Independent peer review report for STAR --- 2019 Pacific mackerel (*Scomber japonicus*) stock assessment

Yan Jiao

Prepared for

Center for Independent Experts

June 2019

Contents

Executive Summary

Activities

The 2019 stock assessment of Pacific mackerel (*Scomber japonicus*) was reviewed by a Stock Assessment Review (STAR) panel. The STAR panel aims to review Pacific mackerel stock assessment documents and to produce a STAR panel report that can be used by the Pacific Fishery Management Council (PFMC) and other interested persons for developing management recommendations for the for Pacific mackerel fishery. The review took place at the Southwest Fisheries Science Center (SWFSC), La Jolla, California during April 23 - 25, 2019. The stock assessment done by the stock assessment team (STAT) was presented publically to the STAR panel and the validity of the data, assessment procedures, and results as to the recommended base model and sensitivity model scenarios were discussed. The SWFSC provided all the background information, documents, and further data and model configuration explorations that were requested by the STAR panel.

All the models were processed using SS3.30.12, and the likelihood approach was used to estimate parameters (Methot et al. 2018). The 2019 STAR panel addressed all the terms of references (TORs) adequately and provided a panel summary report with statements on the recommended model scenario for management considerations. The panel summary report also suggested future improvement on data processing, potential efforts for new data collection and alternative model structures (PFMC 2019).

Main review processes and findings

The recommended pre-STAR base model (model ACL_19_16) by STAT in the draft report is new compared with the one (model H3) recommended by STAR 2015 with both the data and model parameterization changed greatly (Crone and Hill 2015; Crone et al. 2019). The base model has time series starting from 2008 instead of 1983 and a new AT survey index replaced the previously used biomass index of Commercial Passenger Fishing Vessel (CPFV). The corresponding age or length compositions from the AT survey were used in model calibration. The parameters of natural mortality M and AT catchability q were estimated with informative priors specified, but the stock-recruitment steepness h was fixed. The fishery selectivity was modelled as age-specific following a random walk process, while survey selectivity was modelled to be asymptotic with a logistic function. Empirical mean weight-at-age were used in the ALT_19_16.

There were some concerns in the assessment, mainly arising from the lack of fit to the survey data, both the age compositions and the biomass index developed from the Acoustic-Trawl (AT) Survey, and there is a strong retrospective pattern in the estimated age 1+ biomass (Figs. 1-3). STAR panel suggested a series of explorations both on better data organization and process, and alternative model assumptions through Requests (See Requests to STAT by the STAR, PFMC 2019). Such requests helped the STAR and STAT to recommend the base model to be used for management purposes and future research recommendations.

The AT survey team strongly supports the credibility of the AT survey-based biomass estimate of Pacific mackerel of age1+ but admits that biomass of age 0 fish likely does not represent the cohort signals well. STAT also emphasized the biology of Pacific mackerel as one of the Coastal Pelagic Species (CPS), and fishery and survey characteristics caused the difficulty in both data collection and modelling its population dynamics. The data used to convert AT length to age compositions are from the commercial fishery combined from 2008-2018. The STAT provided yearly specific mean length-at-age and weight-at-age from commercial fishery, which varied largely among years and cohorts (Fig. 4). The fishery age compositions were all from the California commercial fishery. The percentage of California commercial fishery in total catch varied among years, but less than 50% in most of the 11 years modelled.

The lack of fit to AT index and age frequency, especially age 0 and older age groups, suggested that alternative model specification of age 0 fish, year specific high quality age-length key, influence from data confliction, and separation of high quality data from low quality data (here age 1+ versus age 0 survey biomass) may help to improve model fitting and reflect the cohort signal better. The STAR panel requested corresponding data and model scenarios that STAT could do within the time limit. The separation of age 0 ~ age 1+ for AT survey index and age-composition was not conducted because of longer time needed for data reorganization. The STAR requests focused on alternative model specifications of age 0 fish selectivity, which include a time-varying random walk process and time-block assumptions.

After exploring alternative model specifications, the STAR and STAT recommended a new base model ACL_19 which decreased the weight for fishery age-compositions to 0.5. There is still a strong retrospective pattern in the estimated biomass when the new base model is used (Fig. 5). Although the new base model cannot be considered fully risk neutral because of the subjective data weighting, it is the most appropriate model scenario considered during the review. The STAR panel suggested year-specific AT age 0 selectivity with a low weight for fishery age-composition data included as sensitivity runs in the final report. These requests were not fully done during the review week because of time limitation. I recommend to the PFMC and its SSC take into account of these uncertainties when considering management decisions for Pacific mackerel.

Given the data available and the life history of Pacific mackerel, I support the accepted base model as the best available science and its projected age 1+ biomass for management consideration.

Main recommendations

There are no obvious disagreements on comments and recommendations between the STAR panel and my findings. Below I include both the recommendations that I agree with on the STAR panel and others' comments and recommendations from myself.

- I suggest that inter-annual growth variation be investigated and year-specific age-length key being used in the future to avoid ignoring life history variation of such a pelagic species, if the sample size is reasonable and the sampling process is credible. This suggestion is supported by the observed large inter-annual variation in growth (Fig. 4) and historically observed temporal changes in growth (Crone and Hill 2015). Although the sensitivity runs did not seem to obviously improve the fit, it does not mean using the combined age-length key is more reasonable. Such kind of results can be because of large uncertainty from other data or model sources that masks the influence of inter-annual variation of biological characteristics.

- I strongly suggest separating data with different qualities and modelling them separately. The AT estimated total biomass includes age 0 and age 1+. However, the AT survey estimated abundances of age 1+ are found to be credible by the AT and STAT teams but not for the age 0 abundance. By adding them together as an index of total biomass, the uncertainty of age 0 and age1+ are mixed together and tends to decrease AT function in calibrating population size, and contribute to the retrospective errors of total biomass since age 0 estimates largely influence age 1 projection in the following year.

- Ideally a full Bayesian approach may be developed in the near future (Punt and Hilborn 1997; Jiao et al. 2012; Hooten and Hobbs 2015). I support the continuation of using biologically meaningful priors for Pacific mackerel stock assessment as now used for M and q.

- Future exploration on the changes in productivity or recruitment of mackerel is suggested. Ages 0 and 1 fishes are the major age groups in CA commercial fisheries. Pacific mackerel biomass has been found to vary dramatically over time and likely heavily influenced by oceanographic conditions. However, its chaotic frequency is less regularly observed for anchovy and sardine stocks. Ecosystem dynamics can be complicated and the mechanisms of the productivity changes can be difficult to specify, but patterns recognized can still be integrated into the stock assessment. Both data mining approaches and time series approaches may be considered in the future (Sun et al. 2009; Munch et al. 2018).

- Future model development by considering time-varying parameters, such as those scenarios on age 0 selectivity explored during the review, may be combined with external sources of information, such as observations of migrations from south to north and age 0 detection time and location variations. AT survey data may help to explore such information through spatiotemporal species distribution analysis before new or extra studies are investigated.

- Biological data collection should be extended in space if possible based on the spatial distribution of Pacific mackerel. The current ageing samples used are all from the California commercial fishery. Future ageing information from the survey should be developed and similarity/differences in the estimated age-length relationships between comparable fishery and survey samples should be compared.

- Age/size compositions of catch from other fisheries especially Mexican fishery should be secured. The California commercial fishery age compositions may not well represent the overall catch age/length composition since its catch is less than 50% of the total catch in 8 of the 11 years during 2008-2018.

- AT survey needs to be improved continuously based on the most recent review comments. The assessment relies on AT survey heavily.

- Ageing uncertainty is suggested to be explored which include both appropriate ageing process and estimation of ageing uncertainty in the stock assessment model (Punt et al. 2008; Hatch and Jiao 2016).

- I recommend the PMFC and its SSC take into account the uncertainties listed in the findings, as well as the extra sensitivity runs not fully done during the review week, when considering management decisions for Pacific mackerel.

- Extra simulation studies are encouraged to validate the CUTOFF value or even the Harvest Control Rule (HCR) in general. The STAT estimated population size back to 1983 by using the fishery catch and AT survey data has a quite different scale comparing with the H3 model results from the 2015 assessment. The change of the scale of the population size reminds us the need of conducting another assessment for the appropriate HCR, if possible.

1. BACKGROUND

The 2019 stock assessment of Pacific mackerel (*Scomber japonicus*) was reviewed by a Stock Assessment Review (STAR) panel. The assessment review panel met at Southwest Fisheries Science Center (SWFSC), La Jolla, California during April 23 - 25, 2019. The review panel chair is Dr. Owen Hamel, and the other panel members include Drs. John Budrick, Ole Shelton and Yan Jiao.

The Pacific mackerel STAR review process was coordinated by Dr. Dale Sweetnam from SWFSC and Dr. Kerry Griffin from Pacific Fishery Management Council (PFMC). The stock assessment documents for Pacific mackerel were prepared by the STAT team and were presented at the meeting by Drs. Paul Crone and Juan Zwolinski.

According to the CIE scope description, " … The STAR panel will review draft stock assessment documents and any other pertinent information for Pacific mackerel, work with the stock assessment teams (STAT) 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 …". As a review panel member, I was provided with draft stock assessment reports and FTP access to relevant files and documents (Appendix 1) and participated in the Stock Assessment Review Meeting. During the review, the assessments of the Pacific mackerel were presented and the validity of the data, assessment models and procedures, and results were discussed (see Agenda in Appendix 2). Extra documents and model runs were provided upon requests from the STAR panel. Discussions on the quality of the data including the data standardization or synthesis, the appropriateness of the model equations, parameterizations, estimation algorithms and strategies to improve model fitting were made throughout the review.

During the review meeting, the STAT team was always available when required for further discussion, additional data and model exploration and clarification, and clarification of how each TOR was addressed. Recommendations from last STAT review were reviewed to determine the extent to which they had been addressed by the STAT team.

As a CIE reviewer, my duty was to evaluate the stock assessments of Pacific mackerel with respect to their TORs (in Appendix 2), and work with the STAR panel to prepare a panel summary report. This report provided the findings and recommendations of the independent review that is undertaken by me in accordance with the CIE Statement of Work (SOW).

2. ROLE OF INDIVIDUAL REVIEWER IN THE REVIEW ACTIVITIES

My role as a CIE independent reviewer was to conduct an impartial and independent peer review in accordance with the SOW and the predefined TORs therein.

About one week before the meeting, assessment documents and supporting materials were made available to the review panel via email and an FTP website by Drs. Dale Sweetnam and Kerry Griffin. I read all the documents that I received prior to the review.

The Pacific mackerel 2019 STAR meeting followed the "tentative agenda (Appendix 2)" of the CIE review. The meeting was open to the public and was organized constructively. On the morning of April 23 before the meeting, the STAT and STAR panel met to discuss the meeting agenda and STAR process, reporting requirements and meeting logistics. During the meeting, all the documents were accessible online or through emails.

Presentations were given during the review according to the agenda to provide the STAR panel the background information on the population characteristics of the species, the data used in the stock assessment models, the new model development, and comparisons with previously used assessment models. I was actively involved in the discussion during the presentations by 1) listening to the presentations carefully, making notes on the points that were not included or not clearly stated in the documents provided prior to the meeting; 2) asking questions for clarification on the data usage and model development; 3) making comments and providing possible alternative solutions to questions arising during the meeting; 4) discussing agreement on each model scenario and stock assessment TOR with the other review panel members.

