aside. Agenda item G.3.c, Supplemental SSC Report, November 2012: 2pp.

SSC. 2013. Scientific and Statistical report on 2013 Pacific sardine stock assessment and management, including tribal set-aside. Agenda item E.5.c, Supplemental SSC Report, November 2013: 1p.

STAR Panel. 2011. Pacific sardine STAR Panel meeting report. Agenda item F.2.b, Attachment 5, November 2011: 24pp.

Model report and outputs on the FTP site (swfscftp.noaa.gov)

Prior to the meeting
Anon. 2014. Differentiating sardine landings (for highlighted section on page 10 of the assessment report – see Hill *et al*. 2014). 1p.

Dorval, E., Macewicz, B.J., Griffith, D.A., Lo, N.C.H. and Y. Gu. 2014. Spawning biomass of Pacific sardine (*Sardinops sagax*) off U.S. in 2013. Draft document: 42pp.

Hill, K.T., Crone, P.R. *et al*. (TBD). 2014. Assessment of the Pacific sardine resource in 2014 for U.S.A. management in 2014-15. Preliminary Draft for STAR Panel Review 3-5 March 2014: 137pp.

Comprehensive model outputs (all files and plots) for models G and H.

During the meeting
Selected model outputs for models H, I, J, P, Q, R, S, T, U, W, G-2 and W-2
Comprehensive model outputs for T-2_0.2_NSP (including retrospective patterns) and T-2_0.2_all (i.e. where environmental-based splitting of fishery data is not applied).

After the meeting
Comprehensive model outputs for models F, G, I, K, M, N, Q, V, W
Selected model outputs for W-3_0.3 and W-3_0.8

Presentations (during the meeting)

Assessment overview
Paul Crone

Assessment data
Background, sub-stocks, biology, fisheries, surveys, management – Kevin Hill
Stock structure and environment-based index (catch/composition) –Juan Zwolinski
Acoustic-trawl method (ATM) survey – David Demer
Daily egg production model (DEPM)/Total egg production (TEP) surveys – Emmanis Dorval
Overlaying spring 2013 survey with favourable habitat – Juan Zwolinski

Assessment results
Blended model (G and H) overview – Paul Crone
Data weighting considerations (composition vs. abundance time series) – Chris Francis
Sensitivity analysis and model G and H results – Paul Crone

Interactive assessment results during the meeting
Paul Crone and Kevin Hill

Annex 2

Copy of CIE Statement of Work

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Appendix 1**. This SoW describes the work tasks and deliverables of the CIE reviewers for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: 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 1-2 years) 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 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 2**. The tentative agenda of the Panel review meeting is attached in **Appendix 3**. Finally, a Panel summary report template is attached as **Appendix 4**.

Requirements for CIE Reviewers: Two CIE reviewers shall participate during a panel review meeting in La Jolla, California during 3-5 March, and shall conduct an impartial and independent peer review accordance with the SoW 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 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 execution of fishery-independent surveys for 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.

Location/Date of Peer Review: The CIE reviewers shall conduct an independent peer review during the STAR Panel review meeting at NOAA Fisheries, Southwest Fisheries Science Center, 8901 La Jolla Shores, La Jolla, California from March 3-5, 2014.

Statement of Tasks: The CIE reviewers shall complete the following tasks in accordance with the SoW, ToRs and Schedule of Milestones and Deliverables specified herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selections by the CIE Steering committee, the CIE shall provide the CIE reviewers information (name, affiliation, and contact details) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and information concerning other pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE 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 CIE reviewers who are non-US citizens. For this reason, the CIE 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/compliance_access_control_procedures/noaa-foreign-national-registration-system.html

Pre-review Background Documents: 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 ToR, 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 SoW 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 SoW scheduled deadlines specified herein.

Panel Review Meeting: The CIE reviewers shall conduct the independent peer review in accordance with the SoW and ToRs. **Modifications to the SoW and ToR cannot be made during the peer review, and any SoW or ToR modification prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE reviewers shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified in the contract SoW.

