Updates on the development of the 2019 stock assessment

PREPARED BY: IPHC SECRETARIAT (I. STEWART, A. HICKS; 24 AUGUST 2019)

PURPOSE

To provide the IPHC's Scientific Review Board (SRB) with a response to requests made during SRB014 (IPHC-2019-SRB014-R), held in June 2019, and to provide the Commission with an update of the 2019 assessment development and preliminary results.

INTRODUCTION

The IPHC's stock assessment and review process has developed from the first *ad hoc* meeting held in 2012 (Stewart et al. 2013) to a formal and documented process involving the SRB (https://www.iphc.int/the-commission/structure-of-the-commission) and periodic external independent peer review (https://www.iphc.int/management/science-and-research/stock-assessment). The IPHC's SRB meets two-three times per year, in June to review stock assessment development, in September to review progress in response to the June review and to finalize the model structure and methods to be used in conducting the year's stock assessment, and as needed in December to review any unexpected results and address any questions arising from the stock assessment. Within this annual review process two types of stock assessments are produced: 1) updated assessments where new data are added but the methods and model structures remain unchanged, and 2) full stock assessments occurring every three years in which model structure and methods are revised to reflect new data, approaches and comments from SRB and independent review. The 2015 stock assessment was a full analysis (Stewart and Martell 2016; Stewart et al. 2016), 2016-2018 were updated assessments (Stewart and Hicks 2018, 2019; Stewart and Hicks 2017), and the 2019 assessment is a full analysis. New data sources including estimates of the sex-ratio of the directed commercial Pacific halibut landings for 2017, a revised modelled survey time series accounting for improved whale depredation criteria, and several improvements to the model structure and software were included in a preliminary assessment provided to the SRB and for the external review in June 2019 (IPHC-2019-SRB014-07).

This document provides detailed responses to the requests made by the SRB (IPHC-2019-SRB014-R). It also includes a list of select suggestions and comments provided by the external independent peer review (https://www.iphc.int/uploads/pdf/sa/2019/stokes_2019-independent_peer_review_for_the_2019_iphc_stock_assessment.pdf), noting where and how each will be addressed.

If available, presentation of any preliminary data sources or updates to data sources will be provided during SRB015, 24-26 September 2019. Any outstanding changes to the model structure, methods or data sets anticipated for inclusion in the final 2019 stock assessment analysis will also be identified during the meeting.

SRB REQUESTS AND RESULTS

The SRB made the following requests during SRB014 (IPHC-2019-SRB014-R):

SRB014–Req.01 (para. 27): *"The SRB REQUESTED the following additional analyses for evaluation in September:*

a) The Pacific Decadal Oscillation (PDO) index affects results that correspond with the presence and absence of FISS age data. As a check, perhaps evaluate models with the *selectivity for the FISS fixed at the current estimates but then do a run which completely down-weights the FISS age data. This is intended as a check for the PDO coefficient.*

b) Evaluate a profile (coarse) over steepness, e.g. 0.65 and 0.85, and check the impact on recruitment estimates and RSB values."

In order to evaluate the relative effect of the FISS age data on the time-series of recruitments and the estimates of the Pacific Decadal Oscillation (PDO) link coefficients (*part a*) a new run was conducted for each of the long time series models (coastwide and Areas-As-Fleets). To structure these alternative models all parameters were first estimated using the structure of the 2019 base model (IPHC-2019-SRB014-07). Next the input files were configured to run using the ".par" file containing the maximum likelihood estimates for all model parameters as starting values and all selectivity parameters associated with the FISS data (base and time-varying deviations) were set to remain at initial values (using negative phases) and not be re-estimated. Finally, the multipliers associated with the likelihood components for all survey age data were set to a value of 0.0, eliminating these data from the objective function. Both models were then re-estimated and the time-series of recruitments as well as the estimates of the PDO link coefficients were compared to the preliminary 2019 base models.