After the peer review meeting, STAR panel chair Dr. Owen Hamel put the panel summary report together, which summarized the panel's views, requests and conclusions; all panel members commented on it. This report reflects my summarized findings and recommendations according to the predefined TORs. This review report is formatted according to my interpretation of the required format and content described in Appendix 2.

3. SUMMARY OF FINDINGS RELATIVE TO TORs

Pacific mackerel is one of the CPS species managed by PFMC. Its population distribution ranges from Vancouver Island (Canada) to Baja California (Mexico). Like all the other CPS species, Pacific mackerel abundance can vary dramatically and is likely heavily influenced by oceanographic conditions. However, previous studies found that this species has population size chaotic patterns less regularly than observed from anchovy and sardine stocks. Harvests of this species are mainly from commercial and recreational fisheries in the US Pacific coast and a commercial fishery in Mexico. Harvests in the US were mainly from Southern California (Fig. 6). However, the AT only surveyed the US side, and the age-length information was only from the commercial fishery samples in Southern California.

In the new assessment, AT survey biomass and age-compositions were used in the model but none of the model scenarios fitted these data well (Figs. 2 and 3). The confliction of believed high quality of AT survey data and poor fits suggests that alternative model specification of age 0 fish, year specific high quality age-length key, influence from data confliction from fishery catch age-composition, and separation of data of high quality versus low quality (here age 0 survey biomass versus age 1+ survey biomass) may help to improve model fitting and reflect the cohort signal better. The STAR panel then requested alternative runs on the data synthesis and selectivity assumptions, especially on age 0 survey selectivity.

Below I provide the summary of findings for Pacific mackerel review, in which the weaknesses and strengths are described, as well as conclusions and recommendations in accordance with the TORs.

3.1. *The principal responsibilities of the STAR Panel are to review stock assessment data inputs, analytical models, and to provide complete STAR Panel reports.*

The new assessment being reviewed for Pacific mackerel has dramatic changes in data used. The pre-STAR base model (ALT_19_16) was with catch time series including the age composition of the catch starting from 2008 instead of 1983, and a new AT survey index replaced the previously used biomass index of Commercial Passenger Fishing Vessel (CPFV) to calibrate population size and structure (Crone and Hill 2015; Crone et al. 2019). The corresponding age/ length composition from the AT survey was used in model calibration. The parameters of natural mortality *M* and AT catchability *q* were estimated with informative priors used but the stock-recruitment steepness *h* was fixed. The fishery selectivity was modelled as age-specific following a random walk process, while survey selectivity was modelled to be asymptotic with a logistic function. Empirical mean weight-at-age were used in all the model scenarios.

The assessment model assumed one fleet, i.e., one catch time series. This is because of lacking catch composition data from areas other than the California commercial fishery. Given the data limitation, this one fleet assumption is appropriate. However, how the catch composition varied over time and space is a source of uncertainty given the variations of the catch from different fisheries (Fig. 6). In some years, the % of the catch from the California commercial fishery was only 17-30% with 8 of the 11 years less than 50% of the total catch during 2008-2018, so to my view, the fishery age-composition may not well represent the overall catch age/length composition.

The fishery age-composition data are only from the California commercial fishery. The sample size seems adequate except in the most recent two years. The spatial coverage and potential differences in age composition in other fishery areas is a concern. During the review, there was a suggestion of potential bigger and older individuals in the Oregon and Washington area. Age and length sampling in these areas are suggested, at least to compare with the commercial samples from the California region, before a long term sampling effort is secured. Biological sampling from Mexican waters may be pursued through international collaboration.

AT survey has been reviewed in 2011 and 2018 (PFMC 2018). Although the AT survey is concluded by the review panel as an appropriate index of the Pacific mackerel population size, its uncertainty related to the survey areas and distributions of the stocks at the times of the surveys was also highlighted.

The credibility of the age groups from the AT survey varies. The AT survey team found that AT age 1+ estimates are much more credible than age 0 fish. I suggest that separating age 1+ and age0 fish as two separate indices with different level of uncertainty is important, which may explain the lack of fit of the model to the age-aggregated AT index and age compositions. The STAR requested a few sensitivity runs not using the AT survey data to investigate the overall influence of this group of dataset on the stock assessment, and runs using time-varying age 0 selectivity to investigate the influence of age 0 AT data on the overall stock assessment. How to model or use AT age 0 fish relative abundance turns out to be important.

The AT age-composition is from AT length composition, which has small sample sizes in general. The age sample size from the AT survey has been small and was not used in transitioning length composition to age composition while all the year combined age-length data from the commercial fishery was used. The sensitivity runs of using year-specific commercial fishery age-length keys to inform AT age-compositions did not seem to improve the fit obviously; the STAR panel then followed the STAT preference of using all year combined age-length key. I would suggest that inter-annual growth variation be investigated and that the year-specific age-length key be used in the future to avoid ignoring life history variation of such a pelagic species, if the sample size is reasonable and sampling process is credible.

To further improve data quality, I would like to echo the previous suggestions by SSC of PFMC and this STAR panel to extend the AT survey spatial coverage to its full population distribution through collaboration with Mexico and increase the biological sample size from AT. I also would like to suggest extra studies on Pacific mackerel age-specific seasonal movement patterns and its relationships with oceanographic conditions to facilitate validation on its time-varying spatial availability to fishery and surveys.

Although the variation can be from year specific growth, it can also be because of sampling time and location; thus, such kinds of variation in data should be included in the document (shown as figures and tables if possible), and I strongly encourage the use of the year-specific age-length key instead of the combined age-length key. Ageing error and the need for more effort in age reading and validation were discussed during the review. The base model did not consider ageing error. Future studies on ageing error identification and estimation, age-length sampling in a wide spatial scope are suggested to improve the quality of age-composition data (Punt et al. 2008; Hatch and Jiao 2016).

The new Pacific mackerel used informative priors for *M* and survey *q*. Extra sensitivity runs on alternative fixed *M* or *q* or uninformative priors indicated that the estimated *q* seemed very robust w/o informative priors. Such an approach can further help to understand the robustness of the parameters, and can be convenient for comparing models through both model goodness-of-fit and model predictive ability (Punt et al. 2008).

The pre-STAR base model (ALT_19_16) recommended by STAT is a statistical age-structured model with dome-shaped fishery selectivity and asymptotic AT survey selectivity. After diagnosing a series of alternative models on selectivities including time-varying AT age 0 selectivity and down-weighting data of fishery age-compositions, the new base model continued to use the pre-STAR based model configurations.

The current time series of the model is short (2008-2018), which may cause the instability of the estimated time-varying parameters and makes it difficult to explain the variation in a meaningful way. The model scenarios with time-varying age 0 AT selectivity is suggested to be included in the STAT final assessment report, which may be useful for SSC to further diagnose their applicability and potential usage in recommending scientific uncertainty and management decisions. In my view, the current time series of the model is short (2008-2018), which may cause the instability of the estimated time-varying selectivity parameters and difficult to explain the variation in a meaningful way. However, potential changes in climate, survey locations and gear behavior under alternative conditions may be explored as to the interpretation of such changes in the future.

In summary, the key configuration of the new base model (labelled as ACL_19 in the final assessment report) is as below:

- Time period from 2008-2018.
- Sexes combined and age groups of 0 to 8+ years.
- Catch from US and Mexico, commercial and recreational fisheries combined as one fleet.
- Empirical annual weight-at-age.

- AT age composition data derived from AT length composition using a time-invariant fishery-derived age-length key. The age-length key is from commercial samples 2008-2018 combined.
- Fishery age-compositions weighted by monthly catches and were down-weighted by 0.5.
- Natural mortality *M* estimated with a diffuse prior at median M=0.61yr^{-1}, and constant over age and time.
- AT survey catchability *q* estimated with a prior at median q = 0.65, and constant over time.
- Maturity is pre-specified.
- Fishery selectivity age-based, time-invariant, and modelled as a random-walk process from age 0 to age 5+ with selectivity for ages 5+ the same.
- AT survey selectivity age-based, and modelled as a logistic function.
- Recruitment deviations estimated from 2008-2018. Virgin recruitment, R_0, estimated, and recruitment variability σ_R and steepness *h* both set to 0.75.

The STAT and STAR recommended the above ALT-19 as the base model after comparing all the model scenarios explored with the time limitation. Given the data available and the life history of Pacific mackerel, I support the accepted base model as the best available science and its projected age 1+ biomass for management consideration. Future research should continue to explore both data synthesis and alternative model configurations. I also suggest that the SSC and PFMC consider the uncertainty described above on data and model selection, the unresolved retrospective pattern when considering management decisions.

A full STAR panel report has been well drafted and reviewed by all the panel members by the time of this report being submitted.

3.2. *The STAR Panel, including the CIE Reviewer, 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 recommendation of the base model is based on the panel consensus. Because of the time limitation, the STAT and STAR could not fully explore alternative data synthesis and model scenarios, including full exploration of time-varying age 0 selectivities for both fishery and AT survey, separating the age 1+ biomass index and age composition from an age-0 recruitment index for the survey. The STAR panel highlighted their research recommendations on expanding the spatial coverage of AT survey, biological sampling and age reading for AT survey, and the use of annual age-length samples if possible in the future studies. My recommendations on the assessment model are generally consistent with the panel recommendations. Please see Section 4 which include both the recommendations that I agreed with the STAR panel and extra comments and recommendations from myself.

3.3. *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.*

This TOR was addressed adequately in general, although further exploitation and documentation are suggested.

There were discussions on the quality of the data from the fishery and from the AT surveys. Both of them have problems in spatial coverage either in their survey or in their data collection. There are also conflictions in their signals in calibrating population dynamics. The decision on how to weight different data sets becomes challenging in being neutral. The STAR and STAT agreed to use 0.5 to down-weight fishery age-compositions. Although I have trouble to state that the new based model ALT_19 is risk neutral, I agree with the Panel that this is the most reasonable and credible model scenario explored during the review. Future improvements on the AT survey including spatial expansion to the Mexico side and biological sampling including ageing are suggested.

Confidence intervals of indices, population biomass and recruitment estimates were provided for the pre-STAR base model and should be included in the new base model (ALT_19) in the final assessment report. Likelihood paradigm is used in estimating parameters and population size for all the models provided before and during the STAR review. Recruitment variation and steepness were both set to 0.75, which are reasonable for such a species but such parameterization decreases the estimated uncertainty of population size.

The uncertainty estimation and exploration were done through likelihood profile, sensitivity analysis, retrospective analysis and convergence diagnostics of each model run. All the explored model scenarios tended not to fit the AT survey index and age-compositions well. The assessment has a strong retrospective pattern. The newly assessed biomass has different biomass scale when data trace back to 1983, which suggests that the CUTOFF value should be re-evaluated. All these uncertainties should be considered when discussing scientific uncertainty and management decisions.

3.4. *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.*

This TOR was completed successfully. The STAR chair Dr. Hamel handled the request and subsequent review excellently, and the STAT team were always collaborative and finished the runs/requests that could be done during the review and explained some of the runs that needed a longer time to handle. The list of requests and responses was included in the Panel Summary Report and also included in this report as Appendix 4.

The STAR panel requests for extra analyses were mainly driven by improving model fitting, decreasing retrospective pattern and finding reasonable explanations for the confliction between high quality of AT survey but lack of fit of the assessment models to AT index and age compositions.