Respective roles of the CIE reviewers and STAR Panel chair are described in Appendix 2 (see p. 6-8). The CIE reviewers will serve a role that is equivalent to the other panelists, differing only in the fact that he/she are considered an 'external' member (i.e., outside the Pacific Fishery Management Council family and not involved in management or assessment of West Coast CPS). The CIE reviewers will serve at the behest of the STAR Panel Chair, adhering to all aspects of the PFMC's ToR as described in Appendix 2. The STAR Panel chair is responsible for: 1) developing an agenda, 2) ensuring that STAR Panel members (including the CIE reviewers), and STAT Teams follow the Terms of Reference, 3) participating in the review of the assessment (along with the CIE reviewers), 4) guiding the STAR Panel (including the CIE Reviewers) and STAT Team to mutually agreeable solutions.

The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: The CIE reviewers shall complete an independent peer review report in accordance with the SoW. The CIE reviewers shall complete the independent peer review according to required format and content as described in Appendix 1. The CIE reviewers shall complete the independent peer review addressing each ToR as described in Appendix 2.

Other Tasks – Contribution to Summary Report: The CIE reviewers will assist the Chair of the panel review meeting with contributions to the Summary Report. The CIE reviewers are not required to reach a consensus, and should instead provide a brief summary of their views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by the CIE reviewers in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review;
2) Participate during the panel review meeting in La Jolla, California during March 3-5, 2014 as called for in the SoW, and conduct an independent peer review in accordance with the ToRs (Appendix 2);
3) No later than March 24, 2014, the CIE reviewers shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Die., CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. The CIE report shall be written using the format and content requirements specified in Appendix 1, and address each ToR in Appendix 2.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

January 20, 2014	CIE sends reviewers contact information to the COTR, who then sends this to the NMFS Project Contact
February 14, 2014	NMFS Project Contact sends the CIE Reviewers the pre-review documents
March 3-5, 2014	The reviewers participate and conduct an independent peer review during the panel review meeting
March 24, 2014	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
April 14, 2014	CIE submits CIE independent peer review reports to the COTR
April 22, 2014	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be made through the Contracting Officer's Technical Representative (COTR) who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and Terms of Reference (ToR) of the SoW as long as the role and ability of the CIE Reviewers to complete the SoW deliverable in accordance with the ToRs and deliverable schedule are not adversely impacted. The SoW and ToRs cannot be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (the CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards: (1) the CIE report shall have the format and content in accordance with Appendix 1, (2) the CIE report shall address each ToR as specified in Appendix 2, (3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon notification of acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the approved CIE reports to the NMFS Project Contact and regional Center Director.

Support Personnel:

William Michaels, Program Manager, COTR
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1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
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Key Personnel:

Dale Sweetnam, **NMFS Project Contact**
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Dr. Russ Vetter, Director, FRD,
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Appendix 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR, and Conclusions and Recommendations in accordance with the ToRs.

   a. Reviewer should describe in their own words the review activities completed during the panel review meeting, including providing a detailed summary of findings, conclusions, and recommendations.

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

   c. Reviewer should elaborate on any points raised in the Summary Report that they feel might require further clarification.

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

   e. The CIE independent report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include as separate appendices as follows:

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

Appendix 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 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 3: Draft agenda: CPS STAR Panel

Monday 3 March

08h30	Call to Order and Administrative Matters	
	Introductions	Punt/Key
	Facilites, e-mail, network, etc.	Sweetnam
	Work plan and Terms of Reference	Griffin
	Report Outline and Appointment of Rapporteurs	Punt/Key
09h00	Pacific Sardine assessment presentation	Hill/Crone
10h00	Break	
10h30	Pacific Sardine assessment presentation	Hill/Crone
11h30	Acoustic and trawl survey	Zwolinski
12h00	Bayesian estimates of spawning fraction	Dorval
12h30	Lunch	
13h30	Pacific Sardine assessment presentation (continue)	Hill/Crone
14h30	Panel discussion and analysis requests	Panel
15h00	Break	
15h30	Public comments and general issues	
17h00	Adjourn	

Tuesday 4 March

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

Wednesday 5 March

08h00.	Assessment Team Responses	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	

Thursday 6 March (Optional, CIE Reviewers not required to attend)

08h00 Data Preparation for future CPS Stock Assessments
17h00 Adjourn

Appendix 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

Annex 3

STAR Panel membership and other pertinent information

STAR Panel Members:
André Punt (Chair), Scientific and Statistical Committee (SSC), Univ. of Washington
Meisha Key, SSC, California Department of Fish and Wildlife
José De Oliveira, Center for Independent Experts (CIE); Cefas
John Simmonds, Center for Independent Experts (CIE); ICES