Both the coastwide long and Areas-As-Fleets long models showed only minor differences after the reconfiguration described above. Specifically, the maximum likelihood estimate of the PDO link coefficient in the coastwide long model changed from a value of 0.40 (in the base model) to a value of 0.39 (with no likelihood contribution from the survey age data), while the coefficient in the Areas-As-Fleets long model changed from a value of 0.29 to a value of 0.31. Similarly the time series' of recruitment estimates showed slightly lower peaks in the larger recruitments but little change overall relative to the confidence intervals on those estimates (Figure 1). From these results, it appears that although the transition between PDO regimes 1977 also divides the early portion of the time series lacking survey age data and the later portion including extensive survey ages, the signal for a correlation between the PDO and mean recruitment (via the estimated link coefficients) is supported by the fishery data as well.

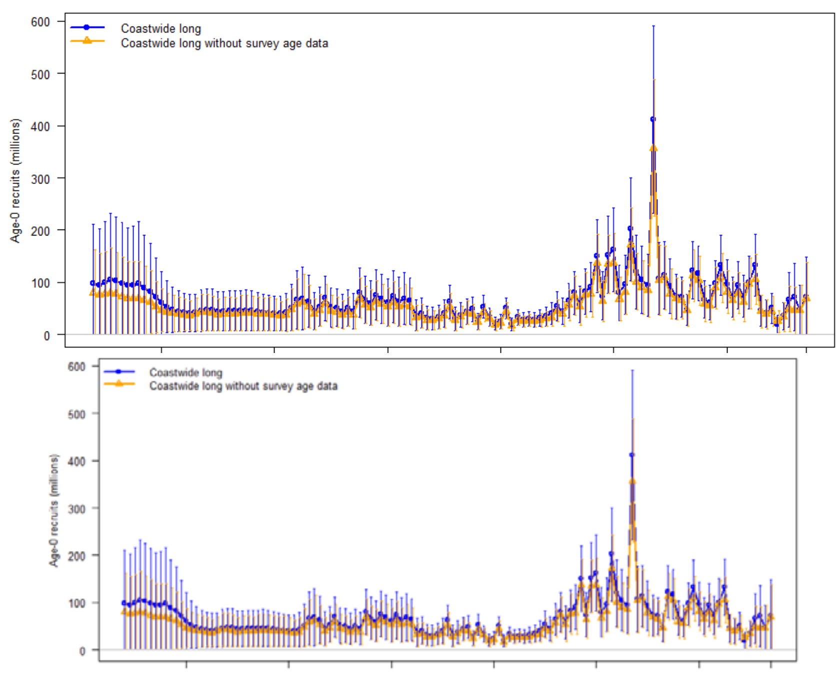
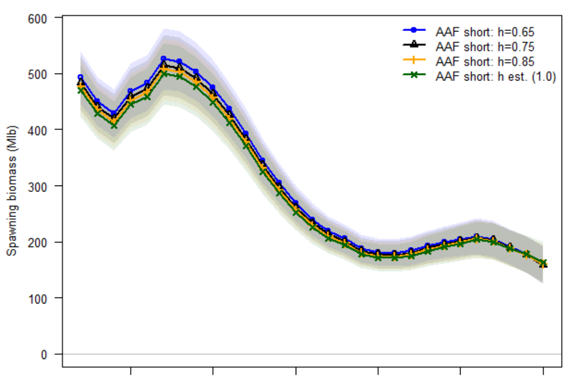


Figure 1. Comparison of the preliminary 2019 model recruitment estimates and a sensitivity conducted by removing the survey age data (but holding selectivity parameters at previous estimates) for the coastwide long (upper panel) and Areas-As-Fleets long (lower panel) models.

In order to evaluate the effect of alternative values of steepness (*part b*) two new model runs were conducted for each of the four stock assessment model using the preliminary 2019 base model (IPHC-2019-SRB014-07): one run with the steepness parameter for the stock-recruitment relationship (*h*) fixed at 0.65 and one with the parameter fixed at 0.85. These two runs were compared with the base model which used a value of steepness of 0.75 and the sensitivity model in which steepness was freely estimated (IPHC-2019-SRB014-07). The results were consistent with those of the preliminary assessment showing very little difference in the spawning biomass time series or the recruitment time series for the coastwide short (Figure 2), Areas-As-Fleets short (Figure 3) and Areas-As-Fleets long models (Figure 4). The coastwide long model, as in the sensitivity analysis in the preliminary assessment showed the greatest sensitivity to alternative values of steepness with a larger magnitude of both spawning biomass and recruitment estimated for lower values of steepness (Figure 5).