The STAR panel suggested looking at the yearly specific mean length-at-age and weight-at-age to explore the influence of using the combined age-length key from commercial fishery from 2008-2018 to inform survey age-length key. The STAT provided yearly specific mean length-at-age and weight-at-age with both of them varied largely among years (Fig. 4). However, by using year specific age-length data did not seem to improve model fitting obviously (also see the differences in estimated age frequency and cohort signals, Fig. 7). So in the subsequent analysis on selectivity alternative models, combined age-length data were used continuously.

The AT survey team strongly supports the credibility of the AT survey based biomass estimate of Pacific mackerel of age1+ but admits that biomass of age 0 fish likely not to represent the cohort signals. The STAT felt that it would take a lengthy amount of time to re-estimate AT age 0 fish and age 1+ fish separately, so the request for conducting assessments by using separated age 0 index and age 1+ index, and age compositions of age 1+ did not go formal but are recommended in future studies.

The STAR requests then focused on alternative model specification of dome-shaped fishery selectivity and AT age 0 fish selectivity modelling. The fishery domed shaped selectivity was suggested in the 2015 STAR review (Crone and Hill 2015). During this review, both double-normal parameterization and random walk process with age 4+ constant were requested and explored as alternatives for fishery selectivity functions. Their influences were found to be limited. The STAR panel agreed with the STAT team to continue using the random walk process with age 5+ selectivity constant for fishery selectivity. Suggested alternative models for AT age 0 selectivity include time-varying following a random walk process and time-block assumptions. There are substantial concerns on the convergence and stability of the models. The time-block approach relies on the initial step of a random walk process and can be less objective. Because of the time limitation, such model scenarios were suggested to be combined with down-weighting fishery data and included in the sensitivity runs in the formal assessment report.

The STAR panel also requested alternative scenarios to explore the influence of data confliction by removing an alternative set of data step by step, such as removing fishery age-composition, removing survey age-compositions, etc. The STAR panel also suggested down-weighting the fishery age-composition because of its data quality, which decreased the negative log-likelihood of the AT index and age-compositions substantially. The STAR and STAT agreed to use 0.5 to down-weight the fishery age-composition in the recommended new base model (ALT_19). This option is not fully objective or risk neutral, but the selection of data weighting can be difficult.

4. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS RELATIVE TO TORs

The STAT and STAR recommended the ALT-19 as the base model after comparing all the model scenarios explored. Given the data available and the life history of Pacific mackerel, I support the accepted base model as the best available science and its projected age 1+ biomass for management consideration.

My conclusions and recommendations are consistent with those from the STAR Panel. There is no obvious disagreement between the STAR panel comments/recommendations and mine. Below I include both the recommendations that I agreed with the STAR panel and extra comments and recommendations from myself.

Recommendations for future Pacific mackerel data collection

To further improve data quality I would like to echo the previous suggestions by SSC of PFMC and this STAR panel on the extension of the AT survey spatial coverage to its full population distribution through collaboration with Mexico and increasing the biological sample size from AT. I also suggest extra studies on Pacific mackerel age-specific seasonal movement patterns and its relationships with oceanographic conditions to facilitate validation on its time-varying spatial availability to fishery and surveys.

Collection of biological data and age/size composition of the catch should be extended in space, if possible, based on the spatial distribution of Pacific mackerel. The current ageing samples used are all from California commercial fishery. The California commercial fishery age compositions may not well represent the overall catch age/length composition since its catch is less than 50% of the total catch in 8 of the 11 years during 2008-2018, the modelled period. I suggest that catch fish age/size compositions from other fisheries, especially from the Mexican side, be secured through collaborations if possible.

Future ageing information from the survey should be developed and similarity/differences in the estimated age-length relationships between comparable fishery and survey samples should be compared. Inter-annual variation of age-length relationships should be diagnosed, which is important in addressing whether inter-annual variation in age-length relationships and age-length keys should be considered in the assessment model. Ageing uncertainty should be explored, which include both an appropriate ageing protocol/process and an estimation of ageing uncertainty in the stock assessment model (Punt et al. 2008; Hatch and Jiao 2016).

Recommendations for future Pacific mackerel assessment model

I suggest that inter-annual growth variation be investigated and year-specific age-length key be used in the future to avoid ignoring life history variation of such a pelagic species, if the sample size is high enough and sampling process is credible. When the fishery age-length key is used to transit age composition of AT survey from length composition, a combined 2008-2018 age-length data was used. The observed averaged length-at-age and weight-at-age varied largely among 2008-2018 (Fig. 4). Although the variation can be from year specific growth, it can also occur due to sampling time and location; thus, such kind of variation in data should be included in the document and shown as figures and tables, if possible. The STAT did use year-specific average empirical weight-at-age when estimating biomass. Although the sensitivity runs did not seem to improve the fit obviously, this does not mean that the combined age-length key is more reasonable to be used. Such kind of results can be due to a large uncertainty from other data or model sources that masks the influence of inter-annual variation of biological characteristics.

I strongly suggest separating data with different qualities and modelling them separately. In this case, it is better to separate age 0 from other age groups in the AT survey both in abundance index and age compositions. That is, use age 0 and age 1+ as 2 separate indices, and use age 1+ age frequencies to calibrate the assessment models. The AT estimated total biomass includes age 0 and age 1+. However, the AT survey estimated abundances of age 1+

are found to be credible by the AT and STAT teams but not for the age 0 abundance. By adding them together as an index of total biomass, the uncertainty of age 0 and age1+ is mixed together and tends to decrease AT function in calibrating population size and contributes to the retrospective errors of total biomass since age 0 estimates largely influence the age 1 projection in the following year.

Ideally, a full Bayesian approach may be developed in the near future to explore uncertainty (Gelman et al. 2014a). Pacific mackerel stock assessment used biologically meaningful priors for M and q but a likelihood approach was used to estimate parameters. Robustness of the parameter estimates was diagnosed through sensitivity runs. I agree with the STAT panel that a full Bayesian approach is ideal, which can further help to understand the robustness of the parameters and is convenient in comparing models through both model goodness-of-fit and model predictive ability (Punt and Hilborn 1997; Patterson et al. 2001; Gelman et al. 2014b; Hooten and Hobbs 2015).

Future model development by considering time-varying parameters, such as those scenarios on age 0 selectivity explored during the review, may be combined with external sources of information, such as observations of migrations from south to north and age 0 detection time and location variations. AT survey data may help to explore such information through spatiotemporal species distribution analysis before new or extra studies are investigated. In my view, the current time series of the model is short (2008-2018), which may cause the instability of the estimated time-varying selectivity parameters and make it difficult to explain the variation in a meaningful way. Potential changes in climate, survey locations, and gear behavior under alternative conditions may be explored as to the interpretation of such changes in the future.

I suggest future exploration on the changes in productivity or recruitment of mackerel. During the review panel, this topic was not discussed because of time limitation. Ages 0 and 1 fishes are the major age groups in CA commercial fisheries, but the AT estimated age 0 fish as less credible and tended to cause non-trivial retrospective errors in the projected age 1 fish. Pacific mackerel biomass has been found to vary dramatically over time and likely heavily influenced by oceanographic conditions. However, its chaotic frequency is less regularly observed than for anchovy and sardine stocks. Ecosystem dynamics can be complicated and the mechanisms of the productivity changes can be difficult to specify, but patterns recognized can still be integrated into the stock assessment. Both data mining approaches and time series approaches may be considered in the future (Sun et al. 2009; Munch et al 2018).

Recommendations for research on Pacific mackerel harvest guideline and overfishing level

I recommend the PMFC and its SSC take into account of the uncertainties listed in the findings, and the extra sensitivity runs not fully done during the review week, when considering management decisions for Pacific mackerel. The recommended base model still has a strong retrospective pattern. The newly assessed biomass has different biomass scale when data trace back to 1983, which suggests that the CUTOFF value should be re-evaluated. All these uncertainties should be considered when discussing scientific uncertainty and management decisions. Both the data and model used in the new base model have changed dramatically from previous stock assessments. I suggest extra simulation studies to validate the CUTOFF value or even the Harvest Control Rule in general based on the new data and model.

5. Comments on the STAR review process

I found the STAR process effective, clear and meaningful. The requirement of written requests with justification and responses largely facilitated the review process and made the Panel report much easier to handle. Such written requests should also facilitate future stock assessment modifications if needed. This specific review done for Pacific mackerel was exceptionally organized, both in the conduct of the meeting and in presentations of the assessment. The STAT team was very patient and cooperative in dealing with requests, which likely had them working overnight during the review. I have no further recommendations about the review process.

6. Acknowledgements

I would like to thank all the Stock Assessment Team members contributing to the meeting for their informative presentations on the stock assessments of Pacific mackerel and for their hard work and willingness to provide helpful responses to the review panel's questions. Many thanks also to the other scientists at the meeting, such as Drs. Kevin Piner and Hui-Hua Lee, for their contributions to the discussions throughout the meeting. I also would like to thank Drs. Kerry Griffin and Dale Sweetnam who facilitated the review process in an enjoyable and productive manner. Special thanks also go to other members of the review panel, Drs. Owen Hamel, John Budrick and Ole Shelton for their respectful and productive discussions on the assessments.

7. References

Crone, P.R., Hill, K.T. 2015. Pacific mackerel (*Scomber japonicus*) stock assessment for USA management in the 2015-16 fishing year. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220. 131 p.

Crone, P.R., Hill. K.T., Zwolinski, J.P., Kinney, M.J. 2019. Pacific mackerel (*Scomber japonicus*) stock assessment for U.S. management in the 2019-20 and 2020-21 fishing years. Pacific Fishery Management Council, Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220, USA. 99 p.

Gelman, A., Carlin, J.B., Stern, H.S., and Rubin, D.B. 2014a. Bayesian Data Analysis. 3rd edition. Chapman & Hall, London, UK. 667 pp.

Gelman, A., Huang, J., and Vehtari, A. 2014b. Understanding predictive information criteria for Bayesian models. Statistics and Computing. 24:997-1016.

Hatch, J. M., Jiao, Y. 2016. A comparison between traditional and measurement-error growth models for weakfish *Cynoscion regalis*. PeerJ 4:e2431; DOI 10.7717/peerj.2431DOI 10.7717/peerj.2431.

Hooten, M.B., and Hobbs, N.T. 2015. A guide to Bayesian model selection for ecologists. Ecological Monographs. 85: 3-28.

Jiao, Y., Smith, E., O'Reilly, R., and Orth, D. 2012. Modeling nonstationary natural mortality in catch-at-age models: an example using the Atlantic weakfish (*Cynoscion regalis*) fishery. ICES Journal of Marine Science. 69:105-118.

Methot, R.D., Wetzel, C.R., Taylor, I. 2018. Stock Synthesis user manual. Model Version 3.30.12 (August 2018). NOAA Fisheries, Seattle, WA. 229 p.

Munch, S.B., Giron-Nava, A., and Sugihara, G. 2018. Nonlinear dynamics and noise in fisheries recruitment: A global meta-analysis. Fish and Fisheries. 19: 964-973.

Pacific Fishery Management Council (PFMC). 2018. Methodology review panel report: acoustic trawl methodology review for use in coastal pelagic species stock assessments. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220 OR. Agenda Item C.3, Attachment 2, April 2018. 75 p.

Pacific Fishery Management Council (PFMC). 2019. Pacific Mackerel Stock Assessment Review (STAR) Panel Meeting Report. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220 OR. Agenda Item F.3, Attachment 2, June 2019. 23 p.