Pacific Fishery Management Council (Council) Representatives:
Kerry Griffin, Council Staff
Diane Pleschner-Steele, CPSAS Advisor to STAR Panel
Chelsea Protasio, CPSMT Advisor to STAR Panel

Pacific Sardine Stock Assessment Team:
Kevin Hill, NOAA / SWFSC
Paul Crone, NOAA / SWFSC
Dave Demer, NOAA / SWFSC
Juan Zwolinski, NOAA / SWFSC
Emmanis Dorval, NOAA / SWFSC
Beverly Macewicz, NOAA / SWFSC

Other Attendees
Jenny McDaniel, SWFSC
Kirk Lynn, CDFG
Dale Sweetnam, SWFSC
Erin Reed, SWFSC
Ed Weber, SWFSC
Josh Lindsay, NMFS WCR
Russ Vetter, SWFSC
Al Carter, Ocean Companies
Richard Carroll, Jessie's Ilwaco Fish Company
Elizabeth Helmers, CDFW
Nancy Lo, SWFSC
Sam McClatchie, SWFSC
Richard Parrish, NMFS Emeritus
Yukong Gu, SWFSC
Jeff Laake, AFSC
Kevin Piner, SWFSC
William Watson, SWFSC
Elaine Acuňa, SWFSC
Anna Holder, CDFW
Joel Van Nord, CWPA
Noelle Bowlin, SWFSC
Mike Okoniewski, Pacific Seafood
Cisco Werner, SWFSC
Sarah Shoffler, SWFSC
Kristen Koch, SWFSC
Chris Francis, NIWA
Emily Gardner, SWFSC

Alex Da Silva, IATTC
Steven Teo, SWFSC
George Cutter, SWFSC
Mark Maunder, IATTC

AFSC – Alaska Fisheries Science Center
CDFW – California Department of Fish and Wildlife
CEFAS - Centre for Environment, Fisheries & Aquaculture Science
CPSAS - Coastal Pelagic Species Advisory Subpanel
CIE – Council on Independent Experts
CPSMT - Coastal Pelagic Species Management Team
CWPA – California Wetfish Producers Association
IATTC – Inter-American Tropical Tuna Commission
ICES – International Council for the Exploration of the Sea
NIWA - National Institute of Water and Atmospheric Research
NMFS - National Marine Fisheries Service
SSC - Scientific and Statistical Committee (of the Pacific Fishery Management Council)
SWFSC - Southwest Fisheries Science Center (National Oceanic and Atmospheric Administration)
WCR – West Coast Region

Annex 4

Relevant information from STAR Panel Report

Table A4.1. Requests, Rationale and Responses from STAR Panel Report. [Note: all Figures and tables referred to in the following table refer back to the STAR Panel Report, unless otherwise indicated.]

Nr	Request	Rationale	Response	Model(s)
A	Compare the yearly length-composition data for the Ensenada fishery that are included in the MexCal data set for the NSP scenario with the corresponding southern California length compositions. Also, compare the yearly length-composition data for the Oregon-Washington catches with those for the British Columbia fishery.	There are no age-length data for the Ensenada fishery or for the British Columbia fishery available for use in the assessment at this time, but model H implicitly assumes that the length frequencies for the Ensenada fishery are the same as those for the southern California fishery and that the length-frequencies for the British Columbia fishery are the same as those for the Oregon-Washington fishery.	This request was not required because the Panel focused on model G (length-based) that was presented as the potential base case model and not model H (age-based). Model H was not a focus for the Panel review because it was not as fully tested as model G and because the construction of the catch age-composition data ignored the length data for Mexico and British Columbia. However, this request has been put forward as a research recommendation.	-
B	Compute age-compositions for the ATM survey by multiplying the survey length-frequencies by the associated age-length keys. Compare the mean age-at-length time-series north and south of 40°10' from the ATM survey.	The age data for the ATM survey presented in the draft report were unweighted.	This request was not required because the Panel focused on model G (length-based) that was presented as potential base case model and not model H (age-based). However, this request has been put forward as a research recommendation.	-
C	Construct catch time series using a one month shorter and longer monthly duration for when the San Pedro and Ensenada fisheries are catching southern subpopulation fish.	To evaluate the sensitivity of the catches to the cutoff (50%) that is used to assign catches to the NSP.	Figure 1 shows that the results are likely to be somewhat sensitive to the cut-off chosen to define catches from the northern subpopulation. A research recommendation was raised to examine this issue further.	-
D	Overlay the habitat map with the spring survey results for the 2013 ATM survey.	The survey did not go north of San Francisco. The Panel was interested to know whether the areas north of San Francisco would have been expected to have been suitable habitat for Pacific sardine.	The plots showed no evidence of substantial suitable habitat north of San Francisco in the two weeks around the time the survey was conducted, which suggests that the survey should have provided an adequate sample of the population.	-
E	Provide additional information regarding the apparent discrepancy between the biomass estimates from the ATM survey in the Washington / Oregon area and the landings in	The Panel wished to have more information on this apparent discrepancy.	Juan Zwolinski noted that the ATM survey sampled the region between 44° 47.2'N and 48°18'N and from the 50m to the 1500m depth isobaths from 07/31/2012 to 08/10/2012. The resulting point estimate of sardine	-