In order to investigate whether the differences in the long coastwide model were related to the tuning of the standard deviation of the recruitment deviations (σ_r), and additional model run was conducted after re-tuning the input value for σ_r from 0.55 to 0.5 to more closely match the model results (following the methods of Methot and Taylor 2011). This led to a slight change in the spawning biomass time series (bringing the results slightly closer) but generally did not account for the difference in the scale of the estimates (Figure 6) The sensitivity to steepness in this model may be related to the very low biomass levels estimated (by this model) to have occurred in the 1930s and 1970s. The best fitting value of steepness (estimated at 1.0) generated a negative log-likelihood that was 2 units better than a value of 0.85 and 4 units better than a value of 0.75. The fit was degraded by 32 units at a value of 0.65. As this model uses tuned input sample sizes, direct interpretation of the change in likelihood is difficult, but these results suggest that values from 0.75-1.0 are consistent with the data. Further, given the use of dynamic reference points that depend on the calculation of the spawning biomass that would be predicted to occur in the absence of fishing a value of 0.75 allows for fishing to effect the central tendency of the expected recruitment which is inherently precautionary, despite that slightly larger biomass estimated at lower values of steepness. The treatment of steepness is also related to other components of the stock-recruitment relationship including σ_r and the PDO (both explored above). At least for the coastwide long model, steepness remains a source of uncertainty that is not currently captured in the ensemble results.



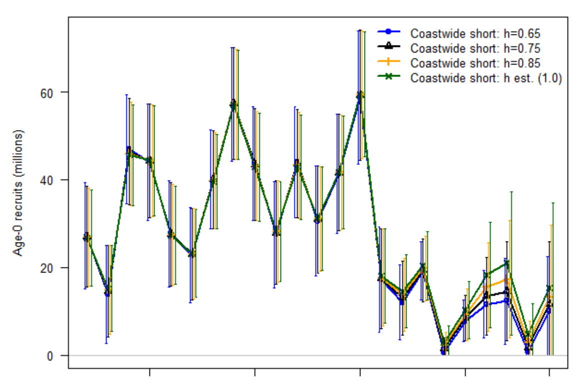


Figure 2. Results of the profile on steepness from the coastwide short model.

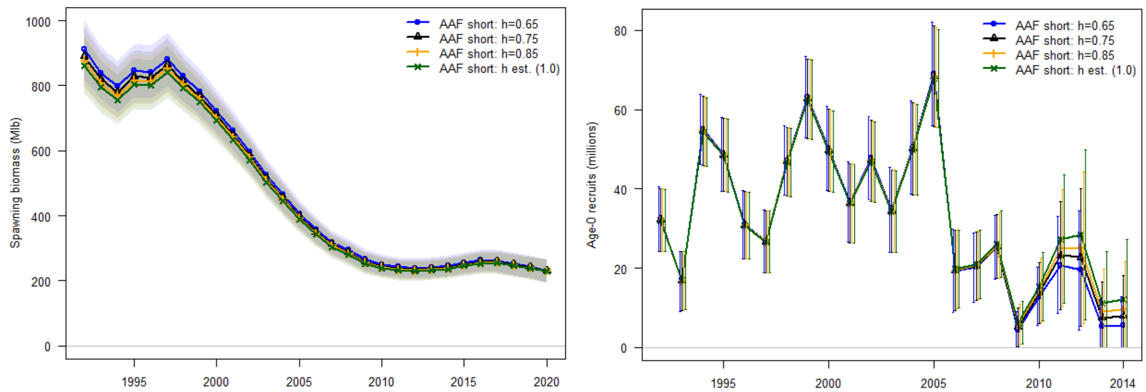


Figure 3. Results of the profile on steepness from the Areas-As-Fleets short model.