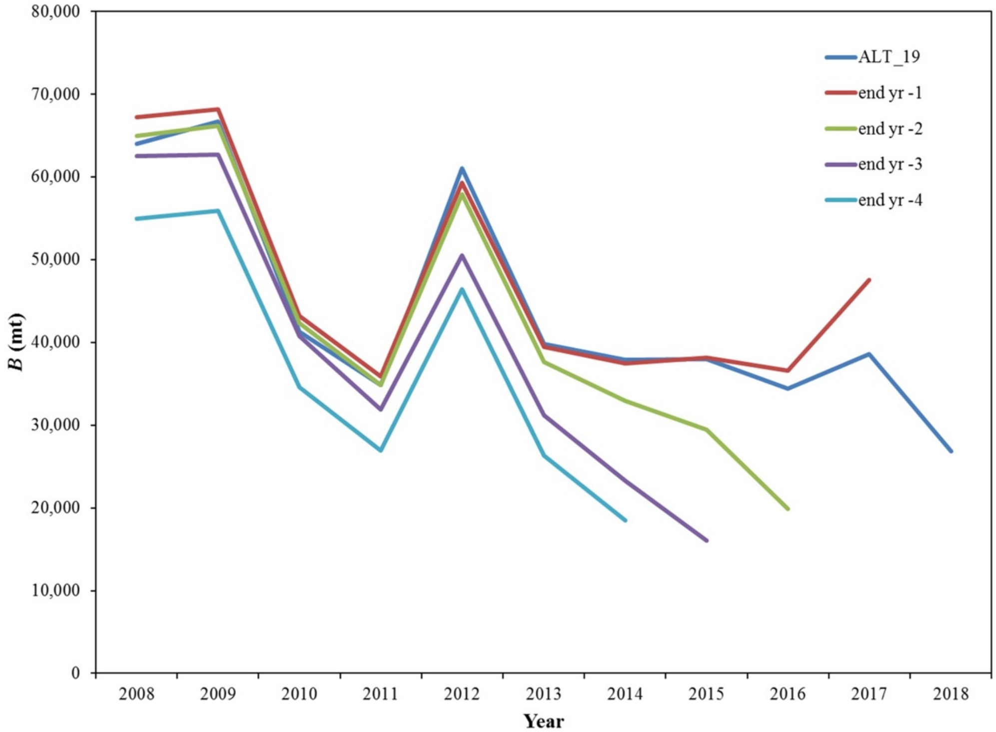
Patterson, K., Cook, R., Darby, C., Gavaris, S., Kell, L., Lewy, P., Mesnil, B., Punt, A., Restrepo, V., Skagen, D.W. and Stefansson, G. 2001. Estimating uncertainty in fish stock assessment and forecasting. Fish and Fisheries. 2:125-157.

Punt, A.E. and Hilborn, R. 1997. Fisheries stock assessment and decision analysis: the Bayesian approach. Reviews in Fish Biology and Fisheries. 7:35-63.

Punt, A.E., Smith, D., KrusiscGolub, K., Robertson, S. 2008. Quantifying age-reading error for use in fisheries stock assessments, with application to species in Australia's southern and eastern scalefish and shark Fishery. Canadian Journal of Fisheries and Aquatic Sciences. 65:1991–2005.

Sun, L., Xiao, H., Yang, D., and Li, D. 2009. Forecasting fish stock recruitment by using neural network. *2009 WRI Global Congress on Intelligent Systems*, pp. 96-100.

8. Figures



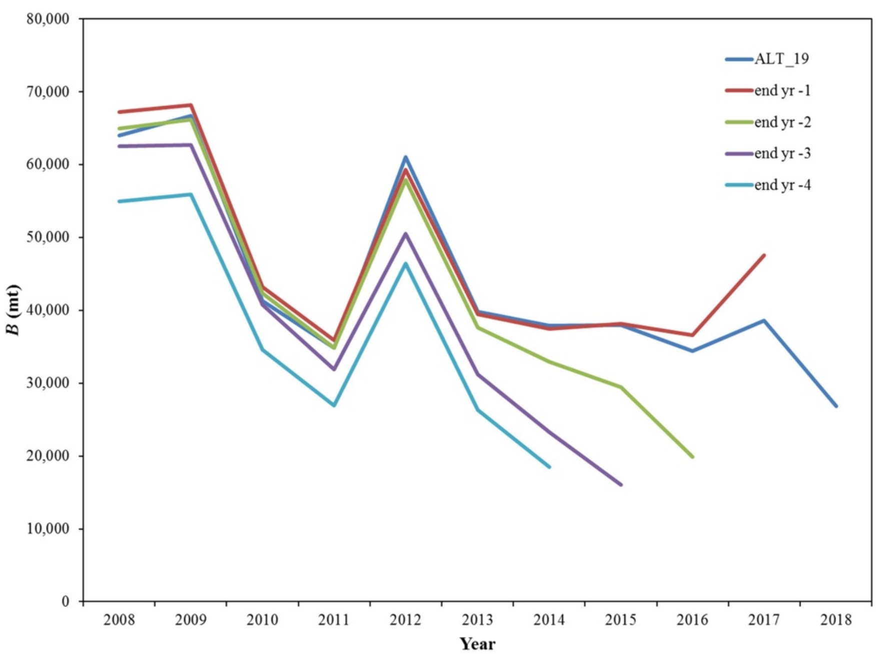


Figure 1: Estimated stock biomass (*B,* age 1+ fish, mt) associated with retrospective analysis for model ALT_19_16, the pre-STAR base model. (cited from Crone et al. 2019 draft STAR report)).

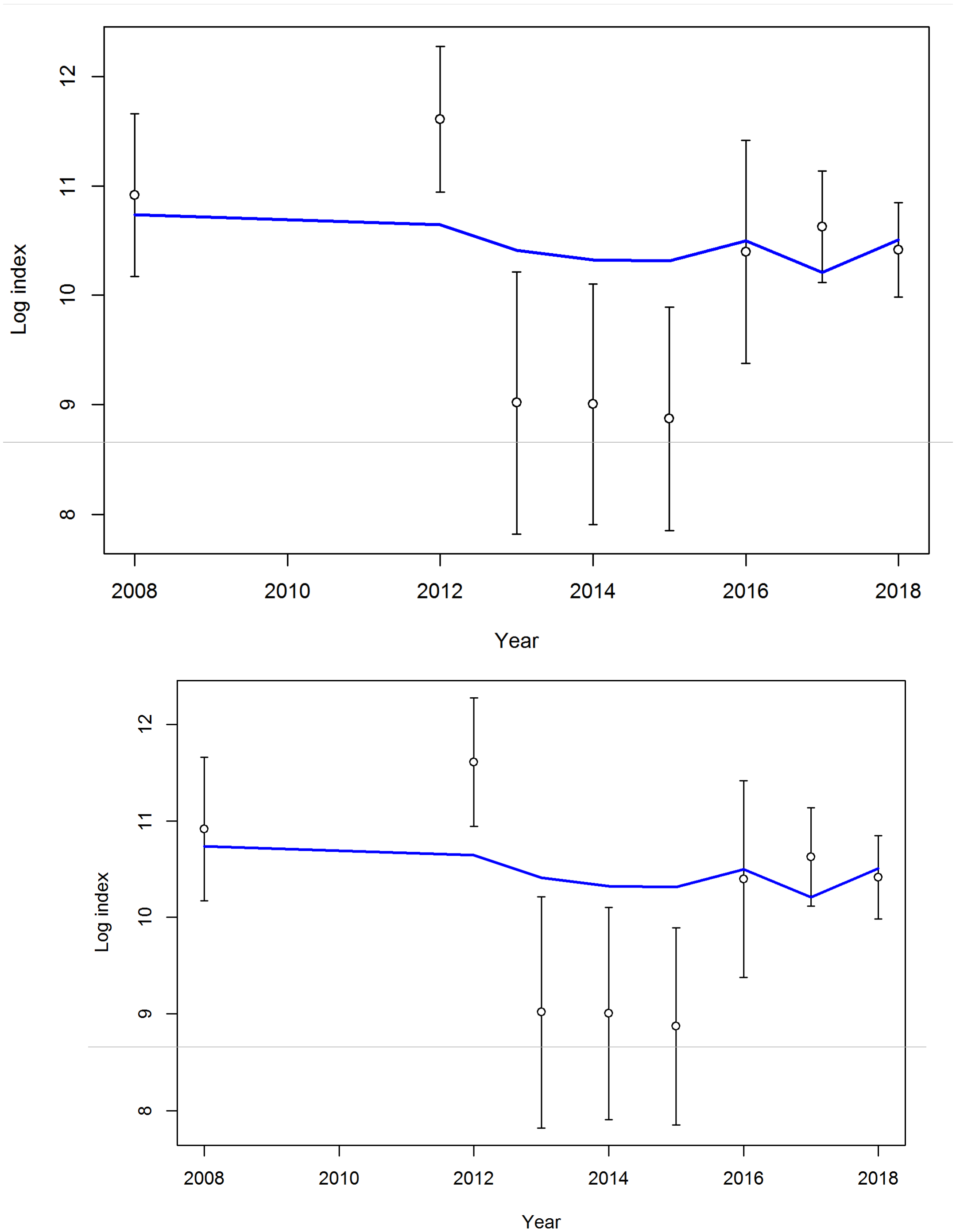
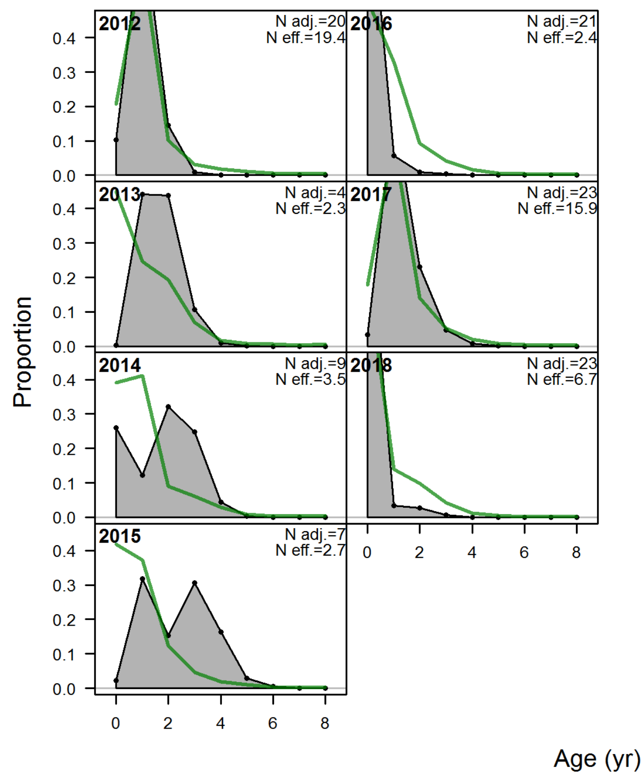


Figure 2: Fits (blue line) to log-transformed AT survey index for model ALT_19_16, the pre-STAR base model. (cited from Crone et al. 2019 draft STAR report).