Nr	Request	Rationale	Response	Model(s)
	this area, based on the information from 2012.		biomass was 13,333 mt. The sampling variance was high, resulting in a 95% confidence interval of [3,918, 27,559] mt. During the same time period, the commercial fishery off Oregon and Washington caught 9,747 mt. The ATM surveyed the area to the north, including northern Washington and western Vancouver Island, B.C. There, the sardine biomass was estimated at 18,675 mt, with a 95% confidence interval of [2,661, 54,017] mt. It was likely that by 08/10/2012, 32,008 mt of sardine, with 95% confidence interval [12,439, 68,945] mt, would have been available for the Oregon and Washington fisheries, assuming that all the sardine observed off western Vancouver Island migrated from the south.	
F	With model G (from initial draft), reweight the fishery and survey length-composition and conditional age-at-length data by applying the Francis (2011) weighting method (Equation TA1.8). The weighting factors should be implemented as changes to the lambdas in the SS model.	The compositional data may not be appropriately weighted.	The upper panel of Table 2 lists the factors to weight the input sample sizes (which are lower than the actual number of fish sized and aged), for each length-composition and conditional age-at-length data component that needs to be weighted. The response to this request (and requests L, M, and N) was based on model 'K' in which the conditional age-at-length data are not downweighted by 0.5 (see Table 1 for the specifications for the models investigated during the Panel requests). The Francis method suggested that the length-compositions needed to be downweighted substantially. In contrast, this method also suggested that the conditional age-at-length data for the MexCal fleets and the ATM survey need to be upweighted. Implementing these weighting factors (model F) led to a markedly lower biomass trajectory and substantially changed selectivity patterns for the two MexCal fisheries. The results from this request led to requests L, M, N and O.	F
G	With model G (from initial draft), include the NWSS aerial survey data. Summarize the results in terms of residual patterns and the information given in Table 8 of the draft document.	The Panel wished to understand whether the aerial survey data would be influential if they were included in the assessment.	The biomass trajectory was lower than for model G when the NWSS aerial survey was included in the assessment, but otherwise the results were not substantially different. The Panel did not see evidence to disagree with the STAT's recommendation to leave	G, but including aerial survey