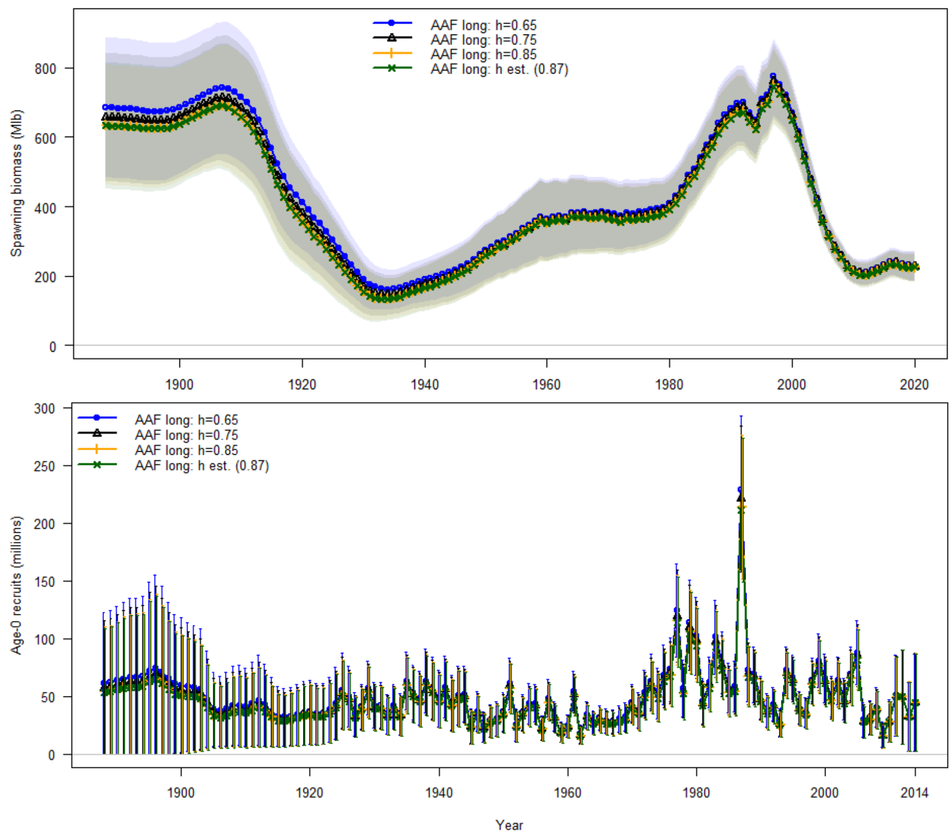


Figure 4. Results of the profile on steepness from the Areas-As-Fleets long model.