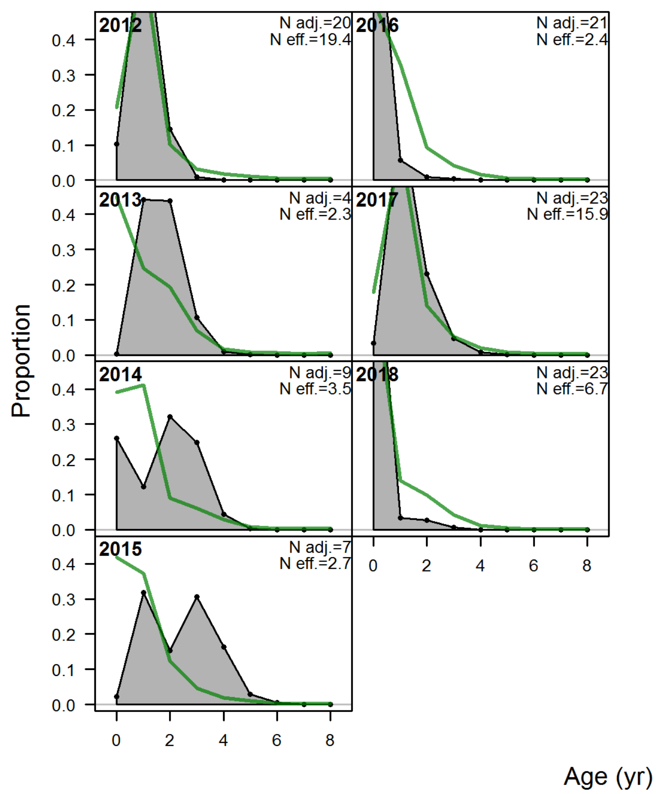
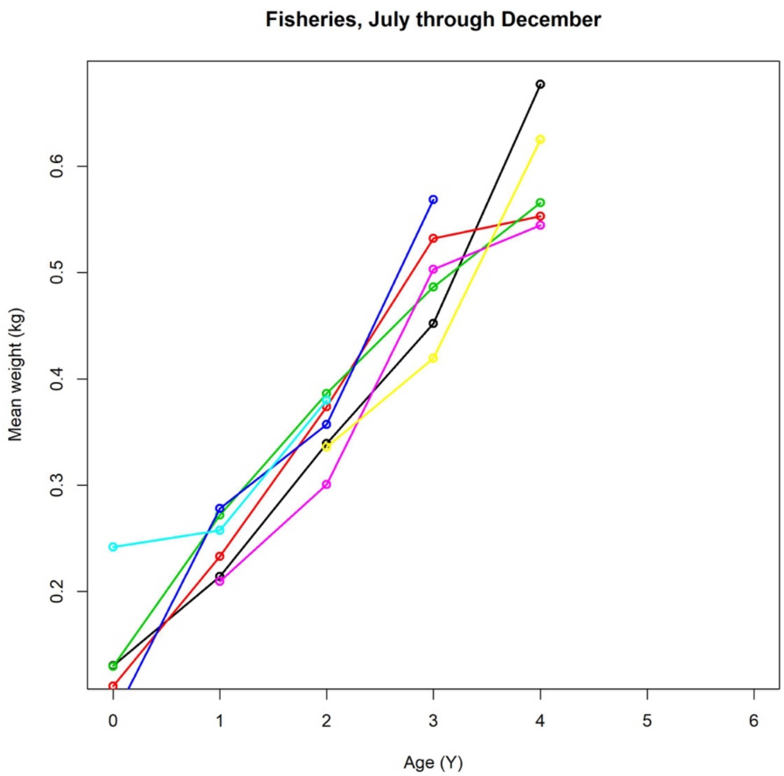


Figure 3: Fits (green lines) to AT survey age-composition (grey bars) for model ALT_19_16. (cited from Crone et al. 2019 draft STAR report).



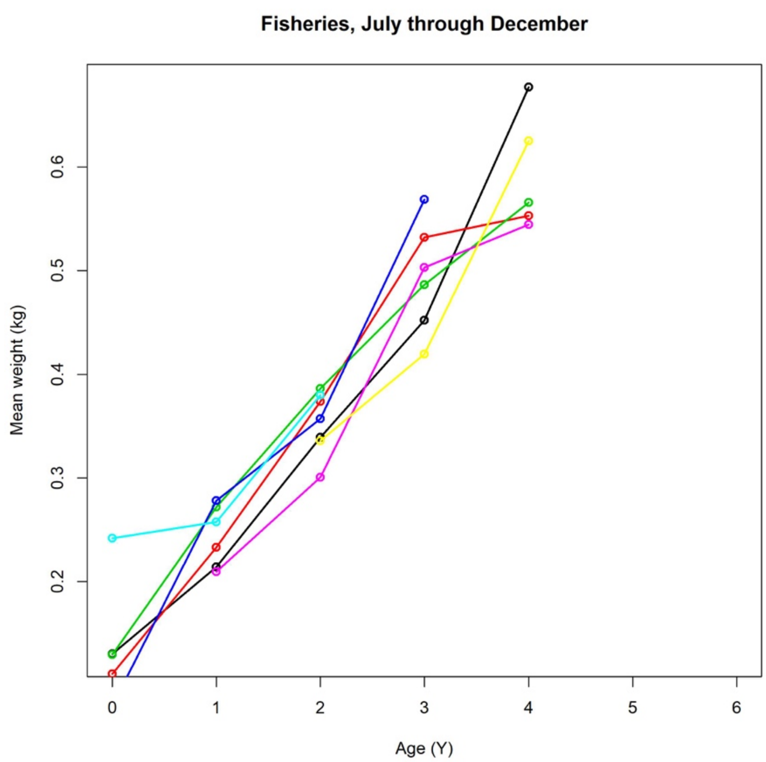
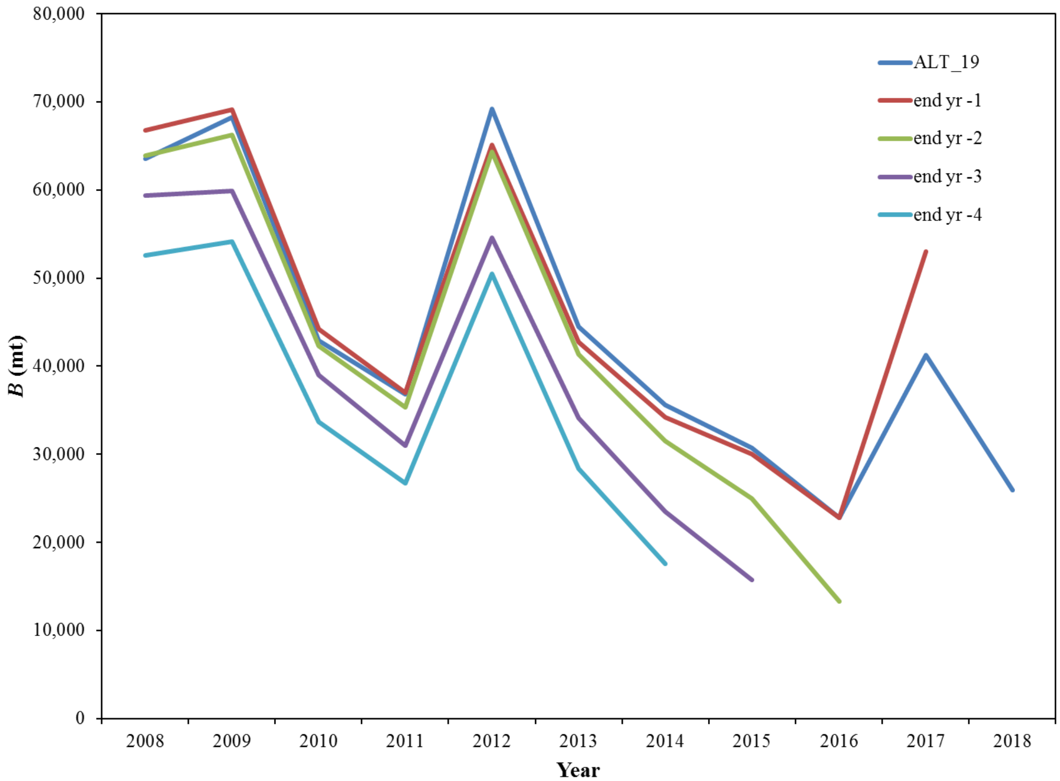


Figure 4: Observed mean weight-at-age from 2008-2018 by cohort. (figure from STAT member Dr. Juan Zwolinski).



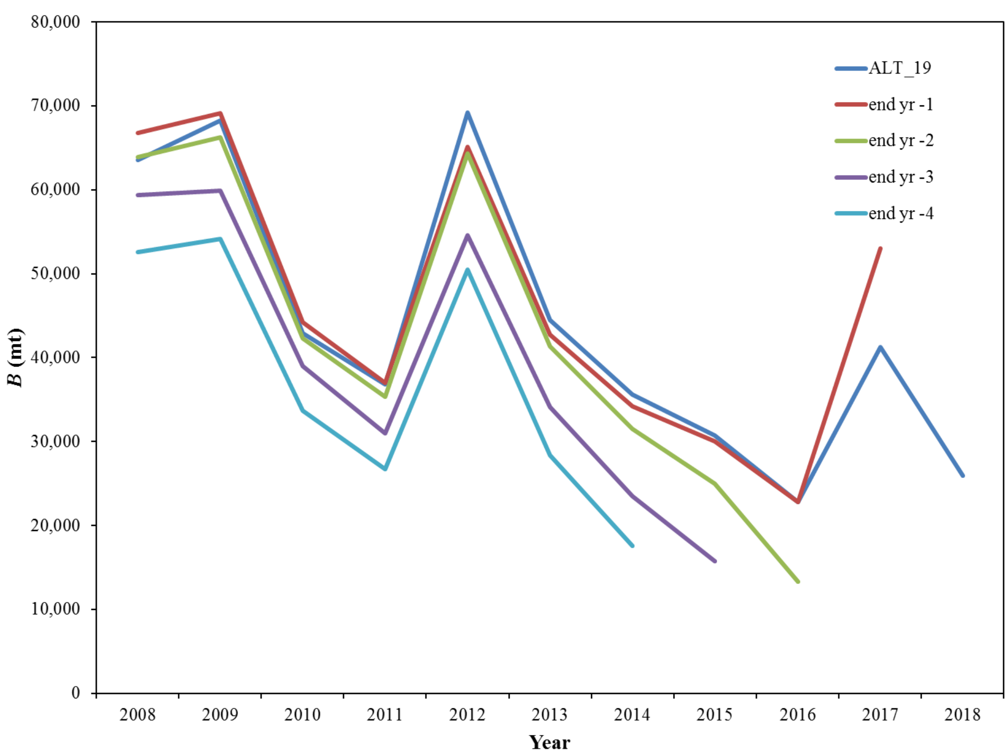
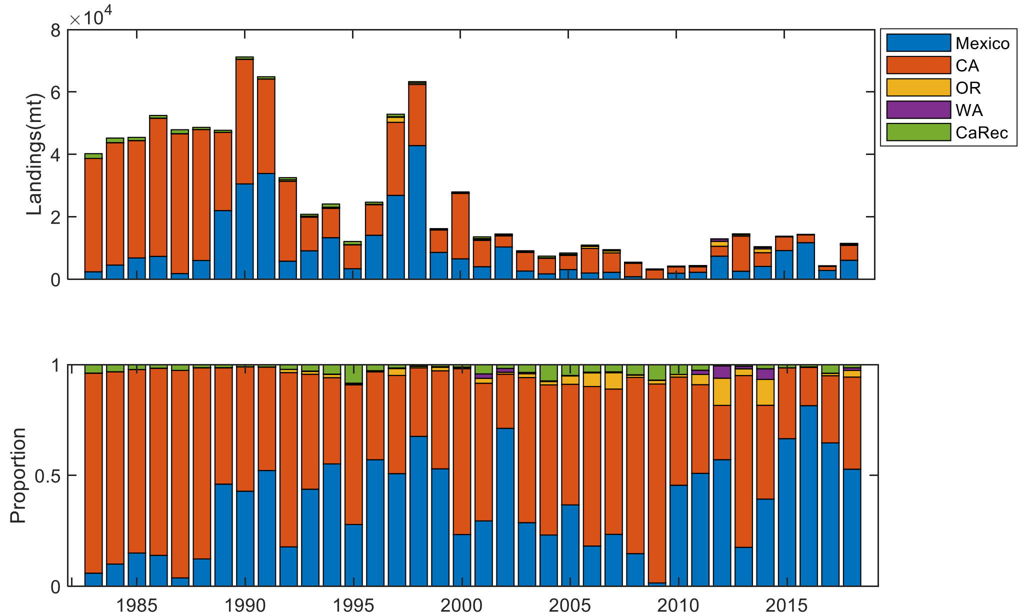


Figure 5: Estimated stock biomass (*B,* age 1+ fish, mt) associated with retrospective analysis for the final base model ALT_19.