Nr	Request	Rationale	Response	Model(s)
			this survey out of the assessment.	
H	With model G (from initial draft), examine scenarios in which catchability is the same for the spring and summer ATM surveys. Consider values for ATM survey catchability from 0.7 to 1.1 in steps of 0.2. Summarize the results in terms of residual patterns and the information given in Table 8 {draft assessment document}.	The Panel noted that the ATM survey scientists expressed the view that the spring and summer surveys were directly comparable and wished to understand whether this view is supported by the data included in the assessment.	There is no evidence to support having separate *q*'s for the spring and summer ATM surveys in terms of the change to the value of the objective function. The single *q* is closer to that from the spring surveys, which is expected given the relative number of ATM survey data points for spring (6) and summer (3). The spring survey selectivity pattern switches to being less knife-edged for the higher *q*s, but the change for this and the biomass trajectory did not occur in a systematic way as the ATM survey catchability was changed from 0.7 to 1.1. This request led to an additional request (P).	G-H
I	With model G (from initial draft), replace the Beverton-Holt stock-recruitment relationship with the Ricker form of this relationship. Estimate steepness rather than assuming it equals 0.8	Several past assessments were based on the Ricker form of the stock-recruitment relationship, with steepness estimated. The Panel wished to explore the sensitivity to this change from prior assessments.	The scale of biomass is slightly lower with the Ricker stock-recruitment relationship, with no difference in likelihoods between the two model runs. Steepness was estimated at 2.05.	G-I
J	With model G (from initial draft), set $M = 0.5\text{yr}^{-1}$.	The analysis of Zwolinski and Demer (2013) suggests that M is higher (0.52yr^{-1}) than the model G assumption of 0.4yr^{-1}.	As expected, the scale of the biomass was higher, and the ATM survey *q*'s were lower (spring=0.58, summer=0.63). The change in likelihood was 3 units with the higher M, but given the concerns with the weights assigned to the length and conditional age-at-length data, this is not considered to be a substantial change.	G-J
K	Conduct an assessment where all the weighting factors (lambdas) are set to 1 and compare the results for this model to those for model G (from the initial draft assessment).	The selection of the factors to weight the length-composition and conditional age-at-length data was based on this model.	The STAT provided model K which showed increasing the weights on the conditional age-at-length data from 0.5 to 1 substantially lowered the biomass trajectory.	K
L	Based on model K, apply the Francis method to estimate weighting factors for the length-composition and conditional age-at-length data, pooling the two MexCal fleets, pooling the spring and summer ATM survey data and analyzing the PacNW separately.	Some of the weighting factors are based on very few compositions and consequently the weighting factors are uncertain (Table 2, upper).	This was model L. The weighting factors for the pooled fleets are as expected, but the confidence intervals, particularly for the ATM survey, are narrower (Table 2, lower). The Panel considered it appropriate to pool across fleets when computing the weights for the length-composition and conditional age-at-length data.	L
M	Based on model K, change only the weights assigned to the length-composition data using	The Panel wished to understand whether the length-frequency or conditional age-at-	This was model M. The biomass estimates for the early years were sensitive to changing the weights assigned	M

Nr	Request	Rationale	Response	Model(s)
	the weighting factors from Request F.	length data were most influential.	to the length-frequency data. However, the trend in abundance over recent years was unchanged and the biomass scale was largely unchanged. The Panel concluded that how the conditional age-at-length data are weighted was the major cause of the change in results observed for request F.	
N	Based on model K, change only the weighting factors assigned to the conditional age-at-length data using the weighting factors from Request F.	The Panel wished to understand whether the length-frequency or conditional age-at-length data were most influential.	The biomass trajectory for model N was markedly lower (and survey q markedly higher) when the conditional age-at-length data were changed.	N
O	Same as for request N, except that the weighting factor for the conditional age-at-length data sets for the PacNW fishery is assumed to equal 1.	The weighting factor for the conditional age-at-length data for the PacNW fleet was less than one, in contrast to the weighting factors for the MexCal fleets and the ATM survey.	The results for model O were essentially identical to those for request N.	O
P	Same as for model G, except that catchability and selectivity for spring and summer ATM surveys are assumed to be the same.	The Panel wished to understand whether there is support for separating the two surveys.	The fits to the survey length-frequency data for model P were not as good as for model G, even after accounting for there being three fewer parameters. The biomass trajectory was lower than for model G, and the ATM survey catchability was 2.38, a value considered implausible. The single ATM survey selectivity was less knife-edged and to the right of those for the spring and summer ATM survey selectivities from model G, which was unexpected. The model appeared to increase the selection at smaller lengths to account for the summer survey which had appreciable catches at these lengths. The consequence was to then reduce selection at the greater lengths that were previously fully selected when the surveys were fitted with separate selection patterns.	P
Q	Same as for model P, except that the weight assigned to ATM survey length-frequency data was increased from 1 to 20.	The Panel wished to understand whether it is possible to fit the length-frequency data for the ATM survey, at least in principle.	The fits to the ATM length-frequency data for model Q were better, but the model was still unable to adequately mimic all of the length-frequencies.	Q
R	Conduct models R, S, T, W and U.	The Panel wished to understand the trade-offs in results among various treatments of ATM survey catchability and selectivity. Some of these models ignore the ATM	Figure 2 summarizes the biomass trajectories from these models. Models R and S, in which selectivity for the spring and summer ATM surveys was assumed to be the same, led to higher estimates of biomass	R, S, T, U, W