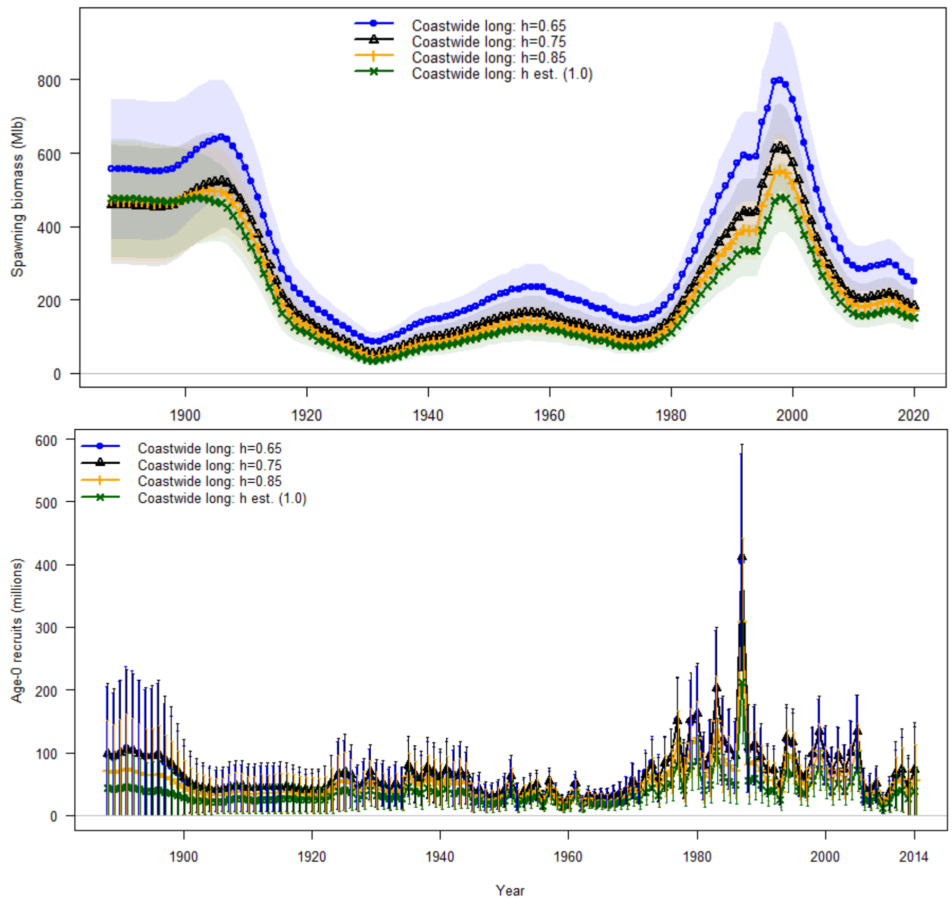


Figure 5. Results of the profile on steepness from the coastwide long model.

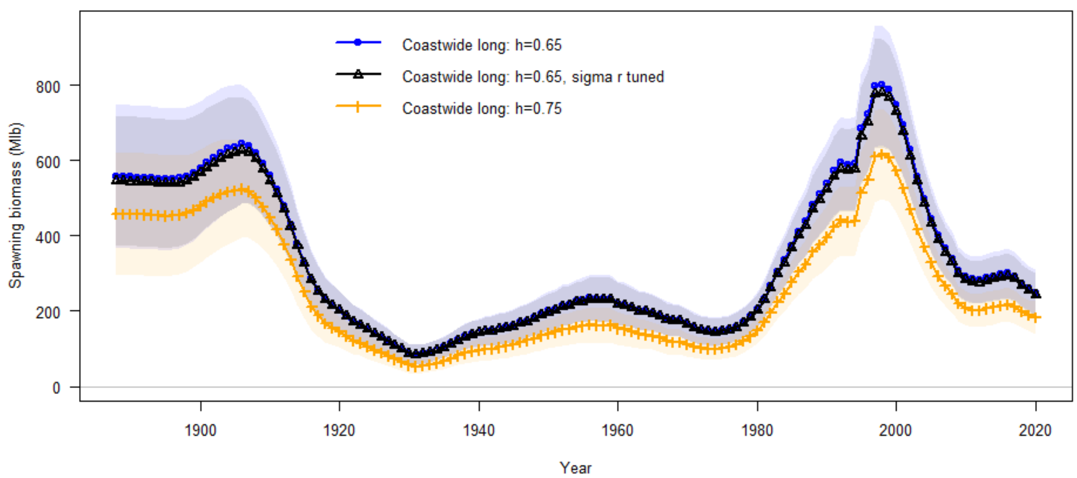


Figure 6. Comparison of spawning biomass time series' estimated from the preliminary 2019 coastwide long model with steepness set at 0.65, 0.75 and 0.65 with σ_r re-tuned.

SELECT COMMENTS FROM THE EXTERNAL PEER REVIEW

Because a detailed presentation of the external peer review will be made during SRB015, a separate summary is not provided here. Rather, a list of select items is highlighted for potential discussion during the meeting, with reference to the location (page number) of each in the review document:

Pages 7 and 22 suggest investigation of the sensitivity of the assessment to whale depredation as a potential component for the 2019 assessment (and MSE). As was done in 2017 and 2018, sensitivity to both constant and trending unobserved mortality will be reported.

Pages 7 and 21 identify the high priority for the sex ratio of the 2018 commercial Pacific halibut fishery landings to supplement the 2017 used in the preliminary assessment. All efforts are being made to ensure these data are available. The potential for extracting sex ratio information from historical samples (prior to 2017) is also being discussed.

Page 9 notes the need for documentation for the revised Fishery Independent Setline Survey (FISS) whale depredation criteria. These criteria were developed for and applied to the 2018 FISS. The 2019 summary of survey activities can provide a further synopsis of the changes to the historical time-series. The IPHC's website also provides tools to explore these data directly, including which historical stations were retrospectively determined to be ineffective and the specific marine mammal responsible for this determination (https://www.iphc.int/data/fiss-performance).

Page 10 discusses the relative importance of weight-at-age for 3-year projections, noting that it may be difficult to identify factors/processes leading to changes in weight-at-age to the degree that they become predictable. This and other specific research needs will be combined with a general discussion of research priorities for SRB015.