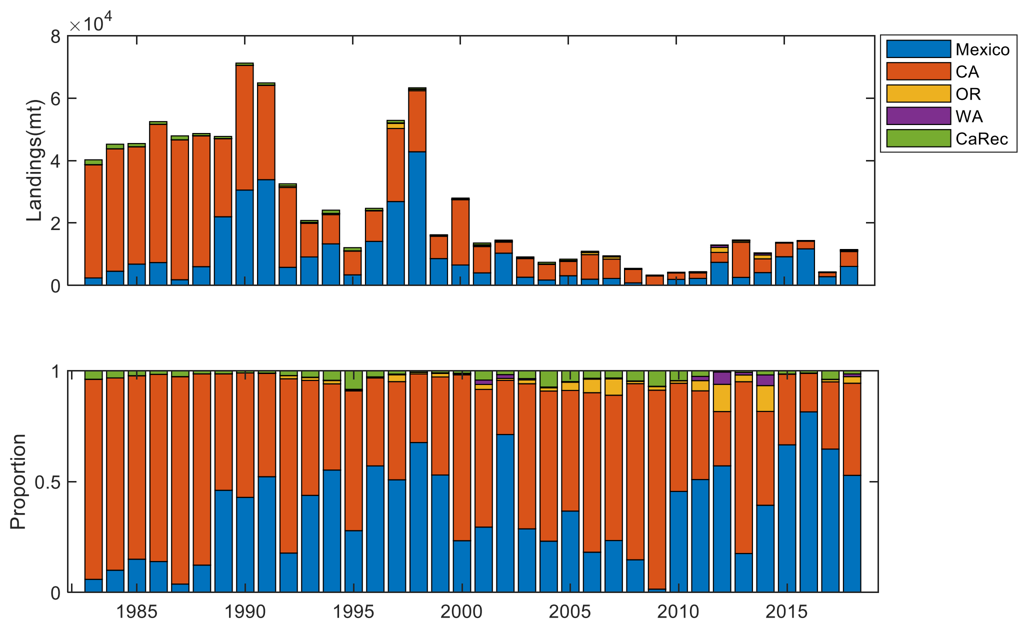
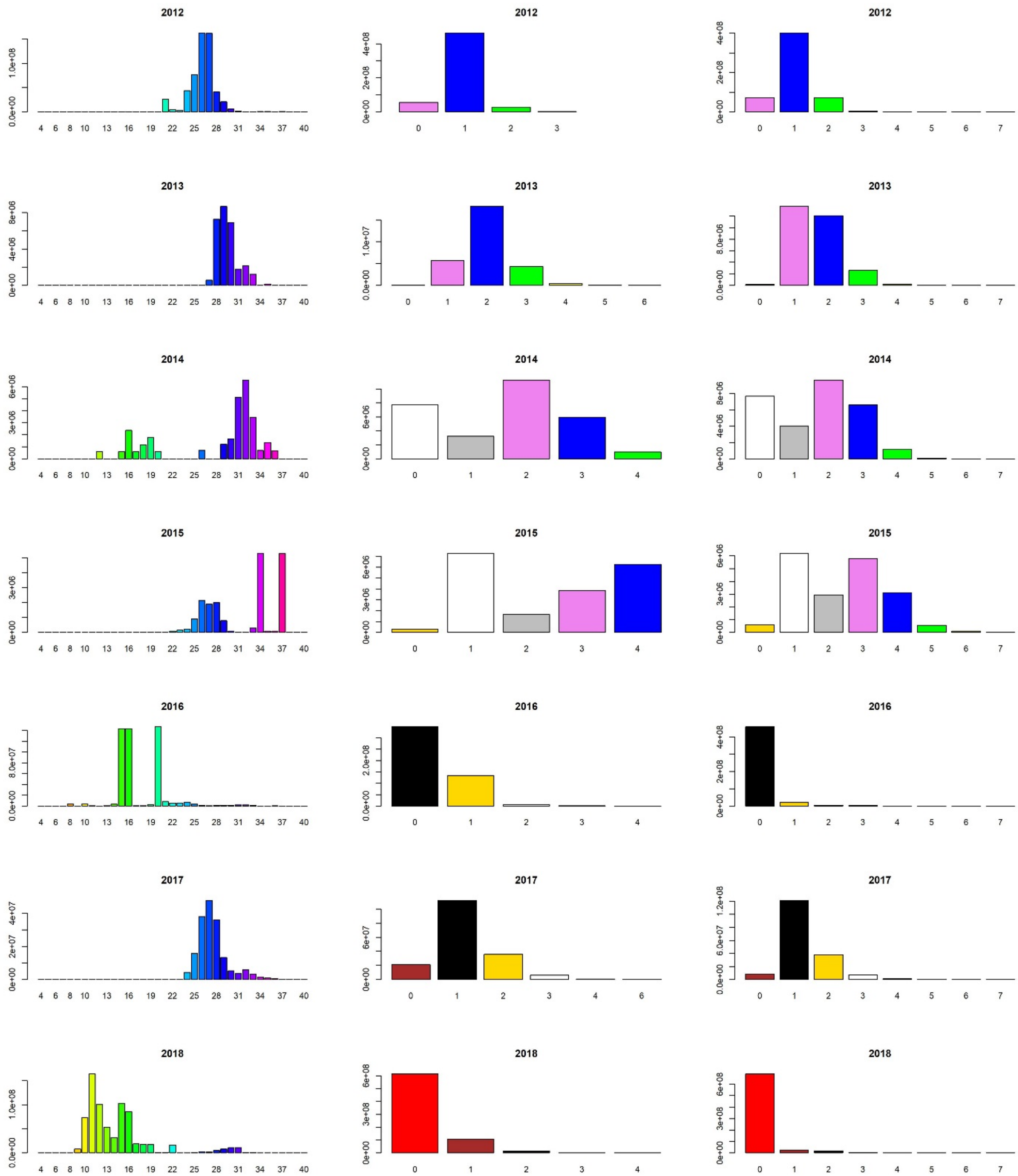


Figure 6: Catch fishery compositions during 1983-2018. (top: in mt; bottom: in proportion; replotted based on Table 1 in Crone et al. 2019 STAR draft report). CA: California commercial fishery; OR: Oregon commercial fishery; WA: Washington commercial fishery; CaRec: California recreational fishery.


2012
2012
2012
2013
2013
2013
2014
2014
2014
2015
2015
2015
2016
2016
2016
2017
2017
2017
2018
2018
2018

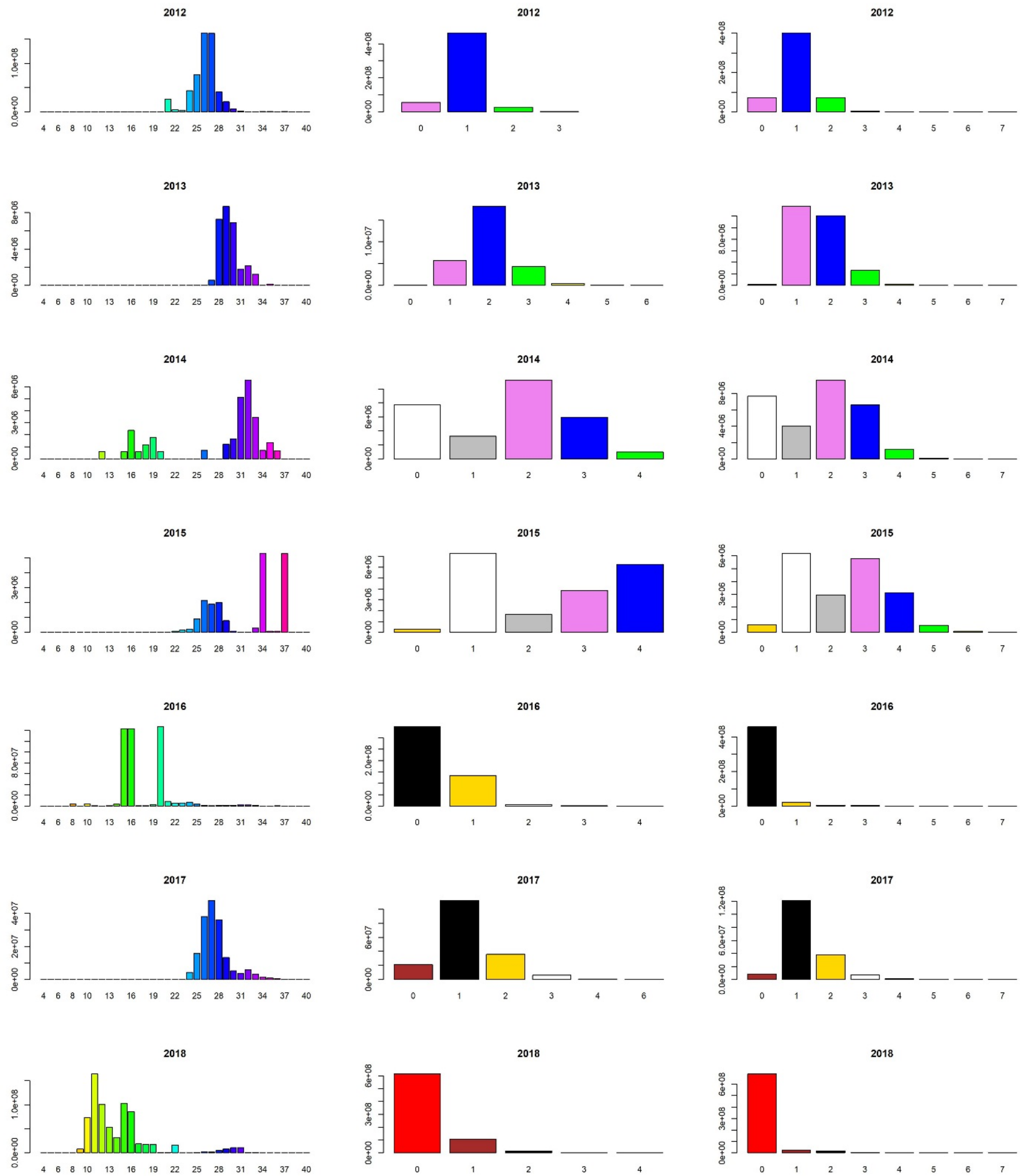


Figure 7: AT survey yearly length composition (left column) and derived age composition using year-specific length-to-age transition matrices (center column) or single combined-year length-to-age transition matrix (right column). (figure from STAT member Dr. Juan Zwolinski).