Nr	Request	Rationale	Response	Model(s)
		survey conditional age-at-length data because these data were not computed accounting for the sampling scheme for the survey.	compared to model G, whereas model T which estimated separate selectivity patterns for the spring and summer ATM surveys, led to lower estimates of biomass; in contrast model W, which is the same as model T but estimates separate catchabilities for the ATM surveys, led to higher estimates of biomass than even model S. Model U in which the conditional age-at-length data for the MexCal and PacNW fisheries were markedly downweighted led to much lower biomass estimates and unrealistically high estimates of survey catchability.	
S	Repeat request Q, but omit the ATM survey length-frequency data for spring 2012.	This length-frequency was considered unreliable by the ATM survey team.	This model (V) was not able to adequately fit the remaining ATM survey length-frequencies.	V
T	Conduct analyses for a range of values to the extent which the conditional age-at-length data are downweighted. The analyses should be conducted for model specifications G-2, W-2, W-3, and T-2 (See Table 1).	The Panel wished to understand the impact of different weighting factors on the results of the model.	The outputs for models based on configuration W-3 all led to values for the ATM survey catchability coefficients which were considered unrealistically low (~0.25). The biomass trajectories for recent years were more robust for the models based on configuration T-2, but there was considerable sensitivity of biomass estimates for the early years (Figure 3). The biomass trajectories for recent years fell into two groups (one group based on weighting factors on the conditional age-at-length data of 0.1, 0.2 and 0.4; another group based on weighting factors of 0.3, and 0.5 and larger). The biomass trajectories were more stable for model runs based on configuration W-2 than configuration W-3. The weighting factor is 0.035 for configuration W-2 if it is chosen so that the average ATM (spring and summer) survey catchability is 1. Alternatively, this weighting factor is ~0.7 if the analysis is based on configuration G-2. Downweighting is more severe for model configuration W-2 because this model configuration ignores the ATM conditional age-at-length data which tends to support lower biomass estimates. However, the STAT noted that choosing a weighting factor to achieve a given average ATM survey catchability coefficient may not be a robust way to provide management advice. The Panel concurred	G-2, W-2, W-3, T-2, T-2_0.2, T-2_0.7

<table>
<tr><th>Nr</th><th>Request</th><th>Rationale</th><th>Response</th><th>Model(s)</th></tr>
<tr><td></td><td></td><td></td><td>with this view.</td><td></td></tr>
<tr><td colspan="5">At this point in the meeting, the STAT and Panel agreed to proceed with models which are variants of configuration T-2, i.e. the weighting factors for the length-frequency data are set to 1, catchability is set to 1 for both the spring and summer ATM surveys, separate selectivity patterns are estimated for the spring and summer ATM surveys, and the ATM survey conditional age-at-length data are ignored. The STAT and Panel agreed to focus on two models: T-2_0.2 and T-2_0.7. The difference between these two models is the weight assigned to the fishery conditional age-at-length data. These choices for weighting factors were selected because they are representative of the two groups in Figure 3.</td></tr>
<tr><td>U</td><td>Apply models T-2_0.2 and T-2_0.7 when the length-frequencies for the 2011 and 2012 spring ATM surveys are ignored.</td><td>It was speculated that some of the model sensitivity was due to attempts to fit these two length-frequencies (the fits to these length-frequencies are always poor).</td><td>The results when the weighting factor for the conditional age-at-length data was set to 0.7 were similar to those when the weighting factor was set to 0.2 (Figure 4), suggesting that at least one reason for the two groups of results in Figure 3 are conflicts when fitting to the length-frequencies for the 2011 and 2012 spring ATM surveys.</td><td>T-2_0.2a, T-2_0.7a</td></tr>
<tr><td>V</td><td>Apply models T-2_0.2 and T-2_0.7 when the data for the last four years are ignored.</td><td>The Panel wished to understand whether a retrospective analysis might help to distinguish between these two models.</td><td>The results from both models changed markedly when the data for last four years were ignored (Figure 5).</td><td>Retros on T-2_0.2 and T-2_0.7</td></tr>
<tr><td colspan="5">The STAT and Panel agreed that model T-2_0.2 would be the base model given the relative lack of sensitivity to omitting data (see request U).</td></tr>
</table>

Table A4.2. Summary of the models requested of the STAT during the review. "F" indicates that the weights assigned to the composition type were based on Francis (2011), method TA1.8; "F-pool" indicates that the factor to weight the composition concerned pooled information across fleets / seasons; "split" under the "ATM Q" and "ATM sel" (selectivity) columns indicates that separate parameters were estimated for the spring / summer surveys; "equal" under the "ATM Q" and "ATM sel" columns indicates that the parameters concerned were assumed to be the same for the spring / summer surveys, "1" under "ATM Q" indicates that survey catchability was assumed to be 1; "profile" in the last three lines implies that the STAT were requested to profile over the weighting factor concerned. The final model is in bold and shaded grey.