Pages 11 and 16 suggest reporting the tuning or data weighting applied to each data source in each model over time (Table 11 in IPHC-2019-SRB014-07). This can be easily included, although it may be more appropriate to summarize for the SRB than to include in the primary assessment document provided for management use. Further, it raises the question as to whether data weighting should be adjusted during updated assessments, or held constant between full assessments (as was done between the 2015 and 2019 analyses).

Page 12 notes that if additional models with alternative values for steepness are included in the ensemble (particularly for the coastwide long model), the weights should reflect that they are nested and not independent additions. This is relevant to the discussion of the steepness analysis described above.

Pages 12 and 20 identify the importance of connectivity between IPHC Convention waters and those of the western Pacific (i.e. Russia). This is an important research recommendation that was inadvertently omitted from the preliminary assessment document.

Page 13 suggests the potential benefits of re-developing the individual Pacific halibut models in an alternative software, perhaps coded specifically for Pacific halibut and able to utilize random effects. This suggestion raises an important consideration of the trade-offs between using a generalized stock assessment platform (in this case stock synthesis) vs. custom-developed code. Both have pros and cons. An upcoming workshop on the next generation of generalized stock assessment models (http://capamresearch.org/Next-Gen-SAM) may provide additional information on which to base this strategic decision.

Page 14 provides support for continued development of Bayesian versions of the individual assessment models, particularly if/when the Commission transitions to a management procedure approach with a longer interval between stock assessments.

Page 15 identifies the inclusion of the deconstruction or step-by-step transition in reference point calculations from the 2018 to 2019 stock assessments as a helpful tool for understanding the changes made. This deconstruction was provided in the preliminary document (IPHC-2019-SRB014-07) and is re-summarized below. It will be extended further to include the addition of the 2019 data in addition to the extension of the time-series, new data available for the preliminary assessment and model updates, and transition from static to dynamic reference points, such that the relative influences of each factor is clear.

Pages 17 to 18 suggest an informal test of the robustness of management quantities to the sequential exclusion of each individual model in the ensemble (a 'leave one out' approach) to be included in the 2019 stock assessment. As with the data weighting table, this raises the question as to whether this is best included for the SRB or in the primary document and when in the process it should be presented.

Page 18 suggests that at this time it may be beneficial to minimize changes to the ensemble in order to facilitate transition to a management procedure.

Page 19 identifies several improvements to the presentation of research recommendations, including ranking and denoting those in progress vs planned. These recommendations are similar to those from SRB014 and will be addressed in the discussion of research priorities during SRB015.

SUMMARY OF PRELIMINARY ASSESSMENT RESULTS

At the time of production of this document there were no new data available with which to update the preliminary 2019 stock assessment results from those provided in June (IPHC-2019-SRB014-07). This section therefore re-summarizes the basic results, noting where differences occurred.

There were four steps taken to update from the 2018 stock assessment (implemented in the newest version of stock synthesis) to the preliminary results for 2019:

1) Add the newly available sex-ratio data from the 2017 commercial fishery landings and estimate male selectivity scale parameters.
2) Extend the time series (for the two short models) from 1996 to 1992 and add a stock-recruitment function to these models.
3) Replace the modelled FISS time-series with the series corrected for whale depredation.
4) Regularize and tune each model to be reliable and internally consistent given all the changes that had been made.

Overall, the inclusion of the 2017 sex-ratio data resulted in higher spawning biomass for all models, and the updated whale depredation data made little difference to the results. Extending the time-series back to 1992 in the two short models resulted in higher estimates of recruitment for 1994 and 1995. Regularizing and tuning the series had different effects on each model. In aggregate, the historical female spawning biomass estimated from the stock assessment ensemble was slightly larger than that estimated in previous assessments at the end of the time series, and considerably larger prior to the early 2000s, although the trend remains very similar in recent years (Figure 7).