Appendix 1: Bibliography of materials provided for review

STAT Working Papers:

Crone, P.R., Hill. K.T., Zwolinski, J.P., Kinney, M.J. 2019. Pacific mackerel (*Scomber japonicus*) stock assessment for U.S. management in the 2019-20 and 2020-21 fishing years. Pacific Fishery Management Council, Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220, USA. 99 p.

Background material provided for* Pacific mackerel STAR review*:

Crone, P.R., Hill, K.T. 2015. Pacific mackerel (*Scomber japonicus*) stock assessment for USA management in the 2015-16 fishing year. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220. 131 p.

Crone, P.R., Hill, K.T. 2017. Pacific mackerel biomass projection estimate for USA management in 2017-18 and 2018-19. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220. 13 p.

Crone, P.R., Hill. K.T., Zwolinski, J.P., Kinney, M.J. 2019. Pacific mackerel (*Scomber japonicus*) stock assessment for U.S. management in the 2019-20 and 2020-21 fishing years. Pacific Fishery Management Council, Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220, USA. 99 p.

Edwards, A.M., Taylor, I.G., Grandin, C.J., Berger, A.M.. 2018. Status of the Pacific hake (whiting) stock in U.S. and Canadian waters in 2018. Prepared by the Joint Technical Committee of the U.S. and Canada Pacific Hake/Whiting Agreement, National Marine Fisheries Service and Fisheries and Oceans Canada. 222 p.

Hill, K.T., Crone, P.R., Zwolinski, J.P. 2018. Assessment of the Pacific sardine resource in 2018 for U.S. management in 2018-19. US Department of Commerce. NOAA Tech. Memo. NMFS-SWFSC-600. 125 p.

Hill, K.T., Crone, P.R., Zwolinski, J.P. 2019. Assessment of the Pacific sardine resource in 2019 for U.S. management in 2019-20. Southwest Fisheries Science Center, 8701 La Jolla Shores Dr., La Jolla, CA 92037. 116 p.

Pacific Fishery Management Council (PFMC). 2018a. Terms of reference for the groundfish and coastal pelagic species stock assessment review process for 2019-20 (September 2018). Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220. OR. 47 p.

Pacific Fishery Management Council (PFMC). 2018b. Methodology review panel report: acoustic trawl methodology review for use in coastal pelagic species stock assessments. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220 OR. Agenda Item C.3, Attachment 2, April 2018. 75 p.

Stierhoff, K.L., Zwolinski, J.P., Demer, D.A. 2019b. 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.

Stierhoff, K.L., Zwolinski, J.P., Palance, D.G., Renfree, J.S., Mau, S.A., Murfin, D.W., Sessions, T.S, Demer, D.A. 2019a. Report on the 2018 California Current Ecosystem (CCE) Survey (1807RL), 26 June to 23 September 2018, conducted aboard NOAA Ship Reuben Lasker. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-609. https://doi.org/10.25923/4ydz-4r44

Stock Assessment Review (STAR). 2011. Acoustic-trawl survey method for coastal pelagic species: Report of methodology review panel meeting. A. Punt (chair) and members F. Gerlotto, O. R. Godø, M. Dorn, and J. Simmonds. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220. OR. 30 p.

Stock Assessment Review (STAR). 2015. Pacific mackerel STAR panel meeting report. A. Punt (chair) and members W. Satterthwaite, V. Haist, and D. Checkley. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220. OR. 27p.

Stock Assessment Review (STAR). 2017. Pacific sardine STAR panel meeting report. A. Punt (chair) and members W. Satterthwaite, E. Brown, J. Volstad and G. Melvin. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220. OR. 24p.

Zwolinski, J. P., Demer, D. A., Macewicz, B. J., Mau, S., Murfin, D., Palance, D., Renfree, J. S., et al. 2017. Distribution, biomass and demography of the central-stock of Northern Anchovy during summer 2016, estimated from acoustic-trawl sampling NOAA Technical Memorandum NMFS-SWFSC-572.

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

Zwolinski, J.P., Stierhoff, K.L., Demer, D.A. 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.

Appendix 2: 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 2019-20 Pacific Mackerel Stock Assessment

April 23-25, 2019

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 reviewer will serve on a Stock Assessment Review (STAR) Panel and be expected to participate in the review of Pacific mackerel stock assessment. The Pacific mackerel stock is assessed regularly (currently, every 3 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 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 mackerel, work with the stock assessment teams (STAT) 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 reviewer shall complete the independent peer review according to required format and content as described in **Appendix 1.** 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

One CIE reviewer shall participate during a panel review meeting in La Jolla, California during 23-25 April, and shall conduct an impartial and independent peer review accordance with the Performance Work Statement (PWS) and ToRs herein. The CIE reviewer shall have the expertise as listed in the following descending order of importance:

- The CIE reviewer shall have expertise in the design and application of fishery-independent surveys for use in stock assessments, particularly, hydro-acoustic surveys for coastal pelagic fishes, such as mackerel spp., sardine spp., and anchovy spp.;
- The CIE reviewer shall have expertise in the application of fish stock (population) assessment methods, particularly, age-structured population modeling approaches, e.g., 'forward-simulation' models (such as Stock Synthesis, SS) and to a lesser extent, familiarity in 'backward-simulation' models (such as Virtual Population Analysis, VPA);
- The CIE reviewer shall have expertise regarding life history strategies and population dynamics of coastal pelagic fishes; and
- It is desirable for the CIE reviewer to be familiar with stock assessment development/modeling for regularly advising resource management bodies, i.e., management vs. research models.

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 reviewer

1. 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 reviewer 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 reviewer shall read all documents in preparation for the peer review, for example:*

    - *Recent stock assessment documents since 2015;*
    - *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 and logistical considerations.*

    Pre-review documents will be provided up to two weeks before the review, scheduled for April 23-25, 2019. Any delays in submission of pre-review documents for the CIE 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 reviewer is responsible only for the pre-review documents that are delivered to the reviewer in accordance to the PWS scheduled deadlines specified herein.
2. Attend and participate in the panel review meeting.
    - The meeting will consist of presentations by the STAT and other collaborators (biologists, researchers, etc.) to facilitate the review, provide any additional information required by the reviewer, and answer any questions from reviewer.
3. After the review meeting, reviewer 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; reviewer is not required to reach a consensus with other panelists.
4. The reviewer may assist the Chair of the meeting with contributions to the summary report, if required by the ToRs.
5. Deliver their report to the Government according to the specified milestone dates.

Foreign National Security Clearance

When a reviewer participates during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for any reviewer who is a non-US citizen. For this reason, the reviewer 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 Southwest Fisheries Science Center in La Jolla, California.

Period of Performance
The period of performance shall be from the time of award through June 2019. The 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.

March 26, 2019	Contractor selects and confirms reviewer
April 9, 2019	Contractor provides the pre-review documents to the reviewer
April 23-25, 2019	The reviewer participates and conducts an independent peer review during the panel review meeting
May 10, 2019	Contractor receives draft reports
May 24, 2019	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. Travel is not to exceed $3,500.

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

NMFS Project Contact:
Dale Sweetnam
dale.sweetnam@noaa.gov
NMFS, Southwest Fisheries Science Center
8901 La Jolla Shores Drive, La Jolla, CA 92037-1509

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 reviewer's role 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. The reviewer 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. The reviewer should discuss their independent view on each ToR even if these were consistent with those of other panelists, but especially where there were divergent views.

   c. The reviewer should elaborate on any points raised in the summary report that the reviewer believes might require further clarification.

   d. The reviewer 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 Performance Work Statement
   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 Mackerel Stock Assessment

The CIE reviewer is 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 Reviewer, 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: PACIFIC MACKEREL STAR PANEL

Tuesday, 23 April

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 mackerel survey-based assessment presentation	Crone/Hill/Zwolinski
10h00	Break	
10h30	Pacific mackerel model-based assessment presentation	Crone/Hill/Zwolinski
11h30	Acoustic-trawl survey operations and data	Zwolinski
12h00		
12h30	Lunch	
13h30	Pacific mackerel assessment presentation (continue)	Crone/Hill/Zwolinski
14h30	Panel discussion and analysis requests	Panel
15h00	Break	
15h30	Public comments and general issues	
17h00	Adjourn	

Wednesday, 24 April

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

Thursday, 25 April

08h00. Assessment Team Responses	Crone/Hill/Zwolinski
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 peer review meeting

STAR Panel Members

Owen Hamel (Chair), Scientific and Statistical Committee (SSC), NOAA/NWFSC
John Budrick, Scientific and Statistical Committee (SSC), CDFW
Andrew Ole Shelton, Scientific and Statistical Committee (SSC), NOAA/NWFSC
Yan Jiao, Center for Independent Experts (CIE)

CPSMT/CPSAS Advisors to STAR Panel

Diane Pleschner-Steele, CPSAS
Lorna Wargo, CPSMT

Pacific Fishery Management Council (Council) Representatives:

Kerry Griffin, Council Staff

Pacific Sardine Stock Assessment Team:

Paul R. Crone, SWFSC
Kevin Hill, SWFSC
Juan P. Zwolinski, SWFSC
Michael Kinney, SWFSC

Other participants and their affiliation and contacts (provided by SWFSC)

Briana Brady, CDFW
Emmanis Dorval, CPSMT, SWFSC
Kerry Griffin, PFMC
Peter Kuriyama, SWFSC
Hui-Hua Lee, SWFSC
Josh Lindsay, CPSMT, NMFS WCR
Kirk Lynn, CPSMT, CDFW
Trung Nguyen, CDFW
Kevin Piner, SWFSC
Dale Sweetnam, SWFSC
Annie Yau, SWFSC
Louis Zimm, PFMC

Abbreviations:

CDFW – California Department of Fish and Wildlife
CPSAS - Coastal Pelagic Species Advisory Subpanel
CIE – Center for Independent Experts
CPSMT - Coastal Pelagic Species Management Team
NMFS – National Marine Fisheries Service (NOAA)
NOAA - National Oceanic and Atmospheric Administration
NWFSC - Northwest Fisheries Science Center (NMFS/NOAA)
PFMC - Pacific Fishery Management Council
SSC - Scientific and Statistical Committee (of the PMFC)
SWFSC - Southwest Fisheries Science Center (NMFS/NOAA)
VT - Virginia Polytechnic Institute and State University
WCR – West Coast Region of NMFS (NOAA)

Appendix 4: Requests to the STAT (cited from the STAR panel draft summary report, PFMC 2019)

Day 1 requests made to the STAT- Monday April 23, 2019

Request 1: Provide information about year-specific mean length-at-age compiled from the fishery sources.

Rationale: Descriptions of length-at-age pooled across years (2008-2018) were presented in the draft stock assessment report. The STAR panel wanted to understand the variation in the raw length-at-age data to determine if there was additional value in incorporating variation in size among years. This variation among years should help inform the value in using pooled data in the length to age conversion.

Response: The STAT provided a plot of year-specific mean length at age. The data summary shown included year-round data, whereas the length-to-age key was restricted to data from July-December. The graph indicated considerable variability in length-at-age, including in 0 to 3 year olds, where sample size is substantial. There were few fish years 5 and older, but the plot showed a consistent pattern of among-years variation in size, with some years having consistently larger fish for each of ages 4 and above, and others, smaller fish at those ages.