	Lambda: Length composition			Lambda: Conditional age-at-length			Q	Sel	Additional
Model	MexCal (1+2)	PacNW	ATM	MexCal (1+2)	PacNW	ATM	ATM	ATM	
G	1	1	1	0.5	0.5	0.5	split	Split	
K	1	1	1	1	1	1	split	Split	
F	F	F	F	F	F	F	split	Split	
L	F-pool	F	F-pool	F-pool	F	F-pool	split	Split	
M	F	F	F	1	1	1	split	Split	
N	1	1	1	F	F	F	split	Split	
O	1	1	1	F	1	F	split	Split	
P	1	1	1	0.5	0.5	0.5	equal	Equal	
Q	1	1	20	0.5	0.5	0.5	equal	Equal	
R	1	1	1	0.5	0.5	0	equal	Equal	
S	1	1	1	0.5	0.5	0	1	Equal	
T	1	1	1	0.5	0.5	0	1	Split	
U	1	1	1	0.01	0.01	0.5	split	Split	
V	1	1	20	0.5	0.5	0.5	equal	Equal	Excl. ATM spr 2012
W	1	1	1	0.5	0.5	0	split	Split	
G-2	1	1	1	profile	profile	profile	split	Split	
W-2	1	1	1	profile	profile	0	split	Split	
W-3	F-pool	F	F-pool	profile	profile	0	split	Split	
T-2	1	1	1	profile	profile	0	1	Split	
T-2-0.2	**1**	**1**	**1**	**0.2**	**0.2**	**0**	**1**	**Split**	
T-2-0.7	1	1	1	0.7	0.7	0	1	Split	
T-2_0.2a	1	1	1	0.2	0.2	0	1	Split	Excl. ATM spr 2011-12
T-2_0.7a	1	1	1	0.7	0.7	0	1	Split	Excl. ATM spr 2011-12
X	1	1	1	1	1	0	1	Split	Time blocking PNW
X-1	1	1	1	1	1	0	split	Split	Time blocking PNW

Models X and X-1, although supplied by STAT, were not requested or considered by the STAR panel due to time constraints.

Annex 5

Final model (T-2_0.2)

The final base model incorporates the following specifications (from STAR Panel report):

- catches for the MexCal fleet computed using the environmentally-based method;
- two seasons (semesters, Jul-Dec=S1 and Jan-Jun=S2) for each assessment year from 1993 to 2013;
- sexes were combined;
- two fisheries (MexCal and PacNW fleets), with an annual selectivity pattern for the PacNW fleet and seasonal selectivity patterns (S1 and S2) for the MexCal fleet;
    - MexCal fleet:
        - dome-shaped length-based selectivity with two periods of time blocking (1993-1998, 1999-2013);
    - PacNW fleet:
        - asymptotic length-based selectivity for a single time period;
    - length compositions with effective sample sizes calculated by dividing the number of fish sampled by 25 (externally) and lambda weighting=1 (internally);
    - conditional age-at-length compositions with effective sample sizes calculated by dividing the number of fish sampled by 25 (externally) and lambda weighting=0.2 (internally);
- Beverton-Holt stock-recruitment relationship "steepness" was fixed (0.8);
- *M* was fixed (0.4 yr^{-1});
- recruitment deviations estimated from 1987-2012;
- virgin (R_0), and initial recruitment offset (R_1) were estimated, and σ_R was fixed (0.75);
- initial *F*s set to 0 for all fleets (non-equilibrium model following the initial age composition method in SS);
- DEPM and TEP indices of spawning biomass with *q* estimated for both surveys;
- ATM survey biomass 2006-2013, partitioned into two (spring and summer) surveys, with *q*=1 for each survey;
    - length compositions with effective sample sizes set to 1 per haul (externally) and lambda weighting=1 (internally);
    - asymptotic length-based selectivity for spring and summer surveys;
    - conditional age-at-length data from the ATM surveys excluded;
- NWSS aerial survey index of abundance (biomass) and associated length compositions excluded.