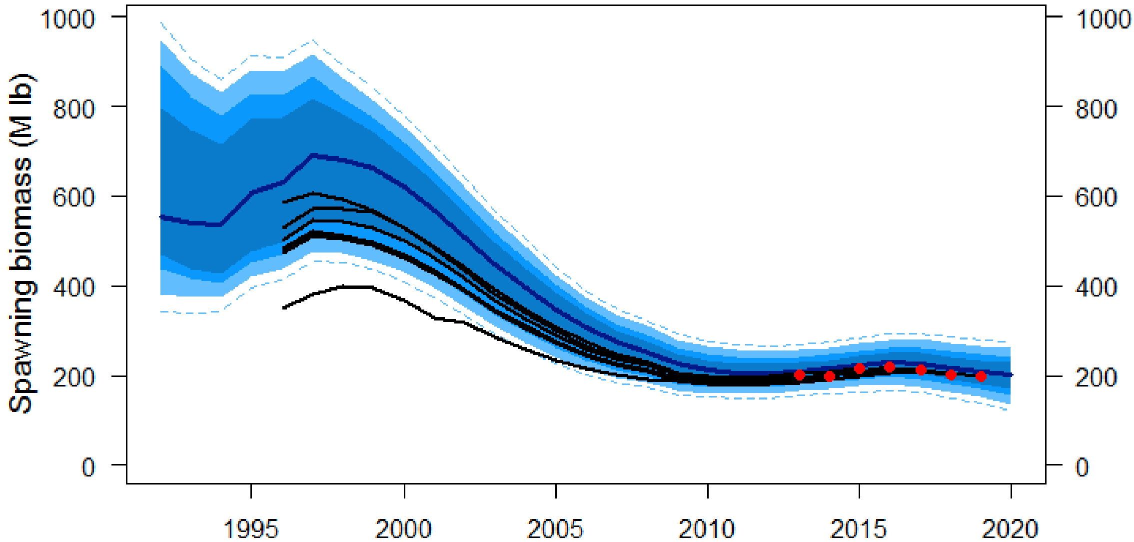


Figure 7. Comparison of estimated biomass time series for the preliminary 2019 ensemble (shaded region; colours indicate quantiles) and recent ensembles from 2013-2018 (black lines; red points indicate terminal estimates).

In addition to the change in the estimated spawning biomass, fishing intensity (via the Spawning Potential Ratio, SPR) is estimated to be somewhat higher since 2003. Because the mortality inputs to the assessment models have not changed and the biomass is larger, this clearly illustrates the effect of an increased fraction of females estimated to occur in the commercial landings, and therefore a greater effect of the lifetime spawning output of the stock. The biomass based reference point calculations changed for 2019 from historical static values to dynamic quantities (IPHC-2019-SRB014-07). Given the change in the calculation of these reference points from the fixed historical inputs to the dynamic calculation, a series of comparisons were made in order to clearly determine how much of the change in status from the 2018 assessment was due to the additional year of projection, the calculation methods, and the new data and updated models. The following reference points were constructed from the 2018 stock assessment and the preliminary 2019 results:

- From the 2018 stock assessment: median relative biomass in 2019 (based on the previous reference points) was estimated to be 43% (95% interval from 27-63%), with a probability of being below $SB_{30\%}$ of 11%, and a probability of being below $SB_{20\%}$ of <1%.
- Extending the 2018 stock assessment time series, but not making any changes to the data or calculations: median relative biomass in 2020 (based on the previous reference points) was estimated to be 38% (95% interval from 22-51%), with a probability of being below $SB_{30\%}$ of 25%, and a probability of being below $SB_{20\%}$ of <1%.
- After updating the assessment to the preliminary 2019 configuration: median relative biomass in 2019 (based on the updated calculations) was estimated to be 32% (95% interval from 23-44%), with a probability of being below $SB_{30\%}$ of 38%, and a probability of being below $SB_{20\%}$ of <1%.
- The median relative spawning biomass at the beginning of 2020 was estimated to be 31% (95% interval from 20-44%), with a probability of being below $SB_{30\%}$ of 44%, and a probability of being below $SB_{20\%}$ of 2%.

Thus, a portion of the change in status (from the beginning of 2019 based on the 2018 assessment to the beginning of 2020 based on the preliminary 2019 assessment) is due to the change in reference points, but the majority of the change (7% of the 12%) is due to the addition of new data and updating of the individual models comprising the ensemble. The considerable uncertainty in these estimates leads to overlapping confidence intervals in all reference point comparisons.