Conclusion: Alternative conclusions can be drawn from this. One could conclude that there is considerable variability in size-at-age in each year, which, coupled with differences in year-class strength, would indicate that using year-specific length-to-age keys would be preferred. Alternatively, one could conclude that the data are too variable, partially due to timing and location of fisheries in each year, and the data should be pooled to make a single length-to-age key.

Request 2: Investigating sensitivity of ALT_19 to aspects of age-composition.

Request 2a: Remove AT survey age-composition data from the assessment while fixing AT survey selectivity from model ALT_19.

Rationale: The panel was interested in investigating the relative influence of fishery vs. survey data. The quality of the AT survey age data in the model may be questionable due to both small sample size and the single year-aggregated fishery-based length-to-age transition matrix used to develop the age data from the length data.

Response: Model results showed that the estimated fishery selectivity changed to increase the selectivity of ages 0 and 1. Changes to older ages were relatively small. With the AT survey age data removed, the large 2018 year-class estimated in the pre-STAR base model (ALT_19_16) is no longer supported. Diagnostics showed no notable improvement in fit to AT survey index of abundance. In terms of parameters, the age data in the AT survey are influential (e.g., estimated M declined from approximately 0.77 in ALT_19_16 to 0.46 when the AT survey age data were removed, and the patterns of estimated recruitment changed dramatically).

Conclusion: The AT survey age data provide substantial information to the model.

Request 2b: Remove fishery age-composition data from the assessment while fixing fishery selectivity from model ALT_19.

Rationale: The panel was interested in investigating how much influence the fishery age data had on the model relative to the survey data.

Response: Removing fishery age-composition data resulted in small changes to the age-0 selectivity for AT survey. Recruitment estimates from years prior to 2012 became more uncertain because there are no age-composition data from the 2008 AT survey. This model produces the closest fit between the model biomass and the AT survey estimate, although the model still over-predicts the 2013 biomass index. Estimates of other main parameters were not substantially changed.

Request 2c: Use fishery year-specific age-at-length distributions to generate age composition time-series for the AT survey. Incorporate in model.
Rationale: The AT survey input age data were developed assuming a year-aggregated fishery-based length-to-age matrix. The annual length to age transition matrices should reflect both year-to-year variation in size at age, and variation in relative year-class strength, although year-to-year variation in actual fishery selectivity (insofar as it is actually age-based rather than length-based), and small sample may cause spurious differences across years.
Response: There was adequate information to develop these transition matrices on an annual basis, although the STAT expressed concern about small sample sizes for some ages in some years. Use of year-specific versus pooled length-age relationships does generate change in the age composition information that is used in the model. The use of year-specific age composition results in similar overall model estimates, but the quality of the model fit *is slightly reduced for the year-specific values according to some panel member's observation but the change of the likelihood may be compared later (to check with the final Panel report).*

Request 3: Remove all survey data, both biomass index and age composition, to investigate the influence of fishery data alone.
Rationale: The panel was interested in seeing how the fishery data drive the model in the absence of survey data.
Response: This run resulted in higher biomass estimates, although generally of the same order of magnitude, and a very different recruitment series. In addition, the parameter estimates changed dramatically. The survey data are driving this assessment more so than fishery age data, although that has some influence as seen in request 2b.
Conclusion: Include AT survey data.

Request 4: Allow selectivity for the AT survey to be dome-shaped.
Rationale: There was no direct information presented by the STAT on the shape of the selectivity curve for the AT survey. This request was intended to investigate the sensitivity of model results to alternative shapes of the AT survey selectivity curve.
Response: The AT survey selectivity was estimated to be strongly dome-shaped when estimated as a random walk over ages. However, the influence on other parameters: M, h, q, etc., was very small. This is largely because age 4+ represent very small proportions of the population, in the observed fishery and in AT survey samples.
Conclusion: Influence of these changes is not great, so fine to leave AT survey selectivity as asymptotic.

Request 5: Modify model H3_19_3 and remove CPFV data. Add AT survey data; or take ALT_19_16 model and add fishery data back to 1983 while using average weight at age.
Rationale: This request was an attempt by the STAR panel to understand the scale of biomass estimated in the ALT model compared to historical information used in previous assessments. It was also an attempt to examine recent age composition patterns relative to historical observations.

Response: The STAT was able to add these data to the ALT_19_16 model. However, they were unsuccessful in getting the model to converge. Addressing this correctly might require quite a bit of exploration. The model is driven by the early data, which is less applicable to recent dynamics.
Conclusion: The STAR panel agreed that leaving out the earlier data was reasonable. However, this suggests that HCRs and reference points need to be revisited.

Request 6: Fix selectivity for fishery to be constant for ages 4+ instead of 5+
Rationale: The empirical weight at age shows that fish ages 4 and older are of roughly equivalent size. If the fish are of equivalent size, it seems they are likely to be of similar or equivalent selectivity. The STAR panel was interested in determining if forcing age 4+ to have the same selectivity affected model estimates.
Response: This change had virtually no effect on any estimates or results.
Conclusion: The STAT and STAR panel agreed to continue with ages 5+ for constant selectivity.

Day 2 requests made to the STAT- Wednesday April 24, 2019

Request 7: Consider the double-normal parameterization, time-invariant for the fishery selectivity.
Rationale: The non-monotonic increase in the time-invariant fishery selection from ages 1 to 3 is unexpected and does not have a good explanation related either to biology or fishery operations.
Response: The change resulted in constant selectivity at ages 1-3, with almost identical results in terms of biomass trajectory, recruitment deviations, and other diagnostics. Upon further inspection, the double normal parameterization with six parameters was difficult to estimate and caused difficulties in convergence. More time would be needed to explore this.
Conclusion: The STAT elected to stay with the random walk approach to fishery selectivity, and the STAR panel agreed.

Request 8: Come to a consensus on the use of year-specific versus pooled length-age relationship for transforming AT survey length compositions to age composition data.
Rationale: The STAR panel prefers the annual length-age transformation matrix, to reflect time-varying growth and relative cohort strength, while recognizing that variance in the fishery and sampling across years, as well as small sample sizes, can lessen the quality of the individual year data.
Response: The STAT preferred to stick with the pooled length-age transformation matrix.
Conclusion: The pooled-length-age transformation matrix was used going forward.

Request 9: Implement two approaches for time-varying selectivity for age-0 in the AT survey.
Rationale: The fit to age-0 in both the fishery and the survey is relatively poor compared to other ages. Additionally, the STAT provided information suggesting that there were reasons why the AT surveys would vary among years in in their detection of age-0 fish. There appears to be some information about age-0 fish in the AT survey, so the panel did not want to remove this information completely.

Request 9a: Implement the penalty approach for allowing age-0 selectivity to vary with time.
Rationale: See rationale for request 9 above.

Response: The time-varying approach with the penalty behaves well and is explicable. However, small movements in value of the penalty function can cause unexpected and unrealistic values. The STAT found that a choice of sigma=0.4 eliminated erratic behavior of the selectivity for age 0s. Larger values of sigma (e.g. sigma =0.5) produced declining selectivity with age for certain years (2016, 2018; e.g. age-0 selectivity = 1.0, age 1+ selectivity = 0.8 or so). As the selectivity should not change for ages 1+ among years, unless *q* is also changed, the use of sigma = 0.4 was viewed as preferable. With sigma= 0.4, this model produced slightly better fit to age zeroes, and, generally, a better fit to the AT survey index. Upon later exploration, finding the model with the lowest likelihood under this configuration was not straightforward.

Conclusion: This approach appears promising, despite the ad-hoc choice of sigma and the convergence issues.

Request 9b: Implement the time-blocking approach for allowing age-0 selectivity to vary with time. This fixes selectivity at 1.0 for all ages in 2016 and 2018, the years where exceptionally high numbers of age zero were seen, and freely estimates age-zero selectivity in every other year.

Rationale: See rationale for request 9 above.

Response: Blocking requires more subjective decision making, in terms of which years to fix at selectivity = 1.0 for age-0 fish, and it may be an issue to make that decision in the future. This approach introduces a lot of flexibility. The resulting model fits the AT survey index a bit better, but doesn't fit the age data as well as one might expect. This removes more of the influence of age-0 data, which affects especially the estimate of the 2018 recruitment for which the age-0 data are the only age data.

Conclusion: This approach was considered more subjective than that in 9a, due to having to decide which years to set within the block, which could have a large influence, especially on the recruitment within the last year of data.

Request 10: Implement request 9 with fixed selectivity for the fishery and remove all fishery age data.

Rationale: There is concern that variability in selectivity of the fishery is resulting in spurious model behavior. Simpler approach than implementing time-varying fishery selectivity, which would also remove the data in terms of informing recruitment, etc. but would inform time-varying selectivity of removals.

Request 10a: Implement request 9a (penalty approach) with fixed selectivity for the fishery and remove all fishery age data.

Rationale: See rationales from 9a and 10.

Response: This results in a better fit to age comp and index.

Conclusion: Use of time-varying age-0 selectivity (or age-0 data as an index of recruitment independent of an age 1+ survey index) is an area that should be explored further.

Request 10b: Implement request 9b (time-blocking approach) with fixed selectivity for the fishery and remove all fishery age data.

Rationale: See rationales from 9b and 10.

Response: This results in a better fit to age comp and index as with 10a.

Conclusion: More work is needed to determine whether the fishery age data provide reliable information on year-class strength and removals, which will determine how to use this data.

<u>Day 3 requests made to the STAT - Thursday April 25, 2019</u>

Request 11: Conduct 6 runs as follows. Down-weight fishery age composition data by setting λ = 0.5 or 0.25. Also, use Francis weighting for both fishery and survey age data. Do each of these with the pre-STAR base model (ALT_19_16) and with the model coming out of request 9a.

Rationale: The STAR panel and STAT were working to arrive at potential base model considerations. One big question is the value (thus weighting) of fishery age data, and another is whether there should be time-varying age-0 selectivity for the AT survey age data.

Response: The discussion focused on the down-weighting of the fishery age data. Due to issues with convergence that could not be resolved at the STAR panel, the STAT preferred not to move forward with the time-varying age-0 selectivity for the AT survey (as in request 9a). The response to down-weighting the fishery age data was as expected, as λ was decreased from 1 to 0, the fit of the model to the AT survey index of abundance improved (Figure 3) and the end-year biomass estimate increased (Figure 4).

Conclusion: The STAT and STAR panel agreed that the model with λ on the fisheries age data set to 0.5 was an acceptable base model, and that of time-varying age-0 AT survey selectivity would be included in the sensitivities in the final assessment document.

The STAR panel asked for 7 sensitivity analyses in the next version of the assessment document beyond the 13 sensitivities outlined in the pre-STAR assessment. These 7 include the 4 sensitivities implied by request 11: λ = 1, 0.25 or 0 on the fishery age composition data, or use of Francis weighting for all age data. The remaining 3 are: 1. A sensitivity incorporating the penalty approach to time-varying AT survey age zero selectivity with sigma = 0.4 (See Request 9a). 2. A sensitivity to dome-shaped AT survey selectivity (see Request 4). 3. A sensitivity to the year specific length-to-age transition matrix to develop AT age compositions (see Request 2c).

Reference:

Pacific Fishery Management Council (PFMC). 2019. Pacific Mackerel Stock Assessment Review (STAR) Panel Meeting Report. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220 OR. Agenda Item F.3, Attachment 2, June 2019. 23 p.