REMAINING DATA FOR INCLUSION IN THE 2019 STOCK ASSESSMENT

The following new updated data (Stewart and Webster 2019) are anticipated for inclusion in the final 2019 stock assessment:

1. Estimates of mortality from all fisheries during 2019 (Erikson 2019).
2. Results of the 2019 IPHC Fishery Independent Setline Survey (FISS; Erikson et al. 2019) and the time series' of modelled catch rates produced using the FISS and other information (Webster 2019).
3. Directed commercial fishery logbook information from the 2019 fishing season (Stewart and Webster 2019).
4. Individual weights, and/or length/age frequency information from the FISS, directed commercial fishery, NOAA Fisheries trawl surveys in Alaska (https://www.iphc.int/management/science-and-research/noaa-groundfish-trawl-surveys-data-partnerships), Alaska Department of Fish and Game (from recreational harvest) and from NOAA fisheries and Fisheries and Oceans Canada for discard mortality in non-directed fisheries (bycatch).

In addition to the updating of standard data sources, it is anticipated that the sex ratio at-age from the 2018 directed commercial Pacific halibut fishery may also be available for the final 2019 stock assessment. This is a new data source for the stock assessment, and adds considerably to the data from 2017 that were used in the preliminary 2019 assessment.

DISCUSSION

At the time of production for this document there were no additional changes proposed from the preliminary 2019 stock assessment (IPHC-2019-SRB014-07). Any large changes recommended by the SRB015 or stemming from analyses suggested by the external peer review (https://www.iphc.int/uploads/pdf/sa/2019/stokes_2019-independent_peer_review_for_the_2019_iphc_stock_assessment.pdf) will likely be explored for evaluation at SRB016. This would allow for inclusion in the 2020 update, or if particularly influential to the results, may be included in the next full assessment currently scheduled for 2022. Minor changes can be evaluated by the Secretariat and SRB as part of SRB015 or inter-sessionally as needed.

RECOMMENDATION/S

That the SRB:

a) **NOTE** paper IPHC-2019-SRB015-07 which provides a response to requests from SRB014.
b) **RECOMMEND** any additional changes to the assessment model structure, ensemble methods or data sources for implementation in the final 2019 stock assessment.
c) **RECOMMEND** any additional changes to the assessment model structure, ensemble methods or data sources for exploration and presentation at SRB016, June 2020.

References

Erikson, L. 2019. Fishery Statistics (2018). IPHC-2019-AM095-05. 23 p.

Erikson, L., Soderlund, E., and Geernaert, T. 2019. Fishery-independent setline survey (FISS) design and implementation in 2018, including current and future expansions. IPHC-2019-AM095-06. 14 p.

Methot, R.D., and Taylor, I.G. 2011. Adjusting for bias due to variability in estimated recruitments in fishery assessment models. Can. J. Fish. Aquat. Sci. 68: 1744-1760.

Stewart, I., and Hicks, A. 2018. Assessment of the Pacific halibut (*Hippoglossus stenolepis*) stock at the end of 2017. IPHC-2018-AM094-10. 25 p.

Stewart, I., and Hicks, A. 2019. Assessment of the Pacific halibut (*Hippoglossus stenolepis*) stock at the end of 2018. IPHC-2019-AM095-09. 26 p.

Stewart, I., and Webster, R. 2019. Overview of data sources for the Pacific halibut stock assessment, harvest policy, and related analyses. IPHC-2019-AM095-08. 76 p.

Stewart, I.J., and Martell, S.J.D. 2016. Appendix: Development of the 2015 stock assessment. IPHC Report of Assessment and Research Activities 2015. p. A1-A146.

Stewart, I.J., and Hicks, A.C. 2017. 4.2 Assessment of the Pacific halibut stock at the end of 2016. IPHC Report of Assessment and Research Activities 2016: 365-394.

Stewart, I.J., Monnahan, C.C., and Martell, S. 2016. Assessment of the Pacific halibut stock at the end of 2015. IPHC Report of Assessment and Research Activities 2015. p. 188-209.

Stewart, I.J., Martell, S., Webster, R.A., Forrest, R., Ianelli, J., and Leaman, B.M. 2013. Assessment review team meeting, October 24-26, 2012. IPHC Report of Assessment and Research Activities 2012. p. 239-266.

Webster, R. 2019. Space-time modelling of survey data. IPHC-2019-AM095-07. 19 p.